OpenCL™ Code builder for Intel® Media Server Studio 2015

User Manual

Contents

Legal Information

Getting Help and Support

To get support, visit the product support forum at http://software.intel.com/en-us/forums/intel-opencl-sdk/.

For information on SDK requirements, known issues and limitations, refer to the Release Notes.

Code Editing and Building with Visual Studio* Plug-in

OpenCL™ API Offline Compiler Plug-in for Microsoft Visual Studio* IDE

OpenCL™ API Offline Compiler plug-in for Microsoft Visual Studio* IDE enables you to develop OpenCL applications with Visual Studio IDE.

The plug-in supports the following features:

- New project templates
- New OpenCL file (`*.cl`) template
- Syntax highlighting
- Types and functions auto-completion
- Offline compilation and build of OpenCL kernels
- LLVM code view
- Assembly code view
- Program IR generation
- Selection of target OpenCL device – CPU or Intel Graphics

NOTE

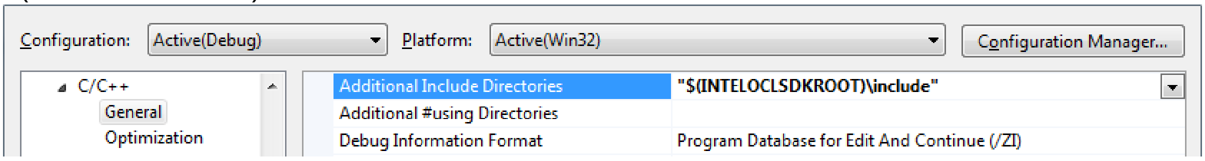
To work with the plug-in features, create an OpenCL project template or convert an existing project into the OpenCL project.

See Also

Converting Existing Projects into OpenCL Projects

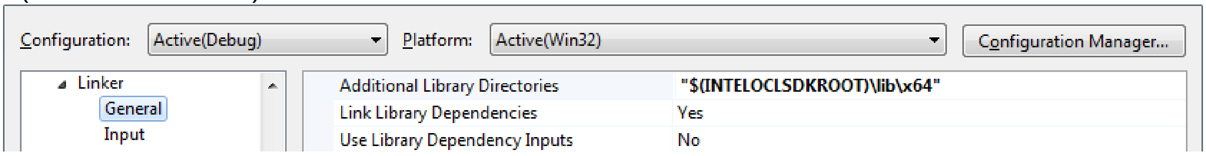
Configuring Microsoft Visual Studio* IDE

To configure the OpenCL™ API Offline Compiler plug-in for Microsoft Visual Studio* IDE, do the following:

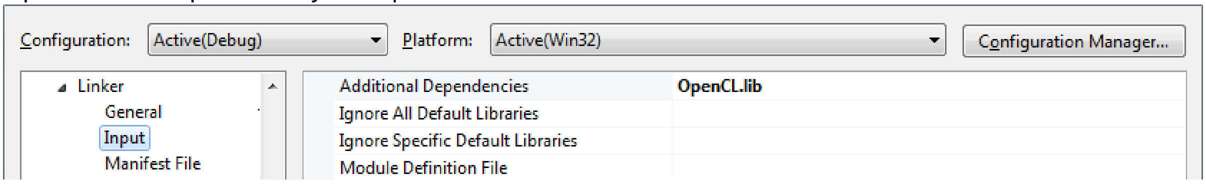
1. In the Visual Studio software select **Project** > **Properties**.
2. In the **C/C++** > **General** property page, under **Additional Include Directories**, enter the full path to the directory where the OpenCL header files are located:
   `$(INTELOCLSDKROOT)\include`
   

3. In the **Linker** > **General** property page, under **Additional Library Directories**, enter the full path to the directory where the OpenCL run-time import library file is located. For example, for 64-bit application:

`$(INTELOCLSDKROOT)\lib\x64`



4. In the **Linker** > **Input** property page, under **Additional Dependencies**, enter the name of the OpenCL ICD import library file `OpenCL.lib`.



Converting Existing Project into OpenCL™ Project

OpenCL™ API Offline Compiler plug-in for Microsoft Visual Studio* IDE enables you to convert a standard C/C++ project to an OpenCL project and vice versa.

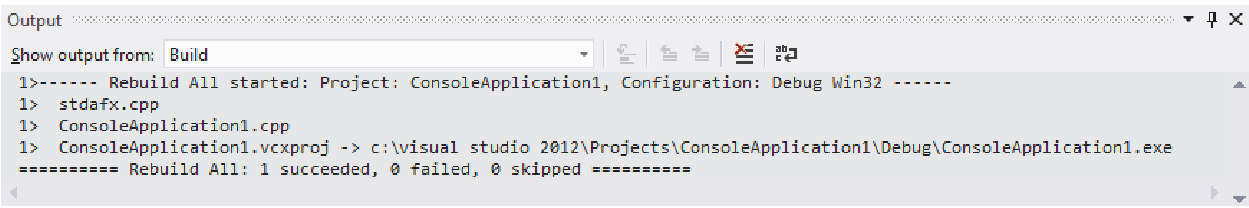
To convert your project, do the following:

1. Right-click the project you want to convert in the **Solution Explorer**.
2. In the project menu click **Convert to a project for OpenCL API**.

Building OpenCL™ Project

To build the solution using OpenCL™ API Offline Compiler plug-in for Microsoft Visual Studio* IDE, click **Build** > **Build Solution**.

When building solution, Intel OpenCL compiler automatically builds attached OpenCL kernels. See the build result in the **Output** build dialog of the Microsoft Visual Studio IDE.

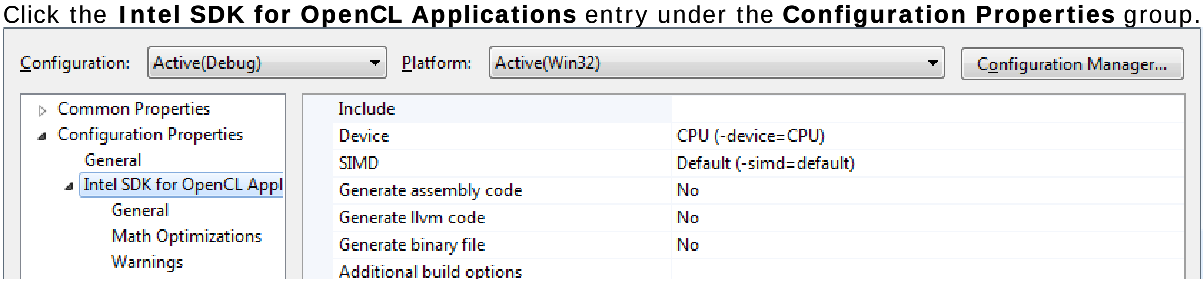


Using OpenCL™ Build Properties

OpenCL Build properties page in the Microsoft Visual Studio* IDE enables you to set compilation flags and change target device when building an OpenCL kernel. To change the settings, do the following:

1. Go to **Project** > **Properties**.

2. Click the **Intel SDK for OpenCL Applications** entry under the **Configuration Properties** group.



3. Modify properties and click **OK**.

NOTE

The **Intel® SDK for OpenCL™ Applications** entry exists for OpenCL projects with `*.cl` source files attached. If the entry does not exist, convert an existing standard project into the OpenCL project.

See Also

Creating an Empty OpenCL™ Project
Converting Existing Project into OpenCL Project

Selecting Target OpenCL™ Device

OpenCL™ API Offline Compiler plug-in for Microsoft Visual Studio* IDE enables you to choose the target device when building your OpenCL code:

- Intel CPU
- Intel® Graphics
- Intel Xeon Phi™ coprocessor
- Intel CPU on Experimental OpenCL 2.0 Platform

The default device is CPU.

To choose a target device, do the following:

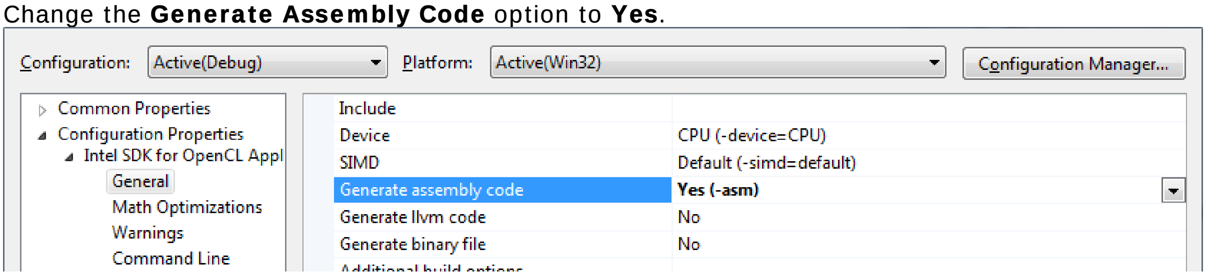
1. Go to **Project** > **Properties**.
2. Click **Configuration Properties** > **Intel SDK for OpenCL Applications** > **General**.
3. Change the **Device** option according your needs.
4. Click **OK**.

Generating and Viewing Assembly Code

OpenCL™ API Offline Compiler plug-in for Microsoft Visual Studio* IDE enables generating assembly representation of the OpenCL code. To enable generating and viewing the assembly code, do the following:

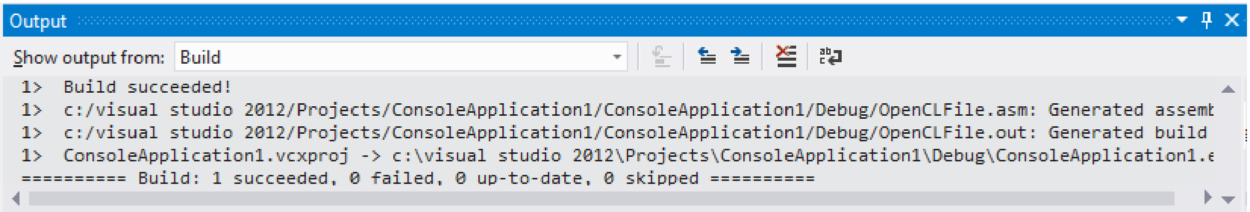
1. Go to **Project** > **Properties**.
2. Click **Configuration Properties** > **Intel SDK for OpenCL Applications** > **General**.

3. Change the **Generate Assembly Code** option to **Yes**.



4. Click **OK**.

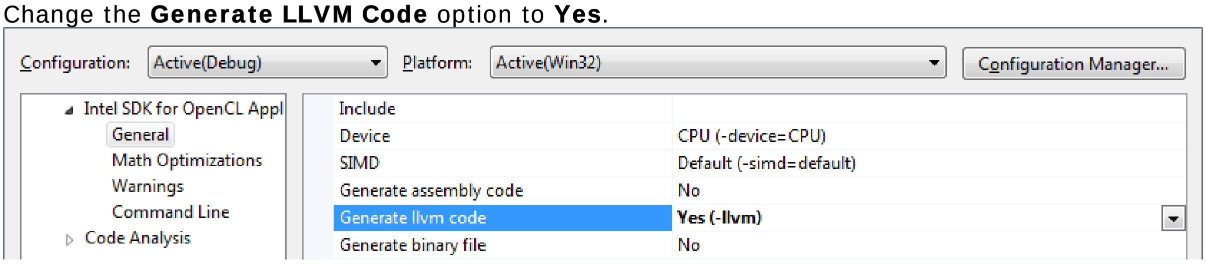
After the build, you can open the generated assembly file in the Visual Studio editor by double-clicking the message in the **Output** view.



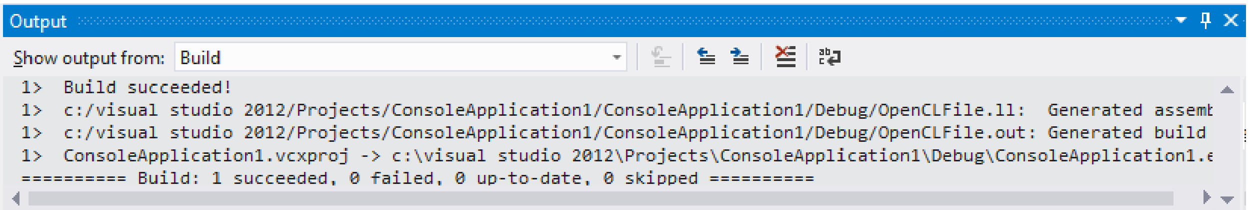
Generating and Viewing LLVM Code

OpenCL™ API Offline Compiler plug-in for Microsoft Visual Studio* IDE enables generating LLVM representation of the OpenCL code. To enable generating and viewing LLVM code, do the following:

1. Go to **Project** > **Properties**.
2. Click **Configuration Properties** > **Intel SDK for OpenCL Applications** > **General**.
3. Change the **Generate LLVM Code** option to **Yes**.



After the build, you can open the generated LLVM file in the Visual Studio editor by double-clicking the message in the **Output** view.

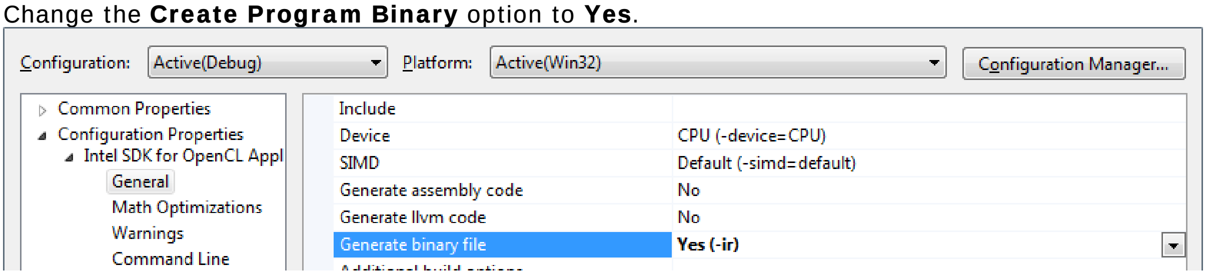


Generating Intermediate Program Binaries with Offline Compiler Plug-in

OpenCL™ API Offline Compiler plug-in for Microsoft Visual Studio* IDE generating program binaries of the OpenCL code.

An application can use generated program binaries to create program from binaries later (`clCreateProgramFromBinary(…)`). To generate intermediate program binaries, do the following:

1. Go to **Project** > **Properties**.
2. Click **Configuration Properties** > **Intel SDK for OpenCl Applications** > **General**.
3. Change the **Create Program Binary** option to **Yes**.

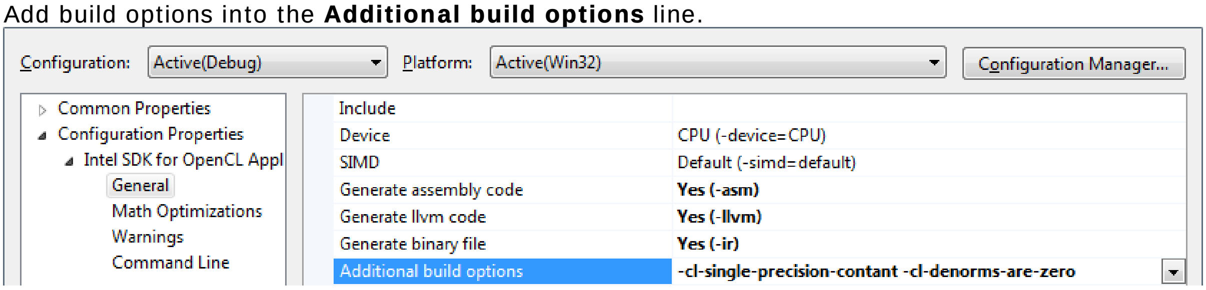


4. Click **OK**.

Configuring OpenCL™ Build Options

OpenCL™ API Offline Compiler plug-in for Microsoft Visual Studio* IDE enables configuring build options for the OpenCL code. To configure the build options, do the following:

1. Go to **Project** > **Properties**.
2. Click **Configuration Properties** > **Intel SDK for OpenCL Applications** > **General**.
3. Add build options into the **Additional build options** line.



4. Click **OK**.

Code Editing and Building with Eclipse* Plug-in

OpenCL™ API Offline Compiler for Eclipse* IDE

OpenCL™ API Offline Compiler plug-in for Eclipse* IDE enables developing OpenCL kernels with the Eclipse IDE. The Offline Compiler plug-in supports Eclipse versions 4.2 (Juno), 4.3 (Kepler), and 4.4 (Luna).

The plug-in supports the following features:

- Offline compilation, build and link of OpenCL kernels
- LLVM code generation
- Assembly code generation
- program IR generation
- Target OpenCL device selection

Configuring OpenCL™ API Offline Compiler Plug-in for Eclipse* IDE

To enable the OpenCL™ API Offline Compiler plug-in for Eclipse* IDE, do the following:

1. Copy the plug-in `*.jar` file from `$(INTELOCLSDKROOT)\bin\eclipse-plug-in` to `$(ECLIPSEROOT)\dropins`.
2. *On Linux* OS* add `$(INTELOCLSDKROOT)\bin` to `LD_LIBRARY_PATH`.
3. Run Eclipse IDE.
4. Select **Window** > **Preferences**.
5. Switch to the **Intel OpenCL** dialog and set OpenCL binary directory`$(INTELOCLSDKROOT)\bin\`

`$(INTELOCLSDKROOT)` represents SDK installation root folder, `$(ECLIPSEROOT)` represents the Eclipse root folder.

To configure other options, select **Intel OpenCL** > **Options**.

Configuring Options

In the OpenCL™ API Offline Compiler Plug-in for Eclipse* IDE, go to **Intel OpenCL** > **Options** and configure the needed options:

- Type the build options into the **Build Options** text box or click "**...**" to add options from list. Hold **Ctrl** to select several options.
- Select the target architecture:
    - x86 for 32-bit architecture
    - x64 for 64-bit architecture
- Select the target instruction set:
    - Streaming SIMD Extension 4.2 (SSE4.2)
    - Advanced Vector Extensions (Intel AVX)
    - Advanced Vector Extensions 2 (Intel AVX2)

- Select the build type:
  - Debug
  - Build
- Select the OpenCL Device type:
  - Intel CPU
  - Intel Graphics
  - Intel Xeon Phi™ coprocessor
  - Intel CPU on Experimental OpenCL 2.0 Platform

NOTE

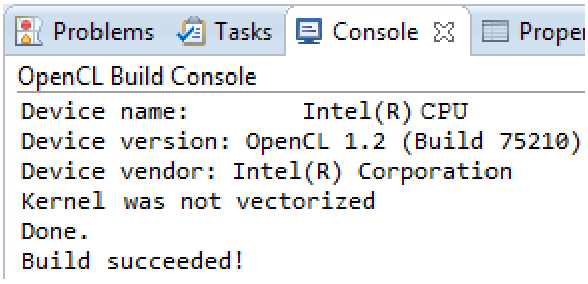
Intel Graphics support is available on Windows* OS only.

Building and Compiling Kernels in Eclipse* IDE

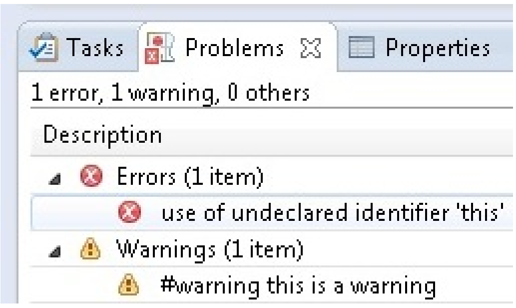
To build or compile an OpenCL™ kernel using the OpenCL™ API Offline Compiler plug-in for Eclipse* IDE, do the following:

1. Write code into the Eclipse code editor or load code from file.
2. Click the **Build** or **Compile** button at the tool bar, or right-click the file in the project explorer and select **Intel OpenCL** > **Build** or **Compile.**

After compilation completes, the output appears in the **Console** tab of the Eclipse IDE.



Error and warning messages appear in the **Problems** tab.



See Also

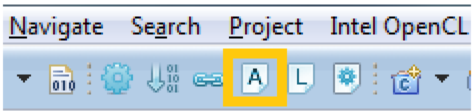
[Saving and Loading OpenCL™ Code in Eclipse* IDE]()

Generating Assembly Code in Eclipse* IDE

OpenCL™ API Offline Compiler plug-in for Eclipse* IDE enables generating and viewing files with assembly code of the input `*.cl` files.

To generate and view the assembly code, do the following:

1. Build the OpenCL code from the Eclipse editor.
2. Click the **Show Assembly** button, or right-click the `*.cl` file in the **Project Explorer**, and select **Intel OpenCL** > **View Assembly**.



See Also

[Building and Compiling Kernels in Eclipse* IDE]()

Linking Program Binaries in Eclipse* IDE

OpenCL™ API Offline Compiler plug-in for Eclipse* IDE enables linking several compiled files.

To link binaries, do the following:

1. Build code in the Eclipse editor.
2. Click the **Link** button, or select **Intel OpenCL** > **Link**.

3. Click **Browse**, select the input files to link, and click **OK**.
4. Type the output file destination into the **Output File** text box, or click **Browse** to specify the path using graphics user interface.
5. Specify OpenCL device type and Architecture in the **Target Configuration** group box and click **OK**.

See Also

[Configuring Offline Compiler for Eclipse* IDE]()
[Building and Compiling Kernels in Eclipse* IDE]()

Saving and Loading OpenCL™ Code in Eclipse* IDE

Create a C/C++ eclipse project to open or link `*.cl` files in Eclipse* IDE.

NOTE

Install the Eclipse C/C++ Development Tool (CDT) to work with the Offline Compiler capabilities.

To save a `*.cl` file using OpenCL™ API Offline Compiler plug-in for Eclipse* IDE, do the following:

1. In the Eclipse user interface select **File** > **Save As...**
2. Enter or select folder to save the file.
3. Type the file name and click **OK**.

To load OpenCL™ code from file into the Eclipse* IDE code editor, do the following:

1. Right-click the target C/C++ project and select **Import...**
2. Go to **General** > **File system** and click **Next**.
3. Click **Browse**, select the folder with the files you need to import, and click **OK**.
4. Select the files you need to import and click **Finish**.

Saving Intermediate Representation Code in Eclipse* IDE

To save the Intermediate Representation code using the OpenCL™ API Offline Compiler plug-in for Eclipse* IDE, do the following:

1. Compile an `*.cl` file using the Offline Compiler plug-in for Eclipse IDE.
2. Select **Intel OpenCL** > **Save IR Binary**, add file name, select path, and click **Save**.

Building and Analyzing with Kernel Builder

Kernel Builder for OpenCL™ API

The Kernel Builder for OpenCL™ API is the standalone version of the OpenCL Code Builder. It enables you to build and analyze OpenCL kernels. The tool supports Intel® processors, Intel Graphics, and Intel Xeon Phi coprocessors. The tool provides full offline OpenCL language compilation, which includes:

- OpenCL syntax checker
- Cross-platform compilation
- Low Level Virtual Machine (LLVM) viewer
- Assembly code viewer
- Intermediate program binary generator

With the Analyze Board of the Kernel Builder you can:

- Assign input to the kernel and test its correctness
- Analyze kernel performance based on:
  - Group size
  - Build options
  - Device
- Perform Deep Kernel Analysis

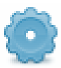
NOTE

Intel Graphics support is available on Windows* OS only.

Using Kernel Builder

Building and Compiling Kernels

To build or compile an OpenCL™ kernel using the Kernel Builder for OpenCL API, do the following:

1. Write your code into the code editor or load code from file.
2. Click **Build**  or **Compile**  .

If you succeed, the **Console** window background color turns green, otherwise, it turns red.

In case of failure the Kernel Builder reports the number of the problematic line. Double-click the error line in the **Console** text box to jump to the relevant line in the code.

You can save the compiled binary by clicking the **Create Program Binary**  button.

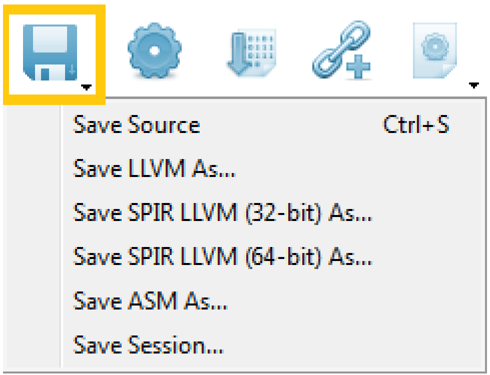
See Also

[Loading Code from File](#)

Saving and Loading Code

Kernel Builder for OpenCL™ API enables saving and loading the generated OpenCL, LLVM, SPIR LLVM, Assembly, and source code.

To save the code, click the **Save As**  button and select code type to save:



To load OpenCL™ code from file, do one of the following:

- Click the **Open** button  and select **Open**.
- Press **Ctrl+O**.
- Select **File** > **Open**.
- Drag and drop file into the code editor window.

Saving and Loading Session

Kernel Builder for OpenCL™ API enables saving the current session. A 'Session' is all the open tabs including their configured options and analysis configurations.

To save the session, click the **Save As**  button and select **Save Session…**

To load a saved session click the **Open** button  and select **Load Session…**

NOTE

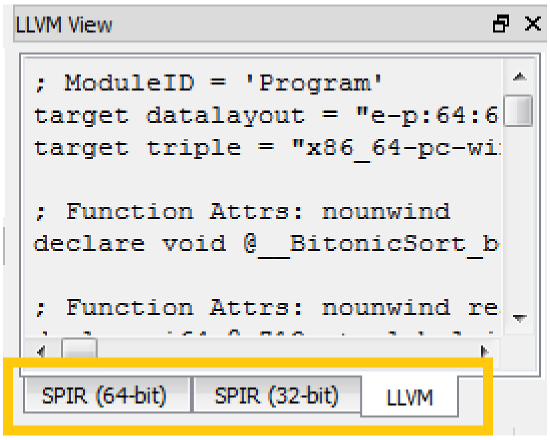
Following an unsuccessful shutdown the Kernel Builder for OpenCL API prompts you to restore one of the last 5 auto saved sessions.

LLVM, SPIR, and Assembly Code View

Kernel Builder for OpenCL™ API enables viewing the generated LLVM, SPIR, and Assembly intermediate representation (IR) of the OpenCL code. To view the LLVM, SPIR, or Assembly code, do the following:

1. Build your kernel.
2. Click **Show LLVM**  or **Show Assembly** .

You can view the SPIR representation by selecting the corresponding tab in the **LLVM View** window:



To hide the view windows, click the corresponding button again.

NOTE

Assembly code view is available for the CPU device only.

See Also

[Building and Compiling Kernels]

Generating Intermediate Program Binaries

The Kernel Builder for OpenCL™ API enables generating program binaries of OpenCL code. An application can use generated program binaries to create program from binaries later (`clCreateProgramFromBinary(…)`).

1. Build the code.
2. Click the **Create Program Binary**  button and select:
   - o Create Program Binary...
   - o Create linked program's binary IR

See Also

[Building and Compiling Kernels]

Linking Program Binaries

To link OpenCL™ program binaries with Kernel Builder for OpenCL™ API, do the following:

1. Click the **Link**  button.
2. In the **Select IR Files** window, click **Choose Files**, and select the compiled objects and libraries to link.
3. Click **Done**.

If the linkage succeeds, the **Console** window background color turns green, otherwise, it turns red.

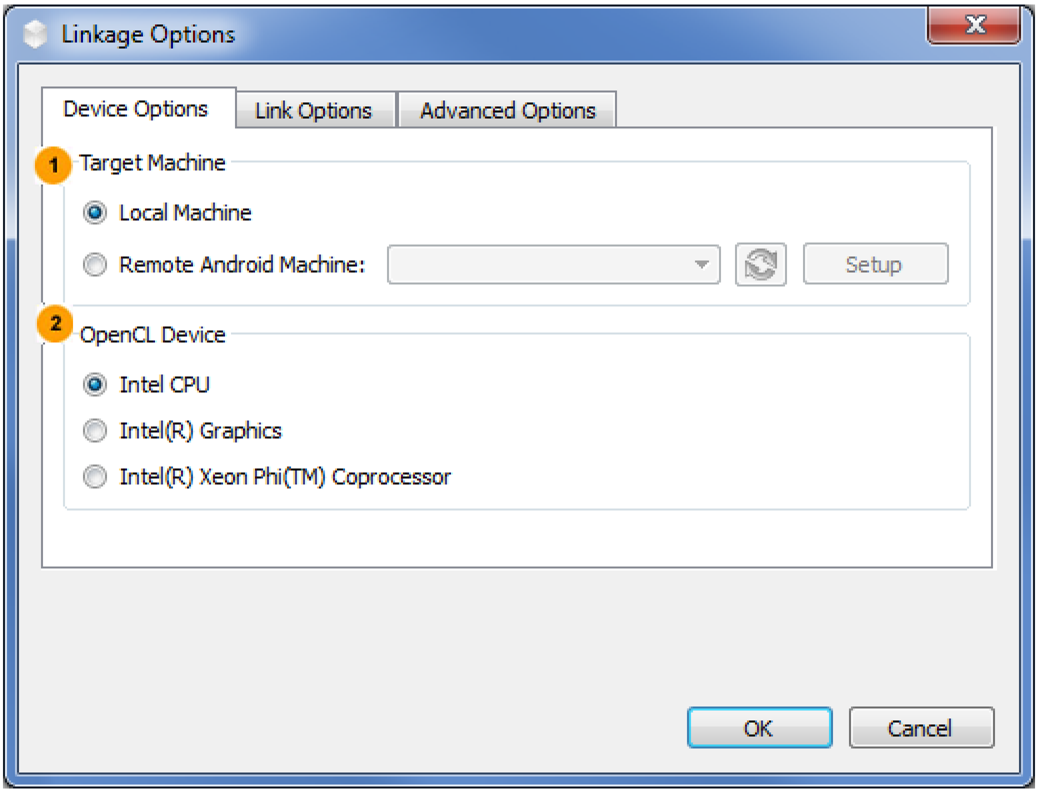
When linkage completes, you can save the created executable or library by clicking the **Create Program Binary**  button.

Configuring Options

To configure the Kernel Builder for OpenCL™ API options, open the **Options** menu by selecting **Tools** > **Options...**

Configuring Device Options

The **Device Options** tab provides several configuration options.



1 **Target Machine** group box, which enables selecting the target machine:

- Local Machine
- Remote Machine

To use the **Remote Machine** option, you need to

1. Connect an Android* device with Intel processor or an emulator based on Intel x86 System Image.
2. Copy OpenCL runtime to the Android device or emulator. See section [Installing OpenCL™ Runtime on Android* OS Emulator](#).
3. Click **Setup** to copy OpenCL tools to the device.

NOTE

You need to use the **Setup** option each time you start an emulator device.

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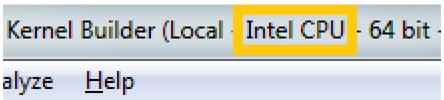
2 **OpenCL Device** group box, which enables selecting the target device for the selected machine:

- Intel CPU
- Intel(R) Graphics
- Intel Xeon Phi(tm) coprocessor
- Intel CPU on Experimental OpenCL 2.0 Platform

NOTE

Intel Graphics support is available on Windows* OS only.

The selected device options can be found in the program window title.

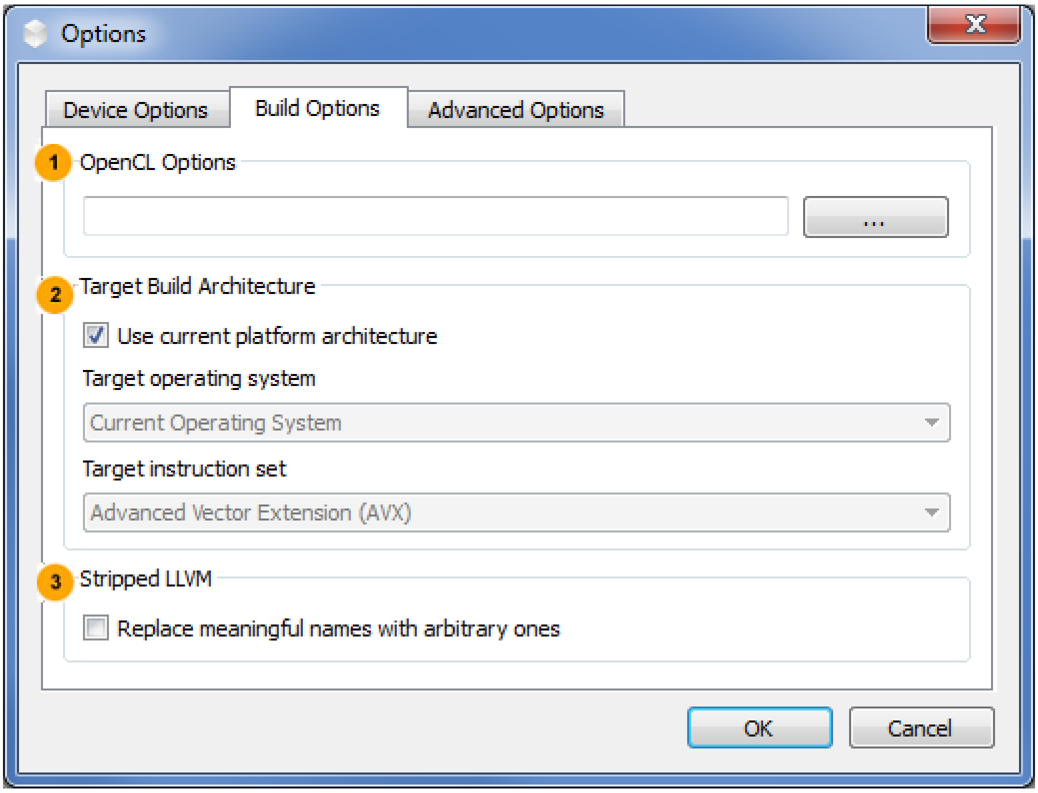


NOTE

Select the target device for each **Code editor** tab separately. CPU device is default for all open tabs.

Configuring Build Options

The **Build Options** tab provides several configuration options.



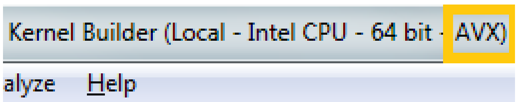
1 **OpenCL Options** group box, which enables

- Typing the options into the text box.
- Selecting options from the list, available on clicking the **...** button. To select several options from the list, hold **Ctrl**.

2 **Target Build Architecture** group box, which enables:

- Using the current platform architecture.
- Configuring the build architecture manually by unchecking the **Use current platform architecture** check box, and selecting:
    - Select **Target operating system**:
        - Current Operating System
        - Android Operating System (available on Windows* OS only)
    - Choosing the **Target instruction set**:
        - Streaming SIMD Extension 4.2 (SSE4.2)
        - Advanced Vector Extension (AVX)
        - Advanced Vector Extension (AVX2)

Name of the selected instruction set architecture appears in the main window top bar as an indicator, next to the file name.



Changing the **Target Build Architecture** options enables viewing assembly code of different instruction set architectures and generating program binaries for different hardware platforms.

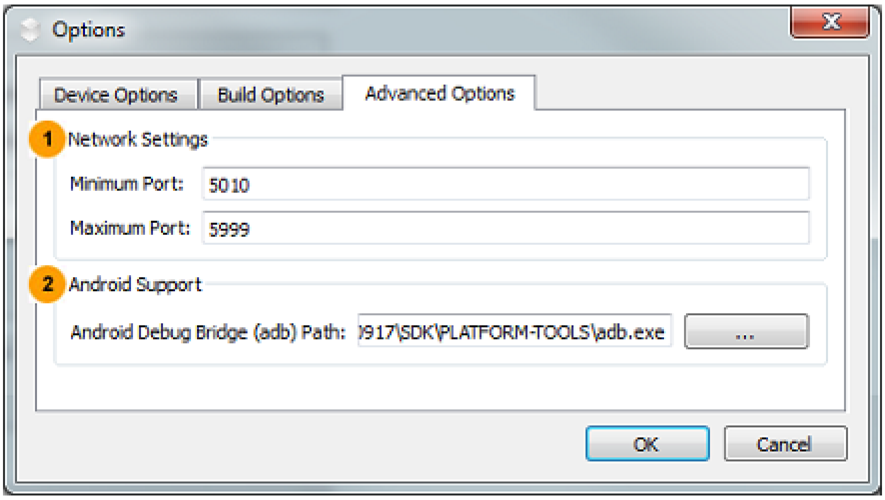
NOTE

Target Build Architecture options are available for the CPU device only.

3 To enable **Stripped LLVM** generation, check the **Replace meaningful names with arbitrary one** checkbox.

Configuring Advanced Options

The **Advanced Options** tab provides several configuration options.



1 **Network Settings** group box, which enables configuring the network port range.

2 **Android Support** text box, which enables specifying the path to the Android* Debug Bridge (adb).

See Also

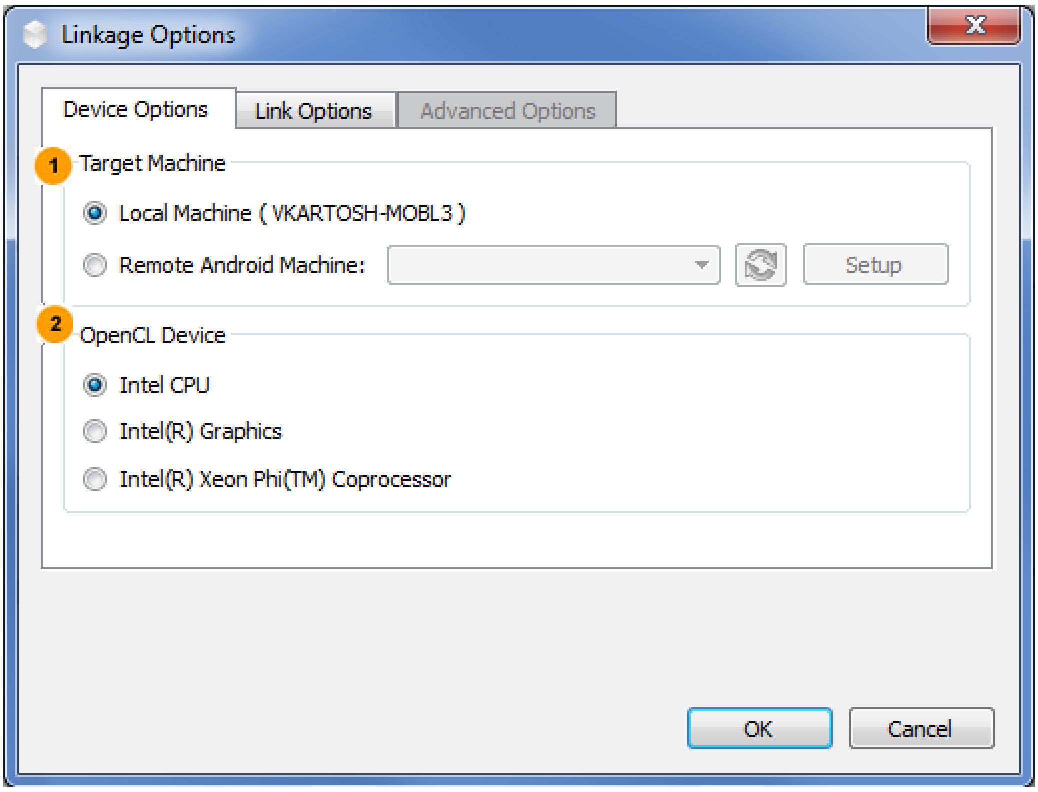
Configuring the Environment
Installing OpenCL™ Runtime on Android* Emulator

Configuring Linkage Options

To configure device options for linkage of the OpenCL™ code, use the **Linkage Options** menu of the Kernel Builder for OpenCL™ API. Open the **Linkage Options** menu by clicking **Linkage button** > **Link Options**.

Configuring Device Options for Linkage

The **Device Options** tab provides several configuration options.



1 **Target Machine** group box, which enables selecting the target machine:

- Local Machine
- Remote Machine

To use the **Remote Machine** option, you need to

1. Connect an Android* device with Intel processor or an emulator based on Intel x86 System Image.
2. Copy OpenCL runtime to the Android device or emulator. See sections Installing OpenCL™ Runtime on Android* OS Emulator and Configuring the Environment.
3. Click Setup to copy OpenCL tools to the device.

NOTE

You need to use the **Setup** option each time you start an emulator device.

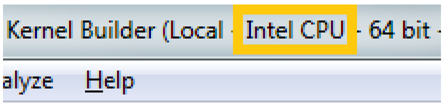
2 **OpenCL Device** group box, which enables selecting the target device for the selected machine:

- Intel CPU
- Intel(R) Graphics
- Intel Xeon Phi(tm) coprocessor
- Intel CPU on Experimental OpenCL 2.0 Platform

NOTE

Intel Graphics support is available on Windows* OS only.

The selected device options can be found in the program window title.

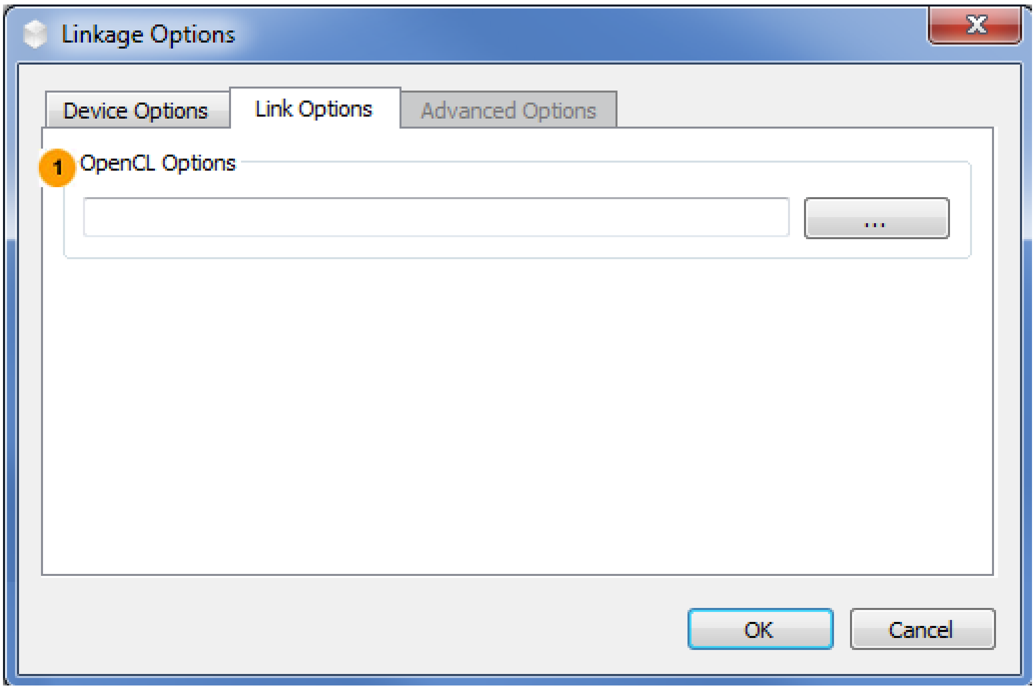


NOTE

Select the target device for each **Code editor** tab separately. CPU device is default for all open tabs.

Configuring Link Options

The **Link Options** tab provides several configuration options.



1 **OpenCL Options** group box, which enables

- Typing the options into the text box.
- Selecting options from the list, available on clicking the **...** button. To select several options from the list, hold **Ctrl**.

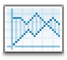
See Also

[Configuring the Environment](#)
[Installing OpenCL™ Runtime on Android* Emulator](#)

Kernel Performance Analysis

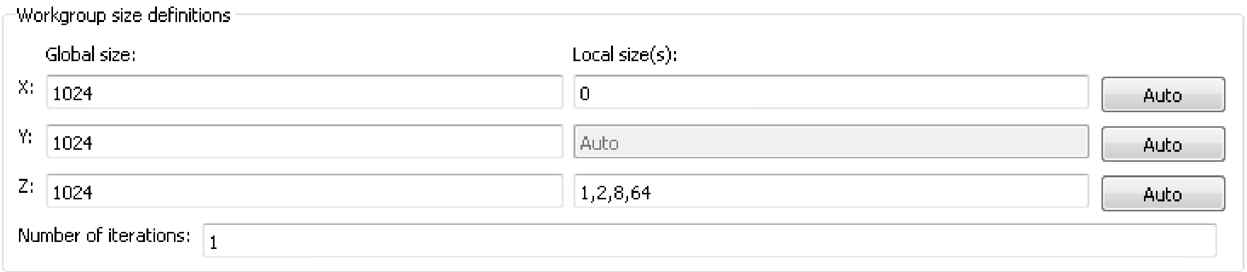
Analyzing OpenCL™ Kernel Performance

To analyze OpenCL™ kernel performance with the Kernel Builder for OpenCL API, do the following:

1. Click the **Analyze**  button.
2. Click **Refresh kernel(s)** to get the list of kernels in the currently open `*.cl` file.
3. Select the target kernel from pull-down menu. If only one kernel is available, it is selected by default.
4. Click cells in the **Assigned Variables** column to create or add variables as kernel arguments. You can assign one-dimensional variables (such as `integer`, `float`, `char`, `half`, and so on) on-the-fly by typing single values into the table. See section "Creating Variables" for details.
5. Set number of iterations, global size and local sizes per workload dimension in the **Workgroup size definitions** group box.
6. Click **Analyze** to wrap a specific kernel and execute analyses.

You can use the **local size(s)** text boxes for several different test configurations:

- Set single size value for a single test.
- Add several comma-separated sizes for multiple tests.
- Set 0 to utilize the default framework-assigned local size.
- Click **Auto** to enable the Kernel Builder iterate on all sizes that are smaller than global size and device maximum local size.



Also consider the following:

- Using each option is available for each dimension.
- To analyze the kernel in its designed conditions, set a single value.
- To find the local size that provides higher performance results, click **Auto** or set a list of comma-separated values.
- To improve the analysis accuracy, run each global and local work size combination several times by increasing the **Number of iterations** value. Several iterations minimize the impact of other system processes or tasks on the kernel execution time.
- Use the **Device Information**  dialog to compare device properties and choose the appropriate device for the kernel.
- When running analysis on Experimental OpencL 2.0 Platform, you may use local WG size as described in OpenCL 2.0 specification
    - o Local work-group size doesn't have to be a divisor of the global WG size.
    - o When choosing "auto", all global work-group size devisors and all powers of 2 smaller than the global work-group size ran in the analysis.

See Also

Creating Variables

Managing Variables

Creating Variables

Creating Buffers

To create buffers using Kernel Builder for OpenCL™ API, do the following:

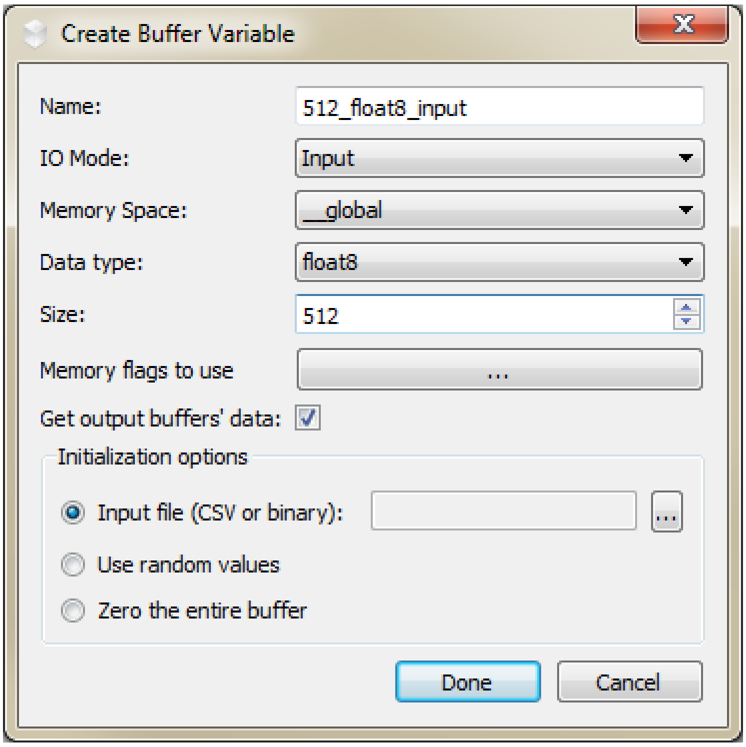
- Select **Analyze** > **Variable management**. Or click cells in the **Assigned Variable** column of the **Analyze Board**.
- In the **Variable Management** dialog click **Add**.
- In the **Select Variable Type** dialog choose **Buffer** from the **Type** combo box.

Use CSV or binary files, random values, or zeroes to create buffers.

- When using CSV files, each line represents one OpenCL data type (like `int4`, `float16`, and so on), with a value in each column to satisfy the type size. For example, for a `long8`, at least eight columns of long numbers should exist in each line. The size of the buffer is used as the number of lines to read from CSV. The CSV file may hold more columns or lines than needed for a specific buffer, but not fewer.
- When using binary files, the content should be a concatenation of the OpenCL data type, and as with using CSV files, the file may hold more data than indicated by the **Size** argument.

NOTE

Output buffers do not need a value assigned to them. If a value is assigned, it is ignored.



See Also

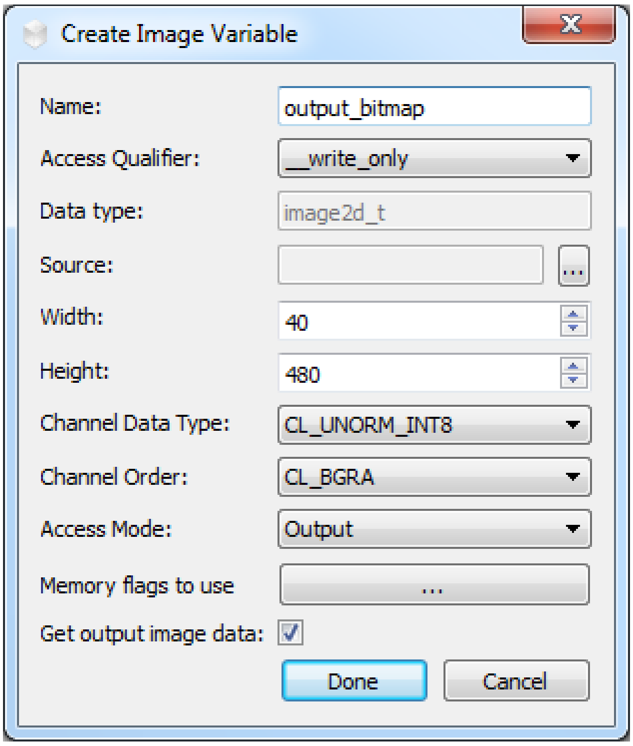
[Creating Images]
[Creating Samplers]
[Choosing Memory Options]

Creating Images

To create images using Kernel Builder for OpenCL™ API, do the following:

- Select **Analyze** > **Variable management**. Or click cells in the **Assigned Variable** column of the **Analyze Board**.
- In the **Variable Management** dialog click **Add**.
- In the **Select Variable Type** dialog choose **Image** from the **Type** combo box.

Use input bitmap files and the parameters to create images. Create output images with the correct size, type, channel order, and so on.



The **Get output image data** checkbox disables reading back the output buffer or image. It means that you can try more than one combination of global or local work sizes, where there is no need to read the same output for all the combinations.

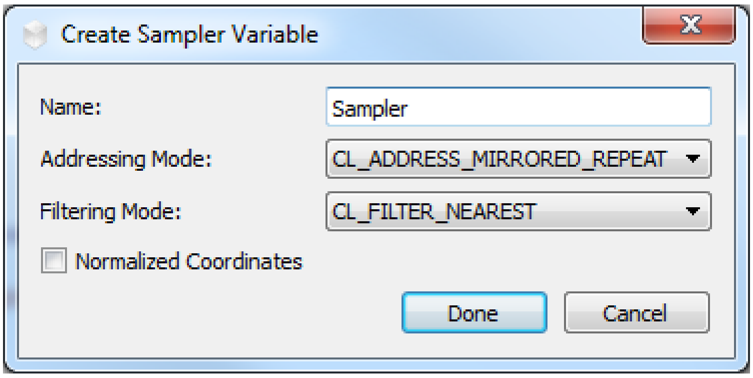
See Also

Creating Buffers
Creating Samplers
Choosing Memory Options

Creating Samplers

To create samplers using Kernel Builder for OpenCL™ API, do the following:

- Select **Analyze** > **Variable management**. Or click cells in the **Assigned Variable** column of the **Analyze Board**.
- In the **Variable Management** dialog click **Add**.
- In the **Select Variable Type** dialog choose **Sampler** from the **Type** combo box.



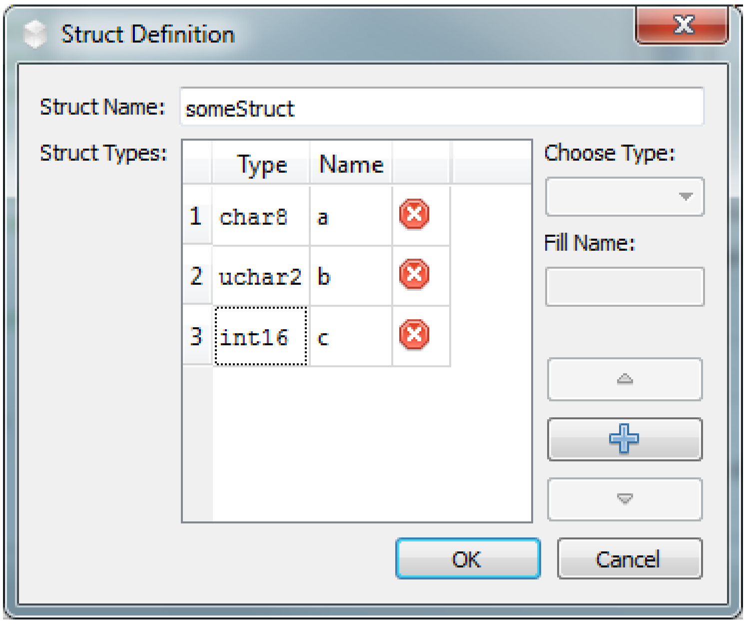
See Also

[Creating Images]
[Creating Buffers]

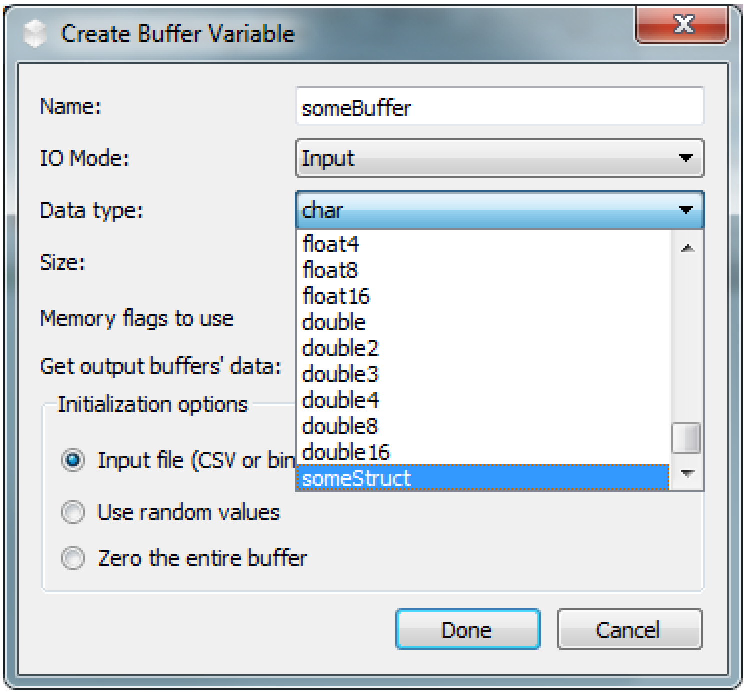
Using Structs

Kernel Builder for OpenCL™ API supports user-defined structs. To use structs for kernel analysis, you need to define them:

1. Go to **Analyze** > **Struct Management**.
2. Choose data type and enter fill name.
3. Click **Add** to add a new field.
4. Click **OK** to save the created field.



After defining the struct, you can select is as type when creating a buffer variable:



A CSV file for a struct buffer should have the following format:

- Line numbers should be greated or equal to the buffer size.
- Each line should contain all concatenated data fields.

For example:

```
typedef struct Point {
    int x;
    int y;
    float value;
}
```

For a buffer of size 4, the CSV file contains:

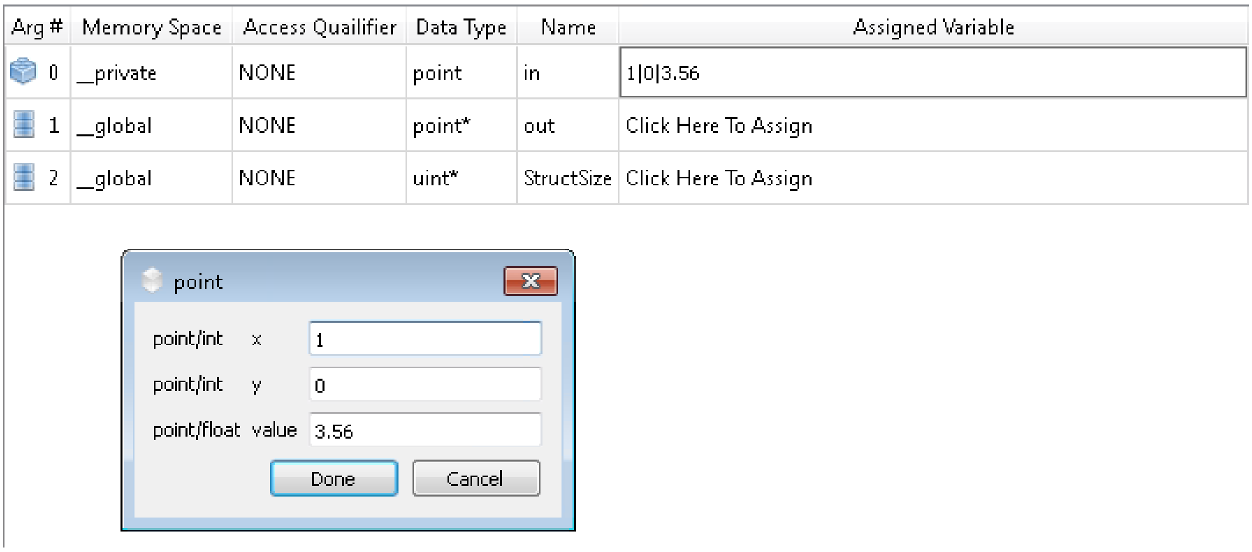
```
0,1,3.56
1,1,33.7
1,0,12.58
0,0,4.85
.
```

Zero and random values are available as with regular-type buffers.

You can edit a struct. In such case any buffer using the struct reinitializes with the new data.

You can delete a struct as long as other structures or buffer variables do not use it.

When working with uniform variables, fill the values in the pop-up dialog for every field to insert values for the struct. For example:



NOTE

You must define structs with the same names as used in the code to enable the Kernel Builder to assign a variable to the argument.

See Also

Creating Variables
Editing Variables

Choosing Memory Options

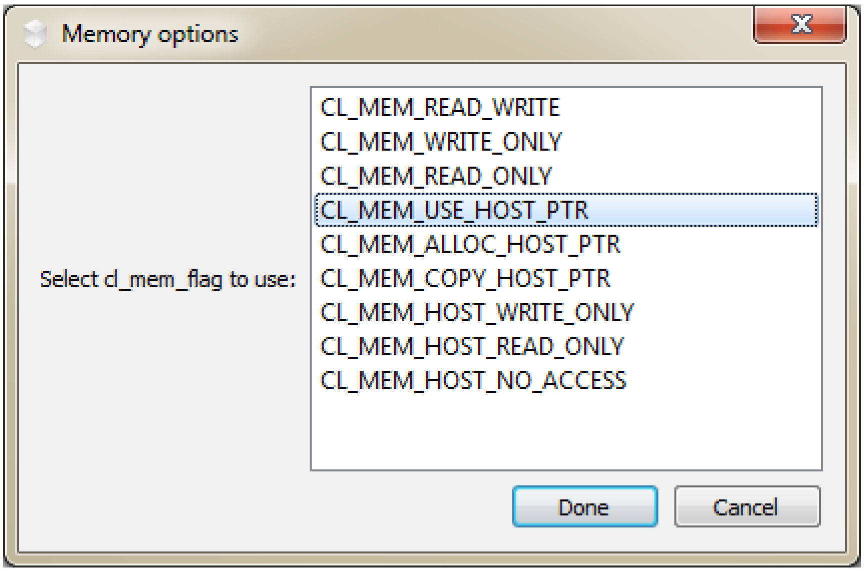
You can change memory options of buffers or images using Kernel Builder for OpenCL™ API. Refer to the relevant sections of this guide for guidelines on creating or editing variables.

NOTE

You are not limited in selecting options. Avoid selecting the option combinations that are forbidden by the OpenCL 1.2 specification, otherwise you may encounter errors upon analysis.

To choose buffers and images memory options, do the following:

1. Open the variable properties by right-clicking an image or buffer variable in the **Variables Management** window.
2. Click the "**...**" button next to **Memory flags to use**.
3. Select options and click **Done**.



See Also

Creating Variables
Editing Variables

Editing Variables

To edit the variables in the system using the Kernel Builder for OpenCL™ API, do the following:

1. Select **Analyze** > **Variable management**. Or click cells in the **Assigned Variable** column of the **Analyze Board**.
2. Right-click a variable name.
3. Click **Edit variable properties**.
4. Change the desired properties and click **Done**.

Viewing Variable Contents

To view buffer or image contents when using the Kernel Builder for OpenCL™ API, do the following:

1. Select **Analyze** > **Variable management**. Or click cells in the **Assigned Variable** column of the **Analyze Board**.
2. Right-click a buffer or image name you want to view.
3. Click **Show variable contents**.

Deleting Variables

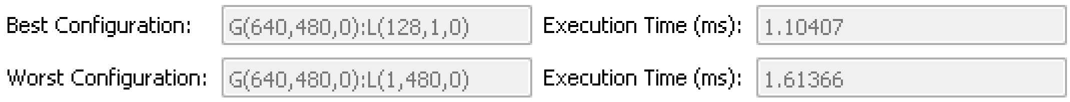
To delete variables when using the Kernel Builder for OpenCL™ API, do the following:

1. Select **Analyze** > **Variable management**. Or click cells in the **Assigned Variable** column of the **Analyze Board**.
2. Right-click a variable name.
3. Click **Delete variable** or **Delete all variables**.

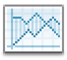
Viewing Analysis Results

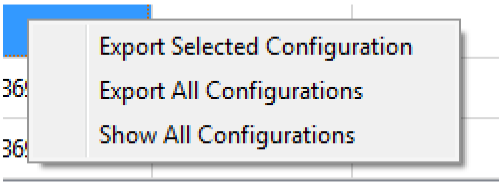
Best and Worst Configurations

The **Analysis Results** tab of the Kernel Builder for OpenCL™ API enables you to see the tested global and local size best and the worst configurations, based on median execution time. In case only one configuration exists, the result appears in both result windows.



To export or view the analysis results, do the following:

1. Click the **Analyze**  button.
2. Switch to the **Analysis Results** tab.
3. Right-click the table and choose the action you need to perform.

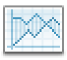


Statistics for Each Configuration

The **Execution Statistics** table in the **Analysis Results** tab of the Kernel Builder for OpenCL™ API enables you to see statistical analysis results for a selected configuration. The statistics consists of the following iteration execution time values for the selected configuration:

- Median
- Average
- Standard deviation
- Maximum
- Minimum

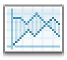
To open the **Execution Statistics** table, do the following:

1. Click the **Analyze**  button.
2. Switch to the **Analysis Results** tab.
3. Click **Execution statistics**.

Statistics per Iteration

The **Execution Iteration Times (ms)** table in the **Analysis Results** tab of the Kernel Builder for OpenCL™ API enables you to see the total run time, the breakdown to queue, submit and execute times per iteration for the given configuration.

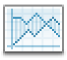
To open the **Execution Iteration Times (ms)** table, do the following:

1. Click the **Analyze**  button.
2. Switch to the **Analysis Results** tab.
3. Click **Execution Iteration Times (ms)**.

Variable Handling

The **Variable Handling** table in the **Analysis Results** tab of the Kernel Builder for OpenCL™ API enables you to see read and read-back times for each variable, as well as the output file path for output parameters. Clicking on this input/output path pops up its content (images and buffers).

To open the **Variable Handling** table, do the following:

1. Click the **Analyze**  button.
2. Switch to the **Analysis Results** tab.
3. Click **Variable Handling**.

NOTE

The analysis results restore each time you select the kernel from the kernel list.

Deep Kernel Analysis in Kernel Builder

About the Deep Kernel Analysis

Deep Kernel Analysis feature of the Kernel Builder for OpenCL™ API enables getting profiling data for OpenCL kernels running on Intel Graphics. The data includes:

- Exact kernel runtime for each execution unit and hardware thread (in GPU cycles).
- Exact execution time for selected OpenCL code lines (in GPU cycles).
- Execution units occupancy and hardware thread utilization across the execution.

The new feature uses the Kernel Builder automatic host application feature, so you only need to write an OpenCL kernel, assign variables to its arguments, and define the global and local group sizes. You may also mark specific OpenCL code lines as IL profiling points, and then use the **Deep Analysis** button to run the analysis.

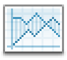
NOTE

To work with the Deep Kernel Analysis feature, add the following key in the registry:
`[HKEY_LOCAL_MACHINE\SOFTWARE\Intel\KMD] "DisableDOPClockGating"=dword:00000001`

Profiling Kernels for Deep Kernel Analysis

To profile kernels using the Deep Kernel Analysis feature of the Kernel Builder for OpenCL™ API, do the following:

1. Run the Kernel Builder.
2. Open an OpenCL code file, or type in your code in the editor.

3. Click the **Analyze**  button, press the **Refresh Kernel(s)** button, and select a kernel for analysis.
4. At the **Assign Parameters** tab assign parameters from previously defined variables or create them on the fly from the popup dialog.
5. Define group sizes for the analysis, and press the **Deep Analysis** button to start profiling.

If desired, mark any of the possible OpenCL code lines for profiling by clicking the red circles on the left of your code lines. The marking can be undone by clicking the filled circles (toggling on and off).

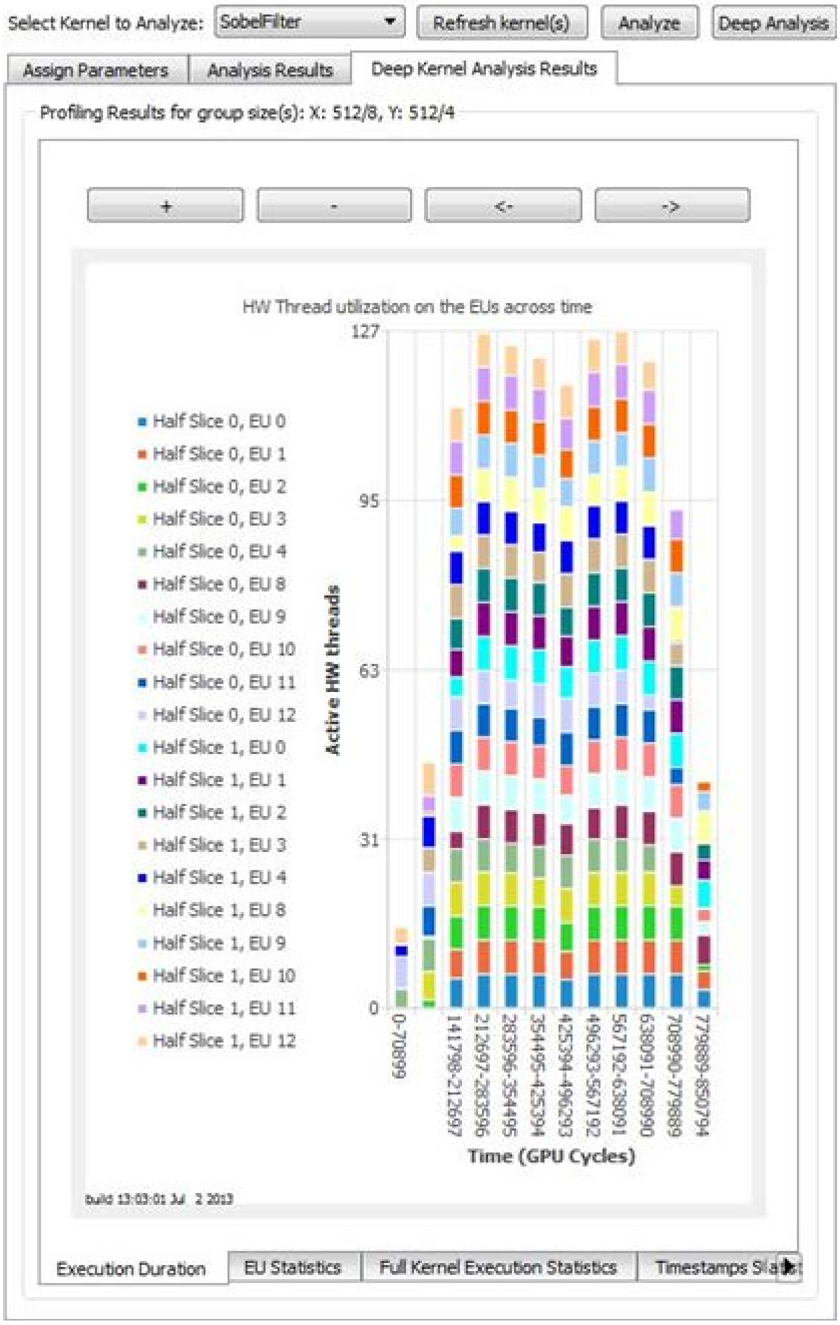
NOTE

Do not use the **Auto** feature for best local group size configuration with Deep Kernel Analysis. Define a single group size for both global and local for each dimension used.

Viewing Deep Kernel Analysis Results

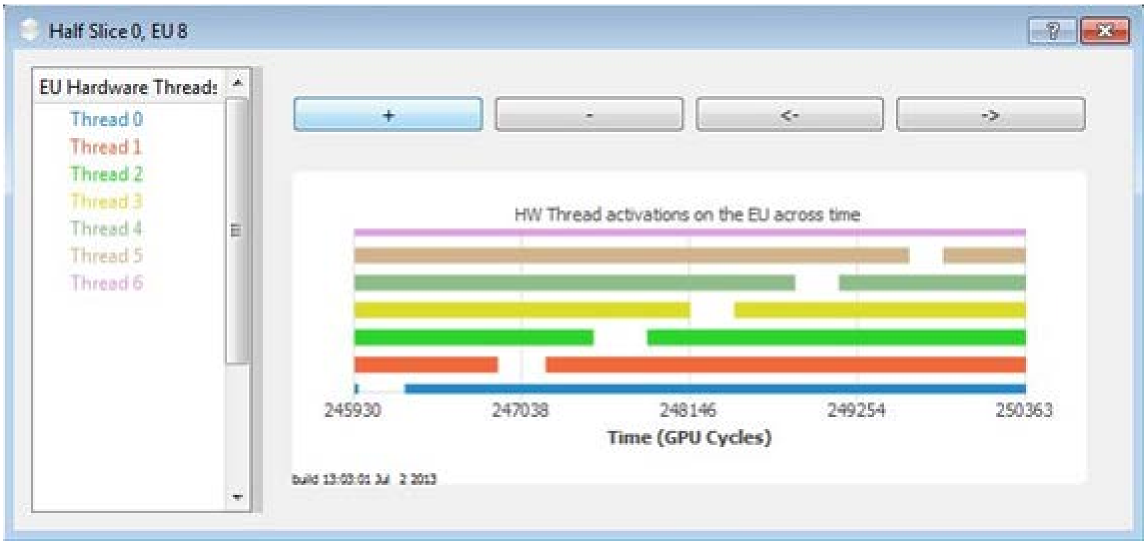
After the profiling is done, the data is collected and is shown in a graph and a few tables.

Execution Duration:



The chart shows 12 bars of utilization across the profiling time. Each color represents a specific EU, while the average time of an EU utilization over time range determines the height of each color on each bar.

Double-clicking any of the colored parts opens a dialog showing the hardware thread activations across time:



Click the legend to the left to toggle each hardware thread appearance on the graph on the right.

Viewing Execution Statistics of Deep Kernel Analysis

The following tables of the Kernel Builder for OpenCL™ API Deep Kernel Analysis Results tabs show textual tables with execution data:

- EU Statistics – data on the execution units on the Intel Processor Graphics (physical location), SIMD width, and number of activations of the hardware threads to run the kernel.
- Full Kernel Execution Statistics – reflects total kernel execution time on each EU, including statistics per execution unit and their averages:
  - Average
  - Median
  - Minimum & maximum
  - Standard deviation
- Timestamps Statistics – reflects total execution time for each of the selected lines.

Building with Kernel Builder Command-Line Interface

Kernel Builder for OpenCL™ API provides a command-line interface. The tool supports Intel® processors, Intel Graphics, and Intel Xeon Phi™ coprocessors, also providing full offline OpenCL language compilation, which includes:

- Creating executable Intermediate Representation (IR) from source code
- Creating compiled object from source code
- Creating executable IR or library from object IR and libraries

The command-line tool is located in `$(INTELOCLSDKROOT)\bin\` under x86 or x64 folder, depending on OS.

To use the Offline Compiler command-line interface,

1. Start the command-line.
2. Type `ioc64` to run 64-bit version

Type the run parameters in the following sequence:

```
ioc<version> -cmd=<command> -<argument> -<options>
```

Offline Compiler supports the following commands:

Command Use	Description
`-cmd=build`	Creates executable IR from source code. Default command in case nothing is specified.
`-cmd=compile`	Creates compiled object IR from source code.
`-cmd=link`	Creates executable IR or library from object IR and libraries.

Offline Compiler supports the following arguments:

Argument Use	Description
`-input=<input_file_path>`	Builds OpenCL code from the `input_file_path` file. Use the `-input` argument with the `build` and `compile` commands.
`-binary=<"binary_files">`	Links comma-separated binary files. Use with the `link` command.
`-version`	Shows the tool version.
`-help`	Shows help menu, containing the list of available commands, arguments, and options.

Offline Compiler supports the following options:

Option Use	Description

-device=<device_type>	Selects target device type: • cpu - Intel CPU device, which is **Default** • gpu - Intel Graphics device • co - Intel Xeon Phi coprocessor device • cpu_2_0 - Intel CPU device on Experimental OpenCL 2.0 Platform
-targetos=<os>	Set target operating system if it is different from current: 'android' (use with 'cpu' device only). The command is supported only in 32-bit version of the tool.
-simd=<instruction_set_arch>	Selects target instruction set architecture. Available on CPU device only. The following instruction set architectures are available: • sse42 - Streaming SIMD Extensions 4.2 • avx - Intel Advanced Vector Extensions (Intel AVX) • avx2 - Intel Advanced Vector Extensions 2 (Intel AVX2)
-output[=<output_file_path>]	Writes build log into the output_file_path. When this option is specified, the build log does not appear in the command-line.
-asm=[<file_path>]	Generates assembly code.
-llvm[=<file_path>]	Generates LLVM code.
-llvm-spir32[=<file_path>]	Generates 32-bit LLVM SPIR code.
-llvm-spir64[=<file_path>]	Generates 64-bit LLVM SPIR code.
-ir[=<file_path>]	Generates intermediate representation binary.
-spir32[=<file_path>]	Generates 32-bit SPIR code.
-spir64[=<file_path>]	Generates 64-bit SPIR code.
-scholar	Enables performance hints.
-bo[="<build_options>"]	Adds comma-separated build options.

OpenCL™ Debugger for Linux* OS

OpenCL™ Debugger for Linux* OS enables debugging OpenCL kernels with the GNU Project Debugger (GDB).

NOTE

Debugger supports kernel debugging on CPU device only.

To debug OpenCL kernels with the Debugger, you need the GNU Project Debugger (GDB) version 7.3.1 or higher with Python support.

Directly link your application to `libpthread.so`. Do not use `LD_PRELOAD`, since `LD_PRELOAD` fails loading the Intel OpenCL devices altogether.

To enable GDB debugging of an OpenCL kernel, in the build options string parameter in the `clBuildProgram` function:

1. Add the –g flag.
2. Specify the full path to the file.

   -s <full path to the OpenCL source file>

NOTE

Relative path to the CL file is not supported.

   Enclose the entire path with double quotes if the path includes spaces.

   For example:

```
err = clBuildProgram(
        <your_cl_program_name>,
        0,
        NULL,
        “-g -s \“<path_to_opencl_source_file>\””,
        NULL,
        NULL);
```

3. Invoke your application that executes the target OpenCL kernel in GDB:

```
$ <path_to_gdb> --args ./<app_name> <app_args>
```

4. Place a breakpoint in the host application after compiling the OpenCL code, and then execute the kernel. Consider using `clEnqueueNDRangeKernel`.
5. Once you hit the breakpoint, place another breakpoint in the target kernel and issue a run command:

```
(gdb) b square
Breakpoint 3 at 0x700000ef: file…
```

6. Continue the run until the GDB stops inside the kernel, and then query the symbols

```
(gdb) l
1       __kernel void square(
2          __global int* input,
3          __global int* output,
4          const unsigned int nElems)
5       {
6          int index = get_global_id(0);
7          if (index < nElems)
8             output[index] = input[index] * input[index];
9       }
10
(gdb) p nElems
$1 = 1024
(gbd) p input[0]
$2 = 1122
(gdb)
```

7. You can also examine the call stack and variables in the calling frames. For example:

```
(gdb) bt
#0 square (input=0x3f7e380, output=0x3eed900, nElems=1024) at
simple_square.cl:6
#2 0x000000007000021c in square()
```

```
#3 0x00007ffff64bdf23 in InvokeKernel (params_size=,

pParameters=, pEntryPont=) at…

[…]

(gbd)
```

When the kernel compilation completes and GDB receives a notification of the kernel code, the GDB stops inside a kernel. After that, you can find the source files GDB recognizes, including the files that contain the OpenCL kernels, by issuing the `i sources` command to GDB.

The path is the full route to the OpenCL source file provided with the `-s` flag while building the kernel.

During the debugging session, all work-items execute simultaneously, which means that different work-items hit a breakpoint multiple times. To examine a specific segment of code for a single work-item, you should manually insert a condition on `get_global_id()`.

Debugging with Visual Studio* Plug-in

OpenCL™ Debugger

OpenCL™ Debugger plug-in for Microsoft Visual Studio* IDE enables debugging OpenCL kernels using the Microsoft Visual Studio software debugger GUI. The Debugger enables debugging host code and OpenCL kernels in a single Microsoft Visual Studio debug session.

Debugger supports existing Microsoft Visual Studio debugging windows such as:

- Breakpoints
- Memory view
- Watch variables – including OpenCL types like `float4`, `int4`, and so on
- Call stack
- Auto and local variables views

NOTE

Debugging is available only for CPU device. If the code should run on Intel Graphics, debug on CPU device during development phase, then change the target device.

For debugger limitations and known issues refer to the *Intel SDK for OpenCL Applications 2014 - Release Notes*.

Enabling Debugging in OpenCL™ Runtime

To enable debugging mode in the Intel OpenCL runtime for compiling OpenCL code using OpenCL™ Debugger plug-in for Microsoft Visual Studio* IDE, do the following:

1. Add the –g flag to the **build options** string parameter in the `clBuildProgram` function.
2. Specify full path to the file in the **build options** string parameter to the `clBuildProgram` function accordingly (including the CL file name):

```
-s <full path to the OpenCL source file>
```

If the path includes spaces, enclose the entire path with double quotes.

NOTE

Relative path to the CL file is not supported.

For example:

```
err = clBuildProgram(
```

```
          g_program,
          0,
          NULL,
          "-g -s \"<path_to_opencl_source_file>\"",
          NULL,
          NULL);
```

According to the OpenCL standard, work-items execute OpenCL kernels simultaneously. The Debugger requires setting in advance the global ID of the work-item to debug, which is before debugging session starts. The Debugger stops on breakpoints in OpenCL code only when the pre-set work-item reaches them.

NOTE

To work with the OpenCL™ Debugger plug-in for Microsoft Visual Studio* IDE, the OpenCL kernel code must exist in a text file, separate from the code of the host. Debugging OpenCL code that appears only in a string embedded in the host application is not supported. Create your OpenCL project with the OpenCL Offline Compiler plug-in for Microsoft Visual Studio* to get seamless integration with the Debugger.

Configuring Debugger

To configure the OpenCL™ Debugger plug-in for Microsoft Visual Studio* IDE, do the following:

1. Run the Visual Studio IDE.
2. Select **CODE-BUILDER** > **OpenCL Debugger** > **Options**.
3. Check **Enable OpenCL Kernel Debugging**.
4. Set applicable values in the **Select Work Items** fields. The values specify its 3D coordinates. You can select only one work-item.

NOTE

If NDRange is not 3D, leave unused dimension values at 0.

Changing Debugging Port

If you receive a “Protocol error" message, change your firewall settings or change debugging port in the OpenCL™ Debugger plug-in for Microsoft Visual Studio* IDE.

NOTE

Default debugging port is 56203.

To change the debugging port number, do the following:

1. Run the Visual Studio IDE.
2. Select **CODE-BUILDER** > **OpenCL Debugger** > **Options**.
3. Switch to the **Advanced Settings** tab.
4. Check the **Use Custom Debugging Port** check box.
5. In the **Debugging Port Number** field enter the port you need.

NOTE

If the **Use Custom Debugging Port** check box is unavailable, switch to the **Basic Settings** tab and check the **Enable OpenCL Kernel Debugging** check box.

Troubleshooting the Debugger

In case of issues with kernel debugging,

1. Set the following environment variables:

```
INTEL_OCL_DBG_LOG=1 INTEL_OCL_DBG_LOG_FILE=c:\temp\debugger.txt
```

2. Restart the Microsoft Visual Studio* IDE.
3. Continue debugging.

Using these environment variables, you generate a log file. Use it to determine the root cause of the issue. You can submit the generated log at http://software.intel.com/en-us/forums/intel-opencl-sdk.

API Debugging in Visual Studio*

OpenCL™ API Debugger

The interface of the Microsoft Visual Studio* IDE provides standard debugging capabilities for the host side of OpenCL™ applications, while the OpenCL Debugger plug-in of the Code Builder enables debugging OpenCL kernels. The stitch between simultaneous debugging of OpenCL kernel and host application might be complicated in different stages. API Debugging feature of the Code Builder - Debugger plug-in for Microsoft Visual Studio covers the stitch.

The API Debugging feature enables monitoring and understanding OpenCL environment of applications throughout execution.

The feature supports the following:

- **API Tracing** - lists a trace of all OpenCL API calls that occurred during the execution, list of trace arguments, return values, and execution time.
- **OpenCL Objects View** - shows all OpenCL objects that exist in memory during the execution.
- **Properties View** - retrieves common information per each OpenCL object.
- **Command-Queue View** - tracks the execution status of the enqueued commands.
- **Problems View** - summarizing all error and warning messages.

- **Image View** - visually displays all 2D image objects as bitmaps.
- **Data View** - visually displays buffer data and 2D image pixel arrays on a grid.
- **Save/Load session** - enables capturing a state/snapshot of all views of the plug-in, saving it on disk, and also loading the stored sessions.
- **Memory Tracing** - enables storing OpenCL Images and Buffers content, and visually examining either by Bitmap or Grid view the contents of the underlying data associated with the memory object throughout the various API calls that affected it.

NOTE

Concurrent debugging sessions are not supported with the OpenCL API Debugger. This includes attaching the debugger to more than one process, or opening multiple instances of the Visual Studio and debugging processes concurrently.

See Also

Trace View
Objects Tree View
Properties View
Command Queue View
Problems View
Image View
Data View
Memory Tracing

Enabling the API Debugger

To use the API Debugger, do the following:

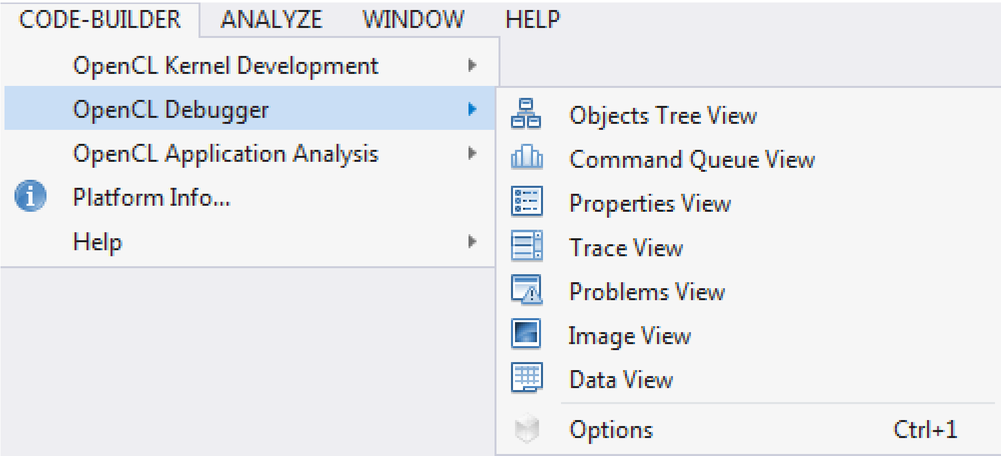
1. Start the Microsoft Visual Studio* IDE.
2. Go to **CODE BUILDER** > **OpenCL Debugger** > **Options** > **API Debugger**.
3. Check **Enable OpenCL API Debugger**.
4. Insert breakpoints in the application in different OpenCL API calls, and then start debugging with **F5**.
5. Open the needed API Debugger views by selecting **CODE BUILDER** > **OpenCL Debugger** and select the view you need.

The API Debugger updates the view panes when:

- The Debugger hits a breakpoint in Microsoft Visual Studio* IDE.
- One of the views behavior changes, which means you click a buttons.
- The host application execution ends.

So, to see data in the views,

1. Insert some breakpoints in your application (in different API calls), or run the application with **Start Debugging (F5)**.
2. Then open the needed views via **CODE BUILDER** > **OpenCL Debugger**.



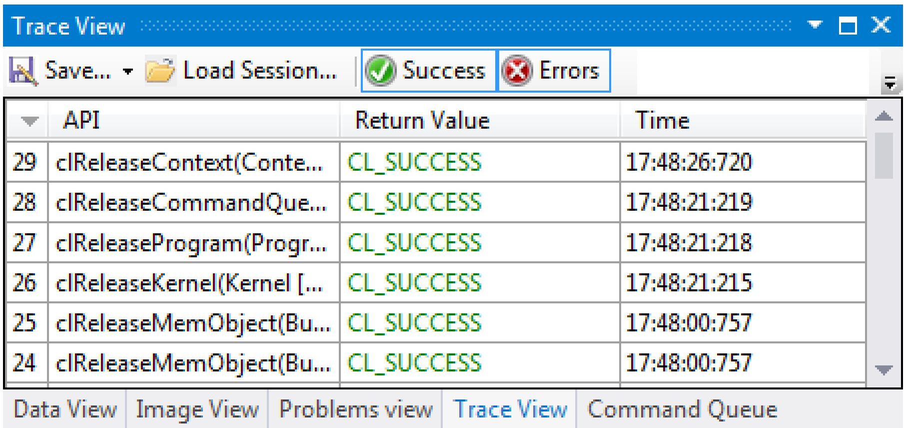
See Also

[Trace View]
[Objects Tree View]
[Properties View]
[Command Queue View]
[Problems View]
[Image View]
[Data View]
[Memory Tracing]

Trace View

The trace view contains trace of all OpenCL™ API Calls during the execution, API call arguments, returned values and time of execution.

To access the trace view, select **CODE BUILDER** > **OpenCL Debugger** > **Trace View**.



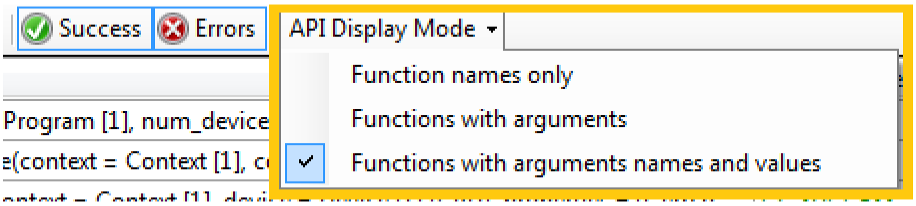
Use the following buttons to control the view:

- **Save** – enables saving the current state of all views with live OpenCL objects, API trace, command queue, and so on,
    - o to either a binary file (`.trace`) that can be later loaded with the **Load Session** button.
    - o or, you can export a list (trace) of all API calls into a CSV file
- **Load Session...** – enables restoring the state of the views from a previously saved `.trace` file either using **Save As...** or **Generate trace file** option in the API Debugger settings.

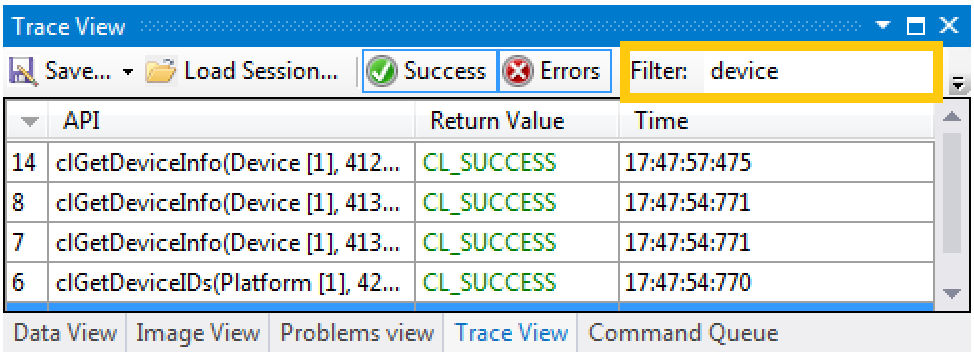
NOTE

This feature is available only when Visual Studio* IDE is not in debug mode, as views are synced with the application you debug.

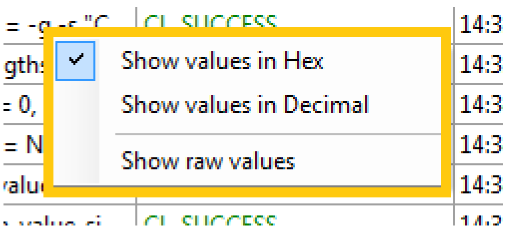
- **Success/Errors** - enables filtering successful or failed API calls.
- **API Display Mode** – toggles between views:
  - o Function name only
  - o Function name and arguments
  - o Function name with argument names and values



- **Filter** – enables filtering out API calls by name. Start typing "device" for example, to get only API calls with device in their name:



- **Right-click context menu** - enables toggling between various display modes of arguments Hex\Decimal, and show raw values (for example, 0x2 instead of `CL_DEVICE_TYPE_CPU`).



To enable automatic trace generation, select **CODE BUILDER** > **OpenCL Debugger** > **API Debugger** > **Auto-generate session**. Traces are saved in the folder that is specified in the **Output Folder** text box.

Automatic trace generation is an equivalent to clicking **Save…** after the host application ended.

See Also

[Enabling the API Debugger]

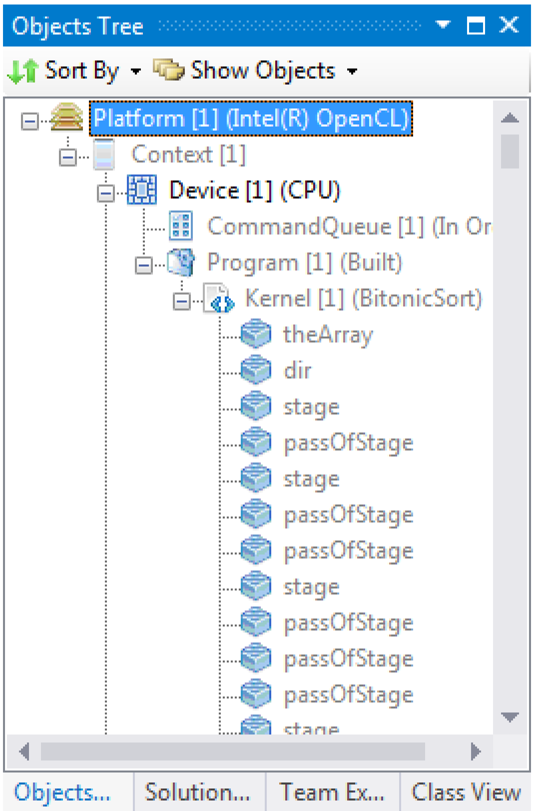
Objects Tree View

OpenCL™ API Debugger plug-in for Microsoft Visual Studio* IDE **Objects Tree** view enables:

- Getting a better understanding of which objects are “alive”/released at any given point of time.
- Showing hierarchy and dependencies of various OpenCL objects.

API Debugger also reflects the OpenCL objects that exist in memory during application execution:

- Platform
- Devices
- Context
- Buffer
- and so on



When creating an OpenCL context for with (for example, `clCreateContext()` API call), the Objects Tree updates immediately with the new context object.

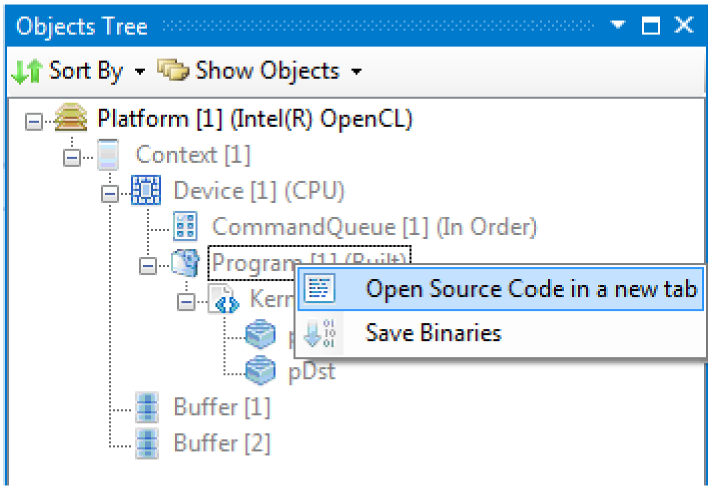
Objects dim when become released by, for example, `clRelease`.

Use the following buttons to control the **Objects Tree** view:

- **Sort By** – enables toggling the way data is displayed:
  - **Sort by Context** – all entities that are associated with a specific context are displayed as context successors.
  - **Sort by Device** – all contexts are displayed as children of the devices.
- **Show Objects** – enables displaying only a subset of the OpenCL objects. Use it when you have a lot of OpenCL objects that are alive at some given moment, and you need to see status of only

several objects or object types.
To view objects of a specific type only,
- o Select **Show Objects** > uncheck **Show All**.
- o Select **Show Objects** > select the object type to display.

- Open **Source Code in a new tab** – enables viewing the source code associated with the program object. Right-click any **Program object** in the tree, then click **Open Source Code in a new tab**.



- **Save Binaries** – enables dumping binary files that were built for the program object with use of `clBuildProgram`, or `clCreateProgramWithBinaries`. Right-click any built program object in the tree, then click **Save Binaries** and select the location to save the binaries.

See Also

Enabling the API Debugger

Properties View

OpenCL™ API Debugger plug-in for Microsoft Visual Studio* IDE exposes miscellaneous properties for each OpenCL object or Command Queue event. Properties view pre-fetches information about OpenCL objects or events, and displays it when a particular object is selected.

Access the **Properties View** by selecting **CODE BUILDER** > **OpenCL Debugger** > **Properties View**.

All properties in the **Properties View** are read-only.

OpenCL Objects Properties

To view properties for an OpenCL object, do the following:

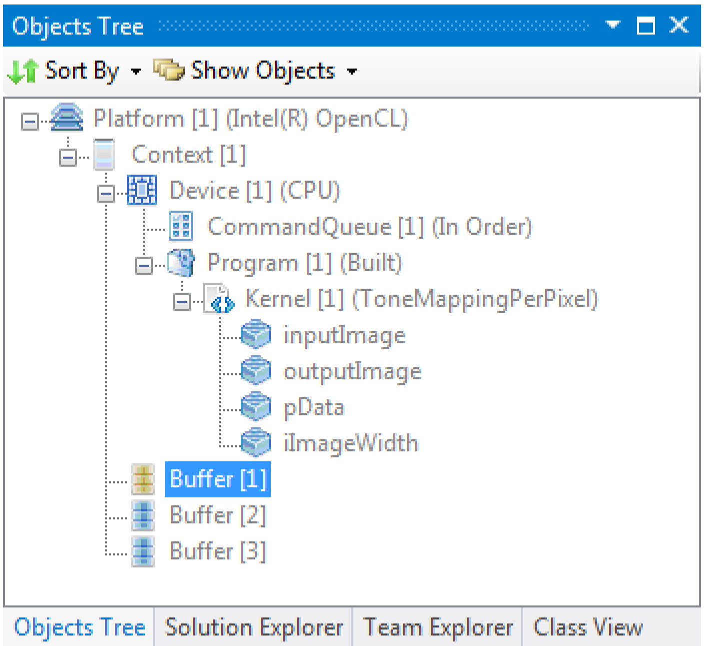
1. Select (left-click) some object from the **Objects View** window.
2. Open the **Properties** view.

The **OpenCL Objects Properties** view is an alternative to calling API calls such as `clGetDeviceInfo()`.

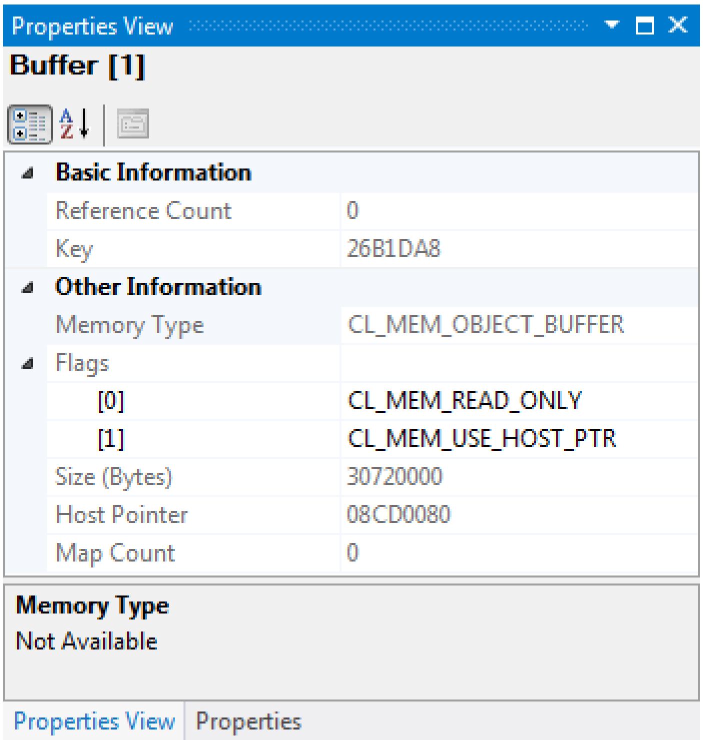
Command Queue Events Properties

To view properties for an OpenCL command-queue event, do the following:

1. Select (left-click) an event from the **Command Queue View** window.



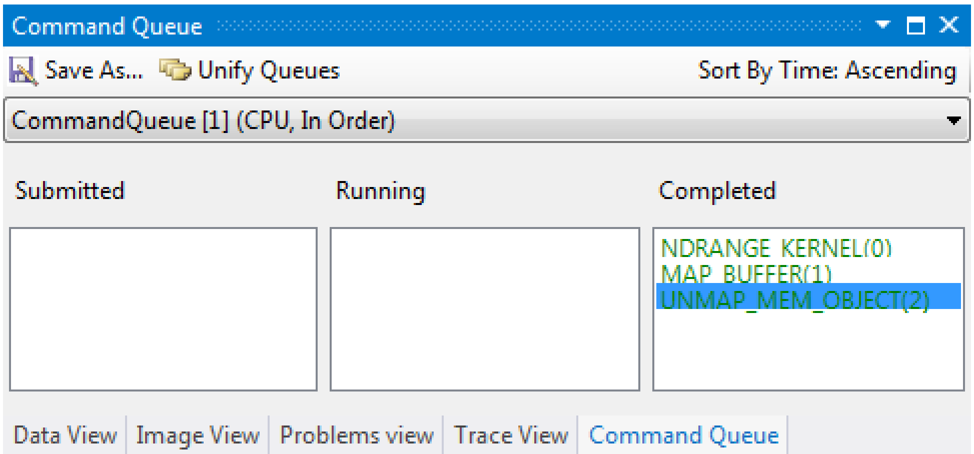
2. Open the **Properties** view.



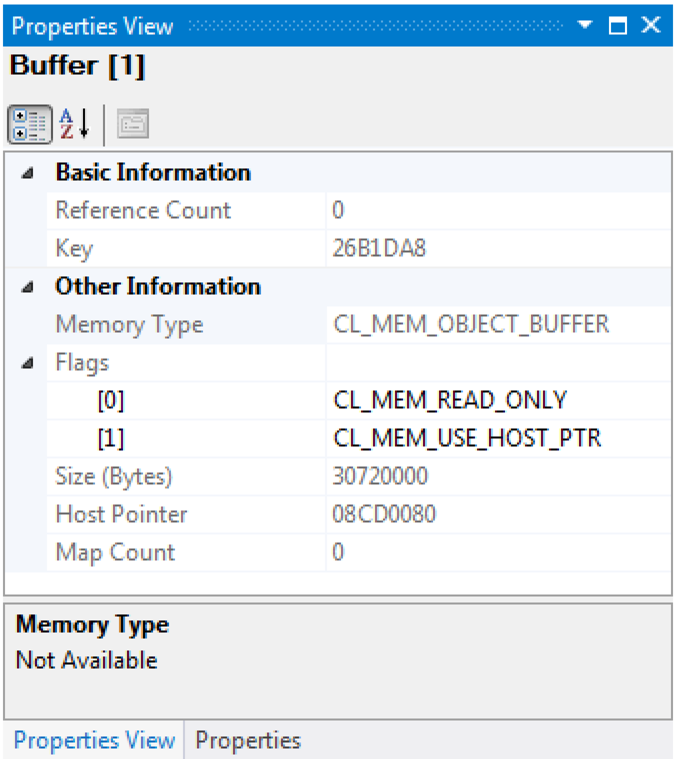
The **Command Queue Events Properties** view is an alternative to retrieving execution time by adding the `CL_QUEUE_PROFILING_ENABLE` parameter to `clCreateCommandQueue()` when creating the command queue to which the commands are enqueued, and then querying the enqueued events execution times using `clGetEventProfilingInfo()`.

To view properties for an OpenCL command-queue event:

1. Select (left-click) some event from the **Command Queue View** window.



2. Open the **Properties** view.



See Also

[Enabling the API Debugger]()

Command Queue View

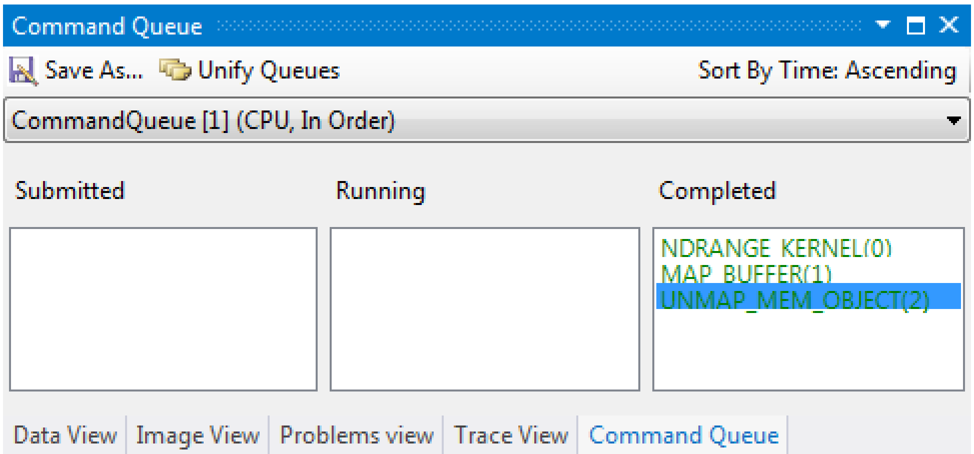
OpenCL™ API Debugger plug-in for Microsoft Visual Studio* IDE provides **Command Queue View**, which enables tracking the execution status of enqueued commands (issued by `clEnqueue` API call).

The status for a command can be either of the following options:

- Submitted
- Running
- Completed

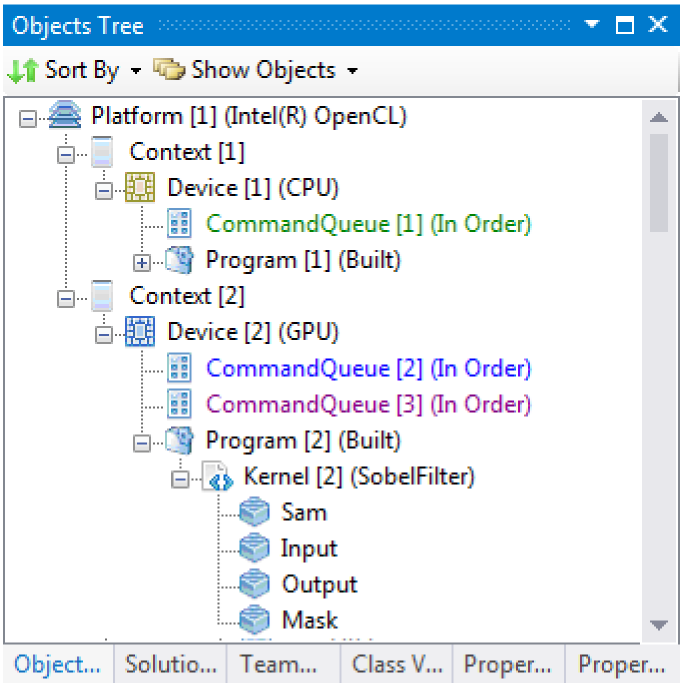
The **Command Queue View** also displays events for a particular command-queue (Separate Queues) or for all events from all queues (Unify Queues).

Access the **Command Queue View** by selecting **CODE BUILDER** > **OpenCL Debugger** > **Command Queue View**.



Use the following buttons to control the **Command Queue View**:

- **Save As...** – enables dumping the current status of commands to a text file for a later investigation.
- **Unify Queues** – enables to view all commands across all queues.
  Also note the following:
  - When working in the **Unified** queues mode, each entry is added a suffix of the form: `CQ [NUMBER]`, which indicates the command-queue number, with which the command is associated.
  - For example: `TASK(3) CQ[1]`, indicates that the 3rd command enqueued to some queue is a `clEnqueueTask` command, and is associated with Command-Queue [1].
  - Each queue has a color and all its corresponding commands have the color of the queue. Such differentiation makes it easy to spot in the eye the corresponding queues of the commands in question:



Command-queues in the **Objects Tree** view share the same color in the view as their color in the **Command Queue** view.

- The **Unify Queues** button changes into **Separate Queues** button after being clicked, which does the opposite operation and shows events status per queue.

- **Separate Queues** – appears when working in **Unified** mode after clicking **Unify Queues**, and does the opposite to **Unify Queues** operation, which is showing the commands per-queue. First select the queue from the drop-down list under the **Save As...** button, then the view updates with the commands that are associated with the selected queue.

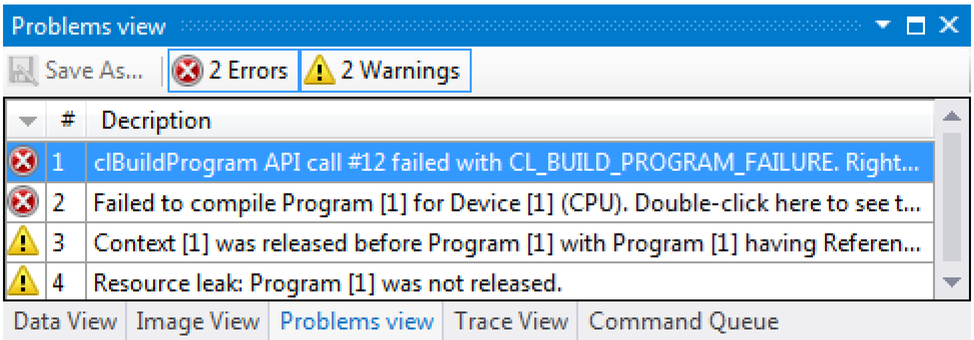
See Also

Enabling the API Debugger

Problems View

OpenCL™ API Debugger plug-in for Microsoft Visual Studio* IDE provides the **Problems View** that summarizes into a single view all errors and warnings that occurred during the execution.

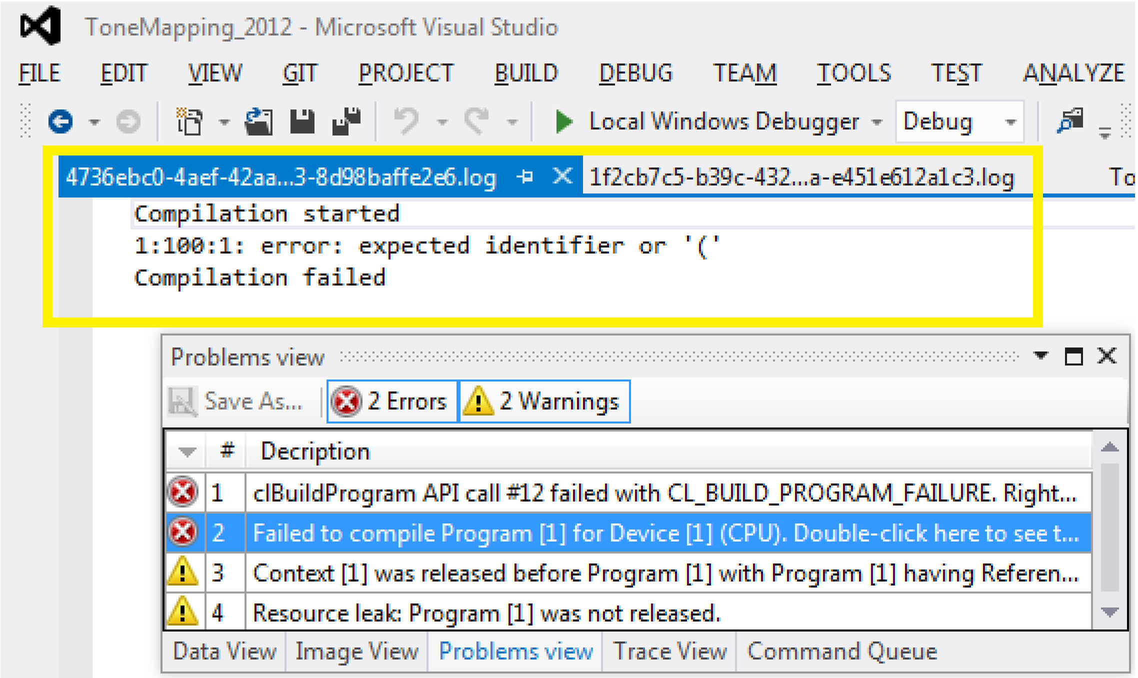
To access the view, select **CODE BUILDER** > **OpenCL Debugger** > **Problems View**.



Problems View supports the following features:

- Displaying warnings and errors of kernel compilation.
- Showing uninitialized kernel arguments, each one of them is set by calling `clSetKernelArg()` for each argument.
- Releasing OpenCL objects in the out-of-order mode, for example, when you release a program object before releasing its kernels (`clReleaseProgram` before `clReleaseKernel`).
- Resource leaks: at the end of the program, an error entry is added for each OpenCL resource (programs, buffers, images, and so on) that is not released
- API call failures – when an OpenCL API call fails, an error entry is added to the problems view. You can right-click the entry, to jump to the line item in the trace view that caused the failure.

Double-clicking an error in the **Problems View** opens the compilation error log message in the code editing area.



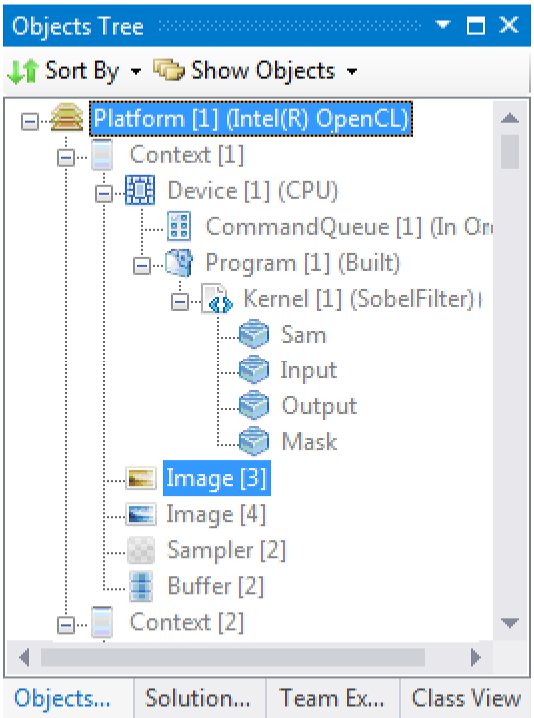
See Also

[Enabling the API Debugger]

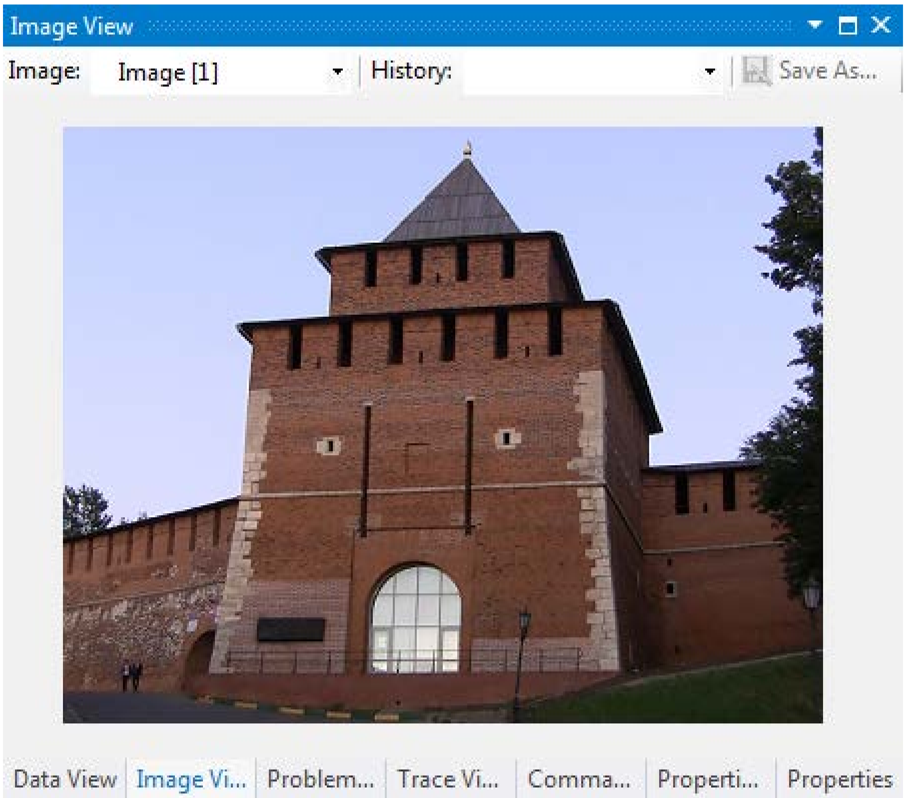
Image View

This view enables visual displaying of the OpenCL™ Image objects in the host application.

Each Image object is added to the **Objects View**, and by double-clicking each Image object, the bitmap is displayed - the underlying pixel array gets translated into bitmap.



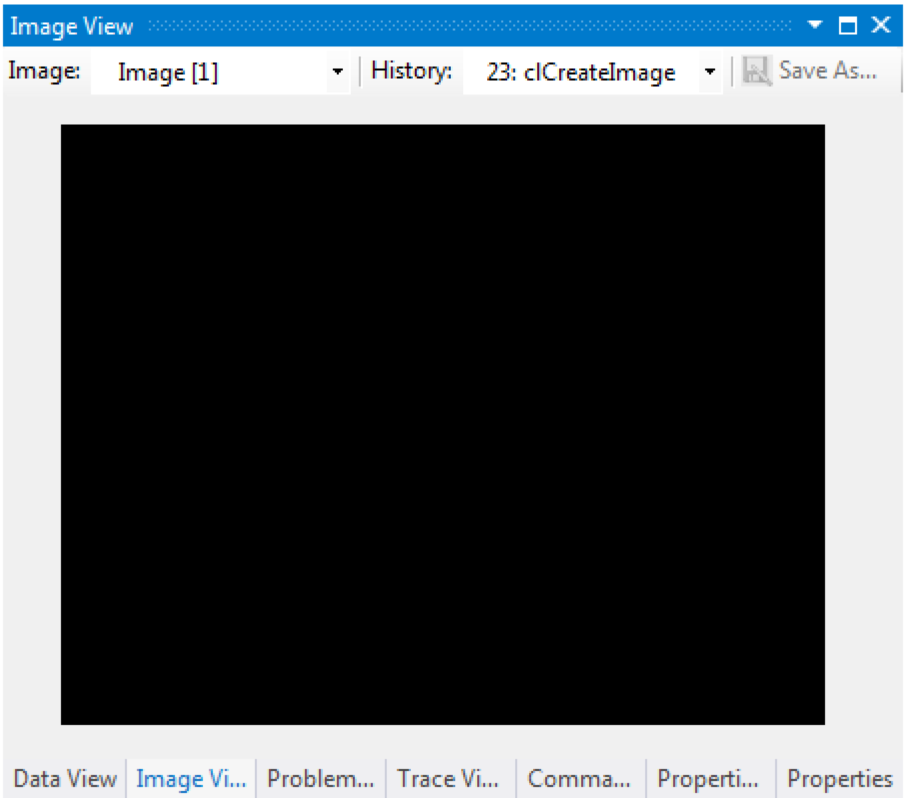
Double-click the Image you need and wait for the **Image View** to appear with the latest state of the image



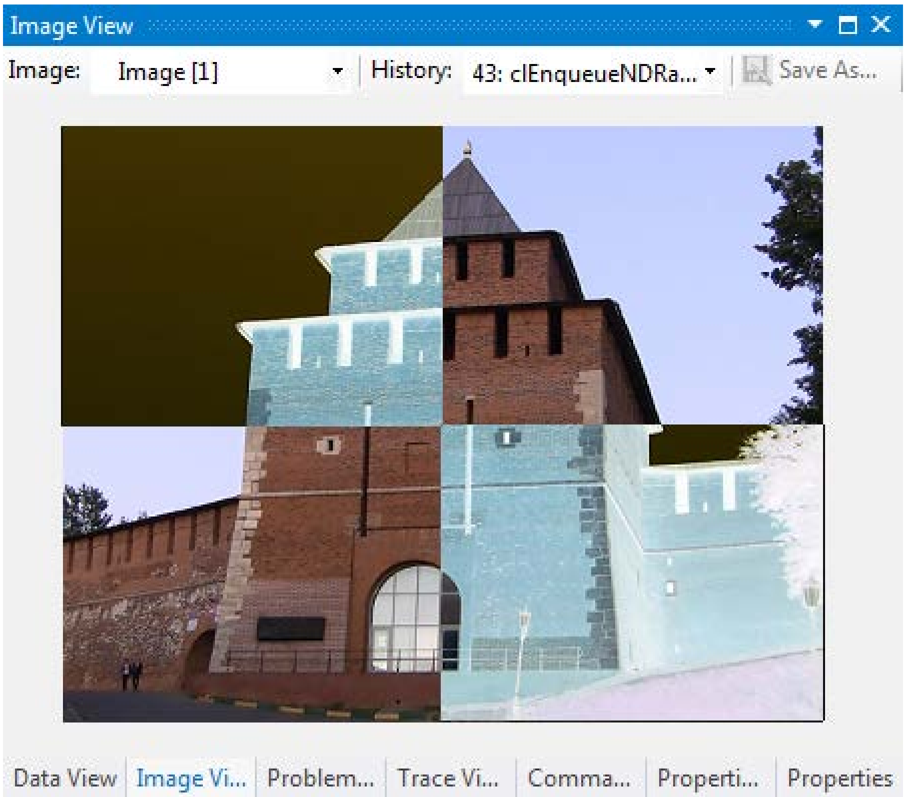
From the Images drop-down, select any Image. The view displays the image as bitmap.

The history drop-down enables viewing various states of the selected image, where each state is a result of an API call.

If, for instance, you create an image with all pixels set to 0, you see on Image creation the following view:



Now, after running the kernel on the selected Image, you can observe that it was updated indirectly by `clEnqueueNDRange` API call (therefore causing the kernel to run).

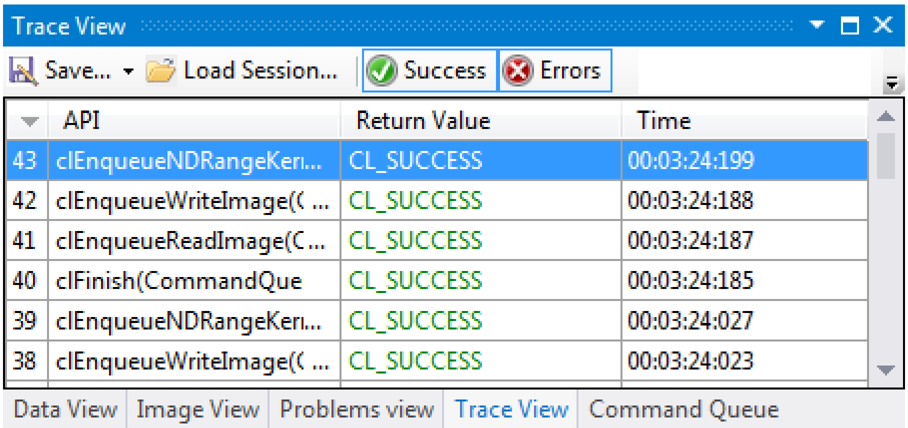


Each state is related to the API call that caused the change, and is in the following format: `#ID: API Call`.

Where `#ID` is the number of API call that caused the change, and `API Call` is the OpenCL API call that affected (changed) the object.

This is the same API call that it shown in the **Trace View**.

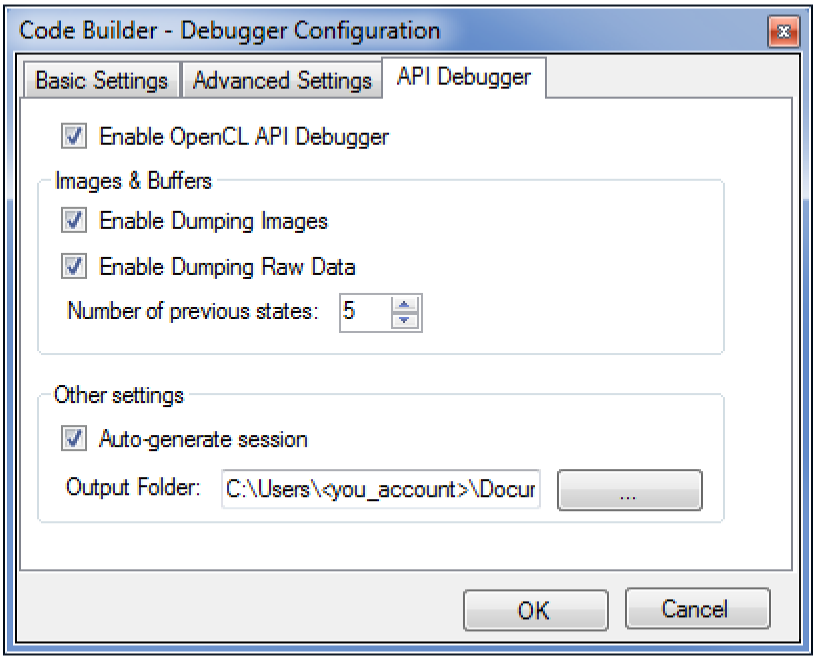
When selecting an Image from the drop-down, or alternatively selecting an Image state, the **Trace View** automatically highlights the API call that is related to that state:



The **Save As** button in the **Image View** enables saving a copy of the displayed image to disk, as bitmap.

The number of states to save per each memory object (Image, Buffers and SubBuffers) can be configured via:

CODE BUILDER > **OpenCL Debugger** > **API Debugger** > **Images** & **Buffers** > **Number of previous states**



You can also disable dumping images by unchecking **Enable Dumping Images**.

Notes:

- To display the data, the plug-in has to perform background activities such as fetching the data, and converting it into a displayable format, which might impact performance when using the **Enable Dumping Images** or **Enable Dumping Raw Data** options.
  Take into account that profiling performance measured by either `clGetEventProfilingInfo` runtime API call / any other method for measuring execution time or occupied host memory, might entail certain performance degradation.
  To get more accurate profiling results, use the runtime directly by pushing **Ctrl+F5**, **Start w/o Debugging**, or disabling API Debugger in the plug-in configuration menu.
- Only 2D images are supported for viewing, which is memory objects that contain `CL_MEM_OBJECT_IMAGE2D` in their `image_type` field inside their descriptor (`cl_image_desc`).
- Images above 2GB are not supported and will not be displayed
- The bitmaps shown in the **Image View** are merely an 8-bit RGBA approximation of the underlying pixel array of the associated images.
  Behind the scenes, the plug-in does a liner color conversion from the input range of the pixels, which can be any type supported by the OpenCL runtime, for example, `CL_SNORM_INT8`, `CL_UNSIGNED_INT16`, and so on) to the [0..255] range.
  As a result, the presented colors might not accurately represent the bitmap as expected.

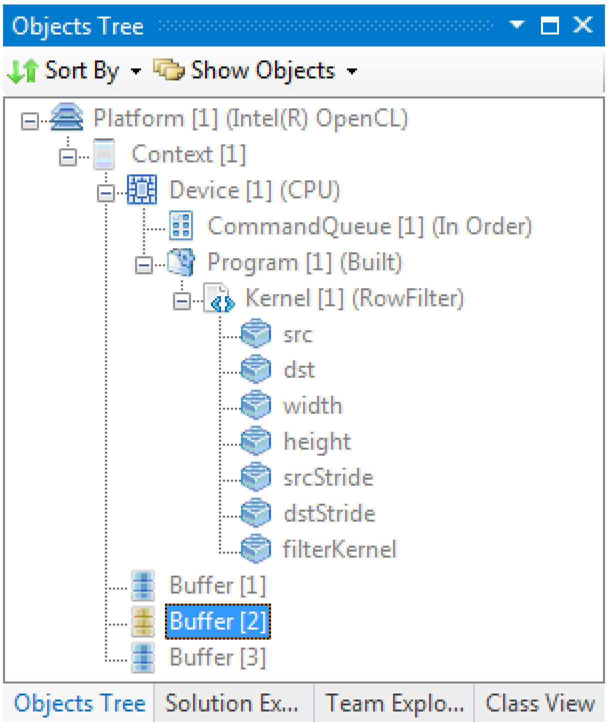
See Also

Enabling the API Debugger

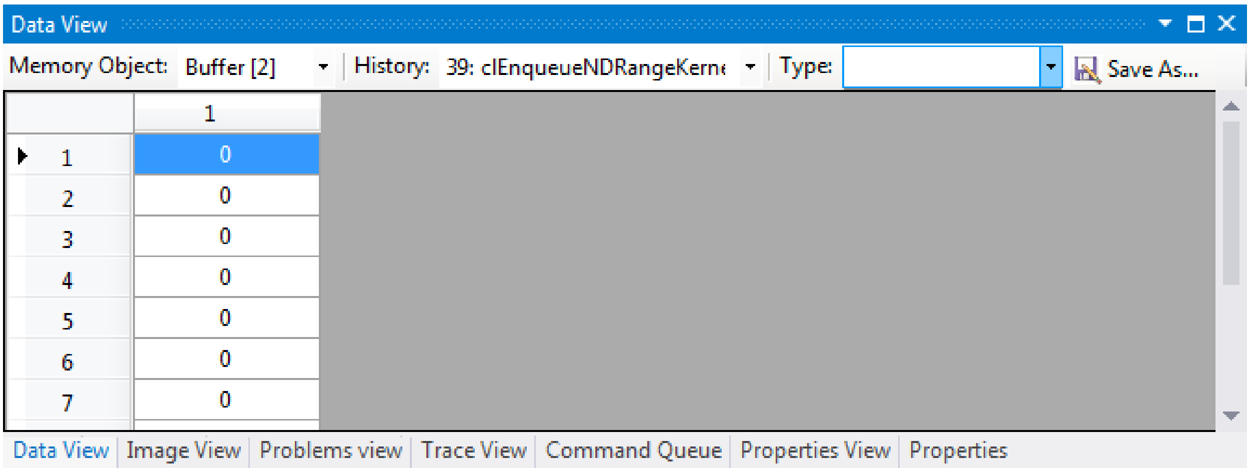
Data View

The Data View enables visual displaying on a grid of all the OpenCL Memory Objects: Images, Buffers and SubBuffers, that were instantiated in the host application.

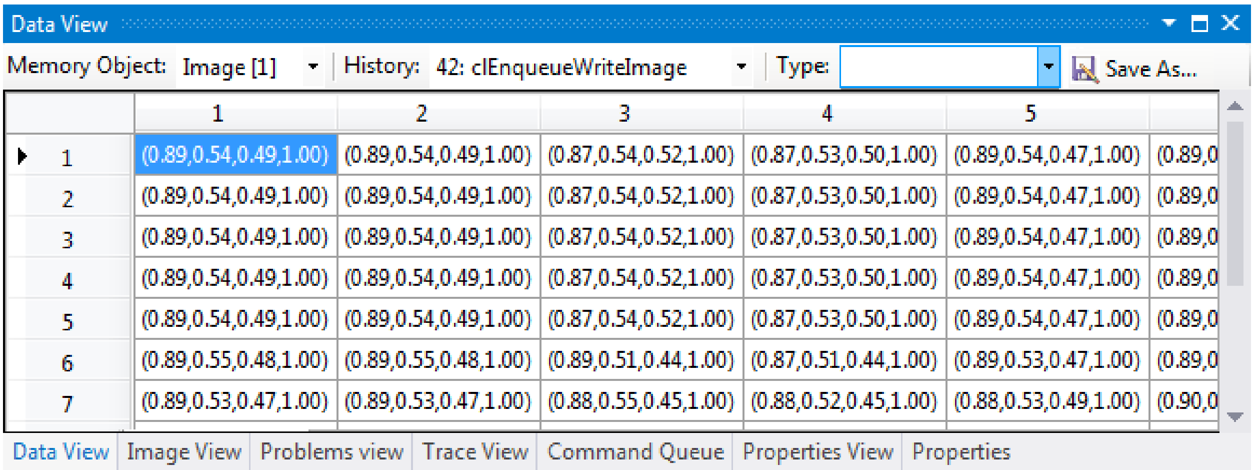
Each Memory Object is added to the **Objects View**, and by double-clicking Buffers/SubBuffers you can display the buffer contents, or by double-clicking an Image you can view the raw pixel data associated with the image.



Double-click the Buffer you need, and **Data View** window appears with the latest state of the buffer/sub-buffer.



From the Memory Objects drop-down, select any memory object and the view shows the raw data associated with the object:



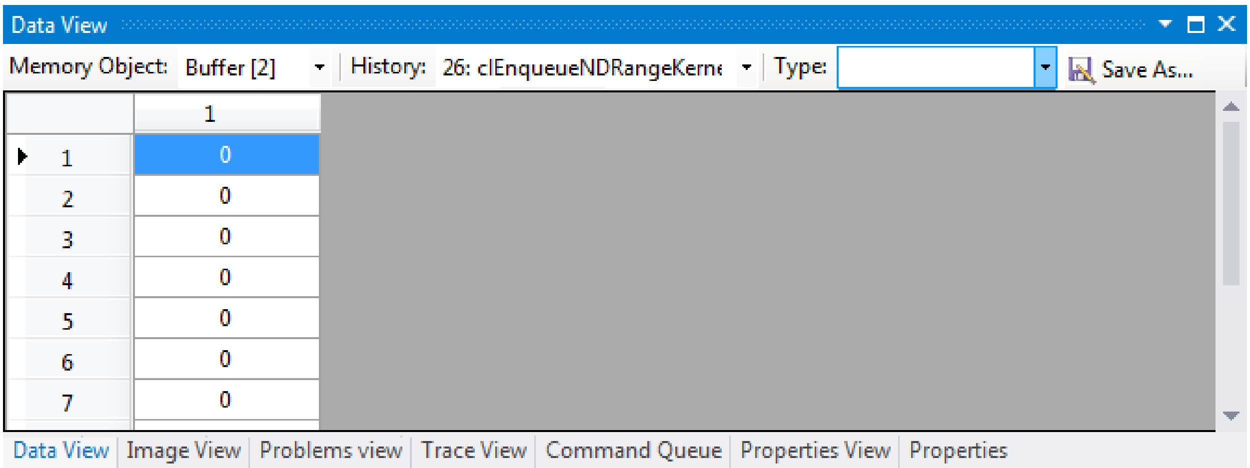
The history drop-down enables viewing various states of the selected memory object, where each state is a result of an API call.

Consider the situation of a host application that calculates a histogram of a grayscale image. For example, use a buffer with 256 bins for each color of the image, to calculate the histogram.

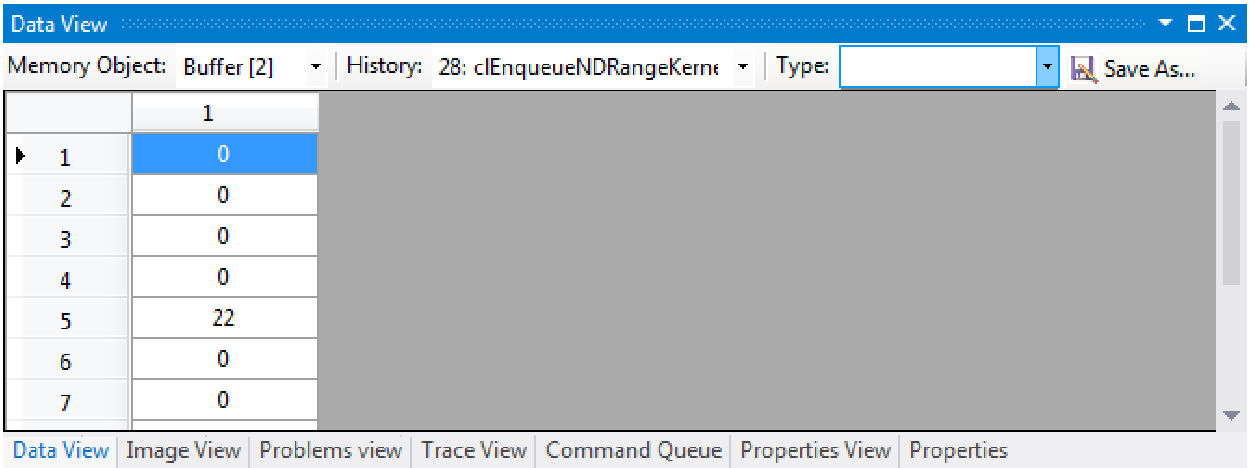
As a first step, issue an NDRange kernel called bzero to initialize the buffer with zeros:

```
__kernel void bzero(__global unsigned int *outBuf,
                                   __const unsigned int cols)
{
       size_t row = get_global_id(0);
       size_t col = get_global_id(1);

       outBuf[row*cols + col] = 0;

}
```

Examine the buffer contents on the grid and see that all buffer elements are set to zero:

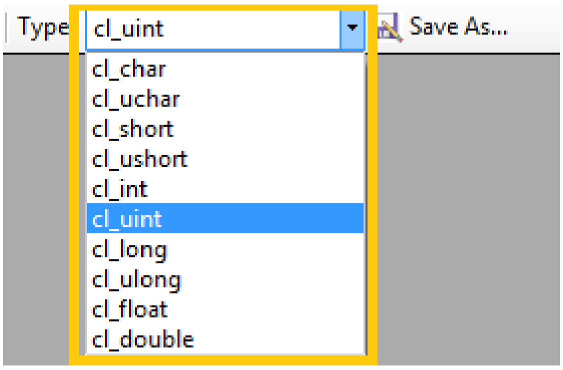


Now, as a second step, issue a 2nd NDRange command that calculates the histogram of the image using the buffer as bins counter:



This example has 22 pixel elements with grayscale value 5, and 27 pixels with grayscale value 9, and so on.

Use the **Type** box to select the underlying data type (for example, `cl_uint`, `cl_double`).



The **Save As** button enables saving a CSV representation of the data to disk.

When exporting Buffer/SubBuffer, you get each buffer cell in a separated line. The Buffer/SubBuffer values are interpreted as a contiguous memory chunk containing unsigned, `chars` as its elements.

When exporting an Image as a CSV, the number of rows in the output CSV is the height of the image (number of rows), and each row represents all columns of that row joined and delimited by commas.

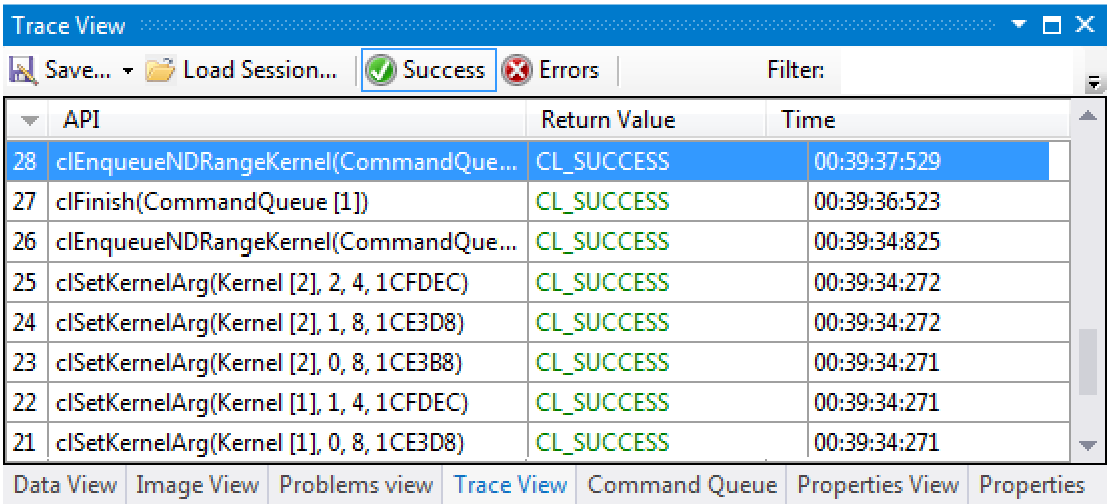
The values in the cells are interpreted according to the image channel data type, so, for example, an Image that has `CL_SIGNED_INT32` as its data-type, causes the resulting output to display each row as an array of signed 32-bit integers.

Each state is related to the API call that caused the change, and is in the following format: `#ID: API Call`.

Where `#ID` is the number of API call that caused the change, and `API Call` is the OpenCL API call that affected (changed) the object.

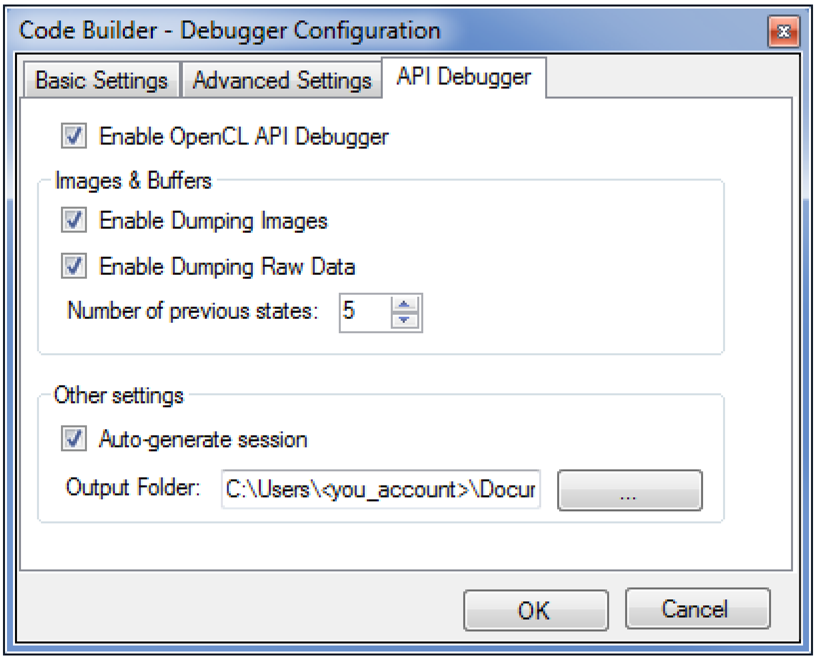
This is the same API call that it shown in the **Trace View**.

When selecting a memory object from the drop-down list, or alternatively selecting a memory object state, the **Trace View** automatically highlights the API call that is related to that state:



The number of states to save per each memory object (Image, Buffers and SubBuffers) can be configured via:

CODE BUILDER > **OpenCL Debugger** > **API Debugger** > **Images & Buffers** > **Number of previous states**



We can also disable dumping raw data by unchecking **Enable Dumping Raw Data**.

Notes:

- To display the data, the plug-in has to perform background activities such as fetching the data, and converting it into a displayable format, which might impact performance when using the **Enable Dumping Images** or **Enable Dumping Raw Data** options.
  Take into account that profiling performance measured by either `clGetEventProfilingInfo` runtime API call / any other method for measuring execution time or occupied host memory, might entail certain performance degradation.
  To get more accurate profiling results, use the runtime directly by pushing **Ctrl+F5**, **Start w/o Debugging**, or disabling API Debugger in the plug-in configuration menu.

- Memory objects above 2GB are not supported and are not displayed.
- Buffers/Sub-Buffers that are set as parameters to kernels via `clSetKernelArg` are fetched into API Debugger after each kernel enqueue operation, regardless of the memory flags they were created with.
  This means that even buffers created with `CL_MEM_READ_ONLY` are fetched behind the scenes.

See Also

Enabling the API Debugger

Memory Tracing

Memory tracing enables the user to capture the session of the debugging into a file, and also to load a previously stored state into the views.

The stored state contains:

- State of all the views – this includes all the data that is filled in the various views of the plug-in
- Images bitmaps (if **Enable Dumping Images** is on)
- Memory objects raw data (if **Enable Raw Data** is on)

The state can be stored by either of the following ways:

- Automatically when host application ends
- Manually, by going to: **Trace View** > **Save** > **Save Session (.trace)**

The automatic memory tracing contains:

- State of all the views
- CSV of all API calls that occurred during the execution

And can be enabled via:

CODE BUILDER > **OpenCL Debugger** > **API Debugger** > **Other settings** > **Auto-generate session**

This option creates a separate directory for each captured session of the plug-in.

The directory is stored under the **Output Folder** specified in the same window.

See Also

Enabling the API Debugger

Configuring the Environment

To develop OpenCL™ applications for Android* OS, you need to configure your system the following way:

1. Download Android* SDK.
2. Put <Android_SDK_Install>\sdk\platform-tools in PATH environment variable.
3. Enable Intel Virtualization Technology (vt-x) in BIOS (Windows* OS only).
4. Run Android SDK Manager from <Android_SDK_Install>\sdk\tools\android.bat
5. Mark and install:
   - **Android 4.2.2 (API 17)** > **Intel x86 Atom System Image**
   - **Extras** > **Google USB Driver**
   - **Extras** > **Intel x86 Emulator Accelerator (HAXM)** (Windows only)
6. Install the OpenCL runtime on an Android* device or emulator.

NOTE

Root permissions are required on Android* devices and emulator.

To make the Android device be accessible without root permissions,

1. Identify the Intel devices by running `lsusb` command, for example:

```
[user@Ubuntu ~]>lsusb
### Output reduced ###
Bus 003 Device 008: ID 8087:0a21 Intel Corp.
```

2. Following the example above, you can either change the ownership of the device file, and/or give permissions to the file:
   - Change ownership of the device file to the desired user and group via the following command:

     ```
     sudo chown USER:GROUP /dev/bus/usb/003/008
     ```

     where `USER` and `GROUP` are the target user and group to have permissions to the device.

   - Give permissions to everyone:

     ```
     Sudo chmod 666 /dev/bus/usb/003/008
     ```

   Udev configuration files should be edited to enable full permissions without sudo.

3. Edit any file(s) that conform to the following convention:

   /etc/udev/rules.d/N-android.rules,

   and append the following line:

   ```
   SUBSYSTEM=="usb", ATTRS{idVendor}=="8087", ATTRS{idProduct}=="0a21", MODE="0666"
   ```

   If no android.rules file are present in /etc/udev/rules.d/, create the following file: /etc/udev/rules.d/51-android.rules.

4. Next step enables read and write opetations on an Android device:

   Call adb root and then call adb remount.

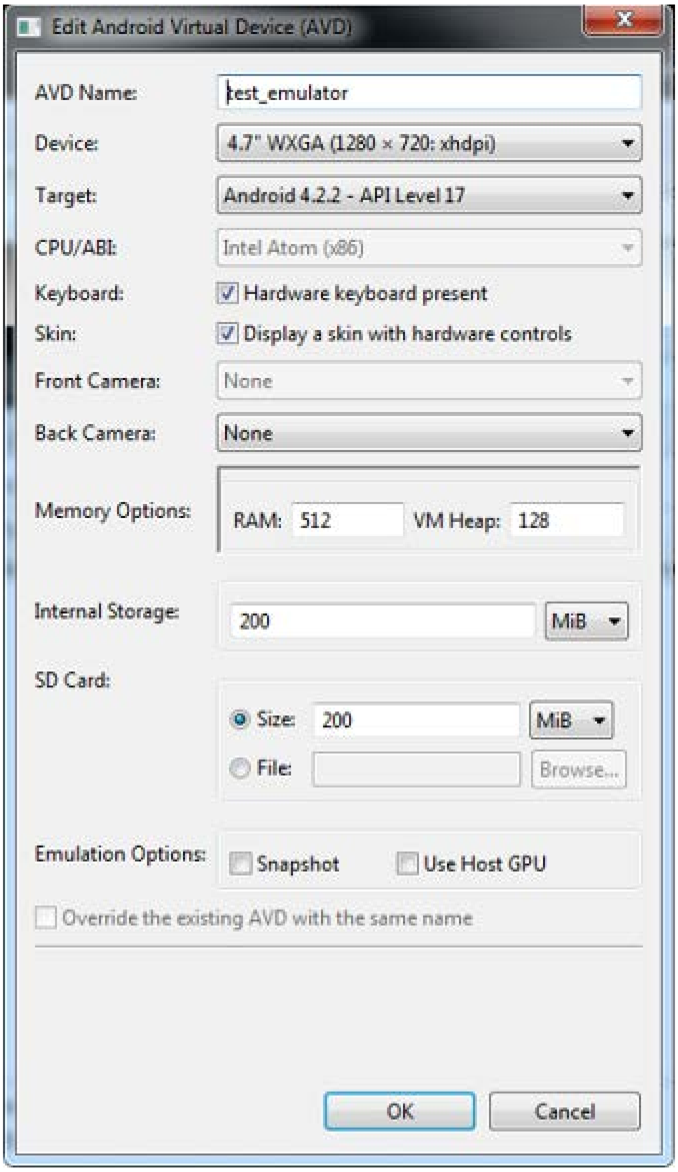
See Also

[Installing OpenCL™ Runtime on Android* OS]

Creating an Android* Emulator

To create a new Android* emulator,

1. Run Android SDK Manager from <Android_SDK_Install>\sdk\tools\android.bat
2. In Android SDK Manager select **Tools** > **Manage AVDs..**, and define new emulator:



To run the created emulator, use the following command:

```
<Android_SDK_Install>\sdk\tools\emulator.exe -avd test_emulator -partition-size 1024
```

Parent topic: Developing OpenCL™ Applications for Android* OS

Installing OpenCL™ Runtime on Android* Emulator

To install the Intel OpenCL™ runtime on Android* Emulator using script, do the following:

1. Go to the `android-preinstall` subfolder of the Intel® SDK for OpenCL™ Applications 2014 installation folder.
2. Use the `OpenCL_Android_Install` script to configure the emulator or Android* device or use the following options to start the emulator manually:

- On Ubuntu* OS `./OpenCL_Android_Install –h`
  The script requests root password.
- On Windows* OS `OpenCL_Android_Install –d <your device/emulator>`

NOTE

On Windows only one device can be running at installation time.

NOTE

Installation of the OpenCL runtime for Android via scripts is supported only on emulator.

NOTE

Root permissions are required on Android emulator.

To configure the emulator manually,

1. Copy the following files from the SDK installation folder to `/system/vendor/lib` using the Android* Debug Bridge:
   - `__ocl_svml_g9.so`
   - `__ocl_svml_n8.so`
   - `__ocl_svml_s9.so`
   - `__ocl_svml_v8.so`
   - `clbltfng9.rtl`
   - `clbltfng9_img_cbk.o`
   - `clbltfng9_img_cbk.rtl`
   - `clbltfnn8.rtl`
   - `clbltfnn8_img_cbk.o`
   - `clbltfnn8_img_cbk.rtl`
   - `clbltfns9.rtl`
   - `clbltfns9_img_cbk.o`
   - `clbltfns9_img_cbk.rtl`
   - `clbltfnv8.rtl`
   - `clbltfnv8_img_cbk.o`
   - `clbltfnv8_img_cbk.rtl`
   - `libcl_logger.so`
   - `libclang_compiler.so`
   - `libcpu_device.so`
   - `libgnustl_shared.so`
   - `libintelocl.so`
   - `libOclCpuBackEnd.so`
   - `libOclCpuDebugging.so`
   - `libOpenCL.so.1.2`
   - `libtask_executor.so`
   - `libtbb_preview.so`
   - `libtbbmalloc.so`
   - `opencl_.pch`

   Use the following command to copy the files:

```
adb -s <Emulator-Name> push <file1> /system/lib
```

2. In the `/system/lib` folder on the Android* device create two links:

```
adb -s <Emulator-Name> shell ‘cd /system/vendor/lib; ln –s libOpenCL.so.1
libOpenCL.so; ln –s libOpenCL.so.1.2 libOpenCL.so.1’
```

3. Copy the `intel.icd` file to `/system/vendor/Khronos/OpenCL/vendors` folder. Use the following command:

```
adb -s <emulator-name> push intel.icd /system/vendor/Khronos/OpenCL/vendors
```

NOTE

If you close the emulator you must reinstall the OpenCL runtime after you run it again.

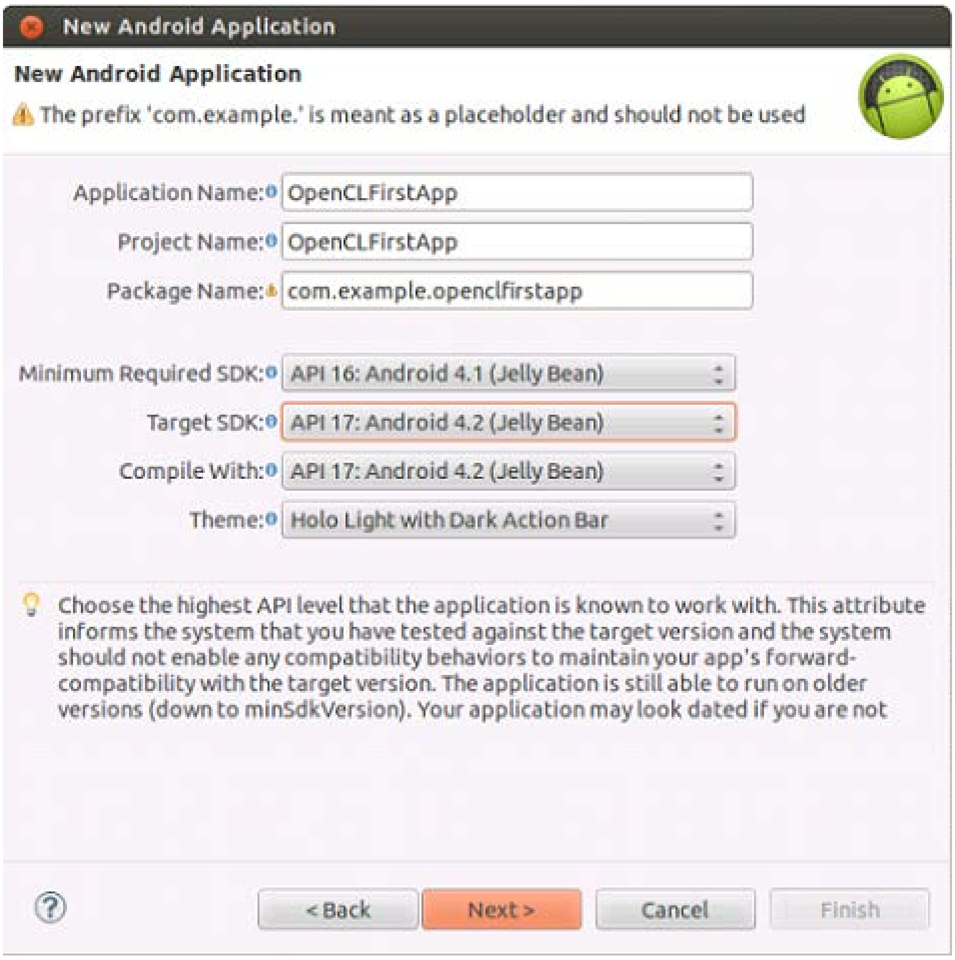
See Also

[Configuring the Environment]

Creating an Android* Application

To create a new application, do the following:

1. Run the Eclipse* IDE from the SDK installation folder:
   - On Windows* OS run `C:\sdk\adt-bundle-windows-x86_64-20130219\eclipse\eclipse`
   - On Ubuntu* OS run `/sdk/adt-bundle-linux-x86_64/eclipse/eclipse`
2. Specify the Android NDK location in Eclipse:
   1. Go to **Window** > **Preferences** > **Android** > **NDK**.
   2. Enter the Android NDK path
3. Create a new Android project:
   1. Go to **File** > **New** > **Project...** > **Android** > **Android Application Project**.
   2. Add the appropriate information. For example:



   3. Click **Next** in all remaining forms.
   4. Click **Finish**.
4. Run the created emulator.
5. Install the OpenCL runtime on the emulator or device.
6. Develop the application and run it using the Intel OpenCL software technology implementation:
   1. Right-click the project name in the **Project Explorer**.
   2. Click **Run As** > **1 Android Application**.

NOTE

Install the Intel® Hardware Accelerated Execution Manager (HAXM) to accelerate the emulator performance on Windows* OS.

Parent topic: Developing OpenCL™ Applications for Android* OS

See Also

Installing OpenCL™ Runtime on Android* OS

Preview Features

OpenCL™ New Project Wizard

About the OpenCL™ New Project Wizard

OpenCL™ New Project wizard is a plug-in for Microsoft Visual Studio* software enables developing Windows* and Android* OpenCL applications with Visual Studio IDE either from scratch (empty project) or based on template projects.

The wizard kit supports the following features:

- Create a new empty OpenCL project for Windows* platforms
- Create a new OpenCL project from OpenCL project template for Windows* platforms
- Create a new OpenCL project from OpenCL project template for Android* devices

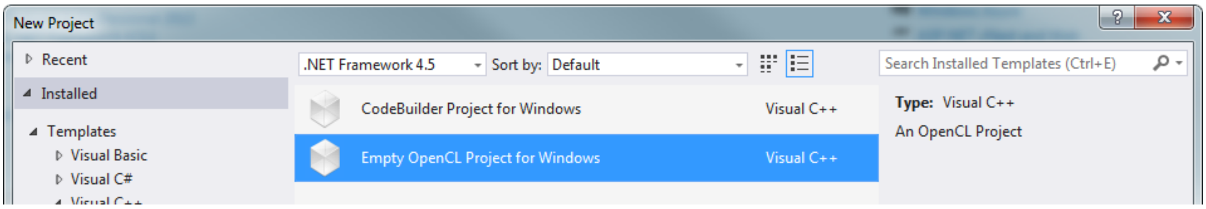
See Also

Creating an empty OpenCL™ Project
Create a new OpenCL project from OpenCL project template

Creating an Empty OpenCL™ Project for Windows*

To create an empty OpenCL™ project for Microsoft Visual Studio* IDE, do the following:

1. Go to **File** > **New** > **Project...**
2. Select OpenCL templates from the **Templates** tree view.

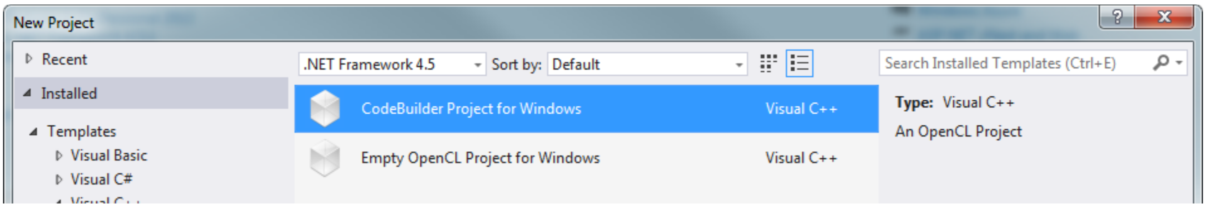


3. Select **Empty OpenCL Project for Windows**.
4. Fill the Name, Location, and Solution name fields and click **OK**

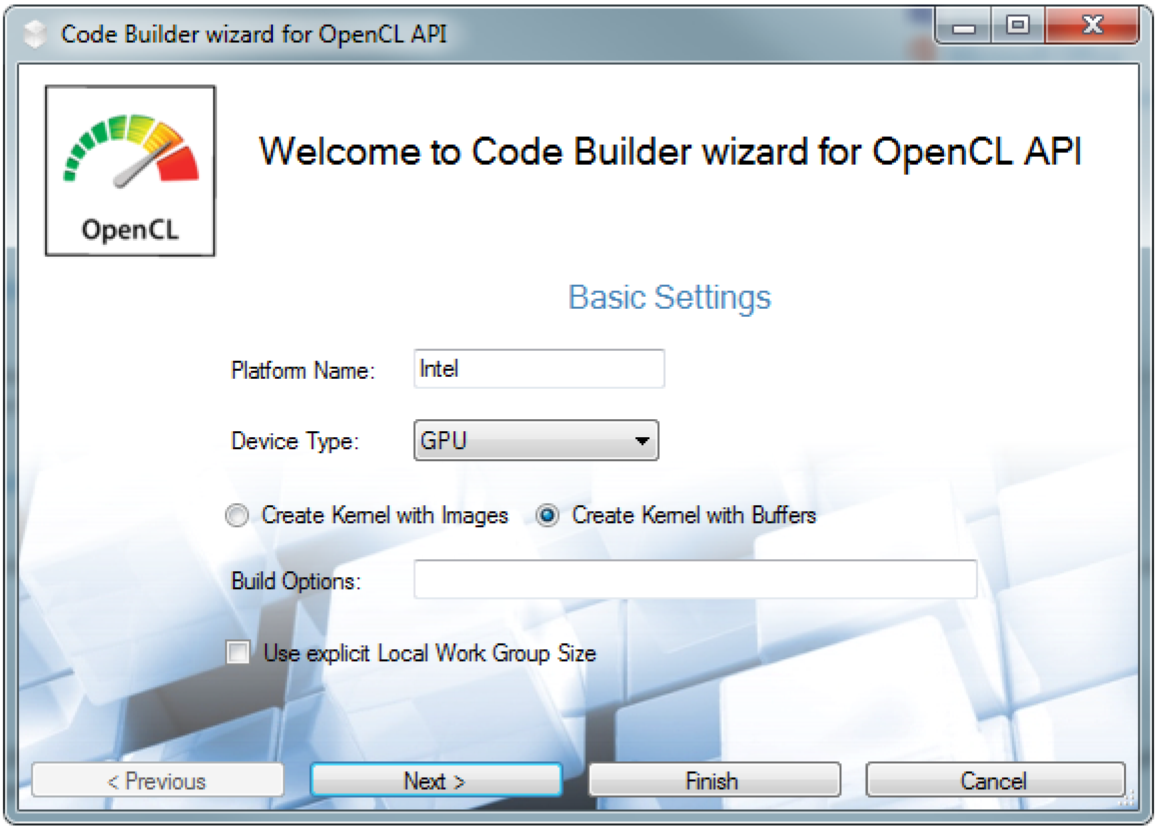
Create a New OpenCL™ Project from OpenCL Project Template for Windows*

To create an OpenCL™ template project for Windows platforms in Microsoft Visual Studio* IDE, do the following:

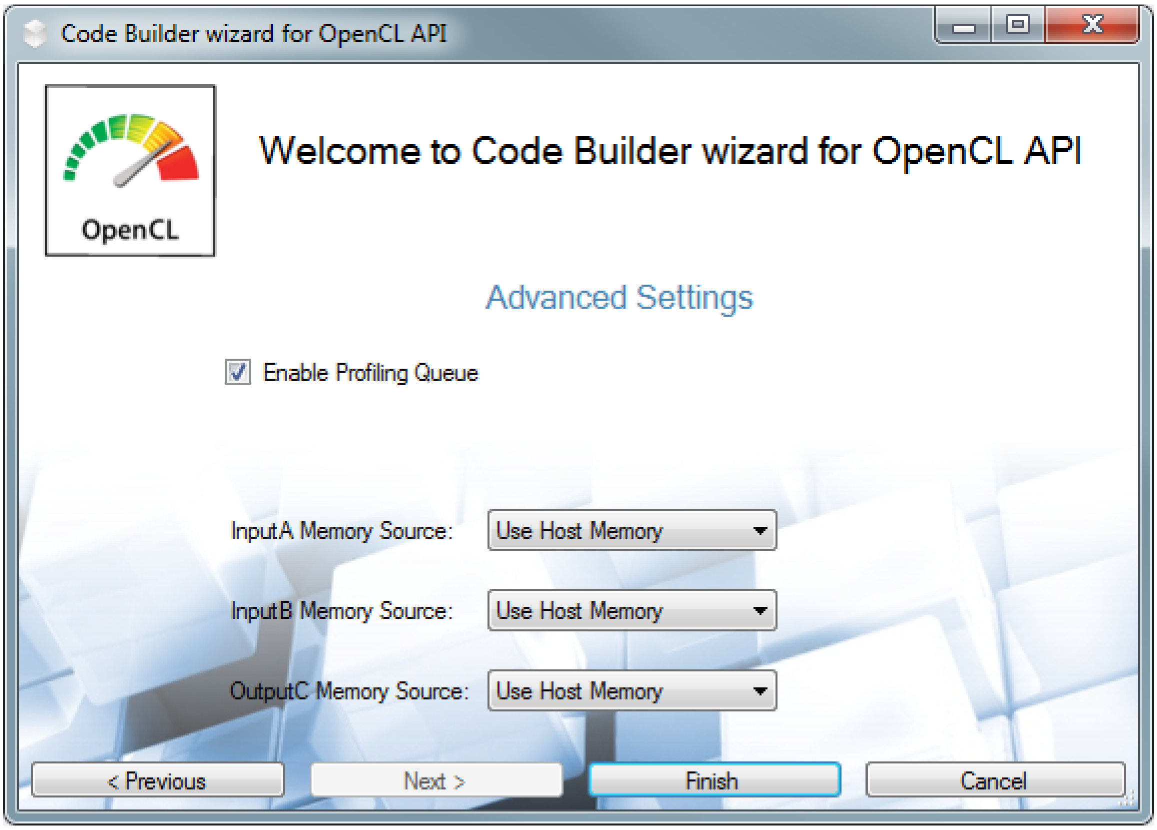
1. Go to **File** > **New** > **Project...**
2. Select OpenCL templates from the **Templates** tree view.
3. Select **Code Builder Project for Windows**.



4. Fill the Name, Location, and Solution name fields and click **OK**.
5. In the **Code Builder wizard for OpenCL API** dialog, you can select the basic settings for the behavior of the OpenCL application and kernel. The parameters that can be set are platform name, device type, kernel type (images or buffer manipulation), build options, and local work group size behavior. Each field has a short tool-tip explanation.



6. Click **Finish** to create the default template project or click **Next** to open the **Advanced Settings** screen enabling you to set some advanced options like whether to enable profiling queue and the kernel's arguments memory source type. For CPU device type, you can also set the out-of-order execution mode and debug mode for the kernel.

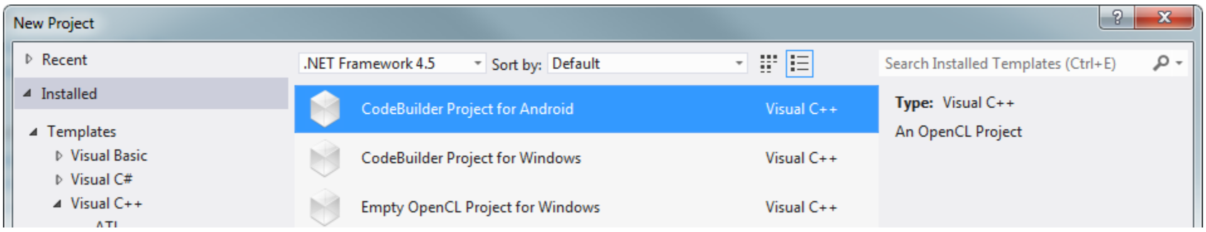


7. Click **Finish** to create the default template project or click **Previous** to return the **Basic Settings** screen.

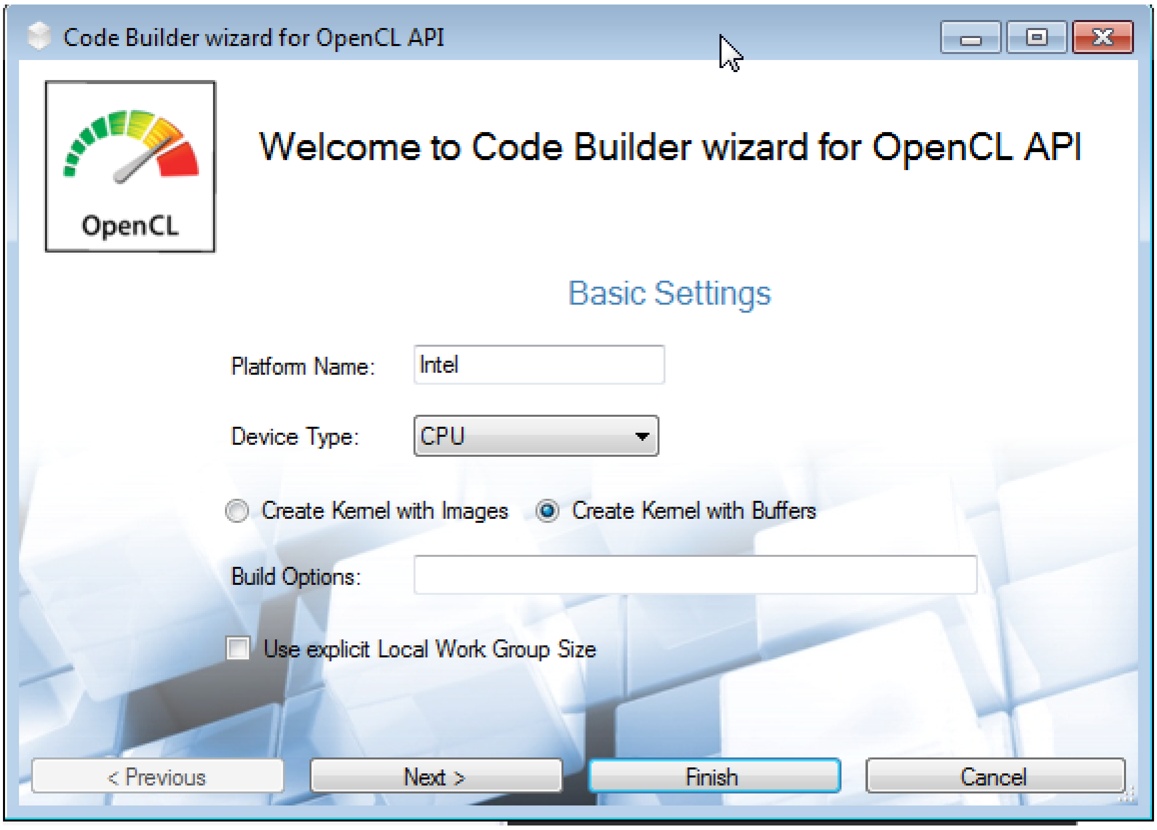
Create a New OpenCL™ Project from OpenCL Project Template for Android*

To create an OpenCL™ template project for Android devices in Microsoft Visual Studio* 2012 **(only!)**, do the following:

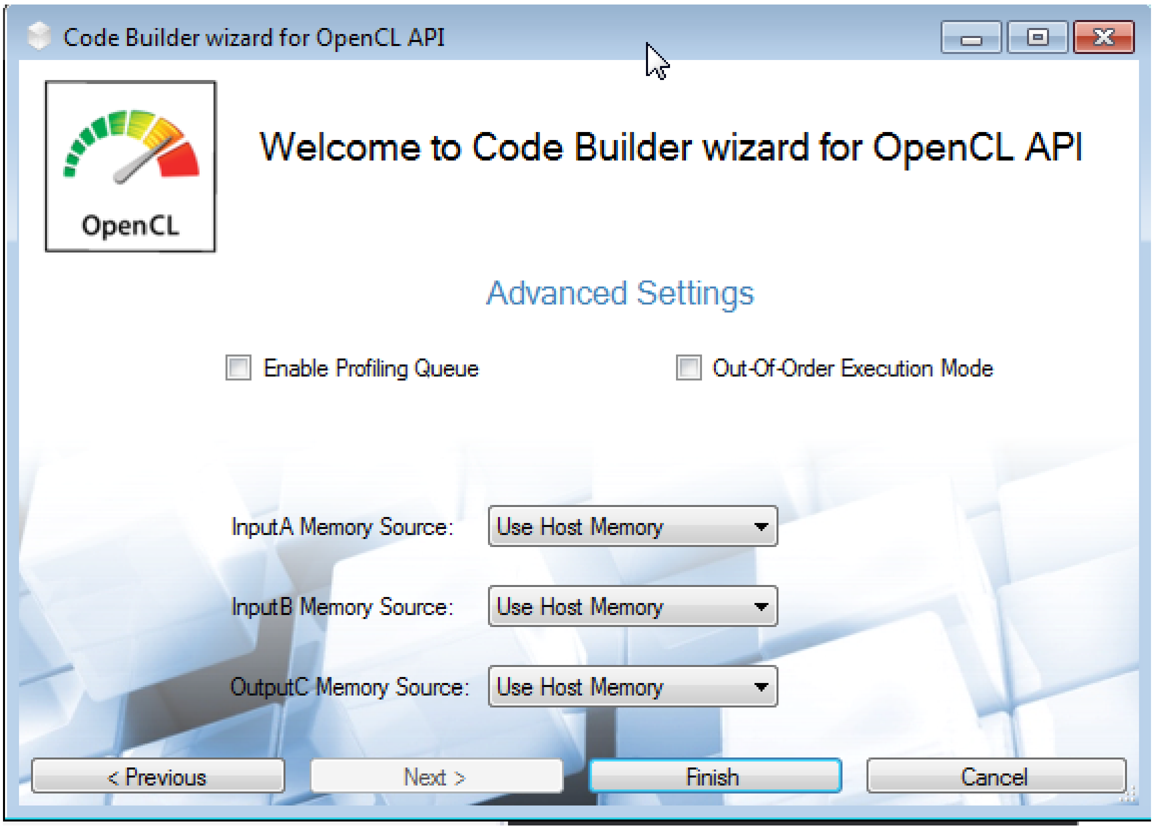
1. Go to **File** > **New** > **Project...**
2. Select OpenCL templates from the **Templates tree view**.
3. Select **CodeBuilder Project for Android**.



4. Fill the Name, Location, and Solution name fields and click **OK**.
5. In the **Code Builder wizard for OpenCL** API dialog, you can select the basic settings for the behavior of the OpenCL application and kernel. The parameters that can be set are platform name, device type, kernel type (images or buffer manipulation), build options, and local work group size behavior. Each field has a short tool-tip explanation.



6. Click **Finish** to create the default template project or click **Next** to open the **Advanced Settings** screen enabling you to set some advanced options like whether to enable profiling queue and the kernel's arguments memory source type. For CPU device type, you can also set the out-of-order execution mode.



7. Click **Finish** to create the default template project or click **Previous** to return the **Basic Settings** screen.

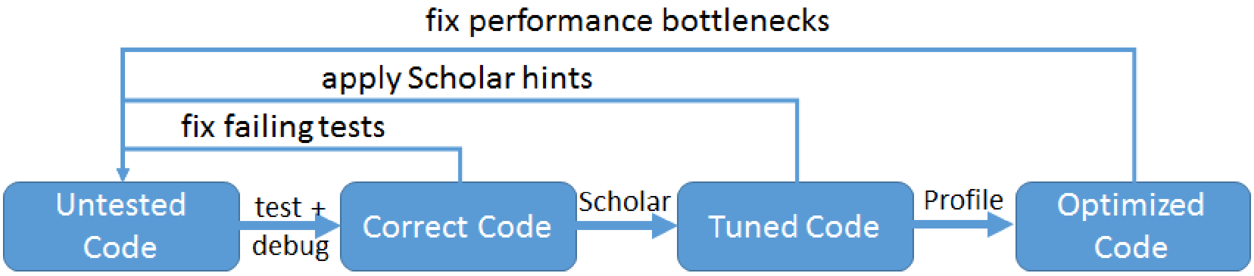
NOTE

You need the Android* NDK installed on your system to use the **Create a New OpenCL Project** feature for Android*.

OpenCL™ Scholar

About OpenCL™ Scholar

OpenCL™ Scholar is a preview feature that reports potential problems and optimization opportunities in OpenCL kernels. Upon enabling the scholar mode, compiling the kernel provides hints on improving the kernel performance. Use Scholar prior to applying any other performance-tuning actions such as profiling, and right after making sure the kernel works as expected.



See Also

[Enabling OpenCL™ Scholar]
[OpenCL™ Scholar Hints]

Enabling OpenCL™ Scholar

You can enable the OpenCL Scholar feature in Intel tools for OpenCL code development.

NOTE

Generating Assembly, IR, LLVM, and SPIR output is not supported in the Scholar mode.

Scholar in Kernel Builder Command-Line Interface

In the Kernel Builder for OpenCL API command-line interface, add the -scholar command-line option. For example:

```
ioc64 -input=mykernel.cl –device=gpu -scholar
```

The tool prints optimization hints in the following format

```
<filename>:<line>:<column>: Scholar: <message>
```

Scholar in Offline Compiler for Eclipse*

To use Scholar in Eclipse*,

1. Go to **Intel OpenCL** > **Options**.
2. Check the **Enable Scholar Support** check box under the **Scholar Configuration** group box.
3. Build an OpenCL kernel file, to see Scholar hints highlighted light-blue in the **Console View**. The hints also appear with an info marker in the **Problems View**.

An info marker appears in the editor for each Scholar hint.

Scholar in Offline Compiler for Visual Studio*

To use Scholar in the Miscrosoft Visual Studio*,

1. Right-click your project and open the project properties.

2. Go to **Configuration Properties** > **Intel SDK for OpenCL Applications** > **General**.
3. Set **Generate Scholar Messages** to **Yes**.
4. Build the project to see the Scholar hints as warnings for each CL kernel code file of the project.

The Scholar hints appear in the **Output View** of the build log as well as in the **Error List** view.

NOTE

The **Intel SDK for OpenCL Applications** group appears in the **Configuration Properties** only if your project is an OpenCL API project.

See Also

Building with Kernel Builder Command-Line Interface
OpenCL™ API Offline Compiler plug-in for Microsoft Visual Studio* IDE
OpenCL™ API Offline Compiler for Eclipse* IDE
Converting Existing Project into OpenCL™ Project

OpenCL™ Scholar Hints

OpenCL Scholar suggests several hints for OpenCL™ code optimization.

Use Floating-Point over Integers for Calculations

Scholar notifies about each integer calculation that can be implemented with floating-point instead. Floating-point calculations are generally faster than the integer equivalents, and have more bandwidth. Still the optimization might negatively affect code readability.

The message location is the beginning of the left-hand operand of the operation, and its content is:

```
prefer floating-point calculations to integer calculations
```

Consider the following code:

```
kernel void f(global int* a) {
  int gid = get_global_id(0);
  a[gid] = a[gid] * a[gid];
}
```

For the code above, Scholar provides the following hint message:

```
mykernel.cl:3:12: Scholar: prefer floating-point calculations to integer calculations
```

Use the Restrict Qualifier for Kernel Arguments

Scholar recommends using the `restrict` qualifier on kernel arguments that may alias other arguments, if you are sure that this aliasing can never actually occur. Such optimization helps the compiler limit the effects of pointer aliasing while aiding the caching optimizations.

The message location is the parameter name, and its content is:

```
parameter '<param name>' should be marked as 'restrict' if it never shares memory with
other arguments
```

Consider the following code:

```
kernel void f(global float* a, global float* b) {

  int gid = get_global_id(0);

  a[gid] = a[gid] + b[gid];

  b[gid] = b[gid] + 1;

}
```

For the code above, Scholar provides the following hint message:

```
mykernel.cl:1:46: Scholar: parameter 'b' should be marked as 'restrict' if it never
shares memory with other arguments
```

Consider native_ and half_ Versions of Builtins

Scholar reports the following math builtins usage as potentially inefficient when the `native_` and `half_` versions might be used instead:

- `sin`
- `cos`
- `exp`
- `log`

`native_` and `half_` versions use hardware instructions directly, potentially greatly decreasing the time needed for these calculations.

The message location is the beginning of the name of the called function, and its content is:

```
using native_<name> or half_<name> can provide greater performance at some accuracy
cost
```

Consider the following code:

```
kernel void f(global int* a) {

  int gid = get_global_id(0);

  a[gid] = sin(a[gid]);

}
```

For the code above, Scholar provides the following hint message:

```
mykernel.cl:3:12: Scholar: using native_sin or half_sin can provide greater
performance at some accuracy cost
```

Avoid Non-Coalesced Memory Access

Scholar suggests avoiding non-coalesced memory accesses. Such memory accesses occur when adjacent work-items access non-adjacent buffer elements. Coalesced memory accesses are translated to wide loads and stores, while non-coalesced accesses translate to gathers and scatters. Wide loads and stores outperform gathers and scatters.

The message location is the beginning of the statement, in which the memory access occurs, and its content is:

```
non-coalesced memory access
```

Consider the following code:

```
kernel void f(global int* a, constant int* b) {

  int gid = get_global_id(0);

  float x = b[gid*2];

  a[gid] = x;

}
```

For the code above, Scholar provides the following hint message:

```
mykernel.cl:3:3: Scholar: non-coalesced memory access
```

Refer to the product *Optimization Guide* for more optimization hints and explanations.

See Also

[Intel® SDK for OpenCL™ Applications - Optimization Guide]

Debugging Kernels on Intel® Graphics

About Kernel Debugger

Kernel Debugger - is a *preview* feature that enables OpenCL™ kernel debugging on Intel® Graphics device through the interface of the Kernel Builder for OpenCL API. The Debugger supports

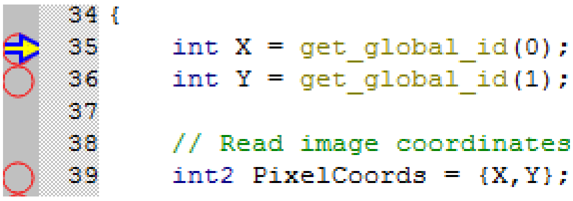
- Running OpenCL kernels on the Intel® Graphics device step-by-step
- Setting breakpoints
- Viewing variable values

To enable the Kernel Debugger, set the `CL_GPU_KERNEL_DEBUGGER_ENABLED` environment to True.

To start debugging,

1. Open an existing OpenCL file or write a new kernel in the Kernel Builder code editor.
2. Click the **Debug** button  or select **Analyze** > **Debug board**.
3. Click the **Refresh kernel(s)** button to get the list of kernels available for debugging.
4. Select a kernel to debug by clicking the kernel name from the pull-down menu. If only one kernel is available, it is selected automatically.
5. Assign parameters for the debug session and click **Debug**.

Upong clicking the **Debug** button, the tab with the Debugger controls opens automatically.



Empty red circles  appear in the kernel code editor next to the executable lines suggesting the locations where you can set breakpoints for kernel debugging.

Yellow and Blue arrows  appear next to the executable line of the selected kernel.

The yellow arrow is the next line to execute in a work-item, while the blue arrow is the next line to execute in a work-group.

See Also

Using Kernel Builder

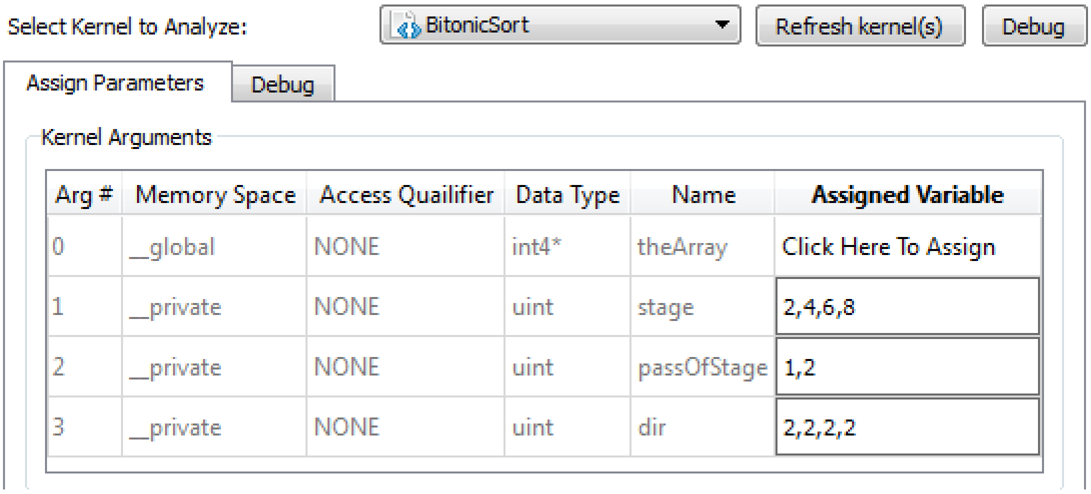
Assigning Debug Parameters

To set kernel arguments for the debug session, refer to the **Assign Parameters** tab on the **Debug Board**. Click cells in the **Assigned Variable** column to create or add variables as kernel arguments.

Use immediate values for primitive types like `int`, `float`, `char`, `half`, and so on.

Add comma-separated immediate values (for example: 2,4,6,8 for a given `uint4` argument) for vector type. If the given values don't correspond to the vector size of the given type, the last specified value is propagated to the correct size. For example, if you type 2 as a value to an `int4` variable, it turns automatically to 2,2,2,2.

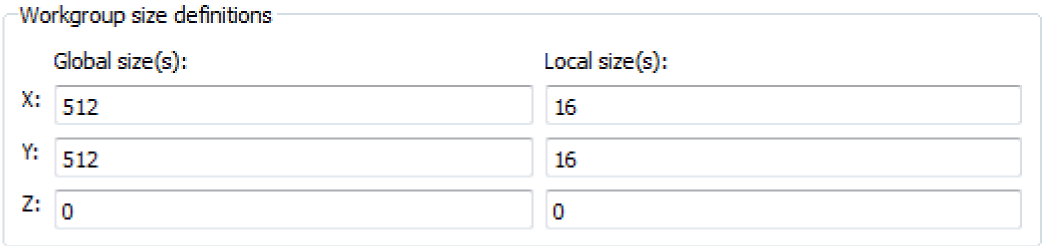
For complex types like arrays, images, and samples, use the **Variable Managment** window, which you can open by clicking cells with **Click Here To Assign**. In the **Variable Managment** window select appropriate variables and click **Assign**.



You can set group sizes by typing the requested global and local work-group sizes in the **Workgroup size definition** group box on the **Assign Parameters** tab of the Kernel Debugger.

NOTE

If a kernel contains input buffer argument or input image argument, the global and local sizes are set automatically according to the sizes of the buffer/image. You can change these values manually.



See Also

Using Kernel Builder

Kernel Debugger Controls

You can control the debugging process using the **Debug** tab of the Kernel Debugger.

The debugger control panel contains several buttons that you can use to control the debugging process. Using *step-over* and *continue* commands, you can perform kernel debugging in three levels:

- Work-item level
- Work-group level
- Kernel level

Work-Item Level

On the work-item level, the Debugger runs commands for a single work-item.

Click the  button or push **F5** to use the *step-over* command for the selected work-item.

Click the  button or push **F9** to use the *continue* command for the selected work-item.

Work-Group Level

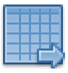
On the work-group level, the Debugger runs commands for a selected work-group. For example, if the local work-group size is 10, the debugger runs 10 work-items that belong to the selected work-group.

Click the  button or push **F6** to use the *step-over* command for the selected work-group.

Click the  button or push **F10** to use the *continue* command for the selected work-group.

Kernel Level

On the kernel level, the Debugger runs commands for the whole set of work-items as defined in the global size.

Click the  button or push **F7** to use the *step-over* command for all work-items.

Click the  button or push **F11** to use the *continue* command for all work-items.

Finish the debugging session by clicking the button or pushing **Ctrl+F5**.

NOTE

Any combination of commands on different levels is possible during debug session.

See Also

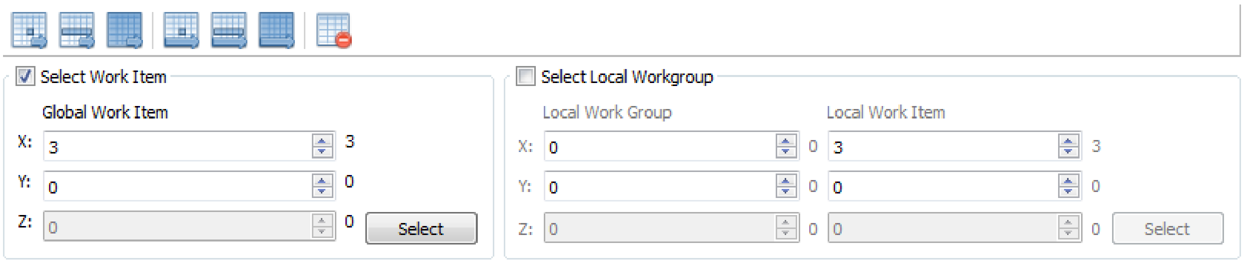
Using Kernel Builder

Selecting Work-Items and Work-Groups to Debug

You can select a work-item to debug via:

- Selecting the global work item:
  1. Select the **Select Work Item** box.
  2. Select the requested global work item.
  3. Click **Select**.
- Or via selecting a local work-group and work-item:

1. Select **Select Local Work Group** box.
2. Select the requested local work-group and local work-item.
3. Click **Select**.



Upon selecting the global work-item, the corresponding local work-group and local work-item entries appear in the **Local work-group** box and vice versa.

You can change the selected work-item or work-group during the debug session via selecting the requested work-item or work-group and clicking **Select**.

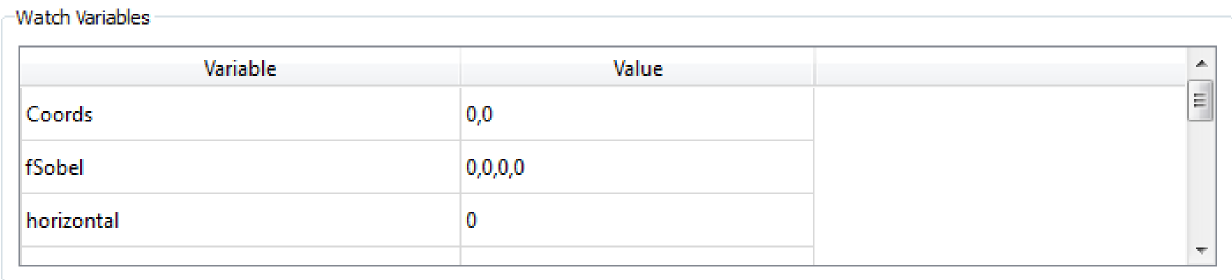
Work-item and work-group dimensions availability is determined by the group size set in the **Assign Parameters** tab of the Kernel Debugger debug board. If the kernel is one-dimensional (the X value is bigger than 0, while Y and Z are set to 0) then only X axis is available when selecting work-item or work-group.

See Also

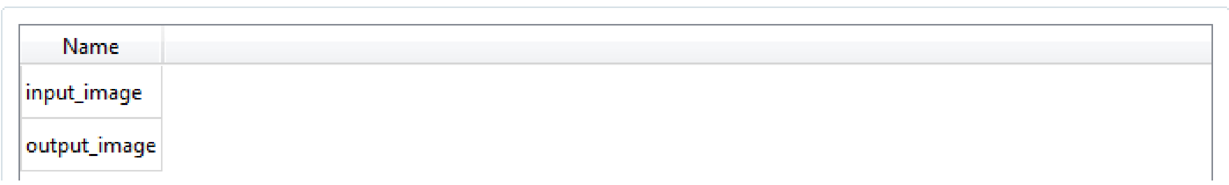
Using Kernel Builder

Watching Variables and Kernel Arguments

The **Watch Variable** box contains variable names and values used by the kernel being debugged:



Buffers and images, passed as kernel arguments appear in the **Arguments** box:



Click any variable name to see its content.

See Also

Using Kernel Builder

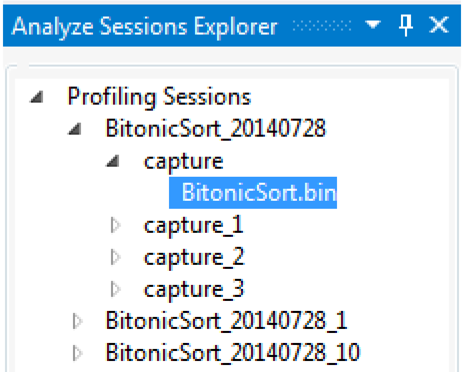
OpenCL™ Analysis Tool

About the OpenCL™ Analyze Tool

OpenCL™ Analyze Tool is a preview feature that provides basic performance information for OpenCL™ applications.

The Analyze Tool enables to collect trace data of OpenCL APIs, OpenCL kernels and OpenCL memory operations. You can use the Analyze Tool to find out the time of execution, the frequency and the work size data of each OpenCL kernel that was launched during your program's execution. You can also find statistics of all OpenCL API calls and data about memory commands executed in your program.

When you use the Analyze Tool, you create an Analyze Session, which contains the configuration data for collecting performance information and the results of the analyze run. You can explore all the analyze sessions that you created in the Analyze Session Explorer window.

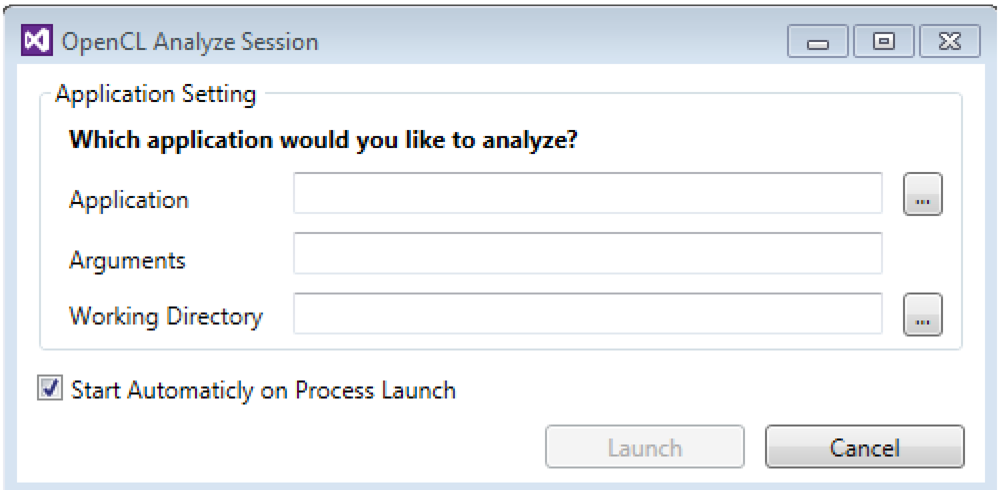


Parent topic: Preview Features

Creating and Launching New Analyze Session

To create and run an Analyze session, do the following:

1. Go to **CODE_BUILDER** > **OpenCL Application Analysis** > **New Analyze Session...**
2. In the **OpenCL Analyze Session** dialog specify information about the application that you want to analyze.
3. Make sure that the **Start Automatically on Process Launch** check box is selected and then click **Launch**.
4. Your application starts and the profiler starts to collect data.
5. Exercise the functionality that might contain performance issues.
6. While the application is running a new **Session Run** tab is opened in the main Visual Studio* window.
7. Click **Pause/Resume analyze** button in the **Session Run** tab to pause or resume data collection.
8. Click **Close analyze** or close the application.

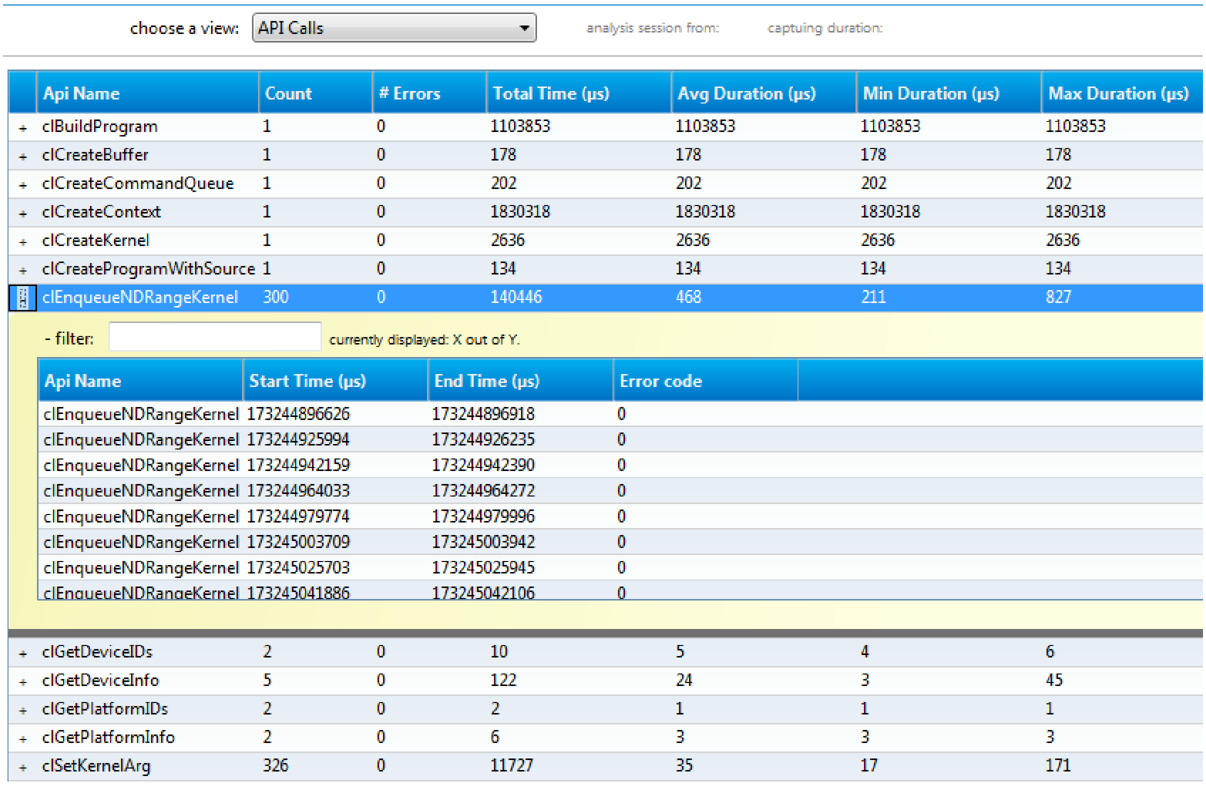


- **Application** – full path to the target application
- **Arguments** – command-line arguments to use when starting the target application
- **Working Directory** – working directory for the target application to be started. If no working directory is specified, the default is the directory that contains the target application.

Analyzing the Data

After you finish running the application, the new analyze session that you created appears in the **Analyze Explorer** window and the following reports are generated and appear in the main Visual Studio* window:

- **API Call** - lists statistics of calls made to the OpenCL API, including the number of times the API call was called, the number of times error returned, and statistics on the elapsed time each API call took while executing



choose a view: API Calls analysis session from: capturing duration:

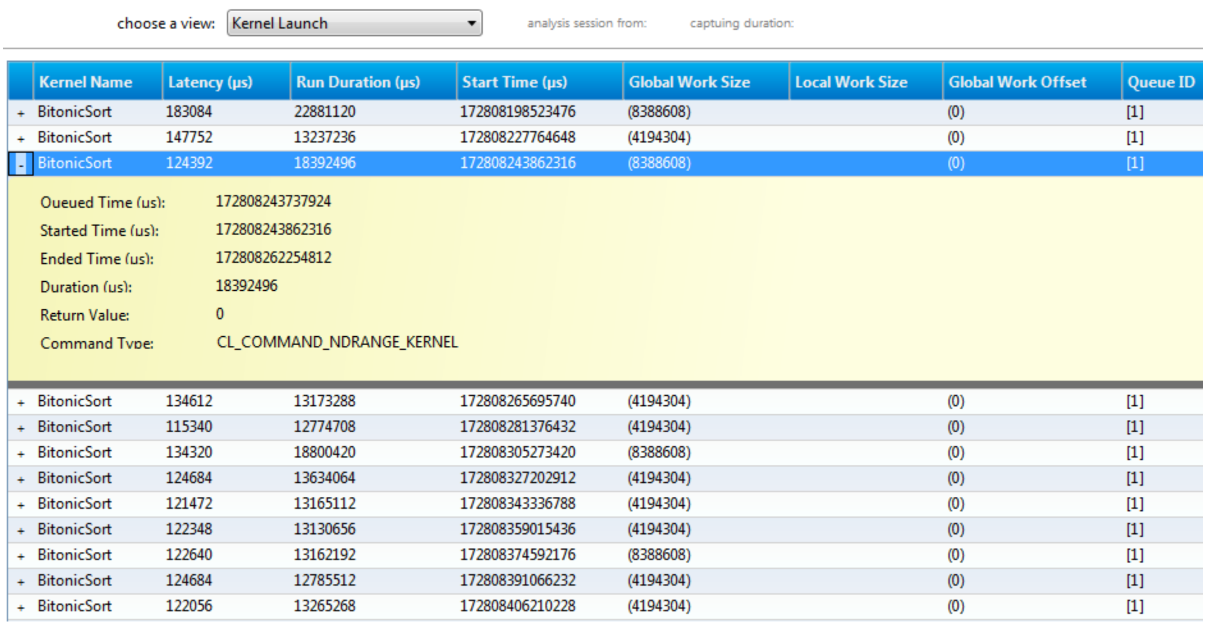
	Api Name	Count	# Errors	Total Time (µs)	Avg Duration (µs)	Min Duration (µs)	Max Duration (µs)
+	clBuildProgram	1	0	1103853	1103853	1103853	1103853
+	clCreateBuffer	1	0	178	178	178	178
+	clCreateCommandQueue	1	0	202	202	202	202
+	clCreateContext	1	0	1830318	1830318	1830318	1830318
+	clCreateKernel	1	0	2636	2636	2636	2636
+	clCreateProgramWithSource	1	0	134	134	134	134
-	clEnqueueNDRangeKernel	300	0	140446	468	211	827

- filter: currently displayed: X out of Y.

Api Name	Start Time (µs)	End Time (µs)	Error code
clEnqueueNDRangeKernel	173244896626	173244896918	0
clEnqueueNDRangeKernel	173244925994	173244926235	0
clEnqueueNDRangeKernel	173244942159	173244942390	0
clEnqueueNDRangeKernel	173244964033	173244964272	0
clEnqueueNDRangeKernel	173244979774	173244979996	0
clEnqueueNDRangeKernel	173245003709	173245003942	0
clEnqueueNDRangeKernel	173245025703	173245025945	0
clEnqueueNDRangeKernel	173245041886	173245042106	0

	Api Name	Count	# Errors	Total Time (µs)	Avg Duration (µs)	Min Duration (µs)	Max Duration (µs)
+	clGetDeviceIDs	2	0	10	5	4	6
+	clGetDeviceInfo	5	0	122	24	3	45
+	clGetPlatformIDs	2	0	2	1	1	1
+	clGetPlatformInfo	2	0	6	3	3	3
+	clSetKernelArg	326	0	11727	35	17	171

- **Kernel Launch Commands** - shows every OpenCL kernel that was launched during program execution. Each row shows the time of execution and work size data for each launch.



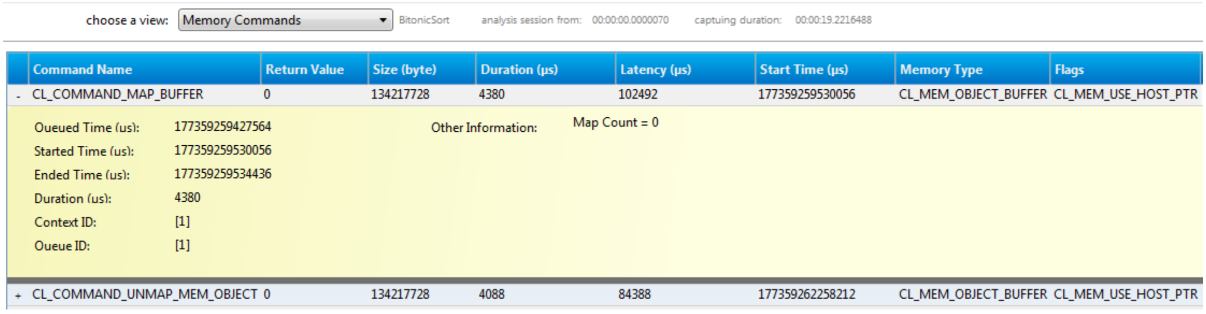
choose a view: Kernel Launch analysis session from: capturing duration:

	Kernel Name	Latency (µs)	Run Duration (µs)	Start Time (µs)	Global Work Size	Local Work Size	Global Work Offset	Queue ID
+	BitonicSort	183084	22881120	172808198523476	(8388608)		(0)	[1]
+	BitonicSort	147752	13237236	172808227764648	(4194304)		(0)	[1]
-	BitonicSort	124392	18392496	172808243862316	(8388608)		(0)	[1]

Queued Time (us):	172808243737924
Started Time (us):	172808243862316
Ended Time (us):	172808262254812
Duration (us):	18392496
Return Value:	0
Command Type:	CL_COMMAND_NDRANGE_KERNEL

	Kernel Name	Latency (µs)	Run Duration (µs)	Start Time (µs)	Global Work Size	Local Work Size	Global Work Offset	Queue ID
+	BitonicSort	134612	13173288	172808265695740	(4194304)		(0)	[1]
+	BitonicSort	115340	12774708	172808281376432	(4194304)		(0)	[1]
+	BitonicSort	134320	18800420	172808305273420	(8388608)		(0)	[1]
+	BitonicSort	124684	13634064	172808327202912	(4194304)		(0)	[1]
+	BitonicSort	121472	13165112	172808343336788	(4194304)		(0)	[1]
+	BitonicSort	122348	13130656	172808359015436	(4194304)		(0)	[1]
+	BitonicSort	122640	13162192	172808374592176	(8388608)		(0)	[1]
+	BitonicSort	124684	12785512	172808391066232	(4194304)		(0)	[1]
+	BitonicSort	122056	13265268	172808406210228	(4194304)		(0)	[1]

- **Memory Commands** - shows every memory command executed in your application.



Revising Code and Rerunning Session

After you optimize your code, you can rerun the profiling session and compare the data to see how your changes improve your application performance.

To rerun an analyze session, do the following:

1. Open the **Analyze Sessions Explore** from **CODE BUILDER** > **OpenCL Application Analysis** > **Windows** > **Analyze Session Explorer**
2. In the **Analyze Sessions Explorer** right-click the analyze session that you want to rerun and select **Rerun**.
3. A new analyze session is created and launched and the profiled application starts.
4. After the application is finished the new analyze session appears in the **Analyze Explorer** window and new reports are generated.

Output Files

For each analysis session, the analysis tool creates a session directory named with application's name, the date, and an incrementing session number. When profiling begins and also each time you pause and resume the data collection during the session, a new capture subdirectory is created in the session directory. The capture directory is called “capture” and an incrementing number (for example, `capture_1`, `capture_2`, and so on). The files in that directory comprise the capture reports.

These are the types of files in a capture directory:

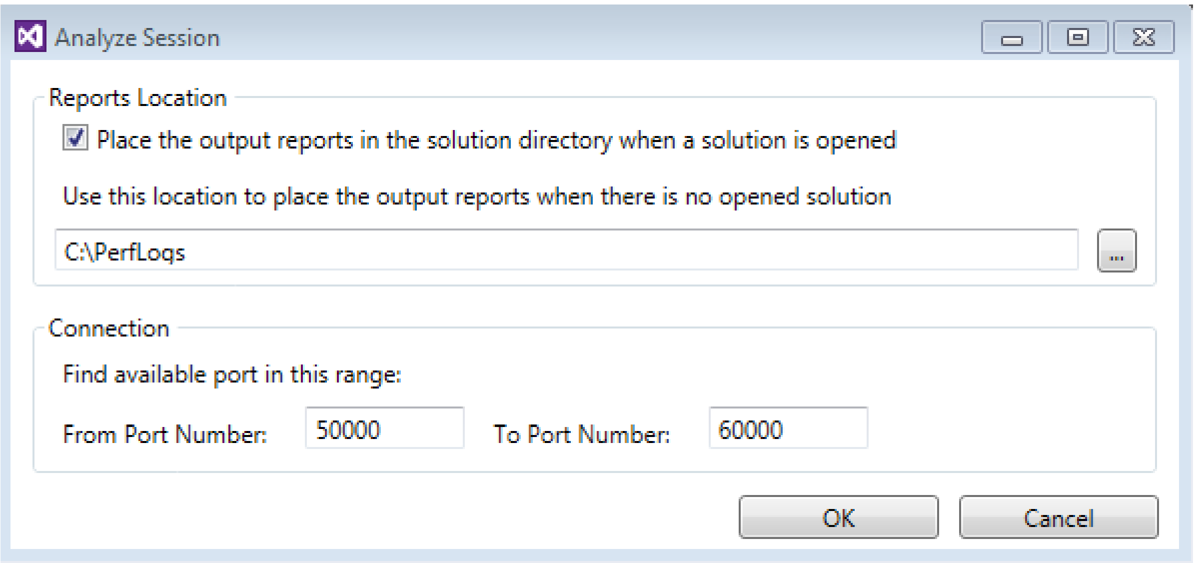
- `*.csv` - capture reports in CSV format.
- `*.bin` - capture reports in binary format – you can open such reports in Visual Studio from the **Analyze Sessions Explorer**.

In addition, a session file is created in the session directory. This file stores the data about session configuration. You can use it to create and run another similar session.

Configuring the Analyze Tool

You can use the **Analyze Session Settings** dialog to change the reports directory and also to change the connection info for the analyze sessions.

To open the **Analyze Session Setting** dialog go to **CODE BUILDER** > **OpenCL Application Analysis** > **Settings**



- **Report Location** – full path to the directory that contains analyze reports. You can mark the **Place output reports in the solution directory** check button. In this case, if you open a solution in Visual Studio*, the Analyze Tool ignores the specified directory and places the analysis reports into the solution directory.
- **Connection** – range of ports number for the Analyze Tool to find an available port. The Analyze Tool uses a port in the specified range to establish connection with Visual Studio*.

Kernel Development Framework

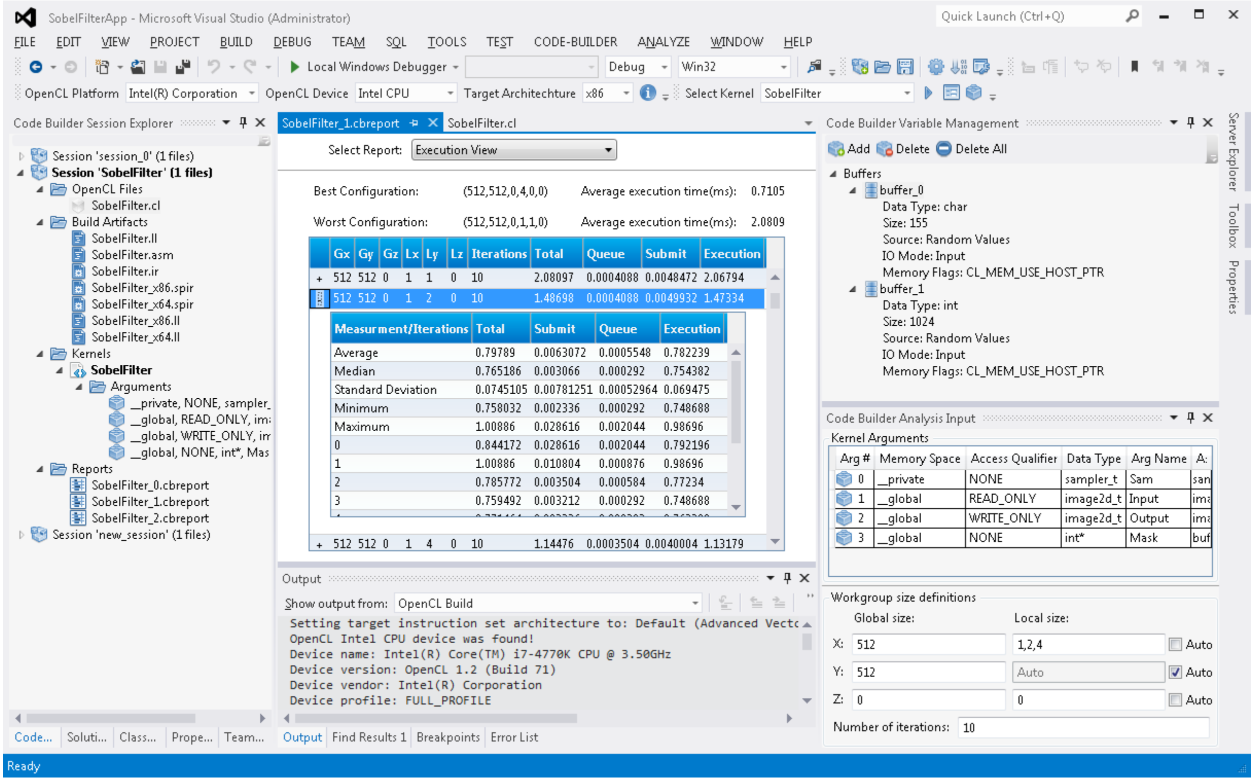
About Kernel Development Framework

Kernel Development Framework is preview feature of native integrated development environment in the Microsoft Visual Studio* that enables you to build and analyze OpenCL kernels.

The framework supports Intel® Architecture processors, Intel Processor Graphics, and Intel Xeon Phi™ coprocessors as well as remote development on Android* devices. The tool provides full offline OpenCL language compilation, which includes:

- OpenCL syntax checker
- Cross-platform compilation
- Low Level Virtual Machine (LLVM) viewer
- Assembly code viewer
- Intermediate program binary Generator

  The feature also provides a way to assign input to the kernel, test the correctness, and analyze kernel performance based on group size, build options, and target device.



NOTE

All screenshots in this user manual originate from Microsoft Visual Studio* 2012. The Kernel Development Framework is also supported in Visual Studio versions 2010 and 2013.

Kernel Development Framework Session

About the Development Sessions

Work in the Kernel Development Framework is managed through session. To create, build, or analyze an OpenCL kernel you need to create a session.

A session contains

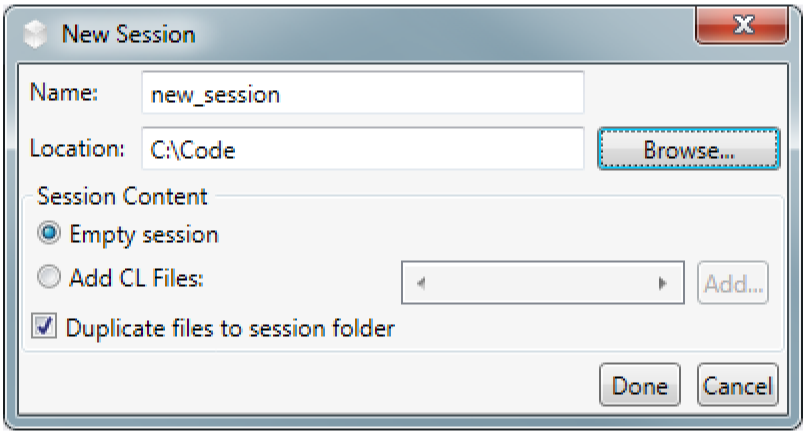
- A file with an OpenCL program
- Build artifacts:
  - o Generated LLVM code
  - o Assembly code
  - o Intermediate binary files
- OpenCL kernels with assigned variables and analysis reports

Creating a New Session

To create a new session, do the following:

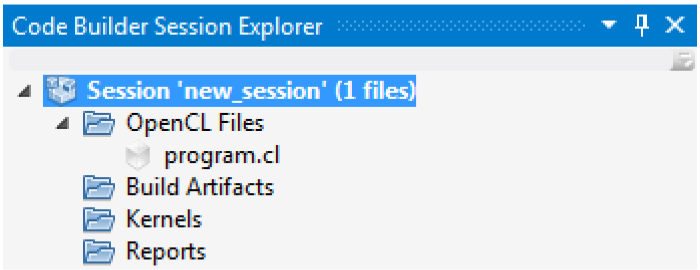
1. Go to **CODE-BUILDER** > **Kernel Development Framework** > **New Sessions** Or click the **New Session** button  in the **Code Builder Build** toolbar menu .

2. Specify the session name, path to the folder to store the session file and the content of the session (can be either empty session or with pre-defined OpenCL code).



3. Click **Done**.

Once the session is created, the new session appears in the **Code Builder Session Explorer Dialog**.

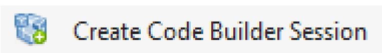


If you don't see the Code Builder Session Explorer dialog, go to: **CODE-BUILDER** > **Kernel Development Framework** > **Windows** > **Code Builder Session Explorer**.

Creating Session from Existing OpenCL Code

The Kernel Development Framework enables you to create a session from an existing application that contains OpenCL™ code files. If you have a project in Microsoft Visual Studio* that contains such files(s), you can do the following:

- Right-click the OpenCL file and select **Create Code Builder Session**



- A new Session is created and becomes available in the **Code Builder Session Explorer** dialog.

Saving and Loading Sessions

To save your session, go to **CODE-BUILDER** > **Kernel Development Framework** > **Save Session**.

Or click the **Save Session** button  in the **Code Builder Build** toolbar menu.

New sessions are saved under the **New Session Default Directory** defined in the **Kernel Development Framework's Settings**. See Kernel Development Framework Settings chapter on how to change these settings.

To load a saved session, do the following:

1. Go to **CODE-BUILDER** > **Kernel Development Framework** > **Load Session**. Or click the **Load Session** button in the **Code Builder - Build** toolbar menu.
2. Select the session to load in the **Open File** dialog and click **Open**.

Removing Sessions

To remove a session from the Code Builder Session Explorer dialog, right-click the session that you want to remove and select **Remove Session (Keep local files)**.

Configuring Sessions

- To configure the session, open the **Session Options** menu by selecting **CODE-BUILDER** > **Kernel Development Framework** > **Session Options**.

The **Session Configuration** window enables you to define

- Target device to perform build or analysis operations
- Build options
- Target platform architecture

Code Builder Configuration Toolbar

You can control some of the Session's options through the Code Builder Config toolbar.

To show the toolbar, go to: **VIEW** > **Toolbars** and make sure that **Code Builder Config** is checked.

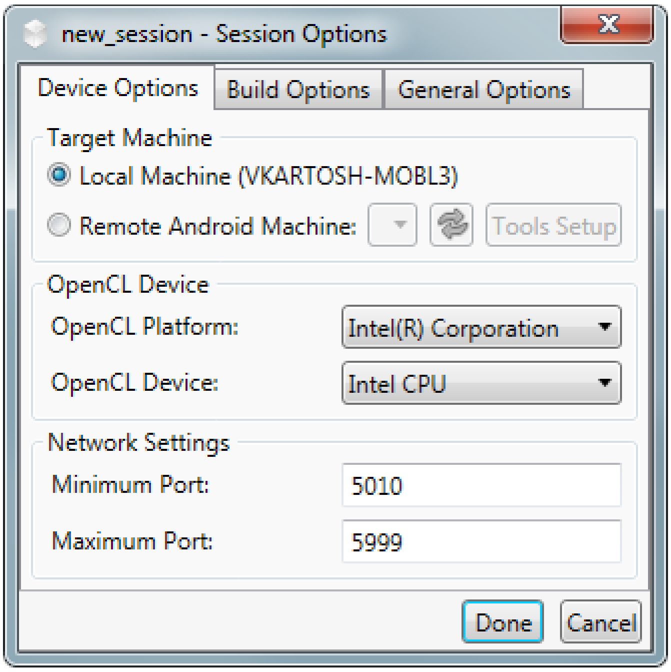
The Code Builder Config toolbar enables you to:

- Select the target OpenCL™ Platform (Currently only Intel's platform is supported)
- Select the target OpenCL Device
- Select the target platform architecture
- Show the platform info dialog

Configuring Device Options

Open the **Session Options** menu via selecting **CODE-BUILDER** > **OpenCL Kernel Development** > **Session Options**.

The **Device Options** tab provides several configuration options.



Target Machine group box enables selecting the target machine:

- Local Machine
- Remote Machine

To use the **Remote Machine** option, you need to

1. Connect an Android* device with Intel processor or an emulator based on Intel x86 System Image.
2. Copy OpenCL runtime to the Android device or emulator. See section Installing OpenCL™ Runtime on Emulator.
3. Click **Setup** to copy OpenCL tools to the device.

NOTE

You need to use the **Setup** option each time you start an emulator device.

OpenCL Device group box enables selecting the target platform and device for the selected machine:

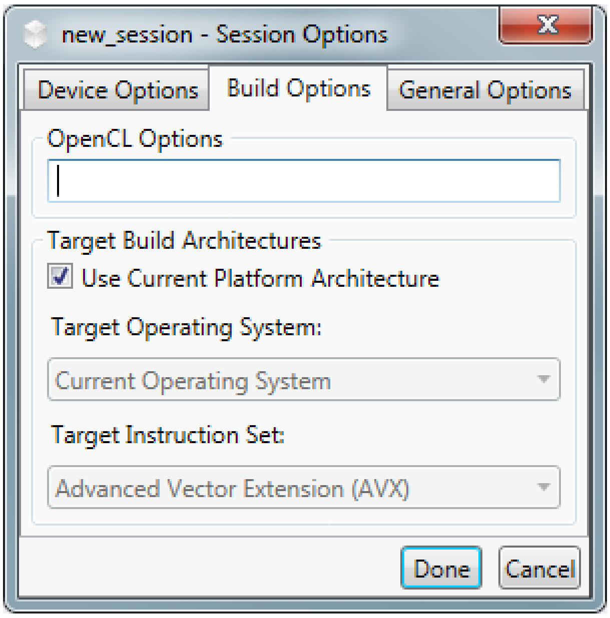
- Intel CPU
- Intel(R) Graphics
- Intel Xeon Phi(tm) coprocessor
- Intel CPU on experimental OpenCL2.0 Platform

Network Settings group box enables configuring the network port range.

Configuring Build Options

Open the **Session Options** menu via selecting **CODE-BUILDER** > **OpenCL Kernel Development** > **Session Options**.

The **Build Options** tab provides several configuration options.



OpenCL Options group box, which enables typing the options into the text box.

Target Build Architecture group box enables:

- Using the current platform architecture.
- Configuring the build architecture manually by unchecking the **Use current platform architecture** check box, and selecting:
  - Select **Target operating system**:
    - Current Operating System
    - Android Operating System (available on Windows* OS only)
  - Choosing the **Target instruction set**:
    - Streaming SIMD Extension 4.2 (SSE4.2)
    - Advanced Vector Extension (AVX)
    - Advanced Vector Extension (AVX2)

Changing the **Target Build Architecture** options enables viewing assembly code of different instruction set architectures and generating program binaries for different hardware platforms.

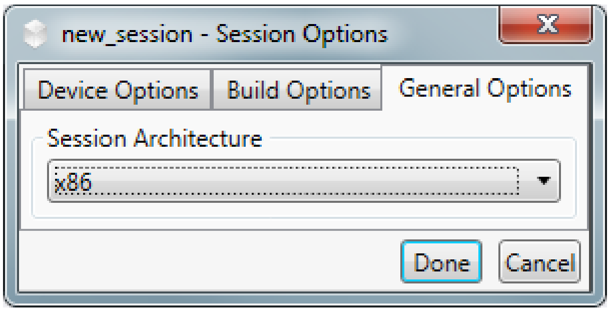
NOTE

Target Build Architecture options are available for the CPU device only.

Configuring General Options

Open the **Session Options** menu via selecting **CODE-BUILDER**

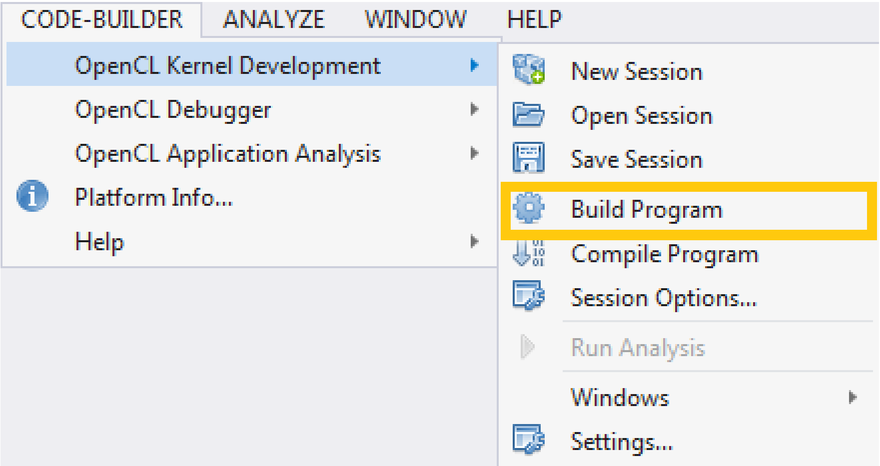
The **General Options** tab enables defining the target session's platform architecture (x86 or x64).



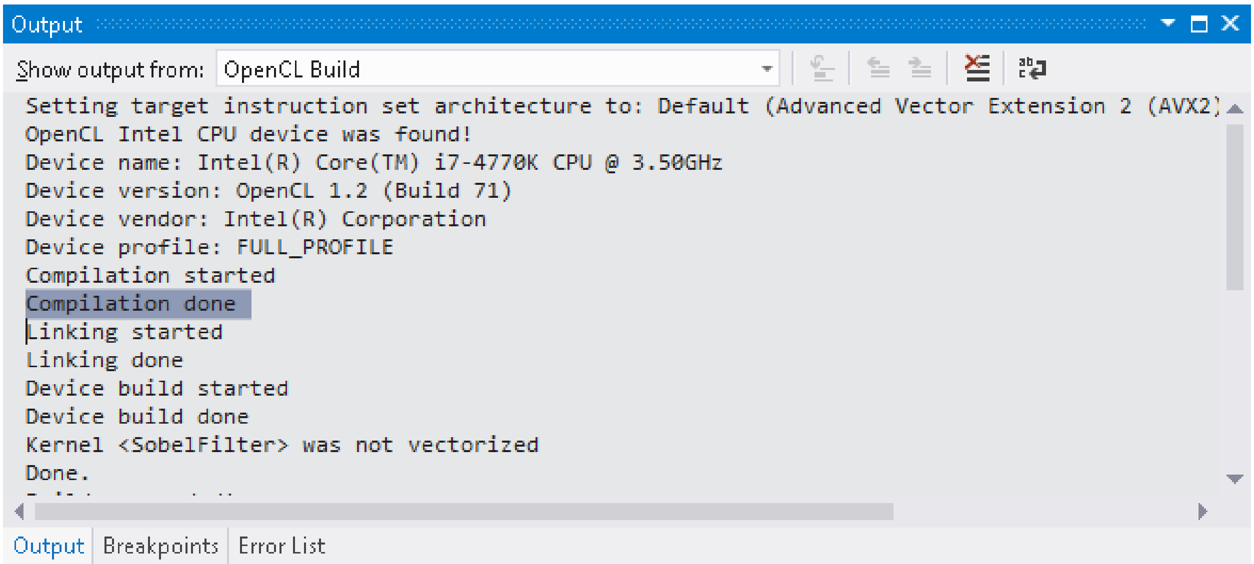
Building and Compiling OpenCL™ Program

To build an OpenCL™ program via the Kernel Development Framework feature of the OpenCL Code Builder, do the following:

1. Select the session with the code that you would like to build.
2. Go to **CODE-BUILDER** > **Kernel Development Framework** > **Build Program**. Or click the **Build Program** button in **Code Builder - Build** toolbar menu.



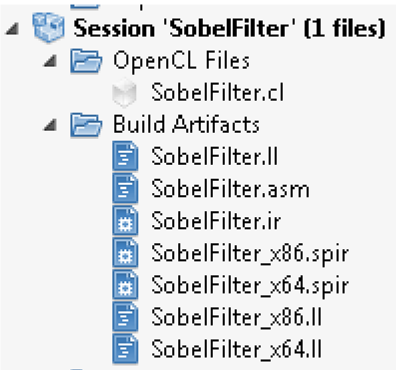
The build log appears in the **Console Output** dialog.



Build Artifacts

Once OpenCL™ program build is completed, the build artifacts appear under the **Builds Artifacts** note in the **Code Builder Session Explorer**. The list of artifacts includes:

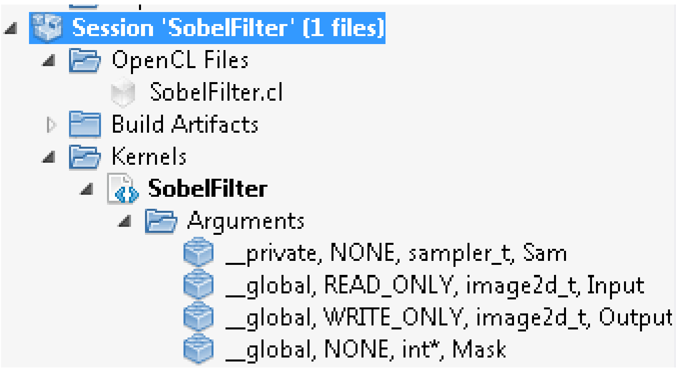
- Generated LLVM code (<file_name>.ll)
- Generated assembly code for CPU and Xeon Phi only (<filen_name>.asm)
- Program's intermediate program's binary (<file_name>.ir)
- 32-bit version of generate SPIR LLVM code (<file_name>_x86.ll)
- 64-bit version of generate SPIR LLVM code (<file_name>_x64.ll)
- 32-bit version of the SPIR binary (<file_name>_x86.spir)
- 32-bit version of the SPIR binary (<file_name>_x64.spir)



All build artifacts are stored in the sessions' folder. You can double-click the LLVM\Assembly code to see its content in the IDE's editor. You can open the containing folder by right-clicking one of the files and selecting **OpenCL Containing Folder**.

Kernel Arguments

Once OpenCL program build is completed successfully you are able to see all built kernels with arguments under the **Kernels** node in the **Code Builder Session Explorer**.



Code Builder Build Toolbar

To show the toolbar go to: **VIEW** > **Toolbars** and make sure that the **Code Builder Build** option is checked.

You can use the **Code Builder Build** toolbar to perform basic operations on sessions such as:

- Create new session
- Load session
- Save session
- Build session
- Compile session
- Open session’s settings dialog

Analyzing Kernel Performance

Using the Code Builder Analysis Toolbar

To show the toolbar go to: **VIEW** > **Toolbars** and make sure that **Code Builder Analysis** option is checked.

You can use the **Code Builder Analysis** toolbar to perform analysis operations on sessions such as:

- Selecting the OpenCL kernel to execute analysis on
- Start Analysis
- Open Code Buidler Analysis Input window
- Open Code Builder Variable Management windows

Analyzing Input

To assign analysis inputs for an OpenCL kernel do the following:

1. Select the desirable kernel from the session’s kernels list in the **Code Builder Session Explorer** or from the **Select Kernel** combobox in the **Code Builder Analysis** toolbar.

2. Open the **Code Builder Analysis Input** window from: **CODE-BUILDER** > **Kernel Development Framework** > **Windows** > **Code Builder Analysis Input** or by clicking the **Open Analysis Input** button in the **Code Builder Analysis** toolbar.
3. Assign a variable for each kernel argument in the **Kernel Arguments** table by clicking the **Click here to assign** link under the **Assigned Variable** column. You can assign one-dimensional variables (such as `integer`, `float`, `char`, `half`, and so on) on-the-fly by typing single values into the table. See section "Creating Variables" for details.

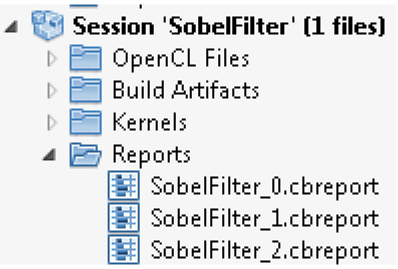
Running Analysis

To start the analysis, go to: **CODE-BUILDER** > **Kernel Development Framework** > **Run Analysis** or click the button in the **Code Builder Analysis** toolbar.

Viewing the Analysis Results

Analysis Results Overview

Once analysis is completed, several reports are being generated. A new report is being generated for each analysis run. The reports are available under the **Reports** node in the **Code Builder Session Explorer** window.



Each report contains several views:

- **Execution View** – provide information on execution times statistics and on the best and worst configurations.
- **Variables View** – provide information on the read and read back time of the memory object being used in the kernel and allows you to see their content.

You can toggle between the views through the **Report Selection** combobox located at the top of the report's layout.

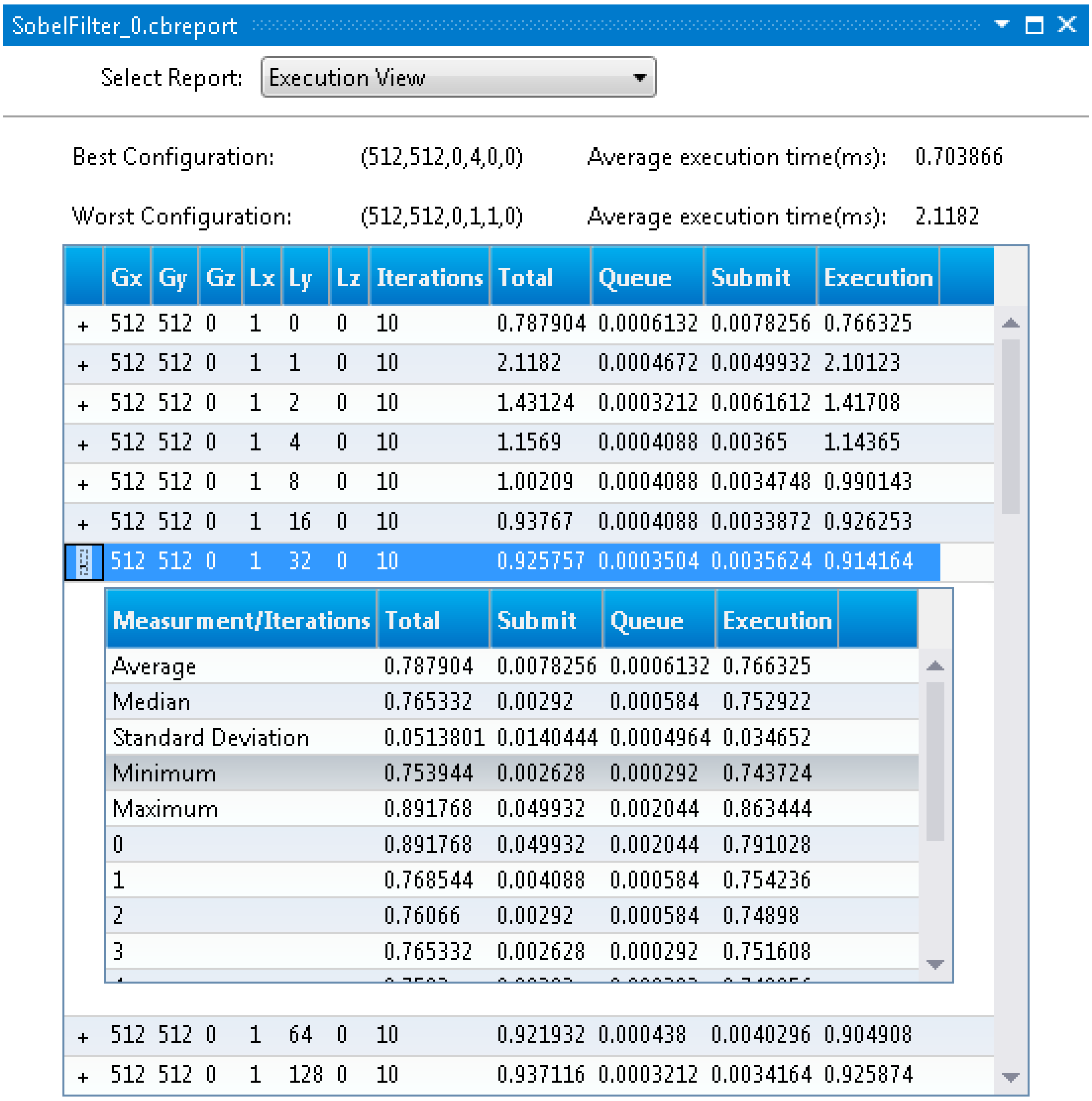
Execution View

The top part of the **Execution View** enables you to see the tested global and local size best and the worst configurations, based on median execution time. In case only one configuration exists, the result appears in both result windows.

The table below enables you to see statistical analysis results for all configurations. The statistics consists of the following iteration execution time values for the selected configuration:

- Median
- Average
- Standard deviation
- Maximum
- Minimum

Expending each row in the table enables you to see the total run time, the breakdown to queue, submit and execute times per iteration for the given configuration.



SobelFilter_0.cbreport

Select Report: Execution View

Best Configuration: (512,512,0,4,0,0) Average execution time(ms): 0.703866

Worst Configuration: (512,512,0,1,1,0) Average execution time(ms): 2.1182

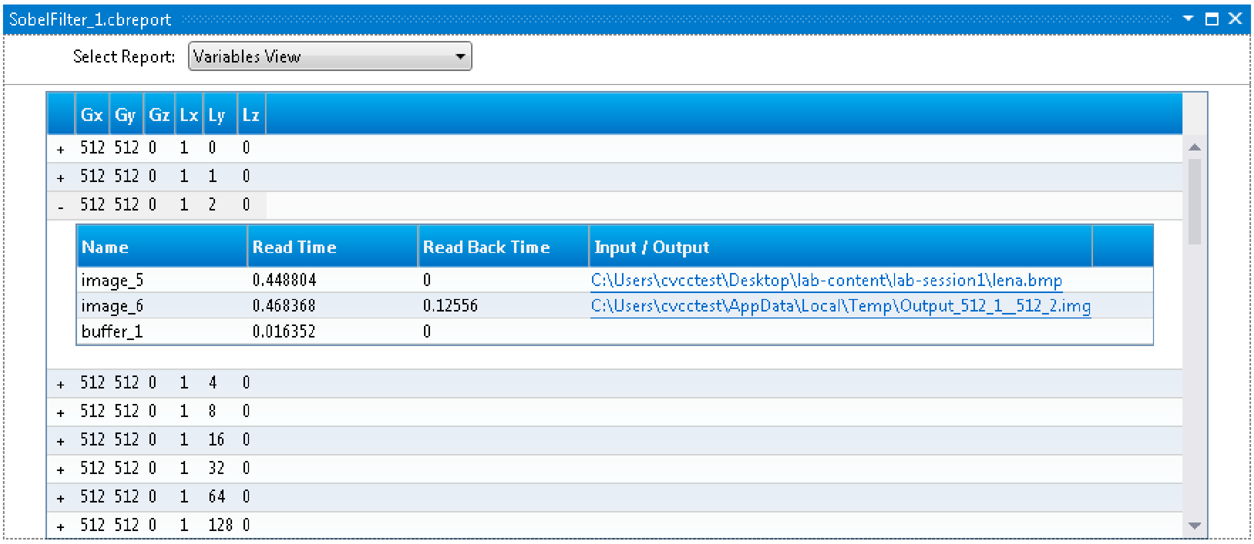
	Gx	Gy	Gz	Lx	Ly	Lz	Iterations	Total	Queue	Submit	Execution
+	512	512	0	1	0	0	10	0.787904	0.0006132	0.0078256	0.766325
+	512	512	0	1	1	0	10	2.1182	0.0004672	0.0049932	2.10123
+	512	512	0	1	2	0	10	1.43124	0.0003212	0.0061612	1.41708
+	512	512	0	1	4	0	10	1.1569	0.0004088	0.00365	1.14365
+	512	512	0	1	8	0	10	1.00209	0.0004088	0.0034748	0.990143
+	512	512	0	1	16	0	10	0.93767	0.0004088	0.0033872	0.926253
-	512	512	0	1	32	0	10	0.925757	0.0003504	0.0035624	0.914164

Measurment/Iterations	Total	Submit	Queue	Execution
Average	0.787904	0.0078256	0.0006132	0.766325
Median	0.765332	0.00292	0.000584	0.752922
Standard Deviation	0.0513801	0.0140444	0.0004964	0.034652
Minimum	0.753944	0.002628	0.000292	0.743724
Maximum	0.891768	0.049932	0.002044	0.863444
0	0.891768	0.049932	0.002044	0.791028
1	0.768544	0.004088	0.000584	0.754236
2	0.76066	0.00292	0.000584	0.74898
3	0.765332	0.002628	0.000292	0.751608

	Gx	Gy	Gz	Lx	Ly	Lz	Iterations	Total	Queue	Submit	Execution
+	512	512	0	1	64	0	10	0.921932	0.000438	0.0040296	0.904908
+	512	512	0	1	128	0	10	0.937116	0.0003212	0.0034164	0.925874

Variables View

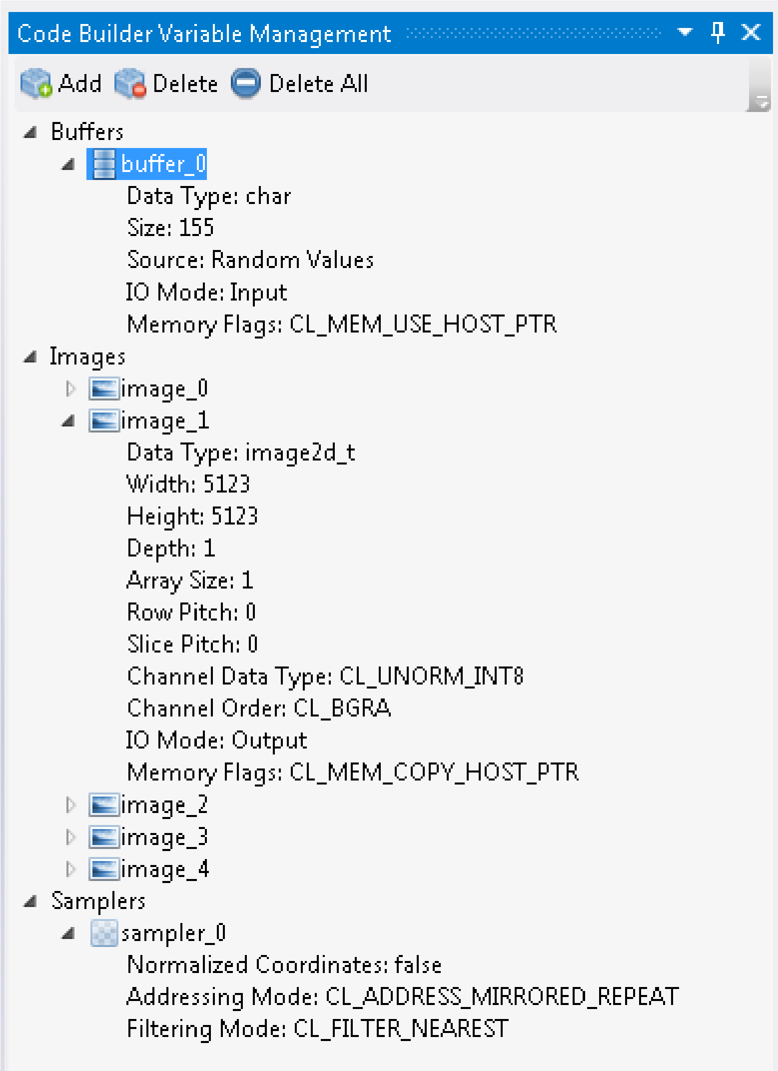
The **Variable View** table enables you to see read and read-back times for each variable, as well as the output file path for output parameters. Clicking on this input/output path pops up its content (images and buffers).



Variable Management

Variable Management Overview

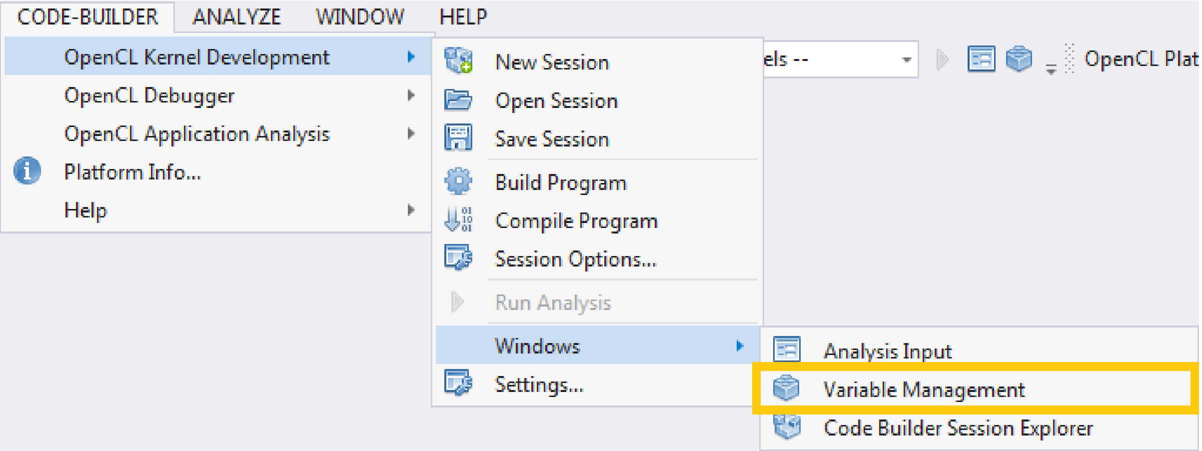
You can manage variables in Kernel Development Framework via the **Code Builder Variable Management** dialog. To open the dialog go to: **CODE-BUILDER** > **Kernel Development Framework** > **Windows** > **Variable Management** or click the **Variable Management** button in the **Code Builder Analysis** toolbar.



Creating Buffer Variables

To create new buffer variable

1. Open the variable management dialog.



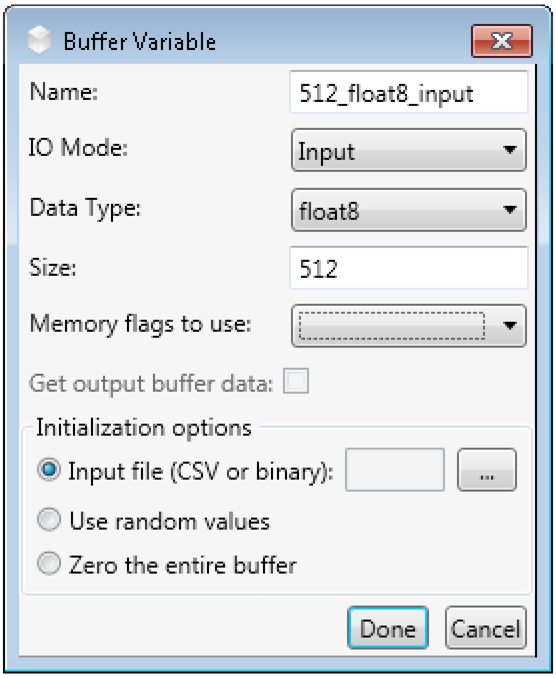
2. Click the **Add** button in the **Code Builder Variable Management** dialog and choose **Buffer** in the opened context menu.

Use CSV or binary files, random values, or zeroes to create buffers.

- When using CSV files, each line represents one OpenCL data type (like `int4`, `float16`, and so on), with a value in each column to satisfy the type size. For example, for a `long8`, at least eight columns of long numbers should exist in each line. The size of the buffer is used as the number of lines to read from CSV. The CSV file may hold more columns or lines than needed for a specific buffer, but not fewer.
- When using binary files, the content should be a concatenation of the OpenCL data type, and as with using CSV files, the file may hold more data than indicated by the **Size** argument.

NOTE

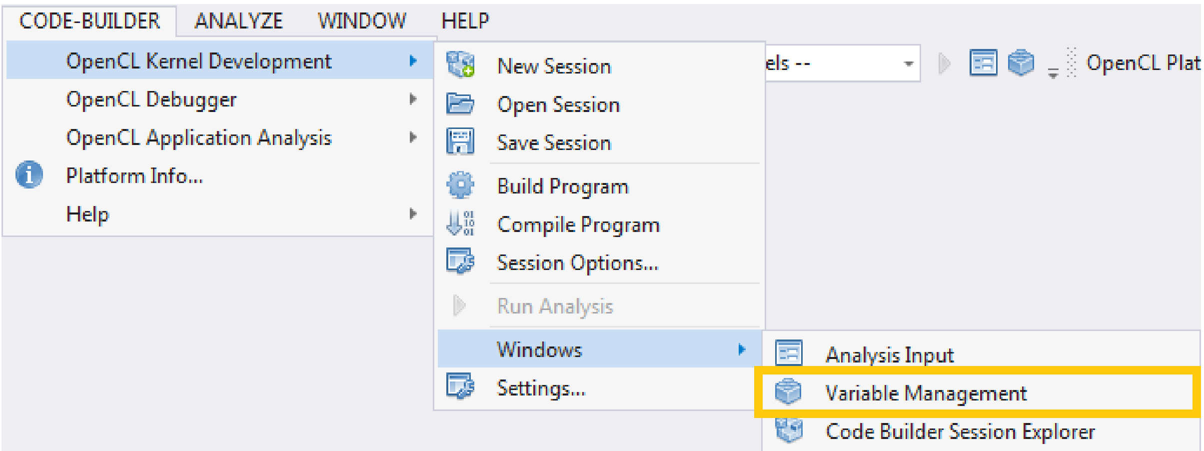
Output buffers do not need a value assigned to them. If a value is assigned, it is ignored.



Creating Image Variables

To create a new image variable,

1. Open the variable management dialog.

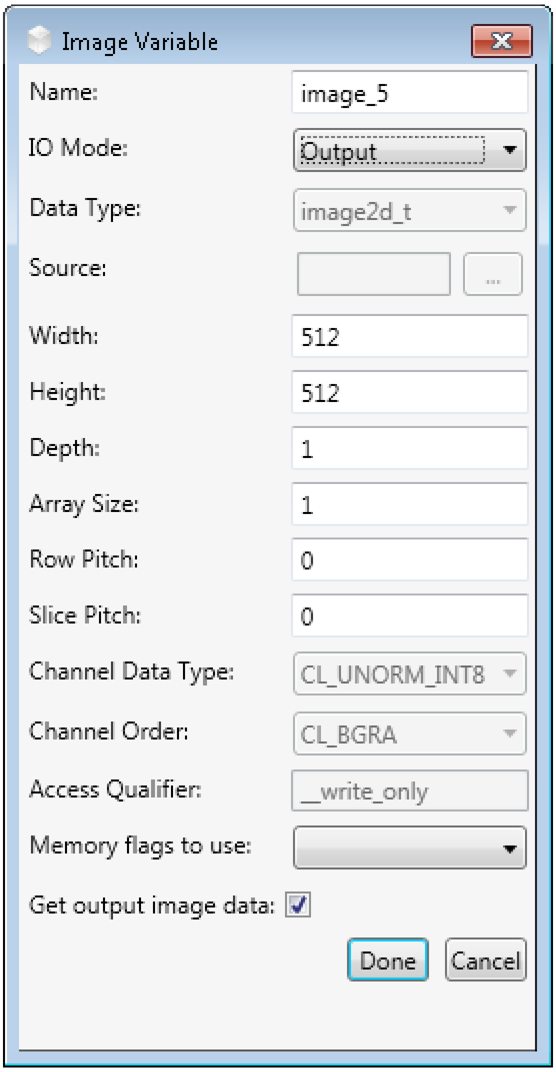


2. Click the **Add** button  in the **Code Builder Variable Management** dialog and choose **Image** in the opened context menu.

Use input bitmap files and the parameters to create images. Create output images with the correct size, type, channel order, and so on.

NOTE

In this version of the tool only 2 dimensional images with **CL_UNORM_INT8** channel data type and **CL_BGRA** channel order are supported.

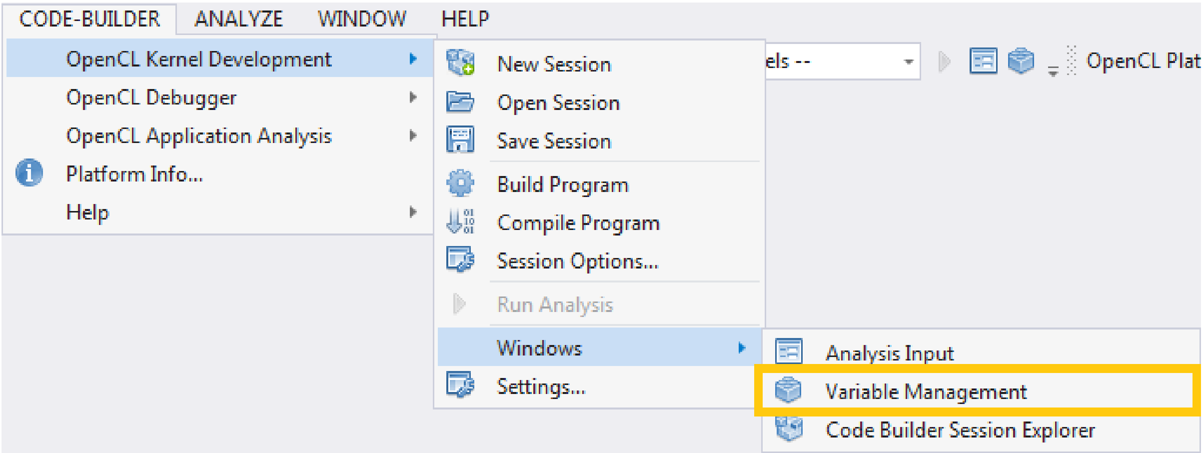


The **Get output image data** checkbox disables reading back the output buffer or image. It means that you can try more than one combination of global or local work sizes, where there is no need to read the same output for all the combinations.

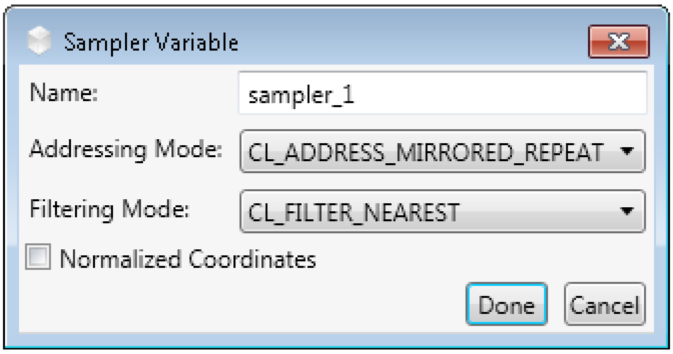
Creating Sampler Variables

To create new sampler variable

1. Open the variable management dialog.



2. Click the **Add** button  in the **Code Builder Variable Management** dialog and choose **Sampler** in the opened context menu.



Selecting Memory Options

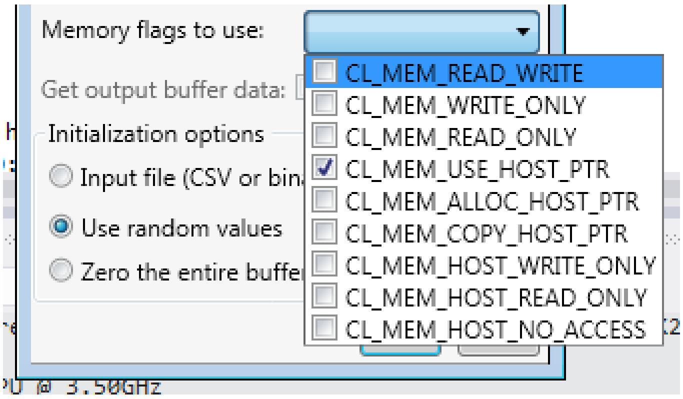
You can change memory options of buffers or images using Kernel Development Framewokr. Refer to the relevant sections of this guide for guidelines on creating or editing variables.

NOTE

You are not limited in selecting options. Avoid selecting the option combinations that are forbidden by the OpenCL 1.2 specification, otherwise you may encounter errors upon analysis.

To choose buffers and images memory options, do the following:

1. Open the variable properties by right-clicking an image or buffer variable in the **Code Builder Variable Management** window and selecting **Edit Variable**.
2. Open the combobox next to **Memory flags to use**.
3. Select options and click **Done**.



Editing the Variables

To edit the variables in the system using the Kernel Development Framework, do the following:

1. Open the **Code Builder Variable management** window.
2. Right-click a variable name.
3. Click **Edit Variable**.
4. Change the desired properties and click **Done**.

Viewing Contents of the Variables

To view buffer or image contents when using the Kernel Development Framework, do the following:

1. Open the **Code Builder Variable management** window.
2. Right-click a buffer or image name you want to view.
3. Click **View Variable**.

Copying Variables

To create a copy of buffer, image, or sampler varialbe when using the Kernel Development Framework, do the following:

1. Open the **Code Builder Variable management** window.
2. Right-click a buffer, image, or sampler name you want to copy.
3. Click **Copy Variable**.

Removing Variables

To delete variables when using the Kernel Development Framework, do the following:

1. Open the **Code Builder Variable management** window.
2. Right-click a variable name.
3. Click **Delete variable** or **Delete all variables**.

You can delete all buffers, images, or samples by right-clicking the corresponding node (Buffers, Images, or Samplers respectively).