Fast and deterministic system tests

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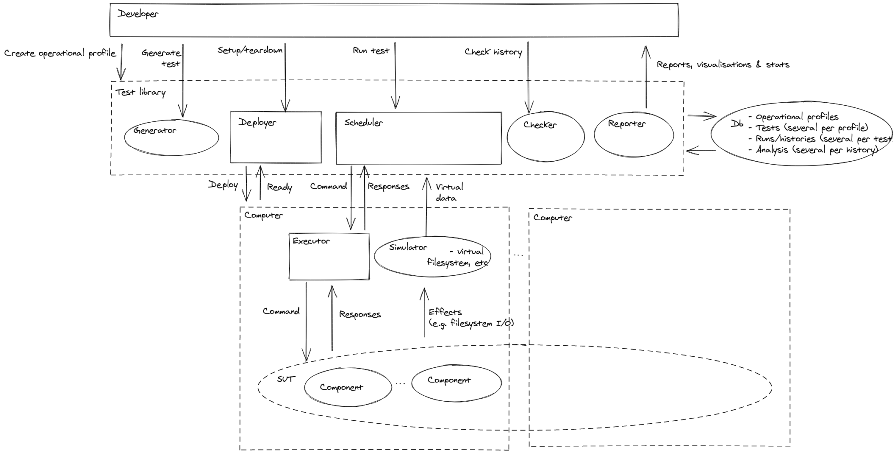
The problem

System tests, in general, are:

- Non-deterministic
  - Running the same test twice can yield different outcomes, esp. around fault-injection;
- Ill-specified or provide weak guarantees
  - What exactly have we shown if the tests pass?
- Ephemeral
  - Can't test performance over time;
  - Can't test upgrades, or backup and restore;
- Language specific
  - Test libraries/frameworks/tools are programming language specific, while the components of systems under test are written in different languages.

Parts of the solution

- Generator: generates random test cases;
- Scheduler: determinstically controls the network traffic during the test;
- Executor: receives messages from the scheduler and executes them against the system under test (SUT);
- Injector: figures out which faults to inject;
- Checker: analyses the output of a test case execution and determines if it was a success or not.


Developer
Create operational profile
Generate test
Setup/teardown
Run test
Check history
Reports, visualisations & stats
Test library
Generator
Deployer
Scheduler
Checker
Reporter
Db
- Operational profiles
- Tests (several per profile)
- Runs/histories (several per test
- Analysis (several per history)
Deploy
Ready
Command
Responses
Virtual data
Computer
Executor
Simulator
- virtual filesystem, etc
Computer
Command
Responses
Effects (e.g. filesystem I/O)
SUT
Component
Component

Solution for non-determinism

- SUT is assumed to be written on reactor form, i.e. given a message and some state, produce a set of messages;
- All messages get set via the Scheduler which randomly, but deterministically using a seed, determines the arrival order of the messages;
- Timeouts and retires are handled by explicit tick messages, that are also deterministically sent by the Scheduler.

Language agnostic solution

- In between the SUT and the Scheduler sits the Executor, whose job is to receive messages from the Scheduler via an http interface and pass them on to the SUT;
- The Executor is written in the same language as the SUT, so once it got the message via http it decodes the message from JSON into a datastructure in the native language and does a simple function call to the the SUT;
- Porting an Executor to a new programming language is simple, which means it's easy to test systems written using many languages.

Solution to ill-specified guarantees

- The Checker component uses Jepsen's state-of-the-art Elle checker, which provides precise models and guarentees;
- Lineage-driven fault injection is used to give guarantees in the presence faults;
- Operational profiles/usage models will later be used to drive test case generation, and guarantee system test coverage.

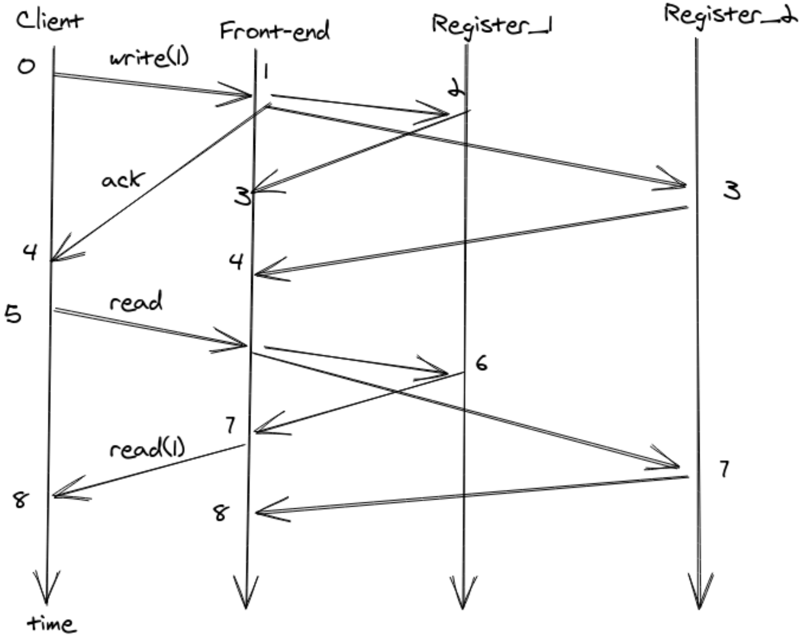
Solution to long-lived testing

- Every interaction that the developer can do, e.g. generation, execution, checking, can be done in isolation because the input and output comes and goes via a database;
- The above in combination with determinism means that we can replay an old test and bring the system to the state it was in at the end of a test, we can then extend the test can carry on from there.

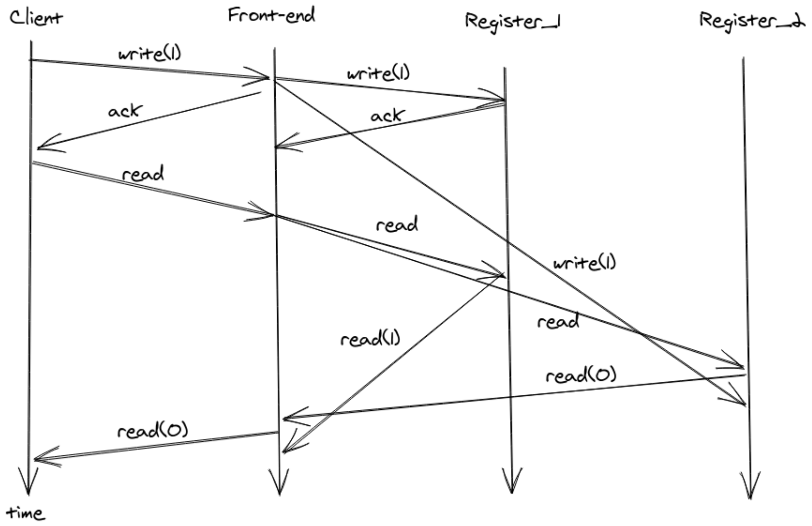
Demo: the SUT

- The example SUT is a integer-valued shared/distributed register;
- Any number of clients can write or read an integer from the register;
- The register is replicated to try to achieve fault tolerance.

Demo: shared register v1, success



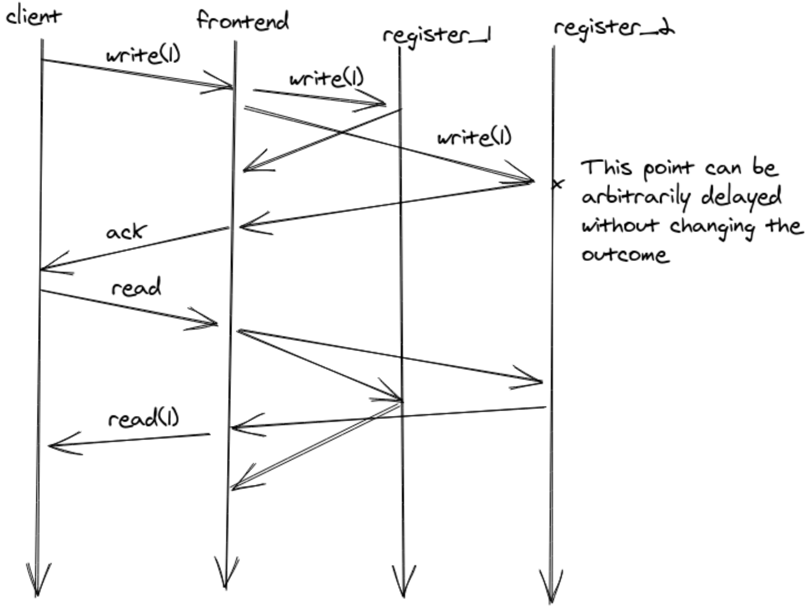
Demo: shared register v1, counterexample



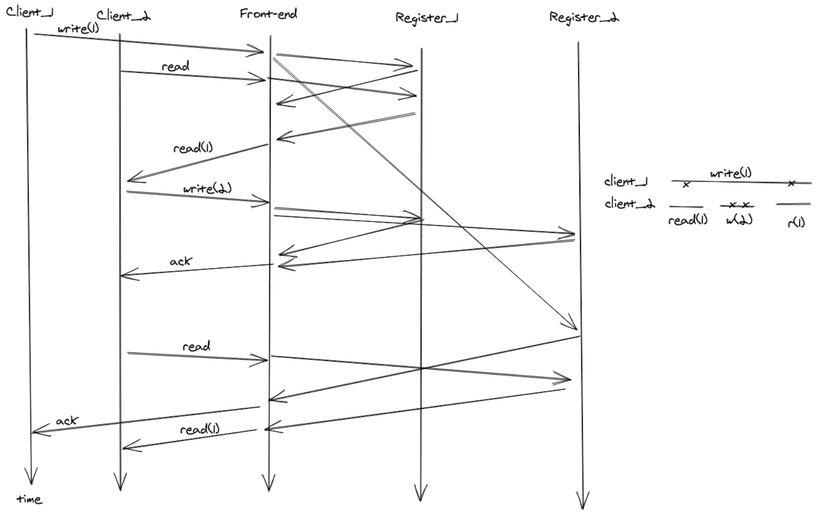
Demo: the testsuite of the SUT

- Show the code of `detsys/sut/register_test.go`;
- `go test`;
- Ensure that we find the problem.

Example: shared register v2, success



Example: shared register v2, counterexample



Bonus: How does the Elle checker work?

Bonus: How does lineage-driven fault injection work?

Future work (next release)

- Regression tests
- Integration with Sean's work

Questions?