Intelligent Vision for the Industrial, Automotive and IoT Edge with the i.MX 8M Plus Applications Processor

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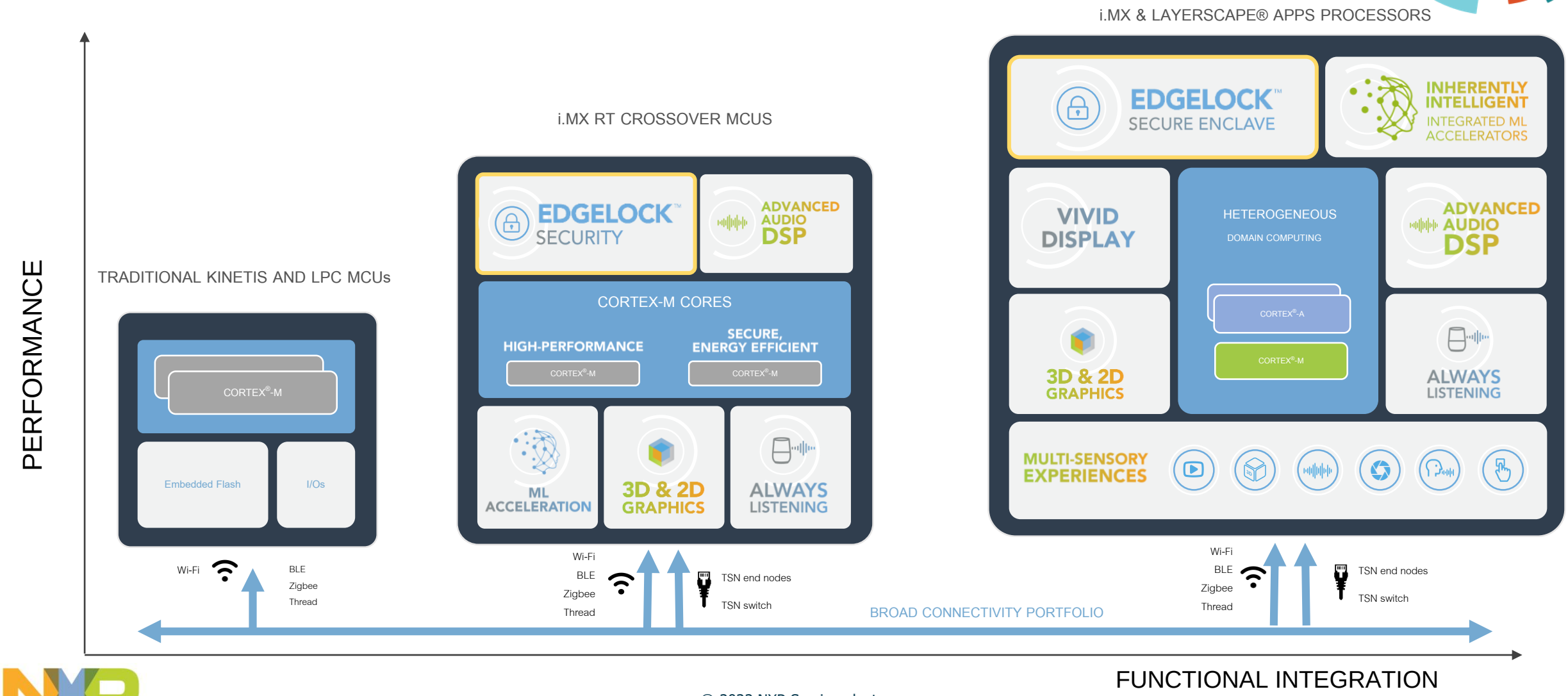
Outline

- Introduction to NXP applications processors
- Introduction to i.MX 8M Plus SoC
- i.MX 8M Plus machine vision features
  - ISP
  - NPU
- AI ML and machine vision software enablement

Scalable Compute Platforms



i.MX Series of Applications Processors

Software Compatible

Pin-to-pin Compatible

- i.MX 6QuadPlus
- i.MX 6Quad
- i.MX 6DualPlus
- i.MX 6Dual
- i.MX 6DualLite
- i.MX 6Solo
- i.MX 6SoloX
- i.MX 6SoloLite
- i.MX 6SLL
- i.MX 6UltraLite
- i.MX 6ULL
- i.MX 6ULZ

A9

A9 M4

A7

Arm® v7-A

i.MX 8 Family — A72 A53 M4
Advanced Graphics, Vision & Performance

i.MX 8M Family — A53 M7/M4 NPU
General Purpose
Edge Processing

i.MX 8ULP Family — A35 M33
Ultra Low Power with Graphics

i.MX 8X Family — A35 M4
Safety Certifiable &
Efficient Performance

Arm® v8-A (32-bit/64-bit)

i.MX 7 Family — A7 M4
Flexible Efficient Connectivity

i.MX 7ULP Family — A7 M4
Ultra Low Power with Graphics

Arm® v7-A (32-bit)

Future i.MX 9 Families
Automotive, Industrial & IoT
Edge Processing

i.MX 93 Family
Automotive, Industrial & IoT
Edge Processing — A55 M33 NPU

Arm® v8.2-A (32-bit/64-bit)

Pin-to-pin Compatible

Software Compatible

i.MX Series of Applications Processors

i.MX 6
- 12 product families
- Offers software and pin-pin compatibility
- Arm® v7-A

i.MX 8 Family

Advanced Graphics, Vision & Performance

i.MX 8M Family
General Purpose
Edge Processing

i.MX 8ULP Family
Ultra Low Power with Graphics

i.MX 8X Family

Safety Certifiable &
Efficient Performance
Arm ® v8-A (32-bit/64-bit)

i.MX 7 Family

Flexible Efficient Connectivity

i.MX 7ULP Family
Ultra Low Power with Graphics
Arm® v7-A (32-bit)

i.MX 8M Plus
2.3 TOPS NPU, Vision (ISP),
1080p video encode/decode,
advanced HMI, multi-display,
USB3/2xGbE/PCIe

i.MX 8M
4K HDR, 4K video decode,
advanced HMI, multi-display
USB3/GbE/2xPCIe

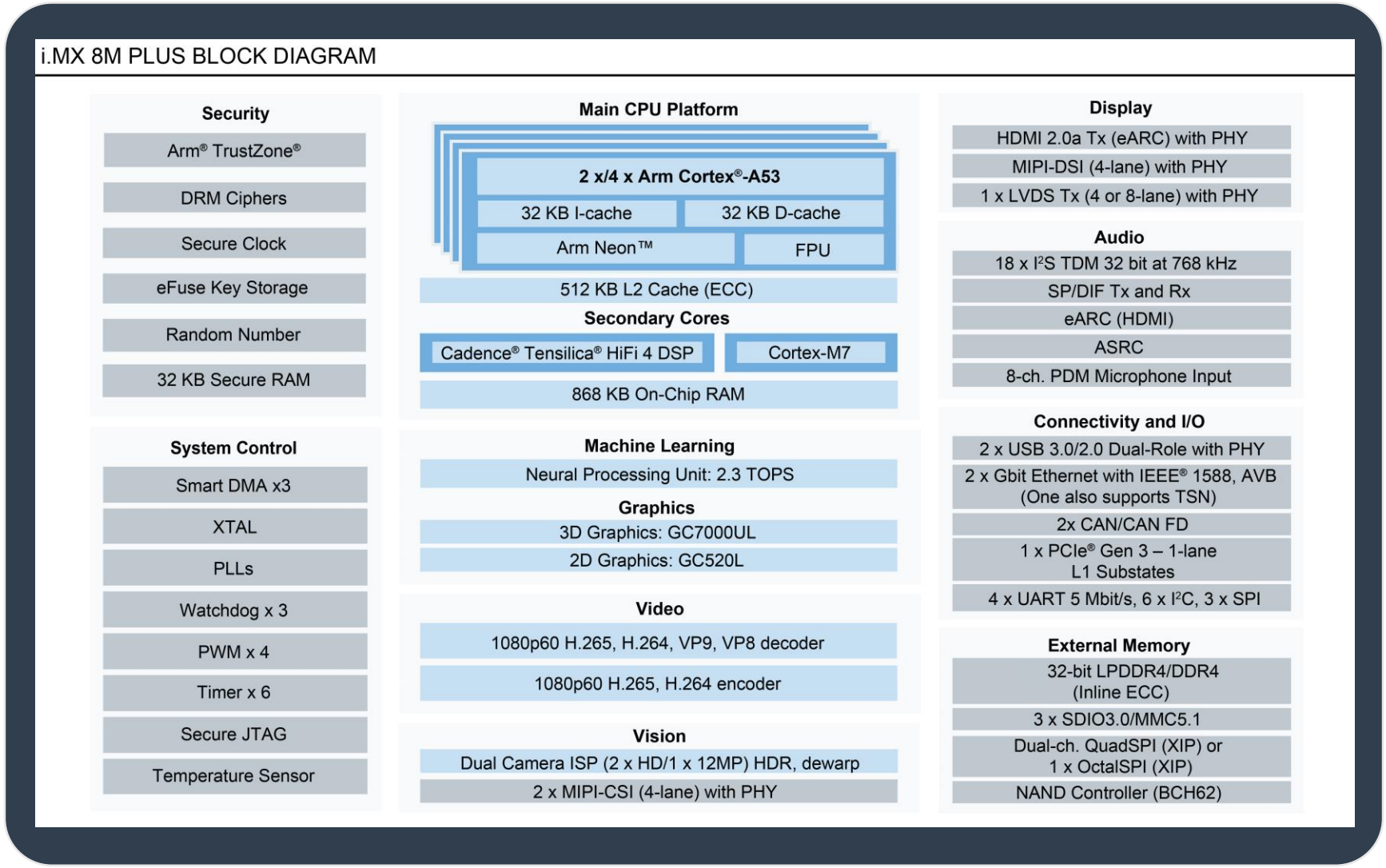
i.MX 8M Mini
Versatile multimedia
applications processor with
1080p video encode/decode,
HMI graphics acceleration,
USB/GbE/PCIe

i.MX 8M Nano
Entry-level multimedia
applications processor with
HMI graphics acceleration,
USB/GbE

Pin-to-pin Compatible

Software Compatible

i.MX 8M Plus Applications Processor with ML & Vision Engines



i.MX 8M Plus Applications Processor with ML & Vision Engines

4x Cortex® A53 @ 1.8GHz

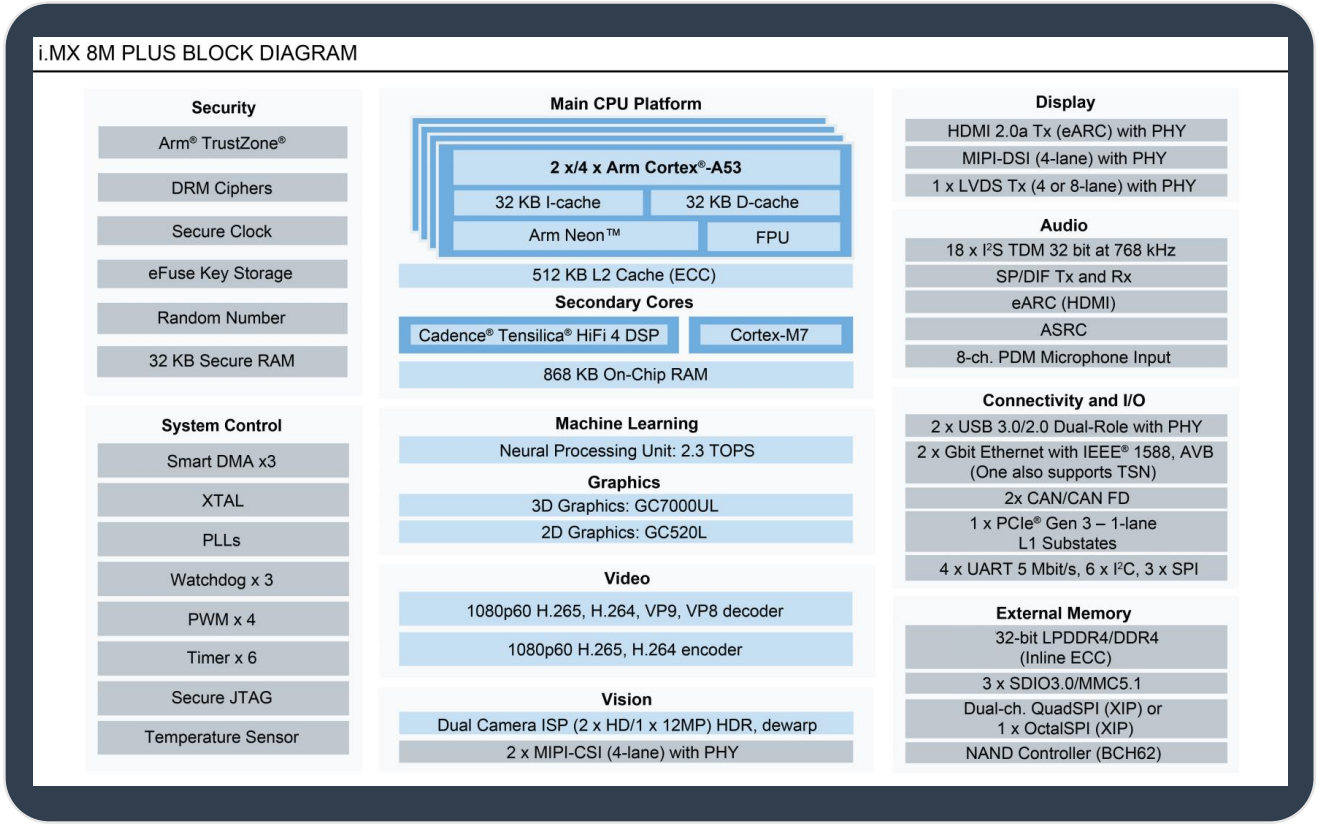
- Speech recognition
- Object detection
- Gesture recognition

HiFi4 DSP @ 800MHz

- Voice/Keyword recognition
- Speech enhancement
- Noise reduction

GC7000UL 3D Graphics Engine (GPU) @ 1GHz

- Object detection classification
- Floating point support



Cortex-M7 @ 800MHz

- Keyword detection
- Sensor fusion
- Anomaly detection

Neural Processing Unit (NPU) @ 1GHz

- Multi-camera classification and detection

Two-channel Image Signal Processor (ISP)

- De-warping and image enhancement

i.MX 8M Plus Target Applications

ML and Industrial Automation

- Machine vision and robot controller
- Industrial computer, gateways, HMI
- Printers and scanners
- Machine visual inspection
- Factory automation

Smart Home, Building & City

- Safety, security and surveillance
- Fleet analytics
- Traffic monitor and flow optimization
- Vision payment systems
- Targeted advertisement
- Service drones
- Alarm and AI server hubs
- Home patient and elderly monitor

Consumer Audio/Voice Systems

- Surround sound and sound bars
- Audio/video receiver
- Immersive audio products
- Wireless or networked smart speakers
- Personal assistant
- Voice-assisted products

ISP (Image Signal Processor)

i.MX 8M Plus SoC: Why an Integrated ISP ?

- **Image Signal Processor (ISP) basic function**
  - Converts the image color code from raw Bayer (output of the image sensor) to YUV so it can be processed by the SoC
  - Provides additional processing to improve the image quality:
    - HDR extracts maximum image detail in high contrast scenes
    - De-Warp: Fisheye lens or low-cost lens geometry correction
    - Image Enhancement

- **i.MX 8M Plus - ISP Benefits:**
  - Low latency and high performance
  - Lower BOM cost for vision system
  - Higher product longevity

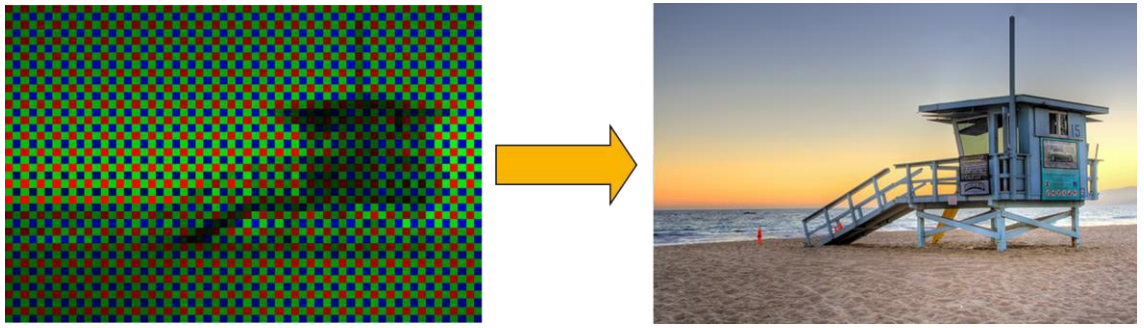


Image Sensor Output

ISP Output

i.MX 8M Plus SoC: ISP Key Features

- Bayer de-mosaicing and filtering (including denoising, sharpening and blurring)
- Defect pixel cluster correction (DPCC)
- Color processor (CPROC)
- Chromatic aberration correction (CAC)
- Denoise
- Histogram
- Lens shading correction (LSC)
- Wide Dynamic Range (local tone mapping)
- Color noise removal (CNR)
- Automatic white balance measurements (AWB)
- Exposure measurement for AE (AEC/AGC)
- Auto focus measurement (AF)
- 2-exposure and 3-exposure DoL/Staggered HDR

AL/ML
NPU (Neural Processing Unit)

i.MX 8M Plus NPU Subsystem

Programmable Engine Unit

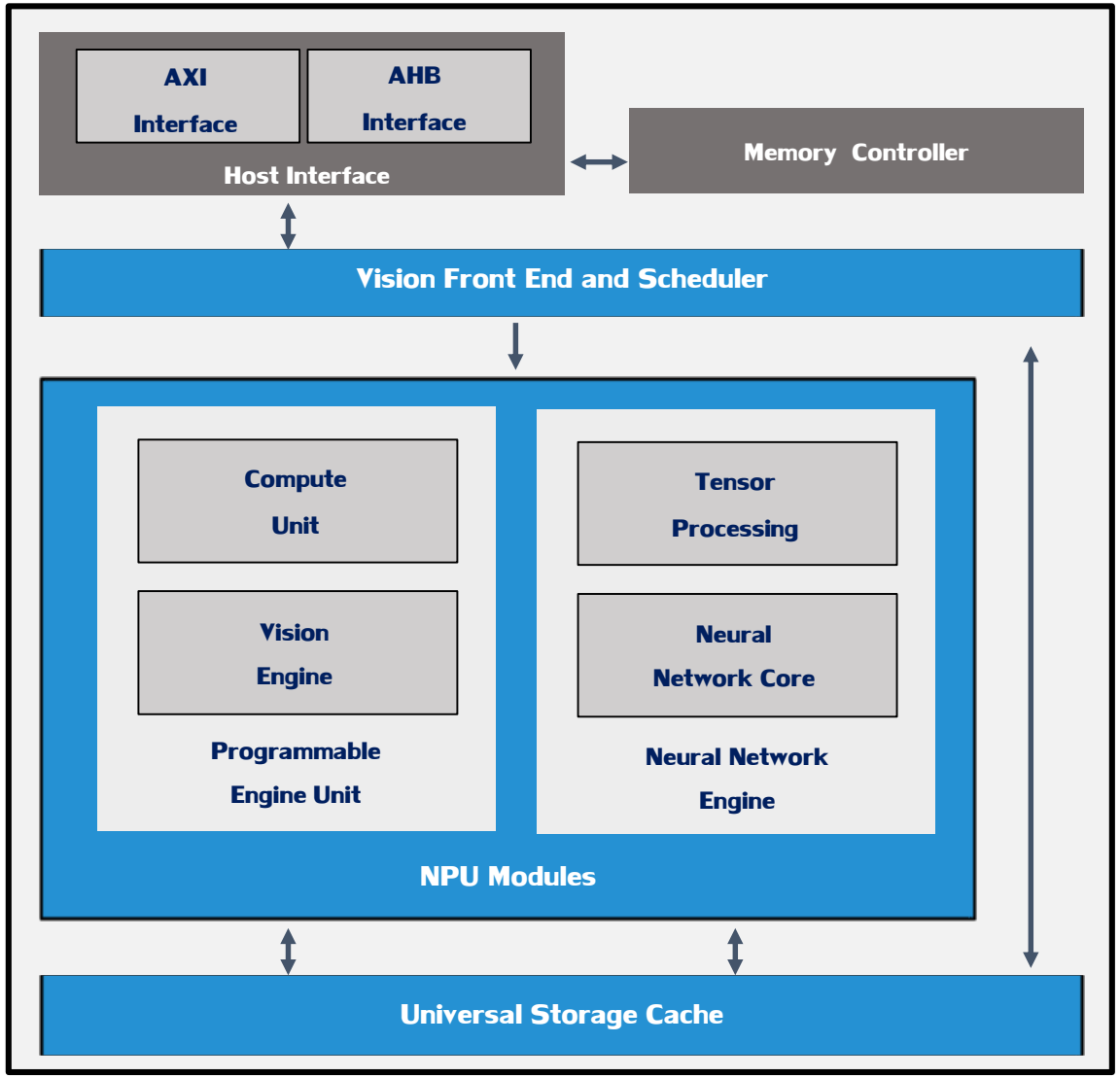
- 128-bit vector processing. INT 8/16/32b, FLOAT 16/32b.
- Most flexible programming unit

Vision Engine

- Provides advanced image processing functions

Universal Storage Cache

- Local memory and L1 cache to pass data amongst NPU modules



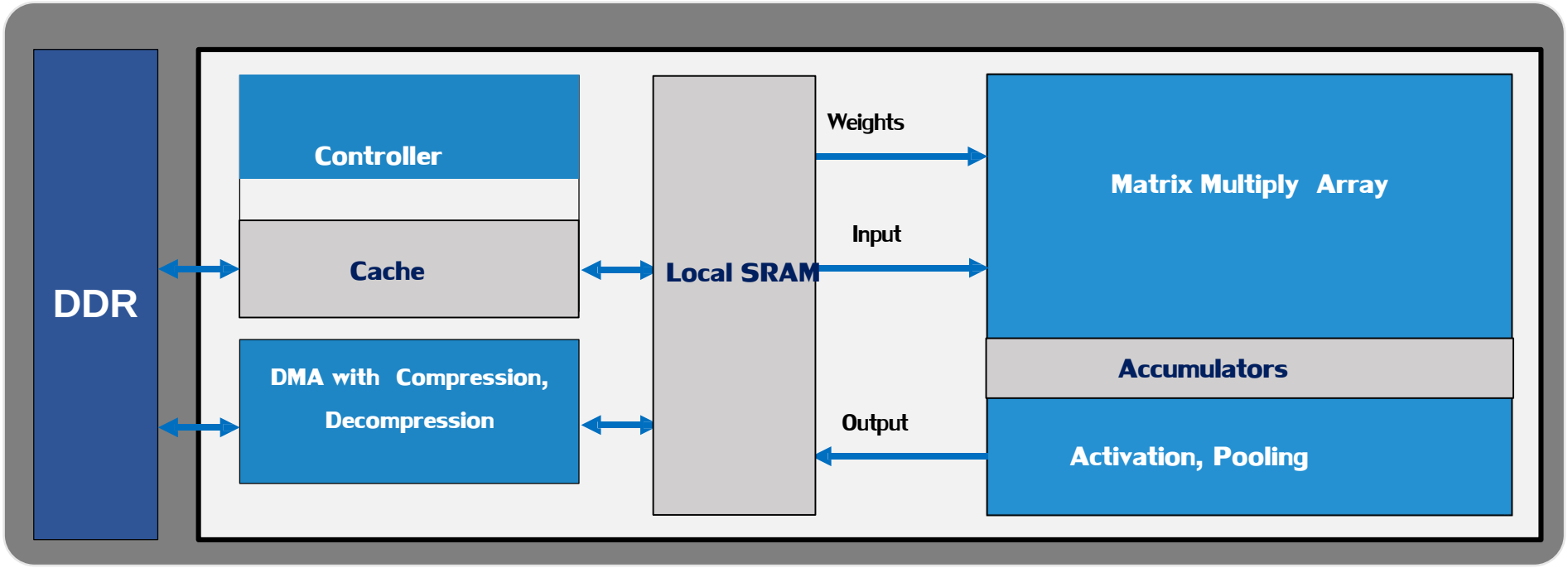
Tensor Processing Core (3 instances)

- INT 8/16b, FLOAT 16b
- Non-convolution layers.
- Multi-lane processing for data shuffling, normalization, pooling/unpooling, LUT, etc.
- Network pruning support, zero skipping, compression

Neural Network Core (6 instances)

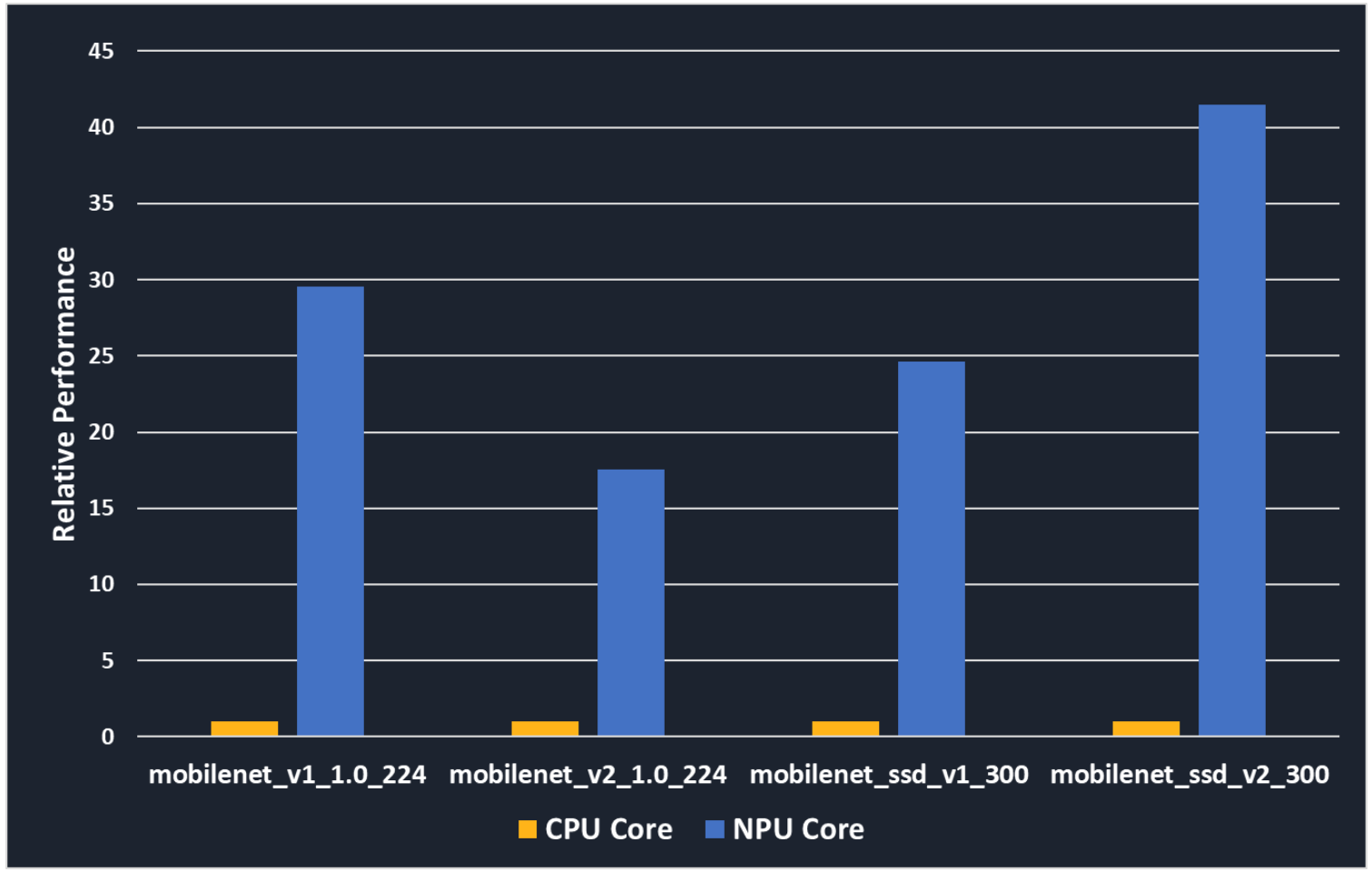
- 2.3 TOPs INT8
- Convolution Layers, RELU, Max Pooling, and Compute Bounded Fully Connected Layers

i.MX 8M Plus NPU Features



- Scalable 8- and 16-bit integer multiply-accumulate (MAC) engine for tensor operations
- Specialized NN hardware supports activation and pooling
- Supports variety of NN topologies:
  - Convolutional (CNN): MobileNet, YOLO, etc
  - Recurrent (RNN, GRU, LSTM): Deep Speech 2, etc.

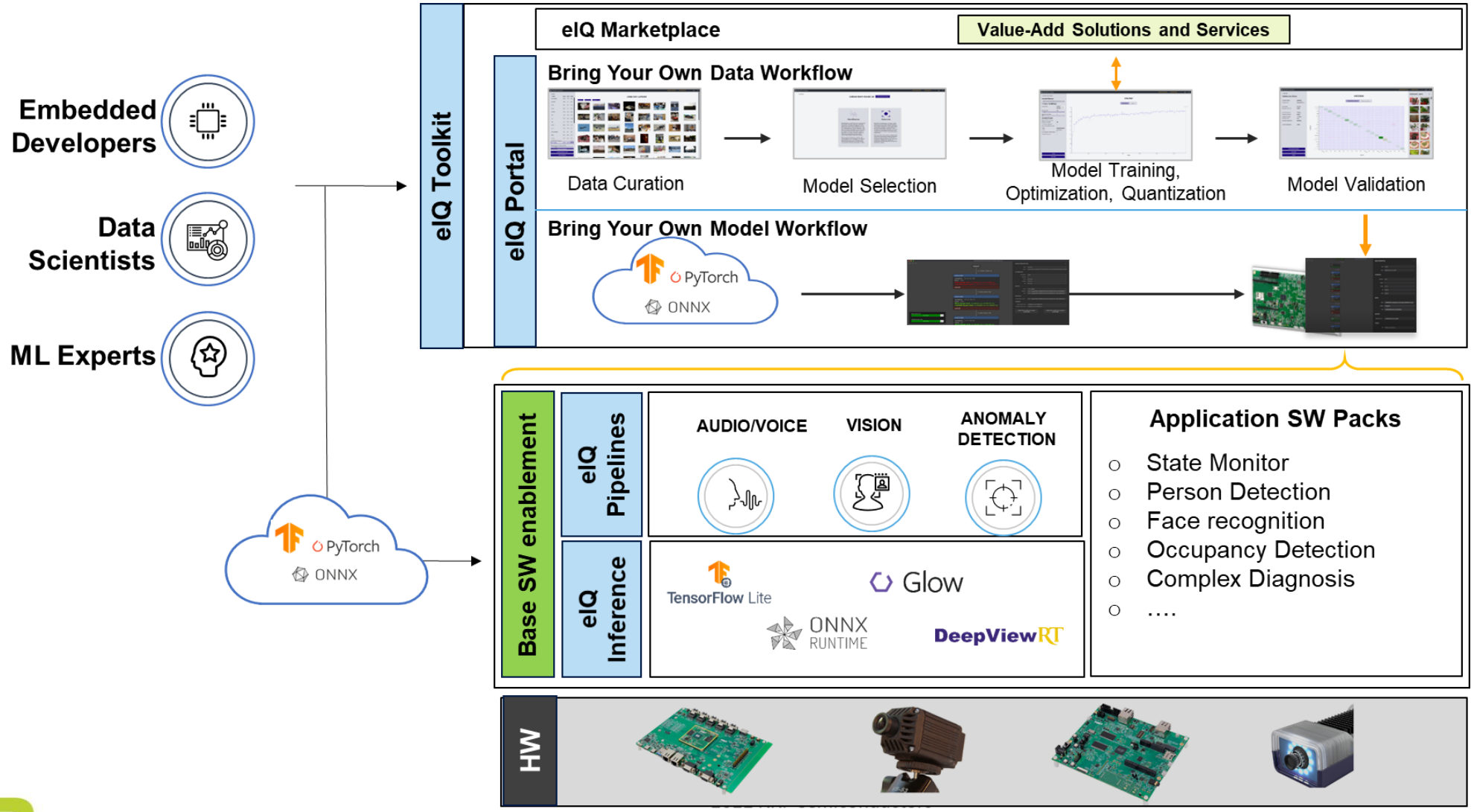
NPU Performance Increase for Quantized Models



- Measured on i.MX 8M Plus with 1 Cortex A53 CPU core vs. NPU normalized to 1 GHz for both cores
- Both A53 and NPU are 8-bit quantized

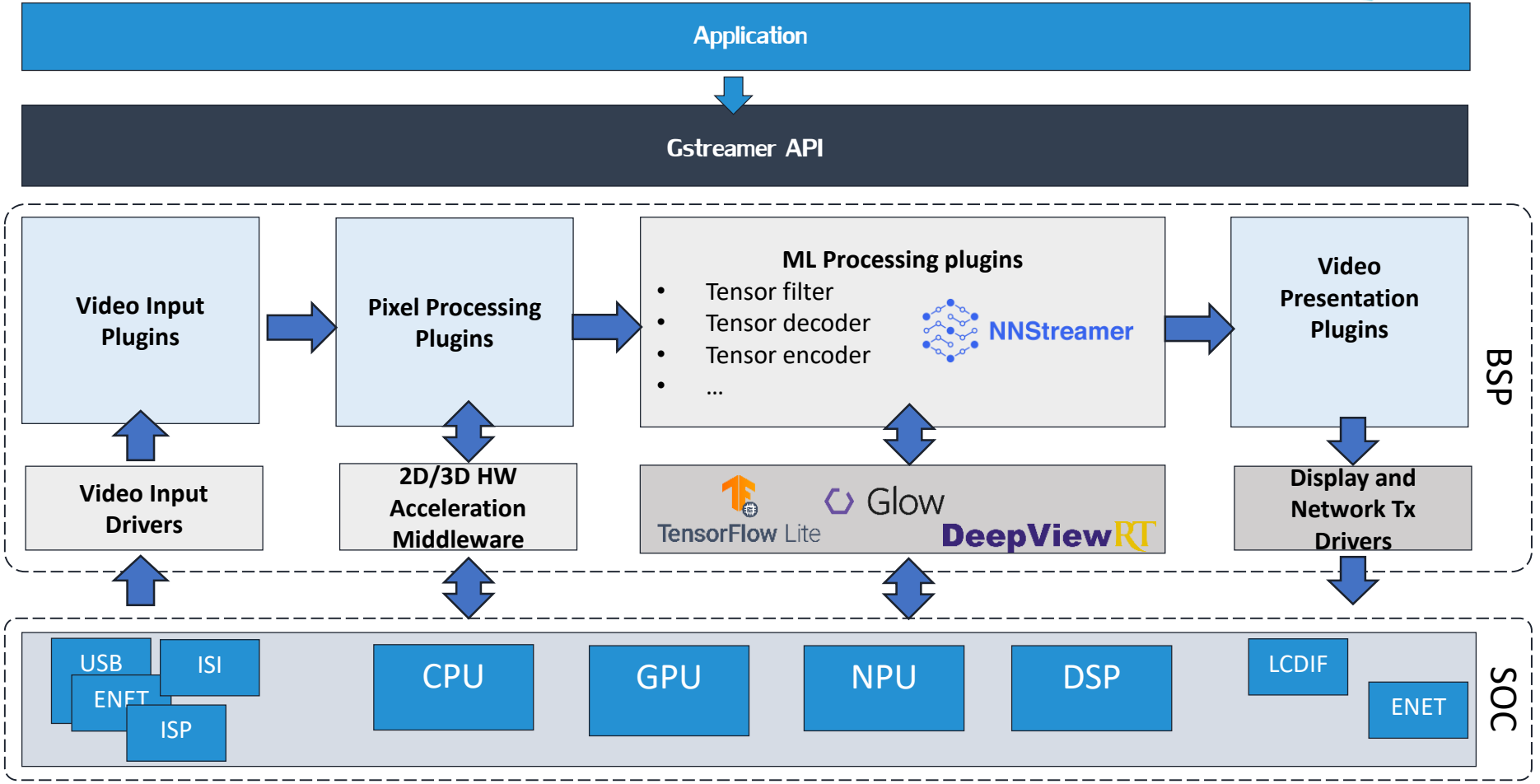
Machine Vision Software Enablement

eIQ® ML Software Development Environment



i.MX 8M Plus Vision Pipeline

- **Gstreamer** offers an open-source industry-standard solution to handling media components for embedded devices.
- **NNStreamer** provides a set of GStreamer plugins allowing developers to apply neural networks, attach related frameworks (including ROS, IIO, FlatBuffers, and Protocol Buffers), and manipulate tensor data streams in GStreamer pipelines easily and execute such pipelines efficiently.



Gstreamer: https://gstreamer.freedesktop.org/
NNStreamer: https://nnstreamer.ai/

Machine Vision Use Case

Available Demos

Multimedia

GStreamer

Video Test Source
Camera Preview
Camera using VPU
Multi-Cam Preview

ISP

ISP Control Demo
Video Dump Demo

Audio

Audio Record
Audio Play

GPU

GLES2

Vivante Launcher
Cover Flow
Vivante Tutorial
Bloom
Blur
DF Graphics Basic 2D
Eight Layer Blend
Fractal Shader
Line Builder 101
Model Loader
S03 Transform
S04 Projection
S06 Texturing
Mapping
Mapping Refraction

OpenVG 2D

Tiger G2D

Not all demos listed are available on all boards

Machine Learning

NNStreamer

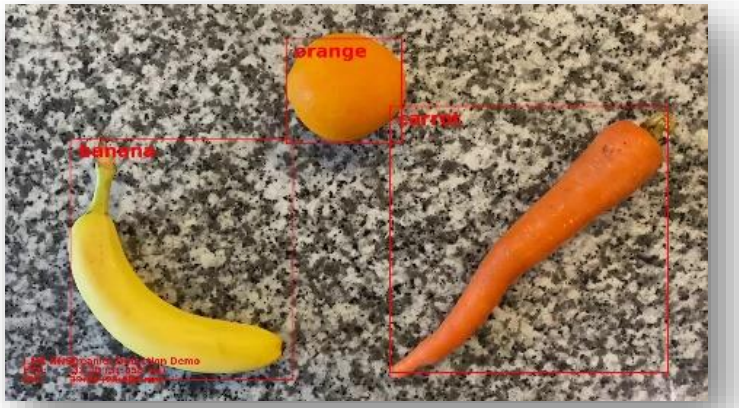
Object Classification
Object Detection
Pose Detection
Brand Detection

PyeIQ

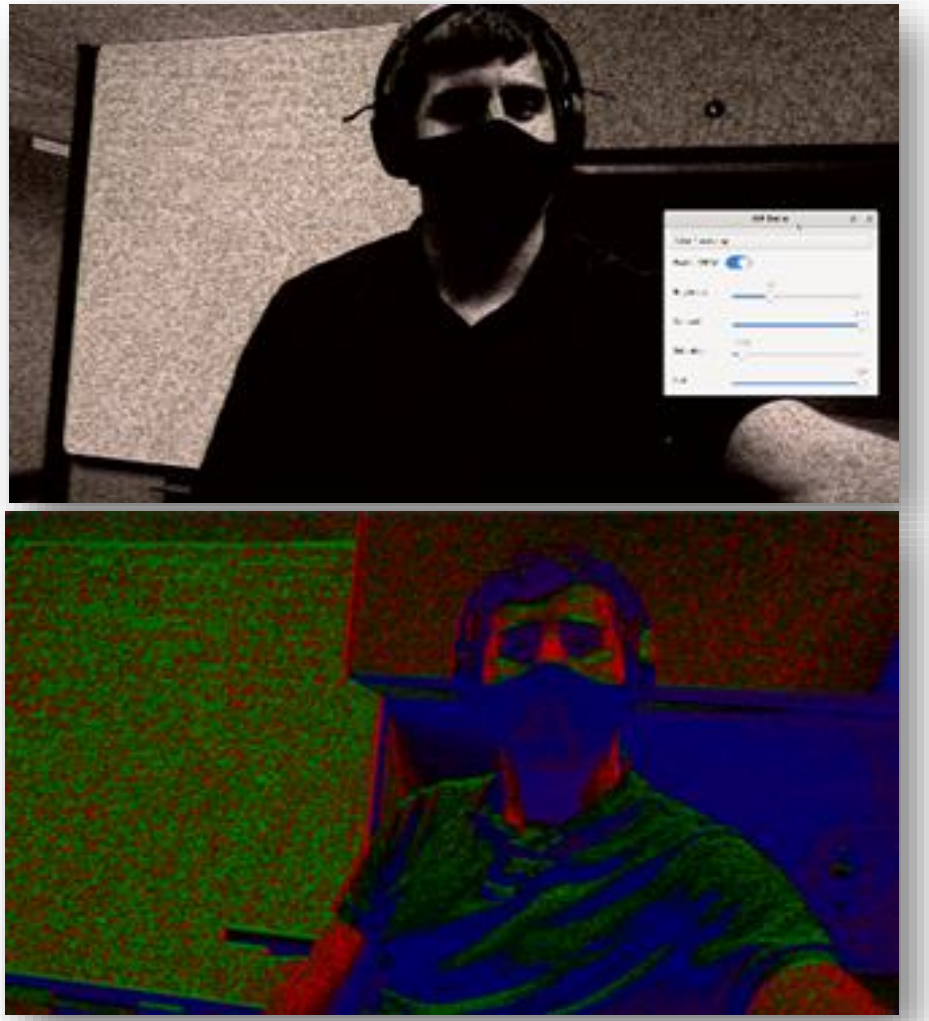
Object Classification
Object Detection
Mask Detection

NNstreamer (ML Vision) Demos

- Object classification demo
- Object detection demo
- Pose detection demo
- Brand classification demo



ISP Demos



- The “ISP control” demos allow users to control the following:
  - De-warp
  - Frames per second
  - Auto white balance
  - Color processing
  - De-mosaicing
  - Gamma control
  - Filtering
  - Black level subtraction
- New demo in 2022 Q1: users can use GUI to dump unprocessed camera data onto a USB drive

Conclusion

The i.MX platforms are some of the most versatile applications processors families for multimedia and display applications

- The i.MX 8M Plus SoC offers
  - Camera capture, network and display drivers / frameworks
  - Multiple ML frameworks available, with multiple inference HW supported (NPU, GPU, CPU, DSP)
  - Multimedia accelerators (2D GPUs, 2.5D GPUs, 3D GPUs…) and industry-standard APIs
  - eIQ ML SW Development Environment
  - Reference code and demos targeting machine vision applications

Resources

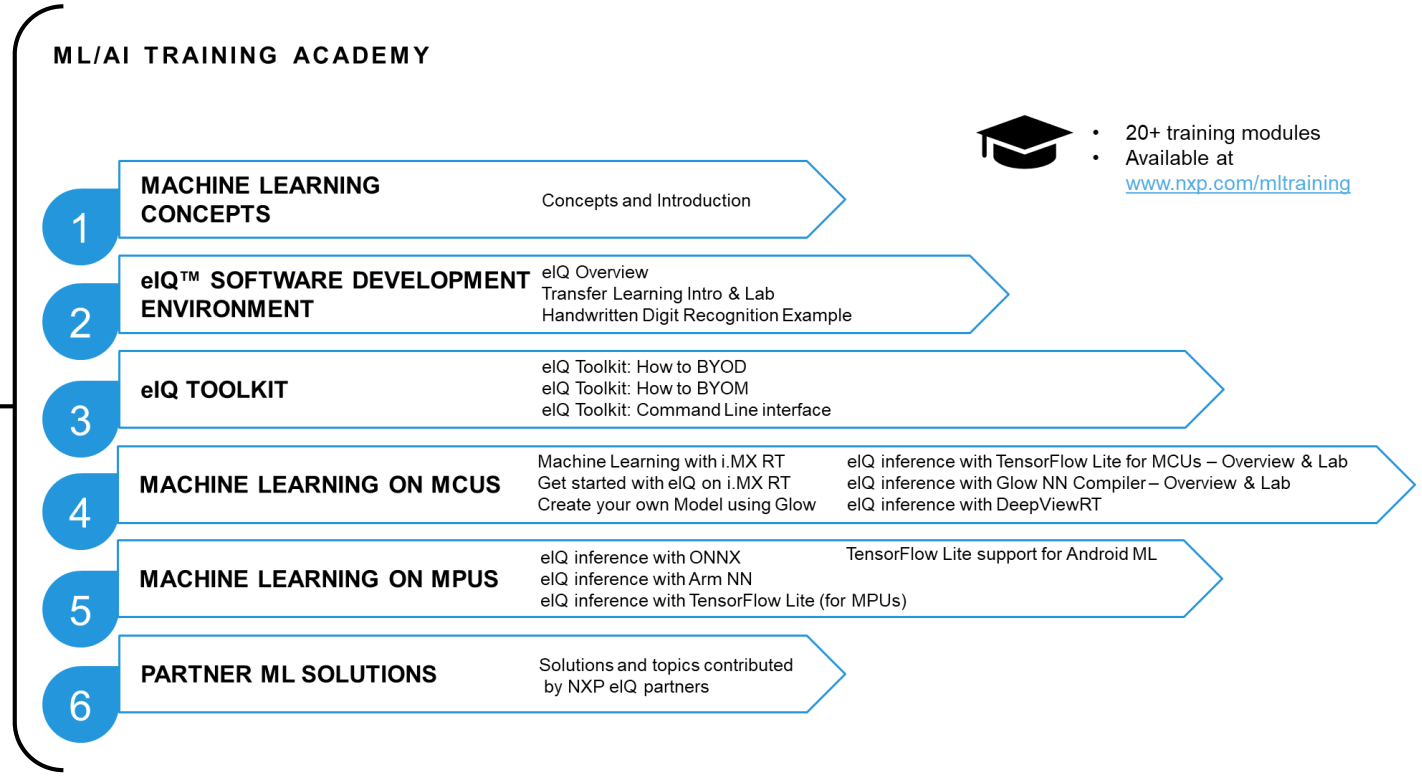
Embedding Intelligence at the Edge
- www.nxp.com/ai

i.MX 8M Plus product page:
- www.nxp.com/imx8mplus

eIQ® ML Software Development Environment
- www.nxp.com/eiq

eIQ ML/AI Training Series
- www.nxp.com/mltraining

NXP Application SW Packs
- www.nxp.com/appswpack



Thank You