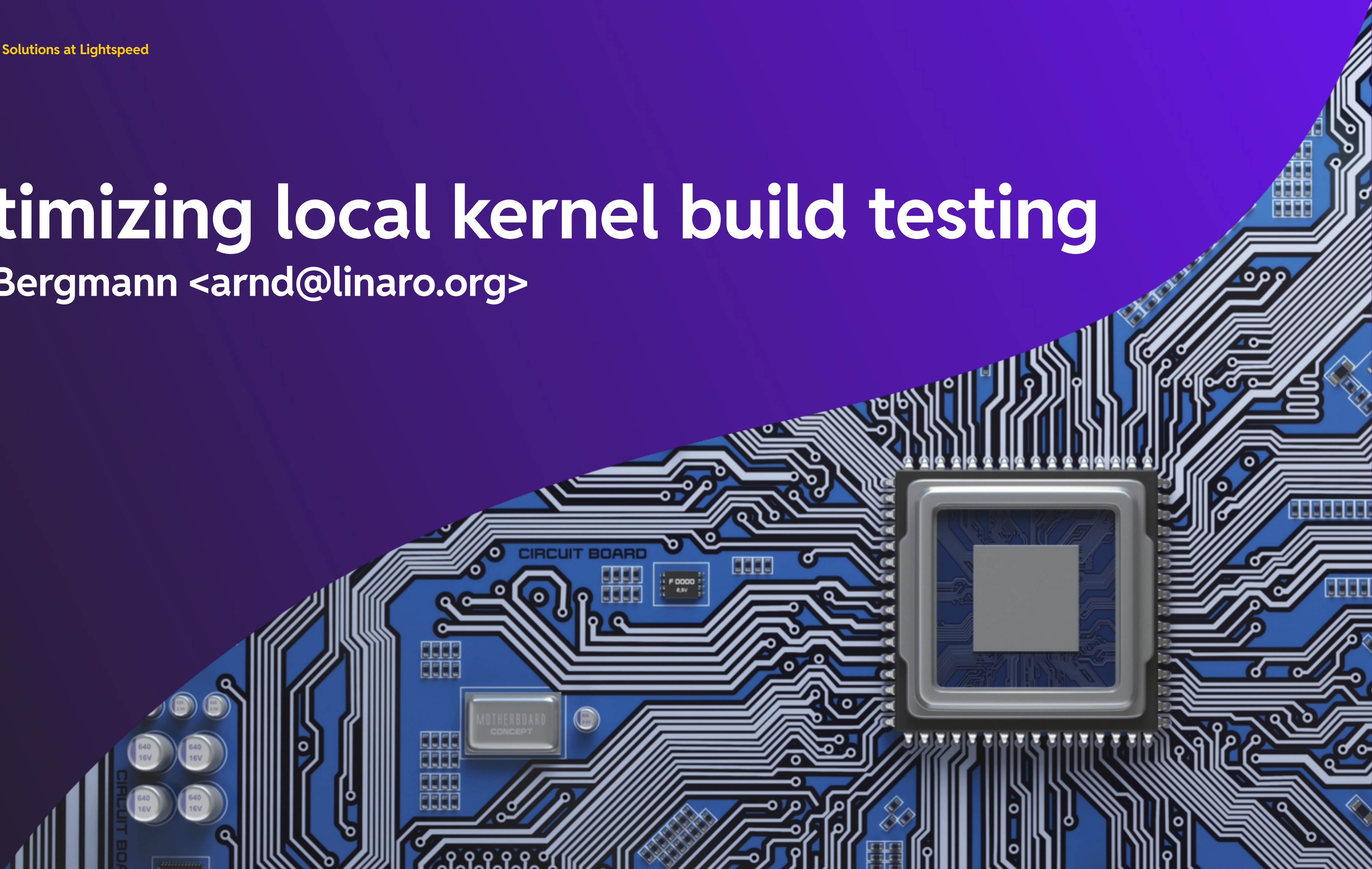


Optimizing local kernel build testing

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A background image of a city skyline at dusk or dawn, with several bright, glowing laser beams in blue and pink colors crisscrossing the sky. The beams originate from various points in the city and extend towards the horizon. The city features a mix of modern high-rise buildings and older, lower-rise structures. The sky is a mix of orange, yellow, and blue hues, suggesting the time is either early morning or late evening. The overall scene has a futuristic, high-tech feel.

Introduction

About me

- Maintainer of the SoC tree
- Working at Linaro since 2010
- Poking around everywhere in the kernel

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- Maintainer of the SoC tree
- Working at Linaro since 2010
- Poking around everywhere in the kernel
- Have built more kernels than you have

Motivation

Why create your own CI system?

Alternatives

- tuxsuite
- kernelci
- Oday bot
- sashiko
- ...

Advantages of my approach

- No remote login
- Testing the SoC tree while merging
- Testing API Changes
- Faster turnaround
- Energy efficiency

Implementation

How to keep an oversized workstation occupied

Hardware

2024-2026 Apple Mac Studio M2 Ultra, 24 cores, 64GB LPDDR5

2022-2024 Apple Mac Studio M1 Ultra, 20 cores, 64GB LPDDR5

2017-2022 AMD Threadripper 1950X
16 cores, 128GB ECC DDR4

2013-2017 Dual AMD Opteron 6344
24 cores, 128GB ECC DDR3



Makefiles and scripts

One top-level makefile

Intercepts Makefile

Runs parallel build jobs

One object tree per job

Shared source tree

Loop per architecture

arm, arm64, x86, s390

randconfig

300 builds in a row

Filter out failed builds

Rebuild failed configs

Retry in parallel

fix/commit/submit

Workflow

- Keep machine busy testing linux-next
- Build with -Werror
- Fix as bugs are found
- Submit fixes if possible
- Rebase backlog to latest linux-next
- Merge in my own projects

Example session

```

arnd@studio:~/arm-soc$ nice -n 19 make -skj20 randconfigs GCCVER=15.3.0
0x40F225B2 Do 17. Sep 03:45:59 CEST 2026 success
0xF0498C20 Do 17. Sep 03:46:49 CEST 2026 success
0x765EB222 Do 17. Sep 03:47:49 CEST 2026 success
0x7CAC9420 Do 17. Sep 03:50:12 CEST 2026 success
0x5E2D2694 Do 17. Sep 03:54:12 CEST 2026 success
0xB8241975 Do 17. Sep 03:55:55 CEST 2026 success
0x9E26C30C Do 17. Sep 03:56:03 CEST 2026 success
0xA128D170 Do 17. Sep 03:56:09 CEST 2026 failed
/home/arnd/cross/arm64/gcc-16.2.0-nolibc/x86_64-linux/bin/x86_64-linux-ld:      drivers/net/ethernet/sfc/efx_cxl.o:      in      function
`efx_cxl_init':
efx_cxl.c:(.text+0xfc): undefined reference to `devm_cxl_probe_mem'
0xEE886ADF Do 17. Sep 04:00:43 CEST 2026 success
0xC9C8A56E Do 17. Sep 04:02:26 CEST 2026 success
0x17A6D7E Do 17. Sep 04:02:28 CEST 2026 failed
In function 'get_tier_idx',
    inlined from 'isolate_folios' at /home/arnd/arm-soc/mm/vmscan.c:4854:14:
/home/arnd/arm-soc/mm/vmscan.c:4812:9: error: 'sp.refaulted' is used uninitialized [-Werror=uninitialized]
4812 |         read_ctrl_pos(lruvec, type, LRU_TIER_MIN, LRU_TIER_MIN, 2, &sp);
      |         ^~~~~~
/home/arnd/arm-soc/mm/vmscan.c: In function 'isolate_folios':

```

Example session

```
0xB03A7A69 Do 17. Sep 08:05:15 CEST 2026 success
0xD6291D20 Do 17. Sep 08:05:27 CEST 2026 success
0x4C445474 Do 17. Sep 08:13:19 CEST 2026 success
0xEBDD6A3E Do 17. Sep 08:13:20 CEST 2026 success
0xDB04E256 Do 17. Sep 08:13:24 CEST 2026 success
^Z
[1]+  Stopped                  make -skj20 randconfigs
arnd@studio:~/arm-soc$ make newrands ; make -skj20 buildall GCCVER=15.3.0 ; fg
'rand86/0xA128D170-config' -> 'arch/x86/configs/0xA128D170_defconfig'
'rand64/0x7D1B5E40-config' -> 'arch/arm64/configs/0x7D1B5E40_defconfig'
'rand64/0xB37A517-config' -> 'arch/arm64/configs/0xB37A517_defconfig'
'rand390/0x34351E5B-config' -> 'arch/s390/configs/0x34351E5B_defconfig'
'rand390/0x6B649E3C-config' -> 'arch/s390/configs/0x6B649E3C_defconfig'
'rand390/0x9548D07-config' -> 'arch/s390/configs/0x9548D07_defconfig'
'rand390/0xC7A824AE-config' -> 'arch/s390/configs/0xC7A824AE_defconfig'
Thu, 17 Sep 2026 08:14:47 +0200 build/arm/0xC63E0B9E_defconfig
Thu, 17 Sep 2026 08:14:47 +0200 build/x86/0x3E604DA0_defconfig
Thu, 17 Sep 2026 08:14:47 +0200 build/x86/0xA128D170_defconfig
Thu, 17 Sep 2026 08:14:48 +0200 build/x86/0xEE534190_defconfig
Thu, 17 Sep 2026 08:14:48 +0200 build/arm64/0x653C516D_defconfig
Thu, 17 Sep 2026 08:14:48 +0200 build/arm64/0x7D1B5E40_defconfig
```

Example session

```
arnd@studio:~/arm-soc$ $ make newrands ; make -skj20 buildall GCCVER=16.2.0 ; fg
Thu, 17 Sep 2026 16:24:39 +0200 build/arm/0xC63E0B9E_defconfig
Thu, 17 Sep 2026 16:24:39 +0200 build/x86/0x3E604DA0_defconfig
Thu, 17 Sep 2026 16:24:40 +0200 build/x86/0xA128D170_defconfig
Thu, 17 Sep 2026 16:24:40 +0200 build/x86/0xC97B6E84_defconfig
Thu, 17 Sep 2026 16:24:40 +0200 build/x86/0xEE534190_defconfig
Thu, 17 Sep 2026 16:24:40 +0200 build/arm64/0x653C516D_defconfig
Thu, 17 Sep 2026 16:24:40 +0200 build/arm64/0xB37A517_defconfig
Thu, 17 Sep 2026 16:24:40 +0200 build/arm64/0xC45640A8_defconfig
Thu, 17 Sep 2026 16:24:40 +0200 build/s390/0x34351E5B_defconfig
Thu, 17 Sep 2026 16:24:40 +0200 build/s390/0x6B649E3C_defconfig
Thu, 17 Sep 2026 16:24:40 +0200 build/s390/0x9548D07_defconfig
Thu, 17 Sep 2026 16:53:33 +0200 build/arm64/0xC45640A8_defconfig success
Thu, 17 Sep 2026 16:54:05 +0200 build/arm/0xC63E0B9E_defconfig fail
Thu, 17 Sep 2026 16:57:48 +0200 build/s390/0x9548D07_defconfig success
Thu, 17 Sep 2026 16:58:15 +0200 build/x86/0xEE534190_defconfig success
Thu, 17 Sep 2026 16:58:25 +0200 build/x86/0x3E604DA0_defconfig success
Thu, 17 Sep 2026 16:58:38 +0200 build/x86/0xC97B6E84_defconfig success
Thu, 17 Sep 2026 16:59:26 +0200 build/arm64/0x653C516D_defconfig success
Thu, 17 Sep 2026 16:59:31 +0200 build/x86/0xA128D170_defconfig fail
Thu, 17 Sep 2026 16:59:32 +0200 build/s390/0x34351E5B_defconfig fail
```

Toolchain

gcc

all targets except hexagon

all supported versions

no userspace/libc support

built locally for arm64/x86/ppc64

uploaded to

<https://mirrors.edge.kernel.org/pub/tools/crosstool/>

Clang

built by Nathan Chancellor

targets: arm64, arm, hexagon,
loongarch, mips, powerpc,
riscv, s390, x86

uploaded to

<https://mirrors.edge.kernel.org/pub/tools/llvm/>

Configuration hacks

Fragment to avoid failed builds

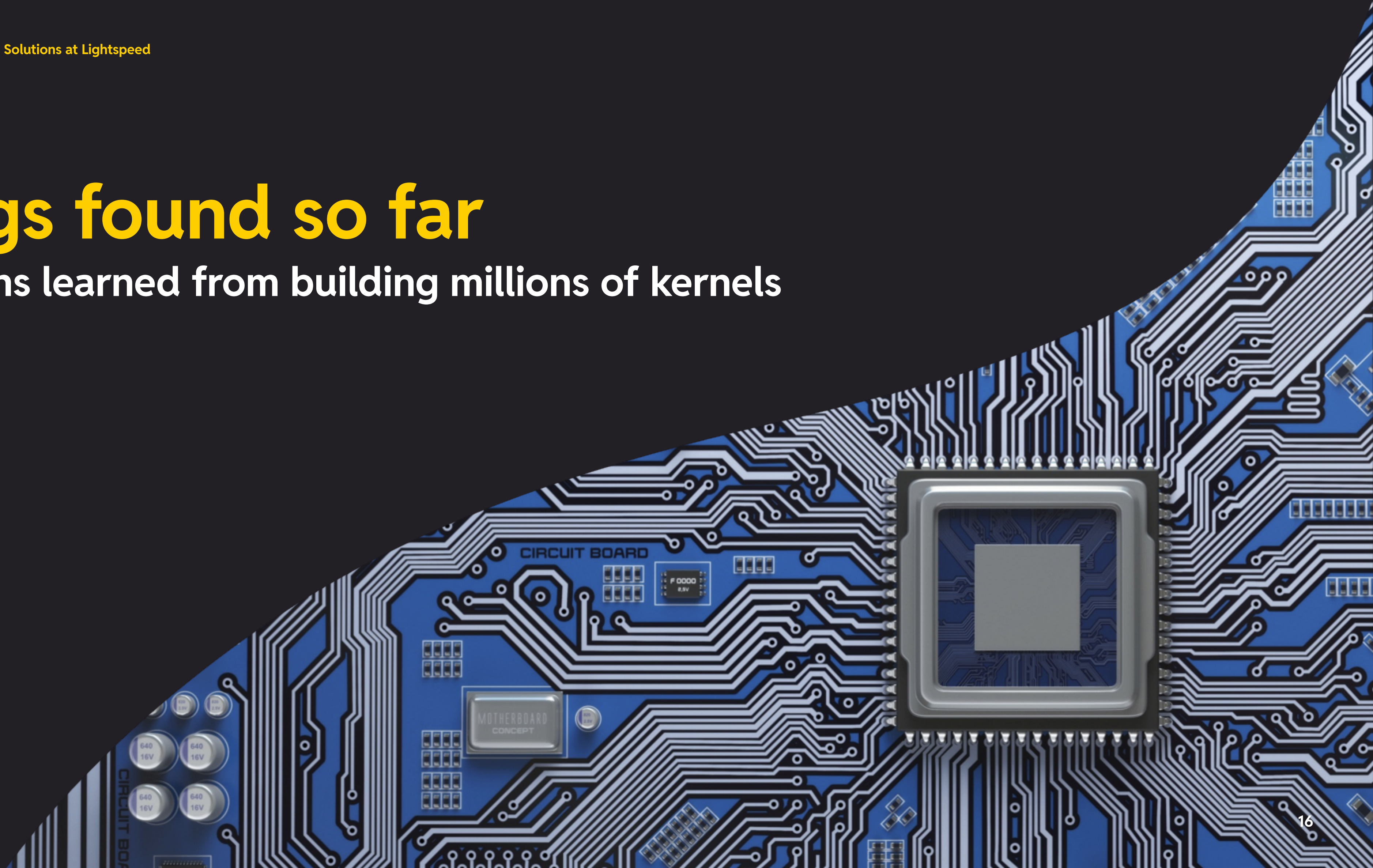
```
$ cat kernel/configs/random.config
# maximize search space, disable options not worth testing
CONFIG_COMPILE_TEST=y
# avoid long build times
# PROFILE_ALL_BRANCHES is not set
# reduce compile-time dependencies
CONFIG_STANDALONE=y
CONFIG_PREVENT_FIRMWARE_BUILD=y
```

Backlog tree

```
arnd@studio:~/arm-soc$ git log --oneline
0a1affa74ef2 (HEAD -> randconfig-7.3-next) rtc: renesas: avouud -Wtautological-constant-out-of-range-compare warning
7e0d683ced55 [SUBMITTED 20260917] usb: gadget: pxa25x: prevent ixp4xx + pxa25x combination
4517c5008ca3 [SUBMITTED 20260917] sfc: fix CONFIG_CXL_MEM dependency
41ae3f9b5c68 [SUBMITTED 20260917] f2fs: quota: fix unused-label warning
2df8a5b2ff63 wait: avoid -Wconstant-logical-operand warning
9e6856c86c1a [SUBMITTED 20260917] [v2] ASoC: rt766: fix HID dependency for SND_SOC_SDCA_HID
9c6e65ae61e1 fixup vmscan
893426e48fa3 [SUBMITTED 20260917] nvme: work around all -Wformat-security warnings
00288e0405a3 fixup! treewide: address -Wformat-security warnings
2bfa4997a200 fixup! x86: kvm: drop 32-bit host support
5fa2a8a4d91c [SUBMITTED 20260916] mm/vmscan: avoid false-positive -Wuninitialized warning, again
d16ce85991bd [SUBMITTED 20260916] firmware: imx: fix build regression
1cb6bf9c09cd [SUBMITTED 20260916] nvme: work around -Wformat-security warning
cb0052abecbf [SUBMITTED 20260916] usb: fotg210: fix USB_EHCI_HCD dependency
958c0814889f [SUBMITTED 20260916] gpiolib: remove linux/gpio.h
015d784ac1ca [SUBMITTED 20260916] gpiolib: turn off legacy interface by default
40ba4190040e [SUBMITTED 20260916] riscv: limit sifive errata to CONFIG_64BIT
11326674e1de [SUBMITTED 20260916] media: i2c: it6625: select CONFIG_HDMI
9271e8a4e9cc fixup! arm64: make swiotlb optional
f4d03eeabc7d [SUBMITTED 20260916] net: dsa: motorcomm: fix unused-function warning
```

Bugs found so far

Lessons learned from building millions of kernels



Bugs found so far

- Thousands of bugs fixed upstream
- Every subsystem touched
- More fixes than anyone else
 - Source: <https://pebblebed.com/blog/kernel-bugs-part2>
- Many more patches folded into other work or dropped

Kconfig dependency errors

- Most common bug in randconfig
- Often not found in allmodconfig builds
 - missing dependency
 - tristate logic errors
 - selecting a symbol with unmet dependency
 - dependency loop
- Nobody can do this correctly
- Latest hope: <https://github.com/julianbraha/kconfirm>

Stack frame warnings

- Unsolved problem
- Hard limit of kernel thread stacks, usually 16KiB
- Per function warning as a crude indicator
- Often very hard to debug
 - compiler heuristic mistakes
 - rare configurations
- Testing limit:
 - 1024b + 256b CONFIG_64BIT + 256b CONFIG_KASAN + 256b KMSAN

Superpowers of a build bot

No idea how else I'd do these

API Changes

Example: GPIOLIB number/descriptor

1. Enforce CONFIG_GPIOLIB_LEGACY guard
2. build and fix interactively
 - a. allmodconfig on arm
 - b. allmodconfig on everything
 - c. randconfig on arm/arm64/x86

Build system changes

Example: clang bringup

- Started in early 2010s
- Countless bugs in weird configurations
- Equal to gcc these days

Kernel warning options

Currently testing with additional options enabled

- Wframe-larger-than=1280
- Wunused-const-variable
- Wtautological-constant-out-of-range-compare
- Wformat-security
- Wformat-overflow
- Wmissing-include-dirs
- Wmain
- Wunused-but-set-variable
- Woverride-init

Other previous changes

- big kernel lock removal
- y2038/time_t conversion
- reducing indirect header inclusions
- asm-generic cleanups
- __rcu attribute annotation

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Future outlook

Backlog

~600 patches as of today

- many submitted before, need to recheck
- UAPI checks for padding
- stack frame warning workarounds
- GFP_DMA cleanups
- GFP_HIGHMEM cleanups
- code removal
- additional compiler warnings

Discussion

- Adding scripts to mainline kbuild
- Better integration of cross compilers in cross builds
- Anything I should test (temporarily)?
- Other suggestions?



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Thank you

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