



CONFIDENTIAL CLOUD

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WHY CONFIDENTIAL CLOUD?

Higher value workloads require security guarantees around processing:

- Personal Identifying Information
- Government Confidential Information
- High Value Assets

Cloud providers already had many programs for convincing their customers on why they should be trusted.

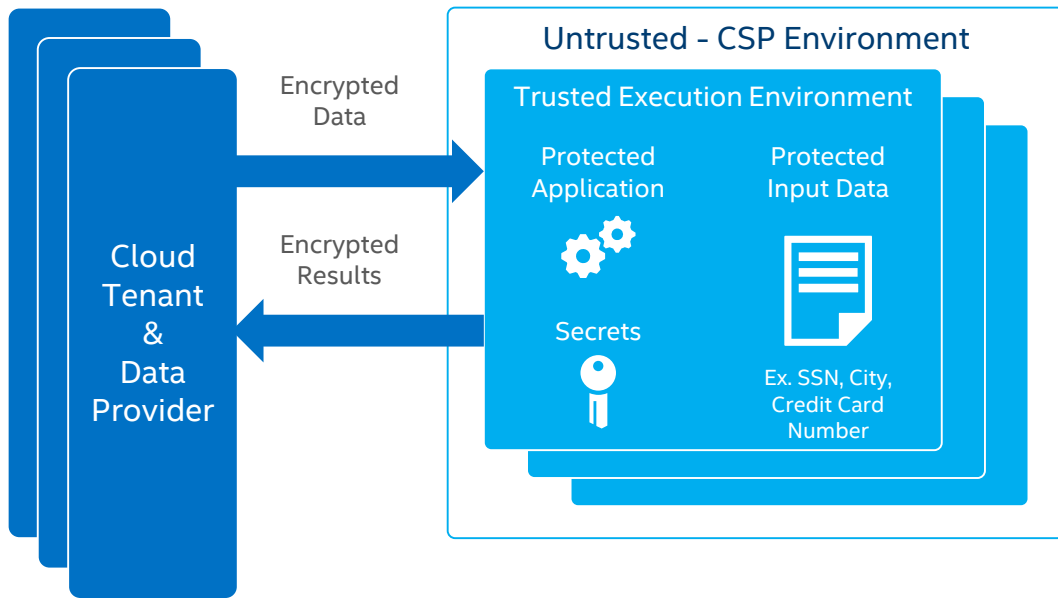
Snowden revelations tipped the conversation cloud security.

CONFIDENTIAL CLOUD paradigm combats rising paranoia of trusting cloud providers with customer secrets.



WHAT IS CONFIDENTIAL CLOUD?

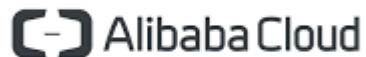
ENABLES ISLANDS OF PROTECTION TO BE CREATED AT SCALE TO ENABLE TENANT APPLICATIONS TO KEEP CODE AND DATA VISIBILITY FROM THE CSP.



- **Hardens against** attacks from SW that does not belong to the cloud tenant
 - Where possible provide the smallest Trusted Computing Base (TCB)
 - Secrets (data/keys/et al) remain protected even when attacker has full control of platform
- **Provides protections from** physical attacks like memory bus snooping, memory tampering, and “cold boot” attacks against memory contents in RAM
 - Protection for hard-to-protect or unprotected spaces
- Provides **hardware-based attestation** capabilities to measure and verify valid code and data signatures
 - Increases transparency and accountability

WHOSE DOING IT?

Cloud Players that have already made announcements in this space include:



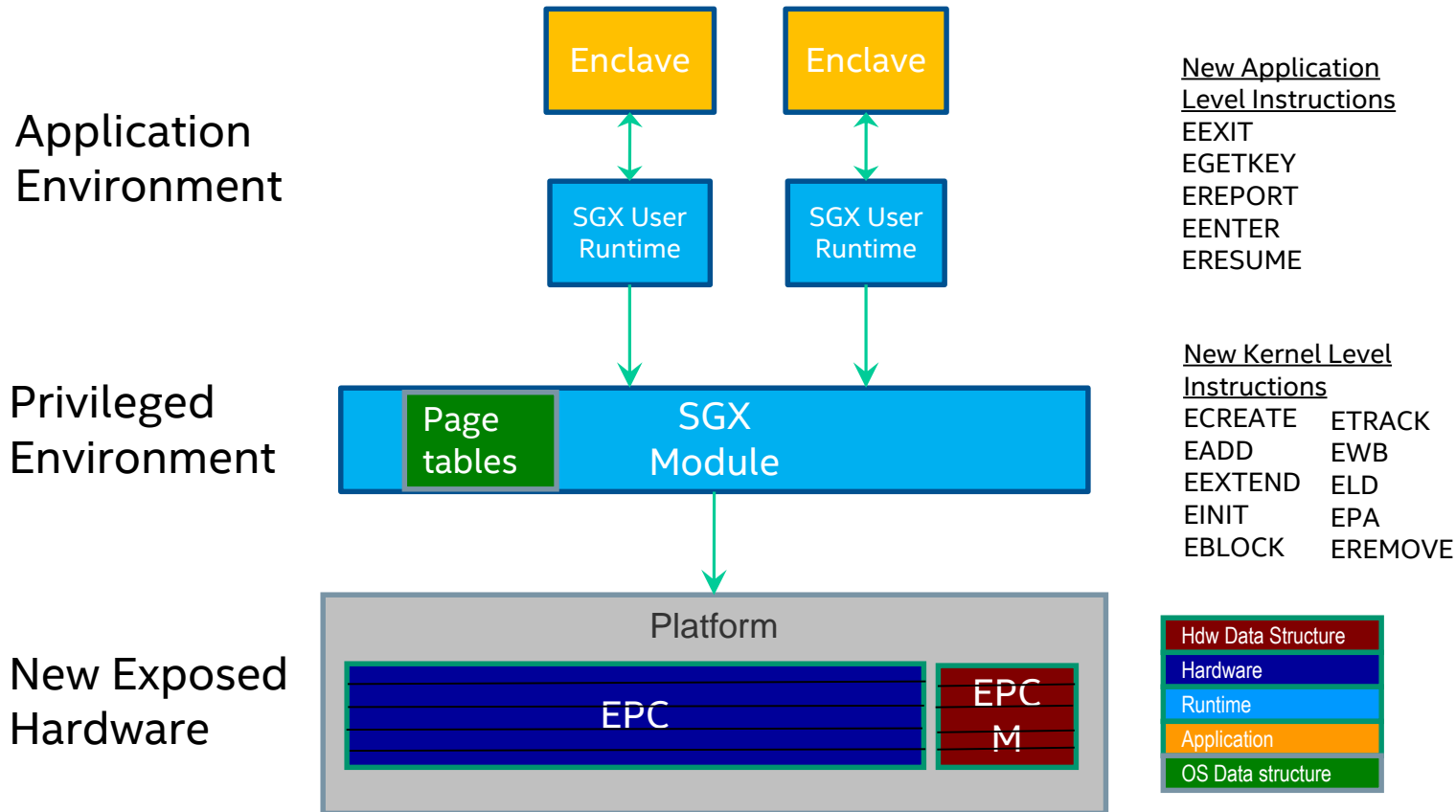
KEY CHALLENGES

- 1 Execution Isolation at the TEE boundary
- 2 Attestation and Sealing at the TEE boundary
- 3 Recovery from HW Issues

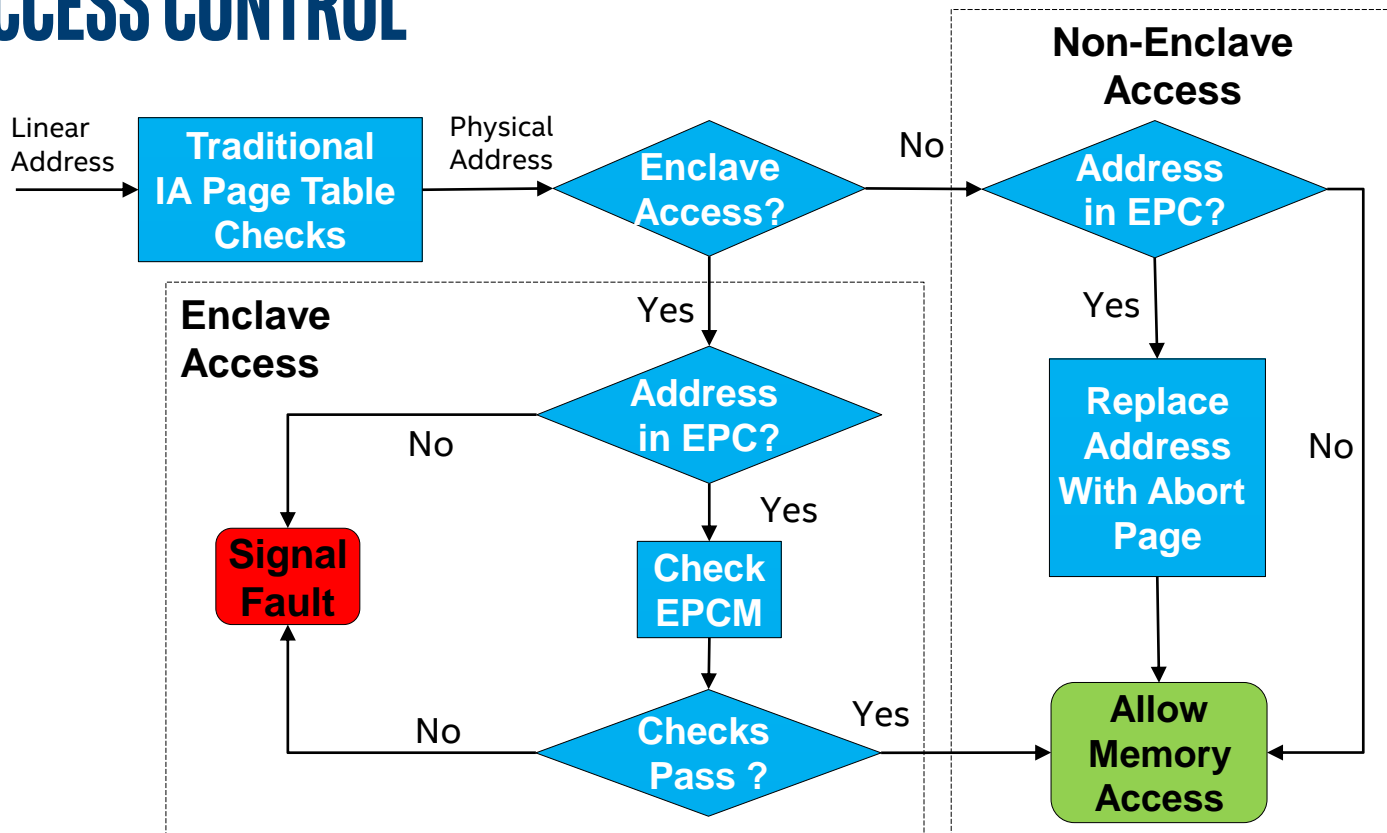
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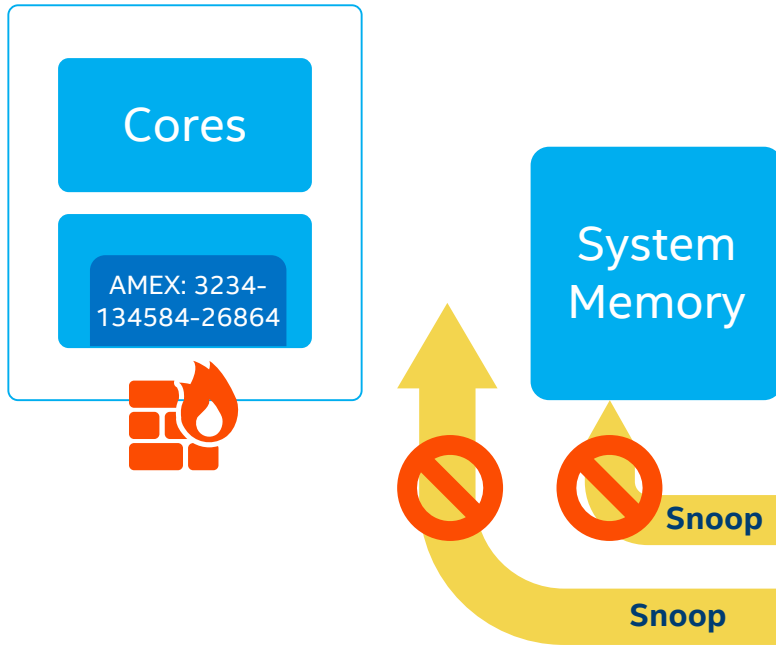
SGX HIGH-LEVEL HARDWARE/SOFTWARE PICTURE



SGX ACCESS CONTROL



SGX: MEMORY PROTECTION OUTSIDE CPU

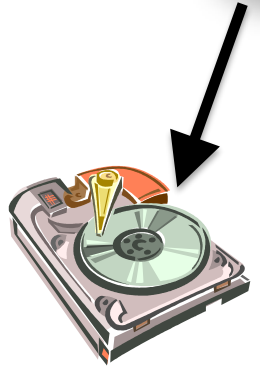
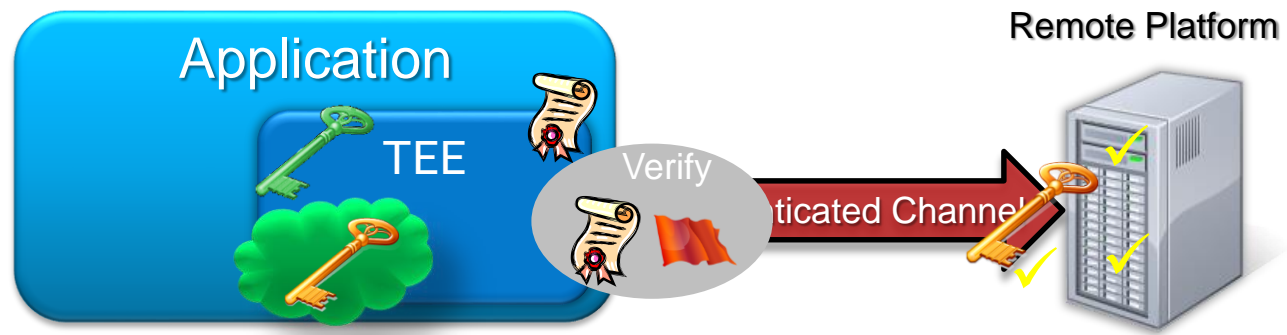


1. Security perimeter is the CPU package boundary
2. Data and code unencrypted inside CPU package
3. Data and code outside CPU package is encrypted and integrity checked
4. External memory reads and bus snoops see only encrypted data

KEY CHALLENGES

- 1 Execution Isolation at the Application boundary
- 2 Attestation and Sealing at the Application boundary
- 3 Recovery from HW Issues

CRITICAL FEATURES: ATTESTATION AND SEALING



- Application executes on local platform
- HW based **Attestation** provides remote platform assurance that “this is the right app executing in the right platform “
=>Remote platform can provision local platform with secrets
- Application can seal secrets to platform for future use

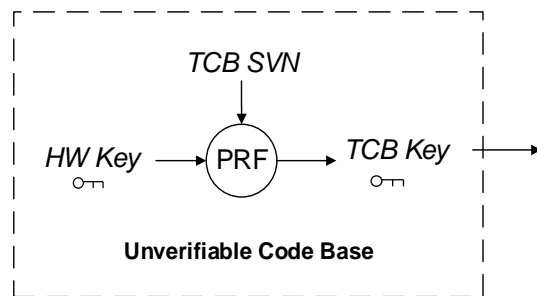
KEY CHALLENGES

- 1 Execution Isolation at the Application boundary
- 2 Attestation and Sealing to the Application boundary
- 3 TCB Recovery

TCB RECOVERY

TCB recovery is the process of being able to cryptographically demonstrate that the TCB has been updated to fix a potential security issue

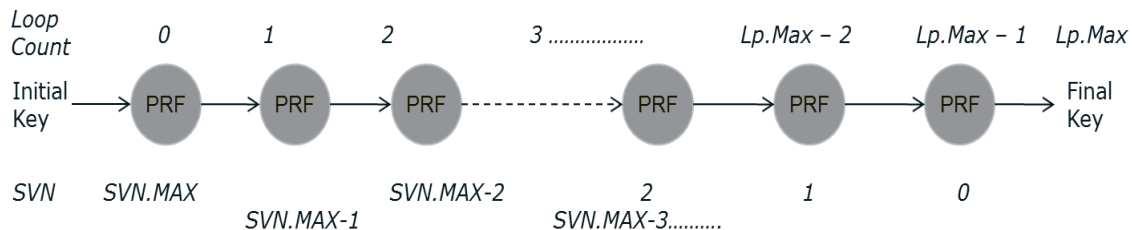
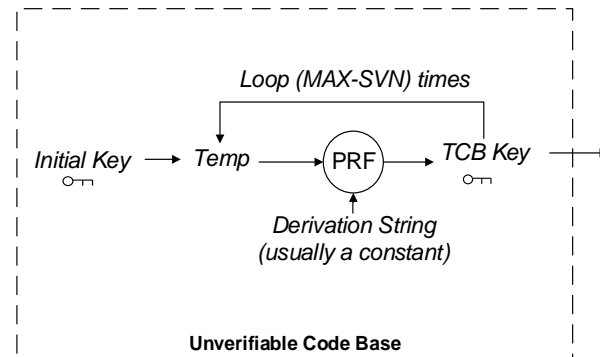
- First we issue all the HW component with a “Security Version Number”
- This is used to derive a “TCB specific” key from the HW key in the part.
- When a new update is issued all keys are derived from the new TCB specific key.
- Note: this mechanism cannot be modified as part of a TCB update itself.



DATA MIGRATION

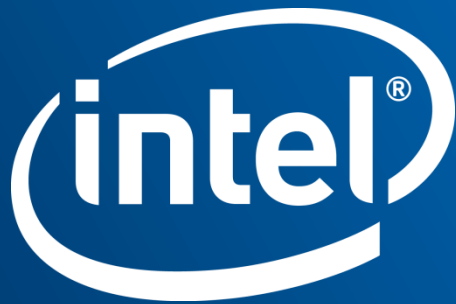
But what about all the data sealed to an previous TCB key?

- A backwards loop is used to provide forward secrecy, but allows “previous” TCB specific keys to be retrieved
- This allows the CPU to “go back” to previous keys by performing additional PRF's



TO DO...

- 1 Language integration and tools
- 2 Moving beyond LibraryOS models
- 3 Integrating Attestation into Applications
- 4 Tools to help developers write safer TEE code
- 5 Test suites for classic Side-Channel protections (e.g. Caches & TLBs)



SOFTWARE.INTEL.COM/SGX

The site has the latest info on:

SDK & Developer Resources

White Papers

Support Forum

The screenshot shows the Intel Developer Zone page for Intel Software Guard Extensions (SGX). The page features a navigation bar with the Intel logo, "Developer Zone", and a search bar. The main content area is titled "Intel® Software Guard Extensions (Intel® SGX)" and includes a sub-header "An Intel® Architecture extension designed to increase the security of application code." Below this, there is a detailed description of the technology and its benefits for developers. A sidebar on the right contains a table of contents with links to Overview, Details, Resource Library, Code Samples & Tutorials, Academic Research, Commercial License Request, and Related Links. The Related Links section includes links for Download the SDK, Access Development Services, Interfacing with Development Services, Forums, ISA Extensions, and Licensing FAQ. At the bottom of the page, there is a social media bar with icons for Facebook, Twitter, Google+, LinkedIn, and YouTube, along with a language selector set to English.

intel Developer Zone

Simon Johnson (IntL)

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Intel® Software Guard Extensions (Intel® SGX)

An Intel® Architecture extension designed to increase the security of application code.

Intel® Software Guard Extensions (Intel® SGX)

Intel® Software Guard Extensions (Intel® SGX) is an Intel technology for application developers who are seeking to protect select code and data from disclosure or modification. Intel SGX makes such protections possible through the use of enclaves, which are protected areas of execution. Application code can be put into an enclave by special instructions and software made available to developers via the Intel® SGX Software Development Kit (SDK). The Intel SGX SDK is a collection of APIs, libraries, documentation, sample source code, and tools that allows software developers to create and debug Intel SGX enabled applications in C/C++.

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