The OpenCL Library Ecosystem

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based on experiences in developing
ViennaCL

International Workshop on OpenCL
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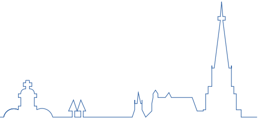
OpenCL Library Ecosystem

- Abacus
- ACML
- Accelerate
- amgCL
- Aparapi
- AQUAgpusph
- ArrayFire
- ASL
- Barracuda
- Bolt
- Boost.Compute
- Bullet Physics
- C++ AMP
- CALDGEMM
- CF4OCL
- clBLAS
- clFFT
- CLFORTRAN
- clMAGMA
- clpp
- clSpMV
- CLTune
- Clyther
- Concord
- COPRTHR
- Data Layout
- DelphiOpenCL
- ForOpenCL
- fortranCL
- FSCL.Compiler
- GMAC
- Go-OpenCL
- GPULib
- gpumatrix
- GPUVerify
- Halide
- Harlan
- Haskell
- HOpenCL
- JOCL
- libCL
- Libra SDK
- Lua
- M3
- MUMPS
- Octave
- OpenFortranP.
- OpenCL.jl
- OpenCL.NET
- OpenCLIPP
- OpenCLLink
- OpenClooVision
- OpenCV-CL
- OpenHMPP
- Paralution
- Pardiso
- Pencil
- PETSc
- PyOpenCL
- RaijinCL
- Rivertrail
- RNG
- ROpenCL
- RoseACC-OpenCL
- Rose Compiler
- Rust-OpenCL
- ScalaCL
- SkelCL
- SnuCL
- SpeedIT 2.4
- streamscan
- SuperLU
- s-u/OpenCL
- TM-Task
- Trilinos
- VexCL
- ViennaCL
- ViNN
- VirtualCL
- VOBLA
- VOCL
- VSI/Pro
- WAMS

83 libraries listed on iwocl.org



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69 libraries from iwocl.org still accessible, no transitives

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53 active libraries (based on list at iwocl.org)

OpenCL Library Ecosystem

Bindings (18)

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Algorithms (35)

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Math (14)

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clBLAS
GPULib
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Primitives (7)

Bolt
Boost.Compute
clFFT
CLTune
libCL
M3
RNG

Other (14)

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OpenCL vs. CUDA for Libraries

OpenCL

Header and shared library

Non-intrusive to build system

jit-compilation

CUDA

Custom compiler wrapper (NVCC)

NVCC dictates your host compiler

Single source

Kernel binaries embedded in executable

How about SyCL?

Bring single-source approach to OpenCL

jit-compilation

Outline

How can we make OpenCL more library-friendly?

Outline

Just-In-Time Kernel Compilation

- Library may provide hundreds of kernels
- Just-in-time compilation entails certain overhead

Kernel Interaction

- Host-function not callable from OpenCL kernel on host
- Hindrance to software composability

OpenCL Heterogeneity

- OpenCL 2.2 was released this week
- Many SDKs still at OpenCL 1.2 or earlier

Not In This Talk

Performance Portability

Not specific to libraries

Several strategies proposed in the past

“There is no secret to performance portability;
it’s just hard.“ — Neil Trevett, IWOCL 2016

ViennaCL Approach

Extensive kernel parameterization

Built-in device database

Match device type, vendor, architecture, device name

Just-In-Time Kernel Compilation

Kernel Compilation

Library may provide hundreds of kernels

Just-in-time compilation entails certain overhead

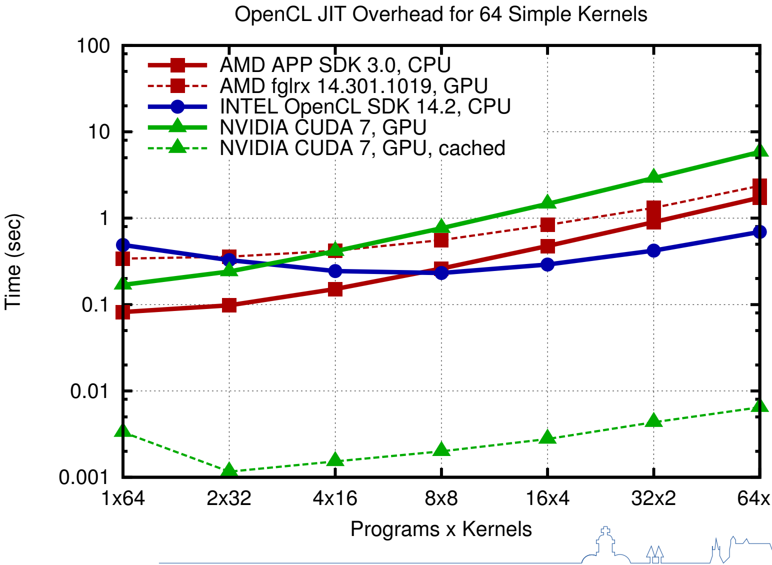
Little Experiment

Compile 64 trivial kernels of the form

```
__kernel void kernel_1_2(__global float *x){ x[1] = 2; }
```

Organize in 1 to 64 programs for 64 to 1 kernels each

Just-In-Time Kernel Compilation



Just-In-Time Kernel Compilation

OpenCL Program Cache

Compiled binaries stored in filesystem

Implement in $\mathcal{O}(10)$ OpenCL SDKs?

Implement in $\mathcal{O}(100)$ OpenCL-based libraries?

Proposed Solution

Make kernel caching a required (optional) feature for OpenCL SDKs

Just-In-Time Kernel Compilation

SyCL to the Rescue?

SyCL compiler cannot generate binaries for all possible targets

jit-overhead still an issue (unlike CUDA)

SPIR-V to the Rescue?

May reduce jit-compilation overhead substantially

Broad availability required

Kernel Interaction

Composability

Mix and match functionality in different libraries

Basic entity: function calls

Example: Sorting

```
void sort_criterion(...) { /* tricky criterion */ }
std::sort(x.begin(), x.end(), sort_criterion);
```

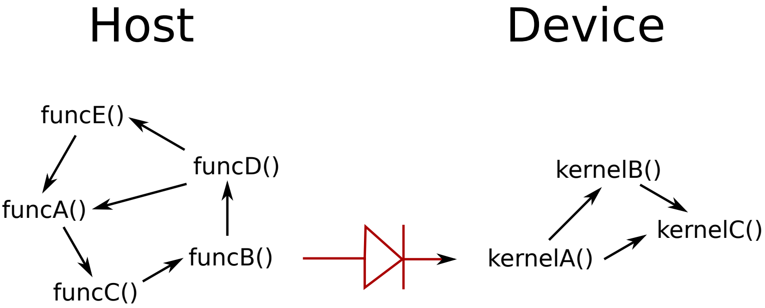
OpenCL on CPU

Plethora of libraries for host available

Easy to call OpenCL libraries from host

(Almost) Impossible to call host libraries from OpenCL kernel

Kernel Interaction



Host

Device

funcE()

funcD()

funcA()

funcB()

funcC()

kernelB()

kernelC()

kernelA()

Proposed Improvement

Allow calling host functions for OpenCL kernels on CPU

OpenCL Heterogeneity

OpenCL Releases

OpenCL 2.2 (recently)

OpenCL 2.1 (2015)

OpenCL 2.0 (2013)

OpenCL 1.2 (2011)

OpenCL 1.1 (2010)

OpenCL 1.0 (2009)

OpenCL Support in SDKs

2.2: -

2.1: -

2.0: AMD, Intel (Win), Qualcomm

1.2: Apple, Beignet, Intel (Linux), Imagination, NVIDIA, pocl, Vivante

1.1: ARM, Sony, TI

1.0: Altera, Xilinx

OpenCL Heterogeneity

The Veto Problem

What if a major vendor stops OpenCL SDK development?

What if SPIR-V is not broadly available?

Possible Reasons for Slow OpenCL SDK Development

Proprietary alternative available

“Will help competitor more than us”

Development too expensive

OpenCL Heterogeneity

How to Encourage?

Make OpenCL a prerequisite for Vulkan certification?

Conclusion

Just-In-Time Kernel Compilation

Require optional kernel caching by OpenCL SDKs

Kernel Interaction

Allow calling host functions for OpenCL kernels on CPU

OpenCL Heterogeneity

Let OpenCL benefit from Vulkan’s momentum