CMPT 473
Software Quality Assurance

Regression Testing

Nick Sumner
The Story So Far

- We have seen how to measure the quality of software
The Story So Far

• We have seen how to measure the quality of software (and even improve it a bit)
The Story So Far

• We have seen how to measure the quality of software
  – Establish quality requirements
The Story So Far

• We have seen how to measure the quality of software
  – Establish quality requirements
  – Build a test suite
The Story So Far

• We have seen how to measure the quality of software
  – Establish quality requirements
  – Build a test suite
  – Run it to identify missed requirements

Requirements  Tests  Results
The Story So Far

• We have seen how to measure the quality of software
  – Establish quality requirements
  – Build a test suite
  – Run it to identify missed requirements

• Are the quality requirements in real software static/fixed?
The Story So Far

• We have seen how to measure the quality of software
  – Establish quality requirements
  – Build a test suite
  – Run it to identify missed requirements
• Are the quality requirements in real software static/fixed?
• Software evolves
The Story So Far

- We have seen how to measure the quality of software
  - Establish quality requirements
  - Build a test suite
  - Run it to identify missed requirements

- Are the quality requirements in real software static/fixed?

- Software evolves
  - The testing process should support and facilitate change
Regression Testing

- Regression Testing

What is it?
Regression Testing

- Regression Testing
  - Retesting software as it evolves to ensure previous functionality
Regression Testing

- Regression Testing
  - Retesting software as it evolves to ensure previous functionality
- Useful as a tool for ratcheting software quality
Regression Testing

- *Regression Testing*
  - Retesting software as it evolves to ensure previous functionality
- Useful as a tool for *ratcheting* software quality

What is a ratchet?
Regression Testing

• *Regression Testing*
  – Retesting software as it evolves to ensure previous functionality

• Useful as a tool for *ratcheting* software quality

What is a ratchet?
Regression Testing

- *Regression Testing*
  - Retesting software as it evolves to ensure previous functionality
- Useful as a tool for *ratcheting* software quality
- Regression tests further enable making changes
Why Use Regression Testing

- As software evolves, previously working functionality can fail.
Why Use Regression Testing

• As software evolves, previously working functionality can fail
  – Software is complex & interconnected.
Why Use Regression Testing

- As software evolves, previously working functionality can fail
  - Software is complex & interconnected.
  - Changing one component can unintentionally impact another.
Why Use Regression Testing

- As software evolves, previously working functionality can fail
  - Software is complex & interconnected.
  - Changing one component can unintentionally impact another.

```cpp
Contents
parseFile(std::path& p) {
    ...
    auto header = parseHeader(...);
    ...
}
```
Why Use Regression Testing

- As software evolves, previously working functionality can fail
  - Software is complex & interconnected.
  - Changing one component can unintentionally impact another.

```cpp
header parseHeader(std::ifstream& in) {
  ...
}
```

```cpp
contents parseFile(std::path& p) {
  ...
  auto header = parseHeader(...);
  ...
}
```
Why Use Regression Testing

- As software evolves, previously working functionality can fail
  - Software is complex & interconnected.
  - Changing one component can unintentionally impact another.

```cpp
Header
parseHeader(std::ifstream& in) {
    ...
}

Contents
parseFile(std::path& p) {
    ...
    auto header = parseHeader(...);
    ...
}
```
Why Use Regression Testing

• As software evolves, previously working functionality can fail
  – Software is complex & interconnected.
  – Changing one component can unintentionally impact another.
  – New environments can introduce unexpected behavior in components that originally work.
Why Use Regression Testing

- As software evolves, previously working functionality can fail
  - Software is complex & interconnected.
  - Changing one component can unintentionally impact another.
  - New environments can introduce unexpected behavior in components that originally work.

- Most testing is regression testing
Why Use Regression Testing

- As software evolves, previously working functionality can fail
  - Software is complex & interconnected.
  - Changing one component can unintentionally impact another.
  - New environments can introduce unexpected behavior in components that originally work.
- Most testing is regression testing
- Ensuring previous functionality can require large test suites. Are they always realistic?
Why Use Regression Testing

- As software evolves, previously working functionality can fail
  - Software is complex & interconnected.
  - Changing one component can unintentionally impact another.
  - New environments can introduce unexpected behavior in components that originally work.
- Most testing is regression testing
- Ensuring previous functionality can require large test suites. Are they always realistic?

How often did you run regression tests in co-ops/internships?
What Is A Regression Test Suite

• Three common components for regression suites:
What Is A Regression Test Suite

• Three common components for regression suites:
  – Tests for previously fixed bugs
What Is A Regression Test Suite

• Three common components for regression suites:
  – Tests for previously fixed bugs
    • Some components are bug prone
    • Helps to identify when previous fixes were inadequate.
What Is A Regression Test Suite

• Three common components for regression suites:
  – Tests for previously fixed bugs
    • Some components are bug prone
    • Helps to identify when previous fixes were inadequate.
  – Unit tests
What Is A Regression Test Suite

• Three common components for regression suites:
  – Tests for previously fixed bugs
    • Some components are bug prone
    • Helps to identify when previous fixes were inadequate.
  – Unit tests
    • Especially useful for refactoring
What Is A Regression Test Suite

• Three common components for regression suites:
  – Tests for previously fixed bugs
    • Some components are bug prone
    • Helps to identify when previous fixes were inadequate.
  – Unit tests
    • Especially useful for refactoring
  – General system tests
What Is A Regression Test Suite

- Three common components for regression suites:
  - Tests for previously fixed bugs
    - Some components are bug prone
    - Helps to identify when previous fixes were inadequate.
  - Unit tests
    - Especially useful for refactoring
  - General system tests

- Regression tests are usually a selected subset of tests generated for other purposes.
Regression Testing In Practice

- Too many & too frequent to do by hand
  - Automate it:
    - e.g. JUnit suites, commit hooks, nightlies
Regression Testing In Practice

• Too many & too frequent to do by hand
  – Automate it:
    e.g. JUnit suites, commit hooks, nightlies

• Over time, regression suites grow even larger
  – Cannot run every time you commit
  – Cannot run every night
Regression Testing In Practice

- Too many & too frequent to do by hand
  - Automate it:
    e.g. JUnit suites, commit hooks, nightlies
- Over time, regression suites grow even larger
  - Cannot run every time you commit
  - Cannot run every night
- Can grow the test bed as well, but that costs $ as well...
Regression Testing In Practice

• Too many & too frequent to do by hand
  – Automate it:
    e.g. JUnit suites, commit hooks, nightlies

• Over time, regression suites grow even larger
  – Cannot run every time you commit
  – Cannot run every night

• Can grow the test bed as well, but that costs $ as well...

How else can we address this problem?
Limiting Regression Suites

- Be careful not to add redundant test to the test suite.
Limiting Regression Suites

- Be careful not to add redundant test to the test suite.
  - Every bug may indicate a useful behavior to test
  - Test adequacy criteria can limit the other tests
Limiting Regression Suites

• Be careful not to add redundant test to the test suite.
  – Every bug may indicate a useful behavior to test
  – Test adequacy criteria can limit the other tests

But this is more or less where we started...
Limiting Regression Suites

• Be careful not to add redundant test to the test suite.
  – Every bug may indicate a useful behavior to test
  – Test adequacy criteria can limit the other tests
• Sometimes not all tests need to run with each commit
Limiting Regression Suites

- Be careful not to add redundant test to the test suite.
  - Every bug may indicate a useful behavior to test
  - Test adequacy criteria can limit the other tests

- Sometimes not all tests need to run with each commit
  - Run a subset of sanity or *smoke tests* for commits
Limiting Regression Suites

- Be careful not to add redundant test to the test suite.
  - Every bug may indicate a useful behavior to test
  - Test adequacy criteria can limit the other tests
- Sometimes not all tests need to run with each commit
  - Run a subset of sanity or *smoke tests* for commits
    
    These mostly validate the build process & core behaviors.
Limiting Regression Suites

- Be careful not to add redundant test to the test suite.
  - Every bug may indicate a useful behavior to test
  - Test adequacy criteria can limit the other tests
- Sometimes not all tests need to run with each commit
  - Run a subset of sanity or *smoke tests* for commits
  - Run more thorough tests nightly
Limiting Regression Suites

- Be careful not to add redundant test to the test suite.
  - Every bug may indicate a useful behavior to test
  - Test adequacy criteria can limit the other tests

- Sometimes not all tests need to run with each commit
  - Run a subset of sanity or smoke tests for commits
  - Run more thorough tests nightly
  - “ ” weekly
  - “ ” preparing for milestones/integration
Limiting Regression Testing

- Can we be smarter about which test we run & when?

What else could we do?
Limiting Regression Testing

- Can we be smarter about which test we run & when?
- **Change Impact Analysis**
  - Identify how changes affect the rest of software
Limiting Regression Testing

• Can we be smarter about which test we run & when?

• Change Impact Analysis
  – Identify how changes affect the rest of software

• Can decide which tests to run on demand
Limiting Regression Testing

- Can we be smarter about which test we run & when?
- **Change Impact Analysis**
  - Identify how changes affect the rest of software
- Can decide which tests to run on demand
  - **Conservative**: run all tests
  - **Cheap**: run tests with test requirements directly related to the changed lines
Limiting Regression Testing

- Can we be smarter about which test we run & when?

- **Change Impact Analysis**
  - Identify how changes affect the rest of software

- Can decide which tests to run on demand
  - **Conservative**: run all tests
  - **Cheap**: run tests with test requirements directly related to the changed lines

  Is the cheap approach enough?
Limiting Regression Testing

• Can we be smarter about which test we run & when?

• Change Impact Analysis
  – Identify how changes affect the rest of software

• Can decide which tests to run on demand
  – **Conservative**: run all tests
  – **Cheap**: run tests with test requirements directly related to the changed lines
  – **Middle ground**: Run those tests affected by how changes propagate through the software?
Limiting Regression Testing

- Can we be smarter about which test we run & when?

- Change Impact Analysis
  - Identify how changes affect the rest of software

- Can decide which tests to run on demand
  - Conservative: run all tests
  - Cheap: run tests with test requirements directly related to the changed lines
  - Middle ground: Run those tests affected by how changes propagate through the software?

In practice, tools can assist in finding out which tests need to be run.
Failure

- Eventually, tests will fail. What do you do?
Failure

- Eventually, tests will fail. What do you do?

  Honestly. What do you do? We are no longer *measuring* quality.
Failure

- Eventually, tests will fail. What do you do?
  - It depends...
Failure

- Eventually, tests will fail. What do you do?
  - It depends...
- If the new and old versions should be equivalent:

  Why might this happen?
Failure

- Eventually, tests will fail. What do you do?
  - It depends...

- If the new and old versions should be equivalent:
  - A failing tests indicates misbehavior to correct
Failure

• Eventually, tests will fail. What do you do?
  – It depends...

• If the new and old versions should be equivalent:
  – A failing tests indicates misbehavior to correct

This yields the ratcheting power of regression tests!
Failure

- Eventually, tests will fail. What do you do?
  - It depends...
- If the new and old versions should be equivalent:
  - A failing tests indicates misbehavior to correct
- Otherwise:
Failure

• Eventually, tests will fail. What do you do?
  – It depends...

• If the new and old versions should be equivalent:
  – A failing tests indicates misbehavior to correct

• Otherwise: (at least one of)
  – The software has a bug to fix
Failure

- Eventually, tests will fail. What do you do?
  - It depends...
- If the new and old versions should be equivalent:
  - A failing tests indicates misbehavior to correct
- Otherwise: (at least one of)
  - The software has a bug to fix
  - Test inputs are stale and must be fixed
Failure

• Eventually, tests will fail. What do you do?
  – It depends...

• If the new and old versions should be equivalent:
  – A failing tests indicates misbehavior to correct

• Otherwise: (at least one of)
  – The software has a bug to fix
  – Test inputs are stale and must be fixed
  – The expected behavior has changed & must be fixed

Input → Program → Output
Failure

• Eventually, tests will fail. What do you do?
  – It depends...

• If the new and old versions should be equivalent:
  – A failing tests indicates misbehavior to correct

• Otherwise:
  – The software has a bug to fix
  – Test inputs may have changed, so test fixes should be fixed
  – The expected behavior has changed & must be fixed

Keeping these cases separate is important. How can we do that?
Failure

- Eventually, tests will fail. What do you do?
  - It depends...
- If the new and old versions should be equivalent:
  - A failing tests indicates misbehavior to correct
- Otherwise:
  - The software has a bug to fix
  - Test inputs are stale and must be fixed
  - The expected behavior has changed & must be fixed
- Maintaining regression tests is costly
Burdens

Burdens of scale
Burdens

Burdens of scale

- Running the tests
Burdens

Burdens of scale

- Running the tests
- Interpreting the results
Burdens of scale

- Running the tests
- Interpreting the results
- Updating tests
Burdens

Burdens of scale

• Running the tests
• Interpreting the results
• Updating tests
• Adding new tests
Burdens

Burdens of scale

- Running the tests
- Interpreting the results
- Updating tests
- Adding new tests

Addressing these burdens is a major focus of automated testing and testability
Summary

- **Regression testing** retests software to ensure previous functionality.
Summary

- Regression testing retests software to ensure previous functionality.
- It increases the confidence of refactoring & supports ratcheting software quality
Summary

- Regression testing retests software to ensure previous functionality.
- It increases the confidence of refactoring & supports ratcheting software quality
- The major trade-off comes from the scale of the regression test suite.
Summary

- Regression testing retests software to ensure previous functionality.
- It increases the confidence of refactoring & supports ratcheting software quality.
- The major trade-off comes from the scale of the regression test suite.
  - Judgment on making trade-offs for regression testing are important for lowering costs.
Summary

- Regression testing retests software to ensure previous functionality.
- It increases the confidence of refactoring & supports ratcheting software quality.
- The major trade-off comes from the scale of the regression test suite.
  - Judgment on making trade-offs for regression testing are important for lowering costs.
  - You may remove tests from the regression suite over time.
Summary

- Regression testing retests software to ensure previous functionality.
- It increases the confidence of refactoring & supports ratcheting software quality.
- The major trade-off comes from the scale of the regression test suite.
  - Judgment on making trade-offs for regression testing are important for lowering costs.
  - You may remove tests from the regression suite over time.

We may also look at techniques for generalizing unit tests to find new bugs...