



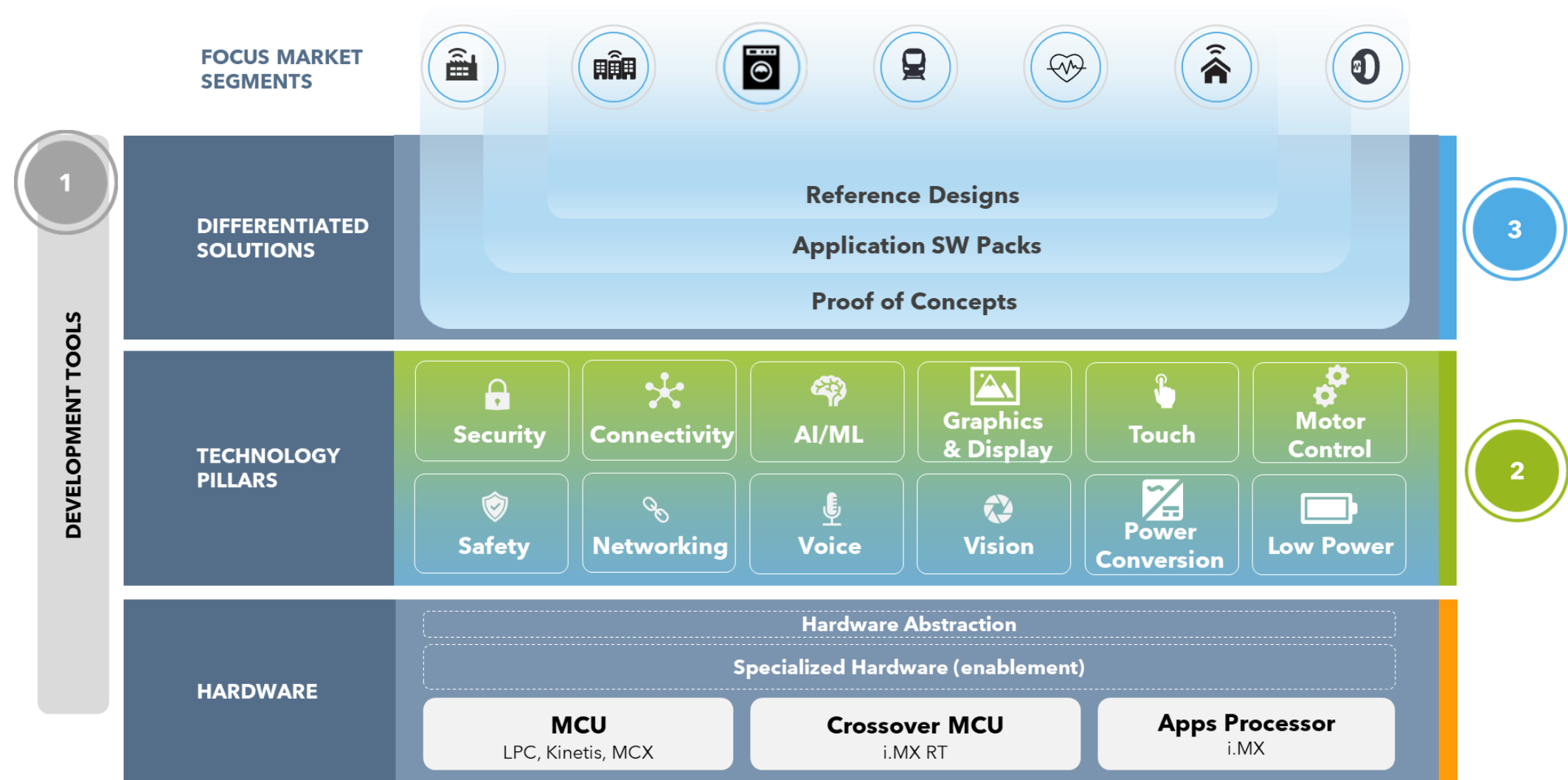
基于微处理器的工业解决方案： HMI/PLC/机器人关键技术

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恩智浦构建以解决方案为核心的价值链



Industrial Automation technology foundation

From Brownfield (Profinet, EtherCAT, CC-Link IE...) to Greenfield (TSN based, CC-Link IE TSN, OPC-UA,...)

Industrial Networking



Real-Time Execution

Time Aware architectures and SW enablement

Enabling industrial security standards (ie IEC62443,...), Regulations and secured communications.

Cyber Security



FuSa

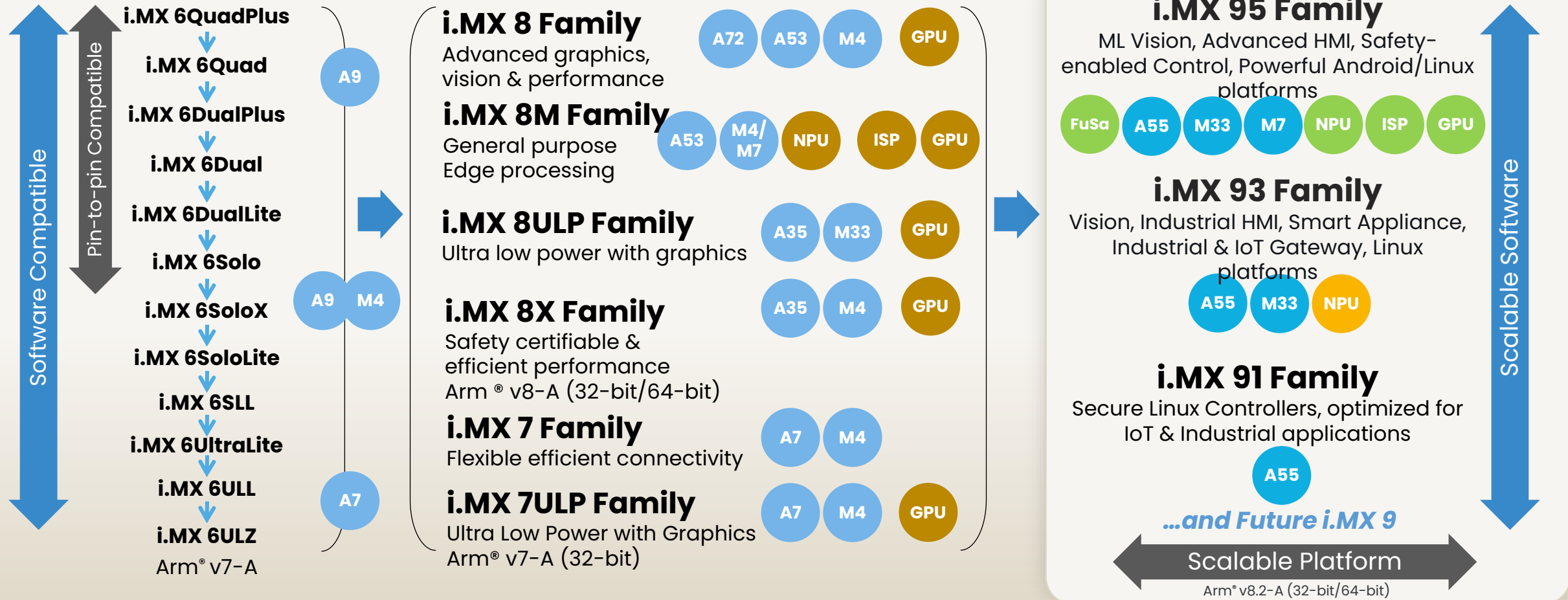
Enabling support of at IEC61508 on chip and system with both HW and SW concepts

Embedded Artificial Intelligence to the edge

eAI



i.MX 系列应用处理器扩展边缘计算处理能力



工业自动化应用概述

工业自动化领域的应用场景

NXP
适合产品

LS, IMX SE
(security)

LS,i.MX 6/8,
i.MX RT,
Wireless,
Field Bus

IMX RT,
DSC, KV,
KE, LPC

i.MX RT,
KV, DSC,
nAFE

Cloud, SCADA

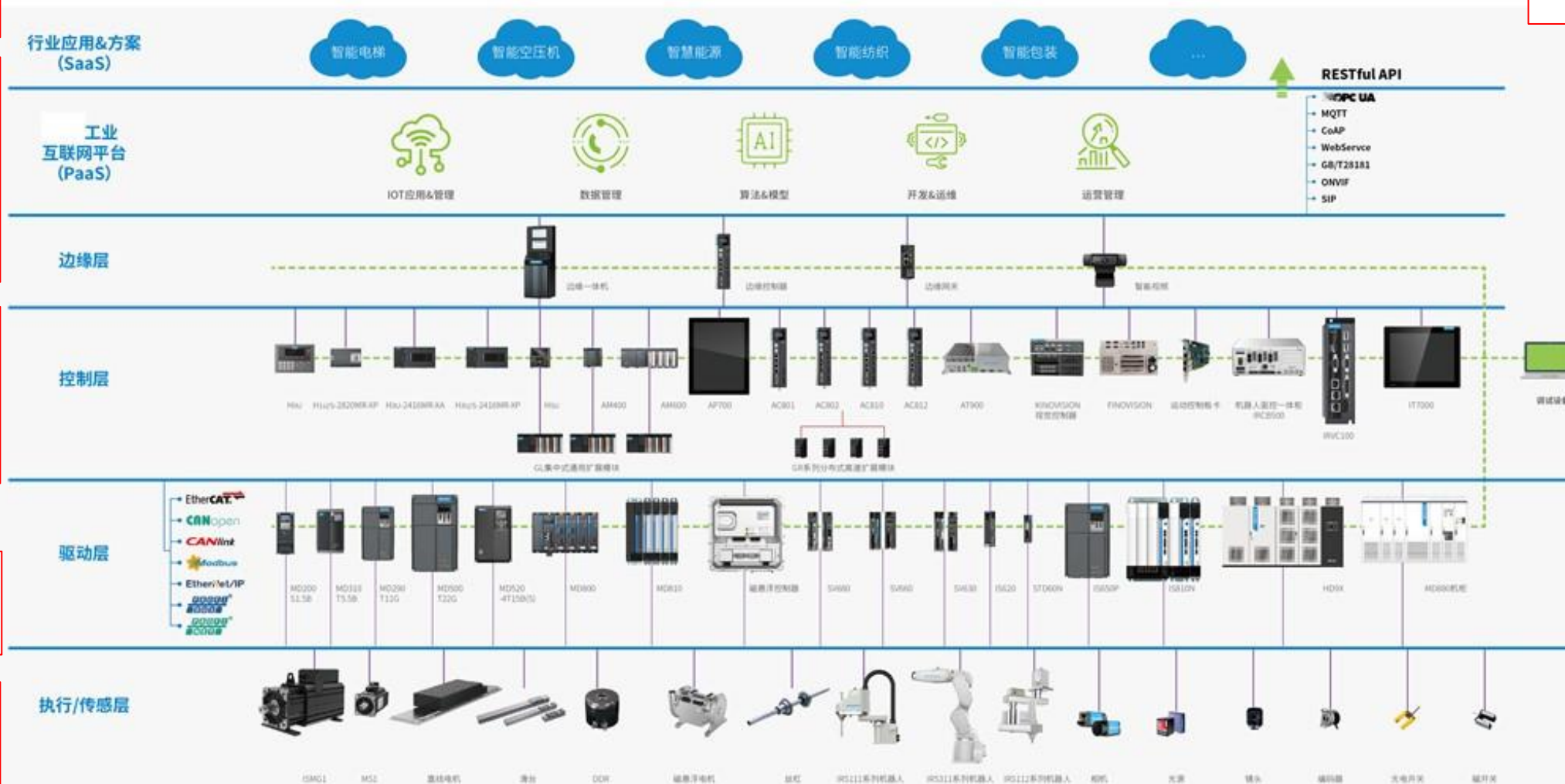
Motion
control
PLC,HMI
CNC,
Gateway,

Servo,
VFD,
stepper,
Robot,

Motors, Actuator

Vision, Encoder, Sensors

工业自动化&数字化综合解决方案



工业应用

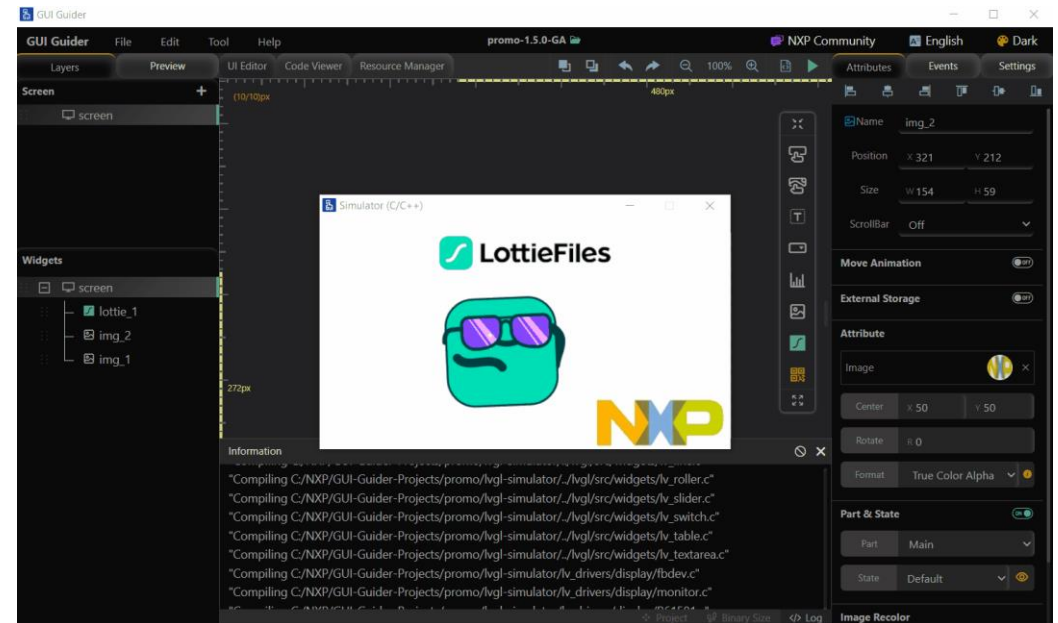
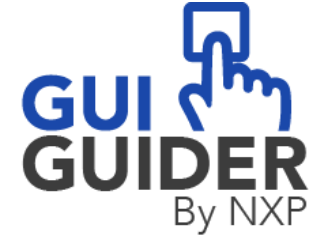
HMI



恩智浦图形界面开发工具包 – GUI GUIDER

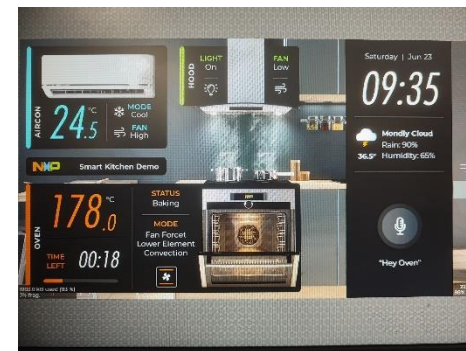
Available at <https://www.nxp.com/gui-guider>

- Offered by NXP for developing ready-to-run GUIs with open source LVGL graphics library
- Free for use with NXP devices
- Built in support for the following devices (can be used without a template)
 - MCX-N9-BRK
 - i.MX RT1170
 - i.MX RT1160
 - i.MX RT101x/2x/40/50/6x
 - i.MX RT500
 - LPC54628/54S018(M)
 - LPC55S06/55S16/55S28/55S69
 - **MPU: i.MX93, i.MX8ULP, i.MX8M, ...**
- More devices and functions will be supported in future releases.

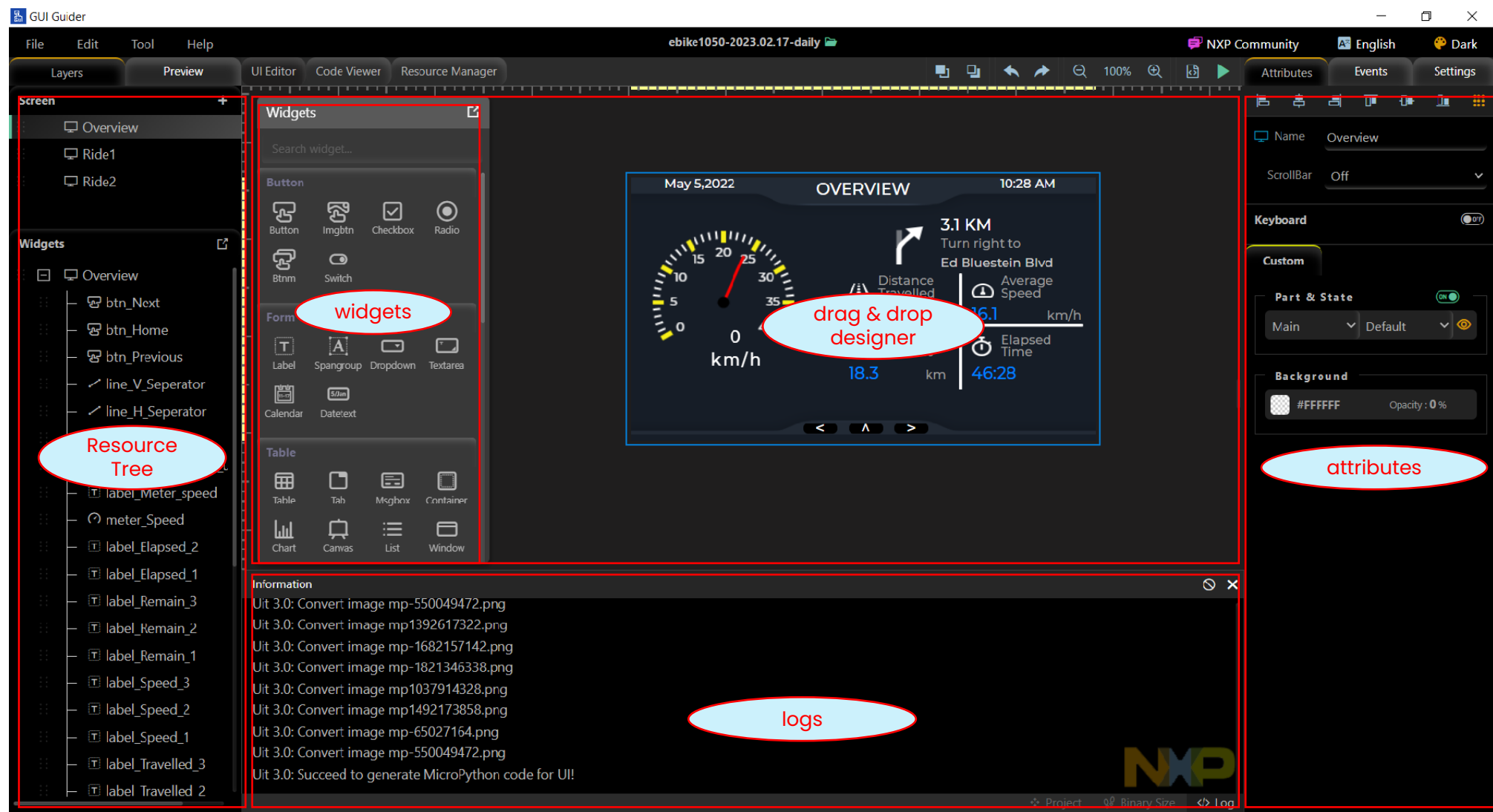


关键特性

- **WYSIWYG** UI designer with drag & drop support
- Ability to add LVGL widgets and configure widget attributes
- Ability to add events, actions and **animations**
- Support importing images/fonts and customizing fonts
- **GUI auto-scaling** for reusing GUI design on different boards
- Auto-generate **C / MicroPython** source files
- **Code viewer** and real-time log viewer
- Auto build and deploy on **simulator** and NXP MCU/**MPU**
- PXP and VGLite enable / disable (for applicable devices)
- **Project upgrader** and backward-compatibility
- **Multiple language**: English and Chinese
- Seamlessly integrate with MCUX, IAR, Keil and **Yocto SDK**
- **Cross host OS**: Windows, Linux and macOS
- **Multi target OS**: FreeRTOS, Zephyr, RT-Thread, **Linux**
- Two LVGL versions support
- Reference design(smart home, smart kitchen, e-bike, medical device and more) [website](#)



所见即所得的开发模式



开发流程图

Create Project

Select LVGL Version

v7.10.0

Printer

An example to design printer UI which

ProgressBar

An example to demonstrate how to

ScreenTransition

An example of two screen application, it

SDcardStorageFor...

An example to use SDcard storage images.

SliderProgress

An example of using slider to adjust

SwitchWidgets

An example of switch widget usage, it

VideoPlayer

An example to show the video player.

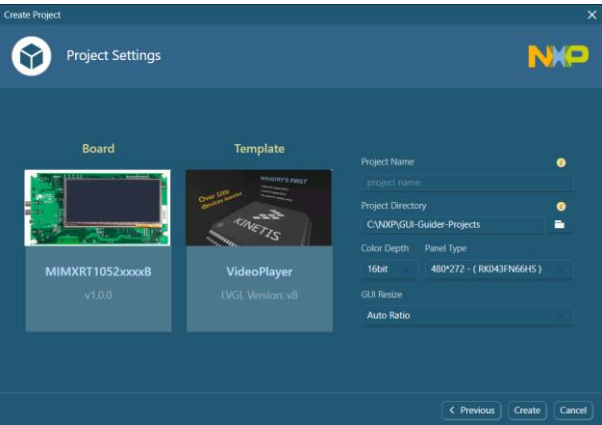
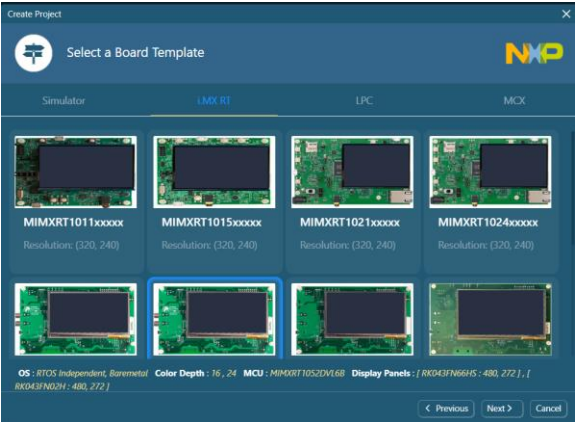
Name : *VideoPlayer* LVGL : *v8* Description : *An example to show the video player.*

< Previous

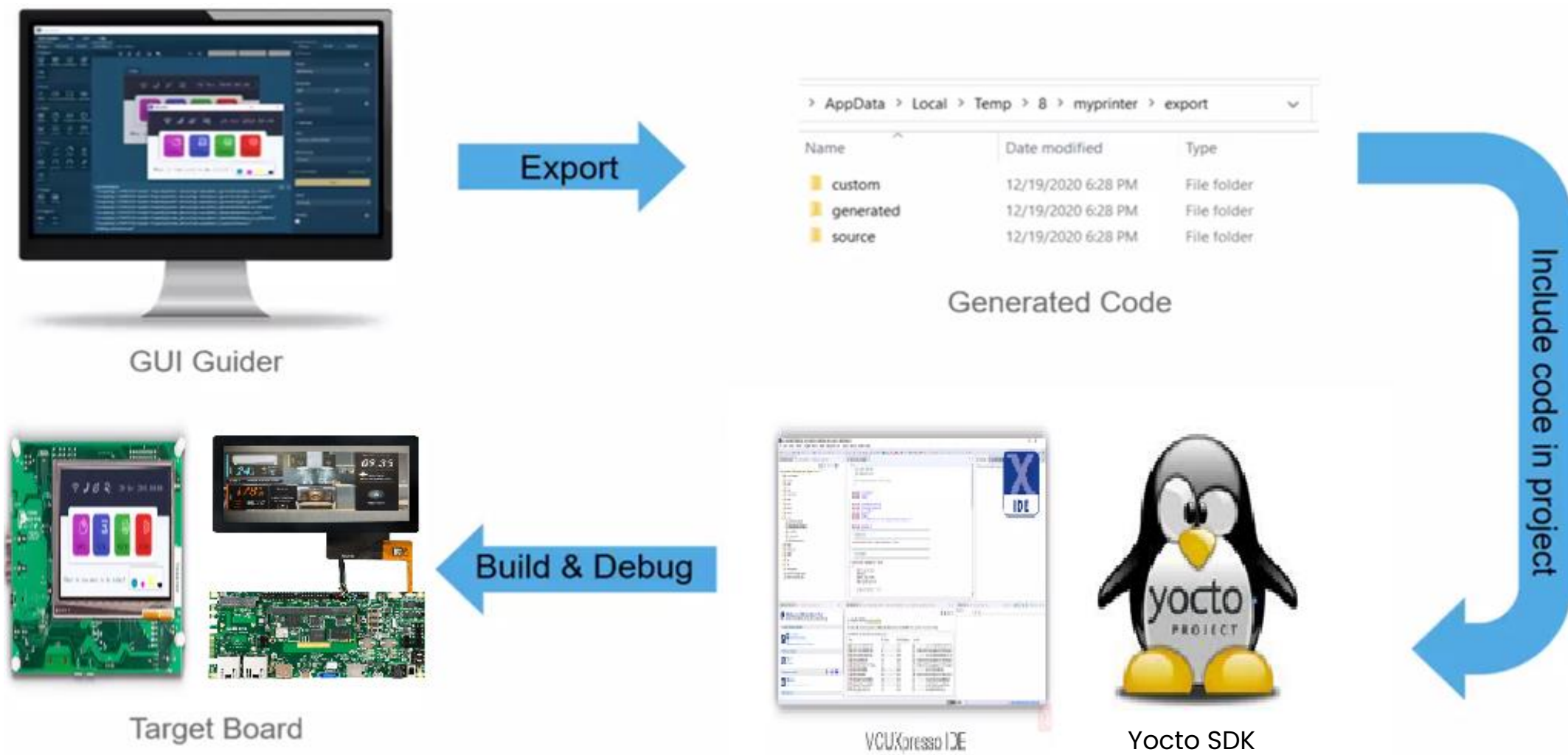
Next >

Cancel

4. Project settings



Linux 快速部署

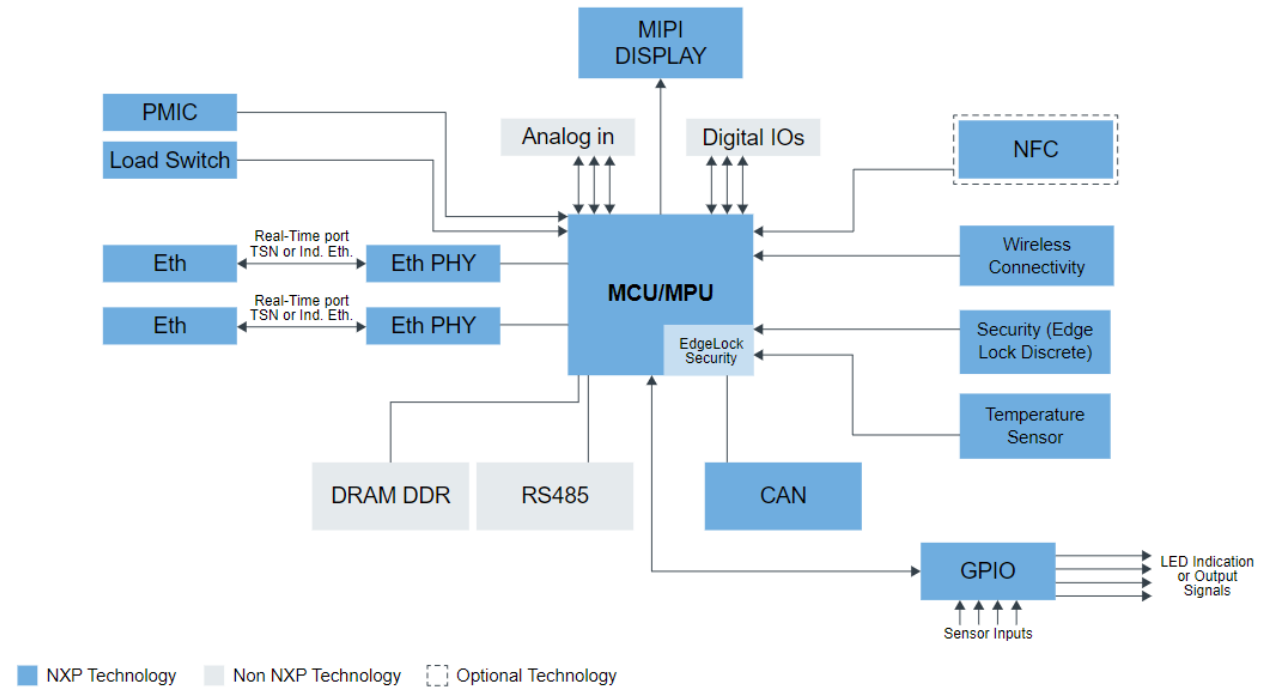


成功案例分享

Application: Industrial HMI

Part Number: i.MX 6ULL, i.MX 93, i.MX 8M Plus

Robust industrial-grade solutions featuring rich graphics capabilities transform complex manufacturing processes into legible and actionable displays for use nearly anywhere.



工业应用

PLC



NXP EtherCAT 主站解决方案

Use Case	Product recommend	IGH (Control loop time)	Codesys PLC Control loop time)	SOEM (Control loop time)
<8 Axis	RT1064			125us~1ms
<8 Axis	RT1170			125us~1ms
<8 Axis	IMX6ULL	125us ~ 4ms	1ms~4ms	
8~64 Axis	IMX93	125us ~ 4ms	1ms~4ms	
8~64 Axis +HMI	IMX8Mplus/IMX8Mmini	125us ~ 4ms	1ms~4ms	125us~4ms
8~64 Axis robotics	LS1043A	125us ~ 4ms	1ms~4ms	
10~128 Axis multi-Master	LS1028A/LS1046A	125us ~ 4ms	1ms~4ms	

i.MX 8M Plus PLC 参考示例介绍

Features

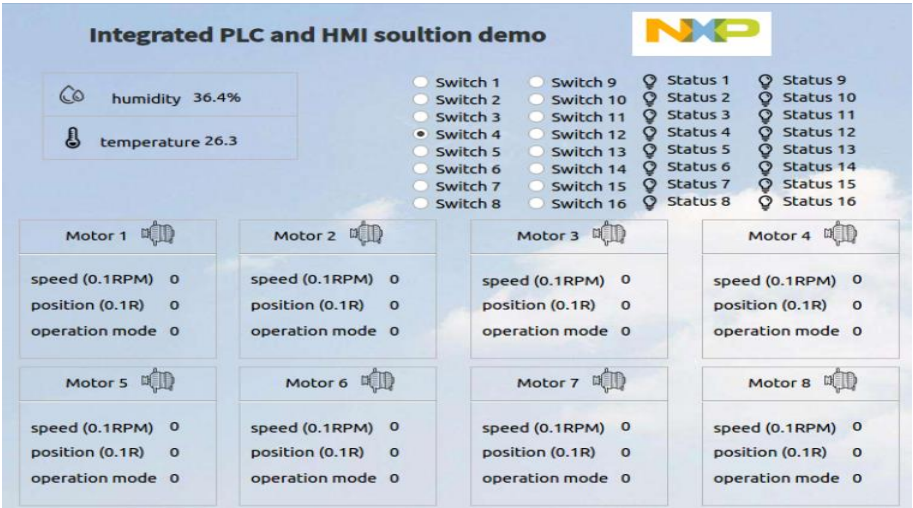
- EtherCAT master with multiple motor axis control capability
- Open source Igh-EtherCAT protocol stack support
- Opcua, Modbus, Ethernet and RS485 industrial bus support
- Temperature and humidity acquisition and monitor
- Integrated open source OpenPLC and ScadaBR system
- Supervisory control and data acquisition via QT HMI
- Multi-channel output voltage control and input voltage acquisition
- Remote IO switch and power control

Target Applications

- Factory automation
- Digital manufacturing
- Smart energy

Main Components

- i.MX 8M Plus
- Commercial 8 Axis Servos



PLC应用参考示例

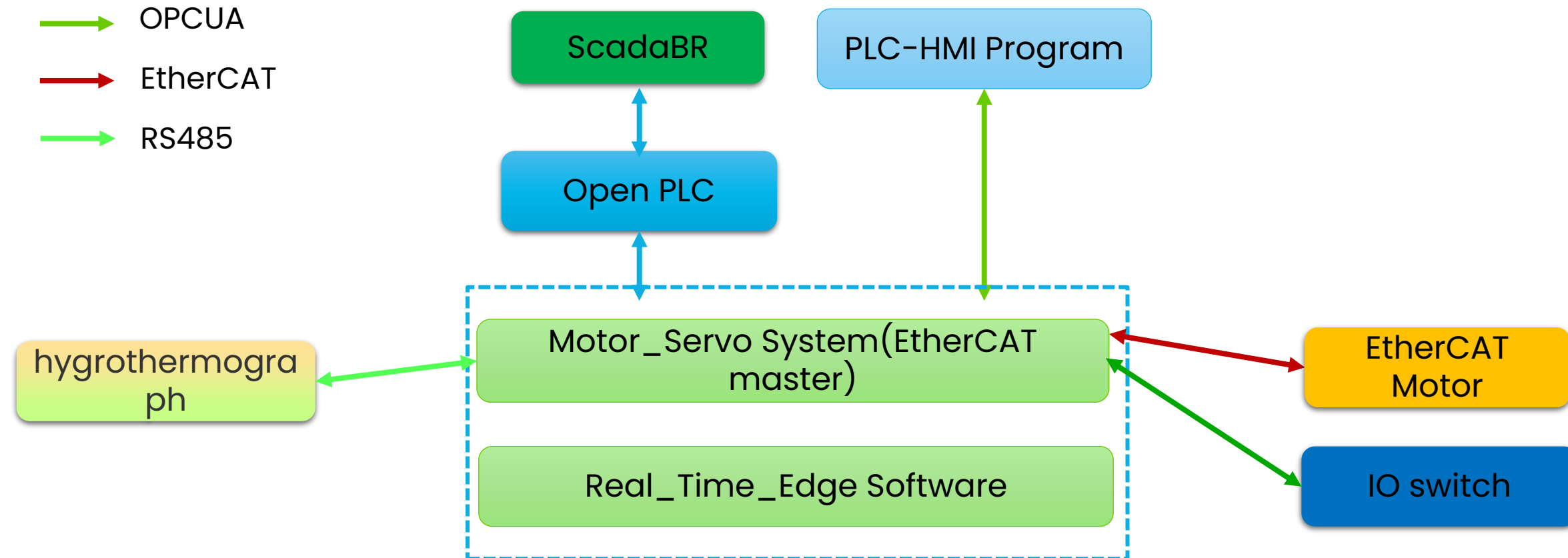
• Connection type:

→ Modbus TCP

→ OPCUA

→ EtherCAT

→ RS485

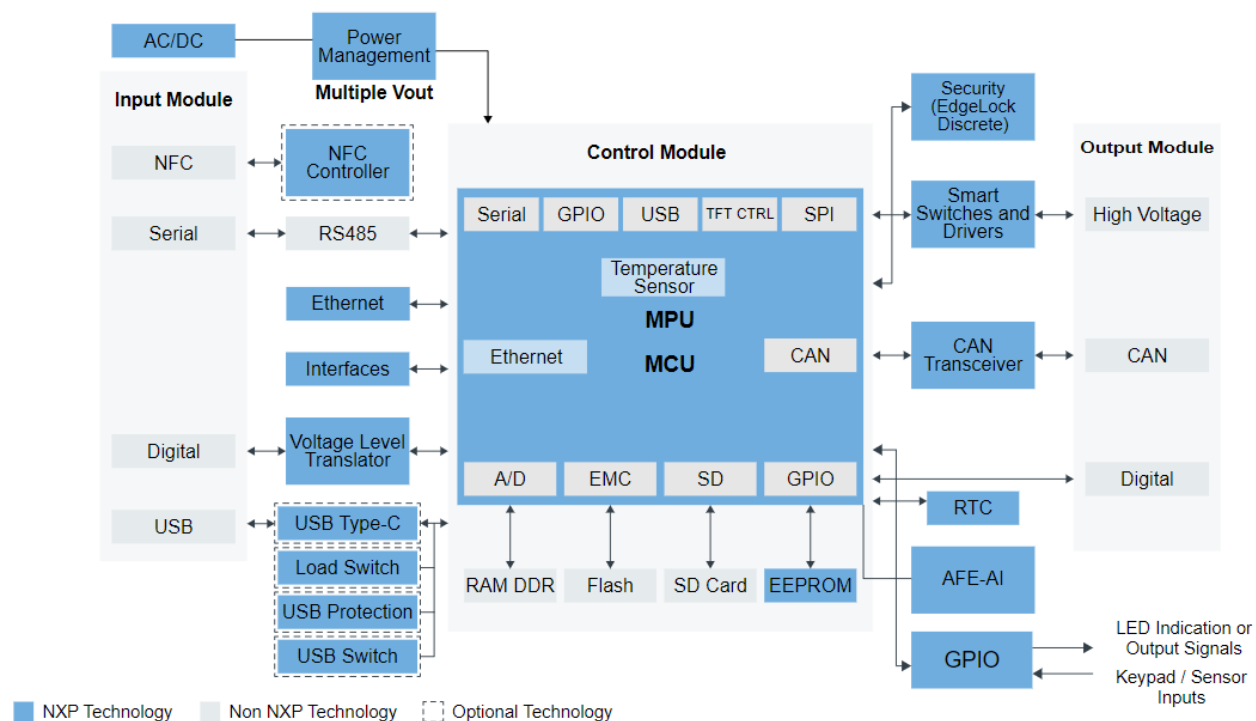


成功案例分享

Application: PLCs and Remote IOs

Part Number: i.MX 6ULL, i.MX 93, i.MX 8M Plus

Secure, safe and reliable real-time computing solutions are required for panel-mounted controllers and distributed control systems that precisely manage machines and processes.



工业应用

移动机器人



工业移动机器人的定义和差异

AGV, AMR, UAR, MPR?



AGV – Automated guided vehicles 自动导引车

- 仓库内程序化自动作业
- 感知和处理能力有限
- 在静态环境中使用人工特征（标记、代码、磁条等）进行导航



AMR – Autonomous mobile robot 自主移动机器人

- 可以自行规划路线
- 更强的感知能力和更高的智能
- 在动态环境中通过确定自然特征（SLAM或vSLAM）进行导航



UAR – Unmanned aerial robot 无人机

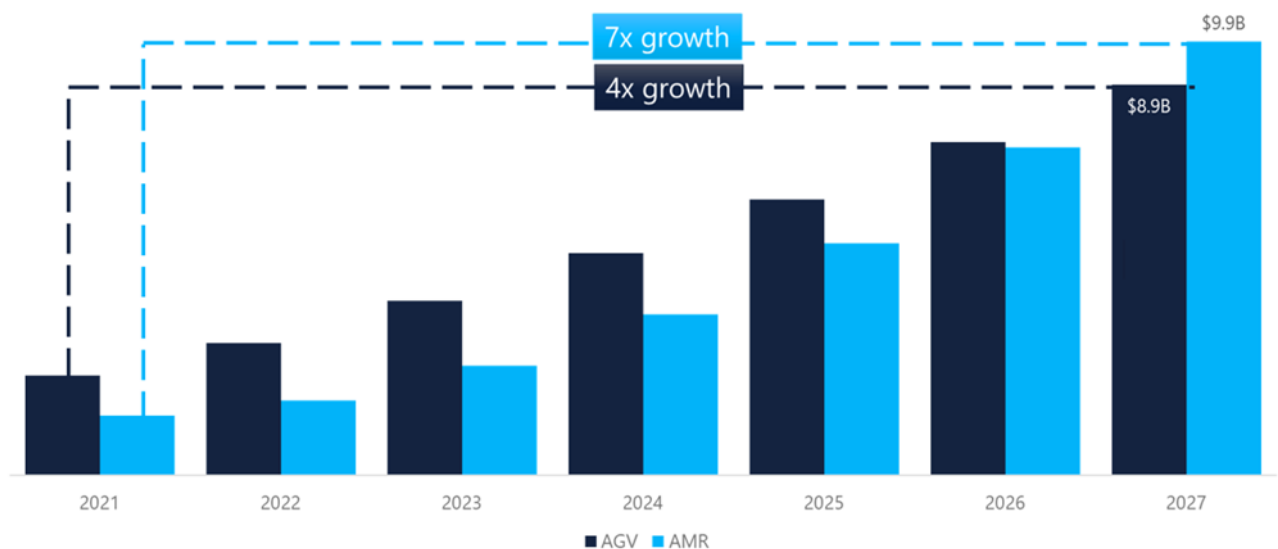
- 不接触地面
- 远程控制、自动化或自主飞行能力
- 自主模式需要智能导航能力



MPR – Mobile picking robot 移动式分拣机器人

- 用于自主物料处理和分拣任务
- 需要最高水平的智能
- 必须具备高级环境感知能力，需要的多传感器融合算法

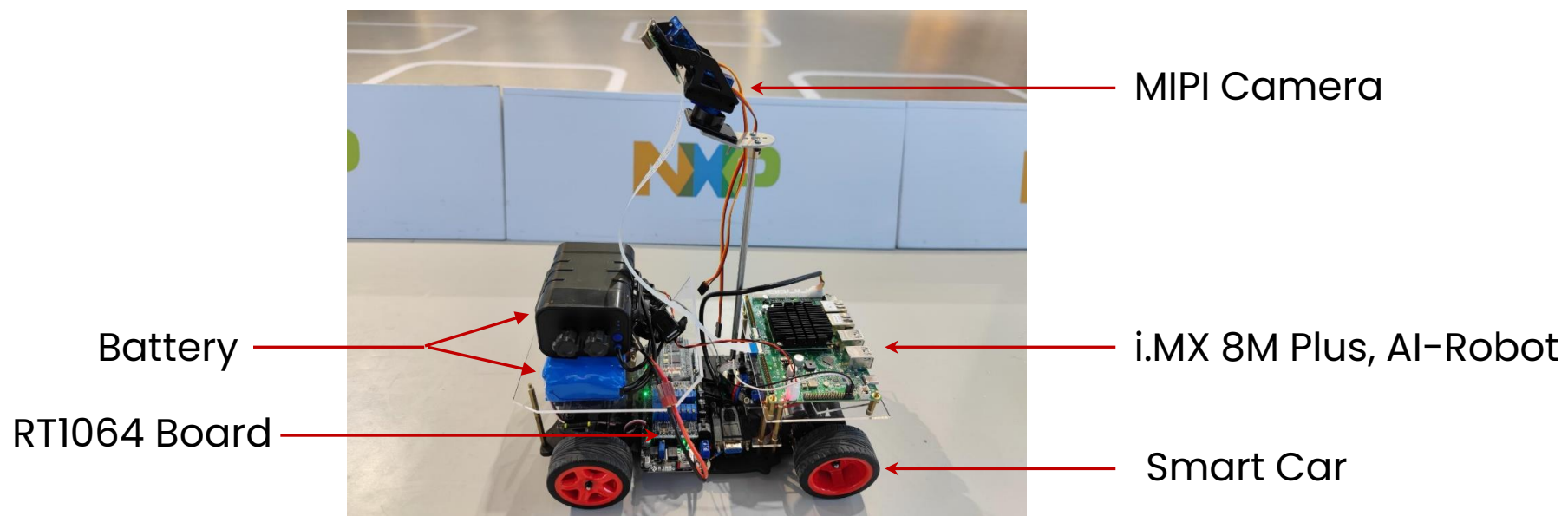
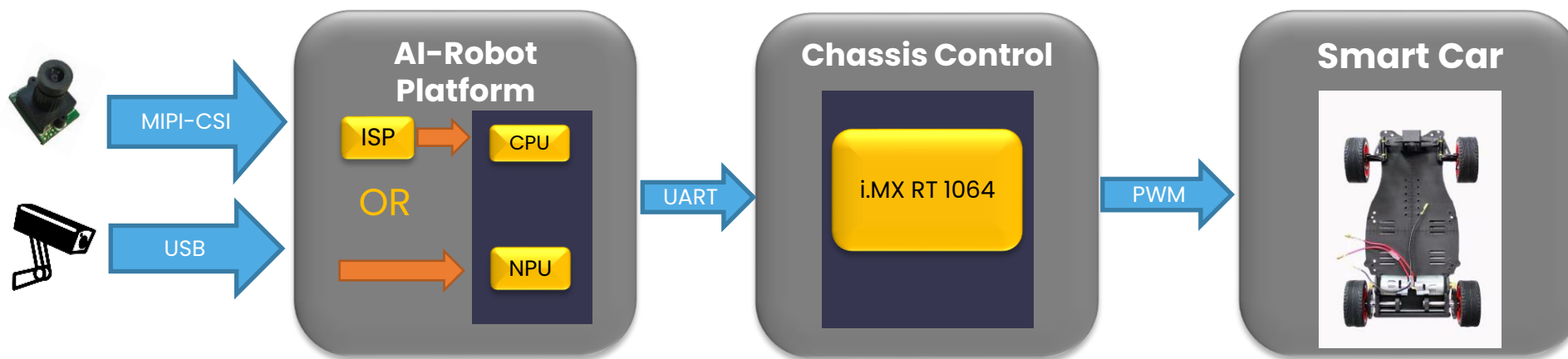
工业移动机器人市场分析与亮点展望



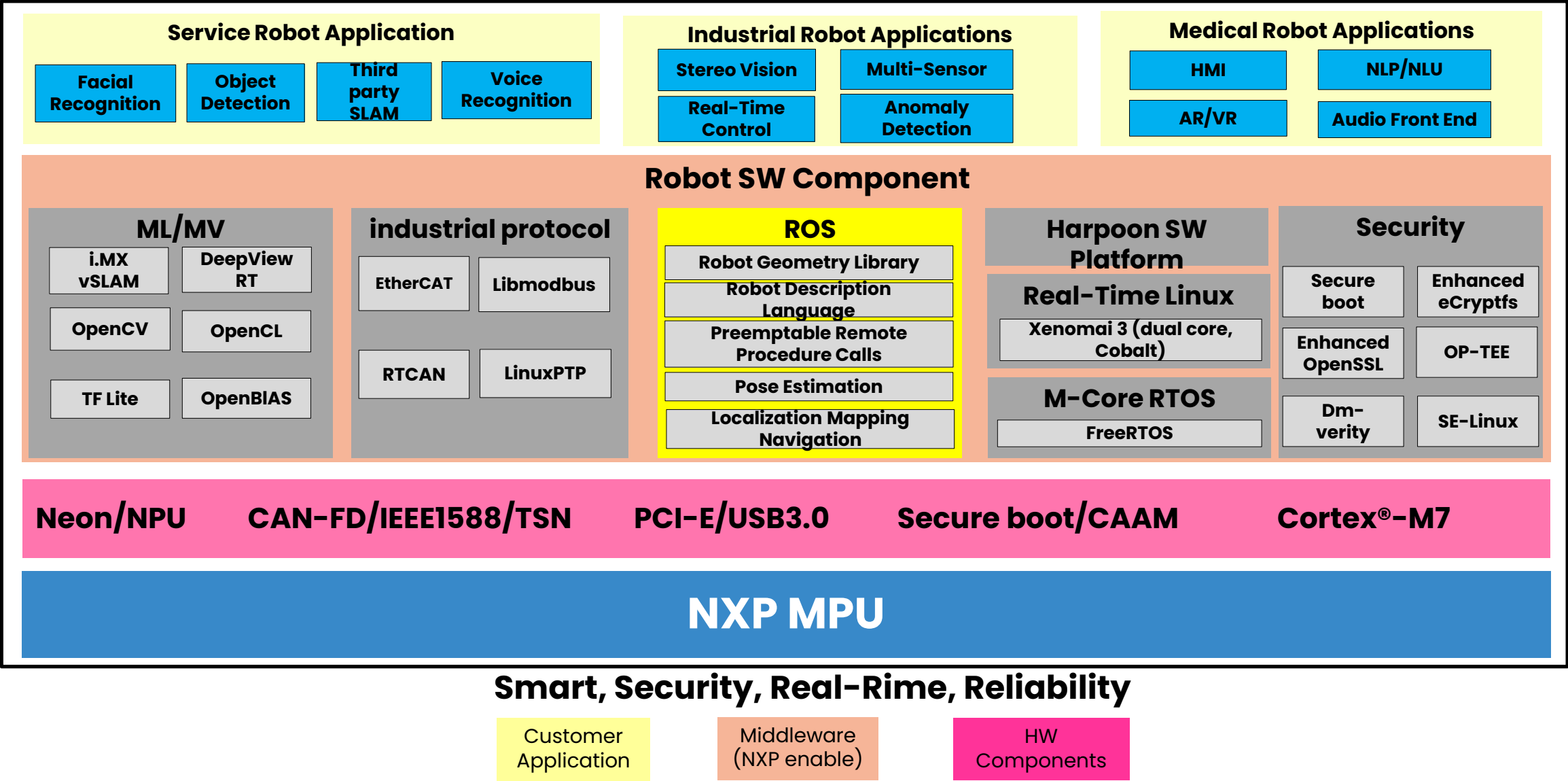
亮点:

- AGV/AMR是仓库自动化市场的关键要素，2027年市场容量将超过400亿美元
- AGV复合年增长率24%
- AMR复合年增长率为43%
- 2027年全球安装数为240万（AGV和AMR）
- 移动分拣机器人-MPR将成为重要的新类别，复合年增长率>45%
- 在需求和供应方面，**中国市场**都被认为是AMR的核心
- 由于劳动力成本优势和中国自身巨大的批量消耗，**中国制造**的AMR将更经济30%-40%
- 有吸引力的新兴应用领域是配送、零售、健康和清洁，复合年增长率>35%

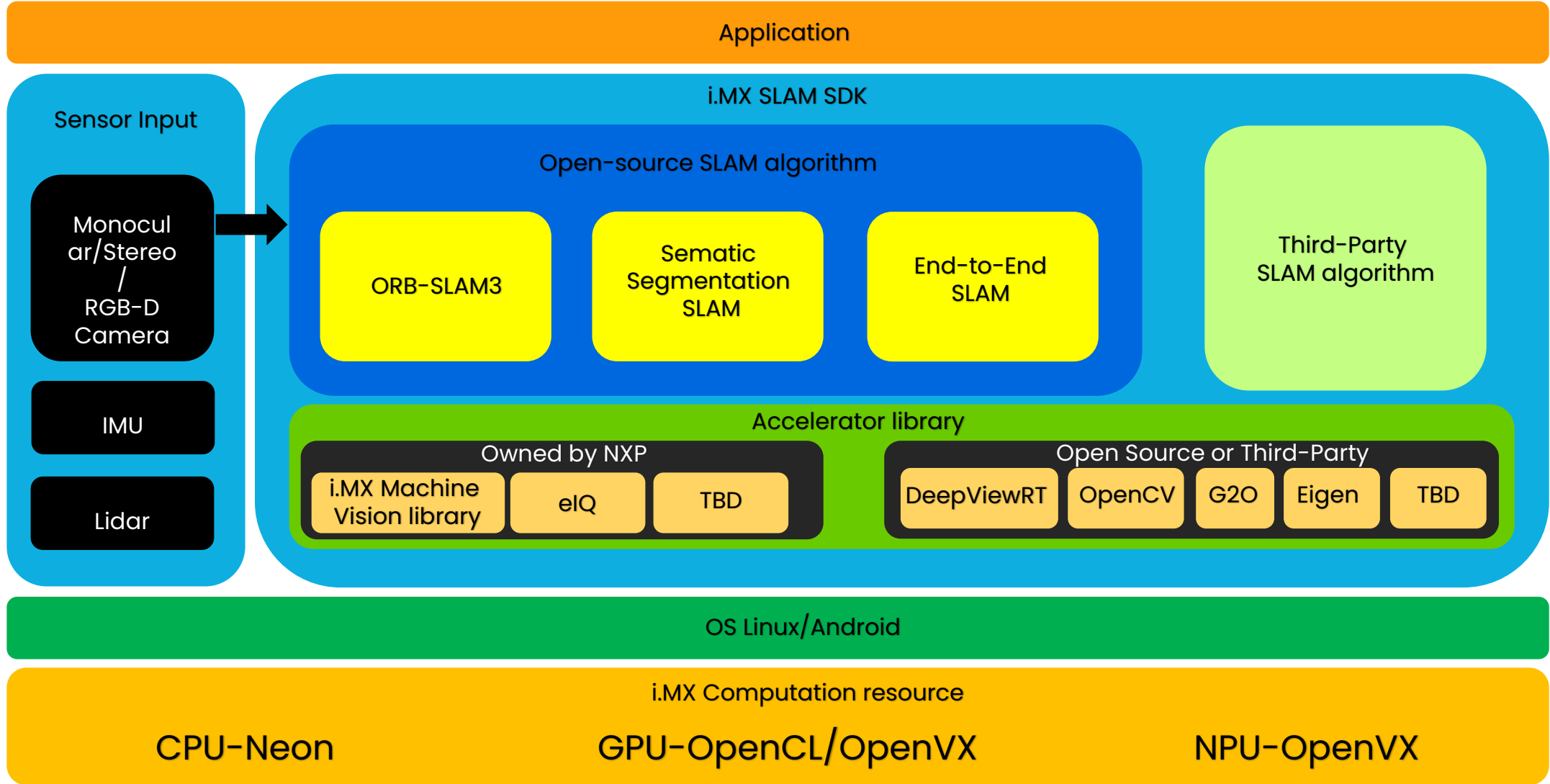
i.MX 8M plus - AI-ROBOT 简介



AI-ROBOT 平台参考设计

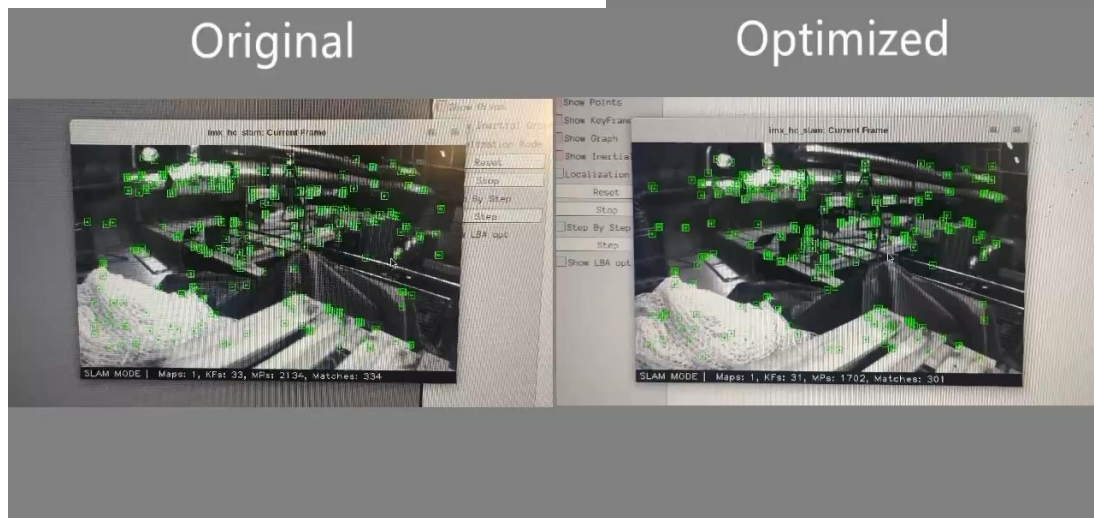


恩智浦 i.MX 8M Plus 平台 SLAM SDK



基于恩智浦应用处理器的视觉处理边缘计算实例

The average execution time of tracking for one frame is reduced from **55ms** to **29ms**.



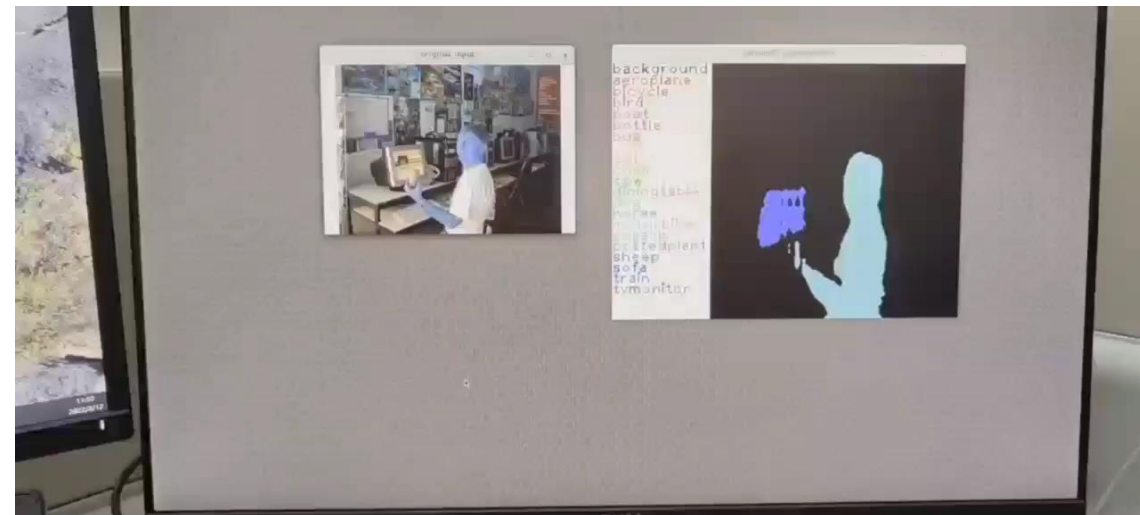
FPS: 18
CPU loading: 120%

Parallel computing

NEON/OpenCL

FPS: 34
CPU loading: 130%

ORB-SLAM3 运行于NXP i.MX 8M Plus应用处理器



图像分割算法SEMANTIC示例运行于NXP i.MX93 应用处理器

恩智浦AGV/AMR参考实例



Line Patrol:

CNN model :

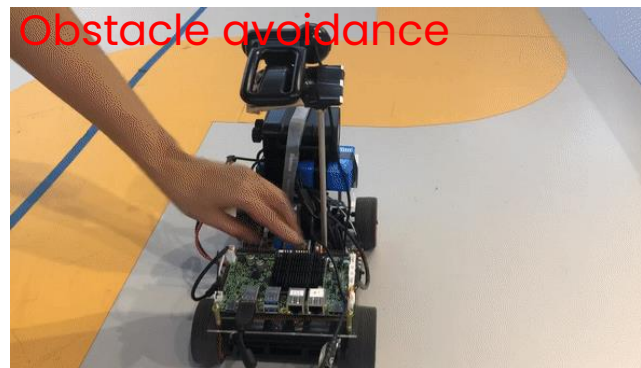
1. Use pretrained Resnet18 model and modify output as a 2D vector
2. Re-train the model with a new dataset (less than 300 samples)

Training framework: PyTorch

Model quantization tool: Tensorflow

Inference engine: eIQ TFLite inference engine

Inference time on NPU: 7.72ms



Obstacle Avoidance:

Image classification model :

1. Modified last layer of Alexnet to a binary classification model.
2. Re-train the model with a new dataset

Training framework: PyTorch

Model quantization tool : eIQ Toolkit

Inference engine: eIQ TFLite inference engine

Inference time on NPU: 7.8ms



Target Following:

Object detection model : MobileNet-ssdV2

Training framework: Tensorflow

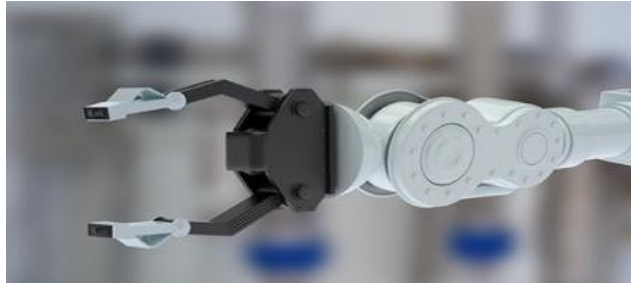
Model quantization tool: TFLITE

Inference engine: eIQ, TFLite

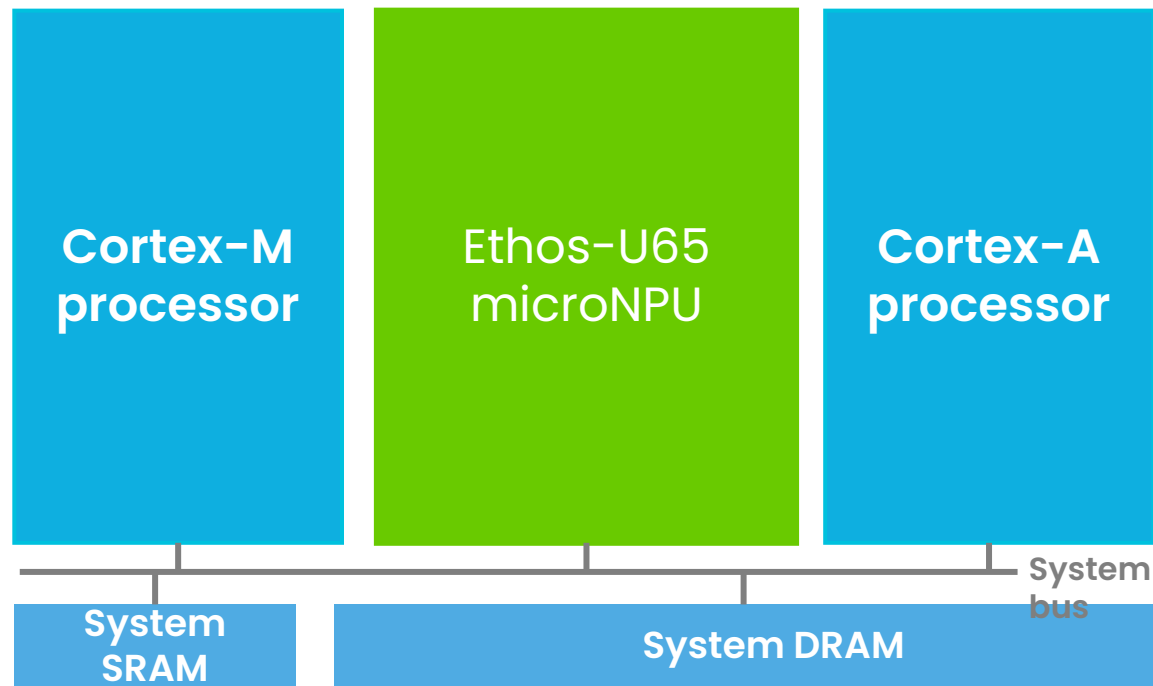
Inference on NPU: 15ms

i.MX 93 industrial and consumer IoT target applications

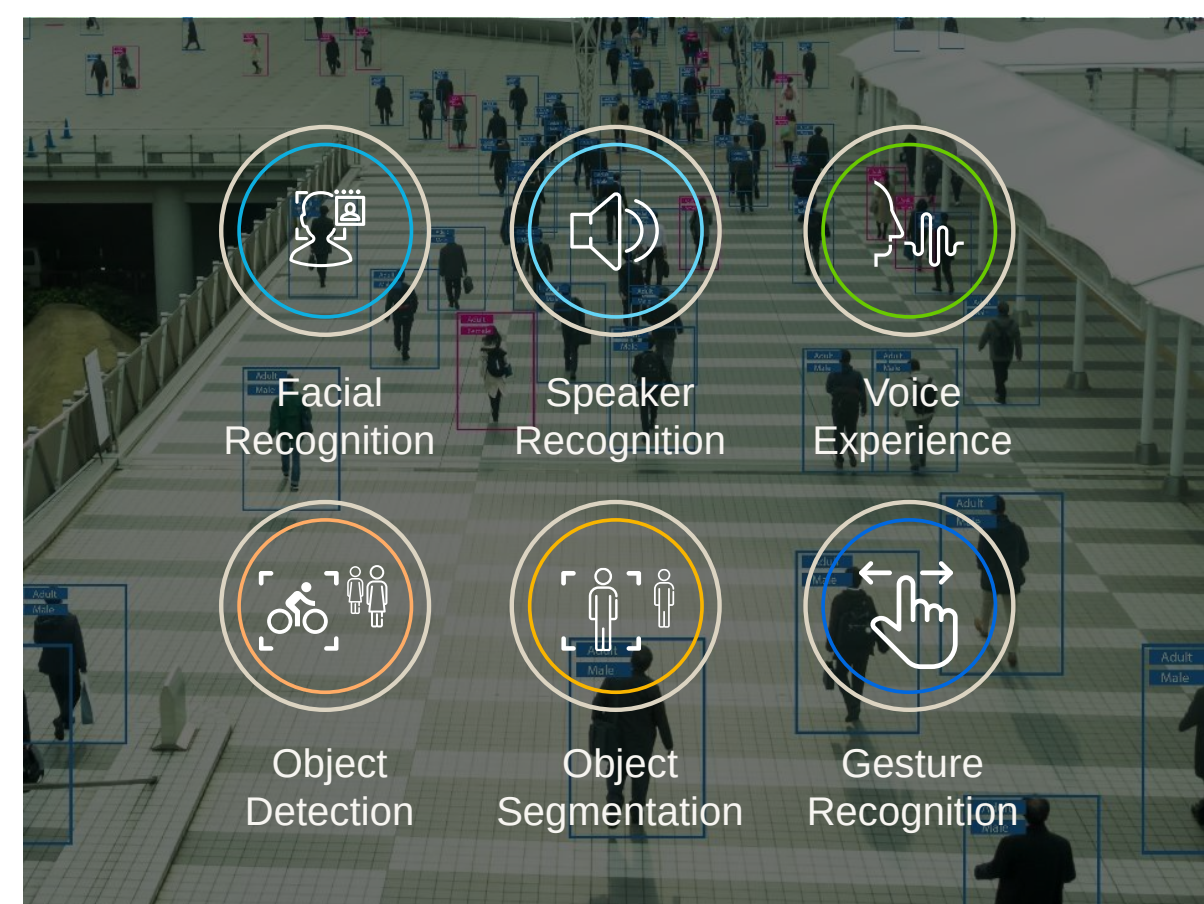
Industrial Automation	Smart Home	Smart City	Building Control & Energy
- Machine vision and scanning - Industrial HMI - Industrial gateway - I/O control - Combines with i.MX RT1180 for larger gateways and IO controller	- Home security hub - Smart doorbell - Smart lock - Hue Bridge - Audio soundbar	- Smart lighting - Safety and security - Traffic control	- Access control - Energy meter - Energy grid equipment - EV charging station - Environmental control - Sensor hub



Expanding edge ML with Arm® Ethos™-u65



- High efficiency and small memory footprint
- HW acceleration for high compute NN + Cortex-M for other operations
- Model compression and on-the-fly weight decompression
- Optimization strategies for DRAM and SRAM
- Comprehensive software and tools with NXP's eIQ® ML Software Development Environment



**BRINGING MCU-CLASS
ML EFFICIENCY TO THE
CORTEX-A WORLD**

i.MX 93 NPU vs Arm® Cortex-A55 performance

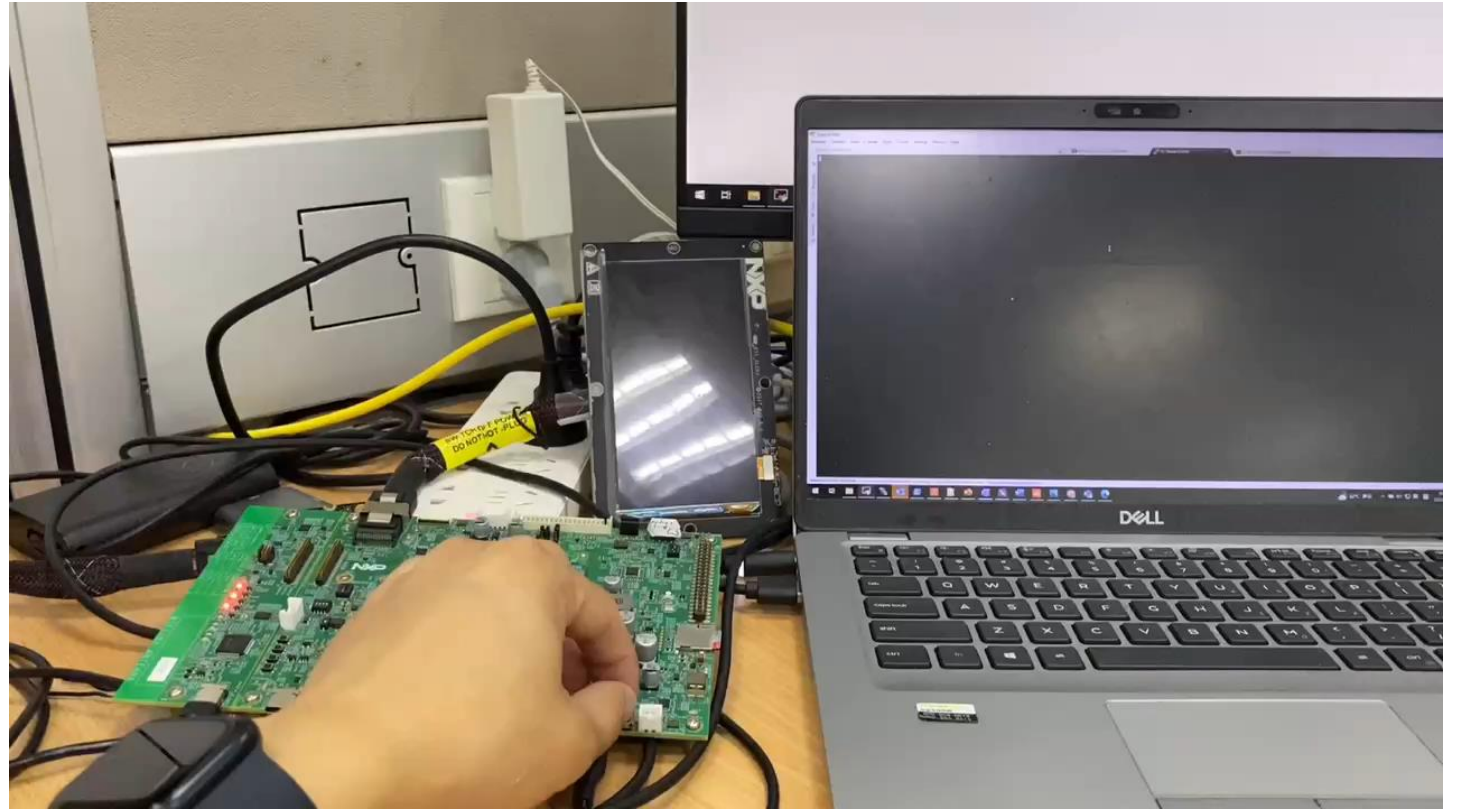
Model	i.MX93 EVK with Ethos-U65 NPU (fps) @ 1 GHz	i.MX93 EVK with A55 Single Core (fps) @ 1.7 GHz
mobilenet_v1_1.0_224_int8 (PCQ)	236	13
mobilenet_v2_1.0_224_int8(PCQ)	282	14
mobilenet_v2_1.0_224_int8(PTQ)	283	14
mobilenet_v3-large_224_1.0_int8(PCQ)	164	13
mobilenet_v3-small_224_1.0_int8(PCQ)	550	39
mobilenet_ssd_v1_int8(PCQ)	98	6
mobilenet_ssd_v2_int8(PCQ)	76	2
mobilenet_ssd_v3_large_int8(PCQ)	90	7
mobilenet_ssd_v3_small_int8(PCQ)	201	18
yolov4--416_int8(PCQ)	5	3
yolov4-tiny-416_int8(PCQ)	45	1

Clear trend
showing
importance of
dedicated NPU

- Used NPU PMU counter to collect NPU cycles

i.MX 93 SoC fast boot and lvgl gui

- 1.2s for uboot logo
- Total 2.8s for LVGL GUI

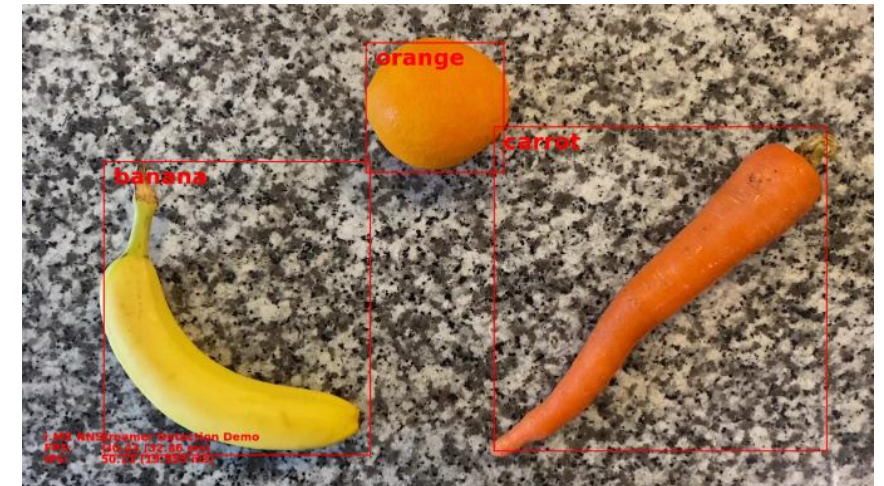
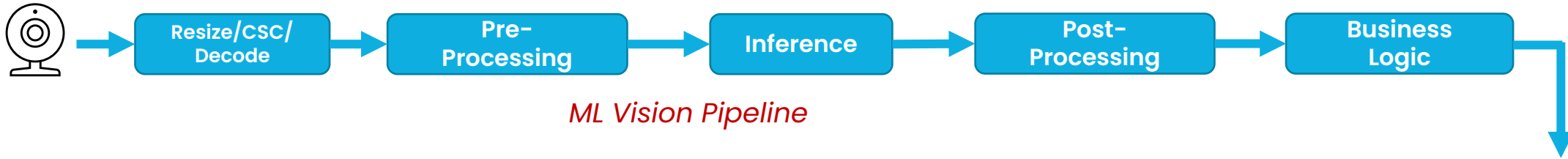


i.MX 93 SoC object detection

- **ML models that are used in the object detection demo**

- ssd_mobilenet_v2_vela.tflite

- Inference time: 13ms





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