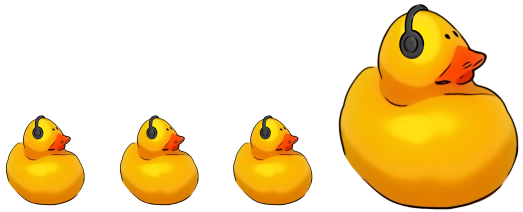
KUnit: New Features and New Growth

Brendan Higgins <brendanhiggins@google.com>
David Gow <davidgow@google.com>

Roadmap

- Growth Since Last Year
- Blockers and Problems
- Features Added
- Non-Technical Growth Efforts

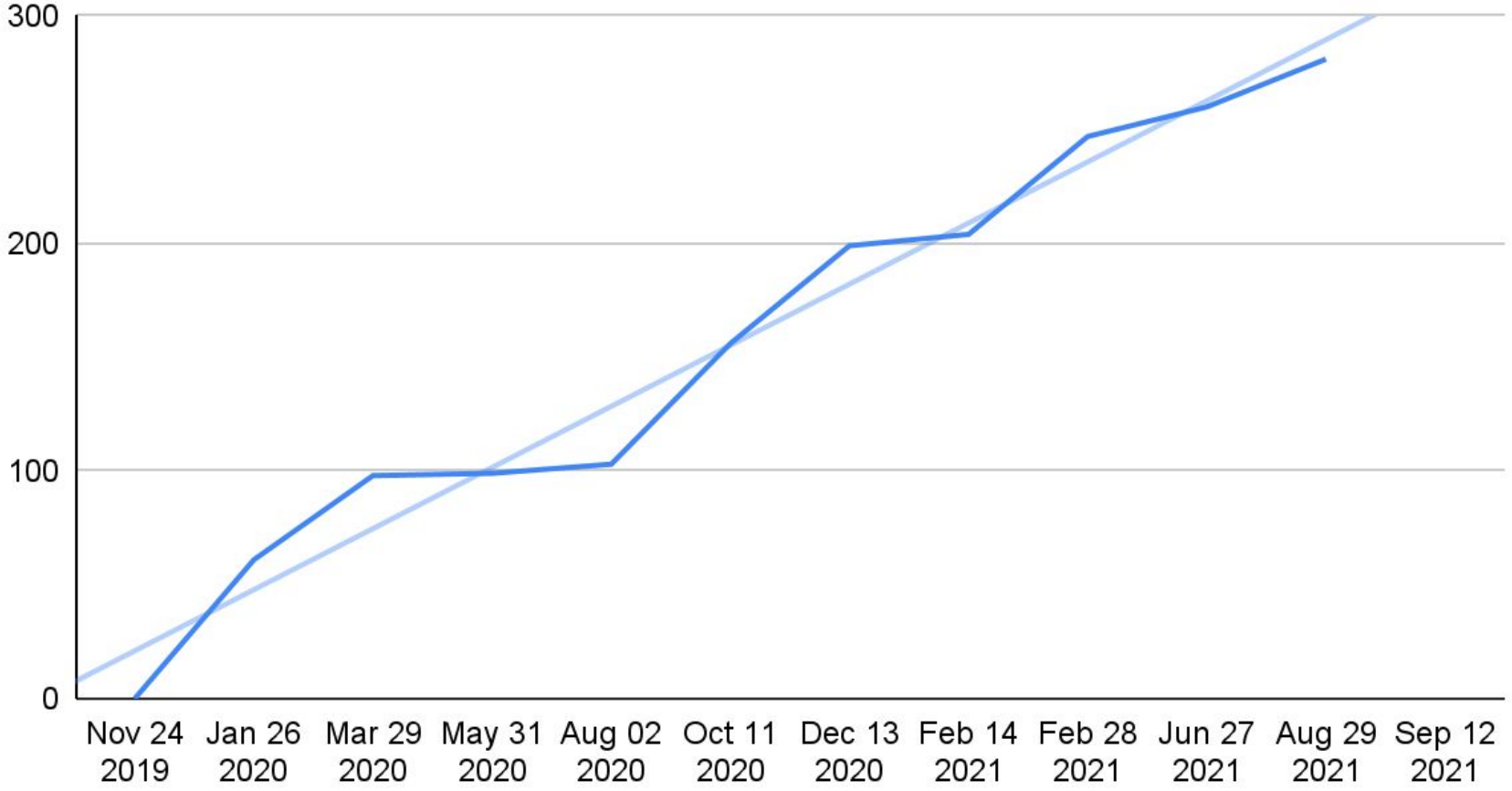
Growth and Usage Stats

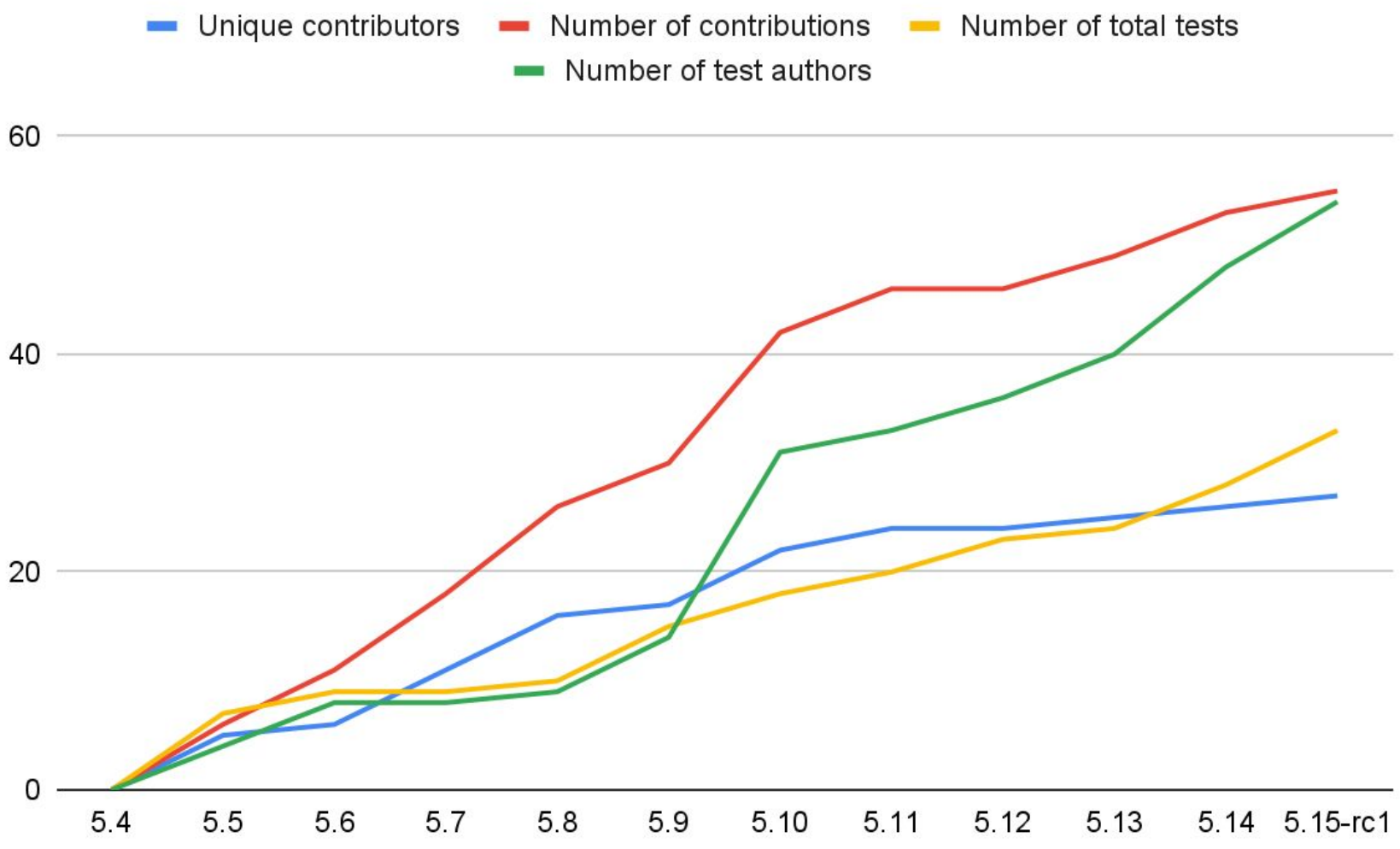


Growth Since Last Year

- v5.8 released on Aug 2 2020
  - 10 test files
  - 9 test contributors
  - 103 test cases
- v5.14 released on Aug 29 2021
  - 28 test files (x2.8)
  - 48 test contributors (x5.3)
  - 281 test cases (x2.7)

Test cases per release

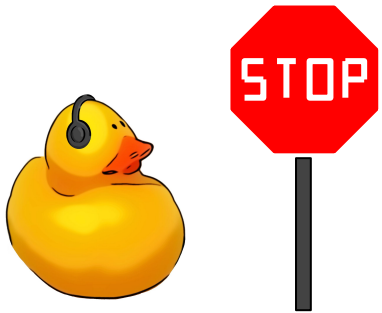



Unique contributors
Number of contributions
Number of total tests
Number of test authors
60
40
20
0
5.4
5.5
5.6
5.7
5.8
5.9
5.10
5.11
5.12
5.13
5.14
5.15-rc1

Some interesting new tests

- DAMON: Data Access MONitor
- SLUB cache error detection
- time64_to_tm() and rtc_time64_to_tm()
  - Used to validate a more performant implementation
- KFENCE (alongside KCSAN and KASAN)
- thunderbolt
  - Continuing to add several new tests
- ALSA SoC topology
- FAT filesystem (timestamps and filename checksums)
- lib/rational
- Many more

Blockers and Problems



Blockers and Problems

- KUnit is pretty good at testing isolated "library" code
  - Code which interacts heavily with kernel or hardware state is more difficult
  - This will always be the case: unit testing works best with "functional" code (limited global state, dependencies, etc)
- Architecture/hardware-dependent tests difficult to work with
  - kunit_tool only supported UML
  - Dependencies only known at runtime
- Difficult to configure and run only some tests
  - Need a way of running only tests for a particular subsystem
- Knowing when to use KUnit
  - When to use KUnit versus (e.g.) kselftest
  - Achieving feature parity / compatibility with other test frameworks

New Features

QEMU Support in kunit_tool

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```

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```
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Running tests with:

$ qemu-system-arm -nodefaults -m 1024
-kernel .kunit/arch/arm/boot/zImage
-append 'mem=1G console=tty
kunit_shutdown=halt console=ttyAMA0
kunit_shutdown=reboot' -no-reboot
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QEMU Support in kunit_tool

- We support the following out of the box:
  - i386
  - x86_64
  - arm
  - arm64
  - alpha
  - powerpc
  - riscv
  - s390
  - sparc

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  - arm
  - arm64
  - alpha
  - powerpc
  - riscv
  - s390
  - sparc
  - Don’t see your architecture? No problem.

SKIP Test Support

- Tests often have dependencies or hardware requirements.
  - Usually handled with Kconfig.
  - Sometimes these aren't known until runtime.
- Solution: SKIP the test at runtime if the dependency isn't around
  - e.g. KCSAN needs an SMP system; KCSAN tests are SKIPped if run on a single-core machine.
- (K)TAP specification provides a "skip" result
  - Also allows a "reason" for the test to be skipped.
  - kselftest has supported this for a while.
  - (Along with similar 'xfail' status)

SKIP Test Support

- Use the kunit_skip() or kunit_mark_skipped() macros to skip a test.
  - Take a "reason" parameter.
  - `kunit_skip(test, "foo required but not present");`

- Results will be of the form:
  - `ok 43 - kasan_bitops_tags # SKIP Test requires CONFIG_KASAN_GENERIC=n`
- And show up in kunit_tool as being skipped (in a yellow colour)

.kunitconfig fragments

Now possible to define specific test configurations:

- Use the --kunitconfig argument to kunit_tool to select a particular .kunitconfig file
  - `./tools/testing/kunit/kunit.py run --kunitconfig=fs/ext4/.kunitconfig`
- Pass in a subdirectory to use the .kunitconfig file in that directory
  - `./tools/testing/kunit/kunit.py run --kunitconfig=fs/ext4`
- The default config now runs all tests with satisfied dependencies

Test Filtering

- KUnit typically runs all tests which are compiled in
- It's now possible to filter the test suites being run by name
  - Support for filtering individual tests (as described below) is under review at the moment.
- New kunit.filter_glob kernel command-line parameter
  - e.g. `kunit.filter_glob=list-kunit-test.*del*`
  - Runs only the list delete tests
- Also usable from kunit_tool
  - Just add it as a parameter:
  - ./tools/testing/kunit/kunit.py run 'example*'

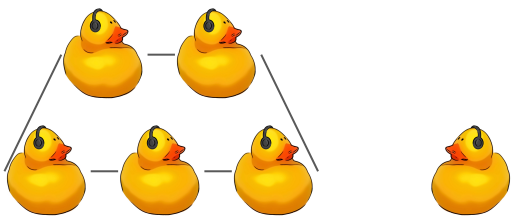
Test statistics

Both kselftest and a number of ad-hoc test modules printed summaries of tests passed/failed/skipped/etc.

- kunit_tool supports this, but it's not available for modules
- Test statistics support makes it easier to read a summary of the results without relying on kunit_tool
  - Based on kselftest's similar output lines
  - This was a functionality regression limiting some tests being ported to KUnit
- Prints two lines to handle nested tests properly:
  - `# example: pass:1 fail:0 skip:2 total:3`
  - `# Totals: pass:1 fail:0 skip:2 total:3`

Documentation Improvements

- Kernel Testing Guide
  - Describes the differences between different kernel testing and validation tools
  - Not exhaustive, but a good introduction.
  - Feel free to contribute!
- Made improvements to KUnit documentation
  - Improvements to kunit_tool documentation
  - Tech Writer working on improving KUnit's documentation



Non Technical Growth Efforts

KTAP Standardisation

- Both KUnit and kselftest use variants on TAP (Test Anything Protocol) as a result format.
  - Needed to be extended and modified for kernel use.
    - Nested tests
  - kselftest and KUnit's extensions are incompatible.
  - Tooling like kunit_tool only supported the features KUnit used.
- Aiming to come up with a standard specifically for kernel use.
  - Any parser should be able to handle both kselftest and KUnit results
  - Reworking the kunit_tool parser to support more features
    - Hopefully will support parsing kselftest results as well.
  - Thanks Rae Moar for much of this work, and Tim Bird and Kees Cook for reviews.

Interns/LKMP

- Every year we have had either interns or LKMP mentees
  - 12 interns/LKMP mentees/engres*!
- Hoping to expand testing and KUnit among new developers
- Presented at Linux Foundation Mentorship series

KUnit Hackathons

- FLUSP and LKCAMP organized a KUnit hackathon
  - 4 test conversions
  - 9 student developers
  - 5 student mentors
  - (thanks Vitor Massaru Iha!)
- We are trying to help them find “more interesting” parts to test
  - DRM subsystem (Daniel Vetter) is interested.
  - Hoping to find some others?
  - More helpful and more fun.

Faking

- Testing code with hardware or complex dependencies is difficult.
- Solution: replace dependencies and other state with 'fakes'
  - Instead of talking to real hardware, implement a "fake" device which responds in a certain way.
  - Can have several "fake" devices which trigger different codepaths
  - Equally, global functions can be replaced with "fake" versions.
  - e.g. A kalloc() function which always errors, or a fake read() from a file.
- Some notes on how to achieve this: https://kunit.dev/mocking.html
  - Not planning to implement a full "mocking" framework at the moment.
- Hoping to try this out with drivers and filesystems.

Subsystem Testing

- Now we have a decent amount of tests spread across the entire kernel
- Some “layers” of the kernel don’t seem to attract tests
- Idea: Whiteglove test a sizable subsystem in the kernel
  - Once people see how an entire subsystem is tested, serve as model for other parts
  - Lots of people look for “similar code and then base new code on it”

Discussion

Discussion

- What shouldn’t we be doing?
- What should we be doing that we aren’t?
- How can we improve what we are already doing?
  - Test Porting
  - Removing blockers
  - Interns/LKMP
  - Faking
  - KTAP Standardization
  - KUnit Hackathon
  - Subsystem Testing

Backup Slides

Growth: Porting Tests

- There are a number of test modules which would work better as KUnit test suites.
  - Typically written without a framework, sometimes with kselftest
  - Usually manually loaded as a module, and results printed out
  - Results are often checked manually
  - Don't use (K)TAP
- Some of these are candidates for being ported to KUnit
  - Can be built-in, as well as run as modules
  - Automatically run both by kunit_tool and other CI (e.g. LKFT)
  - Return a pass/fail result.
- Tests ported include:
  - test_list_sort, test_sort, KASAN, mptcp

QEMU Support in kunit_tool

- Make some config called: `myarch.py`:

```
from ..qemu_config import QemuArchParams

QEMU_ARCH = QemuArchParams(linux_arch='arm',
                           kconfig='''
CONFIG_ARCH_VIRT=y
CONFIG_SERIAL_AMBA_PL010=y
CONFIG_SERIAL_AMBA_PL010_CONSOLE=y
CONFIG_SERIAL_AMBA_PL011=y
CONFIG_SERIAL_AMBA_PL011_CONSOLE=y''',
                           qemu_arch='arm',
                           kernel_path='arch/arm/boot/zImage',
                           kernel_command_line='console=ttyAMA0',
                           extra_qemu_params=['-machine virt'])
```

QEMU Support in kunit_tool

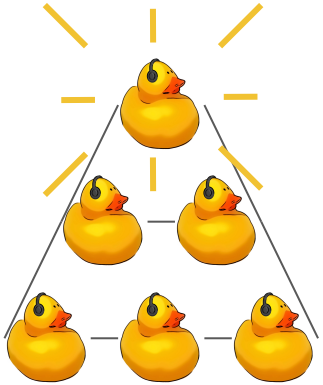
- Run config like this:

```
tools/testing/kunit/kunit.py run
                              --cross_compile=../my-arch-cross-
                              --qemu_config=./myarch.py
```

Hermetic Testing

- Ideally tests should restore any global state they change (i.e., have no side-effects)
- This is not always the case, particularly when debugging
- Hermetic testing is a new (in-progress) feature to run tests independently
  - Split execution of tests across several kernel invocations
  - Collate the results

- Future work:
  - Randomise test ordering



Growth Plans:
Present and Future

Blockers and Problems