Reproducing Field Failures

Daikon assignment

- Submission is now closed.
- Any problems?
- What was hard?
- How do you think you can use Daikon in your work and research?

Research Presentations and Proposal

- Due next Monday
- Who is thinking of presenting a research idea?
- Let's talk about generating ideas

Generating research ideas

- Read a paper
- Think about what's hard in your work
- Browse software engineering professors' webpages
  - skim a few of their papers
- Talk to me and I can help generate ideas

Key things to identify…

- When you read a paper
- When you listen to a lecture
- When you present a paper
- When you think of research ideas:

What is the scientific question?
What's the key new idea that allows answering it?
How do you measure the success of the answer?

Lab Failures

When you are developing a piece of software, and you run it, use it, and it fails, what do you do to debug it?

Field Failures

After you have shipped a piece of software, and a user runs it, uses it, and it fails, what can the developer do to debug it?

Let's try something

Describe for me a time your software failed.

Now describe it for me as your grandpa would.

Problems with Field Failures

- Users skip details
- Users describe what went wrong, not what they did
- Users aren't programmers, so they don't know what's important
- Even if the users are programmers, they didn't build system ➔ don't know what's important

What's worse than a user who doesn't know what's important to report?

A user who "figured out" the system, understand exactly what the system must be doing, and is telling you his or her inferences, not observable effects.

How do we deal with field failures?

- We could record everything that happens at runtime, ship it back to developers.

What's wrong with this?

How do we deal with field failures?

- For privacy, only send stuff when something goes wrong.

What's wrong with this?

How do we deal with field failures?

- Anonymize inputs?
- Record sparingly?
- Deduce stuff locally?
- Find alternate inputs that lead to the same bug?

Let's back up

- Why worry about field failures?
  - Testing is great, but you can't catch everything
  - Software ships with bugs all the time
- Why are field failures hard to debug?
  - You don't know the circumstances
  - The environment (other installations, etc.) may play a role
  - Can't rely on the user

Goals

- Capture the steps necessary to replicate a bug
- Generate a test case automatically
- No effort from user

There are some existing techniques RecrashJ

- Monitor a running JVM, record inputs, method invocations
- If an exception is uncaught, write down the test case that generated it
- Privacy issues, 20X overhead (sometimes), deep call stacks cause problems

There are some existing techniques Scarpe

- Isolate subsystems and monitor what flows in and what flows out
- Replay exceptions, but only within a subsystem
- Faster but still 20X overhead, hasn't been evaluated very well

There are some existing techniques BugRedux

- Use symbolic execution to guide test generation
- Observe an execution, record constraints that get you down a path. When an exception happens, figure out a different input that would follow the same path
- Better for privacy, but constraint logging has to be detailed (and slow) or input reconstruction won't work + symbolic execution scales poorly

Chronicler

Key idea: deterministic parts of the program are easy to recreate. It's the nondeterminism that causes many bugs.

Nondeterminism: output dependence on factors other than initial program state and input

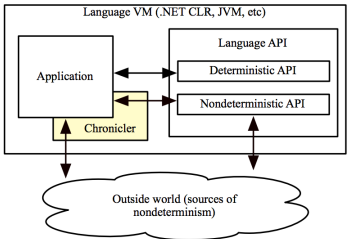
What are some nondeterminism examples?

So what kinds of things do we need to watch?

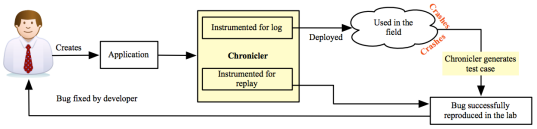
- User input (we'll call that nondeterminism)
  - file.read()
  - buf.readLine()
  - etc.
- Native calls
  - System.currentTimeMillis()
  - Random()
  - etc.

How does Chronicler capture nondeterminism?

Wrap the VM and log at a higher level



How to use Chronicler



Some implementation details

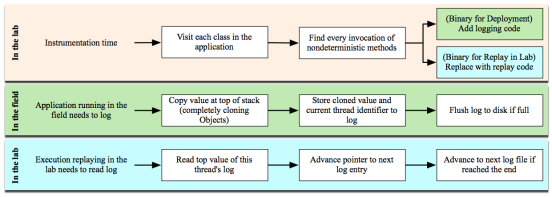
- Scan the API
  - Mark all system methods as nondeterministic
  - Mark anything that calls those as nondeterministic
  - And propagate the nondeterministic upward
- Record and Replay
  - Instrument bytecode to record results of nondeterministic method calls
  - When replaying, simply insert recorded values
  - Can even work for GUI events (e.g., swing)

What can this log?

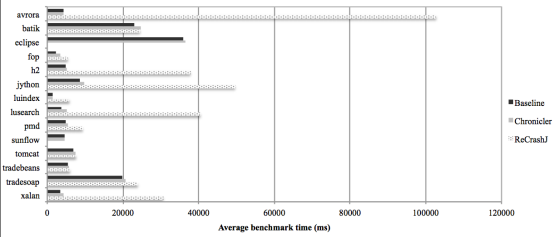
- Nondeterministic event dispatching, (some) thread switches, GUI events, randomness
- If log gets too big, flush it to a file on disk

When do you write out a test to deliver to the developer?

Implementation strategy



Performance (Dacapo benchmark)



What are some Chronicler weaknesses?

- privacy is not addressed
- some threads and processes are not recorded
- Java can do some crazy things, like mutate its own method's parameters and use reflection to redefine a method at runtime

Let's identify the 3 keys

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What's the key new idea that allows answering it?

How do you measure the success of the answer?

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- How to replay field bugs in the lab

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What's the key new idea that allows answering it?

- Recoding all nondeterminism

How do you measure the success of the answer?

- Measure overhead
- Use it to find real bugs

Brainstorm crazy research ideas