

Linux Kernel Function Testing

(LKFT)

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Who am I

- I've been in the kernel validation industry for 15+ years
- A few thanks from random people in the kernel community
 - Linus Torvalds
 - Greg Kroah-Hartman
 - Paul E . McKenney
 - Andrew Morton
 - Steven Rostedt
 - Ard Biesheuvel
 - Mark Rutland

Agenda

- LKFT's mission
- How do LKFT build/test
- Reproduce build/test regressions
- Report regressions

LKFT's mission

- Validate LTS kernels
 - V4.14, v4.19... v6.6
- mainline/next best effort

Builds/tests

- Building 400+ kernels
 - Different configurations
 - Multiple architectures (arm, arm64, x86_64, i386...)
 - Toolchains (gcc-8, gcc-13[latest], clang-17[latest] and clang-nightly)
- Testing 100000+ tests/boots
 - LTP, Kselftest, Perf, libgpiod, kunit, kvm-unit-tests, rcu torture, v4l2 ...
 - Emulated (QEMU platforms, ARM's Fixed Virtual Platform) and real HW (X15, Juno, ...)

Results ready to be reviewed

- All 6 hours
- Most of the virtual environments in less than 1 hour

How do LKFT do build and test

TuxSuite™ is a platform of easy to use, on-demand tools and APIs

- Provides Open Source tools
- Container based
- Building and testing the Linux Kernel, Android, OpenEmbedded and Mbed-TLS in parallel, at scale
- Produce portable and reproducible build(s) and/or test(s)
- tuxsuite approach: **dynamically scalable system**
- Traditional approach: trade Off **throughput vs cost**
 - Why?
 - ... Go onto next slide

TuxSuite's Capabilities

Build

- Linux Kernel via TuxMake
- OpenEmbedded via TuxBake
- Android Kernel and AOSP via Google/Android build script
- Mbed-TLS via Mbed-TLS' build script

Test

- Run tests on virtual hardware via TuxRun (QEMU and FVP [Fixed Virtual Platforms])
- Run tests on real hardware via a LAVA lab as a backend (HW like jun0, db845, rb5, x15, Rpi, E-850)
- Curated rootfs ([debian](#), [buildroot](#)), [test-suites](#) (ltp, libgpiod, kvm-unit-tests,...) and [QEMU](#) master/releases

Plan file

- Concept of a build(s) triggers a test(s) via TuxSuite plan

Monitoring git tree's

- Config file that specifies what tree/branch to track and what plan file to trigger via TuxTrigger

Command line client

- To submit a build/test/plan via TuxSuite cli

Challenges in reporting

- Different types of failures
 - Build
 - Boot
 - Kernel image too big DUTs
 - Kernel modules loading
 - NFS root mount failure
 - MMC root mount failure
 - Mount / mkfs SATA drive
 - A boot can trigger other types of failures too
 - Test (functional test failure)
 - pass/fail/skip
 - A test can trigger other types of failures too
 - Other types of failures that get
 - Bug, exception, fault, opcode, kasan, kfence, oops, panic, warning

Build failure reproducer

- Tuxmake reproducer steps

```
$ sudo apt-get -y install podman  
$ pip3 install -U --user tuxmake
```

```
$ tuxmake \  
  --runtime podman \  
  --target-arch arm64 \  
  --toolchain gcc-13 \  
  --kconfig defconfig  
  --kconfig-add CONFIG_...
```

Ref: <https://tuxmake.org/>

How to Bisect a build failure

```
$ git bisect start NEW_SHA OLD_SHA
$ git bisect run tuxmake \  
  --runtime podman \  
  --target-arch arm64 \  
  --toolchain gcc-13 \  
  --kconfig defconfig \  
  --kconfig-add CONFIG_..
```

Ref: <https://tuxmake.org/>

Quick check of test results

If failure in any of them, we report quickly upstream

- Most of the tests in a virtual environment
- On real Hardware (DUT's)
 - LTP smoketest is checked
 - Confirms boot
 - Confirmed NFS and external SSD are mounted

Test Failure - in ltp-syscalls

- Retrigger the failure X times on the failing platform
 - To see if the failure is consistent or intermittent

```
$ sudo apt-get -y install podman
$ pip3 install -U --user tuxrun==0.49.2
$ tuxrun \
  --runtime podman \
  --device qemu-arm64 \
  --boot-args rw \
  --kernel https://url/Image.gz \
  --modules https://url/modules.tar.xz \
  --rootfs https://storage.tuxboot.com/debian/bookworm/arm64/rootfs.ext4.xz
  --parameters SKIPFILE=skipfile-lkft.yaml \
  --parameters SHARD_NUMBER=6 \
  --parameters SHARD_INDEX=5 \
  --tests ltp-syscalls \
  --timeouts boot=30 ltp-syscalls=50 \
  --overlay https://storage.tuxboot.com/overlays/debian/bookworm/arm64/ltp/20230929/ltp.tar.xz
```

Ref: <https://tuxrun.org/>

Test Failure - in kselftest

- Reproduce a kselftest failure

```
$ tuxrun \  
  --runtime podman \  
  --device qemu-arm64 \  
  --boot-args rw \  
  --kernel https://url/Image.gz \  
  --modules https://url/modules.tar.xz \  
  --rootfs https://storage.tuxboot.com/debian/bookworm/arm64/rootfs.ext4.xz \  
  --parameters SHARD_INDEX=1 --parameters SKIPFILE=skipfile-lkft.yaml --parameters SHARD_NUMBER=5  
--parameters KSELFTEST=https://url/kselftest.tar.xz \  
  --tests kselftest-net \  
  --timeouts boot=30 \  
  kselftest-net=30
```

Ref: <https://tuxrun.org/>

Report regression

Important in a regression report

- When it started to fail
- Is it reproducible
- Bisected or bisect ongoing

Additional information:

- Intermittent or failing consistently
- Device Platform
- Build + toolchain
- URL to log file
- QEMU version
- Steps to reproduce

Lore references

- https://lore.kernel.org/all/CA+G9fYt_b04YNCCv-iTZTtwb5fmNEQ0abiO46qW_-SrA1GQX8w@mail.gmail.com/
- https://lore.kernel.org/all/CA+G9fYtqLarsezP_-6iQqonh8M4Q6McUCEBM9gFv+GU-zZRHAQ@mail.gmail.com/
- <https://lore.kernel.org/linux-fsdevel/CA+G9fYt75r4i39DuB4E3y6jRLaLoSEHGbBcJy=AQZBQ2SmBbiQ@mail.gmail.com/>

Patch validation

- Proposed fix patch(es) from a regression report
 - Retrigger a build with tuxsuite (tuxmake/tuxrun)
 - Validate results
- Run tests multiple times for the confirmation
- Report back the results

Take aways

- TuxSuite is our tooling
- LKFT is our framework for triaging
- We are always looking for collaboration

- Ref:
 - <https://tuxsuite.com/>
 - <https://lkft.linaro.org/>
- Contact:
 - lkft@linaro.org

References: reported regressions

- Reported a [kernel crash on Arm64/x86](#) due to LTP-hugetlb on next-20231016
- Reported a [KASAN bug on RPi4](#) in drm_connector_cleanup on next-20231011
- Reported an [ftrace/ktap kernel crash](#) on v6.5.8-rc2
- Reported a [deadlock on DB845c](#) on v6.1.55
- Reported a [KVM warning with kvm-arm.mode=protected on Arm64](#) on v6.1.56
- Reported a [kernel crash with selftests-cgroup on FVP](#) on next-20231006
 - v2 of the patch [was posted](#)
- Reported a [KASAN bug with FPGA bridge on Juno](#) on next-20231006
- Reported [Inconsistent lock state with IPv6](#)
- Reported and Tested [Patch proposed to backport](#)
- Reported [RCU warning on trc_inspect_reader](#) on x86
- Reported and Tested [Proposed fixes](#) by paulmck
- Reported [Direct IO problems with NFS](#) on Raspberry Pi 4
- Reported [BPF unit_size warning](#) on Armv7
- Reported a [MIPS build failure on a staging driver](#) since next-20230919
- Reported an [ARC linking failure](#) since next-20230922