"The first 90% of the code accounts for the
first 90% of the development time.
The remaining 10% of the code accounts
for the other 90% of the development time."
– Tom Cargill, Bell Labs

"If debugging is the process of removing
software bugs, then programming must
be the process of putting them in."
– Edsger Dijkstra

# CISC 327
# Software Quality Assurance

## Lecture 18

## Continuous Testing

# Continuous Testing

- Today, we look at the role of testing in software maintenance, and the need for continuous testing methods
- We'll look at:
  - Software maintenance and evolution
    - Corrective, adaptive, and perfective maintenance
  - Continuous testing methods
    - Maintaining functionality, failure, operational test suites
    - Regression testing (next Thursday)

# Evolution = Software Maintenance

- Maintenance is the phase of development in which the software is in production day to day by real users
- For successful software, this is almost all of its lifetime, and the software evolves in response to observed failures and new requirements
- Usual estimate is that up to 85% of the total software effort is in maintenance
- Three kinds of maintenance:
  - Corrective, adaptive, and perfective

# Corrective Maintenance

- Corrective maintenance is concerned with fixing reported failures (errors) observed in the software
- Three varieties:
  - Coding errors: typically easy and inexpensive to correct since they are confined within one unit
  - Design errors: more expensive since they may involve changes to several units
  - Requirements errors: most expensive since they often involve extensive system redesign (re-architecting) to correct

# Adaptive Maintenance

- Adaptive maintenance involves changing the software to work in some **new environment:**
  - new platform
  - new operating system
  - new web browser
- Characterized by no change in functionality, just a move to the new environment

# Perfective Maintenance

- Implementing **new or changed functionality** due to changes in requirements
- Normally generated either by users (customers) of the software
  - e.g., need to handle a new transaction or a new kind of bank card or service
- Or by changes in the business environment the software operates in
  - e.g., changes to tax laws, new information interchange formats, competition from other businesses, etc.

# (Not an actual quiz)

- Corrective, Adaptive, Perfective?

1. switching from OS X to Windows because your former teammate, who had filibustered you into using OS X, dropped the course

# (Not an actual quiz)

- Corrective, Adaptive, Perfective?

2. realizing late yesterday that your class hierarchy was nonsensical

# (Not an actual quiz)

- Corrective, Adaptive, Perfective?

3. deciding that ctrl-C, ctrl-D, “quit”, “exit”, and “LET ME OUT” will all be valid ways to quit the Front End

# (Not an actual quiz)

- Corrective, Adaptive, Perfective?

4. fixing a bug that let anyone view a “friends only” Facebook post

# (Not an actual quiz)

- Corrective, Adaptive, Perfective?

5. fixing a bug that let anyone view a “friends only” Facebook post **if** they’re using the latest version of Firefox

# (Not an actual quiz)

- Corrective, Adaptive, Perfective?

6. adding a feature called “Friends Groups” so that changing a “Group” **retroactively** affects who can see old posts

# EVIL TIME

- A fun (or at least evil) digression...

# EVIL STORY TIME: An İ for an i

- [REDACTED], like OS X (mostly), has a **case-insensitive filesystem**
- [Demonstrate how this works on OS X]

# EVIL STORY TIME: An İ for an i

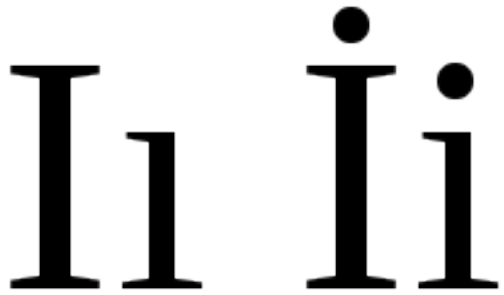
- [REDACTED], possibly unlike OS X, puts (or used to put) filenames into a **canonical form** (all caps)
- Which means there's an OS-level function to make a string all caps

# What could possibly go wrong?

- At some point, [REDACTED] started supporting “non-Western writing systems”, including Turkish
- Turkish has its own alphabet, which is mostly the Latin alphabet but not quite...

# What could possibly go wrong?

- Turkish has **two** letters similar to the Latin ‘i’:



- The **capital dotless letter** is represented perfectly well by the Latin capital I (ASCII 73)
- The **lowercase dotted letter** is represented perfectly well by the Latin lowercase i (ASCII 105)
- However, there is no room in ASCII, or even in the 8-bit space, for the other Turkish letters

# What could possibly go wrong?

- So, you need to use an extended character set with more space, which needs 2 bytes rather than 1 byte...
- What happens when you *correctly* make a string “canonical”, by making it all caps, the string consists only of ASCII 105 (‘i’), and the [REDACTED] OS “locale” is set to Turkey?

# EVIL STORY TIME

“And they all buffer-overflowed happily ever after.

“Now go to sleep.”

# Maintenance Testing

- In practice, about 65-70% of maintenance is perfective, 15-20% adaptive, and 15-20% corrective
- In all three cases, but particularly for perfective maintenance, the biggest risk associated with maintenance is that some existing functionality is broken by the changes
- This is understandable - software typically has complex and intricate relationships between parts, so changing any one part often runs the risk of unexpected effects on the rest

# Maintenance Testing

- Moreover, as time goes on, the software is often maintained by programmers not involved in the original design and development
  - More focussed on the changes than the whole product
- For this reason, testing has an even more important role in quality assurance in the maintenance phase than it does in initial development and delivery
  - Helps to make sure that changes have not broken anything

# Continuous Testing Methods

- Testing as a Maintenance Activity
  - Thus testing is not a one-time thing - we're never "done" testing
  - As software is maintained, if we are to maintain consistent quality, we must continue testing:
    both the **old** existing functionality,
    and the **new** introduced functionality
  - Hence, XP calls for continuous testing (“every day”)
  - At a minimum, we must re-test thoroughly after every set of changes, before the changed software is released

# Test Suites

- Most projects maintain test suites, sets of tests to be run on every release of the software
- Maintained in parallel with the software - often at least as much effort as coding the software itself!
  - As we have already seen, automation is essential to make this practical

# Kinds of Test Suites

- Three related kinds of continuous tests are normally performed and maintained continuously in software maintenance
- Functionality (or acceptance) tests, failure tests, and operational tests

# Continuous Functionality Testing

- We have already seen functionality and acceptance testing suites (you've built one!)
- When used continuously over the evolution of the software, we maintain the functionality tests by:
  - Add a new feature ⇒ add new tests for that feature
  - Recall that in XP, we must have these new tests, since they form the specification for the new software capabilities
  - Every time a feature is changed or extended, we change/extend the corresponding functionality tests

# Failure Suites

- Failure tests are suites of examples that have been observed to cause a failure of the software in the past
- To be effective, failure tests must be maintained over the evolution of the software by:
  - Before correcting any observed failure, create a "failure test" that causes it
  - Becomes the specification of the fix - the changed software must at a minimum correct the error for the test
  - The failure test must cause the error in the old software and not cause the error in the new software
- All these tests go in a failure test suite, re-run on all future versions of the software to ensure that the failure doesn't reappear

# Operational Testing

- There's No Substitute for the Real Thing
  - Operational tests are **actual production runs** observed in the use of the software
    - e.g., for a banking Front End, all of the transactions done at one or more bank terminals over a whole real day of operation
    - e.g., for a banking Back Office, all of the Transaction Summary Files from a set of real front ends

# Operational Testing

- There's No Substitute for the Real Thing
  - Operational test suites must be created early in the production life by sampling actual production runs
    - e.g., instrumenting a bank machine to capture the actual transactions from customers over a day
  - Must be updated to add new real operational tests each time significant new or changed features are added to the software
  - These tests form a sanity check on the software to make sure that when we are about to release a new version, it will not only still run our artificial tests but will also still handle real customer input
    - Could be embarrassing otherwise!

# Regression Testing

- Comprehensive Continuous Testing
  - Regression testing: an automated continuous testing strategy, whose purpose is to make sure that the software does not "regress" - that is, become less effective than it has been in the past
  - Regression test suites are normally comprehensive, including three major components
    - Functionality tests, failure tests, operational tests

# Regression Testing

- Comprehensive Continuous Testing
  - Functionality tests, to make sure that we still meet the basic requirements
  - Failure tests, to make sure that we haven't recreated a past failure
  - Operational tests, to make sure that we can still process real production runs
  - Each of these is maintained, either together or separately, as previously described

# Summary

- Continuous Testing
  - Software maintenance, consisting of corrective, adaptive, and perfective steps, is the longest phase of software development
  - Continuous testing is essential to maintain quality during software maintenance
  - Regression testing combines functionality, failure, and operational testing in an automated continuous testing framework
- Reference: Sommerville Ch. 8

# Next Time

- Mini-Exam #2 is on Monday, Oct. 22nd
- Next lecture
  - Practical regression testing