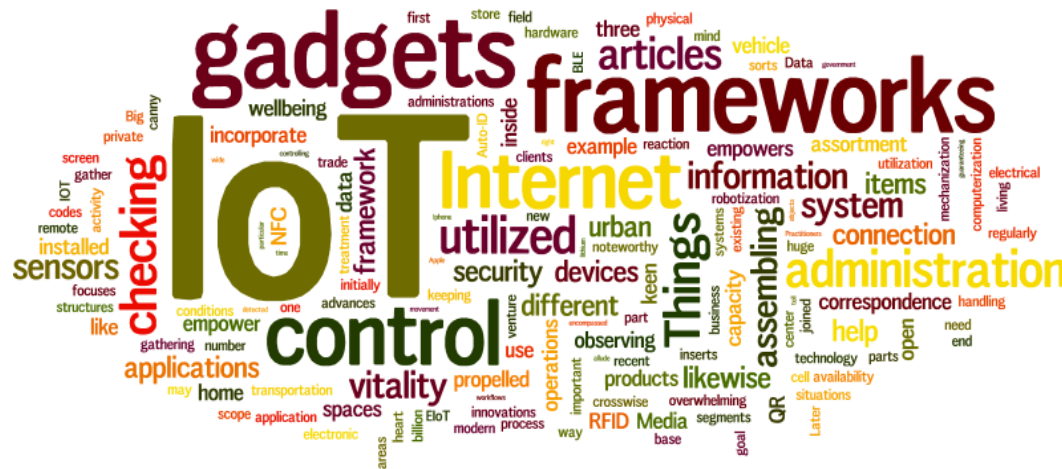


# Internet of Things

# 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

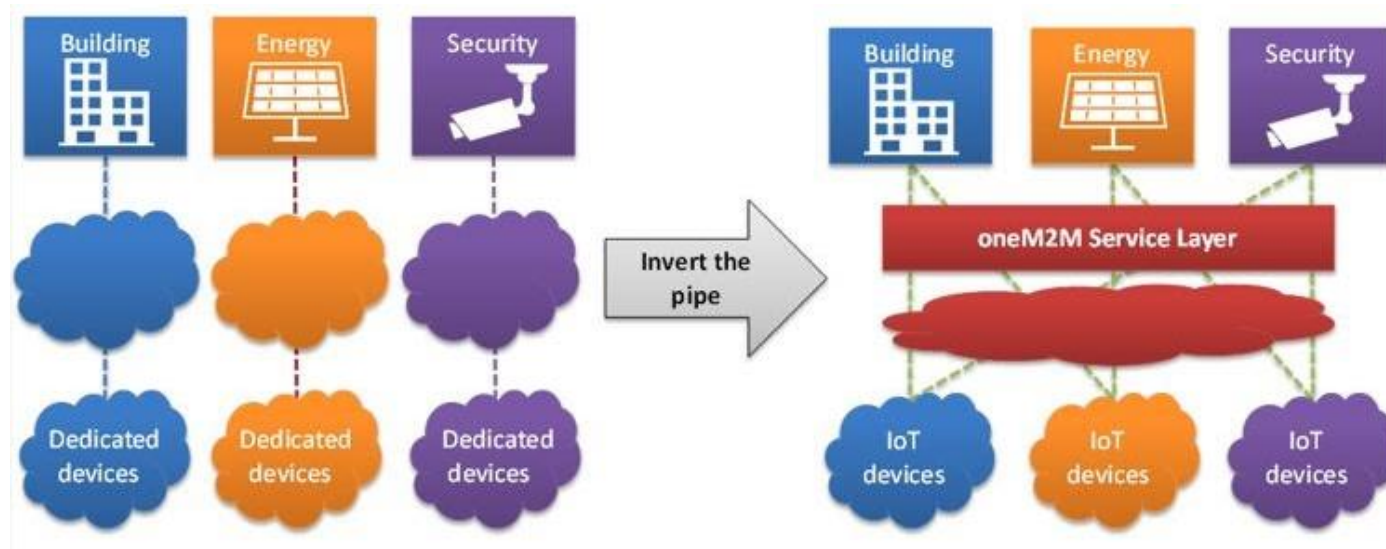
# IoT Framework

- 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 3<sup>rd</sup> party application to built on it, and so on.

Few IoT Framework	Few IoT Framework
RTI (Real-Time Innovations) Connex DD	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

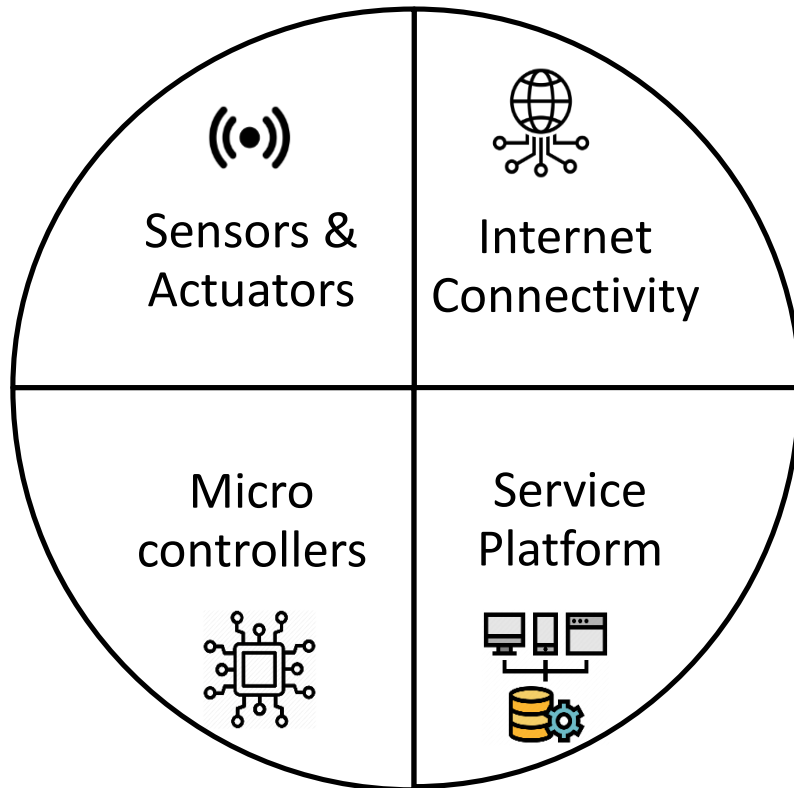
- Network and its application should never be built without careful planning
- Architecture is how you design (i.e. graphical structure) your application or solution.



- 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**

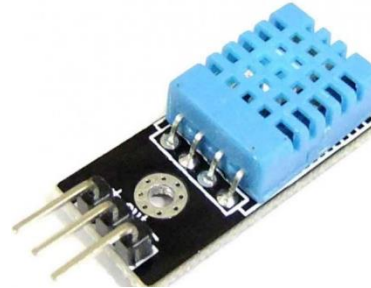
# “Things” in IoT – Sensors



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



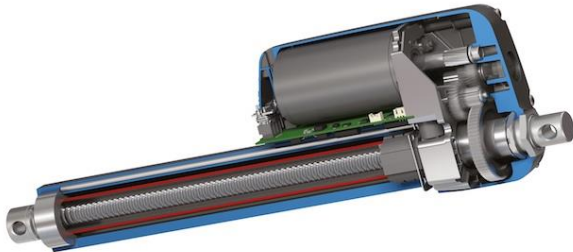
Servo Motor



DC Motor



Solenoid valve



Linear Actuators



LED



LCD Display

# Access Technologies in IoT

## Communication Criteria

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

## IoT Access Technologies





# Comparison of Key Attributes

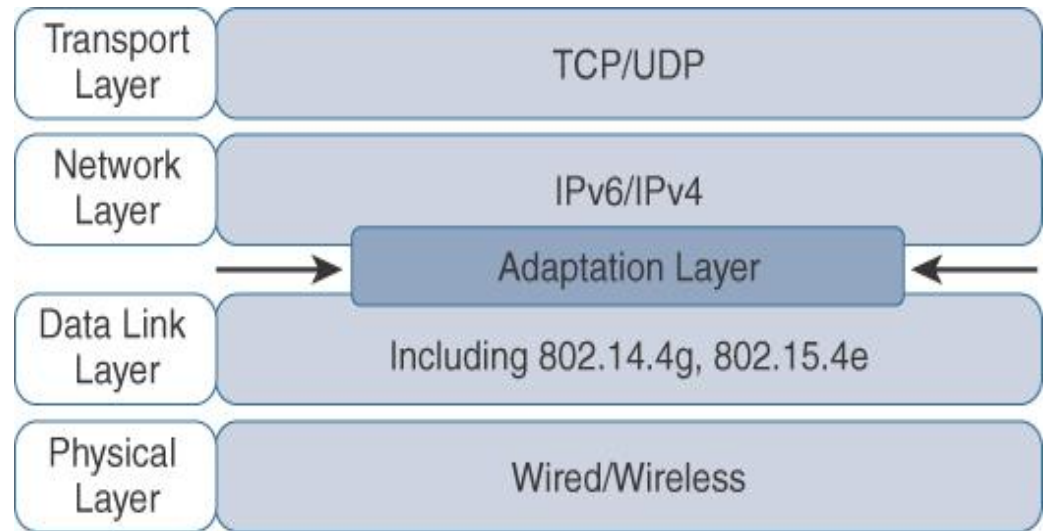
	WiFi	BLE	Thread	Sub-GHz: TI	Sigfox	Zigbee	LoRa
<b>Max. Data throughput</b>	72 Mbps	2 Mbps	250 Kbps	200 Kbps	100 bps	250 Kbps	50 Kbps
<b>Range</b>	100 m	750 m	100 m	4 km	25 km	130 m	10 km
<b>Topology</b>	Star	P2P/ Mesh	Mesh/ Star	Star	Star	Mesh/ Star	Star of Star
<b>Frequency</b>	2.4 GHz	2.4 GHz	2.4 GHz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

IP Protocol Stack

HTTP		RTP	
TCP	UDP	ICMP	
IP			
Ethernet MAC			
Ethernet PHY			

Application

Transport

Network

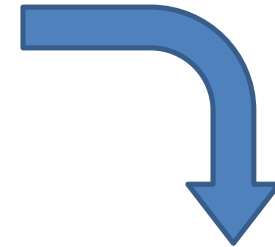
Data Link

Physical

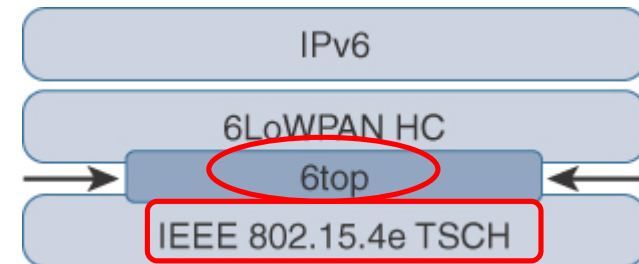
IoT Protocol Stack with  
6LoWPAN Adaptation Layer

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

IEEE 802.15.4e -  
2011 Amendment

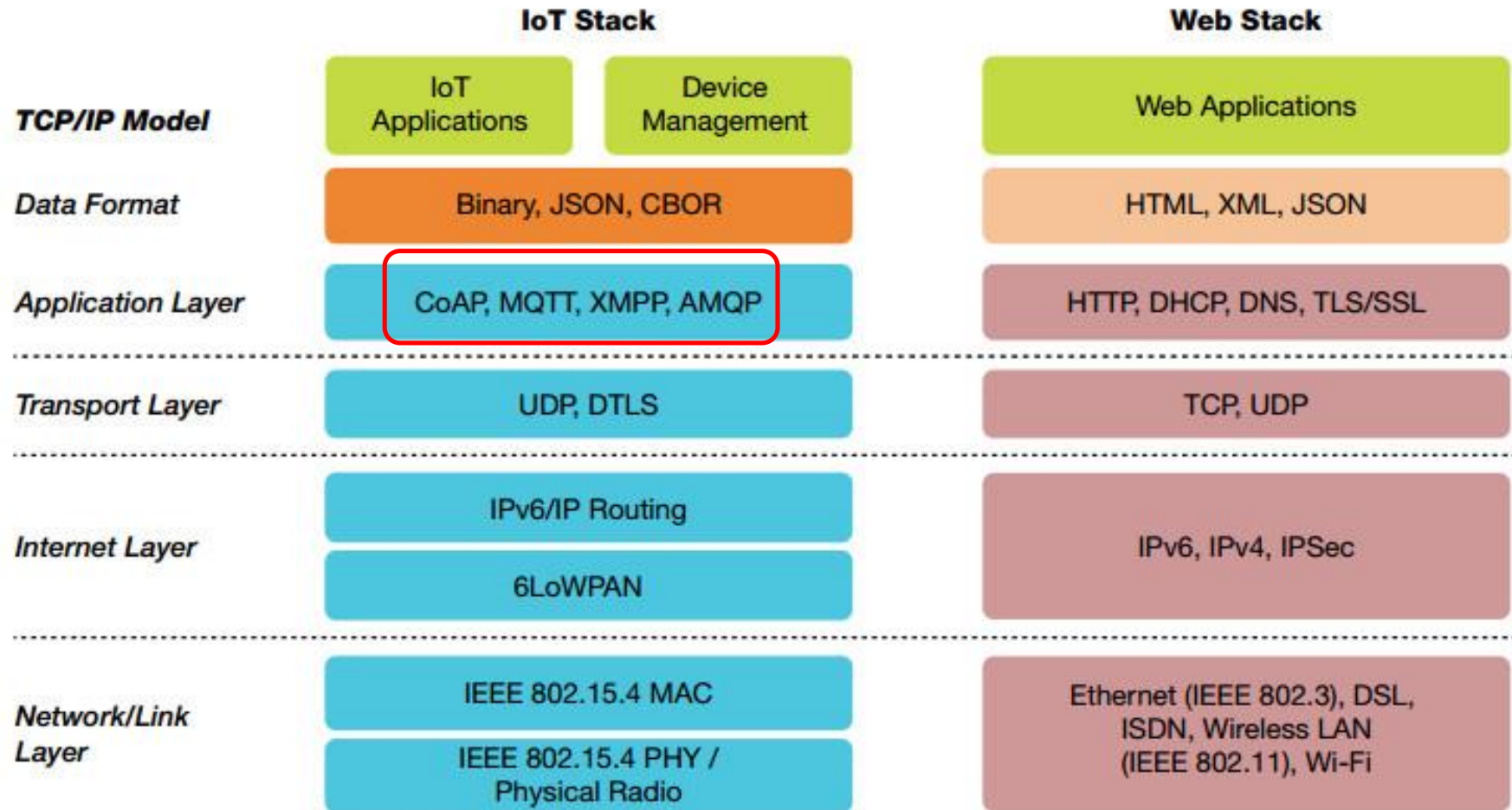


In 6TiSCH IoT Network

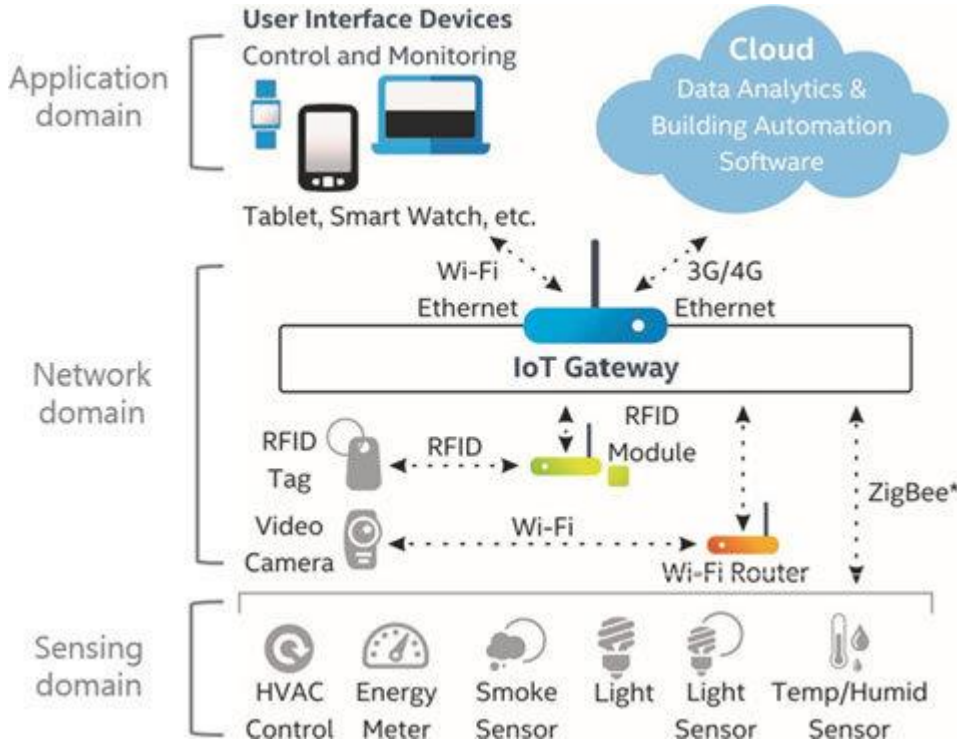


- **WPAN**: Wireless Personal Area Networks
- **IEEE 802.15.4**: Low-rate WPAN
- **LoWPAN**: Low-Power WPAN
- **6LoWPAN**: IPv6 over LoWPAN
- **TSCH**: Time Synchronized Channel Hopping
- **6TiSCH**: IPv6 over the TSCH mode of IEEE 802.15.4e
- **6top**: 6TiSCH Operation Sublayer

# Application Layer



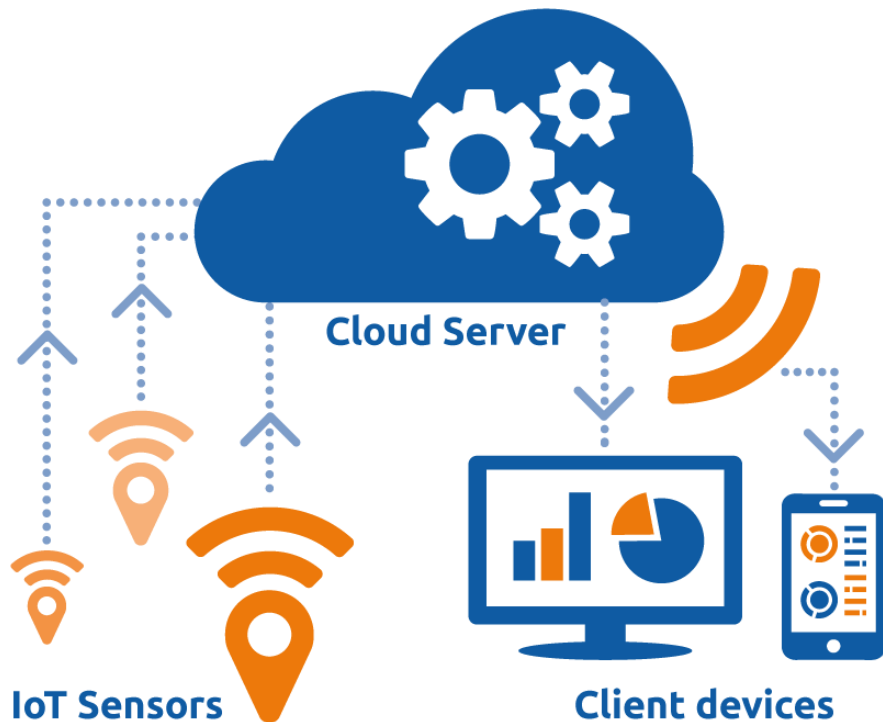
# IoT Gateway



- 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



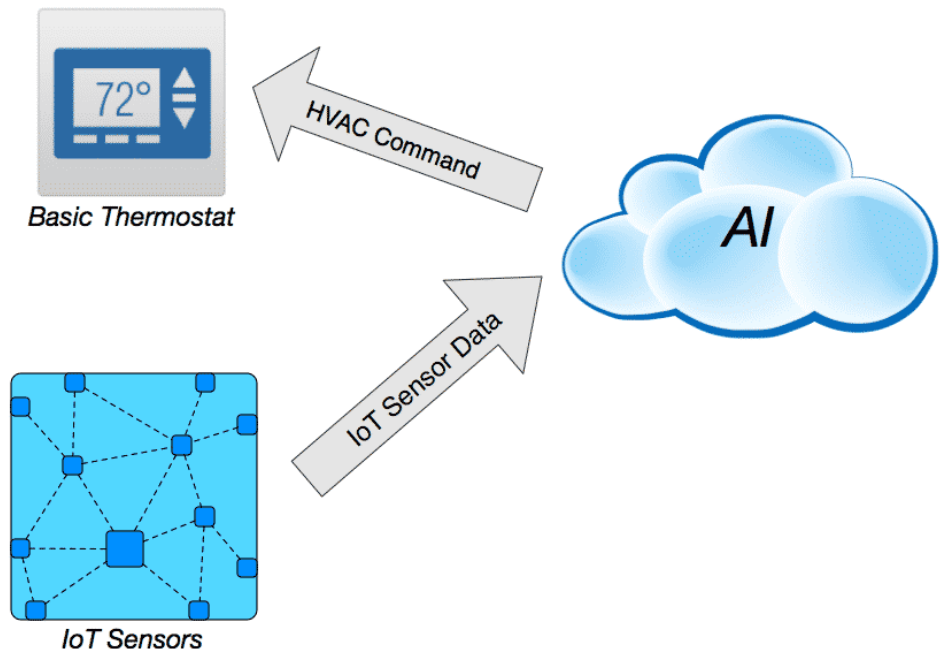
- IoT generates vast amount of Big Data;
- this in turn puts a huge strain on Internet Infrastructure.
- Cloud can facilitate to
  - Provide different services
  - Store huge amount of data
  - Process the data efficiently
- **Benefits of Cloud Platform in IoT**
  - Network Scalability
  - Data Mobility
  - 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

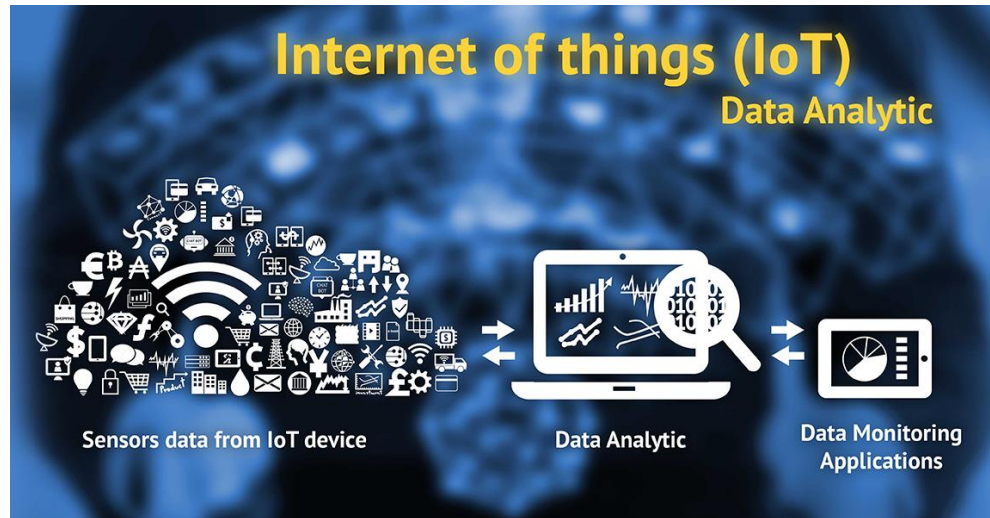




# Data Analytics in IoT

“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**”, 1<sup>st</sup> Edition, 2018, Pearson India.

# Security in IoT



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>

