CHAPTER 1

Module I

Introduction to IOT

Syllabus :

Introduction, History of IOT, Objects in IOT, Identifier in the IOT, Technologies in IOT.

1.1 Introduction

- In the 2000s, we are heading into a new era of ubiquity. Here the “users” of the Internet will be counted in billions. These humans may become the minority as generators and receivers of traffic. Instead, most of the traffic will flow between devices and all kinds of “things”, thereby creating a much wider and more complex Internet of Things.
- The Internet of Things is coming into view for all sectors such as technical, social, and economic significance. Small / big products / Consumer products, durable goods, engines, cars and trucks, industrial and utility components and also processes, various sensors are being integrated with Internet connectivity.
- Data is being captured and stored in the cloud where things objects are kept. Data analytic capabilities are being done using machine learning techniques to transform the way we work, live, and play. Projections for the impact of IoT on the Internet and economy are impressive.
- In 2015, Gartner for seed that in the year of 2020, 20 billion devices will join internet using IoT technology. Apart from IoT, 3D printing will also be there in boom. In Fig. 1.1.1, the different technologies are shown.

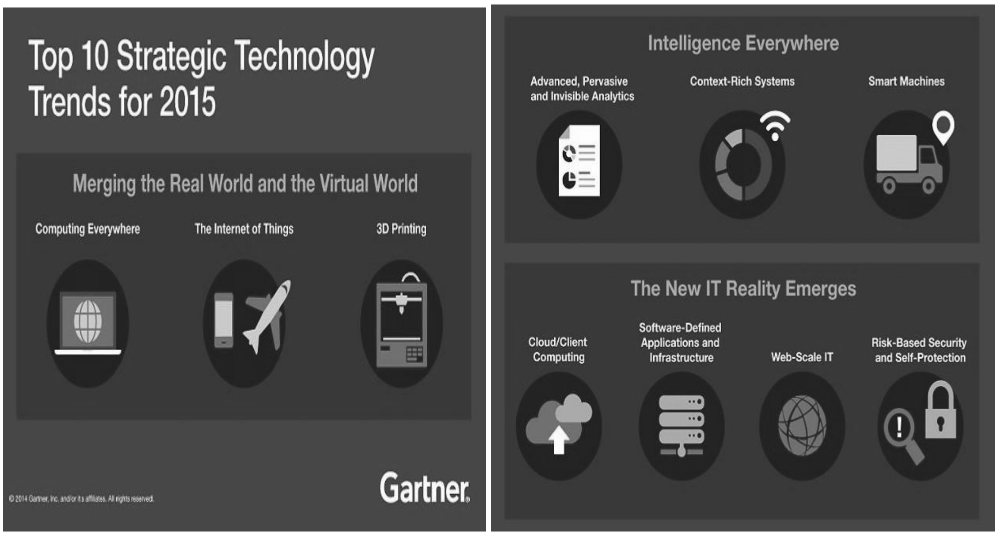

Fig. 1.1.1

- Now a day's are already living in digital world. People use cloud for storing his/her emails, usage of facebook, whatsapp like social media.
- So actually SMAC (Social, The growth of the Internet of Things continues unabated, and constant innovation in the field makes it difficult to anticipate exactly how it will evolve over time Mobility, Analytics and Cloud) is impacted to our life which is shown in Fig. 1.1.2.
- At the same time, however, the Internet of Things raises significant challenges that could stand in the way of realizing its potential benefits. Technical summons remain and new policy, legal and development challenges are emerging.

Fig. 1.1.2 : SMAC is impacted in digital transformation.

- In the actuality now, internet is present everywhere. This is just the link between people to people. In Internet of Things world, anything or everything is going to connect to anything and everything.

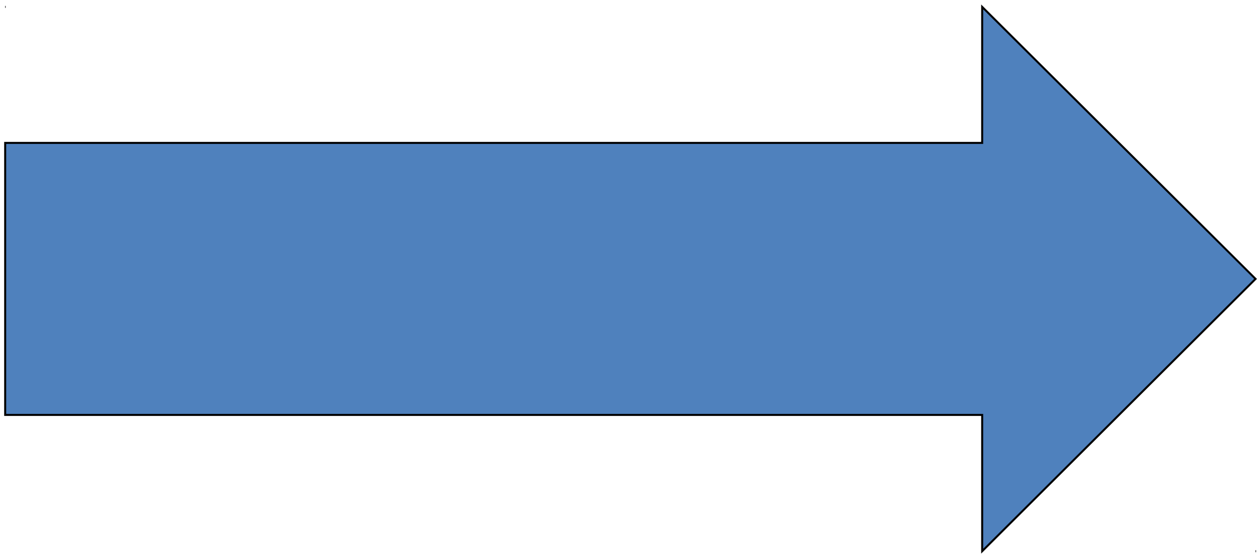

Fig. 1.1.3

- Internet is present everywhere in the world, but it is still a connection between people and people.

1.1.1 What is IoT ?

- Internet links people, so it is called "the Internet of People", And Internet of Things (IoT) links things so it is called "the Internet of Things".

Fig. 1.1.4 : IoT connects things

- IoT things for example, mobile is connected to internet, and bulb is connected to internet, Cow, Temperature monitor device connected to internet. Sensors are connected to these devices / living things whose working is to sense the parameters of the devices. Fig. 1.1.5 shows the various devices.

- Sensor is a device that detects and responds to some type of input from the physical environment. This specific input can be light, heat, motion, moisture, pressure, or any one of a other environmental event.
- This output is generally a signal that is converted to human-readable display on the sensor location or transmitted electronically over a network for reading or further processing.
- The opposite device is an actuator, which converts a signal (usually electrical) to some action, usually mechanical.
- A transducer is a device that converts energy from one form into another. Actuators and sensors are therefore forms of transducers.

Things

+

Sense & Communicat
e

Fig. 1.1.5 : Things + Sense and communicate

IOT Definitions are giving below :

- IOT refers to the interconnection of uniquely identifiable embedded computing-like devices within the existing internet infrastructure. Usually, IOT is expected to offer advanced connectivity of devices, systems, and services that goes beyond M2M. It covers a variety of protocols, domains & applications. The interconnection of these embedded devices (including smart objects), is expected to user in automation at almost all fields. Also, in enabling advanced applications like Smart Grids.
- Things, in IOT, can refer to a wide variety of devices such as heart monitoring implants, bio-chip transponders on farm animals, automobiles with built-in sensors, or field operation devices

that assist fire-fighters in search and rescue. Current market examples include smart thermostat systems and washer/dryers that utilize Wi-Fi for remote monitoring.

1.1.2 IOT Definition – A Different Overview

- Formally, a network of networks which enables to identify digital entities and physical objects whether they are inanimate (including plants) or animate (animals and human beings) directly and without ambiguity, via standardized electronic identification systems and wireless mobile devices, and thus make it possible to retrieve, store, transfer and process data relating to them, without discontinuity between the physical and virtual worlds" (Benghozi, Bureau, Massit-Follea, 2008)
- **Conceptually :** New identities for objects
- "Things have identities and virtual personalities operating in smart space using intelligent interface to connect and communicate within social, environmental, and user contexts" (working group Eposs).
- **Technically :** An extension of the Internet
- **New naming system** : A convergence of digital identifiers where it is possible to identify digital information (URL website addresses for instance) and physical elements (like a pallet in a warehouse, or a sheep in a herd) in a standardized way.
- **User Perspective :** A new space for innovative services

Economic Significance

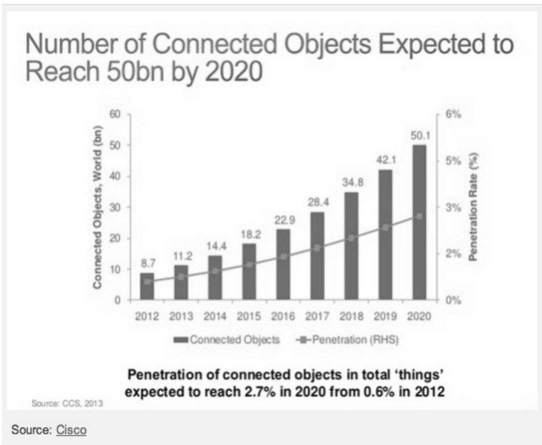

Fig. 1.1.6 : Some predictions of IoT future

- From Fig. 1.1.6 Cisco has predicted that by 2020 year, 50 billion devices will get connected to Internet. That is penetration of connected objects in total things are expected to reach 2.7% in the year 2020 from 0.6% in the year 2012. If we consider that in 2020 if 7 devices are being linked per person to internet.
- So depending the population of people on earth, it comes around 50 billion. At current moment maximum 3 devices per person (like mobile, laptop and computer) are connected to internet. The Fig. 1.1.7 shows some of the truth.

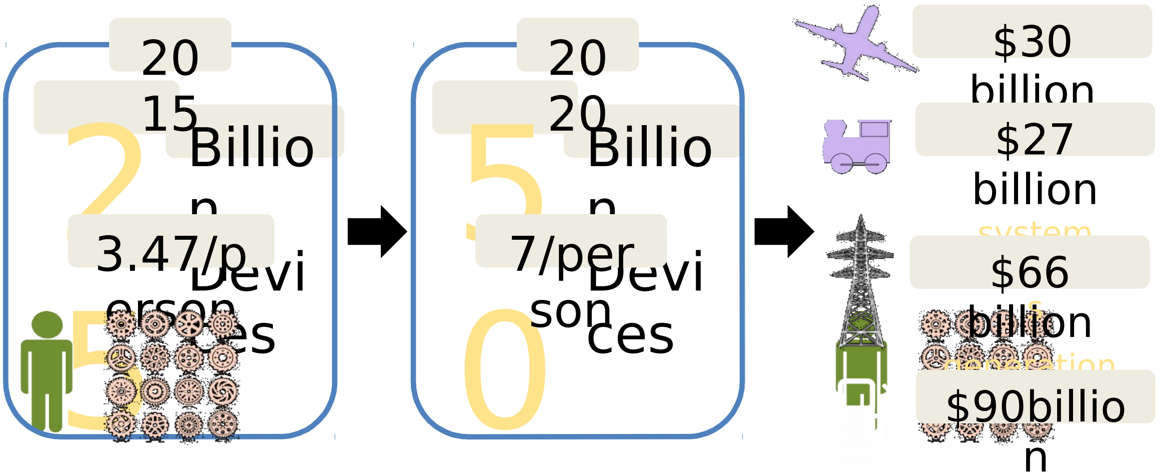

Fig. 1.1.7 : Some truth related to IOT future.

1.1.3 Flavours of Internet of Things

1. The Internet of flying stuff

- Linked "things" or objects that move above the earth's surface. The most recent move in developing the vision or the reality of the Internet of flying stuff was of course Amazon's revealed of its experimental Prime Air and its delivery drones.
- That this is not entirely pie in the sky or just a successful PR stunt by Amazon was made clear by the FAA's announcement on December 30 of the six public entities that will develop research and testing sites for commercial drones.
- Earlier in 2013, Google disclosed Project Loon, "balloon-powered Internet for everyone." It's Google's visions of expand the Internet to remote and rural areas.
- Adding a public sector dimension to this vision, the Brazilian government followed a few months later with its own version of a balloon-based Internet of flying stuff, Project Connect.

2. The Internet of moving stuff

- Linked "things" that move on and below the earth's surface. There came into view the interest in the potential benefits of connecting to underground systems, but the focus today is on the most visible moving things in our world: cars.
- The newly redesigned Ford Fusion has 74 sensors, including radar, sonar, cameras, accelerometers, temperature gauges and rain sensors, soon to substitute for drivers.
- By 2020, says Nissan's CEO Carlos Ghosn, mainstream automakers will offer driverless cars, to avoid being "disrupted" by Silicon Valley. Google has guided the endeavour to get drivers to use the Internet sooner than waste their time driving but it may now be enlarging the vision to include any autonomous moving thing.
- It recently acquired Boston Dynamics, a leader in mobile robots technology, and the eighth robotics company it has acquired in 2013.

- "Google is intent on building a new class of autonomous systems that might do anything from warehouse work to package delivery and even elder care," said The New York Times.
- In a statement that captures the essence of the Internet of moving stuff, Google's Andy Rubin told the Times — "computers are starting to germinate legs and move around in the environment"-promising that his Moonshot project will yield commercial products "in several years."
- One place to see mobile robots already in action, albeit indoors only, is Amazon's hand out centres, especially after it acquired Kiva Systems in 2012. Watch Kiva's Mick Mountz describes his robots "Highway Driving" in the warehouse - how long before they will move to real highways?

3. Internet of social stuff

- Linked content in context or making sense of the quintillions of bytes connected people create every day. Facebook recently announced the formation of a working group that will "use new approaches in AI to help make sense of all the content that people share so we can generate new insights about the world to answer people's questions."
- It then begin a partnership with New York University for a new center for artificial intelligence, headed by YannLeCun. Understanding context is what "search" is all about and of great interest to all members of the FAGA Four.
- In 2013, Apple bought Topsy, which "might have been appealing to Apple because of its expertise in searching and indexing the vast amounts of unstructured content that make up Twitter," says Rob Bailey, CEO of DataSift; Amazon acquired social reading site Goodreads; and, not to be outdone on its own turf, Google launched its "Knowledge Graph," show its growing understanding of the links between people, places, and things.

4. Internet of talking stuff

- Linking moving and stationary "things" that liaise. This is all about user interface and it is Apple's turf to lose. In its 1987 mother-of-all-vision-videos, the knowledge navigator, Apple showed—twenty-four years before it launched Siri—a tablet-based "personal assistant" conversing with the user, a text-to-speech system and a gesture-based interface.
- The aforementioned acquisition of Topsy was considered also as prospective uplift to Siri's search capabilities, but more to the point, "Apple has assembled a small team of notable names in speech technology and is looking to expand those efforts in the Boston area," according to Xconomy.
- The same report points to an Amazon R&D team whose mission is "to push the envelope in automatic speech recognition (ASR), natural language understanding (NLU), and audio signal processing." Google, for its part, continued to expand its capabilities in this area in 2013, e.g., recently extending voice search to PCs.

1.2 History of IOT

- The Internet of Things (IOT) has not been for very long. However, there have been visions of machines communicating with one another since the early 1800's. Machines have been providing direct communications since the telegraph (the first landline) was developed in the 1830s and 1840s.
- Described as "wireless telegraphy," the first radio voice transmission took place on June 3, 1900, providing another necessary component for developing Internet of Things. The development of computers began in the 1950s.
- The Internet, itself a significant component of the IOT, started out as part of DARPA (Defence Advanced Research Projects Agency) in 1962, and evolved into ARPANET in 1969. In the 1980s, commercial service providers began supporting public use of ARPANET, allowing it to evolve into our modern Internet.
- Global Positioning Satellites (GPS) became a reality in early 1993, with the Department of Defence providing a stable, highly functional system of 24 satellites. This was quickly followed by privately owned, commercial satellites being placed in orbit. Satellites and landlines provide basic communications for much of the IOT.
- One additional and important component in developing a functional IOT was IPV6's remarkably intelligent decision to increase address space. Steve Leibson, of the Computer History Museum, states, "The address space expansion means that we could assign an IPV6 address to every atom on the surface of the earth, and still have enough addresses left to do another 100 + earths."

1.2.1 Realizing the Concept

- Internet of Things, as a concept, wasn't officially named until 1999. One of the first examples of an Internet of Things is from the early 1980s, and was a Coca Cola machine, located at the Carnegie Melon University. Local programmers would connect by Internet to the refrigerated appliance, and check to see whether there was a drink available, and if it was cold, before making the trip.
- By the year 2013, Internet of Things had evolved into to a system using multiple technologies, ranging from Internet to wireless communication and from micro-electromechanical systems (MEMS) to embedded systems. The traditional fields of automation (including the automation of buildings and homes), wireless sensor networks, GPS, control systems, and other, all supports IOT.
- Simply stated that Internet of Things consists of any device with an on/off switch connected to the Internet. This includes almost anything you can think of, ranging from cell phones to building maintenance to the jet engine of an airplane. Medical devices, such as a heart monitor

implant or a biochip transponder in a farm animal, can transfer data over a network and are members the IOT.

- If it has an off/on switch, then it can, theoretically, be part of the system. The IOT consists of a gigantic network of internet connected "things" and devices.
- Ring, a doorbell that links to your smart phone, provides an excellent example of a recent addition to the Internet of Things. Ring signals you when the doorbell is pressed, and lets you see who it is and to speak with them.
- Kevin Ashton, the Executive Director of Auto-ID Labs at MIT, was the first to describe the Internet of Things, while making a presentation for Procter & Gamble. During his 1999 speech, Mr. Ashton stated:
- "Today computers, and, therefore, the Internet, are almost wholly dependent on human beings for information. Nearly all of the roughly 50 petabytes (a petabyte is 1,024 terabytes) of data available on the Internet were first captured and created by human beings by typing, pressing a record button, taking a digital picture or scanning a bar code.
- The problem is, people have limited time, attention, and accuracy. All of which means they are not very good at capturing data about things in the real world. If we had computers that knew everything there was to know about things, using data they gathered without any help from us, we would be able to track and count everything and greatly reduce waste, loss and cost. We would know when things needed replacing, repairing or recalling and whether they were fresh or past their best."
- Kevin Ashton believed Radio Frequency Identification (RFID) was a prerequisite for the Internet of Things. He concluded if all devices were "tagged," computers could manage, track, and inventory them. To some extent, the tagging of things has been achieved through technologies such as digital watermarking, barcodes, and QR codes. Inventory control is one of the more obvious advantages of the Internet of Things.

1.3 Objects in IOT

- The concept of smart in IOT is used for physical objects that are active, digital, networked, can operate to some extent autonomously, reconfigurable and has local control of the resources. The smart objects need energy, data storage, etc.
- A **smart object** is an object that enhances the interaction with other smart objects as well as with people also. The world of IoT is the network of interconnected heterogeneous objects (such as smart devices, smart objects, sensors, actuators, RFID, embedded computers, etc.) uniquely addressable and based on standard communication protocols.
- In day to day life, people have a lot of object with internet or wireless or wired connection. Such as :
  1. Smartphone
  2. Tablets

3. TV computer

- These objects can be interconnected among them and facilitate our daily life (smart home, smart cities) no matter the situation, localization, accessibility to a sensor, size, scenario or the risk of danger.
- Smart objects are utilized widely to transform the physical environment around us to digital world using Internet of things (IOT) technologies.
- A smart object carries blocks of application logic that make sense for their local situation and interact with human users. A smart object sense, log, and interpret the occurrence within themselves and the environment, and intercommunicate with each other and exchange information with people.
- Work of smart object has focused on technical aspects (such as software infrastructure, hardware platforms, etc.) and application scenarios. Application areas range from supply-chain management and enterprise applications (home and hospital) to healthcare and industrial workplace support. For human interface aspects of smart-object technologies are just beginning to receive attention from the environment.

1.4 Identifiers in IOT

- In any system of interacting components, identification of these components are needed in order to ensure the correct composition and operation of the system. This applies to all lifecycle phases of a system from development to assembly, commissioning, operations, maintenance and even end of life. Especially, in case of flexible and dynamic interactions between system components identification plays an important role. Identifiers are used to provide identification.
- In general an identifier is a pattern to uniquely identify a single entity (instance identifier) or a class of entities (i.e. type identifier) within a specific context.
- **Definition :** An identifier is a pattern to uniquely identify a single entity (instance identifier) or a class of entities (i.e. type identifier) within a specific context. Depending on the application and user need various types of identifiers are used. IOT is about interaction between things and users by electronic means. Both things and user have to be identified in order to establish such interaction. Various other entities are involved in the interaction and are part of an IOT system and identification is also relevant for them. Figure 1.4.1 shows the different entities with the related identifiers in the IOT Domain Model of the AIOTI WG03 High Level Architecture.
- Various identification schemes already exist, are standardized and deployed. This document :
  - Evaluates IoT identification needs;-
  - Classifies the different identification schemes;-
  - Evaluates and categorises related requirements;-

- Provides examples of identifier standards and elaborates their applicability for IoT ;
- Discusses allocation, registration resolution of identifiers;-
- Considers security and privacy issues;-
- And discusses interoperability of identifiers.

- This is done from a high level viewpoint. This document does not define or recommend specific solutions and standards, but provides examples and summaries in order to indicate what has to be taken into ac-count for identifiers in IOT.
- It should be noted that the document does not cover identity and identity management issues. An identifier is usually part of the identity of an entity, but many other topics are relevant for identities and are not discussed in the document. Specific coding technologies for identifiers like printed numbers, barcodes or Radio Frequency Identification (RFID) are also not evaluated in the document.
- Identifiers in Internet of Things (IoT) Version 1.0, February 2018
- All rights reserved, Alliance for Internet of Things Innovation (AIOTI). Specific coding technologies for identifiers like printed numbers, barcodes or Radio Frequency Identification (RFID) are also not evaluated in the document.

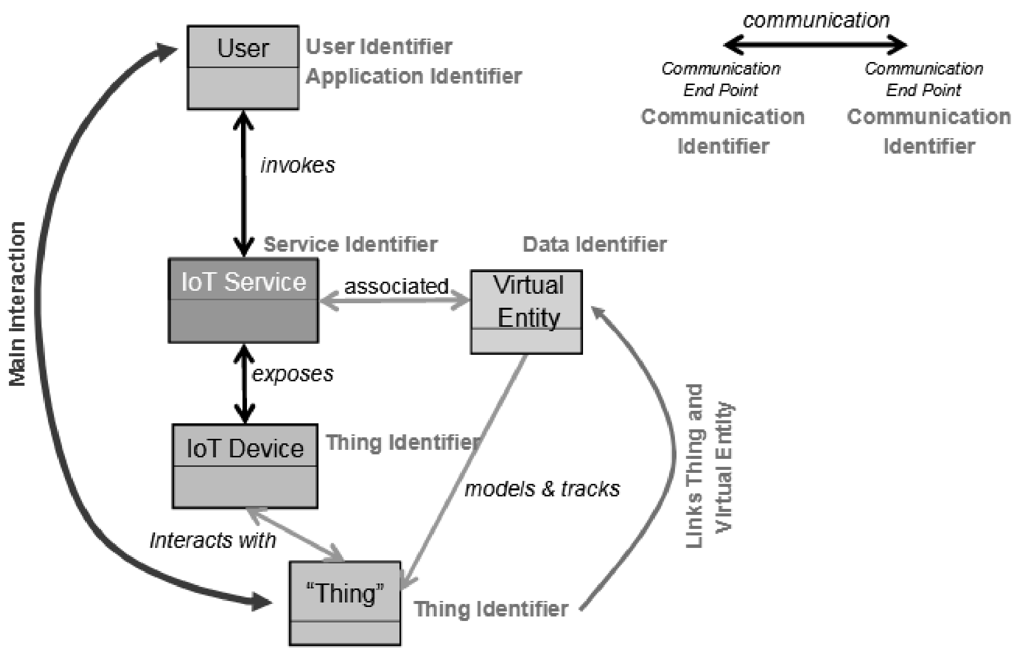

Fig. 1.4.1 : IoT Identifiers in the domain model of the AIOTI high level architecture

1.5 Classification of Identifiers

Identifiers are used for different purposes in IOT applications. Most prominent is the thing identifier which identifies the things, the entities of interest of an IOT application. Other relevant entities that are identified are applications and services, users, data, communication endpoints, protocols and locations. These classes are defined in more detailed in the following sections.

1.5.1 Thing Identifier

- Thing identifiers identify the entity of interest of the IOT application. This can be for example any physical object (e.g. machines, properties, humans, animals, plants) or digital data (e.g. files, data sets, metadata); basically anything that one can interact with.
- Examples for usage of Thing Identifiers :

Predictive Maintenance

- A company provides predictive maintenance services for products (e.g. electrical drives, production machines). The products have built in sensors and communication interfaces. The predictive maintenance service is running in the cloud.
- At the customer premises the product is securely connected (e.g. Virtual Private Network) to the maintenance service using for example the customer's network or a mobile network connection. The product has a thing identifier that is stored in its non-volatile memory and is referenced (logged) by the maintenance service in the cloud.

Asset tracking

A company keeps track of all its assets (large and small, stationery and moveable) by checking regularly where they are. All assets have a thing identifier which is a barcode or RFID tag with a unique identifier attached. They are regularly scanned by staff using a hand scanner that communicates with a server. With each scan status information about the asset can be provided via the scanner user interface.

Provenance and quality control of track and trace information

- The following example shows how important it is to clearly define the thing of interest. A freight and logistics company tags the goods it transports with RFID tags. These tags store the thing identifier of the good together with potentially other attributes of the good (e.g. manufacturer, date of manufacture, etc).
- The location of the good is recorded whenever the tag crosses a reading point. The tags might be reused at a later time for other goods with a different thing identifier. The tag also stores an identifier of the tag itself, which is used by the company to check provenance of the information, control quality of the tags, etc. For this application the tag itself is the thing of interest.

1.5.2 Application and Service Identifier

- Application and Service identifiers identify software applications and services. This also includes identifiers for methods on how to interact with the application or service (i.e. Application Programming Interfaces, Remote Procedure Calls)

- Examples for usage of Application and Service Identifiers:

IoT Platform Services

- An IoT platform provides various services like communication, application store, device management, and device registration. Each service has a unique identifier. Services can be registered in a registry so that applications can search for services. Services can also be announced to the applications. In a federated platform, where the same service (e.g. registration) might be provided by different (e.g. regional) software platforms, there might be several unique identifiers for the same type of service.

1.5.3 Communication Identifier

Communication identifiers identify communication (end) points (e.g. source, destination) and sessions.

1.5.4 User Identifier

User identifiers identify users of IoT applications and services. Users can be humans, parties (e.g. legal entities) or software applications that access and interact with the IoT application or service.

1.5.5 Data Identifier

This class covers both identification of specific data instances and data types (e.g. meta data, properties, classes).

Examples for usage of Data Identifiers :

Digital Twin

A digital twin is a data set containing the virtual representation of the thing. It is related to the thing based on the thing identifier.

1.5.6 Location Identifier

This class is about Identification of locations within a geographic area (e.g. geospatial coordinates, postal addresses, room numbers).

1.5.7 Protocol Identifier

Protocol identifiers inform for example communication protocols about the upper layer protocol they are transporting or applications about the protocol they have to use in order to establish a specific communication exchange.

1.6 Technologies in IOT

According to Jones, the top 10 emerging IOT technologies are :

1. **IOT Security :** Security technologies will be required to protect IOT devices and platforms from both information attacks and physical tampering, to encrypt their communications, and to address new challenges such as impersonating "things" or denial-of-sleep attacks that drain batteries. IOT security will be complicated by the fact that many "things" use simple processors and operating systems that may not support sophisticated security approaches.
2. **IoT Analytics :** IOT business models will exploit the information collected by "things" in many ways, which will demand new analytic tools and algorithms. As data volumes increase over the next five years, the needs of the IOT may diverge further from traditional analytics.
3. **IoT Device (Thing) Management :** Long-lived nontrivial "things" will require management and monitoring, including device monitoring, firmware and software updates, diagnostics, crash analysis and reporting, physical management, and security management. Tools must be capable of managing and monitoring thousands and perhaps even millions of devices.
4. **Low-Power, Short-Range IOT Networks :** Low-power, short-range networks will dominate wireless IOT connectivity through 2025, far outnumbering connections using wide-area IOT networks. However, commercial and technical trade-offs mean that many solutions will coexist, with no single dominant winner.
5. **Low-Power, Wide-Area Networks :** Traditional cellular networks don't deliver a good combination of technical features and operational cost for those IOT applications that need wide-area coverage combined with relatively low bandwidth, good battery life, low hardware and operating cost, and high connection density. Emerging standards such as narrowband IOT will likely dominate this space.
6. **IOT Processors :** The processors and architectures used by IOT devices define many of their capabilities, such as whether they are capable of strong security and encryption, power consumption, whether they are sophisticated enough to support an operating system, updatable firmware, and embedded device management agents. Understanding the implications of processor choices will demand deep technical skills.
7. **IOT Operating Systems :** Traditional operating systems such as Windows and iOS were not designed for IOT applications. They consume too much power, need fast processors, and in some cases, lack features such as guaranteed real-time response. They also have too large a memory footprint for small devices and may not support the chips that IoT developers use. Consequently, a wide range of IOT-specific operating systems has been developed to suit many different hardware footprints and feature needs.
8. **Event Stream Processing :** Some IOT applications will generate extremely high data rates that must be analyzed in real time. Systems creating tens of thousands of events per second are common, and millions of events per second can occur in some situations. To address such requirements, distributed stream computing platforms have emerged that can process very high-rate data streams and perform tasks such as real-time analytics and pattern identification.
9. **IOT Platforms :** IOT platforms bundle many of the infrastructure components of an IOT system into a single product. The services provided by such platforms fall into three main categories:
   1. Low-level device control and operations such as communications, device monitoring and management, security, and firmware updates;
   2. IOTdata acquisition, transformation and management;
   3. IOT application development, including event-driven logic, application programming, visualization, analytics and adapters to connect to enterprise systems.

10. **IOT Standards and Ecosystems :** Standards and their associated application programming interfaces (APIs) will be essential because IOT devices will need to interoperate and communicate, and many IOT business models will rely on sharing data between multiple devices and organizations. Many IoT ecosystems will emerge, and organizations creating products may have to develop variants to support multiple standards or ecosystems and be prepared to update products during their life span as the standards evolve and new standards and APIs emerge.