TOSHIBA

Leading Innovation

TSN Ethernet and Intelligent Applications for Industry 4.0

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Toshiba Electronics Components Taiwan Corporation

Today's Agenda

01 Background

02 Toshiba's solution for IIoT

03 Industrial Ethernet

04 Vision sensing

05 Robot hand

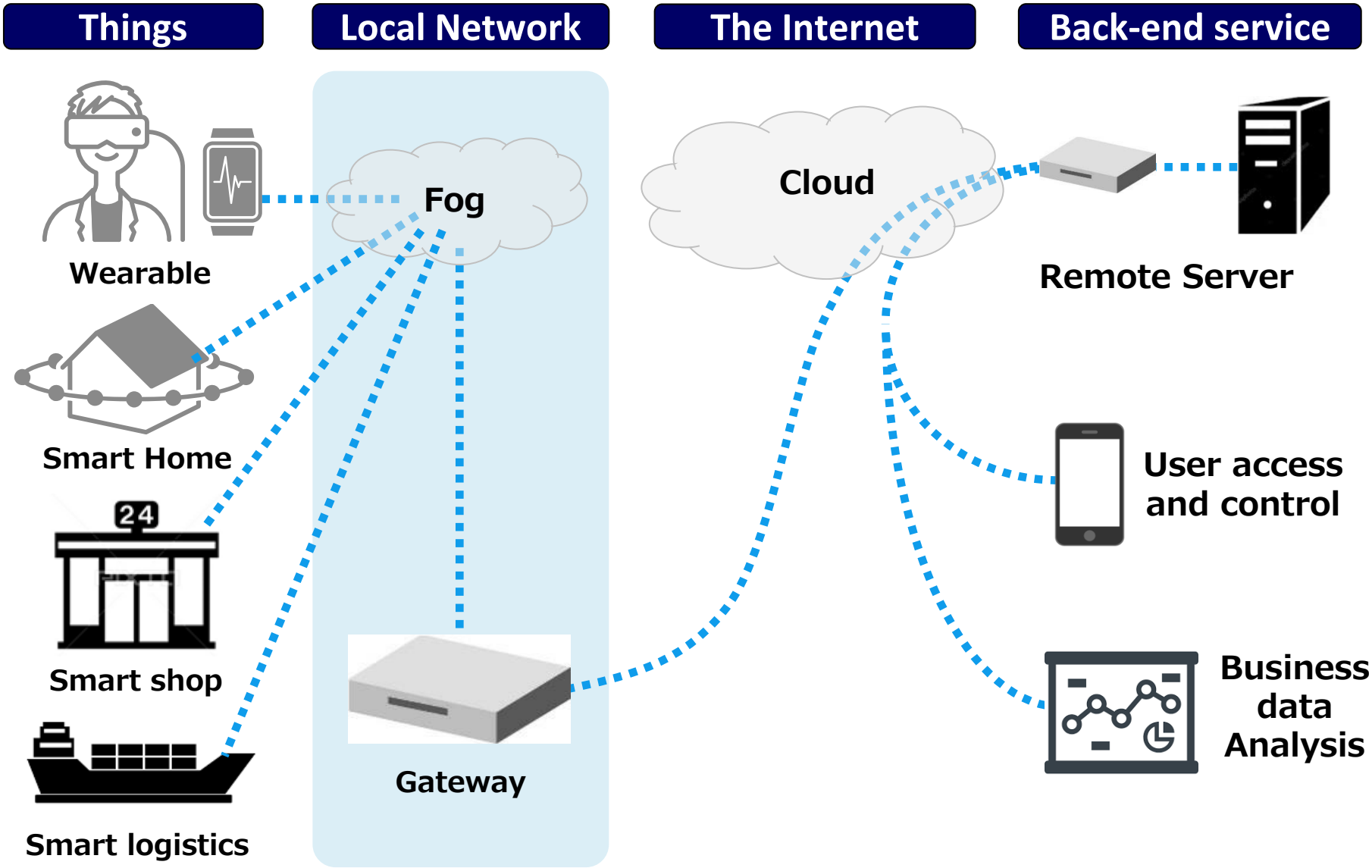
06 Wireless connectivity

01

Background

1. **IIoT network infrastructure**
2. **Field bus vs. Industrial Ethernet**
3. **Why AVB/TSN?**

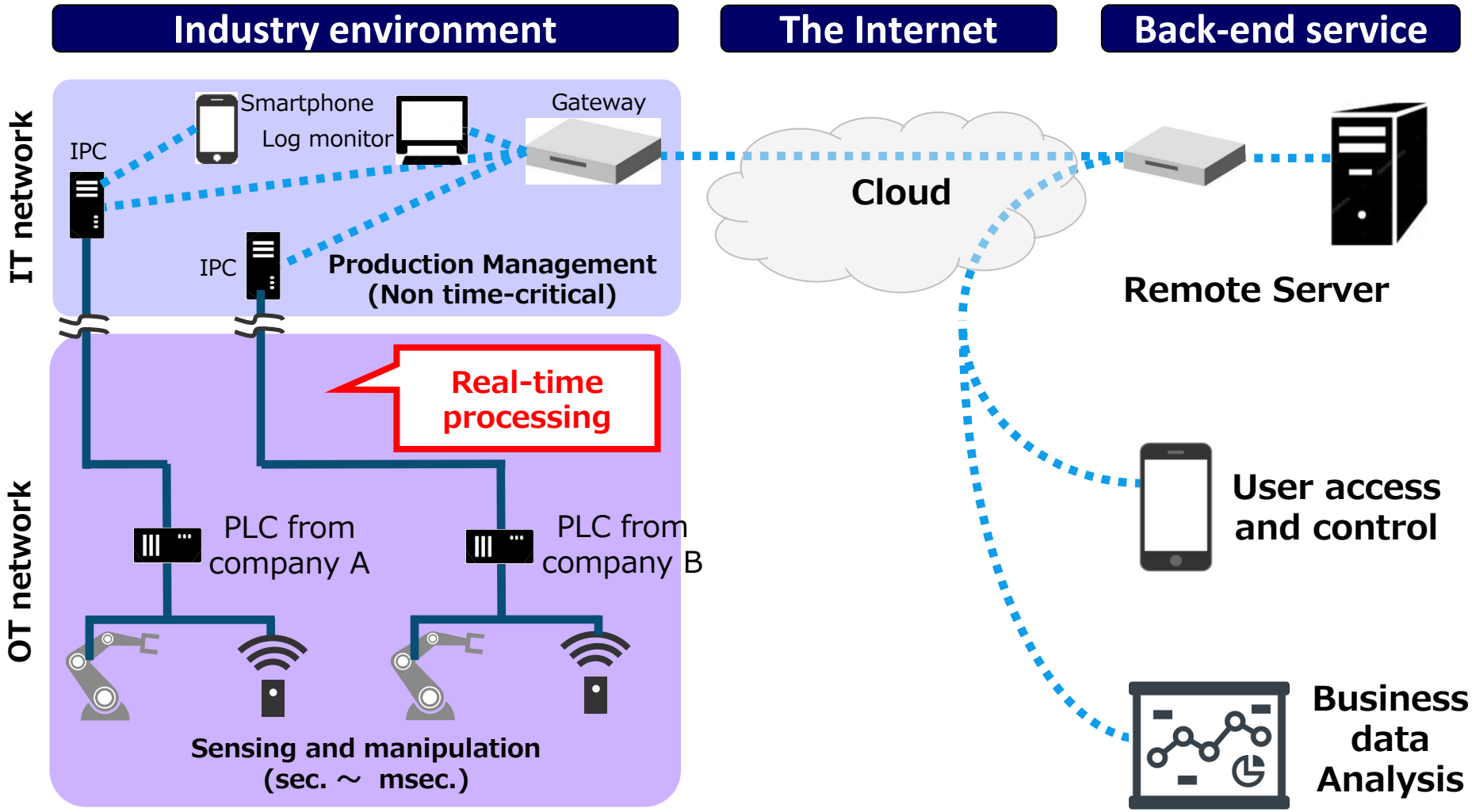
IoT network infrastructure



IIoT network infrastructure

Wireless
Legacy field bus

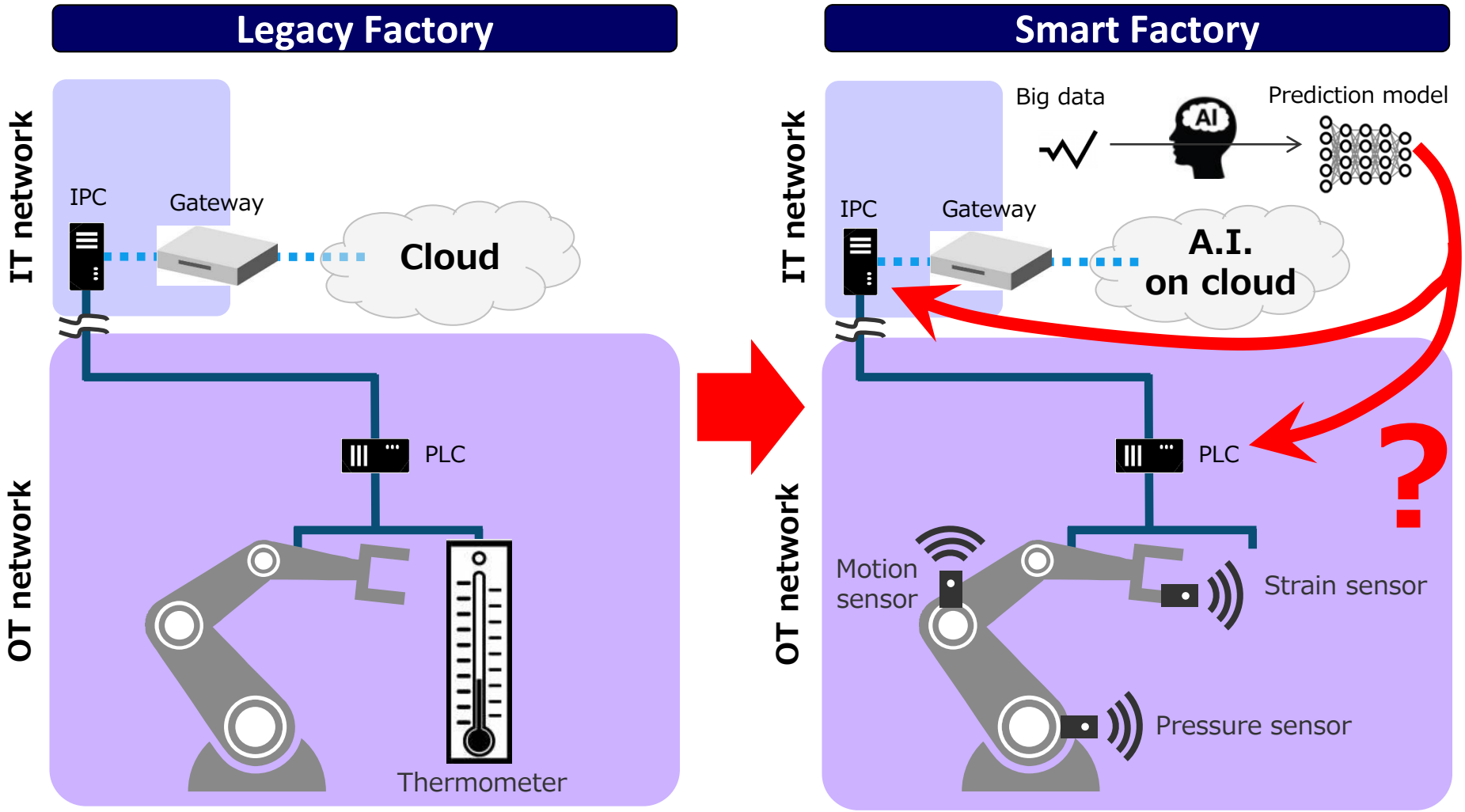
IIoT uses field bus to satisfy real-time constraints



IIoT network infrastructure

Wireless
Legacy field bus

Q: Where should smart algorithm be installed?



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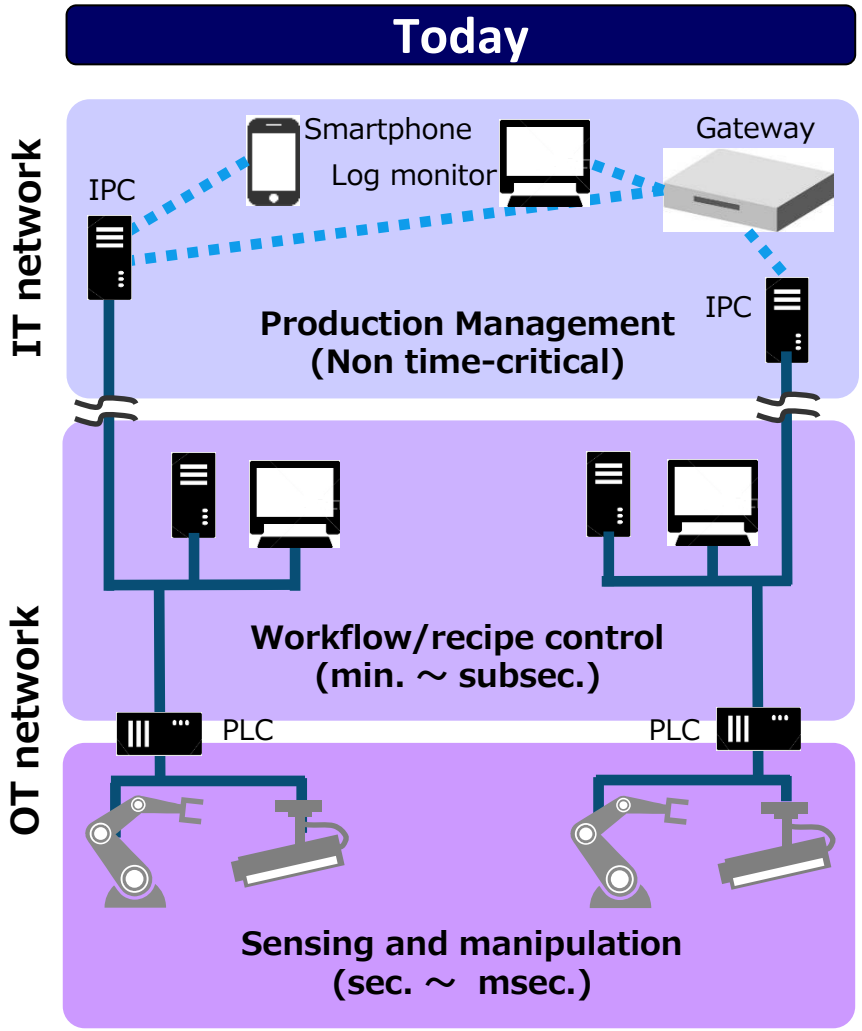
IIoT network infrastructure

Wireless
Legacy field bus

Answer: Locate a new device between IT and OT networks

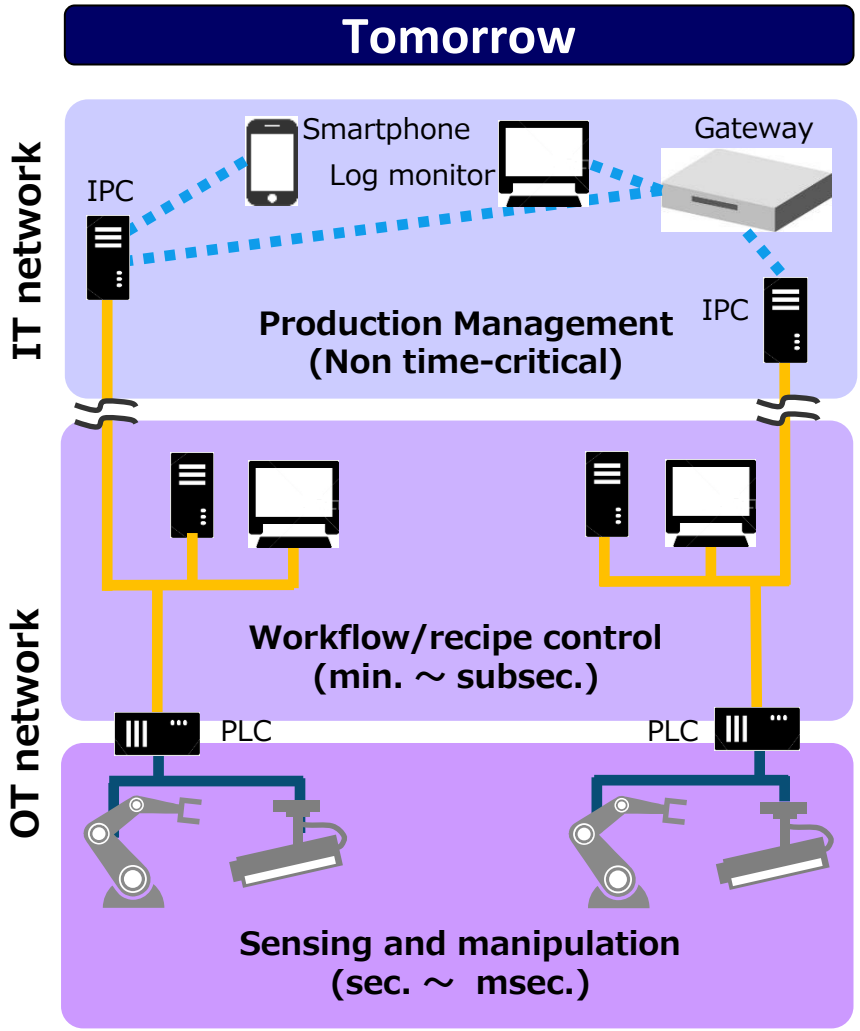


- ✓ **Good, because no need to change existing IT/OT network.**
- ✓ **However, field bus bandwidth down to PLC could be a concern in near future.**

IIoT network infrastructure

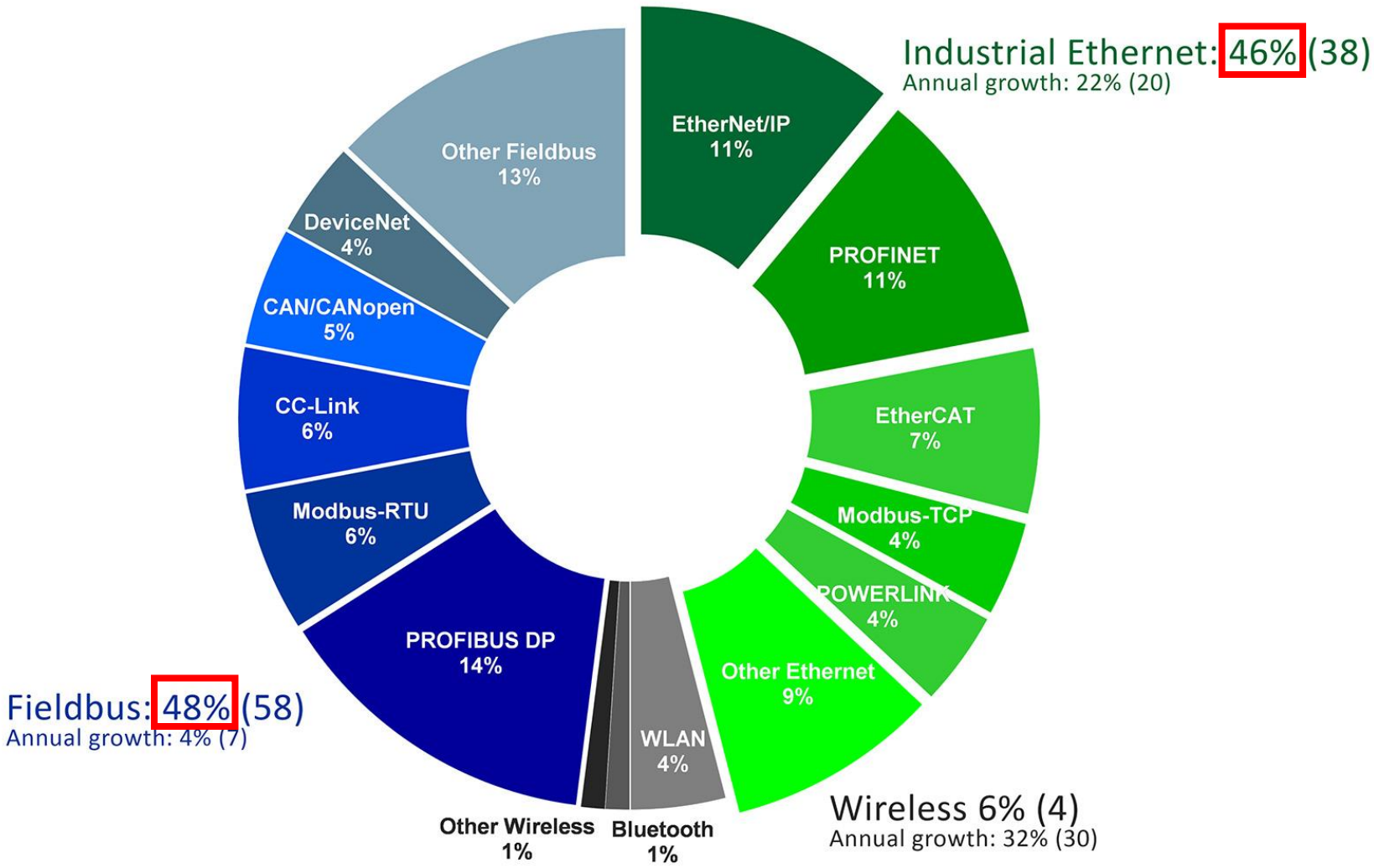
Wireless
Industrial Ethernet
Legacy field bus

Field bus cable is replaced with Ethernet cable to increase OT network bandwidth -> Industrial Ethernet



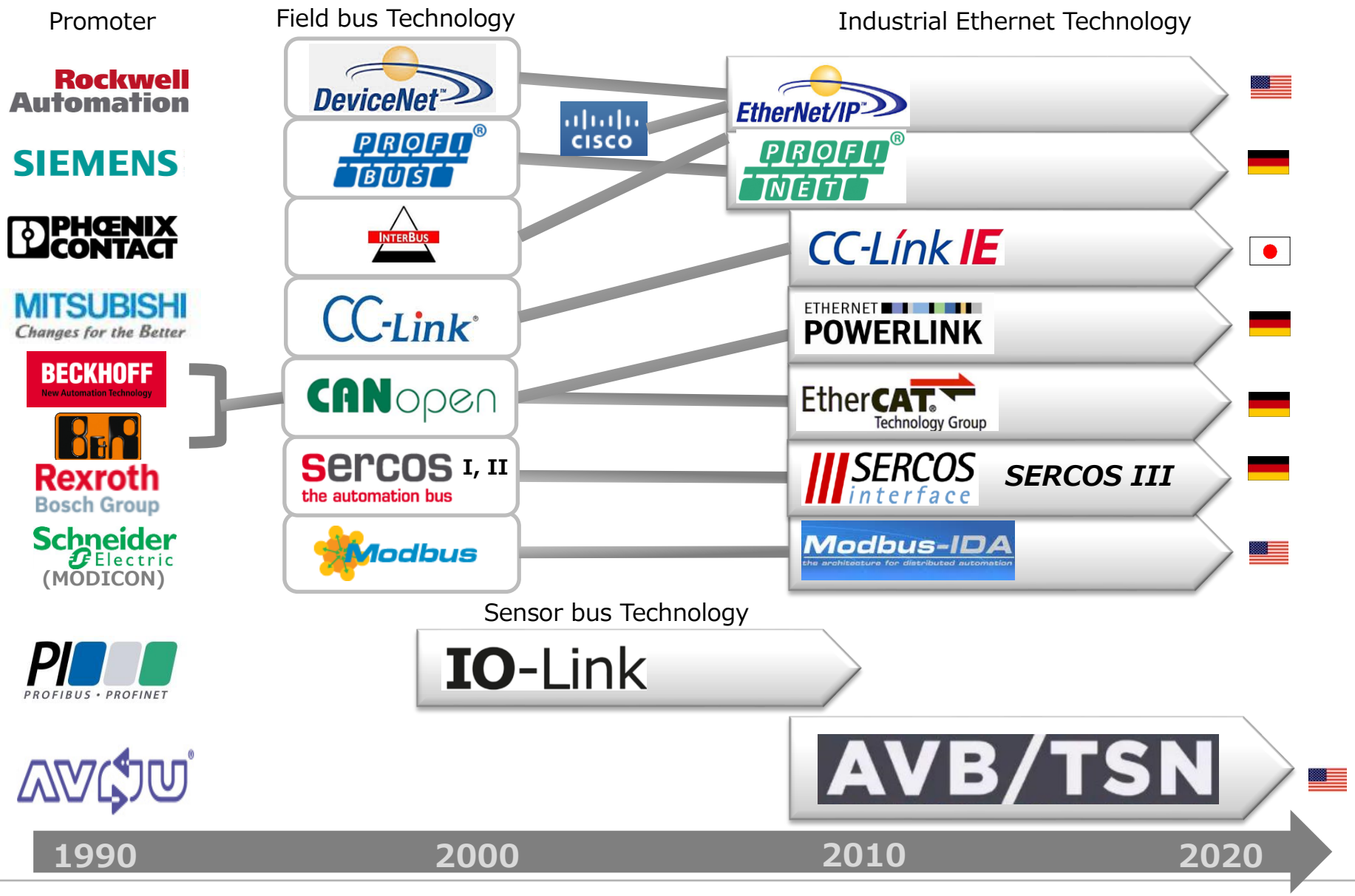
- ✓ **Better, because Ethernet interface is widely used and cabling cost is cheap.**
- ✓ **However, incompatibility of time sensitiveness over different OT network still exists.**

Field bus and Industrial Ethernet in 2017



https://www.anybus.com/about-us/news/2017/02/20/industrial-ethernet-and-wireless-are-growing-fast-industrial-network-market-shares-2017-according-to-hms

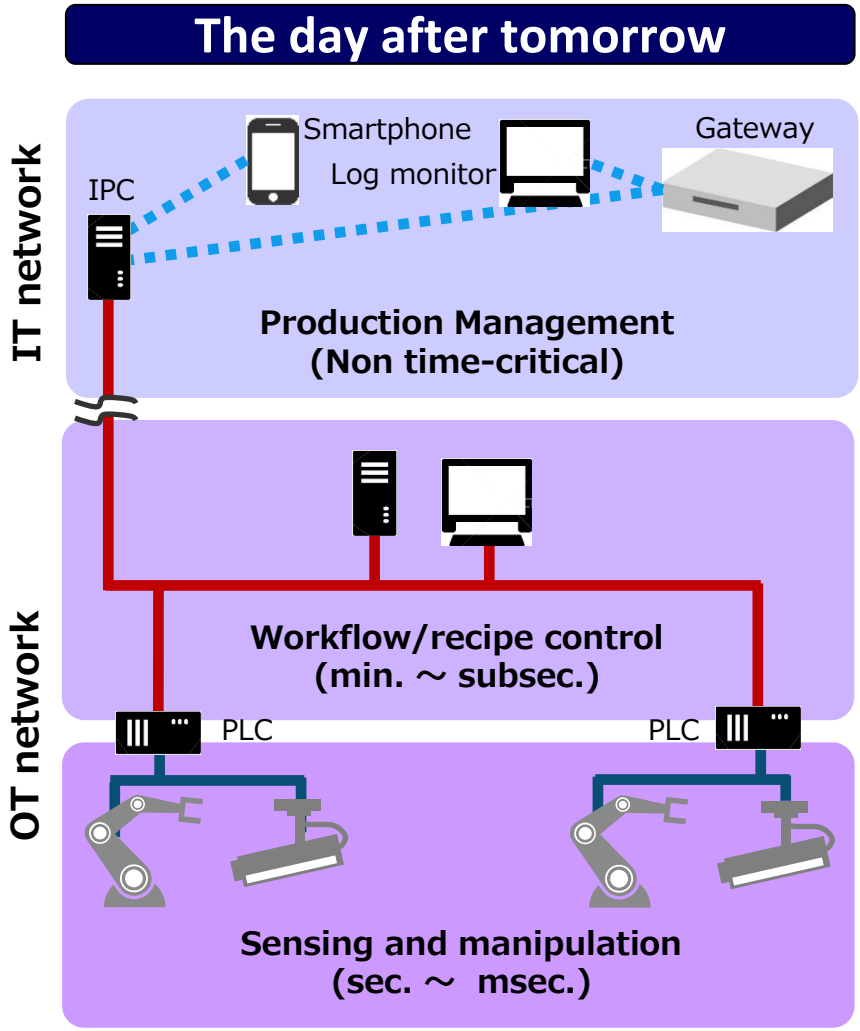
Variety of Industrial Ethernet Protocols



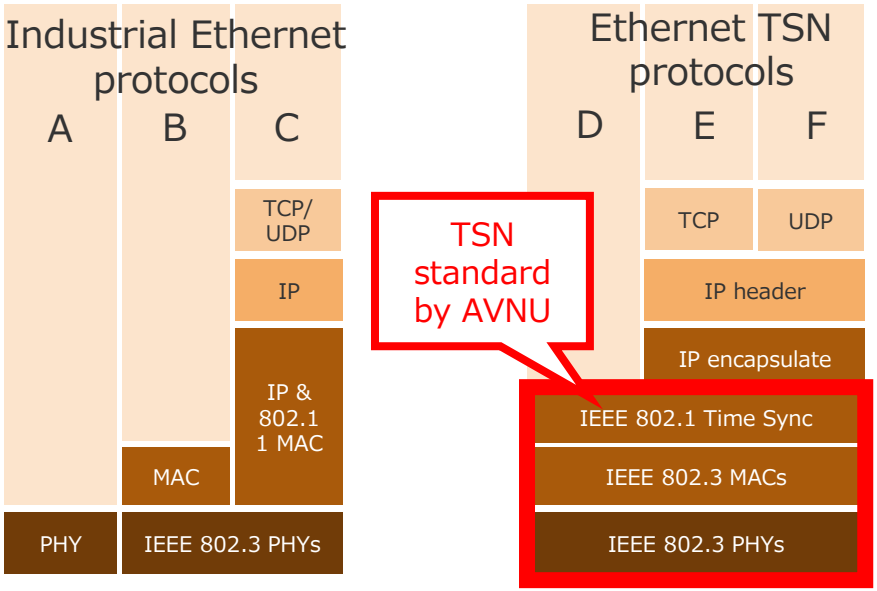
IIoT network infrastructure

Wireless
Industrial Ethernet
Ethernet TSN

Ethernet TSN is best, because it resolves network interoperability



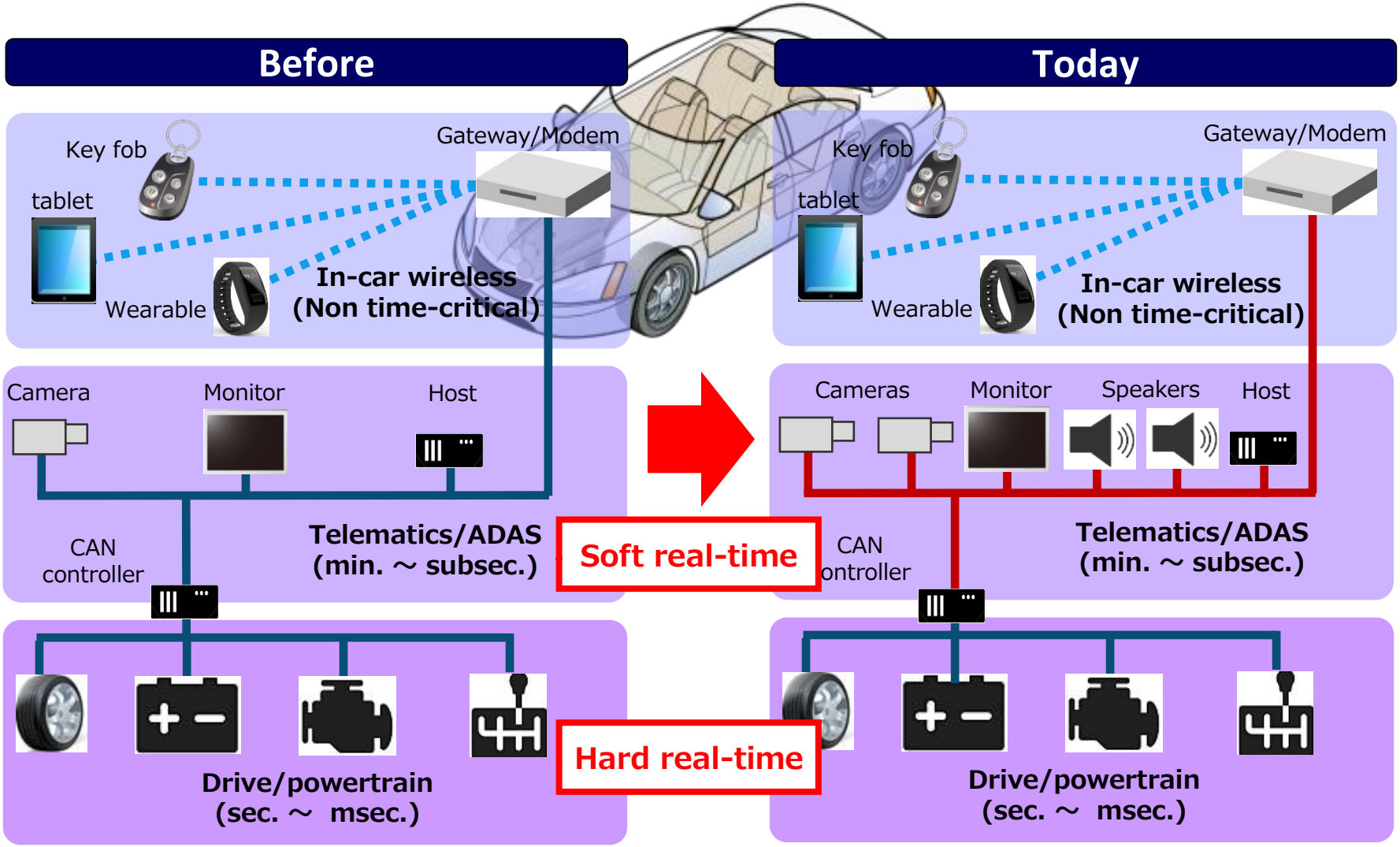
- ✓ **Key concept is to use OSI 2nd layer to support & guarantee time sensitiveness.**
- ✓ **If your protocol is aware of TSN, you can avoid vendor lock-in and minimize network cost by reusing Ethernet asset.**



Analogy with automotive

Wireless
Ethernet AVB
Legacy(CAN/Analog)

The same story already happens in automotive network at EU.



02

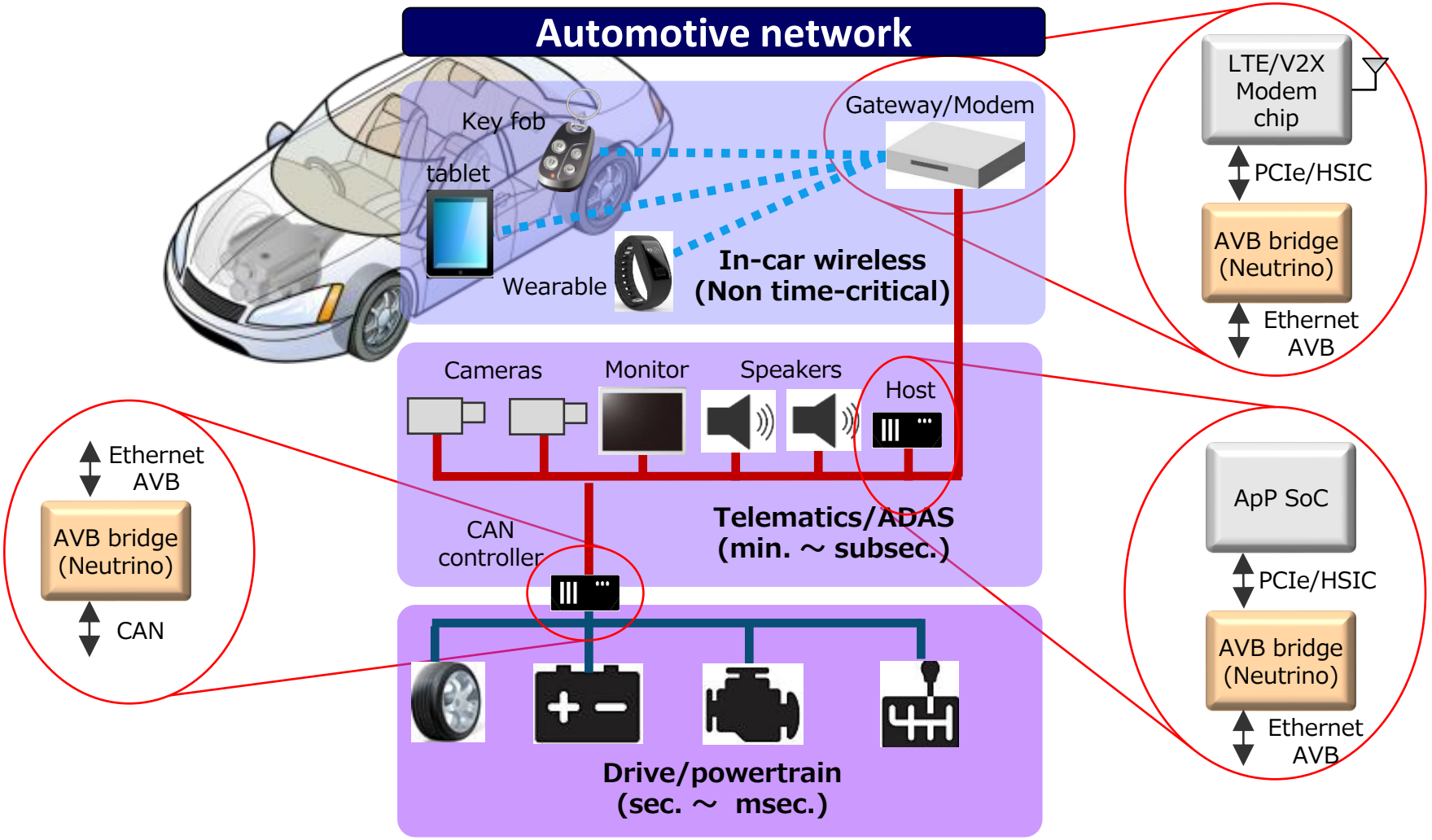
Toshiba solutions for IIoT

1. **Ethernet AVB/TSN bridging**
2. **Vision sensing and robot hand**
3. **Wireless (BLE + SubGHz)**

Toshiba solution for IIoT [1]

Wireless
Ethernet AVB
Legacy(CAN/Analog)

Ethernet AVB bridge IC “Neutrino” phases into MP for automotive

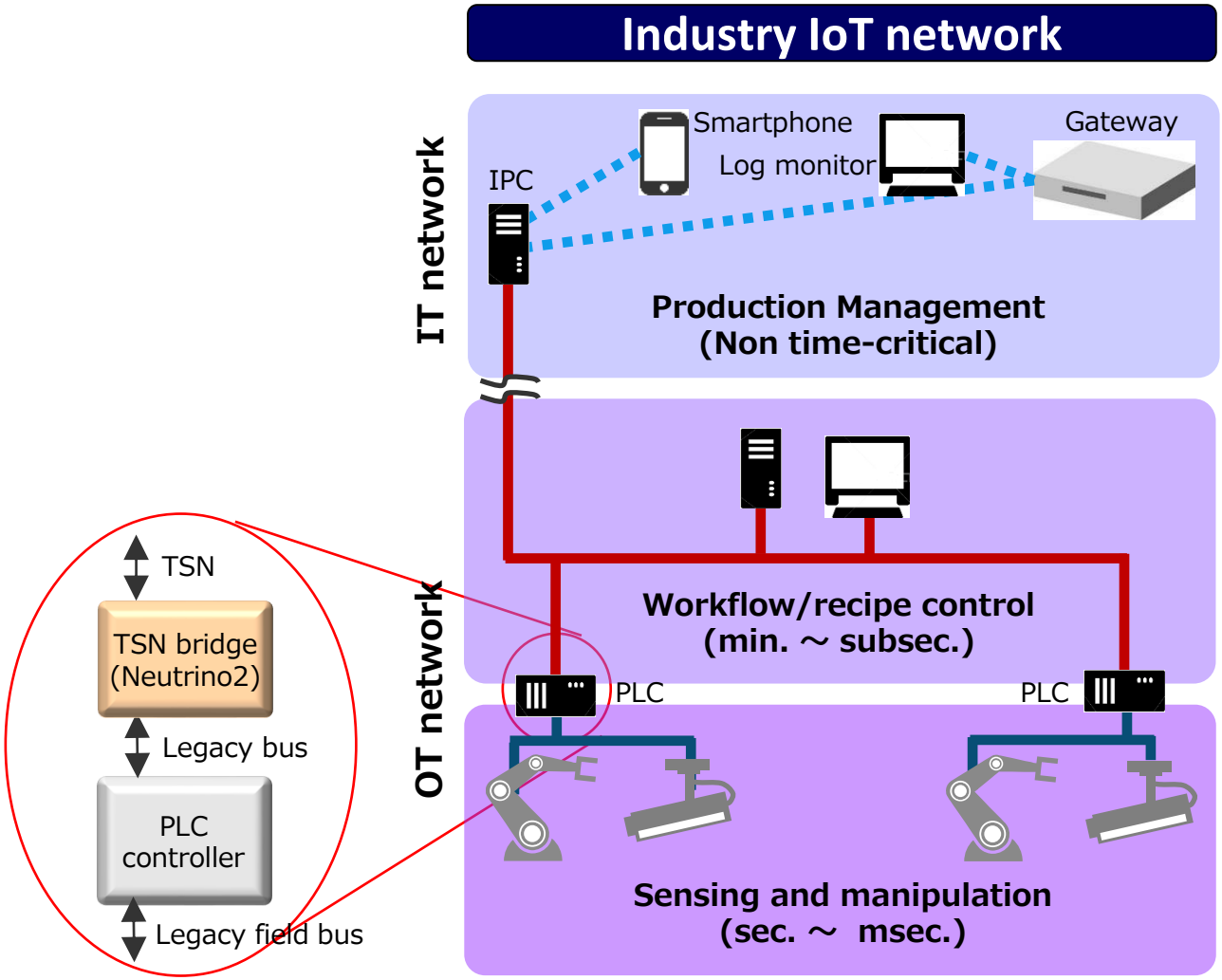


(*) Neutrino is a pet name of TC9560XBG

Toshiba solution for IIoT [2]

Wireless
Industrial Ethernet
Legacy field bus

Neutrino-2 is designed to target TSN bridge for IIoT application

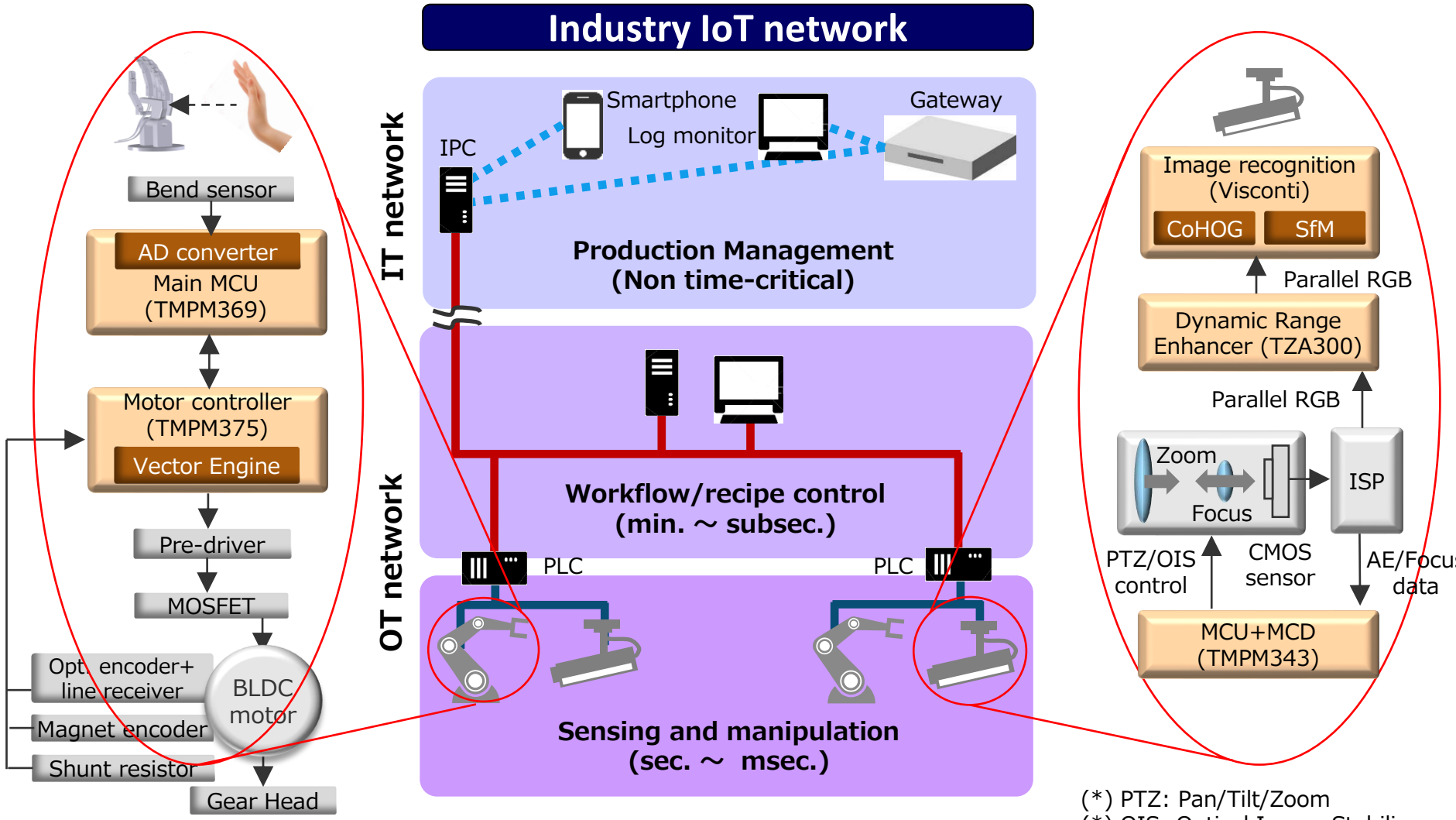


(*) Neutrino-2 is under development

Toshiba solution for IIoT [3]

Wireless
Industrial Ethernet
Legacy field bus

Robot-hand and vision-sensing

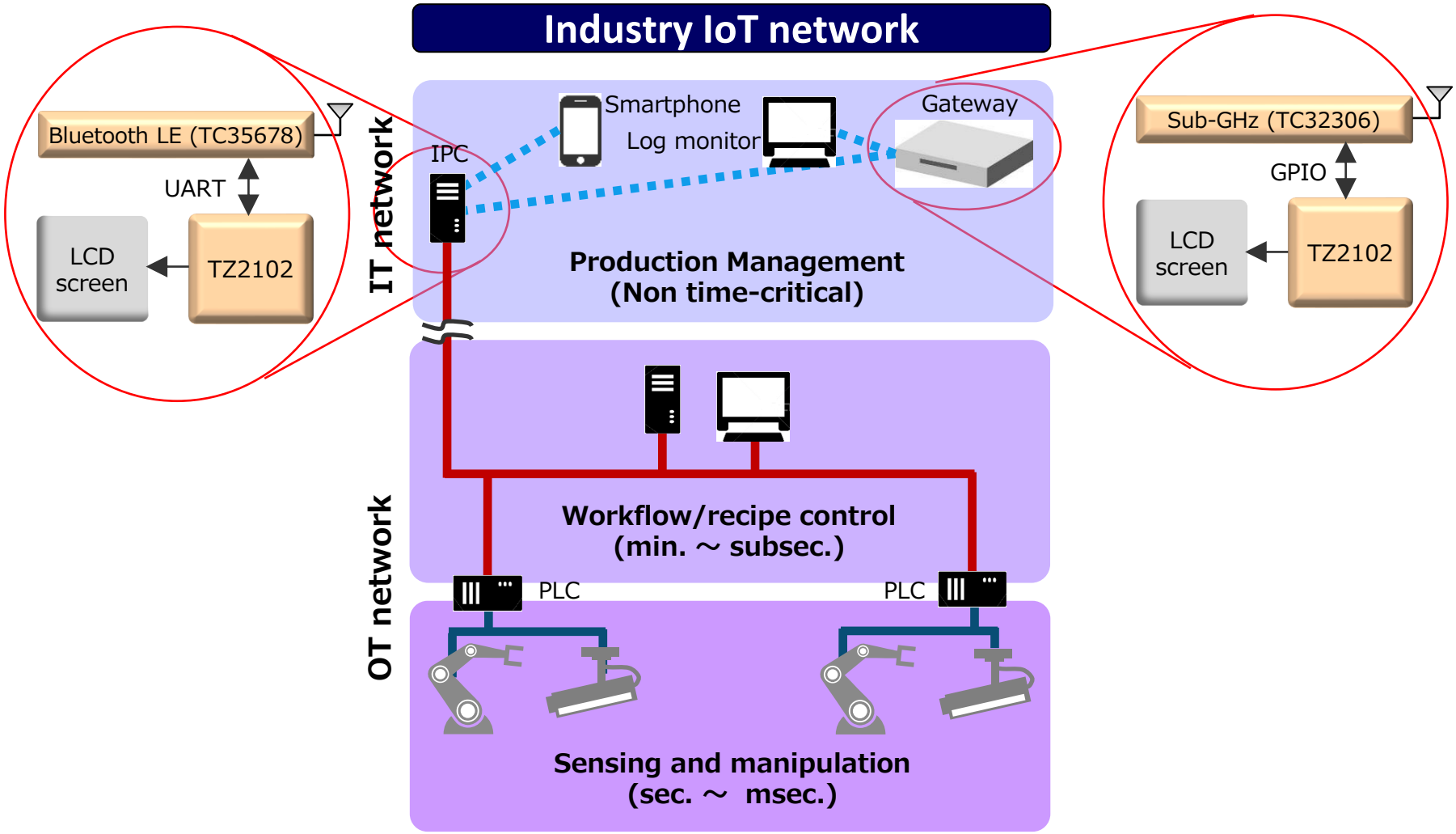


(*) PTZ: Pan/Tilt/Zoom
(*) OIS: Optical Image Stabilizer

Toshiba solution for IIoT [4]

Wireless
Industrial Ethernet
Legacy(CAN/Analog)

BLE and Sub-GHz

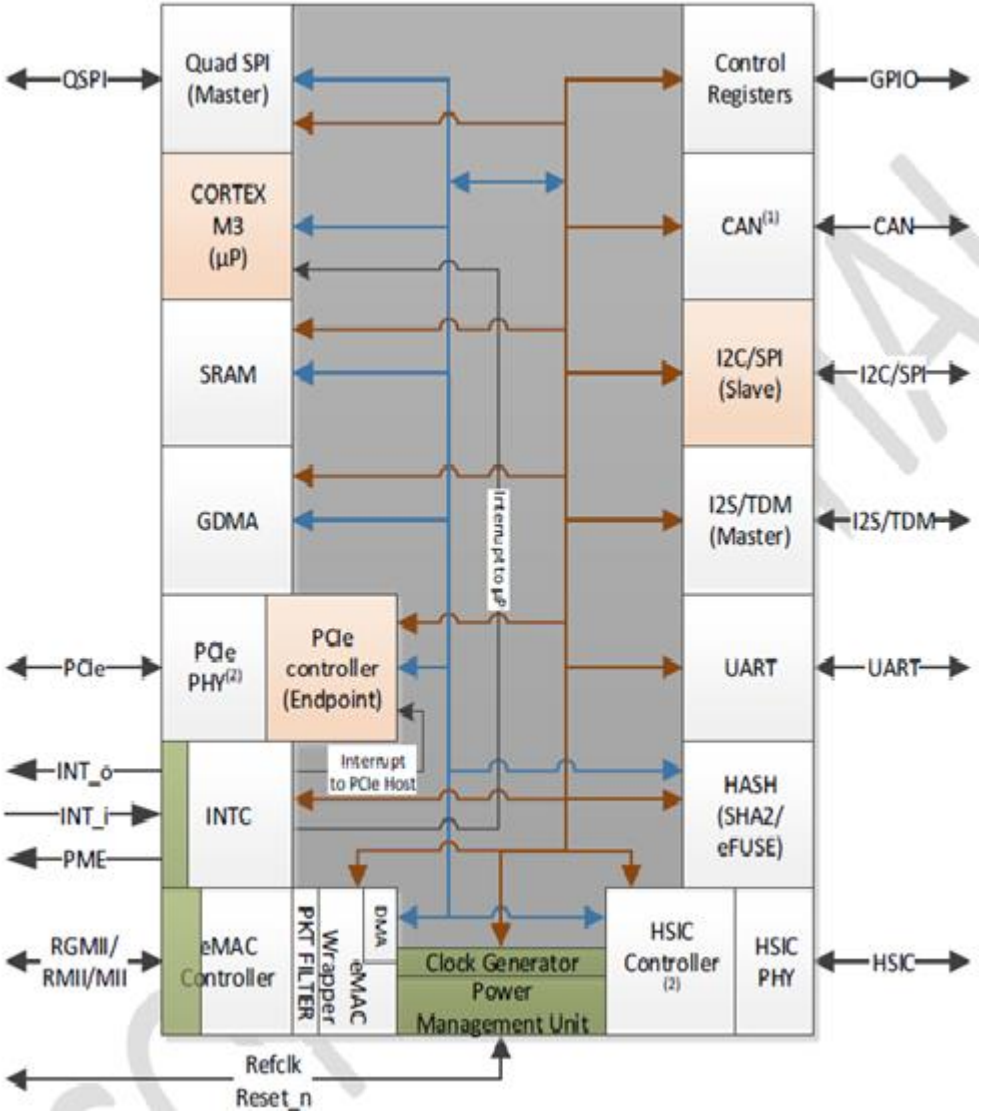


03

Industrial Ethernet (AVB+TSN)

01 Background
02 Toshiba IIoT solution
03 Industrial Ethernet
04 Vision Sensing
05 Robot hand
06 Wireless connectivity

1st GEN Ethernet AVB bridge IC: Neutrino



(*) Neutrino is a pet name of TC9560XBG

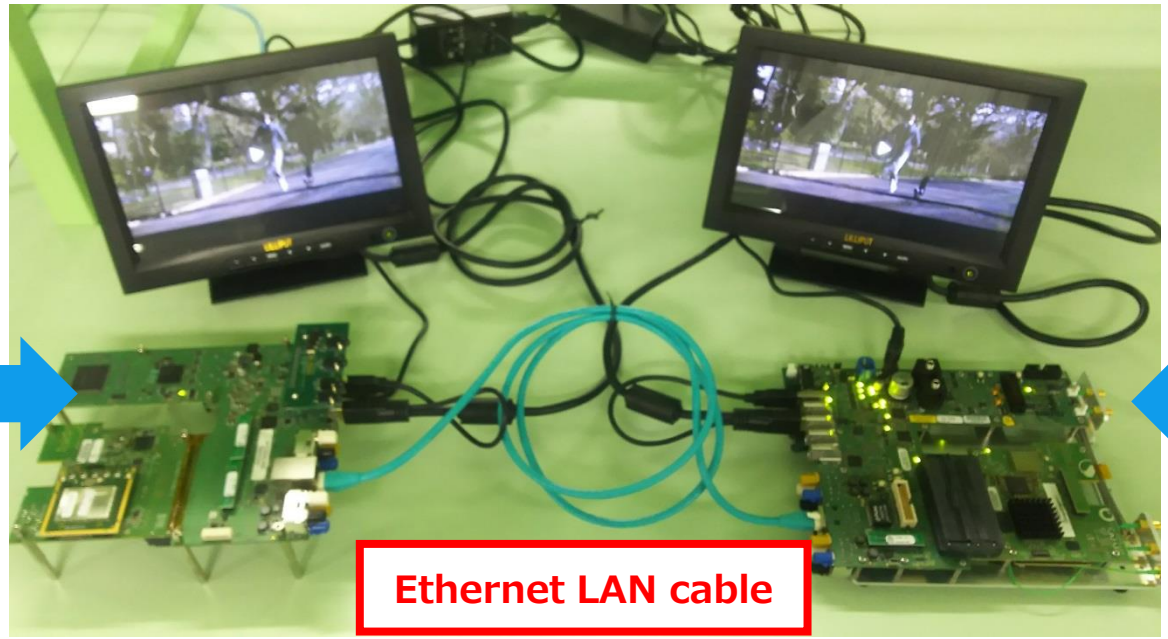
Neutrino family product line

	PCIe	HSIC	CAN
TC9560XBG	○	×	×
TC9560AXBG	○	×	○
TC9560BXBG	×	○	×

- **CPU ARM-M3**
- **AECQ-100 Grade 3**
- **Interfaces**
  - PCIe (EP) one lane (Gen 2) [TC9560XBG, TC9560AXBG]
  - USB HSIC (480 Mbps) [TC9560BXBG]
    - Device only
  - Ethernet (AVB support)
    - RGMII, RMII, MII interface
    - IEEE 802.1AS,IEEE 802.1Qav support
    - Supports 2 x AV traffic queues and 1 best effort queue
    - DMA
  - I2S/TDM master
  - CAN-FD option [TC9560AXBG]
    - 2 channels

Partnership with Qualcomm

- **Environment : 2x Qualcomm S820A Platform with Neutrino**
- **Synchronized video stream from talker to listener**
- **Android OS environment**



AVB/TSN bridge IC roadmap

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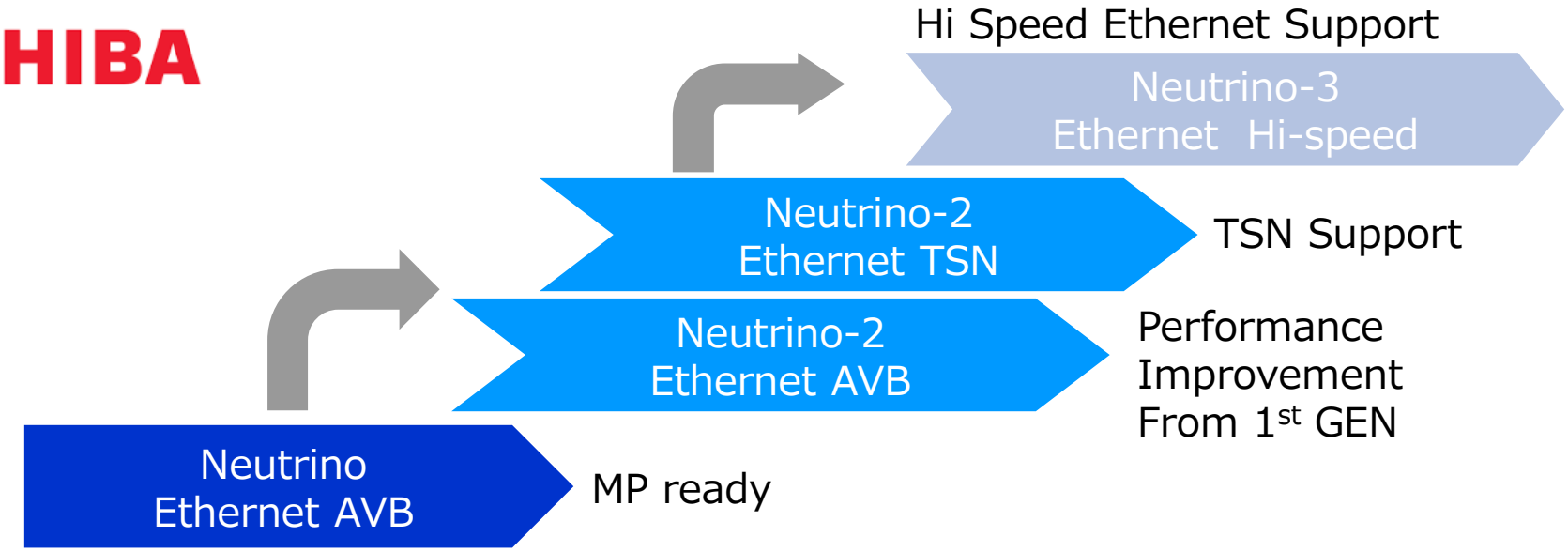

AVNU

04

Vision-sensing

01 Background
02 Toshiba IIoT solution
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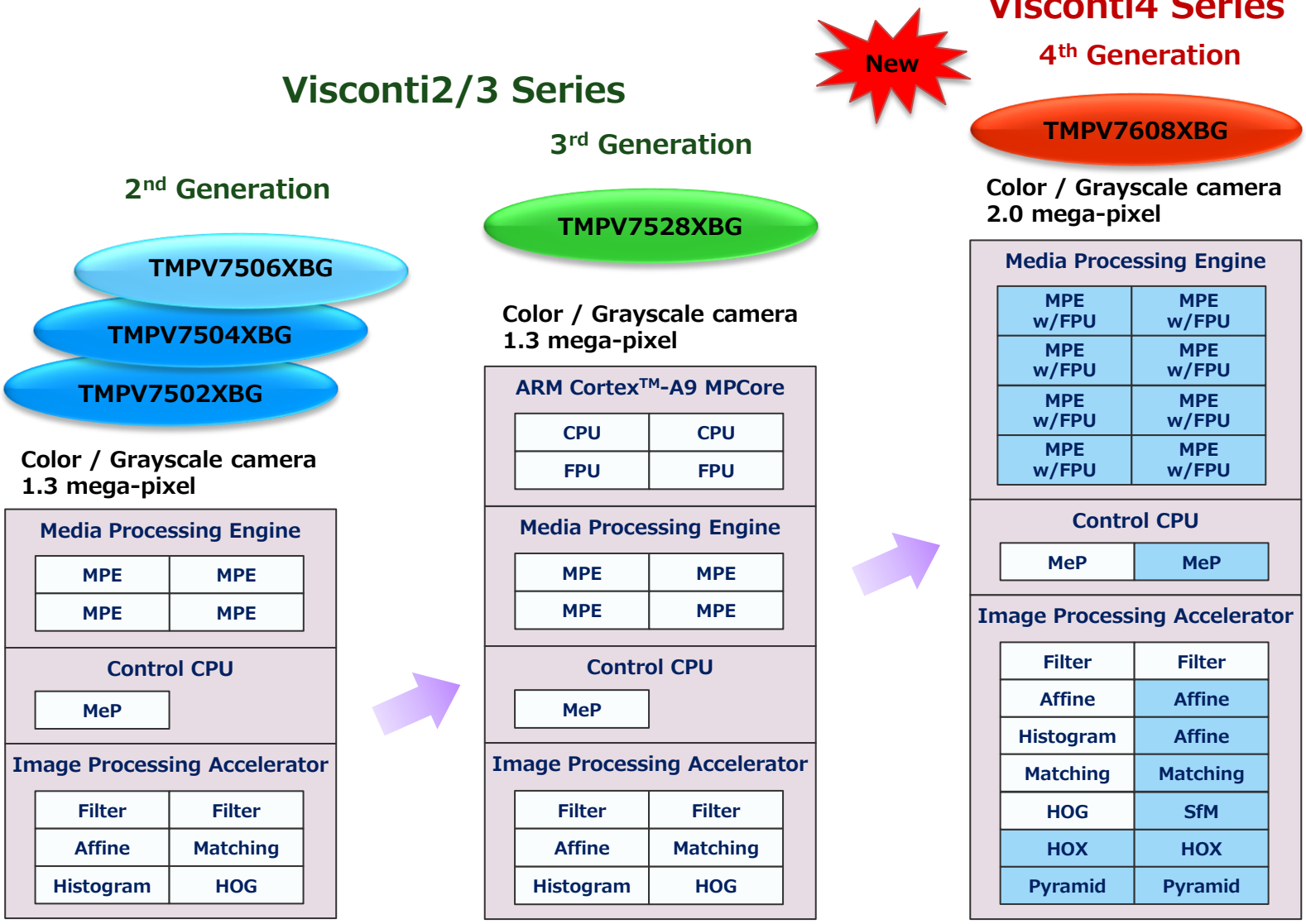
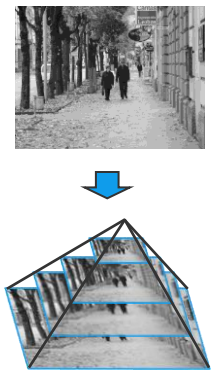
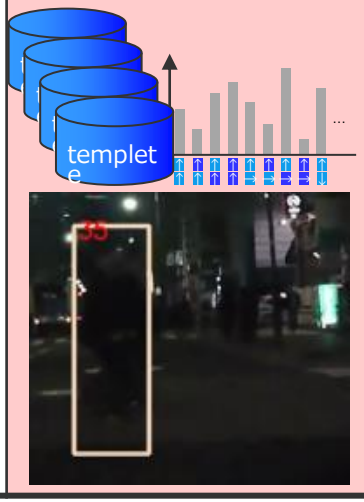
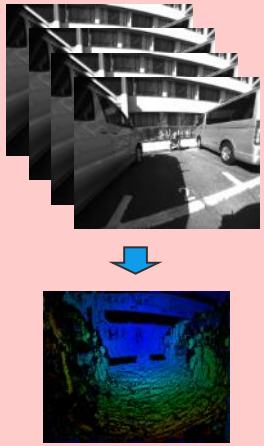
Visconti™4 -Vision Based Sensing Control and Intelligence-



Visconti™ image recognition HW accelerator

Our image recognition IC is called Visconti, which embeds a series of hardware accelerator for image recognition algorithm.

New features at Visconti4 series

Pyramid accelerator (x2)	Color CoHOG Accelerator (x2)	SfM Accelerator
・Create pyramid images (1-In to 4-Out) 	・Enhanced CoHOG Accelerator (Color info. Etc.)+ Linear support vector mathine 	・3D Reconstruction ・Self Motion Estimation 

Enhanced features from previous series

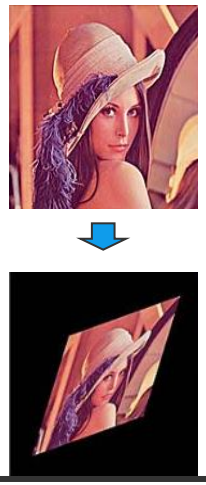
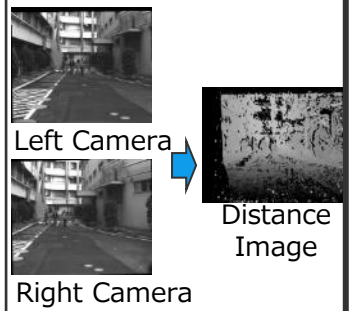
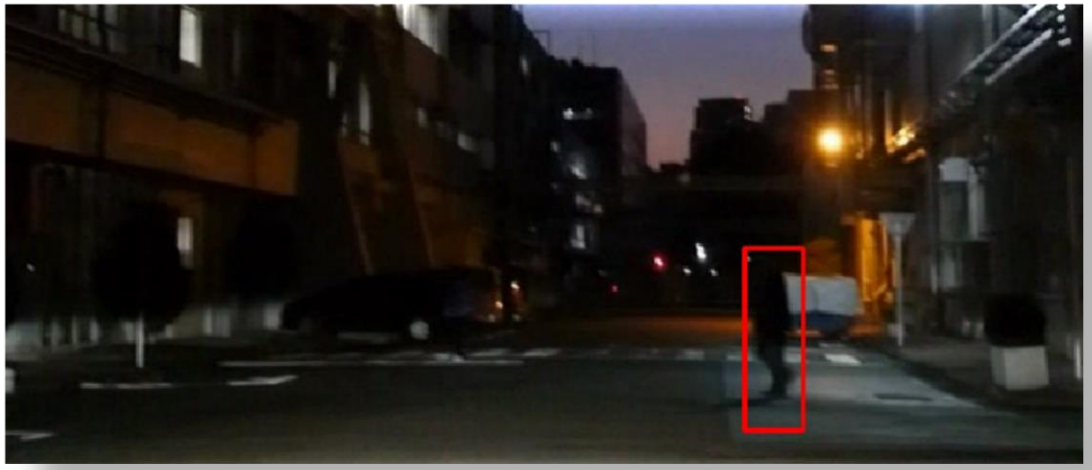
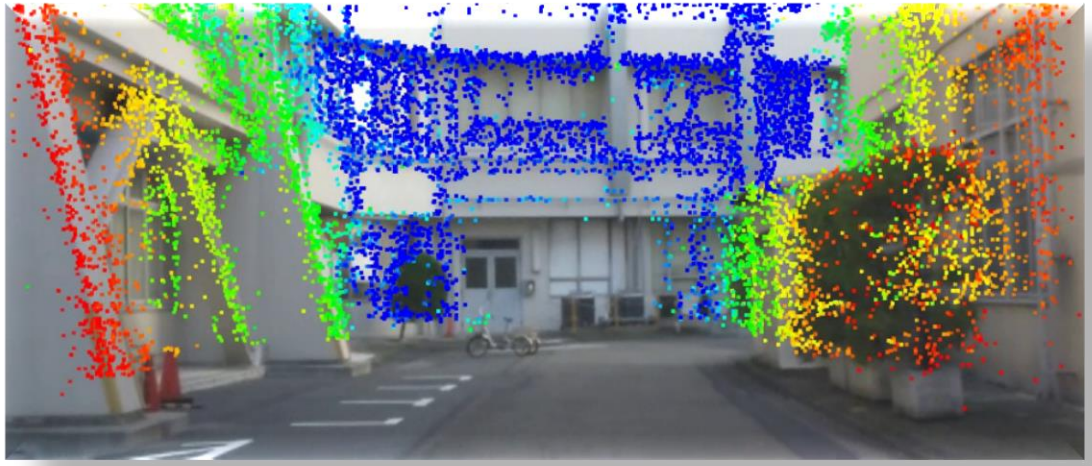
Affine Transformation Accelerator (+2 Total:3)	Matching Accelerator (+1 Total:2)
・3ch（RBG） 	・2ch ・High speed sub-pixel Estimation 

Image recognition accelerators by Toshiba

Color CoHOG detects pedestrians even at night-time



SfM reconstructs 3D shape of an object using mono-camera



05

Robot hand (MCU+MCD)

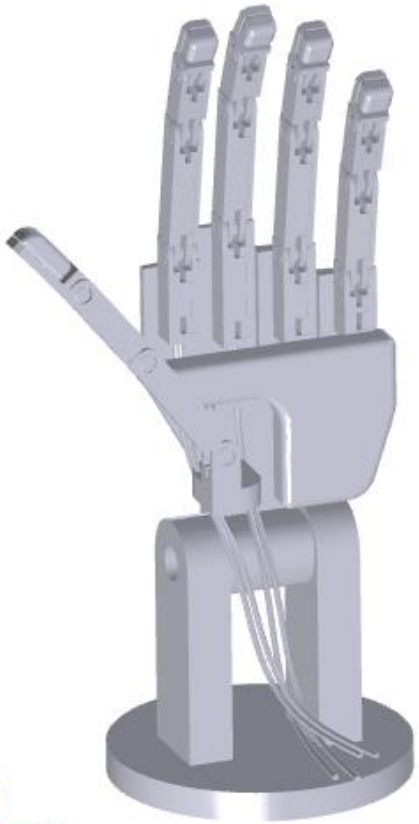
01 Background
02 Toshiba IIoT solution
03 Industrial Ethernet
04 Vision Sensing
05 Robot hand
06 Wireless connectivity

Robot Hand Function overview

- **Operation synchronized with the glove**
  Fitting the glove, and when you hold or open your hand, the robot hand also performs the same operation.

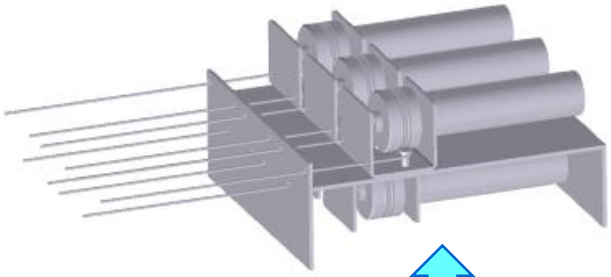
- **Automatic operation for exhibition**
  Automatically the robot hands open, hold and do like behavior of rock-paper-scissors for exhibition.

Robot Hand Demo Overview

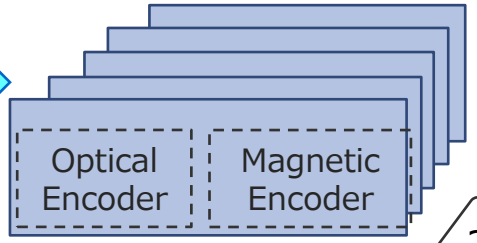


Hand structure

BLDC Motor X5



U/V/W X5



2TypeEncoder X5

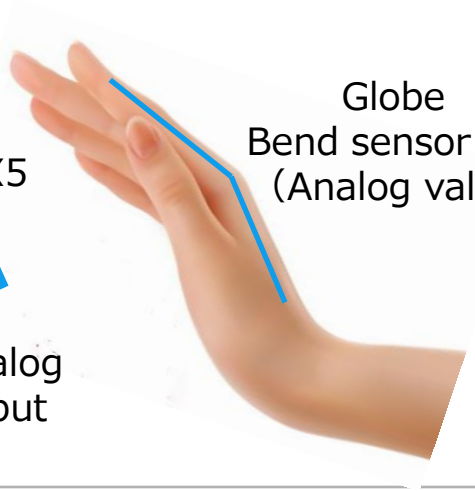
Motor MCU TMPM375FSD MG

Motor Control X5

RS485

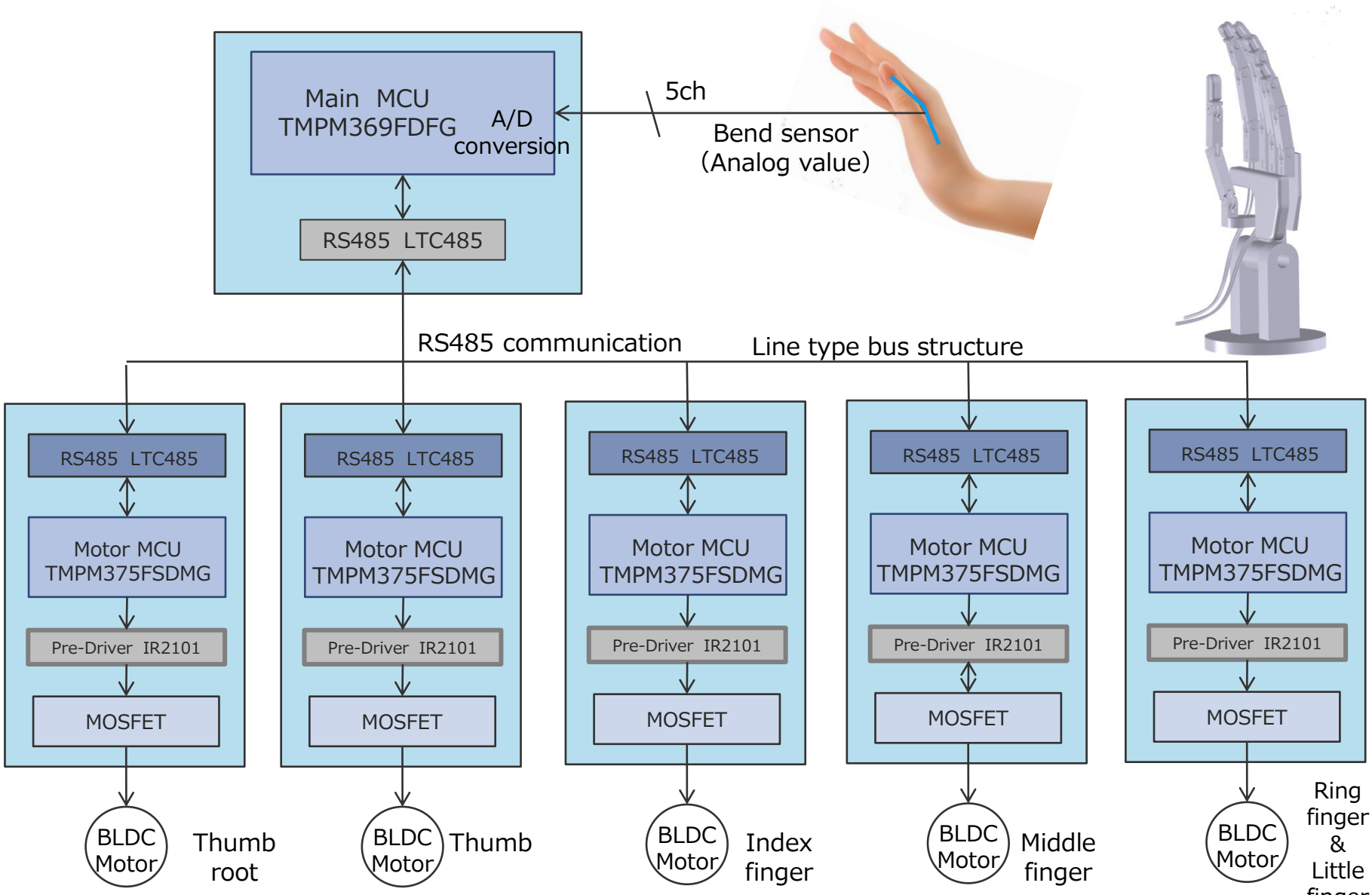
Main MCU TMPM369FD FG

Analog input



Globe Bend sensor x 4 (Analog value)

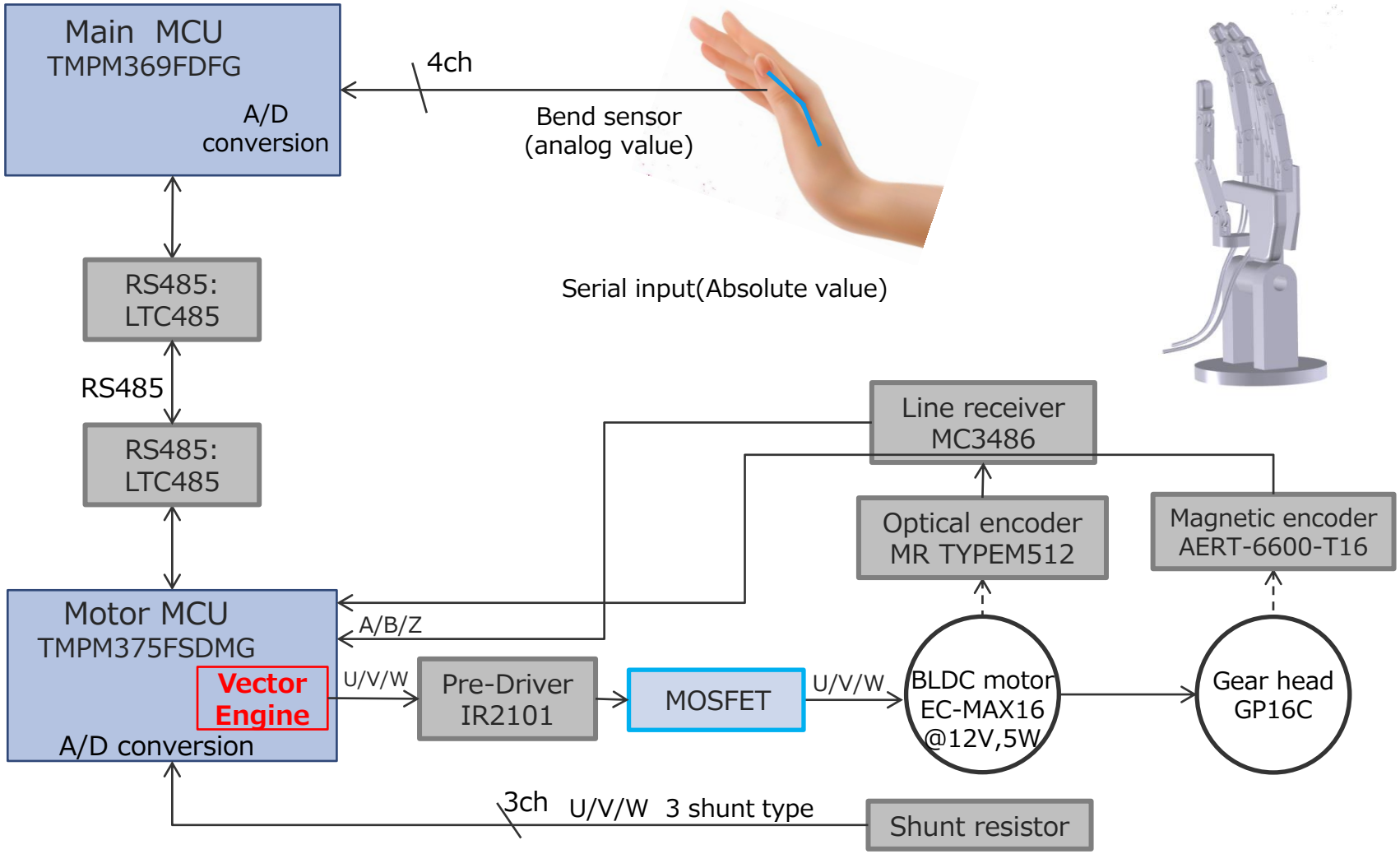
Robot Hand system block diagram 1



Robot Hand system block diagram 2

Demo Video1

Demo Video2



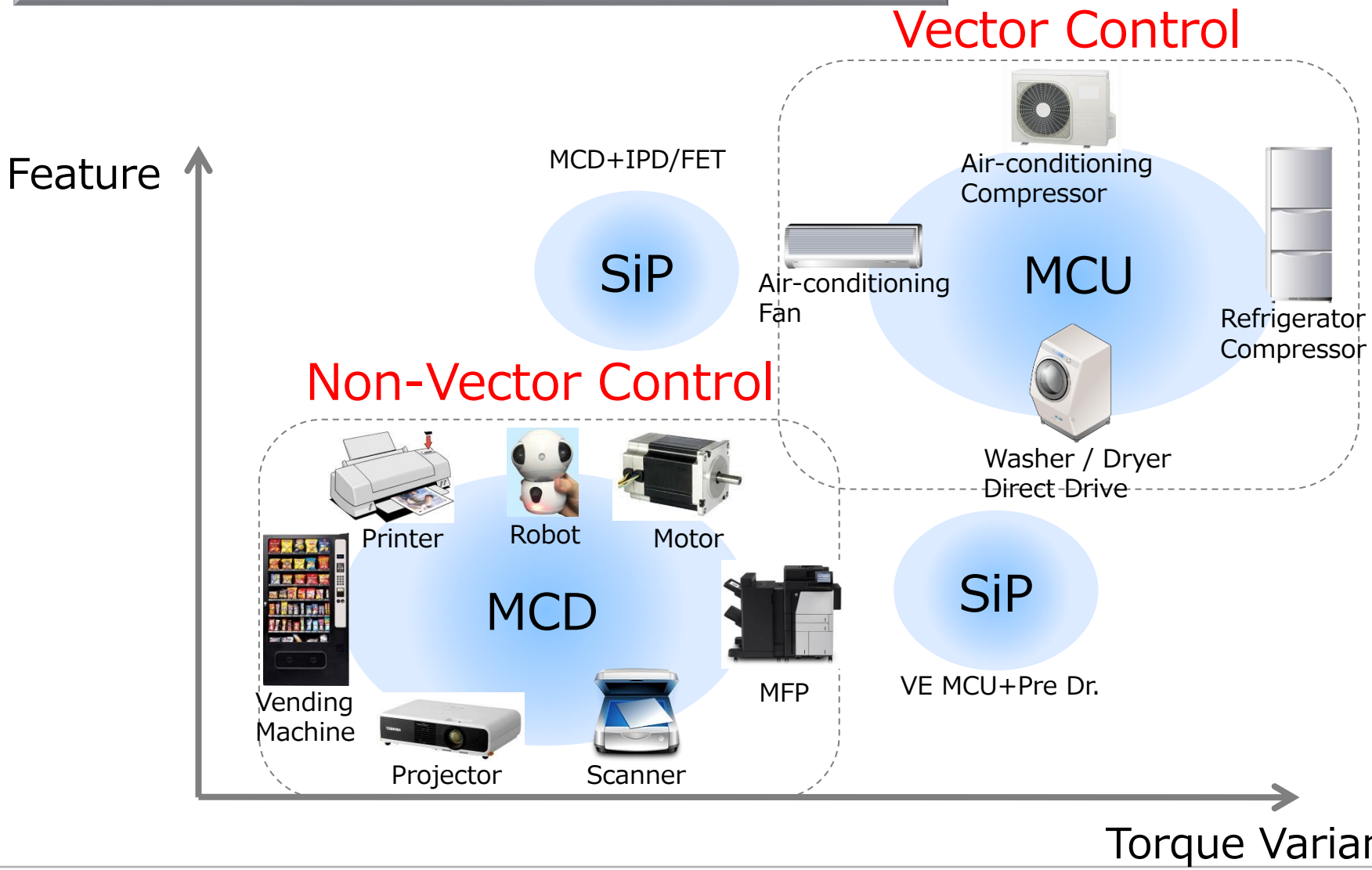
Robot Hand Functions detail

- Main control contents: TMPM375 motor drive board
  - RS485 communication with the main board
  - RS485 command decoding
  - BLDC motor control using vector engine
  - 3-shunt method
  - Position control is maintained at any angle
  - Optical encoder input (A / B / Z signal processing)
  - Serial interface between the magnetic encoder

- Main control contents: TMPM369 main board
  - RS485 communication with the motor drive board
  - A/D conversion processing of analog signal from the bend sensor on the globe
  - Operation mode decision of hand robot (for normal / exhibition)
  - LED display of operating mode

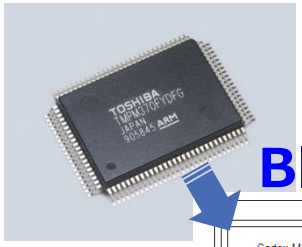
Selection Map of MCD/MCU Motor Control Solution

■ Vector Control : High Efficient, Quiet operation

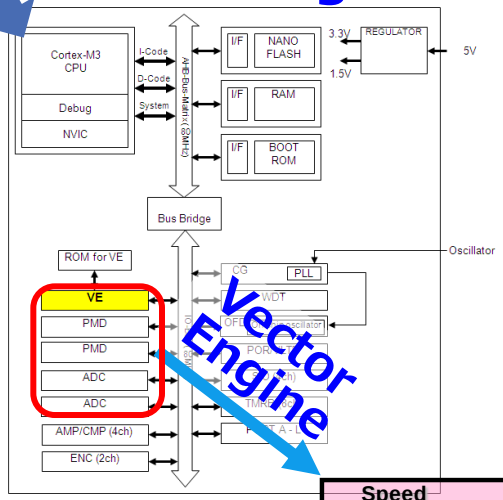


Vector Engine for Motor Drives

TMPM370



Block Diagram



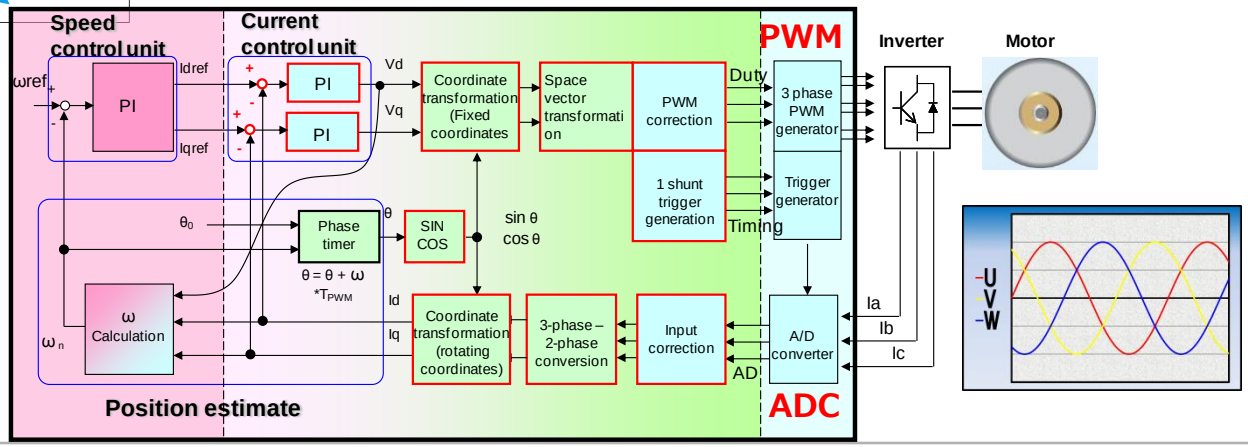
What's Vector Engine ?

Vector Engine(VE) is a dedicated co-processor for Field Oriented Control (FOC). VE automatically manipulates PWM and ADC to perform FOC. VE enhances adopting FOC in your system and realizes ecology system !

◆Configuration of VE

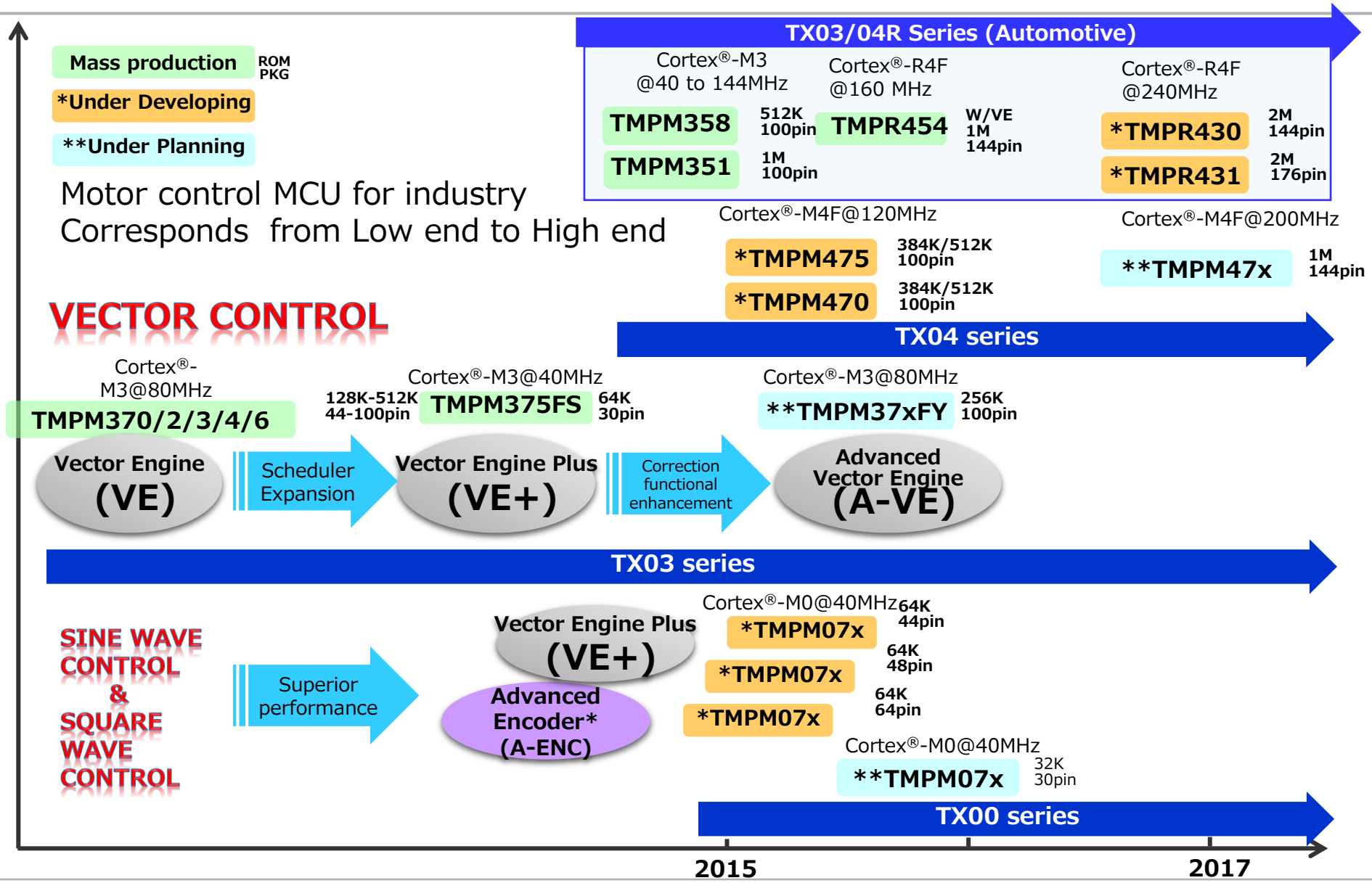
- ➢ADC result manipulation
- ➢Phase conversion
- ➢Coordinate transformation
- ➢SIN/COS computation
- ➢PI calculation
- ➢Phase current calculation
- ➢Trigger generation for ADC

Coprocessor



Green & ECO !

Motor Control MCU Roadmap



Motor Driver IC Features

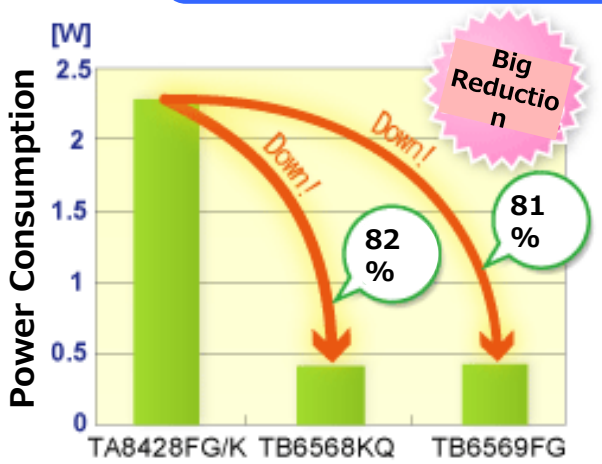
Substantial product line-up fit for various kind of needs.

- DC Brushed Motor Driver
- Stepping Motor Driver
- DC Brush-less Motor Driver

Substantial detection functions of abnormal state support for safety system design.

- Power On Reset (POR)
- Over Current Protection (ISD)
- Thermal Shut Down (TSD)

Low power consumption supports for ecological high-efficient product design.



Low power consumption is realized by reduction of circuit current, output saturation voltage and output DMOS on-resistance.

Motor Driver IC Technologies

High reliability based on latest original technology & over 30 years production

Over 30 Years Activity

◆Long Business History since 1980

* Rolled out with launching into consumer product market and expanded to OA, Industrial, HA product market.
* TSB covers MCD for BLDC, brushed and stepping motors

➔ *Around 1000 customers are using our MCD now!*

Power technology

◆BiCD0.13μm Process

* DMOS process required for power devices
  ➔Improve power efficiency by 0.13μm

◆Power PKG Line-up

* HSOP, HTSSOP, QFN, HZIP, etc

◆Advanced error detection Circuit

* High reliability ISD(Over current shut down) , TSD (Thermal shut down) and POR(Power on reset).

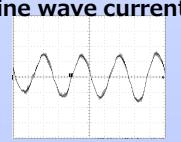
Original System Technology

◆Drive System

➔Cooperation with TSB motor Lab

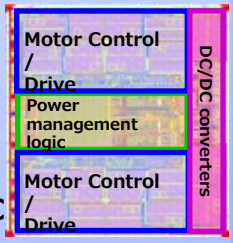
* Sine-wave current control, vector control (For low noise motor drive)
* Sensorless control (Reduce external components)

Sine wave current



◆Combination Technology

* PMMCD（Power management MCD）
* DC/DC converters
* Multi motor drive channels



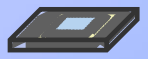
◆MCD+MCU Solution

MCD+DC/DC

➔The edge is MCU-included solution

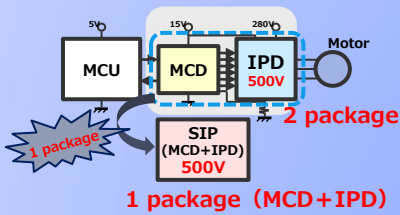
◆MCD+IPD Solution

➔The edge is IPD-included solution



MCD+MCU

MCD+IPD (500V)

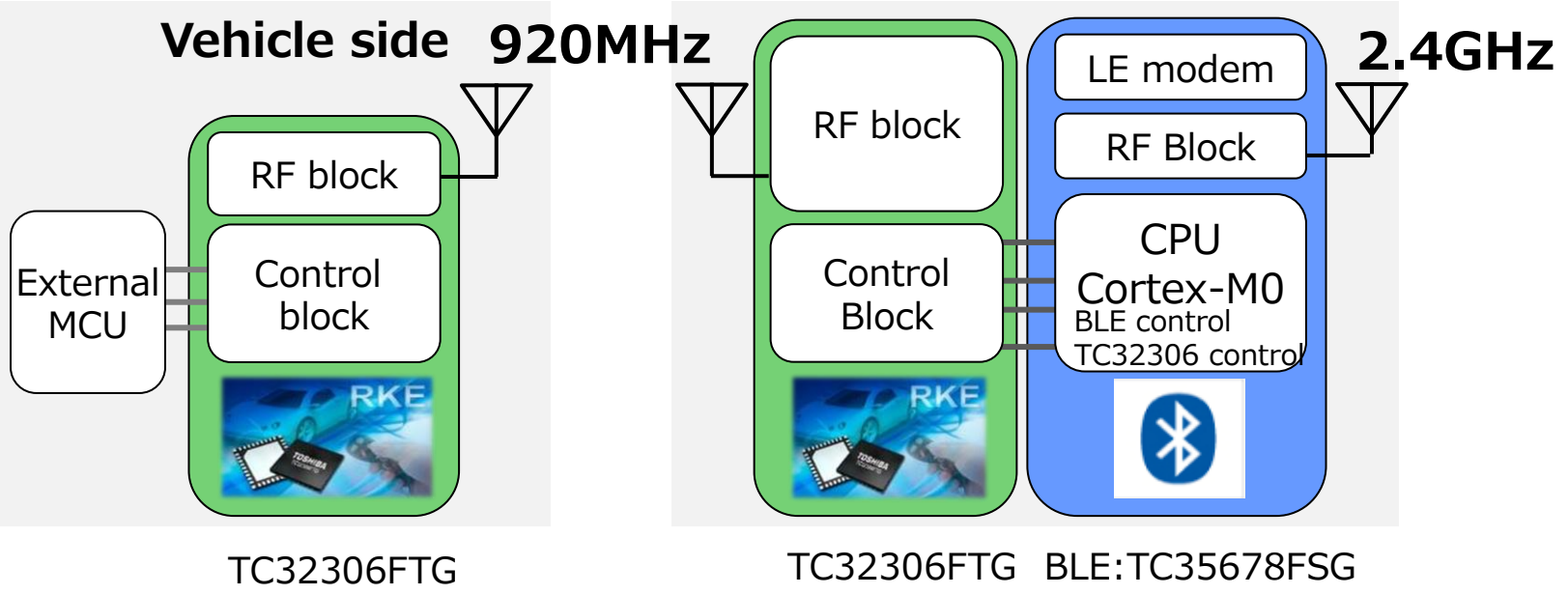


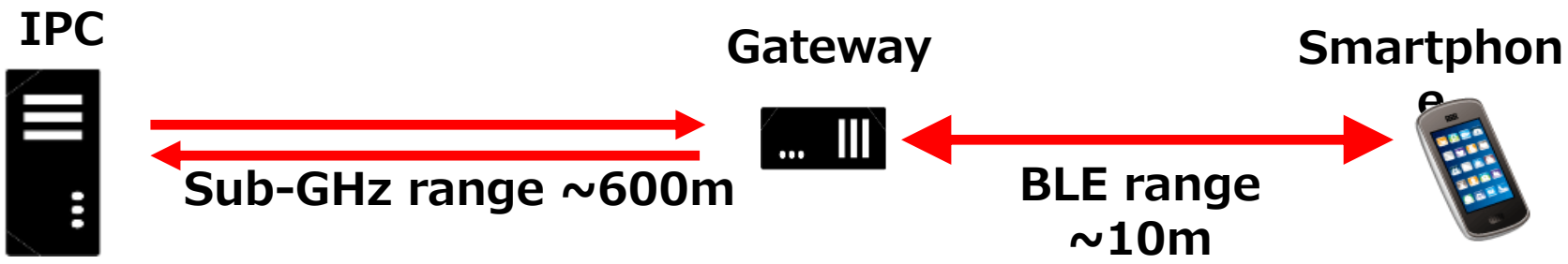
06

Wireless connectivity (BLE+SubGHz)

TC32306FTG(Sub-GHz) + TC35678FSG(BLE) system

Our advantage is to re-use Cortex-M0 of BLE IC to control Sub-GHz IC, reducing two chipset footprint to contribute form factor minimization.





SubGHz spectrum and Toshiba target

Freq.(MHz)	Purpose	Electrical field strength	SPEED (nominal)	Communication distance
~322	RKE, Garage opener, etc.	>500uV/m at 3m distance	–	~50m
315	RKE, TPMS	25uW(EIRP), 250uW(EIRP)	75~19.2Kbps	700m~1km
400	Industrial monitoring application	1mW, 10mW	4800bps	100m~3km
1200		10mW	14.3kbps	300m~1.5km
920~928	Smart meter, HEMS, etc.	1mW, 10mW, 20mW	20~400kbps	~600m
920	Short range wireless system (PAN), Active Tag	250mW	20~400kbps	~1.8km
2400~2497 2471~2497	W-LAN, BT, ZigBee, etc.	3mW/1MHz, 10mW/1MHz	600Mbps	50-250m

Communication range is extendable up to 1.8km at the expense of power consumption increase in 920MHz band.

Industrial Grade BLE ver. 5.0 controller

Bluetooth® Core spec.
Ver. 5.0 compliant, 1M/2Mbps support

High Speed x2

Ultra Low Power consumption
Peak current 6.0mA@TX 0dBm, 1Mbps
11mA@TX +8dBm, 1Mbps
Sleep current < 1.2uA (Advertise)
Deep Sleep current <100nA

RF Performance
TX Output power +8dBm MAX
RX Sensitivity -94.5dBm

High Power Output x8

Interface
UART (Host I/F) 2chs (selectable for test purpose)
SPI 2ch, I²C 2ch
12bit ADC, PWM 4chs, Interrupt input

On-chip DC-DC converter (1.8-3.6V input)
On-chip SiOSC (32kHz)

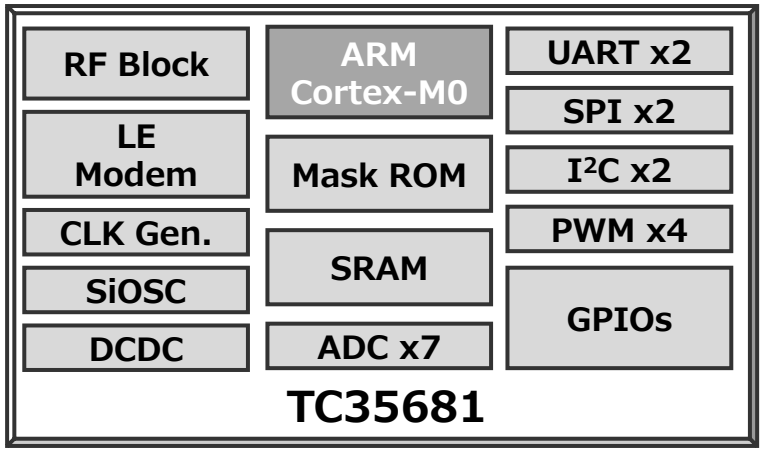
64kB RAM User Area

128kB Flash User Area (TC35680)

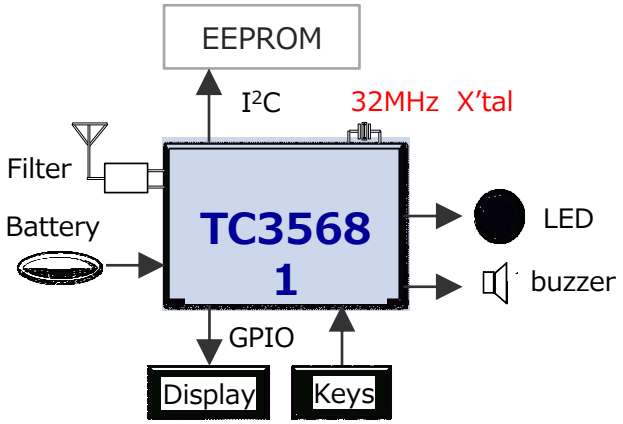
Small package
QFN40 5x5mm, 0.4mm pitch(TC35680/681)
WCSP 0.35mm pitch(TC35681)

Operation Temperature Range
-40 to +125 degree C (TC35681)

Wider Temp.



ES:Dec.2017, MP:3Q.2018



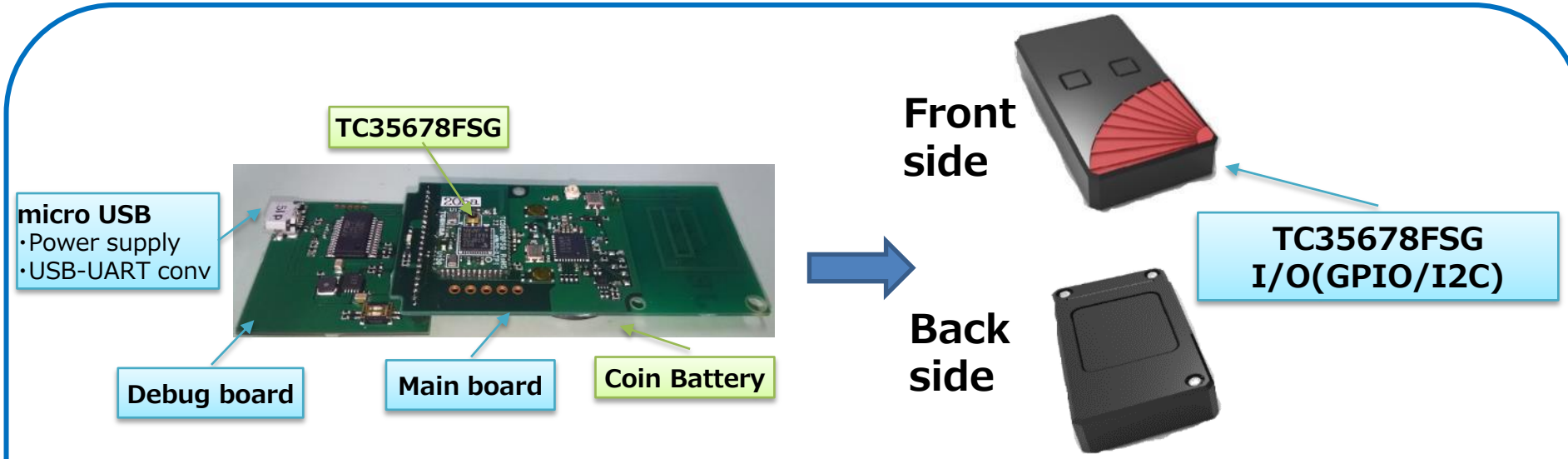
BLE Competitors Analysis - all IC spec -

	Toshiba BLE G3	Nordic nRF52840	TI CC2640R2F
Receipt peak current	4.5mA	5.4mA	6.1mA
Transmission peak current	6.0mA @0dBm +8dBm @ 11.0mA	6.4mA @0dBm +8dBm @ 13.6mA	6.1mA @0dBm +5dBm@ 9.1mA
Maximum output [dBm]	8	8	5(Differential)
Rx Sensitivity [dBm]	-91.5 (2Mbps) -94.5 (1Mbps) -99.0 (500kbps) -105.0 (125kbps)	-92.0 (2Mbps,Ideal Tx) -96.0 (1Mbps,Ideal Tx) -99.0 (500kbps) -103.0 (125kbps)	-92.0 (2Mbps) -97.0 (1Mbps) -101.0 (500kbps) -103.0 (125kbps)
Link budget	113dB	111dB	108dB
BT standard ver.	5	5	5
Number of external component	7	20	27
Operational temperature	-40 to **125℃**	-40 to 85℃	-40 to 85℃

Our strategy is to support both consumer-grade and industrial-grade BLE products at the same time with the same priority. Toshiba is the sole IC supplier supporting temperature range up to 125C.

SubGHz+BLE reference solution by Toshiba

[TC32306FTG+TC35678FSG]



This reference system supports SubGHz RFIC TC32306FTG and BLE IC TC35678FSG for testing a bridge functionality between BLE and Sub-GHz.

DEMO Function:

- GPIO/I2C control at 920MHz band from PC console.
- GPIO/I2C control at 920MHz band from android smartphone.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