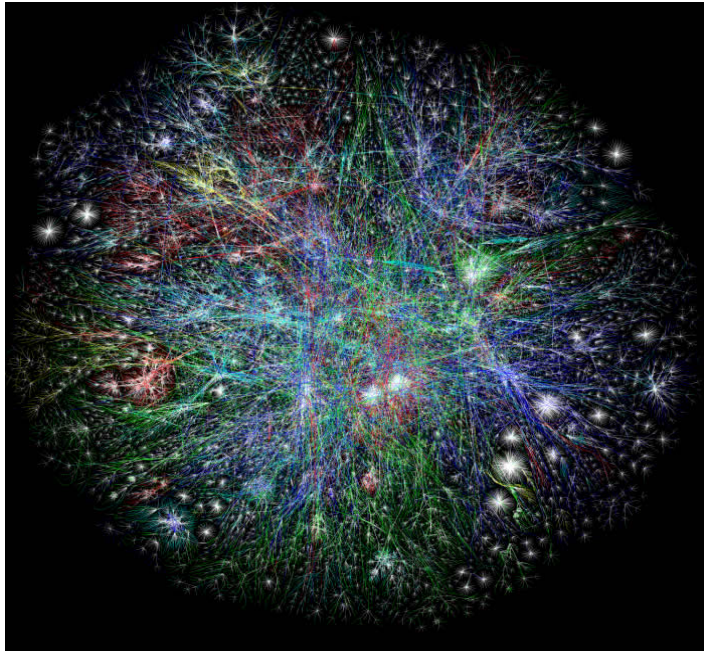# Internet of things (IoT)

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Professor, IIT DU

Starting from the Internet

➢ Internet appears everywhere in the world

➢ but it is still a connection between people and people

What is the Internet of Things?

➢ Internet connects all people, so it is called "the Internet of People"

➢ IoT connects all things, so it is called "the Internet of Things"

What's the Internet of Things

- **Definition**
  (1) The Internet of Things, also called The Internet of Objects, refers to a wireless network between objects, usually the network will be wireless and self-configuring, such as household appliances.
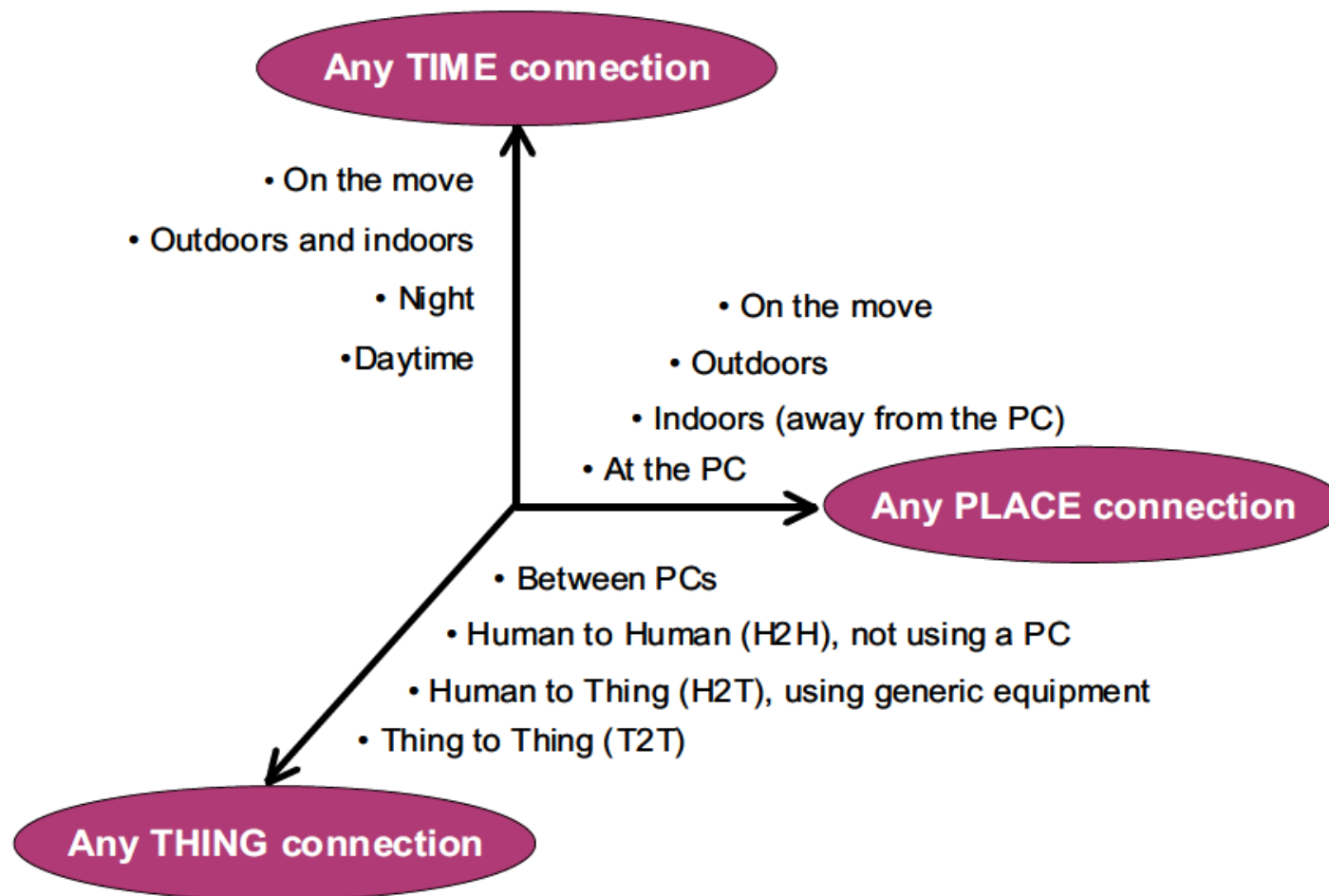
  ------Wikipedia

  (2) By embedding short-range mobile transceivers into a wide array of additional gadgets and everyday items, enabling new forms of communication between people and things, and between things themselves.

  ------WSIS 2005
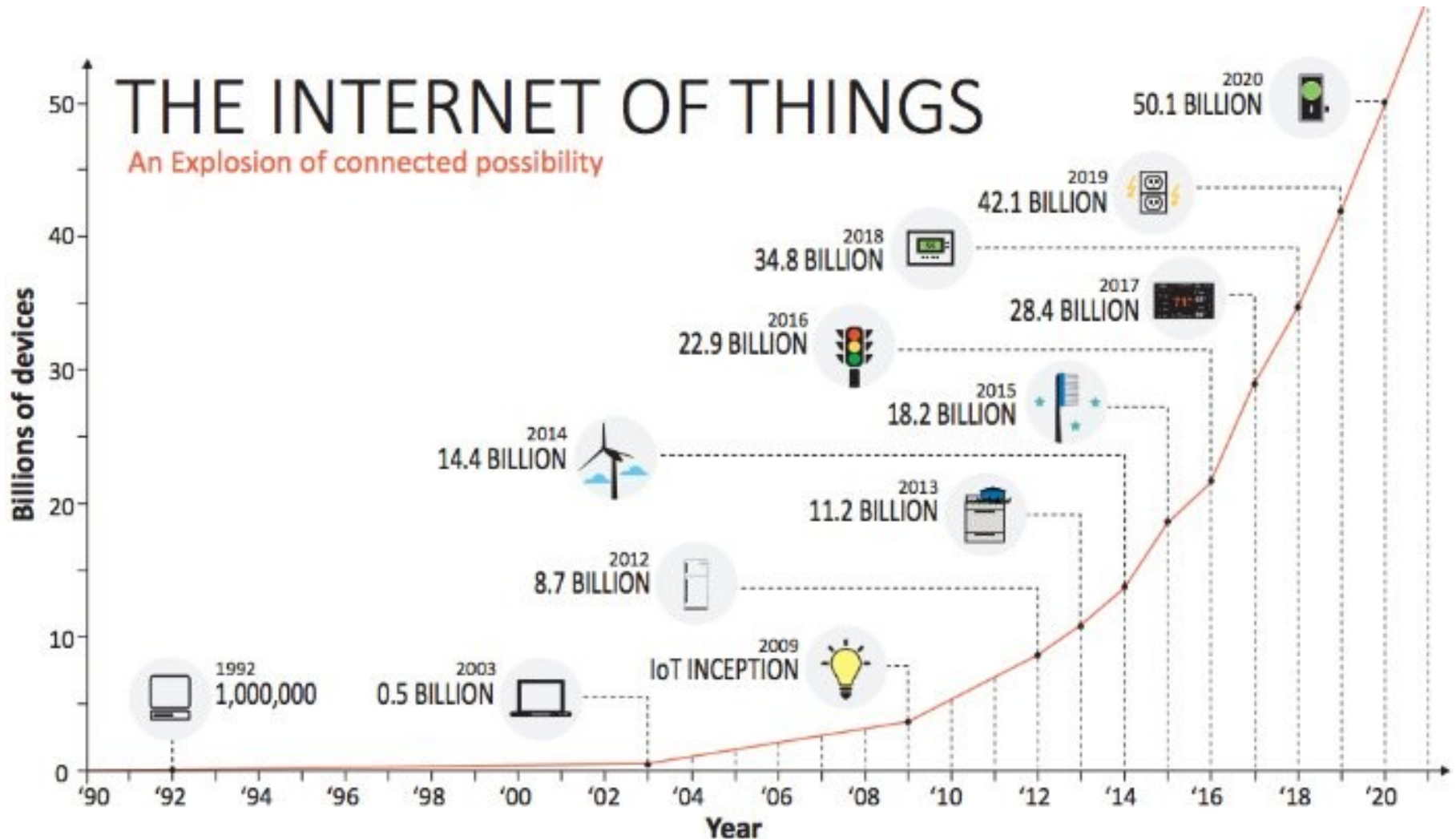
Welcome to our NEW DIMENSION

Figure 1 – A new dimension

Any TIME connection

- On the move
- Outdoors and indoors
- Night
- Daytime

- On the move
- Outdoors
- Indoors (away from the PC)
- At the PC

Any PLACE connection

- Between PCs
- Human to Human (H2H), not using a PC
- Human to Thing (H2T), using generic equipment
- Thing to Thing (T2T)

Any THING connection

Source: ITU adapted from Nomura Research Institute

THE INTERNET OF THINGS

An Explosion of connected possibility

Billions of devices (y-axis)
Year (x-axis)

1992 — 1,000,000
2003 — 0.5 BILLION
2009 — IoT INCEPTION
2012 — 8.7 BILLION
2013 — 11.2 BILLION
2014 — 14.4 BILLION
2015 — 18.2 BILLION
2016 — 22.9 BILLION
2017 — 28.4 BILLION
2018 — 34.8 BILLION
2019 — 42.1 BILLION
2020 — 50.1 BILLION

Will it affect your life?

These things are starting to talk to each other and develop their own intelligence. Imagine a scenario where............

...your meeting was pushed back 45 minutes.

...your car knows it will need gas to make it to the train station. Fill-ups usually take 5 minutes.

This is communicated to your alarm clock, which allows you 5 extra minutes of sleep.

...there was an accident on your driving route causing a 15 minute detour.
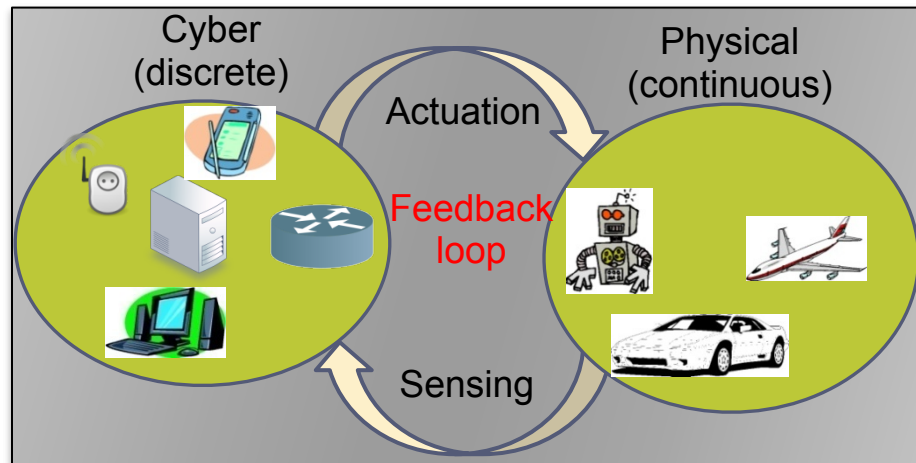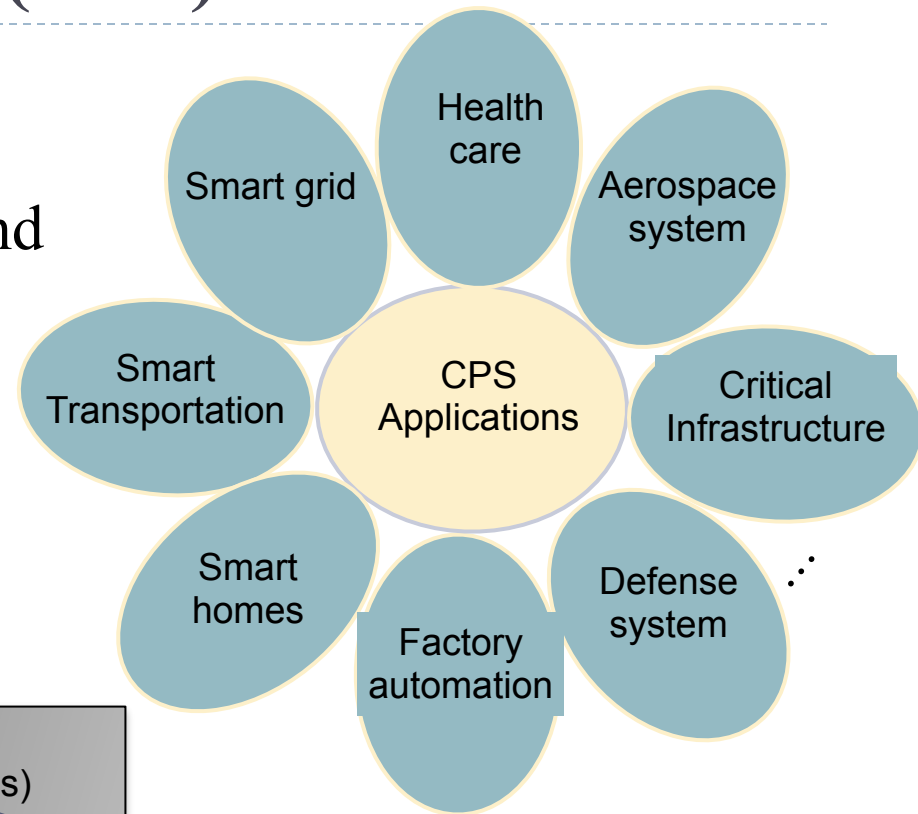
...your train is running 20 minutes behind schedule.

And signals your car to start in 5 minutes to melt the ice accumulated in overnight snow storms.

And signals your coffee maker to turn on 5 minutes late as well.

Cyber-Physical Systems (CPS)

▸ CPS are an integration of computation with physical processes. Embedded computers and networks monitor and control the physical processes, usually with feedback loops where physical processes affect computations and vice versa

CPS Applications: Health care, Smart grid, Aerospace system, Smart Transportation, Critical Infrastructure, Smart homes, Factory automation, Defense system

Cyber (discrete) — Actuation — Physical (continuous) — Feedback loop — Sensing

M2M (Machine-to-Machine)

▸ concept where two or more than two machines communicate with each other without human interaction using a wired or wireless mechanism

▸ M2M is an technology that helps the devices to connect between devices without using internet

▸ security, tracking and tracing, manufacturing and facility management.

Difference Between M2M and IoT
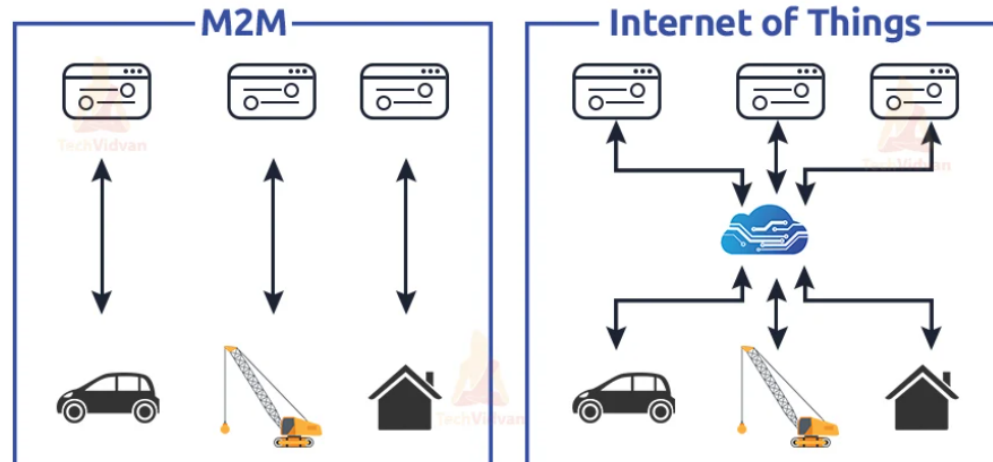
▸ **The IoT device collects data.** That could be a temperature reading, security snapshot, an exact location. To the machine, it's all data.

▸ **The device transmits that data over a network.** Any and all network technologies can be used for IoT: WiFi, Bluetooth, satellite, cellular, even hard-wired ethernet connections

▸ **Data arrives at a storage center.** An IoT data warehouse may be on a server miles away from the device, in the cloud. Or the system may centralize data on a nearby device. We call that the *edge*. Some devices collect, store, and even process data on the edge.
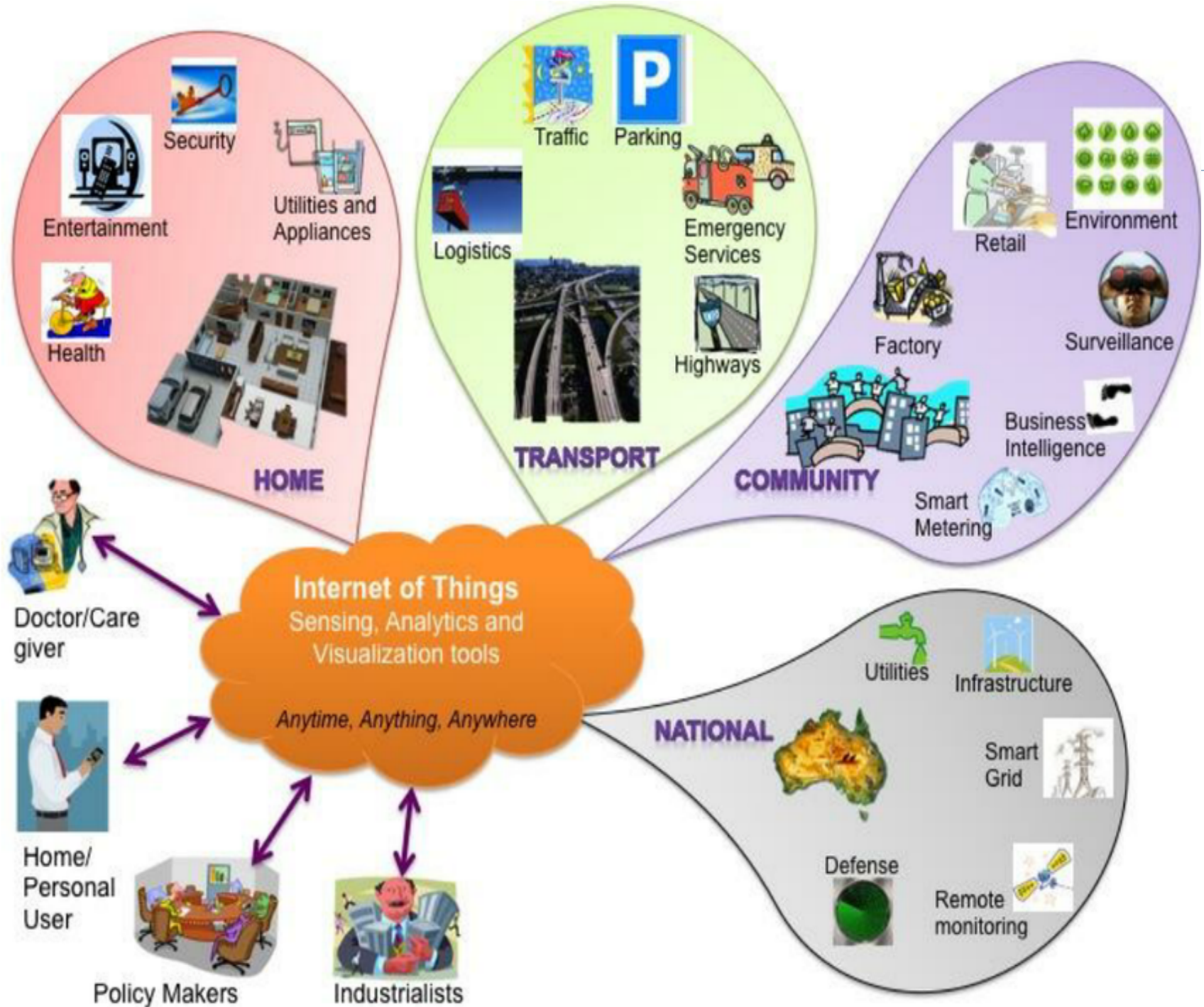
▸

How IoT Devices Work..

‣ **Software processes data and may send an instruction to the device.** Software in the cloud or at the edge uses data to *do something*. It might send an instruction to adjust an HVAC setting, for instance. It might turn on or off a light. Maybe it sends a push notification to a human user, as in predictive maintenance scenarios. Or it might simply organize data for the final step in the IoT process.

‣ **An IoT platform makes insight available to users.** The true strength of IoT is its ability to collect huge data sets. That gives us the business insight we can use to make stronger decisions every time. But to put that information to use, you need an intuitive user interface within a well-designed app.
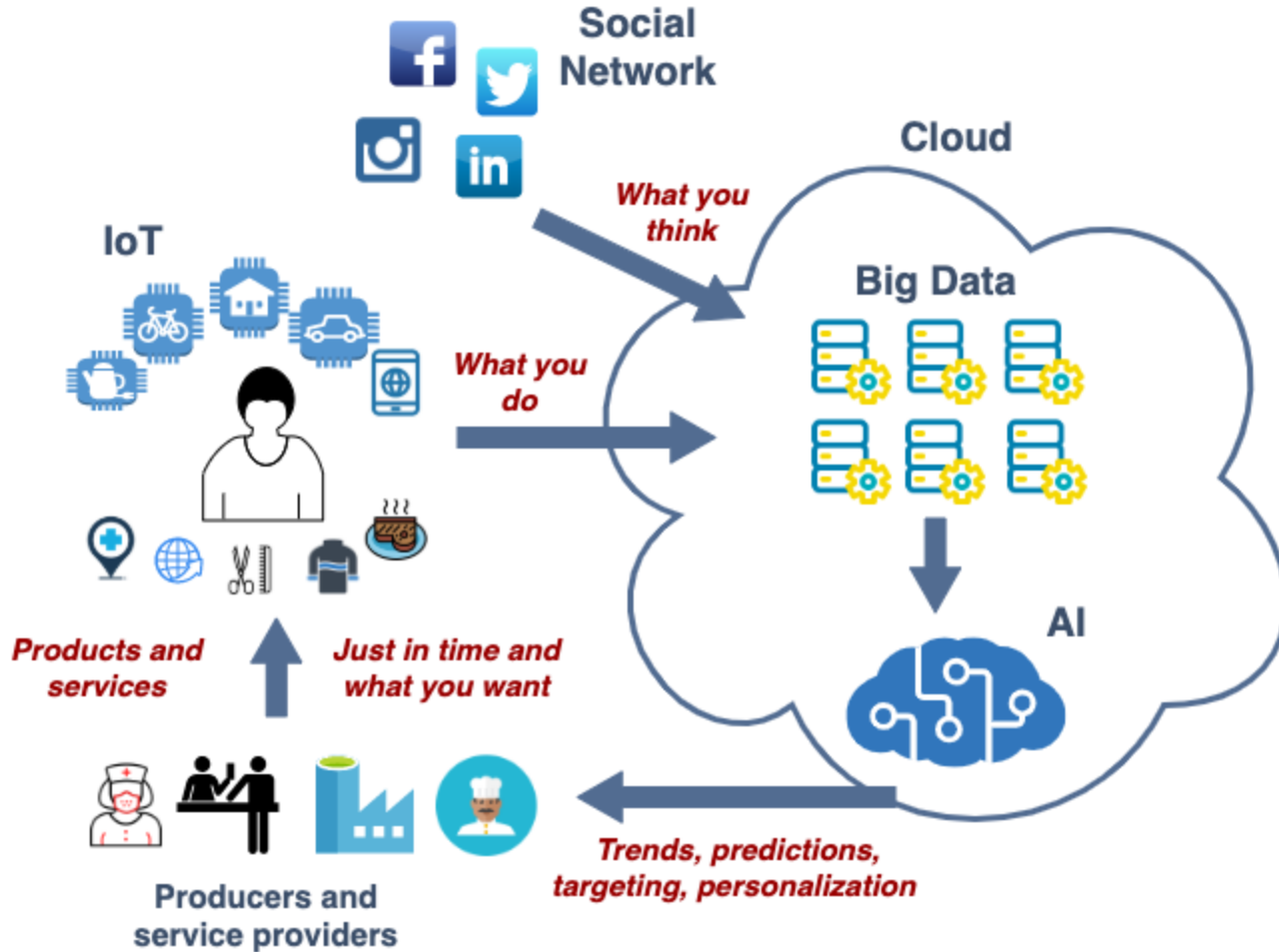
‣

IoT Ecosystem
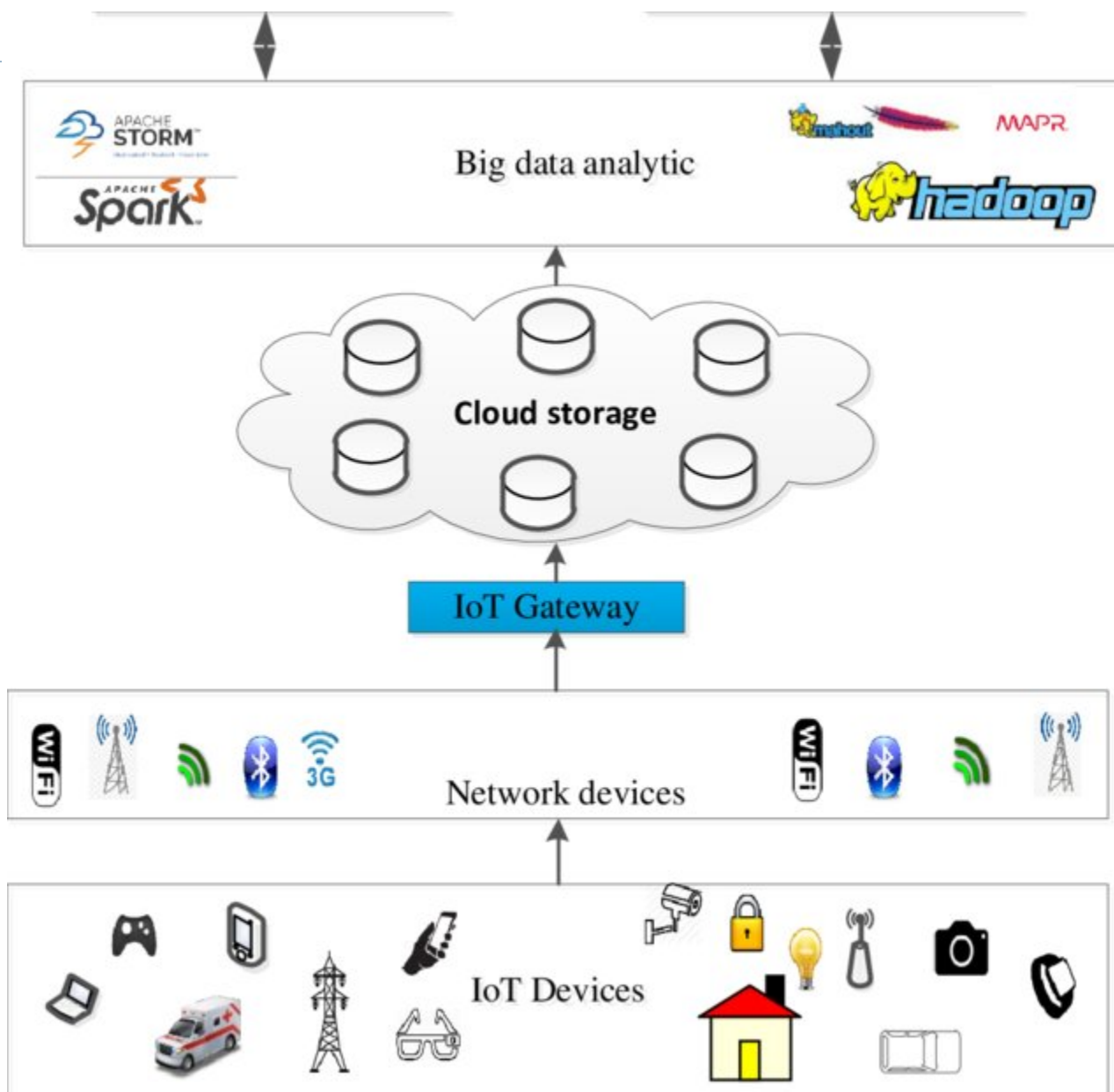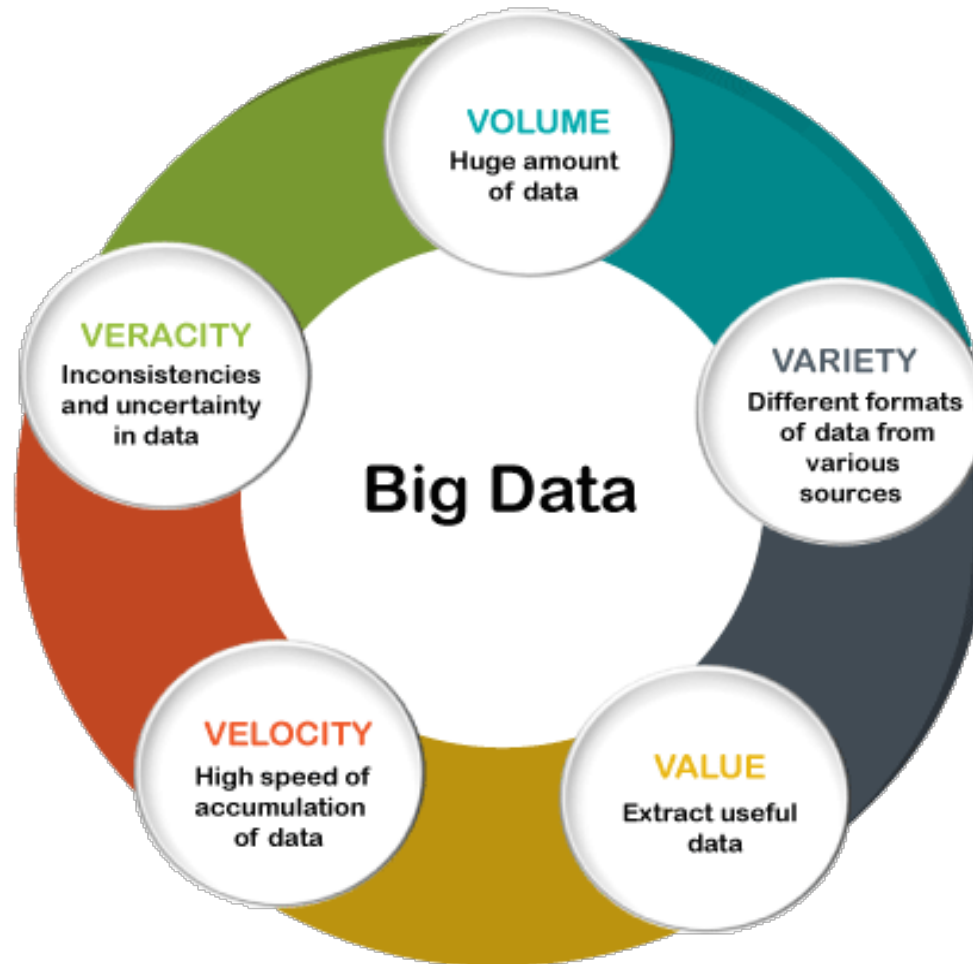

SIGNIFICANT COMPONENTS OF AN IOT ECOSYSTEM

Thing or Device — Data — Wireless Network — Gateway — Data — Cloud — Data — Analytics — Data — User Interface

HOME
- Security
- Entertainment
- Utilities and Appliances
- Health

TRANSPORT
- Traffic
- Parking
- Logistics
- Emergency Services
- Highways

COMMUNITY
- Retail
- Environment
- Factory
- Surveillance
- Business Intelligence
- Smart Metering

NATIONAL
- Utilities
- Infrastructure
- Smart Grid
- Defense
- Remote monitoring

Internet of Things
Sensing, Analytics and Visualization tools

Anytime, Anything, Anywhere

- Doctor/Care giver
- Home/Personal User
- Policy Makers
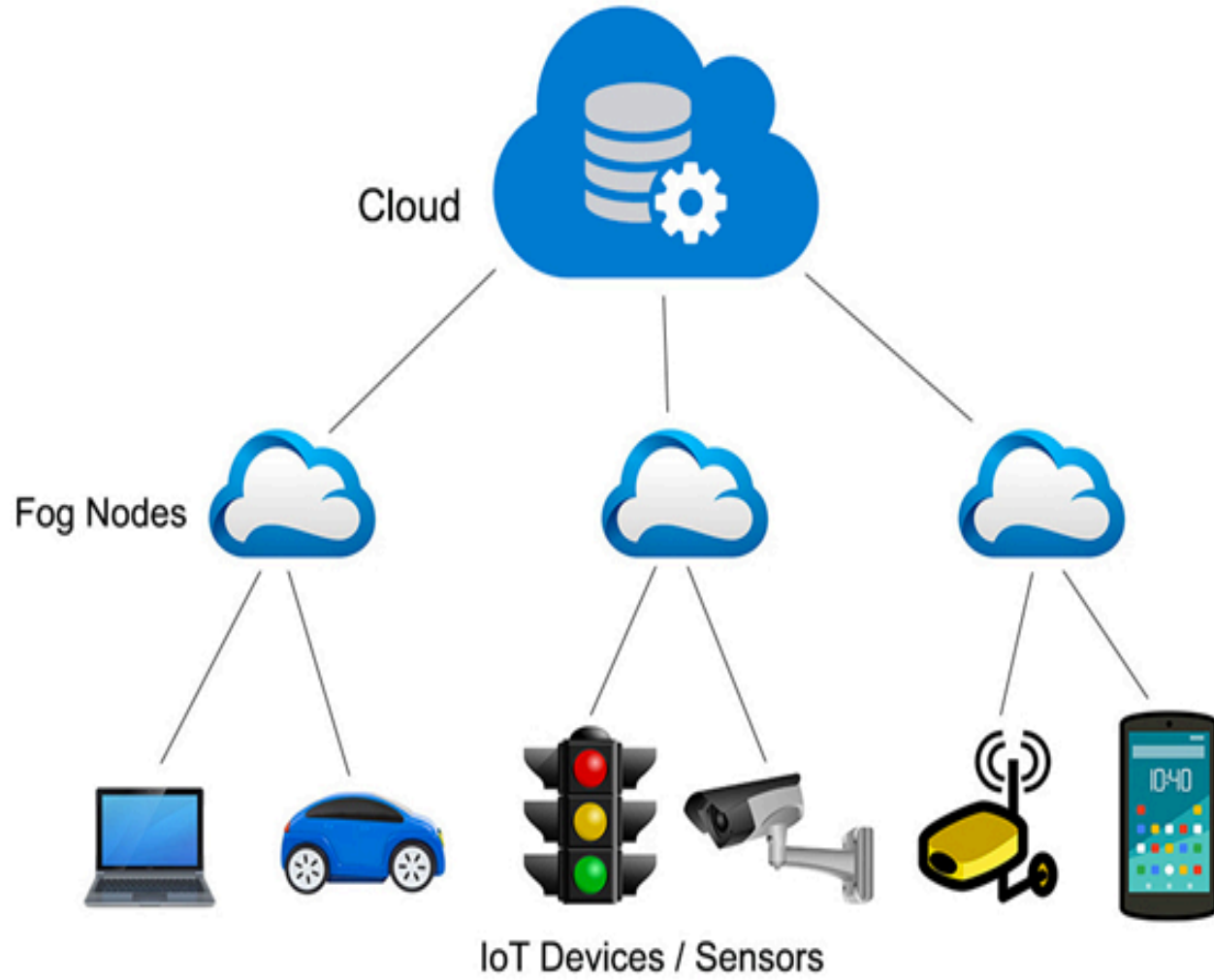- Industrialists

IoT, Big Data and AI

IoT Cloud and Big data

Big data

Fog Computing Architecture

IBM

# Why Cloud is not suitable for certain IoT Data Analytics?

1. **Cloud** is centralized, federated, consolidated, shared, automated, compartmentalized, and programmable Infrastructure

2. **Latency** and **Response time** is often a critical part, especially when you deal with human life or emergency procedure.

3. **Bandwidth Cost and Capacity** is very often underestimated. If you want to use N smart devices requiring each one to communicate M bytes of data then you can quickly reach huge bandwidth requirements reaching Mbit/s or even Gbit/s at a gateway level.

4. **Security and Privacy** - transmitting device data over any open and public network is risky

5. **Power consumption** - Cloud computing is energy-hungry and that it is a concern for a low-carbon economy.

6. **Data obesity** – In a traditional cloud approach, huge amount of untreated data are pumped blindly into the cloud that it is supposed to have magical algorithms written by data scientists. This vision is really not the best efficient and it is much more wise to pre-treat data at a local level and to limit the cloud processes at the strict minimum.

7. **Offline usages** versus only-online usages – Pure cloud services do not allow offline usages. It is a major shortcoming since smart cities and industry 4.0 applications require a dual offline/online paradigm.

Why IoT Data Analytics has to be real-time and at Edge?

- **Volume and Velocity** – ingesting, processing and storing such huge amounts of data which is gathered in real-time.

- **Security** – devices can be located in sensitive environments, control vital systems or send private data.

- **Bandwidth** – if devices constantly send the sensor and video data, it will hog the internet and cost a fortune. Therefore edge analytics approaches must be deployed to achieve scale and lower response time.

- **Real-time Data Capture, Storage, Processing, Analytics, Knowledge Discovery, Decision-making and Actuation**

- **Less Latency and Faster Response**

- **Context-Awareness capability**

- **Combining real-time data with historical state**

Smart Transportation: ITS

- Intelligent Transportation System (ITS) is designed to provide the real-time and reliable delivery of traffic-related information to drivers such as blind spot warnings during lane changing or notification of congestion and rerouting advise that can help to reduce traffic congestion and lost productivity

- ITS involves close coupling by:
  - ➢ Vehicle-to-vehicle (V2V) via wireless network
  - ➢ Vehicles-to-road-side infrastructure (V2I) via wireless network
  - ➢ Multiple infrastructure via wired network
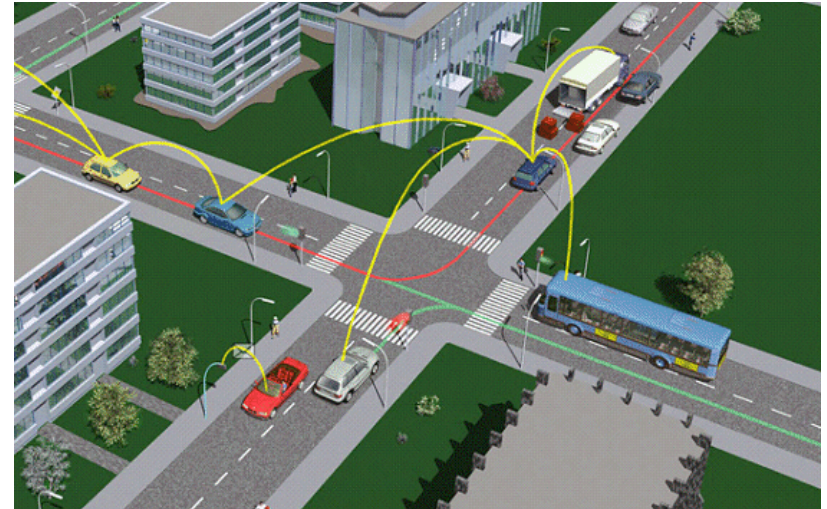
- Real-time and reliable information dissemination for V2V and V2I communications are difficult problem

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- https://www.youtube.com/watch?v=hXC7vCcg2xo

- https://www.youtube.com/watch?v=dDUDO3yA2Bs

- https://www.youtube.com/watch?v=Ge4rG8ER_CU

- https://www.youtube.com/watch?v=Br5aJa6MkBc