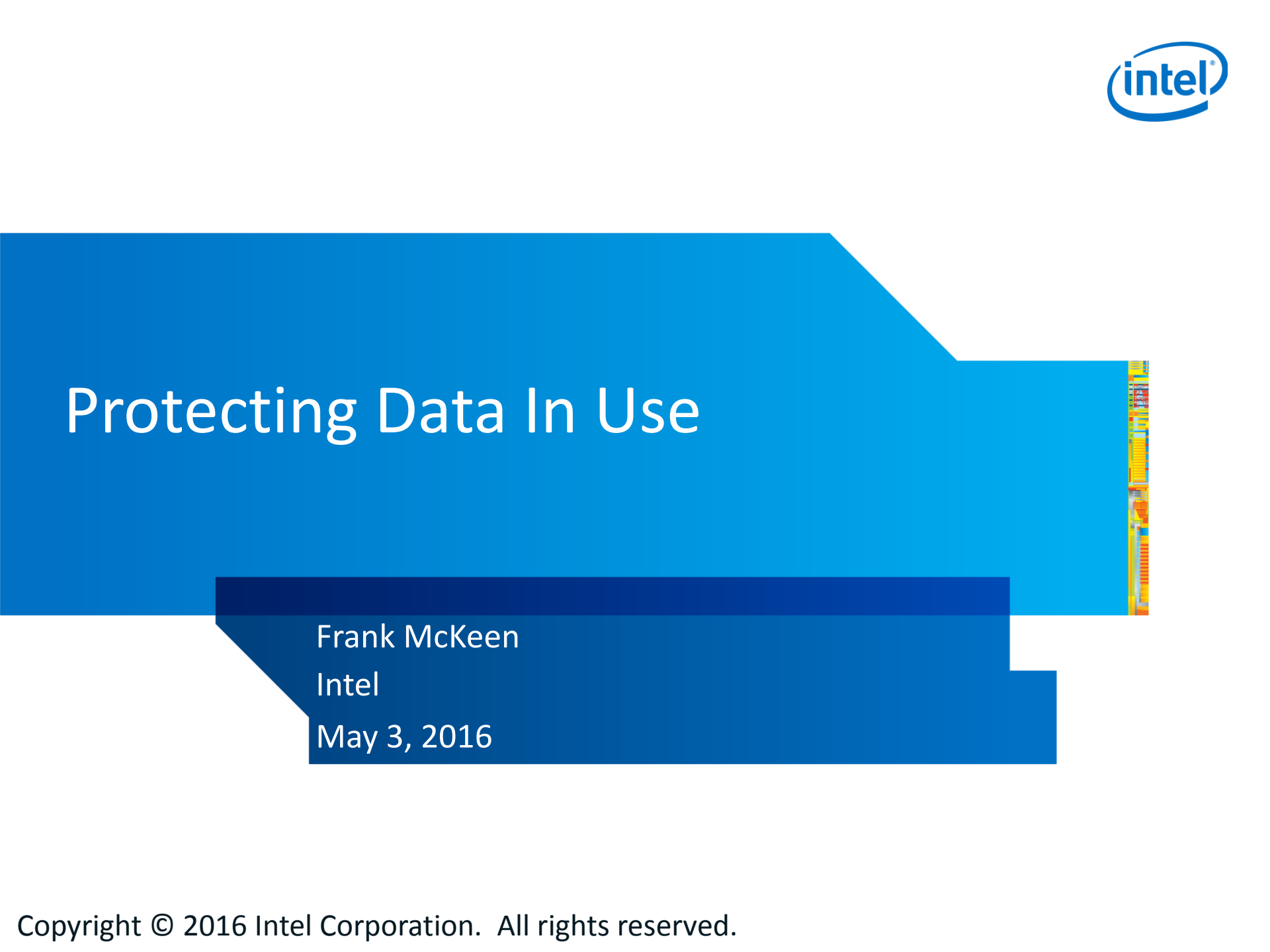


Protecting Data In Use

Frank McKeen
Intel
May 3, 2016

Legal Disclaimers

- The comments and statements are the presenter's and not necessarily Intel's

- Intel technologies' features and benefits depend on system configuration and may require enabled hardware, software or service activation. Learn more at intel.com

- No computer system can be absolutely secure.

System Level Security Features

System Level Security Features

Trusted Channels

System Level Security Features

User
Authentication

System Level Security Features

Protected Storage

System Level Security Features

Biometrics

System Level Security Features

Trusted Cloud Orchestration

System Level Security Features

Anti-Malware Software and Detection

System Level Security Features

Firewalls

System Level Security Features

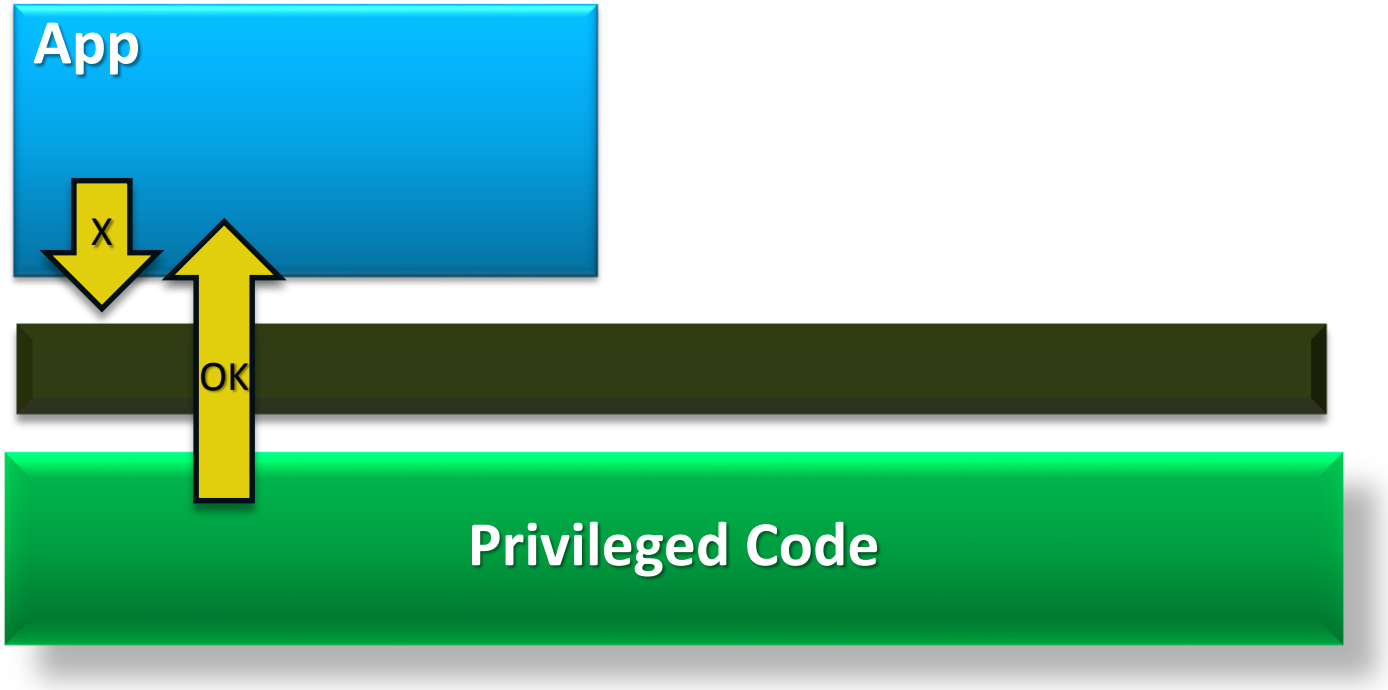
System Level Security Features

Architecture to Protect Application Secrets

Protecting Applications from Privileged Malware Attacks

The Basic Issue: Vulnerabilities in Privileged Code

Protected Mode (rings) protects OS from apps …



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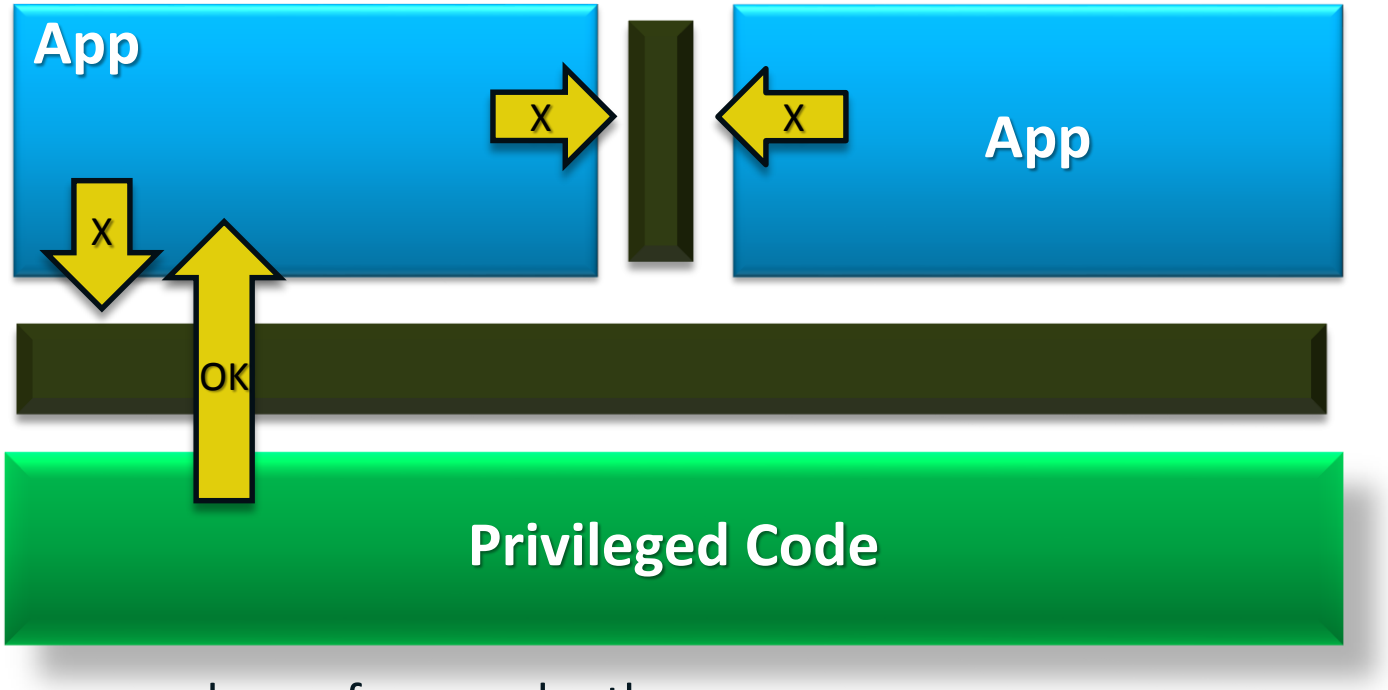

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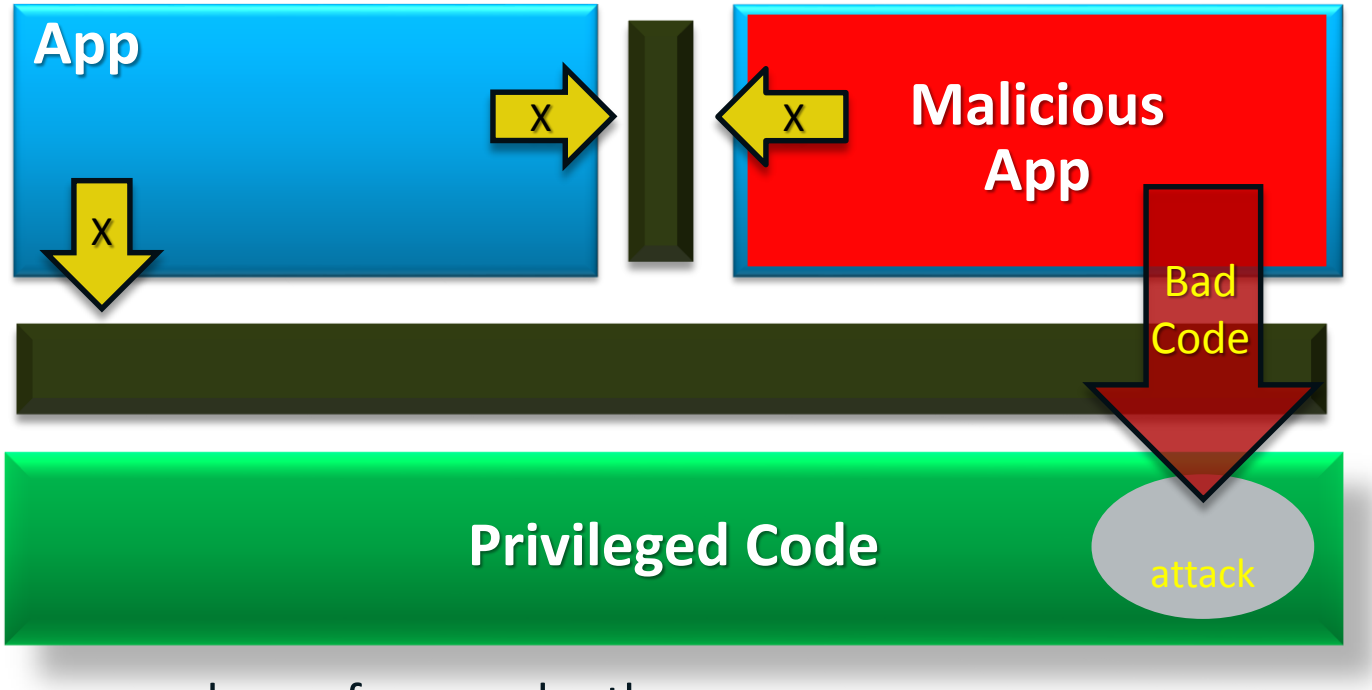

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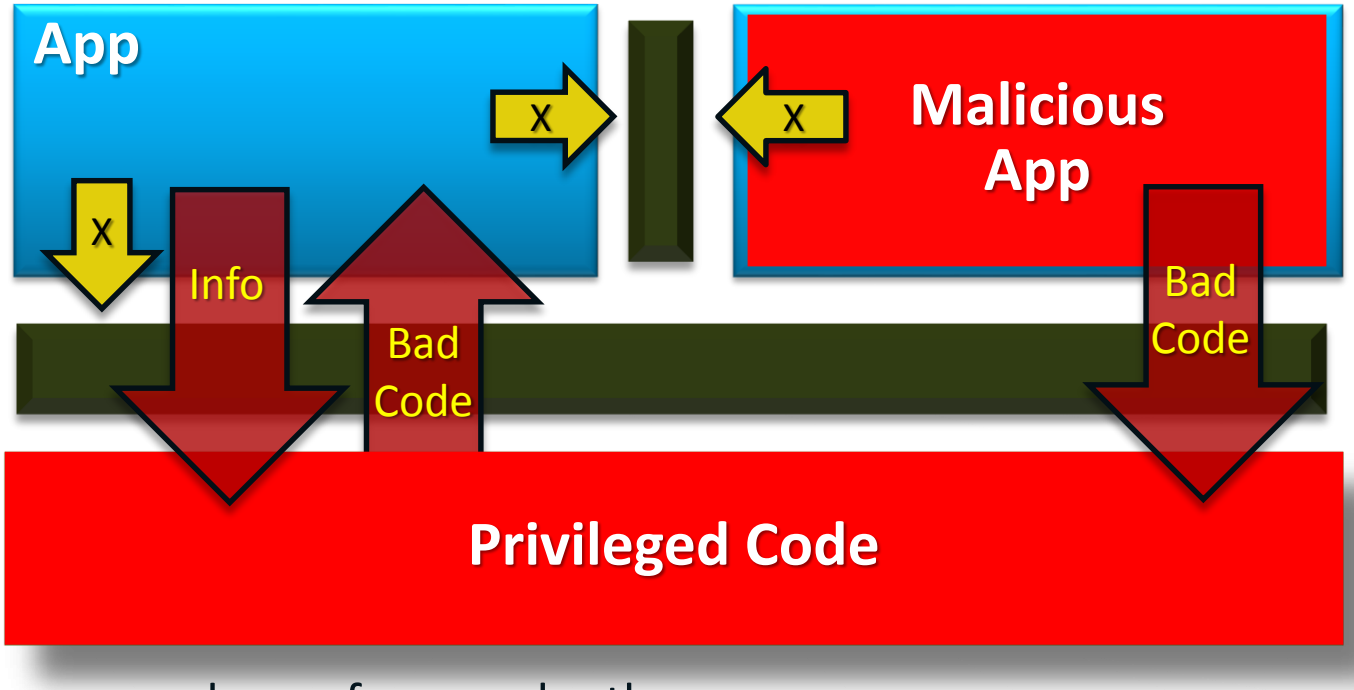

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A Place to Stand

A stable execution environment:

- Not susceptible to Privileged Software manipulation
- Provides confidentiality and integrity to data and code
- Can prove that it resides on protected hardware
- Can provide the details of hardware revision level
- Fits into the current eco-system

Desired Protections

Protection	Description
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Operator Access	Operator can't access restricted data
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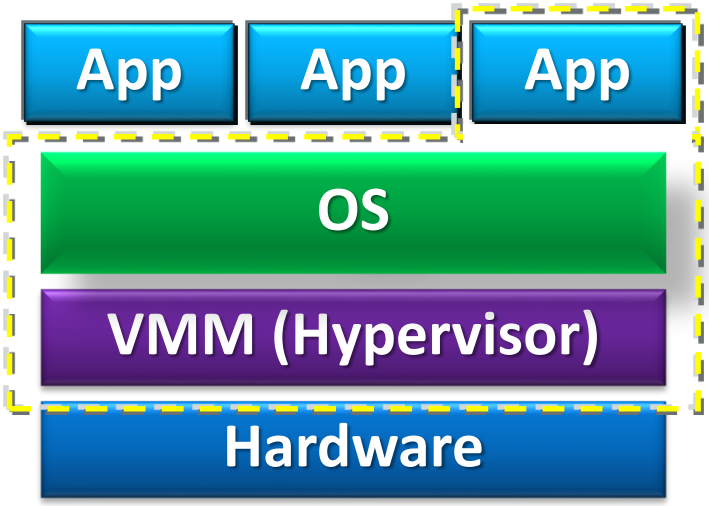
Intel® Software Guard Extensions (Intel® SGX): Principles of Operation

Reduced attack surface with Intel ® SGX

Attack surface today



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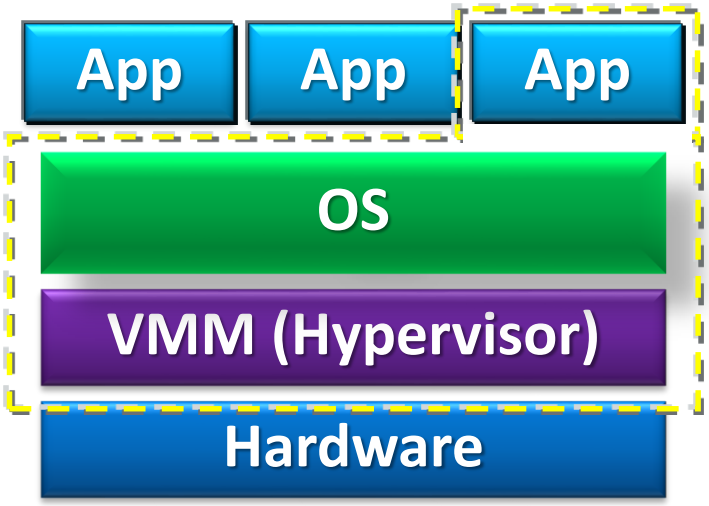

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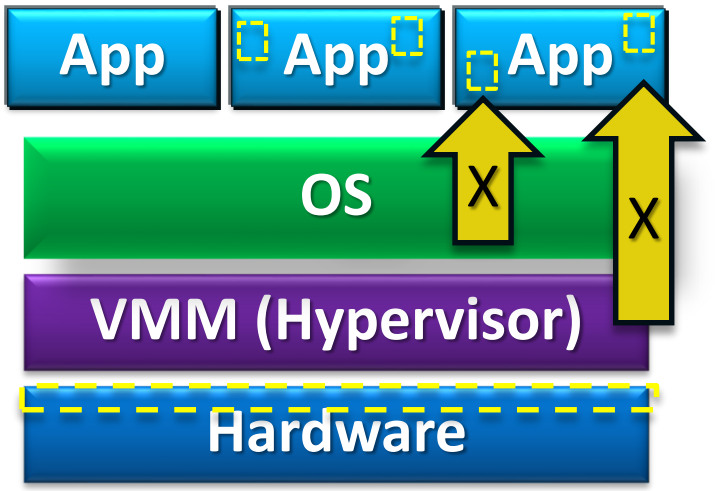

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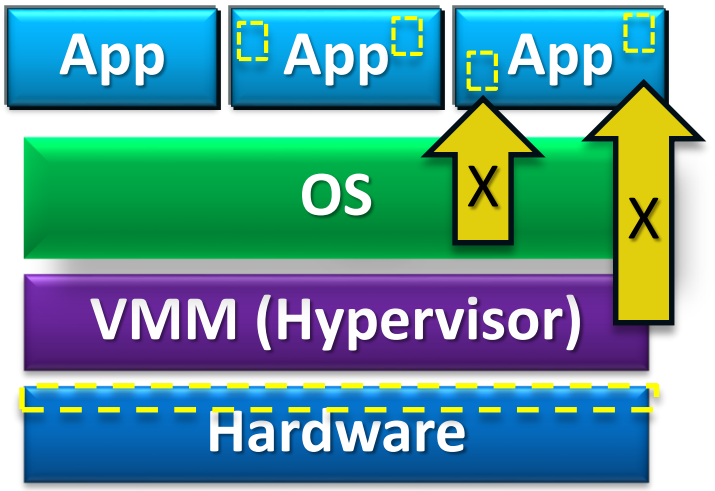

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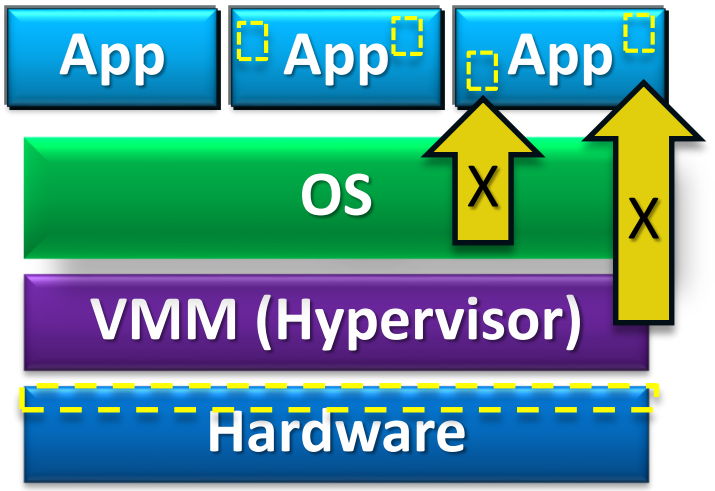

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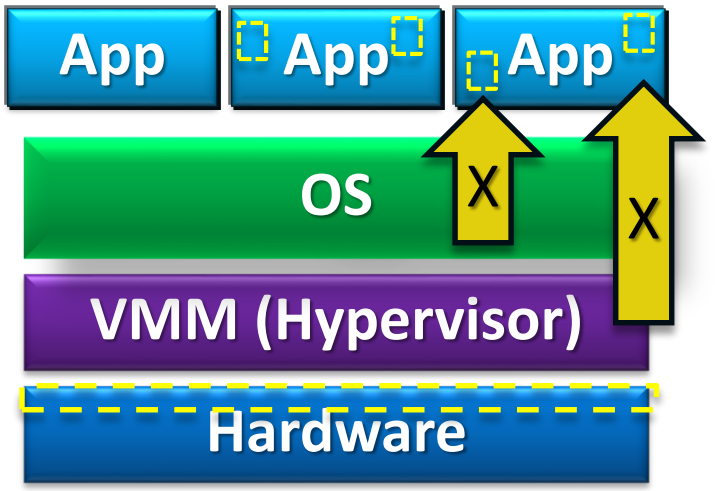

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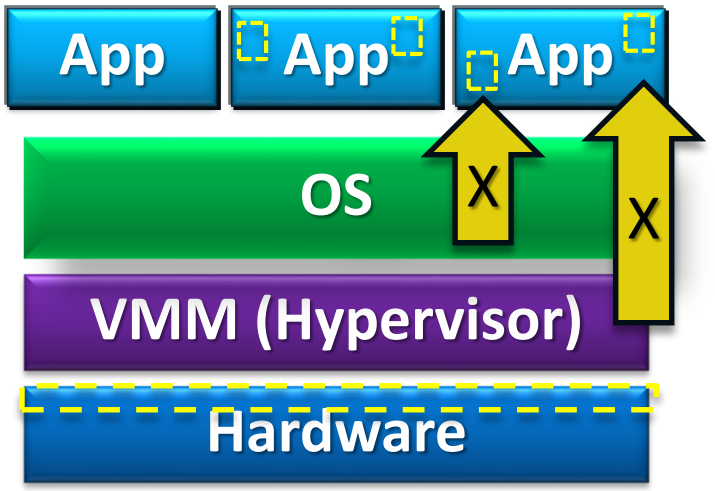

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Familiar deployment model

- Platform integration not a bottleneck to deployment of trusted apps

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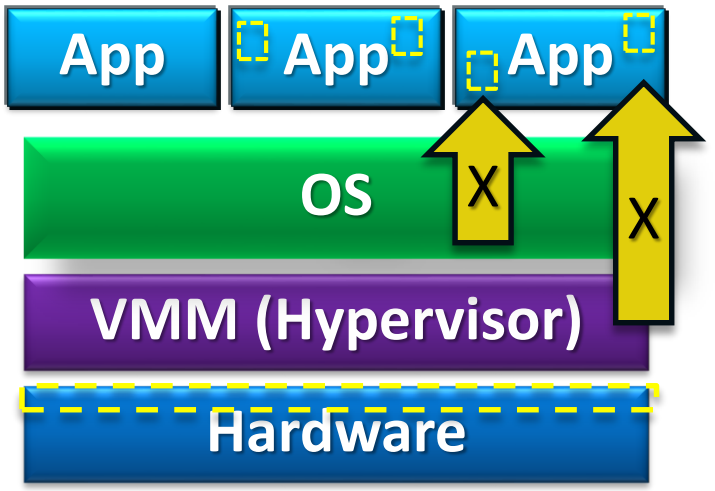
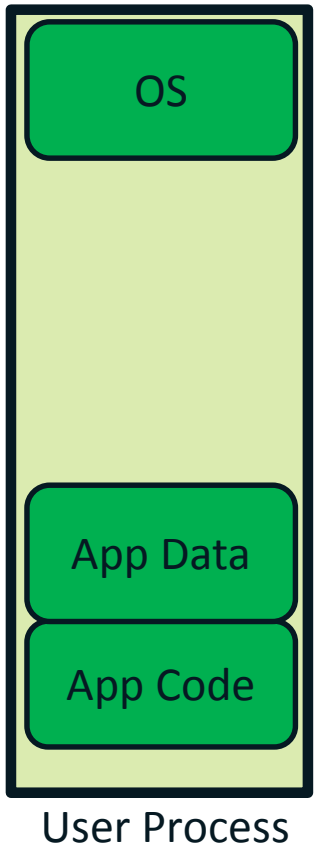


Attack Surface

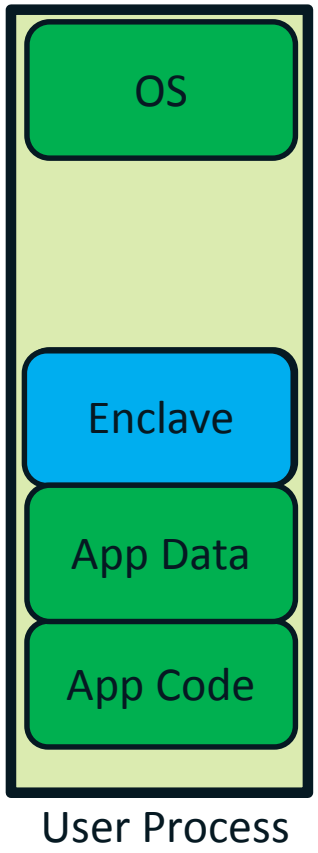
Scalable security within mainstream environment

What is an Enclave?



What is an Enclave?

Enclave: trusted execution environment embedded in a process



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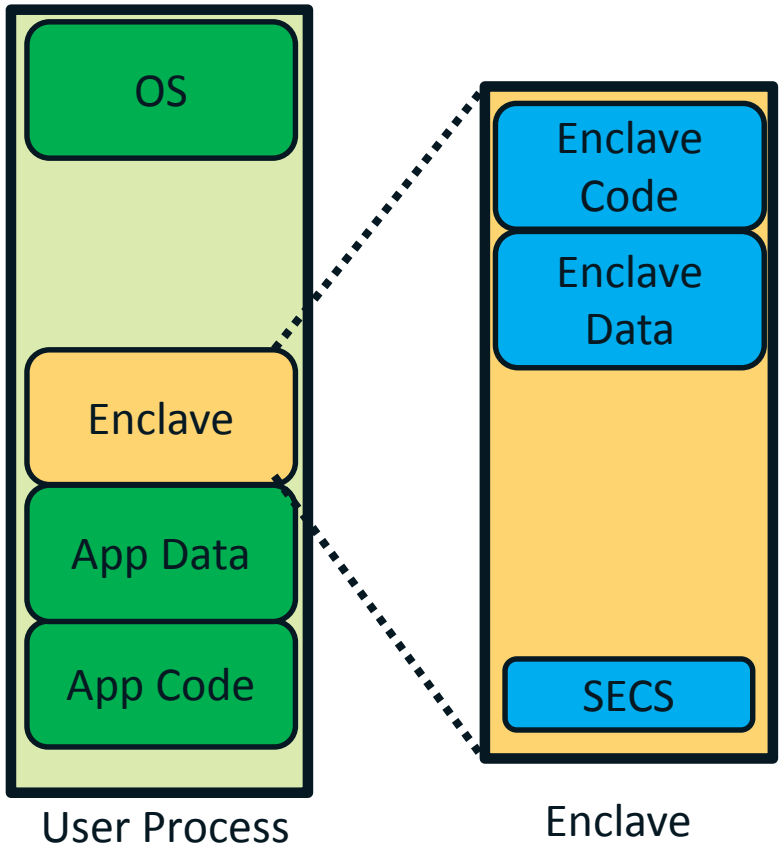

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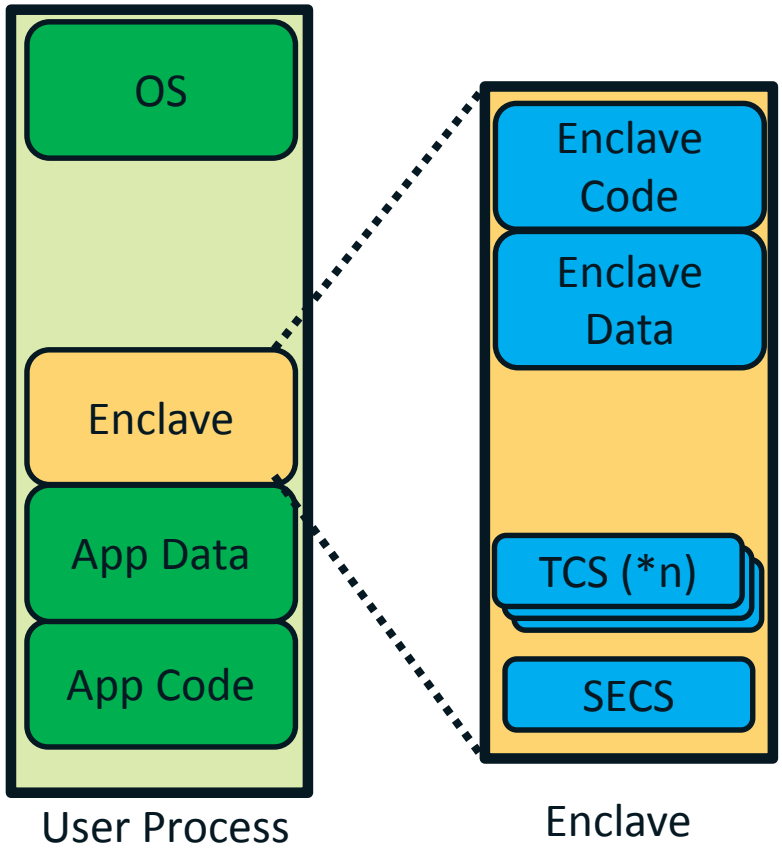

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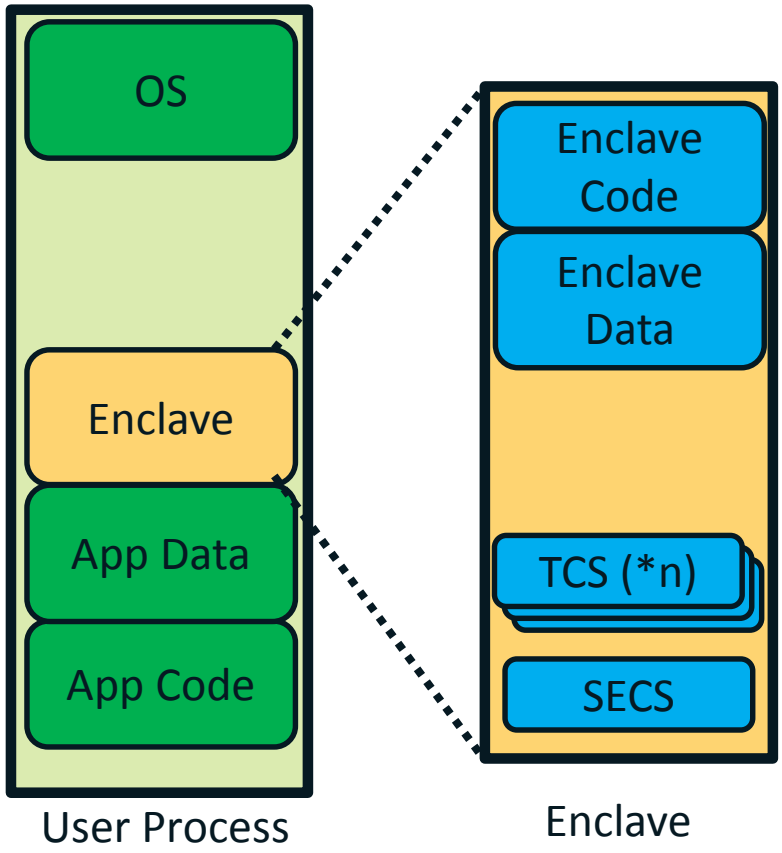

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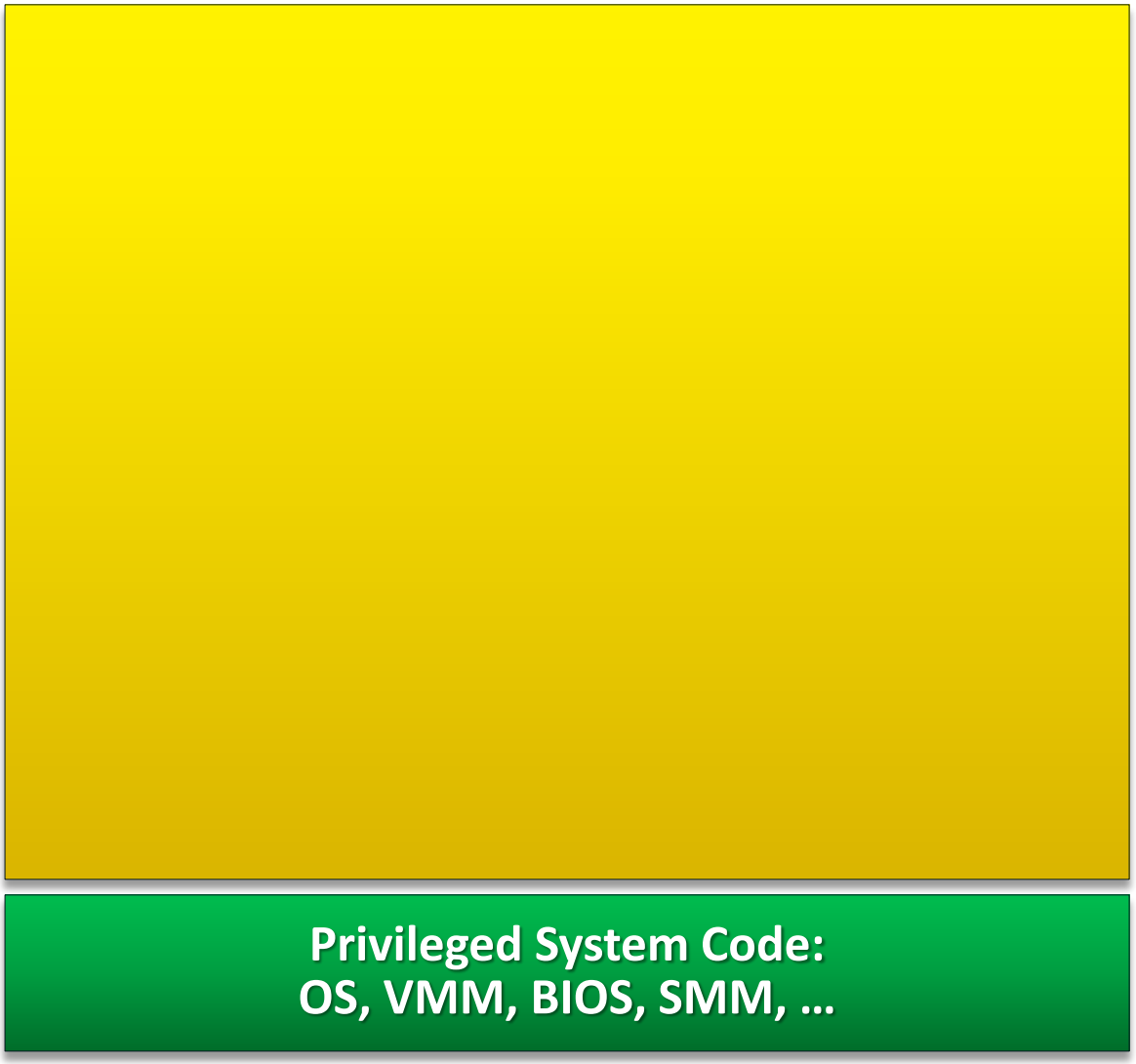
- Supporting multiple threads
- Full access to app memory

How Intel ® SGX Works: Protection vs. Software Attack



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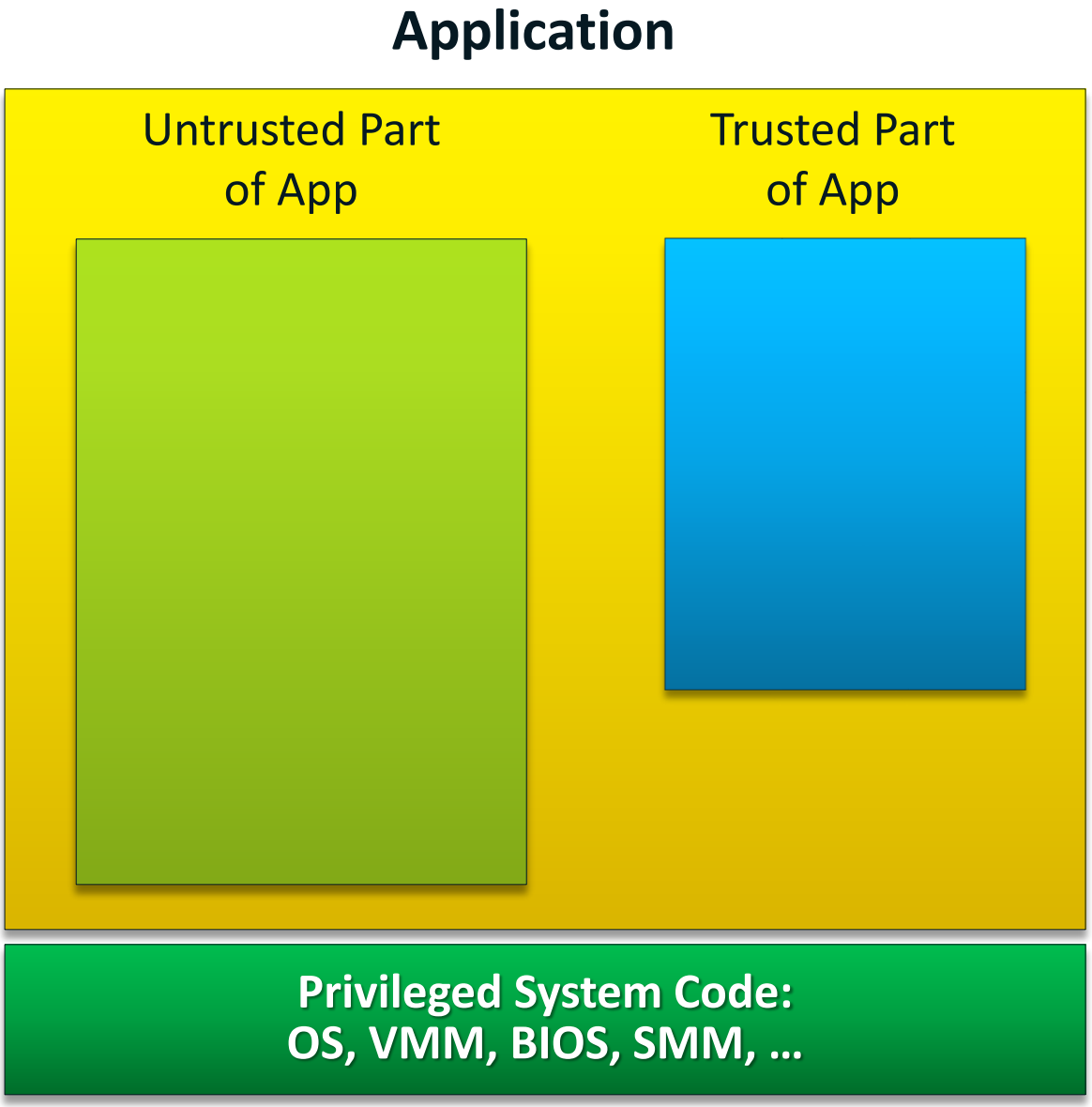

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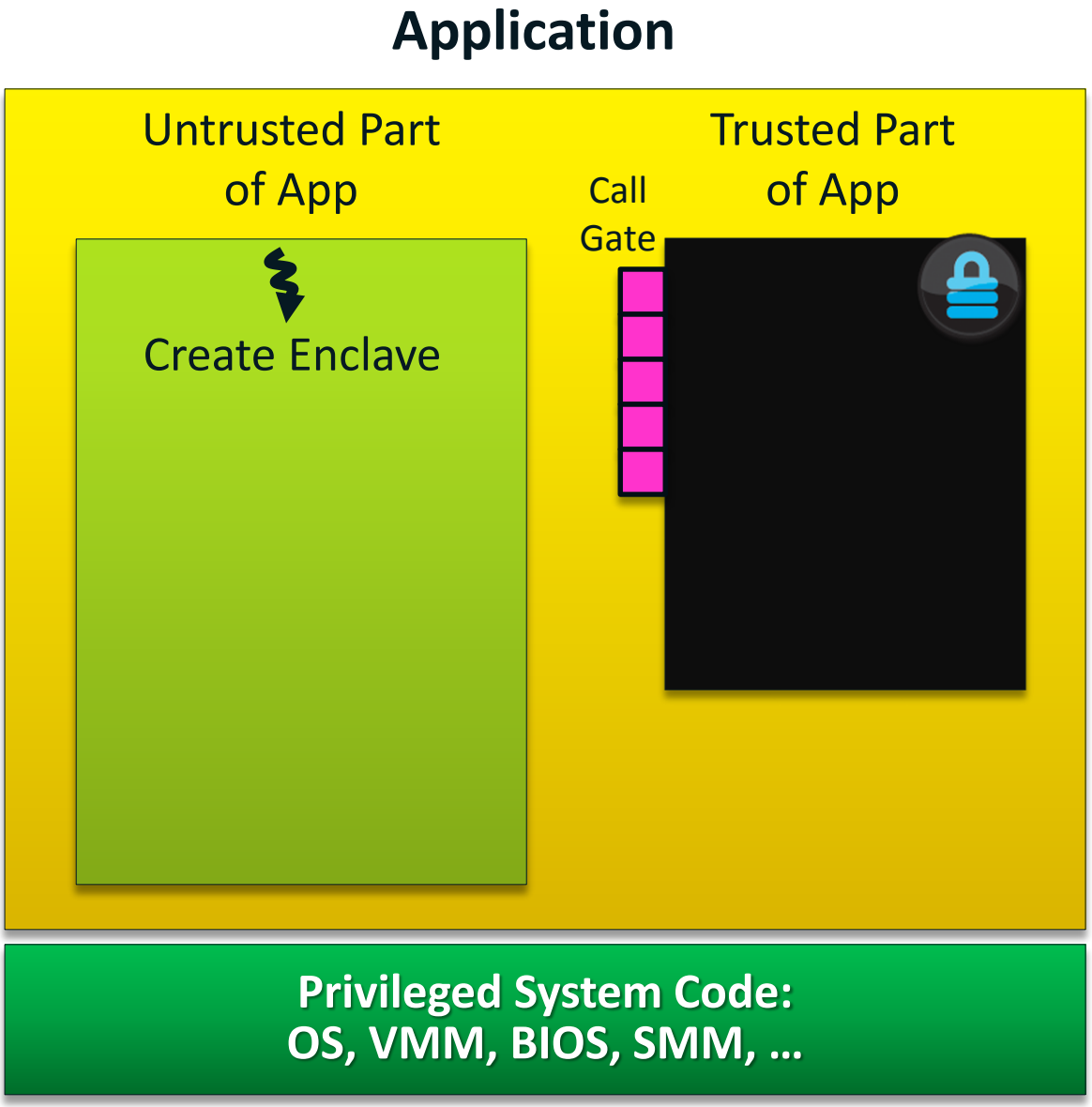

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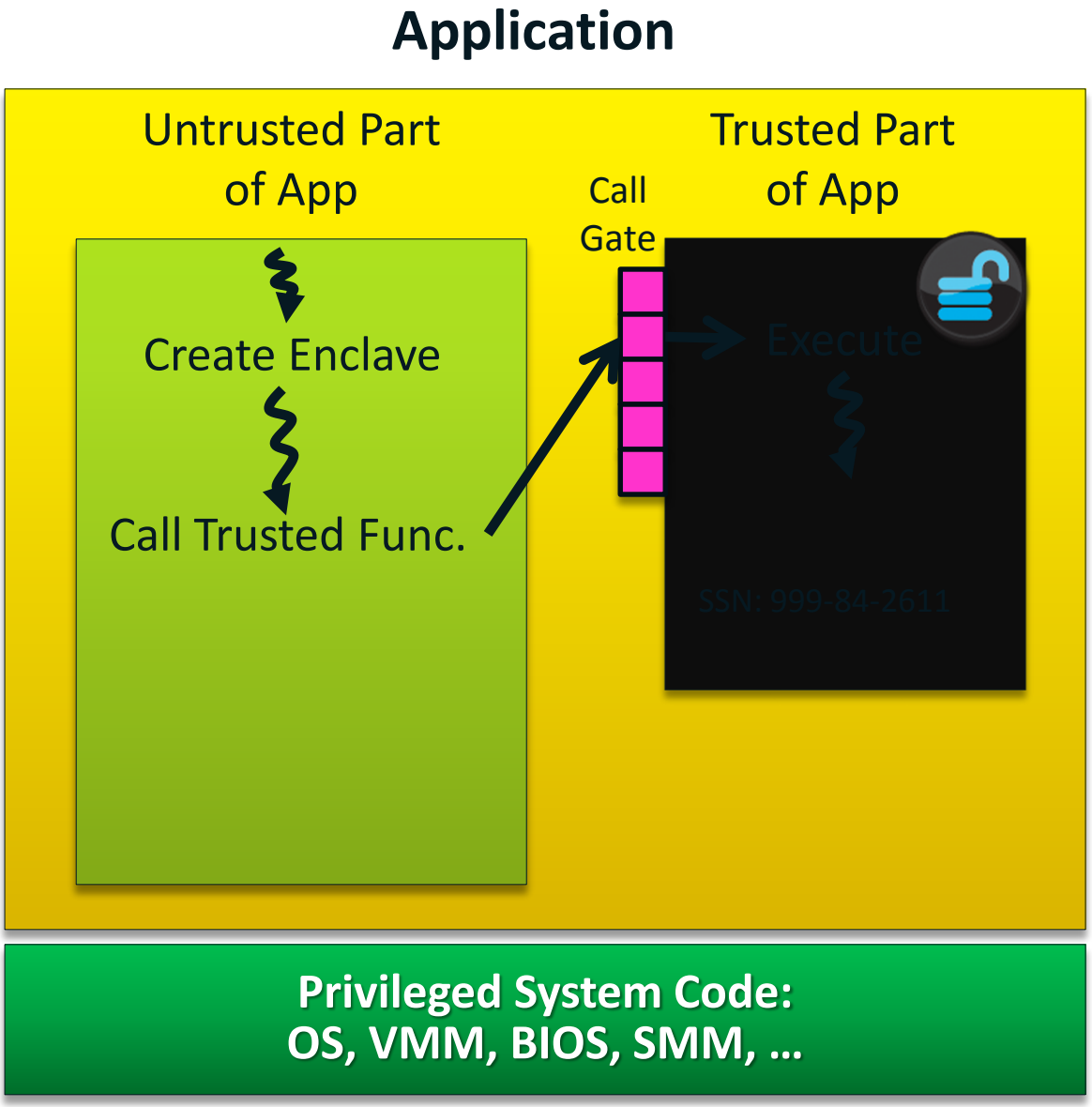

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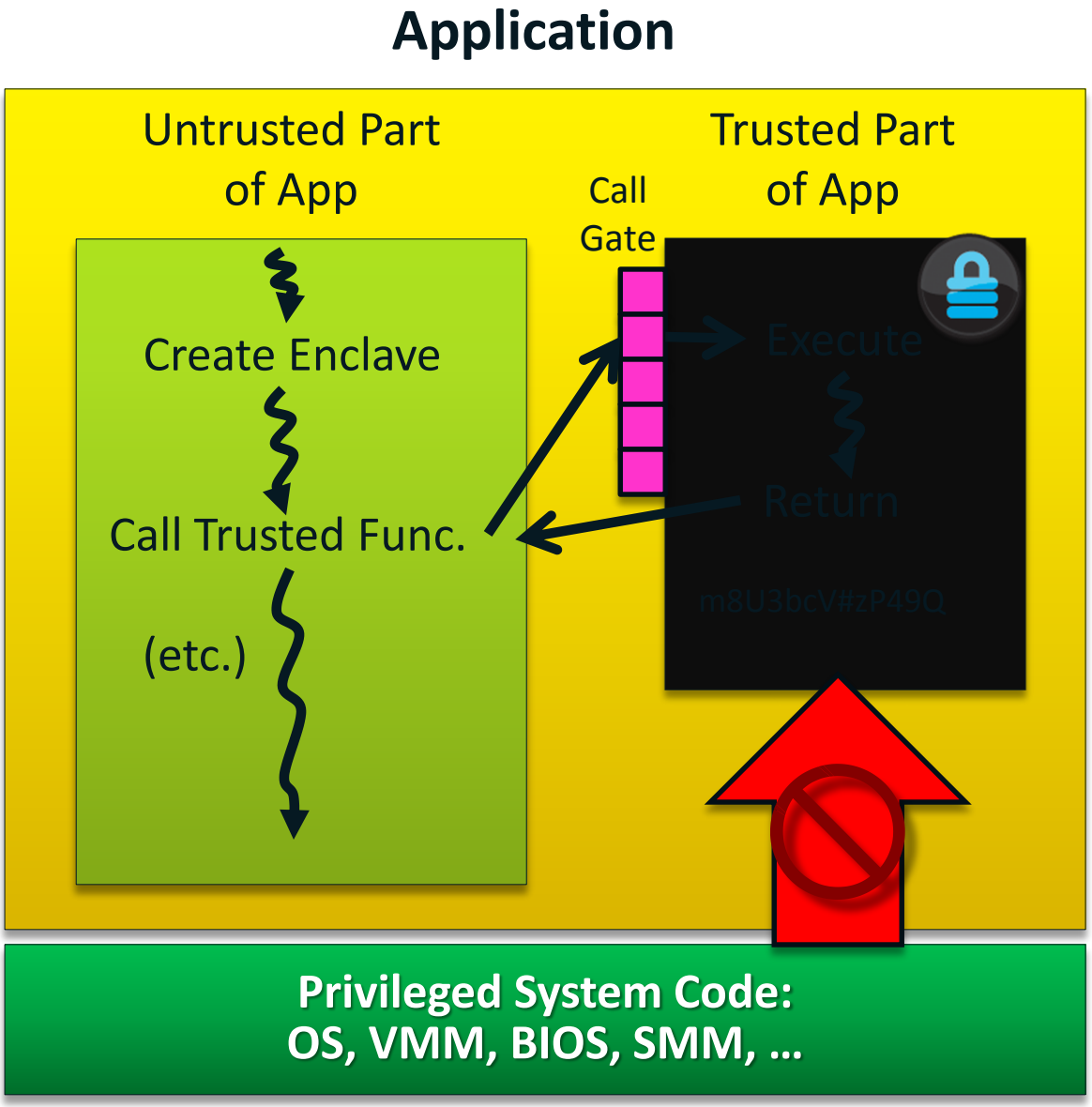

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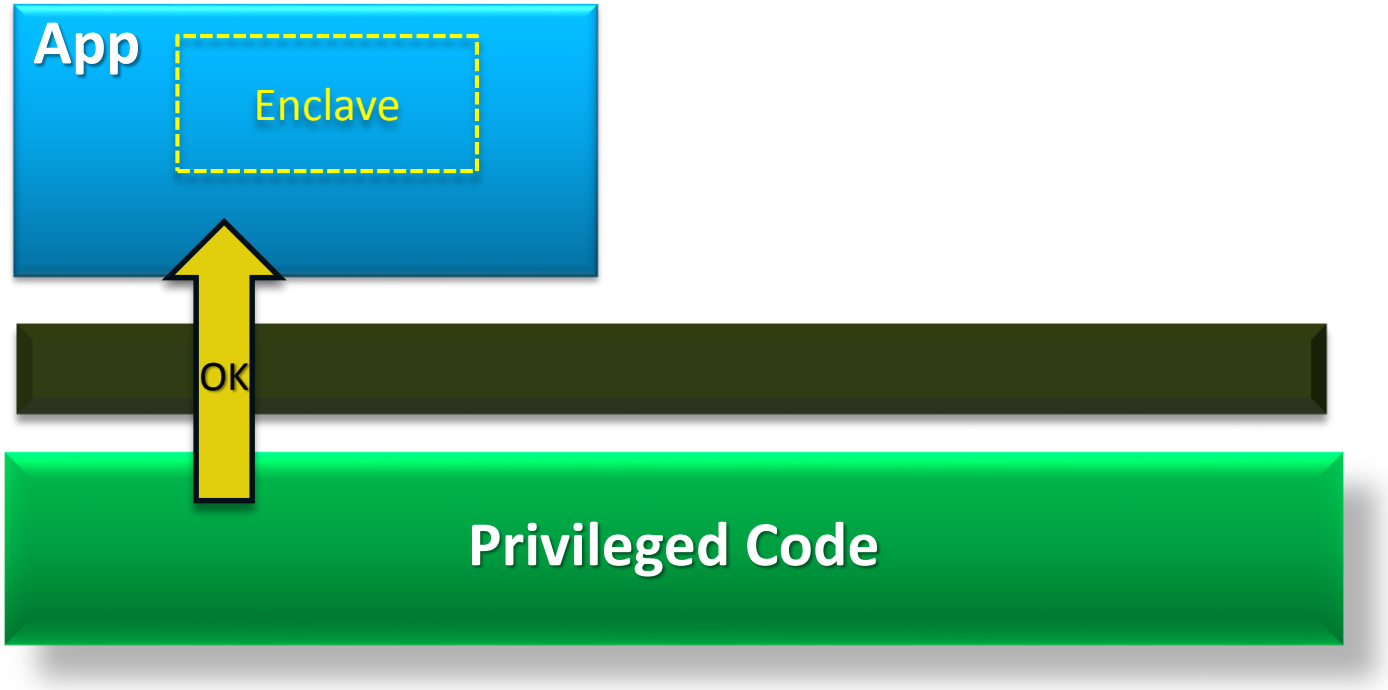
Protected Mode (rings) protects OS from apps …



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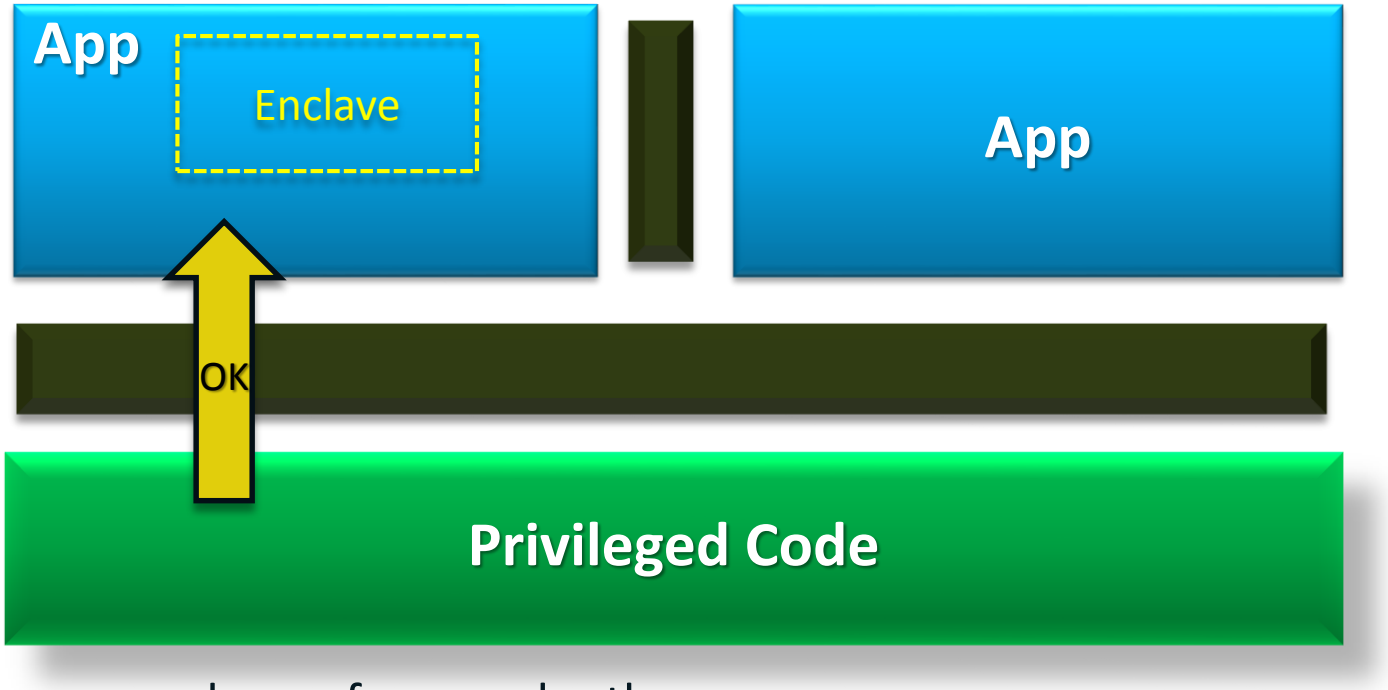

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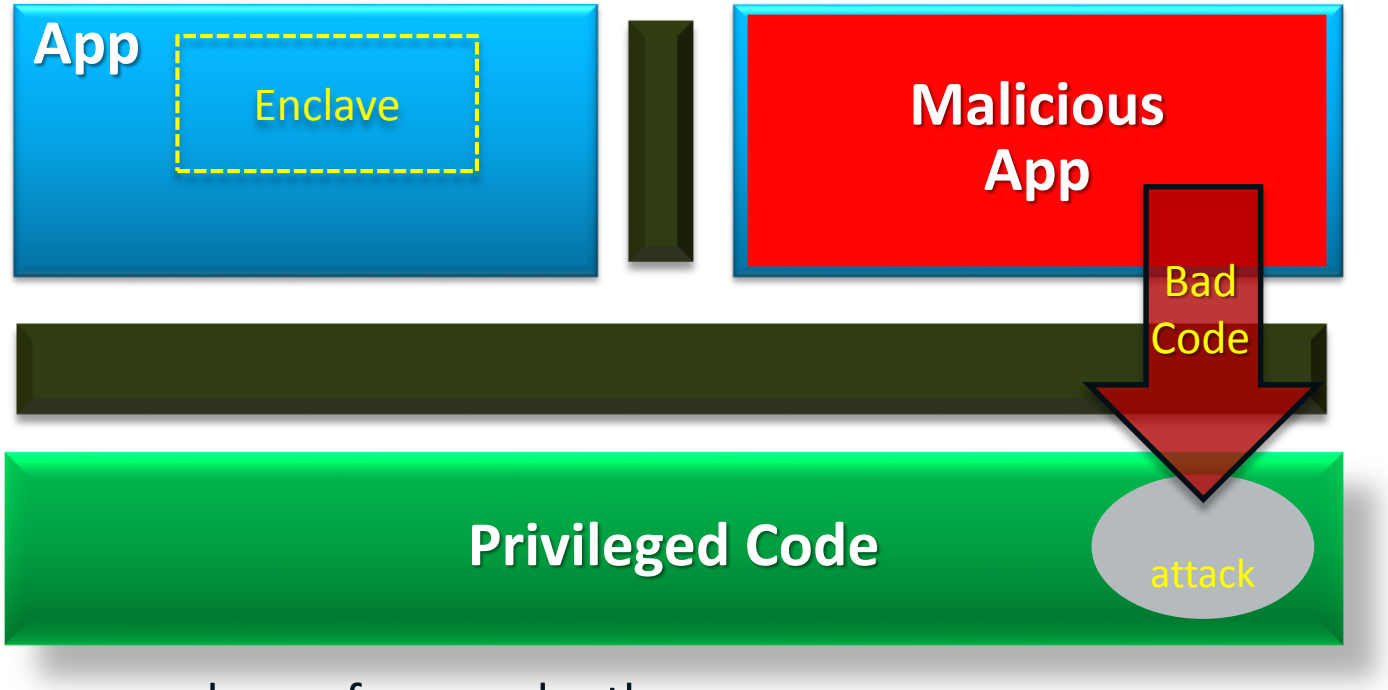

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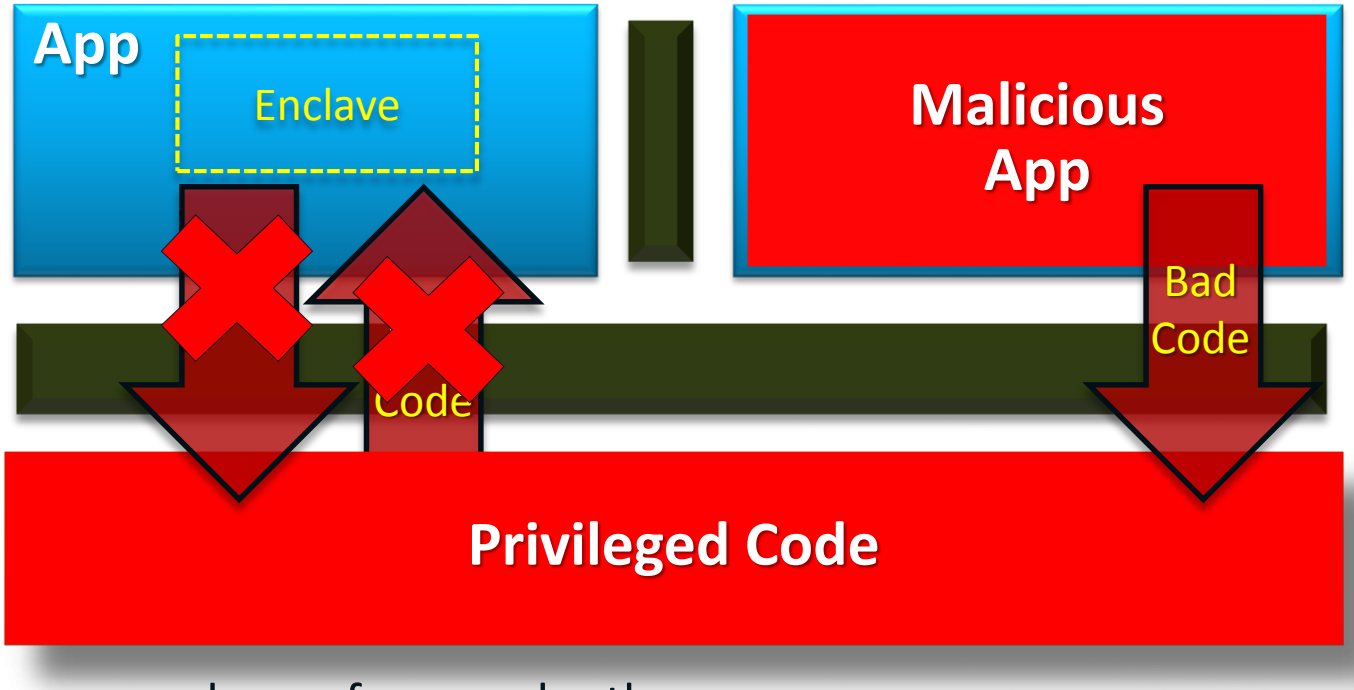

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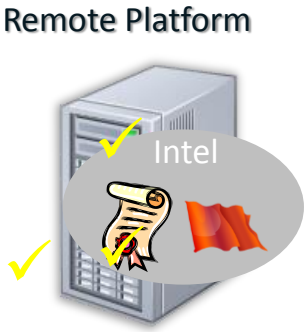

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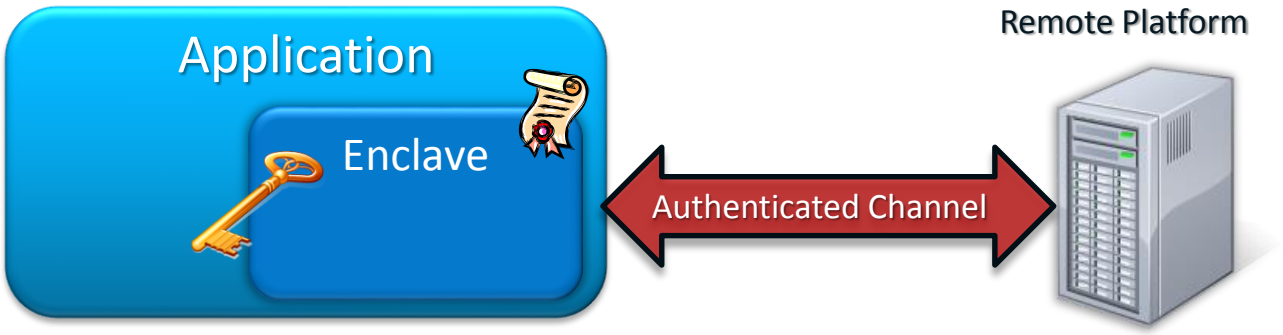

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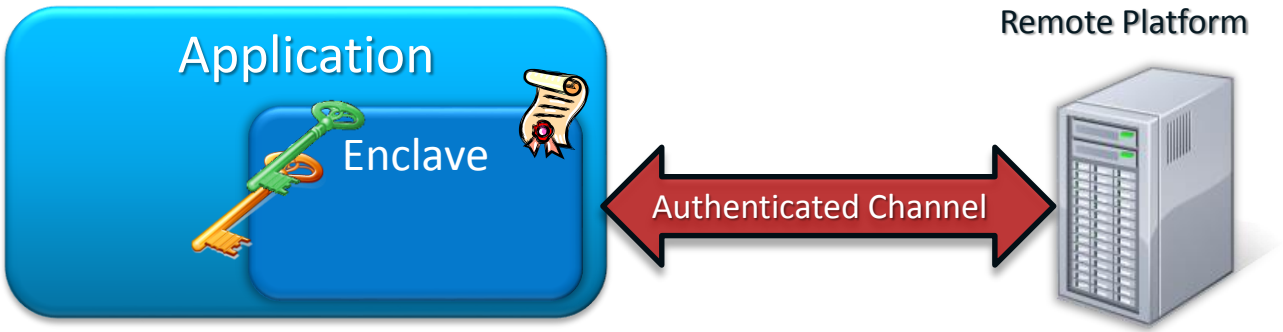

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- App can seal secrets to platform for future use

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Replay Attacks

- Encrypting data is not sufficient to protect against software attacks
- Privileged software can substitute old state to change control flow and data calculations
- Results in cryptographic and control flow changes
- “Paper clip attack”
- Memory aliasing attack from BIOS, VMM, OS

Research Past, Present, and Future

- Intel ® SGX 1 is shipping in client processors today
- Intel ® SGX 2 architecture defined, published, and software being developed
- Intel ® SGX 3 is under development at Intel Labs, Oregon
- Intel ® SGX 4 work starts this year

Links

- SGX Resource Page: https://software.intel.com/en-us/sgx
- Intel's Software Developers Manual Page (Programming Reference): http://www.intel.com/content/www/us/en/processors/architectures-software-developer-manuals.html
- Joint research poster session: http://sigops.org/sosp/sosp13/
- Public Cloud Paper using SGX2: https://www.usenix.org/sites/default/files/osdi14_full_proceedings.pdf
- HASP 2013 Workshop: https://sites.google.com/site/haspworkshop2013/workshop-program
- ISCA 2015 Tutorial: http://sgxisca.weebly.com/
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- MIT Report: https://eprint.iacr.org/2016/086.pdf
- MEE Paper: https://eprint.iacr.org/2016/204

Thank You