OpenCL™ Driver for Intel® HD, Iris™, and Iris™ Pro Graphics for Linux -- Release Notes

Version Information

This document covers the Intel® OpenCL Linux graphics device driver version r4.1-BUILD_ID, hereafter referred to as the intel-opencl-r4.1 driver, where BUILD_ID refers to the build ID of the distributed files.

Overview

The intel-opencl-r4.1 driver for Linux exposes the general-purpose parallel compute capabilities of Intel® graphics for OpenCL applications.

This release provides OpenCL 2.0 support for 5th, 6th and 7th generations of Intel® Core™ and Xeon™ processors with Intel® Processor Graphics Technology not previously disabled by the BIOS or motherboard settings, OpenCL 1.2 support for Intel® Atom™ processor E3900 series, Intel Pentium N4200, J4000 Intel Celeron J3000, N3350 and the following extensions:

- d_intel_accelerator
- d_intel_advanced_motion_estimation (version 2; see notes below)
- d_intel_device_side_avc_motion_estimation
- d_intel_driver_diagnostics
- d_intel_media_block_io
- d_intel_motion_estimation
- d_intel_planar_yuv
- d_intel_packed_yuv
- d_intel_required_subgroup_size
- d_intel_subgroups
- d_intel_subgroups_short
- d_intel_va_api_media_sharing
- d_khr_3d_image_writes
- d_khr_byte_addressable_store
- d_khr_depth_images
- d_khr_fp16 (5th generation Intel® Core™ processors and above)
- d_khr_fp64 (5th generation Intel® Core™ processors and above)
- d_khr_global_int32_base_atomics
- d_khr_global_int32_extended_atomics
- d_khr_icd
- d_khr_image2d_from_buffer (5th generation Intel® Core™ processors and above)
- d_khr_local_int32_base_atomics
- d_khr_local_int32_extended_atomics
- d_khr_mipmap_image

1 Intel®, the Intel logo, Intel® Core™ processors, Intel® VTune™, Intel® Xeon®, Intel® HD, Intel® Iris™, and Intel® Iris™ Pro graphics are trademarks of Intel Corporation in the U.S. and other countries. Other names and brands may be claimed as the property of others. OpenCL™ is a trademark of Apple Inc. used by permission by Khronos. Copyright © 2016 Intel Corporation. All rights reserved.
- cl_khr_mipmap_image_writes
- cl_khr_spir
- cl_khr_subgroups (6th generation Intel® Core™ processors and above)

System Requirements

The intel-opencl-r4.1 driver enables OpenCL 1.2 or 2.0 on the GPU/CPU for the following Intel® processors:

- Intel® 5th, 6th or 7th generation Core™ processor
- Intel Pentium N4200, J4000 and Intel Celeron J3000, N3350
- Intel® Atom™ processor E3900 series
- Intel® Xeon® v4, or Intel® Xeon® v5 Processors with Intel® Graphics Technology enabled by the BIOS or motherboard settings

In addition to the above processor requirements, proper operation also requires Linux kernel source code patches included with Intel® driver to be applied to the kernel. See the intel-opencl-r4 driver installation document for more information on how to apply the patches and to verify that the system meets the necessary requirements.

Changes Since intel-opencl-r4.0

- Functional quality improvements

Changes Since intel-opencl-r3.1

The intel-opencl-r4.1 driver includes the following new features introduced since the intel-opencl-r3.1 release:

- VTune support for 7th generation Intel® Core™ processors
- updated patches for the Linux 4.7 and 4.4 kernels
- cl_intel_device_side_avc_motion_estimation extension to support AVC VME built-in functions callable from OpenCL kernels giving greater flexibility for expert developers and potential performance improvements for simpler VME operations compared to the built-in kernels provided with the cl_intel_motion_estimation and cl_intel_advanced_motion_estimation extensions. The new functions can be used to implement the pre-ENC and ENC stages of an encode pipeline using Intel® GPUs.
- cl_intel_media_block_io extension to augment the block read/write functionality available in the Intel® vendor subgroup extensions, cl_intel_subgroups and cl_intel_subgroups_short, by the specification of additional built-in functions to facilitate the reading and writing of flexible 2D regions from images. This API allows for the explicit specification of the width and height of the image regions. The primary use for this extension is to support the reading of edge texels (or image elements) of neighboring macro-blocks as described in the Intel vendor extension cl_intel_device_side_avc_motion_estimation.
- cl_intel_planar_yuv - Adds native support for the Planar YUV (YCbCr) image format which can be used with the Device-Side AVC Motion Estimation and Video Enhancement extensions.
- cl_intelx_video_enhancement (6th generation Intel® Core™ processors and above) preview extension
- cl_intelx_video_enhancement_camera_pipeline (6th generation Intel® Core™ processors and above) preview extension
- cl_intelx_video_enhancement_color_pipeline (6th generation Intel® Core™ processors and above) preview extension

The video enhancement, video enhancement camera pipeline, and video enhancement color pipeline preview extensions are described in section Preview OpenCL Extensions.
Changes Since intel-opencl-r2.0

In addition to the changes since the intel-opencl-r3.1 release, the intel-opencl-r4.1 driver includes the following new features introduced since the intel-opencl-r2.0 release:

- OpenCL 2.0 support for 7th generation Intel® Core™ processors
- OpenCL 1.2 support for Intel Pentium J4000 and Intel Celeron J3000
- Support for a patched Linux 4.7 kernel
- Deprecation of the Linux 3.10.0 and 4.1 kernels
- 4th generation Intel® Core™ processors are not formally supported in this release
- cl_intel_driver_diagnostics extension allows the driver to pass additional strings containing diagnostic information. The diagnostic messages can help to understand how the driver works and can provide guidance to modify an application to improve performance.
- cl_intel_subgroups_short extension to support improved performance of applications operating on 16-bit data types by extending the subgroup functions described in the cl_intel_subgroups extension to support the 16-bit integer data types short and ushort.

Changes Since 16.5 Release Included with Intel® Media Server Studio 2017

In addition to the changes since the intel-opencl-r2.0 and intel-opencl-r3.1 release, the intel-opencl-r4.1 driver includes the following new features introduced since the 16.5 release:

- cl_intel_driver_diagnostics extension
- cl_intel_subgroups_short extension
- Support for the MSS 2017 R2 media release using the patched Linux 4.4 kernel

System using the Intel® Media Server Studio 2017 release are not supported and must be upgraded to MSS 2017 R2. See the MSS 2017 R2 documentation for installation procedures and hardware requirements.

Supported Configurations

Intel validates the intel-opencl-r4.1 driver on CentOS 7.2 when running the following 64-bit kernels:

- Linux 4.7 kernel patched for OpenCL
- Linux 4.4 kernel patched for MSS 2017 R2

Although Intel validates and provides technical support only for the above Linux kernels on CentOS 7.2, other distributions may be adapted by utilizing our generic operating system installation steps as well as MSS 2017 R2 installation steps.

The CPU OpenCL solution is also packaged with the intel-opencl-r4.1 driver. The combined GPU/CPU platform has been validated with this release.

Preview OpenCL Extensions

This driver release contains optionally accessible preview extensions permitting developers to expose new functionality to OpenCL kernels. Once enabled using an environment variable the preview extensions will be

---

2 Enabling GPU OpenCL for supported Intel Atom, Celeron and Pentium series of processors requires the patched Linux 4.7 kernel as well as a kernel option provided by the boot loader. See section Known Workarounds for more information.

3 System utilizing the Intel® Media Server Studio 2017 R2 must not use included Linux 4.7 kernel patches.
listed in the device extension list provided by clGetDeviceInfo. All preview extensions can be identified by the pattern cl_intelx_ in the extension name.

Developers utilizing the preview extensions are encouraged to provide feedback and to review future releases for changes. Additionally:

- A preview extension is not a final commitment. We may modify the functionality and/or interface or remove it completely. Developers should not depend on the existence of preview extensions in shipping drivers and should not enabled these features on end-user platforms as part of any application installation process.
- Preview extensions may not receive the same amount of testing as production features. If you have enabled a preview extension, please only file bug reports for that extension. If you suspect a bug in non-preview functionality, it would be helpful to confirm that issue with and without preview extensions enabled.
- We appreciate and want all feedback! Your feedback enables us to improve the product and provide you with the best product possible. Please use the feedback channels provided elsewhere in this document, or contribute to the following forum: https://software.intel.com/en-us/forums/opencl

Instructions for Preview OpenCL Features

In Linux, you can use an environmental variable with prefix: “OCL_” in the following manner

```bash
$ OCL_EnablePreviewFeatures=1 path/to/oclapplication
```

or

```bash
$ export OCL_EnablePreviewFeatures=1
```

This release provides preview support for the following Video Enhancement HW block functionality for expert developers as the preview extensions:

- **cl_intelx_video_enhancement** - Exposes a fixed-function pipeline consisting of Denoise, Deinterlace and Hot Pixel Correction stages. It comes together with a number of per-frame and per-block statistics that can be accessed, including global noise estimate statistics, spatial-temporal motion measure, denoise history, histograms, per command and other statistics that the Video Enhancement pipeline generates. Includes support for NV12 image format. The features are based on built-in kernels infrastructure and the cl_intel_accelerator extension.

- **cl_intelx_video_enhancement_camera_pipeline** - Exposes a fixed-function pipeline of operations working on camera inputs in Bayer formats: Black Level Correction, Vignette, White Balance Correction, Denoise, Hot Pixel Correction and Demosaic. The extension reuses the infrastructure defined in the cl_intelx_video_enhancement extension.

- **cl_intelx_video_enhancement_color_pipeline** - Extends the cl_intelx_video_enhancement and cl_intelx_video_enhancement_camera_pipeline extensions with color processing and enhancement pipeline, consisting of the following stages: Color Correction Matrix, Forward Gamma Correction, Front-End Color Space Conversion, Skin-tone Detection and Enhancement, Gamut Compression, Adaptive Contrast Enhancement, Total Color Correction, Process Amplifier, Back-end Color Space Conversion and Gamut Expansion / Color Correction.

Package Contents

The following files are included with the intel-opencl-r4.1 driver distribution:

- **intel-opencl-r4.1-BUILD_ID-* (rpm and .tar.xz)**
The OpenCL 2.0 ICD loader, the OpenCL 2.0 ICD for Intel® HD, Iris, and Iris Pro graphics, and the Intel® OpenCL 2.0 driver and runtime for Intel® processor graphics

- Kernel mode driver patches based against specific distributions or reference kernels
  
  - intel-opencl-devel-r4.1-BUILD_ID-* (.rpm and .tar.xz)
    - Optional OpenCL 2.0 development files for compiling OpenCL applications
  
  - intel-opencl-cpu-r4.1-BUILD_ID-* (.rpm and .tar.xz)
    - Intel® OpenCL 2.0 runtime for Intel® processor

**Linux kernel 4.7 patch description**

Intel validates OpenCL driver with the full set of the 17 patches for Linux 4.7 kernel.

<table>
<thead>
<tr>
<th>#</th>
<th>Title</th>
<th>type</th>
<th>comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>drm/i915: Add L3_LRA_1 Register to cmdparser whitelist</td>
<td>performance</td>
<td>HSW L3 cache</td>
</tr>
<tr>
<td>2</td>
<td>drm/i915: Android MOCS on top of upstream</td>
<td>performance</td>
<td>SKL Mocs</td>
</tr>
<tr>
<td>3</td>
<td>drm/i915: Exec flag to force non IA-Coherent cache for Gen9+</td>
<td>functional</td>
<td>Fine grain</td>
</tr>
<tr>
<td>4</td>
<td>Revert &quot;drm/i915/skl: Fix spurious gpu hang with gt3/gt4 revs&quot;</td>
<td>functional</td>
<td>Fine grain</td>
</tr>
<tr>
<td>5</td>
<td>drm/i915: OA regs configuration for MDAPI TBS</td>
<td>functional</td>
<td>VTune support</td>
</tr>
<tr>
<td>6</td>
<td>drm/i915 - Allow a render node to use perfmon ioctl</td>
<td>functional</td>
<td>VTune support</td>
</tr>
<tr>
<td>7</td>
<td>drm/i915: Fix ref counting for RC6 WA BB alloc/dealloc</td>
<td>functional</td>
<td>VTune support</td>
</tr>
<tr>
<td>8</td>
<td>drm/i915/perfmon: Fixup locking on error path in RC6 WA BB alloc</td>
<td>functional</td>
<td>VTune bug fix</td>
</tr>
<tr>
<td>9</td>
<td>drm/i915: Remove unused &quot;valid&quot; parameter from pte_encode</td>
<td>functional</td>
<td>bug fix</td>
</tr>
<tr>
<td>10</td>
<td>drm/i915/gtt: Split gen8_pgtt_clear_pte_range</td>
<td>functional</td>
<td>bug fix</td>
</tr>
<tr>
<td>11</td>
<td>drm/i915/gtt: Free unused lower-level page tables</td>
<td>functional</td>
<td>bug fix</td>
</tr>
<tr>
<td>12</td>
<td>drm/i915/gtt: Mark tbls dirty on clear</td>
<td>functional</td>
<td>bug fix</td>
</tr>
<tr>
<td>13</td>
<td>drm/i915/gtt: Fix pte clear range</td>
<td>functional</td>
<td>bug fix</td>
</tr>
<tr>
<td>14</td>
<td>drm/i915: Add support for OCL Turbo Boost</td>
<td>performance</td>
<td>enhancement</td>
</tr>
<tr>
<td>15</td>
<td>Subject: drm/i915/bxt: Enable Pooled EU support</td>
<td>functional</td>
<td>BXT specific</td>
</tr>
<tr>
<td>16</td>
<td>drm/i915/bxt: Add WaEnablePooledEuFor2x6</td>
<td>functional</td>
<td>BXT specific</td>
</tr>
<tr>
<td>17</td>
<td>Implement WaDisablePooledEuLoadBalancingFix</td>
<td>functional</td>
<td>BXT specific</td>
</tr>
</tbody>
</table>

**Known Workarounds**

- For workloads that take longer than 1.5 seconds the i915 hang check will reset the GPU, output a kernel message for logging, and clear any pending work items. When necessary, the i915 hang check can be disabled on demand with

  $ sudo bash -c 'echo N > /sys/module/i915/parameters/enable_hangcheck'

  Although the GPU will no longer reset when executing with hang checks disabled, sufficiently large workloads may stall other GPU tasks such as screen updates. These situations can be recovered from by manually resetting the GPU with

  $ sudo bash -c 'echo 1 > /sys/kernel/debug/dri/0/i915_wedged'

- The trade-off between GPU busy (GPU being fed) vs. latency is that the driver might internally choose to submit or flush after $n$ commands being queued and this is an expected behavior. Currently the driver is forced to flush after $n=8$ commands are queued.
The 4.7 linux kernel has preliminary hardware support for Intel® Atom™ processor E3900 series, Intel Pentium N4200, J4000 Intel Celeron J3000, N3350. To enable the OpenCL functionality for those platforms you need to add the parameter to the kernel command line:

`i915.preliminary_hw_support=1`

**Known Issues**

- None

**Feedback and Support**

This user-mode driver and kernel patch set are focused on OpenCL compute use cases. Unless otherwise specified, interoperability with other drivers, operating systems, or platform features is not verified or supported. We welcome feedback to continue to make this product better. Please direct your feedback, including feature requests, through your primary Intel product support channels.

**Legal**

THIS DOCUMENT CONTAINS INFORMATION ON PRODUCTS IN THE DESIGN PHASE OF DEVELOPMENT.

INFORMATION IN THIS DOCUMENT IS PROVIDED IN CONNECTION WITH INTEL PRODUCTS. NO LICENSE, EXPRESS OR IMPLIED, BY ESTOPPEL OR OTHERWISE, TO ANY INTELLECTUAL PROPERTY RIGHTS IS GRANTED BY THIS DOCUMENT. EXCEPT AS PROVIDED IN INTEL’S TERMS AND CONDITIONS OF SALE FOR SUCH PRODUCTS, INTEL ASSUMES NO LIABILITY WHATSOEVER AND INTEL DISCLAIMS ANY EXPRESS OR IMPLIED WARRANTY, RELATING TO SALE AND/OR USE OF INTEL PRODUCTS INCLUDING LIABILITY OR WARRANTIES RELATING TO FITNESS FOR A PARTICULAR PURPOSE, MERCHANTABILITY, OR INFRINGEMENT OF ANY PATENT, COPYRIGHT OR OTHER INTELLECTUAL PROPERTY RIGHT.

UNLESS OTHERWISE AGREED IN WRITING BY INTEL, THE INTEL PRODUCTS ARE NOT DESIGNED NOR INTENDED FOR ANY APPLICATION IN WHICH THE FAILURE OF THE INTEL PRODUCT COULD CREATE A SITUATION WHERE PERSONAL INJURY OR DEATH MAY OCCUR.

Intel may make changes to specifications and product descriptions at any time, without notice. Designers must not rely on the absence or characteristics of any features or instructions marked "reserved" or "undefined." Intel reserves these for future definition and shall have no responsibility whatsoever for conflicts or incompatibilities arising from future changes to them. The information here is subject to change without notice. Do not finalize a design with this information.

The products described in this document may contain design defects or errors known as errata which may cause the product to deviate from published specifications. Current characterized errata are available on request.

Contact your local Intel sales office or your distributor to obtain the latest specifications and before placing your product order.

Copies of documents which have an order number and are referenced in this document, or other Intel literature, may be obtained by calling 1-800-548-4725, or by visiting Intel's Web Site, http://intel.com.

Intel, the Intel logo, Intel Core are trademarks or registered trademarks of Intel Corporation or its subsidiaries in the United States and other countries.

**Optimization Notice**

Intel's compilers may or may not optimize to the same degree for non-Intel microprocessors for optimizations that are not unique to Intel microprocessors. These optimizations include SSE2, SSE3, and
SSSE3 instruction sets and other optimizations. Intel does not guarantee the availability, functionality, or effectiveness of any optimization on microprocessors not manufactured by Intel. Microprocessor-dependent optimizations in this product are intended for use with Intel microprocessors. Certain optimizations not specific to Intel microarchitecture are reserved for Intel microprocessors. Please refer to the applicable product User and Reference Guides for more information regarding the specific instruction sets covered by this notice.

Notice revision #20170404