# Software Testing, Quality Assurance & Maintenance—Lecture 1

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# “The Testing Course”

# Course mechanics

Office Hours: W 10:30-12:30, DC2597D

Textbook: There is still remnant material from Ammann and Offutt.

| | |
|---|---|
| Website | `http://patricklam.ca/stqam` |
| Github | `git@github.com:patricklam/stqam-2015.git` |
| Piazza | (you know where to find it) |

Grace days: You may submit assignments up to 2 days late in total.

# Evaluation

| | | |
|---|---|---|
| 4 individual assignments | 20% | (5% each) |
| Course project (up to 3/group) | 15% | |
| Midterm | 15% | |
| Final exam | 50% | |

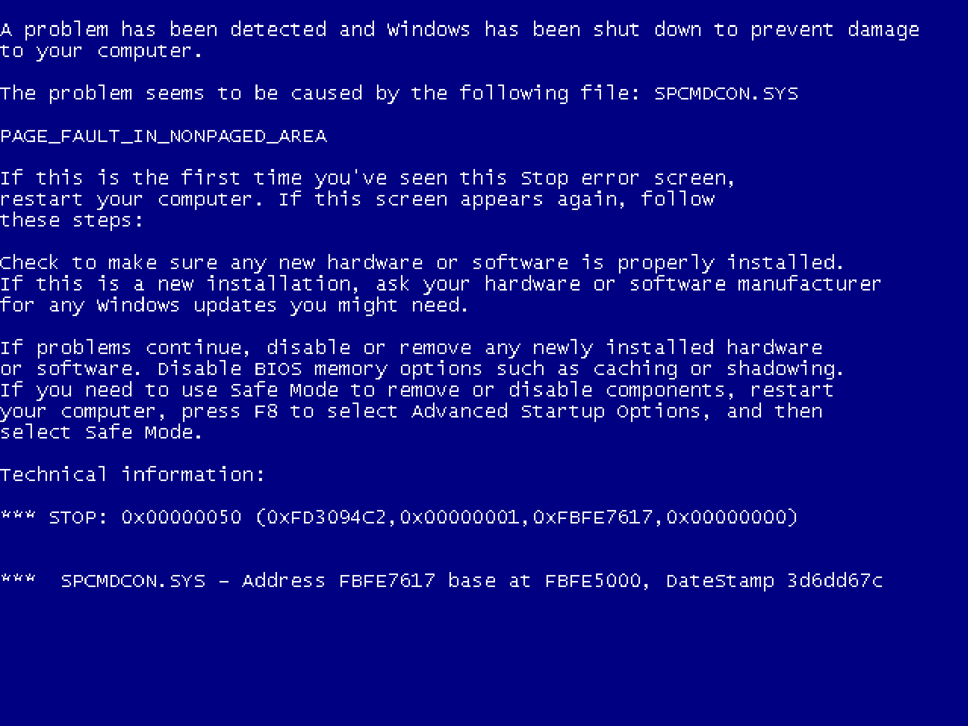
Midterm, final are open-book, open-notes.

Sections: Same assignments, projects, exams.
Minor variations in lecture material.

# Failures

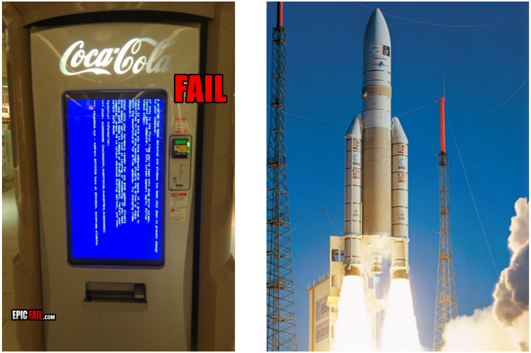
Let's consider:

- consequences;
- causes;
- avoidance (before it's too late);
  - testing
- mitigation (afterwards).



```
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 3d6dd67c
```

# Consequences of Failures



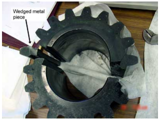
Who suffers from failures?

Photos: (L) epicfail.com; (R) copyright ESA/CNES/ARIANESPACE - Service Optique CSG

# Consequences of Failures

Microsoft®

http://hermosodia.wordpress.com/2008/10/19/definicion-visual-de-workaround/



(United States Centre for Disease Control, 04MI074)

(stephen mantler at Flickr, “A runner’s injury”)

# Infamous Software Bugs

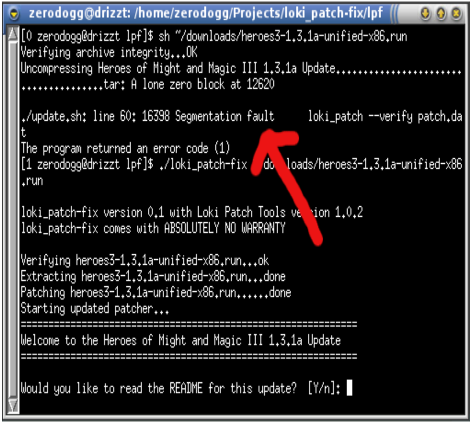
Therac-25, 1985–1987:
    5 deaths, severe injuries
    race conditions, no automated testing

Northeast blackout, 2003
    (no ice storm)

Ariane 5 crash, 1996

Morris Worm, 1988

# Why Does Software Go Wrong?



```
[0 zerodogg@drizzt lpf]$ sh ~/downloads/heroes3-1.3.1a-unified-x86.run
Verifying archive integrity...OK
Uncompressing Heroes of Might and Magic III 1.3.1a Update.......................
...............tar: A lone zero block at 12620

./update.sh: line 60: 16398 Segmentation fault      loki_patch --verify patch.da
t
The program returned an error code (1)
[1 zerodogg@drizzt lpf]$ ./loki_patch-fix ~/downloads/heroes3-1.3.1a-unified-x86
.run

loki_patch-fix version 0.1 with Loki Patch Tools version 1.0.2
loki_patch-fix comes with ABSOLUTELY NO WARRANTY

Verifying heroes3-1.3.1a-unified-x86.run...ok
Extracting heroes3-1.3.1a-unified-x86.run...done
Patching heroes3-1.3.1a-unified-x86.run.....done
Starting updated patcher...
================================================================
Welcome to the Heroes of Might and Magic III 1.3.1a Update
================================================================

Would you like to read the README for this update?  [Y/n]: █
```

1. Segfaults—or crashes; infinite loops too.

# Why Does Software Go Wrong?

```
public int add(int x, int y) {
    return x - y;
}
```

2. Wrong Output:
   - method or module returns wrong information or has unwanted side effect.

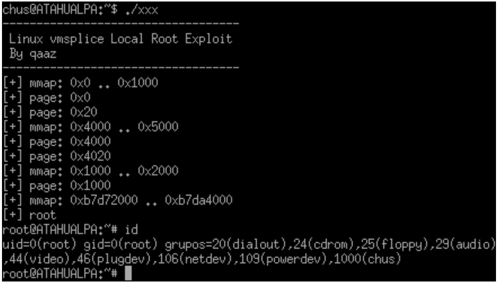
# Why Does Software Go Wrong?

3. Wrong API
   - a library can't do what you need it to do; or
   - subsystems don't work together correctly.

Photo copyright ESA/CNES/ARIANESPACE - Service Optique CSG

# Why Does Software Go Wrong?

4. Bad system-level behaviour:
   - Wrong output to user.
   - Bad security.
   - Wrong specifications.



```
chus@ATAHUALPA:~$ ./xxx
-----------------------------------
 Linux vmsplice Local Root Exploit
 By qaaz
-----------------------------------
[+] mmap: 0x0 .. 0x1000
[+] page: 0x0
[+] page: 0x20
[+] mmap: 0x4000 .. 0x5000
[+] page: 0x4000
[+] page: 0x4020
[+] mmap: 0x1000 .. 0x2000
[+] page: 0x1000
[+] mmap: 0xb7d72000 .. 0xb7da4000
[+] root
root@ATAHUALPA:~# id
uid=0(root) gid=0(root) grupos=20(dialout),24(cdrom),25(floppy),29(audio)
,44(video),46(plugdev),106(netdev),109(powerdev),1000(chus)
root@ATAHUALPA:~# █
```

# Why Does Software Go Wrong?

5. Nonfunctional properties:
   - Leaks (yes, even in Java).
   - Performance.

# Why Does Software Go Wrong?

Regressions to past bugs.

# Avoiding Software Failures

- test the software (in-house, externally)
- require validation suites for plugins
- code review
- better design (“write better code!”)
- include fewer features
- defensive programming
  (especially for plugins)

# Mitigation: Failure is Inevitable

Software never completely works.

Aim: make software that is good enough.

# Coping with an Imperfect World

- disclaim liability

  *25. LIMITATION ON AND EXCLUSION OF DAMAGES. You can recover from Microsoft and its suppliers only direct damages up to the amount you paid for the software. You cannot recover any other damages, including consequential, lost profits, special, indirect or incidental damages.*

  (Vista license)

# Coping with an Imperfect World

- disclaim liability
- release patches
- backup user data
- defensive programming

# More Coping Strategies

- release patches
- back up/replicate user data
- recover from failures

# Ways of Testing Software

- compile it

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- run it on one input

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- compile it
- run it on one input
- run it on many inputs
- run it on a representative set of inputs
- run it on all inputs (static analysis)

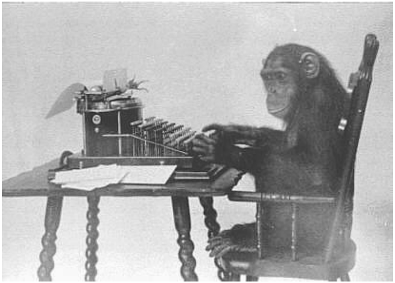
# Other Testing Concerns

- Integration testing
- Nonfunctional properties
- Regression tests

# Goals of This Course

- You will be able to create and evaluate test suites for reasonably-sized software systems.
- You will learn how to use and write tools for software maintenance and verification (particularly automated testing tools).
- You will gain experience with carrying out modifications to a large pre-existing software package.

# Key Concept: Coverage



You'll find bugs eventually, but it'll take longer than you have.

# Coverage

Idea: find a reduced space and cover it with tests.

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Possible spaces: graphs, logic, input space, syntax.

# Concrete Example of Coverage

```
public static numZero(int[] x) {
  int count = 0;
  for (int i = 1; i < x.length; i++) {
    if (x[i] == 0) count++;
  }
  return count;
}
```

Input space: arrays of length $\leq 2$ containing 0 or 1.

$$[], [0], [1], [0, 0], [0, 1], [1, 0], [1, 1]$$

Note: Only some of the inputs will trigger the failure.

# Terminology

Validation: evaluating software prior to release to ensure compliance with intended usage.

Verification: determining whether products of a given phase of the development process fulfill requirements established in a previous phase.

# Terminology

Software fault: static defect in the software.

Software error: incorrect internal state that is the manifestation of some fault.

Software failure: External, incorrect behaviour.

# Testing vs. debugging

Testing: evaluating software by observing its execution.

Debugging: finding (and fixing) a fault given a failure.

# Problem

- Testing tasks are often repetitive (i.e. boring).
- It is easy to make mistakes while carrying out tests.

# Automation

Automation is key to successful testing:

- Enables you to run more tests more quickly.
- Helps ensure coverage.

# A Collection of Topics

Standard topics:

- Graph Coverage
- Logic Coverage
- Input Space Coverage
- Syntax-Based Coverage
- Testing in Practice
  (e.g. test plans, writing bug reports)
- State-of-the-art Techniques
- Using and building Testing Tools

# Tools

We'll discuss a number of software tools:

- git (for assignment submission)
- unit testing libraries (JUnit, Python unittest)
- clang/LLVM
- valgrind
- daikon
- randoop
- Java Path Finder
- cppcheck
- FindBugs
- Splint
- Coverity
- Visual Studio (SAL)
- iComment
- ... and more