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Linux

Developing software using the IBM Software Development Kit for Linux on Power

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Note

Before using this information and the product it supports, read the information in "Notices" on page 99.

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Contents

Developing software using the IBM Software Development Kit for Linux on Power

The IBM® Software Development Kit for Linux on Power® is a free, Eclipse-based Integrated Development Environment (IDE). The SDK integrates C/C++ source development with the IBM Advance Toolchain for Linux on Power and classic Linux debugging and performance analysis tools.

The official version of this user guide is located in the Linux Knowledge Center: Developing software using the IBM Software Development Kit for Linux on Power (http://www.ibm.com/support/knowledgecenter/linuxonibm/liaal/iplsdkmain.htm).

Note: By using the code examples, you agree to the terms of the 10, "Code license and disclaimer information," on page 97.

1 Introducing IBM Software Development Kit for Linux on Power

The IBM SDK for Linux on Power provides you with an all-in-one solution for developing software on Linux on Power servers. It integrates the Eclipse integrated development environment (IDE) with the IBM Advance Toolchain for Linux on Power and open source tools such as OProfile, Valgrind, and Autotools. In addition, it integrates the Feedback Directed Program Restructuring (FDPR®) and Pthread monitoring tool, which are specifically designed to analyze and exploit Power Systems™ servers and includes powerful porting and analytic tools, such as Migration Advisor, Source Code Advisor and CPI Breakdown. The SDK also includes IBM SDK Java™ Technology Edition, Version 8.0-2.10 and IBM Runtime Environment Java Technology Edition, Version 8.0-2.10

The IBM Software Development Kit for Linux on Power is available for x86_64/amd64, ppc64 and ppc64le architectures, providing you with two different development modes:

- Locally on x86_64/amd64, ppc64 and ppc64le
- Remotely using the x86_64/amd64 version to connect to a remote Power System server

Using the x86_64/amd64 version of the SDK, you can:

- Create, debug and profile remote projects using the IBM Advance Toolchain
- Migrate applications using Migration Advisor
- Cross-compile applications using IBM Advance Toolchain cross-compiler
- Take advantage of Qemu or IBM Power 8 Functional Simulator for development if you don't have a real Power machine

With the ppc64 and ppc64le versions, you can:

- Create applications using the IBM Advance Toolchain
- Run, debug, and profile applications
- Migrate applications using Migration Advisor

The SDK includes manuals in the form of help plug-ins for many tools that are included with or integrated with IBM SDK for Linux on Power. To display these manuals, while in the user interface, click Help > Help Contents

Note: The IBM Software Development Kit for Linux on Power is provided as is only. Customers are not entitled to IBM Software Support. However, you can get help from the Linux on Power Community. For information, see 9.1, “Getting customer support,” on page 93.

Related information:

IBM Software Development Kit for Linux on Power website

IBM Advance Toolchain for Linux on Power documentation

1.1 IBM SDK for Linux on Power requirements

The IBM Software Development Kit for Linux on Power has software prerequisites. Most of the prerequisites can be automatically installed by the package manager of the Linux distribution.

Packages required by IBM SDK for Linux on Power

The IBM SDK for Linux on Power includes some required dependent packages to be installed on the Power Systems server while manually installing it. These packages include:

fdprpro-*version*
FDPR post-link optimization tool.

pthread-mon-*version*
Pthread monitoring tool.

fdpr_wrap-*version*
Wrapper scripts for running FDPR under IBM SDK for Linux on Power.

These required packages are included in the IBM SDK for Linux on Power ISO image. If you configure the SDK's apt repository or the IBM Linux on Power Tools Repository, all the required packages are installed automatically.

Note: The IBM Advance Toolchain is not available in the SDK's apt repository.

Other required packages from the distribution

Depending on the packages you installed with your Linux distribution, you might be required to install additional packages from your distribution provider. If you install the SDK automatically using **yum**, **dnf**, **zypper**, or **apt-get**, these packages might be installed automatically. If you are installing using **rpm** or **dpkg**, you must be aware of these dependencies and install them manually from the distribution.

These packages include:

Table 1. Other packages required from the distribution.

Package name	Package description	Required for ppc64 and ppc64le	Required for x86_64/amd64
Autoconf	Produces shell scripts to automatically configure software source code packages.	Yes	Yes
Automake	Automatically generates `Makefile.in` files that are compliant with the GNU coding standards.	Yes	Yes
gettext	Internationalization and localization system for writing multilingual programs.	Yes	Yes
Git	Distributed revision control system. Required on server for synchronized projects.	Yes	No
GLIBC 2.3 or later	GNU C library.	Yes	Yes
GTK2	Used to create graphical user interfaces.	Yes	Yes

Table 1. Other packages required from the distribution (continued).

Package name	**Package description**	**Required for ppc64 and ppc64le**	**Required for x86_64/amd64**
Libtool	GNU Libtool, script for generic shared library support.	Yes	Yes
Perf	Performance monitoring tool for Linux Kernel. Perf is required if you plan to use Perf with IBM SDK for Linux on Power. In addition, Perf is required for using the CPI Breakdown plug-in.	Yes, for using Perf or CPI breakdown plug-in	No
Python	Support for Python programming language.	Yes	Yes

Additional IBM tools installed with IBM SDK for Linux on Power

Table 2. Description of additional tools installed with IBM SDK for Linux on Power

Package name	**Package Description**	**Required for ppc64 and ppc64le**	**Required for x86_64/amd64**
advance-toolchain-at*version*-runtime	Self contained toolchain that provides preview toolchain functionality in GCC, binutils, GLIBC, GDB, Valgrind, and OProfile	Yes	No
advance-toolchain-at*version*-devel	Packages necessary to build applications that use the features provided by the IBM Advance Toolchain for Linux on Power	Yes	No
advance-toolchain-at*version*-perf	Performance library installation targets for Valgrind and OProfile	Yes	No
advance-toolchain-at*version*-mcore-libs	Libraries to build multi-threaded applications using the specialized multi-threaded libraries Animo-CBB, URCU, and Intel TBB	Yes	No

Table 2. Description of additional tools installed with IBM SDK for Linux on Power (continued)

Package name	**Package Description**	**Required for ppc64 and ppc64le**	**Required for x86_64/amd64**
advance-toolchain-at*version*-cross-common advance-toolchain-at*version*-cross-*arch* advance-toolchain-at*version*-cross-*arch*-mcore-libs advance-toolchain-at*version*-cross-*arch*-runtime-extras Where atversion is the version of the Advance Toolchain and arch is the architecture, which can be either ppc64 or ppc64le.	IBM Advance Toolchain for Linux on Power cross-compiler to generate Power-compatible binaries from i686 development environments.	No	Yes
fdprpro-*version*	IBM Feedback Directed Program Restructuring (FDPR), for post-link optimization	Yes	No
fpdr_wrap-*version*	Wrapper scripts for integrating FDPR with IBM SDK for Linux on Power	Yes	No
pthread-mon-*version*	Pthread monitoring tool	Yes	No

Recommended packages

The IBM SDK for Linux on Power includes two plugins that have additional dependencies. These packages may only be installed if you plan to use their respective plugins. Most of the dependencies are available in the repository of the Linux distribution, unless specified below:

Table 3. Description of recommended packages for IBM SDK for Linux on Power

Package name	**Package Description**	**Required for ppc64 and ppc64le**	**Required for x86_64/amd64**
rpmlint	Checks for common errors in RPM packages. rpmlint is required if you plan to use the IBM SDK for Linux on Power RPM plug-in.	Yes[1]	No
rpmdevtools	RPM development tools for creating packages. rpmdevtools is required if you plan to use the IBM SDK for Linux on Power RPM plug-in.	Yes[1]	No
rpm-devel	RPM C library and header files. rpm-devel is required if you plan to use the IBM SDK for Linux on Power RPM plug-in.	Yes	No

Table 3. Description of recommended packages for IBM SDK for Linux on Power (continued)

Package name	Package Description	Required for ppc64 and ppc64le	Required for x86_64/amd64
SystemTap	A tool and scripting language for dynamically monitoring running Linux applications. SystemTap is required if you plan to use SystemTap with IBM SDK for Linux on Power, or Trace Analyzer operating system monitoring with SystemTap.	Yes[2]	No

- [1] Manual installation is required. All of the rpm packages are available only in the Fedora or Red Hat Enterprise Linux repositories. For SUSE Linux Enterprise Server, only rpmlint and rpm-devel are available. These packages are not applicable to Ubuntu, which uses the DEB packaging format.
- [2] SystemTap requires the Linux kernel-devel and kernel-debuginfo packages.

Required authorities for IBM SDK for Linux on Power tasks

Many of the tasks for installing the SDK, such as installing packages, require you to be logged in to the system as root, with super user (administrator) authorities.

1.2 IBM SDK for Linux on Power supported Linux distributions

This information lists the Linux distributions that are supported by the SDK.

The SDK was tested to verify that it works with the Linux distributions listed in the table that follows. The usual compatibility with subsequent releases is assumed. The supported distributions vary according to the different development modes or packages.

Table 4. IBM SDK for Linux on Power supported Linux distributions

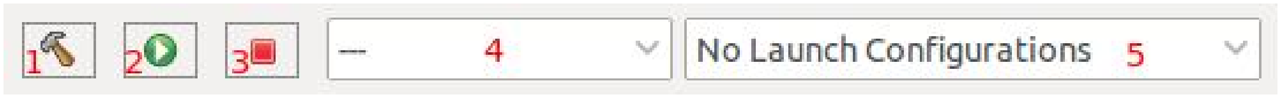
IBM SDK for Linux on Power version	Supported Linux distributions
ppc64	• Red Hat Enterprise Linux 7.2 • Fedora 22
ppc64le	• Red Hat Enterprise Linux 7.2 • SUSE Linux Enterprise Server 12 • Ubuntu 14.04 LTS • Fedora 22
x86_64/amd64	• Red Hat Enterprise Linux 7.2 • SUSE Linux Enterprise Server 12 • Fedora 22 • Ubuntu 14.04 LTS

Note: The IBM Software Development Kit for Linux on Power is provided as is only. Customers are not entitled to IBM Software Support. However, you can get help from the Linux on Power Community. For information, see 9.1, “Getting customer support,” on page 93.

1.3 IBM SDK for Linux on Power user interface

The SDK includes a launch bar that provides quick access to the plugin launches. It works for common tasks like running, debugging, and profiling an application.

This launch bar is composed for three buttons and three selectors.



1. Build the application before launching
2. Run or profile an application after it was built.
3. Stop the active action.
4. Allow selecting the launch mode: Run, Debug or Profile.
5. List all created launches.

The Launch Bar does not replace the default and known steps to complete these tasks; it aims to ease the task of launching configurations.

2 Downloading and installing the IBM SDK for Linux on Power

You can download and install the packages for the SDK on Power Systems server.

2.1 Downloading and installing the SDK

These topics describe how to download and install the ppc64 and ppc64le versions of the SDK.

You can automatically download and install these using the IBM Linux on Power Tools Repository or Personal Package Archives (PPA) of the SDK, or you can manually download and install the IBM SDK for Linux on Power ISO image.

For any download method you choose, you must accept the license agreements and terms and conditions.

2.1.1 Automatically downloading and installing IBM Software Development Kit for Linux on Power

The simplest method for downloading and installing the packages for the SDK on Power Systems server is to download the `install-sdk.sh` script.

You can download the script at Support and Downloads after clicking **I agree**. This method installs the IBM Linux on Power Tools Repository, the IBM Advance Toolchain for Linux on Power, and the SDK.

2.1.2 Automatically downloading and installing using the IBM Linux on Power Tools Repository

You can download and install the packages for the SDK on Power Systems server by using the IBM Linux on Power Tools Repository. This method configures yum, dnf, and zypper, allowing for automatic download and installation. Using the repository speeds the installation because all the required packages are installed in the correct order.

2.1.2.1 Downloading and installing the IBM Linux on Power Tools Repository initialization package

The first step for automatic downloading and installation is to download and install the Linux on Power Software Repository initialization package.

About this task

To download and install the IBM Linux on Power Tools Repository initialization package, complete the following steps.

Procedure

1. Download the Linux on Power Software Repository initialization package to the server in either of the following ways:
   - Download the Linux on Power Software Repository initialization package from the IBM Software Development Kit for Linux on Power website at http://www-304.ibm.com/webapp/set2/sas/f/lopdiags/sdkdownload.html#1.
   - Download the configuration RPM file from the IBM Tools Repository for Linux on Power website at http://www14.software.ibm.com/webapp/set2/sas/f/lopdiags/yum.html.
2. Install the Linux on Power Software Repository initialization package on the server as follows:
   a. Log in as root user.

b. Enter the following command:

   For RHEL: `yum install ibm-power-repo-version.noarch.rpm`

   For Fedora: `dnf install ibm-power-repo-version.noarch.rpm`

   For SLES: `zypper install ibm-power-repo-version.noarch.rpm`

   Note: Replace *version* with the version of the IBM Linux on Power Tools Repository initialization package that you downloaded.

2.1.2.2 Installing the IBM SDK for Linux on Power RPMs using the IBM Linux on Power Tools Repository

After the IBM Linux on Power Tools Repository is installed, you can download the IBM SDK for Linux on Power RPMs to the server.

About this task

Install the SDK packages with the appropriate command for your distribution:

Procedure

- For Red Hat Enterprise Linux:

  ```
  yum install ibm-sdk-lop
  ```

- For SUSE Linux Enterprise Server:

  ```
  zypper install ibm-sdk-lop
  ```

- For Fedora:

  ```
  dnf install ibm-sdk-lop
  ```

Note: The IBM Linux on Power Tools Repository is not available for Ubuntu.

Results

The `ibm-sdk-lop` package is installed, along with other dependent packages, such as the IBM Advance Toolchain. Depending on the packages you installed with your Linux distribution, additional dependent packages from the distribution repository might also be installed. See “Other required packages from the distribution” on page 2 for a list of possible packages.

What to do next

After completing the installation of the SDK, consider installing recommended and optional packages on the Power Systems server. See 2.2, “Recommended and optional packages,” on page 9.

2.1.3 Automatically downloading and installing the IBM SDK for Linux on Power using the apt repository

You can download and install the packages for the SDK on Power Systems server by using the apt repository available for the SDK..

About this task

Install the SDK packages on Ubuntu.

Procedure

1. Download and import the GPG public key using the following commands:

   ```
   $ wget ftp://public.dhe.ibm.com/
   software/server/iplsdk/v1.9.0/packages/deb/repo/dists/trusty/B346CA20.gpg.key
   ```

   ```
   $ sudo apt-key add B346CA20.gpg.key
   ```

2. Add the following line to `/etc/apt/sources.list` file:

   On amd64:

   ```
   deb [arch=amd64] ftp://public.dhe.ibm.com/
   software/server/iplsdk/v1.9.0/packages/deb/repo trusty sdk
   ```

   On ppc64el:

   ```
   deb ftp://public.dhe.ibm.com/
   software/server/iplsdk/v1.9.0/packages/deb/repo trusty sdk
   ```

3. Run update: `$ sudo apt-get update`
4. Install the IBM SDK for Linux on Power: `$ sudo apt-get install ibm-sdk-lop`

Results

The IBM SDK for Linux on Power is installed on your system.

Note: After installing the SDK, be sure to log off to ensure that the group rights are applied correctly.

What to do next

After you complete the installation of the SDK, consider installing recommended and optional packages on the Power Systems server. See 2.2, “Recommended and optional packages.”

2.2 Recommended and optional packages

Depending on your intended use of the SDK, you might want to install recommended and optional packages.

2.2.1 Downloading and installing RPM development packages

The SDK includes a plugin that enables you to easily edit RPM specification files.

About this task

The following packages are needed only if you plan to use the RPM plugin.

Table 5. Packages required for the RPM plugin

Package name	Package Description	Required
rpmlint	Checks for common errors in RPM packages. rpmlint is required if you plan to use the IBM SDK for Linux on Power RPM plug-in.	Yes[1]
rpmdevtools	RPM development tools for creating packages. rpmdevtools is required if you plan to use the IBM SDK for Linux on Power RPM plug-in.	Yes[1]
rpm-devel	RPM C library and header files. rpm-devel is required if you plan to use the IBM SDK for Linux on Power RPM plug-in.	Yes

[1] All of the rpm packages are available only in the Fedora or Red Hat Enterprise Linux repositories. For SUSE Linux Enterprise Server, only rpmlint and rpm-devel are available. These packages are not applicable to Ubuntu, which uses the DEB packaging format.

To install rpmlint, rpmdevtools, and rpm-devel on Fedora or Red Hat Enterprise Linux, execute the following command as root:

```
* yum install rpmlint rpm-devel rpmdevtools
```

To install rpmlint and rpm-devel on SUSE Linux Enterprise Server, execute the following command as root:

```
* zypper install rpmlint rpm-devel
```

2.2.2 Downloading and installing SystemTap

The SDK includes a plugin for SystemTap.

About this task

If you want to use SystemTap, install the following package.

Table 6. Package required for SystemTap

Package name	**Package Description**	**Required**
SystemTap	A tool and scripting language for dynamically monitoring running Linux applications. SystemTap is required if you plan to use SystemTap	Yes[1]

[1] Requires the Linux kernel -devel and kernel-debuginfo packages.

Procedure

To install SystemTap and its dependencies, execute the command for your Linux distribution as root:

- For Fedora:
  ```
  dnf install systemtap kernel-devel kernel-debug
  ```
- For Red Hat Enterprise Linux:
  ```
  yum install systemtap-runtime kernel-devel
  kernel-debuginfo kernel-debuginfo-common
  ```
- For Ubuntu:
  ```
  apt-get install systemtap
  ```

Ensure that the set of the packages kernel-devel, kernel-debuginfo, and kernel-debug-info-common versions (if applicable) match the version of the kernel that is running.

What to do next

You are now ready to set up SystemTap. See 2.2.2.1, “Setting up SystemTap.”

2.2.2.1 Setting up SystemTap

If you have installed the recommended and optional SystemTap packages on the server, you must complete post-installation setup before you can use SystemTap to profile applications. Specifically, you must set up preferences for running remotely and ensure that users have the required permissions.

Before you begin

Ensure that you have installed the recommended SystemTap package, as described in 2.2, “Recommended and optional packages,” on page 9.

2.2.2.1.1 Setting up preferences for running SystemTap remotely:

About this task

Before you can use SystemTap to profile applications, you must set up preferences for running remotely. Because SystemTap runs as a client/server application, you must set these preferences, even for local profiling. Complete the following steps in the SDK user interface.

Procedure

1. Click **Window** > **Preferences**.
2. Expand **SystemTap** > **Remote Server**.
3. On the Remote Server page, complete the following steps.
   a. Type the host name, user name, and password in the appropriate fields.
   b. Ensure that the port number is correct. If you are using a default SystemTap configuration, the port number probably is already correct.
   c. Click **Apply**.
4. Expand **SystemTap** > **SystemTap IDE**.
5. On the SystemTap IDE page, select the **Use remote connection to load SystemTap probes and functions** check box. This selection ensures that all probes and functions displayed are available on the remote server. Click **Apply**.
6. Optional: You can select a remote kernel source to explore while developing SystemTap scripts.
   a. Expand **SystemTap** > **SystemTap IDE** > **Kernel Source Path**.
   b. On the Kernel Source Path page, in the **Kernel Source Location** area, select **Remote Machine**.
   c. In the **Kernel source directory** field, type the path of the kernel source in the remote server.
   d. Click **Apply**.
7. Click **OK**.

2.2.2.1.2 Setting up SystemTap permissions for SUSE Linux Enterprise Server:
About this task

Complete the following steps if you are running SUSE Linux Enterprise Server. These steps are necessary to ensure that users have the required permissions to run SystemTap when logged on from their user names.

Procedure

1. Ensure that you are logged in to the server as root user.
2. Create the user groups stapdev and stapusr with the following commands:
   ```
   groupadd stapdev
   groupadd stapusr
   ```
3. To allow users to run SystemTap, add them to the stapdev and stapuser user groups. Use the following command:
   ```
   usermod -A stapdev,stapusr user_name
   ```
   Insert the user name for *user_name*. Repeat this step for each user that will be running SystemTap on the server.
4. Ensure that the `/usr/bin/staprun` file permission is set to superuser (administrator) and that the stapusr group has permission to run **`staprun`**. Use the following command:
   ```
   chown root:stapusr /usr/bin/staprun
   chmod  04110 /usr/bin/staprun
   ```
5. Reboot the server to apply the changes.
6. To ensure that the changes took effect, complete the following test.
   a. Log in to the server as *user_name*, where *user_name* is one of the users that you added to the stapdev and stapusr user groups.

b. Run the following script to ensure that this user has access:

```
stap -ve 'probe begin { log("hello world") exit () }'
```

The resulting messages will indicate whether the script was successful or failed.

2.2.2.1.3 Setting up SystemTap permissions for Red Hat Enterprise Linux and Fedora:
About this task

Complete the following steps if you are running Red Hat Enterprise Linux or Fedora. These steps are necessary to ensure that users have the required permissions to run SystemTap when logged on from their user names.

Procedure

1. Ensure that you are logged in to the server as root user.
2. To allow users to run SystemTap, add them to the stapdev and stapuser user groups. Use the following command:

   ```
   usermod -aG stapdev,stapusr user_name
   ```

   Insert the user name for *user_name*. Repeat this step for each user that will be running SystemTap on the server.
3. Ensure that the `/usr/bin/staprun` file permission is set to superuser (administrator) and that the stapusr group has permission to run **`staprun`**. Use the following command:

   ```
   chown root:stapusr /usr/bin/staprun
   chmod  04110 /usr/bin/staprun
   ```
4. Reboot the server to apply the changes.
5. To ensure that the changes took effect, complete the following test.
   a. Log in to the server as *user_name*, where *user_name* is one of the users that you added to the stapdev and stapusr user groups.
   b. Run the following script to ensure that this user has access:

   ```
   stap -ve 'probe begin { log("hello world") exit () }'
   ```

   The resulting messages will indicate whether the script was successful or failed.

What to do next

For information about using SystemTap with the IBM Software Development Kit for Linux on Power, see 6.6, “Monitoring performance using SystemTap,” on page 75.

2.2.2.1.4 Setting up SystemTap permissions for Ubuntu:
About this task

If you are running Ubuntu, follow the setup instructions at the Ubuntu SystemTap wiki page (https://wiki.ubuntu.com/Kernel/Systemtap). These steps are necessary to ensure that users have the required permissions to run SystemTap when logged on with their user names.

2.3 Starting the IBM SDK for Linux on Power

You can start the SDK on the Power Systems server, and access it from your workstation.

About this task

To start the SDK, complete the following steps.

Procedure

1. On your workstation, begin either X11 forwarding or Virtual Network Computing (VNC) to connect to the remote Power Systems server.

   X11 forwarding provides the most seamless integration between the workstation and the server. However, if your connection is not fast, you might experience network latency. In that case, VNC might be a better option.

   VNC works with either Linux or Microsoft Windows clients. In addition, when using VNC, you can disconnect from the session while the IBM SDK for Linux on Power continues to run on the server.

   - To use X11 forwarding, ensure that you have a running X Window System server as well as a terminal emulator for the X Window System, such as GNOME Terminal, on your workstation, and the xauth utility and X server font package installed on the server. To connect to the server, open a terminal session and enter the **`ssh`** command with the `-X` option.
   - To use VNC, ensure that you have a VNC server package installed on the Power Systems server, as well as a terminal emulator for the X Window System, such as GNOME Terminal. You also need a VNC client on your workstation. To start VNC, complete the following steps:
     a. Log in to the server console and start a new VNC server by entering the **`vncserver`** command.
     b. When prompted, choose and type a password. You will use this password later to connect to the session.

        When the command completes, it displays an address you will use to connect.
     c. On the workstation, use the VNC client to connect. Specify the address that was displayed and the password that you chose.
2. Once connected to the Power Systems server, choose one of the following options to start IBM SDK for Linux on Power.
   - Open a console and enter the following command:
     ```
     ibm-sdk-lop
     ```
   - If your VNC client provides you access to the System menus, select **Applications** > **Programming** > **IBM SDK for Linux on Power**.

     Note: Depending on the desktop environment you are using, the hierarchy of the System menus might differ.

Results

Note: The first time it is started, the IBM SDK for Linux on Power might take several minutes to launch. The operating system might consider the application unresponsive due to the intensive input/output operations necessary to create the initial workspace. If you are prompted to wait or to end the application, select **Wait**. The user interface loads within a few seconds. If prompted, select the location on the Power Systems server that you will use to store the project files.

2.4 Creating a project

With SDK, you can create projects or import existing ones. You can leverage this integration with the IBM Advance Toolchain to set specific flags for Power Systems.

For more information about remote projects, see 3.3, “Creating and using synchronized projects on x86_64/amd64 clients,” on page 22

2.4.1 Creating a local C/C++ project

You can create a C/C++ project that uses IBM Advance Toolchain for Linux on Power.

About this task

Complete the following steps in the SDK user interface.

Procedure

1. Click **File** > **New** > **Other**.
2. In the New window, expand **IBM Advance Toolchain C/C++**. Select either **IBM Advance Toolchain C Project** or **IBM Advance Toolchain C++ Project**, as appropriate. Click **Next**.
3. In the Project window, type a name for the project in the **Project name** field.

   Tip: At the bottom of the window, verify that the **Show projects type and toolchains only if they are supported on the platform** check box is selected.
4. Optional: The project will be created in a directory structure in the file system. The default file system location is displayed in the **Location** field. If you do not want to save the project in the default location, clear the **Use default location** check box, and specify or browse for a new location.
5. In the Project type pane, expand one of the following, as appropriate:
   - **Executable**
   - **Shared Library**
   - **Static Library**

   Then, select **IBM Advance Toolchain C Project** or **IBM Advance Toolchain C++ Project**, as appropriate. If you do not see IBM Advance Toolchain for Linux on Power in the Toolchains list, ensure that you have installed a supported version of Advance Toolchain. For more information, see IBM Advance Toolchain for Linux on Power prerequisite and recommended packages.
6. In the Toolchains pane, click the **Advance Toolchain** *version* option corresponding to your IBM Advance Toolchain for Linux on Power version. Click **Next**.
7. In the Compiler tuning window, select the appropriate options for tuning your application or library.
   a. **Environment**: Select from **- use default -**, **64-bit**, or **32-bit**.
   b. **Generate POWER-series code that is compatible with**: Select from **- use default -** or the listed **POWER*n*** technology options.
   c. **Tune the instruction scheduling for**: Select from **- use default -** or the listed **POWER*n*** technology options. Click **Next**.
8. Optionally in the Templates window, you can select a project template for a specific version. In the **Library** list, select from the following options:
   - **Do not use any library template**. This is the default option.
   - **SPHDE (Shared Persistent Heap Data Environment)**. SPHDE is composed of two major software layers: The Shared Address Space (SAS) layer provides the basic services for a shared address space and transparent, persistent storage. The Shared Persistent Heap (SPH) layer organizes blocks of SAS storage into useful functions for storing and retrieving data.
   - **AUXV (Auxiliary Vector)**. The AUX vector contains information about the system's platform and hardware capabilities.
9. Optional: To allow optimizations for Power Systems servers when you are building the application or library, complete these steps:
   a. In the Select configurations window, click **Advanced settings**.
   b. In the next window, expand **C/C++ Build** and click **Settings**.
   c. On the **Tool Settings** tab, click **POWER-specific optimizations**. Then, select the appropriate optimization options for your workload and application or library characteristics, and target processor. You can change the default build settings to tune for POWER® processor capabilities and the IBM SDK for Linux on Power analysis tools. See 4.1, “Setting flags,” on page 35 for information about the recommended build settings, and instructions for setting them. When finished, click **OK**.

10. Click **Finish**.

Results

The new project is shown in the Project Explorer pane and will be built using theIBM Advance Toolchain for Linux on Power, with any Power-specific optimizations that you have chosen.

2.4.2 Importing an existing Makefile project

You can import an existing Makefile project into the IBM Software Development Kit for Linux on Power to be used with IBM Advance Toolchain for Linux on Power.

Before you begin

Ensure that the Makefile project already exists on or has been saved to the Power Systems server.

About this task

To import a Makefile project, complete the following steps in the SDK user interface.

Procedure

1. Before importing the project, you should disable the option to build projects automatically. This prevents the SDK from building a project that might not be ready after importing. Click **Project** and clear the **Build Automatically** check box if it is selected.
2. Import the project by clicking **File** > **Import**.
3. In the Import window, expand **C/C++**, then click **Existing Code as Makefile Project**. Click **Next**.
4. In the Import Existing Code window, do the following.
   a. Click **Browse** next to the **Existing Code Location** field. The project must exist on the Power Systems server.
   b. Optional: Type a name for the project in the **Project Name** field.
   c. Successively click the displayed directories to locate the directory that contains the project to be imported.
   d. When you locate the directory, click **OK**.
   e. Back in the Import Existing Code window, under Toolchain for Indexer Settings, click the **Advance Toolchain *version*** option corresponding to your IBM Advance Toolchain for Linux on Power version. *version* is the version number of IBM Advance Toolchain for Linux on Power.
   f. Click **Finish**.

   The project is imported as an Makefile project and is shown in the Project Explorer pane.
5. You must export the environment variables CC or GCC to ensure that the `make` command builds using the correct IBM Advance Toolchain for Linux on Power version. Choose one of the following methods.
   - Use the user interface options to change the settings of the environment variables.
     a. View the project by clicking the project name in the Project Explorer pane.
     b. Right-click the project name and click **Properties**.
     c. Expand **C/C++ Build** and click **Environment**.
     d. Click **Export** and type `CC="/opt/at`*`version`*`/bin/gcc"`.where *version* is the version number of IBM Advance Toolchain for Linux on Power.
     e. Click **OK** when finished.
   - Change the environment variables manually by editing the Makefile. You edit the Makefile by double-clicking on the project in the Project Explorer pane.

6. Optional: You can change the default build settings to tune for POWER processor capabilities and the IBM SDK for Linux on Power analysis tools. See 4.1, “Setting flags,” on page 35 for information about the recommended build settings, and instructions for setting them.

   To change build settings such as CFLAGS, CPPFLAGS, and LDFLAGS, choose one of the following methods.

   - Use the user interface options to change the settings of the environment variables.
     a. View the project by clicking the project name in the Project Explorer pane.
     b. Right-click the project name and click **Properties**.
     c. Expand **C/C++ Build** and click **Environment**.
     d. Click **Add** to add environment variables, or click **Select** to select and change the value of an existing environment variable. For example, a typical set of parameters for POWER8® targets is
        ```
        CC=/opt/at9.0/bin/gcc CFLAGS='-m64 -g -O3 -mcpu=power8' CXXFLAGS='-m64
        -g -O3 -mcpu=power8' LDFLAGS='-m64 -Wl,-q'.
        ```
     e. Click **OK** when finished.
   - Change the build settings manually by editing the Makefile. You edit the Makefile by double-clicking on the project in the Project Explorer pane.

2.4.3 Importing an existing Autotools project

You can import an existing project that uses Autotools into the IBM Software Development Kit for Linux on Power to be used with IBM Advance Toolchain for Linux on Power.

Before you begin

Ensure that the Autotools project already exists on or has been saved to the Power Systems server.

About this task

To import an Autotools project, complete the following steps in the SDK user interface.

Procedure

1. Before importing the project, you should disable the option to build projects automatically. This prevents the SDK from building a project that might not be ready after importing. Click **Project** and clear the **Build Automatically** check box if it is selected.
2. Import the project by clicking **File** > **Import**.
3. In the Import window, expand **C/C++**, then click **Existing Code as Autotools Project**. Click **Next**.
4. In the Import Existing Code window, do the following.
   a. Click **Browse** next to the **Existing Code Location** field. The project must exist on the Power Systems server.
   b. Optional: Type a name for the project in the **Project Name** field.
   c. Successively click the displayed directories to locate the directory that contains the project to be imported.
   d. When you locate the directory, click **OK**.
   e. Click **Finish**.

   The project is imported as an Autotools project and is shown in the Project Explorer pane.

2.4.3.1 Configuring the imported project

About this task

After the project is imported, the SDK automatically indexes the source code for the project. The source files then appear with the project in the Project Explorer pane.

Procedure

1. To view the project, click the project name in the Project Explorer pane. You can explore it and make configuration updates.
   - Use the Project Explorer pane to expand and explore the project.
   - Double-click a project file to open it in the editor. The outline pane shows macro references and program control statements.
   - Open the autoconf configuration file (`configure.ac`) or the makefile configuration file (`makefile.am`). This allows the SDK to index the file and provide proper syntax highlighting.
   - You can set autoconf configuration script options in the project properties.
     - Click **Project** > **Properties**.
     - In the Properties window, expand **Autotools** and click **Configure Settings**.
     - Under Configure, click **Advanced**.
     - You can specify additional options in the **Additional command-line options** field. To use IBM Advance Toolchain for Linux on Power with Autotools projects, type `CC="/opt/at`*`version`*`/bin/gcc"`, where *version* is the version number of IBM Advance Toolchain for Linux on Power. For example: `/opt/at9.0/bin/gcc`. On this field, you can also set other flags for your project. For example, a typical set of parameters for POWER8 targets is

       ```
       CC=/opt/at9.0/bin/gcc CFLAGS='-m64 -g -O3 -mcpu=power8' CXXFLAGS='-m64
       -g -O3 -mcpu=power8' LDFLAGS='-m64 -Wl,-q'.
       ```
     - Click **OK**.
2. After you have made the configuration updates, reconfigure the project.
3. Right-click the project name, and select **Reconfigure Project**.
4. While the project is being configured, you can click the **Console** tab to monitor progress.

2.4.3.2 Building the imported project

About this task

After the project reconfiguration is complete, you can build the project.

Procedure

1. Return to the project view by clicking the project name in the Project Explorer pane.
2. Click **Project** > **Build Project** to build the project.
3. While the project is building, you can click the **Console** tab to monitor progress.

Related information:

An Introduction to the Autotools

2.4.4 Creating an empty Autotools project

You can use the SDK to create an empty Autotools project.

About this task

Complete the following steps in the SDK user interface.

Procedure

1. Click **File** > **New** > **Other**.
2. In the New window, expand **IBM Advance Toolchain C/C++**. Select either **IBM Advance Toolchain C Project** or **IBM Advance Toolchain C++ Project**, as appropriate. Click **Next**.
3. In the Project type pane, expand **GNU Autotools** and select **Empty Project**.
4. In the Project window, type a name for the project in the **Project name** field.

5. The project will be created in a directory structure in the file system. The default file system location is displayed in the **Location** field. If you do not want to save the project in the default location, clear the **Use default location** check box, and specify or browse for a new location.
6. Click **Finish**.

Results

The new project is shown in the Project Explorer pane.

2.4.5 Creating a "Hello World" Autotools project

You can use the SDK to create a "Hello World" Autotools project.

About this task

Complete the following steps in the IBM SDK for Linux on Power user interface.

Procedure

1. Click **File** > **New** > **Other**.
2. In the New window, expand **IBM Advance Toolchain C/C++**. Select either **IBM Advance Toolchain C Project** or **IBM Advance Toolchain C++ Project**, as appropriate. Click **Next**.
3. In the Project type pane, expand **GNU Autotools** and select **Hello World ANSI C Autotools Project**.
4. In the Project window, type a name for the project in the **Project name** field.
5. The project will be created in a directory structure in the file system. The default file system location is displayed in the **Location** field. If you do not want to save the project in the default location, clear the **Use default location** check box, and specify or browse for a new location.
6. Click **Finish**.

Results

The new project is shown in the Project Explorer pane.

2.4.6 Changing the IBM Advance Toolchain version

After you have created a C/C++ Development Toolkit managed C/C++ project that uses the IBM Advance Toolchain for Linux on Power, you can switch between installed IBM Advance Toolchain for Linux on Power versions as needed.

About this task

Complete the following steps in the SDK user interface.

Procedure

1. View the project by clicking the project name in the Project Explorer pane.
2. Right-click the project name and click **Properties**.
3. Expand **C/C++ Build** and click **Tool Chain Editor**.
4. In the Tool Chain Editor window, in the **Current toolchain** field, click the arrows to select the IBM Advance Toolchain for Linux on Power version you want to use.
5. Optional: You can verify the version of IBM Advance Toolchain for Linux on Power being used by doing the following:
   a. Right-click the project name and click **Properties**.
   b. Expand **C/C++ Build** and click **Settings**.

6. Switch the Linux tools path according to the IBM Advance Toolchain for Linux on Power version, to ensure that the analysis and profiling tools use the correct IBM Advance Toolchain for Linux on Power binary files. Complete the following steps:
   a. Right-click the project name and click **Properties**.
   b. Click **Linux Tools Path**.
   c. Ensure that **Prepend string to PATH** is selected.
   d. Select the appropriate IBM Advance Toolchain for Linux on Power version.

2.4.7 Running an executable program in a project

This topic provides instructions for running executable programs in local projects.

About this task

To run an executable program, complete the following steps in the SDK user interface.

Procedure

1. In the Project Explorer pane, right-click the project name. Click **Run as** > **Run configurations**.
2. In the open space under C/C++ Application, double-click to create a new configuration.
3. In the New Run Configuration window, beside the **C/C++ Application** field, click **Search Project** to select the executable program that you want to run.
4. On the Arguments tab, specify any arguments.
5. Click **Run**.

2.4.8 Debugging a project with IBM Advance Toolchain for Linux on Power

This topic provides instructions for debugging a local project using the debugger provided by IBM Advance Toolchain for Linux on Power.

About this task

The C/C++ Development User Guide (http://help.eclipse.org/mars/topic/org.eclipse.cdt.doc.user/concepts/cdt_o_home.htm) in the Eclipse platform help information contains additional general and advanced information about debugging projects.

To begin debugging a project that was built with IBM Advance Toolchain for Linux on Power, complete the following steps in the SDK user interface.

Procedure

1. View the project by clicking the project name in the Project Explorer pane.
2. Click **Debug as** > **Debug Configurations**.
3. In the Debug Configurations window, click **C/C++ Application** in the left pane, and then click the new launch configuration icon near the upper left of the window.
4. On the Main tab, beside the **C/C++ Application** field, click **Search Project** to select the binary file that you want to debug.
5. If necessary, click the arrows in the **Build configuration** field and select **Debug**.
6. On the Arguments tab, specify any arguments.
7. Optional: The GDB debugger path was set when the project was created. However, you can check the path as follows. On the Debugger tab, on the Main tab within the Debugger Options area, in the **GDB debugger** field, verify the path for the location of the debugger to be used, `/opt/at`*`version`*`/bin/gdb`, where *version* is the version number of IBM Advance Toolchain for Linux on Power.. For example: `/opt/at9.0/bin/gdb`.

8. Click **Apply**, then click **Debug** to begin debugging.
9. You might be prompted to open the Debug perspective. If so, click **Yes** to open the Debug perspective.
10. In the Debug perspective, you can use the displayed icons to step through the execution, inspect variables, and set breakpoints.

2.5 Installing the IBM Advance Toolchain for Linux on Power

About this task

The IBM Advance Toolchain for Linux on Power packages are stored in an ftp repository of the University of Campinas, a public university in the state of São Paulo, Brazil. For information about installing IBM Advance Toolchain for Linux on Power, see the IBM developerWorks® page (http://ibm.co/AdvanceToolchain).

Procedure

Install the IBM Advance Toolchain for Linux on Power on the Power Systems server. This table lists the required and recommended prerequisite packages for IBM Advance Toolchain for Linux on Power.

Table 7. IBM Advance Toolchain for Linux on Power required and recommended prerequisites

IBM Advance Toolchain for Linux on Power required prerequisites	**IBM Advance Toolchain for Linux on Power recommended prerequisites**
• advance-toolchain-at8.0-runtime-8.0-6 or greater • advance-toolchain-at8.0-devel-8.0-6 or greater • advance-toolchain-at8.0-perf-8.0-6 or greater • advance-toolchain-at8.0-mcore-libs-8.0-6 or greater	• advance-toolchain-at9.0-runtime-9.0-2 or greater • advance-toolchain-at9.0-devel-9.0-2 or greater • advance-toolchain-at9.0-perf-9.0-2 or greater • advance-toolchain-at9.0-mcore-libs-9.0-2 or greater

3 Setting up the x86_64/amd64 version of the IBM SDK for Linux on Power

You can start the IBM SDK for Linux on Power x86_64/amd64 client on a workstation and then connect to a remote Power System to build, execute, debug, and analyze programs. You can also develop and build your application locally using the IBM Advance Toolchain for Linux on Power cross-compiler.

For remote development, you must install the required dependencies on the remote Power System. The IBM SDK for Linux on Power server ensures that all required dependencies are installed on the remote Power Systems.

3.1 Downloading and installing the x86_64/amd64 client

This topic gives instructions for downloading the and installing the x86_64 version of the SDK.

About this task

Install the x86_64/amd64 version of the SDK.

Procedure

1. Install the IBM Advance Toolchain cross-compiler on the x86_64/amd64 system, if needed

Table 8. IBM Advance Toolchain for Linux on Power required and recommended prerequisites

IBM Advance Toolchain for Linux on Power required prerequisites	**IBM Advance Toolchain for Linux on Power recommended prerequisites**
• advance-toolchain-at8.0-cross-common-8.0-6 • advance-toolchain-at8.0-cross-*arch*-8.0-6 Where *arch* can be either ppc64 or ppc64le.	• advance-toolchain-at9.0-cross-common-9.0-0 • advance-toolchain-at9.0-cross-*arch*-9.0-0 • advance-toolchain-at9.0-cross-*arch*-mcore-libs-8.0-0 • advance-toolchain-at9.0-cross-*arch*-runtime-extras-9.0-0 Where *arch* can be either ppc64 or ppc64le.

   For more details about installing the IBM Advance Toolchain for Linux on Power, see 2.5, “Installing the IBM Advance Toolchain for Linux on Power,” on page 20.

2. For automatic installation, refer to 2.1, “Downloading and installing the SDK,” on page 7 or go to the IBM Software Development Kit for Linux on Power website at http://www-304.ibm.com/webapp/set2/sas/f/lopdiags/sdkdownload.html#2..
3. Select from the following choices to download the x86_64/amd64 version of the SDK.
   - For Red Hat Enterprise Linux, SUSE Linux Enterprise Server, and Fedora, in the Download individual packages for IBM SDK section of the page, download `ibm-sdk-lop-`*`version`*`.x86_64.rpm`.
   - For Ubuntu, in the Download the ISO image or the DEB image section of the page, download the DEB image for the x86_64/amd64 client, `ibm-sdk-lop_`*`version`*`_amd64.deb`.

   version is the version number of the package.
4. Install the IBM SDK for Linux on Power and its dependencies on the x86_64/amd64 host:
   - For Red Hat Enterprise Linux:
     ```
     # yum install ibm-sdk-lop-version.x86_64.rpm
     ```
   - For SUSE Linux Enterprise Server:
     ```
     # zypper install ibm-sdk-lop-version.x86_64.rpm
     ```
   - For Ubuntu:

```
sudo dpkg -i ibm-sdk-lop_version_amd64.deb
```

- For Fedora:

```
# dnf install ibm-sdk-lop-version.x86_64.rpm
```

If the installer warns you about missing dependencies, run the following command to automatically download and install them:

```
sudo apt-get -f install
```

What to do next

Note: After installing the SDK, be sure to log off to ensure that the group rights are applied correctly.

3.2 Setting up remote Power Systems server

The Remote Setup Wizard that is available on the x86_64/amd64 of the SDK allows users to install the SDK packages and their dependencies on Power Systems.

About this task

Complete the following steps to install the SDK with the Remote Setup Wizard:

Procedure

1. Click **Help** in the toolbar and select **Setup Remote Machine**.
2. If no systems are listed in table, complete the following steps:
   a. Click **New Machine**.
   b. In the **Remote Services** field, select **SSH** and click **Add**.
   c. In the New Connection window, complete the fields: New Connection Name, Host, User, and Password. Then, select **Finish**.
   d. In the Preferences window, click **OK**.
3. Select one of the systems that are listed in the table and click **Setup Machine**.
4. In the new window, select the SDK packages and the IBM Advance Toolchain version to be installed, and click **Install**.

   Note: To proceed with installation, you need to agree with the license terms.
5. All the necessary packages will be downloaded. When the download process is completed, a confirmation message is displayed, informing which packages will be installed. Select **Yes** to install those packages.
6. During the installation process, you are prompted to enter your password. Type your user password and select **OK**.

   Note: You need administrative privileges to install the packages.
7. When the installation is completed, a message is displayed, informing you that all the packages were successfully installed. Select **OK** to complete the process.

3.3 Creating and using synchronized projects on x86_64/amd64 clients

If you have installed the x86_64/amd64 version of the SDK on you workstation and the dependencies package on a Power Systems server, you can create synchronized projects on the remote server from the client.

See 3.2, “Setting up remote Power Systems server” for instructions if you have not already installed the packages.

3.3.1 Creating a synchronized C/C++ project

Synchronized projects are mirrored on the local system and the remote system. You can edit locally, and your changes are synchronized with the remote system. This topic details how to create a synchronized project that uses IBM Advance Toolchain for Linux on Power.

Before you begin

If you plan to use synchronized projects, you must first install the git package on the remote server. See "Packages required by IBM SDK for Linux on Power " on page 2.

About this task

Complete the following steps in the IBM SDK for Linux on Power user interface.

Procedure

1. Click **File** > **New** > **Other**.
2. In the New window, expand **Remote IBM Advance Toolchain** and click to select **Synchronized IBM Advance Toolchain C/C++ Project**. Click **Next**.
3. In the New IBM Advance Toolchain Synchronized Project window, type a name for the project in the **Project name** field.
4. In the **Connection Name** field, click the arrows to select a connection to the remote server, or click **New** to create a connection.

   Tip: If you are creating a connection, use your ssh credentials instead of public key. See 9.3, "Setting up SSH credentials," on page 95.
5. For the location, click **Browse** to select the remote location where the project source is stored.
6. In the Project type pane, expand and select a project type for one of the following categories:
   - Remote Advance Toolchain Executable
   - Remote Advance Toolchain Shared Library
   - Remote Advance Toolchain Static Library

   In the project type, select **Empty Project**.
7. In the Toolchain pane, select an available Remote Advance Toolchain. Do not select "Local Toolchain".
8. Click **Next** or **Finish**.

Results

The new project is shown in the Project Explorer pane and will be built using theIBM Advance Toolchain for Linux on Power, with any Power-specific optimizations that you have chosen. The project folder is created on the remote Power Systems server, and a local cached copy is maintained. IBM SDK for Linux on Power operations such as building, running, and profiling can be performed remotely.

3.3.2 Creating a synchronized project by importing an existing Makefile project

You can import an existing Makefile project into the SDK as a synchronized project to be used with IBM Advance Toolchain for Linux on Power.

Before you begin

If you plan to use synchronized projects, ensure that the Makefile project already exists on or has been saved to the Power Systems server.

About this task

Complete the following steps in the IBM SDK for Linux on Power user interface.

Procedure

1. Click **File** > **New** > **Other**.
2. In the New window, expand **Remote IBM Advance Toolchain** and click to select **IBM Advance Toolchain Synchronized C/C++ Project**. Click **Next**.
3. In the New IBM Advance Toolchain Synchronized Project window, type a name for the project in the **Project name** field.
4. In the **Connection Name** field, click the arrows to select a connection to the remote server, or click **New** to create a connection.

   Tip: If you are creating a connection, use your ssh credentials instead of public key. See 9.3, "Setting up SSH credentials," on page 95.
5. For the location, click **Browse** to select the remote location where the project source is stored.
6. In the Project type pane, expand **Makefile Project** and select **Empty Project** .
7. In the Remote Toolchain pane, select the desired **Remote Linux Advance Toolchain**. Do not select "Local Toolchain".
8. Click **Finish**.

3.3.3 Creating a synchronized project by importing an existing Autotools project

You can import an existing project that uses Autotools into the SDK to be used remotely with IBM Advance Toolchain for Linux on Power.

Before you begin

Ensure that the Autotools project already exists on or has been saved to the Power Systems server.

About this task

Complete the following steps in the IBM SDK for Linux on Power user interface.

Procedure

1. Before importing the project, you should disable the option to build projects automatically. This prevents the SDK from building a project that might not be ready after importing. Click **Project** and clear the **Build Automatically** check box if it is selected.
2. Click **File** > **New** > **Other**.
3. In the New window, expand **Remote IBM Advance Toolchain** and click to select **Synchronized IBM Advance Toolchain C/C++ Project**. Click **Next**.
4. In the New IBM Advance Toolchain Synchronized Project window, type a name for the project in the **Project name** field.
5. In the **Connection Name** field, click the arrows to select a connection to the remote server, or click **New** to create a connection.

   Tip: If you are creating a connection, use your ssh credentials instead of public key. See 9.3, "Setting up SSH credentials," on page 95.
6. For the location, click **Browse** to select the remote location where the project source is stored.
7. In the Project type pane, expand **GNU Autotools**, and select **Empty project**.
8. In the Remote Toolchain pane, select **GNU Autotools Toolchain**.

9. Click **Finish**.

Results

The project is imported as an Autotools project and is shown in the Project Explorer pane.

What to do next

Configuring the imported project.

3.3.3.1 Configuring the imported project

About this task

After the project is imported, the SDK automatically indexes the source code for the project. The source files then appear with the project in the Project Explorer pane.

Procedure

1. To view the project, click the project name in the Project Explorer pane. You can explore it and make configuration updates.
   - Use the Project Explorer pane to expand and explore the project.
   - Double-click a project file to open it in the editor. The outline pane shows macro references and program control statements.
   - Open the autoconf configuration file (`configure.ac`) or the makefile configuration file (`makefile.am`). This allows the SDK to index the file and provide proper syntax highlighting.
   - You can set autoconf configuration script options in the project properties.
     - Click **Project** > **Properties**.
     - In the Properties window, expand **Autotools** and click **Configure Settings**.
     - Under Configure, click **Advanced**.
     - You can specify additional options in the **Additional command-line options** field. To use IBM Advance Toolchain for Linux on Power with Autotools projects, type `CC="/opt/at`*`version`*`/bin/gcc"`, where *version* is the version number of IBM Advance Toolchain for Linux on Power. For example: `/opt/at9.0/bin/gcc`. On this field, you can also set other flags for your project. For example, a typical set of parameters for POWER8 targets is

       ```
       CC=/opt/at9.0/bin/gcc CFLAGS='-m64 -g -O3 -mcpu=power8' CXXFLAGS='-m64
       -g -O3 -mcpu=power8' LDFLAGS='-m64 -Wl,-q'.
       ```
     - Click **OK**.
2. After you have made the configuration updates, reconfigure the project.
3. Right-click the project name, and select **Reconfigure Project**.
4. While the project is being configured, you can click the **Console** tab to monitor progress.

3.3.3.2 Building the imported project

About this task

After the project reconfiguration is complete, you can build the project.

Procedure

1. Return to the project view by clicking the project name in the Project Explorer pane.
2. Click **Project** > **Build Project** to build the project.
3. While the project is building, you can click the **Console** tab to monitor progress.

Related information:

An Introduction to the Autotools

3.3.4 Creating a synchronized empty Autotools project

You can use theIBM SDK for Linux on Power to create an empty synchronized Autotools project.

About this task

Complete the following steps in the IBM SDK for Linux on Power user interface.

Procedure

1. Click **File** > **New** > **Other**.
2. In the New window, expand **Remote IBM Advance Toolchain** and click to select **Synchronized IBM Advance Toolchain C/C++ Project**. Click **Next**.
3. In the **Connection Name** field, click the arrows to select a connection to the remote server, or click **New** to create a connection.

   Tip: If you are creating a connection, use your ssh credentials instead of public key. See 9.3, "Setting up SSH credentials," on page 95.
4. Click **Browse** to find the location where the project is to be stored on the remote server.
5. In the Project type pane, expand **GNU Autotools** and select **Empty Project**.
6. In the Project window, type a name for the project in the **Project name** field.
7. Click **Finish**.

Results

The new project is shown in the Project Explorer pane.

Note: Running Autotools in a remote project will fail if there are environment variables with no value assigned in the local system (for example, `VARIABLE=`).

3.3.5 Creating a synchronized "Hello World" Autotools project

You can use IBM SDK for Linux on Power to create a "Hello World" synchronized Autotools project.

About this task

Complete the following steps in the IBM SDK for Linux on Power user interface.

Procedure

1. Click **File** > **New** > **Other**.
2. In the New window, expand **Remote IBM Advance Toolchain** and click to select **Synchronized IBM Advance Toolchain C/C++ Project**. Click **Next**.
3. In the **Connection Name** field, click the arrows to select a connection to the remote server, or click **New** to create a connection.

   Tip: If you are creating a connection, use your ssh credentials instead of public key. See 9.3, "Setting up SSH credentials," on page 95.
4. In the Project type pane, expand **GNU Autotools** and select **Hello World ANSI C Autotools Project**.
5. In the Project window, type a name for the project in the **Project name** field.
6. Click **Finish**.

Results

The new project is shown in the Project Explorer pane.

Note: Running Autotools in a remote project will fail if there are environment variables with no value assigned in the local system (for example, `VARIABLE=`).

3.3.6 Running an executable program in a synchronized project

This topic provides instructions for running an executable program on a remote server.

About this task

To run a remote executable program, complete the following steps in the IBM SDK for Linux on Power user interface.

Procedure

1. In the Project Explorer pane, right-click the remote project name. Click **Run as** > **Run configurations**. Double-click **Parallel Application**.
2. On the Resources tab, complete the following steps.
   a. In the **Target System Configuration** field, click the arrows to select **IBM SDK Remote Connection**.
   b. In the **Remote service provider** field, select **Remote tools**.
   c. In the **Please select a connection** box, click the arrows to select the connection to the remote server, or click **New** to create a connection.
3. On the Application tab, in the **Application program** field, click **Browse** to select the executable program that you want to run.
4. Click **Run**.

3.3.7 Debugging a synchronized project

This topic provides instructions for debugging a synchronized project using the IBM SDK for Linux on Power.

Before you begin

To debug a project on a remote Power Systems server, ensure that all required dependencies are installed by installing the `ibm-sdk-lop-remote-dependencies`.

About this task

To debug a synchronized project, complete the following steps.

Procedure

1. In the Project Explorer pane, right-click the synchronized project name. Click **Debug as** > **Debug configurations**. Double-click **Parallel Application**.
2. On the **Resources** tab, complete the following steps.
   a. In the **Target System Configuration** field, click the arrows to select **IBM SDK Remote Connection**.
   b. In the **Please select a connection** box, click the arrows to select the connection to the remote server, or click **New** to create a connection.
3. On the Application tab, in the **Application program** field, click **Browse** to select the binary file that you want to debug.
4. Click **Debug**. The Parallel Debug perspective opens automatically. You can then debug the application.
5. In the Parallel Debug perspective, you can use the displayed icons to step through the execution, inspect variables, and set breakpoints.

3.4 Creating and using cross-compiled projects

3.4.1 Creating a cross-compiled C/C++ project

You can create a C/C++ project that uses the IBM Advance Toolchain for Linux on Power cross-compiler.

About this task

Complete the following steps in the IBM SDK for Linux on Power user interface.

Procedure

1. Click **File** > **New** > **Other**.
2. In the New window, expand **IBM Advance Toolchain C/C++**. Select either **IBM Advance Toolchain C Project** or **IBM Advance Toolchain C++ Project**, as appropriate. Click **Next**.
3. In the Project window, type a name for the project in the **Project name** field.

   Tip: At the bottom of the window, verify that the **Show projects type and toolchains only if they are supported on the platform** check box is selected.
4. Optional: The project will be created in a directory structure in the file system. The default file system location is displayed in the **Location** field. If you do not want to save the project in the default location, clear the **Use default location** check box, and specify or browse for a new location.
5. In the Project type pane, expand one of the following, as appropriate:
   - **Executable**
   - **Shared Library**
   - **Static Library**

   Then select **IBM Advance Toolchain cross-compiler C Project** or **IBM Advance Toolchain cross-compiler C++ Project**, as appropriate.
6. In the Toolchains pane, select the option corresponding to your IBM Advance Toolchain for Linux on Power cross-compiler. Click **Next**.
7. In the Compiler tuning window, select the appropriate options for tuning your application or library.
   a. **Environment**: Select from **- use default -**, **64-bit**, or **32-bit**.
   b. **Generate POWER-series code that is compatible with**: Select from **- use default -** or the listed **POWER*n*** technology options.
   c. **Tune the instruction scheduling for**: Select from **- use default -** or the listed **POWER*n*** technology options. Click **Next**.
8. Optional: To allow optimizations for Power Systems servers when you are building the application or library, complete these steps:
   a. In the Select configurations window, click **Advanced settings**.
   b. In the next window, expand **C/C++ Build** and click **Settings**.
   c. On the **Tool Settings** tab, click **POWER-specific optimizations**. Then, select the appropriate optimization options for your workload and application or library characteristics, and target processor. You can change the default build settings to tune for POWER processor capabilities and the IBM SDK for Linux on Power analysis tools. See 4.1, “Setting flags,” on page 35 for information about the recommended build settings, and instructions for setting them. When finished, click **OK**.
9. Click **Finish**.
10. If prompted to open the C/C++ perspective, select **Yes**.

Results

The new project is shown in the Project Explorer pane and will be built using theIBM Advance Toolchain for Linux on Power, with any Power-specific optimizations that you have chosen.

3.4.2 Executing a cross-compiled project

This topic provides instructions for running an executable program remotely using the cross-compiler development mode.

About this task

To run a cross-compiled executable program, complete the following steps in the IBM SDK for Linux on Power user interface.

Procedure

1. Switch to the C/C++ perspective by clicking **Window** > **Open Perspective** > **C/C++**. Click **OK**. The cross-compiled project should be displayed under the Project Explorer view.
2. In the Project Explorer pane, right-click the cross-compiled project name. Click **Run as** > **Run configurations**. Double-click **Parallel Application**.
3. On the Resources tab, complete the following steps.
   a. In the **Target System Configuration** field, click the arrows to select **IBM SDK Remote Connection**.
   b. In the **Please select a connection** box, click the arrows to select the connection to the remote server, or click **New** to create a connection.
4. On the Application tab, complete the following steps.
   a. In the **Application program** field, type a name for the application to be created on the remote server.
   b. Select the **Copy executable from local filesystem** check box.
   c. In the **Path to local executable** field, click **Browse** to select the executable program that was generated when the project was built.
   d. Optional: If you want to see the output from the running application, ensure that the **Display output from all processes in a console view** check box is selected.
5. Click **Run**.

3.4.3 Debugging a cross-compiled project

This topic provides instructions for debugging a cross-compiled project using the SDK.

Before you begin

To debug a project on a remote Power Systems server, the `ibm-sdk-lop-server-`*`version`* package must be installed on the remote server.

About this task

To debug a cross-compiled project, complete the following steps.

Procedure

1. Switch to the C/C++ perspective by clicking **Window** > **Open Perspective** > **C/C++**. Click **OK**. The cross-compiled project should be displayed under the Project Explorer view.
2. In the Project Explorer pane, right-click the cross-compiled project name. Click **Debug as** > **Debug configurations**. Select the parallel application that was created previously when you ran the compiled program. The application has the same name as your project.

3. On the Resources tab, complete the following steps.
   a. In the **Target System Configuration** field, click the arrows to select **IBM SDK Remote Connection.**
   b. In the **Please select a connection** box, click the arrows to select the connection to the remote server, or click **New** to create a connection.
4. On the Application tab, in the **Application program** field, click **Browse** to select the binary file that you want to debug.
5. Click **Debug**. The Parallel Debug perspective opens automatically. You can then debug the application.
6. In the Parallel Debug perspective, you can use the displayed icons to step through the execution, inspect variables, and set breakpoints.

3.5 Installing and using QEMU user-mode emulation

The SDK provides integration with QEMU user-mode emulation. In this mode, QEMU can launch processes compiled for one CPU on another CPU, allowing easy cross-compilation and cross-debugging.

Before you begin

Before you begin using QEMU user-mode emulation, ensure that you have the following prerequisites installed on your system:
- The IBM Advance Toolchain for Linux on Power cross-compiler package, as detailed in 2.5, "Installing the IBM Advance Toolchain for Linux on Power," on page 20.
- IBM Software Development Kit for Linux on Power

About this task

At the CPU level, user-mode emulation is a subset of the full system emulation. No memory management unit (MMU) simulation is done because QEMU supposes the user memory mappings are handled by the host operating system. QEMU includes a generic Linux system call converter to handle endianness issues and 32/64 bit conversions. Because QEMU supports exceptions, it emulates the target signals exactly. Each target thread is run in one host thread.

Procedure

1. If you have installed the IBM Power Repository or the Personal Package Archives as listed in 2.1, "Downloading and installing the SDK," on page 7, you can install the package as following:
   - For RHEL: yum install qemu-user-space-emulator
   - For SLES: zypper install qemu-user-space-emulator
   - For Ubuntu: apt-get install qemu-user-space-emulator

   If you prefer, you can download and install the latest packages for your operating system from the Unicamp FTP site (ftp://ftp.unicamp.br/pub/linuxpatch/sdk/qemu/).
2. Install the packages using the command appropriate for your Linux distribution.
   - For Red Hat Enterprise Linux:
     ```
     # yum install -y qemu-user-space-emulator-<version>.x86_64.rpm
     ```
   - For SUSE Linux Enterprise Server:
     ```
     # zypper install -y qemu-user-space-emulator-<version>.x86_64.rpm
     ```
   - For Ubuntu:
     ```
     sudo dpkg -i qemu-user-space-emulator_<version>_amd64.deb
     ```
   - For Fedora:
     ```
     # dnf install -y qemu-user-space-emulator-<version>.x86_64.rpm
     ```

3.5.1 Running a cross-compiled application with QEMU user-mode emulation

Follow these steps to run a cross-compiled application with QEMU user-mode emulation.

Before you begin

Before using QEMU to run your application, you must create (or import) and build a cross-compiled project. See 3.4.1, “Creating a cross-compiled C/C++ project,” on page 28 for details.

About this task

In order to run your cross-compiled application using QEMU user-mode, follow these steps.

Procedure

1. Select the target project, then **Run** > **Run As** > **QEMU**. If this is the first time you are using QEMU, the launcher configuration opens.
2. From the Application options menu, select **Browse**. A new window appears.
3. Select the application binary. If the Advance Toolchain version cannot be detected, you are prompted to select the toolchain used to build the project. After you select the binary and identify the toolchain version, the remaining fields are automatically populated.
4. Optional: Set arguments for your application from **Applications** > **Parameters**.
5. Select from the QEMU options. Descriptions for each options display as you move your cursor over the option name.
6. By default, the **Libraries Paths** fields contains the paths for the Advance Toolchain libraries. If you need to use any other library available on your system, select **Browse** and enter the location of the library.
7. Press **Run**.

3.5.2 Debugging a cross-compiled application with QEMU user-mode emulation

Follow these steps to debug a cross-compiled application with QEMU user-mode emulation.

Procedure

1. After building your application, select **Run** > **Run As** > **Run Configurations** > **QEMU** to open the QEMU launcher. If this is the first time you are using the QEMU launcher, first follow the steps in 3.5.1, “Running a cross-compiled application with QEMU user-mode emulation.”
2. Right-click your application, and select **Run** > **Run As** > **Run Configurations**.
3. From the Run Configurations window, select the QEMU entry related to your project.
4. From the QEMU options menu, set the GNU Project Debugger (GDB) port (for example, 12345). Press **Apply** and then **Run**. QEMU has its own GDB server embedded. When you set the port and press **Run**, QEMU waits for a GDB client connection.
5. Follow these steps to connect to the QEMU GDB session:
   a. Select the target project from the project explorer view.
   b. Right click the project, then select **Debug As** > **Debug Configurations**.
   c. Create a new debug configuration by double-clicking **C/C++ Attach to Application**.
   d. From the Debugger tab, select **GDB server** from the Debugger menu.
   e. From the Debugger options, select the Connection tab, and set the port you selected previously in the **Port Number** field.
   f. Press **Debug**. The Debug perspective opens.

Note: Ensure that you select **Instruction Step Mode** from the main bar. When debugging using QEMU user-mode, you cannot navigate through source code. You may only access the instructions set.

3.6 Installing and executing the IBM POWER8 Functional Simulator

The IBM Software Development Kit for Linux on Power provides integration with the IBM POWER8 Functional Simulator, a POWER8 simulator that can be installed in any x86_64/amd64 system. The simulator instantiates a Power virtual machine to which the x86_64/amd64 version of SDK can connect. Once connected, you can compile and run ppc64le programs, all in the x86_64/amd64 machine.

3.6.1 Installing and setting up the POWER8 Functional Simulator

Follow these steps to install, set up, and run the POWER8 Functional Simulator on your x86_64/amd64 client.

About this task

During the installation process, you will install the simulator and a disk image to boot the virtual machine. You must install the simulator on the same physical system where the x86_64/amd64 version of the SDK is installed.

You will also install a disk image from which to boot the virtual machine. The SDK supports a Debian ppc64le image. The image contains the root filesystem of the standard version of Debian, including system libraries and basic system binaries.

3.6.2 Automatically installing the IBM POWER8 Functional Simulator

If your x86_64/amd64 machine has Internet access, you can install the POWER8 Functional Simulator automatically.

About this task

The installation process is fully automated through a script. This results in a ready-to-use simulator, and a Debian ppc64le system that can be booted into the Simulator.

Procedure

1. Log in to the x86_64/amd64 machine as a non-privileged user.

   Note: Ensure that you logged in as the user who will perform code development using the SDK. The installation process identifies the current user, and grants access to the virtual machine only for this user.
2. Run the setup script as shown here:
   ```
   /opt/ibm/ibm-sdk-lop/simulator/setup_simulator.sh -i
   ```
   The script downloads the Functional Simulator installation package, the disk image, and all necessary dependencies. The setup script will place the disk image and all necessary files in a temporary directory.
3. Wait for the installation to complete. After the installation finishes, it provides you instructions to complete the next step.
4. The instructions provided direct you to enter the following command:
   ```
   /opt/ibm/ibm-sdk-lop/simulator/setup_simulator.sh -f<path_to_disk_image>
   ```
   Where <*path_to_disk_image*> is the location where the setup script has saved the disk image to be used by the simulator.

5. To register the users that are allowed to run simulator, enter the following commands while logged in as a non-privileged user:

```
$ sudo groupadd systemsim_sdk
$ sudo usermod -a -G systemsim_sdk <user>
```

Where <*user*> is the user name in the Linux system.

3.6.3 Running the IBM POWER8 Functional Simulator

To run the IBM POWER8 Functional Simulator, follow these steps.

Before you begin

Before you start the IBM Power8 Functional Simulator, ensure it was properly configured with following actions:

1. The simulator setup script installs a service called `systemsim-sdk-network`. Check whether it exists and is running accordingly. On Ubuntu, for example, use the following command:

```
$ service systemsim-sdk-network status
```

2. Communication between host and the simulator is carried out through a network interface created with the name of `tap_systemsim`. Check that the interface exists and is up with the following command:

```
$ ifconfig tap_systemsim
```

3. To establish communication between the host and the simulator, rules were added to `iptables`. Use following command to check whether those rules are added:

```
$ sudo iptables --list
```

The output of the previous command should contain the following:

```
Chain FORWARD (policy ACCEPT)
target     prot opt source            destination
ACCEPT     all  --  anywhere          172.20.0.0/16
ACCEPT     all  --  172.20.0.0/16     anywhere
ACCEPT     all  --  anywhere          172.20.0.0/16
ACCEPT     all  --  172.20.0.0/16     anywhere
```

If the `iptables` rules does not exist, use following commands to create them:

```
$ sudo iptables -I FORWARD -s 172.20.0.0/16 -i tap_systemsim -j ACCEPT
$ sudo iptables -I FORWARD -d 172.20.0.0/16 -o tap_systemsim -j ACCEPT
```

Then, restart the `systemsim-sdk-network` service. On Ubuntu, for example, use the following command:

```
$ sudo service systemsim-sdk-network restart
```

To start the IBM Power8 Functional Simulator, follow these steps:

Procedure

1. Launch the IBM Software Development Kit for Linux on Power.
2. In the main menu, select **Power8 Simulator > Start Simulator**.

Results

The simulator will start booting. You can set the process to run in the background and continue to work normally with the SDK.

Note: If this is the first time you are starting and booting the disk image, it is necessary to perform the installation of all the required packages for development. This is an automatic task that consumes several minutes, be patient.

What to do next

Note: If you are getting connectivity issues, it is important to certify that your firewall is not blocking the simulator connection with the host. The simulator connects with the host machine through the `tap_systemsim` interface using TCP and UDP protocols. Thus, your firewall needs to unblock these following rules:

```
FORWARD -s 172.20.0.0/16 -i tap_systemsim -j ACCEPT
FORWARD -d 172.20.0.0/16 -o tap_systemsim -j ACCEPT
```

After unblocking the rules, restart the `systemsim-sdk-network` service by running this command:

```
sudo service systemsim-sdk-network restart
```

4 Managing projects

You can use the IBM Software Development Kit for Linux on Power to create C/C++ projects, or to import existing Makefile or Autotools projects. With the SDK, you can edit the application source code, as well as run and debug the executable program.

The C/C++ Development User Guide (http://help.eclipse.org/mars/topic/org.eclipse.cdt.doc.user/concepts/cdt_o_home.htm) in the Eclipse platform help information contains information about creating Eclipse projects, importing Makefile or Autotools projects, and editing, running, and debugging. Much of this information applies to IBM SDK for Linux on Power projects.

4.1 Setting flags

Some of the tools included with the SDK require that certain flags be set. This can be done when you create the project, or by editing the project before you run the tools.

4.1.1 Recommended debug, compiler, and linker settings for Power processor tuning

This topic provides recommendations for debug, compiler, and linker settings to use POWER processor capabilities and the IBM Software Development Kit for Linux on Power analysis tools. These recommendations should be considered along with the workload and characteristics of applications that are being built.

Compiler and linker flags are normally passed along all build stages to avoid failures. The flags are passed by setting environment variables such as CFLAGS, CXXFLAGS, CPPFLAGS, and LDFLAGS for Makefile or Autotools projects in the IBM SDK for Linux on Power. See the following websites for details about the environment variables.

- GCC, the GNU Compiler Collection website (http://gcc.gnu.org)
- GNU Operating System - Make website (http://www.gnu.org/software/make/)
- GNU Operating System - Autoconf website (http://www.gnu.org/software/autoconf/)

Recommendations for debug flags

Many analysis and debug tools in the SDK rely on debugging information that is produced when the `-g` flag is enabled. Therefore, it is highly recommended that you set that option by using the CFLAGS or CXXFLAGS environment variables.

- Source Code Analyzer and FDPR

  Source Code Analyzer and FDPR tools use information that is produced by the `-Wl,-q` option, which leaves relocation sections and contents in fully linked executable programs. These tools are also able to analyze the post-linked executable program (or library) and to make modifications to improve application performance.
- Gprof

  Gprof requires the `-pg` compiler option. This option instruments the resulting binary file to produce profiling information, in the `gmon.out` file, when the executable file or shared library runs.
- Gcov

  Gcov requires the `-ftest-coverage` and `-fprofile-arcs` compiler options. These options produce a text file that the gcov utility uses to show program coverage, and create a program flow graph for each function of your program and a spanning tree for the graph .

See 4.1.2, “Setting debug flags for Autotools-based projects,” on page 40 for instructions for setting debug flags.

Recommendations for optimization level options

Optimization level **`-O0`** is appropriate only for low-level debugging, where every source line must appear to execute sequentially. Other debugging can use optimization levels of **`-O1`** or **`-O2`**. Production builds should use a **`-O3`** optimization level.

If you have installed IBM Advance Toolchain for Linux on Power 8.0 or later, you can use optimization level **`-Ofast`**. **`-Ofast`** sets optimization level **`-O3`** and compiler flag `-ffast-math`.

See Options That Control Optimization(https://gcc.gnu.org/onlinedocs/gcc-5.3.0/gcc/Optimize-Options.html) in the GNU GCC documentation for details about the optimization level options.

See 4.1.3, “Setting optimization level flags for Autotools-based projects,” on page 41 for instructions for setting optimization levels.

Recommendations for compiler flags

Several different compiler flags are recommended for improving performance in applications that are running on Power Systems servers. These compiler flags can be set using the CFLAGS or CXXFLAGS environment variables.

See IBM RS/6000 and PowerPC Options (https://gcc.gnu.org/onlinedocs/gcc-5.3.0/gcc/RS_002f6000-and-PowerPC-Options.html#RS_002f6000-and-PowerPC-Options) in the GNU GCC documentation for details about these and other Power specific compiler flags.

Table 9. Recommended compiler flags

Flag	Short description	Extended description	Values
`-ffast-math`	Enables faster, but non-IEEE 754 compliant math results	Sets `-fno-math-errno`, `-funsafe-math-optimizations`, `-ffinite-math-only`, `-fno-rounding-math`, `-fno-signaling-nans`, and `-fcx-limited-range` options. This option causes the preprocessor macro “__FAST_MATH__” to be defined. This option is not enabled by any `-O` option, because it might result in incorrect output for programs that depend on an exact implementation of IEEE or ISO specifications for math functions. It might, however, yield faster code for programs that do not require the guarantees of these specifications.	
`-ffp-contract`	Generates code that does or does not use floating point multiply and accumulate instructions	Available with IBM Advance Toolchain for Linux on Power 8.0 and later. fast: Generates code that uses floating point multiply and accumulate instructions. Equivalent to `-mfused-madd`. off: Generates code that does not use floating point multiply and accumulate instructions. Equivalent to `-mno-fused-madd`.	fast, off, or on
`-fpeel-loops`	Simplifies loops or splits them into multiple loops to eliminate dependencies	Loop peeling is a special case of loop splitting, which splits any problematic first (or last) few iterations from the loop and performs them outside of the loop body.	

Table 9. Recommended compiler flags (continued)

Flag	Short description	Extended description	Values
`-fPIC`	Specifies to emit position-independent code (PIC) suitable for use in a shared library	Specifies to emit position-independent code (PIC) suitable for use in a shared library. Also, this option avoids any limit on the size of the global offset table. **Note:** At present, `-fPIC` applies only for 32-bit shared libraries. It does not apply for 64-bit.	
`-funroll-loops`	Unrolls loops, and replicates the body of the loop N times to reduce loop system use and improve scheduling opportunities.	Unrolls loops for which the number of iterations can be determined at compile time or upon entry to the loop. This option makes code larger, and might or might not make it run faster.	
`-m32`	Generates code for a 32-bit environment.	Generates code for a 32-bit environment.	
`-m64`	Generates code for a 64-bit environment.	Generates code for a 64-bit environment.	
`-maltivec`	Generates code that uses AltiVec instructions.	Generates code that uses AltiVec instructions, and also enables the use of built-in functions that allow more direct access to the AltiVec instruction set. You might also need to set `-mabi=altivec` (using **Other POWER-specific flags**) to adjust the current ABI with AltiVec ABI enhancements. Setting `-mcpu=power8` is preferred because it sets `-mvsx`, `-maltivec`, and `-mabi=altivec`.	
`-mno-altivec`	Generates code that does not use AltiVec instructions.	Generates code that does not use AltiVec instructions.	
`-mavoid-indexed-addresses`	Generates code that avoids indexed load/store instructions.	Generates code that tries to avoid the use of indexed load or store instructions. These instructions can incur a performance penalty on POWER6® processors in certain situations, such as when a program is stepping through large arrays that cross a 16M boundary. This option is enabled by default when a program is targeting POWER6, and disabled otherwise.	
`-mno-avoid-indexed-addresses`	Generates code that does not avoid indexed load/store instructions	Generates code that does not try to avoid the use of indexed load or store instructions. These instructions can incur a performance penalty on POWER6 processors in certain situations, such as when a program is stepping through large arrays that cross a 16M boundary. This option is enabled by default when a program is targeting POWER6, and disabled otherwise.	

Table 9. Recommended compiler flags (continued)

Flag	Short description	Extended description	Values
`-mcmodel=`*model*	Sets code model	small: Generates PowerPC® 64-bit code for the small model. The TOC is limited to 64 K in size. medium: Generates PowerPC 64-bit code for the medium model. The TOC and other static data is limited to 4G in size. large: Generates PowerPC 64-bit code for the large model. The TOC is limited to 4G in size. Other data and code is limited only by the 64-bit address space. **Note:** • Most applications should use `-mcmodel=medium`. • If you are using `-mcmodel=medium` or `-mcmodel=large`, you should also remove the `-mminimal-toc` flag, if it is set.	small, medium, or large
`-mcpu=`*cpu_type*	Sets machine type parameters	Sets architecture type, register usage, choice of mnemonics, and instruction scheduling parameters for machine type *cpu_type*.	power8 or any Power CPU type
`-mrecip=`*option*	Controls which type of reciprocal estimate instructions can be used	Controls which reciprocal estimate instructions can be used. *option* is a comma-separated list of options, which can be preceded by a "!" to invert the option. **all** enable all estimate instructions **default** enable the default instructions, equivalent to`-m-recip` **none** disable all estimate instructions, equivalent to `-mno-recip` **div** enable the reciprocal approximation instructions for both single and double precision **divf** enable the single precision reciprocal approximation instructions **divd** enable the double precision reciprocal approximation instructions **rsqrt** enable the reciprocal square root approximation instructions for both single and double precision **rsqrtf** enable the single precision reciprocal square root approximation instructions **rsqrtd** enable the double precision reciprocal square root approximation instructions For example,`-mrecip=all,!rsqrtd` enables all reciprocal estimate instructions except for FRSQRTE, XSRSQRTEDP, and XVRSQRTEDP instructions, which handle the double precision reciprocal square root calculations. `-ffast-math` must be enabled to use this option.	all, default, none, div, divf, divd, rsqrt, rsqrtf, or rsqrtd

Table 9. Recommended compiler flags (continued)

Flag	Short description	Extended description	Values
`-mrecip-precision`	Specifies to assume that the reciprocal estimate instructions have higher precision than needed by the ABI	Specifies to assume that the reciprocal estimate instructions provide higher precision estimates than is mandated by the POWERPC ABI. Selecting `-mcpu=power8` automatically selects `-m-recip-precision`. The double precision square root estimate instructions are not generated by default on low precision machines, because they do not provide an estimate that converges after three steps. `-ffast-math` must be enabled to use this option.	
`-mno-recip-precision`	Specifies to not assume that the reciprocal estimate instructions have higher precision than needed by the ABI	Specifies to not assume that the reciprocal estimate instructions provide higher precision estimates than is mandated by the POWERPC ABI. `-ffast-math` must be enabled to use this option.	
`-mtune=`*cpu_type*	Sets machine tuning parameters	Sets the instruction scheduling parameters for machine type *cpu_type*, but does not set the architecture type, register usage, or choice of mnemonics as `-mcpu=`*cpu_type* would. The same values for *cpu_type* are used for `-mtune` as for `-mcpu`. If both are specified, the code that is generated uses the architecture, registers, and mnemonics that are set by `-mcpu`, but the scheduling parameters that are set by `-mtune`.	power8 or any Power CPU type
`-mupdate`	Generates code that updates the base register	Generates code that uses the load or store instructions that update the base register to the address of the calculated memory location. These instructions are generated by default.	
`-mno-update`	Generates code that does not update the base register	Generates code that does not use the load or store instructions that update the base register to the address of the calculated memory location. These instructions are generated by default.	
`-mveclibabi=`MASS	Specifies type of ABI to use for the vectorizing intrinsics	Specifies the ABI type to use for vectorizing intrinsics by using an external library. The only type supported currently is MASS, which specifies to use IBM Mathematical Acceleration Subsystem (MASS) libraries for vectorizing intrinsics by using external libraries when generating code for POWER7®. Flags `-ftree-vectorize`, `-funsafe-math-optimizations`, and `-ffast-math` must be enabled. The MASS libraries must be specified at link time.	
`-mvsx`	Generates code that uses the vector/scalar instructions	Generates code that uses vector/scalar (VSX) instructions, and also enables the use of built-in functions that allow more direct access to the VSX instruction set. Setting `-mcpu=power8` is preferred because it sets `-mvsx`, `-maltivec`, and `-mabi=altivec`.	
`-mno-vsx`	Generates code that does not use the vector/scalar instructions	Generates code that does not use the vector/scalar (VSX) instructions.	

Table 9. Recommended compiler flags (continued)

Flag	Short description	Extended description	Values
`-mpower8-fusion`	Specifies to fuse an integer load with a preceding **addis** instruction and to fuse a vector load with a preceding **addi** instruction.	Specifies to fuse an integer load with a preceding **addis** instruction and to fuse a vector load with a preceding **addi** instruction. Setting `-mtune=power8` specifies this also.	
`-mpower8-vector`	Enables POWER8 vector instructions.	Enables POWER8 vector instructions. This option requires that `-mvsx` also are set.	
`-mcrypto`	Enables POWER8 cryptographic built-in functions.	Enables POWER8 cryptographic built-in functions. This option requires that `-maltivec` also are set.	
`-mdirect-move`	Enables POWER8 moves between general purpose registers and vector registers.	Enables POWER8 moves between general purpose registers and vector registers. This option requires that `-mvsx` also are set.	
`-mquad-memory`	Enables quadword memory instructions, including quadword atomic instructions.	Enables quadword memory instructions, including quadword atomic instructions. This option requires that `-m64` also are set.	

Recommendations for linker flags

The `-Bsymbolic` flag enables the linker to bind global symbol references to local definitions within the shared library. Normally this binding is deferred until program load time. At load time, global symbol references are bound to the definitions that are loaded first, starting with the main program. Early binding to local definitions reduces processor usage during calls, but also disables symbol overrides using preloaded libraries.

The `-m32` and `-m64` flags enable the linker to generate code for 32-bit and 64-bit environments. In most Makefile and Autotools projects, these flags can be passed along all build stages by setting them using the LDFLAGS environment variable.

4.1.2 Setting debug flags for Autotools-based projects

This topic details the steps for setting debug flags to use POWER processor capabilities and the IBM Software Development Kit for Linux on Power analysis tools, Source Code Analyzer and FDPR, gprof, and gcov in Autotools-based projects.

Before you begin

Note: If your project was created by importing a Makefile project, you must manually edit the Makefile file to export build control variables such as CFLAGS and LDFLAGS with debug flags.

See “Recommendations for debug flags” on page 35 for details on the recommended settings.

About this task

To set debug flags for projects that were created by importing Autotools projects, complete the following steps in the IBM SDK for Linux on Power user interface.

Procedure

1. View the project by clicking the project name in the Project Explorer pane.
2. Right-click the project name and click **Properties**.
3. Expand **Autotools** and click **Configure Settings**.
4. Click **Advanced**.
5. Choose from the following steps to set debug flags for particular tools.
   - For gcov and gprof, complete the following steps:
     a. In the right pane, select the **Debug (-g)** check box.
     b. In the right pane, select the **Gprof support (-pg)** or **Gcov support (-fprofile-arcs-ftest-coverage)** check box, as appropriate.
   - For Source Code Analyzer and FDPR, complete the following steps:
     a. In the right pane, ensure that the **Debug (-g)**, **Gprof support (-pg)**, and **Gcov support (-fprofile-arcs-ftest-coverage)** check boxes are not selected. If the source code is compiled with these options, Source Code Analyzer and FDPR cannot work properly.
     b. In the **Additional command-line options** field, set the value of CFLAGS (C) or CXXFLAGS (C++) to `-g -Wl,-q`. For example, type the following in the field:

        ```
        CFLAGS="-g -Wl,-q"
        ```
6. Click **Apply**.

4.1.3 Setting optimization level flags for Autotools-based projects

This topic details the steps for setting optimization levels for debugging with IBM Software Development Kit for Linux on Power in Autotools-based projects.

Before you begin

Note: If your project was created by importing a Makefile project, you must manually edit the Makefile file to export build control variables such as CFLAGS and LDFLAGS with debug flags.

See “Recommendations for optimization level options” on page 36 for details on the recommended settings.

About this task

Complete the following steps in the IBM SDK for Linux on Power user interface.

Procedure

1. View the project by clicking the project name in the Project Explorer pane.
2. Right-click the project name and click **Properties**.
3. Expand **Autotools** and click **Configure Settings**.
4. Click **Advanced**.
5. In the right pane, ensure that the **Debug (-g)**, **Gprof support (-pg)**, and **Gcov support (-fprofile-arcs-ftest-coverage)** check boxes are not selected. If you need any of these flags to be set at build time, you must re-export them together with optimization level flags as described in the next step.
6. In the **Additional command-line options** field, set the value of CFLAGS (C) or CXXFLAGS (C++) with the appropriate optimization level, such as `-O3` or `-Ofast`. For example, type the following in the field:

   ```
   CFLAGS="-g -O3"
   ```
7. Click **Apply**.

4.2 Editing a project

After you have imported or created a project, you can use the IBM Software Development Kit for Linux on Power graphical user interface to edit project preferences, build options, and application source code for the project.

The C/C++ Development User Guide (http://help.eclipse.org/mars/topic/org.eclipse.cdt.doc.user/concepts/cdt_o_home.htm) in the Eclipse platform help information contains the information you need to edit projects using IBM SDK for Linux on Power.

Most project preferences and build options you might want to customize are documented in the C/C++ Development User Guide. See 4.1.1, "Recommended debug, compiler, and linker settings for Power processor tuning," on page 35 for information about setting options for Power Systems.

4.2.1 Setting the Linux tools path

A customization that is unique to IBM SDK for Linux on Power is setting the Linux tools path. The Linux tools path is set automatically when creating a project, but you can change it. See 2.4.6, "Changing the IBM Advance Toolchain version," on page 18 for information about this customization.

4.2.2 Using the coding assistant

IBM SDK for Linux on Power provides a coding assistant that helps with code completion, function templates, and context-sensitive information for libauxv and libsphde libraries and the altivec API when using the C/C++ editor. While you are editing your code, you can use the following methods to display information:

- Move your mouse over a function.
- Type the initial letters, press **Ctrl+Spacebar**, and select a listed function.

4.3 Building a project

After a project is created or imported, you can select to build it or perform a clean build.

The C/C++ Development User Guide (http://help.eclipse.org/mars/topic/org.eclipse.cdt.doc.user/concepts/cdt_o_home.htm) in the Eclipse platform help information contains additional information about building projects.

4.3.1 Building a project

This topic describes a basic project build.

About this task

To build, or compile, a project, complete the following steps.

Procedure

1. View the project by clicking the project name in the Project Explorer pane.
2. Click **Project** > **Build Project** to build the project.
3. While the project is building, you can click the **Console** tab to monitor progress.

4.3.2 Building a project with clean build

A clean build discards previous build status information and problem markers, and causes the project to be rebuilt from the beginning.

About this task

Complete the following steps.

Procedure

1. View the project by clicking the project name in the Project Explorer pane.
2. Click **Project** > **Clean**.
3. In the Clean window, click the **Clean projects specified below** radio button.
4. Select the check box for the project you want to clean. Click **OK**.
5. While the project is building, you can click the **Console** tab to monitor progress.

4.3.3 Adding and using a Make target

For Makefile and Autotools projects, you can add Make targets, for transforming the source file to a specific target result. Example Make targets include "clean", "check", and "install".

About this task

Note: Adding Make targets is intended for advanced users.

Complete the following steps.

Procedure

1. View the project by clicking the project name in the Project Explorer pane.
2. Right-click the project name and select one of the following, as appropriate:
   - **Make Target** > **Create** to add a new Make target to your project. Click **OK** after specifying the information for the new target.
   - **Make Target** > **Build** > ***Target name*** to select a specific Make target. Click **Build** build the selected target.

4.4 Creating a package with the RPM plug-in

The RPM plug-in allows you to create RPM packages containing a compiled version of software, the source code of an application, or scripts. The plug-in includes a wizard for creating a spec file based on pre-existing templates.

The RPM plug-in requires optional packages to be installed on the Power Systems server. See 2.2, "Recommended and optional packages," on page 9.

4.4.1 Creating an RPM project

You can use the RPM plug-in to create an RPM project.

Before you begin

The RPM plug-in requires optional packages to be installed on the Power Systems server. See 2.2, "Recommended and optional packages," on page 9.

About this task

Complete the following steps in the IBM SDK for Linux on Power user interface.

Procedure

1. Click **File** > **New** > **Other**.
2. In the New window, expand **RPM** and click to select **RPM Project**. Click **Next**.
3. In the Create a new RPM project window, complete the following steps:
   a. Type a name for the project in the **Project name** field.
   b. Optional: The project will be created in a directory structure in the file system. The default file system location is displayed in the **Location** field. If you do not want to save the project in the default location, clear the **Use default location** check box, and specify or browse for a new location.
   c. Select a project layout, RPMBUILD or FLAT, from the **Project layout** list. The default is RPMBUILD.

      RPMBUILD
      If you choose the RPMBUILD project layout, then the project is created with the following folders: RPMS, SOURCES, SPECS, and SRPMS.

      FLAT If you choose the FLAT project layout, the project is created with no folders.
4. Click **Finish**. The new project is shown in the Project Explorer pane. If you selected the RPMBUILD project layout, the project contains the folders RPMS, SOURCES, SPECS, and SRPMS. Otherwise, it contains no folders.
5. To import files or create files for the project, complete the following steps.
   a. Right-click on the appropriate folder within the project and click **Import**.
   b. Click **General** > **File System**
   c. Locate the file in your file system.
   d. Click **Finish**.

4.4.2 Creating a remote RPM project

You can create an RPM project on a remote server.

Before you begin

The RPM plug-in requires optional packages to be installed on the Power Systems server. See 2.2, “Recommended and optional packages,” on page 9.

About this task

Complete the following steps in the IBM SDK for Linux on Power user interface.

Procedure

1. Click **File** > **New** > **Other**.
2. In the New window, expand **RPM** and click to select **RPM Project**. Click **Next**.
3. In the Create a new RPM project window, clear the **Use default location** check box if it is selected.
4. In the **Choose file system** field, click the arrows to select **JSch**.
5. Click **Browse** to find the location where the project is to be stored on the remote server.
6. In the **Connection name** box, click the arrows to select the connection to the remote server, or click **New** to create a connection.
7. In the Project window, type a name for the project in the **Project name** field.
8. Click **Finish**. The new project is shown in the Project Explorer pane. The project contains the folders RPMS, SOURCES, SPECS, and SRPMS.
9. To import files or create files for the project, complete the following steps.
   a. Right-click on the appropriate folder within the project and click **Import**.

b. Click **General** > **File System**

c. Locate the file in your file system.

d. Click **Finish**.

4.4.3 Creating a spec file in an existing RPM project

You can use the RPM plug-in create a spec file based on pre-existing templates.

Before you begin

The RPM plug-in requires optional packages to be installed on the Power Systems server. See 2.2, "Recommended and optional packages," on page 9.

About this task

The RPM plug-in uses the **`rpmdev-newspec`** command from rpmdevtools to create a spec file based on pre-existing templates. To create a spec file into an existing RPM project from an RPM, complete the following steps in the IBM SDK for Linux on Power user interface.

Procedure

1. Click **File** > **New** > **Other**.
2. In the New window, expand **RPM** and click to select **Specfile based on template**. Click **Next**.
3. In the **Project** field, select the previously created projects that you want to use as a spec file template.
4. Optional: Customize the following fields as needed:
   - Type of template, for example: minimal, lib, python, and others
   - Name
   - Version
   - Summary
   - License
   - URL
   - Source files
5. Click **Finish**.

4.4.4 Checking an RPM package with rpmlint

You can use rpmlint to check for errors in your RPM project.

Before you begin

The RPM plug-in requires optional packages to be installed on the Power Systems server. See 2.2, "Recommended and optional packages," on page 9.

About this task

Complete the following steps in the IBM SDK for Linux on Power user interface.

Procedure

1. View the project by clicking the project name in the Project Explorer pane.
2. Select from one of the following options to run rpmlint.
   - Right-click the project name, select **RPM**, and click **Add/Remove rpmlint warnings** to enable or disable the program warnings. If the warnings are currently disabled, they become enabled, and rpmlint runs immediately. If the warnings are currently enabled, they become disabled.

- Right-click the project name, select **RPM**, and click **Run rpmlint**. The rpmlint tools runs immediately.

4.4.5 Generating an RPM package

You can generate the RPM package from the RPM project.

About this task

Complete the following steps in the IBM SDK for Linux on Power user interface.

Procedure

1. In the Project Explorer pane, click the project name to view the project.
2. Right-click the project and expand the **RPM** option.
3. Select one of the following options:
   - Build SRPM
   - Build RPMS
   - Build ALL

Results

The generated package is placed within the project in the Project Explorer pane.

5 Migrating an application to Power Systems servers using Migration Advisor

The IBM Software Development Kit for Linux on Power includes a Migration Advisor to help in moving Linux applications to Power Systems servers. The advisor uses the Eclipse C/C++ Development Tools code analysis tool. The code analysis tool locates potential migration problems within a project, such as source code that might produce different results when run on Power Systems servers.

5.1 Enabling Migration Advisor checkers

The IBM Software Development Kit for Linux on Power Migration Advisor contains several checkers that look for code in the project that might produce a different result in Power Systems servers. Warnings are displayed showing the kind of problem found.

About this task

To enable Migration Advisor checkers, complete the following steps.

Procedure

1. Click **Window** > **Preferences**.
2. In the left pane, expand **C/C++** and click **Code Analysis**. The Code Analysis window displays all the installed Migration Advisor checkers.
3. Locate the group of checkers provided by the SDK: **Linux/x86 to Linux on Power**, **Linux/Power 32 bits to Linux/Power 64 bits application migration**, or **Linux/Power application optimization** in the window, by scrolling if needed. Expand this group.
4. Click the check box beside the name of the group to select all the checkers, or click the check boxes for the specific checkers that you want to select.
5. Click **Apply**.

5.1.1 Enabling additional Migration Advisor options

The Migration Advisor has additional options that you can enable.

About this task

Note: By using the code examples, you agree to the terms of the 10, “Code license and disclaimer information,” on page 97.

The following options are available:

Enable checkers in blocks inactivated by the preprocessor and macro definitions
This option causes Migration Advisor to analyze inactive blocks. For example, if this option is not selected, Migration Advisor would not look for problems in this sample code:

```
1. #if 0
2. //Code with problems
3. #endif
```

Report problems in statements that come from macro expansion
This option enables Migration Advisor to flag problems in macro expansions. For example, Migration Advisor displays a warning for the macro definition shown in line 1 of the sample code only if this option is not selected. Conversely, Migration Advisor would display a warning for line 2 of the sample code only when this option is selected.

```
1. #define MACRO asm("asm_with_errors");
2. MACRO
```

Enable Scalability mode in Migration Advisor
Inactive blocks in large files might not be analyzed if this option is enabled. If this option is disabled, blocks from large files are analyzed and a large amount of memory is used.

To enable the additional options, complete the following steps.

Procedure

1. Click **Window** > **Preferences**.
2. In the left pane, expand **C/C++** > **Code Analysis** and click **Migration Advisor**.
3. Click the check box beside one or both of the following options.
   - **Enable checkers in blocks inactivated by the preprocessor and macro definitions**
   - **Report problems in statements that come from macro expansion**
   - **Enable Scalability mode in Migration Advisor**
4. Click **Apply**.

5.1.2 Enabling indexing for Migration Advisor

Some checkers use the C/C++ index, so it is important to enable the C/C++ indexer and to ensure that the indexer has run before using Migration Advisor.

About this task

To enable the C/C++ indexer, complete the following steps.

Procedure

1. In the left pane, expand **C/C++** and click **Indexer**.
2. Click **Apply**.

5.2 Migration Advisor checkers

These topics describe the checkers used by the Migration Advisor.

Note: By using the code examples, you agree to the terms of the 10, “Code license and disclaimer information,” on page 97.

x86-specific compiler built-in checker

Some x86 compiler built-ins are not available for 32-bit POWER or 64-bit POWER architectures. This checker finds all occurrences of x86-specific built-ins.

Example

```
void foo() {
    __builtin_infq(); //x86-specific built-in
}
```

x86-specific assembly checker

Inline assembly code usually cannot be migrated without problems. Therefore, warnings are displayed for inline assembly code.

Example

```
void foo() {
    asm("mov %ax, 0"); //assembly code
    __asm__("mov %ax, 0"); //assembly code
}
```

Struct with bitfields checker

x86 and POWER architectures have different endianness, which refers to the ordering of separately addressable components. Because of this, the order of bit fields in a struct is different in a Power Systems server, which can result in migration issues. It is important to ensure that bit fields are used correctly to avoid problems.

It is also a good idea to see where the struct is referenced to check whether there are endianness issues. To do this, you can navigate in struct declarations and references.

- To navigate in struct references in your project, select the object name, right-click, and select **References** > **Project**. All references display in the Search View. Double-click the file names in the Search View to open them in the Editor View.
- To navigate in struct declarations, select the struct name, right-click, and select **Declarations** > **Project**. The results also display in the Search View.
- Declarations can contain typedefs. Be sure to also check all references of the typedefs.

Examples

The following example would also be flagged by the cast with endianness issues checker.

```
#include <stdio.h>
struct _my_struct {
int a:4;
int b:4;
} my_struct;

void foo() {
 char my_char;
 my_struct.a = 0xFF;
 my_struct.b = 0x00;
 my_char = *(char *)&my_struct;
  //This prints 0x0f in x86 (or x86_64) machines and 0xf0 in ppc (or ppc64) machines.
  printf("%x\n", my_char);
}
```

The following example would also cause endianness problems if it is changed to use the network instead of a file to read and write data.

```
#include
#include
#include

void foo() {
    int file;
    char my_char;
    struct _my_struct {
        int a:4;
        int b:4;
    } my_struct;

    //initial values
    my_struct.a = 0x1;
    my_struct.b = 0x2;

    //Writing to a file
    file = open("my_file", O_CREAT | O_WRONLY);
    write(file, &my_struct, 1);
    close(file);

    //Reading from a file
    file = open("my_file", O_RDONLY);
    read(file, &my_char, 1);
    close(file);
    printf("%x\n", my_char);
}
```

Cast with endianness issues checker

Casting can create endianness problems in C or C++ code. This happens when casting pointers for types with different sizes. The cast with endianness issues checker analyzes all casts in the code and flags the casts that can cause an endianness problem.

Example

```
void foo() {
    short int val = 0xFF00;
    char *char_pointer = (char *) &val;
    //This prints 0 in x86 (or x86_64) machines and ff in ppc (or ppc64) machines.
    printf("%x\n", *char_pointer);
}
```

Union with endianness issues checker

Using the several fields from a union in the same object can cause endianness issues. The union with endianness issues checker analyzes all unions in the code and flags the unions that can cause endianness problems.

It is a good idea to see where the struct is referenced to check whether there are endianness issues. To do this, you can navigate in union declarations and references.

- To navigate in union references in your project, select the object name, right-click, and select **References** > **Project**. All references display in the Search View. Double-click the file names in the Search View to open them in the Editor View.
- To navigate in union declarations, select the union name, right-click, and select **Declarations** > **Project**. The results also display in the Search View.
- Declarations can contain typedefs. Be sure to also check all references of the typedefs.

Example

```
void foo() {
    union {
        short int val1;
        char val2;
    } u;
    u.val1 = 0xFF00;
    //This prints 0 in x86 (or x86_64) machines and ff in POWER 32-bit (or 64-bit) machines.
    printf("%x\n", u.val2);
}
```

Long double usage checker

The use of long double might be a migration problem because of the differences in size and format between x86 and POWER architecture.With current GCC compilers, long double is 128 bits (AIX® double double format) for POWER architecture. Therefore, long double for POWER architecture is in a different format than long double for x86 ILP32 (96 bits) or x86 ILP64 (binary 128).

Performance degradation checker

It is usual to see performance improvements made for one specific architecture in an area of the code. This is mainly done using a preprocessor `#if` statement to check the current architecture. The performance degradation checker looks for `#if` and `#ifdef` statements that contain preprocessor definitions belonging to x86 or x86_64 architectures, but do not contain preprocessor definitions for POWER architectures. This is a sign that the code might not be optimized for POWER processors.

The performance degradation will also try to make the best attempt to convert the code inside the x86 block to PPC. If the code has a specific x86 built-in, the conversion, in some cases will be automatically. For example:

```
#ifdef _x86_
__m128 ra = _mm_load_ps(&a + i);
__m128 rb = _mm_load_ps(&b + i);
_mm_store_ps(%c + i, _mm_add_ps(ra,rb));
#else
c[i] = a[i] + b[i];
c[i + 1] = a[i + 1] + b[i + 1];
c[i + 2] = a[i + 2] + b[i + 2];
c[i + 3] = a[i + 3] + b[i + 3];
#endif
```

The previous code example has an x86 block. The MA will migrate all Intel built-ins to PPC. After the fix, the code will look similar to the following version:

```
#ifdef _x86_
__m128 ra = _mm_load_ps(a + i);
__m128 rb = _mm_load_ps(b + i);
_mm_store_ps(c + i, _mm_add_ps(ra,rb));
#elif defined __PPC__
// TODO: write an optimized code for Power
__vector float ra = *(__vector float*) (a + i);
__vector float rb = *(__vector float*) (b + i);
*(__vector float*) (c + i) = vec_add(ra, rb);
#else
c[i] = a[i] + b[i];
c[i + 1] = a[i + 1] + b[i + 1];
c[i + 2] = a[i + 2] + b[i + 2];
c[i + 3] = a[i + 3] + b[i + 3];
#endif
```

You can change the preprocessor definitions used by the performance degradation checker. For information, see 5.2.4, "Customizing the performance degradation checker," on page 55.

Example

```
#if defined(__x86__)
//code specific for x86 architectures
#else
//code that will work for all architectures, but it isn't optimized.
#endif
```

Syscall not available for Linux on Power checker

Almost all x86 and x86_64 Linux system calls (syscalls) are available for POWER architecture. Using an x86-specific system call causes problems when migrating your code to POWER architecture. The syscall not available for Linux on Power checker analyzes all system calls in your code and displays a warning for system calls that are not available for 32-bit or 64-bit POWER architectures. The warning message states whether the system call is unavailable only for 32-bit POWER, only for 64-bit POWER, or unavailable for both architectures.

You can specify that this checker look for only those system calls that are not available for 32-bit or 64-bit POWER architectures. For information, see 5.2.5, “Customizing the syscall not available for Linux on Power checker,” on page 56.

Linux/x86-specific API checker

The Intel-specific API checker looks for usage of functions from the following libraries:
- Intel Integrated Performance Primitives 7.0
- Intel Math Kernel Library 10.3
- Message Passing Interface Library 2.2
- Decimal Floating-Point Math Library 2.0

You can customize the Linux/x86-specific API checker by selecting which library APIs the checker looks for. In addition, you can add, edit, and remove APIs from the checker. For information, see 5.2.6, “Customizing the Linux/x86-specific API checker,” on page 56.

Hardware Transaction Memory checker

This checker finds occurrences of x86 hardware transaction memory usage, which is not supported for POWER architectures. Transactional Synchronization Extensions (TSX), an x86 instruction set extension, enables hardware transaction memory support to speed up the execution of multithreaded programs.

```
#include <rtmintrin.h>

void foo(unsigned int a, unsigned int b){
    while(1){
    unsigned status = _xbegin();
       if(status == XBEGIN_STARTED) {
       trans_func(a, b);
          _xend();
          break;
       }
       else{
          _xabort();
       }
    }
}
```

Non-portable Pthreads implementation checker

Some Pthreads functions and data types are not supported on POWER architectures. This checker finds occurrences of non-portable Pthreads API usage.

```
#include <pthread.h>
void foo(){
    pthread_id_np_t tid;
    tid = pthread_getthreadid_np();
}
```

5.2.1 Linux/x86 to Linux/Power application migration checker

This topic describes the Linux/x86 to Linux/Power application migration checker.

Char usage checker

The use of char might be a problem when assigning a numeric value to a variable of type char. By default, the char type is signed in x86 but it is unsigned in POWER architecture. The safe mode to use a char that receives a numeric value is to declare it as signed or unsigned.

Example

```
void foo() {
  char c = -1;
  int x = (int) c;
  // This prints -1 in x86 machines and 255 in ppc machines.
  printf("x = %d\n", x);
}
```

5.2.2 Linux/Power application optimization checker

This topic describes the Linux/Power application optimization checker.

Sync built-in to C11 standard atomic built-in checker

Sync built-ins are defined for IA64 and adopted for general use by GCC. However, it does not have a good performance for POWER architecture. Instead of using Sync, use the Atomics built-ins that are intended to replace the legacy Sync built-ins.

Note: The Atomic built-ins assume that programs conform to the C++11 memory model.

Example

```
void foo() {
 int x = 20;
 int y = 80;
 int result = 0;
 result = __sync_fetch_and_add(&x, y);
}
```

5.2.3 Linux/Power 32bit to Linux/Power 64bit application migration checkers

These topics describe the checkers used for Linux/Power 32bit to Linux/Power 64bit application migration.

Long usage checker

When you are migrating an application from ILP32 to LP64, you must take care about the difference in size of some types. The long type for example, has 32 bit in ILP32 and 64 in LP64. Therefore, this checker searches for long declarations and warns you about possible problems.

Example - unsafe code

```
long x = 0xFFFFFFFF;
  cout << x << endl;
```

Example - fixed code

```
int x = 0xFFFFFFFF;
  cout << x << endl;
```

Implicit Cast Checker

This checker performs a deep static analysis of the code, searching for patterns where an implicit cast could cause an invalid result depending on the value generated by a variable or expression.

Example - unsafe code

For example, a downcast from unsigned int type to long type can generate a different result in LP64 power computer.

```
unsigned int a = 0;
     long b = --a;
     cout << b << endl;

     // Output ppc32 -> -1
     // Output ppc64 -> 4294967295
```

Example - fixed code

```
unsigned int a = 0;
     int b = --a;
     cout << b << endl;
```

Example - unsafe code

Moreover, some libraries might have a different type declaration depending on the system environment. Therefore, this checker is designed to also detect cast between types declared in libraries and macros.

```
#include <stdint.h>
 intptr_t a = -1;
 uintptr_t b = a; // dangerous implicit cast.
```

Example - fixed code

```
#include <stdint.h>
 int a = -1;
 unsigned int b = a;
```

Pointer Cast Checker

This checker is an extension of the implicit cast checker and also performs a static analysis, searching for problems related to explicit casts. Moreover, it reports cast between pointers with different sizes. For example, if you declare a pointer and force a cast to another pointer of a different type, it might result in an unexpected behavior.

Example - unsafe code

```
const char *a = "abcdefghj";
     long *b = (long *) a;
     cout << *b << endl;
```

Example - fixed code

```
const char *a = "abcdefghj";
     int *b = (int *) a;
     cout << *b << endl;
```

Heterogeneous Type checker

This checker searches for structs, unions, and classes and warns you about incompatible declarations inside those data types. For example, if you declare a long variable inside a heterogeneous data structure, you can face a variety of problems such as, different result due to a memory overlap, different data alignment, endianness incompatibility or difference in size. The code below shows a memory overlap problem:

Example - unsafe code

```
union Pixel {
           unsigned long color;
           unsigned char rgba[4];
      };
```

Example - fixed code

```
union Pixel {
          unsigned int color; // on uint32_t color;
          unsigned char rgba[4];
     };
```

Format Specifiers Checker

A format specifier is a symbol used in ANSI C/C++ to format input/output strings. The table below summarizes all valid C/C++ combinations. For more information, see PRINTF.

	d or i	u, o, x or X	f, F, e, E, g, G, a or A	c	s	p	n
-	int	unsigned int	double	unsigned char	char*	void*	int*
h	short	unsigned short	double				short*
hh	char	unsigned char	double				char*
l	long	unsigned long	double	wint_t	wchar_t*		long*
ll	long long	unsigned long long	double				long long*
j	intmax_t	uintmax_t	double				intmax_t*
z	size_t	size_t	double				size_t*
t	ptrdiff_t	ptrdiff_t	double				ptrdiff_t*
L	long	unsigned long	long double		char		

The format specifier usage is a common problem because, C/C++ performs type promotion and downcast depending on the type passed as parameter. Therefore, this checker searches for variables that are not compatible with the format specifier. It also reports the usage of types that changes its size in an LP64 programming model.

Example - unsafe code

```
int x;
 scanf("%ld",&x);
```

Example - fixed code

```
int x;
 scanf("%d",&x);
```

5.2.4 Customizing the performance degradation checker

You can change the preprocessor definitions used by the performance degradation checker.

About this task

To change the definitions, complete the following steps.

Procedure

1. Click **Window** > **Preferences**.
2. In the left pane, expand **C/C++** and click **Code Analysis**. The Code Analysis window displays all the installed Migration Advisor checkers.
3. Locate the group of checkers provided by the SDK: **Linux/x86 to Linux on Power**, **Linux/Power 32 bits to Linux/Power 64 bits application migration**, or **Linux/Power application optimization** in the window, by scrolling if needed. Expand this group.
4. Select the **Performance Degradation** checker and click **Customize** > **Customize Selected**.
5. Edit preferences as needed.
   - Add or remove the predefined macros for Power and non-Power architectures.
   - Select or clear the check box for **Case sensitive when comparing preprocessor definitions**.

   Click **OK** when finished.

5.2.5 Customizing the syscall not available for Linux on Power checker

You can specify that this checker look for only those system calls that are not available for 32-bit or 64-bit POWER architectures.

About this task

To select this option, complete the following steps.

Procedure

1. Click **Window** > **Preferences**.
2. In the left pane, expand **C/C++** and click **Code Analysis**. The Code Analysis window displays all the installed Migration Advisor checkers.
3. Locate the group of checkers provided by the SDK: **Linux/x86 to Linux on Power**, **Linux/Power 32 bits to Linux/Power 64 bits application migration**, or **Linux/Power application optimization** in the window, by scrolling if needed. Expand this group.
4. Select the **Syscall not available for Linux on Power** checker and click **Customize** > **Customize Selected**.
5. Edit the preferences to select the check box for **Check for syscalls only unavailable for 32-bit Power architecture**, **Check for syscalls only unavailable for 64-bit Power architecture**, or both. Click **OK** when finished.
6. Click **Apply**.

5.2.6 Customizing the Linux/x86-specific API checker

You can customize the Linux/x86-specific API checker by selecting which library APIs the checker looks for. In addition, you can add, edit, and remove APIs from the checker.

About this task

To customize the checker, complete the following steps.

Procedure

1. Click **Window** > **Preferences**.
2. In the left pane, expand **C/C++** > **Code Analysis** > **Migration Advisor**.
3. In the Migration Advisor window, click **Customize the API Checker**. The API customization window is displayed.
4. In the API customization window, choose from the following options:
   - Select the check box for each API that you want the API checker to look for. Clear the check box for each API that you do not want the checker to look for.
   - To add an API to the checker, click **Add API**. Type the name, optionally type a description, and click **OK**.
   - To edit an API, click the API name to select it, then click **Edit API**. Type a different name or description, and click **OK**.
   - To add a function to an API, click the API name to select it, then click **Add function**. Type the function name, and click **OK**. To display the new function name if it is not already displayed, expand the API name in the API customization window. You can add multiple functions to an API.
   - To add a type to an API, click the API name to select it, then click **Add type**. Type the type name, and click **OK**. To display the new type name if it is not already displayed, expand the API name in the API customization window. You can add multiple types to an API.
   - To add a function from a file, click the API name to select it, then click **Add function from a file**. Type the file name or click **Browse** to locate and select it.

Note: The file must contain only the function names, with one name per line.
After you specify the file, click **OK**. All the functions that are listed in the specified file are added and displayed.

- To add a type from a file, click the API name to select it, then click **Add type from a file**. Type the file name or click **Browse** to locate and select it.

  Note: The file must contain only the type names, with only one name per line.
  After you specify the file, click **OK**. All the types that are listed in the specified file are added and displayed.
- To remove an API from the checker, click the API name to select it, then click **Remove**. When prompted, click **OK** to confirm.
- To export an API and any functions or types that it contains to an XML file to be imported later, click the API name to select it. Then, click **Export to a XML file**. Type the file name, including file type `xml`, or click **Browse** to locate and select it. Then, click **OK**.
- To import an API and any functions or types that it contains from an existing XML file, click the API name to select it, then click **Import a XML file**. Type the file name, including file type `xml`, or click **Browse** to locate and select it. Then, click **OK**.
- To restore the API checker to the default list of APIs included in the Migration Advisor, click **Restore Defaults**.

  Note: All customization changes will be lost.

5. When finished customizing, click **OK** to save your changes.

5.3 Running Migration Advisor

After checkers are enabled, you can run the IBM Software Development Kit for Linux on Power Migration Advisor.

About this task

To run Migration Advisor on a project in the Project Explorer pane, right-click the project name and select **Run Migration Advisor**.

From the Migration Advisor options, select the target architecture to port your application. If you select **Power Little Endian**, all the endianness checkers from Migration Advisor are disabled. If you select **Power Big Endian**, Migration Advisor uses all the checkers. To enable or disable the project checkers, right-click the project and select **Properties**. Select **C/C++ General** > **Code Analysis**.

The Migration Advisor begins running. Large projects might take several minutes to complete. The Migration Advisor View is displayed, and all potential migration issues are displayed as warnings.

In addition to warnings, you might see a single error displayed. If this occurs, it is because the C/C++ Development Toolkit Codan (CODe ANalysis) tool has not yet run after importing the project.

The following are actions you can take using Migration Advisor and the Migration Advisor View.

Procedure

- To display the code that has a reported potential issue, double-click the warning and the correct file is loaded in the editor view.
- You can continue to type in the editor window while the Migration Advisor is running. Because Migration Advisor is a live tool, the warnings are updated automatically as you edit.
- Because some issues might not be a problem for your project, Migration Advisor allows you to ignore, or hide, them. To ignore an issue, right-click the warning and select the **Ignore Warning** option. The warning no longer displayed.

- You can also decide to display ignored warnings again. Click the menu arrow in the upper right of the Migration Advisor View, and choose one of the following options.
  - Click **Disable Ignored Warnings** to display all ignored warnings. This option redisplays the ignored warnings, but it still retains the information that they are ignored.
  - Click **Enable Ignored Warnings** to hide all ignored warnings that you selected to redisplay with the **Disable Ignored Warnings**.
  - Click **Forget All Ignored Warnings** to stop ignoring all warnings.

    Note: You cannot undo this option, so be sure that you want to stop ignoring all warnings before you select it.
- If a single error is displayed, you can run the code analysis tool to find all the errors in the project.
  1. Right-click the project name and click **Run C/C++ Code Analysis**.
  2. Refer to Problems view (C/C++) in the C/C++ Development User Guide for information about working with the errors.

5.4 Using Migration Advisor quick fixes

Quick fixes can help you resolve migration problems found by running the Migration Advisor. Quick fixes are suggestions or tips that might help correct identified migration issues.

About this task

Migration Advisor quick fixes are available only for the following checkers:
- x86-specific compiler built-in checker. See “x86-specific compiler built-in checker” on page 48.
- x86-specific assembly checker. See “x86-specific assembly checker” on page 48.
- Struct with bitfields checker. See “Struct with bitfields checker” on page 49.
- Performance degradation checker. See “Performance degradation checker” on page 51.
- Decimal Floating-Point Math Library as part of Linux/x86-specific API checker. See “Linux/x86-specific API checker” on page 52.
- Hardware Transaction Memory checker. See “Hardware Transaction Memory checker” on page 52.

After you run Migration Advisor, you can take the following actions using the Migration Advisor view.

Procedure

1. If a line of code has a warning, you can determine whether there is a quick fix available by selecting the line. A pop-up window appears stating if there is a quick fix available.
2. If a quick fix is available, right-click the line and click **Quick Fix**. Alternatively, you can press **Ctrl+1**. A window displays the Migration Advisor quick fixes, along with any other quick fixes, that are available. For the Migration Advisor quick fixes, the associated checker is displayed.
3. To see a description of the quick fix, click the title. The description of the quick fix is displayed, including either a suggested code sample, or documentation of the solution, or both.

   Note: Consider whether it makes sense to implement the suggested fix for your migration.
4. To implement the suggested fix, double-click or press **Enter**.

6 Analyzing application performance on Power Systems servers

IBM Software Development Kit for Linux on Power provides many performance analysis tools.

6.1 Analyzing performance with the CPI breakdown plug-in

The CPI breakdown plug-in profiles C/C++ applications with the CPI (cycles per instruction) breakdown model for POWER8 and POWER7 systems.

If you want to use the CPI Breakdown plug-in, you must download and install Perf as described in 2.2, "Recommended and optional packages," on page 9.

6.1.1 CPI analysis overview

CPI (cycles per instruction) analysis can be used to improve application performance.

CPI refers to how many processor cycles are needed to complete an instruction. An instruction can be a read/write from memory operation, an arithmetic calculation, or bit-wise operation. The more cycles the processor takes to complete an instruction, the poorer the performance of the application in the processor.

Application performance can be improved by decreasing the number of cycles that are needed for the processor to complete instructions. In the CPI breakdown model, a set of processor events is broken down into components. Processor performance counters calculate metrics for the event components. This approach provides a complete view of how the application behaves concerning processor performance.

Because each processor architecture has different performance counters, POWER and Intel have different CPI breakdown models. Even within Power Systems servers, differences exist between each version of the processor.

Processor performance can be measured by profiling the application with tools such as OProfile or Perf. The CPI breakdown plug-in automates this process, enabling you to access the CPI breakdown model of any C/C++ application without manually tracking the events and calculating the metrics.

6.1.2 CPI events and metrics for POWER7

The CPI breakdown plug-in collects several required events, and then calculates metrics for the CPI breakdown model. These are the CPI events and metrics collected for POWER7.

The **perf stat** command collects the following POWER7 events:

- PM_RUN_CYC: Run cycles.
- PM_1PLUS_PPC_CMPL: 1 or more ppc instructions finished.
- PM_CMPLU_STALL: No groups completed, GCT not empty.
- PM_CMPLU_STALL_BRU: Completion stall due to BRU.
- PM_CMPLU_STALL_DCACHE_MISS: Completion stall caused by D cache miss.
- PM_CMPLU_STALL_DFU: Completion stall caused by Decimal Floating Point Unit.
- PM_CMPLU_STALL_DIV: Completion stall caused by DIV instruction.
- PM_CMPLU_STALL_ERAT_MISS: Completion stall caused by ERAT miss.
- PM_CMPLU_STALL_FXU: Completion stall caused by FXU instruction.
- PM_CMPLU_STALL_IFU: Completion stall due to IFU.
- PM_CMPLU_STALL_LSU: Completion stall caused by LSU instruction.

- PM_CMPLU_STALL_REJECT: Completion stall caused by reject.
- PM_CMPLU_STALL_SCALAR: Completion stall caused by FPU instruction.
- PM_CMPLU_STALL_SCALAR_LONG: Completion stall caused by long latency scalar instruction.
- PM_CMPLU_STALL_STORE: Completion stall due to store instruction.
- PM_CMPLU_STALL_THRD: Completion stall due to thread conflict. Group ready to complete but it was another thread's turn.
- PM_CMPLU_STALL_VECTOR: Completion stall caused by Vector instruction.
- PM_CMPLU_STALL_VECTOR_LONG: Completion stall due to long latency vector instruction.
- PM_GCT_NOSLOT_BR_MPRED: GCT empty by branch misprediction.
- PM_GCT_NOSLOT_BR_MPRED_IC_MISS: GCT empty by branch misprediction + IC miss.
- PM_GCT_NOSLOT_CYC: No itags assigned.
- PM_GCT_NOSLOT_IC_MISS GCT: empty by I-cache miss.
- PM_GRP_CMPL: Group completed

After collecting the events, the **perf stat** command calculates the necessary metrics for the CPI breakdown model.

Table 10. CPI breakdown metrics for POWER7

Metric	Formula
BASE_COMPLETION_CPI: Base Completion Cycles	PM_1PLUS_PPC_CMPL/PM_RUN_INST_CMPL
COMPLETION_CPI: Cycles in which a Group Completed	PM_GRP_CMPL/PM_RUN_INST_CMPL
EXPANSION_OVERHEAD_CPI: Cycles due to go overhead of expansion	COMPLETION_CPI - BASE_COMPLETION_CPI
FXU_STALL_CPI Cycles: stalled by Fixed-point Unit	PM_CMPLU_STALL_FXU/PM_RUN_INST_CMPL
FXU_MULTI_CYC_CPI: Cycles stalled by FXU Multi-Cycle Instructions	PM_CMPLU_STALL_DIV/PM_RUN_INST_CMPL
FXU_STALL_OTHER_CPI: Other cycles stalled by FXU	FXU_STALL_CPI - FXU_MULTI_CYC_CPI
GCT_EMPTY_CPI GCT: empty cycles	PM_GCT_NOSLOT_CYC/PM_RUN_INST_CMPL
GCT_EMPTY_IC_MISS_CPI: Cycles GCT empty due to I-Cache Misses	PM_GCT_NOSLOT_IC_MISS/PM_RUN_INST_CMPL
GCT_EMPTY_BR_MPRED_CPI: Cycles GCT empty due to Branch Mispredicts	PM_GCT_NOSLOT_BR_MPRED/PM_RUN_INST_CMPL
GCT_EMPTY_BR_MPRED_IC_MISS_CPI: Cycles GCT empty due to Branch Mispredicts and I-cache Misses	PM_GCT_NOSLOT_BR_MPRED_IC_MISS/ PM_RUN_INST_CMPL
GCT_EMPTY_OTHER_CPI: Other GCT empty cycles	(PM_GCT_NOSLOT_CYC- PM_GCT_NOSLOT_IC_MISSPM_ GCT_NOSLOT_BR_MPREDPM_ GCT_NOSLOT_BR_MPRED_IC_MISS) / PM_RUN_INST_CMPL
IFU_STALL_CPI: Cycles stalled due to Instruction Fetch Unit	PM_CMPLU_STALL_IFU/PM_RUN_INST_CMPL
IFU_STALL_BRU_CPI: Cycles stalled by branches	PM_CMPLU_STALL_BRU/PM_RUN_INST_CMPL
IFU_STALL_OTHER_CPI: Cycles stalled by other IFU operations	IFU_STALL_CPI - IFU_STALL_BRU_CPI
LSU_STALL_CPI: Cycles stalled by Load/Store Unit	PM_CMPLU_STALL_LSU/PM_RUN_INST_CMPL
LSU_STALL_REJECT_CPI: Cycles stalled by LSU Rejects	PM_CMPLU_STALL_REJECT/PM_RUN_INST_CMPL
LSU_STALL_ERAT_MISS_CPI: Cycles stalled by ERAT Translations	PM_CMPLU_STALL_ERAT_MISS/ PM_RUN_INST_CMPL

Table 10. CPI breakdown metrics for POWER7 (continued)

Metric	Formula
LSU_STALL_REJECT_OTHER_CPI: Cycles stalled by Other LSU Rejects	LSU_STALL_REJECT_CPI - LSU_STALL_ERAT_MISS_CPI
LSU_STALL_DCACHE_MISS_CPI: Cycles stalled by Data Cache (L1) Misses	PM_CMPLU_STALL_DCACHE_MISS/ PM_RUN_INST_CMPL
LSU_STALL_STORE_CPI: Cycles stalled by Data Store (L1) Misses	PM_CMPLU_STALL_STORE/PM_RUN_INST_CMPL
LSU_STALL_OTHER_CPI: Cycles stalled by Other LSU Operations	LSU_STALL_CPI - LSU_STALL_REJECT_CPI - LSU_STALL_DCACHE_MISS_CPI - LSU_STALL_STORE_CPI
OTHER_STALL_CPI: Other stall cycles	STALL_CPI - FXU_STALL_CPI - VSU_STALL_CPI - LSU_STALL_CPI - IFU_STALL_CPI - SMT_STALL_CPI
RUN_CPI: Total cycles	PM_RUN_CYC/PM_RUN_INST_CMPL
SMT_STALL_CPI: Cycles stalled due to Symmetric Multithreading	PM_CMPLU_STALL_THRD/PM_RUN_INST_CMPL
STALL_CPI: Completion Stall Cycles	PM_CMPLU_STALL/PM_RUN_INST_CMPL
VSU_STALL_CPI: Cycles stalled by Vector-and-Scalar Unit	(PM_CMPLU_STALL_SCALAR + PM_CMPLU_STALL_VECTOR + PM_CMPLU_STALL_DFU)/PM_RUN_INST_CMPL
VSU_STALL_DFU_CPI: Cycles stalled by Decimal Floating-point Unit	PM_CMPLU_STALL_DFU/PM_RUN_INST_CMPL
VSU_STALL_SCALAR_CPI: Cycles stalled by VSU Scalar Operations	PM_CMPLU_STALL_SCALAR/PM_RUN_INST_CMPL
VSU_STALL_SCALAR_LONG_CPI: Cycles stalled by VSU Scalar Long Operations	PM_CMPLU_STALL_SCALAR_LONG/ PM_RUN_INST_CMPL
VSU_STALL_SCALAR_OTHER_CPI: Cycles stalled by Other VSU Scalar Operations	VSU_STALL_SCALAR_CPI - VSU_STALL_SCALAR_LONG_CPI
VSU_STALL_VECTOR_CPI: Cycles stalled by VSU Vector Operations	PM_CMPLU_STALL_VECTOR/PM_RUN_INST_CMPL
VSU_STALL_VECTOR_LONG_CPI: Cycles stalled by VSU Vector Long Operations	PM_CMPLU_STALL_VECTOR_LONG/ PM_RUN_INST_CMPL
VSU_STALL_VECTOR_OTHER_CPI: Cycles stalled by VSU Vector Other	VSU_STALL_VECTOR_CPI - VSU_STALL_VECTOR_LONG_CPI

The CPI breakdown model flow defined for POWER7 Systems servers is depicted in the following table. The sum of the events in a column is the same for each column across the table.

Table 11. CPI breakdown model flow for POWER7

Cycles	Breakdown 1	Breakdown 2	Breakdown 3	Breakdown 4
PM_RUN_CYC	PM_CMPLU_STALL	PM_CMPLU_STALL _FXU	PM_CMPLU_STALL_DIV	
			PM_CMPLU_STALL_FXU_OTHER	
		PM_CMPLU_STALL _VSU	PM_CMPLU_STALL _SCALAR	PM_CMPLU_STALL _SCALAR_LONG
				PM_CMPLU_STALL _SCALAR_OTHER
			PM_CMPLU_STALL _VECTOR	PM_CMPLU_STALL _VECTOR_LONG
				PM_CMPLU_STALL _VECTOR_OTHER
			PM_CMPLU_STALL_DFP	
		PM_CMPLU_STALL _LSU	PM_CMPLU_STALL _REJECT	PM_CMPLU _STALL _ERAT_MISS
				PM_CMPLU_STALL _REJECT_OTHER
			PM_CMPLU_STALL_DCACHE_MISS	
			PM_CMPLU_STALL_STORE	
			PM_CMPLU_STALL_LSU_OTHER	
		PM_CMPLU_STALL_THRD		
		PM_CMPLU_STALL _IFU	PM_CMPLU_STALL_BRU	
			PM_CMPLU_STALL_IFU_OTHER	
		PM_CMPLU_STALL_OTHER		
	PM_GCT_NOSLOT _CYC	PM_GCT_NOSLOT_IC_MISS		
		PM_GCT_NOSLOT_BR_MPRED		
		PM_GCT_NOSLOT_BR_MPRED_IC_MISS		
		PM_GCT_NOSLOT_EMPTY_OTHER		
	PM_GRP_CMPL	PM_1PLUS_PPC_CMPL		
		Overhead of Expansion (PM_GRP_CMPL - PM_1PLUS_PPC_CMPL)		

6.1.3 CPI events and metrics for POWER8

The CPI breakdown plug-in collects several required events, and then calculates metrics for the CPI breakdown model. These are the CPI events and metrics collected for POWER8.

The **perf stat** command collects the following POWER8 events:

- PM_RUN_CYC: Processor Cycles gated by the run latch. Operating systems use the run latch to indicate when they are doing useful work. The run latch is typically cleared in the OS idle loop. Gating by the run latch filters out the idle loop.
- PM_CMPLU_STALL: Cycles where a thread was not completing any groups, when the group completion table had entries for that thread.
- PM_GCT_NOSLOT_CYC: Cycles when the Global Completion Table has no slots from this thread.
- PM_GRP_CMPL: A group completed. Microcoded instructions that span multiple groups will generate this event once per group.
- PM_CMPLU_STALL_LSU: Following a completion stall (any period when no groups completed, while group completion table was not empty for that thread) the last instruction to finish before completion resumes was from the Load store Unit.
- PM_CMPLU_STALL_VSU: Cycles stalled by Vector-and-Scalar Unit (PM_CMPLU_STALL_VECTOR, PM_CMPLU_STALL_SCALAR and PM_CMPLU_STALL_DFP).

- PM_CMPLU_STALL_FXU: Following a completion stall (any period when no groups completed, while group completion table was not empty for that thread) the last instruction to finish before completion resumes was from the Fixed Point Unit.
- PM_CMPLU_STALL_SCALAR: Following a completion stall (any period when no groups completed, while group completion table was not empty for that thread) the last instruction to finish before completion resumes was a scalar floating point instruction.
- PM_CMPLU_STALL_VECTOR: Following a completion stall (any period when no groups completed, while group completion table was not empty for that thread) the last instruction to finish before completion resumes was a vector instruction.
- PM_CMPLU_STALL_REJECT: Following a completion stall (any period when no groups completed, while group completion table was not empty for that thread) the last instruction to finish before completion resumes suffered a load/store reject.
- PM_CMPLU_STALL_DIV: Following a completion stall (any period when no groups completed, while group completion table was not empty for that thread) the last instruction to finish before completion resumes was a fixed-point divide instruction.
- PM_CMPLU_STALL_SCALAR_LONG: Following a completion stall (any period when no groups completed, while group completion table was not empty for that thread) the last instruction to finish before completion resumes was a floating point divide or square root instruction.
- PM_CMPLU_STALL_VECTOR_LONG: Following a completion stall (any period when no groups completed, while group completion table was not empty for that thread) the last instruction to finish before completion resumes was a long latency vector instruction.
- PM_CMPLU_STALL_DFU: Following a completion stall (any period when no groups completed, while group completion table was not empty for that thread) the last instruction to finish before completion resumes was from the Decimal Floating Point Unit.
- PM_CMPLU_STALL_ERAT_MISS: Following a completion stall (any period when no groups completed, while group completion table was not empty for that thread) the last instruction to finish before completion resumes suffered an ERAT miss.
- PM_CMPLU_STALL_DCACHE_MISS: Cycles stalled by Data Cache (L1) misses.
- PM_CMPLU_STALL_STORE: Following a completion stall (any period when no groups completed, while group completion table was not empty for that thread) the last instruction to finish before completion resumes was a store. This generally happens when we run out of real SRQ entries, which prevents stores from issuing.
- PM_CMPLU_STALL_THRD: Following a completion stall (any period when no groups completed, while group completion table was not empty for that thread) the thread could not complete a group because the completion port its sharing was being used by another thread. In SMT4 mode Thread0 and Thread2 share a completion port and Thread1 and Thread3 share another completion port.
- PM_CMPLU_STALL_IFU: Following a completion stall (any period when no groups completed, while group completion table was not empty for that thread) the last instruction to finish before completion resumes was from the Instruction fetch unit (either Branch Unit or CR unit).
- PM_CMPLU_STALL_BRU: Following a completion stall (any period when no groups completed, while group completion table was not empty for that thread) the last instruction to finish before completion resumes was from the Branch Unit. This mostly occurs where the branch has dependencies on a long latency instruction such as a load.
- PM_GCT_NOSLOT_IC_MISS: Cycles when the Global Completion Table has no slots from this thread because of an Instruction Cache miss.
- PM_GCT_NOSLOT_BR_MPRED: Cycles when the Global Completion Table has no slots from this thread because of a branch misprediction.
- PM_GCT_NOSLOT_BR_MPRED_IC_MISS: Cycles when the Global Completion Table has no slots from this thread because of a branch misprediction and Instruction cache miss.
- PM_1PLUS_PPC_CMPL: A group containing at least one PowerPC instruction completed. For microcoded instructions that span multiple groups, this will only occur once.

- PM_1PLUS_PPC_DISP: Cycles at least one Instr Dispatched.
- PM_CMPLU_STALL_VECTOR_LONG: Completion stall due to long latency vector instruction
- PM_CYC: Processor Cycles.
- PM_CMPLU_STALL_BRU_CRU: Completion stall due to IFU.
- PM_CMPLU_STALL_FXLONG: Completion stall due to a long latency fixed point instruction.
- PM_CMPLU_STALL_DMISS_L2L3: Completion stall by Dcache miss which resolved in L2/L3.
- PM_CMPLU_STALL_DMISS_L2L3_CONFLICT: Completion stall due to cache miss due to L2 L3 conflict.
- PM_CMPLU_STALL_DMISS_L3MISS: Completion stall due to cache miss resolving missed the L3.
- PM_CMPLU_STALL_DMISS_LMEM: Completion stall due to data cache miss that resolved in local memory.
- PM_CMPLU_STALL_DMISS_L21_L31: Completion stall by Dcache miss which resolved on chip (excluding local L2/L3).
- PM_CMPLU_STALL_DMISS_REMOTE: Completion stall by Dcache miss which resolved from remote chip (cache or memory).
- PM_CMPLU_STALL_REJECT_LHS: Completion stall due to reject (Load Hit Store).
- PM_CMPLU_STALL_ERAT_MISS: Completion stall due to LSU reject ERAT miss.
- PM_CMPLU_STALL_REJ_LMQ_FULL: Completion stall due to LSU reject LMQ full.
- PM_CMPLU_STALL_LOAD_FINISH: Completion stall due to a Load finish.
- PM_CMPLU_STALL_ST_FWD: Completion stall due to store forward.
- PM_CMPLU_STALL_NTCG_FLUSH: Completion stall due to NTCG flush.
- PM_NTCG_ALL_FIN: Cycles in which all instructions in the group have finished but completion is still pending.
- PM_CMPLU_STALL_LWSYNC: Completion stall due to ISYNC/LWSYNC.
- PM_CMPLU_STALL_HWSYNC: Completion stall due to HWSYNC.
- PM_CMPLU_STALL_MEM_ECC_DELAY: Completion stall due to mem ECC delay.
- PM_CMPLU_STALL_FLUSH: Completion stall due to flush by own thread.
- PM_CMPLU_STALL_COQ_FULL: Completion stall due to CO q full.
- PM_GCT_NOSLOT_IC_L3MISS: GCT empty for this thread due to Icache L3 miss.
- PM_GCT_NOSLOT_BR_MPRED_ICMISS: GCT empty for this thread due to Icache Miss and branch mispred.
- PM_GCT_NOSLOT_DISP_HELD_MAP: GCT empty for this thread due to dispatch hold on this thread due to Mapper full.
- PM_GCT_NOSLOT_DISP_HELD_SRQ: GCT empty for this thread due to dispatch hold on this thread due to SRQ full.
- PM_GCT_NOSLOT_DISP_HELD_ISSQ: GCT empty for this thread due to dispatch hold on this thread due to Issue q full.
- PM_CMPLU_STALL_DMISS_DISTANT: Cycles stalled by L1 reloads from distant interventions and distant memory.

After collecting the events, the **perf stat** command calculates the necessary metrics for the CPI breakdown model.

Table 12. CPI breakdown metrics for POWER8

Metric	Formula
PM_CMPLU_STALL_CRU	PM_CMPLU_STALL_BRU_CRU - PM_CMPLU_STALL_BRU

Table 12. CPI breakdown metrics for POWER8 (continued)

Metric	Formula
PM_CMPLU_STALL_FXU_OTHER	PM_CMPLU_STALL_FXU - PM_CMPLU_STALL_FXLONG
PM_CMPLU_STALL_VECTOR_OTHER	PM_CMPLU_STALL_VECTOR - PM_CMPLU_STALL_VECTOR_LONG
PM_CMPLU_STALL_SCALAR_OTHER	PM_CMPLU_STALL_SCALAR - PM_CMPLU_STALL_SCALAR_LONG
PM_CMPLU_STALL_VSU_OTHER	PM_CMPLU_STALL_VSU - PM_CMPLU_STALL_VECTOR - PM_CMPLU_STALL_SCALAR_LONG
PM_CMPLU_STALL_DMISS_L2L3_NO_CONFLICT	PM_CMPLU_STALL_DMISS_L2L3 - PM_CMPLU_STALL_DMISS_L2L3_CONFLICT
PM_CMPLU_STALL_DMISS_DISTANT	(PM_CMPLU_STALL_DMISS_L3MISS - (PM_CMPLU_STALL_DMISS_LMEM + PM_CMPLU_STALL_DMISS_L21_L31 + PM_CMPLU_STALL_DMISS_REMOTE))
PM_CMPLU_STALL_REJECT_OTHER	(PM_CMPLU_STALL_REJECT - (PM_CMPLU_STALL_REJECT_LHS + PM_CMPLU_STALL_ERAT_MISS + PM_CMPLU_STALL_REJ_LMQ_FULL))
PM_CMPLU_STALL_LSU_OTHER	(PM_CMPLU_STALL_LSU - (PM_CMPLU_STALL_DCACHE_MISS + PM_CMPLU_STALL_REJECT + PM_CMPLU_STALL_STORE + PM_CMPLU_STALL_LOAD_FINISH + PM_CMPLU_STALL_ST_FWD))
PM_CMPLU_STALL_OTHER	PM_CMPLU_STALL - PM_CMPLU_STALL_BRU_CRU - PM_CMPLU_STALL_FXU - PM_CMPLU_STALL_VSU - PM_CMPLU_STALL_LSU - PM_CMPLU_STALL_NTCG_FLUSH
PM_CMPLU_STALL_BLOCK_OTHER	(PM_CMPLU_STALL_THRD - (PM_CMPLU_STALL_LWSYNC + PM_CMPLU_STALL_HWSYNC + PM_CMPLU_STALL_MEM_ECC_DELAY + PM_CMPLU_STALL_FLUSH + PM_CMPLU_STALL_COQ_FULL))
PM_GCT_NOSLOT_IC_L2L3	PM_GCT_NOSLOT_IC_MISS - PM_GCT_NOSLOT_IC_L3MISS
PM_GCT_NOSLOT_DISP_HELD	PM_GCT_NOSLOT_DISP_HELD_MAP + PM_GCT_NOSLOT_DISP_HELD_SRQ + PM_GCT_NOSLOT_DISP_HELD_ISSQ + PM_GCT_NOSLOT_DISP_HELD_OTHER
PM_GCT_EMPTY_OTHER	PM_GCT_NOSLOT_CYC - PM_GCT_NOSLOT_IC_MISS - PM_GCT_NOSLOT_BR_MPRED - PM_GCT_NOSLOT_BR_MPRED_IC_MISS - PM_GCT_NOSLOT_DISP_HELD_MAP - PM_GCT_NOSLOT_DISP_HELD_SRQ - PM_GCT_NOSLOT_DISP_HELD_ISSQ - PM_GCT_NOSLOT_DISP_HELD_OTHER
OTHER_CPI	PM_RUN_CYC - PM_CMPLU_STALL - PM_NTCG_ALL_FIN - PM_CMPLU_STALL_THRD - PM_GCT_NOSLOT_CYC - PM_GRP_CMPL

Table 12. CPI breakdown metrics for POWER8 (continued)

Metric	Formula
STALL_CPI	PM_CMPLU_STALL / PM_RUN_INST_CMPL
RUN_CPI	PM_RUN_CYC / PM_RUN_INST_CMPL

The CPI breakdown model flow that is defined for POWER8 technology enablement is depicted in the following table. The sum of the events in a column is the same for each column across the table.

Table 13. CPI breakdown model flow for POWER8

Cycles	Breakdown 1	Breakdown 2	Breakdown 3	Breakdown 4	Breakdown 5
PM_RUN_CYC	PM_CMPLU_STALL	PM_CMPLU_STALL_BRU_CRU	PM_CMPLU_STALL_BRU		
			PM_CMPLU_STALL_CRU		
		PM_CMPLU_STALL_FXU	PM_CMPLU_STALL_FXLONG		
			PM_CMPLU_STALL_FXU_OTHER		
		PM_CMPLU_STALL_VSU	PM_CMPLU_STALL_VECTOR	PM_CMPLU_STALL_VECTOR_LONG	
				PM_CMPLU_STALL_VECTOR_OTHER	
			PM_CMPLU_STALL_SCALAR	PM_CMPLU_STALL_SCALAR_LONG	
				PM_CMPLU_STALL_SCALAR_OTHER	
			PM_CMPLU_STALL_VSU_OTHER		
		PM_CMPLU_STALL_LSU	PM_CMPLU_STALL_DCACHE_MISS	PM_CMPLU_STALL_DMISS_L2L3	PM_CMPLU_STALL_DMISS_L2L3_CONFLICT
					PM_CMPLU_STALL_DMISS_L2L3_NO_CONFLICT
				PM_CMPLU_STALL_DMISS_L3MISS	PM_CMPLU_STALL_DMISS_LMEM
					PM_CMPLU_STALL_DMISS_L21_L31
					PM_CMPLU_STALL_DMISS_REMOTE
					PM_CMPLU_STALL_DMISS_DISTANT
			PM_CMPLU_STALL_REJECT	PM_CMPLU_STALL_REJECT_LHS	
				PM_CMPLU_STALL_ERAT_MISS	
				PM_CMPLU_STALL_REJ_LMQ_FULL	
				PM_CMPLU_STALL_REJECT_OTHER	
			PM_CMPLU_STALL_STORE		
			PM_CMPLU_STALL_LOAD_FINISH		
			PM_CMPLU_STALL_ST_FWD		
			PM_CMPLU_STALL_LSU_OTHER		
		PM_CMPLU_STALL_NTCG_FLUSH			
		PM_CMPLU_STALL_OTHER			
	PM_NCTG_ALL_FIN				
	PM_CMPLU_STALL_THRD	PM_CMPLU_STALL_LWSYNC			
		PM_CMPLU_STALL_HWSYNC			
		PM_CMPLU_STALL_MEM_ECC_DELAY			
		PM_CMPLU_STALL_FLUSH			
		PM_CMPLU_STALL_COQ_FULL			
		PM_CMPLU_STALL_BLOCK_OTHER			
	PM_GCT_NOSLOT_CYC	PM_GCT_NOSLOT_IC_MISS	PM_GCT_NOSLOT_IC_L3MISS		
			PM_GCT_NOSLOT_IC_L2L3		
		PM_GCT_NOSLOT_BR_MPRED			
		PM_GCT_NOSLOT_BR_MPRED_ICMISS			
		PM_GCT_NOSLOT_DISP_HELD	PM_GCT_NOSLOT_DISP_HELD_MAP		
			PM_GCT_NOSLOT_DISP_HELD_SRQ		
			PM_GCT_NOSLOT_DISP_HELD_ISSQ		
			PM_GCT_NOSLOT_DISP_HELD_OTHER		
		PM_GCT _EMPTY_OTHER			
	PM_GRP_CMPL				
	OTHER_CPI				

6.1.4 Profiling a binary application with CPI from the command line

You can use a simplified version of the CPI breakdown plug-in in the command line, outside the IDE.

About this task

Complete these steps to profile a binary application with CPI from the command line:

Procedure

1. On your Power Systems server, navigate to the `/opt/ibm/ibm-sdk-lop/bin` folder.
2. Locate the **`cpi_profile.sh`** script
3. Run the script.

   Note: Run the script without parameters to see the usage instructions.

6.1.5 Profiling a project with the CPI breakdown plug-in

You can use the CPI breakdown plug-in to analyze your project for performance improvement through the CPI breakdown model.

About this task

Complete these steps to profile a project on the local system using the CPI breakdown plug-in.

Procedure

1. In the Project Explorer pane, right-click the project name. Click **Profile as** > **Profile Configurations**.
2. In the Profile Configurations window, click **Profile with CPI** in the left pane, and then select the New launch configuration icon near the upper left of the window.
3. Optional: On the Main tab, beside the **C/C++ Application** field, select the binary file that you want to profile.
4. On the Main tab, click **Browse** from the **Working directory** field to select the folder to be used by the profiling tool.
5. On the Arguments tab, specify any arguments to pass to the binary file to be profiled.
6. Optional: On the CPI Options tab, set the maximum duration for CPI Breakdown analysis.
7. Click **Profile** to begin the profiling. After the profiling completes, a CPI Breakdown perspective opens, with the CPI breakdown model (CBM) view shown. The CPI Breakdown Model view shows all the metrics, events, and their values. Red boxes represent hot spot events.

   In addition, the following views open in the lower left:

   - The Events view shows all the events that were gathered using the **`ocount`** tool. Use the search field to quickly find a specific event.
   - The Metrics view shows all the metrics that were calculated. Use the search field to quickly find a specific metric.
   - The Radar Chart View provides a graphical visualization of the profiling, allowing you to compare several rounds of execution.

   To compare rounds, locate the files with *.cpi extension at the project explorer view and proceed as following:

   a. Load a CPI-Breakdown round: Right click on the *.cpi file and select **CPI Analyzes** > **Load events**.
   b. Compare CPI-Breakdown rounds: Select at least two *.cpi files, and right click to select **CPI Analyzes** > **Events Compare**.
   c. Average of CPI-Breakdown rounds: Select one or more *.cpi files, and right click to select **CPI Analyzes** > **Events Average**.
8. You can drill down through the profiling results to the source code.

a. In the CPI breakdown model view, double-click any red box that represents a hot spot. The Drilldown view opens in the lower left. The Drilldown view lists the source code elements that caused the event you selected.
b. In the Drilldown view, double-click a source code element. This action displays the source code, at the line that corresponds to the selected event, in the source code view on the lower right. The source code view lists the source file name as the tab name.

6.2 Analyzing performance with OProfile

OProfile is a system-wide profiler for Linux systems that allows for the analysis of system performance and the identification of code hot spots. It also contains support for hardware performance counters. IBM Software Development Kit for Linux on Power provides integration with OProfile to allow you to profile running applications while conserving system resources.

OProfile profiles hardware and software interrupt handlers, kernel modules, the kernel, shared libraries, and applications. OProfile provides commands, or utilities, for controlling profiling.

Legacy OProfile consists of the **`opcontrol`** shell script for configuring, starting, and stopping a profiling session. To this purpose, a kernel driver is used for collecting samples, which are recorded into sample files. A disadvantage of this mode is the necessity of elevated user privileges to run **`opcontrol`**.

`Operf` was designed to be used in place of **`opcontrol`** for profiling. It uses the Linux Performance Events Subsystem, and therefore, does not require the use of the **`opcontrol`** daemon or any elevated privileges.

You can use either method, **`opcontrol`** or **`operf`**, to profile with OProfile and IBM SDK for Linux on Power.

6.2.1 Profiling a project with OProfile

You can use OProfile to profile your project to analyze system performance while running applications.

Before you begin

Ensure that you have completed the following:
1. OProfile available on your system.
2. Building the project.
3. Verifying that the Linux tools path specifies the version of IBM Advance Toolchain for Linux on Power you want to use during profiling. See 2.4.6, "Changing the IBM Advance Toolchain version," on page 18 for information.

About this task

Complete these steps to profile a project using OProfile.

Procedure

1. Switch to the C/C++ perspective by clicking **Window** > **Open Perspective** > **C/C++**. Click **OK**.
2. View the project by clicking the project name in the Project Explorer pane.
3. Click **Profiling Tools** > **Profiling Tools Configurations**.
4. In the Profiling Tools Configurations window, click **Profile with OProfile** in the left pane, and then click the **New launch configuration** icon near the upper left of the window.
5. On the Main tab, beside the **C/C++ Application** field, click **Search Project** to select the binary file that you want to profile.
6. If necessary, click the arrows in the **Build configuration** field and select **Default**.
7. On the Arguments tab, specify any arguments to pass to the binary file to be profiled.

8. On the Global tab, click the arrow in the **Profile with** field to select which profiling method, `opcontrol` or `operf`, to use. If you select `opcontrol`, you can also select from the following options:
   - Specify a **kernel image file**. This option collects more detailed information about the operation of a program in the Linux kernel. Type the file name or click **Browse** to locate and select it.

     Note: When you select this option, you must also select the **Include dependent kernel modules** option.
   - **Include dependent shared libraries**. Select this option to include samples from shared libraries that are used by the profiled program. These samples are then aggregated in the profile results.
9. Optional: On the Events tab, you can clear the **Use default event** check box to select a different event to be monitored. You can also select multiple events within the same group. The number of events varies by system, but typically you can select up to six events.
10. Click **Profile** to begin the profiling. After the profiling completes, an OProfile tab opens and displays the event types that were profiled.
11. You can expand the events to view the binary image, function, and line numbers where the profiling collected most of the events that were profiled. The results are sorted with the functions that the program spent the most time executing shown first. You can click on an item to open the source code.

Related information:

Taking advantage of OProfile

6.2.2 Profiling a synchronized project with OProfile

You can use OProfile to profile a synchronized project to analyze system performance while running applications.

Before you begin

Ensure that you have completed the following:
1. OProfile available on your system.
2. Building the project.
3. Verifying that the Linux tools path specifies the version of IBM Advance Toolchain for Linux on Power you want to use during profiling. See 2.4.6, "Changing the IBM Advance Toolchain version," on page 18 for information.

About this task

Complete these steps to profile a synchronized project using OProfile.

Procedure

1. In the Project Explorer pane, right-click the project name. Click **Profiling Tools** > **Profiling Tools Configurations**.
2. In the Profiling Tools Configurations window, click **Profile with OProfile (Remote)** in the left pane, and then click the New launch configuration icon near the upper left of the window.
3. On the Main tab, below C/C++ Executable, click **Browse** to select the binary file that you want to profile.
4. If necessary, click the arrows in the **Build configuration** field and select **Default**.
5. On the Arguments tab, specify any arguments to pass to the binary file to be profiled.
6. Optional: On the Events tab, you can clear the **Use default event** check box to select a different event to be monitored. You can also select multiple events within the same group. The number of events varies by system, but typically you can select up to six events.

7. On the Global tab, click the arrow in the **Profile with** field to select which profiling method, `opcontrol` or `operf`, to use. If you select `opcontrol`, you can also select from the following options:
   - Specify a **kernel image file**. This option collects more detailed information about the operation of a program in the Linux kernel. Type the file name or click **Browse** to locate and select it.

     Note: When you select this option, you must also select the **Include dependent kernel modules** option.
   - **Include dependent shared libraries**. Select this option to include samples from shared libraries that are used by the profiled program. These samples are then aggregated in the profile results.
8. Click **Profile** to begin the profiling. After the profiling completes, an OProfile tab opens and displays the event types that were profiled.
9. You can expand the events to view the binary image, function, and line numbers where the profiling collected most of the events that were profiled. The results are sorted with the functions that the program spent the most time executing shown first. You can click on an item to open the source code.

Related information:

Taking advantage of OProfile

6.3 Analyzing performance with Perf

You can use Perf to profile your project and analyze its performance. Perf uses information produced by the Linux kernel perf events subsystem to profile a running application. Perf analyzes software, hardware, and tracepoint events.

Perf is an optional but recommended package. If you want to use Perf, you must download and install it as described in 2.2, "Recommended and optional packages," on page 9.

6.3.1 Profiling a project with Perf

You can use Perf to profile your project to analyze its performance.

Before you begin

Before you can use Perf, you must ensure that you have downloaded and installed it as described in 2.2, "Recommended and optional packages," on page 9.

About this task

Complete these steps to profile a project using Perf.

Procedure

1. Switch to the C/C++ perspective by clicking **Window** > **Open Perspective** > **C/C++**. Click **OK**.
2. View the project by clicking the project name in the Project Explorer pane.
3. Click **Profiling Tools** > **Profiling Tools Configurations**.
4. In the Profiling Tools Configurations window, click **Profile with Perf** in the left pane, and then click the New launch configuration icon near the upper left of the window.
5. On the Main tab, beside the **C/C++ Application** field, click **Search Project** to select the binary file that you want to profile.
6. On the Arguments tab, specify any arguments to pass to the binary file to be profiled.
7. Optional: On the Perf Options tab, you can change default profiling settings.
8. Optional: On the Perf Events tab, you can clear the **Default Event** check box to select a different event to be monitored. You can also select multiple events.

9. Click **Profile** to begin the profiling. After the profiling completes, a Perf tab opens and displays the event types that were profiled.
10. You can expand the events to view the binary image, function, and line numbers where the profiling collected most of the events that were profiled. The results are sorted with the functions that the program spent the most time executing shown first. You can click on an item to open the source code.

6.3.2 Profiling a synchronized project with Perf

You can use Perf to profile a synchronized project to analyze its performance.

Before you begin

Before you can use Perf, you must ensure that you have downloaded and installed it as described in 2.2, "Recommended and optional packages," on page 9.

About this task

Complete these steps to profile a synchronized project using Perf.

Procedure

1. In the Project Explorer pane, right-click the project name. Click **Profiling Tools** > **Profiling Tools Configurations**.
2. In the Profiling Tools Configurations window, click **Profile with Remote Perf** in the left pane, and then click the New launch configuration icon near the upper left of the window.
3. On the Main tab, below **C/C++ Executable**, click **Browse** to select the binary file that you want to profile.
4. On the Arguments tab, specify any arguments to pass to the binary file to be profiled.
5. Optional: On the Perf Options tab, you can change default profiling settings.
6. Optional: On the Perf Events tab, you can clear the **Default Event** check box to select a different event to be monitored. You can also select multiple events.
7. Click **Profile** to begin the profiling. After the profiling completes, a Perf tab opens and displays the event types that were profiled.
8. You can expand the events to view the binary image, function, and line numbers where the profiling collected most of the events that were profiled. The results are sorted with the functions that the program spent the most time executing shown first. You can click on an item to open the source code.

6.4 Profiling a project with gprof

The GNU profiler, or gprof, is a performance analysis tool that creates an execution profile of your C or C++ program. Gprof uses static instrumentation to calculate the amount of time expended in a function of the program, and the number of times the function is called.

Before you begin

You must compile the binary files with the `-pg` option. This option produces profiling information required for analysis by gprof. See "Recommendations for debug flags" on page 35 and 4.1.2, "Setting debug flags for Autotools-based projects," on page 40 for details and instructions for setting the flags.

About this task

Complete these steps to profile a project with gprof.

Procedure

1. Run the application. See 2.4.7, "Running an executable program in a project," on page 19. Profiling information is output to the `gmon.out` file in the same folder location as the application binary file.
2. Refresh the view by right-clicking the project name and clicking **Refresh**.
3. Double-click the `gmon.out` file.
4. In the Binary File selection window, click **Workspace** or **File System** to select the binary file that produced the profile data. Click **OK**. A gprof view tab appears. The view enables you to visualize profiling information.
5. Optional: Use the controls in the upper right of the view to change information visualization.

6.5 Analyzing application behavior using Valgrind

Valgrind is an open source programming tool used for detecting memory leaks, memory debugging, and performing detailed profiling to find blockages in programs. Supported Valgrind tools include Memcheck memory error detector, Helgrind thread error detector, Massif memory usage profiler, and Cachegrind cache and branch-prediction profiler.

Memcheck detects memory management problems, reporting these errors as they occur. Memcheck gives the source line number at which the error occurred, and a stack trace of the functions called up to that line. Problems detected by Memcheck include the following:

- Illegal read and write operations
- Use of unitialized values
- Use of uninitialized or unaddressable values in system calls
- Illegal freeing of memory
- Memory freed with inappropriate deallocation functions
- Overlapping of source and destination blocks on memory copy functions
- Memory leaks

Helgrind is a POSIX thread (Pthreads) debugger that finds data races in multithreaded programs as well as other Pthread-related problems. Problems detected by Helgrind include the following:

- Misuses of the Pthreads API
- Deadlock caused by lock ordering
- Data race conditions

Massif is a memory profiler that analyzes heap and stack usage.

Cachegrind is a cache and branch-prediction profiler. Cachegrind identifies the number of cache misses, memory references, and instructions executed for each line of source code.

6.5.1 Profiling a project using Valgrind

You can use Valgrind to profile your project to detect memory leaks, debug memory issues, and perform detailed profiling.

Before you begin

Before you profile a project, ensure that the project has been built.

About this task

Complete these steps to profile a project using Valgrind.

Procedure

1. Switch to the C/C++ perspective by clicking **Window** > **Open Perspective** > **C/C++**. Click **OK**.
2. View the project by clicking the project name in the Project Explorer pane.
3. Click **Profiling Tools** > **Profiling Tools Configurations**.
4. In the Profiling Tools Configurations window, click **Profile with Valgrind** in the left pane, and then click the **New launch configuration** icon near the upper left of the window.
5. On the Main tab, beside the **C/C++ Application** field, click **Search Project** to select the binary file that you want to profile.
6. If necessary, click the arrows in the **Build configuration** field and select **Default**.
7. On the Arguments tab, specify any arguments to pass to the binary file to be profiled.
8. On the **Valgrind Options** tab, select the tool to run and select the options that best fit your profiling needs.
9. Click **Profile** to begin the profiling.

Results

The source code is displayed. Lines that have errors that were detected by Valgrind are highlighted with an "X". See 6.5.3, "Applying quick fixes for Valgrind-reported errors," on page 75 for information about how to resolve them.

6.5.2 Profiling a synchronized project using Valgrind

You can use Valgrind to profile your synchronized project to detect memory leaks, debug memory issues, and perform detailed profiling.

Before you begin

Before you profile a project, ensure that the project has been built.

About this task

Complete these steps to profile a synchronized project using Valgrind.

Procedure

1. Switch to the remote C/C++ perspective by clicking **Window** > **Open Perspective** > **Other** > **Remote C/C++**. Click **OK**. The synchronized project should be displayed under the Project Explorer view.
2. In the Project Explorer pane, right-click the project name. Click **Profiling Tools** > **Profiling Tools Configurations**.
3. In the Profiling Tools Configurations window, click **Profile with Valgrind (Remote)** in the left pane, and then click the New launch configuration icon near the upper left of the window.
4. On the Main tab, beside the **C/C++ Application** field, click **Browse** to select the binary file that you want to profile.
5. If necessary, click the arrows in the **Build configuration** field and select **Default**.
6. On the Arguments tab, specify any arguments to pass to the binary file to be profiled.
7. On the **Valgrind Options** tab, select the tool to run and select the options that best fit your profiling needs.
8. Click **Profile** to begin the profiling.

Results

The source code is displayed. Lines that have errors that were detected by Valgrind are highlighted with an "X". See 6.5.3, "Applying quick fixes for Valgrind-reported errors" for information about how to resolve them.

6.5.3 Applying quick fixes for Valgrind-reported errors

IBM SDK for Linux on Power provides quick fixes for errors found by Valgrind. Quick fixes are suggestions or tips that might help correct identified errors.

Before you begin

Ensure that you have profiled your project with Valgrind, as described in 6.5.1, "Profiling a project using Valgrind," on page 73 and 6.5.2, "Profiling a synchronized project using Valgrind," on page 74.

About this task

After you run Valgrind, the source code is displayed, and the lines that have errors are highlighted with an "X". Complete these steps to fix problems that are found with Valgrind.

Procedure

1. Right-click the line with the error, and select **Quick Fix**. If there are any quick fixes available, they are displayed in a list.
2. Select the appropriate quick fix. The fix is applied and the program source changed automatically to fix the source.

6.6 Monitoring performance using SystemTap

SystemTap is a tool and scripting language you can use to dynamically monitor running Linux applications. SystemTap allows you to gather data and diagnose complex performance problems.

Ensure that you complete post-installation setup tasks described in 2.2.2.1, "Setting up SystemTap," on page 10

6.6.1 Editing a SystemTap script

Use the SystemTap IDE perspective to create and edit SystemTap scripts.

Before you begin

Ensure that you have completed the following:
1. Installed the optional SystemTap package, as described in 2.2, "Recommended and optional packages," on page 9.
2. Completed the setup tasks in 2.2.2.1, "Setting up SystemTap," on page 10.

About this task

Complete these steps to edit or create a SystemTap script.

Procedure

1. Switch to the SystemTap IDE perspective by clicking **Window** > **Open Perspective** > **Other**. In the Open Perspective window, click **SystemTap IDE**. Click **OK**.
2. Open a SystemTap script. SystemTap scripts must have a file extension of `.stp`.
   - To edit an existing script, click **Open a File** in the toolbar and select the script.

- To create a script, click **File** > **New** > **Other**. Specify a name for the script with the file extension `.stp`.

3. Edit the SystemTap script. Make selections from the three tabs displayed on the left.
   - The Probe Alias tab displays all available kernel probes. Kernel probes are a set of tools that collect Linux kernel debugging and performance information. To add a probe to the current SystemTap script, double-click it on the Probe Alias tab.
   - The Function tab displays all available functions for SystemTap scripts. To add a function to the current SystemTap script, double-click it on the Function tab.
   - The Kernel Source tab is used to explore the kernel source, while editing a SystemTap script. To open a kernel source file, double-click it on Kernel Source tab.

6.6.2 Running a SystemTap script

You can run a SystemTap script from the SystemTap IDE perspective. Optionally, you can select to generate a chart containing your results.

Before you begin

Ensure that you have completed the following:

1. Installed the optional SystemTap package, as described in 2.2, “Recommended and optional packages,” on page 9.
2. Completed the setup tasks in 2.2.2.1, “Setting up SystemTap,” on page 10.

About this task

Complete these steps to run a SystemTap script.

Procedure

1. Switch to the SystemTap IDE perspective by clicking **Window** > **Open Perspective** > **Other**. In the Open Perspective window, click **SystemTap IDE**. Click **OK**.
2. Open a SystemTap script by clicking **Open a File** in the toolbar and selecting the script.
3. To run the script, click **Run the Script** in the toolbar. The results of the script are displayed in the Console view.
4. To stop a running script, click **Stop running Script** in the toolbar.

Results

The chart is displayed in the main view.

6.6.3 Running a SystemTap script with chart

You can run a SystemTap script and generate a chart containing your results from the SystemTap IDE perspective.

Before you begin

Ensure that you have completed the following:

1. Installed the optional SystemTap package, as described in 2.2, “Recommended and optional packages,” on page 9.
2. Completed the setup tasks in 2.2.2.1, “Setting up SystemTap,” on page 10.

About this task

Complete these steps to run a SystemTap script and produce a chart with results.

Procedure

1. Switch to the SystemTap IDE perspective by clicking **Window** > **Open Perspective** > **Other**. In the Open Perspective window, click **SystemTap IDE**. Click **OK**.
2. Open a SystemTap script by clicking **Open a File** in the toolbar and selecting the script.
3. To run the script, click **Run the Script w/ Chart** in the toolbar. The Create Data Set window is displayed.
4. In the Create Data Set window, select either **Row Data Set** or **Table Data Set** to specify how your data is to be formatted.

   Tip: An example of the formatting type are displayed on the right when you select the option. Click **Next**.
5. In the Select Row Data Set Parsing window, specify the number of columns and type the names of each column. Click **Finish**. The SystemTap Graphing perspective displays and the results display in the Console view and in a table in the Data View tab.
6. Click **Create Graph**, in the left of the Data View tab. The Create Graph window is displayed.
7. In the Create Graph window, complete the following steps.
   a. Select an option to specify the type of chart you want to generate. Click **Next**.
   b. Type a title for the chart, and select the X axis and Y axis to be used to plot the chart. Click **Finish**.

Results

The chart is displayed in the main view.

6.7 Analyzing POSIX Threads using Trace Analyzer

The IBM Software Development Kit for Linux on Power includes Trace Analyzer, a plug-in for graphical and numerical analysis of performance traces.

6.7.1 Trace Analyzer overview

Trace Analyzer allows graphic visualization and analysis of POSIX Threads (Pthreads) concurrency.

Concurrency information is generated by a Pthread monitoring tool running on Pthread-based applications. The monitoring tool can be invoked from within the visualizer or from the command line. The concurrency information includes synchronization using mutexes, spinlocks, and conditional variable signaling.

With the Trace Analyzer, you can perform the following analysis tasks:
- Collect the Pthreads profile and view the resulting trace.
- View the active threads and the blocking operations.
- View the active locks and spinlocks, threads waiting on locks, threads holding locks, and queue sizes.
- View conditional variables, threads waiting for them, and the contention for the associated mutexes.
- Collect a trace of blocking I/O requests, and view the trace together with the synchronization data.

6.7.2 Profiling a project with Trace Analyzer

You can profile a project with Trace Analyzer to analyze Pthreads concurrency.

Before you begin

Before you profile a project, ensure that it has been built.

Procedure

1. In the Project Explorer pane, right-click the project name and select **Profile as** > **Profile Configurations**.
2. In the Profile Configurations window, select **Profile with Trace Analyzer for Pthreads** in the left pane, and then select the **New launch configuration** icon near the upper left of the window.
3. On the Main tab, click **Browse** from the **C/C++ executable** to select the binary to be profiled.
4. On the Main tab, click **Browse** from the **Working directory** to select the folder to be used by the profiling tool.
5. On the Arguments tab, specify the necessary arguments to run the application.
6. Click **Profile**.
7. Optional: To enable operating system I/O monitoring using SystemTap along with data collection, complete this step. On the pthread-mon+ tab in the Operating system monitoring section, select the **I/O** option from the list of available options. The default is no I/O monitoring. If I/O monitoring is enabled, the I/O monitoring traces read and write system calls. The system call times are shown with application times.
8. Optional: To adjust the depth of stack trace information to be collected in the traces, complete this step. On the pthread-mon tab in the Number of frames to back trace section, select the number of frames from the list of available options. Available values are 0 - 9; the default is 2.

6.7.3 Collecting a trace by setting variables from the command line

You can set variables from the command line to affect how a trace is collected.

About this task

Select from the following options.

Procedure

- Set the **`SASSTOREPATH`** variable to point to a directory for temporary log files. Ensure that you have write permission and enough disk space in the directory. 32-bit and 64-bit applications must use different directories. Different profiling runs can use the same directory if they use different tags.
  - If the application under monitoring terminates abnormally, clean the data directory by setting the **`SASSTOREPATH`** variable as follows:

    ```
    SASSTOREPATH=directory <$PMHOME>/pthreadmon/ bin/sasutil
    ```

    Specify the same directory as in the monitoring run for *directory*. Running this command displays a list of options; select `6` to remove the data.
- Set the **`MONITOREDAPPTAG`** variable to be the identifier of the monitored execution. Allowed characters are `a` to `z`, `A` to `Z`, and `0` to `9`. Usually the tag contains the application name, settings description, and date and time of the run. The tag cannot be longer than 100 characters.
- Optional: Set the **`BT_LEVEL`** variable to be the depth of the call stack to be recorded with monitored events. Allowed values are 0 - 4; the default is 2.
- Optional: Set the **`OSMONITOR`** variable to describe the operating system data to collect. The only supported value is `io`, which triggers logging of read/write system calls. It is supported only for 64-bit programs and might not work with large logs.

Results

The log files are written to `($MONITOREDAPPTAG)_log`*`file_number`*`.pthreads` files in the current directory. If the monitored data is large, the log is split into multiple files, for example: `($MONITOREDAPPTAG)_log0.pthreads`, `($MONITOREDAPPTAG)_log1.pthreads`, `($MONITOREDAPPTAG)_log2.pthreads`, and so on.

Note: If there is not enough space to hold all of the events, the logger might drop events in the beginning of the trace.

Example

Note: By using the code examples, you agree to the terms of the 10, "Code license and disclaimer information," on page 97.

```
[pmhome/pthread-mon/test]# SASSTOREPATH=/tmp/sasdata64
MONITOREDAPPTAG=appTag BT_LEVEL=2 ../scripts/pthread-mon ./app64
<... snip ...>
Hello world!

[pmhome/pthread-mon/test]# cat appTag_log0.pthreadss
0 1350069905206059 27241 0x10010c90
1 1350069905216439 27241 0 4398060282400
2 1350069905216827 27241 4398060282400 0x10000758 0x4000014276c
99 0x10000758 ../app/app ./app.c:20
99 0x4000014276c /lib64/power5/libc.so.6 ??:0
3 1350069905296762 27241 0
```

6.7.4 Record Details view

The Record Details view shows name/value pairs for all the fields defined for the selected record.

The call-stack information in the Record Details view can be used to match specific blocking events to source code lines. For example, BacktraceExec0 is the executable program, and BacktraceLine0 is the line in that executable program from which the blocking function is called.

The Record Details view includes the following tabs: Overview, Waits by thread, Hot locks, Hot spins, and Hot Cond Var. In each tab of the view, the x axis is the time, increasing from left to right. Each Pthread view has options available in the Properties view for toggling the display of each metric.

Overview tab

The Overview tab view gives an overview of all threads synchronization actions . The threads are shown as gray blocks spanning the entire thread lifetime. Synchronization events are shown above the thread block, and operating system events (if available) are shown below it.

Start Indicates when the thread is created.

End Indicates when the thread is ended.

Join Indicates that the thread is waiting to join another thread.

Mutex_lock
Indicates that the thread is blocking because it is trying to acquire a mutex.

Condvar_wait
Indicates that the thread is blocking because it is waiting on a conditional variable.

IO Indicates that the thread was blocked in I/O (operating system event).

Waits by thread tab

The Waits by thread tab view displays the Pthread locks for each thread that is blocked, waiting to acquire a specific mutex. The display includes colors to differentiate between the different mutexes. The list of displayed threads can be edited through the Properties view.

Hot locks tab

The Hot locks tab view shows the number of Pthreads that are blocked, waiting to acquire each mutex.

Blocking before lock
Shows the number of threads blocking as a result of calling pthread_mutex_lock. The color displayed is determined by the last thread in the queue.

Hold Shows the lock lifetime and the intervals for which the lock was held. The colors displayed for lock lifetime match those in the Waits by thread view. The color displayed for the intervals is determined by the holding thread.

Blocking after wait
Shows the number of threads blocking while trying to reacquire a mutex that was lost while waiting on a conditional variable. The color displayed is determined by the last thread in the queue.

Hot spins tab

The Hot spins tab view shows the thread holding the spin lock and number of threads waiting on that spin lock over time.

Wait Shows the number of threads blocking as a result of calling pthread_spin_lock. The color displayed is determined by the oldest thread in the queue.

Hold Shows the spin lock lifetime and the intervals in which it was held. The colors displayed for lock lifetime match those in the Waits by thread view. The color displayed for the intervals is determined by the holding thread.

Hot Cond Var tab

The Hot Cond Var tab view shows the number of Pthreads waiting for each conditional variable. In addition, the view shows how many threads are blocking, waiting to acquire this mutex, for each mutex guarding the conditional variable. As in the Hot locks tab, the view on this tab contains two graphs for each mutex.

Blocking before lock
Shows the number of threads blocking as a result of calling pthread_mutex_lock. The color displayed is determined by the last thread in the queue.

Hold Shows the lock lifetime and the intervals for which the lock was held. The colors displayed for lock lifetime match those in the Waits by thread view. The color displayed for the intervals is determined by the holding thread.

Blocking after wait
Shows the number of threads blocking while trying to reacquire a mutex that was lost while waiting on a conditional variable. The color displayed is determined by the last thread in the queue.

The list of displayed conditional variables can be edited through the Properties view.

6.8 Analyzing coverage with gcov

The GNU test coverage program, or gcov, is a tool that uses static instrumentation to generate test coverage information.

Before you begin

Ensure that the following steps have been completed before you use gcov.

1. Compile the binary files with the `-ftest-coverage` and `-fprofile-arcs` options.

`-ftest-coverage` produces a text file that gcov uses to show program coverage. `-fprofile-arcs` instruments the resulting binary flow arcs. See "Recommendations for debug flags" on page 35 and 4.1.2, "Setting debug flags for Autotools-based projects," on page 40 for details and instructions for setting the flags.

2. Link the binary files to the gcov library. Complete the following steps.
   a. Expand **C/C++ Build** > **Settings**.
   b. Expand **GCC C++ Linker** > **Libraries**.
   c. In the Libraries window, click **+**, the "Add..." icon.
   d. In the **Libraries** field in the Enter Value window, type `gcov`.

About this task

Complete these steps to profile a project with gcov.

Procedure

1. Run the application. See 2.4.7, "Running an executable program in a project," on page 19. Coverage data is saved to *`object_name`*`.gcda` files, one for each object.
2. Refresh the view by right-clicking the project name and clicking **Refresh**.
3. Double-click the *`object_name`*`.gcda` file.
4. In the Binary File selection window, click **Workspace** or **File System** to select the binary file that produced the coverage data. Click **OK**. A gcov view tab appears. The view enables you to visualize profiling information. Double-click any row in the report to display source code with coverage highlighted.
5. Optional: Use the controls in the upper right of the view to change information visualization.

6.9 Analyzing performance with Power Performance Advisor

The POWER Performance Advisor (PPA) plug-in allow users to profile C/C++ applications selecting a set of metrics based on the chosen target processor. PPA leverages Ocount tool; an OProfile tool used to count native hardware events, to gather the processor performance data and calculate the metrics.

About this task

Complete those steps to profile a local or a synchronized project that uses PPA plug-in.

Procedure

1. Switch to the C/C++ perspective by selecting **Window** > **Open Perspective** > **C/C++**. Click **OK**.
2. Right-click the project in the Project Explorer pane.
3. Select **Profile as** > **Profile Configurations**.
4. In the Profiling Configurations window, select **Profile with PPA** in the left pane, and then select the **New launch configuration** icon near the upper left of the window.
5. On the Metrics tab, complete the following fields:

   POWER CPU version in **CPU Model** field

   Metric analysis type in the **Analysis type** field

   Metrics in the **Metrics group**field

   Note: To change the Ocount that is used during the profile, select **Change path** from the **Counter Tool** group.
6. On the Main tab, click **Browse** from the **C/C++ executable** field to select the binary file to be profiled.
7. On the Main tab, click **Browse** from the **Working directory** field to select the folder to be used by the profiling tool.

8. On the Arguments tab, specify any arguments to pass to the binary file to be profiled.
9. Click **Profile** to begin the profiling. After the profiling completes, a PPA view opens and displays each metrics value with their corresponding events.

6.10 Analyzing projects built with the Build Advisor

The Build Advisor plug-in allows users to receive advice on the set of flags that can be tuned for Power during the build process in order to improve the application performance.

The Build Advisor parsers the build output, analyzes the set flags used and based on that analysis, gives advice on what flags can make the application perform better.

6.10.1 Enabling the Build Advisor

By default, the Build Advisor is disabled for new projects.

About this task

Use the following steps to activate it:

Procedure

1. Right-click the project in the **Project Explorer** pane and select **Properties**.
2. In the **Properties** window, expand **C/C++ Build**and select **Settings**.
3. In **Settings** windows, change to **Error Parsers** tab and mark the option **Build Advisor Output Parser**.
4. Press **OK**

Results

The Build Advisor is now successfully enabled.

6.10.2 Enabling extra advice from Build Advisor

There are some advice provided by Build Advisor that are not activate by default because they might change the binary behavior. For example, some flags can increase the binary size or reduce the floating point operation precision in order to gain performance.

About this task

Follow the steps below to activate those extra advice:

Procedure

1. Right-click the project in the **Project Explorer** pane and select **Properties**.
2. In the **Properties** window, select **Build Advisor**.
3. Under the option **Enable extra advice**, enable the extra advice that will be used during the analysis.
4. Press **OK**.

Results

The Build Advisor is now successfully activated.

6.10.3 Using the Build Advisor

About this task

Complete the steps below to use Build Advisor.

Note: It is important to ensure that the Build Advisor is enabled.

Procedure

1. Right-click the project in the **Project Explorer** pane and select **Build Project**.
2. After the project build, the advice will be shown in the **Build Advisor** view.

7 Analyzing performance with Source Code Advisor and FDPR

The IBM Software Development Kit for Linux on Power provides two related tools, Source Code Advisor (SCA) and the Feedback Directed Program Restructuring tool (FDPR), that implement feedback-directed, post-link program analysis and optimization technology. SCA finds and visualizes performance problems in the application source code, using journaling information produced by using FDPR. SCA alerts you to problems, and provides you with tips for restructuring source code and modifying compiler flags.

7.1 Source Code Advisor and FDPR overview

Source Code Advisor (SCA) and Feedback-Directed Program Restructuring (FDPR) work together to allow you to analyze and optimize your applications.

FDPR works similarly to a compiler: it reads a linked executable program and produces an optimized version of it. Both regular executable and shared library forms are supported. The optimization uses an execution profile, collected by running an instrumented version of the input.

During the code optimization process, FDPR produces a journal of the optimizations performed. The Source Code Advisor uses this journal, produced as an XML file, to highlight potential problems in your source code and to offer suggested solutions. The journal explains each optimization site, including the source location, execution count, the performance problem found, and the user action required to resolve the problem. It is important to select a representative workload for both SCA and for FDPR so that the optimization step is effective.

Because SCA uses information gathered by FDPR, knowledge of this tool is important. To understand the main requirements and principles, review the FDPR Getting Started document, available in the IBM SDK for Linux on Power online help. (You can access this document from the user interface by clicking **Help** > **Help Contents**. Then expand **FDPR Optimization Tools Documentation** > **Getting Started**.)

The combination of SCA and FDPR provide you with two major approaches to performance analysis and optimization:
- Find and visualize performance problems in the source program using feedback-directed analysis.
- Perform feedback-directed optimization of an executable program (or a shared library).

Performance problem visualization using Source Code Advisor

The SCA configuration allows you to specify the workload needed to collect the profile of the program. When running this configuration, the program is built, if necessary, using the standard project build process. Once the executable is available, FDPR creates an instrumented version and runs it using the specified workload. FDPR then performs a pseudo optimization step producing a journal of the performance problems found. The result is an XML-formatted file that lists the specific problems found, their exact location in the source, and so on. With the XML journal available, the Source Code Advisor view is displayed to visualize the set of problems, allowing you to navigate through the problems and the corresponding places in the source where they were found. The view provides a recommended course of action for each problem at various abstraction levels (source change, compiler switches, and so on.)

Feedback-directed optimization using FDPR

FDPR optimization is begun through the FDPR configuration. As with the SCA configuration, you specify a workload, typically the same workload. You can also specify the set of optimizations to be used. Running the FDPR configuration includes optional instrumentation and profiling steps. These steps are needed if the original program has changed, if no profile exists yet, or if you specifically requested to re-create it. Following that, the optimization step is performed, producing the optimized version.

7.2 Running the Source Code Advisor on a project

You can run SCA on a project to begin the process of performance problem visualization.

Before you begin

Ensure that you compile the binary files with the `-Wl` and `-q` flags. See "Recommendations for debug flags" on page 35 and 4.1.2, "Setting debug flags for Autotools-based projects," on page 40 for details and instructions for setting the flags.

About this task

Complete the following steps.

Procedure

1. In the Project Explorer pane, right-click the project name. Click **Profile as** > **Profile Configurations**.
2. In the Profile Configurations window, expand **Profile with Source Code Advisor** in the left pane and select the **New launch configuration** icon near the upper left of the window.
3. On the FDPR Options tab, select appropriate options. See 7.6, "Optimizing executable code using FDPR," on page 88 for more details on specifying FDPR options.
4. On the Main tab, click **Browse** from the **C/C++ Application** field to select the binary file to be profiled.
5. On the Main tab, click **Browse** from the **Working directory** field to select the folder to be used by the profiling tool.
6. On the Arguments tab, specify any arguments to pass to the binary file to be profiled.
7. Click **Profile**.

Results

SCA first builds the program, if necessary, using the standard project build process. After the executable file is available, an instrumented version is created by FDPR and run using the specified workload. FDPR then performs a pseudo-optimization step, producing a journal of the performance problems found and fixed. The journal is an XML formatted file that lists the specific problems found and their exact location in the source. The journal corresponds to a specific workload, as specified on the Arguments tab in the profile configuration.

When the journal is available, the SCA results are displayed automatically in the Source Code Advisor view. See 7.4, "Reviewing the Source Code Advisor results," on page 87 for information about using the SCA view.

7.3 Viewing Source Code Advisor on an existing journal

You can open SCA on a journal that has already been collected.

About this task

Complete the following steps.

Procedure

1. If the SCA view is not already open, complete the following steps to open the SCA view.
   a. Click **Window** > **Show View** > **Other**.

b. In the Show View window, expand **FDPR** and click **Source Code Advisor**. Click **OK**.
2. In the Project Explorer pane, select the journal file to be viewed. The journal file name begins with the name of the program and ends with `-jour.xml`. See 7.4, "Reviewing the Source Code Advisor results" for information about using the SCA view.
3. If you reprofile the program with SCA, the profile will be replaced. If you want to keep the journal file but collect a journal for a different workload, you can save it with a different name. To save the file, copy and paste it with a different name. Ensure that the new name ends with `-jour.xml`.

7.4 Reviewing the Source Code Advisor results

After you run SCA, you can review the results including the specific performance problems.

About this task

The SCA results are shown in the Source Code Advisor view. This view consists of the following panes:
- A performance event pane, in an expandable tree format, on the left.
- A problem/solution pane on the right.

At the top level, the performance event tree shows each of the performance event types, such as FIX LOAD-HIT-STORE, UNROLL LOOP, and INLINE FUNCTION. The right pane shows the problem and solution for the selected event. Refer to 7.5, "Source Code Advisor events" for information about the performance events and the various levels (source code, compiler, and linker).

The performance event tree provides detailed information about the actual instances of the performance events in the user program.

Procedure

- To display the functions where a performance event occurred, expand an event type at the root level . The function entries are sorted by frequency of occurrence when the instrumented program was run.
- To display site-specific parameters for the event, expand a line entry for the event. For example, select a parameter the represents a site in the program such as a line number or function. This displays the corresponding source code in the editor.

7.5 Source Code Advisor events

Events flagged by the Source Code Advisor are journal entries produced by FDPR. Each journal entry includes information about the performance problem and a general approach for solving it. It also includes suggested changes for compiler or linker command-line flags, and suggested source code changes.

The Source Code Advisor supports the following FDPR journal entries.

Table 14. SCA events

Event	Problem description
INLINE FUNCTION	High overhead for frequent calls to a small function
UNROLL LOOP	High branch penalty in a small loop
DIRECT TOC ACCESS	Data cache pressure is caused by TOC-load instructions
REDUCE FOR EARLY EXIT	High overhead for function which very frequently returns quickly (for example, saving registers that are not changed before returning)
MOVE HOT CODE TO COLD AREA	Invariant or infrequently executed code found within a loop

Table 14. SCA events (continued)

Event	Problem description
FIX LOAD-HIT-STORE	A data store operation followed closely by a load from the same address causes the load to take extra time to complete
DE-VIRTUALIZE FUNCTION CALL	Indirect function calls (virtual functions or by function pointers) have higher overhead than direct function calls
SHORTCUT PLT CALL	Call-through-PLT to local procedure has high call overhead. A call to a function that is contained in the same object is routed indirectly through the Procedure Linkage Table (PLT). This is normal, to allow for symbols being overridden within the process. However, it is more expensive than a direct call.
EXTSW INSTRUCTION	A frequently encountered conversion of a signed 32-bit integer type (int) to a signed 64-bit integer type (long), possibly implicitly, requires an extra "sign extension" instruction that can also delay subsequent dependent instructions
FMRTOXXLOR	High latency of the FMR/FPR instruction
XSCPSGNDPXXLOR	High latency of the Xscpsgndp instruction
TARGET TO SOURCE DEPENDENT INSTRUCTIONS	Sequence of dependent instructions is not optimal
INT TO FLOAT CONVERSION	High penalty for int to float conversion
LOADING FROM A CONST AREA	High penalty for loading from a const area
BRANCH PREDICTION	High penalty for wrong branch prediction
KILLED REGISTERS	High penalty for stores and restores of registers that are killed (overwritten) after frequently executed function calls
LINK REGISTER OPTIMIZATION	High penalty for saves and restores of the link register in frequently executed functions
TOC STORE IN LOOP OPTIMIZATION	High penalty for TOC store in loop operation

For information about the suggested solution, compiler and linker flag changes, and source code changes, see the Source Code Advisor Problems/Solutions Reference document, available in the IBM SDK for Linux on Power online help. (You can access this document from the user interface by clicking **Help** > **Help Contents**. Then expand **FDPR Optimization Tools Documentation** > **Reference** > **Source Code Advisor problem/solution reference**.)

7.6 Optimizing executable code using FDPR

Feedback Directed Program Restructuring (FDPR) allows you to perform feedback-directed optimization of an executable or shared library. Also known as the post-link optimization tool, FDPR optimizes the executable image of a program based on a typical profile.

FDPR optimization is performed in three distinct steps:

- Instrumentation: FDPR analyzes the input program and creates an instrumented version and an empty profile.
- Profiling: The instrumented program is run with some representative input. During this run, the profile is filled with various counts, such as how many times each branch was executed.
- Optimization: FDPR processes the input program together with the now filled profile. It performs various optimizations based on this profile, such as code restructuring, making the program run more efficiently.

The IBM Software Development Kit for Linux on Power allows you to run FDPR through the FDPR plug-in.

7.6.1 Specifying FDPR optimization for a project

You can specify workload and optimization flags for FDPR for a project.

About this task

To specify workload and optimization flags for FDPR, complete the following steps.

Procedure

1. In the Project Explorer pane, right-click the project name. Click **Run as** > **Run Configurations**.
2. In the Profile Configurations window, right click in **FDPR** and click **New** to create a configuration profile.
3. On the Main tab, click **Browse** from the **C/C++ Application** field to select the binary file to be profiled.
4. On the Main tab, click **Browse** from the **Working directory** field to select the folder to be used by the profiling tool.
5. On the Arguments tab, specify the workload to be used to form the execution profile. It is important to select a representative workload so that the following optimization step is effective. Typically the same workload should be used for both SCA and for FDPR.
6. On the FDPR Options tab, select appropriate options.
   - The Optimized binary section specifies the component of the application that is being optimized. Select the main executable program or a shared library.
   - The Optimization level section allows you to specify the optimization flags used by FDPR. Select from options such as **O**, **O2**, **O3**, and **O4**. Or you can specify **Other** to specify specific options.

     Note: For more detailed information about specifying options for FDPR, refer to the FDPR reference manual, available in the IBM SDK for Linux on Power online help. You can access this document from the user interface by clicking **Help** > **Help Contents**. Then expand **FDPR Optimization Tools Documentation** > **Reference** > **FDPR reference manual**.
   - The **Architecture** field controls architecture-specific optimizations, like code alignment. Select a specific architecture, such as **power8** or **power7**.
   - The Info output section lists options to control the informational output. Select the maximum level of warnings printed to the console and whether to print progress messages to the console.
   - The Start/continue profile and program section lists options for profiling or optimizing a running server application. This section includes three radio button groups to control the way the profile and program are started or continued.
     - **Start program** (default) or **Continue program**: **Start program** causes the program to be restarted. The program is kept running if **Continue program** is selected.
     - **Start with empty profile** (default) or **Continue with last profile**: By default, the profile is cleared before actual profiling begins. If **Continue with last profile** is selected, the last profile collected is used to initialize the profile.
     - **Profile until completion** (default) or **Profile for ___ seconds**: By default, the profile is collected until the program completes. If the other option is selected, a number of seconds must be specified. The profile is collected only for that amount of time, and the program continues to run.

   For example, some typical cases might include the following:

   a. Start the program with an empty profile and profile until the program terminates.
   b. Start the program with an empty profile. Profile for a specified number of seconds, and leave the program running.

   c. Begin with the previous case to start the program or server, and collect an initial profile. Then, continue the program with the existing profile and profile for a specified number of seconds. This case can be repeated multiple times, accumulating profile information across several time periods.
7. On the Environment tab, you can specify the following environment variables:

   FDPR_BINDIR
      The directory where FDPR binary files were installed. Default: `/opt/ibm/fdprpro/bin`.

   FDPR_LIBDIR
      The directory where FDPR libraries were installed. Default: `/opt/ibm/fdprpro/lib`.

   FDPR_PROF_COMMAND
      A user-provided script used to profile the program. The script is invoked as script *`prog`* `arg ...`, where *prog* is the instrumented program or, when profiling a shared library, the original program. The default is to directly execute the program with the specified arguments.
8. Click **Run**.

Related information:

Feedback Directed Program Restructuring (FDPR)

8 Automatic updates

The SDK provides an update site that allows consuming updates automatically.

By activating the automatic updates the SDK will periodically look for updates at the IBM public FTP located at `ftp://public.dhe.ibm.com/software/server/iplsdk/<SDK_Version>/repository`. The SDK will not collect or share any information about your environment and will not install anything without your authorization. Once an update is found you will be asked on how to proceed. You can review your decision at **Window** > **Preferences** > **Install/Update** > **Automatic Updates**.

Note: When installing the SDK, a group called `ibmsdklop` is created and the users whom have access to the graphical interface will be automatic added to it. Only the members of this group can perform the automatic updates of the SDK components.

Adding a new user to the `ibmsdklop` group

To add a user to the `ibmsdklop` group, run `#usermod -aG ibmsdklop <USER>`.

Granting access to the updates installed to all users

When an user installs an update for the SDK, the permissions of the files that are installed are assigned to that specific user. All other users are not able to access the newest installed resources. In order to make these resources available to all users, you must restore the correct permissions. Follow the instructions below:

```
#chgrp -R ibmsdklop /opt/ibm/ibm-sdk-lop
#chmod -R 775 /opt/ibm/ibm-sdk-lop
```

9 Support for IBM SDK for Linux on Power

This section provides information about troubleshooting problems with using IBM Software Development Kit for Linux on Power.

9.1 Getting customer support

The IBM Software Development Kit for Linux on Power is provided as is only. Customers are not entitled to IBM Software Support. However, you can get help from the Linux on Power Community.

Getting product updates

The IBM SDK for Linux on Power latest ISO image, related packages, and this user guide can be found at the IBM SDK for Linux on Power page (http://www14.software.ibm.com/webapp/set2/sas/f/lopdiags/installtools/home.html).

Getting help from the Linux on Power Community

You can submit questions and review technical information about the IBM SDK for Linux on Power in the IBM developerWorks Linux on Power Community. You can go directly to the Linux on Power Community page (http://ibm.biz/BdxXrC2), or go to IBM developerWorks (https://www.ibm.com/developerworks/mydeveloperworks/) and search for the "PowerLinux™ community group".

You can also use IBM SDK for Linux on Power integrated bug reporting, which allows you to create a report that contains source code, error markers, and logs to be posted in the IBMdeveloperWorks Linux on Power Community message board. See 9.2, "Using integrated bug reporting" for information.

9.2 Using integrated bug reporting

The IBM SDK for Linux on Power includes integrated bug reporting, which allows you to create a report that contains source code, error markers, and logs to be posted in the IBM developerWorks Linux on Power Community message board. You can include specifics about your question or problem.

9.2.1 Creating a report

You can create a report that contains source code, error markers, and logs to be posted in the IBM developerWorks Linux on Power Community message board. The report also includes information about your system. You can include specifics about your question or problem.

About this task

You can create a report in three different ways. Choose from the following options.

Procedure

- Create a report about a code excerpt in your C/C++ project on which you have a question. Complete the following steps:
  1. Within your C/C++ project, select the code excerpt on which you have a question.
  2. Right-click the code excerpt and click **Ask for help in Linux on Power Community**. The Code Reports view is displayed.
  3. In the Code Reports view, expand **Code** to see the code report you created.
  4. To edit the report, double-click the report name. In the Report Editor window, type a name for the report and other details that you want to include in the report. Click **File** > **Save** or press **Ctrl+S**.

- Create a report about a problem that was flagged by IBM SDK for Linux on Power in the Problems view. Complete the following steps:
  1. Within the Problems view, select the problem for which you want to create a report.
  2. Right-click the problem and click **Ask for help in Linux on Power Community**. The Code Reports view is displayed.
  3. In the Code Reports view, expand **Problems** to see the problem report you created.
  4. To edit the report, double-click the report name. In the Report Editor window, type a name for the report and other details that you want to include in the report. Click **File** > **Save** or press **Ctrl+S**.
- Create an empty report to which you can add your own content. Complete the following steps.
  1. Open the Code Reports view, if it is not already open. To open the Code Reports view, click **Window** > **Show View** > **Reports**. The remaining steps take place in the Code Reports view.
  2. Optional: You can create the report in an existing report category, or in a new report category. To create a report category, click **+** (**Create a new Category**). Type a name for the category and click **OK**. The Code Reports view is updated to show the new category.
  3. Right-click the category and click **New Item**. The Report Editor window is displayed.
  4. In the Report Editor window, type a name for the report and other details that you want to include in the report. Click **File** > **Save** or press **Ctrl+S**.

9.2.2 Submitting a report to the Linux on Power Community

After you have created a report, you can use integrated bug reporting to submit the report to the IBM developerWorks Linux on Power Community message board.

Before you begin

Ensure that you have an IBM ID and have joined the Linux on Power Community.

- To get an IBM ID, go to developerWorks registration.
- To join the Linux on Power Community, go to The Linux on Power Community, sign in, and click **Join this Group**.

About this task

To submit a bug report that you have created, complete the following steps.

Procedure

1. Open the Code Reports view, if it is not already open. To open the Code Reports view, click **Window** > **Show View** > **Reports**.
2. Expand the report category to see the report you want to submit.
3. Right-click the report and click **Ask for Help**. A warning is displayed to let you know that a report will be created including system data. Click **OK**.

   Your default browser opens with a new window to the Linux on Power Community message board.
4. If prompted, sign in with your IBM ID.
5. To submit the report, you must create a topic to contain the report. On the Linux on Power Community message board page, click **Start a topic**.
6. In the New Topic window, add your report as follows:
   a. Type a topic name that describes your report.
   b. In the content area, right-click and click **Paste** to add your report to the topic.
   c. Click **OK**.
7. To subscribe to comments that are made by other Linux on Power Community members on your submission, use one of the **Feed** options at the bottom of the page.

9.3 Setting up SSH credentials

You can set up SSH credentials so that you can create a connection without a password.

About this task

This method allows you to set up SSH with DSA public key authentication.

Procedure

1. On your workstation, generate a DSA Key Pair. Log into the workstation and enter the following command:
   ```
   ssh-keygen -t dsa
   ```
   a. When prompted to enter a file in which to save the key, press **Enter**.
   b. When prompted, specify a password, and then confirm it.

   The private key is saved to `/home/user_name/.ssh/id_dsa`
2. Ensure that you have permissions for the `.ssh` directory. Enter the following commands:
   ```
   cd
   chmod 755 .ssh
   ```
3. Copy the public key file from your workstation to the remote server as `~/.ssh/authorized_keys`. Enter the following command:
   ```
   scp ~/.ssh/id_dsa.pub user@remote_server_name:.ssh/authorized_keys
   ```
4. On the remote server, ensure that you have permissions for the `.ssh/authorized_keys` file. Log into the remote server and enter the following command:
   ```
   chmod 600 ~/.ssh/authorized_keys
   ```

9.3.1 Logging in from workstation to remote server with DSA key

About this task

You can use scp or ssh from the workstation to log in to the remote server. These methods still require you to enter the password you created.

Procedure

- `ssh user@remote_server_name`
- `ssh user@remote-server.com`
- `scp file user@remote_server_name:/tmp`

9.3.2 Logging in with DSA key but no password

About this task

You can use a shell prompt to specify your password, and not be prompted to specify it again when using ssh or scp.

Procedure

1. At a shell prompt, enter the following commands:
   ```
   exec /usr/bin/ssh-agent $SHELL
   ssh-add
   ```
2. When you are prompted, enter your password. This sets your identity and allows you to avoid being prompted for passwords when using ssh or scp.

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