Unit-2

What is Internet Of Things(IoT)?

- The Internet of Things (IoT) is the inter-networking of “physical devices” also referred to as "connected devices" and "smart devices”
- Sometimes referred to as the Internet of Everything (IoE) and Machine to Machine (M2M) communicating.
- IOT is expected to offer advanced connectivity of devices, systems, and services that covers a variety of protocols, domains, and applications.
- The goal of IoT is to extend to internet connectivity from standard devices like computer, mobile, tablet to relatively dumb devices like a toaster.
- IoT makes virtually everything "smart," by improving aspects of our life with the power of data collection, AI algorithm, and networks.
- The thing in IoT can also be a person with a diabetes monitor implant, an animal with tracking devices, etc

- The Internet of Things is a rising topic in present world. Many definitions are given many people.
- 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 house hold application.
- The internet of things is the network of physical objects or things embedded with electronics, software, sensors and network connectivity which enables these objects to collect and exchange data ---Wikipedia
- Internet of things refers to the concept that the internet is no longer just a global network for people to communicate with one another using computers, but it is also a platform for devices to communicate electronically with the world around them.

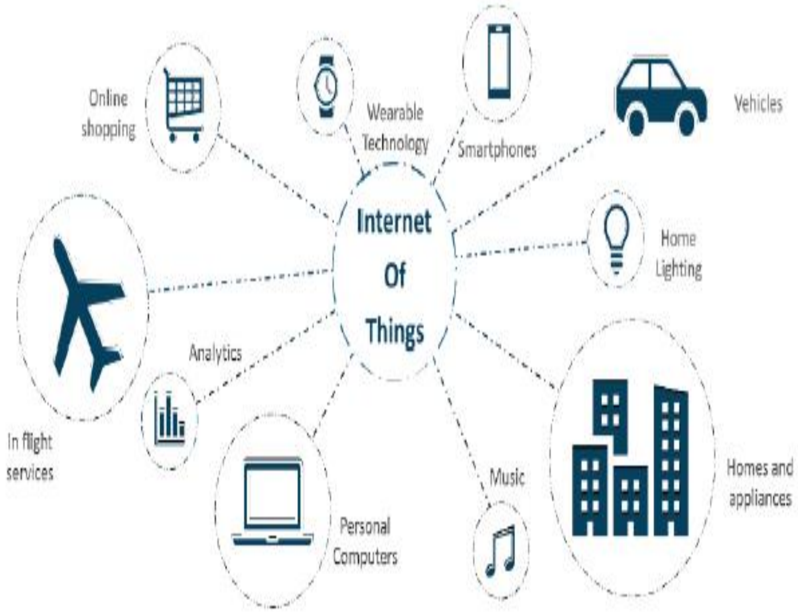
  --Center for Data and Innovation

"The Ultimate Goal of IoT to Automate Human life".

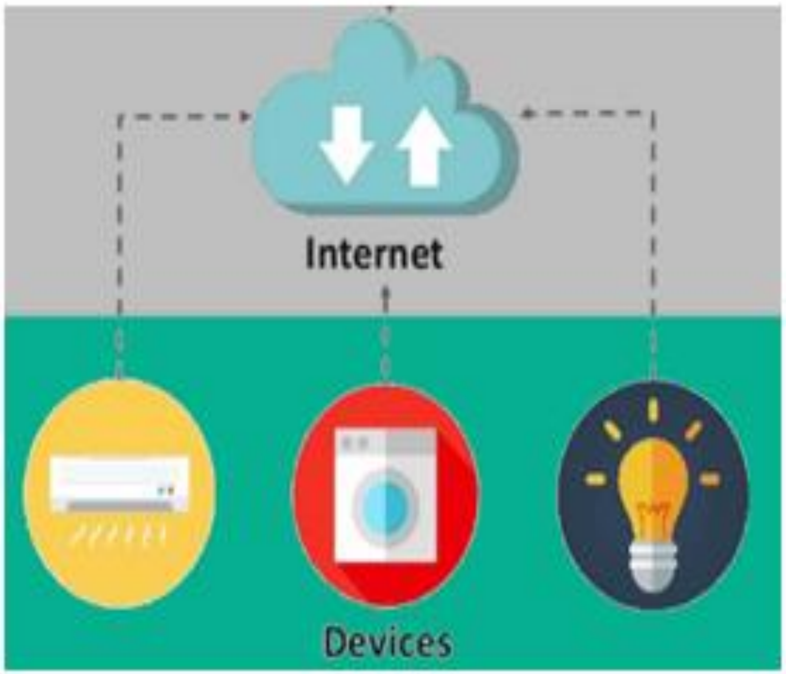
- ✓ technology connecting devices, machines and tools to the internet by means of wireless technologies.
- ✓ Over 9 billion ‘Things’ connected to the Internet, as of now.
- ✓ ‘Things’ Internet connected to the Internet are projected to cross 20 billion in the near future.
- ✓ Unification of technologies such as low-power embedded systems, cloud computing, big-data, machine learning, and networking

Alternate Definition

- The Internet of Things (IoT) is the network of physical objects that contain embedded technology to communicate and sense or interact with their internal states or the external environment.



. IoT application in every field.



History of IOT

- 1970- The actual idea of connected devices was proposed
- 1990- John Romkey created a toaster which could be turned on/off over the Internet
- 1995- Siemens introduced the first cellular module built for M2M
- 1999- The term "Internet of Things" was used by Kevin Ashton during his work at P&G which became widely accepted.

The first time internet of things word used is KEVINASHTON he is father of IOT.

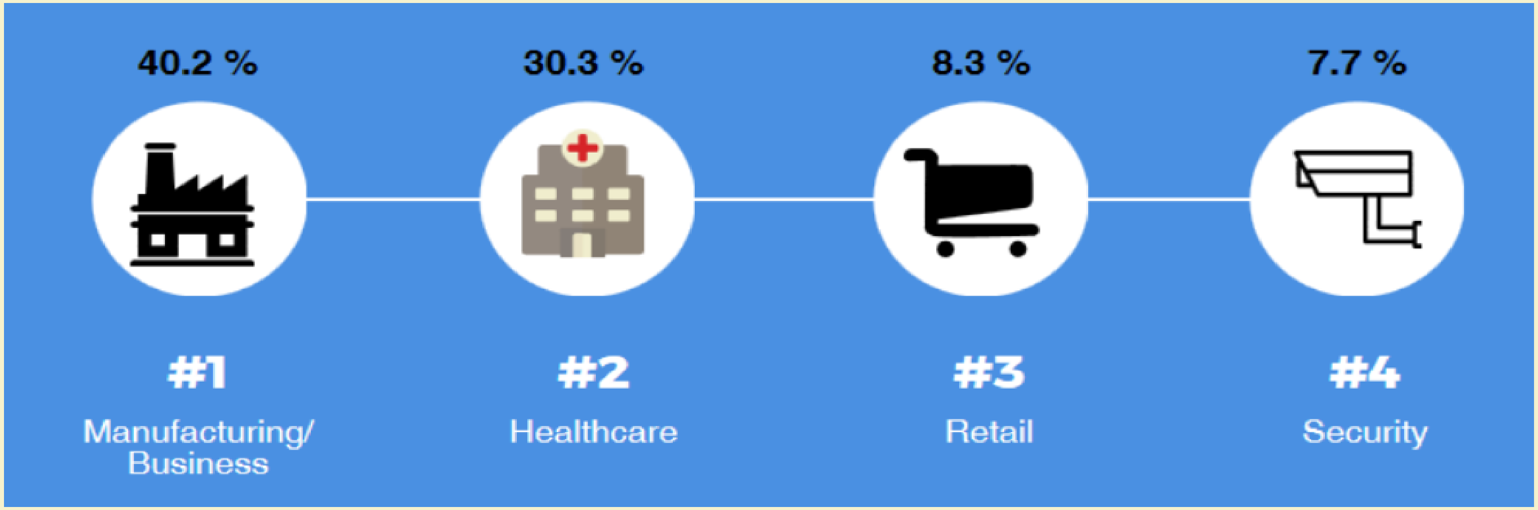
- 2004 - The term was mentioned in famous publications like the Guardian, Boston Globe, and Scientific American
- 2005-UN's International Telecommunications Union (ITU) published its first report on this topic.
- 2008- The Internet of Things was born
- 2011- Gartner, the market research company, include "The Internet of Things" technology in their research

What is the Internet of Things

Characteristics

- Efficient, scalable and associated architecture
- Unambiguous naming and addressing
- Abundance of sleeping nodes, mobile and non-IP devices
- Intermittent connectivity

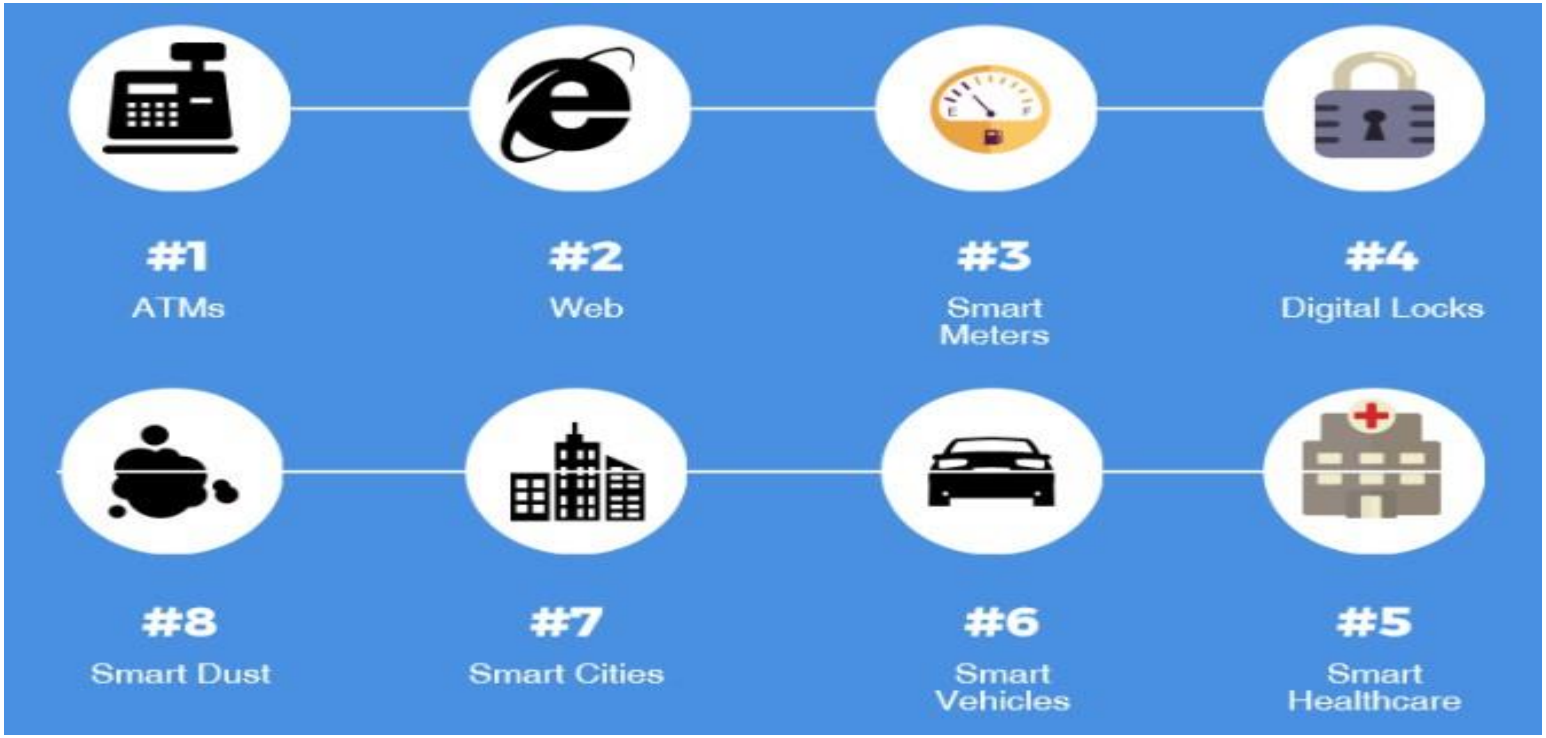
IoT Market Share



- ✓ Business/Manufacturing
  - Real-time analytics of supply chains and equipment, robotic machinery.
- ✓ Healthcare
  - Portable health monitoring, electronic recordkeeping, pharmaceutical safeguards.
- ✓ Retail
  - Inventory tracking, smartphone purchasing, anonymous analytics of consumer choices.
- ✓ Security
  - Biometric and facial recognition locks, remote sensors.

Source:Intel

Evolution of Connected Devices



- ATM
    - These ubiquitous money dispensers went online for the first time way back in 1974.
- WEB
    - World Wide Web made its debut in 1991 to revolutionize computing and communications.
- SMART METERS
    - The first power meters to communicate remotely with the grid were installed in the early 2000s.
- DIGITAL LOCKS
    - Smartphones can be used to lock and unlock doors remotely, and business owners can change key codes rapidly to grant or restrict access to employees and guests.
- SMART HEALTHCARE
    - Devices connect to hospitals, doctors and relatives to alert them of medical emergencies and take preventive measures.
- SMART VEHICLES
    - Vehicles self-diagnose themselves and alert owners about system failures.
- SMART CITIES
    - City-wide infrastructure communicating amongst themselves for unified and synchronized operations and information dissemination.

- SMART DUST

Modern Day IoT Applications

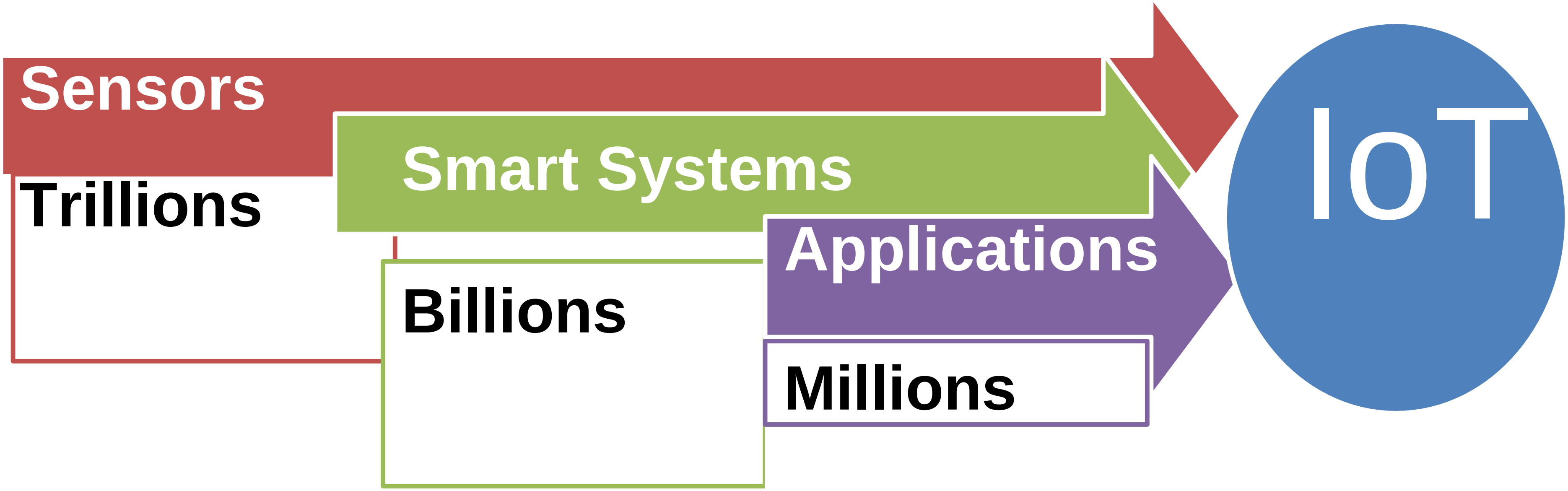
- ✓ Smart Parking
- ✓ Structural health
- ✓ Noise Urban Maps
- ✓ Smartphone Detection
- ✓ Traffic Congestion
- ✓ Smart Lighting
- ✓ Waste Management
- ✓ Smart Roads
- ✓ **Radiation Levels**
- ✓ **Explosive and Hazardous Gases**
- ✓ **Supply Chain Control**
- ✓ **NFC Payment**
- ✓ **Intelligent Shopping Applications**
- ✓ **Smart Product Managemen**

- ✓ River Floods
- ✓ Smart Grid
- ✓ Tank level
- ✓ Photovoltaic Installations
- ✓ Water Flow
- ✓ Silos Stock Calculation
- ✓ Perimeter Access Control
- ✓ Liquid Presence
- ✓ **Forest Fire Detection**
- ✓ **Air Pollution**
- ✓ **Snow Level Monitoring**
- ✓ **Landslide and Avalanche Prevention**
- ✓ **Earthquake Early Detection**
- ✓ **Water Leakages**

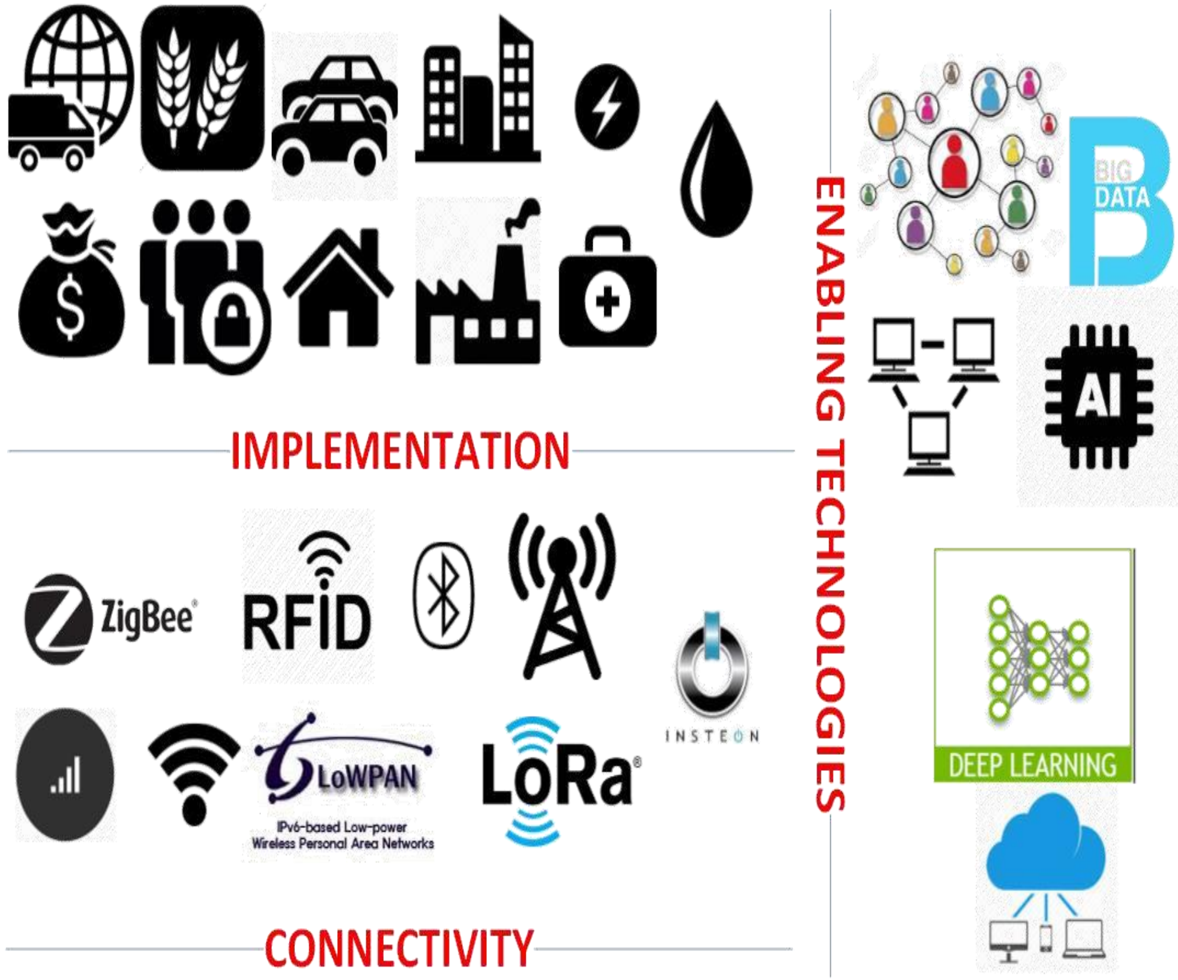
The given table is iot applications with examples

S.No	Application	examples	Overall popularity (%)
1	Smart home	Smart doors, smart fridge	100
2	wearbles	Smart glass, smart watch, activity tracker	63
3	Smart city	Smart parking, street lights	34
4	Smart grid	Smart metering	28
5	Industrial internet	Remote asset control	25
6	Smart car	Remote car control	19
7	health	Future Path Medical's UroSense ,Philips' Medication Dispensing Service	6
8	Smart retail	Smart retail solution	2
9	Smart agriculture	Automatic motor	1

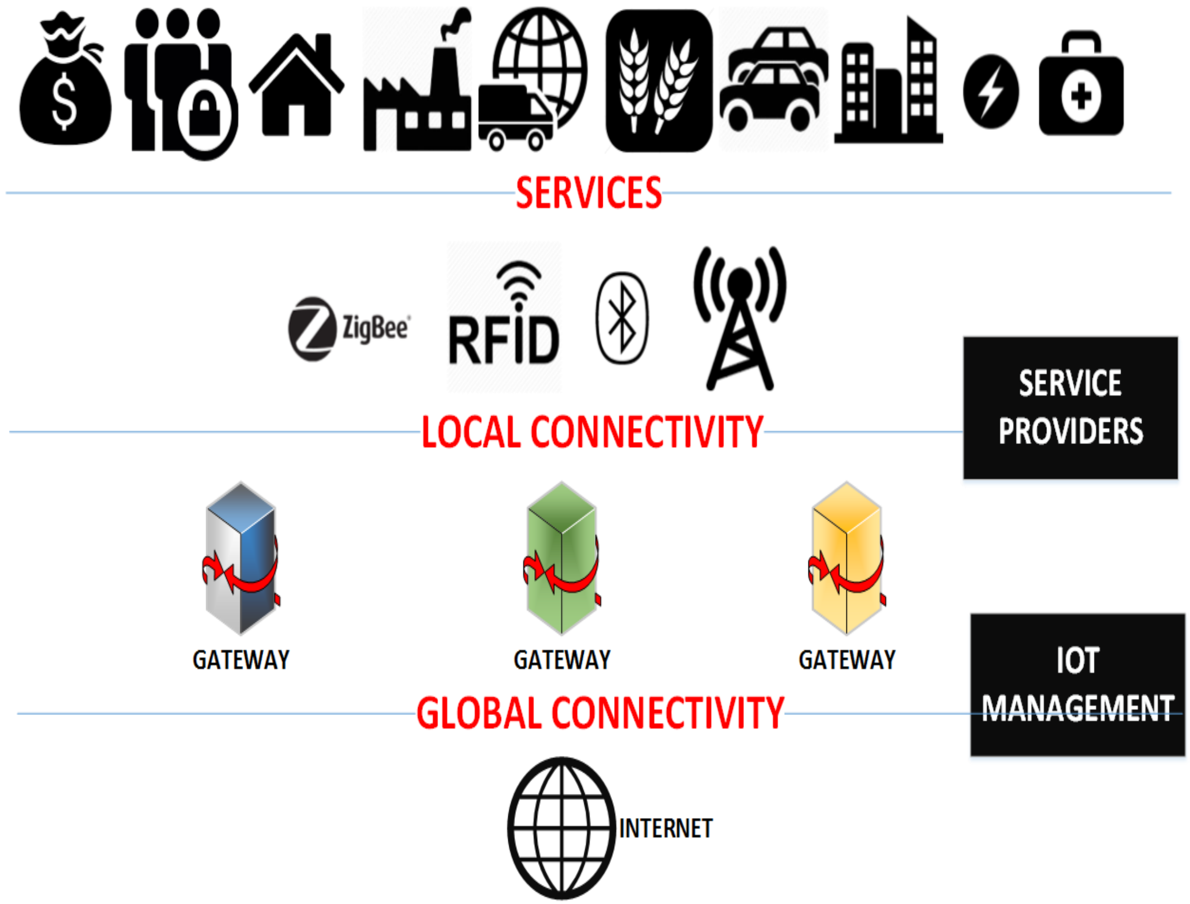
Expected!!


Sensors
Trillions
Smart Systems
Billions
Applications
Millions
IoT

IoT Enablers



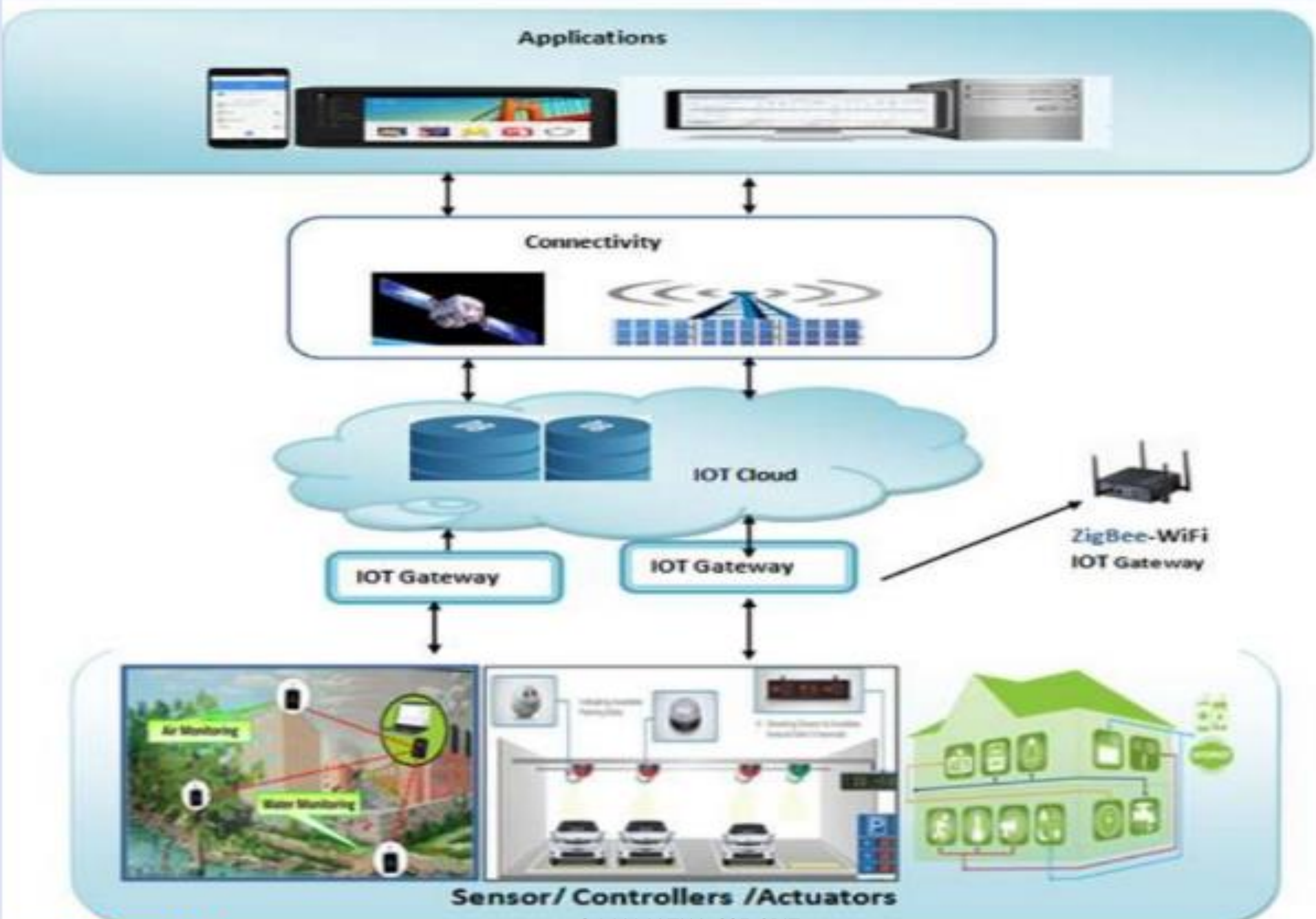
Connectivity Layers



How IoT Works?

- The Internet of Things (IoT), also sometimes referred to as the Internet of Everything (IoE), consists of all the web-enabled devices that collect, send and act on data they acquire from their surrounding environments using embedded sensors, processors and communication hardware. These devices, often called "connected" or "smart" devices, can sometimes talk to other related devices, a process called machine-to-machine (M2M) communication, and act on the information they get from one another. Humans can interact with the gadgets to set them up, give them instructions or access the data, but the devices do most of the work on their own without human intervention. Their existence has been made possible by all the tiny mobile components that are available these days, as well as the always- online nature of our home and business networks.

IoT Platform



Collection: **Devices and sensors are collecting data every where**.

- At your home
- In your car
- At the office
- At the manufacturing plants.

Communication: Sending data and events through networks to some destination.

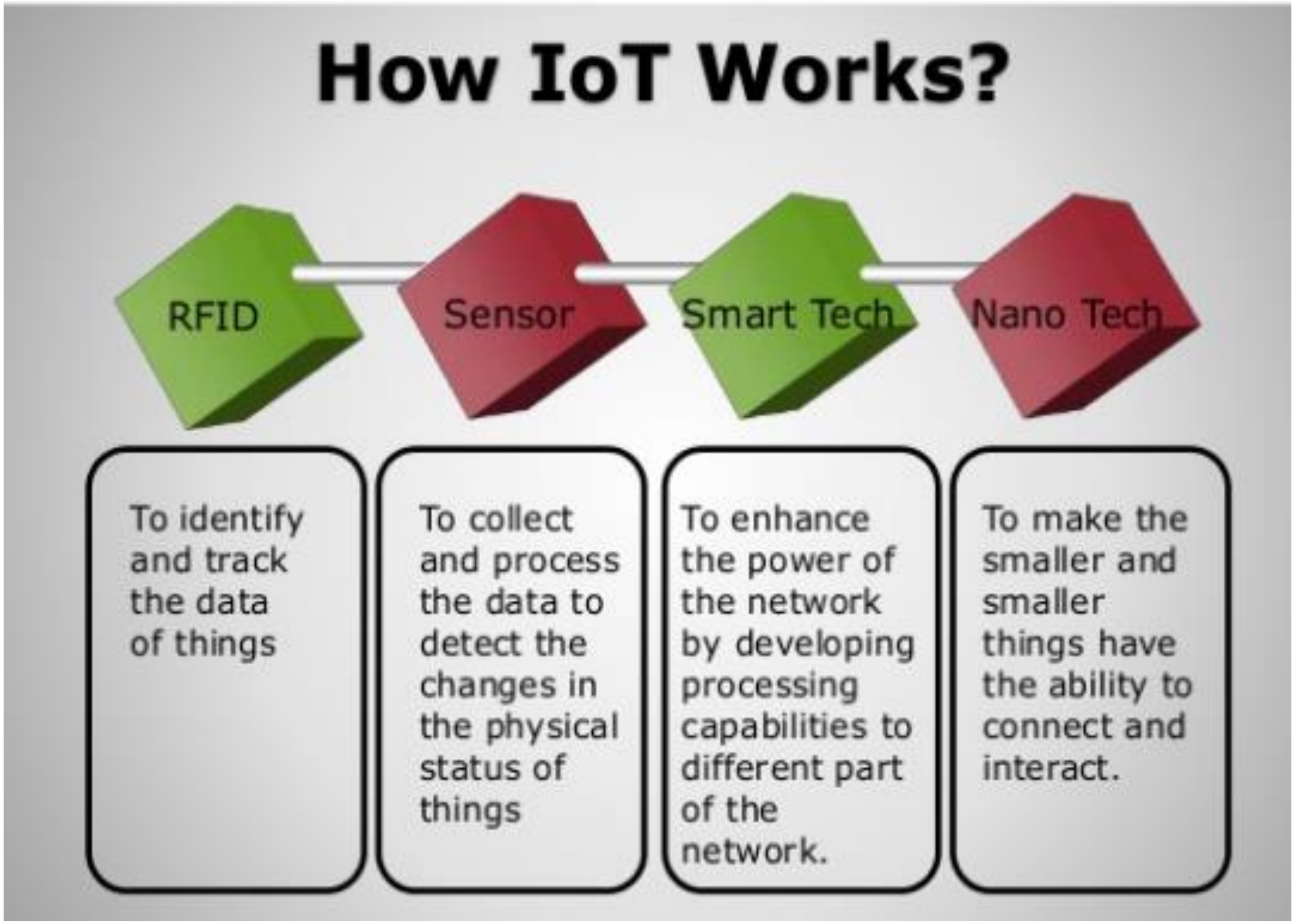
- A cloud platform
- Private data center
- Home network

Analysis: Creating information from the data

- Visualizing the data
- Building reports
- Filtering data (paring it down)

Action: Taking action based on the information and data

- Communicate with another machine (M2M)
- Send notification(SMS, email,text)
- Talk to another system


How IoT Works?
RFID
Sensor
Smart Tech
Nano Tech
To identify and track the data of things
To collect and process the data to detect the changes in the physical status of things
To enhance the power of the network by developing processing capabilities to different part of the network.
To make the smaller and smaller things have the ability to connect and interact.

The Structure of IoT

- The IoT can be viewed as a gigantic network consisting of networks of devices and computers connected through a series of intermediate technologies where numerous technologies like RFIDs, wireless connections may act as enablers of this connectivity.
- **Tagging Things** : Real-time item traceability and addressability by RFIDs.
- **Feeling Things** : Sensors act as primary devices to collect data from the environment.
- **Shrinking Things** : Miniaturization and Nanotechnology has provoked the ability of smaller things to interact and connect within the “things” or “smart devices.”
- **Thinking Things** : Embedded intelligence in devices through sensors has formed the network connection to the Internet. It can make the “things” realizing the intelligent control.

IoT – Key Features

The most important features of IoT include artificial intelligence, connectivity, sensors, active engagement, and small device use. A brief review of these features is given below:

AI – IoT essentially makes virtually anything "smart", meaning it enhances every aspect of life with the power of data collection, artificial intelligence algorithms, and networks. This can mean something as simple as enhancing your refrigerator and cabinets to detect when milk and your favorite cereal run low, and to then place an order with your preferred grocer.

Connectivity – New enabling technologies for networking, and specifically IoT networking, mean networks are no longer exclusively tied to major providers. Networks can exist on a much smaller and cheaper scale while still being practical. IoT creates these small networks between its system devices.

Sensors – IoT loses its distinction without sensors. They act as defining instruments which transform IoT from a standard passive network of devices into an active system capable of real-world integration.

Active Engagement – Much of today's interaction with connected technology happens through passive engagement. IoT introduces a new paradigm for active content, product, or service engagement.

Small Devices – Devices, as predicted, have become smaller, cheaper, and more powerful over time. IoT exploits purpose-built small devices to deliver its precision, scalability, and versatility.

IoT – Advantages

The advantages of IoT span across every area of lifestyle and business. Here is a list of some of the advantages that IoT has to offer:

Improved Customer Engagement – Current analytics suffer from blind-spots and significant flaws in accuracy; and as noted, engagement remains passive. IoT completely transforms this to achieve richer and more effective engagement with audiences.

Technology Optimization – The same technologies and data which improve the customer experience also improve device use, and aid in more potent improvements to technology. IoT unlocks a world of critical functional and field data.

Reduced Waste – IoT makes areas of improvement clear. Current analytics give us superficial insight, but IoT provides real-world information leading to more effective management of resources.

Enhanced Data Collection – Modern data collection suffers from its limitations and its design for passive use. IoT breaks it out of those spaces, and places it exactly where humans really want to go to analyze our world. It allows an accurate picture of everything.

IoT – Disadvantages

Though IoT delivers an impressive set of benefits, it also presents a significant set of challenges.

Here is a list of some its major issues:

Security – IoT creates an ecosystem of constantly connected devices communicating over networks. The system offers little control despite any security measures. This leaves users exposed to various kinds of attackers.

Privacy – The sophistication of IoT provides substantial personal data in extreme detail without the user's active participation.

Complexity – Some find IoT systems complicated in terms of design, deployment, and maintenance given their use of multiple technologies and a large set of new enabling technologies.

Flexibility – Many are concerned about the flexibility of an IoT system to integrate easily with another. They worry about finding themselves with several conflicting or locked systems.

Compliance – IoT, like any other technology in the realm of business, must comply with regulations. Its complexity makes the issue of compliance seem incredibly challenging when many consider standard software compliance a battle.

Industrial Internet (II)

- Internet of things, computers and people, machines all together make Industrial Internet.
- It enables industrial intelligent actions to use advanced data analytic tools for gettable business results.
- Autonomous cars, intelligent rail-road systems are applications of industrial internet.

Why IIoT Security Standards is required?

- Industries will need to use diverse systems and equipment but everything will be integrated on smart factory floor.
- Legacy systems must be brought under implementation.
- Every weak line in the chain puts whole factory at risk.
- Leaving security at the hands of individual IIoT implementers is dangerous.

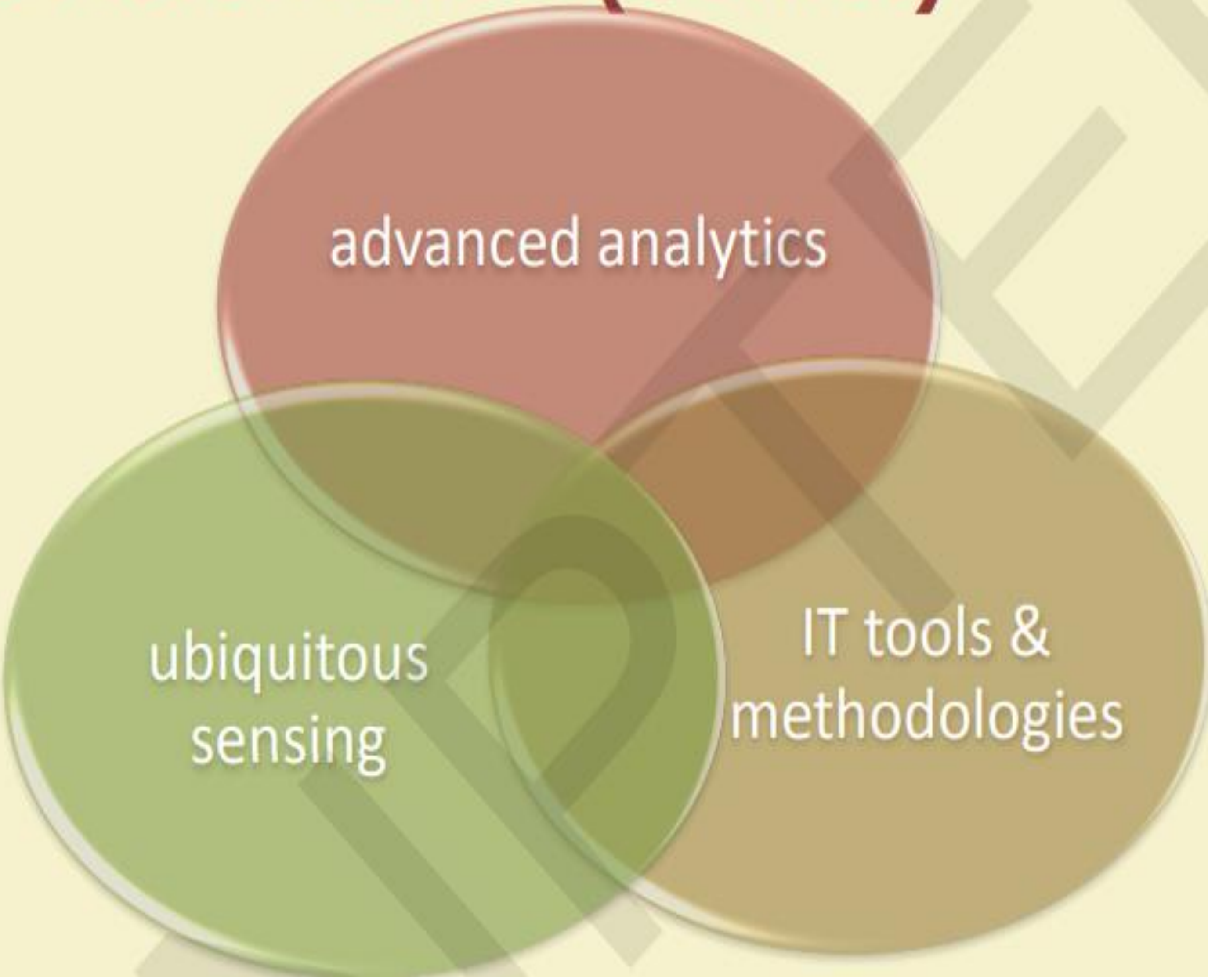
Industrial internet of Things (IIoT)

- Industrial internet of Things (IIoT) can be considered as a branch of Internet of Things (IoT)
- IIoT is the application of IoT in manufacturing and other industrial processes with the aim to enhance the working condition, increase machine life and optimize operational efficiency.

IIoT vs Automation

- There are three key differences between IIoT and Automation which have been deployed in industries for decades.
- They are:
  - ubiquitous sensing
  - advanced analytics, and
  - IT Tools andmethodologies

IIoT vs Automation (contd.)



- **Ubiquitous Sensing**

- ➢ In traditional automation, sensors and actuators are used to control critical elements (industrial machines, etc).
- ➢ In IIoT, sensors and actuators are used almost everywhere to control, enhance and optimize various functions.
  - ➢ E.g. To monitor machine health, to track various operations, emergency system etc.
- ➢ Ubiquitous Sensing enables Advanced Analytics

- **Advanced Analytics**

- ➢ The various data from array of deployed sensors and actuators can be exploited and extracted to decipher latent meanings using varieties of advanced analytic tools and algorithms.
- ➢ In IIoT, data much more and varied compared to traditional Automation.
- ➢ In IIoTadvanced analytics helps to enhance the working condition, increase machine life and optimize operational efficiency etc

- **IT methodologies**

- ➢ IIoT modifies the traditional automation techniques by exploiting IT technology.
- ➢ This modification gives three main benefits:
- Availability of talent pool
- Standardization
- Accessibility of already available IT hardware and software solutions

Challenges in IIoT

- The challenges in deployment of IIoT are
- **Data integration challenges:**
- Big data volume
  - Complex and different varieties of data from different sensors and actuators
  - Frequency of data generated by multiple devices
- Data integration is one of the main challenges
- Understanding the generated data for analysis and application in business is not an easy task

- **Cybersecurity :**
- Cybersecurity is one of the most essential elements of IIoT, because in IIoT all the devices are interconnected and these connected devices interact with the real world
- The two most important security concerns of IIoT are -
  - information security
  - data privacy protection
- Examples:
  - Healthcare Industries: Data integrity is highly essential in healthcare industries
  - Food Industries : Information that can harm the reputation of the company should be made confidential
  - Power Grid: Collapse of a power grip can give huge impact
  - National Transportation: National Transportation is like the veins of the nation. Making them secure is very crucial

Source: “Industrial Internet of Things, A high-level architecture discussion”

- **Lack of standardization:**
  - Large automation supplier firms do not encourage open standardization, as it will reduce the customer’s reliance on them
  - Small automation supplier firms lacks the capability to incentivize this huge step
  - It leads to different issues related to :
    - Device interoperability
    - Semantic interoperability (data semantics)
    - Security and privacy etc.
- **Legacy installations :**
  - Technology evolves fast
  - Coexistence of the fast evolving technology with legacy equipment is a huge complication

- **Lack of skills**
  - Limitation of workers with IIoT related skills, like data integration etc. because
    - The technologies associated with IIoT are new
    - Workers should have vast and diverse knowledge

Source: “Industrial Internet of Things, A high-level architectural discussion”

Applications of IIoT

- The key application areas of IIoT are –
- **Healthcare industry :**

- Availability of the information and reputations of doctors helps the patients to choose the right doctor
- Connectivity of healthcare devices to the internet helps in location each devices and also knows the status of the connected devices and the patients monitor by them
- Availability of healthcare data helps in advance healthcare researches

Source: “The Industrial Internet of Things (IIoT): the business guide to Industrial IoT”

- **Manufacturing industry:**
- ➢ The interconnection and integration of devices, equipment, workforce, supply chain, work platform comprises smart manufacturing
- ➢ This provides
  - ➢ reduction in operational costs
  - ➢ efficiency of the worker
  - ➢ Improved safety at the workplace
  - ➢ resource optimization and waste reduction
  - ➢ end-to-end automation

- **Transportation & logistics:**
- ➢ Easy monitoring of equipment, engines, tracks using the connected devices, deployed sensors, GPS etc.
- ➢ Analysis of data from devices will provide the information related to
  - ➢ maintenance
  - ➢ status and performance
  - ➢ optimum scheduling
- ➢ Optimum scheduling will
  - ➢ provide good customer services by reducing cancellation and delays
  - ➢ reduce fuel consumption
- ➢ Proper maintenance of the equipment will
  - ➢ provide better safety to both the on boarded passengers and machines
  - ➢ reduce maintenance expenses

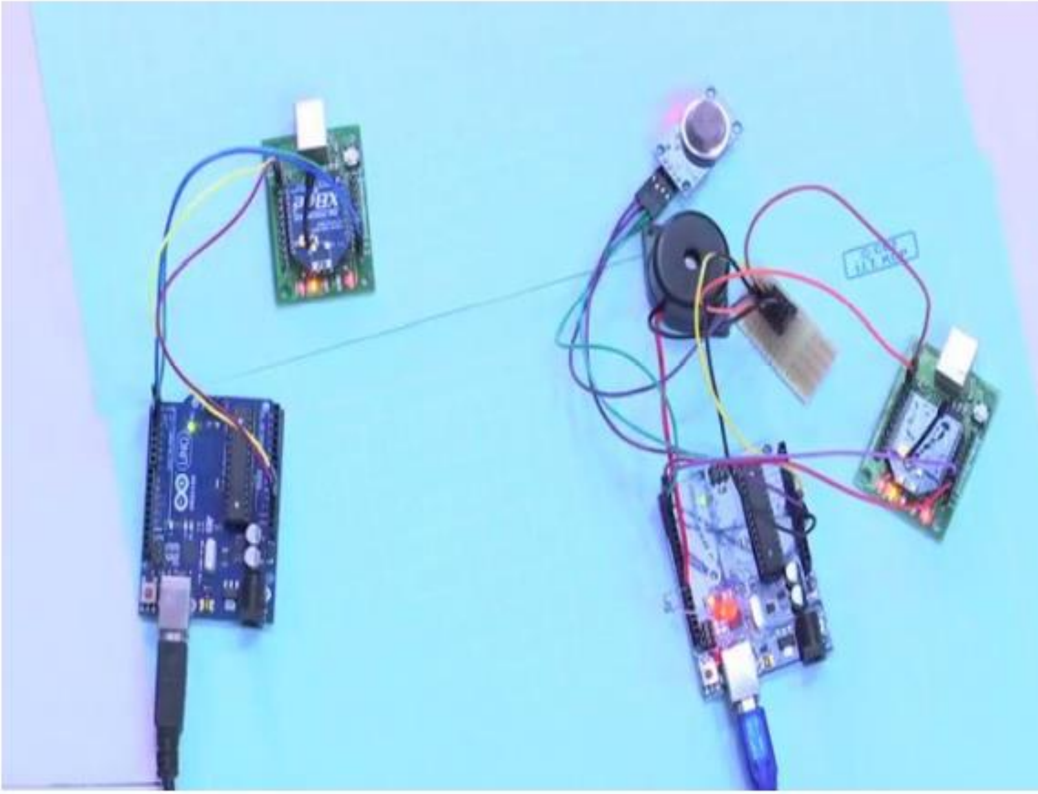
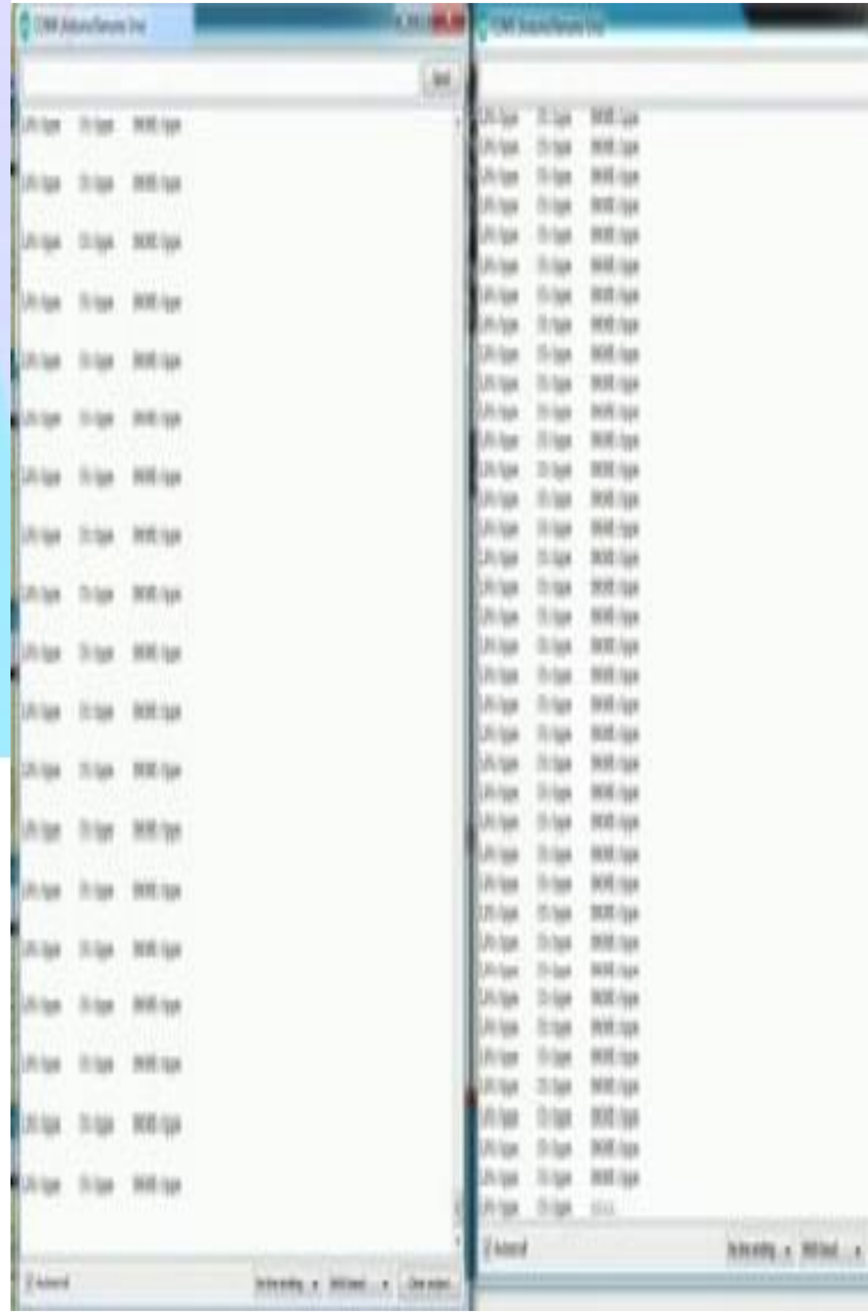
Benefits of IIoT

- Improves connectivity among devices
- Improves operational efficiency
- Improves productivity
- Optimizes asset utilization
- Creates new jobs and business opportunities
- Reduces operation time
- Remote diagnosis
- Cost effective
- Boost worker safety
- In depth knowledge of customer demand

Source: “The Industrial Internet of Things (IIoT): the business guide to Industrial IoT”

Mining industry:

- Sensor networks comprise of
  - different gas sensors for detecting oxygen, combustible gas like methane, poisonous gases etc.
  - strata monitoring device, rock mass deformation device to detect the internal structural condition of the mine
  - RFID tags for tracking miners
  - iWain-Fd other wireless networking module
- These will benefit in
  - early disaster warning
  - working condition of the miners
  - locating and monitoring miners
  - Safety and increasing efficiency

What is IIoT for Smart Manufacturing?

- IoT stands for Internet of Things which stands for a totally connected world and smart decision making
- In a connected world all the equipment will be connected to a central platform and / or to each other for data transfer and / or control
- It is estimated that 50 billion devices will be connected to the internet by 2020
- Devices such as (Smart Homes)

✓ Lights
✓ Ovens
✓ Refrigerators
✓ Air-conditioners
✓ CCTV Cameras
✓ Security Locks Etc.

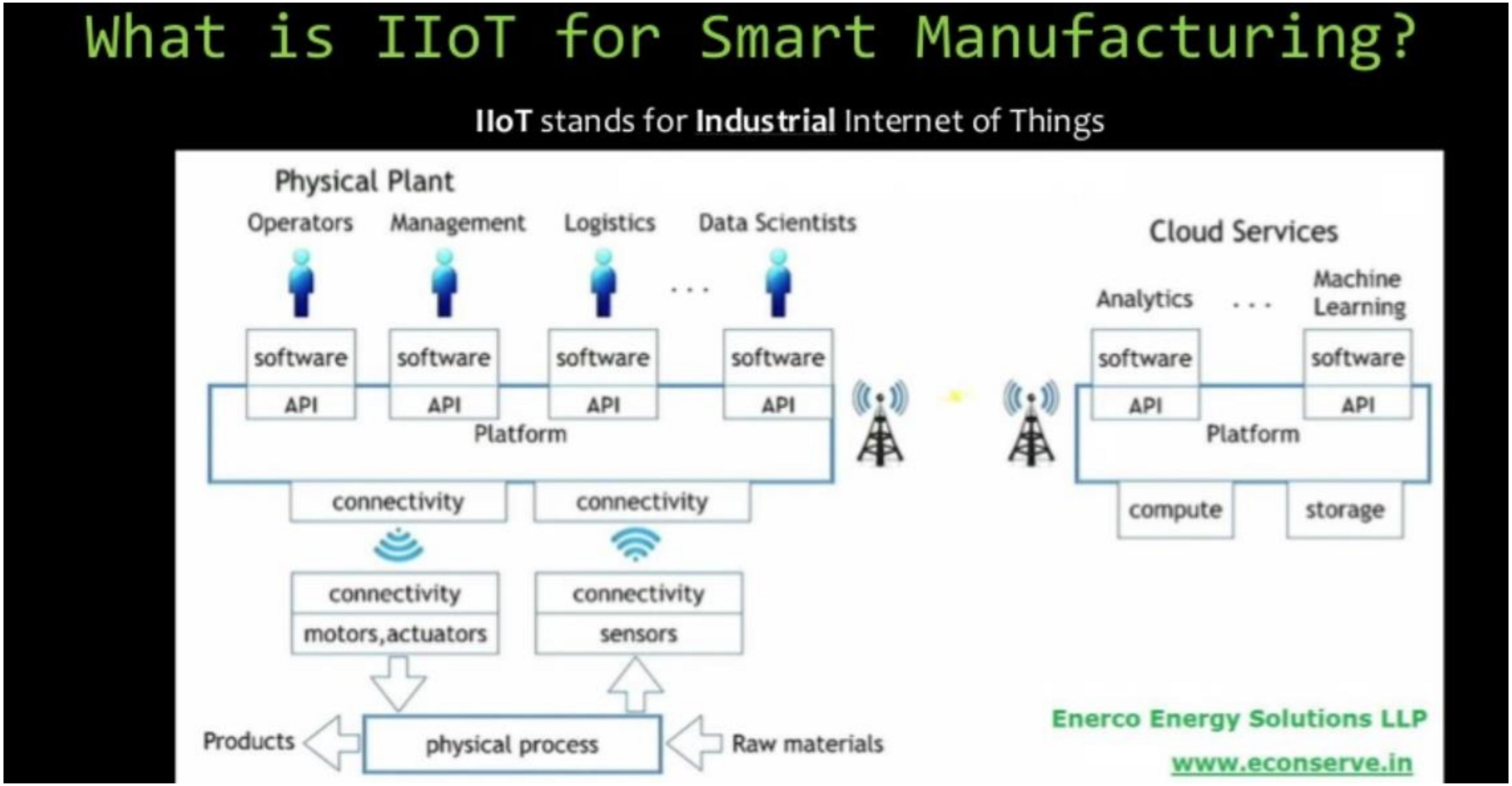
- Same principles are being extended to logistics and automobile industry (also a part of the overall umbrella of Industry 4.0)
- In fact some cars are already connected to their manufacturers, dealers and owners to ensure

✓ Safety -– accident reporting

✓ Security – tracking in logistics industry or kids tracking in school bus

✓ Comfort – remotely switching on Car AC before you start driving

✓ Efficiency – Fuel level monitoring in logistics Etc.


What is IIoT for Smart Manufacturing?
IIoT stands for Industrial Internet of Things
Physical Plant
Operators
Management
Logistics
Data Scientists
software
API
Platform
connectivity
connectivity
motors,actuators
sensors
physical process
Products
Raw materials
Cloud Services
Analytics
Machine Learning
compute
storage
Enerco Energy Solutions LLP
www.econserve.in

What is IIoT for Smart Manufacturing?

- So IIoT in manufacturing means
- All your plant equipment can talk to you by giving necessary data and by presenting insightful data for your action
- Your plant equipment can talk to each other and present insightful data points and ideas to improve your productivity
- An intelligent platform can help you with sound decision-making backed by data for important business decisions such as

✓ Resource Planning
✓ Production Planning
✓ Maintenance scheduling
✓ Market Cycles (recession, slowdown)
✓ Raw material ordering Etc.

- Smart Manufacturing in Industry 4.0 implies usage of
- ✓ Connectivity
- ✓ Data handling and processing
- ✓ AI (Artificial Intelligence) & ML (Machine Learning)
- ✓ Platform & App Access
- ✓ 24 x 7 Cloud Access
- ✓ Consists of top-down approach wherein IIoT can directly have a positive impact on the business

Transportation & logistics

- Easy monitoring of equipment, engines, tracks using the connected devices, deployed sensors, GPS etc.
- Analysis of data from devices will provide the information related to
  - maintenance
  - status and performance
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- Optimum scheduling will
  - provide good customer services by reducing cancellation and delays
  - reduce fuel consumption
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  - reduce maintenance expenses

Why smart and connected products?

- Connecting the physical objects.
- Sharing the data between physical objects.
- Increasing the resource efficiency.
- Increasing the productivity.

Source: "Industry 4.0:Managing The Digital Transformation", Springer.

Benefits of smart and connected products

- Faster.
- Cheaper.
- Better usage of product.
- Improved recall process of product.
- Decreased environmental impact.
- Smart supply chain.

Source: “Why Your Products Must be Smart and Connected ”, TCS.

Medium of getting smart and connected

- Embedded Systems.
- Cloud computing.
- Internet of things (IOT).
- Sensors.

Source: “Industry 4.0:Managing The Digital Transformation”, Springer.

Fundamental building blocks

- Customer values.
- Blueprint of profits.
- Key resources.
- Key processes.

What is smart factory?

- According to Deloitte University Press –

"The smart factory is a flexible system that can self-optimize performance across a broader network, self-adapt to and learn from new conditions in real or near-real time, and autonomously run entire production processes. "

Source : "The smart factory", Deloitte

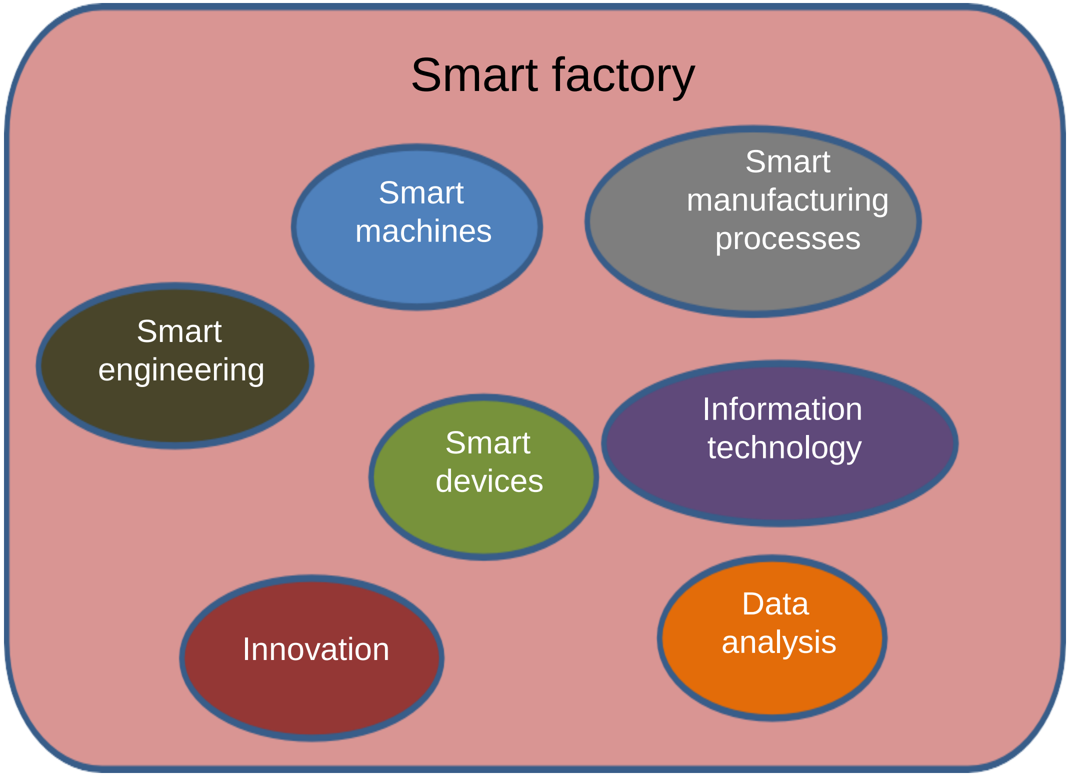
Why do we need smart factories?

- Evolution of technologies.
- High competitive market.
- High amount of production within minimum timeline.
- Reduce risk of failure.

Advantages of running smart factories

- Reducing cost.
- Increasing efficiency.
- Improving quality.
- Improving predictability.
- Improving safety.

Components of smart



Source: "Smart factories in Industry 4.0: A review of the concept and of energy management approached in production based on the Internet of Things paradigm. **",** IEEE ICIEEM.

Smart machines

- Communicate with other machines.
- Communicate with other smart devices.
- Communicate with humans.

Smart devices

- Connected with smart devices including
  - Field devices.
  - Mobile devices.
  - Operating devices.

Smart manufacturing process

- Dynamic.
- Automation.
- Real time.
- Efficient.

Smart engineering

- Smart design of product.
- Smart development of product.
- Smart planning.

Information technology

- Smart software application.
- Monitoring.
- Control.
- Smart management process.

Characteristics of smart factories

- Connection.
- Optimization
- Transparent.
- Proactivity.
- Agility.

Connection

- ➢ Connected smart devices.
- ➢ Connected smart machines.
- ➢ Connected with data.
- ➢ Connected processes.

Optimization

- ➢ Optimizing the task scheduling.
- ➢ Optimizing the use of energy.
- ➢ Optimizing the cost of production.
- ➢ Optimizing the tracking.
- ➢ Optimizing the throughput.
- ➢ Optimizing the reliability.

Transparent

- Real-Time monitoring
- Taking required action on time.
- Generating alert messages.
- Real-time tracking

Proactivity

- Predicting the quality issues.
- Improving safety.
- Forecasting the future outcomes.
- Predicting the future challenges

Agility

- Flexibility.
- Adaptation.
- Self-configuration

Supporting technologies for smart factories

- Big Data.
- Cloud computing.
- Smart grid.

Use of Cloud computing in smart factories

- Provides the capability of high-performance computing.
- Easy access for product designing software and tools.
- Easy access for present and past data for analyzing.
- Scalability provides freedom in terms of computing and data storage.

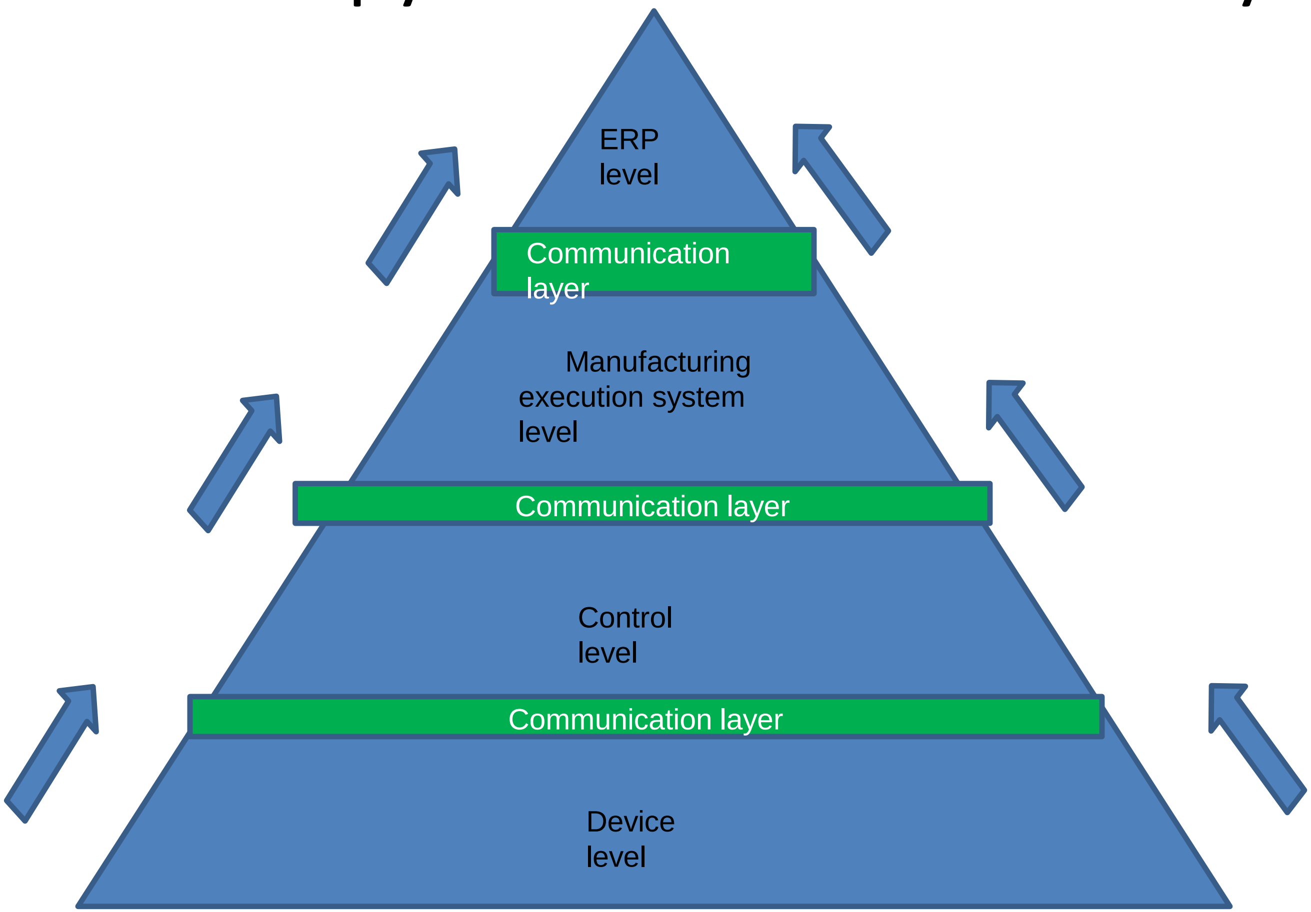
Use of Big Data analytics in smart factories

- Generating knowledge.
- Improving value streams.
- Future prediction.
- Key Performance Indicator (KPI).

Use of smart grid in smart factories

- Persistence in energy consumption.
- Load balancing.
- Reduction of energy consumption cost.
- Increase the life cycle of electronic equipment.

Automation pyramid of a smart factory

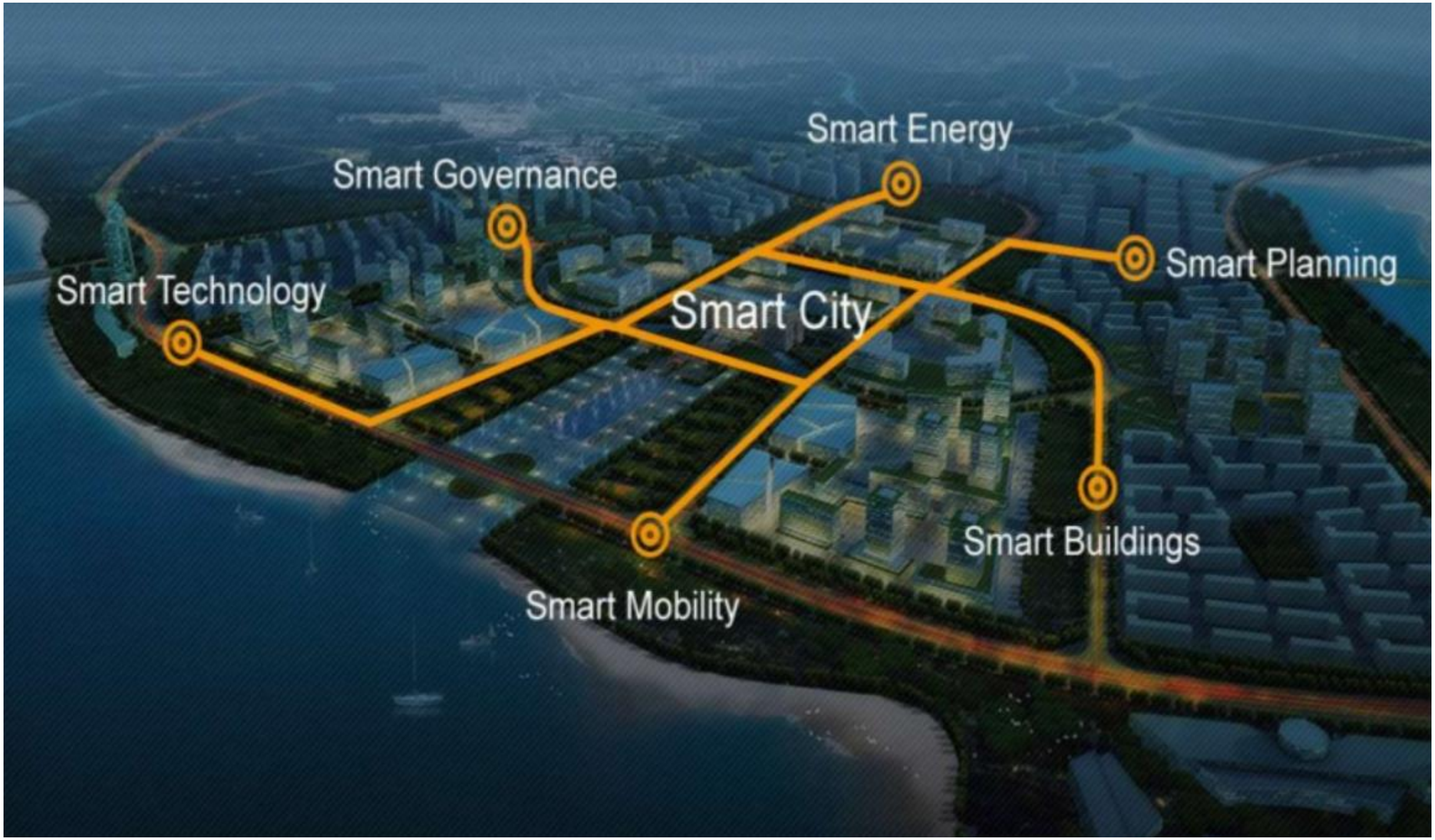


Source: **“**Towards a factory-of-things**”,**
ESLEVIER

Use of augmented reality in smart factories

- Operate instruments from remote.
- Providing precision.
- Providing safety especially for radio active zones.

Smart Cities



Smart Cities

- “A developed urban area that creates sustainable economic development and high quality of life by excelling in multiple key areas; economy, mobility, environment, people, living, and government. Excelling in these key areas can be done so through strong human capital, social capital, and/or ICT infrastructure”.

Introduction

- A Smart City is-
  - An urban system
  - Uses Information & Communication Technology (ICT)
  - Makes infrastructure more interactive, accessible and efficient.
- Need for Smart Cities arose due to-
  - Rapidly growing urban population
  - Fast depleting natural resources
  - Changes in environment and climate

Source: Pellicer, Soledad, et al. "A global perspective of smart cities: A survey." IEEE *Seventh International Conference on Innovative Mobile and Internet Services in Ubiquitous Computing (IMIS), 2013*.

Analogy

Humans	Smart Cities
Skeleton	Buildings, Industries, People
Skin	Transportation, Logistics
Organs	Hospital, Police, Banks, Schools
Brain	Ubiquitously embedded intelligence
Nerves	Digital telecommunication networks
Sensory Organs	Sensors, Tags
Cognition	Software

Some applications in this domain include the following:

- Traffic flow management system in combination with dynamic traffic light control
- Street light control
- Passenger information system for public transportation

City Automation Use Case 1: Traffic Flow Management System in Combination with Dynamic Traffic Light Control

- Thee flow of road traffic within cities depends on a number of factors
- such as the number of vehicles on the road,
- the time and the day,
- the current or expected weather,
- current traffic issues and accidents, as well as road construction work.
- Traffic flow sensors provide key traffic flow information to a central traffic flow management system;
- the traffic flow management system can develop a real time traffic optimization strategy and, thus, endeavor to control the traffic flow.
- The traffic control can be achieved by dynamic information displays informing the driver about traffic jams and congested roads traffic signs can direct the traffic to utilize less used roads.
- The traffic flow management system can also interact with controllable traffic lights to extend or to reduce the green light period to increase the vehicle throughput on heavy used roads dynamically changeable traffic signs can lead to an environment where the vehicular traffic is managed more efficiently, This enables cities to reduce fuel consumption, air pollution, congestions, and the time spent on the road.

City Automation Use Case 2: Street Light Control.

- Street lights are not required to shine at the same intensity to accomplish the intended safety goal.
- The intensity of light depend on conditions such as moonlight or weather.
- Adjusting the intensity helps to reduce the energy consumption and the expenditures incurred by a municipality.
- The street light controller of each street light segment is connected (often wirelessly) with the central street light managing and control system.
- The control system can dim the corresponding street lights of a segment remotely or is able to switch street lights on and off.

City Automation Use Case 3: Passenger Information System for Public Transportation

- Public transportation vehicles, such as busses, subways, and commuter trains, operate on a schedule that may be impacted by external variables and, thus, have a degree of variability compared with a baseline formal schedule.
- Passengers need to know when their next connection is available; this information also allows passengers to select alternative connections in the case of longer delays.
- In this application, the current locations of the various public transport vehicles are provided to the central system that is able to match the current location with the forecasted location at each time or at specific checkpoints also calculate the current delay and the expected arrival time at the upcoming stops.
- The vehicle current location can be tracked via GPS/general packet radio service (GPRS) tracking devices that provide the position information in regular intervals.

Current Focus Areas

- Smart Homes
  - Health monitoring.
  - Conservation of resources (e.g. electricity, water, fuel).
  - Security and safety.
- Smart Parking Lots
  - Auto routing of vehicles to empty slots.
  - Auto charging for services provided.
  - Detection of vacant slots in the parking lot.
- Smart Vehicles
  - Assistance to drivers during bad weather or low-visibility.
  - Detection of bad driving patterns or driving under the influence of substances.
  - Auto alert generation during crashes.
  - Self diagnostics.
- Smart Health
  - Low cost, portable, at-home medical diagnosis kits.
  - Remote check-ups and diagnosis.
  - On-body sensors for effortless and accurate health monitoring.
  - Auto alert generation in case of emergency medical episodes (e.g. Heart attacks, seizures).

Current Focus Areas (contd.)

- Pollution and Calamity Monitoring
  - Monitoring for weather or man-made based calamities.
  - Alert generation in case of above-threshold pollutants in the air or water.
  - Resource reallocation and rerouting of services in the event of calamities.
- Smart Energy
  - Smart metering systems.
  - Smart energy allocation and distribution system.
  - Incorporation of traditional and renewable sources of energy in the same grid.
- Smart Agriculture
  - Automatic detection of plant water stress.
  - Monitoring of crop health status.
  - Auto detection of crop infection.
  - Auto application of fertilizers and pesticides.
  - Scheduling harvesting and arranging proper transfer of harvests to warehouses or markets.

Application Focus Areas

Smart Economy

- Competitiveness

Smart Governance

- Citizen participation

Smart People

- Social and Human Capital

Smart Mobility

- Transport and ICT

Smart Environment

- Natural resources

Smart Living

- Quality of life

Source: Pellicer, Soledad, et al. "A global perspective of smart cities: A survey." IEEE *Seventh International Conference on Innovative Mobile and Internet Services in Ubiquitous Computing (IMIS), 2013*.

IoT Challenges in Smart Cities

- Security and Privacy
  - Exposure to attacks (e.g. cross-site scripting, side channel, etc.).
  - Exposure to vulnerabilities.
  - Multi-tenancy induces the risk of data leakage.
- Heterogeneity
  - Integration of varying hardware platforms and specifications.
  - Integration of different radio specifications.
  - Integration of various software platforms.
  - Accommodating varying user requirements.
- Reliability
  - Unreliable communication due to vehicle mobility.
  - Device failures still significant
- Large scale
  - Delay due to large scale deployments.
  - Delay due to mobility of deployed nodes.
  - Distribution of devices can affect monitoring tasks

Source: Arasteh, H., et al. "Iot-based smart cities: A survey." *IEEE 16th International Conference on Environment and Electrical Engineering (EEEIC), 2016*.

IoT Challenges in Smart Cities (contd.)

- Legal and Social aspects
  - Services based on user provided information may be subject to local or international laws.
  - Individual and informed consent required for using humans as data sources.
- Big data
  - Transfer, storage and maintenance of huge volumes of data is expensive.
  - Data cleaning and purification is time consuming.
  - Analytics on gigantic data volumes is processing intensive.
- Sensor Networks
  - Choice of appropriate sensors for individual sensing tasks is crucial.
  - Energy planning is crucial.
  - Device placement and network architecture is important for reliable end-to-end IoT implementation.
  - Communication medium and means play an important role in seamless function of IoT in smart cities.

Source: Arasteh, H., et al. "Iot-based smart cities: A survey." *IEEE 16th International Conference on Environment and Electrical Engineering (EEEIC), 2016*.

Big Data: Definition

- *"Big data will represent the data of which acquisition speed, data volume or data characterization restricts the capacity of using conventional associated methods to manage successful analysis or the data which can be successfully operated with important horizontal zoom technologies*."

  [NIST(National Institute of Standards and Technology)]

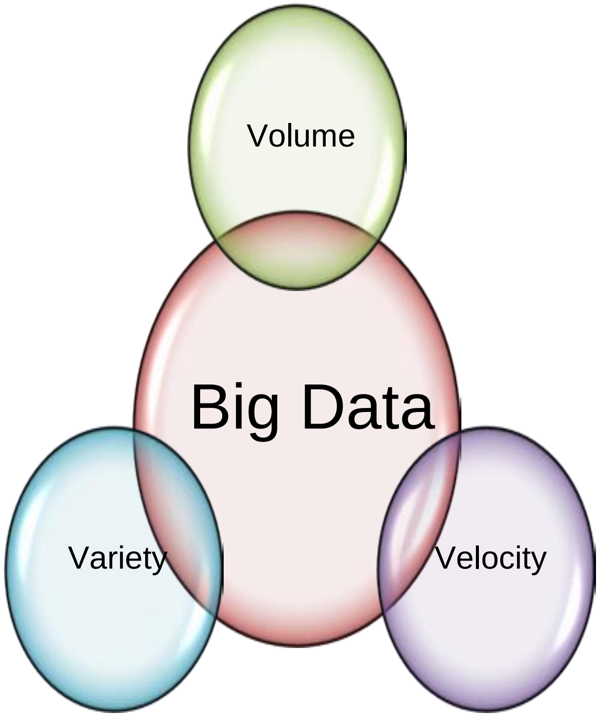
Source: cs.kent.edu: Big data

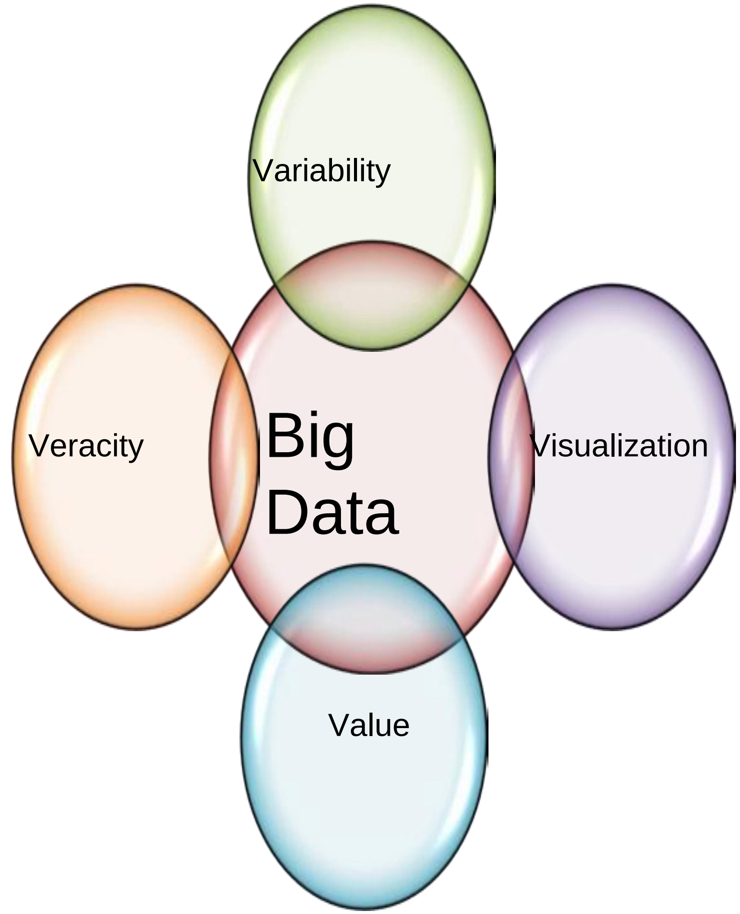
Data Types

- Structured data
  - Data that can be easily organized.
  - It is stored in relational databases.
  - It is managed by Structured Query Language (SQL) in databases.
  - It accounts for only 20% of the total available data today in the world.
- Unstructured data
  - Data that do not possess any pre-defined model.
  - Traditional RDBMSs are unable to process unstructured data.
  - Enhances the ability to provide better insight to huge datasets.
  - It accounts for 80% of the total data available today in the world.

Source: Big data analytics : Srinivasa

Characteristics of Big Data





- There are mainly 3 Vs in Big Data
- Some authors also include another 4 Vs

Source: Big data analytics : Srinivasa

Characteristics of Big Data

- Volume
  - Quantity of created data.
  - Sources of data are added continuously.
  - Example of *volume* -
    - More than 32TB of pictures will be created each night from the Large Synoptic Survey Telescope (LSST).
    - In every minute, 70 hours of video is uploaded to Youtube.

- Velocity
  - Speed of generation of data.
  - Data processing time is decreasing day by day to provide real-time services.
  - Older processing technologies can not help to handle high velocity of data.
  - Example of *velocity* –
    - 140 million tweets per day on average (according to a survey conducted in 2011)
    - NYSE(New York Stock Exchange) measures 1TB of exchange data during every exchanging session.

- Variety
  - Category of the data.
  - No restriction over the input data formats.
  - Mostly data are not structured.
  - Example of *variety* –
    - Pure text, images, audio, video, web, GPS data, sensor data, SMS, documents, PDFs, flash etc.

Source: Big data analytics : Srinivasa

Characteristics of Big Data (Contd.)

- Variability
  - Variability is different from variety.
  - Data whose meaning is constantly changing.
  - Such data appear as an indecipherable mass without structure.
  - Example:
    - Language processing, Hashtags, Geo-spatial data, Multimedia, Sensor events.

- Veracity
  - Veracity indicates biasness in the data, unusualness and noise in data.
  - It is important in programs which involve automated decision-making.
  - It is also important for feeding the data into an unsupervised machine learning algorithm.
- Veracity deals about the data understandability, not just the data quality

- Visualization
  - Data can be in form of pictures or in form of a graphical format.
  - Visualization provides the power to decision makers to see visually.
  - It is helpful to identify new patterns.
- Value
  - It means extracting useful business information from scattered data.
  - Simple to access and provides quality investigation that empowers informed decisions.

Source: Big data analytics : Srinivasa

Data Sources

Enterprise data

- Online trading & data analysis
- Production and inventory data
- Sales and other financial data

IoT data

- Industrial data
- Healthcare data
- Agricultural data

Source: The Making of ENCODE: Lessons for Big-Data Projects : Birney

Data Sources

Biomedical data

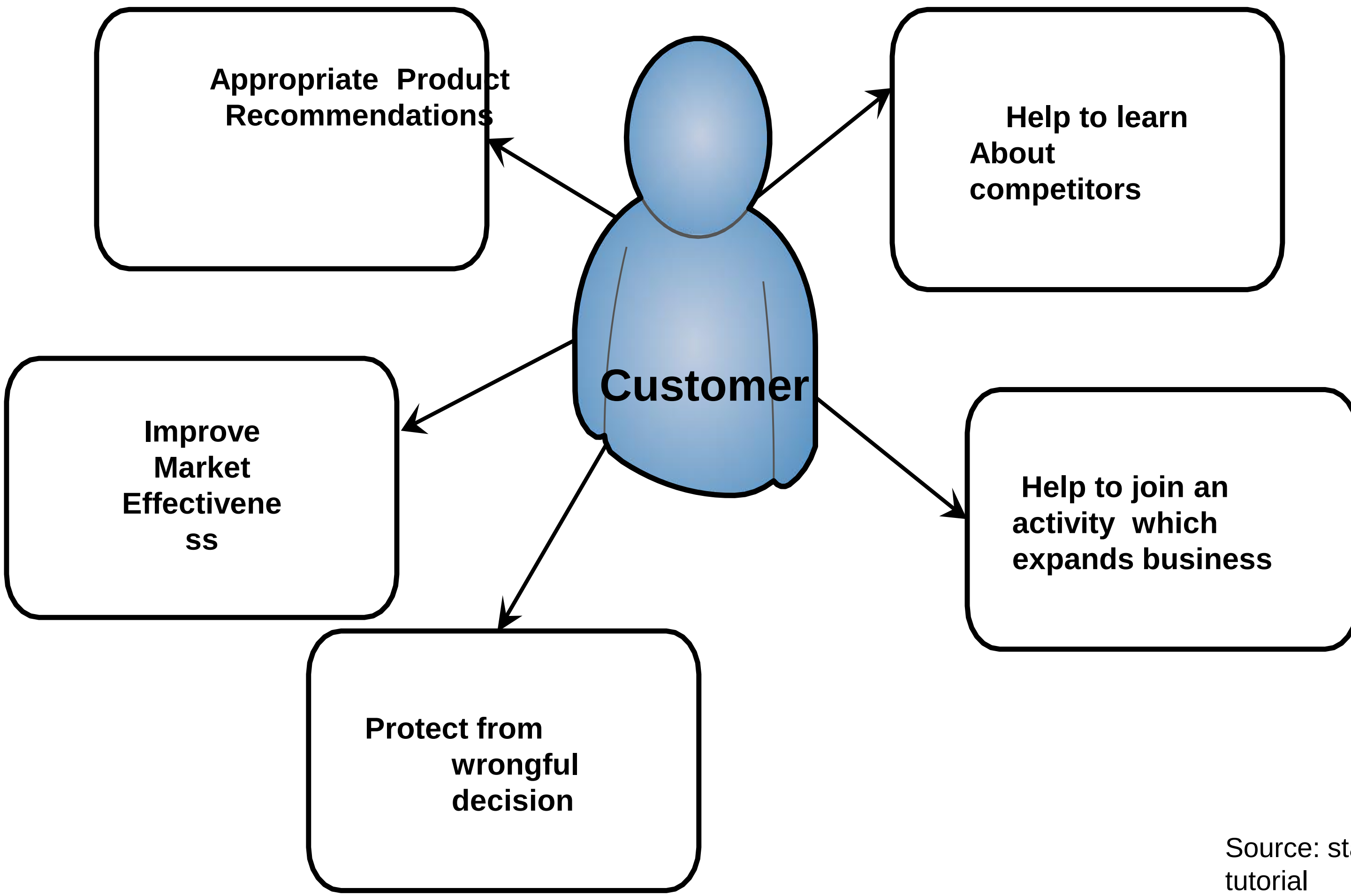
- Data generated from gene sequencing
- Data from medical clinics

Others

- Computational biology
- Astronomy
- Nuclear research

Source: The Making of ENCODE: Lessons for Big-Data Projects : Birney

Why Data Analytics?



Source: stat.si: Big data tutorial

Big Data Analytics

- Big data is different from conventional Data Warehouse (DW) approaches.
- Big data apps cannot be fit in traditional DW architectures (e.g. Exadata, Teradata).
- Distributed nothing, mighty parallel performing, scale out frameworks are convenient for big data apps.

Source: Industry 4.0:The Industrial Internet of Things: Gilchrist

Big Data Analytics for Industry 4.0

- Industrial Internet require an approach to manage and process data coming from thousand of sensors for precious perceptions .
- To manage and handle the huge data in health services and manufacturing etc. is not new. For example-
  - An event is detected by a sensor and sent to the operational recorder. An operational recorder is a database which stores data. After that this data is optimized by querying such as, what about this hour's production from the norm.

Source: Industry 4.0:The Industrial Internet of Things: Gilchrist

Big Data Analytics for Industry 4.0 (Contd.)

- IIOT can be recognized as a big benefactor of Big Data.
- It needs new technologies to manage vast data.
- Cloud services are accessible to handle Big Data with no-limit of storage on demand.
- In IIoT, Hadoop (open source cloud based distributed data storage) is also available for managing the data.

Source: Industry 4.0:The Industrial Internet of Things: Gilchrist

Cloud-Based Method for Analytics

- Essential features (according to NIST)
  - On demand selfservice
  - Wide network access
  - Method grouping
  - Fast flexibility
  - Measured service

Source: Industry 4.0:The Industrial Internet of Things: Gilchrist

Types of Analytics

Prescriptive Analytics

-> Best action?

-> Should we try this?

Predictive Analytics

->What next?

->Pattern?

Descriptive Analytics

->When, where?

->What happened?

Source: Industry 4.0:The Industrial Internet of Things: Gilchrist

HOW DOES IOT PREDICTIVE MAINTENANCE ACTUALLY WORK?

- here are several components that must exist for a industrial asset to be predictively maintained and therefore considered Industry 4.0.
- SENSORS
- The first step in any IoT enabled process is having high quality sensors that are streaming live data. Sensors will ideally be collecting a wide variety of metrics, without bias.
- DATA COMMUNICATION
- The next critical component is a secure systems by which data can flow between assets and the central data lake.
- CENTRAL DATA LAKE
- Creating a data lake that can act as a secure home for all source data is the next important step. It's irrelevant if this is on premise or cloud based, just that it's accessible by the programs that need it - including your predictive analysis software.
- PREDICTIVE ANALYTICS
- Powered by artificial intelligence for profound insight, machine learning algorithms will ingest, aggregate and synthesize data, with the ability to recognize complex patterns and generating detailed insights.
- TIME TO FAILURE AND ROOT CAUSE ANALYSIS PREDICTIONS
- Predictions are ideally in the form of a user friendly dashboard that provides time-to-failure and root cause analysis alerts and insights. Operational staff can quickly and easily identify and action preventative maintenance as and when required.
- INCREASED UPTIME
- Every company wants to remove the word 'downtime' from their vocabulary and their operations. With predictive maintenance you can eliminate unscheduled maintenance and instead plan for it with optimal material and staff resourcing, increasing productivity and profits.

THE FUTURE OF PREDICTIVE MAINTENANCE IN INDSUTRY 4.0?

- Predictive maintenance is already playing a key role in Industry 4.0. As machines get smarter and AI technology and platforms get more advanced, maintenance decisions will be increasingly left up to them to reduce the risk of human error and increase the chances of optimal performance.

  Data - the currency of our age - is already and will continue to usher in a new era of industrial operations, smart factories and revolutionised ways of working.

  As more and more companies recognize the value of implementing asset management software, we will only see a faster gallop towards the end of Industry 4.0 and the start of whatever comes next.

- **[What is the future impact of Industry 4.0 on Third-Party logistics (3PL) providers?]**
- Industry 4.0 has been partially defined by its use of machine-to-machine communication and Internet-of-Things (IoT) devices to create factories that operate like smart homes: an array of appliances and machines are brought into constant communication in order to create a cohesive, highly visible system. Logistics 4.0 operates under these same principles, but with a different set of component parts. Specifically, it makes use of “smart” containers, vehicles, pallets, and transport systems in order to create a fully networked supply stream that offers supply chain managers, shippers, freight forwarders, and others the necessary visibility to route transport and perform other logistics tasks in an optimal way. The concepts of Logistics 4.0 are becoming popular as logistics management evolves. Industry 4.0 impacts the corporate world through digitization both horizontal and vertical supply chains, products, services, business models, and customer relations.
- How much this will affect the Third-Party Logistics (3PL) providers?