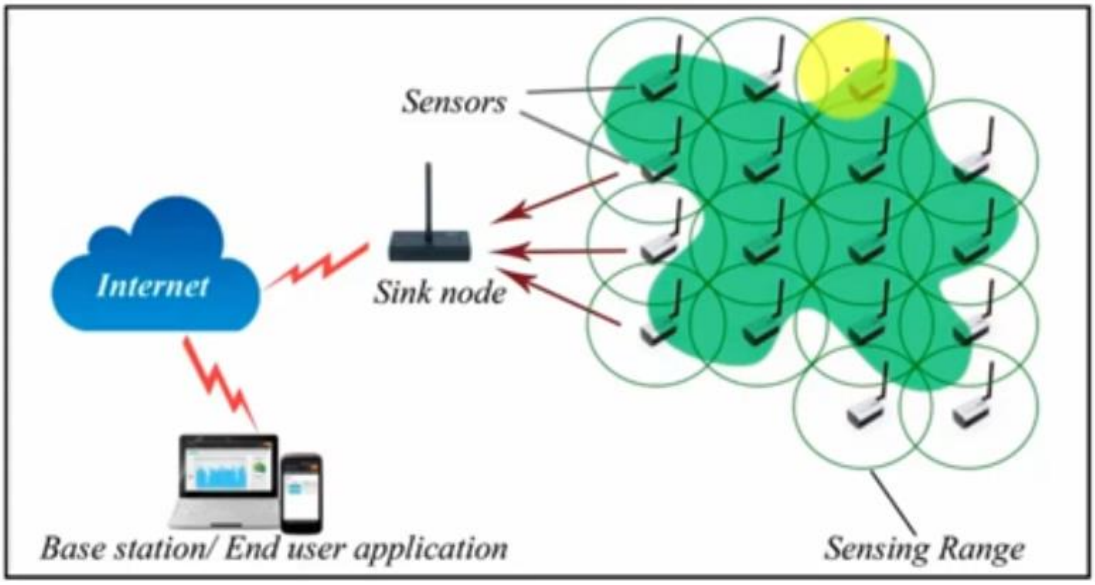
Enabling Technologies

- Wireless Sensor Networks
- Cloud Computing
- BigData Analytics
- Communication Protocols
- Embedded Systems

Wireless Sensor Networks



- A WSN consists of distributed devices with sensors which are used to monitor the environmental and physical conditions
- A WSN consists of a number of end nodes, routers and coordinators
- End nodes can also act as routers
- A coordinator collects data from all the nodes and is connected to Internet

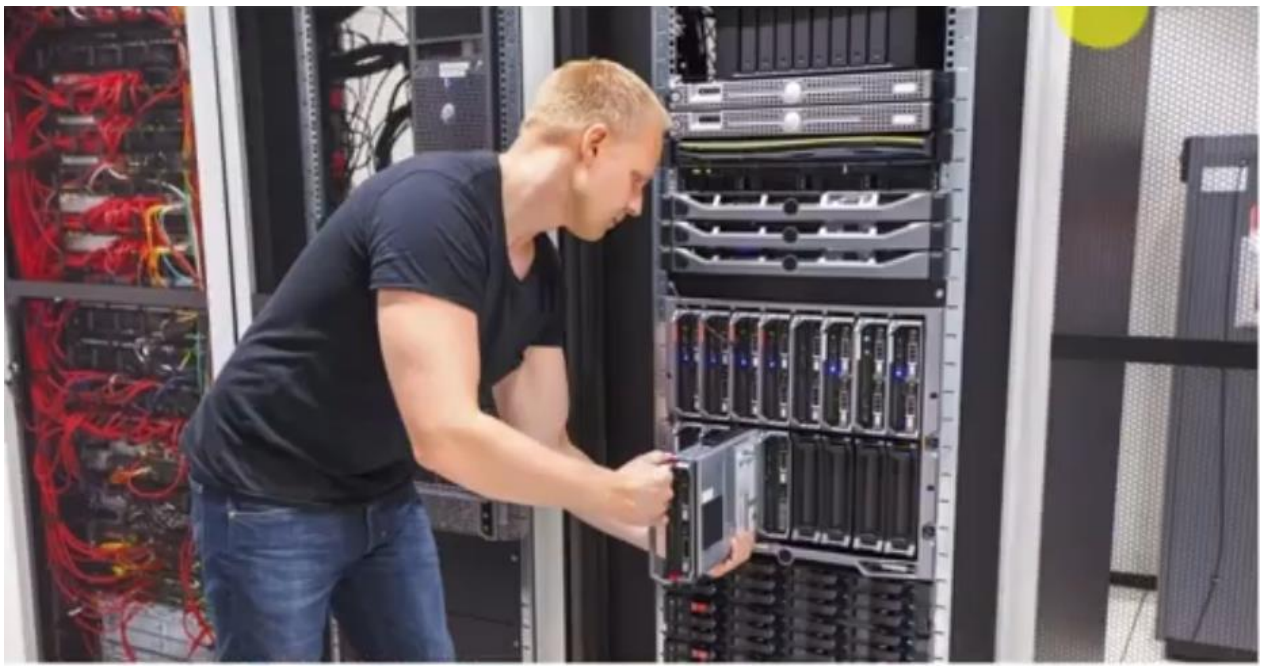
- Examples of WSNs used in IoT systems:
  - Weather monitoring systems
  - Indoor air quality monitoring systems
  - Soil moisture monitoring systems
  - Surveillance systems
  - Smart grids
  - Structural health monitoring systems

Cloud Computing

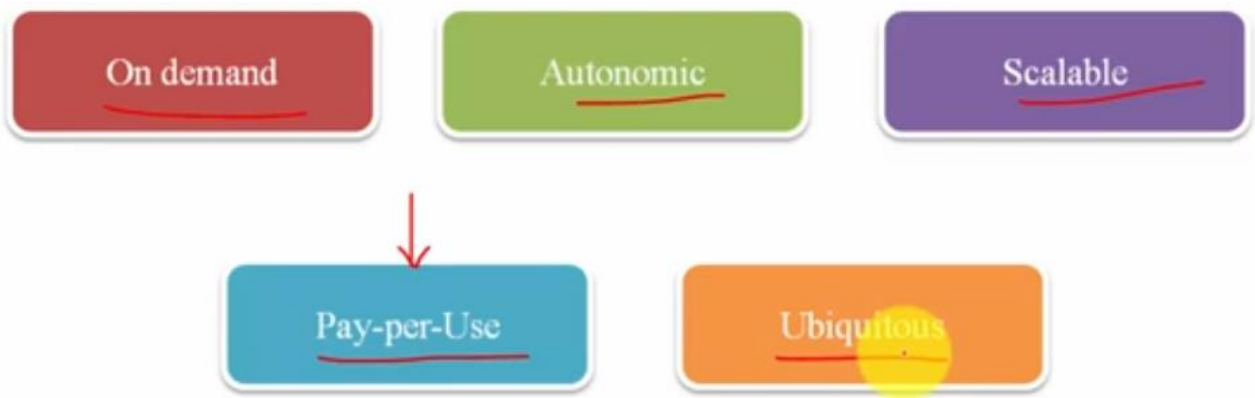
- Cloud computing is a computing model in which applications and services are delivered over Internet
- The resources provisioned by cloud can be compute, networking or storage
- Cloud allows the users to access resources based on utility model

Data Center

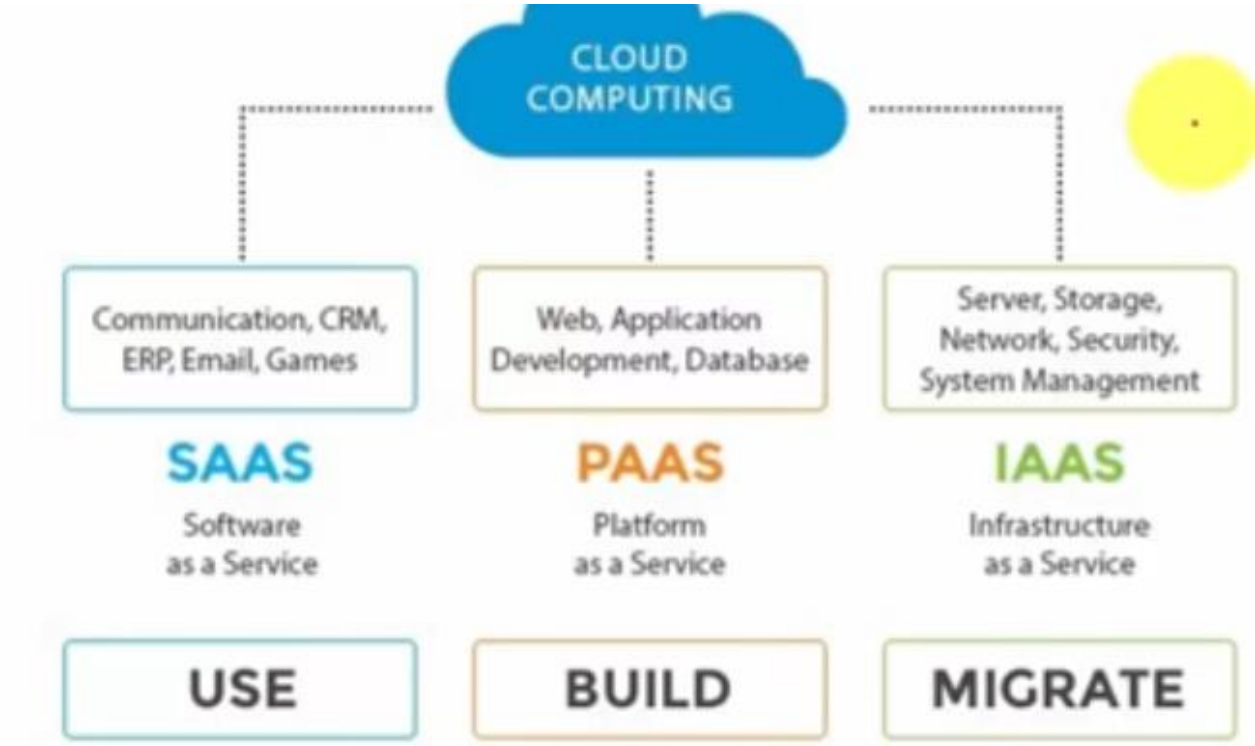
Rack or Blade Servers



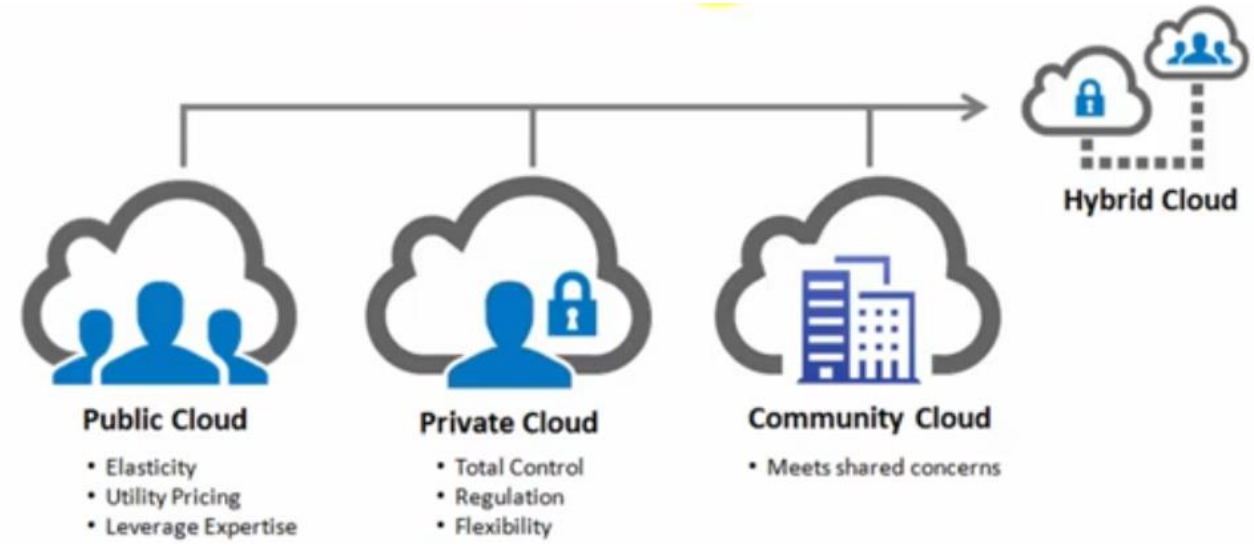
Cloud Computing Characteristics



Cloud Service Models



Cloud Deployment Models

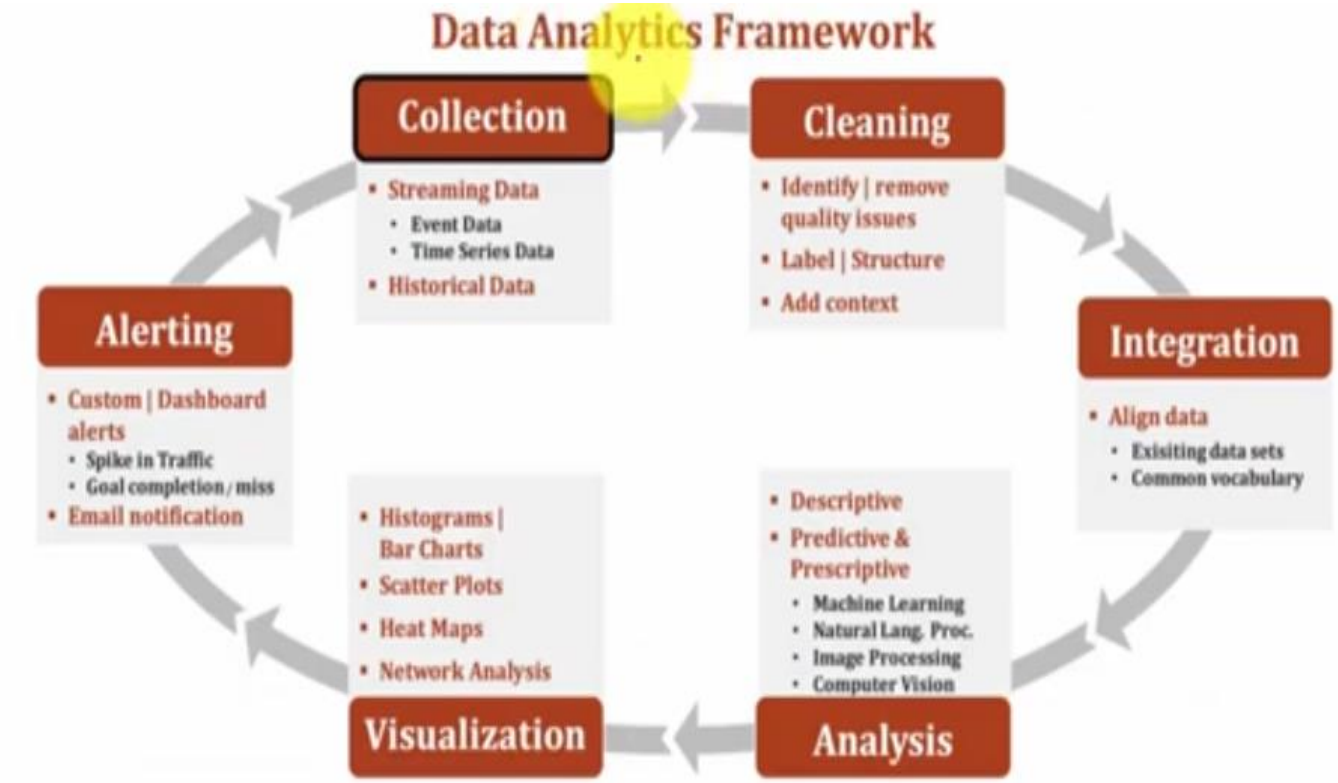


BigData Analytics

The six Vs of big data

Big data is a collection of data from various sources, often characterized by what's become known as the 3Vs: *volume*, *variety* and *velocity*. Over time, other Vs have been added to descriptions of big data:

VOLUME	VARIETY	VELOCITY	VERACITY	VALUE	VARIABILITY
The amount of data from myriad sources.	The types of data: structured, semi-structured, unstructured.	The speed at which big data is generated.	The degree to which big data can be trusted.	The business value of the data collected.	The ways in which the big data can be used and formatted.



Communication Protocols

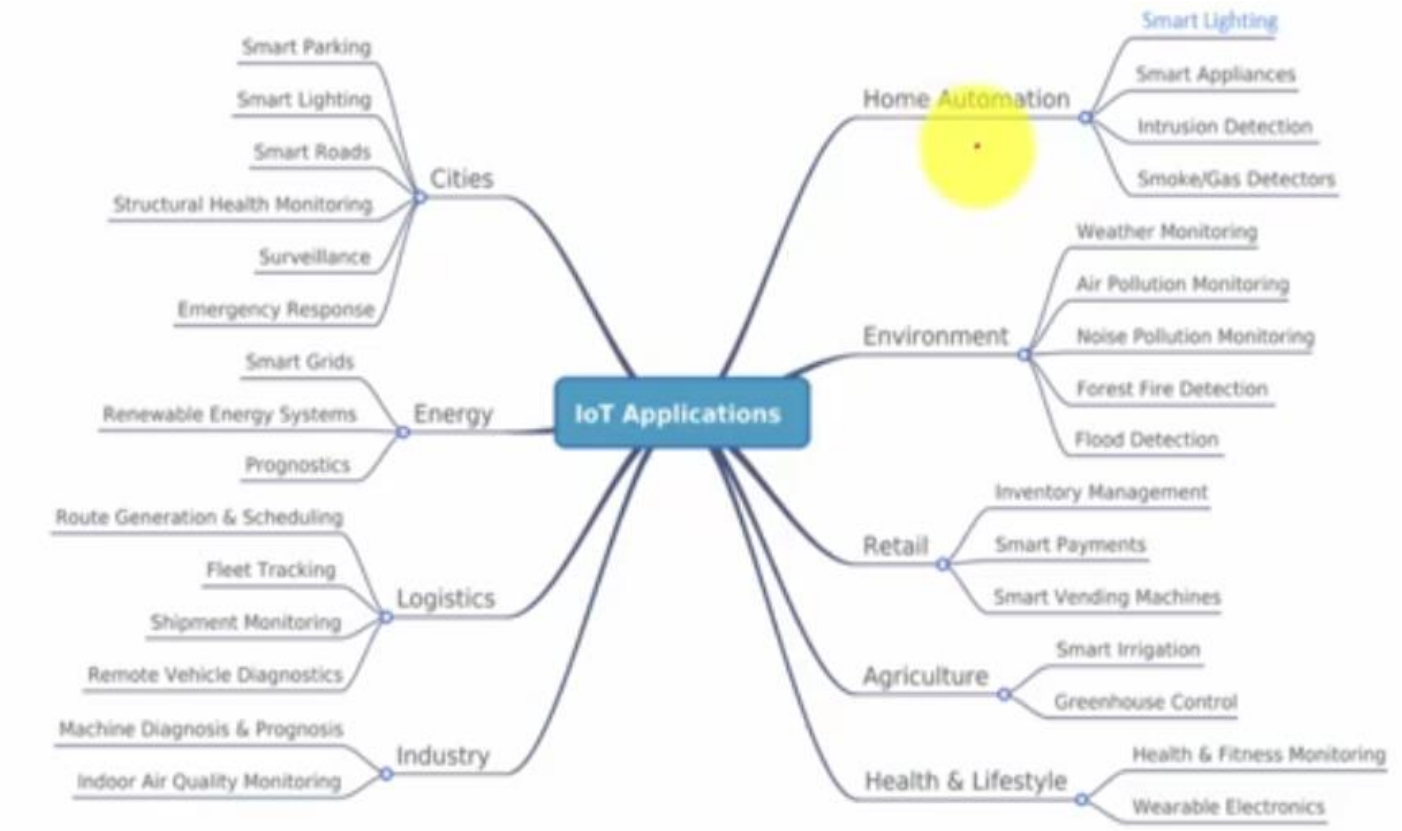
- Communications protocols form the backbone for IoT systems
- Allows devices to communicate with each other
- Defines the data exchange formats, data encoding and addressing schemes for devices
- Includes flow control, error control, and other functions

Embedded Systems

- Computing system having both hardware and software that performs a specific task
- Key components include microcontroller, memory, networking units, I/O, and storage
- Runs Real-Time Operating Systems (RTOS)

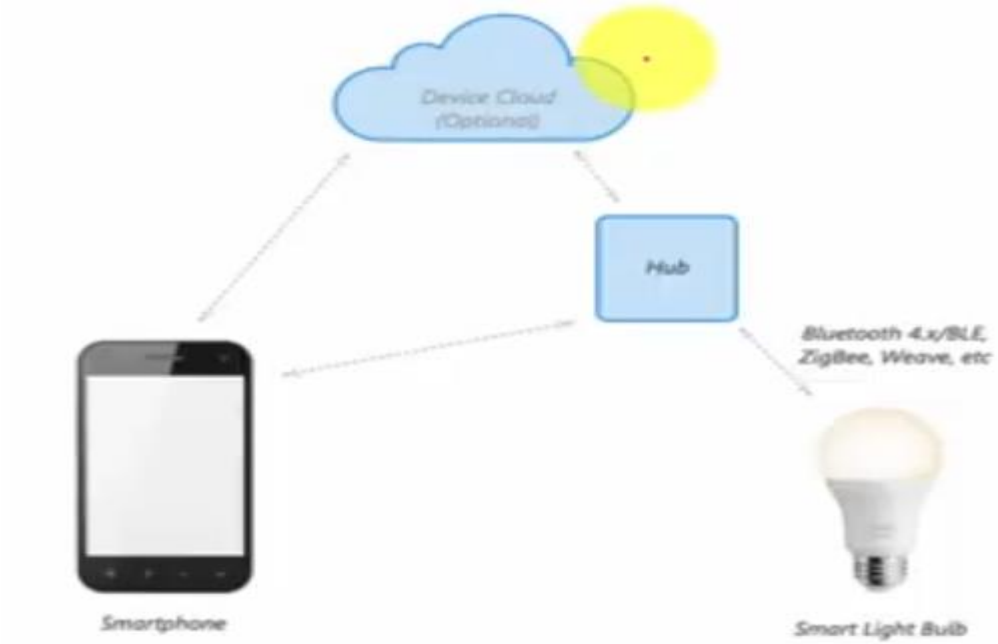
Domain Specific IoT

- IoT applications span a wide range of domains like:
  - Home
  - Cities
  - Environment
  - Energy systems
  - Retail
  - Logistics
  - Industry
  - Agriculture
  - Health



Home Automation

Smart Lighting



- Smart lighting for home helps in saving the energy by adapting the lighting to the ambient conditions
- Energy can be saved by sensing human movements and their environment
- Wireless and Internet connected lights can be operated remotely using mobile or web application
- Smart appliances makes the management easier and also provide status information to the users remotely
- For example, a smart refrigerator can keep track of items and notify the user when a item is low on stock
- Examples of smart appliances are TVs, refrigerators, music systems, washing machines, etc

Intrusion Detection

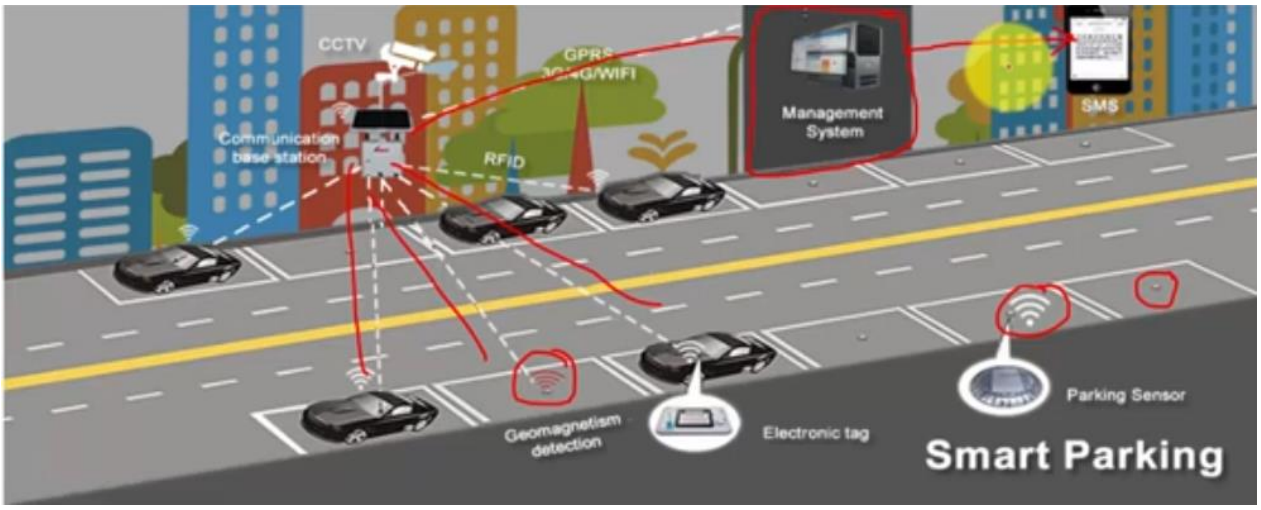
- Home intrusion detection systems use cameras and sensors to detect intrusions and for raising alerts
- Alerts can be sound, SMS or email sent to the user
- An advanced system can even send an image or a short video clip related to the intrusion event

Smoke/Gas Detectors

- Smoke detectors installed at home can detect smoke and alert the users
- Smoke detectors use optical detection, ionization, or air sampling techniques to detect smoke
- Gas detectors can detect harmful gases like CO or LPG
- These detectors can send alerts in the form of email, SMS, or voice

Cities

Cities – Smart Parking

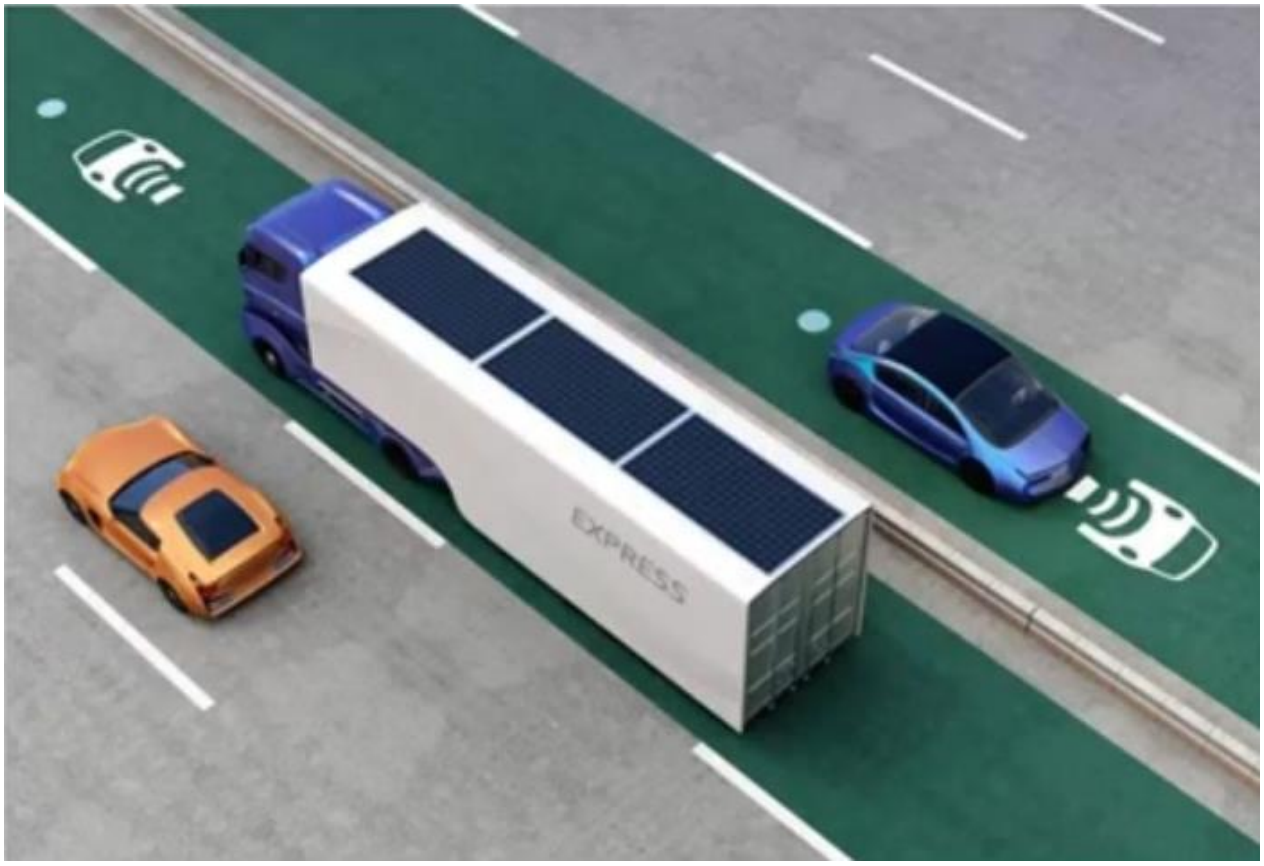


- Smart parking makes the search for parking space easier and convenient for drivers
- In smart parking, sensors are used for each parking slot, to detect whether the slot is occupied or not
- This information is aggregated by local controllers and sent over the Internet to the database
- Drivers can use an application to know about empty parking slots

Cities – Smart Lighting

- Smart lighting systems for roads, parks, and buildings can help in saving energy
- Smart lighting allows lighting to be dynamically controlled and also adaptive to the ambient conditions
- Smart lights connected to the Internet can be controlled remotely to configure lighting intensity and lighting schedule

Cities – Smart Roads



- Smart roads equipped with sensors can alert the users about poor driving conditions, traffic congestion, and accidents
- Information sensed from the roads can be sent via Internet to applications or social media
- This helps in reducing traffic jams

Cities – Structural Health Monitoring

- A network of sensors are used to monitor the vibration levels in the structures
- Data from the sensors is analyzed to assess the health of the structures
- By analyzing the data it is possible to detect cracks, locate damages to the structures and also calculate the remaining life of the structure

Cities – Surveillance

- Surveillance of infrastructure, public transport and events in cities is required to ensure safety and security
- City wide surveillance requires a large network of connected cameras
- The video feeds from the cameras can be aggregated in cloud-based storage
- Video analytics applications can be used to search for specific patterns in the collected feeds

Cities – Emergency Response

- IoT systems can be used to monitor buildings, gas and water pipelines, public transport and power substations
- These systems provides alerts and helps in mitigating disasters
- Along with cloud-based applications IoT systems helps to provide near real-time detection of adverse events

Environment – Weather Monitoring

- IoT-based weather monitoring systems use different sensors to gather data
- That data is sent to the cloud-based storage
- The collected can be analyzed and visualized with applications
- Weather alerts can be subscribed by users from such applications

Environment – Air Pollution Monitoring

- IoT-based air pollution monitoring systems can monitor harmful gas emissions by factories and vehicles using gaseous and meteorological sensors
- The collected data can be analyzed to take decisions on pollution control approaches

Environment – Noise Pollution Monitoring

- IoT-based noise pollution monitoring systems use a number of noise pollution monitoring systems that are deployed at different places in the city

- The data on noise levels from the stations is collected on servers or in the cloud

- The collected data can be analyzed to generate noise maps

Environment – Forest Fire Detection

Environment – River Floods Detection

- IoT-based flood monitor systems use number of sensor nodes to monitor the water level
- Data from the sensors is aggregated on the server or in the cloud
- Monitoring applications raise alerts in case of rapid increase in water level or when rapid flow rate is detected