Enhanced Security Features for Confidential Computing

Data security using new hardware-based controls

Intel® SGX enables confidential computing solutions that allow you to unlock the secrets within your siloed data or collaborate with partners and other organizations while keeping everyone’s data private—regardless of where that data sits.

Enhances Confidentiality and Integrity
Protects sensitive data even in the presence of privileged malware at the OS, BIOS, VMM, or SMM layers.

Choice in How You Deploy
Run your existing application with an SGX library OS or develop purpose-built applications with a range of available SDKs.

Remotely Attest and Provision
A relying part can verify an application enclave’s identity and enhance security of provisioning keys, credentials, and other sensitive data in the enclave.

Reduce Attack Size
Bypassing the OS and VM, applications can communicate directly with the CPU.

The Confidential Computing Challenge
Until recently, security has focused just on encrypting data that is at-rest in storage or being transmitted on a network, but not protecting data while it is in use. Intel SGX leverages the strengths of the CPU platform and builds on a foundation of security to protect data and applications while in use.

Intel SGX – Getting Started
If you have an existing application that you want to use with Intel SGX, you just need to use an open-source Library OS (LibOS) solution like Gramine-SGX or any of the other commercial SGX LibOS offerings available. LibOS’s are lightweight OS’s that maintain SGX security boundaries and that can be easily deployed to a cloud service provider (CSP) that supports Intel SGX or deployed in a company’s data center on Intel SGX-enabled servers.

For new application development, you can pick from a variety of SDKs that support Intel SGX. The Intel SGX SDK and the Confidential Computing Consortium’s Open Enclave SDK are two examples.

“Thanks to the Intel SGX technology, we can verify that the piece of code running on someone else’s computer is the same piece of code running on your computer—and we use that knowledge to build a trusted system.”

Shane Glynn, Cofounder and General Counsel, MobileCoin
Figure 2 shows an example of an Intel SGX application that includes two parts: an untrusted part that launches the enclave, and a trusted part where production code runs in an enclave. A developer can create multiple enclaves that work in concert to support distributed architectures.

Many solutions benefit from the additional protection provided by Intel SGX. Solution examples include privacy preserving AI and ML processing, key management, proprietary algorithms, protection of biometrics, etc.

In this example, at runtime (see Figure 3), the Intel SGX instructions build and execute the enclave inside a special encrypted memory region with restricted entry/exit locations defined by the developer. This helps prevent data leakage: data is only in plain-text when it is isolated and protected by the SGX enclave. Upon exit from the enclave, it is encrypted. Snoops on the memory bus or system memory will find only cypher-text.

Intel SGX includes an instruction for generating a CPU/platform and/or enclave-specific “Sealing Key” that can be used to more safely store and retrieve sensitive information that may need to be stored to disk or protected while outside the enclave.

“Using Intel SGX has allowed us to build a platform that can securely and privately process data from a variety of partners. This allows us to all collaborate better and create more effective advertising campaigns for customers.”

Fabian Schaefer, Director of Analytics and Data Management, Magnit
Data Center Attestation

Intel® SGX Data Center Attestation Primitives (Intel® SGX DCAP) (see Figure 5) allows the enterprise, data center, and cloud service providers to build and deliver an attestation service themselves, rather than using the remote attestation from a 3rd party provider. This also removes the need for direct Internet access and allows all provisioning and quote verification to remain on the local network.

Intel SGX Helps Enable New Security Models and Innovation

The foundational capability of Intel SGX is to help enable software to be significantly less vulnerable to attacks by providing a higher level of isolation and attestation for program code, data and critical IP from the OS, applications, and hardware on the platform. Intel SGX has been used to help enhance security within multiple use cases and applications. Examples of these applications are listed on the following page.

Use Cases

**Artificial Intelligence (AI)/Machine Learning (ML)**
Protect your AI and ML workloads and applications while they are running.

**Cloud Infrastructure**
Confidentiality of customer applications and workloads in public cloud infrastructures.

**Trusted Multi-Party Compute/Multi-Party Analytics**
Enable multiple parties to collaborate on shared data while keeping sensitive data confidential.

**Secure Key Management**
Use enclaves to help protect cryptographic keys and provide HSM-like functionality.

**Blockchain**
Increase privacy and security for transaction processing, consensus, smart contracts, and key storage.

**Network Function Virtualization**
Establish trust for virtualized network functions.

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**Intel SGX Resources**

Intel SGX  

Intel Developer Zone (IDZ) – SGX  
[http://software.intel.com/sgx](http://software.intel.com/sgx)

Intel Data Center Attestation Primitives (DCAP) and Intel SGX SDK  
[https://01.org/intel-software-guard-extensions](https://01.org/intel-software-guard-extensions)
Specifications

<table>
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<tr>
<th>Required Hardware</th>
<th>Supported Development Software</th>
<th>SGX-compatible OSs</th>
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<tr>
<td>Intel® Xeon® 3rd generation Scalable platform, code-named “Ice Lake”</td>
<td><strong>Windows:</strong> Microsoft Visual Studio 2019&lt;br&gt;<strong>Linux:</strong> GNU toolchain&lt;br&gt;Intel® SGX Eclipse Plug-in</td>
<td><strong>Windows:</strong> Window 10&lt;br&gt;Windows Server&lt;br&gt;<strong>Linux:</strong> Ubuntu&lt;br&gt;Red Hat&lt;br&gt;Fedora&lt;br&gt;SUSE&lt;br&gt;CentOS&lt;br&gt;To find the latest pre-built binaries that reflect specific OS support, go to: <a href="https://01.org/intel-software-guard-extensions/downloads">https://01.org/intel-software-guard-extensions/downloads</a></td>
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<tr>
<td>Intel® Xeon® processor E3-1500 v5 and v6</td>
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<td>Intel® Xeon® processor E family 2100</td>
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For the latest information on Intel SGX go to: intel.com/sgx

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