

IceCube's Development Environment.

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When the IceCube experiment started serious software development it needed a development environment in which both its developers and clients could work and that would encourage and support a good software development process. Some of the key features that IceCube wanted in such an environment were: the separation of the configuration and build tools; inclusion of an issue tracking system; support for the Unified Change Model; support for unit testing; and support for continuous building. No single, affordable, off the shelf, environment offered all these features. However there are many open source tools that address subsets of these features, therefore IceCube set about selecting those tools which it could use in developing its own environment and adding its own tools where no suitable tools were found. This paper outlines the tools that were chosen, what are their responsibilities in the development environment and how they fit together. The complete environment will be demonstrated with a walk through of single cycle of the development process.

1. Introduction

1.1. IceCube Overview

The IceCube experiment is a neutrino telescope in which 1 km³ of ice is instrumented with Digital Optical Modules (DOMs), i.e. light detectors. The experiment is comprised of around 150 collaborators from all over Europe and America, but it is located at the South Pole. This location provides some fairly unique problems such as the following:

- For 8 months of the year the Pole is manned by “Winter-overs” only and there is no outside access.
- These “Winter-overs” are not usually the same people who develop the experiment’s software.
- The satellite connection to the Pole is limited and can also be intermittent.

Given these conditions not only is software reliability a *major* asset to the experiment, but it is also essential for the “Winter-overs” to be able to handle any software issue that arise during the 8 months that the Pole is shut. Therefore it is important for IceCube to have a software development environment that can help mitigate these issues.

2. Software Development Environment

2.1. Requirements

The software reliability issue led IceCube to make the decision that one of its key requirements for its software development environment is that it must support and encourage industry proven “good practices”. This was considered to be one of the best ways to mitigate the risk to the whole project contributed by the

software reliability issue. This led to the environment needing to provide tools which covered the following practices:

Work Space Management This includes support for some version of the “Unified Change Management” model [1].

Code Building This is separate for the work space management, as this tools will have language dependent portions, whereas work space management should be language neutral.

Unit Testing This helps capture the requirements of the software in a concrete form. It also means that software units can be replaced provided that the new code passes these tests.

Continuous integration This covers the repeated building, testing and reporting of any new code additions, so that errors can be found early in the development process.

Issue Tracking This provides an institutional memory for the experiment as there is expected to be significant turnover of personnel due to the long lifetime of the experiment.

Another decision, that also addressed reliability risk, was that as much software as possible at the Pole should be written in Java as this was found to be a more robust language than C++. However the physicists required that their online filter code be written in C++ so that they would be able to exploit the resources provided by the ROOT package [2]. Similarly, DOM programming is best done in C, due to the nature of the hardware. This meant the development environment needed multi-language support.

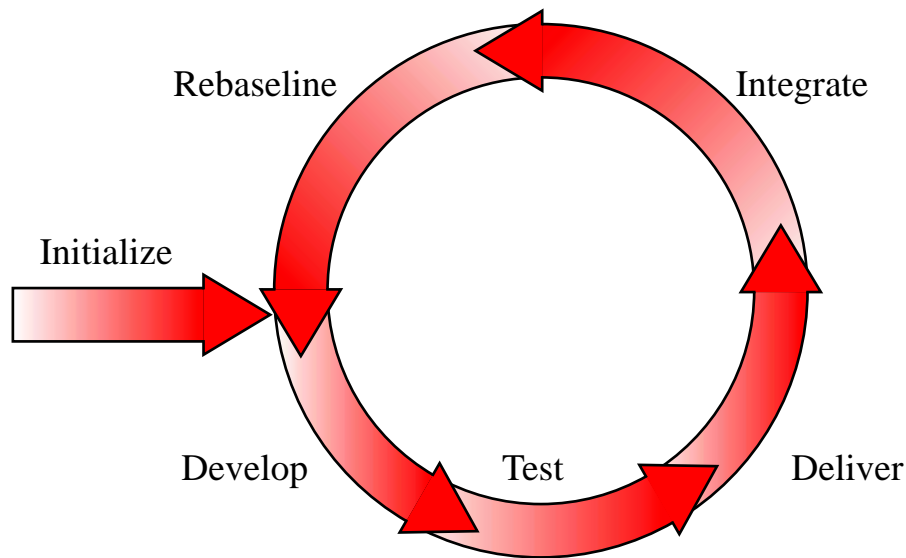


Figure 1: The work space management cycle as defined by the Unified Change Management model.

2.2. Implementation

No single, affordable, off the shelf product was found that fulfilled all these requirements. Meanwhile it was observed that there were many open source tools that addressed subsets of these requirements. Therefore IceCube decided to create its own development environment by selecting those open source tools which it could exploit and develop its own tools in those areas where no open source solution existed. In the end this turned out to be only one area, work space management.

2.2.1. Work Space Management

Figure 1 illustrates the basic ideas behind the work space management cycle as defined by the Unified Change Management model. A developer enters the cycle by initializing an area to be a work space to tack a specified issue. Once the space is established, the developer is free to work on the code and its test, including adding new code and new tests if the issue is an enhancement request. Eventually the point should be reached when the change is notional complete. At this point in time the code should pass all of its unit tests. Once this requirement has been satisfied the code is then delivered, ready for integration with the rest of the software product.

The exact results of code delivery depends a great deal on the size of the product. For small products delivery may simply be inclusion of the new and mod-

ified code in the next continuous integration test of the product. Large projects, on the other hand, will be broken down into hierarchical subsystems and “delivery” will mean that the new and modified code is passed on to an integrator who will bring together all the changes in that subsystem, test that they work together and then pass the resulting code base on to the next level of the hierarchy.

As noted above, no open source tool was found to handle these responsibilities so the **bfd** tool has been created. This initializes work spaces with the files and soft links they need to be able to work. It also adds a layer of policy on top of a code archive system, in IceCube’s case this is CVS, that handles code checkout, checkin and tagging.

2.2.2. Code Building

As the core of the IceCube software system will be written in Java, it was decided that **ant** [3] would be the best choice as the main build tool for the environment. This tool is already the standard build tool for many Java products. One of the major benefits is that it is written in Java which means that it can execute anywhere you expect Java code to execute.

Also, by being written in Java, **ant** is easily extensible although there are already plenty of “tasks” for handling the more common duties associated with code building such as; skeleton processing; running **JUnit** (see below); integration with other tools such as **JDepend** [4] - a metric calculation program.

Main targets:

<code>clean</code>	Clean all directories and files built for this project
<code>compile</code>	Compile this project
<code>createClass</code>	Create new .java files for a class and its matching test
<code>createInterface</code>	Create new .java files for an interface and its matching test
<code>createPackage</code>	Create a new package
<code>docs</code>	Create API and test documents for this project
<code>javadocs</code>	Create the Javadocs for this project
<code>lib</code>	Create the library for this project
<code>report</code>	Create the report on the tests run for this project
<code>test</code>	Run the tests for this project

Figure 2: The public targets for the standard `build.xml` file for a project.

The execution of `ant` is driven by a `build.xml` file, therefore a standard `build.xml` file is provided for each project within the IceCube software system. Figure 2 shows the public targets for the standard file.

Similarly a standard `build.xml` file is provided for each work space. This file contains call downs to the public targets of each project contained in a work space, as well as extra targets that handle work space level issues. e.g. creation of deployment tar-balls.

2.2.3. Unit Testing

The model adopted for unit testing in IceCube is the XUnit framework [5]. The Java implementation of this framework is called JUnit [6]. In this framework a set of test for a particular unit (at the base level this is a class) are created and grouped together in a “TestCase” for that unit. Each test codifies one of the requirements that has been specified for that unit.

A skeleton for the TestCase for a class is generated by `ant` when `ant` is used to generate the class skeleton. Thus, for the simpler classes the developer simply needs to provide a set of implementations that test all requirements and the job is complete.

JUnit provides both a GUI and text based interface for testing. However `ant` also provides its own interface and this is the one used by IceCube. The `ant` interface generates an XML file as well as providing a summary of the execution of the tests. A further `ant` task can be used to convert this XML file into a set of HTML frames that can easily be viewed to see which tests succeeded and which failed and why.

2.2.4. Continuous integration

The earlier a problem can be discovered the sooner it can be fixed and the less impact it will have on the overall development of a software product. To that end it makes sense to continuously integrate all parts of a product to check that no change has broken another part of the software. IceCube’s solution to this issue is to use the CruiseControl [7] software. This can be integrated with `ant` build files so is a good

match to the rest of the IceCube system. Builds are currently executed every time a change committed to the CVS archive and a build is not in progress. Work is in progress to also allow builds to be scheduled, e.g. every night.

The results of a build can be readily made available on the Web, along with the results of the unit test.

As well as the standard CruiseControl output, the results can be passed to the Tinderbox [8] program which can display a graphical of the current state of various different configurations of builds.

2.2.5. Issue Tracking

In the initial incarnation of the IceCube development environment Issuezilla was chosen to handle issue tracking. This product was an outgrowth of the Bugzilla product used by Netscape to track Mozilla issues. However the future of this product is unclear as its developers are now focused on a Java based replacement, Scarab, whose development appears to be stalled over the last half year or so.

In the meantime an open source development of the old SourceForge project, GForge [9], has recently announced its presence. This tool not only provides issue tracking facilities, but it can also act as a “portal” through which the entire software effort of IceCube could be accessed.

All this means that the Issue tracking portion of the IceCube development environment has yet to be finally settled.

3. Walk Through of a User Session

In this section of the paper we will see an example walk through of the development environment highlighting many of the typical uses. Some features of the environment, e.g. baselining, are not yet implemented and so are not included in this example.

```
[patton@glacier patton]$ mkdir work
[patton@glacier patton]$ cd work
[patton@glacier work]$ bfd init /home/icecube/tools
... <output skipped> ...
[patton@glacier work]$ ls -l
total 24
-rw-rw-r-- 1 patton patton 297 Jun 9 15:31 build.xml
-rw-rw-r-- 1 patton patton 5443 Jun 9 15:31 setup.csh
-rw-rw-r-- 1 patton patton 5065 Jun 9 15:31 setup.sh
drwxrwxr-x 6 patton patton 4096 Jun 9 15:31 tools
[patton@glacier work]$ source setup.sh
```

Figure 3: An example of work space creation.

3.1. Creating a Work Space

Figure 3 shows an example of how a work space can be initialized. It is fairly straightforward. A directory, which will be the work space, is created and then `bfd init` is executed in that directory. This created the necessary files and soft links. The example shows the contents of the work space after it is initialized.

The final set of the example shows the “sourcing” of the appropriate `setup` file that sets up the necessary environmental variables to use the work space. This command needs to be executed every time a session begins work in the work space.

3.2. Checking out and Building a Project

Figure 4 shows how to checkout a project, in this case the `icebucket` project, from the code archive and then build it using the `ant` command. As you can see in the example two jar files are created, one holds the project code, and the other holds the code and resources needed to run the unit tests of the project.

3.3. Creating a New Project

Figure 5 shows how the contents of a new project, `gromit`, can be created using `ant`. Dependencies of one project on another are stored in the `project.xml` file of project, thus the need to edit this file in the example to include the fact that `gromit` is dependent upon `icebucket`.

3.4. Creating a New Class

Figure 6 shows how `ant` can be used to create new class files. It also shows that the test file for a class is also created at the same time as the class itself.

3.5. Implementing a Class

Figure 7 shows the steps that can now be taken to provide an implementation of a class and its unit test.

It also shows how a `JUnit` test can be run outside `ant`.

3.6. Delivering a Project

Figure 8 shows how, once development of a class has been completed, it can be delivered and thus made available to the next stage of integration.

3.7. Cleaning up

Figure 9 shows how you can clean up a work space once its task has been accomplished. Using this command, rather than simply using a `rm -rf`, checks that everything has been safely stored in the code archive.

4. Summary

IceCube has created a development environment for its software based, where possible, on open source tools. The aim of this environment has been to simplify the developers work load by integrating “good practices” into the environment. So far these goals have been achieved and early adopters of the environment have been pleased by the ease it has brought to their development process.

References

- [1] <http://www.rational.com/products/whitepapers/415.jsp>
- [2] <http://root.cern.ch/>
- [3] <http://ant.apache.org/>
- [4] <http://www.clarkware.com/software/JJDepend.html>
- [5] <http://www.xprogramming.com/testfram.htm>
- [6] <http://junit.org>
- [7] <http://cruisecontrol.sf.net/>
- [8] <http://www.mozilla.org/tinderbox.html>
- [9] <http://www.gforge.org/>

```
[patton@glacier work]$ bfd co icebucket
... <output skipped> ...
[patton@glacier work]$ cd icebucket
[patton@glacier icebucket]$ ant
Buildfile: build.xml
... <output skipped> ...
BUILD SUCCESSFUL
Total time: 9 seconds
[patton@glacier icebucket]$ cd ..
[patton@glacier work]$ ls -l lib
total 8
-rw-rw-r-- 1 patton patton 3455 Jun 9 15:39 icebucket.jar
-rw-rw-r-- 1 patton patton 3004 Jun 9 15:39 icebucket-test.jar
```

Figure 4: An example of checking out and building the icebucket project.

```
[patton@glacier work]$ bfd co gromit
... <output skipped> ...
[patton@glacier work]$ ant -DPACKAGE=icecube.tools.examples \
> -DPROJECT=gromit createProject
Buildfile: build.xml
... <output skipped> ...
BUILD SUCCESSFUL
Total time: 2 seconds
[patton@glacier work]$ ls -l gromit
total 16
-rw-rw-r-- 1 patton patton 397 Jun 9 15:45 build.xml
-rw-rw-r-- 1 patton patton 292 Jun 9 15:45 project.xml
drwxrwxr-x 4 patton patton 4096 Jun 9 15:45 resources
drwxrwxr-x 3 patton patton 4096 Jun 9 15:45 src
[patton@glacier work]$ emacs gromit/project.xml
... <add dependency on icebucket> ...
[patton@glacier work]$ bfd uadd gromit
```

Figure 5: An example of populating a new project with its default files.

```
[patton@glacier work]$ cd gromit
[patton@glacier gromit]$ ant -DCLASS=Counter2 createClass
... <output skipped> ...
[patton@glacier gromit]$ ls -lR src/icecube/tools/examples/
src/icecube/tools/examples/:
total 12
-rw-rw-r-- 1 patton patton 1008 Jun 9 15:50 Counter2.java
-rw-rw-r-- 1 patton patton 575 Jun 9 15:45 package.html
drwxrwxr-x 2 patton patton 4096 Jun 9 15:50 test

src/icecube/tools/examples/test:
total 8
-rw-rw-r-- 1 patton patton 2178 Jun 9 15:50 Counter2Test.java
-rw-rw-r-- 1 patton patton 424 Jun 9 15:45 package.html
```

Figure 6: An example of creating a skeleton file for a new class and its tests

```
[patton@glacier gromit]$ cd src/icecube/tools/examples/
[patton@glacier examples]$ emacs test/Counter2Test.java
... <write tests> ...
[patton@glacier examples]$ emacs Counter2.java
... <implement class> ...
[patton@glacier examples]$ cd ../../../../
[patton@glacier gromit]$ ant lib
... <output skipped> ...
[patton@glacier gromit]$ cd ..
[patton@glacier work]$ java -cp lib/gromit-test.jar \
> junit.textui.TestRunner icecube.tools.examples.test.Counter2Test
.....
Time: 0.159

OK (5 tests)
```

Figure 7: An example showing the steps used to implement a new class and its tests.

```
[patton@glacier work]$ bfd uadd gromit
... <output skipped> ...
[patton@glacier work]$ bfd archive -m "New example project" gromit
... <output skipped> ...
[patton@glacier work]$ bfd deliver -j gromit
Are you sure you want to deliver "gromit" with tag V01-00-00
y/n: y
V01-00-00 of "gromit" has been delivered.
```

Figure 8: An example delivering a project after its modifications have been completed.

```
[patton@glacier work]$ bfd dispose gromit
No files have been added to, or modified in, "gromit".
There are no unknown files in, "gromit".
Disposed of "gromit"
[patton@glacier work]$ bfd dispose
Are you sure you want to dispose of the entire workspace?
y/n: y
No files have been added to, or modified in, "icebucket".
There are no unknown files in, "icebucket".
Disposed of "icebucket"
Disposed of workspace files...anything left is your own problem.
[patton@glacier work]$ ls -l
total 0
```

Figure 9: An example of cleaning up a work space once its task has been accomplished.