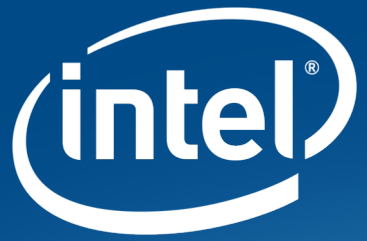

ACCELERATE DEEP LEARNING INFERENCE USING INTEL TECHNOLOGIES

INTRODUCTION: SMART VIDEO

September 2018

Core and Visual Computing Group

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EMERGENCY RESPONSE


FINANCIAL SERVICES


MACHINE VISION


CITIES/TRANSPORTATION

VIDEO: THE "EYE OF IOT"

USE OF VIDEO, COMPUTER VISION AND DEEP LEARNING IS GROWING RAPIDLY


AUTONOMOUS VEHICLES


RESPONSIVE RETAIL

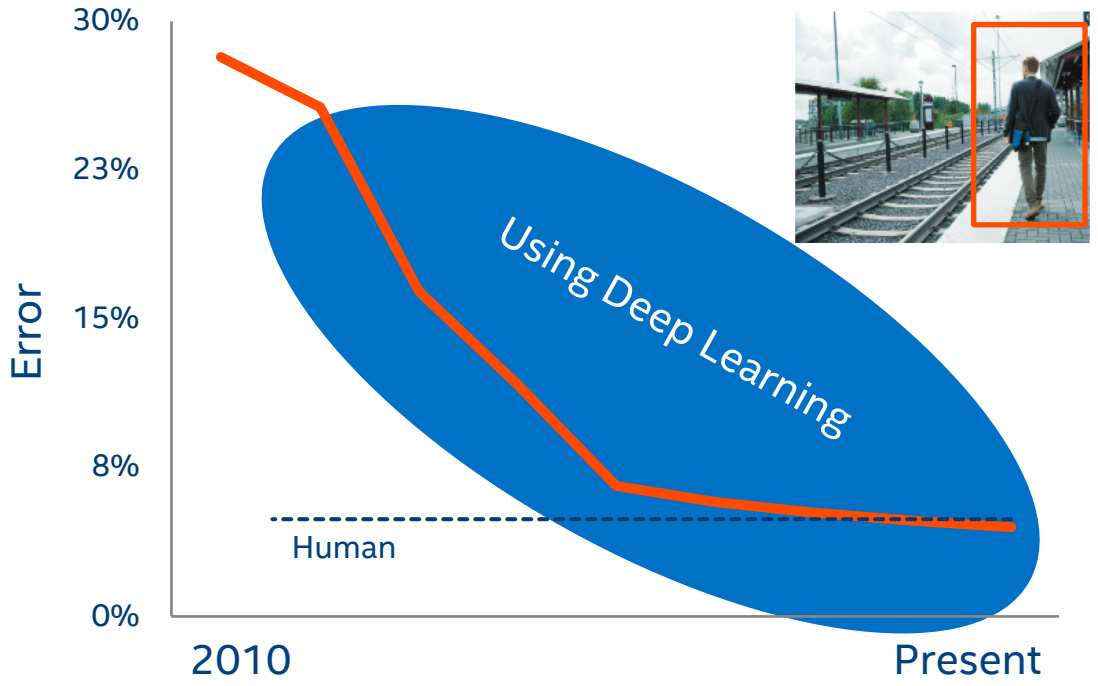

MANUFACTURING


PUBLIC SECTOR

Deep Learning Usage Is Increasing

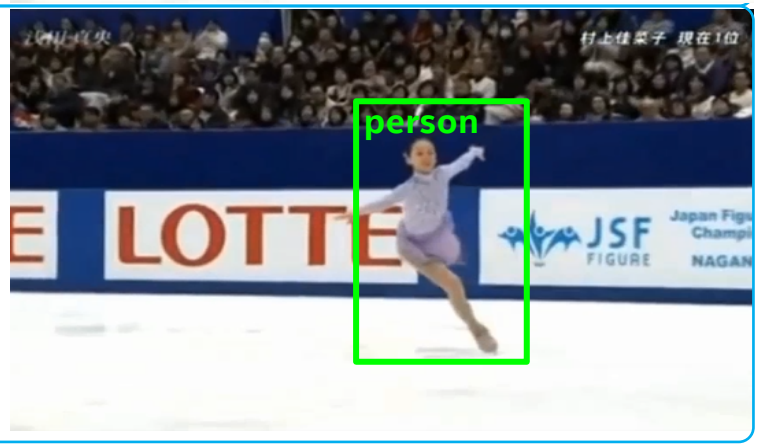
Deep learning revenue is estimated to grow from $655M in 2016 to $35B by 2025[1].

Image Recognition



Traditional Computer Vision
Object Detection

Deep Learning Computer Vision
Person Recognition

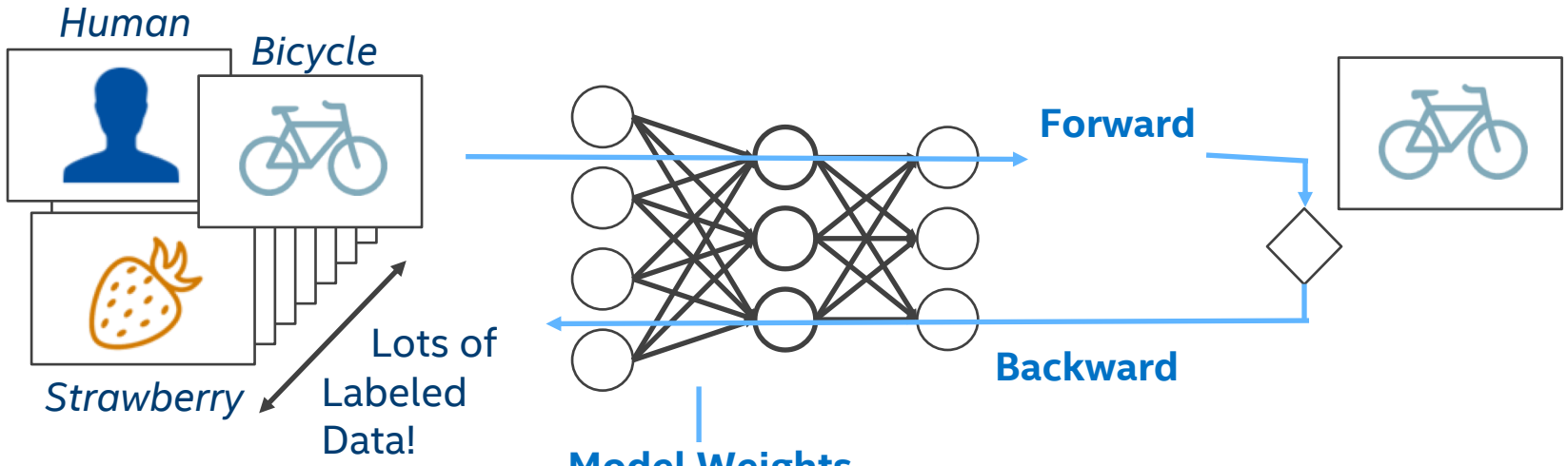


Market Opportunities + Advanced Technologies Have Accelerated Deep Learning Adoption

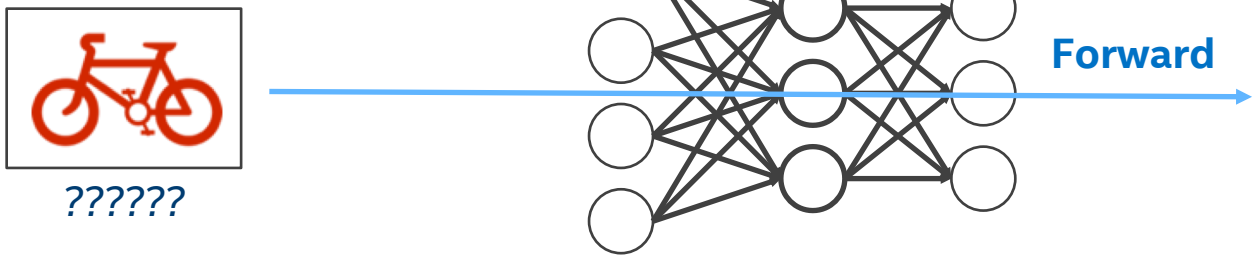
[1]Tractica* 2Q 2017

Deep Learning: Training vs. Inference

Training

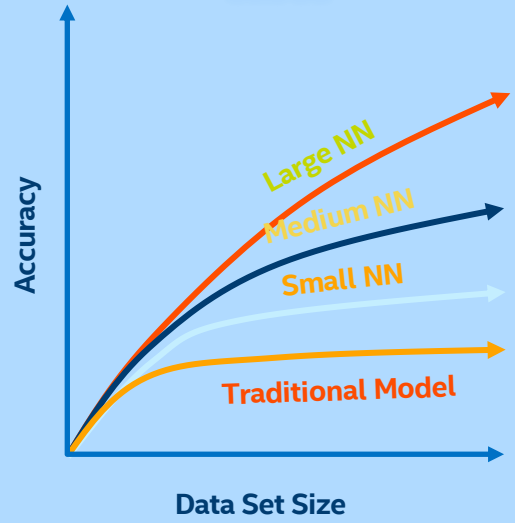


Inference



Did You Know?

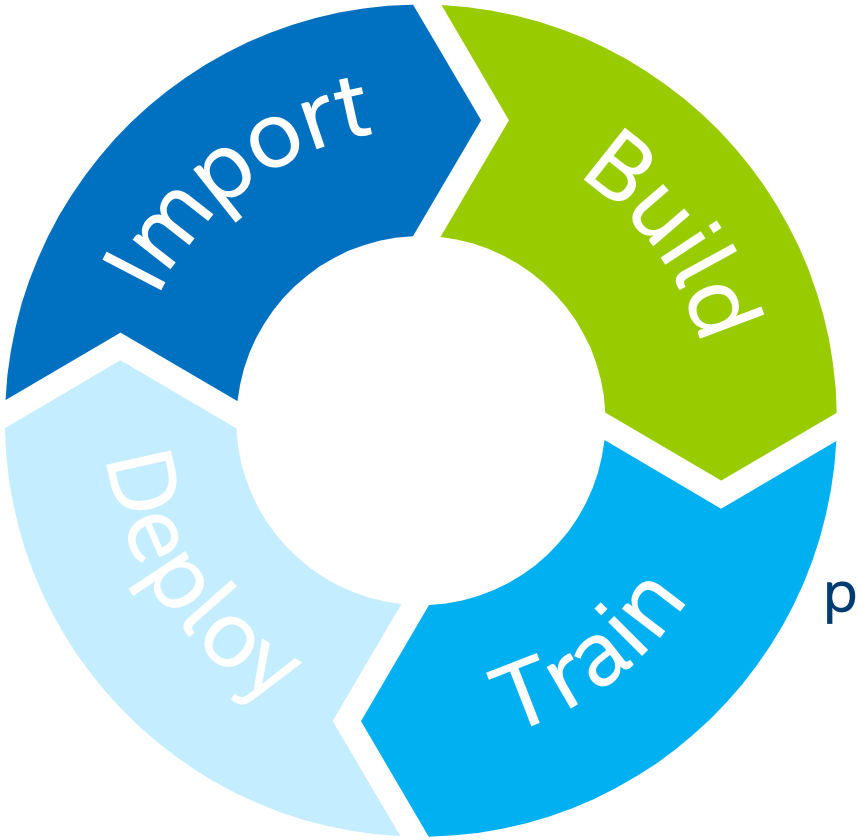
Training requires a very large data set and deep neural network (many layers) to achieve the highest accuracy in most cases



Artificial Intelligence Development Cycle

Data aquisition and organization

Create models



Integrate trained models with application code

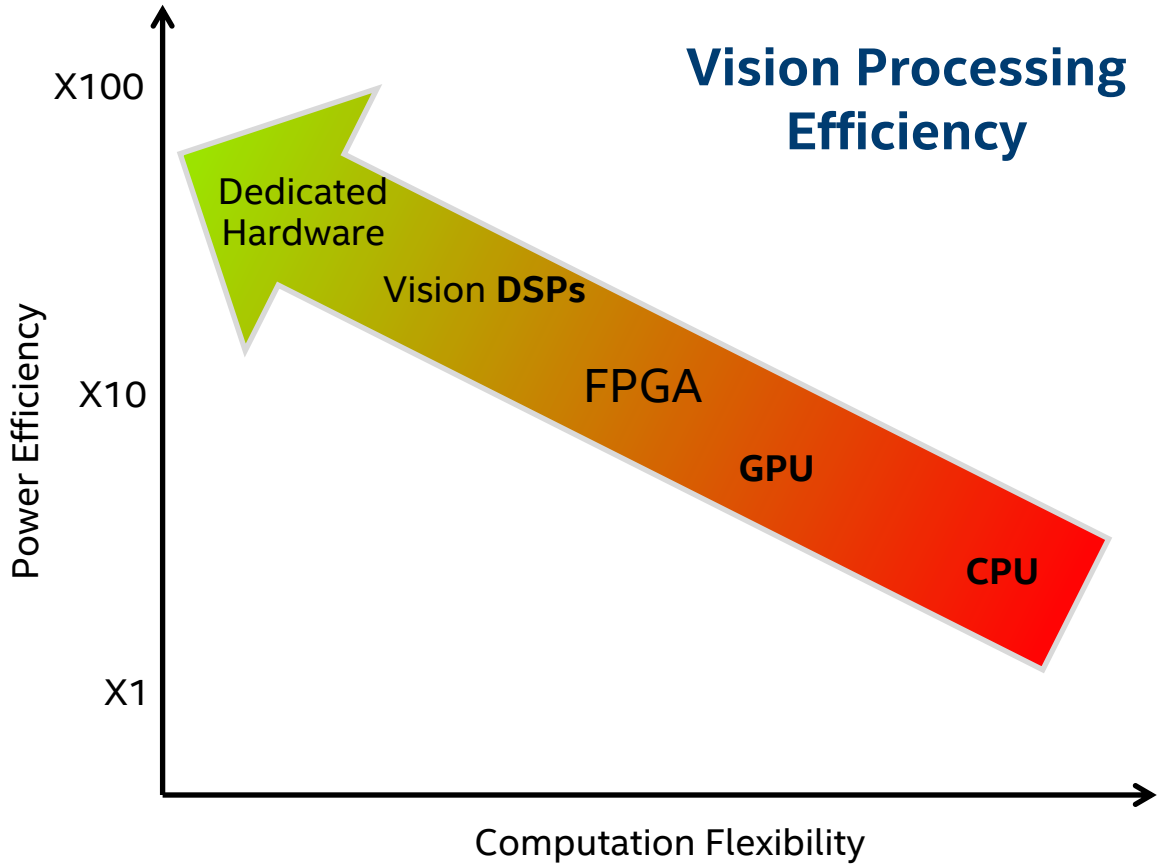
Adjust models to meet performance and accuracy objectives

Intel® Deep Learning Deployment Toolkit Provides Deployment from Intel® Edge to Cloud

Choosing the “Right” Hardware

Power/Performance Efficiency Varies

- Running the right workload on the right piece of hardware → higher efficiency
- Hardware acceleration is a must
- Heterogeneous computing?

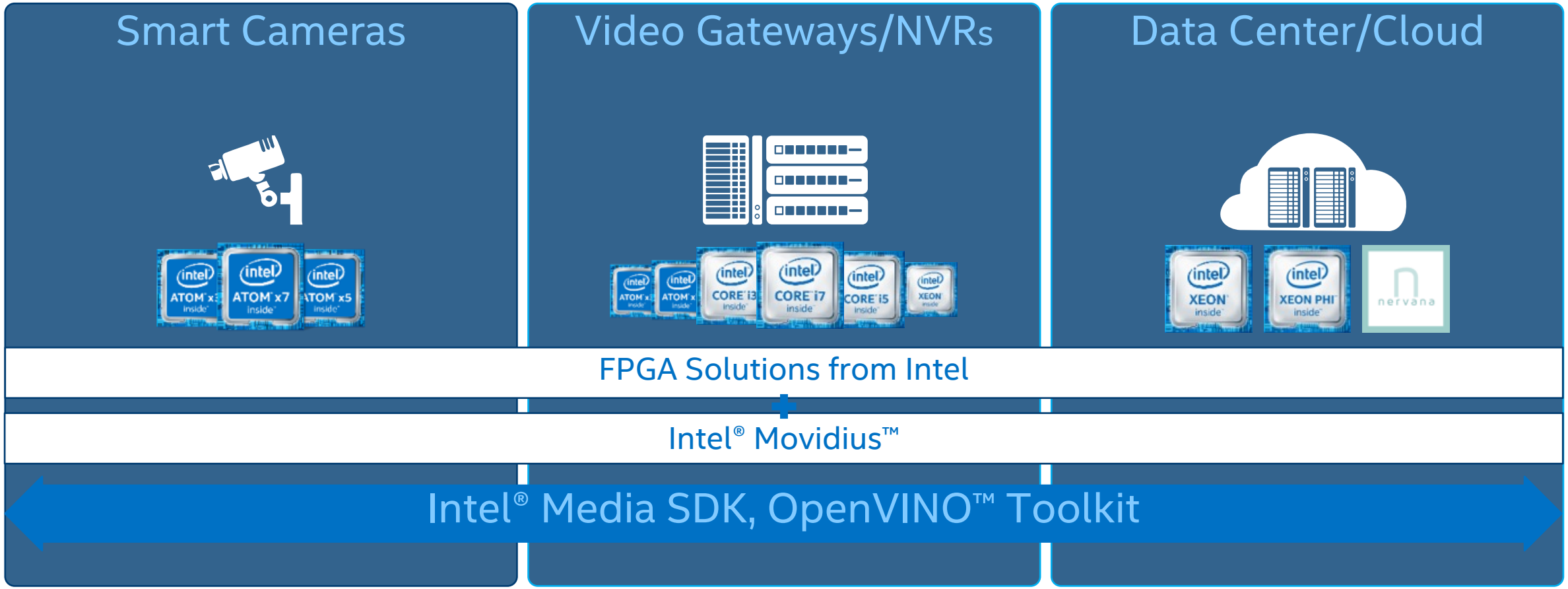


Tradeoffs

- Power/performance
- Price
- Software flexibility, portability

Intel Internet of Things (IoT) Video Portfolio

Intel Invests in AI, Computer Vision, and Deep Learning for IoT



Industry's Broadest Media and Computer Vision and Deep Learning Portfolio

Open Visual Inference & Neural network Optimization (OpenVINO™) toolkit & Components

Intel® Deep Learning Deployment Toolkit

Model Optimizer
Convert & Optimize

IR

Inference Engine
Optimized Inference

20+ Pre-trained Models

Computer Vision Algorithms

Samples

IR = Intermediate Representation file

Traditional Computer Vision Tools & Libraries

Optimized Libraries

OpenCV*

OpenVX*

Photography Vision

Code Samples

For Intel® CPU & CPU with integrated graphics

Increase Media/Video/Graphics Performance

Intel® Media SDK
Open Source version

OpenCL™ Drivers & Runtimes

For CPU with integrated graphics

Optimize Intel® FPGA

FPGA RunTime Environment
(from Intel® FPGA SDK for OpenCL™)

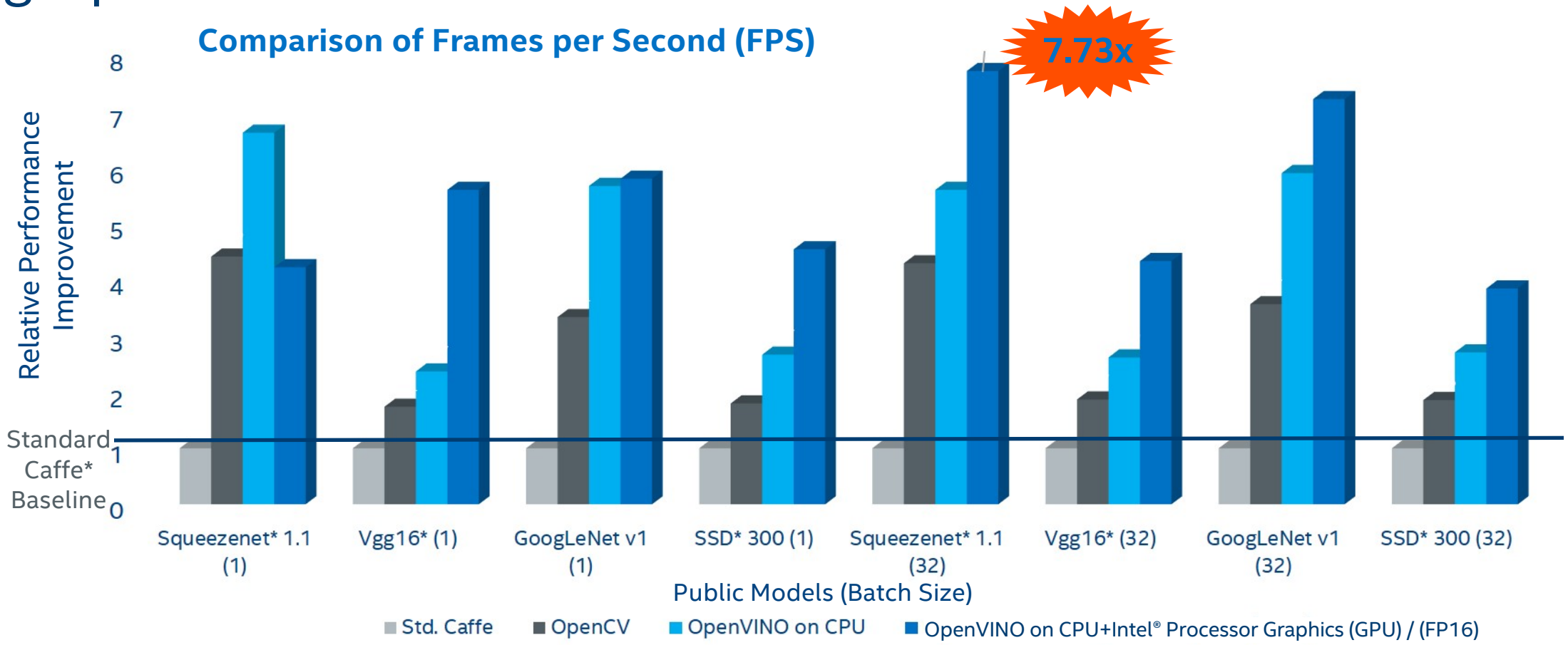
Bitstreams

FPGA – Linux* only

OS Support CentOS* 7.4 (64 bit) Ubuntu* 16.04.3 LTS (64 bit) Microsoft Windows* 10 (64 bit) Yocto Project* version Poky Jethro v2.0.3 (64 bit)

Intel® Architecture-Based Platforms Support

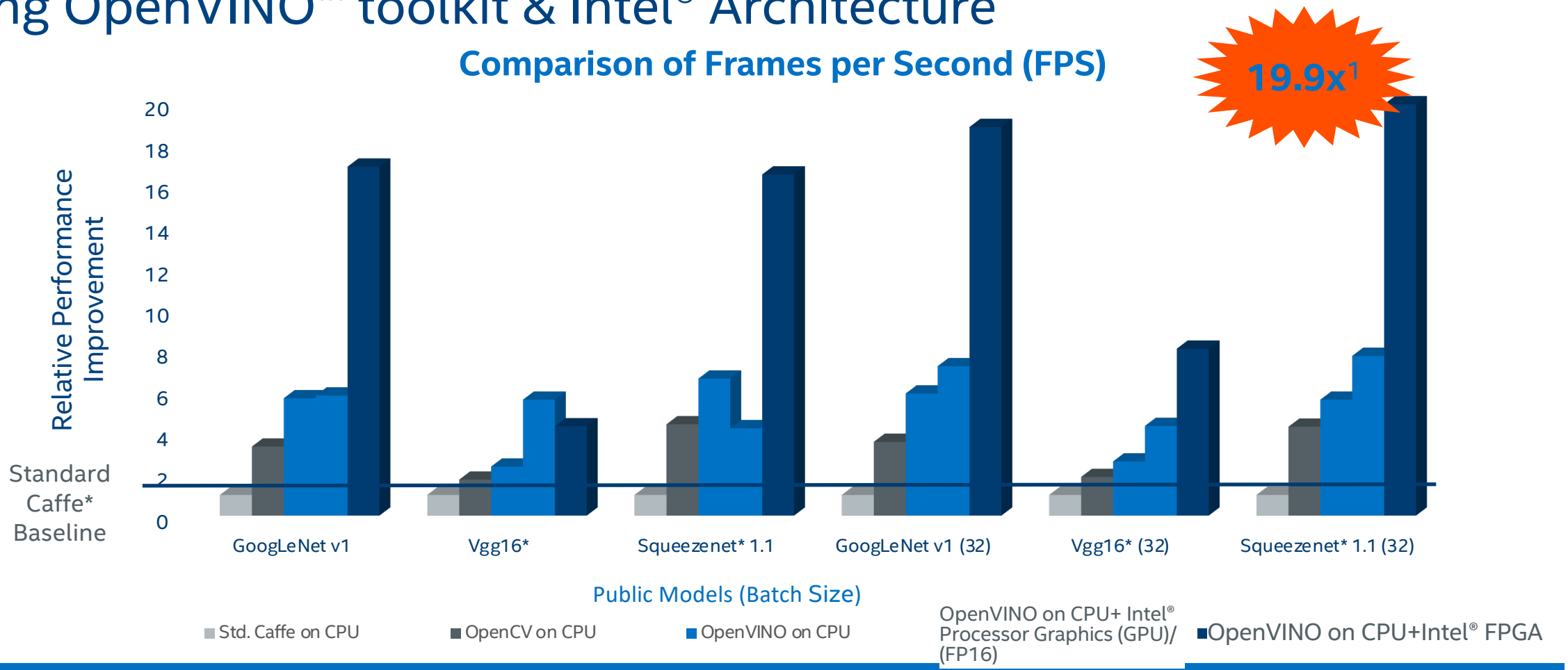
Increase Deep Learning Workload Performance on Public Models using OpenVINO™ toolkit & Intel® Architecture



Fast Results on Intel Hardware, even before using Accelerators

[1]Depending on workload, quality/resolution for FP16 may be marginally impacted. A performance/quality tradeoff from FP32 to FP16 can affect accuracy; customers are encouraged to experiment to find what works best for their situation. The benchmark results reported in this deck may need to be revised as additional testing is conducted. Performance results are based on testing as of April 10, 2018 and may not reflect all publicly available security updates. See configuration disclosure for details. No product can be absolutely secure. For more complete information about performance and benchmark results, visit www.intel.com/benchmarks.
Configuration: Testing by Intel as of April 10, 2018. Intel® Core™ i7-6700K CPU @ 2.90GHz fixed, GPU GT2 @ 1.00GHz fixed Internal ONLY testing, Test v312.30 – Ubuntu* 16.04, OpenVINO™ 2018 RC4. Tests were based on various parameters such as model used (these are public), batch size, and other factors. Different models can be accelerated with different Intel hardware solutions, yet use the same Intel software tools.

Increase Deep Learning Workload Performance on Public Models using OpenVINO™ toolkit & Intel® Architecture

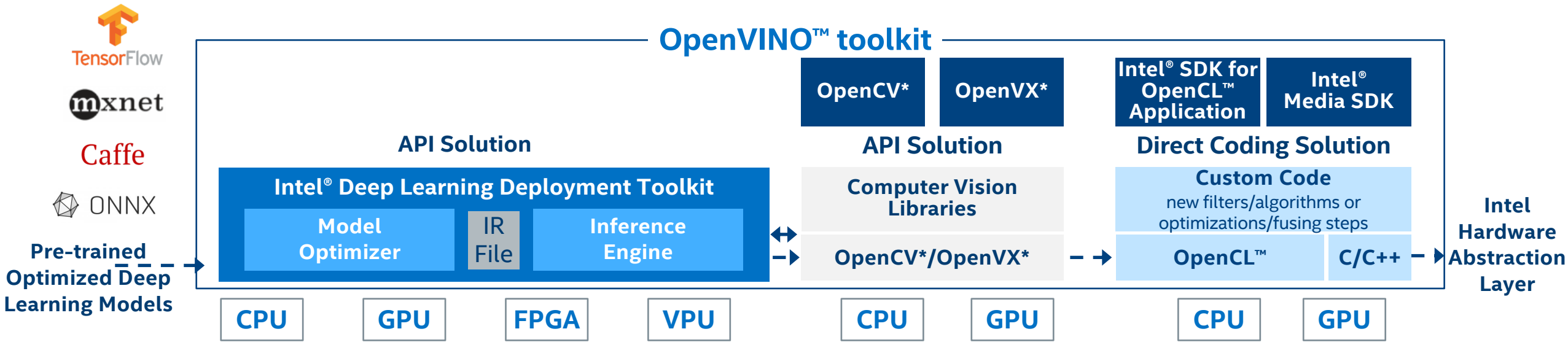


Get an even Bigger Performance Boost with Intel® FPGA

[1]Depending on workload, quality/resolution for FP16 may be marginally impacted. A performance/quality tradeoff from FP32 to FP16 can affect accuracy; customers are encouraged to experiment to find what works best for their situation. Performance results are based on testing as of June 13, 2018 and may not reflect all publicly available security updates. See configuration disclosure for details. No product can be absolutely secure. For more complete information about performance and benchmark results, visit www.intel.com/benchmarks. **Configuration:** Testing by Intel as of June 13, 2018. Intel® Core™ i7-6700K CPU @ 2.90GHz fixed, GPU GT2 @ 1.00GHz fixed Internal ONLY testing, Test v3.15.21 – Ubuntu* 16.04, OpenVINO 2018 RC4, Intel® Arria® 10 FPGA 1150GX. Tests were based on various parameters such as model used (these are public), batch size, and other factors. Different models can be accelerated with different Intel hardware solutions, yet use the same Intel software tools.

Deep Learning vs. Traditional Computer Vision

OpenVINO™ toolkit has Tools for an End-to-End Vision Pipeline



Deep Learning Computer Vision

- Based on application of a large number of filters to an image to extract features.
- Features in the object(s) are analyzed with the goal of associating each input image with an output node for each type of object.
- Values are assigned to output node representing the probability that the image is the object associated with the output node.

Traditional Computer Vision

- Based on selection and connections of computational filters to abstract key features and correlating them to an object.
- Works well with well defined objects and controlled scene.
- Difficult to predict critical features in larger number of objects or varying scenes.

IR = Intermediate Representation File
GPU = Intel CPU with integrated graphics processing unit/Intel® Processor Graphics
VPU = Intel® Movidius™ Vision Processing Unit

Application development with OpenVINO™ Toolkit

Train

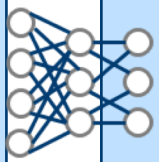
Train a DL model.
Currently supports:

- Caffe*
- Mxnet*
- TensorFlow*
- ONNX*

TensorFlow

Caffe

mxnet



.prototxt
.caffemodel

Prepare Optimize

Model optimizer:

- Converting
- Optimizing
- Preparing to inference

(device agnostic, generic optimization)

Run Model Optimizer

IR

.xml
.bin

Inference

Inference engine lightweight API to use in applications for inference.

User Application

Inference Engine

Optimize/ Heterogeneous

Inference engine supports multiple devices for heterogeneous flows.

(device-level optimization)

MKL-DNN → CPU: Intel® Xeon®/Intel® Core™/Intel Atom®

cl-DNN → GPU

DLA → FPGA

Intel® Movidius™ API → Movidius Myriad™ 2/X

Extend

Inference engine supports extensibility and allows custom kernels for various devices.

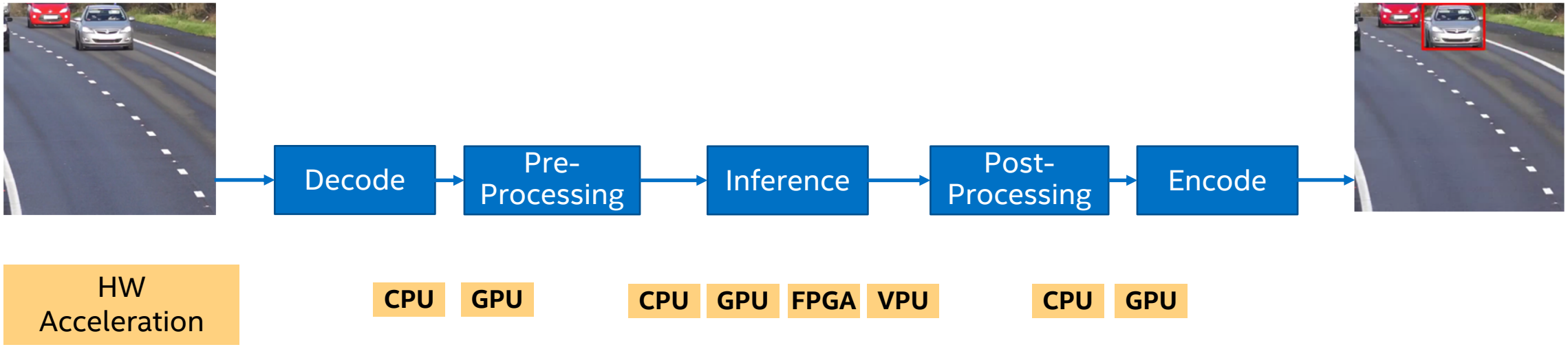
Extensibility C++

Extensibility OpenCL™

Extensibility OpenCL™/TBD

Extensibility TBD

Full Pipeline Optimization



Intel® Media SDK

API to Access Intel® Quick Sync Video: Hardware Accelerated Encoding, Decoding, and Processing

- H.265 (HEVC)
- H.264 (AVC)
- MPEG-2 and more
- Resize, scale, deinterlace
- Color conversion, composition
- Denoise, sharpen, and more

Benefits

- Outstanding performance
- Rich API to tune encoding pipeline
- Future proofed: support new processor without code changes

Targeting Digital Security and Surveillance, Connected Car Applications, and More

Smart Camera

Car Infotainment and Cluster Display

using

Intel Atom®, Pentium®, and Celeron® [1]

and

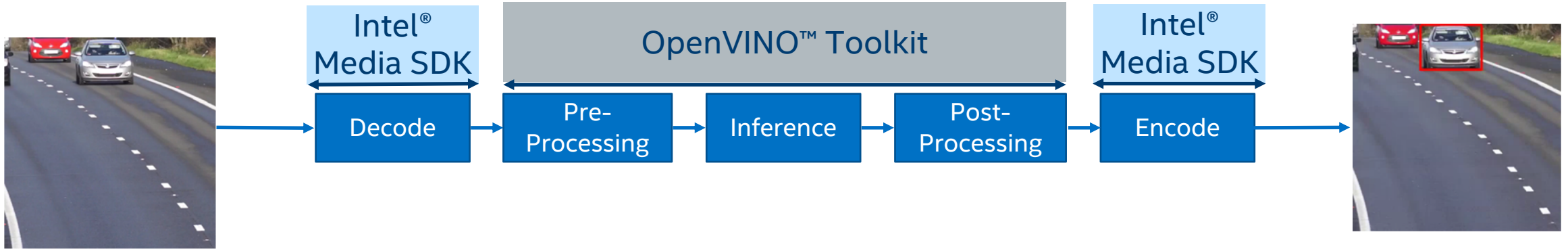
Embedded Linux*

yocto PROJECT

[1] Intel® Celeron® Processor N3350, Intel® Pentium® Processor N4200, Intel Atom® E3930, E3940, E3950 processors

Accelerate Streaming Performance, Integrate Video Analytics Computer Vision Needs Intel® Media SDK

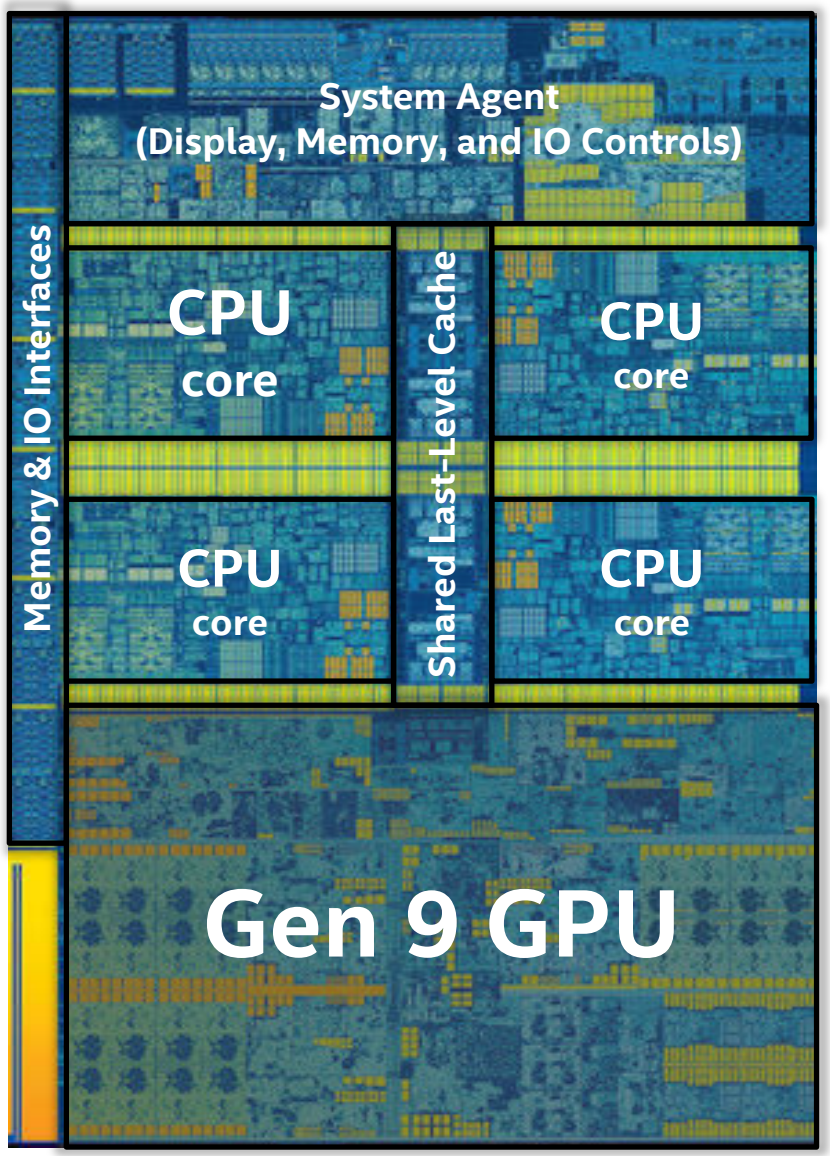
Using Intel® Media SDK and the OpenVINO™ toolkit together enables customers to build high performance, intelligent vision solutions.



Intel Integrated Graphics

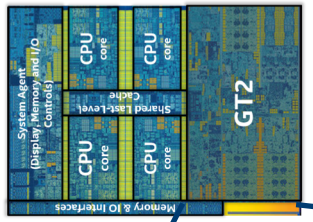
Gen is the internal name for Intel's on-die GPU solution. It's a hardware ingredient with various configurations.

- Intel® Core™ Processors include Gen hardware.
- Gen GPUs can be used for graphics and also as general compute resources.
- Libraries contained in the OpenVINO™ toolkit (and many others) support Gen offload using OpenCL™.



6th Generation Intel® Core™ i7 (Skylake) Processor

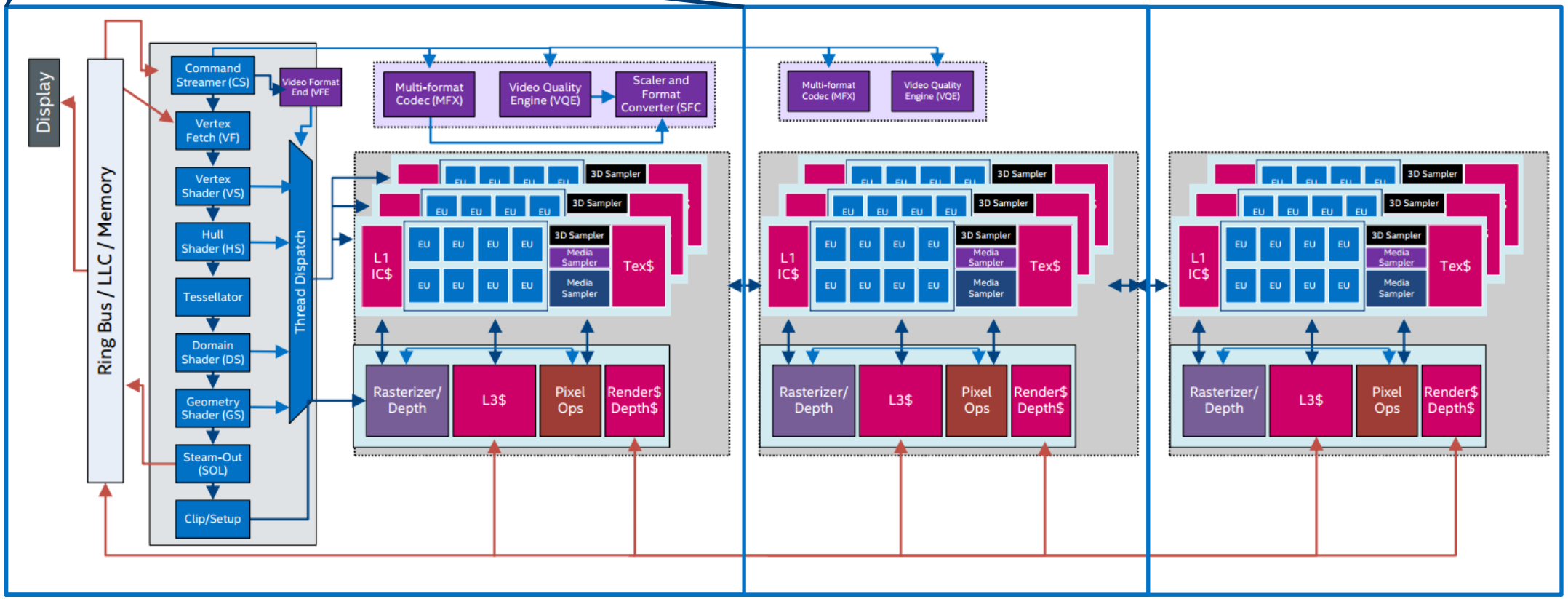
Intel GPU Configurations



GT2
Intel® HD Graphics
24 EUs, 1 MFX

GT3
Intel® Iris® Graphics
48 EUs, 2 MFX

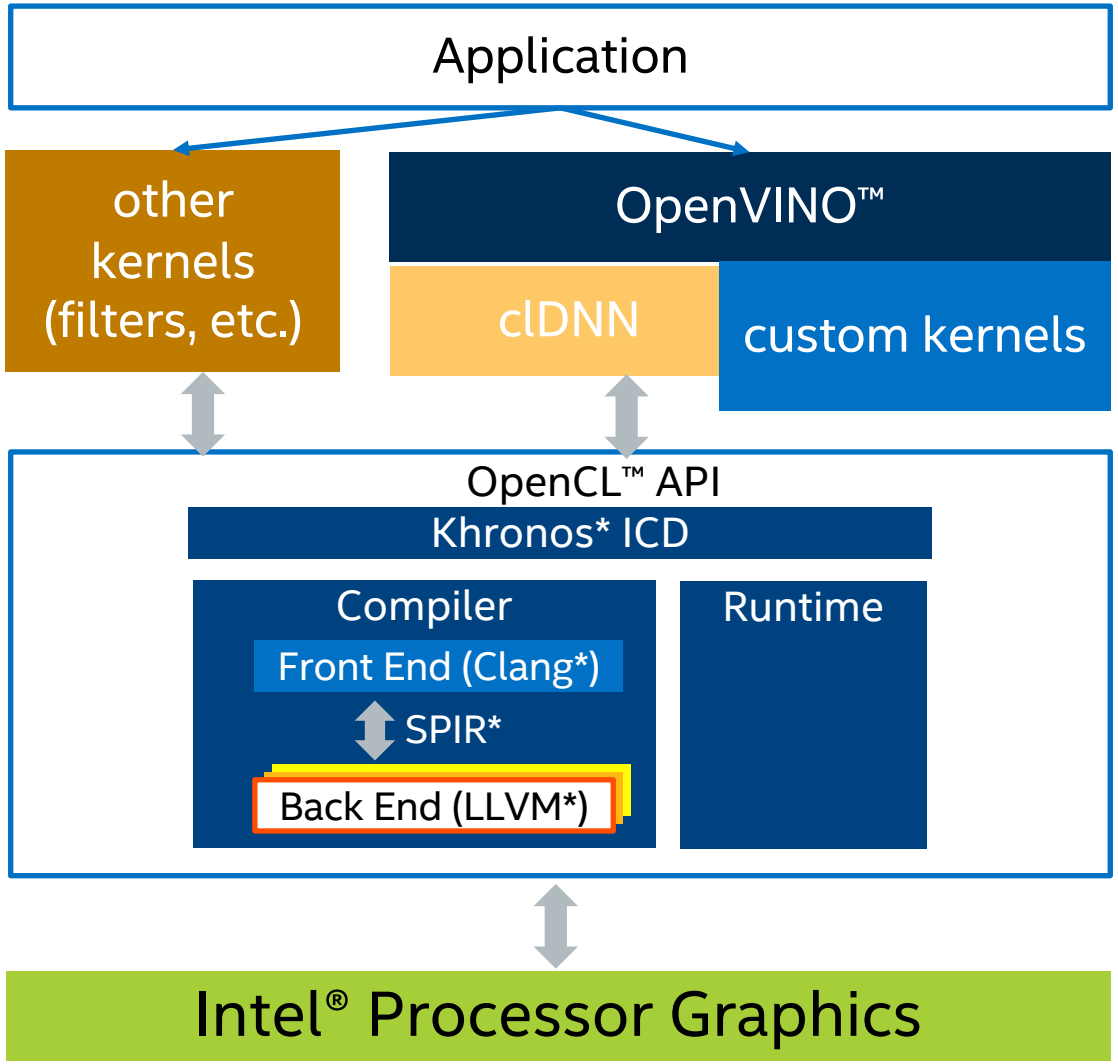
GT4
Intel® Iris® Pro Graphics
72 EUs, 2 MFX



OpenCL™

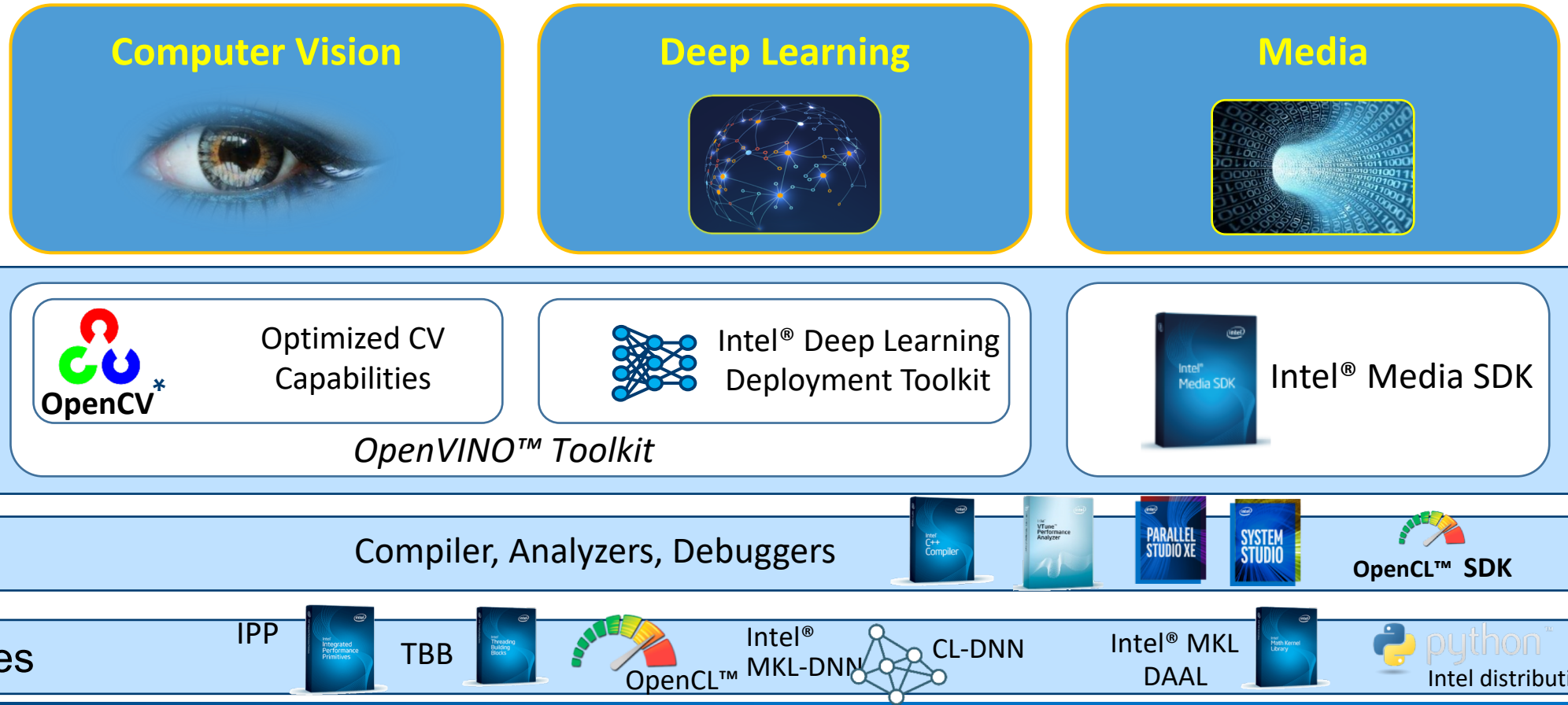
OpenCL™:

- Required to run with a GPU target (clDNN) using Intel® Processor Graphics
- Custom kernels
- Other kernels can be used for other non-inference pipeline stages, such as color conversions



Putting It All Together

- A major challenge is to get all these tool and libraries to work together in the best possible way to minimize development time and optimize system power/performance.
- A good way to abstract that workload is using an end-to-end pipeline



Smart Video Workshop Overview

Introduction

1. Introduction to Intel technologies for deep learning inference
2. Hardware acceleration techniques

Each module contains a hands-on lab exercise that introduces various Intel technologies to accelerate computer vision application with hardware heterogeneity.

OpenVINO™ 101

2. Basic End-to-End Object Detection Example

Hardware Acceleration

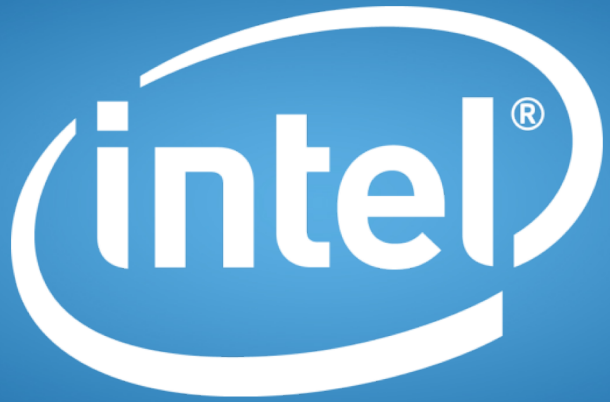
3./4./5. Hardware Acceleration with CPU, Integrated GPU, Intel® Movidius™ NCS, FPGA

Optimization

6. Optimization Tools and Techniques

Application

7. Advanced Video Analytics


intel