

恩智浦I.MX RT跨界MCU 在工业领域的应用

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SECURE CONNECTIONS
FOR A SMARTER WORLD

PUBLIC

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SECURE CONNECTIONS FOR THE SMARTER WORLD

Everything
Smart



40B+ devices with
intelligence shipped in 2020

Processing

Automotive

Everything
Connected



1B+ additional consumers online,
30B+ connected devices

Connectivity

Industrial

Everything
Secure



Potential economy savings
up to half trillion dollars

Security

IoT

UNIQUELY POSITIONED TO DELIVER FULL SYSTEM SOLUTIONS

COMPREHENSIVE CONNECTIVITY PORTFOLIO



SCALABLE MCU & MPU PORTFOLIO

Layerscape™
High-speed TSN/networking
processors

i.MX 6, 7, 8 Series
High-performance, multimedia
MPUs

i.MX RT Crossover
Highest performing MCUs

Kinetis™ LPC DSC S08
Low cost to high integration

PROVEN SECURITY SOLUTIONS



IoT Secure
Elements



Secure Processors
for IoT



Authentication

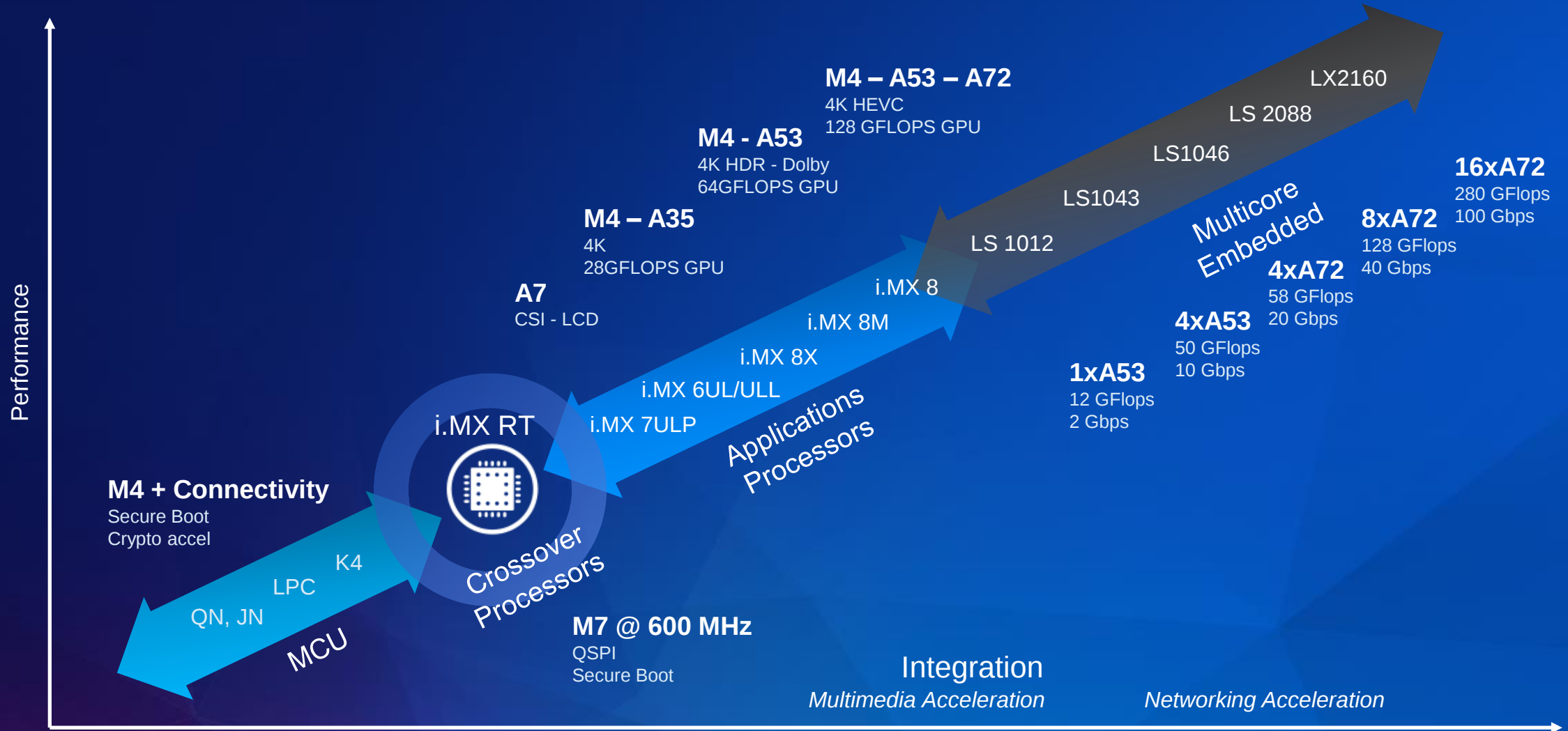


Secure Automotive
Products

TRUSTED ECOSYSTEM PARTNERS



BL EDGE PROCESSING PRODUCTS





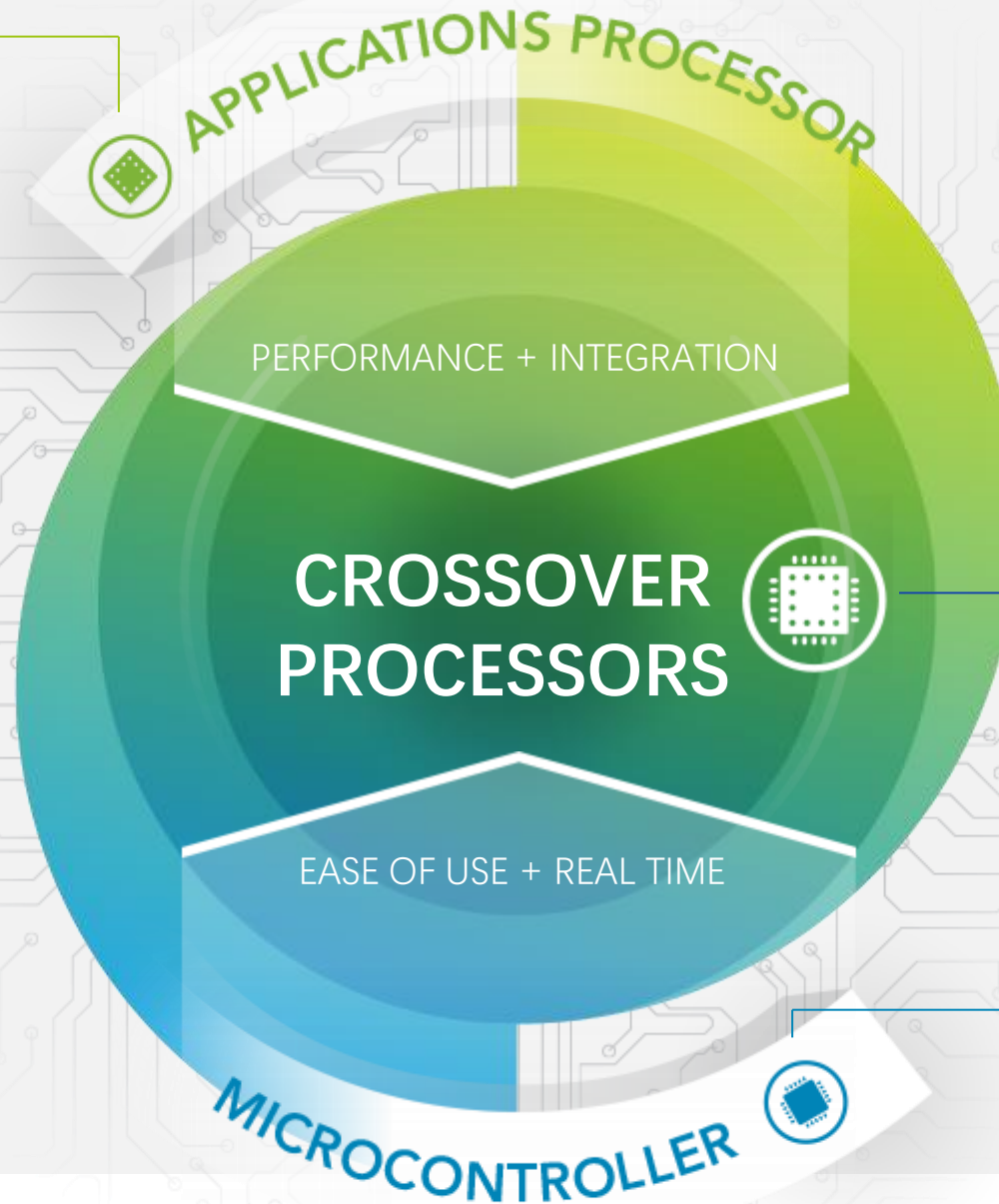
恩智浦i.MX RT系列 产品介绍

i.MX

Application Processors



- ARM Cortex-A & Cortex-M cores
- 600 MHz to 2 GHz performance
- Rich HMI experience
- Full open-source OS platforms



i.MX RT

Crossover MCUs



- Arm Cortex-M cores (v7m/v8m)
- Up to **GHz** performance
- DSP & Co-processor Acceleration
- High integration
- Deterministic instructions
- Short latency
- Easy to use tools
- RTOS support



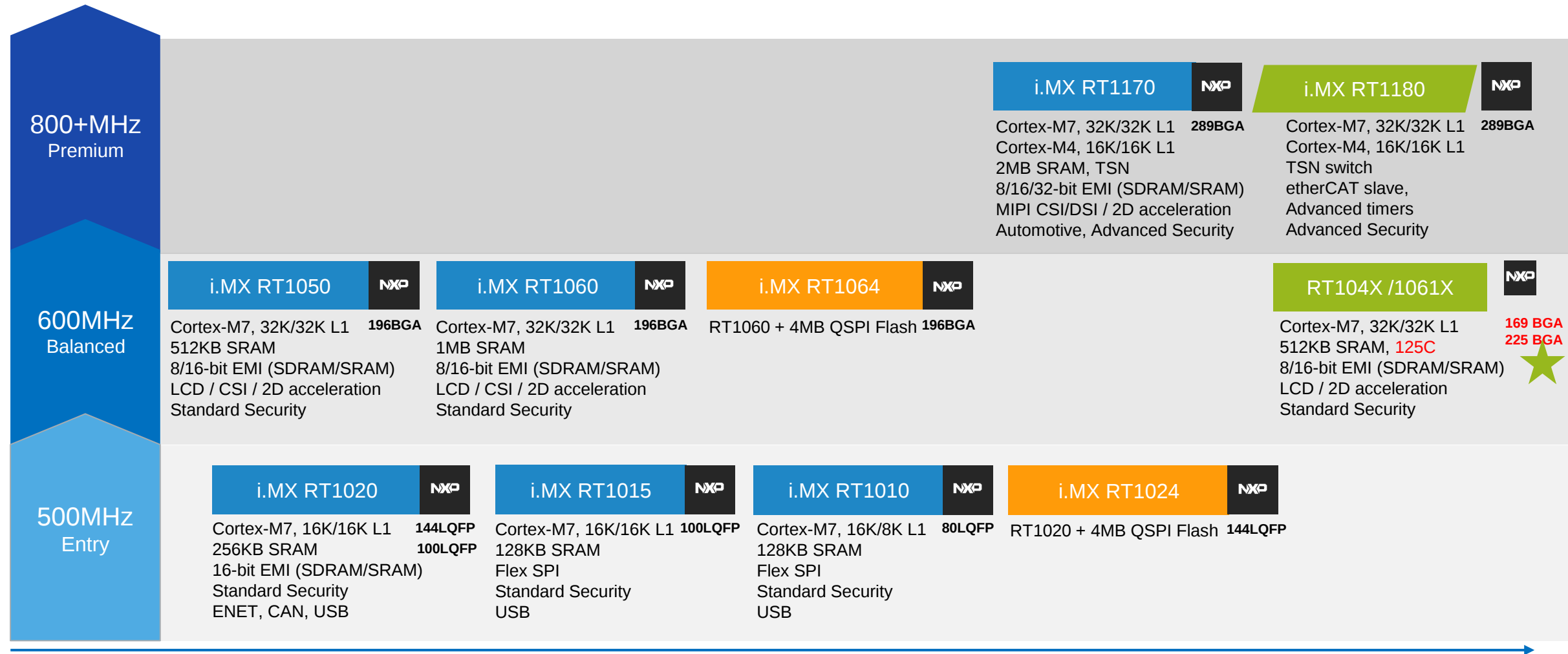
- ARM Cortex-M cores
- Performance up to 300 MHz
- Embedded memory
- Easy to use tools
- RTOS support



KINETIS & LPC Microcontrollers



i.MX RT1000 SERIES CROSSOVER MCU



2021

i.MX RT1170 DIFFERENTIATION



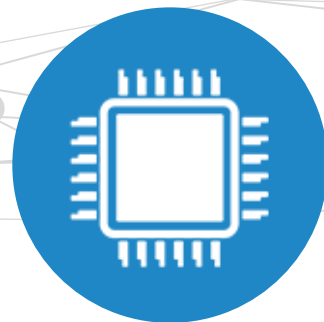
1GHz Cortex-M7
with 512KB TCM
Over **5000** Coremark

High Performance



High-Performance Crypto
Tamper Detection
On-The-Fly Memory
Encryption & Decryption
Secure Boot

Advanced Security



Up to **2MB** SRAM
High-speed ADC, DAC
1Gbps Ethernet (TSN)
MIPI CSI / DSI

Rich Feature Set



28nm FD-SOI Process
Optimized for both active
power & leakage power

Low Power

i.MX RT1170 / RT1160 CROSSOVER MCU FAMILY

Specifications

- Process: SEC 28FD-SOI
- Core Voltage: 1.0V
- Package: MAPBGA289, 14x14mm, 0.8mm pitch
- Temperature: -40C to 125C (Tj)

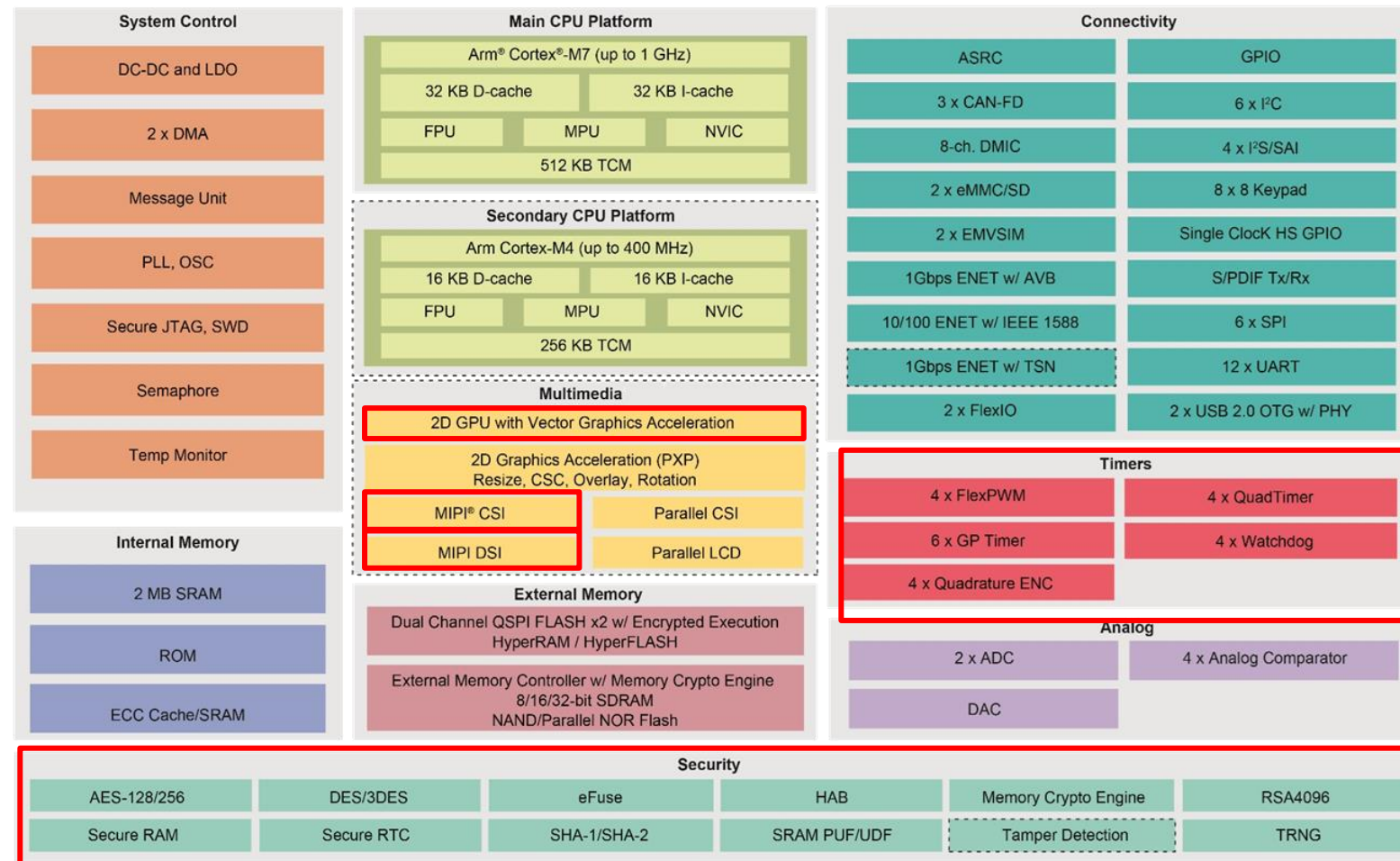
Key Features and Advantages

- Arm Cortex-M7 processor, 1 GHz, 32KB/32KB L1 Cache, 512KB TCM
- Arm Cortex-M4 processor, 400MHz, 16KB/16KB L1 Cache, 256KB TCM
- 2MB on-chip SRAM (including TCM for CPU core)
- Parallel LCD Display up to WXGA (1280x800)
- 8/16-bit Parallel Camera Sensor Interface
- 2-lane MIPI CSI and 2-lane MIPI DSI
- 2D Graphics Acceleration & OpenVG Acceleration
- 8/16/32-bit SDRAM controller up to 200MHz
- 8/16-bit Parallel NOR FLASH / NAND FLASH / PSRAM
- 2x QSPI NOR FLASH / HyperRAM / HyperFLASH Interface
- 2x eMMC 5.0/SD 3.0/SDIO Port
- 2x USB 2.0 OTG, HS/FS, Device or Host with PHY
- Audio: 4x I2S/SAI, 1x S/PDIF Tx/Rx, ASRC, digital microphone input
- 3x ENET: 1Gbps ENET w/ AVB + 10/100 ENET w/ IEEE 1588 + 1Gbps ENET w/ TSN
- 2x 12-bit ADC, 2Msamples/s, up to 24 input channels total
- 8x Analog comparator w/ 2x DAC
- Full PMU Integration, DCDC+LDOs
- Secure Boot, TRNG, RSA4096, Tamper Detection, Secure Key Storage

Enablement

- MCUXpresso, FreeRTOS with SDK
- Autosar

 Available on certain products within the family



I.MX RT1170 PROPOSED CONFIGURATIONS

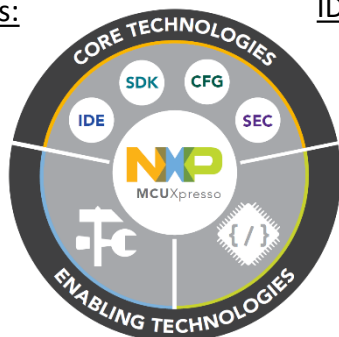
	1051/1061 升级版	1052/1062 升级版	Security Processor (POS)	RT1171+M4	RT1172 + M4, Superset, Dual Core
PN	RT1171	RT1172	RT1173	RT1175	RT1176
Cortex-M7	1GHz / 800MHz	1GHz / 800MHz	800MHz	1GHz / 800MHz	1GHz / 800MHz
Cortex-M4	-	-	400MHz	400MHz	400MHz
MIPI CSI / DSI	-	Y	Y	-	Y
OpenVG 1.1	-	Y	Y	-	Y
CSI / LCDIF / PXP	-	Y	Y	-	Y
Ethernet	Y	Y	Y	Y	Y
HAB / AES / DES	Y	Y	Y	Y	Y
Tamper Protection	-	-	Y	-	-
Packages	289 MAPBGA	289 MAPBGA	289 MAPBGA	289 MAPBGA	289 MAPBGA

i.MX Family Security Features	RT 500 RT 600	RT 10xx	RT 117x
Secure Enclave			
AES128/192/256, SHA1/224/256, DES/3DES	AES-256, SHA1/256	AES128, SHA1/256	✓
Elliptic Curve (modulus up to 1024) RSA (up to 4096)	✓ ECC		✓
Hardware Crypto Accelerator	✓ AES	✓ DCP	✓ CAAM
Certifiable RNG	✓	✓	✓
Run Time Integrity Protection (RTIC)			✓
Secure Execution (Trustzone TZ, TZ- M, SHE)	✓ TZ-M		
High Assurance Boot (RSA/ECDSA)	✓ RSA	✓ RSA	✓ RSA ECDSA
Encrypted Boot	✓	✓	✓
Always ON domain		✓	✓
Secure Storage (non-volatile)	✓	✓	✓
Secure Key Storage	PUF/OTP	eFUSE	PUF/OTP
Tamper Detection Pins (Passive/Active)			✓ 10/5
Volt/Temp/Frequency Detection			✓
Inline Encryption	OTFAD	BEE (OTFAD - RT1010)	OTFAD IEE
Secure Debug	✓	✓	✓
Manufacturing Protection			✓
Resource Domain Isolation (RDC,XRDC)			✓

I.MX RT SERIES ENABLEMENT OVERVIEW

Runtime Software

NXP Solutions:



RTOS, Middleware Partners:



Comprehensive frameworks and solutions for low-power, connected, and secure embedded systems

Software Development Tools

IDE / Toolchains:

Industry leading IDE support and intuitive software configuration tools to accelerate application development

Hardware Development Tools

Evaluation Kits:



Partner Solutions



Low cost hardware platforms for evaluation and application development. Partner solutions for hardware debugging solutions

Application Specific



- Graphics
- Touch HMI
- Camera interface
- Motor Control
- Voice activation
- Audio
- Sensor Fusion
- Cloud Connectivity

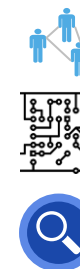
Connectivity Solutions



Software frameworks and development tools for targeted applications and certified connectivity solutions

Support

Broad Market:



- NXP Community
- Solution Designs
- Application Notes
- Schematics

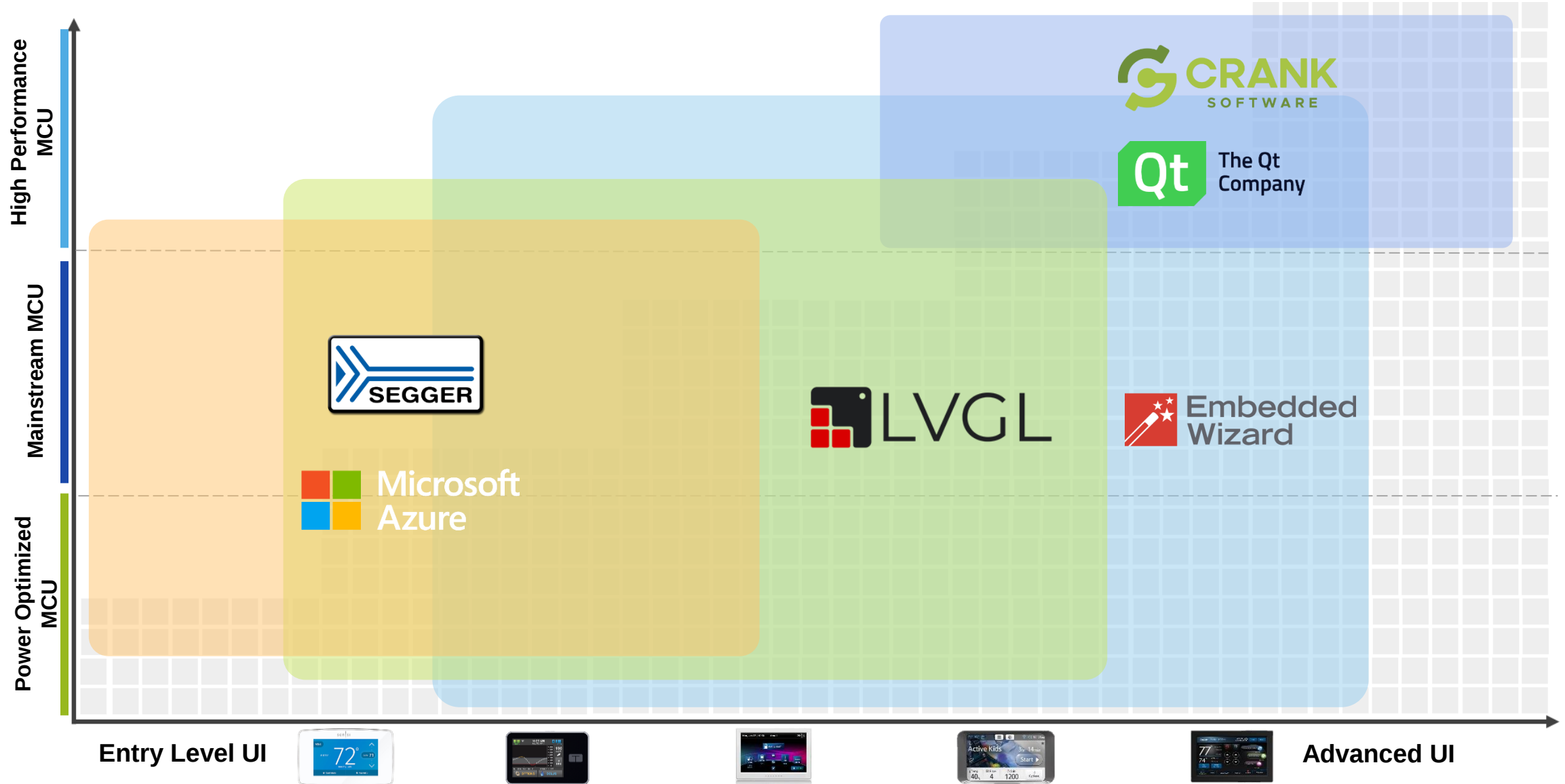
High Touch:



- Professional Support
- Professional Services

Get started quickly and get the support you need, when you need it

ENABLING SOFTWARE TECHNOLOGIES – EMBEDDED GRAPHICS



GRAPHICS MIDDLEWARE OVERVIEW

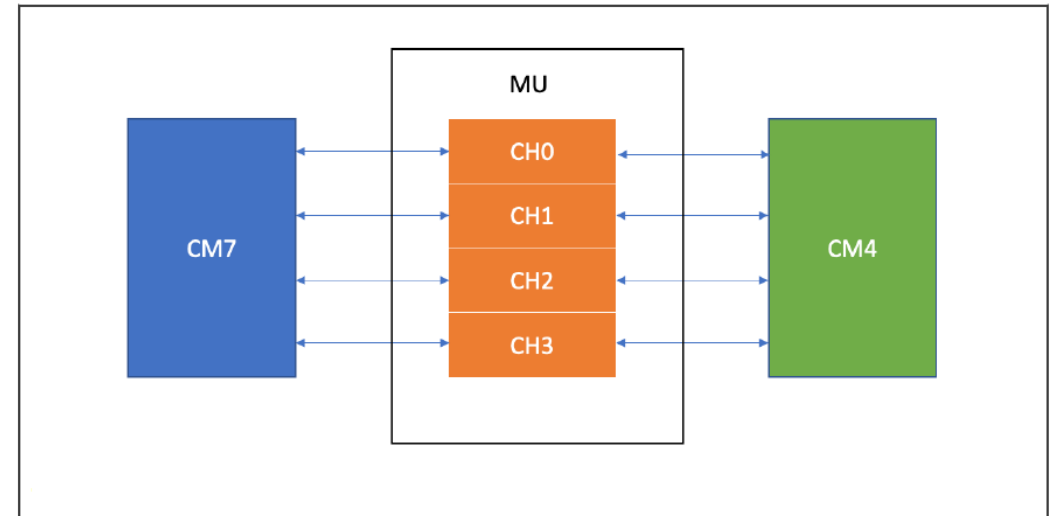
PROVIDER / PRODUCT	TYPE	LANGUAGE	BUSINESS MODEL	UI DEVELOPMENT TOOL	RTOS REQUIRED	OPTIMIZATION	MCUXpresso INTEGRATION
	Library + API	C	Free pre-compiled libraries via NXP MCUXpresso SDK (source code license available from SEGGER)	AppWizard	Optional (any)	-	✓
	Library + API	C	Open source	GUI Guider from NXP	Optional (any)	PXP, VGLite, GPU	✓
 GUI Solutions by TARA Systems	Source code generator	C / JavaScript	Developer seats, volume-based product line license	Embedded Wizard Studio	Optional (any)	PXP, VGLite, GPU	✓
	Library + API	C / C++	Developer seats, volume-based product line license	Storyboard Designer	Optional (any)	PXP, VGLite, GPU	✓
 The Qt Company	Library + API	C++	Developer seats, volume-based product line license	Qt Design Studio, Qt Creator	Optional (any)	PXP, VGLite, GPU	-



双核协同处理

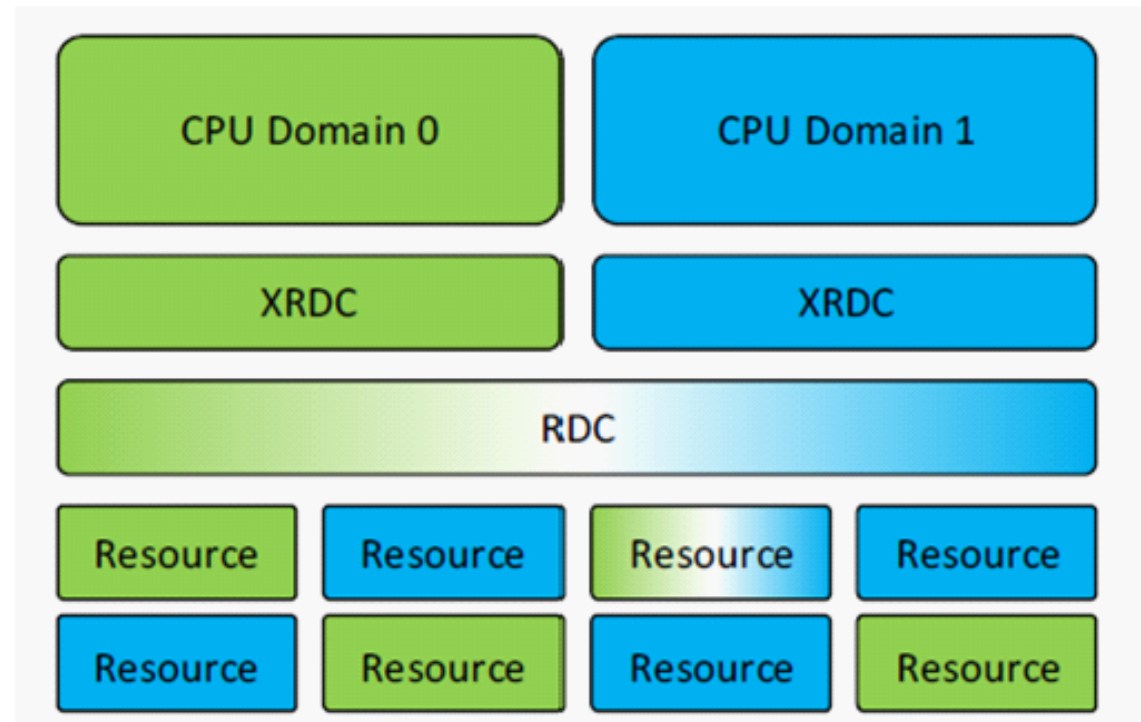
I.MX RT1170 HARDWARE MODULES FOR DUAL CORE APPLICATION

- Resource Domain Controller (RDC)
- Extended Resource Domain Controller 2 (XRDC2)
- Semaphores (SEMA4)
- Messaging Unit (MU)
- Shared Memory



RESOURCE DOMAIN CONTROLLER (RDC) EXTENDED RESOURCE DOMAIN CONTROLLER 2 (XRDC2)

- The Resource Domain Controller (RDC) provides robust support for the isolation of destination memory mapped locations such as peripherals and memory to a single core, a bus master, or set of cores and bus masters
 - RDC/XRDC2 is used for resource isolation
 - RDC is used as first-level control
 - XRDC2 is used as second-level control
 - Secure/non-secure access
 - Privileged/user access



SEMAPHORES (SEMA4)

- Prevent different masters using one resource at the same time
 - The resource can be a memory block, a peripheral or even an SW object in memory
- Semaphores support up to 16 gates
- SDK example: SDK root/boards/evkmimxrt1170/driver_examples/sema4

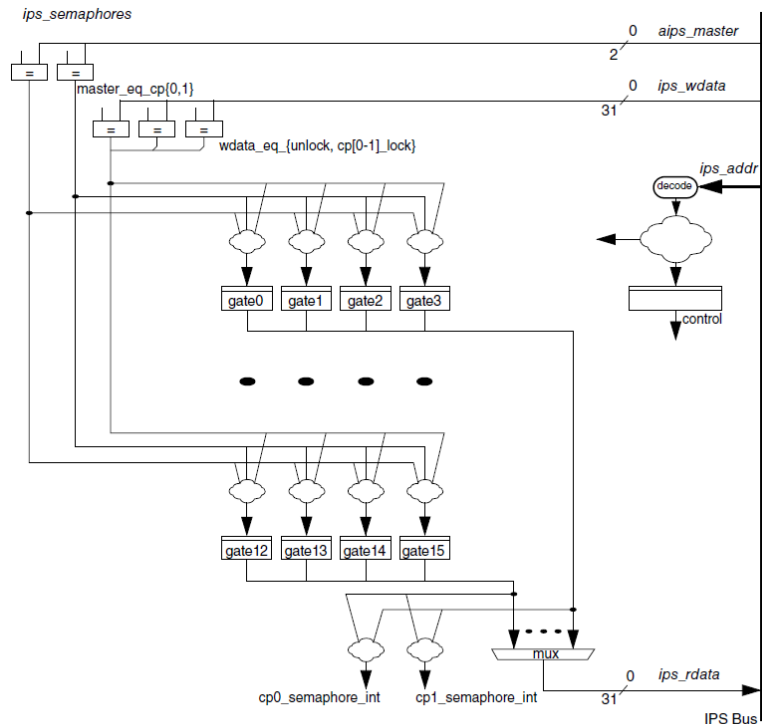
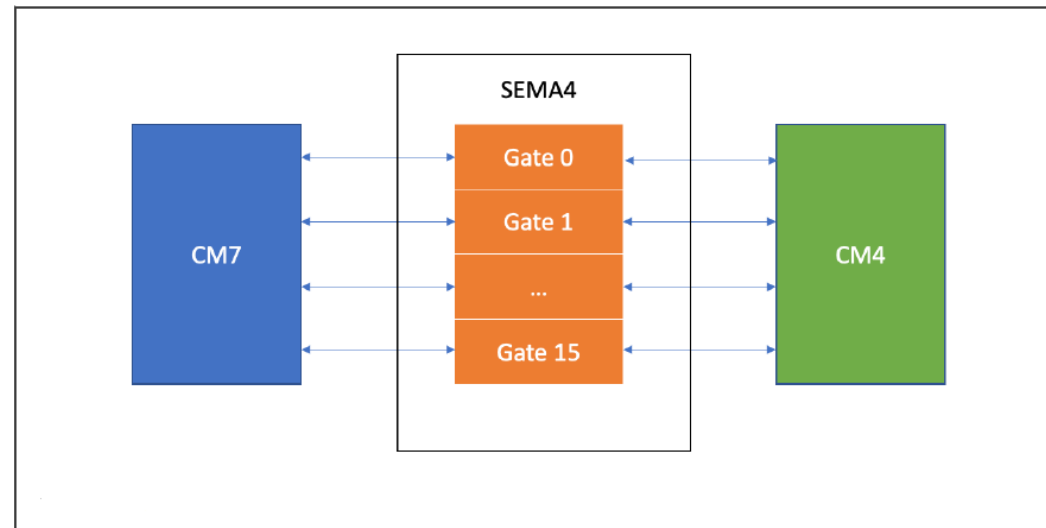


Figure 41-1. Semaphores Block Diagram



MESSAGING UNIT (MU)

- The Messaging Unit (MU) module enables two processors within the SoC to communicate and coordinate by passing messages through the MU interface.
 - One core can deliver a 32-bit message to the other and trigger an interrupt immediately
 - Supports four bi-directional channels
 - SDK example: `SDK root/boards/evkmimxrt1170/driver_examples/mu`

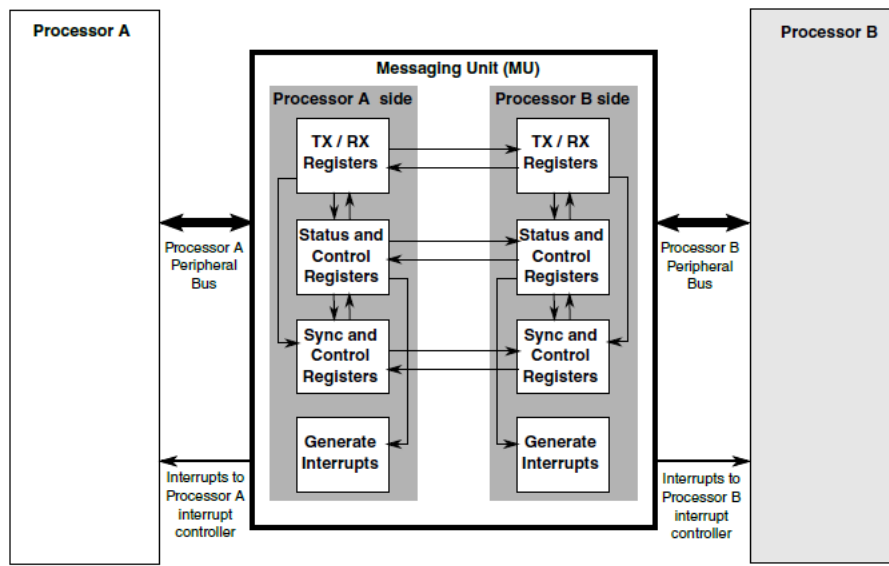
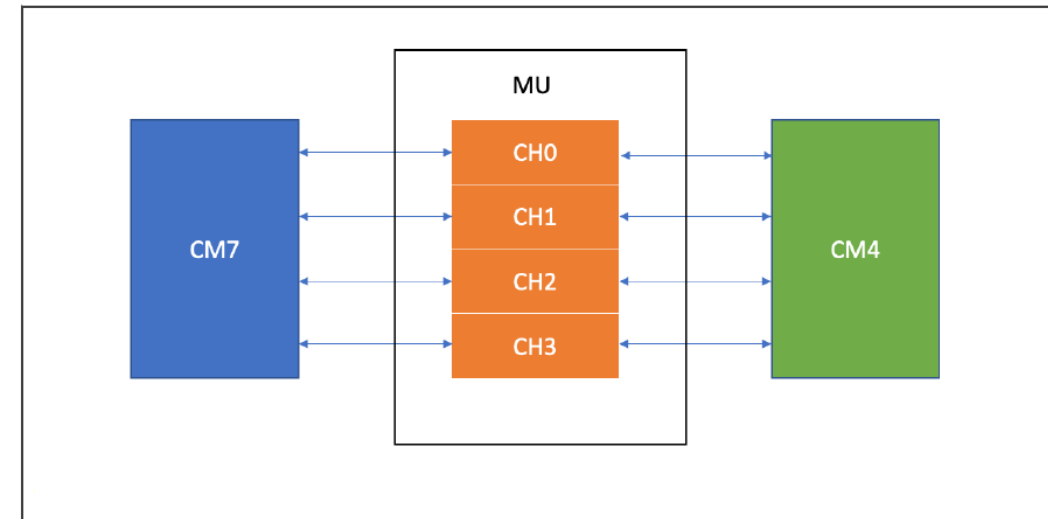


Figure 35-1. MU Block Diagram

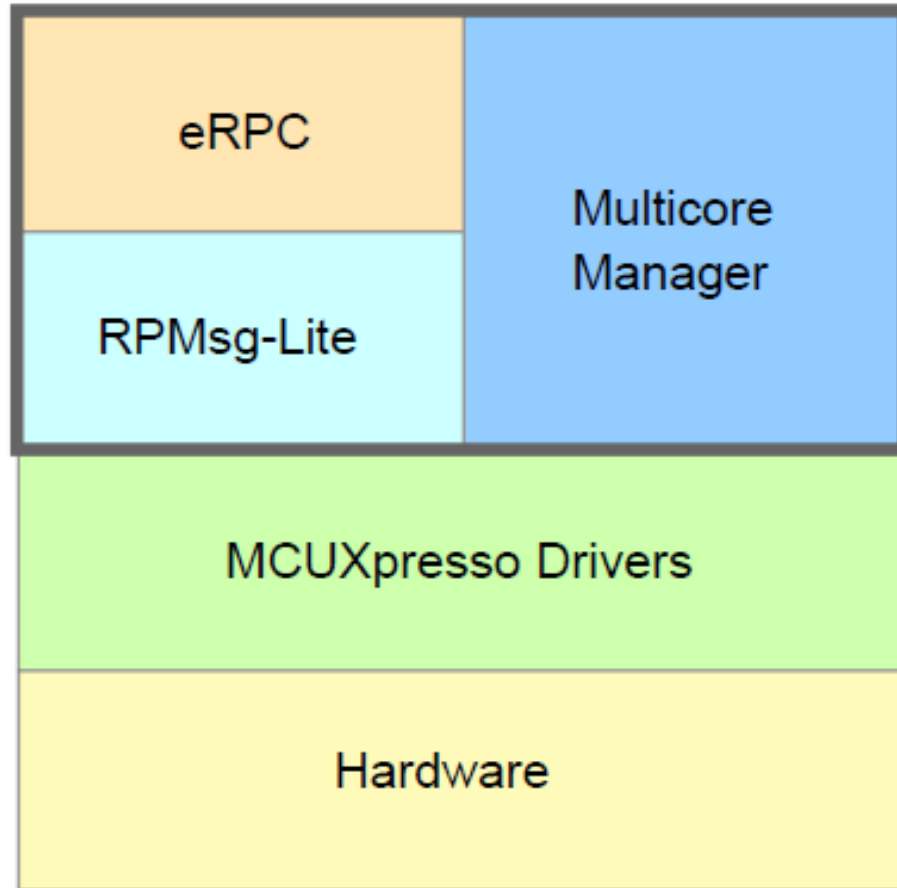


SHARED MEMORY

- Shared memory can be accessed by both CM7 and CM4 core
- Using Messaging Unit (MU) for memory data sharing
 - Core A writes a block data in shared memory
 - Trigger a MU interrupt to Core B
 - After Core B finish reading the block data, trigger a MU interrupt to Core A.

Typical memory which can be used for shared memory

	Access address for CM7	Access address for CM4	Size
CM4 DTCM	0x2022_0000	0x2000_0000	128 KB
OCRAM1	0x2024_0000	Same as CM7	512 KB
OCRAM2	0x202C_0000	Same as CM7	512 KB
OCRAM1_ECC	0x2034_0000	Same as CM7	64 KB
OCRAM2_ECC	0x2035_0000	Same as CM7	64 KB



MCSDK layers

MULTICORE SOFTWARE DEVELOPMENT KIT (MCSDK)

- The MCSDK is combined with the MCUXpresso SDK to make the software framework for easy development of multicore applications.
 - Multicore Manager (MCMGR)
 - Embedded Remote Procedure Call (eRPC)
 - Remote Processor Messaging - Lite (RPMsg-Lite)

MULTICORE MANAGER (MCMGR)

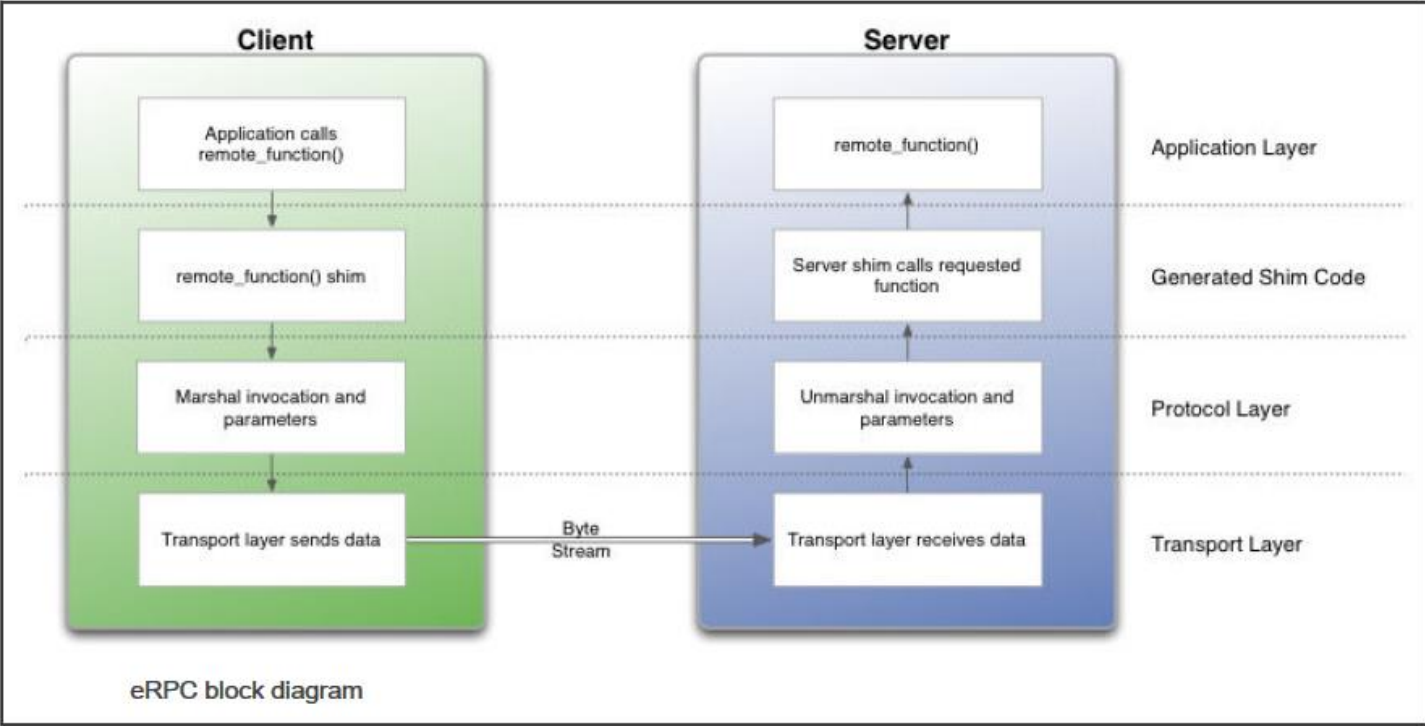
- The Multicore Manager (MCMGR) software library provides numbers of services for multicore systems
 - Maintains information about all cores in system
 - Secondary/auxiliary core(s) startup and shutdown
 - Remote core monitoring and event handling.

REMOTE PROCESSOR MESSAGING LITE (RPMSG-LITE)

- RPMsg-Lite is a lightweight implementation of the RPMsg protocol
 - The RPMsg protocol defines a standardized binary interface used to communicate between multiple cores in a heterogeneous multicore system
 - RPMsg-Lite offers a code size reduction, API simplification, and improved modularity

EMBEDDED REMOTE PROCEDURE CALL (ERPC)

- The Embedded Remote Procedure Call (eRPC) is the RPC system created by NXP. eRPC is a mechanism used to invoke a software routine on a remote system via a simple local function call.



SDK > SDK_2_10_0_MIMXRT1170-EVK > boards > evkmimxrt1170 > multicore_examples

Name	Date modified	Type
erpc_common	2021/7/15 下午 01:43	File folder
erpc_matrix_multiply_mu	2021/7/15 下午 01:44	File folder
erpc_matrix_multiply_mu_rtos	2021/7/15 下午 01:44	File folder
erpc_matrix_multiply_rpmsg	2021/7/15 下午 01:44	File folder
erpc_matrix_multiply_rpmsg_rtos	2021/7/15 下午 01:44	File folder
erpc_two_way_rpc_rpmsg_rtos	2021/7/15 下午 01:44	File folder
freertos_message_buffers	2021/7/15 下午 01:44	File folder
hello_world	2021/7/15 下午 01:44	File folder
multicore_manager	2021/7/15 下午 01:44	File folder
rpmsg_lite_pingpong	2021/7/15 下午 01:44	File folder
rpmsg_lite_pingpong_rtos	2021/7/15 下午 01:44	File folder

应用笔记AN13264中有详细介绍，欢迎下载学习交流。



典型应用及方案

i.MX RT 系列

i.MX RT1010/ 1015/1020

Cortex-M7 500MHz
128KB to 256KB
SRAM
External Memory I/F
High Security
LQFP Packages

i.MX RT1050/ 1060/1064

Cortex-M7 600MHz
512KB to 1MB SRAM
External Memory I/F
LCD / CSI / 2D
acceleration
High Security

i.MX RT1170

Cortex-M7 1GHz
Cortex-M4 400MHz
2MB SRAM
External Memory I/F
LCD / CSI / MPI /
2D GPU
Advanced Security

i.MX RT600

Cortex-M33 with
TrustZone
300 MHz
HiFi4 DSP @ 600MHz
4.5MB SRAM
Advanced Audio
Integration
Advanced Security

i.MX RT500

Cortex-M33 with
TrustZone
200 MHz
Fusion F1 DSP @
200MHz
5MB SRAM
Advanced GPU
Integration
Advanced Security

General Purpose

i.MX RT1010 / 1015 / 1020/4

扩展IO

High Performance

i.MX RT1050 / 1060 / 1064

伺服 / HMI

Advanced Security

i.MX RT1170 /1160

高性能计算
PLC/伺服

Segment Focus

i.MX RT600 (audio / voice)

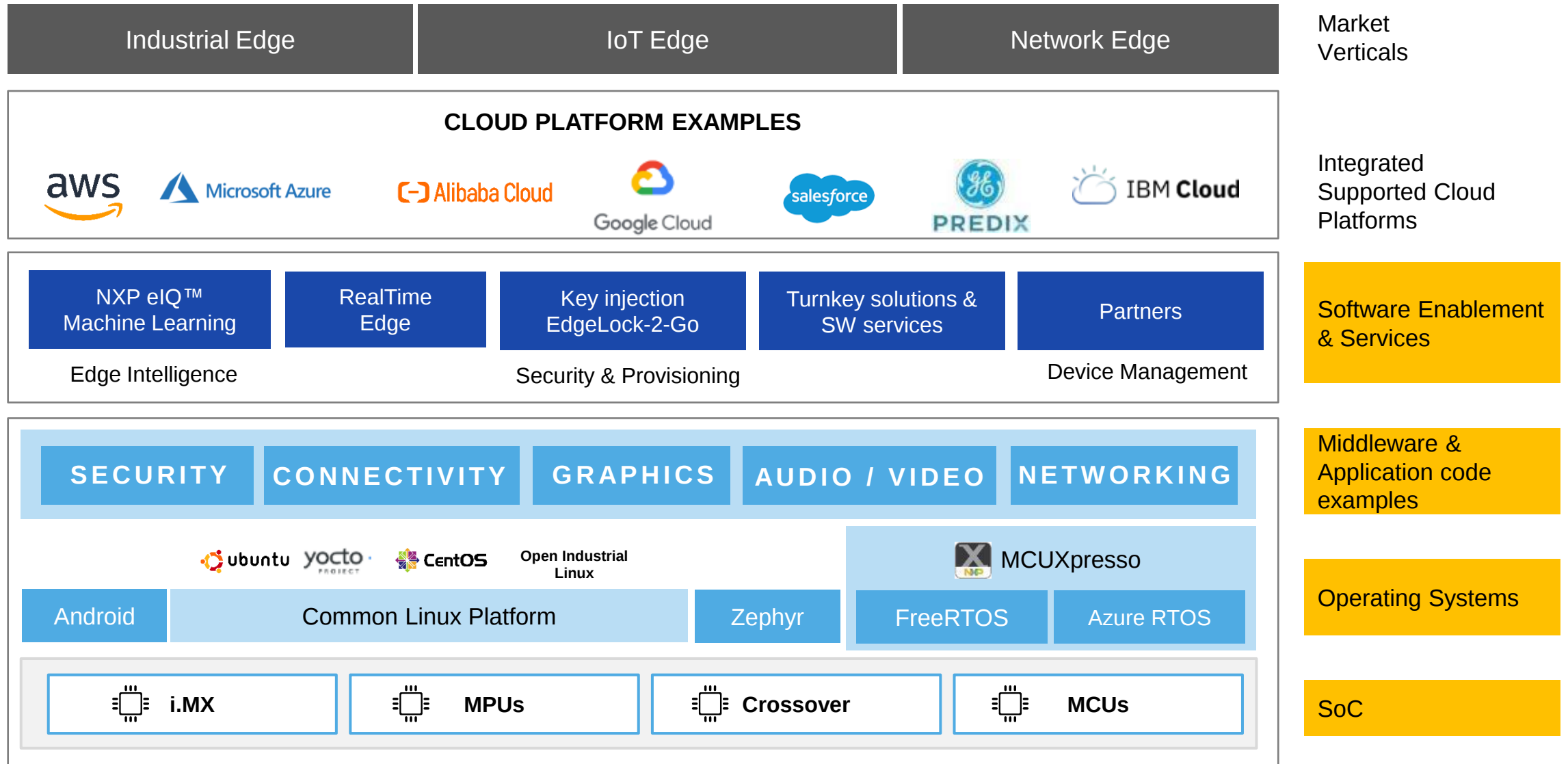
音箱

Segment Focus

i.MX RT500
(wearables, low-power HMI)

手表

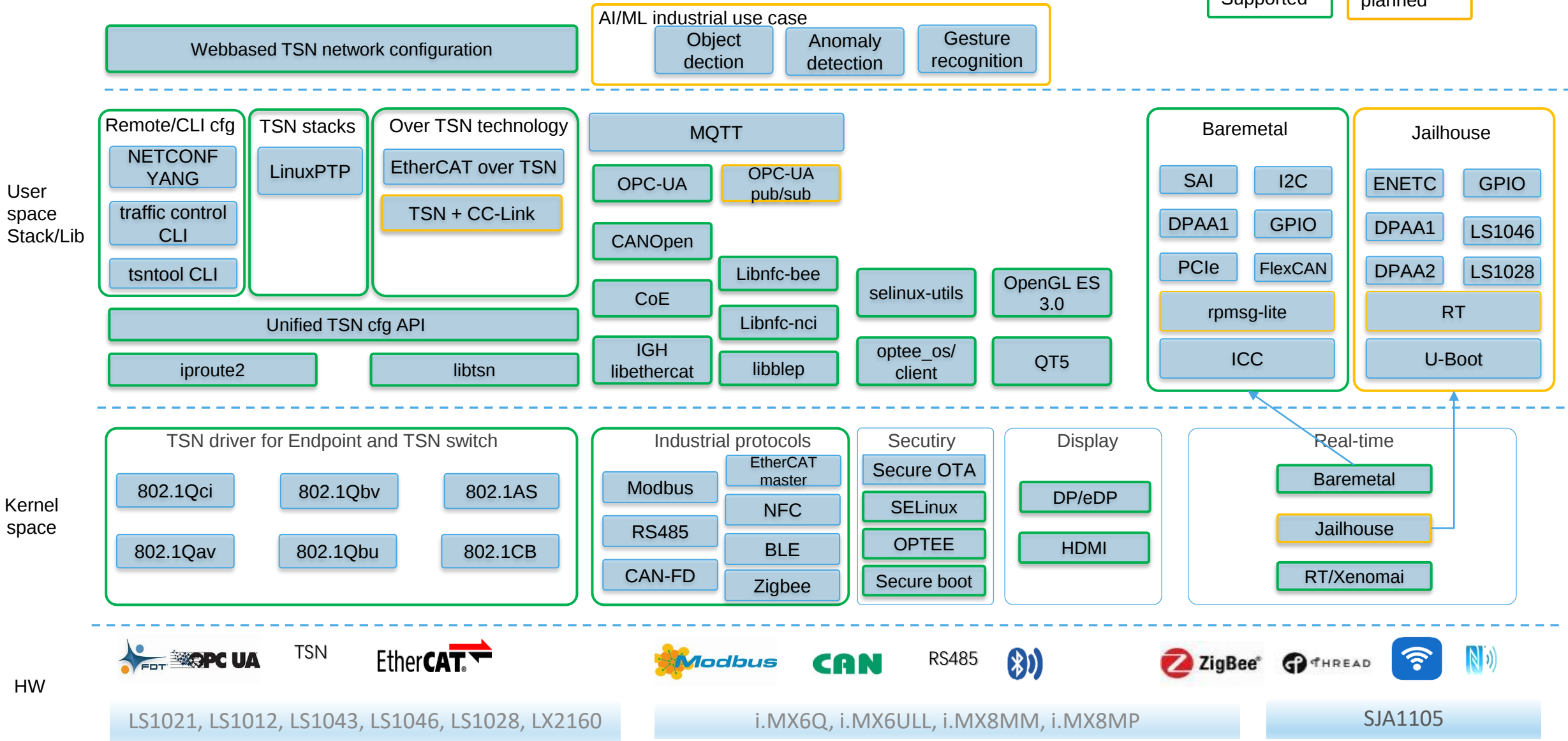
完整的软硬件产品和生态



REAL-TIME EDGE ARCHITECTURE

Supported

planned



I.MX RT SERIES TARGET APPLICATIONS

Voice & Audio

High-end, consumer audio devices, including specialty equipment such as:

- Home Audio
- Professional microphone
- Guitar pedals
- Audio Tuners



Consumer & Healthcare

- Wearables
- Smart appliances
- Cameras & LCDs
- Mobile patient care, e.g. infusion pump or respirator
- Blood pressure monitor
- Activity & wellness monitor
- Exercise equipment with display



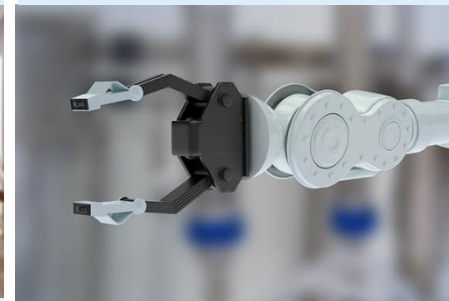
Home & Building Automation

- HVAC climate control
- Security
- Lighting control panels
- IoT gateways
- Smoke Detectors
- Thermostats
- Energy conversion



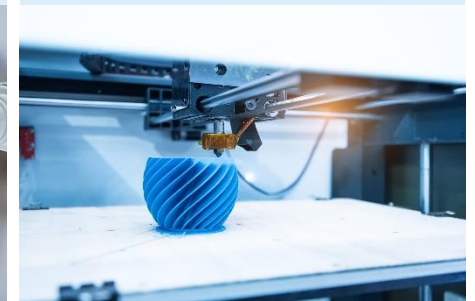
Industrial Computing

- EBS
- High end computing
- Security / gateway
- PLCs
- RTK
- Factory automation
- Test and measurement
- HMI control robotics
- QR Readers
- Barcode Scanners



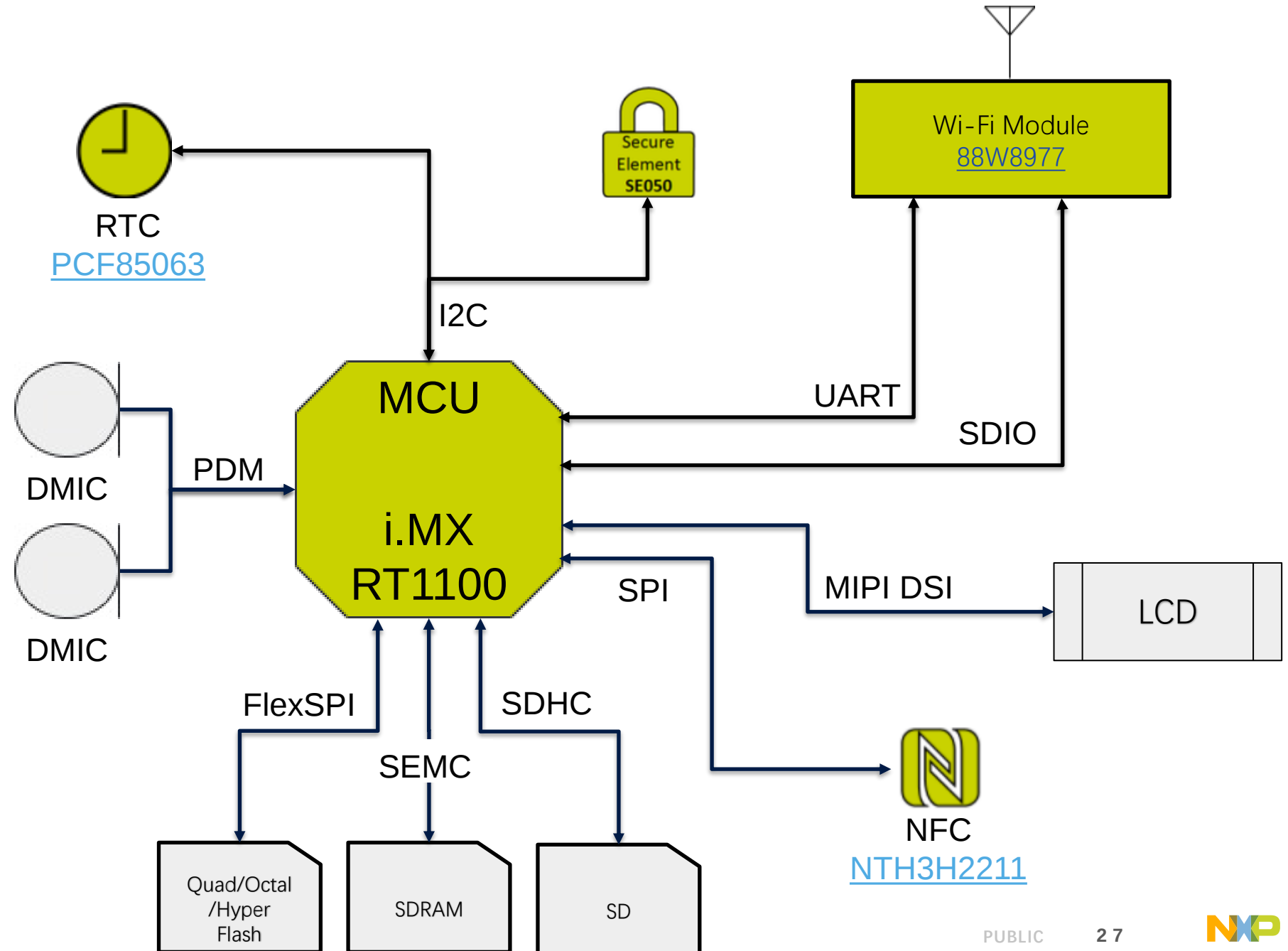
Motor Control & Power Conversion

- 3D printers
- Thermal printers
- Unmanned autonomous vehicles
- Robotic vacuum cleaners
- Drones
- Multi-shaft motor



温控器 - RT11XX

- Arm® Cortex®-M4 boot first and control entire system:
 - Security Subsystem
 - Handles system monitoring and sensor interfaces
 - Wake-up Cortex-M7 on Voice Detection, proximity detection
- Arm Cortex-M7 is enabled on need
 - UI maintenance via 2D GPU
 - Computationally heavy tasks such as machine learning



QUAD MOTORS CONTROL DEVELOPMENT PLATFORM – GEN. 1

Value Proposition



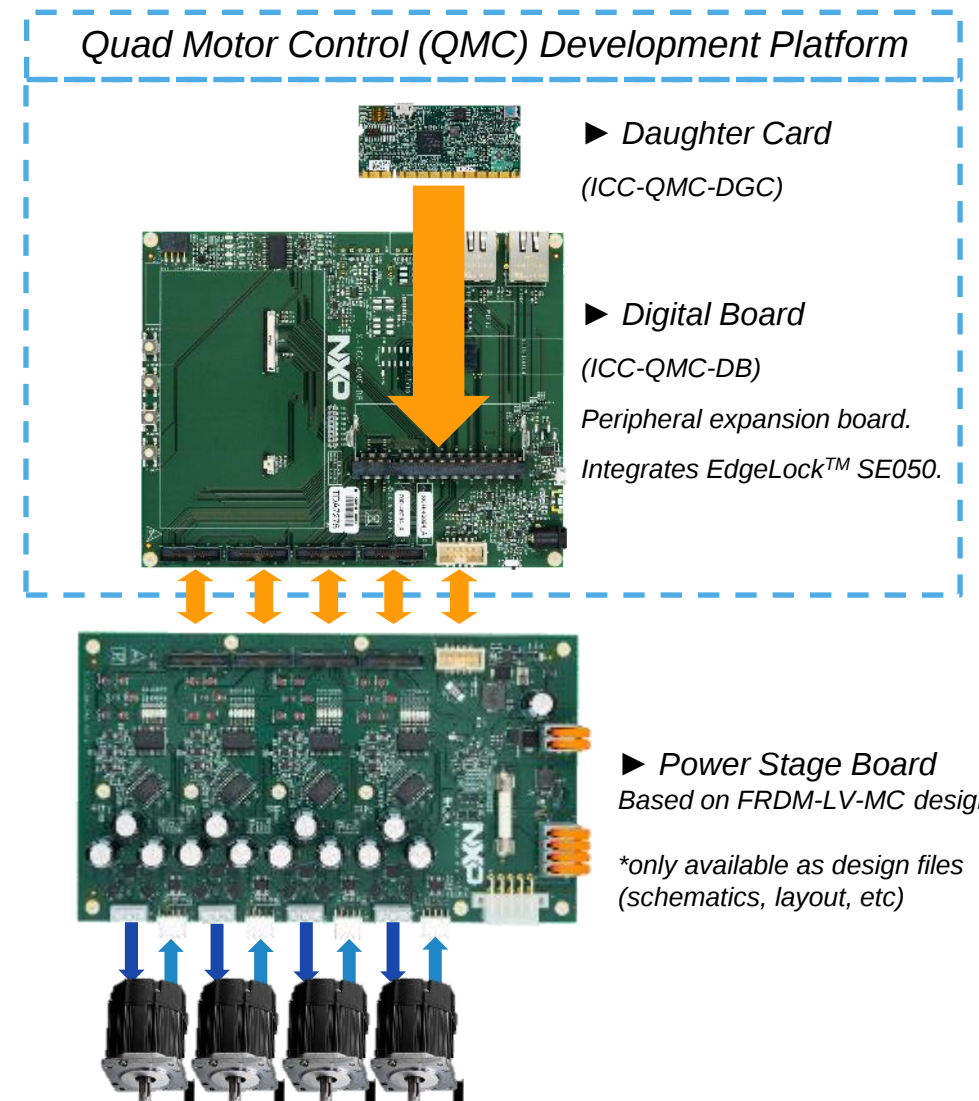
Use Cases

Motor Control

Speed control – multi motor (4 motor synchronization)
Position control – multi motor (4 motor synchronization)
Closed loop motor control – multi motor Field Oriented Control (Vector Control)
Open loop motor control – multi motor Scalar (V/F) Control

Secure Communications

Secure device authentication
Secure communication channel (TLS)

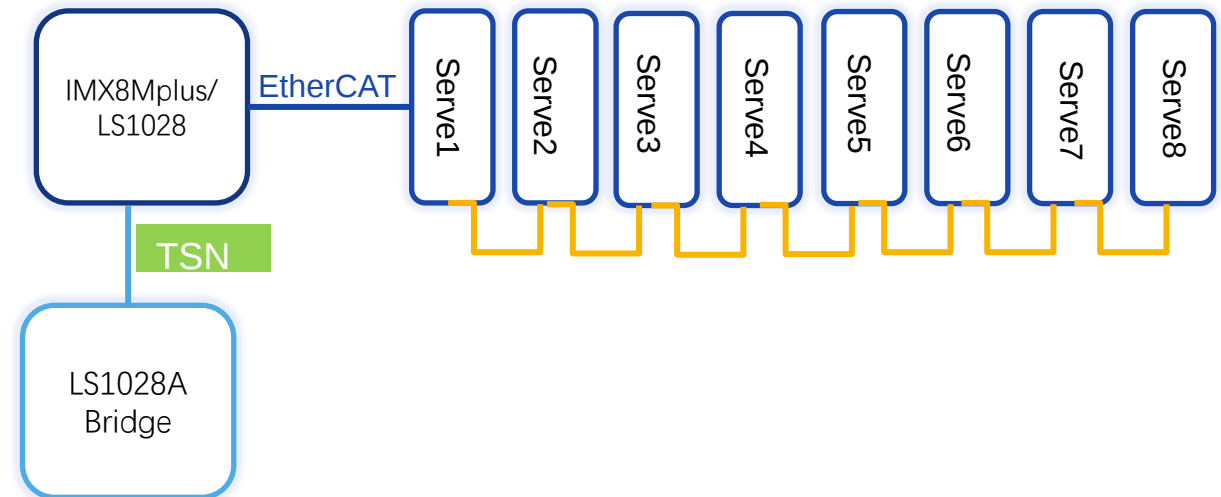
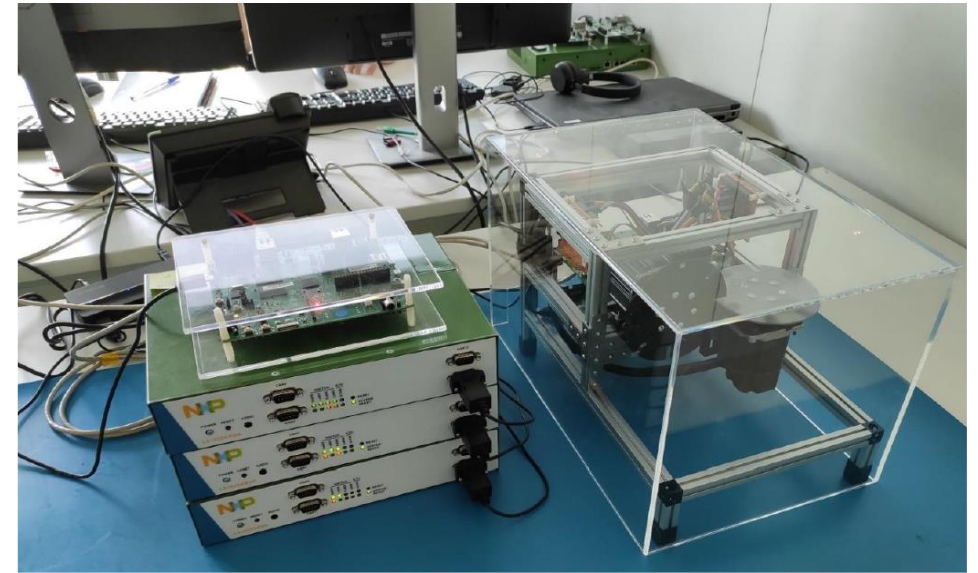


www.nxp.com/quadmotorcontrol

TSN DISTRIBUTED MOTOR CONTROL DEMO

Key Features:

- Based on RT1170 as TSN endpoint and LS1028A as TSN switch
- One RT1170 TSN endpoint works as the motion controller, two RT1170 TSN endpoint work as the motor controller slave
- TSN is used to communicate the torque command and current motor rotor position/speed information between motion controller and motor controller slave
- Supports back-to-back mode and TSN bridge mode



I.MX RT1100 AVB AND TSN

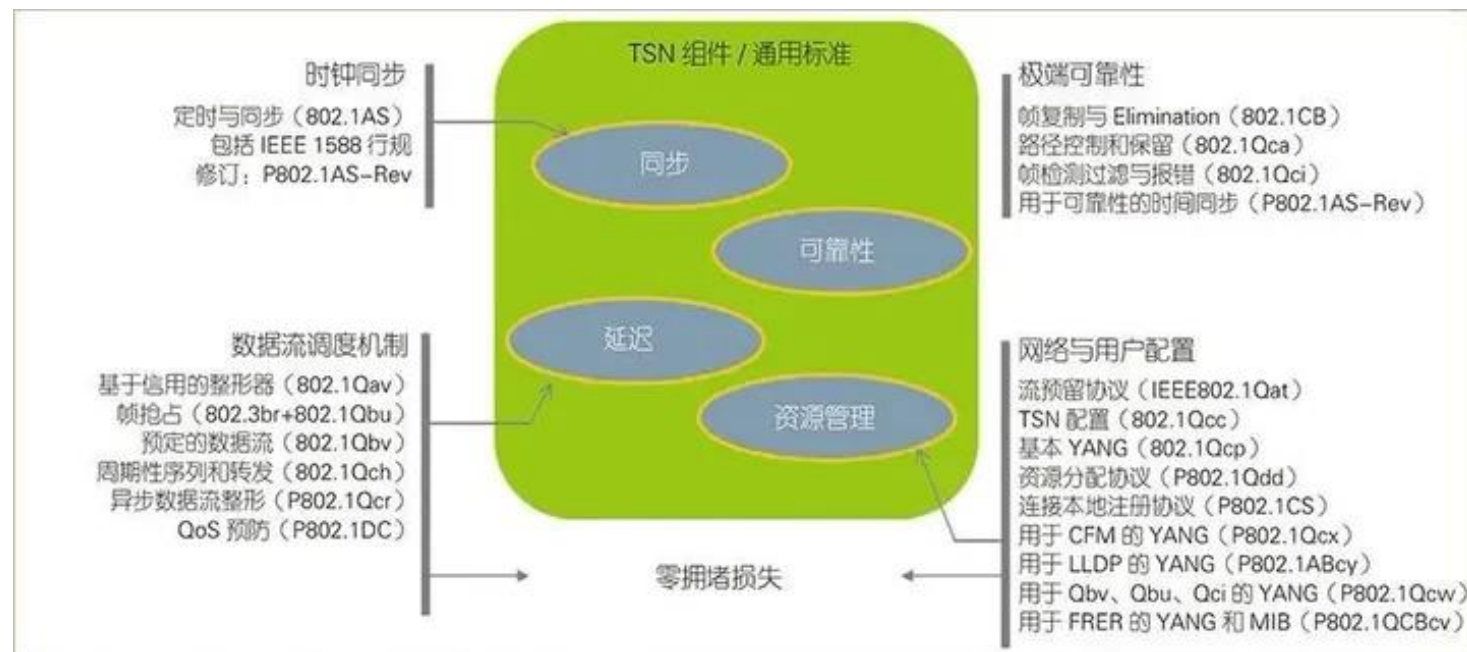
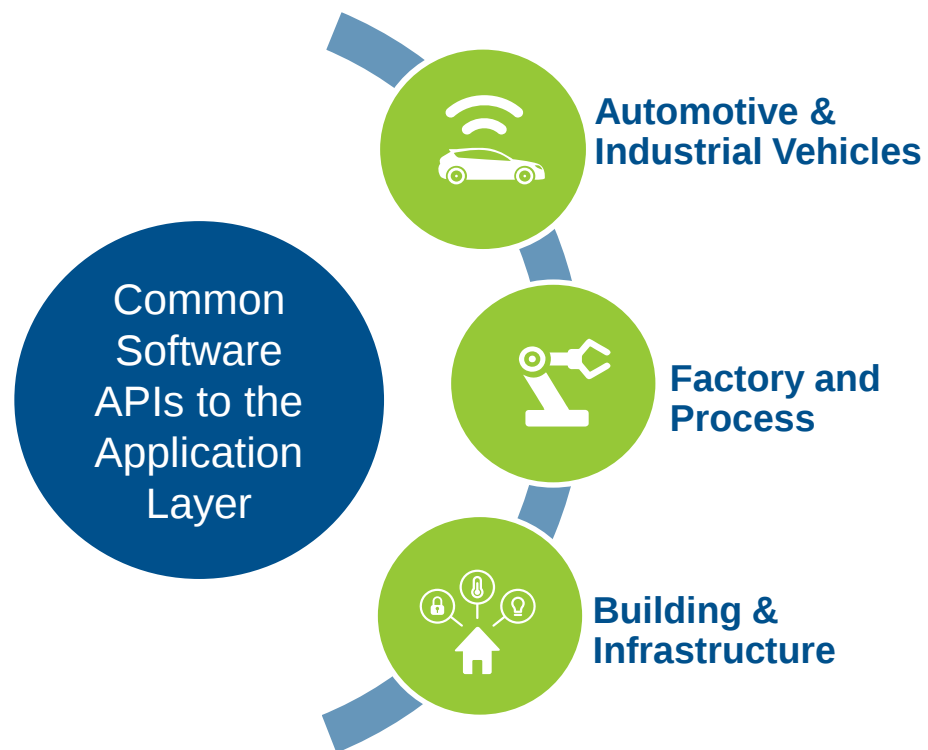


图 4 TSN 相关的标准

Standard	Description
802.1Qav	Forwarding and Queuing Enhancements (AVB) including Credit Based Shaping
802.1Qbv	Time-aware shaping (per-queue based)
802.1Qbu, 802.3BR	Frame pre-emption
802.1Qat	Stream Reservation Protocol (SRP)
802.1AS	Timing and synchronization in bridged LAN (gPTP), including TSN enhancements (redundant GM clocks, GM failover)



SECURE CONNECTIONS
FOR A SMARTER WORLD