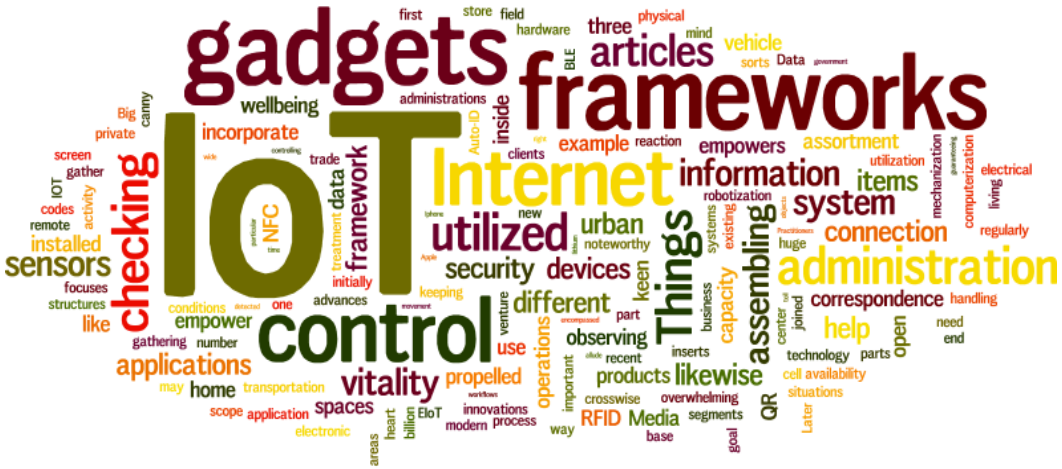
CS578: Internet of Things

Introduction to IoT



Dr. Manas Khatua

Assistant Professor

Dept. of CSE, IIT Guwahati

E-mail: manaskhatua@iitg.ac.in

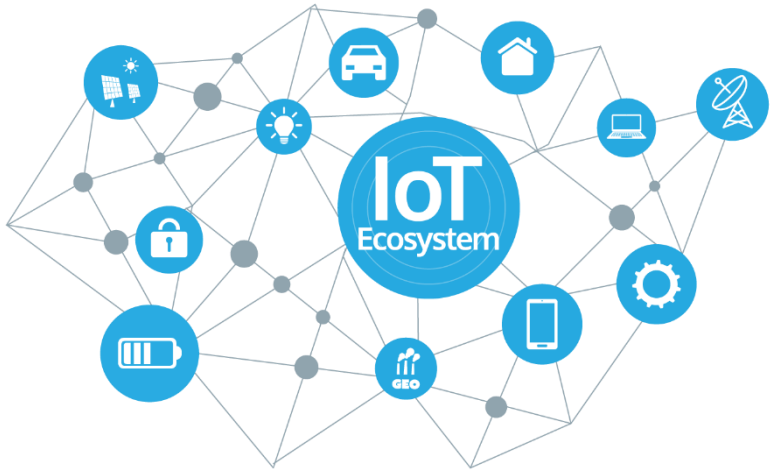
"I have no special talent. I am only passionately curious." – **Albert Einstein**

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.

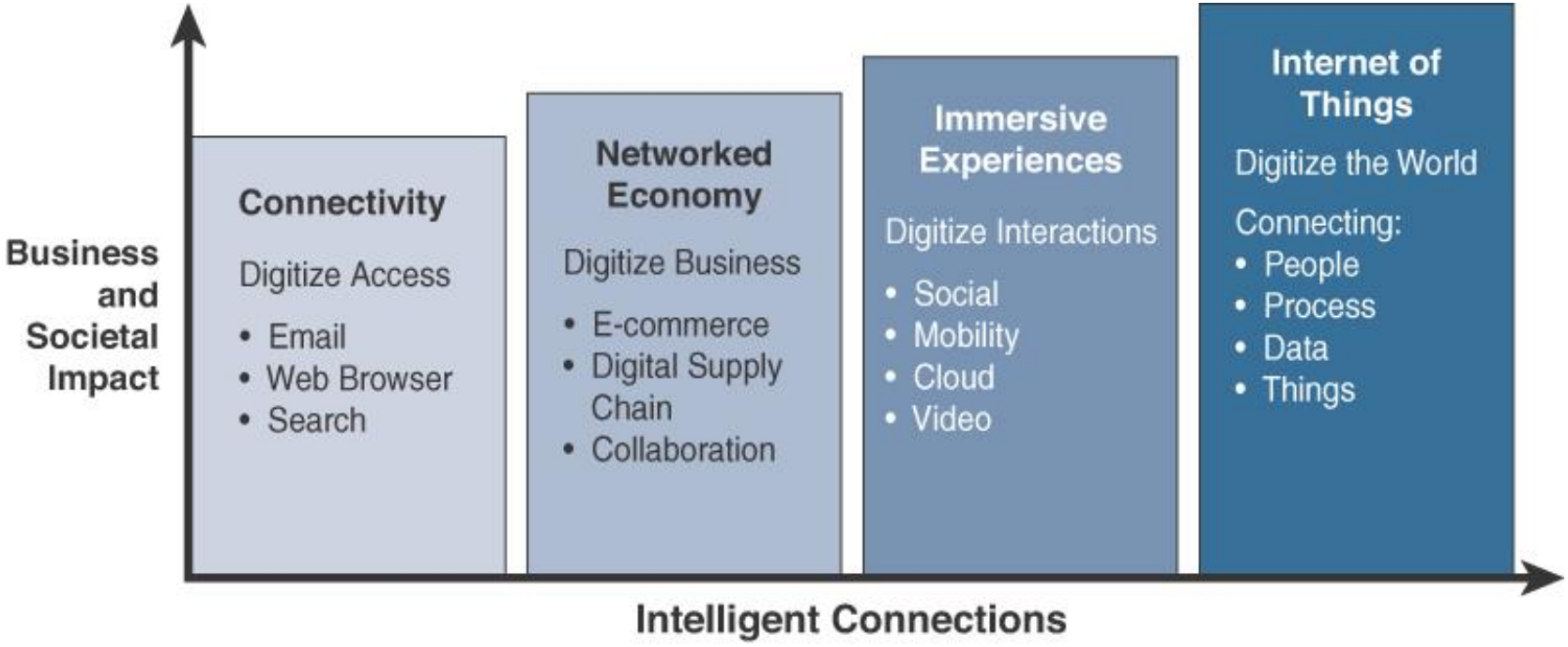
- The basic premise and goal of IoT is to "connect the unconnected"

- 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!



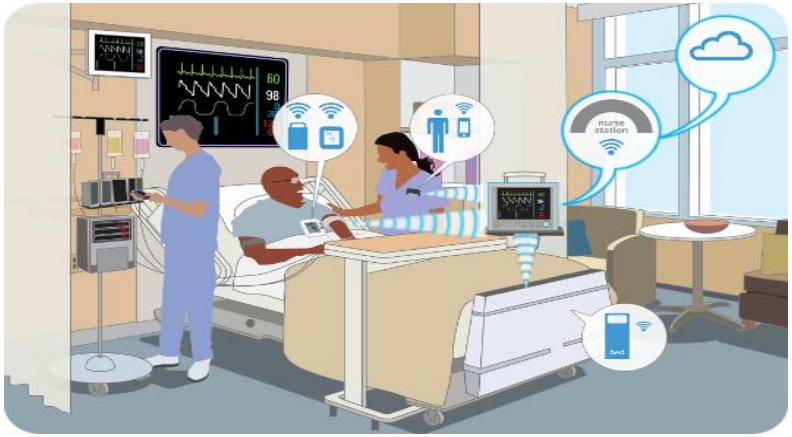
Evolutionary Phases of the Internet

Where is IoT?

Wearable
Tech Devices

Smart Appliances

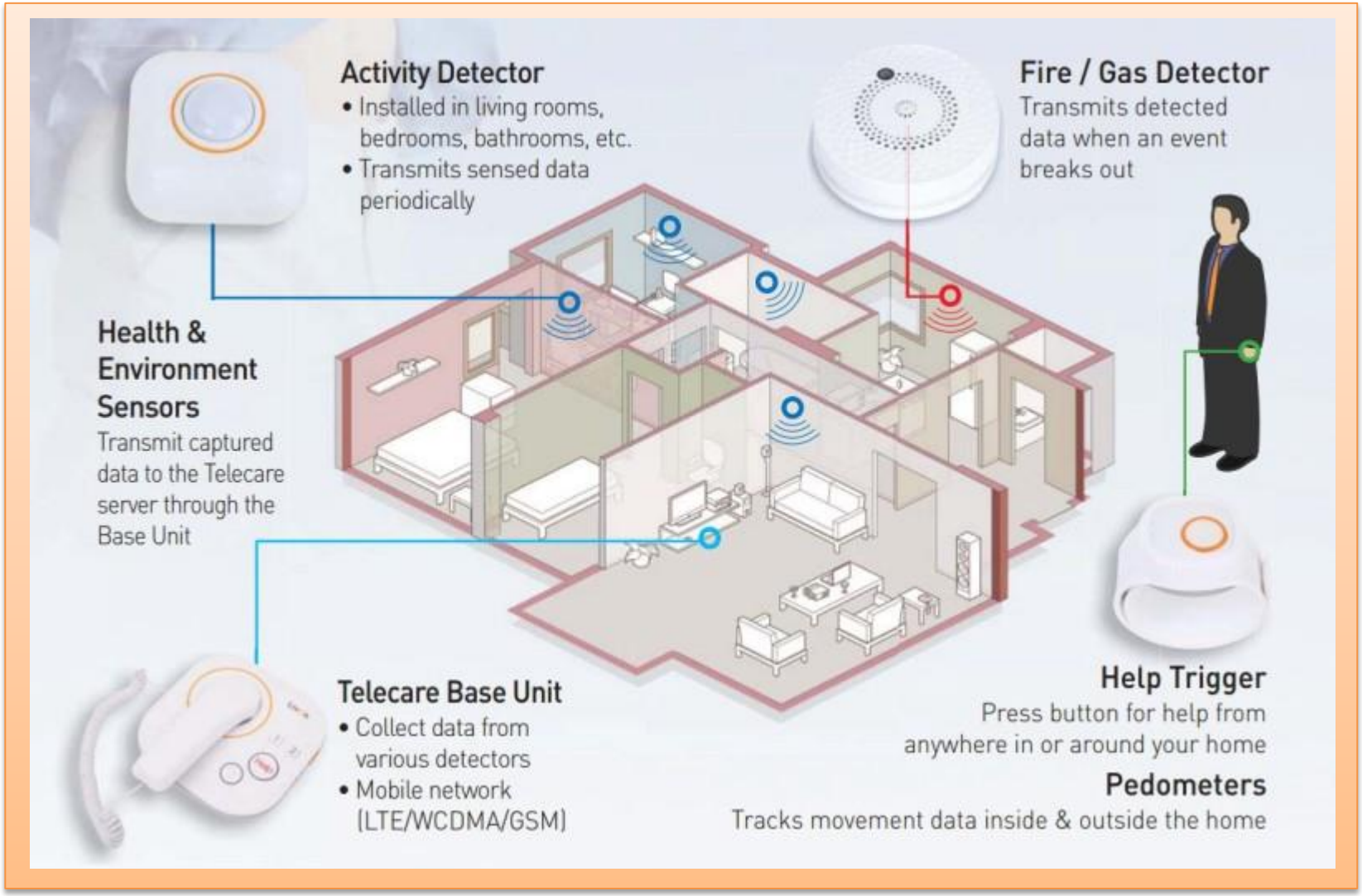
It's everywhere!



Healthcare

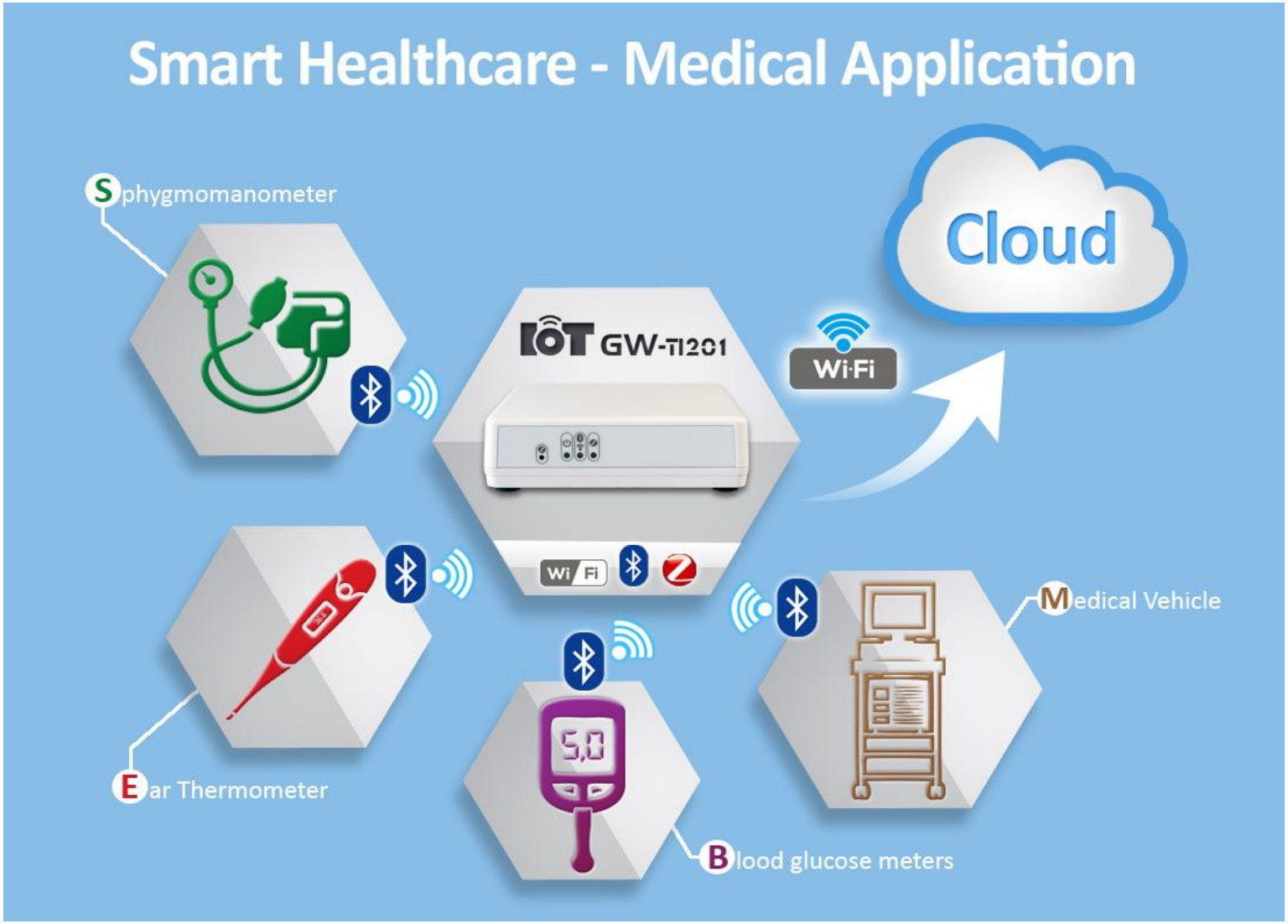
Industry Automation
and Monitoring

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

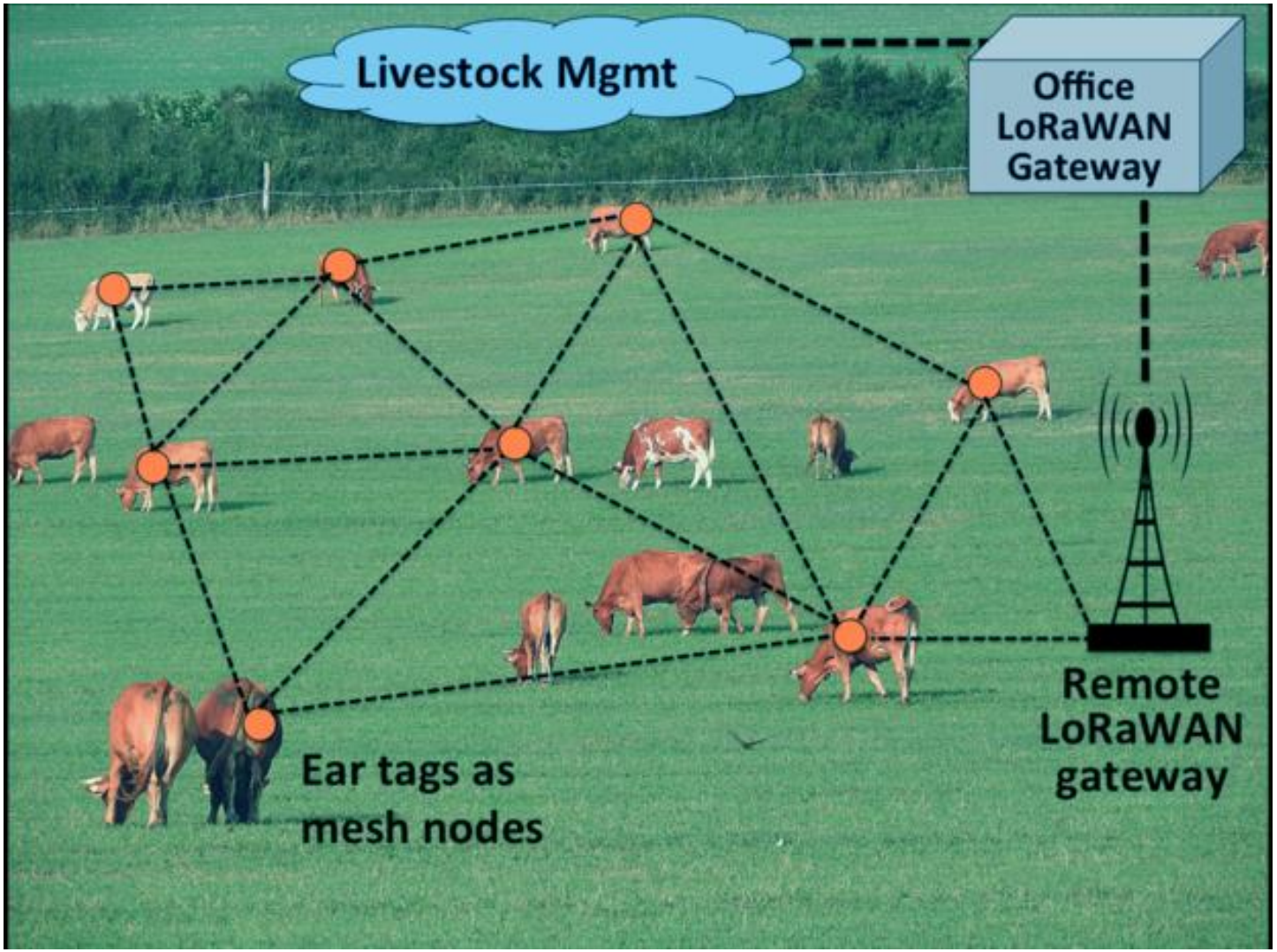


Source: http://iot.fit-foxconn.com/

Smart Agriculture

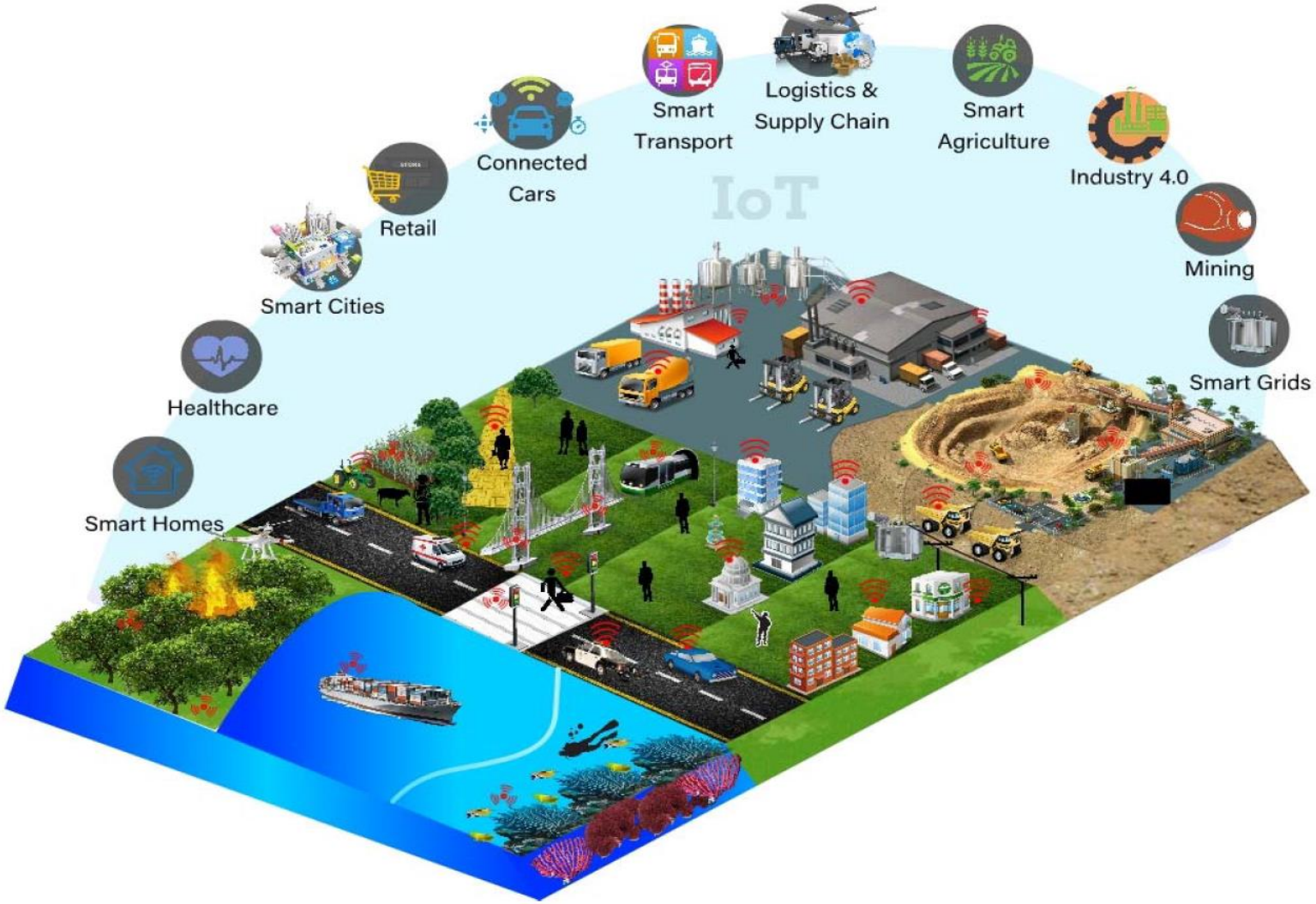
Source: https://in.pinterest.com/pin/515380751093603767/?lp=true

Livestock Management



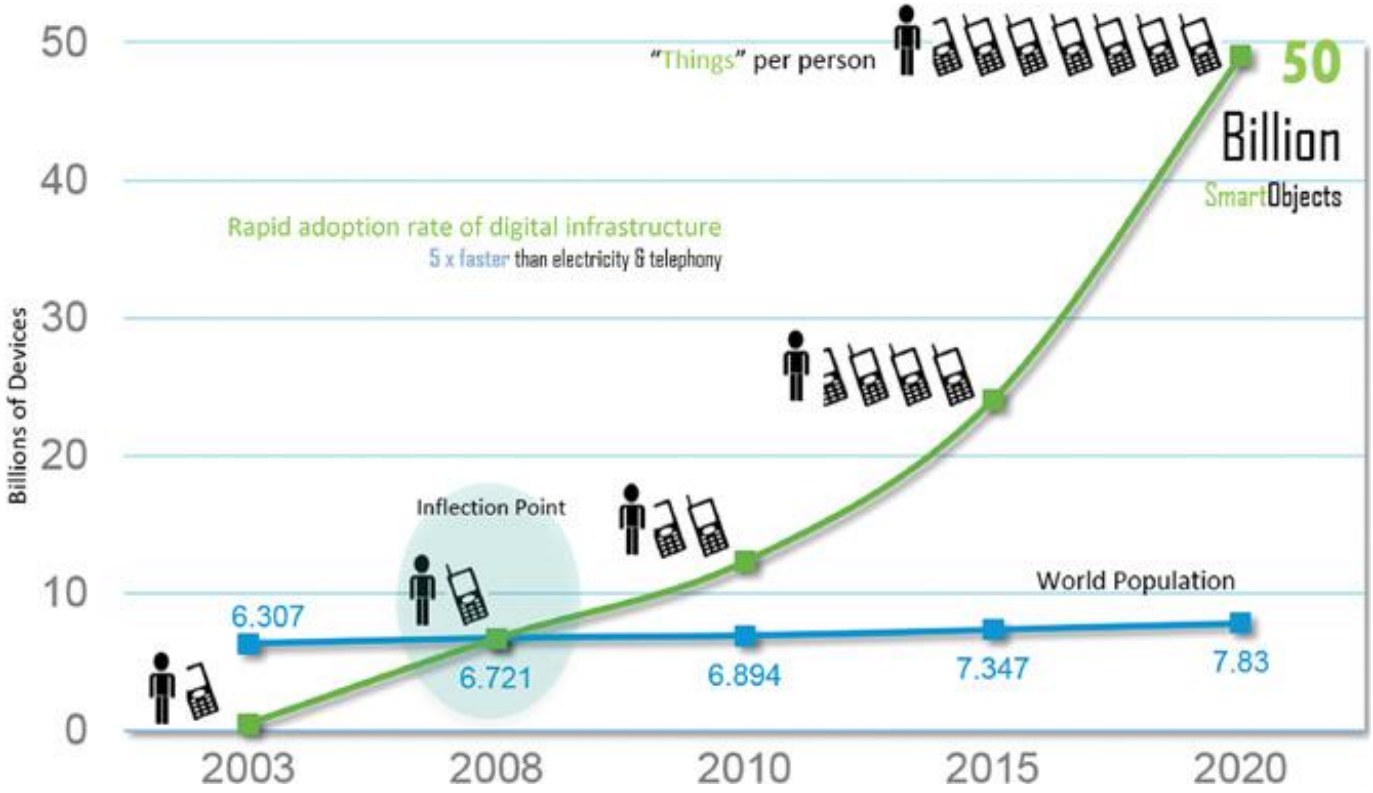
Source: https://data-flair.training/blogs/iot-applications-in-agriculture/

Many More ….



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

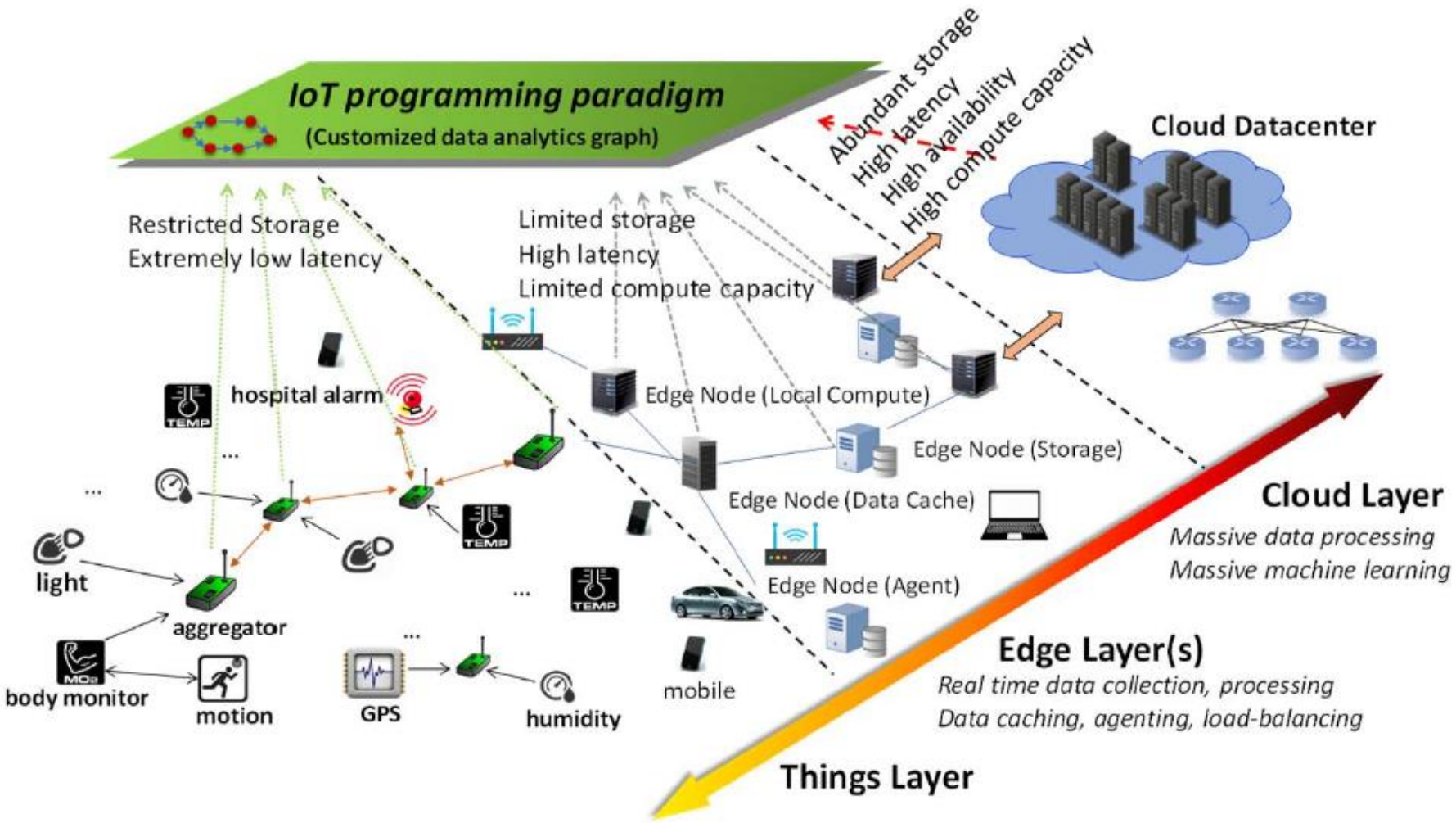
The IoT Market



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

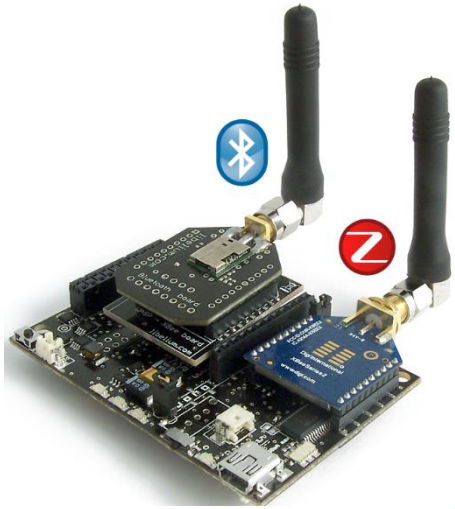
- massive amount of sensor data
- different sources and various forms
- extract intelligence form the heaps of data

Interoperability

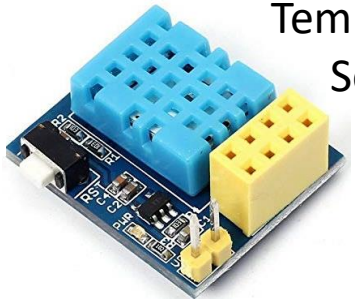
- various protocol and architecture
- different technology leads to interoperability issue
- Recent IoT standards are helping minimizing this problem

Main Components in IoT

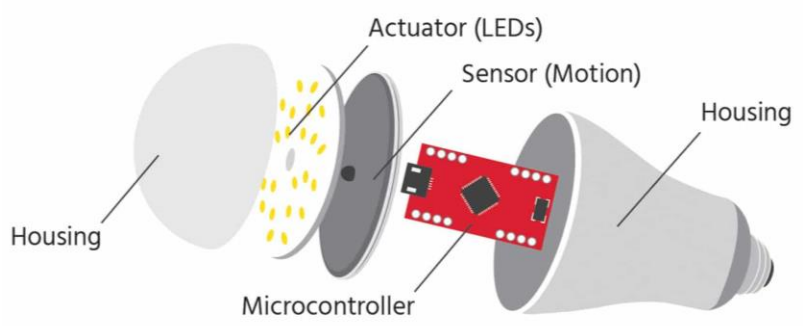
- Sensors, Actuators, Devices
- Connectivity, Networks
- Data, Analytics
- Business Applications
- Security, Privacy

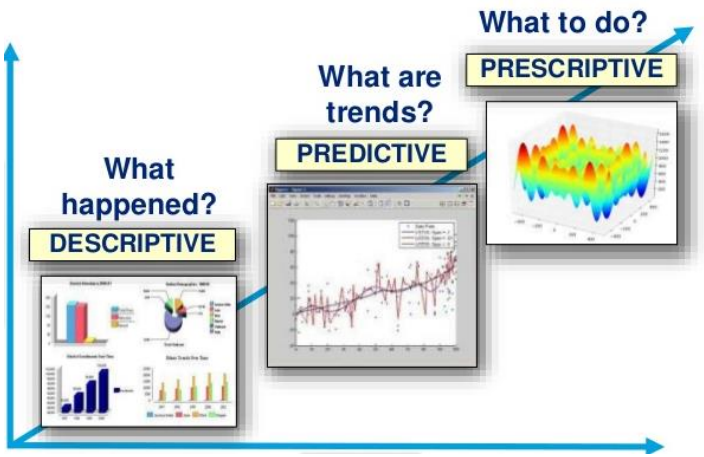


LPG Gas Sensor

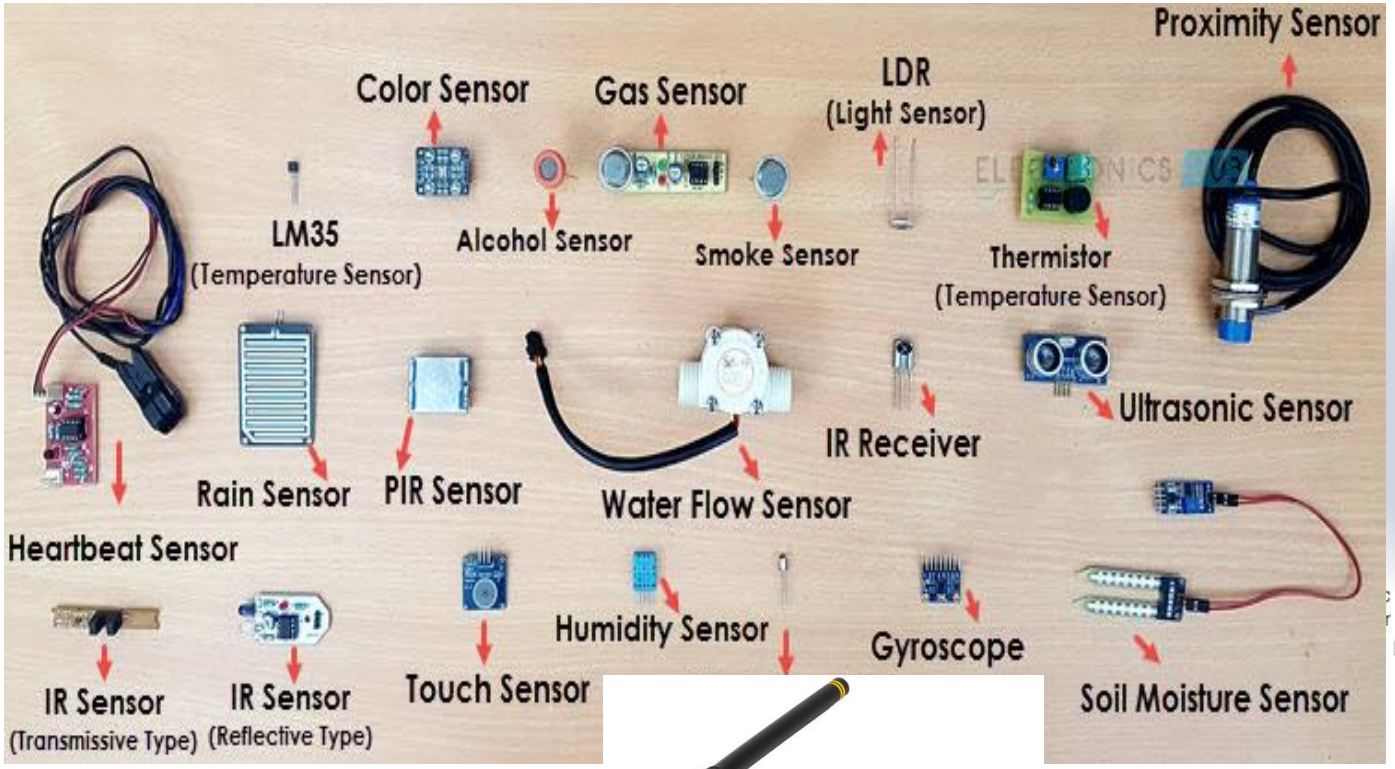


Temperature Sensor

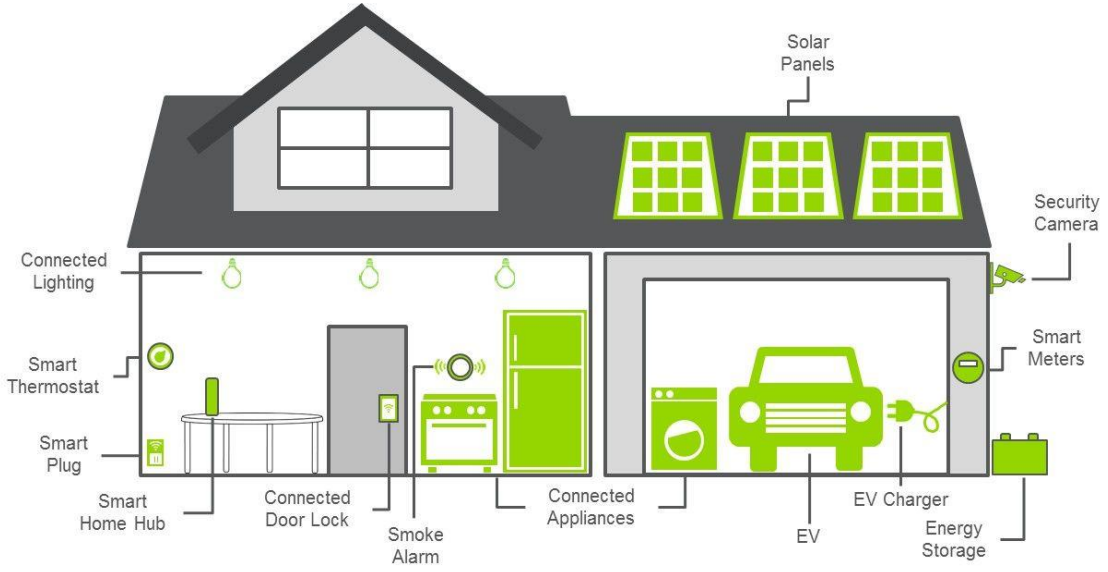




“Things” in IoT



IoT Network Architecture



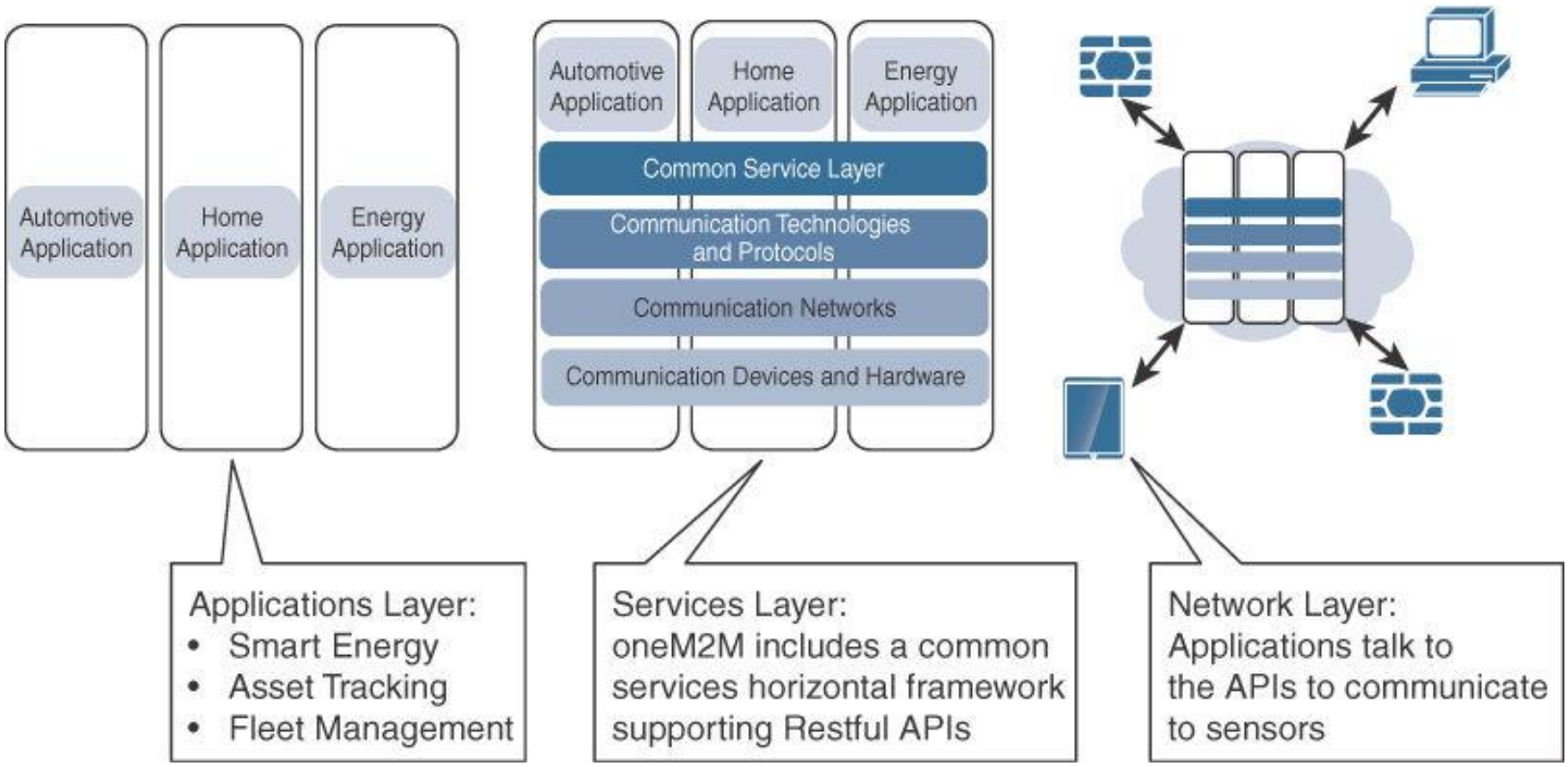
Driving forces:

- Scale
- Security
- Constrained devices
- Massive data
- Data analysis
- Support to legacy devices

- Networks run the business
- It should never be built without careful planning
- The key difference between IT and IoT networks is the data

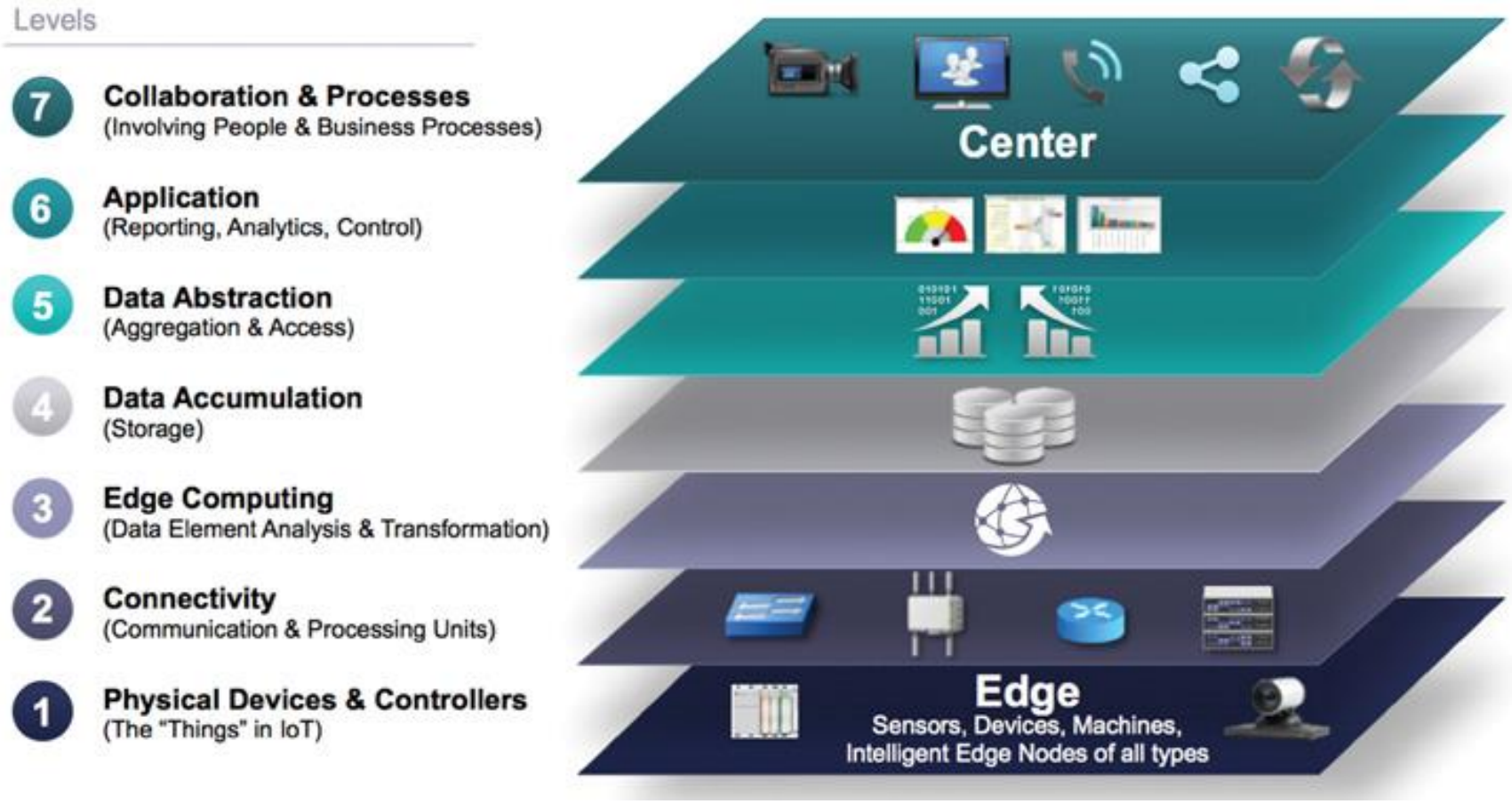
oneM2M IoT Architecture

- Proposed by European Telecommunications **S**tandards 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

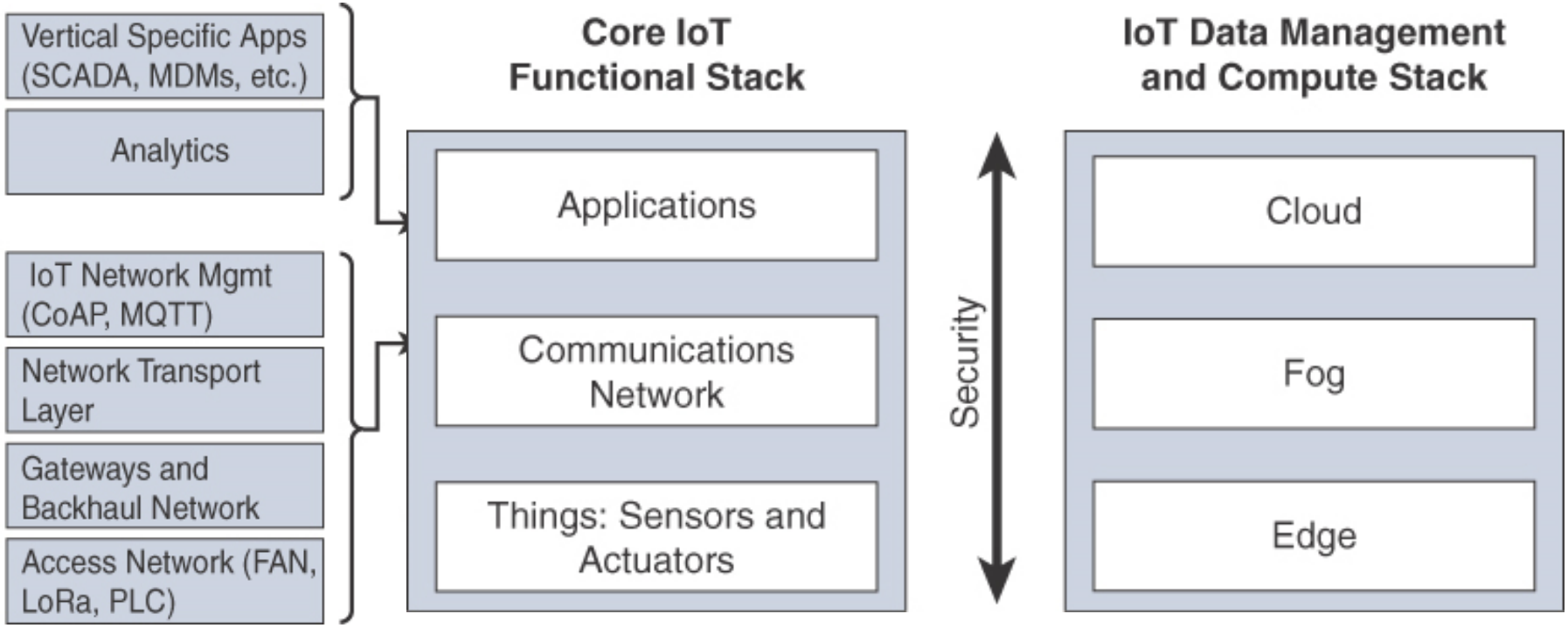
- IoTWF architectural committee (led by Cisco, IBM, Rockwell Automation, and others)
- way of visualizing IoT from a technical perspective



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

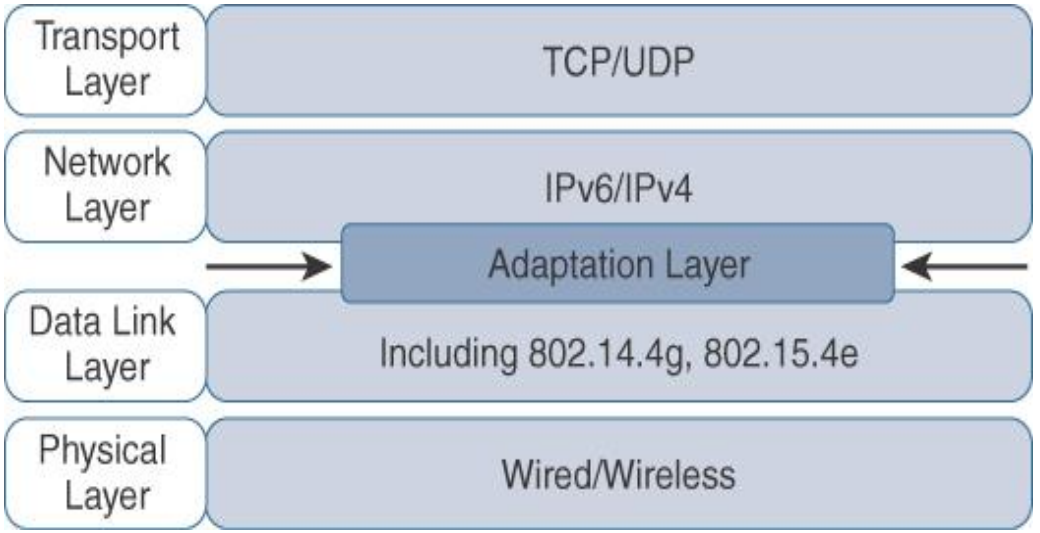
	WiFi	BLE	Thread	Sub-GHz: TI	Sigfox	Zigbee	LoRa
Max. Data throughput	72 Mbps	2 Mbps	250 Kbps	200 Kbps	100 bps	250 Kbps	50 Kbps
Range	100 m	750 m	100 m	4 km	25 km	130 m	10 km
Topology	Star	P2P/ Mesh	Mesh/ Star	Star	Star	Mesh/ Star	Star of Star
Frequency	2.4 GHz	2.4 GHz	2.4 GHz	Sub-GHz	Sub-GHz	2.4 GHz	Sub-1GHz
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

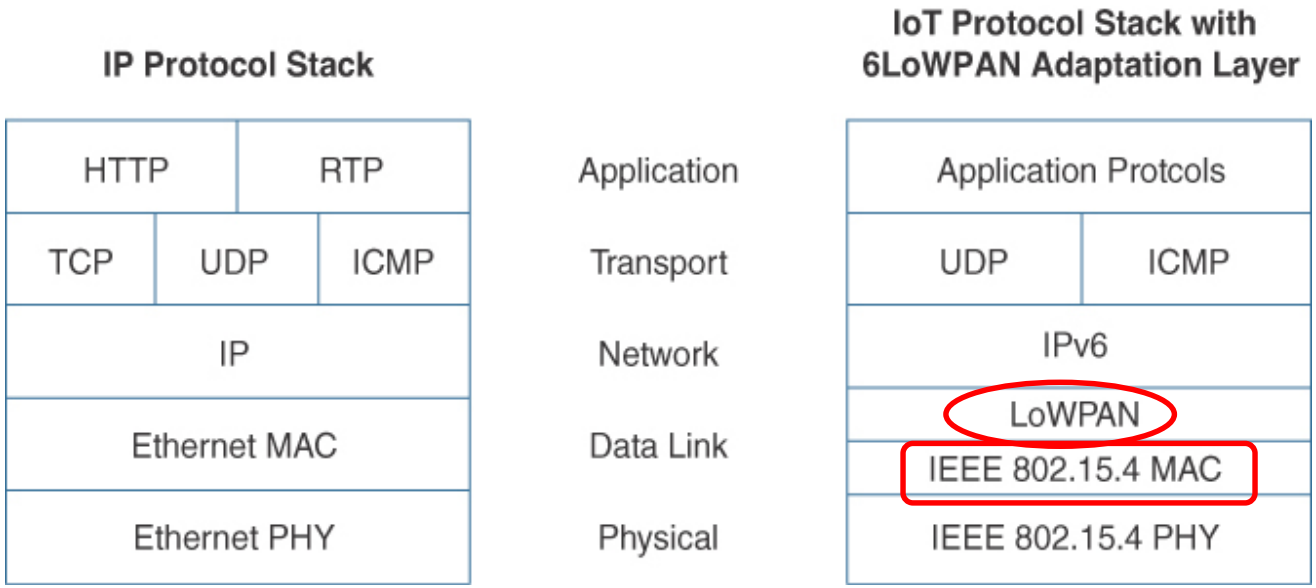
- Open and standard-based
- Versatile
- Ubiquitous
- Scalable
- Manageable
- Highly secure
- Stable and resilient



Need of optimization for

- Constrained Nodes
- Constrained Networks

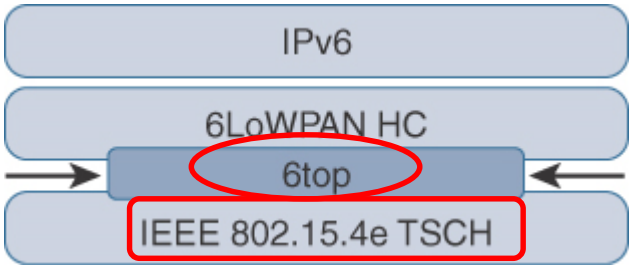
Modification in TCP/IP Stack



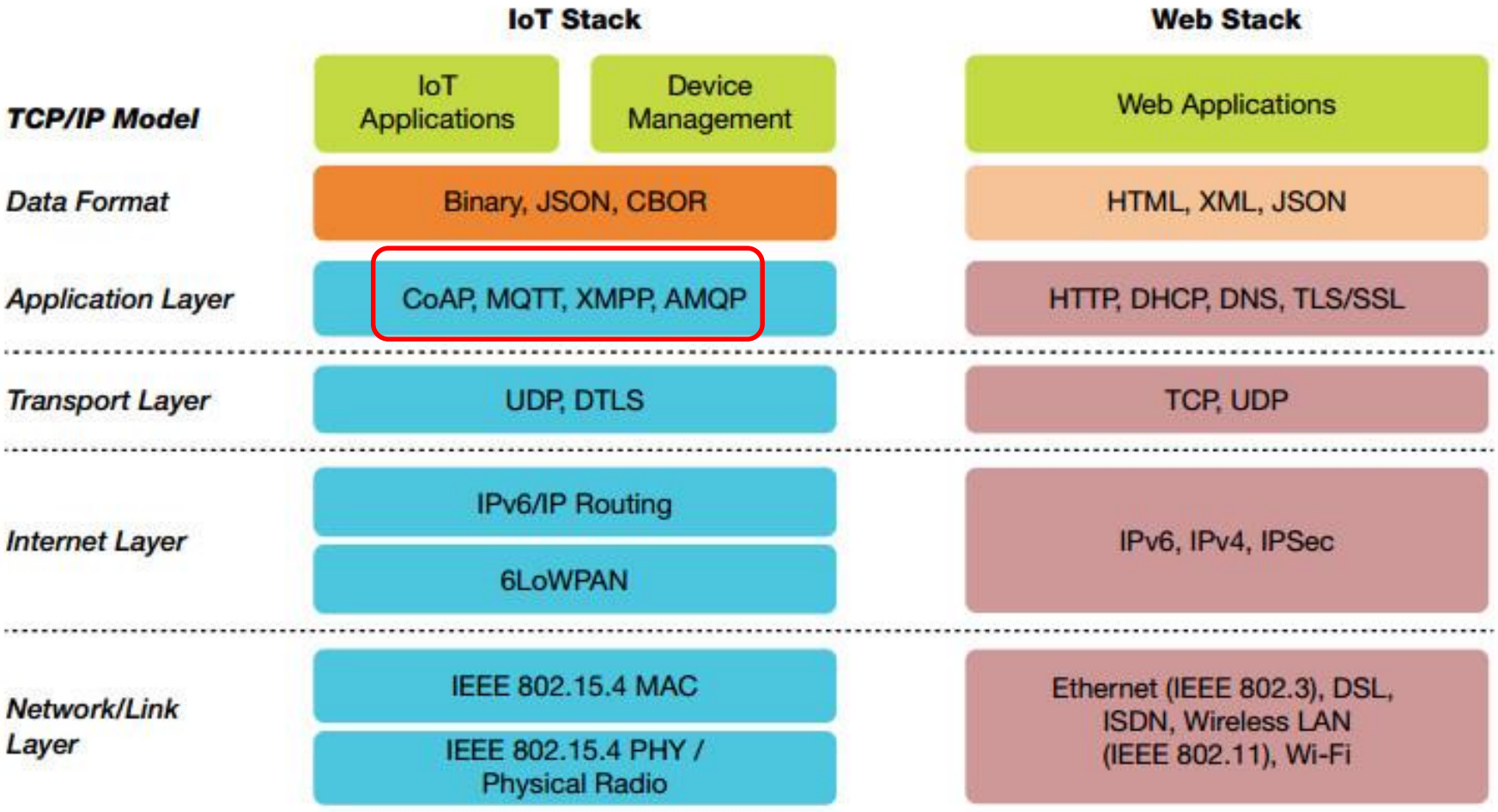
- WPAN: Wireless Personal Area Networks
- IEEE 802.15.4: Low-rate WPAN

- 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



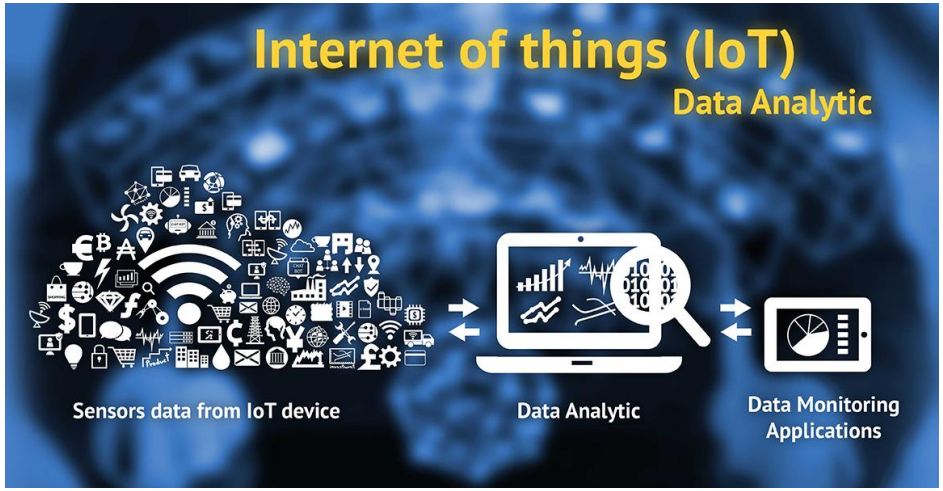
Application Layer



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...

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

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

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

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.