

Continuous Integration

Ádám Révész, Attila Ulbert, Norbert Pataki, Zoltán Gera



Eötvös Loránd University,
Budapest, Hungary

Introduction to
Cloud Technologies

Contents

1 Introduction

2 CI

3 Jenkins

4 Conclusion

Introduction

- Software development – teamwork
- Teamwork needs tools
 - Version control: svn, git, Perforce, etc.
 - Command-line build tools: CMake, gradle, maven, etc.
 - Bug tracking/Issue tracking tools: Bugzilla, Atlassian Jira, etc.

Motivating Problems

- The version control cannot guarantee that the code in the repository is “correct”
 - The code may cannot be compiled or essential unit tests fail
 - When the developers can update their local checkout?
 - Which parts of the software can be updated in the local checkout?
 - Which previous revision is proper/stable?
 - Tester: “This feature doesn’t work on my computer.”
Developer: This feature does work on my computer pretty well.”
 - Developer: “The tests pass on my computer.”
 - When a feature or a test case went wrong?
 - Who is the responsible for the problem? Who committed into the version control? Who did not commit a referred code?
- Does a bugfix causes new problems?

Motivation

- Frequent releases – at least once per month
- Radically reduce integration costs – avoid integration hell
- Reduce the costs of finding the cause of an abnormal behavior

Definition

- Software development practice
- Frequent integration of the developed code and baseline
- Automated build with QA
 - compilation
 - unit, component, integration, end-to-end tests
 - static analysis, code coverage, etc.
- Transparent reports
- XP development method

Principles

- Maintain a Single Source Repository
- Automate the Build – IDE is not a build system
- Make Your Build Self-Testing
- Everyone Commits To the Mainline Every Day
- Every Commit Should Build the Mainline on an Integration Machine

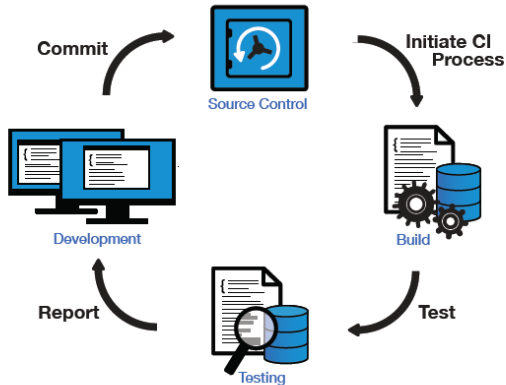
Principles

- Fix Broken Builds Immediately
- Keep the Build Fast (split the tasks, but unfortunately, tests may take longer)
- Test in a Clone of the Production Environment
- Make it Easy for Anyone to Get the Latest Executable
- Everyone can see what's happening
- Automate Deployment

Benefits

- Quickly reveals that the code in the repository does not compile
- Quickly reveals if the code does not pass a testcase
- It may reveal which commit breaks the build
- It can be seen which is the latest working revision
- Previous builds data (console log, test running, etc.) is stored and available
- Report: e-mail, Slack, web ui, etc.
- Referential point - the definitive machine to decide if a test fails

CI Cycle



Importance of Fast Build Jobs

- Runtime of Build and Test Jobs is important
- Not so many changes in the baseline during execution
- What are changes since the jobs was successful?
- Deterministic test cases
- Parallel, split jobs, Master-slave CI architecture
- Multi-stage build processes

Build Times

- Compilation with Unit Tests: should be under 20 minutes
- Unit testcase: under 1 second.
- Speed-up:
 - Mocked features
 - In-memory Databases
 - Removing dead code
- Slow processes (e.g. security) – nightly build

CI – Lava lamp, Build light indicator



Tools

- Cruise Control
(<http://cruisecontrol.sourceforge.net/>)
- Jenkins/Hudson (<https://jenkins-ci.org/>)
- IBM Rational Team Concert
- Microsoft Team Foundation Server
- Travis CI (<https://travis-ci.org/>)
- GoCD (<https://www.gocd.org/>)
- etc.

Jenkins



Jenkins

- CI tool, system
- Widely-used
- Open source, multiplatform CI server
- Web UI, REST API
- Various configuration options
- Many useful available plugins
- Pipelines – Jenkins 1 vs. Jenkins 2

The Jenkins Dashboard

Jenkins search log in [ENABLE AUTO REFRESH](#)

[Jenkins](#)

People

Build History

Project Relationship

Check File Fingerprint

Build Queue

No builds in the queue.

Build Executor Status

master

- 1 Idle
- 2 Idle

Docker Swarm-50027969044a

- 1 [Extragear.digikam.kf5-qt5.SUSEQt5.9](#) [#893](#) (Compiling)

Docker Swarm-715a1dfd6e41

- 1 [Extragear.kmymoney.kf5-qt5.SUSEQt5.9](#) [#210](#) (Setup Dependencies)

































To request adjustments to the CI system please create a task on Phabricator: <https://phabricator.kde.org/tag/build.kde.org/>

All Applications CI Management Extragear Frameworks Grouped KDE PIM KDevelop Plasma

S	W	Name ↓	Last Success	Last Failure	Last Duration
🔴	🔴	Applications.akonadi.kf5-qt5.SUSEQt5.9	2 days 9 hr - #48	N/A	35 min
🔵	🔴	Applications.akonadi.kf5-qt5.WindowsMSVCQt5.9	2 days 9 hr - #131	17 days - #116	20 min
🔴	🔴	Applications.akonadi.stable.kf5-qt5.SUSEQt5.9	8 days 15 hr - #24	N/A	46 min
🔵	🔴	Applications.akonadi.stable.kf5-qt5.WindowsMSVCQt5.9	8 days 15 hr - #43	11 days - #39	31 min
🔵	🔴	Applications.akonadi-calendar.kf5-qt5.SUSEQt5.9	14 days - #9	N/A	29 min
🔵	🔴	Applications.akonadi-calendar.stable.kf5-qt5.SUSEQt5.9	11 days - #9	N/A	32 min
🔵	🔴	Applications.akonadi-calendar-tools.kf5-qt5.SUSEQt5.9	14 days - #7	N/A	4 min 24 sec
🔵	🔴	Applications.akonadi-calendar-tools.stable.kf5-qt5.SUSEQt5.9	11 days - #11	11 days - #10	2 min 19 sec
🔵	🔴	Applications.akonadi-contacts.kf5-qt5.SUSEQt5.9	8 days 16 hr - #17	N/A	3 min 29 sec
🔵	🔴	Applications.akonadi-contacts.stable.kf5-qt5.SUSEQt5.9	8 days 15 hr - #14	N/A	3 min 8 sec
🔵	🔴	Applications.akonadi-import-wizard.kf5-qt5.SUSEQt5.9	4 days 7 hr - #17	25 days - #10	8 min 24 sec
🔵	🔴	Applications.akonadi-import-wizard.stable.kf5-qt5.SUSEQt5.9	4 days 7 hr - #15	22 days - #11	2 min 2 sec

Navigation icons: back, forward, search, etc.

Jobs


		Applications_kdegraphics-thumbnailers kf5-qt5 FreeBSDQt5.9	17 days - #1	N/A	5 hr 20 min
		Applications_kdegraphics-thumbnailers kf5-qt5 SUSEQt5.9	1 mo 15 days - #1	N/A	18 min
		Applications_kdegraphics-thumbnailers stable-kf5-qt5 FreeBSDQt5.9	17 days - #1	N/A	9 hr 12 min
		Applications_kdegraphics-thumbnailers stable-kf5-qt5 SUSEQt5.9	1 mo 12 days - #2	N/A	1 hr 1 min
		Applications_kdenetwork-filesharing kf5-qt5 FreeBSDQt5.9	17 days - #1	N/A	5 hr 3 min
		Applications_kdenetwork-filesharing kf5-qt5 SUSEQt5.9	1 mo 15 days - #1	N/A	32 min
		Applications_kdenetwork-filesharing stable-kf5-qt5 FreeBSDQt5.9	17 days - #1	N/A	8 hr 10 min
		Applications_kdenetwork-filesharing stable-kf5-qt5 SUSEQt5.9	1 mo 12 days - #2	N/A	29 min
		Applications_kdenlive kf5-qt5 FreeBSDQt5.9	2 days 2 hr - #2	N/A	9 min 57 sec
		Applications_kdenlive kf5-qt5 SUSEQt5.9	2 days 2 hr - #7	1 mo 15 days - #1	15 min
		Applications_kdenlive kf5-qt5 WindowsMSVCQt5.9	N/A	2 mo 22 days - #3	59 min
		Applications_kdenlive stable-kf5-qt5 FreeBSDQt5.9	2 days 1 hr - #3	N/A	18 min
		Applications_kdenlive stable-kf5-qt5 SUSEQt5.9	2 days 1 hr - #14	N/A	3 min 51 sec
		Applications_kdenlive stable-kf5-qt5 WindowsMSVCQt5.9	N/A	2 days 1 hr - #22	21 min
		Applications_kdepim-addons kf5-qt5 SUSEQt5.9	9 hr 25 min - #108	N/A	37 min
		Applications_kdepim-addons stable-kf5-qt5 SUSEQt5.9	11 days - #31	N/A	42 min

Starting of Jobs


- SCM, Software configuration management:
(* / 5 * * * * – checking new revision(s))
- Timer, cron-like (00 23 * * * – nightly build)
- Executed manually
- After another job's finish – pipeline


Build Info

SUSEQ15.9 > #5


 **Changes**

1. GIT_SILENT: Time to increase version ([detail](#) / [cgit](#))


 [Started by an SCM change](#)

 **git** **Revision:** 41bda0c3efc2315c981a260a40c471761a210313


- origin/master

 **git** **Revision:** 139f68b528771a15a9e1394abd89da09969dda97


- origin/master

 **git** **Revision:** 9413af76df3d6bb10b1da0565ec19f6d996903a4


- origin/master

 **git** **Revision:** 191224048912b0d5dcb1f9750a01ae6176502137


- origin/master


 **git** **Revision:** a5a402aac02b5dc846c6ee3d82e592548af3001

- origin/master

 **git** **Revision:** 4e8c366aa5157182e797446d503afe268d27ae74

- origin/master

 [Test Result](#) (1 failure / 0)









 GNU Make + GNU C Compiler Warnings: [5 warnings](#).


Console log

```
03:25:43 -- Build files have been written to: /home/jenkins/workspace/Applications bovo stable-kf5-qt5 SUSEQt5.9/build
[Pipeline] }
[Pipeline] // stage
[Pipeline] stage
[Pipeline] { (Compiling)
[Pipeline] sh
03:25:43 [Applications bovo stable-kf5-qt5 SUSEQt5.9] Running shell script
03:25:43 + python3 -u ci-tooling/helpers/compile-build.py --product Applications --project bovo --branchGroup stable-
kf5-qt5 --platform SUSEQt5.9 --usingInstall /home/jenkins//install-prefix/
03:25:43 Scanning dependencies of target bovo_autogen
03:25:43 [ 3%] Generating settings.h, settings.cpp
03:25:43 [ 6%] Automatic MOC for target bovo
03:25:44 Generating MOC predefs moc_predefs.h
03:25:44 Generating MOC source AOUW3KFNJ0/moc_ai.cpp
03:25:44 Generating MOC source AOUW3KFNJ0/moc_aifactory.cpp
03:25:44 Generating MOC source TTHINB22PQ/moc_aaron.cpp
03:25:44 Generating MOC source OJNGYDLRA/moc_aigabor.cpp
03:25:44 Generating MOC source ZL6H5ELRUJ/moc_game.cpp
03:25:44 Generating MOC source DMHXEJ42XS/moc_hintitem.cpp
03:25:44 Generating MOC source DMHXEJ42XS/moc_mainwindow.cpp
03:25:44 Generating MOC source DMHXEJ42XS/moc_mark.cpp
03:25:44 Generating MOC source DMHXEJ42XS/moc_scene.cpp
03:25:44 Generating MOC compilation mocs_compilation.cpp
03:25:44 [ 6%] Built target bovo_autogen
03:25:44 Scanning dependencies of target doc-index-cache-bz2
03:25:44 [ 10%] Generating index.cache.bz2
03:25:44 Scanning dependencies of target bovo
03:25:44 [ 13%] Building CXX object CMakeFiles/bovo.dir/gui/hintitem.cc.o
03:25:44 [ 16%] Building CXX object CMakeFiles/bovo.dir/gui/mark.cc.o
03:25:44 [ 20%] Building CXX object CMakeFiles/bovo.dir/gui/theme.cc.o
03:25:45 Note: namespace. add : added namespace before processing
03:25:45 [ 23%] Building CXX object CMakeFiles/bovo.dir/gui/view.cc.o
03:25:45 [ 23%] Built target doc-index-cache-bz2
03:25:45 [ 26%] Building CXX object CMakeFiles/bovo.dir/gui/mainwindow.cc.o
```


The Bovo Handbook

Workspace



-  [Back to Dashboard](#)
-  [Status](#)
-  [Changes](#)
-  **Workspace ¹**
-  [Wipe Out Current Workspace](#)
-  [Build Now](#)
-  [Delete Project](#)
-  [Configure](#)


 **Build History** [trend ▾](#)


x


 **#1**
May 21, 2016 12:47 PM

Workspace of FirstJob-CreateFile on master







 

 [script1.txt](#) 13 B [view ²](#)

 [script2.txt](#) 19 B [view](#)

 [\(all files in zip\)](#)

Build History

Build History trend	
<input type="text" value="find"/> x	
 #15	Dec 12, 2017 5:53 AM
 #14	Dec 10, 2017 10:49 AM
 #13	Dec 7, 2017 6:58 AM
 #12	Dec 7, 2017 6:12 AM
 #11	Dec 4, 2017 2:10 AM
 #10	Nov 30, 2017 2:35 AM
 #9	Nov 28, 2017 10:20 PM
 #8	Nov 28, 2017 6:05 AM
 #7	Nov 27, 2017 8:33 PM
 #6	Nov 27, 2017 2:19 AM
 #5	Nov 23, 2017 4:07 PM
 #4	Nov 22, 2017 8:06 AM
 #3	Nov 22, 2017 4:07 AM
 #2	Nov 21, 2017 6:41 PM
 #1	Nov 11, 2017 2:39 AM

Changes

Changes

Summary

1. GIT_SILENT Upgrade KDE Applications version to 17.11.80. ([details](#))
2. ArkViewer: close on Escape ([details](#))
3. ExtractJob: set destination URL in the job description ([details](#))

Commit [510d93dcda38195857a6e945079a20b825ce81ae](#) by [Albert Astals Cid](#)
GIT_SILENT Upgrade KDE Applications version to 17.11.80.

 [CMakeLists.txt](#) ([diff](#))

Commit [ae758226b8b630572de715054b4b965443a4ef11](#) by [Elvis Angelaccio](#)
ArkViewer: close on Escape
BUG: 386729 FIXED-IN: 17.11.80
Test Plan: Open preview for a text file, then check whether Esc closes the window. If some operation is happening in the kate part (e.g. text selected, or search bar open), make sure Esc aborts the operation rather than closing the window.
Reviewed By: broulik
Differential Revision: D8761

 [part/arkviewer.cpp](#) ([diff](#))

Commit [52cbbd803a2f57a971372fde1b5ebcc3808bf7a](#) by [Elvis Angelaccio](#)
ExtractJob: set destination URL in the job description
The plasma notification applet looks for it for the "Open" button within the notification. If it doesn't find it, it falls back to the archive URL which is not what one would expect.
BUG: 385043 FIXED-IN: 17.11.90
Differential Revision: D8861

 [kernutils/jobs.cpp](#) ([diff](#))

Test Result

Test Result

1 failures (±0)

15 tests (±0)

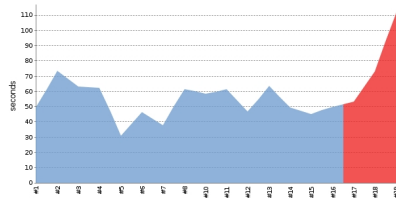
Took 1 min 51 sec.

All Failed Tests

Test Name	Duration	Age
TestSuite.placesitemmodetest		
Error Details		
	Failed	
	(
	2	
)	
Stack Trace		
Standard Output		
	BuildName: (empty) BuildStamp: 20171220-0606-Experimental Name: (empty) Generator: ctest-3.9.5 CompilerName: OSName: Linux Hostname: d896c109ceab OSRelease: 4.4.0-98-generic OSVersion: #121-Ubuntu SMP Tue Oct 10 14:24:03 UTC 2017 OSPlatform: x86_64 Is64Bits: 1 VendorString: GenuineIntel VendorID: Intel Corporation	49 sec 3

Test History

History for Test Results

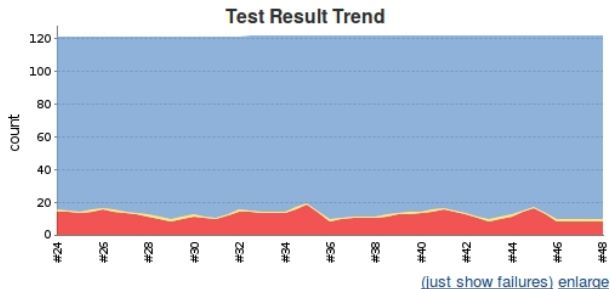


[show count](#)

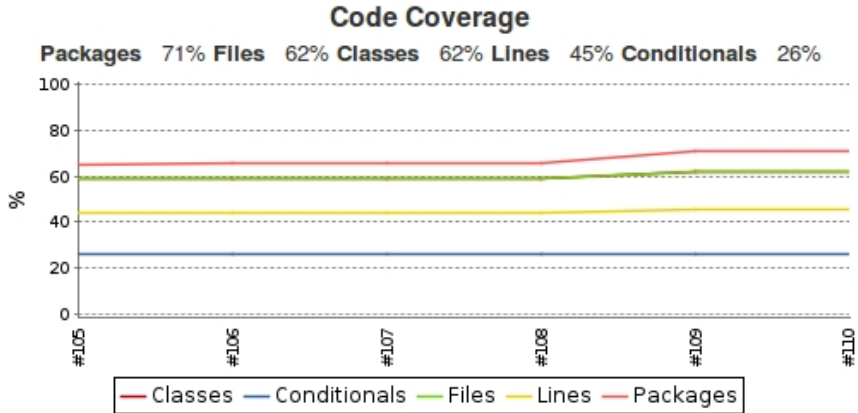
Build	Description	Duration	Fail	Skip	Total
Applications_dolphin_kf5-qt5_SUSEQt5.9_#19		1 min 51 sec	1	0	15
Applications_dolphin_kf5-qt5_SUSEQt5.9_#18		1 min 12 sec	1	0	15
Applications_dolphin_kf5-qt5_SUSEQt5.9_#17		53 sec	1	0	15
Applications_dolphin_kf5-qt5_SUSEQt5.9_#16		49 sec	0	0	15
Applications_dolphin_kf5-qt5_SUSEQt5.9_#15		44 sec	0	0	15
Applications_dolphin_kf5-qt5_SUSEQt5.9_#14		49 sec	0	0	15
Applications_dolphin_kf5-qt5_SUSEQt5.9_#13		1 min 3 sec	0	0	15
Applications_dolphin_kf5-qt5_SUSEQt5.9_#12		46 sec	0	0	15
Applications_dolphin_kf5-qt5_SUSEQt5.9_#11		1 min 1 sec	0	0	14
Applications_dolphin_kf5-qt5_SUSEQt5.9_#10		58 sec	0	0	14

Test Result Trend

akonadi kf5-qt5 SUSEQt5.9



Code Coverage



Pipeline – Stage View

Jenkins 2: Declarative/Scripted (Groovy) pipeline jobs

Applications kcalutils stable-kf5-qt5 SUSEQt5.9 - Stage View

		Checkout Sources	Setup Dependencies	Configuring Build	Compiling	Installing	Capturing Installation	Running Tests	Checking Code Quality
Average stage times:		35s	36s	9s	35s	1s	10s	20s	3s
#10	Dec 15 07:58 1 commits	18s	42s	12s	53s	1s	7s	17s	1s
#9	Dec 04 11:30 No Changes	41s	14s	13s	55s	2s	9s	20s	1s
#8	Dec 04 11:20 1 commits	22s	14s	15s	43s	1s	6s	18s	1s
#7	Dec 02 21:02 1 commits	2min 10s	41s	7s	42s	2s	35s	30s	13s
#6	Nov 23 15:30 1 commits	17s	41s	2s	19s	674ms	5s	14s	1s
#5	Nov 21 20:17 No Changes	24s	22s	13s	46s	672ms	9s	15s	1s

Reports

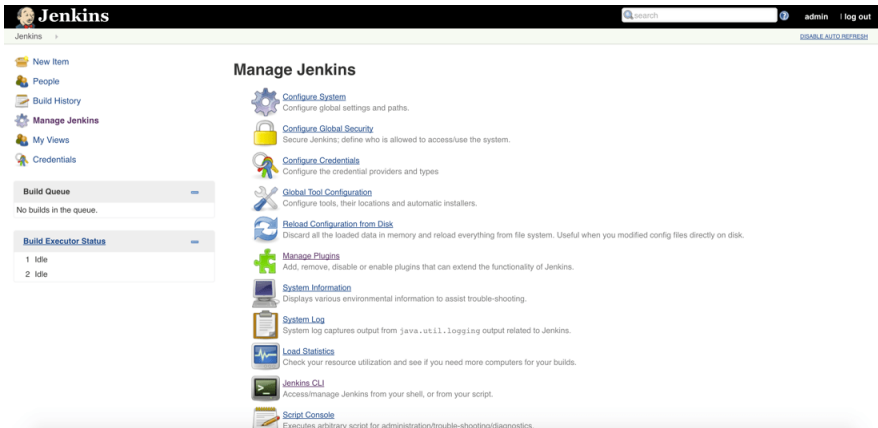
Many reporting options can be used:

- Jenkins UI
- E-mail
- Slack notification
- etc.

Creating New Jobs

- UI support
- Jobs are stored in xml files (e.g. `/var/lib/jenkins/jobs`)
- The jobs can be stored in version control
- Jenkins reload can be triggered by updating the version controlled job(s)

The Configuration Dashboard



The screenshot shows the Jenkins Configuration Dashboard. The top navigation bar includes the Jenkins logo, a search bar, and links for 'admin' and 'log out'. Below the navigation bar, the left sidebar contains links for 'New Item', 'People', 'Build History', 'Manage Jenkins' (highlighted), 'My Views', and 'Credentials'. The main content area is titled 'Manage Jenkins' and lists various configuration options, each with an icon and a brief description. The 'Build Queue' section shows 'No builds in the queue.' The 'Build Executor Status' section shows two executors in 'Idle' state. The 'Manage Jenkins' list includes: 'Configure System' (gear icon), 'Configure Global Security' (lock icon), 'Configure Credentials' (key icon), 'Global Tool Configuration' (wrench icon), 'Reload Configuration from Disk' (refresh icon), 'Manage Plugins' (puzzle piece icon), 'System Information' (monitor icon), 'System Log' (notepad icon), 'Load Statistics' (heart rate icon), 'Jenkins CLI' (terminal icon), and 'Script Console' (pencil icon).

Jenkins [admin](#) [log out](#) [DISABLE AUTO REFRESH](#)

Manage Jenkins

- [Configure System](#)
Configure global settings and paths.
- [Configure Global Security](#)
Secure Jenkins; define who is allowed to access/use the system.
- [Configure Credentials](#)
Configure the credential providers and types
- [Global Tool Configuration](#)
Configure tools, their locations and automatic installers.
- [Reload Configuration from Disk](#)
Discard all the loaded data in memory and reload everything from file system. Useful when you modified config files directly on disk.
- [Manage Plugins](#)
Add, remove, disable or enable plugins that can extend the functionality of Jenkins.
- [System Information](#)
Displays various environmental information to assist trouble-shooting.
- [System Log](#)
System log captures output from `java.util`. Logging output related to Jenkins.
- [Load Statistics](#)
Check your resource utilization and see if you need more computers for your builds.
- [Jenkins CLI](#)
Access/manage Jenkins from your shell, or from your script.
- [Script Console](#)
Executes arbitrary script for administration/trouble-shooting/diagnostics.

Build Queue [-](#)
No builds in the queue.

Build Executor Status [-](#)

1	Idle
2	Idle

Configuration

- Number of executors
- Number of jobs, tests split into jobs
- Length of build history per jobs

Configuration

Master - Slave nodes:

- Reduced CPU, memory and I/O load
- Parallel execution
- High Availability
- May using different Operating Systems

The screenshot shows two panels from the Jenkins web interface. The top panel, 'Build Queue', has a minus sign icon and shows 'No builds in the queue.' The bottom panel, 'Build Executor Status', has a minus sign icon and lists the following nodes:

- master**
 - 1 Idle
 - 2 Idle
- slave0**
 - 1 Idle
 - 2 Idle
- slave1** (offline)
- slave2** (offline)

The screenshot shows the Jenkins sidebar with several links. The 'Manage Nodes' link is highlighted with a red rectangle. The links and their descriptions are:

- System Log**: System log captures output from `java.util.logging` output related to Jenkins.
- Load Statistics**: Check your resource utilization and see if you need more computers for your builds.
- Jenkins CLI**: Access/manage Jenkins from your shell, or from your script.
- Script Console**: Executes arbitrary script for administration/trouble-shooting/diagnostics.
- Manage Nodes**: Add, remove, control and monitor the various nodes that Jenkins runs jobs on.
- Manage Credentials**: Create/delete/modify the credentials that can be used by Jenkins and by jobs running in Jenkins to connect to 3rd party services.
- About Jenkins**: See the version and license information.

Plugins

More hundreds plugins are available:

- SCM: svn, perforce, git, mercurial, clear case, etc.
- shell, batch execution
- Building: MSBuild, CMake, ant, maven, etc.
- Testing: CppTest, JUnit, Selenium, etc.
- Static analyzers: Cppcheck, CheckStyle, etc.
- Code coverage: gcov, Clover, etc.
- Others: scp, radiator, lava lamp, etc.

Conclusion

- CI – Supporting the software development in teamwork
- Avoid Integration hell
- CI Principles and tools
- Jenkins: widely-used CI server with many useful plugins
- Jenkins Web UI:
 - Jobs
 - Console log
 - Previous builds
 - Test running
 - Trends
 - etc.

Useful Links

- **Martin Fowler: Continuous Integration:**
<https://martinfowler.com/articles/continuousIntegration.html>
- **Darko Fabijan: Why We Need Continuous Integration:**
<https://semaphoreci.com/community/tutorials/continuous-integration>
- **Jenkins:** <https://jenkins-ci.org/>
- **Jenkins pipelines:**
<https://jenkins.io/2.0/#pipelines>

Thank You

Thank you for your attention!

