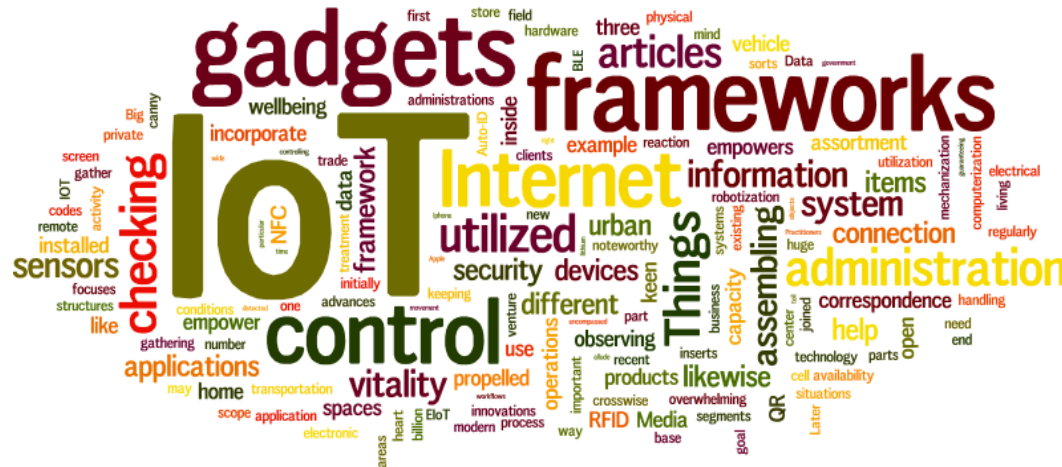


CS578: Internet of Things

Introduction to IoT



Dr. Manas Khatua

Assistant Professor

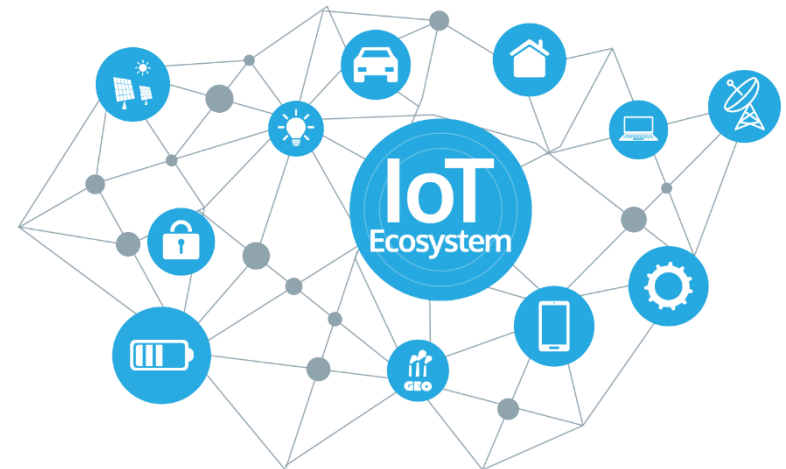
Dept. of CSE, IIT Guwahati

E-mail: manaskhatua@iitg.ac.in

"I have no special talent. I am only passionately curious." – **Albert Einstein**

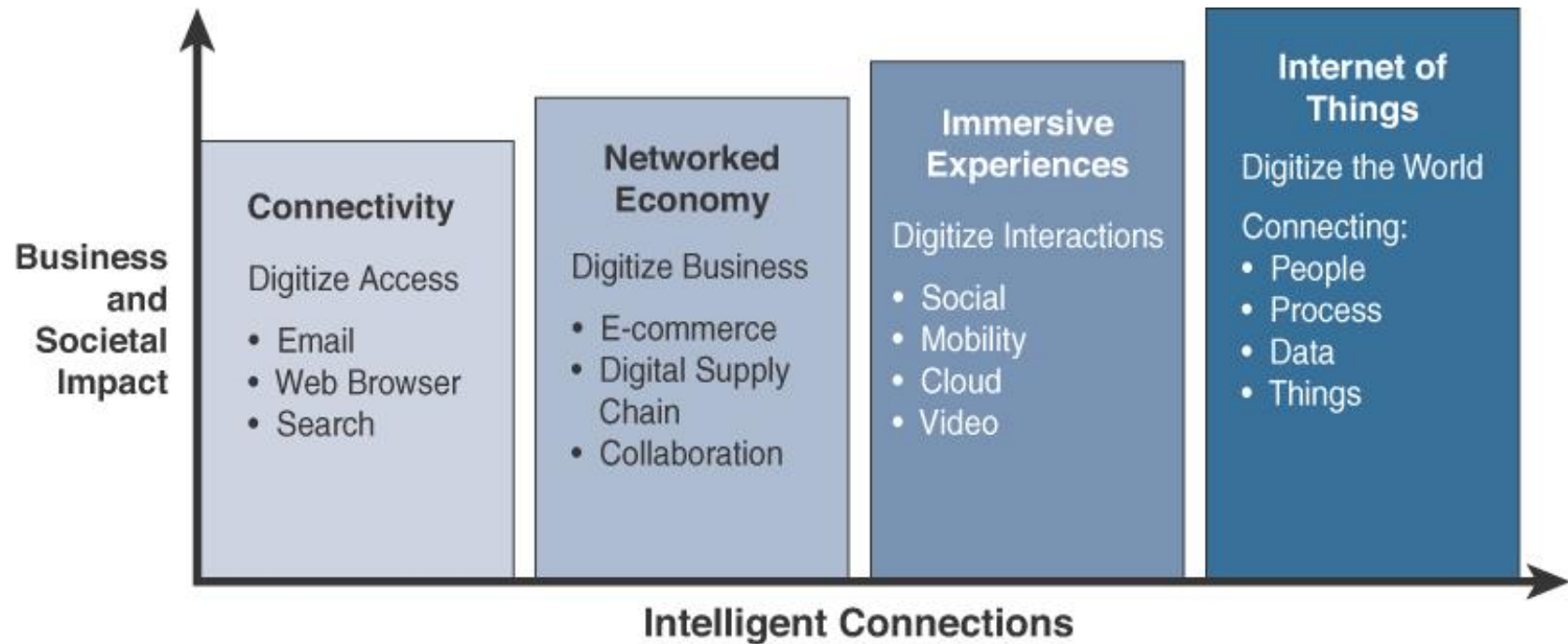
What is IoT?

- The **Internet of Things (IoT)** is the network of physical objects – devices, vehicles, buildings and other items embedded with electronics, software, sensors, and network connectivity – that enables these objects to collect and exchange data.
- The basic premise and goal of IoT is to “**connect the unconnected**”
- IoT is a **technology transition** in computer network
 - allow us to **sense** and **control** the physical world by making objects smarter and connecting them through an intelligent network



Genesis of IoT

- The term "**Internet of things**" was likely coined by **Kevin Ashton** of Procter & Gamble, later MIT's Auto-ID Center, in 1999.
- He told: "In the twentieth century, computers were brains without senses — they only knew what we told them." IoT is changing this paradigm; in the twenty-first century, **computers are sensing things for themselves!**



Evolutionary Phases of the Internet

Where is IoT?



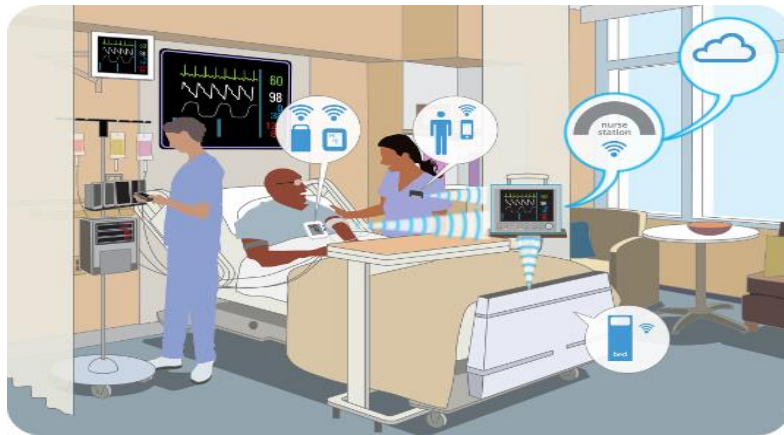
Wearable
Tech Devices



Smart Appliances



It's everywhere!

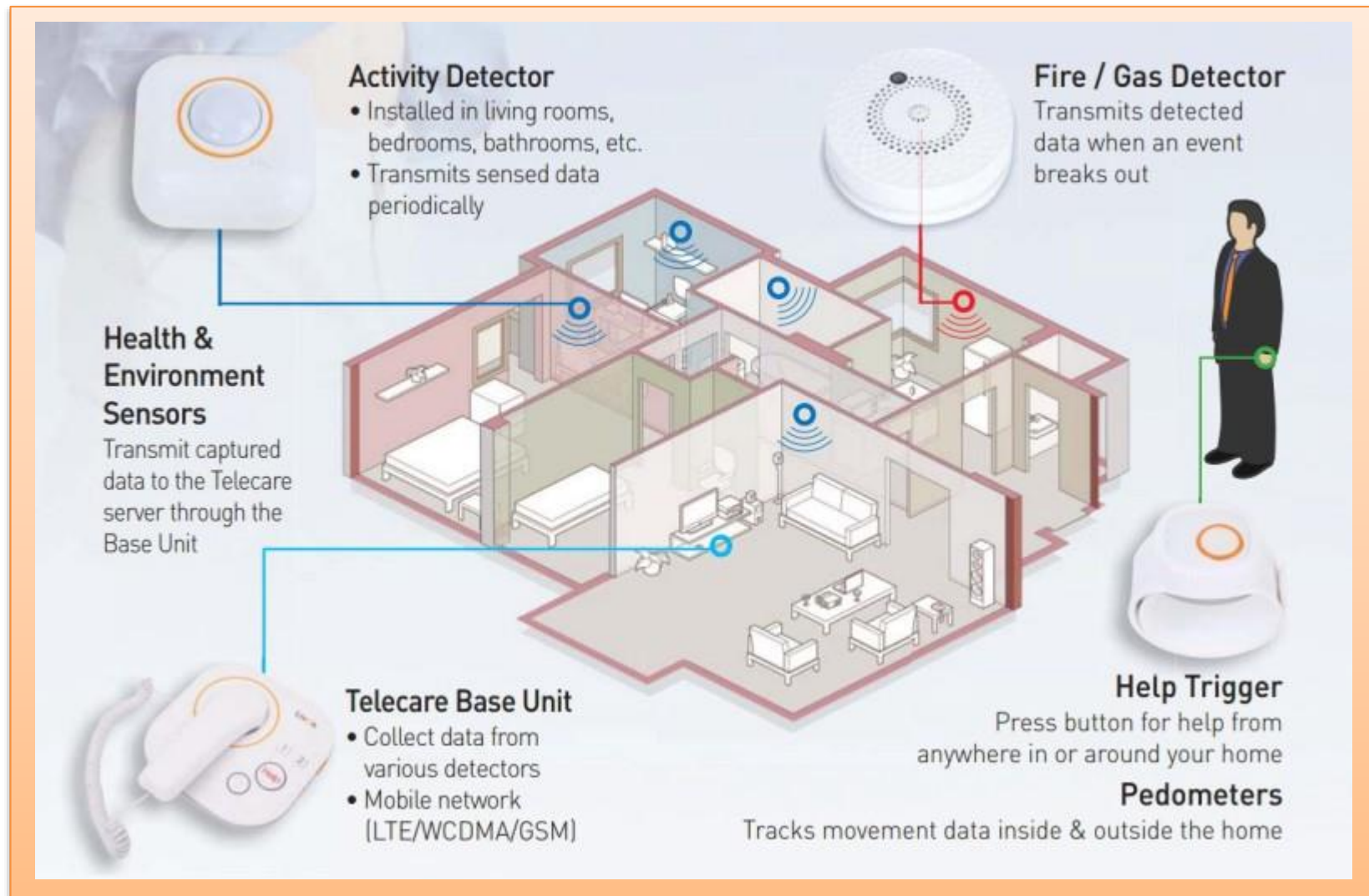


Healthcare



Industry Automation
and Monitoring

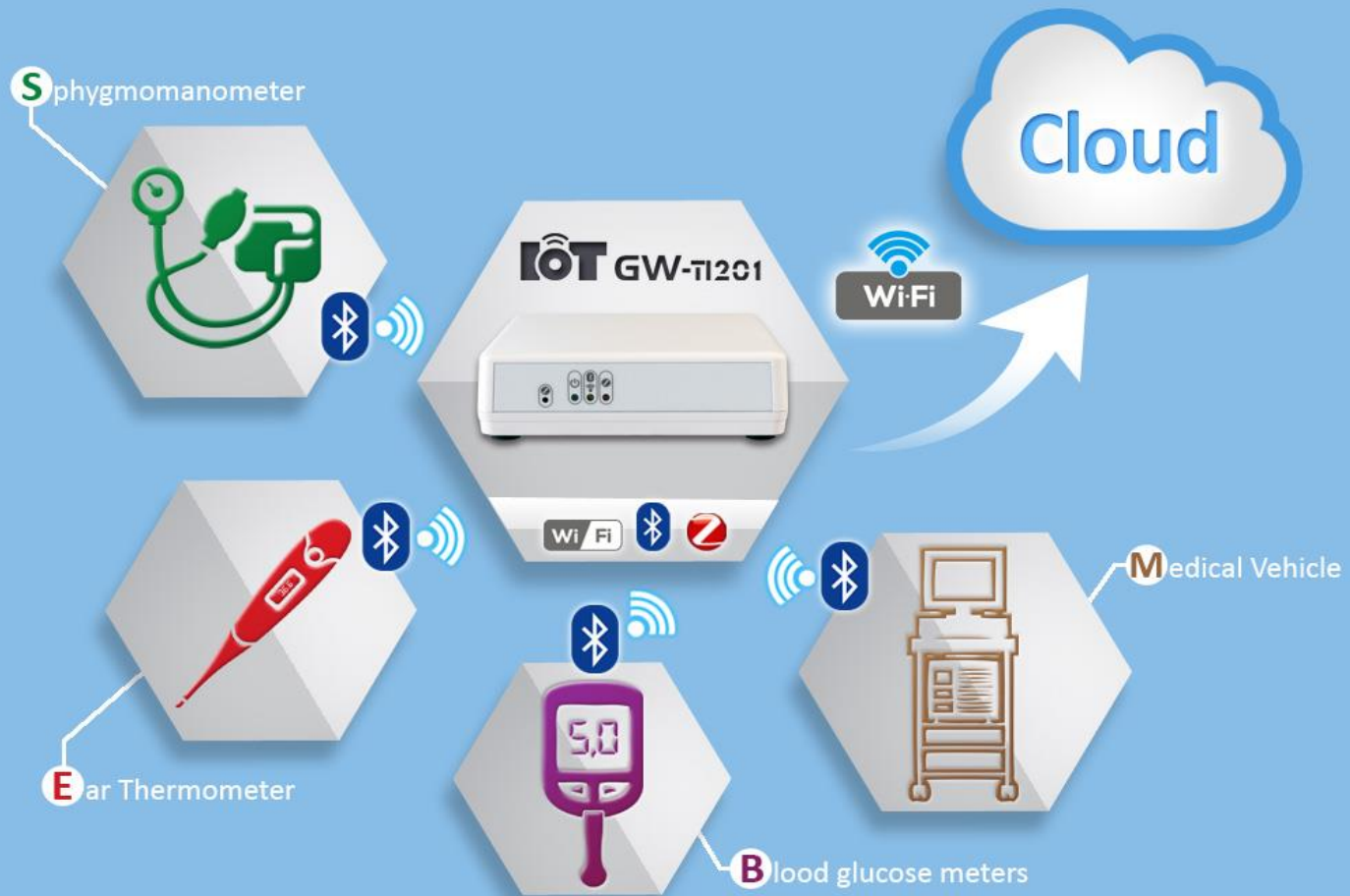
Smart Home



Source: <https://medium.com/@globalindnews/north-america-accounted-for-major-share-in-the-global-smart-home-healthcare-market-in-2015-cc9cc1974ac5>

Smart Healthcare

Smart Healthcare - Medical Application



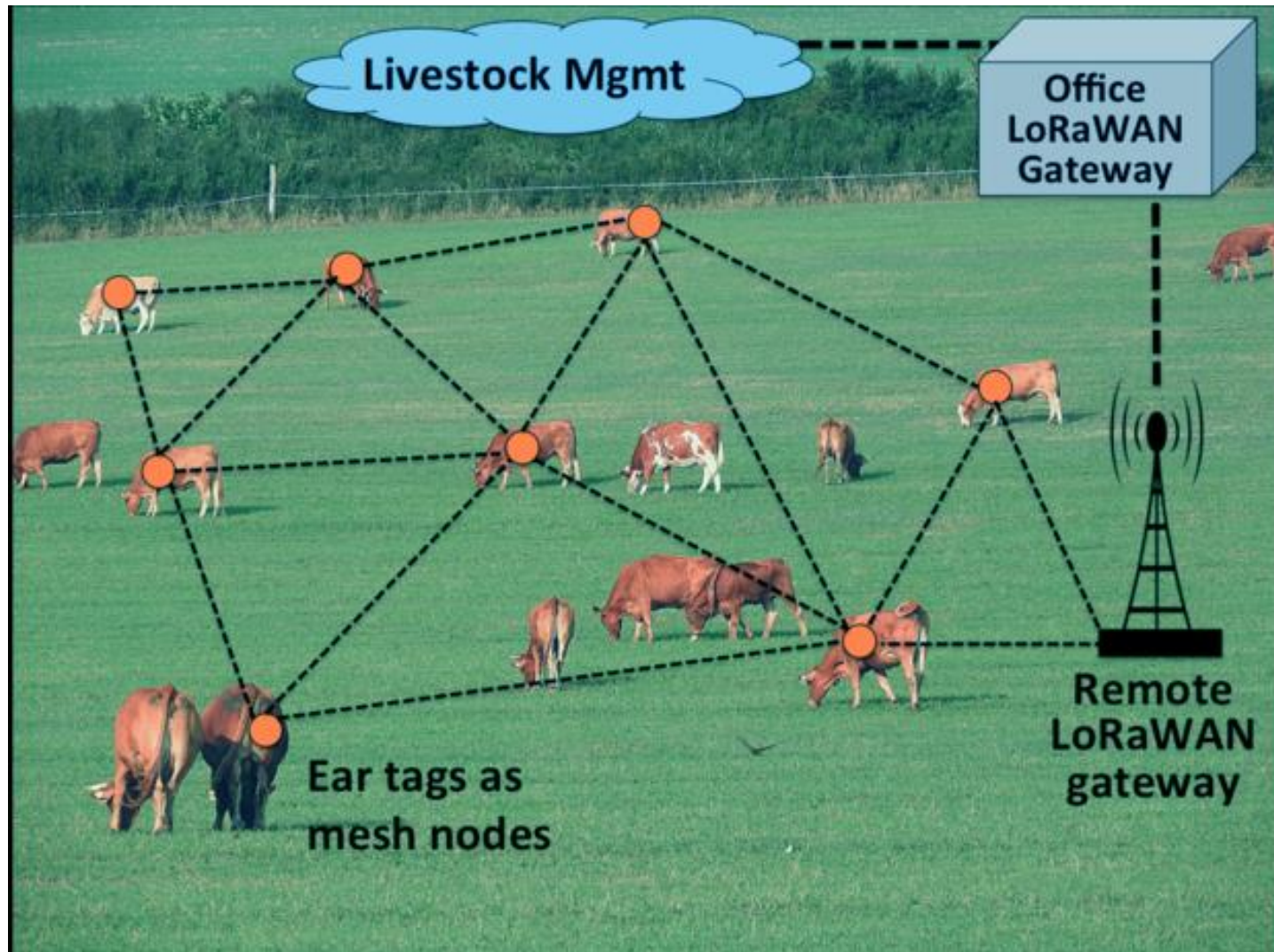
Source: <http://iot.fit-foxconn.com/>

Smart Agriculture



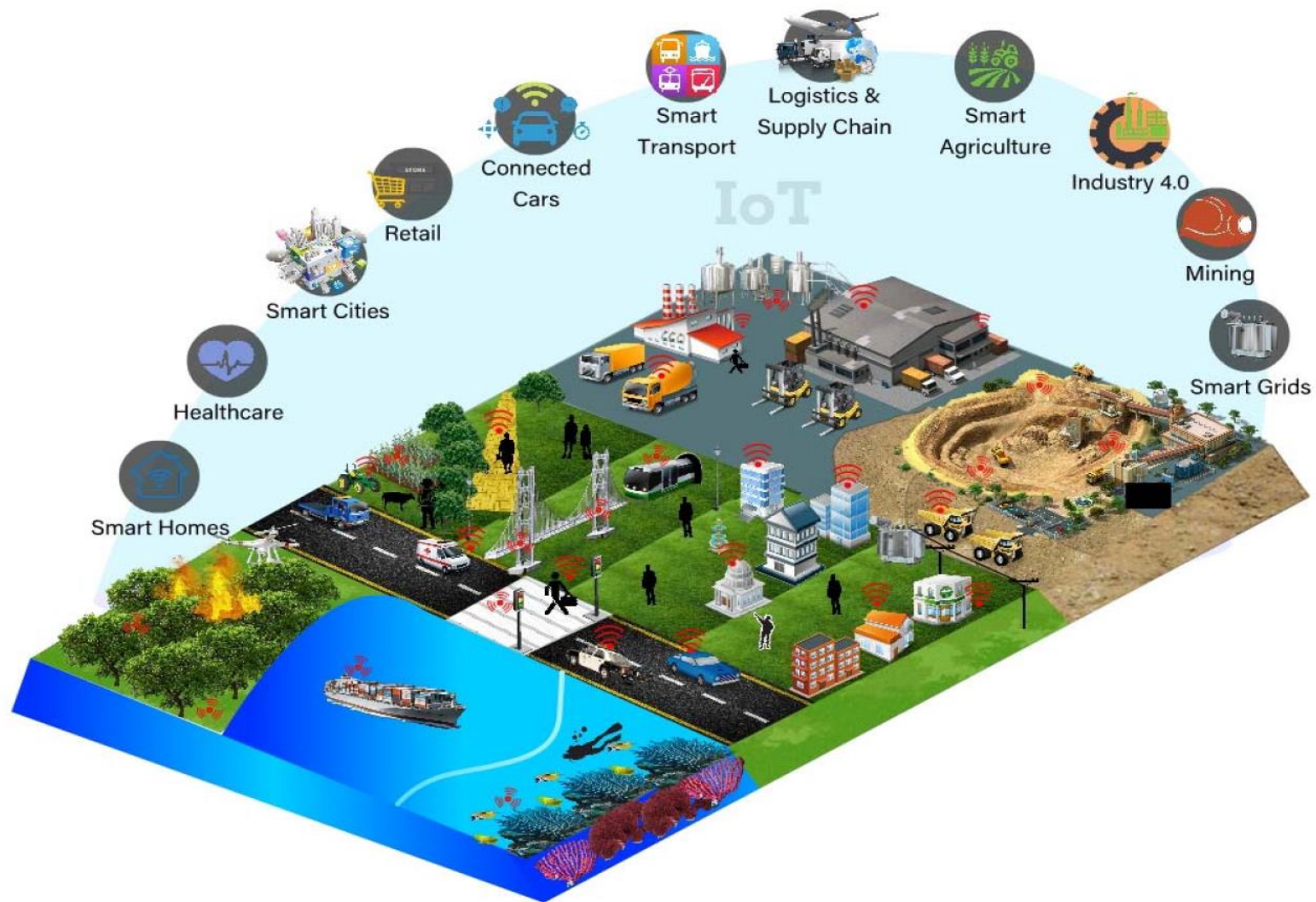
Source: <https://in.pinterest.com/pin/515380751093603767/?lp=true>

Livestock Management



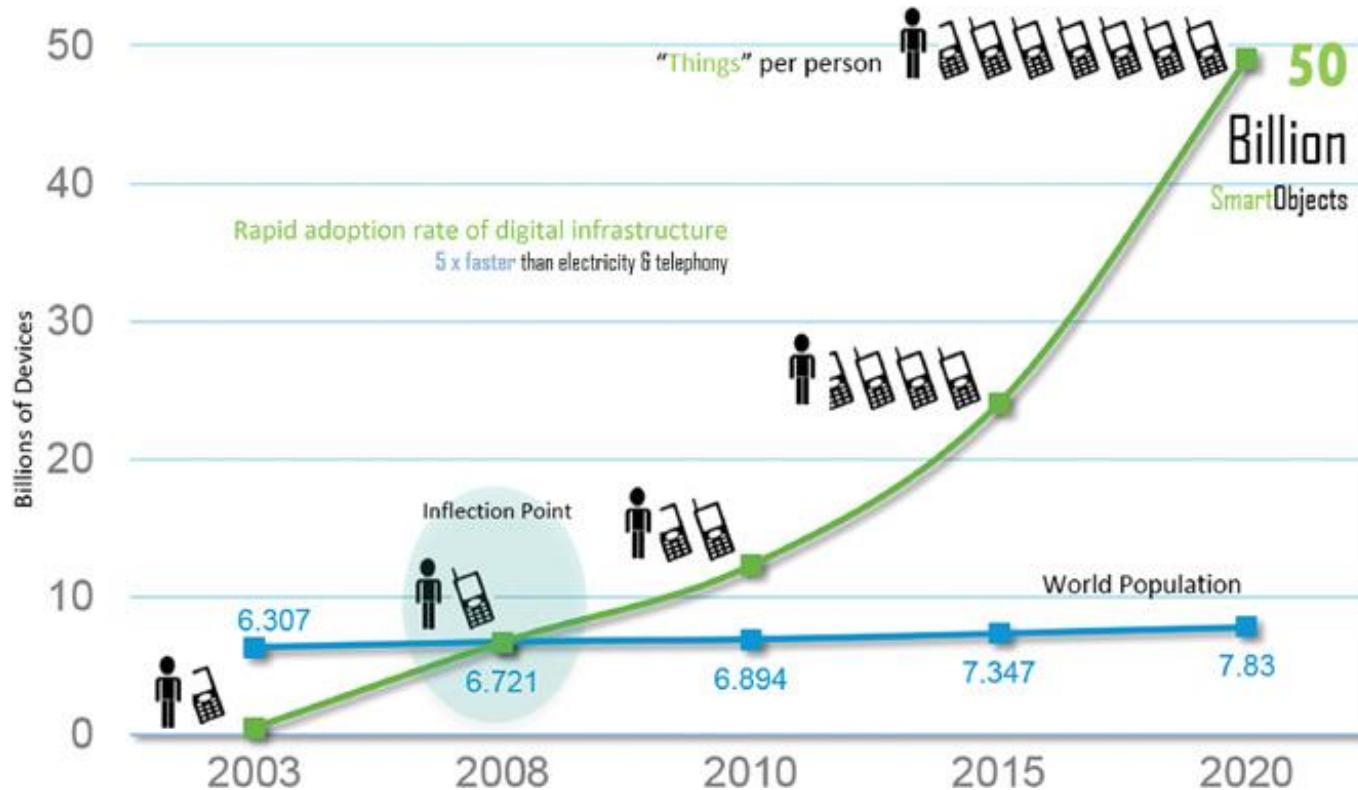
Source: <https://data-flair.training/blogs/iot-applications-in-agriculture/>

Many More



Source: Rajiv Ranjan *et. al.*, "Integrating the IoT and Data Science" *IEEE Cloud Computing*, 2018

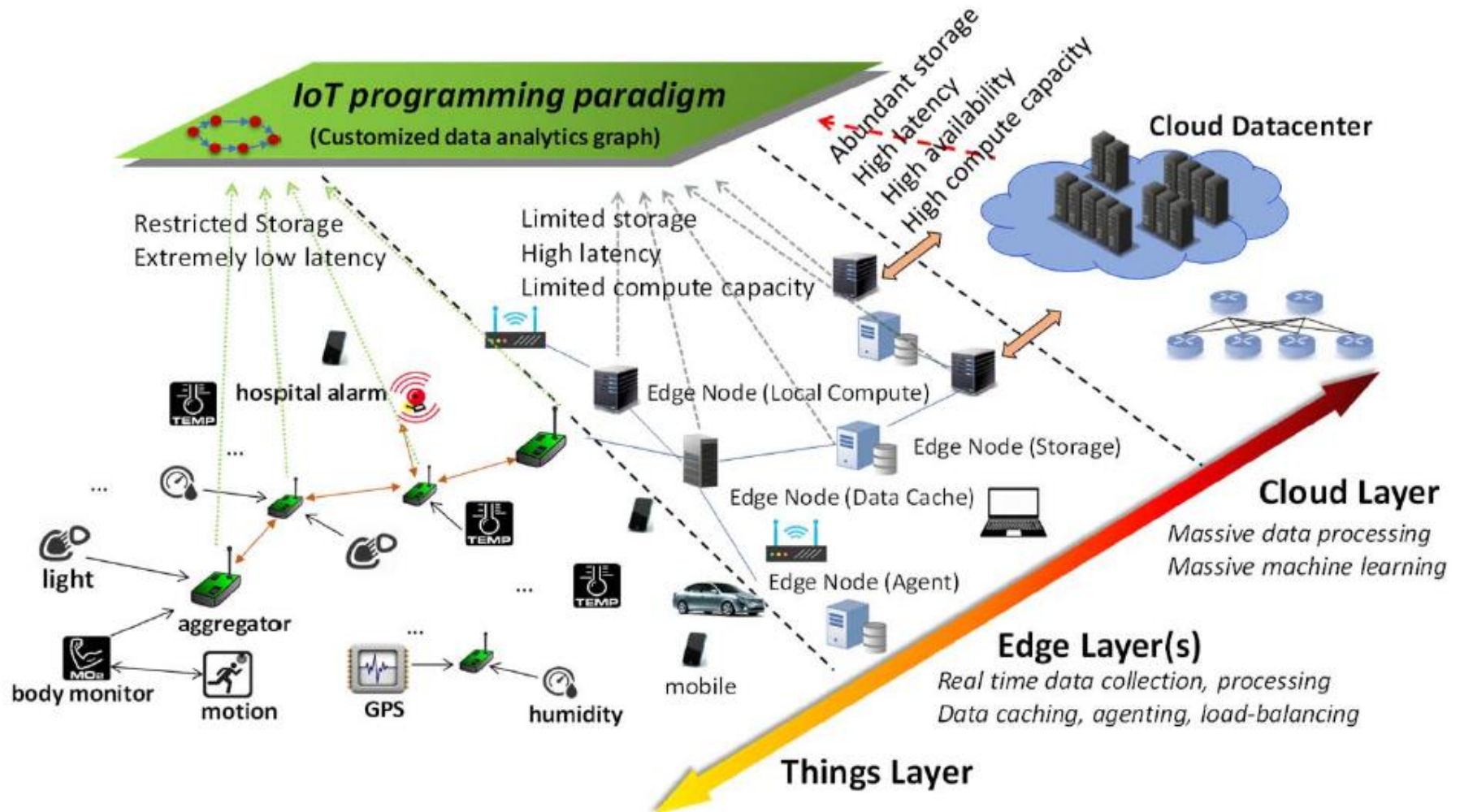
The IoT Market



Cisco System's prediction

- estimates that these new connections will lead to **\$19 trillion** in profits and cost savings

How IoT works?



Source: Rajiv Ranjan *et. al.*, "Integrating the IoT and Data Science" *IEEE Cloud Computing*, 2018

Main Challenges in IoT

Scale

- millions of devices are connected to form IoT

Security

- “things” becomes connected, so security becomes complex

Privacy

- which personal data to share with whom
- how to control

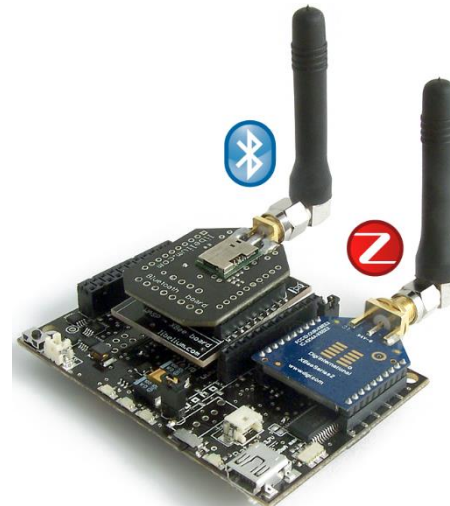
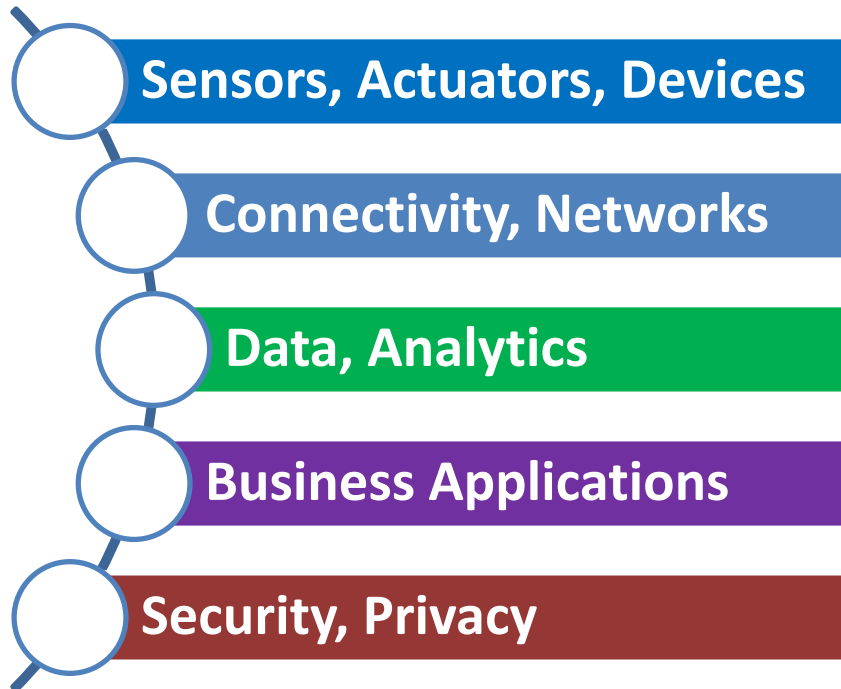
Big data and Data analytics

- massive amount of sensor data
- different sources and various forms
- extract intelligence from the heaps of data

Interoperability

- various protocol and architecture
- different technology leads to interoperability issue
- Recent IoT standards are helping minimizing this problem

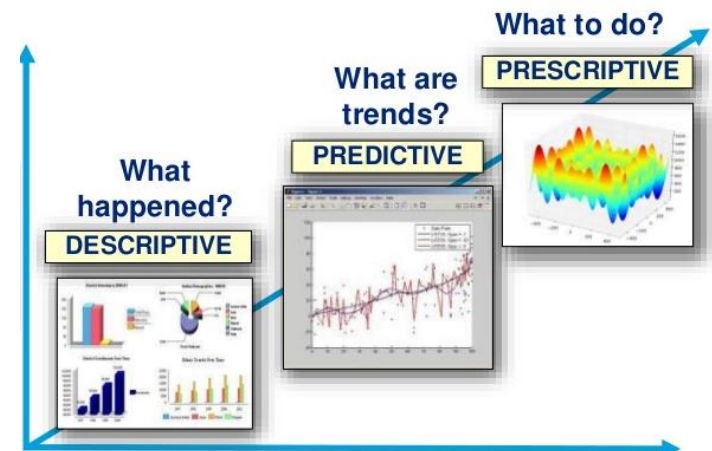
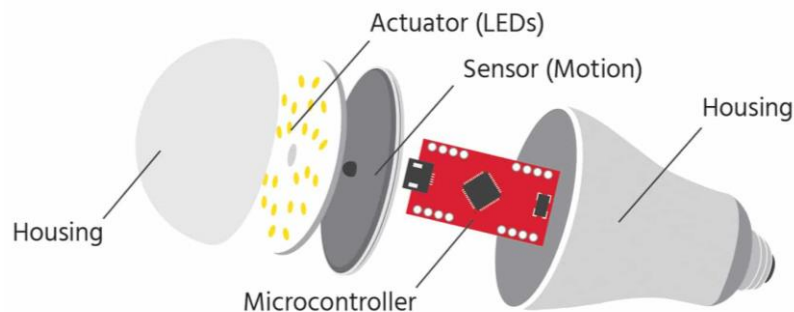
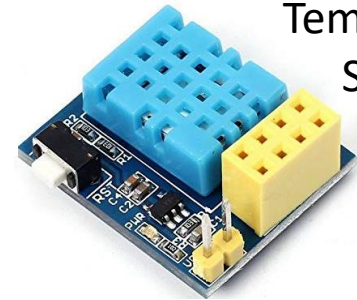
Main Components in IoT



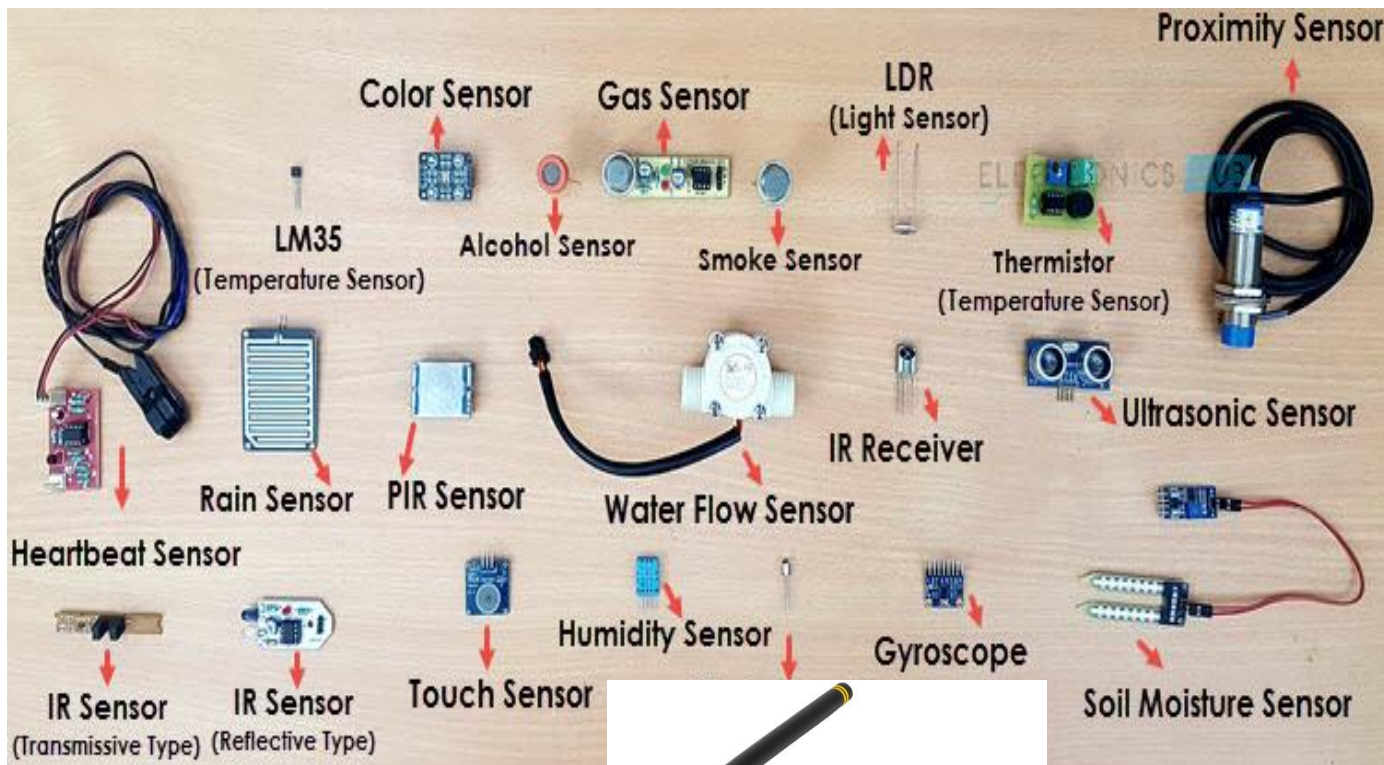
LPG Gas Sensor



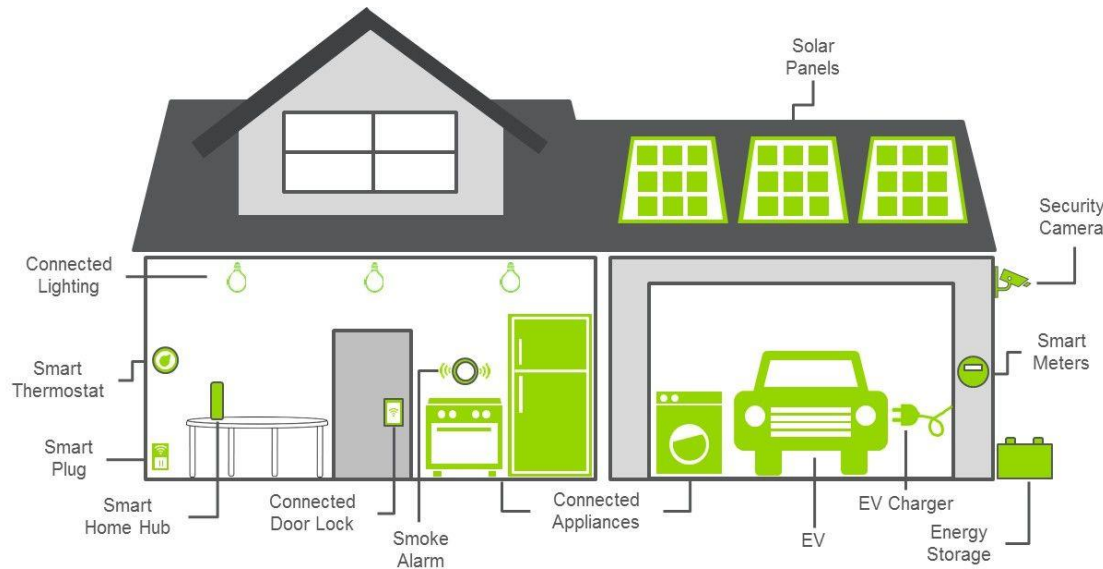
Temperature Sensor



"Things" in IoT



IoT Network Architecture

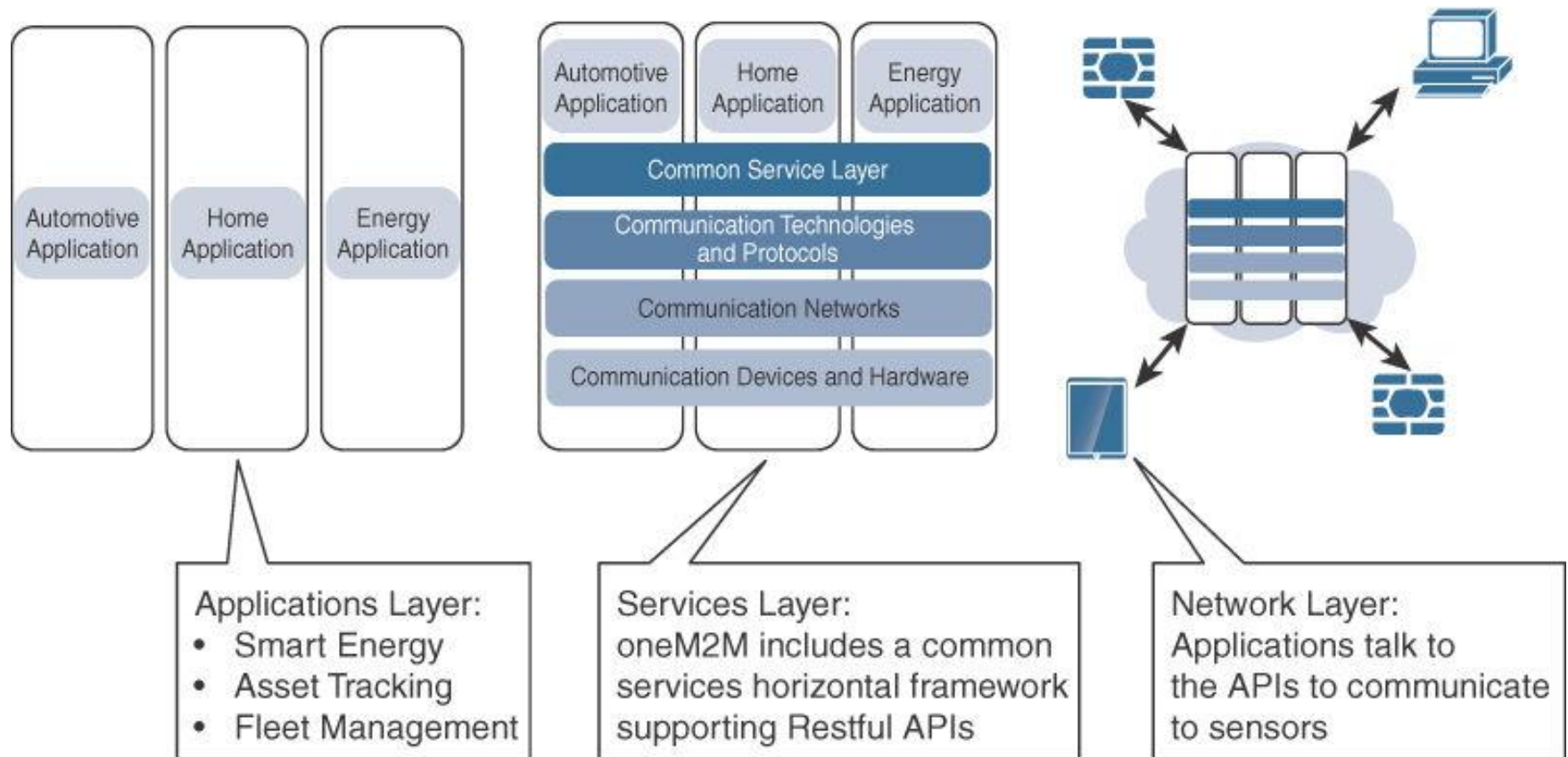


Driving forces:

- Networks run the business
 - It should never be built without careful planning
 - The key difference between IT and IoT networks is the **data**
- Scale
 - Security
 - Constrained devices
 - Massive data
 - Data analysis
 - Support to legacy devices

oneM2M IoT Architecture

- Proposed by European Telecommunications Standards Institute (ETSI)
- Goal** : to create a **common services layer**, which can be readily **embedded in field devices** to allow communication with application servers.

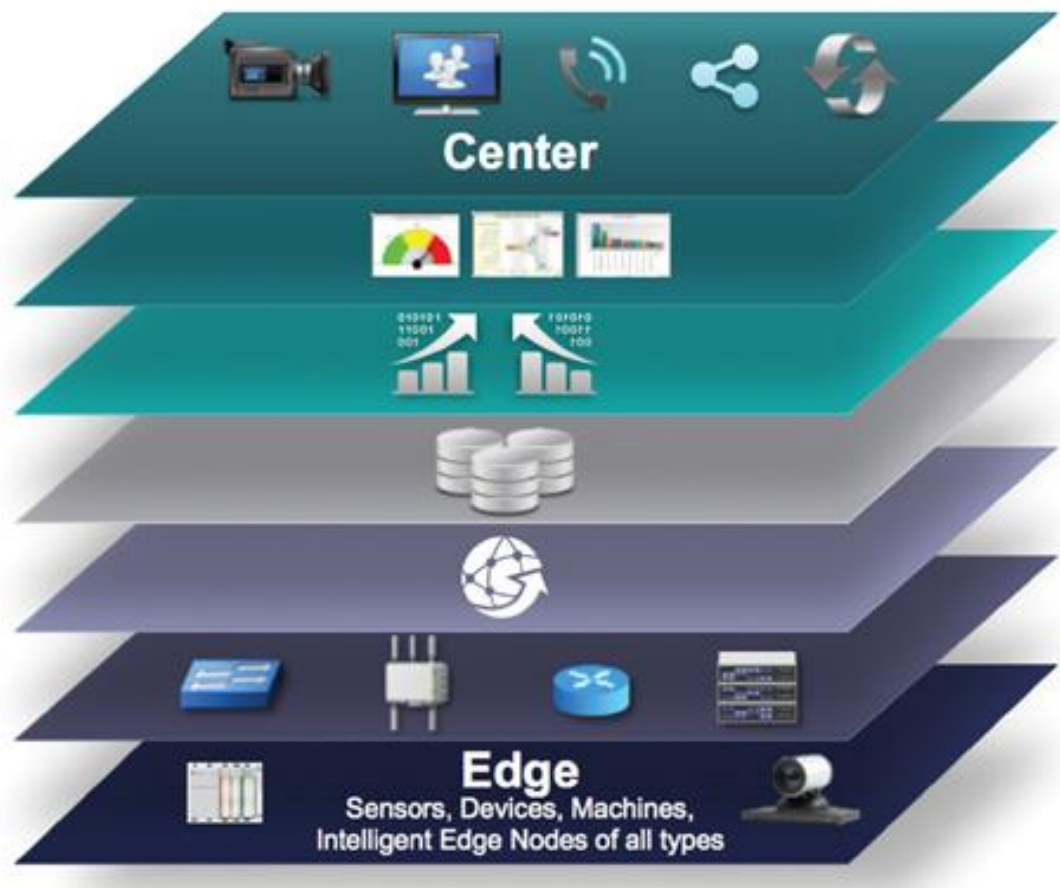


IoTWF Architecture

- IoTWF architectural committee (led by Cisco, IBM, Rockwell Automation, and others)
- way of visualizing IoT from a technical perspective

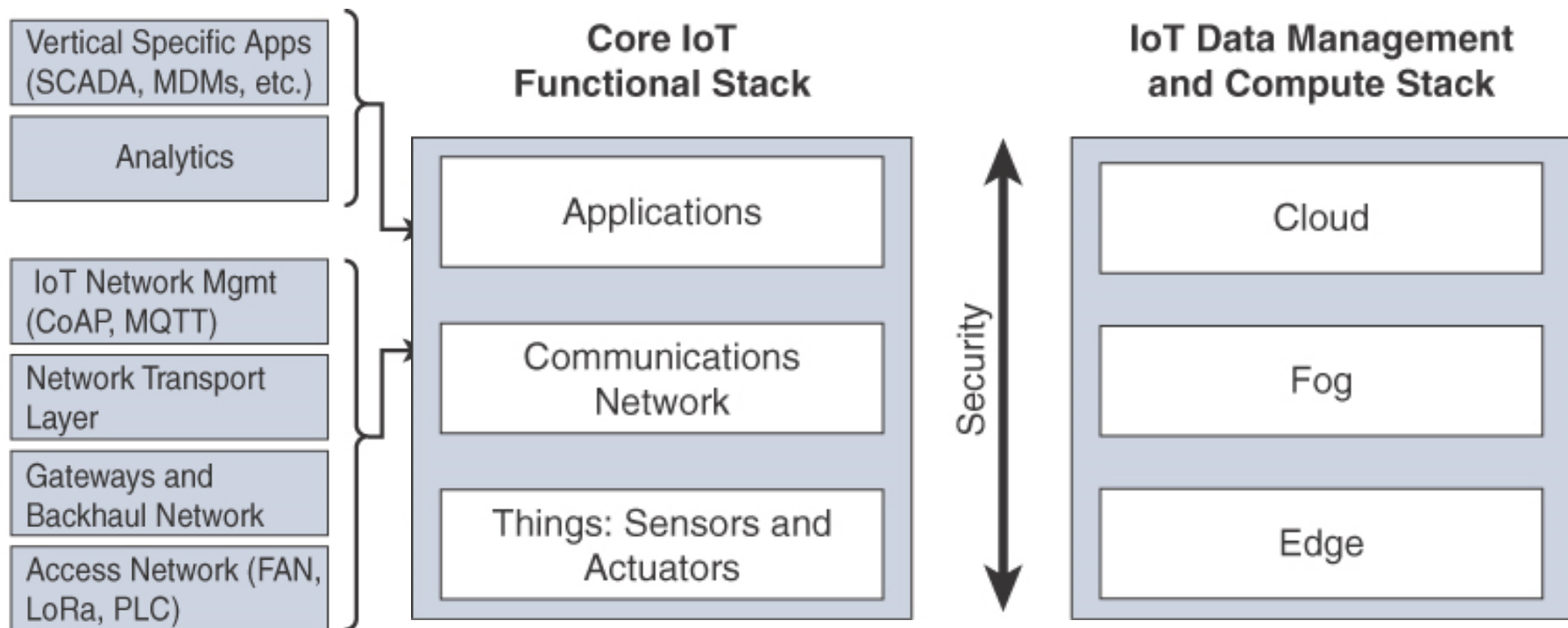
Levels

- 7 Collaboration & Processes**
(Involving People & Business Processes)
- 6 Application**
(Reporting, Analytics, Control)
- 5 Data Abstraction**
(Aggregation & Access)
- 4 Data Accumulation**
(Storage)
- 3 Edge Computing**
(Data Element Analysis & Transformation)
- 2 Connectivity**
(Communication & Processing Units)
- 1 Physical Devices & Controllers**
(The "Things" in IoT)



Simplified IoT Architecture

- It highlights the **fundamental building blocks** that are common to most IoT systems and which is intended to help in designing an IoT network.
- IoT architectural framework** is presented as **two parallel stacks**
 - Core IoT Functional Stack
 - IoT Data Management and Compute Stack



Connecting Smart Objects

Communication Criteria

- Range
- Frequency Bands
- Power Consumption
- Topology
- Constrained Devices
- Constrained-Node Networks

IoT Access Technologies



Comparison of Key Attributes



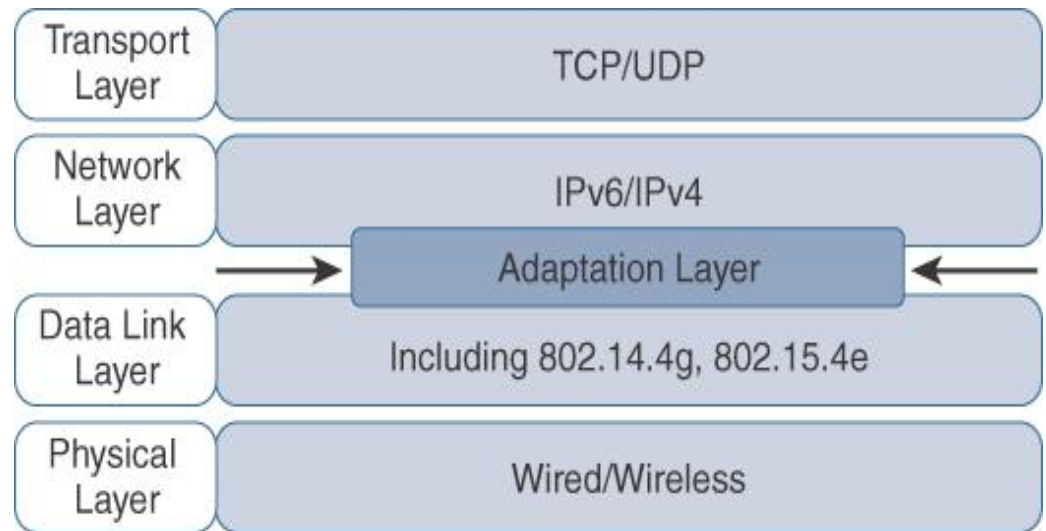
	WiFi	BLE	Thread	Sub-GHz: TI	Sigfox	Zigbee	LoRa
Max. Data throughput	72 Mbps	2 Mbps	250 Kbps	200 Kbps	100 bps	250 Kbps	50 Kbps
Range	100 m	750 m	100 m	4 km	25 km	130 m	10 km
Topology	Star	P2P/ Mesh	Mesh/ Star	Star	Star	Mesh/ Star	Star of Star
Frequency	2.4 GHz	2.4 GHz	2.4 GHz	Sub-GHz	Sub-GHz	2.4 GHz	Sub-1GHz
Power consumption	1 Year (AA battery)	Up to years on a coin-cell battery for limited range					Few Years (AA battery)
IP at the device node	Yes	No	Yes	No	No	No	No
Deployed Devices	AP	smart phones	No	No	No	No	No

Source: Nick Lethaby “Wireless Connectivity for the IoT: one size does not fit all”, Texas Instruments, 2017

Utilizing IP for IoT

Key Advantages of IP

- Open and standard-based
- Versatile
- Ubiquitous
- Scalable
- Manageable
- Highly secure
- Stable and resilient



Need of optimization for

- Constrained Nodes
- Constrained Networks

Modification in TCP/IP Stack

IP Protocol Stack

HTTP		RTP	
TCP	UDP		ICMP
IP			
Ethernet MAC			
Ethernet PHY			

Application

Transport

Network

Data Link

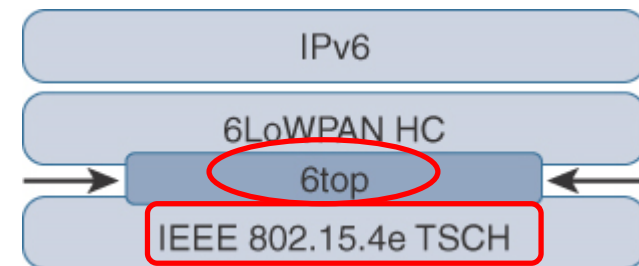
Physical

IoT Protocol Stack with
6LoWPAN Adaptation Layer

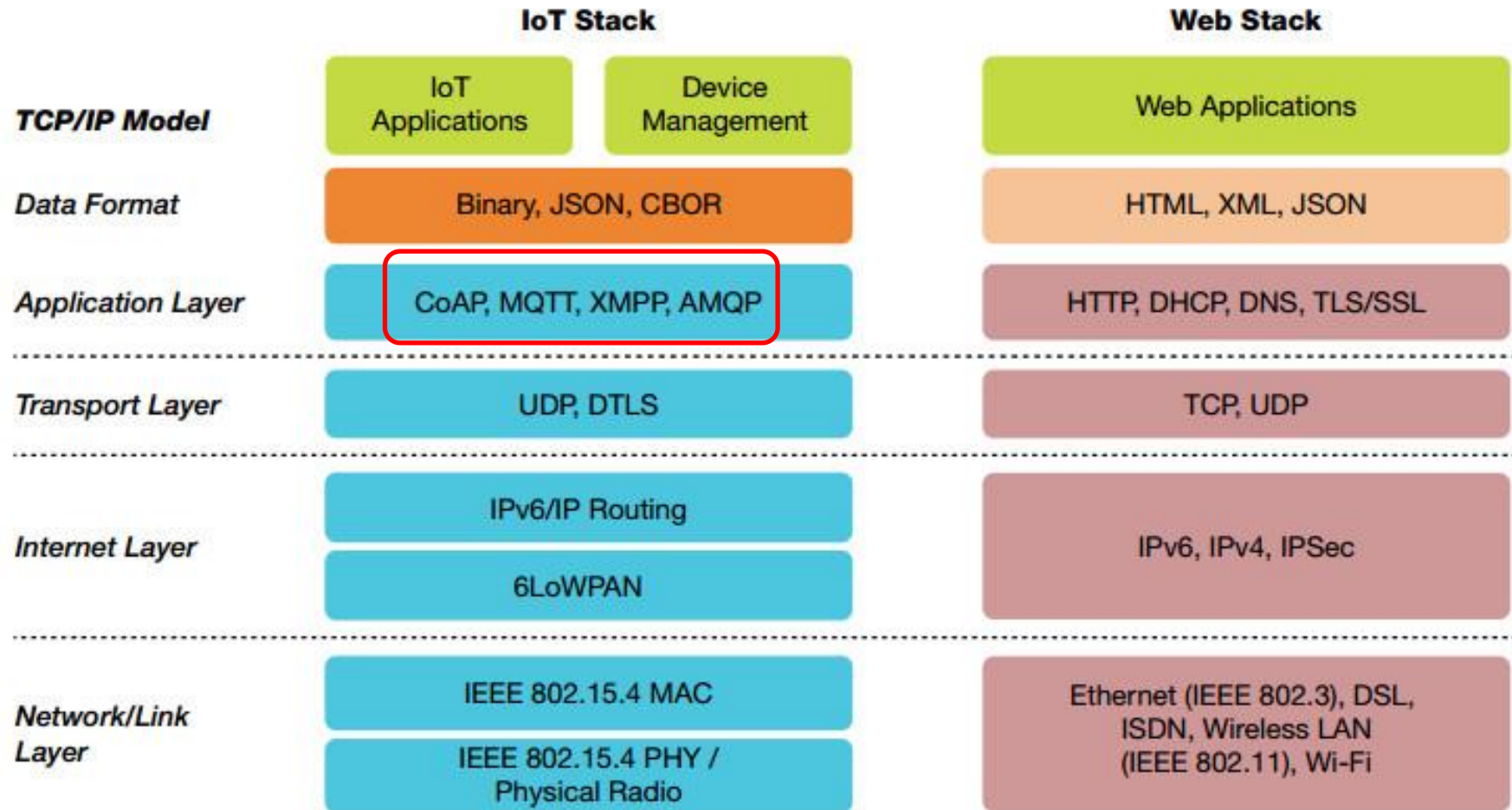
Application Protocols	
UDP	ICMP
IPv6	
LoWPAN	
IEEE 802.15.4 MAC	
IEEE 802.15.4 PHY	

- **WPAN**: Wireless Personal Area Networks
- **IEEE 802.15.4**: Low-rate WPAN
- **LoWPAN**: Low-Power WPAN
- **6LoWPAN**: IPv6 over LoWPAN
- **TSCH**: Time Synchronized Channel Hopping
- **6TiSCH**: IPv6 over the TSCH mode of IEEE 802.15.4e
- **6top**: 6TiSCH Operation Sublayer

In 6TiSCH IoT Network



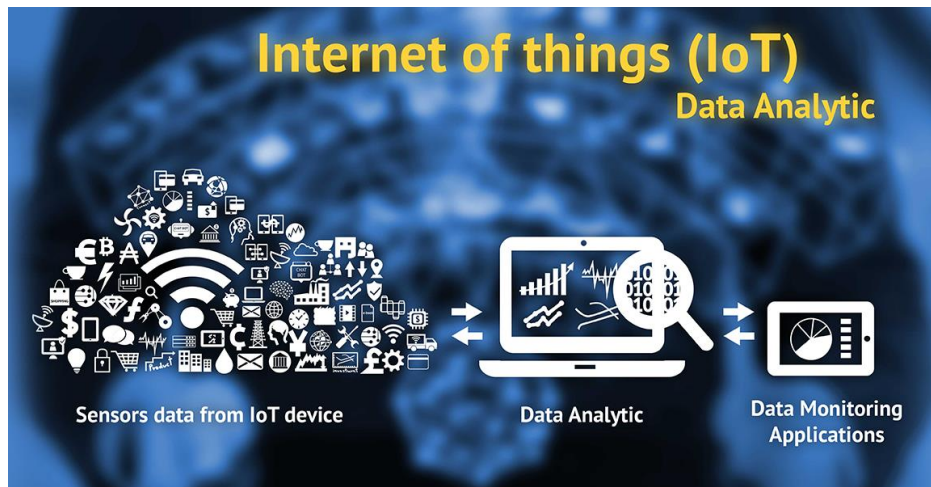
Application Layer



Data & Analytics in IoT

Data Analytics + IoT => Smart Business Solutions

- ❖ The **business value of IoT** is not just in the ability to **connect devices** but comes from **understanding the data** these devices create.



Challenges:

- Huge Volume
 - Unstructured data
 - Changing data model
 - Variety of data types
-
- **IoT analytics** is the application of data analysis tools and procedures to realize value from the huge volumes of data generated by connected IoT devices

Securing IoT

- Both the IoT **manufacturers** and their **customers** didn't care about the security !

Unauthorized access to IoT devices



Source: <https://www.theguardian.com/technology/2016/oct/26/ddos-attack-dyn-mirai-botnet>

Major cyber attack disrupts internet service across Europe and US;
October 26, 2016

Unauthorized access to IoT network



Source: <http://metropolitan.fi/entry/ddos-attack-halts-heating-in-finland-amidst-winter>

DDoS attack halts heating in Finland amidst winter;
November 7, 2016

Cont...



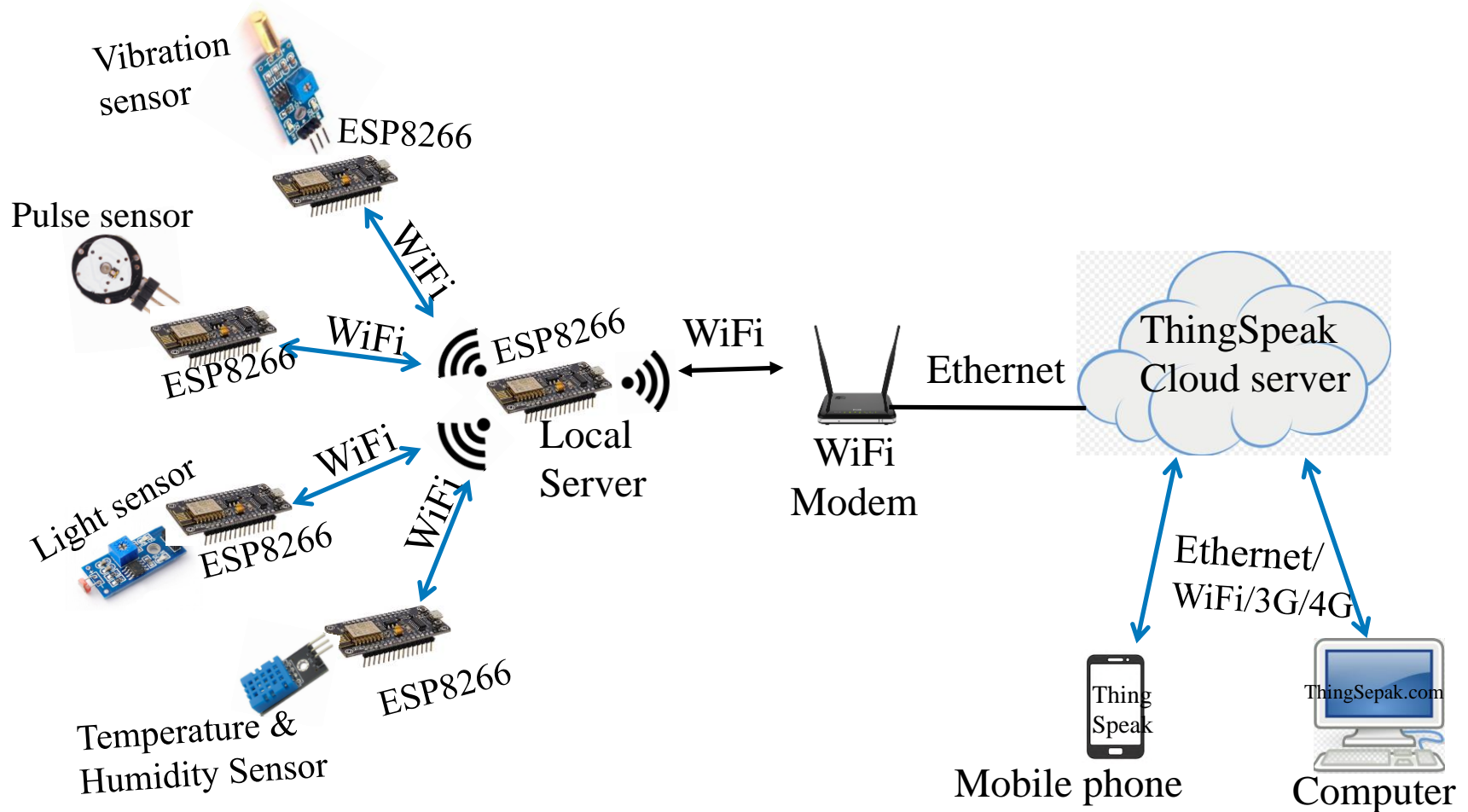
Source: <https://www.youtube.com/watch?v=4oONdV5RYp8>

- US Military's Defense Advanced Research Projects Agency (DARPA) demonstrates hacking smart "Things"

Source: <https://www.youtube.com/watch?v=7E1WsdODxu0>



Demo: Smart Home Monitoring



Thanks!



Figures and slide materials are taken from the following sources:

1. David Hanes *et al.*, “IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things”, 1st Edition, 2018, Pearson India.