NO SAFETY WITHOUT SECURITY

Cybersecurity for Autonomous Vehicles

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Cybersecurity: 1st Class Safety Issue

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Fundamental rules of cyber space:

1. **The internet is a hostile environment**
2. **Anything that is internet-connected *can* be attacked**
3. **Anything that *can* be attacked *will* be attacked**

Examples:

- **Cars**
- **Trains**
- **Aircraft**

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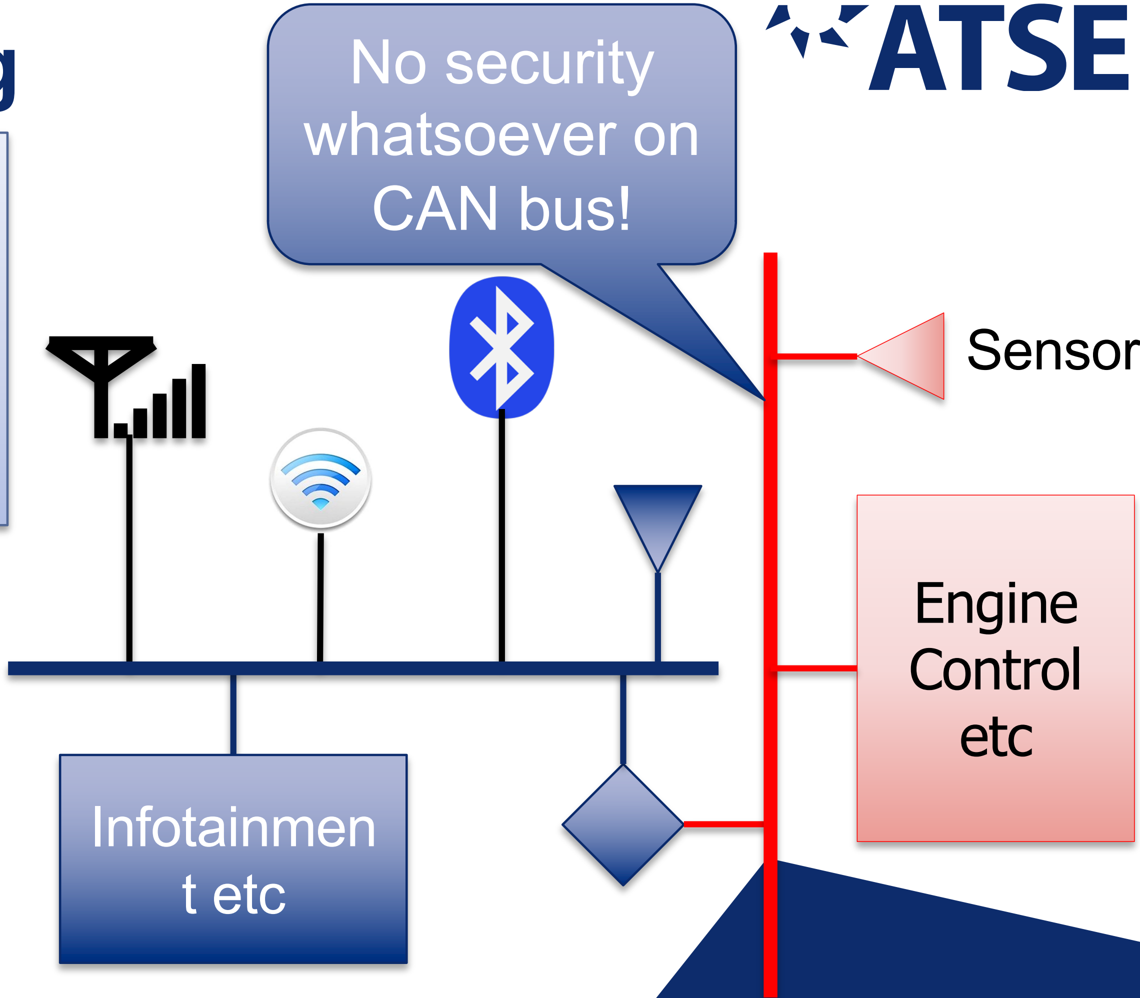
Example Car Hacking

Networking for:

- Entertainment
- Driver information
- Safety (tire pressure…)
- Maintenance (OTA upgrades)



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Challenge of Networking

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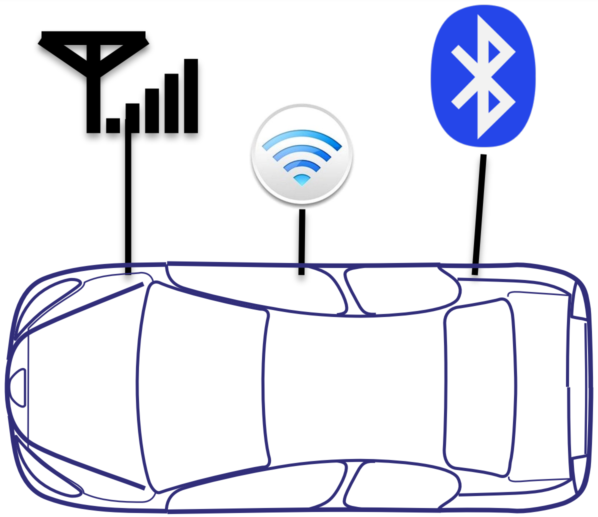
Networking creates remote attack opportunities

- from passengers (wifi, Bluetooth)
- from nearby cars (wifi, Bluetooth) – incl infected ones!
- from anywhere (cellular)

BlueBorne



Attack vectors:

- Insecure protocols
- Reusing crypto keys
- Software vulnerabilities

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WHY ARE SYSTEMS SO VULNERABLE?

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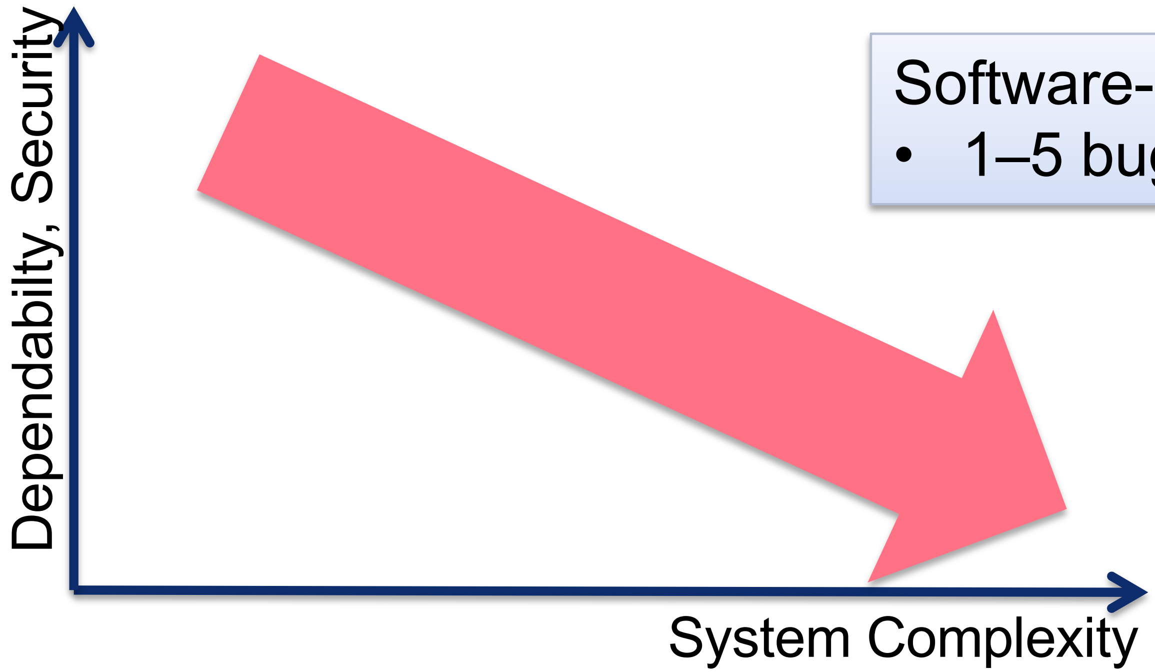
Failure Reason #1: Complexity



Software-engineering rule of thumb:
- 1–5 bugs per 1,000 lines of *quality* code

Bluetooth protocol stack:
Multiple 100,000 lines

Linux/Windows kernel:
Tens of millions lines

Complexity Drivers
- Features/functionality
- Legacy reuse

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Operating-System "Security"

ars TECHNICA — BIZ & IT · TECH · SCIENCE · POLICY · CARS · GAMIN

RISK ASSESSMENT —

Windows is no better!

Unsafe at any clock speed: Linux kernel secu[...] rethink[...]

Software will break

The enemy will be on the platform!

Ars reports from the Linux Security Summit—and finds much work that needs to be done.

Autonomy Increases Complexity

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Requires new functionality

- Core autonomy functionality
- Computer vision
- Sensor fusion, from vastly increased number of sensors
- Collision avoidance

Increased integration of automotive control with external world

Much increased attack surface!

Failure Reason #2: Care Factor

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Developer priorities

1. Features/functionality
2. Cost
3. Time to market
4. …
5. ...
6. ...
7. ...

....

....

999. Security

Developer expertise

1. Undergraduate programming
2. Application domain
3. Maybe hardware
4. …
5. ...
6. ...
7. ...

....

....

999. Security

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Failure Reason #3: Security ≠ Safety

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Classic safety thinking (eg automotive, avionics, electrical):

- Failures are *random*
- Failure rates can be kept *very low* through systematic process
- Multiple failures are *independent*

No safety without security!

Reality of software security weaknesses:

- Failure is *deterministic*
- Failure rates are *high*
- Attackers *systematically combine* multiple vulnerabilities
- **Classic safety approaches do not work against cyber attacks!**

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STANDARD DEFENCES

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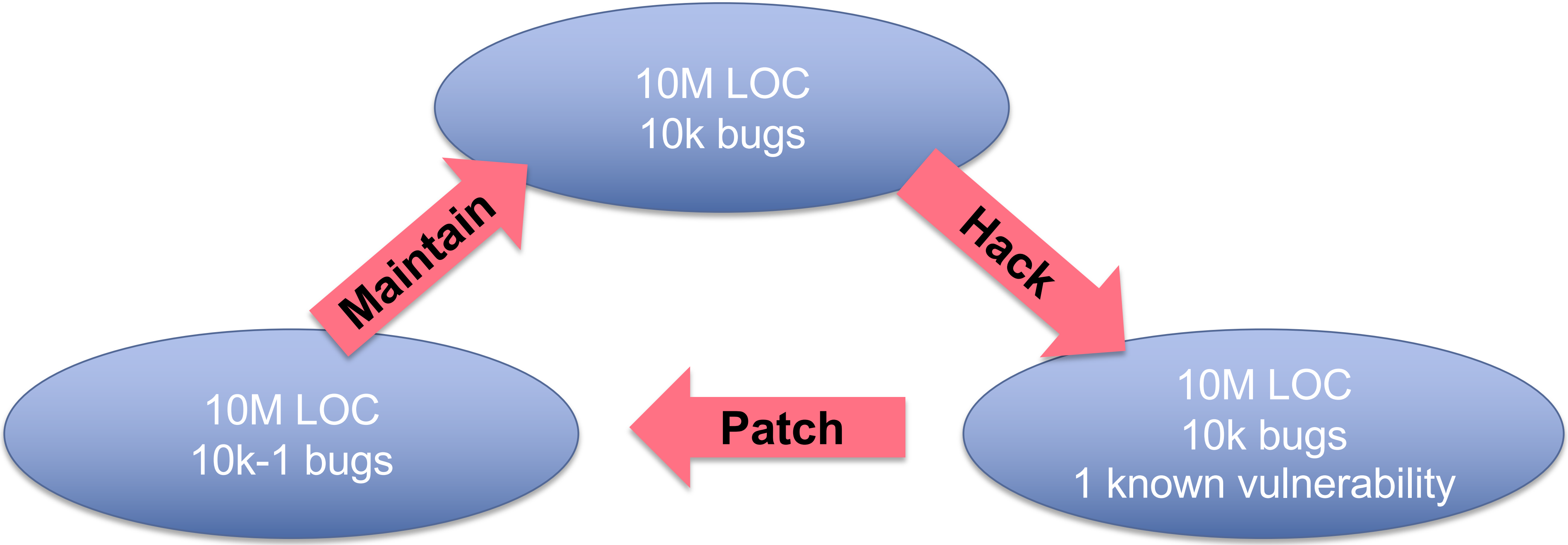
OK, So Let's Patch Regularly



Patch-and-Pray: A losing proposition

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So, Let’s Use Firewalls!

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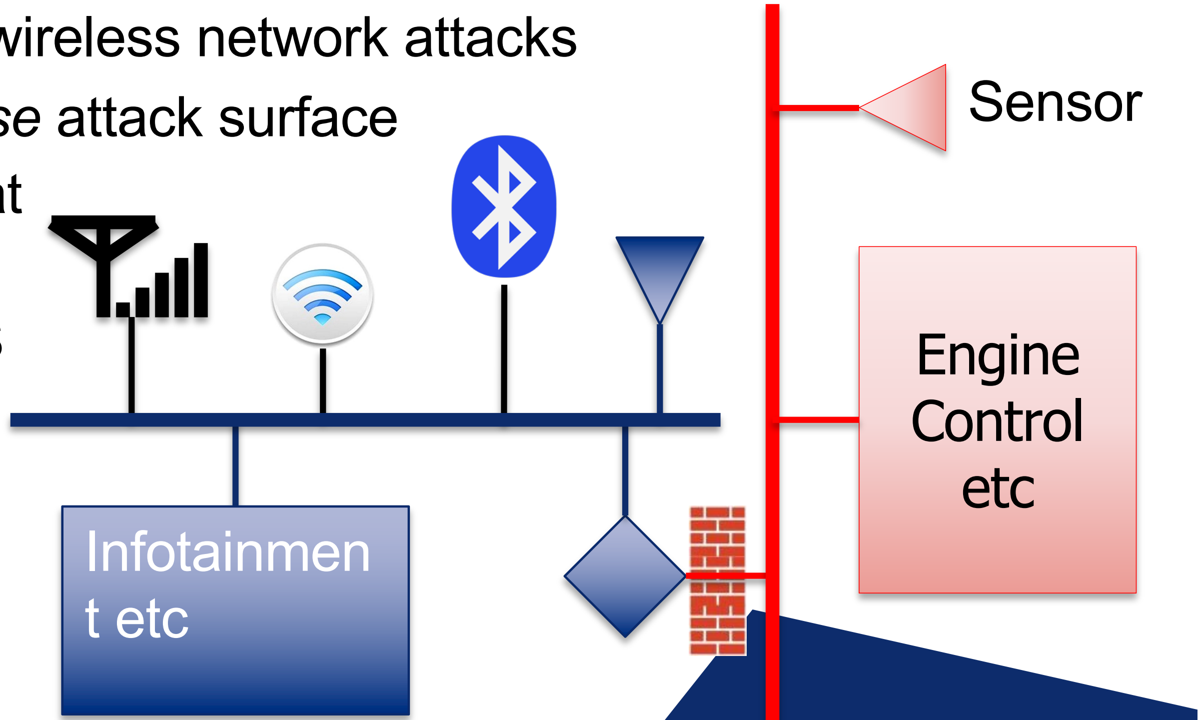
- Imposes overhead (SWaP)
- Doesn’t protect against edge, wireless network attacks
- Even more code – may *increase* attack surface
- No help for valid messages that trigger bugs in software
- Firewall runs on vulnerable OS



Firewalls treat symptoms, not causes of problems, are just another arms race!

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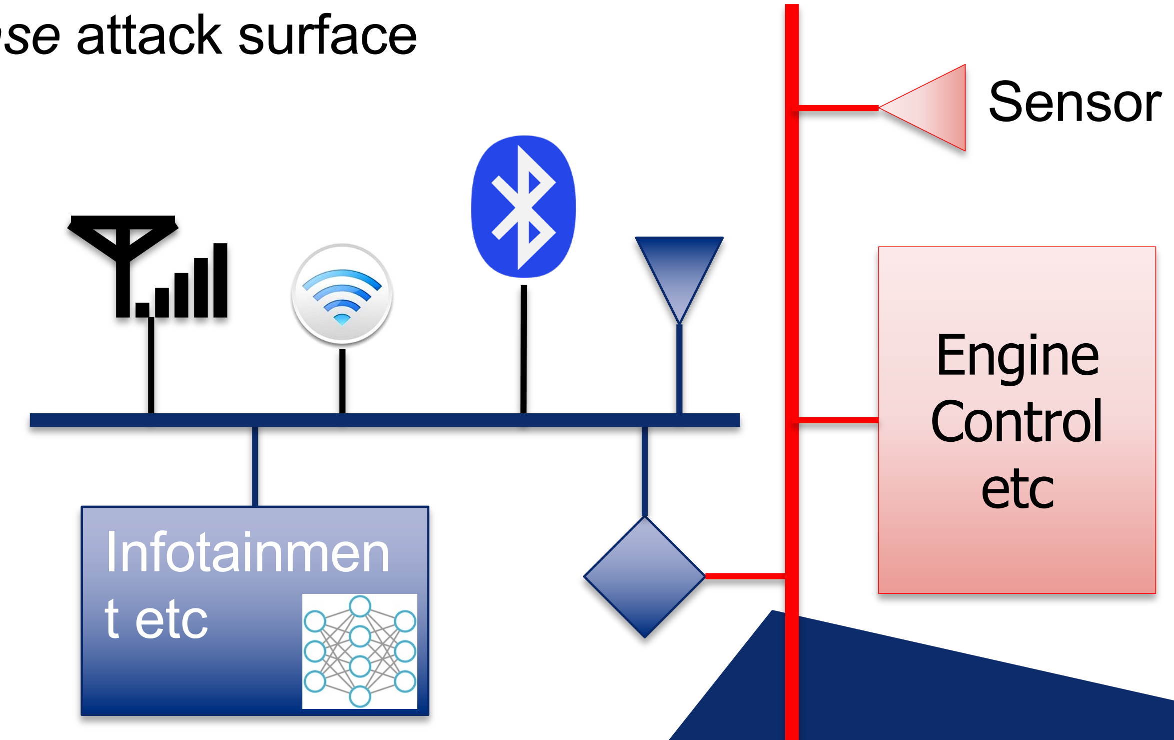
Let's Use AI to Detect Compromise!

- Can only detect that system is already compromised
- Even more code – may *increase* attack surface
- Runs on compromised OS!

Intrusion detection – admission of defeat



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WHAT IS NEEDED?

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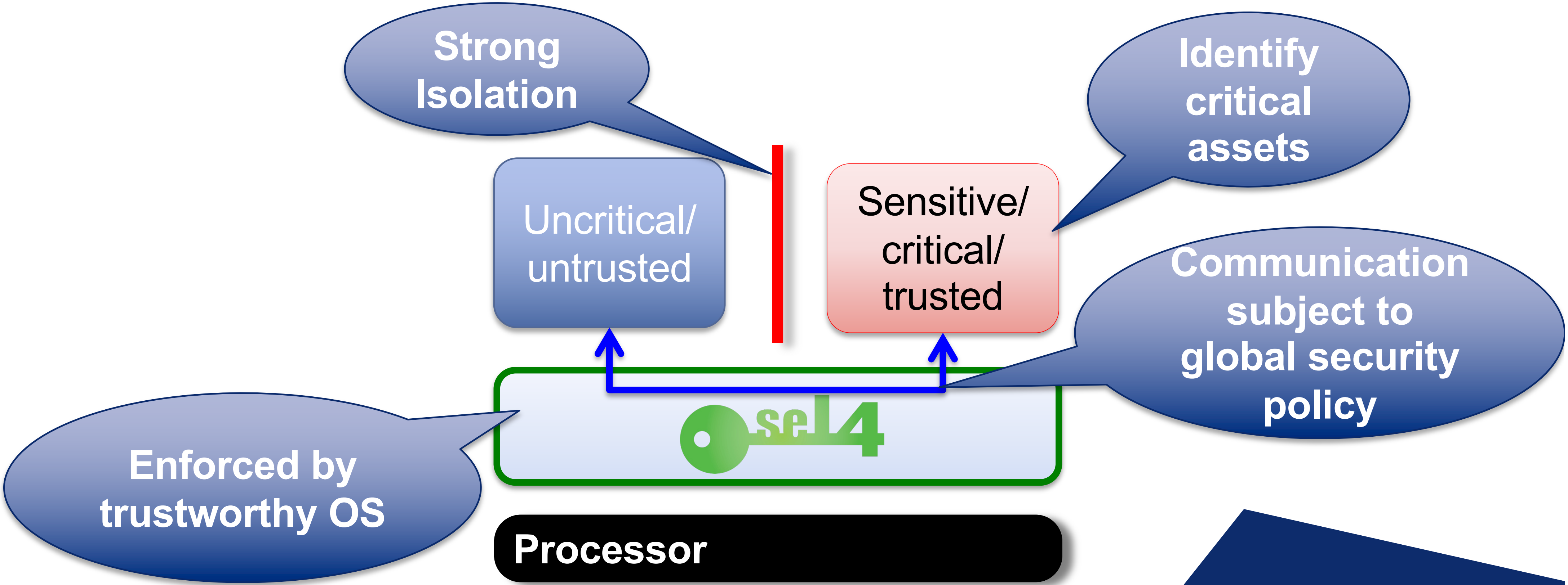
Fundamental Requirement: Isolation



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Trustworthiness: Can We Rely on Isolation?

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A system is **trustworthy** if and only if:

- it behaves **exactly** as it is specified,
- in a **timely** manner, and
- while ensuring **secure** execution

***Claim*:**

A system must be considered *untrustworthy*, unless *proved* otherwise!

Corollary [with apologies to Dijkstra]:

Testing, code inspection, etc. can only show *lack of trustworthiness*!

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seL4 Microkernel: We Have Proof!

Confidentiality | Integrity | Availability

Proof | Proof | Proof

Isolation

Abstract Model

Proof — Functional correctness

C Implementation

Proof — Translation correctness

Binary code

Provably impossible:

- memory leaks
- buffer overflows
- null-pointer dereference
- code injection
- kernel crash
- undefined behaviour
- privilege escalation

Exclusions (in progress):

- Initialisation
- Privileged state & caches
- Multicore
- Temporal isolation

How Does seL4 Compare?

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Feature	seL4	Others
Performance	Fastest	5–10 × slower
Impl. bugs	Provably none	No guarantee
Isolation	Proved	No guarantee
Latency bounds	Sound and complete	Estimates only
Storage channels	Provably none	No guarantee
Timing channels	Low-overhead prevention	No story or high overhead
Mixed criticality	Supported with high utilisation	None or resource-wastive

“World’s most verified kernel”

“Software you can depend on, data access you can trust”

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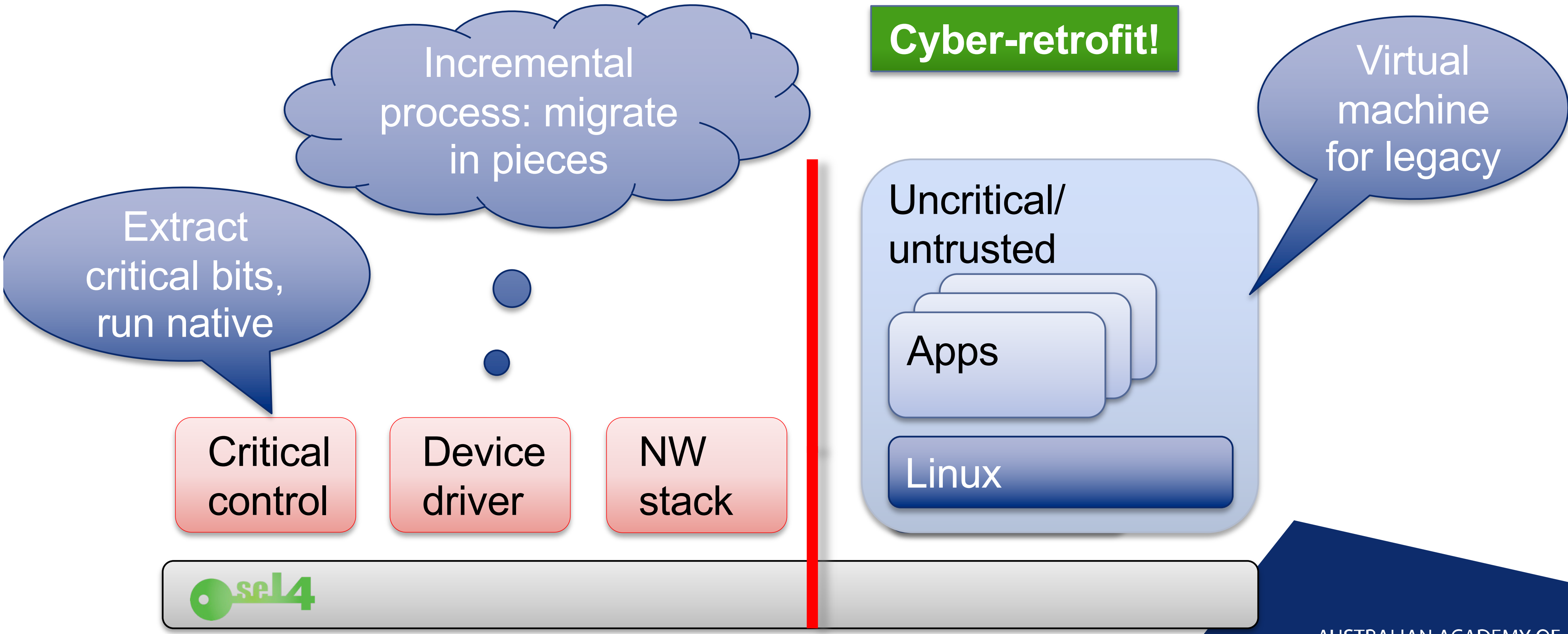
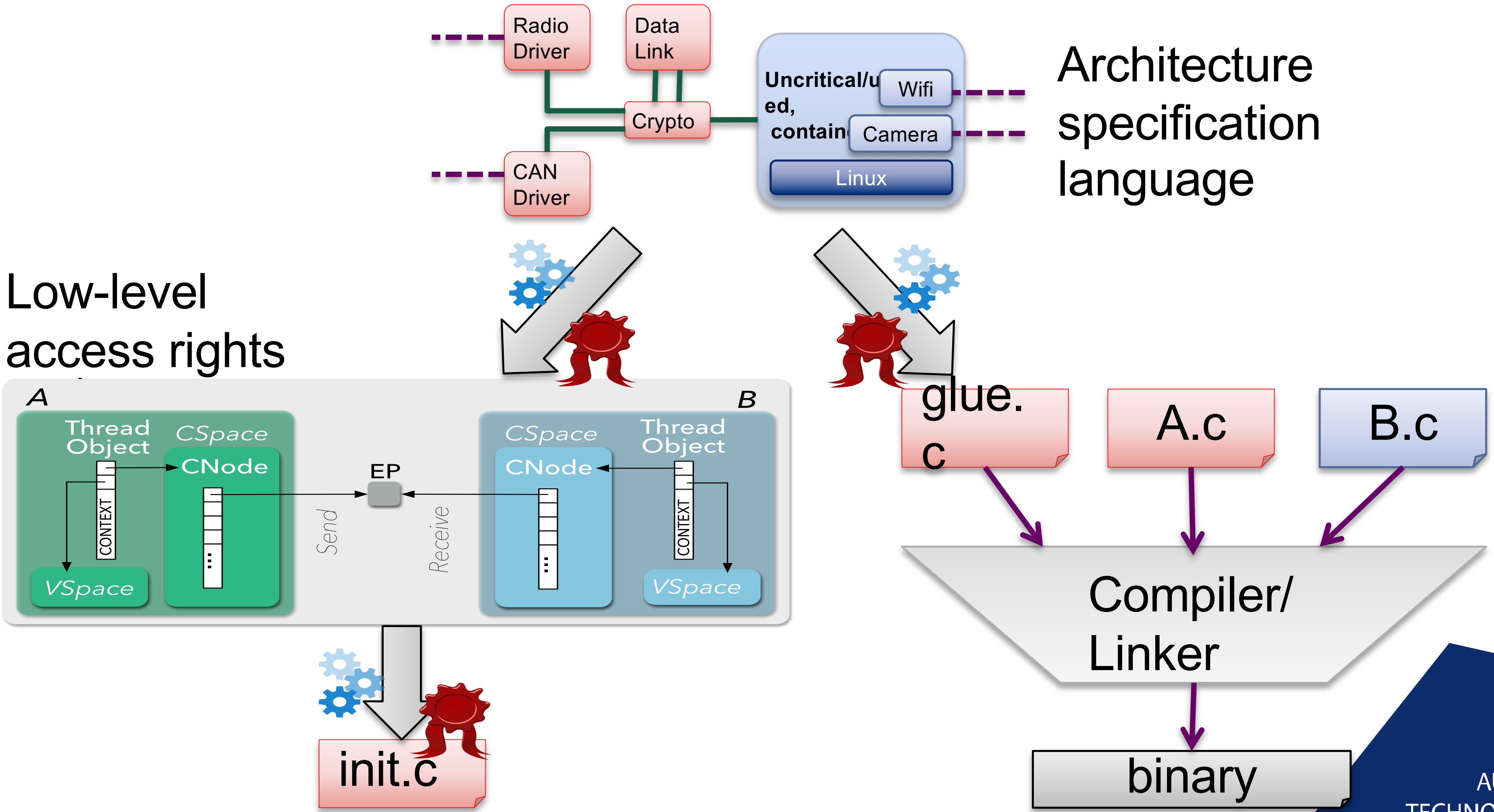
Security by Architecture



Enforcing the Architecture



Military-Grade Security

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Cross-Domain Desktop Compositor

Boeing Unmanned Helicopter

Crypto Stick

US Army Autonomous Trucks

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Trustworthy Software At Work

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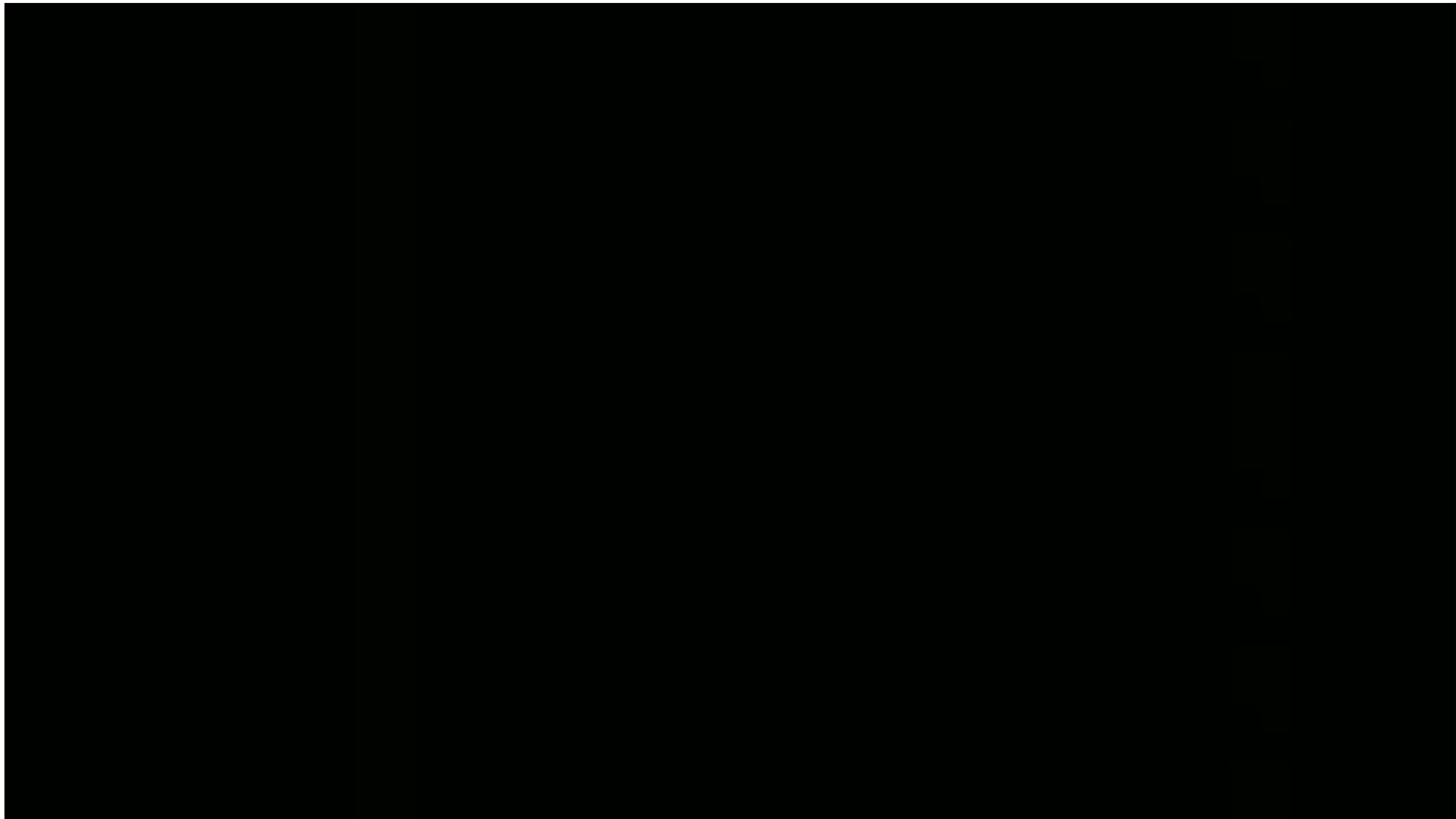

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https://trustworthy.systems

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