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COMP1047: Systems and Architecture

Dr. Fazl Ullah (Khan)

AY2023-24, Spring Semester
Week 11

Computer Networks:
Internet of Things



Introduction

- Most of the slides are based on the slides of
Prof. James Won-Ki Hong
POSTECH Korea

and
Prof. Jong-Moon Chung
Yonsei University Korea



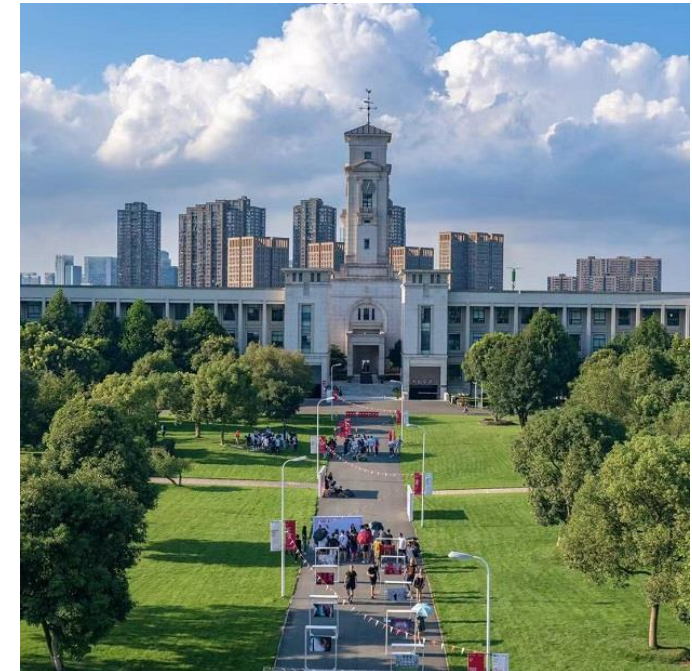
Overview-Internet of Things

Learning Outcomes

- Understand the basics of IoT
- Analyze IoT Use Cases
- Learn Security Problems

Roadmap:

- IoT: Internet of Things
 - Services and Architecture
 - Technologies
- IoT Use Cases
 - Healthcare
 - Transportation
- Security Issues
 - Smart Home
 - Autonomous Cars





■ *Recap from last Week*

■ The Industrial Revolution

- Four Revolutions
- IoT Market and Industry

■ Introduction to IoT

- Services
- Architecture
- Technologies

■ Standardization

- Open Connectivity Foundation
- oneM2M

■ Similar Technologies

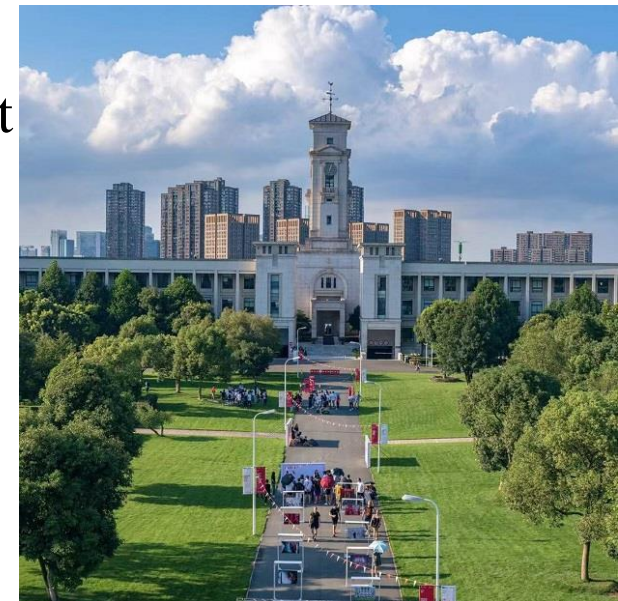
■ IoT Use Cases

- IoT Applications
- Healthcare
- Transportation
- Farming

■ Security Problems in IoT

- Smart Home
- Assets Management
- Autonomous Car

■ IoT vision



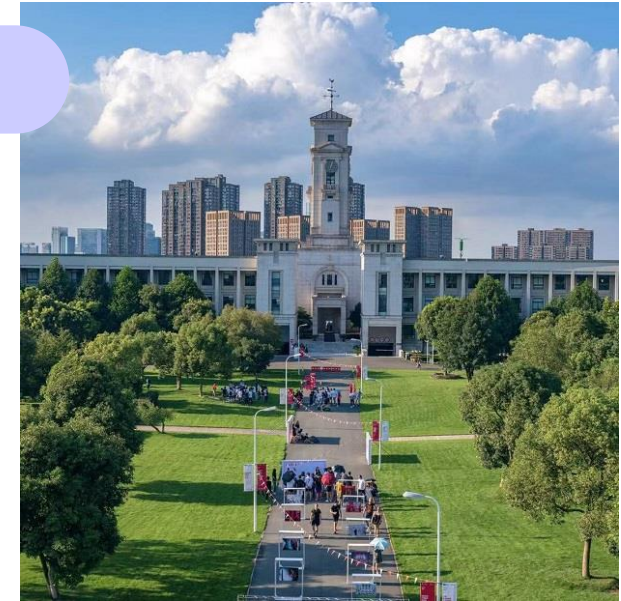


Recap from the Last Week

Last Week, we discussed

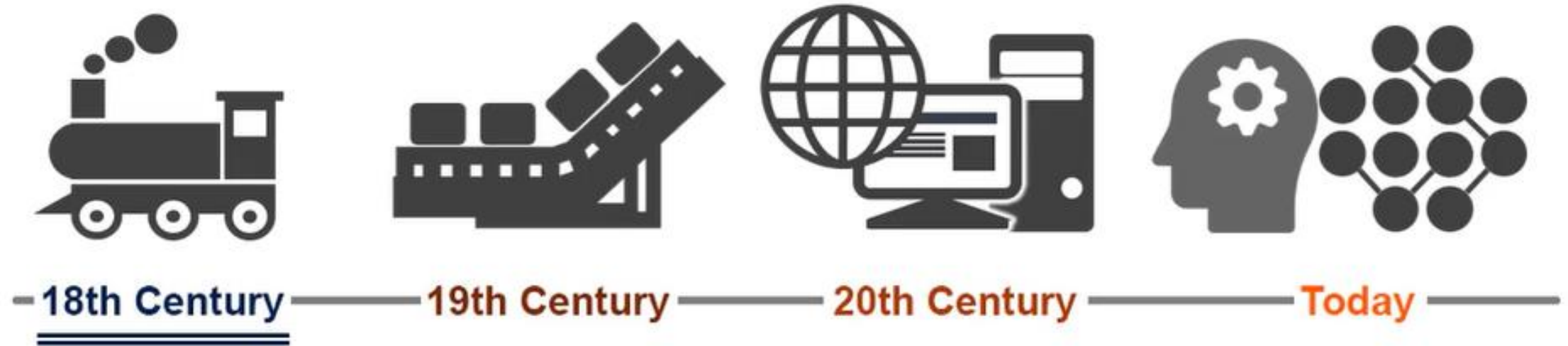
- Internet Protocol
 - IP Datagram Format and Header
- Connectionless Networking
 - Design issues
- IP: Addressing
 - Classes and Types
 - Subnetting and Supernetting
 - Classless Inter-Domain Routing
 - Variable length subnet masking
- IPv6
 - Rules
 - Notations

**Any
question
in
previous
lecture?**



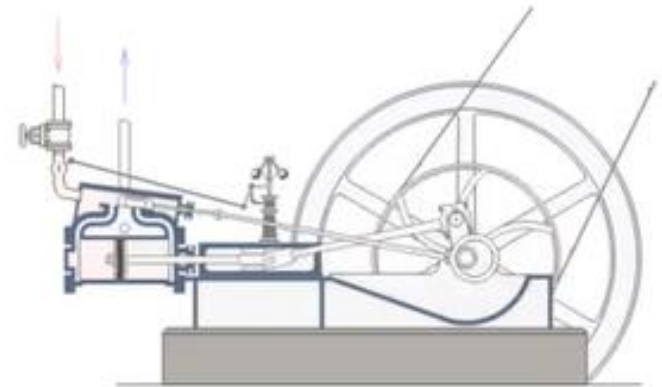


The Four Industrial Revolutions (1/4)



1st Industrial Revolution

- Began in Great Britain
- Steam engine and coal
- **Mechanical Production**





The Four Industrial Revolutions (2/4)



2nd Industrial Revolution

- Began in Europe and America
- Electricity, Petroleum, and Steel
- **Mass production assembly lines** requiring labor and electrical energy





The Four Industrial Revolutions (3/4)



18th Century



19th Century



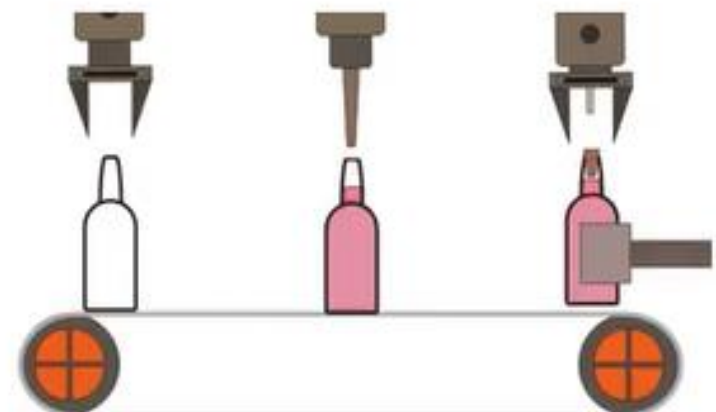
20th Century



Today

3rd Industrial
Revolution

- Electronics and IT
- Automated production





The Four Industrial Revolutions (4/4)



– 18th Century



– 19th Century



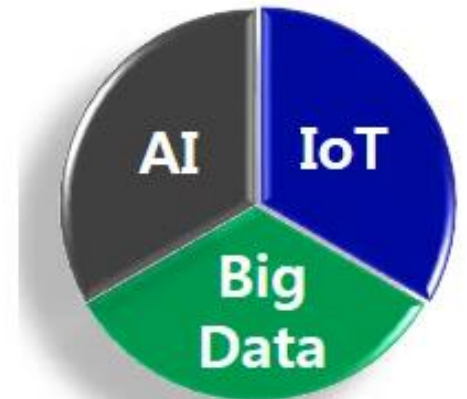
– 20th Century



– Today

4th Industrial
Revolution

- Convergence of Information and Communications Technology (ICT)
- **Intelligent production** via Internet of Things (IoT), Artificial Intelligence (AI), and Big Data





IoT Market and Industry

Smart Consumer & User

Facilitative reality



Connected homes



Connected cars



Smart health



Shared economy



Transportation



Retail



Building & Construction



Manufacturing




Oil & Gas / Energy



Healthcare



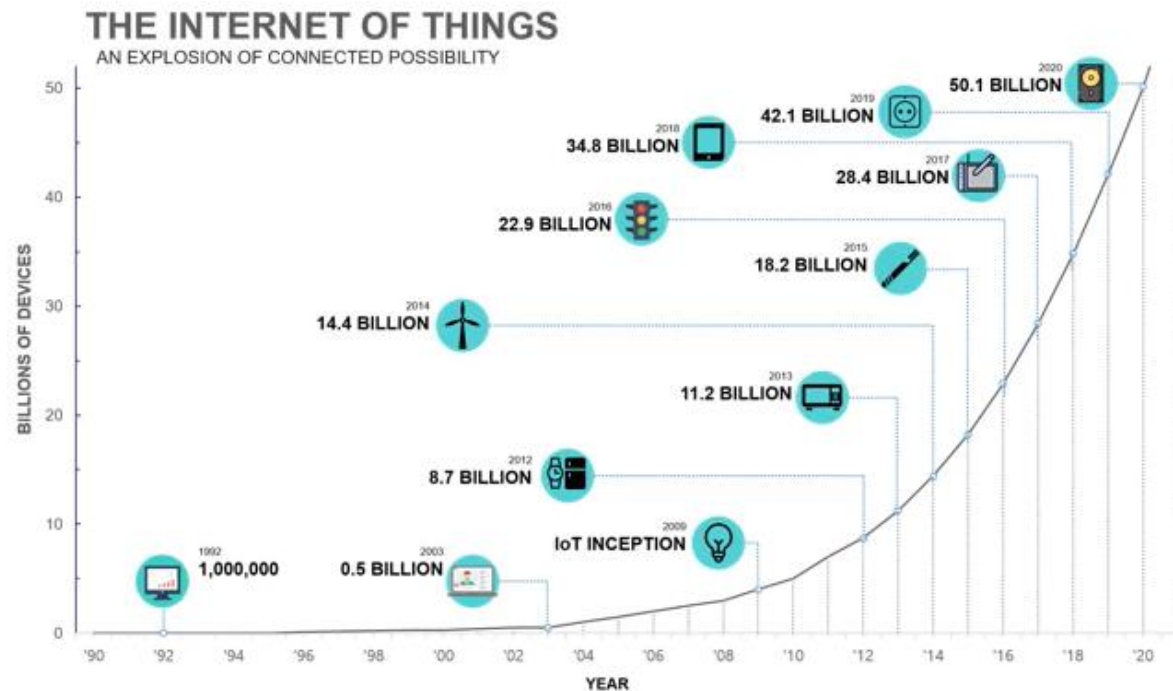
What is IoT (1/2)

- The Internet of Things (IoT) is the **internetworking of things embedded with software, sensors, and network connectivity** which enable these things to collect and exchange data
 - The IoT allows things to be sensed or controlled remotely, resulting in improved efficiency, accuracy, and economic benefits in addition to reduced human intervention
 - “**Things**” includes everything from temperature sensors, cameras, smartphones, buses, trains, and almost anything else we can think of.
- 



What is IoT (2/2)

- According to a survey by Cisco, the number of things using IoT technology was estimated at **14.4 Billion** in 2014 but is expected to reach **50.1 Billion** by 2020
- IDC, a US market research firm, estimates that the global IoT market will grow from **\$1.9 Trillion** in 2013 to **\$7.1 Trillion** by 2020



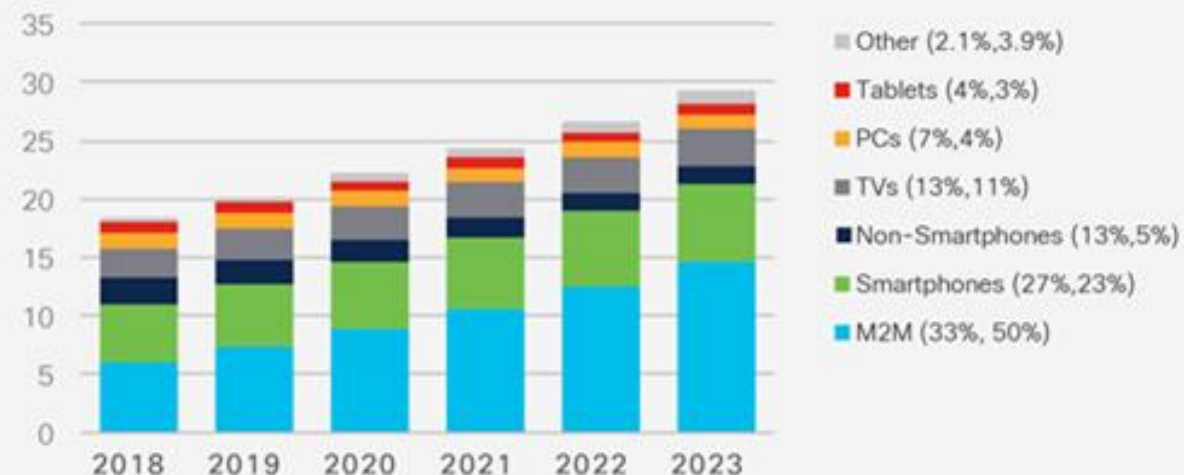
Source: CISCO



User/Devices and Connections

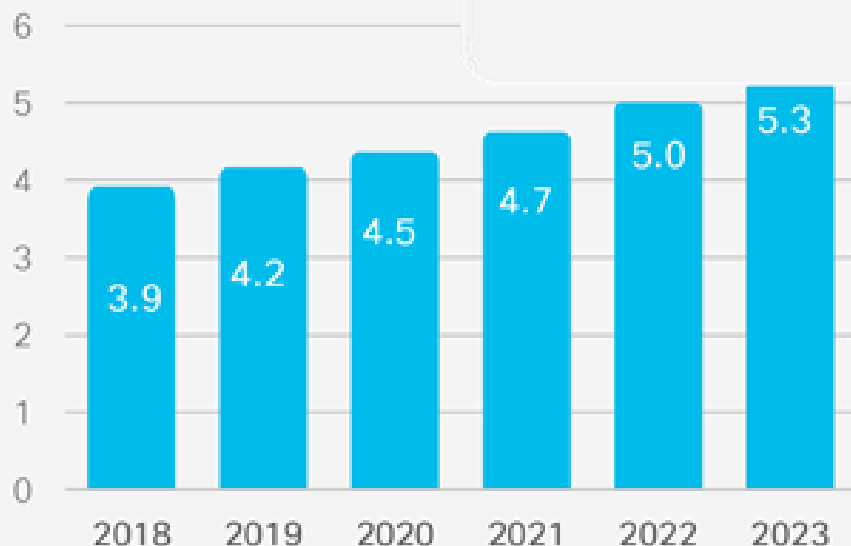
10% CAGR
2018-2023

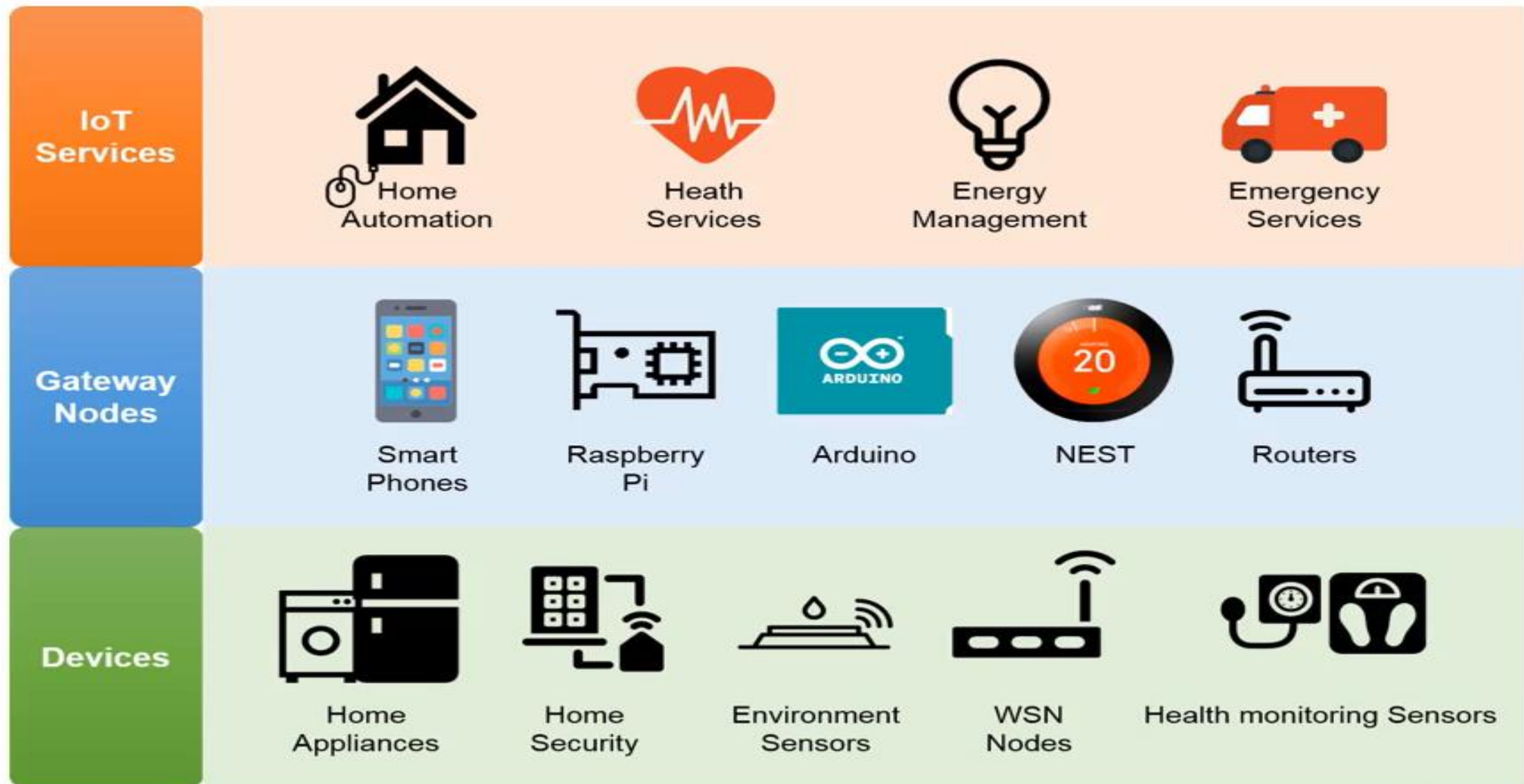
Billions of
Devices



6% CAGR
2018-2023

Billions of
Internet
Users







IoT Services- Products

- **Some IoT Companies that provide different services**
- So many companies doing a great job and provide services



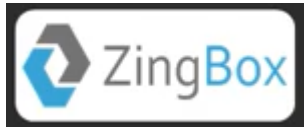
- Atmel Corporation
 - IoT Hardware, microcontroller



- Android Things
 - IoT Software, lighter OS



- Samsara
 - IoT solution (HW, SW, Network)






- ZingBox
 - IoT Security based on deep-learning



- Uber
 - IoT Applications, connect Things to Servers

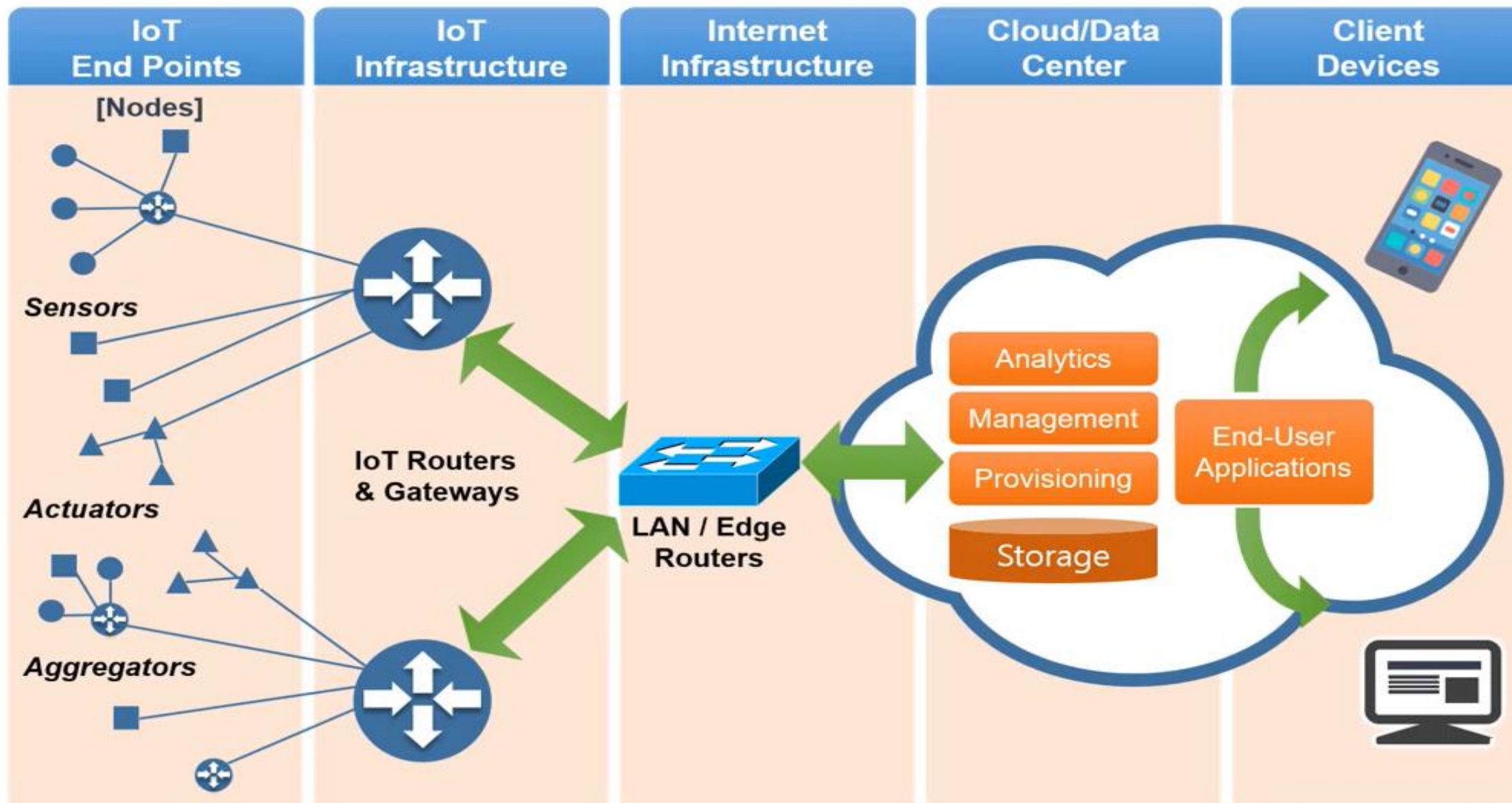


IoT Services- M2M Eco System

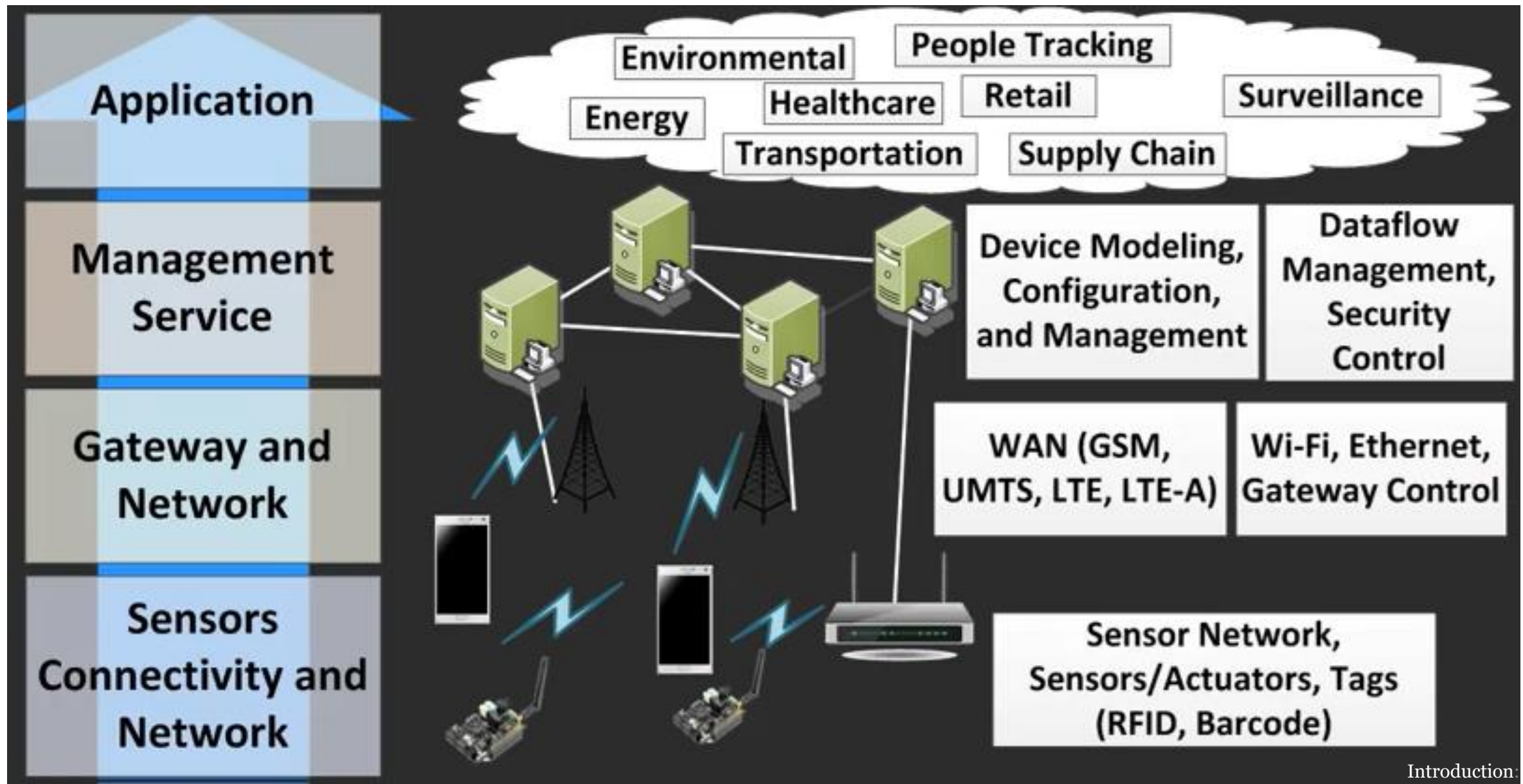
Companies/Organization	Description
	BSP (Business Service Provider / Business Solution Provider)
	System Integrator and IoT solution providers for enterprises
	Network operator, Communication, Service providers, and transport infrastructure providers

- M2M
 - Machine-to-Machine
- P2P
 - Person-to-Person
- P2M
 - Person-to-Machine
- M2P
 - Machine-to-Person

IoT Architecture

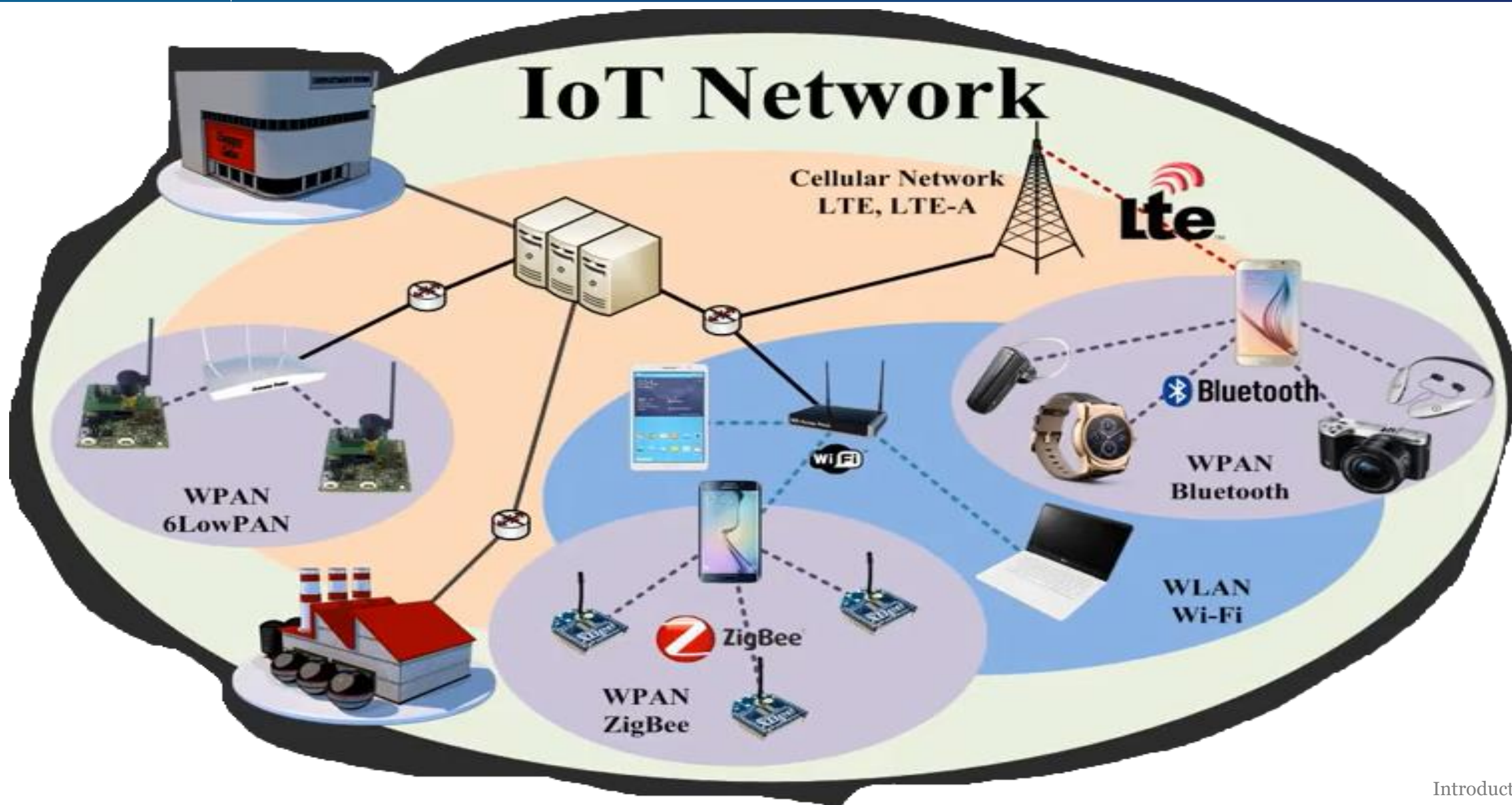


IoT Architecture-Layers



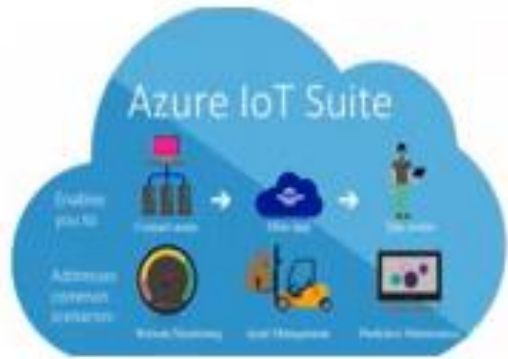


IoT Network Architecture





IoT Cloud Software Platform










Communications Technologies used in IoT

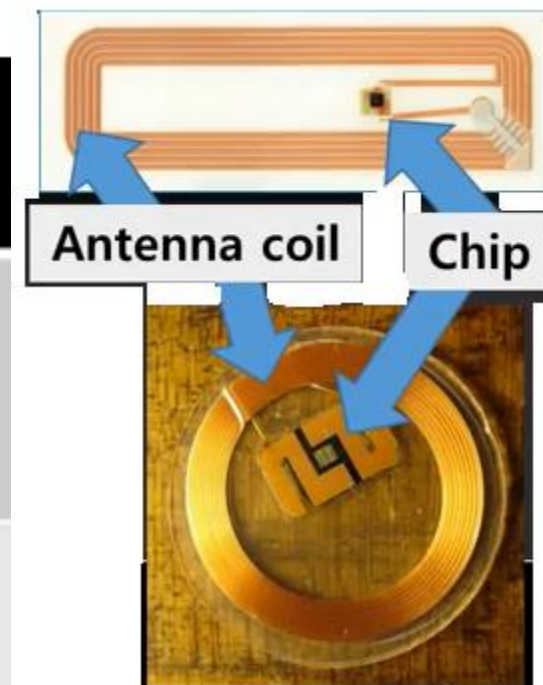
1. Bluetooth
2. Zigbee
3. Z-Wave
4. NFC (Near-Field Communication)
5. RFID
6. WiFi
7. PLC (Power Line Communication)
8. 2G/3G/LTE
9. Wibro/Mobile WiMax
10. Lora/NB-IoT/Sigfox

IoT Technologies-Sensors

Type	Measurement	Shape
Temperature/ Humidity sensor	Temperature: -40 ~ 80 °C Humidity: 0 ~ 100% RH	
Pressure sensor	SPD005G: 0 kPa ~ 35 kPa SPD100G: 0 kPa ~ 650 kPa	
Flow sensor	1 to 30 Liters/Minute	
Imaging sensor	Maximum 30 fps, 640 x 480 VGA resolutions (= 0.3 Megapixels)	
Ultrasonic sensor	2 ~ 400 cm non-contact measurement @ 40 Hz	

IoT Technologies-RFIDs

Type	Working frequency	Read range	Standard
Low frequency RFID	125 ~134.3 kHz	10~ 30 cm	ISO 14223 ISO/IEC 18000-2
High frequency RFID	13.56 MHz	10 cm ~ 1 m	ISO 15693 ECMA-340, ISO/IEC 18092 NFC (Near Field Communication)
Ultra-high Frequency RFID	860 ~ 960 MHz	12 m	ISO 18000-63





IoT Devices Platform

	Arduino Uno	Raspberry Pi 3 Model B	Beaglebone Black
Category	Microcontroller	Single-board micro computer	Single-board micro computer
SoC/CPU	16 MHz ATmega 328	<ul style="list-style-type: none">Broadcom BCM2837 SoC1.2 GHz ARM Cortex-A53 Quad-core @ 700 MHz	<ul style="list-style-type: none">Sitara AM33581 GHz ARM Cortex-A8 Single core @ 1000 MHz + Dual PRU @ 200 MHz
Memory	2 KB SRAM / 32 KB Flash	1 GB LPDDR2 / Micro SDHC support	512 MB DDR3 / 4GB Micro SDHC
I/O	14 (Digital GPIO) 6 (10-bit analog Input)	40 (Digital GPIO), 4 USB 2.0	69 GPIO 4 UART Serial, 8 PWM
Size	68.6 x 53.4 mm, 25 g	85.60 x 56.5 mm, 45 g	86.40 x 53.3 mm, 39.68 g



IoT Standardization Organization

- **Open Connectivity Foundation (OCF):** <https://openconnectivity.org/>
 - Primarily led by Consumer Electronics manufacturers
 - Standardizes short range unlicensed spectrum technologies such as Wi-Fi and Bluetooth and tests interoperability
 - More than 300 member companies including Samsung, LG, Sony, Haier, ZTE
- **oneM2M:** <http://www.onem2m.org/>
 - Led by telcos and telecommunication equipment manufacturers
 - Standardizes cellular communication technology to cover distant areas
 - More than 200 members consisting of AT&T, KT, SKT, LGU+, NTT, Docomo, Orange, Verizon, and Telus



Technologies similar to IoT

- USN (Ubiquitous Sensor Networks)
- M2M (Machine-to-Machine)
- IoE (Internet of Everything)
- Cloud of Things
- Web of Things
- IoV (Internet of Vehicles)



IoT Use Cases

IoT Use Cases-Smart Thermostat

- Nest - Learning Thermostat
 - A device that intelligently controls heating and cooling by learning the user's schedule and the season change
 - Nest warms up the house as the user gets out of bed. If the user is not in home, then it gets itself to an Eco temperature to save energy
 - The user can adjust the temperature from smartphone before heading to home.
 - Google acquired Nest for US\$3.2 billion in January 2014



IoT Use Cases-Smart Healthcare



Fitness Coach



Fitness Tracking



Improve posture



Improve eating behavior

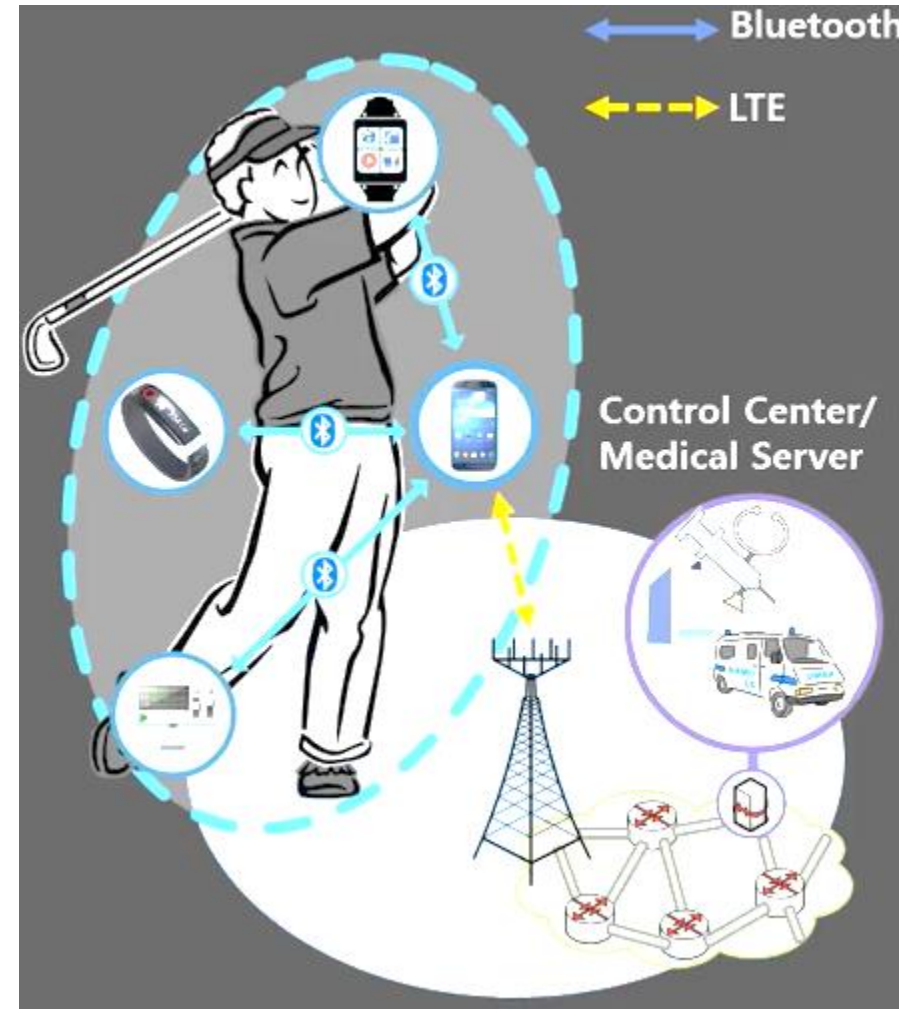
Wearable Devices

- Smart electronic devices that can be worn on the body as accessories
- Collect information about the environment or sense changes in the body
- Bluetooth allows wearable devices to be paired with a smartphone
- A user can send texts, get emails, and even make calls without a smartphone
- Example
 - Fitbit, Jawbone, Galaxy Gear/Fit, Pebble Watch, Apple Watch, Google glass



Wearable Devices

- Wearable devices can be used to detect biometric information
 - Shoes
 - Watch
 - Glasses
 - Belt
 - Pacer, etc





Smart Bus (1/3)

- Guide for Bus Arrival Time

Map of Seoul, Korea



420 routes for 7967 buses

Seoul Bus App & Bus Arrival Information



새로운 기능

v3.1.2

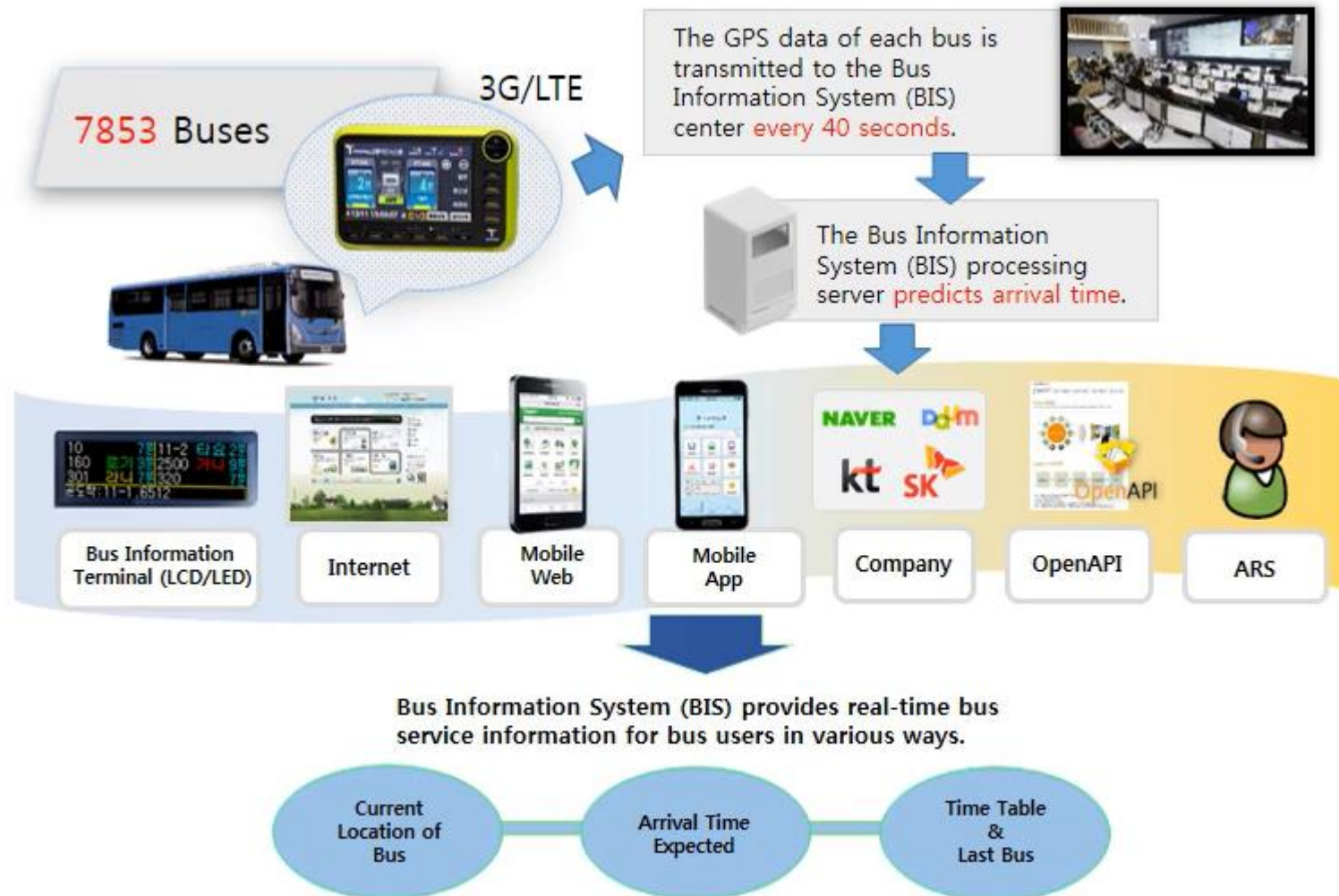
- 도착시간 자동 카운트다운 표시 (더보기 - 설정 에서 끝
수 있습니다.)

- 버그 수정 및 기타



Smart Bus (2/3)

- Bus Information System





Smart Bus (3/3)

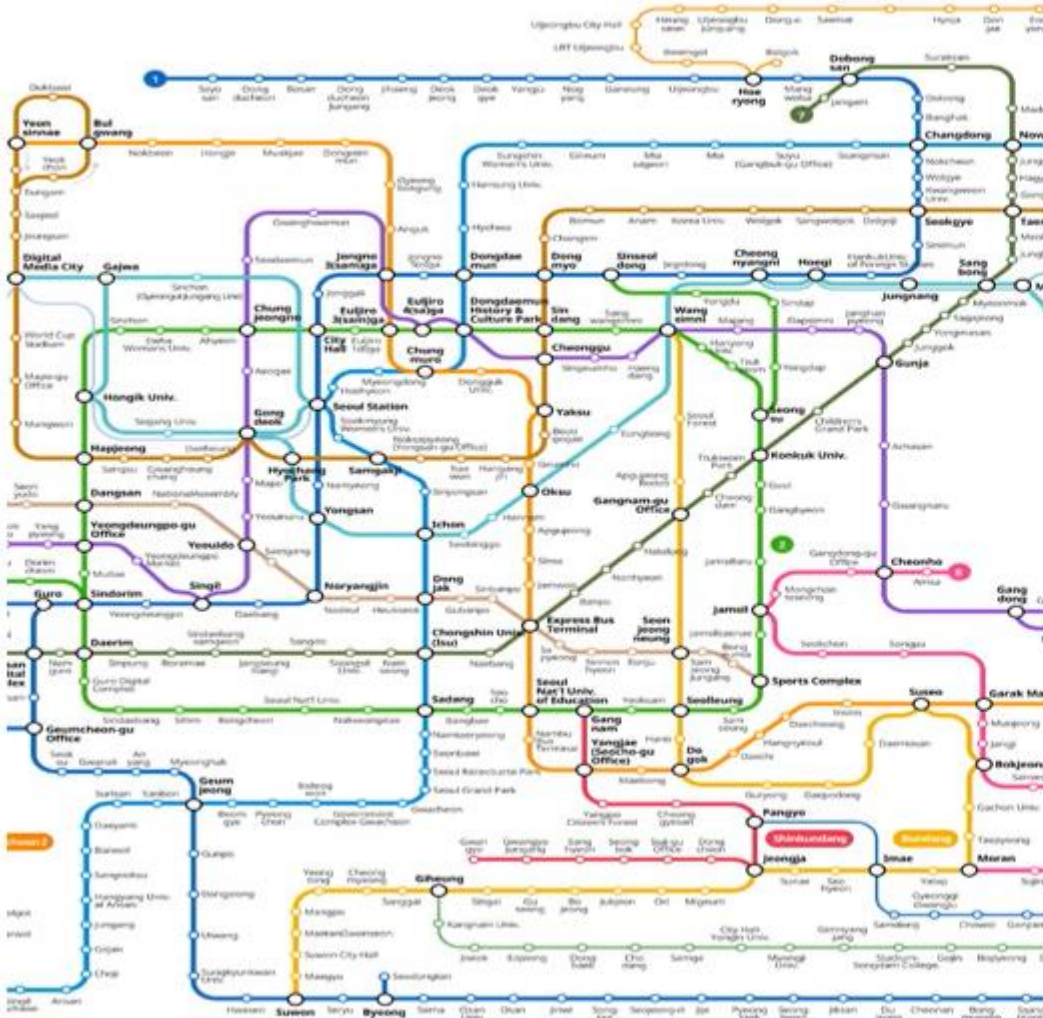
- Bus Routes in Ningbo



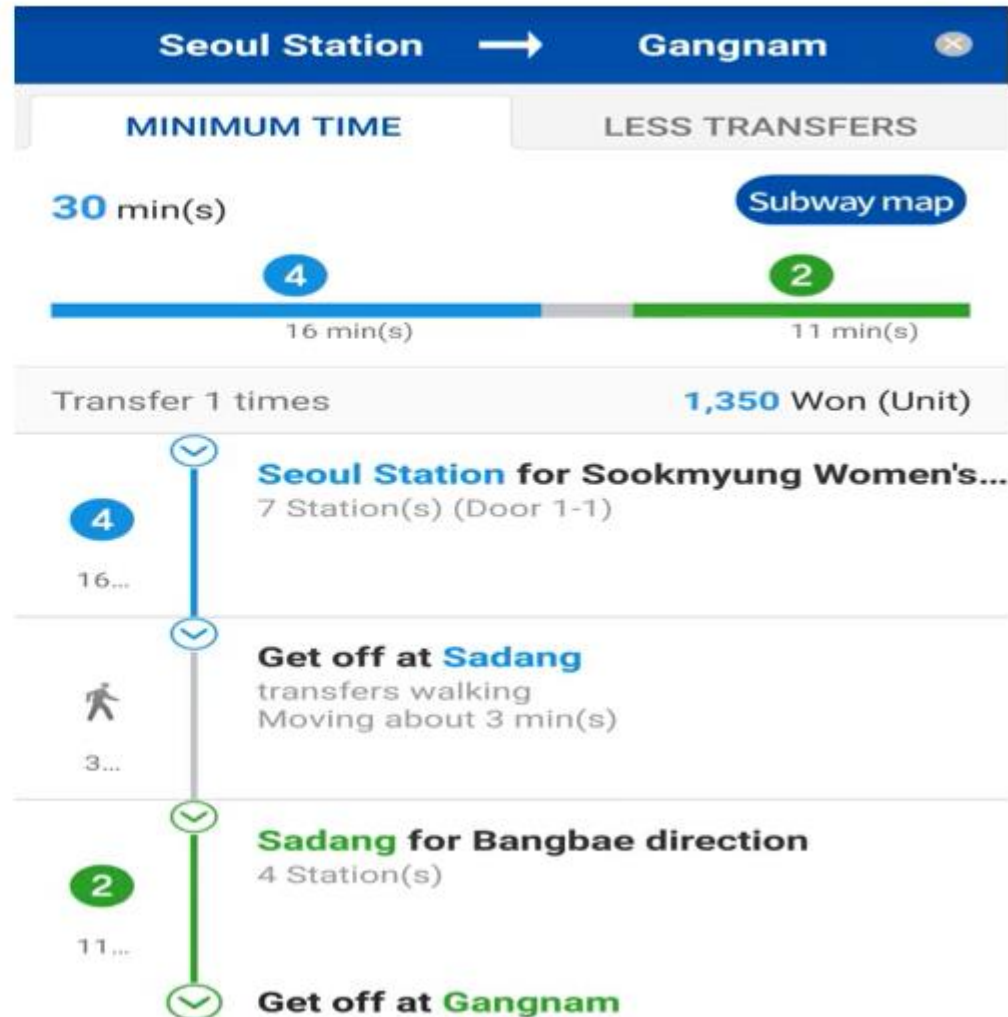


Smart Subway

Seoul Subway Map

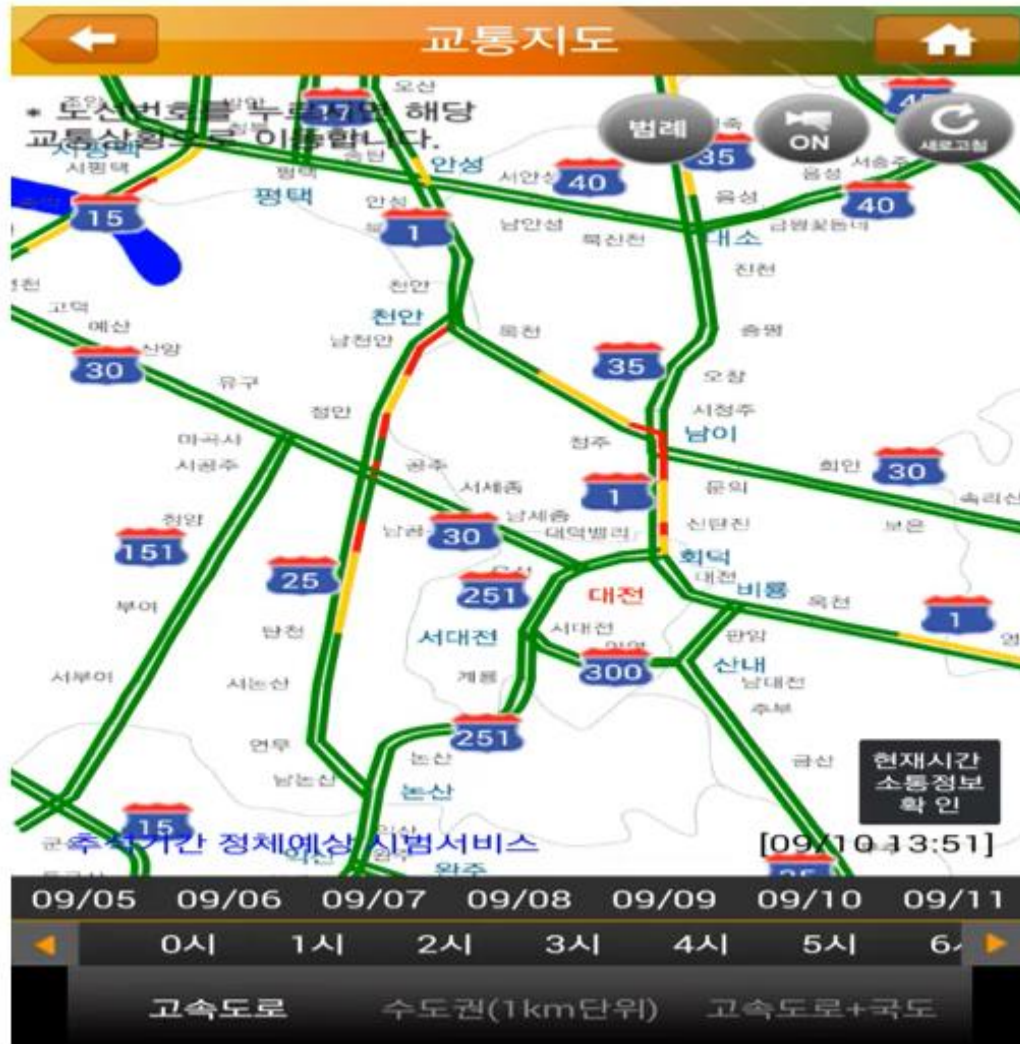


Smart Transfer



Smart Highway

Highway Traffic Congestion Monitoring

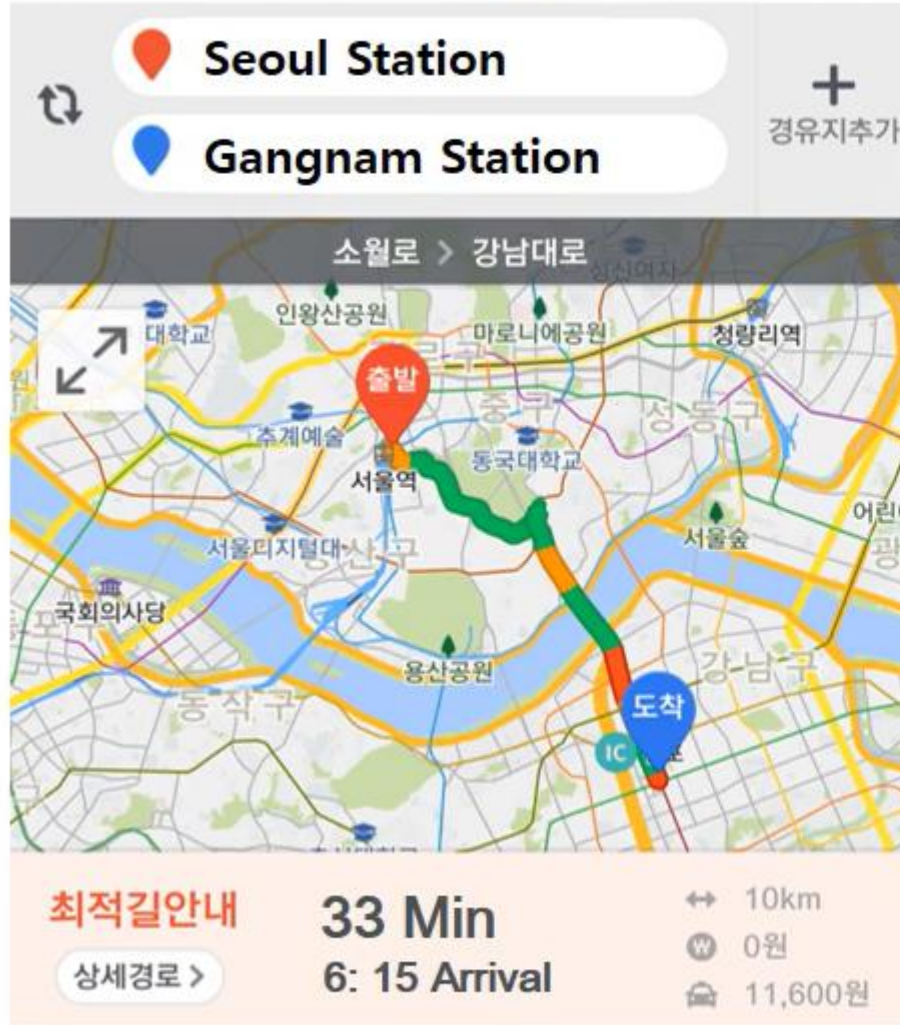


CCTVs show Highway Traffic condition



Smart Navigation

Guide route reflecting real-time traffic



Provide real-time traffic information





Self-driving Car



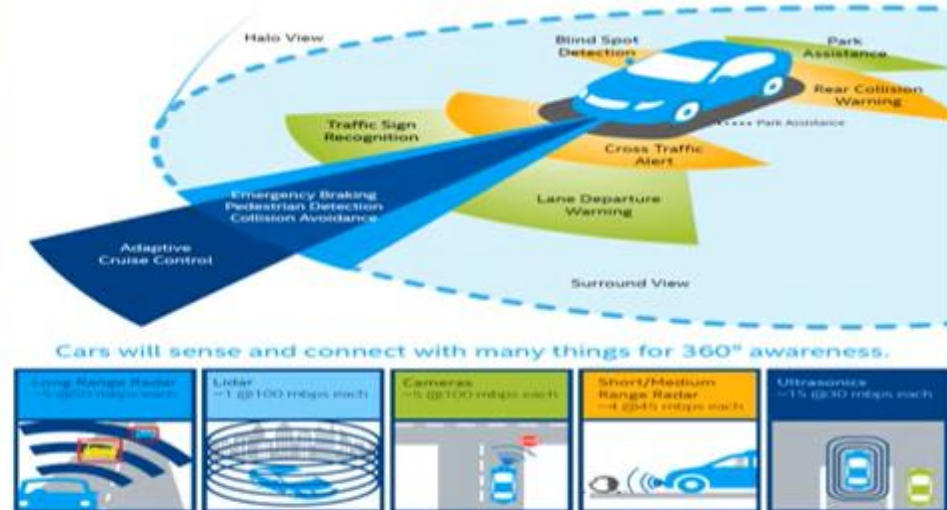
Self-driving Car- Google



Self-driving Car - Uber



Self-driving Technology - Volvo

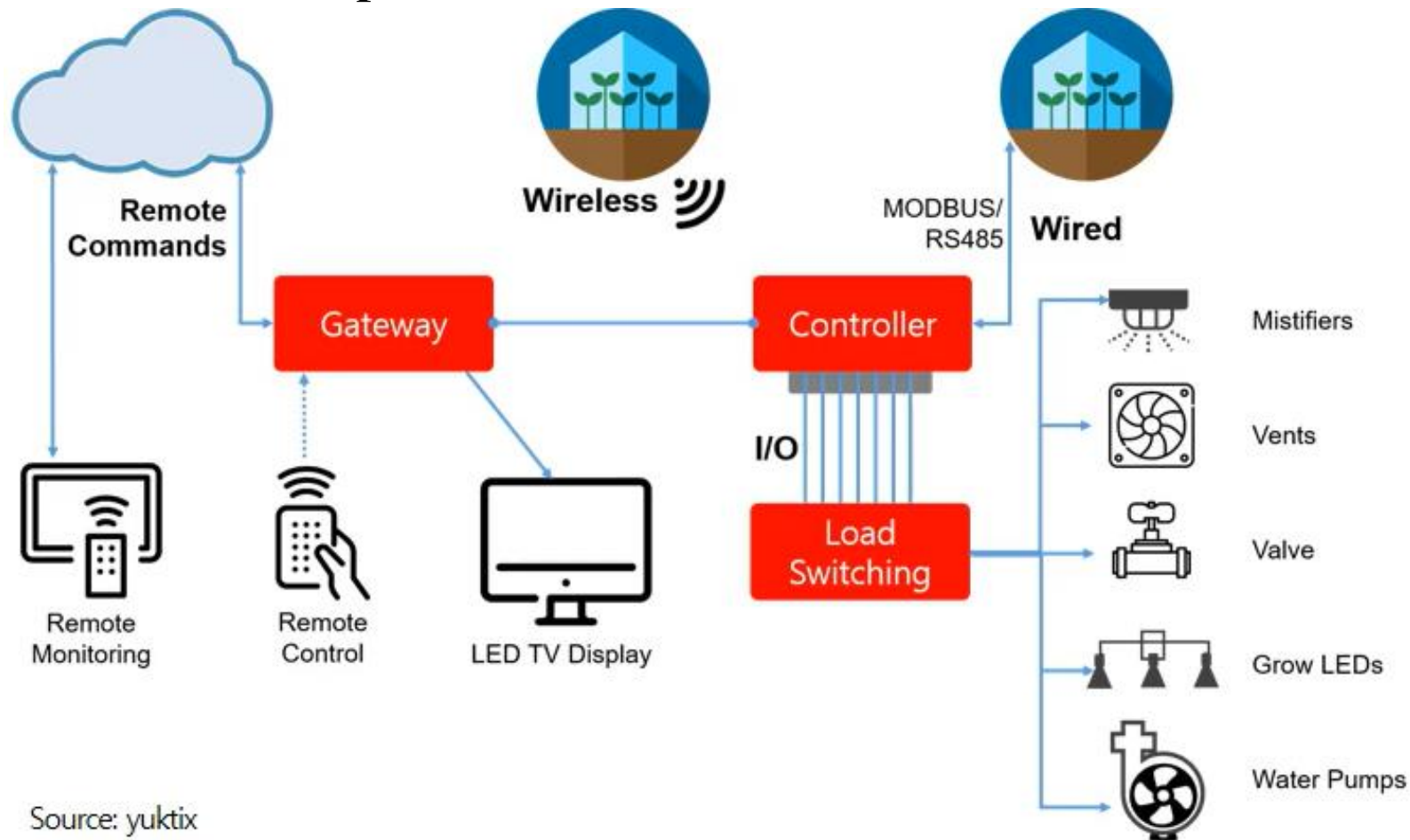


Self-driving Technology- Intel

Smart Farm

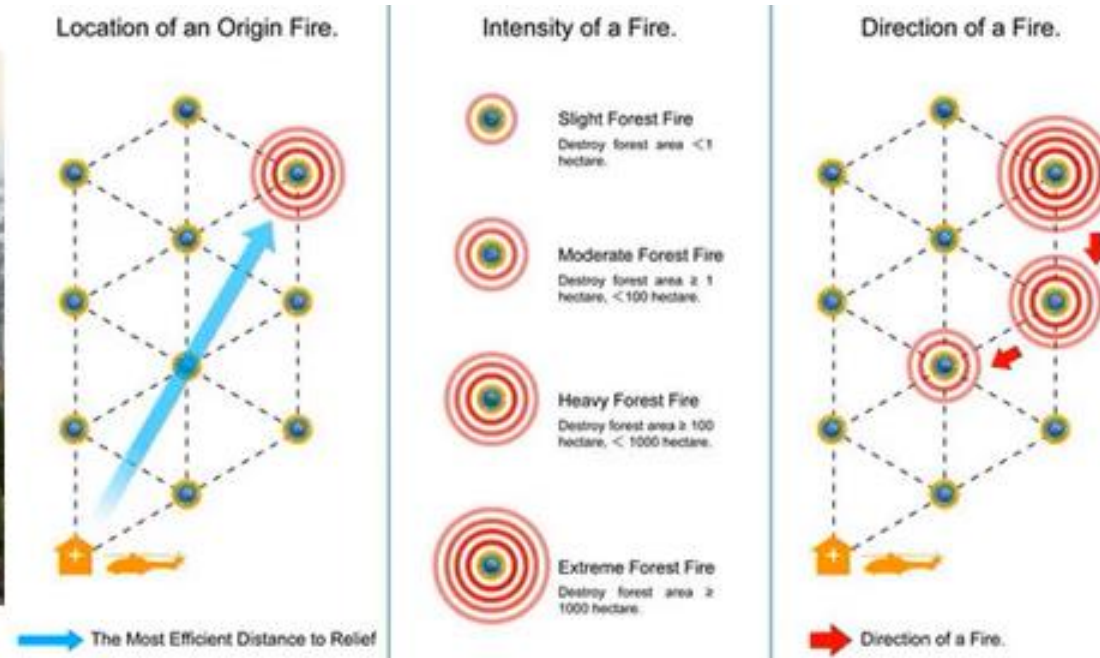
- **Smart Farm with IoT**

- Farm that utilizes IoT to remotely and automatically manage the growth environment of crops and livestock.



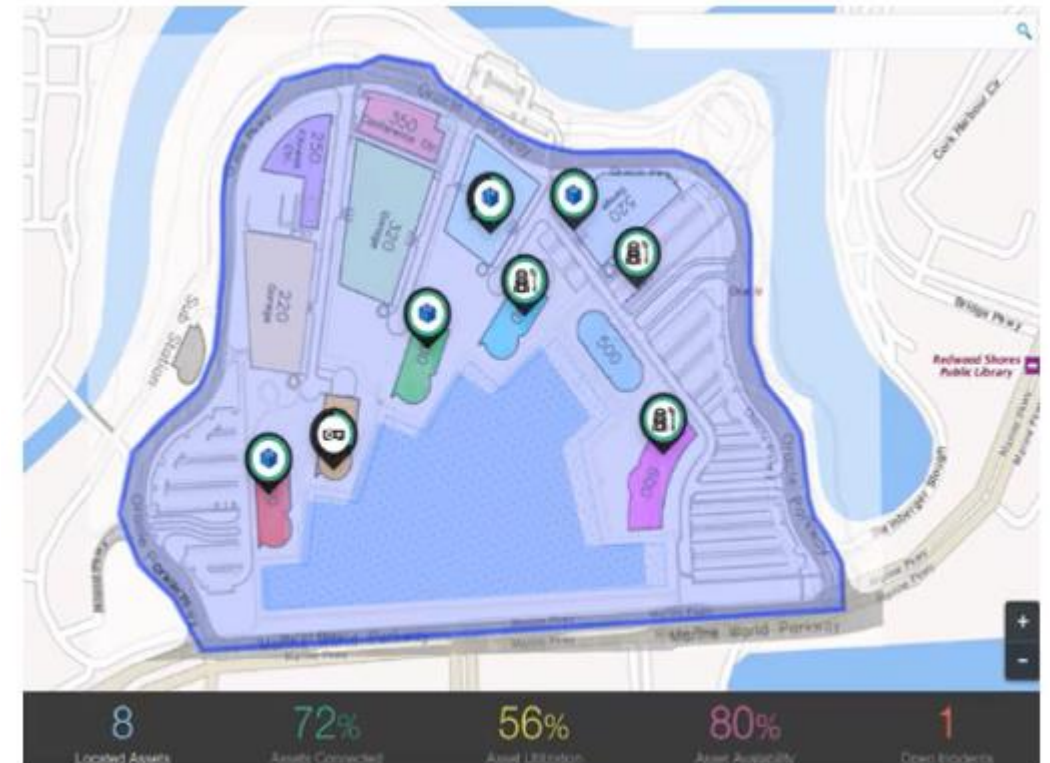
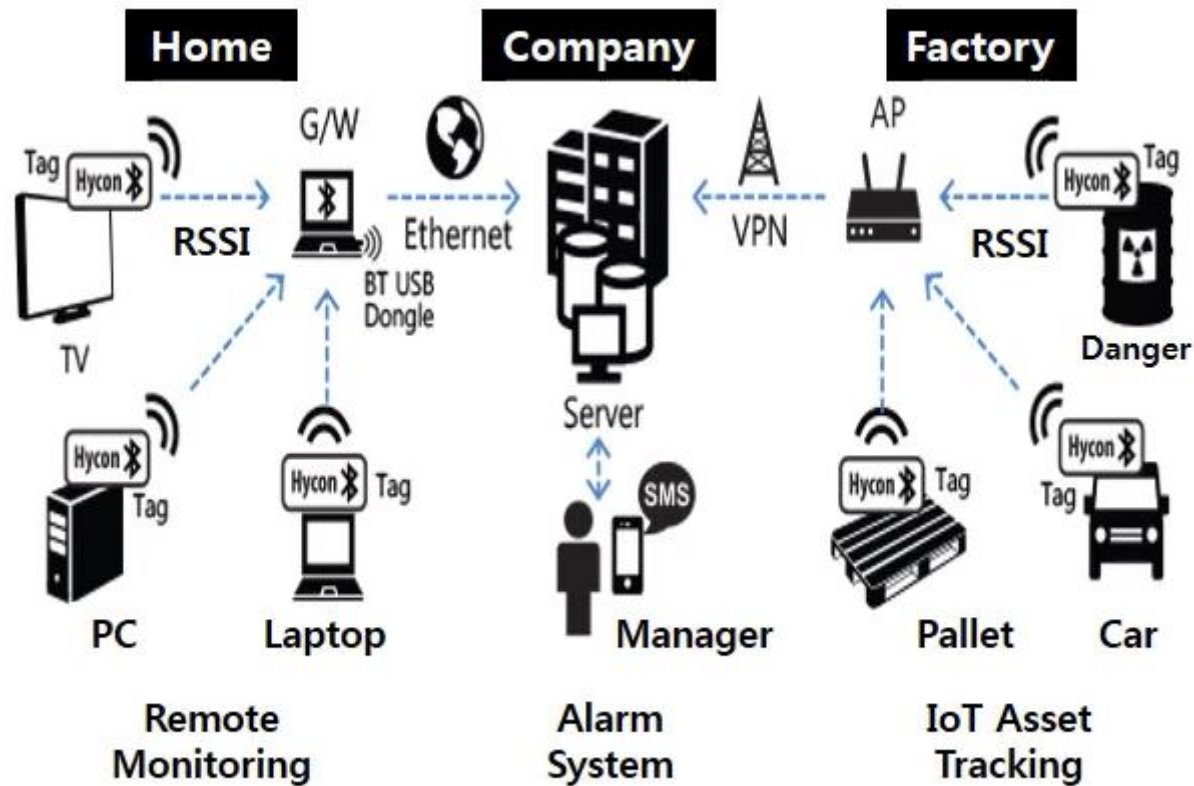
Forest Fire Monitoring

- Forest Fire Alarm using IoT sensors
 - Set the sensors every other fixed distance
 - Main goal
 - Detect a fire in the forest
 - Aware of the intensity, location, and direction of the fire



Asset Monitoring

- Track and Locate Assets Instantly using IoT





IoT with Google

- Google Home



<https://youtu.be/dpnxTXILS4s> and <https://www.youtube.com/watch?v=ysL4VPjaL0g>



IoT with AT&T

- Google Home





IoT with Rogers

- The Internet of Things: Technology with big results



rogers.com/DiscoverIoT

<https://youtu.be/TqRN7r7mGmk> and <https://www.youtube.com/watch?v=HrQH6ajVStc>



Security Problems

- Hackers demonstrated the first ransomware for IoT thermostats at DEF CON Aug 8, 2016 6:05 AM PT
- Ransomware-infected smart thermostats, it's no longer hypothetical. An attacker could crank up the heat and lock the IoT device until sweltering occupants paid a ransom to unlock it



- Jeep drivers can be HACK to DEATH: All you need is the car's IP address
- Hackers can connect to brakes, and engines over cellular networks By Iain Thomson in San Francisco 21 July 2015 at 19:11



- Hacked road sign curses Winnipeg drivers CBC News posted Oct 17, 2011 09:31 AM CT
- A roadside meant to caution Winnipeg drivers about deer was hacked on the weekend and given a much more direct, and profane message
- The flashing message. That once stated, "Be Alert for Deer" was reprogrammed with the message, "Slow the F-down"
- Brian Smiley, spokesman for Manitoba Public Insurance (MPI), said he's not sure how someone could have hacked into the security system



- IoT makes our lives more
 - Comfortable
 - Convenient
 - Safe
 - Enjoyable
 - Healthy ...
- IoT increases
 - Productivity
 - Efficiently in industry
- IoT is applied to various areas by combining **Artificial Intelligence** and **Big Data** technology.
- It is expected to be applied to new areas to improve our lives and industry in various fields.



References (1/4)

- IoT Development Kit

- Raspberry Pi
 - <https://www.raspberrypi.org/>
- Arduino
 - <https://www.arduino.cc/>
- ARTIK
 - <https://www.artik.io/>

- Self-driving Car

- Uber
 - <https://www.uber.com/blog/pittsburgh/pittsburgh-self-driving-uber/>
- Intel
 - <https://www.intel.com/conetnt/www/us/en/automotive-overview.html>
 - <https://www.blogs.intel.com/iot/2015/08/02/intellignet-driving-experience-a-ride-with-intel-inter-of-things/>

- Forest Fire Alarm

- Forest Wizard
- <http://www.yankodesign.com/2014/07/07/the-forest-fire-alarm/>

References (2/4)

- Smart Thermostat

- Nest
 - <https://nest.com/>

- Smart Health Care

- LUMOback
 - <https://www.kickstarter.com/projects/lumoback/lumoback-the-smart-posture-sensor/>
- HAPIform
 - <https://www.hapi.com/product/hapifork>
- IOFIT
 - <https://ccei.creativekorea.or.kr/daegu/case/caseDetail.do?rnum=8&no=162&storyList=story>

- Asset Monitoring

- Hycon
 - <http://www.hyconcard.com/hycon-series/>
- Oracle
 - https://cloud.oracle.com/ko_KR/iot-asset-monitoring-cloud/features/

- Smart Farm

- Yuktix
 - <http://www.yuktix.com/agriculture/#>
- Arirang NEWS
 - <https://www.youtube.com/watch?v=vBDT8JFZtdY>

References (3/4)

• IoT Cloud Software/Analytics Platforms

- Amazon AWS IoT: <https://www.aws.amazon.com/iot/>
- IBM Watson IoT : <https://www.ibm.com/internet-of-things/>
- Microsoft Azure IoT Hub : <https://www.microsoft.com/en-us/internet-of-things/>
- Apple IoT HomeKit : <https://developer.apple.com/jomekit/>
- Google Cloud Platform : <https://www.cloud.google.com/>
- KT IoTmakers : <https://www.iotmakers.olleh.com/>
- Samsung ARTIK Cloud : <https://www.artik.cloud/>
- IoT OCEAN : <https://www.iotocean.org/>
- Things+ : <https://www.thingsplus.net/>

• IoT Standardization Organization

- Open Connectivity Foundation (OCF)
 - <https://openconnectivity.org/>
- oneM2M
 - <https://www.onem2m.org/>



References (4/4)

- Google

- Google Home: <https://youtu.be/dpnxTXILS4s> and <https://www.youtube.com/watch?v=ysL4VPjaL0g>

- AT&T

- The Internet of Things with AT&T
- Explore the Internet of Things with AT&T

- Rogers

- The inter of things: Technology with big results

- Verizon

- Verizon Internet of Things
- Verizon Intelligent Lighting Solutions (Smart Street Lightening System)

- Telus

- TELUS shares how IoT improves everyday lives:

- Bell Canada

- Run your Business better with IoT Solutions from Bell
- Run your retail business better with IoT solutions from Bell



References (5/5)

- Smart Farm
 - Yuktix
 - <http://www.yuktix.com/agriculture/#>
 - Arirang NEWS
 - <https://www.youtube.com/watch?v=vBDT8JFZtdY>



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Thanks