

The OpenCL Library Ecosystem

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now:

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based on experiences in developing

The logo for ViennaCL, featuring a stylized blue symbol resembling a square root or a similar mathematical symbol followed by the text "ViennaCL" in a blue serif font.

International Workshop on OpenCL

April 21, 2016



OpenCL Library Ecosystem

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

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)

Aparapi
CF4OCL
CLFORTRAN
FSCL.Compiler
Halide
Harlan
HOpenCL
JOCL
Lua
OpenCL.jl
OpenCLIPP
OpenCLLink
PyOpenCL
Rivertrail
ROpenCL
Rose-OpenCL
Rust-OpenCL
ScalaCL

Algorithms (35)

Abacus
ACML
Accelerate
amgCL
AQUAgnusph
ArrayFire
ASL
Bolt
Boost.Compute
Bullet Physics
C++ AMP
CALDGEMM
cBLAS
cFFT
CLTune
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(based on list at iwocl.org, filtering applied)

OpenCL Library Ecosystem

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ROpenCL
Rose-OpenCL
Rust-OpenCL
ScalaCL

Math (14)

Abacus
ACML
amgCL
ArrayFire
CALDGEMM
cBLAS
GPULib
Paralution
RaijinCL
SkelCL
SpeedIT 2.4
VexCL
ViennaCL
VOBLA

Primitives (7)

Bolt
Boost.Compute
cFFT
CLTune
libCL
M3
RNG

Other (14)

Accelerate
AQUAgpu
ASL
Bullet Physics
C++ AMP
COPRTHR
Data Layout
GMAC
Libra SDK
OpenCV-CL
SnuCL
TM-Task
ViNN
VirtualCL

(based on list at iwocl.org, filtering applied)



OpenCL

- Header and shared library
- Non-intrusive to build system
- jit-compilation

CUDA

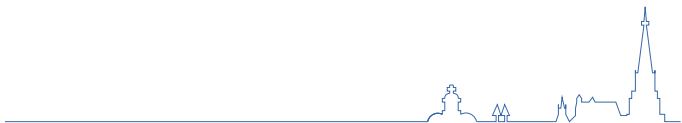
- Custom compiler wrapper (NVCC)
- NVCC dictates your host compiler
- Single source
- Kernel binaries embedded in executable

How about SyCL?

- Bring single-source approach to OpenCL
- jit-compilation



How can we make OpenCL more library-friendly?



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



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



Kernel Compilation

Library may provide hundreds of kernels

Just-in-time compilation entails certain overhead

Little Experiment

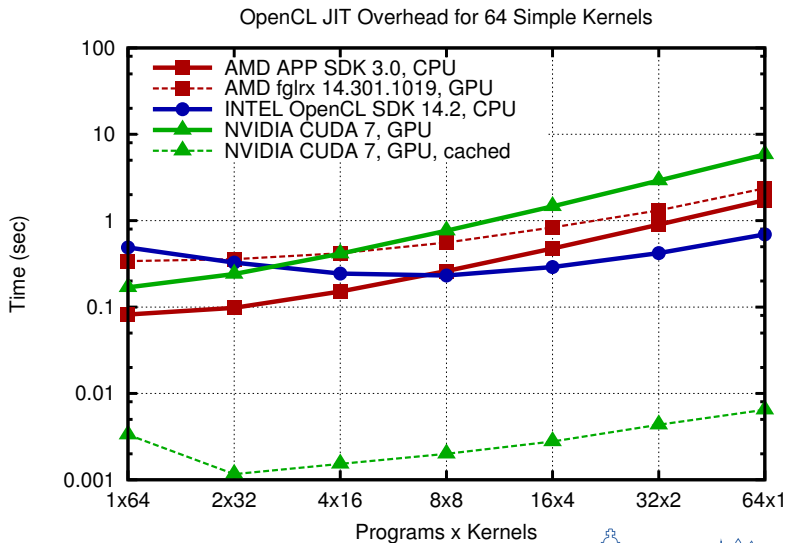
Compile 64 trivial kernels of the form

```
__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



OpenCL Program Cache

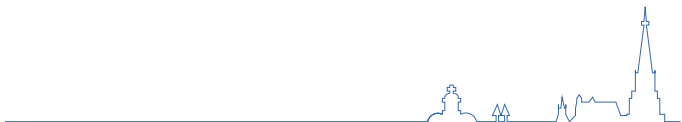
Compiled binaries stored in filesystem

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

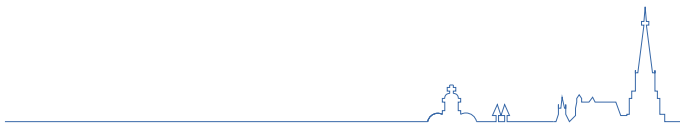


SyCL to the Rescue?

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



Composability

Mix and match functionality in different libraries

Basic entity: function calls

Example: Sorting

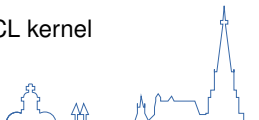
```
void sort_criterion(...) { /* tricky criterion */ }  
std::sort(x.begin(), x.end(), sort_criterion);
```

OpenCL on CPU

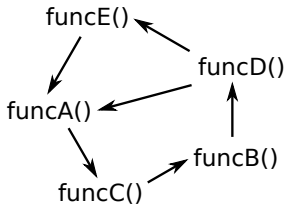
Plethora of libraries for host available

Easy to call OpenCL libraries from host

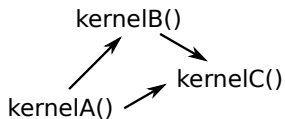
(Almost) Impossible to call host libraries from OpenCL kernel



Host



Device



Proposed Improvement

Allow calling host functions for OpenCL kernels on CPU



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: -

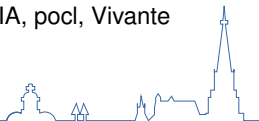
2.1: -

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



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



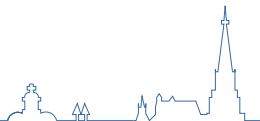
How to Encourage?



OpenCL



Make OpenCL a prerequisite for Vulkan certification?



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

