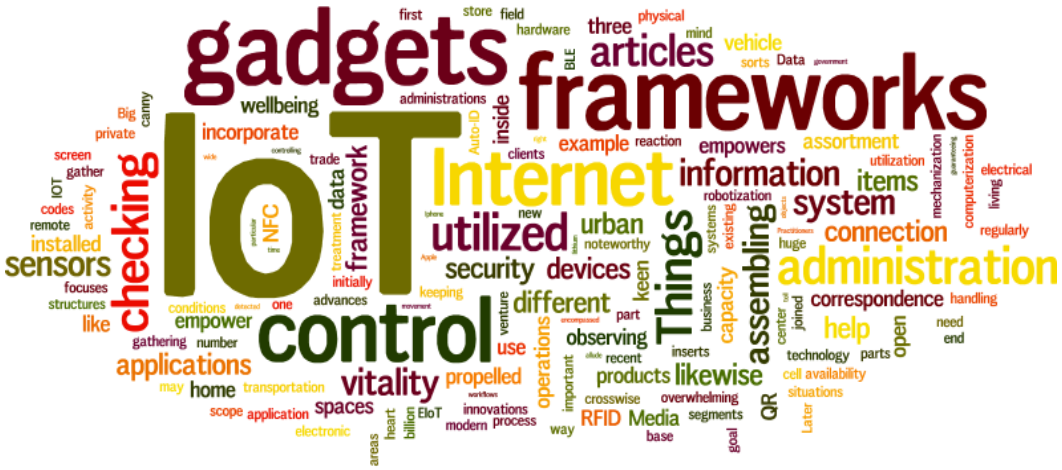
Internet of Things

IoT Ecosystem

Different components of IoT



Thanks to Dr. Manas Khatua for slides

"Strength is Life, Weakness is Death." – **Swami Vivekananda**

IoT Ecosystem

IoT is **not just a technology**; it is **an ecosystem!**

- Community components:
  - ✓ IoT Frameworks
    - Tools needed to design and implement IoT-based solutions and products
  - ✓ IoT Architectures
    - Graphical structure of the designed IoT-based solutions and products
  - ✓ IoT Core
    - Sensors & Actuators, microcontrollers, internet connectivity, service platform including security
  - ✓ IoT Gateway
    - It carries the responsibility to ensure bidirectional communication between IoT protocols and other networks
  - ✓ Cloud
    - Accepts, accumulates, maintains, stores, and process data in real time
  - ✓ Analytics
    - It indulges in conversion and analysis of data which results in recommendations and future decision making
  - ✓ User Interface / Visualization
    - Design sleek, visually appealing, interactive, and ease-of-use graphical user interface

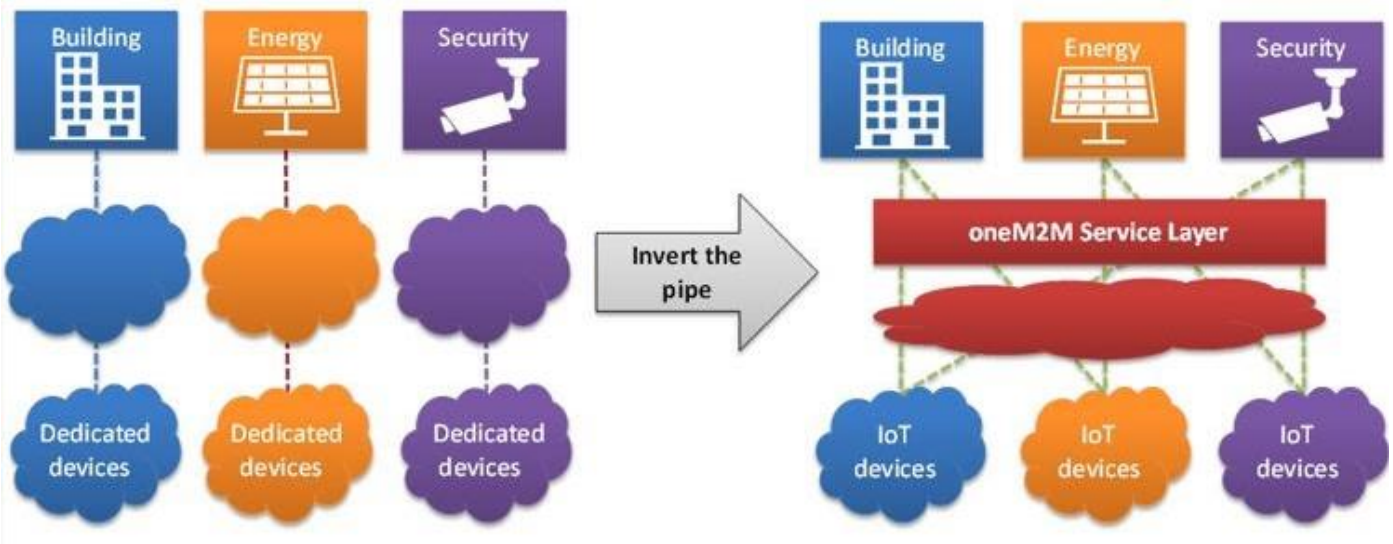
IoT Framework

- Framework provides a development environment.
  - It provides appropriate infrastructure to design and implement the architecture
- IoT framework comprises of large number of components
  - sensors, sensor systems, gateways, mobile app, embedded controller, data management platform, analytical platform, and so on.
  - support interoperability among all devices, provides secure connectivity, reliability in data transfer, interface to 3rd party application to built on it, and so on.

Few IoT Framework	Few IoT Framework
RTI (Real-Time Innovations) Connext DDS	Cisco Ultra IoT
Salesforce IoT cloud	Microsoft Azure IoT
Eclipse IoT	PTC ThingWorx
GE (General Electronic) Predix	Amazon AWS IoT
IBM Watson IoT	Kaa

IoT Network Architecture

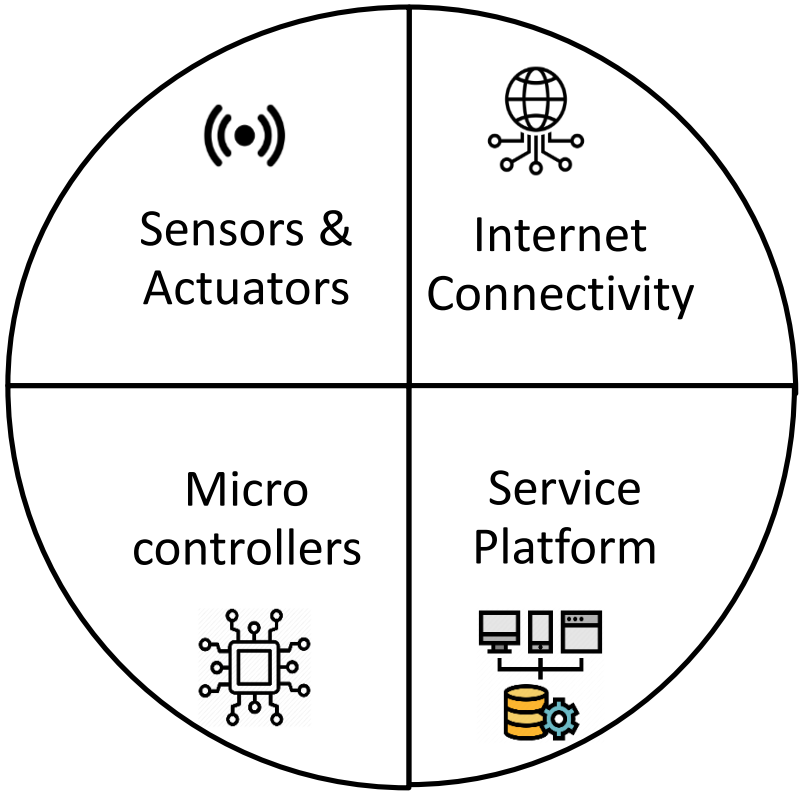
- Network and its application should never be built without careful planning
- Architecture is how you design (i.e. graphical structure) your application or solution.



- The practice of building single-purpose and "vertical" domain applications leads to isolated silos.
- Using the smart building use case, a security application can detect when nobody is in the building.
- It could then trigger lights to be switched off and for the air conditioning system to operate on a reduced setting.

Source: https://onem2m.org/using-onem2m/developers/basics

Core Components of IoT

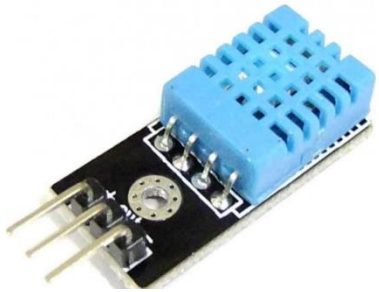


- Sensors - to gather data and events
- Actuators – responsible for moving and controlling a mechanism or system
- Microcontrollers - automatically controls sensors and actuators; makes them smart
- Internet connectivity – responsible for sharing information and control command
- Service Platform – ability to deploy and manage the IoT devices and applications including data management, data analytics and all aspects of security

“Things” in IoT – Sensors

MQ135 - Air Quality Gas Sensor

Sound Detection Sensor



DHT11 - Temperature and Humidity Sensor

PIR Motion Detector Sensor

Pulse Sensor

LDR Light Sensor

Ultrasonic Distance Sensor

IR Sensor

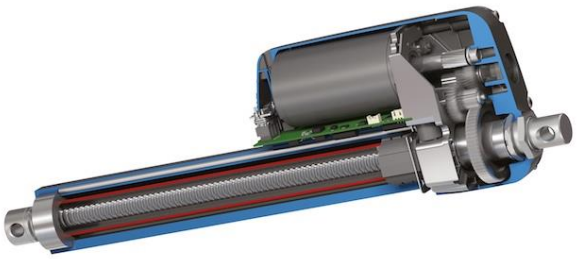
“Things” in IoT – Actuators

4 Channel 5V Relay

Servo Motor

DC Motor

Solenoid valve



Linear Actuators

LED

LCD Diplay

Access Technologies in IoT

Communication Criteria

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

IoT Access Technologies

Comparison of Key Attributes

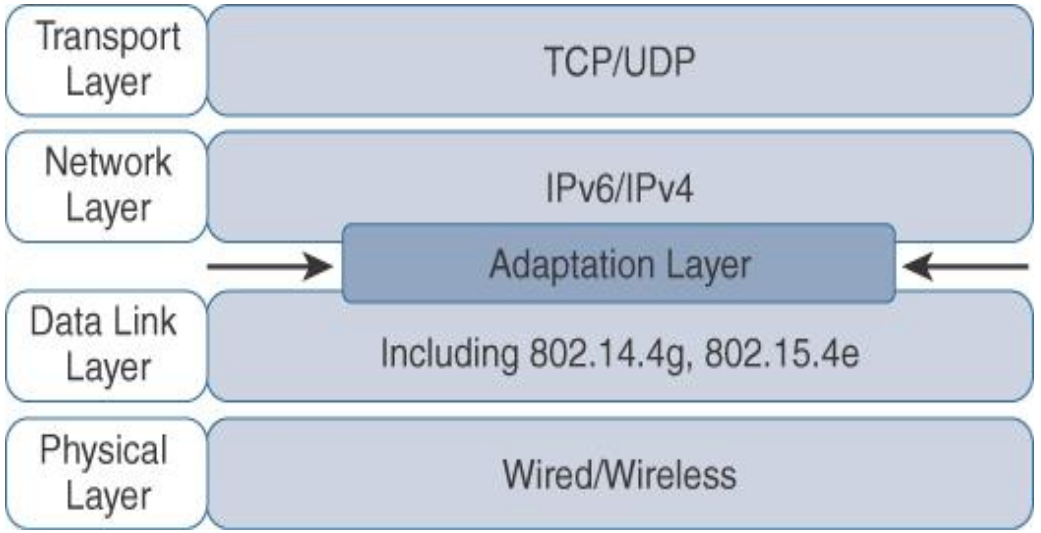
	WiFi	BLE	Thread	Sub-GHz: TI	Sigfox	Zigbee	LoRa
Max. Data throughput	72 Mbps	2 Mbps	250 Kbps	200 Kbps	100 bps	250 Kbps	50 Kbps
Range	100 m	750 m	100 m	4 km	25 km	130 m	10 km
Topology	Star	P2P/ Mesh	Mesh/ Star	Star	Star	Mesh/ Star	Star of Star
Frequency	2.4 GHz	2.4 GHz	2.4 GHz	Sub-GHz	Sub-GHz	2.4 GHz	Sub-1GHz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

Use of Internet

Key Advantages of IP

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

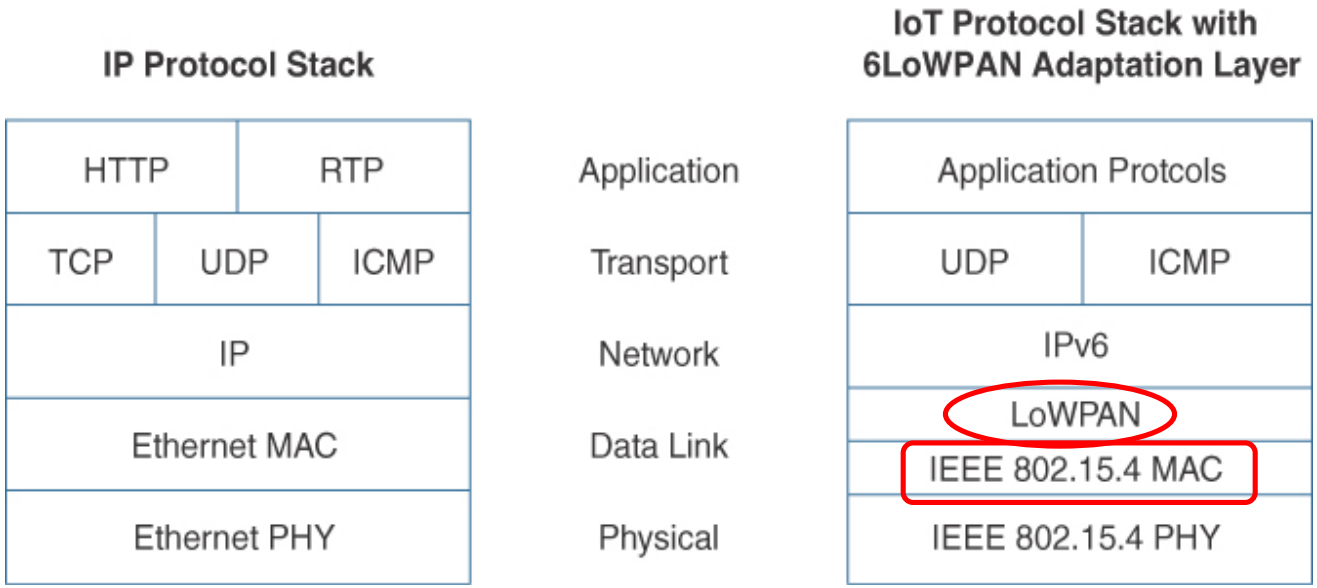


- IPv6 packets require a minimum MTU/PDU size of 1280 bytes.
- The maximum size of a MAC layer frame in IEEE 802.15.4 is 127 bytes.
  - It gives just 102 bytes for an IPv6 packet !!

Need of packet/frame size optimization due to

- Constrained Nodes
- Constrained Networks

Modification in TCP/IP Stack

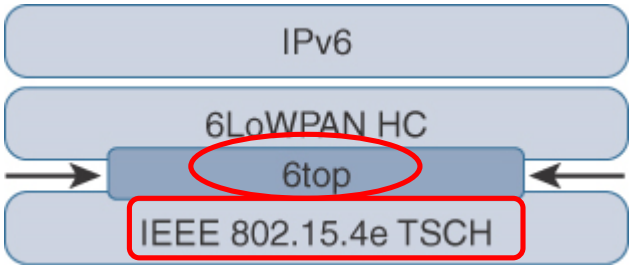


IEEE 802.15.4e - 2011 Amendment

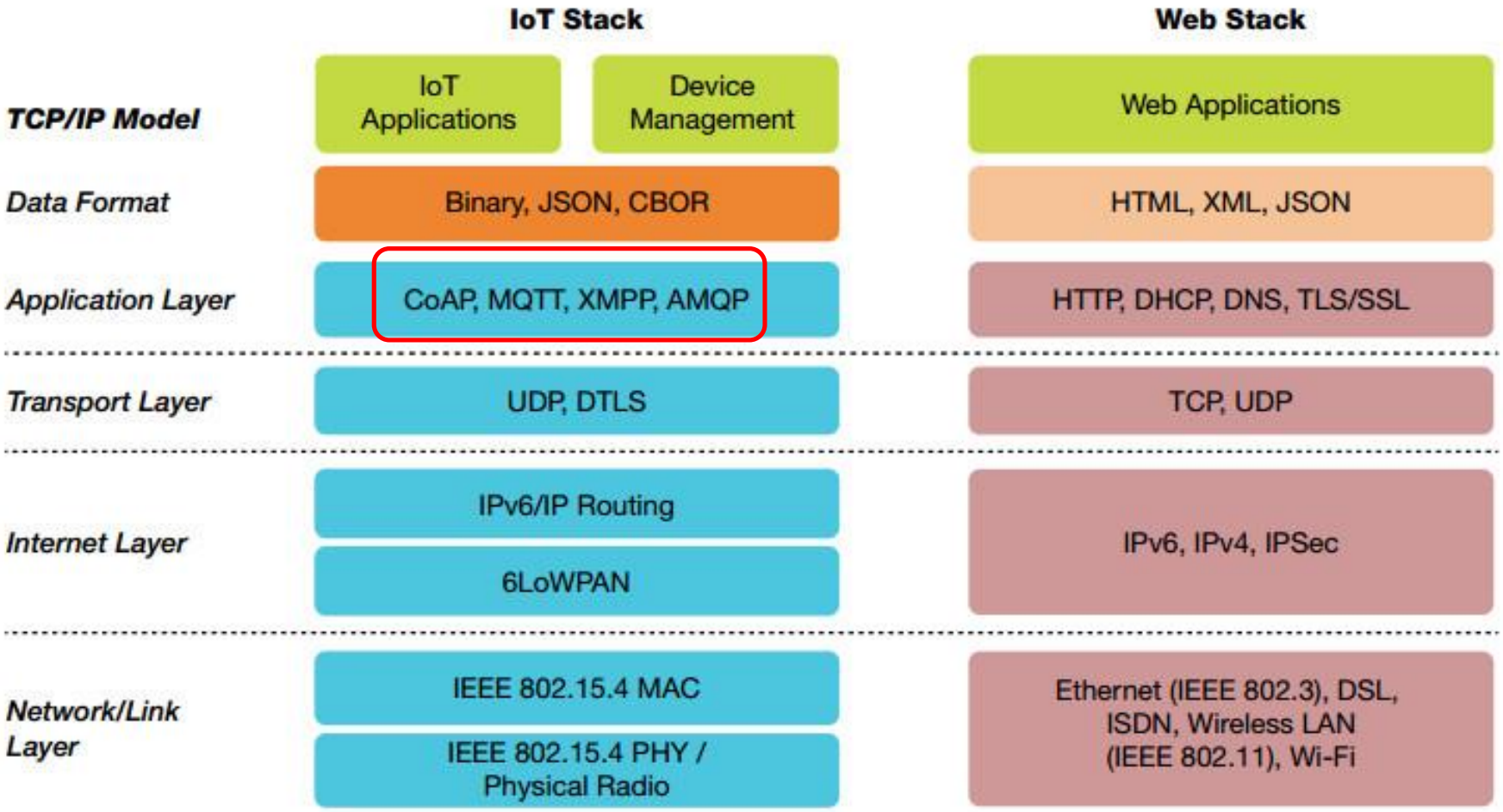
- WPAN: Wireless Personal Area Networks
- IEEE 802.15.4: Low-rate WPAN

- 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

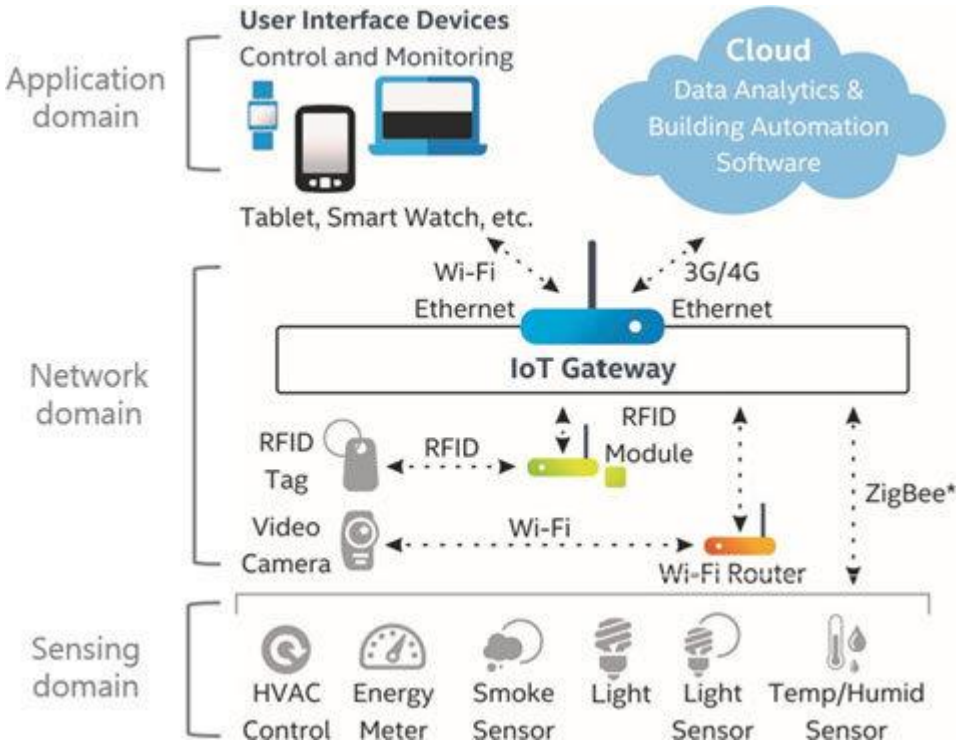
In 6TiSCH IoT Network



Application Layer



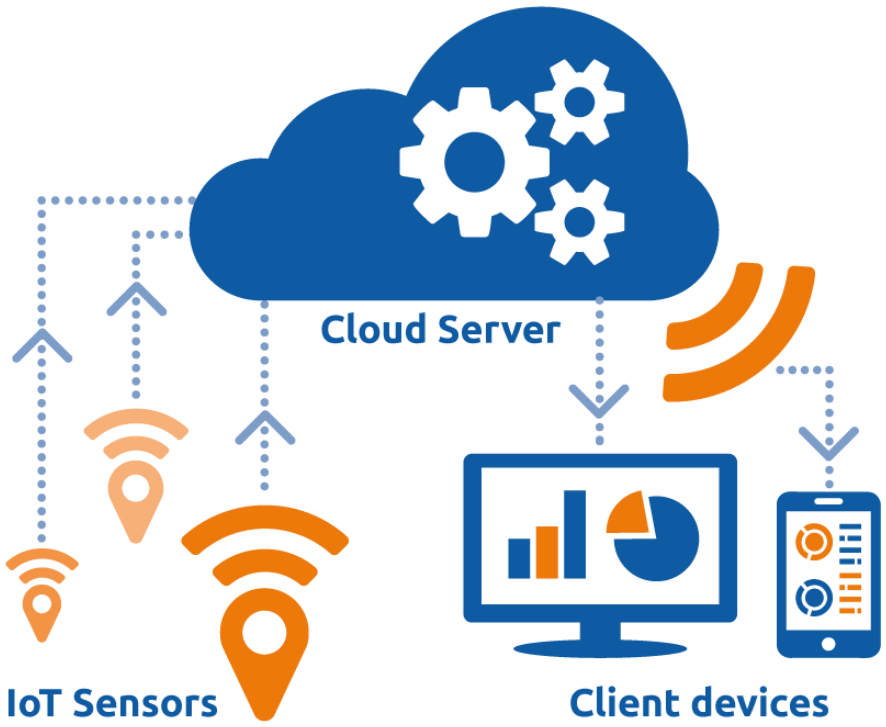
IoT Gateway



- It is a physical device or software program that serves as the connection point between the two different types of networks
- Provide bidirectional communication
  - Between IoT protocols and other networks
    - e.g. Zigbee <--> Ethernet
- Sometimes programmed to execute some processing operations
  - Edge computing
- It is necessary to maintain security to a certain extent
  - Can shield the entire IoT systems from any cyberattack

Source: B. Kang, D. Kim, H. Choo, "Internet of Everything: A Large-Scale Autonomic IoT Gateway", IEEE Transactions on Multi-scale Computing Systems, vol. 3, no. 3, 2017, pp. 206-214.

Use of Cloud



- IoT generates vast amount of Big Data;
- this in turn puts a huge strain on Internet Infrastructure.

- Cloud can facilitate to
  - Provide different services
  - Store huge amount of data
  - Process the data efficiently

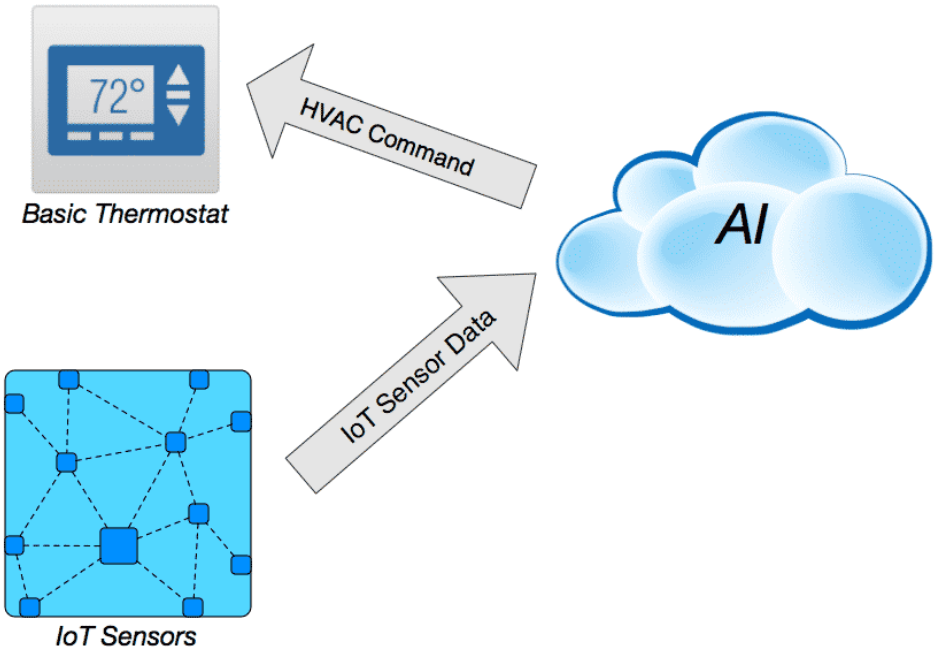
- **Benefits of Cloud Platform in IoT**
  - Network Scalability
  - Data Mobility
  - Time to market
  - Security
  - Cost-effectiveness

AI for IoT

- AI focuses on putting human intelligence in machine
- It gives the ability to a machine/program to think and learn by itself

Use of AI in IoT:

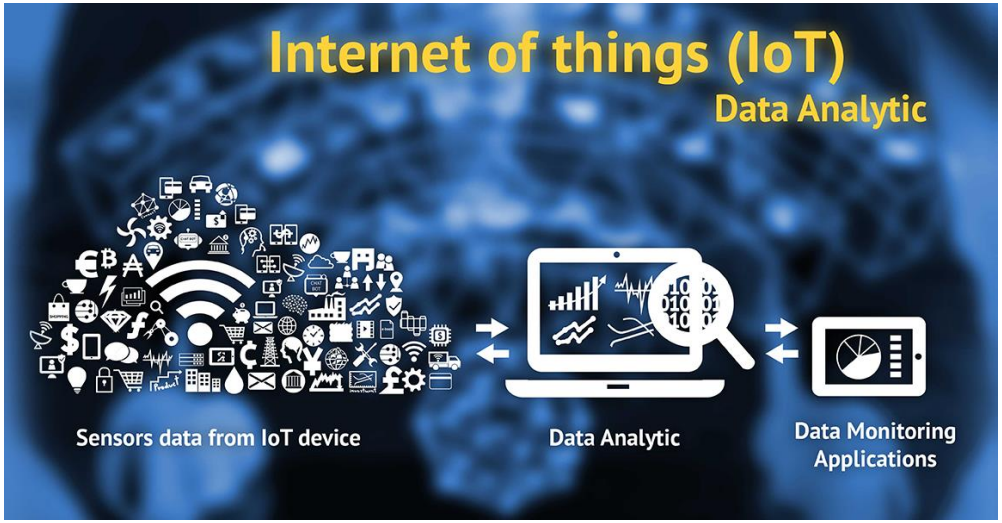
- Smart Home
  - Automated HVAC control
- Industrial IoT
  - Predictive maintenance
  - Optimized supply chain
- Farming
  - Smart farming
  - Interruption warning
- Self-driving Car
  - Mimic human driving on road
- Health
  - Auto-diagnosing any disease
  - Assistive healthcare



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 it comes from understanding the data these devices create.



Challenges:

- Huge Volume
- Real-time data flow
- Variety of data types
  - e.g. XML, video, SMS
- Unstructured data
- Variable data model and meaning / value

- 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

User Interface

- Information made available to the end-users
- Users can actively check and act in for their IOT system

Important Characteristics:

- ✓ Sleek design
- ✓ Visually appealing
- ✓ Interactive UI
- ✓ Ease-of-use
- ✓ Handy

Source: https://www.daikin.com/about/design/2017/05/entry-15

Lessons Learned

- ✓ What is IoT Ecosystem
- ✓ Different components of IoT
- ✓ IoT Framework
- ✓ IoT Architecture
- ✓ IoT Core
- ✓ Sensors & Actuators
- ✓ IoT Access Technologies
- ✓ IoT Gateway
- ✓ Use of Cloud in IoT
- ✓ Data Analytics in IoT
- ✓ AI for IoT
- ✓ Security in IoT
- ✓ User Interface for IoT

Thanks!

Figures and slide materials are taken from the following Books:

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

Security in IoT

- 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