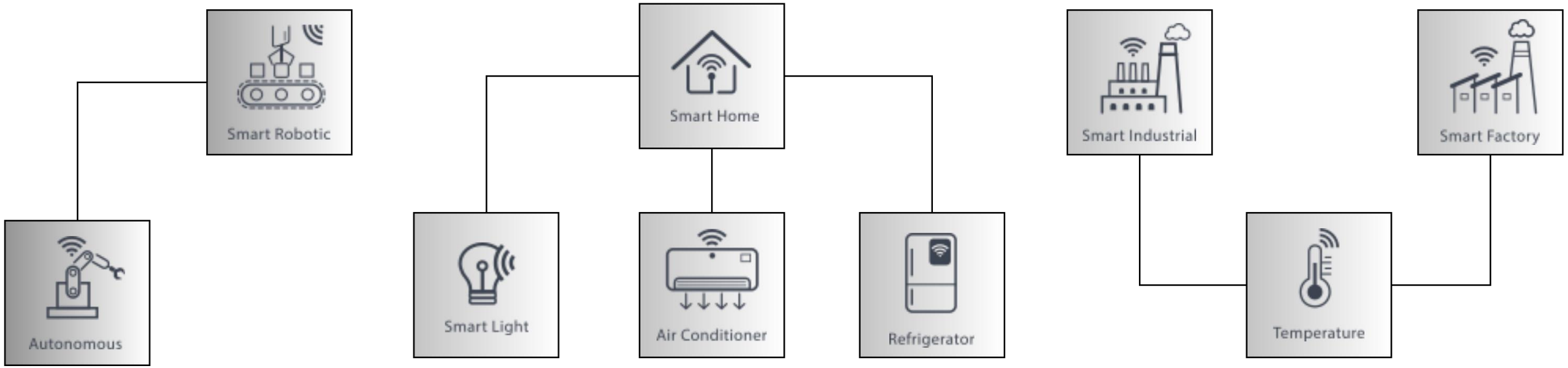
Benefits of Shifting Cloud Data Management and Processing to Powerful Edge IoT Devices

IoT Data and Device Local Data Management



IoT Systems Produce Large Quantity of Data

ITTIA
Database Software & Services

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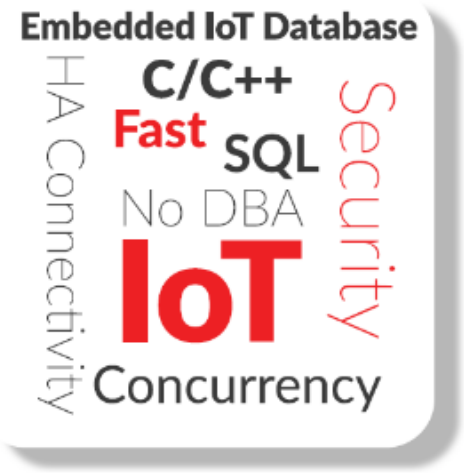
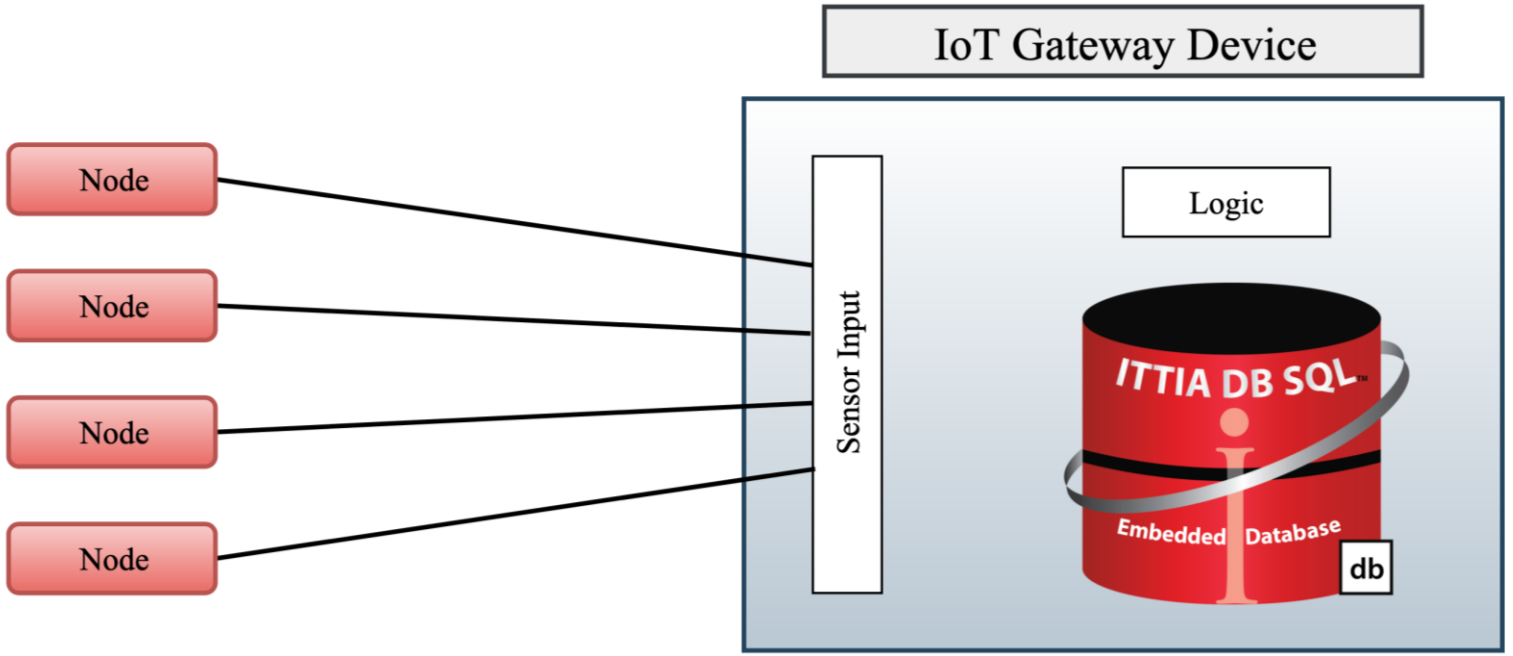
https://www.ittia.com/NXP2019prize

IoT Data Accessibility, Maintainability Interoperability





Potential of Sensors, Data Analysis & SQL

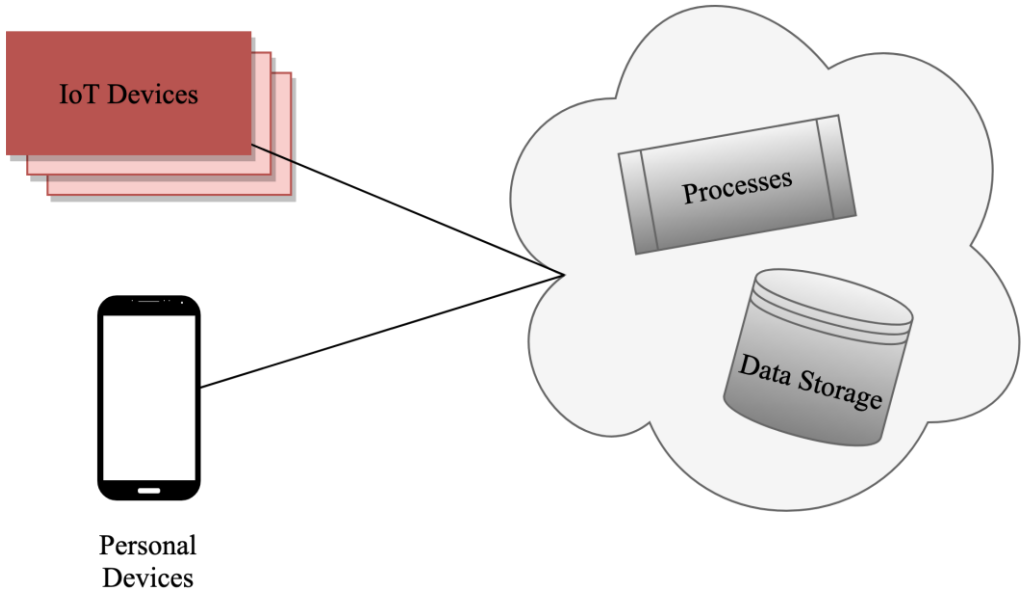
ITTIA
Database Software & Services

Top Benefits of Local Data Management

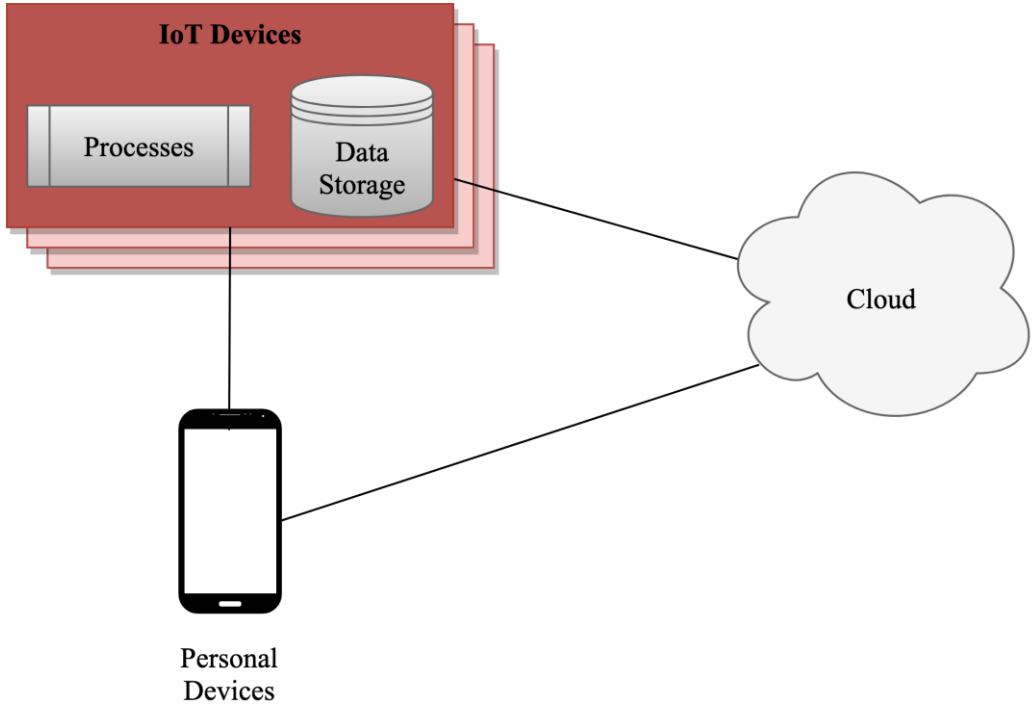
High Performance, Maintainability and Low Total Cost of Ownership

Shifting to Local Data Management

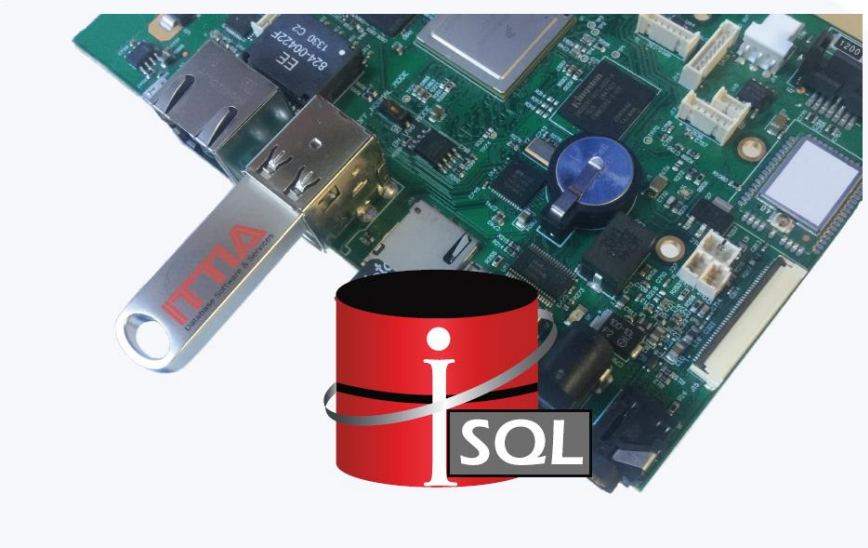
CLOUD-ORIENTED DATA MANAGEMENT



LOCAL-ORIENTED DATA MANAGEMENT

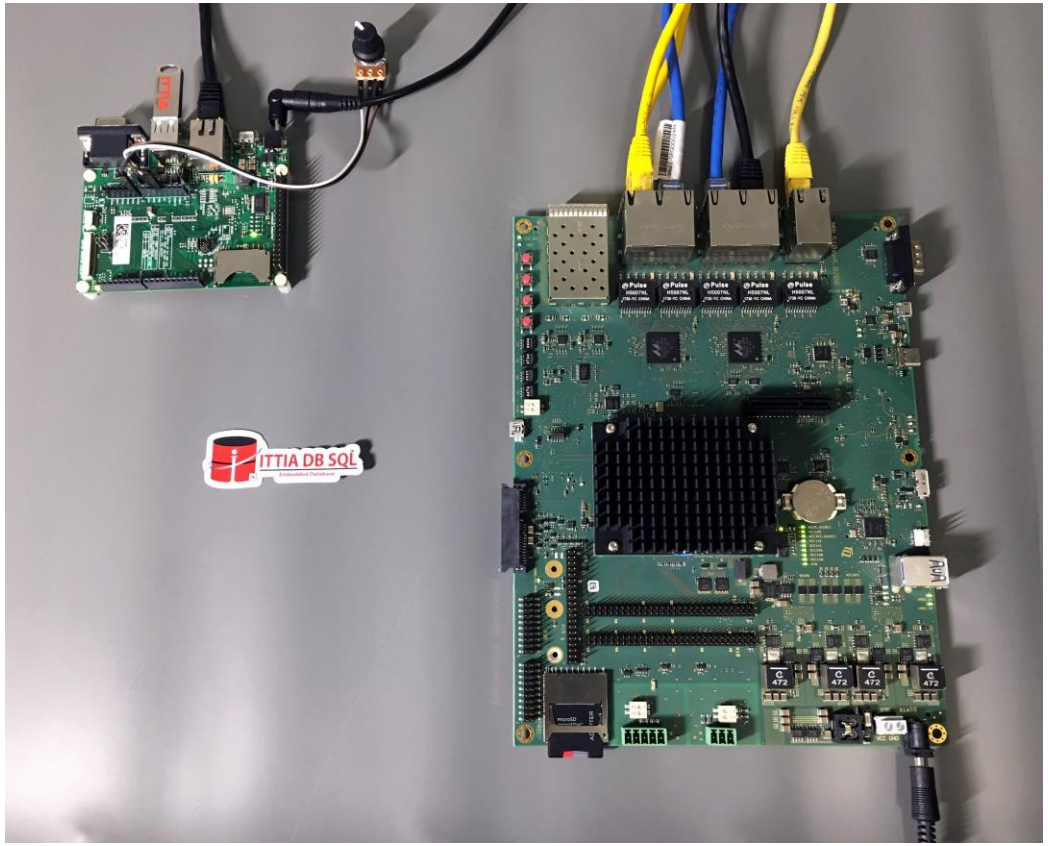


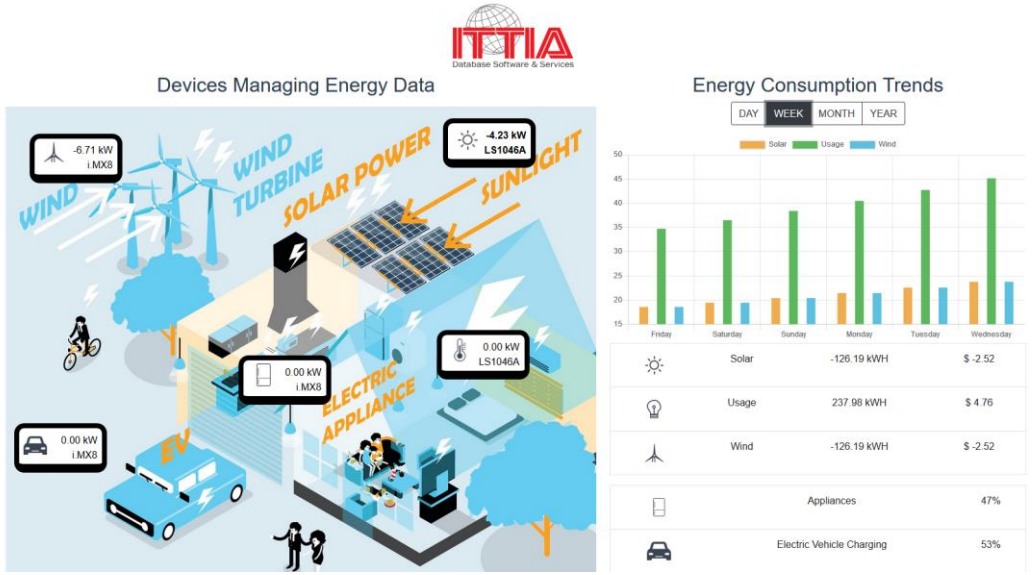
ITTIA Uniqueness



Reporting, Monitoring and Distributing Information

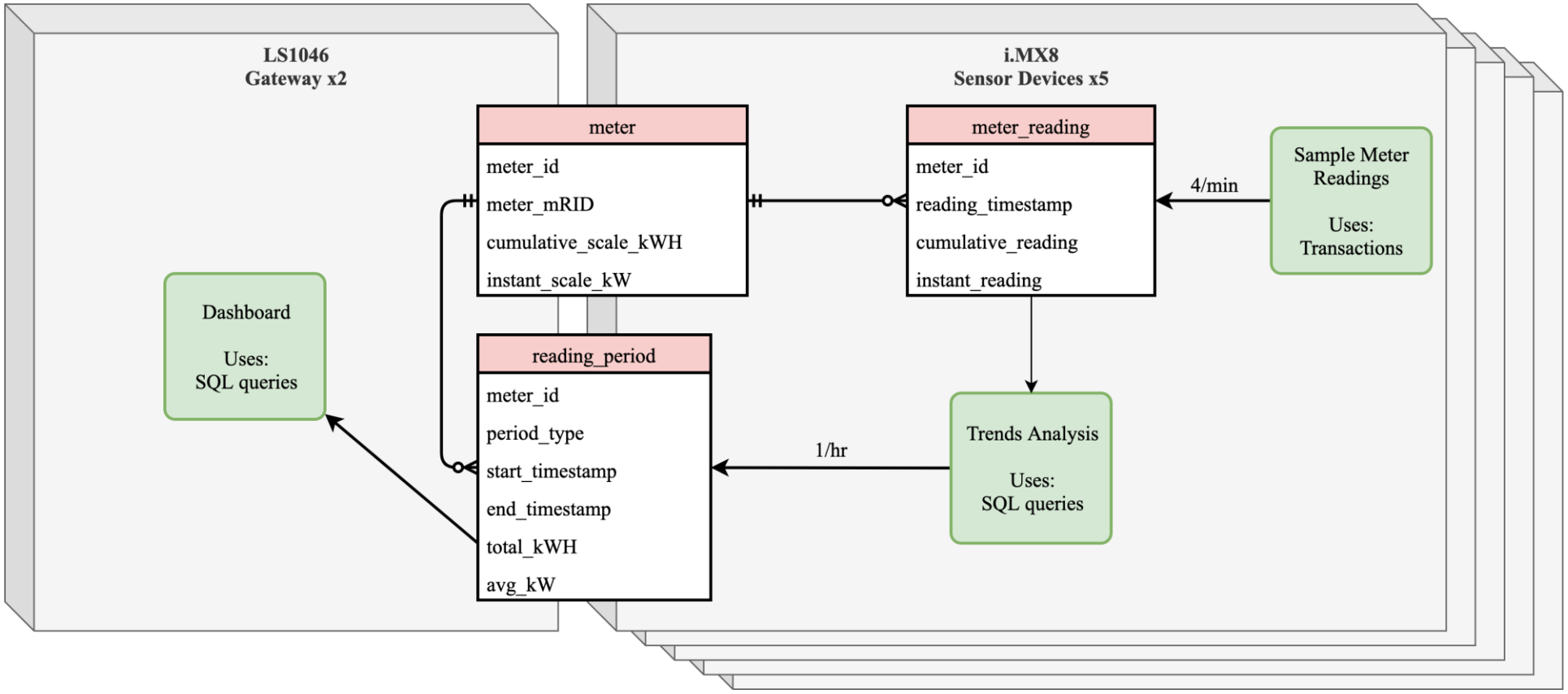
Practical Demonstration on Real Devices





Microgrid: Devices Manage & Process Real Time Data

Demonstration Database Schema



Store Sample Readings in Local Database

```
insert into meter_reading (
    meter_id,
    reading_timestamp,
    cumulative_reading,
    instant_reading_kW
  )
  select meter_id,
         utc_timestamp as new_timestamp,
         cast(
           :<float32>0 * cast(
             (utc_timestamp - :<timestamp>1) second
             as float32)
             / 3600
             / cumulative_scale_kWh
           as uint64)
         + :<uint64>2 as new_reading,
         :<float32>0
    from meter
    where meter_id = :<sint32>3
```

- Record data at a high level of detail
  - Not limited by connection speed, bandwidth, …
  - Only share refined information with Cloud
- To store 100 million sensor readings:
  - 4 GB MicroSD costs < $10
  - 4 GB NAND SPI costs < $4

meter_id	reading_timestamp	cumulative_reading	instant_reading_kW
102	2019-09-19 5:48 AM	70537	-8.74213
102	2019-09-19 5:48 AM	70640	-8.98715
102	2019-09-19 5:49 AM	70740	-8.88684

Database Software & Services

Analyze Energy Trends

```
select meter.meter_id, meter_mRID, meter_name,
       low.cumulative_reading as low_reading,
       high.cumulative_reading as high_reading,
       :<timestamp>1,
       low.cumulative_reading + cast(
           (high.cumulative_reading - low.cumulative_reading)
         * cast((:<timestamp>1 - low.reading_timestamp) second as float)
         / cast((high.reading_timestamp - low.reading_timestamp) second as float)
         as uint64
       )
  from meter
  left outer join meter_reading as low on meter.meter_id = low.meter_id
  left outer join meter_reading as high on meter.meter_id = high.meter_id
  where meter.meter_id = :<integer>0
    and low.reading_timestamp in (
      select max(reading_timestamp)
        from meter_reading
        where meter_id = :<integer>0
          and reading_timestamp < :<timestamp>1
    )
    and high.reading_timestamp in (
      select min(reading_timestamp)
        from meter_reading
        where meter_id = :<integer>0
          and reading_timestamp > :<timestamp>1
    )
```

Perform local analysis on each device

Distribute computing and storage costs over many devices

Leverage industry-standard SQL

- Simplify program source code
- Easy date and time calculations
  - Rate of change
  - Linear interpolation
  - Timestamp format conversion

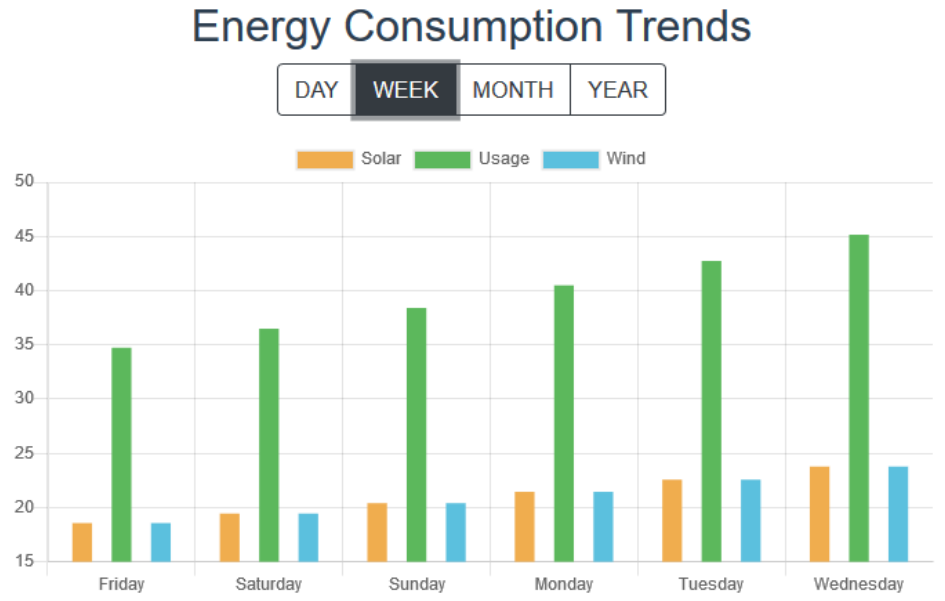
Reports in Microgrid Dashboard

User can access data even without Internet

- No connection
- Service interruption/discontinued

Use SQL to:

- Find data over any time range
- Group and aggregate data
- Format data for graphs and charts
- Compare energy usage vs. energy production
- Identify highest sources of energy cost




```
select meter_type,
       start_timestamp,
       date_format(start_timestamp, 'H:mm') as t,
       abs(sum(total_kWH)) as total_kWH
  from reading_period
  join meter using (meter_id)
  where period_type = 'H'
    and start_timestamp between current_date - interval '1' day and current_date
  group by meter_type, start_timestamp
```

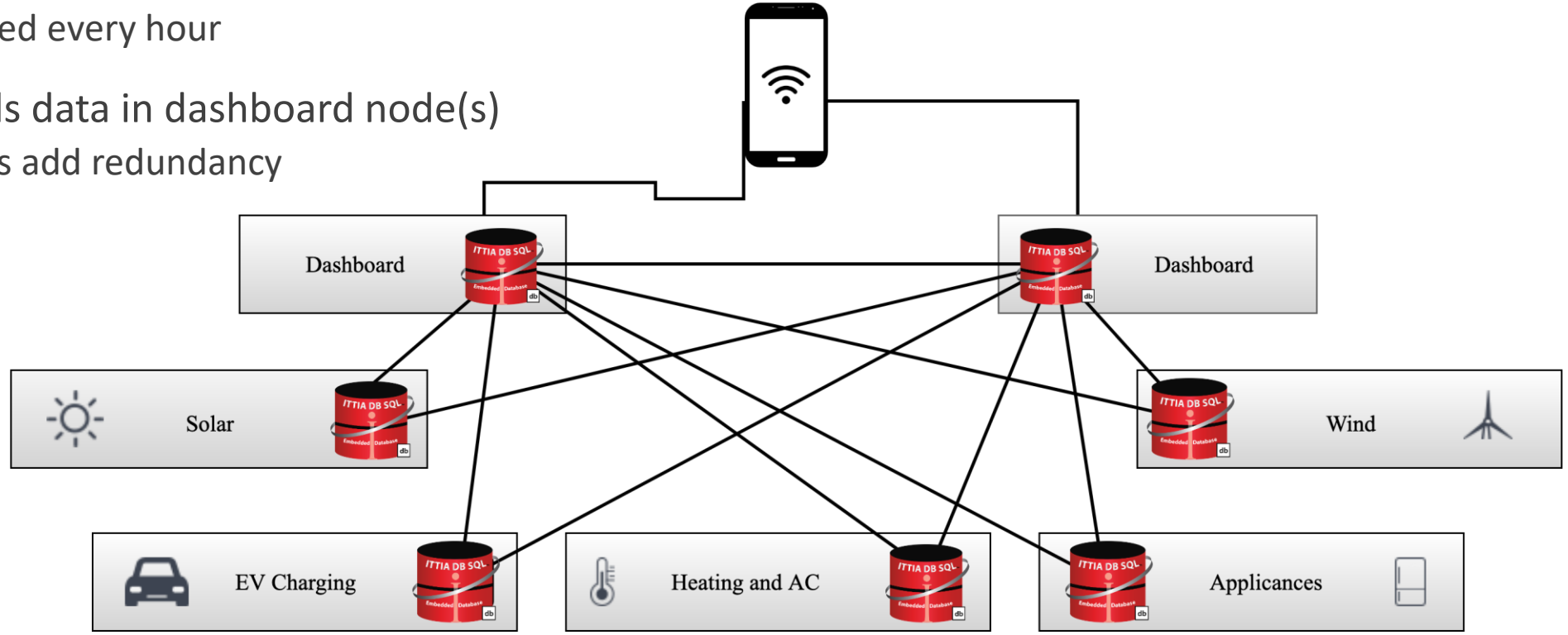
Database High Availability

Each meter is a replication node

- With a local database
- Analysis scheduled every hour

Accumulate trends data in dashboard node(s)

- Extra dashboards add redundancy



Device Data Management Components

Software

- ITTIA DB SQL embedded database software
- Embedded REST web server
- Linux Operating system
  - Real-time operating systems

Hardware

- NXP processors and partner solutions
  - Toradex **Colibri iMX8X**
    - Built with NXP i.MX 8QuadXPlus applications processor
  - TQ **TQMLS1046A Starter Kit**
    - Built with NXP Layerscape LS1046A processor

NXP Layerscape®

NXP i.MX 8QuadXPlus Applications Processor

NXP, Toradex and TQ

ITTIA
Database Software & Services

https://www.ittia.com/NXP2019prize

Register for a chance to win a Get Started Kit

- One (1) development board based on either the i.MX 8X or Layerscape® LS1046A processor
  - ITTIA DB SQL Development Licenses
  - Three (3) hours of online IoT software and hardware development training
  - Up to two (2) hours of device data management consulting

ITTIA Added Value

- SQL – Standards for accessing and modifying device data with efficient queries
- Licensing - Clear single source
  - Predicted data management cost
- Flexible, ease of use and scalability
  - One database library for all embedded applications
- Cross platform
  - (i.e. Windows® OS, Linux® OS, QNX® RTOS, VxWorks® RTOS, INTEGRITY® RTOS, Torizon, ThreadX RTOS, ….)
  - Unified embedded database API for all platforms

NXP and Our Partners Together Serve 26,000+ Customers

Employees in
30+ Countries
Headquartered in Eindhoven, Netherlands

~30,000
Employees

9,000
Patent Families

$9.41B
Annual Revenue[1]

60+
Year History

~9,000
R&D Engineers

[1] Posted revenue for 2018 – Please refer to the Financial Information page of the Investor Relations section of our website at www.nxp.com/investor for additional information

Together With Our Valued Customers and Partners,

We Are Creating Secure Connections for a Smarter World

NXP Supply Longevity

Industrial applications require product longevity

- Long product lifecycles
- Special product certification

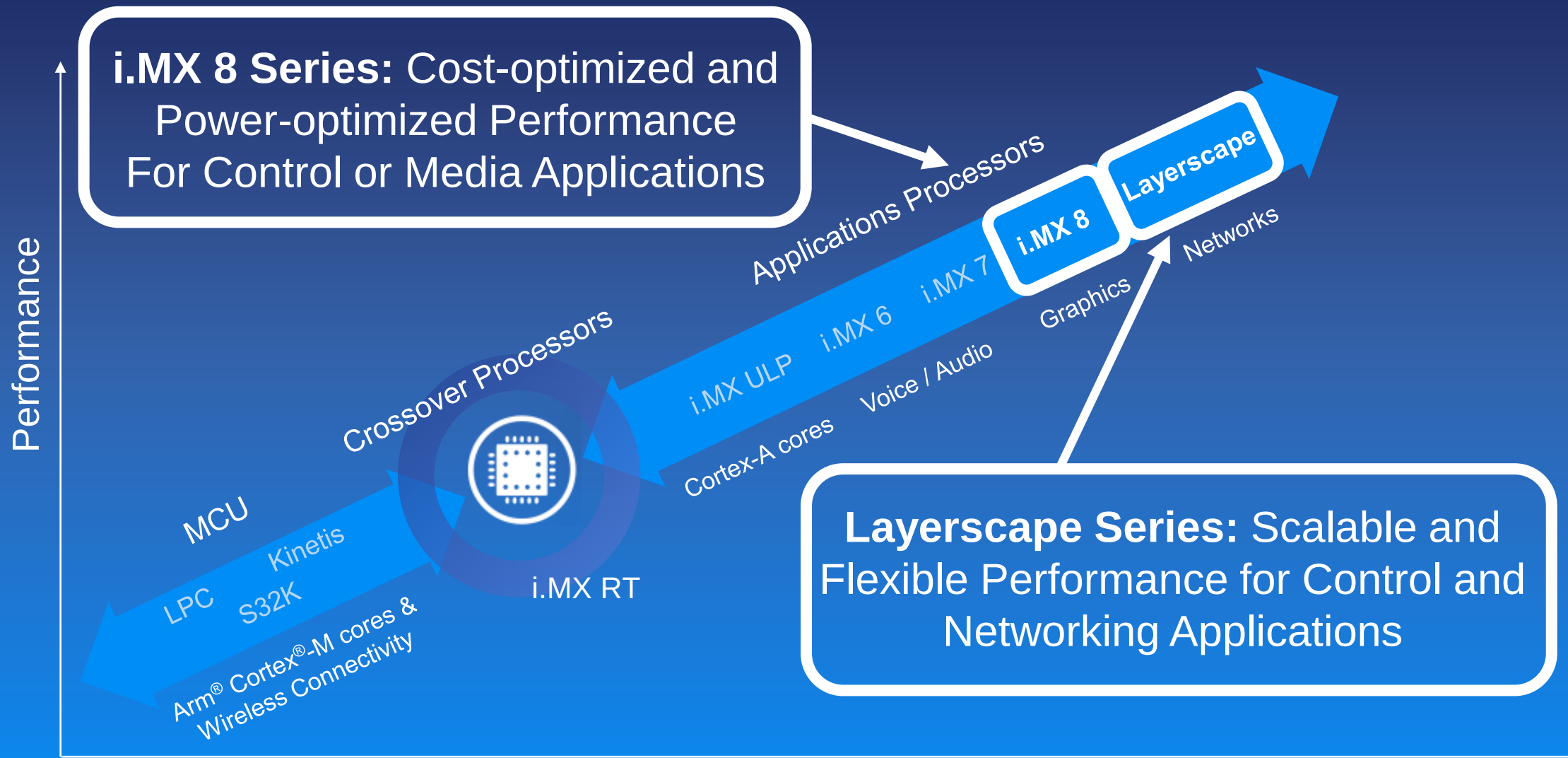
NXP Industrial Application Processors

- 10 and 15 year supply longevity options
- Formal program with products listed at www.nxp.com/productlongevity

NXP Qualification Specifications

Qualification Level	Characteristics
Commercial or Consumer Highest MHz	5-year life, 50% on Typically: 0C to +85C Tj
Industrial Longest operating life	10-year life, 100% always on Typically: -40C to +105C Tj
Automotive Widest temperature range	15-year life, 10% on Typically: -40C to +125C Tj

NXP Scalable Arm® Processing Continuum



i.MX 8 Series for Consumer, Industrial & Automotive Applications

Advanced graphics, video, image processing, vision, audio and voice

i.MX 8M Family

A53 M4 GPU

Advanced Computing,
Audio/Video & Voice




i.MX 8X Family

A35 M4 GPU DSP

Safety Certifiable &
Efficient Performance



i.MX 8 Family

A72 A53 M4 GPU DSP

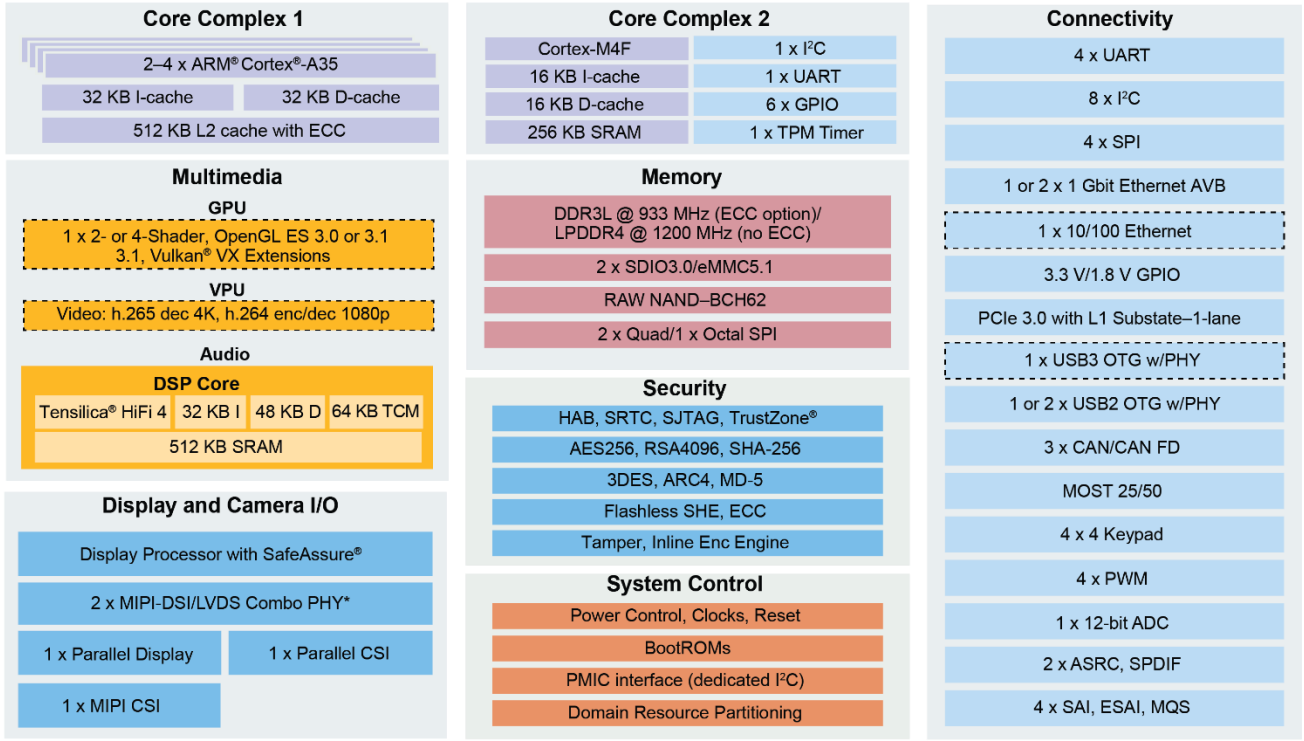
Advanced Graphics,
Vision & Performance



i.MX 8QuadXPlus and 8DualXPlus

Targeting mid-range industrial HMI and Control:

- **2x or 4x Arm Cortex-A35** @ 1.0GHz (7,120 DMIPs)
  - 512KB L2 cache and DDR3L with **ECC for reliability and safety certification**
- **1x Cortex-M4F** @ 200MHz, 256KB TCM with **ECC**
- **Drive up to 3 displays:**
  - 2x MIPI-DSI (4-lanes) @ 1080p or 2x LVDS (4-lanes); OR merge to 1x LVDS (8-lanes)
  - 1x Parallel display (WVGA)
- **VPU and GPU**
- **Attach up to 4 cameras**
  - 1x MIPI CSI2 (4 lanes, 1.5 Gbits/lane)
  - 1x parallel camera CSI
- 2x GbE Controller with AVB and IEEE® 1588
- 3x CAN/CAN-FD
- 12-bit ADC (6 channels)
- 70% hardware reuse from i.MX 8QuadMax



* Each single PHY can either be a 1× 4 lane MIPI-DSI or a 1×1 channel LVDS interface for a total of 2 display interfaces. In combination, the two PHYs can be configured to be a single 2-channel LVDS interface.

- 21x21 FCBGA 0.8mm pitch; easier layout & manufacturing
- 17x17 FCBGA 0.8mm pitch has 16-bit LPDDR4 bus

Layerscape Series: Scalable, Flexible Control & Networking

Leverage One Design into Diverse Product Portfolio

Scalable series of **64-bit** ARM-based SoC Families

LS1012A	LS1028A	LS1023A	LS1043A	LS1026A	LS1046A	LS1048A	LS1088A	LS2048A	LS2088A	LX2160A
A53	2x A72	2x A53	4x A53	2x A72	4x A72	4x A53	8x A53	4x A72	8x A72	16x A72
LS1012A	**LS1028A**	**LS1023A**	**LS1043A**	**LS1026A**	**LS1046A**	**LS1048A**	**LS1088A**	**LS2048A**	**LS2088A**	**LX2160A**
2Gbps Packet 1Gbps Crypto 1-2W	Integrated GPU 5Gbps Crypto 4- 9W	10Gbps Pkt 5Gbps Crypto 3.5-5W	10Gbps Pkt 5Gbps Crypto 5-8W	20Gbps Pkt 10Gbps Crypto 6-10W	20Gbps Pkt 10Gbps Crypto 8-12W	20Gbps Pkt 10Gbps Crypto 15-20W	20Gbps Pkt 10Gbps Crypto 15-20W	40G Pkt 20G Crypto 20-35W	40G Pkt 20G Crypto 20-35W	100G Pkt 50G Crypto 20-30W

Pin-to-pin Compatible

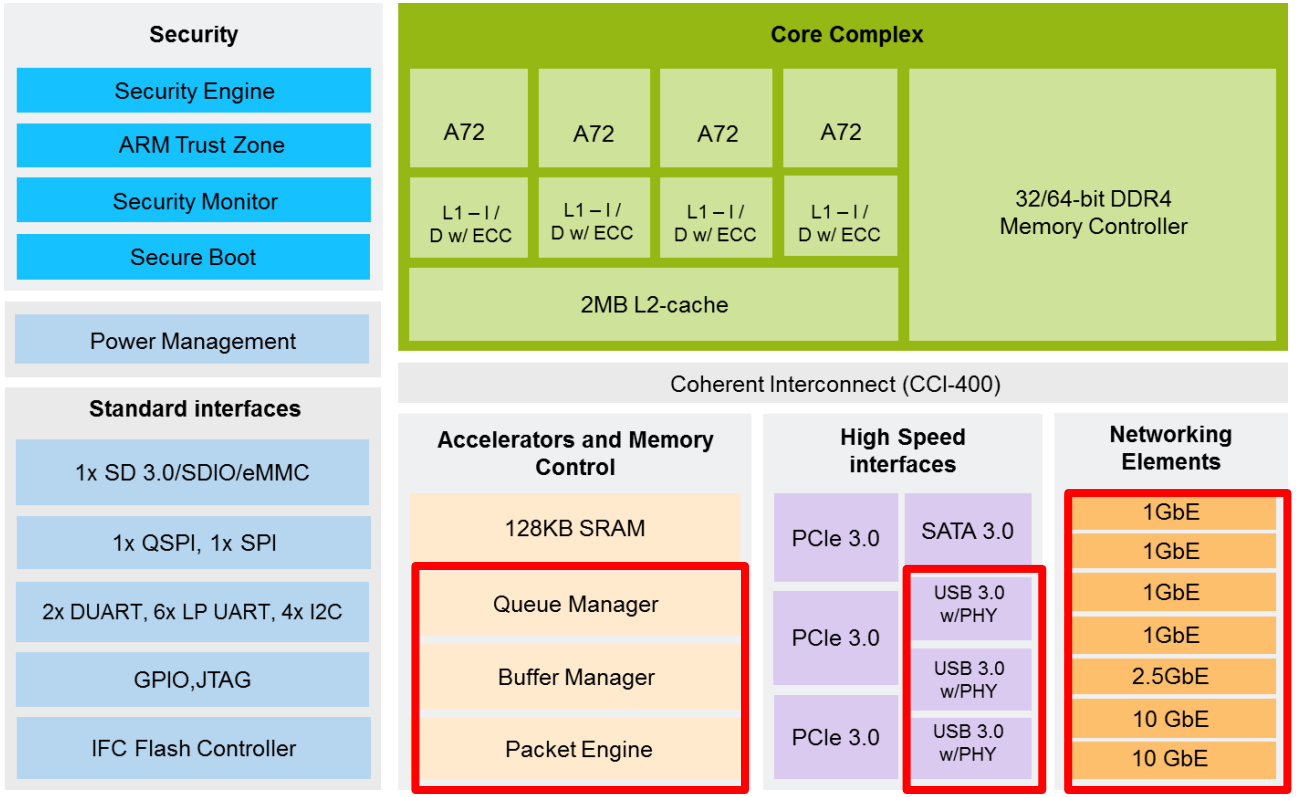
Pin-to-pin Compatible

Software Compatible

Expanded series for performance, power efficiency and lower BOM

LS1046A: Quad Arm Cortex-A72 Processor

Value Tier Cortex-A72 for gateways, routers and controllers



Core complex

- 4x 32/64-bit Cortex-A72 with Neon SIMD engine, up to 1800 MHz
- Parity and **ECC** protected 48 KB L1 instruction and 32 KB L1 data cache
- 2 MB L2 cache with **ECC protection**

Basic peripheral and Interconnect

- 3x USB 3.0 controllers with integrated PHY
- 1x eSDHC controllers supporting SD 3.0, and eMMC 4.5 modes

Networking elements

- Packet parsing, classification, and distribution
- Queue Management for scheduling, packet sequencing and congestion management
- Hardware buffer management for buffer allocation and de-allocation
- Up to five SGMII supporting 1 Gbps
- Up to three SGMII supporting 2.5 Gbps
- Up to two XFI supporting 10 Gbps
- Up to one QSGMII
- 3x PCI Express Gen 3 controller
- 1x SATA Gen 3.0 controller

Accelerators and Memory Control

- 1x 32-bit DDR4 Controller with **ECC support** up to 2.1 GT/s
- Security Engine (SEC)
- QorIQ Trust architecture: Secure boot, ARM Trust zone and security monitor

Qualification

- Commercial and industrial extended temperature

Target Applications:

- Enterprise routers and switches
- Line card controllers
- Network attached storage
- Security appliances
- Virtual customer premise equipment (vCPE)
- Service provider gateways
- Single board computers

Development platform:

- LS1046A-RDB

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Toradex

Embedded Computing Made Easy

https://www.toradex.com

September 2019

SECURE CONNECTIONS
FOR A SMARTER WORLD

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Proven Partner

NXP

Make Embedded Computing Easy

Reliable Arm System on Modules

Lowest Cost of Ownership

Industry-leading Support

Global Presence Close to You

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Arm System on Modules
Reliable
Scalable
Long-term Maintenance

Torizon

Production-ready Software
Torizon easy-to-use Linux
Yocto-based Linux
Windows Embedded Compact
Development Tools
Long-term Maintenance

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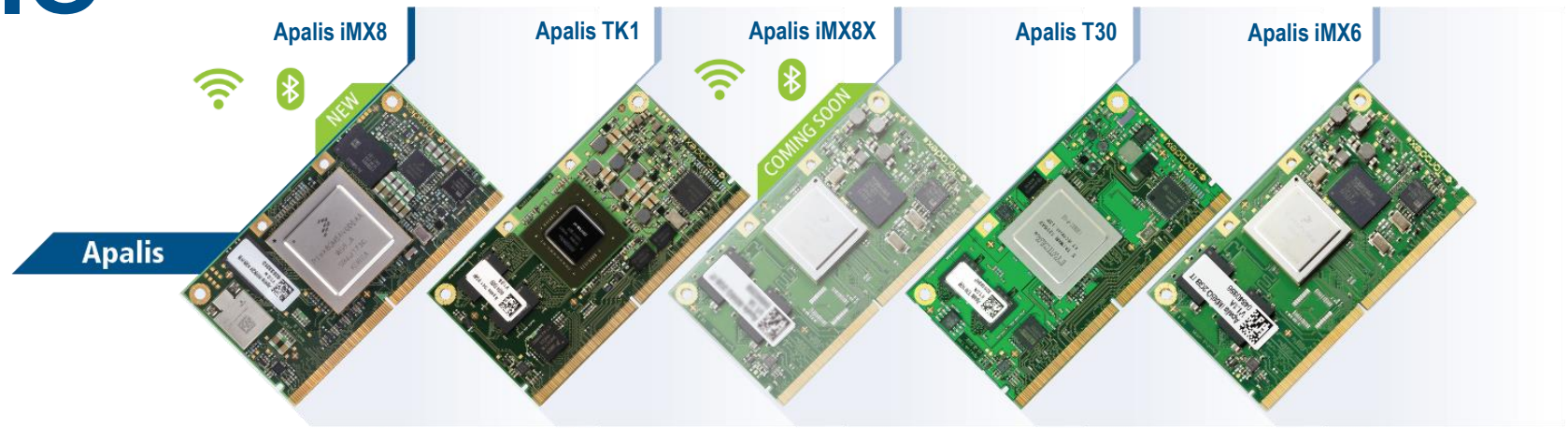
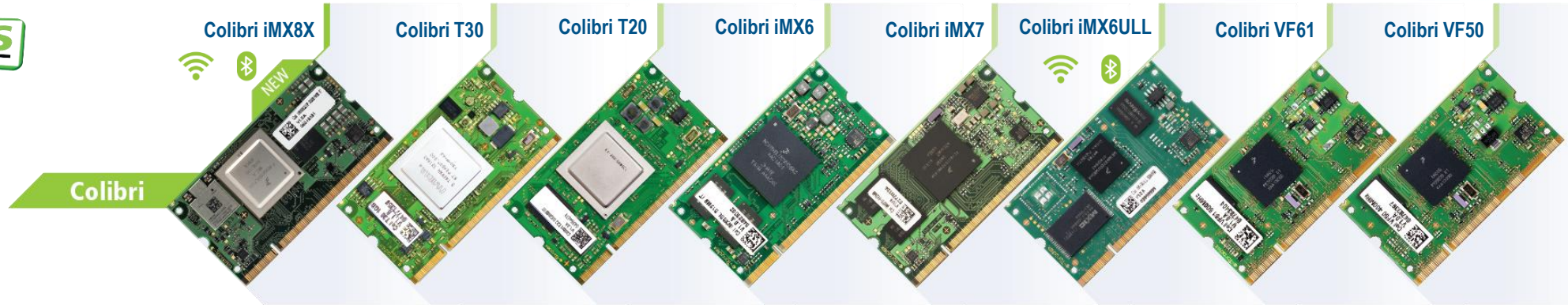
Ease-of-use
Support
Ecosystem

Proven Partner
NXP

PRODUCT PORTFOLIO

Torizon





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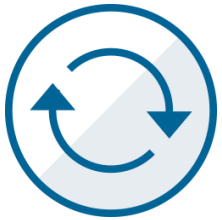
Easy-to-use Industrial Linux Software Platform

Fast time-to-market
Ready-to-use
Linux distribution



Simple updates
Built-in, automotive-grade,
over-the-air update capabilities

Secure
Frequent updates, accessible
security features

Real-time
Optimized real-time option

Stable
Modern continuous integration
infrastructure and verification

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COLIBRI iMX8X

NXP i.MX 8QuadXPlus, 8DualXPlus and 8DualX

Small, Proven SODIMM Form Factor

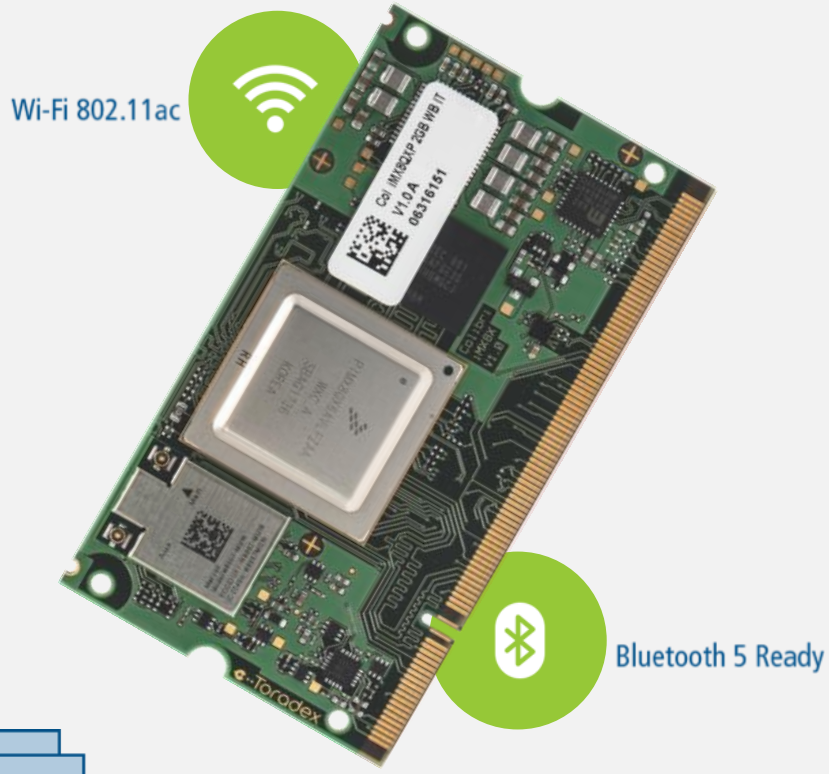
Optimized for **Lowest Power**

Designed for **Safety** and **Real-time**

Pin-compatible with all SoMs across the Colibri Family

Large **Partner Ecosystem**

Qt, CODESYS, QNX, GreenHills, ITTIA…



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PRE-INSTALLED
TORADEX EASY INSTALLER

www.toradex.com/computer-on-modules/colibri-arm-family/nxp-imx-8x

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Leading technology solutions "designed in Germany"

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September 2019

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The technology company **TQ Group** is one of the largest electronics specialists in Germany, and offers the complete range of services from the initial idea to the finished product.

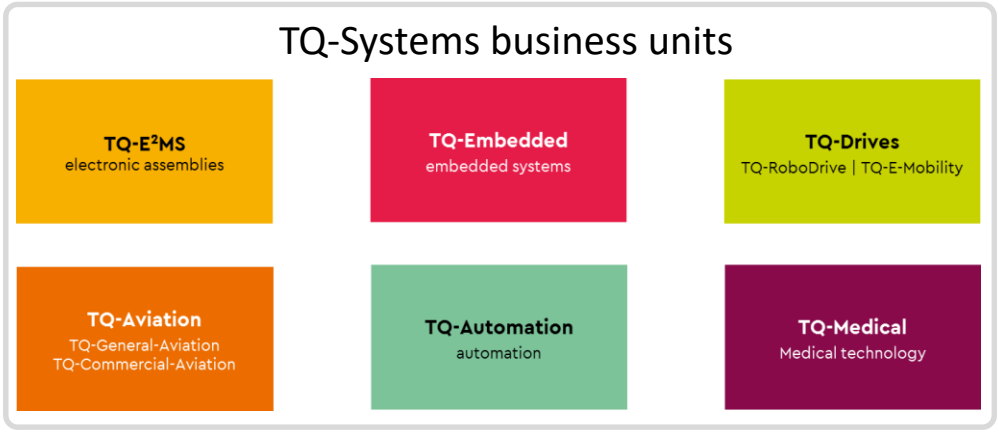
The TQ Group offers products and services in the fields of E²MS, Embedded, Drives, Robotics, Automation, Medical and Aviation.

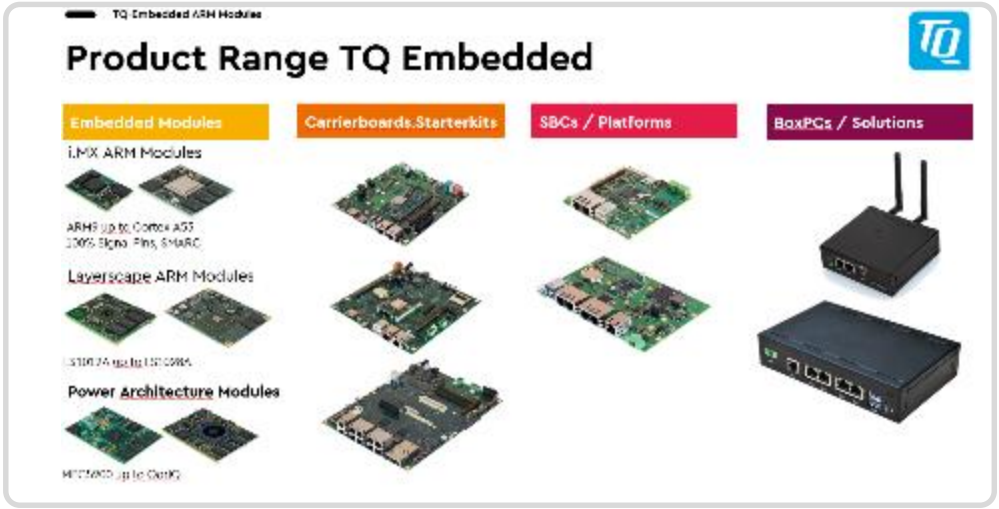
Headquarters:
Gut Delling, Seefeld, Germany

Regions Served:
11x Germany, 1x Switzerland, 1x USA, 1x China

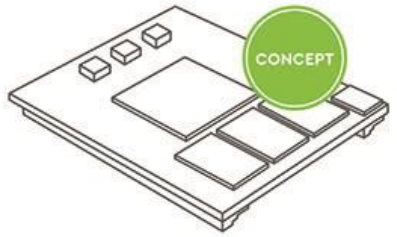
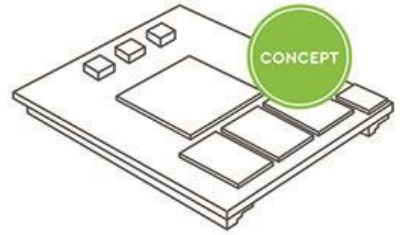
Business Models

- Embedded Modules + Hardware and Software Support
- Common hardware and software features evaluation
- Customer-specific carrier board designs
- Customer-specific software adjustments





Arm® product line – more than 10 years of history (1)

Cortex® A35 TQMa8Xx	Cortex® A35 TQMa8XxS	Cortex® A53/A72 TQMa8x	Cortex® A53 TQMa8Mx	Cortex® A53 TQMa8MxML
				
TQMa8XD TQMa8XDP TQMa8XQP	TQMa8XDS TQMa8XDPS TQMa8XQPS	TQMa8DM TQMa8QP TQMa8QM	TQMa8MD TQMa8MQL TQMa8MQ	TQMa8MSML TQMa8MDLML TQMa8MDML TQMa8MQLML TQMa8MQML TQMa8MSNL
				

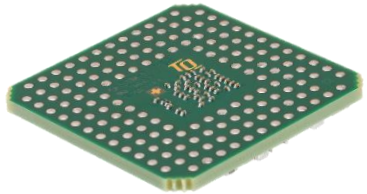
Arm® product line – more than 10 years of history (2)

Cortex® A7
TQMLS102xA

TQMLS1020A
TQMLS1021A
TQMLS1022A

Cortex® A53
TQMLS1012A

TQMLS1012AL



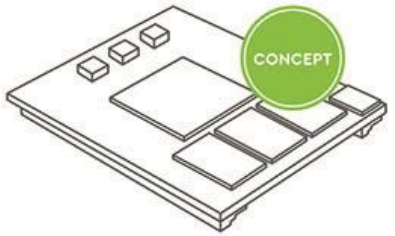
Cortex® A53/A72
TQMLS10xxA

TQMLS1026A
TQMLS1046A
TQMLS1023A
TQMLS1043A
TQMLS1088A

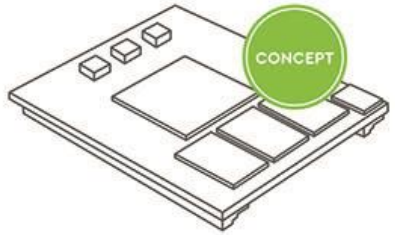
Cortex® A72
TQMLS1028A

TQMLS1028A
TQMLS1018A
TQMLS1027A
TQMLS1017A

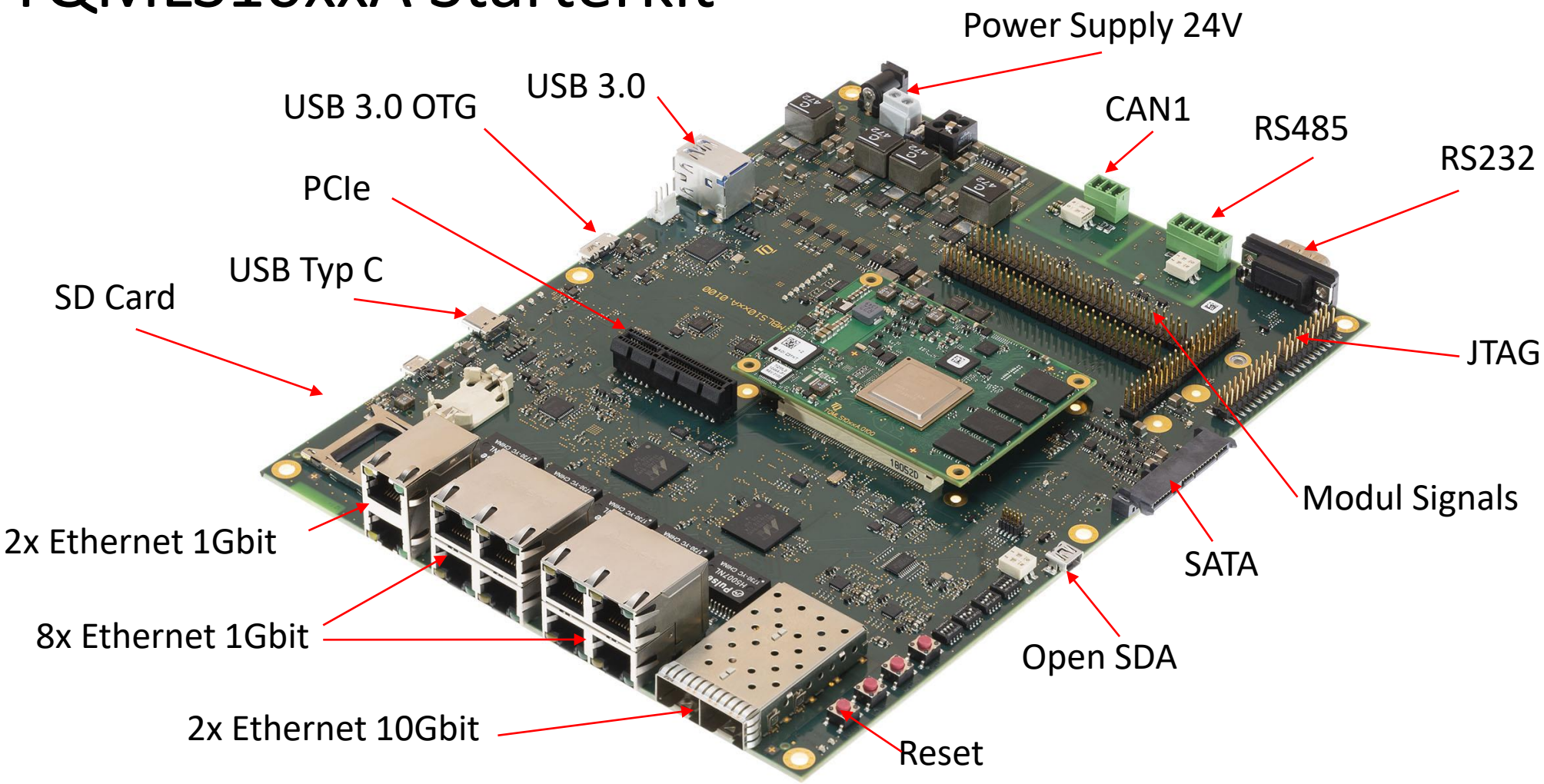
Cortex® A72
TQMLX2160A



TQMLX2160A
TQMLX2120A
TQMLX2080A

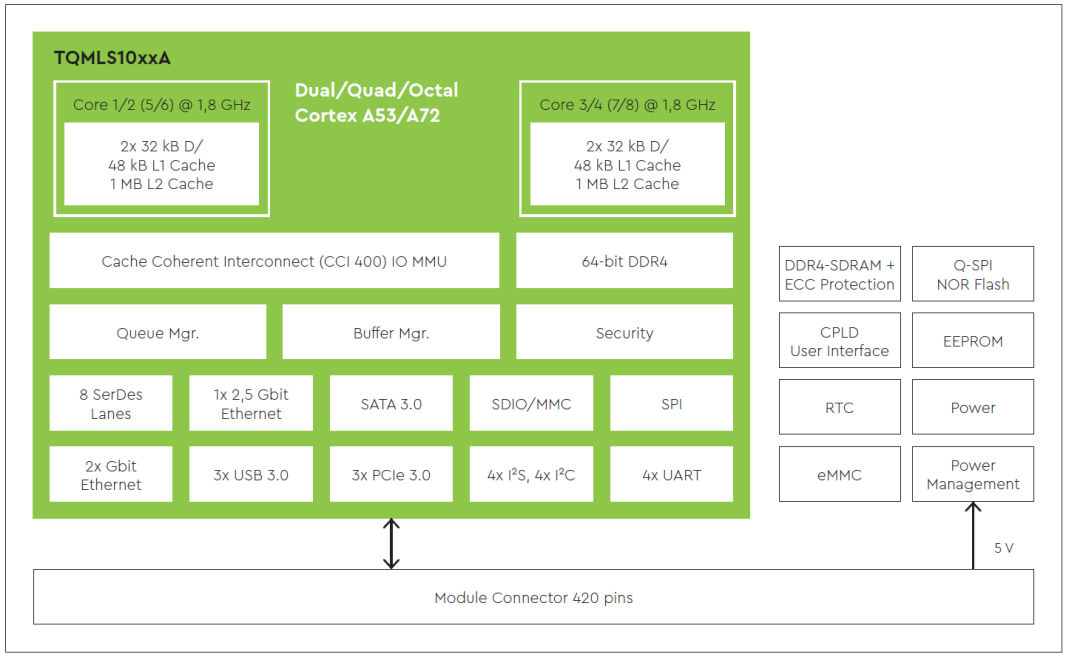


TQMLS10xxA Starterkit



Bottom side: 2x Mini PCIe Slot (1xSIM Card support), M.2 PCIe,

TQMLS10xxA (Cortex® A53 / A72)



Processor	QorIQ LS1023A, LS1043A LS1026, LS1046, LS1088A
Memory	DDR4 SDRAM, eMMC flash, NOR flash, EEPROM
Power Supply	5 VDC
Ambient conditions	Extended
Plug-in System	420 pin, 0.8 mm pitch
Dimensions	80 mm * 60 mm
Status	pre-series

TQMLS1046A (26A), TQMLS1043A (23A), TQMLS1088A

- 2x 10 Gigabit Ethernet for the first time at the Layerscape CPU‘s
- 5 CPU derivatives in one design (Cortex A53, Cortex A72)
- Up to eight Cortex A53 cores
- Highest data throughput due to the latest network technology
- Possible applications with high real-time requirements in combination with a high computing power
- High energy efficiency due to the latest Cortex A technology

ITTIA
Database Software & Services

Summary

Innovate faster with proven hardware and software

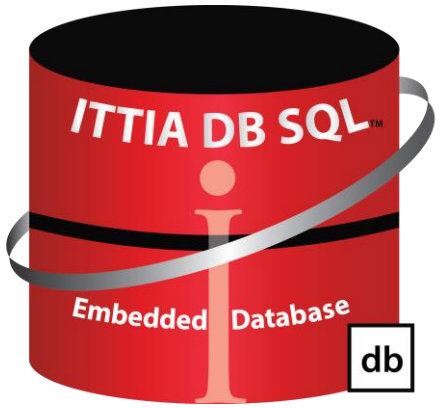
- ❑ Collect/manage/analyze large volumes of IoT data on local devices
- ❑ Build on production-ready Arm modules and software solutions
- ❑ Reduce application development time and cost

Extend your development team with reliable, expert partners

- ❑ Leverage partner tools, resources and experience
- ❑ Avoid unnecessary risk for complex designs
- ❑ Empower developers with state-of-the-art technologies

Q & A

- Alexandra Dopplinger, NXP
  - *Industrial Applications Processors*
- Sasan Montaseri, ITTIA
  - *Founder and President*
- Ryan Phillips, ITTIA
  - *Architect*
- Daniel Lang, Toradex
  - *Chief Marketing Officer*
- Konrad Zoepf, TQ-Group
  - *Product Management*



תודה Спасибо ਤੁਹਾਡਾ ਧੰਨਵਾਦ Grazie

ありがとうございました 감사합니다

谢谢 teşekkür ederim

Je vous remercie Danke متشكرم Kiitos

Thank you