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THE HETEROGENEOUS SYSTEMS EXPERTS

Applying OpenCL

IWOCL, May 2017

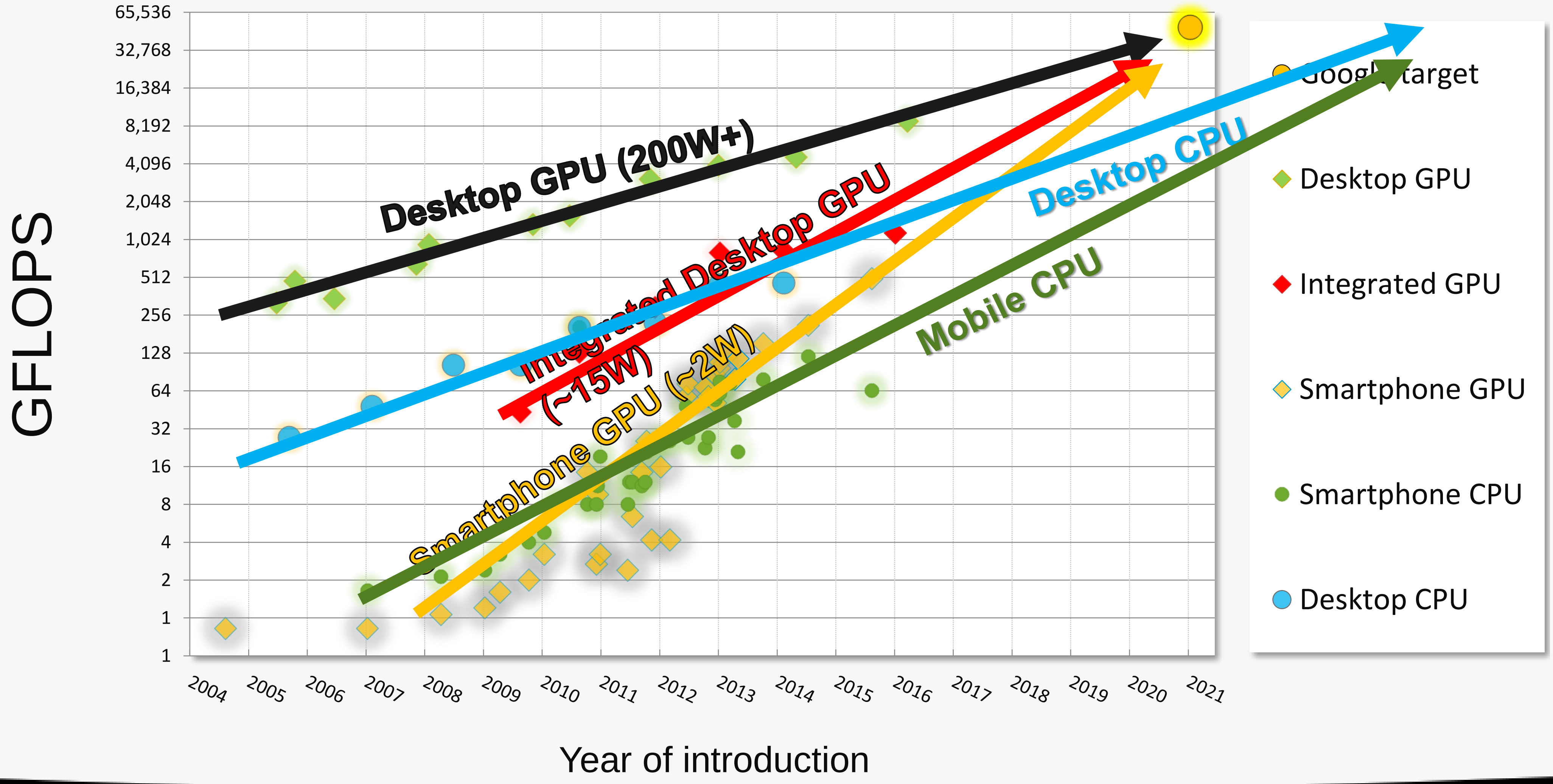
Andrew Richards

The next generation of software will not be built on CPUs

“On a 100 millimetre-squared chip, Google needs something like 50 teraflops of performance”

- Daniel Rosenband (Google’s self-driving car project) at HotChips 2016

Performance trends



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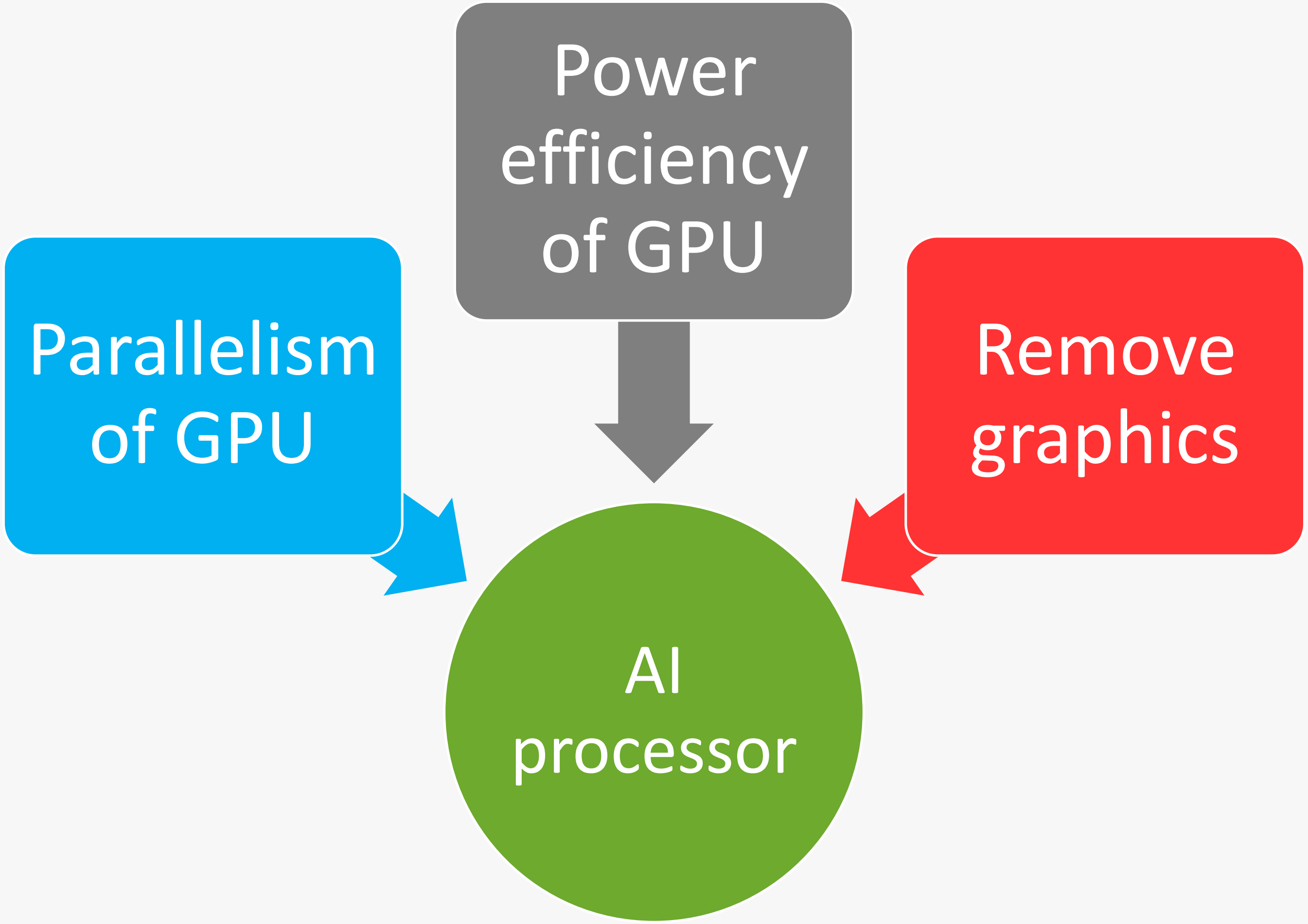
The rise of the AI processor



Power efficiency of GPU

Parallelism of GPU

Remove graphics

AI processor

KHRONOS™
GROUP

CONNECTING SOFTWARE TO SILICON

How do we connect tomorrow’s software to tomorrow’s silicon?

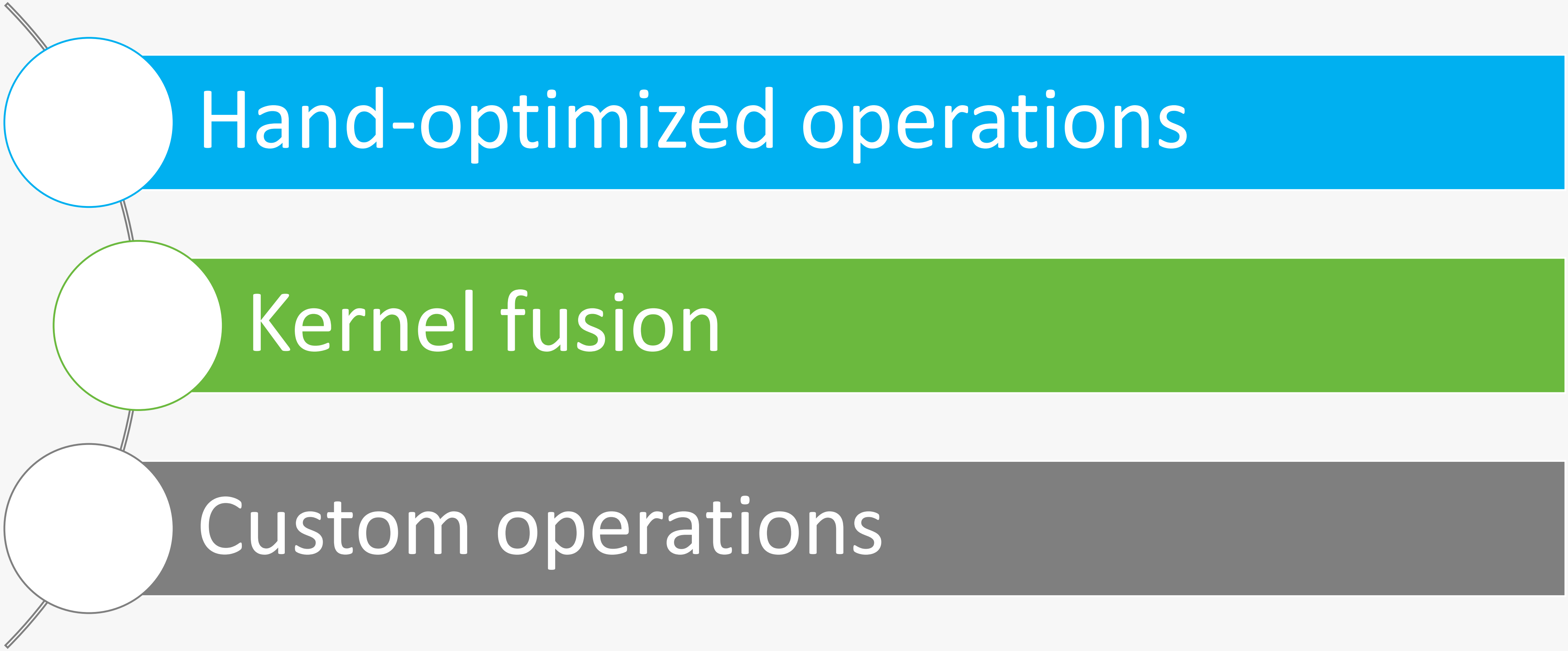
OpenCL: Our targets for 2017 and beyond

1. Make it fast

2. Make it safe

3. Make it ubiquitous

How do we get performance on accelerators?



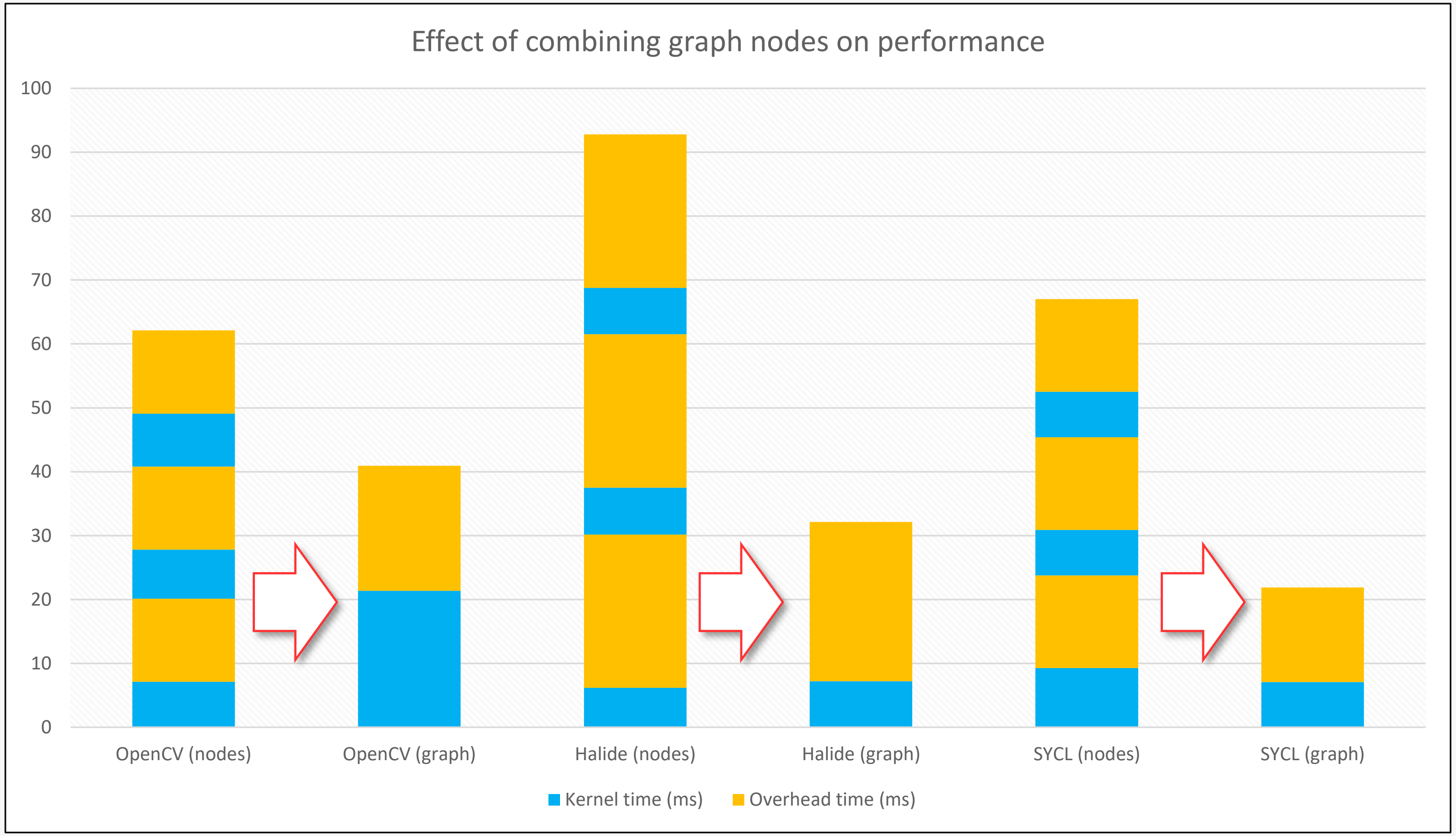
Hand-optimized operations

Kernel fusion

Custom operations

Kernel fusion: some numbers

In this example, we perform 3 image processing operations on an accelerator and compare 3 systems when executing individual nodes, or a whole graph



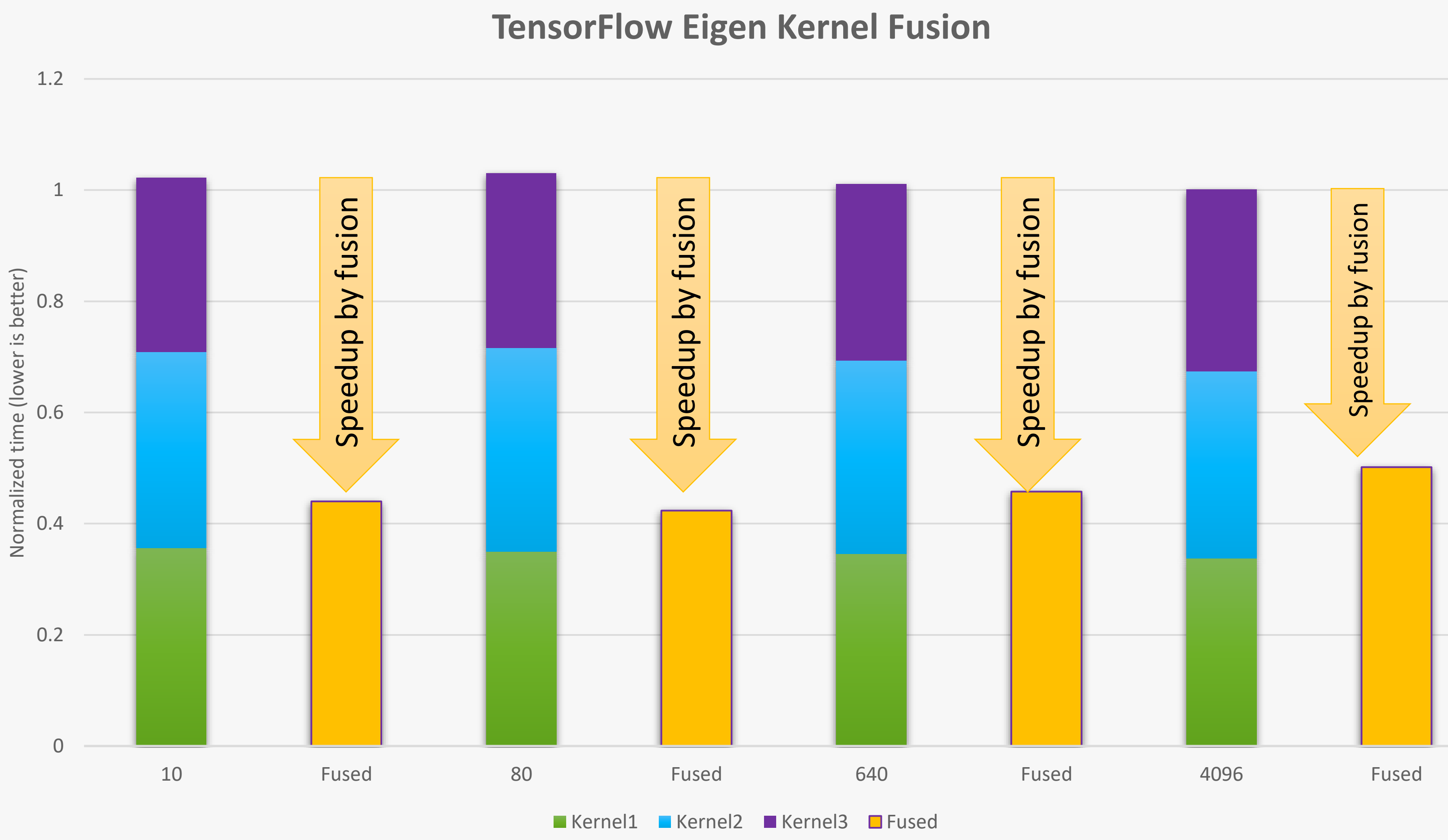
Halide and SYCL use kernel fusion, whereas OpenCV does not. For all 3 systems, the performance of the whole graph is significantly better than individual nodes executed on their own

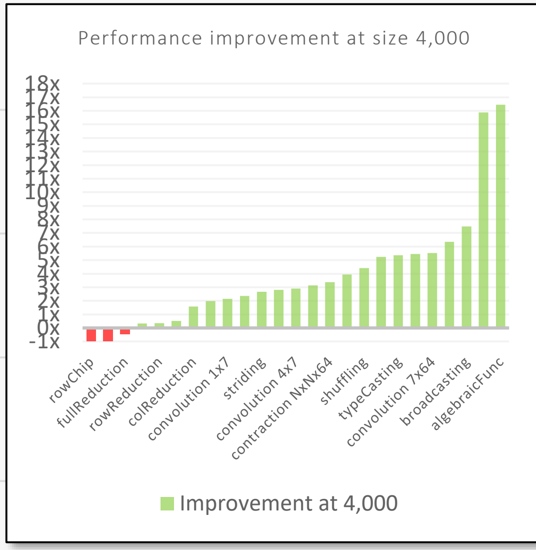
The system is an AMD APU and the operations are: RGB->HSV, channel masking, HSV->RGB

Applying fusion to TensorFlow Eigen

This is how TensorFlow uses Eigen to achieve kernel-fusion

CUDA does this for NVIDIA GPUs, SYCL is used here for AMD GPUs

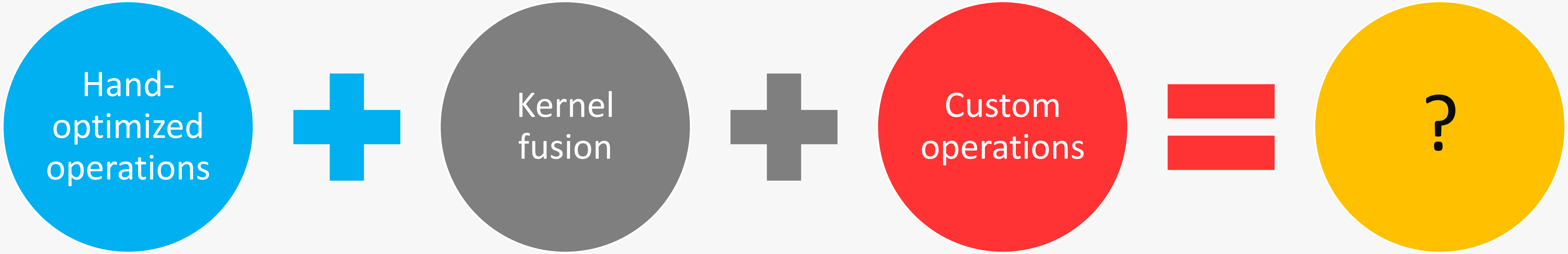




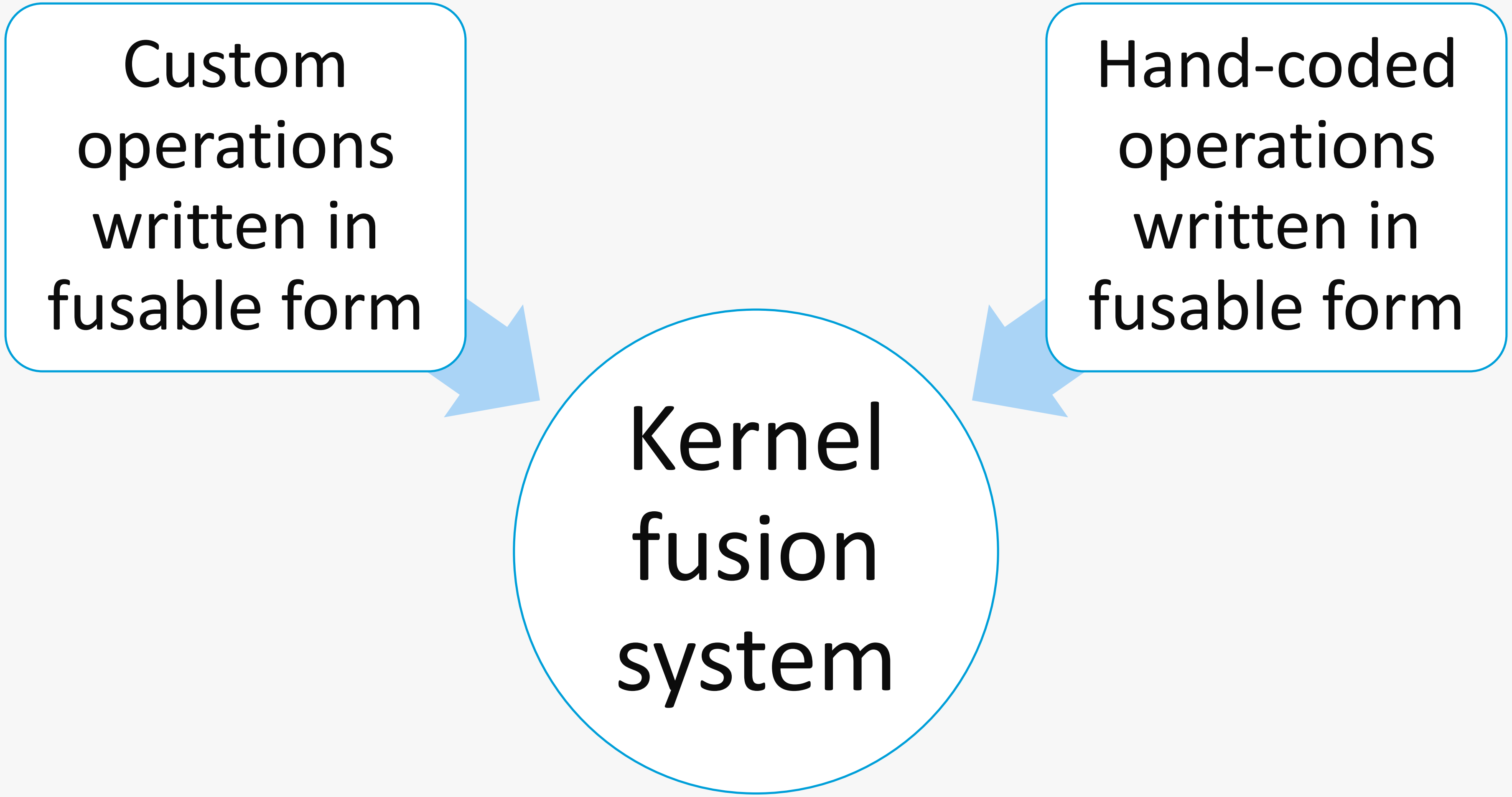
Unfused performance improvement: AMD GPU vs multi-core Intel CPU

Total performance improvement delivered by SYCL is both of these graphs *combined*

How do we combine our requirements?



How do we fuse custom and hand-coded kernels?



Custom operations written in fusable form

Hand-coded operations written in fusable form

Kernel fusion system

- We need a language and compiler that:

  1. Lets users easily write custom operations

  2. Lets hardware experts drill-down and write device-specific optimized code

  3. Allows code to be efficiently fused

- We need a language and compiler that:

1. Lets users easily write custom operations
   - ➢ C++ is a well-understood programming language that programmers can use

2. Lets hardware experts drill-down and write device-specific optimized code
   - ➢ C++ allows expert programmers to write low-level device-specific optimized code

3. Allows code to be efficiently fused
   - ➢ C++ single-source lets us fuse kernels
   - ➢ … and is already used

SYCL™

- We need a language and compiler that:

  1. Lets users easily write custom operations

  2. Lets hardware experts drill-down and write device-specific optimized code

  3. Allows code to be efficiently fused

     ➢ But, now we have SPIR/SPIR-V, you could write your own compiler to solve this

Make it safe

OpenCL SC

- Our challenges:
  - We need all the tools to follow standard safety-critical processes
  - We need predictable timing
  - We need to test the OpenCL implementations thoroughly
  - We need to test OpenCL code in extreme situations
  - We need to be able to handle highly parallel errors and recovery

OpenCL SC: We need to work together

- Each challenge is a massive challenge
- We need to come together to solve these challenges
  - Academics and industry
  - Parallelism, safety, automotive, medical, formal methods, testing…

Make it ubiquitous

Making OpenCL ubiquitous

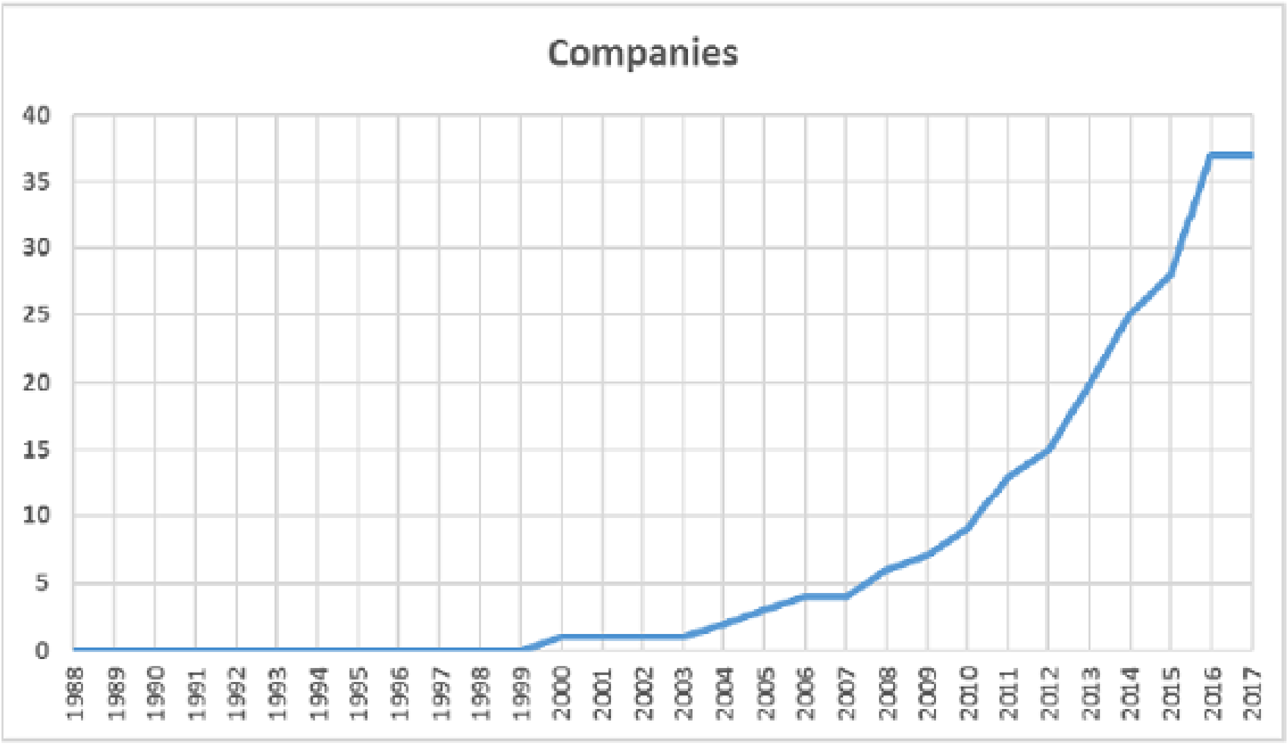


Figure 1: Population of companies making VPUs over time

Jon Peddie Research: Feb 2017 report on the VPU market

Why OpenCL for new AI/vision processors?

- It’s royalty-free
- It’s programmable
- It’s very widely supported already
- Providing OpenCL brings in a wide ecosystem of software:
  - OpenCV, Halide, SYCL, OpenVX, clBLAS/clBLAST, TensorFlow, Caffe, ViennaCL, Boost.compute, ….

But, what do we need to solve?

- We need to bring OpenCL to devices that are not GPUs
  - And so we need to focus on adding non-GPU features
  - And removing GPU features

- While also still supporting the capabilities of GPUs
  - and CPUs, FPGAs, DSPS…

- We need to build out the ecosystem
  - Make it easier to bring OpenCL to new devices
  - Make it easier to test OpenCL devices
  - Make it easier to find all the existing OpenCL software

SYCL	http://sycl.tech
OpenCL	https://www.khronos.org/opencl/
OpenVX	https://www.khronos.org/openvx/
OpenCV	http://opencv.org/
Halide	http://halide-lang.org/
VisionCpp	https://github.com/codeplaysoftware/visioncpp
OpenCL org	http://opencl.org/
CLsmith	http://multicore.doc.ic.ac.uk/tools/CLsmith/clsmith.php
TensorFlow OpenCL	http://ci.tensorflow.org/view/OpenCL/

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What do you want to accelerate?

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