東京大学 THE UNIVERSITY OF TOKYO

TRON

Open IoT Platform & IoT-Engine

Ken Sakamura

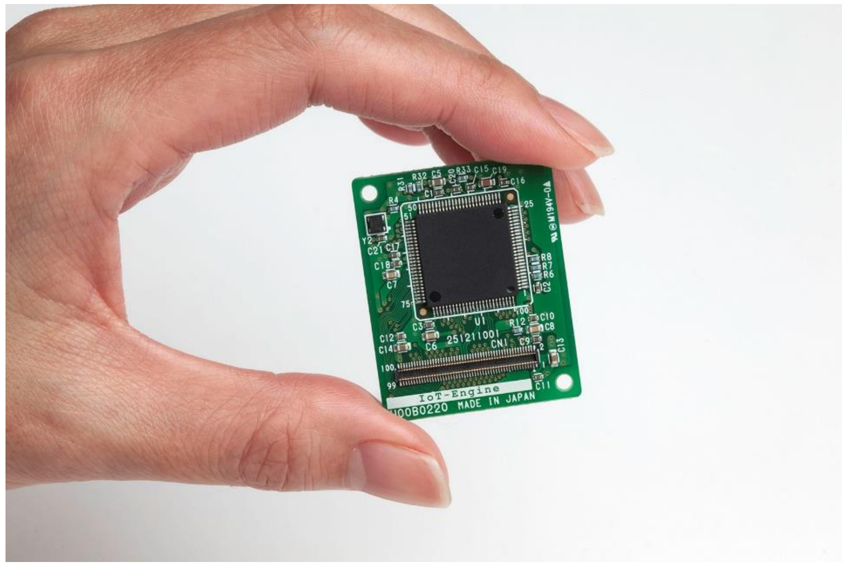
Professor, Director of Institute of Infrastructure Application of Ubiquitous Computing (IAUC), Interfaculty Initiative in Information Studies, Graduate School, the University of Tokyo

Director, YRP Ubiquitous Networking Laboratory

Chair, TRON Forum / uID Center

Seven semiconductor manufacturers from six countries and regions have already expressed intention to commcericialize IoT-Engine

- Participating semiconductor manufacturers (at the time of the press conference on April 27, 2016)
  - Toshiba Microelectronics Corporation
  - Renesas Electronics Corporation
  - Cypress Semiconductor Corporatation
  - Imagination Technologies Limited
  - Nuvoton Technology Corporation
  - NXP Semiconductors N.V.
  - STMicroelectronics



- Sales of IoT-Engine and Development kit
  - Personal Media Corporation
  - Ubiqutious Computing Technology Corporation

IoT

Internet of Things

The IoT Can Change the World Only If It Is Open.

The Internet changed society because it is an open network which anyone can use for any purpose.

Is the "I" in "IoT" truly the "I" of "Internet"?

Governance Is Required in the Age of the Open IoT

The advanced management "to use something appropriately" requires advanced judgment.

Policy-based group management of access rights and partial exposure of data, changing of access rights based on the ordinary and emergency setting, and automatic/augmented judgment by aritificial intelligence

The Pressing Issues of Future Embedded Systems

Advanced governance management of data and control will become very important.

New governence management requires advanced processing and more database resources than the conservative "don't release anything".

Hardship of Embedded Systems in the Age of the IoT

Access control, which is not the essential function of the embedded systems, requires large amount of computing resource.

It is unrealistic to expect the proper full-fledged implementation on otherwise lightweight edge nodes.

The IoT Requires Lightweight Edge Nodes.

Edge nodes (= Embedded Systems) should be lightweight, and advanced functions should be performed in clouds.

The Model of Open IoT in TRON Project Now

Aggregate Computing Model

Aggregate: referring to the composed whole

Aggregate Computing Model

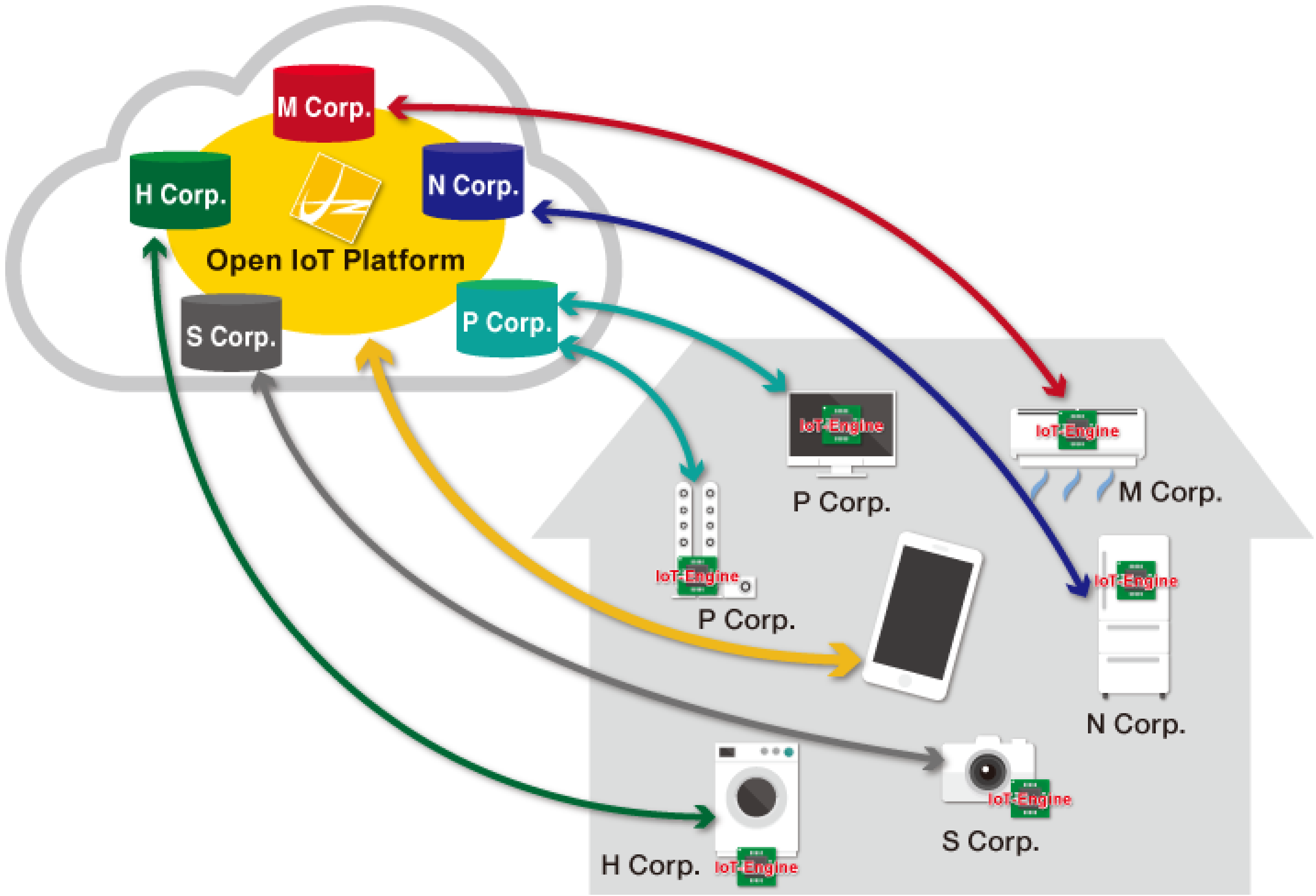
Embedded system products talk to the manufacturers' clouds directly.

Such clouds have Open API.

These cloud services collaborate with other clouds.

Products that are equipped with general information processing OS and have built-in published API can be the targets of collaboration, too.

IoT by Aggregate Computing Model

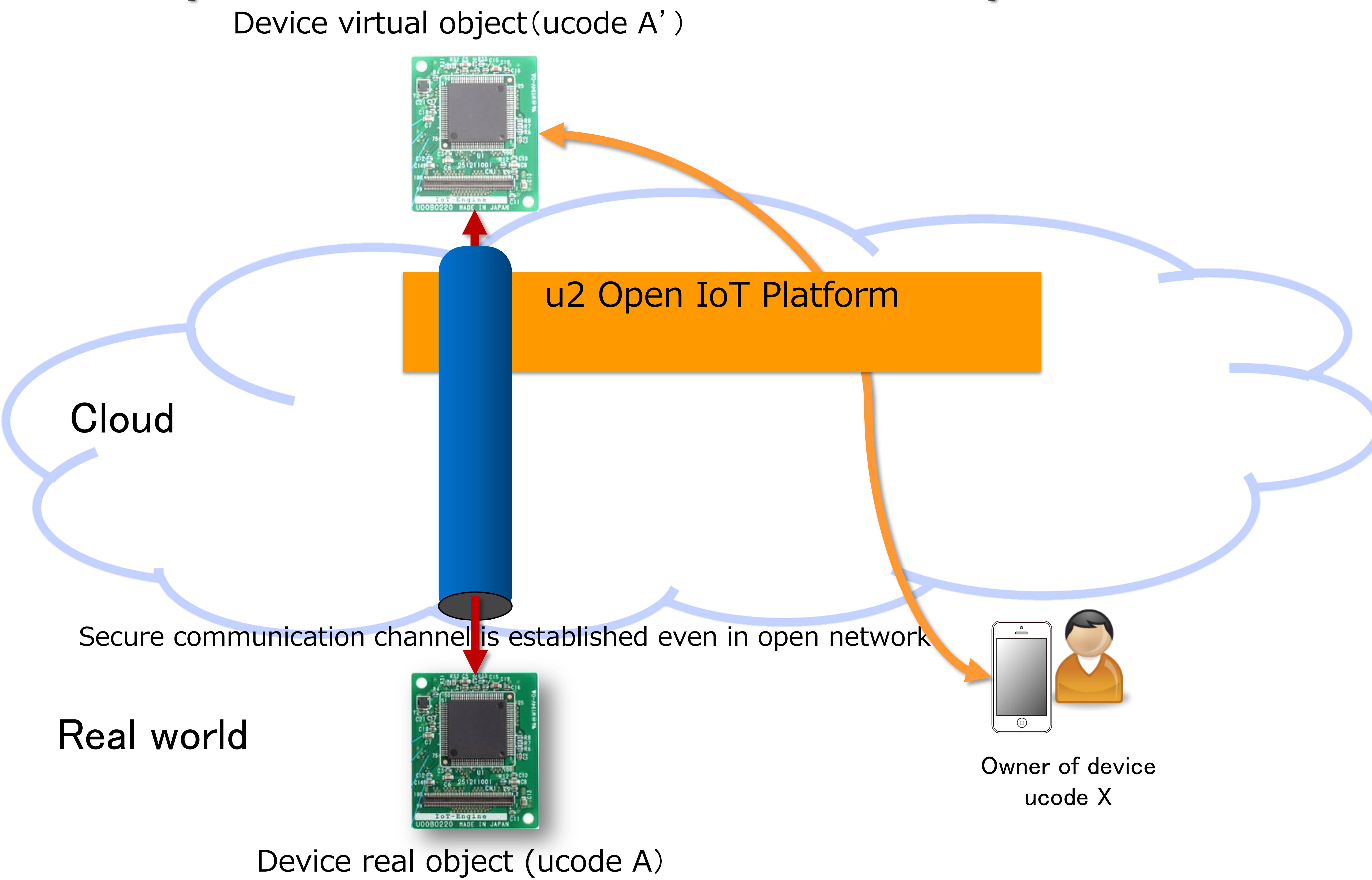


Direct Connection Using Tunneling

If we only need to focus on the particular connection with a preselected cloud

We can implement a simple and strong security using relatively small amount of computing resources.

u2 Open IoT Platform Concept



In Aggregate Model, Advanced Governance Management Is Handled by Cloud Services.

Edge nodes and cloud services are considered to be virtually always connected.

We do not need complex governance management locally.

Approach to Advance the Intelligence of the Aggregated Whole

Solving issues which embedded systems face by advancing the intelligence of the aggregated whole of local edge nodes and the cloud services

Advanced Services Should be Implemented by Cloud.

For example:

- Artificial Intelligence Processing
  - Determination of how long a food plate should be heated by the image recognition andor the automatic recording of the calorie intake
  - Voice interface using natural language
- Big Data Processing
  - Preventive maintenance of operation data of home electronics appliances
  - Advanced medical care advise based on measured data
  - Automatic scene completion using database
- Group control beyond individual household
  - Energy saving in a small area by fine-grained demand side management

Meta-OS That Controls the Aggregated Whole Is the New Market

Meta-OS = Open IoT Platform

Context-awareness/big data analysis

Federation of different databases/integration of heterogeneous API

Security/Access Control

Governance policy

u2

uID Architecture 2.0

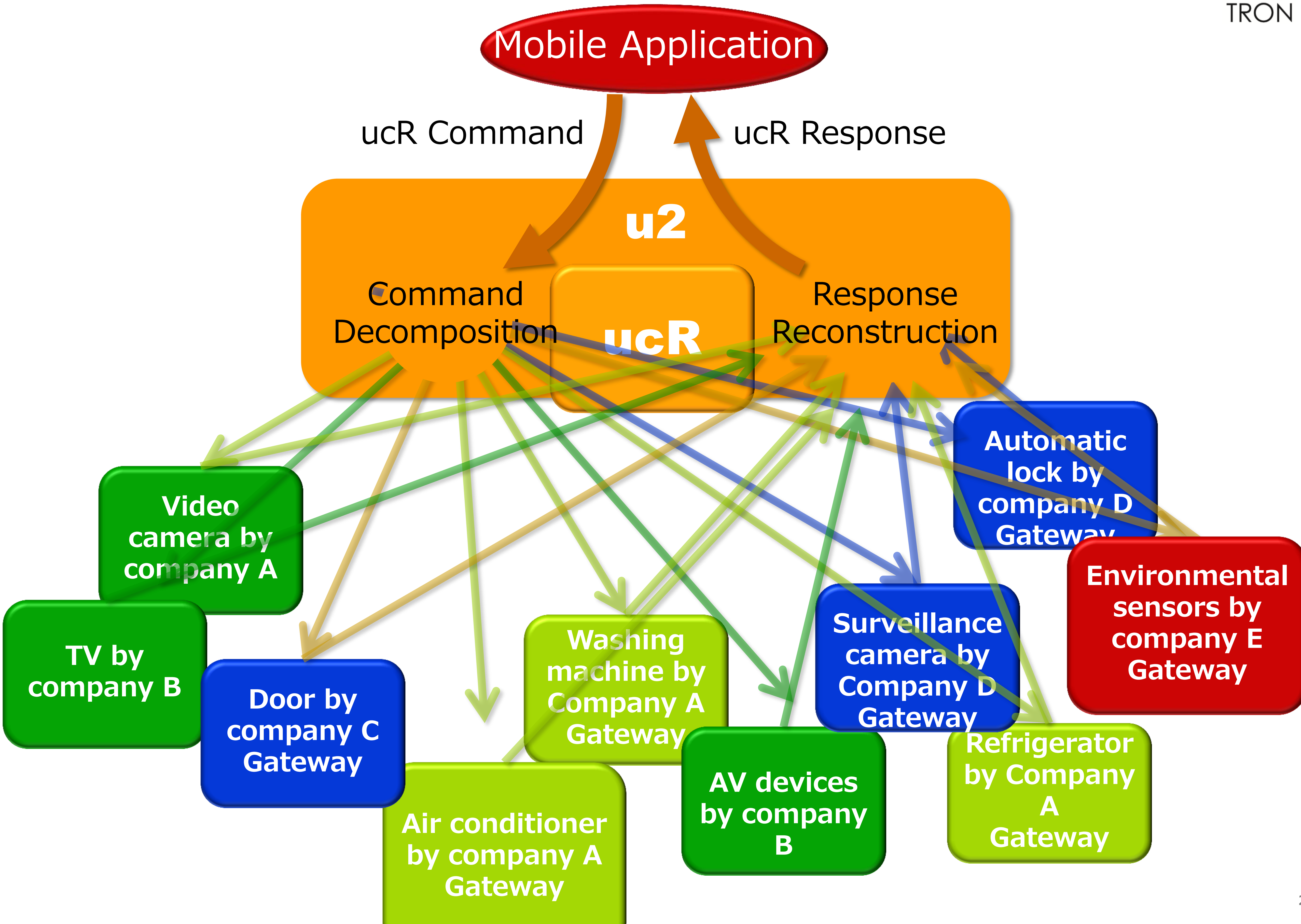
Integrated Framework for the Future Embedded Systems

It will be based on ucode, which has been the basis of ITU-T Recommendation (standard).

ucode: it identifies things or objects irrespective of the application fields and is assured to be uniquely assigned as 128-bit non-semantic ID.

A federated framework for collaboration that permits the control of various groups of embedded devices across organizational and company boundaries by means of ucR cross-queries.

ucR: RDF consisting of ucode triplets


Mobile Application
ucR Command
ucR Response
u2
Command Decomposition
ucR
Response Reconstruction
Automatic lock by company D Gateway
Video camera by company A
Environmental sensors by company E Gateway
TV by company B
Door by company C Gateway
Washing machine by Company A Gateway
Surveillance camera by Company D Gateway
AV devices by company B
Refrigerator by Company A Gateway
Air conditioner by company A Gateway

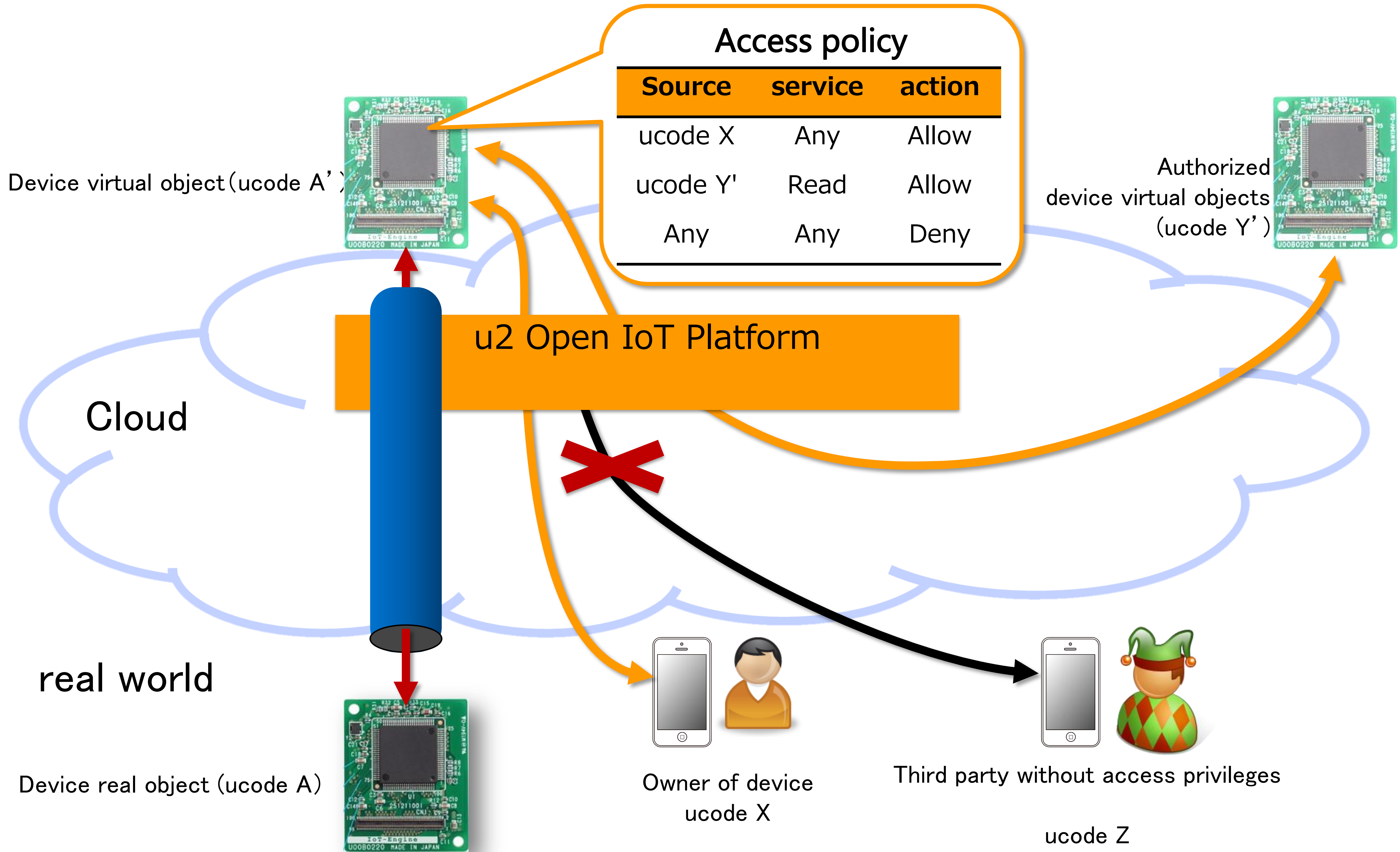
u2 Open IoT Platform Overview

- An open platform to manage IoT devices and data for them

- Features
  - Device virtual object that provides interface accessible from other systems
    - You can program IoT devices by mixing them as if they were lego blocks
    - Pasting the virtual device object into the dashboard on a website will display the graph of sensor values
    - You can paste the device virtual object into a document on a website.
  - Advanced policy-based control of real devices
    - Access to real deivces is properly controlled and restricted access is implemented
    - We can create a software model of virtual device such as a room that consists of many devices.

      Example: Controlling air-conditioner by looking at the condition of a room as a whole, etc.

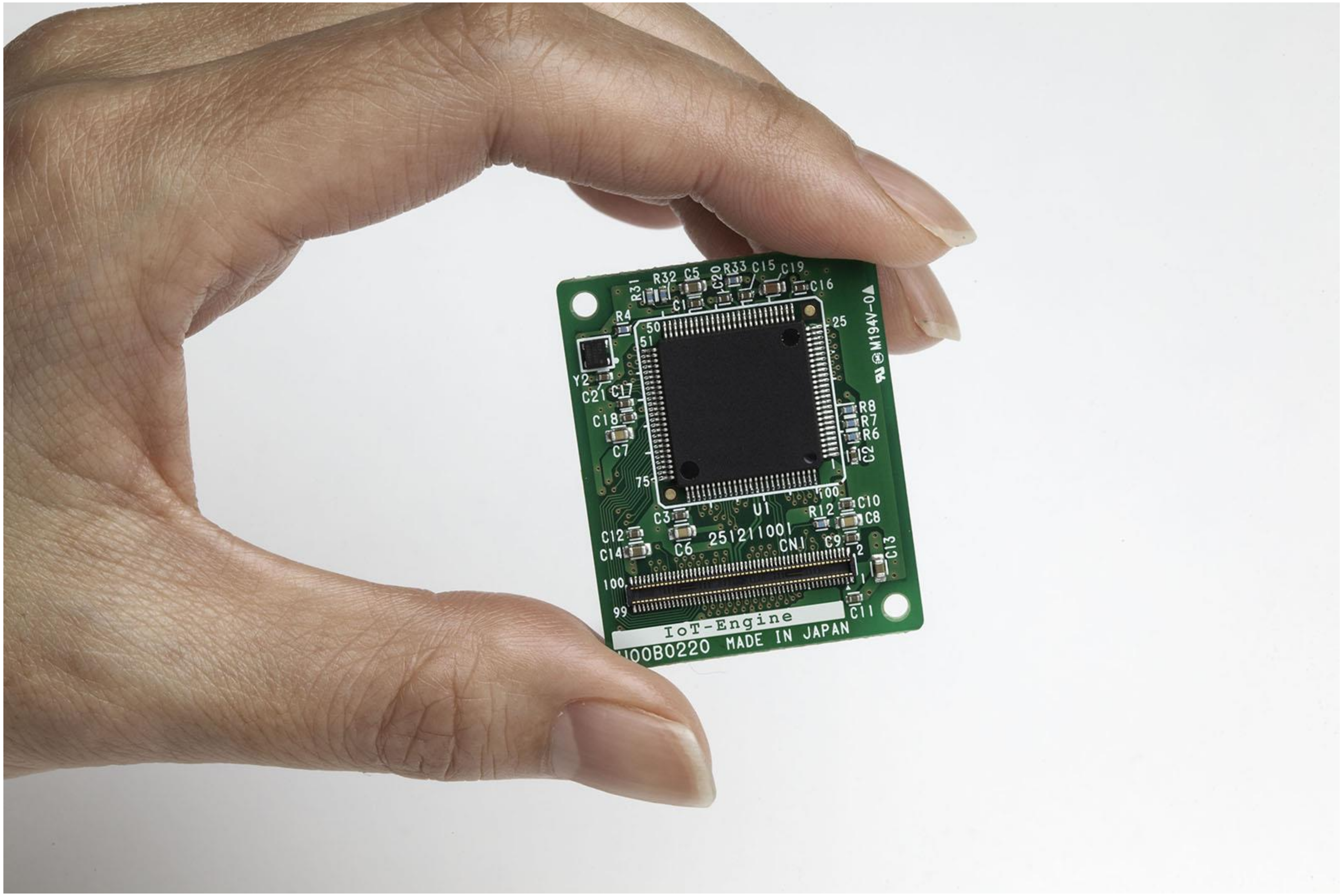
Policy-based Governmance Management



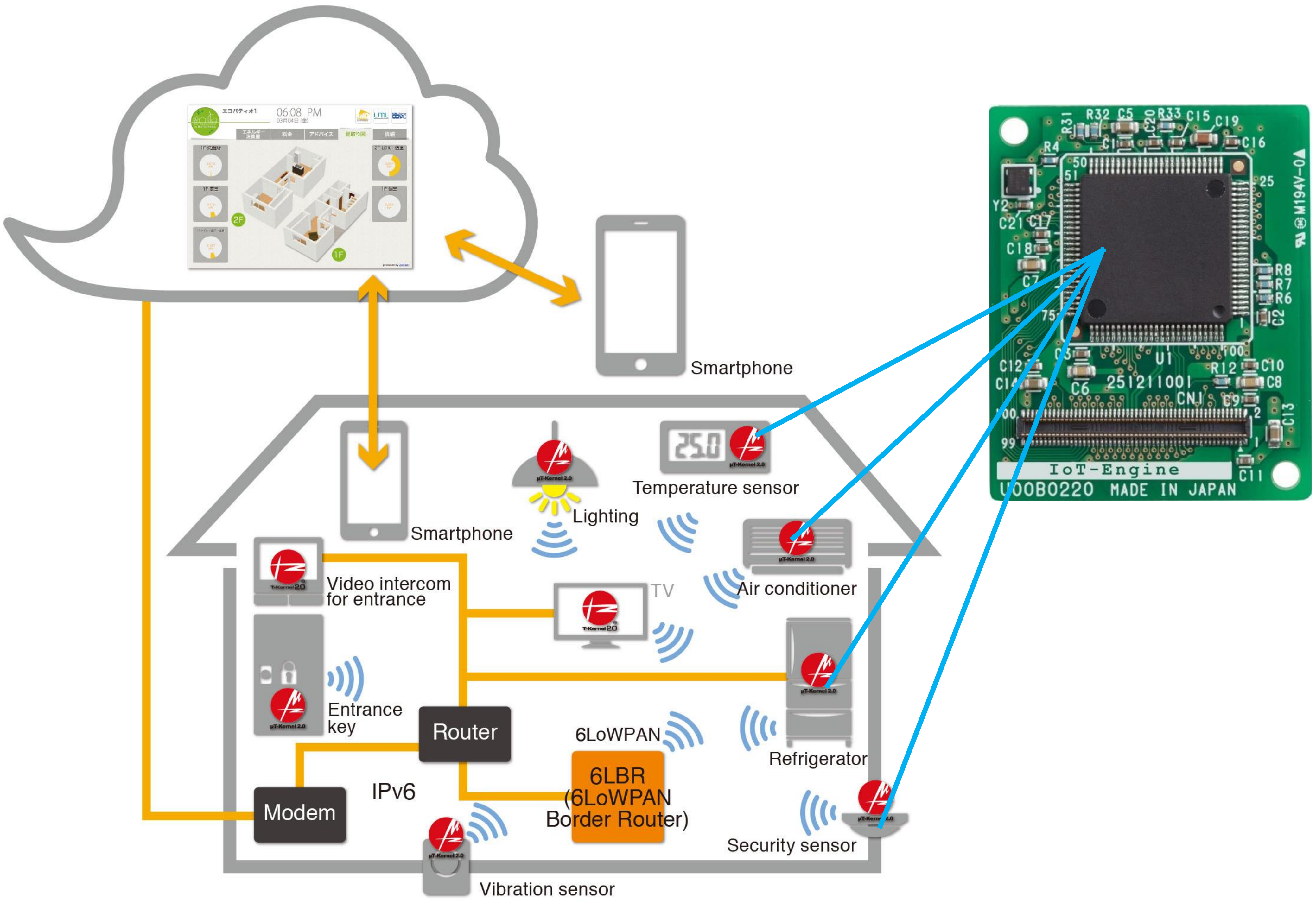
Source	service	action
ucode X	Any	Allow
ucode Y'	Read	Allow
Any	Any	Deny

IoT-Engine

Standard platform for the IoT devices


IoT-Engine
MADE IN JAPAN

IoT-Engine


Smartphone
Smartphone
Lighting
Temperature sensor
Air conditioner
TV
Video intercom
for entrance
Entrance
key
Router
6LoWPAN
Refrigerator
6LBR
(6LoWPAN
Border Router)
IPv6
Modem
Security sensor
Vibration sensor
IoT-Engine
U00B0220 MADE IN JAPAN

Features of IoT-Engine

- **Aiming for small size and low power with WPAN(IEEE802.15.4) communication**
  - Frequency may change according to areas/countries: 780 MHz (China), 868 MHz (EU, India), 915 MHz (North America, Australia), 920 MHz (Japan), 2.4 GHz (common throughout the world), etc.

    ✧WPAN : Wireless Personal Area Network
  - Suited to very low-power operation of devices that is powered by a battery or energy harvesting
- **Equipped with the support for CoAP and 6LoWPAN protocols**
  - Connects to the Internet via 6LoWPAN Border Router.
  - CoAP is friendly to Web API in the clouds.
- **Open IoT Platform connection**

Features of IoT-Engine

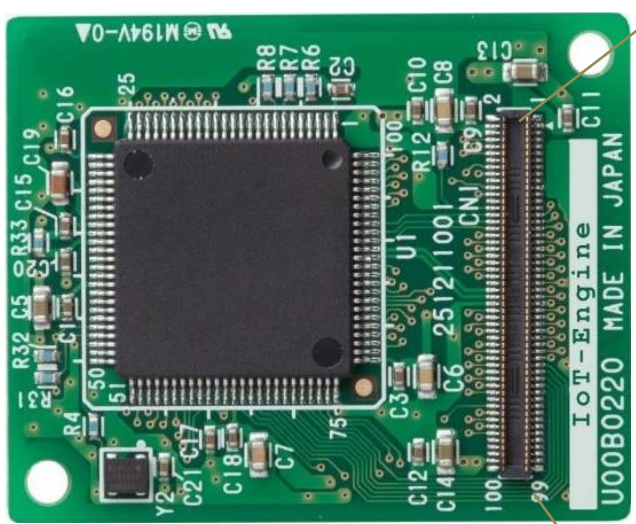
- **Equipped with μT-Kernel 2.0 real-time OS that supports low-power applications**
  - It is easy to implement advanced control logic by means of multi-task programming.
  - Very low-power consumption by placing the processor into Deep Sleep mode during IEEE802.15.4 beacon mode operation
- **Standardized connector of IoT-Engine**
  - A 0.4 mm pitch 100-pin connector and the positions of the screw holes next to the connector
  - Flexible pin assignment that can be used for different microprocessors
  - Arduino compatible I/O connector pin assignment leads to low cost and short time-to-market development.

Standardized specification of IoT-Engine

- Size factor of connectors, and board
- Guideline for connector signal assignment
- Typical device driver interfaces
- Middleware interface

- Provision of the framework that permits the productization of standard-conforming IoT-Engine boards that use different CPUs, and the distribution of commercial middleware products.

Connector Signal Standard of IoT-Engine



IoT-Engine Connector Assignment

EDGE-SIDE OUT-SIDE IN-SIDE

TYPE		SIGNAL ASIGNMENT		CONNECTOR PIN#		SIGNAL ASIGNMENT		TYPE	
VBATT			VBATT	1	2	D3.3V		D3.3V	
GPIO/INT	[S3]	-WKUP	1	3	4	D3.3V			
		SCK	2	5	6	1	USER-OPT1	[U0]	USER OP
		TXD	3	7	8	2	USER-OPT2		
		RXD	4	9	10	3	USER-OPT3		
		GPIO	5	11	12	1	USER-OPT4	[U1]	
UART	[P0]	GPIO, IO7(IO)	1	13	14	2	USER-OPT5		
		RXD, IO0(RX)	2	15	16	3	USER-OPT6		
		TXD, IO1(TX)	3	17	18	GND		GND	
GND			GND	19	20	1	SWCLK	[JS]	DEBUG
PWM	[P1]	-INT, IO2(INT)	1	21	22	2	SWDIO		
		GPIO, IO4(IO)	2	23	24	3	SWO		
		PWM, IO3(PWM/INT)	3	25	26	4	Vref		
		PWM, IO5(PWM)	4	27	28	1	-NMI	[Q0]	NMI/INT
		PWM, IO6(PWM)	5	29	30	2	-INT		
	[GP]	PWM	1	31	32	3	-INT		
		PWM	2	33	34	1	-INT	[Q1]	
		PWM	3	35	36	2	-INT		
GND			GND	37	38	3	-INT		
SPI	[S1]	MISO, IO12	1	39	40	1	SS	[SD]	SD
		MOSI, IO11	2	41	42	2	MISO		
		CLK, IO13	3	43	44	3	MOSI		
		SS, IO10	4	45	46	4	CLK		
GND			GND	47	48	GND		GND	
	[P2]	PWM, IO9(PWM)	2	49	50	1	D+	[USB]	USB
		GPIO, IO8(IO)	1	51	52	2	D-		
GND			GND	53	54	GND		GND	
RTC	[RS]	32kHz-IN	6	55	56	4	GPIO	[S4]	GPIO
		32kHz-OUT	5	57	58	3	GPIO		
			4	59	60	2	GPIO		
			3	61	62	1	GPIO		
		-RESET_OUT	2	63	64	GND		GND	
		-WKUP	1	65	66	3	-RESET	[MS]	SYSTEM
I2C	[P3]	SDA	2	67	68	2	MODE0		
		SCL	1	69	70	1	MODE1		
ANALOG	[A1]	AIN, A3	3	71	72	5	CTS	[S2] or [A5]	UART
		AIN, A4	2	73	74	4	RXD		
		AIN, A5	1	75	76	3	TXD		
	[A0]	AIN, A0	3	77	78	2	SCK		
		AIN, A1	2	79	80	1	RTS		
		AIN, A2	1	81	82	AGND		AGND	
AGND			AGND	83	84	2	AI	[A2]	ANALOG
RF CONTROL /DEBUG	[R1]	RF_SWCLK	3	85	86	1	AI		
		RF_SWDIO	2	87	88	3	AI	[A3]	
		RF_SWO	1	89	90	2	AI		
	[R2]	RF_NMI	3	91	92	1	AI		
		RF_RESET	2	93	94	3	AI	[A4]	
		RF_MODE	1	95	96	2	AI		
KEY	[KEY]		KEY2	97	98	1	AI		
			KEY1	99	100	AVCC	AVCC	AVCC	

Arduino I/O connector compatible signals

Connector : **HIROSE DF40C-100DP-0.4V**

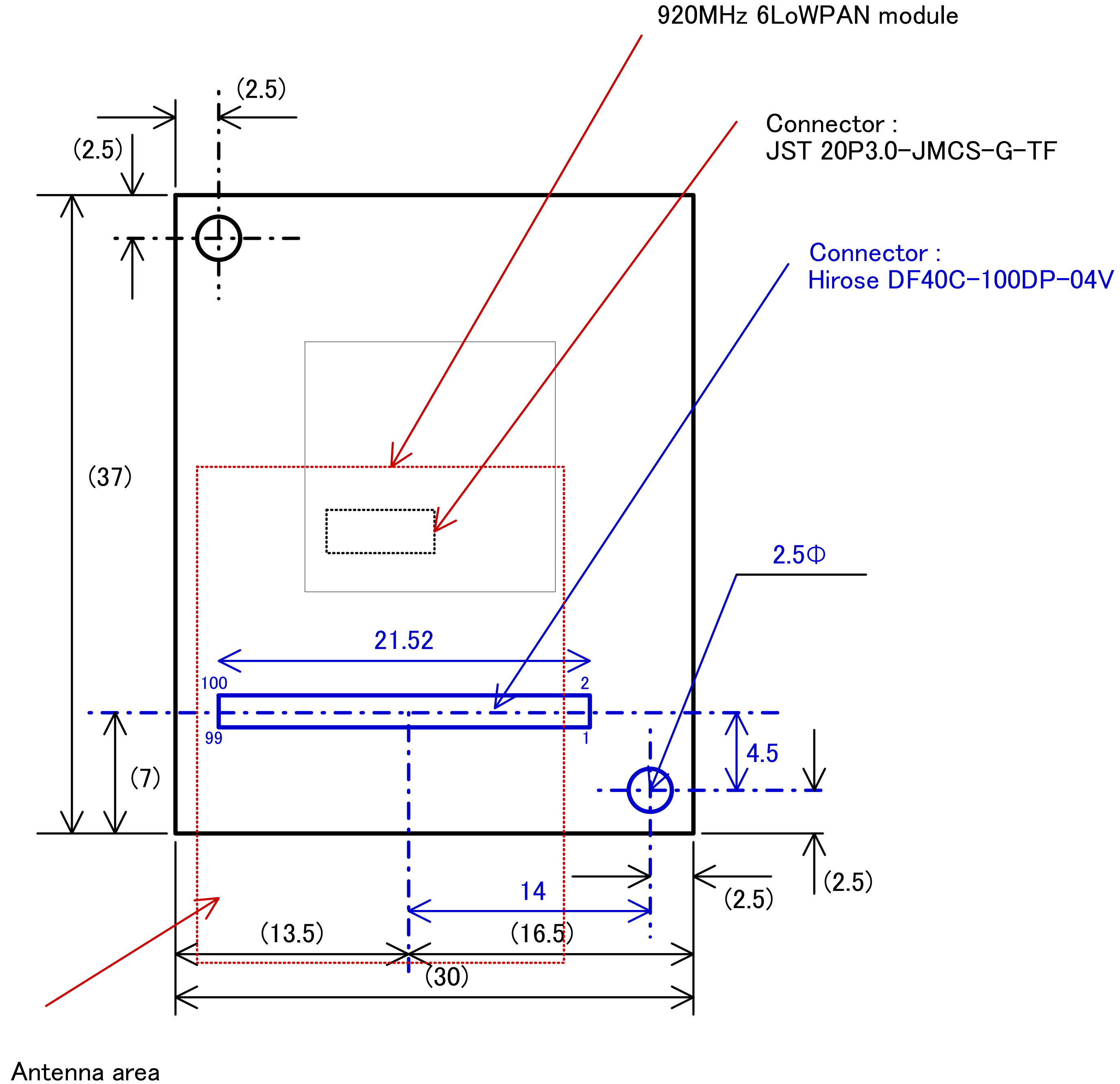
Signals in light blue are compatible with Arduino I/O connector

Mechanical Size Factor Standard

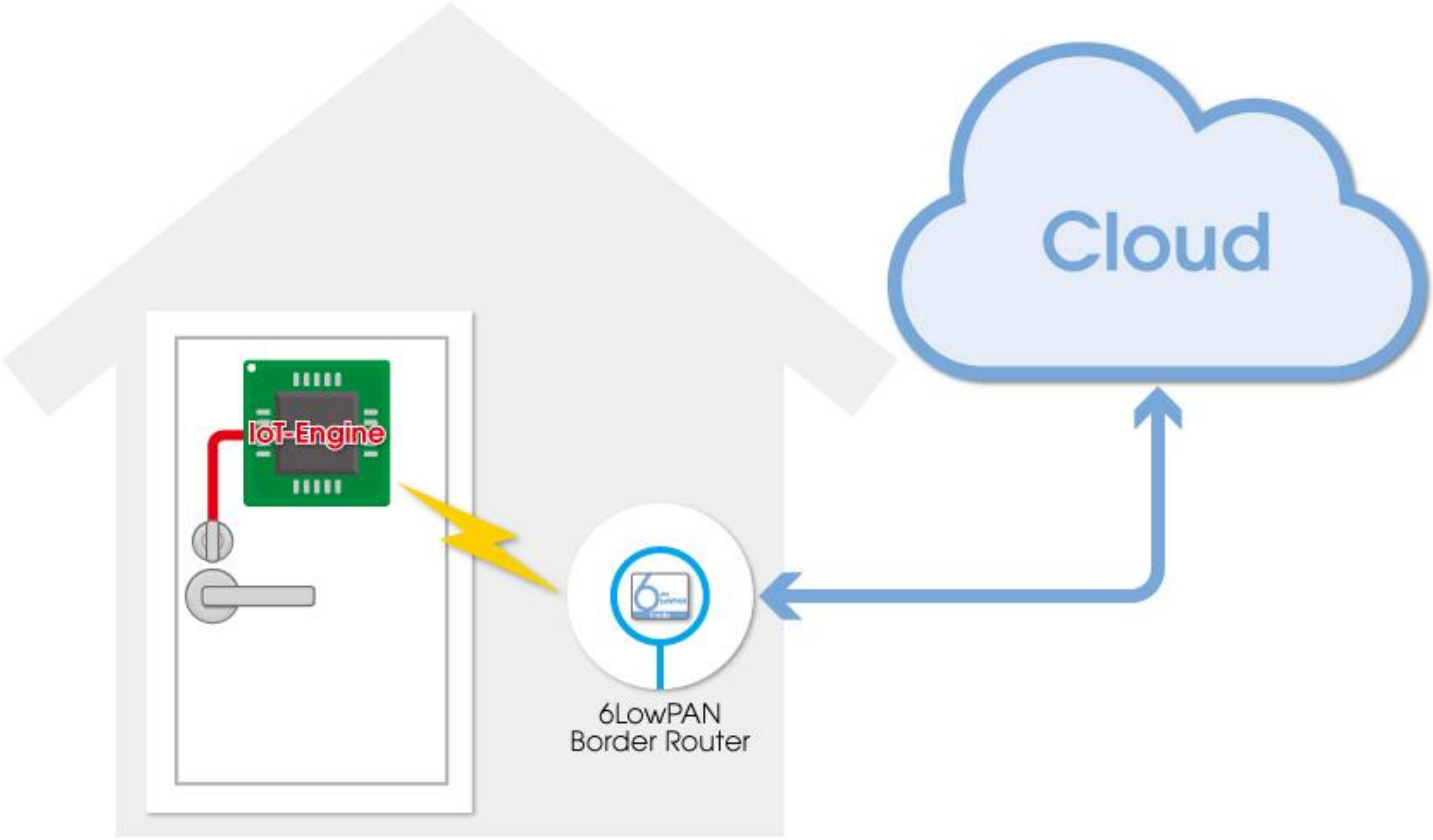
Mechanical size factor standard is done for the blue parts in the figure to the right.

1. Connectors
2. Screw holes
3. Relative position of the connectors and screw holes

Other size factors are just for reference.



Simple Demonstration



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UC Technology

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Presentation from participating companies

- Imagination Technologies
  - ✧Mr. Matsue Shigeki
- STMicroelectronics
  - ✧Mr. Paolo Oteri
- NXP Semiconductors
  - ✧ Mr. Hiroaki Yasuda
- Toshiba Microelectronics
  - ✧Mr. Yutaka Tamanoi
- Renesas Electronics
  - ✧Mr. Jun Hasegawa
- Ubiquitous Computing Technology Corp.
  - ✧Mr. Tatsushi Morokuma
- Personal Media Corporation
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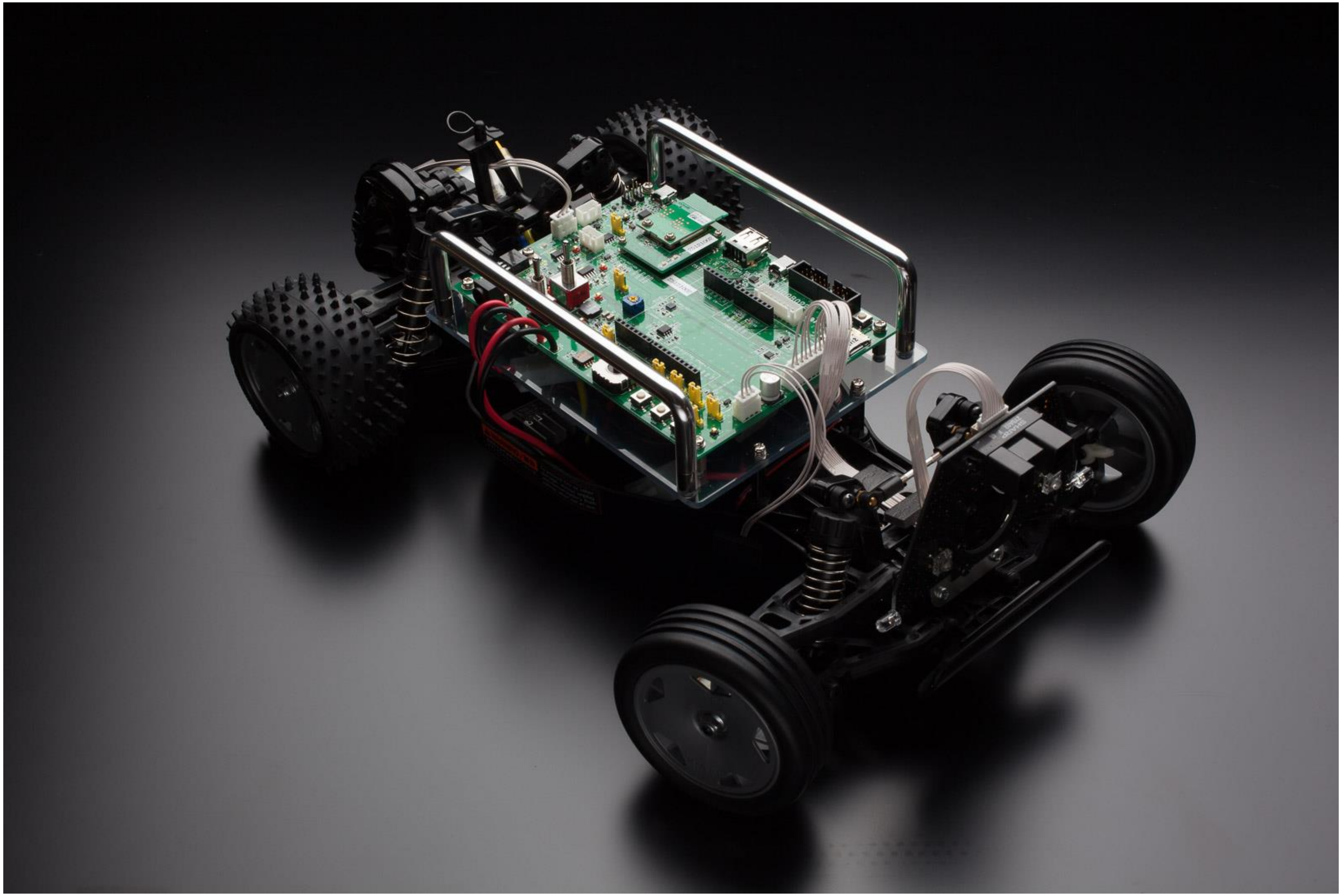
T-Car IoT Training Package

T-Car

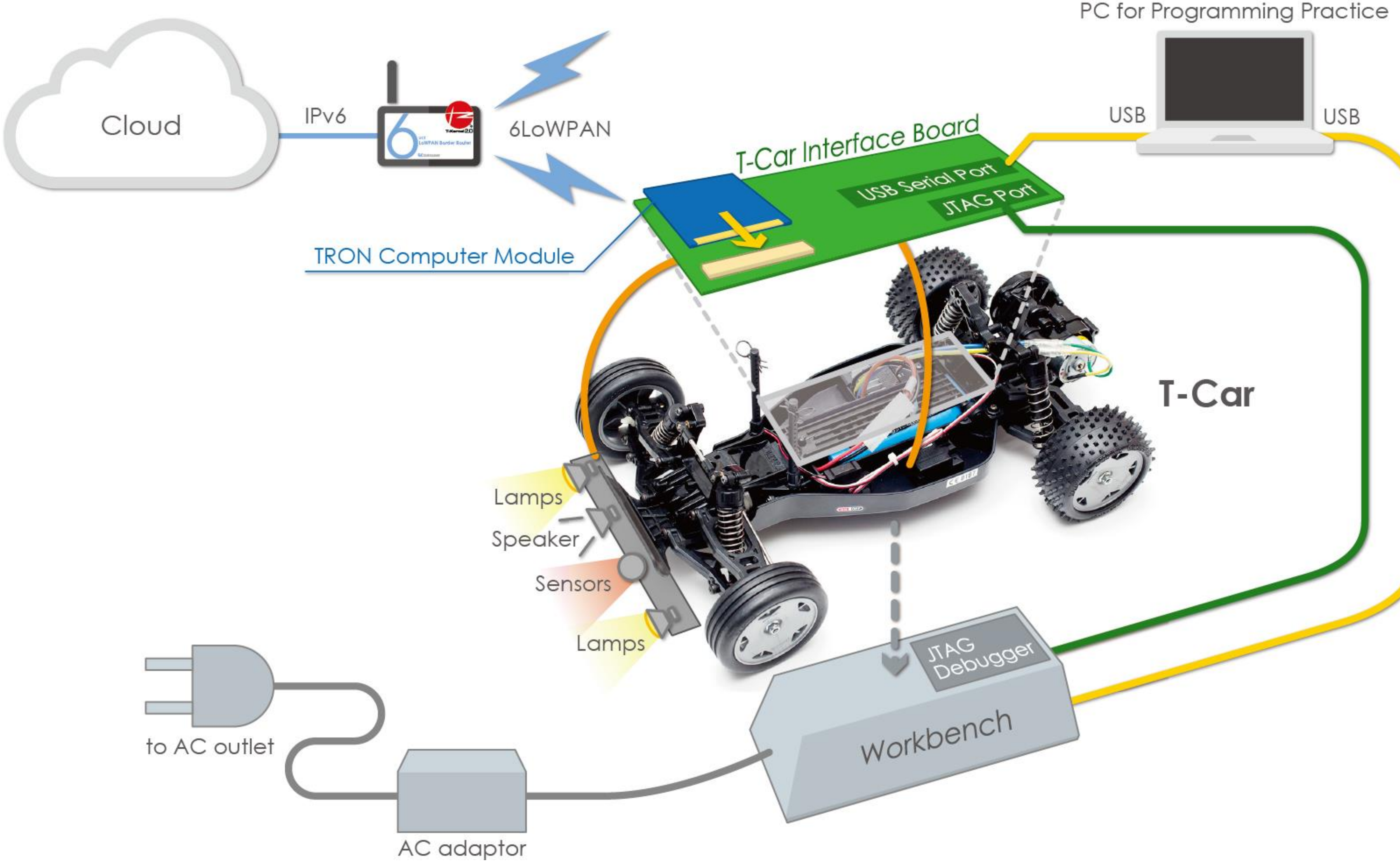


T-Car

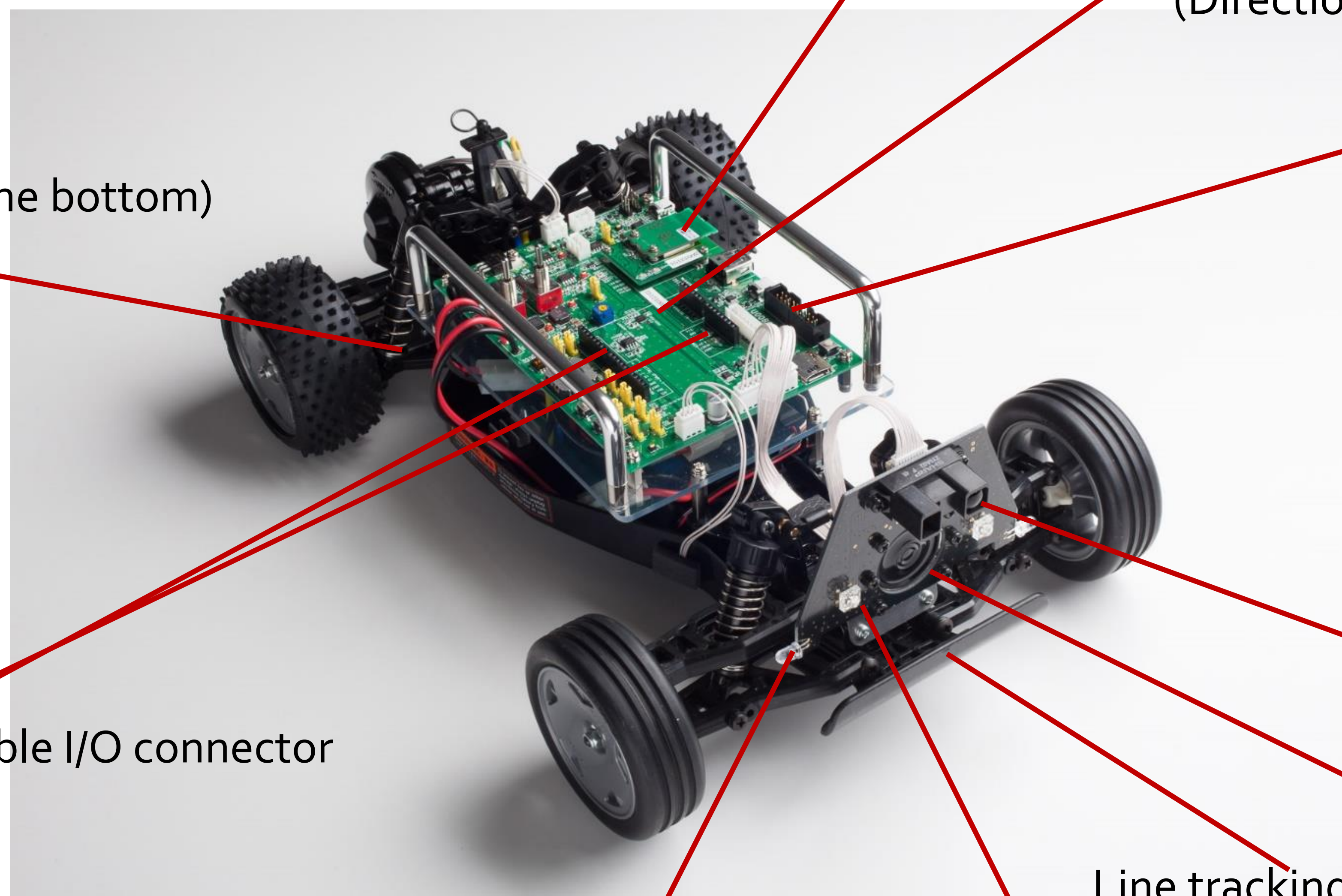
IoT Training Package

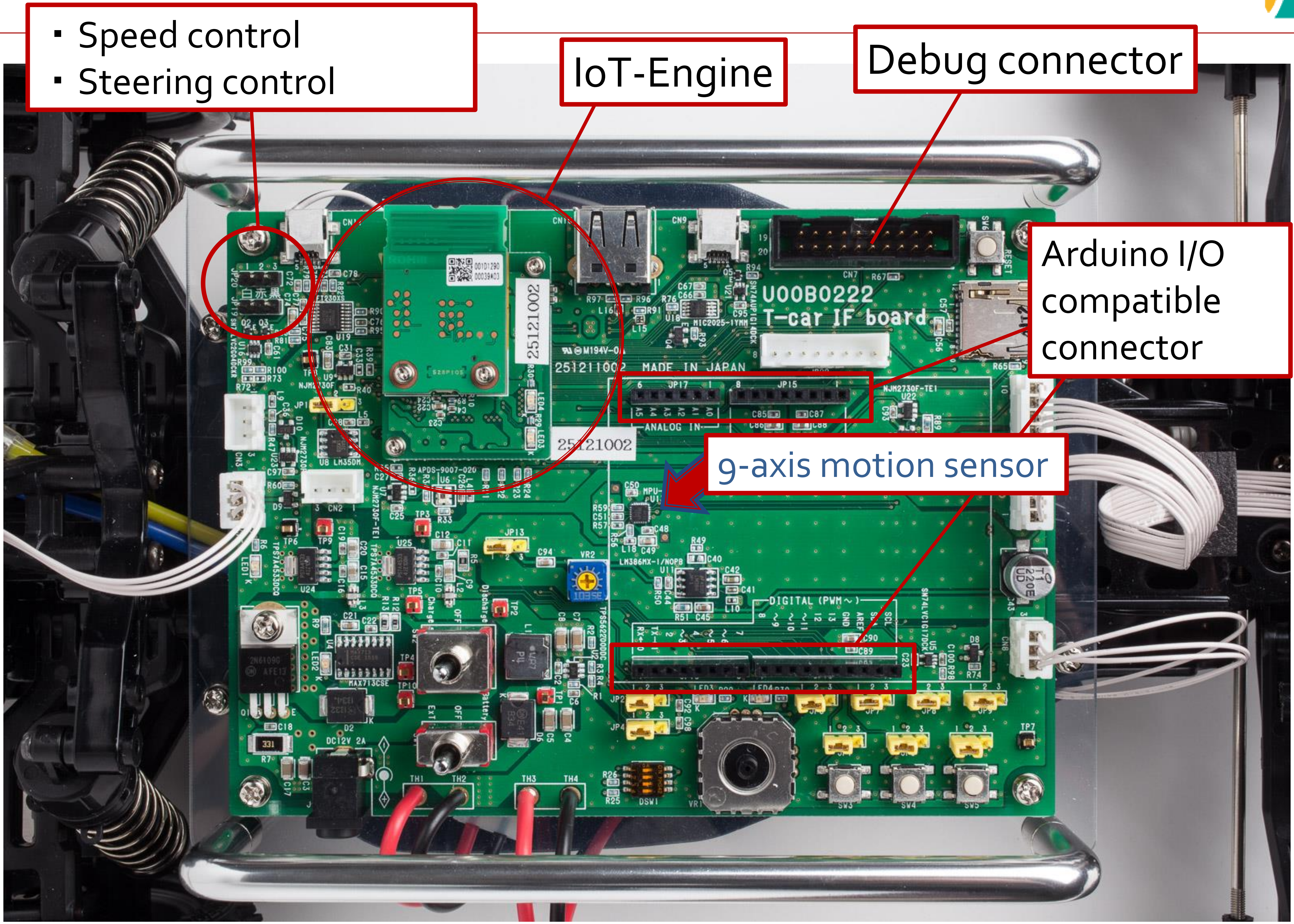
- Model car (scale: 1/10) is equipped with many sensors and IoT-Engine
  - ✧Speed sensor, line tracking sensor, 9-axis motion sensor, distance sensor, temperature, illuminance, etc.
  - ✧It comes with connector that is compatible with Arduino I/O connector and is easy to extend the function by using commercial offerings such as so called Shields or one's home-brew boards.
- Connects to the Internet via UCT 6LoWPAN Border Router (available separately).
  - ✧Control by consolidating information in the clouds from the networked external sensors
- Workbench for program development and debugging

T-Car: IoT training material with IoT- Engine

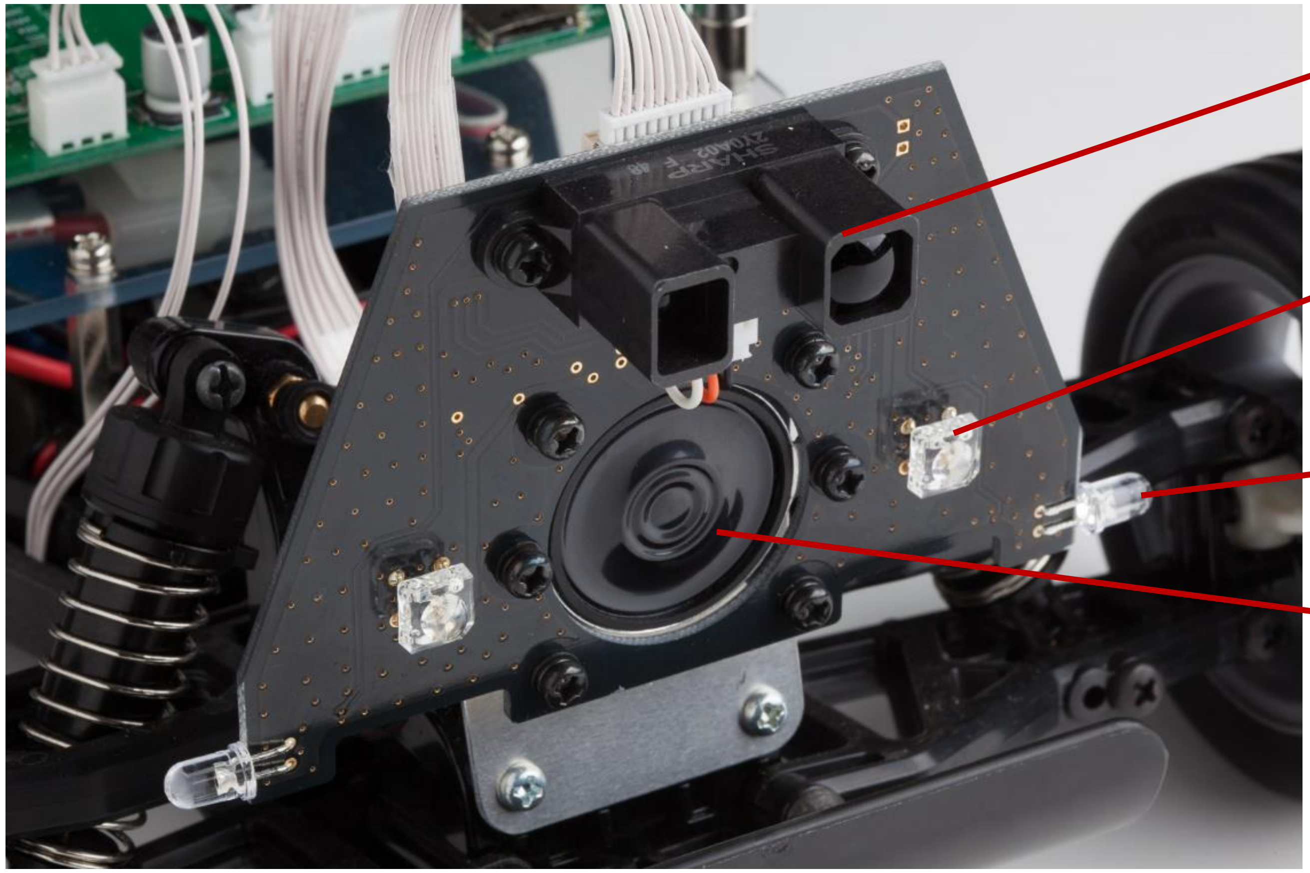


Main sensor devices aboard T-Car





▪ Speed control
▪ Steering control
IoT-Engine
Debug connector
Arduino I/O compatible connector
9-axis motion sensor

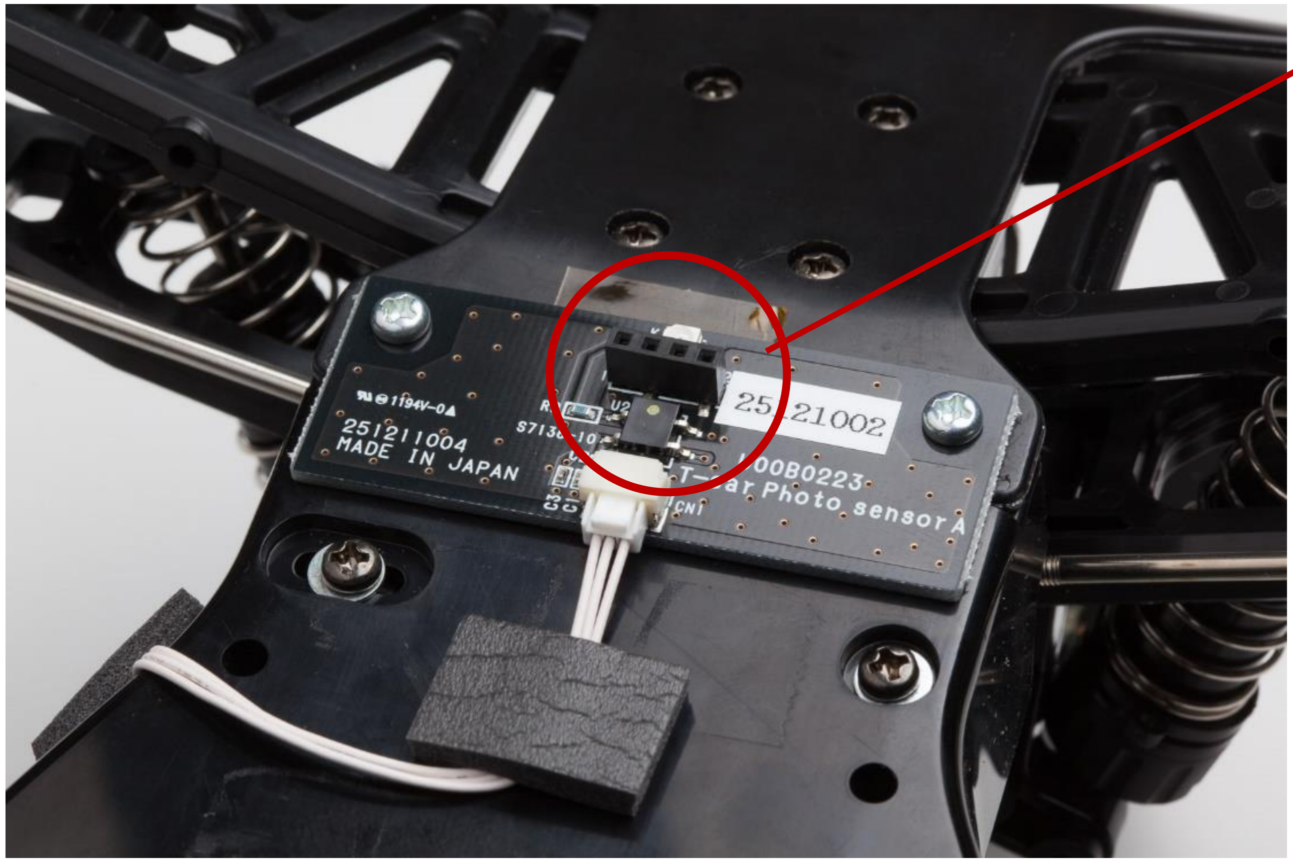


Infrared distance sensor (analog)
Measurement between 20-150 cm

Adjustable RGB LED

Orange LED

Speaker



Line tracking sensor

This detects the reflection from the road surface using LED and photo sensor.

This can be used to control steering by tracking black stripe on a white road surface.

Speed sensor

The same mechanism as line tracking sensor is used.

A white tape marking is placed on the inside of tire wheels.

Rotational speed and accumulated traveled distance are calculated.

T-Car U02C0205 Specification

Item	Specification
Control unit	IoT-Engine U00B0220
Chassis	Scale of 1/10 DT-02 Steering/Speed control, Lithium ion battery (7.2V)
Onboard sensors	Speed sensor (optical), line tracking sensor (optical)
Front unit	Front LED(RGB) Side LED (Orange) Distance sensor (infrared) Speaker

Item	Item
Main unit Sensors	9-axis sensor, temprature, illuminance, push buttons, analog joystick
Drivers	Amplifiers for steering/speed control, speaker, and microphone
Interface	Arduino-compatible I/O, µSD, USB(host/device mode switchable), USB-UART
Debug	20pin JTAG connector (for J-Link)
Workbench	J-Link debugger and AC-adaptor onboard
Power	12V 1A AC adaptor

www.tron.org