

Experiments on automation of formal verification of devices at the binary level

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Section 1

Motivation

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- 1 Motivation
 - Formal verification
 - Security critical systems
 - Network Interface Controllers (NIC)
- 2 Non proof-producing verification
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- 3 Proof-producing verification
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HOL4

Proof-producing analysis

Machine-checked proofs

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Security critical systems

Privacy

- Smartphones
- Smart TVs

Security

- Hospital equipment
- Traffic control systems
- Power plants

Security critical systems - vulnerable

<https://www.wired.com/2014/04/hospital-equipment-vulnerable/>
It's Insanely Easy to Hack
Hospital Equipment

<https://www.wired.com/2015/07/hackers-remotely-kill-jEEP-highway/>
Hackers Remotely Kill a Jeep on
the Highway—With Me in It

Security critical systems - vulnerable

Vulnerabilities come because of:

- Increased surface of attack (more and more features, codebases explode in size)
- Connected to networks → remote attacks

Secure operating systems



¹<https://sel4.systems/Info/FAQ/proof.pml>

Secure operating systems



Formal proof¹:

- The binary code correctly implements its **abstract specification**.
- The specification guarantees **integrity and confidentiality**.

¹<https://sel4.systems/Info/FAQ/proof.pml>

Secure operating systems



Formal proof¹:

- The binary code correctly implements its **abstract specification**.
- The specification guarantees **integrity** and **confidentiality**.
- **Integrity**: data cannot be *changed* without permission.
- **Confidentiality**: data cannot be *read* without permission.

¹<https://sel4.systems/Info/FAQ/proof.pml>

Secure operating systems

Proof assumptions²:



²<https://docs.sel4.systems/FrequentlyAskedQuestions#is-sel4-proven-secure>

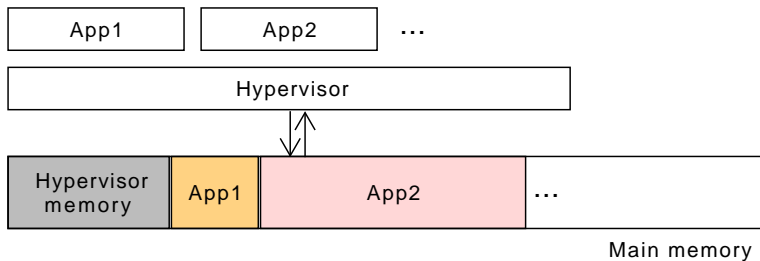
Secure operating systems

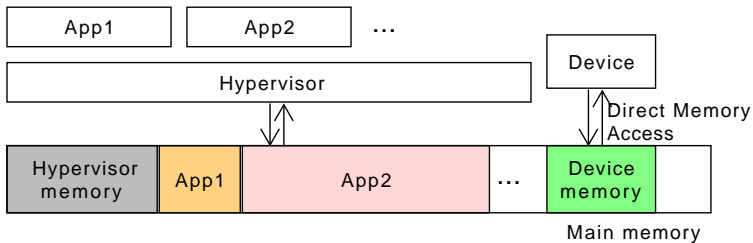


Proof assumptions²:

- Use of Direct Memory Access (DMA) is excluded, or only allowed for **trusted drivers that have to be formally verified by the user.**

²<https://docs.sel4.systems/FrequentlyAskedQuestions#is-sel4-proven-secure>





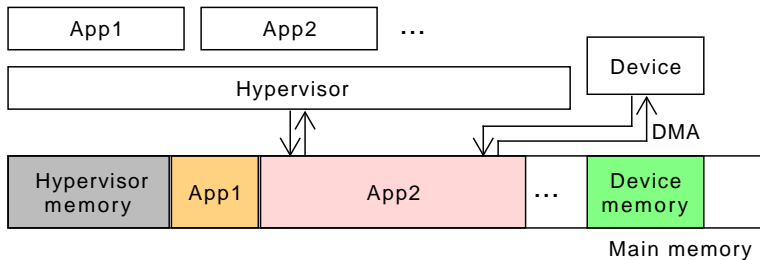


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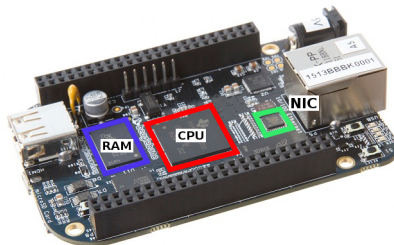
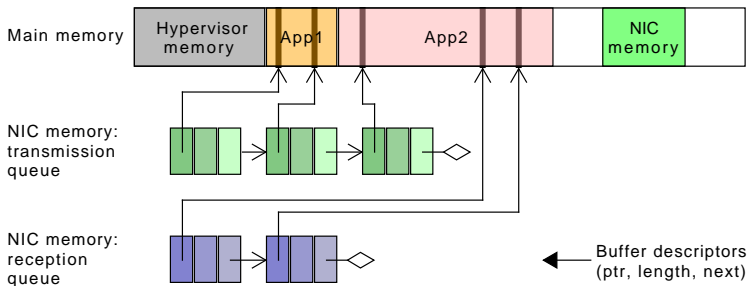
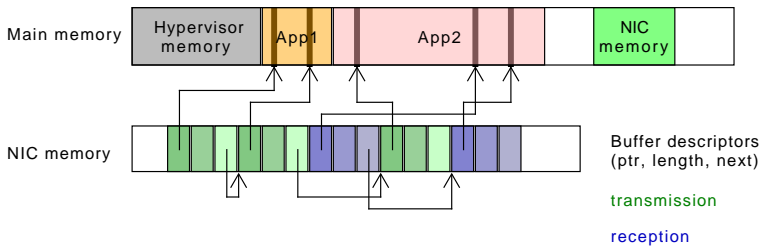
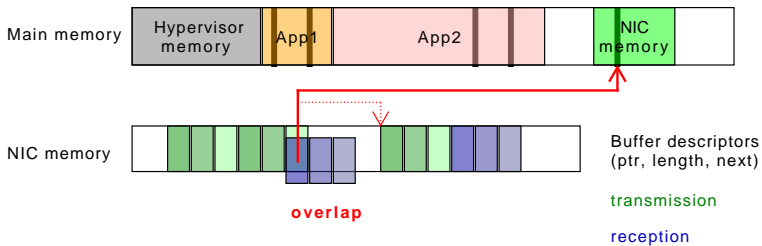


Figure: BeagleBone Black.







Research question

Can we apply traditional software verification techniques and tools to show security properties of hardware devices?

Section 2

Non proof-producing verification

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Section 3

Proof-producing verification

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Section 4

Conclusion

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