Innovativeness of IoT and Future of Control Systems

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"Internet of Things" is a Buzzword.

Don't care the definition.

Importance is in its innovativeness.

The structures of control systems will be changed by IoT.

IoT(Internet of Things)

Internet
(Common Spaces)

Almost everything has been connected to internet.

What is the Innovation?

Innovation of “Things”

⓪ Powered by Human, Horse, Wind

① Powered by Steam Engine **Industry Revolution**

② Powered by Electricity

②‘ Intelligence by Electric Circuits

③ Intelligence by Micro Processer

“Things” have their own intelligence.

④ Intelligence by Communication **IoT**

Intelligence is relieved from “Things”.

What is ④ ?

Siri (in iPhone) can work when internet is connected.

What happen if intelligence is released from “Things”? ①

(Case 1) Micro-computerized Rice Jar

【Issue】 At Top of Mt. Fuji, Taste of the Rice is not good.

Kaizen(Improvement before Revolution)

→Add Pressure Sensor to the jar.

→Renew Micro-processor and Increase Memories.

After Revolution

→Communicate with Cloud and Get Location of the jar.

→Get Pressure information from Meteorological Agency.

→Design Fire adjustment for the pressure.

→ Realize it Local controller of the jar.

From the communication through smart-phone, Preference of rice can be taken in account.

Professional Fire adjustment technique is programmed In micro-processer.

If Communication and Simple Control are available,

It is not necessary to add devices for improvement of the function of the jar.

What happen if intelligence is released from “Things”? ②

(Case 2) Automatic Driving Car

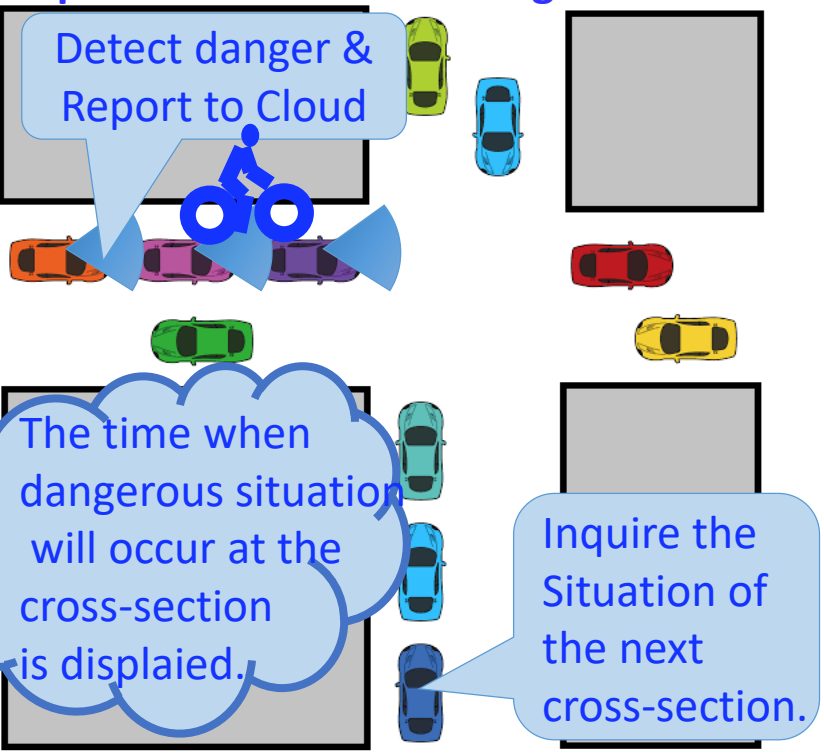
【Issue】 Detection of dangers which will happen in Future

Before Revolution?

→Enhance infrastructure.(Detection system is arranged to every cross-section?)

→Deliver the signal to the cars around the cross-section.

Can avoid the bicycle at breakneck speed behind the building?



After revolution

→Report the situation around the car to Cloud not only for their own profits.

→Future dangerous situation is calculated for every cross-section.

→Display the predicted information on Cloud.

→The information is utilized by users who access the site.

Google Map shows traffic jam information based on the GPS information from users who want to get the maps around their location.

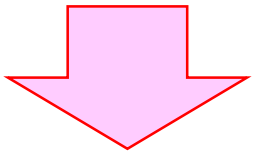
Innovativeness of IoT

The movement of Intelligence from "Things" to "Cloud" realizes

Release from

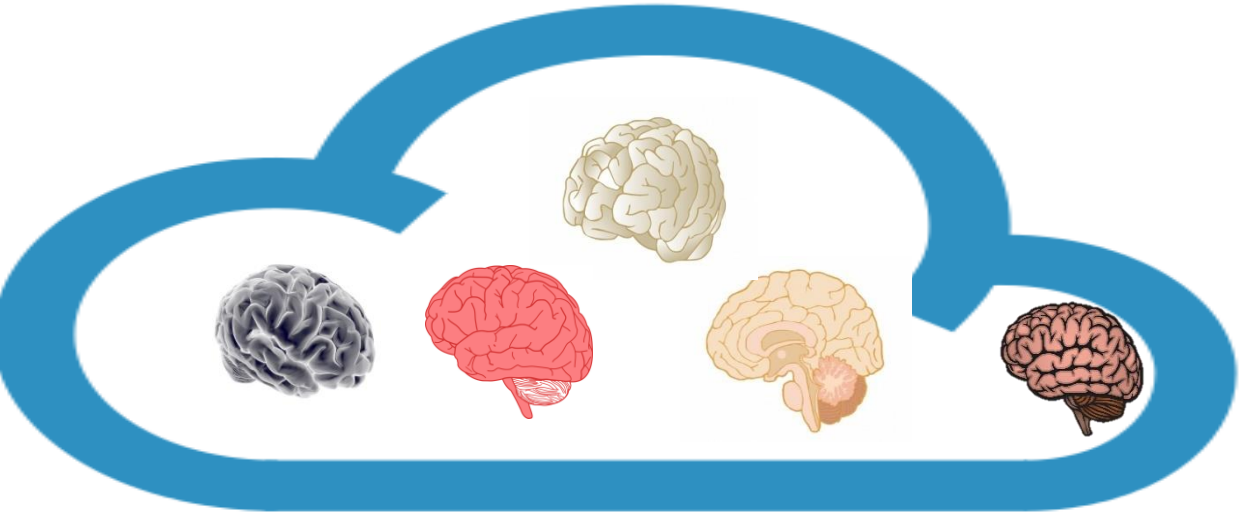
- **Physical** (CPU, Memory, HDD, etc.)
- **Spatial** (Access to all over the world)
- **Temporal** (Past, Present, Future)

Constraints.

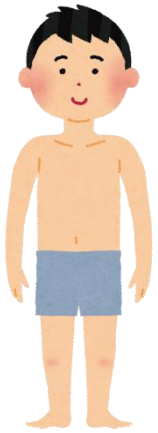


Innovation

Cloud is the world “Idea is everything”.



In Cloud, various brains influence each other and grow up, and the brain of a new idea is born.

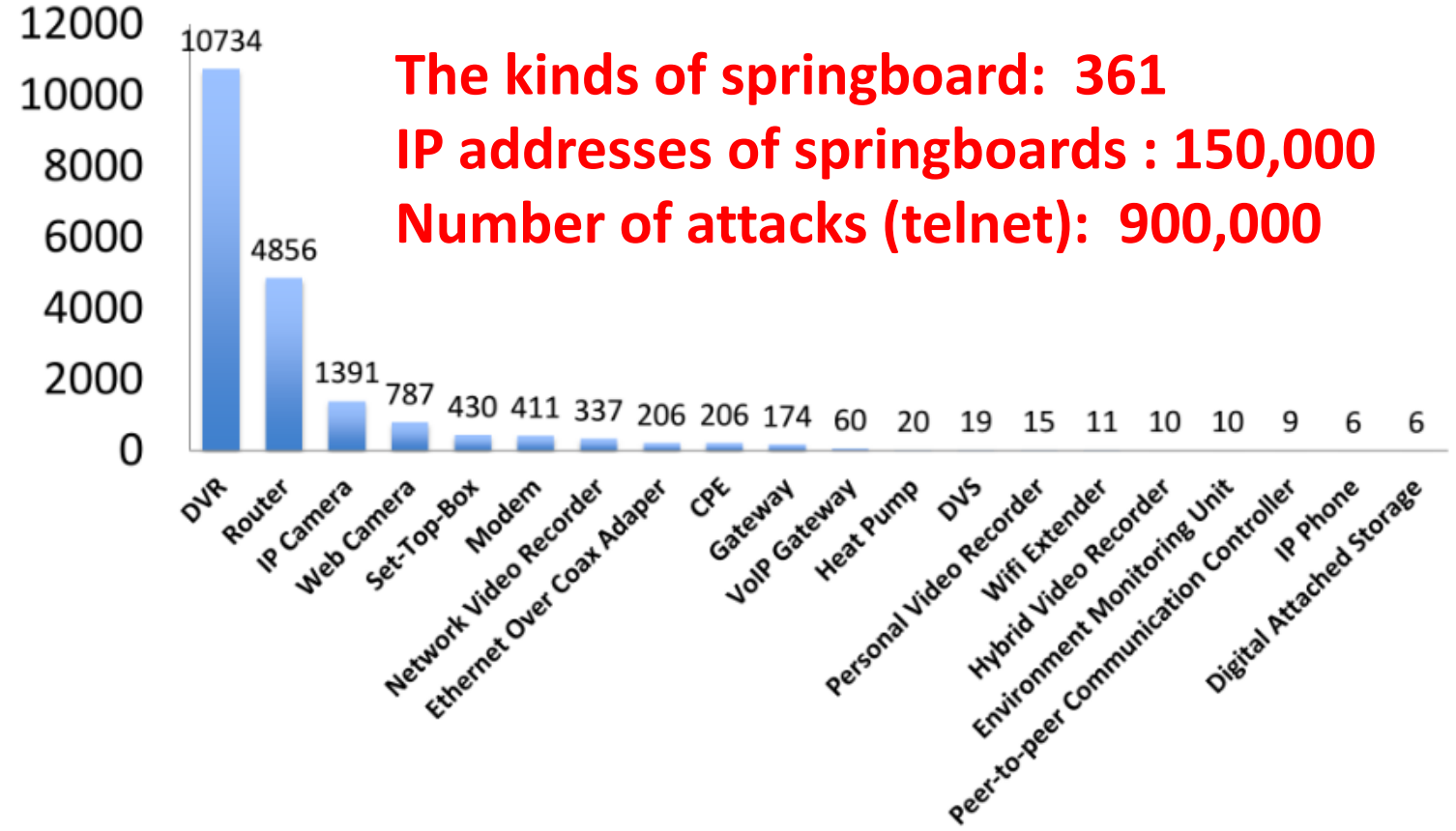


Body was made by Toyota, but Brain may be Google.

Download is more important than upload for changes of “Things” (innovativeness of IoT).

IoT is already a target of cyber attacks.

Devices from which cyber attacks came to the honey pot set in Yoshioka Lab, Yokohama National Univ. from April to July in 2015.

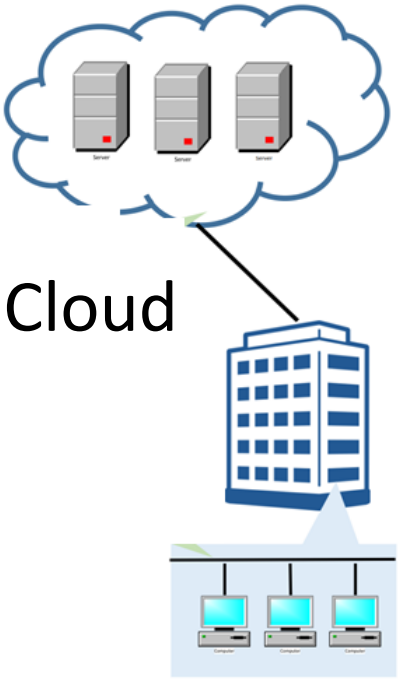


The kinds of springboard: 361
IP addresses of springboards : 150,000
Number of attacks (telnet): 900,000

Reported by Prof. Katsunari Yoshioka, Yokohama National University (2015)

“Control” also wants to leave from “Things”?

- Single-loop controller, PLC and DCS is separated from the plant equipment.
- But they are connected to sensors and actuators.
- If a controller is replaced, the service of control is stopped.
- Although vulnerability is found frequently, replace of DCS is done every 15~20 years.
- Cloud can continue the service even when a part of hardware is broken.
- Controllers should also have the advantage of Cloud to continue the service of control.



Fog (local cloud on the site)

Intelligence (program) has issue of security

There are many programs in Plant Automation Systems

MES (Manufacturing Execution System)

- Production Planning Program
- Material Management Program
- Asset Management Program

Plant Control System

- SCADA (Supervisory Control And Data Acquisition system) Program
- Operation Support System Program
- DCS (Distributed Control System) Program
- PLC (Programmable Logic Controller) Program

- Smart Sensor Program
- Smart Valves Program

Vulnerability might be found in Programs.

Security management becomes difficult when intelligence scatters

Security Management of Programs

Example of Issue of cyber-security

It was reported that vulnerability was found in the module being used in the program developed by employees ten years ago.

Even in the module for secure communication, Open SSL, vulnerability had been found.

- Who will modify the program?
  What is the current job of the employee?
- When can the modified version of the module be obtained?
- How test the modified program?
  Is its affect to real-time processing acceptable?
- Is there no other program inside the company that uses the module?

Paradigm Shift in Control Systems Management

Not only functions but also integrity are necessary to be checked in developing, testing and maintaining.

- Does it satisfy the specification

  Can it work? → (Test) → OK!
- How nice is the performance?

  Optimization of operating condition

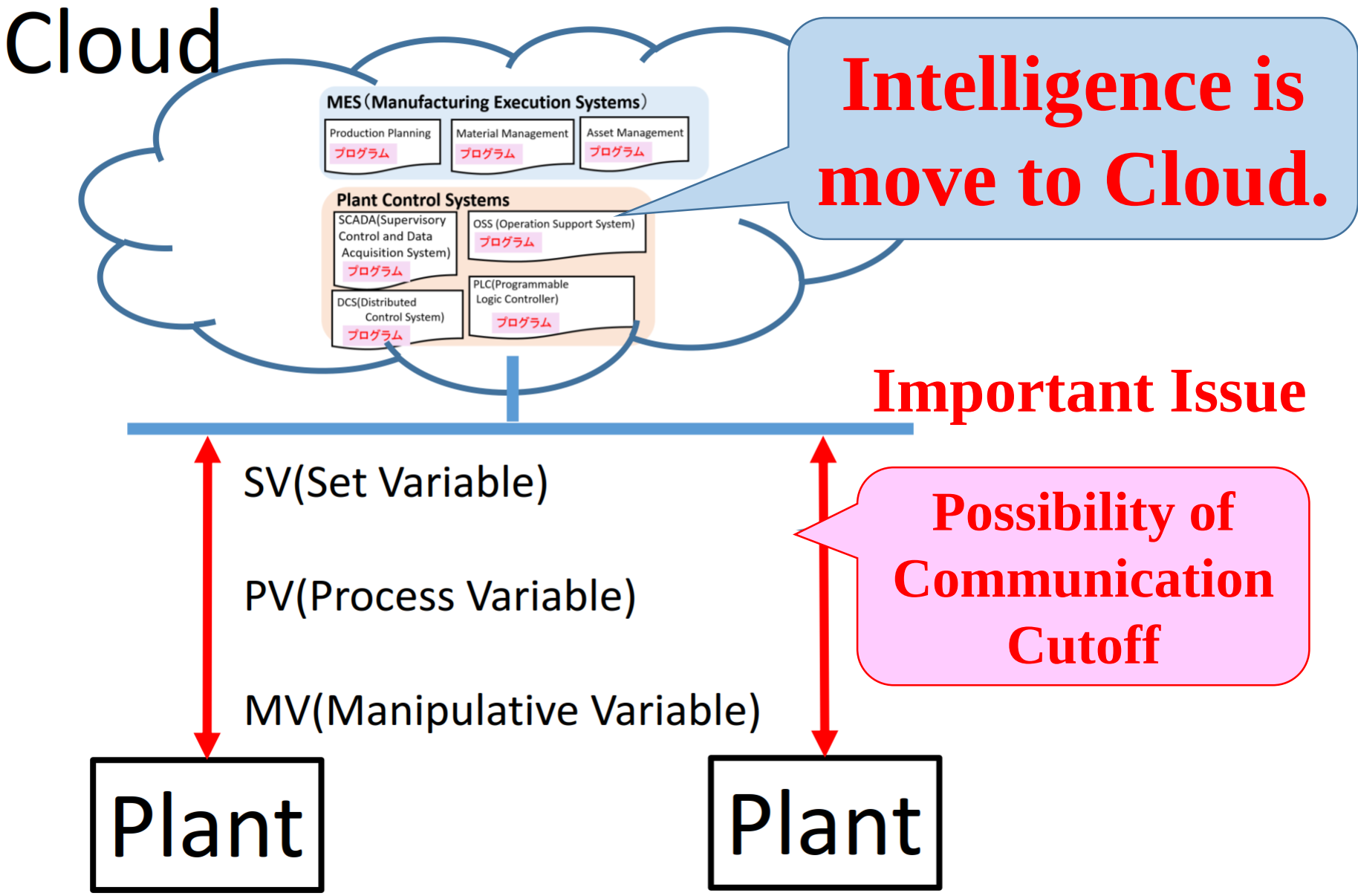
- Won't it behave wrong?

  Isn't warm hiding?

  Is there any vulnerability?

  How can be maintained focusing on cyber-security.

Future image of Control System ①



Future image of Control System ②

Realization of Continuity of Service by Fog

Place the Programs which does not require real-time execution in Cloud.

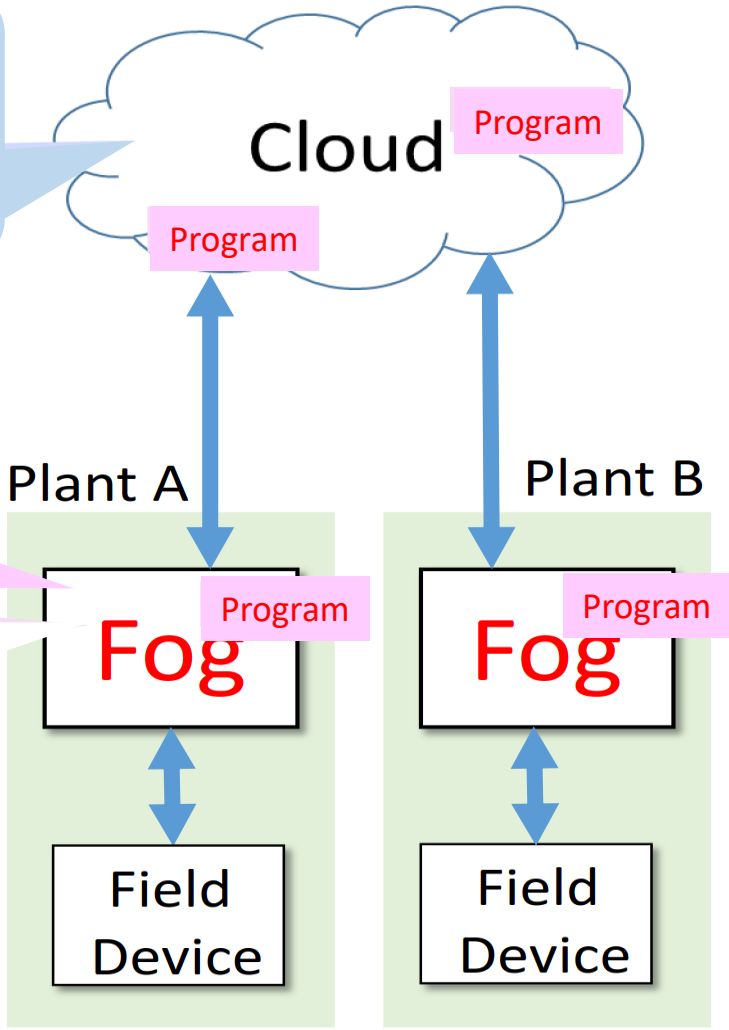
Fog is local Cloud at a plant site.

Consolidate real-time programs in Fog.

Every Intelligence for Plant Control is managed in Fog or Cloud.

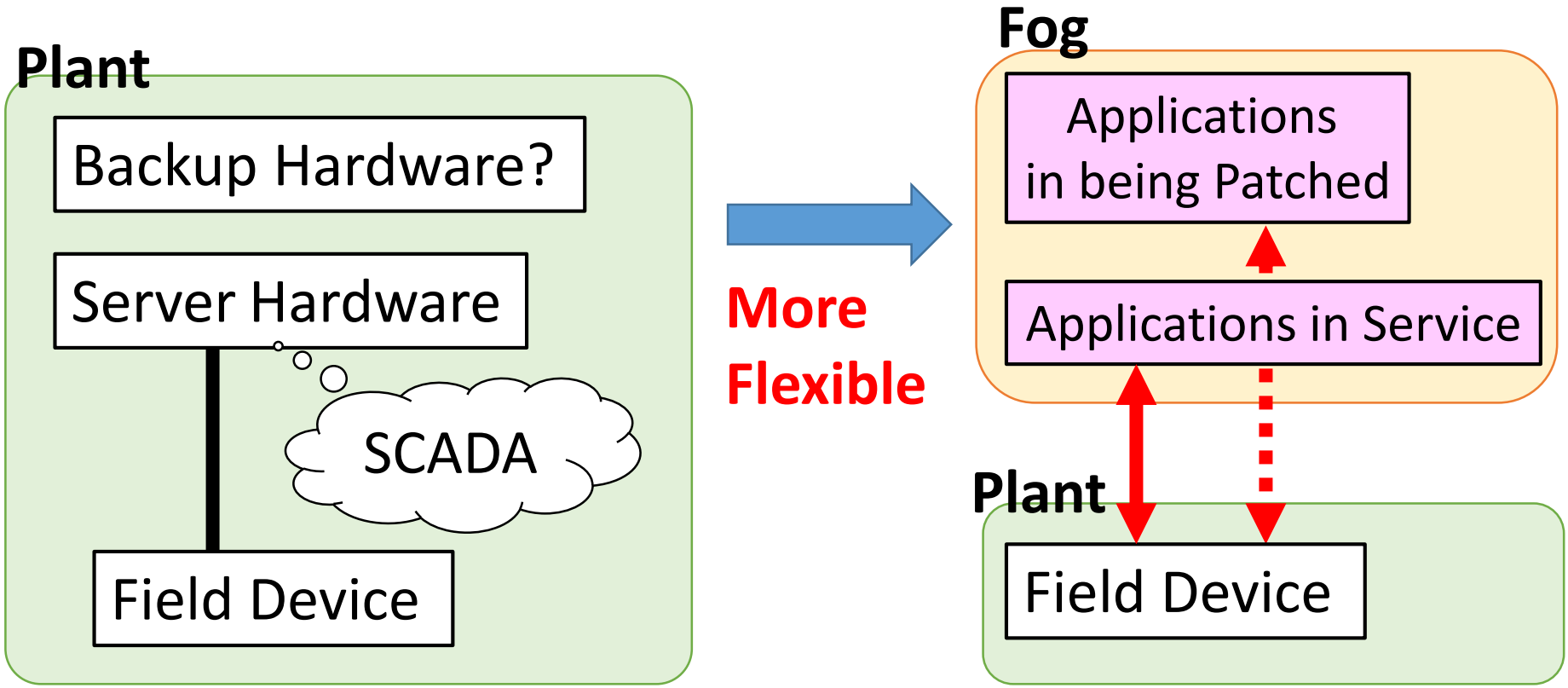
⇒Flexible and Continuous Service

⇒ Robust Security Management



Security improvement by Fog

Prompt countermeasure such as Patch against vulnerability in continuing service is necessary.



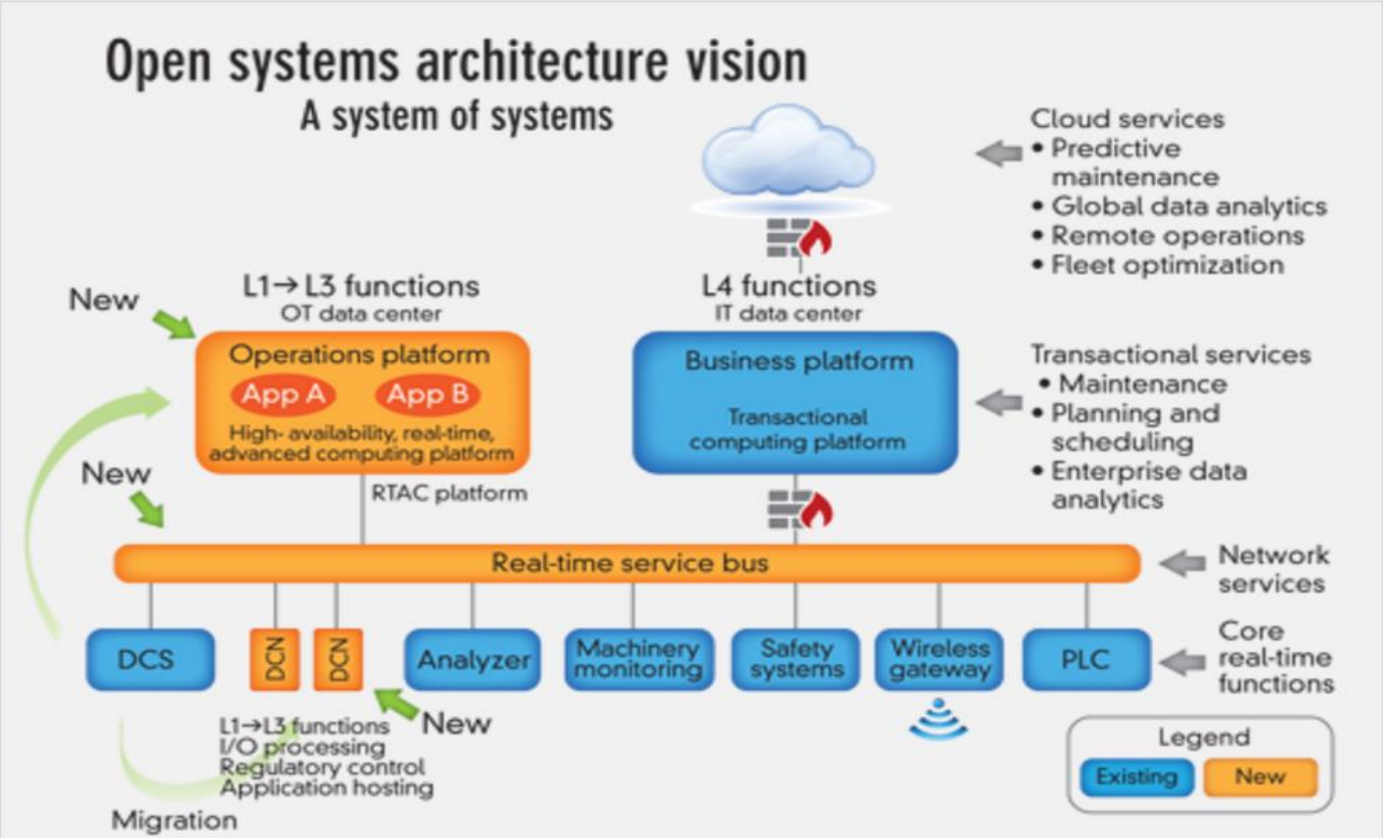
In our laboratory Fog is already implemented with Openstack by students on inexpensive servers.

It is not only virtualization but also hardware backup.

It is effective countermeasure against hardware breakdown.

Next generation control system in ExxonMobil

Lockeed Martin contracts to Exxon mobile as the system integrator of next-generation, open and secure automation system for process industries on Janualy 14th in 2016.



DCS dream taking flight

ExxonMobil envisions a new "system of systems" that will allow it to more easily adapt its operations environment to change needs and opportunities. Graphic by ExxonMobil.

Lockeed Martin: Future Airborne Capability Environment (FACE) Consortium since 2010

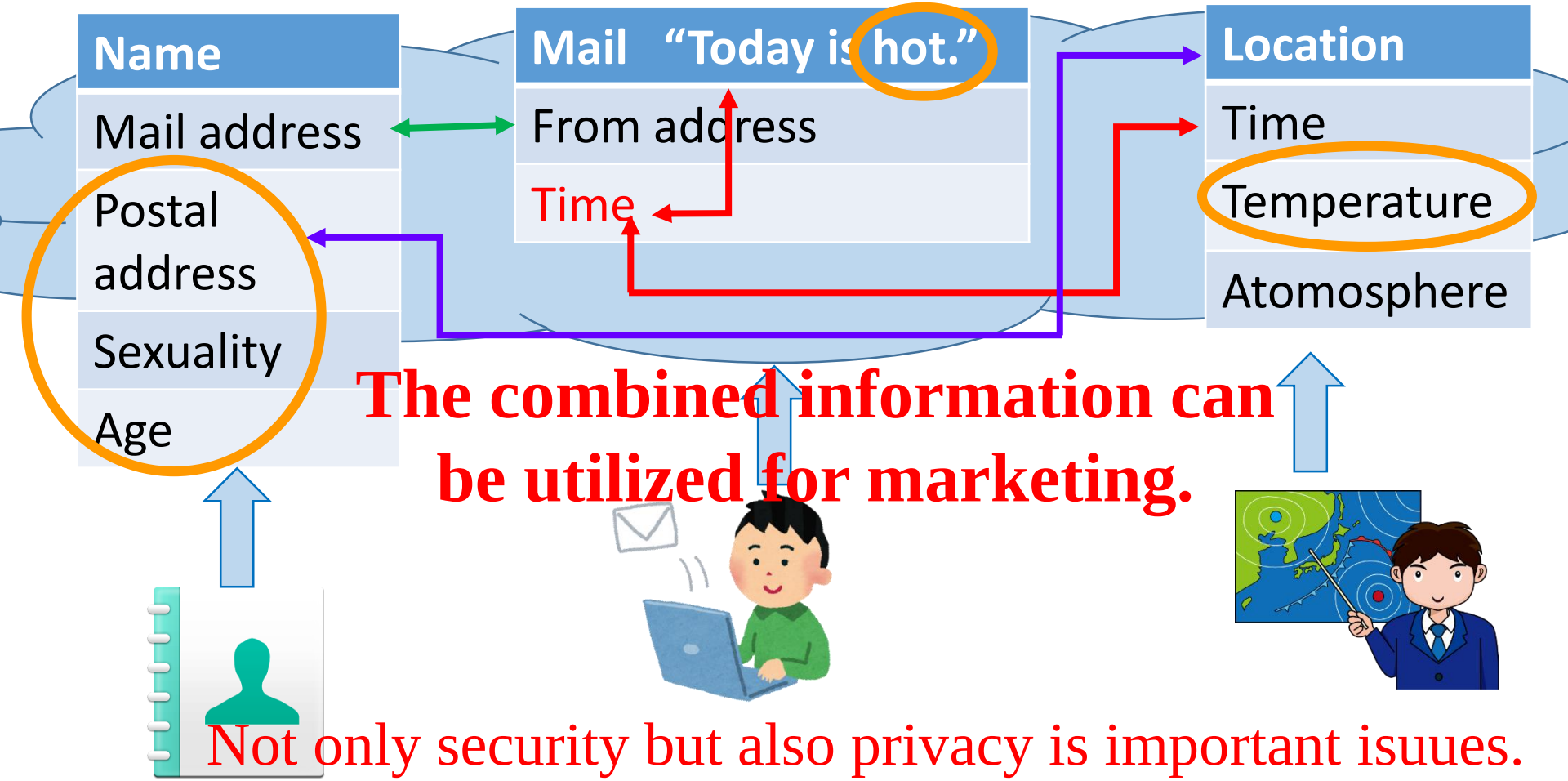
Other Topics related to IoT

1. Great disparity is generated in information capability.
   - Attitude toward standardization
   - Difference in Cognitive engines
   - Difference in Budget scales to match the investment costs

2. Things and Services is changed by 3D printers.
   - U.S. Army will repair damaged parts in aircraft and ground vehicles in combat zones with 3D printers.
   - US Army will create drones with certain specifications in combat zones by using 3D printers.
   - 3D image model for virtual realization can be generated very easily and promptly based on photos.
   - Many types of wearable devices are developed.

Exploitation of information in Cloud

- Not only gathering sentences from mails but also following links make information for other objects than the original ones.



Innovation by combining information

- **To realize Innovation systematically,**
  [Not by Kaizen (improvement)]
  new combination of information might be effective.
- To utilize the data effectively, the background information such as application, user, date and etc. is necessary.
- The data structure has been discussed from 1990s in
  CALS(Commerce At Light Speed),
  STEP(Standard for the Exchange of Process model data) and etc.

Industrie 4.0

RAMI4.0(Reference Architecture Model Industrie 4.0)と

Industrial Internet Consortium

IIRA(Industrial Internet Reference Architecture)

The difference from the previous ones is that huge information is already dealt with in constructing the standards.

Reference model is discussed to cover various activities and levels

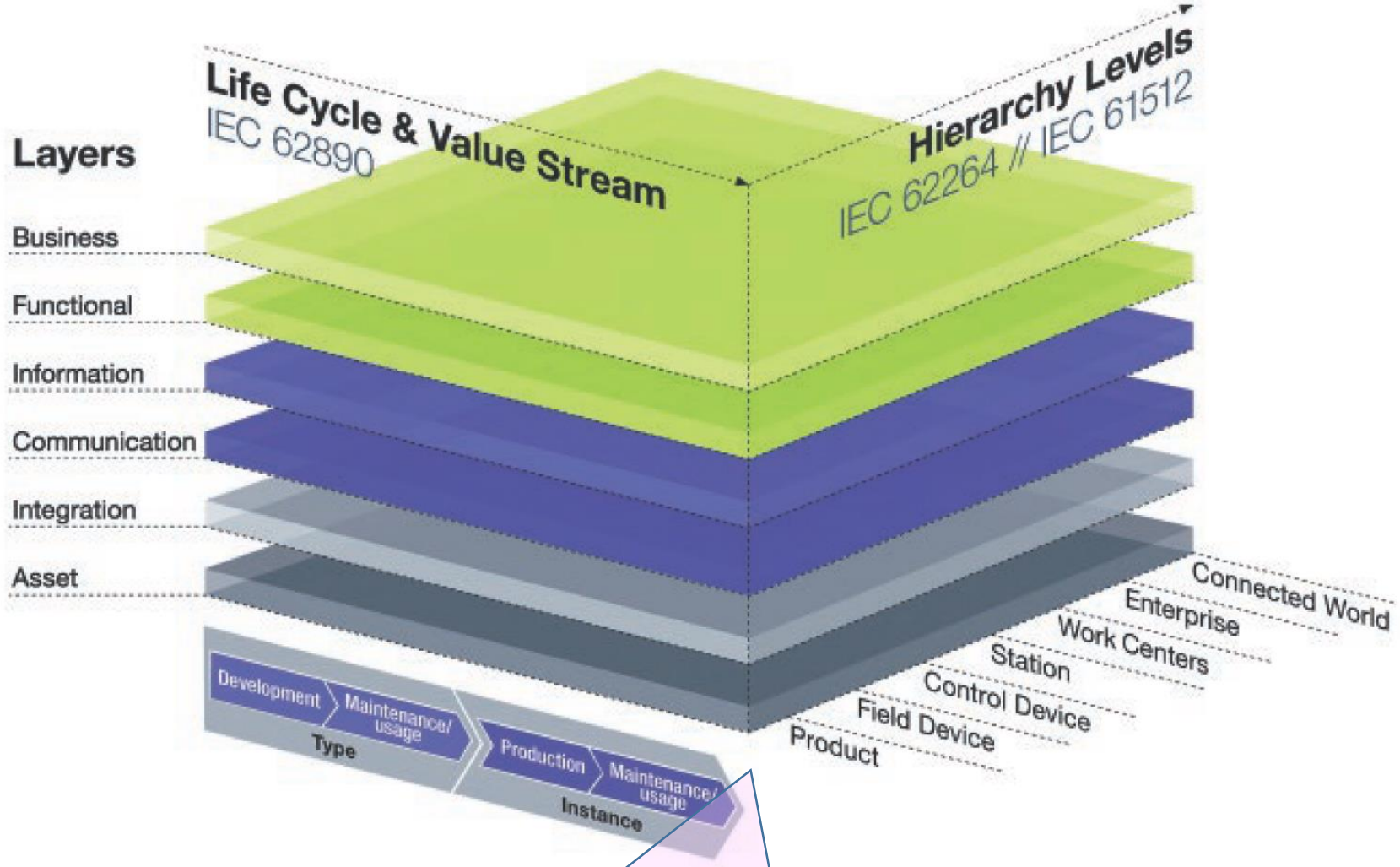
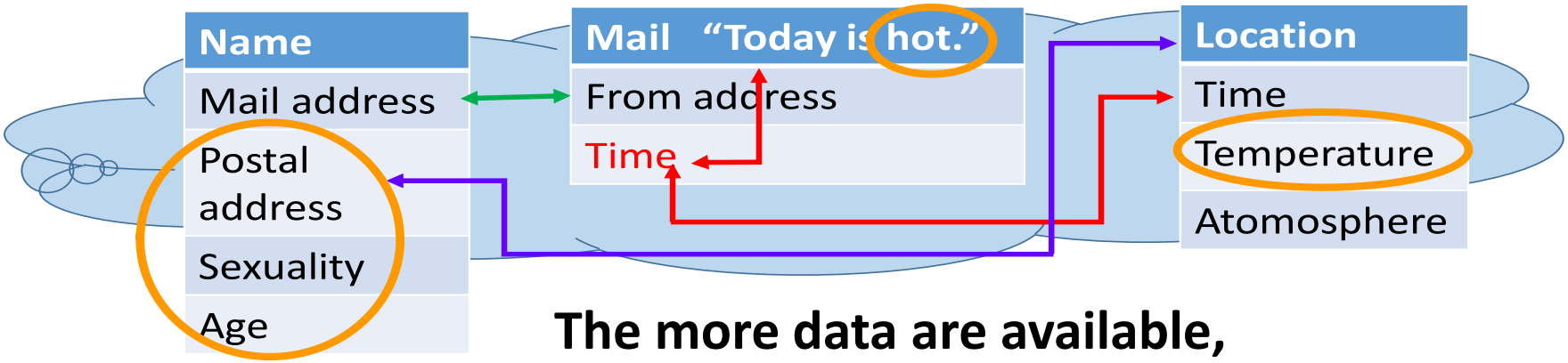


Figure 1. Reference architecture model for Industrie 4.0 (RAMI4.0)
Copyright „Umsetzungsstrategie Industrie 4.0 – Ergebnisbericht, Berlin, April 2015"

It must take very long time to authorize the all standards.
In discussing them, data must be accumulated.
Otherwise, huge difference in information power is generated.

IBM Watson Explore

By combining structured or unstructured data in inner or outer databases, unified view is induced according to contexts.



The more data are available,
the more relationships can be generated.

Because compliance is important,
data must be prepared by each customer.
Only baby Watson can be provided.

A comp. Watson

B corp. Watson

Differences from Languages

- Language is important to cognition.
  Cognitive engines are different in countries.
- Because the capability of Watson depends on learning data, the organization to collect data is important.
- The difference of Baby Watson is widen.

English Watson

Between United States and Japan,
there is a big difference in scales of projects.
2% cost cut in a maintenance project
in USA companies
can more than 500 million dollars.
In Japan, such a large project does not exist.
It is difficult to find a project to apply Watson
in their budget in Japan.

Japanese Watson cannot grow up.

Serious problem in Japan

Managers in Japan

- Big data, Deep learning and AI must be great. Our company must use them anyway.

Engineers in Japan

- We have learned successes in GE, IBM and so on, which are global Giant companies.
- Similar approach might be applicable to our department.
- Their merits are huge even if 2% of the total costs. But, it is difficult to create a large project to match the investment cost, which might exceed 100 million yen, in our department.
- We are looking for successes in small cost in other companies.

How can they obtain their own success?

Technology to promote IoT

Progress of Communication Technology

・Mobile communication

1G (Analog)	1979～
2G (28.8KBPS)	1993～
3G (14MBPS)	2000～
LTE (110MBPS)	2006～
4G (100~200MPS)	2012～
5G (10～50GBPS)	2020～

・One Movie can be downloaded only in 5 seconds with 5G while more than 8 minutes are necessary with 4G.

・Electricity consumption is reduced. Buttery is not necessary for RFID tags.

Spread of Internet

IPv4(32bits≒4.3billion)⇒

IPv6(128bits=3.4×10^38)

Everything can own its original address.

Cloud

・AWS, Azure, ThingWork,…

・Huge number of servers

・User friendly applications

Cheap and High-Function Smart Devices

・Raspberry Pi, Xbee, etc.

Progress of Image device and Processing

8K Camera, Image Processing applications, Virtual Reality, Augmented Reality

3D printers

Not only plastic but also metal materials

“Things” will be changed?

Such business has not appeared…

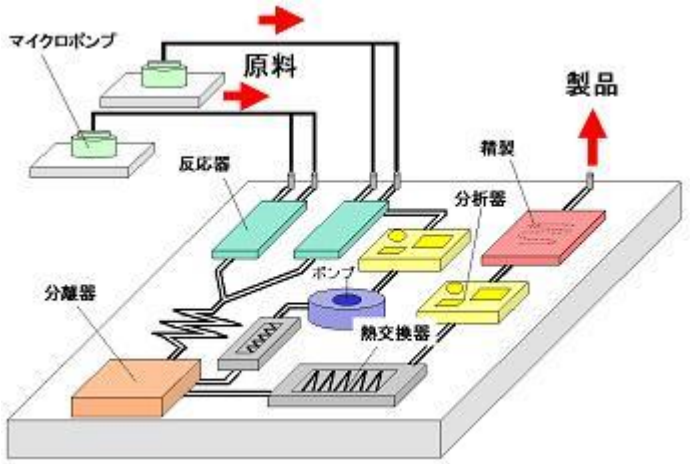
Personal medicine can be produced on a table.

The plant can also be produced with 3D printer.

Personal Information(DNA, etc.)

Health information

Design charts



Sensors, Actuators and other devices can be arranged and connected in generating layers with the 3D printer.

The concept of “parts” will also be changed.