The Edward S. Rogers Sr. Department
of Electrical & Computer Engineering
UNIVERSITY OF TORONTO

csc444h:
software engineering I

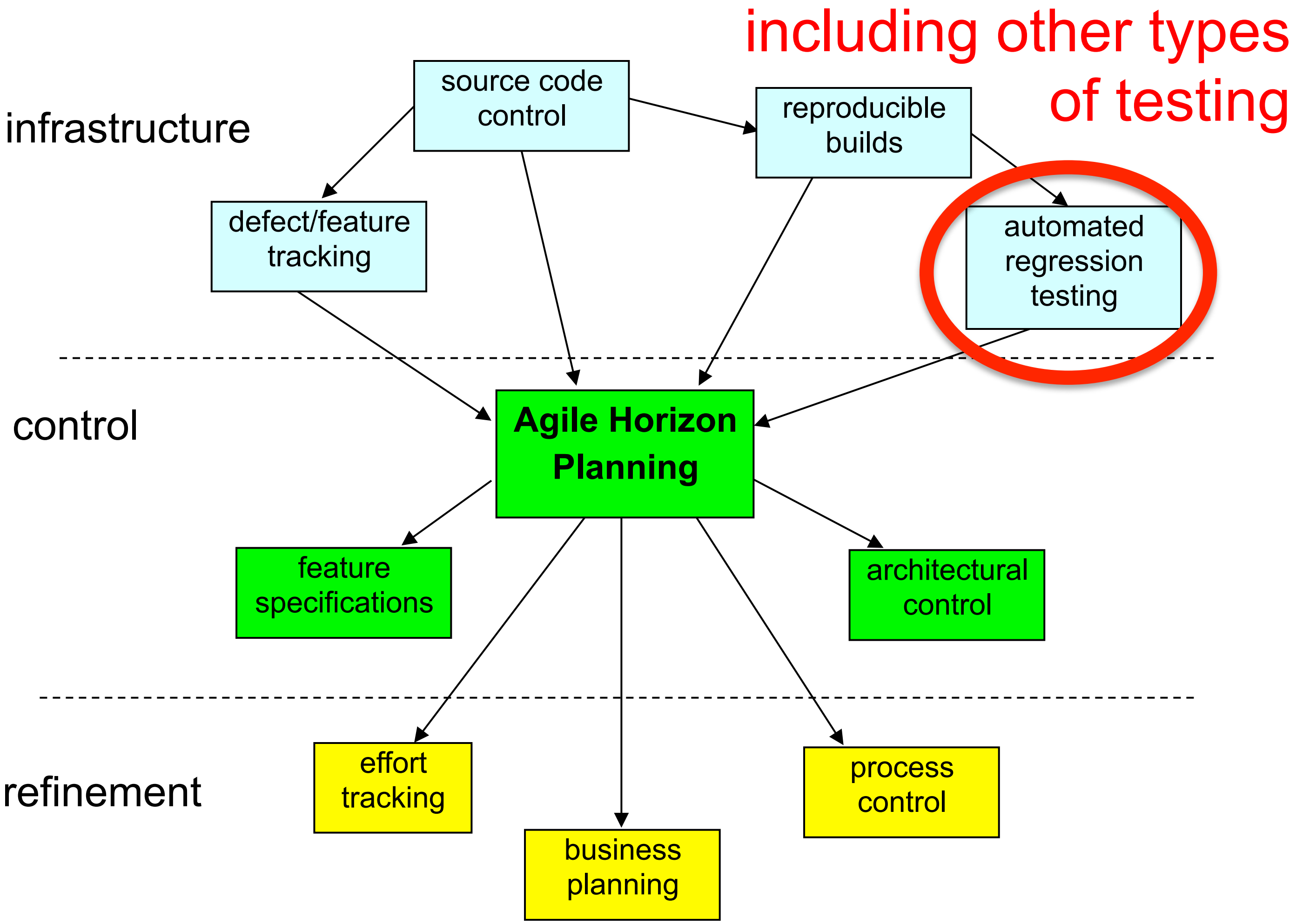
matt medland

matt@cs.utoronto.ca

http://www.cs.utoronto.ca/~matt/csc444

testing

top-10



should have read ch 1-12 now (ch 10 today, skip ch 6)

software quality assurance

- humans are fallible
  - infeasible to completely fix the humans
  - need to double and triple check their work to find the problems
- testing
  - running the software to see if it works the way it is supposed to.
    - works according to specifications
    - ensures specifications are reasonable (that they solve the intended problem)

software quality assurance (2)

- reviews
  - inspecting written work products looking for errors
    - requirements, specifications, designs, and code
- proofs
  - proving that the software behaves according to a written, formal specification
    - important in control systems and other critical software amenable to proof
    - can useful for general-purpose software as well

proving programs correct

- should think of programs logically, not operationally.
- understand the program as a *predicate transformer*

- *predicate:*
  - *a logical expression that characterizes the state of the system*

- *pre {P} post*
  - the program transforms the pre predicate into the post predicate.
  - each line of the program should be thought if in those terms
    - each line transforms the pre condition closer and closer to the post condition

example

precondition: array has >= 5 elements

code

post-condition: # of elements printed == 5

proven!

no “off-by-one” errors here

this kind of thinking becomes second nature when programming

a very, very powerful tool

induction

- proving by induction is also a useful technique

- ex, prove that:

$$\mathit{factorial}(n) = n!$$

- for all natural numbers n
  - start with base case, usually $n = 0$ or $n = 1$
  - prove by induction that if it's true for n then it must be true for $(n+1)$

unit test

- testing performed by the coder as they are coding.
- will test in their dev debug build
- will want to build “test scaffolding” to test the code they have written independent of the final application.
  - can use pre-build unit testing frameworks such as xUnit (Kent Beck – Extreme Programming)
    - JUnit, CUnit, CPPUnit, PyUnit Test::Unit, VbUnit, …
  - best practices is to not just test and discard, but consistently maintain the automated unit tests and have them execute after every nightly build.
  - try to break dependence on any other modules, use “mockups” and DI (dependency injection) instead.
  - catches problems very early, right at the source.
  - confident in changing a module
  - living “documentation” of how to use a module
  - strengthens interface v.s. implementation

component (or function) test

- started when a feature is relatively complete and stable.
- occurs during coding phase (pre-dcut).
- performed by a tester, not by the coder.
- uses a nightly dev release build.

- tester will:
  - try out those parts of the feature that the coder says are supposed to work
  - communicate issues back to the coder in an informal fashion
    - i.e., not counted as "defects" yet
  - re-test as coder works out issues
  - develop a test plan for the feature
    - a document describing how the feature will be tested
  - develop automated tests for the feature

integration test

- after dcut.
- all features of all executables have been coded
- testers begin executing their test plans
- test that the features work together as expected
- problems are recorded as formal “defects”.

system test

- as the system stabilizes.
- tests of full production installs
- tests on how this application works with other related applications

final release test

- last minute checklist before a release goes out the door
  - not rushed!

regression testing

- tests made to ensure that functionality that once worked continues to work.
- test made to ensure that previously discovered and corrected defects do not re-appear
  - a fertile source of defects
- can be performed manually
  - but would take too long

automated regression testing

- an extension of the nightly builds
- software scripts will execute a set series of tests and report the results back into a database
- QA will examine the results each morning
  - 4 reasons for a failure:
    - the function was broken
    - the function was changed
    - the function was improved
    - the test is faulty
- the function of the test team is to ensure good coverage on automated regression tests
  - each new function should get a suite of regression tests
    - should be formalized in the feature creation process
  - each defect should get a test that would have caught it
    - should be formalized in the defect resolution process

performance regressions

- easy to build test cases and forget to measure the time it takes to execute them
- systematically
  - collecting this information,
  - consolidating it,
  - and reporting on it

  will show up performance trends

- required because sometimes coders will check-in a change that looks to be functionally ok, but has very negative performance implications
  - e.g., if coder only tested on a few simple test cases and did not notice because the run-time was swamped by the overhead

memory leak regressions

- run a special version of the software, instrumented to find memory leaks, bad memory allocation errors, and bad pointer chasing
  - e.g., Purify from IBM/Rational/Pure

- runs slowly, but can use a representative sample of the nightly regression tests.

- less required when running *managed code*
  - *C# .NET*
  - *Java*

benefits of regression testing

- locks-in quality
  - once you achieve quality, you don't backslide
  - everybody focuses on new features and forgets the old
- finding defects sooner
  - finds the defect nearest the point in time it was injected
  - freshest in the coder's mind
  - least expensive time to fix it
- development aid
  - can work on complex, central bits of the code without fear of breaking something major on not finding out
- releasing
  - if need a last minute critical defect fix to release
  - if no/poor automated regression, might have to delay until re-tested

regression coverage

- to manage a program to institute or improve automated regression testing, you require a coverage metric.

- what % of the application is tested.
  - can count functions from the outside
    - coverage of all functions
    - # of tests per function
  - can count lines of code traversed
    - excellent coverage metric
    - will not necessarily get all combinations

- other measures of coverage…

testing the GUI

two general approaches to testing GUI-based apps:

1) use a GUI test tool (ex. selenium)

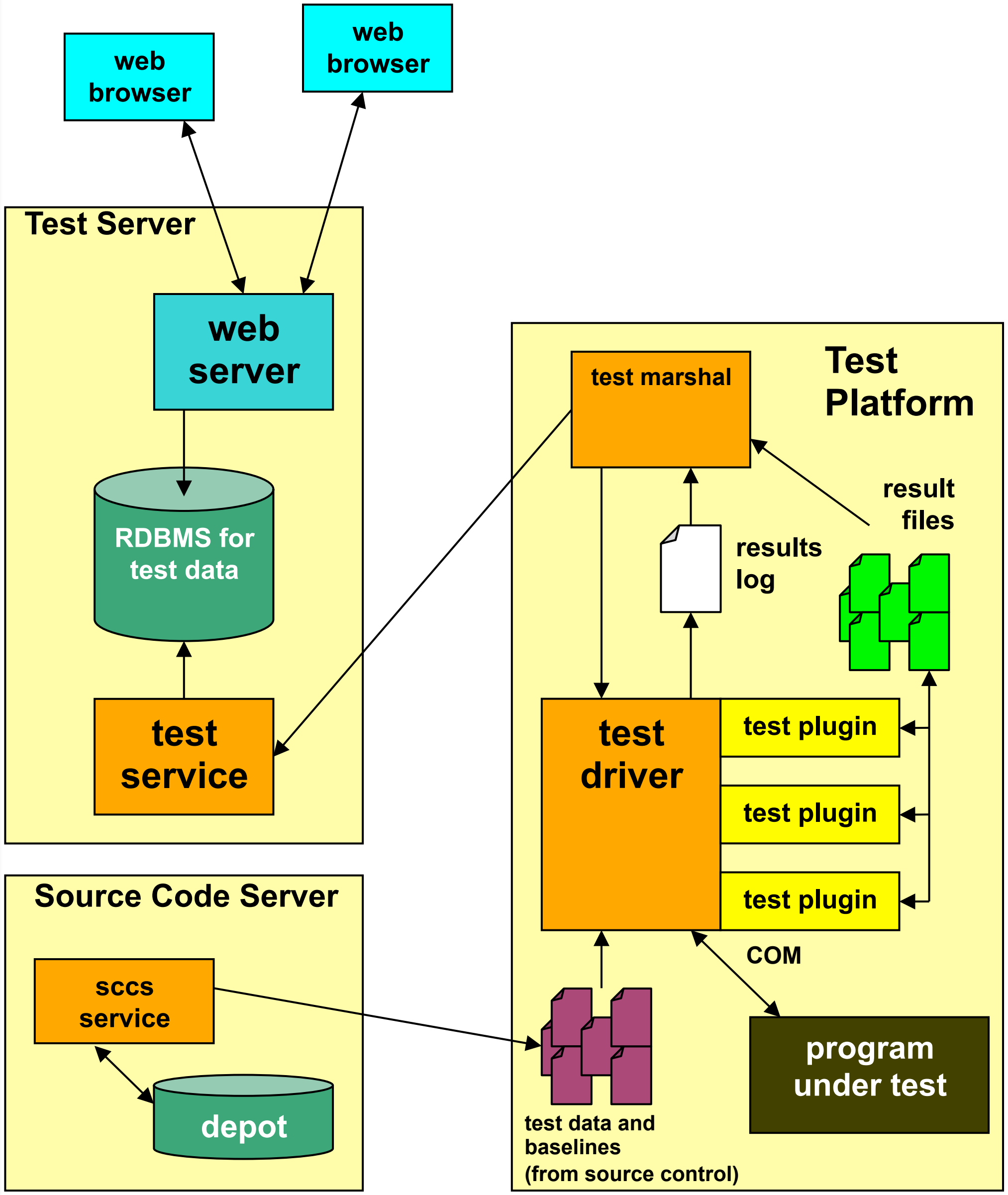
- pumps UI events at the app
- extracts results from text widgets, bitmaps, files
- problems:
  - very sensitive to changes in the GUI
  - very sensitive to changes in GUI sequencing
  - many false positives
  - costly to maintain
  - easy to drive the app, hard to see if results are correct
  - hard to get at the results
  - throw it all away if make a big gui change

testing the GUI (2)

2) architect to test at a layer just beneath the GUI

- create an a.r.t. API
- might use an embedded interpreter
  - Perl, Python, VBScript
- might hit the app from outside
  - COM
  - C/C++ API
- problems:
  - not really testing the GUI, testing something a bit different
  - coders need to develop and maintain APIs

example automated regression architecture



- execute nightly, and from dev/ test desktops
- cross-platform
- plug-ins for new types of tests
- extreme fault tolerance
  - constantly monitoring itself
  - re-start if hangs or dies
  - try last test again
  - if fails then go on
- log all actions
  - maintain history prior to a crash
- records results to an RDBMS
- records timings as well
- reports accessible via web browsers
- all test cases and baselines in source control

SaaS automated regression

- trick with SaaS is so much code is now javascript running in various browsers (not all of which behave the same way)
- open source frameworks to the rescue:
  - **Selenium**
    for recording and executing "in browser" tests
    (also has Selenium Hub for parallelizing tests)
    can output tests in a scripting language for storage.
  - **Bromine**
    for storing tests, organizing them, scheduling them, recording results, and reporting on results
- commercial services
  - **SauceLabs**
    for running Selenium instances in the cloud
    (pay per "test-minute") – Bromine integrates with SauceLabs