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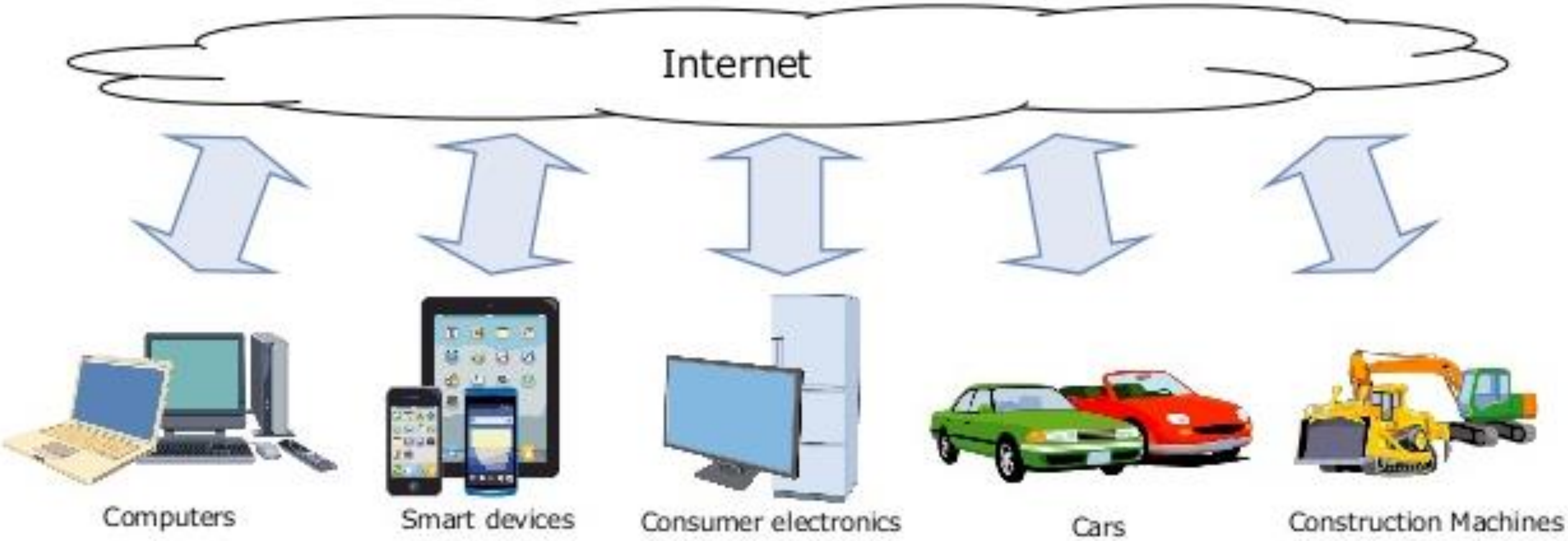
Technologies Enabling the Internet of Things

Everything is connected to the Internet



IoT enables data gathering, controlling over the Internet

Evolution of IOT

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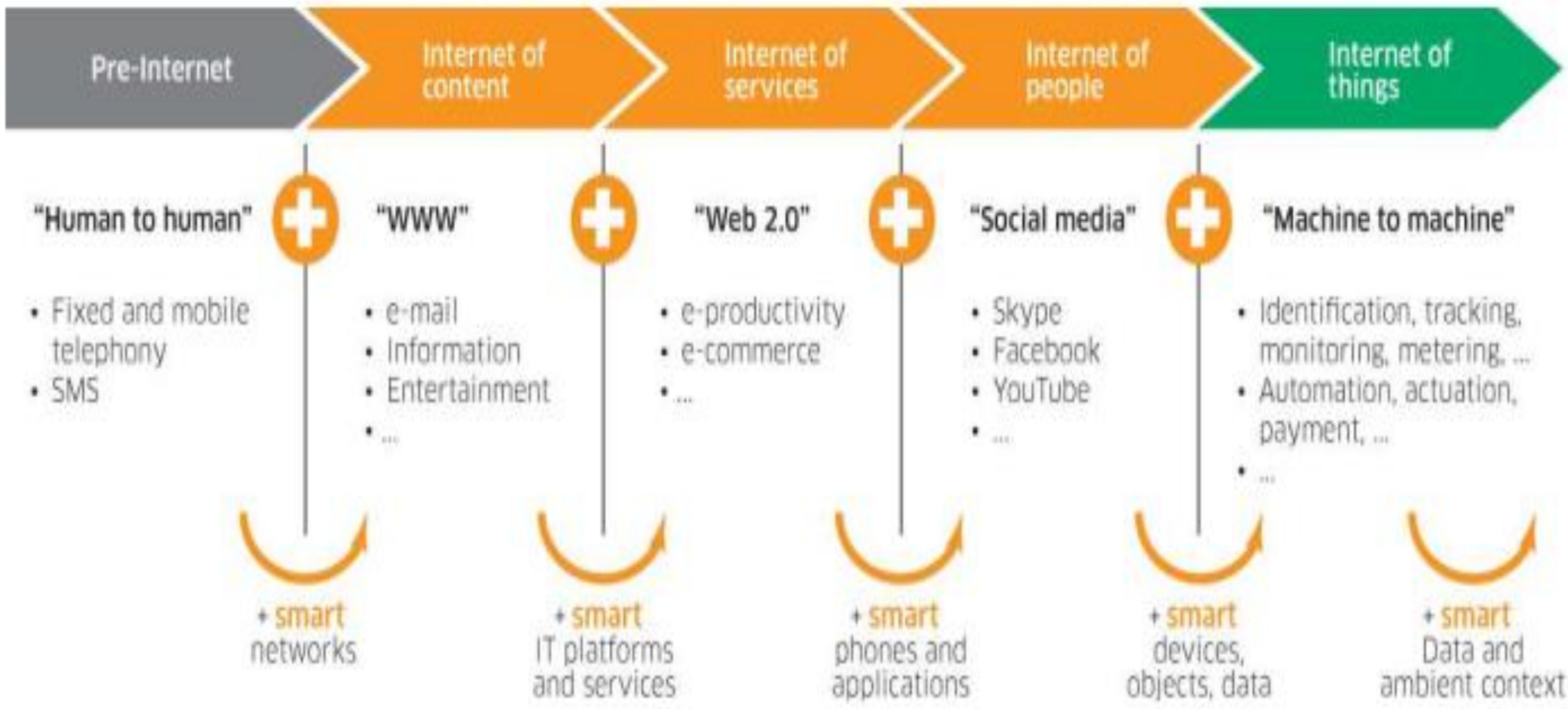

Enabling Technologies

IOT Smart Objects: end points

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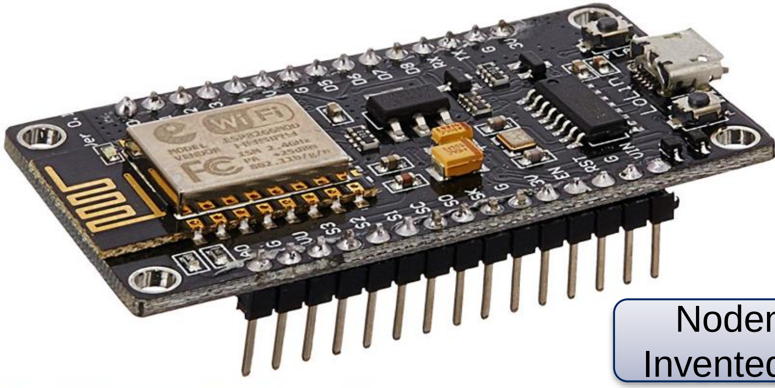
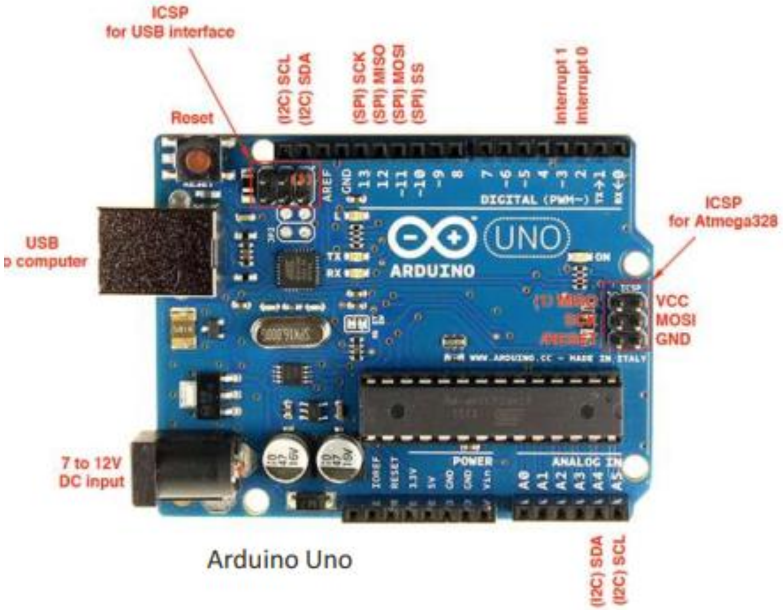


Nodemcu: Invented 2014

Intel Galileo



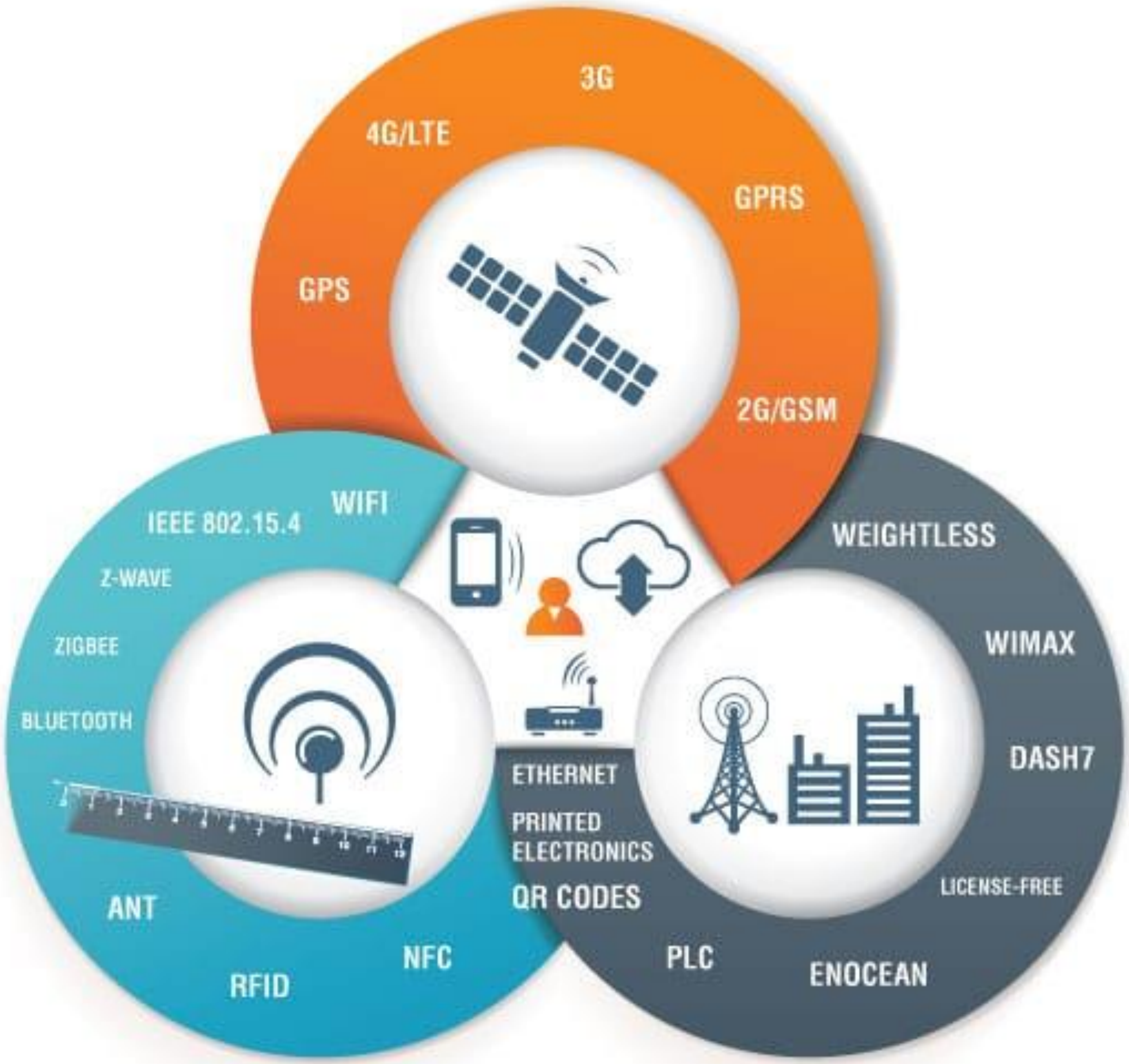
Arduino Uno

Raspberry Pi

Arduino: Invented 2004

Rpi: Invented 2012

IOT Communication Technologies



Sensor Networks (SNs)

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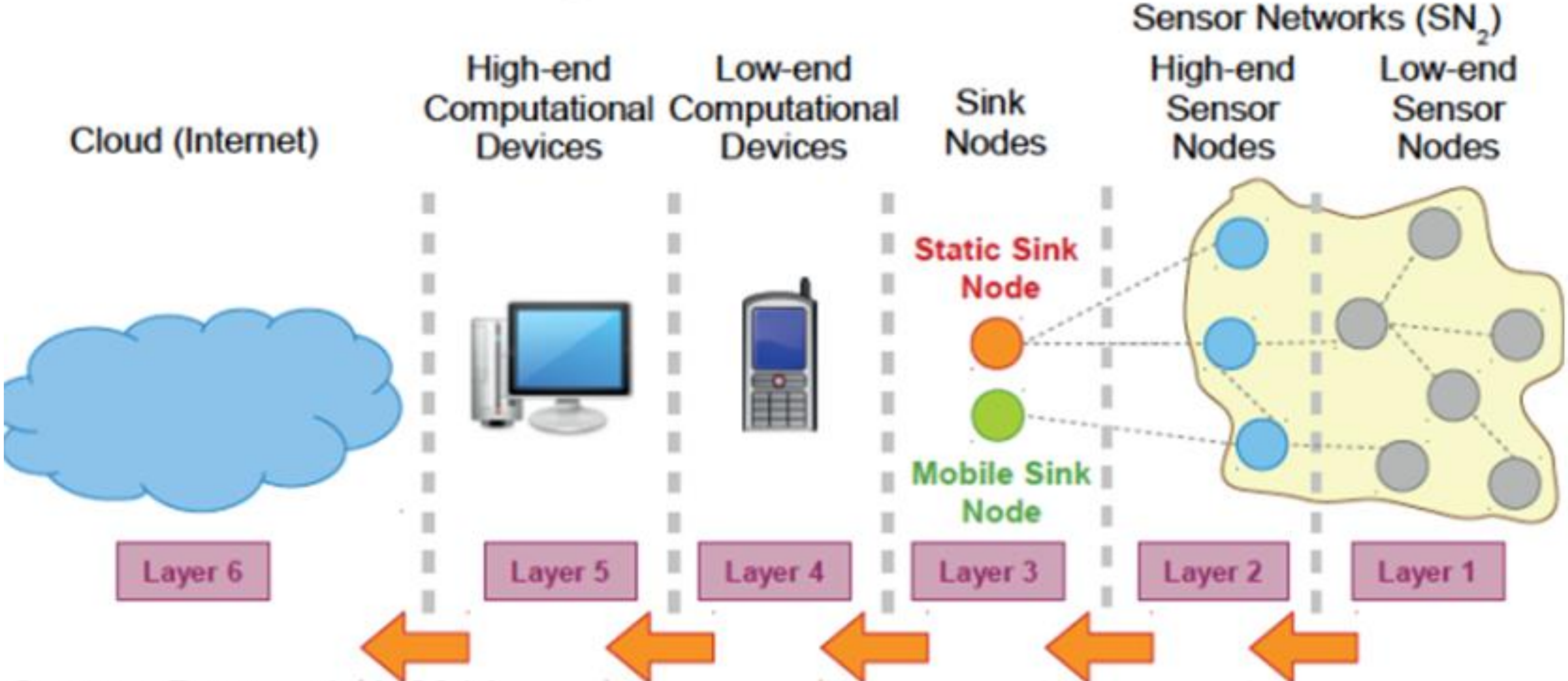
- Consist of a certain number (which can be very high) of sensing nodes (generally wireless) communicating in a wireless multi-hop fashion



Source: Perera et al. 2014

Sensor Networks (SNs)

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- SNs generally exist without IoT but IoT cannot exist without SNs
- SNs have been designed, developed, and used for specific application purposes
  - Environmental monitoring, agriculture, medical care, event detection etc.
- For IoT purposes, SNs need to have a middleware addressing these issues:
  - Abstraction support, data fusion, resource constraints, dynamic topology, application knowledge, programming paradigm, adaptability, scalability, security, and QoS support

Wireless Technologies

- Short range:
  - Direct connection between devices – sensor networks
  - Typical low power usage
  - Examples: Bluetooth, Zigbee, Z-wave (house products)
- Other examples:
  - Satellite systems
    - Global coverage
    - Applications: audio/TV broadcast, positioning, personal communications
  - Broadcast systems
    - Satellite/terrestrial
    - Support for high speed mobiles
  - Fixed wireless access
    - Several technologies including DECT, WLAN, IEEE802.16, etc.

Many More coming up: LORA, 5G, 6G etc.

Characteristics of IOT

1. Intelligence
   – Knowledge extraction from the generated data
2. Architecture
   – A hybrid architecture supporting many others
3. Complex system
   – A diverse set of dynamically changing objects
4. Size considerations
   – Scalability
5. Time considerations
   – Billions of parallel and simultaneous events
6. Space considerations
   – Localization
7. Everything-as-a-service
   – Consuming resources as a service

Example of IoT Cycle

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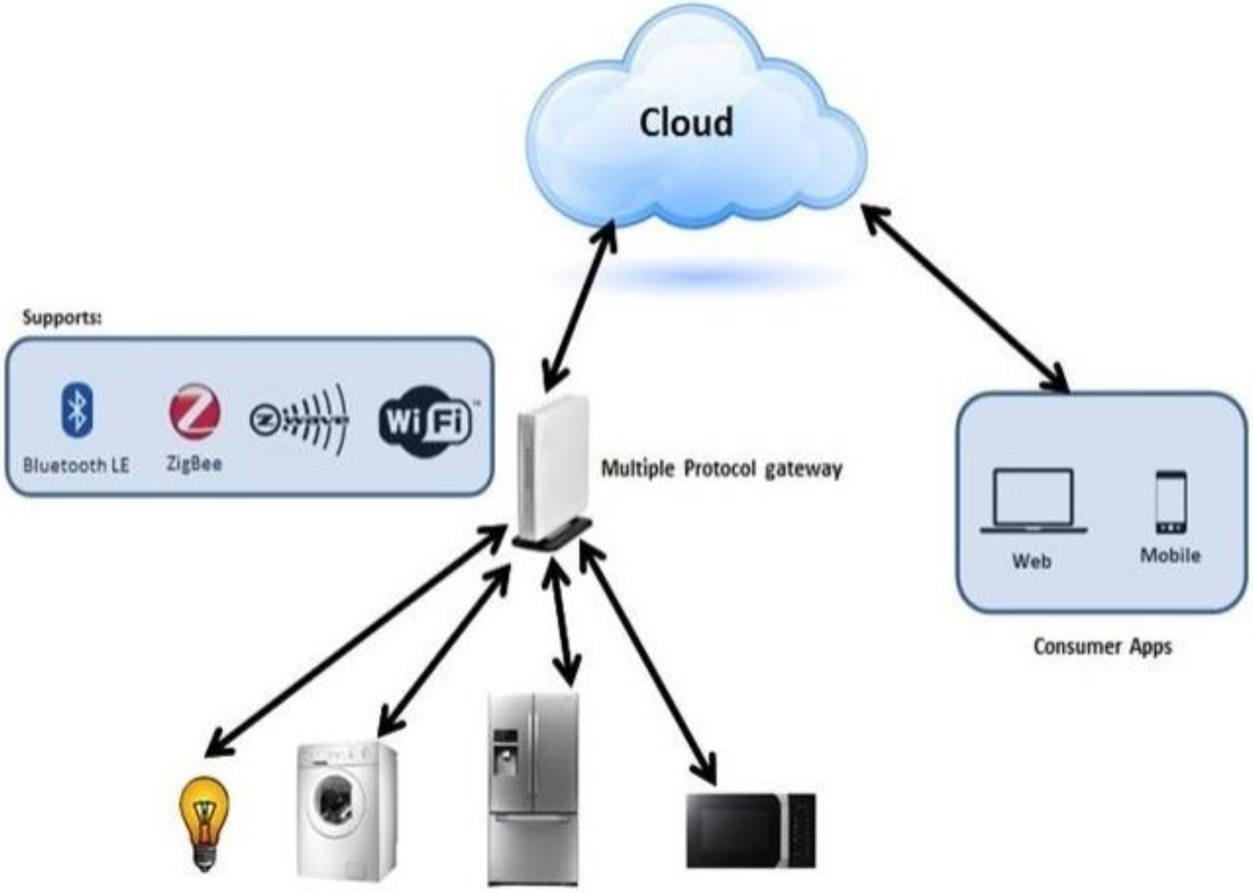

Cloud computing and Edge computing

Cloud platforms

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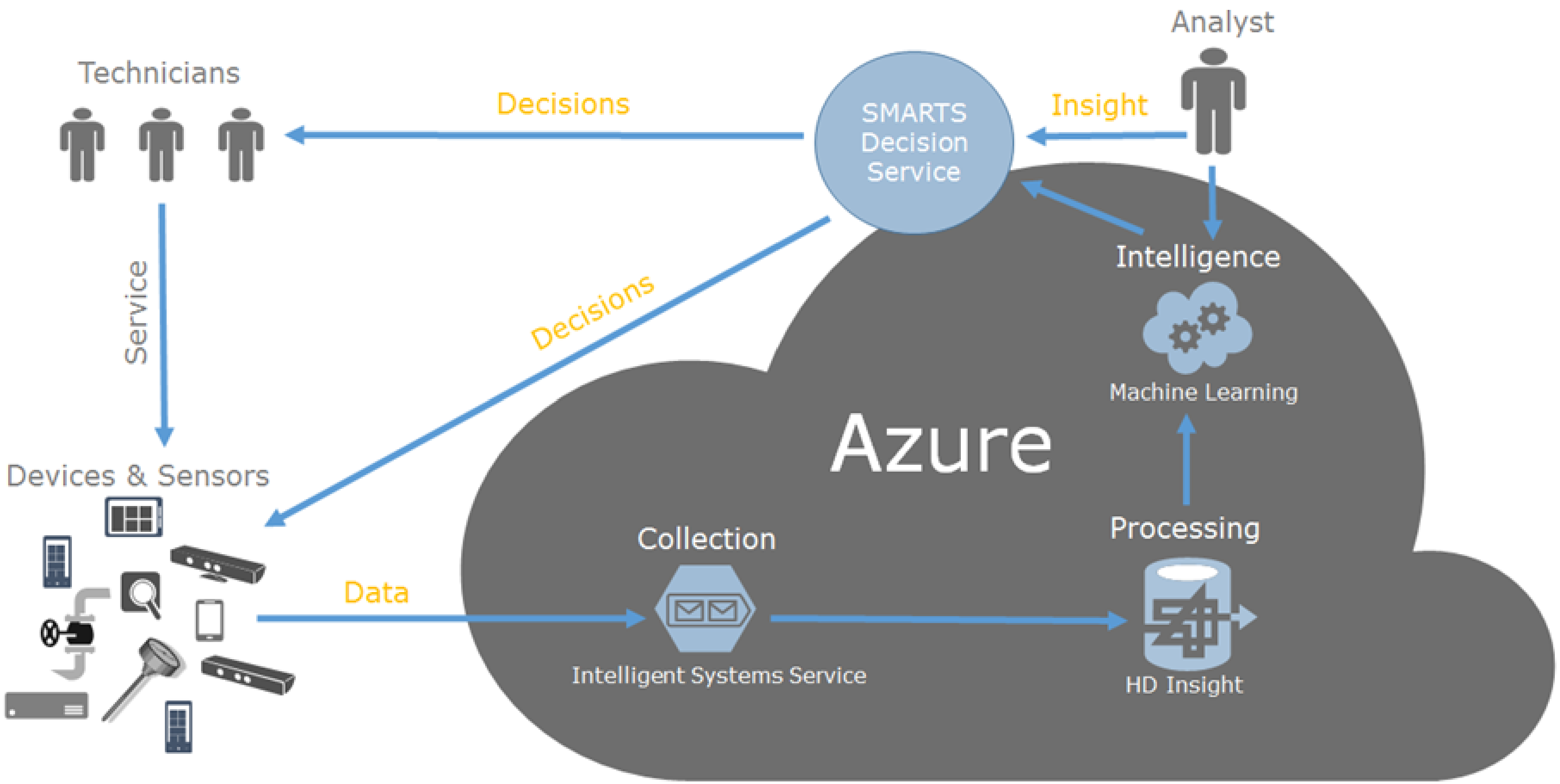
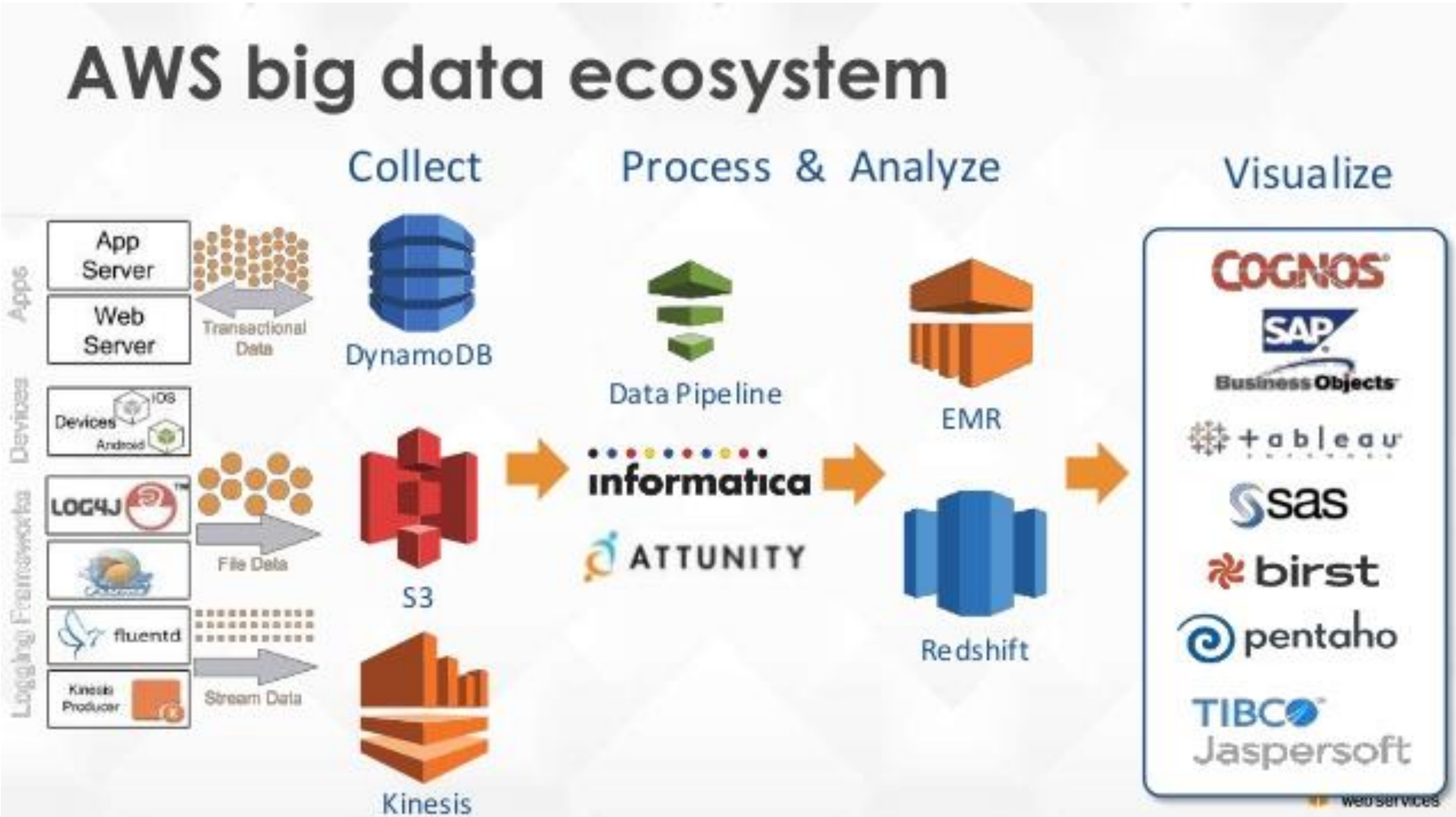
Microsoft azure data processing services



AWS ecosystem



Cloud computing services

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- Cloud computing services are offered to the users in different forms
  - Infrastructure as a service (IaaS)
  - Platform as a service (PaaS)
  - Software as a service (SaaS)

Infrastructure as a service (IaaS)

- **Provides provision computing and storage resources**.
- These resources are provided to users as **virtual machine instances or virtual storage**
- Users **can start, stop configuration and manage the virtual machine instances and storage.**
- Users can **deploy OS and applications of their choice** on the virtual resources.
- The cloud service provider manages the underlying infra structure.

Platform as a service (PaaS)

- Provides ability to **develop and deploy applications in the cloud** using **development tools, APIs, software libraries and services** provided by the cloud service provider.
- . The cloud service provider manages the underlying cloud infrastructure – **including servers, networks, OS and storage.**
- The users themselves are responsible for **developing, deploying, configuring and managing applications** in a cloud infrastructure.

Software as a service (SaaS)

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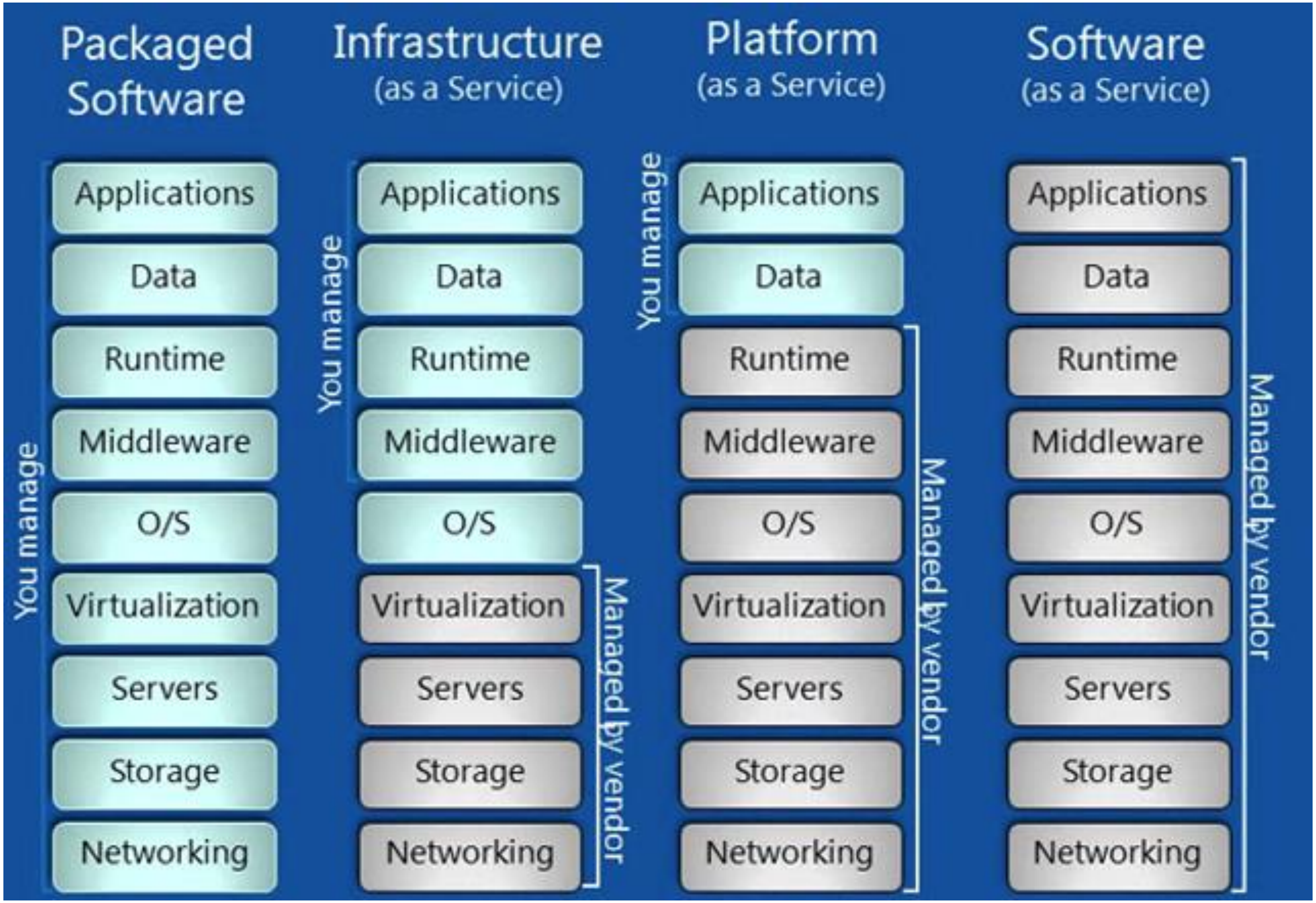
- **provides the user a complete software application** or the user interface to the applications itself.
- The **cloud service provider manages the underlying cloud infrastructure** including servers, networks, OS, storage and application software
- User is **unaware of the underlying architecture** of the cloud.
- Applications are provided to user through **client interface (e.g. browser).**

- applications are **platform independent** and can be accessed from various client devices such as **workstations, laptop, tablet, smart phones etc**
- Since the cloud service provider manages both the applications and data – **users can access the applications from anywhere.**


Packaged Software
Infrastructure (as a Service)
Platform (as a Service)
Software (as a Service)
Applications
Data
Runtime
Middleware
O/S
Virtualization
Servers
Storage
Networking
You manage
Managed by vendor

Big Data Analytics

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- Big data is defined as collections of data set whose **volume, velocity (in terms of its temporal variations) or variety is so large that it is difficult to store, manage, process and analysis** using traditional data bases and data processing tools.

- Big data analytics involves several steps starting from **data cleansing, data munging (wrangling), data processing and visualization.**

Big Data Analytics

- Some examples of big data generated by IoT systems.

- Sensor data collected from **sensors embedded in industrial and energy systems** monitoring their health and detecting failures.
- **Health and fitness data** generated by IoT devices such as **fitbit.**
- Data generated by IoT systems for **location and tracking of vehicles**.
- Data generated by **retail inventory monitoring systems**.

Characteristics of Big Data

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- ***Volume:*** *massive scale data that is difficult to store, manage and process using traditional databases and data processing architectures.*

  The volume of data generated by modern IT industrial and health care systems is growing **exponentially driven by the low cost of data storage and processing architectures** in the need to **extract valuable insights from the data to improve business processes, efficiency, and service for consumer**.

- ***Velocity :*** *refers to* ***how fast the data is generated and how frequently it varies.***

  Modern IT, industrial and other system are generating data at increasingly higher speeds.

- ***Variety:*** *refers to the* ***forms of the data big data*** *comes in different forms such as structured/unstructured data, including text, image, audio, video and sensor data.*

A different case scenario: Need for Cloud computing

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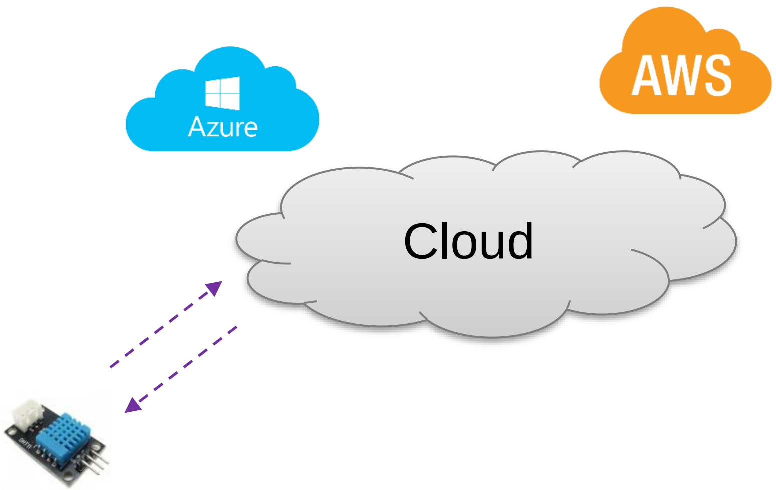
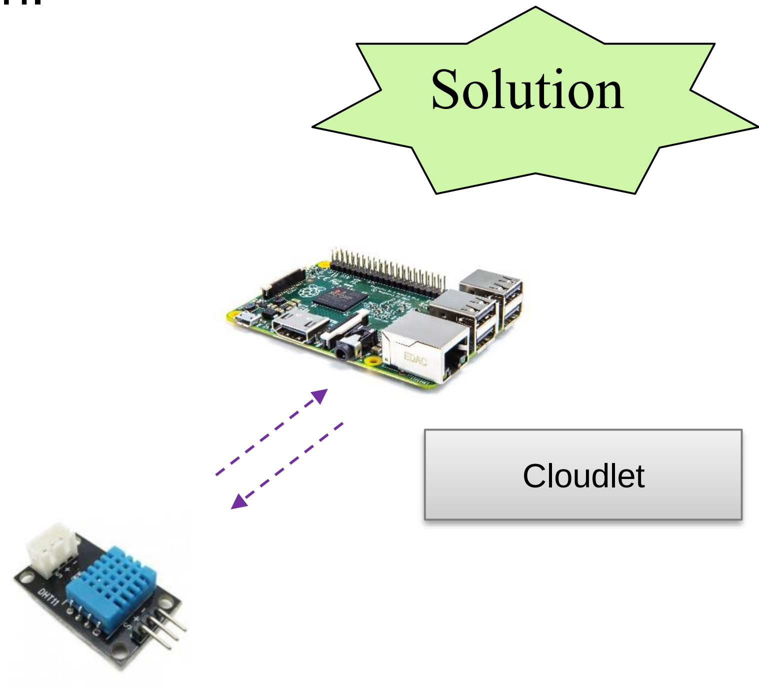
- Smarter Mobiles
- Smarter applications
  i. Image processing
  ii. Playing games
  iii. Zipping files and uploading
- Computationally more intensive

- Limitations of phone:
  i. Limited battery
  ii. Limited storage
  iii. Limited computational power

Need of Edge computing

- Challenges/ Drawbacks of using Cloud services
  i. Need for dedicated internet connection.
  ii. Latency due to cloud server being distant.
  iii. Cost associated with using cloud services.
  iv. Cost associated with internet connection.





Distributed processing (with edge computing)

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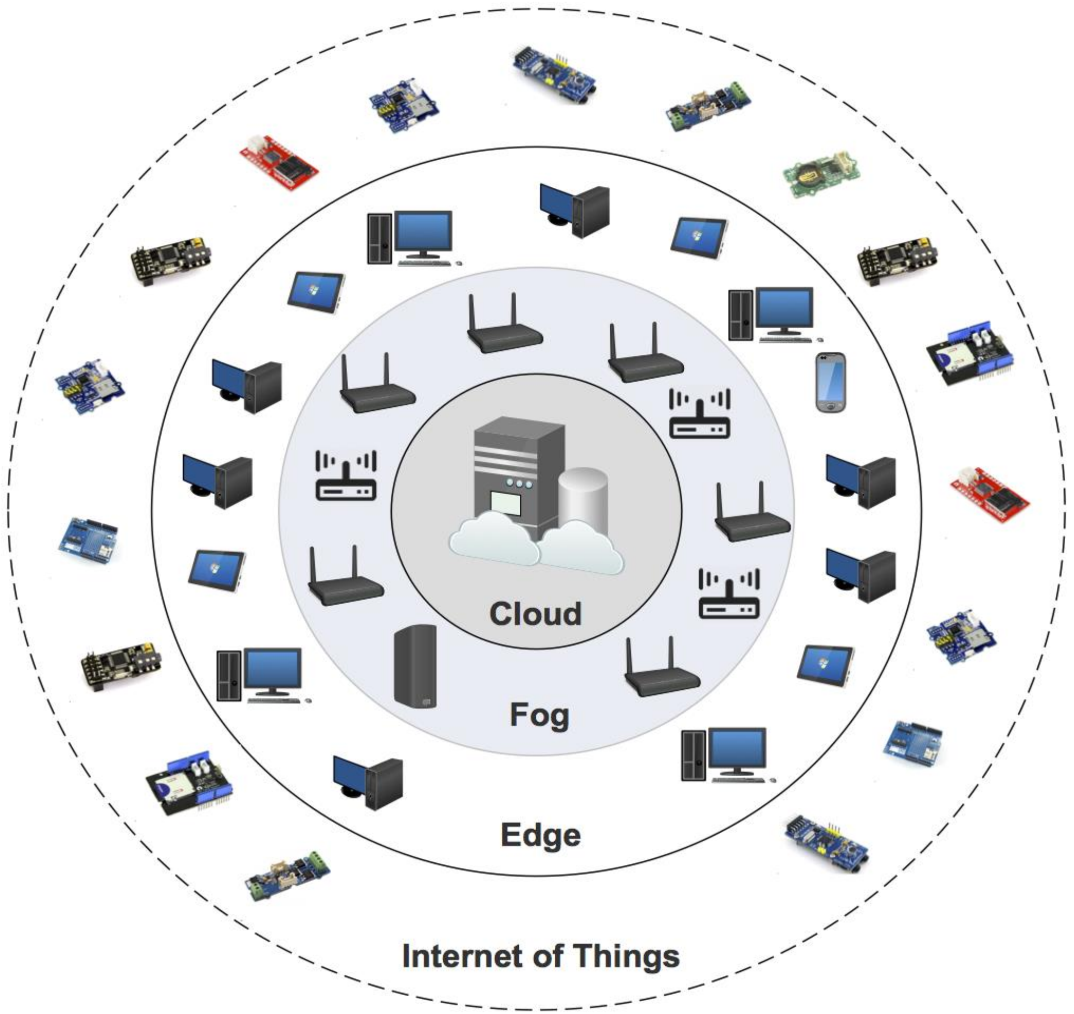


https://www.helsinki.fi/en/news/sustainability/edge-fog-cloud-a-distributed-cloud-for-internet-of-things-computations

Different levels for distributed processing

Edge

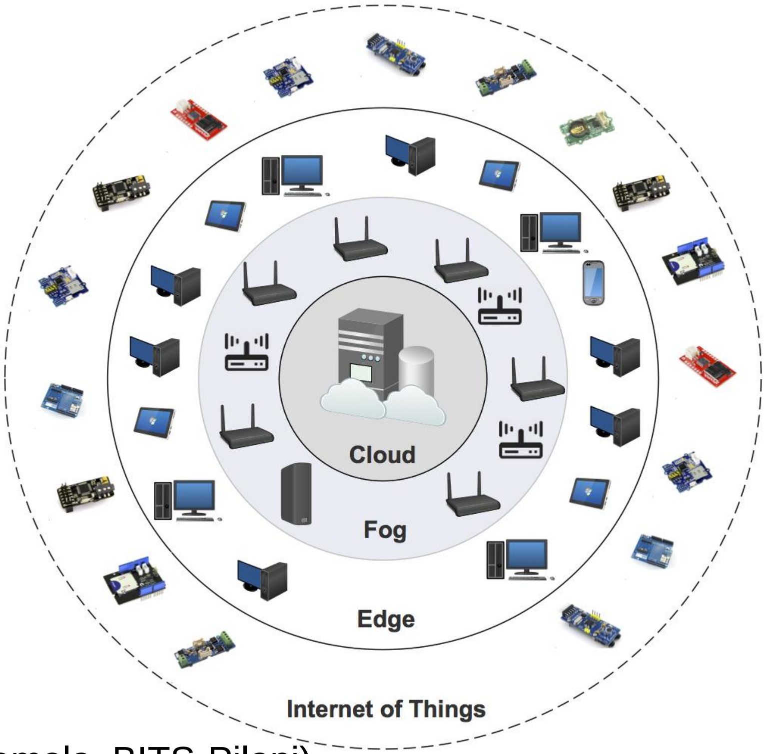
- Collection of devices
- 1-2 hops away from the sensors and clients
- Ad-hoc device-to-device connectivity (e.g. through wifi)
- devices having varying processing capabilities (e.g. Raspberry pi, desktop, laptop etc.)

Fog

- Networked devices with high compute capability
- managed, manufactured and deployed by cloud vendors like CISCO
- lies farther from sensors
- dense connectivity within later
- reliable connectivity to Edge

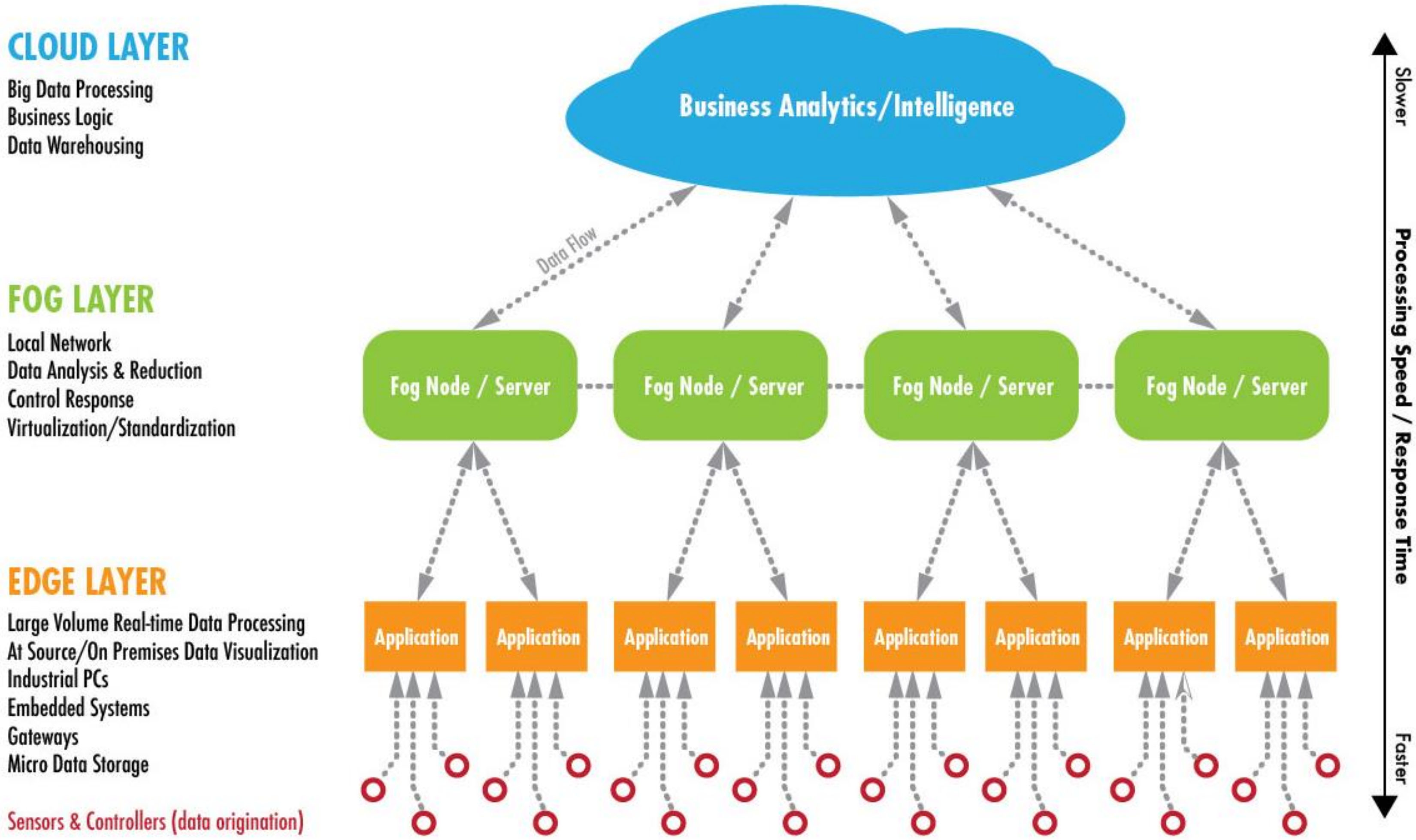
Cloud

- Much higher computational capabilities and services



Distributed processing scenario

TS Pilani



https://www.winsystems.com/cloud-fog-and-edge-computing-whats-the-difference/

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Difference Between Smart System And IoT System

Understanding the difference between Smart and IoT

From devices to smart devices to IOT – The IOT enabling Technologies

Example: A simple lawn sprinkler

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The system is used to water the lawns for certain duration every day. The system is made up of a series of underground pipes and valves as shown below.

Working

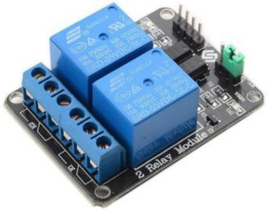
- valves laid out in a regular pattern at certain distances
- spraying system made up of rotor sprinklers, impact sprays, bubblers etc.
- release of water to these sprinklers done via valves.
- Every line has its own set of valves with an overall valve to control water flow.
- A normal sprinkler system (non-smart): *user comes and turns on the valve manually or uses a remote button and turns on the valve regularly for some hours every day*

System to Smart System

- we add intelligence-system to convert it (sprinkler system) into a smart system (embedded system)

- we add 16/32bit microcontroller, soil moisture sensors

- add relays to control the valves individually. The microcontroller at regular intervals of time checks soil moisture and at pre-programmed time of day look at the data collected and based on pre-programmed information open/closed valves.



- The system is no longer dumb.

- The system has now some amount of intelligence added to it – The smart sprinkler system is now IOT – it is an embedded system – smart definitely – **but IOT?** No.

Smart System to IoT System

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- At regular interval of time the soil moisture is still monitored-but the microcontroller before deciding on the sprinkling schedule also queries the database of a weather monitoring system to determine whether

- ➢ there is possibility for rainfall in the next few hours
- ➢ what is expected day-time/night-time temperature
- ➢ what is the expected humidity
- ➢ was there dew early morning

Based on this the sprinkling schedule is decided.

More features

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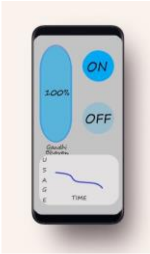
- The smart system is now **connected to the global internet** making it **an IOT system**. We can continue adding more feature to the system.

- **Water level in the tank** supplying water to the sprinkler system can be monitored. If the water level is low then the **sprinkler system can be alerted** and its sprinkling schedule can be delayed.

- While **relays controlling inlet and outlet** of water into the tank can be turned off and on respectively and the water pumping can be turned.



- If water pumping system does not work the user of the water tank/sprinkler system can be altered via an **SMS** sent from the sprinkler system automatically to his mobile via the cellular network - Another IOT feature.

More features

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- More features can be added by using **sensors to monitor the condition of the pipeline underground** via which water is being supplied to the sprinkler systems.

- **Cracks, breakages in the underground pipeline** can be detected by the sprinkler system. When this happens the sprinkler system can look-up a **database of plumbers**-select; some-one who is available-use the internet to mail the plumber the details of the error in the system, **book an appointment** and even do a **transfer of money** as the advance …. The possibilities can grow.

- All this happens in the background – with minimal to no intervention from the user of sprinkler system-hence also the term **Ambient or calm computing**. This connection of day-to-day objects to the internet has also been called as **ubiquitous computing (ubicomp) or pervasive computing.**

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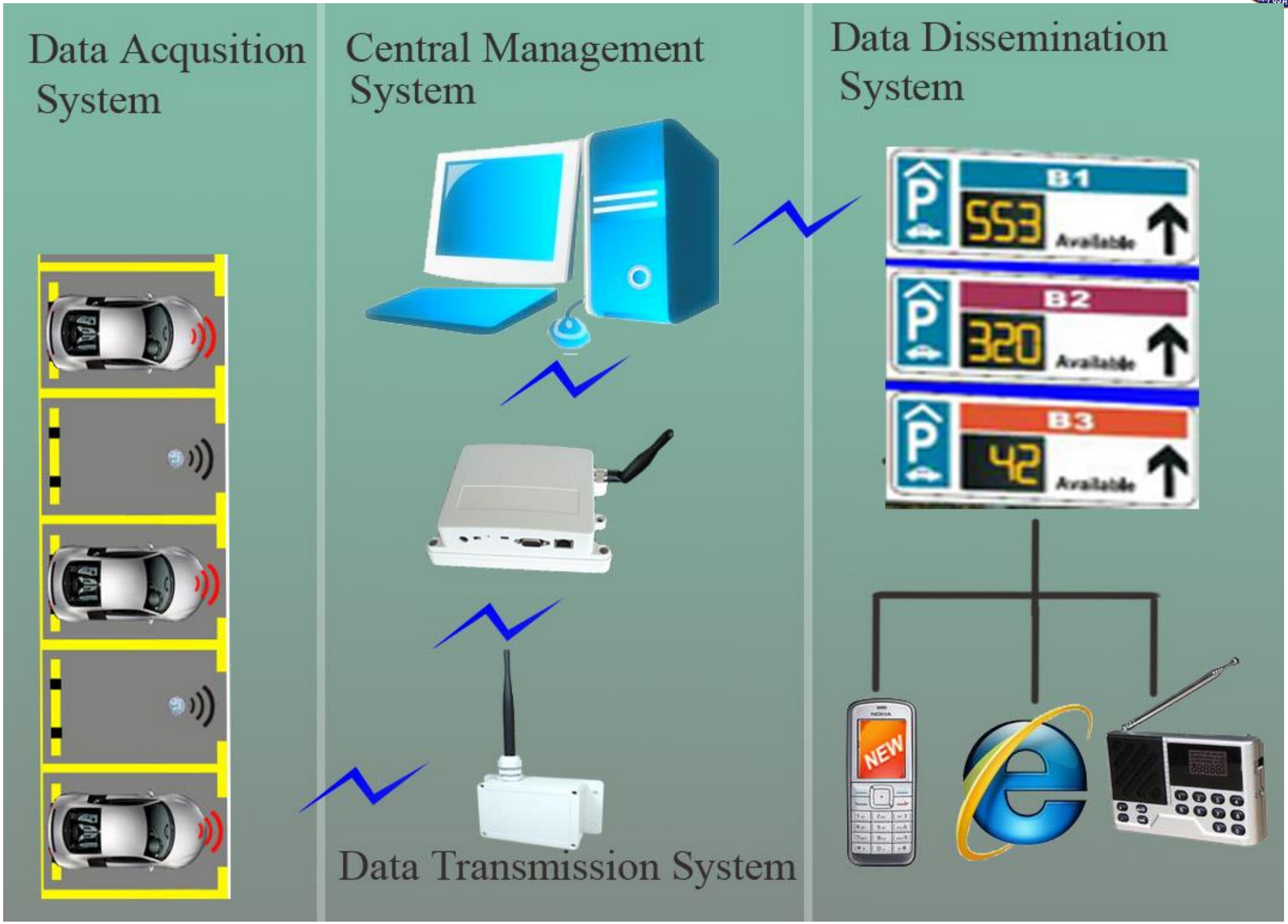
IoT System design

IoT system design Challenge

Design IoT based:

1. Smart Parking System
2. Smart Healthcare System
3. Home automation
4. Security System

Example 1: Smart Parking system



Example 2: Smart Health monitoring system

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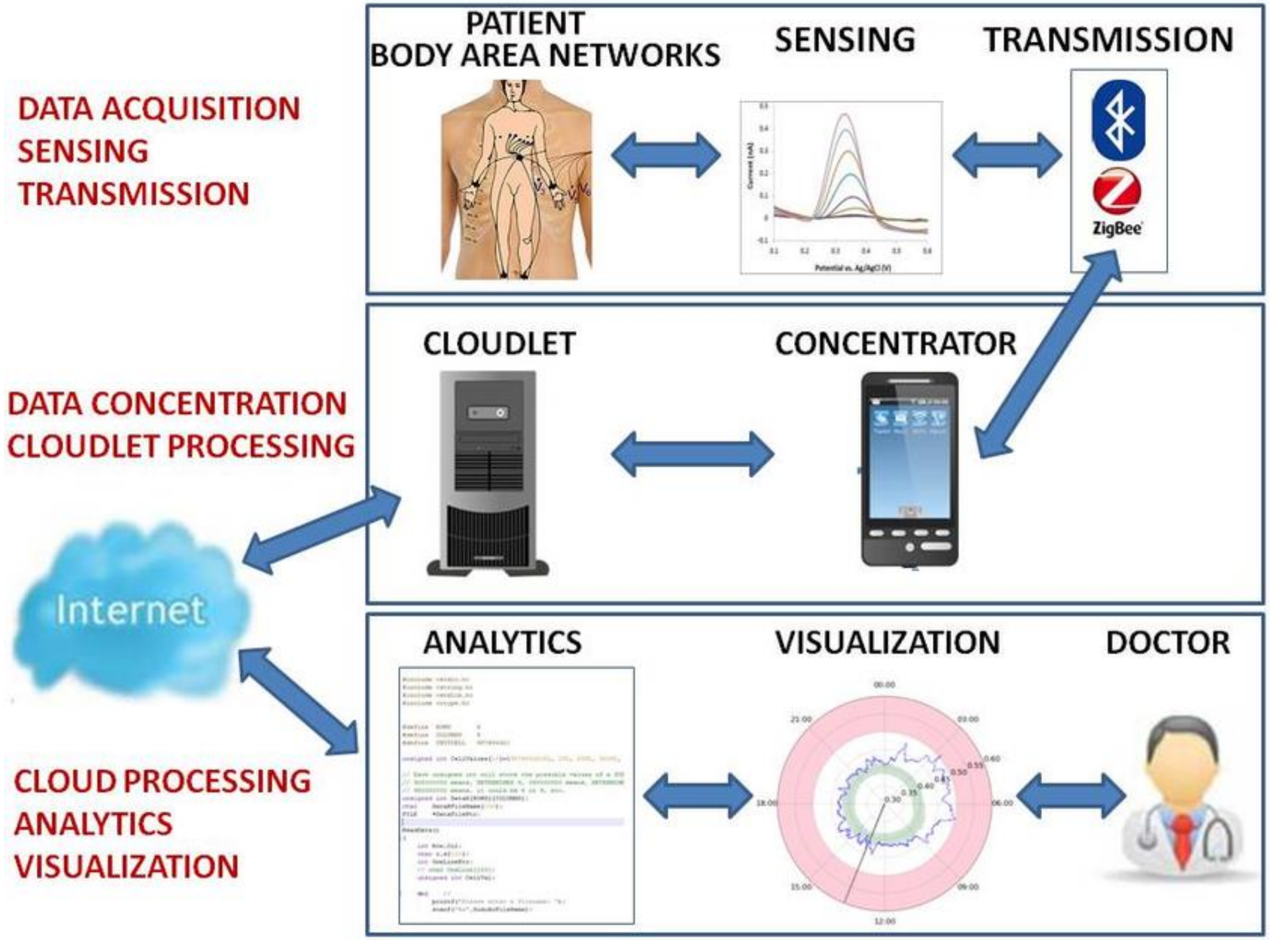

M. Hassanalieragh, et.al. “Health monitoring and management using Internet-of-Things (IoT) sensing with cloud-based processing: Opportunities and challenges”. IEEE International Conference on InServices Computing (SCC), 2015 Jun 27 (pp. 285-292).

Example 3: Home automation

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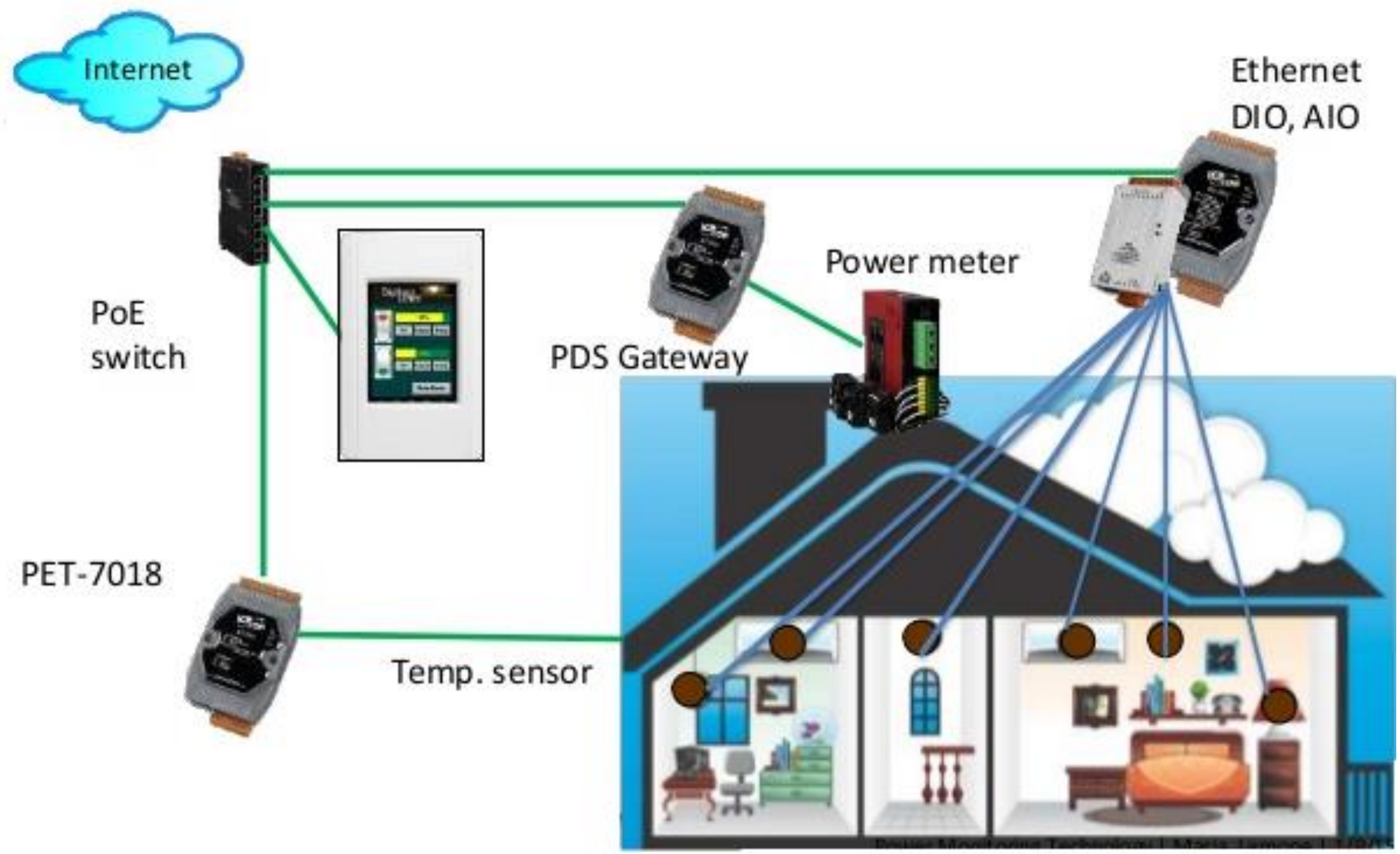
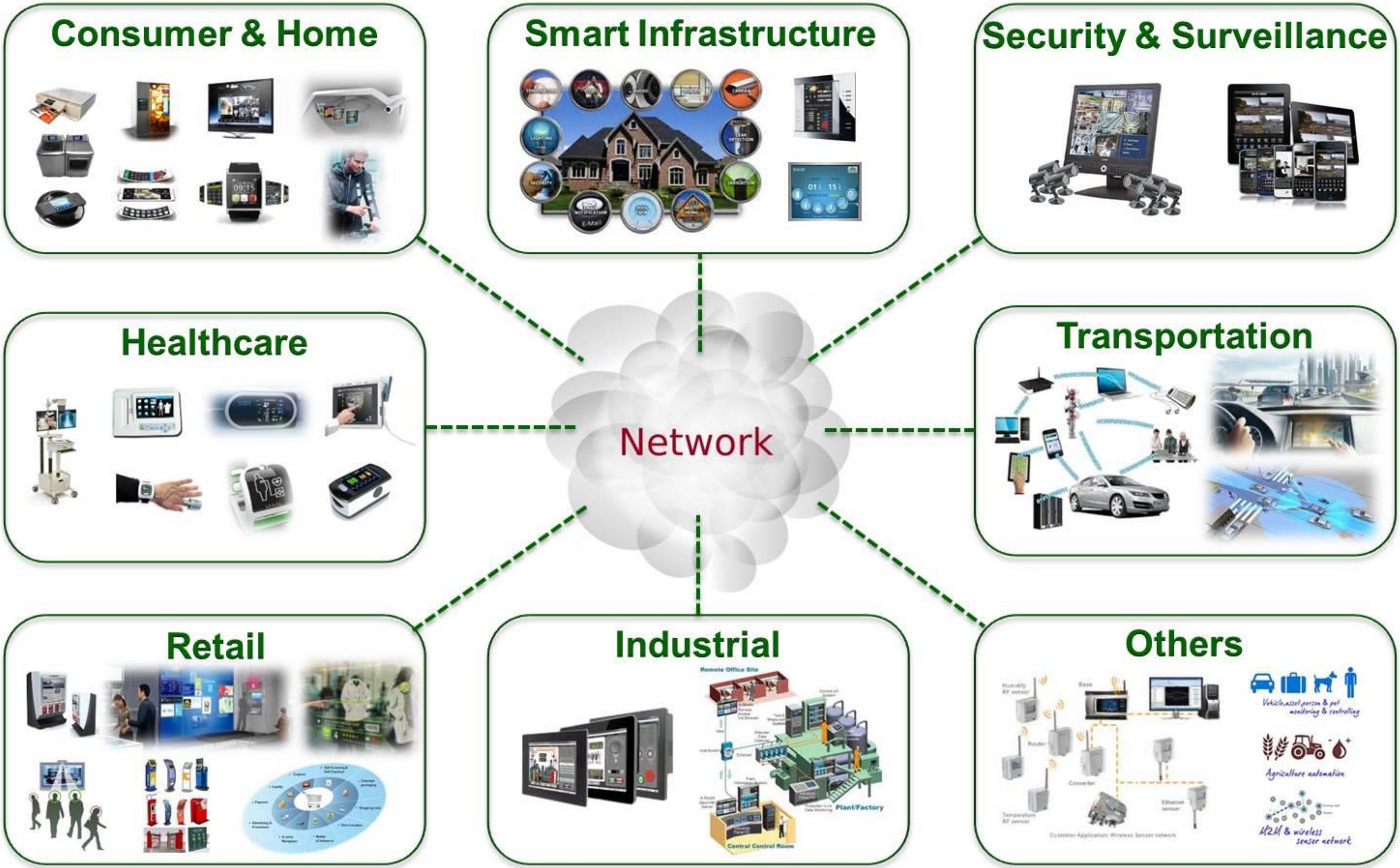


http://www.icpdas.com/index.php

Example 4: Security system


Consumer & Home
Smart Infrastructure
Security & Surveillance
Healthcare
Network
Transportation
Retail
Industrial
Others