

# An Overview on IoT and its Applications

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## ABSTRACT

In computer science, IoT systems allow users to achieve deeper automation, analysis, and integration within a system. They improve the reach of these areas and their accuracy. IoT utilizes existing and emerging technology for sensing, networking, and robotics.

IoT exploits recent advances in software, falling hardware prices, and modern attitudes towards technology. Its new and advanced elements bring major changes in the delivery of products, goods, and services; and the social, economic, and political impact of those changes.

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## 1. Introduction

The Internet is a global system of interconnected computer networks that use the standard Internet protocol suite (TCP/IP) to serve billions of users across the world. It is a network of networks that consists of millions of private, public, academic, business, and government networks, of local to global scope, that are linked by a broad array of electronic, wireless and optical networking technologies [3]. Today more than 100 countries are linked into exchanges of data, news and opinions through Internet. According to Internet World Statistics, as of December 31, 2011 there was an estimated 2, 267, 233, 742 Internet users worldwide (Accessed data dated on 06/06/2013: from the Universal Resource Location <http://www.webopedia.com/TERM/I/Internet.html>). This signifies 32.7% of the world's total population is using Internet. Even Internet is going into space through Cisco's Internet Routing in Space (IRIS) program in the coming fourth years (Accessed on 10/05/2012: (<http://www.cisco.com/web/strategy/government/space-routing.html>)). While coming to the Things that can be any object or person which can be distinguishable by the real world. Everyday objects include not only electronic devices we encounter and use daily and technologically advanced products such as equipment and gadgets, but "things" that we do not do normally think of as electronic at all—such as food, clothing; and furniture; materials, parts and equipment, merchandise and specialized items; landmarks, monuments intelligence, connectivity, sensors, active engagement, and small and works of art and all the miscellany of commerce, culture device use. A brief review of these features is given below – and sophistication [4]. That means here things can be both living things like person, animals—cow, calf, dog, pigeons, rabbit etc., plants—mango tree, jasmine, banyan and so on and nonliving things like chair, fridge, tube light, curtain, plate etc. any home appliances or industry apparatus. So at this point, things are real objects in this physical or material world.

## 2. Evolution

An instance of exemplary projecting and merging of two worlds i.e Physical World with the Digital World is the Internet of Things (IoT). IoT is simply a event of an augmented world which aims at achieving ubiquitous computing. As expressed in the Black Swan Seminar Series on IOT, Internet of Things

apprehend the notion of "Connect Anywhere, Anytime with Anything". The term Internet of Things came into existence in 1999 by Kevin Ashton. IoT which was just an unachievable vision then, today is one of the technological trend and rigorous work on its effective implementation is in progress. Implementation of IoT has added a new way for smart cities, smart environment, smart water system etc and has overwhelming applications in logistics, security & emergencies. One such smart application is the IOT based Smart parking System which is implemented in the city of Santander, which is divided into 22 zones each and having its own network parameter resulting in independent sensor networks. Around 375 Waspnotes equipped with magnetic field sensors which are deployed in different locations which detects the change of magnetic field generated by car which is parked on it. This information is send periodically to the meshlium router and is displayed on panels every after 5 min to help citizens to find free parking space.

Nevertheless, failure of any one of the component of this system will lead to degrade in its performance as it will no longer deliver consistent service with its specification and would require human intervention to resolve it.

## 3. 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 –

3.1 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.

3.2 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.

3.3 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.

3.4 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.

3.5 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.

4. ITU Architecture

According to the recommendations of the International Telecommunication Union (ITU), the network, Architecture of Internet of Things consists of

- (a) The Sensing Layer
- (b) The Access Layer

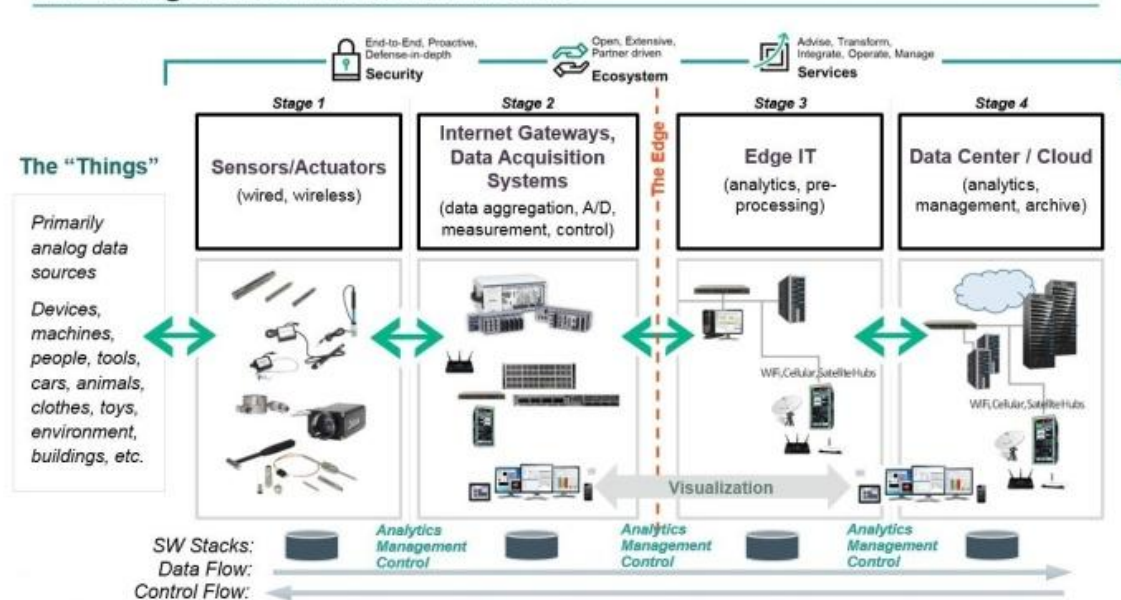
- (c) The Network Layer
- (d) The Middleware Layer
- (e) The Application Layers

These are like the Open Systems Interconnection (OSI) reference model in network and data communication.

4.1 The four-stage architecture of an IoT system

Stage 1 of an IoT architecture consists of your networked things, typically wireless sensors and actuators. Stage 2 includes sensor data aggregation systems and analog-to-digital data conversion. In Stage 3, edge IT systems perform preprocessing of the data before it moves on to the data center or cloud. Finally, in Stage 4, the data is analyzed, managed, and stored on traditional back-end data center systems. Clearly, the sensor/actuator state is the province of operations technology (OT) professionals. So is Stage 2. Stages 3 and 4 are typically controlled by IT, although the location of edge IT processing may be at a remote site or nearer to the data center. The dashed vertical line labeled "the edge" is the traditional demarcation between OT and IT responsibilities, although this is blurring. Here's a look at each in detail.

The 4 Stage IoT Solutions Architecture



Stage 1. Sensors/actuators  
Sensors collect data from the environment or object under measurement and turn it into useful data.

Stage 2. The Internet gateway  
The data from the sensors starts in analog form. That data needs to be aggregated and converted into digital streams for further processing downstream.

Stage 3. Edge IT  
Once IoT data has been digitized and aggregated, it's ready to cross into the realm of IT. However, the data may require further processing before it enters the data center.

Stage 4. The data center and cloud  
Data that needs more in-depth processing, and where feedback doesn't have to be immediate, gets forwarded to physical data center or cloud-based systems, where more powerful IT systems can analyze, manage, and securely store the data.

5. Technologies

The Internet of Things [15] was initially inspired by members of the RFID community, who referred to the possibility of discovering information about a tagged object by browsing an internet address or database entry that corresponds to a particular RFID or Near Field Communication [16] technologies. In the research paper "Research and

application on the smart home based on component technologies and Internet of Things”, the included key technologies of IoT are RFID, the sensor technology, nano technology and intelligence embedded technology. Among them, RFID is the foundation and networking core of the construction of Internet of Things[17]. The Internet of Things (IoT) enabled users to bring physical objects into the sphere of cyber world. This was made possible by different tagging technologies like NFC, RFID and 2D barcode which allowed physical objects to be identified and referred over the internet [18]. IoT, which is integrated with Sensor Technology and Radio Frequency Technology, is the ubiquitous network based on the omnipresent hardware resources of Internet, is the Internet contents objects together. It is also a new wave of IT industry since the application of computing fields, communication network and global roaming technology had been applied. It involves in addition to sophisticated technologies of computer and communication network outside, still including many new supporting technologies of Internet of Things, such as collecting Information Technology, Remote Communication Technology, Remote Information Transmission Technology, Sea Measures Information Intelligence Analyzes and Controlling Technology etc

### 5.1. Radio Frequency Identification (RFID)

Radio Frequency Identification (RFID) is a system that transmits the identity of an object or person wirelessly using radio waves in the form of a serial number [20]. First use of RFID device was happened in 2nd world war in Brittan and it is used for Identify of Friend or Foe in 1948. Later RFID technology is founded at Auto-ID center in MIT in the year 1999. RFID technology plays an important role in IoT for solving identification issues of objects around us in a cost effective manner [5]. The technology is classified into three categories based on the method of power supply provision in Tags: Active RFID, Passive RFID and Semi Passive RFID. The main components of RFID are tag, reader, antenna, access controller, software and server. It is more reliable, efficient, secured, inexpensive and accurate. RFID has an extensive range of wireless applications such as distribution, tracing, patient monitoring, military apps etc. [21].

### 5.2. Internet Protocol (IP)

Internet Protocol (IP) is the primary network protocol used on the Internet, developed in 1970s. IP is the principal communications protocol in the Internet protocol suite for relaying datagrams across network boundaries.

The two versions of Internet Protocol (IP) are in use: IPv4 and IPv6. Each version defines an IP address differently. Because of its prevalence, the generic term IP address typically still refers to the addresses defined by IPv4. There are five classes of available IP ranges in IPv4: Class A, Class B, Class C, Class D and Class E, while only A, B, and C are commonly used. The actual protocol provides for 4.3 billion IPv4 addresses while the IPv6 will significantly augment the availability to 85,000 trillion addresses [22]. IPv6 is the 21st century Internet Protocol. This supports around for 2<sup>128</sup> addresses.

### 5.3. Electronic Product Code (EPC)

Electronic Product Code (EPC) is a 64 bit or 98 bit code electronically recorded on an RFID tag and intended to design an improvement in the EPC barcode system. EPC code can store information about the type of EPC, unique serial number of product, its specifications, manufacturer information etc. EPC was developed by AutoID centre in MIT in 1999. EPCglobal Organisation [Wikipedia, “EPCglobal”, 2010] which is responsible for standardization of Electronic Product Code (EPC) technology, created EPCglobal Network [Wikipedia, “EPCglobal Network”, 2010] for sharing RFID information. It has four components namely Object Naming Service (ONS), EPC Discovery Service (EPCDS), EPC Information Services (EPCIS) and EPC Security Services (EPCSS).

### 5.4. Barcode

Barcode is just a different way of encoding numbers and letters by using combination of bars and spaces of varying width. Behind Bars [23] serves its original intent to be descriptive but is not critical. In The Bar Code Book, Palmer (1995) acknowledges that there are alternative methods of data entry techniques. Quick Response (QR) Codes the trademark for a type of matrix barcode first designed for the automotive industry in Japan. Bar codes are optical machine-readable labels attached to items that record information related to the item. Recently, the QR Code system has become popular outside the automotive industry due to its fast readability and greater storage capacity compared to standard. There are 3 types of barcodes of Alpha Numeric, Numeric and 2 Dimensional. Barcodes are designed to be machine readable. Usually they are read by laser scanners, they can also be read using a cameras.

### 5.5. Wireless Fidelity (Wi-Fi)

Wireless Fidelity (Wi-Fi) is a networking technology that allows computers and other devices to communicate over a wireless signal. Vic Hayes has been named as father of Wireless Fidelity. The precursor to Wi-Fi was invented in 1991 by NCR Corporation in Nieuwege in the Netherland. The first wireless products were brought on the market under the name WaveLAN with speeds of 1 Mbps to 2 Mbps. Today, there are nearly pervasive Wi-Fi that delivers the high speed Wireless Local Area Network (WLAN) connectivity to millions of offices, homes, and public locations such as hotels, cafes, and airports. The integration of Wi-Fi into notebooks, handhelds and Consumer Electronics (CE) devices has accelerated the adoption of Wi-Fi to the point where it is nearly a default in these devices [24]. Technology contains any type of WLAN product support any of the IEEE 802.11 together with dual-band, 802.11a, 802.11b, 802.11g and 802.11n. Nowadays entire cities are becoming Wi-Fi corridors through wireless APs.

### 5.6. Bluetooth

Bluetooth wireless technology is an inexpensive, short-range radio technology that eliminates the need for proprietary cabling between devices such as notebook PCs, handheld PCs, PDAs, cameras, and printers and effective range of 10 - 100 meters. And generally communicate at less than 1 Mbps and Bluetooth uses specification of IEEE

802.15.1 standard. At first in 1994 Ericson Mobile Communication company started project named

"Bluetooth". It is used for creation of Personal Area Networks (PAN). A set of Bluetooth devices sharing a common channel for communication is called Piconet. This Piconet is capable of 2 - 8 devices at a time for data sharing, and that data may be text, picture, video and sound. The Bluetooth Special Interest Group comprises more than 1000 companies with Intel, Cisco, HP, Aruba, Intel, Ericson, IBM, Motorola and Toshiba.

### 5.7. ZigBee

ZigBee is one of the protocols developed for enhancing the features of wireless sensor networks. ZigBee technology is created by the ZigBee Alliance which is founded in the year 2001. Characteristics of ZigBee are low cost, low data rate, relatively short transmission range, scalability, reliability, flexible protocol design. It is a low power wireless network protocol based on the IEEE 802.15.4 standard [25]. ZigBee has range of around 100 meters and a bandwidth of 250 kbps and the topologies that it works are star, cluster tree and mesh. It is widely used in home automation, digital agriculture, industrial controls, medical monitoring & power systems.

### 5.8. Near Field Communication (NFC)

Near Field Communication (NFC) is a set of short-range wireless technology at 13.56 MHz, typically requiring a distance of 4 cm. NFC technology makes life easier and more convenient for consumers around the world by making it simpler to make transactions, exchange digital content, and connect electronic devices with a touch. Allows intuitive initialization of wireless networks and NFC is complementary to Bluetooth and 802.11 with their long distance capabilities at a distance circa up to 10 cm. It also works in dirty environment, does not require line of sight, easy and simple connection method. It is first developed by Philips and Sony companies. Data exchange rate now days approximately 424 kbps. Power consumption during data reading in NFC is under 15ma

### 5.9. Actuators

An actuator is something that converts energy into motion, which means actuators drive motions into mechanical systems. It takes hydraulic fluid, electric current or some other source of power. Actuators can create a linearmotion, rotary motion or oscillatory motion. Cover short distances, typically up to 30 feet and generally communicate at less than 1 Mbps. Actuators typically are used in manufacturing or industrial applications. There are three types of actuators are (1) Electrical: ac and dc motors, stepper motors, solenoids (2) Hydraulic: use hydraulic fluid to actuate motion (3) Pneumatic: use compressed air to actuate motion. All these three types of actuators are very much in use today. Among these, electric actuators are the most commonly used type. Hydraulic and pneumatic systems allow for increased force and torque from smaller motor.

### 5.10. Wireless Sensor Networks (WSN)

A WSN is a wireless network consisting of spatially distributed autonomous devices using sensors to cooperatively

monitor physical or environmental conditions, such as temperature, sound, vibration, pressure, motion or pollutants, at different locations (Wikipedia). Formed by hundreds or thousands of nodes that communicate with each other and pass data along from one to another. A wireless sensor network is an important element in IoT paradigm. Sensor nodes may not have global ID because of the large amount of overhead and large number of sensors. WSN based on IoT has received remarkable attention in many areas, such as military, homeland security, healthcare, precision agriculture monitoring, manufacturing, habitat monitoring, forest fire and flood detection and so on [26]. Sensors mounted to a patient's body are monitoring the responses to the medication, so that doctors can measure the effects of the medicines [27].

## 6. Applications

### 6.1 Manufacturing Applications

#### 6.1.1 Intelligent Product Enhancements

Much like IoT in content delivery, IoT in manufacturing allows richer insight in real-time. This dramatically reduces the time and resources devoted to this one area, which traditionally requires heavy market research before, during, and well after the products hit the market. IoT also reduces the risks associated with launching new or modified products because it provides more reliable and detailed information. The information comes directly from market use and buyers rather than assorted sources of varied credibility.

### 6.2 Healthcare Applications

IoT systems applied to healthcare enhance existing technology, and the general practice of medicine. They expand the reach of professionals within a facility and far beyond it. They increase both the accuracy and size of medical data through diverse data collection from large sets of real-world cases. They also improve the precision of medical care delivery through more sophisticated integration of the healthcare system.

### 6.3 Transportation Applications

#### 6.3.1 Rails and Mass Transit

Current systems deliver sophisticated integration and performance, however, they employ older technology and approaches to MRT. The improvements brought by IoT deliver more complete control and monitoring. This results in better management of overall performance, maintenance issues, maintenance, and improvements. Mass transit options beyond standard MRT suffer from a lack of the integration necessary to transform them from an option to a dedicated service. IoT provides an inexpensive and advanced way to optimize performance and bring qualities of MRT to other transportation options like buses. This improves services and service delivery in the areas of scheduling, optimizing transport times, reliability, managing equipment issues, and responding to customer needs.

#### 6.3.2 Automobile

Many in the automotive industry envision a future for cars in which IoT technology makes cars "smart," attractive options equal to MRT. IoT offers few significant improvements to personal vehicles. Most benefits come from better control over

related infrastructure and the inherent flaws in automobile transport; however, IoT does improve personal vehicles as personal spaces. IoT brings the same improvements and customization to a vehicle as those in the home.

## 7. 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 –

7.1 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.

7.2 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.

7.3 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.

7.4 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.

## 8. Disadvantages

Though IoT delivers an impressive set of benefits, it also presents a significant set of challenges. Here is a list of some of its major issues –

8.1 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.

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

8.3 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.

8.4 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.

8.5 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.

## 9. Conclusion

The future of IoT is virtually unlimited due to advances in technology and consumers' desire to integrate devices such as smart phones with household machines. Wi-Fi has made it

possible to connect people and machines on land, in the air and at sea. It is critical that both companies and governments keep in ethics in mind as we approach the fourth Industrial Revolution (Pye, 2014). With so much data traveling from device to device, security in technology will be required to grow just as fast as connectivity in order to keep up with demands. Governments will undoubtedly face tough decisions as to how far the private sector is allowed to go in terms of robotics and information sharing. The possibilities are exciting, productivity will increase and amazing things will come by connecting the world.

## 10. Future scope

We are in the early days of another transformative technology revolution. Wired magazine described a new era where “the most mundane items in our lives can talk wirelessly among themselves, performing tasks on command, giving us data we've never had before.” The Internet of Things (IoT) is a world where up to 50 billion things (or devices) will be connected to the Internet by 2020; or, the equivalent of 6 devices for every person on the planet. We are already starting to see the emergence of smart cities, connected utilities, connected railways, connected factories, connected cars, and even connected mines, to name but a few. The Internet of Things will fundamentally transform businesses, generate enormous economic wealth and create immeasurable social value. What does the future have in store for IoT? The following are my ten predictions of what we have to look forward to:

The platform is the key to success – The “things” will get increasingly cheaper, applications will multiply and connectivity will cost pennies. The real value will be created in the horizontal platform that ties it all together – the new OS. This platform will be composed of 3 different layers: management, infrastructure, and data analytics and insights. The industry will look completely different than it does today – Like in the early days of the Internet, IoT is a greenfield market. New players, with new business models, approaches, and solutions can appear out of nowhere and overtake incumbents.

Business is the key market – While there is lots of talk about wearables and connected homes, the real value and immediate market for IoT is with businesses and enterprises. The adoption of IoT will be much more like the traditional IT diffusion model (businesses to consumers) than the Consumer-led adoption of social media and personal mobility. The “Connected Car” will be all about the car – There is currently a lot of hype about turning your car into a mobile entertainment center – music, video, social media and all of the apps that we currently enjoy on our smartphones. However, the real value and transformation is in connecting the car operations (e.g., service updates, advanced notifications of failures) and drastically improving safety (e.g., inter-car communications, semi-autonomous driving). These services will most likely be paid for by the manufacturer or through new, alternative business models, rather than directly by the driver. IoT will force business transformation – Businesses which connected to the Internet saw the real value when they re-designed their businesses models and processes for a connected world, and found new online products and services to offer. Some

companies immediately embraced the Dot-Com world, many had false starts and many others took a long time to jump on, or the revolution passed them by completely. The same will be true of IoT. Businesses need to develop strategies and plans for how they can leverage IoT to transform all aspects of their businesses and capture the real value of this revolutionary technology.

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