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SECURE EMBEDDED SYSTEMS NEED MICROKERNELS

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EMBEDDED SYSTEM ARE UBIQUITOUS

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But are they *Secure?*

SECURITY CHALLENGES

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- Growing functionality
- Wireless connectivity
- Downloaded contents (entertainment)

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  - ➜ increasing software complexity
  - ➜ increased number of faults
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- Wireless connectivity
  - ➜ subject to attacks from outside (crackers)
- Downloaded contents (entertainment)
  - ➜ subject to attacks from inside (viruses, worms)
- Increasing dependence on embedded systems
  - ➜ increased exposure to embedded-systems security weaknesses

Present Approaches

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  - ⋆ dubious or non-existent real-time capabilities
    - ➜ unsuitable for hard real-time systems
  - ⋆ huge code base (millions of lines of code)
    - ➜ excessive for small embedded system
    - ➜ too much code on which security of system is dependent

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REQUIRES MINIMAL TRUSTED COMPUTING BASE (TCB)

TCB: The part of system that must *be relied on for the correct operation of the system*

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... otherwise the security issue is intractable!

Embedded-Systems Security

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Requires minimal trusted computing base (TCB)

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Minimal TCB means:

1. Split software into trusted and untrusted part

EMBEDDED-SYSTEMS SECURITY

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MINIMAL TCB MEANS:

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2. Minimise the trusted part

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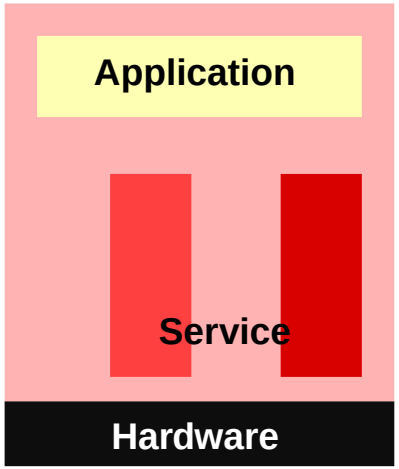
MINIMAL TCB MEANS:

1. Split software into trusted and untrusted part
2. Minimise the trusted part
3. Make the trusted part *trustworthy*

MINIMISING THE TCB



System: traditional
embedded

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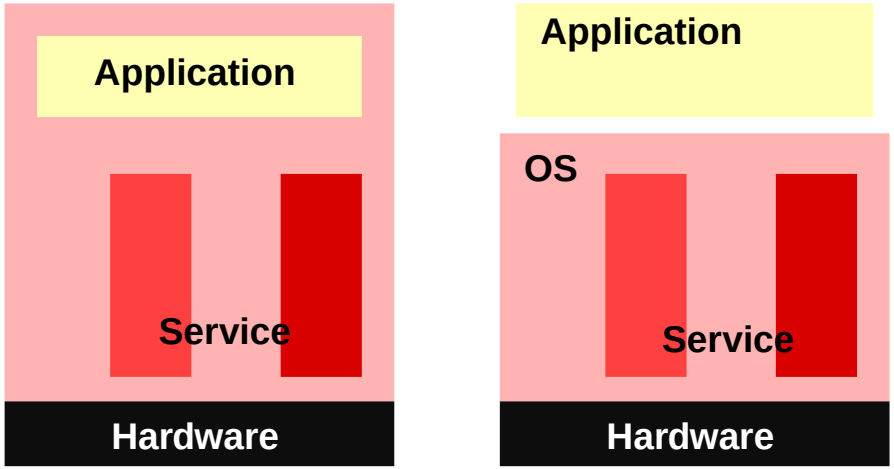

System:	traditional embedded	Linux/ Windows

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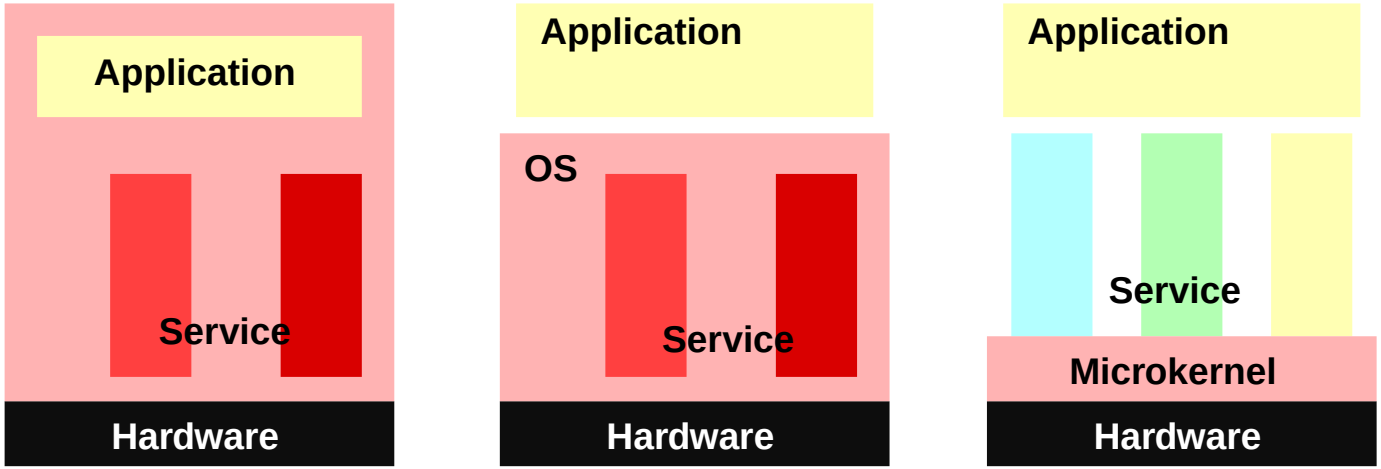

System:	traditional embedded	Linux/ Windows	Microkernel-based

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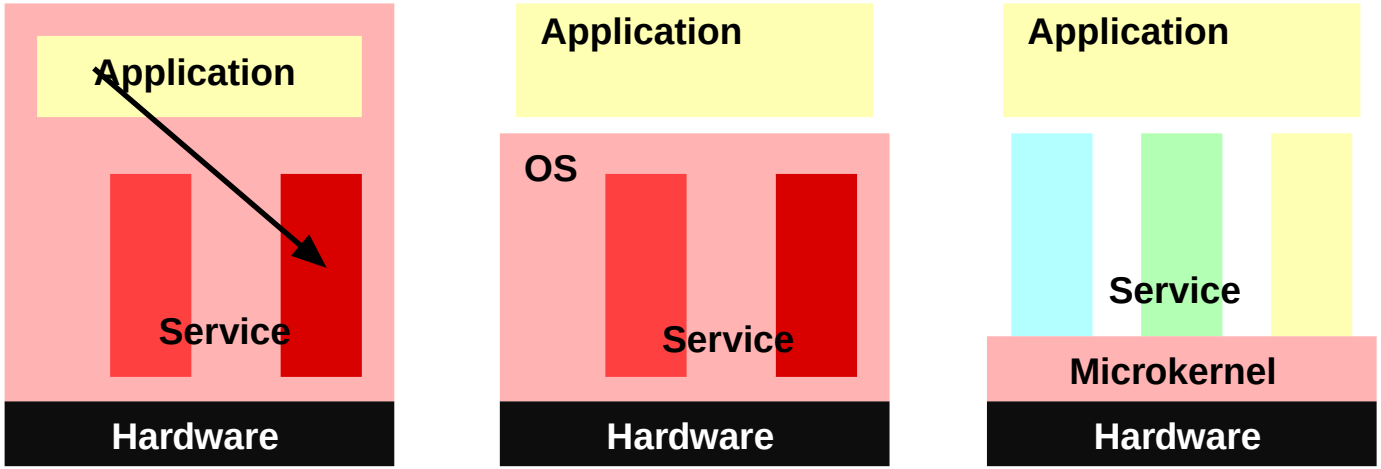

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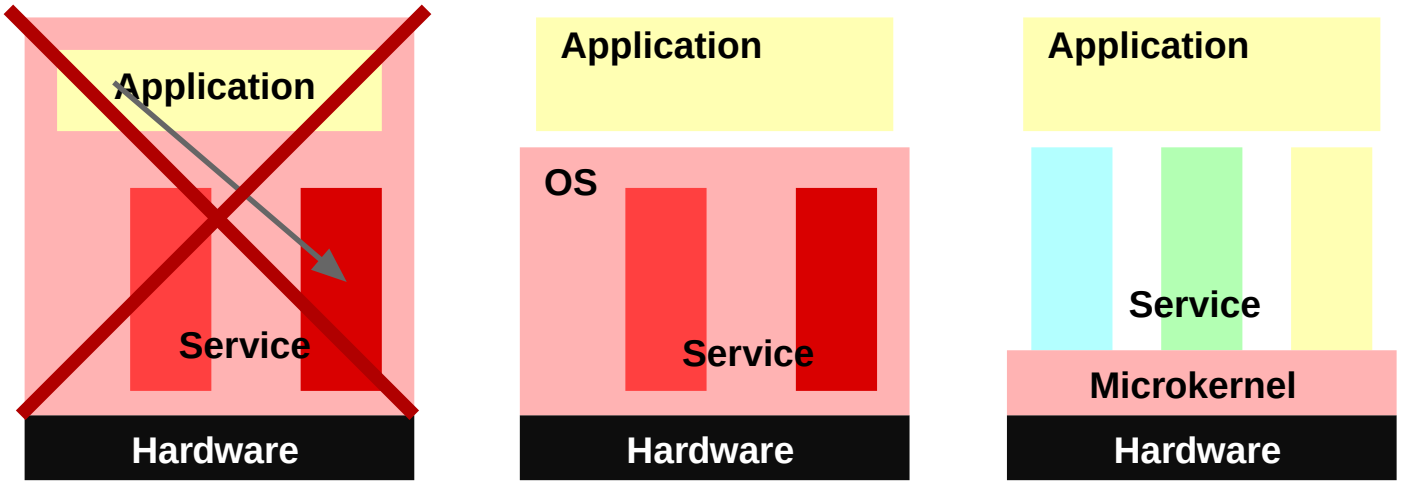

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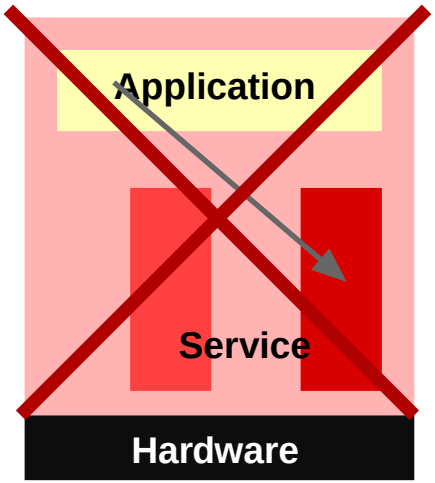

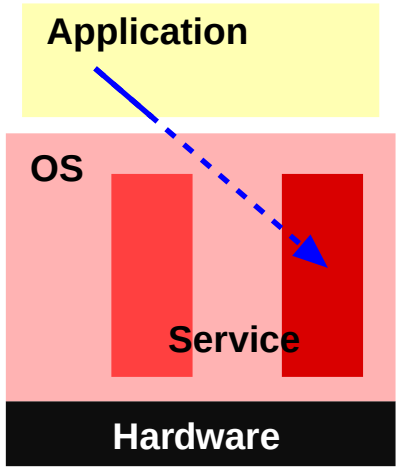

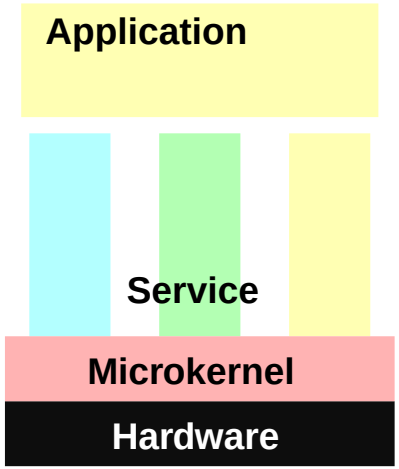

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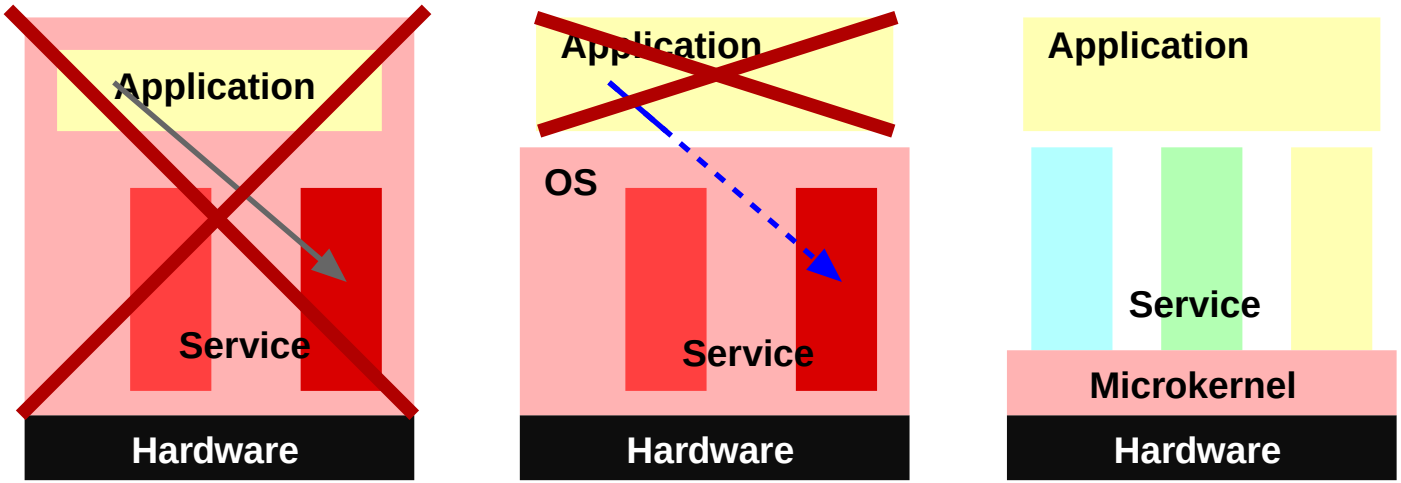

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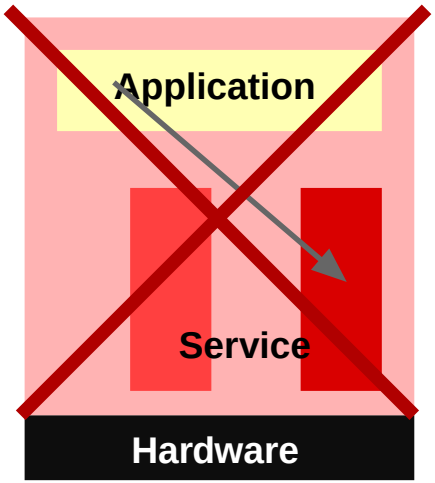

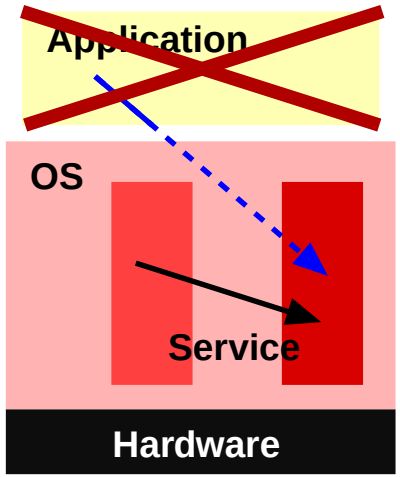

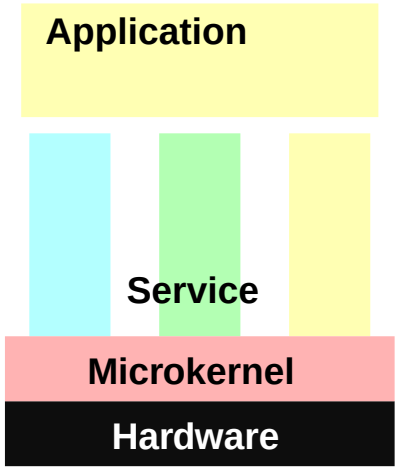

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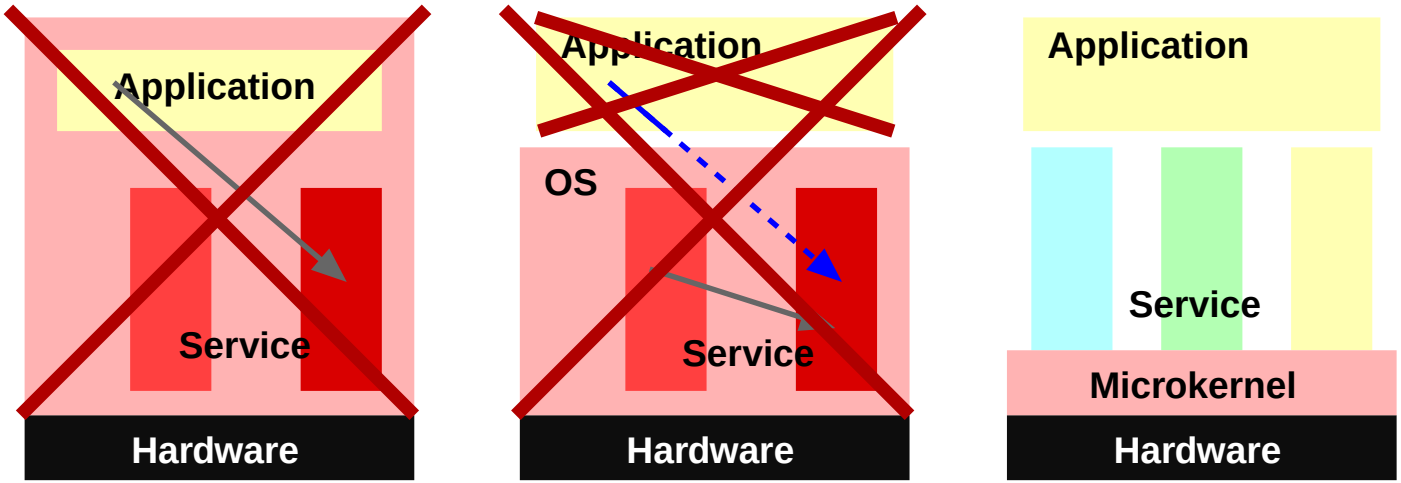

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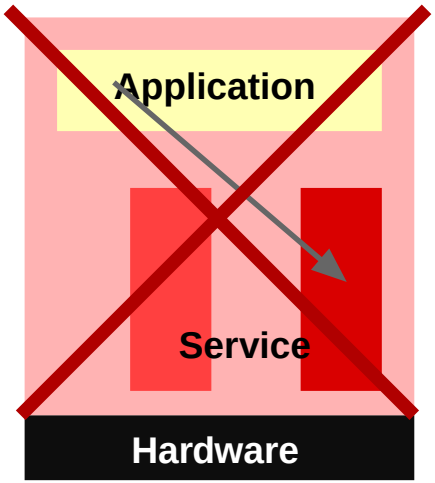

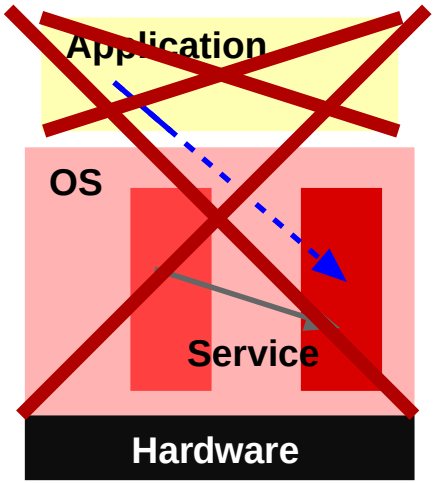

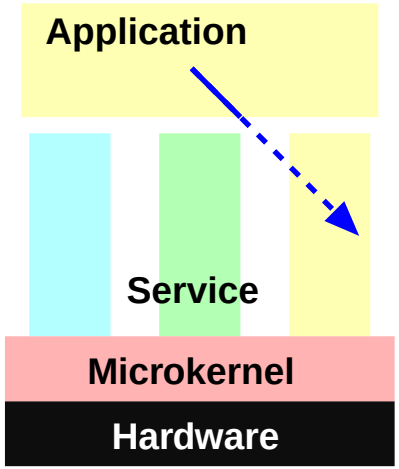

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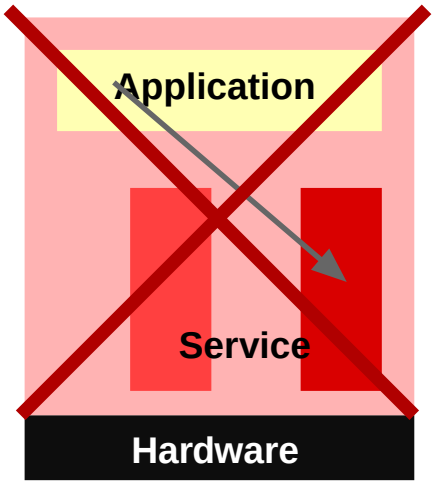

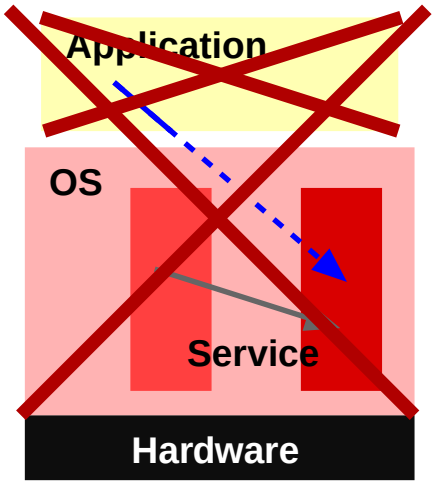

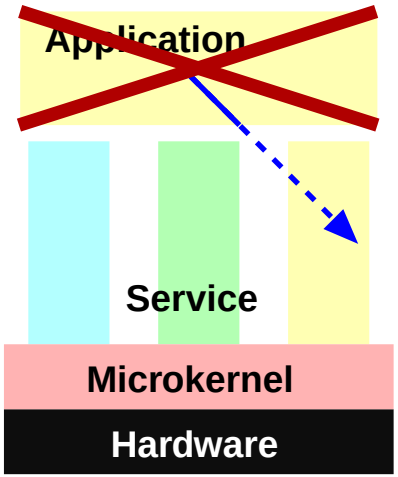

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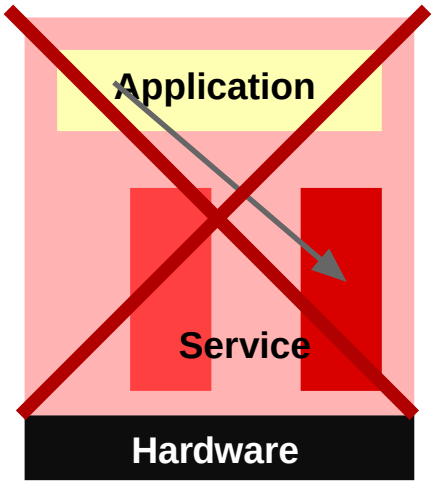

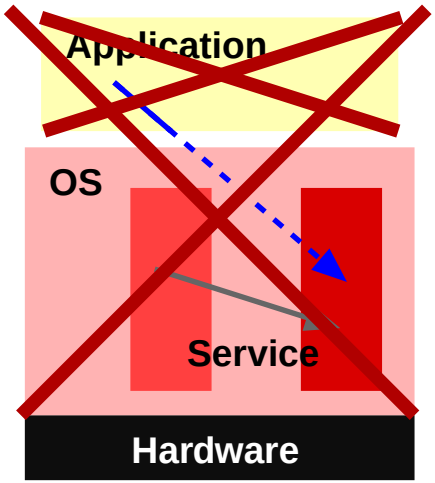

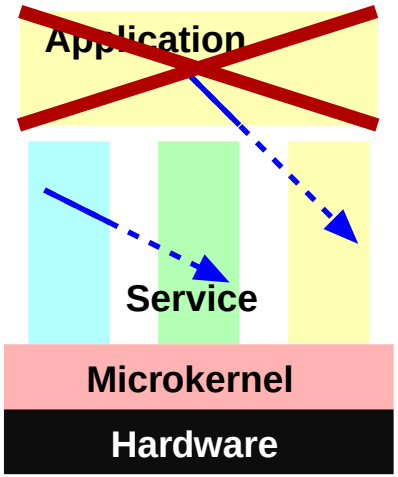

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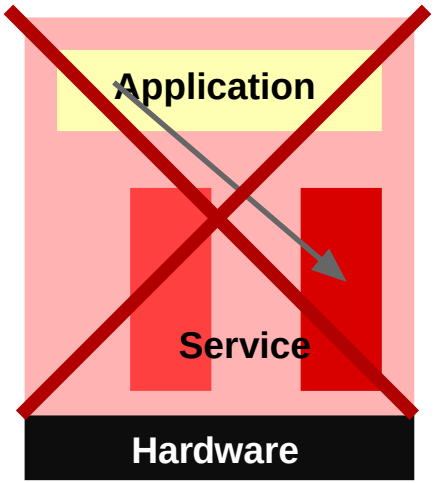

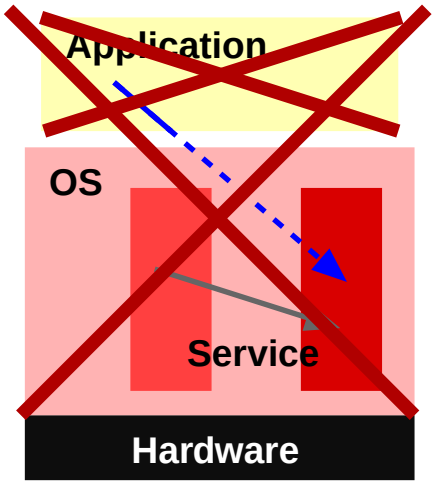

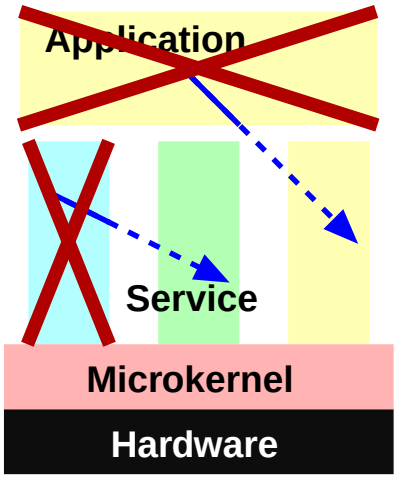

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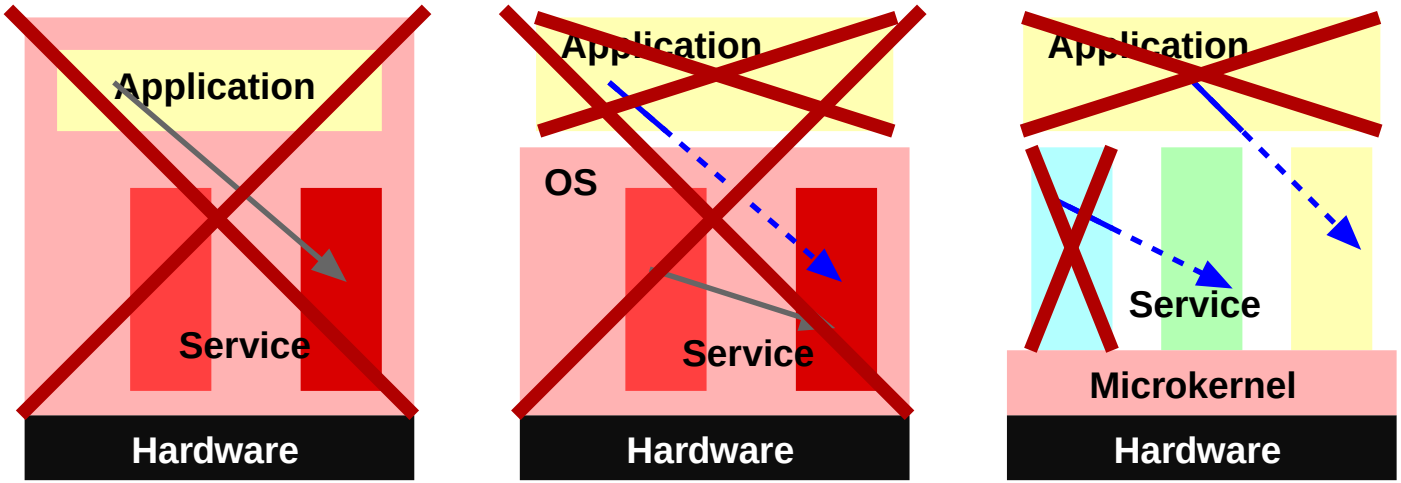

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Small kernel ⇒ small TCB ⇒ more trustworthy TCB!

Making the TCB Trustworthy

Traditional approaches

Advanced approaches

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Traditional approaches

- Testing
- Code inspection

Advanced approaches

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☑ Smaller TCB ⇒ fewer remaining bugs

☒ ... but no *assurance* of absence of bugs!

Advanced approaches

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Advanced approaches

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Advanced approaches

- *Prove* the correctness of the TCB
  - ☑ assurance of absence of bugs
  - ☒ unfeasible for 100,000s loc
  - ☑ feasible for very small microkernel

MICROKERNEL VERIFICATION

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Proof of correctness of microkernel

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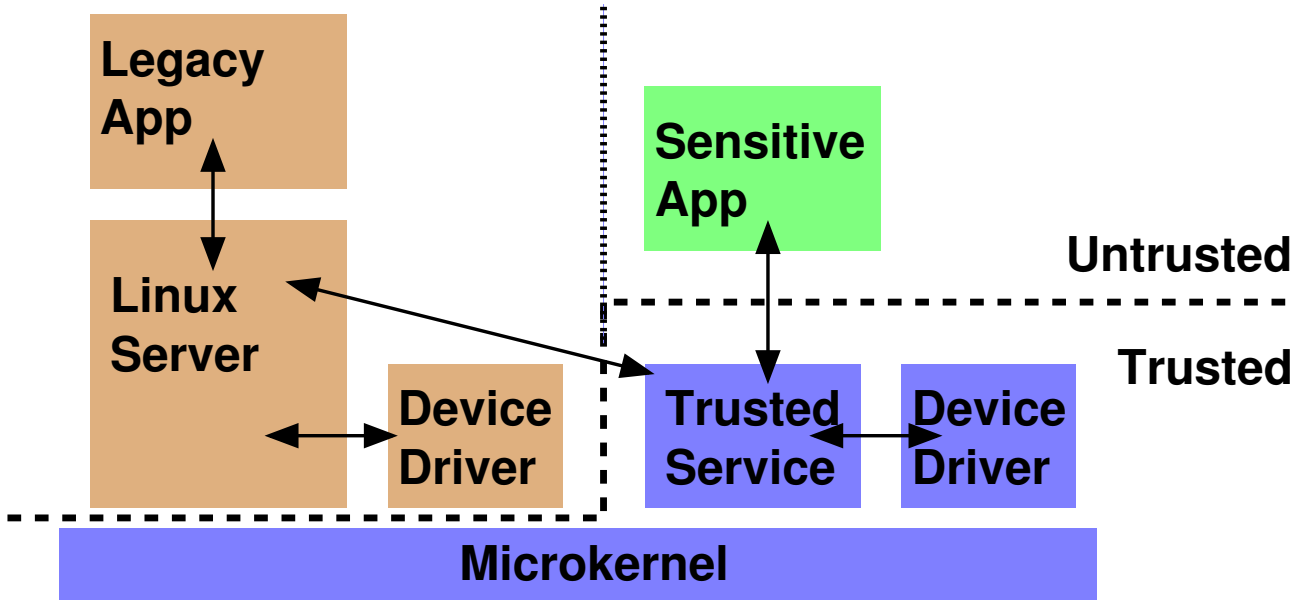
COMPLETE TEMPORAL MODEL OF MICROKERNEL

- exhaustive measurement of latencies of kernel operations
  - ➜ prerequisite for real-time analysis of whole system

A Sample System



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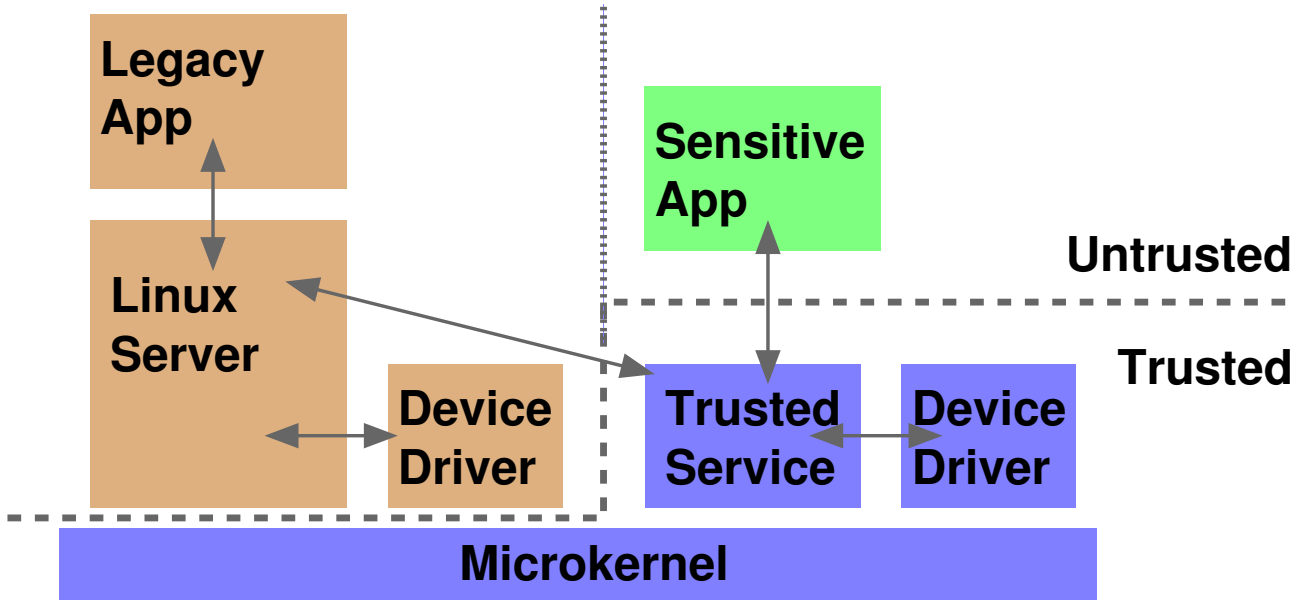

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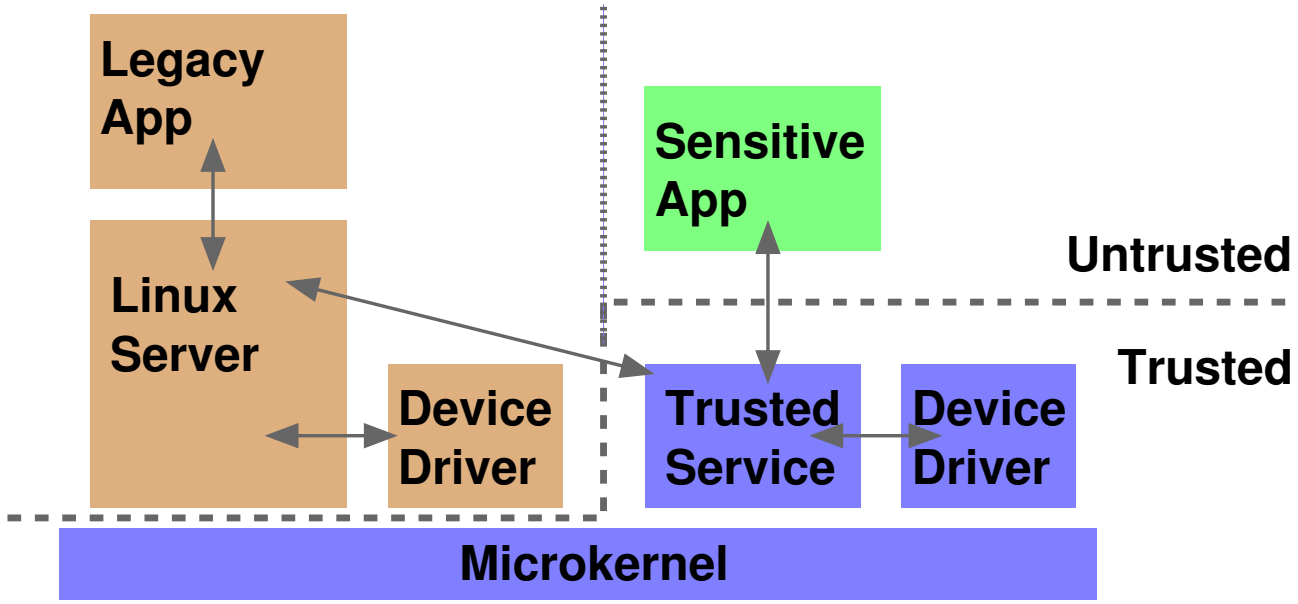

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- Standard API supported by de-privileged Linux server
  - ➜ full binary compatibility with native Linux
- Compromised legacy system cannot interfere with trusted part

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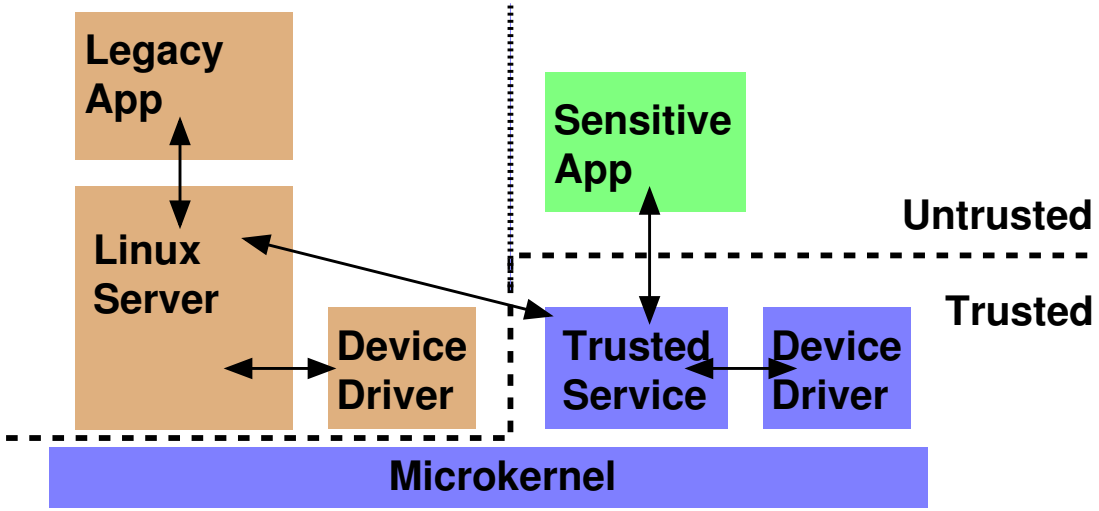
  - ➜ 10,000 lines of code
  - ➜ highly efficient



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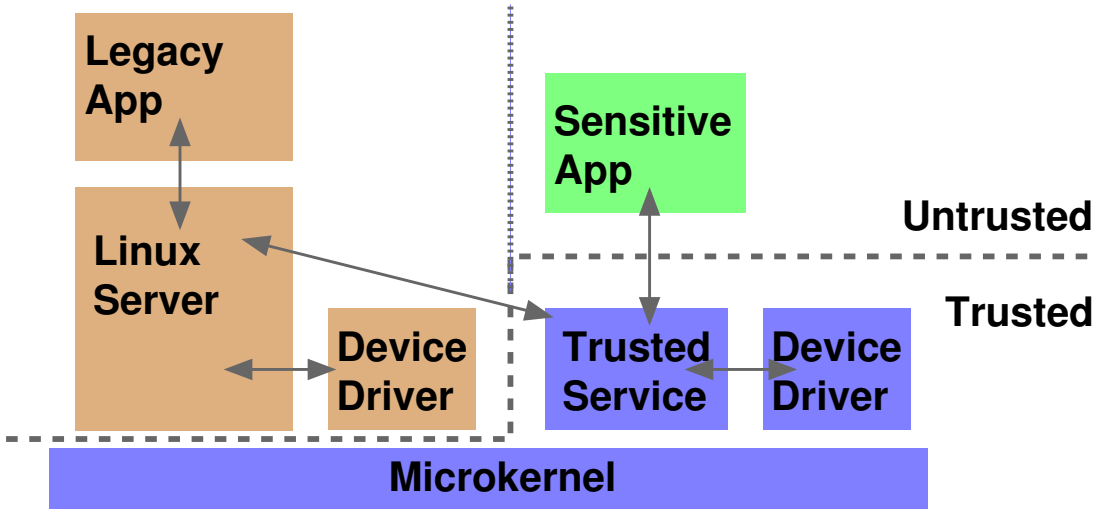

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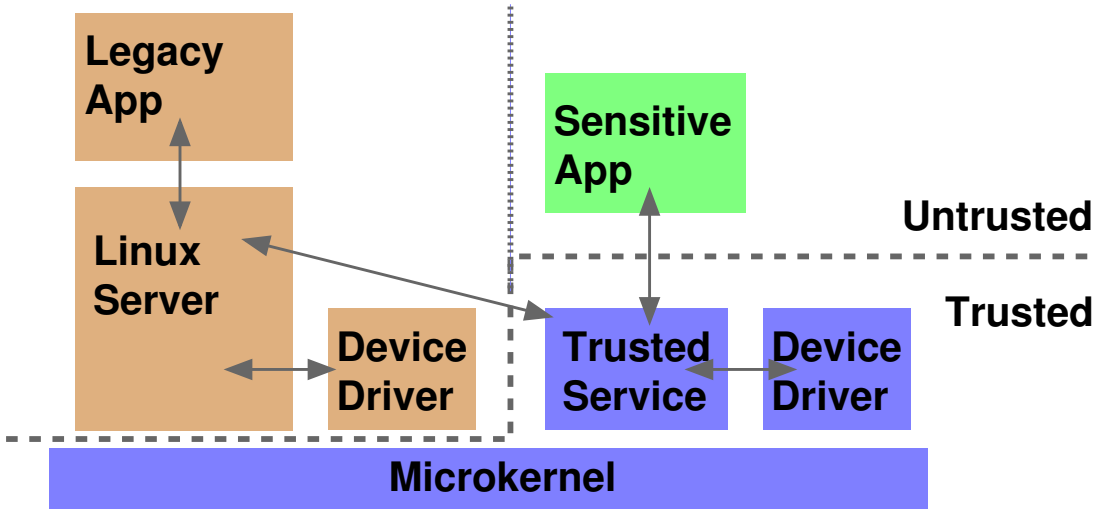

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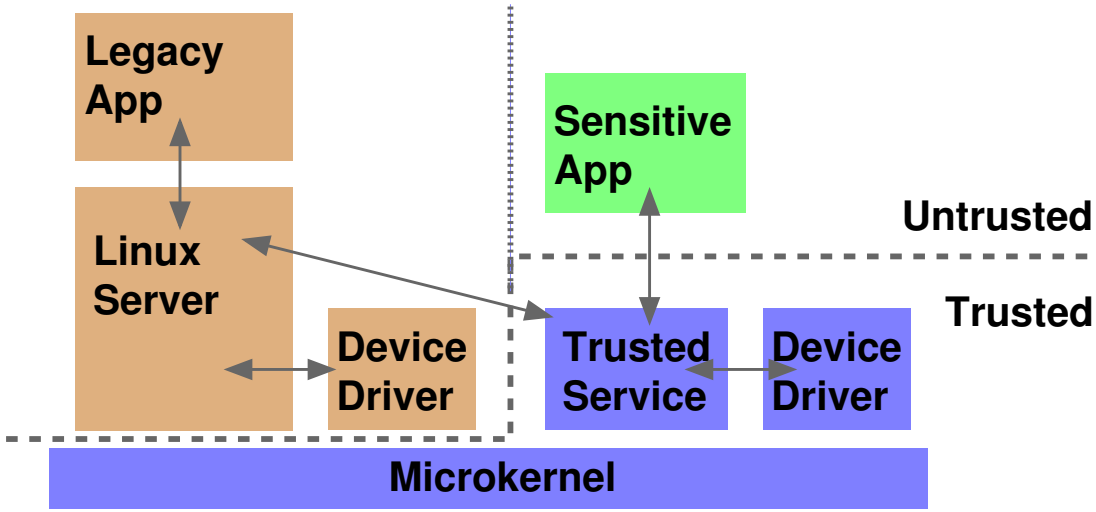

- Verification in progress
  - ➜ successful pilot project for verification of API “slice”
  - ➜ full-scale correctness proof project commencing
  - ➜ temporal analysis commencing