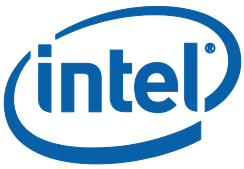

Intel® Software Guard Extensions (Intel® SGX) SDK for Linux* OS

Installation Guide

Legal Information

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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

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

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.

Download the following installation packages:

- Intel® SGX driver: `sgx_linux_x64_driver.bin`
- Intel® SGX SDK: `sgx_linux_<os>_x64_sdk_<version>.bin`

NOTE

Only 64-bit installation packages are available.

NOTE

If Secure Boot is enabled, the Intel® SGX driver needs to be signed. Please consult the distribution documentation on how to sign drivers for Secure Boot.

Hardware Requirements

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

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.

Prerequisites

Ensure that you have one of the following operating systems:

- Ubuntu* 16.04 LTS 64-bit Desktop version
- Ubuntu* 16.04 LTS 64-bit Server version
- Ubuntu* 18.04 LTS 64-bit Desktop version
- Ubuntu* 18.04 LTS 64-bit Server version
- Red Hat* Enterprise Linux Server release 7.4 64bits
- Red Hat* Enterprise Linux Server release 8.0 64bits
- CentOS* 7.5 64bits
- Fedora* 27 Server 64bits
- SUSE* Linux Enterprise Server 12 64bits.

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

- On Ubuntu* 16.04 and Ubuntu* 18.04

  ```
  $ sudo apt-get install libssl-dev libcurl4-openssl-dev libprotobuf-dev
  ```

- On Red Hat* Enterprise Linux 7.4, Red Hat Enterprise Linux 8.0, CentOS* 7.5 and Fedora 27:

  ```
  $ sudo yum install openssl-devel libcurl-devel protobuf-devel yum-utils
  ```

- On SUSE Linux Enterprise Server 12:

  ```
  $ sudo yum install openssl-devel libcurl-devel protobuf-devel yum-utils
  ```

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

- On Ubuntu* 18.04:

  ```
  $ sudo apt-get install build-essential python
  ```

- On Red Hat* Enterprise Linux 8.0:

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

NOTE

Intel® SGX SDK 2.9 release 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:

- Ubuntu 16.04 LTS Server 64bits
- Red Hat Enterprise Linux Server release 7.4 64bits
- CentOS 7.5 64bits
- Fedora 27 Server 64bits
- SUSE Linux Enterprise Server 12 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 without ECDSA attestation, use 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.

- 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).

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* 16.04:

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

- 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
```

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.

Upgrade from a legacy installation:

Before the Intel® SGX 2.8 release, Intel® SGX PSW is installed as a single package named `libsgx-enclave-common`. Starting with the Intel® SGX 2.8 release, Intel® SGX PSW is split into multiple packages (`libsgx-enclave-common` is one of them). As a result, a simple upgrade will end up with a subset of the Intel® SGX PSW being installed on the system. To enable the required feature, you need to install additional packages. At the same time, you will encounter several error messages when you try to upgrade to the Intel® SGX 2.8 release from an old installation. To address the issue, choose any of the methods below:

- Uninstall the old installation and install new packages.
- Add `-o Dpkg::Options::="--force-overwrite"` option to overwrite existing files and use "`dist-upgrade`" instead of "`upgrade`" to install new packages when upgrading. To perform these actions, use the following command:

  ```
  $ sudo apt-get dist-upgrade -o Dpkg::Options::="--force-overwrite"
  ```

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 16.04 and Ubuntu 18.04:

  `--no-install-recommends`

  NOTE
  On .rpm-based system, rpmbuild>=4.12 is required to enable similar features.

Install the Intel® SGX PSW RPM packages 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 7.4, Red Hat Enterprise Linux 8.0, CentOS 7.5, Fedora 27:

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

- On SUSE Linux Enterprise Server 12:

  ```
  $ sudo zypper addrepo PATH_TO_LOCAL_REPO LOCAL_REPO_
  ALIAS
  ```

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

3. Install the RPM packages:

- On Red Hat Enterprise Linux* 7.4, Red Hat Enterprise Linux* 8.0, CentOS 7.5, Fedora 27:
  - 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
    ```

- On SUSE Linux Enterprise Server 12:
  - Install launch service:

    ```
    $ sudo zypper --no-gpg-checks install libsgx-
    launch 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
    ```

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

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

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.

Intel® SGX SDK Installation

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.

> ***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.

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.

On Ubuntu* 18.4 and Red Hat* Enterprise Linux 8.0, download the mitigation tools which is named as.ld.objdump.gold.r1.tar.gz from here and unzip them 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*
     ```

     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 Linux* 7.4, Red Hat Enterprise Linux 8.0, CentOS* 7.5, Fedora* 27:

       ```
       $ sudo yum remove *sgx*
       ```
     - On SUSE Linux Enterprise Server 12:

       ```
       $ sudo zypper 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 cab use it to uninstall the Intel® SGX SDK.

ECDSA attestation

To enable ECDSA attestion:

- 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).
  Follow the Intel® SGX DCAP Installation Guide for Linux* OS to install the Intel® SGX DCAP driver.

  NOTE
  If you had already installed Intel® SGX driver without ECDSA attestation, please uninstall the driver firstly.

  Or the newly installed ECDSA attestation enabled Intel® SGX driver will unworkable.

- Install Provisioning Certificate Caching Service(PCCS). About how to install and configure PCCS, please refer SGXDataCenterAttestationPrimitives.

- 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(R) Software Guard Extensions Eclipse* Plug-in

The Intel(R) 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(R) 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

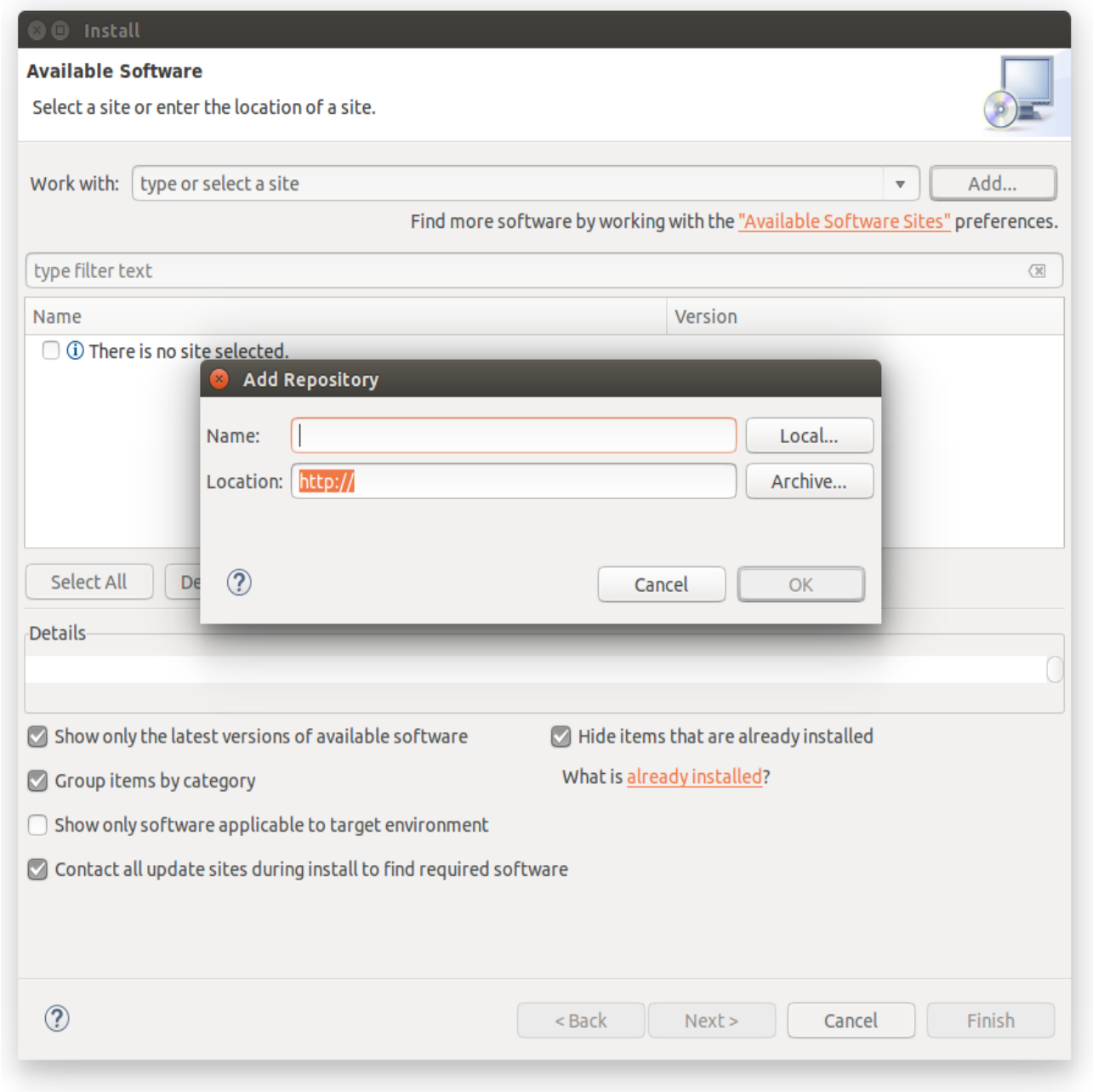
To use Intel(R) Software Guard Extensions Eclipse Plug-in, install the following softwares:

- Eclipse* Mars 1 with CDT IDE for C/C++ Developpers (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

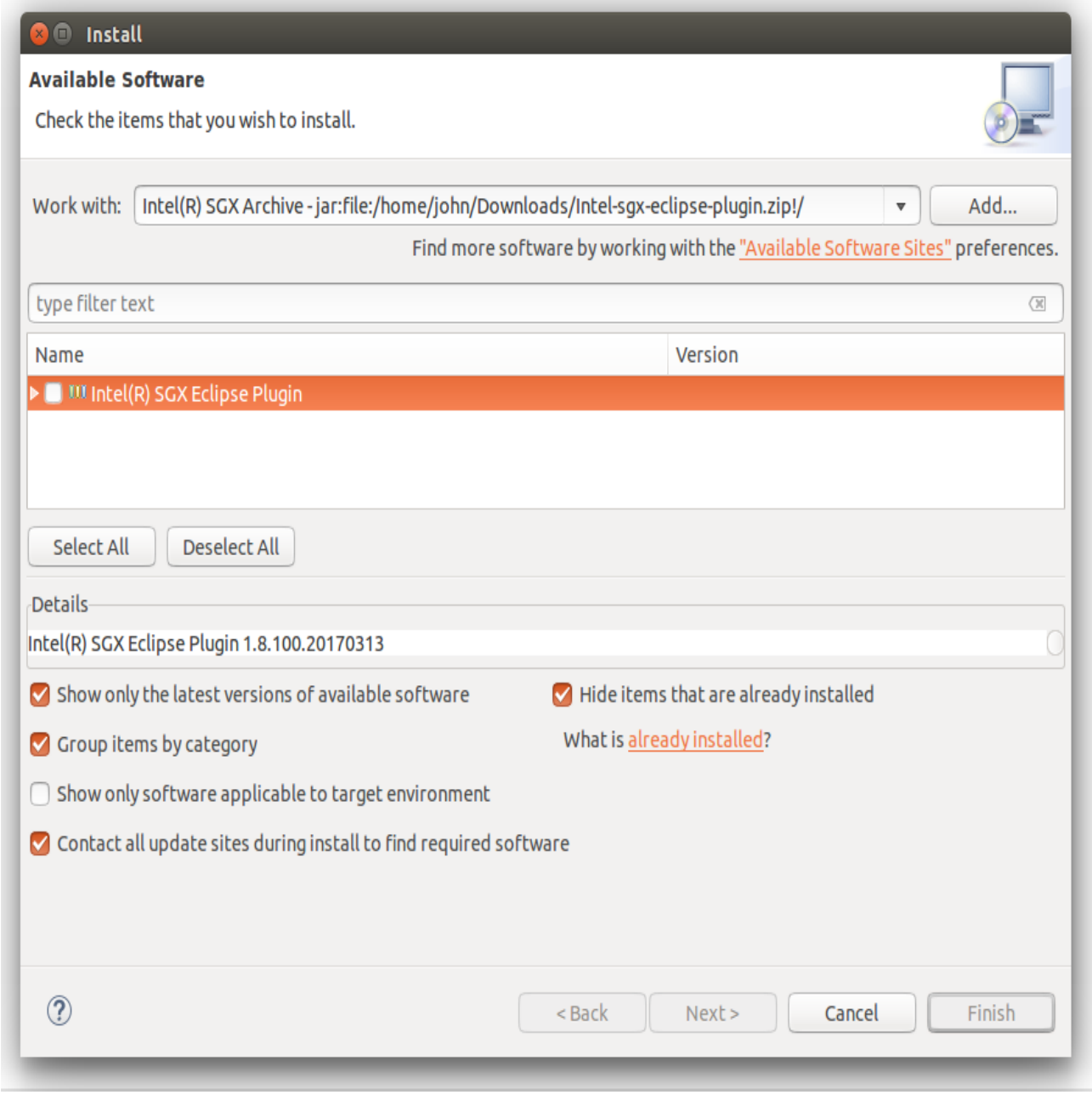
Install the Intel® Software Guard Extensions Eclipse* Plug-in as a regular Eclipse Plugin:

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:



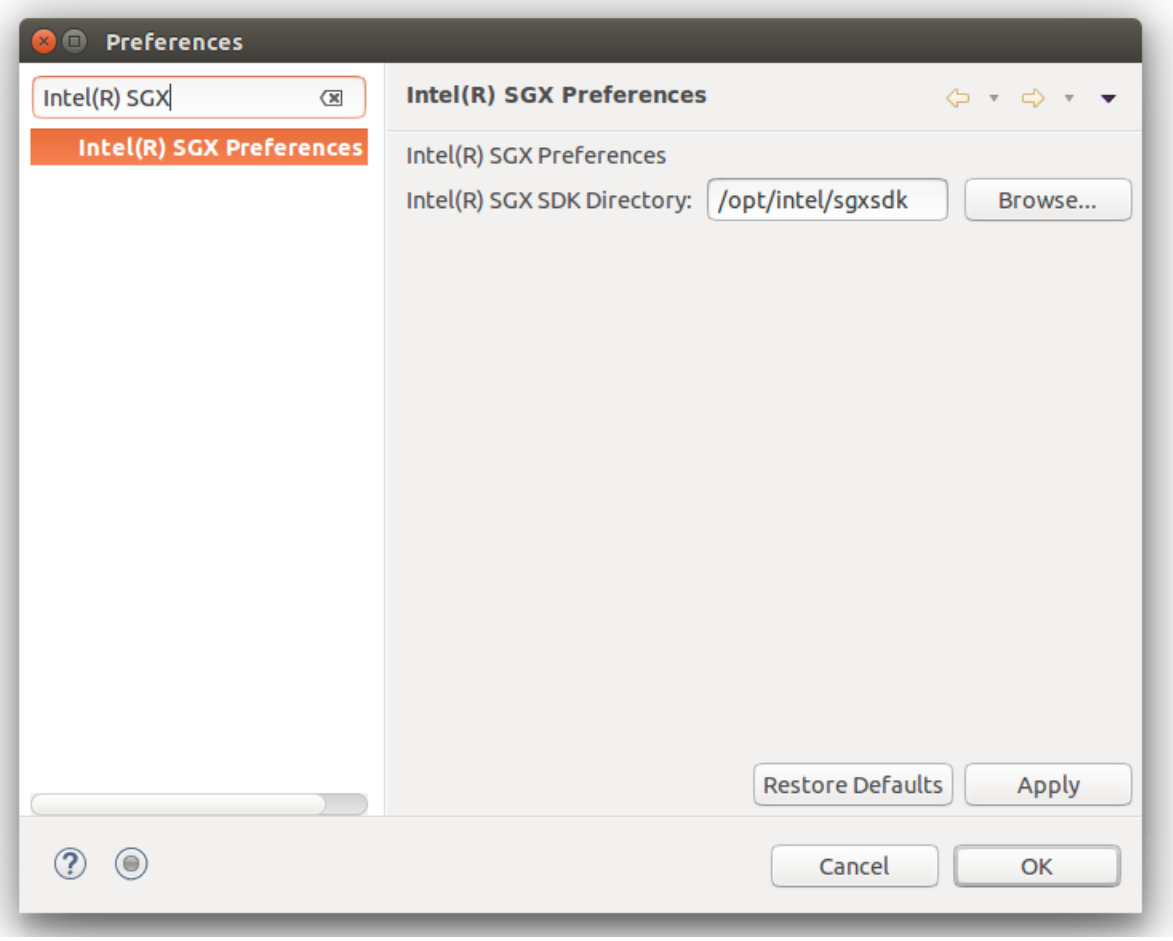
The Location of the Plugin zip Archive

4. Press **OK** to add the archive as a repository.
5. In the **Install** dialog, select the **Intel(R) Software Guard Extensions Plug-in** 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.