CMPT 473
Software Quality Assurance

Debugging

Nick Sumner
wsumner@sfu.ca
Debugging

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  – Handling bugs during execution
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  - Submitting effective bug reports
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  - Bug triage and management
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- Debugging involves 2 keys issues
  - *Understanding* why a program misbehaves
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  – Understanding *why* a program misbehaves
  – Correcting the behavior
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Anecdotally, the people I see who are best at debugging are also the best programmers.
Antipatterns in debugging

- Blaming the computer immediately
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  - Even if the computer is at fault, you don’t know
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  - Is systematic
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  - Is systematic
  - Progressively hones in on the source of misbehavior
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Good debugging involves investigation.
Understanding bugs is an investigation

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   - The comments may not be correct
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2) Reproduce the bug (preferably deterministically!)
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1) Start by foregoing assumptions
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3) Ask: Why did the code produce the wrong behavior?
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2) Reproduce the bug

3) Ask: Why did the code produce the wrong behavior?
   - Read the code
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2) Reproduce the bug

3) Ask: Why did the code produce the wrong behavior?
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   - Think of several possibilities
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How can you identify the possible causes?
Can you write code to help?
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3) Ask: Why did the code produce the wrong behavior?
   - Read the code
   - Think of several possibilities
   - Each is a *hypothesis* about the buggy behavior
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4) Rank the hypotheses
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4) Rank the hypotheses
   – How easy are they to eliminate?
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5) Try to disprove each hypothesis
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5) Try to disprove each hypothesis
   - Collect more information & update your list as you go
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This should sound very familiar. Why?
The scientific method

- Understanding a bug is a scientific investigation

Ask a question
The scientific method

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Ask a question → Collect initial information
The scientific method

- Understanding a bug is a scientific investigation

Ask a question → Collect initial information → Hypothesize
The scientific method

- Understanding a bug is a scientific investigation

1. Ask a question
2. Collect initial information
3. Hypothesize
4. Test a hypothesis
The scientific method

- Understanding a bug is a scientific investigation

1. Ask a question
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4. Test a hypothesis
5. Analyze the results
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Ask a question ➔ Collect initial information ➔ Hypothesize ➔ Test a hypothesis ➔ Analyze the results ➔ Hypothesize ➔...
The scientific method

- Understanding a bug is a scientific investigation

1. Ask a question
2. Collect initial information
3. Hypothesize
4. Test a hypothesis
5. Analyze the results
6. Act on outcomes
The scientific method

- Understanding a bug is a scientific investigation

Ask a question ➔ Collect initial information ➔ Hypothesize ➔ Test a hypothesis ➔ Analyze the results ➔ Act on outcomes

All built on a foundation of skepticism
Debuggers

- Interactive debuggers are a key part of the investigation
  - Built into an IDE (like MSVC) or external (like GDB)
- Common set of features helps with
  - Fact finding
  - Identifying possible causes
  - Testing the causes as hypotheses
- We will use GDB as a driving example
Common Features

Basic commands for exploring

- Running
- Breakpoints
- Stepping
- Continuing
- Backtraces
Common Features

Basic commands for investigation

- Printing state
- Calling functions
  - Designing for debugging
- Changing state and continuing (hypothesis testing)
- Watchpoints
GDB Specifics

- TUI Mode
GDB Specifics

- Built in Python interpreter
  - Defining your own GDB commands
  - Programmatic breakpoint manipulation
Reverse Execution

- Available in GDB, MSVC, Mozilla RR, ...
- Mozilla RR (record & replay based debugging)
  - Records behavior to a trace file
  - Allows deterministic replay of the same execution
  - The trace may even be shared across computers
  - System design enables running an execution backward
Reverse Execution

- Reverse stepping
- Reverse continue
- Interacting with watchpoints & breakpoints

[Demo]
Debugging

- Follow a methodical process
- Hone in on the actual buggy behavior
- Make the most of your investigative tools.