

Industrial Use of Artificial Intelligence

Sam Fuller

Director of Solutions and Strategy
NXP Digital Networking

June 2019 | Session #AMF-EDG-T3634



SECURE CONNECTIONS
FOR A SMARTER WORLD

Agenda

- What is AI?
- Industrial AI Applications
- NXP Layerscape Processors for AI
- Software Considerations
- Looking Forward



Common Terms

- **Artificial intelligence (AI)**
 - A computer performs tasks considered heretofore to require human intelligence
- **Machine learning (ML)**
 - Key term is *learning*: input data teaches the model how to function
 - Learning is typically supervised (the model is **trained** using input and the correct output)
 - Application of the trained model is called **inferencing**
 - But learning may be unsupervised (e.g., cluster analysis)
- **Neural network (NN)**
 - A class of ML algorithms
 - Convolutional neural networks (CNN) (typically applied against spatial data)
 - Recurrent neural networks (RNN), including LSTM (typically applied against sequential data)
- **Deep learning**
 - ML using a big neural net
- **Computer vision (CV)**
 - Techniques—not necessarily based on AI—for computers and embedded systems to perceive images

Neural Networks Are Not the Only Type of AI/ML Algorithm



Source: <https://machinelearningmastery.com/>

Why AI?



ARTIFICIAL
INTELLIGENCE

Faster than human analysis

Cooler under pressure

Analyzes more data than humanly possible

Better insights than man-made models

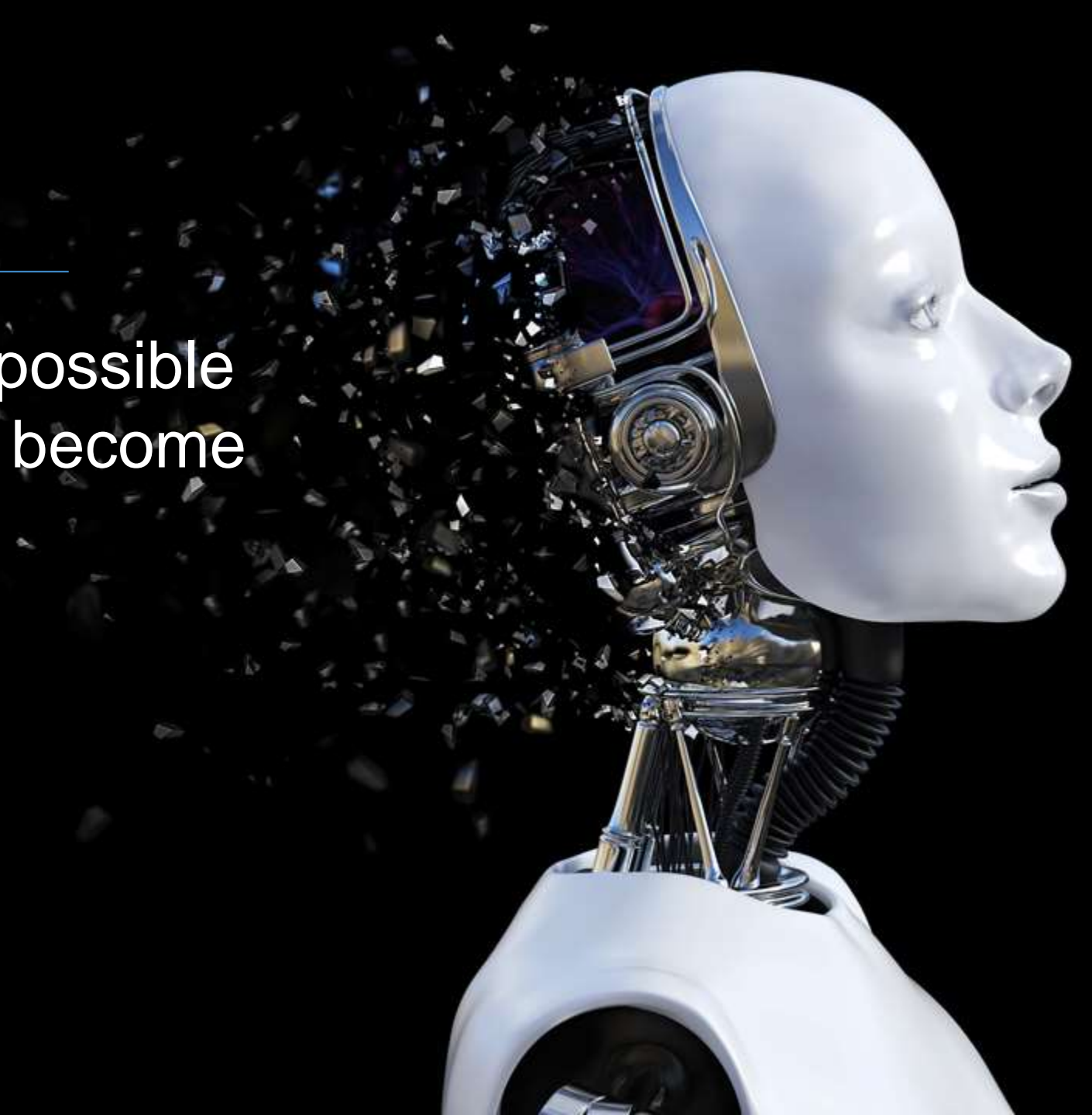
Improves profitability and quality

Increases **safety**

Reduces waste and pollution

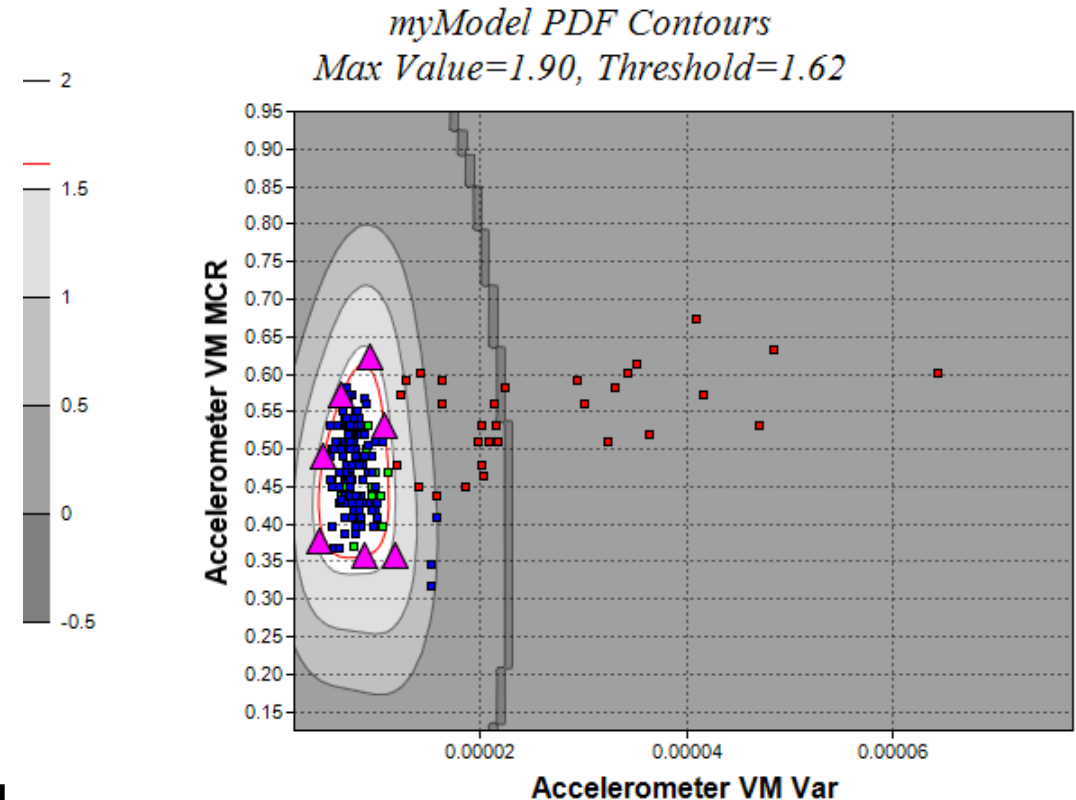
Why AI?

Information that is impossible
to perceive today will become
discernable



AI Application: Smart Maintenance

- Asset failure leads to costly unplanned downtime
- Scheduled maintenance reduces utilization
- **MCU-only approach (figure at right)**
 - Gather data from vibration, temp, torque, acoustic, and electrical sensors
 - Run SVM for anomaly detection NXP microcontrollers
- **Microprocessor-based approach**
 - Extract “features” from data
 - Associate features with indicators using a CNN
 - Predict indicators and estimate RUL with SVR





AI Improves Quality

- Quality management reduces manufacturing cost
- High-quality products improve customer satisfaction
- Object-detection techniques can be adapted to visual quality inspection
- Other sensors (e.g., acoustic) can inspect in ways people cannot
- Technology for smart maintenance can be adapted to process monitoring (Quality 4.0)



Security and Surveillance

- Fire, theft, trespassing cost businesses
- AI is more attentive than human agents
- AI frees people to focus on addressing issues
- AI-based security can be lower cost and less discriminatory
- Typical approach is to identify and track people
- AI systems can learn on their own to identify anomalous behavior

Industrial Safety Examples



Virtual-fencing of safety zones

Recognize faces to enforce authorization policies

Detect objects to enforce PPE policies

Monitor operator attention with gaze detection

Track and monitor equipment and vehicles



AI in Warehousing

- Physical inventory using object detection
- Pick & place robots (see recent Boston Dynamics robot)
- Received-goods inspection (crate damage)



Robotics

- AI coordinates robot interaction with people (collaborative robots)
- AI/CV can identify objects for robot to interact with
- AI learns optimal paths vs following a set route
- Example uses: pick and place, assembly, packaging, AGV



IT-OT Convergence

- OT supplies sensor data and provides first level of data analysis
- IT synthesizes OT input with ERP, etc to forecast process variables
- OT uses these variables for process control
- Example uses:, process optimization, JIT inventories, autonomous factory automation
- Also: generative design

Breakdown of an AI Video-Analysis Application

Capture Video

Image Processing

Analysis & Prediction
(CNN)

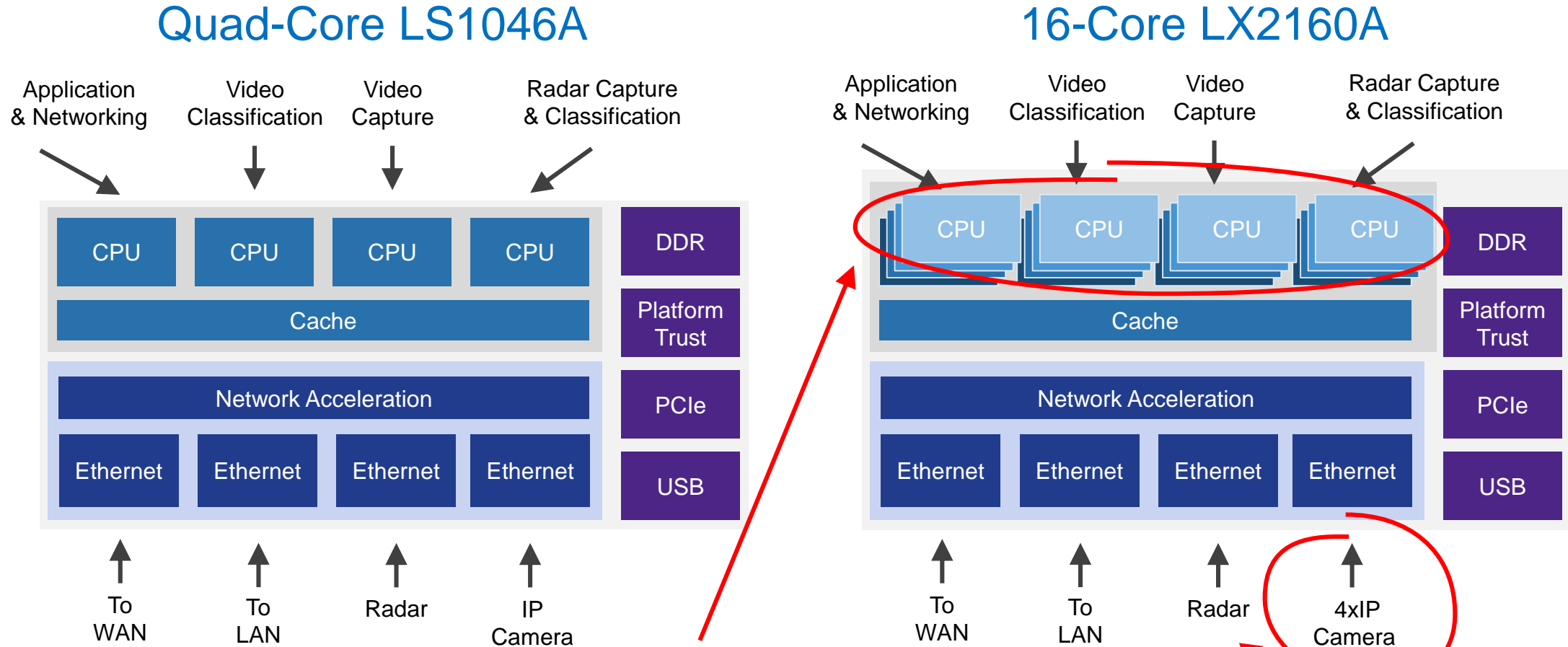
Application
(Logic, UI,
DB, etc)

Transmit
or Store



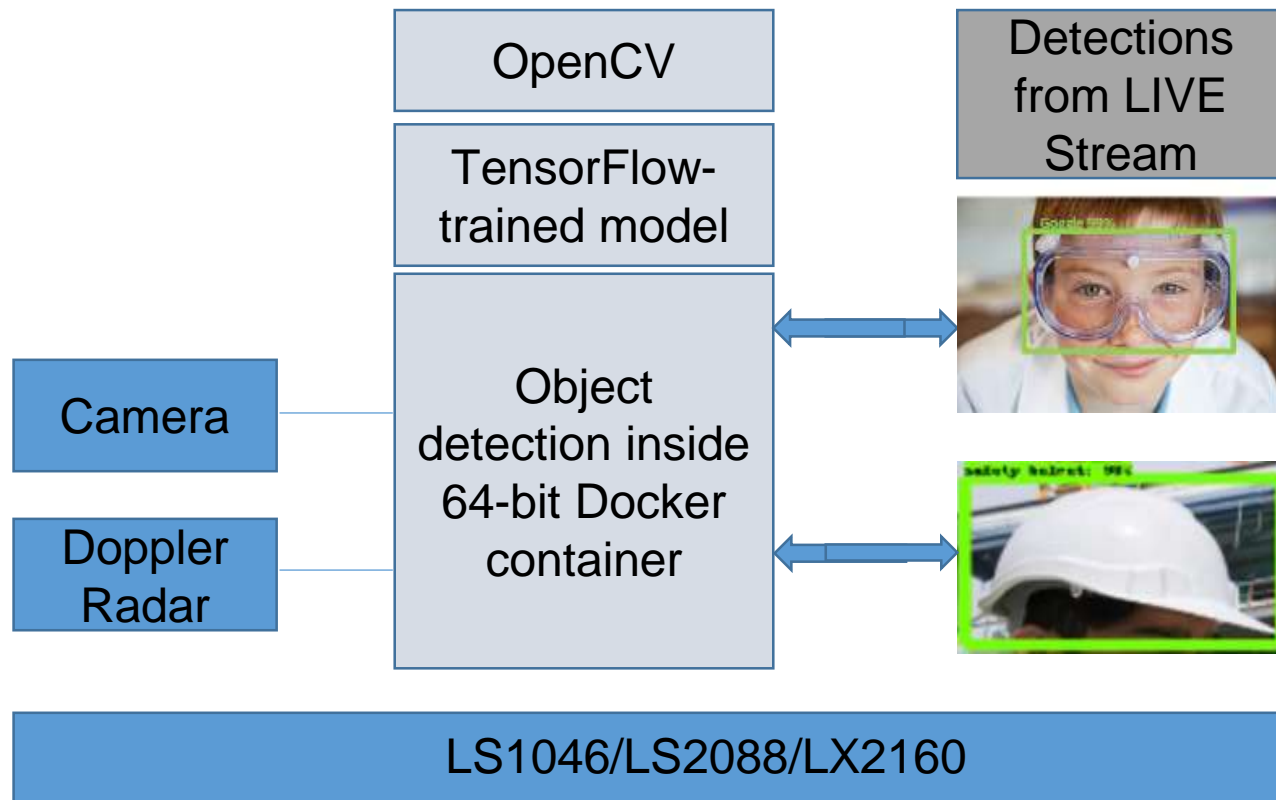
Hardware	USB Ethernet/IP MIPI to ISP (pref)	CPU, HW codec (preferred)	CPU, NN Accel (GPU, TPU, VSPA)	CPU GPIO, USB, PCIE	USB Ethernet/IP SATA NVMe
Software	Drivers, V4L	V4L, G-streamer, video codecs	Frameworks (e.g., TensorFlow) Turnkey Models Training	Custom	Linux Network stack, File-system

Example of Using Layerscape to Achieve Scalability



4x the compute power enables processing 4x the camera input

Industrial Safety Demo Using NXP Layerscape



- Demonstrates AI for detection of PPE in safety zone
- Doppler radar sets safety zone
- Cameras capture operators
- AI/ML software using TensorFlow and OpenCV and custom training data detect helmet and goggles

AI @ the Edge vs. Cloud – Performance vs. Practicality

	Cloud Server + GPU	Edge Appliance
Compute	AMD Ryzen 2600 + nVidia GTX 1080Ti (12 TOPs)	Layerscape LS1046
Power	~250W	~10W
Input Video	MI 6 trailer – 1080p	MI 6 trailer – 720p
Algorithm	YOLOv3	YOLOv3
Performance – (FPS)	25 fps	3 fps
CPU Utilization	100% 2 cores @ 3.4 Ghz + 85% GPU	100% 4 cores @ 1.8 Ghz

Great for Formula 1 close finishes.

Efficient at counting cars and people in a parking lot.

Watch LS1046 object detection sample @ <https://youtu.be/EEc5-oiccuM>

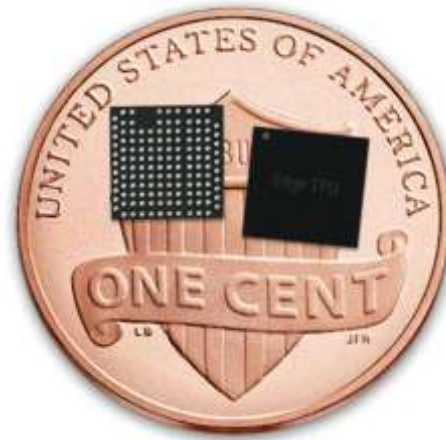
Choosing the Right Algorithm Matters

	Option 1	Option 2
Algorithm	FaceNet	MobileFaceNet
Inference Framework	Tensorflow	NCNN
Implementation	Tensorflow (Python)	C++ (no lib dependency)
Performance (LS1046 – 4x A72@1.8GHz)	4 core: ~200 msec	4 core: ~10ms 1 core: ~50ms
Accuracy (improvable with training)	99.6%	99.5%
Model Complexity (#weights)	19.5M	1M
Model File Size (MB @Float32)	93	4
OS	Linux	Linux, Android, RTOS

- AI algorithms and frameworks are rapidly evolving
- What works well on servers may not be optimized for the embedded edge
- General purpose cores may perform as well as accelerators for certain workloads

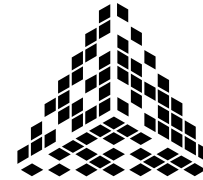
External Coprocessors Like Google Edge TPU Turbocharges AI on Layerscape

Model	Performance (connected through USB or PCIe)
GoogLeNet:	600 fps
Inception v2:	400 fps
MobileNet:	700 fps



NXP is working with Google to explore Edge TPU usage in professional/industrial markets.

NXP's Third-Party Ecosystem Simplifies Development



PILOT.AI

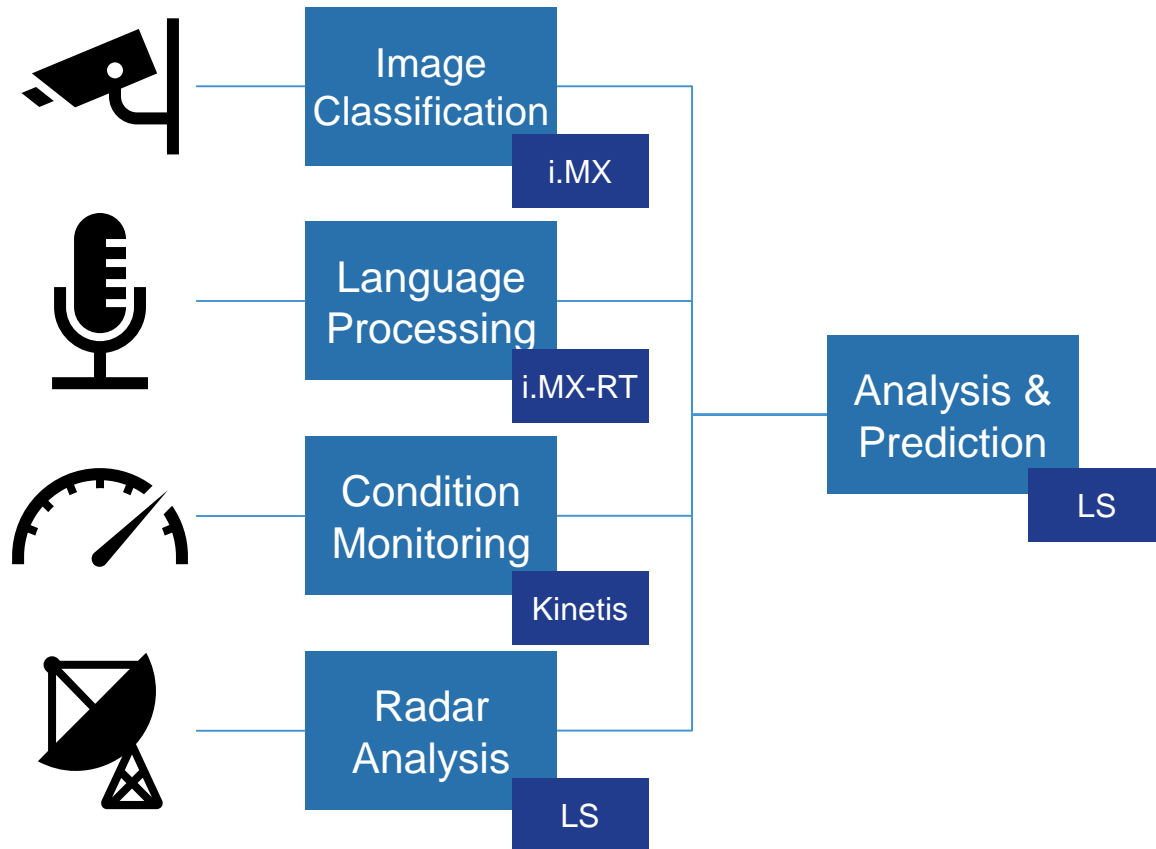


IN·VISION
ARTIFICIAL INTELLIGENCE



IRIDA LABS

Cascade Layerscape and i.MX Processors for Complex Designs



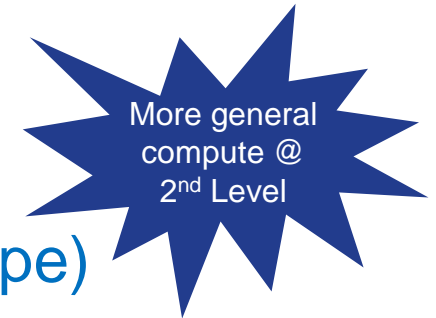
- **First-level functions (i.MX, LS, MCU)**

- Classify/perceive
- Recognize/model
- Preprocess

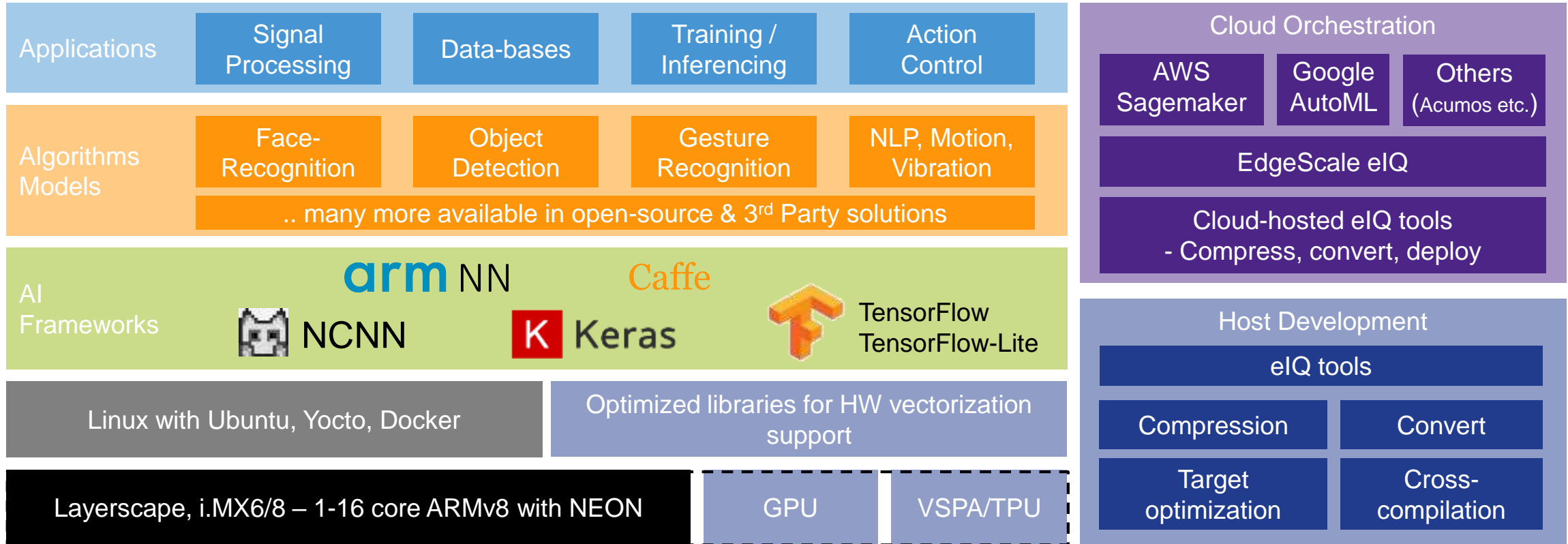


- **Second-level functions (LayerScape)**

- Fuse first-level inputs
- Interpret data and model behavior
- Predict and plan responses
- Log data
- Communicate



Edgescale and eIQ for AI on Layerscape & i.MX

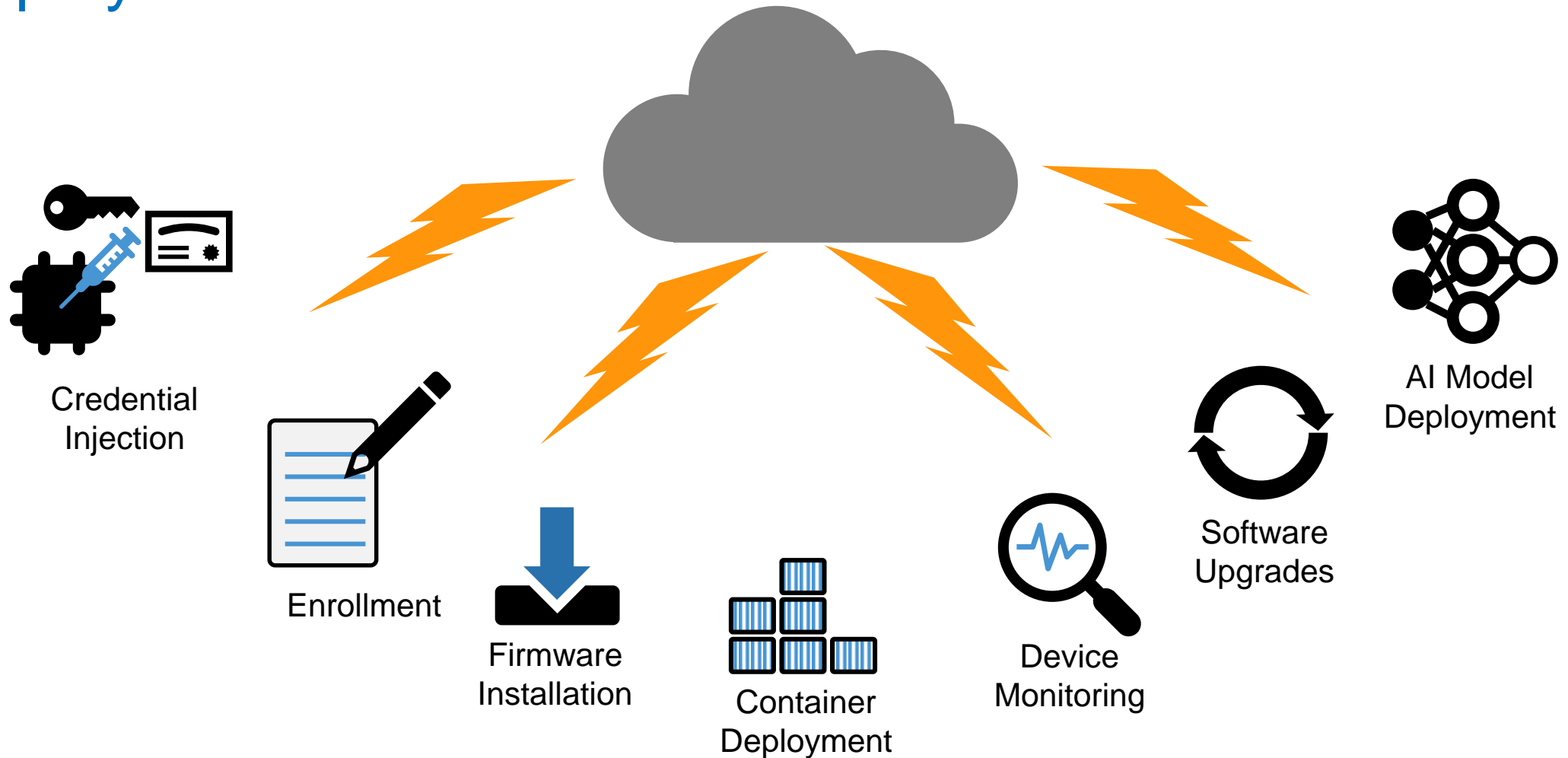


- NXP provides the right enablement for cloud-connected AI/ML applications @ Edge.
- Host-based eIQ tools for model conversion, optimization and target optimization.
- Edgescale leverages eIQ tools for cloud-based orchestration and integration with Sagemaker, AutoML etc.
- Helps customer leverage open-source frameworks, models and communities.

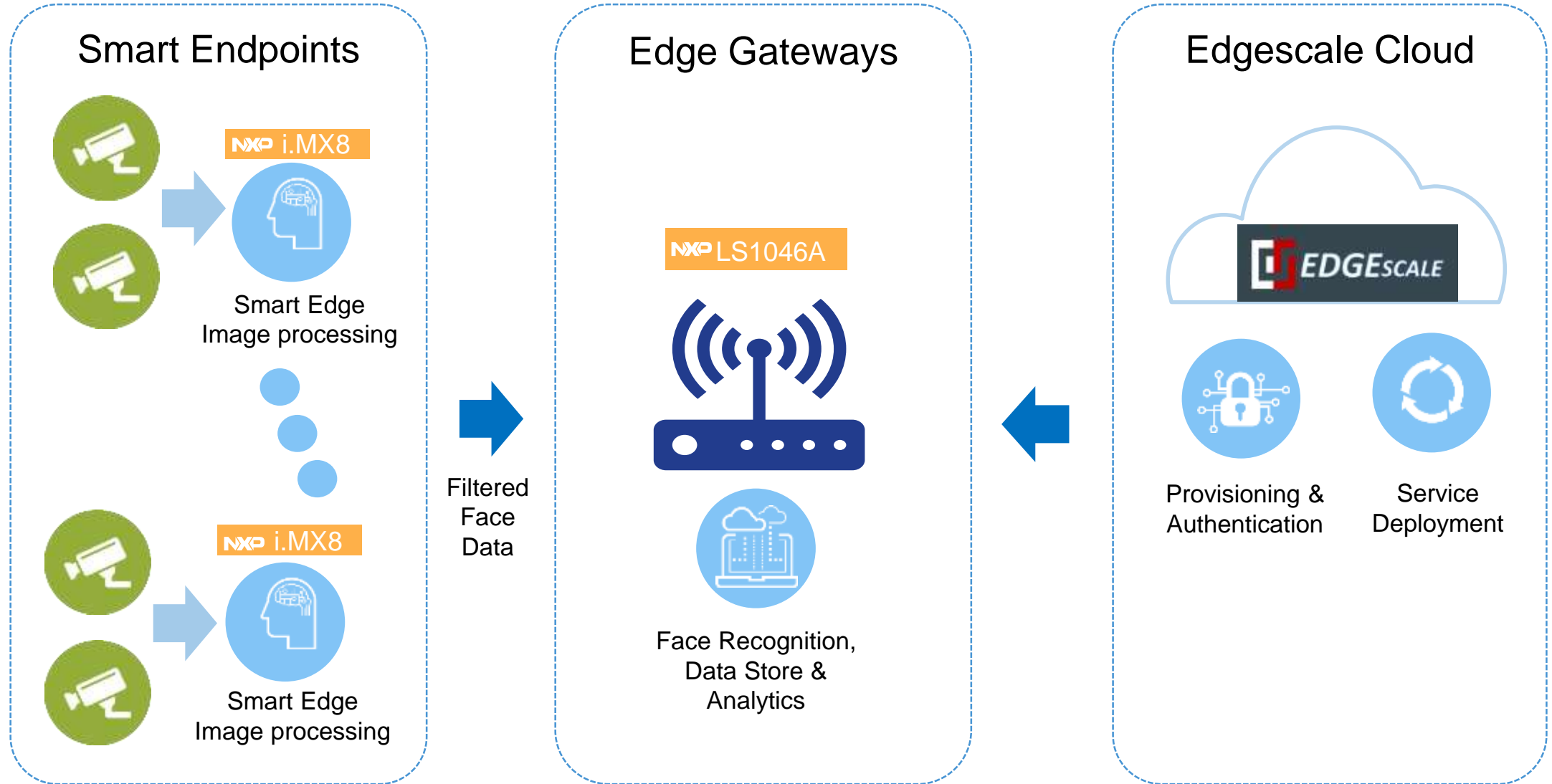
Layerscape SDK Simplifies Getting to AI “Hello World”

1. apt-get install python
2. > pip install tensorflow
3. Download a model and labels from https://www.tensorflow.org/lite/guide/hosted_models
4. > label_image --model *model* --labels *labels* --image *image*
5. Rest

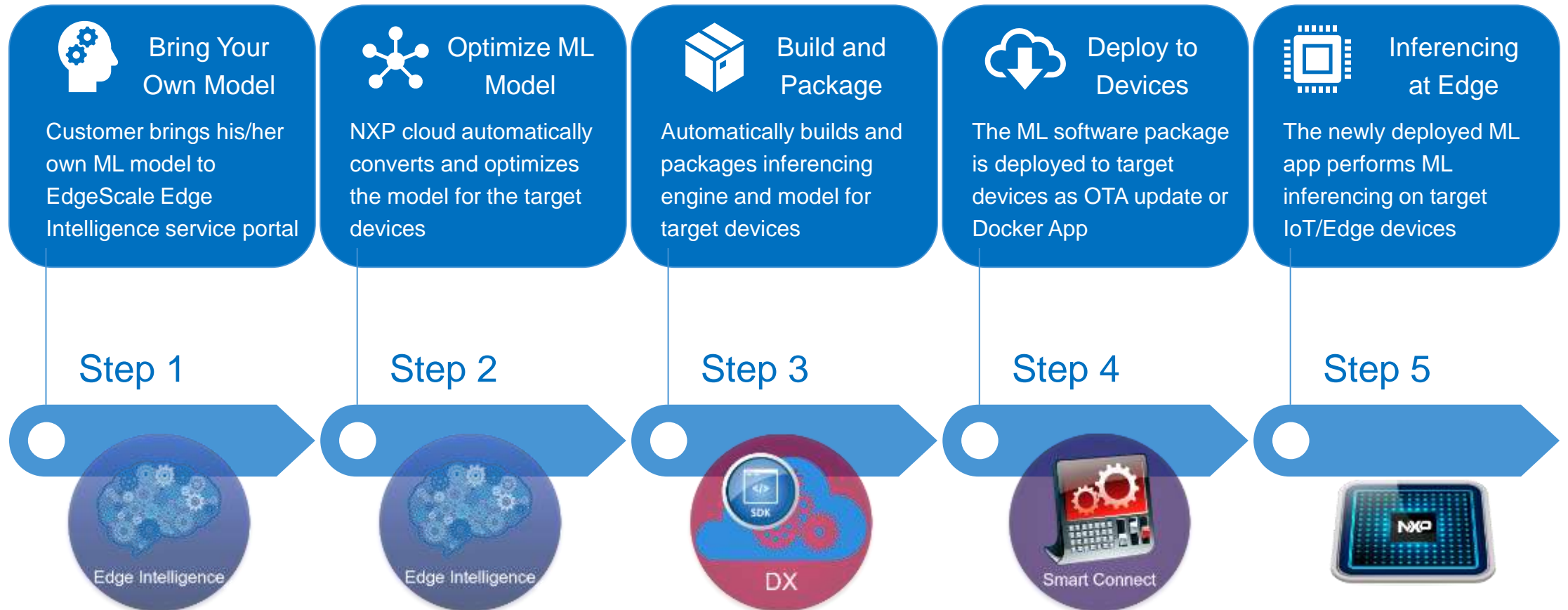
EdgeScale Cloud-Based Device Management Facilitates AI Deployment



Scalable Video Analytics Solution



AI/ML Developer Experience Example – Bring Your Own Model



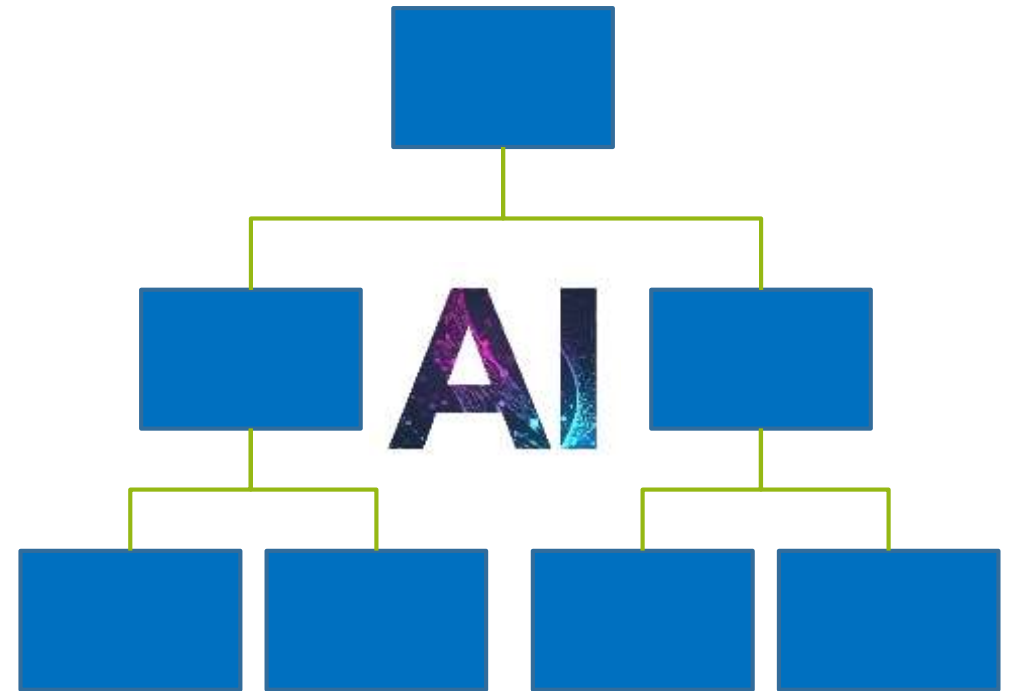


AI Acceleration Will Come to Even Low-Cost Processors

- Classification plus image-processing will yield semantic media formats
- AI will do stuff that digital or even analog circuits do today
- Video, speech, and text analysis and NLP will appear in unusual places

Collaborative Edge Topologies Will Amplify AI

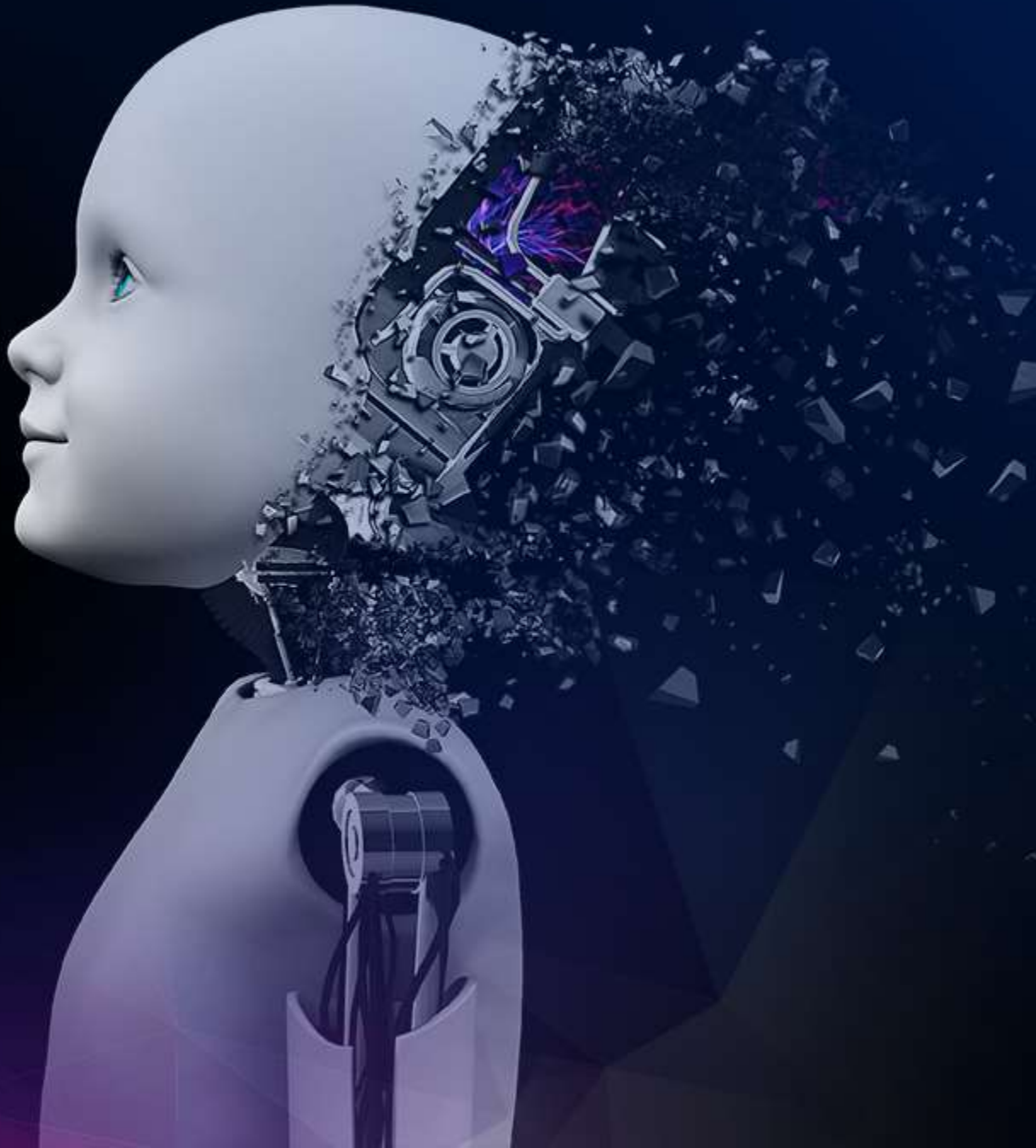
- End-node processor will do first-level classification, such as:
object location within field of view,
type, unique ID
- Second-level processor will do additional classification, predict objects' next moves
- Third-level processor will take action or stitch together second-level processors' assessments





Networking AI Systems Breeds New Edge-Based Applications

- HVAC starts cooling your office when security camera says you've arrived
- Security camera spies overheating coffee pot and warns fire system
- Emotion recognition system feeds into driver-performance system



Key Take-Aways

AI has numerous industrial uses

NXP has the hardware, software, and ecosystem to enable you to get started today

The power of AI will only improve

Next Steps for Developers

Think about how AI can enhance your business

Get started today: a lot of AI can be done with just CPUs

Explore hierarchical and peer-to-peer topologies

Prepare for a 10x performance gain





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