



# Intel® Software Guard Extensions (Intel® SGX) SDK for Linux\* OS

## **Installation Guide**

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## Revision History

| Revision Number | Description                    | Revision Date  |
|-----------------|--------------------------------|----------------|
| 1.5             | Intel® SGX Linux 1.5 release   | May 2016       |
| 1.6             | Intel® SGX Linux 1.6 release   | September 2016 |
| 1.7             | Intel® SGX Linux 1.7 release   | December 2016  |
| 1.8             | Intel® SGX Linux 1.8 release   | March 2017     |
| 1.9             | Intel® SGX Linux 1.9 release   | July 2017      |
| 2.0             | Intel® SGX Linux 2.0 release   | November 2017  |
| 2.1             | Intel® SGX Linux 2.1 release   | December 2017  |
| 2.1.1           | Intel® SGX Linux 2.1.1 release | March 2018     |
| 2.1.2           | Intel® SGX Linux 2.1.2 release | March 2018     |
| 2.1.3           | Intel® SGX Linux 2.1.3 release | April 2018     |
| 2.2             | Intel® SGX Linux 2.2 release   | July 2018      |
| 2.3             | Intel® SGX Linux 2.3 release   | September 2018 |
| 2.4             | Intel® SGX Linux 2.4 release   | November 2018  |
| 2.5             | Intel® SGX Linux 2.5 release   | March 2019     |
| 2.6             | Intel® SGX Linux 2.6 release   | June 2019      |
| 2.7             | Intel® SGX Linux 2.7 release   | September 2019 |
| 2.7.1           | Intel® SGX Linux 2.7.1 release | November 2019  |
| 2.8             | Intel® SGX Linux 2.8 release   | January 2020   |
| 2.9             | Intel® SGX Linux 2.9 release   | March 2020     |
| 2.9.1           | Intel® SGX Linux 2.9.1 release | April 2020     |
| 2.10            | Intel® SGX Linux 2.10 release  | June 2020      |
| 2.11            | Intel® SGX Linux 2.11 release  | August 2020    |
| 2.12            | Intel® SGX Linux 2.12 release  | November 2020  |
| 2.13            | Intel® SGX Linux 2.13 release  | January 2021   |
| 2.14            | Intel® SGX Linux 2.14 release  | June 2021      |

## Intel® Software Guard Extensions SDK and Platform Software Installation

This document provides the instructions on how to install the Intel® SGX SDK and platform software. You can see the details in the following topics:

- [Install Intel® Software Guard Extensions SDK and Platform Software](#)
- [Install Intel® Software Guard Extensions Eclipse\\* Plug-in](#)

### Install Intel® Software Guard Extensions SDK and Platform Software

The current Linux\* OS installation packages include three parts separately:

- Installation package for the Intel® Software Guard Extensions (Intel® SGX) driver
- Installation package for the Intel® SGX platform software (Intel® SGX PSW)
- Installation package for the Intel® SGX SDK.

### Hardware Requirements

- 6th Generation Intel® Core™ Processor or newer
- Intel® SGX option enabled in BIOS.

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#### **NOTE**

This is required when you install the Intel® SGX driver or Intel® SGX PSW, but not required when you install the Intel® SGX SDK installer.

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### Prerequisites

Ensure that you have one of the following operating systems:

- Ubuntu\* 18.04 LTS 64-bit Desktop version
- Ubuntu\* 18.04 LTS 64-bit Server version
- Ubuntu\* 20.04 LTS 64-bit Desktop version
- Ubuntu\* 20.04 LTS 64-bit Server version
- Red Hat\* Enterprise Linux Server release 7.6 64bits
- Red Hat\* Enterprise Linux Server release 8.2 64bits
- CentOS\* 8.2 64bits
- Fedora\* 31 Server 64bits
- 

To install the Intel® SGX PSW, first install the following tools:

- On Ubuntu\* 18.04 and Ubuntu 20.04  

```
$ sudo apt-get install libssl-dev libcurl4-openssl-  
dev libprotobuf-dev
```
- On Red Hat\* Enterprise Linux 7.6, Red Hat Enterprise Linux 8.2 and  
Fedora\* 31:  

```
$ sudo yum install openssl-devel libcurl-devel pro-  
tobuf-devel yum-utils
```
- On CentOS\* 8.2:  

```
$ sudo dnf --enablerepo=PowerTools install openssl-  
devel libcurl-devel protobuf-devel yum-utils
```

To install the Intel® SGX SDK, install the following tools:

- On Ubuntu\* 18.04:  

```
$ sudo apt-get install build-essential python
```
- On Ubuntu\* 20.04:  

```
$ sudo apt-get install build-essential python-is-  
python3
```
- On Red Hat\* Enterprise Linux 8.2, CentOS\* 8.2 and Fedora\* 31:  

```
$ sudo yum groupinstall 'Development Tools'
```

```
$ sudo yum install python2
```

```
$ sudo alternatives --set python /usr/bin/python2
```

---

### **NOTE**

Intel® SGX SDK requires GCC 7.3 or above.

The SDK installer will not be provided for below OSes because the native GCC version doesn't meet the requirement:

- Red Hat\* Enterprise Linux Server release 7.6 64bits
- 

### **Installation**

To install the driver, PSW, and SDK packages, you need the root (or sudo) privilege. Install the components in following order:

1. Intel® SGX driver
2. Intel® SGX PSW
3. Intel® SGX SDK

Use the following steps to install these packages:

### Intel® SGX Driver Installation

Install the Intel® SGX driver package:

- To install the Intel® SGX driver with ECDSA attestation enabled, see how to [install Intel® Software Guard Extensions Driver for Data Center Attestation Primitives \(Intel® SGX DCAP\)](#).
- To install the Intel® SGX driver without ECDSA attestation:
  1. Download Intel® SGX DCAP driver package.
  2. Run the following command:

```
$ sudo ./sgx_linux_x64_driver.bin
```

The installer also loads the driver and sets it to `auto-load` when the system reboots.

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#### **NOTE**

Only 64-bit installation packages are available.

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#### **NOTE**

If Secure Boot is enabled, you need to sign the Intel® SGX. Please refer to the distribution documentation on how to sign drivers for Secure Boot.

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### Intel® SGX PSW Installation

The Intel® SGX PSW provides 3 services:

- launch
- EPID-based attestation
- algorithm agnostic attestation

Starting from 2.8 release, it is split into multiple packages and users can choose which features and services to install.

Install Intel® SGX PSW Debian packages from the Intel® SGX repository:

1. Connect your system to the network with internet access and open a terminal.
2. Add the repository to your sources.

- On Ubuntu\* 18.04:

```
$ echo 'deb [arch=amd64] https://download.01.org/intel-sgx/sgx_repo/ubuntu bionic'
```

```
main' | sudo tee /etc/apt/sources.list.d/intel-sgx.l-  
ist
```

- On Ubuntu\* 20.04:

```
$ echo 'deb [arch=amd64] https://-  
download.01.org/intel-sgx/sgx_repo/ubuntu focal  
main' | sudo tee /etc/apt/sources.list.d/intel-sgx.l-  
ist
```

### 3. Add the key to the list of trusted keys used by the apt to authenticate packages:

```
$ wget -qO - https://download.01.org/intel-sgx/sgx_  
repo/ubuntu/intel-sgx-deb.key | sudo apt-key add -
```

### 4. Update the apt and install the packages:

```
$ sudo apt-get update
```

- Install launch service:

```
$ sudo apt-get install libsgx-launch libsgx-urts
```

- Install EPID-based attestation service:

```
$ sudo apt-get install libsgx-epid libsgx-urts
```

- Install algorithm agnostic attestation service:

```
$ sudo apt-get install libsgx-quote-ex libsgx-urts
```

---

#### **NOTE**

Optionally, you can install `*-dbgsym` packages to get the debug symbols, and install `*-dev` packages to get the header files for development.

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#### Upgrade from a legacy installation:

Before release version 2.8, the Intel® SGX PSW was installed from a single package named `libsgx-enclave-common`. Starting with the 2.8 release, the Intel® SGX PSW is split into many smaller packages with individual libraries. `libsgx-enclave-common` now only contains the `libsgx-enclave-common` library. As a result, a simple upgrade will end up with a subset of the Intel® SGX PSW being installed on the system. You need to install the additional packages listed above. In addition, you will encounter some error message when you attempt to install the extra packages with an older



version of `libsgx-enclave-common`, because the older `libsgx-enclave-common` package have files attributed to it that are now installed from the new packages. The suggested method to upgrade is:

- Uninstall the old versions by following instructions in the [Uninstallation](#) section.
- Update and install the appropriate packages:

```
$ sudo apt-get update
```

```
$ sudo apt-get install <package_name>
```

Configure the installation:

Several packages are configured with recommended dependency on other packages that are not required for certain usage. For instance, the background daemon is not required for container usage. It is installed by default but you can drop it by using the additional option during the installation:

- On Ubuntu 18.04 and Ubuntu 20.04:

```
--no-install-recommends
```

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**NOTE**

On .rpm-based system, `rpmbuild` ≥ 4.12 is required to enable similar features.

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Install the Intel® SGX PSW RPM packages by using the Intel® SGX RPM local repository:

1. Download the Intel® SGX RPM local repository from <https://download.01.org/intel-sgx/>.

2. Add the RPM local repository to your repository list.

- On Red Hat\* Enterprise Linux 7.6, Red Hat\* Enterprise Linux 8.2, CentOS\* 8.2 and Fedora\* 31:

```
$ sudo yum-config-manager --add-repo file://PATH_TO_LOCAL_REPO
```

---

• **NOTE**

Replace `PATH_TO_LOCAL_REPO` and `LOCAL_REPO_ALIAS` with proper path and name on your system.

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### 3. Install the RPM packages:

- On Red Hat\* Enterprise Linux 7.6, Red Hat\* Enterprise Linux 8.2, CentOS\* 8.2, and Fedora\* 31:
  - Install launch service:  

```
$ sudo yum --nogpgcheck install libsgx-launch libsgx-urts
```
  - Install EPID-based attestation service:  

```
$ sudo yum --nogpgcheck install libsgx-epid libsgx-urts
```
  - Install algorithm agnostic attestation service:  

```
$ sudo yum --nogpgcheck install libsgx-quote-ex libsgx-urts
```
- - Install EPID-based attestation service:  

```
$ sudo zypper --no-gpg-checks install libsgx-epid libsgx-urts
```
  - Install algorithm agnostic attestation service:  

```
$ sudo zypper --no-gpg-checks install libsgx-quote-ex libsgx-urts
```

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#### **NOTE**

The Intel® SGX RPM local repository is not signed with GPG. Ignore `gpgcheck` when installing the packages.

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#### **NOTE**

Optionally, you can install `*-debuginfo` packages to get the debug symbols, and install `*-devel` packages to get the header files for development.

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The Intel® SGX platform software package includes user space libraries such as uRTS and AESM. After installation, the libraries are installed to the `directory/usr/lib` or `/usr/lib/x86_64-linux-gnu` or `/usr/lib64`.

The AESM service executable and the AE libraries are installed to the directory:

- If Intel® SGX PSW is installed with Debian or RPM packages  
`/opt/intel/sgx-aesm-service`

The installer also configures the AESM service as a system daemon, which starts with the user ID `aesmd`. The default home directory of the AESM service is `/var/opt/aesmd`.

After installing the platform software, you may need to setup an http proxy server for the AESM service. For instructions on setting up the proxy, refer to the file `/etc/aesmd.conf`. The setup example is commented out.

Logs are added to help debug configuration errors. By default, the SGX shares libraries output logs to standard output or to standard error. The AESM as a system service/daemon outputs the log to syslog. Use “`journalctl -u aesmd`” to check the log.

### Intel® SGX SDK Installation

Download Intel® SGX SDK package: `sgx_linux_<os>_x64_sdk_<version>.bin`.

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#### **NOTE**

Only 64-bit installation packages are available.

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Install the Intel® SGX SDK using the following command:

```
$ ./sgx_linux_<os>_x64_sdk_<version>.bin
```

This command starts the setup program in the interactive mode on the command line. When the question **Do you want to install in current directory?** **[yes/no]** appears, type **yes** and press **Enter** to install into the current directory or type **no** and press **Enter** to enter another path for installation.

After the installation, the Intel® SGX SDK package is installed into the directory `[User Input Path]/sgxsdk`. Run the command `source [User Input Path]/sgxsdk/environment` to set all environment variables.

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#### **NOTE**

The default installation directories for Intel® SGX PSW and Intel® SGX SDK are different:

- The Intel® SGX PSW binary package installs the user space libraries in `/usr/lib`.
  - The Intel® SGX PSW Debian packages install the user space libraries in `/usr/lib/x86_64-linux-gnu`.
  - The Intel® SGX PSW RPM packages install the user space libraries in `/usr/lib64`.
-

- 
- The Intel® SGX SDK package installs the corresponding shell libraries in `[User Input Path]/sgxsdk/lib64`.

Shell libraries contain the declaration of the public APIs and are only needed for building Intel® SGX applications. At runtime, the standard user-space libraries in `/usr/lib` or `/usr/lib/x86_64-linux-gnu` or `/usr/lib64` are loaded automatically.

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### **NOTE**

Sample code is installed under `[User Input Path]/sgxsdk/SampleCode` directory with read-only permissions for normal users. Each user can make separate copies to modify, build, and experiment with the sample codes.

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On Ubuntu\* 18.04, Ubuntu\* 20.04, Red Hat\* Enterprise Linux 8.2, CentOS\* 8.2, and Fedora\* 31, download the mitigation tools that are named `as.ld.objdump.gold.r2.tar.gz` from [here](#), unzip them and copy the tools from the directory that corresponds to current OS distribution to the directory of `/usr/local/bin`. Make sure that these tools have execute permission.

See <https://nvd.nist.gov/vuln/detail/CVE-2020-0551> and <https://software.intel.com/security-software-guidance/software-guidance/load-value-injection> for information related to these mitigation tools.

### **Uninstallation**

To uninstall the driver, PSW, and SDK packages, you need the root (or sudo) privilege. Uninstall the components in the following order:

1. Intel® SGX driver
2. Intel® SGX PSW
3. Intel® SGX SDK.

Use the following steps to uninstall these packages:

1. Uninstall the Intel® SGX driver package:  
After the installation, a generated script `uninstall.sh` appears in the `/opt/intel/sgxdriver` directory. You can use this script to uninstall the driver.
2. Uninstall the Intel® SGX PSW package:

- Intel® SGX PSW is installed with `sgx_linux_<os>_x64_psw_<version>.bin`:  
After the installation, a generated script `uninstall.sh` appears in the `/opt/intel/sgxpsw` directory. You can use this script to uninstall the platform software.

- Intel® SGX PSW is installed with Intel® SGX Debian repo:

```
$ sudo apt-get remove '^sgx-.*' '^libsgx-.*'
```

To uninstall the Intel® SGX PSW Debian debug symbol package if installed, run the following command:

```
$ sudo apt-get remove libsgx-enclave-common-dbg-sym
```

- Intel® SGX PSW is installed with Intel® SGX RPM local repository.  
To uninstall the Intel® SGX PSW debian package, run the following command with the root privilege:

- On Red Hat\* Enterprise 7.6, Red Hat\* Enterprise Linux 8.2, CentOS\* 8.2 and Fedora\* 31:

```
$ sudo yum remove libsgx-* && sudo yum  
remove sgx-*
```

### 3. Uninstall the Intel® SGX SDK package:

After installation, a generated script `uninstall.sh` appears in the `[User Input Path]/sgxsdk` directory. You can use it to uninstall the Intel® SGX SDK.

## ECDSA attestation

To enable ECDSA attestation:

- Ensure that you have the following required hardware:
  - 8th Generation Intel® Core™ Processor or newer with Flexible Launch Control support\*.
  - Intel® Atom™ Processor with Flexible Launch Control support\*.
- To use ECDSA attestation, you must install the Intel® Software Guard Extensions Driver for Data Center Attestation Primitives (Intel® SGX DCAP):
  - Install the required components that support the Intel® SGX PSW installation, because the Intel SGX Driver is built from the driver package.

```
sudo apt-get install build-essential ocaml auto-  
make autoconf libtool wget python libssl-dev
```

---

**NOTE**

This command line contains modules needed beyond the Intel® SGX Driver installation.

---

- Download the latest Intel® SGX Driver binary file from the Intel® SGX DCAP download directory: <https://download.01.org/intel-sgx/latest/linux-latest/distro/>

For example, to download the driver for Ubuntu\* server 18.04, use the following command:

```
sudo wget - https://download.01.org/intel-sgx/latest/linux-latest/distro/ubuntu18.04-server/sgx\_linux\_x64\_driver\_1.36.2.bin
```

- Set the protections to allow for the .bin file execution:  

```
chmod 777 sgx_linux_x64_driver_1.32.bin
```
- Install the driver using the following command:  

```
sudo ./sgx_linux_x64_driver_1.32.bin
```

The installer also loads the Intel® SGX Driver and sets it to be auto-load when the system reboots.

After the Intel® SGX Driver installation, you can see a generated script `uninstall.sh` under the `/opt/intel/sgxdriver` directory. You can use this script to uninstall the driver.

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**NOTE**

If you already installed Intel® SGX driver without ECDSA attestation, please uninstall this driver, or the newly installed ECDSA attestation enabled Intel® SGX driver will not work.

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- Install Provisioning Certificate Caching Service(PCCS). About how to install and configure PCCS, please refer [SGXDataCenterAttestationPrimitives](#).
- Install Platform Quote Provider Library. Follow [Intel® Software Guard Extensions Data Center Attestation Primitives Installation Guide For Linux\\* OS](#) to install Intel® SGX DCAP Default Quote Provider Library

- Ensure the PCCS is setup correctly by local administrator or data center administrator. Please also setup `/etc/sgx_default_qcnl.conf` for Default Quote provider library according to your real environment:  
USE\_SECURE\_CERT=TRUE  
  
PCCS\_URL=https://your\_pccs\_server:8081/sgx/certification/v2/
- PCCS\_URL is the URL of your PCCS caching service. Set USE\_SECURE\_CERT to FALSE if PCCS uses self-signed certificates, and TRUE for a production PCCS with authenticated certificates.

## Install Intel® Software Guard Extensions Eclipse\* Plug-in

The Intel® Software Guard Extensions Eclipse\* Plug-in for Linux\* OS helps the enclave developer to maintain enclaves and untrusted related code inside Eclipse\* C/C++ projects.

This section contains steps to set up your Intel® Software Guard Extensions Eclipse\* Plugin on a Linux\* system, including necessary softwares, steps to install the product, and steps to configure your preferred product directory.

- [Prerequisites](#)
- [Installation](#)
- [Configuration](#)

### Prerequisites

To use Intel(R) Software Guard Extensions Eclipse Plug-in, install the following softwares:

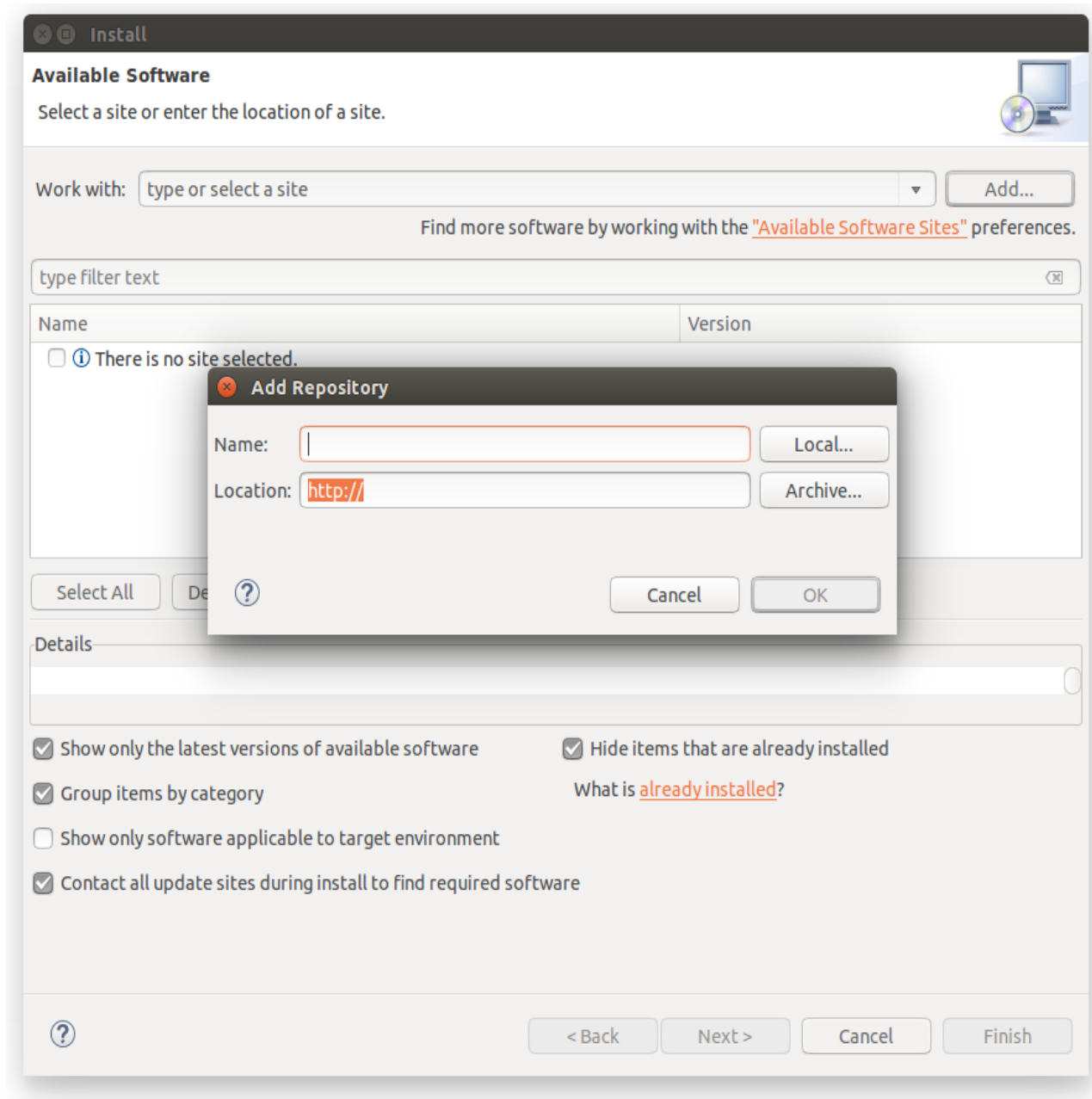
- Eclipse\* Mars 1 with CDT IDE for C/C++ Developers (version 4.5.1). To use this version, install Java\* Development Kit (JDK) or Java\* Runtime Environment (JRE) version 1.8 or above.
- gcc\*/g++ tools
- OpenSSL\*
- Intel(R) SGX SDK for Linux\* OS

### Installation

Install the Intel® Software Guard Extensions Eclipse\* Plug-in as a regular Eclipse Plugin:

1. Download the .zip archive of Intel® Software Guard Extensions Eclipse Plug-in from [\[Intel Site\]](#)

2. Open Eclipse and go to **Help menu -> Install New Software**. Click the **Add** button for the **Work with** field to open the **Add Repository** dialog as shown in the following graphic:

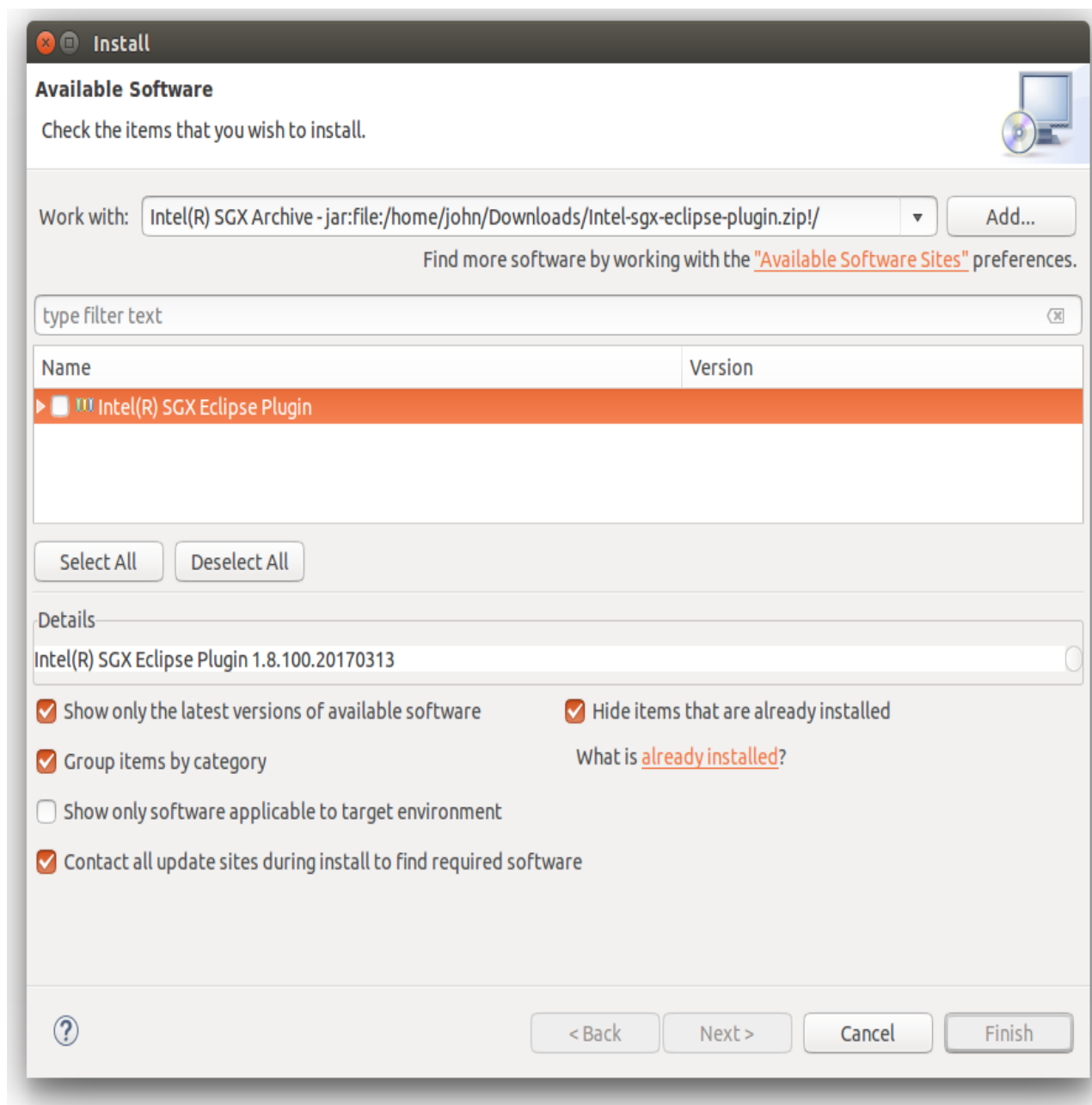


### Add Repository Dialog

3. Enter Intel(R) SGX Archive in the **Name** field . Click the **Archive...**



button and select the location of the downloaded archive as shown in the following graphic:



### The Location of the Plugin zip Archive

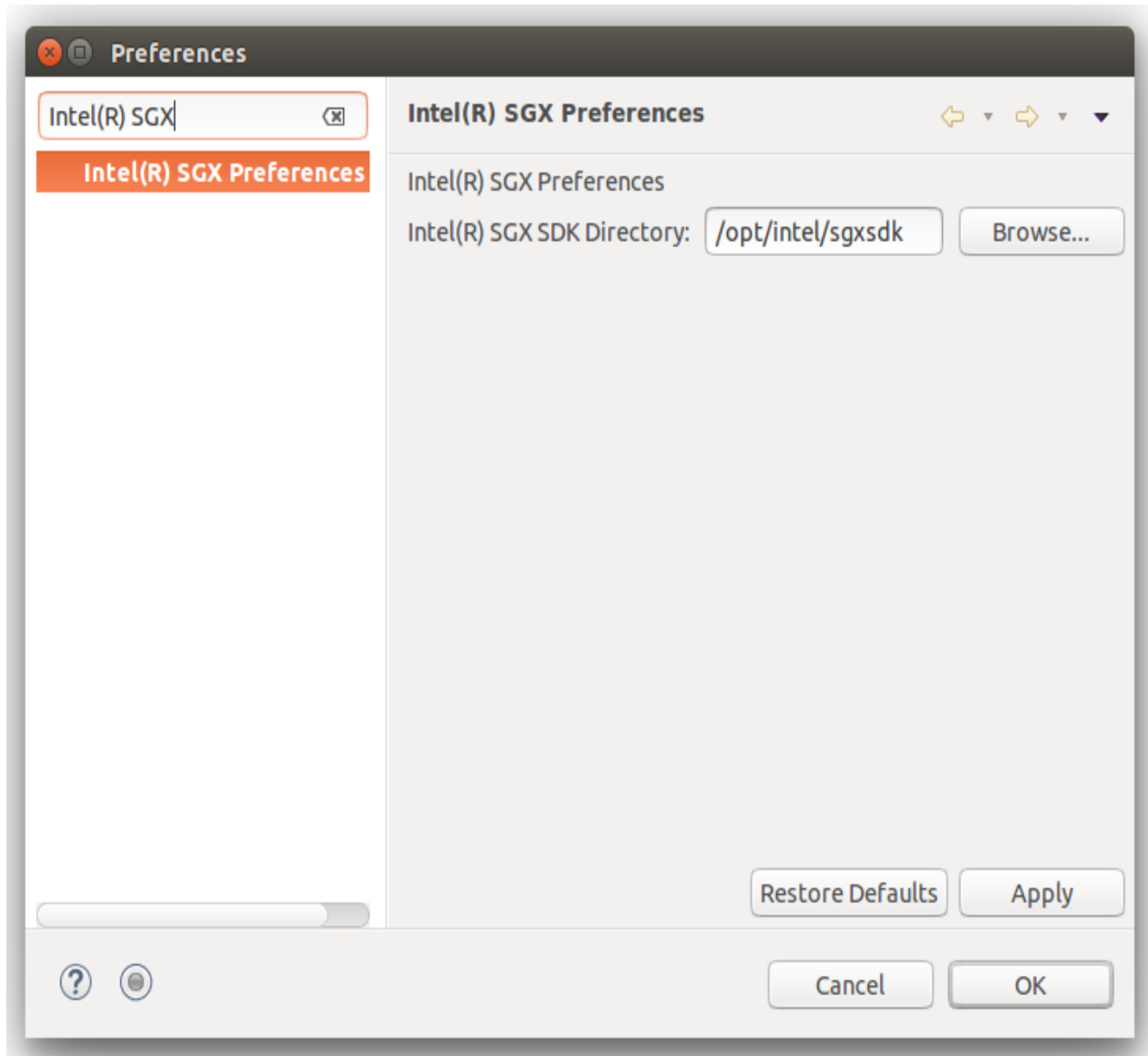
4. Press **OK** to add the archive as a repository.

5. In the **Install** dialog, select the **Intel(R) Software Guard Extensions Plugin** check-box and proceed with the usual steps.

### Configuration

If you do not install Intel(R) SGX SDK for Linux\* OS in the default location, you need to specify the path for Intel(R) SGX SDK using the following steps:

1. Go to **Window menu -> Preferences**. Enter Intel(R) SGX in the filter text field to quickly locate the **Intel(R) SGX Preferences** page.



### **Intel(R) SGX Preference Page**

2. Enter the path for Intel(R) SGX SDK for Linux OS in the **Intel(R) SGX SDK Directory** field.