# OpenCL Interoperability with OpenVX

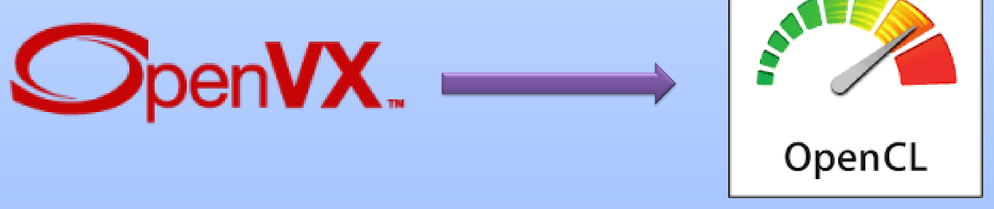
## Introduction

**OpenVX**

- Open computer vision framework
- Graph-based API => system-level optimization.
- Includes many kernels but not all.
- Supports C based user kernels.

**The problem**

- No accelerated user kernels.
- Two solutions proposed[1].




## First: OpenCL-C kernels[2]

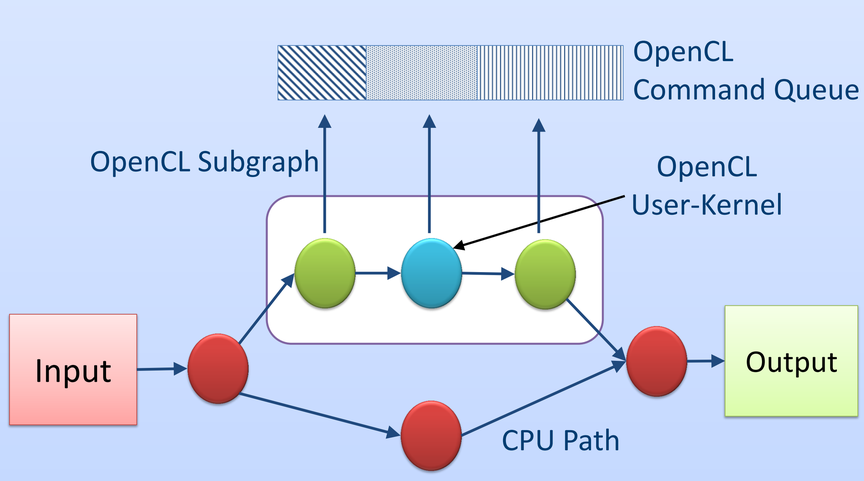
- OpenCL programs are passed to the framework
- Framework compiles kernels
- Users specify inputs and outputs and work item sizes.
- Map is needed between OpenVX objects and OpenCL kernel arguments.
- No OpenCL runtime required.
- Some OpenCL kernels are not supported.

## Second: OpenCL Interop kernels[3]

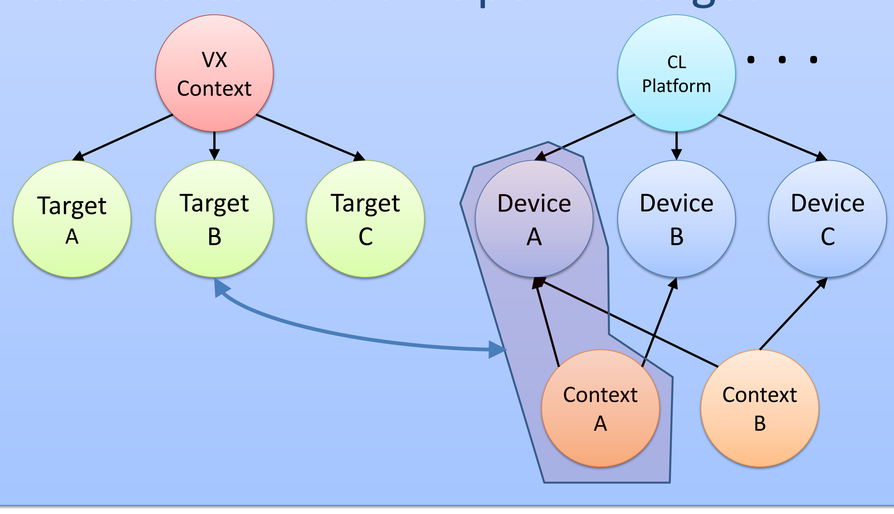
- A general solution, no OpenCL kernel restrictions.
- Many OpenCL kernels in one OpenVX kernel.
- User determine how to enqueue them.

## Interop Kernels – OpenCL Context

- OpenVX inserts OpenCL user kernels in the graph.
- The framework may use the same command queue for built-in kernels using OpenCL and Interop kernels.




- An OpenCL (context, device) pair is associated with an OpenVX target.




## Interop Kernel Example

- Users can request the OpenCL context, create multiple OpenCL kernels and add them to an OpenVX user-kernel.

```
// Get OpenCL context associated with an OpenVX target
cl_context clContext = vxGetOpenCLContext(vxContext, targt);
// OpenCL standard code for creating kernels
cl_program clProgram = clCreateProgramWithSource(&src, ...);
cl_kernel clKernel0 = clCreateKernel(clProgram, "k0", ...);
cl_kernel clKernel1 = clCreateKernel(clProgram, "k1", ...);
...
// Create OpenCL interop kernel
vx_kernel vxKernel = vxAddOpenCLInteropKernel(targets, ...,
                                userFunc, userVal, userInit, userDeinit);
vxAddOpenCLKernelToKernel(vxKernel, 0, clKernel0);
vxAddOpenCLKernelToKernel(vxKernel, 1, clKernel1);
vxAddParameterToKernel(vxKernel, 0, VX_INPUT, ...);
vxAddParameterToKernel(vxKernel, 1, VX_OUTPUT, ...);
vxFinalizeKernel(vxKernel);
// Create a generic node
vx_node node = vxCreateGenericNode(graph, kernel);
vxSetParameterByIndex(node, 0, inputImage);
vxSetParameterByIndex(node, 1, outputImage);
vxProcessGraph(graph);
```

- OpenCL buffers can be obtained from OpenVX objects.
- **vx_image** can be interpreted as a buffer or image2d.

```
vx_status userFunc(vx_node node, vx_reference* parameters,
                   cl_kernel* kernels, cl_command_queue queue)
{
  vx_image vxImg = (vx_image) parameters[0];
  vx_array vxArr = (vx_array) parameters[1];
  cl_mem clBuf = vxGetOpenCLBufferFromImage(node, vxImg);
  cl_mem clImage = vxGetOpenCLImage2DFromImage(node,   vxImg);
  cl_mem clArray = vxGetOpenCLBufferFromArray(node, vxArr);
  // This can be moved to the initializer
  clSetKernelArgs(kernels[0], 0, sizeof(cl_mem), &clImage);
  ...
  clEnqueueNDRangeKernel(queue, clKernel[0], ...);
}
```

[1]Design is not limited to Intel architectures.
[2]Intel currently supports this device kernel extension.
[3]Currently in POC stage, OpenVX1.1 sample.



By Ben Ashbaugh and Ariel Bernal, Intel® Corporation