KUnit - Unit Testing for the Linux Kernel

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Who am I?

- Brendan Higgins <brendanhiggins@google.com>
- I work at Google
- Previously I worked on
  - server bringup at Google
  - OpenBMC

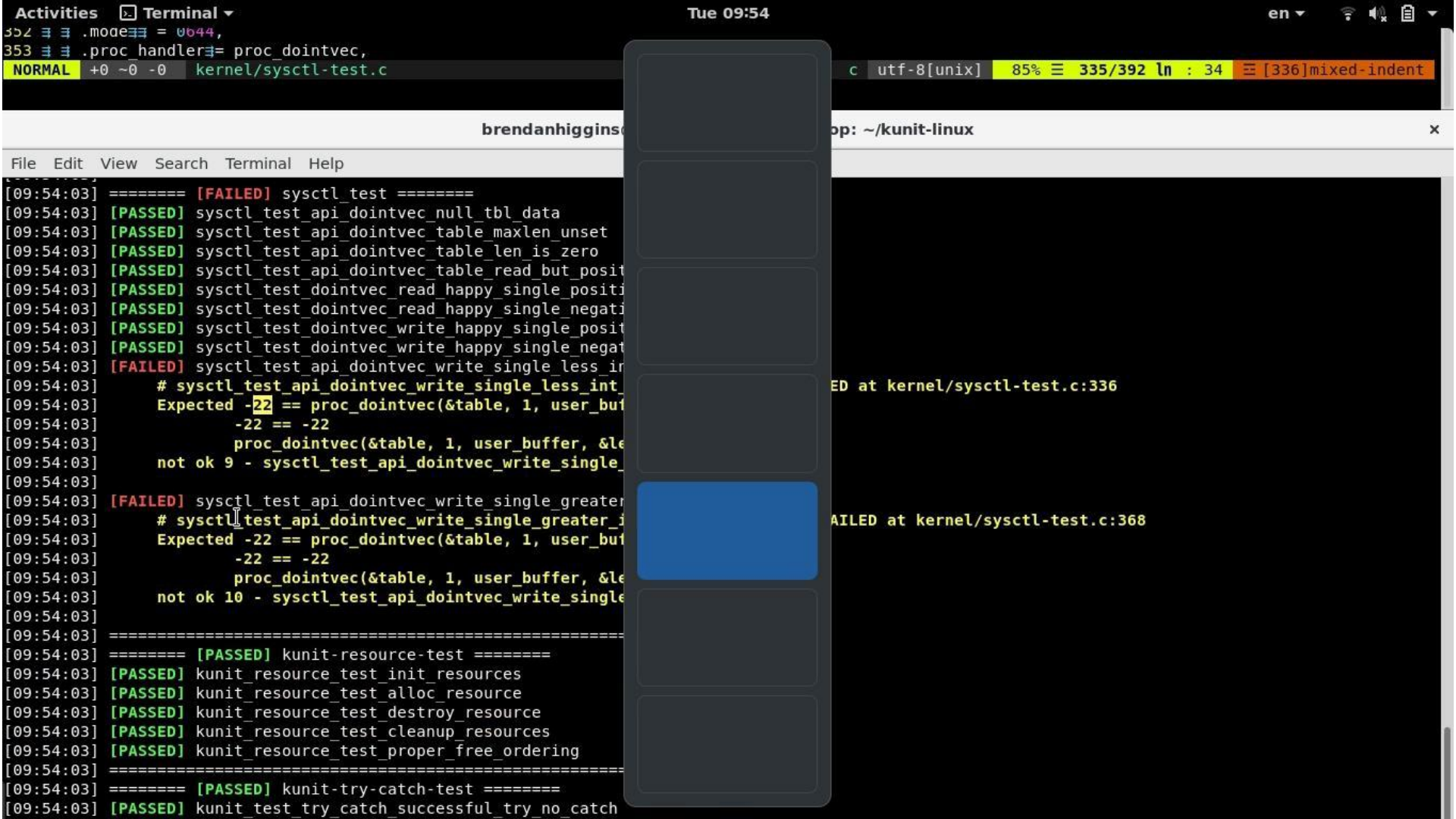
Please interrupt me!

- This talk is for you!
- I hate slide decks, so mine aren’t usually very good.

Why Unit Testing, Why KUnit?

Why Unit Testing, Why KUnit?

- I will let it speak for itself…
- (Demo time)


Activities
Terminal
Tue 09:54
en
.mode = 0644,
.proc_handler= proc_dointvec,
NORMAL +0 ~0 -0 kernel/sysctl-test.c
c utf-8[unix] 85% 335/392 ln : 34 [336]mixed-indent
brendanhiggins
op: ~/kunit-linux
File Edit View Search Terminal Help
[09:54:03] ======== [FAILED] sysctl_test ========
[09:54:03] [PASSED] sysctl_test_api_dointvec_null_tbl_data
[09:54:03] [PASSED] sysctl_test_api_dointvec_table_maxlen_unset
[09:54:03] [PASSED] sysctl_test_api_dointvec_table_len_is_zero
[09:54:03] [PASSED] sysctl_test_api_dointvec_table_read_but_posit
[09:54:03] [PASSED] sysctl_test_dointvec_read_happy_single_positi
[09:54:03] [PASSED] sysctl_test_dointvec_read_happy_single_negati
[09:54:03] [PASSED] sysctl_test_dointvec_write_happy_single_posit
[09:54:03] [PASSED] sysctl_test_dointvec_write_happy_single_negat
[09:54:03] [FAILED] sysctl_test_api_dointvec_write_single_less_in
[09:54:03] # sysctl_test_api_dointvec_write_single_less_int_
ED at kernel/sysctl-test.c:336
[09:54:03] Expected -22 == proc_dointvec(&table, 1, user_buf
[09:54:03] -22 == -22
[09:54:03] proc_dointvec(&table, 1, user_buffer, &le
[09:54:03] not ok 9 - sysctl_test_api_dointvec_write_single_
[09:54:03]
[09:54:03] [FAILED] sysctl_test_api_dointvec_write_single_greater
[09:54:03] # sysctl_test_api_dointvec_write_single_greater_i
AILED at kernel/sysctl-test.c:368
[09:54:03] Expected -22 == proc_dointvec(&table, 1, user_buf
[09:54:03] -22 == -22
[09:54:03] proc_dointvec(&table, 1, user_buffer, &le
[09:54:03] not ok 10 - sysctl_test_api_dointvec_write_single
[09:54:03]
[09:54:03] ==========
[09:54:03] ======== [PASSED] kunit-resource-test ========
[09:54:03] [PASSED] kunit_resource_test_init_resources
[09:54:03] [PASSED] kunit_resource_test_alloc_resource
[09:54:03] [PASSED] kunit_resource_test_destroy_resource
[09:54:03] [PASSED] kunit_resource_test_cleanup_resources
[09:54:03] [PASSED] kunit_resource_test_proper_free_ordering
[09:54:03] ==========
[09:54:03] ======== [PASSED] kunit-try-catch-test ========
[09:54:03] [PASSED] kunit_test_try_catch_successful_try_no_catch

How is this different?

- Well, it’s fast!
- It doesn’t depend on userland
- It has no external dependencies
- Writing tests is no different from writing normal kernel code

How is this different?

- Unit testing!

What’s unit testing?

- “Unit testing” is not synonymous with “testing”
- Testing is typically divided into 3 domains:
  - unit testing
  - integration testing
  - end-to-end/system testing

Types of Testing

- An end-to-end test:
  - usually tests the entire system from the perspective of the code under test
  - For example, someone might write an end-to-end test for the kernel by installing a production configuration of the kernel on production hardware with a production userspace and then trying to exercise some behavior that depends on interactions between the hardware, the kernel, and userspace
  - As close to production environment as possible

Types of Testing

- A unit test:
  - is supposed to test a single unit of code in isolation, hence the name
  - should be the finest granularity of testing and as such should allow all possible code paths to be tested in the code under test
  - this is only possible if the code under test is very small and does not have any external dependencies outside of the test’s control like hardware
  - should be very fast
  - Should be able to be run without any special set up
  - Executes in less than 100 ms
  - Multiple threads are discouraged

Types of Testing

- An integration test:
  - tests the interaction between a minimal set of components, usually just two or three
  - For example, someone might write an integration test to test the interaction between a driver and a piece of hardware
  - Or to test the interaction between the userspace libraries the kernel provides and the kernel itself
  - Nevertheless, one of these tests would probably not test the entire kernel along with hardware interactions and interactions with the userspace
  - Minimal external dependencies
  - Runs on the order of seconds/minutes

Types of Testing

	Unit Test	Integration Test	End-to-End Test
Scope	Small	Medium	Large
Coverage	High	Medium	Small
Speed	Fast	Medium	Slow
Confidence in Parts	High	Medium	Low
Confidence in System	Low	Medium	High

KUnit is not a new idea

- KUnit is a typical example of an x-unit style testing framework
- Many other x-unit testing frameworks/libraries have been written before:
  - JUnit (for Java)
  - Python’s unittest module (for Python)
  - Googletest/Googlemock (for C++)

What’s x-unit?

- Usually has a concept of a test suite broken up into test cases
- Each test case tests one aspect of functionality
- Together, the test suite tests a logical unit: a class, or a group of related functions
- The test cases often share a test fixture:
  - setup
  - teardown
  - context

KUnit Example

```
static void list_del_init_test(struct test *test)
{
        struct list_head a, b;
        LIST_HEAD(list);

        list_add_tail(&a, &list);
        list_add_tail(&b, &list);

        /* before: [list] -> a -> b */
        list_del_init(&a);

        /* after: [list] -> b, a initialised */
        KUNIT_EXPECT_EQ(test, list.next, &b);
        KUNIT_EXPECT_EQ(test, b.prev, &list);
        KUNIT_EXPECT_TRUE(test, list_empty_careful(&a));
}
```

More on x-unit

- https://google.github.io/kunit-docs/third_party/kernel/docs/usage.html
- https://martinfowler.com/bliki/Xunit.html

Where are we going?

Where is KUnit today

- Initial patchset is in linux-next
- We have:
  - Basic test suite and test case definition
  - Expectations and assertions
  - Test resource management API
  - Tests!
  - Command line script for parsing test results (and other stuff)

What are KUnit's current challenges?

- The Linux kernel wasn't written to be unit tested
- The code is pretty good for the most part
  - The Linux kernel is reasonably well structured: encapsulation, code sharing, modularity, etc
  - Actually pretty object oriented
- Dependencies are poorly defined
  - Kbuild cares about feature dependencies, not code dependencies
  - Some core dependencies are just always implicitly included

Where does KUnit fit into the kernel's test paradigm?

- There are a lot of test frameworks/suites for the Linux kernel
- Most are end-to-end tests
- There are currently not many unit tests, all are ad hoc

Where does KUnit fit into the kernel's test paradigm?

- A well tested code base has:
  - Lots of unit tests (~80%)
  - A moderate number of integration tests (~15%)
  - And some end-to-end tests (~5%)

Where does KUnit fit into the kernel's test paradigm?

- Lot's of unit tests (~80%)
  - This is where KUnit lives
- A moderate number of integration tests (~15%)
  - ???
- And some end-to-end tests (~5%)
  - We got this covered (kselftest, xfstest, etc)

What we are planning on doing in the future?

- Improving Documentation
- Mocking/Faking
  - C-style class mocking
  - Function mocking
  - Faking hardware
- Improving test result parsing
  - Make test parser stand alone
  - Improve output
- CI/CD
  - We have an open source CI/CD system - make it work with LKML
  - Provide coverage results for every patch

What are we planning on focussing on near term?

- Getting usage
- Improving documentation
- Improving usage
- Adding tests
- (Maybe) Work on matchers API
- (Maybe) Work on mocking

Let’s talk!

- What types of things should we be focusing on?
  - Near term?
  - Long term?
- What should we do about the dependency problem?
  - Should Kbuild know about code dependencies?
- What should be done about integration testing?
  - KUnit can currently address kernel - hardware boundary.
  - KUnit can be made to address user space - kernel boundary.
  - Is this what we want?

Connect with us!

- kunit-dev@googlegroups.com
- linux-kselftest@vger.kernel.org
- #kunit on oftc.net