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User Guide

Developer Guide

Apache Brooklyn

Welcome to the Apache Brooklyn documentation.

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This guide will walk you through deploying an example 3-tier web application to a public cloud, and demonstrate the autoscaling capabilities of the Brooklyn platform.

Two methods of deployment are detailed in this tutorial, using virtualisation with Vagrant and an install in your own environment (such as your local machine or in your private/public cloud).

The latter assumes that you have a Java Runtime Environment (JRE){:target="_blank"} installed (version 7 or later), as Brooklyn is Java under the covers.

To get you up-and-running quickly, the Vagrant option will provision four compute nodes for you to deploy applications to.

Install Apache Brooklyn

Vagrant{:target="_blank"} is a software package which automates the process of setting up virtual machines (VM) such as Oracle VirtualBox{:target="_blank"}. We recommend it as the easiest way of getting started with Apache Brooklyn.

Firstly, download and install:

- Vagrant{:target="_blank"}
- Oracle VirtualBox{:target="_blank"}

Then download the provided Apache Brooklyn vagrant configuration from

```
[here](https://www.apache.org/dyn/closer.lua?action=download&filename=brooklyn/apache-brooklyn-NaN/apache-brook
lyn-NaN-vagrant.tar.gz).
```

This archive contains everything you need to create an environment for use with this guide, providing an Apache Brooklyn instance and some blank VMs.

Extract the `tar.gz` archive and navigate into the expanded `apache-brooklyn-{{book.brooklyn-version}}-vagrant` folder

```
$ tar xvf apache-brooklyn-{{book.brooklyn-version}}-vagrant.tar.gz
$ cd apache-brooklyn-{{book.brooklyn-version}}-vagrant
```

For Centos 7 and RHEL 7 users, the recommended way to install Apache Brooklyn on RPM-based Linux distributions is by using the RPM package.

RPM is the de facto standard for packaging software on these Linux distributions and provides a mechanism for installing, upgrading and removing packages such as Apache Brooklyn. The RPM package contains all the necessary files associated with the Apache Brooklyn application.

Download the Apache Brooklyn RPM distribution{:target="_blank"}.

Once downloaded, run the following shell command as root:

```
$ yum install apache-brooklyn-{{book.brooklyn-version}}-1.rpm
```

For Ubuntu and Debian users, the recommended way to install Apache Brooklyn is to use the deb file.

The deb file is the de facto standard for packaging software on these Linux distributions and provides a mechanism for installing, upgrading and removing packages such as Apache Brooklyn. The deb package contains all the necessary files associated with the Apache Brooklyn application.

Download the Apache Brooklyn deb distribution{:target="_blank"}.

Once downloaded, run the following shell command:

```
$ sudo dpkg -i apache-brooklyn_{{book.brooklyn-version}}_noarch.deb
```

For Linux or OSX please download the Apache Brooklyn `tar.gz` archive from the download{:target="_blank"} section.

Extract the `tar.gz` archive and navigate into the expanded `apache-brooklyn-{{ book.brooklyn-version }}` folder.

```
$ tar -zxf apache-brooklyn-{{ book.brooklyn-version }}-dist.tar.gz
$ cd apache-brooklyn-{{ book.brooklyn.version }}
```

For all versions of Microsoft Windows, please download the Apache Brooklyn zip file from here{:target="_blank"}.

Extract this zip file to a directory on your computer such as `c:\Program Files\brooklyn` where `c` is the letter of your operating system drive.

By default, no authentication is required and the web-console will listen on all network interfaces. For a production system, or if Apache Brooklyn is publicly reachable, it is strongly recommended to configure security. Documentation of configuration options include:

- Security
- Persistence
- Cloud credentials

Launch Apache Brooklyn

Now start Apache Brooklyn with the following command:

```
$ vagrant up brooklyn
```

You can see if Apache Brooklyn launched OK by viewing the log files with the command

```
$ vagrant ssh brooklyn --command 'sudo journalctl -n15 -f -u brooklyn'
```

Apache Brooklyn should now have been installed and be running as a system service. It can stopped and started with the standard systemctl commands:

```
$ systemctl start|stop|restart|status brooklyn
```

The application should then output its logs to `brooklyn.debug.log` and `brooklyn.info.log`, please refer to the paths page for the locations of these.

Apache Brooklyn should now have been installed and be running as a system service. It can be stopped and started with the standard service commands:

```
$ sudo service brooklyn start|stop|restart|status
```

The application should then output its logs to `brooklyn.debug.log` and `brooklyn.info.log` , please refer to the paths page for the locations of these.

Now start Apache Brooklyn with the following command:

```
$ bin/start
```

The application should then output its log to `brooklyn.debug.log` and `brooklyn.info.log` , please refer to the paths page for the locations of these.

You can now start Apache Brooklyn by running `c:\Program Files\brooklyn\bin\start.bat`

The application should then output its log into the console and also `c:\Program Files\brooklyn\data\log\brooklyn.debug.log` and `c:\Program Files\brooklyn\data\log\brooklyn.info.log`

</div> *Notice! Before launching Apache Brooklyn, please check the `date` on the local machine. Even several minutes before or after the actual time could cause problems.* </div>

Control Apache Brooklyn

Apache Brooklyn has a web console which can be used to control the application. The Brooklyn log will contain the address of the management interface:

```
INFO  Started Brooklyn console at http://127.0.0.1:8081/, running
classpath://brooklyn.war
```

By default it can be accessed by opening 127.0.0.1:8081{:target="_blank"} in your web browser.

The rest of this getting started guide uses the Apache Brooklyn command line interface (CLI) tool, `br` . This tool is both distributed with Apache Brooklyn or can be downloaded using the most appropriate link for your OS:

- Windows
- Linux
- OSX

For details on the CLI, see the Client CLI Reference page.

Next

The first thing we want to do with Brooklyn is **[deploy a blueprint](/guide/start/blueprints.html)**.

Blueprints are descriptors or patterns which describe how Apache Brooklyn should deploy applications. Blueprints are written in YAML{:target="*blank"} and many of the entities available are defined in the _Brooklyn Catalog*.

Launching from a Blueprint

We'll start by deploying an application with a simple YAML blueprint containing an Apache Tomcat{:target="_blank"} server.

Copy the blueprint below into a text file, "myapp.yaml", in your workspace (Note, to copy the file you can hover your mouse over the right side of the text box below to get a Javascript "copy" button).

```
name: Tomcat
services:
- type: org.apache.brooklyn.entity.webapp.tomcat.TomcatServer
  name: tomcatServer
location: <your-location-definition-goes-here>
```

Locations

Before you can create an application with this configuration, you need to modify the YAML to specify a location. Locations in Apache Brooklyn are server resources which Brooklyn can use to deploy applications. These locations may be servers or cloud providers which provide access to servers.

In order to configure the location in which Apache Brooklyn launches an application, replace the `location:` element with values for your chosen target environment. Here are some examples of the various location types:

{::options parse_block_html="true" /}

- Vagrant
- Clouds
- BYON

The Vagrant configuration described in [Running Apache Brooklyn](./running.html), on the previous page is the recommended way of running this tutorial. This configuration comes with four blank vagrant configurations called byon1 to byon4. These can be launched by entering the following command into the terminal in the vagrant configuration directory. ```bash $ vagrant up byon1 byon2 byon3 byon4 ``` The location in "myapp.yaml" can now be replaced with the following YAML to launch using these vagrant servers. ```yaml location: byon: user: vagrant password: vagrant hosts: - 10.10.10.101 - 10.10.10.102 - 10.10.10.103 - 10.10.10.104 ```
Apache Brooklyn uses [Apcahe jclouds](http://jclouds.apache.org/){:target="_blank"} to support a range of cloud locations. More information on the range of providers and configurations is available [here](/guide/locations/#clouds){:target="_blank"}. As an example, here is a configuration for [Amazon Web Services (AWS)](http://www.aws.amazon.com){:target="_blank"}. Swap the identity and credential with your AWS account details, then replace the location in your "myapp.yaml" with this. ```yaml location: jclouds:aws-ec2: identity: ABCDEFGHIJKLMNOPQRST credential: s3cr3tsq1rr3ls3cr3tsq1rr3ls3cr3tsq1rr3l ```
The Bring Your Own Nodes (BYON) configuration allows Apache Brooklyn to make use of already available servers. These can be specified by a list of IP addresses with a user and password as shown below. More information including the full range of configuration options is available [here](/guide/locations/#byon){:target="_blank"}. Replace the hosts, user and password in the example below with your own server details, then replace the location in your "myapp.yaml" with this. ```yaml location: byon: user: myuser password: mypassword # or... #privateKeyFile: ~/.ssh/my.pem hosts: - 192.168.0.18 - 192.168.0.19 ```

Note: For instructions on setting up a variety of locations or storing credentials/locations in a file on disk rather than in the blueprint, see **Locations** in the Operations section of the User Guide.

Deploying the Application

First, log in to brooklyn with the command line interface (CLI) tool by typing:

```
$ br login http://localhost:8081/
```

To secure the Apache Brooklyn instance, you can add a username and password to Brooklyn's properties file, as described in the User Guide here{:target="_blank"}. If this is configured, the login command will require an additional parameter for the userid and will then prompt for a password.

Now you can create the application with the command below:

```
$ br deploy myapp.yaml
```

```
Id:       hTPAF19s
Name:     Tomcat
Status:   In progress
```

Depending on your choice of location it may take some time for the application to start, the next page describes how you can monitor the progress of the application deployment and verify if it was successful.

Next

Having deployed an application, the next step is **[monitoring and managing](managing.html)** it.

So far we have gone through Apache Brooklyn's ability to *deploy* an application blueprint to a location, but this just the beginning. Next we will outline how to *manage* the application that has been deployed.

Applications

Having created the application, we can find a summary of all deployed applications using:

```
$ br application
```

```
 Id         Name     Status    Location
 hTPAF19s   Tomcat   RUNNING   ajVVAhER
```

`application` can be shortened to the alias `app`, for example:

```
$ br app
```

```
 Id         Name     Status    Location
 hTPAF19s   Tomcat   RUNNING   ajVVAhER
```

A full list of abbreviations such as this can be found in the CLI reference guide{:target="_blank"}.

In the above example the Id `hTPAF19s` and the Name `Tomcat` are shown. You can use either of these handles to monitor and control the application. The Id shown for your application will be different to this but the name should be the same, note that if you are running multiple applications the Name may not be unique.

Things we might want to do

Get the application details

Using the name `Tomcat` we can get the application details:

```bash $ br application Tomcat ```

```
  Id:              hTPAF19s
  Name:            Tomcat
  Status:          RUNNING
  ServiceUp:       true
  Type:            org.apache.brooklyn.entity.stock.BasicApplication
  CatalogItemId:   null
  LocationId:      ajVVAhER
  LocationName:    FixedListMachineProvisioningLocation:ajVV
  LocationSpec:    vagrantbyon
  LocationType:
org.apache.brooklyn.location.byon.FixedListMachineProvisioningLocation
```

Explore the hierarchy of all applications

We can explore the management hierarchy of all applications, which will show us the entities they are composed of.

```bash $ br tree ```

```
|- Tomcat
+- org.apache.brooklyn.entity.stock.BasicApplication
  |- tomcatServer
  +- org.apache.brooklyn.entity.webapp.tomcat.TomcatServer
```

View our application's blueprint

You can view the blueprint for the application again:

```bash $ br application Tomcat spec ```

```
"name: Tomcat\nlocation:\n  mylocation\nservices:\n- serviceType:
brooklyn.entity.webapp.tomcat.TomcatServer\n"
```

View our application's configuration

You can view the configuration of the application:

```bash $ br application Tomcat config ```

```
Key                     Value
camp.template.id        l67i25CM
brooklyn.wrapper_app    true
```

Entities

An *Entity* is Apache Brooklyn's representation of a software package or service which it can control or interact with. All of the entities Apache Brooklyn can use are listed in the **Brooklyn Catalog**.

To list the entities of the application you can use the `entity` or `ent` command:

```
$ br application Tomcat entity
```

```
Id         Name                Type
Wx7r1C4e   tomcatServer   org.apache.brooklyn.entity.webapp.tomcat.TomcatServer
```

This shows one entity is available: `tomcatServer` . Note that this is the name we gave the entity in the YAML in Launching from a Blueprint on the previous page.

You can get summary information for this entity by providing its name (or ID).

```
$ br application Tomcat entity tomcatServer
```

```
Id:              Wx7r1C4e
Name:            tomcatServer
Status:          RUNNING
ServiceUp:       true
Type:            org.apache.brooklyn.entity.webapp.tomcat.TomcatServer
CatalogItemId:   null
```

Also you can see the configuration of this entity with the `config` command.

```
$ br application Tomcat entity tomcatServer config
```

```
Key                       Value
jmx.agent.mode            JMXMP_AND_RMI
brooklyn.wrapper_app      true
camp.template.id          yBcQuFZe
onbox.base.dir            /home/vagrant/brooklyn-managed-processes
onbox.base.dir.resolved   true
install.unique_label      TomcatServer_7.0.65
```

Sensors

Sensors are properties which show the state of an *entity* and provide a real-time picture of an *entity* within an application.

You can view the sensors available on the application using:

```
$ br application Tomcat sensor
```

```
Name                         Description
Value
service.isUp                 Whether the service is active and availability
(confirmed and monitored)                   true
service.notUp.indicators     A map of namespaced indicators that the service is not
up                                 {}
service.problems             A map of namespaced indicators of problems with a
service                                 {}
service.state                Actual lifecycle state of the service
"RUNNING"
service.state.expected       Last controlled change to service state, indicating what
the expected state should be   "running @ 1450356994928 / Thu Dec 17 12:56:34 GMT
2015"
```

To explore sensors on a specific entity use the `sensor` command with an entity specified:

```
$ br application Tomcat entity tomcatServer sensor
```

```
Name                  Description
Value
download.addon.urls   URL patterns for downloading named add-ons (will substitute
things like ${version} automatically)
download.url          URL pattern for downloading the installer (will substitute
things like ${version} automatically)
"http://download.nextag.com/apache/tomcat/tomcat-7/v${version}/bin/apache-tomcat-
${version}.tar.gz"
```

```
expandedinstall.dir  Directory for installed artifacts (e.g. expanded dir after
unpacking .tgz)                        "/home/vagrant/brooklyn-managed-
processes/installs/TomcatServer_7.0.65/apache-tomcat-7.0.65"
host.address         Host IP address
"10.10.10.101"
host.name            Host name
"10.10.10.101"
host.sshAddress      user@host:port for ssh'ing (or null if inappropriate)
"vagrant@10.10.10.101:22"
host.subnet.address  Host address as known internally in the subnet where it is
running (if different to host.name)    "10.10.10.101"
host.subnet.hostname Host name as known internally in the subnet where it is
running (if different to host.name)       "10.10.10.101"
# etc. etc.
```

To display the value of a selected sensor, give the command the sensor name as an argument

```
$ br application Tomcat entity tomcatServer sensor webapp.url
```

```
"http://10.10.10.101:8080/"
```

Effectors

Effectors are a means by which you can manipulate the entities in an application. You can list the available effectors for your application using:

```
$ br application Tomcat effector
```

```
Name            Description                                         Parameters
restart         Restart the process/service represented by an entity
start           Start the process/service represented by an entity    locations
stop            Stop the process/service represented by an entity
```

For example, to stop an application, use the `stop` effector. This will cleanly shutdown all components in the application and return any cloud machines that were being used. Note that the three "lifecycle" related effectors, `start` , `stop` , and `restart` , are common to all applications and software process entities in Brooklyn.

You can list the effectors for a specific entity using the command:

```
$ br application Tomcat entity tomcatServer effector
```

```
Name                              Description
Parameters
deploy                            Deploys the given artifact, from a source URL, to
a given deployment filename/context     url,targetName
populateServiceNotUpDiagnostics   Populates the attribute
service.notUp.diagnostics, with any available health indicators
```

```
restart                          Restart the process/service represented by an
entity                                    restartChildren,restartMachine
start                            Start the process/service represented by an
entity                                      locations
stop                             Stop the process/service represented by an entity
stopProcessMode,stopMachineMode
undeploy                         Undeploys the given context/artifact
targetName
```

To view the details for a specific effector, append it's name to the command:

```
$ br application Tomcat entity tomcatServer effector deploy
```

```
Name     Description
Parameters
deploy   Deploys the given artifact, from a source URL, to a given deployment
filename/context   url,targetName
```

These effectors can also be invoked by appending `invoke` to this command. Some effectors require parameters for their invocation. For example, if we look at the details for `deploy` above we can see it requires a url and targetName.

These parameters can be supplied using `--param parm=value` or just `-P parm=value` .

The commands below deploy the Apache Tomcat hello world example{:target="_blank"} to our Tomcat Server. In these commands, a variable is created for the root URL using the appropriate sensor and the index page html is displayed.

```
$ br application Tomcat entity tomcatServer effector deploy invoke -P url=https://tomcat.apache.org/tomcat-6.0-
doc/appdev/sample/sample.war -P targetName=sample
$ webapp=$(br application Tomcat entity tomcatServer sensor webapp.url | tr -d '"')
$ curl $webapp/sample/
```

```
<html>
<head>
<title>Sample "Hello, World" Application</title>
</head>
...
```

Note that at present a `tr` command is required in the second line below to strip quotation characters from the returned sensor value.

Activities

Activities are the actions an application or entity takes within Apache Brooklyn. The `activity` command allows us to list out these activities.

To view a list of all activities associated with an entity enter:

```
$ br application Tomcat entity tomcatServer activity
```

```
Id          Task                                          Submitted
```

```
Status      Streams
LtD5P1cb   start                                      Thu Dec 17 15:04:43 GMT 2015
Completed
l2qo4vTl   provisioning (FixedListMachineProvisi...   Thu Dec 17 15:04:43 GMT 2015
Completed
wLD764HE   pre-start                                  Thu Dec 17 15:04:43 GMT 2015
Completed
KLTxDkoa   ssh: initializing on-box base dir ./b...   Thu Dec 17 15:04:43 GMT 2015
Completed   env,stderr,stdin,stdout
jwwcJWmF   start (processes)                          Thu Dec 17 15:04:43 GMT 2015
Completed
...
```

To view the details of an individual activity, add its ID to the command. In our case this is `jwwcJWmF`

```
$ br application Tomcat entity tomcatServer activity jwwcJWmF
```

```
Id:                    jwwcJWmF
DisplayName:           start (processes)
Description:
EntityId:              efUvVWAw
EntityDisplayName:     TomcatServer:efUv
Submitted:             Thu Dec 17 15:04:43 GMT 2015
Started:               Thu Dec 17 15:04:43 GMT 2015
Ended:                 Thu Dec 17 15:08:59 GMT 2015
CurrentStatus:         Completed
IsError:               false
IsCancelled:           false
SubmittedByTask:       LtD5P1cb
Streams:
DetailedStatus:        "Completed after 4m 16s

No return value (null)"
```

Things we might want to do

View Input and Output Streams

If an activity has associated input and output streams, these may be viewed by providing the activity scope and using the commands, "env", "stdin", "stdout", and "stderr". For example, for the "initializing on-box base dir" activity from the result of the earlier example,

```bash $ br application Tomcat entity tomcatServer act KLTxDkoa stdout ```

```
BASE_DIR_RESULT:/home/vagrant/brooklyn-managed-processes:BASE_DIR_RESULT
```

Monitor the progress of an effector

To monitor progress on an application as it deploys, for example, one could use a shell loop:

```bash $ while br application Tomcat entity tomcatServer activity | grep 'In progress' ; do sleep 1; echo ; date; done ``` This loop will exit when the application has deployed successfully or has failed. If it fails then the 'stderr' command may provide information about what happened in any activities that have associated streams:

```bash $ br application Tomcat entity tomcatServer act KLTxDkoa stderr ```

Diagnose a failure

If an activity has failed, the "DetailedStatus" value will help us diagnose what went wrong by showing information about the failure.

```bash $ br application evHUlq0n entity tomcatServer activity lZZ9x662 ```

```
Id:                     lZZ9x662
DisplayName:            post-start
Description:
EntityId:               qZeyoITy
EntityDisplayName:      tomcatServer
Submitted:              Mon Jan 25 12:54:55 GMT 2016
Started:                Mon Jan 25 12:54:55 GMT 2016
Ended:                  Mon Jan 25 12:59:56 GMT 2016
CurrentStatus:          Failed
IsError:                true
IsCancelled:            false
SubmittedByTask:        hWU7Qvgm
Streams:
DetailedStatus:         "Failed after 5m: Software process entity
TomcatServerImpl{id=qZeyoITy} did not pass is-running check within the required 5m
limit (5m elapsed)

java.lang.IllegalStateException: Software process entity
TomcatServerImpl{id=qZeyoITy} did not pass is-running check within the required 5m
limit (5m elapsed)
    at
org.apache.brooklyn.entity.software.base.SoftwareProcessImpl.waitForEntityStart(Sof
twareProcessImpl.java:586)
    at
org.apache.brooklyn.entity.software.base.SoftwareProcessImpl.postDriverStart(Softwa
reProcessImpl.java:260)
    at
org.apache.brooklyn.entity.software.base.SoftwareProcessDriverLifecycleEffectorTask
s.postStartCustom(SoftwareProcessDriverLifecycleEffectorTasks.java:169)
    at
org.apache.brooklyn.entity.software.base.lifecycle.MachineLifecycleEffectorTasks$Po
stStartTask.run(MachineLifecycleEffectorTasks.java:570)
    at java.util.concurrent.Executors$RunnableAdapter.call(Executors.java:511)
    at
org.apache.brooklyn.util.core.task.DynamicSequentialTask$DstJob.call(DynamicSequent
ialTask.java:342)
    at
org.apache.brooklyn.util.core.task.BasicExecutionManager$SubmissionCallable.call(Ba
sicExecutionManager.java:468)
```

```
    at java.util.concurrent.FutureTask.run(FutureTask.java:266)
    at
java.util.concurrent.ThreadPoolExecutor.runWorker(ThreadPoolExecutor.java:1142)
    at
java.util.concurrent.ThreadPoolExecutor$Worker.run(ThreadPoolExecutor.java:617)
    at java.lang.Thread.run(Thread.java:745)"
```

Adding the "--children" or "-c" parameter will show the activity's child activities, to allow the hierarchical structure of the activities to be investigated:

```bash $ br application Tomcat entity tomcatServer activity -c jwwcJWmF ```

```
Id         Task                          Submitted                       Status
UpYRc3fw   copy-pre-install-resources    Thu Dec 17 15:04:43 GMT 2015    Completed
ig8sBHQr   pre-install                   Thu Dec 17 15:04:43 GMT 2015    Completed
Elp4HaVj   pre-install-command           Thu Dec 17 15:04:43 GMT 2015    Completed
YOvNobJk   setup                         Thu Dec 17 15:04:43 GMT 2015    Completed
VN3cDKki   copy-install-resources        Thu Dec 17 15:08:43 GMT 2015    Completed
xDJXQC0J   install                       Thu Dec 17 15:08:43 GMT 2015    Completed
zxMDXUxz   post-install-command          Thu Dec 17 15:08:58 GMT 2015    Completed
qnQnw7Oc   customize                     Thu Dec 17 15:08:58 GMT 2015    Completed
ug044ArS   copy-runtime-resources        Thu Dec 17 15:08:58 GMT 2015    Completed
STavcRc8   pre-launch-command            Thu Dec 17 15:08:58 GMT 2015    Completed
HKrYfH6h   launch                        Thu Dec 17 15:08:58 GMT 2015    Completed
T1m8VXbq   post-launch-command           Thu Dec 17 15:08:59 GMT 2015    Completed
n8eK5USE   post-launch                   Thu Dec 17 15:08:59 GMT 2015    Completed
```

{::comment}

Scopes in CLI commands

Many commands require a "scope" expression to indicate the target on which they operate. The scope expressions are as follows (values in brackets are aliases for the scope):

- `application` APP-ID (app, a)
  Selects an application, e.g. "br application myapp"
- `entity` ENT-ID (ent, e)
  Selects an entity within an application scope, e.g. `br application myapp entity myserver`
- `effector` EFF-ID (eff, f)
  Selects an effector of an entity or application, e.g. `br a myapp e myserver eff xyz`
- `config` CONF-KEY (conf, con, c)
  Selects a configuration key of an entity e.g. `br a myapp e myserver config jmx.agent.mode`
- `activity` ACT-ID (act, v)
  Selects an activity of an entity e.g. `br a myapp e myserver act iHG7sq1`

For example

```
$ br application Tomcat entity tomcatServer config
```

runs the `config` command with application scope of `Tomcat` and entity scope of `tomcatServer`.

{:/comment}

Next

We will look next at a slightly more complex example, which will illustrate the capabilities of Brooklyn's **policies** mechanism, and how to configure dependencies between application entities.

A Clustered Example

We'll now look at a more complex example that better shows the capabilities of Brooklyn, including management of a running clustered application.

Below is the annotated blueprint. Download the blueprint into a text file, `mycluster.yaml`, in your workspace. *Before* you create an application with it, review and/or change the the location where the application will be deployed.

You will need four machines for this example: one for the load-balancer (nginx), and three for the Tomcat cluster (but you can reduce this by changing the `maxPoolSize` below).

Hover over an element to learn more
This message will go away in 3s
Describe your application
Start by giving it a name, optionally adding a version and other metadata.

name: Tomcat Cluster
Define the target location
Blueprints are designed for portability. Pick from dozens of clouds in hundreds of datacenters. Or machines with fixed IP addresses, localhost, Docker on Clocker, etc.

Here we target pre-existing Vagrant VMs.

location: byon: user: vagrant password: vagrant hosts: - 10.10.10.101 - 10.10.10.102 - 10.10.10.103 - 10.10.10.104
Define a cluster
Choose your cluster type.

Customize with config keys, such as the initial size. Define the members of the cluster.

services: - type: org.apache.brooklyn.entity.group.DynamicCluster name: Cluster id: cluster brooklyn.config: cluster.initial.size: 1 dynamiccluster.memberspec: $brooklyn:entitySpec: type: org.apache.brooklyn.entity.webapp.tomcat.TomcatServer name: Tomcat Server brooklyn.config: wars.root: http://search.maven.org/remotecontent?filepath=org/apache/brooklyn/example/brooklyn-example-hello-world-webapp/0.8.0-incubating/brooklyn-example-hello-world-webapp-0.8.0-incubating.war
Tomcat auto-repair policy
For each member of the cluster, include an auto-repair policy that restarts the service.

If it repeatedly fails, the service will be propagate a failure notification.

brooklyn.policies: - type: org.apache.brooklyn.policy.ha.ServiceRestarter brooklyn.config: failOnRecurringFailuresInThisDuration: 5m brooklyn.enrichers: - type: org.apache.brooklyn.policy.ha.ServiceFailureDetector brooklyn.config: entityFailed.stabilizationDelay: 30s
Cluster auto-replace policy
On the cluster, handle a member's failure by replacing it with a brand new member.

brooklyn.policies: - type: org.apache.brooklyn.policy.ha.ServiceReplacer
Auto-scaling policy
Auto-scale the cluster, based on runtime metrics of the cluster.

For a simplistic demonstration, this uses requests per second.

- type: org.apache.brooklyn.policy.autoscaling.AutoScalerPolicy brooklyn.config: metric: webapp.reqs.perSec.perNode metricUpperBound: 3 metricLowerBound: 1 resizeUpStabilizationDelay: 2s resizeDownStabilizationDelay: 1m maxPoolSize: 3
Aggregate the member's metrics.
Add an enricher to aggregate the member's requests per second.

For a simplistic demonstration, this uses requests per second.

brooklyn.enrichers: - type: org.apache.brooklyn.enricher.stock.Aggregator brooklyn.config: enricher.sourceSensor: $brooklyn:sensor("webapp.reqs.perSec.windowed") enricher.targetSensor: $brooklyn:sensor("webapp.reqs.perSec.perNode") enricher.aggregating.fromMembers: true transformation: average
Define a load-balancer
Add a load balancer entity.

Configure it to monitor and balance across the cluster of Tomcat servers, which was given:

id: cluster

- type: org.apache.brooklyn.entity.proxy.nginx.NginxController name: Load Balancer (nginx) brooklyn.config: loadbalancer.serverpool: $brooklyn:entity("cluster") nginx.sticky: false
</div></div> </div>

The following section provides a quick summary of the main Brooklyn concepts you will encounter in Getting Started. For further discussion of these concepts see The Theory Behind Brooklyn, and the detailed descriptions in Brooklyn Concepts.

Deployment and Management Brooklyn is built for agile deployment of applications across cloud and other targets, and real-time autonomic management. "Autonomic computing" is the concept of components looking after themselves where possible (self-healing, self-optimizing, etc).

Blueprints A blueprint defines an application by specifying its components, such as processes, or combinations of processes across multiple machines and services. The blueprint also specifies the inter-relationships between the configurations of the components.

Entities The central concept in a Brooklyn deployment is that of an entity. An entity represents a resource under management (individual machines or software processes) or logical collections of these. Entities are arranged hierarchically. They can have events, operations, and processing logic associated with them, and it is through this mechanism that the active management is delivered.

Applications are the top level entities that are the parents of all other entities.

Configuration Entities can have arbitrary configuration values, which get inherited by their child entities. You can set global (Brooklyn-wide) properties in (`~/.brooklyn/brooklyn.properties`). Common configuration keys have convenient aliases called "flags".

Sensors are the mechanism for entities to expose information for other entities to see. Sensors from an entity can be subscribed to by other entities to track changes in the entity’s activity. Sensors can be updated, potentially frequently, by the entity or associated tasks.

Effectors are the mechanism for entities to expose the operations that can be invoked on it by other entities. The invoker is able to track the execution of that effector with tasks.

Lifecycle The management context of Brooklyn associates a "lifecycle" with Brooklyn entities. Common operations are start, stop, and restart (whose meaning differs slightly for applications and processes; the details are in the concepts guide linked above). Starting an application results in the start() operation being performed recursively (typically in parallel) on the application's children.

Tasks Lifecycle and other operations in Brooklyn are tracked as tasks. This allows current and past processing to be observed by operators, and processing to be managed across multiple management nodes.

Locations can be defined in order to specify where the processes of an application will run. Brooklyn supports different cloud providers and pre-prepared machines (including localhost), known as "BYON" (Bring Your Own Nodes).

Policies Policies perform the active management enabled by Brooklyn. Entities can have Policy instances attached to them, which can subscribe to sensors from other entities or run periodically. When they run they can perform calculations, look up other values, invoke effectors or emit sensor values from the entity with which they are associated.

Enrichers These are mechanisms that subscribe to a sensor, or multiple sensors, and output a new sensor. For example, the enricher which sums a sensor across multiple entities (used to get the total requests-per-second for all the web servers in a cluster), and the enricher which calculates a 60-second rolling average.

Download Version NaN

Download	File/Format	checksums (?)
Binary distribution Server & client	apache-brooklyn-NaN-bin.tar.gz	SHA1
	apache-brooklyn-NaN-bin.zip	SHA1
RPM package CentOS7, RHEL7, etc.	apache-brooklyn-NaN-1.noarch.rpm	SHA1
DEB package Ubuntu, Debian, etc.	apache-brooklyn-NaN.all.deb	SHA1
Client CLI only	apache-brooklyn-NaN-client-cli-linux.tar.gz	SHA1
	apache-brooklyn-NaN-client-cli-linux.zip	SHA1
	apache-brooklyn-NaN-client-cli-macosx.tar.gz	SHA1
	apache-brooklyn-NaN-client-cli-macosx.zip	SHA1
	apache-brooklyn-NaN-client-cli-windows.tar.gz	SHA1
	apache-brooklyn-NaN-client-cli-windows.zip	SHA1
Source code	apache-brooklyn-NaN-src.tar.gz	SHA1
	apache-brooklyn-NaN-src.zip	SHA1

Release Notes

Release notes can be found here.

Maven

If you use Maven, you can add Brooklyn with the following in your pom:

```
<!-- include all Brooklyn items in our project -->
    <dependencies>
        <dependency>
            <groupId>org.apache.brooklyn</groupId>
            <artifactId>brooklyn-all</artifactId>
            <version>{{ book.brooklyn-version }}</version>
        </dependency>
    </dependencies>
```

`brooklyn-all` brings in all dependencies, including jclouds. If you prefer a smaller repo you might want just `brooklyn-core` , `brooklyn-policies` , and some of `brooklyn-software-webapp` , `brooklyn-software-database` , `brooklyn-software-messaging` , or others (browse the full list here).

If you wish to use the Apache snapshot repo, you can add this to you `pom.xml` :

```
<!-- include repos for snapshot items and other dependencies -->
    <repositories>
        <repository>
            <id>apache-nexus-snapshots</id>
            <name>Apache Nexus Snapshots</name>
            <url>https://repository.apache.org/content/repositories/snapshots</url>
            <releases> <enabled>false</enabled> </releases>
            <snapshots> <enabled>true</enabled> </snapshots>
        </repository>
    </repositories>
```

Source Code

Source code is hosted at github.com/apache/brooklyn, with this version in branch . These locations have a `README.md` in the root which explains how to get the code including submodules.

Useful information on working with the source is here.

The central concept in a Brooklyn deployment is that of an ***entity***. An entity represents a resource under management, either *base* entities (individual machines or software processes) or logical collections of these entities.

Fundamental to the processing model is the capability of entities to be the *parent* of other entities (the mechanism by which collections are formed), with every entity having a single parent entity, up to the privileged top-level ***application*** entity.

Entities are code, so they can be extended, overridden, and modified. Entities can have events, operations, and processing logic associated with them, and it is through this mechanism that the active management is delivered.

The main responsibilities of an entity are:

- Provisioning the entity in the given location or locations
- Holding configuration and state (attributes) for the entity
- Reporting monitoring data (sensors) about the status of the entity
- Exposing operations (effectors) that can be performed on the entity
- Hosting management policies and tasks related to the entity

All entities have a ***parent*** entity, which creates and manages it, with one important exception: *applications*. Application entities are the top-level entities created and managed externally, manually or programmatically.

Applications are typically defined in Brooklyn as an ***application descriptor***. This is a Java class specifying the entities which make up the application, by extending the class `AbstractApplication`, and specifying how these entities should be configured and managed.

All entities, including applications, can be the parent of other entities. This means that the "child" is typically started, configured, and managed by the parent. For example, an application may be the parent of a web cluster; that cluster in turn is the parent of web server processes. In the management console, this is represented hierarchically in a tree view.

A parallel concept is that of ***membership***: in addition to one fixed parent, and entity may be a ***member*** of any number of special entities called ***groups***. Membership of a group can be used for whatever purpose is required; for example, it can be used to manage a collection of entities together for one purpose (e.g. wide-area load-balancing between locations) even though they may have been created by different parents (e.g. a multi-tier stack within a location).

Configuration

All entities contain a map of config information. This can contain arbitrary values, typically keyed under static `ConfigKey` fields on the `Entity` sub-class. These values are inherited, so setting a configuration value at the application level will make it available in all entities underneath unless it is overridden.

Configuration is propagated when an application "goes live" (i.e. it becomes "managed", either explicitly or when its `start()` method is invoked), so config values must be set before this occurs.

Configuration values can be specified in a configuration file (`brooklyn.cfg`) to apply universally, and/or programmatically to a specific entity and its descendants by calling `.configure(KEY, VALUE)` in the entity spec when creating it. There is also an `entity.config().set(KEY, VALUE)` method.

Additionally, many common configuration parameters are available as "flags" which can be supplied as Strings when constructing then entity, in the form `EntitySpec.create(MyEntity.class).configure("config1", "value1").configure("config2", "value2")` .

Documentation of the flags available for individual entities can normally be found in the javadocs. The `@SetFromFlag` annotations on `ConfigKey` static field definitions in the entity's interface is the recommended mechanism for exposing configuration options.

Sensors and Effectors

Sensors (activity information and notifications) and ***effectors*** (operations that can be invoked on the entity) are defined by entities as static fields on the `Entity` subclass.

Sensors can be updated by the entity or associated tasks, and sensors from an entity can be subscribed to by its parent or other entities to track changes in an entity's activity.

Effectors can be invoked by an entity's parent remotely, and the invoker is able to track the execution of that effector. Effectors can be invoked by other entities, but use this functionality with care to prevent too many managers!

An entity consists of a Java interface (used when interacting with the entity) and a Java class. For resilience. it is recommended to store the entity's state in attributes (see `getAttribute(AttributeKey)`). If internal fields can be used then the data will be lost on brooklyn restart, and may cause problems if the entity is to be moved to a different brooklyn management node.

Under-the-covers, at heart of the brooklyn management plane is the `ManagementContext`. This is started automatically when using launching an application using the brooklyn CLI. For programmatic use, see `BrooklynLauncher.newLauncher().launch()`.

A Brooklyn deployment consists of many entities in a hierarchical tree, with the privileged *application* entity at the top level.

An application entity (`Application` class) is responsible for starting the deployment of all its child entities (i.e. the entire entity tree under its ownership).

An `Application`'s `start()` method begins provisioning the child entities of the application (and their entities, recursively).

Provisioning of entities typically happens in parallel automatically, although this can be customized. This is implemented as ***tasks*** which are tracked by the management plane and is accessible in the web-based management console and REST API.

Customized provisioning can be useful where two starting entities depend on each other. For example, it is often necessary to delay start of one entity until another entity reaches a certain state, and to supply run-time information about the latter to the former.

When new entities are created, the entity is wired up to an application by giving it a parent. The entity is then explicitly "managed", which allows other entities to discover it.

Typically a Brooklyn deployment has a single management context which records:

- all entities under management that are reachable by the application(s) via the parent-child relationships,
- the state associated with each entity,
- subscribers (listeners) to sensor events arising from the entities,
- active tasks (jobs) associated with any the entity,
- which Brooklyn management node is mastering (managing) each entity.

In a multi-location deployment, management operates in all regions, with brooklyn entity instances being mastered in the relevant region.

When management is distributed a Brooklyn deployment may consist of multiple Brooklyn management nodes each with a `ManagementContext` instance.

Under the covers Brooklyn has a sophisticated sensor event and subscription model, but conveniences around this model make it very simple to express cross-entity dependencies. Consider the example where Tomcat instances need to know the URL of a database (or a set of URLs to connect to a Monterey processing fabric, or other entities)

```
setConfiguration(UsesJava.JAVA_OPTIONS, ImmutableMap.of("mysql.url",
        attributeWhenReady(mysql, MySqlNode.MY_SQL_URL) ))
```

The `attributeWhenReady(Entity, Sensor)` call (a static method on the class `DependentConfiguration`) causes the configuration value to be set when that given entity's attribue is ready. In the example, `attributeWhenReady()` causes the JVM system property `mysql.url` to be set to the value of the `MySqlNode.MY_SQL_URL` sensor from `mysql` when that value is ready. As soon as the database URL is announced by the MySql entity, the configuration value will be available to the Tomcat cluster.

By default "ready" means being *set* (non-null) and, if appropriate, *non-empty* (for collections and strings) or *non-zero* (for numbers). Formally the interpretation of ready is that of "Groovy truth" defined by an `asBoolean()` method on the class and in the Groovy language extensions.

You can customize "readiness" by supplying a `Predicate` (Google common) or `Closure` (Groovy) in a third parameter. This evaluates candidate values reported by the sensor until one is found to be `true` . For example, passing `{ it.size()>=3 }` as the readiness argument would require at least three management plane URLs.

More information on this can be found in the javadoc for `DependentConfiguration` , along with a few other methods such as `valueWhenAttributeReady` which allow post-processing of an attribute value.

Note that if the value of `CONFIG_KEY` passed to `Entity.getConfig` is a Closure or Task (such as returned by `attributeWhenReady`), the first access of `Entity.getConfig(CONFIG_KEY)` will block until the task completes. Typically this does the right thing, blocking when necessary to generate the right start-up sequence without the developer having to think through the order, but it can take some getting used to. Be careful not to request config information until really necessary (or to use non-blocking "raw" mechanisms), and in complicated situations be ready to attend to circular dependencies. The management console gives useful information for understanding what is happening and resolving the cycle.

Entities can be provisioned/started in the location of your choice. Brooklyn transparently uses jclouds to support different cloud providers and to support BYON (Bring Your Own Nodes).

The implementation of an entity (e.g. Tomcat) is agnostic about where it will be installed/started. When writing the application definition specify the location or list of possible locations (`Location` instances) for hosting the entity.

`Location` instances represent where they run and indicate how that location (resource or service) can be accessed.

For example, a `JBoss7Server` will usually be running in an `SshMachineLocation`, which contains the credentials and address for sshing to the machine. A cluster of such servers may be running in a `MachineProvisioningLocation`, capable of creating new `SshMachineLocation` instances as required.

Policies perform the active management enabled by Brooklyn. Entities can have zero or more `Policy` instances attached to them.

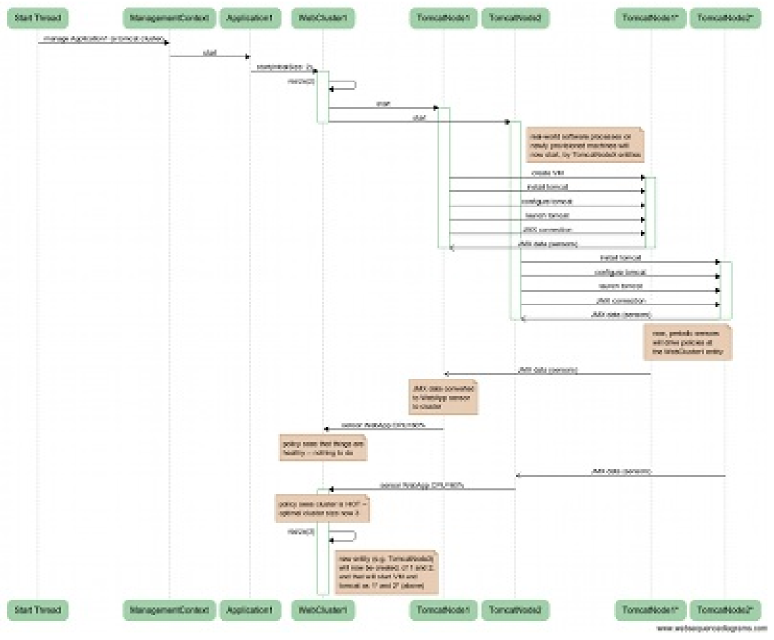
Policies can subscribe to sensors from entities or run periodically, and when they run they can perform calculations, look up other values, and if deemed necessary invoke effectors or emit sensor values from the entity with which they are associated.

All processing, whether an effector invocation or a policy cycle, are tracked as ***tasks***. This allows several important capabilities:

- active and historic processing can be observed by operators
- the invocation context is available in the thread, to check entitlement (permissions) and maintain a hierarchical causal chain even when operations are run in parallel
- processing can be managed across multiple management nodes

Some executions create new entities, which can then have tasks associated with them, and the system will record, for example, that a start effector on the new entity is a task associated with that entity, with that task created by a task associated with a different entity.

The execution of a typical overall start-up sequence is shown below:



Integration

One vital aspect of Brooklyn is its ability to communicate with the systems it starts. This is abstracted using a ***driver*** facility in Brooklyn, where a driver describes how a process or service can be installed and managed using a particular technology.

For example, a `TomcatServer` may implement start and other effectors using a `TomcatSshDriver` which inherits from `JavaSoftwareProcessSshDriver` (for JVM and JMX start confguration), inheriting from `AbstractSoftwareProcessSshDriver` (for SSH scripting support).

Particularly for sensors, some technologies are used so frequently that they are packaged as ***feeds*** which can discover their configuration (including from drivers). These include JMX and HTTP (see `JmxFeed` and `HttpFeed`).

Brooklyn comes with entity implementations for a growing number of commonly used systems, including various web application servers, databases and NoSQL data stores, and messaging systems.

Many entities expose `start` , `stop` and `restart` effectors. The semantics of these operations (and the parameters they take) depends on the type of entity.

Top-level applications

A top-level application is a grouping of other entities, pulling them together into the "application" of your choice. This could range from a single app-server, to an app that is a composite of a no-sql cluster (e.g. MongoDB sharded cluster, or Cassandra spread over multiple datacenters), a cluster of load-balanced app-servers, message brokers, etc.

start(Collection <Location>)

This will start the application in the given location(s). Each child-entity within the application will be started concurrently, passing the location(s) to each child. The start effector will be called automatically when the application is deployed through the catalog. Is is strongly recommended to not call start again.

stop()

Stop will terminate the application and all its child entities (including releasing all their resources). The application will also be unmanaged, **removing** it from Brooklyn.

restart()

This will invoke `restart()` on each child-entity concurrently (with the default values for the child-entity's restart effector parameters). Is is strongly recommended to not call this, unless the application has been explicitly written to implement restart.

Software Process (e.g MySql, Tomcat, JBoss app-server, MongoDB)

start(Collection <Location>)

This will start the software process in the given location. If a machine location is passed in, then the software process is started there. If a cloud location is passed in, then a new VM will be created in that cloud - the software process will be **installed+launched** on that new VM.

The start effector will have been called automatically when deploying an application through the catalog. In normal usage, do not invoke start again.

If calling `start()` a second time, with no locations passed in (e.g. an empty list), then it will go through the start sequence on the existing location from the previous call. It will **install+customize+launch** the process. For some entities, this could be *dangerous*. The customize step might execute a database initialisation script, which could cause data to be overwritten (depending how the initialisation script was written).

If calling `start()` a second time with additional locations, then these additional locations will be added to the set of locations. In normal usage it is not recommended. This could be desired behaviour if the entity had previously been entirely stopped (including its VM terminated) - but for a simple one-entity app then you might as well have deleted the entire app and created a new one.

stop(boolean stopMachine)

If `stopMachine==true`, this effector will stop the software process and then terminate the VM (if a VM had been created as part of `start()`). This behaviour is the inverse of the first `start()` effector call. When stopping the software process, it does not uninstall the software packages / files.

If `stopMachine==false`, this effector will stop just the software process (leaving the VM and all configuration files / install artifacts in place).

restart(boolean restartMachine, boolean restartChildren)

This will restart the software process.

If `restartMachine==true`, it will also terminate the VM and create a new VM. It will then install+customize+launch the software process on the new VM. It is equivalent of invoking `stop(true)` and then `start(Collections.EMPTY_LIST)`. If `restartMachine==false`, it will first attempt to stop the software process (which should be a no-op if the process is not running), and will then start the software process (without going through the **install+customize** steps).

If `restartChildren==true`, then after restarting itself it will call `restart(restartMachine, restartChildren)` on each child-entity concurrently.

Recommended operations

The recommended operations to invoke to stop just the software process, and then to restart it are:

- Select the software process entity in the tree (*not* the parent application, but the child of that application).
- Invoke `stop(stopMachine=false)`
- Invoke `restart(restartMachine=false, restartChildren=false)`

A First Blueprint

The easiest way to write a blueprint is as a YAML file. This follows the OASIS CAMP plan specification, with some extensions described below. (A YAML reference has more information, and if the YAML doesn't yet do what you want, it's easy to add new extensions using your favorite JVM language.)

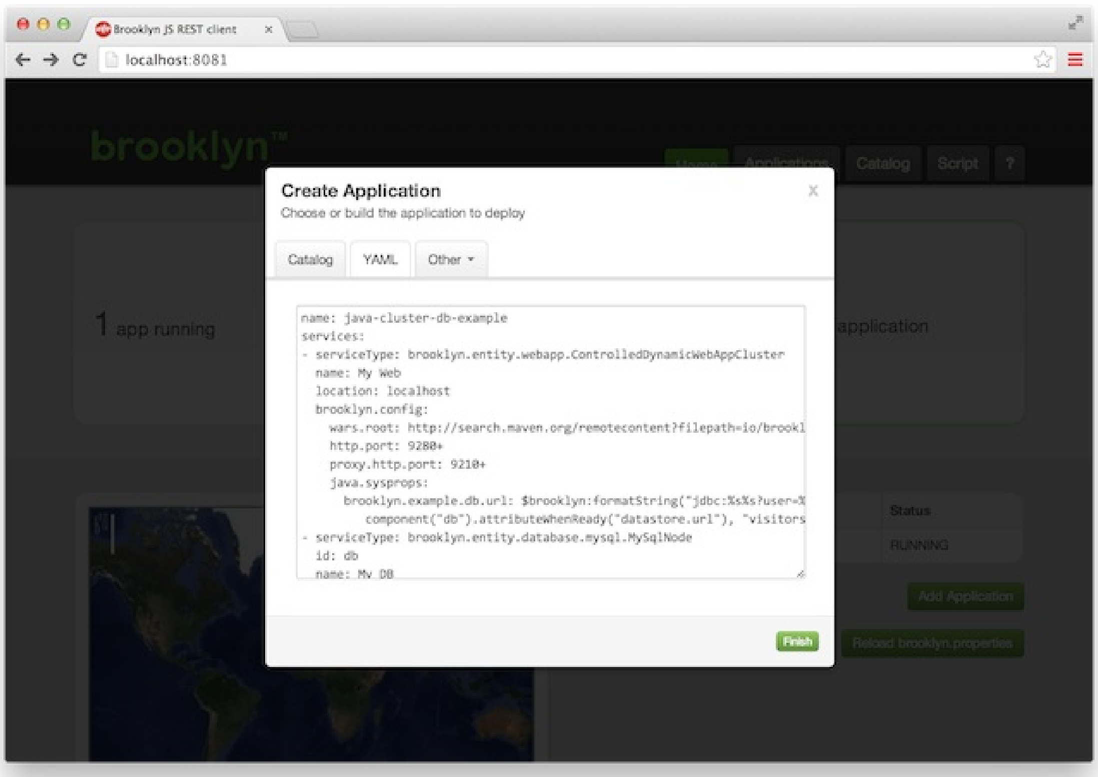
The Basic Structure

Here's a very simple YAML blueprint plan, to explain the structure:

```
name: simple-appserver
location: localhost
services:
- type: org.apache.brooklyn.entity.webapp.jboss.JBoss7Server
```

- The `name` is just for the benefit of us humans.
- The `location` specifies where this should be deployed. If you've set up passwordless localhost SSH access you can use `localhost` as above, but if not, just wait ten seconds for the next example.
- The `services` block takes a list of the typed services we want to deploy. This is the meat of the blueprint plan, as you'll see below.

Finally, the clipboard in the top-right corner of the example plan box above (hover your cursor over the box) lets you easily copy-and-paste into the web-console: simply download and launch Brooklyn, then in the "Create Application" dialog at the web console (usually http://127.0.0.1:8081/, paste the copied YAML into the "Yaml" tab of the dialog and press "Finish". There are several other ways to deploy, including `curl` and via the command-line, and you can configure users, https, persistence, and more, as described in the ops guide.



```
name: java-cluster-db-example
services:
- serviceType: brooklyn.entity.webapp.ControlledDynamicWebAppCluster
  name: My Web
  location: localhost
  brooklyn.config:
    wars.root: http://search.maven.org/remotecontent?filepath=io/brookl
    http.port: 9280+
    proxy.http.port: 9210+
    java.sysprops:
      brooklyn.example.db.url: $brooklyn:formatString("jdbc:%s%s?user=%
         component("db").attributeWhenReady("datastore.url"), "visitors
- serviceType: brooklyn.entity.database.mysql.MySqlNode
  id: db
  name: My DB
```

More Information

Topics to explore next on the topic of YAML blueprints are:

Plenty of examples of blueprints exist in the Brooklyn codebase, so another starting point is to `git clone` it and search for `*.yaml` files therein.

Brooklyn lived as a Java framework for many years before we felt confident to make a declarative front-end, so you can do pretty much anything you want to by dropping to the JVM. For more information on Java:

- start with a Maven archetype
- see all Brooklyn Java guide topics
- look at test cases in the codebase

You can also come talk to us, on IRC (#brooklyncentral on Freenode) or any of the usual hailing frequencies, as these documents are a work in progress.

Within a blueprint or catalog item, entities can be configured. The rules for setting this configuration, including when composing and extending existing entities, is described in this section.

Basic Configuration

Within a YAML file, entity configuration should be supplied within a `brooklyn.config` map. It is also possible to supply configuration at the top-level of the entity. However, that approach is discouraged as it can sometimes be ambiguous (e.g. if the config key is called "name" or "type"), and also it does not work in all contexts such as for an enricher's configuration.

A simple example is shown below:

```
services:
- type: org.apache.brooklyn.entity.webapp.tomcat.TomcatServer
  brooklyn.config:
    webapp.enabledProtocols: http
    http.port: 9080
    wars.root: http://search.maven.org/remotecontent?filepath=org/apache/brooklyn/example/brooklyn-example-hell
o-world-webapp/0.9.0/brooklyn-example-hello-world-webapp-0.9.0.war
```

If no config value is supplied, the default for that config key will be used. For example, `http.port` would default to 8080 if not explicitly supplied.

Some config keys also have a short-form (e.g. `httpPort` instead of `http.port` would also work in the YAML example above). However, that approach is discouraged as it does not work in all contexts such as for inheriting configuration from a parent entity.

Configuration in a Catalog Item

When defining an entity in the catalog, it can include configuration values like any other blueprint (i.e. inside the `brooklyn.config` block).

It can also explicitly declare config keys, using the `brooklyn.parameters` block. The example below illustrates the principle:

```
brooklyn.catalog:
  items:
  - id: entity-config-example
    itemType: entity
    name: Entity Config Example
    item:
      type: org.apache.brooklyn.entity.software.base.VanillaSoftwareProcess
      brooklyn.parameters:
      - name: custom.message
        type: string
        description: Message to be displayed
        default: Hello
      brooklyn.config:
        shell.env:
          MESSAGE: $brooklyn:config("custom.message")
        launch.command: |
          echo "My example launch command: $MESSAGE"
        checkRunning.command: |
          echo "My example checkRunning command: $MESSAGE"
```

Once added to the catalog, it can be used with the simple blueprint below (substituting the location of your choice). Because no configuration has been overridden, this will use the default value for `custom.message` , and will use the given values for `launch.command` and `checkRunning.command` :

```
location: aws-ec2:us-east-1
services:
- type: entity-config-example
```

For details of how to write and add catalog items, see Catalog.

Config Key Constraints

The config keys in the `brooklyn.parameters` can also have constraints defined, for what values are valid. If more than one constraint is defined, then they must all be satisfied. The constraints can be any of:

- `required` : deployment will fail if no value is supplied for this config key.
- `regex: ...` : the value will be compared against the given regular expression.
- A predicate, declared using the DSL `$brooklyn:object` .

This is illustrated in the example below:

```
brooklyn.catalog:
  items:
  - id: entity-constraint-example
    itemType: entity
    name: Entity Config Example
    item:
      type: org.apache.brooklyn.entity.stock.BasicEntity
      brooklyn.parameters:
      - name: compulsoryExample
        type: string
        constraints:
        - required
      - name: addressExample
        type: string
        constraints:
        - regex: ^(?:[0-9]{1,3}\.){3}[0-9]{1,3}$
      - name: numberExample
        type: double
        constraints:
        - $brooklyn:object:
            type: org.apache.brooklyn.util.math.MathPredicates
            factoryMethod.name: greaterThan
            factoryMethod.args:
            - 0.0
        - $brooklyn:object:
            type: org.apache.brooklyn.util.math.MathPredicates
            factoryMethod.name: lessThan
            factoryMethod.args:
            - 256.0
```

An example usage of this toy example, once added to the catalog, is shown below:

```
services:
- type: entity-constraint-example
  brooklyn.config:
    compulsoryExample: foo
    addressExample: 1.1.1.1
    numberExample: 2.0
```

Inheriting Configuration

Configuration can be inherited from a super-type, and from a parent entity in the runtime management hierarchy. This applies to entities and locations. In a future release, this will be extended to also apply to policies and enrichers.

When a blueprint author defines a config key, they can explicitly specify the rules for inheritance (both for super/sub-types, and for the runtime management hiearchy). This gives great flexibilty, but should be used with care so as not to surprise users of the blueprint.

The default behaviour is outlined below, along with examples and details of how to explilcitly define the desired behaviour.

Normal Configuration Precedence

There are several places that a configuration value can come from. If different values are specified in multiple places, then the order of precedence is as listed below:

1. Configuration on the entity itself
2. Inherited configuration from the super-type
3. Inherited configuration from the runtime type hierarchy
4. The config key's default value

Inheriting Configuration from Super-type

When using an entity from the catalog, its configuration values can be overridden. For example, consider the `entity-config-example` added to the catalog in the section Configuration in a Catalog Item. We can override these values. If not overridden, then the existing values from the super-type will be used:

```
location: aws-ec2:us-east-1
services:
- type: entity-config-example
  brooklyn.config:
    custom.message: Goodbye
    launch.command: |
      echo "Sub-type launch command: $MESSAGE"
```

In this example, the `custom.message` overrides the default defined on the config key. The `launch.command` overrides the original command. The other config (e.g. `checkRunning.command`) is inherited unchanged.

It will write out: `Sub-type launch command: Goodbye`.

Inheriting Configuration from a Parent in the Runtime Management Hieararchy

Configuration passed to an entity is inherited by all child entities, unless explicitly overridden.

In the example below, the `wars.root` config key is inherited by all TomcatServer entities created under the cluster, so they will use that war:

```
services:
- type: org.apache.brooklyn.entity.group.DynamicCluster
  brooklyn.config:
    wars.root: http://search.maven.org/remotecontent?filepath=org/apache/brooklyn/example/brooklyn-example-hell
o-world-webapp/0.9.0/brooklyn-example-hello-world-webapp-0.9.0.war
    dynamiccluster.memberspec:
      $brooklyn:entitySpec:
        type: org.apache.brooklyn.entity.webapp.tomcat.TomcatServer
```

In the above example, it would be better to have specified the `wars.root` configuration in the `TomcatServer` entity spec, rather than at the top level. This would make it clearer for the reader what is actually being configured.

The technique of inherited config can simplify some blueprints, but care should be taken. For more complex (composite) blueprints, this can be difficult to use safely; it relies on knowledge of the internals of the child components. For example, the inherited config may impact multiple sub-components, rather than just the specific entity to be changed. This is particularly true when using complex items from the catalog, and when using common config values (e.g. `install.version`).

An alternative approach is to declare the expected configuration options at the top level of the catalog item, and then (within the catalog item) explicitly inject those values into the correct sub-components. Users of this catalog item would set only those exposed config options, rather than trying to inject config directly into the nested entities.

DSL Evaluation of Inherited Config

When writing blueprints that rely on inheritance from the runtime management hierarchy, it is important to understand how config keys that use DSL will be evaluated. In particular, when evaluating a DSL expression, it will be done in the context of the entity declaring the config value (rather than on the entity using the config value).

For example, consider the config value `$brooklyn:attributeWhenReady("host.name")` declared on entity X, and inherited by child entity Y. If entity Y uses this config value, it will get the "host.name" attribute of entity X.

Below is another (contrived!) example of this DSL evaluation. When evaluating `refExampleConfig`, it retrievies the value of `exampleConfig` which is the DSL expression, and evaluates this in the context of the parent entity that declares it. Therefore `$brooklyn:config("ownConfig")` returns the parent's `ownConfig` value, and the final result for `refExampleConfig` is set to "parentValue":

```
services:
- type: org.apache.brooklyn.entity.stock.BasicApplication
  brooklyn.config:
    ownConfig: parentValue
    exampleConfig: $brooklyn:config("ownConfig")

  brooklyn.children:
  - type: org.apache.brooklyn.entity.stock.BasicEntity
    brooklyn.config:
      ownConfig: childValue
      refExampleConfig: $brooklyn:config("exampleConfig")
```

However, the web-console also shows other misleading (incorrect!) config values for the child entity. It shows the inherited config value of `exampleConfig` as "childValue" (because the REST api did not evaluate the DSL in the correct context, when retrieving the value! See https://issues.apache.org/jira/browse/BROOKLYN-455.

Merging Configuration Values

For some configuration values, the most logical behaviour is to merge the configuration value with that in the super-type. This depends on the type and meaning of the config key, and is thus an option when defining the config key.

Currently it is only supported for merging config keys of type Map.

Some common config keys will default to merging the values from the super-type. These config keys include those below. The value is merged with that of its super-type (but will not be merged with the value on a parent entity):

- `shell.env` : a map of environment variables to pass to the runtime shell
- `files.preinstall` : a mapping of files, to be copied before install, to destination name relative to installDir
- `templates.preinstall` : a mapping of templates, to be filled in and copied before pre-install, to destination name relative to installDir
- `files.install` : a mapping of files, to be copied before install, to destination name relative to installDir

- `templates.install` : a mapping of templates, to be filled in and copied before install, to destination name relative to installDir
- `files.runtime` : a mapping of files, to be copied before customisation, to destination name relative to runDir
- `templates.runtime` : a mapping of templates, to be filled in and copied before customisation, to destination name relative to runDir
- `provisioning.properties` : custom properties to be passed in when provisioning a new machine

A simple example of merging `shell.env` is shown below (building on the `entity-config-example` in the section Configuration in a Catalog Item). The environment variables will include the `MESSAGE` set in the super-type and the `MESSAGE2` set here:

```
location: aws-ec2:us-east-1
services:
- type: entity-config-example
  brooklyn.config:
    shell.env:
      MESSAGE2: Goodbye
    launch.command: |
      echo "Different example launch command: $MESSAGE and $MESSAGE2"
```

To explicitly remove a value from the super-type's map (rather than adding to it), a blank entry can be defined.

Entity provisioning.properties: Overriding and Merging

An entity (which extends `SoftwareProcess`) can define a map of `provisioning.properties` . If the entity then provisions a location, it passes this map of properties to the location for obtaining the machine. These properties will override and augment the configuration on the location itself.

When deploying to a jclouds location, one can specify `templateOptions` (of type map). Rather than overriding, these will be merged with any templateOptions defined on the location.

In the example below, the VM will be provisioned with minimum 2G ram and minimum 2 cores. It will also use the merged template options value of `{placementGroup: myPlacementGroup, securityGroupIds: sg-000c3a6a}` :

```
location:
  aws-ec2:us-east-1:
    minRam: 2G
    templateOptions:
      placementGroup: myPlacementGroup
services:
- type: org.apache.brooklyn.entity.machine.MachineEntity
  brooklyn.config:
    provisioning.properties:
      minCores: 2
      templateOptions:
        securityGroupIds: sg-000c3a6a
```

The merging of `templateOptions` is shallow (i.e. maps within the `templateOptions` are not merged). In the example below, the `userMetadata` value within `templateOptions` will be overridden by the entity's value, rather than the maps being merged; the value used when provisioning will be `{key2: val2}` :

```
location:
  aws-ec2:us-east-1:
    templateOptions:
      userMetadata:
        key1: val1
services:
- type: org.apache.brooklyn.entity.machine.MachineEntity
  brooklyn.config:
    provisioning.properties:
      userMetadata:
        key2: val2
```

Re-inherited Versus not Re-inherited

For some configuration values, the most logical behaviour is for an entity to "consume" the config key's value, and thus not pass it down to children in the runtime type hierarchy. This is called "not re-inherited".

Some common config keys that will not re-inherited include:

- `install.command` (and the `pre.install.command` and `post.install.command`)
- `customize.command` (and the `pre.customize.command` and `post.customize.command`)
- `launch.command` (and the `` `pre.launch.command `` and `post.launch.command`)
- `checkRunning.command`
- `stop.command`
- The similar commands for `VanillaWindowsProcess` powershell.
- The file and template install config keys (e.g. `files.preinstall` , `templates.preinstall` , etc)

An example is shown below. Here, the "logstash-child" is a sub-type of `VanillaSoftwareProcess` , and is co-located on the same VM as Tomcat. We don't want the Tomcat's configuration, such as `install.command` , to be inherited by the logstash child. If it was inherited, the logstash-child entity might re-execute the Tomcat's install command! Instead, the `install.command` config is "consumed" by the Tomcat instance and is not re-inherited:

```
services:
- type: org.apache.brooklyn.entity.webapp.tomcat.Tomcat8Server
  brooklyn.config:
    children.startable.mode: background_late
  brooklyn.children:
  - type: logstash-child
    brooklyn.config:
      logstash.elasticsearch.host: $brooklyn:entity("es").attributeWhenReady("urls.http.withBrackets")
...
```

"Not re-inherited" differs from "never inherited". The example below illustrates the difference, though this use is discouraged (it is mostly for backwards compatibility). The `post.install.command` is not consumed by the `BasicApplication` , so will be inherited by the `Tomcat8Server` which will consume it. The config value will therefore not be inherited by the `logstash-child` .

```
services:
- type: org.apache.brooklyn.entity.stock.BasicApplication
  brooklyn.config:
    post.install.command: echo "My post.install command"
  brooklyn.children:
  - type: org.apache.brooklyn.entity.webapp.tomcat.Tomcat8Server
    brooklyn.config:
      children.startable.mode: background_late
    brooklyn.children:
    - type: logstash-child
      brooklyn.config:
        logstash.elasticsearch.host: $brooklyn:entity("es").attributeWhenReady("urls.http.withBrackets")
...
```

Never Inherited

For some configuration values, the most logical behaviour is for the value to never be inherited in the runtime management hiearchy.

Some common config keys that will never inherited include:

- `defaultDisplayName` : this is the name to use for the entity, if an explicit name is not supplied. This is particularly useful when adding an entity in a catalog item (so if the user does not give a name, it will get a sensible default). It would not be intuitive for all the children of that entity to also get that default name.
- `id` : the id of an entity (as supplied in the YAML, to allow references to that entity) is not inherited. It is the id of that specific entity, so must not be shared by all its children.

Inheritance Modes: Deep Dive

The javadoc in the code is useful for anyone who wants to go deep! See `org.apache.brooklyn.config.BasicConfigInheritance` and `org.apache.brooklyn.config.ConfigInheritances` in the repo https://github.com/apache/brooklyn-server.

When defining a new config key, the exact semantics for inheritance can be defined. There are separate options to control config inheritance from the super-type, and config inheritance from the parent in the runtime management hierarchy.

The possible modes are:

- `NEVER_INHERITED` : indicates that a key's value should never be inherited (even if defined on an entity that does not know the key). Most usages will prefer `NOT_REINHERITED` .
- `NOT_REINHERITED` : indicates that a config key value (if used) should not be passed down to children / sub-types. Unlike `NEVER_INHERITED` , these values can be passed down if they are not used by the entity (i.e. if the entity does not expect it). However, when used by a child, it will not be passed down any further. If the inheritor also defines a value the parent's value is ignored irrespective (as in `OVERWRITE` ; see `NOT_REINHERITED_ELSE_DEEP_MERGE` if merging is desired).
- `NOT_REINHERITED_ELSE_DEEP_MERGE` : as `NOT_REINHERITED` but in cases where a value is inherited because a parent did not recognize it, if the inheritor also defines a value the two values should be merged.
- `OVERWRITE` : indicates that if a key has a value at both an ancestor and a descendant, the descendant and his descendants will prefer the value at the descendant.
- `DEEP_MERGE` : indicates that if a key has a value at both an ancestor and a descendant, the descendant and his descendants should attempt to merge the values. If the values are not mergable, behaviour is undefined (and often the descendant's value will simply overwrite).

Explicit Inheritance Modes

The YAML support for explicitly defining the inheritance mode is still work-in-progress. The options documented below will be enhanced in a future version of Brooklyn, to better support the modes described above.

In a YAML blueprint, within the `brooklyn.parameters` section for declaring new config keys, one can set the mode for `inheritance.type` and `inheritance.parent` (i.e. for inheritance from the super-type, and inheritance in the runtime management hierarchy). The possible values are:

- `deep_merge` : the inherited and the given value should be merged; maps within the map will also be merged
- `always` : the inherited value should be used, unless explicitly overridden by the entity
- `none` : the value should not be inherited; if there is no explicit value on the entity then the default value will be used

Below is a (contrived!) example of inheriting the `example.map` config key. When using this entity in a blueprint, the entity's config will be merged with that defined in the super-type, and the parent entity's value will never be inherited:

```
brooklyn.catalog:
  items:
  - id: entity-config-inheritance-example
    version: "1.1.0-SNAPSHOT"
    itemType: entity
    name: Entity Config Inheritance Example
    item:
      type: org.apache.brooklyn.entity.machine.MachineEntity
      brooklyn.parameters:
      - name: example.map
        type: java.util.Map
        inheritance.type: deep_merge
        inheritance.parent: none
        default:
          MESSAGE_IN_DEFAULT: InDefault
      brooklyn.config:
        example.map:
          MESSAGE: Hello
```

The blueprints below demonstrate the various permutations for setting configuration for the config `example.map`. This can be inspected by looking at the entity's config. The config we see for app1 is the inherited `{MESSAGE: "Hello"}`; in app2 we define additional configuration, which will be merged to give `{MESSAGE: "Hello", MESSAGE_IN_CHILD: "InChild"}`; in app3, the config from the parent is not inherited because there is an explicit inheritance.parent of "none", so it just has the value `{MESSAGE: "Hello"}`; in app4 again the parent's config is ignored, with the super-type and entity's config being merged to give `{MESSAGE: "Hello", MESSAGE_IN_CHILD: "InChild"}`.

```
location: aws-ec2:us-east-1
services:
- type: org.apache.brooklyn.entity.stock.BasicApplication
  name: app1
  brooklyn.children:
  - type: entity-config-inheritance-example

- type: org.apache.brooklyn.entity.stock.BasicApplication
  name: app2
  brooklyn.children:
  - type: entity-config-inheritance-example
    brooklyn.config:
      example.map:
        MESSAGE_IN_CHILD: InChild

- type: org.apache.brooklyn.entity.stock.BasicApplication
  name: app3
  brooklyn.config:
    example.map:
      MESSAGE_IN_PARENT: InParent
  brooklyn.children:
  - type: entity-config-inheritance-example

- type: org.apache.brooklyn.entity.stock.BasicApplication
  name: app4
  brooklyn.config:
    example.map:
      MESSAGE_IN_PARENT: InParent
  brooklyn.children:
  - type: entity-config-inheritance-example
    brooklyn.config:
      example.map:
        MESSAGE_IN_CHILD: InChild
```

A limitations of `inheritance.parent` is when inheriting values from parent and grandparent entities: a value specified on the parent will override (rather than be merged with) the value on the grandparent.

Merging Policy and Enricher Configuration Values

A current limitation is that sub-type inheritance is not supported for configuration of policies and enrichers. The current behaviour is that config is not inherited. The concept of inheritance from the runtime management hierarchy does not apply for policies and enrichers (they do not have "parents"; they are attached to an entity).

Brooklyn supports a very wide range of target locations. With deep integration to Apache jclouds, most well-known clouds and cloud platforms are supported. See the Locations guide for details and more examples.

Cloud Example

The following example is for Amazon EC2:

```
name: simple-appserver-with-location
location:
  jclouds:aws-ec2:
    region: us-east-1
    identity: AKA_YOUR_ACCESS_KEY_ID
    credential: <access-key-hex-digits>
services:
- type: org.apache.brooklyn.entity.webapp.tomcat.Tomcat8Server
```

(You'll need to replace the `identity` and `credential` with the "Access Key ID" and "Secret Access Key" for your account, as configured in the AWS Console.)

Other popular public clouds include `softlayer` , `google-compute-engine` , and `rackspace-cloudservers-us` . Private cloud systems including `openstack-nova` and `cloudstack` are also supported, although for these you'll supply an `endpoint: https://9.9.9.9:9999/v2.0/` (or `client/api/` in the case of CloudStack) instead of the `region` .

"Bring Your Own Nodes" (BYON) Example

You can also specify pre-existing servers to use -- "bring-your-own-nodes". The example below shows a pool of machines that will be used by the entities within the application.

```
name: simple-appserver-with-location-byon
location:
  byon:
    user: brooklyn
    privateKeyFile: ~/.ssh/brooklyn.pem
    hosts:
    - 192.168.0.18
    - 192.168.0.19
services:
- type: org.apache.brooklyn.entity.webapp.tomcat.Tomcat8Server
```

Single Line and Multi Line Locations

A simple location can be specified on a single line. Alternatively, it can be split to have one configuration option per line (recommended for all but the simplest locations).

For example, the two examples below are equivalent:

```
location: byon(name="my loc",hosts="1.2.3.4",user="bob",privateKeyFile="~/.ssh/bob_id_rsa")
```

```
location:
  byon:
    name: "my loc"
    hosts:
    - "1.2.3.4"
    user: "bob"
    privateKeyFile: "~/.ssh/bob_id_rsa"
```

Specific Locations for Specific Entities

One can define specific locations on specific entities within the blueprint (instead of, or as well as, defining the location at the top-level of the blueprint).

The example below will deploy Tomcat and JBoss App Server to different Bring Your Own Nodes locations:

```
name: simple-appserver-with-location-per-entity
services:
- type: org.apache.brooklyn.entity.webapp.tomcat.Tomcat8Server
  location:
    byon(hosts="192.168.0.18",user="brooklyn",privateKeyFile="~/.ssh/brooklyn.pem")
- type: org.apache.brooklyn.entity.webapp.jboss.JBoss7Server
  location:
    byon(hosts="192.168.0.19",user="brooklyn",privateKeyFile="~/.ssh/brooklyn.pem")
```

The rules for precedence when defining a location for an entity are:

- The location defined on that specific entity.
- If no location is defined, then the first ancestor that defines an explicit location.
- If still no location is defined, then the location defined at the top-level of the blueprint.

This means, for example, that if you define an explicit location on a cluster then it will be used for all members of that cluster.

Multiple Locations

Some entities are written to expect a set of locations. For example, a `DynamicFabric` will create a member entity in each location that it is given. To supply multiple locations, simply use `locations` with a yaml list.

In the example below, it will create a cluster of app-servers in each location. One location is used for each `DynamicCluster` ; all app-servers inside that cluster will obtain a machine from that given location.

```
name: fabric-of-app-server-clusters
locations:
- aws-ec2:us-east-1
- aws-ec2:us-west-1
services:
- type: org.apache.brooklyn.entity.group.DynamicFabric
  brooklyn.config:
    dynamiccluster.memberspec:
      $brooklyn:entitySpec:
        type: org.apache.brooklyn.entity.group.DynamicCluster
        brooklyn.config:
          cluster.initial.size: 3
          dynamiccluster.memberspec:
            $brooklyn:entitySpec:
              type: org.apache.brooklyn.entity.webapp.tomcat.Tomcat8Server
```

The entity hierarchy at runtime will have a `DynamicFabric` with two children, each of type `DynamicCluster` (each running in different locations), each of which initially has three app-servers.

For brevity, this example excludes the credentials for aws-ec2. These could either be specificed in-line or defined as named locations in the catalog (see below).

Adding Locations to the Catalog

The examples above have given all the location details within the application blueprint. It is also possible (and indeed preferred) to add the location definitions to the catalog so that they can be referenced by name in any blueprint.

For more information see the Operations: Catalog section of the User Guide.

Externalized Configuration

For simplicity, the examples above have included the cloud credentials. For a production system, it is strongly recommended to use Externalized Configuration to retrieve the credentials from a secure credentials store, such as Vault.

Use of provisioning.properties

An entity that represents a "software process" can use the configuration option `provisioning.properties` to augment the location's configuration. For more information, see Entity Configuration details.

Another simple blueprint will just create a VM which you can use, without any software installed upon it:

```
name: simple-vm
services:
- type: org.apache.brooklyn.entity.software.base.EmptySoftwareProcess
  name: VM
  brooklyn.config:
    provisioning.properties:
      minRam: 8192mb
      minCores: 4
      minDisk: 100gb
```

We've omitted the `location` section here and in many of the examples below; add the appropriate choice when you paste your YAML. Note that the `provisioning.properties` will be ignored if deploying to `localhost` or `byon` fixed-IP machines.

This will create a VM with the specified parameters in your choice of cloud. In the GUI (and in the REST API), the entity is called "VM", and the hostname and IP address(es) are reported as sensors. There are many more `provisioning.properties` supported here, including:

- a `user` to create (if not specified it creates the same username as `brooklyn` is running under)
- a `password` for him or a `publicKeyFile` and `privateKeyFile` (defaulting to keys in `~/.ssh/id_rsa{.pub,}` and no password, so if you have keys set up you can immediately ssh in!)
- `machineCreateAttempts` (for dodgy clouds, and they nearly all fail occasionally!)
- and things like `imageId` and `userMetadata` and disk and networking options (e.g. `autoAssignFloatingIp` for private clouds)

For more information, see Operations: Locations.

We've seen the configuration of machines and how to build up clusters. Now let's return to our app-server example and explore how more interesting services can be configured, composed, and combined.

Service Configuration

We'll begin by using more key-value pairs to configure the JBoss server to run a real app:

```
name: appserver-configured
services:
- type: org.apache.brooklyn.entity.webapp.jboss.JBoss7Server
  brooklyn.config:
    wars.root: http://search.maven.org/remotecontent?filepath=org/apache/brooklyn/example/brooklyn-example-hell
o-world-sql-webapp/0.8.0-incubating/brooklyn-example-hello-world-sql-webapp-0.8.0-incubating.war
    http.port: 8080
```

(As before, you'll need to add the `location` info; `localhost` will work for these and subsequent examples.)

When this is deployed, you can see management information in the Brooklyn Web Console, including a link to the deployed application (downloaded to the target machine from the `hello-world` URL), running on port 8080.

Tip: If port 8080 might be in use, you can specify `8080+` to take the first available port >= 8080; the actual port will be reported as a sensor by Brooklyn.

Multiple Services

If you explored the `hello-world-sql` application we just deployed, you'll have noticed it tries to access a database. And it fails, because we have not set one up. Let's do that now:

```
name: appserver-w-db
services:
- type: org.apache.brooklyn.entity.webapp.jboss.JBoss7Server
  name: AppServer HelloWorld
  brooklyn.config:
    wars.root: http://search.maven.org/remotecontent?filepath=org/apache/brooklyn/example/brooklyn-example-hell
o-world-sql-webapp/0.8.0-incubating/brooklyn-example-hello-world-sql-webapp-0.8.0-incubating.war
    http.port: 8080+
    java.sysprops:
      brooklyn.example.db.url:
        $brooklyn:formatString:
          - jdbc:%s%s?user=%s\\&password=%s
          - $brooklyn:component("db").attributeWhenReady("datastore.url")
          - visitors
          - brooklyn
          - $brooklyn:external("brooklyn-demo-sample", "hidden-brooklyn-password")
- type: org.apache.brooklyn.entity.database.mysql.MySqlNode
  id: db
  name: DB HelloWorld Visitors
  brooklyn.config:
    creation.script.password: $brooklyn:external("brooklyn-demo-sample", "hidden-brooklyn-password")
    datastore.creation.script.url: https://github.com/apache/brooklyn-library/raw/master/examples/simple-web-cl
uster/src/main/resources/visitors-creation-script.sql
```

Here there are a few things going on:

- We've added a second service, which will be the database; you'll note the database has been configured to run a custom setup script
- We've injected the URL of the second service into the appserver as a Java system property (so our app knows where to find the database)
- We've used externalized config to keep secret information out of the blueprint; this is loaded at runtime from an externalized config provider, such as a remote credentials store

Caution: Be careful if you write your YAML in an editor which attempts to put "smart-quotes" in. All quote characters must be plain ASCII, not fancy left-double-quotes and right-double-quotes!

There are as many ways to do dependency injection as there are developers, it sometimes seems; our aim in Brooklyn is not to say this has to be done one way, but to support the various mechanisms people might need, for whatever reasons. (We each have our opinions about what works well, of course; the one thing we do want to call out is that being able to dynamically update the injection is useful in a modern agile application -- so we are definitively **not** recommending this Java system property approach ... but it is an easy one to demo!)

The way the dependency injection works is again by using the `$brooklyn:` DSL, this time referring to the `component("db")` (looked up by the `id` field on our DB component), and then to a sensor emitted by that component. All the database entities emit a `database.url` sensor when they are up and running; the `attributeWhenReady` DSL method will store a pointer to that sensor (a Java Future under the covers) in the Java system properties map which the JBoss entity reads at launch time, blocking if needed.

This means that the deployment occurs in parallel, and if the database comes up first, there is no blocking; but if the JBoss entity completes its installation and downloading the WAR, it will wait for the database before it launches. At that point the URL is injected, first passing it through `formatString` to include the credentials for the database (which are defined in the database creation script).

An Aside: Substitutability

Don't like JBoss? Is there something about Maria? One of the modular principles we follow in Brooklyn is substitutability: in many cases, the config keys, sensors, and effectors are defined in superclasses and are portable across multiple implementations.

Here's an example deploying the same application but with different flavors of the components:

```
name: appserver-w-db-other-flavor
services:
- type: org.apache.brooklyn.entity.webapp.tomcat.TomcatServer
  name: AppServer HelloWorld
  brooklyn.config:
    wars.root: http://search.maven.org/remotecontent?filepath=org/apache/brooklyn/example/brooklyn-example-hell
o-world-sql-webapp/0.8.0-incubating/brooklyn-example-hello-world-sql-webapp-0.8.0-incubating.war
    http.port: 8080+
    java.sysprops:
      brooklyn.example.db.url:
        $brooklyn:formatString:
          - jdbc:%s%s?user=%s\\&password=%s
          - $brooklyn:component("db").attributeWhenReady("datastore.url")
          - visitors
          - brooklyn
          - $brooklyn:external("brooklyn-demo-sample", "hidden-brooklyn-password")
- type: org.apache.brooklyn.entity.database.mariadb.MariaDbNode
  id: db
  name: DB HelloWorld Visitors
  brooklyn.config:
    creation.script.password: $brooklyn:external("brooklyn-demo-sample", "hidden-brooklyn-password")
    datastore.creation.script.url: https://github.com/apache/brooklyn-library/raw/master/examples/simple-web-cl
uster/src/main/resources/visitors-creation-script.sql
    provisioning.properties:
      minRam: 8192
```

By changing two lines we've switched from JBoss and MySQL to Tomcat and MariaDB.

We've also brought in the `provisioning.properties` from the VM example earlier so our database has 8GB RAM. Any of those properties, including `imageId` and `user`, can be defined on a per-entity basis.

So far we've covered how to configure and compose entities. There's a large library of blueprints available, but there are also times when you'll want to write your own.

For complex use cases, you can write JVM, but for many common situations, some of the highly-configurable blueprints make it easy to write in YAML, including `bash` and Chef.

Vanilla Software using `bash`

The following blueprint shows how a simple script can be embedded in the YAML (the `|` character is special YAML which makes it easier to insert multi-line text):

```
name: Simple Netcat Server Example
location: localhost
services:
- type: org.apache.brooklyn.entity.software.base.VanillaSoftwareProcess
  name: Simple Netcat Server
  brooklyn.config:
    launch.command: |
      echo hello | nc -l 4321 &
      echo $! > $PID_FILE
```

This starts a simple `nc` listener on port 4321 which will respond `hello` to the first session which connects to it. Test it by running `telnet localhost 4321` or opening `http://localhost:4321` in a browser.

Note that it only allows you connect once, and after that it fails. This is deliberate! We'll repair this later in this example. Until then however, in the *Applications* view you can click the server, go to the `Effectors` tab, and click `restart` to bring if back to life.

This is just a simple script, but it shows how any script can be easily embedded here, including a script to download and run other artifacts. Many artifacts are already packaged such that they can be downloaded and launched with a simple script, and `VanillaSoftwareProcess` can also be used for them.

Downloading Files

We can specify a `download.url` which downloads an artifact (and automatically unpacking TAR, TGZ, and ZIP archives) before running `launch.command` relative to where that file is installed (or unpacked), with the default `launch.command` being `./start.sh`.

So if we create a file `/tmp/netcat-server.tgz` containing just `start.sh` in the root which contains the line `echo hello | nc -l 4321`, we can instead write our example as:

```
name: Simple Netcat Example From File
location: localhost
services:
- type: org.apache.brooklyn.entity.software.base.VanillaSoftwareProcess
  name: Simple Netcat Server
  brooklyn.config:
    download.url: file:///tmp/netcat-server.tgz
    launch.command: |
      ./start.sh &
      echo $! > $PID_FILE
```

Determining Successful Launch

The default method used to determine a successful launch of `VanillaSoftwareProcess` is to run a command over ssh to do a health check. The health check is done post-launch (repeating until it succeeds, before then reporting that the entity has started).

The default command used to carry out this health check will determine if the pid, written to `$PID_FILE` is running. This is why we included in the entity's launch script the line `echo $! > $PID_FILE`.

You'll observe this if you connect to one of the netcat services (e.g. via `telnet localhost 4321`): the `nc` process exits afterwards, causing Brooklyn to set the entity to an `ON_FIRE` state. (You can also test this with a `killall nc`).

There are other options for determining health: you can set `checkRunning.command` and `stop.command` instead, as documented on the javadoc and config keys of the org.apache.brooklyn.entity.software.base.VanillaSoftwareProcess class, and those scripts will be used instead of checking and stopping the process whose PID is in `$PID_FILE`. For example:

```
name: Netcat Example with Explicit Check and Stop Commands
location: localhost
services:
- type: org.apache.brooklyn.entity.software.base.VanillaSoftwareProcess
  name: Simple Netcat Server
  brooklyn.config:
    launch.command: |
      echo hello | nc -l 4321 &
      echo $! > $PID_FILE

    # The following overrides demonstrate the use of a custom shell environment as well as
    # check-running and stop commands. These are optional; default behavior will "do the
    # right thing" with the pid file automatically.

    shell.env:
      CHECK_MARKER: "checkRunning"
      STOP_MARKER: "stop"
    checkRunning.command: |
      echo $CHECK_MARKER >> DATE && test -f "$PID_FILE" && ps -p `cat $PID_FILE` >/dev/null
    stop.command: |
      echo $STOP_MARKER  >> DATE && test -f "$PID_FILE" && { kill -9 `cat $PID_FILE`; rm $PID_FILE; }
```

Periodic Health Check

After start-up is complete, the health check described above is also run periodically, defaulting to every 5 seconds (configured with the config key `softwareProcess.serviceProcessIsRunningPollPeriod`).

This ssh-based polling can be turned off by configuring `sshMonitoring.enabled: false`. However, if no alternative health-check is defined then failure of the process would never be detected by Brooklyn.

See Health Check Sensors for alternative ways of detecting failures.

Port Inferencing

If you're deploying to a cloud machine, a firewall might block the port 4321. We can tell Brooklyn to open this port explicitly by specifying `inboundPorts: [ 4321 ]`; however a more idiomatic way is to specify a config ending with `.port`, such as:

```
name: Netcat Example with Port Opened
location: localhost
services:
- type: org.apache.brooklyn.entity.software.base.VanillaSoftwareProcess
  name: Simple Netcat Server

  brooklyn.config:
    # matching the regex `.*\.port` will cause the port to be opened
    # if in a cloud where configurable security groups are available
    netcat.port: 4321

    launch.command: |
      echo hello | nc -l 4321 &
      echo $! > $PID_FILE
```

The regex for ports to be opened can be configured using the config `inboundPorts.configRegex` (which has `.*\.port` as the default value).

Config keys of type `org.apache.brooklyn.api.location.PortRange` (aka `port`) have special behaviour: when configuring, you can use range notation `8000-8100` or `8000+` to tell Brooklyn to find **one** port matching; this is useful when ports might be in use. In addition, any such config key will be opened, irrespective of whether it matches the `inboundPorts.configRegex`. To prevent any inferencing of ports to open, you can set the config `inboundPorts.autoInfer` to `false`.

Furthermore, the port inferencing capability takes in account static `ConfigKey` fields that are defined on any Entity sub-class. So, `ConfigKey` fields that are based on `PortRanges` type will be also included as required open ports.

Note that in the example above, `netcat.port` must be specified in a `brooklyn.config` block. This block can be used to hold any config (including for example the `launch.command`), but for convenience Brooklyn allows config keys declared on the underlying type to be specified up one level, alongside the type. However config keys which are *not* declared on the type *must* be declared in the `brooklyn.config` block.

Passing custom variables

Blueprint scripts can be parametrised through environment variables, making them reusable in different use-cases. Define the variables in the `env` block and then reference them using the standard bash notation:

```
name: Netcat Example with Environment Vars
location: localhost
services:
- type: org.apache.brooklyn.entity.software.base.VanillaSoftwareProcess
  name: Simple Netcat Server

  brooklyn.config:
    launch.command: |
      echo $MESSAGE | nc -l $NETCAT_PORT &
      echo $! > $PID_FILE

    shell.env:
      MESSAGE: hello
      NETCAT_PORT: 4321
```

Non-string objects in the `env` map will be serialized to JSON before passing them to the script.

Declaring New Config Keys

We can define config keys to be presented to the user using the `brooklyn.parameters` block:

```
name: Netcat Example with Parameter
location: localhost
services:
- type: org.apache.brooklyn.entity.software.base.VanillaSoftwareProcess
  name: Simple Netcat Server
  brooklyn.config:
    launch.command: |
      echo $MESSAGE | nc -l $NETCAT_PORT &
      echo $! > $PID_FILE

    shell.env:
      MESSAGE: $brooklyn:config("message")
      NETCAT_PORT: $brooklyn:attributeWhenReady("netcat.port")
  brooklyn.parameters:
  - name: message
    description: a message to send to the caller
    default: hello
  - name: netcat.port
    type: port
    description: the port netcat should run on
    default: 4321+
```

The example above will allow a user to specify a message to send back and the port where netcat will listen. The metadata on these parameters is available at runtime in the UI and through the API, and is used when populating a catalog.

The example also shows how these values can be passed as environment variables to the launch command. The `$brooklyn:config(...)` function returns the config value supplied or default. For the type `port`, an attribute sensor is also created to report the *actual* port used after port inference, and so the `$brooklyn:attributeWhenReady(...)` function is used. (If `$brooklyn:config("netcat.port")` had been used, `4321+` would be passed as `NETCAT_PORT`.)

This gives us quite a bit more power in writing our blueprint:

- Multiple instances of the server can be launched simultaneously on the same host, as the `4321+` syntax enables Brooklyn to assign them different ports
- If this type is added to the catalog, a user can configure the message and the port; we'll show this in the next section

Using the Catalog and Clustering

The *Catalog* tab allows you to add blueprints which you can refer to in other blueprints. In that tab, click + then *YAML*, and enter the following:

```
brooklyn.catalog:
  id: netcat-example
  version: "1.0"
  itemType: entity
  item:
    type: org.apache.brooklyn.entity.software.base.VanillaSoftwareProcess
    name: Simple Netcat Server

    brooklyn.config:
      launch.command: |
        echo $MESSAGE | nc -l $NETCAT_PORT &
        echo $! > $PID_FILE

      shell.env:
        MESSAGE: $brooklyn:config("message")
        NETCAT_PORT: $brooklyn:attributeWhenReady("netcat.port")

    brooklyn.parameters:
    - name: message
      description: a message to send to the caller
      default: hello
    - name: netcat.port
      type: port
      description: the port netcat should run on
      default: 4321+

    brooklyn.enrichers:
    - type: org.apache.brooklyn.enricher.stock.Transformer
      brooklyn.config:
        uniqueTag: main-uri-generator
        enricher.sourceSensor: $brooklyn:sensor("host.address")
        enricher.targetSensor: $brooklyn:sensor("main.uri")
        enricher.targetValue:
          $brooklyn:formatString:
          - "http://%s:%s/"
          - $brooklyn:attributeWhenReady("host.address")
          - $brooklyn:attributeWhenReady("netcat.port")
```

This is the same example as in the previous section, wrapped according to the catalog YAML requirements, with one new block added defining an enricher. An enricher creates a new sensor from other values; in this case it will create a `main.uri` sensor by populating a `printf` -style string `"http://%s:%s"` with the sensor values.

With this added to the catalog, we can reference the type `netcat-example` when we deploy an application. Return to the *Home* or *Applications* tab, click +, and submit this YAML blueprint:

```
name: Netcat Type Reference Example
location: localhost
services:
- type: netcat-example
  message: hello from netcat using a registered type
```

This extends the previous blueprint which we registered in the catalog, meaning that we don't need to include it each time. Here, we've elected to supply our own message, but we'll use the default port. More importantly, we can package it for others to consume -- or take items others have built.

We can go further and use this to deploy a cluster, this time giving a custom port as well as a custom message:

```
name: Netcat Cluster Example
location: localhost
services:
- type: org.apache.brooklyn.entity.group.DynamicCluster
  brooklyn.config:
    dynamiccluster.memberspec:
      $brooklyn:entitySpec:
        type: netcat-example
        message: hello from cluster member
        netcat.port: 8000+
    cluster.initial.size: 3
    dynamiccluster.restartMode: parallel
```

In either of the above examples, if you explore the tree in the *Applications* view and look at the *Summary* tab of any of the server instances, you'll now see the URL where netcat is running. But remember, netcat will stop after one run, so you'll only be able to use each link once before you have to restart it. You can also run `restart` on the cluster, and if you haven't yet experimented with `resize` on the cluster you might want to do that.

Attaching Policies

Besides detecting this failure, Brooklyn policies can be added to the YAML to take appropriate action. A simple recovery here might just to automatically restart the process:

```
name: Netcat Example with Restarter Policy
location: localhost
services:
- type: org.apache.brooklyn.entity.software.base.VanillaSoftwareProcess
  id: netcat-server
  name: Simple Netcat Server
  brooklyn.config:
    launch.command: |
      echo hello | nc -l 4321 &
      echo $! > $PID_FILE
  brooklyn.enrichers:
  - type: org.apache.brooklyn.policy.ha.ServiceFailureDetector
    brooklyn.config:
      # wait 15s after service fails before propagating failure
      serviceFailedStabilizationDelay: 15s
  brooklyn.policies:
  - type: org.apache.brooklyn.policy.ha.ServiceRestarter
    brooklyn.config:
      # repeated failures in a time window can cause the restarter to abort,
      # propagating the failure; a time window of 0 will mean it always restarts!
      failOnRecurringFailuresInThisDuration: 0
```

Autonomic management in Brooklyn often follows the principle that complex behaviours emerge from composing simple policies. The blueprint above uses one policy to triggering a failure sensor when the service is down, and another responds to such failures by restarting the service. This makes it easy to configure various aspects, such as to delay to see if the service itself recovers (which here we've set to 15 seconds) or to bail out on multiple failures within a time window (which again we are not doing). Running with this blueprint, you'll see that the service shows as on fire for 15s after a `telnet localhost 4321`, before the policy restarts it.

Sensors and Effectors

Effectors

For an even more interesting way to test it, look at the blueprint defining a netcat server and client. This uses `brooklyn.initializers` to define an effector to `sayHiNetcat` on the `Simple Pinger` client, using `env` variables to inject the `netcat-server` location and `parameters` to pass in per-effector data:

```
  env:
    TARGET_HOSTNAME: $brooklyn:entity("netcat-server").attributeWhenReady("host.name")
  brooklyn.initializers:
  - type: org.apache.brooklyn.core.effector.ssh.SshCommandEffector
    brooklyn.config:
      name: sayHiNetcat
      description: Echo a small hello string to the netcat entity
      command: |
        echo $message | nc $TARGET_HOSTNAME 4321
      parameters:
        message:
          description: The string to pass to netcat
          defaultValue: hi netcat
```

Sensors

This blueprint also uses initializers to define sensors on the `netcat-server` entity so that the `$message` we passed above gets logged and reported back:

```
  launch.command: |
    echo hello | nc -l 4321 >> server-input &
    echo $! > $PID_FILE
  brooklyn.initializers:
  - type: org.apache.brooklyn.core.sensor.ssh.SshCommandSensor
    brooklyn.config:
      name: output.last
      period: 1s
      command: tail -1 server-input
```

Windows Command Sensor

Like the blueprint above, the following example also uses `brooklyn.initializers` to define sensors on the entity, this time however it is a windows VM and uses `WinRmCommandSensor`.

```
- type: org.apache.brooklyn.entity.software.base.VanillaWindowsProcess
  brooklyn.config:
    launch.command: echo launching
    checkRunning.command: echo running
  brooklyn.initializers:
  - type: org.apache.brooklyn.core.sensor.windows.WinRmCommandSensor
    brooklyn.config:
      name: ip.config
      period: 60s
      command: hostname
```

Health Check Sensors

As mentioned previously, the default health check is to execute the check-running command over ssh every 5 seconds. This can be very CPU intensive when there are many entities. An alternative is to disable the ssh-polling (by setting `sshMonitoring.enabled: false`) and to configure a different health-check.

See documentation on the Entity's error status for how Brooklyn models an entity's health.

In the snippet below, we'll define a new health-check sensor (via http polling), and will automatically add this to the `service.notUp.indicators` . If that map is non-empty, then the entity's `service.isUp` will be set automatically to `false` :

```
services:
- type: org.apache.brooklyn.entity.software.base.VanillaSoftwareProcess
  brooklyn.config:
    launch.command: |
      ...
    checkRunning.command: true
    sshMonitoring.enabled: false

  brooklyn.initializers:
    - type: org.apache.brooklyn.core.sensor.http.HttpRequestSensor
      brooklyn.config:
        name: http.healthy
        period: 5s
        suppressDuplicates: true
        jsonPath: "$"
        uri:
          $brooklyn:formatString:
          - "http://%s:8080/healthy"
          - $brooklyn:attributeWhenReady("host.name")

  brooklyn.enrichers:
    - type: org.apache.brooklyn.enricher.stock.UpdatingMap
      brooklyn.config:
        enricher.sourceSensor: $brooklyn:sensor("http.healthy")
        enricher.targetSensor: $brooklyn:sensor("service.notUp.indicators")
        enricher.updatingMap.computing:
          $brooklyn:object:
            type: "com.google.guava:com.google.common.base.Functions"
            factoryMethod.name: "forMap"
            factoryMethod.args:
              - true: null
                false: "false"
              - "no value"
```

The `HttpRequestSensor` configures the entity to poll every 5 seconds on the given URI, taking the json result as the sensor value.

The `UpdatingMap` enricher uses that sensor to populate an entry in the `service.notUp.indicators` . It transforms the `http.healthy` sensor value using the given function: if the http poll returned `true` , then it is mapped to `null` (so is removed from the `service.noUp.indicators`); if the poll returned `false` , then `"false"` is added to the indicators map; otherwise `"no value"` is added to the indicators map.

Summary

These examples do relatively simple things, but they illustrate many of the building blocks used in real-world blueprints, and how they can often be easily described and combined in Brooklyn YAML blueprints.

Apache Brooklyn provides a **catalog**, which is a persisted collection of versioned blueprints and other resources. A set of blueprints is loaded from the `default.catalog.bom` in the Brooklyn folder by default and additional ones can be added through the web console or CLI. Blueprints in the catalog can be deployed directly, via the Brooklyn CLI or the web console, or referenced in other blueprints using their `id`.

What if you want multiple machines?

One way is just to repeat the `- type: org.apache.brooklyn.entity.software.base.EmptySoftwareProcess` block, but there's another way which will keep your powder DRY:

```
name: cluster-vm
services:
- type: org.apache.brooklyn.entity.group.DynamicCluster
  brooklyn.config:
    cluster.initial.size: 5
    dynamiccluster.memberspec:
      $brooklyn:entitySpec:
        type: org.apache.brooklyn.entity.software.base.EmptySoftwareProcess
        name: VM
        provisioning.properties:
          minRam: 8g
          minCores: 4
          minDisk: 100g
```

Here we've composed the previous blueprint introducing some new important concepts, the `DynamicCluster` the `$brooklyn` DSL, and the "entity-spec". Let's unpack these.

The `DynamicCluster` creates a set of homogeneous instances. At design-time, you specify an initial size and the specification for the entity it should create. At runtime you can restart and stop these instances as a group (on the `DynamicCluster`) or refer to them individually. You can resize the cluster, attach enrichers which aggregate sensors across the cluster, and attach policies which, for example, replace failed members or resize the cluster dynamically.

The specification is defined in the `dynamiccluster.memberspec` key. As you can see it looks very much like the previous blueprint, with one extra line. Entries in the blueprint which start with `$brooklyn:` refer to the Brooklyn DSL and allow a small amount of logic to be embedded (if there's a lot of logic, it's recommended to write a blueprint YAML plugin or write the blueprint itself as a plugin, in Java or a JVM-supported language).

In this case we want to indicate that the parameter to `dynamiccluster.memberspec` is an entity specification (`EntitySpec` in the underlying type system); the `entitySpec` DSL command will do this for us. The example above thus gives us 5 VMs identical to the one we created in the previous section.

Enrichers provide advanced manipulation of an entity's sensor values. See below for documentation of the stock enrichers available in Apache Brooklyn.

Transformer

`org.apache.brooklyn.enricher.stock.Transformer`

Takes a source sensor and modifies it in some way before publishing the result in a new sensor. See below an example using `$brooklyn:formatString`.

```
brooklyn.enrichers:
- type: org.apache.brooklyn.enricher.stock.Transformer
  brooklyn.config:
    enricher.sourceSensor: $brooklyn:sensor("urls.tcp.string")
    enricher.targetSensor: $brooklyn:sensor("urls.tcp.withBrackets")
    enricher.targetValue: $brooklyn:formatString("[%s]", $brooklyn:attributeWhenReady("urls.tcp.string"))
```

Propagator

`org.apache.brooklyn.enricher.stock.Propagator`

Use propagator to duplicate one sensor as another, giving the supplied sensor mapping. The other use of Propagator is where you specify a producer (using `$brooklyn:entity(...)` as below) from which to take sensors; in that mode you can specify `propagate` as a list of sensors whose names are unchanged, instead of (or in addition to) this map.

```
brooklyn.enrichers:
- type: org.apache.brooklyn.enricher.stock.Propagator
  brooklyn.config:
    enricher.producer: $brooklyn:entity("cluster")
- type: org.apache.brooklyn.enricher.stock.Propagator
  brooklyn.config:
    sensorMapping:
      $brooklyn:sensor("url"): $brooklyn:sensor("org.apache.brooklyn.core.entity.Attributes", "main.uri")
```

Custom Aggregating

`org.apache.brooklyn.enricher.stock.Aggregator`

Aggregates multiple sensor values (usually across a tier, esp. a cluster) and performs a supplied aggregation method to them to return an aggregate figure, e.g. sum, mean, median, etc.

```
brooklyn.enrichers:
- type: org.apache.brooklyn.enricher.stock.Aggregator
  brooklyn.config:
    enricher.sourceSensor: $brooklyn:sensor("webapp.reqs.perSec.windowed")
    enricher.targetSensor: $brooklyn:sensor("webapp.reqs.perSec.perNode")
    enricher.aggregating.fromMembers: true
    transformation: average
```

There are a number of additional configuration keys available for the Aggregators:

Configuration Key	Default	Description
enricher.transformation.untyped	list	Specifies a transformation, as a function from a collection to the value, or as a string matching a pre-defined named transformation, such as 'average' (for numbers), 'sum' (for numbers), 'isQuorate' (to compute a quorum), 'first' (the first value, or null if empty), or 'list' (the default, putting any collection of items into a list)

quorum.check.type		The requirement to be considered quorate -- possible values: 'all', 'allAndAtLeastOne', 'atLeastOne', 'atLeastOneUnlessEmpty', 'alwaysHealthy'", "allAndAtLeastOne"
quorum.total.size	1	The total size to consider when determining if quorate

Joiner

`org.apache.brooklyn.enricher.stock.Joiner`

Joins a sensor whose output is a list into a single item joined by a separator.

```
brooklyn.enrichers:
- type: org.apache.brooklyn.enricher.stock.Joiner
  brooklyn.config:
    enricher.sourceSensor: $brooklyn:sensor("urls.tcp.list")
    enricher.targetSensor: $brooklyn:sensor("urls.tcp.string")
    uniqueTag: urls.quoted.string
```

There are a number of additional configuration keys available for the joiner:

Configuration Key	Default	Description
enricher.joiner.separator	,	Separator string to insert between each argument
enricher.joiner.keyValueSeparator	=	Separator string to insert between each key-value pair
enricher.joiner.joinMapEntries	false	Whether to add map entries as key-value pairs or just use the value
enricher.joiner.quote	true	Whether to bash-escape each parameter and wrap in double-quotes
enricher.joiner.minimum	0	Minimum number of elements to join; if fewer than this, sets null
enricher.joiner.maximum	null	Maximum number of elements to join (null means all elements taken)

Delta Enricher

`org.apache.brooklyn.policy.enricher.DeltaEnricher`

Converts an absolute sensor into a delta sensor (i.e. the difference between the current and previous value)

Time-weighted Delta

`org.apache.brooklyn.enricher.stock.YamlTimeWeightedDeltaEnricher`

Converts absolute sensor values into a difference over time. The `enricher.delta.period` indicates the measurement interval.

```
brooklyn.enrichers:
- type: org.apache.brooklyn.enricher.stock.YamlTimeWeightedDeltaEnricher
  brooklyn.config:
    enricher.sourceSensor: reqs.count
    enricher.targetSensor: reqs.per_sec
    enricher.delta.period: 1s
```

Rolling Mean

`org.apache.brooklyn.policy.enricher.RollingMeanEnricher`

Transforms a sensor into a rolling average based on a fixed window size. This is useful for smoothing sample type metrics, such as latency or CPU time

Rolling Time-window Mean

`org.apache.brooklyn.policy.enricher.RollingTimeWindowMeanEnricher`

Transforms a sensor's data into a rolling average based on a time window. This time window can be specified with the config key `confidenceRequired` - Minimum confidence level (ie period covered) required to publish a rolling average (default `8d`).

Http Latency Detector

`org.apache.brooklyn.policy.enricher.RollingTimeWindowMeanEnricher.HttpLatencyDetector`

An Enricher which computes latency in accessing a URL, normally by periodically polling that URL. This is then published in the sensors `web.request.latency.last` and `web.request.latency.windowed` .

There are a number of additional configuration keys available for the Http Latency Detector:

Configuration Key	Default	Description
latencyDetector.url		The URL to compute the latency of
latencyDetector.urlSensor		A sensor containing the URL to compute the latency of
latencyDetector.urlPostProcessing		Function applied to the urlSensor value, to determine the URL to use
latencyDetector.rollup		The window size (in duration) over which to compute
latencyDetector.requireServiceUp	false	Require the service is up
latencyDetector.period	1s	The period of polling

Combiner

`org.apache.brooklyn.enricher.stock.Combiner`

Can be used to combine the values of sensors. This enricher should be instantiated using `Enrichers.builder().combining(..)` . This enricher is only available in Java blueprints and cannot be used in YAML.

Note On Enricher Producers

If an entity needs an enricher whose source sensor (`enricher.sourceSensor`) belongs to another entity, then the enricher configuration must include an `enricher.producer` key referring to the other entity.

For example, if we consider the Transfomer from above, suppose that `enricher.sourceSensor: $brooklyn:sensor("urls.tcp.list")` is actually a sensor on a different entity called `load.balancer` . In this case, we would need to supply an `enricher.producer` value.

```
brooklyn.enrichers:
- type: org.apache.brooklyn.enricher.stock.Transformer
  brooklyn.config:
    enricher.sourceSensor: $brooklyn:sensor("urls.tcp.string")
    enricher.targetSensor: $brooklyn:sensor("urls.tcp.withBrackets")
    enricher.targetValue: $brooklyn:formatString("[%s]", $brooklyn:attributeWhenReady("urls.tcp.string"))
```

It is important to note that the value supplied to `enricher.producer` must be immediately resolvable. While it would be valid DSL syntax to write:

```
enricher.producer: brooklyn:entity($brooklyn:attributeWhenReady("load.balancer.entity"))
```

(assuming the `load.balancer.entity` sensor returns a Brooklyn entity), this will not function properly because `enricher.producer` will unsuccessfully attempt to get the supplied entity immediately.

Policies perform the active management enabled by Brooklyn. They can subscribe to entity sensors and be triggered by them (or they can run periodically, or be triggered by external systems).

Policies can add subscriptions to sensors on any entity. Normally a policy will subscribe to sensors on either its associated entity, that entity's children and/or to the members of a "group" entity.

Common uses of a policy include the following:

- perform calculations,
- look up other values,
- invoke effectors (management policies) or,
- cause the entity associated with the policy to emit sensor values (enricher policies).

Entities can have zero or more `Policy` instances attached to them.

Off-the-Shelf Policies

Policies are highly reusable as their inputs, thresholds and targets are customizable. Config key details for each policy can be found in the Catalog in the Brooklyn UI.

HA/DR and Scaling Policies

AutoScaler Policy

- org.apache.brooklyn.policy.autoscaling.AutoScalerPolicy

Increases or decreases the size of a Resizable entity based on an aggregate sensor value, the current size of the entity, and customized high/low watermarks.

An AutoScaler policy can take any sensor as a metric, have its watermarks tuned live, and target any resizable entity - be it an application server managing how many instances it handles, or a tier managing global capacity.

e.g. if the average request per second across a cluster of Tomcat servers goes over the high watermark, it will resize the cluster to bring the average back to within the watermarks.

```
brooklyn.policies:
- type: org.apache.brooklyn.policy.autoscaling.AutoScalerPolicy
  brooklyn.config:
    metric: webapp.reqs.perSec.perNode
    metricUpperBound: 3
    metricLowerBound: 1
    resizeUpStabilizationDelay: 2s
    resizeDownStabilizationDelay: 1m
    maxPoolSize: 3
```

ServiceRestarter Policy

- org.apache.brooklyn.policy.ha.ServiceRestarter

Attaches to a SoftwareProcess or to anything Startable which emits `ha.entityFailed` on failure (or other configurable sensor), and invokes `restart` on that failure. If there is a subsequent failure within a configurable time interval or if the restart fails, this gives up and emits `ha.entityFailed.restart` for other policies to act upon or for manual intervention.

```
brooklyn.policies:
- type: org.apache.brooklyn.policy.ha.ServiceRestarter
  brooklyn.config:
    failOnRecurringFailuresInThisDuration: 5m
```

Typically this is used in conjunction with the FailureDetector enricher to emit the trigger sensor. The introduction to policies shows a worked example of these working together.

ServiceReplacer Policy

- org.apache.brooklyn.policy.ha.ServiceReplacer

The ServiceReplacer attaches to a DynamicCluster and replaces a failed member in response to `ha.entityFailed` (or other configurable sensor).
The introduction to policies shows a worked example of this policy in use.

SshMachineFailureDetector Policy

- org.apache.brooklyn.policy.ha.SshMachineFailureDetector

The SshMachineFailureDetector is an HA policy for monitoring an SshMachine, emitting an event if the connection is lost/restored.

ConnectionFailureDetector Policy

- org.apache.brooklyn.policy.ha.ConnectionFailureDetector

The ConnectionFailureDetector is an HA policy for monitoring an http connection, emitting an event if the connection is lost/restored.

Optimization Policies

PeriodicEffector Policy

- org.apache.brooklyn.policy.action.PeriodicEffectorPolicy

The `PeriodicEffectorPolicy` calls an effector with a set of arguments at a specified time and date. The policy monitors the sensor configured by `start.sensor` and will only start when this is set to `true`. The default sensor checked is `service.isUp`, so that the policy will not execute the effector until the entity is started. The following example calls a `resize` effector to resize a cluster up to 10 members at 8am and then down to 1 member at 6pm.

```
- type: org.apache.brooklyn.policy.action.PeriodicEffectorPolicy
  brooklyn.config:
    effector: resize
    args:
      desiredSize: 10
    period: 1 day
    time: 08:00:00
- type: org.apache.brooklyn.policy.action.PeriodicEffectorPolicy
  brooklyn.config:
    effector: resize
    args:
      desiredSize: 1
    period: 1 day
    time: 18:00:00
```

ScheduledEffector Policy

- org.apache.brooklyn.policy.action.ScheduledEffectorPolicy

The `ScheduledEffectorPolicy` calls an effector at a specific time. The policy monitors the sensor configured by `start.sensor` and will only execute the effector at the specified time if this is set to `true`.

There are two modes of operation, one based solely on policy configuration where the effector will execute at the time set using the `time` key or after the duration set using the `wait` key, or by monitoring sensors. The policy monitors the `scheduler.invoke.now` sensor and will execute the effector immediately when its value changes to `true`. When the `scheduler.invoke.at` sensor changes, it will set a time in the future when the effector should be executed.

The following example calls a `backup` effector every night at midnight.

```
- type: org.apache.brooklyn.policy.action.ScheduledEffectorPolicy
  brooklyn.config:
    effector: backup
    time: 00:00:00
```

FollowTheSun Policy

- org.apache.brooklyn.policy.followthesun.FollowTheSunPolicy

The FollowTheSunPolicy is for moving work around to follow the demand. The work can be any Movable entity. This currently available in yaml blueprints.

LoadBalancing Policy

- org.apache.brooklyn.policy.loadbalancing.LoadBalancingPolicy

The LoadBalancingPolicy is attached to a pool of "containers", each of which can host one or more migratable "items". The policy monitors the workrates of the items and effects migrations in an attempt to ensure that the containers are all sufficiently utilized without any of them being overloaded.

Lifecycle and User Management Policies

StopAfterDuration Policy

- org.apache.brooklyn.policy.action.StopAfterDurationPolicy

The StopAfterDurationPolicy can be used to limit the lifetime of an entity. After a configure time period expires the entity will be stopped.

ConditionalSuspend Policy

- org.apache.brooklyn.policy.ha.ConditionalSuspendPolicy

The ConditionalSuspendPolicy will suspend and resume a target policy based on configured suspend and resume sensors.

CreateUser Policy

- org.apache.brooklyn.policy.jclouds.os.CreateUserPolicy

The CreateUserPolicy Attaches to an Entity and monitors for the addition of a location to that entity, the policy then adds a new user to the VM with a randomly generated password, with the SSH connection details set on the entity as the createuser.vm.user.credentials sensor.

AdvertiseWinRMLogin Policy

- org.apache.brooklyn.location.winrm.WinRmMachineLocation

This is similar to the CreateUserPolicy. It will monitor the addition of WinRmMachineLocation to an entity and then create a sensor advertising the administrative user's credentials.

Writing a Policy

Your First Policy

Policies perform the active management enabled by Brooklyn. Each policy instance is associated with an entity, and at runtime it will typically subscribe to sensors on that entity or children, performing some computation and optionally actions when a subscribed sensor event occurs. This action might be invoking an effector or emitting a new sensor, depending the desired behavior is.

Writing a policy is straightforward. Simply extend `AbstractPolicy`, overriding the `setEntity` method to supply any subscriptions desired:

```
    @Override
    public void setEntity(EntityLocal entity) {
        super.setEntity(entity)
        subscribe(entity, TARGET_SENSOR, this)
    }
```

and supply the computation and/or activity desired whenever that event occurs:

```
    @Override
    public void onEvent(SensorEvent<Integer> event) {
        int val = event.getValue()
        if (val % 2 == 1)
            entity.sayYoureOdd();
    }
```

You'll want to do more complicated things, no doubt, like access other entities, perform multiple subscriptions, and emit other sensors -- and you can. See the best practices below and source code for some commonly used policies and enrichers, such as `AutoScalerPolicy` and `RollingMeanEnricher`.

One rule of thumb, to close on: try to keep policies simple, and compose them together at runtime; for instance, if a complex computation triggers an action, define one **enricher** policy to aggregate other sensors and emit a new sensor, then write a second policy to perform that action.

Best Practice

The following recommendations should be considered when designing policies:

Management should take place as "low" as possible in the hierarchy

- place management responsibility in policies at the entity, as much as possible ideally management should take run as a policy on the relevant entity
- place escalated management responsibility at the parent entity. Where this is impractical, perhaps because two aspects of an entity are best handled in two different places, ensure that the separation of responsibilities is documented and there is a group membership relationship between secondary/aspect managers.

Policies should be small and composable

e.g. one policy which takes a sensor and emits a different, enriched sensor, and a second policy which responds to the enriched sensor of the first (e.g. a policy detects a process is maxed out and emits a TOO_HOT sensor; a second policy responds to this by scaling up the VM where it is running, requesting more CPU)

Where a policy cannot resolve a situation at an entity, the issue should be escalated to a manager with a compatible policy.

Typically escalation will go to the entity parent, and then cascade up. e.g. if the earlier VM CPU cannot be increased, the TOO_HOT event may go to the parent, a cluster entity, which attempts to balance. If the cluster cannot balance, then to another policy which attempts to scale out the cluster, and should the cluster be unable to scale, to a third policy which emits TOO_HOT for the cluster.

Management escalation should be carefully designed so that policies are not incompatible

Order policies carefully, and mark sensors as "handled" (or potentially "swallow" them locally), so that subsequent policies and parent entities do not take superfluous (or contradictory) corrective action.

Implementation Classes

Extend `AbstractPolicy` , or override an existing policy.

Effectors perform an operation of some kind, carried out by a Brooklyn Entity. They can be manually invoked or triggered by a Policy.

Common uses of an effector include the following:

- Perform a command on a remote machine.
- Collect data and publish them to sensors.

Entities have default effectors, the lifecycle management effectors like `start` , `stop` , `restart` , and clearly more `Effectors` can be attached to them.

Off-the-Shelf Effectors

Effectors are highly reusable as their inputs, thresholds and targets are customizable.

SSHCommandEffector

An `Effector` to invoke a command on a node accessible via SSH.

It enables execution of a `command` in a specific `execution director` (executionDir) by using a custom `shell environment` (shellEnv). By default, the specified command will be executed on the entity where the effector is attached or on all *children* or all *members* (if it is a group) by configuring `executionTarget` .

There are a number of additional configuration keys available for the `SSHCommandEffector` :

Configuration Key	Default	Description
command		command to be executed on the execution target
executionDir		possible values: 'GET', 'HEAD', 'POST', 'PUT', 'PATCH', 'DELETE', 'OPTIONS', 'TRACE'
shellEnv		custom shell environment where the command is executed
executionTarget	ENTITY	possible values: 'MEMBERS', 'CHILDREN'

Here is a simple example of an `SshCommandEffector` definition:

```
brooklyn.initializers:
- type: org.apache.brooklyn.core.effector.ssh.SshCommandEffector
  brooklyn.config:
    name: sayHiNetcat
    description: Echo a small hello string to the netcat entity
    command: |
      echo $message | nc $TARGET_HOSTNAME 4321
    parameters:
      message:
        description: The string to pass to netcat
        defaultValue: hi netcat
```

See `here` for more details.

HTTPCommandEffector

An `Effector` to invoke HTTP endpoints.

It allows the user to specify the URI, the HTTP verb, credentials for authentication and HTTP headers.

There are a number of additional configuration keys available for the `HTTPCommandEffector` :

Configuration Key	Default	Description
uri		URI of the endpoint
httpVerb		possible values: 'GET', 'HEAD', 'POST', 'PUT', 'PATCH', 'DELETE', 'OPTIONS', 'TRACE'
httpUsername		user name for the authentication
httpPassword		password for the authentication
headers	application/json	It explicitly supports `application/x-www-form-urlencoded`
httpPayload		The body of the http request
jsonPath		A jsonPath expression to extract values from a json object
jsonPathAndSensors		A map where keys are jsonPath expressions and values the name of the sensor where to publish extracted values

When a the header `HttpHeaders.CONTENT_TYPE` is equals to *application/x-www-form-urlencoded* and the `httpPayload` is a `map` , the payload is transformed into a single string using `URLEncoded` .

```
brooklyn.initializers:
- type: org.apache.brooklyn.core.effector.http.HttpCommandEffector
  brooklyn.config:
    name: request-access-token
    description: Request an access token for the Azure API
    uri:
      $brooklyn:formatString:
      - "https://login.windows.net/%s/oauth2/token"
      - $brooklyn:config("tenant.id")
    httpVerb: POST
    httpPayload:
      resource: https://management.core.windows.net/
      client_id: $brooklyn:config("application.id")
      grant_type: client_credentials
      client_secret: $brooklyn:config("application.secret")
    jsonPathAndSensors:
      $.access_token: access.token
    headers:
      Content-Type: "application/x-www-form-urlencoded"
```

See `here` for more details.

AddChildrenEffector

An `Effector` to add a child blueprint to an entity.

```
brooklyn.initializers:
- type: org.apache.brooklyn.core.effector.AddChildrenEffector
  brooklyn.config:
    name: add_tomcat
    blueprint_yaml: |
        name: sample
        description: Tomcat sample JSP and servlet application.
        origin: http://www.oracle.com/nCAMP/Hand
        services:
        -
            type: io.camp.mock:AppServer
            name: Hello WAR
            wars:
                /: hello.war
            controller.spec:
                port: 80
        brooklyn.catalog:
        name: catalog-name
        type: io.camp.mock.MyApplication
        version: 0.9
        libraries:
        - name: org.apache.brooklyn.test.resources.osgi.brooklyn-test-osgi-entities
            version: 0.1.0
            url: classpath:/brooklyn/osgi/brooklyn-test-osgi-entities.jar
    auto_start: true
```

One of the config keys `BLUEPRINT_YAML` (containing a YAML blueprint (map or string)) or `BLUEPRINT_TYPE` (containing a string referring to a catalog type) should be supplied, but not both.

See `here` for more details.

Writing an Effector

Your First Effector

Effectors generally perform actions on entities. Each effector instance is associated with an entity, and at runtime it will typically exectute an operation, collect the result and, potentially, publish it as sensor on that entity, performing some computation.

Writing an effector is straightforward. Simply extend `AddEffector`, providing an implementation for `newEffectorBuilder` and adding a constructor that consumes the builder or override an existing effector.

```
 public MyEffector(ConfigBag params) {
    super(newEffectorBuilder(params).build());
}

public static EffectorBuilder<String> newEffectorBuilder(ConfigBag params) {
    EffectorBuilder<String> eff = AddEffector.newEffectorBuilder(String.class, params);
    eff.impl(new Body(eff.buildAbstract(), params));
    return eff;
}
```

and supply an `EffectorBody` similar to:

```
protected static class Body extends EffectorBody<String> {
    ...

    @Override
    public String call(final ConfigBag params) {
     ...
    }
}
```

Best Practice

The following recommendations should be considered when designing effectors:

Effectors should be small and composable

One effector which executes a command and emits a sensor, and a second effector which uses the previous sensor, if defined, to execute another operation.

Now let's bring the concept of the "cluster" back in. We could wrap our appserver in the same `DynamicCluster` we used earlier, although then we'd need to define and configure the load balancer. But another blueprint, the `ControlledDynamicWebAppCluster`, does this for us. It takes the same `dynamiccluster.memberspec`, so we can build a fully functional elastic 3-tier deployment of our `hello-world-sql` application as follows:

```
name: appserver-clustered-w-db
services:
- type: org.apache.brooklyn.entity.webapp.ControlledDynamicWebAppCluster
  brooklyn.config:
    cluster.initial.size: 2
    dynamiccluster.memberspec:
      $brooklyn:entitySpec:
        type: org.apache.brooklyn.entity.webapp.jboss.JBoss7Server
        brooklyn.config:
          wars.root: http://search.maven.org/remotecontent?filepath=org/apache/brooklyn/example/brooklyn-exampl
e-hello-world-sql-webapp/0.8.0-incubating/brooklyn-example-hello-world-sql-webapp-0.8.0-incubating.war
          http.port: 8080+
          java.sysprops:
            brooklyn.example.db.url:
              $brooklyn:formatString:
                - jdbc:%s%s?user=%s\\&password=%s
                - $brooklyn:component("db").attributeWhenReady("datastore.url")
                - visitors
                - brooklyn
                - $brooklyn:external("brooklyn-demo-sample", "hidden-brooklyn-password")
- type: org.apache.brooklyn.entity.database.mysql.MySqlNode
  id: db
  name: DB HelloWorld Visitors
  brooklyn.config:
    creation.script.password: $brooklyn:external("brooklyn-demo-sample", "hidden-brooklyn-password")
    datastore.creation.script.url: https://github.com/apache/brooklyn-library/blob/master/examples/simple-web-c
luster/src/main/resources/visitors-creation-script.sql
```

This sets up Nginx as the controller by default, but that can be configured using the `controllerSpec` key. This uses the same externalized config as in other examples to hide the password.

JBoss is actually the default appserver in the `ControlledDynamicWebAppCluster`, so because `brooklyn.config` keys in Brooklyn are inherited by default, the same blueprint can be expressed more concisely as:

```
name: appserver-clustered-w-db-concise
services:
- type: org.apache.brooklyn.entity.webapp.ControlledDynamicWebAppCluster
  brooklyn.config:
    cluster.initial.size: 2
    wars.root: http://search.maven.org/remotecontent?filepath=org/apache/brooklyn/example/brooklyn-example-hell
o-world-sql-webapp/0.8.0-incubating/brooklyn-example-hello-world-sql-webapp-0.8.0-incubating.war
    http.port: 8080+
    java.sysprops:
      brooklyn.example.db.url: $brooklyn:formatString("jdbc:%s%s?user=%s\\&password=%s", component("db").attrib
uteWhenReady("datastore.url"), "visitors", "brooklyn", $brooklyn:external("brooklyn-demo-sample", "hidden-brook
lyn-password"))
- type: org.apache.brooklyn.entity.database.mysql.MySqlNode
  id: db
  name: DB HelloWorld Visitors
  brooklyn.config:
    creation.script.password: $brooklyn:external("brooklyn-demo-sample", "hidden-brooklyn-password")
    datastore.creation.script.url: https://github.com/apache/brooklyn-library/blob/master/examples/simple-web-c
luster/src/main/resources/visitors-creation-script.sql
```

The other nicety supplied by the `ControlledDynamicWebAppCluster` blueprint is that it aggregates sensors from the appserver, so we have access to things like `webapp.reqs.perSec.windowed.perNode`. These are convenient for plugging in to policies! We can set up our blueprint to do autoscaling based on requests per second (keeping it in the range 10..100, with a maximum of 5 appserver nodes) as follows:

```
name: appserver-w-policy
services:
- type: org.apache.brooklyn.entity.webapp.ControlledDynamicWebAppCluster
  brooklyn.config:
    cluster.initial.size: 1
    dynamiccluster.memberspec:
      $brooklyn:entitySpec:
        type: org.apache.brooklyn.entity.webapp.jboss.JBoss7Server
        brooklyn.config:
          wars.root: http://search.maven.org/remotecontent?filepath=org/apache/brooklyn/example/brooklyn-exampl
e-hello-world-sql-webapp/0.8.0-incubating/brooklyn-example-hello-world-sql-webapp-0.8.0-incubating.war
          http.port: 8080+
          java.sysprops:
            brooklyn.example.db.url:
              $brooklyn:formatString:
              - jdbc:%s%s?user=%s\\&password=%s
              - $brooklyn:component("db").attributeWhenReady("datastore.url")
              - visitors
              - brooklyn
              - $brooklyn:external("brooklyn-demo-sample", "hidden-brooklyn-password")
  brooklyn.policies:
  - type: org.apache.brooklyn.policy.autoscaling.AutoScalerPolicy
    brooklyn.config:
      metric: $brooklyn:sensor("brooklyn.entity.webapp.DynamicWebAppCluster", "webapp.reqs.perSec.windowed.perN
ode")
      metricLowerBound: 10
      metricUpperBound: 100
      minPoolSize: 1
      maxPoolSize: 5
- type: org.apache.brooklyn.entity.database.mysql.MySqlNode
  id: db
  name: DB HelloWorld Visitors
  brooklyn.config:
    creation.script.password: $brooklyn:external("brooklyn-demo-sample", "hidden-brooklyn-password")
    datastore.creation.script.url: https://github.com/apache/brooklyn-library/raw/master/examples/simple-web-cl
uster/src/main/resources/visitors-creation-script.sql
```

Use your favorite load-generation tool (`jmeter` is one good example) to send a huge volume of requests against the server and see the policies kick in to resize it.

Java blueprints are powerful, but also rather more difficult to write than YAML. Advanced Java skills are required.

The main uses of Java-based blueprints are:

- Integration with a service's API (e.g. for an on-line DNS service). This could take advantage of existing Java-based clients, or of Java's flexibility to chain together multiple calls.
- Complex management logic, for example when the best practices for adding/removing nodes from a cluster is fiddly and has many conditionals.
- Where the developer has a strong preference for Java. Anything that can be done in YAML can be done in the Java API. Once the blueprint is added to the catalog, the use of Java will be entirely hidden from users of that blueprint.

The Apache Brooklyn community is striving to make YAML-based blueprints as simple as possible - if you come across a use-case that is hard to do in YAML then please let the community know.

Maven Archetype

Brooklyn includes a maven archetype, which can be used to create the project structure for developing a new Java entity, and generating the OSGi bundle for it.

Generating the Project

The archetype can be used interactively, by running:

```
$ mvn archetype:generate
```

The user will be prompted for the archetype to use (i.e. group "org.apache.brooklyn" and artifact "brooklyn-archetype-quickstart"), as well as options for the project to be created.

Alternatively, all options can be supplied at the command line. For example, if creating a project named "autobrick" for "com.acme":

```
$ BROOKLYN_VERSION={{ book.brooklyn-version }}
$ mvn archetype:generate \
    -DarchetypeGroupId=org.apache.brooklyn \
    -DarchetypeArtifactId=brooklyn-archetype-quickstart \
    -DarchetypeVersion=${BROOKLYN_VERSION} \
    -DgroupId=com.acme \
    -DartifactId=autobrick \
    -Dversion=0.1.0-SNAPSHOT \
    -DpackageName=com.acme.autobrick \
    -DinteractiveMode=false
```

This will create a directory with the artifact name (e.g. "autobrick" in the example above). Note that if run from a directory containing a pom, it will also modify that pom to add this as a module!

The project will contain an example Java entity. You can test this using the supplied unit tests, and also replace it with your own code.

The `README.md` file within the project gives further guidance.

Building

To build, run the commands:

```
$ cd autobrick
$ mvn clean install
```

Adding to the Catalog

The build will produce an OSGi bundle in `target/autobrick-0.1.0-SNAPSHOT.jar` , suitable for use in the Brooklyn catalog (using `brooklyn.libraries`).

To use this in your Brooklyn catalog you will first have to copy the target jar to a suitable location. For developing/testing purposes storing on the local filesystem is fine. For production use, we recommend uploading to a remote maven repository or similar.

Once your jar is in a suitable location the next step is to add a new catalog item to Brooklyn. The project comes with a `catalog.bom` file, located in `src/main/resources` . Modify this file by adding a 'brooklyn.libraries' statement to the bom pointing to the jar. For example:

```
brooklyn.catalog:
    brooklyn.libraries:
    - file:///path/to/jar/autobrick-0.1.0-SNAPSHOT.jar
    version: "0.1.0-SNAPSHOT"
    itemType: entity
    items:
    - id: com.acme.autobrick.MySample
      item:
        type: com.acme.autobrick.MySample
```

The command below will use the CLI to add this to the catalog of a running Brooklyn instance:

```
    br catalog add catalog.bom
```

After running that command, the OSGi bundle will have been added to the OSGi container, and the entity will have been added to your catalog. It can then be used in the same way as regular Brooklyn entities.

For example, you can use the blueprint:

```
services:
- type: com.acme.autobrick.MySample
```

Testing Entities

The project comes with unit tests that demonstrate how to test entities, both within Java and also using YAML-based blueprints.

A strongly recommended way is to write a YAML test blueprint using the test framework, and making this available to anyone who will use your entity. This will allow users to easily run the test blueprint in their own environment (simply by deploying it to their own Brooklyn server) to confirm that the entity is working as expected. An example is contained within the project at `src/test/resources/sample-test.yaml`.

Intro

This walkthrough will set up a simple entity, add it to the catalog, and provision it.

For illustration purposes, we will write an integration with Github Gist, with an effector to create new gists.

Project Setup

Follow the instructions to create a new Java project using the archetype, and import it into your favorite IDE. This example assumes you used the groupId `com.acme` and artifact id `autobrick`.

First ensure you can build this project at the command line, using `mvn clean install`.

Java Entity Classes

For this particular example, we will use a third party Gist library, so will need to add that as a dependency. Add the following to your `pom.xml` inside the `<dependencies>` section (see Maven for more details):

```
<dependency>
  <groupId>org.eclipse.mylyn.github</groupId>
  <artifactId>org.eclipse.egit.github.core</artifactId>
  <version>2.1.5</version>
</dependency>
```

Create a new Java interface, `GistGenerator`, to describe the entity's interface (i.e. the configuration options, sensors, and effectors). The code below assumes you have created this in the package `com.acme` for `src/main/java`.

```
package com.acme;

import java.io.IOException;

import org.apache.brooklyn.api.entity.Entity;
import org.apache.brooklyn.api.entity.ImplementedBy;
import org.apache.brooklyn.config.ConfigKey;
import org.apache.brooklyn.core.annotation.Effector;
import org.apache.brooklyn.core.annotation.EffectorParam;
import org.apache.brooklyn.core.config.ConfigKeys;

@ImplementedBy(GistGeneratorImpl.class)
public interface GistGenerator extends Entity {

    ConfigKey<String> OAUTH_KEY = ConfigKeys.newStringConfigKey("oauth.key", "OAuth key for creating a gist",
            "xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx");

    @Effector(description="Create a Gist")
    String createGist(
            @EffectorParam(name="gistName", description="Gist Name", defaultValue="Demo Gist") String gistName,
            @EffectorParam(name="fileName", description="File Name", defaultValue="Hello.java") String fileName
,
            @EffectorParam(name="gistContents", description="Gist Contents", defaultValue="System.out.println(\
"Hello World\");") String gistContents,
            @EffectorParam(name="oauth.key", description="OAuth key for creating a gist", defaultValue="") Stri
ng oauthKey) throws IOException;

    @Effector(description="Retrieve a Gist")
    public String getGist(
            @EffectorParam(name="id", description="Gist id") String id,
            @EffectorParam(name="oauth.key", description="OAuth key for creating a gist", defaultValue="") Stri
ng oauthKey) throws IOException;
}
```

To describe each part of this:

- The `@ImplementedBy` indicates the implementation class for this entity type - i.e. the class to instantiate when an entity of this type is created.
- By extending `Entity`, we indicate that this interface is an Entity type. We could alternatively have extended one of the other sub-types of Entity.
- The `OAUTH_KEY` is a configuration key - it is configuration that can be set on the entity when it is being instantiated.
- The `@Effector` annotation indicates that the given method is an effector, so should be presented and tracked as such. Execution of the effector is intercepted, to track it as a task and show its execution in the Activity view.
- The `@EffectorParam` annotations give metadata about the effector's parameters. This metadata, such as the parameter description, is available to those using the client CLI, rest API and web-console.

Note there is an alternative way of defining effectors - adding them to the entity dynamically, discussed in the section Dynamically Added Effectors.

Next lets add the implementation. Create a new Java class named `GistGeneratorImpl`.

```
package com.acme;

import java.io.IOException;
import java.util.Collections;

import org.apache.brooklyn.core.entity.AbstractEntity;
import org.apache.brooklyn.util.text.Strings;
import org.eclipse.egit.github.core.Gist;
import org.eclipse.egit.github.core.GistFile;
import org.eclipse.egit.github.core.service.GistService;
import org.slf4j.Logger;
import org.slf4j.LoggerFactory;

import com.google.common.collect.Iterables;

public class GistGeneratorImpl extends AbstractEntity implements GistGenerator {

    private static final Logger LOG = LoggerFactory.getLogger(GistGeneratorImpl.class);

    @Override
    public String createGist(String gistName, String fileName, String gistContents, String oathToken) throws IO
Exception {
        if (Strings.isBlank(oathToken)) oathToken = config().get(OAUTH_KEY);

        GistFile file = new GistFile();
        file.setContent(gistContents);
        Gist gist = new Gist();
        gist.setDescription(gistName);
        gist.setFiles(Collections.singletonMap(fileName, file));
        gist.setPublic(true);

        GistService service = new GistService();
        service.getClient().setOAuth2Token(oathToken);
        LOG.info("Creating Gist: " +  gistName);
        Gist result = service.createGist(gist);
        return result.getId();
    }

    @Override
    public String getGist(String id, String oathToken) throws IOException {
        if (Strings.isBlank(oathToken)) oathToken = config().get(OAUTH_KEY);

        GistService service = new GistService();
```

```
            service.getClient().setOAuth2Token(oathToken);
            Gist gist = service.getGist(id);
            return Iterables.getOnlyElement(gist.getFiles().values()).getContent();
        }
    }
```

To describe each part of this:

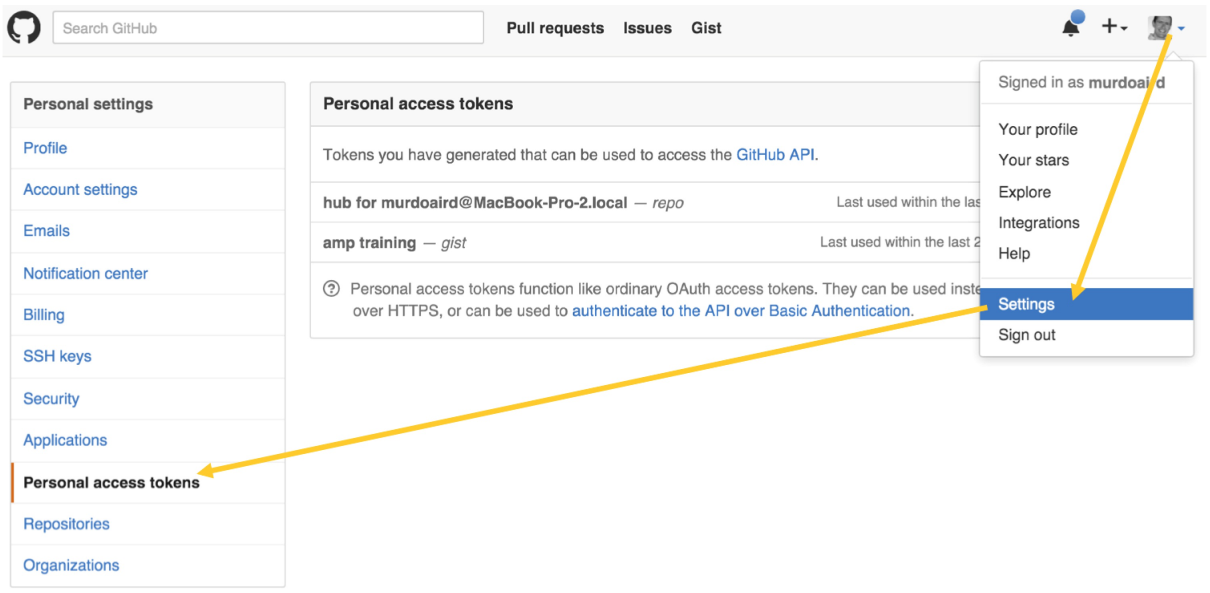
- Extends `AbstractEntity` - all entity implementations should extend this, or one of its sub-types.
- Implements `GistGenerator` : this is the Entity type definition, so must be implemented. Users of the entity will only refer to the interface; they will never be given an instance of the concrete class - instead a dynamic proxy is used (to allow remoting).
- `org.slf4j.Logger` is the logger used throughout Apache Brooklyn.
- Implements the `createGist` effector - we do not need to re-declare all the annotations.
- If no `oath.key` parameter was passed in, then use the configuration set on the entity.
- Use the third party library to create the gist.

Configuring GitHub

First, create a github.com account, if you do not already have one.

Before running the blueprint, we'll need to generate an access token that has permissions to create a gist programmatically.

First create a new access token that our blueprint will use to create a gist:



Personal access tokens

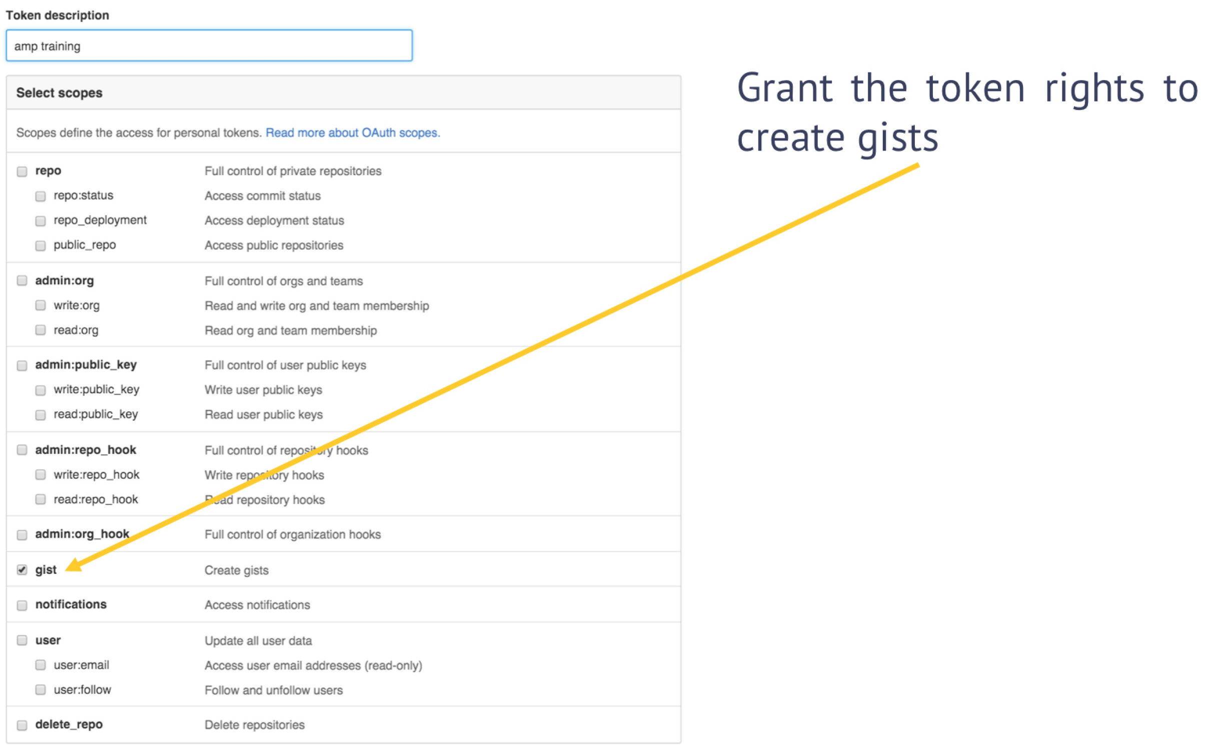
Tokens you have generated that can be used to access the GitHub API.

hub for murdoaird@MacBook-Pro-2.local — *repo* Last used within the las

amp training — *gist* Last used within the last 2

Personal access tokens function like ordinary OAuth access tokens. They can be used inste over HTTPS, or can be used to authenticate to the API over Basic Authentication.

Next, grant the token rights to create gists:



Token description

amp training

Select scopes

Scopes define the access for personal tokens. Read more about OAuth scopes.

☐ repo	Full control of private repositories
☐ repo:status	Access commit status
☐ repo_deployment	Access deployment status
☐ public_repo	Access public repositories
☐ admin:org	Full control of orgs and teams
☐ write:org	Read and write org and team membership
☐ read:org	Read org and team membership
☐ admin:public_key	Full control of user public keys
☐ write:public_key	Write user public keys
☐ read:public_key	Read user public keys
☐ admin:repo_hook	Full control of repository hooks
☐ write:repo_hook	Write repository hooks
☐ read:repo_hook	Read repository hooks
☐ admin:org_hook	Full control of organization hooks
✓ gist	Create gists
☐ notifications	Access notifications
☐ user	Update all user data
☐ user:email	Access user email addresses (read-only)
☐ user:follow	Follow and unfollow users
☐ delete_repo	Delete repositories

Testing

The archetype project comes with example unit tests that demonstrate how to test entities, both within Java and also using YAML-based blueprints.

We will create a similar Java-based test for this blueprint. Create a new Java class named `GistGeneratorTest` in the package `com.acme`, inside `src/test/java`.

You will need to substitute the github access token you generated in the previous section for the placeholder text `xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx`.

```
package com.acme;

import static org.testng.Assert.assertEquals;

import org.apache.brooklyn.api.entity.EntitySpec;
import org.apache.brooklyn.core.test.BrooklynAppUnitTestSupport;
import org.testng.annotations.Test;

public class GistGeneratorTest extends BrooklynAppUnitTestSupport {

    @Test
    public void testEntity() throws Exception {
        String oathKey = "xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx";
        GistGenerator entity = app.createAndManageChild(EntitySpec.create(GistGenerator.class));
        String id = entity.createGist("myGistName", "myFileName", "myGistContents", oathKey);

        String contents = entity.getGist(id, oathKey);
        assertEquals(contents, "myGistContents");
    }
}
```

Similarly, we can write a test that uses the `GistGenerator` from a YAML blueprint. Create a new Java class named `GistGeneratorYamlTest` in the package `com.acme`, inside `src/test/java`.

Again you will need to substitute the github access token you generated in the previous section for the placeholder text `xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx` . See the section on externalised configuration for how to store these credentials more securely.

```
package com.acme;

import static org.testng.Assert.assertEquals;

import org.apache.brooklyn.api.entity.Entity;
import org.apache.brooklyn.camp.brooklyn.AbstractYamlTest;
import org.apache.brooklyn.core.entity.Entities;
import org.testng.annotations.Test;

import com.google.common.base.Joiner;
import com.google.common.collect.Iterables;

public class GistGeneratorYamlTest extends AbstractYamlTest {

    private String contents;

    @Test
    public void testEntity() throws Exception {
        String oathKey = "xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx";

        String yaml = Joiner.on("\n").join(
            "name: my test",
            "services:",
            "- type: com.acme.GistGenerator",
            "  brooklyn.config:",
            "    oauth.key: "+oathKey);

        Entity app = createAndStartApplication(yaml);
        waitForApplicationTasks(app);

        Entities.dumpInfo(app);

        GistGenerator entity = (GistGenerator) Iterables.getOnlyElement(app.getChildren());
        String id = entity.createGist("myGistName", "myFileName", "myGistContents", null);

        contents = entity.getGist(id, null);
        assertEquals(contents, "myGistContents");
    }
}
```

Building the OSGi Bundle

Next we will build this example as an OSGi Bundle so that it can be added to the Apache Brooklyn server at runtime, and so multiple versions of the
blueprint can be managed.

The `mvn clean install` will automatically do this, creating a jar inside the `target/` sub-directory of the project. This works by using the Maven Bundle Plugin which we get automatically by declaring the `pom.xml` 's parent as `brooklyn-downstream-parent` .

Adding to the catalog

Similar to the `sample.bom` entity that ships with the archetype, we will define a `.bom` file to add our `GistGenerator` to the catalog. Substitute the URL below for your own newly built artifact (which will be in the `target` sub-directory after running `mvn clean install`).

```
brooklyn.catalog:
  libraries:
  - http://search.maven.org/remotecontent?filepath=com/google/code/gson/gson/2.2.2/gson-2.2.2.jar
  - http://repo1.maven.org/maven2/org/apache/servicemix/bundles/org.apache.servicemix.bundles.egit.github.core/
2.1.5_1/org.apache.servicemix.bundles.egit.github.core-2.1.5_1.jar
  - http://developers.cloudsoftcorp.com/brooklyn/guide/blueprints/java/gist_generator/autobrick-0.1.0-SNAPSHOT.
jar
  id: example.GistGenerator
  version: "0.1.0-SNAPSHOT"
  itemType: template
  description: For programmatically generating GitHub Gists
  displayName: Gist Generator
  iconUrl: classpath:///sample-icon.png
  item:
    services:
    - type: com.acme.GistGenerator
```

See Handling Bundle Dependencies for a description of the `brooklyn.libraries` used above, and for other alternative approaches.

The command below will use the `br` CLI to add this to the catalog of a running Brooklyn instance. Substitute the credentials, URL and port for those of your server.

```
$ br login https://127.0.0.1:8443 admin pa55w0rd
$ br catalog add gist_generator.bom
```

Using the blueprint

The YAML blueprint below shows an example usage of this blueprint:

```
name: my sample
services:
- type: example.GistGenerator
  brooklyn.config:
    oauth.key: xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
```

Note the type name matches the id defined in the `.bom` file.

You can now call the effector by any of the standard means - web console, REST api, or Client CLI.

Some Java blueprints will require third party libraries. These need to be made available to the Apache Brooklyn runtime. There are a number of ways this can be achieved.

Classic Mode: Dropins Folder

In Brooklyn classic mode (i.e. when not using Karaf), jars can be added to `./lib/dropins/`. After restarting Brooklyn, these will be available on the classpath.

In Brooklyn classic mode, there is an embedded OSGi container. This is used for installing libraries referenced in catalog items.

OSGi Bundles

Introduction to OSGi Bundles

An OSGi bundle is a jar file with additional metadata in its manifest file. The `MANIFEST.MF` file contains the symbolic name and version of the bundle, along with details of its dependencies and of the packages it exports (which are thus visible to other bundles).

The maven-bundle-plugin is a convenient way of building OSGi bundles.

OSGi Bundles Declared in Catalog Items

Within a catalog item, a list of URLs can be supplied under `brooklyn.libraries`. Each URL should point to an OSGi bundle. This list should include the OSGi bundle that has the Java code for your blueprint, and also the OSGi bundles that it depends on (including all transitive dependencies).

It is vital that these jars are built correctly as OSGi bundles, and that all transitive dependencies are included. The bundles will be added to Karaf in the order given, so a bundle's dependencies should be listed before the bundle(s) that depend on them.

In the GistGenerator example, the catalog.bom file included the URL of the dependency `org.eclipse.egit.github.core`. It also (before that line) included its transitive dependency, which is a specific version of `gson`.

For Java blueprint developers, this is often the most convenient way to share a blueprint.

Similarly for those wishing to use a new blueprint, this is often the simplest mechanism: the dependencies are fully described in the catalog item, which makes it convenient for deploying to Apache Brooklyn instances where there is not direct access to Karaf or the file system.

Adding Bundles and Features Directly to Karaf

Bundles and features can be added manually, directly to Karaf.

However, note this only affects the single Karaf instance. If running in HA mode or if provisioning a new instance of Apache Brooklyn, the bundles will also need to be added to these Karaf instances.

Karaf Console

Login to the Karaf console using `./bin/client`, and add the bundles and features as desired.

Examples of some useful commands are shown below:

```
karaf@amp> bundle:install -s http://repo1.maven.org/maven2/org/apache/servicemix/bundles/org.apache.servicemix.
bundles.egit.github.core/2.1.5_1/org.apache.servicemix.bundles.egit.github.core-2.1.5_1.jar
Bundle ID: 316
```

```
karaf@amp> bundle:list -t 0 -s | grep github
318 | Active   |  80 | 2.1.5.1                       | org.apache.servicemix.bundles.egit.github.core

karaf@amp> bundle:headers org.apache.servicemix.bundles.egit.github.core
...

karaf@amp> bundle:uninstall org.apache.servicemix.bundles.egit.github.core
```

Karaf Deploy Folder

Karaf support hot deployment. There are a set of deployers, such as feature and KAR deployers, that handle deployment of artifacts added to the `deploy` folder.

Note that the Karaf console can give finer control (including for uninstall).

Karaf KAR files

Karaf KAR is an archive format (Karaf ARchive). A KAR is a jar file (so a zip file), which contains a set of feature descriptors and bundle jar files.

This can be a useful way to bundle a more complex Java blueprint (along with its dependencies), to make it easier for others to install.

A KAR file can be built using the maven plugin org.apache.karaf.tooling:features-maven-plugin.

Karaf Features

A karaf feature.xml defines a set of bundles that make up a feature. Once a feature is defined, one can add it to a Karaf instance: either directly (e.g. using the Karaf console), or by referencing it in another feature.xml file.

Embedded Dependencies

An OSGi bundle can embed jar dependencies within it. This allows dependencies to be kept private within a bundle, and easily shipped with that bundle.

To keep these private, it is vital that the OSGi bundle does not import or export the packages contained within those embedded jars, and does not rely on any of those packages in the public signatures of any packages that are exported or imported.

Converting Non-OSGi Dependencies to Bundles

If a dependencies is not available as an OSGi bundle (and you don't want to just embed the jar), there are a few options for getting an equivalent OSGi bundle:

- Use a ServiceMix re-packaged jar, if available. ServiceMix have re-packed many common dependencies as OSGi bundles, and published them on Maven Central.
- Use the `wrap:` prefix. The PAX URL Wrap protocol is an OSGi URL handler that can process your legacy jar at runtime and transform it into an OSGi bundle.
  This can be used when declaring a dependency in your feature.xml, and when using the Karaf console's `bundle:install`. Note that it is not yet supported in Brooklyn's `brooklyn.libraries` catalog items.
- Re-package the bundle yourself, offline, to produce a valid OSGi bundle.

Applications written in YAML can similarly be written in Java. However, the YAML approach is recommended.

Define your Application Blueprint

The example below creates a three tier web service, composed of an Nginx load-balancer, a cluster of Tomcat app-servers, and a MySQL database. It is similar to the YAML policies example, but also includes the MySQL database to demonstrate the use of dependent configuration.

```
package com.acme.autobrick;

import org.apache.brooklyn.api.entity.EntitySpec;
import org.apache.brooklyn.api.policy.PolicySpec;
import org.apache.brooklyn.api.sensor.AttributeSensor;
import org.apache.brooklyn.api.sensor.EnricherSpec;
import org.apache.brooklyn.core.entity.AbstractApplication;
import org.apache.brooklyn.core.sensor.DependentConfiguration;
import org.apache.brooklyn.core.sensor.Sensors;
import org.apache.brooklyn.enricher.stock.Enrichers;
import org.apache.brooklyn.entity.database.mysql.MySqlNode;
import org.apache.brooklyn.entity.group.DynamicCluster;
import org.apache.brooklyn.entity.proxy.nginx.NginxController;
import org.apache.brooklyn.entity.webapp.tomcat.TomcatServer;
import org.apache.brooklyn.policy.autoscaling.AutoScalerPolicy;
import org.apache.brooklyn.policy.ha.ServiceFailureDetector;
import org.apache.brooklyn.policy.ha.ServiceReplacer;
import org.apache.brooklyn.policy.ha.ServiceRestarter;
import org.apache.brooklyn.util.time.Duration;

public class ExampleWebApp extends AbstractApplication {

    @Override
    public void init() {
        AttributeSensor<Double> reqsPerSecPerNodeSensor = Sensors.newDoubleSensor(
                "webapp.reqs.perSec.perNode",
                "Reqs/sec averaged over all nodes");

        MySqlNode db = addChild(EntitySpec.create(MySqlNode.class)
                .configure(MySqlNode.CREATION_SCRIPT_URL, "https://bit.ly/brooklyn-visitors-creation-script"));

        DynamicCluster cluster = addChild(EntitySpec.create(DynamicCluster.class)
                .displayName("Cluster")
                .configure(DynamicCluster.MEMBER_SPEC, EntitySpec.create(TomcatServer.class)
                        .configure(TomcatServer.ROOT_WAR,
                                "http://search.maven.org/remotecontent?filepath=org/apache/brooklyn/example/bro
oklyn-example-hello-world-sql-webapp/0.8.0-incubating/brooklyn-example-hello-world-sql-webapp-0.8.0-incubating.
war")
                        .configure(TomcatServer.JAVA_SYSPROPS.subKey("brooklyn.example.db.url"),
                                DependentConfiguration.formatString("jdbc:%s%s?user=%s&password=%s",
                                        DependentConfiguration.attributeWhenReady(db, MySqlNode.DATASTORE_URL),
                                        "visitors", "brooklyn", "br00k11n"))
                        .policy(PolicySpec.create(ServiceRestarter.class)
                                .configure(ServiceRestarter.FAIL_ON_RECURRING_FAILURES_IN_THIS_DURATION, Durati
on.minutes(5)))
                        .enricher(EnricherSpec.create(ServiceFailureDetector.class)
                                .configure(ServiceFailureDetector.ENTITY_FAILED_STABILIZATION_DELAY, Duration.s
econds(30))))
                .policy(PolicySpec.create(ServiceReplacer.class))
                .policy(PolicySpec.create(AutoScalerPolicy.class)
                        .configure(AutoScalerPolicy.METRIC, reqsPerSecPerNodeSensor)
                        .configure(AutoScalerPolicy.METRIC_LOWER_BOUND, 1)
                        .configure(AutoScalerPolicy.METRIC_UPPER_BOUND, 3)
                        .configure(AutoScalerPolicy.RESIZE_UP_STABILIZATION_DELAY, Duration.seconds(2))
                        .configure(AutoScalerPolicy.RESIZE_DOWN_STABILIZATION_DELAY, Duration.minutes(1))
                        .configure(AutoScalerPolicy.MAX_POOL_SIZE, 3))
                .enricher(Enrichers.builder().aggregating(TomcatServer.REQUESTS_PER_SECOND_IN_WINDOW)
                        .computingAverage()
                        .fromMembers()
                        .publishing(reqsPerSecPerNodeSensor)
                        .build()));
        addChild(EntitySpec.create(NginxController.class)
                .configure(NginxController.SERVER_POOL, cluster)
                .configure(NginxController.STICKY, false));
    }
}
```

To describe each part of this:

- The application extends `AbstractApplication`.
- It implements `init()`, to add its child entities. The `init` method is called only once, when instantiating the entity instance.
- The `addChild` method takes an `EntitySpec`. This describes the entity to be created, defining its type and its configuration.
- The `brooklyn.example.db.url` is a system property that will be passed to each `TomcatServer` instance. Its value is the database's URL (discussed below).
- The policies and enrichers provide in-life management of the application, to restart failed instances and to replace those components that repeatedly fail.
- The `NginxController` is the load-balancer and reverse-proxy: by default, it round-robins to the ip:port of each member of the cluster configured as the `SERVER_POOL`.

Dependent Configuration

Often a component of an application will depend on another component, where the dependency information is only available at runtime (e.g. it requires the IP of a dynamically provisioned component). For example, the app-servers in the example above require the database URL to be injected.

The "DependentConfiguration" methods returns a future (or a "promise" in the language of some other programming languages): when the value is needed, the caller will block to wait for
the future to resolve. It will block only "at the last moment" when the value is needed (e.g. after the VMs have been provisioned and the software is installed, thus optimising the provisioning time). It will automatically monitor the given entity's sensor, and generate the value when the sensor is populated.

The `attributeWhenReady` is used to generate a configuration value that depends on the dynamic sensor value of another entity - in the example above, it will not be available until that `MySqlNode.DATASTORE_URL` sensor is populated. At that point, the JDBC URL will be constructed (as defined in the `formatString` method, which also returns a future).

Entity Class Hierarchy

By convention in Brooklyn the following words have a particular meaning:

- *Group* - a homogeneous grouping of entities (which need not all be managed by the same parent entity)
- *Cluster* - a homogeneous collection of entities (all managed by the "cluster" entity)
- *Fabric* - a multi-location collection of entities, with one per location; often used with a cluster per location
- *Application* - a top-level entity, which can have one or more child entities.

The following constructs are often used for Java entities:

- *entity spec* defines an entity to be created; used to define a child entity, or often to define the type of entity in a cluster.
- *traits* (mixins) providing certain capabilities, such as *Resizable* and *Startable*.
- *Resizable* entities can re-sized dynamically, to increase/decrease the number of child entities. For example, scaling up or down a cluster. It could similarly be used to vertically scale a VM, or to resize a disk.
- *Startable* indicates the effector to be executed on initial deployment (`start()`) and on tear down (`stop()`).

Configuration

Configuration keys are typically defined as static named fields on the Entity interface. These define the configuration values that can be passed to the entity during construction. For example:

```
public static final ConfigKey<String> ROOT_WAR = new ConfigKeys.newStringConfigKey(
        "wars.root",
        "WAR file to deploy as the ROOT, as URL (supporting file: and classpath: prefixes)");
```

If supplying a default value, it is important that this be immutable. Otherwise, it risks users of the blueprint modifying the default value, which would affect blueprints that are subsequently deployed.

One can optionally define a `@SetFromFlag("war")` . This defines a short-hand for configuring the entity. However, it should be used with caution - when using configuration set on a parent entity (and thus inherited), the `@SetFromFlag` short-form names are not checked. The long form defined in the constructor should be meaningful and sufficient. The usage of `@SetFromFlag` is therefore discouraged.

The type `AttributeSensorAndConfigKey<?>` can be used to indicate that a config key should be resolved, and its value set as a sensor on the entity (when `ConfigToAttributes.apply(entity)` is called).

A special case of this is `PortAttributeSensorAndConfigKey` . This is resolved to find an available port (by querying the target location). For example, the value `8081+` means that then next available port starting from 8081 will be used.

Declaring Sensors

Sensors are typically defined as static named fields on the Entity interface. These define the events published by the entity, which interested parties can subscribe to. For example:

```
AttributeSensor<String> MANAGEMENT_URL = Sensors.newStringSensor(
        "crate.managementUri",
        "The address at which the Crate server listens");
```

Declaring Effectors

Effectors are the operations that an entity supports. There are multiple ways that an entity can be defined. Examples of each are given below.

Effector Annotation

A method on the entity interface can be annotated to indicate it is an effector, and to provide metadata about the effector and its parameters.

```
@org.apache.brooklyn.core.annotation.Effector(description="Retrieve a Gist")
public String getGist(@EffectorParam(name="id", description="Gist id") String id);
```

Static Field Effector Declaration

A static field can be defined on the entity to define an effector, giving metadata about that effector.

```
public static final Effector<String> EXECUTE_SCRIPT = Effectors.effector(String.class, "executeScript")
        .description("invokes a script")
        .parameter(ExecuteScriptEffectorBody.SCRIPT)
        .impl(new ExecuteScriptEffectorBody())
        .build();
```

In this example, the implementation of the effector is an instance of `ExecuteScriptEffectorBody` . This implements `EffectorBody` . It will be invoked whenever the effector is called.

Dynamically Added Effectors

An effector can be added to an entity dynamically - either as part of the entity's `init()` or as separate initialization code. This allows the implementation of the effector to be shared amongst multiple entities, without sub-classing. For example:

```
Effector<Void> GET_GIST = Effectors.effector(Void.class, "createGist")
        .description("Create a Gist")
        .parameter(String.class, "id", "Gist id")
        .buildAbstract();

public static void CreateGistEffectorBody implements EffectorBody<Void>() {
    @Override
    public Void call(ConfigBag parameters) {
        // impl
        return null;
    }
}

@Override
public void init() {
    getMutableEntityType().addEffector(CREATE_GIST, new CreateGistEffectorBody());
}
```

Effector Invocation

There are several ways to invoke an effector programmatically:

- Where there is an annotated method, simply call the method on the interface.
- Call the `invoke` method on the entity, using the static effector declaration. For example: `entity.invoke(CREATE_GIST, ImmutableMap.of("id", id));` .
- Call the utility method `org.apache.brooklyn.core.entity.Entities.invokeEffector` . For example: `Entities.invokeEffector(this, targetEntity, CREATE_GIST, ImmutableMap.of("id", id));` .

When an effector is invoked, the call is intercepted to wrap it in a task. In this way, the effector invocation is tracked - it is shown in the Activity view.

When `invoke` or `invokeEffector` is used, the call returns a `Task` object (which extends `Future`). This allows the caller to understand progress and errors on the task, as well as calling `task.get()` to retrieve the return value. Be aware that `task.get()` is a blocking function that will wait until a value is available before returning.

Tasks

Warning: the task API may be changed in a future release. However, backwards compatibility will be maintained where possible.

When implementing entities and policies, all work done within Brooklyn is executed as Tasks. This makes it trackable and visible to administrators. For the activity list to show a break-down of an effector's work (in real-time, and also after completion), tasks and sub-tasks must be created.

In common situations, tasks are implicitly created and executed. For example, when implementing an effector using the `@Effector` annotation on a method, the method invocation is automatically wrapped as a task. Similarly, when a subscription is passed an event (e.g. when using `SensorEventListener.onEvent(SensorEvent<T> event)` , that call is done inside a task.

Within a task, it is possible to create and execute sub-tasks. A common way to do this is to use `DynamicTasks.queue` . If called from within a a "task queuing context" (e.g. from inside an effector implementation), it will add the task to be executed. By default, the outer task will not be marked as done until its queued sub-tasks are complete.

When creating tasks, the `TaskBuilder` can be used to create simple tasks or to create compound tasks whose sub-tasks are to be executed either sequentially or in parallel. For example:

```
TaskBuilder.<Integer>builder()
        .displayName("stdout-example")
        .body(new Callable<Integer>() { public Integer call() { System.out.println("example"; } })
        .build();
```

There are also builder and factory utilities for common types of operation, such as executing SSH commands using `SshTasks` .

A lower level way to submit tasks within an entity is to call `getExecutionContext().submit(...)` . This automatically tags the task to indicate that its context is the given entity.

An even lower level way to execute tasks (to be ignored except for power-users) is to go straight to the `getManagementContext().getExecutionManager().submit(...)` . This is similar to the standard Java `Executor` , but also supports more metadata about tasks such as descriptions and tags. It also supports querying for tasks. There is also support for submitting `ScheduledTask` instances which run periodically.

The `Tasks` and `BrooklynTaskTags` classes supply a number of conveniences including builders to make working with tasks easier.

Subscriptions and the Subscription Manager

Entities, locations, policies and enrichers can subscribe to events. These events could be attribute-change events from other entities, or other events explicitly published by the entities.

A subscription is created by calling `subscriptions().subscribe(entity, sensorType, sensorEventListener)` . The `sensorEventListener` will be called with the event whenever the given entity emits a sensor of the given type. If `null` is used for either the entity or sensor type, this is treated as a wildcard.

It is very common for a policy or enricher to subscribe to events, to kick off actions or to publish other aggregated attributes or events.

Feeds

`Feed` s within Apache Brooklyn are used to populate an entity's sensors. There are a variety of feed types, which commonly poll to retrieve the raw metrics of the entity (for example polling an HTTP management API, or over JMX).

Persistence

There are two ways to associate a feed with an entity.

The first way is (within the entity) to call `feeds().addFeed(...)` . This persists the feed: the feed will be automatically added to the entity when the Brooklyn server restarts. It is important that all configuration of the feed is persistable (e.g. not using any in-line anonymous inner classes to define functions).

The feed builders can be passed a `uniqueTag(...)` , which will be used to ensure that on rebind there will not be multiple copied of the feed (e.g. if `rebind()` had already re-created the feed).

The second way is to just pass to the feed's builder the entity. When using this mechanism, the feed will be wired up to the entity but it will not be persisted. In this case, it is important that the entity's `rebind()` method recreates the feed.

Types of Feed

HTTP Feed

An `HttpFeed` polls over http(s). An example is shown below:

```
private HttpFeed feed;

@Override
protected void connectSensors() {
  super.connectSensors();

  feed = feeds().addFeed(HttpFeed.builder()
      .period(200)
      .baseUri(String.format("http://%s:%s/management/subsystem/web/connector/http/read-resource", host, port))
      .baseUriVars(ImmutableMap.of("include-runtime","true"))
      .poll(new HttpPollConfig(SERVICE_UP)
          .onSuccess(HttpValueFunctions.responseCodeEquals(200))
          .onError(Functions.constant(false)))
      .poll(new HttpPollConfig(REQUEST_COUNT)
          .onSuccess(HttpValueFunctions.jsonContents("requestCount", Integer.class)))
      .build());
}

@Override
protected void disconnectSensors() {
  super.disconnectSensors();
  if (feed != null) feed.stop();
}
```

SSH Feed

An SSH feed executes a command over ssh periodically. An example is shown below:

```
private AbstractCommandFeed feed;

@Override
protected void connectSensors() {
  super.connectSensors();
```

```
    feed = feeds.addFeed(SshFeed.builder()
        .machine(mySshMachineLachine)
        .poll(new CommandPollConfig(SERVICE_UP)
            .command("rabbitmqctl -q status")
            .onSuccess(new Function() {
                public Boolean apply(SshPollValue input) {
                  return (input.getExitStatus() == 0);
                }}))
        .build());
  }

  @Override
  protected void disconnectSensors() {
    super.disconnectSensors();
    if (feed != null) feed.stop();
  }
```

WinRm CMD Feed

A WinRM feed executes a windows command over winrm periodically. An example is shown below:

```
private AbstractCommandFeed feed;

//@Override
protected void connectSensors() {
  super.connectSensors();

  feed = feeds.addFeed(CmdFeed.builder()
                .entity(entity)
                .machine(machine)
                .poll(new CommandPollConfig<String>(SENSOR_STRING)
                        .command("ipconfig")
                        .onSuccess(SshValueFunctions.stdout()))
                .build());
}

@Override
protected void disconnectSensors() {
  super.disconnectSensors();
  if (feed != null) feed.stop();
}
```

Windows Performance Counter Feed

This type of feed retrieves performance counters from a Windows host, and posts the values to sensors.

One must supply a collection of mappings between Windows performance counter names and Brooklyn attribute sensors.

This feed uses WinRM to invoke the windows utility `typeperf` to query for a specific set of performance counters, by name. The values are extracted from the response, and published to the entity's sensors. An example is shown below:

```
private WindowsPerformanceCounterFeed feed;

@Override
protected void connectSensors() {
  feed = feeds.addFeed(WindowsPerformanceCounterFeed.builder()
      .addSensor("\\Processor(_total)\\% Idle Time", CPU_IDLE_TIME)
      .addSensor("\\Memory\\Available MBytes", AVAILABLE_MEMORY)
      .build());
}

@Override
protected void disconnectSensors() {
  super.disconnectSensors();
  if (feed != null) feed.stop();
}
```

JMX Feed

This type of feed queries over JMX to retrieve sensor values. This can query attribute values or call operations.

The JMX connection details can be automatically inferred from the entity's standard attributes, or it can be explicitly supplied.

An example is shown below:

```
private JmxFeed feed;

@Override
protected void connectSensors() {
  super.connectSensors();

  feed = feeds().addFeed(JmxFeed.builder()
      .period(5, TimeUnit.SECONDS)
      .pollAttribute(new JmxAttributePollConfig<Integer>(ERROR_COUNT)
          .objectName(requestProcessorMbeanName)
          .attributeName("errorCount"))
      .pollAttribute(new JmxAttributePollConfig<Boolean>(SERVICE_UP)
          .objectName(serverMbeanName)
          .attributeName("Started")
          .onError(Functions.constant(false)))
      .build());
}

Override
protected void disconnectSensors() {
  super.disconnectSensors();
  if (feed != null) feed.stop();
}
```

Function Feed

This type of feed periodically executes something to compute the attribute values. This can be a `Callable`, `Supplier` or Groovy `Closure`. It must be persistable (e.g. not use an in-line anonymous inner classes).

An example is shown below:

```
public static class ErrorCountRetriever implements Callable<Integer> {
  private final Entity entity;

  public ErrorCountRetriever(Entity entity) {
    this.entity = entity;
  }

  @Override
  public Integer call() throws Exception {
    // TODO your implementation...
    return 0;
  }
}

private FunctionFeed feed;

@Override
protected void connectSensors() {
  super.connectSensors();

  feed = feeds().addFeed(FunctionFeed.builder()
    .poll(new FunctionPollConfig<Object, Integer>(ERROR_COUNT)
        .period(500, TimeUnit.MILLISECONDS)
        .callable(new ErrorCountRetriever(this))
        .onExceptionOrFailure(Functions.<Integer>constant(null))
    .build());
}

@Override
protected void disconnectSensors() {
  super.disconnectSensors();
  if (feed != null) feed.stop();
}
```

Ways to write an entity

There are several ways to write a new entity:

- For Unix/Linux, write YAML blueprints, for example using a **`VanillaSoftwareProcess`** and configuring it with your scripts.
- For Windows, write YAML blueprints using **`VanillaWindowsProcess`** and configure the PowerShell scripts.
- For composite entities, use YAML to compose exiting types of entities (potentially overwriting parts of their configuration), and wire them together.
- Use **Chef recipes**.
- Use **Salt formulas**.
- Use **Ansible playbooks**.
- Write pure-java, extending existing base-classes. For example, the `GistGenerator` example. These can use utilities such as `HttpTool` and `BashCommands` .
- Write pure-Java blueprints that extend `SoftwareProcess` . However, the YAML approach is strongly recommended over this approach.
- Write pure-Java blueprints that compose together existing entities, for example to manage a cluster. Often this is possible in YAML and that approach is strongly recommended. However, sometimes the management logic may be so complex that it is easier to use Java.

The rest of this section covers writing an entity in pure-java (or other JVM languages).

Things To Know

All entities have an interface and an implementation. The methods on the interface are its effectors; the interface also defines its sensors.

Entities are created through the management context (rather than calling the
constructor directly). This returns a proxy for the entity rather than the real instance, which is important in a distributed management plane.

All entity implementations inherit from `AbstractEntity` , often through one of the following:

- **`SoftwareProcessImpl`** : if it's a software process
- **`VanillaJavaAppImpl`** : if it's a plain-old-java app
- **`JavaWebAppSoftwareProcessImpl`** : if it's a JVM-based web-app
- **`DynamicClusterImpl`** , **`DynamicGroupImpl`** or **`AbstractGroupImpl`** : if it's a collection of other entities

Software-based processes tend to use *drivers* to install and launch the remote processes onto *locations* which support that driver type. For example, `AbstractSoftwareProcessSshDriver` is a common driver superclass, targetting `SshMachineLocation` (a machine to which Brooklyn can ssh). The various `SoftwareProcess` entities above (and some of the exemplars listed at the end of this page) have their own dedicated drivers.

Finally, there are a collection of *traits*, such as `Resizable` , in the package `brooklyn.entity.trait` . These provide common sensors and effectors on entities, supplied as interfaces. Choose one (or more) as appropriate.

Key Steps

NOTE: Consider instead writing a YAML blueprint for your entity.

So to get started:

1. Create your entity interface, extending the appropriate selection from above, to define the effectors and sensors.
2. Include an annotation like `@ImplementedBy(YourEntityImpl.class)` on your interface, where `YourEntityImpl` will be the class name for your entity implementation.
3. Create your entity class, implementing your entity interface and extending the classes for your chosen entity super-types. Naming convention is a suffix "Impl" for the entity class, but this is not essential.
4. Create a driver interface, again extending as appropriate (e.g. `SoftwareProcessDriver`). The naming convention is to have a suffix "Driver".
5. Create the driver class, implementing your driver interface, and again extending as appropriate. Naming convention is to have a suffix "SshDriver" for an ssh-based implementation. The correct driver implementation is found using this naming convention, or via custom namings provided by the `BasicEntityDriverFactory` .
6. Wire the `public Class getDriverInterface()` method in the entity implementation, to specify your driver interface.
7. Provide the implementation of missing lifecycle methods in your driver class (details below)
8. Connect the sensors from your entity (e.g. overriding `connectSensors()` of `SoftwareProcessImpl`).. See the sensor feeds, such as `HttpFeed` and `JmxFeed` .

Any JVM language can be used to write an entity. However use of pure Java is encouraged for entities in core brooklyn.

Helpful References

A few handy pointers will help make it easy to build your own entities. Check out some of the exemplar existing entities (note, some of the other entities use deprecated utilities and a deprecated class hierarchy; it is suggested to avoid these, looking at the ones below instead):

- `JBoss7Server`
- `MySqlNode`

You might also find the following helpful:

- **Entity Design Tips**
- The **User Guide**
- The **Mailing List**

This section details how to create new custom application components or groups as brooklyn entities.

The Entity Lifecycle

- Importance of serialization, ref to How mananagement works
- Parents and Membership (groups)

What to Extend -- Implementation Classes

- entity implementation class hierarchy
    - `SoftwareProcess` as the main starting point for base entities (corresponding to software processes), and subclasses such as `VanillaJavaApp`
    - `DynamicCluster` (multiple instances of the same entity in a location) and `DynamicFabric` (clusters in multiple location) for automatically creating many instances, supplied with an `EntityFactory` (e.g. `BaseEntityFactory`) in the `factory` flag
    - `AbstractGroup` for collecting entities which are parented elsewhere in the hierachy
    - `AbstractEntity` if nothing else fits
- traits (mixins, otherwise known as interfaces with statics) to define available config keys, sensors, and effectors; and conveniences e.g. `StartableMethods.{start,stop}` is useful for entities which implement `Startable`
- the `Entities` class provides some generic convenience methods; worth looking at it for any work you do

A common lifecycle pattern is that the `start` effector (see more on effectors below) is invoked, often delegating either to a driver (for software processes) or children entities (for clusters etc).

Configuration

- AttributeSensorAndConfigKey fields can be automatically converted for `SoftwareProcess` . This is done in `preStart()` . This must be done manually if required for other entities, often with `ConfigToAttributes.apply(this)` .
- Setting ports is a special challenge, and one which the `AttributeSensorAndConfigKey` is particularly helpful for, cf `PortAttributeSensorAndConfigKey` (a subclass), causing ports automatically get assigned from a range and compared with the target `PortSupplied` location.

  Syntax is as described in the PortRange interface. For example, "8080-8099,8800+" will try port 8080, try sequentially through 8099, then try from 8800 until all ports are exhausted.

  This is particularly useful on a contended machine (localhost!). Like ordinary configuration, the config is done by the user, and the actual port used is reported back as a sensor on the entity.

- Validation of config values can be applied by supplying a `Predicate` to the `constraint` of a ConfigKey builder. Constraints are tested after an entity is initialised and before an entity managed. Useful predicates include:
    - `StringPredicates.isNonBlank` : require that a String key is neither null nor empty.
    - `ResourcePredicates.urlExists` : require that a URL that is loadable by Brooklyn. Use this to confirm that necessary resources are available to the entity.
    - `Predicates.in` : require one of a fixed set of values.
    - `Predicates.containsPattern` : require that a value match a regular expression pattern.

  An important caveat is that only constraints on config keys that are on an entity's type hierarchy can be tested automatically. Brooklyn has no knowledge of the true type of other keys until they are retrieved with a `config().get(key)` .

Implementing Sensors

- e.g. HTTP, JMX

Sensors at base entities are often retrieved by feeds which poll the entity's corresponding instance in the real world. The `SoftwareProcess` provides a good example; by subclassing it and overriding the `connectSensors()` method you could wire some example sensors using the following:

```
public void connectSensors() {
    super.connectSensors()

    httpFeed = HttpFeed.builder()
            .entity(this)
            .period(200)
            .baseUri(mgmtUrl)
            .poll(new HttpPollConfig<Boolean>(SERVICE_UP)
                    .onSuccess(HttpValueFunctions.responseCodeEquals(200))
                    .onError(Functions.constant(false)))
            .poll(new HttpPollConfig<Integer>(REQUEST_COUNT)
                    .onSuccess(HttpValueFunctions.jsonContents("requestCount", Integer.class)))
            .build();
}

@Override
protected void disconnectSensors() {
    super.disconnectSensors();
    if (httpFeed != null) httpFeed.stop();
}
```

In this example (a simplified version of `JBoss7Server`), the url returns metrics in JSON. We report the entity as up if we get back an http response code of 200, or down if any other response code or exception. We retrieve the request count from the response body, and convert it to an integer.

Note the first line (`super.connectSensors()`); as one descends into specific convenience subclasses (such as for Java web-apps), the work done by the parent class's overridden methods may be relevant, and will want to be invoked or even added to a resulting list.

For some sensors, and often at compound entities, the values are obtained by monitoring values of other sensors on the same (in the case of a rolling average) or different (in the case of the average of children nodes) entities. This is achieved by policies, described below.

Implementing Effectors

The `Entity` interface defines the sensors and effectors available. The entity class provides wiring for the sensors, and the effector implementations. In simple cases it may be straightforward to capture the behaviour of the effectors in a simple methods. For example deploying a WAR to a cluster can be done as follows:

This section is not complete. Feel free to fork the docs and lend a hand.

For some entities, specifically base entities, the implementation of effectors might need other tools (such as SSH), and may vary by location, so having a single implementation is not appropriate.

The problem of multiple inheritance (e.g. SSH functionality and entity inheritance) and multiple implementations (e.g. SSH versus Windows) is handled in brooklyn using delegates called *drivers*.

In the implementations of `JavaWebApp` entities, the behaviour which the entity always does is captured in the entity class (for example, breaking deployment of multiple WARs into atomic actions), whereas implementations which is specific to a particular entity and driver (e.g. using scp to copy the WARs to the right place and install them, which of course is different among appservers, or using an HTTP or JMX management API, again where details vary between appservers) is captured in a driver class.

Routines which are convenient for specific drivers can then be inherited in the driver class hierarchy. For example, when passing JMX environment variables to Java over SSH, `JavaSoftwareProcessSshDriver` extends `AbstractSoftwareProcessSshDriver` and parents `JBoss7SshDriver`.

Testing

- Unit tests can make use of `SimulatedLocation` and `TestEntity`, and can extend `BrooklynAppUnitTestSupport`.
- Integration tests and use a `LocalhostMachineProvisioningLocation`, and can also extend `BrooklynAppUnitTestSupport`.

SoftwareProcess Lifecycle

`SoftwareProcess` is the common super-type of most integration components (when implementing in Java).

See `JBoss7Server` and `MySqlNode` for exemplars.

The methods called in a `SoftwareProcess` entity's lifecycle are described below. The most important steps are shown in bold (when writing a new entity, these are the methods most often implemented).

- Initial creation (via `EntitySpec` or YAML):
    - **no-arg constructor**
    - **init**
    - add locations
    - apply initializers
    - add enrichers
    - add policies
    - add children
    - manages entity (so is discoverable by other entities)
- Start:
    - provisions new machine, if the location is a `MachineProvisioningLocation`
    - creates new driver
        - **calls `getDriverInterface`**
        - Infers the concrete driver class from the machine-type, e.g. by default it adds "Ssh" before the word "Driver" in "JBoss7Driver".
        - instantiates the driver, **calling the constructor** to pass in the entity itself and the machine location
    - sets attributes from config (e.g. for ports being used)
    - calls `entity.preStart()`
    - calls `driver.start()`, which:
        - runs pre-install command (see config key `pre.install.command`)
        - uploads install resources (see config keys `files.install` and `templates.install`)
        - **calls `driver.install()`**
        - runs post-install command (see config key `post.install.command`)
        - **calls `driver.customize()`**
        - uploads runtime resources (see config keys `files.runtime` and `templates.runtime`)
        - runs pre-launch command (see config key `pre.launch.command`)
        - **calls `driver.launch()`**
        - runs post-launch command (see config key `post.launch.command`)

        - calls `driver.postLaunch()`
    - calls `entity.postDriverStart()` , which:
        - calls `enity.waitForEntityStart()` - **waits for `driver.isRunning()` to report true**
    - **calls `entity.connectSensors()`**
    - calls `entity.waitForServicUp()`
    - calls `entity.postStart()`
- Restart:
    - If restarting machine...
        - calls `entity.stop()` , with `stopMachine` set to true.
        - calls start
        - restarts children (if configured to do so)
    - Else (i.e. not restarting machine)...
        - calls `entity.preRestart()`
        - calls `driver.restart()`
            - **calls `driver.stop()`**
            - **calls `driver.launch()`**
            - calls `driver.postLaunch()`
        - restarts children (if configured to do so)
        - calls `entity.postDriverStart()` , which:
            - calls `enity.waitForEntityStart()` - **polls `driver.isRunning()`** , waiting for true
        - calls `entity.waitForServicUp()`
        - calls `entity.postStart()`
- Stop:
    - calls `entity.preStopConfirmCustom()` - aborts if exception.
    - calls `entity.preStop()`
    - stops the process:
        - stops children (if configured to do so)
        - **calls `driver.stop()`**
    - stops the machine (if configured to do so)
    - calls `entity.postStop()`
- Rebind (i.e. when Brooklyn is restarted):
    - **no-arg constructor**
    - reconstitutes entity (e.g. setting config and attributes)
    - If entity was running...
        - calls `entity.rebind()` ; if previously started then:
            - creates the driver (same steps as for start)
            - calls `driver.rebind()`
            - **calls `entity.connectSensors()`**
    - attaches policies, enrichers and persisted feeds
    - manages the entity (so is discoverable by other entities)

Any entity can use the standard "service-up" and "service-state" sensors to inform other entities and the GUI about its status.

In normal operation, entities should publish at least one "service not-up indicator", using the `ServiceNotUpLogic.updateNotUpIndicator` method. Each such indicator should have a unique name or input sensor. `Attributes.SERVICE_UP` will then be updated automatically when there are no not-up indicators.

When there are transient problems that can be detected, to trigger `ON_FIRE` status entity code can similarly set `ServiceProblemsLogic.updateProblemsIndicator` with a unique namespace, and subsequently clear it when the problem goes away. These problems are reflected at runtime in the `SERVICE_PROBLEMS` sensor, allowing multiple problems to be tracked independently.

When an entity is changing the expected state, e.g. starting or stopping, the expected state can be set using `ServiceStateLogic.setExpectedState` ; this expected lifecycle state is considered together with `SERVICE_UP` and `SERVICE_PROBLEMS` to compute the actual state. By default the logic in `ComputeServiceState` is applied.

For common entities, good out-of-the-box logic is applied, as follows:

- For `SoftwareProcess` entities, lifecycle service state is updated by the framework and a service not-up indicator is linked to the driver `isRunning()` check.
- For common parents, including `AbstractApplication` and `AbstractGroup` subclasses (including clusters, fabrics, etc), the default enrichers analyse children and members to set a not-up indicator (requiring at least one child or member who is up) and a problem indicator (if any children or members are on-fire). In some cases other quorum checks are preferable; this can be set e.g. by overriding the `UP_QUORUM_CHECK` or the `RUNNING_QUORUM_CHECK` , as follows:

  ```
  public static final ConfigKey<QuorumCheck> UP_QUORUM_CHECK = ConfigKeys.newConfigKeyWithDefault(AbstractGro
  up.UP_QUORUM_CHECK,
      "Require all children and members to be up for this node to be up",
      QuorumChecks.all());
  ```

  Alternatively the `initEnrichers()` method can be overridden to specify a custom-configured enricher or set custom config key values (as done e.g. in `DynamicClusterImpl` so that zero children is permitted provided when the initial size is configured to be 0).

For sample code to set and more information on these methods' behaviours, see javadoc in `ServiceStateLogic` , overrides of `AbstractEntity.initEnrichers()` and tests in `ServiceStateLogicTests` .

Notes on Advanced Use

The enricher to derive `SERVICE_UP` and `SERVICE_STATE_ACTUAL` from the maps and expected state values discussed above is added by the `AbstractEntity.initEnrichers()` method. This method can be overridden -- or excluded altogether by by overriding `init()` -- and can add enrichers created using the `ServiceStateLogic.newEnricherFromChildren()` method suitably customized using methods on the returned spec object, for instance to look only at members or specify a quorum function (from `QuorumChecks`). If different logic is required for computing `SERVICE_UP` and `SERVICE_STATE_ACTUAL` , use `ServiceStateLogic.newEnricherFromChildrenState()` and `ServiceStateLogic.newEnricherFromChildrenUp()` , noting that the first of these will replace the enricher added by the default `initEnrichers()` , whereas the second one runs with a different namespace (unique tag). For more information consult the javadoc on those classes.

Entities can set `SERVICE_UP` and `SERVICE_STATE_ACTUAL` directly. Provided these entities never use the `SERVICE_NOT_UP_INDICATORS` and `SERVICE_PROBLEMS` map, the default enrichers will not override these values.

Brooklyn supports a plug-in system for defining "entitlements" -- essentially permissions.

Any entitlement scheme can be implemented by supplying a class which implements one method on one class:

```
public interface EntitlementManager {
    public <T> boolean isEntitled(@Nullable EntitlementContext context, @Nonnull EntitlementClass<T> entitlemen
tClass, @Nullable T entitlementClassArgument);
}
```

This answers the question who is allowed do what to whom, looking at the following fields:

- `context` : the user who is logged in and is attempting an action (extensions can contain additional metadata)
- `entitlementClass` : the type of action being queried, e.g. `DEPLOY_APPLICATION` or `SEE_SENSOR` (declared in the class `Entitlements`)
- `entitlementClassArgument` : details of the action being queried, such as the blueprint in the case of `DEPLOY_APPLICATION` or the entity and sensor name in the case of `SEE_SENSOR`

To set a custom entitlements manager to apply across the board, simply use:

```
brooklyn.entitlements.global=org.apache.brooklyn.core.mgmt.entitlement.AcmeEntitlementManager
```

The example above refers to a sample manager which is included in the test JARs of Brooklyn, which you can see here, and include in your project by adding the core tests JAR to your `dropins` folder.

There are some entitlements schemes which exist out of the box, so for a simpler setup, see Operations: Entitlements.

There are also more complex schemes which some users have developed, including LDAP extensions which re-use the LDAP authorization support in Brooklyn, allowing permissions objects to be declared in LDAP leveraging regular expressions. For more information on this, ask on IRC or the mailing list, and see

EntitlementManager.

Brooklyn can deploy to Windows servers using WinRM to run commands. These deployments can be expressed in pure YAML, and utilise Powershell to install and manage the software process. This approach is similar to the use of SSH for UNIX-like servers.

About WinRM

WinRM - or *Windows Remote Management* to give its full title - is a system administration service provided in all recent Windows Server operating systems. It allows remote access to system information (provided via WMI) and the ability to execute commands. For more information refer to Microsoft's MSDN article on Windows Remote Management.aspx).

WinRM is available by default in Windows Server, but is not enabled by default. Brooklyn will, in most cases, be able to switch on WinRM support, but this is dependent on your cloud provider supporting a user metadata service with script execution (see below).

Locations for Windows

You must define a new location in Brooklyn for Windows deployments. Windows deployments require a different VM image ID to Linux, as well as some other special configuration, so you must have separate Brooklyn locations for Windows and Linux deployments.

In particular, you will most likely want to set these properties on your location:

- `imageId` or `imageNameRegex` - select your preferred Windows Server image from your cloud provider.
- `hardwareId` or `minRam` / `minCores` - since Windows machines generally require more powerful servers, ensure you get a machine with the required specification.
- `useJcloudsSshInit` - this must be set to `false` . Without this setting, jclouds will attempt to connect to the new VMs using SSH, which will fail on Windows Server.
- `templateOptions` - you may also wish to request a larger disk size. This setting is cloud specific; on AWS, you can request a 100GB disk by setting this property to `{mapNewVolumeToDeviceName: ["/dev/sda1", 100, true]}` .

In your YAML blueprint:

```
...
location:
  jclouds:aws-ec2:
    region: us-west-2
    identity: AKA_YOUR_ACCESS_KEY_ID
    credential: <access-key-hex-digits>
    imageNameRegex: Windows_Server-2012-R2_RTM-English-64Bit-Base-.*
    imageOwner: 801119661308
    hardwareId: m3.medium
    useJcloudsSshInit: false
    templateOptions: {mapNewVolumeToDeviceName: ["/dev/sda1", 100, true]}
...
```

Alternatively, you can define a new named location in `brooklyn.properties` :

```
brooklyn.location.named.AWS\ Oregon\ Win = jclouds:aws-ec2:us-west-2
brooklyn.location.named.AWS\ Oregon\ Win.displayName = AWS Oregon (Windows)
brooklyn.location.named.AWS\ Oregon\ Win.imageNameRegex = Windows_Server-2012-R2_RTM-English-64Bit-Base-.*
brooklyn.location.named.AWS\ Oregon\ Win.imageOwner = 801119661308
brooklyn.location.named.AWS\ Oregon\ Win.hardwareId = m3.medium
brooklyn.location.named.AWS\ Oregon\ Win.useJcloudsSshInit = false
brooklyn.location.named.AWS\ Oregon\ Win.templateOptions = {mapNewVolumeToDeviceName: ["/dev/sda1", 100, true]}
```

A Sample Blueprint

Creating a Windows VM is done using the `org.apache.brooklyn.entity.software.base.VanillaWindowsProcess` entity type. This is very similar to `VanillaSoftwareProcess` , but adapted to work for Windows and WinRM instead of Linux. We suggest you read the documentation for VanillaSoftwareProcess to find out what you can do with this entity.

Entity authors are strongly encouraged to write Windows Powershell or Batch scripts as separate files, to configure these to be uploaded, and then to configure the appropriate command as a single line that executes given script.

For example - here is a simplified blueprint (but see Tips and Tricks below!):

```
name: Server with 7-Zip

location:
  jclouds:aws-ec2:
    region: us-west-2
    identity: AKA_YOUR_ACCESS_KEY_ID
    credential: <access-key-hex-digits>
    imageNameRegex: Windows_Server-2012-R2_RTM-English-64Bit-Base-.*
    imageOwner: 801119661308
    hardwareId: m3.medium
    useJcloudsSshInit: false
    templateOptions: {mapNewVolumeToDeviceName: ["/dev/sda1", 100, true]}

services:
- type: org.apache.brooklyn.entity.software.base.VanillaWindowsProcess
  brooklyn.config:
    templates.preinstall:
      file:///Users/richard/install7zip.ps1: "C:\\install7zip.ps1"
    install.command: powershell -command "C:\\install7zip.ps1"
    customize.command: echo true
    launch.command: echo true
    stop.command: echo true
    checkRunning.command: echo true
    installer.download.url: http://www.7-zip.org/a/7z938-x64.msi
```

The installation script - referred to as `/Users/richard/install7zip.ps1` in the example above - is:

```
$Path = "C:\InstallTemp"
New-Item -ItemType Directory -Force -Path $Path

$Url = "${config['installer.download.url']}"
$Dl = [System.IO.Path]::Combine($Path, "installer.msi")
$WebClient = New-Object System.Net.WebClient
$WebClient.DownloadFile( $Url, $Dl )

Start-Process "msiexec" -ArgumentList '/qn','/i',$Dl -RedirectStandardOutput ( [System.IO.Path]::Combine($Path,
 "stdout.txt") ) -RedirectStandardError ( [System.IO.Path]::Combine($Path, "stderr.txt") ) -Wait
```

Where security-related operation are to be executed, it may require the use of `CredSSP` to obtain the correct Administrator privileges: you may otherwise get an access denied error. See the sub-section How and Why to re-authenticate within a powershell script for more details.

This is only a very simple example. A more complex example can be found in the Microsoft SQL Server blueprint in the Brooklyn source code.

Tips and Tricks

The best practices for other entities (e.g. using VanillaSoftwareProcess) apply for WinRM as well.

Execution Phases

Blueprint authors are strongly encouraged to provide an implementation for install, launch, stop and checkRunning. These are vital for the generic effectors such as stopping and restarting the process.

Powershell

Powershell commands can be supplied using config options such as `launch.powershell.command`.

This is an alternative to supplying a standard batch command using config such as `launch.command`. For a given phase, only one of the commands (Powershell or Batch) should be supplied.

Getting the Right Exit Codes

WinRM (or at least the chosen WinRM client!) can return a zero exit code even on error in certain circumstances. It is therefore advisable to follow the guidelines below.

For a given command, write the Powershell or Batch script as a separate multi-command file. Upload this (e.g. by including it in the `files.preinstall` configuration). For the configuration of the given command, execute the file.

When you have a command inside the powershell script which want to report its non zero exiting, please consider adding a check for its exit code after it. Example:

```
& "C:\install.exe"
If ($lastexitcode -ne 0) {
    exit $lastexitcode
}
```

For Powershell files, consider including

```
$ErrorActionPreference = "Stop"
```

at the start of the file. `$ErrorActionPreference` Determines how Windows PowerShell responds to a non-terminating error (an error that does not stop the cmdlet processing) at the command line or in a script, cmdlet, or provider, such as the errors generated by the Write-Error cmdlet. https://technet.microsoft.com/en-us/library/hh847796.aspx

See Incorrect Exit Codes under Known Limitations below.

Executing Scripts From Batch Commands

In a batch command, you can execute a batch file or Powershell file. For example:

```
install.command: powershell -NonInteractive -NoProfile -Command "C:\\install7zip.ps1"
```

Or alternatively:

```
install.command: C:\\install7zip.bat
```

Executing Scripts From Powershell

In a Powershell command, you can execute a batch file or Powershell file. There are many ways to do this (see official Powershell docs). For example:

```
install.powershell.command: "& C:\\install7zip.ps1"
```

Or alternatively:

```
install.powershell.command: "& C:\\install7zip.bat"
```

Note the quotes around the command. This is because the "&" has special meaning in a YAML value.

Parameterised Scripts

Calling parameterised Batch and Powershell scripts is done in the normal Windows way - see offical Microsoft docs. For example:

```
install.command: "c:\\myscript.bat myarg1 myarg2"
```

Or as a Powershell example:

```
install.powershell.command: "& c:\\myscript.ps1 -key1 myarg1 -key2 myarg2"
```

It is also possible to construct the script parameters by referencing attributes of this or other entities using the standard `attributeWhenReady` mechanism. For example:

```
install.command: $brooklyn:formatString("c:\\myscript.bat %s", component("db").attributeWhenReady("datastore.ur
l"))
```

Powershell - Using Start-Process

When you are invoking a command from a powershell script with `Start-Process` cmdlet, please use the `-Wait` and the `-PassThru` arguments. Example `Start-Process C:\mycommand -Wait -PassThru`

Using `-Wait` guarantees that the script process and its children and thus the winrm session won't be terminated until it is finished. `-PassThru` Returns a process object for each process that the cmdlet started. By default, this cmdlet does not generate any output. See https://technet.microsoft.com/en-us/library/hh849848.aspx

Rebooting

Where a reboot is required as part of the entity setup, this can be configured using config like `pre.install.reboot.required` and `install.reboot.required`. If required, the installation commands can be split between the pre-install, install and post-install phases in order to do a reboot at the appropriate point of the VM setup.

We Strongly recommend to **write blueprints in a way that they do NOT restart automatically windows** and use one of the `pre.install.reboot.required` or `install.reboot.required` parameters to perform restart.

Install Location

Blueprint authors are encouraged to explicitly specify the full path for file uploads, and for paths in their Powershell scripts (e.g. for installation, configuration files, log files, etc).

How and Why to re-authenticate within a powershell script

Some installation scripts require the use of security-related operations. In some environments,
these fail by default when executed over WinRM, even though the script may succeed when run locally
(e.g. by using RDP to connect to the machine and running the script manually). There may be no

clear indication from Windows why it failed (e.g. for MSSQL install, the only clue is a security exception in the installation log).

When a script is run over WinRM, the credentials under which the script are run are marked as 'remote' credentials, which are prohibited from running certain security-related operations. The solution is to obtain a new set of credentials within the script and use those credentials to required commands.

The WinRM client uses Negotiate+NTLM to authenticate against the machine. This mechanism applies certain restrictions to executing commands on the windows host.

For this reason you should enable CredSSP on the windows host which grants all privileges available to the user. https://technet.microsoft.com/en-us/library/hh849719.aspx#sectionSection4

To use `Invoke-Command -Authentication CredSSP` the Windows Machine has to have:

- Up and running WinRM over http. The custom-enable-credssp.ps1 script enables winrm over http because `Invoke-Command` use winrm over http by default. Invoke-Command can be used with -UseSSL option but this will lead to modifying powershell scripts. With always enabling winrm over http on the host, blueprint's powershell scripts remain consistent and not depend on the winrm https/http environments. We hope future versions of winrm4j will support CredSSP out of the box and wrapping commands in Invoke-Command will not be needed.
- Added trusted host entries which will use Invoke-Command
- Allowed CredSSP

All the above requirements are enabled in Apache Brooklyn through brooklyn-server/software/base/src/main/resources/org/apache/brooklyn/software/base/custom-enable-credssp.ps1 script which enables executing commands with CredSSP in the general case. The script works for most of the Windows images out there version 2008 and later.

Please ensure that Brooklyn's changes are compatible with your organisation's security policy.

Check Microsoft Documentation for more information about Negotiate authenticate mechanism on technet.microsoft.com.aspx)

Re-authentication also requires that the password credentials are passed in plain text within the script. Please be aware that it is normal for script files - and therefore the plaintext password - to be saved to the VM's disk. The scripts are also accessible via the Brooklyn web-console's activity view. Access to the latter can be controlled via Entitlements.

As an example (taken from MSSQL install), the command below works when run locally, but fails over WinRM:

```
( $driveLetter + "setup.exe") /ConfigurationFile=C:\ConfigurationFile.ini
```

The code below can be used instead (note this example uses Freemarker templating):

```
& winrm set winrm/config/service/auth '@{CredSSP="true"}'
& winrm set winrm/config/client/auth '@{CredSSP="true"}'
#
$pass = '${attribute['windows.password']}'
$secpasswd = ConvertTo-SecureString $pass -AsPlainText -Force
$mycreds = New-Object System.Management.Automation.PSCredential ($($env:COMPUTERNAME + "\${location.user}"), $s
ecpasswd)
#
$exitCode = Invoke-Command -ComputerName $env:COMPUTERNAME -Credential $mycreds -ScriptBlock {
    param($driveLetter)
    $process = Start-Process ( $driveLetter + "setup.exe") -ArgumentList "/ConfigurationFile=C:\ConfigurationFi
le.ini" -RedirectStandardOutput "C:\sqlout.txt" -RedirectStandardError "C:\sqlerr.txt" -Wait -PassThru -NoNewWi
ndow
    $process.ExitCode
} -Authentication CredSSP -ArgumentList $driveLetter
#
```

```
exit $exitCode
```

In this example, the `${...}` format is FreeMarker templating. Those sections will be substituted before the script is uploaded for execution. To explain this example in more detail:

- `${attribute['windows.password']}` is substituted for the entity's attribute "windows.password". This (clear-text) password is sent as part of the script. Assuming that HTTPS and NTLM is used, the script will be encrypted while in-flight.
- The `${location.user}` gets (from the entity's machine location) the username, substituting this text for the actual username. In many cases, this will be "Administrator". However, on some clouds a different username (with admin privileges) will be used.
- The username and password are used to create a new credential object (having first converted the password to a secure string).
- Credential Security Service Provider (CredSSP) is used for authentication, to pass the explicit credentials when using `Invoke-Command`.

Windows AMIs on AWS

Windows AMIs in AWS change regularly (to include the latest Windows updates). If using the community AMI, it is recommended to use an AMI name regex, rather than an image id, so that the latest AMI is always picked up. If an image id is used, it may fail as Amazon will delete their old Windows AMIs.

If using an image regex, it is recommended to include the image owner in case someone else uploads a similarly named AMI. For example:

```
brooklyn.location.named.AWS\ Oregon\ Win = jclouds:aws-ec2:us-west-2
brooklyn.location.named.AWS\ Oregon\ Win.imageNameRegex = Windows_Server-2012-R2_RTM-English-64Bit-Base-.*
brooklyn.location.named.AWS\ Oregon\ Win.imageOwner = 801119661308
...
```

stdout and stderr in a Powershell script

When calling an executable in a Powershell script, the stdout and stderr will usually be output to the console. This is captured by Brooklyn, and shown in the activities view under the specific tasks.

An alternative is to redirect stdout and stderr to a file on the VM, which can be helpful if one expects sys admins to log into the VM. However, be warned that this would hide the stdout/stderr from Brooklyn's activities view.

For example, instead of running the following:

```
D:\setup.exe /ConfigurationFile=C:\ConfigurationFile.ini
```

The redirect can be achieved by using the `Start-Process` scriptlet:

```
Start-Process D:\setup.exe -ArgumentList "/ConfigurationFile=C:\ConfigurationFile.ini" -RedirectStandardOutput
"C:\sqlout.txt" -RedirectStandardError "C:\sqlerr.txt" -PassThru -Wait
```

The `-ArgumentList` is simply the arguments that are to be passed to the executable, `-RedirectStandardOutput` and `RedirectStandardError` take file locations for the output (if the file already exists, it will be overwritten). The `-PassThru` argument indicates that Powershell should write to the file *in addition* to the console, rather than *instead* of the console. The `-Wait` argument will cause the scriptlet to block until the process is complete.

Further details can be found on the Start-Process documentation page on the Microsoft TechNet site.

Troubleshooting

Much of the operations troubleshooting guide is applicable for Windows blueprints.

User metadata service requirement

WinRM requires activation and configuration before it will work in a standard Windows Server deployment. To automate this, Brooklyn will place a setup script in the user metadata blob. Services such as Amazon EC2's `Ec2ConfigService` will automatically load and execute this script. If your chosen cloud provider does not support `Ec2ConfigService` or a similar package, or if your cloud provider does not support user metadata, then you must pre-configure a Windows image with the required WinRM setup and make Brooklyn use this image.

If the configuration options `userMetadata` or `userMetadataString` are used on the location, then this will override the default setup script. This allows one to supply a custom setup script. However, if userMetadata contains something else then the setup will not be done and the VM may not not be accessible remotely over WinRM.

Credentials issue requiring special configuration

When a script is run over WinRM over HTTP, the credentials under which the script are run are marked as 'remote' credentials, which are prohibited from running certain security-related operations. This may prevent certain operations. The installer from Microsoft SQL Server is known to fail in this case, for example. For a workaround, please refer to How and Why to re-authenticate withing a powershell script above.

WebServiceException: Could not send Message

We detected a `WebServiceException` and different `SocketException` during deployment of long lasting Application Blueprint against VcloudDirector.

Launching the blueprint bellow was giving constantly this type of error on launch step.

```
services:
  type: org.apache.brooklyn.entity.software.base.VanillaWindowsProcess
  brooklyn.config:
    pre.install.command: echo preInstallCommand
    install.command: echo installCommand > C:\\install.txt
    post.install.command: echo postInstallCommand
    customize.command: echo customizeCommand
    pre.launch.command: echo preLaunchCommand
    launch.powershell.command: |
      Start-Sleep -s 400
      Write-Host Test Completed
    post.launch.command: echo postLaunchCommand
    checkRunning.command: echo checkRunningCommand
    stop.command: echo stopCommand
```

With series of tests we concluded that on the Vcloud Director environment we were using a restart was happening ~2 minutes after the VM is provisioned. Logging in the host and search for System event of type 1074 in Windows Event Viewer, we found two 1074 events where the second one was

```
The process C:\Windows\system32\winlogon.exe (W2K12-STD) has initiated the restart of computer WIN-XXXX on beha
lf of user
NT AUTHORITY\SYSTEM for the following reason: Operating System: Upgrade (Planned) Reason Code: 0x80020003 Shutd
own Type: restart Comment:
```

Normally on other clouds only one restart event is registered and the first time winrm connection is made the Windows VM is ready for use.

For this particular case when you want this second restart to finish we made `waitWindowsToStart` location parameter which basically adds additional check assuring the Windows VM provisioning is done.

For example when using `waitWindowsToStart: 5m` location parameter, Apache Brooklyn will wait 5 minutes to see if a disconnect occurs. If it does, then it will again wait 5m for the machine to come back up. The default behaviour in Apache Brooklyn is to consider provisioning done on the first successful winrm connection, without waiting for restart.

To determine whether you should use this parameter you should carefully inspect how the image you choose to provision is behaving. If the description above matches your case and you are getting **connection failure message in the middle of the installation process** for your blueprints, a restart probably occurred and you should try this parameter.

Before using this parameter we advice to check whether this is really your case. To verify the behavior check as described above.

AMIs not found

If using the imageId of a Windows community AMI, you may find that the AMI is deleted after a few weeks. See Windows AMIs on AWS above.

VM Provisioning Times Out

In some environments, provisioning of Windows VMs can take a very long time to return a usable VM. If the image is old, it may install many security updates (and reboot several times) before it is usable.

On a VMware vCloud Director environment, the guest customizations can cause the VM to reboot (sometimes several times) before the VM is usable.

This could cause the WinRM connection attempts to timeout. The location configuration option `waitForWinRmAvailable` defaults to `30m` (i.e. 30 minutes). This can be increased if required.

Incorrectly prepared Windows template can cause the deployment to time-out expecting an interaction by the user. You can verify if this is the case by RDP to the deployment which is taking to much time to complete. It is recommended to manually deploy a single VM for every newly created Windows template to verify that it can be used for unattended installations and it doesn't wait and/or require an input by the user. See Windows template settings for an Unattended Installation under Known Limitations below.

Windows log files

Details of the commands executed, and their results, can be found in the Brooklyn log and in the Brooklyn web-console's activity view.

There will also be log files on the Windows Server. System errors in Windows are usually reported in the Windows Event Log -
see https://technet.microsoft.com/en-us/library/cc766042.aspx for more information.

Additional logs may be created by some Windows programs. For example, MSSQL creates a log in `%programfiles%\Microsoft SQL Server\130\Setup Bootstrap\Log\` - for more information see https://msdn.microsoft.com/en-us/library/ms143702.aspx.

Known Limitations

WinRM 2.0 supports encryption mechanisms on top of HTTP. However those are not supported in Apache Brooklyn. For production adoptions please make sure you follow Microsoft Guidelines https://msdn.microsoft.com/en-us/library/ee309366(v=vs.85).aspx

Apache Brooklyn limitations on using WinRM over HTTP and HTTPS

By default Apache Brooklyn is currently using unencrypted HTTP for WinRM communication. It does not support encrypted HTTP for WinRM.

HTTPS is supported but there is no mechanism of specifying which certificates to trust. Currently Apache Brooklyn will accept any certificate used in a HTTPS WinRM connection.

Incorrect Exit Codes

Some limitations with WinRM (or at least the chosen WinRM Client!) are listed below:

Single-line Powershell files

When a Powershell file contains just a single command, the execution of that file over WinRM returns exit code 0 even if the command fails! This is the case for even simple examples like `exit 1` or `thisFileDoesNotExist.exe`.

A workaround is to add an initial command, for example:

```
Write-Host dummy line for workaround
exit 1
```

Direct Configuration of Powershell commands

If a command is directly configured with Powershell that includes `exit`, the return code over WinRM is not respected. For example, the command below will receive an exit code of 0.

```
launch.powershell.command: |
  echo first
  exit 1
```

Direct Configuration of Batch commands

If a command is directly configured with a batch exit, the return code over WinRM is not respected. For example, the command below will receive an exit code of 0.

```
launch.command: exit /B 1
```

Non-zero Exit Code Returned as One

If a batch or Powershell file exits with an exit code greater than one (or negative), this will be reported as 1 over WinRM.

We advise you to use native commands (non-powershell ones) since executing it as a native command will return the exact exit code rather than 1. For instance if you have installmssql.ps1 script use `install.command: powershell -command "C:\\installmssql.ps1"` rather than using `install.powershell.command: "C:\\installmssql.ps1"` The first will give you an exact exit code rather than 1

PowerShell "Preparing modules for first use"

The first command executed over WinRM has been observed to include stderr saying "Preparing modules for first use", such as that below:

```
< CLIXML
<Objs Version="1.1.0.1" xmlns="http://schemas.microsoft.com/powershell/2004/04"><Obj S="progress" RefId="0"><TN
 RefId="0"><T>System.Management.Automation.PSCustomObject</T><T>System.Object</T></TN><MS><I64 N="SourceId">1</
I64><PR N="Record"><AV>Preparing modules for first use.</AV><AI>0</AI><Nil /><PI>-1</PI><PC>-1</PC><T>Completed
</T><SR>-1</SR><SD> </SD></PR></MS></Obj><Obj S="progress" RefId="1"><TNRef RefId="0" /><MS><I64 N="SourceId">2
</I64><PR N="Record"><AV>Preparing modules for first use.</AV><AI>0</AI><Nil /><PI>-1</PI><PC>-1</PC><T>Complet
ed</T><SR>-1</SR><SD> </SD></PR></MS></Obj></Objs>
```

The command still succeeded. This has only been observed on private clouds (e.g. not on AWS). It could be related to the specific Windows images in use. It is recommended that VM images are prepared carefully, e.g. so that security patches are up-to-date and the VM is suitably initialised.

WinRM executeScript failed: httplib.BadStatusLine: ''

As described in https://issues.apache.org/jira/browse/BROOKLYN-173, a failure has been observed where the 10 attempts to execute the command over WinRM failed with:

```
httplib.BadStatusLine: ''
```

Subsequently retrying the command worked. It is unclear what caused the failure, but could have been that the Windows VM was not yet in the right state.

One possible workaround is to ensure the Windows VM is in a good state for immediate use (e.g. security updates are up-to-date). Another option is to increase the number of retries, which defaults to 10. This is a configuration option on the machine location, so can be set on the location's brooklyn.properties or in the YAML:

```
execTries: 20
```

Direct Configuration of Multi-line Batch Commands Not Executed

If a command is directly configured with multi-line batch commands, then only the first line will be executed. For example the command below will only output "first":

```
launch.command: |
  echo first
  echo second
```

The workaround is to write a file with the batch commands, have that file uploaded, and execute it.

Note this is not done automatically because that could affect the capture and returning of the exit code for the commands executed.

Install location

Work is required to better configure a default install location on the VM (e.g. so that environment variables are set). The installation pattern for linux-based blueprints, of using brooklyn-managed-processes/installs, is not used or recommended on Windows. Files will be uploaded to C:\ if no explicit directory is supplied, which is untidy, unnecessarily exposes the scripts to the user, and could cause conflicts if multiple entities are installed.

Blueprint authors are strongly encourages to explicitly specific directories for file uploads and in their Powershell scripts.

Windows template settings for an Unattended Installation

Windows template needs certain configuration to be applied to prevent windows setup UI from being displayed. The default behavior is to display it if there are incorrect or empty settings. Showing Setup UI will prevent the proper deployment, because it will expect interaction by the user such as agreeing on the license agreement or some of the setup dialogs.

Detailed instruction how to prepare an Unattended installation are provided at https://technet.microsoft.com/en-us/library/cc722411%28v=ws.10%29.aspx.

Brooklyn provides a selection of test entities which can be used to validate Blueprints via YAML. The basic building block is a TargetableTestComponent, which is used to resolve a target. There are two different groups of entities that inherit from TargetableTestComponent. The first is structural, which effects how the tests are run, for example by affecting the order they are run in. The second group is validation, which is used to confirm the application is deployed as intended, for example by checking some sensor value.

Structural test entities include:

- `TestCase` - starts child entities sequentially.
- `ParallelTestCase` - starts child entities in parallel.
- `LoopOverGroupMembersTestCase` - creates a TargetableTestComponent for each member of a group.
- `InfrastructureDeploymentTestCase` - will create the specified Infrastructure and then deploy the target entity specifications there.

Validation test entities include:

- `TestSensor` - perform assertion on a specified sensor.
- `TestEffector` - perform assertion on response to effector call.
- `TestHttpCall` - perform assertion on response to specified HTTP GET Request.
- `TestSshCommand` - test assertions on the result of an ssh command on the same machine as the target entity.
- `TestWinrmCommand` - test assertions on the result of a WinRM command on the same machine as the target entity.
- `TestEndpointReachable` - assert that a TCP endpoint is reachable. The endpoint can be in a number of different formats: a string in the form of `ip:port` or URI format; or a `com.google.common.net.HostAndPort` instance; or a `java.net.URI` instance; or a `java.net.URL` instance.

TargetableTestComponents can be chained together, with the target being inherited by the components children. For example, a ParallelTestCase could be created that has a TestHttpCall as a child. As long as the TestHttpCall itself does not have a target, it will use the target of it's parent, ParallelTestCase. Using this technique, we can build up complex test scenarios.

The following sections provide details on each test entity along with examples of their use.

This guide describes how Brooklyn entities can be created using the Ansible infrastructure management tool (ansible.com). At present Brooklyn provides basic support for Ansible, operating in a 'masterless' mode. Comments on this support and suggestions for further development are welcome.

This guide assumes you are familiar with the basics of creating YAML blueprints.

This guide describes how Brooklyn entities can be easily created from Chef cookbooks. As of this writing (May 2014) some of the integration points are under active development, and comments are welcome. A plan for the full integration is online here.

This guide assumes you are familiar with the basics of creating YAML blueprints.

This guide describes how Brooklyn entities can be created using the Salt infrastructure management tool (saltstack.com). At present Brooklyn provides basic support for Salt, operating in a 'masterless' mode. Comments on this support and suggestions for further development are welcome.

This guide assumes you are familiar with the basics of creating YAML blueprints.

By this point you should be familiar with the fundamental concepts behind both Apache Brooklyn and YAML blueprints. This section of the documentation is intended to show a complete, advanced example of a YAML blueprint.

The intention is that this example is used to learn the more in-depth concepts, and also to serve as a reference when writing your own blueprints. This page will first explain what the example application is and how to run it, then it will spotlight interesting features.

Please note, there is now a much more up-to-date ELK blueprint that can be found here. We've using an older version of this in the tutorial as it highlights some key Brooklyn concepts.

ELK Stack Example

This example demonstrates the deployment of an ELK Stack (Elasticsearch, Logstash and Kibana), using the provided blueprint to deploy, install, run and manage all three. Briefly, the component parts are:

- Elasticsearch: A clustered search engine
- Logstash: Collects, parses and stores logs. For our example it will store logs in Elasticsearch
- Kibana: A web front end to Elasticsearch

We also deploy a simple webserver whose logs will be collected.

- Tomcat 8: Web server whose logs will be stored in Elasticsearch by Logstash.

For more about the ELK stack, please see the documentation here.

The Blueprints

There are four blueprints that make up this application. Each of them are used to add one or more catalog items to Brooklyn. You can find them below:

- Elasticsearch
- Logstash
- Kibana
- ELK

Running the example

First, add all four blueprints to the Brooklyn Catalog. This can be done by clicking the 'Catalog' tab, clicking the '+' symbol and pasting the YAML. Once this is done, click the 'Application' tab, then the '+' button to bring up the add application wizard. A new Catalog application will be available called 'ELK Stack'. Using the add application wizard, you should be able to deploy an ELK stack to a location of your choosing. Alternatively use the `br` Brooklyn command line tool and add the files with `br catalog add`.

Exploring the example

After the application has been deployed, you can ensure it is working as expected by checking the following:

- There is a Kibana sensor called `main.uri`, the value of which points to the Kibana front end. You can explore this front end, and observe the logs stored in Elasticsearch. Many Brooklyn applications have a `main.uri` set to point you in the right direction.
- You can also use the Elasticsearch REST API to explore further. The Elasticsearch Cluster entity has a `urls.http.list` sensor. Using a host:port from that list you will be able to access the REST API. The following URL will give you the state of the cluster `http://<host:port>/_cluster/health?pretty=true`. As you can see the `number_of_nodes` is currently 2, indicating that the Elasticsearch nodes are communicating with each other.

Interesting Feature Spotlight

We will mainly focus on the Elasticsearch blueprint, and will be clear when another blueprint is being discussed. This blueprint describes a cluster of Elasticsearch nodes.

Provisioning Properties

Our Elasticsearch blueprint has a few requirements of the location in which it is run. Firstly, it must be run on an Ubuntu machine as the example has been written specifically for this OS. Secondly, two ports must opened to ensure that the entities can be accessed from the outside world. Both of these requirements are configured via `provisioning.properties` as follows:

```
brooklyn.config:
  elasticsearch.http.port: 9220
  elasticsearch.tcp.port: 9330
  provisioning.properties:
    osFamily: ubuntu
    inboundPorts:
    - $brooklyn:config("elasticsearch.http.port")
    - $brooklyn:config("elasticsearch.tcp.port")
```

VanillaSoftwareProcess

When composing a YAML blueprint, the VanillaSoftwareProcess is a very useful entity to be aware of. A VanillaSoftwareProcess will instruct Brooklyn to provision an instance, and run a series of shell commands to setup, run, monitor and teardown your program. The commands are specified as configuration on the VanillaSoftwareProcess and there are several available. We will spotlight a few now. To simplify this blueprint, we have specified ubuntu only installs so that our commands can be tailored to this system (e.g. use apt-get rather than yum).

Customize Command

The Customize Command is run after the application has been installed but before it is run. It is the perfect place to create and amend config files. Please refer to the following section of the Elasticsearch blueprint:

```
customize.command: |
  sudo rm -fr sudo tee /etc/elasticsearch/elasticsearch.yml
  echo discovery.zen.ping.multicast.enabled: false | sudo tee -a /etc/elasticsearch/elasticsearch.yml
  echo discovery.zen.ping.unicast.enabled: true | sudo tee -a /etc/elasticsearch/elasticsearch.yml
  echo discovery.zen.ping.unicast.hosts: ${URLS_WITH_BRACKETS} | sudo tee -a /etc/elasticsearch/elasticsearch.y
ml
  echo http.port: ${ES_HTTP_PORT} | sudo tee -a /etc/elasticsearch/elasticsearch.yml
  echo transport.tcp.port: ${ES_TCP_PORT} | sudo tee -a /etc/elasticsearch/elasticsearch.yml
  echo network.host: ${IP_ADDRESS} | sudo tee -a /etc/elasticsearch/elasticsearch.yml
```

The purpose of this section is to create a YAML file with all of the required configuration. We use the YAML literal style `|` indicator to write a multi line command. We start our series of commands by using the `rm` command to remove the previous config file. We then use `echo` and `tee` to create the new config file and insert the config. Part of the configuration is a list of all hosts that is set on the parent entity- this is done by using a combination of the `component` and `attributeWhenReady` DSL commands. More on how this is generated later.

Check running

After an app is installed and run, this command is scheduled to run regularly and used to populate the `service.isUp` sensor. If this command is not specified, or returns an exit code of anything other than zero, then Brooklyn will assume that your entity has failed and will display the fire status symbol. Please refer to the following section of the

Elasticsearch blueprint:

```
checkRunning.command: sudo systemctl status kibana.service
```

There are many different ways to implement this command. For this example, we are simply using the systemctl status of the appropriate service.

Enrichers

Elasticsearch URLS

To ensure that all Elasticsearch nodes can communicate with each other they need to be configured with the TCP URL of all other nodes. Similarly, the Logstash instances need to be configured with all the HTTP URLs of the Elasticsearch nodes. The mechanism for doing this is the same, and involves using Transformers, Aggregators and Joiners, as follows:

```
brooklyn.enrichers:
  - type: org.apache.brooklyn.enricher.stock.Transformer
    brooklyn.config:
      enricher.sourceSensor: $brooklyn:sensor("host.subnet.address")
      enricher.targetSensor: $brooklyn:sensor("url.tcp")
      enricher.targetValue: $brooklyn:formatString("%s:%s", $brooklyn:attributeWhenReady("host.subnet.address")
, $brooklyn:config("elasticsearch.tcp.port"))
```

In this example, we take the host.subnet.address and append the TCP port, outputting the result as `url.tcp`. After this has been done, we now need to collect all the URLs into a list in the Cluster entity, as follows:

```
brooklyn.enrichers:
  - type: org.apache.brooklyn.enricher.stock.Aggregator
    brooklyn.config:
      enricher.sourceSensor: $brooklyn:sensor("url.tcp")
      enricher.targetSensor: $brooklyn:sensor("urls.tcp.list")
      enricher.aggregating.fromMembers: true
```

In the preceding example, we aggregated all of the TCP URLs generated in the early example. These are then stored in a sensor called `urls.tcp.list`. This list is then joined together into one long string:

```
- type: org.apache.brooklyn.enricher.stock.Joiner
  brooklyn.config:
    enricher.sourceSensor: $brooklyn:sensor("urls.tcp.list")
    enricher.targetSensor: $brooklyn:sensor("urls.tcp.string")
    uniqueTag: urls.quoted.string
```

Finally, the string has brackets added to the start and end:

```
- type: org.apache.brooklyn.enricher.stock.Transformer
  brooklyn.config:
    enricher.sourceSensor: $brooklyn:sensor("urls.tcp.string")
    enricher.targetSensor: $brooklyn:sensor("urls.tcp.withBrackets")
    enricher.targetValue: $brooklyn:formatString("[%s]", $brooklyn:attributeWhenReady("urls.tcp.string"))
```

The resulting sensor will be called `urls.tcp.withBrackets` and will be used by all Elasticsearch nodes during setup.

Kibana URL

Kibana also needs to be configured such that it can access the Elasticsearch cluster. However, Kibana can only be configured to point at one Elasticsearch instance. To enable this, we use another enricher in the cluster to select the first URL from the list, as follows:

```
- type: org.apache.brooklyn.enricher.stock.Aggregator
  brooklyn.config:
    enricher.sourceSensor: $brooklyn:sensor("host.subnet.address")
    enricher.targetSensor: $brooklyn:sensor("host.address.first")
    enricher.aggregating.fromMembers: true
    enricher.transformation:
     $brooklyn:object:
       type: "org.apache.brooklyn.util.collections.CollectionFunctionals$FirstElementFunction"
```

Similar to the above Aggregator, this Aggregator collects all the URLs from the members of the cluster. However, this Aggregator specifies a transformation. In this instance a transformation is a Java class that implements a Guava Function `<? super Collection<?>, ?>>`, i.e. a function that takes in a collection and returns something. In this case we specify the FirstElementFunction from the CollectionFunctionals to ensure that we only get the first member of the URL list.

Latches

In the ELK blueprint, there is a good example of a latch. Latches are used to force an entity to wait until certain conditions are met before continuing. For example:

```
- type: kibana-standalone
  id: kibana
  name: Kibana Server
  latch.customize: $brooklyn:component("es").attributeWhenReady("service.isUp")
```

This latch is used to stop Kibana customizing until the Elasticsearch cluster is up. We do this to ensure that the URL sensors have been setup, so that they can be passed into Kibana during the customization phase.

Latches can also be used to control how many entities can execute the same step at any given moment. When a latch is given the value of a `MaxConcurrencySensor` it will unblock execution only when there are available "slots" to execute (think of it as a semaphore). For example to let a single entity execute the launch step of the start effector:

```
services:
- type: cluster

  brooklyn.initializers:
  - type: org.apache.brooklyn.core.sensor.MaxConcurrencySensor
    brooklyn.config:
      name: single-executor
      latch.concurrency.max: 1

  brooklyn.config:
    initialSize: 10
    memberSpec:
      $brooklyn:entitySpec:
        type: vanilla-bash-server
        brooklyn.config:
          launch.command: sleep 2
          checkRunning.command: true
          latch.launch: $brooklyn:parent().attributeWhenReady("single-executor")
```

It's important to note that the above setup is not reentrant. This means that users should be careful to avoid deadlocks. For example having a start and launch latches against the `single-executor` from above. The launch latch will block forever since the start latch already would've acquired the free slot.

Child entities

The ELK blueprint also contains a good example of a child entity.

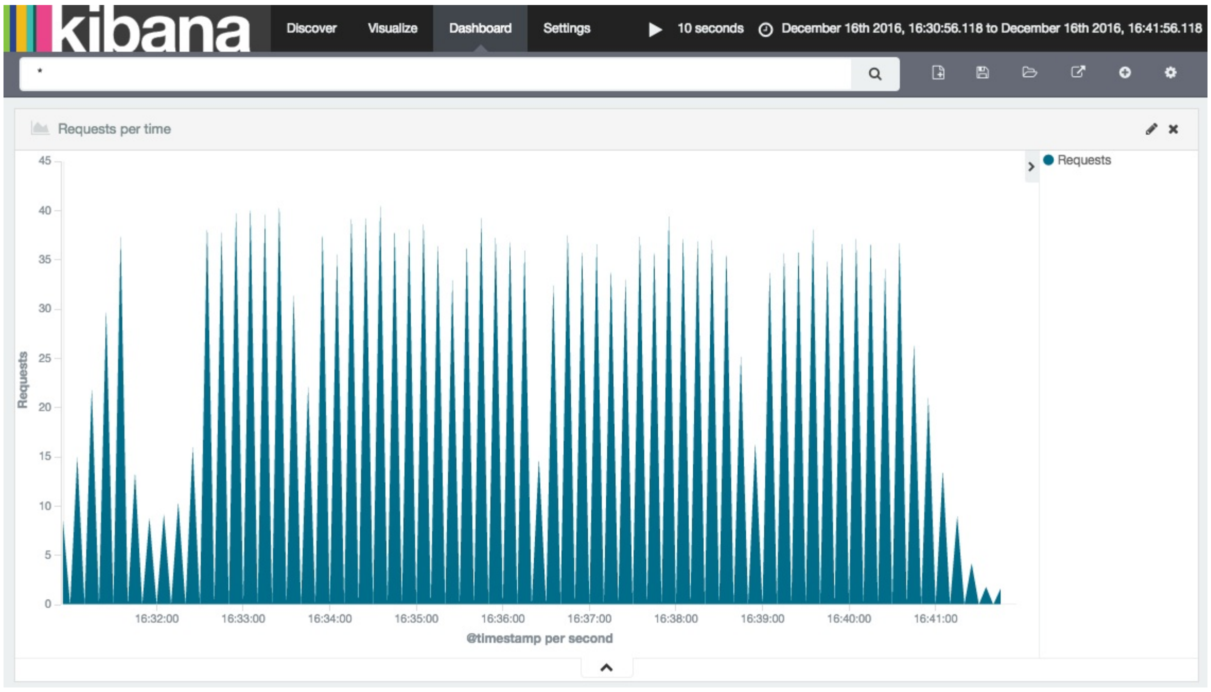
```
- type: org.apache.brooklyn.entity.webapp.tomcat.Tomcat8Server
  brooklyn.config:
    children.startable.mode: background_late
  ...
  brooklyn.children:
  - type: logstash-child
```

In this example, a logstash-child is started as a child of the parent Tomcat server. The Tomcat server needs to be configured with a `children.startable.mode` to inform Brooklyn when to bring up the child. In this case we have selected background so that the child is disassociated from the parent entity, and late to specify that the parent entity should start before we start the child.

The example also shows how to configure Logstash inputs and filters, if necessary, for a particular application, in this case Tomcat.

```
- type: logstash-child
  name: Logstash
  brooklyn.config:
    logstash.elasticsearch.hosts: $brooklyn:entity("es").attributeWhenReady("urls.http.withBrackets")
    logstash.config.input:
      $brooklyn:formatString:
      - |
        input {
          file {
            path => "%s/logs/localhost_access_log.*"
            start_position => "beginning"
          }
        }
      - $brooklyn:entity("tomcat").attributeWhenReady("run.dir")
    logstash.config.filter: |
      filter {
        grok {
          match => { "message" => "%{COMBINEDAPACHELOG}" }
        }
        date {
          match => [ "timestamp" , "dd/MMM/yyyy:HH:mm:ss Z" ]
        }
      }
```

Configuring an appropriate visualisation on the Kibana server (access it via the URL on the summary tab for that entity) allows a dashboard to be created such as


kibana
Discover
Visualize
Dashboard
Settings
10 seconds
December 16th 2016, 16:30:56.118 to December 16th 2016, 16:41:56.118
*
Requests per time
● Requests
Requests
@timestamp per second
0
5
10
15
20
25
30
35
40
45
16:32:00
16:33:00
16:34:00
16:35:00
16:36:00
16:37:00
16:38:00
16:39:00
16:40:00
16:41:00

YAML Recommended

The recommended way to write a blueprint is as a YAML file. This is true both for building an application out of existing blueprints, and for building new integrations.

The use of Java is reserved for those use-cases where the provisioning or configuration logic is very complicated.

Be Familiar with Brooklyn

Be familiar with the stock entities available in Brooklyn. For example, prove you understand
the concepts by making a deployment of a cluster of Tomcat servers before you begin writing your own blueprints.

Ask For Help

Ask for help early. The community is keen to help, and also keen to find out what people find hard and how people use the product. Such feedback is invaluable for improving future versions.

Faster Dev-Test

Writing a blueprint is most efficient and simple when testing is fast, and when testing is done incrementally as features of the blueprint are written.

The slowest stages of deploying a blueprint are usually VM provisioning and downloading/installing of artifacts (e.g. RPMs, zip files, etc).

Options for speeding up provisioning include those below.

Deploying to Bring Your Own Nodes (BYON)

A BYON location can be defined, which avoids the time required to provision VMs. This is fast, but has the downside that artifacts installed during a previous run can interfere with subsequent runs.

A variant of this is to use Vagrant (e.g. with VirtualBox) to create VMs on your local machine, and to use these as the target for a BYON location.

These VMs should mirror the target environment as much as possible.

Deploying to the "localhost" location

This is fast and simple, but has some obvious downsides:

- Artifacts are installed directly on your desktop/server.
- The artifacts installed during previous runs can interfere with subsequent runs.
- Some entities require `sudo` rights, which must be granted to the user running Brooklyn.

Deploying to Clocker

Docker containers provide a convenient way to test blueprints (and also to run blueprints in production!).

The Clocker project allows the simple setup of Docker Engine(s), and for Docker containers to be used instead of VMs. For testing, this allows each run to start from a fresh container (i.e. no install artifacts from previous runs), while taking advantage of the speed of starting containers.

Local Repository of Install Artifacts

To avoid re-downloading install artifacts on every run, these can be saved to `~/.brooklyn/repository/`. The file structure is a sub-directory with the entity's simple name, then a sub-directory with the version number, and then the files to be downloaded. For example, `~/.brooklyn/repository/TomcatServer/7.0.56/apache-tomcat-7.0.56.tar.gz`.

If possible, synchronise this directory with your test VMs.

Re-install on BYON

If using BYON or localhost, the install artifacts will by default be installed to a directory like `/tmp/brooklyn-myname/installs/`. If install completed successfully, then the install stage will be subsequently skipped (a marker file being used to indicate completion). To re-test the install phase, delete the install directory (e.g. delete `/tmp/brooklyn-myname/installs/TomcatServer_7.0.56/`).

Where installation used something like `apt-get install` or `yum install`, then re-testing the install phase will require uninstalling these artifacts manually.

Monitoring and Managing Applications

Think about what it really means for an application to be running. The out-of-the-box default for a software process is the lowest common denominator: that the process is still running. Consider checking that the app responds over HTTP etc.

If you have control of the app code, then consider adding an explicit health check URL that does more than basic connectivity tests. For example, can it reach the database, message broker, and other components that it will need for different operations.

Writing Composite Blueprints

Write everything in discrete chunks that can be composed into larger pieces. Do not write a single mega-blueprint. For example, ensure each component is added to the catalog independently, along with a blueprint for the composite app.

Experiment with lots of small blueprints to test independent areas before combining them into the real thing.

Writing Entity Tests

Use the test framework to write test cases. This will make automated (regression) testing easier, and will allow others to easily confirm that the entity works in their environment.

If using Maven/Gradle then use the Brooklyn Maven plugin to test blueprints at build time.

Custom Entity Development

If writing a custom integration, the following recommendations may be useful:

- Always be comfortable installing and running the process yourself before attempting to automate it.

- For the software to be installed, use its Installation and Admin guides to ensure best practices are being followed. Use blogs and advice from experts, when available.
- Where there is a choice of installation approaches, use the approach that is most appropriate for production use-cases (even if this is harder to test on locahost). For example, prefer the use of RPMs versus unpacking zip files, and prefer the use of services versus invoking a `bin/start` script.
- Ensure every step is scriptable (e.g. manual install does not involve using a text editor to modify configuration files, or clicking on things in a web-console).
- Write scripts (or Chef recipes, or Puppet manifests, etc), and test these by executing manually. Only once these work in isolation, add them to the entity blueprint.
- Externalise the configuration where appropriate. For example, if there is a configuration file then include a config key for the URL of the configuration file to use. Consider using FreeMarker templating for such configuration files.
- Focus on a single OS distro/version first, and clearly document these assumptions.
- Breakdown the integration into separate components, where possible (and thus develop/test them separately). For example, if deploying a MongoDB cluster then first focus on single-node MongoDB, and then make that configurable and composable for a cluster.
- Where appropriate, share the new entity with the Brooklyn community so that it can be reviewed, tested and improved by others in the community!

Cloud Portability

You get a lot of support out-of-the-box for deploying blueprints to different clouds. The points below may also be of help:

- Test (and regression test) on each target cloud.
- Be aware that images on different clouds can be very different. For example, two CentOS 6.6 VMs might have different pre-installed libraries, different default iptables or SE Linux settings, different repos, different sudo configuration, etc.
- Different clouds handle private and public IPs differently. One must be careful about which address to advertise to for use by other entities.
- VMs on some clouds may not have a well-configured hostname (e.g. `ping $(hostname)` can fail).
- VMs in different clouds have a different number of NICs. This is important when choosing whether to listen on 0.0.0.0 or on a specific NIC.

Investigating Errors

ALWAYS keep logs when there is an error.

See the Troubleshooting guide for more information.

Locations are the environments to which Brooklyn deploys applications. Most commonly these are cloud services such as AWS, GCE, and IBM Softlayer. Brooklyn also supports deploying to a pre-provisioned network or to localhost (primarily useful for testing blueprints).

See also:

- The Locations yaml guide
- Use within an entity of the configuration option provisioning.properties
- How to add location definitions to the Catalog; and
- How to use Externalized Configuration.

The requirements for how a provisioned machine should behave will depend on the entites subsequently deployed there.

Below are a set of common assumptions, made by many entity implementations, which could cause subsequent errors if they do not hold. These relate to the machine's configuration, rather than additional networking or security that a given Cloud might offer.

Also see the Troubleshooting docs.

Remote Access

SSH or WinRM Access

Many entities require ssh'ing (or using WinRM for Windows), to install and configure the software.

An example of disabling all ssh'ing is shown below:

```
location:
  aws-ec2:us-east-1:
    identity: XXXXXXXX
    credential: XXXXXXXX
    waitForSshable: false
    pollForFirstReachableAddress: false
services:
- type: org.apache.brooklyn.entity.software.base.EmptySoftwareProcess
  brooklyn.config:
    onbox.base.dir.skipResolution: true
    sshMonitoring.enabled: false
```

Parsing SSH stdout: No Extra Lines

For entities that execute ssh commands, these sometimes parse the resulting stdout.

It is strongly recommended that VMs are configured so that no additional stdout is written when executing remote ssh (or WinRM) commands. Such stdout risks interfering with the response parsing in some blueprints.

For example, if configuring the VM to write out "Last login" information, this should be done for only "interactive" shells (see Stackoverflow for more details).

Passwordless Sudo

Does passwordless sudo work?

Try executing:

```
sudo whoami
```

See Passwordless Sudo.

Advertised Addresses

Hostname Resolves Locally

Does the hostname known at the box resolve at the box?

Try executing:

```
ping $(hostname)
```

if not, consider setting `generate.hostname: true` in the location config, for jclouds-based locations.

IP Resolves Locally

For the IP address advertised in Brooklyn using the sensor `host.addresses.private` (or `host.subnet.address`), can the machine reach that IP?

Get the sensor value, and then try executing:

```
ping ${PRIVATE_IP}
```

Is there a public IP (advertised using the sensor `host.addresses.public`, or `host.address`), and can the machine reach it?

Get the sensor value, and then try executing:

```
ping ${PUBLIC_IP}
```

Networking

Public Internet Access

Can the machine reach the public internet, and does DNS resolve?

Try executing:

```
ping www.example.org
```

Machine's Hostname in DNS

Is the machine hostname well-known? If ones does a DNS lookup, e.g. from the Brooklyn server, does it resolve and does it return the expected IP (e.g. the same IP as the `host.addresses.public` sensor)? Try using the hostname that the machine reports when you execute `hostname`.

Many blueprints do not require this, instead using IP addresses directly. Some blueprints may include registration with an appropriate DNS server. Some clouds do this automatically.

Reachability

When provisioning two machines, can these two machines reach each other on the expected IP(s) and hostname(s)?

Try using `ping` from one machine to another using the public or subnet ip or hostname. However, note that `ping` requires access over ICMP, which may be disabled. Alternatively, try connecting to a specific TCP port using `telnet <address> <port>`.

Firewalls

What firewall(s) are running on the machine, and are the required ports open? On linux, check things like `iptables`, `firewalld`, `ufw` or other commercial firewalls. On Windows, check the settings of the Windows Firewall.

Consider using `openIptables: true`, or even `stopIptables: true`.

Sufficient Entropy for /dev/random

Is there sufficient entropy on the machine, for `/dev/random` to respond quickly?

Try executing:

```
{ cat /dev/random > /tmp/x & } ; sleep 10 ; kill %1 ; { cat /dev/random > /tmp/x & } ; sleep 1 ; kill %1 ; wc /
tmp/x | awk '{print $3}'
```

The result should be more than 1M.

If not, consider setting `installDevUrandom: true` for jclouds-based locations.

See instructions to Increase Entropy.

File System

Permissions of /tmp

Is `/tmp` writable?

Try executing:

```
touch /tmp/amp-test-file ; rm /tmp/amp-test-file
```

Are files in `/tmp` executable (e.g. some places it has been mounted NO_EXECUTE)?

Try executing:

```
echo date > /tmp/brooklyn-test.sh && chmod +x /tmp/brooklyn-test.sh && /tmp/brooklyn-test.sh && rm /tmp/brookly
n-test.sh
```

---

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Clouds

For most cloud provisioning tasks, Brooklyn uses Apache jclouds. The identifiers for some of the most commonly used jclouds-supported clouds are (or see the full list):

- `jclouds:aws-ec2:<region>` : Amazon EC2, where `:<region>` might be `us-east-1` or `eu-west-1` (or omitted)
- `jclouds:softlayer:<region>` : IBM Softlayer, where `:<region>` might be `dal05` or `ams01` (or omitted)
- `jclouds:google-compute-engine` : Google Compute Engine
- `jclouds:openstack-nova:<endpoint>` : OpenStack, where `:<endpoint>` is the access URL (required)
- `jclouds:cloudstack:<endpoint>` : Apache CloudStack, where `:<endpoint>` is the access URL (required)

For any of these, of course, Brooklyn needs to be configured with an `identity` and a `credential` :

```
location:
  jclouds:aws-ec2:
    identity: ABCDEFGHIJKLMNOPQRST
    credential: s3cr3tsq1rr3ls3cr3tsq1rr3ls3cr3tsq1rr3l
```

The above YAML can be embedded directly in blueprints, either at the root or on individual services. If you prefer to keep the credentials separate, you can instead store them as a catalog entry or set them in `brooklyn.properties` in the `jclouds.<provider>` namespace:

```
brooklyn.location.jclouds.aws-ec2.identity=ABCDEFGHIJKLMNOPQRST
brooklyn.location.jclouds.aws-ec2.credential=s3cr3tsq1rr3ls3cr3tsq1rr3ls3cr3tsq1rr3l
```

And in this case you can reference the location in YAML with `location: jclouds:aws-ec2` .

Alternatively, you can use the location wizard tool available within the web console to create any cloud location supported by Apache jclouds. This location will be saved as a catalog entry for easy reusability.

Brooklyn irons out many of the differences between clouds so that blueprints run similarly in a wide range of locations, including setting up access and configuring images and machine specs. The configuration options are described in more detail below.

In some cases, cloud providers have special features or unusual requirements. These are outlined in **More Details for Specific Clouds**.

OS Initial Login and Setup

Once a machine is provisioned, Brooklyn will normally attempt to log in via SSH and configure the machine sensibly.

The credentials for the initial OS log on are typically discovered from the cloud, but in some environments this is not possible. The keys `loginUser` and either `loginUser.password` or `loginUser.privateKeyFile` can be used to force Brooklyn to use specific credentials for the initial login to a cloud-provisioned machine.

(This custom login is particularly useful when using a custom image templates where the cloud-side account management logic is not enabled. For example, a vCloud (vCD) template can have guest customization that will change the root password. This setting tells Apache Brooklyn to only use the given password, rather than the initial randomly generated password that vCD returns. Without this property, there is a race for such templates: does Brooklyn manage to create the admin user before the guest customization changes the login and reboots, or is the password reset first (the latter means Brooklyn can never ssh to the VM). With this property, Brooklyn will always wait for guest customization to complete before it is able to ssh at all. In such cases, it is also recommended to use `useJcloudsSshInit=false` .)

Following a successful logon, Brooklyn performs the following steps to configure the machine:

1. creates a new user with the same name as the user `brooklyn` is running as locally (this can be overridden with `user` , below).

2. install the local user's `~/.ssh/id_rsa.pub` as an `authorized_keys` on the new machine, to make it easy for the operator to `ssh` in (override with `privateKeyFile` ; or if there is no `id_{r,d}sa{,.pub}` an ad hoc keypair will be generated for the regular Brooklyn user; if there is a passphrase on the key, this must be supplied)
3. give `sudo` access to the newly created user (override with `grantUserSudo: false`)
4. disable direct `root` login to the machine

These steps can be skipped or customized as described below.

jclouds Config Keys

The following is a subset of the most commonly used configuration keys used to customize cloud provisioning. For more keys and more detail on the keys below, see JcloudsLocationConfig.

VM Creation

- Most providers require exactly one of either `region` (e.g. `us-east-1`) or `endpoint` (the URL, usually for private cloud deployments)
- Hardware requirements can be specified, including `minRam` , `minCores` , `minDisk` and `os64Bit` ; or as a specific `hardwareId`
- VM image constraints can be set using `osFamily` (e.g. `Ubuntu` , `CentOS` , `Debian` , `RHEL`) and `osVersionRegex` , or specific VM images can be specified using `imageId` or `imageNameRegex`
- Specific VM images can be specified using `imageId` or `imageNameRegex`
- Specific Security Groups can be specified using `securityGroups` , as a list of strings (the existing security group names), or `inboundPorts` can be set, as a list of numeric ports (selected clouds only)
- Where a key pair is registered with a target cloud for logging in to machines, Brooklyn can be configured to request this when provisioning VMs by setting `keyPair` (selected clouds only). Note that if this `keyPair` does not correspond your default `~/.ssh/id_rsa` , you must typically also specify the corresponding `loginUser.privateKeyFile` as a file or URL accessible from Brooklyn.
- A specific VM name (often the hostname) base to be used can be specified by setting `groupId` . By default, this name is constructed based on the entity which is creating it, including the ID of the app and of the entity. (As many cloud portals let you filter views, this can help find a specific entity or all machines for a given application.) For more sophisticated control over host naming, you can supply a custom CloudMachineNamer, for example `cloudMachineNamer: CustomMachineNamer` . CustomMachineNamer will use the entity's name or following a template you supply. On many clouds, a random suffix will be appended to help guarantee uniqueness; this can be removed by setting `vmNameSaltLength: 0` (selected clouds only).
- A DNS domain name where this host should be placed can be specified with `domainName` (in selected clouds only)
- User metadata can be attached using the syntax `userMetadata: { key: value, key2: "value 2" }` (or `userMetadata=key=value,key2="value 2"` in a properties file)
- By default, several pieces of user metadata are set to correlate VMs with Brooklyn entities, prefixed with `brooklyn-` . This user metadata can be omitted by setting `includeBrooklynUserMetadata: false` .
- You can specify the number of attempts Brooklyn should make to create machines with `machineCreateAttempts` (jclouds only). This is useful as an efficient low-level fix for those occasions when cloud providers give machines that are dead on arrival. You can of course also resolve it at a higher level with a policy such as ServiceRestarter.

- If you want to investigate failures, set `destroyOnFailure: false` to keep failed VM's around. (You'll have to manually clean them up.) The default is false: if a VM fails to start, or is never ssh'able, then the VM will be terminated.
- You can set `useMachinePublicAddressAsPrivateAddress` to true to overwrite the VMs private IP with its public IP. This is useful as it can be difficult to get VMs communicating via the private IPs they are assigned in some clouds. Using this config, blueprints which use private IPs can still be deployed to these clouds.

OS Setup

- `user` and `password` can be used to configure the operating user created on cloud-provisioned machines
- The `loginUser` config key (and subkeys) control the initial user to log in as, in cases where this cannot be discovered from the cloud provider
- Private keys can be specified using `privateKeyFile`; these are not copied to provisioned machines, but are required if using a local public key or a pre-defined `authorized_keys` on the server. (For more information on SSH keys, see here.)
- If there is a passphrase on the key file being used, you must supply it to Brooklyn for it to work, of course! `privateKeyPassphrase` does the trick (as in `brooklyn.location.jclouds.privateKeyPassphrase`, or other places where `privateKeyFile` is valid). If you don't like keys, you can just use a plain old `password`.
- Public keys can be specified using `publicKeyFile`, although these can usually be omitted if they follow the common pattern of being the private key file with the suffix `.pub` appended. (It is useful in the case of `loginUser.publicKeyFile`, where you shouldn't need, or might not even have, the private key of the `root` user when you log in.)
- Provide a list of URLs to public keys in `extraSshPublicKeyUrls`, or the data of one key in `extraSshPublicKeyData`, to have additional public keys added to the `authorized_keys` file for logging in. (This is supported in most but not all locations.)
- Use `dontCreateUser` to have Brooklyn run as the initial `loginUser` (usually `root`), without creating any other user.
- A post-provisioning `setup.script` can be specified to run an additional script, before making the `Location` available to entities. This may take the form of a URL of a script or a data URI. Note that if using a data URI it is usually a good idea to base64 this string to escape problem characters in more complex scripts. The base64 encoded script should then be prefixed with `data:text/plain;base64,` to denote this. For example if you wanted to disable a yum repository called `reponame` prior to using the machine, you could use the following command:

  ```
  sudo yum-config-manager --disable reponame
  ```

  Base64 encoding can be done with a with a tool such as this or a linux command such as:

  ```
  echo "sudo yum-config-manager --disable reponame" | base64
  ```

  With the base64 prefix this would then look like this:

  ```
  setup.script: data:text/plain;base64,c3VkbyB5dW0tY29uZmlnLW1hbmFnZXIgLS1kaXNhYmxlIHJlcG9uYW1l
  ```

  The `setup.script` can also take FreeMarker variables in a `setup.script.vars` property. Variables are set in the format `key1:value1,key2:value2` and used in the form `${key1}`. So for the above example:

  ```
  setup.script.vars: repository:reponame
  ```

  then

  ```
  setup.script: data:sudo yum-config-manager --disable ${repository}
  ```

  or encoded in base64:

`setup.script: data:text/plain;base64,c3VkbyB5dW0tY29uZmlnLW1hbmFnZXIgLS1kaXNhYmxlICR7cmVwb3NpdG9yeX0=`

This enables the name of the repository to be passed in to the script.

- Use `openIptables: true` to automatically configure `iptables`, to open the TCP ports required by the software process. One can alternatively use `stopIptables: true` to entirely stop the iptables service.
- Use Entity configuration flag `effector.add.openInboundPorts: true` to add an effector for opening ports in a cloud Security Group. The config is supported for all SoftwareProcessImpl implementations.
- Use `installDevUrandom: true` to fall back to using `/dev/urandom` rather than `/dev/random`. This setting is useful for cloud VMs where there is not enough random entropy, which can cause `/dev/random` to be extremely slow (causing `ssh` to be extremely slow to respond).
- Use `useJcloudsSshInit: false` to disable the use of the native jclouds support for initial commands executed on the VM (e.g. for creating new users, setting root passwords, etc.). Instead, Brooklyn's ssh support will be used. Timeouts and retries are more configurable within Brooklyn itself. Therefore this option is particularly recommended when the VM startup is unusual (for example, if guest customizations will cause reboots and/or will change login credentials).
- Use `brooklyn.ssh.config.noDeleteAfterExec: true` to keep scripts on the server after execution. The contents of the scripts and the stdout/stderr of their execution are available in the Brooklyn web console, but sometimes it can also be useful to have them on the box. This setting prevents scripts executed on the VMs from being deleted on completion. Note that some scripts run periodically so this can eventually fill a disk; it should only be used for dev/test.

Custom Template Options

jclouds supports many additional options for configuring how a virtual machine is created and deployed, many of which are for cloud-specific features and enhancements. Brooklyn supports some of these, but if what you are looking for is not supported directly by Brooklyn, we instead offer a mechanism to set any parameter that is supported by the jclouds template options for your cloud.

Part of the process for creating a virtual machine is the creation of a jclouds `TemplateOptions` object. jclouds providers extends this with extra options for each cloud - so when using the AWS provider, the object will be of type `AWSEC2TemplateOptions`. By examining the source code, you can see all of the options available to you.

The `templateOptions` config key takes a map. The keys to the map are method names, and Brooklyn will find the method on the `TemplateOptions` instance; it then invokes the method with arguments taken from the map value. If a method takes a single parameter, then simply give the argument as the value of the key; if the method takes multiple parameters, the value of the key should be an array, containing the argument for each parameter.

For example, here is a complete blueprint that sets some AWS EC2 specific options:

```
location: AWS_eu-west-1
services:
- type: org.apache.brooklyn.entity.software.base.EmptySoftwareProcess
  provisioning.properties:
    templateOptions:
      subnetId: subnet-041c8373
      mapNewVolumeToDeviceName: ["/dev/sda1", 100, true]
      securityGroupIds: ['sg-4db68928']
```

Here you can see that we set three template options:

- `subnetId` is an example of a single parameter method. Brooklyn will effectively try to run the statement `templateOptions.subnetId("subnet-041c88373");`
- `mapNewVolumeToDeviceName` is an example of a multiple parameter method, so the value of the key is an array.

Brooklyn will effectively true to run the statement `templateOptions.mapNewVolumeToDeviceName("/dev/sda1", 100, true);`

- `securityGroupIds` demonstrates an ambiguity between the two types; Brooklyn will first try to parse the value as a multiple parameter method, but there is no method that matches this parameter. In this case, Brooklyn will next try to parse the value as a single parameter method which takes a parameter of type `List`; such a method does exist so the operation will succeed.

If the method call cannot be matched to the template options available - for example if you are trying to set an AWS EC2 specific option but your location is an OpenStack cloud - then a warning is logged and the option is ignored.

Cloud Machine Naming

The name that Apache Brooklyn generates for your virtual machine will, by default, be based on your Apache Brooklyn server name and the IDs of the entities involved. This is the name you see in places such as the AWS console and will look something like:

```
brooklyn-o8jql4-machinename-rkix-tomcat-wi-nca6-14b
```

If you have created a lot of virtual machines, this kind of naming may not be helpful. This can be changed using the following YAML in your location's `brooklyn.config`:

```
cloudMachineNamer: org.apache.brooklyn.core.location.cloud.names.CustomMachineNamer
custom.machine.namer.machine: My-Custom-Name-${entity.displayName}
```

A FreeMarker format is used in `custom.machine.namer.machine` which can take values from places such as the launching entity or location.

The above example will create a name such as:

```
My-Custom-Name-Tomcat
```

Allowing you to more easily identify your virtual machines.

More Details on Specific Clouds

Clouds vary in the format of the identity, credential, endpoint, and region. Some also have their own idiosyncracies. More details for configuring some common clouds is included below. You may also find these sources helpful:

- The **template brooklyn.properties** file in the Getting Started guide contains numerous examples of configuring specific clouds, including the format of credentials and options for sometimes-fiddly private clouds.
- The **jclouds guides** describes low-level configuration sometimes required for various clouds.

---

section: Amazon Web Services (AWS) title: Amazon Web Services section_type: inline

section_position: 2

Amazon Web Services (AWS)

Credentials

AWS has an "access key" and a "secret key", which correspond to Brooklyn's identity and credential respectively.

These keys are the way for any programmatic mechanism to access the AWS API.

To generate an access key and a secret key, see jclouds instructions and AWS IAM instructions.

An example of the expected format is shown below:

```
location:
  jclouds:aws-ec2:
    region: us-east-1
    identity: ABCDEFGHIJKLMNOPQRST
    credential: abcdefghijklmnopqrstu+vwxyzabcdefghijklm
```

Users are strongly recommended to use externalized configuration for better credential management, for example using Vault.

Common Configuration Options

Below are examples of configuration options that use values specific to AWS EC2:

- The `region` is the AWS region code. For example, `region: us-east-1`. You can in-line the region name using the following format: `jclouds:aws-ec2:us-east-1`. A specific availability zone within the region can be specified by including its letter identifier as a suffix. For example, `region: us-east-1a`.
- The `hardwareId` is the instance type. For example, `hardwareId: m4.large`.
- The `imageId` is the region-specific AMI id. For example, `imageId: us-east-1/ami-05ebd06c`.
- The `securityGroups` option takes one or more names of pre-existing security groups. For example, `securityGroups: mygroup1` or `securityGroups: [ mygroup1, mygroup2 ]`.

Using Subnets and Security Groups

Apache Brooklyn can run with AWS VPC and both public and private subnets. Simply provide the `subnet-a1b2c3d4` as the `networkName` when deploying:

```
location:
  jclouds:aws-ec2:
    region: us-west-1
    networkName: subnet-a1b2c3d4   # use your subnet ID
```

Subnets are typically used in conjunction with security groups. Brooklyn does *not* attempt to open additional ports when private subnets or security groups are supplied, so the subnet and ports must be configured appropriately for the blueprints being deployed. You can configure a default security group with appropriate (or all) ports opened for access from the appropriate (or all) CIDRs and security groups, or you can define specific `securityGroups` on the location or as `provisioning.properties` on the entities.

Make sure that Brooklyn has access to the machines under management. This includes SSH, which might be done with a public IP created with inbound access on port 22 permitted for a CIDR range including the IP from which Brooklyn contacts it. Alternatively you can run Brooklyn on a machine in that same subnet, or set up a VPN or jumphost which Brooklyn will use.

EC2 "Classic" Problems with VPC-only Hardware Instance Types

If you have a pre-2014 Amazon account, it is likely configured in some regions to run in "EC2 Classic" mode by default, instead of the more modern "VPC" default mode. This can cause failures when requesting certain hardware configurations because many of the more recent hardware "instance types" only run in "VPC" mode. For instance when requesting an instance with `minRam: 8gb` , Brooklyn may opt for an `m4.large` , which is a VPC-only instance type. If you are in a region configured to use "EC2 Classic" mode, you may see a message such as this:

```
400 VPCResourceNotSpecified: The specified instance type can only be used in a VPC.
A subnet ID or network interface ID is required to carry out the request.
```

This is a limitation of "legacy" accounts. The easiest fixes are either:

- specify an instance type which is supported in classic, such as `m3.xlarge` (see below)
- move to a different region where VPC is the default (`eu-central-1` should work as it *only* offers VPC mode, irrespective of the age of your AWS account)
- get a new AWS account -- "VPC" will be the default mode (Amazon recommend this and if you want to migrate existing deployments they provide detailed instructions)

To understand the situation, the following resources may be useful:

- Background on VPC vs Classic: http://docs.aws.amazon.com/AWSEC2/latest/UserGuide/using-vpc.html
- Good succinct answers to FAQs: http://aws.amazon.com/vpc/faqs/#Default_VPCs
- Check if a region in your account is "VPC" or "Classic": http://docs.aws.amazon.com/AmazonVPC/latest/UserGuide/default-vpc.html#default-vpc-availability
- Regarding instance types:
    - All instance types: https://aws.amazon.com/ec2/instance-types
    - Those which require VPC: http://docs.aws.amazon.com/AWSEC2/latest/UserGuide/using-vpc.html#vpc-only-instance-types

If you want to solve this problem with your existing account, you can create a VPC and instruct Brooklyn to use it:

1. Use the "Start VPC Wizard" option in the VPC dashboard, making sure it is for the right region, and selecting a "Single Public Subnet". (More information is in these AWS instructions.)
2. Once the VPC is created, open the "Subnets" view and modify the "Public subnet" so that it will "Auto-assign Public IP".
3. Next click on the "Security Groups" and find the `default` security group for that VPC. Modify its "Inbound Rules" to allow "All traffic" from "Anywhere". (Or for more secure options, see the instructions in the previous section, "Using Subnets".)
4. Finally make a note of the subnet ID (e.g. `subnet-a1b2c3d4`) for use in Brooklyn.

You can then deploy blueprints to the subnet, allowing VPC hardware instance types, by specifying the subnet ID as the `networkName` in your YAML blueprint. This is covered in the previous section, "Using Subnets".

Tidying up after jclouds

Security groups are not always deleted by jclouds. This is due to a limitation in AWS (see https://issues.apache.org/jira/browse/JCLOUDS-207). In brief, AWS prevents the security group from being deleted until there are no VMs using it. However, there is eventual consistency for recording which VMs still reference those security groups: after deleting the VM, it can sometimes take several minutes before the security group can be deleted. jclouds retries for 3 seconds, but does not block for longer.

Whilst there is eventual consistency for recording which VMs still reference security groups, after deleting a VM, it can sometimes take several minutes before a security group can be deleted

There is utility written by Cloudsoft for deleting these unused resources: http://blog.abstractvisitorpattern.co.uk/2013/03/tidying-up-after-jclouds.html.

---

section: Azure Compute ARM section_type: inline

section_position: 2

Azure Compute ARM

Azure Resource Manager (ARM) is a framework for deploying and managing applications across resources and managing groups of resources as single logical units on the Microsoft Azure cloud computing platform.

Setup the Azure credentials

Azure CLI 2.0

Firstly, install and configure Azure CLI following these steps.

You will need to obtain your *subscription ID* and *tenant ID* from Azure. To do this using the CLI, first, log in:

```
az login
```

Or, if you are already logged in, request an account listing:

```
az account list
```

In either case, this will return a subscription listing, similar to that shown below.

```
[
  {
    "cloudName": "AzureCloud",
    "id": "012e832d-XXXX-XXXX-XXXX-XXXXXXXXXXXX",
    "isDefault": true,
    "name": "QA Team",
    "state": "Enabled",
    "tenantId": "ba85e8cd-XXXX-XXXX-XXXX-XXXXXXXXXXXX",
    "user": {
      "name": "qa@example.com",
      "type": "user"
    }
  },
  {
    "cloudName": "AzureCloud",
    "id": "341751b0-XXXX-XXXX-XXXX-XXXXXXXXXXXX",
    "isDefault": false,
    "name": "Developer Team",
    "state": "Enabled",
    "tenantId": "ba85e8cd-XXXX-XXXX-XXXX-XXXXXXXXXXXX",
    "user": {
      "name": "dev@example.com",
      "type": "user"
    }
  }
]
```

Choose one of the subscriptions and make a note of its *id* - henceforth the subscription ID - and the *tenantId*.

Next we need to create an *application* and a *service principle*, and grant permissions to the service principle. Use these commands:

```
# Create an AAD application with your information.
az ad app create --display-name <name> --password <Password> --homepage <home-page> --identifier-uris <identifi
er-uris>

# For example: az ad app create --display-name "myappname"  --password abcd --homepage "https://myappwebsite" -
-identifier-uris "https://myappwebsite"
```

Take a note of the *appId* shown.

```
# Create a Service Principal
az ad sp create --id <Application-id>
```

Take a note of the *objectId* shown - this will be the service principal object ID. (Note that any of the *servicePrincipalNames* can also be used in place of the object ID.)

```
# Assign roles for this service principal. The "principal" can be the "objectId" or any one of the "servicePrin
cipalNames" from the previous step
az role assignment create --assignee <Service-Principal> --role Contributor --scope /subscriptions/<Subscriptio
n-ID>/
```

By this stage you should have the following information:

- A subscription ID
- A tenant ID
- An application ID
- A service principle (either by its object ID, or by any one of its names)

We can now verify this information that this information can be used to log in to Azure:

```
az login --service-principal -u <Application-ID> --password abcd --tenant <Tenant-ID>
```

Azure CLI 1.0

Firstly, install and configure Azure CLI following these steps.

Using the Azure CLI, run the following commands to create a service principal

```
# Set mode to ARM
azure config mode arm

# Enter your Microsoft account credentials when prompted
azure login

# Set current subscription to create a service principal
azure account set <Subscription-id>

# Create an AAD application with your information.
azure ad app create --name <name> --password <Password> --home-page <home-page> --identifier-uris <identifier-u
ris>

# For example: azure ad app create --name "myappname"  --password abcd --home-page "https://myappwebsite" --ide
ntifier-uris "https://myappwebsite"

# Output will include a value for `Application Id`, which will be used for the live tests

# Create a Service Principal
azure ad sp create --applicationId <Application-id>

# Output will include a value for `Object Id`, to be used in the next step
```

Run the following commands to assign roles to the service principal

```
# Assign roles for this service principal
azure role assignment create --objectId <Object-id> -o Contributor -c /subscriptions/<Subscription-id>/
```

Look up the the tenant Id

```
azure account show -s <Subscription-id> --json

# output will be a JSON which will include the `Tenant id`
```

Verify service principal

```
azure login -u <Application-id> -p <Password> --service-principal --tenant <Tenant-id>
```

Using the Azure ARM Location

Below is an example Azure ARM location in YAML which will launch a Ubuntu instance in south east asia:

```
brooklyn.catalog:
  id: my-azure-arm-location
  name: "My Azure ARM location"
  itemType: location
  item:
    type: jclouds:azurecompute-arm
    brooklyn.config:
      identity: <Application-id>
      credential: <Password>
      endpoint: https://management.azure.com/subscriptions/<Subscription-id>
      oauth.endpoint: https://login.microsoftonline.com/<Tenant-id>/oauth2/token

      jclouds.azurecompute.arm.publishers: OpenLogic
      region: southeastasia
      loginUser: brooklyn
      templateOptions:
        overrideAuthenticateSudo: true
```

Fill the values `<Application-id>` , `<Password>` , `<Subscription-id>` and `<Tenant-id>` in from the values generated when setting up your credentials. In addition; several keys, not required in other locations need to be specified in order to use the Azure Compute ARM location. These are:

```
jclouds.azurecompute.arm.publishers: OpenLogic
```

The publishers is any item from the list available here: https://docs.microsoft.com/en-us/azure/virtual-machines/virtual-machines-linux-cli-ps-findimage

```
region: southeastasia
```

The region is any region from the list available here: https://azure.microsoft.com/en-us/regions/

```
loginUser: brooklyn
```

The loginUser can be anything, as long as it's specified.

```
templateOptions:
    overrideAuthenticateSudo: true
```

The `overrideAuthenticateSudo: true` key tells Apache Brooklyn that default on Azure images do not have passwordless sudo configured by default.

Useful configuration options for Azure ARM

You can add these options directly under the `brooklyn.config` element in the example above:

- `jclouds.compute.resourcename-prefix` and `jclouds.compute.resourcename-delimiter` - defaults to `jclouds` and `-` respectively. If jclouds is choosing the name for a resource (for example, a virtual machine), these properties will alter the way the resource is named.

You can add these options into the `templateOptions` element inside the `brooklyn.config` element in the example above:

- `resourceGroup` - select a Resource Group to deploy resources into. If not given, jclouds will generate a new resource group with a partly-random name.

Using Windows on Azure ARM

This section contains material how to create a Windows location on Azure ARM. Some of the used parameters are explained in the section above.

Windows on Azure ARM requires manually created Azure KeyVault Azure KeyVaults can be created via Azure cli or Azure portal UI. KeyVault's secret is a key stored in protected .PFX file. It needs to be prepared upfront or created with the Add-AzureKeyVaultKey cmdlet.

- `osFamily: windows` tells Apache Brooklyn to consider it as a Windows machine
- `useJcloudsSshInit: false` tells jclouds to not try to connect to the VM
- `vmNameMaxLength: 15` tells the cloud client to strip the VM name to maximum 15 characters. This is the maximum size supported by Azure Windows VMs.
- `winrm.useHttps` tells Apache Brooklyn to configure the WinRM client to use HTTPS.
- `secrets` Specifies the KeyVault configuration

  `sourceVault` Resource `id` of the KeyVault

  `vaultCertificates` `certificateStore` has to use `My` as a value. KeyVault's `certificateUrl` . An URI to the Secret Identifier

- `windowsConfiguration`

  `provisionVMAgent` whether Azure to install an agent on the VM. It must be set to `true`

  `winRM` It defines the `listeners` section. If `listeners` is `https` then `certificateUrl` needs to be set. Its value must match the one of `secrets` 's `certificateUrl` .

- `additionalUnattendContent` Additional content. Normally it can be defined as `null`
- `enableAutomaticUpdates` whether to enable the automatic windows updates. It can be set to `false` , if automatic updates are not desired

Sample Windows Blueprint

Placeholders surrounded with `<>` have to be replcaced with their respective values.

```
brooklyn.catalog:
  id: my-azure-arm-location
  name: "My Azure ARM location"
  itemType: location
  item:
    type: jclouds:azurecompute-arm
    brooklyn.config:
      identity: <Application-id>
      credential: <Password>
      endpoint: https://management.azure.com/subscriptions/<Subscription-id>
      oauth.endpoint: https://login.microsoftonline.com/<Tenant-id>/oauth2/token
      jclouds.azurecompute.arm.publishers: MicrosoftWindowsServer
      jclouds.azurecompute.operation.timeout: 120000

      winrm.useHttps: true
      osFamily: windows
      imageId: <Azure_location>/MicrosoftWindowsServer/WindowsServer/2012-R2-Datacenter
      region: <Azure_location>
      vmNameMaxLength: 15
      useJcloudsSshInit: false
      destroyOnFailure: false

      templateOptions:
        overrideLoginUser: brooklyn
        overrideLoginPassword: "secretPass1!"
        secrets:
        - sourceVault:
            id: "/subscriptions/<Subscription-id>/resourceGroups/<ResourceGroup>/providers/Microsoft.KeyVault/v
aults/<KeyVault-name>"
          vaultCertificates:
          - certificateUrl: "<KeyVault-uri>"
            certificateStore: My
        windowsConfiguration:
          provisionVMAgent: true
          winRM:
            listeners:
            - protocol: https
              certificateUrl: "<KeyVault-uri>"
          additionalUnattendContent: null
          enableAutomaticUpdates: true
```

Known issues

There are currently two known issues with Azure ARM:

- It can take a long time for VMs to be provisioned
- The Azure ARM APIs appear to have some fairly strict rate limiting that can result in AzureComputeRateLimitExceededException

---

section: Azure Compute Classic section_type: inline

section_position: 3

Azure Compute Classic

Azure is a cloud computing platform and infrastructure created by Microsoft. Apache Brooklyn includes support for both Azure Classic and Azure ARM, as one of the Apache jclouds supported clouds `Microsoft Azure Compute`.

The two modes of using Azure are the "classic deployment" model and the newer "Azure Resource Manager" (ARM) model. See https://azure.microsoft.com/en-gb/documentation/articles/resource-manager-deployment-model/ for details.

Setup the Azure credentials

Microsoft Azure requests are signed by SSL certificate. You need to upload one into your account in order to use an Azure location.

```
# create the certificate request
mkdir -m 700 $HOME/.brooklyn
openssl req -x509 -nodes -days 365 -newkey rsa:1024 -keyout $HOME/.brooklyn/azure.pem -out $HOME/.brooklyn/azur
e.pem
# create the p12 file, and note your export password. This will be your test credentials.
openssl pkcs12 -export -out $HOME/.brooklyn/azure.p12 -in $HOME/.brooklyn/azure.pem -name "brooklyn :: $USER"
# create a cer file
openssl x509 -inform pem -in $HOME/.brooklyn/azure.pem -outform der -out $HOME/.brooklyn/azure.cer
```

Finally, upload .cer file to the management console at https://manage.windowsazure.com/@myId#Workspaces/AdminTasks/ListManagementCertificates to authorize this certificate.

Please note, you can find the "myId" value for this link by looking at the URL when logged into the Azure management portal.

Note, you will need to use `.p12` format in the `brooklyn.properties`.

How to configure Apache Brooklyn to use Azure Compute

First, in your `brooklyn.properties` define a location as follows:

```
brooklyn.location.jclouds.azurecompute.identity=$HOME/.brooklyn/azure.p12
brooklyn.location.jclouds.azurecompute.credential=<P12_EXPORT_PASSWORD>
brooklyn.location.jclouds.azurecompute.endpoint=https://management.core.windows.net/<YOUR_SUBSCRIPTION_ID>
brooklyn.location.jclouds.azurecompute.vmNameMaxLength=45
brooklyn.location.jclouds.azurecompute.jclouds.azurecompute.operation.timeout=120000
brooklyn.location.jclouds.azurecompute.user=<USER_NAME>
brooklyn.location.jclouds.azurecompute.password=<PASSWORD>
```

During the VM provisioning, Azure will set up the account with `<USER_NAME>` and `<PASSWORD>` automatically. Notice, `<PASSWORD>` must be a minimum of 8 characters and must contain 3 of the following: a lowercase character, an uppercase character, a number, a special character.

To force Apache Brooklyn to use a particular image in Azure, say Ubuntu 14.04.1 64bit, one can add:

```
brooklyn.location.jclouds.azurecompute.imageId=b39f27a8b8c64d52b05eac6a62ebad85__Ubuntu-14_04_1-LTS-amd64-serve
r-20150123-en-us-30GB
```

From $BROOKLYN_HOME, you can list the image IDs available using the following command:

```
./bin/client "list-images --location azure-west-europe"
```

To force Brooklyn to use a particular hardwareSpec in Azure, one can add something like:

```
brooklyn.location.jclouds.azurecompute.hardwareId=BASIC_A2
```

From $BROOKLYN_HOME, you can list the hardware profile IDs available using the following command:

```
./bin/client "list-hardware-profiles --location azure-west-europe"
```

At the time of writing, the classic deployment model has the possible values shown below. See https://azure.microsoft.com/en-us/documentation/articles/virtual-machines-size-specs/ for further details, though that description focuses on the new "resource manager deployment" rather than "classic".

- `Basic_A0` to `Basic_A4`
- `Standard_D1` to `Standard_D4`
- `Standard_G1` to `Standard_G5`
- `ExtraSmall` , `Small` , `Medium` , `Large` , `ExtraLarge`

Named location

For convenience, you can define a named location, like:

```
brooklyn.location.named.azure-west-europe=jclouds:azurecompute:West Europe
brooklyn.location.named.azure-west-europe.displayName=Azure West Europe
brooklyn.location.named.azure-west-europe.imageId=b39f27a8b8c64d52b05eac6a62ebad85__Ubuntu-14_04_1-LTS-amd64-se
rver-20150123-en-us-30GB
brooklyn.location.named.azure-west-europe.hardwareId=BASIC_A2
brooklyn.location.named.azure-west-europe.user=test
brooklyn.location.named.azure-west-europe.password=MyPassword1!
```

This will create a location named `azure-west-europe` . It will inherit all the configuration defined on `brooklyn.location.jclouds.azurecompute` . It will also augment and override this configuration (e.g. setting the display name, image id and hardware id).

On Linux VMs, The `user` and `password` will create a user with that name and set its password, disabling the normal login user and password defined on the `azurecompute` location.

Windows VMs on Azure

The following configuration options are important for provisioning Windows VMs in Azure:

- `osFamily: windows` tells Apache Brooklyn to consider it as a Windows machine
- `useJcloudsSshInit: false` tells jclouds to not try to connect to the VM
- `vmNameMaxLength: 15` tells the cloud client to strip the VM name to maximum 15 characters. This is the maximum size supported by Azure Windows VMs.
- `winrm.useHttps` tells Apache Brooklyn to configure the WinRM client to use HTTPS.

  This is currently not supported in the default configuration for other clouds, where Apache Brooklyn is deploying Windows VMs.

  If the parameter value is `false` the default WinRM port is 5985; if `true` the default port for WinRM will be 5986. Use of default ports is stongly recommended.

- `winrm.useNtlm` tells Apache Brooklyn to configure the WinRM client to use NTLM protocol.

  For Azure, this is mandatory.

  For other clouds, this value is used in the cloud init script to configure WinRM on the VM.
  If the value is `true` then Basic Authentication will be disabled and the WinRM client will only use Negotiate plus NTLM.
  If the value is `false` then Basic Authentication will be enabled and the WinRM client will use Basic Authentication.

  NTLM is the default Authentication Protocol.

The format of this configuration option is subject to change: WinRM supports several authentication mechanisms, so this may be changed to a prioritised list so as to provide fallback options.

- `user` tells Apache Brooklyn which user to login as. The value should match that supplied in the `overrideLoginUser` of the `templateOptions`.
- `password`: tells Apache Brooklyn the password to use when connecting. The value should match that supplied in the `overrideLoginPassword` of the `templateOptions`.
- `templateOptions: { overrideLoginUser: adminuser, overrideLoginPassword: Pa55w0rd! }` tells the Azure Cloud to provision a VM with the given admin username and password. Note that no "Administrator" user will be created.

  If this config is not set then the VM will have a default user named "jclouds" with password "Azur3Compute!". It is **Strongly Recommended** that these template options are set.

  Notice: one cannot use `Administrator` as the user in Azure.

  This configuration is subject to change in future releases.

Sample Windows Blueprint

Below is an example for provisioning a Windows-based entity on Azure. Note the placeholder values for the identity, credential and password.

```
name: Windows Test @ Azure
location:
  jclouds:azurecompute:West Europe:
    identity: /home/users/brooklyn/.brooklyn/azure.p12
    credential: xxxxxxxp12
    endpoint: https://management.core.windows.net/12345678-1234-1234-1234-123456789abc
    imageId: 3a50f22b388a4ff7ab41029918570fa6__Windows-Server-2012-Essentials-20141204-enus
    hardwareId: BASIC_A2
    osFamily: windows
    useJcloudsSshInit: false
    vmNameMaxLength: 15
    winrm.useHttps: true
    user: brooklyn
    password: secretPass1!
    templateOptions:
      overrideLoginUser: brooklyn
      overrideLoginPassword: secretPass1!
services:
- type: org.apache.brooklyn.entity.software.base.VanillaWindowsProcess
  brooklyn.config:
    install.command: echo install phase
    launch.command: echo launch phase
    checkRunning.command: echo launch phase
```

Below is an example named location for Azure, configured in `brooklyn.properties`. Note the placeholder values for the identity, credential and password.

```
brooklyn.location.named.myazure=jclouds:azurecompute:West Europe
brooklyn.location.named.myazure.displayName=Azure West Europe (windows)
brooklyn.location.named.myazure.identity=$HOME/.brooklyn/azure.p12
brooklyn.location.named.myazure.credential=<P12_EXPORT_PASSWORD>
brooklyn.location.named.myazure.endpoint=https://management.core.windows.net/<YOUR_SUBSCRIPTION_ID>
brooklyn.location.named.myazure.vmNameMaxLength=15
brooklyn.location.named.myazure.jclouds.azurecompute.operation.timeout=120000
brooklyn.location.named.myazure.imageId=3a50f22b388a4ff7ab41029918570fa6__Windows-Server-2012-Essentials-201412
04-enus
brooklyn.location.named.myazure.hardwareId=BASIC_A2
brooklyn.location.named.myazure.osFamily=windows
brooklyn.location.named.myazure.useJcloudsSshInit=false
brooklyn.location.named.myazure.winrm.useHttps=true
brooklyn.location.named.myazure.user=brooklyn
brooklyn.location.named.myazure.password=secretPass1!
brooklyn.location.named.myazure.templateOptions={ overrideLoginUser: amp, overrideLoginPassword: secretPass1! }
```

User and Password Configuration

As described under the configuration options, the username and password must be explicitly supplied in the configuration.

This is passed to the Azure Cloud during provisioning, to create the required user. These values correspond to the options `AdminUsername` and `AdminPassword` in the Azure API.

If a hard-coded password is not desired, then within Java code a random password could be auto-generated and passed into the call to `location.obtain(Map<?,?>)` to override these values.

This approach differs from the behaviour of clouds like AWS, where the password is auto-generated by the cloud provider and is then retrieved via the cloud provider's API after provisioning the VM.

WinRM Configuration

The WinRM initialization in Azure is achieved through configuration options in the VM provisioning request. The required configuration is to enabled HTTPS (if Azure is told to use http, the VM comes pre-configured with WinRM encrypted over HTTP). The default is then to support NTLM protocol.

The setup of Windows VMs on Azure differs from that on other clouds, such as AWS. In contrast, on AWS an init script is passed to the cloud API to configure WinRM appropriately.

Windows initialization scripts in Azure are unfortunately not supported in "classic deployment" model, but are available in the newer "resource manager deployment" model as an "Azure VM Extension".

---

section: CloudStack title: Apache CloudStack section_type: inline

section_position: 4

Apache CloudStack

Connection Details

The endpoint URI will normally have the suffix `/client/api/` .

The identity is the "api key" and the credential is the "secret key". These can be generated in the CloudStack gui: under accounts, select "view users", then "generate key".

```
location:
  jclouds:cloudstack:
    endpoint: https://cloud.acme.com/client/api
    identity: abcdefghijklmnopqrstuvwxyz01234567890-abcdefghijklmnopqrstuvwxyz01234567890-abcdefghij
    credential: mycred-abcdefghijklmnopqrstuvwxyz01234567890-abcdefghijklmnopqrstuvwxyz01234567890-abc
```

Users are strongly recommended to use externalized configuration for better credential management, for example using Vault.

Common Configuration Options

Below are examples of configuration options that use values specific to CloudStack environments:

- The `imageId` is the template id. For example, `imageId: db0bcce3-9e9e-4a87-a953-2f46b603498f` .
- The `region` is CloudStack zone id. For example `region: 84539b9c-078e-458a-ae26-c3ffc5bb1ec9` ..
- `networkName` is the network id (within the given zone) to be used. For example, `networkName: 961c03d4-9828-4037-9f4d-3dd597f60c4f` .

For further configuration options, consult jclouds CloudStack template options. These can be used with the **templateOptions** configuration option.

Using a Pre-existing Key Pair

The configuration below uses a pre-existing key pair:

```
location:
  jclouds:cloudstack:
    ...
    loginUser: root
    loginUser.privateKeyFile: /path/to/keypair.pem
    keyPair: my-keypair
```

Using Pre-existing Security Groups

To specify existing security groups, their IDs must be used rather than their names (note this differs from the configuration on other clouds!).

The configuration below uses a pre-existing security group:

```
location:
  jclouds:cloudstack:
    ...
    templateOptions:
      generateSecurityGroup: false
      securityGroupIds:
      - 12345678-90ab-def0-1234-567890abcdef
```

Using Static NAT

Assigning a public IP to a VM at provision-time is referred to as "static NAT" in CloudStack parlance. To give some consistency across different clouds, the configuration option is named `autoAssignFloatingIp` . For example, `autoAssignFloatingIp: false` .

CloudMonkey CLI

The CloudStack CloudMonkey CLI is a very useful tool. It gives is an easy way to validate that credentials are correct, and to query
the API to find the correct zone IDs etc.

Useful commands include:

```
# for finding the ids of the zones:
cloudmonkey api listZones

# for finding the ids of the networks.
```

```
cloudmonkey api listNetworks | grep -E "id =|name =|========="
```

CloudStack Troubleshooting

These troubleshooting tips are more geared towards problems encountered in old test/dev CloudStack environment.

Resource Garbage Collection Issues

The environment may run out of resources, due to GC issues, preventing the user from creating new VMs or allocating IP addresses (May respond with this error message: `errorCode=INTERNAL_ERROR, errorText=Job failed due to exception Unable to create a deployment for VM`). There are two options worth checking it to enforce clearing up the zombie resources:

- Go to the Accounts tab in the webconsole and tap on the Update Resource Count button.
- Restart the VPC in question from the Network tab.

Releasing Allocated Public IP Addresses

Releasing an allocated Public IP from the web console did not free up the resources. Instead CloudMonkey can be used to dissociate IPs and expunge VMs.

Here is a CloudMonkey script to dissociate any zombie IPs:

```
cloudmonkey set display json;
cloudmonkey api listPublicIpAddresses | grep '"id":' > ips.txt;
sed -i -e s/'      "id": "'/''/g ips.txt;
sed -i -e s/'",'/''/g ips.txt
for line in $(cat ips.txt); do cloudmonkey api disassociateIpAddress id="$line"; done
rm ips.txt;
cloudmonkey set display default;
```

Restarting VPCs

Errors have been encountered when a zone failed to provision new VMs, with messages like:

```
Job failed due to exception Resource [Host:15] is unreachable: Host 15: Unable to start instance due to null
```

The workaround was to restart the VPC networks:

- Log into the CloudStack web-console.
- Go to Network -> VPC (from the "select view")
- For each of the VPCs, click on the "+" in the "quickview" column, and invoke "restart VPC".

Other symptoms of this issue were that: 1) an administrator could still provision VMs using the admin account, which used a different network; and 2) the host number was very low, so it was likely to be a system host/VM that was faulty.

---

section: Google Compute Engine (GCE) title: Google Compute Engine section_type: inline

section_position: 5

Google Compute Engine (GCE)

Credentials

GCE uses a service account e-mail address for the identity and a private key as the credential.

To obtain credentials for GCE, use the GCE web page's "APIs & auth -> Credentials" page, creating a "Service Account" of type JSON, then extracting the client_email as the identity and private_key as the credential. For more information, see the jclouds instructions.

An example of the expected format is shown below. Note that when supplying the credential in a properties file, it can either be one long line with `\n` representing the new line characters, or in YAML it can be split over multiple lines as below:

```
location:
  jclouds:google-compute-engine:
    region: us-central1-a
    identity: 1234567890-somet1mesArand0mU1Dhere@developer.gserviceaccount.com
    credential: |
      -----BEGIN RSA PRIVATE KEY-----
      abcdefghijklmnopqrstuvwxyz0123456789/+abcdefghijklmnopqrstuvwxyz
      0123456789/+abcdefghijklmnopqrstuvwxyz0123456789/+abcdefghijklmn
      opqrstuvwxyz0123456789/+abcdefghijklmnopqrstuvwxyz0123456789/+ab
      cdefghijklmnopqrstuvwxyz0123456789/+abcdefghijklmnopqrstuvwxyz01
      23456789/+abcdefghijklmnopqrstuvwxyz0123456789/+abcdefghijklmnop
      qrstuvwxyz0123456789/+abcdefghijklmnopqrstuvwxyz0123456789/+abcd
      efghijklmnopqrstuvwxyz0123456789/+abcdefghijklmnopqrstuvwxyz0123
      456789/+abcdefghijklmnopqrstuvwxyz0123456789/+abcdefghijklmnopqr
      stuvwxyz0123456789/+abcdefghijklmnopqrstuvwxyz0123456789/+abcdef
      ghijklmnopqrstuvwxyz0123456789/+abcdefghijklmnopqrstuvwxyz012345
      6789/+abcdefghijklmnopqrstuvwxyz0123456789/+abcdefghijklmnopqrst
      uvwxyz0123456789/+abcdefghijklmnopqrstuvwxyz0123456789/+abcdefgh
      ijklmnopqrstuvwxyz0123456789/+abcdefghijklmnopqrstuvwxyz01234567
      89/+abcdefghijklmnopqrstuvwxyz0123456789/+abcdefghijklmnopqrstuv
      wxyz0123456789/+abcdefghijklmnopqrstuvwxyz0123456789/+abcdefghij
      klmnopqrstuvwxyz0123456789/+abcdefghijklmnopqrstuvwxyz0123456789
      /+abcdefghijklmnopqrstuvwxyz0123456789/+abcdefghijklmnopqrstuvwx
      yz0123456789/+abcdefghijklmnopqrstuvwxyz0123456789/+abcdefghijkl
      mnopqrstuvwxyz0123456789/+abcdefghijklmnopqrstuvwxyz0123456789/+
      abcdefghijklmnopqrstuvwxyz0123456789/+abcdefghijklmnopqrstuvwxyz
      0123456789/+abcdefghijklmnopqrstuvwxyz0123456789/+abcdefghijklmn
      opqrstuvwxyz0123456789/+abcdefghijklmnopqrstuvwxyz0123456789/+ab
      cdefghijklmnopqrstuvwxyz
      -----END RSA PRIVATE KEY-----
```

It is also possible to have the credential be the path of a local file that contains the key. However, this can make it harder to setup and manage multiple Brooklyn servers (particularly when using high availability mode).

Users are strongly recommended to use externalized configuration for better credential management, for example using Vault.

Quotas

GCE accounts can have low default quotas.

It is easy to request a quota increase by submitting a quota increase form.

Networks

GCE accounts often have a limit to the number of networks that can be created. One work around is to manually create a network with the required open ports, and to refer to that named network in Brooklyn's location configuration.

To create a network, see GCE network instructions.

For example, for dev/demo purposes an "everything" network could be created that opens all ports.

|| Name || everything | || Description || opens all tcp ports | || Source IP Ranges || 0.0.0.0/0 | || Allowed protocols and ports || tcp:0-65535 and udp:0-65535 |

To configure the location to use this, you can include a location configuration option like:

```
templateOptions:
  network: https://www.googleapis.com/compute/v1/projects/<project name>/global/networks/everything
```

---

section: IBM Softlayer title: IBM Softlayer section_type: inline

section_position: 6

IBM SoftLayer

Credentials

Credentials can be obtained from the Softlayer API, under "administrative -> user administration -> api-access".

For example:

```
location:
  jclouds:softlayer:
    region: ams01
    identity: my-user-name
    credential: 1234567890abcdef1234567890abcdef1234567890abcdef1234567890abcdef
```

Users are strongly recommended to use externalized configuration for better credential management, for example using Vault.

Common Configuration Options

Below are examples of configuration options that use values specific to Softlayer:

- The `region` is the Softlayer datacenter. For example, `region: dal05` .
- The `hardwareId` is an auto-generated combination of the hardware configuration options. This is because there is no concept of hardwareId or hardware profile names in Softlayer. An example value is `hardwareId: "cpu=1,memory=1024,disk=25,type=LOCAL"` .
- The `imageId` is the Image template. For example, `imageId: CENTOS_6_64` .

VLAN Selection

SoftLayer may provision VMs in different VLANs, even within the same region. Some applications require VMs to be on the *same* internal subnet; blueprints for these can specify this behaviour in SoftLayer in one of two ways.

The VLAN ID can be set explicitly using the fields `primaryNetworkComponentNetworkVlanId` and `primaryBackendNetworkComponentNetworkVlanId` of `SoftLayerTemplateOptions` when specifying the location being used in the blueprint, as follows:

```
location:
  jclouds:softlayer:
    region: ams01
    templateOptions:
      # Enter your preferred network IDs
      primaryNetworkComponentNetworkVlanId: 1153481
      primaryBackendNetworkComponentNetworkVlanId: 1153483
```

This method requires that a VM already exist and you look up the IDs of its VLANs, for example in the SoftLayer console UI, and that subsequently at least one VM in that VLAN is kept around. If all VMs on a VLAN are destroyed SoftLayer may destroy the VLAN. Creating VLANs directly and then specifying them as IDs here may not work. Add a line note

The second method tells Brooklyn to discover VLAN information automatically: it will provision one VM first, and use the VLAN information from it when provisioning subsequent machines. This ensures that all VMs are on the same subnet without requiring any manual VLAN referencing, making it very easy for end-users.

To use this method, we tell brooklyn to use `SoftLayerSameVlanLocationCustomizer` as a location customizer. This can be done on a location as follows:

```
location:
  jclouds:softlayer:
    region: lon02
    customizers:
    - $brooklyn:object:
        type: org.apache.brooklyn.location.jclouds.softlayer.SoftLayerSameVlanLocationCustomizer
    softlayer.vlan.scopeUid: "my-custom-scope"
    softlayer.vlan.timeout: 10m
```

Usually you will want the scope to be unique to a single application, but if you need multiple applications to share the same VLAN, simply configure them with the same scope identifier.

It is also possible with many blueprints to specify this as one of the `provisioning.properties` on an *application*:

```
services:
- type: org.apache.brooklyn.entity.stock.BasicApplication
  id: same-vlan-application
  brooklyn.config:
    provisioning.properties:
      customizers:
      - $brooklyn:object:
          type: org.apache.brooklyn.location.jclouds.softlayer.SoftLayerSameVlanLocationCustomizer
    softlayer.vlan.scopeUid: "my-custom-scope"
    softlayer.vlan.timeout: 10m
```

If you are writing an entity in Java, you can also use the helper method `forScope(String)` to create the customizer. Configure the provisioning flags as follows:

```
JcloudsLocationCustomizer vlans = SoftLayerSameVlanLocationCustomizer.forScope("my-custom-scope");
flags.put(JcloudsLocationConfig.JCLOUDS_LOCATION_CUSTOMIZERS.getName(), ImmutableList.of(vlans));
```

Configuration Options

The allowed configuration keys for the `SoftLayerSameVlanLocationCustomizer` are:

- **softlayer.vlan.scopeUid** The scope identifier for locations whose VMs will have the same VLAN.
- **softlayer.vlan.timeout** The amount of time to wait for a VM to be configured before timing out without setting the VLAN ids.

- **softlayer.vlan.publicId** A specific public VLAN ID to use for the specified scope.
- **softlayer.vlan.privateId** A specific private VLAN ID to use for the specified scope.

An entity being deployed to a customized location will have the VLAN ids set as sensors, with the same names as the last two configuration keys.

NOTE If the SoftLayer location is already configured with specific VLANs then this customizer will have no effect.

---

section: OpenStack title: OpenStack section_type: inline

section_position: 7

OpenStack

Apache jclouds

Support for OpenStack is provided by Apache jclouds. For more information, see their guide here.

Connection Details

The endpoint URI is that of keystone (normally on port 5000).

The identity normally consists of a colon-separated tenant and username. The credential is the password. For example:

```
location:
  jclouds:openstack-nova:
    endpoint: http://x.x.x.x:5000/v2.0/
    identity: "your-tenant:your-username"
    credential: your-password
```

OpenStack Nova access information can be downloaded from the openstack web interface, for example as an openrc.sh file. It is usually available from API Access tab in "Access & Security" section. This file will normally contain the identity and credential.

Users are strongly recommended to use externalized configuration for better credential management, for example using Vault.

Common Configuration Options

Below are examples of configuration options that use values specific to OpenStack environments:

- The `imageId` is the id of an image. For example, `imageId: RegionOne/08086159-8b0b-4970-b332-a7a929ee601f`. These ids can be found from the the CLI or the web-console, for example in IBM Blue Box London, the URL is https://tenant-region.openstack.blueboxgrid.com/project/images/.
- The `hardwareId` is the flavor id. For example `hardwareId: RegionOne/1`. These ids can be found from the the CLI or the web-console, for example in IBM Blue Box, the URL is https://tenant-region.openstack.blueboxgrid.com/admin/flavors/.

The default flavors are shown below (though the set of flavors can be managed by the admin):

```
+-----+-----------+-----------+------+
| ID  | Name      | Memory_MB | Disk |
+-----+-----------+-----------+------+
| 1   | m1.tiny   | 512       | 1    |
| 2   | m1.small  | 2048      | 20   |
| 3   | m1.medium | 4096      | 40   |
| 4   | m1.large  | 8192      | 80   |
| 5   | m1.xlarge | 16384     | 160  |
+-----+-----------+-----------+------+
```

For further configuration options, consult jclouds Nova template options. These can be used with the **templateOptions** configuration option.

Networks

When multiple networks are available you should indicate which ones machines should join. Do this by setting the desired values id as an option in the **templateOptions** configuration:

```
location:
  jclouds:openstack-nova:
    ...
    templateOptions:
      # Assign the node to all networks in the list.
      networks:
      - network-one-id
      - network-two-id
      - ...
```

Floating IPs

The `autoAssignFloatingIp` option means that a floating ip will be assigned to the VM at provision-time.

A floating IP pool name can also be specified. If not set, a floating IP from any available pool will be chosen. This is set using the template option. For example:

```
location:
  jclouds:openstack-nova:
    ...
    autoAssignFloatingIp: true
    templateOptions:
      # Pool names to use when allocating a floating IP
      floatingIpPoolNames:
      - "pool name"
```

Basic Location Structure

This is a basic inline YAML template for an OpenStack location:

```
location:
    jclouds:openstack-nova:
        endpoint: http://x.x.x.x:5000/v2.0/
        identity: "your-tenant:your-username"
        credential: your-password

        # imageId, hardwareId, and loginUser* are optional
        imageId: your-region-name/your-image-id
        hardwareId: your-region-name/your-flavor-id
        loginUser: 'ubuntu'
        loginUser.privateKeyFile: /path/to/your/privatekey

        jclouds.openstack-nova.auto-generate-keypairs: false
        jclouds.openstack-nova.auto-create-floating-ips: true

        templateOptions:
            networks: [ "your-network-id" ]
            floatingIpPoolNames: [ "your-floatingIp-pool" ]
            securityGroups: ['your-security-group']

            # Optional if 'jclouds.openstack-nova.auto-generate-keypairs' is assigned to 'true'
            keyPairName: "your-keypair"
```

This is the same OpenStack location in a format that can be added to your `brooklyn.properties` file:

```
brooklyn.location.named.My\ OpenStack=jclouds:openstack-nova:http://x.x.x.x:5000/v2.0/
brooklyn.location.named.My\ OpenStack.identity=your-tenant:your-username
brooklyn.location.named.My\ OpenStack.credential=your-password
brooklyn.location.named.My\ OpenStack.endpoint=http://x.x.x.x:5000/v2.0/

brooklyn.location.named.My\ OpenStack.imageId=your-region-name/your-image-id
brooklyn.location.named.My\ OpenStack.hardwareId=your-region-name/your-flavor-id
brooklyn.location.named.My\ OpenStack.loginUser=ubuntu
brooklyn.location.named.My\ OpenStack.loginUser.privateKeyFile=/path/to/your/privatekey
brooklyn.location.named.My\ OpenStack.openstack-nova.auto-generate-keypairs=false
brooklyn.location.named.My\ OpenStack.openstack-nova.auto-create-floating-ips=true

brooklyn.location.named.My\ OpenStack.networks=your-network-id
brooklyn.location.named.My\ OpenStack.floatingIpPoolNames=your-floatingIp-pool
brooklyn.location.named.My\ OpenStack.securityGroups=your-security-group
brooklyn.location.named.My\ OpenStack.keyPair=your-keypair
```

Troubleshooting

Cloud Credentials Failing

If the cloud API calls return `401 Unauthorized` (e.g. in a `org.jclouds.rest.AuthorizationException`), then this could be because the credentials are incorrect.

A good way to check this is to try the same credentials with the OpenStack nova command line client.

Unable to SSH: Wrong User

If SSH authentication fails, it could be that the login user is incorrect. For most clouds, this is inferred from the image metadata, but if no (or the wrong) login user is specified then it will
default to root. The correct login user can be specified using the configuration option `loginUser` . For example, `loginUser: ubuntu` .

The use of the wrong login user can also result in the obscure message, caused by an unexpected response saying to use a different user. For more technical information, see this sshj github issue. The message is:

```
Received message too long 1349281121
```

I Want to Use My Own KeyPair

By default, jclouds will auto-generate a new key pair for the VM. This key pair will be deleted automatically when the VM is deleted.

Alternatively, you can use a pre-existing key pair. If so, you must also specify the corresponding private key (pem file, or data) to be used for the initial login. The name used in the `keyPair` configuration must match the name of a key pair that has already been added in OpenStack. For example:

```
location:
  jclouds:clouds:openstack-nova:
    ...
    jclouds.openstack-nova.auto-generate-keypairs: false
    keyPair: "my-keypair"
    loginUser: ubuntu
    loginUser.privateKeyFile: /path/to/my/privatekey.pem
```

Error "doesn't contain ... -----BEGIN"

If using `loginUser.privateKeyFile` (or `loginUser.privateKeyData`), this is expected to be a .pem file. If a different format is used (e.g. a .ppk file), it will give an error like that below:

```
Error invoking start at EmptySoftwareProcessImpl{id=TrmhitVc}: chars
PuTTY-User-Key-File-2: ssh-rsa
...
doesn't contain % line [-----BEGIN ]
```

Warning Message: "Ignoring request to set..."

If you see a warning log message like that below:

```
2016-06-23 06:05:12,297 WARN  o.a.b.l.j.JcloudsLocation [brooklyn-execmanager-XlwkWB3k-312]:
Ignoring request to set template option loginUser because this is not supported by
org.jclouds.openstack.nova.v2_0.compute.options.NovaTemplateOptions
```

It can mean that the location configuration option is in the wrong place. The configuration under `templateOptions` must correspond to those options on the jclouds Nova template options. However, template options such as `loginUser` are top-level configuration options that should not be inside the `templateOptions` section.

HttpResponseException Accessing Compute Endpoint

The Keystone endpoint is first queried to get the API access endpoints for the appropriate services.

Some private OpenStack installs are (mis)configured such that the returned addresses are not always directly accessible. It could be that the service is behind a VPN, or that they rely on hostnames that are only in a private DNS.

You can find the service endpoints in OpenStack, either using the CLI or the web-console. For example, in Blue Box the URL is https://tenant-region.openstack.blueboxgrid.com/project/access_and_security/. You can then check if the Compute service endpoint is directly reachable.

VM Failing to Provision

It can be useful to drop down to the OpenStack nova CLI, or to jclouds, to confirm that VM provisioning is working and to check which options are required.

For example, try following these jclouds instructions.

jclouds Namespace Issue

A change to Nova's API (in the Mitaka release) resulted in all extensions having the same "fake" namespace which the current version of jclouds does not yet support.

If you are having problems deploying to OpenStack, consult your Brooklyn debug log and look for the following:

```
"namespace": "http://docs.openstack.org/compute/ext/fake_xml"
```

If you already have `jclouds:openstack-mitaka-nova`, then try using this instead of the vanilla `jclouds:openstack-nova`. For example:

```
location:
    jclouds:openstack-mitaka-nova:
        endpoint: http://x.x.x.x:5000/v2.0/
        identity: "your-tenant:your-username"
        credential: your-password
        templateOptions:
            networks: [ "your-network-id" ]
            floatingIpPoolNames: [ "your-floatingIp-pool" ]
```

Note that the following values will be set by default when omitted above:

```
jclouds.keystone.credential-type=passwordCredentials
jclouds.openstack-nova.auto-generate-keypairs: true
jclouds.openstack-nova.auto-create-floating-ips: true
```

---

section: Inheritance and Named Locations title: Named Locations section_type: inline

section_position: 7

Inheritance and Named Locations

Named locations can be defined for commonly used groups of properties, with the syntax `brooklyn.location.named.your-group-name.` followed by the relevant properties. These can be accessed at runtime using the syntax `named:your-group-name` as the deployment location.

Some illustrative examples using named locations and showing the syntax and properties above are as follows:

```
# Production pool of machines for my application (deploy to named:prod1)
brooklyn.location.named.prod1=byon:(hosts="10.9.1.1,10.9.1.2,produser2@10.9.2.{10,11,20-29}")
brooklyn.location.named.prod1.user=produser1
brooklyn.location.named.prod1.privateKeyFile=~/.ssh/produser_id_rsa
brooklyn.location.named.prod1.privateKeyPassphrase=s3cr3tCOMPANYpassphrase

# AWS using my company's credentials and image standard, then labelling images so others know they're mine
brooklyn.location.named.company-jungle=jclouds:aws-ec2:us-west-1
brooklyn.location.named.company-jungle.identity=BCDEFGHIJKLMNOPQRSTU
brooklyn.location.named.company-jungle.privateKeyFile=~/.ssh/public_clouds/company_aws_id_rsa
brooklyn.location.named.company-jungle.imageId=ami-12345
brooklyn.location.named.company-jungle.minRam=2048
brooklyn.location.named.company-jungle.userMetadata=application=my-jungle-app,owner="Bob Johnson"
brooklyn.location.named.company-jungle.machineCreateAttempts=2

brooklyn.location.named.AWS\ Virginia\ Large\ Centos = jclouds:aws-ec2
brooklyn.location.named.AWS\ Virginia\ Large\ Centos.region = us-east-1
brooklyn.location.named.AWS\ Virginia\ Large\ Centos.imageId=us-east-1/ami-7d7bfc14
brooklyn.location.named.AWS\ Virginia\ Large\ Centos.user=root
brooklyn.location.named.AWS\ Virginia\ Large\ Centos.minRam=4096
```

Named locations can refer to other named locations using `named:xxx` as their value. These will inherit the configuration and can override selected keys. Properties set in the namespace of the provider (e.g. `b.l.jclouds.aws-ec2.KEY=VALUE`) will be inherited by everything which extends AWS Sub-prefix strings are also inherited up to `brooklyn.location.*` , except that they are filtered for single-word and other known keys (so that we exclude provider-scoped properties when looking at sub-prefix keys). The precedence for configuration defined at different levels is that the value defined in the most specific context will apply.

This is rather straightforward and powerful to use, although it sounds rather more complicated than it is! The examples below should make it clear. You could use the following to install a public key on all provisioned machines, an additional public key in all AWS machines, and no extra public key in `prod1` :

```
brooklyn.location.extraSshPublicKeyUrls=http://me.com/public_key
brooklyn.location.jclouds.aws-ec2.extraSshPublicKeyUrls="[ \"http://me.com/public_key\", \"http://me.com/aws_pu
blic_key\" ]"
brooklyn.location.named.prod1.extraSshPublicKeyUrls=
```

And in the example below, a config key is repeatedly overridden. Deploying `location: named:my-extended-aws` will result in an `aws-ec2` machine in `us-west-1` (by inheritance) with `VAL6` for `KEY` :

```
brooklyn.location.KEY=VAL1
brooklyn.location.jclouds.KEY=VAL2
brooklyn.location.jclouds.aws-ec2.KEY=VAL3
brooklyn.location.jclouds.aws-ec2@us-west-1.KEY=VAL4
brooklyn.location.named.my-aws=jclouds:aws-ec2:us-west-1
brooklyn.location.named.my-aws.KEY=VAL5
brooklyn.location.named.my-extended-aws=named:my-aws
brooklyn.location.named.my-extended-aws.KEY=VAL6
```

---

section: BYON section_position: 8

section_type: inline

BYON

"Bring-your-own-nodes" mode is useful in production, where machines have been provisioned by someone else, and during testing, to cut down provisioning time.

Your nodes must meet the following prerequisites:

- A suitable OS must have been installed on all nodes
- The node must be running sshd (or similar)
- the brooklyn user must be able to ssh to each node as root or as a user with passwordless sudo permission. (For more information on SSH keys, see here.)

To deploy to machines with known IP's in a blueprint, use the following syntax:

```
location:
  byon:
    user: brooklyn
    privateKeyFile: ~/.ssh/brooklyn.pem
    hosts:
    - 192.168.0.18
    - 192.168.0.19
```

Some of the login properties as described above for jclouds are supported, but not `loginUser` (as no users are created), and not any of the VM creation parameters such as `minRam` and `imageId` . (These clearly do not apply in the same way, and they are *not* by default treated as constraints, although an entity can confirm these where needed.) As before, if the brooklyn user and its default key are authorized for the hosts, those fields can be omitted.

Named locations can also be configured in your `brooklyn.properties`, using the format `byon:(key=value,key2=value2)`. For convenience, for hosts wildcard globs are supported.

```
brooklyn.location.named.On-Prem\ Iron\ Example=byon:(hosts="10.9.1.1,10.9.1.2,produser2@10.9.2.{10,11,20-29}")
brooklyn.location.named.On-Prem\ Iron\ Example.user=produser1
brooklyn.location.named.On-Prem\ Iron\ Example.privateKeyFile=~/.ssh/produser_id_rsa
brooklyn.location.named.On-Prem\ Iron\ Example.privateKeyPassphrase=s3cr3tpassphrase
```

Alternatively, you can create a specific BYON location through the location wizard tool available within the web console. This location will be saved as a catalog entry for easy reusability.

For more complex host configuration, one can define custom config values per machine. In the example below, there will be two machines. The first will be a machine reachable on `ssh -i ~/.ssh/brooklyn.pem -p 8022 myuser@50.51.52.53`. The second is a windows machine, reachable over WinRM. Each machine has also has a private address (e.g. for within a private network).

```
location:
  byon:
    hosts:
    - ssh: 50.51.52.53:8022
      privateAddresses: [10.0.0.1]
      privateKeyFile: ~/.ssh/brooklyn.pem
      user: myuser
    - winrm: 50.51.52.54:8985
      privateAddresses: [10.0.0.2]
      password: mypassword
      user: myuser
      osFamily: windows
```

The BYON location also supports a machine chooser, using the config key `byon.machineChooser`. This allows one to plugin logic to choose from the set of available machines in the pool. For example, additional config could be supplied for each machine. This could be used (during the call to `location.obtain()`) to find the config that matches the requirements of the entity being

provisioned. See `FixedListMachineProvisioningLocation.MACHINE_CHOOSER`.

section: SSH Keys section_position: 9

section_type: inline

SSH Keys

SSH keys are one of the simplest and most secure ways to access remote servers. They consist of two parts:

- A private key (e.g. `id_rsa`) which is known only to one party or group
- A public key (e.g. `id_rsa.pub`) which can be given to anyone and everyone, and which can be used to confirm that a party has a private key (or has signed a communication with the private key)

In this way, someone -- such as you -- can have a private key, and can install a public key on a remote machine (in an `authorized_keys` file) for secure automated access. Commands such as `ssh` (and Brooklyn) can log in without revealing the private key to the remote machine, the remote machine can confirm it is you accessing it (if no one else has the private key), and no one snooping on the network can decrypt of any of the traffic.

Creating an SSH Key

If you don't have an SSH key, create one with:

```
$ ssh-keygen -t rsa -N "" -f ~/.ssh/id_rsa
```

Localhost Setup

If you want to deploy to `localhost`, ensure that you have a public and private key, and that your key is authorized for ssh access:

```
# _Appends_ id_rsa.pub to authorized_keys. Other keys are unaffected.
$ cat ~/.ssh/id_rsa.pub >> ~/.ssh/authorized_keys
```

Now verify that your setup by running the command: `ssh localhost echo hello world`

If your setup is correct, you should see `hello world` printed back at you.

On the first connection, you may see a message similar to this:

```
The authenticity of host 'localhost (::1)' can't be established.
RSA key fingerprint is 7b:e3:8e:c6:5b:2a:05:a1:7c:8a:cf:d1:6a:83:c2:ad.
Are you sure you want to continue connecting (yes/no)?
```

Simply answer 'yes' and then repeat the command again.

If this isn't the case, see below.

Potential Problems

- **MacOS user?** In addition to the above, enable "Remote Login" in "System Preferences > Sharing".
- **Got a passphrase?** Set `brooklyn.location.localhost.privateKeyPassphrase` as described here. If you're not sure, or you don't know what a passphrase is, you can test this by executing `ssh-keygen -y`. If it does *not* ask for a passphrase, then your key has no passphrase. If your key does have a passphrase, you can remove it by running `ssh-keygen -p`.
- Check that you have an `~/.ssh/id_rsa` file (or `id_dsa`) and a corresponding public key with a `.pub` extension; if not, create one as described above
- `~/.ssh/` or files in that directory may have permissions they shouldn't: they should be visible only to the user (apart from public keys), both on the source machine and the target machine. You can verify this with `ls -l ~/.ssh/`: lines should start with `-rw-------` or `-r--------` (or `-rwx------` for directories). If it does not, execute `chmod go-rwx ~/.ssh ~/.ssh/*`.
- Sometimes machines are configured with different sets of support SSL/TLS versions and ciphers; if command-line `ssh` and `scp` work, but Brooklyn/java does not, check the versions enabled in Java and on both servers.
- Missing entropy: creating and using ssh keys requires randomness available on the servers, usually in `/dev/random`; see here for more information

---

section: Localhost section_position: 10

section_type: inline

Localhost

If passwordless ssh login to `localhost` and passwordless `sudo` is enabled on your machine, you should be able to deploy some blueprints with no special configuration, just by specifying `location: localhost` in YAML.

If you use a passphrase or prefer a different key, these can be configured as follows:

```
location:
  localhost:
    privateKeyFile=~/.ssh/brooklyn_key
    privateKeyPassphrase=s3cr3tPASSPHRASE
```

Alternatively, you can create a specific localhost location through the location wizard tool available within the web console. This location will be saved as a catalog entry for easy reusability.

Passwordless Sudo

If you encounter issues or for more information, see SSH Keys Localhost Setup.

For some blueprints, passwordless sudo is required. (Try executing `sudo whoami` to see if it prompts for a password. To enable passwordless `sudo` for your account, a line must be added to the system `/etc/sudoers` file. To edit the file, use the `visudo` command:

```
sudo visudo
```

Add this line at the bottom of the file, replacing `username` with your own user:

```
username ALL=(ALL) NOPASSWD: ALL
```

If executing the following command does not ask for your password, then `sudo` has been setup correctly:

```
sudo whoami
```

---

section: Location Customizers section_type: inline

section_position: 11

Location Customizers

Apache Brooklyn supports a number of ways to configure and customize locations. These include the `JcloudsLocationCustomizer`, which is for advanced customization of VM provisioning through jclouds. There is also a `MachineLocationCustomizer`, which allows customization of machines being obtained from any kind of location (including Bring Your Own Nodes).

Usage Guidelines

Clearly there is an overlap for where things can be done. This section describes the recommended separation of responsibilities.

These are guidelines only - users are obviously free to make alternative usage decisions based on their particular use-cases.

Responsibilities of Entity versus Location

From an entity's perspective, it calls `location.obtain(options)` and gets back a usable `MachineLocation` that has a standard base operating system that gives remote access (e.g. for Linux it expects credentials for a user with `sudo` rights, and ssh access).

However, there are special cases - for example the `location.obtain(options)` could return a Docker container with the software pre-installed, and no remote access (see the Clocker project for more information on use of Docker with Brooklyn).

The entity is then responsible for configuring that machine according to the needs of the software to be installed.

For example, the entity may install software packages, upload/update configuration files, launch processes, etc.

The entity may also configure `iptables`. This is also possible through the `JcloudsLocation` configuration. However, it is preferable to do this in the entity because it is part of configuring the machine in the way required for the given software component.

The entity may also perform custom OS setup, such as installing security patches. However, whether this is appropriate depends on the nature of the security patch: if the security patch is specific to the entity type, then it should be done within the entity; but if it is to harden the base OS to make it comply with an organisation's standards (e.g. to overcome shortcomings of the base image, or to install security patches) then a `MachineLocationCustomizer` is more appropriate.

Location Configuration Options

This refers to standard location configuration: explicit config keys, and explicit jclouds template configuration that can be passed through.

This kind of configuration is simplest to use. It is the favoured mechanism when it comes to VM provisioning, and should be used wherever possible.

Note that a jclouds `TemplateBuilder` and cloud-specific `TemplateOptions` are the generic mechanisms within jclouds for specifying the details of the compute resource to be provisioned.

Jclouds Location Customizer

A `JcloudsLocationCustomizer` has customization hooks to execute code at the various points of building up the jclouds template and provisioning the machine. Where jclouds is being used and where the required use of jclouds goes beyond simple configuration, this is an appropriate solution.

For example, there is a `org.apache.brooklyn.location.jclouds.networking.JcloudsLocationSecurityGroupCustomizer` which gives more advanced support for setting up security groups (e.g. in AWS-EC2).

Machine Customizer

The `MachineLocationCustomizer` allows customization of machines being obtained from any kind of location. For example, this includes for jclouds and for Bring Your Own Nodes (BYON).

It provides customization hooks for when the machine has been provisioned (before it is returned by the location) and when the machine is about to be released by the location.

An example use would be to register (and de-register) the machine in a CMDB.

Jclouds Location Customizers

Warning: additional methods (i.e. customization hooks) may be added to the `JcloudsLocationCustomizer` *interface in future releases. Users are therefore strongly encouraged to sub-class* `BasicJcloudsLocationCustomizer` *, rather than implementing JcloudsLocationCustomizer directly.*

The `JcloudsLocationCustomizer` provides customization hooks at various points of the Brooklyn's use of jclouds. These can be used to adjust the configuration, to do additional setup, to do custom logging, etc.

- Customize the `org.jclouds.compute.domain.TemplateBuilder` , before it is used to build the template. This is used to influence the choice of VM image, hardware profile, etc. This hook is not normally required as the location configuration options can be used in instead.
- Customize the `org.jclouds.compute.domain.Template` , to be used when creating the machine. This hook is most often used for performing custom actions - for example to create or modify a security group or volume, and to update the template's options to use that.
- Customize the `org.jclouds.compute.options.TemplateOptions` to be used when creating the machine. The `TemplateOptions` could be cast to a cloud-specific sub-type (if this does not have to work across different clouds). Where the use-case is to just set simple configuration on the `TemplateOptions` , consider instead using the config key `templateOptions` , which takes a map of type String to Object - the strings should match the method names in the `TemplateOptions` .
- Customize the `org.apache.brooklyn.location.jclouds.JcloudsMachineLocation` that has been created. For Linux-based VMs, if the config `waitForSshable` was not false, then this machine is guaranteed to be ssh'able. Similarly for WinRM access to Windows machines, if `waitForWinRmAvailable` was not false.
- Pre-release of the machine. If the actions required are specific to jclouds (e.g. using jclouds to make calls to the cloud provider) then this should be used; otherwise one should use the more generic `MachineLocationCustomizer` .
- Post-release of the machine (i.e. after asking jclouds to destroying the machine).

To register a `JcloudsLocationCustomizer` in YAML, the config key `customizers` can be used to provide a list of instances. Each instance can be defined using `$brooklyn:object` to indicate the type and its configuration. For example:

```
location:
  jclouds:aws-ec2:us-east-1:
    customizers:
    - $brooklyn:object:
        type: com.acme.brooklyn.MyJcloudsLocationCustomizer
```

To register `JcloudsLocationCustomizer` instances programmatically, set the config key `JcloudsLocationConfig.JCLOUDS_LOCATION_CUSTOMIZERS` on the location, or pass this config option when calling `location.obtain(options)` .

The `SharedLocationSecurityGroupCustomizer` configures a shared security group on Jclouds locations. It only works on AWS and Azure ARM.

To register a `SharedLocationSecurityGroupCustomizer` in YAML, you can use the config key `customizers` and configure it with `$brooklyn:object` and `object.fields` . For example:

```
location:
  jclouds:aws-ec2:us-east-1:
    customizers:
    - $brooklyn:object:
        type: org.apache.brooklyn.location.jclouds.networking.SharedLocationSecurityGroupCustomizer
        object.fields: {locationName: "myloc", tcpPortRanges: ["22", "8080", "9443"], udpPortRanges: ["2001", "
4013"], cidr: "82.40.153.101/24"}
```

where `cidr` can be optionally set to restrict the range that the ports that are to be opened can be accessed from.

Machine Location Customizers

Warning: additional methods (i.e. customization hooks) may be added to the `MachineLocationCustomizer` interface in future releases. Users are therefore strongly encouraged to sub-class `BasicMachineLocationCustomizer`, rather than implementing `MachineLocationCustomizer` directly.

The `MachineLocationCustomizer` provides customization hooks for when a machine is obtained/released from a `MachineProvisioningLocation`. The following hooks are supported:

- After the machine has been provisioned/allocated, but before it has been returned.
- When the machine is about to be released, but prior to actually destroying/unallocating the machine.

To register a `MachineLocationCustomizer` in YAML, the config key `machineCustomizers` can be used to provide a list of instances. Each instance can be defined using `$brooklyn:object` to indicate the type and its configuration. For example:

```
location:
  jclouds:aws-ec2:us-east-1:
    machineCustomizers:
    - $brooklyn:object:
        type: com.acme.brooklyn.MyMachineLocationCustomizer
```

To register `MachineLocationCustomizer` instances programmatically, set the config key `CloudLocationConfig.MACHINE_LOCATION_CUSTOMIZERS` on the location, or pass this config option when calling `location.obtain(options)`.

Hostname Customizer

org.apache.brooklyn.entity.machine.SetHostnameCustomizer Sets the hostname on an ssh'able machine. Currently only CentOS and RHEL are supported. The customizer can be configured with a hard-coded hostname, or with a freemarker template whose value (after substitutions) will be used for the hostname.

---

section: Customizing Cloud Security Groups section_position: 12

section_type: inline

Customizing Cloud Security Groups

Before using SharedLocationSecurityGroupCustomizer, please first refer to Port Inferencing.

A security group is a named collection of network access rules that are use to limit the types of traffic that have access to instances.
Security group is the standard way to set firewall restrictions on the AWS-EC2 environment.
docs.aws.amazon.com/AmazonVPC/latest/UserGuide/VPC_SecurityGroups.html

When deploying to AWS EC2 target, by default Apache Brooklyn creates security group attached to the VM. It is easy to add additional rules to the initial security group using `org.apache.brooklyn SharedLocationSecurityGroupCustomizer`.

YAML Example:

```
name: ports @ AWS
location: jclouds:aws-ec2:us-west-2:
services:
- type: org.apache.brooklyn.entity.software.base.EmptySoftwareProcess
  brooklyn.config:
    provisioning.properties:
      customizers:
      - $brooklyn:object:
          type: org.apache.brooklyn.location.jclouds.networking.SharedLocationSecurityGroupCustomizer
          object.fields: {tcpPortRanges: ["900-910", "915", "22"], udpPortRanges: ["100","200-300"], cidr: "82.
40.153.101/24"}
```

Make sure that you have rule which makes port 22 accessible from Apache Brooklyn.

Opening ports during runtime.

Apache Brooklyn exposes the SharedLocationSecurityGroupCustomizer functionality after entity is deployed just by supplying `effector.add.openInboundPorts: true` "brooklyn.config". Example configuration in effector

```
location: jclouds:aws-ec2:us-west-2
services:
- type: org.apache.brooklyn.entity.software.base.EmptySoftwareProcess
  brooklyn.config:
    effector.add.openInboundPorts: true
```

Known limitations

Not all cloud providers support Security Group abstraction. `SharedLocationSecurityGroupCustomizer` is known to work well with Amazon EC2.
Other clouds which support Security Groups:

- Openstack
- Azure - jclouds-labs azurecompute implementation uses endpoints rules when creating a VM instance. jclouds:azurecompute based location do not have security groups so SharedLocationSecurityGroupCustomizer is used it will fail to find a security group.

---

section: Specialized Locations section_position: 13

section_type: inline

Specialized Locations

Some additional location types are supported for specialized situations:

Single Host

The spec `host` , taking a string argument (the address) or a map (`host` , `user` , `password` , etc.), provides a convenient syntax when specifying a single host. For example:

```
location: host:(192.168.0.1)
services:
- type: org.apache.brooklyn.entity.webapp.jboss.JBoss7Server
```

Or, in `brooklyn.properties`, set `brooklyn.location.named.host1=host:(192.168.0.1)`.

The Multi Location

The spec `multi` allows multiple locations, specified as `targets`, to be combined and treated as one location.

Sequential Consumption

In its simplest form, this will use the first target location where possible, and will then switch to the second and subsequent locations when there are no machines available.

In the example below, it provisions the first node to `192.168.0.1`, then it provisions into AWS us-east-1 region (because the bring-your-own-nodes region will have run out of nodes).

```
location:
  multi:
    targets:
    - byon:(hosts=192.168.0.1)
    - jclouds:aws-ec2:us-east-1
services:
- type: org.apache.brooklyn.entity.group.DynamicCluster
  brooklyn.config:
    cluster.initial.size: 3
    dynamiccluster.memberspec:
      $brooklyn:entitySpec:
        type: org.apache.brooklyn.entity.machine.MachineEntity
```

Round-Robin Consumption and Availability Zones for Clustered Applications

A `DynamicCluster` can be configured to cycle through its deployment targets round-robin when provided with a location that supports the `AvailabilityZoneExtension` -- the `multi` location supports this extension.

The configuration option `dynamiccluster.zone.enable` on `DynamicCluster` tells it to query the given location for `AvailabilityZoneExtension` support. If the location supports it, then the cluster will query for the list of availability zones (which in this case is simply the list of targets) and deploy to them round-robin.

In the example below, the cluster will request VMs round-robin across three different locations (in this case, the locations were already added to the catalog, or defined in `brooklyn.properties`).

```
location:
  multi:
    targets:
    - my-location-1
    - my-location-2
    - my-location-3
services:
- type: org.apache.brooklyn.entity.group.DynamicCluster
  brooklyn.config:
    dynamiccluster.zone.enable: true
    cluster.initial.size: 3
    dynamiccluster.memberspec:
      $brooklyn:entitySpec:
        type: org.apache.brooklyn.entity.machine.MachineEntity
```

Of course, clusters can also be deployed round-robin to real availability zones offered by cloud providers, as long as their locations support `AvailabilityZoneExtension`. Currently, only AWS EC2 locations support this feature.

In the example below, the cluster will request VMs round-robin across the availability zones provided by AWS EC2 in the "us-east-1" region.

```
location: jclouds:aws-ec2:us-east-1
services:
- type: org.apache.brooklyn.entity.group.DynamicCluster
  brooklyn.config:
    dynamiccluster.zone.enable: true
    cluster.initial.size: 3
    dynamiccluster.memberspec:
      $brooklyn:entitySpec:
        type: org.apache.brooklyn.entity.machine.MachineEntity
```

For more information about AWS EC2 availability zones, see this guide.

Custom alternatives to round-robin are also possible using the configuration option `dynamiccluster.zone.placementStrategy` on `DynamicCluster`.

The Server Pool

The ServerPool entity type allows defining an entity which becomes available as a location.

To install Apache Brooklyn on a production server:

1. Set up the prerequisites
2. Download Apache Brooklyn
3. Configuring brooklyn.cfg
4. Configuring Karaf Security
5. Configuring default.catalog.bom
6. Test the installation

This guide covers the basics. You may also wish to configure:

- Logging
- Persistence
- High availability

Set up the Prerequisites

Check that the server meets the requirements. Then configure the server as follows:

- install Java JRE or JDK (version 8 or later)
- enable "Java Cryptography Extension" (already enabled out of the box of OpenJDK installs)
- install an SSH key, if not available
- if the "localhost" location will be used, enable passwordless ssh login
- create a `~/.brooklyn` directory on the host with `$ mkdir ~/.brooklyn`
- check your `iptables` or other firewall service, making sure that incoming connections on port 8443 is not blocked
- check that the linux kernel entropy is sufficient
- check that the ulimit values are sufficiently high
- ensure external libraries are up-to-date, including `nss` for SSL.
- ensure the time is continually accurate, ideally by running a service like the ntp daemon.

Download Apache Brooklyn

Download Brooklyn and obtain a binary build as described on the download page.

Expand the `tar.gz` archive:

```
% tar -zxf apache-brooklyn-{{ book.brooklyn-stable-version }}-dist.tar.gz
```

This will create a `apache-brooklyn-{{ book.brooklyn-stable-version }}` folder.

Let's setup some paths for easy commands.

```
% cd apache-brooklyn-{{ book.brooklyn-stable-version }}
% BROOKLYN_DIR="$(pwd)"
% export PATH=$PATH:$BROOKLYN_DIR/bin/
```

Configuring brooklyn.cfg

Set up `brooklyn.cfg` as described here:

- Configure the users who should have access
- Turn on HTTPS
- Supply credentials for any pre-defined clouds

Configuring Karaf Security

Out of the box, Apache Brooklyn includes the default Karaf security configuration. This configuration is used to manage connections to the ssh port of Karaf (which is available to localhost connections only). It is recommended that you update the credentials as detailed in the Karaf Security page.

Configuring the Catalog

By default Brooklyn loads the catalog of available application components and services from `default.catalog.bom` on the classpath. The initial catalog is in `conf/brooklyn/` in the dist. If you have a preferred catalog, simply replace that file.

More information on the catalog is available here.

Confirm Installation

Launch Brooklyn in a disconnected session so it will remain running after you have logged out:

```
% nohup bin/brooklyn launch > /dev/null 2&>1 &
```

Apache Brooklyn should now be running on port 8081 (or other port if so specified).

To install on a different port edit config in `etc/org.ops4j.pax.web.cfg` .

NOTE: This document is for information on starting an Apache Brooklyn Server. For information on using the Brooklyn Client CLI to access an already running Brooklyn Server, refer to Client CLI Reference.

Packages for RHEL/CentOS and Ubuntu

If you are using the `.rpm` or `.deb` package of Apache Brooklyn, then Brooklyn will integrate with your OS service management. Commands such as `service brooklyn start` will work as expected, and Brooklyn's PID file will be stored in the normal location for your OS, such as `/var/run/brooklyn.pid`.

Platform-independent distributions

The platform-independent distributions are packaged in `.tar.gz` and `.zip` files.

Starting

To launch Brooklyn, from the directory where Brooklyn is unpacked, run:

```
% bin/start
```

With no configuration, this will launch the Brooklyn web console and REST API on `http://localhost:8081/`, listening on all network interfaces. No credentials are required by default. It is strongly recommended to configure security.

See the Server CLI Reference for more information about the Brooklyn server process.

Stopping

To stop Brooklyn, from the directory where Brooklyn is unpacked, run:

For example:

~~~
% bin/stop
{% endhighlight bash %}


## Monitoring

For `.tar.gz` and `.zip` distributions of Brooklyn, the Brooklyn startup script
will create a file name `pid_java` at the root of the Brooklyn directory, which
contains the PID of the last Brooklyn process to be started. You can examine
this file to discover the PID, and then test that the process is still running.
`.rpm` and `.deb` distributions of Brooklyn will use the normal mechanism that
your OS uses, such as writing to `/var/run/brooklyn.pid`.

This should lead to a fairly straightforward integration with many monitoring
tools - the monitoring tool can discover the expected PID, and can execute the
start or stop commands shown above as necessary.

For example, here is a fragment of a `monitrc` file as used by
[Monit](https://mmonit.com/monit/), for a Brooklyn `.tar.gz` distribution
unpacked and installed at `/opt/apache-brooklyn`:

```text
check process apachebrooklyn with pidfile /opt/apache-brooklyn/pid_java
    start program = "/bin/bash -c '/opt/apache-brooklyn/bin/brooklyn launch --persist auto & disown'" with time
out 10 seconds
    stop  program = "/bin/bash -c 'kill $( cat /opt/apache-brooklyn/pid_java )'"
~~~

In addition to monitoring the Brooklyn process itself, you will almost certainly want to monitor resource usage of Brooklyn. In particular, please see the Requirements section for a discussion on Brooklyn's disk space requirements.

NOTE: This document is for information on starting a Brooklyn Server. For information on using the Brooklyn Client CLI to access an already running Brooklyn Server, refer to Client CLI Reference.

Launch command

To launch Brooklyn, from the directory where Brooklyn is unpacked, run:

```
% nohup bin/brooklyn launch > /dev/null 2>&1 &
```

With no configuration, this will launch the Brooklyn web console and REST API on `http://localhost:8081/`, listening on all network interfaces. No credentials are required by default. For a production system, or if Apache Brooklyn is publicly reachable, it is strongly recommended to configure security.

By default, Brooklyn will write log messages at the INFO level or above to `brooklyn.info.log` and messgages at the DEBUG level or above to `brooklyn.debug.log`. Redirecting the output to `/dev/null` prevents the default console output being written to `nohup.out`.

You may wish to add Brooklyn to your path; assuming you've done this, to get information the supported CLI options at any time, just run `brooklyn help`:

```
% bin/brooklyn help

usage: brooklyn [(-q | --quiet)] [(-v | --verbose)] <command> [<args>]

The most commonly used brooklyn commands are:
    help     Display help information about brooklyn
    info     Display information about brooklyn
    launch   Starts a brooklyn application. Note that a BROOKLYN_CLASSPATH environment variable needs to be set
 up beforehand to point to the user application classpath.

See 'brooklyn help <command>' for more information on a specific command.
```

It is important that Brooklyn is launched with either `nohup ... &` or `... & disown`, to ensure it keeps running after the shell terminates.

Other Server CLI Arguments

The Server CLI arguments for persistence and HA and the catalog are described separately.

Path Setup

In order to have easy access to the server cli it is useful to configure the PATH environment variable to also point to the cli's bin directory:

```
BROOKLYN_HOME=/path/to/brooklyn/
export PATH=$PATH:$BROOKLYN_HOME/usage/dist/target/brooklyn-dist/bin/
```

Memory Usage

The amount of memory required by the Brooklyn process depends on the usage -- for example the number of entities/VMs under management.

For a standard Brooklyn deployment, the defaults are to start with 256m, and to grow to 1g of memory. These numbers can be overridden by setting the environment variable `JAVA_OPTS` before launching the `brooklyn script`, as follows:

```
JAVA_OPTS="-Xms1g -Xmx4g"
```

(On Java 8 and later the last entry has no effect and can be dropped.)

Brooklyn stores a task history in-memory using soft references. This means that, once the task history is large, Brooklyn will continually use the maximum allocated memory. It will only expunge tasks from memory when this space is required for other objects within the Brooklyn process.

See Memory Usage for more information on memory usage and other suggested `JAVA_OPTS`.

Web Console Bind Address

The web console will by default bind to 0.0.0.0. It's restricted to 127.0.0.1 if the `--noConsoleSecurity` flag is used. To specify a local interface, or use the local loopback (127.0.0.1), for the web console to bind to you should use:

```
--bindAddress <IP>
```

Configuration

Configuration Files

Brooklyn reads configuration from a variety of places. It aggregates the configuration. The list below shows increasing precedence (i.e. the later ones will override values from earlier ones, if exactly the same property is specified multiple times).

1. `classpath://brooklyn/location-metadata.properties` is shipped as part of Brooklyn, containing generic metadata such as jurisdiction and geographic information about Cloud providers.
2. The file `~/.brooklyn/location-metadata.properties` (unless `--noGlobalBrooklynProperties` is specified). This is intended to contain custom metadata about additional locations.
3. The file `brooklyn.cfg` (unless `--noGlobalBrooklynProperties` is specified).
4. Another properties file, if the `--localBrooklynProperties <local brooklyn.properties file>` is specified.
5. Shell environment variables
6. System properties, supplied with `-D` on the brooklyn (Java) command-line.

These properties are described in more detail here.

Extending the Classpath

The default Brooklyn directory structure includes:

- `./conf/` : for configuration resources.
- `./lib/patch/` : for Jar files containing patches.
- `./lib/brooklyn/` : for the brooklyn libraries.
- `./lib/dropins/` : for additional Jars.

Resources added to `conf/` will be available on the classpath.

A patch can be applied by adding a Jar to the `lib/patch/` directory, and restarting Brooklyn. All jars in this directory will be at the head of the classpath.

Additional Jars should be added to `lib/dropins/`, prior to starting Brooklyn. These jars will be at the end of the classpath.

The initial classpath, as set in the `brooklyn` script, is:

```
conf:lib/patch/*:lib/brooklyn/*:lib/dropins/*
```

Additional entries can be added at the head of the classpath by setting the environment variable `BROOKLYN_CLASSPATH` before running the `brooklyn` script.

Replacing the web-console

Work in progress.

The Brooklyn web-console is loaded from the classpath as the resource `classpath://brooklyn.war`.

To replace this, an alternative WAR with that name can be added at the head of the classpath. However, this approach is likely to change in a future release - consider this feature as "beta".

Cloud Explorer

The `brooklyn` command line tool includes support for querying (and managing) cloud compute resources and blob-store resources.

For example, `brooklyn cloud-compute list-instances --location aws-ec2:eu-west-1` will use the AWS credentials from `brooklyn.properties` and list the VM instances running in the given EC2 region.

Use `brooklyn help` and `brooklyn help cloud-compute` to find out more information.

This functionality is not intended as a generic cloud management CLI, but instead solves specific Brooklyn use-cases. The main use-case is discovering the valid configuration options on a given cloud, such as for `imageId` and `hardwareId`.

Cloud Compute

The command `brooklyn cloud-compute` has the following options:

- `list-images`: lists VM images within the given cloud, which can be chosen when provisioning new VMs. This is useful for finding the possible values for the `imageId` configuration.
- `get-image <imageId1> <imageId2> ...`: retrieves metadata about the specific images.
- `list-hardware-profiles`: lists the ids and the details of the hardware profiles available when provisioning. This is useful for finding the possible values for the `hardwareId` configuration.
- `default-template`: retrieves metadata about the image and hardware profile that will be used by Brooklyn for that location, if no additional configuration options are supplied.
- `list-instances`: lists the VM instances within the given cloud.
- `terminate-instances <instanceId1> <instanceId2> ...`: Terminates the instances with the given ids.

Blob Store

The command `brooklyn cloud-blobstore` is used to access a given object store, such as S3 or Swift. It has the following options:

- `list-containers` : lists the containers (i.e. buckets in S3 terminology) within the given object store.
- `list-container <containerName>` : lists all the blobs (i.e. objects) contained within the given container.
- `blob --container <containerName> --blob <blobName>` : retrieves the given blob (i.e. object), including metadata and its contents.

NOTE: These documents are for using the Brooklyn Client CLI tool to access a running Brooklyn Server. For information on starting on a Brooklyn Server, refer to Server CLI Reference.

Obtaining the CLI tool

A selection of distributions of the CLI tool, `br` , are available to download from the download site here:

- Windows
- Linux
- OSX

Alternatively the CLI tool is available as an executable binary for many more platforms in the Apache Brooklyn distribution, under `bin/brooklyn-client-cli/` , with each build in its own subdirectory:

- Mac: `darwin.amd64/`
- Windows 32-bit: `windows.386/`
- Windows 64-bit: `windows.amd64/`
- Linux 32-bit: `linux.386/`
- Linux 64-bit: `linux.amd64/`

The binary is completely self-contained so you can either copy it to your `bin/` directory or add the appropriate directory above to your path:

```
PATH=$PATH:$HOME/apache-brooklyn/bin/brooklyn-client-cli/linux.amd64/
```

Documentation

This guide will walk you through connecting to the Brooklyn Server Graphical User Interface and performing various tasks.

For an explanation of common Brooklyn Concepts see the Brooklyn Concepts Quickstart or see the full guide in the Brooklyn Concepts chapter of the User Guide.

This guide assumes that you are using Linux or Mac OS X and that Brooklyn Server will be running on your local system.

Launch Apache Brooklyn

If you haven't already done so, you will need to start Brooklyn Server using the commands shown below.
It is not necessary at this time, but depending on what you are going to do, you may wish to set up some other configuration options first,

- Security
- Persistence

Now start Brooklyn with the following command:

```
$ cd apache-brooklyn-{{ book.brooklyn.version }}
$ bin/brooklyn launch
```

Please refer to the Server CLI Reference for details of other possible command line options.

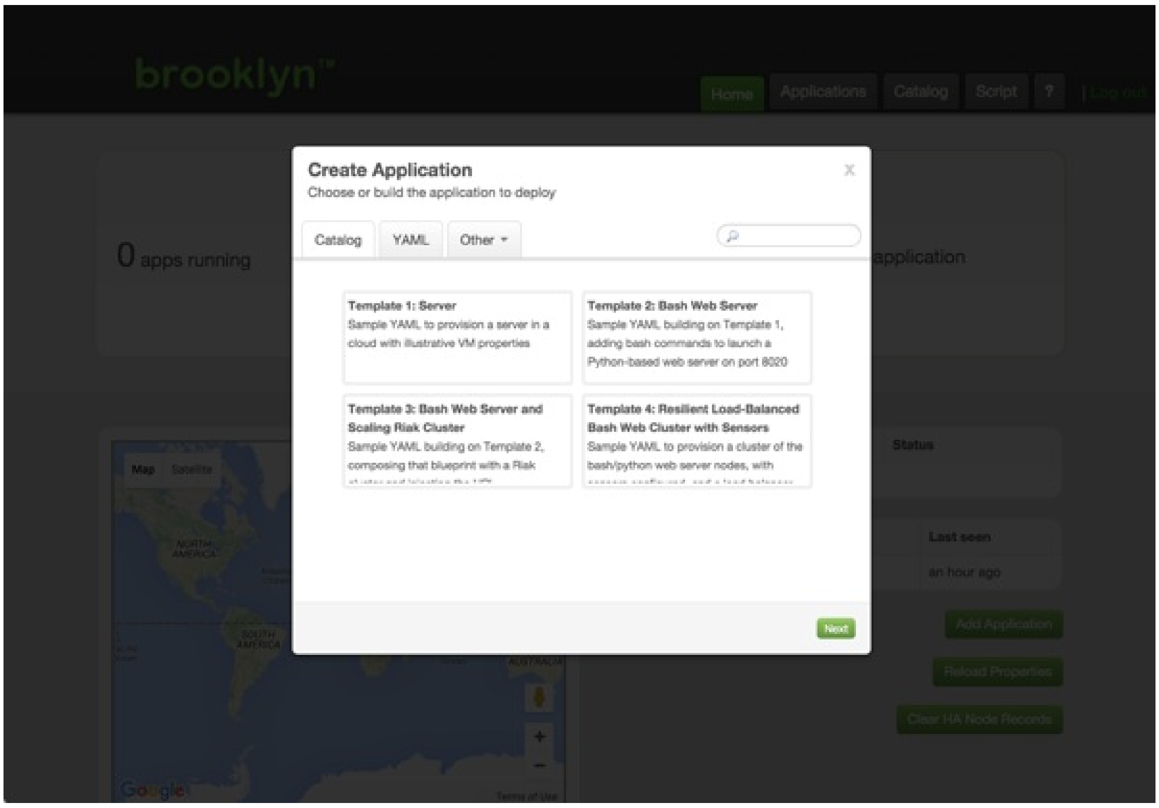
Brooklyn will output the address of the management interface:

```
INFO  Starting Brooklyn web-console with no security options (defaulting to no
authentication), on bind address
INFO  Started Brooklyn console at http://127.0.0.1:8081/, running
classpath://brooklyn.war@
INFO  Persistence disabled
INFO  High availability disabled
INFO  Launched Brooklyn; will now block until shutdown command received via GUI/API
(recommended) or process interrupt.
```

Notice! Before launching Apache Brooklyn, please check the `date` on the local machine. Even several minutes before or after the actual time could cause problems.

Connect with Browser

Next, open the web console on http://127.0.0.1:8081. No applications have been deployed yet, so the "Create Application" dialog opens automatically.



Create Application

Choose or build the application to deploy

Template 1: Server
Sample YAML to provision a server in a cloud with illustrative VM properties

Template 2: Bash Web Server
Sample YAML building on Template 1, adding bash commands to launch a Python-based web server on port 8020

Template 3: Bash Web Server and Scaling Riak Cluster
Sample YAML building on Template 2, composing that blueprint with a Riak

Template 4: Resilient Load-Balanced Bash Web Cluster with Sensors
Sample YAML to provision a cluster of the bash/python web server nodes, with

Next

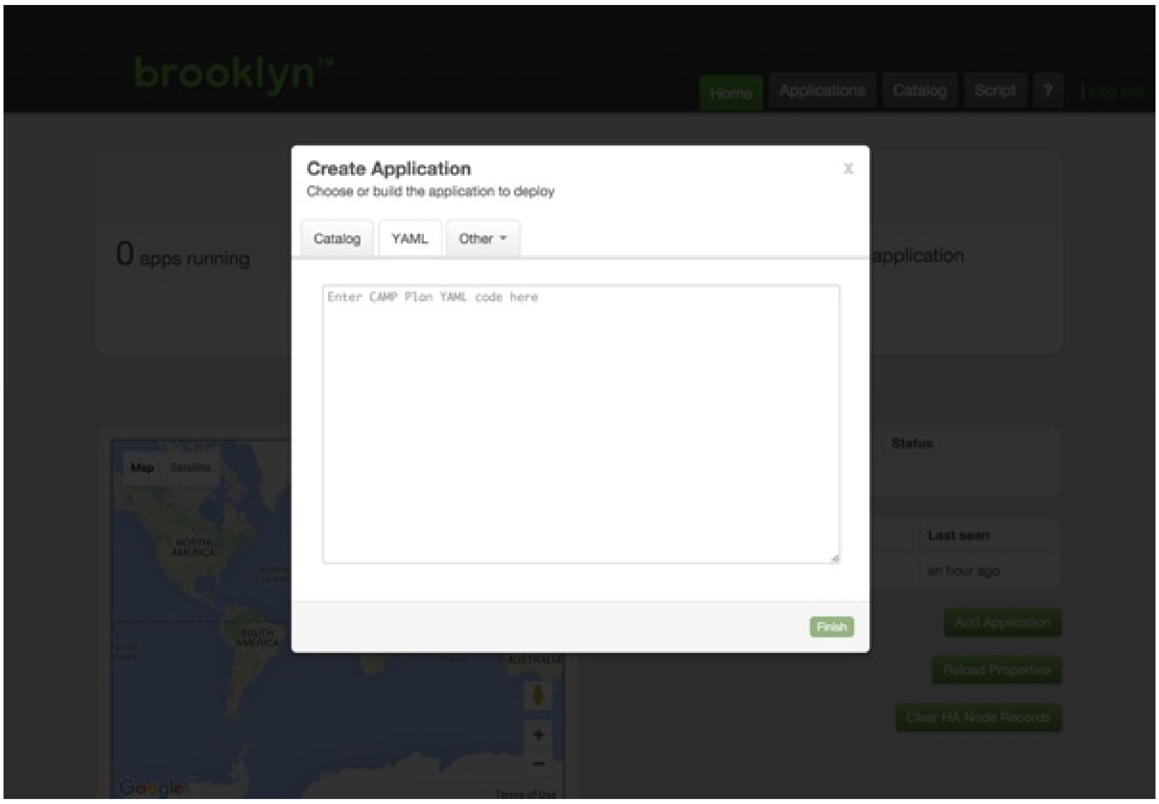
The next section will show how to **deploy a blueprint**.

Launching from a Blueprint

When you first access the web console on http://127.0.0.1:8081 you will be requested to create your first application.

We'll start by deploying an application via a YAML blueprint consisting of the following layers.

- MySQL DB
- Dynamic web application cluster
  - Nginx load balancer
  - Tomcat app server cluster



Switch to the YAML tab and copy the blueprint below into the large text box.

But *before* you submit it, modify the YAML to specify the location where the application will be deployed.

```
name: My Web Cluster

location:
  jclouds:aws-ec2:
    identity: ABCDEFGHIJKLMNOPQRST
    credential: s3cr3tsq1rr3ls3cr3tsq1rr3ls3cr3tsq1rr3l

services:
- type: org.apache.brooklyn.entity.webapp.ControlledDynamicWebAppCluster
  name: My Web
  id: webappcluster
  brooklyn.config:
    wars.root: http://search.maven.org/remotecontent?filepath=org/apache/brooklyn/example/brooklyn-example-hell
o-world-sql-webapp/0.8.0-incubating/brooklyn-example-hello-world-sql-webapp-0.8.0-incubating.war
    java.sysprops:
      brooklyn.example.db.url: >
        $brooklyn:formatString("jdbc:%s%s?user=%s&password=%s",
        component("db").attributeWhenReady("datastore.url"),
        "visitors", "brooklyn", $brooklyn:external("brooklyn-demo-sample", "hidden-brooklyn-password"))
```

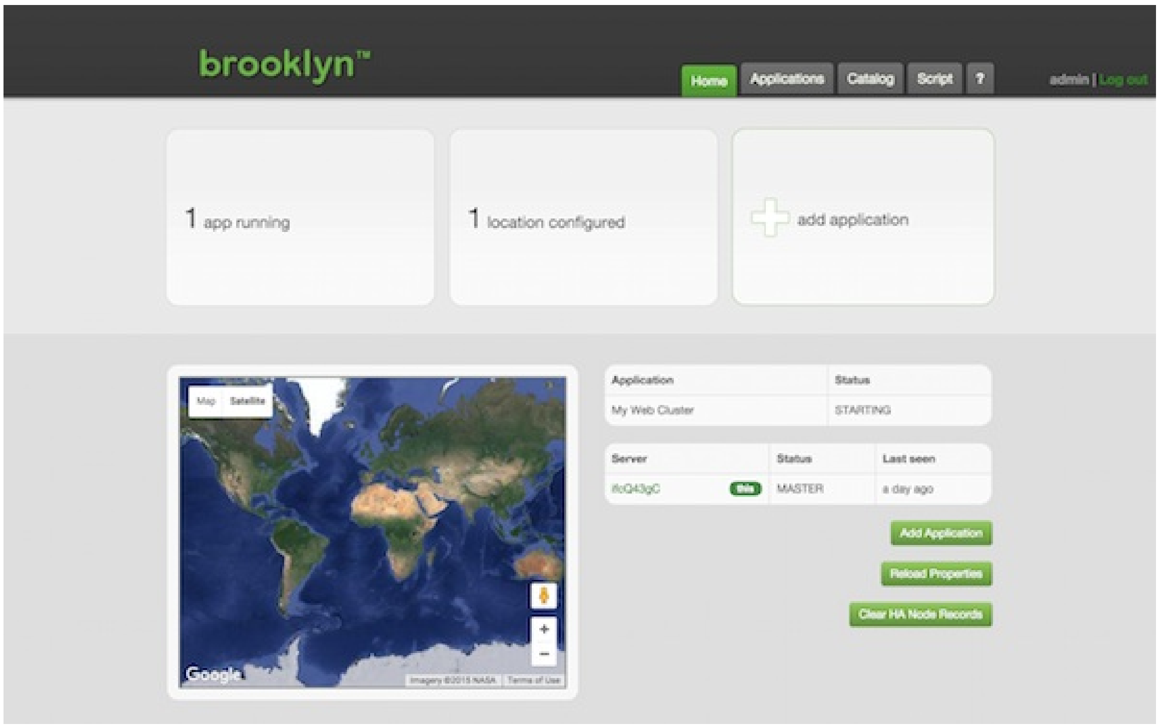
```
- type: org.apache.brooklyn.entity.database.mysql.MySqlNode
  name: My DB
  id: db
  brooklyn.config:
    creation.script.password: $brooklyn:external("brooklyn-demo-sample", "hidden-brooklyn-password")
    datastore.creation.script.url: https://bit.ly/brooklyn-visitors-creation-script
```

Replace the `location:` element with values for your chosen target environment, for example to use SoftLayer rather than AWS (updating with your own credentials):

```
location:
  jclouds:softlayer:
    identity: ABCDEFGHIJKLMNOPQRST
    credential: s3cr3tsq1rr3ls3cr3tsq1rr3ls3cr3tsq1rr3l
```

NOTE: See **Locations** in the Operations section of the User Guide for instructions on setting up alternate cloud providers, bring-your-own-nodes, or localhost targets, and storing credentials/locations in a file on disk rather than in the blueprint.

With the modified YAML in the dialog, click "Finish". The dialog will close and Brooklyn will begin deploying your application. Your application will be shown as "Starting" on the web console's front page.



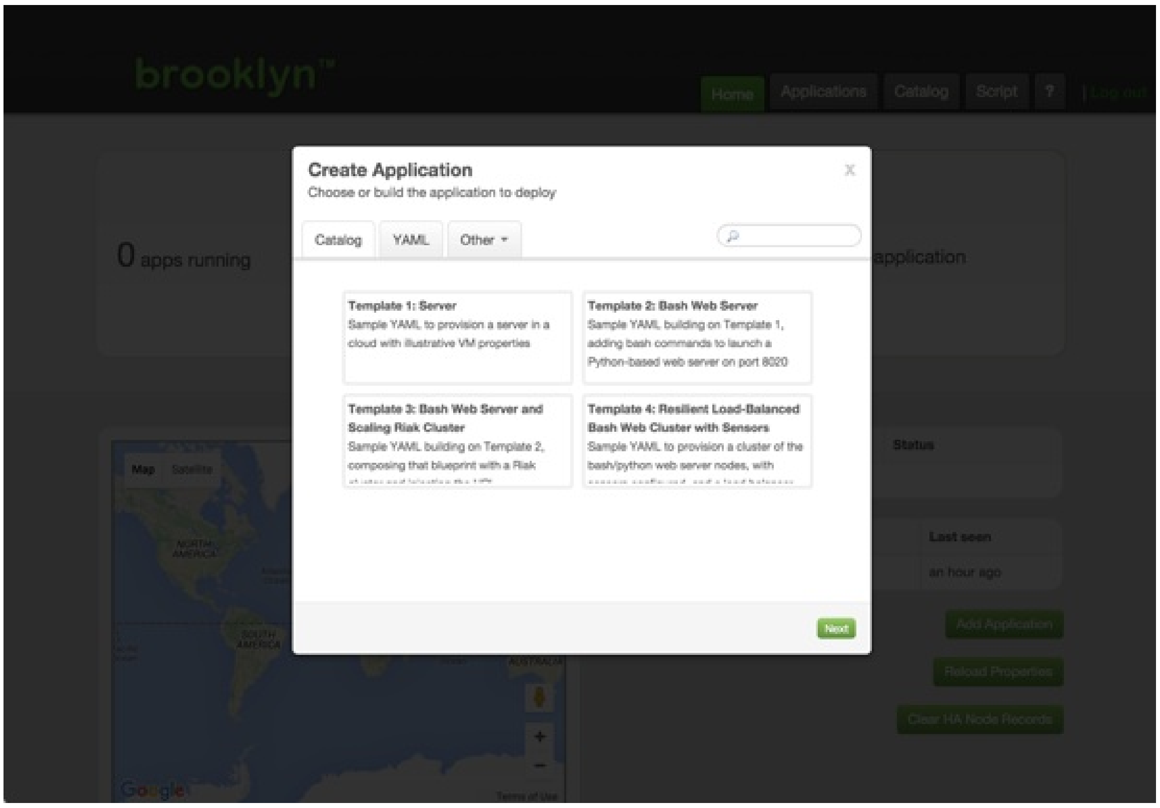
Application	Status
My Web Cluster	STARTING

Server	Status	Last seen
ifcQ43gC this	MASTER	a day ago

Depending on your choice of location it may take some time for the application nodes to start, the next page describes how you can monitor the progress of the application deployment and verify its successful deployment.

Launching from the Catalog

Instead of pasting the YAML blueprint each time, it can be added to the Brooklyn Catalog where it will be accessible from the Catalog tab of the Create Application dialog.



Create Application

Choose or build the application to deploy

Template 1: Server
Sample YAML to provision a server in a cloud with illustrative VM properties

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Sample YAML to provision a cluster of the bash/python web server nodes, with

See **Catalog** in the Operations section of the User Guide for instructions on creating a new Catalog entry from your Blueprint YAML.

Next

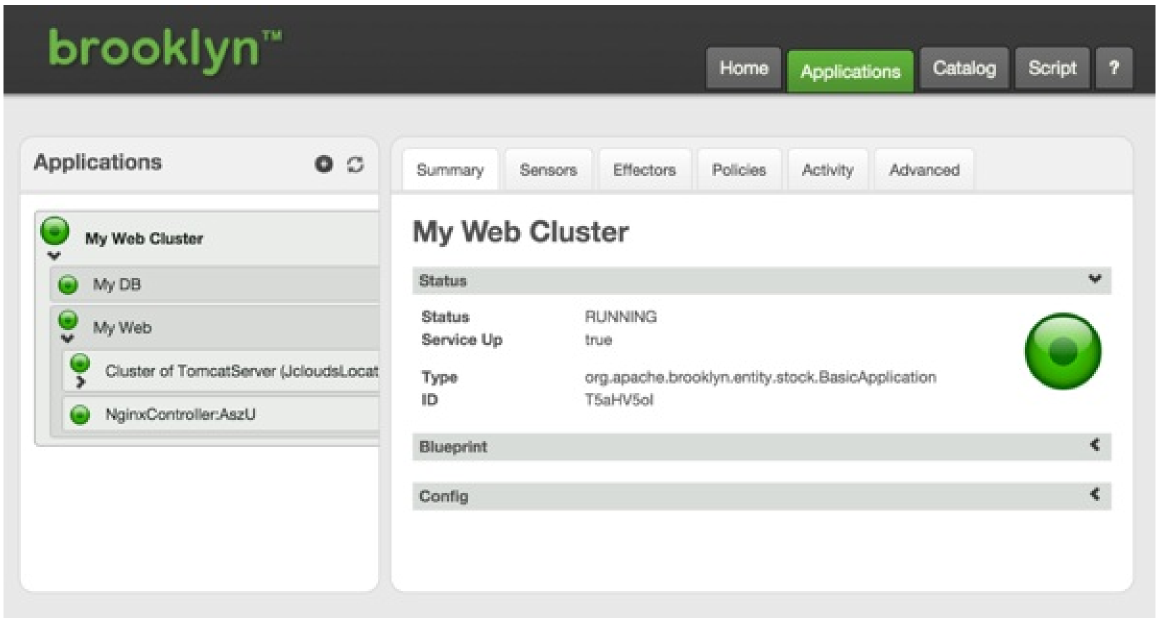
So far we have touched on Brooklyn's ability to *deploy* an application blueprint to a cloud provider.
The next section will show how to **Monitor and Manage Applications**.

From the Home page, click on the application name or open the Applications tab.

We can explore the management hierarchy of the application, which will show us the entities it is composed of. Starting from the application use the arrows to expand out the list of entities, or hover over the arrow until a menu popup is displayed so that you can select `Expand All`.

- My Web Cluster (A `BasicApplication`)
  - My DB (A `MySqlNode`)
  - My Web (A `ControlledDynamicWebAppCluster`)
    - Cluster of TomcatServer (A `DynamicWebAppCluster`)
      - quarantine (A `QuarantineGroup`)
      - TomcatServer (A `TomcatServer`)
    - NginxController (An `NginxController`)

Clicking on the "My Web Cluster" entity will show the "Summary" tab, giving a very high level of what that component is doing. Click on each of the child components in turn for more detail on that component. Note that the cluster of web servers includes a "quarantine group", to which members of the cluster that fail will be added. These are excluded from the load-balancer's targets.



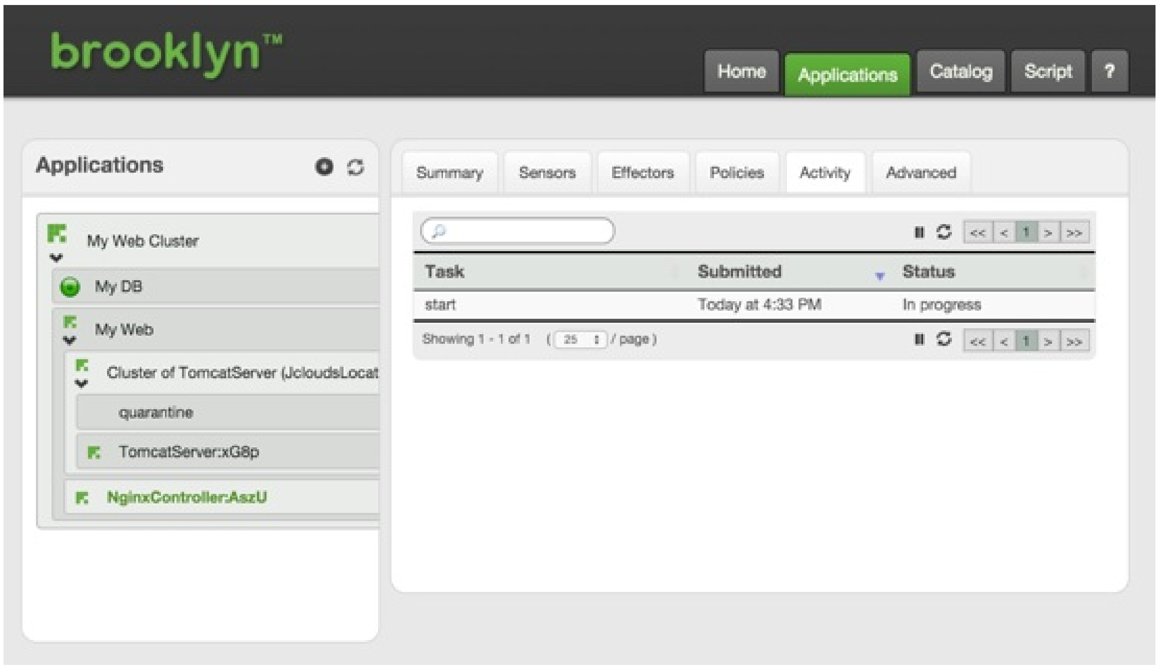
Status	RUNNING
Service Up	true
Type	org.apache.brooklyn.entity.stock.BasicApplication
ID	T5aHV5ol

Activities

The Activity tab allows us to drill down into the tasks each entity is currently executing or has recently completed. It is possible to drill down through all child tasks, and view the commands issued, along with any errors or warnings that occurred.

For example clicking on the NginxController in the left hand tree and opening its Activity tab you can observe the 'start' task is 'In progress'.

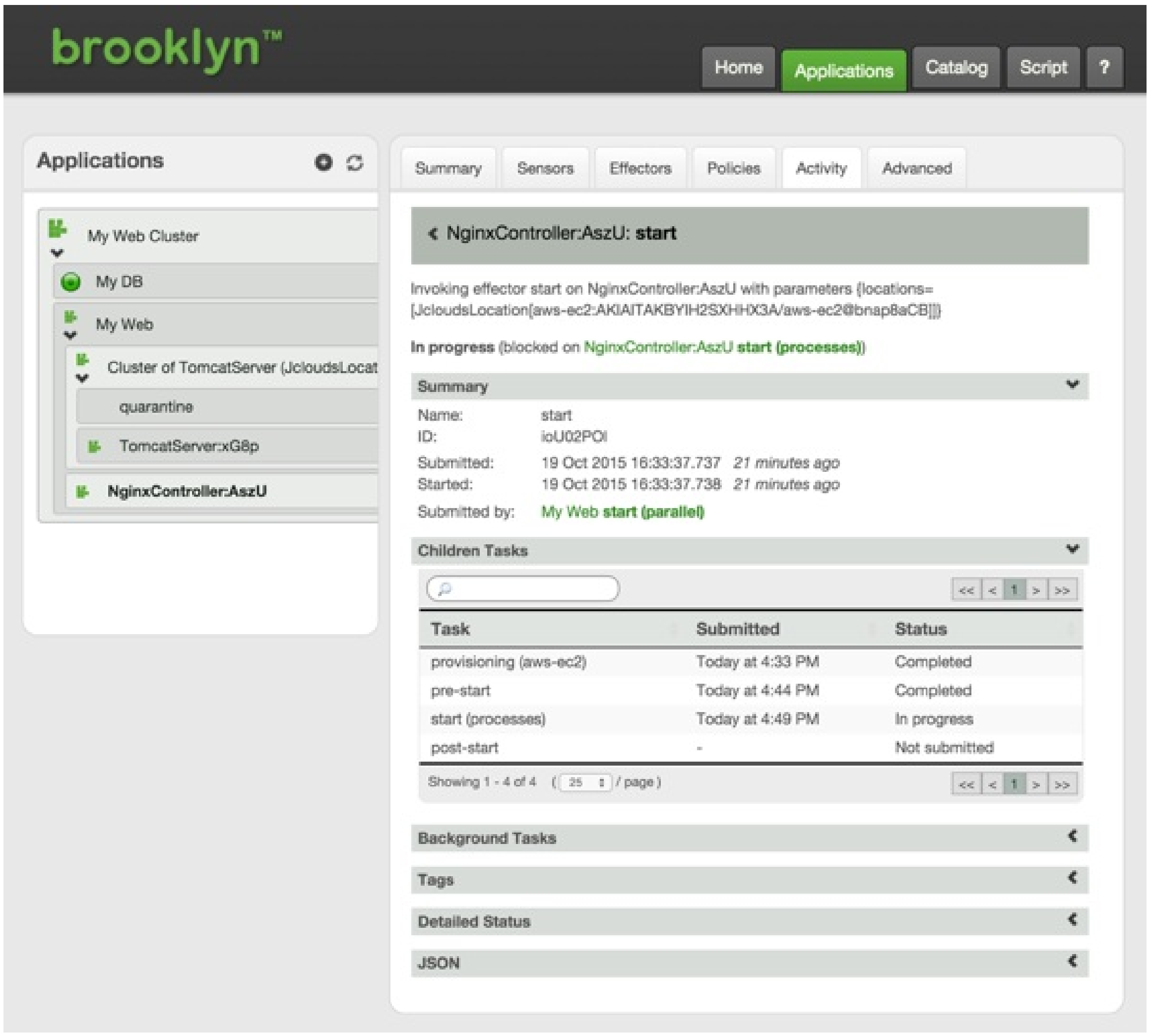
Note: You may observe different tasks depending on how far your deployment has progressed).



Task	Submitted	Status
start	Today at 4:33 PM	In progress

Showing 1 - 1 of 1 (25 / page)

Clicking on the 'start' task you can discover more details on the actions being carried out by that task (a task may consist of additional subtasks).



NginxController:AszU: **start**

Invoking effector start on NginxController:AszU with parameters {locations=[JcloudsLocation[aws-ec2:AKIAITAKBYIH2SXHHX3A/aws-ec2@bnap8aCB]]}

In progress (blocked on NginxController:AszU **start (processes)**)

Summary

Name:	start
ID:	ioU02POI
Submitted:	19 Oct 2015 16:33:37.737 *21 minutes ago*
Started:	19 Oct 2015 16:33:37.738 *21 minutes ago*
Submitted by:	My Web **start (parallel)**

Children Tasks

Task	Submitted	Status
provisioning (aws-ec2)	Today at 4:33 PM	Completed
pre-start	Today at 4:44 PM	Completed
start (processes)	Today at 4:49 PM	In progress
post-start	-	Not submitted

Showing 1 - 4 of 4 (25 / page)

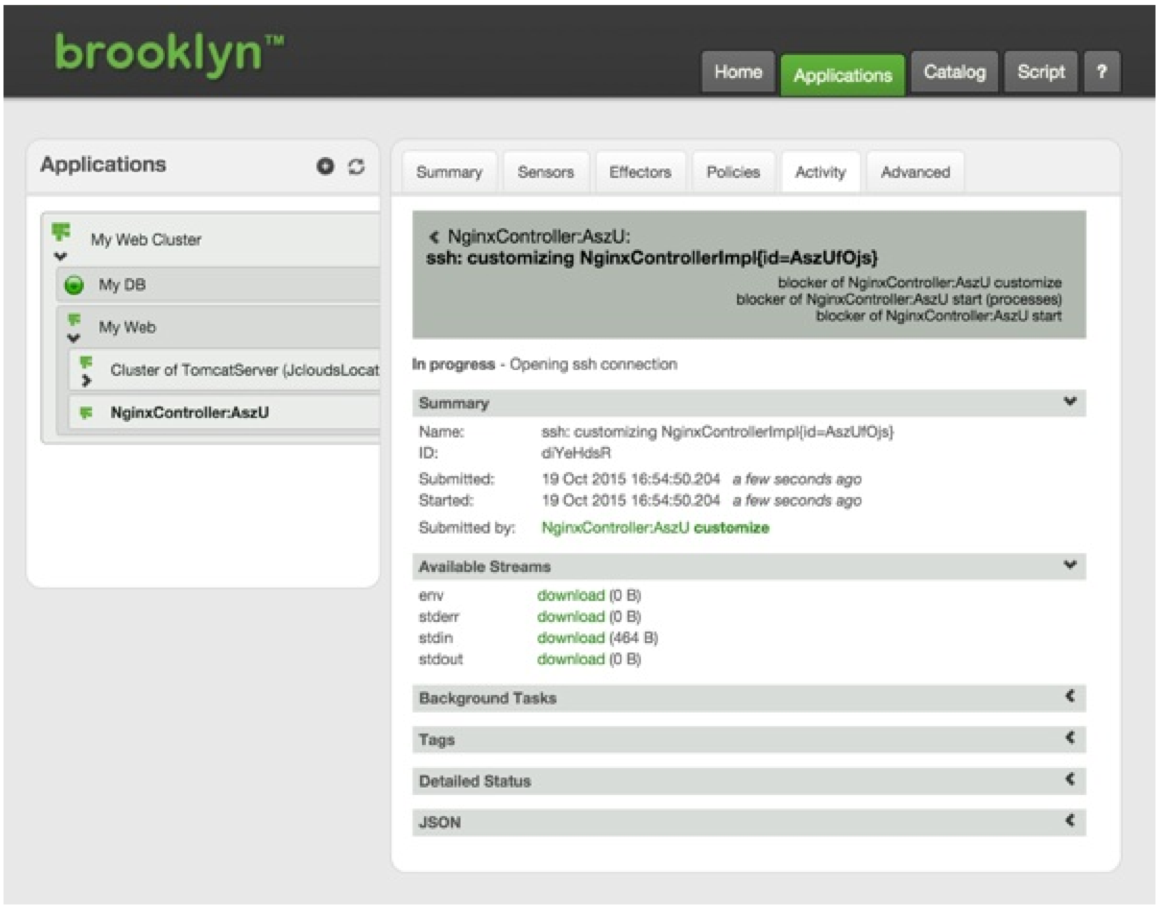
Background Tasks

Tags

Detailed Status

JSON

Continuing to drill down into the 'In progress' tasks you will eventually reach the currently active task where you can investigate the ssh command executed on the target node including the current stdin, stdout and stderr output.



NginxController:AszU:
ssh: customizing NginxControllerImpl{id=AszUfOjs}
blocker of NginxController:AszU customize
blocker of NginxController:AszU start (processes)
blocker of NginxController:AszU start

In progress - Opening ssh connection

Summary

Name: ssh: customizing NginxControllerImpl{id=AszUfOjs}
ID: diYeHdsR
Submitted: 19 Oct 2015 16:54:50.204 *a few seconds ago*
Started: 19 Oct 2015 16:54:50.204 *a few seconds ago*
Submitted by: NginxController:AszU **customize**

Available Streams

env download (0 B)
stderr download (0 B)
stdin download (464 B)
stdout download (0 B)

Background Tasks
Tags
Detailed Status
JSON

Sensors

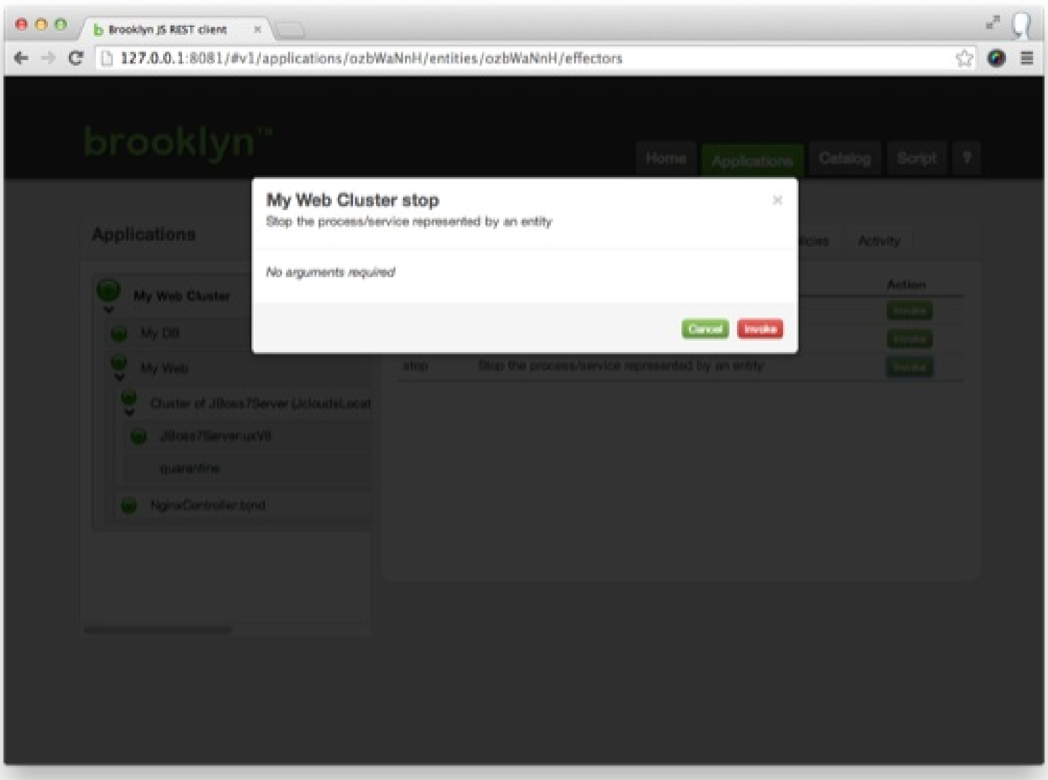
Now click on the "Sensors" tab: these data feeds drive the real-time picture of the application. As you navigate in the tree at the left, you can see more targeted statistics coming in in real-time.

Explore the sensors and the tree to find the URL where the *NginxController* for the webapp we just deployed is running. This can be found in '**My Web Cluster** -> **My Web** -> **NginxController** -> ***main.uri***'.

Quickly return to the **'Brooklyn JS REST client'** web browser tab showing the "Sensors" and observe the '**My Web Cluster** -> **My Web** -> **Cluster of TomcatServer** -> ***webapp.reqs.perSec.last***' sensor value increase.

Stopping the Application

To stop an application, select the application in the tree view (the top/root entity), click on the Effectors tab, and invoke the "Stop" effector. This will cleanly shutdown all components in the application and return any cloud machines that were being used.



My Web Cluster stop

Stop the process/service represented by an entity

No arguments required

Next

Brooklyn's real power is in using **Policies** to automatically *manage* applications.

Exploring and Testing Policies

To see an example of policy based management, please deploy the following blueprint (changing the location details as for the example shown earlier):

```
name: My Web Cluster

location: localhost

services:

- type: org.apache.brooklyn.entity.webapp.ControlledDynamicWebAppCluster
  name: My Web
  brooklyn.config:
    wars.root: http://search.maven.org/remotecontent?filepath=org/apache/brooklyn/example/brooklyn-example-hell
o-world-sql-webapp/0.8.0-incubating/brooklyn-example-hello-world-sql-webapp-0.8.0-incubating.war
    java.sysprops:
      brooklyn.example.db.url: >
        $brooklyn:formatString("jdbc:%s%s?user=%s&password=%s",
        component("db").attributeWhenReady("datastore.url"),
        "visitors", "brooklyn", $brooklyn:external("brooklyn-demo-sample", "hidden-brooklyn-password"))
  brooklyn.policies:
  - type: org.apache.brooklyn.policy.autoscaling.AutoScalerPolicy
    brooklyn.config:
      metric: webapp.reqs.perSec.windowed.perNode
      metricLowerBound: 0.1
      metricUpperBound: 10
      minPoolSize: 1
      maxPoolSize: 4
      resizeUpStabilizationDelay: 10s
      resizeDownStabilizationDelay: 1m

- type: org.apache.brooklyn.entity.database.mysql.MySqlNode
  id: db
  name: My DB
  brooklyn.config:
    creation.script.password: $brooklyn:external("brooklyn-demo-sample", "hidden-brooklyn-password")
    datastore.creation.script.url: https://bit.ly/brooklyn-visitors-creation-script
```

The app server cluster has an `AutoScalerPolicy`, and the loadbalancer has a `targets` policy.

Use the Applications tab in the web console to drill down into the Policies section of the ControlledDynamicWebAppCluster. You will see that the `AutoScalerPolicy` is running.

This policy automatically scales the cluster up or down to be the right size for the cluster's current load. One server is the minimum size allowed by the policy.

The loadbalancer's `targets` policy ensures that the loadbalancer is updated as the cluster size changes.

Sitting idle, this cluster will only contain one server, but you can use a tool like jmeter pointed at the nginx endpoint to create load on the cluster. Download a jmeter test plan here.

As load is added, Apache Brooklyn requests a new cloud machine, creates a new app server, and adds it to the cluster. As load is removed, servers are removed from the cluster, and the infrastructure is handed back to the cloud.

Under the Covers

The `AutoScalerPolicy` here is configured to respond to the sensor reporting requests per second per node, invoking the default `resize` effector. By clicking on the policy, you can configure it to respond to a much lower threshhold or set long stabilization delays (the period before it scales out or back).

An even simpler test is to manually suspend the policy, by clicking "Suspend" in the policies list. You can then switch to the "Effectors" tab and manually trigger a `resize`. On resize, new nodes are created and configured, and in this case a policy on the nginx node reconfigures nginx whenever the set of active targets changes.

Next

This guide has given a quick overview of using the Apache Brooklyn GUI to deploy, monitor and manage applications. The GUI also allows you to perform various Advanced management tasks and to explore and use the REST API (from the Script tab). Please take some time now to become more familiar with the GUI.

Then continue to read through the Operations Guide.

Apache Brooklyn exposes a powerful REST API, allowing it to be scripted from bash or integrated with other systems.

For many commands, the REST call follows the same structure as the web console URL scheme, but with the `#` at the start of the path removed; for instance the catalog item `cluster` in the web console is displayed at:

```
http://localhost:8081/#v1/catalog/entities/cluster:0.13.0-SNAPSHOT
```

And in the REST API it is accessed at:

```
http://localhost:8081/v1/catalog/entities/cluster:0.13.0-SNAPSHOT
```

A full reference for the REST API is automatically generated by the server at runtime. It can be found in the Brooklyn web console, under the Script tab.

Here we include some of the most common REST examples and other advice for working with the REST API.

Tooling Tips

For command-line access, we recommend `curl`, with tips below.

For navigating in a browser we recommend getting a plugin for working with REST; these are available for most browsers and make it easier to authenticate, set headers, and see JSON responses.

For manipulating JSON responses on the command-line, the library `jq` from stedolan's github is very useful, and available in most package repositories, including `port` and `brew` on Mac.

Common REST Examples

Here are some useful snippets:

- List applications

  ```
  curl http://localhost:8081/v1/applications
  ```

- Deploy an application from `__FILE__`

  ```
  curl http://localhost:8081/v1/applications --data-binary @__FILE__
  ```

- Get details of a task with ID `__ID__` (where the `id` is returned by the above, optionally piped to `jq .id`)

  ```
  curl http://localhost:8081/v1/activities/__ID__
  ```

- Get the value of sensor `service.state` on entity `e1` in application `app1` (note you can use either the entity's ID or its name)

  ```
  curl http://localhost:8081/v1/applications/app1/entities/e1/sensors/service.state
  ```

- Get all sensor values (using the pseudo-sensor `current-state`)

  ```
  curl http://localhost:8081/v1/applications/app1/entities/e1/sensors/service.state
  ```

- Invoke an effector `eff` on `e1`, with argument `arg1` equal to `hi` (note if no arguments, you must specify `-d ""`; for multiple args, just use multiple `-d` entries, or a JSON file with `--data-binary @...`)

```
curl http://localhost:8081/v1/applications/app1/entities/e1/effectors/eff -d arg1=hi
```

- Add an item to the catalog from `__FILE__`

```
curl http://localhost:8081/v1/catalog --data-binary @__FILE__
```

Curl Cheat Sheet

- if authentication is required, use `--user username:password`
- to see detailed output, including headers, code, and errors, use `-v`
- where the request is not a simple HTTP GET, use `-X POST` or `-X DELETE`
- to pass key-value data to a post, use `-d key=value`
- where you are posting from a file `__FILE__` , use `--data-binary @__FILE__` (implies a POST) or `-T __FILE__ -X POST`
- to add a header, use `-H "key: value"` , for example `-H "Brooklyn-Allow-Non-Master-Access: true"`
- to specify that a specific content-type is being uploaded, use `-H "Content-Type: application/json"` (or `application/yaml`)
- to specify the content-type required for the result, use `-H "Accept: application/json"` (or `application/yaml` , or for sensor values, `text/plain`)

Apache Brooklyn contains a number of configuration options managed across several files. Historically Brooklyn has been configured through a brooklyn.properties file, this changed to a brooklyn.cfg file when the Karaf release became the default in Brooklyn 0.12.0.

The configurations for persistence and high availability are described elsewhere in this manual.

Configuration of Apache Brooklyn when running under Karaf is largely done through standard Karaf mechanisms. The Karaf "Configuration Admin" subsystem is used to manage configuration values loaded at first boot from the `.cfg` files in the `etc` directory of the distribution. In the Karaf command line these can then be viewed and manipulated by the `config:` commands, see the Karaf documentation for full details.

Configuring Brooklyn Properties

To configure the Brooklyn runtime create an `etc/brooklyn.cfg` file. If you have previously used `brooklyn.properties` it follows the same file format. Values can be viewed and managed dynamically via the OSGI configuration admin commands in Karaf, e.g. `config:property-set` . The global `~/.brooklyn/brooklyn.properties` is still supported and has higher priority for duplicate keys, but it's values can't be manipulated with the Karaf commands, so its use is discouraged.

You can use the standard `~/.brooklyn/brooklyn.properties` file to configure Brooklyn. Alternatively create `etc/brooklyn.cfg` inside the distribution folder (same file format). The keys in the former override those in the latter.

Web console related configuration is done through the corresponding Karaf mechanisms:

- The port is set in `etc/org.ops4j.pax.web.cfg` , key `org.osgi.service.http.port` .
- For authentication the JAAS realm "webconsole" is used; by default it will use any SecurityProvider implementations configured in Brooklyn falling back to auto generating the password. To configure a custom JAAS realm see the `jetty.xml` file in `brooklyn-server/karaf/jetty-config/src/main/resources` and override it by creating a custom one in `etc` folder. Point the "webconsole" login service to the JAAS realm you would like to use.
    - For other Jetty related configuration consult the Karaf and pax-web docs.

Memory Usage

The amount of memory required by Apache Brooklyn process depends on the usage - for example the number of entities/VMs under management.

For a standard Brooklyn deployment, the defaults are to start with 256m, and to grow to 2g of memory. These numbers can be overridden by setting the `JAVA_MAX_MEM` and `JAVA_MAX_PERM_MEM` in the `bin/setenv` script:

```
export JAVA_MAX_MEM="2G"
```

Apache Brooklyn stores a task history in-memory using soft references. This means that, once the task history is large, Brooklyn will continually use the maximum allocated memory. It will only expunge tasks from memory when this space is required for other objects within the Brooklyn process.

Authentication and Security

There are two areas of authentication used in Apache Brooklyn, these are as follows:

- Karaf authentication

Apache Brooklyn uses Apache Karaf as a core platform, this has user level security and groups which can be configured as detailed here.

- Apache Brooklyn authentication

Users and passwords for Brooklyn can be configured in the brooklyn.cfg as detailed here.

HTTPS Configuration

See HTTPS Configuration for general information on configuring HTTPS.

<!--

-- NOTE: comment out this section on catalog as the behaviour described is not enabled by default since

-- https://github.com/apache/brooklyn-server/pull/233; re-enable this when that changes

Catalog in Karaf

With the traditional launcher, Brooklyn loads the initial contents of the catalog from a `default.catalog.bom` file as described in the section on installation. Brooklyn finds Java implementations to provide for certain things in blueprints (entities, enrichers etc.) by scanning the classpath.

In the OSGI world this approach is not used, as each bundle only has visibility of its own and its imported Java packages. Instead, in Karaf, each bundle can declare its own `catalog.bom` file, in the root of the bundle, with the catalog declarations for any entities etc. that the bundle contains.

For example, the `catalog.bom` file for Brooklyn's Webapp bundle looks like (abbreviated):

```
brooklyn.catalog:
    version: ...
    items:
    - id: org.apache.brooklyn.entity.webapp.nodejs.NodeJsWebAppService
      itemType: entity
      item:
        type: org.apache.brooklyn.entity.webapp.nodejs.NodeJsWebAppService
        name: Node.JS Application
    ...
    - id: resilient-bash-web-cluster-template
      itemType: template
      name: "Template: Resilient Load-Balanced Bash Web Cluster with Sensors"
      description: |
        Sample YAML to provision a cluster of the bash/python web server nodes,
        with sensors configured, and a load balancer pointing at them,
        and resilience policies for node replacement and scaling
      item:
        name: Resilient Load-Balanced Bash Web Cluster (Brooklyn Example)
```

In the above YAML the first item declares that the bundle provides an entity whose type is `org.apache.brooklyn.entity.webapp.nodejs.NodeJsWebAppService`, and whose name is 'Node.JS Application'. The second item declares that the bundle provides a template application, with id `resilient-bash-web-cluster-template`, and includes a description for what this is.

Configuring the applications in the Catalog

When running some particular deployment of Brooklyn it may not be desirable for the sample applications to appear in the catalog (for clarity, "application" here in the sense of an item with `itemType: template`). For example, if you have developed some bundle with your own application and added it to Karaf then you might want only your own application to appear in the catalog.

Brooklyn contains a mechanism to allow you to configure what bundles will add their applications to the catalog. The Karaf configuration file `/etc/org.apache.brooklyn.core.catalog.bomscanner.cfg` contains two properties, one `whitelist` and the other `blacklist`, that bundles must satisfy for their applications to be added to the catalog. Each property value is a comma-separated list of regular expressions. The symbolic id of the bundle must match one of the regular expressions on the whitelist, and not match any expression on the blacklist, if its applications are to be added to the bundle. The default values of these properties are to admit all bundles, and forbid none.

Caveats

In the OSGi world specifying class names by string in Brooklyn's configuration will work only for classes living in Brooklyn's core modules. Raise an issue or ping us on IRC if you find a case where this doesn't work for you. For custom SecurityProvider implementations refer to the documentation of BrooklynLoginModule.

END Catalog in Karaf comment -->

By default Brooklyn persists its state to storage so that a server can be restarted without loss or so a high availability standby server can take over.

Brooklyn can persist its state to one of two places: the file system, or to an object store of your choice.

Configuration

To configure persistence, edit the file `org.apache.brooklyn.osgilauncher.cfg` in the `etc` directory of your Brooklyn instance. The following options are available:

`persistMode` - This is the mode in which persistence is running, in and is set to `AUTO` by default. The possible values are:

- `AUTO` - will rebind to any existing state, or start up fresh if no state;
- `DISABLED` - will not read or persist any state;
- `REBIND` - will rebind to the existing state, or fail if no state available;
- `CLEAN` - will start up fresh (removing any existing state)

`persistenceDir` - This is the directory to which Apache Brooklyn reads and writes its persistence data. The default location depends on your installation method. Checkout this page for more information.

`persistenceLocation` - This is the location for an object store to read and write persisted state.

`persistPeriod` - This is an interval period which can be set to reduce the frequency with which persistence is carried out, for example `1s`.

File-based Persistence

Apache Brooklyn starts with file-based persistence by default, saving data in the persisted state folder. For the rest of this document we will refer to this location as `%persistence-home%`.

If there is already data at `%persistence-home%/data`, then a backup of the directory will be made. This will have a name like `%persistence-home%/backups/%date%-%time%-jvyX7Wis-promotion-igFH`. This means backups of the data directory will be automatically created each time Brooklyn is restarted (or if a standby Brooklyn instances takes over as master).

The state is written to the given path. The file structure under that path is:

- `./catalog/`
- `./enrichers/`
- `./entities/`
- `./feeds/`
- `./locations/`
- `./nodes/`
- `./plane/`
- `./policies/`

In each of those directories, an XML file will be created per item - for example a file per entity in `./entities/`. This file will capture all of the state - for example, an entity's: id; display name; type; config; attributes; tags; relationships to locations, child entities, group membership, policies and enrichers; and dynamically added effectors and sensors.

Object Store Persistence

Apache Brooklyn can persist its state to any Object Store API supported by Apache jclouds including S3, Swift and Azure. This gives access to any compatible Object Store product or cloud provider including AWS-S3, SoftLayer, Rackspace, HP and Microsoft Azure. For a complete list of supported providers, see jclouds.

To configure the Object Store, add the credentials to `brooklyn.cfg` such as:

```
brooklyn.location.named.aws-s3-eu-west-1=aws-s3:eu-west-1
brooklyn.location.named.aws-s3-eu-west-1.identity=ABCDEFGHIJKLMNOPQRSTU
brooklyn.location.named.aws-s3-eu-west-1.credential=abcdefghijklmnopqrstuvwxyz1234567890ab/c
```

or:

```
brooklyn.location.named.softlayer-swift-ams01=jclouds:openstack-swift:https://ams01.objectstorage.softlayer.net
/auth/v1.0
brooklyn.location.named.softlayer-swift-ams01.identity=ABCDEFGHIJKLM:myname
brooklyn.location.named.softlayer-swift-ams01.credential=abcdefghijklmnopqrstuvwxyz1234567890abcdefghijklmnopqr
stuvwxyz12
brooklyn.location.named.softlayer-swift-ams01.jclouds.keystone.credential-type=tempAuthCredentials
```

Then edit the `persistenceLocation` to point at this object store: `softlayer-swift-ams01`.

Rebinding to State

When Brooklyn starts up pointing at existing state, it will recreate the entities, locations and policies based on that persisted state.

Once all have been created, Brooklyn will "manage" the entities. This will bind to the underlying entities under management to update the each entity's sensors (e.g. to poll over HTTP or JMX). This new state will be reported in the web-console and can also trigger any registered policies.

Handling Rebind Failures

If rebind fails fail for any reason, details of the underlying failures will be reported in the `brooklyn.debug.log`. This will include the entities, locations or policies which caused an issue, and in what way it failed. There are several approaches to resolving problems.

1) Determine Underlying Cause

Go through the log and identify the likely areas in the code from the error message.

2) Seek Help

Help can be found by contacting the Apache Brooklyn mailing list.

3) Fix-up the State

The state of each entity, location, policy and enricher is persisted in XML. It is thus human readable and editable.

After first taking a backup of the state, it is possible to modify the state. For example, an offending entity could be removed, or references to that entity removed, or its XML could be fixed to remove the problem.

4) Fixing with Groovy Scripts

The final (powerful and dangerous!) tool is to execute Groovy code on the running Brooklyn instance. If authorized, the REST api allows arbitrary Groovy scripts to be passed in and executed. This allows the state of entities to be modified (and thus fixed) at runtime.

If used, it is strongly recommended that Groovy scripts are run against a disconnected Brooklyn instance. After fixing the entities, locations and/or policies, the Brooklyn instance's new persisted state can be copied and used to fix the production instance.

Writing Persistable Code

The most common problem on rebind is that custom entity code has not been written in a way that can be persisted and/or rebound.

The rule of thumb when implementing new entities, locations, policies and enrichers is that all state must be persistable. All state must be stored as config or as attributes, and must be serializable. For making backwards compatibility simpler, the persisted state should be clean.

Below are tips and best practices for when implementing an entity in Java (or any other JVM language).

How to store entity state:

- Config keys and values are persisted.
- Store an entity's runtime state as attributes.
- Don't store state in arbitrary fields - the field will not be persisted (this is a design decision, because Brooklyn cannot intercept the field being written to, so cannot know when to persist).
- Don't just modify the retrieved attribute value (e.g. `getAttribute(MY_LIST).add("a")` is bad). The value may not be persisted unless setAttribute() is called.
- For special cases, it is possible to call `entity.requestPerist()` which will trigger asynchronous persistence of the entity.
- Overriding (and customizing) of `getRebindSupport()` is discouraged - this will change in a future version.

How to store policy/enricher/location state:

- Store values as config keys where applicable.
- Unfortunately these (currently) do not have attributes. Normally the state of a policy or enricher is transient - on rebind it starts afresh, for example with monitoring the performance or health metrics rather than relying on the persisted values.
- For special cases, you can annotate a field with `@SetFromFlag` for it be persisted. When you call `requestPersist()` then values of these fields will be scheduled to be persisted. *Warning: the `@SetFromFlag` functionality may change in future versions.*

Persistable state:

- Ensure values can be serialized. This (currently) uses xstream, which means it does not need to implement `Serializable` .
- Always use static (or top-level) classes. Otherwise it will try to also persist the outer instance!
- Any reference to an entity or location will be automatically swapped out for marker, and re-injected with the new entity/location instance on rebind. The same applies for policies, enrichers, feeds, catalog items and `ManagementContext` .

Behaviour on rebind:

- By extending `SoftwareProcess` , entities get a lot of the rebind logic for free. For example, the default `rebind()` method will call `connectSensors()` . See `SoftwareProcess` Lifecycle for more details.
- If necessary, implement rebind. The `entity.rebind()` is called automatically by the Brooklyn framework on rebind, after configuring the entity's config/attributes but before the entity is managed. Note that `init()` will not be called on rebind.
- Feeds will be persisted if and only if `entity.addFeed(...)` was called. Otherwise the feed needs to be re-registered on rebind. *Warning: this behaviour may change in future version.*

- All functions/predicates used with persisted feeds must themselves be persistable - use of anonymous inner classes is strongly discouraged.
- Subscriptions (e.g. from calls to `subscribe(...)` for sensor events) are not persisted. They must be re-registered on rebind. *Warning: this behaviour may change in future version.*

Below are tips to make backwards-compatibility easier for persisted state:

- Never use anonymous inner classes - even in static contexts. The auto-generated class names are brittle, making backwards compatibility harder.
- Always use sensible field names (and use `transient` whenever you don't want it persisted). The field names are part of the persisted state.
- Consider using Value Objects for persisted values. This can give clearer separation of responsibilities in your code, and clearer control of what fields are being persisted.
- Consider writing transformers to handle backwards-incompatible code changes. Brooklyn supports applying transformations to the persisted state, which can be done as part of an upgrade process.

Persisted State Backup

File system backup

When using the file system it is important to ensure it is backed up regularly.

One could use `rsync` to regularly backup the contents to another server.

It is also recommended to periodically create a complete archive of the state. A simple mechanism is to run a CRON job periodically (e.g. every 30 minutes) that creates an archive of the persistence directory, and uploads that to a backup facility (e.g. to S3).

Optionally, to avoid excessive load on the Brooklyn server, the archive-generation could be done on another "data" server. This could get a copy of the data via an `rsync` job.

An example script to be invoked by CRON is shown below:

```
DATE=`date "+%Y%m%d.%H%M.%S"`
BACKUP_FILENAME=/path/to/archives/back-${DATE}.tar.gz
DATA_DIR=/path/to/base/dir/data

tar --exclude '*/backups/*' -czvf $BACKUP_FILENAME $DATA_DIR
# For s3cmd installation see http://s3tools.org/repositories
s3cmd put $BACKUP_FILENAME s3://mybackupbucket
rm $BACKUP_FILENAME
```

Object store backup

Object Stores will normally handle replication. However, many such object stores do not handle versioning (i.e. to allow access to an old version, if an object has been incorrectly changed or deleted).

The state can be downloaded periodically from the object store, archived and backed up.

An example script to be invoked by CRON is shown below:

```
DATE=`date "+%Y%m%d.%H%M.%S"`
BACKUP_FILENAME=/path/to/archives/back-${DATE}.tar.gz
TEMP_DATA_DIR=/path/to/tempdir

brooklyn copy-state \
        --persistenceLocation named:my-persistence-location \
        --persistenceDir /path/to/bucket \
        --destinationDir $TEMP_DATA_DIR

tar --exclude '*/backups/*' -czvf $BACKUP_FILENAME $TEMP_DATA_DIR
# For s3cmd installation see http://s3tools.org/repositories
s3cmd put $BACKUP_FILENAME s3://mybackupbucket
rm $BACKUP_FILENAME
rm -r $TEMP_DATA_DIR
```

Brooklyn will automatically run in HA mode if multiple Brooklyn instances are started pointing at the same persistence store. One Brooklyn node (e.g. the first one started) is elected as HA master: all *write operations* against Brooklyn entities, such as creating an application or invoking an effector, should be directed to the master.

Once one node is running as `MASTER` , other nodes start in either `STANDBY` or `HOT_STANDBY` mode:

- In `STANDBY` mode, a Brooklyn instance will monitor the master and will be a candidate to become `MASTER` should the master fail. Standby nodes do *not* attempt to rebind until they are elected master, so the state of existing entities is not available at the standby node. However a standby server consumes very little resource until it is promoted.
- In `HOT_STANDBY` mode, a Brooklyn instance will read and make available the live state of entities. Thus a hot-standby node is available as a read-only copy. As with the standby node, if a hot-standby node detects that the master fails, it will be a candidate for promotion to master.
- In `HOT_BACKUP` mode, a Brooklyn instance will read and make available the live state of entities, as a read-only copy. However this node is not able to become master, so it can safely be used to test compatibility across different versions.

To explicitly specify what HA mode a node should be in, the following options are available for the config option `highAvailabilityMode` in `org.apache.brooklyn.osgilauncher.cfg` :

- `DISABLED` : management node works in isolation; it will not cooperate with any other standby/master nodes in management plane
- `AUTO` : will look for other management nodes, and will allocate itself as standby or master based on other nodes' states
- `MASTER` : will startup as master; if there is already a master then fails immediately
- `STANDBY` : will start up as lukewarm standby; if there is not already a master then fails immediately
- `HOT_STANDBY` : will start up as hot standby; if there is not already a master then fails immediately
- `HOT_BACKUP` : will start up as hot backup; this can be done even if there is not already a master; this node will not be a master

The REST API offers live detection and control of the HA mode, including setting priority to control which nodes will be promoted on master failure:

- `/server/ha/state` : Returns the HA state of a management node (GET), or changes the state (POST)
- `/server/ha/states` : Returns the HA states and detail for all nodes in a management plane
- `/server/ha/priority` : Returns the HA node priority for MASTER failover (GET), or sets that priority (POST)

Note that when POSTing to a non-master server it is necessary to pass a `Brooklyn-Allow-Non-Master-Access: true` header. For example, the following cURL command could be used to change the state of a `STANDBY` node on `localhost:8082` to `HOT_STANDBY` :

```
curl -v -X POST -d mode=HOT_STANDBY -H "Brooklyn-Allow-Non-Master-Access: true" http://localhost:8082/v1/server
/ha/state
```

This supplements the High Availability documentation and provides an example of how to configure a pair of Apache Brooklyn servers to run in master-standby mode with a shared NFS datastore

Prerequisites

- Two VMs (or physical machines) have been provisioned
- NFS or another suitable file system has been configured and is available to both VMs*
- An NFS folder has been mounted on both VMs at `/mnt/brooklyn-persistence` and both machines can write to the folder

* Brooklyn can be configured to use either an object store such as S3, or a shared NFS mount. The recommended option is to use an object store as described in the Object Store Persistence documentation. For simplicity, a shared NFS folder is assumed in this example

Launching

To start, download and install the latest Apache Brooklyn release on both VMs following the instructions in Running Apache Brooklyn

On the first VM, which will be the master node, set the following configuration options in `org.apache.brooklyn.osgilauncher.cfg`:

- highAvailabilityMode: MASTER
- persistMode: AUTO
- persistenceDir: /mnt/brooklyn-persistence

Then launch Brooklyn with:

```
$ bin/start
```

If you are using RPMs/deb to install, please see the Running Apache Brooklyn documentation for the appropriate launch commands

Once Brooklyn has launched, on the second VM, set the following configuration options in `org.apache.brooklyn.osgilauncher.cfg`:

- highAvailabilityMode: AUTO
- persistMode: AUTO
- persistenceDir: /mnt/brooklyn-persistence

Then launch the standby Brooklyn with:

```
$ bin/start
```

Failover

When running as a HA standby node, each standby Brooklyn server (in this case there is only one standby) will check the shared persisted state every one second to determine the state of the HA master. If no heartbeat has been recorded for 30 seconds, then an election will be performed and one of the standby nodes will be promoted to master. At this point all requests should be directed to the new master node. If the master is terminated gracefully, the secondary will be immediately promoted to mater. Otherwise, the secondary will be promoted after heartbeats are missed for a given length of time. This defaults to 30 seconds, and is configured in `brooklyn.cfg` using `brooklyn.ha.heartbeatTimeout`

In the event that tasks - such as the provisioning of a new entity - are running when a failover occurs, the new master will display the current state of the entity, but will not resume its provisioning or re-run any partially completed tasks. In this case it may be necessary to remove the entity and reprovision it. In the case of a failover whilst executing a task called by an effector, it may be possible to simple call the effector again

Client Configuration

It is the responsibility of the client to connect to the master Brooklyn server. This can be accomplished in a variety of ways:

- ### Reverse Proxy

  To allow the client application to automatically fail over in the event of a master server becoming unavailable, or the promotion of a new master, a reverse proxy can be configured to route traffic depending on the response returned by `https://<ip-address>:8443/v1/server/ha/state` (see above). If a server returns `"MASTER"` , then traffic should be routed to that server, otherwise it should not be. The client software should be configured to connect to the reverse proxy server and no action is required by the client in the event of a failover. It can take up to 30 seconds for the standby to be promoted, so the reverse proxy should retry for at least this period, or the failover time should be reconfigured to be shorter

- ### Re-allocating an Elastic IP on Failover

  If the cloud provider you are using supports Elastic or Floating IPs, then the IP address should be allocated to the HA master, and the client application configured to connect to the floating IP address. In the event of a failure of the master node, the standby node will automatically be promoted to master, and the floating IP will need to be manually re-allocated to the new master node. No action is required by the client in the event of a failover. It is possible to automate the re-allocation of the floating IP if the Brooklyn servers are deployed and managed by Brooklyn using the entity `org.apache.brooklyn.entity.brooklynnode.BrooklynCluster`

- ### Client-based failover

  In this scenario, the responsibilty for determining the Brooklyn master server falls on the client application. When configuring the client application, a list of all servers in the cluster is passed in at application startup. On first connection, the client application connects to any of the members of the cluster to retrieve the HA states (see above). The JSON object returned is used to determine the addresses of all members of the cluster, and also to determine which node is the HA master

  In the event of a failure of the master node, the client application should then retrieve the HA states of the cluster from any of the other cluster members. This is the same process as when the application first connects to the cluster. The client should refresh its list of cluster memebers and determine which node is the HA master

  It is also recommended that the client application periodically checks the status of the cluster and updates its list of addresses. This will ensure that failover is still possible if the standby server(s) has been replaced. It also allows additional standby servers to be added at any time

Testing

You can confirm that Brooklyn is running in high availibility mode on the master by logging into the web console at `https://<ip-address>:8443` . Similarly you can log into the web console on the standby VM where you will see a warning that the server is not the high availability master.

To test a failover, you can simply terminate the process on the first VM and log into the web console on the second VM. Upon launch, Brooklyn will output its PID to the file `pid.txt` ; you can force an immediate (non-graceful) termination of the process by running the following command from the same directory from which you launched Brooklyn:

```
$ kill -9 $(cat pid.txt)
```

It is also possiblity to check the high availability state of a running Brooklyn server using the following curl command:

```
$ curl -k -u myusername:mypassword https://<ip-address>:8443/v1/server/ha/state
```

This will return one of the following states:

```
"INITIALIZING"
"STANDBY"
"HOT_STANDBY"
"HOT_BACKUP"
"MASTER"
"FAILED"
"TERMINATED"
```

Note: The quotation characters will be included in the reply

To obtain information about all of the nodes in the cluster, run the following command against any of the nodes in the cluster:

```
$ curl -k -u myusername:mypassword https://<ip-address>:8443/v1/server/ha/states
```

This will return a JSON document describing the Brooklyn nodes in the cluster. An example of two HA Brooklyn nodes is as follows (whitespace formatting has been added for clarity):

```
{
  ownId: "XkJeXUXE",
  masterId: "yAVz0fzo",
  nodes: {
    yAVz0fzo: {
      nodeId: "yAVz0fzo",
      nodeUri: "https://<server1-ip-address>:8443/",
      status: "MASTER",
      localTimestamp: 1466414301065,
      remoteTimestamp: 1466414301000
    },
    XkJeXUXE: {
      nodeId: "XkJeXUXE",
      nodeUri: "https://<server2-ip-address>:8443/",
      status: "STANDBY",
      localTimestamp: 1466414301066,
      remoteTimestamp: 1466414301000
    }
  },
  links: { }
}
```

The examples above show how to use `curl` to manually check the status of Brooklyn via its REST API. The same REST API calls can also be used by automated third party monitoring tools such as Nagios

Brooklyn uses the SLF4J logging facade, which allows use of many popular frameworks including `logback`, `java.util.logging` and `log4j`.

The convention for log levels is as follows:

- `ERROR` and above: exceptional situations which indicate that something has unexpectedly failed or some other problem has occured which the user is expected to attend to
- `WARN` : exceptional situations which the user may which to know about but which do not necessarily indicate failure or require a response
- `INFO` : a synopsis of activity, but which should not generate large volumes of events nor overwhelm a human observer
- `DEBUG` and lower: detail of activity which is not normally of interest, but which might merit closer inspection under certain circumstances.

Loggers follow the `package.ClassName` naming standard.

Using Logback through OSGi Pax Logging

In the OSGi based Apache Brooklyn logging is configured from ops4j pax logging.

See: Logging - OSGi based Apache Brooklyn
https://ops4j1.jira.com/wiki/display/paxlogging/Configuration

Standard Configuration

A `logback.xml` file is included in the `conf/` directly of the Brooklyn distro; this is read by `brooklyn` at launch time. Changes to the logging configuration, such as new appenders or different log levels, can be made directly in this file or in a new file included from this.

Advanced Configuration

The default `logback.xml` file references a collection of other log configuration files included in the Brooklyn jars. It is necessary to understand the source structure in the logback-includes project.

For example, to change the debug log inclusions, create a folder `brooklyn` under `conf` and create a file `logback-debug.xml` based on the brooklyn/logback-debug.xml from that project.

Log File Backup

This sub-section is a work in progress; feedback from the community is extremely welcome.

The default rolling log files can be backed up periodically, e.g. using a CRON job.

Note however that the rolling log file naming scheme will rename the historic zipped log files such that `brooklyn.debug-1.log.zip` is the most recent zipped log file. When the current `brooklyn.debug.log` is to be zipped, the previous zip file will be renamed `brooklyn.debug-2.log.zip`. This renaming of files can make RSYNC or backups tricky.

An option is to covert/move the file to a name that includes the last-modified timestamp. For example (on mac):

```
LOG_FILE=brooklyn.debug-1.log.zip
TIMESTAMP=`stat -f '%Um' $LOG_FILE`
mv $LOG_FILE /path/to/archive/brooklyn.debug-$TIMESTAMP.log.zip
```

Logging aggregators

Integration with systems like Logstash and Splunk is possible using standard logback configuration. Logback can be configured to write to the syslog, which can then feed its logs to Logstash.

For More Information

The following resources may be useful when configuring logging:

- The logback-includes project
- Brooklyn Developer Guide logging tips
- The Logback Project home page

Sometimes it is useful that configuration in a blueprint, or in Brooklyn itself, is not given explicitly, but is instead replaced with a reference to some other storage system. For example, it is undesirable for a blueprint to contain a plain-text password for a production system, especially if (as we often recommend) the blueprints are kept in the developer's source code control system.

To handle this problem, Apache Brooklyn supports externalized configuration. This allows a blueprint to refer to a piece of information that is stored elsewhere. `brooklyn.cfg` defines the external suppliers of configuration information. At runtime, when Brooklyn finds a reference to externalized configuration in a blueprint, it consults `brooklyn.cfg` for information about the supplier, and then requests that the supplier return the information required by the blueprint.

Take, as a simple example, a web app which connects to a database. In development, the developer is running a local instance of PostgreSQL with a simple username and password. But in production, an enterprise-grade cluster of PostgreSQL is used, and a dedicated service is used to provide passwords. The same blueprint can be used to service both groups of users, with `brooklyn.cfg` changing the behaviour depending on the deployment environment.

Here is the blueprint:

```
name: MyApplication
services:
- type: brooklyn.entity.webapp.jboss.JBoss7Server
  name: AppServer HelloWorld
  brooklyn.config:
    wars.root: http://search.maven.org/remotecontent?filepath=org/apache/brooklyn/example/brooklyn-example-hell
o-world-sql-webapp/0.8.0-incubating/brooklyn-example-hello-world-sql-webapp-0.8.0-incubating.war
    http.port: 8080+
    java.sysprops:
      brooklyn.example.db.url:
        $brooklyn:formatString:
          - jdbc:postgresql://%s/myappdb?user=%s\\&password=%s
          - $brooklyn:external("servers", "postgresql")
          - $brooklyn:external("credentials", "postgresql-user")
          - $brooklyn:external("credentials", "postgresql-password")
```

You can see that when we are building up the JDBC URL, we are using the `external` function. This takes two parameters: the first is the name of the configuration supplier, the second is the name of a key that is stored by the configuration supplier. In this case we are using two different suppliers: `servers` to store the location of the server, and `credentials` which is a security-optimized supplier of secrets.

Developers would add lines like this to the `brooklyn.cfg` file on their workstation:

```
brooklyn.external.servers=org.apache.brooklyn.core.config.external.InPlaceExternalConfigSupplier
brooklyn.external.servers.postgresql=127.0.0.1
brooklyn.external.credentials=org.apache.brooklyn.core.config.external.InPlaceExternalConfigSupplier
brooklyn.external.credentials.postgresql-user=admin
brooklyn.external.credentials.postgresql-password=admin
```

In this case, all of the required information is included in-line in the local `brooklyn.cfg` .

Whereas in production, `brooklyn.cfg` might look like this:

```
brooklyn.external.servers=org.apache.brooklyn.core.config.external.PropertiesFileExternalConfigSupplier
brooklyn.external.servers.propertiesUrl=https://ops.example.com/servers.properties
brooklyn.external.credentials=org.apache.brooklyn.core.config.external.vault.VaultAppIdExternalConfigSupplier
brooklyn.external.credentials.endpoint=https://vault.example.com
brooklyn.external.credentials.path=secret/enterprise-postgres
brooklyn.external.credentials.appId=MyApp
```

In this case, the list of servers is stored in a properties file located on an Operations Department web server, and the credentials are stored in an instance of Vault. More information on these providers is below.

For demo purposes, there is a pre-defined external provider called `brooklyn-demo-sample` which defines `hidden-brooklyn-password` as `br00k11n`. This is used in some of the sample blueprints, referencing `$brooklyn:external("brooklyn-demo-sample", "hidden-brooklyn-password")`. The value used here can be overridden with the following in your `brooklyn.cfg`:

```
brooklyn.external.brooklyn-demo-sample=org.apache.brooklyn.core.config.external.InPlaceExternalConfigSupplier
brooklyn.external.brooklyn-demo-sample.hidden-brooklyn-password=new_password
```

Defining Suppliers

External configuration suppliers are defined in `brooklyn.cfg`. The minimal definition is of the form:

brooklyn.external.*supplierName* = *className*

This defines a supplier named *supplierName*. Brooklyn will attempt to instantiate *className*; it is this class which will provide the behaviour of how to retrieve data from the supplier. Brooklyn includes a number of supplier implementations; see below for more details.

Suppliers may require additional configuration options. These are given as additional properties in `brooklyn.cfg`:

```
brooklyn.external.supplierName = className
brooklyn.external.supplierName.firstConfig = value
brooklyn.external.supplierName.secondConfig = value
```

Referring to External Configuration in Blueprints

Externalized configuration adds a new function to the Brooklyn blueprint language DSL, `$brooklyn:external`. This function takes two parameters:

1. supplier
2. key

When resolving the external reference, Brooklyn will first identify the *supplier* of the information, then it will give the supplier the *key*. The returned value will be substituted into the blueprint.

You can use `$brooklyn:external` directly:

```
name: MyApplication
brooklyn.config:
  example: $brooklyn:external("supplier", "key")
```

or embed the `external` function inside another `$brooklyn` DSL function, such as `$brooklyn:formatString`:

```
name: MyApplication
brooklyn.config:
  example: $brooklyn:formatString("%s", external("supplier", "key"))
```

Referring to External Configuration in brooklyn.cfg

The same blueprint language DSL can be used from `brooklyn.cfg`. For example:

```
brooklyn.location.jclouds.aws-ec2.identity=$brooklyn:external("mysupplier", "aws-identity")
brooklyn.location.jclouds.aws-ec2.credential=$brooklyn:external("mysupplier", "aws-credential")
```

Referring to External Configuration in Catalog Items

The same blueprint language DSL can be used within YAML catalog items. For example:

```
brooklyn.catalog:
  id: com.example.myblueprint
  version: "1.2.3"
  itemType: entity
  brooklyn.libraries:
  - >
    $brooklyn:formatString("https://%s:%s@repo.example.com/libs/myblueprint-1.2.3.jar",
    external("mysupplier", "username"), external("mysupplier", "password"))
  item:
    type: com.example.MyBlueprint
```

Note the `>` in the example above is used to split across multiple lines.

Suppliers available with Brooklyn

Brooklyn ships with a number of external configuration suppliers ready to use.

In-place

InPlaceExternalConfigSupplier embeds the configuration keys and values as properties inside `brooklyn.cfg`. For example:

```
brooklyn.external.servers=org.apache.brooklyn.core.config.external.InPlaceExternalConfigSupplier
brooklyn.external.servers.postgresql=127.0.0.1
```

Then, a blueprint which referred to `$brooklyn:external("servers", "postgresql")` would receive the value `127.0.0.1`.

Properties file

PropertiesFileExternalConfigSupplier loads a properties file from a URL, and uses the keys and values in this file to respond to configuration lookups.

Given this configuration:

```
brooklyn.external.servers=org.apache.brooklyn.core.config.external.PropertiesFileExternalConfigSupplier
brooklyn.external.servers.propertiesUrl=https://ops.example.com/servers.properties
```

This would cause the supplier to download the given URL. Assuming that the file contained this entry:

```
postgresql=127.0.0.1
```

Then, a blueprint which referred to `$brooklyn:external("servers", "postgresql")` would receive the value `127.0.0.1`.

Vault

Vault is a server-based tool for managing secrets. Brooklyn provides suppliers that are able to query the Vault REST API for configuration values. The different suppliers implement alternative authentication options that Vault provides.

For *all* of the authentication methods, you must always set these properties in `brooklyn.cfg`:

```
brooklyn.external.supplierName.endpoint=<Vault HTTP/HTTPs endpoint>
brooklyn.external.supplierName.path=<path to a Vault object>
```

For example, if the path is set to `secret/brooklyn`, then attempting to retrieve the key `foo` would cause Brooklyn to retrieve the value of the `foo` key on the `secret/brooklyn` object. This value can be set using the Vault CLI like this:

```
vault write secret/brooklyn foo=bar
```

Authentication by username and password

The `userpass` plugin for Vault allows authentication with username and password.

```
brooklyn.external.supplierName=org.apache.brooklyn.core.config.external.vault.VaultUserPassExternalConfigSuppli
er
brooklyn.external.supplierName.username=fred
brooklyn.external.supplierName.password=s3kr1t
```

Authentication using App ID

The `app_id` plugin for Vault allows you to specify an "app ID", and then designate particular "user IDs" to be part of the app. Typically the app ID would be known and shared, but user ID would be autogenerated on the client in some way. Brooklyn implements this by determining the MAC address of the server running Brooklyn (expressed as 12 lower case hexadecimal digits without separators) and passing this as the user ID.

```
brooklyn.external.supplierName=org.apache.brooklyn.core.config.external.vault.VaultAppIdExternalConfigSupplier
brooklyn.external.supplierName.appId=MyApp
```

If you do not wish to use the MAC address as the user ID, you can override it with your own choice of user ID:

```
brooklyn.external.supplierName.userId=server3.cluster2.europe
```

Authentication by fixed token

If you have a fixed token string, then you can use the *VaultTokenExternalConfigSupplier* class and provide the token in `brooklyn.cfg`:

```
brooklyn.external.supplierName=org.apache.brooklyn.core.config.external.vault.VaultTokenExternalConfigSupplier
brooklyn.external.supplierName.token=1091fc84-70c1-b266-b99f-781684dd0d2b
```

This supplier is suitable for "smoke testing" the Vault supplier using the Initial Root Token or similar. However it is not suitable for production use as it is inherently insecure - should the token be compromised, an attacker could have complete access to your Vault, and the cleanup operation would be difficult. Instead you should use one of the other suppliers.

Writing Custom External Configuration Suppliers

Supplier implementations must conform to the brooklyn.config.external.ExternalConfigSupplier interface, which is very simple:

```
String getName();
String get(String key);
```

Classes implementing this interface can be placed in the `lib/dropins` folder of Brooklyn, and then the supplier defined in `brooklyn.cfg` as normal.

Server Specification

The size of server required by Brooklyn depends on the amount of activity. This includes:

- the number of entities/VMs being managed
- the number of VMs being deployed concurrently
- the amount of management and monitoring required per entity

For dev/test or when there are only a handful of VMs being managed, a small VM is sufficient. For example, an AWS m3.medium with one vCPU, 3.75GiB RAM and 4GB disk.

For larger production uses, a more appropriate machine spec would be two or more cores, at least 8GB RAM and 100GB disk. The disk is just for logs, a small amount of persisted state, and any binaries for custom blueprints/integrations.

Disk Space

There are three main consumers of disk space:

- **Static files**: these are the Apache Brooklyn distribution with its own dependencies, OSGi bundles for custom blueprints and integrations installed to the `deploy/` directory, plus `data/` directory which is generated on first launch. Note that Brooklyn requires that Java is installed which you may have to consider when calculating disk space requirements.
- **Persisted state**: when using Persistence -- which is a prerequisite for High Availability -- Brooklyn will save data to a store location. Items in the persisted state include metadata about the Brooklyn servers, catalog items, and metadata about all running applications and entities.
- **Log files**: Brooklyn writes info and debug log files. By default, these are written to the local filesystem. This can be reconfigured to set the destination and to increase or decrease the detail in the logs. See the Logging section for more details.

The Apache Brooklyn distribution itself, when unpacked, consumes approximately 75MB of disk space. This includes everything needed to run Brooklyn except for a Java VM. The space consumed by additional binaries for custom blueprints and integrations is application-specific.

Persisted state, excluding catalog data, is relatively small, starting at approximately 300KB for a clean, idle Brooklyn server. Deploying blueprints will add to this - how much depends exactly on the entities involved and is therefore application specific, but as a guideline, a 3-node Riak cluster adds approximately 500KB to the persistence store.

Log data can be a large consumer of disk space. By default Brooklyn generates two logfiles, one which logs notable information only, and another which logs at a debug level. Each logfile rotates when it hits a size of 100MB; a maximum of 10 log files are retained for each type. The two logging streams combined, therefore, can consume up to 2GB of disk space.

In the default configuration of Brooklyn's `.tar.gz` and `.zip` distributions, logs are saved to the Brooklyn installation directory. You will most likely want to reconfigure Brooklyn's logging to save logs to a location elsewhere. In the `.rpm` and `.deb` packaging, logging files will be located under `/var/log`. You can further reconfiguring the logging detail level and log rotation according to your organisation's policy.

OS Requirements

Brooklyn is tested against CentOS (6 or later), RHEL (6 or later), Ubuntu (14.04 or later), OS X, and Windows.

Software Requirements

Brooklyn requires Java 8 (JRE or JDK) or later. OpenJDK is recommended. Brooklyn has also been tested on the Oracle JVM and IBM J9.

Configuration Requirements

Ports

The ports used by Brooklyn are:

- 8443 for https, to expose the web-console and REST api.
- 8081 for http, to expose the web-console and REST api.

Whether to use https rather than http is configurable using the CLI option `--https`; the port to use is configurable using the CLI option `--port <port>`.

To enable remote Brooklyn access, ensure these ports are open in the firewall. For example, to open port 8443 in iptables, ues the command:

```
/sbin/iptables -I INPUT -p TCP --dport 8443 -j ACCEPT
```

Locale

Brooklyn expects a sensible set of locale information and time zones to be available; without this, some time-and-date handling may be surprising.

Brooklyn parses and reports times according to the time zone set at the server. If Brooklyn is targetting geographically distributed users, it is normally recommended that the server's time zone be set to UTC.

User Setup

It is normally recommended that Brooklyn run as a non-root user with keys installed to `~/.ssh/id_rsa{,.pub}`.

Linux Kernel Entropy

Check that the linux kernel entropy is sufficient.

System Resource Limits

Check that the ulimit values are sufficiently high.

This guide provides all necessary information to upgrade Apache Brooklyn for both the RPM/DEB and Tarball packages.

Backwards Compatibility

Apache Brooklyn version 0.12.0 onward runs primarily inside a Karaf container. When upgrading from 0.11.0 or below, this update changes the mechanisms for launching Brooklyn. This will impact any custom scripting around the launching of Brooklyn, and the supplying of command line arguments.

Use of the `lib/dropins` and `lib/patch` folders will no longer work (because Karaf does not support that kind of classloading). Instead, code must be built and installed as OSGi bundles.

Upgrading

- Use of RPM and DEB is now recommended where possible, rather than the tar.gz. This entirely replaces the previous install.
- CentOS 7.x is recommended over CentOS 6.x (note: the RPM **will not work** on CentOS 6.x)

Upgrade from Apache Brooklyn 0.12.0 onward

{::options parse_block_html="true" /}

- RPM / DEB Packages
- Tarball

1. **Important!** Backup persisted state and custom configuration, in case you need to rollback to a previous version. 1. By default, persisted state is located at `/var/lib/brooklyn`. The `persistenceDir` and `persistenceLocation` are configured in the file `/etc/brooklyn/org.apache.brooklyn.osgilauncher.cfg`. The persistence details will be logged in `/var/log/brooklyn/brooklyn.info.log` at startup time. 2. Configuration files are in `/etc/brooklyn`. 2. Upgrade Apache Brooklyn: 1. [Download](../misc/download.html) the new RPM/DEB package 2. Upgrade Apache Brooklyn: # CentOS / RHEL sudo yum upgrade apache-brooklyn-xxxx.noarch.rpm # Ubuntu / Debian sudo dpkg -i apache-brooklyn-xxxx.all.deb If there are conflicts in configuration files (located in `/etc/brooklyn`), the upgrade will behave differently based on the package you are using: * RPM: the upgrade will keep the previously installed one and save the new version, with the suffix `.rpmsave`. You will then need to check and manually resolve those. * DEB: the upgrade will ask you what to do. 3. Start Apache Brooklyn: # CentOS 7 / RHEL sudo systemctl start brooklyn # CentOS 6 and older sudo initctl start brooklyn # Ubuntu / Debian start brooklyn Wait for Brooklyn to be running (i.e. its web-console is responsive)
1. Stop Apache Brooklyn: ./bin/stop brooklyn If this does not stop it within a few seconds (as checked with `sudo ps aux | grep karaf`), then use `sudo kill ` 2. **Important!** Backup persisted state and custom configuration. 1. By default, persisted state is located at `~/.brooklyn/brooklyn-persisted-state`. The `persistenceDir` and `persistenceLocation` are configured in the file `./etc/org.apache.brooklyn.osgilauncher.cfg`. The persistence details will be logged in `./log/brooklyn.info.log` at startup time. 2. Configuration files are in `./etc/`. Any changes to these configuration files will need to be re-applied after reinstalling Brooklyn. 3. Install new version of Apache Brooklyn: 1. [Download](../misc/download.html) the new tarball zip package. 2. Install Brooklyn: tar -zxf apache-brooklyn-xxxx.tar.gz cd apache-brooklyn-xxxx 4. Restore any changes to the configuration files (see step 2). 5. Validate that the new release works, by starting in "HOT_BACKUP" mode. 1. Before starting Brooklyn, reconfigure `./etc/org.apache.brooklyn.osgilauncher.cfg` and set `highAvailabilityMode=HOT_BACKUP`. This way when Brooklyn is started, it will only read and validate the persisted state and will not write into it. 2. Start Apache Brooklyn: ./bin/start brooklyn 3. Check whether you have rebind ERROR messages in `./log/brooklyn.info.log`, e.g. `sudo grep -E "WARN|ERROR" /opt/brooklyn/log/brooklyn.debug.log`. If you do not have such errors you can proceed. 4. Stop

Apache Brooklyn: ./bin/stop brooklyn 5. Change the `highAvailabilityMode` to the default (AUTO) by commenting it out in `./etc/org.apache.brooklyn.osgilauncher.cfg`. 6. Start Apache Brooklyn: ./bin/start brooklyn Wait for Brooklyn to be running (i.e. its web-console is responsive). 7. Update the catalog, using the br command: 1. [Download](https://brooklyn.apache.org/download/index.html#command-line-client) the br tool. 2. Login with br: `br login http://localhost:8081 `. 3. Update the catalog: `br catalog add /opt/brooklyn/catalog/catalog.bom`.

Upgrade from Apache Brooklyn 0.11.0 and below

- RPM / DEB Packages
- Tarball

1. Stop Apache Brooklyn: # CentOS 7 / RHEL sudo systemctl stop brooklyn # CentOS6 and older sudo initctl stop brooklyn # Ubuntu / Debian stop brooklyn If this does not stop it within a few seconds (as checked with `sudo ps aux | grep brooklyn`), then use `sudo kill `. 2. **Important!** Backup persisted state and custom configuration. 1. By default, persisted state is located at `/opt/brooklyn/.brooklyn/`.. The `persistenceDir` and `persistenceLocation` are configured in the file `./etc/org.apache.brooklyn.osgilauncher.cfg`. The persistence details will be logged in `./log/brooklyn.info.log` at startup time. 2. Configuration files are in `./etc/`. Any changes to these configuration files will need to be re-applied after reinstalling Brooklyn. 3. Delete the existing Apache Brooklyn install: 1. Remove Brooklyn package: # CentOS / RHEL sudo yum erase apache-brooklyn # Ubuntu / Debian sudo dpkg -r apache-brooklyn 2. On CentOS 7 run `sudo systemctl daemon-reload`. 3. Confirm that Brooklyn is definitely not running (see step 1 above). 4. Delete the Brooklyn install directory: `sudo rm -r /opt/brooklyn` as well as the Brooklyn log directory: `sudo rm -r /var/log/brooklyn/` 4. Make sure you have Java 8. By default CentOS images come with JRE6 which is incompatible version for Brooklyn. If CentOS is prior to 6.8 upgrade nss: `yum -y upgrade nss` 5. Install new version of Apache Brooklyn: 1. [Download](../misc/download.html) the new RPM/DEB package. 2. Install Apache Brooklyn: # CentOS / RHEL sudo yum install apache-brooklyn-xxxx.noarch.rpm # Ubuntu / Debian sudo dpkg -i apache-brooklyn-xxxx.all.deb 6. Restore the persisted state and configuration. 1. Stop the Brooklyn service: # CentOS 7 / RHEL sudo systemctl stop brooklyn # CentOS 6 and older sudo initctl stop brooklyn # Ubuntu / Debian stop brooklyn Confirm that Brooklyn is no longer running (see step 1). 2. Restore the persisted state directory into `/var/lib/brooklyn` and any changes to the configuration files (see step 2). Ensure owner/permissions are correct for the persisted state directory, e.g.: `sudo chown -r brooklyn:brooklyn /var/lib/brooklyn` 7. Validate that the new release works, by starting in "HOT_BACKUP" mode. 1. Before starting Brooklyn, reconfigure `/etc/brooklyn/org.apache.brooklyn.osgilauncher.cfg` and set `highAvailabilityMode=HOT_BACKUP`. This way when Brooklyn is started, it will only read and validate the persisted state and will not write into it. 2. Start Apache Brooklyn: # CentOS 7 / RHEL sudo systemctl start brooklyn # CentOS 6 and older sudo initctl start brooklyn # Ubuntu / Debian start brooklyn 3. Check whether you have rebind ERROR messages in the Brooklyn logs, e.g. `sudo grep -E "Rebind|WARN|ERROR" /var/log/brooklyn/brooklyn.debug.log`. If you do not have such errors you can proceed. 4. Stop Brooklyn: # CentOS 7 / RHEL sudo systemctl stop brooklyn # CentOS 6 and older sudo initctl stop brooklyn # Ubuntu / Debian stop brooklyn 5. Change the `highAvailabilityMode` to the default (AUTO) by commenting it out in `./etc/org.apache.brooklyn.osgilauncher.cfg`. 8. Start Apache Brooklyn: # CentOS 7 / RHEL sudo systemctl start brooklyn # CentOS 6 and older sudo initctl start brooklyn # Ubuntu / Debian start brooklyn Wait for Brooklyn to be running (i.e. its web-console is responsive). 9. Update the catalog, using the br command: 1. Download the br tool (i.e. from the "CLI Download" link in the web-console). 2. Login with br: `br login http://localhost:8081 `. 3. Update the catalog: `br catalog add /opt/brooklyn/catalog/catalog.bom`.
Same instructions as above.

Rollback

This section applies only with you are using the RPM/DEB packages. To perform a rollback, please follow these instructions:

```
# CentOS / RHEL
```

```
yum downgrade apache-brooklyn.noarch

# Ubuntu Debian
dpkg -i apache-brooklyn-xxxx.all.deb
```

Note that to downgrade a DEB package is essentially installing a previous version therefore you need to download the version you want to downgrade to before hand.

How to stop your service

On systemd:

```
systemctl stop brooklyn
```

On upstart:

```
stop brooklyn
```

Web login credentials

- User credentials should now be recorded in `brooklyn.cfg`.
- Brooklyn will still read them from both `brooklyn.cfg` and `~/.brooklyn/brooklyn.properties`.
- Configure a username/password by modifying `brooklyn.cfg`. An example entry is:

```
brooklyn.webconsole.security.users=admin
brooklyn.webconsole.security.user.admin.password=password2
```

Persistence

If you have persisted state you wish to rebind to, persistence is now configured in the following files:

- `brooklyn.cfg`
- `org.apache.brooklyn.osgilauncher.cfg`

For example, to use S3 for the persisted state, add the following to `brooklyn.cfg`:

```
brooklyn.location.named.aws-s3-eu-west-1:aws-s3:eu-west-1
brooklyn.location.named.aws-s3-eu-west-1.identity=<ADD CREDS>
brooklyn.location.named.aws-s3-eu-west-1.credential=<ADD CREDS>
```

To continue the S3 example, for the persisted state, add the following to `org.apache.brooklyn.osgilauncher.cfg`:

```
persistenceLocation=aws-s3-eu-west-1
persistenceDir=<ADD HERE>
```

Apache Brooklyn should be stopped before this file is modified, and then restarted with the new configuration.

Note that you can not store the credentials (for e.g. aws-s3-eu-west-1) in the catalog because that catalog is stored in the persisted state. Apache Brooklyn needs to know it in order to read the persisted state at startup time.

If binding to existing persisted state, an additional command is required to update the existing catalog with the Brooklyn 0.12.0 versions. Assuming Brooklyn has been installed to `/opt/brooklyn` (as is done by the RPM and DEB):

```
br catalog add /opt/brooklyn/catalog/catalog.bom
```

All existing custom jars previously added to lib/plugins (e.g. for Java-based entities) need to be converted to OSGi bundles, and installed in Karaf. The use of the "brooklyn.libraries" section in catalog.bom files will continue to work.

Brooklyn Server

Web-console and REST api

Users are strongly encouraged to use HTTPS, rather than HTTP.

The use of LDAP is encouraged, rather than basic auth.

Configuration of "entitlements" is encouraged, to lock down access to the REST api for different users.

Brooklyn user

Users are strongly discouraged from running Brooklyn as root.

For production use-cases (i.e. where Brooklyn will never deploy to "localhost"), the user under which Brooklyn is running should not have `sudo` rights.

Persisted State

Use of an object store is recommended (e.g. using S3 compliant or Swift API) - thus making use of the security features offered by the chosen object store.

File-based persistence is also supported. Permissions of the files will automatically be 600 (i.e. read-write only by the owner). Care should be taken for permissions of the relevant mount points, disks and directories.

Credential Storage

For credential storage, users are strongly encouraged to consider using the "externalised configuration" feature. This allows credentials to be retrieved from a store managed by you, rather than being stored within YAML blueprints or `brooklyn.cfg`.

A secure credential store is strongly recommended, such as use of HashiCorp's Vault - see `org.apache.brooklyn.core.config.external.vault.VaultExternalConfigSupplier`.

Infrastructure Access

Cloud Credentials and Access

Users are strongly encouraged to create separate cloud credentials for Brooklyn's API access.

Users are also encouraged to (where possible) configure the cloud provider for only minimal API access (e.g. using AWS IAM).

VM Image Credentials

Users are strongly discouraged from using hard-coded passwords within VM images. Most cloud providers/APIs provide a mechanism to instead set an auto-generated password or to create an entry in `~/.ssh/authorized_keys` (prior to the VM being returned by the cloud provider).

If a hard-coded credential is used, then Brooklyn can be configured with this "loginUser" and "loginUser.password" (or "loginUser.privateKeyData"), and can change the password and disable root login.

VM Users

It is strongly discouraged to use the root user on VMs being created or managed by Brooklyn. SSH-ing on the VM should be done on rare cases such as initial Apache Brooklyn setup, Apache Brooklyn upgrade and other important maintenance occasions.

SSH keys

Users are strongly encouraged to use SSH keys for VM access, rather than passwords.

This SSH key could be a file on the Brooklyn server. However, a better solution is to use the "externalised configuration" to return the "privateKeyData". This better supports upgrading of credentials.

Install Artifact Downloads

When Brooklyn executes scripts on remote VMs to install software, it often requires downloading the install artifacts. For example, this could be from an RPM repository or to retrieve `.zip` installers.

By default, the RPM repositories will be whatever the VM image is configured with. For artifacts to be downloaded directly, these often default to the public site (or mirror) for that software product.

Where users have a private RPM repository, it is strongly encouraged to ensure the VMs are configured to point at this.

For other artifacts, users should consider hosting these artifacts in their own web-server and configuring Brooklyn to use this. See the documentation for `org.apache.brooklyn.core.entity.drivers.downloads.DownloadProducerFromProperties`.

Further documentation specific to this version of Brooklyn includes:

Also see the other versions or general documentation.

The Basics

The full build requires the following software to be installed:

- Maven (v3.1+)
- Java (v1.7+, 1.8 recommended)
- Go (v1.6+) [if building the CLI client]
- rpm tools [if building the dist packages for those platforms]

With these in place, you should be able to build everything with a:

```
% mvn clean install
```

Alternatively you can build most things with just Java and Maven installed using:

```
mvn clean install -Dno-go-client -Dno-rpm`
```

Other tips:

- Add `-DskipTests` to skip tests (builds much faster, but not as safe)
- You may need more JVM memory, e.g. at the command-line (or in `.profile`):

  `export MAVEN_OPTS="-Xmx1024m -Xms512m"`
- Run `-PIntegration` to run integration tests, or `-PLive` to run live tests (tests described here)
- You may need to install `rpm` package to build RPM packages: `brew install rpm` for Mac OS, `apt-get install rpm` for Ubuntu, `yum install rpm` for Centos/RHEL. On Mac OS you may also need to set `%_tmppath /tmp` in `~/.rpmmacros`.
- If you're looking at the maven internals, note that many of the settings are inherited from parent projects (see for instance `brooklyn-server/parent/pom.xml`)
- For tips on building within various IDEs, look here.

When the RAT Bites

We use RAT to ensure that all files are compliant to Apache standards. Most of the time you shouldn't see it or need to know about it, but if it detects a violation, you'll get a message such as:

```
[ERROR] Failed to execute goal org.apache.rat:apache-rat-plugin:0.10:check (default) on project brooklyn-parent
: Too many files with unapproved license: 1 See RAT report in: /Users/alex/Data/cloudsoft/dev/gits/brooklyn/tar
get/rat.txt -> [Help 1]
```

If there's a problem, see the file `rat.txt` in the `target` directory of the failed project. (Maven will show you this link in its output.)

Often the problem is one of the following:

- You've added a file which requires the license header but doesn't have it

  Resolution: Simply copy the header from another file
- You've got some temporary files which RAT things should have headers

Resolution: Move the files away, add headers, or turn off RAT (see below)

- The project structure has changed and you have stale files (e.g. in a `target` directory)

  Resolution: Remove the stale files, e.g. with `git clean -df` (and if needed a `find . -name target -prune -exec rm -rf {} \;` to delete folders named `target`)

To disable RAT checking on a build, set `rat.ignoreErrors` , e.g. `mvn -Drat.ignoreErrors=true clean install` . (But note you will need RAT to pass in order for a PR to be accepted!)

If there is a good reason that a file, pattern, or directory should be permanently ignored, that is easy to add inside the root `pom.xml` .

Other Handy Hints

- On some **Ubuntu** (e.g. 10.4 LTS) maven v3 is not currently available from the repositories. Some instructions for installing at are at superuser.com.
- The **mvnf** script (get the gist here) simplifies building selected projects, so if you just change something in `software-webapp` and then want to re-run the examples you can do:

  `examples/simple-web-cluster% mvnf ../../{software/webapp,usage/all}`

Appendix: Sample Output

A healthy build will look something like the following, including a few warnings (which we have looked into and understand to be benign and hard to get rid of them, although we'd love to if anyone can help!):

```
% mvn clean install
[INFO] Scanning for projects...
[INFO] ------------------------------------------------------------------------
[INFO] Reactor Build Order:
[INFO]
[INFO] Brooklyn REST JavaScript Web GUI
[INFO] Brooklyn Server Root
[INFO] Brooklyn Parent Project
[INFO] Brooklyn Test Support Utilities
[INFO] Brooklyn Logback Includable Configuration
[INFO] Brooklyn Common Utilities

...

[WARNING] Ignoring project type war - supportedProjectTypes = [jar]

...

[WARNING] We have a duplicate org/xmlpull/v1/XmlPullParser.class in ~/.m2/repository/xpp3/xpp3_min/1.1.4c/xpp3_
min-1.1.4c.jar

...

[INFO] — maven-assembly-plugin:2.3:single (build-distribution-dir) @ brooklyn-dist —
[INFO] Reading assembly descriptor: src/main/config/build-distribution-dir.xml
{% comment %}BROOKLYN_VERSION{% endcomment %}[WARNING] Cannot include project artifact: io.brooklyn:brooklyn-di
st:jar:0.13.0-SNAPSHOT; it doesn't have an associated file or directory.
[INFO] Copying files to ~/repos/apache/brooklyn/usage/dist/target/brooklyn-dist
[WARNING] Assembly file: ~/repos/apache/brooklyn/usage/dist/target/brooklyn-dist is not a regular file (it may
be a directory). It cannot be attached to the project build for installation or deployment.

...
```

```
[INFO] — maven-assembly-plugin:2.3:single (build-distribution-archive) @ brooklyn-dist —
[INFO] Reading assembly descriptor: src/main/config/build-distribution-archive.xml
{% comment %}BROOKLYN_VERSION{% endcomment %}[WARNING] Cannot include project artifact: io.brooklyn:brooklyn-di
st:jar:0.13.0-SNAPSHOT; it doesn't have an associated file or directory.
{% comment %}BROOKLYN_VERSION{% endcomment %}[INFO] Building tar: /Users/aled/repos/apache/brooklyn/usage/dist/
target/brooklyn-0.13.0-SNAPSHOT-dist.tar.gz
{% comment %}BROOKLYN_VERSION{% endcomment %}[WARNING] Cannot include project artifact: io.brooklyn:brooklyn-di
st:jar:0.13.0-SNAPSHOT; it doesn't have an associated file or directory.

...

[WARNING] Don't override file /Users/aled/repos/apache/brooklyn/usage/archetypes/quickstart/target/test-classes
/projects/integration-test-1/project/brooklyn-sample/src/main/resources/sample-icon.png

...

[INFO] Reactor Summary:
[INFO]
[INFO] Brooklyn Parent Project ........................... SUCCESS [3.072s]
[INFO] Brooklyn Utilities to Support Testing (listeners etc)  SUCCESS [3.114s]
[INFO] Brooklyn Logback Includable Configuration ......... SUCCESS [0.680s]
[INFO] Brooklyn Common Utilities ......................... SUCCESS [7.263s]
[INFO] Brooklyn Groovy Utilities ......................... SUCCESS [5.193s]
[INFO] Brooklyn API ...................................... SUCCESS [2.146s]
[INFO] Brooklyn Test Support ............................. SUCCESS [2.517s]
[INFO] CAMP Server Parent Project ........................ SUCCESS [0.075s]
[INFO] CAMP Base ......................................... SUCCESS [4.079s]
[INFO] Brooklyn REST Swagger Apidoc Utilities ............ SUCCESS [1.983s]
[INFO] Brooklyn Logback Configuration .................... SUCCESS [0.625s]
[INFO] CAMP Server ....................................... SUCCESS [5.446s]
[INFO] Brooklyn Core ..................................... SUCCESS [1:24.122s]
[INFO] Brooklyn Policies ................................. SUCCESS [44.425s]
[INFO] Brooklyn Hazelcast Storage ........................ SUCCESS [7.143s]
[INFO] Brooklyn Jclouds Location Targets ................. SUCCESS [16.488s]
[INFO] Brooklyn Secure JMXMP Agent ....................... SUCCESS [8.634s]
[INFO] Brooklyn JMX RMI Agent ............................ SUCCESS [2.315s]
[INFO] Brooklyn Software Base ............................ SUCCESS [28.538s]
[INFO] Brooklyn Network Software Entities ................ SUCCESS [3.896s]
[INFO] Brooklyn OSGi Software Entities ................... SUCCESS [4.589s]
[INFO] Brooklyn Web App Software Entities ................ SUCCESS [17.484s]
[INFO] Brooklyn Messaging Software Entities .............. SUCCESS [7.106s]
[INFO] Brooklyn Database Software Entities ............... SUCCESS [5.229s]
[INFO] Brooklyn NoSQL Data Store Software Entities ....... SUCCESS [11.901s]
[INFO] Brooklyn Monitoring Software Entities ............. SUCCESS [4.027s]
[INFO] Brooklyn CAMP REST API ............................ SUCCESS [15.285s]
[INFO] Brooklyn REST API ................................. SUCCESS [4.489s]
[INFO] Brooklyn REST Server .............................. SUCCESS [30.270s]
[INFO] Brooklyn REST Client .............................. SUCCESS [7.007s]
[INFO] Brooklyn REST JavaScript Web GUI .................. SUCCESS [24.397s]
[INFO] Brooklyn Launcher ................................. SUCCESS [15.923s]
[INFO] Brooklyn Command Line Interface ................... SUCCESS [9.279s]
[INFO] Brooklyn All Things ............................... SUCCESS [13.875s]
[INFO] Brooklyn Distribution ............................. SUCCESS [49.370s]
[INFO] Brooklyn Quick-Start Project Archetype ............ SUCCESS [12.053s]
[INFO] Brooklyn Examples Aggregator Project .............. SUCCESS [0.085s]
[INFO] Brooklyn Examples Support Aggregator Project - Webapps  SUCCESS [0.053s]
[INFO] hello-world-webapp Maven Webapp ................... SUCCESS [0.751s]
[INFO] hello-world-sql-webapp Maven Webapp ............... SUCCESS [0.623s]
[INFO] Brooklyn Simple Web Cluster Example ............... SUCCESS [5.398s]
[INFO] Brooklyn Global Web Fabric Example ................ SUCCESS [3.176s]
[INFO] Brooklyn Simple Messaging Publish-Subscribe Example  SUCCESS [3.217s]
[INFO] Brooklyn NoSQL Cluster Examples ................... SUCCESS [6.790s]
[INFO] Brooklyn QA ....................................... SUCCESS [7.117s]
[INFO] ------------------------------------------------------------------------
[INFO] BUILD SUCCESS
[INFO] ------------------------------------------------------------------------
[INFO] Total time: 8:33.983s
[INFO] Finished at: Mon Jul 21 14:56:46 BST 2014
[INFO] Final Memory: 66M/554M
```

```
[INFO] ------------------------------------------------------------------------
```

Gone are the days when IDE integration always just works... Maven and Eclipse fight, neither quite gets along perfectly with Groovy, git branch switches (sooo nice) can be slow, etc etc.

But with a bit of a dance the IDE can still be your friend, making it much easier to run tests and debug.

As a general tip, don't always trust the IDE to build correctly; if you hit a snag, do a command-line `mvn clean install` (optionally with `-DskipTests` and/or `-Dno-go-client`) then refresh the project.

See instructions below for specific IDEs.

Eclipse

The default Eclipse downloads already include all of the plugins needed for working with the Brooklyn project. Optionally you can install the Groovy and TestNG plugins, but they are not required for building the project. You can install these using Help -> Install New Software, or from the Eclipse Marketplace:

- Groovy Plugin: GRECLIPSE from dist.springsource.org/snapshot/GRECLIPSE/e4.5/; Be sure to include Groovy 2.3 compiler support and Maven-Eclipse (m2e) support. More details including download sites for other versions can be found at the Groovy Eclipse Plugin site.
- TestNG Plugin: beust TestNG from beust.com/eclipse

As of this writing, Eclipse 4.5 and Eclipse 4.4 are commonly used, and the codebase can be imported (Import -> Existing Maven Projects) and successfully built and run inside an IDE. However there are quirks, and mileage may vary. Disable `Build Automatically` from the `Project` menu if the IDE is slow to respond.

If you encounter issues, the following hints may be helpful:

- If m2e reports import problems, it is usually okay (even good) to mark all to "Resolve All Later". The build-helper connector is useful if you're prompted for it, but do *not* install the Tycho OSGi configurator (this causes show-stopping IAE's, and we don't need Eclipse to make bundles anyway). You can manually mark as permanently ignored certain errors; this updates the pom.xml (and should be current).
- A quick command-line build (`mvn clean install -DskipTests -Dno-go-client`) followed by a workspace refresh can be useful to re-populate files which need to be copied to `target/`
- m2e likes to put `excluding="**"` on `resources` directories; if you're seeing funny missing files (things like not resolving jclouds/aws-ec2 locations or missing WARs), try building clean install from the command-line then doing Maven -> Update Project (clean uses a maven-replacer-plugin to fix `.classpath` s). Alternatively you can go through and remove these manually in Eclipse (Build Path -> Configure) or the filesystem, or use the following command to remove these rogue blocks in the generated `.classpath` files:

```
% find . -name .classpath -exec sed -i.bak 's/[ ]*..cluding="[\*\/]*\(\.java\)*"//g' {} \;
```

- You may need to ensure `src/main/{java,resources}` is created in each project dir, if (older versions) complain about missing directories, and the same for `src/test/{java,resources}` *if* there are tests (`src/test` exists):

```
find . \( -path "*/src/main" -or -path "*/src/test" \) -exec echo {} \; -exec mkdir -p {}/{java,resources} \;
```

If the pain starts to be too much, come find us on IRC #brooklyncentral or elsewhere and we can hopefully share our pearls. (And if you have a tip we haven't mentioned please let us know that too!)

IntelliJ IDEA

To develop or debug Brooklyn in IntelliJ, you will need to ensure that the Groovy and TestNG plugins are installed via the IntelliJ IDEA | Preferences | Plugins menu. Once installed, you can open Brooklyn from the root folder, (e.g. `~/myfiles/brooklyn`) which will automatically open the subprojects.

Brooklyn has informally standardized on arranging `import` statements as per Eclipse's default configuration. IntelliJ's default configuration is different, which can result in unwanted "noise" in commits where imports are shuffled backward and forward between the two types - PRs which do this will likely fail the review. To avoid this, reconfigure IntelliJ to organize imports similar to Eclipse. See this StackOverflow answer for a suitable configuration.

Netbeans

Tips from Netbeans users wanted!

Debugging Tips

To debug Brooklyn, create a launch configuration which launches the `BrooklynJavascriptGuiLauncher` class. NOTE: You may need to add additional projects or folders to the classpath of the run configuration (e.g. add the brooklyn-software-nosql project if you wish to deploy a MongoDBServer). You will also need to ensure that the working directory is set to the jsgui folder. For IntelliJ, you can set the 'Working directory' of the Run/Debug Configuration to `$MODULE_DIR$/../jsgui` . For Eclipse, use the default option of `${workspace_loc:brooklyn-jsgui}` .

To debug the jsgui (the Brooklyn web console), you will need to build Brooklyn with -DskipOptimization to prevent the build from minifying the javascript. When building via the command line, use the command `mvn clean install -DskipOptimization` , and if you are using IntelliJ IDEA, you can add the option to the Maven Runner by clicking on the Maven Settings icon in the Maven Projects tool window and adding the `skipOptimization` property with no value.

When running at the command line you can enable remote connections so that one can attach a debugger to the Java process: Run Java with the following on the command line or in JAVA_OPTS: `-agentlib:jdwp=transport=dt_socket,server=y,suspend=n,address=5005`

To debug a brooklyn instance that has been run with the above JAVA_OPTS, create a remote build configuration (IntelliJ - Run | Edit Configurations | + | Remote) with the default options, ensuring the port matches the address specified in JAVA_OPTS.

Brooklyn is split into the following subprojects:

- **brooklyn-server**:
    - **api**: the pure-Java interfaces for interacting with the system
    - **camp**: the components for a server which speaks with the CAMP REST API and understands the CAMP YAML plan language
    - **core**: the base class implementations for entities and applications, entity traits, locations, policies, sensor and effector support, tasks, and more
    - **karaf**: OSGi support
    - **launcher**: for launching brooklyn, either using a main method or invoked from the cli project
    - **locations**: specific location integrations
        - **jclouds**: integration with many cloud APIs and providers via Apache jclouds
    - **logging**: how we enable configurable logging
        - **logback-includes**: Various helpful logback XML files that can be included; does not contain logback.xml
        - **logback-xml**: Contains a logback.xml that references the include files in brooklyn-logback-includes
    - **parent**: a meta-project parent to collect dependencies and other maven configuration for re-use
    - **policy**: collection of useful policies for automating entity activity
    - **rest**: supporting the REST API
        - **rest-api**: The API classes for the Brooklyn REST api
        - **rest-client**: A client Java implementation for using the Brooklyn REST API
        - **rest-server**: The server-side implementation of the Brooklyn REST API
    - **server-cli**: implementation of the Brooklyn *server* command line interface; not to be confused with the client CLI
    - **software**: support frameworks for creating entities which mainly launch software processes on machines
        - **base**: software process lifecycle abstract classes and drivers (e.g. SSH)
        - **winrm**: support for connecting to Windows machines
    - **test-framework**: provides Brooklyn entities for building YAML tests for other entities
    - **test-support**: provides Brooklyn-specific support for Java TestNG tests, used by nearly all projects in scope `test` , building on `utils/test-support`
    - **utils**: projects with lower level utilities
        - **common**: Utility classes and methods developed for Brooklyn but not dependent on Brooklyn
        - **groovy**: Groovy extensions and utility classes and methods developed for Brooklyn but not dependent on Brooklyn
        - **jmx/jmxmp-ssl-agent**: An agent implementation that can be attached to a Java process, to give expose secure JMXMP
        - **jmx/jmxrmi-agent**: An agent implementation that can be attached to a Java process, to give expose JMX-RMI without requiring all high-number ports to be open
        - **rest-swagger**: Swagger REST API utility classes and methods developed for Brooklyn but not dependent on Brooklyn
        - **test-support**: Test utility classes and methods developed for Brooklyn but not dependent on Brooklyn
- **brooklyn-ui**: Javascript web-app for the brooklyn management web console (builds a WAR)
- **brooklyn-library**: a library of useful blueprints
    - **examples**: some canonical examples
    - **qa**: longevity and stress tests
    - **sandbox**: experimental items
    - **software**: blueprints for software processes
        - **webapp**: web servers (JBoss, Tomcat), load-balancers (Nginx), and DNS (Geoscaling)
        - **database**: relational databases (SQL)
        - **nosql**: datastores other than RDBMS/SQL (often better in distributed environments)
        - **messaging**: messaging systems, including Qpid, Apache MQ, RabbitMQ

    - **monitoring**: monitoring tools, including Monit
    - **osgi**: OSGi servers
- **brooklyn-docs**: the markdown source code for this documentation

- **brooklyn-dist**: projects for packaging Brooklyn and making it easier to consume

  ```
  * **all**: maven project to supply a shaded JAR (containing all dependencies) for convenience
  * **archetypes**: A maven archetype for easily generating the structure of new downstream projects
  * **dist**: builds brooklyn as a downloadable .zip and .tar.gz
  * **scripts**: various scripts useful for building, updating, etc. (see comments in the scripts)
  ```

We have the following tests groups:

- normal (i.e. no group) -- should run quickly, not need internet, and not side effect the machine (apart from a few /tmp files)
- Integration -- deploys locally, may read and write from internet, takes longer.

  ```
  If you change an entity, rerun the relevant integration test to make sure all is well!
  ```

- Live -- deploys remotely, may provision machines (but should clean up, getting rid of them in a try block)
- Live-sanity -- a sub-set of "Live" that can be run regularly; a trade-off of optimal code coverage for the time/cost of those tests.
- WIP -- short for "work in progress", this will disable the test from being run by the normal brooklyn maven profiles, while leaving the test enabled so that one can work on it in IDEs or run the selected test(s) from the command line.
- Acceptance -- this (currently little-used) group is for very long running tests, such as soak tests

To run these from the command line, use something like the following:

- normal: `mvn clean install`
- integration: `mvn clean verify -PEssentials,Locations,Entities,Integration -Dmaven.test.failure.ignore=true --fail-never`
- Live: `mvn clean verify -PEntities,Locations,Entities,Live -Dmaven.test.failure.ignore=true --fail-never`
- Live-sanity: `mvn clean verify -PEntities,Locations,Entities,Live-sanity -Dmaven.test.failure.ignore=true --fail-never`

To run a single test, use something like the following:

- run a single test class: `mvn -Dtest=org.apache.brooklyn.enricher.stock.EnrichersTest -DfailIfNoTests=false test`
- run a single test method: `mvn -Dtest=org.apache.brooklyn.enricher.stock.EnrichersTest#testAdding -DfailIfNoTests=false test`

The Apache Software Foundation, quite rightly, place a high standard on code provenance and license compliance. The Apache license is flexible and compatible with many other types of license, meaning there is generally little problem with incorporating other open source works into Brooklyn (with GPL being the notable exception). However diligence is required to ensure that the project is legally sound, and third parties are rightfully credited where appropriate.

This page is an interpretation of the Apache Legal Previously Asked Questions page as it specifically applies to the Brooklyn project, such as how we organise our code and the releases that we make. However this page is not authoritative; if there is any conflict between this page and the Previously Asked Questions or other Apache Legal authority, they will take precedence over this page.

If you have any doubt, please ask on the Brooklyn mailing list, and/or the Apache Legal mailing list.

What code licenses can we bundle?

Apache Legal maintains the "Category A" list, which is a list of licenses that are compatible with the Apache License; that is, code under these licenses can be imported into Brooklyn without violating Brooklyn's Apache License nor the code's original license (subject to correctly modifying the `LICENSE` and/or `NOTICE` files; see below).

Apache Legal also maintain the "Category X" list. Code licensed under a Category X license **cannot** be imported into Brooklyn without violating either Brooklyn's Apache license or the code's original license.

There is also a "Category B" list, which are licenses that are compatible with the Apache license only under certain circumstances. In practice, this means that we can declare a dependency on a library licensed under a Category B license, and bundle the binary build of the library in our binary builds, but we cannot import its source code into the Brooklyn codebase.

If the code you are seeking to import does not appear on any of these lists, check to see if the license content is the same as a known license. For example, many projects actually use a BSD license but do not label it as "The BSD License". If you are still not certain about the license, please ask on the Brooklyn mailing list, and/or the Apache Legal mailing list.

About LICENSE and NOTICE files

Apache Legal requires that *each* artifact that the project releases contains a `LICENSE` and `NOTICE` file that is *accurate for the contents of that artifact*. This means that, potentially, **every artifact that Brooklyn releases may contain a different `LICENSE` and `NOTICE` file**. In practice, it's not usually that complicated and there are only a few variations of these files needed.

Furthermore, *accurate* `LICENSE` and `NOTICE` files means that it correctly attributes the contents of the artifact, and it does not contain anything unnecessary. This provision is what prevents us creating a mega LICENSE file and using it in every single artifact we release, because in many cases it will contain information that is not relevant to an artifact.

What is a correct `LICENSE` and `NOTICE` file?

- A correct `LICENSE` file is one that contains the text of the licence of any part of the code. The Apache Software License V2 will naturally be the first part of this file, as it's the license which we use for all the original code in Brooklyn. If some *Category A* licensed third-party code is bundled with this artifact, then the `LICENSE` file should identify what the third-party code is, and include a copy of its license. For example, if jquery is bundled with a web app, the `LICENSE` file would include a note jquery.js, its copyright and its license (MIT), and include a full copy of the MIT license.
- A correct `NOTICE` file contains notices required by bundled third-party code above and beyond that which we have already noted in `LICENSE`. In practice modifying `NOTICE` is rarely required beyond the initial note about

Apache Brooklyn. See What Are Required Third-party Notices? for more information

Applying LICENSE and NOTICE files to Brooklyn

When the Brooklyn project makes a release, we produce and release the following types of artifacts:

1. One source release artifact
2. One binary release artifact
3. A large number of Maven release artifacts

Therefore, our source release, our binary release, and every one of our Maven release artifacts, must **each** have their own, individually-tailored, `LICENSE` and `NOTICE` files.

To some extent, this is automated, using scripts in `usage/dist/licensing` ; but this must be manually run, and wherever source code is included or a project has insufficient information in its POM, you'll need to add project-specific metadata (with a project-specific `source-inclusions.yaml` file and/or in the dist project's `overrides.yaml` file). See the README.md in that project's folder for more information.

Maven artifacts

Each Maven module will generally produce a JAR file from code under `src/main` , and a JAR file from code under `src/test` . (There are some exceptions which may produce different artifacts.)

If the contents of the module are purely Apache Brooklyn original code, and the outputs are JAR files, then *no action is required*. The default build process will incorporate a general-purpose `LICENSE` and `NOTICE` file into all built JAR files. `LICENSE` will contain just a copy of the Apache Software License v2, and `NOTICE` will contain just the module's own notice fragment.

However you will need to take action if either of these conditions are true:

- the module produces an artifact that is **not** a JAR file - for example, the jsgui project produces a WAR file;
- the module bundles third-party code that requires a change to `LICENSE` and/or `NOTICE` .

In this case you will need to disable the automatic insertion of `LICENSE` and `NOTICE` and insert your own versions instead.

For an example of a JAR file with customized `LICENSE` / `NOTICE` files, refer to the `usage/cli` project. For an example of a WAR file with customized `LICENSE` / `NOTICE` files, refer to the `usage/jsgui` project.

The source release

In practice, the source release contains nothing that isn't in the individual produced Maven artifacts (the obvious difference about it being source instead of binary isn't relevant). Therefore, the source release `LICENSE` and `NOTICE` can be considered to be the union of every Maven artifact's `LICENSE` and `NOTICE` . The amalgamated files are kept in the root of the repository.

The binary release

This is the trickiest one to get right. The binary release includes everything that is in the source and Maven releases, **plus every Java dependency of the project**. This means that the binary release is pulling in many additional items, each of which have their own license, and which will therefore impact on `LICENSE` and `NOTICE` .

Therefore you must inspect every file that is present in the binary distribution, ascertain its license status, and ensure that `LICENSE` and `NOTICE` are correct.

General Good Ways of Working

- If working on something which could be contributed to Brooklyn, do it in a project under the `sandbox` directory. This means we can accept pulls more easily (as sandbox items aren't built as part of the main build) and speed up collaboration.
- When debugging an entity, make sure the brooklyn.SSH logger is set to DEBUG and accessible.
- Use tests heavily! These are pretty good to run in the IDE (once you've completed IDE setup), and far quicker to spot problems than runtime, plus we get early-warning of problems introduced in the future. (In particular, Groovy's laxity with compilation means it is easy to introduce silly errors which good test coverage will find much faster.)
- If you hit inexplicable problems at runtime, try clearing your Maven caches, or the brooklyn-relevant parts, under `~/.m2/repository`. Also note your IDE might be recompiling at the same time as a Maven command-line build, so consider turning off auto-build.
- When a class or method becomes deprecated, always include `@deprecated` in the Javadoc e.g. " `@deprecated since 0.7.0; instead use {@link ...}` "
  - Include when it was deprecated
  - Suggest what to use instead -- e.g. link to alternative method, and/or code snippet, etc.
  - Consider logging a warning message when a deprecated method or config option is used, saying who is using it (e.g. useful if deprecated config keys are used in yaml) -- if it's a method which might be called a lot, some convenience for "warn once per entity" would be helpful)
  - See the Java deprecation documentation

Entity Design Tips

- Look at related entities and understand what they've done, in particular which sensors and config keys can be re-used. (Many are inherited from interfaces, where they are declared as constants, e.g. `Attributes` and `UsesJmx`.)
- Understand the location hierarchy: software process entities typically get an `SshMachineLocation`, and use a `*SshDriver` to do what they need. This will usually have a `MachineProvisioningLocation` parent, e.g. a `JcloudsLocation` (e.g. AWS eu-west-1 with credentials) or possibly a `LocalhostMachineProvisioningLocation`. Clusters will take such a `MachineProvisioningLocation` (or a singleton list); fabircs take a list of locations. Some PaaS systems have their own location model, such as `OpenShiftLocation`.
- Finally, don't be shy about talking with others, that's far better than spinning your wheels (or worse, having a bad experience), plus it means we can hopefully improve things for other people!

YAML Blueprint Debugging

- Brooklyn will reject any YAML blueprint that contains syntax errors and will alert the user of such errors.
- However, it is possible to create a blueprint that is syntactically legal but results in runtime problems for Brooklyn (for example, if an enricher's `enricher.producer` value is not immediately resolvable).
- If Brooklyn appears to freeze after deploying a blueprint, run the `jstack <brooklyn-pid>` command to view the state of all running threads. By examining this output, it may become obvious which thread(s) are causing the problem, and the details of the stack trace will provide insight into which part of the blueprint is incorrectly written.

Project Maintenance

- Adding a new project may need updates to `/pom.xml` `modules` section and `usage/all` dependencies
- Adding a new example project may need updates to `/pom.xml` and `/examples/pom.xml` (and the documentation too!)

Logging: A Quick Overview

For logging, we use **logback** which implements the slf4j API. This means you can use any slf4j compliant logging framework, with a default configuration which just works out of the box and bindings to the other common libraries (`java.util.logging` , `log4j` , ...) if you prefer one of those.

OSGi based Apache Brooklyn

While developing it may be useful to change logging level of some of the Apache Brooklyn modules. The easiest way to do that is via the karaf console which can be started by `bin/client` . (Details regarding using Apache Brooklyn Karaf console) For example if you would like to inspect jclouds API calls, enable jclouds.wire logging just enable it from karaf client.

```
log:set DEBUG jclouds.wire
```

To check other log levels.

```
log:list
```

If for some reason log level needs modified before the first start of Karaf then you can modify the config file `etc/org.ops4j.pax.logging.cfg` before hand. For more information check https://ops4j1.jira.com/wiki/display/paxlogging/Configuration.

Classic - non-OSGI based Apache Brooklyn

To use:

- **Users**: If using a brooklyn binary installation, simply edit the `logback.xml` or `logback-custom.xml` supplied in the archive, sometimes in a `conf/` directory.
- **Developers**: When setting up a new project, if you want logging it is recommended to include the `brooklyn-logback-xml` project as an *optional* and *provided* maven dependency, and then to put custom logging configuration in either `logback-custom.xml` or `logback-main.xml` , as described below.

Customizing Your Logging

The project `brooklyn-logback-xml` supplies a `logback.xml` configuration, with a mechanism which allows it to be easily customized, consumed, and overridden. You may wish to include this as an *optional* dependency so that it is not forced upon downstream projects. This `logback.xml` file supplied contains just one instruction, to include `logback-main.xml` , and that file in turn includes:

- `logback-custom.xml`
- `brooklyn/logback-appender-file.xml`
- `brooklyn/logback-appender-stdout.xml`
- `brooklyn/logback-logger-excludes.xml`
- `brooklyn/logback-debug.xml`

For the most common customizations, simply create a `logback-custom.xml` on your classpath (ensuring it is loaded *before* brooklyn classes in classpath ordering in the pom) and supply your customizations there:

```
<included>
    <!-- filename to log to -->
    <property name="logging.basename" scope="context" value="acme-app" />

    <!-- additional loggers -->
    <logger name="com.acme.app" level="DEBUG"/>
</included>
```

For other configuration, you can override individual files listed above. For example:

- To remove debug logging, create a trivial `brooklyn/logback-debug.xml`, containing simply `<included/>`.
- To customise stdout logging, perhaps to give it a threshhold WARN instead of INFO, create a `brooklyn/logback-appender-stdout.xml` which defines an appender STDOUT.
- To discard all brooklyn's default logging, create a `logback-main.xml` which contains your configuration. This should look like a standard logback configuration file, except it should be wrapped in `<included>` XML tags rather than `<configuration>` XML tags (because it is included from the `logback.xml` which comes with `brooklyn-logback-xml`.)
- To redirect all jclouds logging to a separate file include `brooklyn/logback-logger-debug-jclouds.xml`. This redirects all logging from `org.jclouds` and `jclouds` to one of two files: anything logged from Brooklyn's persistence thread will end up in a `persistence.log`, everything else will end up in `jclouds.log`.

You should **not** supply your own `logback.xml` if you are using `brooklyn-logback-xml`. If you do, logback will detect multiple files with that name and will scream at you. If you wish to supply your own `logback.xml`, do **not** include `brooklyn-logback-xml`. (Alternatively you can include a `logback.groovy` which causes logback to ignore `logback.xml`.)

You can set a specific logback config file to use with:

```
-Dlogback.configurationFile=/path/to/config.xml
```

Assemblies

When building an assembly, it is recommended to create a `conf/logback.xml` which simply includes `logback-main.xml` (which comes from the classpath). Users of the assembly can then edit the `logback.xml` file in the usual way, or they can plug in to the configuration mechanisms described above, by creating files such as `logback-custom.xml` under `conf/`.

Including `brooklyn-logback-xml` as an *optional* and *provided* dependency means everything should work correctly in IDE's but it will not include the extra `logback.xml` file in the assembly. (Alternatively if you include the `conf/` dir in your IDE build, you should exclude this dependency.)

With this mechanism, you can include `logback-custom.xml` and/or other files underneath `src/main/resources/` of a project, as described above (for instance to include custom logging categories and define the log file name) and it should get picked up, both in the IDE and in the assembly.

Tests

Brooklyn projects `test` scope includes the `brooklyn-utils-test-support` project which supplies a `logback-test.xml`. logback uses this file in preference to `logback.xml` when available (ie when running tests). However the `logback-test.xml` Brooklyn uses includes the same `logback-main.xml` call path above, so your configurations should still work.

The only differences of the `logback-test.xml` configuration is that:

- Debug logging is included for all Brooklyn packages
- The log file is called `brooklyn-tests.log`

Caveats

- logback uses SLF4J version 1.6 which is **not compatible** with 1.5.x. If you have dependent projects using 1.5.x (such as older Grails) things may break.
- If you're not getting the logging you expect in the IDE, make sure `src/main/resources` is included in the classpath. (In eclipse, right-click the project, the Build Path -> Configure, then make sure all dirs are included (All) and excluded (None) -- `mvn clean install` should do this for you.)
- You may find that your IDE logs to a file `brooklyn-tests.log` if it doesn't distinguish between test build classpaths and normal classpaths.
- Logging configuration using file overrides such as this is very sensitive to classpath order. To get a separate `brooklyn-tests.log` file during testing, for example, the `brooklyn-test-support` project with scope `test` must be declared as a dependency *before* `brooklyn-logback-includes`, due to the way both files declare `logback-appender-file.xml`.
- Similarly note that the `logback-custom.xml` file is included *after* logging categories and levels are declared, but before appenders are declared, so that logging levels declared in that file dominate, and that properties from that file apply to appenders.
- Finally remember this is open to improvement. It's the best system we've found so far but we welcome advice. In particular if it could be possible to include files from the classpath with wildcards in alphabetical order, we'd be able to remove some of the quirks listed above (though at a cost of some complexity!).

Usually during development, you will be running Brooklyn from your IDE (see IDE Setup), in which case debugging is as simple as setting a breakpoint. There may however be times when you need to debug an existing remote Brooklyn instance (often referred to as Resident Brooklyn, or rBrooklyn) on another machine, usually in the cloud.

Thankfully, the tools are available to do this, and setting it up is quite straightforward. The steps are as follows:

- Getting the right source code version
- Starting Brooklyn with a debug listener
- Creating an SSH tunnel
- Connecting your IDE

Getting the right source code version

The first step is to ensure that your local copy of the source code is at the version used to build the remote Brooklyn instance. The git commit that was used to build Brooklyn is available via the REST API:

```
http://<remote-address>:<remote-port>/v1/server/version
```

This should return details of the build as a JSON string similar to the following (formatted for clarity):

```
{
    "version": "0.13.0-SNAPSHOT",  {% comment %}BROOKLYN_VERSION{% endcomment %}
    "buildSha1": "c0fdc15291702281acdebf1b11d431a6385f5224",
    "buildBranch": "UNKNOWN"
}
```

The value that we're interested in is `buildSha1`. This is the git commit that was used to build Brooklyn. We can now checkout and build the Brooklyn code at this commit by running the following in the root of your Brooklyn repo:

```
% git checkout c0fdc15291702281acdebf1b11d431a6385f5224
% mvn clean install -DskipTests
```

Whilst building the code isn't strictly necessary, it can help prevent some IDE issues.

Starting Brooklyn with a debug listener

By default, Brooklyn does not listen for a debugger to be attached, however this behaviour can be set by setting JAVA_OPTS, which will require a restart of the Brooklyn node. To do this, SSH to the remote Brooklyn node and run the following in the root of the Brooklyn installation:

```
# NOTE: Running this kill command will lose existing apps and machines if persistence is disabled.
% kill `cat pid_java`
% export JAVA_OPTS="-Xms256m -Xmx1g -agentlib:jdwp=transport=dt_socket,address=127.0.0.1:8888,server=y,suspend=
n"
% bin/brooklyn launch &
```

If `JAVA_OPTS` is not set, Brooklyn will automatically set it to `"-Xms256m -Xmx1g"`, which is why we have prepended the agentlib settings with these values here.

You should see the following in the console output:

```
Listening for transport dt_socket at address: 8888
```

This will indicate the Brooklyn is listening on port 8888 for a debugger to be attached.

Creating an SSH tunnel

If port 8888 is accessible on the remote Brooklyn server, then you can skip this step and simply use the address of the server in place of 127.0.0.1 in the Connecting your IDE section below. It will normally be possible to make the port accessible by configuring Security Groups, iptables, endpoints etc., but for a quick ad-hoc connection it's usually simpler to create an SSH tunnel. This will create an open SSH connection that will redirect traffic from a port on a local interface via SSH to a port on the remote machine. To create the tunnel, run the following on your local machine:

```
# replace this with the address or IP of the remote Brooklyn node
REMOTE_HOST=<remote-address>
# if you wish to use a different port, this value must match the port specified in the JAVA_OPTS
REMOTE_PORT=8888
# if you wish to use a different local port, this value must match the port specified in the IDE configuration
LOCAL_PORT=8888
# set this to the login user you use to SSH to the remote Brooklyn node
SSH_USER=root
# The private key file used to SSH to the remote node. If you use a password, see the alternative command below
PRIVATE_KEY_FILE=~/.ssh/id_rsa

% ssh -YNf -i $PRIVATE_KEY_FILE -l $SSH_USER -L $LOCAL_PORT:127.0.0.1:$REMOTE_PORT $REMOTE_HOST
```

If you use a password to SSH to the remote Brooklyn node, simply remove the `-i $PRIVATE_KEY_FILE` section like so:

```
ssh -YNf -l $SSH_USER -L $LOCAL_PORT:127.0.0.1:$REMOTE_PORT $REMOTE_HOST
```

If you are using a password to connect, you will be prompted to enter your password to connect to the remote node upon running the SSH command.

The SSH tunnel should now be redirecting traffic from port 8888 on the local 127.0.0.1 network interface via the SSH tunnel to port 8888 on the remote 127.0.0.1 interface. It should now be possible to connect the debugger and start debugging.

Connecting your IDE

Setting up your IDE will differ depending upon which IDE you are using. Instructions are given here for Eclipse and IntelliJ, and have been tested with Eclipse Luna and IntelliJ Ultimate 14.

Eclipse Setup

To debug using Eclipse, first open the Brooklyn project in Eclipse (see IDE Setup).

Now create a debug configuration by clicking `Run` | `Debug Configurations...`. You will then be presented with the Debug Configuration dialog.

Select `Remote Java Application` from the list and click the 'New' button to create a new configuration. Set the name to something suitable such as 'Remote debug on 8888'. The Project can be set to any of the Brooklyn projects, the Connection Type should be set to 'Standard (Socket Attach)'. The Host should be set to either localhost or 127.0.0.1 and the Port should be set to 8888. Click 'Debug' to start debugging.

IntelliJ Setup

To debug using IntelliJ, first open the Brooklyn project in IntelliJ (see IDE Setup).

Now create a debug configuration by clicking `Run` | `Edit Configurations`. You will then be presented with the Run/Debug Configurations dialog.

Click on the `+` button and select 'Remote' to create a new remote configuration. Set the name to something suitable such as 'Remote debug on 8888'. The first three sections simply give the command line arguments for starting the java process using different versions of java, however we have already done this in Starting Brooklyn with a debug listener. The Transport option should be set to 'Socket', the Debugger Mode should be set to 'Attach', the Host should be set to localhost or 127.0.0.1 (or the address of the remote machine if you are not using an SSH tunnel), and the Port should be set to 8888. The 'Search sources' section should be set to `<whole project>`. Click OK to save the configuration, then select the configuration from the configurations drop-down and click the debug button to start debugging.

Testing

The easiest way to test that remote debugging has been setup correctly is to set a breakpoint and see if it is hit. An easy place to start is to create a breakpoint in the `ServerResource.java` class, in the `getStatus()` method.