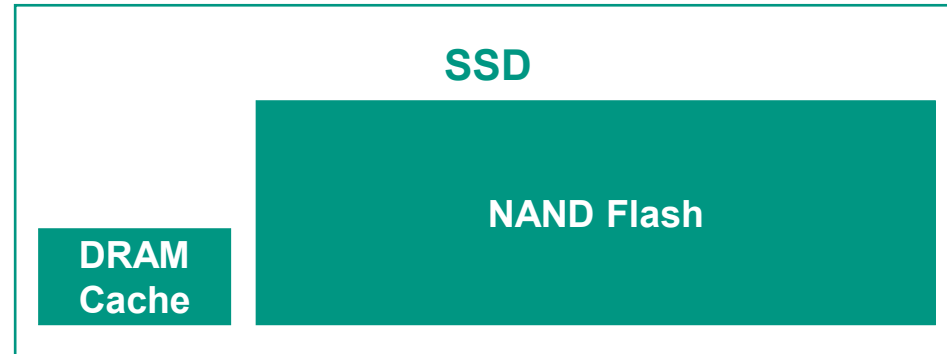


Firmware in Systems Research at KIT

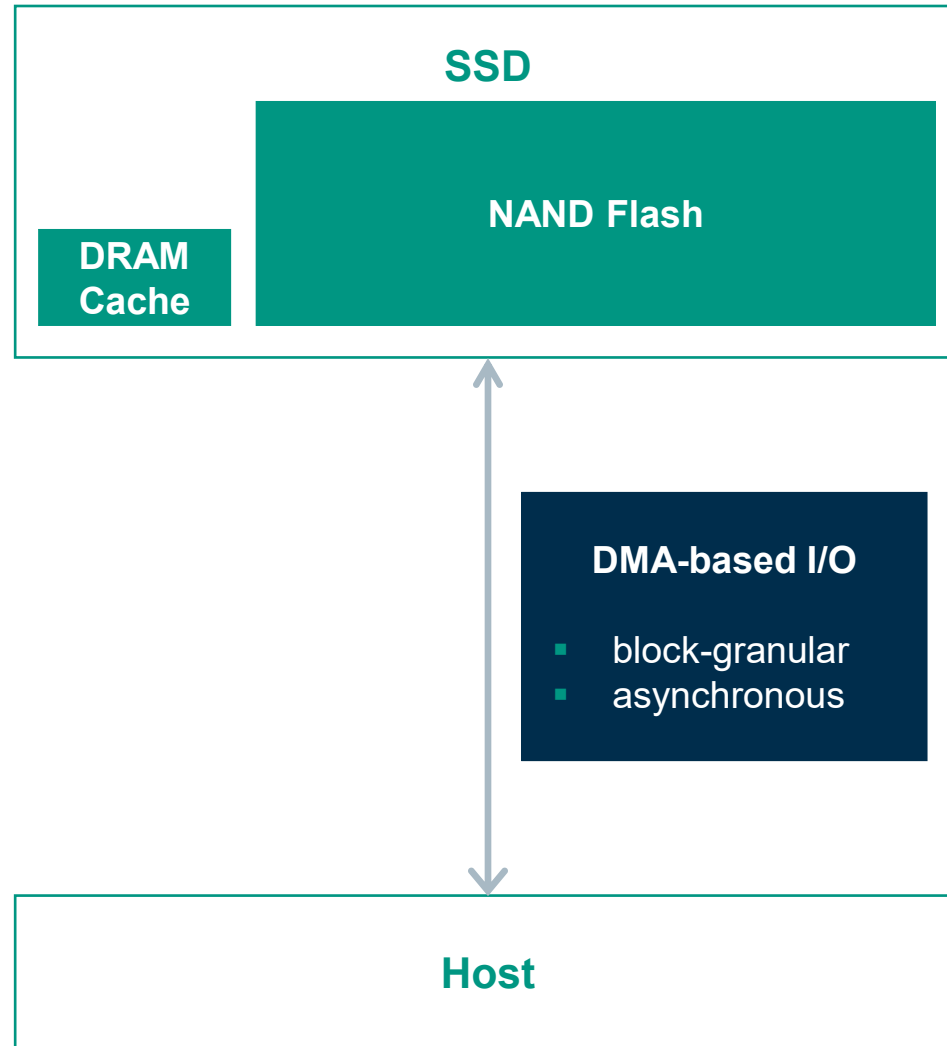
Yussuf Khalil
25 September 2026



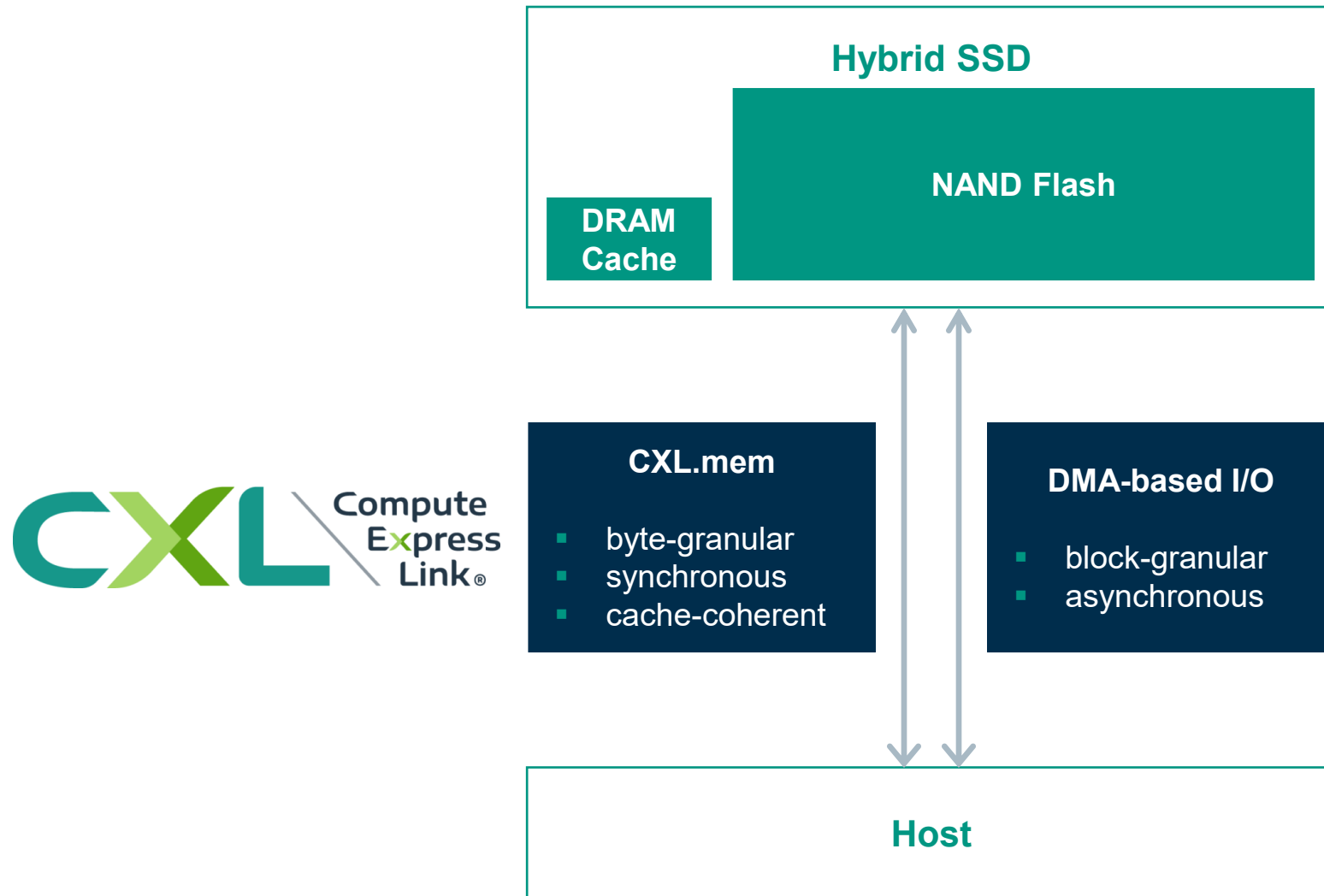
What Is a CXL-Based Hybrid SSD?



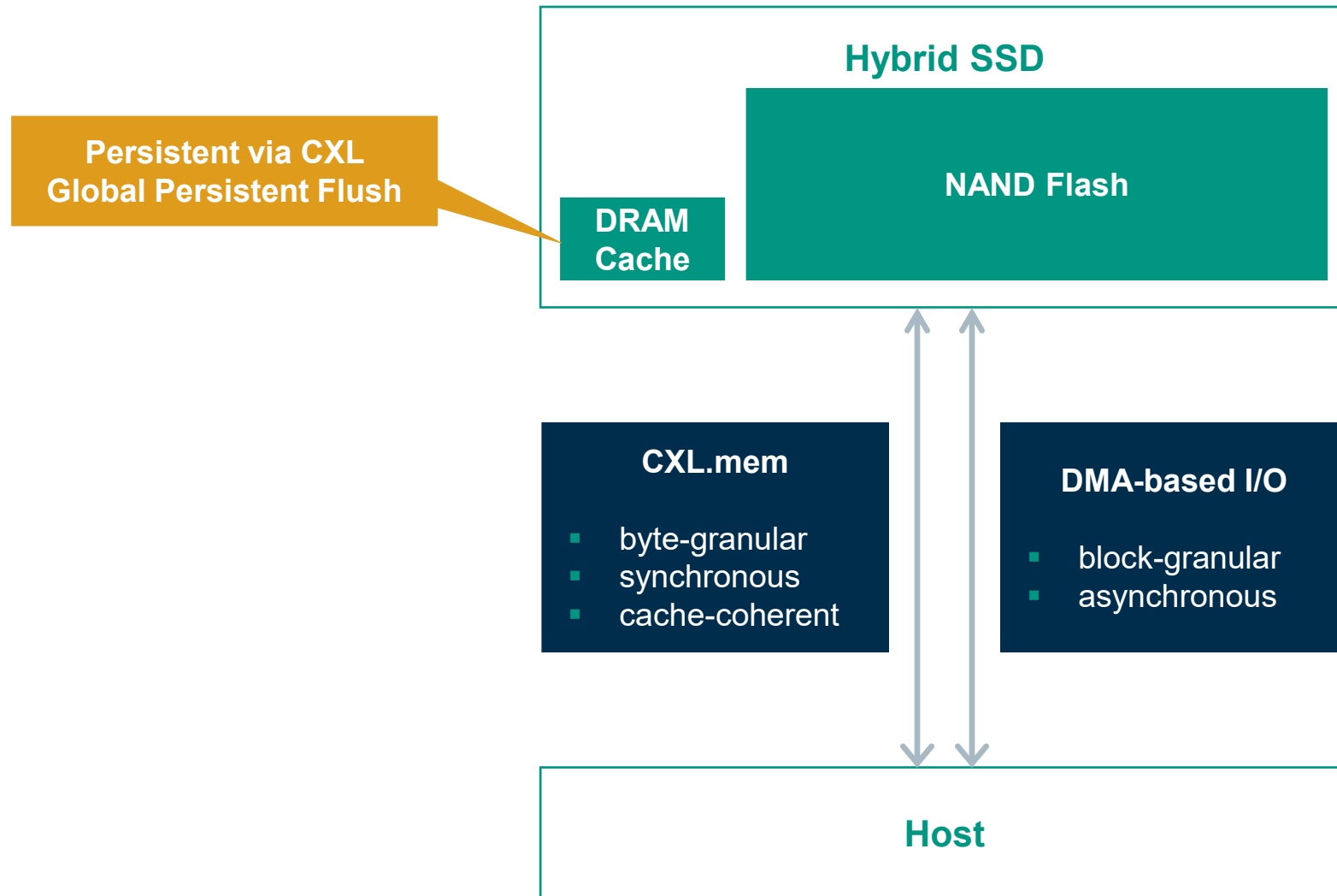
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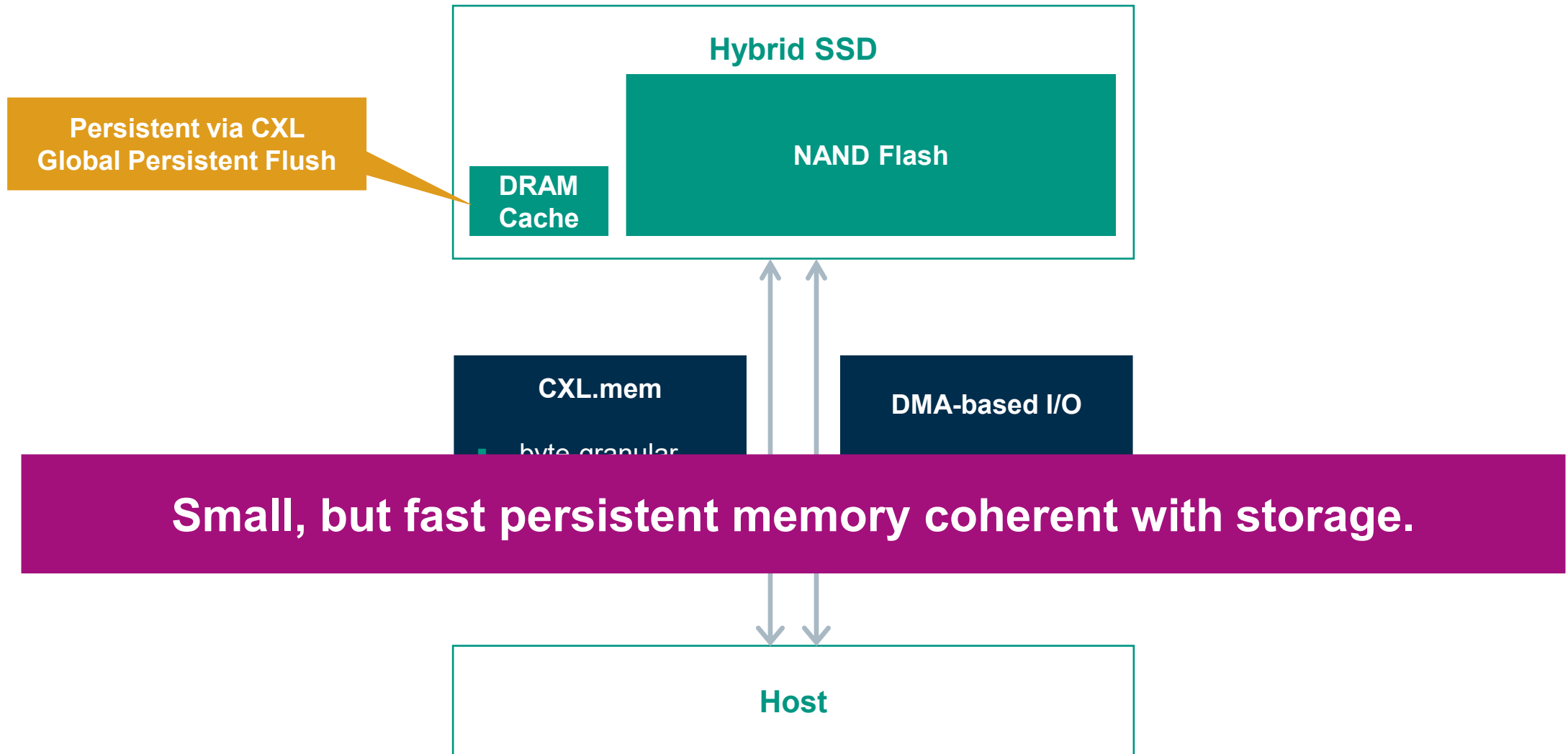
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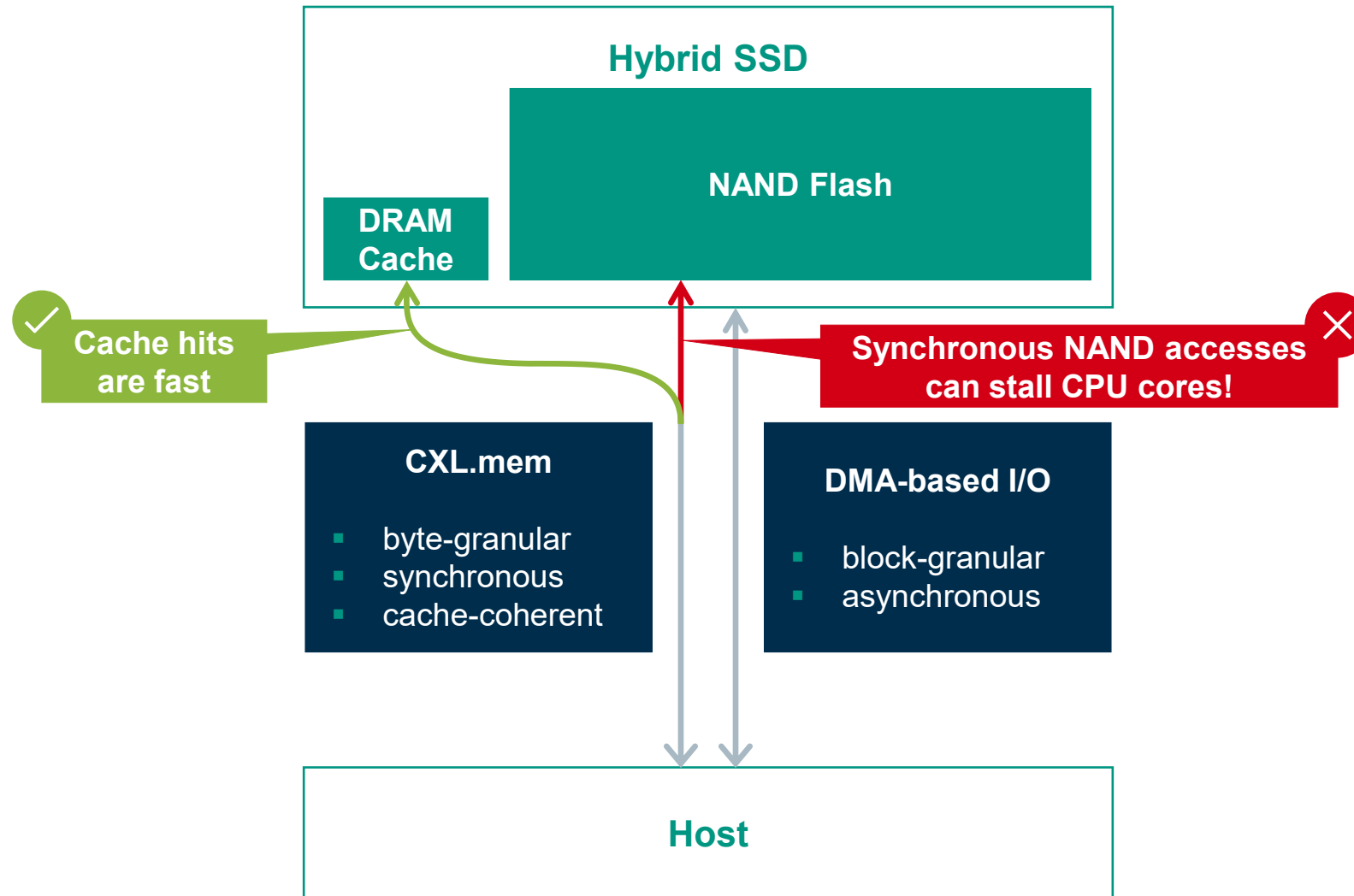
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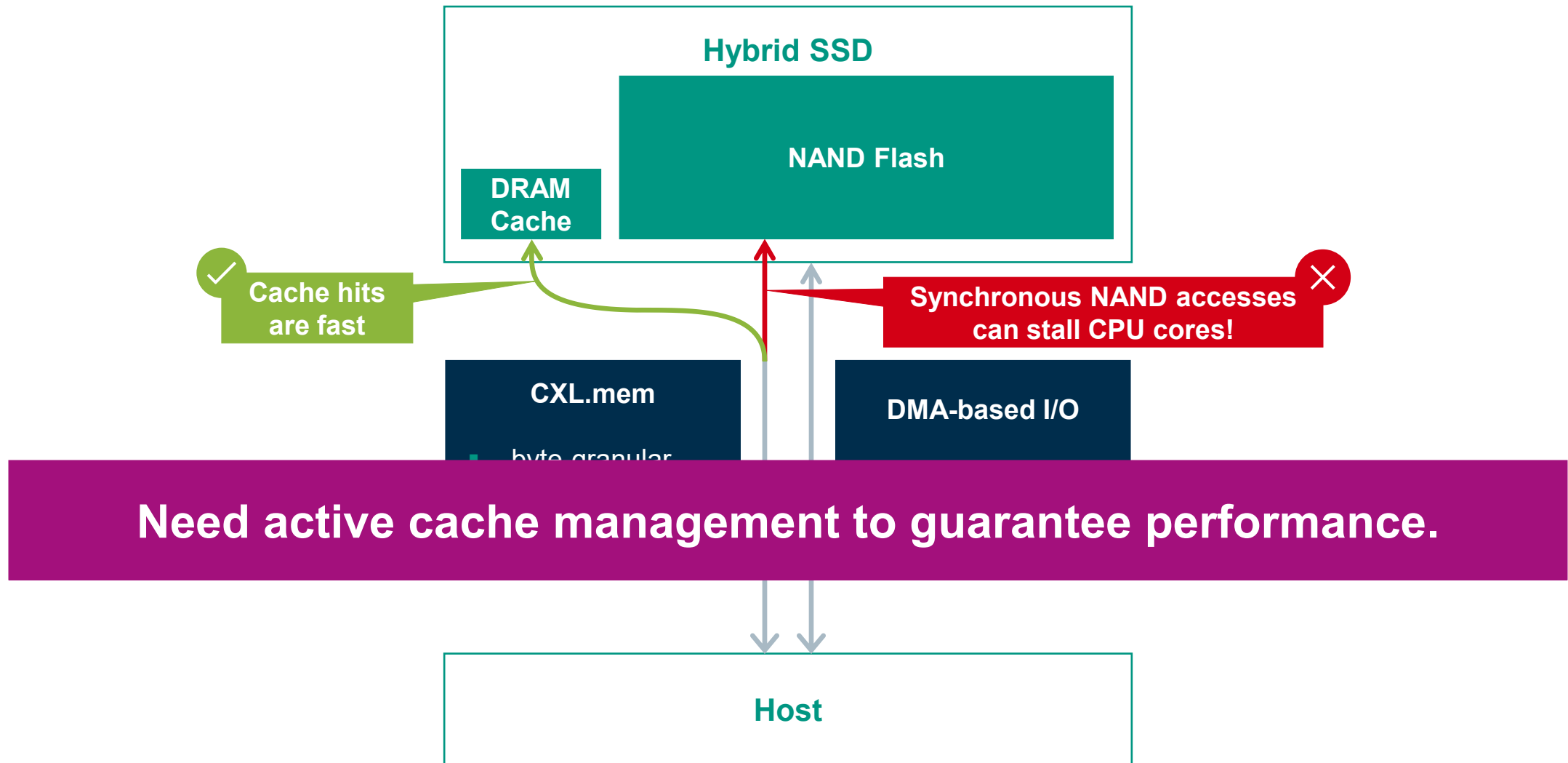
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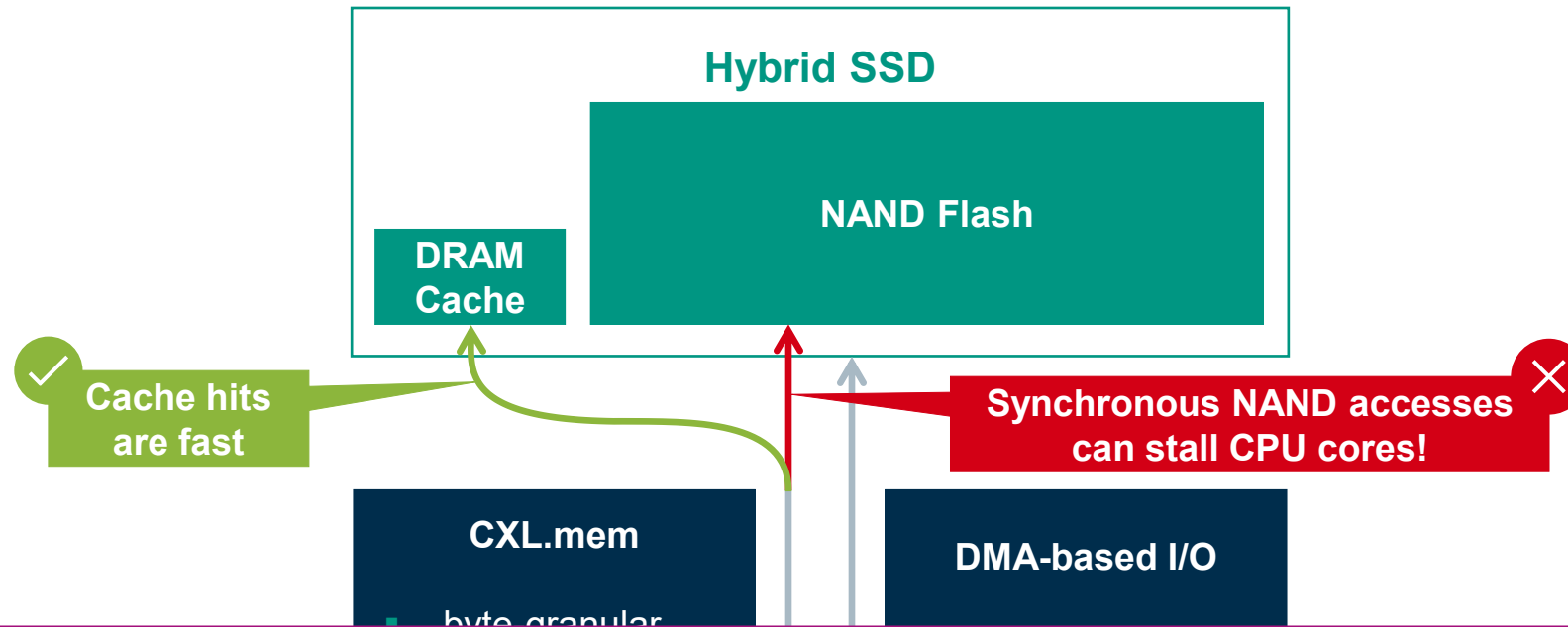
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What Is a CXL-Based Hybrid SSD?



What Is a CXL-Based Hybrid SSD?



Need active cache management to guarantee performance.

Host-based cache management is my research focus.

What Can We Do With That?

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Today: Novel system suspend design

System Suspend: Today's Reality

Suspend-to-Memory (S3, s2idle)

Suspend-to-Disk (S4)

System Suspend: Today's Reality

Suspend-to-Memory (S3, s2idle)

- + Fast resume
- Energy consumption while suspended
- Data loss on power loss

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- + Data secured
- Slow resume

Want to combine the best of both worlds.

System Suspend: Fundamental Approach

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Treat CXL-based hybrid SSD as memory during resume

Execute processes directly from SSD

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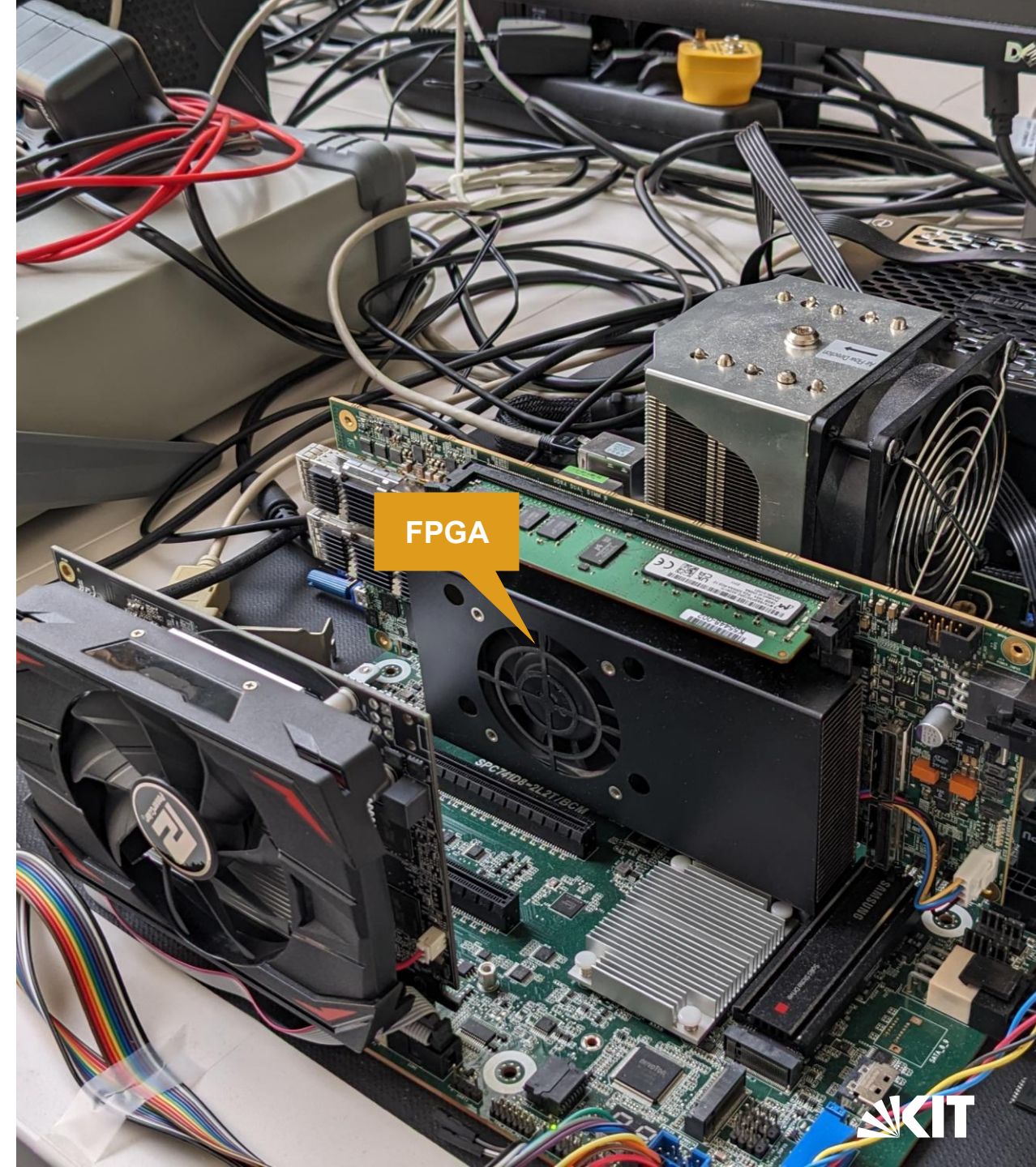
Pipeline prefetching based on OS directives

Achieve S3-style resume from a powered off state.

Implementation: Hardware Prototype

Custom FPGA-based prototype

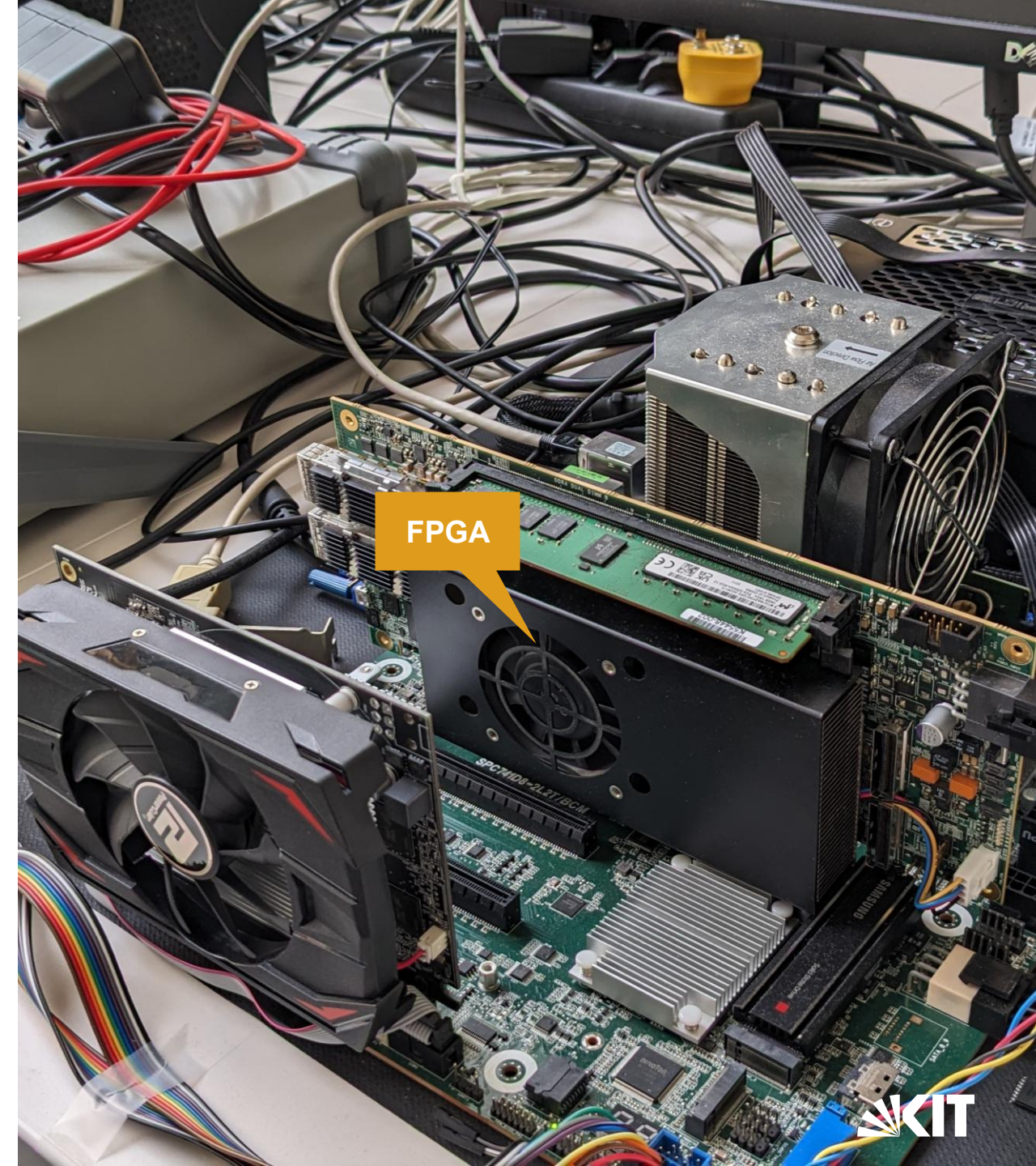
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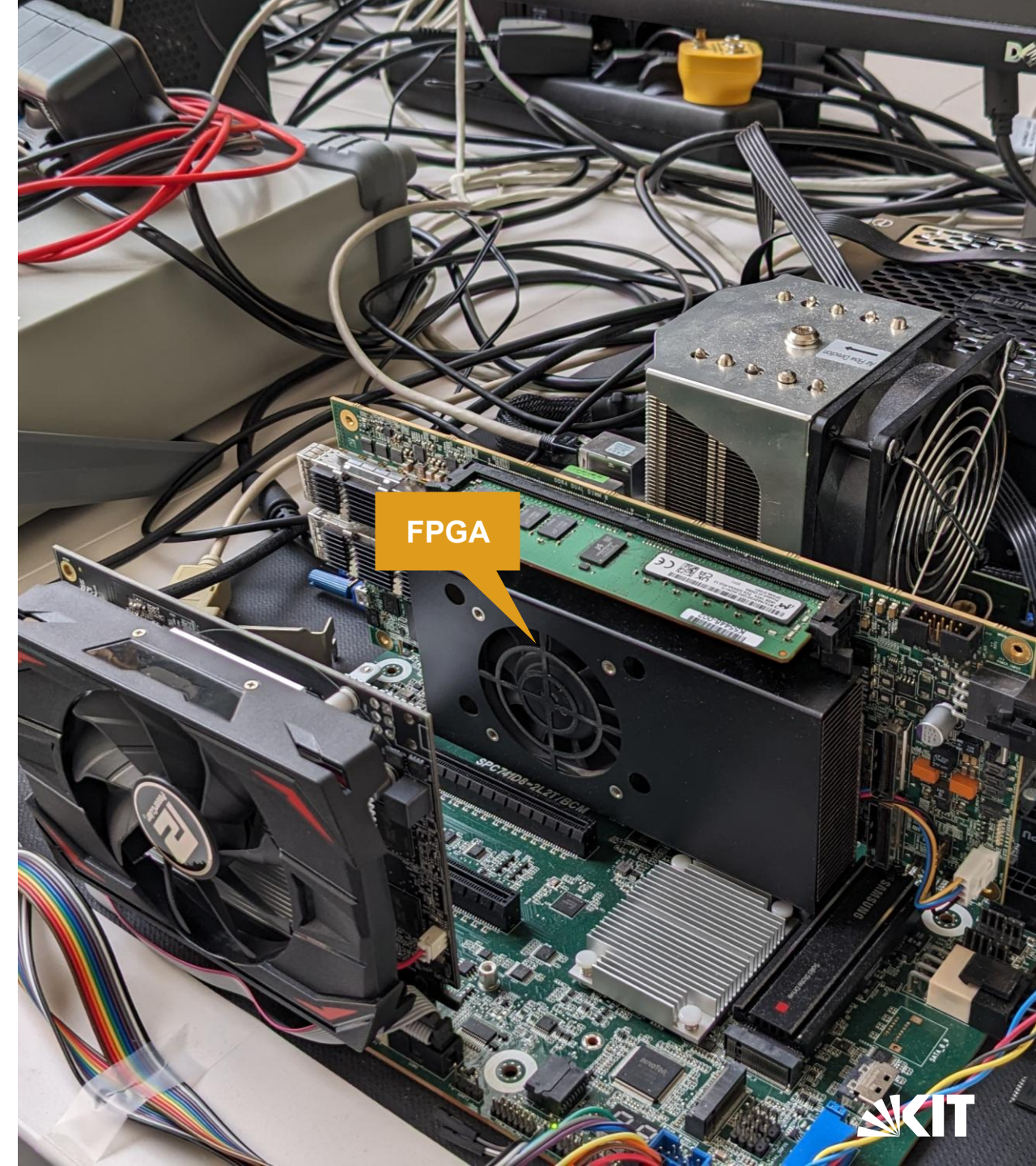
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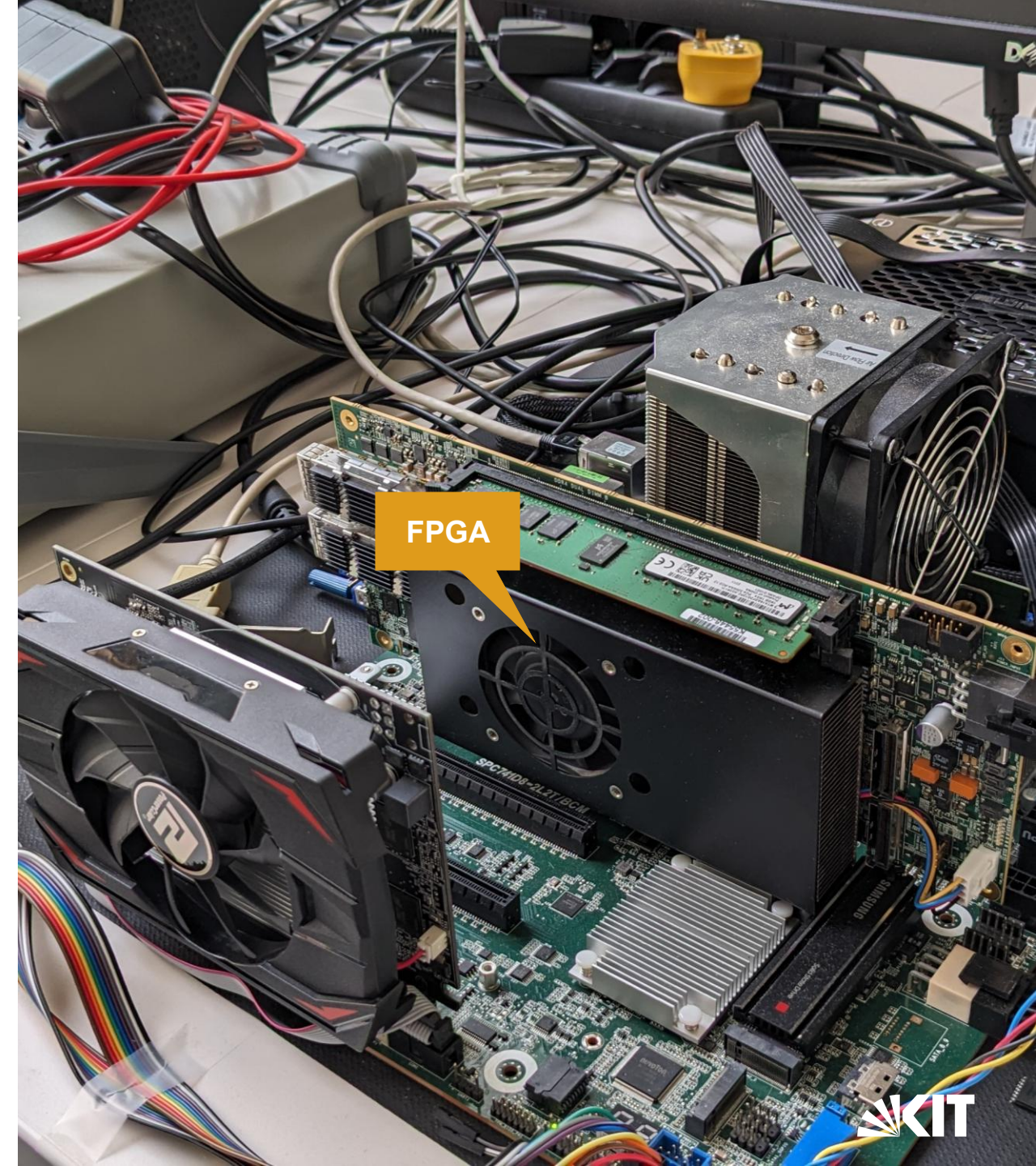
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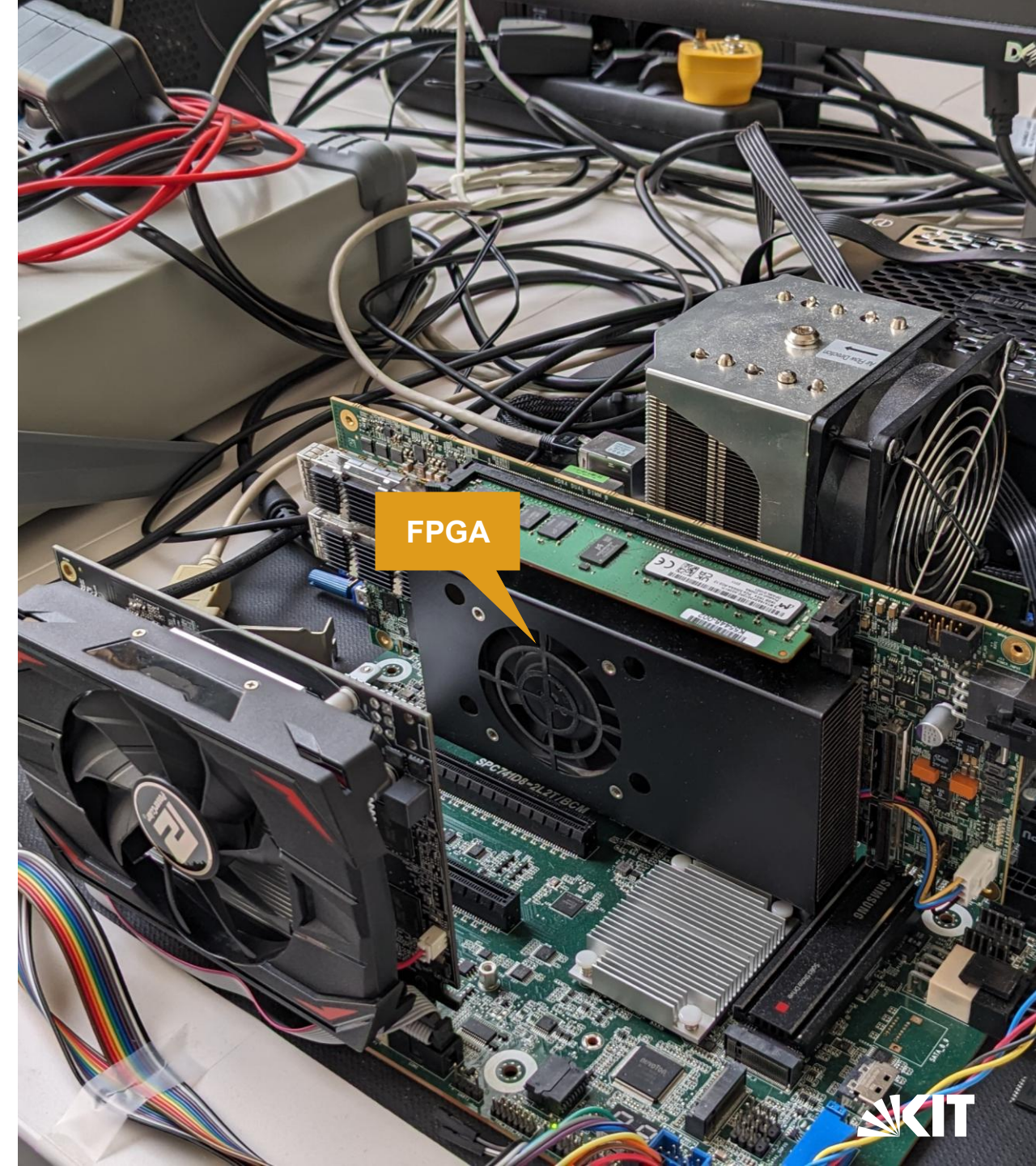
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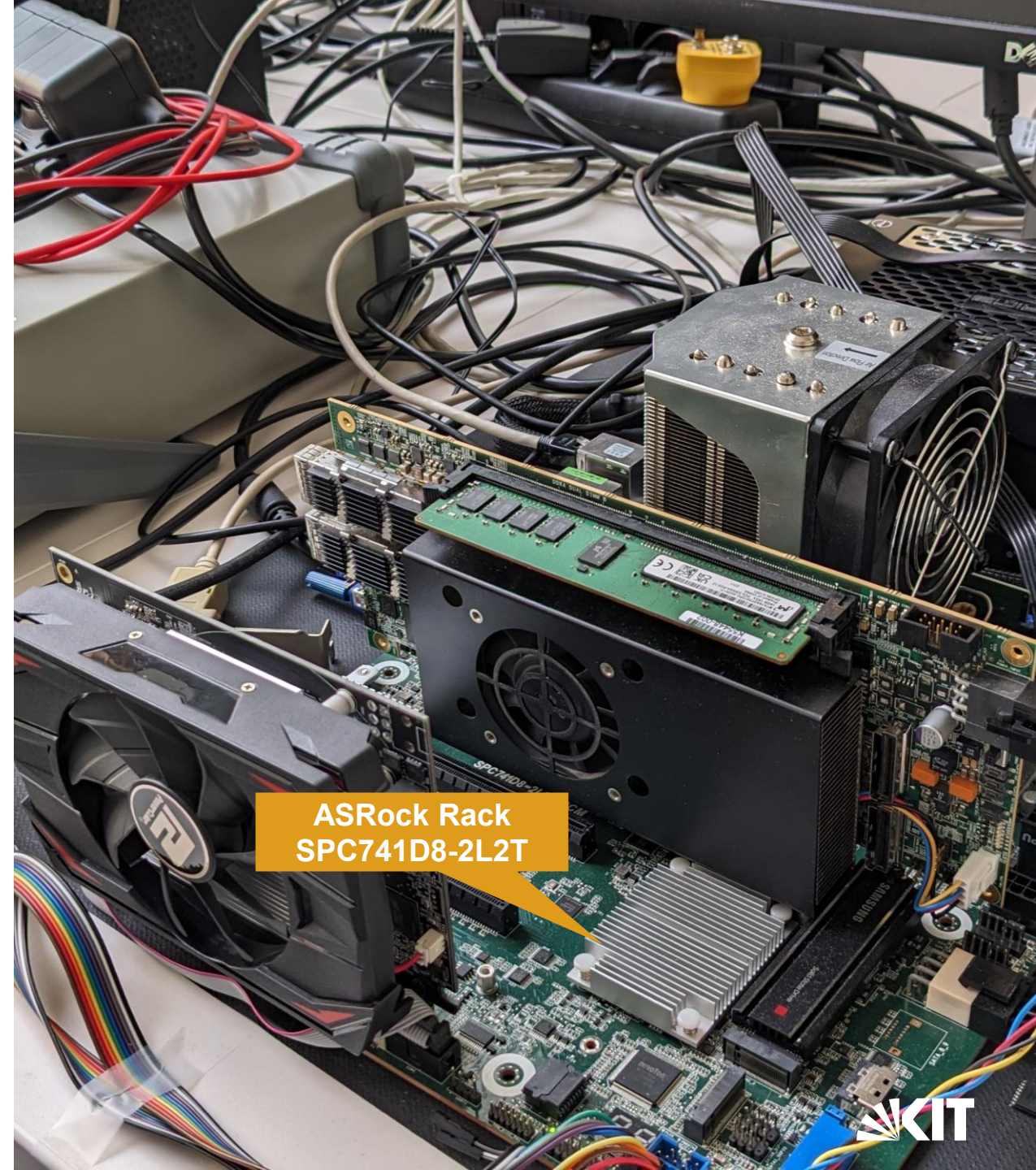
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- More features not to be disclosed today 😊



Implementation: coreboot

Homemade coreboot port

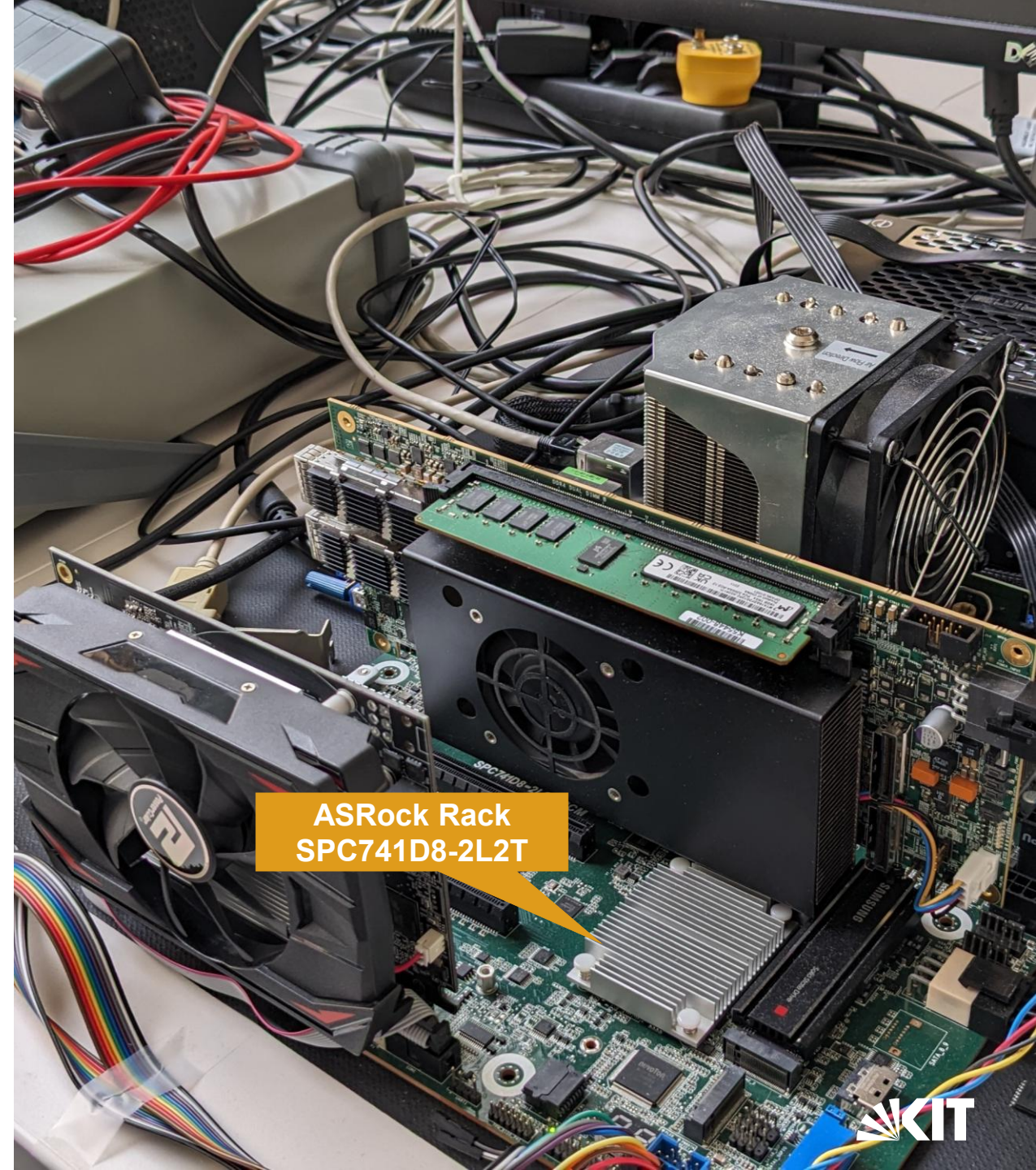
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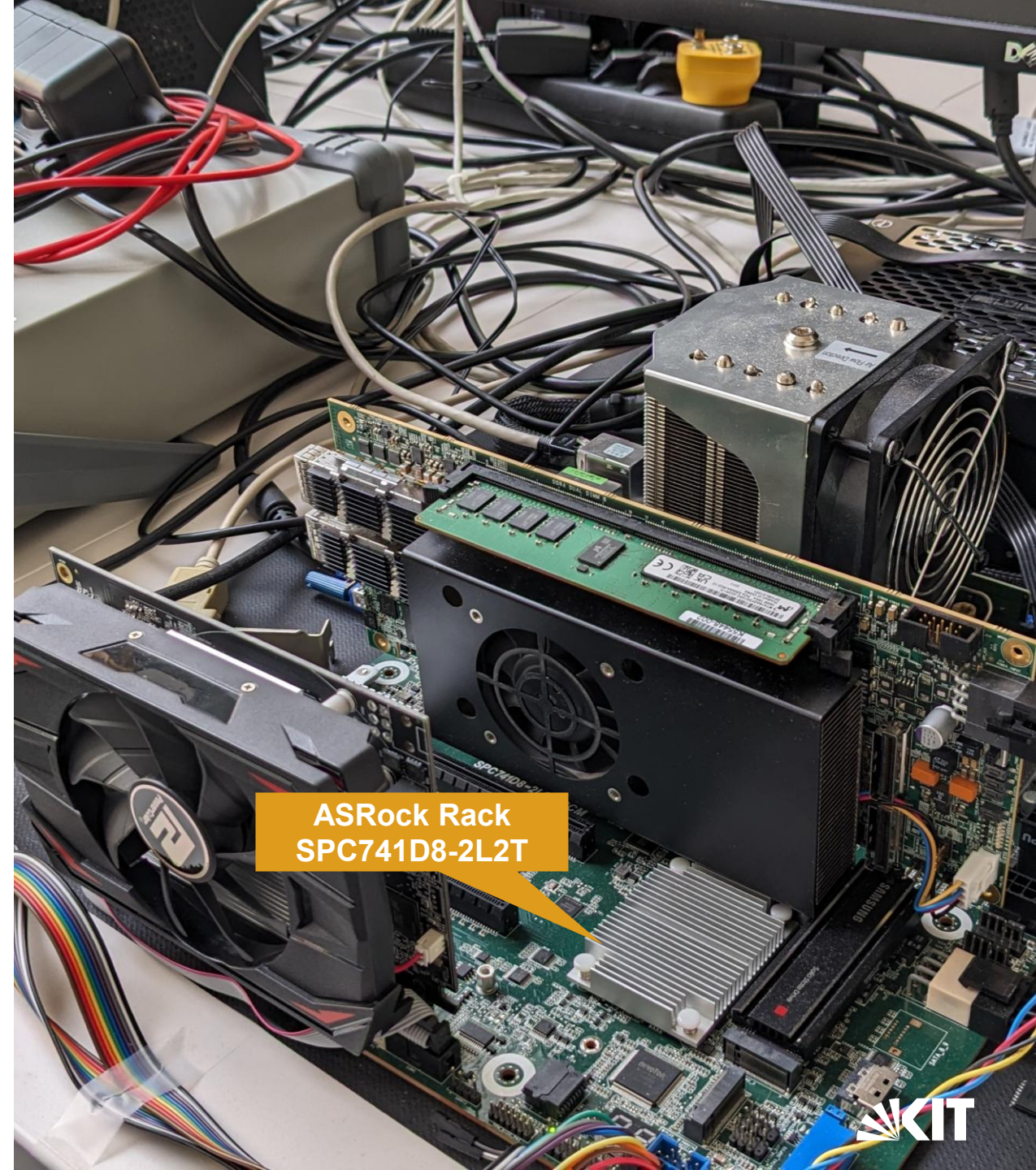
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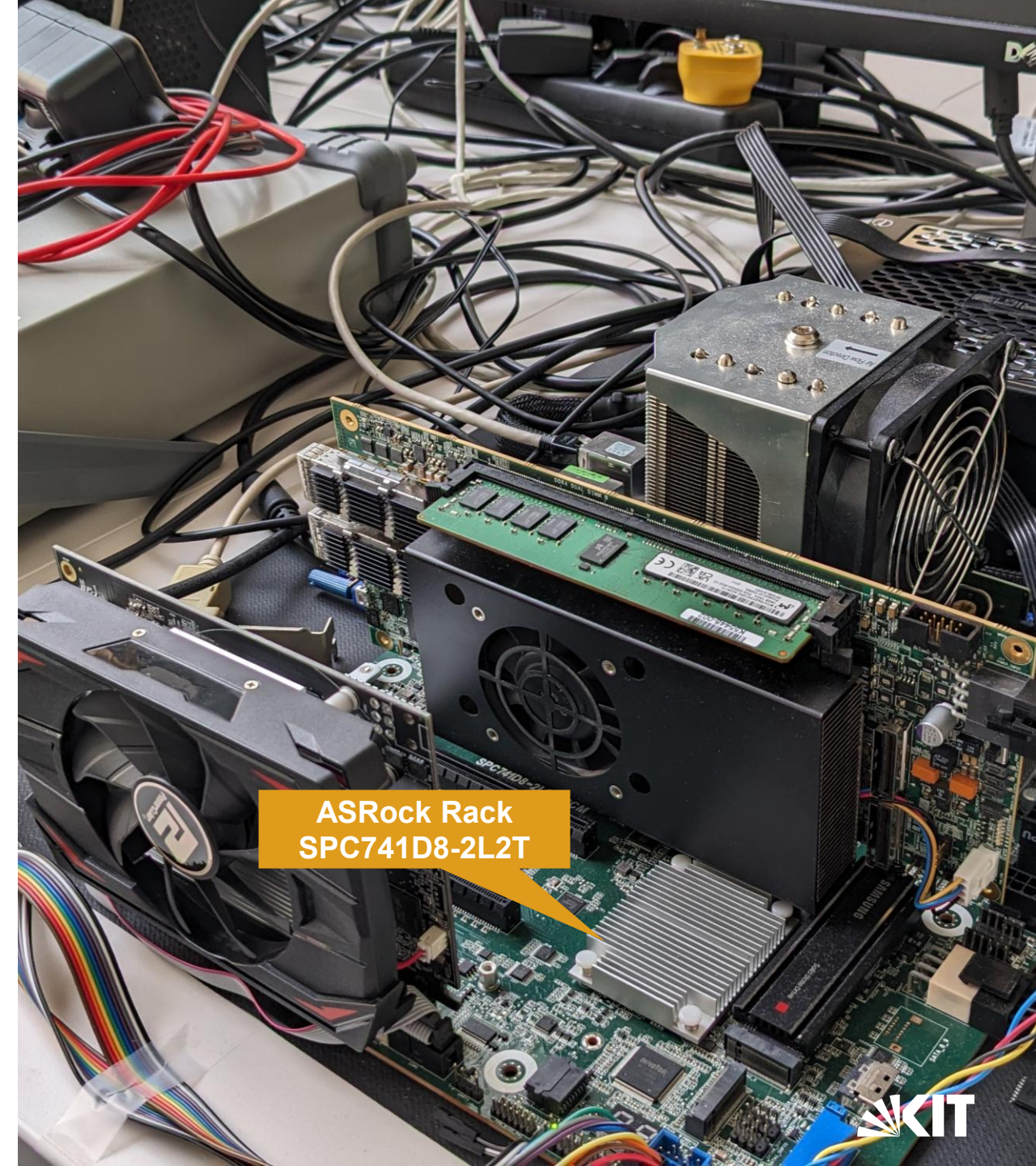
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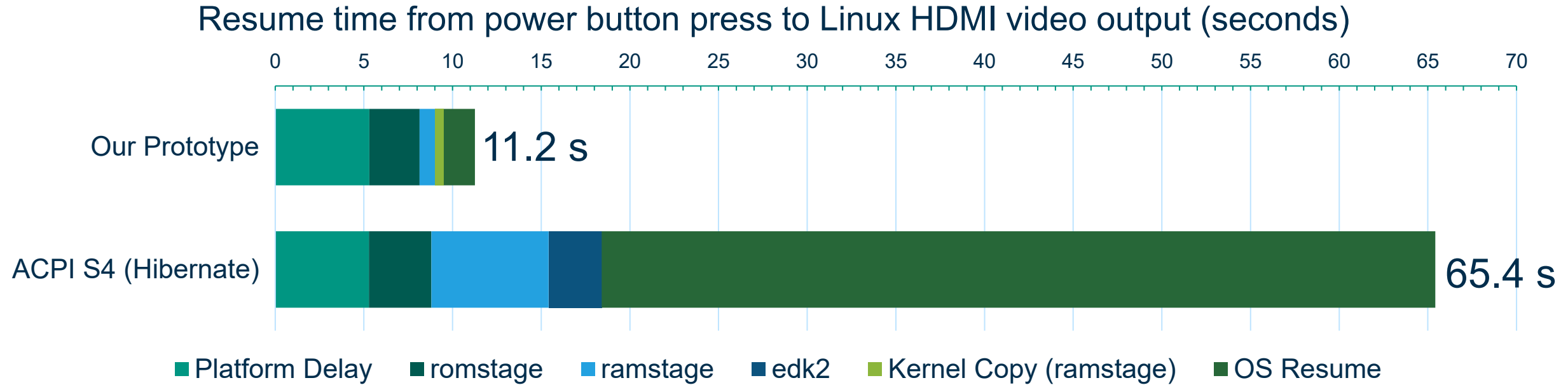
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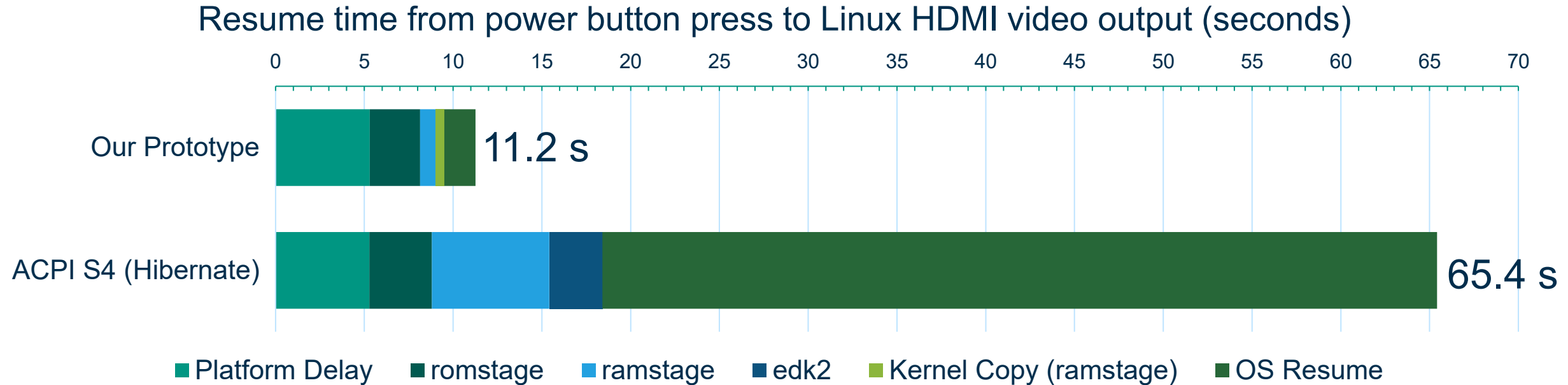
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- 3mdeb's Dasharo now available for this mainboard



Preliminary Numbers



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S3 likely similar fast.

Thanks  !
coreboot

Our suspend project would not be possible without boot chain transparency.

But We Are Not There Yet

Want to compare energy consumption and resume time versus S3

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No S3 support in Intel Eagle Stream FSP



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CXL and S3 are supported in Intel Granite Rapids-WS



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No coreboot support for GNR-WS



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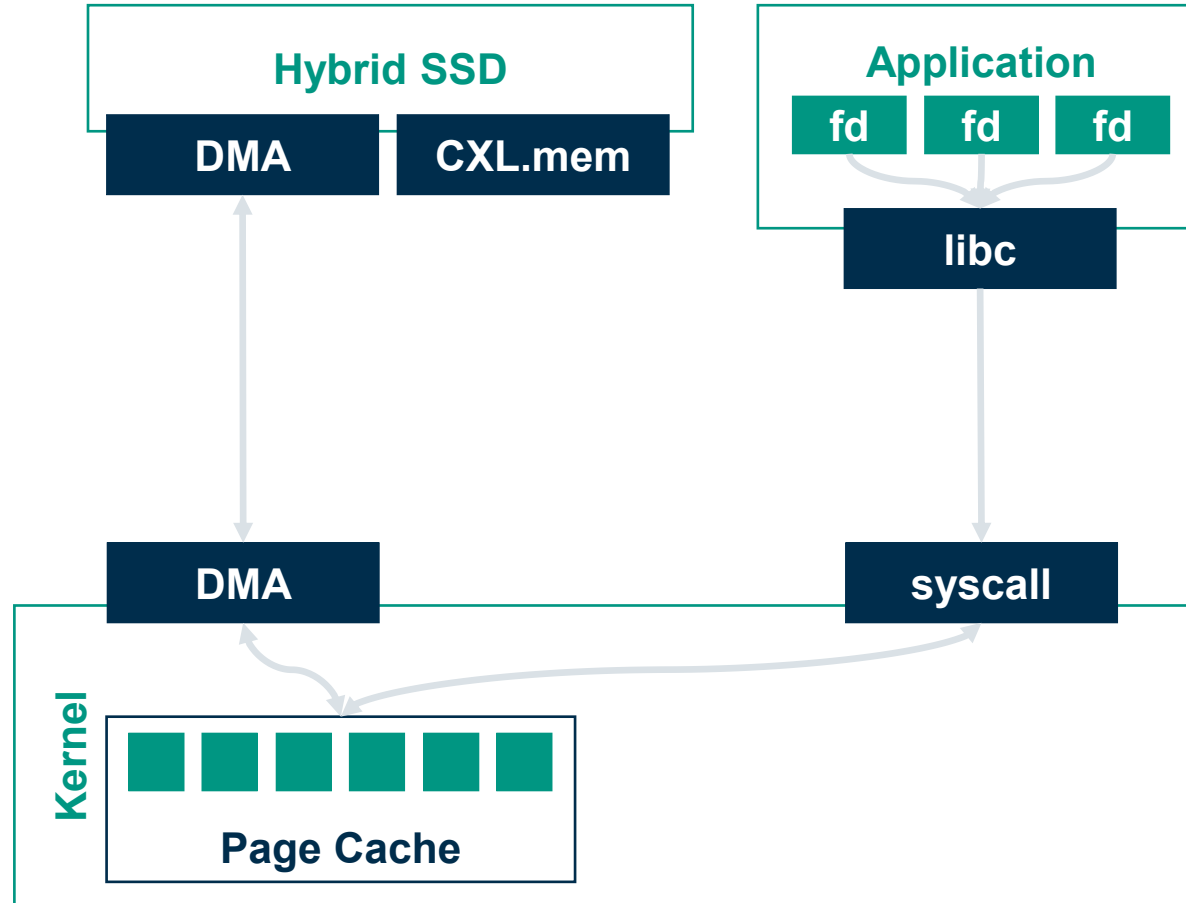


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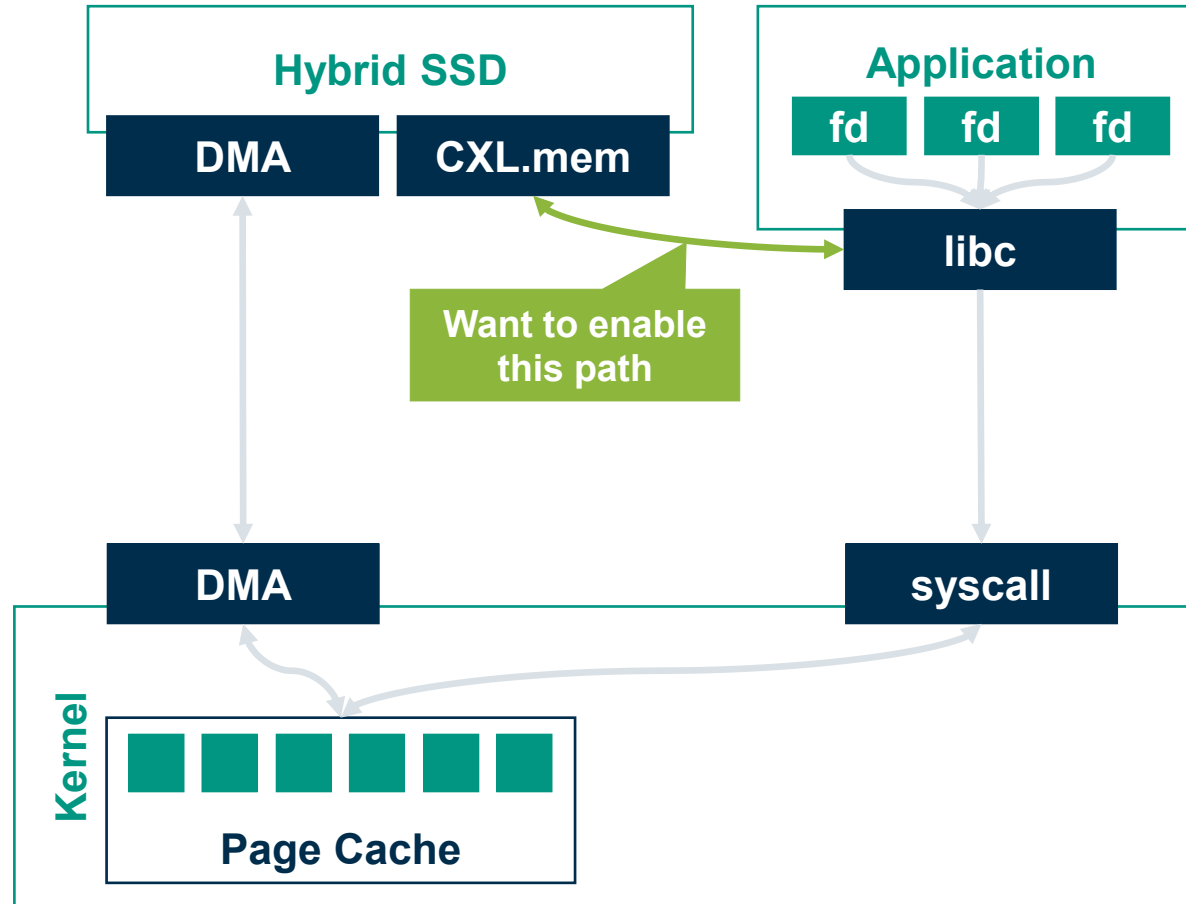


Need ***MORE*** boot chain transparency.

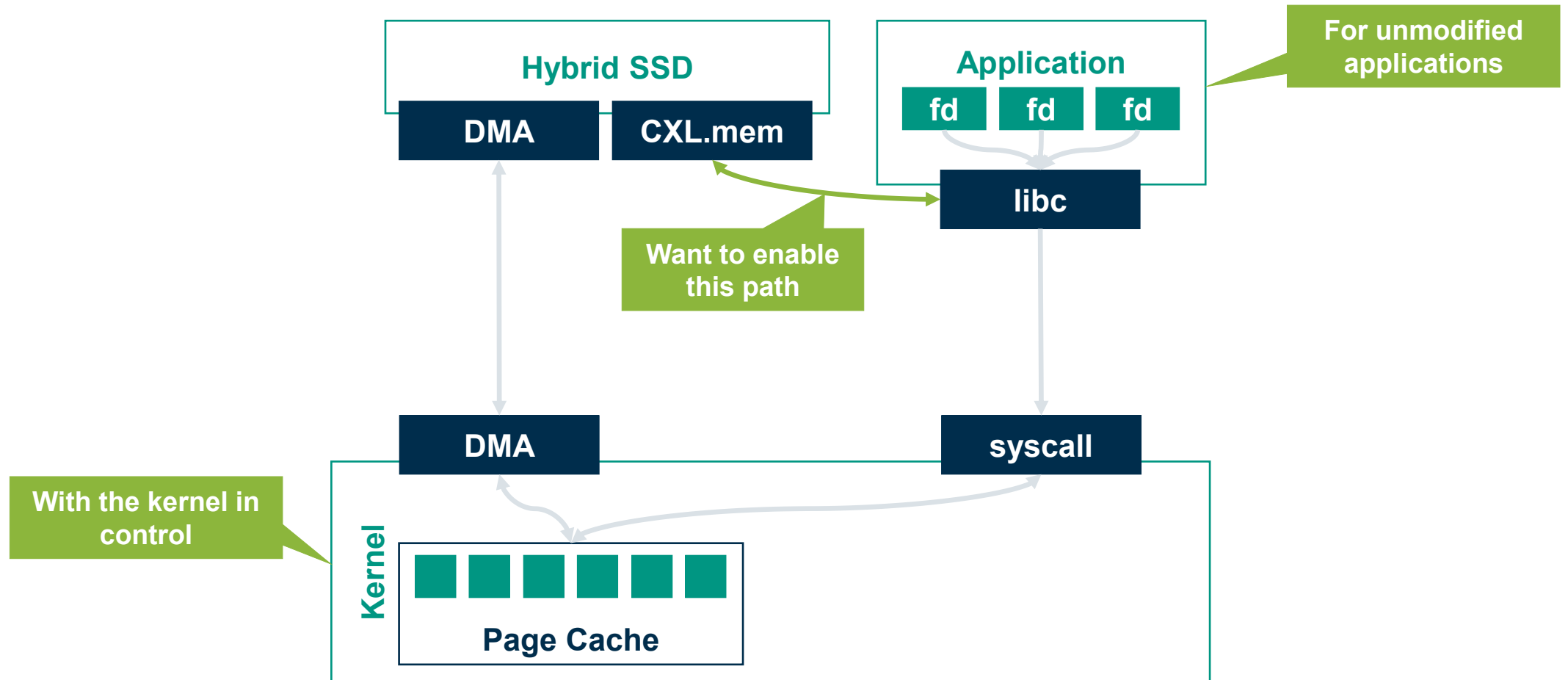
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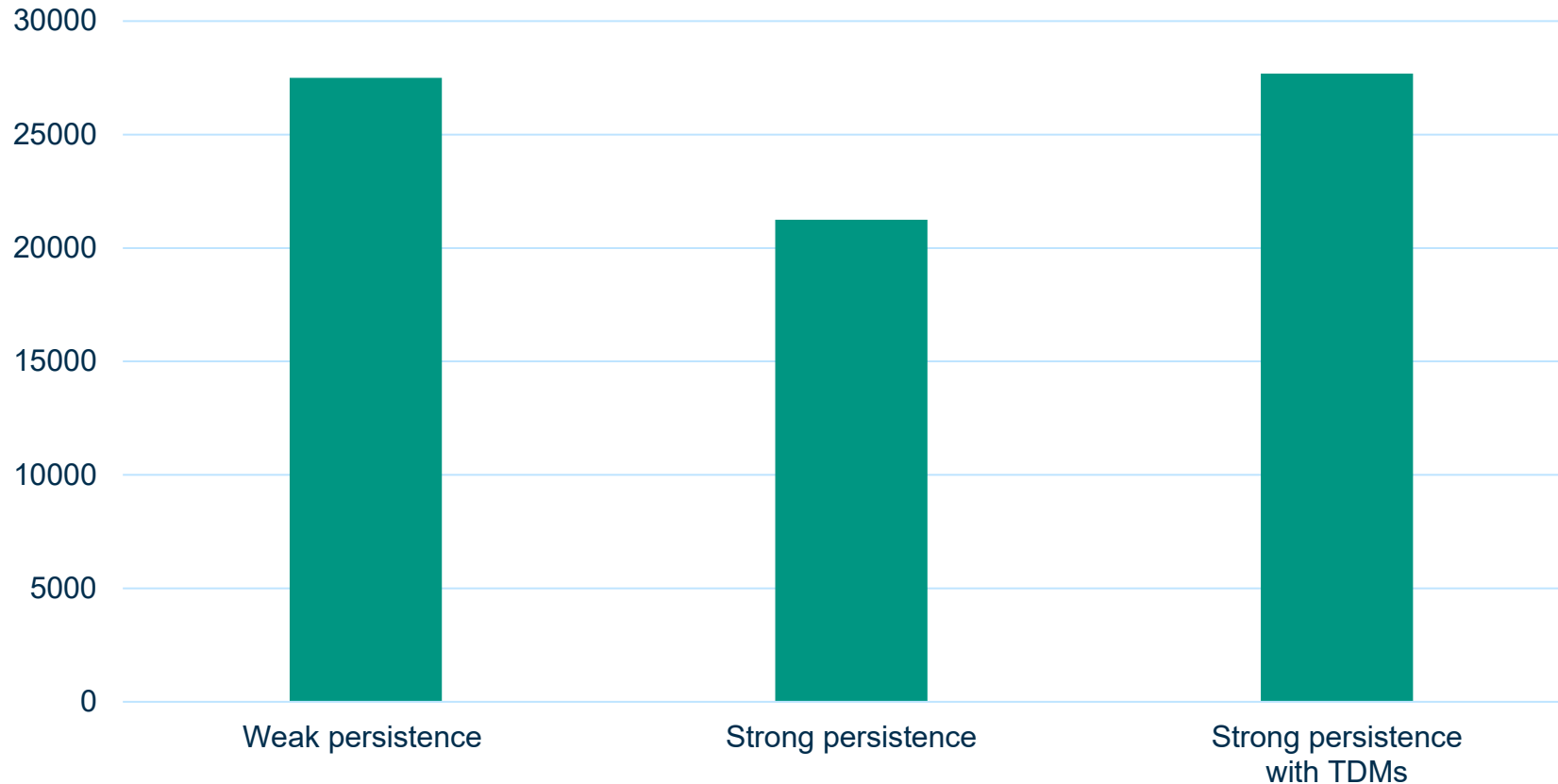


Outlook: Transparent DAX Mappings



Outlook: Valkey/YCSB with Transparent DAX Mappings

Geometric Mean Throughput



TDMs make persistence *cheap*.

Conclusion

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Boot chain transparency is what enables our suspend research.

