
Dart: Testing, Reports and Dashboards

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Introduction

1.1 Dart Statement of Purpose

Dart shall aggregate data across many independent distributed build and test hosts, summarizing the software quality aspects of the project in a concise and informative fashion cross-sectionally and longitudinally.

1.2 To Do

- Calendar for easy day navigation
- Notes
- Fix display of gcov results, not currently indented correctly
- Use Javascript column sorting, rather than server side sorting
- Document notification, for user and developer

Tutorial

2.1 Quick Start

If you are building Dart from source, please refer to [Section 5.1](#) to build `DartServer.jar`, then return to this Section. If you've downloaded the jar file, you may begin here. The distributions are build using JDK 1.4. For users upgrading from a pre 0.4 release, please see [Section 3.7](#).

1. Create the Server directory and configuration

```
java -jar DartServer.jar --createserver TestServer
```

The `--createserver` flag creates a new Server directory and an default configuration file `Server.xml`.

2. Initialize the server

```
java -jar DartServer.jar --initializeserver TestServer
```

Initializes the Server database.

3. Create the project

```
java -jar DartServer.jar --create TestProject
```

The `--create` flag requires a directory name argument. Dart will create this directory for the Project (`TestProject` in this example).

4. Configure the Project By default, a reasonable settings file is found in `TestProject/Project.xml`. If desired, this file may be edited to change the projects settings (see [Section 3.2](#)). Now is a good time to do this.
5. Start the project

```
java -jar DartServer.jar \  
    --initialize --refresh --refreshServer TestServer TestProject
```

The `--initialize` flag instructs the server to create the database tables that Dart requires for the project, while `--refresh` copies the project resources into the `TestProject` directory. `TestServer` is the name of the Dart Server, while any projects to be started can be configured in `TestServer/Server.xml` and are overridden by the commandline arguments. Note that `\` indicates line continuation; that is, the code above should be typed on one line. The `--refreshServer` puts some server specific files in the correct locations in the `Server` directory.

6. View the dashboard. Point your browser to `http://localhost:8081/TestProject/Dashboard/` to view the (empty) Dashboard.

The project `TestProject` is now up and running accepting XML-RPC submissions on port 8080 and serving HTML pages on port 8081. The ports and other configurations are covered in [Section 3](#).

2.2 Submission

Dart ships with a utility called `DartClient` to submit results to the server. The basic use is:

```
# java -jar DartClient.jar TestProject Results.xml
```

This submits `Results.xml` to the `TestProject` Project on the Server running on `localhost`. Submission is only a copy, and does not provide feedback on the XML validity.

`DartClient` also provides other options:

```
# java -jar DartClient.jar --help  
0 [main] INFO dart.DartClient - Starting DartClient  
usage: DartClient [options] Project <foo.xml> <foo2.xml> ... <fooN.xml>  
-g,--getstatus    Get Server status  
-h,--help         Print help message  
-p,--port         XML-RPC Port to connect to, 8080 is default  
-q,--shutdown     Shutdown the Server  
-r,--refresh      Refresh Project resources  
-s,--server       Server to connect to, localhost is default
```

To connect through a proxy or firewall use:

```
java -Dhttp.proxyPort=8080 -Dhttp.proxyHost=proxyhost.mydomain.org \  
    -jar DartClient.jar --help
```

with `http.proxyPort` and `http.proxyHost` replaced by your proxy port and server.

2.3 Software Installation

To be completed.

Server Setup

3.1 Command Line

The Server has several command line options.

```
# java -jar DartServer.jar
usage: DartServer [options] Server.xml <Project0.xml> <Project1.xml> ...
        <ProjectN.xml>
-R,--refreshServer      Refresh server resources
-a,--archive            Archive the project
-c,--create             Create a new project in the directory specified
-d,--database          At project creation time, configure the
                        Schema.sql file for generic, Postgres, Derby
-h,--help              Print help message
-i,--initialize         Initialize the database from the Schema.sql file
                        in the project directory
-j,--initializeserver   Initialize the database from the
                        ServerSchema.sql file in the dart server directory
-k,--createserver       Create a new server in the directory specified
-l,--logconfiguration  File to configure log4j from, defaults are used
                        if not present
-q,--createqed         Create a new QED in the directory specified
-r,--refresh           Refresh project resources
-t,--projecttemplate    Create a new Project using the specified default
                        template: dart/Resources/Server/DartDefault.xml in the jar file is t
                        default
-u,--upgradeprojectdb   Update all Project's databases to the latest
                        version
```

The `--archive` flag dumps all the Submissions in each project in Dart XML format into the Project/Archive directory. This is the best way to archive a Project all at once.

The `--projecttemplate` flag is used in conjunction with the `--create` argument at project creation time. If not specified, the file `dart/Resources/Server/DartDefault.xml` is used as the Project template. To extract this file, use the command:

```
jar fxv DartServer.jar dart/Resources/Server/DartDefault.xml
```

The `DartDefault.xml` file may be edited to suit the site specific needs. Take care to preserve the FreeMarker tags in the original file, as they are specific to some parts of the Project creation process.

3.2 Server Configuration

In the `TestServer` directory, there is a file named `Server.xml`. This contains the default settings for a dart server. The sections of the Server configuration are as follows.

3.2.1 Server Info

```
<?xml version="1.0" encoding="utf-8"?>
<Server>
  <Title>TestServer</Title>
  <BaseDirectory>f:\Source\Dart\TestServer</BaseDirectory>
```

This is the XML preamble followed by the Server information: Title and BaseDirectory.

3.2.2 Ports

```
<HTTPPort>8081</HTTPPort>
<XMLRPCPort>8080</XMLRPCPort>
```

These are the HTTP and XML-RPC port specifications. They are required to be different.

3.2.3 Scheduler

```
<Scheduler>
  <ThreadPoolSize>10</ThreadPoolSize>
</Scheduler>
```

The Scheduler has a default `ThreadPoolSize` of 10, indicating that 10 jobs may be executed concurrent by all the Projects managed by this Server instance.

3.2.4 Database

```
<!-- Configure the database parameters derby-->
<Database>
  <!-- Derby database -->
  <Driver>org.apache.derby.jdbc.EmbeddedDriver</Driver>
  <URL>jdbc:derby:f:\Source\Dart\TestServer/Database/TestServer;create=true</URL>
  <ShutdownURL>jdbc:derby:f:\Source\Dart\TestServer/Database/TestServer;shutdown=true
  </ShutdownURL>
  <Username/>
```

```

    <Password/>
    <!-- Maximum active / idle connections, -1 is infinite -->
    <MaxActive>10</MaxActive>
    <MaxIdle>3</MaxIdle>
</Database>

```

This section specifies the connection to the Server's database. In this example, the database is Derby. The Driver tag specifies the class implementing the JDBC connection. URL is the connection string, ShutdownURL is used to shutdown the Derby database cleanly, it may be safely left blank for other JDBC packages. The Username and Password tags specify the connection parameters. Dart uses a connection pooling mechanism for the database with two parameters: MaxActive specifies the maximum number of active connections, and MaxIdle specifies the maximum number of idle threads. If a connection is needed when MaxActive threads are already active, the connection will hang until a connection is return to the pool.

3.2.5 Servlet Manager

```

<!-- Servlet configuration -->
<ServletManager>
  <Servlet>
    <Class>dart.server.servlet.Server</Class>
    <Context>/Dart/*</Context>
    <Properties/>
  </Servlet>
</ServletManager>

```

The Servlet manager is responsible for configuring Jetty. Different Servlets can respond to different URLs. In this case, the dart.server.servlet.Server class is configured to respond to requests starting with /Dart/*.

3.3 Project Configuration

After following the directions in Section 2.1, in the TestProject directory, there is a file named Project.xml. This is a preconfigured Project configuration file containing all the settings required to run a basic Dart Project. The contents of the file are not presented in their entirety, but will be discussed section by section.

3.3.1 Project Info

```

<?xml version="1.0" encoding="utf-8"?>
<Project>
  <Title>TestProject</Title>
  <BaseDirectory>/projects/Dart/TestProject</BaseDirectory>

```

The first line is the xml preamble, and is required for all xml files. The <Project> tag indicates the start of the Project configuration. <Title> is the project title, and <BaseDirectory> is the absolute path name to the Project directory. If the Project is moved to a new location on the file system, <BaseDirectory> must be changed to reflect the new location.

3.3.2 Project Properties

Certain aspects of a Dart project can be customized by properties assigned to the project.

```
<Properties>
  <Property name="MaxTestsPerSubmission">1500</Property>
  <Property name="RepositoryURL">http://www.itk.org/cgi-bin/viewcvs.cgi/</Property>
  <Property name="RepositoryURL.Type">viewcvs</Property>
  <Property name="RepositoryURL.Repository">Insight</Property>
  <Property name="Menu">
    <![CDATA[
      <ul>
        <li><a href="#">Repository &gt;</a>
          <ul>
            <li><a href="http://www.itk.org/cgi-bin/viewcvs.cgi?cvsroot=Insight">
              Insight</a>
            </li>
            <li>
              <a href="http://www.itk.org/cgi-bin/viewcvs.cgi?cvsroot=InsightApplications">
                Insight Applications
              </a>
            </li>
          </ul>
        </li>
        <li><a href="http://www.itk.org/Bug">Bugs</a></li>
        <li><a href="#">Documentation &gt;</a>
          <ul>
            <li><a href="http://www.itk.org/Insight/Doxygen/html/">Doxygen (API)</a></li>
            <li><a href="http://www.itk.org/">www.itk.org</a></li>
            <li><a href="http://www.itk.org/Wiki/ITK">ITK Wiki</a></li>
            <li><a href="http://www.insightsoftwareconsortium.org/">
              Insight Software Consortium</a>
            </li>
          </ul>
        </li>
        <li><a href="http://www.itk.org/">Home</a></li>
      </ul>
    </li>
  </Property>
</Properties>
```

MaxTestsPerSubmission Defines a throttle for the number of tests that can be included in a submission.

RepositoryURL URL for accessing a project's software repository via the web.

RepositoryURL.Type Identifies the type of the web portal for the repository (viewcvs, cvsweb, websvn).

RepositoryURL.Repository Identifies the repository to reference at the specified RepositoryURL.

Menu Definition of a menu to display on web pages. This menu can include links to navigate within Dart or to navigate to external sites such as documentation, bug trackers, *etc.* Menu is defined as an HTML list (encapsulated in a `CData` section), with submenus being sublists. Each menu item is modelled with an `HREF` within an `LI`. If a menu item is the title of a submenu, then the `HREF` should link to `"#"` and the item label should indicate a drop down menu is available (for instance, suffixing the name with a `>` sign).

3.3.3 Database Configuration

```
<!-- Derby database -->
<Database>
  <Driver>org.apache.derby.jdbc.EmbeddedDriver</Driver>
  <URL>jdbc:derby:/projects/Dart/TestProject/Database/TestProject;create=true</URL>
  <ShutdownURL>jdbc:derby:/projects/Dart/TestProject/Database/TestProject
    ;shutdown=true</ShutdownURL>

  <Username/>
  <Password/>
</Database>
```

This section configures the Database connection that the Project will use. The `<Driver>` tag indicates the JDBC Java class for the particular type of relational database management system (RDBMS). In the example, `org.apache.derby.jdbc.EmbeddedDriver` is the driver for the Derby Open Source embedded RDBMS system. Note: the `<ShutdownURL>` was broken across two lines for display purposes, and should not be broken in an actual configuration file.

The `<URL>` tag specifies the connection URL for the RDBMS. This is a RDBMS specific string. In the above example, the `create=true` property indicates that the driver should create the database if it does not exist. Please consult your RDBMS documentation for the proper setting for the `<URL>` tag. Because Derby is an embedded RDBMS, it must be properly shutdown to leave the database in a consistent state. This is specified in the `<ShutdownURL>` tag. If the RDBMS does not require special shutdown processing, leave this tag empty and it will be ignored.

`<Username/>` and `<Password>` tags specify the authentication settings for the RDBMS. In the case of Derby, no Username/Password is required.

3.3.4 CommandManager Configuration

```
<CommandManager>
  <Command>
    <Name>Submit</Name>
    <Class>dart.server.command.Submit</Class>
    <Properties>
      <Property name="DeleteWhenDigested">true</Property>
    </Properties>
  </Command>
</CommandManager>
```

The Dart Server provides an XML-RPC server for results to be submitted to a Project. This server operates through a Servlet configured in the ServletManager (see Section 3.3.5 below). For the CommandManager to operate, a `dart.server.servlet.CommandServlet` object must be added to the ServletManager. In addition, the `CommandServer` can be configured to respond to any query using specialized `Commands`. The `<CommandServer>` section specifies the settings for the Project specific settings.

In the instance above, the `<Command>` tag specifies an object that the Project will use to respond to XML-RPC calls. `Commands` must implement the `dart.server.command.Command` interface. `<Name>` is the object name, `<Class>` is the name of the class that the CommandManager instantiates and any `Properties` for the object are specified using the `<Properties>` tags. Any public methods of the object are exposed to XML-RPC calls.

3.3.5 ServletManager Configuration

```
<!-- Servlet configuration -->
<ServletManager>
  <Servlet>
    <Class>dart.server.servlet.Dashboard</Class>
    <Context>/Dashboard/*</Context>
    <Properties>
    </Properties>
  </Servlet>
  <Servlet>
    <Class>dart.server.servlet.CommandServlet</Class>
    <Context>/Command/</Context>
    <Properties/>
  </Servlet>
  <Servlet>
    <Class>dart.server.servlet.ChartServlet</Class>
    <Context>/Chart</Context>
    <Properties/>
  </Servlet>
</ServletManager>
```

To generate Dashboard pages, the Server uses the Jetty Servlet engine in conjunction with the FreeMarker template engine. Stock Project Servlets are automatically configured at project creation time. User defined Servlets may be added if desired. The `<Class>` tag indicates the class of the Servlet, `<Context>` tag indicates how the Servlet is found by Jetty. By default, the Project title is stored in the Servlet's initial parameters as "project" and may be accessed as `getInitParameter ("project")` within the Servlet. Parameters in the `<Properties>` section are also put in the initial parameters map.

The second Servlet in the stock configuration is `dart.server.servlet.CommandServlet`. `CommandServlet` accepts XML-RPC calls and delegates them to the appropriate handler object as configured in the CommandManager. The last Servlet is the `ChartServlet` used to generate charts for the dashboard.

To call an XML-RPC method, the URL needed is determined by the root project URL, *i.e.* `http://localhost:8081/ProjectName/Command/Command.Method`. For example, the URL to submit some results to the Dart project `TestProject` running on the local system is: `http://localhost:8081/TestProject/Command/` and the method is `Submit.put`.

3.3.5.1 Adding a new servlet to Dart

If you are building Dart from source, you can add additional servlets to the DartServer.jar by adding the servlet's source code to `Dart/Source/dart/server/servlet` directory and rebuilding. The servlet can be activated for a project as in the above example.

If you are running from a pre-built DartServer.jar, you can still add additional servlets to Dart. This is done by adding the `classpath` property to the servlet definition in the Project.xml file.

```
<Servlet>
  <Class>user.servlet.MyDashboard</Class>
  <Context>/MyDashboard/*</Context>
  <Properties>
    <Property name="Foo">10</Property>
    <Property name="classpath">foo.jar</Property>
  </Properties>
</Servlet>
```

This example adds the class `user.servlet.MyDashboard` from the `foo.jar` archive to the project and assigns it the url space of `/MyDashboard/*`.

3.3.6 ListenerManager Configuration

```
<!-- Listener manager. Do specific things when events happen in the Project -->
<ListenerManager>
  <Listener>
    <Type>dart.server.listener.SubmissionErrorsListener</Type>
    <ListenTo>
      <Type>dart.server.event.SubmissionEvent</Type>
    </ListenTo>
    <Properties/>
  </Listener>
</ListenerManager>
```

During the running of a Dart Project different Events of note may occur. The ListenerManager receives Events from the Project and queries each defined Listener's `<ListenTo>` list to see if the Listener is interested in this particular type of Event. If so, the Listener's trigger method is called with the Event as an argument. Note: more than one Listener of a given type may exist in the ListenerManager, *e.g.* when the Listeners are given different parameters. Further Note: the `<ListenTo>` and `<Properties>` tags are mandatory! More information is in Section [3.3.6](#).

3.3.7 Task Configuration

```
<!-- Scheduled tasks. The Schedule tag is in cron format. -->
<Task>
  <Type>dart.server.task.QueueManager</Type>
  <Schedule>0/10 * * * * ?</Schedule>
```

```

    <Properties>
      <Property name="MaxTasks">10</Property>
    </Properties>
  </Task>

```

Tasks configured in the `Dart.xml` file are periodically scheduled. Tasks must implement the `dart.server.task.Task` interface. In the above example, the `dart.server.task.QueueManager` is scheduled to run every 10 seconds. The `QueueManager` class processes other Tasks that have been placed in the `TaskQueue`. The `Properties` tag specifies settings that are passed into the Task when it executes. For `QueueManager`, the “MaxTasks” property indicates how many queued tasks will be processed at during each execution, providing a “throttling” mechanism.

```

<Task>
  <!-- Reindex Tracks if the definition has changed every night at 2am -->
  <Type>dart.server.task.ReindexTrackTask</Type>
  <Schedule>0 0 2 * * ?</Schedule>
  <Properties/>
</Task>

```

The `ReindexTrackTask` visits all existing Tracks in the database. A Track is deleted and the Submissions contained in it are reindexed if (1) the Track definition has been removed from `Project.xml`, (2) if the Track does not contain any Submissions, (3) if the Track has changed duration. This is scheduled to occur at 2am each day.

The format of the `<Schedule>` tag is detailed at <http://quartz.sourceforge.net/javadoc/org/quartz/CronTrigger.htm> and is reproduced here for clarity.

3.3.7.1 Cron Expressions

For those unfamiliar with “cron”, this means being able to create a firing schedule such as: “At 8:00am every Monday through Friday” or “At 1:30am every last Friday of the month”.

A “Cron-Expression” is a string comprised of 6 or 7 fields separated by white space. The 6 mandatory and 1 optional fields are as follows:

Field Name	Allowed Values	Allowed Special Characters
Seconds	0-59	, - * /
Minutes	0-59	, - * /
Hours	0-23	, - * /
Day-of-month	1-31	, - * ? / L W C
Month	1-12 or JAN-DEC	, - * /
Day-of-Week	1-7 or SUN-SAT	, - * ? / L C #
Year (Optional)	empty, 1970-2099	, - * /

The “*” character is used to specify all values. For example, “*” in the minute field means “every minute”.

The “?” character is allowed for the day-of-month and day-of-week fields. It is used to specify ‘no specific value’. This is useful when you need to specify something in one of the two fields, but not the other. See the examples below for clarification.

The “-” character is used to specify ranges. For example “10-12” in the hour field means “the hours 10, 11 and 12”.

The “,” character is used to specify additional values. For example “MON,WED,FRI” in the day-of-week field means “the days Monday, Wednesday, and Friday”.

The “/” character is used to specify increments. For example “0/15” in the seconds field means “the seconds 0, 15, 30, and 45”. And “5/15” in the seconds field means “the seconds 5, 20, 35, and 50”. You can also specify “/” after the “*” character - in this case “*” is equivalent to having “0” before the “/”.

The “L” character is allowed for the day-of-month and day-of-week fields. This character is short-hand for “last”, but it has different meaning in each of the two fields. For example, the value “L” in the day-of-month field means “the last day of the month” - day 31 for January, day 28 for February on non-leap years. If used in the day-of-week field by itself, it simply means “7” or “SAT”. But if used in the day-of-week field after another value, it means “the last xxx day of the month” - for example “6L” means “the last friday of the month”. When using the “L” option, it is important not to specify lists, or ranges of values, as you’ll get confusing results.

The “W” character is allowed for the day-of-month field. This character is used to specify the weekday (Monday-Friday) nearest the given day. As an example, if you were to specify “15W” as the value for the day-of-month field, the meaning is: “the nearest weekday to the 15th of the month”. So if the 15th is a Saturday, the trigger will fire on Friday the 14th. If the 15th is a Sunday, the trigger will fire on Monday the 16th. If the 15th is a Tuesday, then it will fire on Tuesday the 15th. However if you specify “1W” as the value for day-of-month, and the 1st is a Saturday, the trigger will fire on Monday the 3rd, as it will not ‘jump’ over the boundary of a month’s days. The “W” character can only be specified when the day-of-month is a single day, not a range or list of days.

The “L” and “W” characters can also be combined for the day-of-month expression to yield “LW”, which translates to “last weekday of the month”.

The “#” character is allowed for the day-of-week field. This character is used to specify “the nth” XXX day of the month. For example, the value of “6#3” in the day-of-week field means the third Friday of the month (day 6 = Friday and “#3” = the 3rd one in the month). Other examples: “2#1” = the first Monday of the month and “4#5” = the fifth Wednesday of the month. Note that if you specify “#5” and there is not 5 of the given day-of-week in the month, then no firing will occur that month.

The “C” character is allowed for the day-of-month and day-of-week fields. This character is short-hand for “calendar”. This means values are calculated against the associated calendar, if any. If no calendar is associated, then it is equivalent to having an all-inclusive calendar. A value of “5C” in the day-of-month field means “the first day included by the calendar on or after the 5th”. A value of “1C” in the day-of-week field means “the first day included by the calendar on or after sunday”.

The legal characters and the names of months and days of the week are not case sensitive.

Here are some full examples:

Expression	Meaning
"0 0 12 * * ?"	Fire at 12pm (noon) every day
"0 15 10 ? * *"	Fire at 10:15am every day
"0 15 10 * * ?"	Fire at 10:15am every day
"0 15 10 * * ? *"	Fire at 10:15am every day
"0 15 10 * * ? 2005"	Fire at 10:15am every day during the year 2005
"0 * 14 * * ?"	Fire every minute starting at 2pm and ending at 2:59pm, every day
"0 0/5 14 * * ?"	Fire every 5 minutes starting at 2pm and ending at 2:55pm, every day
"0 0/5 14,18 * * ?"	Fire every 5 minutes starting at 2pm and ending at 2:55pm, AND fire every 5 minutes starting at 6pm and ending at 6:55pm, every day
"0 0-5 14 * * ?"	Fire every minute starting at 2pm and ending at 2:05pm, every day
"0 10,44 14 ? 3 WED"	Fire at 2:10pm and at 2:44pm every Wednesday in the month of March.
"0 15 10 ? * MON-FRI"	Fire at 10:15am every Monday, Tuesday, Wednesday, Thursday and Friday
"0 15 10 15 * ?"	Fire at 10:15am on the 15th day of every month
"0 15 10 L * ?"	Fire at 10:15am on the last day of every month
"0 15 10 ? * 6L"	Fire at 10:15am on the last Friday of every month
"0 15 10 ? * 6L"	Fire at 10:15am on the last Friday of every month
"0 15 10 ? * 6L 2002-2005"	Fire at 10:15am on every last friday of every month during the years 2002, 2003, 2004 and 2005
"0 15 10 ? * 6#3"	Fire at 10:15am on the third Friday of every month

Pay attention to the effects of "?" and "*" in the day-of-week and day-of-month fields!

NOTES:

- Support for the features described for the "C" character is not complete.
- Support for specifying both a day-of-week and a day-of-month value is not complete (you'll need to use the "?" character in one of these fields).
- Be careful when setting fire times between mid-night and 1:00 AM - "daylight savings" can cause a skip or a repeat depending on whether the time moves back or jumps forward.

Another example Task is the `SaveStatistics` Task which writes the Project statistics to the file system on a regular basis. The Task does not have any parameters, and saves the statistics in a file named `Statistics.txt` in the Project directory.

```
<Task>
  <Type>dart.server.task.SaveStatistics</Type>
  <Schedule>0 * * * * ?</Schedule>
  <Properties>
  </Properties>
</Task>
```

An extremely important Task is the `ArchiveTask`. This Task is detailed in [Section 3.6](#).

3.3.8 Task List

These are the currently available Tasks:

ArchiveTask The ArchiveTask is responsible for finding old data in removing it from the Project, potentially archiving the data to the filesystem.

DeleteDataTask The DeleteDataTask is used internally by the ArchiveTask. It is responsible for deleting files from the Project, if they are no longer referenced in the database.

GarbageCollectionTask The GarbageCollectionTask simply runs the Java garbage collector.

PlaceSubmissionInTrackTask The PlaceSubmissionInTrackTask determines which Track a Submission belongs to and places it there. This Task should only be used internally and is queued by the XMLResultProcessor as configured in Section 3.4.

QueueManager This is the most important Task. The QueueManagerTask pulls queued Tasks from the TaskQueue table and executes them. The QueueManager is scheduled to run every 10 minutes by default (see Section 3.3.7).

SaveStatistics The SaveStatistics Task writes out the Project's statistics to disk (see Section 3.3.7).

SummarizeBuildTask The SummarizeBuildTask collects and rolls up summary information for a build. This Task should only be used internally and is queued by the XMLResultProcessor as configured in Section 3.4.

SummarizeCoverage The SummarizeCoverageTask collects and rolls up coverage summary information. This Task should only be used internally and is queued by the XMLResultProcessor as configured in Section 3.4.

SummarizeDynamicAnalysis The SummarizeDynamicAnalysis collects and rolls up Dynamic Analysis summary information for a Submission This Task should only be used internally and is queued by the XMLResultProcessor as configured in Section 3.4.

SummarizeTests The SummarizeTests collects and rolls up Test summary information for a build. This Task should only be used internally and is queued by the XMLResultProcessor as configured in Section 3.4.

Task Task is the interface that each Task in this list implements.

XMLResultProcessor The XMLResultProcessor is queued when a Submission is pushed to the server. This Task parses the XML file and puts the Submission data into the database. The XMLResultProcessor uses the RollupManager configuration as set in Section 3.4 to queue further Tasks.

3.4 RollupManager

After a Submission is process and the raw data placed in the database, the configuration in the RollupManager section of the Project.xml file controls which Tasks the XMLResultProcessor queues to summarize and further process the Submission's data. When queued, the Task is given a the SubmissionId through the SubmissionId Property. The default RollupManager configuration is below, each Task may be given a set of Properties, and is queued with the Priority given by the tag.

```
<RollupManager>
  <Rollup>
```

```

        <Type>dart.server.task.SummarizeTests</Type>
        <Priority>4</Priority>
        <Properties/>
    </Rollup>
</Rollup>
    <Type>dart.server.task.SummarizeBuildTask</Type>
    <Priority>4</Priority>
    <Properties/>
</Rollup>
<Rollup>
    <Type>dart.server.task.SummarizeCoverage</Type>
    <Priority>4</Priority>
    <Properties/>
</Rollup>
<Rollup>
    <Type>dart.server.task.SummarizeDynamicAnalysis</Type>
    <Priority>4</Priority>
    <Properties/>
</Rollup>
<Rollup>
    <Type>dart.server.task.PlaceSubmissionInTrackTask</Type>
    <Priority>4</Priority>
    <Properties/>
</Rollup>
<Rollup>
    <!-- Note, the SubmissionEvent must be the last Task -->
    <Type>dart.server.event.SubmissionEventTask</Type>
    <Priority>5</Priority>
    <Properties/>
</Rollup>
</RollupManager>

```

3.5 Events

While the Dart server is running, various interesting events may occur; *e.g.* Nightly Submissions present/absent, low disk space, build failures, *etc.* To monitor and respond to Events, the Dart Server may be configured with different Listeners that receive Events and have the opportunity to respond in a variety of ways. The Event subsystem has two components, Event sources and Listeners. Events are generated automatically (and programatically) by the Dart Server and are handled immediately by the ListenerManager. The ListenerManager checks each Listener defined by the Project, if the Listener is registered to ListenTo the particular type of Event, the Listener's trigger method is called. The Listener is free to take any action based on the contents of the Event, but is not allowed to modify the Event in any way.

Currently defined Events:

SubmissionEvent This Event is triggered by the RollupManager after all the other Rollups have been done. This Event signifies that a Submission has been completely processed.

Currently defined Listeners:

SubmissionErrorsListener This Listener determines if a Submission is of a particular type and sends the appropriate email to the list of registered Users.

3.6 Archiving a Dart Server

Though the ArchiveTask strictly belongs in the Task section of the configuration file, it's options are quite complex and deserve a section of it's own. The basic job of the ArchiveTask is to copy data from the Dart database to the file system in a easy to restore format and, optionally, delete the data from the database.

A project can have 0 or more "Archivers". Each Archiver selects a set of Submissions that matches some criteria. The current selection criteria are:

- **AgeInDays** A submission must be older than this to be considered (may be BuildStamp or CreatedTimeStamp[when the submission happened])
- **MatchTrack** a comma seperated list of regular expressions to match against the track of each Submission
- **MatchSite** a comma seperated list of regular expressions to match against the Site
- **MatchBuildName** a comma seperated list of regular expressions to match against the BuildName
- **MatchTest** a comma seperated list of regular expressions to match against each test in the submission

Once a submission is matched, it is archived, if not already archive, to a user specified directory (default is ProjectDirectory/Archive). When the "Working" directory reaches a specific size (MaxDirectorySizeMB default is 700), it is renamed using the current date time stamp and a new Working directory is created. In this way, a set of 700MB directories is created and may be safely moved to CDROM or other archival media and deleted.

Each Archiver has specified levels of archive, specified by the ArchiveLevel:

- 0 default, all data is still in the Database
- 1 remove least amount of data. All bulk data (images, logs, *etc.*) are to be removed
- 2 remove all leaf tests and data, leaving only intermediate levels in the Test hierarchy
- 3 remove all non-root Tests, leaving rollup info at the root level of the Test hierarchy
- 4 remove all data and the Submission itself. This is as if the submission had never existed

This is an example of an ArchiveTask definition:

```
<Task>
  <!-- Archive task, runs at 3am each morning -->
  <Type>dart.server.task.ArchiveTask</Type>
```

```

<Schedule>*/30 * * * * ?</Schedule>
<Properties>
  <Property name="ArchiverList">Nightly</Property>

  <Property name="Archiver.Nightly.WriteArchive">true</Property>
  <Property name="Archiver.Nightly.FileNamePattern">Archive-%L-%P-%S-%B-%T-%D.xml.gz</Property>
  <Property name="Archiver.Nightly.Template">ArchiveSubmission.xml</Property>
  <Property name="Archiver.Nightly.MatchTrack">.*</Property>
  <Property name="Archiver.Nightly.AgeInDays">0.010</Property>
  <Property name="Archiver.Nightly.ArchiveLevel">3</Property>
  <Property name="Archiver.Nightly.MatchTest">.*</Property>
  <Property name="Archiver.Nightly.MatchSite">.*</Property>
  <Property name="Archiver.Nightly.ArchiveBy">CreatedTimeStamp</Property>
  <Property name="Archiver.Nightly.MaxDirectorySizeMB">700</Property>
  <Property name="Archiver.Nightly.ArchiveDirectory">/tmp/DartArchive</Property>

</Properties>
</Task>

```

This tag defines the list of Archivers (comma separated). So we only have one called “Nightly”

```

<Property name="ArchiverList">Nightly</Property>

```

Each Archiver is run in the order of the ArchiverList Property.

All properties for this Archiver are indicated by “Archiver.Foo.PropertyName” where Foo is the name of the property. For example: “Archiver.Nightly.AgeInDays”. Below, when I refer to a Property, it is assumed there is a “Archiver.Nightly.” prefix to it. So ArchiveLevel really refers to “Archiver.Nightly.ArchiveLevel”.

The first check is to see match Submissions by AgeInDays. In this case, 0.010 is about 10 minutes. The Database column to match is the CreatedTimeStamp. This is when the submission hit the Dart Server. The other option for ArchiveBy is TimeStamp, which is the datetime reported by the Client. The last criteria is that the Submission must have an ArchiveLevel less than the one specified for this Archiver (this is explained below). Thus to match, a Submission must be older than 0.01 days by CreatedTimeStamp, and have an archive level of ; 3.

```

<Property name="Archiver.Nightly.AgeInDays">0.010</Property>
<Property name="Archiver.Nightly.ArchiveBy">CreatedTimeStamp</Property>
<Property name="Archiver.Nightly.ArchiveLevel">3</Property>

```

From the list of Submissions return, each is examined in turn. The first test is by Site and BuildStamp:

```

<Property name="Archiver.Nightly.MatchSite">.*</Property>
<Property name="Archiver.Nightly.MatchBuildName">.*</Property>

```

MatchSite is a comma separated list of regular expressions. “.*” matches all sites. If the Submission does not match any of the expressions, it is ignored. The same matching is applied for MatchBuildName.

The next test is to Match the Track:


```
<Property name="Archiver.Nightly.MatchTrack">.*</Property>
```

Again, a comma separated list. Here we match all tracks.

If a Submission matches by Site, Track and BuildName, the Submission's ArchiveDateStamp and ArchiveLevel are examined. If ArchiveDateStamp is null, then go ahead and archive the Submission to disk as outlined below. If the CreatedTimeStamp is later than the ARchiveDateStamp, some new data has hit the database since the last archive, so go ahead and archive the Submission to disk.

To archive to Disk, the Archiver writes all the Submission data to one big XML file using the new Dart v2 XML format. This is specified as a FreeMarker template by this Property.

```
<Property name="Archiver.Nightly.Template">ArchiveSubmission.xml</Property>
```

ArchiveSubmission.xml is the default. This file is suitable for re-submitting to the Dart Server. However, if the WriteArchive property is false, the data will not be written to disk. This is useful for Experimental and continuous builds that you may not care about. "true" is the default.

```
<Property name="Archiver.Nightly.WriteArchive">true</Property>
```

Once the file has been generated, it is written to disk. Each Archiver has a location to write to. The default is the "ProjectDirectory/Archive" directory that is created when the project starts up. In our case we write to /tmp/DartArchive:

```
<Property name="Archiver.Nightly.ArchiveDirectory">/tmp/DartArchive</Property>
```

Inside /tmp/DartArchive two directories will be created: Working and Temporary. Once the XML is generated in Temporary, it is gzipped and moved to Working. The filename is generated by this Property:

```
<Property name="Archiver.Nightly.FileNamePattern">Archive-%L-%P-%S-%B-%T-%D.xml.gz</Property>
```

Where:

- %L is replaced by ArchiveLevel
- %P is replaced by the project name
- %S is replaced by the Site name
- %B is replaced by the BuildName
- %T is replaced by the TrackName
- %D is replaced by the DateTimeStamp
- %N is replaced by the current time "now" in UTC

So you can have as much or as little info encoded in the filename as you like.

If moving the file from Temporary would push the Working Directory over the limit set by:

```
<Property name="Archiver.Nightly.MaxDirectorySizeMB">700</Property>
```

The Working directory is renamed by the current time in UTC and a new Working directory is started. We could specify that the Working directory is rolled over on a regular time schedule rather than a file size criteria if that would be useful.

Finally, the Archiver decides which data from the Submission to remove (since it's all been archived by now). This is decided by ArchiveLevel

```
<Property name="Archiver.Nightly.ArchiveLevel">3</Property>
```

ArchiveLevel indicates how much data to remove

- 1 remove least amount of data. All bulk data (images, logs, *etc.*) are to be removed
- 2 remove all leaf tests and data, leaving only intermediate levels in the Test hierarchy
- 3 remove all non-root Tests, leaving rollup info at the root level of the Test hierarchy
- 4 remove all data and the Submission itself

Each Test is matched using the MatchTest Property:

```
<Property name="Archiver.Nightly.MatchTest">.*</Property>
```

Except at level 4, where everything is removed. If a test does not match, it is ignored and no data is deleted from it.

Finally, the Submission's ArchiveLevel is updated, as is the ArchivedTimeStamp. Now this Submission will not match the initial select, as it's ArchiveLevel is equal to the ArchiveLevel for this Archiver.

The Archiver then processes the next Submission until no more are found.

3.6.1 Default Archivers

By default, several Archivers are defined in the Project, however the Archivers are not active. They are:

- Nightly
 - Level 1 after 2 months (NightlyLevel1)
 - Level 2 after 4 months (NightlyLevel2)
 - Level 3 after 6 months (NightlyLevel3)
- Continuous
 - Level 2 after 1 week (ContinuousLevel2)
 - Level 4 after 1 month (ContinuousLevel4)
- Experimental
 - Level 4 after 1 week - No files saved (ExperimentalLevel4)

To enable the default Archivers, uncomment this line(broken for clarity):

```
<!--  
<Property name="ArchiverList">NightlyLevel1,NightlyLevel2,NightlyLevel3,  
    ContinuousLevel2,ContinuousLevel4,ExperimentalLevel4</Property>  
-->
```

The definition of the default Archivers are:

```
<!-- Nightly archivers -->
<Property name="Archiver.NightlyLevel1.AgeInDays">60</Property>
<Property name="Archiver.NightlyLevel1.ArchiveLevel">1</Property>
<Property name="Archiver.NightlyLevel1.MatchTrack">Nightly</Property>

<Property name="Archiver.NightlyLevel2.AgeInDays">120</Property>
<Property name="Archiver.NightlyLevel2.ArchiveLevel">2</Property>
<Property name="Archiver.NightlyLevel2.MatchTrack">Nightly</Property>

<Property name="Archiver.NightlyLevel3.AgeInDays">180</Property>
<Property name="Archiver.NightlyLevel3.ArchiveLevel">3</Property>
<Property name="Archiver.NightlyLevel3.MatchTrack">Nightly</Property>

<!-- Continuous archivers -->
<Property name="Archiver.ContinuousLevel2.AgeInDays">7</Property>
<Property name="Archiver.ContinuousLevel2.ArchiveLevel">2</Property>
<Property name="Archiver.ContinuousLevel2.MatchTrack">Continuous</Property>

<Property name="Archiver.ContinuousLevel4.AgeInDays">30</Property>
<Property name="Archiver.ContinuousLevel4.ArchiveLevel">4</Property>
<Property name="Archiver.ContinuousLevel4.MatchTrack">Continuous</Property>

<!-- Experimental archiver -->
<Property name="Archiver.ExperimentalLevel4.AgeInDays">7</Property>
<Property name="Archiver.ExperimentalLevel4.ArchiveLevel">4</Property>
<Property name="Archiver.ExperimentalLevel4.MatchTrack">Experimental</Property>
<Property name="Archiver.ExperimentalLevel4.WriteArchive">false</Property>
```

3.7 Upgrade from 0.5

When the Server starts a Project, it performs an internal check to ensure the version of the database (held in the Version table) matches the expected version in the code. If the Project does not match the expected version, the Server logs an error and exits. To upgrade the Project from a prior revision, restart the Server with the `-upgradeprojectdb (-u)` flag. Each Project will run the correct upgrade SQL commands to bring the database to the proper revision. This will only work for Projects using version 0.5 or later.

3.8 Upgrade from pre-0.5

If you have been building Dart from source and would like to migrate to the first stable release (0.5), you must archive your Projects and re-create them. The basic structure of the Dart database has changed significantly, requiring a complete Archive and reloading of your data. The basic steps are:

1. Download the 0.4 and 0.5 releases of Dart from <http://na-mic.org/Wiki/index.php/Dart2Summary>.

2. Stop your Dart server

```
java -jar DartClient.jar --shutdown TestProject
```

3. Extract the 0.4 jar file, and Archive your Projects

```
java -jar DartServer.jar --archive DartServer TestProject
```

Note: Replace DartServer and TestProject with you installation specific directories.

4. Check the status of the Archive project by looking at the Project dashboard. When the Archive is complete, no data should remain on the Dashboard. The Server will not start up the HTTP server until all the data is Archived. In addition, log messages should be generated indicating the status of the Archive process.

5. Shutdown the Server.

```
java -jar DartClient.jar --shutdown TestProject
```

6. Rename Project directories to OldTestProject. Inside each Project directory is a sub-directory called Archive that contains all of the data from the Project that must be re-submitted to the 0.5 version.

7. Extract the 0.5 jar file.

8. Recreate the Projects. DartServers do not need to be recreated. Be sure to use the 0.5 jar.

9. Restart your Server

10. Resubmit old data for each Archived project.

```
java -jar DartClient.jar TestProject OldTestProject/Archive/Working/*
```

After all the Archived Submissions are digested you are finished!

3.9 Using Apache to proxy requests to Dart

While Dart ships with its own internal HTTP server and servlet container (thanks to jetty, <http://jetty.mortbay.org/>), Dart can also be run from behind any web server that will proxy and rewrite urls. Running Dart from behind another web server allows a site to provide a single access point to their website and web applications. It also allows for a limited type load balancing, where the Dart server can be a different machine than the public web server.

In this section we describe how to configure Apache to proxy requests to a Dart server. Apache must be configured to proxy requests and to rewrite urls. Several Apache modules must be enable in the Apache web server if they are not already built in. Add these lines to the Apache configuration file (http.conf):

```
LoadModule proxy_module modules/mod_proxy.so
LoadModule proxy_connect_module modules/mod_proxy_connect.so
LoadModule proxy_http_module modules/mod_proxy_http.so
LoadModule rewrite_module modules/mod_rewrite.so
```

These modules may need to be activated by added the lines

```
AddModule mod_rewrite.c
AddModule mod_proxy.c
```

Next, you need to establish the proxy. In this example, we assume the Dart server is on the same machine as the Apache server and we will map the Dart server to Apache's url space under /Dart/.

```
ProxyPass /Dart/ http://localhost:8081/
ProxyPassReverse /Dart/ http://localhost:8081/
```

Finally, we need to rewrite some urls. The Dart server and each Dart project have their own set of resources (icons, images, and style sheets) that are referenced by the dynamically generated web pages. The urls to these resources need to be redirected to the Dart server. This requires the activation of the rewrite engine

```
RewriteEngine on
```

and the establishing a rewrite rule for the Dart server and for *each* Dart project. If your Dart server is called DartServer and your project is named TestProject, then the rewrite rules will be

```
RewriteRule ^/DartServer/(.*)$ http://localhost:8081/DartServer/$1 [P]
RewriteRule ^/TestProject/(.*)$ http://localhost:8081/TestProject/$1 [P]
```

If the Dart server is hosted on a different machine than the Apache web server, then you'll need to replace the use of localhost with the url to your Dart server.

Tool Integration

4.1 Cruise Control

Cruise Control (<http://cruisecontrol.sourceforge.net/>) is a build/test control project aimed to integrate with Java projects using Ant. Built into Dart are the capabilities to parse Cruise Control XML log files. Dart itself is tested using Cruise Control. This section is written for Cruise Control version 2.3.

4.1.1 Dart Integration

For Java, Cruise Control functions as a Dart client. To enable a Cruise Control project to submit to a Dart Server, first set up the Dart Server as described in Section 2.1. The instructions below assume you have installed Cruise Control, have configured Cruise Control according to the quick start guide at <http://cruisecontrol.sourceforge.net/gettingstarted.html>, and are running a Dart Project named MyProject running on a server called MyServer. This tutorial will cover Continuous builds and Nightly builds.

There are only a few extra requirements when submitting a standard Cruise Control log to a Dart Server. **Note:** Remember to set the dateformat to UTC in config.xml. Otherwise, Dart will not correctly parse the BuildStamp of the Submission and will assume a BuildStamp of the date/time when the Submission is parsed.

4.1.2 Configure the Cruise Control Project

In this example, we will have two Cruise Control Projects: a Nightly and Continuous build. It is best to work through the Cruise Control quick start guide to ensure the builds function correctly. The Nightly build configuration should look something like this:

```
<!-- Nightly build at 10pm local time, see the schedule/ant tag, time attribute -->
<!-- Should update code from the last nightly build -->
<project name="Nightly">
  <dateformat format="yyyy-MM-dd'T'HH:mm:ss.SZ"/>
  <schedule interval="300">
    <ant buildfile="build-MyProject.xml"
      target="build"
      uselogger="true"
```

```

        usedebug="false"
        time="2200"
    />
</schedule>

```

This Project will perform a build at 10:00pm local time each night, capturing the code changes from the previous 24 hours.

For the Continuous Project, the `config.xml` file should contain tags similar to this:

```

<project name="Continuous" buildafterfailed="false">
    <dateformat format="yyyy-MM-dd'T'HH:mm:ss.SZ"/>

```

The `<dateformat>` tag specifies that Cruise Control format dates according to UTC, a uniform time format. This allows Dart to easily parse dates and is required for proper placement of the Submission in the Dart database. The “buildafterfailed” attribute instructs the Continuous project to build only if files have been updated.

4.1.2.1 Describe the Submission

Dart requires three items of information to properly categorize a Submission, the BuildName, Site and Track. Edit a file called `BuildInfoNightly.xml`. This file should look like this:

```

<?xml version="1.0" encoding="utf-8"?>
<BuildInfo>
    <BuildName>Linux-JDK-1.5</BuildName>
    <Site>MyClient</Site>
    <Track>Nightly</Track>
</BuildInfo>

```

The tags in `BuildInfoNightly.xml` instruct the Dart Server that this Submission is for the Nightly track, from a Site called `MyClient` and is a Linux build using JDK 1.5. For the continuous build, create a file called `BuildInfoContinuous.xml` which contains almost the same information:

```

<?xml version="1.0" encoding="utf-8"?>
<BuildInfo>
    <BuildName>Linux-JDK-1.5</BuildName>
    <Site>MyClient</Site>
    <Track>Continuous</Track>
</BuildInfo>

```

In this case, the Submission will go in the Continuous Track. It is also possible to have Ant configure this file automatically. Create a template XML file called `BuildInfoTemplate.xml` with these contents:

```

<?xml version="1.0" encoding="utf-8"?>
<BuildInfo>
    <BuildName>@Dart.BuildName@</BuildName>
    <Site>@Dart.Site@</Site>

```



```

    <Track>@Dart.Track@</Track>
</BuildInfo>

```

Ant can configure this file during a copy operation using the following Task definition and Properties:

```

<!-- Access environment variables -->
<property environment="env"/>

<!-- Get the HOSTNAME in an os independant way -->
<!-- Under Windows, COMPUTERNAME is set, for Unix-like systems
      HOSTNAME is used -->
<property name="env.HOSTNAME" value="\${env.COMPUTERNAME}"/>

<!-- BuildName is composed of a number of Ant and Java properties -->
<property name="Dart.BuildName"
      value="\${os.name}-\${os.arch}-\${os.version}-JDK-\${java.version}"/>
<property name="Dart.Site" value="\${env.HOSTNAME}"/>

<target name="configure.dart">
  <!-- Create the BuildName info, if necessary -->
  <filter token="Dart.BuildName" value="\${Dart.BuildName}"/>
  <filter token="Dart.Site" value="\${Dart.Site}"/>

  <!-- Filter tokens while copying the file -->
  <filter token="Dart.Track" value="Continuous"/>
  <copy file="BuildNameTemplate.xml" tofile="BuildNameContinuous.xml" filtering="true"/>

  <!-- Now do the Nightly version -->
  <filter token="Dart.Track" value="Nightly"/>
  <copy file="BuildNameTemplate.xml" tofile="BuildNameNightly.xml" filtering="true"/>
</target>

```

In this manner, each Client submitting to the Dart Dashboard will be self-configuring. The Ant task should produce the BuildNameNightly.xml and BuildNameContinuous.xml exactly as above. These two files will be merged into the Cruise Control log automatically.

4.1.2.2 Merge Build Name information

The Cruise Control getting started directions show how to merge JUnit logs into the Cruise Control log. The same mechanism is used to merge the Build Name information from the previous section into the final log. In your Cruise Control config.xml file, add or modify this section:

```

<!-- directory to write build logs to -->
<log logdir="logs/MyProject">
  <merge dir="checkout/MyProject/build/junit-reports/" />
  <merge file="BuildNameContinuous.xml" />
</log>

```

This will merge the `BuildNameContinuous.xml` file into the resultant log. If this build loop is for a Nightly build, substitute `BuildNameNightly.xml` instead.

4.1.2.3 Submit the log

To submit the Cruise Control log, we use `AntPublisher`. The getting started page recommends that you write a short Ant script to drive the build process. To submit the log after a build, edit this script (assume it's named `build-MyProject.xml`) adding a new target:

```
<target name="publish">
  <!-- Optional call to set the HTTP proxy if behind a firewall -->
  <setproxy proxyhost="proxy.host.com" proxyport="8080"/>

  <java classname="dart.DartClient">
    <classpath>
      <pathelement location="DartClient.jar"/>
    </classpath>
    <arg value="--server"/>
    <arg value="MyServer"/>
    <arg value="MyProject"/>
    <arg value="\${logdir}/${logfile}"/>
  </java>
</target>
```

`DartClient.jar` is distributed as part of Dart, and contains a minimal Client suitable for submitting Cruise Control logs. Once this Ant target is established, edit `config.xml` to instruct Cruise Control to publish the log via the publish target:

```
<publishers>
  <antpublisher buildfile="build-MyProject.xml" target="publish">
  </antpublisher>
</publishers>
```

Now Cruise Control will submit the log as part of the Publish step in the build loop.

4.1.3 Testing Dart with Cruise Control

The steps required to test Dart using Cruise Control are:

- Install Cruise Control from <http://cruisecontrol.sourceforge.net/>
- Check out Dart (be sure svn is in your path):

```
svn co http://svn.na-mic.org:8000/svn/Dart
```

- Run Cruise Control

```
/path/cruisecontrol-2.3.0.1/main/bin/cruisecontrol.sh
```

The default Cruise Control configuration (see config.xml) will run a Continuous build every 5 minutes, only building if changes have occurred and a nightly build each night at 10:00pm local time (22:00 on the 24 hour clock). Though the default settings should work in most cases, they may be over ridden using a properties file “build.properties”. The properties honored in this file are:

- proxyhost : Name of the proxy to use for XML/HTTP
- proxyport : Port number on the proxy
- Dart.BuildName : Name of this build
- Dart.Site : Build site

Dart.BuildName is taken from the environment variable `COMPUTERNAME` on Windows and `HOSTNAME` on Unix-based systems. If an HTTP proxy is required, that setting is taken from the `HTTP_PROXY` and `HTTP_PROXY_PORT` on both Unix-based and Windows systems. The properties file takes precedence over the environment variables.

4.1.4 Python Submissions

Python may be used to submit properly formed Dart XML. Here is an example snippet:

```
try:
    import xmlrpclib

    server = xmlrpclib.ServerProxy(
        "http://www.na-mic.org:8081/%s/Command/" % project)
    print server

    try:
        fp = open(fullPathToDestinationXMLFile)
        bin = xmlrpclib.Binary(fp.read())
        print "Server responded: [%s]" % server.Submit.put(bin)
    except Exception, v:
        print "ERROR", v
except:
    print "Problem submitting XML-RPC for the file: %s" % xmlfile
```

4.1.5 ctest Integration

The latest CVS version of ctest (<http://www.cmake.org/>) can be used to submit to a Dart Server. Instructions may be found at <http://na-mic.org/Wiki/index.php/User:Andy>. The settings needed in the project’s CMake file are:

```
ENABLE_TESTING()  
INCLUDE(Dart)
```

```
SET (DROP_METHOD "xmlrpc")  
SET (DROP_SITE "http://myserver.org:8081")  
SET (DROP_LOCATION "TestProject")  
SET (COMPRESS_SUBMISSION ON)
```

```
ADD_TEST(name executable arg1 arg2 ...) # see CMake documentation
```

In DartConfiguration.tcl, this translates to:

```
DropSite: http://myserver.org:8081/  
DropLocation: TestProject  
DropMethod: xmlrpc
```

Development

5.1 Requirements

To work on Dart, you will need:

- Subversion (<http://subversion.tigris.org/>). Dart source code is maintained in a Subversion repository.
- Java SDK (<http://java.sun.com>). Version 1.4.2 or later is needed.
- Apache Ant (<http://ant.apache.org/>), version 1.6.2 or greater. This is a build system, similar in concept to Unix Makefiles.
- JUnit (<http://www.junit.org/>). Java unit testing framework. This is used to define and run regression tests on the Dart source. The JUnit jar file is included in the checkout. Drop the `junit.jar` file in `ant/lib` directory to enable JUnit to run as an ant task.
- The Dart source (see below).

The other packages required by Dart, such as Quartz and Jaxor, are available as part of the Dart source. You do not need to obtain these separately.

5.2 Obtaining the source

Obtain a copy of the source code by checking it out of the repository:

```
cd MySrc
svn co http://svn.na-mic.org:8000/svn/Dart
```

This will create a directory `MySrc/Dart` containing the current Dart source.

If you have a HTTP proxy server, you will need to specify the variables `http-proxy-exceptions`, `http-proxy-host` and `http-proxy-port` in your `/.subversion/servers` (Unix) or `c:/Documents and Settings/User/Application Data/Subversion/servers` (Windows) file. Refer to the Subversion documentation for more details.

5.3 Build the source

The most straight forward method of building is

```
cd MySrc/Dart
ant all
```

basic steps are

```
cd MySrc/Dart
ant wrap
ant compile
ant jar
ant test
```

Each of “wrap”, “compile”, “jar” and “test” are compile targets, similar to Makefile targets. The full list is:

wrap Generate the Jaxor wrapping code. This generates Java objects to wrap the SQL queries defined in `Source/Wrap`. The wrapping process can be time consuming, and so is not run automatically for every compile. Wrap must be run when any of the Jaxor sources changes.

compile Compile the `.java` files to `.class` files. This is the default target.

jar Generate `DartServer.jar` containing the compiled Dart code.

test Run regression tests, with summary output.

testverbose Run regression tests with verbose output.

clean Clean the `.class` files.

fullclean Clean the `.class` files and the `.java` files generated by “wrap” above.

doc Runs JavaDoc to generate the API documentation into `Documentation/api`.

all Does a clean compile of Dart, runs the tests and builds the jar file.

5.4 Troubleshooting

- ‘Unexpected element “setproxy” ’
 - ▷ You need a newer version of Apache Ant. 1.6.2 is the minimum required Ant version.
- ‘org.apache.velocity.runtime.exception.ReferenceException: reference : template = FinderImpl.vm [line 45,column 36] : \${primaryKeyQuery.getMethodName()} is not a valid reference’, while wrapping.
 - ▷ The wrapping process did not execute correctly. This could be due to clock skew on NFS mounted file systems, which incorrectly causes some rules to not fire.

Custom Test Results

This chapter is intended to introduce the Dart XML format for submitting testing results to a Server. Though Dart, through Digestor, is capable of parsing a variety of XML, new tool writers are encouraged to use the standard Dart XML format. Details on Digestor customization will be forthcoming as demanded.

The Dart XML format is intentionally simple, but able to capture all the data a testing system may need. As the Dashboard functions go hand in hand with the data collected by the Server, some detail regarding the Dashboard generation process and assumptions will be part of this

6.1 XML Format

Though Dart has the capability to parse and translate XML (provided through Digestor), submitting data to Dart in the native XML format is preferred. Dart XML is intentionally simple and straightforward. The main elements are illustrated in this example file:

```
<?xml version="1.0" encoding="utf-8"?>
<DartSubmission version="2.0" createdby="ArchiveTask">
  <Site>Machine.MySite.com</Site>

  <!-- BuildName will be the concationation of OS and Compiler -->
  <BuildName>Linux-2.6-jdk1.5</BuildName>
  <Track>Nightly</Track>

  <!-- DateTimeStamp is a non-locale specific date/timestamp following
       ISO -->
  <!-- The format string for Java's SimpleDateFormat is:
       "yyyy-MM-dd'T'HH:mm:ss.SZ" -->
  <DateTimeStamp>2005-07-19T01:00:00.102-0400</DateTimeStamp>
  <Test>
    <Name>.Test.dart.server.serverTest</Name>
    <Status>passed</Status>
    <Measurement name="TimeInSeconds" type="numeric/float">0.12</Measurement>
    <Measurement name="Count" type="numeric/integer">12</Measurement>
    <Measurement name="Message" type="text/string">A simple message</Measurement>
    <Measurement name="LongMessage" type="text/text">A longer message</Measurement>
    <Measurement name="HTMLMessage" type="text/html">
```

```

    <![CDATA[<html><body><h1>HTML Code</h1></body></html>]]>
</Measurement>
<Measurement name="XML" type="text/xml">
    <![CDATA[<?xml version="1.0" encoding="utf-8"?>
        <generic>
            <tag>Value</tag>
        </generic>]]>
</Measurement>
<Measurement name="Archive" type="archive/zip">
    UEsDBAoAAAAAJxIfjMAAAAAAAAAAAAAEAAAAY3NzL1BLAwQKAAACACc
</Measurement>
<Measurement name="PNGImage" type="image/png">
    UEsDBAoAAAAAJxIfjMAAAAAAAAAAAAAEAAAAY3NzL1BLAwQKAAACACc
</Measurement>
<Measurement name="JPEGImage" type="image/jpeg">
    UEsDBAoAAAAAJxIfjMAAAAAAAAAAAAAEAAAAY3NzL1BLAwQKAAACACc
</Measurement>
</Test>
</DartSubmission>

```

Though much of the format is self describing, it is worth mentioning several of the more important tags.

Site A name for this submission, generally a machine name

BuildName A description if this submission, generally the OS and compiler

Track The Track to file this Submission under

DateTimeStamp The ISO standard found here: <http://www.ietf.org/rfc/rfc3339.txt> In Java, this may be formatted using the SimpleDateFormat class. String s = (new SimpleDateFormat ("yyyy-MM-dd'T'HH:mm:ss.SZ").format (Calendar.getInstance().getTime());

Test The Test tag describes the contents of the submitted Test

Name This is the “.” qualified Test name

Status Test status, one of “passed”, “failed”, “notrun”

The Measurements recorded by the test are contained in <Measurement> tags, and may be of several different types.

numeric/float The contents of this tag are stored verbatim, and presented as a floating point number on the Dashboard. numeric/float types may be plotted.

numeric/integer A numeric value that may be plotted on the Dashboard.

text/string A short (less that 2000 characters) text string. text/string Measurements are stored directly in the Dart database.

text/text A longer text string that is stored on the filesystem.

text/html A complete HTML document. text/html Measurements are stored in the filesystem and present as links by the Dashboard. It is often advisable to enclose text/html Measurements in `<![CDATA[]]>` containers.

text/xml A complete XML document. text/xml Measurements are stored in the filesystem and present as links by the Dashboard. It is often advisable to enclose text/xml Measurements in `<![CDATA[]]>` containers.

image/png A uuencoded PNG image. The contents of this tag should be a valid uuencoding of the binary file. The PNG image is decoded and stored in the filesystem and presented as an image on the dashboard.

image/jpeg A uuencoded JPEG image. The contents of this tag should be a valid uuencoding of the binary file. The JPEG image is decoded and stored in the filesystem and presented as an image on the dashboard.

archive/zip An archive/zip Measurement is a set of zipped files. Generally, Measurements of these types contain web sites such as those generated by Javadoc (see <http://java.sun.com/j2se/1.5.0/docs/api/>) for an example. These Measurements are presented as a link. When clicked, Dart attempts to find an index.html file in the root level of the zip file. If that file is found, it is served as an HTML document. Relative links are correctly resolved from inside the archive/zip Measurement. This type of Measurement is useful for Submitting results of various Java tools that follow the Javadoc output format, *e.g.* Cobertura (<http://cobertura.sourceforge.net/>) for code coverage, JCS (C) (<http://jcsc.sourceforge.net/>) for Java code style checking. The output of such tools can be zipped by the client and submitted. Though Dart could be made to parse and present results from such tools, being able to collect and serve the output in the native format was deemed a desirable feature.

It is important to take care with Measurements of type archive/zip. Though the storage and retrieval of such Measurements is efficient, the Server can quickly consume much disk space. To help with storage, each Measurement that is to be stored on disk has an MD5 sum calculated. If an existing file has that exact hash value, the new Measurement merely references the existing file. Thus for testing systems that tend to generate the same results day after day, only one copy of the data will be stored in the Server file system.

6.2 Classes of Results

The Test tag specifies Test data. In Dart, there is no distinction between a Test used for unit testing and a Test that reports, *e.g.* , Coverage results. To distinguish Tests for the purposes of Coverage, DynamicAnalysis, Builds, *etc.* , the first portion of the qualified Test Name is used. The proper name formatting convention and required Measurements are listed below.

Dart has conventions for handling different types of Tests, resulting in different entries on the Dashboard, *e.g.* Coverage, Style, DynamicAnalysis. The current classes of results that are handled by Dart include Test, Coverage, Style, and DynamicAnalysis. They are detailed below to aid the developer in cohercing data into the proper convention to be recognized and presented by Dart.

In the following sections, the term “Test” is used both to indicate the contents of the `<Test>` tag as described above and to indicate the “Test” class of results. Hopefully, the context will disambiguate the particular use.

6.2.1 Test

The Test class of results are presented as a line on the Dashboard by the origin Submission. To be recognized as the Test class, a submitted Test's name must begin with ".Test". This signifies to Dart to include this Test on the Dashboard summary line for the Submission. There is no requirement to have a full hierarchy when submitting Tests, as Dart fills in the gaps and rolls up sub-Test status as part of the submission process.

For a Test to be rolled up as part of the Test column on the dashboard, its Name must have start with ".Test". There are no additional requirements. The recognized values for the Status tag are: passed, failed, notrun. During the rollup process, results from sub-Tests will be summarized by higher level test. For instance, if .Test.dart.server.Test1 and .Test.dart.server.Test2 are submitted, placeholder tests called .Test.dart, .Test.dart.server will be created and contain the count of sub-Tests that have passed, failed or were not run. If a Measurement called "Output" is present, it will be displayed on the Test page as the standard output of the Test.

6.2.2 Builds

Like Test results, Build results are also presented as a line on the Dashboard by the origin Submission. To be recognized as the Build class, a submitted Test's name must begin with ".Build". Build "tests" fall into three types: lines, stages, and placeholders.

Lines A build line represents a specific error or warning in a build. It has the following (optional) measurements:

SourceFile The name of the source file containing the error or warning.

SourceLineNumber The line in the source file.

BuildLogLine The line number in the build log from which this error or warning was detected.

Text The text of the error or warning, typically from the build log.

PreContext A few lines of the log before the error or warning.

PostContext A few lines of the log after the error or warning.

RepeatCount The number of times this error or warning is repeated elsewhere in the build log.

A build line test must be named `.Build*.ErrorN` or `.Build*.WarningN`, where *N* is an optional sequence of digits. Examples of valid names are `Build.Error032` and `Build.Stage5.Error`.

Stages Essentially, a stage represents a single build log. For example, a project could have three stages, such as "configure", "make bootstrap", and "make". These stages are typically launched sequentially, and their results are typically processed separately. Each stage contains the following measurements:

StageName A human readable name for the stage.

StartDateTime The start time of the stage.

EndDateTime The end time of the stage.

BuildCommand The command used to launch this stage.

BuildStatus The return status of the build command.

Log The build log. This is often omitted if the log has been parsed into specified error and warning lines.

Placeholder A placeholder is simply a placeholder test used to define a node in the test subtree. A placeholder is *not* named `*ErrorN` or `*WarningN`, and *does not* have a measurement named “StageName”.

As an example, the three stage build example could be represented by a placeholder test called `.Build`, a stage called `.Build.StageA` with a `StageName` of “Configure”, a stage called `.Build.StageB` with a `StageName` of “Bootstrap”, and a stage called `.Build.StageC` with a `StageName` of “Build”. Each of the stages may have build lines (e.g. `.Build.StageA.Warning8`) to represent errors detected during that stage.

Of course, a project that only has one build stage does not need an elaborate tree of build stages. It will simply have a single stage called `.Build`.

6.2.3 Coverage

Coverage results are displayed in a separate place at the bottom of the Dashboard. To be considered Coverage results, a Test’s Name must be “.Coverage”. In the `.Coverage` Test, Dart looks for the `PercentCoverage` Measurement. If this Measurement exists, a row is added to the Coverage section. Other Measurements, if present, are summarized: `LOCTested`, `LOCUnTested`. The passed and failed sub-tests of the `.Coverage` Test are presented as covered and not-covered files. The Coverage information links to the `CoverageCatalog` page. If there are sub Tests to the `.Coverage` Test, the user can navigate to any subtests. If the `.Coverage` Test contains a Log measurement of type `archive/zip`, the `CoverageCatalog` page merely consists of a link to the enclosed web pages. This is quite useful in the case of the Java coverage tool Cobertura.

6.2.4 Style

Style results are displayed in a separate place at the bottom of the Dashboard. To be considered Style results, a Test’s Name must be “.Style”. In the `.Style` Test, Dart looks for several Measurements to summarize: `FilesChecked`, `Violations` and `Log`. Clicking on any entry goes directly to the contents of the Log (assumed to be an `archive/zip` Measurement). Again, this is useful for style checking tools such as JCSC. In the future, a `StyleCatalog` page will be constructed.

6.2.5 DynamicAnalysis

If a Test is submitted with the name `.DynamicAnalysis`, Dart creates a `DynamicAnalysis` section on the Dashboard. The Dashboard rolls up the count of the defects contained in the `.DynamicAnalysis` Test by summing over all the Measurements in the Test. The links in the `DynamicAnalysis` section point to the `DynamicAnalysisCatalog` page which provides details of the Test.

The `DynamicAnalysisCatalog` page is quite flexible and finds all numeric Measurements in the `.DynamicAnalysis` Test and presents them in a summary page.

Dart Requirements and Design

This chapter describes the requirements and design criteria for the next version of Dart.

7.1 Dart Statement of Purpose

Dart shall aggregate data across many independent distributed build and test hosts, summarizing the software quality aspects of the project in a concise and informative fashion cross-sectionally and longitudinally.

7.2 User Requirements

1. A single server instance shall process multiple projects, with simple, flexible configuration and management.
2. Presentation of results shall be configurable, allowing results to persist on the dashboard for different periods. For instance, coverage information is time consuming to produce but slowly changing and ought to persist for more than one day.
3. Dashboards may be aggregated into Meta-Dashboards. For instance, Slicer depends on VTK, ITK, gsl and Tcl/Tk. The Slicer Meta-Dashboard shall present summary information from these dependencies.
4. Dart shall support submission authentication and selectively reject or expire unauthenticated submissions.
5. Dart shall provide resource management tools for disk space, bandwidth and processing time allowing both Clients and Servers to efficiently manage resources.

7.3 Design Requirements

Basic

1. The server shall contain all components required and shall not require any external packages, nor operating system applications. The server shall run as a daemon and shall include these components:
 - (a) Scheduler: Dart shall include an internal scheduling system for routine systems tasks, *etc.*

- (b) RDBMS: Dart shall include an embedded database to handle small Projects.
 - (c) Web Server: Dart shall include an embedded web server to publish dashboard pages.
 - (d) Web Services: Dart shall communicate using an established protocol for web services, allowing Results submissions and query of Project status from remote, homogeneous clients.
2. The server shall be extensible with user supplied components, including:
- (a) RDBMS: Dart shall use JDBC compliant drivers for all DB access allowing different database systems such as MySQL, Postgres, Oracle, *etc.*
 - (b) Web Server: Apache and other web servers shall be capable of serving Dart generated pages.
 - (c) Web Services: Dart shall allow the ability to communicate using external web servers such as Apache, Tomcat, *etc.*
 - (d) Portal Server: If desired, a Portal server such as Jetspeed may be used to interface with Dart results database. This capability is currently unspecified.

Resource Management (Section [7.3.1](#))

1. Dart shall, as an option, maintain compressed XML files, using on-the-fly decompression. This will result in approximately 10:1 spacing savings for the XML.
2. Dart shall provide a policy mechanism to selectively delete or archive unnecessary Builds. An archived Build shall consume less than 10K of disk space by retaining only summary information.

Storage, Processing and Presentation Engines

1. Dart shall comprise three engines: Storage, Processing and Presentation.
2. The Storage engine shall accept submissions from clients parse the input and store results in a generic format with large data items (*e.g.* images) stored in the file system, and with numeric and shorter text information stored in a database system.
3. The Processing engine shall process and summarize the results organized by the Storage engine at regular intervals and upon user-defined event triggering processing actions.
4. The Presentation engine shall provide a customizable view of data: both “raw” data from the Storage engine, and from the Processing engine. In the first instance, the Presentation engine shall simply be HTML, potentially migrating to a Portal based server.

Customization

1. Dart shall provide an easy to modify template engine for summarizing results.
2. Dart shall provide a server side plug in mechanism allowing custom data aggregation and flexible reporting.
3. Dart shall make provide mechanisms for simple localization and internationalization, where appropriate.

7.3.1 Resource Management

7.3.1.1 Disk Space

The Insight toolkit is the largest Dart project to date. Currently, with compressed HTML files, one day consumes over 650M of disk space. This includes (from November 4, 2004):

- One Doxygen run (400K for XML, 13K for HTMLZ)
- One Master Update (13K for XML, 4K for HTMLZ)
- One Dashboard (12M for XML, 9K for HTMLZ)
- One BuildOverview (250K for XML, 8K for HTMLZ)
- One TestOverview (25M for XML, 2 x 29K for HTMLZ)
- One Coverage build (24M for XML, 21M for HTMLZ)
- Builds (average of 9M for XML and HTMLZ)
 - 52 Nightly Builds
 - 19 Continuous Builds
 - 22 Experimental Builds

Breaking down an example day, we have:

File	Size	Notes
Build.xml	140K	111 Warnings, average of 1.2K per warning
Configure.xml	0.8K	
Test.xml	4.3M	859 Tests, average of 5K per test
Update.xml	1.4K	1 Update, 1.4K per updated file
TestSummary.xml	215K	Total for 8 HTMLZ files
All.htmlz	86K	

The largest generator of data is test output. Errors/Warnings and Update information are rather verbose, capturing context information. In general, XML is verbose with low entropy. A 4.3M Test.xml file is 522K compressed with gzip.

7.3.1.2 Dashboard Generation Time

7.3.1.3 Bandwidth

7.3.2 Historical Data

Dart currently preserves data from previous days, it is not linked across temporal Builds on the same system. While simple, this restriction increases the difficulty of monitoring the quality of a project. To overcome this limitation, Dart shall link data in a temporal fashion.

7.3.3 Hierarchical Data

7.3.3.1 Dashboards

7.3.3.2 Tests

7.3.3.3 Builds

7.3.4 Persistence of Builds/Results

7.3.4.1 Stream Concept

7.3.5 Documentation

7.3.6 Submissions

7.3.6.1 Incremental Submission

7.3.6.2 Mechanisms

7.3.6.3 Authentication

7.3.7 Configuration

7.3.7.1 Initial Setup

7.3.7.2 Options

7.3.8 Customization

7.3.8.1 Dashboard presentation

7.3.9 Extensibility

Design

8.1 Server

The Dart server is implemented in Java. It is composed of several different services, outlined below.

8.2 DartServer

The DartServer is responsible for starting up the other services. Projects are created, configured, loaded and started by the DartServer class.

8.2.1 Command Manager

Commands to Dart are passed to the DartServer via XML-RPC. The DartServer starts up a the Apache XML-RPC server on the same port as the HTTP Server by default.

8.2.2 Scheduler

The Quartz enterprise Scheduler is initialized and passed to each Project. In turn, each Project adds Tasks to the Scheduler to be executed as needed.

8.2.3 HTTP Server

Jetty is used in an embedded mode to serve static content, and generate dynamic content.

8.3 Project

Each Project hosted on a DartServer is created by loading the Dart.xml file in the Project directory. A Project is composed of several components.

8.3.1 Database

The Database object coordinates all access to the underlying RDBMS. The Database provides Connections to other Project components as needed.

8.3.2 ResultServer

The ResultServer object is responsible for handling XML-RPC requests. During startup, a service is added to the DartServer SubmissionServer.

8.3.3 ServletManager

The ServletManager is responsible for creating the Project specific Servlets and adding them to the Server's HTTP Server. User Servlets may be added to the Project's Plugins directory.

Implementation Ideas

This section captures some implementation ideas.

9.1 Server

Language Of all cross-platform languages, Java provides the most robust set of libraries suitable for Dart. Java also allows simple distribution of compiled libraries, *i.e.* jar files, as plug-ins. Potentially, a client could query the server for a list of available plug-ins downloading and installing as needed.

RDBMS There are several embeddable Java RDBMS available, two of the more interesting projects are Cloudscape, recently released from IBM, and renamed Derby on the Apache site and Hypersonic SQL (HSQLDB) project hosted on SourceForge. Dart is envisioned to have a RDBMS holding summary data; embedding a database into the server should help to make it transparent and invisible to the casual Dart user. For more scalability, the backing store could be any RDBMS with a JDBC driver. MySQL and Postgres come to mind.

Transport Though over-designed and complex, SOAP has the elements need to transmit XML files to the server from the client. Specifically, SOAP with attachments could deliver chunks of compressed XML to the server via HTTP, since most (all?) firewalls allow HTTP traffic. SOAP could also be used for Dashboard to Dashboard (D2D?) communication and remote management and monitoring of Dart servers. XML-RPC is a much simpler API, and identically suitable. XML-RPC will be considered at the same level as SOAP. Another possible use is dissemination of plug-ins for clients. The Java Messaging Service (JMS) is another possibility. JMS gives great flexibility to transport mechanisms and can operate asynchronously.

Scheduling Quartz is an open source enterprise strength scheduling system for Java. Quartz will drive scheduled events such as Dashboard roll ups, DB tasks, and archiving/deletion of old results. Quartz will replace cron.

Template Engine There are several competing Template engines for Java. Velocity is an Apache sponsored project and has some great features including close integration with other Apache projects. FreeMarker is another engine that is more sophisticated than Velocity, but not as integrated. The Template engine will be the driver to produce HTML and other reports replacing XSLT.

Jakarta The Apache Jakarta project provides several packages of immediate use.

- Digester builds objects from XML, greatly simplifying configuration from XML files. Each object is constructed as needed and automatically configured.
- CLI should provide a great command line parsing interface.
- Commons eMail provides a simple java email client.
- ORO and RegExp, two regular expression packages.

Portal Though the current Dart HTML pages serve the purpose well, adding a portal on top would allow custom portlets to be developed for specific purposes. For instance, one portlet could be configured to show a particular build over the last several days, or perhaps graph the performance of a Test or Result through time across several architectures. Dynamic generation of all the Dart results places undo burden on the server, where a Portal could dynamically generate limited data in an efficient manner. One Portal project that is interesting is Jetspeed 2, an Apache sponsored project.

Portals do add administrative overhead. It is preferable to have the ability to use Dart without a Portal, but easily being able to add the increased utility if desired.

9.2 Client

External Packages

10.1 Packages

Dart is built upon many Open Source packages. Each of these packages has different licenses. To comply with the licenses of each of these, we have listed the packages, their licenses and copyrights in this chapter.

Apache v1.1 Apache XML-RPC, Apache CLI

Apache Version 2.0 Bean Utilities, Derby, Collections, DBCP, Digester, Pool, VFS, Jetty

BSD License Jaxor

Common Public License, v1.0 JUnit

BSD-Like license Quartz

Freemarker License Freemarker

GNU Lesser General Public License JFreeChart (<http://www.jfree.org/jfreechart/>)

HTTPUnit License HTTPUnit

CyberNeko Software License, Version 1.0 NekoHTML

10.2 Apache License, Version 1.1

The Apache Software License, Version 1.1

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