



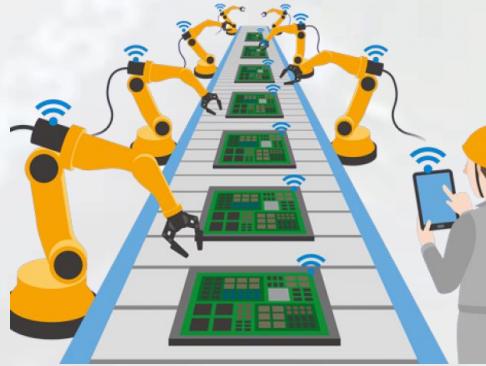
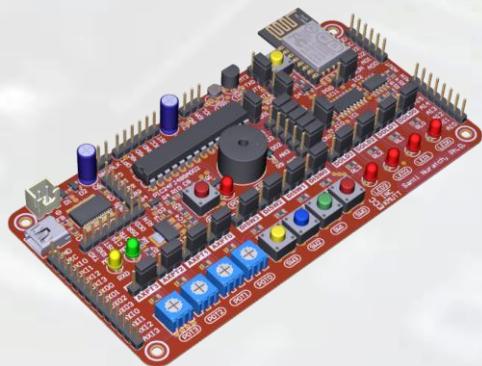
เทคนิคการออกแบบและพัฒนาฮาร์ดแวร์และซอฟต์แวร์สำหรับระบบ อินเตอร์เน็ตอອฟริงส์และอุตสาหกรรม 4.0

Hardware/Software Design and Implementation Techniques
for Internet-of-Things and Industrial 4.0 Applications

มหาวิทยาลัยอุบลราชธานี

21-22 กันยายน 2561

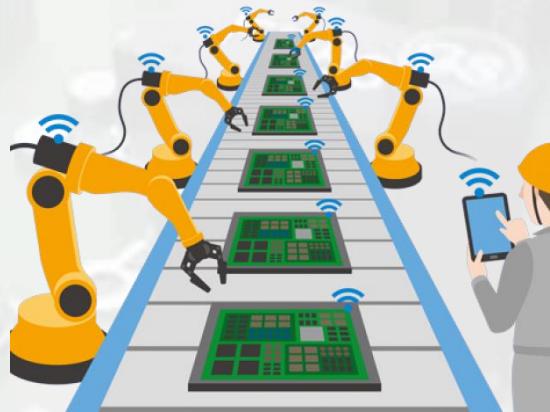
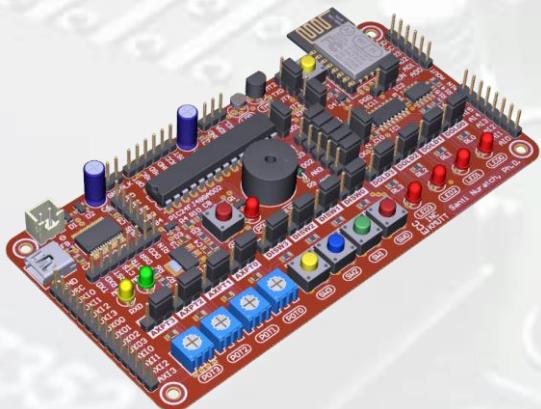
ดร.สันติ นุราษ



Day #1, Section #1

Embedded C Programming

Hardware/Software Design and
Implementation Techniques for Internet-
of-Things and Industrial 4.0 Applications



we make computers do more.



ดร.สันติ นุราษ

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Who am I?



ดร.สันติ นุราษ

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Embedded Computing and Control Laboratory (ECC Lab.)

Department of Control System and Instrumentation Engineering (INC)

King Mongkut's University of Technology Thonburi (KMUTT), THAILAND

- ▶ Embedded Systems, Real-time Systems, Wireless Control and Monitoring
- ▶ Digital Signal Processing, Real-time Signal Processing, Active Filter
- ▶ Speech Signal Processing, Speech Recognition, Speaker Recognition, Speech Enhancement
- ▶ Artificial Intelligence, Machine Learning, Pattern Recognition
- ▶ System Dynamics (Modelling and Control)
- ▶ Power Electronics (Modelling and Digital Control, Digital and Analog Circuits)
- ▶ Industrial Automation and Instrumentation Systems
- ▶ Internet of Things (IoT), Industry 4.0, and Computer Technologies
- ▶ Industrial Software Design and Implementation (Embedded, Com/Web-based applications)

Embedded Computing and Control Lab.



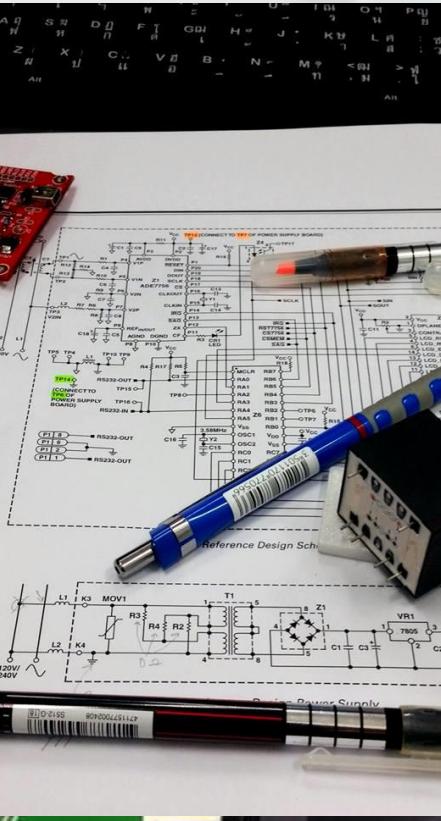
ECC



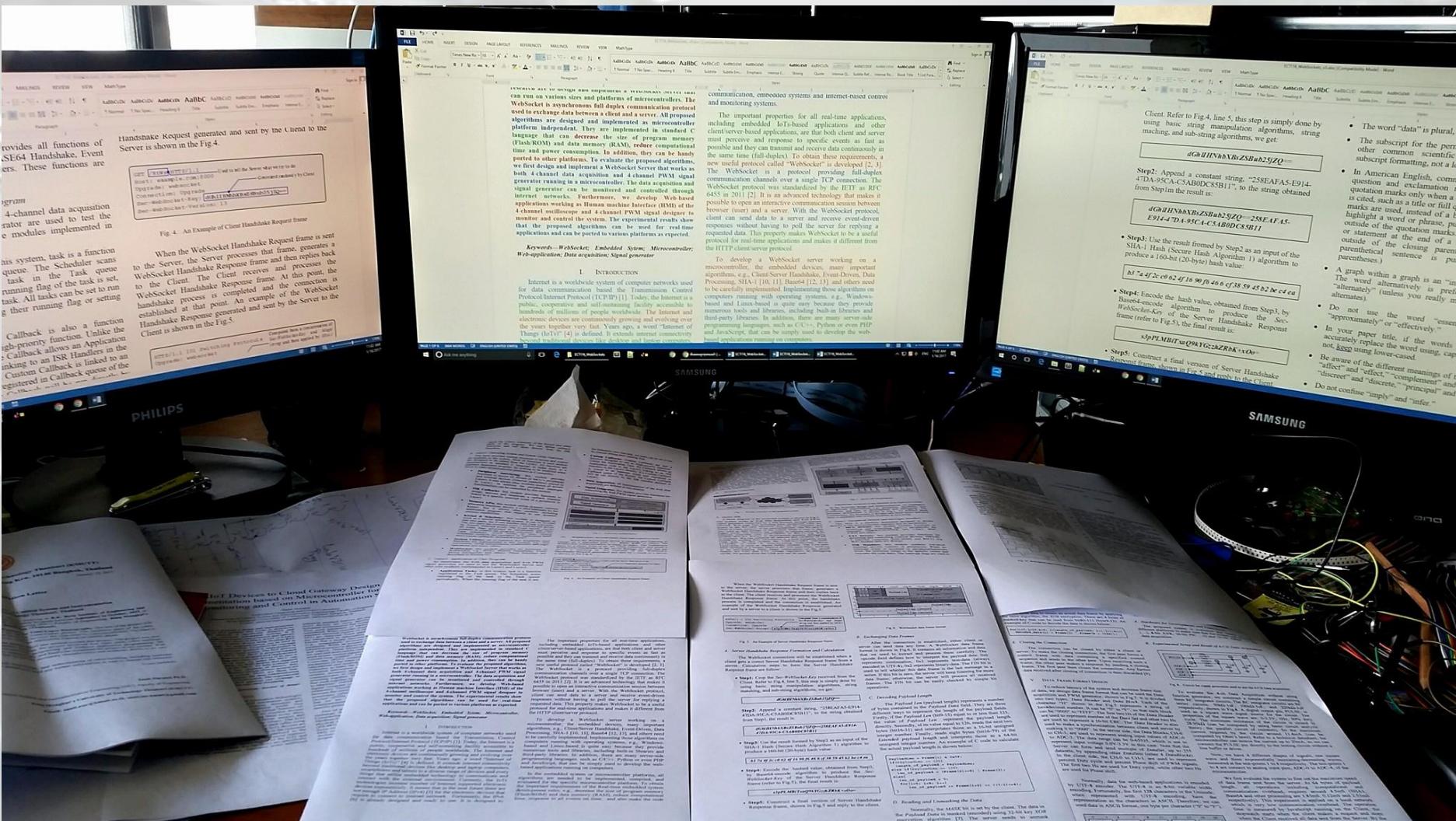
- Embedded Systems, Real-time Systems
 - Wireless/Internet-based Control and Monitoring
 - Embedded Digital Signal Processing, Digital Filter
-
- Digital Signal Processing, Speech Recognition
 - Speaker Recognition, Speech Enhancement
 - Machine Learning, Pattern Recognition
-
- System Dynamics: Modelling and Control
 - Robotics: Modelling and Control
-
- Power Electronics: Modelling and Digital Control
 - Digital and Analog Circuits
-
- Industrial Automation and Instrumentation Systems
 - Internet of Things (IoT), Industry 4.0, and Computer Technologies
 - Industrial Software Design and Implementation



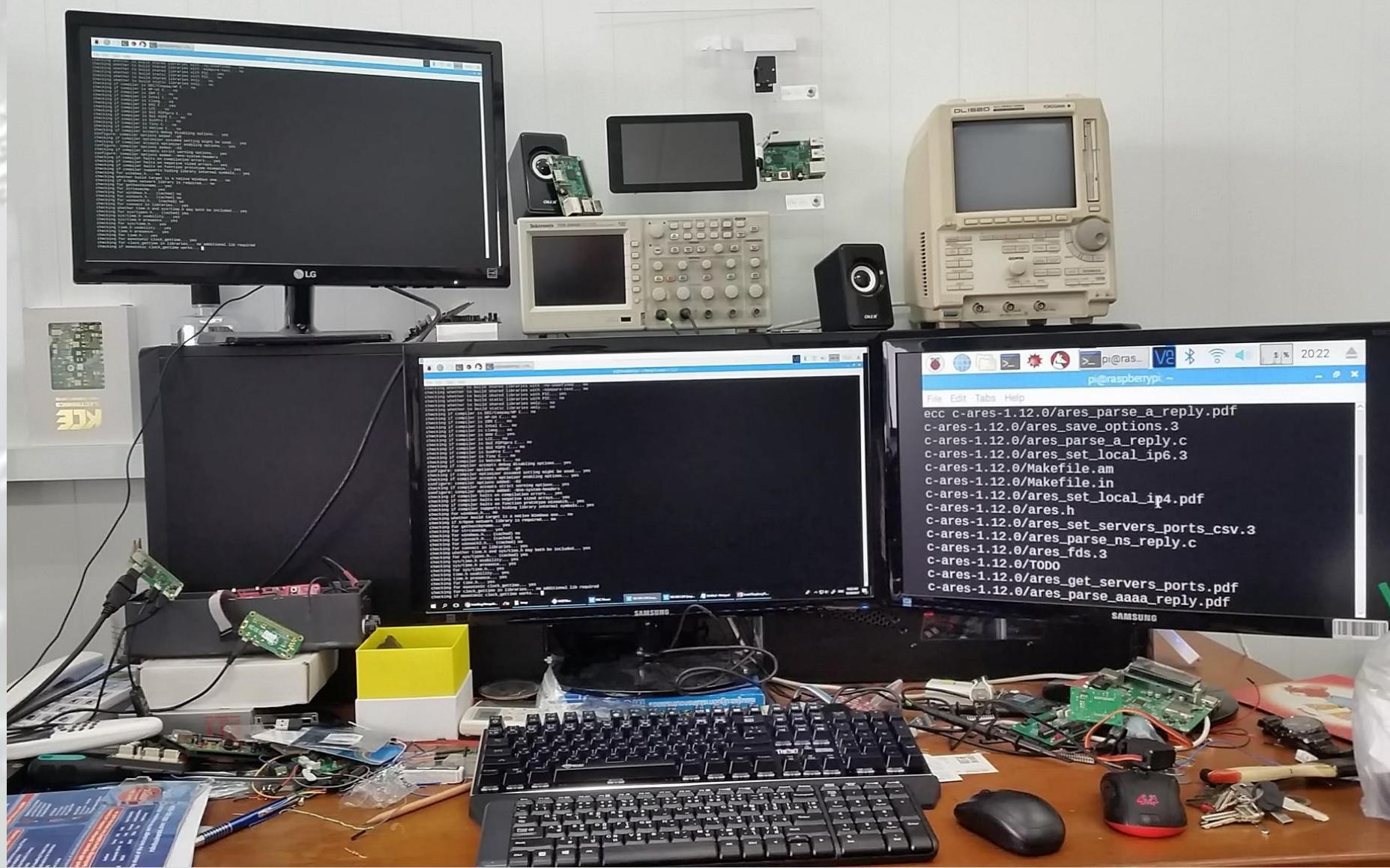
What I'm doing?



In-depth Theory



Skill in Embedded and Computer



Not only Engineering but also Arts



**UNREAL
ENGINE**



BLENDER



SUBSTANCE

Main Modules of IoT Applications

IoT Device



- Electronic Circuits (Sensors/Actuators)
- Microcontroller Circuit & System
- Embedded C Programming

Embedded Programming

Embedded C

Algorithms

IoT Application



- Web/GUI Design (HTML, CSS)
- JavaScript Programming (ES6)
- Web-based Control & Data Visualization

Web (Client/Server) Programming

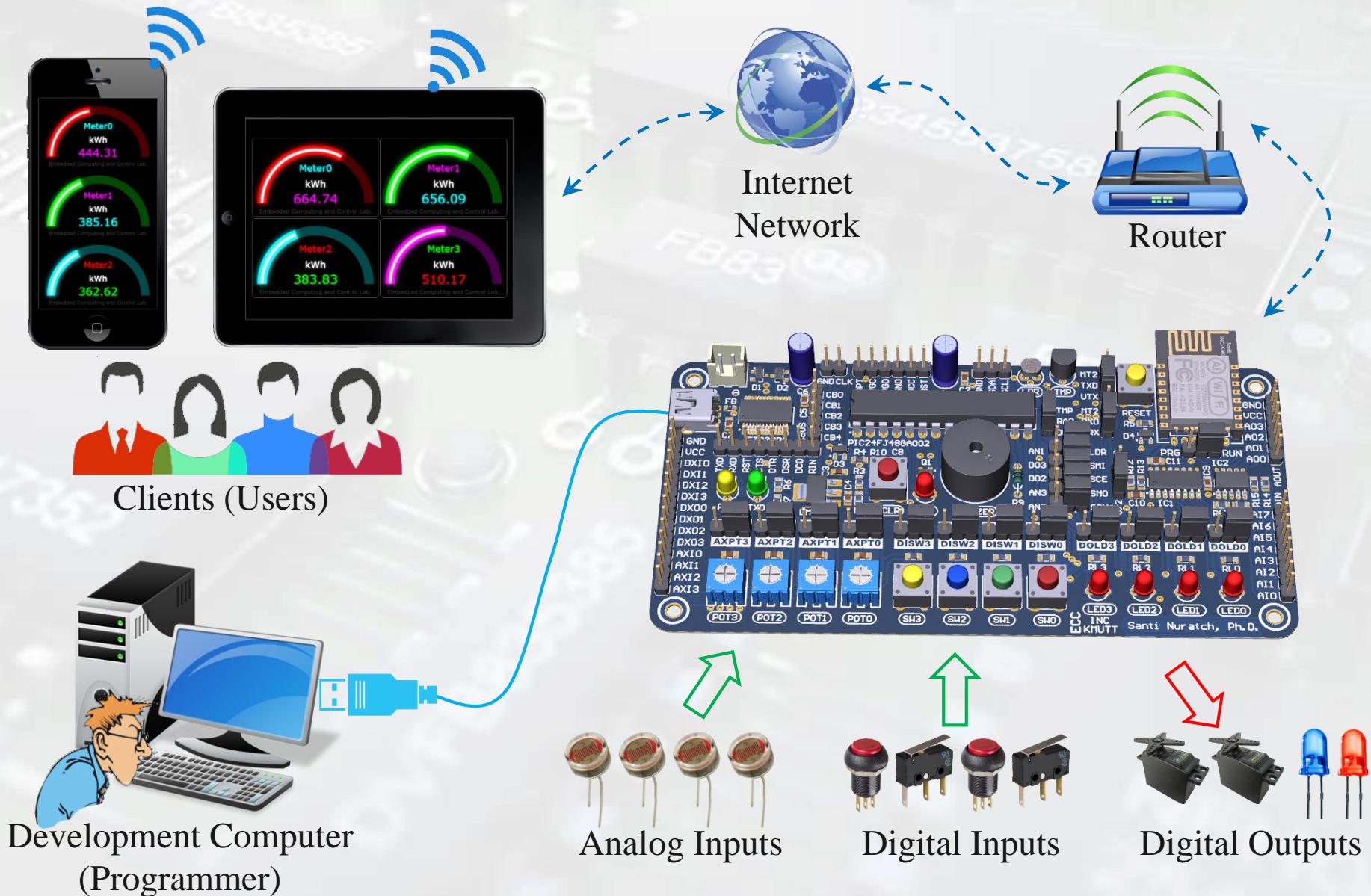
Web

Node.js

MongoDB



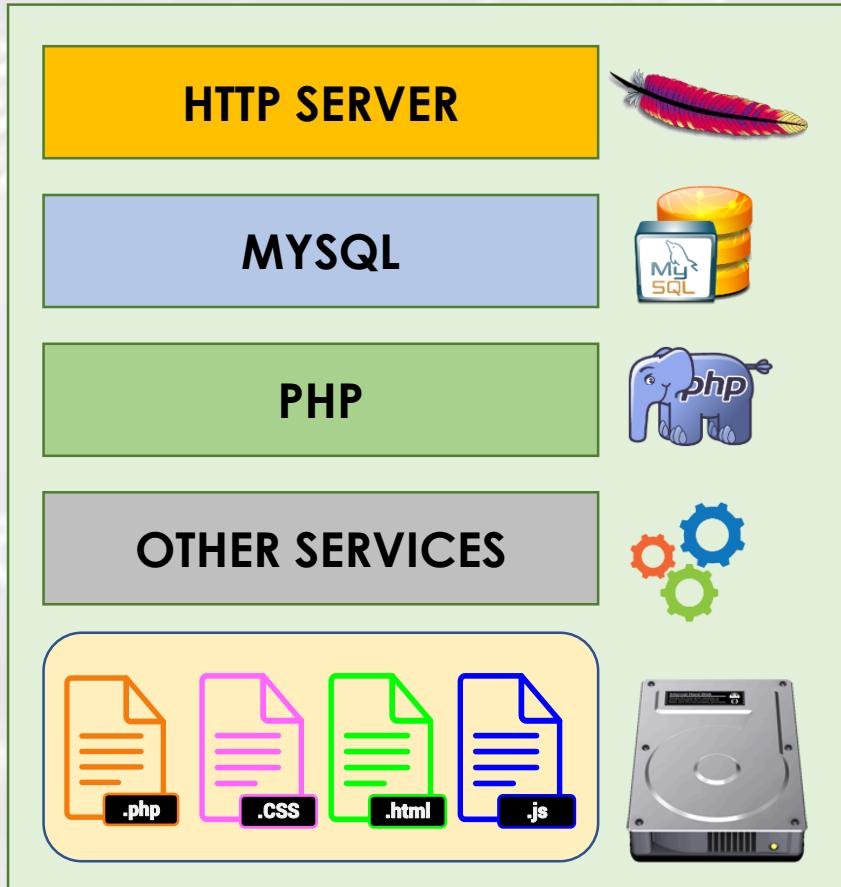
What is IoT-based Application?



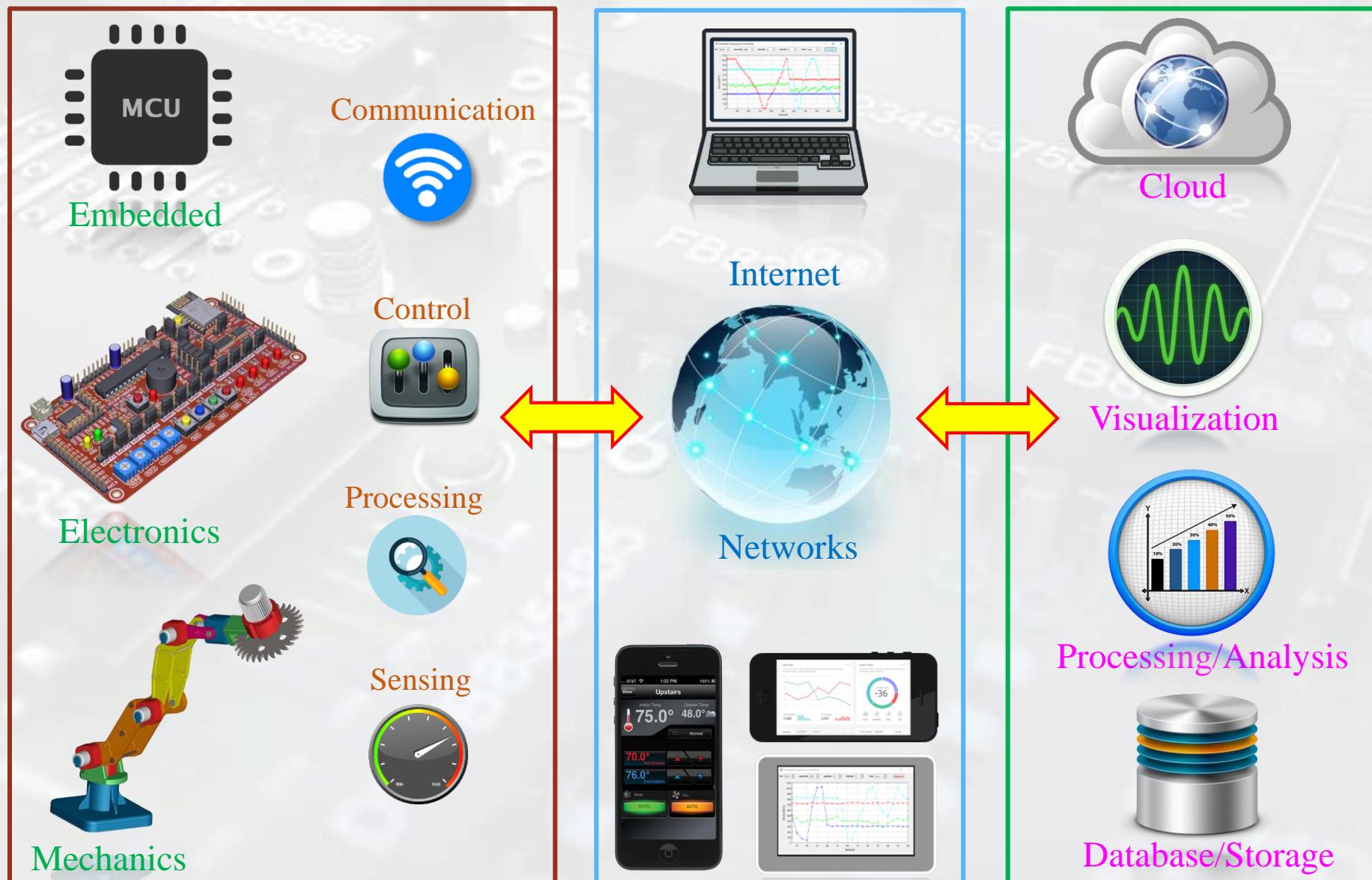
What is IoT-based Application?



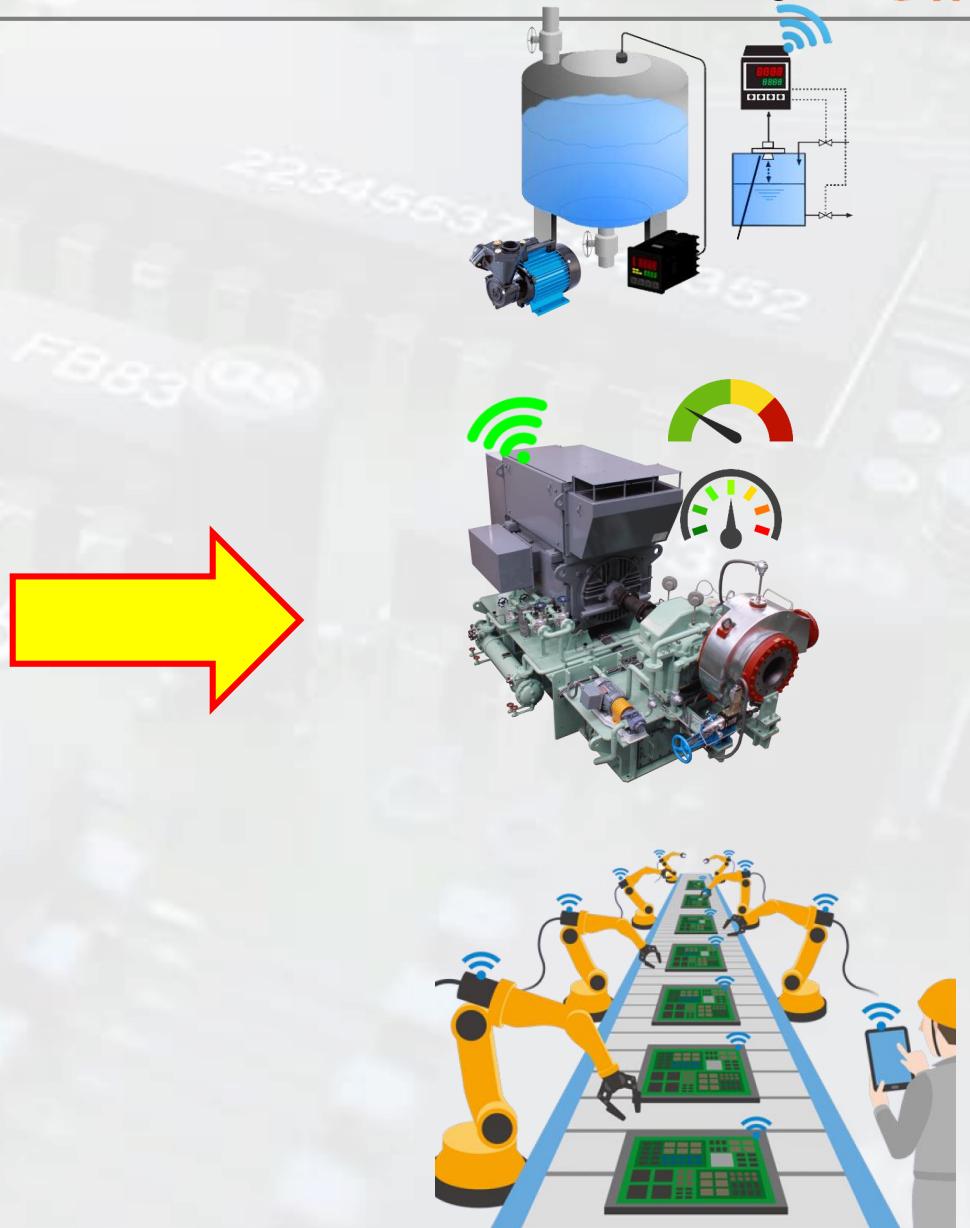
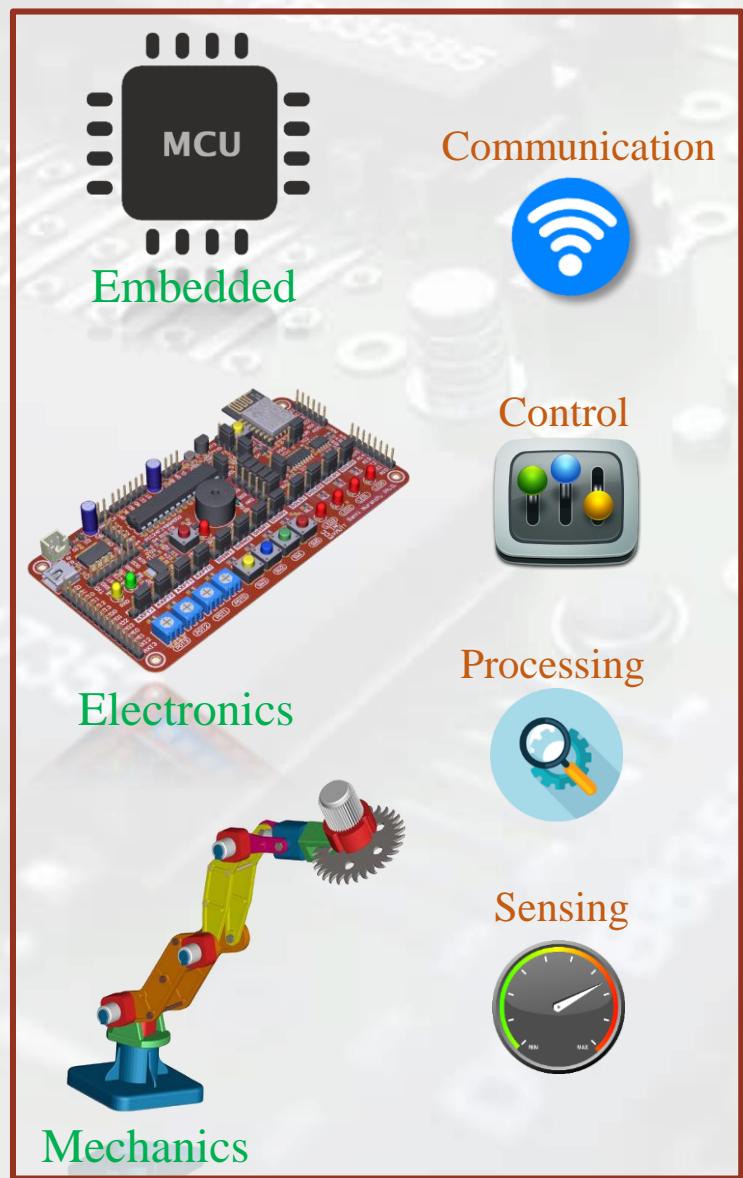
Classical Web-base Application?



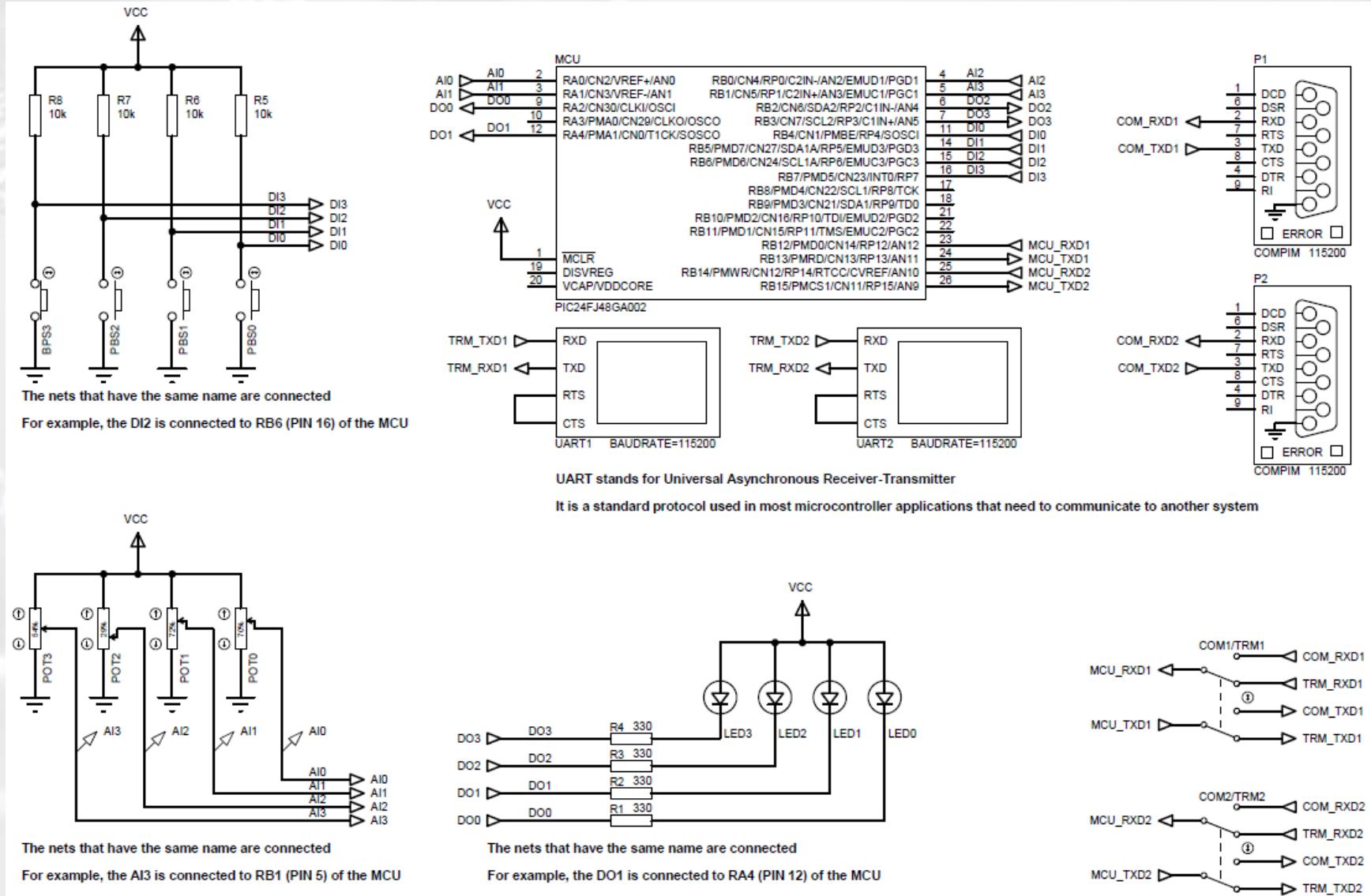
IoT-based Application Components



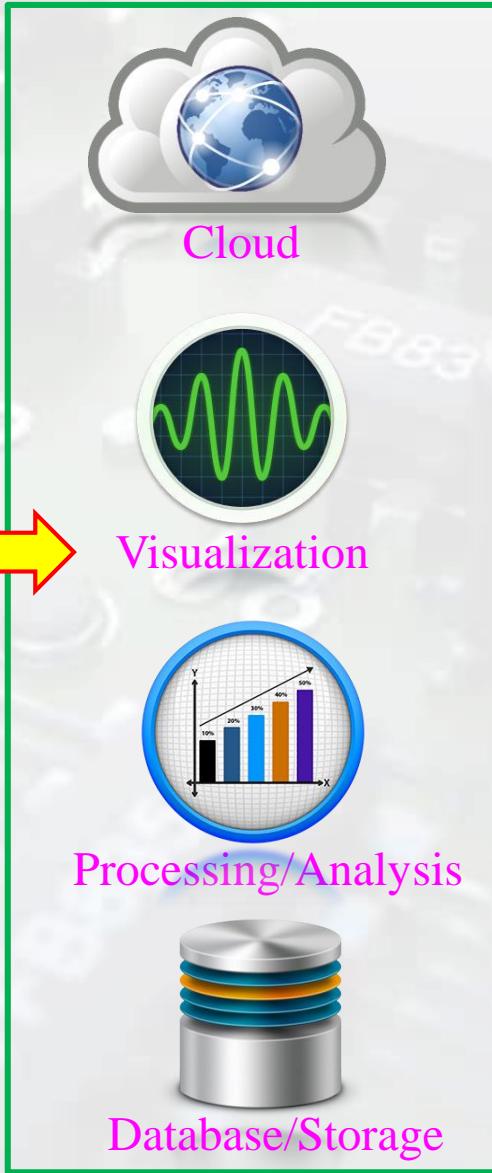
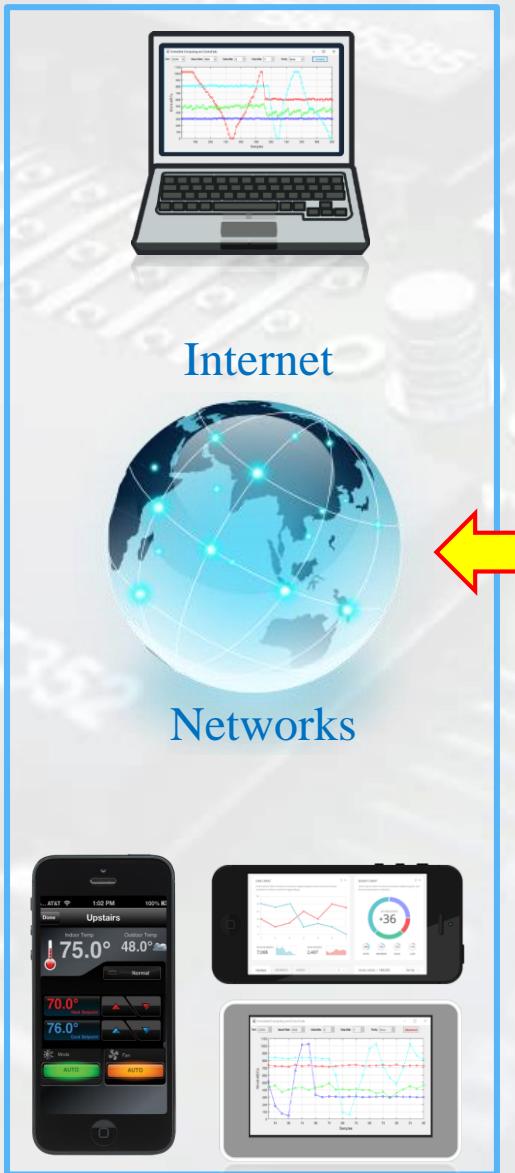
IoT Devices Everywhere



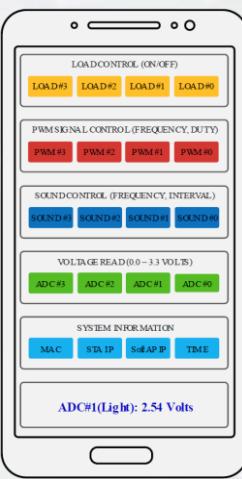
The core of IoT device is the circuit!



Software development cannot be avoided



Web Programming!! Web Programming!! Web Programming!!
Special techniques are provided in this class only, don't close your eyes

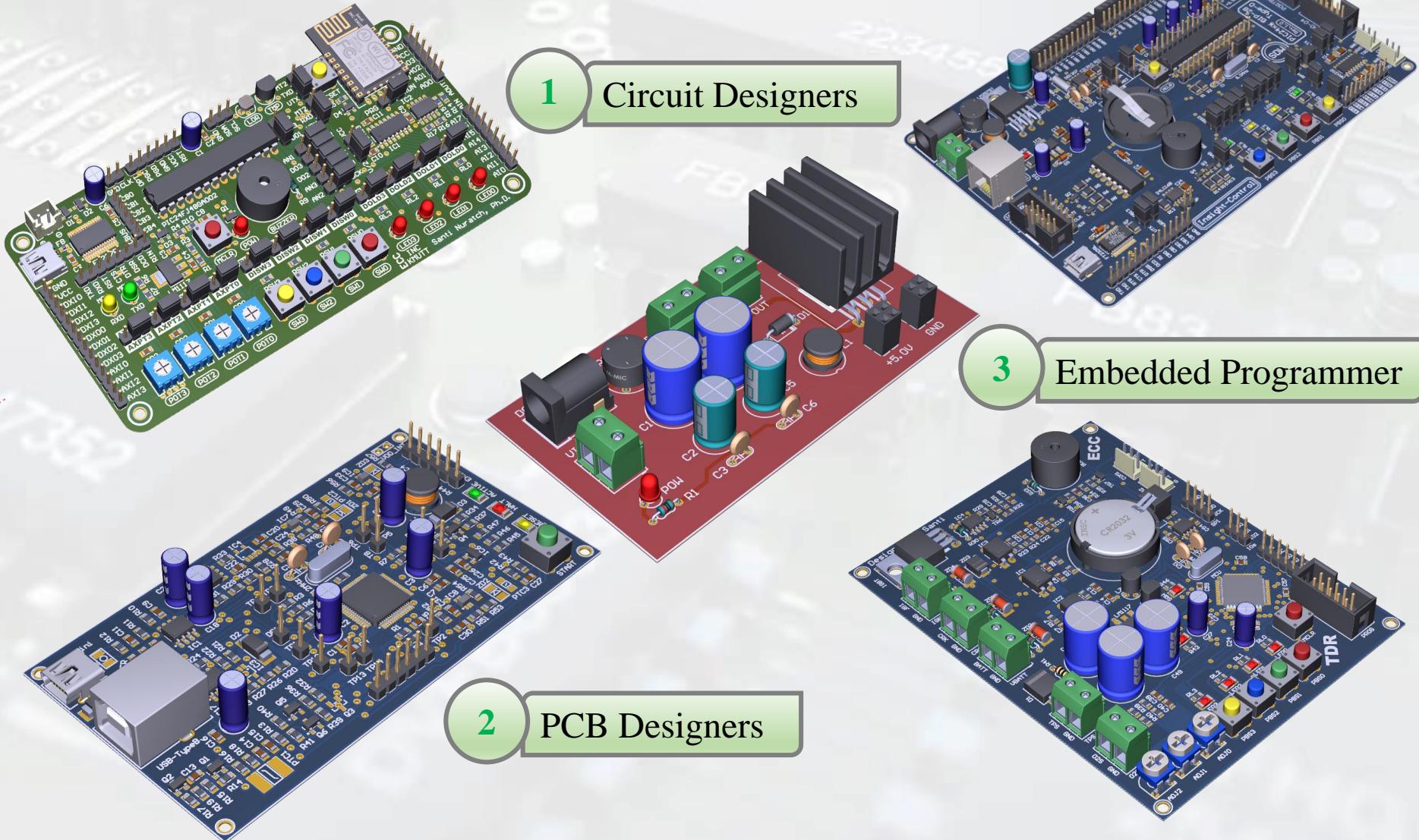


The Keys

Key Components of IoT and Industrial 4.0

First: Embedded Programming

Electronics Design Engineers



Second: Embedded Programming

Embedded System Engineers/Programmers

3 RTOS & Real-time Multitasking Engineers

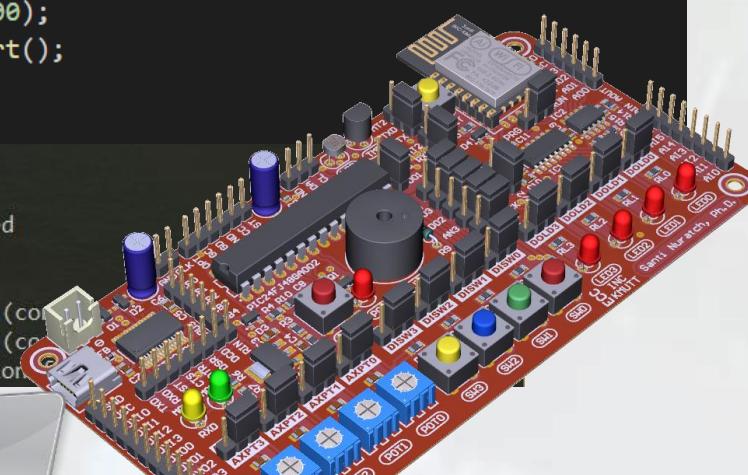
```
D:\MCU_Projects\EccOS\edf\usr.X
λ ecc-pic24-cli -h
+-----+
| ECC-PIC24-CLI v1.0.2
| Dr.Santi Nuratch
| Embedded Computing and Control Lab.
| (ECC Lab)
| KMUTT, Thailand
+-----+
```

2 Embedded C Programmers

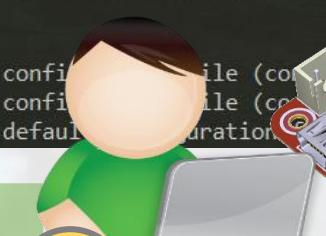
```
ecc-pic24-cli -build <config_file>      - Build, create *.hex
ecc-pic24-cli -flash <config_file>        - Flash, write *.hex
ecc-pic24-cli -update <config_file>         - Build and Flash, l
ecc-pic24-cli -hex <hex_file>              - Flash, write *.hex
ecc-pic24-cli -monitor                      - Open monitor/consc
ecc-pic24-cli -restart                      - Restart the microc
ecc-pic24-cli -help                         - Print this message
ecc-pic24-cli -version                      - Print version
ecc-pic24-cli -library <libbuild_file>     - Create a library file *.a
ecc-pic24-cli <-cmd1 -cmd2 -cmdk>           - The combination of commands can be used
```

```
Examples:
ecc-pic24-cli -build
ecc-pic24-cli -flash
ecc-pic24-cli -update
```

```
544 {  
545     OS_Init();  
546     AT_Init();  
547     ESP_Init();  
548     WiFi_Init();  
549     Internet_Init();  
550     OS_TimerCreate("AT_Service", 100, 1, AT_Service);  
551     OS_WorkerCreate("WiFi_Init", Worker_ESPInitialise);  
552     OS_Uart2SetLineReceivedCallback(ESP_LineReceived);  
553     UART1_AsyncWriteString("\r\nMQTT Client...\r\n");  
554     Beep(100);  
555     }  
556 }
```



Unfortunately, Arduino is not designed for the real-world applications (by design)



1

Embedded System Designers

Third: Mobile/Web Application Programming

Mobile/Web Application Programmers/Developers



1 Mobile Native Developers



2 Web-based Developers



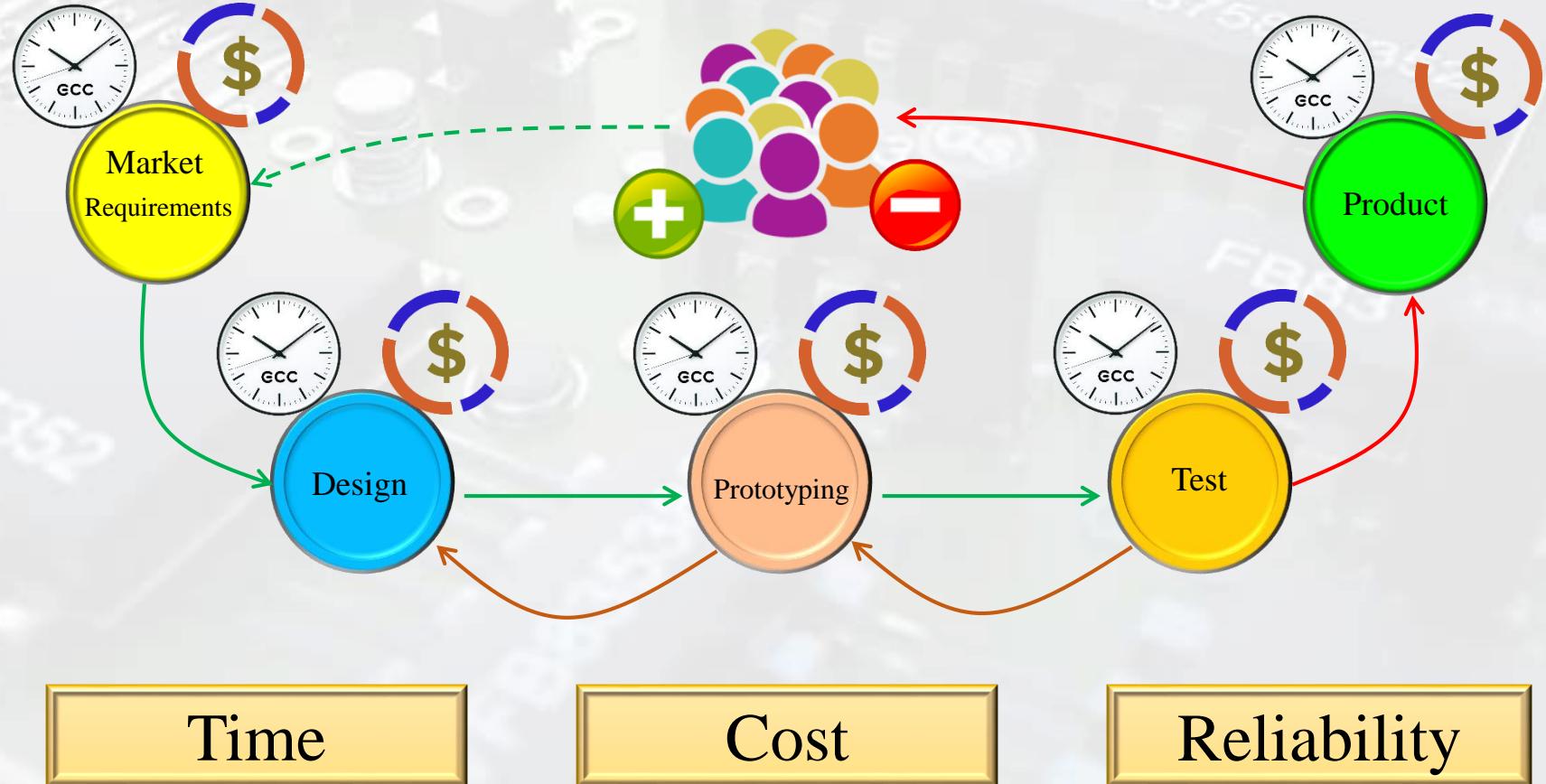
3 UI/Graphics Designers

What is Your Project?

Embedded System Developer/Researcher

Embedded System Developer/Researcher

Business requires better Knowledge & better Skills



Embedded System Developer/Researcher

Hardware and Software are very important knowledge & skills



1 Fundamental Knowledge & Skills

Electronic Circuits

Amplifier

Converter

Coupler

Filter

Buffer

Driver

Digital Circuits

Decoder

Clocking

Synchronous

Encoder

Timing

Asynchronous

Microprocessor Circuits

Electronic

Memory

Programming

Digital

Peripherals

Protocols

2 Important Knowledge & Skills

1

Electronic Circuits

Digital Circuits

Microprocessor Circuits

Embedded Programming

Embedded Real-time OS

Interfacing & Protocols

3 Required Knowledge & Skills

1

Electronic Circuits

Digital Circuits

Microprocessor Circuits

2

Embedded Programming

Embedded Real-time OS

Interfacing & Protocols

Internet Communication

Web-based Development

Mobile-based Development

4 Advanced Knowledge & Skills

1

Electronic Circuits

Digital Circuits

Microprocessor Circuits

2

Embedded Programming

Embedded Real-time OS

Interfacing & Protocols

3

Internet/Network Communication

Web-based Development

Mobile-based Development

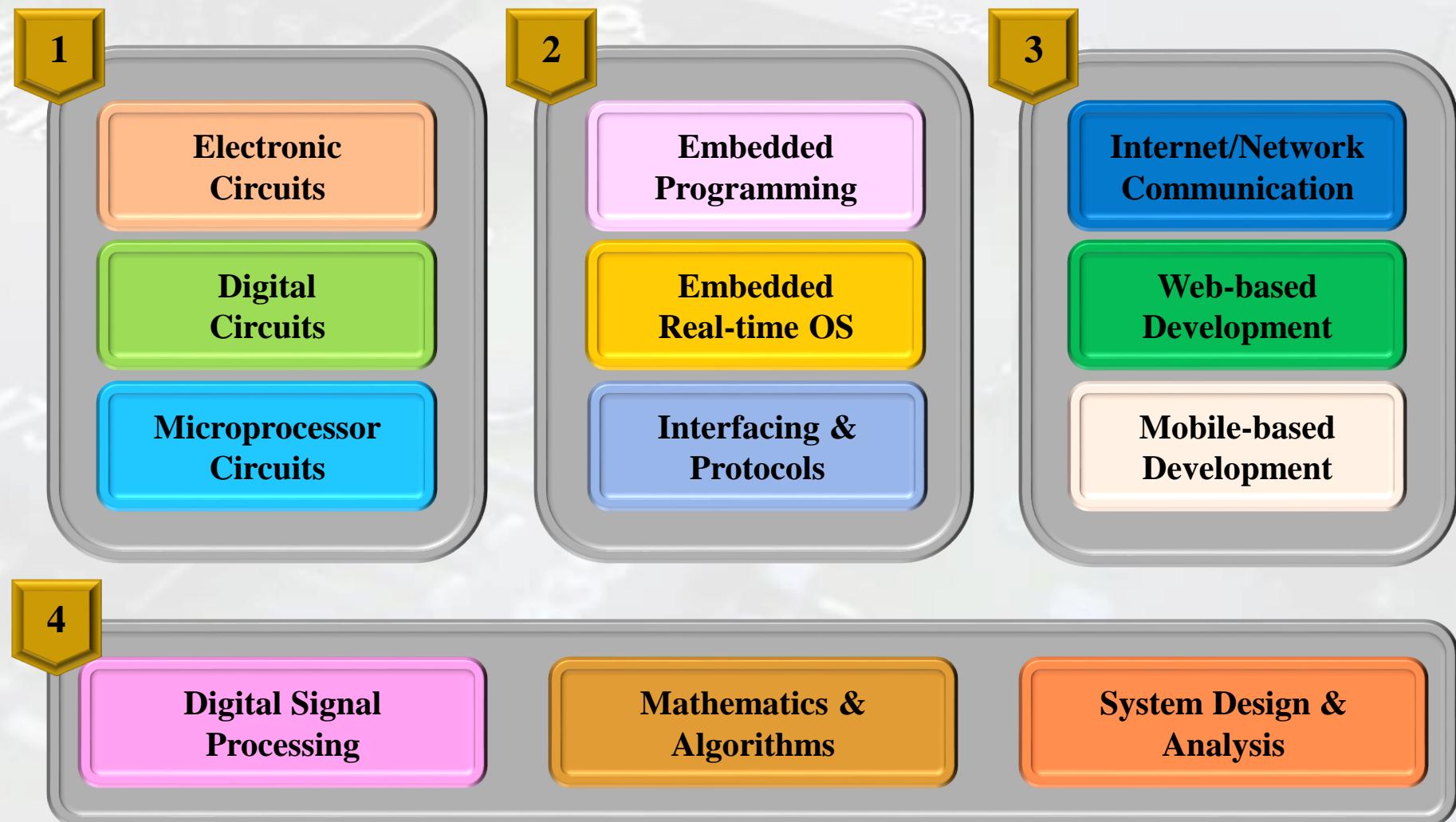
Digital Signal Processing

Mathematics & Algorithms

System Design & Analysis

Embedded System Developer/Researcher

They are the CORE of Embedded Developers

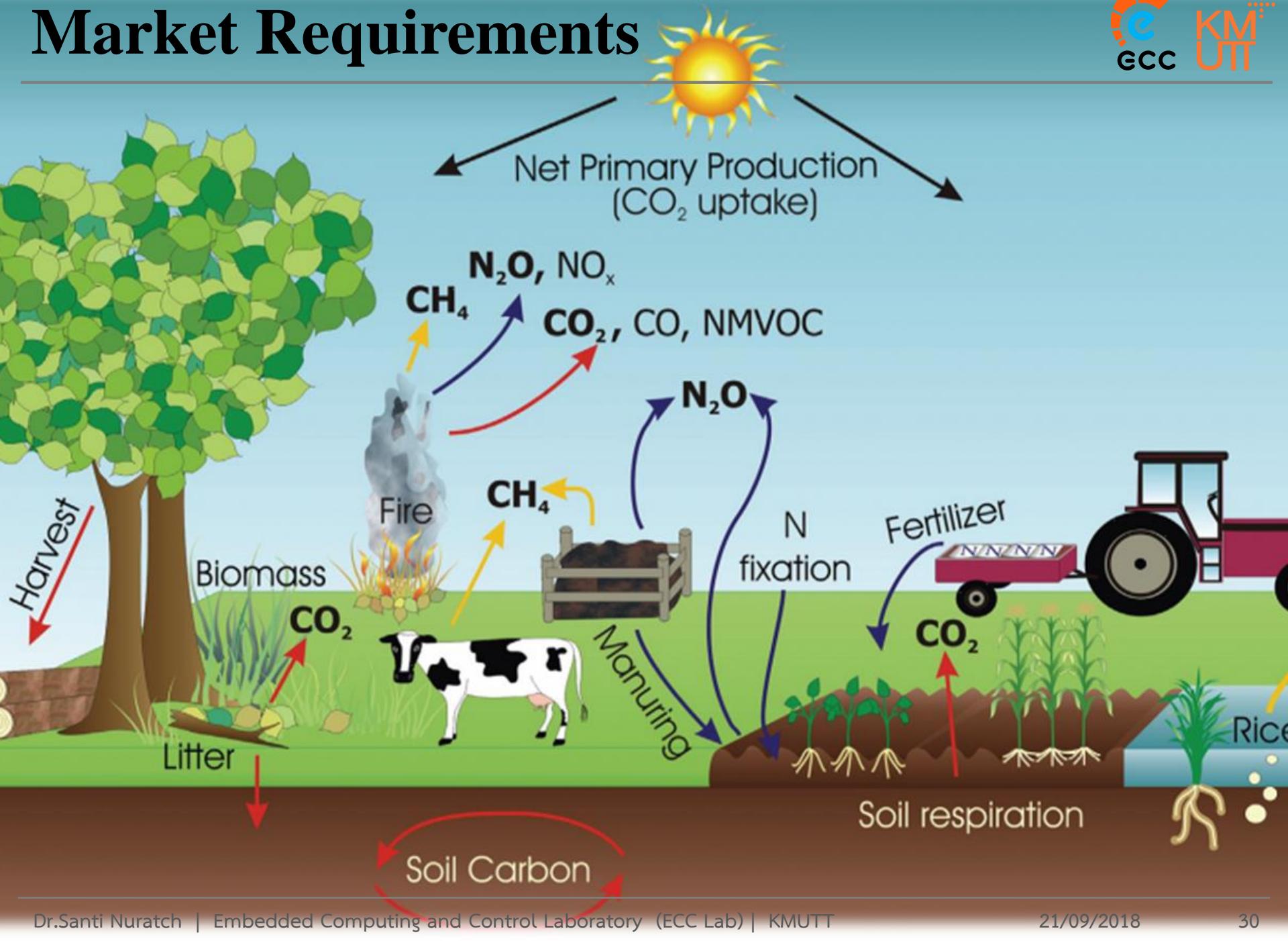


Market Requirements

Market Requirements



Market Requirements

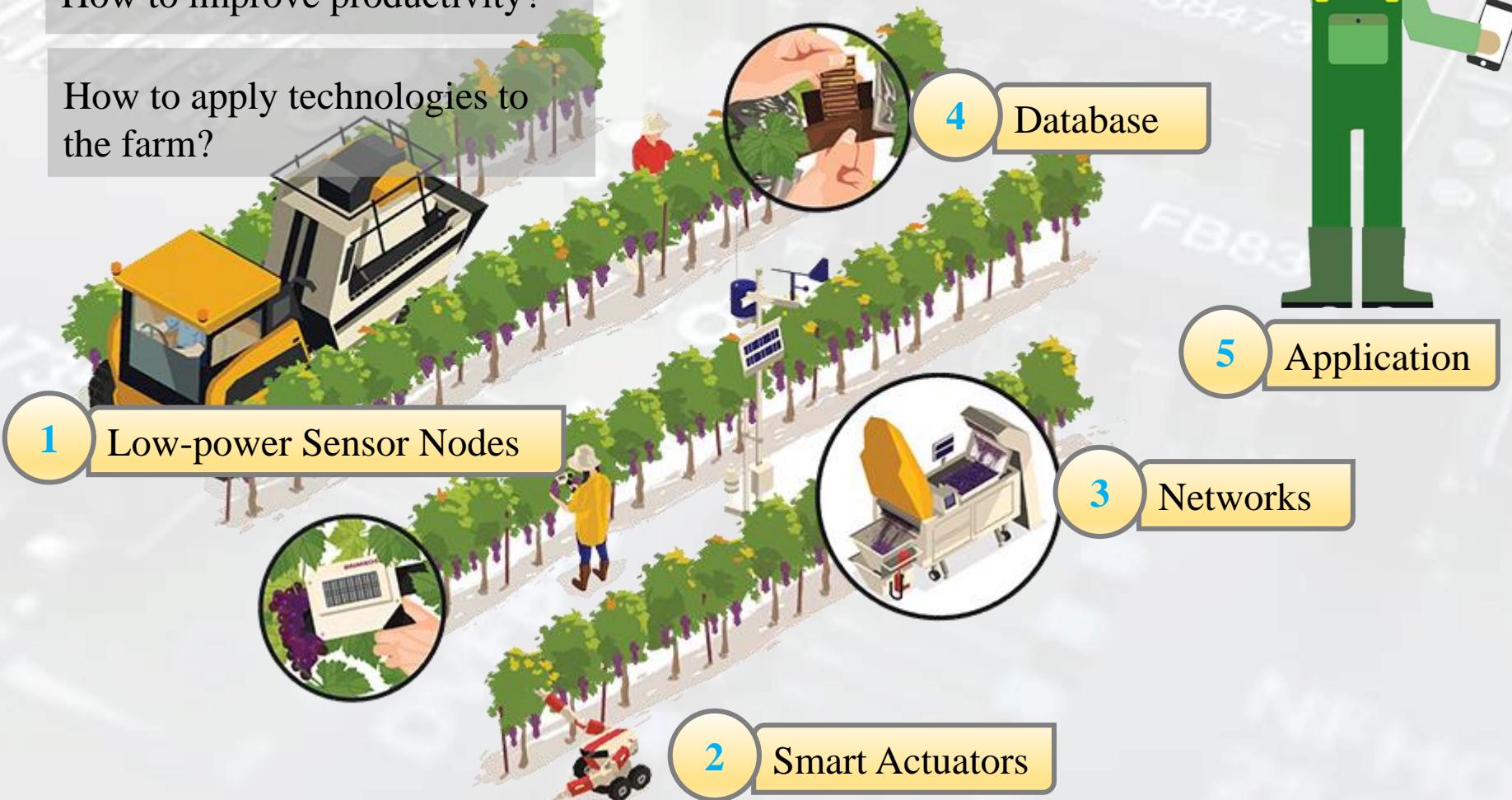


Market Requirements

Smart Farming/Agriculture

How to improve productivity?

How to apply technologies to the farm?



Market Requirements

Smart Home/Office/Living



How to make things give us more happiness and convenience?

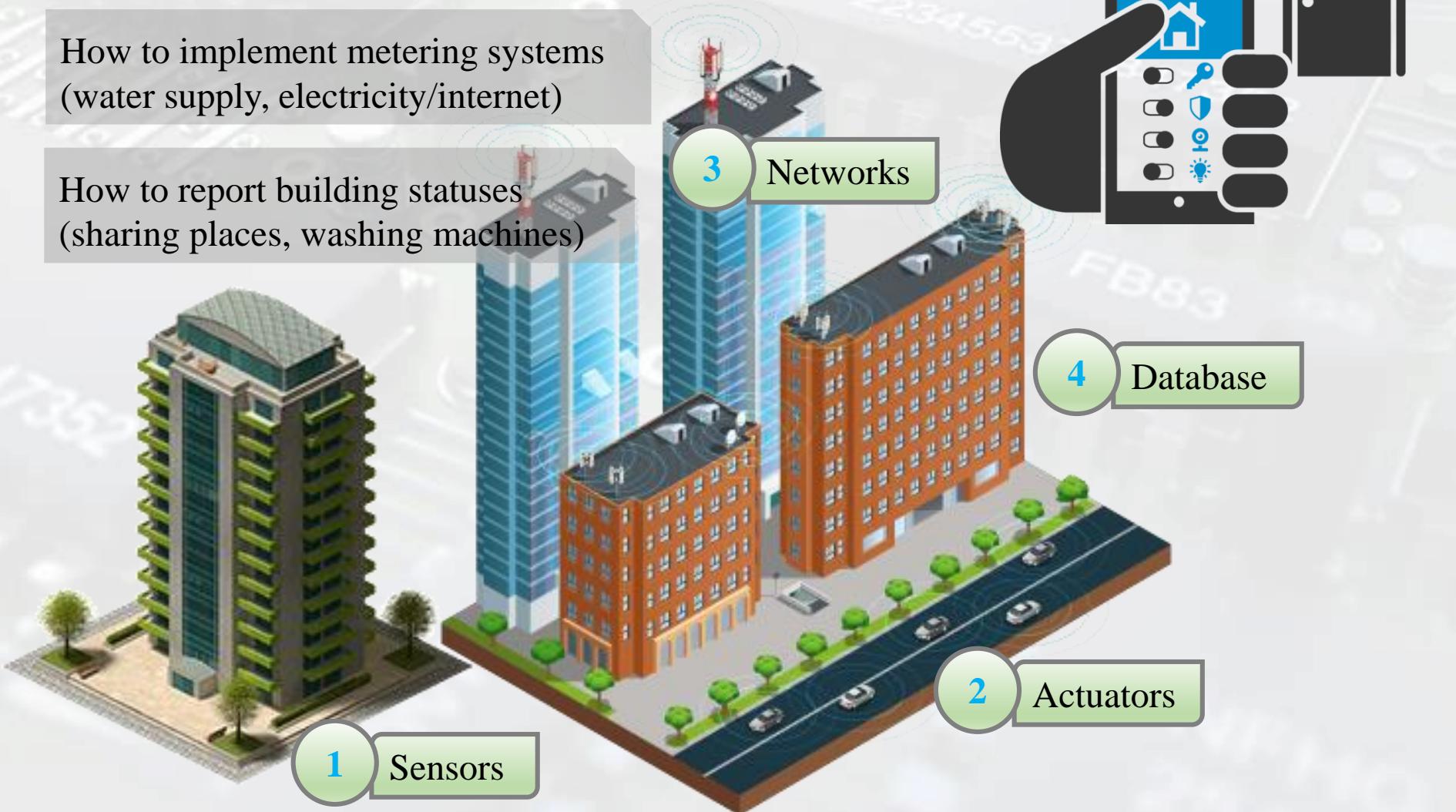


Market Requirements

Smart Condominium/Building

How to implement metering systems
(water supply, electricity/internet)

How to report building statuses
(sharing places, washing machines)



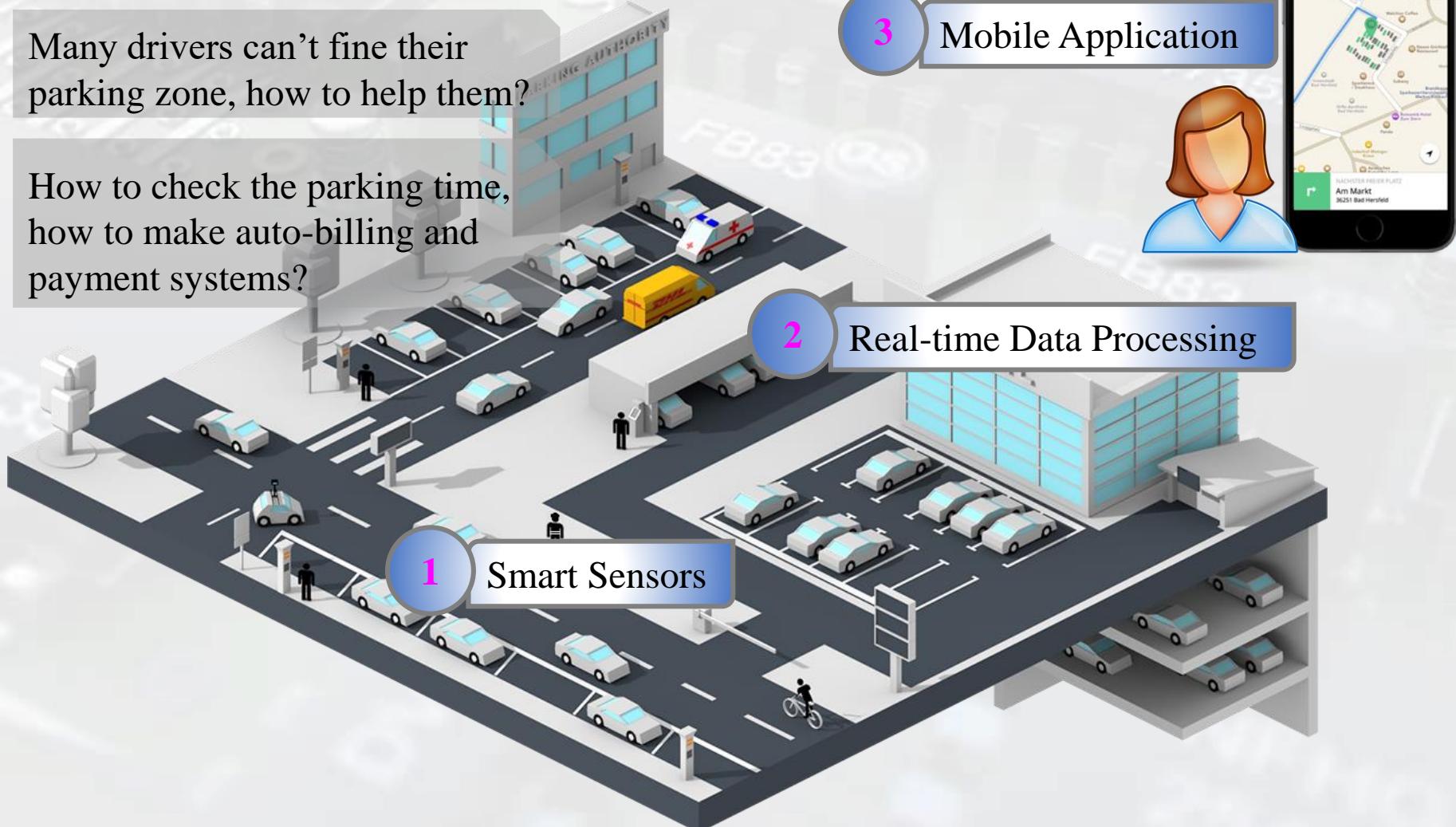
Market Requirements

Smart Parking

How to make our customers known which floor available?

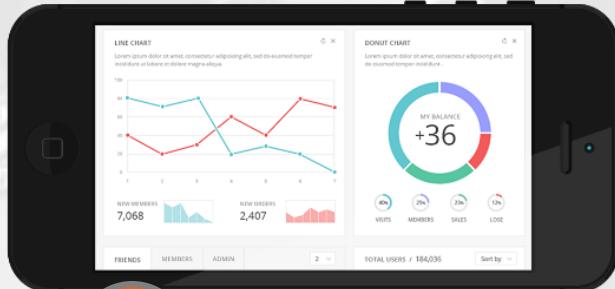
Many drivers can't fine their parking zone, how to help them?

How to check the parking time, how to make auto-billing and payment systems?



Market Requirements

Smart Vending Machines



How to make the vending machines online and take their information?

How to utilize the information to improve the system?



3 Data Processing



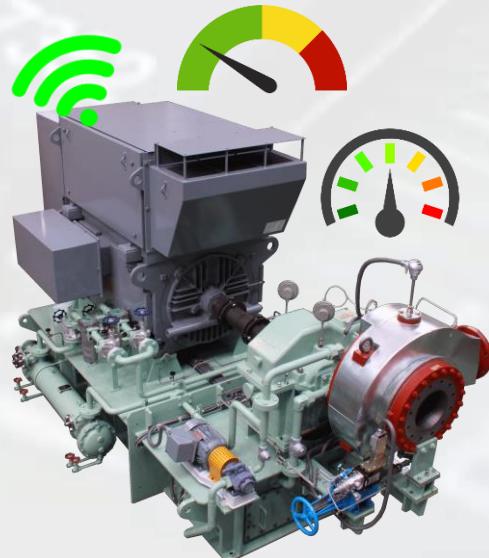
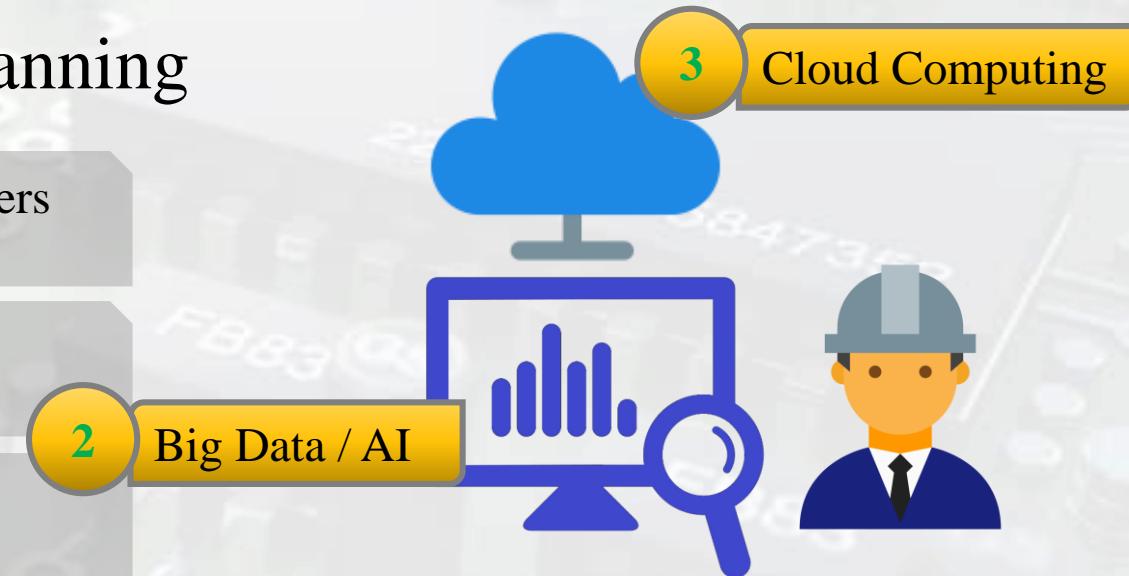
Market Requirements

Smart Maintenance Planning

How to continuously get parameters from our industrial equipment?

When the machines require maintenance/replacement?

How to improve operation of the machines?



Internet-of-Things & Industrial 4.0

Industrial Internet-of-Things (IIoT)



What is Industry 4.0 ?

Industry 4.0

What is Industry 4.0 ?

1 Mechanization



2 Electrification



3 Automation



4 Networking

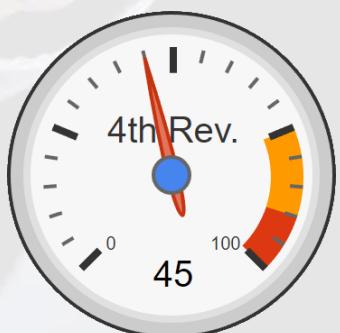


1st Revolution
Water/Steam
(1784/2327—233)

2nd Revolution
Electricity
(1870/2413—147)

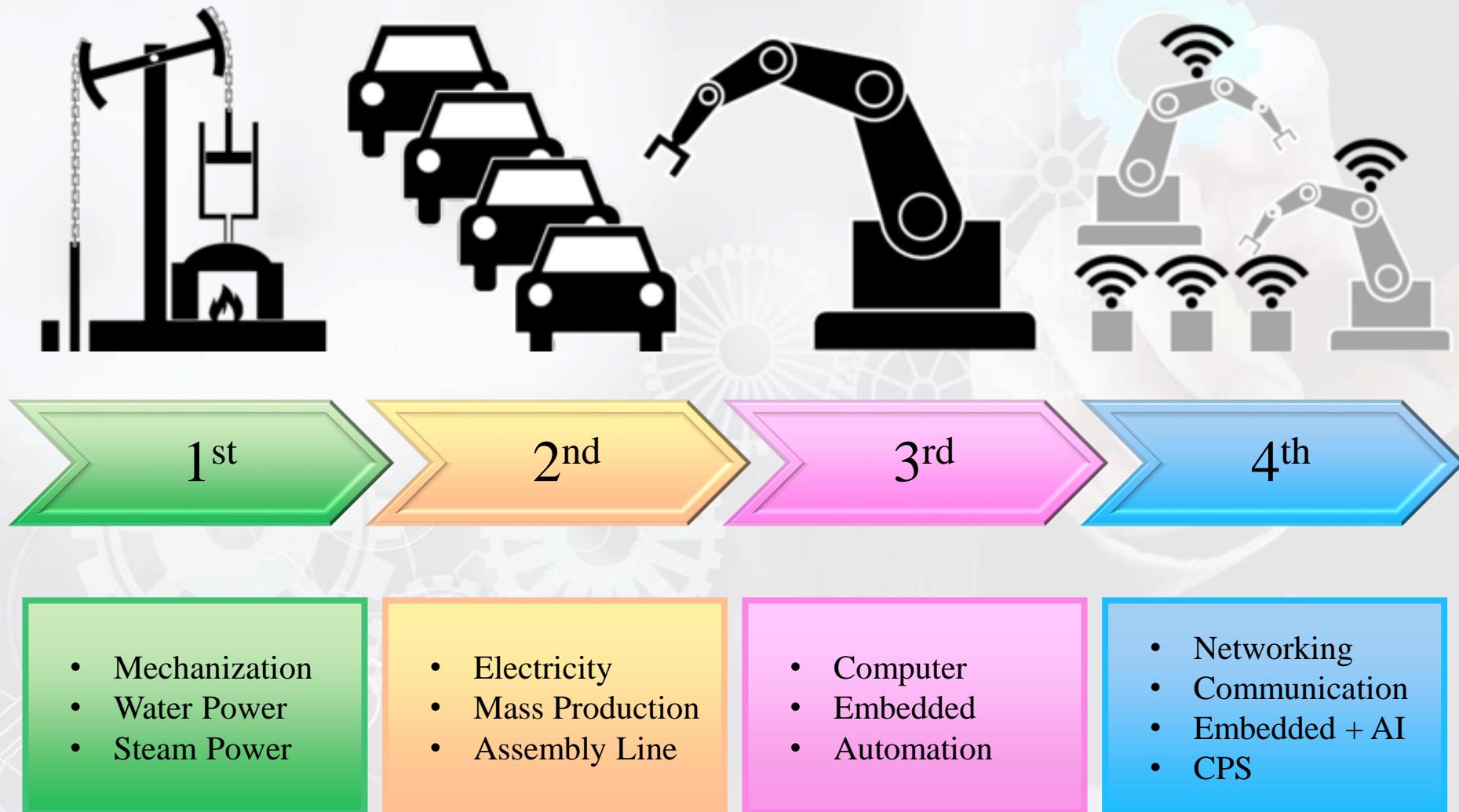
3rd Revolution
Automation
(1969/2512—48)

4th Revolution
Cyber physical systems
(2013-Todays)

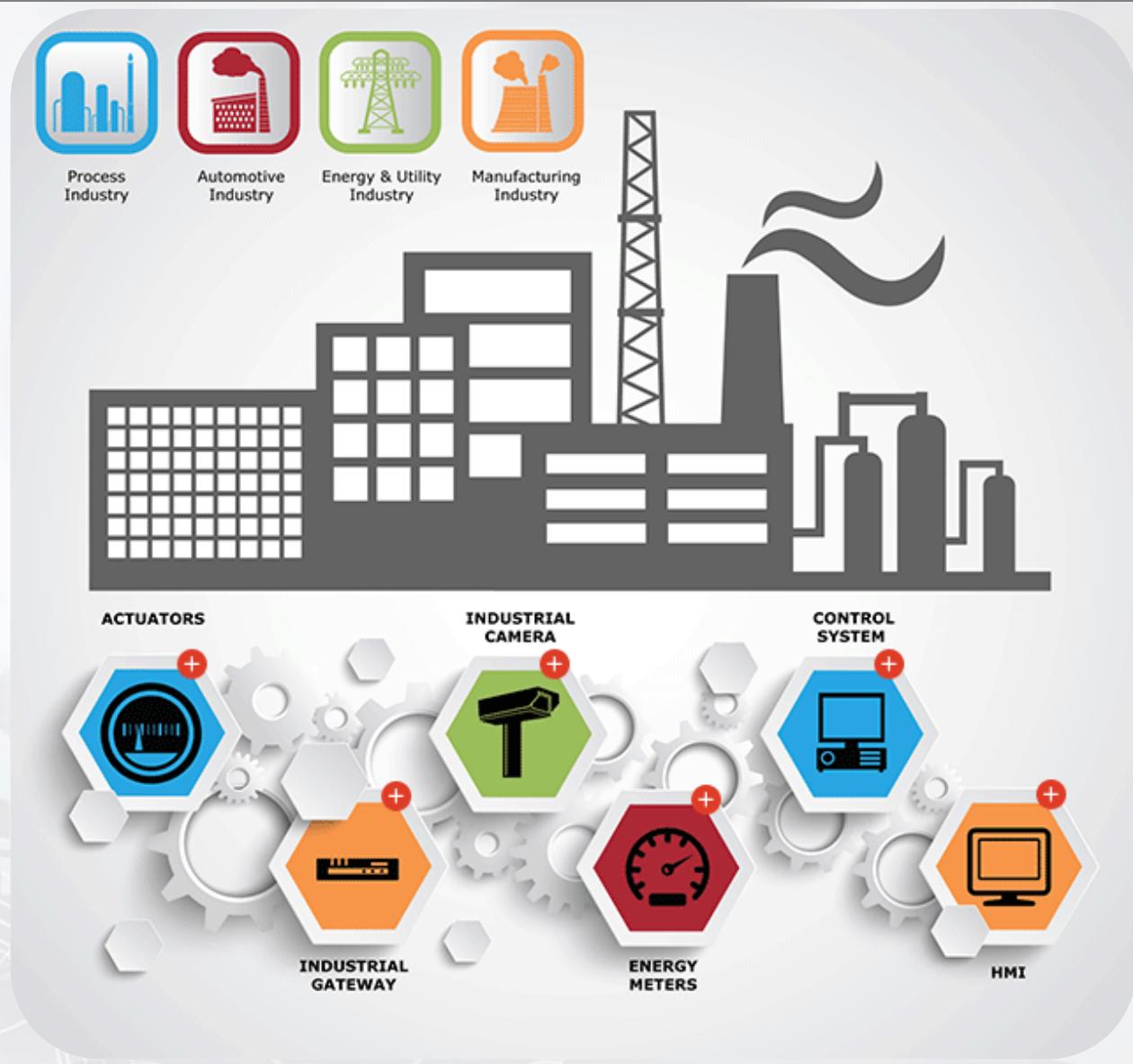


What is Industry 4.0 ?

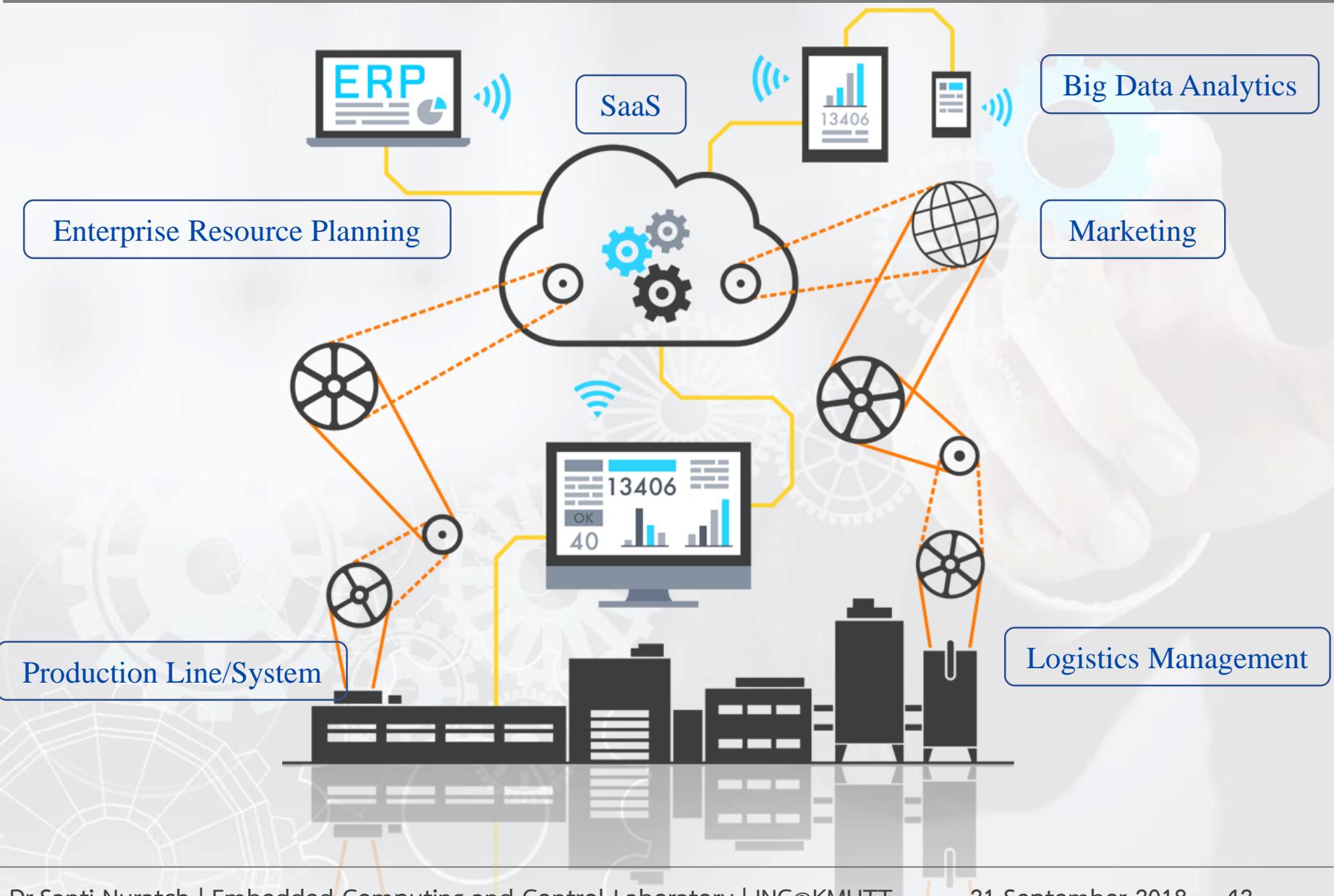
Industrial Development



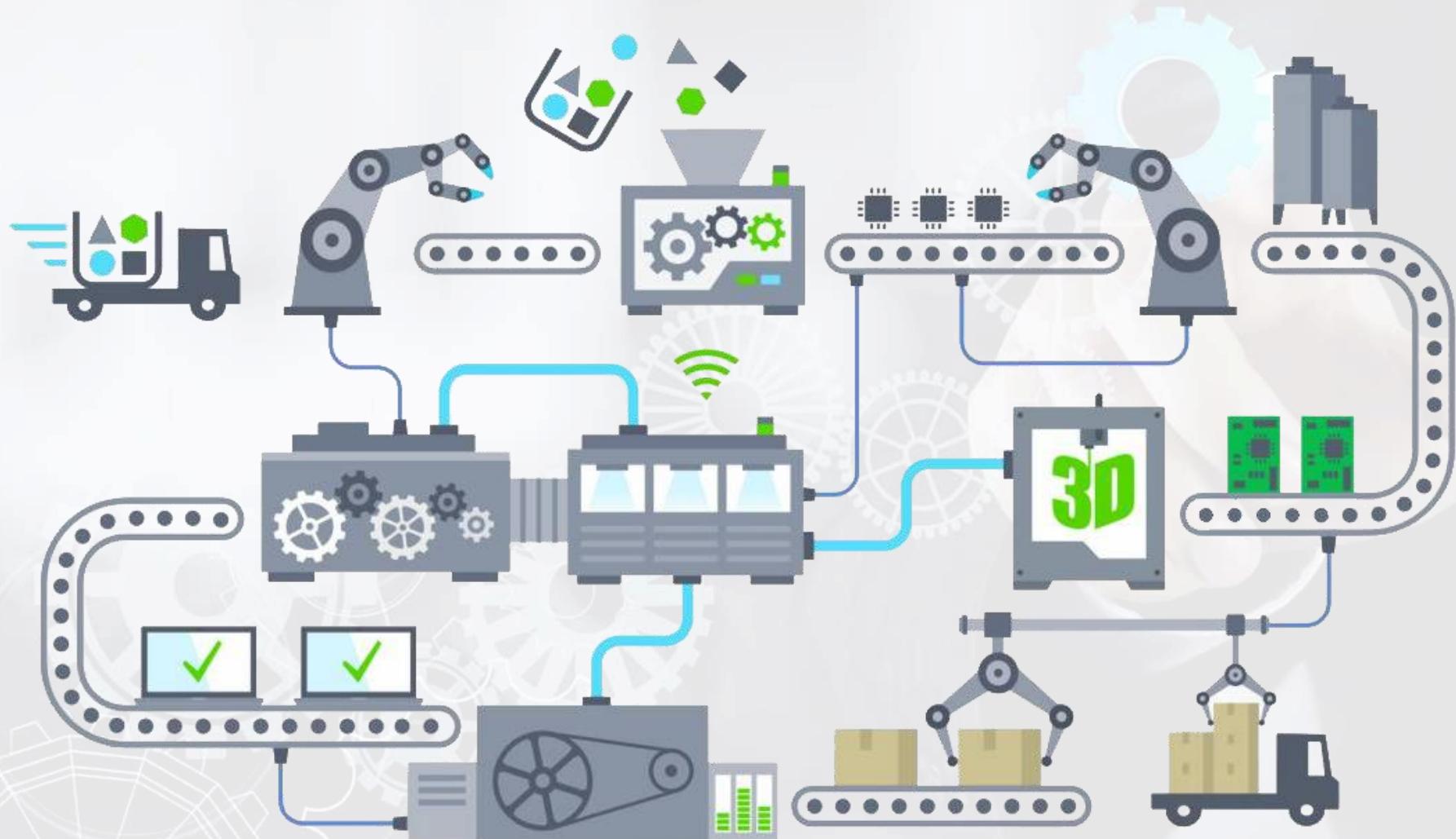
What is Industry 4.0 ?



What is Industry 4.0 ?



What is Industry 4.0 ?



Required Technologies

There are many technologies



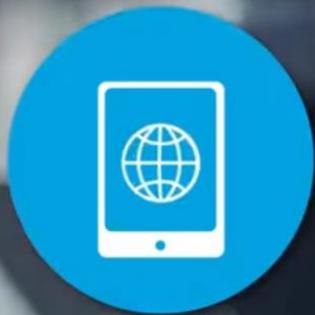
Internet of Things



Machine Learning



Augmented Reality



Mobile and Edge Computing



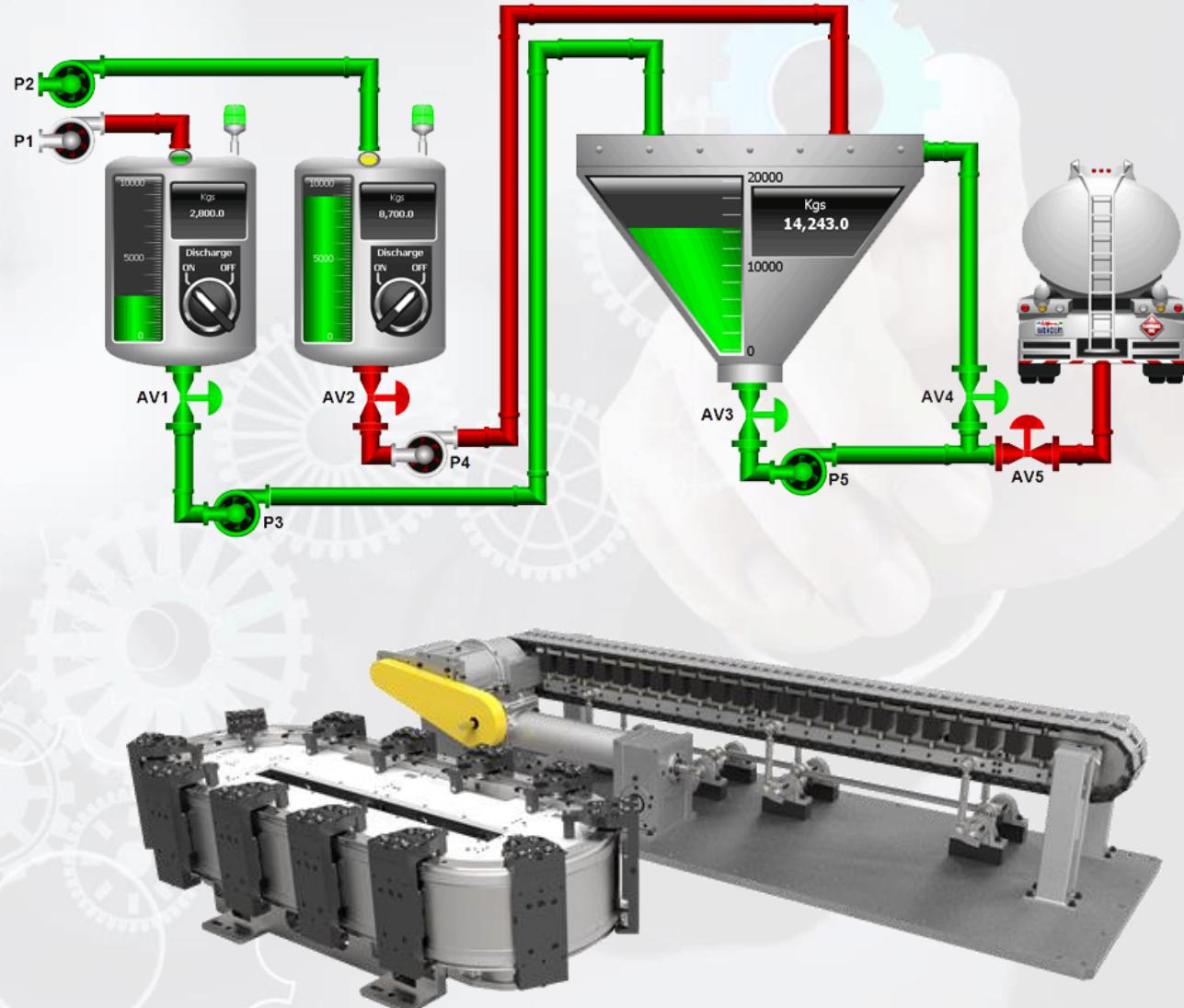
3D Printing



Big Data Processing

<https://www.youtube.com/watch?v=ktcRXyE8SaY>

IoT-based Industrial Automation Systems



IoT-based Industrial Automation Systems

IoT-based Industrial Automation Systems



Automation System Modules



Measurement

Data



Analysis

Problems

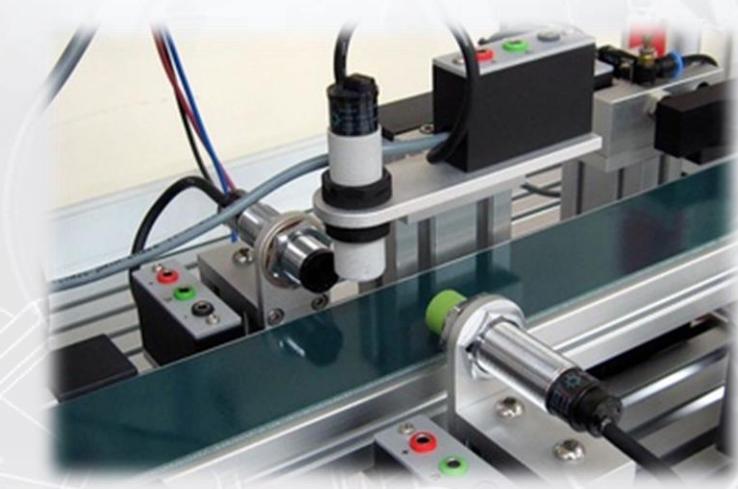


Solutions



Control

High Efficiency





Measurement

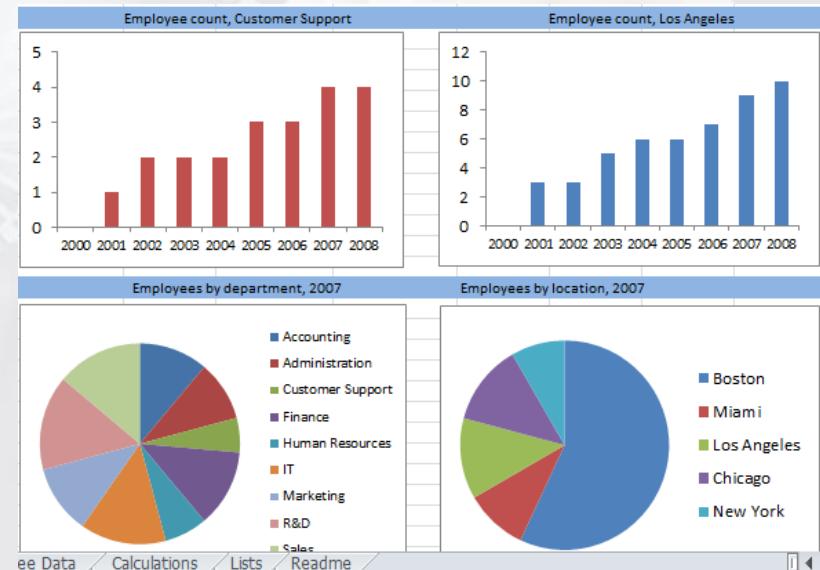
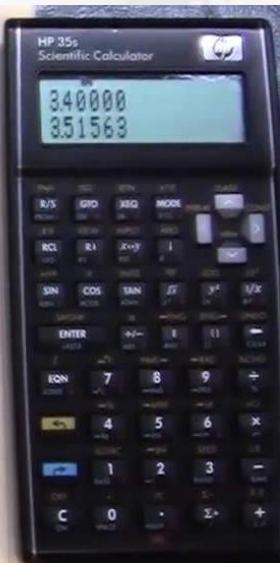
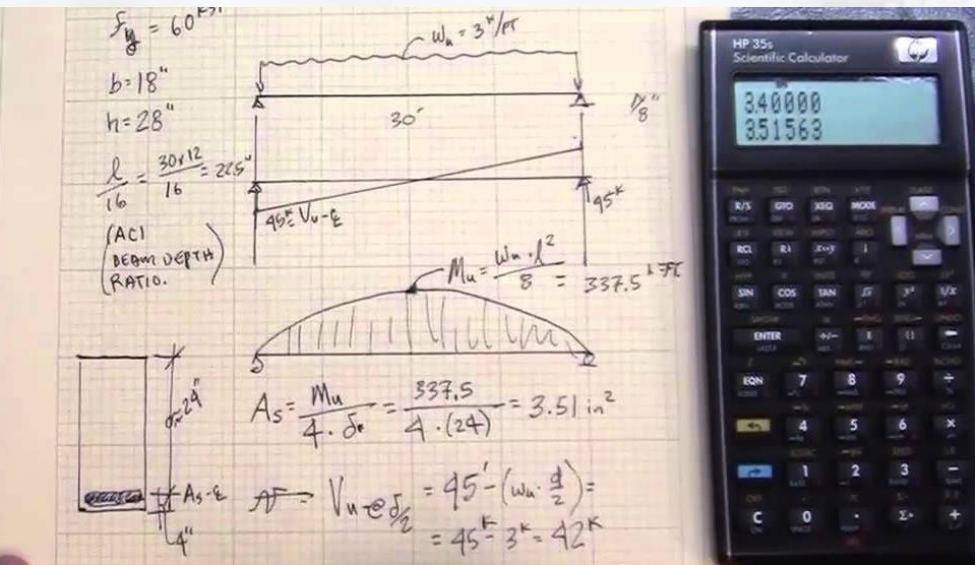
Data





Analysis

Problems
Solutions



Analysis

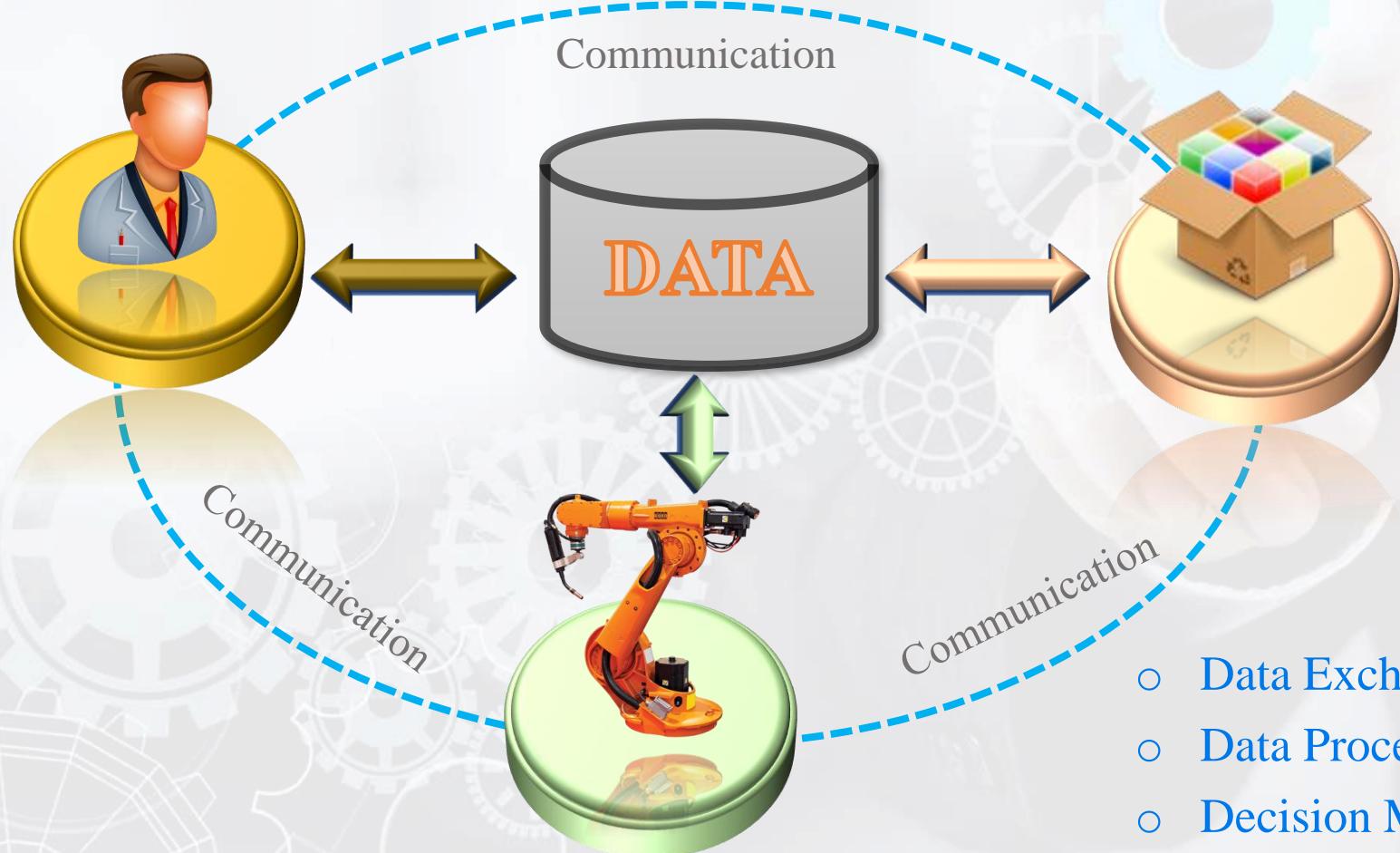
Problems
Solutions



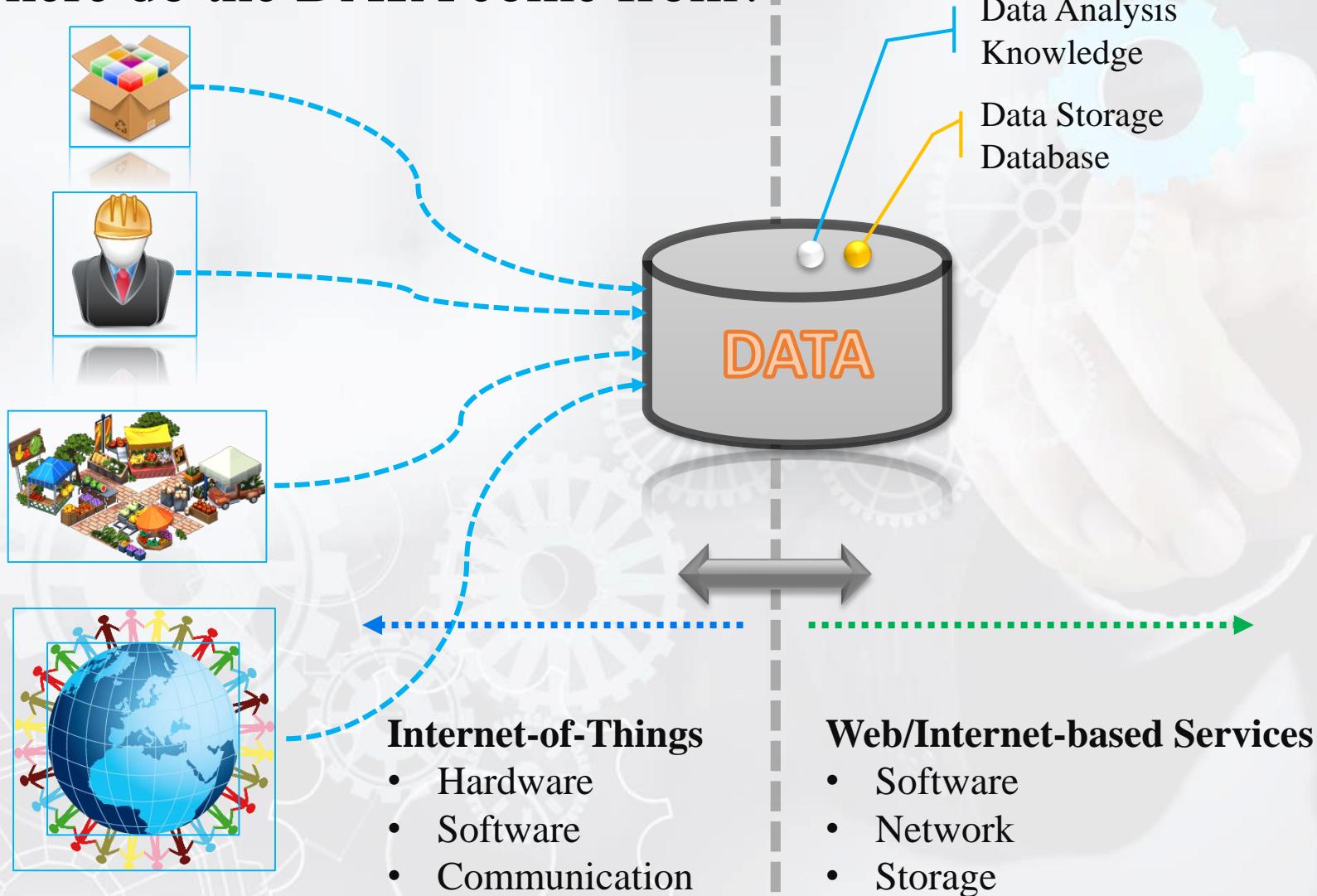
DATA



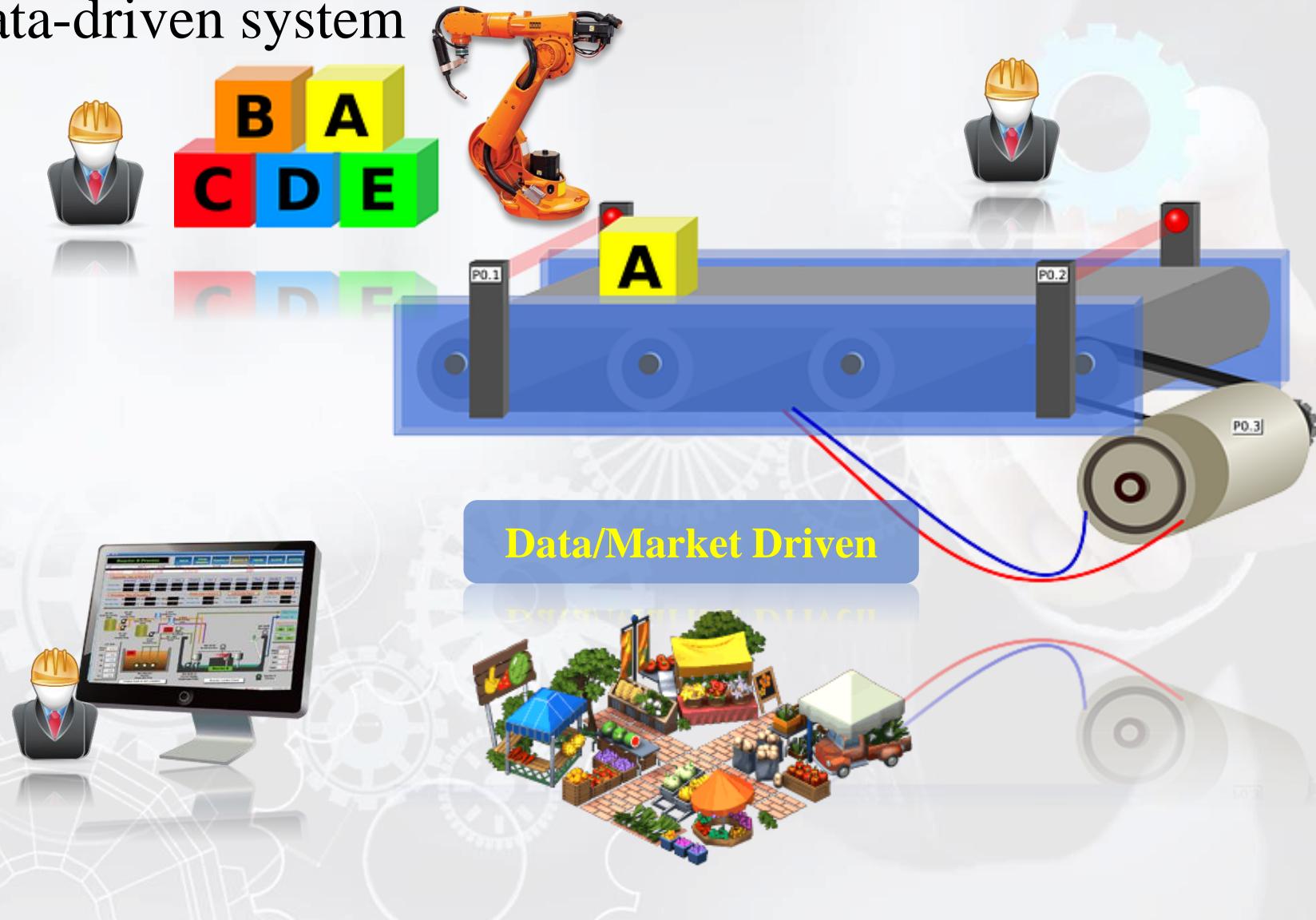
Each unit generates and exchanges its data to others



Where do the DATA come from?



Data-driven system



READY.
SET.



GO!



Let's moving to the future

Are we ready?

New Knowledge → New Smart Systems



Human/Engineers



Automation System



Communication



Computer

Human/Engineers

Machines/Systems

Computer/Microcontroller

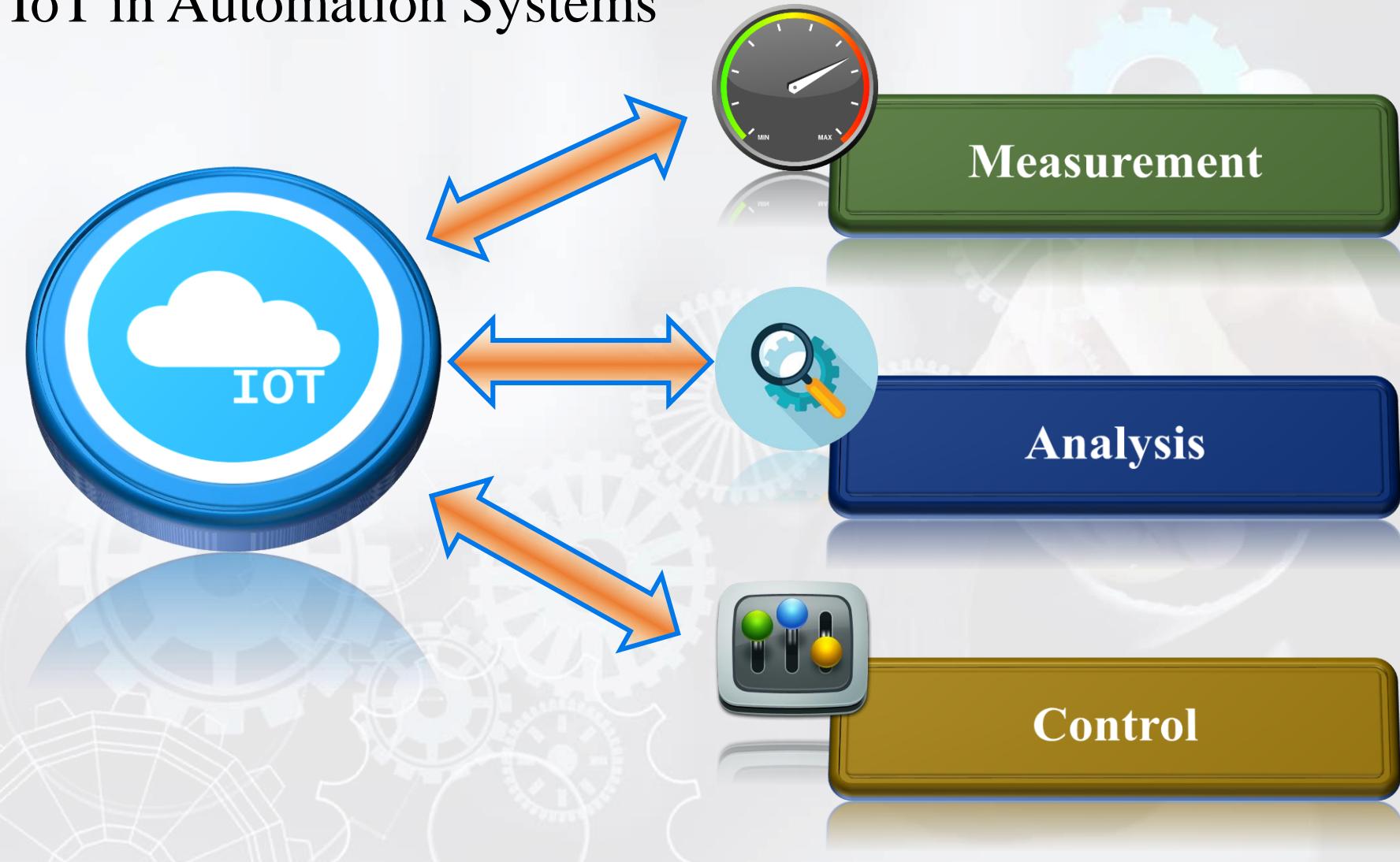
Internet/Communication

Internet-of-Things

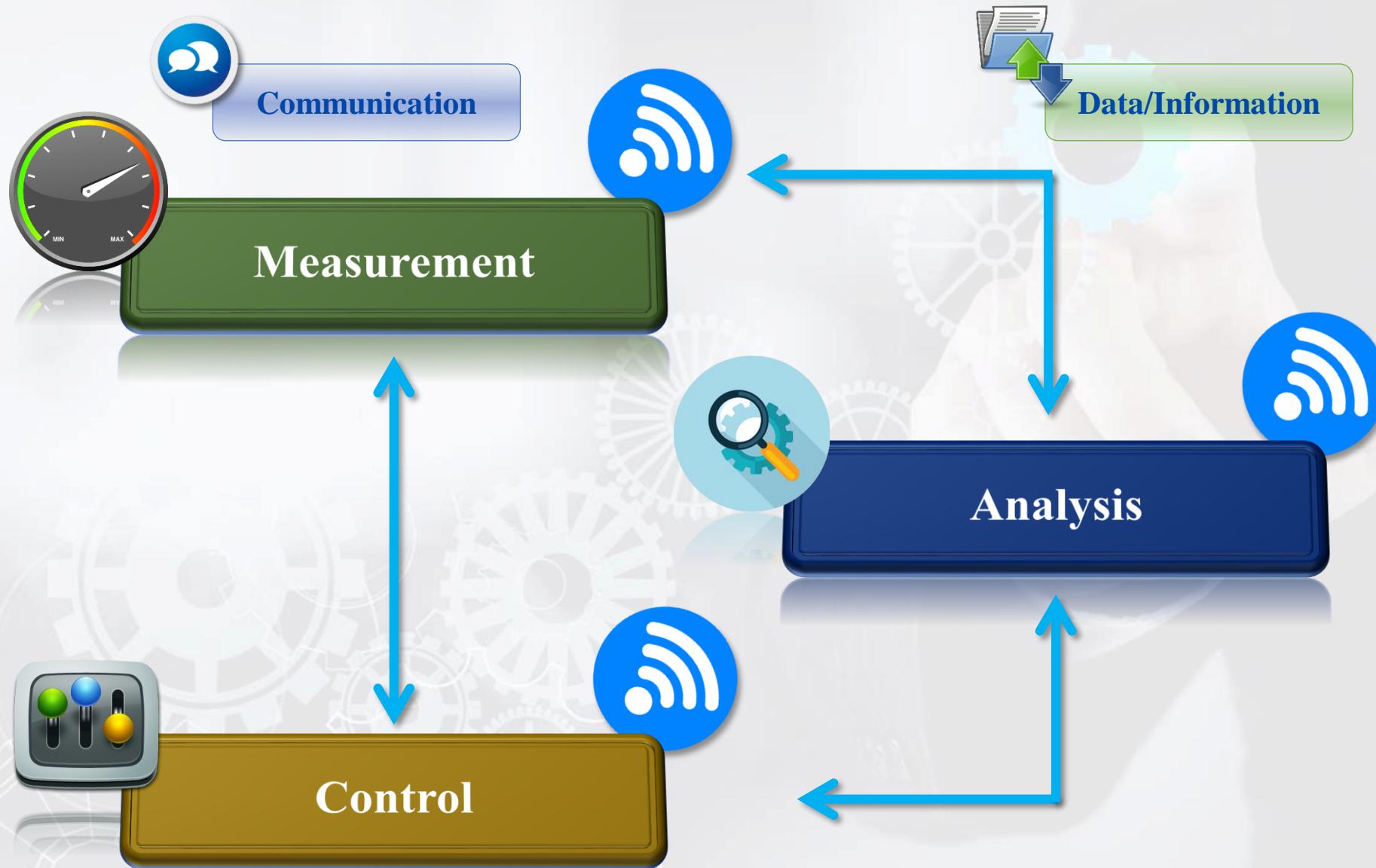
AI & CPS

Internet-of-Things for Industry 4.0

IoT in Automation Systems



Internet-of-Things for Industry 4.0



IoT in Automation Systems



Measurement



Analysis



Control

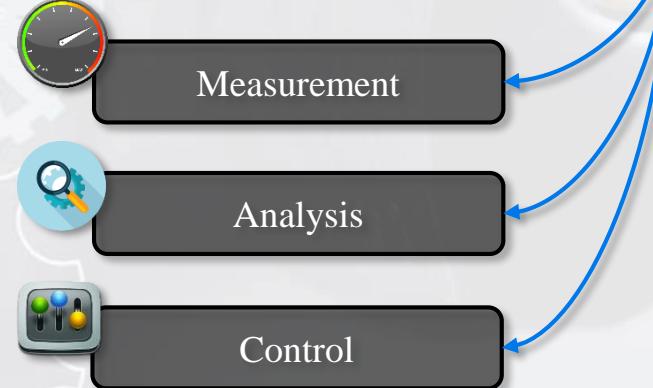


Internet-of-Things & Embedded Systems

IoT and Embedded Systems



IoT / Smart
Embedded Device

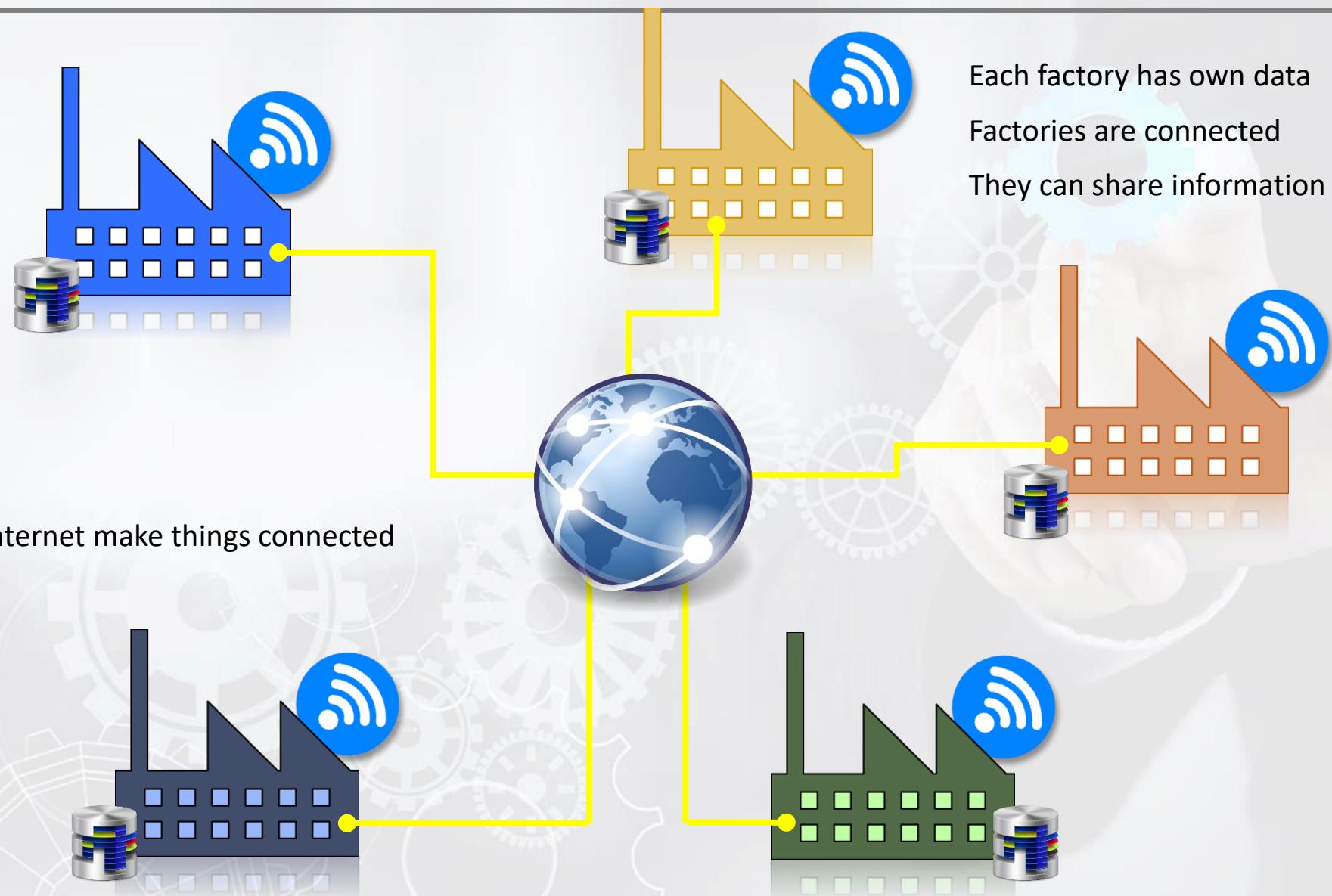


Communication and Networks

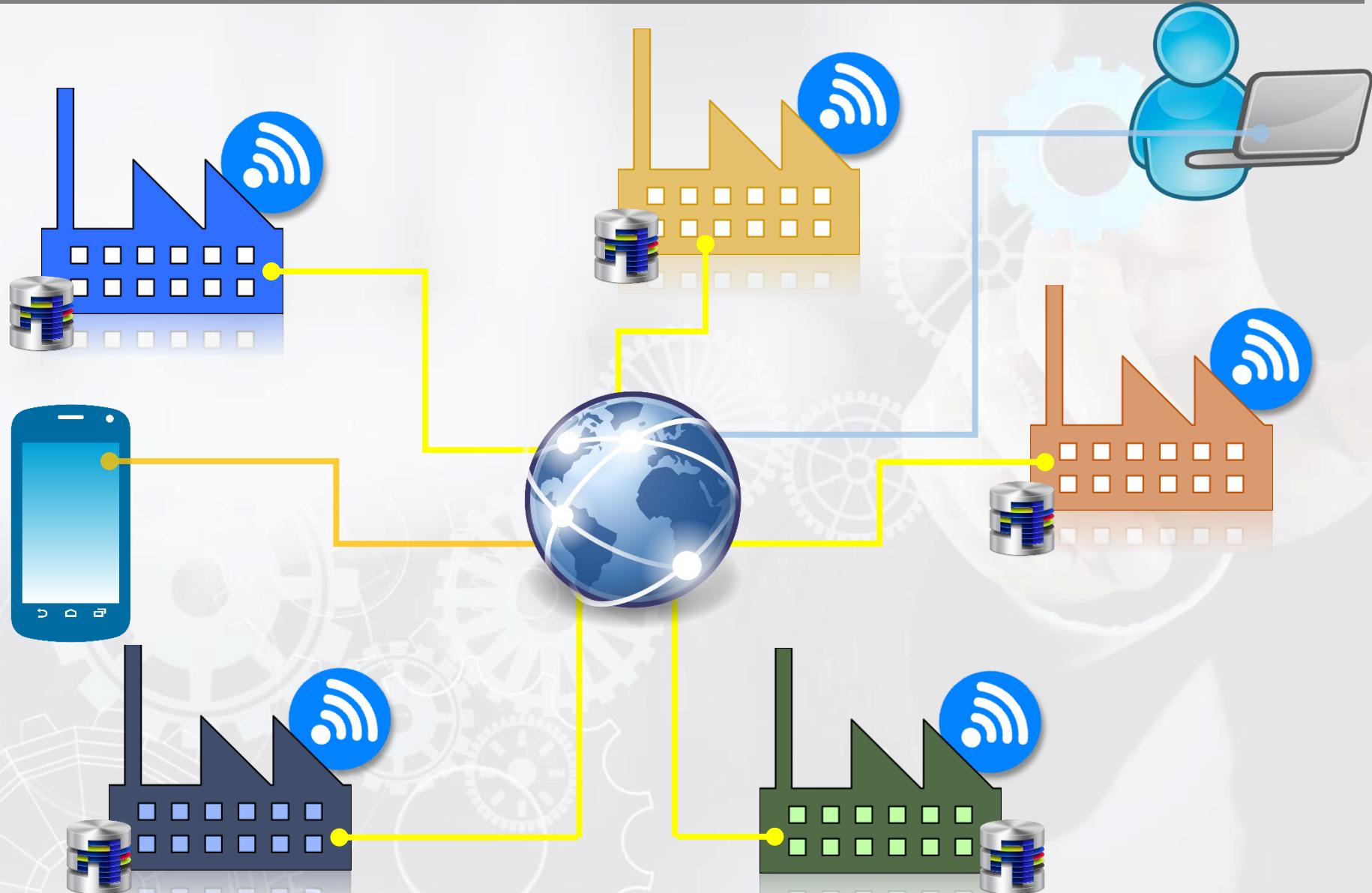
Communication and Networks



Communication and Networks



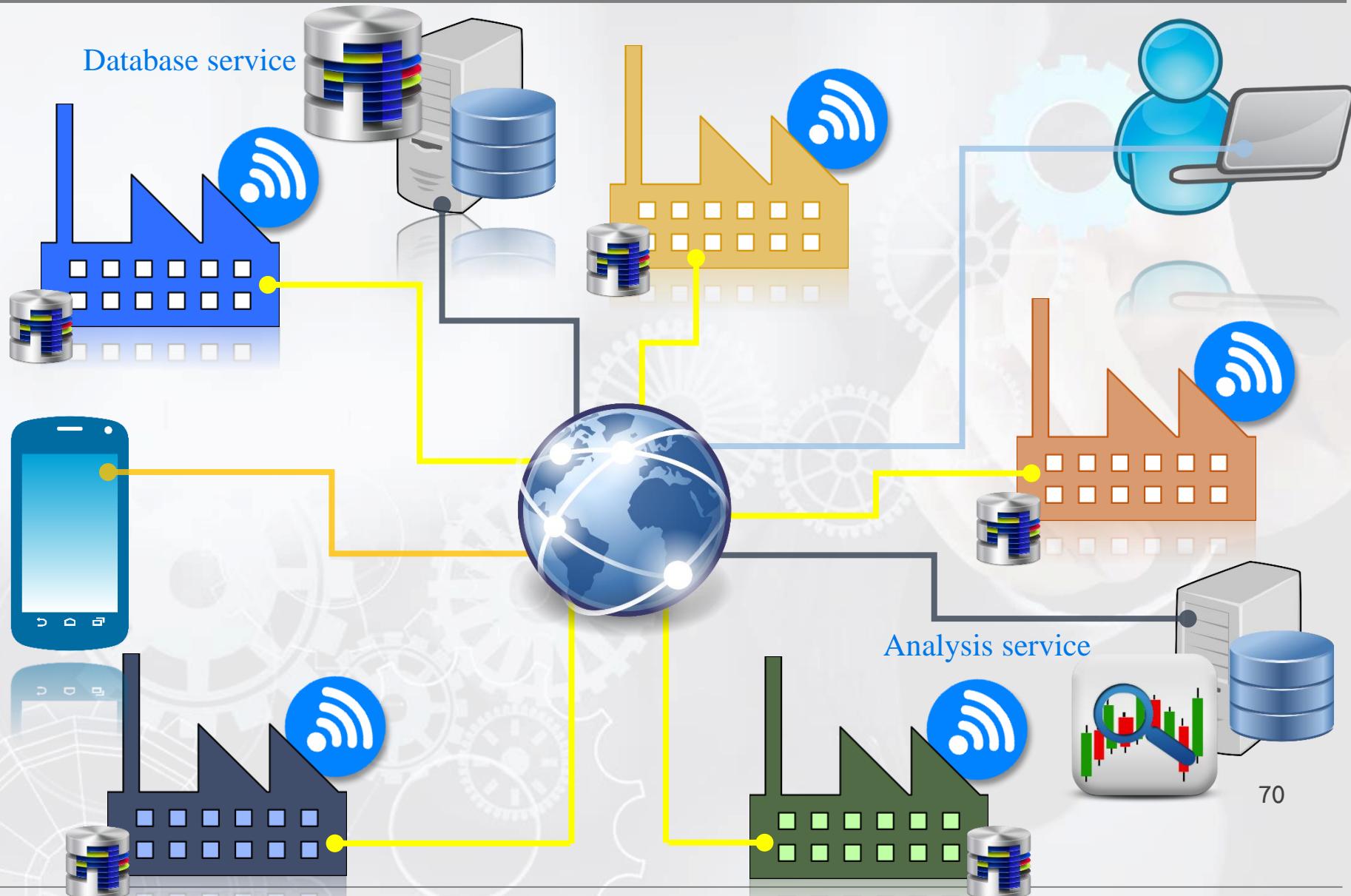
Communication and Networks



Online Services (Software as a Service)



Online Services



Communication and Transportation

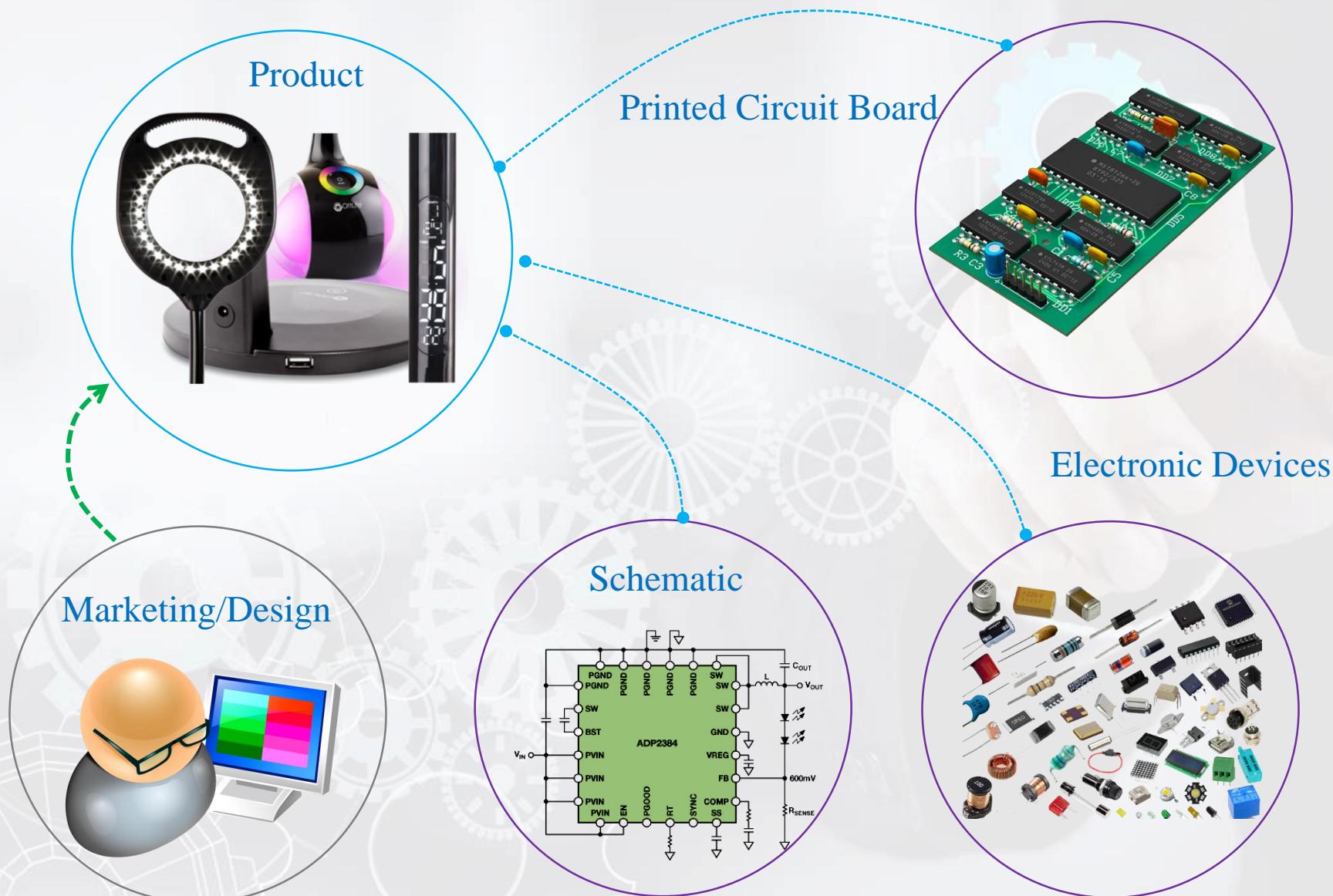
Industry 4.0



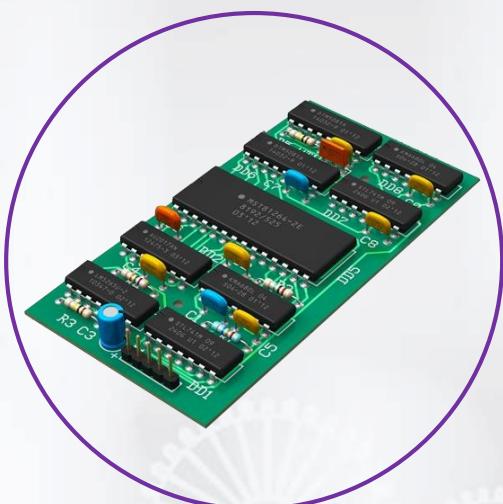
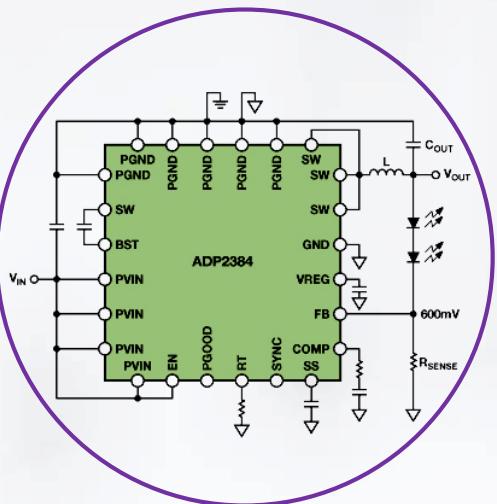
DATA is the KEY



Electronic and Computer Technologies



Electronic and Computer Technologies



R&D



Supported Factories

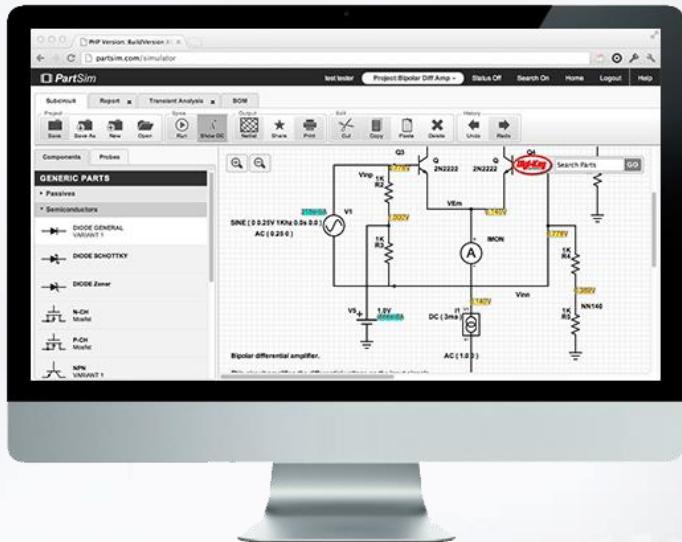


Input Materials/Market

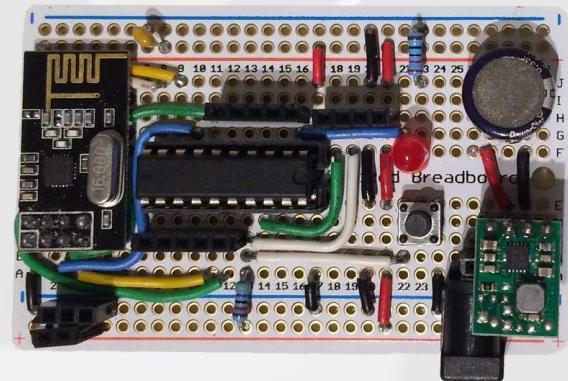
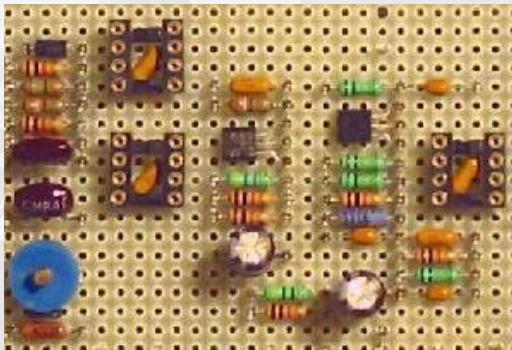
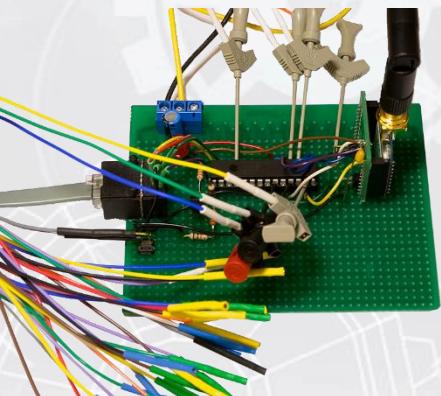
Electronic and Computer Technologies



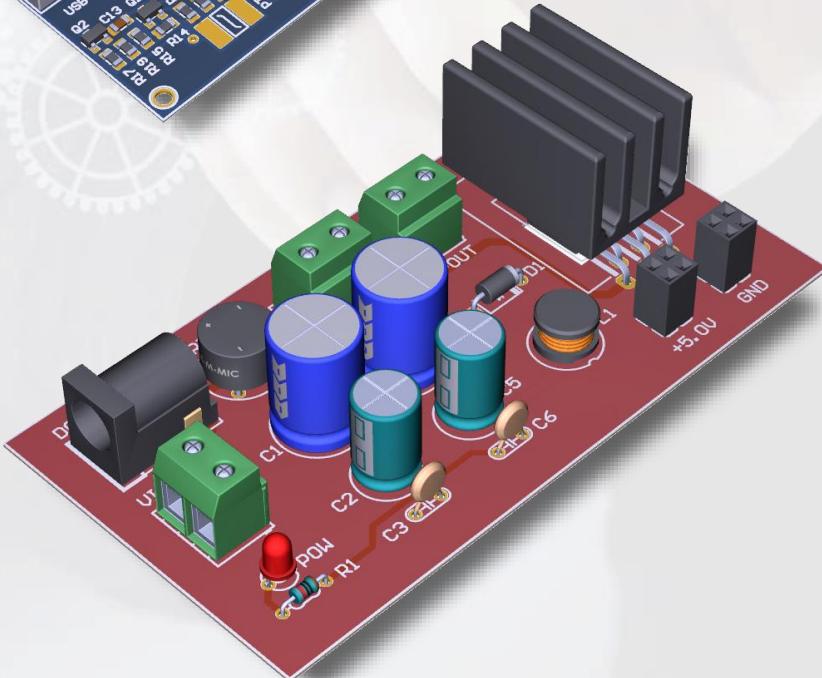
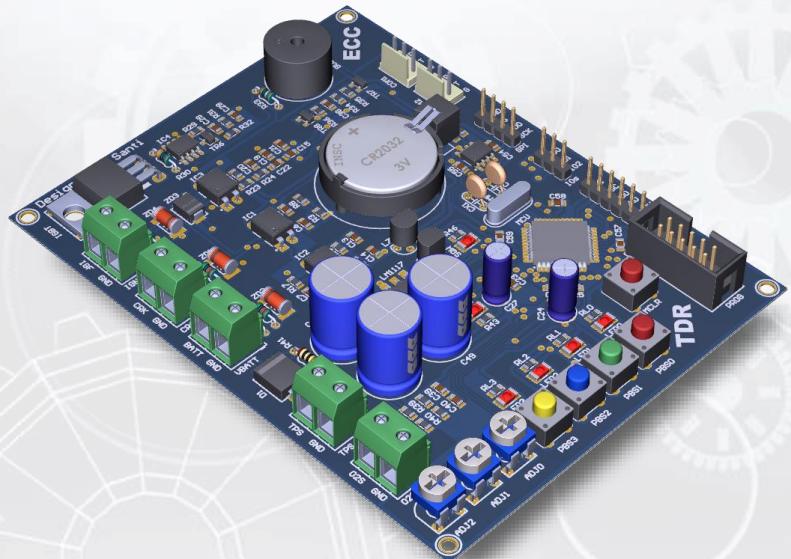
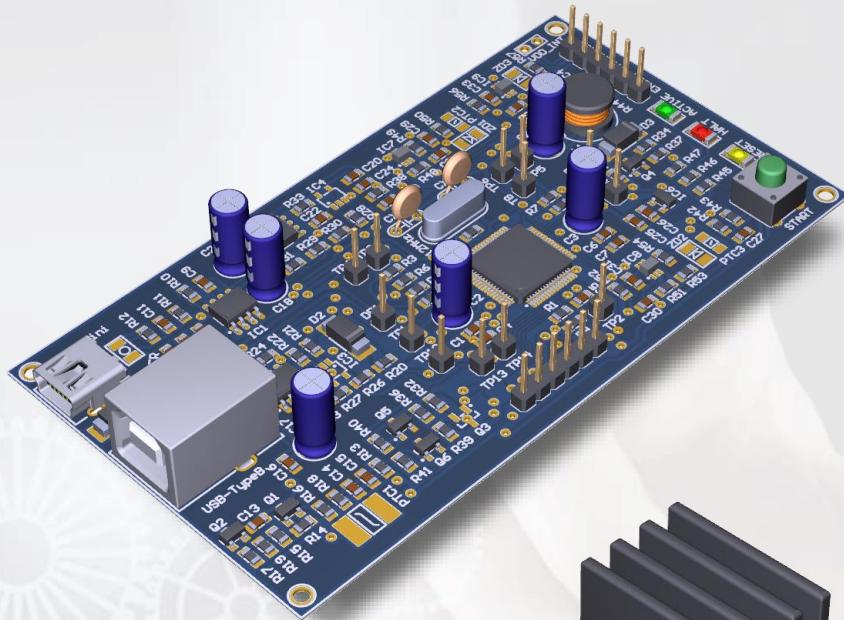
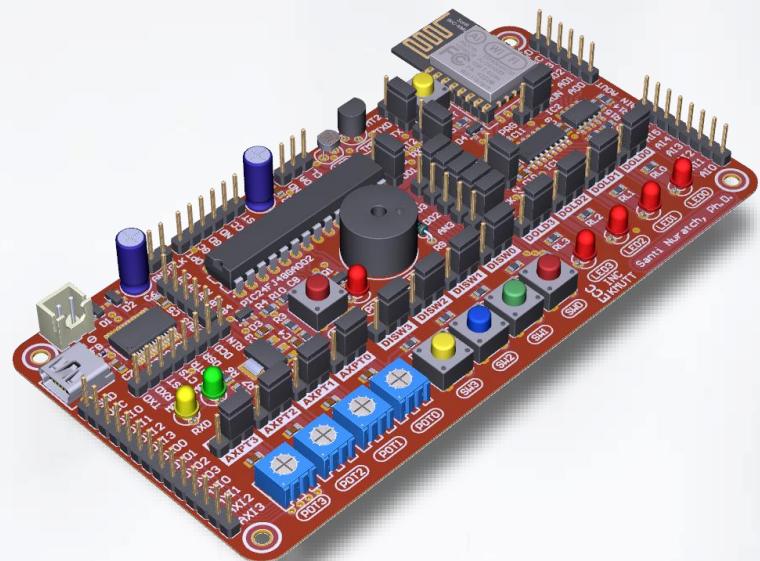
Simulation



Prototyping

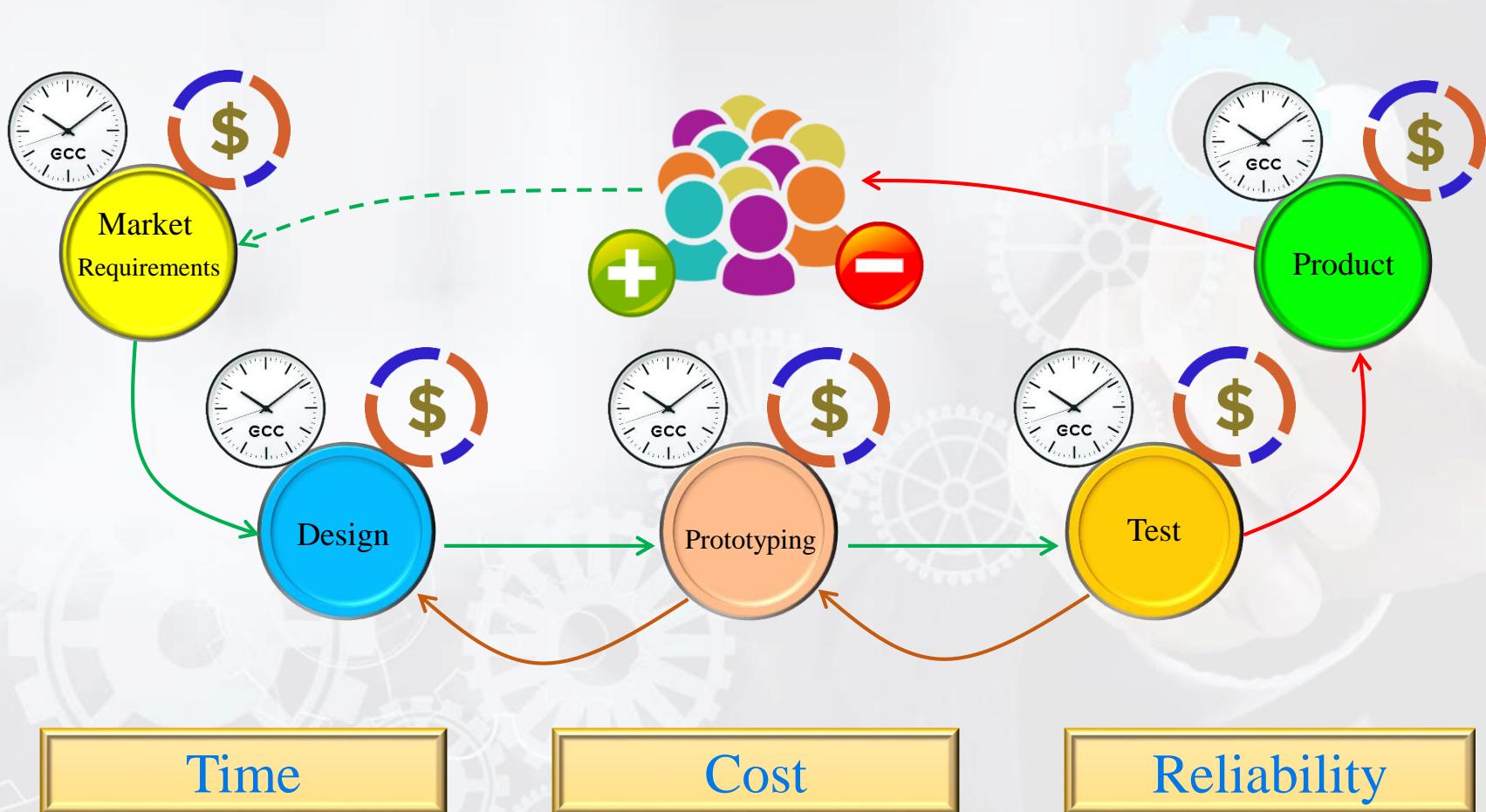


Electronic and Computer Technologies



Case Studies & Examples

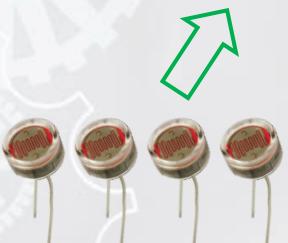
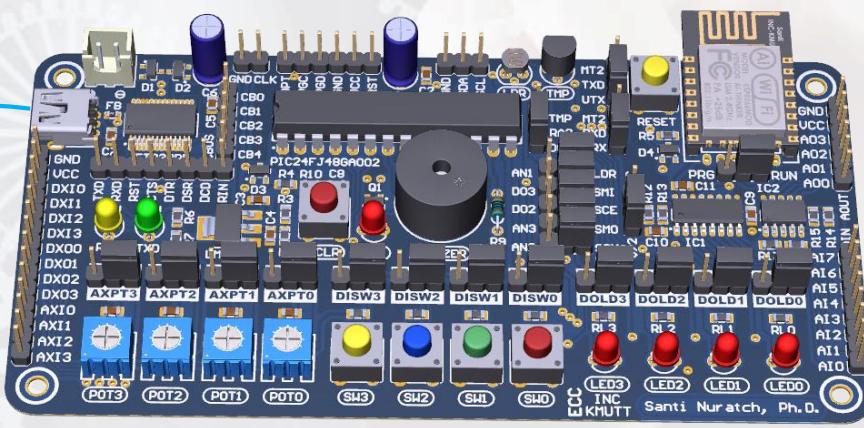
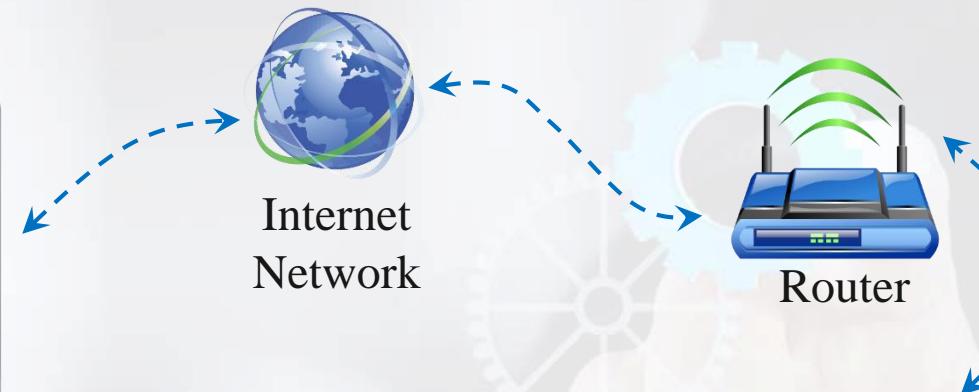
Case Studies & Examples



Case Studies & Examples



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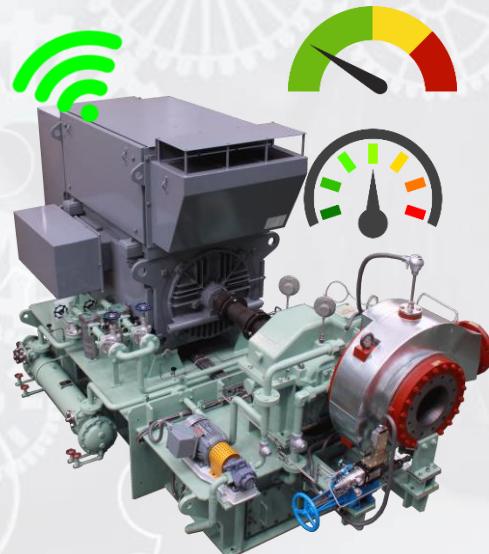
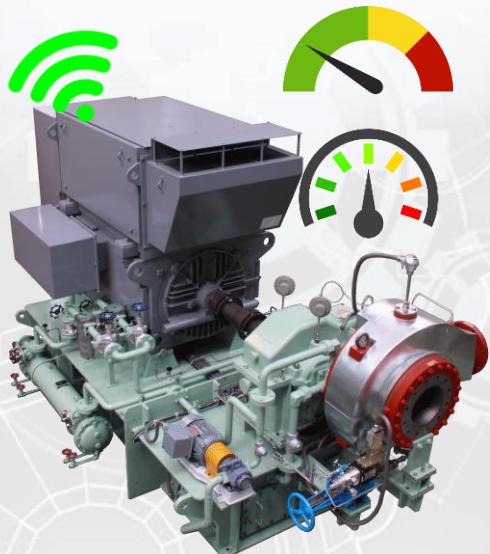
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Case Studies & Examples



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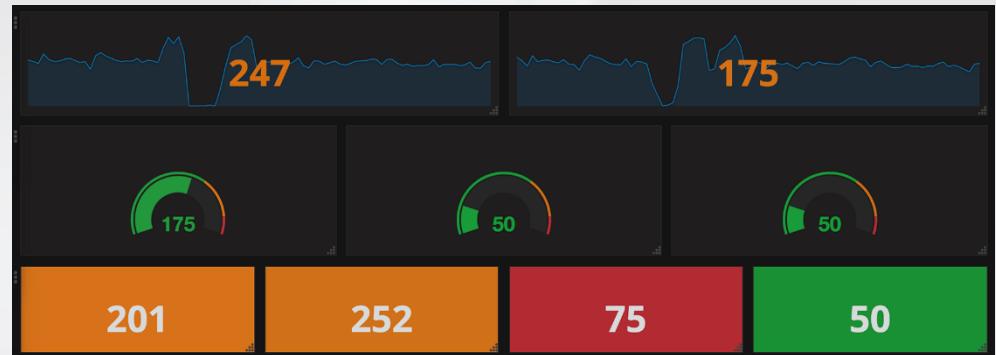
Case Studies & Examples



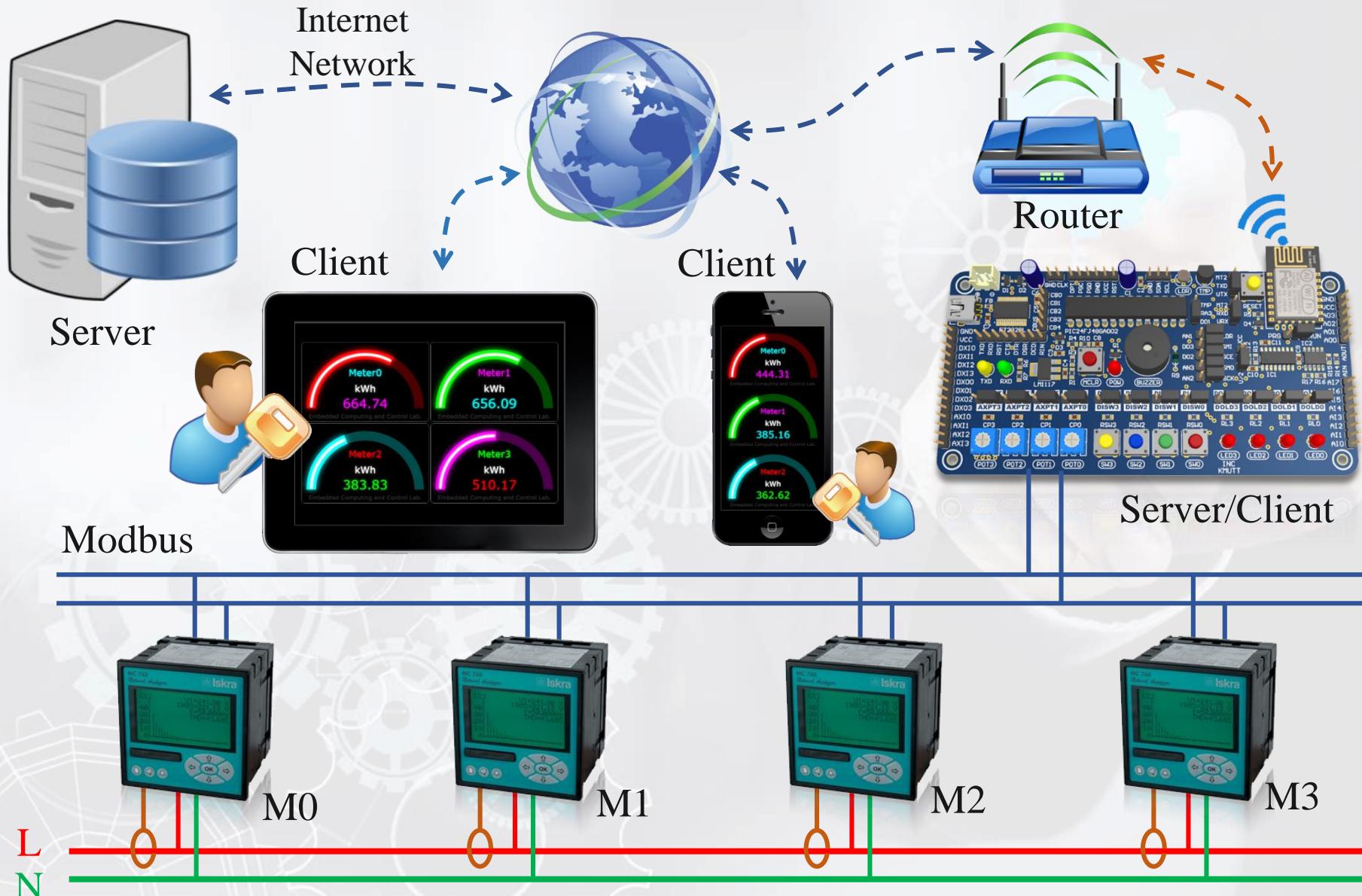
Case Studies & Examples



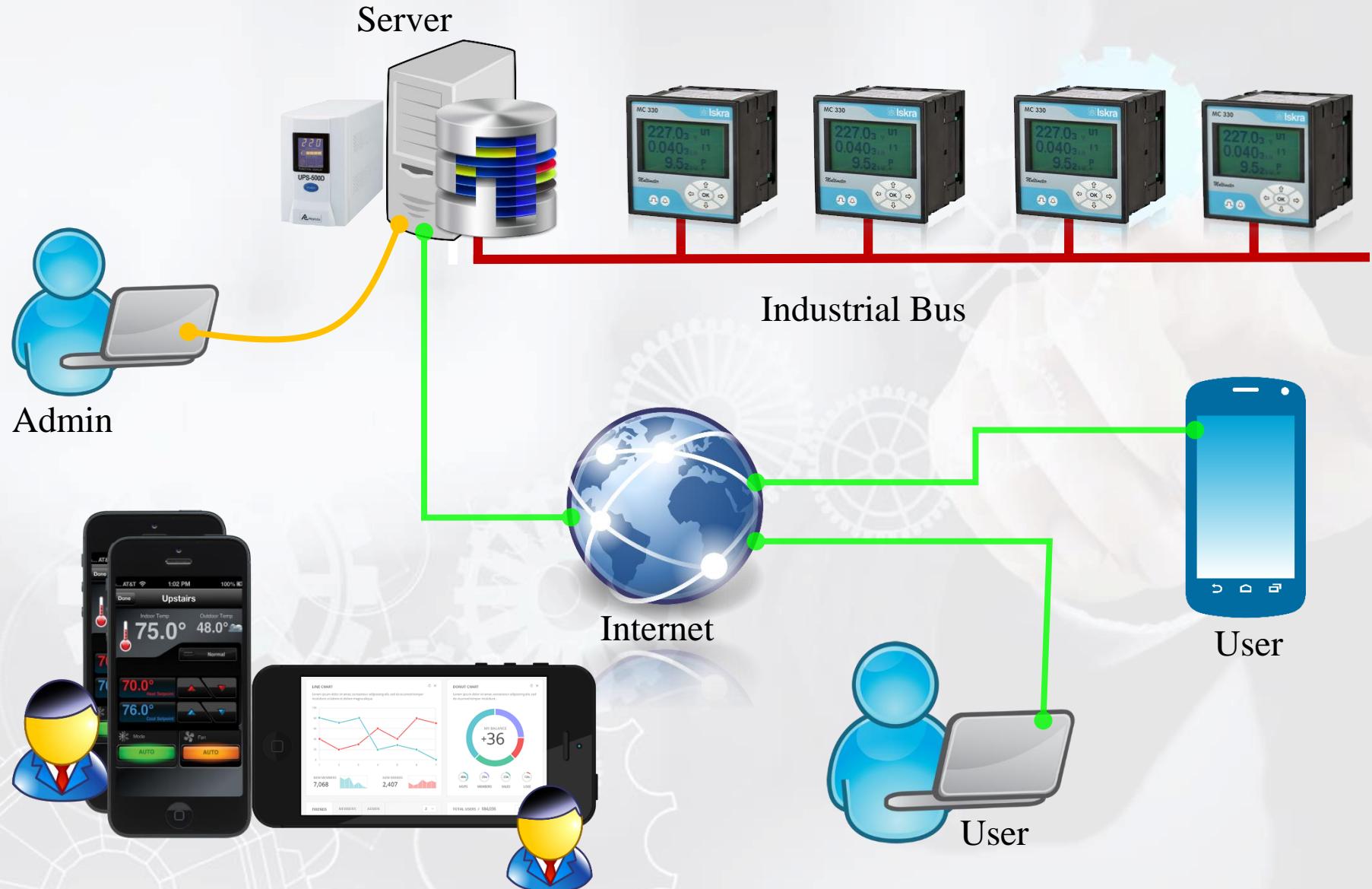
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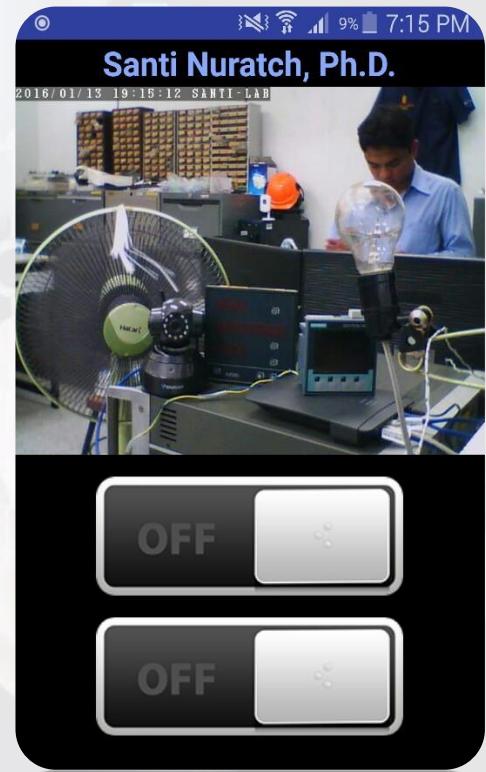
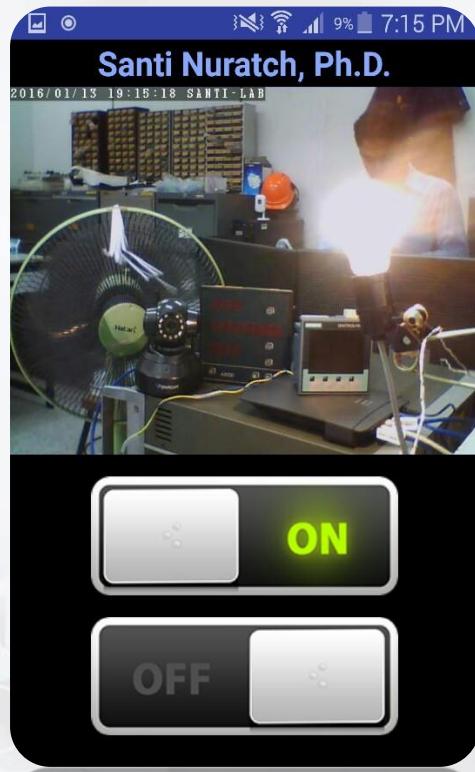
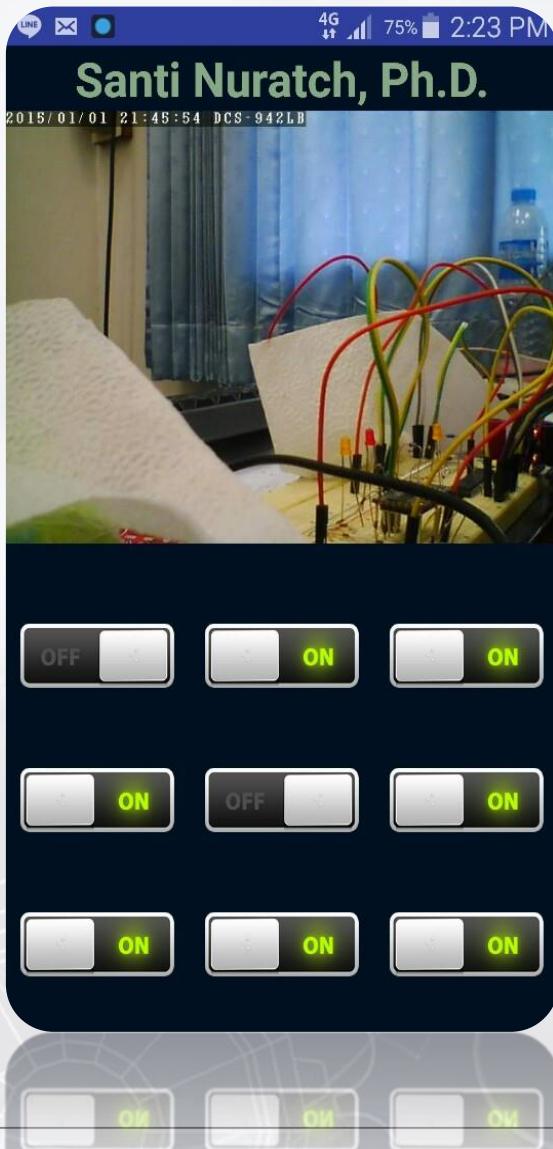
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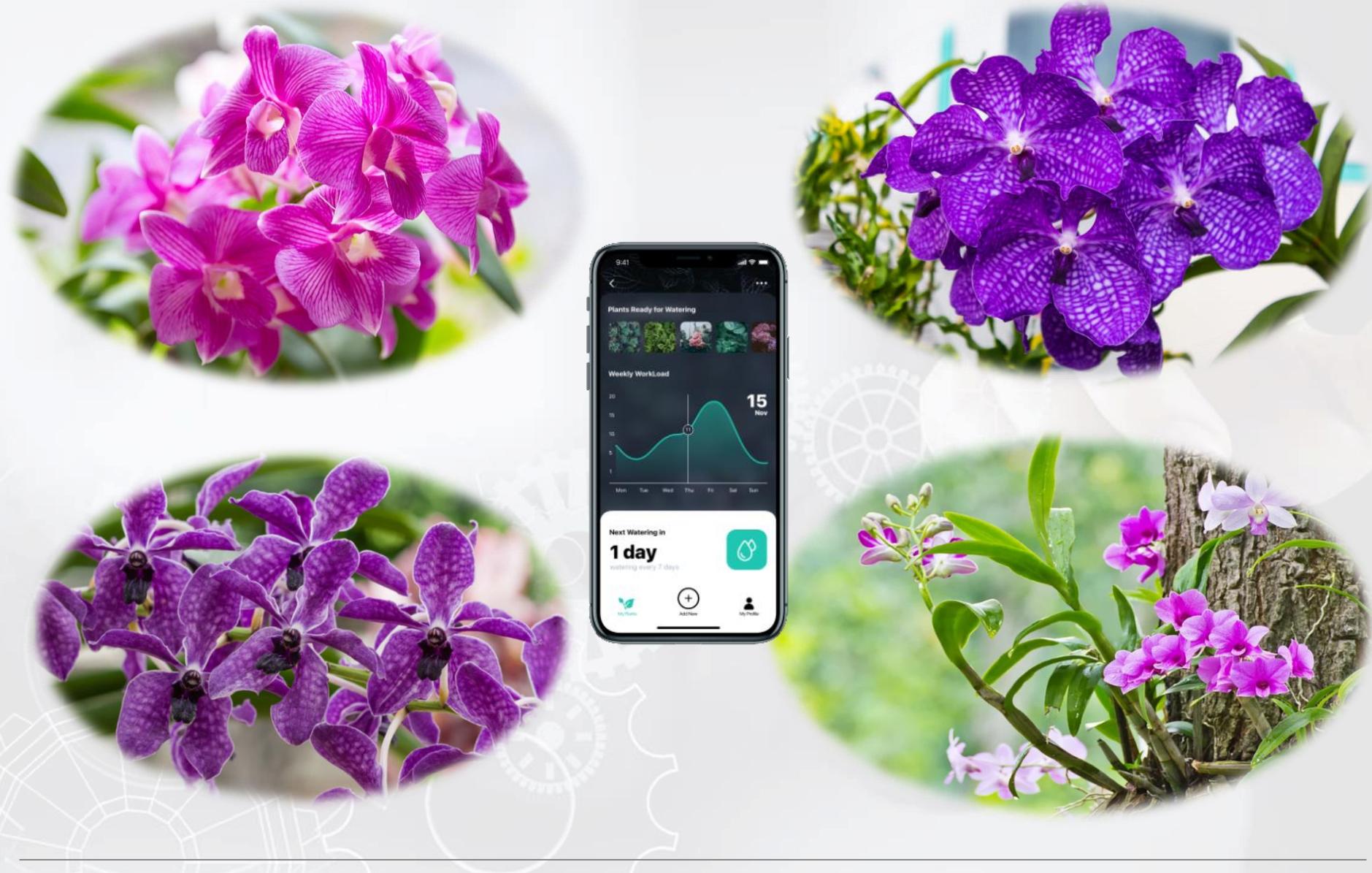
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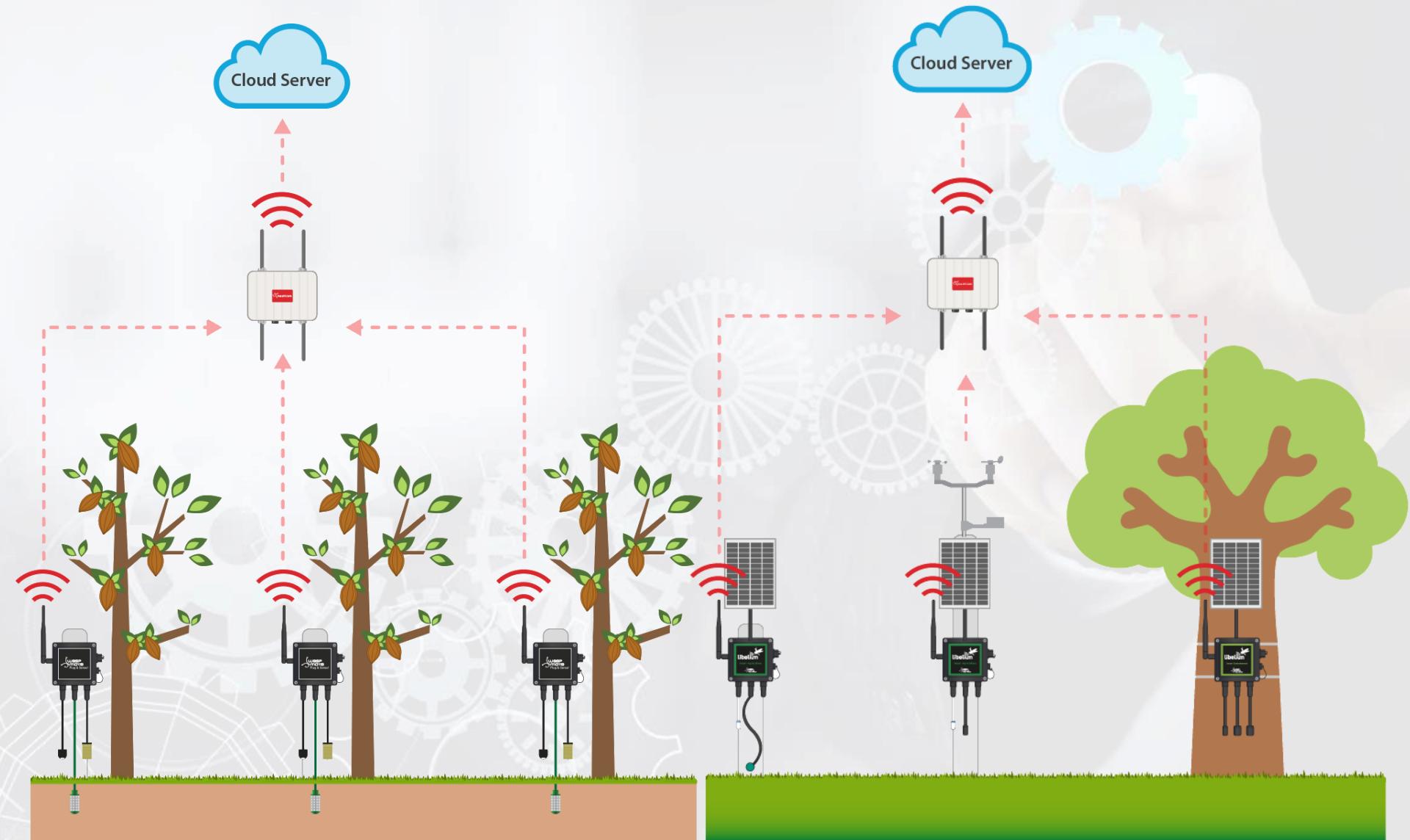
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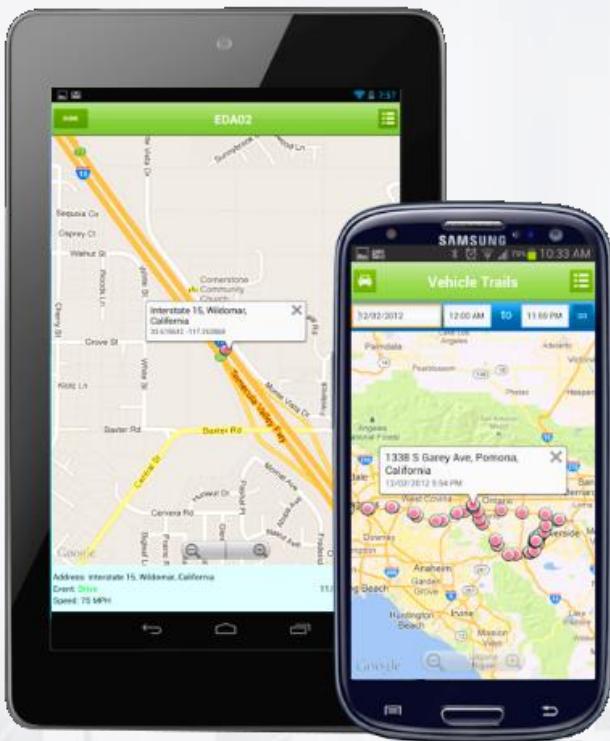
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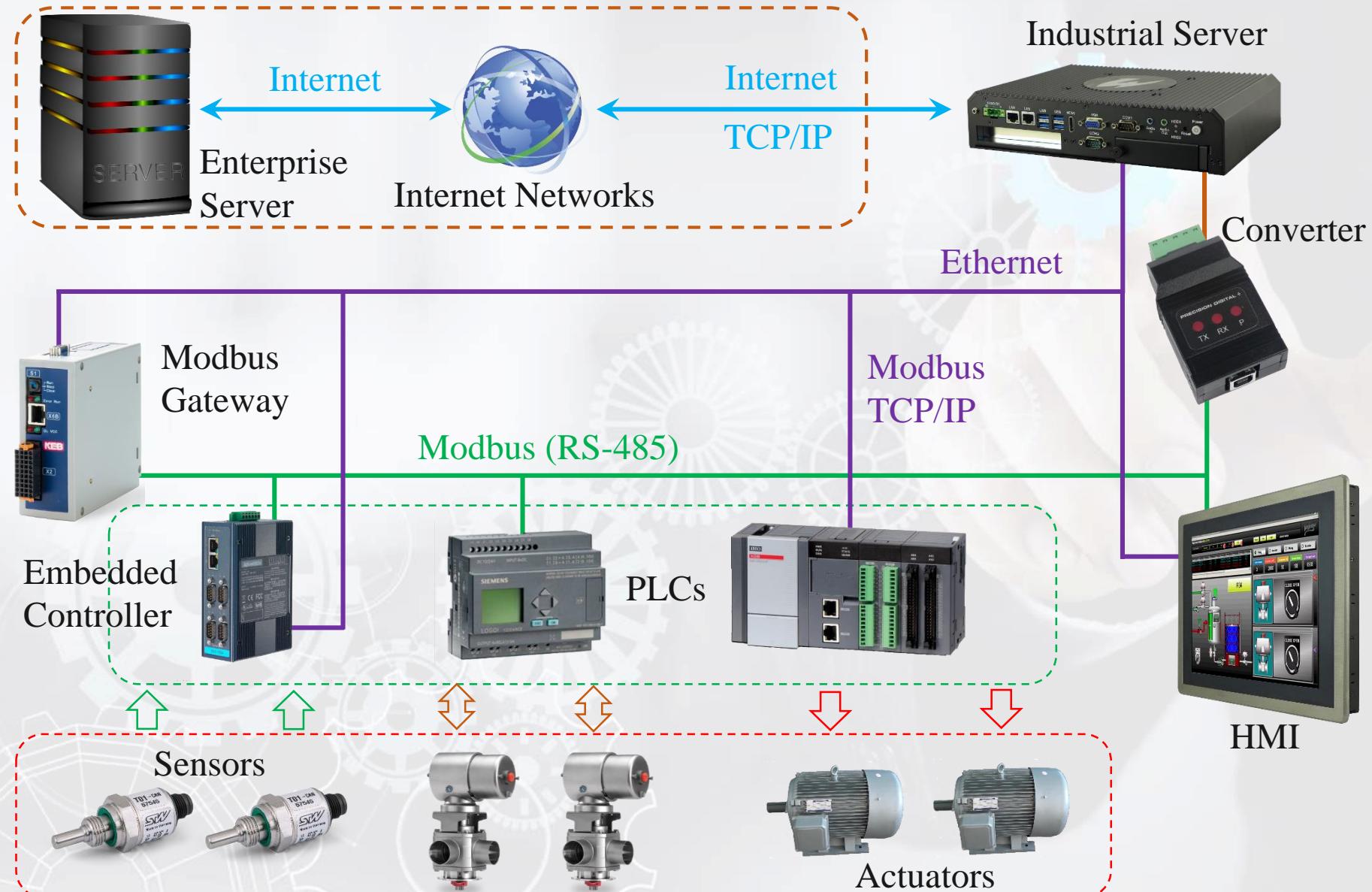
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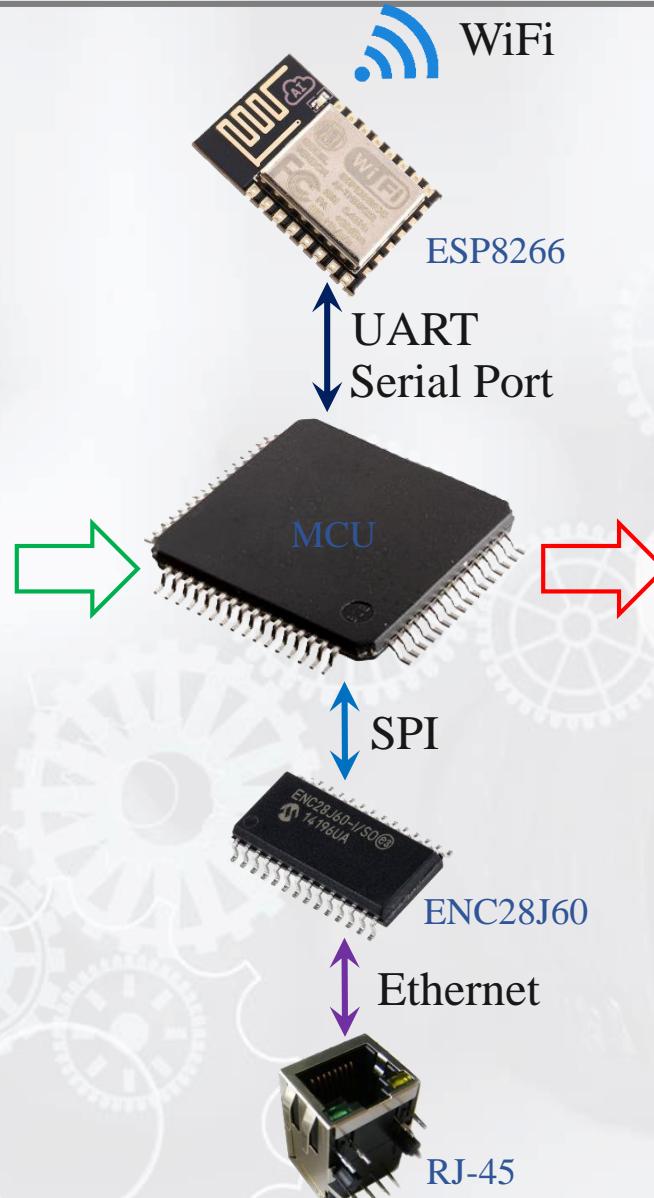


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Embedded System is the KEY

Microcontroller System



Electronic Devices/Equipment are Required



Computer/Mobile Applications are Required

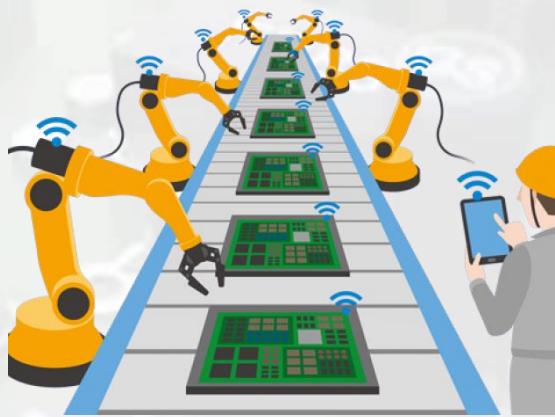
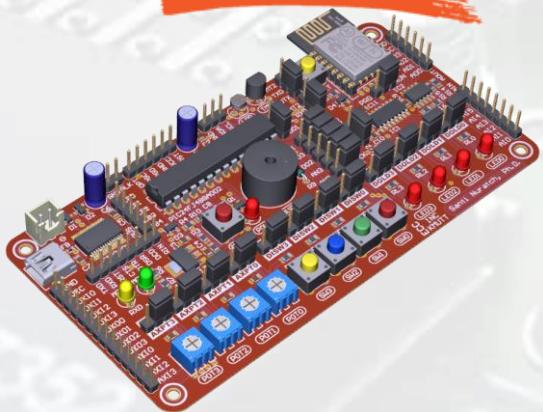


THANK YOU!

READY.
SET.
GO!



THANK YOU!



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