

ACCELERATE DEEP LEARNING INFERENCE USING INTEL TECHNOLOGIES

INTRODUCTION: SMART VIDEO

November 2018

Core and Visual Computing Group

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No computer system can be absolutely secure.

Tests document performance of components on a particular test, in specific systems. Differences in hardware, software, or configuration will affect actual performance. Consult other sources of information to evaluate performance as you consider your purchase. For more complete information about performance and benchmark results, visit www.intel.com/performance.

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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

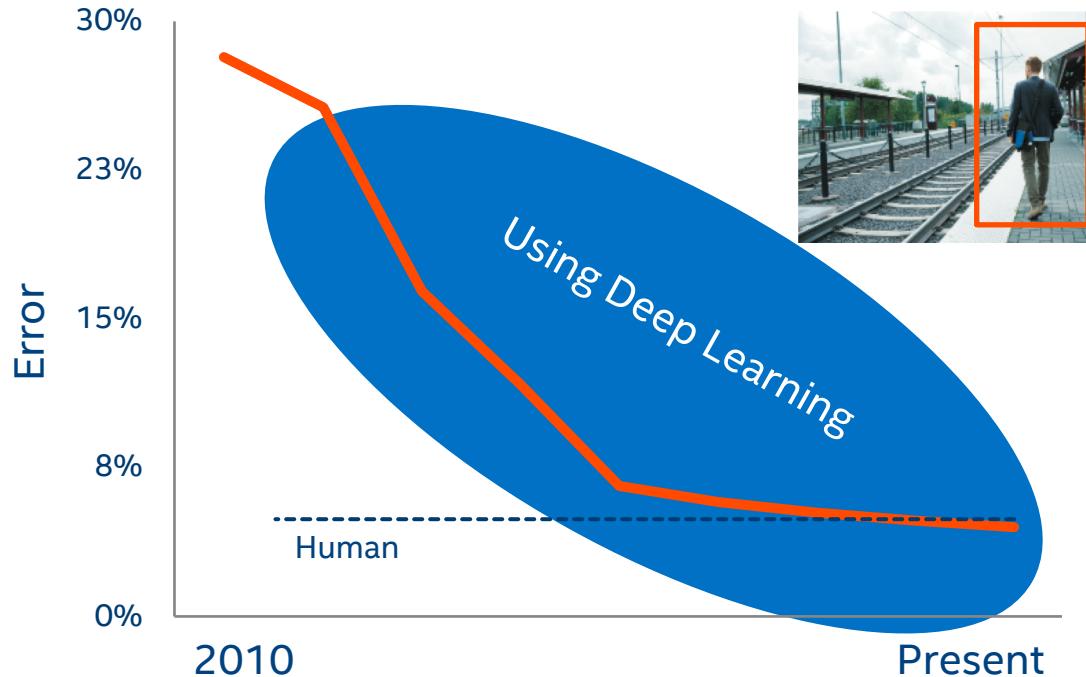


PUBLIC SECTOR

Deep Learning Usage Is Increasing

Deep learning revenue is estimated to grow from \$655M in 2016 to **\$35B** by 2025¹.

Image Recognition



Traditional Computer Vision Object Detection



Deep Learning Computer Vision Person Recognition

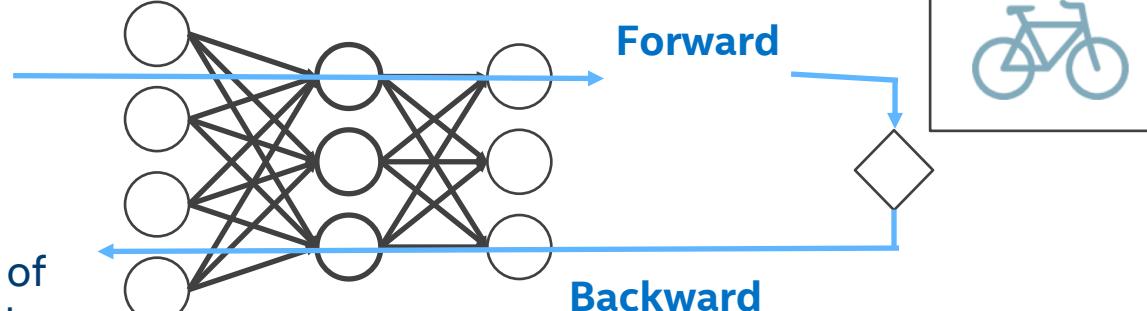
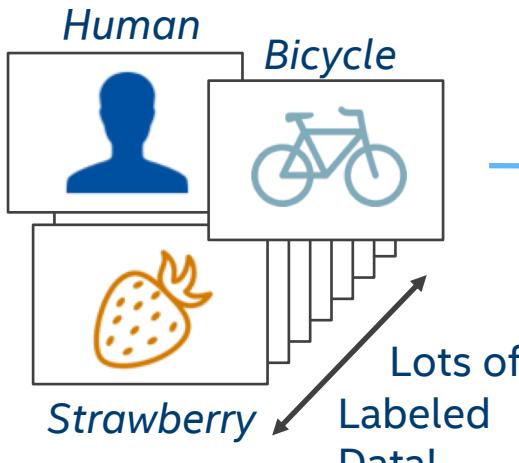


Market Opportunities + Advanced Technologies Have Accelerated Deep Learning Adoption

¹Tractica* 2Q 2017

Deep Learning: Training vs. Inference

Training

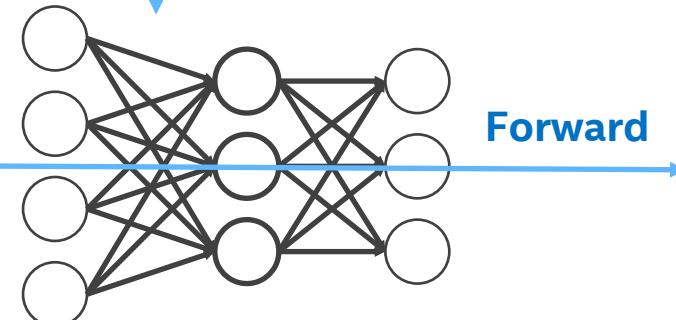


Model Weights

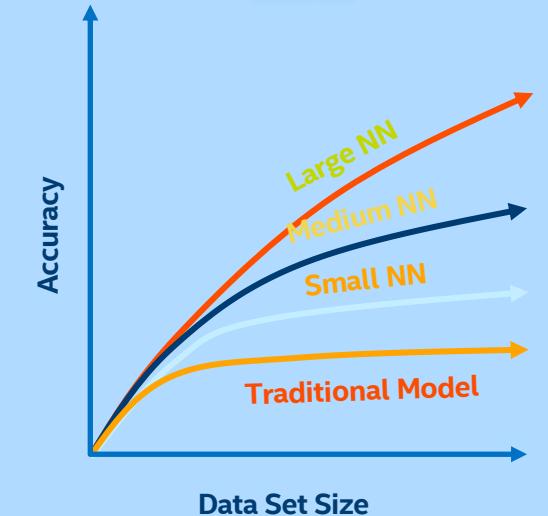
Inference



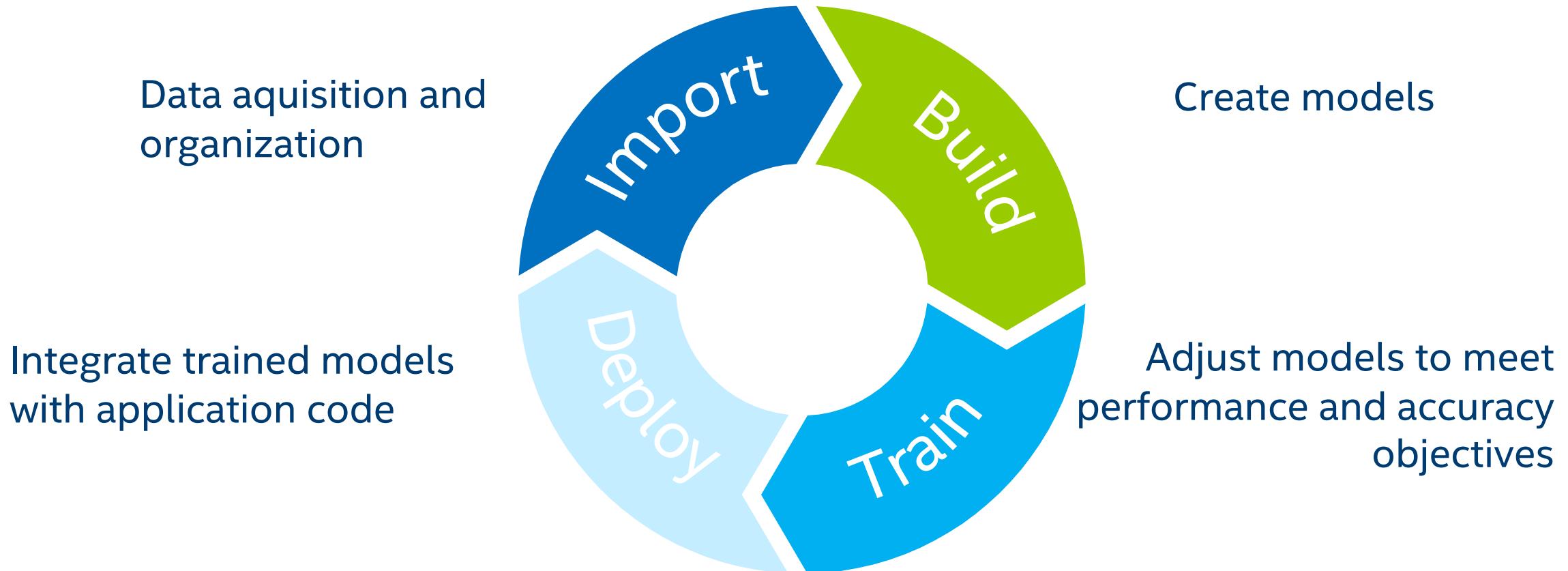
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Training requires a very large data set and deep neural network (many layers) to achieve the highest accuracy in most cases



Artificial Intelligence Development Cycle

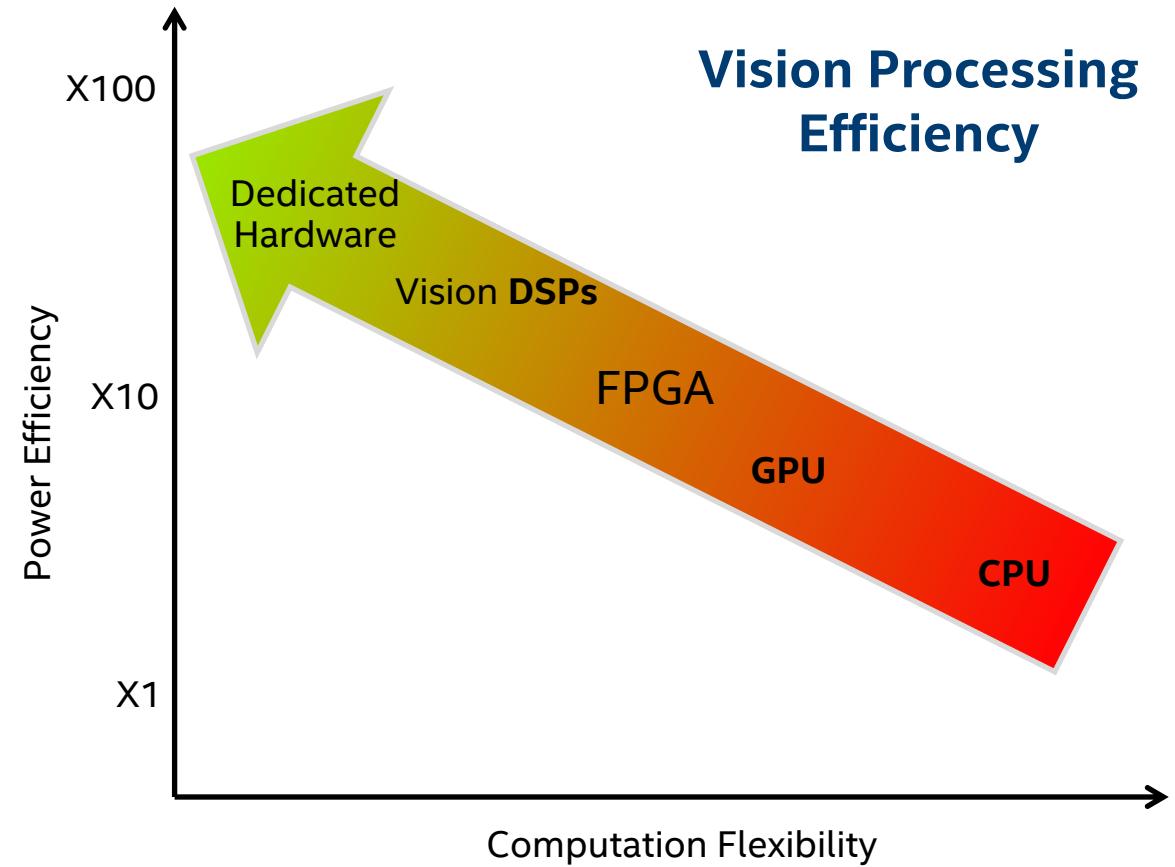


Intel® Deep Learning Deployment Toolkit Provides Deployment from Intel® Edge to Cloud

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 Computer Vision Portfolio

EXPERIENCES



TOOLS

Intel® Parallel Studio XE
Intel® System Studio
Intel® SDK for OpenCL™ Applications

Intel® Media SDK / Media Server Studio
Intel® Distribution of OpenVINO™ toolkit

FRAMEWORKS



theano



Caffe



ONNX

LIBRARIES

Intel® Data
Analytics
Acceleration
Library

Intel®
Distribution for python

Intel® Math Kernel Library

Intel® Nervana™ Graph

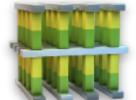


Movidius Stack

HARDWARE



Compute



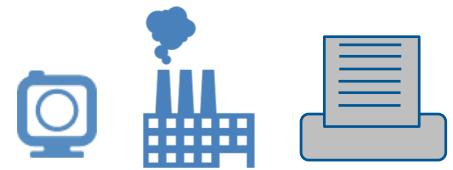
Memory & Storage



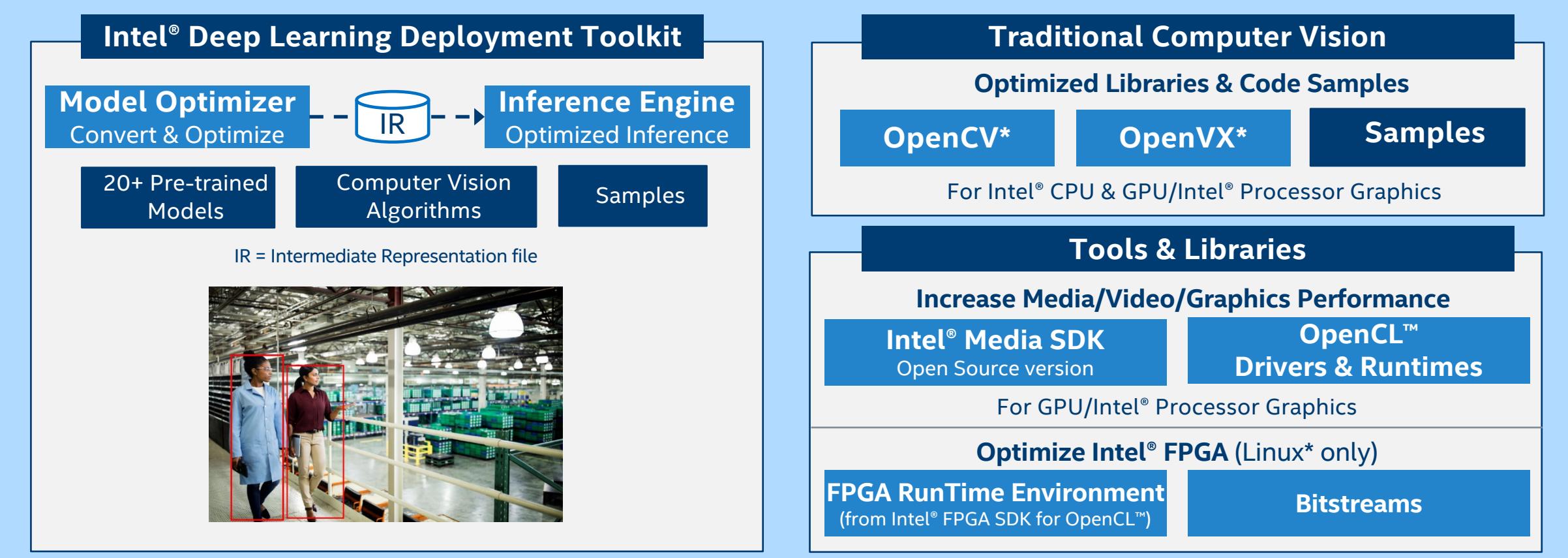
Networking



Visual Intelligence



Intel® Distribution of Open Visual Inference & Neural network Optimization (OpenVINO™) toolkit & Components



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



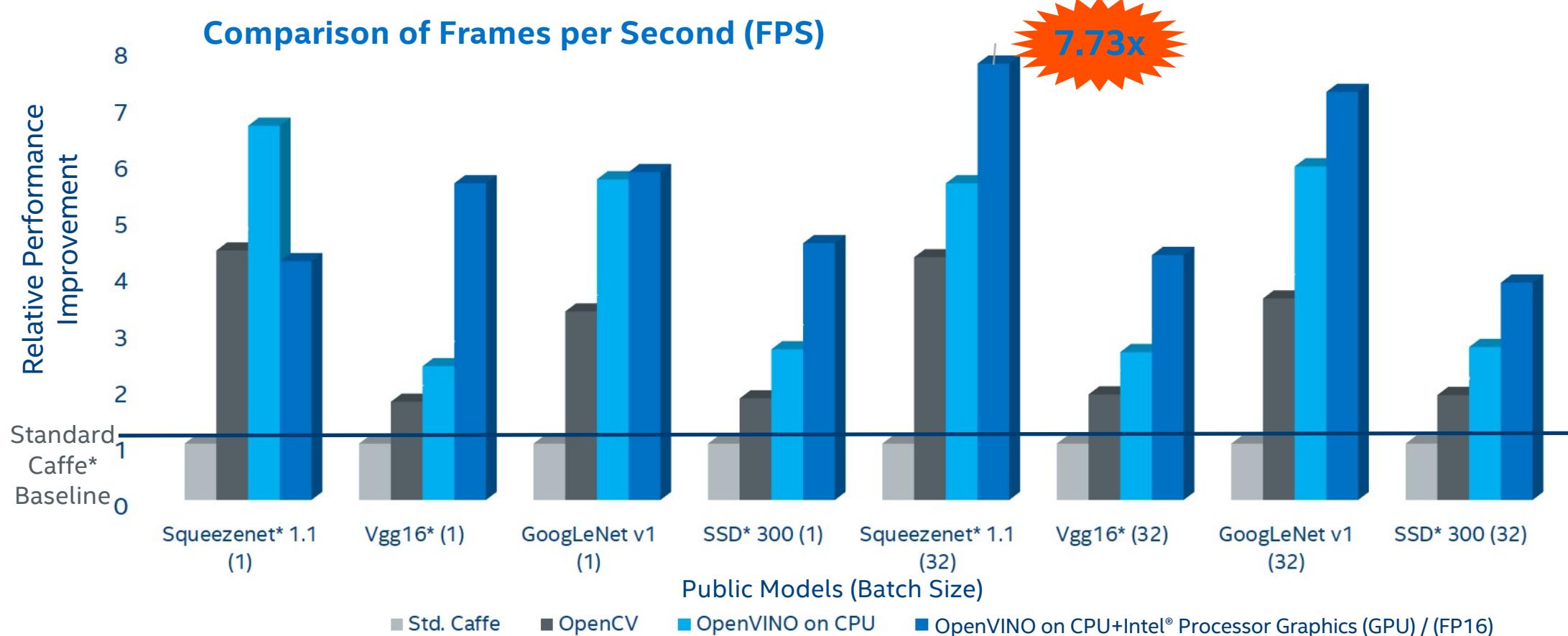
An open source version is available at 01.org/openvino/toolkit (some deep learning functions support Intel CPU/GPU only).

Benefits of Intel® Distribution of OpenVINO™ toolkit

Maximize the Power of Intel® Processors
CPU, GPU/Intel® Processor Graphics, FPGA,VPU

|  ACCELERATE PERFORMANCE |  INTEGRATE DEEP LEARNING |
|--|---|
| <p>Access Intel computer vision accelerators. Speed code performance. Supports heterogeneous execution.</p> | <p>Unleash CNN-based deep learning inference using a common API, 20+ pre-trained models, & computer vision algorithms. Validated on more than 100 public/custom models.</p> |
|  SPEED DEVELOPMENT |  INNOVATE & CUSTOMIZE |
| <p>Reduce time using a library of optimized OpenCV* & OpenVX* functions, & 15+ samples. Develop once, deploy for current & future Intel-based devices.</p> | <p>Use OpenCL™ kernels/tools to add your own unique code. Customize layers without the overhead of frameworks.</p> |

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

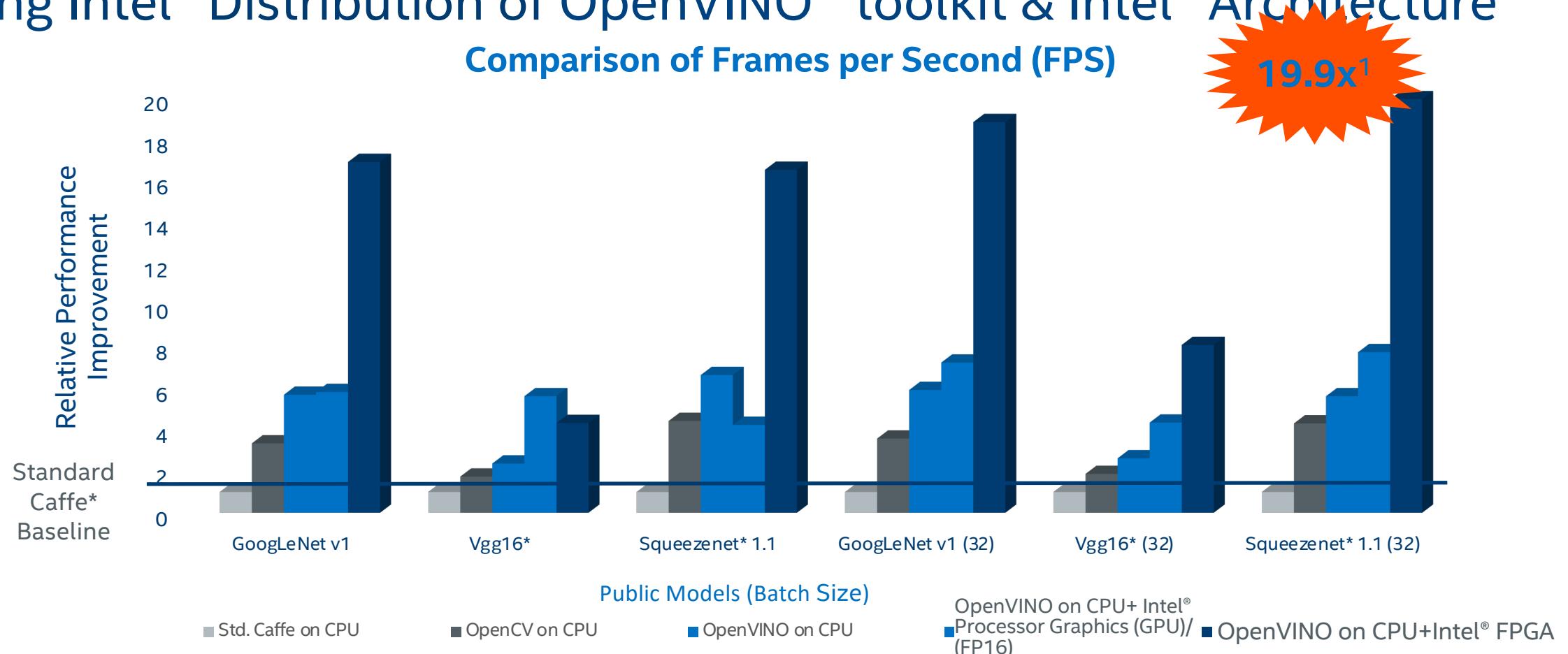


Fast Results on Intel Hardware, even before using Accelerators

1Depending 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 Intel® Distribution of OpenVINO™ toolkit & Intel® Architecture

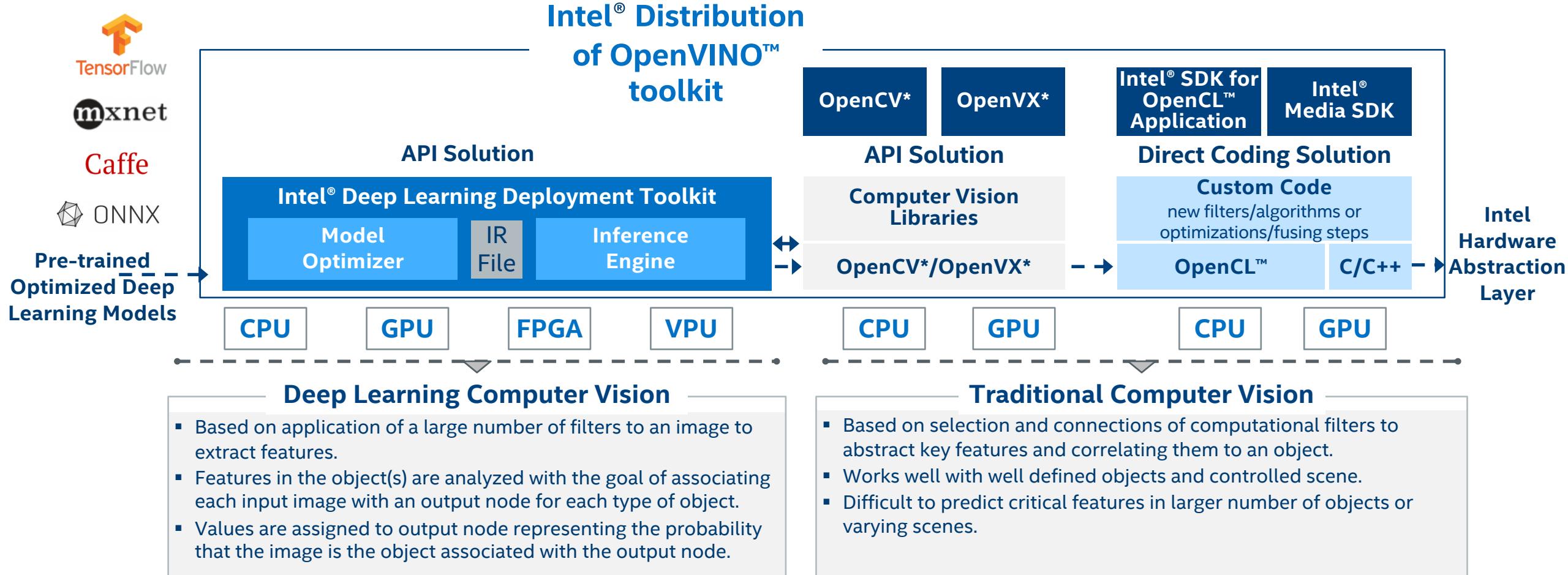


Get an even Bigger Performance Boost with Intel® FPGA

¹Depending 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

Intel® Distribution of OpenVINO™ toolkit has Tools for an End-to-End Vision Pipeline



IR = Intermediate Representation File

GPU = Intel CPU with integrated graphics processing unit/Intel® Processor Graphics

VPU = Intel® Movidius™ Vision Processing Unit

Optimization Notice

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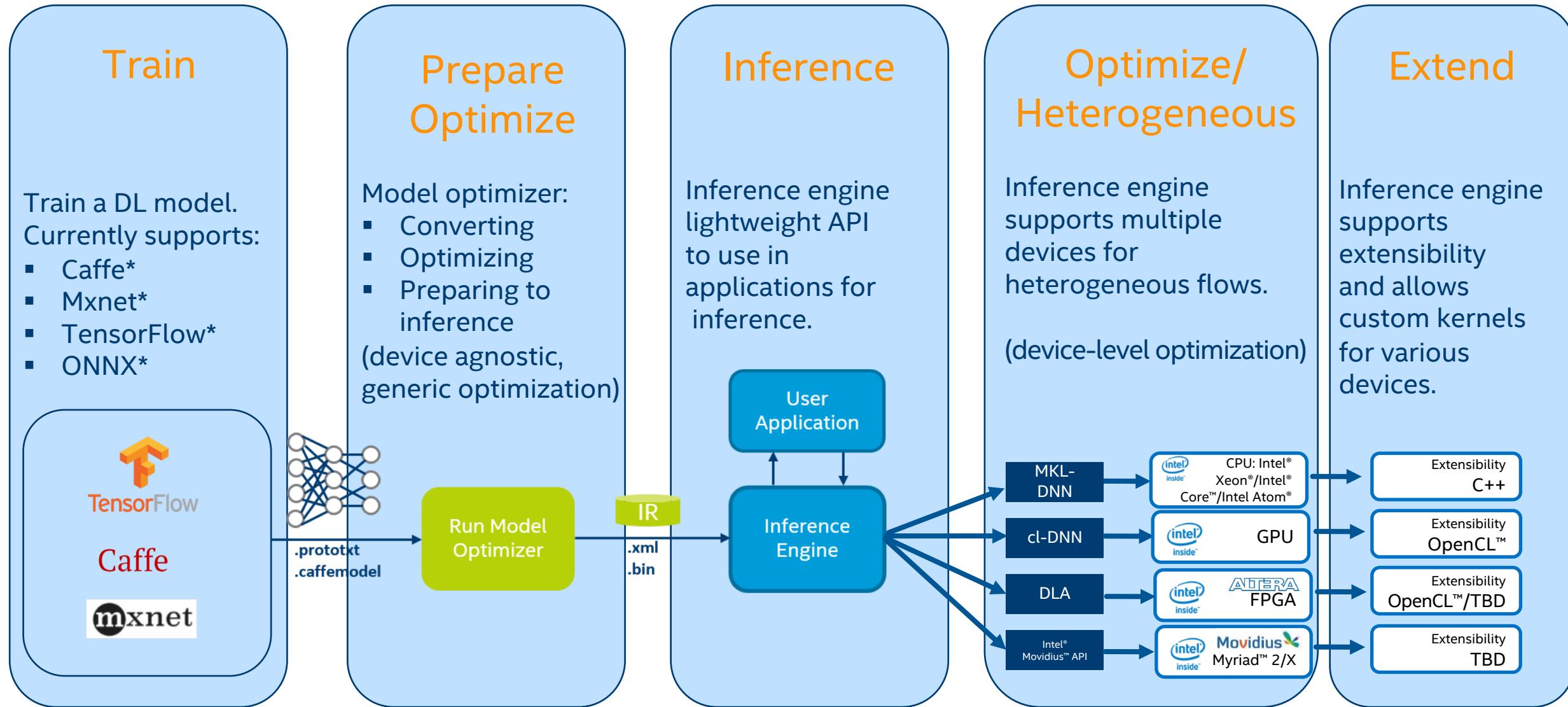
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Application development with Intel® Distribution of OpenVINO™ Toolkit



Speed Deployment with Intel Optimized Pre-trained Models

OpenVINO™ toolkit includes optimized pre-trained models that can expedite development and improve deep learning inference on Intel® processors. Use these models for development and production deployment without the need to search for or to train your own models.

Pre-Trained Models

- Age & Gender
- Face Detection – standard & enhanced
- Head Position
- Human Detection – eye-level & high-angle detection
- Detect People, Vehicles & Bikes
- License Plate Detection: small & front facing
- Vehicle Metadata
- Human Pose Estimation
- Vehicle Detection
- Retail Environment
- Pedestrian Detection
- Pedestrian & Vehicle Detection
- Person Attributes Recognition Crossroad
- Emotion Recognition
- Identify Someone from Different Videos – standard & enhanced
- Facial Landmarks
- Identify Roadside objects
- Advanced Roadside Identification
- Person Detection & Action Recognition
- Person Re-identification – ultra small/ultra fast
- Face Re-identification
- Landmarks Regression
- Smart Classroom Use Cases
- Single image Super Resolution

Save Time with Deep Learning Samples & Computer Vision Algorithms

Samples

Use Model Optimizer & Inference Engine for public models and Intel pretrained models.

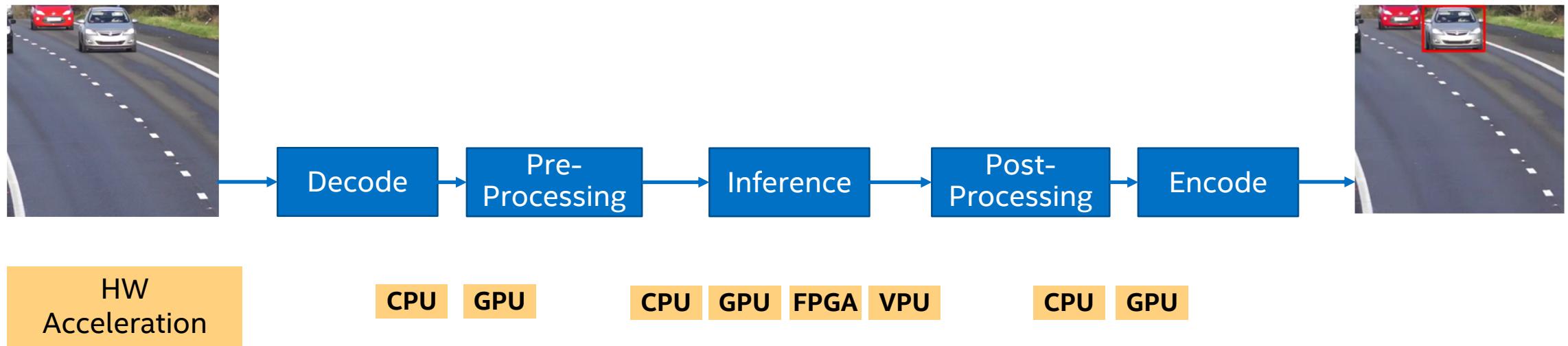
- Object Detection
- Standard & Pipelined Image Classification
- Security Barrier
- Object Detection for Single Shot Multibox Detector (SSD) using Asynch API
- Object Detection SSD
- Neural Style Transfer
- Hello Infer Classification
- Interactive Face Detection
- Image Segmentation
- Validation Application
- Multi-channel Face Detection

Computer Vision Algorithms

Get started quickly with highly-optimized, ready-to-deploy, custom-built algorithms using Intel pretrained models.

- Face Detector
- Age & Gender Recognizer
- Camera Tampering Detector
- Emotions Recognizer
- Person Re-identification
- Crossroad Object Detector

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

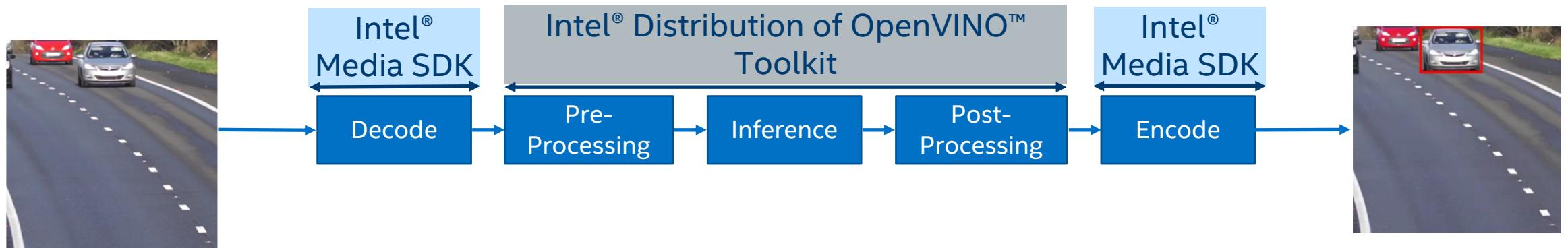
Embedded Linux*



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 Intel® Distribution of OpenVINO™ toolkit together enables customers to build high performance, intelligent vision solutions.

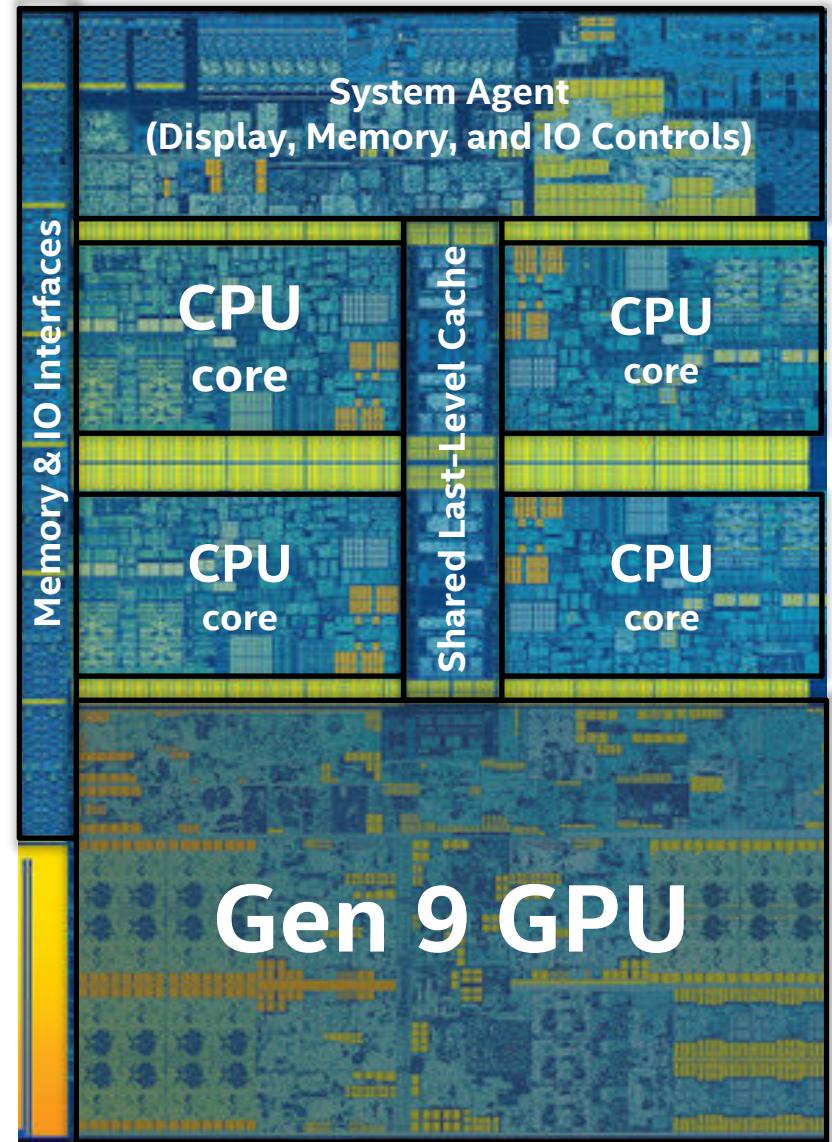


Intel Integrated Graphics

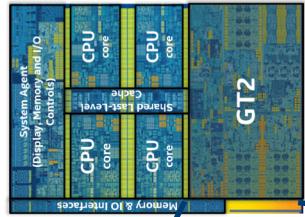
Gen is the internal name for Intel's on-die GPU solution. It's a hardware ingredient with various configurations.

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

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



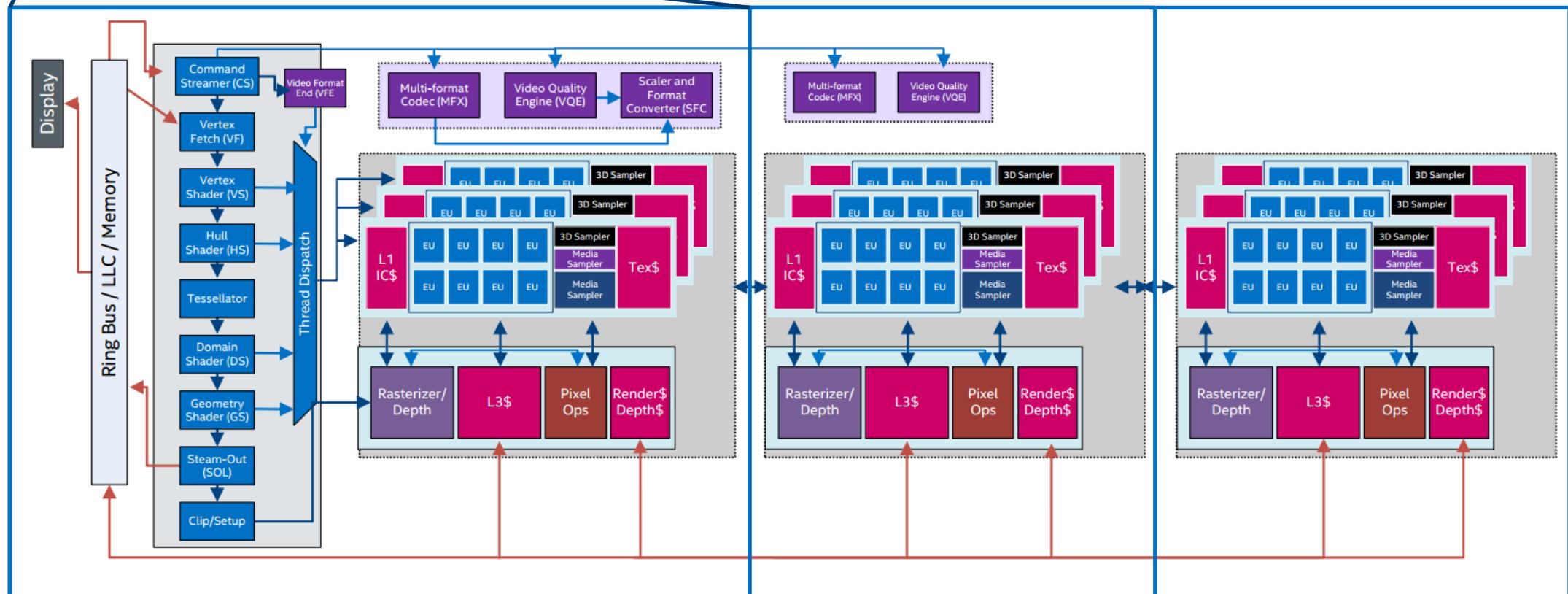
Intel GPU Configurations



GT2
Intel® HD Graphics
24 EUs, 1 MFX

GT3
Intel® Iris® Graphics
48 EUs, 2 MFX

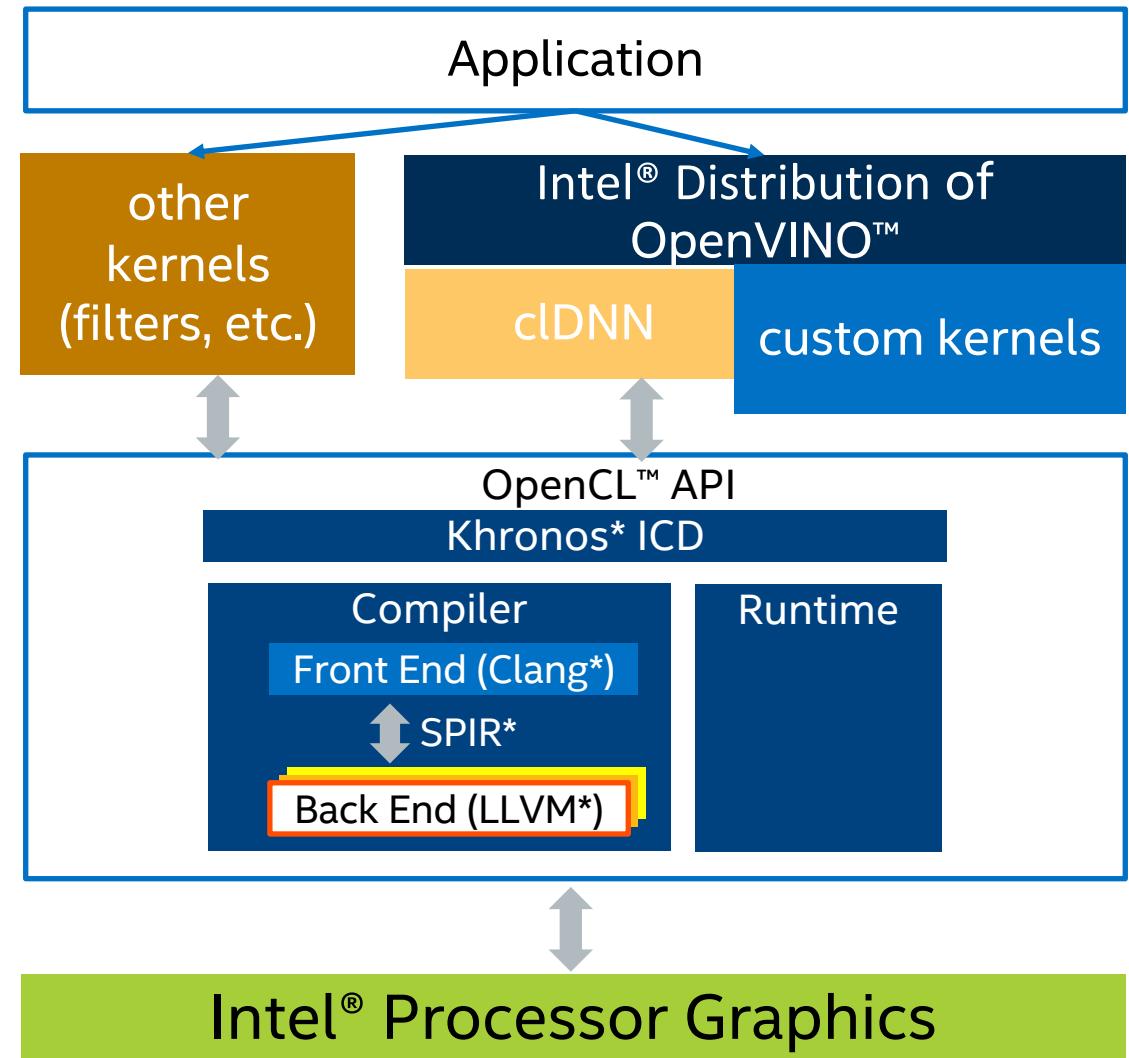
GT4
Intel® Iris® Pro Graphics
72 EUs, 2 MFX



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

Computer Vision



Deep Learning



Media



SDKs



Optimized CV
Capabilities

Intel® Distribution of OpenVINO™ Toolkit



Intel® Deep Learning
Deployment Toolkit



Intel® Media SDK

Tools

Compiler, Analyzers, Debuggers



Libraries

IPP



TBB



Intel®
MKL-DNN



Intel® MKL
DAAL



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.

Intel® Distribution of OpenVINO™ 101

Hardware Acceleration

Optimization

Application

Edge deployment

2. Basic End-to-End Object Detection Example

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

6. Optimization Tools and Techniques

7. Advanced Video Analytics

8. UP2 AI Vision Development kit as Edge

