

Foundations of Software Engineering

Quality-Assurance Process

Christian Kästner

Foundations of Software Engineering

How to get developers to
[write tests | use static analysis | appreciate testers]

Christian Kästner

Agenda

- QA in the context of process
- Case study: QA at Microsoft from 1980 to today
- Case study: Static analysis at Google

Learning Goals

- Understand process aspects of QA
- Describe the tradeoffs of QA techniques
- Select an appropriate QA technique for a given project and quality attribute
- Decide the when and how much of QA
- Overview of concepts how to enforce QA techniques in a process
- Select when and how to integrate tools and policies into the process: daily builds, continuous integration, test automation, static analysis, issue tracking, ...
- Understand human and social challenges of adopting QA techniques
- Understand how process and tool improvement can solve the dilemma between features and quality

QA Process

QA Process Considerations

- We covered several QA techniques:
 - Formal verification (15-112)
 - Unit testing, test driven development
 - Various forms of advanced testing for quality attributes (GUI testing, fuzz testing, ...)
 - Static analysis
 - Dynamic analysis
 - Formal inspections and other forms of code reviews
- But: When to use? Which techniques? How much? How to introduce? How to establish a quality culture? How to ensure compliance? Social issues? What about external components?

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75mm 67 grams

~~6.00 EUR~~

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Small
60mm 53 grams

~~4.00 EUR~~

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Viking Norwik

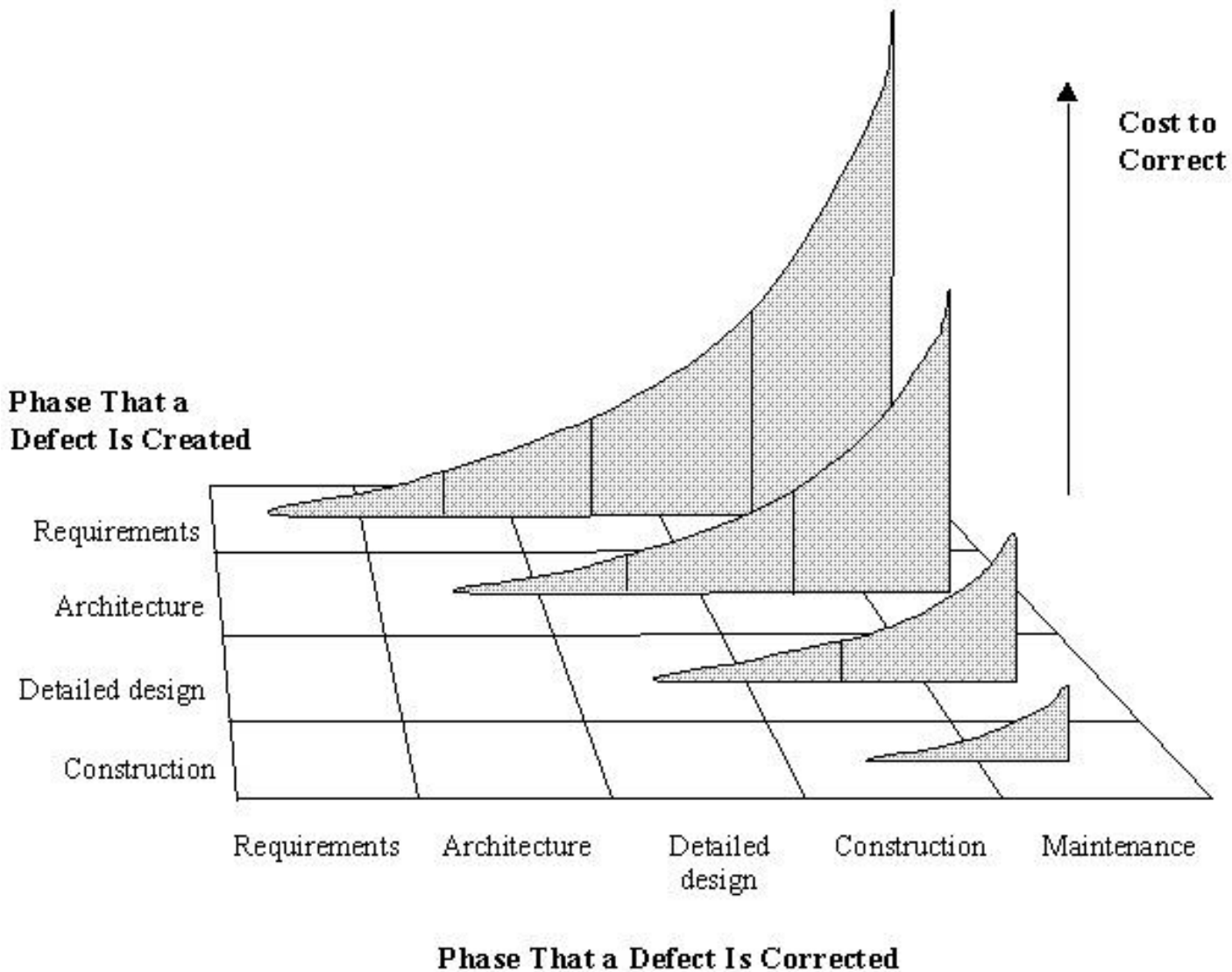
75mm 134g-402g | 134g 7€ | 201g 8€ | 268g 9€ | 335g 10€ | 402g 11€ |

~~8.00 EUR~~

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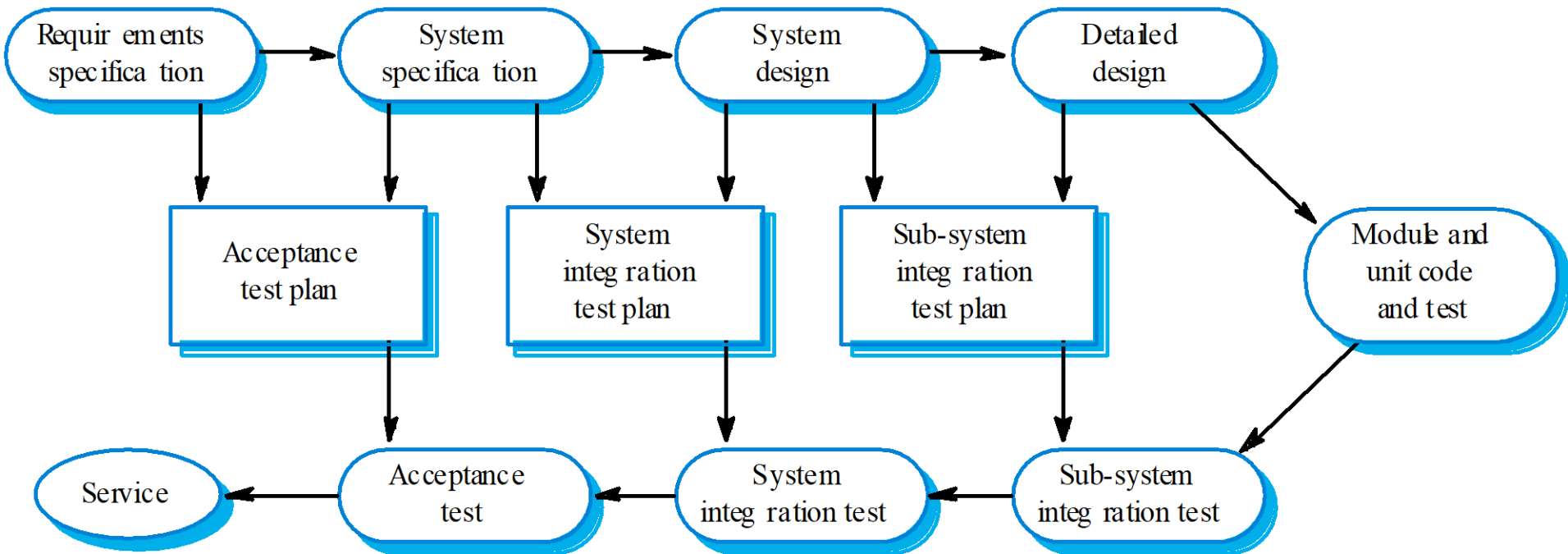


Copyright 1998 Steven C. McConnell. Reprinted with permission from *Software Project Survival Guide* (Microsoft Press, 1998).

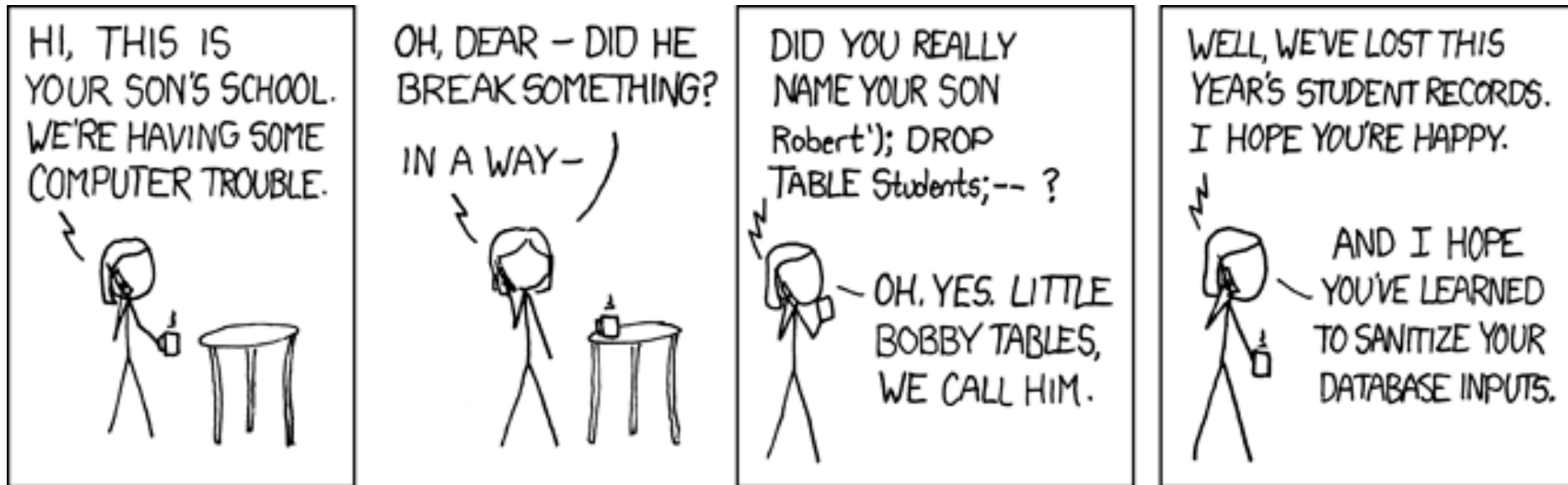
Qualities and Risks

- What qualities are required?
(requirements engineering)
- What risks are expected?
- Align QA strategy based on qualities and risks

Example: Test plans linking development and testing



Example: SQL Injection Attacks



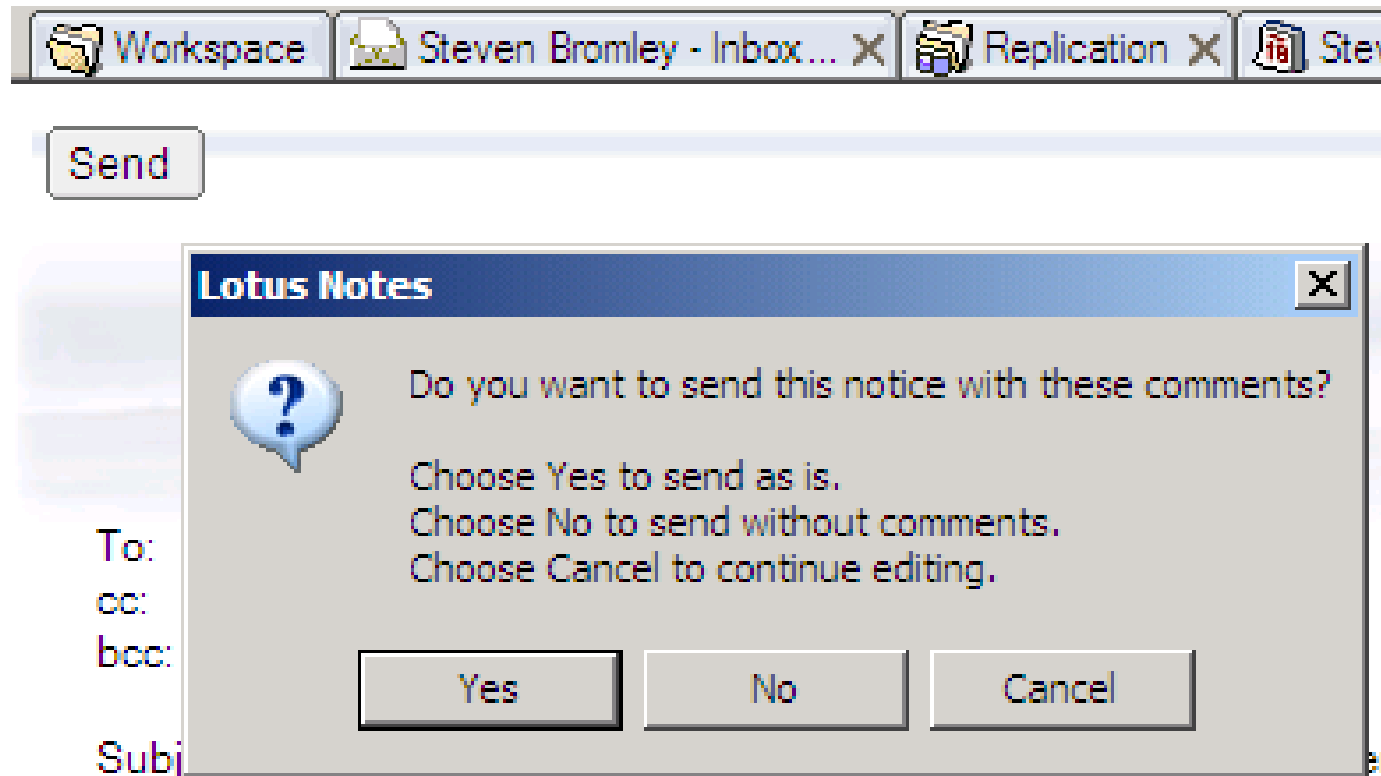
Which QA strategy is suitable?

<http://xkcd.com/327/>

Example: Scalability



Example: Usability



Which QA strategy is suitable?

QA Tradeoffs

- Understand limitations of QA approaches
 - e.g. testing vs static analysis,
formal verification vs inspection, ...
- Mix and match techniques
- Different techniques for different qualities



Case Study: QA at Microsoft

A problem has been detected and windows has been shut down to prevent damage to your computer.

THREAD_NOT_MUTEX_OWNER

If this is the first time you've seen this Stop error screen, restart your computer. If this screen appears again, follow these steps:

Check to make sure any new hardware or software is properly installed. If this is a new installation, ask your hardware or software manufacturer for any windows updates you might need.

If problems continue, disable or remove any newly installed hardware or software. Disable BIOS memory options such as caching or shadowing. If you need to use Safe Mode to remove or disable components, restart your computer, press F8 to select Advanced Startup Options, and then select Safe Mode.

Technical information:

*** STOP: 0x00000011 (0x00234234,0x00005345,0x05345345,0xFFFFFFFF)

NATIONAL BESTSELLER

"A meticulous accounting of how Microsoft operates...A blueprint for any company...facing fast-paced markets and narrowing competition." —Business Week

Microsoft SECRETS

How the World's Most Powerful Software Company
Creates Technology,
Shapes Markets,
and Manages People

Michael A. Cusumano
Richard W. Selby

WITH A NEW PREFACE BY THE AUTHORS

Throughout the case studies,
look for nontechnical challenges
and how they were addressed
(social issues, process issues, ...)

Microsoft's Culture

- Hiring the best developers
 - “Microsoft can achieve with a few hundred top-notch developers for what IBM would need thousands”
- Giving them freedom
- Teams for products largely independent
- Relatively short development cycles
 - Version updates (eg. Excel 3->4) 1-2 month
 - New products 1-4 years
 - Driven by release date
- Little upfront specification, flexible for change and cutting features

Early Days (1984): Separate testing from development

- after complaints over bugs from hardware manufacturers (eg. wrong computations in BASIC)
- customers complained about products
- IBM insisted that Microsoft improves process for development and quality control
- Serious data-destroying bug forced Microsoft to ship update of Multiplan to 20000 users at 10\$ cost each
- Resistance from developers and some management (incl. Balmer):
“developers could test their own products, assisted on occasion by high school students, secretaries, and some outside contractors”
- Hired outside testers
- Avoided bureaucracy of formal inspections, signoff between stages, or time logging
- Separate testing group; automated tests; code reviews for new people and critical components

Early Days (1986): Testing groups

- “Developers got lazy”, relied on test team for QA
- “Infinite defects” - Testers find defects faster than developers can fix them
- Late and large integrations (“big bang”) - long testing periods, delayed releases
- Mac Word 3 desaster: 8 month late, hundreds of bugs, including crashing and data destroying bugs; 1M\$ for free upgrades
- Pressure on delivering quality grew

1989 Retreat and “Zero defects”

- see memo

Zero-Defect Rules for Excel 4

- All changes must compile and link
- All changes must pass the automated quick tests on Mac and Windows
- Any developer who has more than 10 open bugs assigned must fix them before moving to new features

Testing Buddies

- Development and test teams separate, roughly similar size
- Developers test their own code, run automated tests daily
- Individual testers often assigned to one developer
 - Testing their private releases (branch), giving direct, rapid feedback by email before code is merged

Testers

- Encouraged to communicate with support team and customers, review media evaluations
- Develop testing strategy for high-risk areas
- Many forms of testing (internally called): unstructured testing, ad hoc testing, gorilla testing, free-form Fridays

Early-mid 90s

- Zero defect goal (1989 memo)
- Milestones (first with Publisher 1.0 in 1988)
- Version control, branches, frequent integration
- Daily builds
- Automated tests (“quick autotest”) - must succeed before checkin
- Usability labs
- Beta testing (400000 beta testers for Win 95) with instrumentation
- Brief formal design reviews; selected code reviews
- Defect tracking and metrics
- Developers stay in product group for more than one release cycle

Metrics

- Number of open bugs by severity
 - Number of open bugs expected to decrease before milestone
 - All know severe bugs need to be fixed before release
 - Severity 1 (product crash), Severity 2 (feature crash), Severity 3 (bug with workaround), Severity 4 (cosmetic/minor)
 - Metrics tracked across releases and projects
- Performance metrics
- Bug data used for deciding when “ready to ship”
 - Relative and pragmatic, not absolute view
 - “The market will forgive us for being late, but they won't forgive us for being buggy”

Challenges of Microsoft's Culture

- Little communication among product teams
- Developers and testers often “not so well read in with software-engineering literature, reinventing the wheel”
 - Long underestimated architecture, design, sharing of components, quality metrics, ...
- Developers resistant to change and “bureaucracy”

Project Postmortem

- Identify systematic problems and good practices (10-150 page report)
 - document recurring problems and practices that work well
 - e.g.,
 - breadth-first → depth-first & tested milestones
 - insufficient specification
 - not reviewing commits
 - using asserts to communicate assumptions
 - lack of adequate tools → automated tests
 - instrumented versions for testers and beta releases
 - zero defect rule not a priority for developers
- Circulate insights as memos, encourage cross-team learning

Process Audits

- Informal 1-week audits in problematic problems
- Analyzing metrics, interviewing team members
- Recommendations to pick up best practices from other teams
 - daily builds, automated tests, milestones, reviews

The 2002 Trustworthy Computing Memo

<http://news.microsoft.com/2012/01/11/memo-from-bill-gates/>

Code Reviews

- Own code review tools (passaround style)
- Internal studies on how effective reviews are
- Internal tools to improve code reviews

A problem has been detected and windows has been shut down to prevent damage to your computer.

The problem seems to be caused by the following file: SPCMDCON.SYS

PAGE_FAULT_IN_NONPAGED_AREA

If this is the first time you've seen this Stop error screen, restart your computer. If this screen appears again, follow these steps:

Check to make sure any new hardware or software is properly installed. If this is a new installation, ask your hardware or software manufacturer for any windows updates you might need.

If problems continue, disable or remove any newly installed hardware or software. Disable BIOS memory options such as caching or shadowing. If you need to use Safe Mode to remove or disable components, restart your computer, press F8 to select Advanced Startup Options, and then select Safe Mode.

Technical information:

*** STOP: 0x00000050 (0xFD3094C2,0x00000001,0xFBFE7617,0x00000000)

*** SPCMDCON.SYS - Address FBFE7617 base at FBFE5000, DateStamp 3

SLAM/SDV (since 2000)



- Goal: Reducing blue screens, often caused by drivers
- Driver verification tool for C
- Model checking technology
- Finds narrow class of protocol violations
 - Use characteristics of drivers (not general C code)
 - Found several bugs in Microsoft's well tested sample drivers
- Fully automated in Microsoft compiler suite
- Available for free
- Enforcement through driver certification program

Ball, Thomas, Vladimir Levin, and Sriram K. Rajamani. "A decade of software model checking with SLAM." Communications of the ACM 54.7 (2011): 68-76.

SLAM

- Compelling business case: eliminated most blue screens
- Based on basic science of model checking: originated in university labs with public funding

2010: Agile

- Web-based services and C++ evolution requires faster iteration
- Embrace of agile methods
- Massive reduction of testing team (from two testers per developers toward one): developers now expected to do their own testing

Case Study 2:

Static Analysis at Google

Case Study

- Problems
- Insights
- Solutions
- Lessons learned transferable to other companies?

```
package com.google.devtools.staticanalysis;
```

```
public class Test {
```

▼ **Lint** Missing a Javadoc comment.

Java

1:02 AM, Aug 21

[Please fix](#)

[Not useful](#)

```
public boolean foo() {  
    return getString() == "foo".toString();  
}
```

▼ **ErrorProne** String comparison using reference equality instead of value equality
(see <http://code.google.com/p/error-prone/wiki/StringEquality>)

StringEquality

1:03 AM, Aug 21

[Please fix](#)

Suggested fix attached: [show](#)

[Not useful](#)

```
}  
  
public String getString() {  
    return new String("foo");  
}  
}
```

```
package com.google.devtools.staticanalysis;
```

```
public class Test {
```

▼ **Lint** Missing a Javadoc comment.

Java
1:02 AM, Aug 21

[Please fix](#)

[Not useful](#)

```
public boolean foo() {  
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}
```

▼ **ErrorProne** String comparison using reference equality instead of value equality
(see <http://code.google.com/p/error-prone/wiki/StringEquality>)

StringEquality
1:03 AM, Aug 21

[Please fix](#)

//depot/google3/java/com/google/devtools/staticanalysis/Test.java

```
package com.google.devtools.staticanalysis;
```

```
public class Test {  
    public boolean foo() {  
        return getString() == "foo".toString();  
    }  
}
```

```
    public String getString() {  
        return new String("foo");  
    }  
}
```

```
package com.google.devtools.staticanalysis;
```

```
import java.util.Objects;
```

```
public class Test {  
    public boolean foo() {  
        return Objects.equals(getString(), "foo".toString());  
    }  
}
```

```
    public String getString() {  
        return new String("foo");  
    }  
}
```

Apply

Cancel

QA within the Process

QA as part of the process

- Have QA deliverables at milestones (management policy)
 - Inspection / test report before milestone
- Change development practices (req. developer buy-in)
 - e.g., continuous integration, pair programming, reviewed checkins, zero-bug static analysis before checking
- Static analysis part of code review (Google)
- Track bugs and other quality metrics

Defect tracking

- Issues: Bug, feature request, query
- Basis for measurement
 - reported in which phase
 - duration to repair, difficulty
 - categorization
 - > root cause analysis
- Facilitates communication
 - questions back to reporter
 - ensures reports are not forgotten
- Accountability

Bug List: (48 of 200) [First](#) [Last](#) [Prev](#) [Next](#) [Show last search results](#) [Search page](#) [Enter new bug](#)

[Eclipse] Bug#: 160502 Hardware: OS: Reporter: [Clare Carty](#)
[Product](#): Version: [Priority](#): [Add CC](#):
[Component](#): [Severity](#): CC: [ccarty@ca.ibm.com](#)
[Status](#): REOPENED [Target](#): [john_arthorne@ca.ibm.com](#)
[Resolution](#): platform-runtime-inbox [Milestone](#):
[Assigned To](#): <platform-runtime-inbox@eclipse.org> ☐ Remove selected CC

[QA Contact](#):
[URL](#):
[Summary](#): JVM crash at random intervals on SUSE 9 with Sun JRE 1.5
[Status](#):
[Whiteboard](#):
[Keywords](#):

Attachment	Type	Created	Size	Actions
screenshot of crash	image/jpeg	2006-10-11 12:14	131.55 KB	Edit
Create a New Attachment (proposed patch, testcase, etc.)				View All

Bug 160502 depends on: [Show dependency tree](#)
Bug 160502 blocks:
[Votes](#): 0 [Show votes for this bug](#) [Vote for this bug](#)

Enforcement

- Microsoft: check in gates
 - Cannot check in code unless analysis suite has been run and produced no errors (test coverage, dependency violation, insufficient/bad design intent, integer overflow, allocation arithmetic, buffer overruns, memory errors, security issues)
- eBay: dev/QA handoff
 - Developers run FindBugs on desktop
 - QA runs FindBugs on receipt of code, posts results, require high-priority fixes.
- Google: static analysis on commits, shown in review
- Requirements for success
 - Low false positives
 - A way to override false positive warnings (typically through inspection).
 - Developers must buy into static analysis first

Reminder: Continuous Integration

Jenkins

search

admin | log out

Jenkins

ENABLE AUTO REFRESH

New Job

People

Build History

Project Relationship

Check File Fingerprint

Manage Jenkins

My Views

Disk usage

Build Queue

No builds in the queue.

Build Executor Status

#	Status
1	Idle

All +

S	W	Name	Last Success	Last Failure	Last Duration	
		FOSPL	1 hr 40 min (#186)	6 days 8 hr (#164)	47 sec	
		IVM	2 days 19 hr (#288)	12 days (#279)	4 min 35 sec	
		IVMBranch	3 mo 19 days (#139)	3 mo 25 days (#125)	4 min 27 sec	
		IVMBranchEval	3 mo 24 days (#70)	3 mo 28 days (#57)	12 min	
		IVMBranchTest	3 mo 24 days (#110)	3 mo 19 days (#118)	11 min	
		IVMTest	2 days 19 hr (#160)	10 days (#155)	12 min	
		TypeChef	21 days (#354)	7 hr 54 min (#357)	16 min	
		variational	1 yr 2 mo (#11)	1 yr 2 mo (#3)	3 min 43 sec	

Icon: [S](#) [M](#) [L](#)

Legend

[RSS for all](#)

[RSS for failures](#)

[RSS for just latest builds](#)

[Help us localize this page](#)

Page generated: Jan 29, 2013 10:41:11 PM

[REST API](#)

[Jenkins ver. 1.500](#)

Automating Test Execution

```
ckaestne@kastner-desktop:~/work/TypeChef/TypeChef$ sbt "project FeatureExprLib" test
Detected sbt version 0.12.2
[info] Loading global plugins from /usr0/home/ckaestne/.sbt/plugins
[info] Loading project definition from /usr0/home/ckaestne/work/TypeChef/TypeChef/project/project
[info] Loading project definition from /usr0/home/ckaestne/work/TypeChef/TypeChef/project
[info] Set current project to TypeChef (in build file:/usr0/home/ckaestne/work/TypeChef/TypeChef/)
[info] Set current project to FeatureExprLib (in build file:/usr0/home/ckaestne/work/TypeChef/TypeChef/)
[info] Compiling 10 Scala sources to /usr0/home/ckaestne/work/TypeChef/TypeChef/FeatureExprLib/target/scala-2.10/test-classes...
[info] + FeatureExpr.parse(print(x))==x: OK, passed 100 tests.
[info] + FeatureExpr.and1: OK, passed 100 tests.
[info] + FeatureExpr.and0: OK, passed 100 tests.
[info] + FeatureExpr.andSelf: OK, passed 100 tests.
[info] + FeatureExpr.or1: OK, passed 100 tests.
[info] + FeatureExpr.or0: OK, passed 100 tests.
[info] + FeatureExpr.orSelf: OK, passed 100 tests.
[info] + FeatureExpr.a eq a: OK, passed 100 tests.
[info] + FeatureExpr.a equals a: OK, passed 100 tests.
[info] + FeatureExpr.a equivalent a: OK, passed 100 tests.
[info] + FeatureExpr.a implies a: OK, passed 100 tests.
[info] + FeatureExpr.creating (a and b) twice creates equal object: OK, passed 100 tests.
[info] + FeatureExpr.creating (a or b) twice creates equal object: OK, passed 100 tests.
[info] + FeatureExpr.creating (not a) twice creates equal object: OK, passed 100 tests.
[info] + FeatureExpr.applying not twice yields an equivalent formula: OK, passed 100 tests.
[info] + FeatureExpr.Commutativity wrt. equivalence: (a and b) produces the same object as (b and a): OK, passed 100 tests.
[info] + FeatureExpr.Commutativity wrt. equivalence: (a or b) produces the same object as (b or a): OK, passed 100 tests.
[info] + FeatureExpr.taut(a=>b) == contr(a and !b): OK, passed 100 tests.
[info] + FeatureExpr.featuremodel.tautology: OK, passed 100 tests.
```

Continuous Integration with Travis-CI

 ravis

HomeStatsBlogDocs

 miles

Fork me on GitHub

RecentMy Repositories

 diaspor/diaspora#209

Duration: 19 min 26 sec, Finished: 9 minutes ago

 rubinius/rubinius#815

Duration: 16 min 28 sec, Finished: about an hour ago

 robgleeson/ed#31

Duration: 4 min 33 sec, Finished: about an hour ago

 niku/frange#4

Duration: 51 sec, Finished: about 2 hours ago

 tedsuo/raaraa#48

Duration: 1 min, Finished: about 2 hours ago

 holman/play#84

Duration: 4 min 49 sec, Finished: about 2 hours ago

 crcn/sift.js#35

Duration: 41 sec, Finished: about 2 hours ago

 BonzaiProject/Bonzai#19

Duration: 40 sec, Finished: about 2 hours ago

rails/rails

Ruby on Rails

11762 2563

CurrentBuild History

Build 1995

Commitf3e079e (master)

Finishedabout 6 hours ago

Compareb5927b8...f3e079e

Duration1 hr 33 min 32 sec

AuthorVijay Dev

MessageMerge pull request #4248 from andrew/2012 Updated copyright notices for 2012

Build Matrix

Job	Duration	Finished	Rvm	Env
 1995.1	19 min 5 sec	about 6 hours ago	1.9.3	GEM=railties
 1995.2	12 min 38 sec	about 6 hours ago	1.9.3	GEM=ap,am,amo,ares,as
 1995.3	16 min 57 sec	about 6 hours ago	1.9.3	GEM=ar:mysql
 1995.4	12 min 55 sec	about 6 hours ago	1.9.3	GEM=ar:mysql2
 1995.5	12 min 34 sec	about 6 hours ago	1.9.3	GEM=ar:sqlite3
 1995.6	19 min 23 sec	about 6 hours ago	1.9.3	GEM=ar:postgresql

Workers

erlang.worker.travis-ci.org
nodejs1.worker.travis-ci.org
php1.worker.travis-ci.org
rails1.worker.travis-ci.org
rails2.worker.travis-ci.org
ruby1.worker.travis-ci.org
ruby2.worker.travis-ci.org
ruby3.worker.travis-ci.org
spree.worker.travis-ci.org

Queue: Common

No jobs

Queue: NodeJs

No jobs

Queue: Php

No jobs

Queue: Rails

No jobs

Queue: Erlang

No jobs

Queue: Spree

No jobs

Social Aspects

Social issues

- Developer attitude toward defects
- Developer education about security
- Using peer pressure to enforce QA practices
 - Breaking the build – various rules

Social issues

- Developer vs tester culture
- Testers tend to deliver bad news
- Defects in performance evaluations?
- Issues vs defects
- Good test suits raise confidence, encourage shared code ownership

Reporting Defects

- Reproducible defects
- Simple and general
- One defect per report
- Non-antagonistic
 - (testers usually bring bad news)
 - State the problem
 - Don't blame

read: To much is to much

Thread Tools ▼

Search Thread ▼

Display ▼

21-05-2012, 15:05

#1

ouchy •

ined
aten Date: Apr 2012
ts: 8 **To much is to much**

I am fed up of all the bugs.
Production never update i must go through the army to updaye the production
disconnection very often
loss of gold and forge point
loss of life points of soldiers without fighting
diasapearing soldiers
and at las but not least my copper foundry diasapered while i was trying to change its emplacement.

YOU ARE SORRY FOR ALL THESE INCONVIENIENCE,I KNOW,YOU ARE GOING TO SAY IT IS BECAUSE IT S A BETA,I KNOW
BUT THIS GAME SUCKS FROM THE TOP TO THE BOTTOM,PAY 10 MONKEYS AS DEVELLOPERS AND YOU WILL HAVE THE SAME RESULTS.
BY THE WAY IF YOU WANT TO TEST A CAR BEFORE BUYING IT YOU DO NOT HAVE TO PAY,HERE WITH THE DIAMONDS OPTION IS YOU WANT TO BUY THE CAR OK,YOU WANT TO TEST IT OK SO YOU MUST PAY.
SO PLEASE THIS TIME NO APOLOGISE,I NEED EXPLANATION AND NOT AS BETA BLA BLA BLA.
IS INNO CIE ARE BELONGING TO BANKSTERS GANG?

Last edited by Carasus; 23-05-2012 at 02:13.

21-05-2012, 15:14

rmerlynch •

adier-General



you DO NOT have to buy diamonds. its your choice, and you should r
diamonds are paying for this game to be developed. if your so upset
bottom then don't let the door hit you in the a\$\$ on the way out ☹

FORGE OF EMPIRES**NOT REGISTERED YET?**

ON THE FORUM YOU CAN
BE A PART OF THE
COMMUNITY AND
PARTICIPATE IN TOPICS
REGARDING THE GAME.
YOU CAN ALSO FIND NEW
GUILD MEMBERS AND
DISCUSS THE WORLDS
DEVELOPMENT.

**SO DONT FORGET TO
CREATE AN ACCOUNT!**



#2

- *To:* debian-devel@lists.debian.org
 - *Subject:* Reporting 1.2K crashes
 - *From:* Alexandre Rebert <alexandre.rebert@gmail.com>
 - *Date:* Tue, 25 Jun 2013 01:28:10 -0400
 - *Message-id:* <CAF1AS2itHonB5KTnqNnX5xat4Bh7ytr0dG2txX6BSKzboVSMzA@mail.gmail.com>
-

Hi,

I am a security researcher at Carnegie Mellon University, and my team has found thousands of crashes in binaries downloaded from debian wheezy packages. After contacting owner@bugs.debian.org, Don Armstrong advised us to contact you before submitting ~1.2K bug reports to the Debian BTS using maintonly@bugs.debian.org (to avoid spamming `debian-bugs-dist`).

We found the bugs using Mayhem [1], an automatic bug finding system that we've been developing in David Brumley's research lab for a couple of years. We recently ran Mayhem on almost all ELF binaries of Debian Wheezy (~23K binaries) [2], and it reported thousands of crashes.

Our goal here is to make our bug reports as complete and accurate as possible. To minimize duplicates, we are reporting only one crash per binary, and at most 5 crashes per package. This amounts to ~1.2K crashes. Moreover, to ensure accuracy, we confirmed all the crashes by re-running them in a fresh unstable installation. Finally, we also filter out assertion failures for now, as they seemed less important. In short, every report is reproducible and actionable.

You can download the list of affected packages, with their maintainers [3], generated with `dd-list`, as well as a sample bug report for `gcov-4.6` [4]. The bug report contains:

- 1) the bug report that will be mailed to maintonly@bugs.debian.org (`report.txt`)
- 2) a testcase reproducing the crash in `./crash/`
- 3) information about the crash in `./crash_info/`: a core dump (`core`), the output of the crash (`crash_output.txt`), the `dmesg` of the crash (`dmesg.txt`), as well as the exit status (`exit_status.txt`).

This is a lot of bugs, and we want to make sure we're doing bug reports right, so that we don't make anyone angry by spamming the BTS with bad reports. Please let us know if the reports are good enough to proceed with the filing, or if any additional information should be

Summary

- Developing a QA plan:
 - Identify quality goals and risks
 - Mix and match approaches
 - Enforce QA, establish practices
- Case study from Microsoft
- Integrate QA in process
- Social issues in QA

Further Reading

- Cusumano, Michael A., and Richard W. Selby. "Microsoft secrets." (1997).
 - Book covers quality assurance at Microsoft until the mid 90s (and much more)
- Ball, Thomas, Vladimir Levin, and Sriram K. Rajamani. "A decade of software model checking with SLAM." *Communications of the ACM* 54.7 (2011): 68-76.
 - An overview of SLAM at Microsoft
- Jaspan, Ciera, I. Chen, and Anoop Sharma. "Understanding the value of program analysis tools." *Companion OOPSLA*. ACM, 2007.
 - Description of eBay evaluating FindBugs
- Sadowski, C., van Gogh, J., Jaspan, C., Söderberg, E., & Winter, C. Tricorder: Building a Program Analysis Ecosystem. ICSE 2015
 - Integrating static analysis into code reviews at Google in a data-driven way
- Sommerville. *Software Engineering*. 8th Edition. Chapter 27
 - QA planning and process improvement, standards