Reducing the reliance on verification experts for seL4 proofs

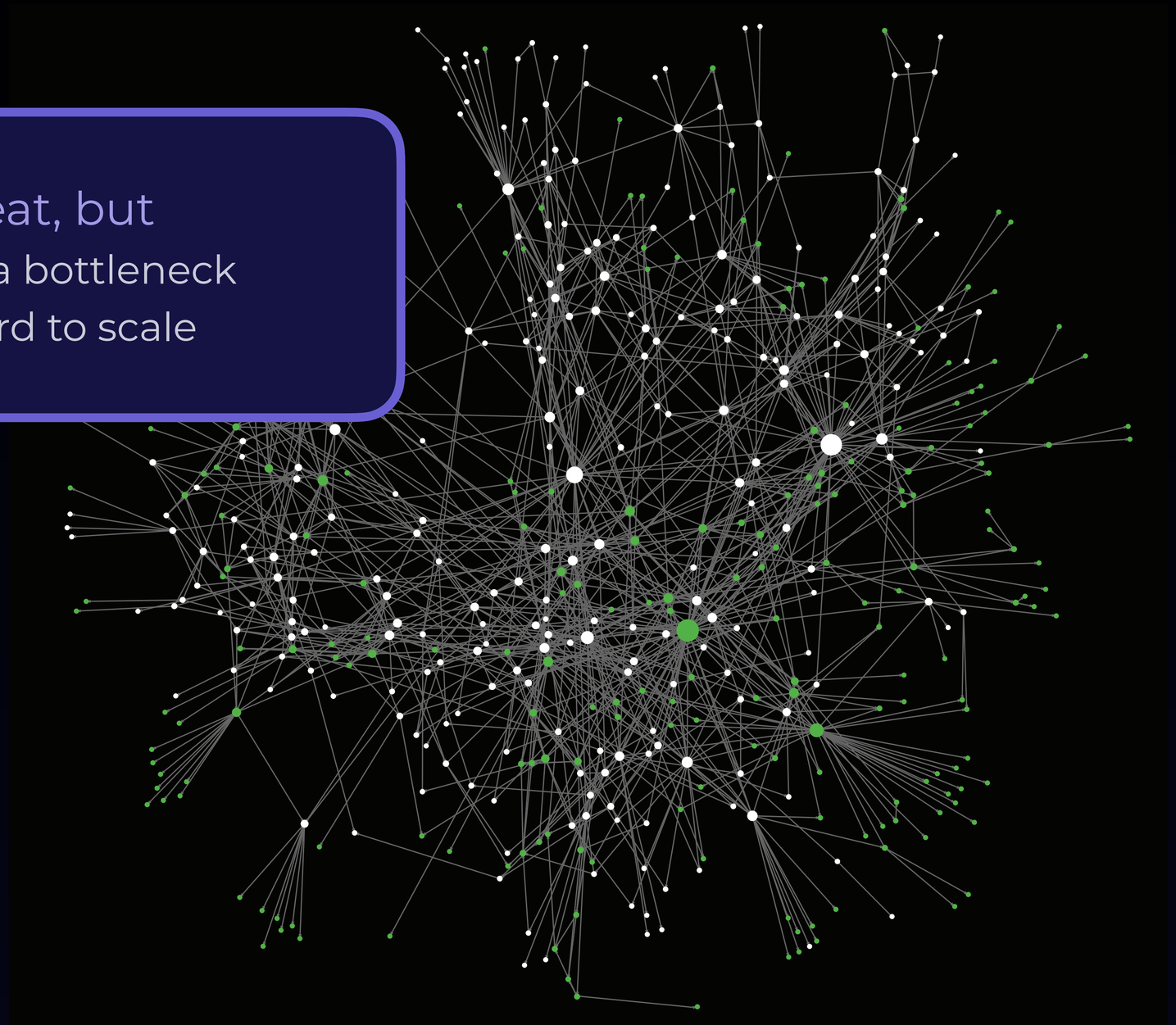
Gerwin Klein | seL4 summit 2023

faster + cheaper = better

sometimes you only need to pick two

How we plan to become faster and cheaper

- Formal verification is great, but
  - availability of experts still a bottleneck
  - development time still hard to scale



How we plan to become faster and cheaper

- Formal verification is great, but
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- We can improve that
  - reduce proof maintenance cost
  - increase proof development speed
  - make specific verification tasks automatic

Automatic Verification of Platform Ports

Verified seL4 Architectures

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- Platform coverage recently extended for Arm 32bit
  - 3 different verified Arm platforms: Sabre Lite, Exynos 5, IMX8MM-EVK
  - but git branches brittle in maintenance
  - not scalable to many boards

Verified seL4 Platforms (currently)

- https://docs.sel4.systems/Hardware/

  seL4 supports 32 different platforms

elect ARMv7 and ARMv8 Platforms.

RM Platforms

stem- -chip	Core	Arch	Virtualisation	IOMMU	Status
Exynos5	Cortex-A15	ARMv7A	ARM Hyp	No	Unverified
i.MX8MQ	Cortex-A53 Quad 1.5 GHz	ARMv8A	No	No	Unverified
OMAP3	Cortex-A8	ARMv7A	No	No	Unverified
AM335x	Cortex-A8	ARMv7A	No	No	Unverified
Kirin 620	Cortex-A53	ARMv8A	ARM HYP	No	Unverified
IMX8MM-	Cortex-A53	ARMv8A,	No	No	FC,

Arndale

Avnet MaaXBoard

BeagleBoard

BeagleBone Black / Blue

HiKey

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6 of these support verification

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Verified seL4 Platforms (plan)

- Ideally, all platforms should have verification
- Even 90% would already be great

and ARMv8 Platforms.

ns

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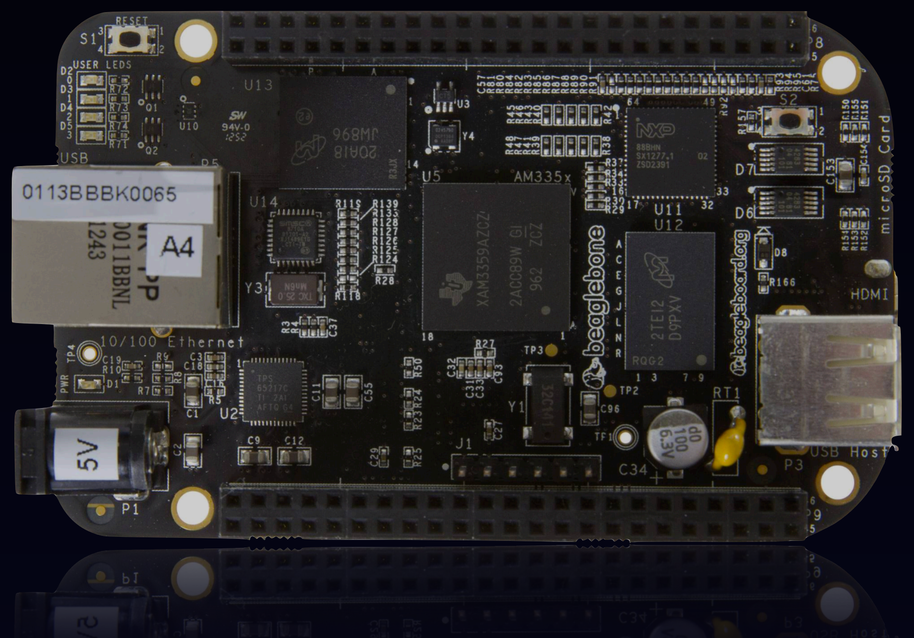

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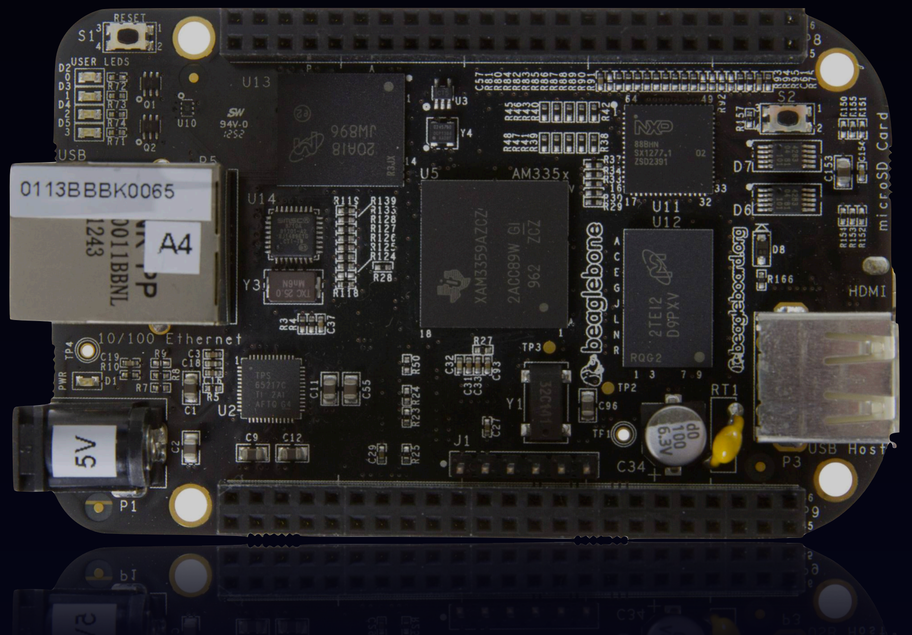

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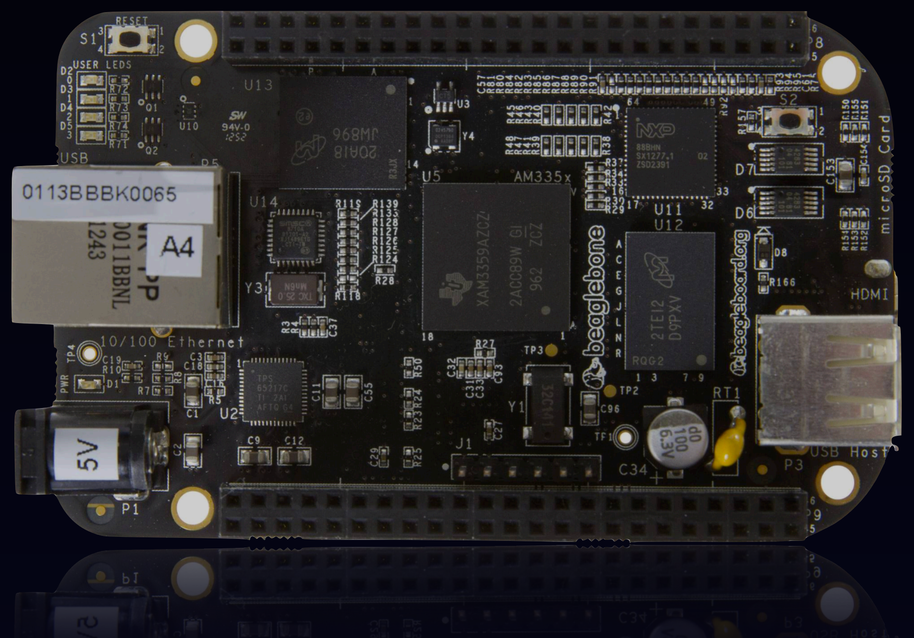

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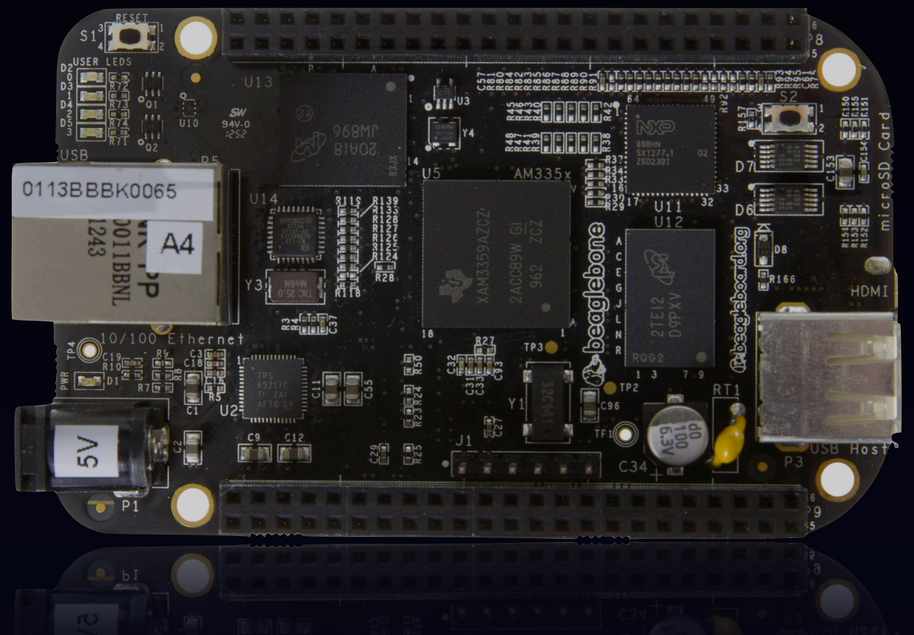

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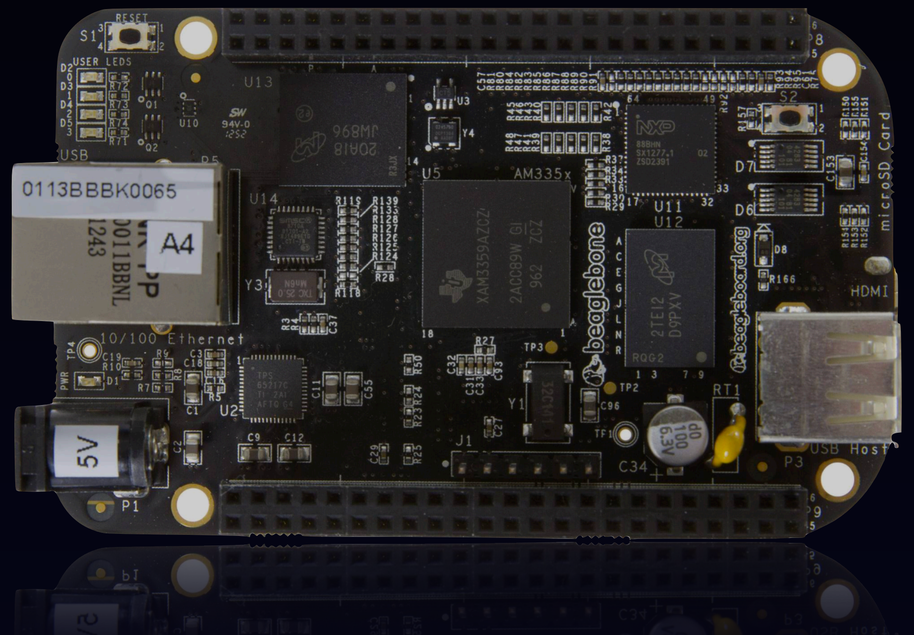

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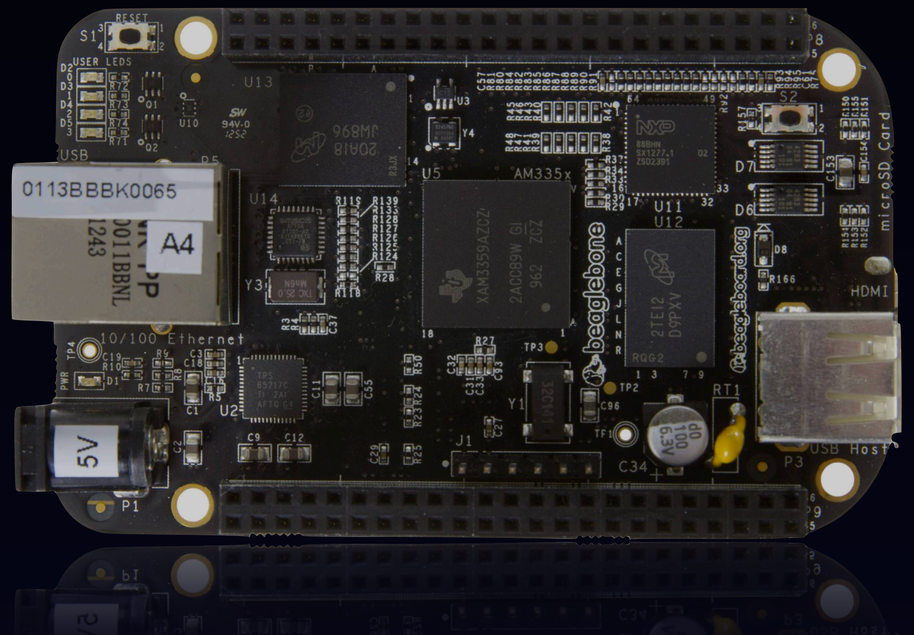

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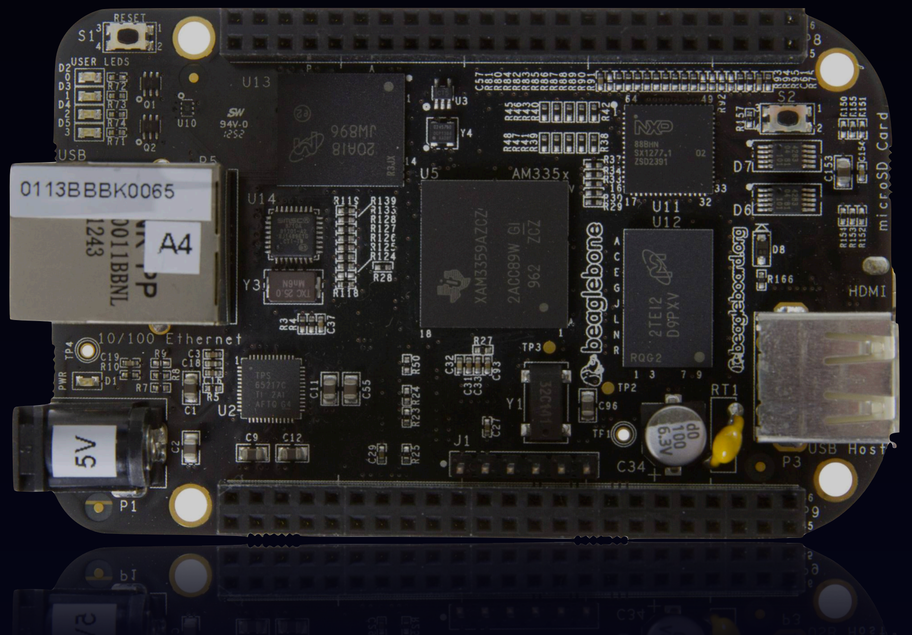

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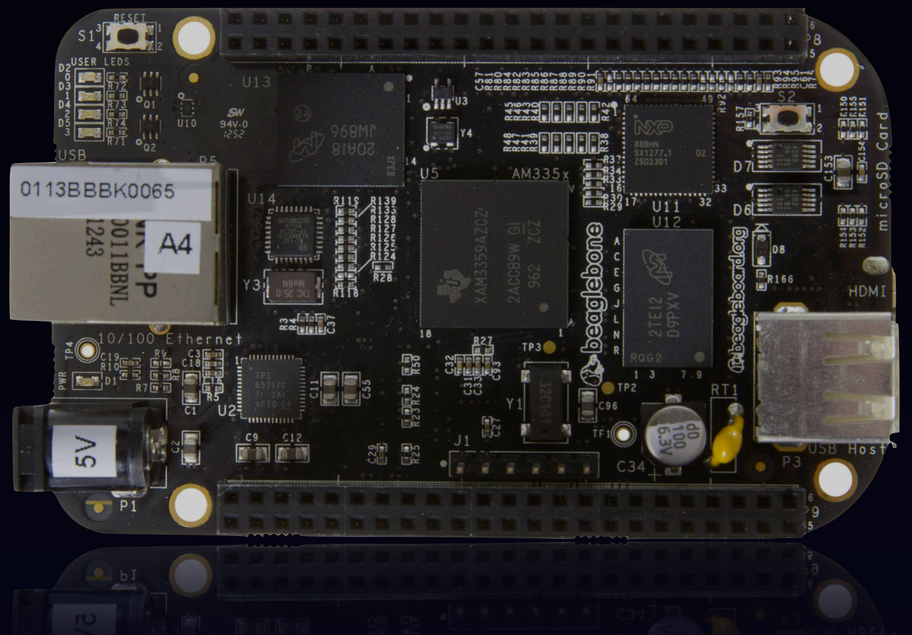

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- Update usually easy
- Maintaining multiple proof versions is painful
  (> 6h run time for a single proof check)
- When something does break, many copies to update
- Makes maintenance boring and expensive
- High incentive to eliminate these completely

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- No need for verification experts in most cases
- No new branches or maintenance explosion
- When build checks fail, there is likely a real problem that needs deeper expertise

Why and How?

What changes in a platform port

- Platform parameters
- Config parameters

```
/ {
        chosen {
                seL4,elfloader-devices =
                    "serial0";
                seL4,kernel-devices =
                    "serial0",
                    &{/ocp/interrupt-controller@48200000},
                    /* The following devices are used to s
                    /* dmtimer4, OMAP Dual-Mode timer */
                    &{/ocp/timer@48044000},
                    &{/ocp/l4_wkup@44c00000/prcm@200000},
                    &{/ocp/wdt@44e35000}; /* Watchdog time
        };
};
```

```
declare_platform(am335x KernelPlatformAM335X PLAT_AM335X KernelSel4ArchAarch32)
set(c_configs PLAT_AM335X_BONEBLACK PLAT_AM335X_BONEBLUE PLAT_AM335X_BONE)
set(
    cmake_configs
    KernelPlatformAM335XBoneBlack
    KernelPlatformAM335XBoneBlue
    KernelPlatformAM335XBone
)
set(plat_lists am335x-boneblack am335x-boneblue am335x-bone)
foreach(config IN LISTS cmake_configs)
    unset(${config} CACHE)
endforeach()

if(KernelPlatformAM335X)
    declare_seL4_arch(aarch32)

    set(KernelHardwareDebugAPIUnsupported ON CACHE INTERNAL "")

    set(KernelArmCortexA8 ON)
    set(KernelArchArmV7a ON)
    check_platform_and_fallback_to_default(KernelARMPlatform "am335x-boneblack")
    list(FIND plat_lists ${KernelARMPlatform} index)
    if("${index}" STREQUAL "-1")
        message(FATAL_ERROR "Which am335x platform not specified")
    endif()
```

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set(KernelA
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Can be automated

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selects different code,
will be harder

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selects different proof setup

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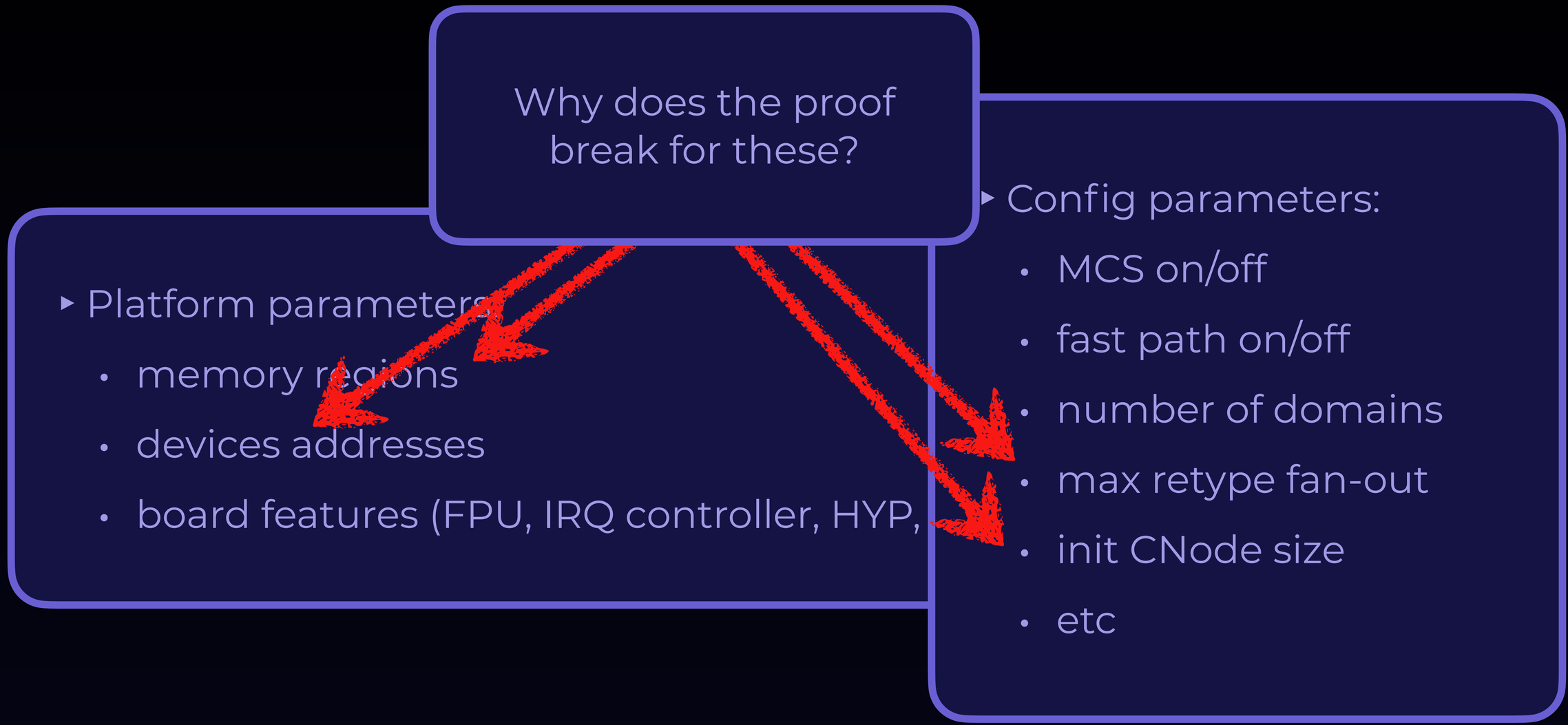

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  - this kind of validation usually easier with concrete testing
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  - still leads to combination explosion
  - still needs you to re-run the full proofs for each change

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- Instead: proof parameterisation
  - find sufficient conditions, e.g.:
    - physical base address must be aligned to x bits
    - must be greater than y
    - must be smaller than other config value
  - prove once:
    - all values that satisfy these conditions are safe

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Ok, I won’t, but I have a bunch of ideas, and they might work.

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- Looks achievable for a large set of platforms and config changes
- We'll be working on it.

When can I have this?

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    - **platform proof automation**
    - more generic proofs, more agility

Summary

Towards more agile proofs

The Plan:

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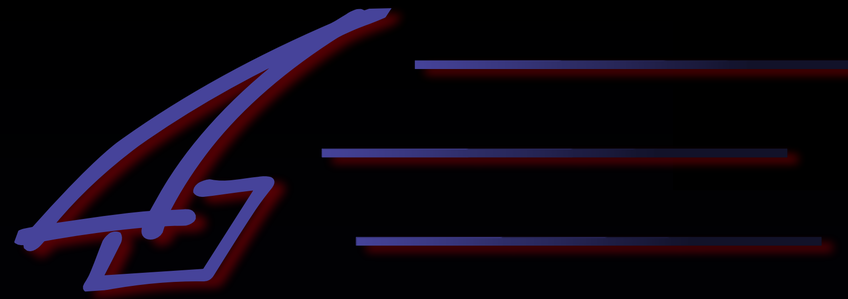
- Proof maintenance: faster and cheaper
- Proof engineers: happier and less of a bottleneck

Towards more agile proofs



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More capacity for features and updates

Thank You