Lecture 1 : Introducing Internet of Things

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Outline

- Internet of Things – Basic concepts, Examples
- History , Progression
- Basic Idea of the IoT Ecosystem
- IoT Architecture
- Why IoT Now?
- Summary of the course content
  - Module 1 : Enabling Technologies – Sensing, Processing, Communication
  - Module 2 : Communication Technologies
  - Module 3 : Cloud Computing for IoT
  - Module 4 : Data Analytics for IoT
  - Module 5 : Advanced Topics – Fog and Edge Computing, IoT security
- Challenges and Research Directions

Internet of Things

Internet of things

From Wikipedia, the free encyclopedia

The **Internet of things** (**IoT**) describes the network of physical objects—"things"—that are embedded with sensors, software, and other technologies for the purpose of connecting and exchanging data with other devices and systems over the Internet.[1][2][3][4]

Things have evolved due to the convergence of multiple technologies, real-time analytics, machine learning, commodity sensors, and embedded systems.[1] Traditional fields of embedded systems, wireless sensor networks, control systems, automation (including home and building automation), and others all contribute to enabling the Internet of things. In the consumer market, IoT technology is most synonymous with products pertaining to the concept of the "smart home", including devices and appliances (such as lighting fixtures, thermostats, home security systems and cameras, and other home appliances) that support one or more common ecosystems, and can be controlled via devices associated with that ecosystem, such as smartphones and smart speakers. IoT can also be used in healthcare systems.[5]

Things, People and Cloud Services get connected via Internet to enable new use cases and business models

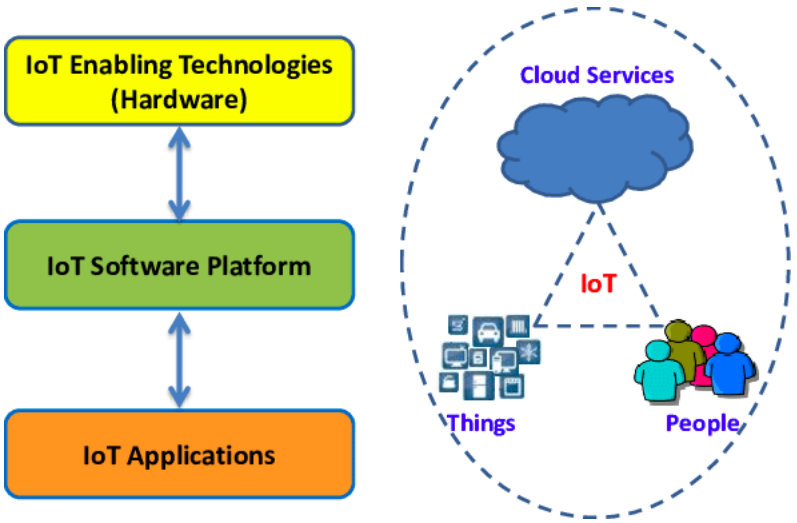
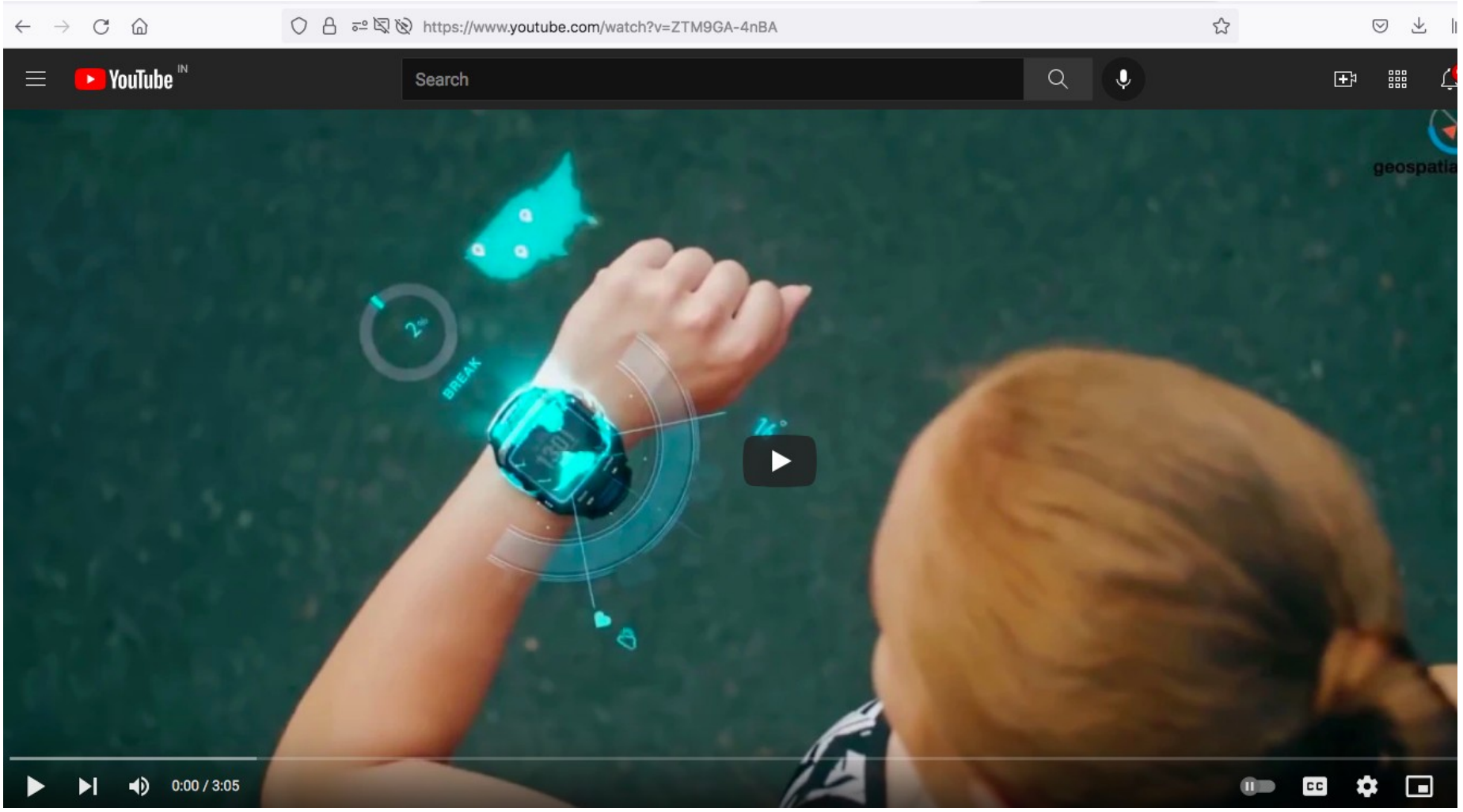


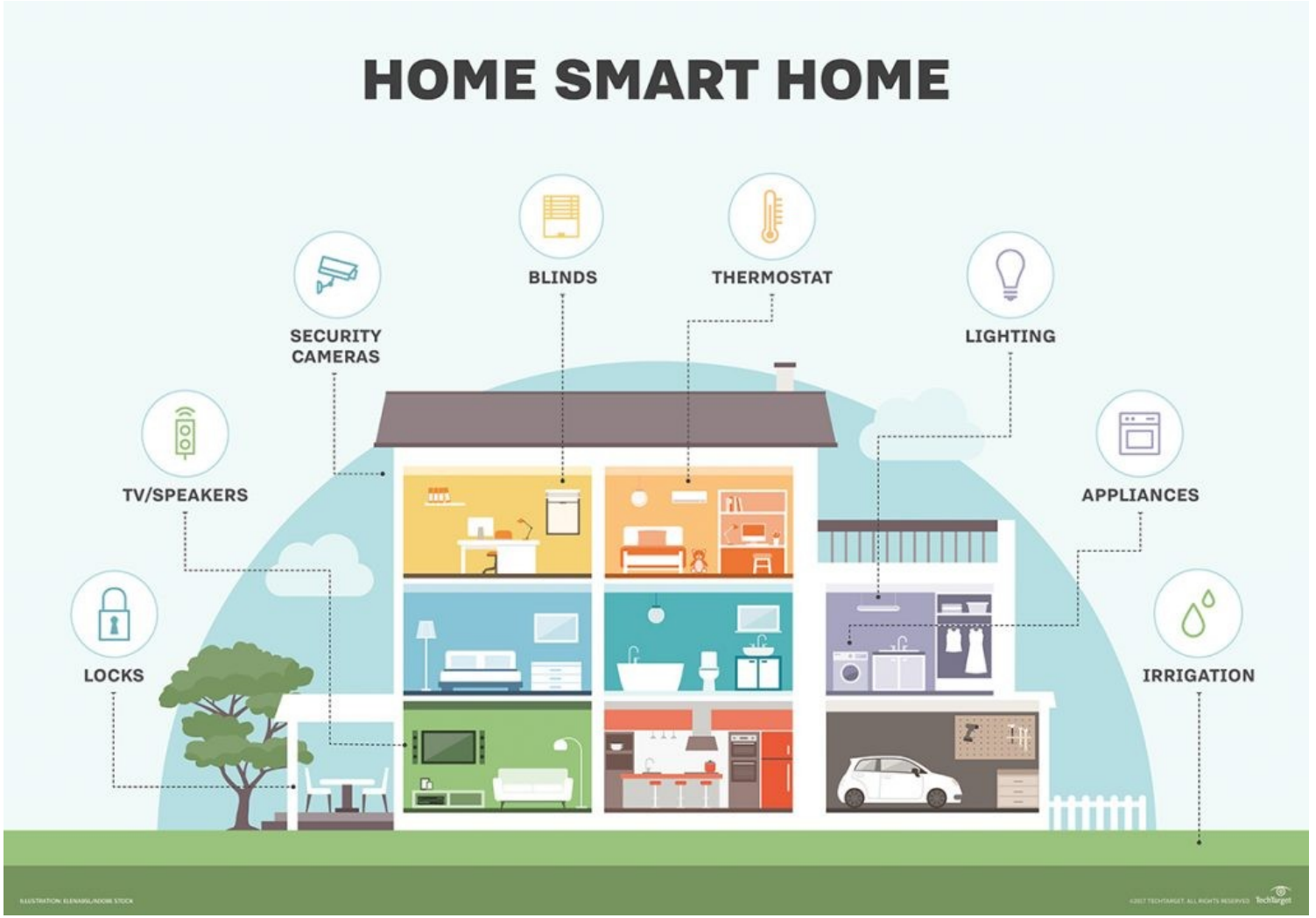
Figure source : Iman Khajenisiri et.al., A Review of Internet of Things Solution for Intelligent Energy Control in Buildings for Smart City Applications, Energy Procedia, Volume 111, 2017

Internet of Things : Applications

Let us Watch This !!!!!

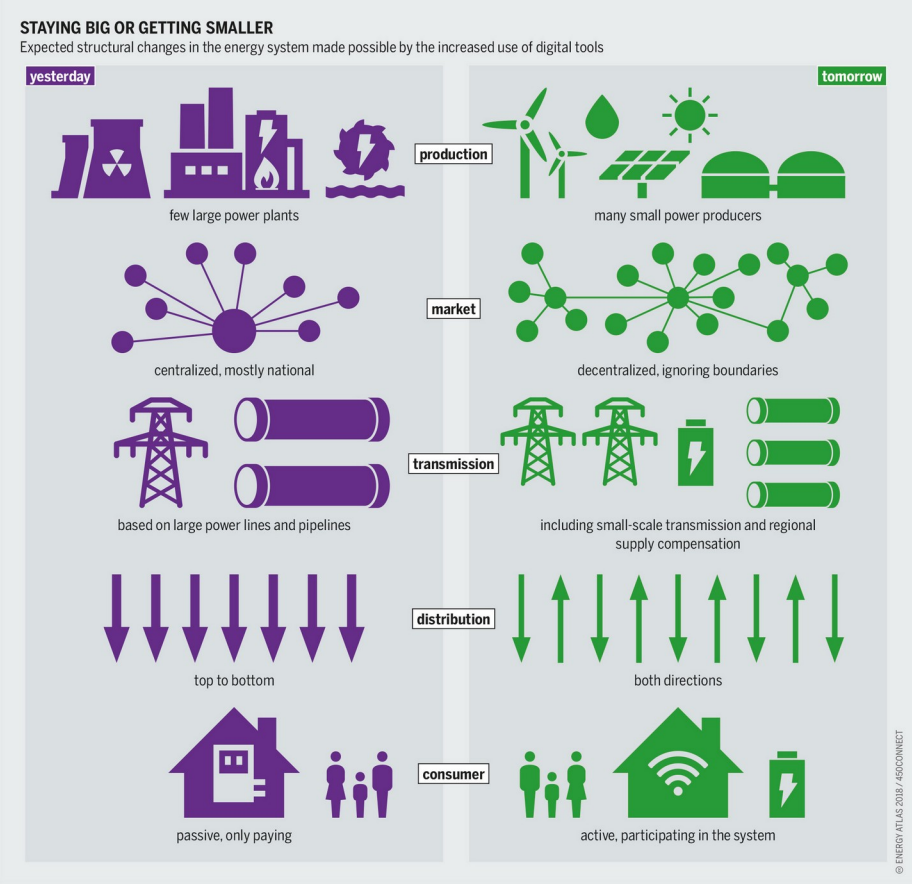


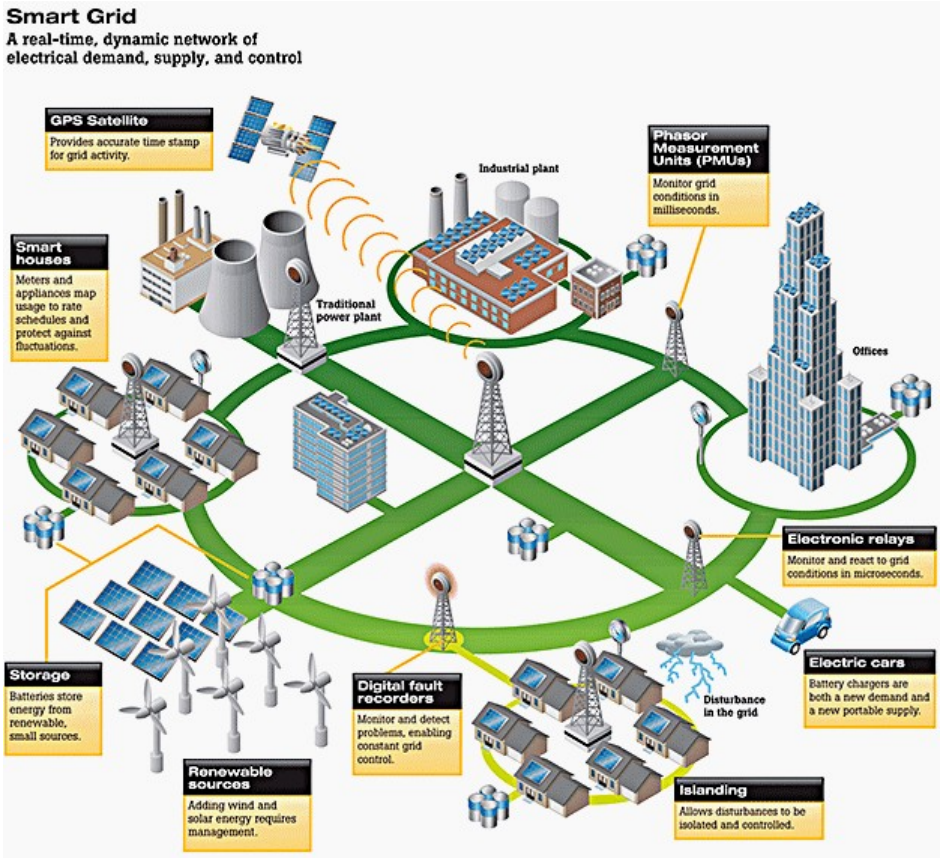
Internet of Things Applications



Source : TechTarget

Internet of Things Applications : Smart Grid





Source : Internet

Watch This : Smart Grids in India by TU Delft! :

Internet of Things Applications : Healthcare

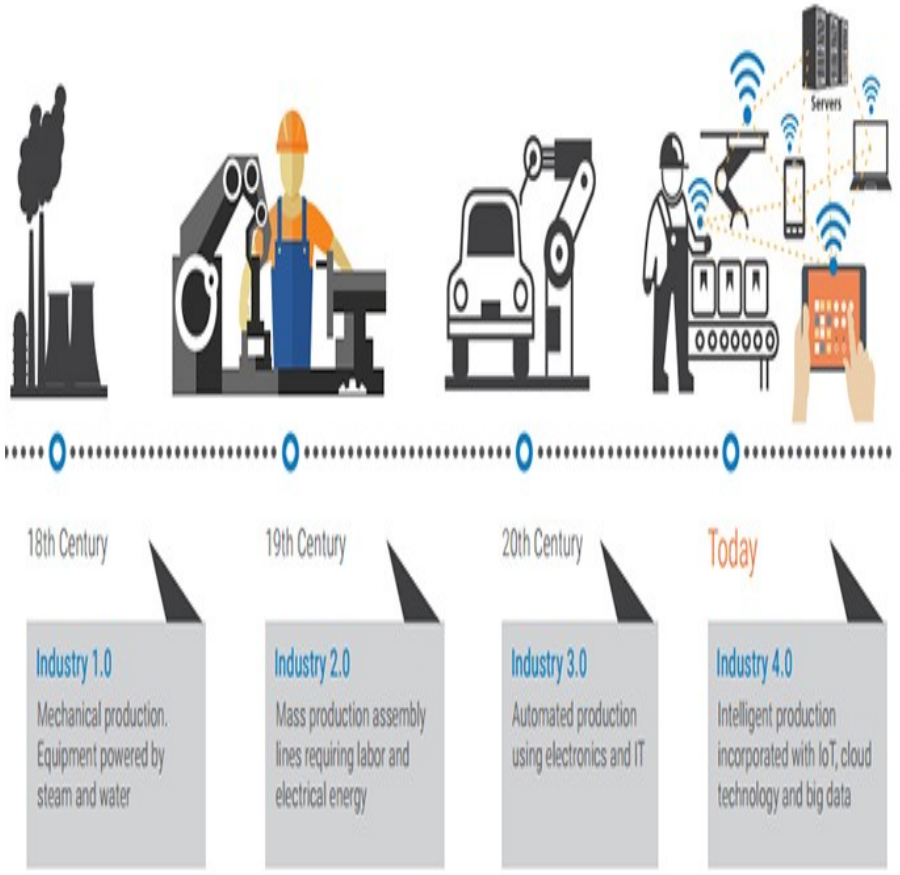
Role of IoT in Healthcare

Source : Internet

Wearables

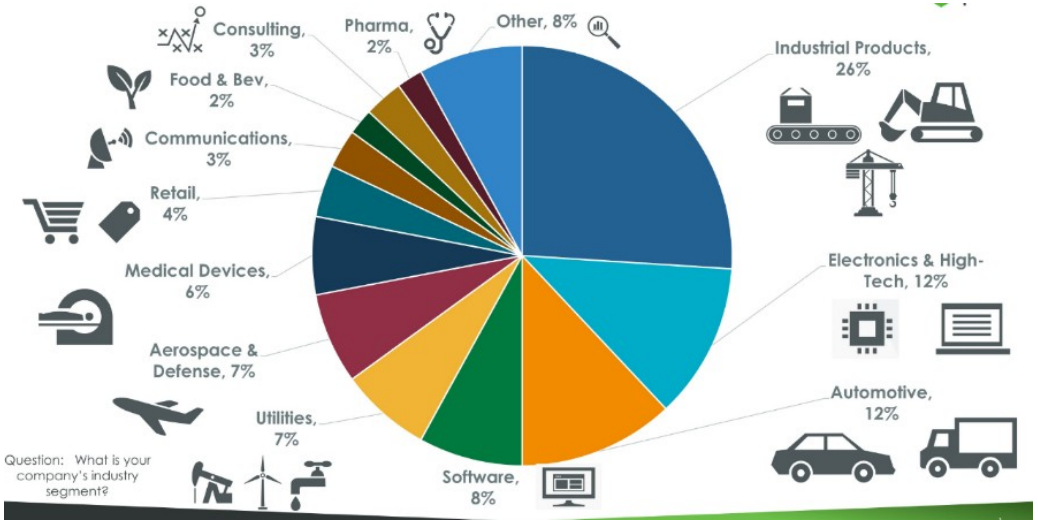
Source : Internet

Internet of Things Applications : Industry 4.0



Industrial Revolutions

Source : Internet



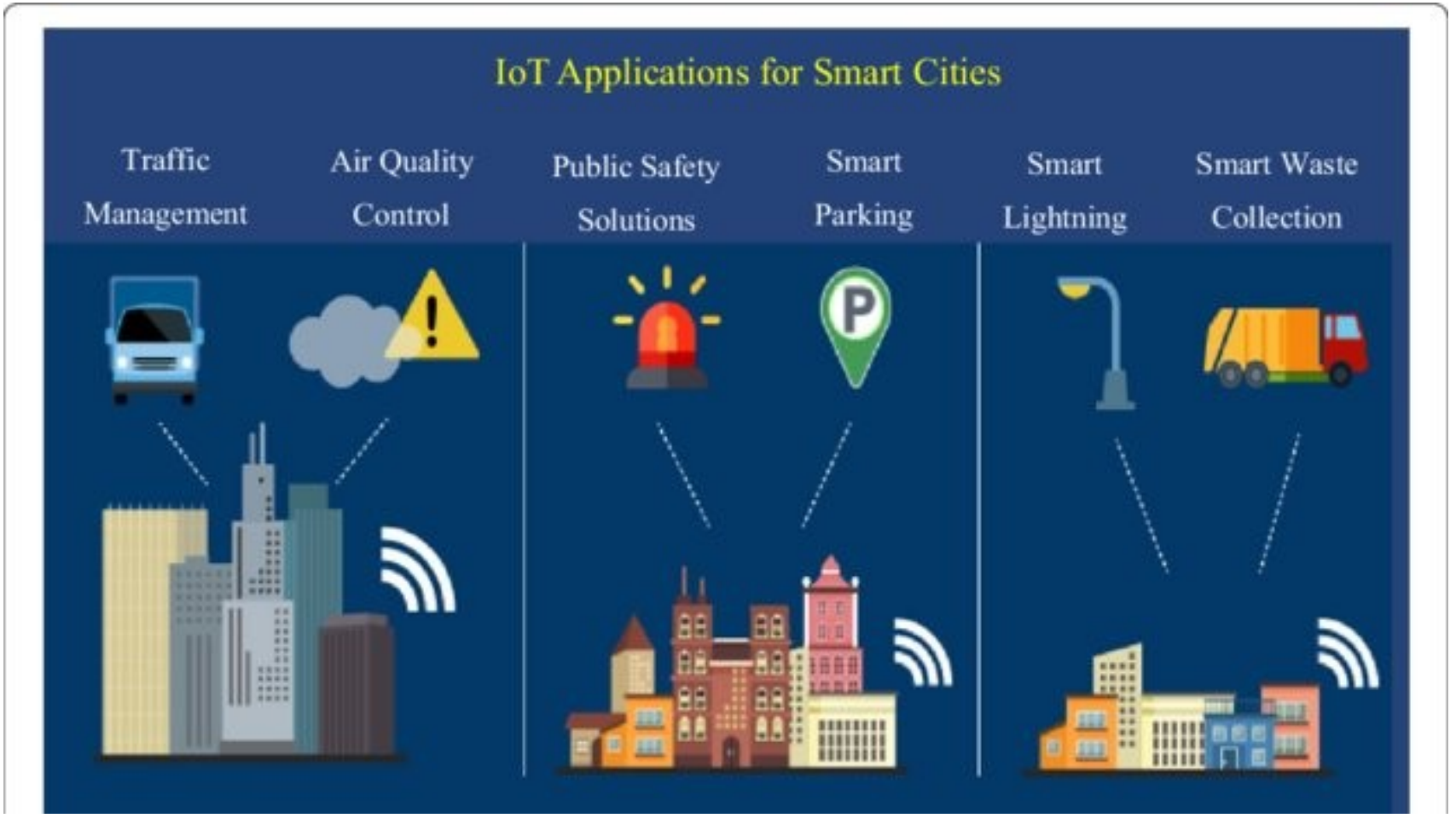
Source : Internet

Internet of Things Applications : Agriculture

Source : Internet

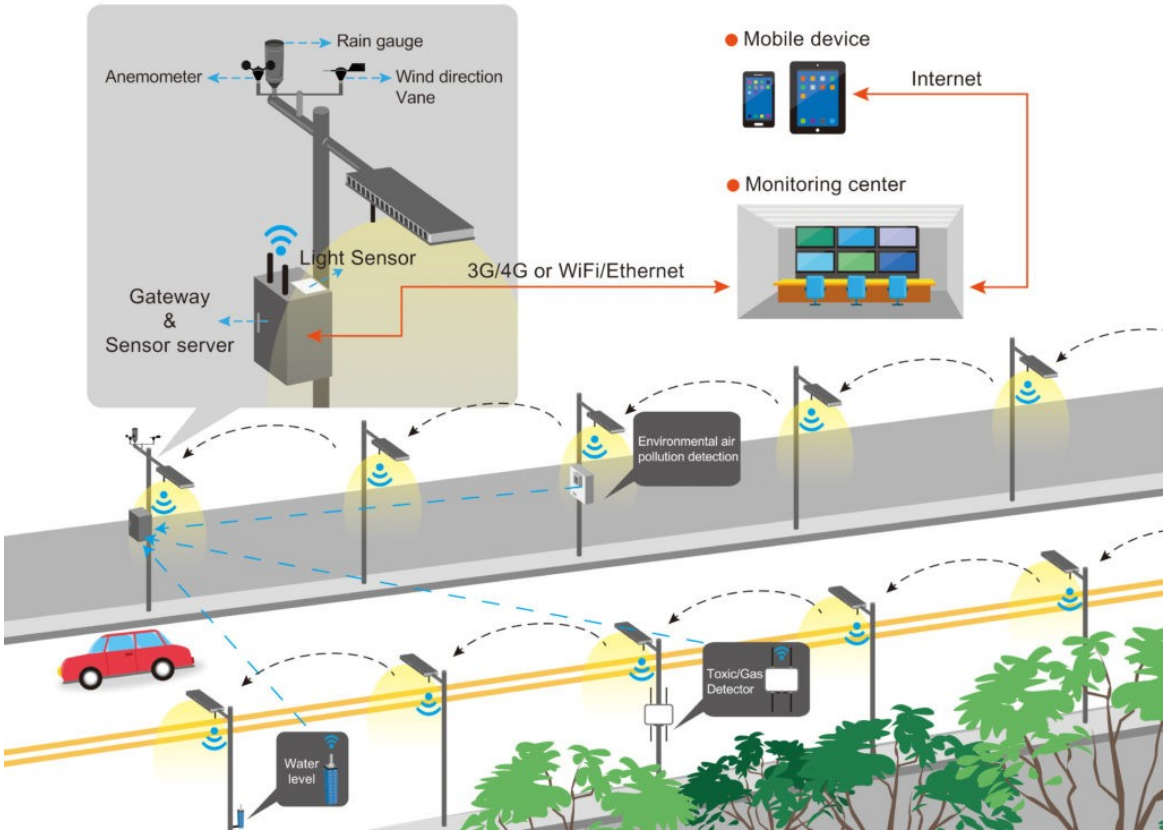
Watch This : Smart Agriculture Solution by Infosys

Internet of Things Applications : Smart City



Source : Internet of Things is a revolutionary approach for future technology enhancement: a review, Sachin Kumar et al. , Journal of Big Data, Springer, 2019

Internet of Things Applications : Smart Street Lights



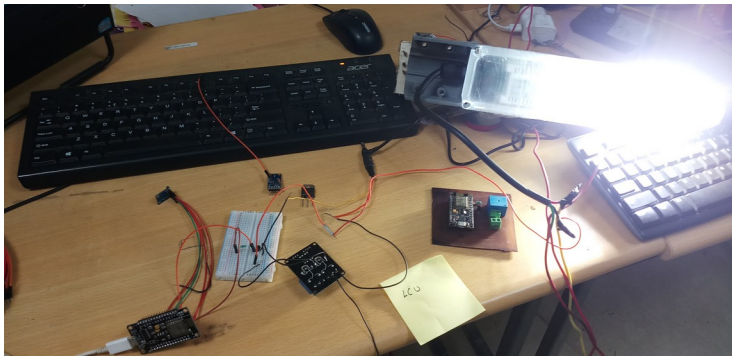
Source : Internet

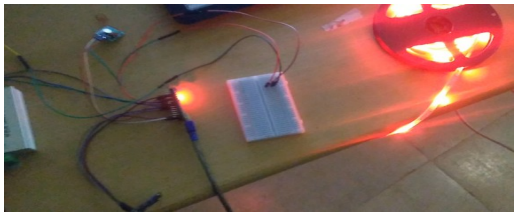
Smart Street Lights Project – Systems Lab IIITA

Systems Lab IIITA aims at providing IoT based smart city infrastructure in the form of smart street lighting appending the Street Light National Program initiated by GoI in 2015 with the aim to promote energy efficiency in the country.

Objectives :

1. Energy Saving : Intelligent Lighting System which uses smart LEDs offering varying degrees of illumination based on surrounding environment (surrounding light intensity, pedestrians, vehicles, weather conditions)
2. Easy and prompt maintenance with reduced manual labour , periodic status checks of each light and automatic notification in case of fault
3. Novel, generic and scalable solution that can be implemented with any smart LED light
4. Additional services such as housing WLAN access points to deliver internet services selectively for educational content, data source for data analysis of street light consumption

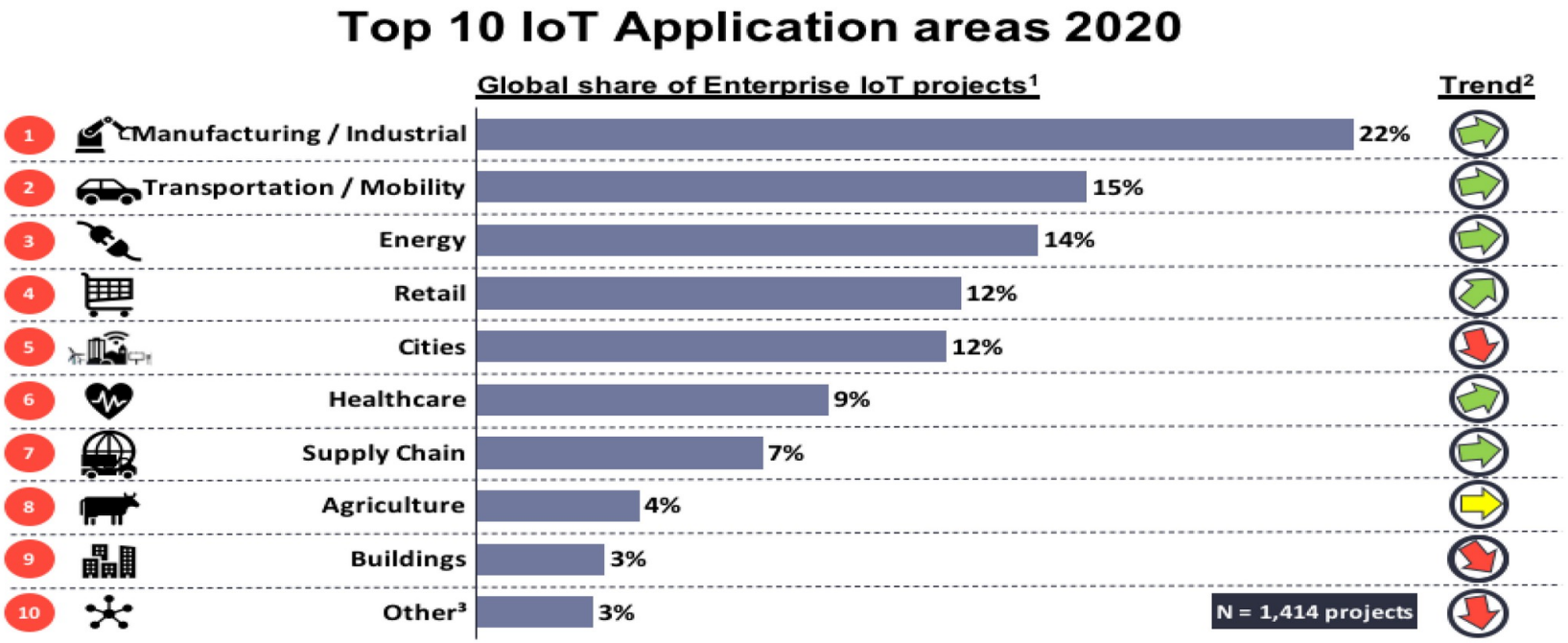




Internet of Things Applications

Source : Introduction to the Internet of Things, Marco Zennaro, Telecommunications/ICT4D Lab, The Abdus Salam International Centre for Theoretical Physics, Trieste, Italy

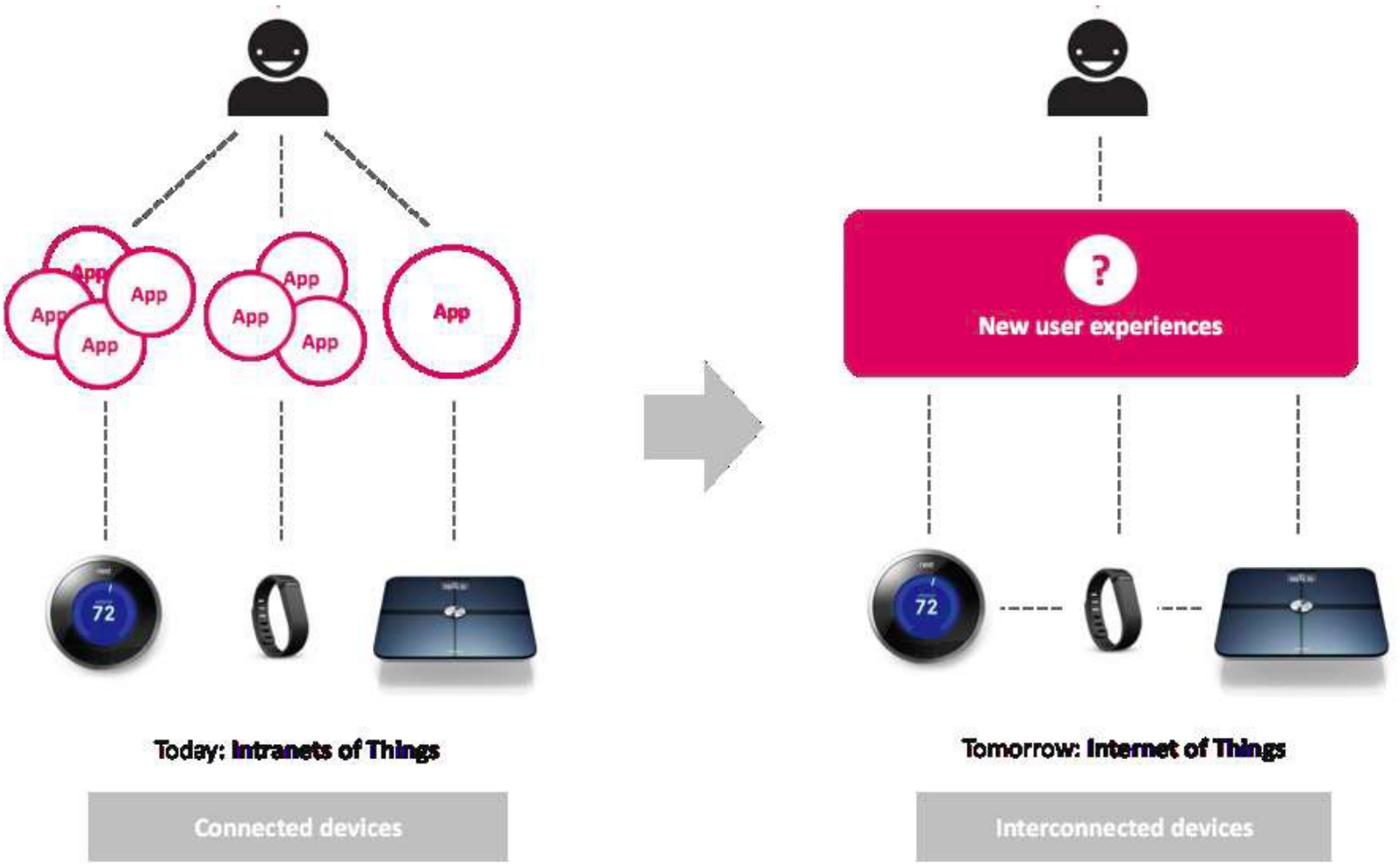
Internet of Things Applications : Review



Top 10 IoT Applications in 2020

Source : IoT Analytics

Internet of Things : Connectivity of Devices



Source : Introduction to the Internet of Things, Marco Zennaro, Telecommunications/ICT4D Lab, The Abdus Salam International Centre for Theoretical Physics, Trieste, Italy

History of Internet of Things

First IoT Device : RFID (1940-1950), Major efforts in development for Tracking and identifying aircrafts in World War II (Friends or Foe)

1960 : RFID was used for monitoring nuclear and other hazardous materials, RFID companies founded

1973 : Mario W. Cadullo received the first US Patent for an active RFID tag

1980 : RFID research started, marks the beginning of transforming RFID into more widespread technology

1990 : First UHF Reader invented, RFID usage expanded to shipments, Walmart introduces their RFID program

Source : Internet

History of Internet of Things

"Machine to Machine" (M2M)
(~1970s +)

Internet of Things Beginnings

Carnegie Mellon Internet
Coke Machine (1982, 1990)

Internet Toaster
(1990)

Trojan Room Coffee
Pot
(first webcam)
(1991)

Source : Introduction to the Internet of Things, Marco Zennaro, Telecommunications/ICT4D Lab, The Abdus Salam International Centre for Theoretical Physics, Trieste, Italy

History of Internet of Things : Progression

Progression in 1980's : **Cloud and Server Space (Data moved to centralized server)**

Progression in 1990's : **Machine to Machine interaction**

1995 : First cellular module built, First GPS network (version 1) complete
1998 : IPv6 adds 2^128 new IP addresses
1999 : Kevin Ashton of MIT coins a new term IoT

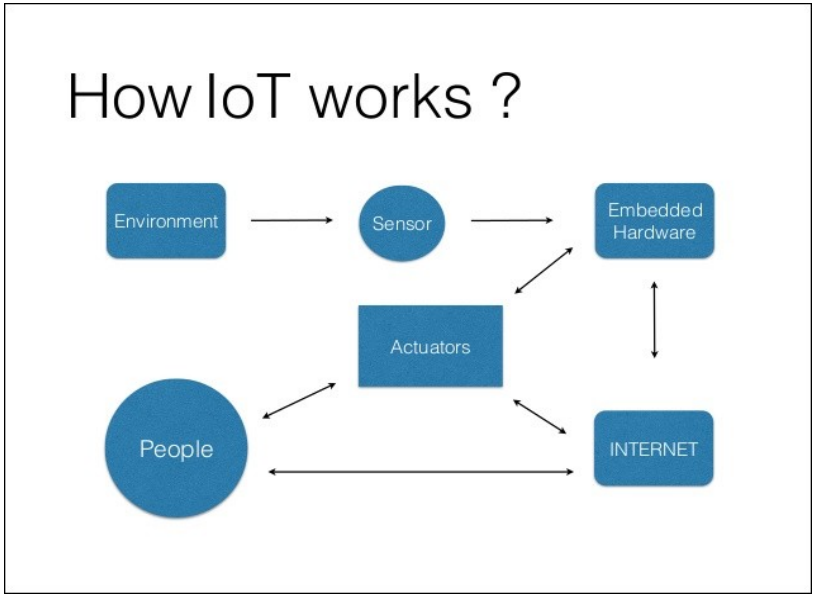
Progression in 2000-2010 : **Fog oriented architectures (Central Server to Regional Server located closer to Data Server subnetwork)**

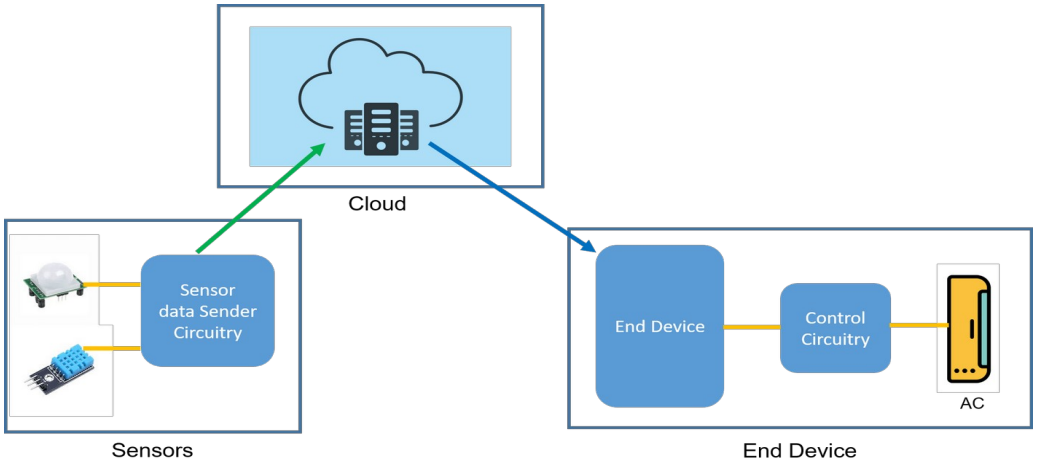
2000 : LG announces first smart fridge
2007 : First iPhone released
2008 : First International Conference on IoT held
2009 : Google started testing self driving cars

Progression in 2010-onwards : **High Processing power and Edge computing**

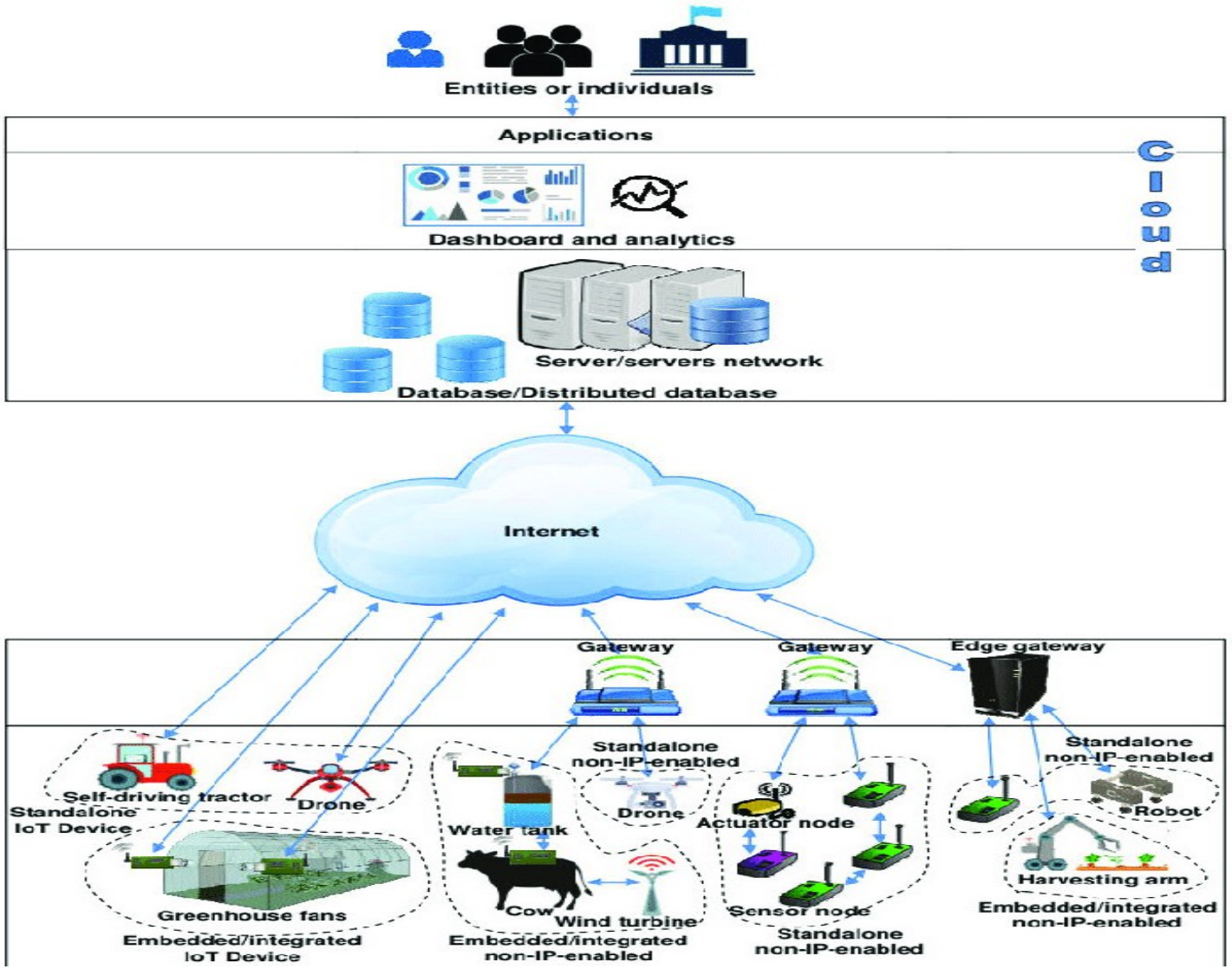
2013 : Google glass is released
2014 : Amazon releases Echo (smart home market opens)
2015 : GM, Uber, Tesla are testing self driving cars
2017- : IoT continues to grow,

IoT – Basic Idea

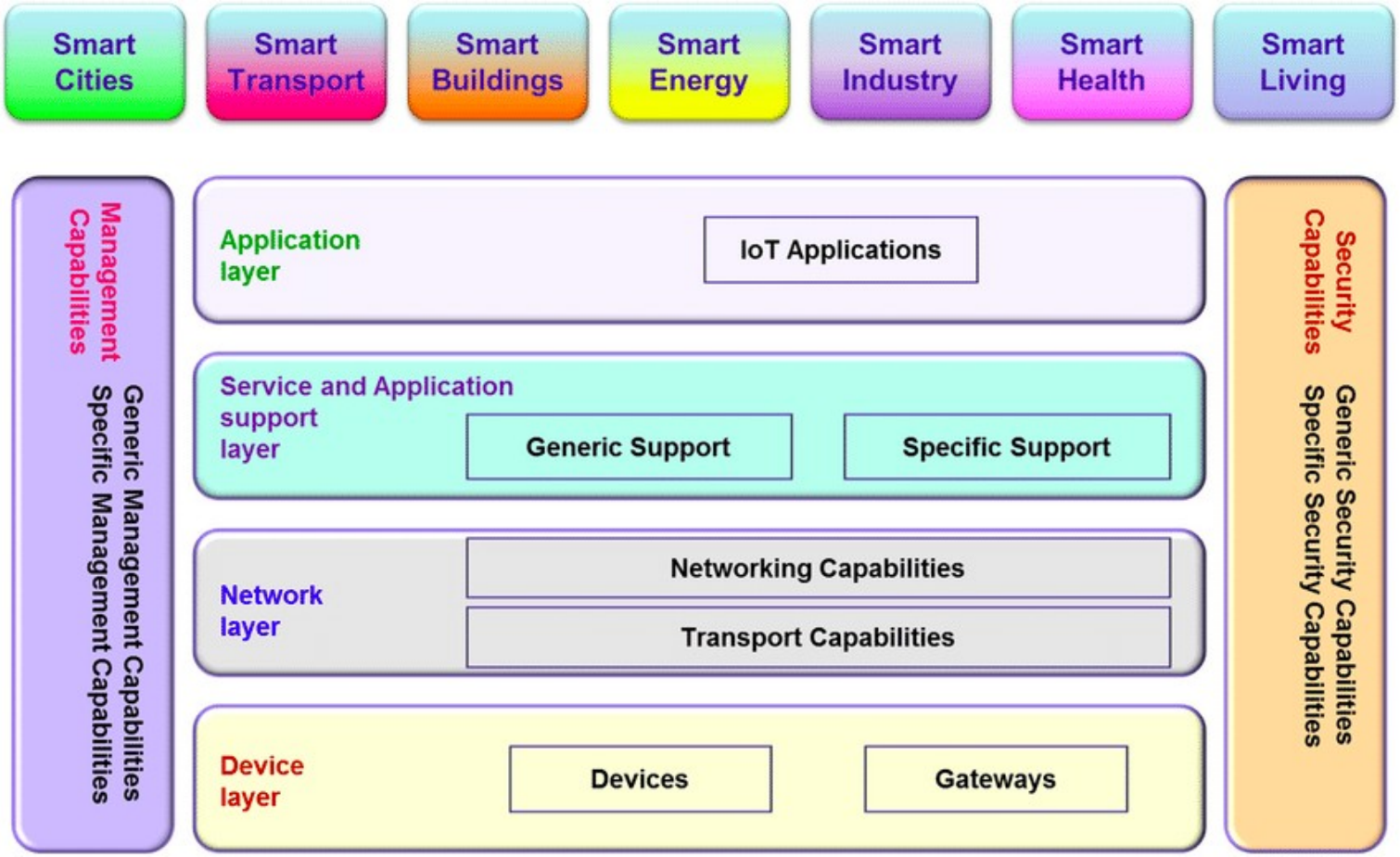




IoT Ecosystem



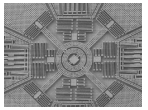
The Four Layered IoT Architecture



Source : ITU-T

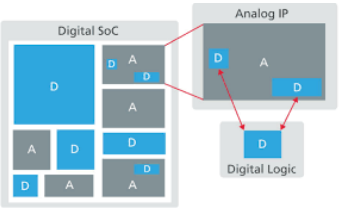
Why IoT Now?

- **Improved VLSI Technology – Miniaturization, MEMS Technology for Sensing**



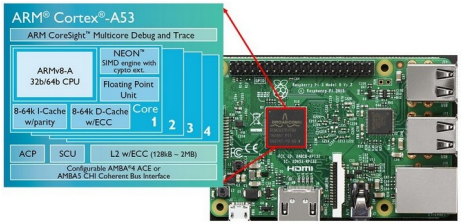
Accelerometer

Gyroscope

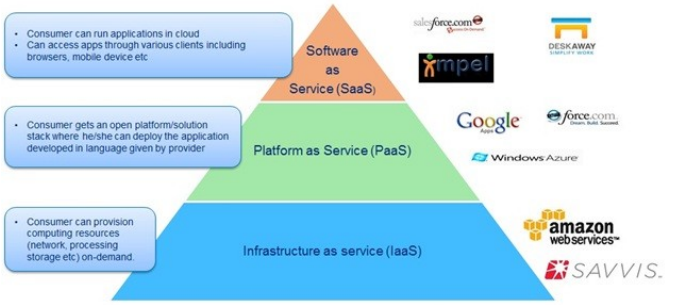


- **Widespread Adoption of Intellectual Properties**

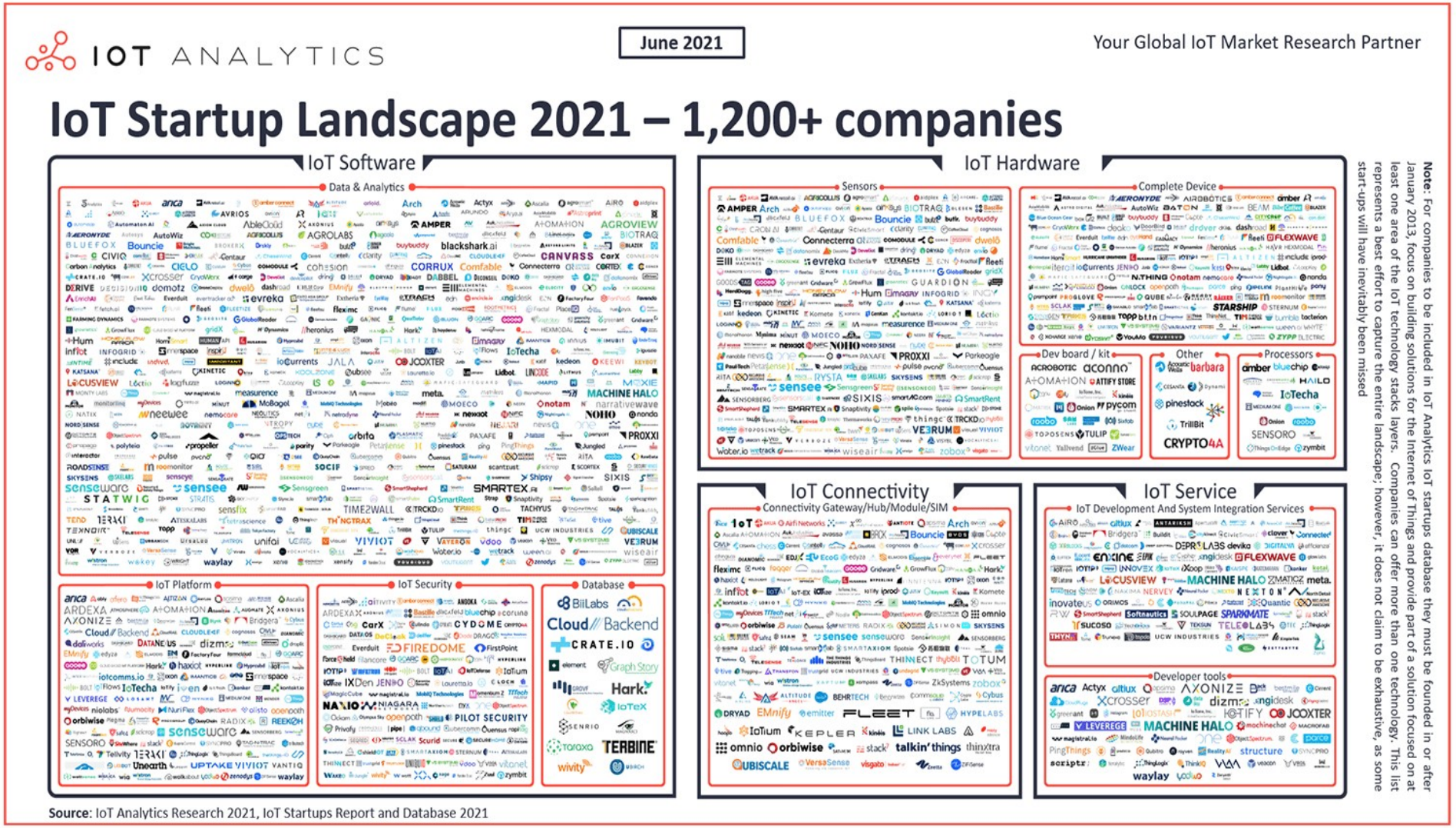
- **Computing Economics - Availability of System-on-Chips**



- **Data Analytics – Descriptive, Diagnostic, Predictive, Prescriptive**
- **Fast connectivity**
- **Rise of Cloud Computing – Provides scalability to the Big Data generated by IoT Devices**



IoT Startup Landscape 2021



What do we learn in this course ?

Course Outline

Module 1 :

1. IoT Fundamentals - Architecture, Elements of IoT – Sensors, Actuators, Processing Elements, Communication modules, cloud based infrastructure
2. IoT Enabling Technologies and APIs
3. IoT Design Principles (Hands-on sessions using different IoT Platforms)

Module 2 :

1. Communications used in IoT – Device-Device, Device – Gateway, Device – Cloud, Back-end sharing model
2. IoT Communication Protocols –

Link Layer : Ethernet (802.3), Wifi(802.11), Wimax(802.16), LR-PAN(802.15.4), 2G/3G/4G

Network Layer : IPv4, IPv6, 6LoWPAN

Transport : TCP, UDP

Application : HTTP, CoAP, MQTT, XMPP

3. Tutorial sessions on different application layer protocols – MQTT, CoAP

What do we learn in this course ?

Course Outline

Module 3 :

1. Distributed Computing , Virtualization, Cloud Computing – Basic Idea, Service models – Infrastructure as a Service (I-a-a-S), Platform-as-a Service (P-a-a-S), Application/Software as a Service (S-a-a-S), Software Components, APIs, Role of Cloud in IoT

2. Software Defined Networking (SDN)

3. Social Internet of Things (SIoT) – Lysis Platform

4. Hands on session on different cloud platforms for IoT – ThinkSpeak, Google Cloud

Module 4:

1. IoT Application Development – Solution Framework for Implementation of Data Acquisition, Device Integration and Data Storage

2. Data Analytics for IoT – Summary of different Machine learning and Deep Learning models,

3. Apache Hadoop, Map-Reduce, Apache Spark

4. Tutorial sessions on Hadoop and Map-Reduce

What do we learn in this course ?

Course Outline

Module 5 :

1. Fault Tolerant in IoT based Systems
2. IoT Security
3. Challenges in Design of IoT Based Systems
4. Research problems related to IoT

Resources :

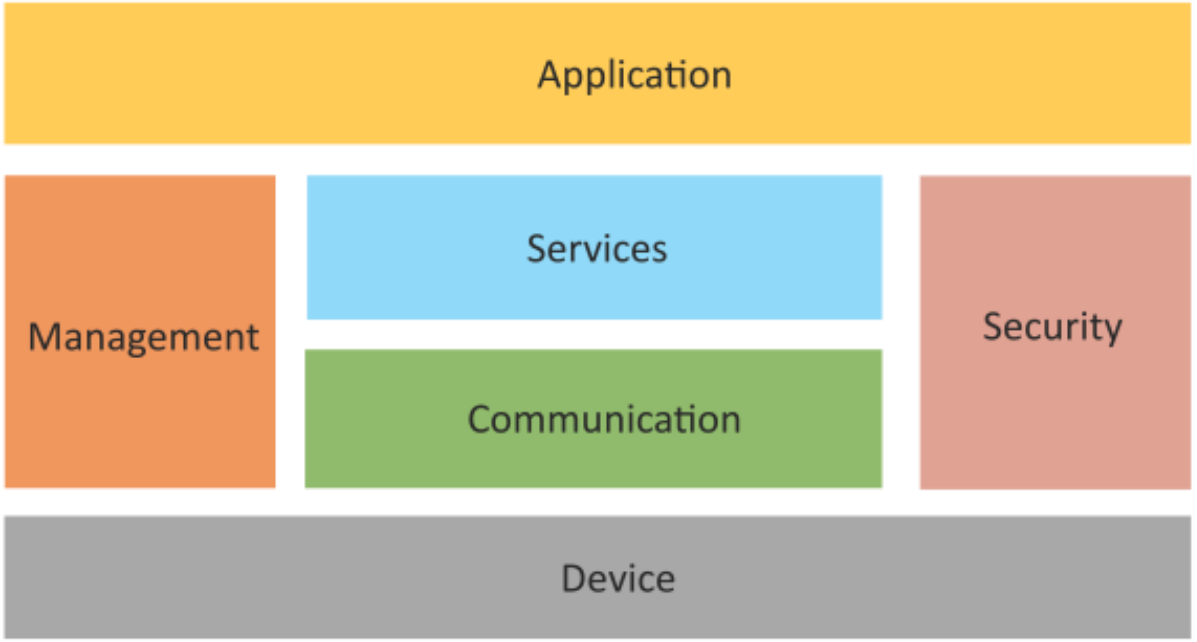
1. Pethuru Raj and Anupama C. Raman (CRC Press) , The Internet of Things : Enabling Technologies, Platforms and Use Cases
2. Arshdeep Bagha and Vijay Madisetti Internet of Things : A Hands-on Approach
3. IEEE Internet of Things Journal
4. IEEE Transactions on Mobile Computing

Web : http://profile.iiita.ac.in/bibhas.ghoshal

Module 1 : Design of IoT Based Systems

Logical design of an IoT system refers to an abstract representation of the entities and processes without going into the low-level specifics of the implementation.

An IoT system comprises a number of functional blocks that provide the system the capabilities for identification, sensing, actuation, communication and management.



Logical Design of IoT

Source: Book website: http://www.internet-of-things-book.com

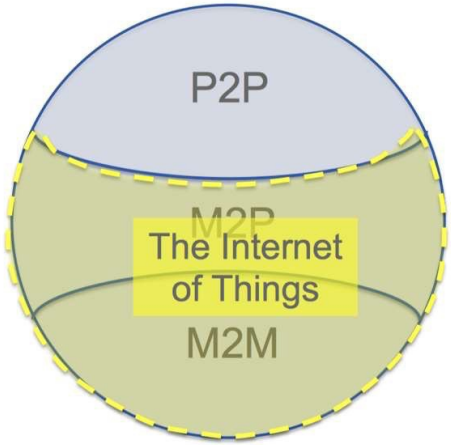
Devices

Device is a piece of equipment with the capabilities of communication and optional capabilities of sensing, actuation, data capture, data storage and data processing. The devices collect various kinds of information and provide it to the information and communication networks for further processing.

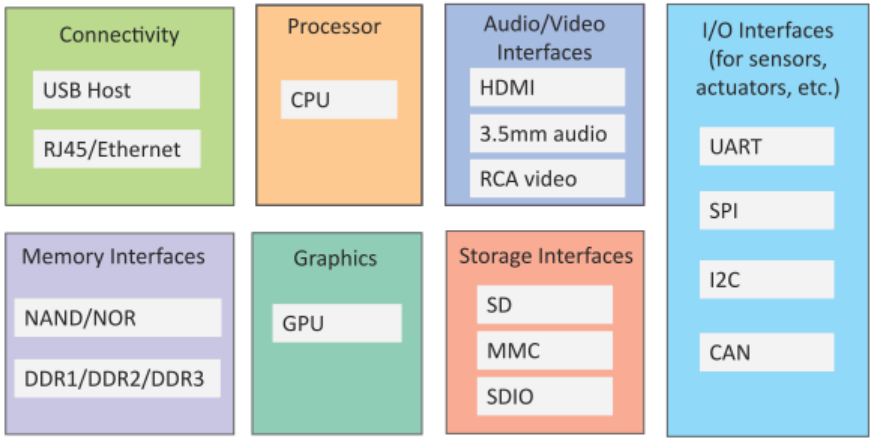
Some devices also execute operations based on information received from the information and communication networks.

An IoT device may consist of several interfaces for connections to other devices,both wired and wireless. I/O interfaces for sensors,

Interfaces for internet connectivity, Memory and storage interfaces, Audio/video interfaces



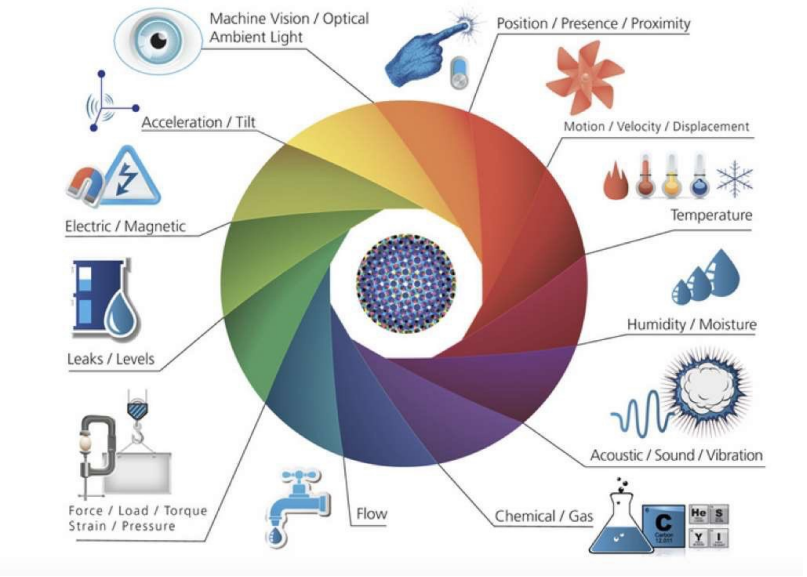
Source: ITU-T Y.2060



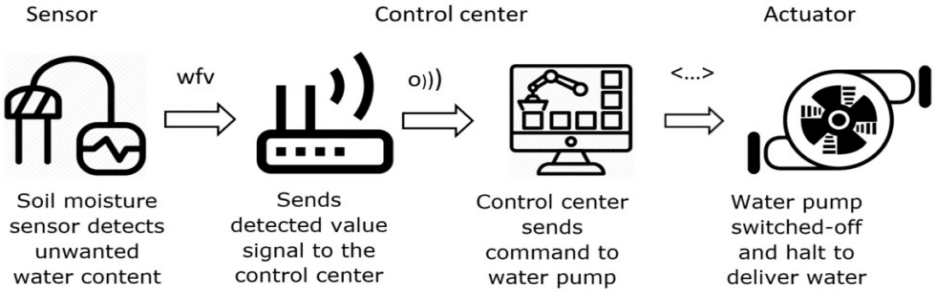
Source: Book website: http://www.internet-of-things-book.com

Enabling Technologies
Sensors and Actuators (Usage and Calibration)

Sensors



Actuators

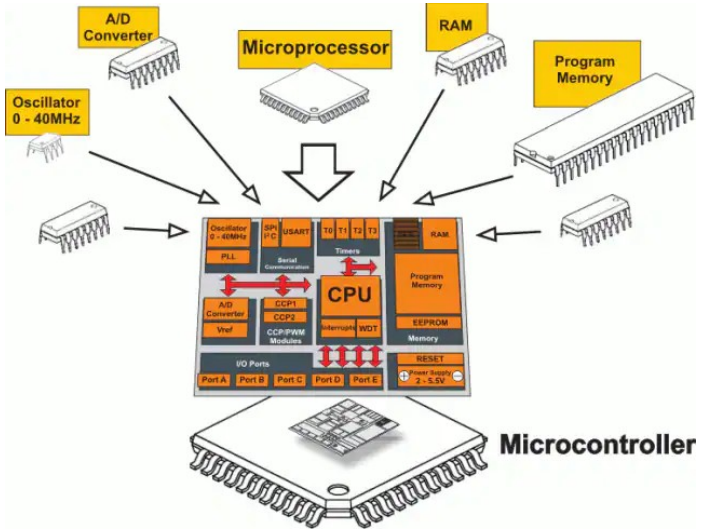


Source: Internet

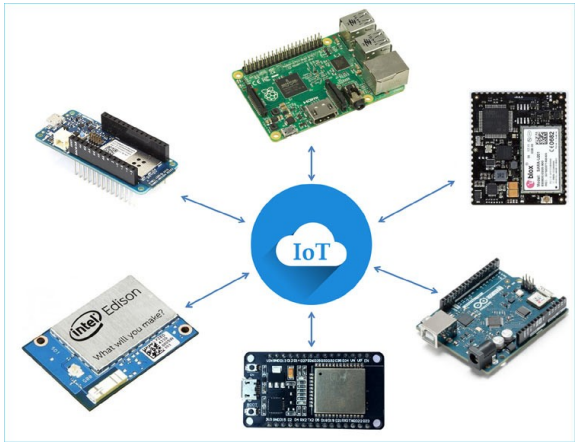
IoT Based Soil Watering System utilizing Sensors and Actuator

Enabling Technologies
Microcontrollers

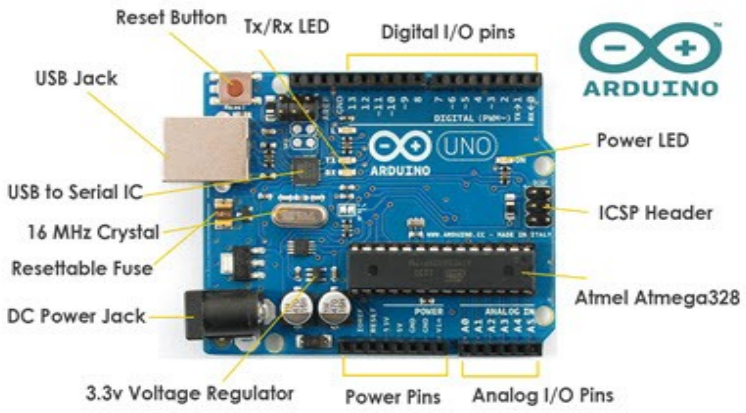
Microcontroller



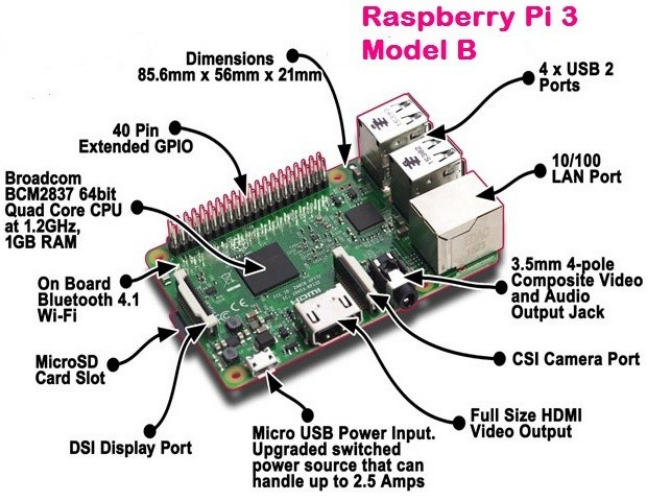
IoT Hardware Platforms



Arduino Uno



Raspberry Pi



Source: Internet

Module 2 : Connectivity Technologies in IoT

Key aspects when considering network connectivity:

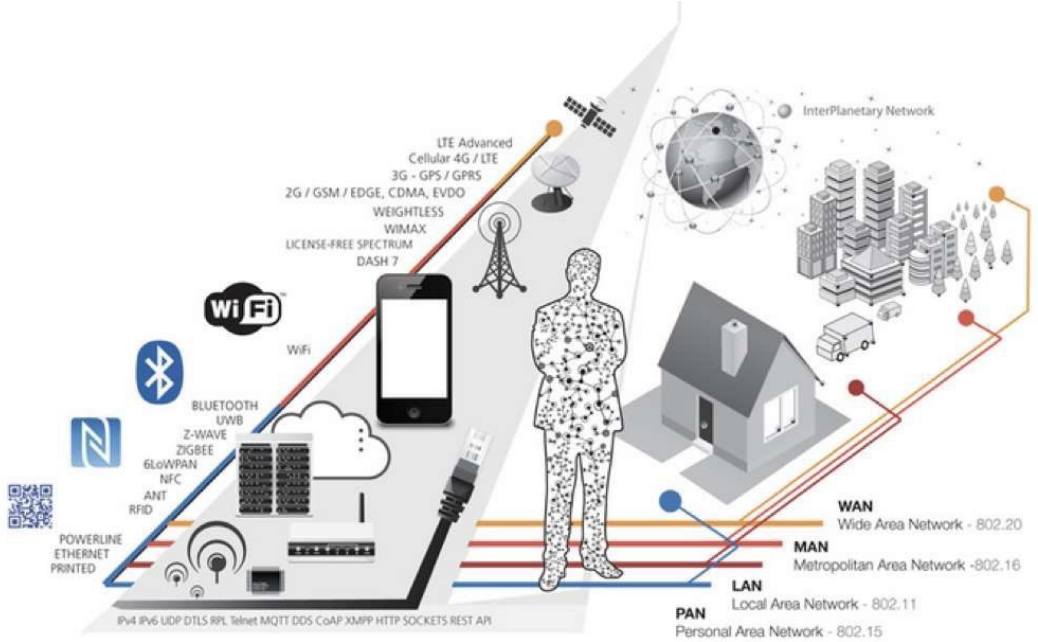
Range - are you deploying to a single office floor or an entire city?

Data Rate - how much bandwidth do you require? How often does your data change?

Power - is your sensor running on mains or battery?

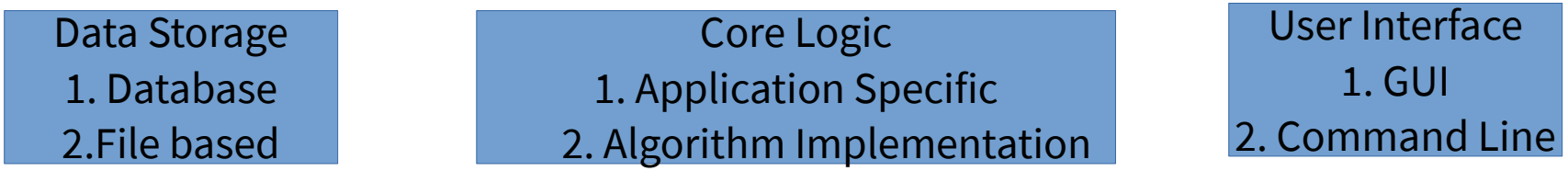
Frequency - have you considered channel blocking and signal interference?

Security - will your sensors be supporting mission critical applications?



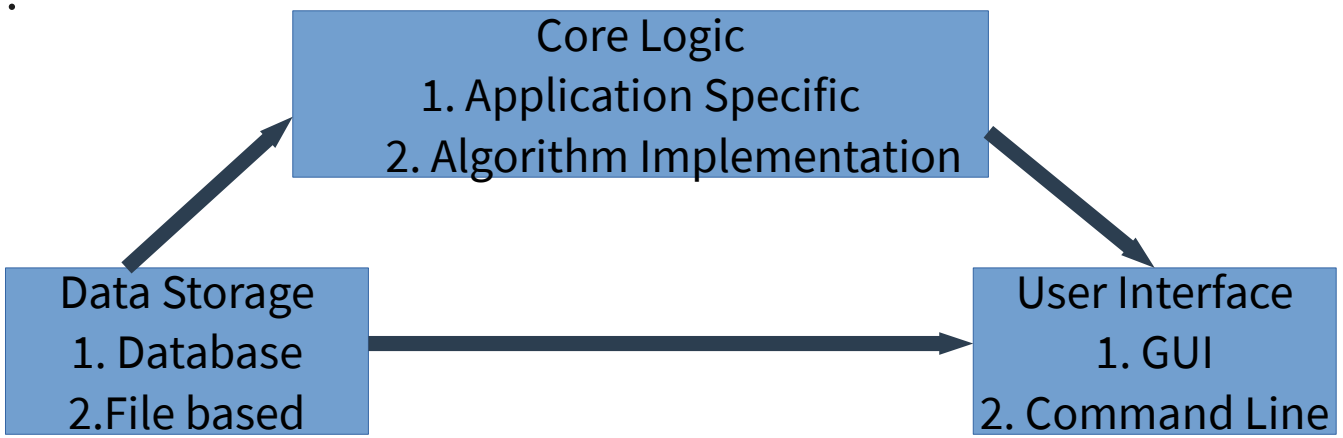
Module 3 : Distributed and Cloud Computing

Traditional Computing Components:



All Components sit on the same computer

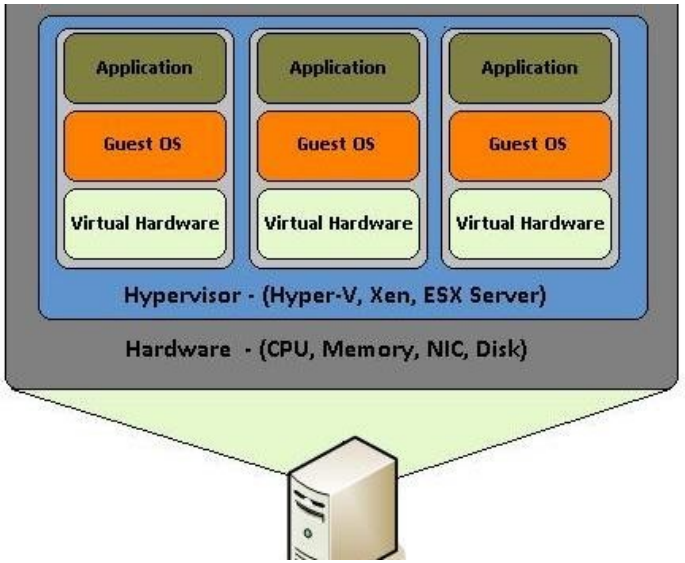
Distributed Computing :

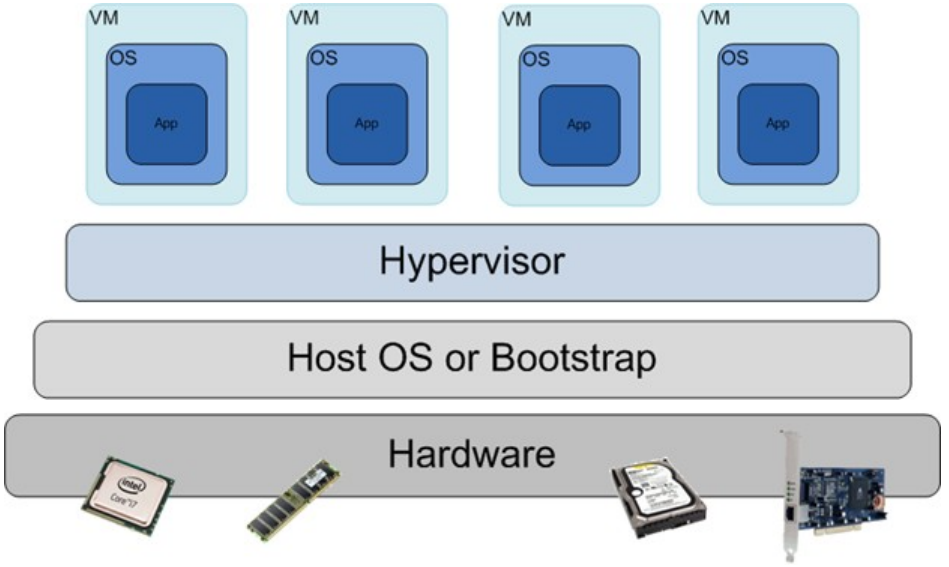


Cloud Computing = Innovative Application of Distributed Computing

Cloud Computing : Virtualization

- Consists of self contained components

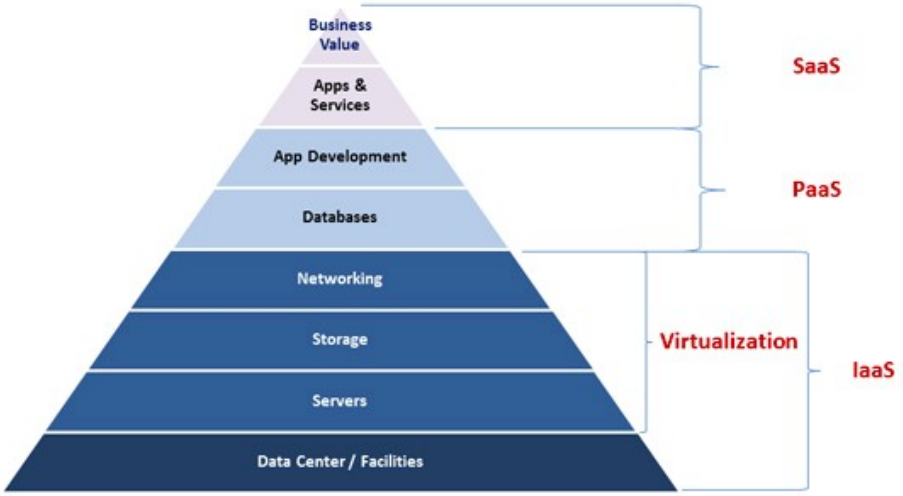




- Types of Virtualization : Desktop, Application, Network, Storage

Cloud Computing Service Model

- Delivers components as Services
- Pay-per-use model such as electricity, mobile network
- Software as a Service (SaaS)
- Platform as a Service (PaaS)
- Infrastructure as a Service (IaaS)



Cloud Computing for IoT

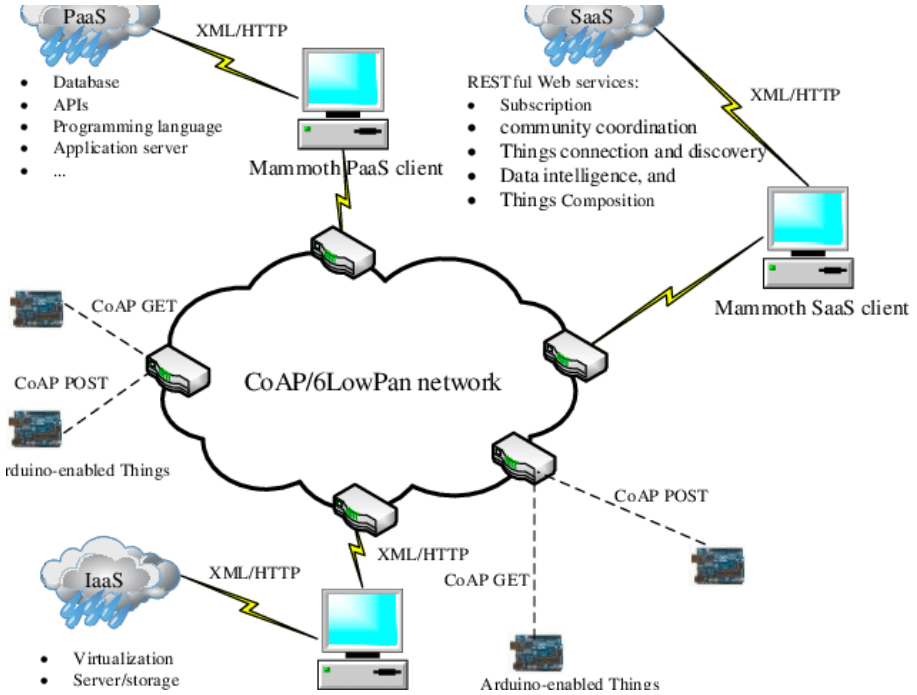
Cloud is an IoT enabler :

Huge amount of IoT Data needs storage, retrieval and management (sustained services)

Fast Analytics for Prediction and Critical Decision making

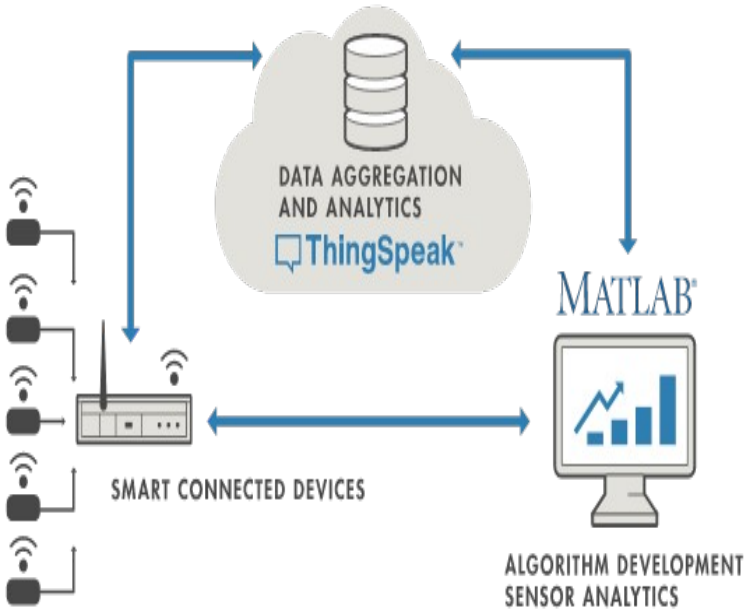
Benefits of Cloud in IoT :

Scalability ; Data Mobility; Time to Market; Security; Cost effectiveness



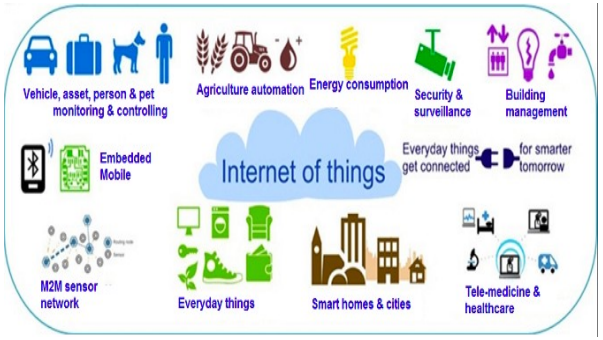
IoT Platform Implementation

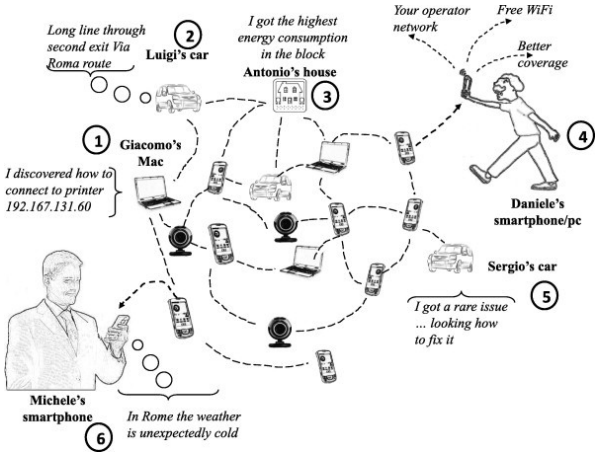
Source : http://www.xively.com



Source : www.thingspeak.com

Social Internet of Things (SIoT)



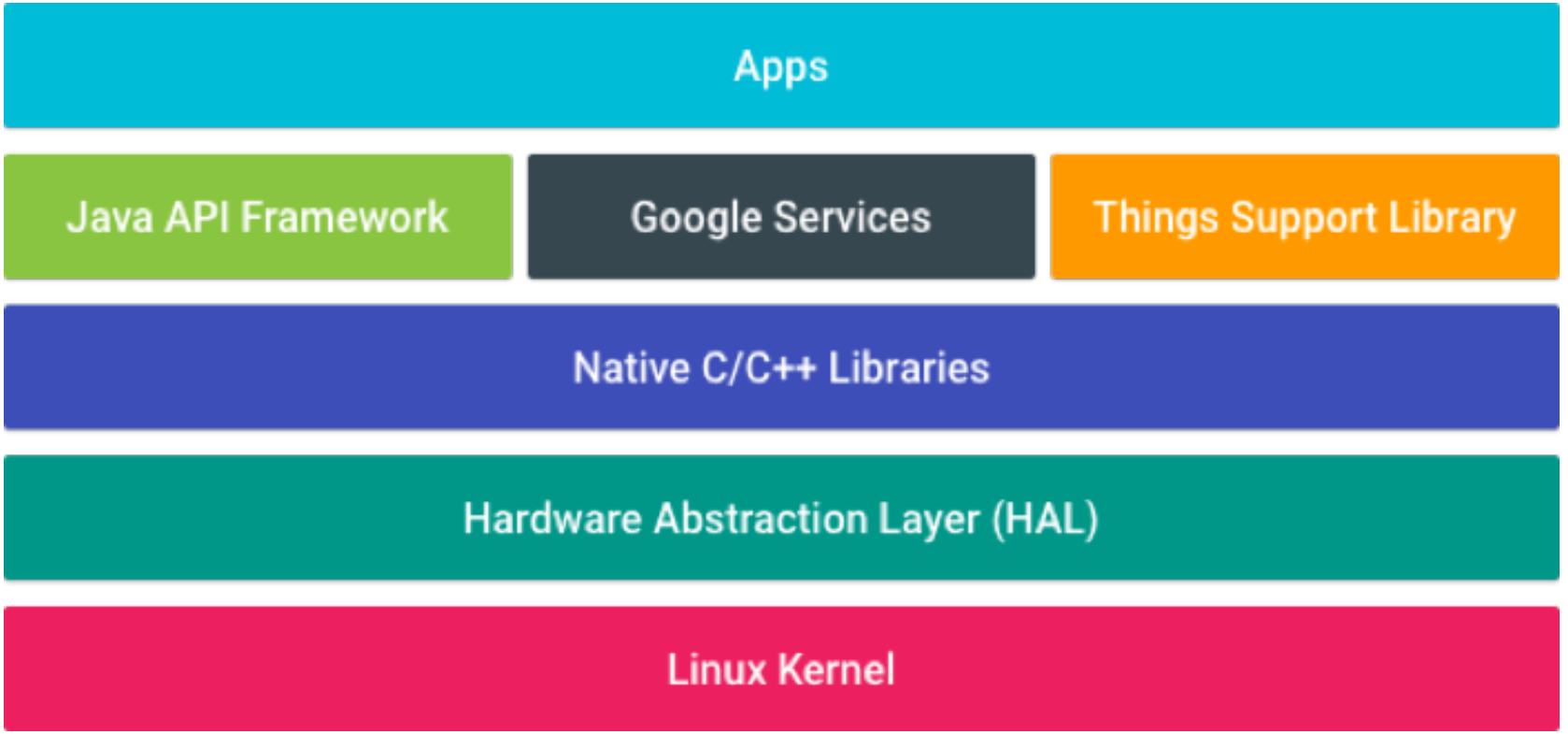


Social Networks + Intelligent Objects = Social Relation of Objects

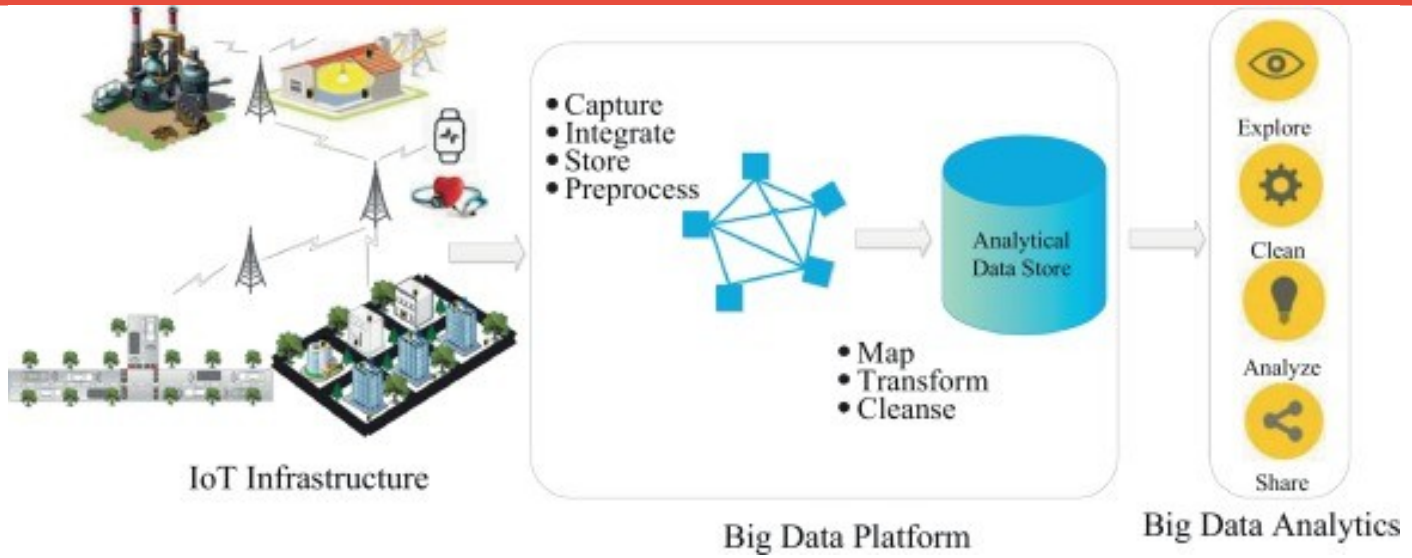
- Example 1 : A set of mobile phones in a geographical area provide data on the radio coverage to the new visitor.
- Example 2 : PCs in the same local area establish relationship to solve common setting problem such as installing drivers
- Example 3 : Cars of the same brand, make, year share data to overcome a common electrical problem

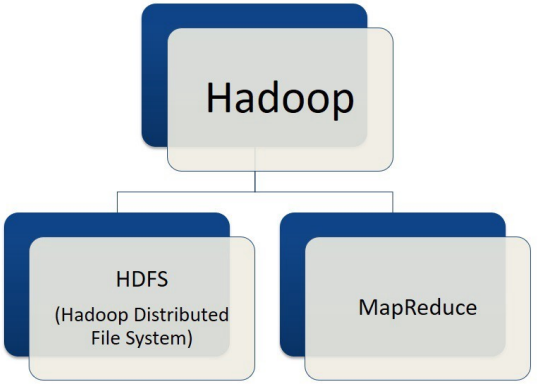
Module 4 : IoT Application Development

Software Stack for IoT Architecture: Software stack for devices, gateway and cloud

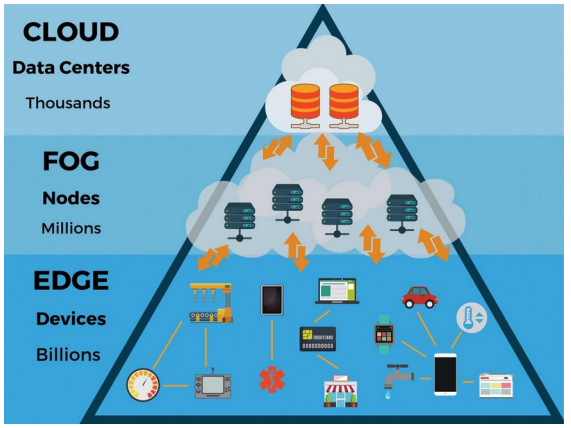


Module 5 : Data Analytics for IoT

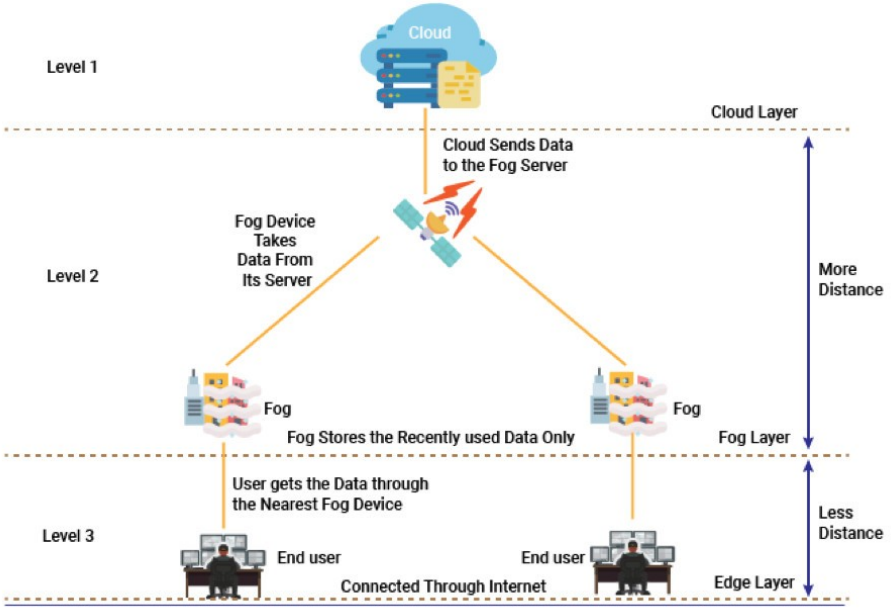




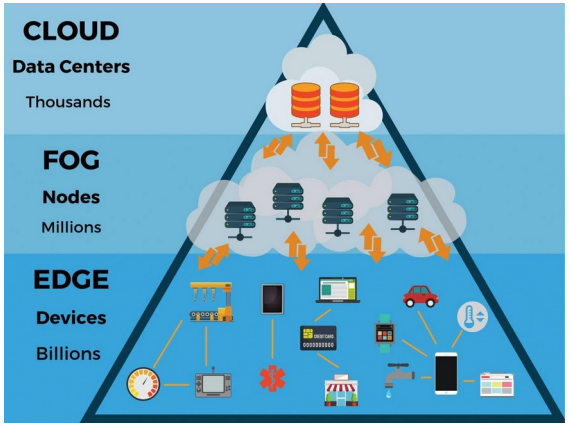
Module 5 : Advanced Topics



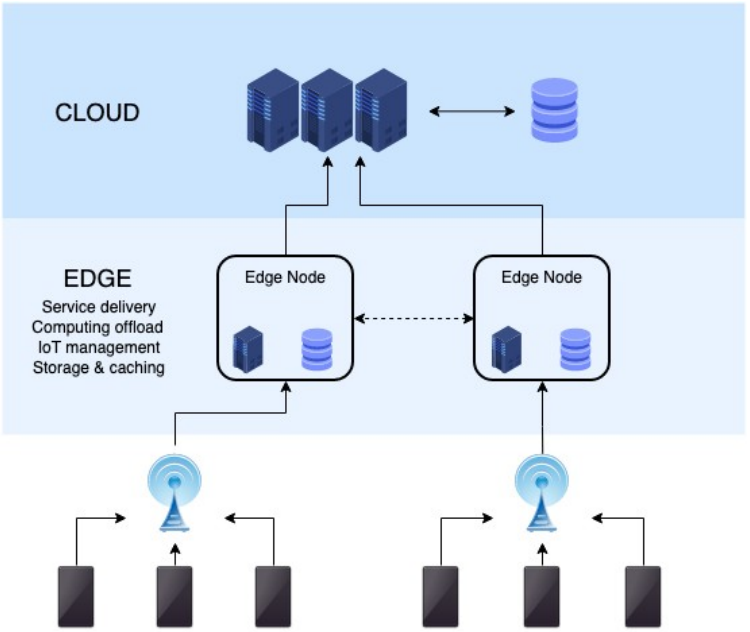
1. Fog Computing



Module 5 : Advanced Topics



2. Edge Computing



Module 5 : Advanced Topics

3. IoT Security

Security Principles :

a. User / Devices
Secure Devices (Hardware) – Device Intelligence, Edge processing

b. Gateway and Connection
Secure Communication - Device initiated connection, Messaging control

c. Cloud and Applications
Secure Cloud – Identification, Authentication and Encryption

d. Secure Lifecycle Management
Remote control and updates of devices

Register yourself on Google Classroom

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