Course Title
IoT Wireless & Cloud Emerging Technologies

❖ **Modules**

- ▪ 0. Introduction
- ▪ 1. IoT Business & Products
- ▪ 2. IoT Architecture & Technologies
- ▪ 3. IoT Networks
- ▪ 4. Wi-Fi & Bluetooth
- ▪ 5. Cloud Technology
- ▪ 6. IoT Bluetooth & Wi-Fi & AWS EC2 Project

Emerging Technologies:
From Smartphones to IoT to Big Data

IoT Wireless & Cloud Emerging Technologies

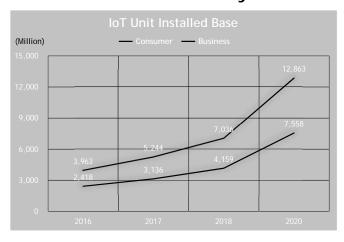**Prof. Jong-Moon Chung**

Yonsei University
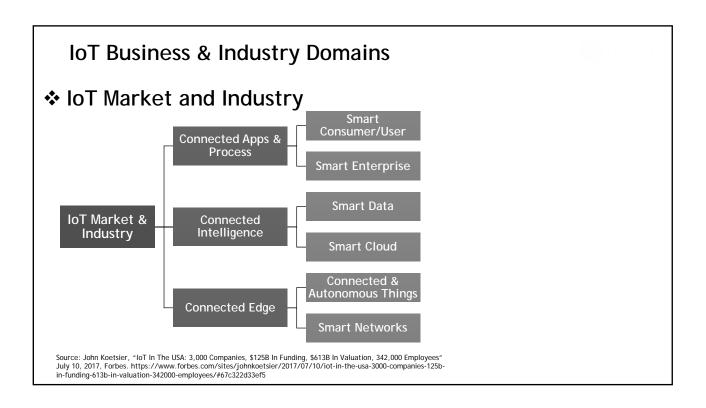
IoT Wireless & Cloud Emerging Technologies

❖ Modules

1. IoT Business & Products

2. IoT Architecture & Technologies

3. IoT Networks

4. Wi-Fi & Bluetooth

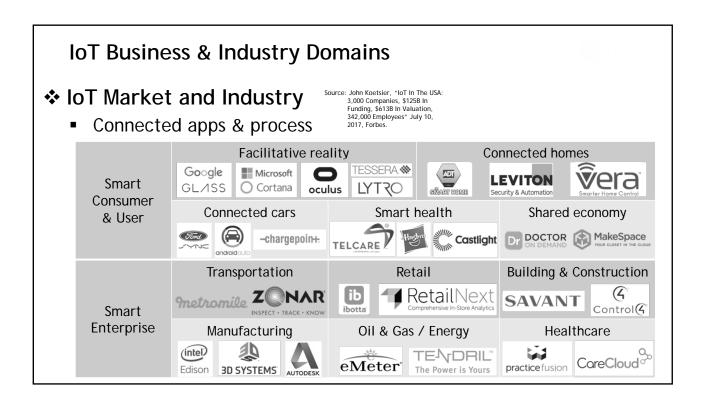5. Cloud Technology

6. IoT Bluetooth & Wi-Fi & AWS EC2 Project

IoT Business & Industry Domains

❖ IoT Market and Industry

Source: Rob van der Meulen, "Gartner Says 8.4 Billion Connected "Things" Will Be in Use in 2017, Up 31 Percent From 2016," Feb. 7, 2017, Gartner. https://www.gartner.com/newsroom/id/3598917

IoT Business & Industry Domains

❖ **IoT Market and Industry**

```
                    ┌──────────────────────┐
                    │   Smart              │
          ┌─────────┤   Consumer/User      │
  Connected Apps &  ├──────────────────────┤
  Process           │   Smart Enterprise   │
                    └──────────────────────┘

                    ┌──────────────────────┐
                    │   Smart Data         │
IoT Market &  ──────┤ Connected  ──────────┤
Industry            │ Intelligence         │
                    │   Smart Cloud        │
                    └──────────────────────┘

                    ┌──────────────────────┐
                    │   Connected &        │
          ┌─────────┤   Autonomous Things  │
  Connected Edge    ├──────────────────────┤
                    │   Smart Networks     │
                    └──────────────────────┘
```

Source: John Koetsier, "IoT In The USA: 3,000 Companies, $125B In Funding, $613B In Valuation, 342,000 Employees"
July 10, 2017, Forbes. https://www.forbes.com/sites/johnkoetsier/2017/07/10/iot-in-the-usa-3000-companies-125b-
in-funding-613b-in-valuation-342000-employees/#67c322d33ef5

IoT Business & Industry Domains

❖ **IoT Market and Industry**

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3,000 Companies, $125B In
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2017, Forbes.

- Connected apps & process

	Facilitative reality				Connected homes		
Smart Consumer & User	Google GLASS	Microsoft Cortana	oculus	TESSERA LYTRO	ADT SMART HOME	LEVITON Security & Automation	vera Smarter Home Control
	Connected cars			Smart health		Shared economy	
	Ford SYNC	android auto	–chargepoint–	TELCARE	Hasbro Castlight	Dr DOCTOR ON DEMAND	MakeSpace YOUR CLOSET IN THE CLOUD
Smart Enterprise	Transportation			Retail		Building & Construction	
	metromile	ZONAR INSPECT · TRACK · KNOW		ibotta	RetailNext Comprehensive In-Store Analytics	SAVANT	Control4
	Manufacturing			Oil & Gas / Energy		Healthcare	
	intel Edison	3D SYSTEMS	AUTODESK	eMeter	TENDRIL The Power is Yours	practice fusion	CareCloud

IoT Products & Services

❖ IoT Products & Services

- ▪ IoT companies
  - Atmel Corporation
  - Android Things
  - Samsara
  - ZingBox
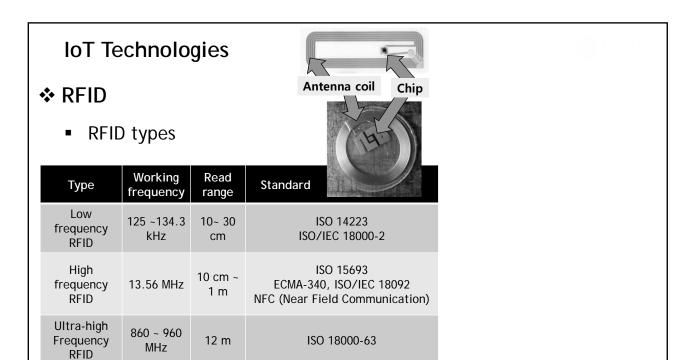 - Uber
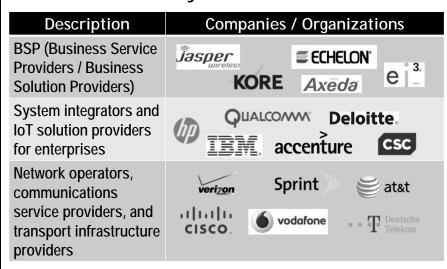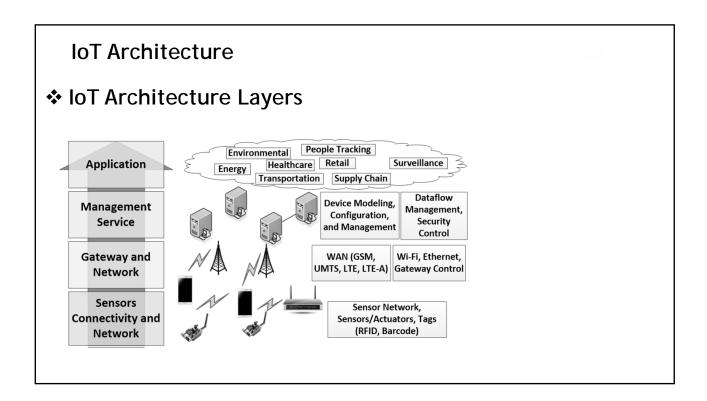
IoT Products & Services

❖ IoT & M2M Ecosystem

Description	Companies / Organizations
BSP (Business Service Providers / Business Solution Providers)	Jasper wireless, ECHELON, KORE, Axeda, ei³
System integrators and IoT solution providers for enterprises	hp, QUALCOMM, Deloitte, IBM, accenture, CSC
Network operators, communications service providers, and transport infrastructure providers	verizon, Sprint, at&t, CISCO, vodafone, Deutsche Telekom

IoT Architecture

❖ IoT Architecture Layers

IoT Technologies

❖ Sensors

Type	Measurement	Shape
Temperature/ Humidity sensor	Temperature: -40 ~ 80 ℃ 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

Antenna coil   **Chip**

❖ RFID

- RFID types

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 Technologies

❖ Arduino

- Arduino Product Types
  - Arduino Uno R3 (Entry and General purpose)

  - Arduino Yun (IoT)
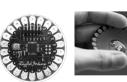
  - Arduino Lilypad (Wearable)
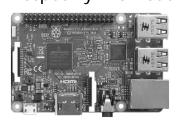
IoT Technologies

❖ Raspberry Pi

- Raspberry Pi 3 Model B

- Raspberry Pi Zero W

❖ BeagleBoard

- Beaglebone Black
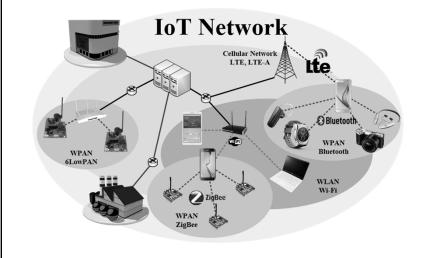
IoT Technologies

❖ IoT Device Platforms

|	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	• Broadcom BCM2837 SoC • 1.2 GHz ARM Cortex-A53 Quad-core @ 700 MHz	• Sitara AM3358 • 1 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 Wireless Networks
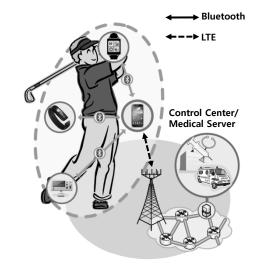
❖ IoT Network Architecture

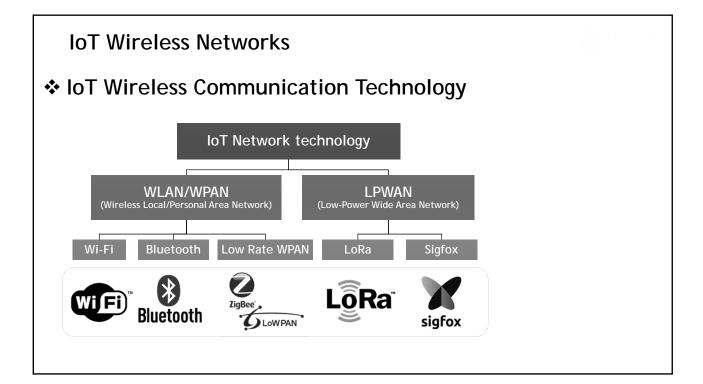## IoT Wireless Networks

❖ Wearable IoT Networks

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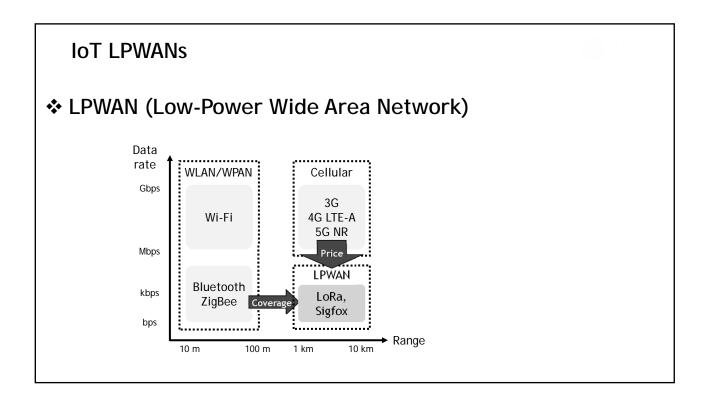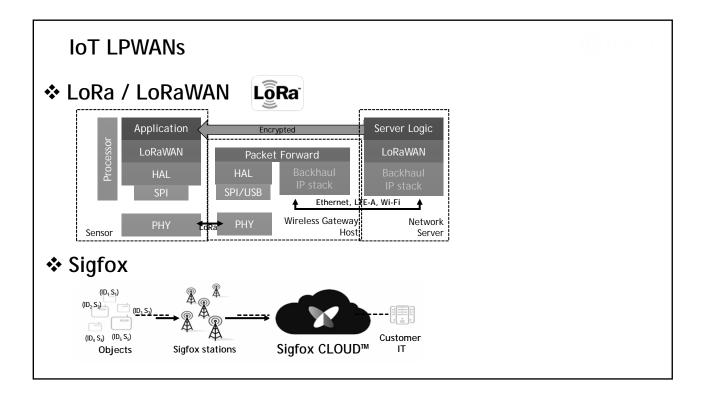 - Shoes
  - Watch
  - Glasses
  - Belt
  - Pacer, etc.

IoT Wireless Frequency Bands
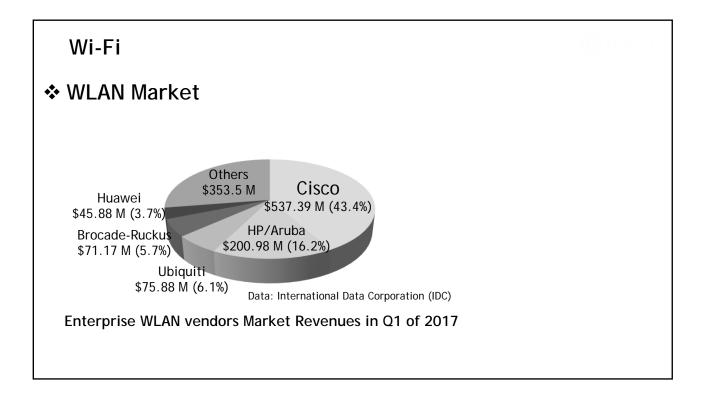
❖ ISM (Industrial, Scientific and Medical) Band

Frequency range		Bandwidth	Center Frequency	Availability
6.765 MHz	6.795 MHz	30 kHz	6.780 MHz	Subject to local acceptance
13.553 MHz	13.567 MHz	14 kHz	13.560 MHz	Worldwide
26.957 MHz	27.283 MHz	326 kHz	27.120 MHz	Worldwide
40.660 MHz	40.700 MHz	40 kHz	40.680 MHz	Worldwide
433.050 MHz	434.790 MHz	1.74 MHz	433.920 MHz	local acceptance
902.000 MHz	928.000 MHz	26 MHz	915.000 MHz	local acceptance
2.400 GHz	2.500 GHz	100 MHz	2.450 GHz	Worldwide

IoT Wireless Networks

❖ IoT Wireless Communication Technology

IoT LPWANs

❖ LPWAN (Low-Power Wide Area Network)

IoT LPWANs

❖ LoRa / LoRaWAN

❖ Sigfox
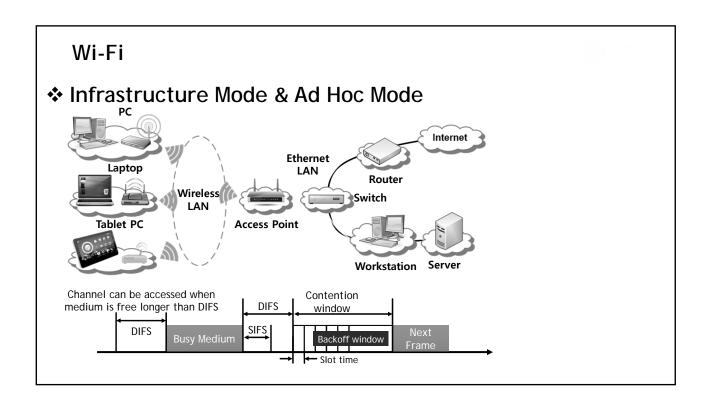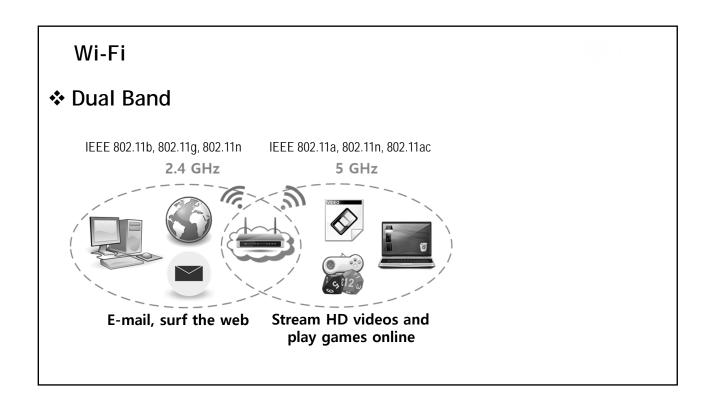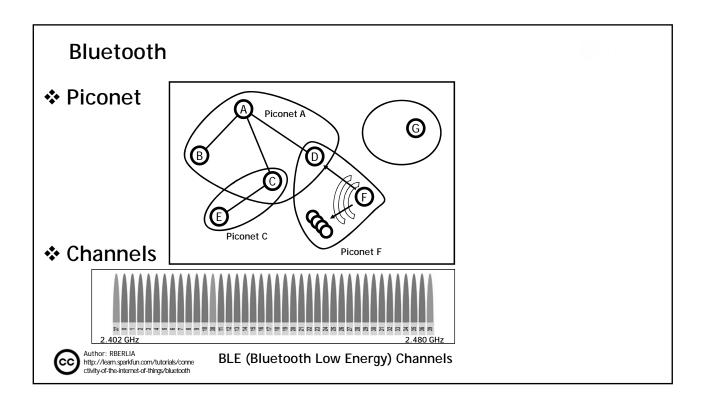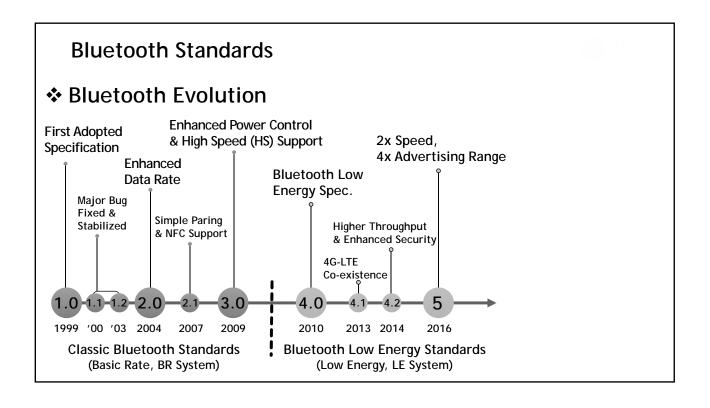
IoT & Mobile Communication Networks

❖ 3GPP & IoT

Rel. 8	Rel. 9	Rel. 10	Rel. 11	Rel. 12	Rel. 13	Rel. 14
LTE Cat 1						
LTE-MTC		NIMTC	SIMTC	LTE Cat 0		
	LTE MTC (Machine Type Communication)				LTE Cat M1 (eMTC)	
LP-WAN				NB-cIoT / NB-LTE	NB-IoT	
	Low Power Wide Area Network					
GSM-MTC		NIMTC	SIMTC		EC-GSM-IoT	
	Global System for Mobile Communication - MTC					

Wi-Fi

❖ WLAN Market

Others $353.5 M

Cisco $537.39 M (43.4%)

Huawei $45.88 M (3.7%)

Brocade-Ruckus $71.17 M (5.7%)

HP/Aruba $200.98 M (16.2%)

Ubiquiti $75.88 M (6.1%)

Data: International Data Corporation (IDC)

Enterprise WLAN vendors Market Revenues in Q1 of 2017

Wi-Fi

❖ Infrastructure Mode & Ad Hoc Mode

Wi-Fi

❖ Dual Band

IEEE 802.11b, 802.11g, 802.11n   IEEE 802.11a, 802.11n, 802.11ac

2.4 GHz   5 GHz

E-mail, surf the web   **Stream HD videos and play games online**

Bluetooth

❖ Piconet

❖ Channels

2.402 GHz   2.480 GHz

BLE (Bluetooth Low Energy) Channels

Bluetooth Standards

❖ Bluetooth Evolution

First Adopted
Specification

Enhanced Power Control
& High Speed (HS) Support

2x Speed,
4x Advertising Range

Enhanced
Data Rate

Bluetooth Low
Energy Spec.

Major Bug
Fixed &
Stabilized

Simple Paring
& NFC Support

Higher Throughput
& Enhanced Security

4G-LTE
Co-existence

1.0	1.1	1.2	2.0	2.1	3.0	4.0	4.1	4.2	5
1999	'00	'03	2004	2007	2009	2010	2013	2014	2016

Classic Bluetooth Standards
(Basic Rate, BR System)

Bluetooth Low Energy Standards
(Low Energy, LE System)

Bluetooth Standards

❖ Bluetooth Spec. Evolution

Specifications	1.1	1.2	2.0 + EDR	2.1 + EDR	3.0 +HS	4.0	5
Adopted	2002	2005	2004	2007	2009	2010	2016
Max. Transmission Rate (↑ : BR, ↓ : LE)	723.1 kbps	723.1 kbps	2.1 Mbps	3 Mbps	25 Mbps	25 Mbps / 1 Mbps	25 Mbps / 2 Mbps
Standard WPAN Range	10 m	10 m	10 m	10 m	10 m	50 m	50 m
Improved Pairing (without a PIN)				Yes	Yes	Yes	Yes
Improved Security		Yes	Yes	Yes	Yes	Yes	Yes
NFC Support			Yes	Yes	Yes	Yes	Yes

Cloud Market Analysis

❖ 2017 Cloud Infrastructure Services

Top Ten Reasons to Leverage SaaS for Your Business
Posted on August 19, 2016 by Nathaniel Lewis in Best Practices, Cloud Best Practices

Figure 9. SaaS Most Highly Deployed Global Cloud Service by 2018

Source: Cisco Global Cloud Index, 2013–2018

Reference :https://solutionsreview.com/devops/2016/08/19/top-ten-reasons-leverage-saas-business/

Cloud Companies & Services

❖ **Top Cloud Service Providers**

- Amazon Web Service **aws**

- Microsoft **Microsoft**

- IBM **IBM**

- Google **Google Cloud Platform**

Clouds

❖ **Cloud Service Models**

Application

Cloud Clients
Web Browser
Mobile App, Thin Client

Platform

Infrastructure

SaaS
CRM, E-mail
Games, Virtual Desktop

PaaS
Database, Web Server
Deployment tools

IaaS
Virtual Machines, Servers
Storage, Networks

- SaaS: Software as a Service
- PaaS: Platform as a Service
- IaaS: Infrastructure as a Service

IaaS, PaaS, SaaS

❖ **IaaS (Infrastructure as a Service)**

IaaS, PaaS, SaaS

❖ **PaaS (Platform as a Service)**

IaaS, PaaS, SaaS

❖ **SaaS (Software as a Service)**

IoT & Mobile Cloud Technology

Bluetooth Scan Project

App. 1
BLE Scanner
Available at Play store

App. 2
Bluetooth 4.0 Scanner
Available at Play store

② Packet Information
- Device name
  - Gear S3, n/a etc.
- Device MAC address
  - C4:31:CC:07:62:2D
- Connection
  - Bond means connection

Bluetooth Scan Project

❖ Bluetooth Scan in iPhone
- RSSI Plot
  - Shows real-time RSSI and averaged RSSI

Wi-Fi Analysis Project

Network Analyzer
Available at Google Play Store and Apple App Store

AWS EC2 Project

Build a solution
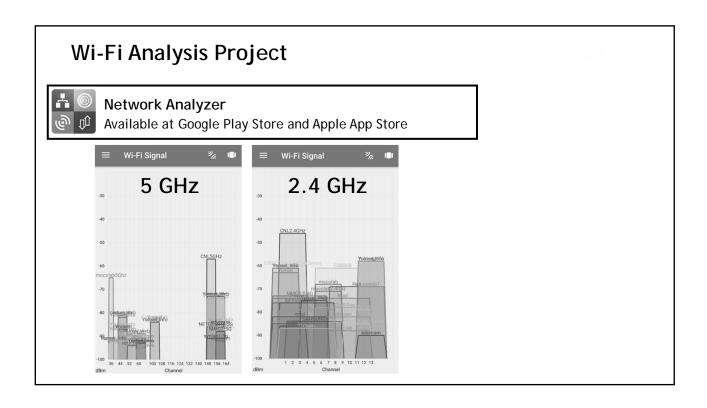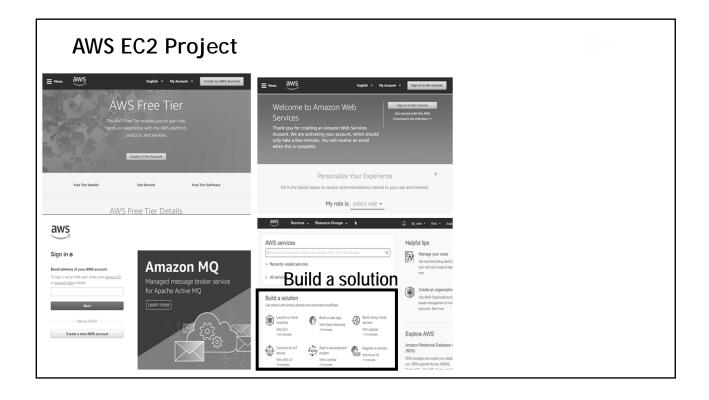
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