

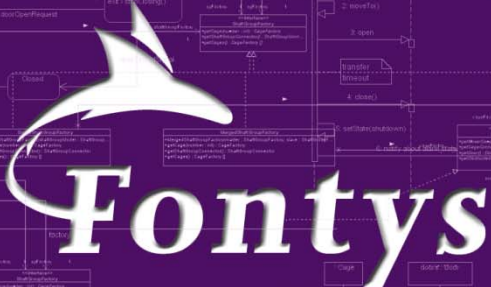
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Continuous Integration

What companies expect and solutions provide

Author

Georg Fleischer



Hogeschool Techniek Venlo

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Fontys University of Applied Sciences
Venlo / The Netherlands

Software Engineering

Client

Ferd van Odenhoven
Fontys University of Applied Sciences

Commissionee

Georg Fleischer

Contact: Fleischer.Georg@gmail.com

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Summary

Continuous Integration is a software development practice that is used by many companies in order to automate their build process. Since the first article by Martin Fowler on this topic eight years have passed. During this time, many Continuous Integration solutions have been developed and enhanced so it is time to take a look at the current situation and the available solutions.

The importance of a single feature of a Continuous Integration solution is defined by its usage level. But what features are used? How do the companies run their integration processes and what is important to them? Development is a process, not a state. That is why expectations can change towards existing solutions. Summarized this research covers the question What do companies expect from Continuous Integration solutions and how can available Continuous Integration solutions fulfill their needs?

To answer this question a structured search on the internet was conducted in order to get an overview over the available solutions. A list of all features was created for each solution and the features were compared in a feature matrix. The expectations of the companies have been inspected through an online survey that consisted of many open questions to give the participants enough room to tell their needs and expectations.

As a result the currently available Continuous Integration solutions provide a rich set of features starting with supporting a large amount of version control systems. They support building projects in many different languages, provide web-interfaces for status controlling, administration or statistics and have a rich set of notification options to provide feedback. IDE plug-ins and extensibility options provide optimal support for developers and additional features. Advanced features that the solutions provide are dependent builds, multi-platform builds and remote build agents to set up a distributed build process on a build farm.

According the results of the online survey, these available solutions fulfill the needs of the people in companies working with Continuous Integration. The expectations and wishes for future features are all implemented in the currently available solutions. All information about the available solutions and the results of the online survey are illustrated in this report in order to provide an objective overview over the current situation of Continuous Integration solutions.

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1 Introduction

1.1 Background

1.1.1 Integration

Integration is a key criterion for successful software projects. The integration process covers an imported part in software projects, because it consists of complete system builds and tests. Software projects that are developed in separate parts are often integrated in a late state of the development process. According to an example Martin Fowler gave in his article “Continuous Integration” [CI] the integration process that covers complete system builds and tests can last an indefinite time in these projects.

1.1.2 Continuous Integration

Continuous Integration is a software development practice that addresses this problem. It is described in the article “Continuous Integration” [CI] by Martin Fowler. This practice defines that the developers should integrate their work frequently, at least once a day. Continuous Integration also defines that integration should become a “nonevent” to spend more time on the development rather than repeating the same steps again and again.

This can be achieved by automating the integration process as a single build and running it whenever changes have been made to the software system. This process assumes that bugs that lead to failing builds or failing tests are identified and fixed in a very short period of time – usually directly after its occurrence. From this it follows that a stable build is nearly always available during the complete development process. Time expensive integration scenarios at the end of the software project can be avoided by this practice from the start.

Preliminaries for using Continuous Integration are a single project repository that contains the complete source code, the database scripts and all other elements that are related to the project. In Continuous Integration, checking in changes into the repository should cause the run of a complete build and the execution of tests. The practice assumes that the persons who check in the changes to the repository are in charge of the fixing build errors immediately.

1.2 Motivation

On the market there are several solutions available which provide support for Continuous Integration in various ways by providing lots of different features. It is often hard to indentify which feature is available or is not available in which solution, because many feature descriptions are hidden deep in the documentations of the solutions. That makes it very hard to compare the available solutions among each other to decide which solution to buy or to use. Another problem is that people who are new to the topic Continuous Integration do not know which features are of major and which are of minor importance.

1.3 Aim and objectives

The overall aim of this research project is to give a qualitative answer to the question:

What do companies expect from Continuous Integration solutions and how can available Continuous Integration solutions fulfill these expectations?

Therefore the overall aim is devised into two sub-aims. The first sub-aim is to give the reader an overview over the available solutions that enable the usage of Continuous Integration in a software development environment. This overview gives answers to the following sub-questions:

What Continuous Integration solutions are available?

What features are offered by these solutions?

The second sub-aim is to find out, what companies expect from Continuous Integration solutions and how they are using Continuous Integration. In details:

What do companies expect from Continuous Integration solutions?

1.4 Demarcation

Continuous Integration is a system independent software development practice. That is why it is important that Continuous Integration solutions support a variety of development platforms. Because of that, this research only covers Continuous Integration solutions that support multiple development platforms including the major platforms Java, .NET and C++. Due to the fact that this research should give practical advice for people who want to start using Continuous Integration this research leaves out solutions that are still in their beta phase.

This research is setting its focus on the existence or absence of certain features in order to compare them properly among each other. Apart from that, the Continuous Integration solutions all have an individual style and handling processes which are not covered by this research. So the factors usability, performance, scalability and applicability in certain environments are not tested or evaluated.

In order to find out what companies expect from Continuous Integration solutions it was important to get most of the information from companies that are already using Continuous Integration or are planning to start using it. That is why the focus of this research laid on the people from the software development departments that deal with Continuous Integration.

2 Method

The two sub-aims mentioned in the introduction are covered in different sections so they can be analyzed independently from each other. The first part deals with the available Continuous Integration solutions and the second part deals with the company's expectations. The method that was used to conduct this research was taken from the book "Doing Research" by Nel Verhoeven [DR].

2.1 Continuous Integration solutions

To give an answer to the first two sub-questions, finding the available Continuous Integration solutions and comparing them in their supported features, it is important to be complete in the search for Continuous Integration solutions. Therefore a structured search on the internet was conducted in order to find the available Continuous Integration solutions. For the search, the search engine Google was used.

The found solutions have many things in common. In order to have a possibility of comparing all solutions to each other, all provided features for each product were listed. These features were compared in a feature matrix that shows where the solutions have features in common and where they differ. It is also mentioned if the feature is a built-in feature of the solution or a feature that is available through installing a certain plug-in.

Apart from having features in common, the Continuous Integration solutions also each have unique features. These features are not comparable to features of other solutions. That is why the research has an individual section for each of the solutions in order to describe the solution as a whole and to name the unique features.

2.1.1 Constructs

The analysis constructs in the research were the general information about the solution, the supported platforms, the compatibility with the different version control systems, the supported notification services and to it belonging options, the integration into other tools, the directly supported build and test tools as well as the build triggers and security features. A special view allows the comparison in the main features of remote and distributed builds.

2.1.2 Sources

All information about the solutions and features was taken from the web sites of the product vendors or project pages. The information was gathered through information screens and product documentations. A full list of significant information pages is listed in the appendix in the bibliography.

2.2 Company's expectations

The second part of the research deals with company's expectations towards Continuous Integration solutions. For that we first look at the population and the sampling areas for this part of the research and move on to the survey that was conducted. The part analysis shows how the gathered data was analyzed and evaluated. The research type on this topic was of quantitative and qualitative nature.

2.2.1 Population and sample

The population for examining the company's expectations towards Continuous Integration solutions was all employees in companies who deal with the topic Continuous Integration or who plan to use it. To find these people two sampling areas were used.

The first sampling area was a mailing list that deals exclusively with the topic Continuous Integration. It can be found in the Yahoo Groups under the address <http://tech.groups.yahoo.com/group/citcon>. The mailing list consists of 605 members. Due to the topic relevance of this user group a high feedback was expected from this sampling area.

The second sampling area were the members of the XING groups "Java Entwicklung", ".NET Entwicklung", "Mobile development" and "Software testing" which can be found in the XING business network on <http://www.xing.com>. Though the groups have a total amount of 19.000 members, the XING groups are visited by the members very sparsely. That is why a very low feedback from this sampling area was expected.

2.2.2 Survey

To get an overview over the employees' expectations a questionnaire was developed. This questionnaire is shown in the appendix at page 25. To invite the people of the sampling areas, an invitation was posted to these groups. The invitation is shown in the appendix on page 27.

The questionnaire was divided into four sections where the first section consisted of questions related to the development environment of the people to make the results measurable. The second part consisted of questions on the current usage of Continuous Integration to find out what experiences the people have with the topic. The third part dealt with the personal opinions of the people towards Continuous Integration which was designed with many open questions to give the surveyed people a chance to tell their personal opinions not only by yes/no questions. The last part was designed to retrieve some information about the location of the company and what position in the company the surveyed person had.

In order to test and discuss the survey, an appointment was made with a software engineer from the company OCE in Venlo, the Netherlands. OCE is a company which is producing printers and is developing the printer software on different development platforms. The development takes place in many different countries and uses Continuous Integration for their development process. The software-engineer gave the advice to study the book "Continuous Integration – Improving Software Quality and Reducing Risk" by Paul M. Duval [CIS-Q].

The final survey was published on the internet and could be filled out by every person who visited this page. The results were collected by the commercial survey provider www.zoomerang.com.

2.2.3 Analysis

The data from the survey was analyzed quantitatively and qualitatively by using statistical and analytical evaluation methods. The base data was the exported csv file from the survey provider that contained the complete answer data of the participants.

Each question was analyzed separately in order to provide no interpretations in the first step. The answers were evaluated and visually prepared as diagrams. The open questions were analyzed qualitatively by separating each single piece of information to find commonness among them. In order to reproduce the opinions that the informants stated without any interpretation, the original sentences were quoted fully. Some sentences were shortened in order to provide a better readability without touching its essence. In order to show some direct opinions of the informants, the report shows boxes with quotations from the answerers.

The data and the statements provided in the results section of this report are completely based on the answers that the informant gave on the survey question for keeping the results objectively and evaluable. Personal opinions from the author are not included in this report.

3 Results

The results of this research are divided into two sections. The first section shows the results from the research for Continuous Integration solutions on the internet and the second part deals with the company's experiences with and expectations towards Continuous Integration that were determined with the online survey.

3.1 Continuous Integration solutions

This section deals with the Continuous Integration solutions and their features that could have been determined. It is divided into three parts where the first part gives an overview over the found solutions. The second part covers the common features that are comparable among all solutions and the last part covers the individual features and concepts of each solution.

3.1.1 Overview

The search for Continuous Integration solutions ended up with twelve different solutions that are shown in the following table. The origin describes the vendor of the solution or the project platform where the project is hosted. The table also shows which solutions are open source (●). The version number provides information about the version of the solution that was inspected for this research followed by the column that shows the year of the first release of the solution. A link to the vendor/project location allows getting further information.

Solution	Origin	Open source	Current version	First release	Link
AnthillPro	Urbancode	-	3.5	2001	http://www.anthillpro.com
Bamboo	Atlassian	-	2.1.5	2007	http://www.atlassian.com
Continuum	Apache project	●	1.2.3	2005	http://continuum.apache.org
Cruise ¹⁾	ThoughtWorks	-	1.1	2008	http://studios.thoughtworks.com/cruise
Cruise Control	Sourceforge project	●	2.8.2	2001	http://cruisecontrol.sourceforge.net
FinalBuilder	VSoft Technologies	-	6.2	2001	http://www.FinalBuilder.com
Hudson	java.net project	●	1.274	2007	http://hudson.dev.java.net
Lunt build	Javaforge project	●	1.6	2004	http://luntbuild.javaforge.com
Parabuild	Viewtier	-	3.2	2005	http://www.viewtier.com
Pulse	Zutubi	●	2.0	2006	http://www.zutubi.com/
Quick build ²⁾	PMEase	●	2.0	2004	http://www.pmease.com
TeamCity	JetBrains	●	4.0	2006	http://www.jetbrains.com/teamcity

table 1: Analyzed Continuous Integration solutions

- 1) Cruise is the successor of "Cruise Control"
- 2) Quick build is the commercial version of Lunt build.

The following table gives an overview over the platforms that are supported for the installation of the Continuous Integration solutions. It shows that all solutions run on multiple platforms except for FinalBuilder. FinalBuilder only supports installation on Windows systems. What is common to all solutions is that they support all programming languages that can be built through a command line tool. These are namely Java, .NET, C++, Ruby and many others. A web-frontend is also provided by every solution in order to view the status of the builds. Most of the solutions offer a web-based configuration of the system.

Solution	Installation platform	Build languages	Web-frontend	Configuration
AnthillPro	Java 1.5	All	Yes	Web-frontend
Bamboo	Java 1.5	All	Yes	Web-frontend
Continuum	Java 1.5	All	Yes	XML file
Cruise	Java 1.6	All	Yes	Web-frontend
Cruise Control	Java 1.4	All	Yes	XML file
FinalBuilder	Windows	All	Yes	Web-frontend
Hudson	Java 1.4	All	Yes	Web-frontend
Lunt build	Java 1.4	All	Yes	Web-frontend
Parabuild	Windows, Linux, MacOS X, Solaris, HP-UX-11, Generic Unix	All	Yes	Web-frontend
Pulse	Java 1.5	All	Yes	Web-frontend
Quick build	Java 1.4	All	Yes	Web-frontend
TeamCity	Windows, Linux, MacOS X	All	Yes	Web-frontend

table 2: Installation platforms, build languages, web-frontend, configuration

3.1.2 Common features

The following sections give an overview over the features that the Continuous Integration solutions provide. The tables contain the features as rows and the Continuous Integration solutions as columns. The crossing point in this table can have three different entries. A hyphen (-) shows that a feature is not supported, a green spot (●) tells that the feature is supported and a green spot with a “p” (●_p) indicates that a feature is supported through a separate plug-in.

3.1.2.1 Extended build platform support

As already mentioned in the overview all solutions are able to build software projects that can be built via a command line tool. Apart from that the solutions offer extended support for the listed tools in order to help the user configuring the build process.

Build implementations	AnthillPro	Bamboo	Continuum	Cruise	Cruise Control	FinalBuilder	Hudson	Lunt build	Parabuild	Pulse	Quick build	TeamCity
Ant	●	●	●	●	●	●	●	●	-	●	●	●
Command line tool	●	●	●	●	●	●	●	●	●	●	●	●
Maven	●	●	●	-	●	-	●	●	-	●	●	●
MSBuild	-	●	-	-	-	●	● _p	-	-	●	-	●
NAnt	-	●	-	●	●	●	● _p	-	-	-	●	●
Rake	-	-	-	●	●	-	●	●	-	-	●	●

table 3: Extended build platform support

3.1.2.2 Version control system

The version control system is the base preliminary for every Continuous Integration solution. It contains all software project relevant files. There are a lot of version control systems available that have each an individual API. For that a Continuous Integration solution needs special support for each specific version control system. The following table shows which Continuous Integration solution works together with which version control system.

Version control system	AnthillPro	Bamboo	Continuum	Cruise	Cruise Control	FinalBuilder	Hudson	Lunt build	Parabuild	Pulse	Quick build	TeamCity
Accurev	●	-	-	-	●	●	●	●	-	-	●	● ^p
AlienBrain	-	-	-	-	●	●	-	-	-	-	-	-
Bazaar	-	-	●	-	-	-	-	-	-	-	-	-
BitKeeper	-	-	-	-	-	-	● ^p	-	-	-	-	-
ClearCase	●	●	●	-	●	●	● ^p	●	●	-	●	●
CVS	●	●	●	-	●	●	●	●	●	●	●	●
Dimension	●	●	-	-	-	-	-	-	-	-	-	-
Git	-	-	-	●	●	-	● ^p	-	-	●	-	-
Harvest	●	-	-	-	●	-	-	-	-	-	-	-
Jedi	-	-	-	-	-	●	-	-	-	-	-	-
Mercurial	●	●	●	●	●	-	● ^p	-	-	-	-	● ^p
MKS Source Integrity	●	-	-	-	●	●	-	-	●	-	-	-
Perforce	●	●	●	●	●	●	● ^p	●	●	●	●	●
PureCM	-	-	-	-	-	●	-	-	-	-	-	-
PVCS	●	-	-	-	●	●	● ^p	-	●	-	-	-
QCVS	-	-	-	-	-	●	-	-	-	-	-	-
SourceGear Vault	●	-	-	-	-	-	-	-	●	-	-	-
StarTeam	●	-	●	-	●	●	● ^p	●	●	-	●	-
Subversion	●	●	●	●	●	●	●	●	●	●	●	●
Surround	-	-	-	-	●	●	-	-	●	-	-	-
Synergy	●	-	●	-	●	-	● ^p	-	-	-	-	-
Team Coherence	-	-	-	-	-	●	-	-	-	-	-	-
Team Foundation Server	●	-	-	-	●	●	● ^p	-	-	-	-	●
Visual Source Safe	●	-	●	-	●	●	● ^p	●	●	-	●	●

table 4: Version control systems

3.1.2.3 Build triggers

A build is the main purpose of a Continuous Integration solution. The regular workflow described by the article by Martin Fowler is that a build should be executed by checking in changes into the version control system. This feature is supported by all solutions. A build can also be executed by hand, by a certain schedule or by calling the appropriate function in the API, if the solution provides a separate one. The last possibility of invoking a build is after another build has finished. With that builds can easily be connected to each other. The following table shows the supported build triggers of the Continuous Integration solutions.

Build triggers	AnthillPro	Bamboo	Continuum	Cruise	Cruise Control	FinalBuilder	Hudson	Lunt build	Parabuild	Pulse	Quick build	TeamCity
API call	●	●	●	●	-	-	-	●	-	●	●	-
Manual	●	●	●	●	-	●	●	●	●	●	●	●
Repository check-in	●	●	●	●	●	●	●	●	●	●	●	●
Scheduled	●	●	●	-	●	●	●	●	●	●	●	●
Successful finished build	●	●	●	●	●	●	●	●	●	●	●	●

table 5: Build triggers

3.1.2.4 Test tools results

The following section shows how the solutions provide additional support for evaluating test results that were executed by the build. The tests itself can be run by all solutions but the following table shows which solutions provide support for evaluating and rendering the test results in their web-frontend.

Test tools result evaluation and rendering	AnthillPro	Bamboo	Continuum	Cruise	Cruise Control	FinalBuilder	Hudson	Lunt build	Parabuild	Pulse	Quick build	TeamCity
Agitar	●	-	-	-	●	-	-	-	-	-	-	-
AQTest	-	-	-	●	-	●	-	-	-	-	-	-
CppUnit	●	●	-	●	-	-	-	-	●	●	-	● ^P
Gallio	-	-	-	-	-	-	-	-	-	-	-	● ^P
JUnit	●	●	-	●	●	-	●	-	●	●	-	●
MbUnit	-	-	-	●	-	●	-	-	-	-	-	-
MSTest	-	●	-	●	-	●	-	-	-	-	-	●
Nose	-	●	-	●	-	-	-	-	-	-	-	● ^P
NUnit	●	●	-	●	●	●	-	-	●	-	-	●
ocunit	-	-	-	-	-	-	-	-	-	●	-	-
PHPUnit	-	-	-	●	-	-	-	-	●	-	-	-
Python Unit	-	-	-	-	-	-	-	-	-	-	-	● ^P
Quality Center & QuickTest Pro	●	-	-	●	-	-	-	-	-	-	-	-
SilkCentral	●	-	-	●	-	-	-	-	-	-	-	-
TestNG	-	-	-	-	-	-	●	-	-	-	-	-
Typemock	-	-	-	●	-	●	-	-	-	-	-	-

table 6: Test tools

3.1.2.5 Notification

Feedback is an important feature for Continuous Integration solutions. After a build has finished the invoker of the build should be informed about the outcome of the build – whether the build has succeeded or failed. This can be done in various ways, either via email, real simple syndication (RSS), instant messaging (IM) and many other services. The following table shows which solutions provide support for which notification services.

Notification services	AnthillPro	Bamboo	Continuum	Cruise	Cruise Control	FinalBuilder	Hudson	Lunt build	Parabuild	Pulse	Quick build	TeamCity
Blog	-	-	-	-	-	-	-	●	-	-	●	-
Email	●	●	●	-	●	●	●	●	●	●	●	●
Google Calendar	-	-	-	-	-	-	p	-	-	-	-	-
Google Talk	●	●	●	-	-	-	-	-	-	-	-	-
ICQ	-	-	-	-	-	●	-	-	-	-	-	-
IRC	-	-	●	-	-	-	p	-	-	-	-	-
Jabber	●	●	●	-	●	-	p	●	●	●	●	●
MSN	●	-	●	-	-	●	-	●	-	-	●	-
Nabaztag	-	-	-	-	-	-	p	-	-	-	-	p
Newsgroup	-	-	-	-	-	●	-	-	-	-	-	-
RSS	-	●	-	-	●	●	●	-	●	●	●	●
Sametime	-	-	-	-	●	-	-	●	-	-	●	-
System tray notifyer	-	-	-	-	●	●	p	-	●	●	p	●
Twitter	-	-	-	-	-	-	p	-	-	-	-	-
Wagon	-	-	●	-	-	-	-	-	-	-	-	-
Yahoo	●	-	-	-	●	-	-	-	-	-	-	-

table 7: Notification services

The invoker of the build is not the only person that is interested in the result. E.g. if a build fails it could be interesting to the whole team. Therefore solutions allow the administrator of the system to specify the users or groups that should additionally be informed. The following table shows the options how the solutions can be configured.

Notification options	AnthillPro	Bamboo	Continuum	Cruise	Cruise Control	FinalBuilder	Hudson	Lunt build	Parabuild	Pulse	Quick build	TeamCity
Only inform on new build errors	-	-	-	-	-	-	●	-	-	-	-	-
Specify recipient groups / roles	●	●	-	-	●	●	-	-	-	●	●	●
Specify recipients users	●	●	-	-	●	●	●	●	●	●	●	●
Specify type of notifications	●	●	-	-	●	●	-	-	●	●	-	-

table 8: Notification options

3.1.2.6 Application integration

To support optimal integration in other applications, some solutions offer plug-ins to control the builds or to show their state directly from these specific applications. To support developers, some Continuous Integration solutions have plug-ins for integrated development environments (IDE). The availability of the plug-ins is shown in the following table.

Application integration	AnthillPro	Bamboo	Continuum	Cruise	Cruise Control	FinalBuilder	Hudson	Lunt build	Parabuild	Pulse	Quick build	TeamCity
Eclipse		-	-	-		-			-	-		
Firefox build monitor	-	-	-	-	-	-		-	-	-	-	-
IntelliJ	-		-	-		-		-	-	-		
NetBeans	-	-	-	-	-	-		-	-	-	-	-
Visual Studio		-	-	-	-	-	-	-	-	-		

table 9: Application integration

3.1.2.7 Security

Security features allow controlling who is allowed to change the build configuration in the Continuous Integration solution. Almost all solutions have a user authentication mechanism with additional group/role support. LDAP allows attaching an external user management system. The following table gives an overview over the standard security features.

Security	AnthillPro	Bamboo	Continuum	Cruise	Cruise Control	FinalBuilder	Hudson	Lunt build	Parabuild	Pulse	Quick build	TeamCity
Users					-			-				
Groups/roles			-		-			-				
LDAP support		-						-				
User defined security settings			-		-			-				-

table 10: Security

3.1.2.8 Multiplatform builds & other build types

Continuous Integration solutions can support multiplatform builds and a variety of other build types. The supported build types are shown in the table below.

To support builds on multiple platforms, a Continuous Integration solution must be able to distribute the build to a remote build agent and take care of the result in order to run the after-build processes. All solutions except for Cruise Control and FinalBuilder support this form of build distribution.

Apart from that the solutions support other types of builds. With dependent builds, builds can be run serialized. That makes it possible to first run a build with normal unit testing and then afterwards run a build with full integration and regression tests. All solutions support these kinds of builds in their own way. History builds allow running a build based on a specific changeset or label from the version control system. With

resource locking certain resources can be locked during the build process exclusively in order to guarantee that only one build can access this resource at a time. Another possibility is controlling VMware machines for running the build remotely. Some solutions provide support for directly controlling these machines.

Almost all solutions are extensible. This is either through an API that allows controlling the Continuous Integration sever remotely, or via plug-ins that allow the configuration of additional tasks before, during and after the build process. The extensibility of FinalBuilder is based on “actions” that can be developed separately and then be integrated into the application.

A quite new feature is the support of personal server builds. The normal Continuous Integration workflow is that the build is executed after the changes were committed to the version control system. Pulse and TeamCity support a new way of invoking builds. They use separate client tools to send the local changes to the Continuous Integration server. The server invokes a build and runs the tests with the files from the version control system and the changes from the client. That gives the user a feedback if the build was successful or if it failed. If the build was successful the client can commit the changes to the version control system.

Tabelle 1: Extended build options

Solution	Dependent builds	Remote build agents	History builds	Resource locking	VMware support	Extensibility	Personal server builds
AnthillPro	●	●	●	●	● via VMware Lab Manager	API	-
Bamboo	●	●	-	-	-	API Plug-ins	-
Continuum	●	●	●	-	-	API	-
Cruise	●	●	-	-	-	API	-
Cruise Control	●	-	-	● “lockfilelistener”	-	Plug-ins	-
FinalBuilder	●	-	-	-	●	Actions	-
Hudson	●	●	-	● “Locks and Latches”	● “VMware”	API Plug-ins	-
Lunt build	●	●	●	-	-	API	-
Parabuild	●	●	●	-	-	-	-
Pulse	●	●	●	-	-	API Plug-ins	via separate client program
Quick build	●	●	●	-	-	API	-
TeamCity	●	●	●	-	-	API Plug-ins	via IDE plug-ins; Changes can't be committed if tests are failing

3.1.3 Individual features and concepts

The previous section gave an overview over the features that are available among many solutions, while this section covers the features and concepts that are mostly unique to certain solutions.

AnthillPro offers a technique which is called build-life which makes it possible to trace a build through a given workflow. It has a very fine graded security system that allows controlling very detailed which user or role should be able to execute which action of the build process. It also supports different environment groups which allow to group different machines together in order to assign builds to them.

Via the web-interface **Bamboo** provides functionality for commenting builds. A statistic tool allows evaluating the past builds and test results from the user level to inter-project statistics. It is the only tool that provides a two-way communication via an instant messaging client. It is possible to label certain builds and perform other actions on the server via predefined commands.

Continuum allows accessing a statistic module via the web-interface.

Cruise has a complete X509-certificate based communication architecture which provides secure communication when controlling the application. It uses a concept called build pipelines with additional manual approval that allows focusing on the release-management. Cruise enables the user to configure showing every output of certain builds by displaying them in the build web page.

FinalBuilder is the solution that has a completely different usage concept. It has a desktop client that acts like a visual scripting tool. It helps to administer the different builds and then submits the builds to the server. The builds are assembled from over 600 different actions that the user can choose. These actions cover e.g. archiver-, build tools-, compiler-, system-, file-system- and cd-burning-commands.

Hudson has a very large amount of available plug-ins – currently 101. These plug-ins cover among others build wrappers, build notifiers, build reports and artifact uploaders. Hudson makes MD5 fingerprints of the artifacts in order to make it possible to find out which artifact belongs to which build. It also archives build artifacts and provides static URLs to the latest download artifacts.

Parabuild has a special feature called “practically unbreakable scheduled build”. The solution ensures that a nightly build can be run that is based on the last working build with the most recent working changes to provide a stable build every night.

Teamcity is the only solution that provides an intelligent test execution system. It runs the recently failed and new tests first in order to give rapid feedback if the tests are still failing. It already starts the notification process when the first test fails in order to give rapid feedback to the developer. With that a developer can react immediately. Teamcity is also the only tool that provides a mechanism for detecting build-hangs and for showing thread-dumps of Java and .NET to examine hangs and deadlocks.

3.2 Company's expectations

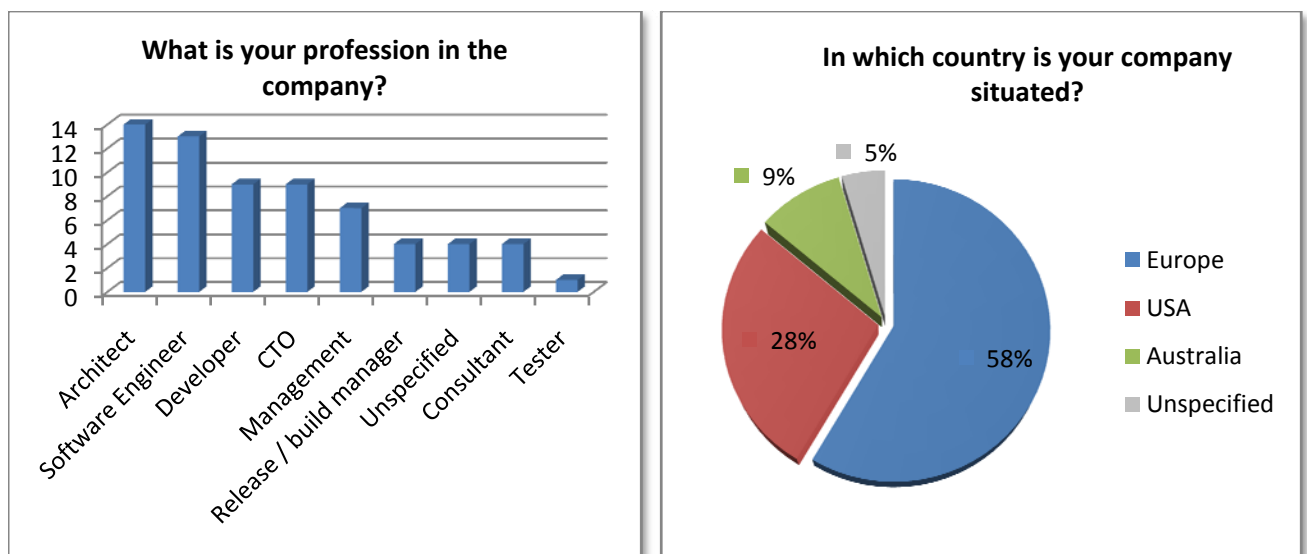
In the second part of the results the company's expectations are exposed. The first section deals with the research group themselves to get an idea of who the people behind the answers are. The next section deals with the facts how the informants are currently using Continuous Integration. The last part of the results deals with the wishes and opinions of the informants.

3.2.1.1 Research group

The research group consists of 65 people who filled out the questionnaire that was published. The questionnaire can be revisited in the appendix on page **INSERT PAGE**. To introduce this group some questions were asked about the people and the company as well as their development environment.

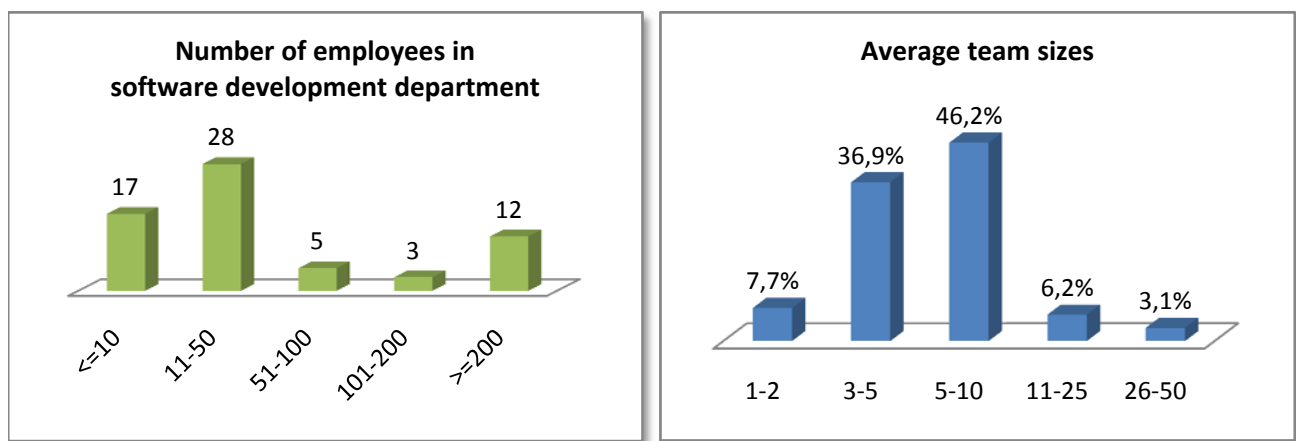
3.2.1.1.1 Companies continents and professions

The companies of the informants are located all over the world. The largest group comes from Europe with 58 %, followed by the USA with 28% and 9% from Australia. 5% didn't specify their company's origin. The overview is shown in the diagram below. The professions of the participants vary from architects and software engineers over operational and technical managers to release specialists and consultants. The following diagram shows the number of answerers.



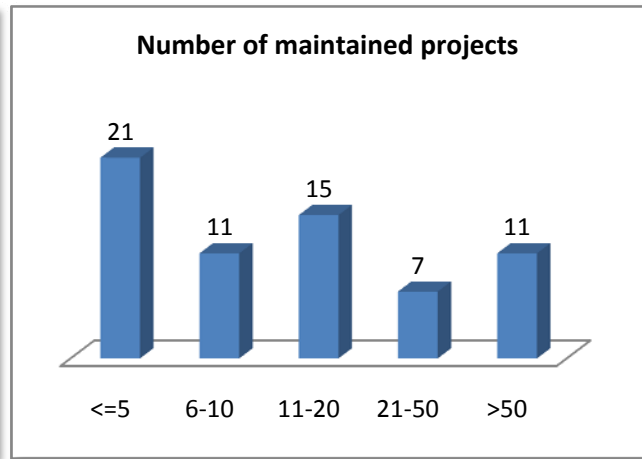
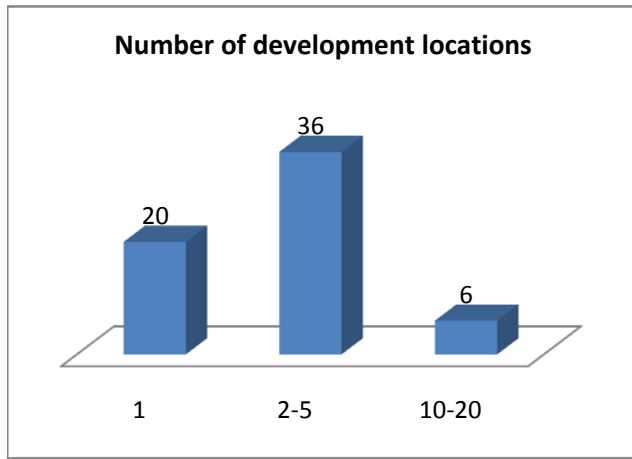
3.2.1.1.2 Software development departments

The participants were asked how many people are working in their company's software development department and how large their team sizes are. Among the participants were people from all department sizes. The results are shown in the diagram below. The highest amount of participants worked in companies with a software development department from 11 to 50 employees. The average team sizes mentioned were from 3 to 5 and 5 to 10 members. Together these two values make an amount of 83%.



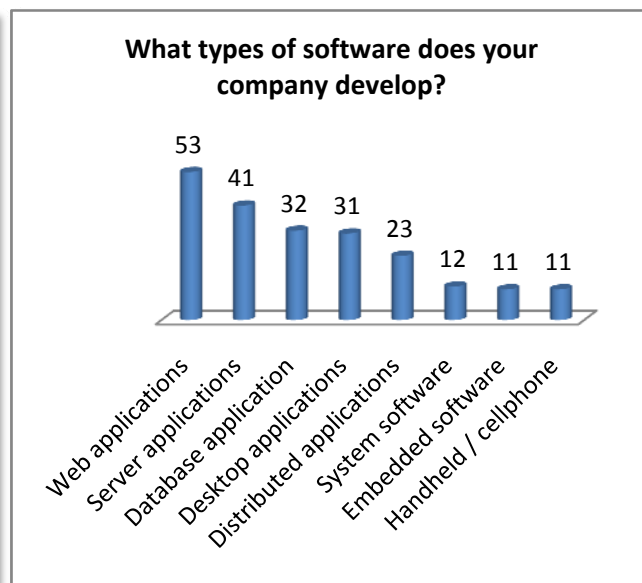
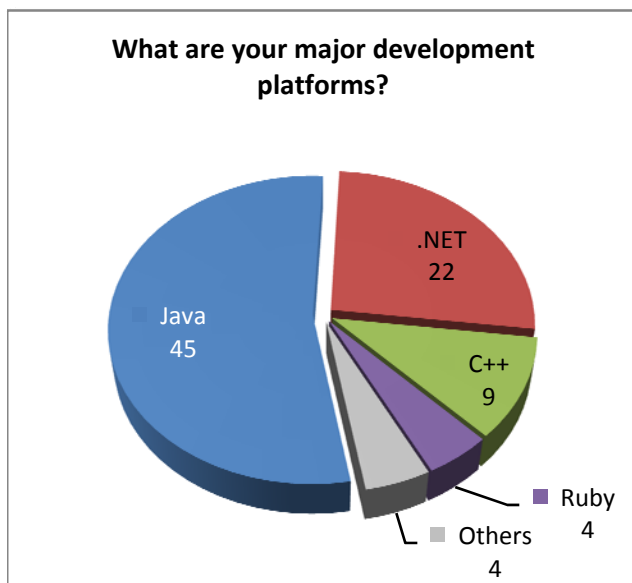
3.2.1.1.3 Development locations and projects

The participants were asked how many development locations they use for their software development processes. 20 answered that they would develop their software on a single location, 36 were in the range of 2 to 5 locations and 6 informants wrote that their company had between 10 and 20 development locations. The number of maintained projects varied from under 5 to more than 50 showing also a broad spectrum in the apportionment. Both parameters are shown in details in the diagrams below.



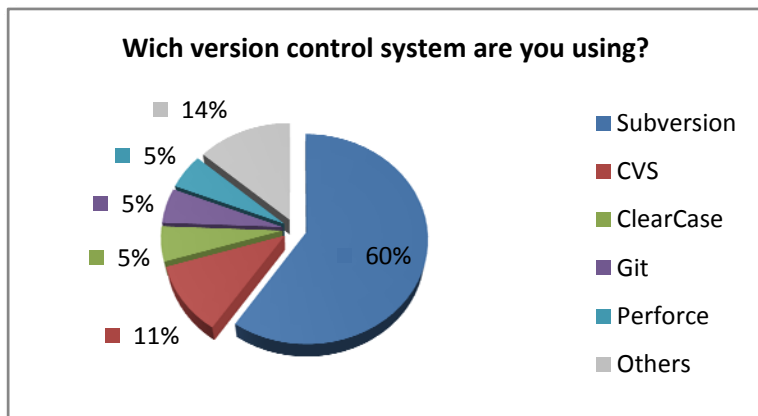
3.2.1.1.4 Development platform and project types

The research group was also asked for their major development platforms and which type of software their companies develop. The majority of answerers (45) stated that their major development platform would be Java, followed by .NET with 22 answers. The most people (53) named the software type web- and server applications as their main domains. The full results are shown in the diagrams below.



3.2.1.1.5 Version control system

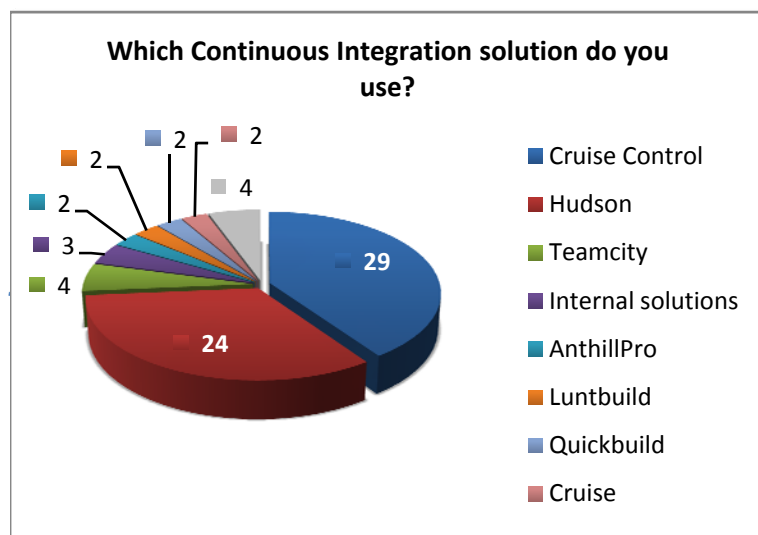
The question which version control system the companies would use was answered with 60% for the open source product subversion. CVS was named with 11% and the version control systems ClearCase, Git and Perforce were mentioned each with 5%. The diagram below gives a graphical overview over the results.



3.2.1.2 Continuous Integration - Current usage

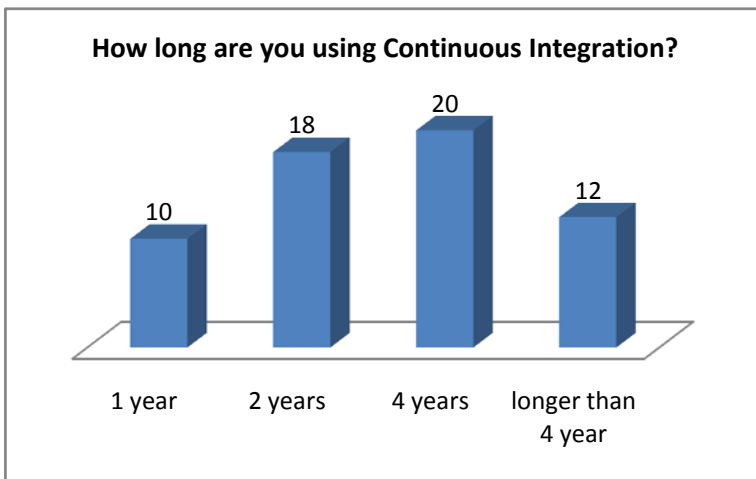
This section covers the current usage of Continuous Integration. We asked the survey participants for the solution they are currently using and how long they are already using Continuous Integration. Further questions set their focus on general and feature specific terms.

The first question was about if the participants were using Continuous Integration where 90.8% stated yes and 7.7% stated no. On the question which Continuous Integration solution they would use the informants mentioned Cruise Control 29 times and Hudson 24 times. This question was designed as a multiple choice question. The results are shown in the diagram and the table below.

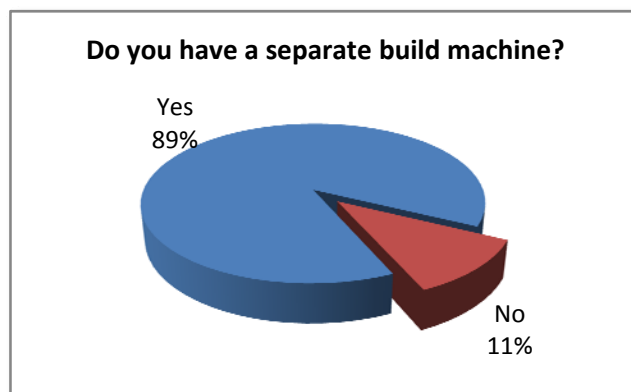
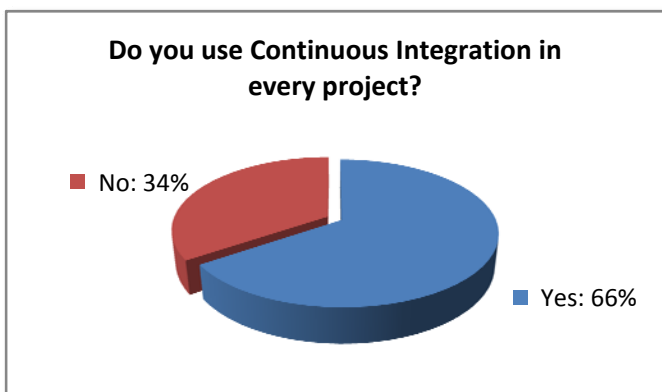


CI Solution	Quantity
Cruise Control	29
Hudson	24
Teamcity	4
Internal solutions	3
AnthillPro	2
Luntbuild	2
Quickbuild	2
Cruise	2
Integrated in Dynamics AX	1
Cerberus	1
Buildbot	1
Vulcan	1

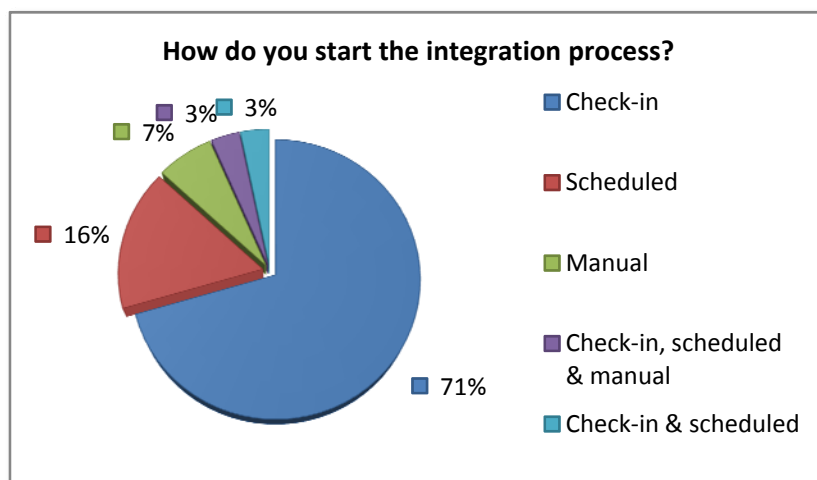
On the question how long they participants were already using Continuous Integration, 10 people stated that this is their first year of usage. 18 people are using Continuous Integration for two years and 20 people already use this software development practice for four years now. 12 people are among the participants that are using CI for longer than four years. The apportionment is shown in the diagram to the right.

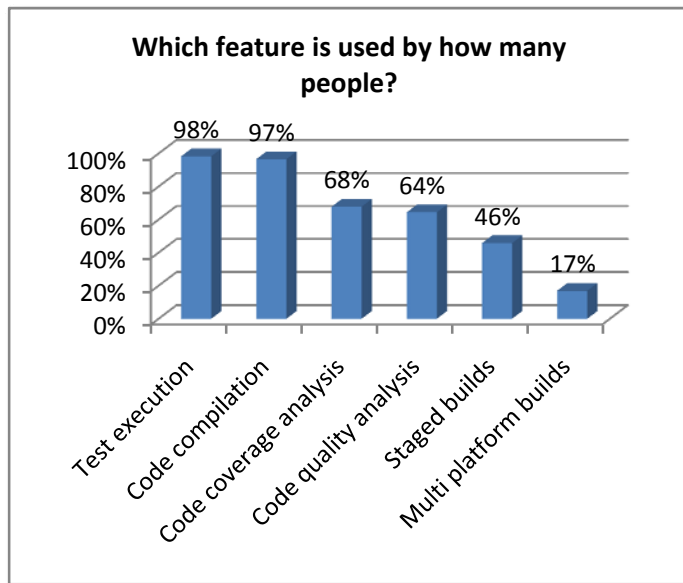


On the question if they would use Continuous Integration in every project, 66% of the people using CI answered with yes. The additional comments from the 40% that answered with “no” were that they would not use CI in projects without unit tests, that they did not have the chance to implement it across all projects or that they would not use CI for one time projects with a short lifetime. 89% of the surveyed persons stated that they would have a separate build machine. Some even noted that they would have multiple build machines organized in build farms. The results of these two questions are shown in the diagrams below.



The people were also asked how they are invoking their integration process where 77% chose the “Check-in” option. 22% are starting their integration process scheduled and 10% invoke their build manually. This question was set-up as a multiple choice question. The detailed results are shown in the diagram below.





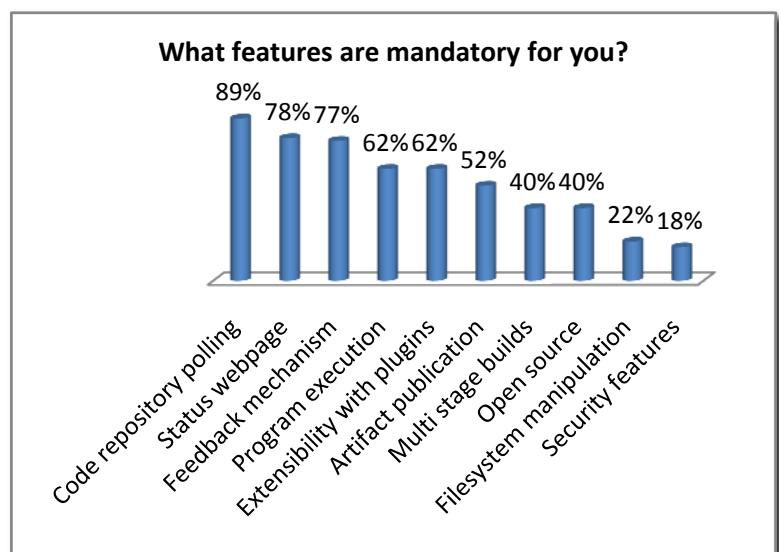
The last question in the Continuous Integration usage section was which feature the participants would use. Almost all people noted test execution and code compilation while two third named the features “code coverage analysis” and “code quality analysis”. Staged builds were mentioned by 46% and multi platform builds are used by 17%. The features that were also mentioned by single persons were “build promotion / pipelines”, “auto deployment of integration instances” and deployment to production”. The results are based on the people that are using Continuous Integration.

3.2.1.4 Continuous Integration – Participants opinions

The last part of the results deals with the opinions of the participants towards Continuous Integration. The surveyed persons were asked for about the features they consider as important and their wish features for the future. The last questions are about if CI has improved their development process and if they will use it in future projects right from the start.

3.2.1.4.1 Mandatory features

The surveyed persons were asked which features are mandatory to them. The base for this question is all surveyed people, not only the ones that are already using Continuous Integration. 89% named code repository polling as their main mandatory feature. Right after that comes with 78% and 77% the status page and the feedback mechanism. At the end of list stand the file system manipulation and the security features with about 20% each. The full list is shown in the diagram to the right.



3.2.1.4.2 Wish features for the future?

The participants were asked what would be their wish features in Continuous Integration solutions for the future. The question was analyzed in relation to the currently used Continuous Integration solution.

The wishes of the participants that are only using **Cruise Control** are very similar among each other. They wish a more comfortable configuration, a simpler setup and simpler maintenance. Two other wish features are the support for distributed and multi platform builds as well as a better scalability. Last but not least some wishes covered the improvement of visual presentation of the project health status and improvements on project dependencies.

The people that are using **Hudson** have the need for better project dependency management, better integration of virtual machines and a mechanism for feature tracking. It also should be easier to write plug-ins. The wish for a better documentation was also mentioned.

People that use **Hudson** and **CruiseControl** have a need for a release management, easier distributed builds and integration with system management tools like puppet.

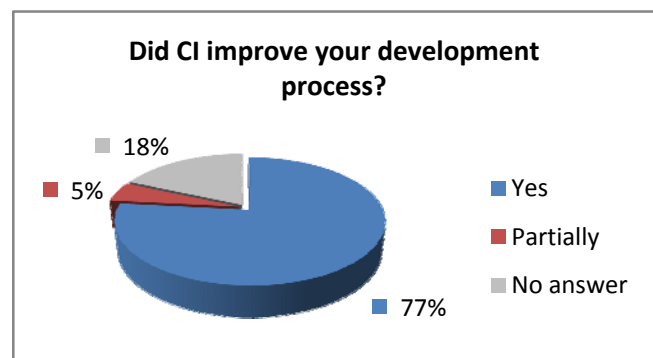
The participants using **internally developed solutions** came up with feature wishes like code quality checking possibilities, a status website and possibilities for selective testing.

The wishes that were mentioned by the participants that are currently using **Luntbuild** were a support for multi-stage builds, better release and deployment planning possibilities, a better web-interface and better configuration possibilities. Also mentioned was the wish for a better integration with maven and an option to commit code only when the tests passed.

The person that is using **Quickbuild** uttered the wish for pretty reports for the management.

3.2.1.4.3 Did CI improve your development process?

In an open question the research group was asked if Continuous Integration had improved their development process. The general answers on this topic were that 77% gave a positive answer, 5% stated that it partially improved their process and 18% gave no answer to that question. Negative answers have not been given. The overall result is shown in the diagram on the right.



But due to the fact that this question was set up as an open question many of the participants wrote down their detailed opinions on this question. The aspects in the answers of the people answering with "partially" were that it took a long time to overcome the starting problems and that it would only make sense on long term projects, because the administrative overhead would outbalance the positive impact.

The aspects that were stated by the participants who answered with "yes" were that the time in finding bugs was significantly reduced (mentioned by 13 people) and that CI has improved their development speed in general (7 people). 6 people mentioned that the overall quality of the software projects has increased.

Other statements were that the fast positive feedback has increased the awareness of the whole team towards the quality of the software. One statement was that with Continuous Integration no more surprises came up at release time and the confidence in the latest code was increased too.

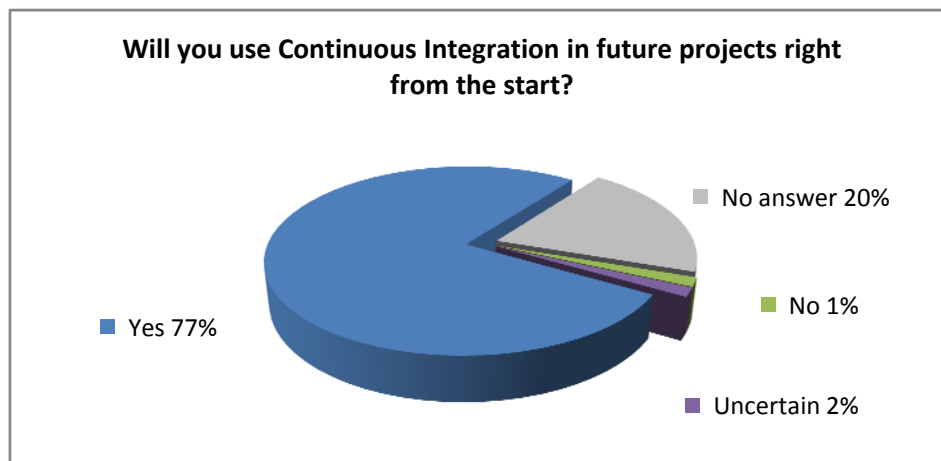
We plan on moving towards CI in all projects this year

Build master – USA

Developing up to 10 Java projects with up to 50 employees in two development locations

3.2.1.4.4 Looking into the future

In the last question of the questionnaire the participants were asked if they would use Continuous Integration in future software projects right from the start. 77% answered with yes while 20% did not give any answer. 3% of the informants were uncertain or negated the question. The results are shown in the following diagram.



The question was set up as an open question which gave the informants the possibility of publishing their opinions. The uncertain and negative answering informants wrote that it would depend on the ease of setting up new projects and if the project would be maintained over a while. They noted that it would be too time consuming at the start.

The main positive aspects that were mentioned by the informants were that it would be much easier to implement a CI solution from the start than adding it later on. They wrote that Continuous Integration has improved the overall quality of their software projects and lead to more confidence and reduced technical debts. Other positive aspects were that there are no drawbacks, just benefits and that short feedback loops are a must have.

Any dev team that doesn't use CI is technically deficient

Infrastructure specialist – United Kingdom

maintaining more than 50 software projects with more than 200 employees in 5 development locations

Some positive answering participants noted that the only issues they had would be finding the right moment to move the project to the CI server, because in the first weeks and months the folder structures would change so rapidly that the external build could not keep up with the changes causing many CI build failures.

4 Conclusion and discussion

In this section we want to take a look at the results and will give answers to the questions that this research projects was based on. We will first discuss the sub-questions and then combine these answers to finally answer our central question what companies expect and solutions provide. At the end a short recommendation is noted.

4.1 Questions

4.1.1 What Continuous Integration solutions are available?

During this research, twelve solutions were determined. The determined solutions are AnthillPro (Urbancode), Bamboo (Atlassian), Continuum (Apache project), Cruise (ThoughtWorks), Cruise Control (Sourceforge project), FinalBuilder (VSoft Technologies), Hudson (java.net project), Lunt build (Javaforge project), Parabuild (Viewtier), Pulse (Zutubi), QuickBuild (PMEase) and TeamCity (JetBrains).

The complete list of the found solutions is shown in table 1 on page 6. 7 of these solutions have an open source license and 5 solutions have a commercial license. The solution FinalBuilder has the specialty that it only runs on Microsoft Windows platforms while all other solutions run on multiple platforms.

4.1.2 What features are offered by these solutions?

All of the solutions provide support for building programs for every language that has at least a command-line build tool. Each of the solutions has a web-frontend to view the status of the builds. The solutions have all support for the version control systems Subversion and Perforce. All in all 24 different version control system are supported by the solutions, but not every solution supports every version control system. Revisit table 4 on page 8 for details.

Results from the test-tools can be evaluated by the solutions and/or be reviewed in the web-interface – which test-tool is supported by which solution is shown in table 6 on page 9. The feedback mechanism provided by the solutions offer a large variety of communication options to inform the committers or other team members about a failed or succeeded build. Almost all solutions except for Cruise offer a notification option. The supported notification types are Email, RSS, Instant Messaging, Jabber, Sametime and many others. The complete notification support list can be revisited in table 7 on page 10.

In order to provide a better support for the developers some of the solutions provide plug-ins for direct integration in the integrated developer environments (IDE) Eclipse, IntelliJ, NetBeans and Visual Studio. These plug-ins provide functionality for status-control or separate check-in methods (table 9 on page 11).

Almost all solutions have a basic user authentication system in order to control the permissions on the status/administration web page. All solutions except for Bamboo and Luntbuild provide LDAP support to attach external user directories to the Continuous Integration solution.

All of the solutions offer a technique to established dependent builds, meaning that it is possible to execute a second build after a first build has finished. All solutions except for CruiseControl and FinalBuilder have built-in support for multi-platform builds by providing remote-agents to execute the build jobs on other systems. In order to start, stop and configure virtual machines the solutions AnthillPro, FinalBuilder and Hudson provide support for VMware either via Action (FinalBuilder), plug-in (Hudson) or VMware Lab Manager (AnthillPro).

All solutions except for Parabuild provide an API or a support for plug-ins in order to control the solutions from other tools or to extend them with additional features. Every solution that supports plug-ins has a variety of plug-ins available – from code coverage support to FTP support. Full plug-in lists can be revisited on the web-pages shown in table 1 on page 6.

Pulse and TeamCity have a very interesting additional feature called “personal server builds”. With this feature it is possible to break the normal Continuous Integration workflow of first checking in the changes to the version control system and then executing the build. Personal server builds make it possible to submit a build-request together with the local changes to the Continuous Integration server and see if the build succeeds. TeamCity also provides an option to allow check-in to the version control system only if none of the tests is failing.

Each solution has its own unique feature. These features are all listed in the results and can be revisited in the section “Individual features and concepts” on page 13.

4.1.3 What do companies expect from Continuous Integration solutions?

If we look at the results, we can see that two fields have been covered, the current usage of Continuous Integration solutions and the personal opinions of the surveyed people.

The current usage tells us a lot about the basic needs towards Continuous Integration of the participants. The usage analysis for the used solution resulted with the fact that over 75% of the surveyed people are using open source solutions. By the direct question if open source is important to participants 40% answered with yes. This shows that 35% are using open source solutions, but are not bound to them.

The usage analysis stated further that 89% have a separate build machine. 77% of the surveyed people use repository changes as build trigger while 16% use scheduled-only build triggering. What companies expect from CI solutions can be read from the usage percentages of the different features. Almost all participants stated that test execution and code compilation are the main functions they use. Two third of the people are using code coverage and code quality analysis while only 46% are using staged builds and only 17% use multi platform builds. This shows that currently companies expect implicitly that these features are well supported.

When asked for their opinions the main mandatory features named were code repository polling, the status web-page and the feedback mechanism. Thus these features are important to the participants it is important for every solution to provide good concepts in these disciplines. Program execution and extensibility with plug-ins are important for 62% which shows that these features are also heavily used. Especially extensibility provides lots of other opportunities for future features.

Multi platform builds are used by 17% of the participants but were stated as “mandatory” by 40% of the people. That shows that 23% plan to use it in the future. Security features are of minor importance to the people. Only 18% stated that these features are mandatory to them.

The participants were asked for their wish features for the future. They stated that they have the need to a system that is simple to maintain and to administer. A good documentation and an intuitive support for dependent projects were claimed. Other wishes that were mentioned are the need for a good scalability and integration for controlling virtual machines.

Quality is another important point for the participants. They use their build machine running Continuous Integration as the reference system for the quality of their software projects. By creating an objective view on tests and other estimation factors the CI system gives a high awareness of the quality to team.

The people noted further that Continuous Integration should not stop in the development department and should also cover the release management. This is obviously the next step in the development of Continuous Integration solutions the people are waiting for.

4.2 Comparing solutions with expectations

Now that we have inspected the solutions with their features and the expectations of the companies towards Continuous Integration solutions we are able to answer the central question of this research:

What do companies expect from Continuous Integration solutions and how can available Continuous Integration solutions fulfill these expectations?

By comparing the expectation with the provided features we can discover that the solutions provide all the features that are used or wished by the participants. New solutions were created in the last years and existing solutions were extended with new features. But due to the fact that the people still claim these features it becomes clear that information about the new Continuous Integration features has not been spread among all the users of Continuous Integration.

With the web-based configuration possibilities the solutions have made a big step towards ease of configuration and maintenance which was claimed by the participants. The scalability of the solutions is also ensured due to the fact that almost all solutions have remote build agent that run on multiple platforms.

4.3 Recommendations

Each Continuous Integration solution has its own rich set of features, starting with the supported version control systems. People who are bound to a certain version control system or any other feature should decide for themselves which solutions they should choose.

We have seen interesting individual concepts like person server builds or an enhanced release management system using promotion pipelines. But also the fact that a solution is highly extensible should not be underestimated.

The results of this research show that there is not “the solution” that should be used by everybody. All solutions provide a rich set of features which can be compared with the data in this research. The people should decide for themselves which solution is the most suitable for their needs.

5 Appendices

5.1 Bibliography

5.1.1 Product information Continuous Integration solutions

The query for all pages listed in this section was done on 28th January 2009 at 3.00 pm.

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- No author, configuration reference, published on the internet, URL: <http://cruisecontrol.sourceforge.net/main/configxml.html>,
- No author, Luntbuild Feature List, published on the internet, URL: http://luntbuild.javaforge.com/feature_list.html,
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5.2 Questionnaire

The following graphics show the published questionnaire.

Fontys
University of Applied Sciences *Survey on Continuous Integration*

Your development environment (page 1/3)

To analyse the different needs in different companies we would like to ask you first for some questions about your development environment.

1 What are your major **development platforms**?

- Java
- .Net
- C++
- IBM ISeries
- Other, please specify

2 What **source code repository / software development suite** are you using?

3 How many **employees** are working at your **software development department**?

▼

- up to 10 employees
- up to 50 employees
- up to 100 employees
- up to 200 employees
- more than 200 employees

4 What is your average **team size**?

▼

- up to 2 members
- up to 5 members
- up to 10 members
- up to 25 members
- up to 50 members
- more than 50 members

5 How many **projects** does your company maintain?

▼

- up to 5 projects
- up to 10 projects
- up to 20 projects
- up to 50 projects
- more than 50 projects

6 How many **development locations** does your company have?

7 What **types of software** does your company develop?

- Desktop applications
- Server applications
- Web applications
- Embedded software
- Distributed applications
- Handheld / Cellphone applications
- Games
- System software
- Database applications
- Other, please specify

Fontys
University of Applied Sciences *Survey on Continuous Integration*

Your usage of Continuous Integration (page 2/3)

Continuous Integration is only a part of the software development process with lots of possibilities of usage. Please specify in the following questions how you and your company are using Continuous Integration.

8 Are you using Continuous Integration?

9 If yes, which solution are you using?

- Cruise Control
- Teamcity
- DamageControl
- Build Forge
- Others, please specify

10 If yes, how long are you using Continuous Integration?

- up to 1 year
- up to 2 years
- up to 4 years
- longer than 4 years

11 Do you use Continuous Integration in every software project?

Additional Comment

12 Do you have a separate build machine?

Additional Comment

13 How do you integrate?

- Manually (executing the build process by hand)
- Automatic - on every repository check-in
- Automatic - scheduled
- Other, please specify

14 How are you using Continuous Integration?

- Code compilation
- Test execution
- Code quality analysis
- Code coverage analysis
- Staged builds
- Multi platform builds
- Others, please specify

Your opinion on Continuous Integration (page 3/3)

Features and matrixes can be analyzed and compared, but the most interesting information can be gathered from personal oppinions and experiences. We would like to ask you some questions on your oppinion.

15 What Continuous Integration **features** are **mandatory** for you?

- Code repository polling
- Program execution
- Feedback mechanism (Email / SMS / Pager)
- Status webpage
- Filesystem manipulation
- Extensibility with plugins
- Multi stage builds
- Artifact publication
- Security features
- Open source
- Others, please specify

16 What are your **wish future features** in Continuous Integration solutions?

17 Did Continuous Integration **improve** your **development process**? Why, or why not?

18 Will you use Continuous Integration in **future software projects** right from the start? Why, or why not?

Final questions

These questions are the final questions in this survey. We would like to thank you for helping us with your oppinion and experiences.

19 In which **country** is your company situated?

20 What is your **position** in your company?

21 Would you like to **receive a link** to the **final study**? Just write down your email address in the following field. Your **email address** will be deleted right after you receive the link to the final study.



Fontys University of Applied Sciences
 Department Software-Engineering

Contact
 Georg Fleischer
 g.fleischer@student.fontys.nl

5.3 Survey invitation

The following sections show the survey invitation in English and German that were used to invite the people to take part in the survey.

5.3.1 English

Subject: University Research on Continuous Integration

Hello altogether,

The Software-Engineering department of the Fontys University of Applied Sciences in Venlo / the Netherlands is conducting a research on the topic Continuous Integration.

We are researching what experiences companies have with Continuous Integration and how they are using the tools that are available. Therefore we developed an online survey which will take about 5 minutes of your time.

The results of the research will be freely available on the internet and the link to the results will also be posted to this group.

The following link will take you directly to the survey:

<http://www.zoomerang.com/Survey/?p=WEB228NK7GHEKH>

Best regards,
Georg Fleischer

Student, Software-Engineering
Fontys University of Applied Sciences
Venlo / The Netherlands

5.3.2 German

Betreff: Universitätsstudie zum Thema Continuous Integration

Die Software-Engineering Abteilung der Fontys University of Applied Sciences in Venlo / Niederlanden führt eine Untersuchung zum Thema Continuous Integration durch.

Dazu untersuchen wir die Erfahrungen, die Firmen mit dem Thema Continuous Integration haben und wie sie vorhandene Tools einsetzen. Wir haben einen Online-Fragebogen entwickelt, der ca. 5 Minuten Ihrer Zeit in Anspruch nimmt.

Nach Auswertung der Ergebnisse wird der Abschlussbericht der Studie online frei zugänglich zur Verfügung stehen. Ein Link zu diesem Bericht wird in diesem Forum bereitgestellt werden.

Über den folgenden Link gelangen Sie direkt zur Umfrage:

<http://www.zoomerang.com/Survey/?p=WEB228NK7GHEKH>

Mit freundlichen Grüßen,
Georg Fleischer

Student, Software-Engineering
Fontys University of Applied Sciences
Venlo / Niederlande