The Corus Guide

version 4.x

www.sapia-oss.org

REVISION HISTORY

Author	*Description*	*Date*	*Version*
Y.D	Added tagging, remote property update, execution configurations, process restart from the CLI,	2009/10/19	1.3.5
Y.D	Added Corus 3.0 new features documentation: • Avis support (for discovery without IP multicast) • Alerts • Property includes	2012/05/10	3.0
Y.D	Added Corus 4.0 documentation: • Repository functionality: Corus nodes can act as either repository servers or repository client. A repo client will synchronize its state with a repo server upon startup. • Shell script deployment and execution: shell scripts may be deployed to Corus nodes and executed remotely through the Corus CLI. • File deployment: arbitrary files can be deployed to Corus, enabling use of Corus as a file repository.	2013/05/26	4.0
Y.D	Added Corus 4.1 documentation: • The “ripple” command • Cloud integration	2013/08/26	4.1
Y.D	Added Corus 4.1.2 documentation: • New `conf merge` command supported by the CLI. • New `preExec` and `cmd` elements in the Corus descriptor, allowing exectution of CLI commands on the server-side, prior to process execution.	2014/02/02	4.1.2

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Introduction

Corus is an infrastructure that allows centrally controlling application processes in distributed environments. In a short list, here are Corus' features:

- Centralized, remote, replicated application deployment/undeployment across multiple hosts.
- Centralized, remote, replicated execution/termination of application processes across multiple hosts.
- Monitoring of running processes to detect crashes (and restart crashed processes automatically).
- Possibility for processes to publish status information at the application level, through the Corus infrastructure. Status information can then be monitored centrally.
- Possibility for processes to trigger their own restart.
- Replicated, JNDI-compliant naming service: based on Sapia's Ubik distributed computing framework (guaranteeing fail-over and load-balancing), the naming service can be used by deployed Java applications.
- Platform agnostic: potentially allows ANY type of applications to be deployed -Java, Python, C++ (currently only Java support offered).
- Allows centralized distribution of «standard» Java applications (Java classes with a «main» method), and remote control of corresponding JVMs.
- Allows multiple Java applications per-JVM, through the use of Magnet (http://www.sapia-oss.org/projects/magnet).
- Integration with the Java Service Wrapper (http://wrapper.tanukisoftware.org/doc/english/introduction.html) to ensure high-availability of Corus instances (and startup at OS boot time).
- HTTP/XML hook allowing to integrate Corus has part of a monitoring infrastructure.
- Support for gradual replication of commands across a cluster (allows for avoiding service degradation when performing application upgrades or performing server restarts).
- Repository functionality: automatic synchronization between Corus nodes so that newly appearing nodes become exact copies of existing ones.
- Alternate node discovery support for use in environments where IP multicast is not supported.
- Free and open source with mixed Apache 2.0 and GPL v3 licenses – see the *Licensing* section (next) for more details.

In short, what Corus gives you is full, centralized control of distributed applications and application processes.

Licensing

The Corus source code has been subdivided into two modules:

1) A "client" module, released under the Apache 2.0 license, which produces a library (jar file) that can be placed into the classpath of client applications, allowing these applications to connect to Corus instances and use the Corus server API directly (a rarely necessary thing, unless one wants to develop his own tools for interacting with Corus). It also must be placed in the classpath of applications that use Corus' JNDI.

2) A "server" module, released under the GPL, which strictly consists of the server-side Corus classes, which client applications do NOT need in their classpath. This module depends on the client module, for it implements some of the interfaces in it. Applications deployed using Corus absolutely do NOT need to depend on the server module in any way. The artifact produced by this server is the actual Corus distribution.

The above means the following:

1. Client applications linked to the Corus client classes are not bound by the viral effect of the GPL. They depend entirely on classes released under the Apache 2.0 license, the most liberal of all open source license. It means that code linked to these classes does not require its source to be redistributed; that it can be proprietary; it also means that the Corus client .jar can be redistributed without restrictions as part of client applications.

2. For the server part, it means that no one can modify and redistribute Corus without providing their entire modifications as source to their customers; it also means that their modifications automatically become subjected to the GPL.

In 99.9% of cases, this licensing scheme has no impact on the projects using Corus: client applications will use the client classes, which fall under the Apache 2.0 license, and are therefore shielded from any viral licensing restrictions or obligations.

Note on third-party LGPL libraries used by Corus

Corus is built upon Ubik, Sapia's distributed computing framework. Ubik uses the **JBoss Serialization** library by default, and it can support discovery using **Avis** (which provides an alternative for environments where IP multicast is not supported) – see the Avis router home page for more: http://avis.sourceforge.net/.

Both the JBoss Serialization and Avis client libraries are released under the LGPL, which is more permissive than the GPL: it only becomes "viral" if you distribute code that uses modified version of the LGPL'd code. It is very unlikely that you will customize the JBoss Serialization or Avis code, therefore this also should not impact you.

If the LGPL bothers you, you may then simply remove these libraries from the Corus classpath. In the case of serialization, Corus will then just fall back to the JDK's standard serialization.

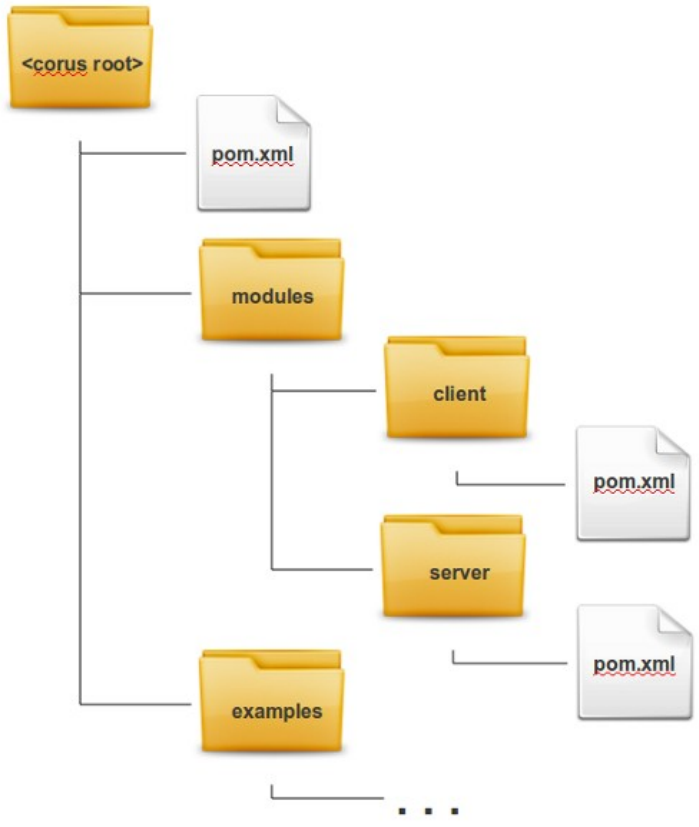
For more information about use of these libraries, see the Ubik web site (http://www.sapia-oss.org/projects/ubik/index.html).

Source Code

The Corus source code is hosted at Google Code (http://code.google.com/p/sapia), and can be built with Maven.

Structure

Corus is subdivided into two modules, and the project's structure is given below:



The folder identified as `<corus root>` actually corresponds to the Corus directory that you've checked out – see the next section about checking out the source.

As can be seen, there is a client and a server module. The client module falls under the Apache 2.0 license. The server module (which depends on the artifact produced in the context of the client module) is licensed under the GPL v3.

The artifact produced by the client module (`sapia_corus_client-<version>.jar`) can therefore at no risk be used as part of third-party

applications, since it is released under the business-friendly Apache 2.0 license. The artifact contains all the classes and interfaces necessary to connect to a Corus server, and to that end the server artifact is absolutely not required (it is only necessary for running the server itself, and is therefore packaged as part of its classpath in the server's distribution).

Building from Source

The source code can be checked out anonymously (see http://code.google.com/p/sapia/source/checkout) and built with Maven.

If you browse Sapia's Subversion repository, you'll see that there are many projects that are kept following Subversion's conventions:

- trunk: where the main branches of the different projects is kept (each Sapia project has its own subfolder under the trunk).
- tags: where the releases (generated by the Maven release plugin) are created.
- branches: where the development branches are created (each Sapia project has its own subfolder under "branches").

The folders under "tags" are created by the Maven release plugin, which uses a combination of the artifact ID and version for the subfolder's name. Each such subfolder therefore corresponds to a specific project release.

In any case, to build from the source, you can checkout the corresponding subfolder from either "trunk" or "tags" - if you want the sources corresponding to a specific release, we recommend that you checkout from "tags").

To build, just cd into the directory where you've done the checkout, and type: `mvn install`.

The Corus server's distributions (which come in the form of zip and tar archives) are generated under the modules/server/target directory (more precisely, under the "target" directory of the server module).

Corus depends on other Sapia projects. The artifacts for these projects are hosted at the Java.net repository and at Sapia's own Maven repository – we had issues with Java.net and created our own public repository as a workaround. Ideally, you should have these repositories configured in your Maven settings (`settings.xml`), both for "normal" dependencies and for plugins. Here's an example:

```
…
<repositories>
  <repository>
    <id>java.net-m2-repository</id>
    <name>Java.net Repository for Maven</name>
    <url>http://download.java.net/maven/2</url>
  </repository>
  <repository>
    <id>sapia-m2-repository</id>
    <name>Sapia Repository for Maven</name>
    <url>http://www.sapia-oss.org/maven2</url>
```

```
  </repository>
</repositories>
<pluginRepositories>
  <pluginRepository>
    <id>java.net-m2-repository</id>
    <name>Java.net Repository for Maven</name>
    <url>http://download.java.net/maven/2</url>
  </pluginRepository>
  <pluginRepository>
    <id>sapia-m2-repository</id>
    <name>Sapia Repository for Maven</name>
    <url>http://www.sapia-oss.org/maven2</url>
  </pluginRepository>
</pluginRepositories>
…
```

Architecture

This section gives a high-level view of the Corus architecture.

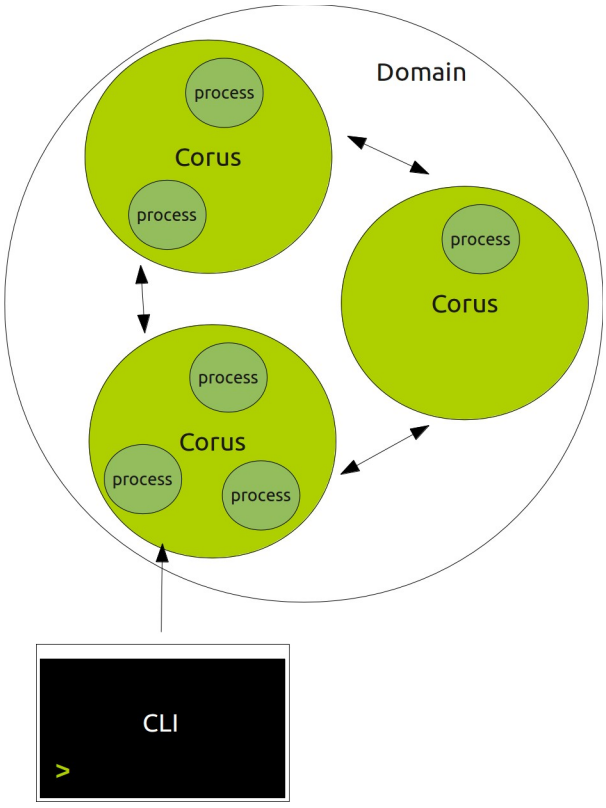
Components

From the user's point of view, Corus comes as three components:

- A lightweight Java server that is installed on a host in order to allow remote deployment and remote execution of processes on that host.
- A Java command-line interface (CLI) that gives centralized control over multiple Corus servers.
- A Java monitoring tool that helps users/administrators see what is happening in a remote Corus server at runtime.

Topology

A typical Corus topology is illustrated below:



A Corus server is typically installed on a given host (such hosts are identified in the diagram above by the larger green circles with the "Corus" label in them). Corus servers are grouped by domains (or clusters). A domain of Corus servers can be centrally managed through the command-line interface (illustrated by the figure with the "CLI" label). Each Corus server monitors/controls processes on the host on which it is installed.

Corus servers discover each other through multicast (either IP multicast, or relying on a TCP-based multicast mechanism, based on Avis – see http://avis.sourceforge.net/). The following describes how Corus servers are grouped into domains:

- At startup, Corus servers are given a domain name through the command-line, or through their configuration file.
- When a new Corus server appears in the network, it broadcasts an event stating the domain it is part of.

- Existing Corus servers will trap the event. If their domain name corresponds to the domain name that is part of the received event, they then in turn broadcast an event stating their existence.
- The newly started Corus server will in turn trap the events coming from existing servers. It will add these servers (or, rather, their corresponding addresses) in its internal sibling list.

The Corus Server

As was explained, a Corus server is installed on a given host to remotely execute and terminate processes on that host, as well as to deploy/undeploy distributions from which processes are eventually instantiated. At the core, that is all there is to it.

In fact, at a high-level, a Corus server does no more than a human being: typically, when wanting to use an application, we acquire it (very often, we download a zip or setup.exe file); then we install it; and then we start an instance of it (we «execute» it). When we're finished, we shut it down.

Of course, Corus (i.e.: a Corus server) will not download a zip file or an executable on its own. In this case, this part is replaced by an administrator deploying the required distribution into Corus, and then starting processes from it. The big advantage that Corus gives us is pretty obvious: typically, executing an application means invoking some executable on the machine on which the corresponding distribution has been installed. With Corus, local execution is handled by a server; the latter will execute processes upon request by «us», the users. Such requests are made with Corus' command-line interface (see next section).

The remote execution scheme becomes all the more powerful when multiple Corus servers collaborate in a domain: multiple processes on multiple machines can be controlled centrally, from the command-line interface.

In addition, Corus' functionalities do not stop at deployment/undeployment of application distributions, and at process execution/termination. Corus has full control over running processes. Through that control, Corus can offer the following features:

- Executed processes are monitored; those that are deemed crashed or in an unstable state are automatically terminated (and optionally restarted) by the Corus server that started them.
- When executing processes, Corus acquires their «original» process identifier (or PID) - the one that is assigned by the OS. This identifier is used to eventually agressively kill processes that do not obey the shutdown requests from their Corus server. It can also be used in problem-solving by system administrators.
- Client applications (running within Corus-executed processes) can publish status information to their corresponding Corus server. That status information can then be perused by administrators (using the command-line interface – see next section).

The command-line interface is used to:

- Deploy application distributions into Corus servers that are part of a given domain - when targeted at more than one Corus server, a deployment is replicated (the distribution is simultaneously deployed to all Corus servers).
- Start processes from the given distributions. Process execution can be replicated also: processes corresponding to given deployed distributions can be started on multiple hosts simultaneously.
- Undeploy applications from a single Corus server, or from multiple Corus servers in a domain.
- Stop running processes at a single Corus server, or at multiple Corus servers in a domain.
- Obtain status information from processes in a domain.
- View what distributions have been deployed.
- View what processes are running.
- Deploy shell scripts and execute them remotely, on the Corus nodes.

To ease its use, the CLI emulates Unix commands (`ls` lists deployed distributions, `ps` and `kill` respectively list and stop running processes, etc.).

The CLI in addition supports pattern matching operations. The following examples illustrate typical use cases:

Command	Description
`deploy dist/*.zip`	Deploys all distribution archives ending with the .zip extension, under the dist directory.
`exec -d myapp -v 1.* -n echoServer -p test`	Starts the echoServer process corresponding to all 1.xx versions of the myapp distribution under the test profile
`exec -d * -v * -n * -p test -cluster`	Starts the processes corresponding to all versions of all distributions under the test profile, on all Corus hosts in the cluster.
`kill -d myapp -v 1.* -n echoServer -p test`	Kill all echoServer processes corresponding to all 1.xx versions of the myapp distribution under the test profile.
`kill -d myapp -v 1.* -n * -p test`	Kills all processes corresponding to all 1.xx versions of the myapp distribution under the test profile.
`kill -d * -v * -n * -p test -cluster`	Kills all processes under the test profile, on all Corus hosts in the cluster.

`kill all -p test -cluster`	A shortcut that amounts to the same thing as the above.

Help on the available commands can be obtained through the `man` command in the CLI. Typing `man` will display all available commands; typing `man <command_name>` will display help on the specified command.

Processes

Process execution occurs upon request of Corus administrators. Concretely: the `exec` command is typed at the CLI (with required command-line arguments), and a corresponding command object is sent to the Corus server to which the user is connected. If performed in clustered mode (if the `-cluster` switch has been entered at the command-line), the command is replicated to other Corus servers.

Upon receiving the command, the Corus server will start the specified process. From then on, processes executed by Corus servers are required to poll their respective Corus server, according to the protocol explained by the ***Corus Interoperability Specification*** (http://www.sapia-oss.org/projects/corus/CorusInterop.pdf).

All communications between Corus-controlled processes and their server indeed follow that specification, which details a SOAP/HTTP-based protocol (where processes are in fact clients). The following diagram illustrates a Corus server and the processes it controls:

The protocol specifies a series of commands, corresponding to the life-cycle of processes started by a Corus server. That life-cycle can be summed up as follows:

- Processes are started following an `exec` command.
- After startup, processes poll their Corus server at a predefined interval to signal that they are up and running. At a predefined interval also, processes send status information to their server (application-code within the process can take part in status generation).
- When polling, processes eventually get back their list of pending events (the server keeps an object representation of each process, and within these objects, a queue of pending commands targeted at the «real» process).
- Processes are eventually killed using the `kill` command (not the one of the OS, but the one emulated by the CLI). The object corresponding to the kill command is sent to the desired Corus servers. Internally, the servers introspect the `kill` command to figure out what processes must be stopped; the objects representing the processes that must be killed have a «kill» event queued up in them. At the next poll, that signal is «recuperated» (sent as part of a SOAP response) to polling processes.
- Processes that are shutting down following a «kill» event must confirm their shutdown to their Corus server. As a matter of precaution, processes that fail doing so are eventually killed using an «OS» kill by their Corus server.

- Processes that do not poll their Corus server within the predefined interval are deemed crashed or unstable, and thus automatically killed (and optionally restarted, depending configuration information provided at deployment).

The fact that interoperability between Corus servers and their corresponding processes is implemented using SOAP over HTTP means that even if Corus is implemented in Java, potentially any type of application processes can be controlled with it (C++, Python, Perl, etc.). Currently though, the only implementation of the *Corus Interoperability Specification* is in Java.

Naming and Remoting

A Corus server embeds a JNDI naming service that can be accessed remotely by Java applications that wish to bind/look up services. The naming service is based on Sapia's Ubik (http://www.sapia-oss.org/projects/ubik) distributed computing framework: Ubik is thus used by the Corus infrastructure as its remoting backbone (in fact, the Corus JNDI provider is based on Ubik's).

The JNDI module that is part of a Corus server offers the following features (directly inherited from Ubik):

- Multiple services can be bound under the same name (which enables the next two features)
- Load-balancing (according to two strategies: statefull/sticky, and stateless).
- Fail-over at the naming service (upon lookup) and at the stubs.
- Client-side discovery (client applications automatically discover JNDI server instances; stubs discover corresponding new servers appearing on the network).
- Replicated JNDI tree (service stubs bound to the naming service are replicated among all Corus servers in a domain).

The naming service is the glue that makes Java applications distributed with the Corus infrastructure fully scalable[1], without sacrificing manageability: multiple service instances can be centrally controlled and executed on multiple hosts (and even have multiple JVMs per host). These services bind themselves (or, rather, their corresponding stub) to the Corus JNDI, under the same name. Client applications lookup the services according to their given name; the JNDI implementation returns the appropriate stub to the client (in a round-robin fashion) - for more information pertaining to Corus' distributed computing framework, see the Ubik web site.

From the programmer's point of view, binding services to Corus' JNDI is similar to binding any object to a JNDI provider. The only difference is that the objects that are bound are automatically "remoted": a stub for the object is created and sent to the JNDI server that resides within Corus. More concretely, here are the steps involved:

- Create an interface for the service (contrary to Sun's RMI, your interface does not have to extend `java.rmi.Remote`, and your methods need not throwing `RemoteExceptions`).

1 Of course other distribution communication mechanisms, such as JMS, may be used.

- Create an implementation of the interface (which will be bound to the Corus JNDI provider)
- Create the client of the service.
- There are examples of the above steps in Corus' source tree, under the `org.sapia.corus.naming.example` package. The snippet below, taken from these examples, illustrates how to bind a service:

```
try{
  TimeServer svr = new TimeServer();
  Properties props = new Properties();
  props.setProperty(Context.INITIAL_CONTEXT_FACTORY,
    RemoteInitialContextFactory.class.getName());
  props.setProperty(
    RemoteInitialContextFactory.UBIK_DOMAIN_NAME,
    "default");
  props.setProperty(Context.PROVIDER_URL,
    "ubik://localhost:33000");
  InitialContext ctx = new InitialContext(props);
  ctx.bind("timeService", svr);
  System.out.println("Time server bound...");
  while(true){
    Thread.sleep(100000);
  }
} catch(Throwable t) {
  t.printStackTrace();
}
```

And now the client part:

```
try {
  Properties props = new Properties();
  props.setProperty(Context.INITIAL_CONTEXT_FACTORY,
    RemoteInitialContextFactory.class.getName());
  props.setProperty(
    RemoteInitialContextFactory.UBIK_DOMAIN_NAME,
    "default");
  props.setProperty(Context.PROVIDER_URL,
    "ubik://localhost:33000");
  InitialContext ctx = new InitialContext(props);
  TimeService ts = (TimeService)ctx.lookup("timeService");
  while(true){
    System.out.println("Got time: " + ts.getTime());
    Thread.sleep(2000);
  }
} catch (Throwable t) {
  t.printStackTrace();
}
```

Note that the domain name is used has part of client-side discovery: if no Corus server is found on the given host and port, the JNDI implementation uses multicast to discover any Corus server that is part of the given domain and connect to it.

> Since Corus' JNDI is inherited from Ubik, we will spare ourselves from further details and encourage you to browse Ubik's web site. Working with Ubik RMI is very similar to working with the JDK's RMI – except that Ubik offers more advanced features.

Installation

Installing Corus is straightforward. Concise instructions can be found on the Corus web site (http://www.sapia-oss.org/projects/corus/install.html) – you will also find OS-specific installation procedures on the Corus wiki (http://code.google.com/p/sapia/wiki/CorusInstallationProcedure).

We advise that you look at the wiki for the latest instructions. Nevertheless, here is a summary:

Download the latest Corus distribution from Google code (http://code.google.com/p/sapia/downloads/list) – the distribution comes as a .gzip or .zip file, depending on your target platform.

- On the host where Corus will be installed, create a directory where the distribution will be "unzipped".

> Make sure that the full path to the directory you have chose does not contain spaces.

- On Unix/Linux, create a user (by convention, it is named `corus`) that will own the above-created directory.
- Create the `CORUS_HOME` environment variable on the Corus host; the variable should correspond to the full path of the directory that has been created in the previous step (under Linux/Unix, you can also define that variable in a file that is loaded when users log in – such as in `/etc/profile` on some Linux distributions).
- Add the `bin` directory under `CORUS_HOME` to your `PATH` environment variable.

That's it. You can start corus by typing `corus` in a terminal.

Corus Network Address

As mentioned in other sections of this document, Corus is built upon Sapia's Ubik distributed computing framework.

A special Ubik property may be used to specify on which network address Corus should listen, That address will also be returned as part of the remote stubs that Corus generates in the course of communicating with clients (which is the case in the context of JNDI lookups for example, or when using the CLI).

The property to set (in the `corus.properties` file) is as follows:

```
ubik.rmi.address-pattern=192\\.168\\.\\d+\\.\\d+
```

The value of the property is expected to be a regexp that will be matched against the network interfaces that Corus detects. Note the double-backslashes; the single-backslash is an escape character in Java, but in this case we want it to be interpreted literally so that it is processed by the regexp evaluation.

Testing the Server

You are ready to start a Corus server. To test your installation, go to the command-line of your OS and type:

```
corus
```

Typing the above with no arguments should display the Corus server help. Read it for further information. Typically, to start a Corus server, you provide the name of the domain "under" which the server should start, and the port on which it should listen (by default, the port is 33000, and the domain is simply "default"). Hence:

```
corus -d mercury -p 33100
```

Will start the server under the "mercury" domain, on port 33100.

Installing as a Service

The Corus wiki contains instructions describing how to install Corus as a service on your target platform. See:

http://code.google.com/p/sapia/wiki/CorusInstallationProcedure.

Also, you may look at the **Corus Configuration Properties** section for more information about how to configure Corus, The `corus.properties` file under the `config` directory also contains instructive comments.

All of the links below appear on the Corus wiki, and might prove more up to date.

Linux

If your Linux flavor does not appear below, you may base yourself on a distribution that supports Corus as a service through `init.d` (such as Fedora).

Ubuntu: http://code.google.com/p/sapia/wiki/CorusInstallationProcedure_Ubuntu

Fedora: http://code.google.com/p/sapia/wiki/CorusInstallationProcedure_Fedora

Mandriva: http://code.google.com/p/sapia/wiki/CorusInstallationProcedure_Mandriva

OpenSuse: http://code.google.com/p/sapia/wiki/CorusInstallationProcedure_OpenSUSE

Mac

We're supporting Mac through `launchd`. See:

http://code.google.com/p/sapia/wiki/CorusInstallationProcedure_SnowLeopard.

Windows

XP: http://code.google.com/p/sapia/wiki/CorusInstallationProcedure_WindowsXP

Vista: http://code.google.com/p/sapia/wiki/CorusInstallationProcedure_WindowsVista

Testing the Client

To connect to the above server using the command-line interface, type:

```
coruscli -h localhost -p 33100
```

As you might have guessed, the arguments passed at the command-line specify the host of the server we wish to connect to, as well as the port of that server (for help, type the command without any arguments). As for the server, the h and p options are optional and will default to localhost and 33000 respectively.

Once you are in the CLI, you can see the list of available commands by typing:

```
man
```

Yes, you are right: just like Unix. You should see the list of available commands then. To read help about one of them, type:

```
man <name_of_command>
```

And off you go: help about the specified command is displayed.

To exist the CLI, type:

```
exit
```

> Reading the help of every command, as explained above, should give you a pretty clear idea of what you can concretely do with Corus. It is very much recommended doing that before going further.

Testing the Monitor

The Corus monitor is a nifty utility that displays logging output received from a Corus server, at runtime, remotely. It is great to introspect what the server is doing

while you're deploying, executing processes, etc.

To start the Corus monitor, type (of course, a Corus server must be running):

```
corusmon -h localhost -p 33100
```

As for the server, the h and p options are optional and will default to localhost and 33000 respectively.

It can be a little while before you see something, but you will, eventually. To exit the monitor, just type `CTRL-C`.

Packaging Applications

The deployment unit in Corus is called a "distribution". There are currently two ways to configure a distribution in Corus so that it can be deployed.

Distributions

With Corus, you deploy J2SE applications (meaning: Java classes with a `main()` method) packaged in .jar files. By convention, these .jar files are in fact named with a .car extension, but this is strictly a convention used to help distinguish Corus archives from other types of archives.

Corus does not force a programming model upon the programmer: learning and using a bloated API (such as EJB) is out of the question. With Corus, you deploy standard Java apps, period.

> Corus complements the lightweight-container approach very neatly: you can embed your lightweight-container in a `main()` method and deploy your application within Corus; you can use Corus' JNDI implementation to publish your "lightweight" services on the network, in a scalable and robust manner.

The .zip file that you deploy within Corus (dubbed a "distribution" in Corus' jargon) is only mandated to provide a Corus descriptor under the `META-INF` directory (under the root of the archive). An example of that file is given below:

```
<distribution name="demo" version="1.0"
xmlns="http://www.sapia-oss.org/xsd/corus/distribution-3.0.xsd">
  <process name="echoServer"
           maxKillRetry="3"
           shutdownTimeout="30000" invoke="true">
    <port name="test" />
    <java mainClass="org.sapia.corus.examples.EchoServer"
            profile="test"
            vmType="server">
      <xoption name="ms" value="16M" />
    </magnet>
  </process>
</distribution>
```

Before delving into the details of the configuration format, we will discuss it at large:

- In Corus, a distribution is the deployment unit. As was mentioned previously, Corus allows only managing Java applications for now, and thus a distribution consists of a set of Java process definitions.
- Process definitions are in fact blue prints for Java virtual machines: these Java virtual machines are started up by the Corus server, upon request by the user.
- The Java virtual machines started by Corus may optionally be configured with Magnet (see http://www.sapia-oss.org/projects/magnet). Magnet is simply a tool that is used to start multiple Java applications (Java classes with a main method) within the same VM; it allows configuring the classpath of each application (and much more) through a convenient XML format. Thus, what happens really is that Corus starts a Magnet process, which in turn invokes the `main()` method of each of its configured Java applications. Each application in turn has its own classloader, independent from the classloader of other applications (see Magnet's documentation for more information).
- Without the Java applications "knowing" it, Magnet starts a lightweight client that implements the *Corus Interoperability Specification*. That client polls the Corus server at a regular interval to let Corus know that the process in which it "lives " is still up and running. This is where Corus' process management functionality kicks in: a Corus server is aware of which processes it has started and will monitor them, making sure that they are polling at their predefined interval.

Deploying with Magnet: Step-by-Step

Rather then delving further into abstraction, we will go through implementing an application that is meant to be deployed into Corus (the configuration format will be explained in the next section). Implementing such applications is not much different then implementing them for "normal" use (except for the packaging part). The steps involved are as follows:

- Implement a J2SE application.
- Write the Magnet file for the application.
- Write the Corus descriptor for the application.
- Package the application in a .jar file, with the Corus descriptor (named `corus.xml`) under the `META-INF` directory.
- Deploy the distribution (the .jar file) into Corus.
- Execute processes that are defined in the distribution.

To better illustrate the above steps, we provide the appropriate concrete examples:

Implement a J2SE Application

The applications consists of a naive echo server implementation. As can be seen, it does not make use of any special class and does not follow any predefined development model in order to be deployed into Corus; it is a plain Java server started from a `main()` method:

```
package org.sapia.corus.examples;

import java.io.BufferedReader;
import java.io.IOException;
import java.io.InputStreamReader;
import java.io.PrintWriter;
import java.net.ServerSocket;
import java.net.Socket;
import java.util.ArrayList;
import java.util.Collections;
import java.util.List;

public class EchoServer extends Thread{

  private ServerSocket _server;
  private List _clients = Collections.synchronizedList(
    new ArrayList());

  /** Creates a new instance of EchoServer */
  public EchoServer(ServerSocket server) {
    _server = server;
  }

  public void close() throws IOException{
    _server.close();
  }

  public void run(){
    while(true){
      try{
        System.out.println("EchoServer::accept...");
        Socket client = _server.accept();
        System.out.println("EchoServer::client connection");
        ClientThread ct = new ClientThread(client, _clients);
        _clients.add(ct);
        ct.start();
      }catch(Exception e){
        e.printStackTrace();
        break;
      }
    }
    System.out.println("EchoServer::exiting...");
  }

  public static void main(String[] args){
    try{
      int port = Integer.parseInt(args[0]);
      EchoServer server = new EchoServer(
        new ServerSocket(port));
      server.start();
      Runtime.getRuntime().addShutdownHook(
        new Shutdown(server));
    }catch(Exception e){
      e.printStackTrace();
    }

  }

  /////////// INNER CLASSES ////////////

  public static class ClientThread extends Thread{

    Socket _client;
    private List _queue;

    public ClientThread(Socket client, List queue){
```

```
      _client = client;
      _queue = queue;
    }

    public void run(){

      BufferedReader reader;
      PrintWriter pw;
      try{
        reader = new BufferedReader(new
          InputStreamReader(_client.getInputStream()));
        pw = new PrintWriter(_client.getOutputStream(), true);
      }catch(IOException e){
        System.out.println("Client::terminated");
        _queue.remove(this);
        return;
      }
      while(true){
        try{
          String line;
          while((line = reader.readLine()) != null){
            System.out.println("Client::ECHO: " + line);
            if(System.getProperty(line) != null){
             pw.println("ECHO: " + System.getProperty(line));
            }
            else{
              pw.println("ECHO: " + line);
            }
            pw.flush();
          }
        }catch(IOException e){
          e.printStackTrace();
          try{
            _client.close();
          }catch(IOException e2){}
          break;
        }
      }
      System.out.println("Client::terminated");
      _queue.remove(this);
    }
  }

  public static class Shutdown extends Thread{

    private EchoServer _server;

    public Shutdown(EchoServer server){
      _server = server;
    }

    public void run(){
      try{
        _server.close();
      }catch(Exception e){}
    }
  }
}
```

2) Write the Magnet File

Magnet has been originally written to provide a multi-platform way of describing runtime parameters for Java applications that are typically started with os-specific startup scripts (such as `.sh` or `.bat` scripts, for example). In the case of Java applications, runtime parameters generally consist of system properties, the name of the Java application class, command-line arguments, and classpath information. Magnet's powerful XML format allows specifying all of that in a convenient and portable way (refer to Magnet's web site for more information). Here is the Magnet file for our echo server:

```
<magnet xmlns="http://schemas.sapia-oss.org/magnet/core/"
        name="EchoServer" description="A basic echo server">
```

```
  <launcher type="java" name="echoServer"
            mainClass="org.sapia.corus.examples.EchoServer"
            default="test" isDaemon="false" waitTime="2000"
            args="5656">
    <profile name="test">
      <classpath>
        <path directory="lib">
          <include pattern="*.jar" />
        </path>
      </classpath>
    </profile>
  </launcher>
</magnet>
```

In the above example, file resources (namely, the libraries that are part of the classpath) are resolved relatively to the "current directory", (available in Java under the `user.dir` system property). In terms of directory structure, the application is therefore organized in the following way:

`<user.dir>/echoServerMagnet.xml`

`<user.dir>/lib`

The `echoServerMagnet.xml` file contains the above Magnet configuration. Of course required libraries (if any) would appear under the `lib` directory. At development time, the `user.dir` variable corresponds to the "working" directory of your IDE.

One convenient way to work with Corus is to test the application prior to deploying it into Corus. Making sure that everything works properly prior to deployment allows sparing the dreadful deploy-test-redeploy cycle that is so common with EJB applications and consumes a lot of development time. In this case, we would invoke Magnet from the command-line (after compiling and generating a .jar for our echo server under the lib directory):

```
sh magnet.sh –magnetfile echoServer.xml –p test
```

The first command-line option consists of the name of our Magnet configuration file (if not specified, Magnet expects a `magnet.xml` file under the current directory). The second option consists of the name of the profile under which the Magnet VM should be started (for more information on the concept of profile, have a look at the Magnet web site).

If everything works fine, we are ready to write our Corus descriptor (there is a client for the server as part of Corus but we won't show it here; have a look in the package to see the source if you feel like it).

> The great strength of Corus in terms of application development is the absence of a rigid programming model that forbids starting applications from a simple command-line; it does not force deployment into a bloated container prior to be able to use and test applications.

3) Write the Corus Descriptor

The Corus descriptor is expected under the `META-INF` directory of the the archive that will be generated and deployed. In the case of this example, the `META-INF` directory is created under the current directory (since the distribution will be generated from that directory). The content of the `corus.xml` file for the echo server is provided below:

```
<distribution name=”demo” version=”1.0”
xmlns=”http://www.sapia-oss.org/xsd/corus/distribution-3.0.xsd”>
  <process name="echoServer"
           maxKillRetry="3"
           shutdownTimeout="30000"
           invoke="true">
    <port name="test" />
    <magnet magnetFile="echoServerMagnet.xml" vmType=”server” profile="test">
      <xoption name="ms" value="16M" />
    </magnet>
  </process>
</distribution>
```

One thing to note is that the `corus.xml` file contains a `magnet` element. Since Corus' architecture was thought to eventually allow different types of processes to be started (for example, Python or Perl applications), the `magnet` element is a side-effect of that intent (eventually, a `python` element could be introduced): it is meant to indicate that a Magnet VM should be invoked; more concretely: a Magnet bridge instantiated within Corus is invoked and triggers the execution of the Magnet command-line, consistently with the parameters that are configured in the `corus.xml` file.

As can be noted, the `magnetFile` attribute indicates which Magnet configuration file should be used; the file's location should be given as a path that is relative to the root of the eventual Corus distribution (i.e.: the root of the .jar file). This is because as part of the deployment procedure, Magnet distributions are extracted under a predefined directory under Corus; the directory where a given distribution was extracted is the directory relatively to which Magnet configuration files of that distribution are resolved.

Another noticeable detail are the `name` and `version` attributes of the `distribution` element: every distribution deployed into Corus is uniquely identified by the value of its name and version. This also means that you can have multiple distributions with the same name, but that in this case the versions must differ.

> The Corus descriptor will be explained in more details further below.

4) Package the Distribution in a .zip File

Packaging a Corus distribution only requires putting in a .zip file the required resources: application libraries, Magnet file(s), Corus descriptor. In the context of your example, we could use Ant to package everything that is under the root of the working directory. This would in effect mirror the structure on the file system, and that is one of the main goals: to eliminate disparities between usage in a local, standalone mode, and deployment on a multi-VM, distributed mode. The application that you implement and use locally on your workstation is the exact same one that will be deployed into Corus.

Thus, our application archive would have the following structure:

`echoServerMagnet.xml`

`lib/`

`META-INF/corus.xml`

5) Deploy the Distribution

Since an archive properly packaged as a Corus-deployable unit may contain more than one application (given as multiple process definitions or as multiple applications in the same Magnet configuration or both), that archive is named a "distribution", not an application anymore. That is such even in the case of our example, where only one application is involved.

Deploying an application into Corus involves calling the following command through the Corus command-line:

```
deploy <distribution_path>
```

Where `<distribution_path>` is the path to the Corus distribution that is to be deployed (if a relative, the path is resolved from the directory in which you have invoked the Corus command-line interface).

> See the *Installation* section further below for instructions on how to use the command-line interface.

6) Execute

Once a distribution has been successfully deployed, processes described as part of the distribution can be started. In the case of our example, we would invoke the `exec` command from the Corus client console:

```
exec -d demo -v 1.0 -n echoServer -p test
```

The above command will start a Java virtual machine "containing" an instance of our echo server (more precisely: a Magnet VM is invoked, with the configuration corresponding to the process that we want to execute).

In the above case, we are indicating to Corus that we want to start a VM corresponding to the demo distribution, version 1.0. We indicate the name of the process configuration (`-n`) since many such configurations could be part of a Corus descriptor. The last option tells Corus under which profile the process will be started (the notion of profile is fully explained in the *Advanced Issues* section, later on).

Note that we could also have passed the `-cluster` option to the command:

```
exec -d demo -v 1.0 -n echoServer -p test -cluster
```

This would actually start the process on all Corus servers in the domain that have the corresponding distributions.

Furthermore, we could have started more than one process, by specifying the `-i` option, indicating to Corus how many instances of the processes are to be started:

```
exec -d demo -v 1.0 -n echoServer -p test -i 3
```

or

```
exec -d demo -v 1.0 -n echoServer -p test -i 3 -cluster
```

In the latter case, we are requesting the startup of 3 echo servers at all Corus servers in the domain (note that this would result in port conflicts, since our echo servers on the same host all listen to the same port).

It is important to understand that processes are executed by a Corus server on the host machine of that Corus server; meaning: a process (a JVM in the case of our example) is started by a Corus server on its own host for each invocation of the `exec` command it receives.

Deploying using Standard Java

If you find using Magnet unsuitable, you may use a simpler method (in this case, you will not benefit from Magnet's powerful multi-application and classpath management features).

In such a case, you must create a Corus archive that will have the following structure:

`classes/`

`lib/`

`META-INF/corus.xml`

Upon startup, the JVM corresponding to your application will be assigned the "classes" directory and all the archives under the "lib" directory as part of its classpath.

The `classes` directory is meant to contain resources (Java classes, arbitrary files) that are not packaged as libraries (in .jar files). The `lib` directory, for its part, is meant to hold libraries (.jar files).

> The content of the `lib` directory (and subdirectories) must consist of archives with either the .jar or .zip extension – and supporting the zip format. The archives will be "inserted" in the classpath in alphabetical order. Corus will include archives in subdirectories, but will only sort based on the names of the files (excluding the path). Note also that the content of **the `classes` directory will be inserted into the classpath first**.

The content of the `corus.xml` file will in this case consist of the following:

```
<distribution name="demo" version="1.0"
xmlns="http://www.sapia-oss.org/xsd/corus/distribution-3.0.xsd">
  <process name="echoServer"
           maxKillRetry="3"
           shutdownTimeout="30000"
           invoke="true">
    <port name="test" />
    <java mainClass="org.sapia.corus.examples.EchoServer"
              profile="test" vmType="server">
      <xoption name="ms" value="16M" />
    </java>
  </process>
</distribution>
```

Note that the location of libraries may be chosen to be something else than a "lib" directory. The descriptor supports a `libDirs` element to that end, which takes a semicolon-delimited of directories (relative to the root of the distribution zip) to include in the classpath. For example:

```
<distribution name="demo" version="1.0"
xmlns="http://www.sapia-oss.org/xsd/corus/distribution-3.0.xsd">
  <process name="echoServer"
           maxKillRetry="3"
           shutdownTimeout="30000"
           invoke="true">
    <port name="test" />
    <java mainClass="org.sapia.corus.examples.EchoServer"
              profile="test" vmType="server" libDirs="patches;lib">
      <xoption name="ms" value="16M" />
    </java>
  </process>
 </distribution>
```

Again, if a `classes` directory is present under the root, the file it contains will be inserted in the classpath, and will have precedence over the library directories.

Advanced Issues

Corus Server Working Directory

You can start multiple Corus servers on the same hosts if you please, as part of the same domain, or as part of different ones. In any case, each server instance will have its own working directory under the Corus home directory. The working directory of a given server instance is identified by the following pattern:

`<domain>_<port>`

For example, a Corus server instance listening on port 33000, as part of domain "dev", would have `dev_33000` as its working directory.

Corus Distribution Directories

As was mentioned previously, when a distribution is deployed into Corus, it is extracted under the server's `deploy` directory. More precisely, Corus creates the following structure under the deployment directory:

```
distribution_name
            /version_number
                        /common
                        /processes
```

The actual distribution archive is extracted under the `common` directory. When executing a process of that distribution, Corus internally assigns an identifier to that process; it then creates a directory under the `processes` directory that is given the process identifier as a name. For example, if the process identifier is 1234567, then the `1234567` is created under the `processes` directory.

As is described in the *Corus System Properties* section further below, processes are passed the above information (their `common` and `process` directories) as the following system properties, respectively: `user.dir` and `corus.process.dir`.

The Corus Descriptor

The Corus descriptor is the XML file (named `corus.xml`) which must be packaged as part of Corus distributions, under the `META-INF` directory (which itself must be present under the root of the distribution .zip).

Here is an elaborate Corus descriptor (all elements are formally explained in the table further below) :

```
<distribution
               xmlns="http://www.sapia-oss.org/xsd/corus/distribution-4.0.xsd"
               name="demo"
               version="1.0" tags="someTag">
  <process name="echoServer"
           maxKillRetry="3"
           shutdownTimeout="30000"
           deleteOnKill="false"
           invoke="true"
           pollInterval="15"
           statusInterval="45"
           tags="someOtherTag">
    <port name="test" />
    <magnet magnetFile="echoServerMagnet.xml"
            profile="test"
            javaCmd="java">
                  <!-- Alternate standard Java configuration:
                       simpler, but less powerful than Magnet -->
    <!-- java mainClass="org.sapia.corus.examples.EchoServer"
            profile="test"
            javaCmd="java">
      <xoption  name="ms" value="16M" />
                <dependency dist="testDist"
                version="1.0"
                process="testApp"
                profile="prod" />
    </magnet>
  </process>
</distribution>
```

The Corus descriptor's XML schema can be dowloaded from: http://www.sapia-oss.org/xsd/corus/distribution-4.0.xsd. The table below provides a description for each element and attribute specified in the schema:

Name	*Description*	*Attributes / child elements*		
		Name	*Reqd.*	*Description*
distribution	The root element of all Corus descriptors	name	Yes	The name of the distribution.
		version	Yes	The version of the distribution.
		tags	No	A comma-delimited list of tags used to determine if the configured processes should be started (based on the tags of the current Corus server) – see the *Tagging* section.
process (1-*)	Holds process description information.	name	Yes	The name that identifies the process configuration.

Name	*Description*	*Attributes / child elements*		
		maxKillRetry	No	The number of times Corus should attempt to kill processes corresponding to this process configuration that are deemed stalled or "down" (defaults to 3).
		shutdownTimeout	No	The number of milliseconds that is given to processes to confirm their clean shutdown (defaults to 30000).
		deleteOnKill	No	Indicates if processes corresponding to this process configuration should have their process directory deleted after shutdown (defaults to false).
		invoke	No	Indicates if processes corresponding to this distribution will be started automatically when invoking `exec` for the distribution without indicating which process configuration to create processes from (if true, the value of this attribute indicates that processes corresponding to this process configuration must be invoked explicitly by passing the `-n` option to the `exec` command) – defaults to false.
		pollInterval	No	The interval (in seconds) at which processes corresponding to this configuration are expected to poll their Corus server (defaults to 10).
		statusInterval	No	The interval (in seconds) at which processes corresponding to this configuration are expected to provided their runtime status to the Corus server (defaults to 30).
		tags	No	A comma-delimited list of tags used to determine if the process should be started (based on the tags of the current Corus server) – see the *Tagging* section.
		preExec	No	A single such element can be specified.
port (0-*)	Used to indicate a network port number that should be passed to the insances of the process.	name	Yes	The name of a port range, as configured in the Corus server (see the *Port Management* section futher on for more information).

Name	*Description*	*Attributes / child elements*		
preExec (0-1)	Allows specifiying multiple **cmd** child elements, each corresponding to a Corus CLI command. Each such command will be executed on the server-side (that is, at the Corus node) prior to the process itself being executed.	cmd	Yes	Multiple such elements can be specified. See the *Pre-Execution* section, further below, for more information.
cmd (0-*)	The element's content is meant to hold a Corus command-line which will be executed on the server-side (at the Corus node)	N/A	N/A	N/A
magnet (0-1)	Encapsulates information required by the underlying Magnet launcher when starting up JVMs.	magnetFile	Yes	The path to the Magnet configuration file, relatively to the root of the Corus distribution archive.
		profile	Yes	The name of the profile under which processes are to be started.
		javaHome	No	Allows specifying usage of a different JVM by specifiying the home of the JDK or JRE installation directory that is desired (defaults to the same Java home as the Corus server by which processes are executed).
		javaCmd	No	Allows specifying the name of the Java executable that is to be invoked when starting JVMs (defaults to `java`).
		vmType	No	Indicates the type of VM (-client or -server for Java Hotspot) that is to be started.
java (0-1)	Encapsulates information required to launch a standalone Java application in its own JVM.	mainClass	Yes	The name of the application class (class with a “main” method) to invoke upon JVM startup.

Name	*Description*	*Attributes / child elements*		
		profile	Yes	The name of the profile under which processes are to be started.
		javaHome	No	Allows specifying usage of a different JVM by specifiying the home of the JDK or JRE installation directory that is desired (defaults to the same Java home as the Corus server by which processes are executed).
		javaCmd	No	Allows specifying the name of the Java executable that is to be invoked when starting JVMs (defaults to `java`).
		vmType	No	Indicates the type of VM (-client or -server for Java Hotspot) that is to be started.
		libDirs	No	Allows overridding the default `lib` directory expected to contain the libraries with which the JVM's classpath will be built. The value must be a semicolon-delimited list of directories (interpreted relatively to the distribution's root – that is, the root of its .zip file). The libraries in these directories will then instead be used to build the JVM's classpath.
dependency (0-*)	Used to indicate that a given process depends on another	distribution or dist	No	The name of the distribution to which the other process belongs. If not specified, the current distribution will be assumed.
		process	Yes	The name of the process on which the current process depends.
		version	No	The version of the distribution to which the other process belongs. If not specified, the version of the current distribution will be assumed.
		profile	No	If not specified, the profile of the parent **magnet** or **java** element is used.
arg (0-*)	Corresponds to a VM argument, such as `-javaagent:`.	value	Yes	The value of the the argument.
option (0-*)	Corresponds to a VM option – such as `-cp` or `-jar` (see the help of the `java` command for more information).	name	Yes	The name of the option.
		value	Yes	The value of the option.

Name	*Description*	*Attributes / child elements*		
property (0-*)	Corresponds to a VM system property that will be passed to processes using the form: `-Dname=value`.	name	Yes	The name of the system property.
		value	Yes	The value of the system property.

Profiles

Corus supports the concept of "profile". A profile is simply a character string that identifies the "type" of execution of a process. To be more precise, imagine that you have a distribution (in Corus' sense) that contains multiple process configurations corresponding to applications that are deployed in different environments, or used under different conditions. For example, you could deploy a distribution to a Corus server in your development environment, and deploy that same distribution in QA or pre-prod. By the same token, you could connect to some server simulator in a development environment, but to the real one in pre-prod or QA. A common problem is also the database, which could have different addresses across environments, and even be of a different brand (HSQLDB, Postgres) in these different environments.

The notion of profile is a simple way to work around the configuration problems that arise when working in different environments or using applications under different conditions. Based on the profile (passed around as a string, remember...) you could use different configuration files.

Therefore, Corus makes no assumption with regards to the profile; it just passes it to executed processes as a system property (the `corus.process.profile` system property). In addition, the Magnet starter (used by Corus to start Magnet processes) passes the profile to the VM through the `magnet.profile.name` system property (this is because Magnet also supports the notion of profile and uses that system property to identify the current profile – having a look at the Magnet web site will enlighten you).

So from your application, you only need "interpreting" that system property (i.e.: implement code that acts based on the value of that system property).

Process Properties

When executing a process, Corus passes to it process properties (in fact, VM system properties as supported in Java). Theses properties consist of all the ones specified as part of a) the process configuration in the Corus descriptor; b) the `corus_process.properties` file under `CORUS_HOME/config`; c) the properties

stored in the server's configuration module, which can be administered through the command line – see the *Corus Properties* section further below. In addition, Corus will pass the following properties to new processes:

Name	*Description*	*Value*
`corus.process.id`	The unique identifier of the process that was started.	A Corus process identifier.
`corus.process.name`	The name of the process that was started.	A process name.
`corus.server.host`	The address of the Corus server that started the process.	An IP address.
`corus.server.port`	The port of the Corus server that started the process.	A port.
`corus.server.domain`	The name of the domain of the Corus server that started the process.	A domain name.
`corus.distribution.name`	The name of the distribution to which the process corresponds.	An absolute path to a directory.
`corus.process.dir`	The directory of the process.	The directory of the process.
`corus.process.poll.interval`	The interval at which the process is expected to poll its Corus server.	A time interval in seconds.
`corus.process.status.interval`	The interval at which the process is expected to send its status to its Corus server.	A time interval in seconds.
`corus.process.profile`	The name of the profile under which the process was started.	The name of a profile.
`user.dir`	The "common" directory of all processes of the distribution of which the process is part.	An absolute path to a directory.

Process Pre-Execution

It is possible to have Corus commands executed prior to the execution of a process. Commands executed in this manner are processed by a command interpreter embedded within the Corus instance: their execution is meant to be strictly in-VM, the `-cluster` option is not supported in their case; and some commands make no sense in embedded mode, their use having potentially unpredictable effects (such as `deploy`, for example).

Such commands (the same ones that are typically typed in the Corus CLI) are specified int the `preExec` element of the Corus descriptor (which is itself under the `process` element). A `preExec` element can have any number of `cmd` elements as children. The snippet below illustrates such an element.

```
<process ...>
```

```
  <preExec>
    <cmd>conf export -f ${corus.process.dir}/conf/app.properties</cmd>
  </preExec>
  <java ... libDirs="${corus.process.dir}/conf/;lib">
     ...
  </java>
</process>
```

In the above, prior to execution, Corus process properties are exported to the given file (`${corus.process.dir}/conf/app.properties`).

Then, in the `libDirs` attribute of the `java` element, the directory containing that file is inserted in the classpath (note that the ending with a forward-slash is required if the whole directory is to be included in the classpath. If the directory does not end with a forward-slash, Corus will look for .jar files in that directory, and these will be added to the classpath – the *Corus Descriptor* section, further above, has a note to that effect).

The intent above is to make process properties available to the application being deployed, which can then load the properties file through its classloader.

> It is recommended to export properties in a process-specific directory, so that different processes do not overwrite each other's properties. The best guarantee then is to store such files under the folder corresponding to the one created specifically for the process – to which the `corus.process.dir` property is mapped.

A more advanced use could be the following:

```
<process ...>
  <preExec>
    <cmd>conf merge -r -b ${user.dir}/conf/apps.properties -f $
{corus.process.dir}/conf/app.properties</cmd>
  </preExec>
  <java ... libDirs="${corus.process.dir}/conf/;lib">
     ...
  </java>
</process>
```

The above uses the `conf merge` command, which proceeds as follows:

1. Loads the properties specified by the `-b` option (the properties are considered the "base").
2. Adds the Corus process properties to properties thus loaded in memory (the process properties will override any identically-named properties in the base properties)
3. Saves the resulting properties to the file (know as the "target") specified by the `-f` option.

The `-r` option triggers the replacement of variables in the propertie loaded from the base file, using the process properties (in a bit more, as explained just below) for looking up their corresponding value. Meaning: given such a property in the base properties: `app.environment=${env}`, and the following process property: `env=qa`, then the resulting property will be `app.environment=qa`.

The process properties are used for variable values, but the properties passed to the process by Corus (`corus.process.id`, `corus.process.dir`, etc.) and Corus' own system properties as well. The lookup order is as follows:

1. The properties that are dynamically created and passed to the process by Corus

(`corus.process.id`...).

2. The process properties stored in Corus.
3. Corus' own system properties.

If some variables cannot be replaced (due to having no match in terms of their name in neither of the above-define properties), then they are left as is and will be saved in this manner in the resulting target file.

The same variable resolution rules apply when processing the command-lines specified by the `cmd` element in the descriptor.

Process Dependencies

It may occur that some processes depend on other processes, and that these processes themselves depend on other ones, and so on. The Corus descriptor supports declaring such dependencies, through `dependency` elements.

When such dependencies are detected, Corus will process them so that processes are started in the appropriate order. This will startup multiple processes consecutively, in such a case the `corus.process.start-interval` property should be set properly in order to not bottleneck the CPU while applications complete their initialization phase.

The excerpt below (corresponding to a Corus descriptor) shows a dependencies can be declared on a per-process basis:

```
<distribution
xmlns="http://www.sapia-oss.org/xsd/corus/distribution-3.0.xsd"
               name=”demo” version=”1.0”>
  <process name="echoServer"
           maxKillRetry="3"
           shutdownTimeout="30000"
           invoke="true">
    <java mainClass="org.sapia.corus.examples.EchoServer" profile="test" vmType=”server”>
      <xoption name="ms" value="16M" />
      <dependency dist=”demo” version=”1.0” process=”configurator” />
    </java>
  </process>
</distribution>
```

Dependencies (processes on which other processes depend) are executed first, in the order in which they are declared: if process A depends on process B, and process B depends on process C, the execution order will be as such: C, B, A.

Execution Configurations

It may become tedious to start multiple processes manually. The process dependency feature may help work around this hassle, but what if some processes have no other processes that depend on them ? In such a case, if not started

explicitly, they will never execute.

Corus allows defining so-called "execution configuration". These configurations consist of XML files that are uploaded (through the `deploy` command) to a Corus server (or to multiple servers, in cluster mode).

An example process configuration is given below:

```
<exec xmlns="http://www.sapia-oss.org/xsd/corus/exec-3.0.xsd"
  name="test" startOnBoot="true">
  <process dist="web" version="1.0" name="httpServer" profile="prod" />
</exec>
```

The exec element takes the following attributes:

- **name** (mandatory): an arbitrary name used to refer to the configuration later on.
- **startOnBoot** (defaults to false): indicates if the configured processes are to be started when the Corus server itself boots up.

In addition, the exec element contains one to many process elements, each indicating which processes should be started. Each process element takes the following attributes:

- **dist** (mandatory): the distribution to which the process belongs.
- **version** (mandatory): the distribution's version.
- **name** (mandatory): the name of the process.
- **profile** (mandatory): the profile under which to start the process.
- **instances** (defaults to 1): the number of process instances that should be started.

Execution configurations can be deployed, listed, undeployed, and "executed", all through the command line. The following shows example commands – see the command line help of the appropriate command for more information.

1) To deploy

```
deploy -e myTestConfig.xml
```

2) To list the currently deployed execution configurations

```
ls -e
```

3) To undeploy

```
undeploy -e test
```

4) To execute

```
exec -e test
```

The processes corresponding to an execution configuration are treated the same way as if they had been started manually: process dependencies are resolved, and processed are started in the appropriate order. Thus, if all dependencies are declared appropriately, there is no need to specify processes on which other process depends as part of execution configurations: these will be started through the normal dependency resolution mechanisms.

Distributed Applications

As was explained in a previous section, Corus supports distributed application development by embedding a Ubik JNDI server. Therefore, your applications can use the Ubik distributed computing with Corus in a transparent manner; the only requirement is that you use Corus' JNDI provider on the application's side (and put the Corus client library – `sapia_corus_client.jar` – in your classpath).

Of course, your are not mandated to use Ubik (and the Corus JNDI provider). You could start Java RMI servers, or as a matter of fact any type of server with Corus. Your could for example elect to use ActiveMQ (http://www.activemq.org/), and start ActiveMQ servers with Corus on multiple hosts, thereby providing an asynchronous, scalable and robust messaging fabric.

The real strength of Corus is that it allows deploying and controlling processes on multiple hosts, in a centralized manner. Corus has a grid-like feel to it, and allows you to do things that were possible only by paying expensive application server licenses.

Corus Configuration Properties

A Corus server takes into account two configuration files (actually, Java property files), both in its `config` directory. It also support remotely overriding the properties in these files: in such cases, the properties are kept in Corus' internal database. These files are:

- `corus.properties`: holds the server's configuration parameters
- `corus_process.properties`: holds properties that are passed to each started process.

Both of these files must respect the Java properties format. The `corus_process.properties` file holds arbitratry properties that are passed to executed processes (through the command-line) as Java system properties. This means a command-line option respecting the format below is created for every property in the file:

```
-D<property_name>=<property_value>
```

For its part, as stated, the file named `corus.properties`, contains the server's configuration properties. Note that since Corus rests on Sapia's Ubik distributed computing framework, it also supports all Ubik properties (which is of interest when wanting to use Avis as a node discovery mechanism).

The Corus server's configuration properties are described below (the description tells if the current property can be remotely updated - the **Remote Property Update** section, further below, describes the mechanism for storing configuration properties (either Corus server properties or process properties) within the Corus server itself. Please see that section for it provides relevant information about where to keep configuration properties.):

Property	*Description*	*Required*	*Remote Update*

`corus.server.properties.include.01`
`[corus.server.properties.include.02`
`corus.server.properties.include.N`
`...]`
	One ore more property includes, each consisting of the path to one or more property files that should be included and are stored in arbitrary locationiuin the file system (potentiallly in mounted network drives).
	The files in each path should be separated by either ':' or ';' - without the quotes.
	This mechanism allows sharing configuration across multiple Corus instances.
		No	No

`corus.server.domain`	The name of this property corresponds to the name of the domain to which the Corus server belongs. If the domain is specified at the startup script of the Corus server (through the `-d` option), this property is not taken into account.	No (if not specified in the file, must be given as the `-d` option at the Corus server startup script).	No
`corus.server.port`	The port on which the Corus server should listen. If the port is specified at the startup script of the Corus server (through the `-p` option), this property is not taken into account.	No (defaults to 33000)	
`corus.server.tmp.dir`	The directory where distributions are deployed, pending their extraction under the `deploy` directory.	No (defaults to `<server_dir>/tmp`)	Yes
`corus.server.deploy.dir`	The directory where distributions are extracted and kept.	No (defaults to `<server_dir>/deploy`)	Yes
`corus.server.db.dir`	The directory where Corus' internal database stores its files.	No (defaults to `<server_dir>/db`)	Yes
`corus.server.uploads.dir`	The directory where file uploads (that is, files deployed with the -f switch in the CLI) are kept. See the **File Uploads** subsection under the **Advanced Issues** section of this document.	No (defaults to `<server_dir>/files/uploads`)	Yes
`corus.server.scripts.dir`	The directory where deployed shell scripts (with the -s switch in the CLI) are kept. See the **Shell Scripts** subsection under the **Advanced Issues** section of this document.	No (defaults to `<server_dir>/files/scripts`)	Yes
`corus.process.timeout`	Delay(in seconds) after which processes that have not polled their Corus server are considered "timed out".	Yes	Yes

Property	*Description*	*Required*	*Remote Update*
`corus.process.start-at-boot.enabled`	Indicates if a processes should be started automatically at Corus server boot time, provided these processes have an execution configuration that is flagged as startable on boot – i.e: the `startOnBoot` flag is set to `true`.	No (defaults to true)	Yes
`corus.process.check-interval`	Interval(in seconds) at which the Corus server checks for timed out processes.	Yes	Yes
`corus.process.kill-interval`	Interval(in seconds) at which the Corus server attempts killing a crashed process.	Yes	Yes
`corus.process.start-interval`	Amount of time that Corus will wait for between process startups, when multiple processes are started at once by end-users.	No (defaults to 15)	Yes
`corus.process.restart-interval`	Amount of time (in seconds) a process must have been running for before it crashed and in order for an automatic restart to be authorized.	Yes	Yes

`corus.server.multicast.address`
`corus.server.multicast.port`
or
`ubik.rmi.naming.mcast.address`
`ubik.rmi.naming.mcast.port`
	Multicast address and port used for discovery, respectively.
	As of version 3.0, Corus also supports the Ubik variants.
	Note: the values of these properties are by default made to correspond with the default values used by Ubik (the distributed computing framework on which Corus is based).
		Yes	Yes

`ubik.rmi.address-pattern`	A regexp specifying on which network address the Corus server should listen. It is preferrable to set that property if the host on which Corus is installed has more than one network interface. By default, Corus will listen on all network interfaces. It will also attempt to return as part of the remote stubs that it generates the first network address it finds that is not localhost – otherwise, localhost will be used.	No	No

Property	*Description*	*Required*	*Remote Update*

`corus.server.security.hostPattern.allow`
`corus.server.security.hostPattern.deny`
	Each property is expected to hold a comma-delimited list of patterns of IP addresses from which clients are either allowed or denied connection, respectively.
	Here are valid patterns:
	`192.168.*.*`
	`192.*.*.*`
	`192.**`
	`192.**.*`
		No	Yes

`corus.server.syslog.protocol`	The protocol to use to connect to the Syslog daemon - value may be udp, tcp. **Note**: for Syslog integration to be activated, all properties under corus.servder.syslog.* must be set.	No	No
`corus.server.syslog.host`	The host of the Syslog daemon.	No	No
`corus.server.syslog.port`	The port of the Syslog daemon.	No	No
`corus.server.alert.enabled`	Indicates if email alerting should be enabled.	No (defaults to false)	Yes
`corus.server.alert.smtp.host`	The host of the SMTP relay to use to send alert emails.	Yes (defaults to localhost)	Yes
`corus.server.alert.smtp.host`	The port of the SMTP relay to use to send alert emails.	Yes (defaults to 25)	Yes
`corus.server.alert.smtp.password`	The SMTP password to use when connecting to the SMTP relay upon sending email alerts.	No	Yes
`corus.server.alert.recipients`	The semicolon-delimited list of recipient email addresses to use when sending alert emails.	Yes	Yes
`corus.server.alert.sender`	The email address that should appear in the "from" field when sending alert emails.	Yes (if not specified, a default is built based on the host of the SMTP relay)	Yes

Remote Property Update

Corus supports remotely updating server or process properties. In such cases, it is not the actual property files that are modified: rather, Corus adds/removes the properties to/from its internal database; if specified, the properties will override the corresponding ones in the file.

The updates are performed using the Corus command line interface. The `conf` command allows adding, deleting, and listing either server or process properties. The command also supports updating so-called "tags" (explained in the next section). The syntax goes as follows:

1) To add a property, or a list of properties:

```
conf add -s s|p -p name1=value1[,name2=value2[,nameN=valueN[...]]
```

Where:

- **s** specifies the scope (indicating if the property is a server or process property)
- **p** consists of a comma-delimited list of name-value pairs corresponding to actual properties (there must be no space in the list for it to be parsed properly).

2) To list the properties

```
conf ls -s s|p
```

Where:

- **s** specifies the scope (indicating if the property is a server or process property)

3) To remove a property

```
conf del -s s|p -p some.property
```

```
conf del -s s|p -p some.*
```

Where:

- **s** specifies the scope (indicating if the property is a server or process property)
- **p** specifies the property to remove (may include wildcards corresponding to a property name pattern – in which case all matching properties will be removed

> For the properties with the "server" scope, the Corus instance must be restarted for the new values to be taken into account.

Property Includes

It may be convenient to share configuration properties across multiple Corus instances.

This is possible through a mechanism dubbed "property includes". How this works is very simple: you configure includes in the `corus.properties` file, as follows:

```
corus.server.properties.include.01=$
{user.home}/.corus/corus.properties
```

```
corus.server.properties.include.02=/opt/corus/corus.properties:
/etc/corus/corus.properties
```

To configure includes, you have to follow the format below for property names:

```
corus.server.properties.include.<suffix>
```

This format allows configuring multiple includes on different lines. The suffix can be any string, but you should design them keeping in mind that Corus will evaluate includes based on the sort order of their corresponding suffix.

On the right-hand side, the property value is expected to be a path composed of multiple segments, each pointing to a file to include, and where each segment is separated by either a colon (:) or semicolon (;).

As you can see, property values may also contain variables in the following format:

`${<name>}`

Variables are expected to correspond to JVM properties (such as `user.dir`, `user.home`, etc.). Such variables are evaluated at Corus startup.

Alerts

Corus can be configured to send email alerts in three situations:

1. When it restarts an unresponsive process.
2. When a new distribution is deployed.
3. When a distribution is undeployed.

For this feature to be enabled, the following must be configured (in the `corus.properties` file):

- The `corus.server.alert.enabled` property must be set to true.
- The `corus.server.alert.recipients` property must correspond to list of recipients (email addresses) separated by a semicolon.

In addition, you should make sure that the following properties are properly configured (defaults are used which may be unsuitable for your setup):

- `corus.server.alert.smtp.host`: defaults to localhost.
- `corus.server.alert.smtp.port`: defaults to 25.
- `corus.server.alert.smtp.password`: empty by default.
- `corus.server.alert.sender`: a default one is constructed using the SMTP host.

> The `corus.properties` file that comes with Corus has complementary explanations regarding those properties.

Tagging

In might be desirable to start given processes on specific hosts, and not on others. For example, imagine a process that scans a database table periodically, performs an action based on the data that is retrieved, and then deletes that data. Multiple such processes acting in parallel will pose a concurrency issue: the action will be performed redundantly. Thus, in such a case, one would want to make sure that this process is executed on a single host.

To support this, Corus has a so-called “tagging” feature: a tag is an arbitrary string that is used to determine if a process can be executed by a given corus instance.

Concretely, it works has follows:

1) The Corus descriptor may be enriched with tags: both the distribution and process elements of the descriptor support a tags attribute: the value of the attribute takes a comma-delimited list of tokens, each corresponding to an actual tag.
2) A Corus server itself may be attributed with given tags: the conf command of the command-line interface may be used to add, list, and remove tags to/from a Corus server.
3) Prior to starting a process, the Corus server will determine if the tags of that process match the ones it has configured: if the process and its distribution have no tags, the process is started; if all the tags assigned to a process and its distribution are contained in the set of tags of the server, the process is started; if all the tags assign to a process and its distribution are not contained in the set of tags of the server, the process is NOT started.

The example descriptor below shows how to configure tags: they can be specified as a comma-separated list on the **`distribution`** element:

```
<distribution xmlns="http://www.sapia-oss.org/xsd/corus/distribution-3.0.xsd"
  name="id-generator" version="1.0" tags="singleton">
  <process name="server"
           maxKillRetry="3"
           shutdownTimeout="30000"
           invoke="true">
    <java mainClass="org.myapp.IDGenerator"
              profile="test" vmType="server">
      <xoption name="ms" value="16M" />
    </java>
  </process>
</distribution>
```

The can also be specified on a per-process basis:

```
<distribution xmlns="http://www.sapia-oss.org/xsd/corus/distribution-3.0.xsd" name="id-
generator" version="1.0">
  <process name="server"
           maxKillRetry="3"
           shutdownTimeout="30000"
           invoke="true" tags="singleton">
    <java mainClass="org.myapp.IDGenerator"
              profile="test" vmType="server">
      <xoption name="ms" value="16M" />
    </java>
  </process>
</distribution>
```

At runtime, the Corus server will determine the tags of a process by merging the tags at the process level with the ones at the distribution level: it is thus the union of these tags that is used for validating against the server's own tags, according to the previously defined algorithm.

Remote Tag Update

The Corus command-line can be used to add, remove and list the tags of a Corus server. The following provides examples (see the documentation of the `conf` command – by typing `man conf`) for more details.

1) Adding tags

```
conf add -t someTag,someOtherTag
```

2) Listing tags

```
conf ls -t
```

3) Removing tags

```
conf del -t someTag
conf del -t *
```

Shell Scripts

The ability to deploy shell scripts into Corus and execute them remotely from the CLI has been introduced as of version 4.0. This feature is meant to further extend the centrally controlled execution of distributed processes offered by Corus.

Basically, the functionality allows:

- Deploying a shell script into a Corus node (or multiple Corus nodes).
- Triggering the execution of the shell script from the CLI (either in clustered or non-clustered mode).

There is no restriction on what the shell scripts do, their nature being left entirely to system administrators. One thing to note though is that the scripts are run under whichever user the Corus instance is itself being run. So if the scripts require specific permissions, it is important that these be granted to the Corus user.

Deployed shell scripts are kept under the `$CORUS_HOME/files/scripts` directory. This location is configurable, by modifying the `corus.server.scripts.dir` in the **corus.properties** configuration file (itself under `$CORUS_HOME/config` directory).

Deploying a Shell Script

A shell script is deployed to a Corus instance using the using the deploy command in the CLI, in conjunction with the following options:

- **s**: the path to the shell script to deploy.
- **a**: the script's alias, which is used to refer to the script later on, when executing it.
- **d**: the description to associate to the script. That description is used for display purposes – not that this option is optional.

Here's an example:

```
deploy -s /home/jdoe/restart_memcached.sh -a restart-memcached
-d “Restarts memcached”
```

Of course, as with any Corus command, using the -**cluster** option will have the effect of deploying the shell script across all nodes in the cluster:

```
deploy -s /home/jdoe/restart_memcached.sh -a restart-memcached
```

```
-d "Restarts memcached" -cluster
```

Listing the Deployed Shell Scripts

To view the currently deployed shell scripts, use the `ls` command in conjunction with the **-s** option:

```
ls -s
```

Executing a Shell Script

To execute a shell script, type the `exec` command with the **-s** option – the value to assign to the option should correspond to the alias of the script to execute:

```
exec -s restart-memcached
```

Undeploying a Shell Script

To undeploy a shell script, type the undeploy command with the -s option specifying the alias of the script to undeploy:

```
undeploy -s restart-memcached
```

You call also use pattern matching to undeploy multiple scripts at once:

```
undeploy -s restart* -cluster
```

File Uploads

As part of Corus 4.0, the ability to deploy arbitrary files to Corus has been introduced. This feature is meant as a convenience, whereby the distributed management facility of Corus can be used to deploy files across multiple hosts at once.

When When files are deployed in such a manner, Corus makes no attempt to determine what these files are about (it will not attempt, for example, that such a deployed file may consist of a Corus application distribution).

By default, such files are kept under the `$CORUS_HOME/files/uploads` directory. This location is configurable, by modifying the `corus.server.uploads.dir` in the **corus.properties** configuration file (itself under `$CORUS_HOME/config` directory).

Deploying a File

To deploy a file, simply type the deploy command in the CLI, together with the **-f** option, whose value should be set to the path of the file to deploy.

```
deploy –f myArchive.zip
```

The **-cluster** option works its magic for this command also, triggering the deployment of the file across all hosts in the cluster.

```
deploy –f myArchive.zip –cluster
```

In addition the, the command also takes a **-d** option. The option can be used to provide a user-defined directory where the file is to be uploaded on the Corus node:

```
deploy –f myArchive.zip –d /opt/uploads
```

Listing the Deployed Files

To list the currently deployed files, use the `ls` command with the **-f** option:

```
ls –f –cluster
```

Note that this will only list the files present under Corus' `uploads` directory. If you have deployed files with the **-d** option set to another directory, it will not be magically remembered by Corus.

Undeploying a File

To undeploy, just use `undeploy`, with the **-f** option also. Here are examples:

```
undeploy –f myArchive.zip
```

```
undeploy –f myArchive.zip –cluster
```

```
undeploy –f *.zip
```

Similarly to the `ls` command, the files deployed to user-defined directories will not be seen by Corus, and thus you will not be able to undeploy files from under such directories.

Repository

As of release 4.0, Corus has been enriched with a repository functionality: this allows some Corus nodes (configured as “repository clients”) to synchronize their state with other nodes (which are themselves configured as “repository servers”).

Rationale

The functionality has been introduced in order to facilitate installation of new Corus nodes: newly installed nodes configured as repository clients will automatically end up having the same distributions, execution configurations, shell scripts, file uploads, port ranges, process properties, and tags, as the repository servers with which they synchronize themselves.

In addition, the functionality proves handy when running Corus in the cloud: new Corus instances configured as repo clients have their distributions automatically copied to them, and the application processes configured as part of these distributions may then be automatically launched.

Mechanism

The synchronization between repository clients and servers occurs when a repository client node starts up: upon appearing in the domain, it will detect which nodes in the domain act as repository servers. The repo client node will then notify the repo servers it has discovered that it wishes to synchronize its state with them.

Exchanges follow between the repo client and the repo servers, in the context of which the latter send to the repo client their distributions, execution configurations, shell scripts, file uploads, port ranges, process properties, and tags. Upon completion of this synchronization, a repo client node ends up having the same state as the whole of its repo servers,

> Synchronization is restricted to the domain (or cluster). That is: repo clients will not "see" repo servers outside of their own domain. For a given domain, it is recommended to have one repo server node at the most, to make things simpler.

In addition to the synchronization of state, any execution configuration that has its `startOnBoot` property set to `true` will have the corresponding ***processes automatically started*** upon completion of the synchronization phase.

The synchronization mechanism has been optimized to avoid redundant transfers between repository servers and clients: a client will request from the repo servers that it discovers which artifacts (distributions, shell scripts, etc.) these have. It will compare these artifacts with the ones it already has, and only request from the repo servers the artifacts it does not already have.

Configuration

Enabling the repository functionality, is done through configuration. The property to set is **`corus.server.repository.node.type`** in the **`corus.properties`** file – under the `$CORUS_HOME/config`. It is by default set to `none`, meaning that the Corus instance will act as neither a respository client or server – and thus that will will not take part in any repository interaction. This is the default value.

To configure a Corus instance as a repo client, the value of the above property should be set to `client`. To configure it as a server, it should be set to `server`.

Also, in addition, by default, the push of state from servers to clients applies by default to all synchronizable elements, that is:

- distributions and execution configurations
- shell scripts
- file uploads
- port ranges
- process properties
- tags

It is possible to fine-tune both the push of synchronizable elements from servers to clients, and the pull of such elements by clients from servers.

Such customization as been introduced in order to guarantee maximum control over synchronization behavior. For example, it might be desirable to configure a repo client as having the pull of tags disabled, because one wishes to only run certain types of processes on that node. In this case then, one wants to make sure that only the tags for these processes will be set on that node, and none other.

Property	*Description*	*Default*
`corus.server.repository.node.type`	Indicates the repository role of the Corus instance: • **none**: means that the Corus node will not take part in repository operations. • **client**: means that the Corus node will act as a repository client. • **server**: means that this Corus node will act as a repository server.	`none`
`corus.server.repository.tags.push.enabled`	Indicates if the push of tags from the Corus instance is enabled (this property is taken into account only if the Corus instance is configured as a repository server).	`true`
`corus.server.repository.properties.push.enabled`	Indicates if the push of process properties from the Corus instance is enabled (this property is taken into account only if the Corus instance is configured as a repository server).	`true`
`corus.server.repository.uploads.push.enabled`	Indicates if the push of file uploads from the Corus instance is enabled (this property is taken into account only if the Corus instance is configured as a repository server).	`true`
`corus.server.repository.scripts.push.enabled`	Indicates if the push of shell scripts from the Corus instance is enabled (this property is taken into account only if the Corus instance is configured as a repository server).	`true`
`corus.server.repository.port-ranges.push.enabled`	Indicates if the push of port ranges from the Corus instance is enabled (this property is taken into account only if the Corus instance is configured as a repository server).	`true`
`corus.server.repository.tags.pull.enabled`	Indicates if the pull of tags by the Corus instance is enabled (this property is taken into account only if the Corus instance is configured as a repository client).	`true`
`corus.server.repository.properties.pull.enabled`	Indicates if the pull of process properties by the Corus instance is enabled (this property is taken into account only if the Corus instance is configured as a repository client).	`true`

corus.server.repository.uploads.pull.enabled	Indicates if the pull of file uploads by the Corus instance is enabled (this property is taken into account only if the Corus instance is configured as a repository client).	true
corus.server.repository.scripts.pull.enabled	Indicates if the pull of shell scripts by the Corus instance is enabled (this property is taken into account only if the Corus instance is configured as a repository client).	true
corus.server.repository.port-ranges.pull.enabled	Indicates if the pull of port ranges by the Corus instance is enabled (this property is taken into account only if the Corus instance is configured as a repository client).	true

Using the Pull Command

The `pull` command may be used to trigger the synchronization mechanism – automatic pull is done at Corus startup only, and it must be explicitely triggered at other times. The `pull` command is only executed by Corus nodes configured as repo clients (it will simply be ignored by others).

You can invoke the command from the Corus CLI. Just type:

```
pull
```

Or:

```
pull -cluster
```

The command is used to force the synchronization of repo client nodes post startup.

Discovery with Avis

If your network does not support IP multicast, then you may use Avis (http://avis.sourceforge.net/) as a discovery mechanism. This means you must setup an Avis router (or multiple federated ones), and configure your Corus instances as clients of this router.

The properties you have to configure to enable Avis-based discovery are the following:

```
ubik.rmi.naming.broadcast.provider=ubik.rmi.naming.broadcast.avis
```

```
ubik.rmi.naming.broadcast.avis.url=elvin://<host>:<port>
```

As indicated, in the last property, you must provide the host and port of the Avis router to which to connect.

> Please consult the Avis documentation for more details about setting up Avis and the URL format it mandates.

Port Management

Corus has a port management feature allowing the specification of so-called "port ranges". Network ports belonging to these ranges are leased to started processes and "recuperated" upon process termination – in order to be leased to other processes.

This feature was implemented as a workaround that can pose a configuration challenge when dealing with distributed applications that must run on a well-known port (a port known by the client, not a dynamic one that is abstracted by a naming service).

Since ports on a given host cannot be shared, applications using static ports must have them explicitly configured, which quickly becomes burdensome when dealing with multiple running instances of applications performing the same service.

Hence the Corus port management feature, which works as follows:

- The administrator creates port ranges (with a minimum and a maximum port) that are given a unique name.
- As part of the corus.xml file, if a process requires a port, then a corresponding `port` XML element should appear for that process' configuration. The element takes a `name` attribute whose value must correspond to the name of a configured port range.
- Upon process start-up, the Corus server remove an available port from the range that matches the port specified as part of the process configuration (Corus keeps a an internal list of leased and available ports for every configured port range).
- The acquire port is "passed" to the process as a system property (through the command-line that starts the process). The system property format is given below:

  `-Dcorus.process.port.<range_name>=<port>`

- That property can then be recuperated by the started process from application code.

The port manager built within Corus can be administered through the Corus command-line interface (type `man ports` at the command-line for more information).

The configuration snippet below shows how a port is configured; of course multiple `port` elements can be configured for each `process` element.

```
<distribution  xmlns="http://www.sapia-oss.org/xsd/corus/distribution-3.0.xsd"  name="demo"
version="1.0">

  <process name="echoServer"
           maxKillRetry="3"
           shutdownTimeout="30000"
           invoke="true">

    <port name="test" />
    <magnet magnetFile="echoServerMagnet.xml" profile="test" vmType="server">
      <xoption name="ms" value="16M" />
    </magnet>
  </process>
```

```
</distribution>
```

Syslog Integration

It is possible to redirect the Corus server's internal task manager output to a Syslog daemon (the Syslog4j library is used to that end – see http://syslog4j.org/).

To activate integration with Syslog, the following properties must be confured in the `CORUS_HOME/config/corus.properties` file (see the Corus Properties section):

- `corus.server.syslog.protocol`
- `corus.server.syslog.host`
- `corus.server.syslog.port`

Here is an example configuration:

```
corus.server.syslog.protocol=udp
corus.server.syslog.host=localhost
corus.server.syslog.port=5555
```

HTTP Extensions

Corus provides a mechanism dubbed "HTTP extensions" that allows various internal services to provide remote access over HTTP. The extensions are accessed through HTTP, at predefined URIs (each extension as an exclusive context path). The URL format to have access to a HTTP extension is as follows:

```
http://<corus_server_host>:<corus_server_port>/<extension_context_path>/...
```

Corus currenlty supports many convenient extensions, of which certain provide XML output, and are meant first and foremost for integration into monitoring infrastructures. The Corus home page is available at the following URL:

```
http://<corus_server_host>:<corus_server_port>/
```

This displays a HTML page describing the various extensions, and their respective URIs. These extensions explained in the next sub-sections.

File System

The file system extension is bound under the **files** context path. This extension simply serves the files under $CORUS_HOME over HTTP (meaning that the Corus home directory serves as the document root).

The extension is accessed as follows:

```
http://<corus_server_host>:<corus_server_port>/files/
```

Any additional data after the context path (excluding the query string) is interpreted as the path to a file or directory under the document root.

> Note that the trailing slash character (**/**) at the end of the URI is mandatory for proper access to directories.

JMX

The JMX extension (available under the **jmx** context path) provides status information gathered from the plattorm MBeans of the Corus VM. The resulting XML output is provided as follows:

```
<vmStatus>
  <attribute name="runtime.startTime" value="1180649263641"/>
  <attribute name="runtime.startDate" value="Thu May 31 18:07:43 EDT 2007"/>
  <attribute name="runtime.upTime" value="7961"/>
</vmStatus>
```

Of course more data than illustrated above is provided. The format can easily be parsed by monitoring scripts. The goal of the JMX extension is indeed to allow remote monitoring by system administrators.

The JMX extension is accessed as follows:

```
http://<corus_server_host>:<corus_server_port>/jmx
```

Deployer

The Deployer is the internal module that manages the distributions deployed in Corus. It offers an extension that displays the currenlty deployed distributions (such as when using the `ls` command in the CLI). It can be accessed through the following:

```
http://<corus_server_host>:<corus_server_port>/deployer/ls
```

In addition, query string parameters can be used to filter the result (the parameters correspond to the options available for the `ls` command in the CLI), as the examples below illustrate:

```
http://<corus_server_host>:<corus_server_port>/deployer/ls?d=demo
```

```
http://<corus_server_host>:<corus_server_port>/deployer/ls?d=demo&v=1.0
```

```
http://<corus_server_host>:<corus_server_port>/deployer/ls?d=demo&v=1.*
```

As showed in the last URL, pattern matching is supported.

Processor

The Processor is the internal module that manages the processes that have been started through Corus. It provides an extension that allows viewing these processes and their respective status, mirroring the functionality of the `ps` and `status` command in the CLI. Two URIs are supported by the deployer extension, one displaying running processes, the other displaying their status. These URIs are the following, respectively:

```
http://<corus_server_host>:<corus_server_port>/processor/ps
```

```
http://<corus_server_host>:<corus_server_port>/processor/status
```

Both of these URIs support query string parameters corresponding to the options available through the `ps` and `status` commands in the CLI.

```
http://<corus_server_host>:<corus_server_port>/processor/ps?d=demo&v=1.0&p=prod
```

```
http://<corus_server_host>:<corus_server_port>/processor/ps?d=demo&v=1.*&p=prod
```

```
http://<corus_server_host>:<corus_server_port>/processor/status?i=1178989398
```

As can be observed, pattern matching is supported.

Java Processes

As was mentioned earlier, Corus allows starting any type of process (provided it interacts with Corus according to the Corus interoperability specification – http://www.sapia-oss.org/projects/corus/CorusInterop.pdf). As far as Java processes are concerned, there are a few things to know...

Corus Interoperability Specification in Java

The Corus interop spec implementation in Java is another Sapia project. It is part of the Sapia CVS repository at SourceForge. The implementation consists of a small .jar file named `sapia_corus_iop.jar`. That library consists of a small XML/HTTP client (as required by the spec).

When executing Java VMs from Corus, that library is "placed" in Magnet's classpath. The library is made "invisible" to your applications since it is not placed at the level of the system classloader, but at the level of a classloader that is a child of the system classloader.

The Java interop implementation detects that it has been started by a Corus server by looking up the system properties; if it finds a value for the `corus.process.id` property, then it determines that it should poll the corresponding Corus server. In order to do so, it needs the host/port on which the Corus server is listening, which it acquires through the `corus.server.host` and `corus.server.port` system properties. Using the values specified through these properties, the Corus interop instance connects to the Corus server and starts the polling process.

Troubleshooting

In order to facilitate troubleshooting, the Java interop client creates the following files under the process directory:

- `stdout.txt`
- `stderr.txt`

These files hold the output resulting from the redirection of the `java.lang.System.out` and `java.lang.System.err` output streams.

In addition, when a Corus server starts a process, it logs that process' initial output to the given process' directory, in the following file:

- `process.out`

In the case of Java processes, this allows tracking errors that have occurred before the Magnet runtime could be loaded.

Interacting with Corus from Java

Java applications can interact with Corus to:

- Request a process restart or shutdown.
- Be notified upon shutdown.
- Transmit status information.

Dependency

In all cases, to interact with Corus from your applications, you will need the `sapia_corus_iop_api` library in your classpath. This library can be configured as a dependency, as part of your Maven build, as such:

```
<dependency>
  <groupId>org.sapia</groupId>
  <artifactId>sapia_corus_iop_api</artifactId>
  <version>2.1</version>
</dependency>
```

The API provided by the library allows you to hook your application to the lifecycle of the JVM, as it's managed by Corus.

Triggering a Restart

An application can request a JVM restart with code such as the following:

```
import org.sapia.corus.interop.api.InteropLink;
InteropLink.getImpl().restart();
```

Triggering a Shutdown

An application can request a JVM shutdown as follows:

```
import org.sapia.corus.interop.api.InteropLink;
InteropLink.getImpl().shutdown();
```

Registering a Shutdown Listener

You can register a `org.sapia.corus.interop.api.ShutdownListener` in order to be notified of a JVM shutdown originating from Corus:

```
import org.sapia.corus.interop.api.InteropLink;
import org.sapia.corus.interop.api.ShutdownListener;
```

```
public class MyListener implements ShutdownListener {

  public void onShutdown() {
    ...
  }

}

ShutdownListener listener = new MyListener();
InteropLink.getImpl().addShutdownListener(listener);
```

Note that `ShutdownListeners` are internally kept as `SoftReference` instances, so it is important that you keep a hard reference on any such listener in your application.

Producing Status Data

It is possible for applications to publish status information through Corus. That information will be viewable through Corus' `status` command, or through the status HTTP Extension (see the section on HTTP extensions for more details about that specific extension).

In order to publish status information, you must register a `StatusRequestListener`:

```
import org.sapia.corus.interop.api.InteropLink;
import org.sapia.corus.interop.Status;
import org.sapia.corus.interop.api.StatusRequestListener;

public class MyListener implements StatusRequestListener {

  public void onStatus(Status status) {
    ...
  }

}

StatusRequestListener listener = new MyListener();
InteropLink.getImpl().addStatusRequestListener(listener);
```

Since listeners are kept as `SoftRerences`, you must keep a hard reference on them in your code.

The listener will be invoked periodically (at the interval at which the process will poll the Corus server). It will be passed a `Status` instance, to which the listener can then add status information, as follows:

```
public void onStatus(Status status) {
    Context context = new Context("org.sapia.corus.sample.jetty");
    context.addParam(createParam("dispatched", stats.getDispatched()));
    context.addParam(createParam("dispatchedActive", stats.getDispatchedActive()));
    context.addParam(createParam("dispatchedActiveMax", stats.getDispatchedActiveMax()));
    context.addParam(createParam("dispatchedTimeMax", stats.getDispatchedTimeMax()));
    context.addParam(createParam("dispatchedTimeTotal", stats.getDispatchedTimeTotal()));
    context.addParam(createParam("dispatchedTimeMean", stats.getDispatchedTimeMean()));
    context.addParam(createParam("requests", stats.getRequests()));
    context.addParam(createParam("requestsActive", stats.getRequestsActive()));
    context.addParam(createParam("requestsActiveMax", stats.getRequestsActiveMax()));
    context.addParam(createParam("requestsTimeMax", stats.getRequestTimeMax()));
    context.addParam(createParam("requestsTimeMean", stats.getRequestTimeMean()));
    context.addParam(createParam("requestsTimeTotal", stats.getRequestTimeTotal()));
    context.addParam(createParam("suspends", stats.getSuspends()));
    context.addParam(createParam("suspendsActive", stats.getSuspendsActive()));
    context.addParam(createParam("suspendsActiveMax", stats.getSuspendsActiveMax()));
    status.addContext(context);
}
```

In the above code, the listener creates a `Context` instance, adding status parameters to it. Lastly, the `Context` is added to the `Status` instance that's passed in.

Corus Scripts

All the commands provided as part of the Corus command-line interface can also be executed as part of scripts (which are simply text files containing Corus commands).

There are three ways to execute a script:

1. Through the script command available as part of the Corus CLI.
2. By specifying the `-s` option when invoking the CLI; the option is expected to consist of the path to the script to execute.
3. Through the Corus Maven plugin (which is the subject of the next section).

Here's an example of such a script:

```
kill all -w -cluster
undeploy all -cluster
deloy myapp-*.zip -cluster
exec -e myapp -cluster
```

The content of the script above could be saved in a plain text file and executed from the CLI like this:

```
coruscli -s <path_to_script>
```

> The `kill`, `exec` and `restart` commands all support a **`-w`** option, meaning "wait", which forces the command-line to block until the command has completed on the server-side prior to moving on to the next command. This is convenient in the case of scripted deployments.
>
> For example, in the above, it is necessary to wait that the kill has completed prior to invoking `undeploy`, since that command will result in an error if processes corresponding to the distribution to undeploy are still running.

The “Ripple” Functionality

When domains (or clusters) have many hosts, it may be impractical to perform some operations on all these hosts at once. We're thinking about the restart of processes, or the deployment of new distributions, for example: in such cases, it involves performing a shutdown of all application processes at the same time, which is something that obviously should be avoided in the context of 24/7 live traffic operations: losing the processing power of, say, 10 hosts at once is probably not desirable.

As of the 4.1 release, there exists a feature in Corus which allows applying commands gradually to a whole cluster. The feature as been dubbed “rippling”, for it implies a kind of ripple effect, as commands are applied to successive cluster subsets, until the whole cluster has been touched.

The feature is supported through the `ripple` command, which allows:

- Applying a single (or “a few”) command to the cluster, to a given number of nodes at a time;
- applying multiple commands (specified in a Corus script), to a given number of nodes at a time.

Common Options

The command takes options that are common to both usage types:

- `b`: the batch size – that is, the number of nodes at a time to which rippling is to be performed.
- `m`: the minimum number of nodes required in the cluster for the specified batch size to be applied (defaults to 1).

The `-m` option is provided in order to ensure that the specified batch size will not defeat the intent of the command: say for example you have a cluster of 3 nodes, and you specify a batch size of 3: all nodes will then be impacted at the same time.

Ripple with a Single or a Few Commands

The command allows rippling one or a few commands, which must be specified with the `–c` option, as shown below:

```
ripple -b 2 –c “restart all -w | pause 45”
```

The commands must be **enclosed in quotes**. In the above example, the restart is applied to the whole cluster 2 nodes at a time.

As the example above shows, the option allows specifying multiple successive commands: in this case, these must be separated by the pipe (“|”) character.

In the above example, it makes sense to pause for a given amount of seconds prior to moving on to the next batch of nodes: the intent is obviously to give time to the applications to boot completely.

Ripple with a Corus Script

Typically, a deployment procedure involves many steps, and therefore many commands. It is more convenient, in such contexts, to use a script. The ripple command supports a `-s` option, whose value must correspond to the path of the script to execute.

Here's an example of such a script:

```
kill all -w -cluster ${cluster.targets}
undeploy all -cluster ${cluster.targets}
deloy myapp-*.zip -cluster ${cluster.targets}
exec -e myapp -w -cluster ${cluster.targets}
pause 45
```

As you can see, a `${cluster.targets}` variable has been specified in the script, for each command. The value of that variable is dynamically set by the `ripple` command and made to correspond to the current batch of nodes that are targeted.

Here's how invocation of the command would look like:

```
ripple -s deployment.txt -b 2
```

So the above means that the deployment script would be executed on 2 nodes at a time. Given the script's contents, a pause of 45 seconds would be observed at the end of each script invocation (giving time to the applications to start up). Of course, the given pause is completely arbitrary and has been provided for the sake of providing a concise example.

Cloud Integration

As of 4.1, Corus supports "cloud integration", that is: a Corus instance can be configured through "user data", which makes it easy to start Corus nodes and assign to them configuration parameters dynamically.

Namely, what will need per-instance configuration are typically the following:

- The domain name of the Corus node being started.
- The group configuration parameters (since IP multicast is usually not available in the Cloud, usage of Avis must be configured – see the **Discovery with Avis** section for more details).

A preferred way to deploy Corus in the cloud is to configure an instance as a repository server (see the **Repository** section for more details), and the others as repository clients: newly appearing repo clients will thus automatically synchronize themselves with the repo server instance at startup (repo client instances could be "elastic" ones, automatically launched by the cloud provider).

> The advantage of using Corus in the cloud in such a manner is that you only need configuring a single machine image with a Corus installation, and decide thereafter, through custom user data configuration, what their actual startup parameters will be.

Corus expects user data to be available at a predefined URL. In the case of AWS for example, user data can be fetched from the following:

```
http://169.254.169.254/latest/user-data
```

The content that is available at that endpoint is configurable through the AWS admin tools.

Corus, for its part, expects a JSON document corresponding to the following structure:

```
{
  "corus": {

    "server": {

      "properties": [
        {
          "name": "corus.server.domain",
          "value": "prod-01"
        },
        {
          "name": "ubik.rmi.naming.broadcast.provider",
          "value": "ubik.rmi.naming.broadcast.avis "
        },
        {
          "name": "ubik.rmi.naming.broadcast.avis.url",
          "value": "elvin://10.0.1.11"
        },

      ],

      "tags": [ "scheduler", "read-write"]

    },

    "processes" : {

      "properties": [
        {
          "name": "jdbc.connections.max",
          "value": "50"
        }
      ]
    }
  }
}
```

The above shows that the following can be configured:

- Corus server configuration properties
- Corus server tags
- Process properties

In order for the fetching of user data to be enabled, the `-u` option must be specified as part of the Corus server command-line. If you start Corus as a daemon process, this involves either modifying the Corus configuration for the Java Service Wrapper, or the Corus `init.d` script (if you're not using the Java Service Wrapper).

> Note that the **-u** option does not have to have a value. In such a case, Corus will attempt fetch the user data JSON document from the following endpoints by default (in the specified order):
>
> ```
> http://169.254.169.254/latest/user-data
> http://169.254.169.254/openstack/latest/user-data
> ```
>
> The first endpoint corresponds to AWS' user data endpoint, the second to Open Stack's.

Modifying the JSW Configuration

If you're starting Corus with the Java Service Wrapper, you have to modify your `corus.service.wrapper.properties` file. The file holds configuration parameters that are used to configure command-line arguments and options that are passed to the Corus server command-line. Look for the section corresponding to the following parameters:

```
wrapper.app.parameter.1=-c
wrapper.app.parameter.2=%CORUS_CONFIG_FILE%
wrapper.app.parameter.3=-v
wrapper.app.parameter.4=INFO
wrapper.app.parameter.5=-f
```

Add the following parameter:

```
wrapper.app.parameter.6=-u
```

If you want to explicitly specify the enpoint from which to fetch user data, add it as another parameter. For example:

```
wrapper.app.parameter.6=-u
wrapper.app.parameter.7=http://169.254.169.254/latest/user-data
```

Modifying the init.d Script

If you're not using the Java Service Wrapper, but are rather using the plain-vanilla init.d script that's provided as part of the Corus distribution, then modify it by adding the **-u** option to the `javaArgs` parameter:

```
javaArgs="-Dcorus_instance=$javaCommandLineKeyword $CORUS_OPTS -cp $CLASSPATH
org.sapia.corus.core.CorusServer -p $CORUS_PORT -v $CORUS_LOG_LEVEL -f $serviceLogDir -u"
```

Or if you want to specify the URL explicitly:

```
javaArgs="-Dcorus_instance=$javaCommandLineKeyword $CORUS_OPTS -cp $CLASSPATH
org.sapia.corus.core.CorusServer -p $CORUS_PORT -v $CORUS_LOG_LEVEL -f $serviceLogDir -u
http://169.254.169.254/latest/user-data"
```

Maven

Corus comes with a Maven plugin, which allows running Corus scripts as part of Maven builds. Here's a sample configuration:

```
<plugin>
  <groupId>org.sapia</groupId>
  <artifactId>sapia_corus_mvn_plugin</artifactId>
  <version>4.1</version>
  <executions>
    <execution>
      <id>deploy-to-dev</id>
      <goals>
        <goal>run</goal>
      </goals>
      <configuration>
```

```
        <scriptProperties>
          <env>dev</env>
        </scriptProperties>
        <host>172.31.1.2</host>
        <port>33000</port>
        <scriptFile>${project.basedir}/scripts/deploy-V1.txt</scriptFile>
      </configuration>
    </execution>
  </executions>
</plugin>
```

The plugin takes the following configuration elements:

- **scriptProperties**: optional key/value pairs that are passed to scripts in the context of variable substitution.
- **host**: the host of the Corus daemon against which the script should be executed (Mandatory).
- **port**: the port of the Corus daemon against which the script should be executed (Optional: defaults to 33000).

Corus scripts are passed the properties that are optionally specified as a) part of the plugin's `scriptProperties` element; b) those of your Maven build (defined in `properties` element either in your POM or in your Maven settings; and c) the following Maven project properties:

- `project.id`
- `project.description`
- `project.name`
- `project.groupId`
- `project.artifactId`
- `project.version`
- `project.inceptionYear`
- `project.basedir or project.baseDir`
- `project.build.finalName`
- `project.build.directory`
- `project.build.sourceDirectory`
- `project.build.scriptSourceDirectory`

Scripts executed from the plugin have access to all the properties mentioned above (as well as system properties) using the following notation:

`${<property_name>}`

For example, here's a script that would correspond to usage of the sample plugin configuration above:

```
kill -d * -v * -p ${dev} -w
undeploy -d * -v *
deploy ${project.build.directory}/*-${project.version}.zip
```

Conclusion

Corus is an infrastructure that allows centrally managing application processes collectively, across multiple nodes. It offers a low-cost, non-intrusive way to distribute applications on a large scale.

For additional and complementary information, see the Corus web site (http://www.sapia-oss.org/projects/corus/index.html),