

# Internet of Things (IoT): Securing the Next Frontier in Connectivity

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**Abstract**— The paper highlights the impact of Internet of Things (IoT) on various sectors. It looks at sections ranging from healthcare, automotive, agriculture, industrial and consumer electronics. It also looks at the security concerns and cost of implementation. It concludes by stating why IoT is the inevitable future of technology.

**Keywords**— IoT, security, emerging economies, implementation.

## I. INTRODUCTION

The internet can perhaps be termed as the modern day equivalent of what fire was to the Stone Age man. As per industry sources, the internet has grown from a modest 16 million users in 1995 to an absolute behemoth with around 3.6 billion users, accounting for nearly 50 percent of the global population in 2016. In a little over two decades, as global internet penetration has skyrocketed—connecting even the remotest corners of the world—so also has been the proliferation of its myriad applications.

With the advent of wireless connectivity solutions, consumer goods manufacturers have jumped onto the bandwagon and offer a wide range of connected devices ranging from smart fitness trackers to connected home security systems. At the heart of all these devices that 'communicate' with each other is a rather inconspicuous, yet extremely powerful system called Internet of Things (IoT). These seemingly magical systems provide the proverbial breath of life to your otherwise inanimate devices and enable them to 'communicate' with the user.

Even Kevin Ashton—a British technologist and cofounder of Auto-ID at the Massachusetts Institute of Technology—who coined the term, might not have perceived the extent to which IoT is permeating into the very fabric of almost every industry under the sun. Market research firm Gartner estimates around 6.4 billion 'connected' devices were in use across the globe in 2016. To put things into perspective, that would mean a unique IoT connected system for roughly 86% of the global population. As incredibly impressive as these numbers may seem, the technology is still in the nascent stage. With rampant technological advancements, the technology is expected to gain major traction in the near future, with the market expected to be pegged at a whopping US\$ 150 billion by 2020.

### A. What is IoT?

IoT can be defined as a concept that enables transmission and reception of data packets to and from connected devices and/or components for diagnosis and/or analysis of a device/component. These smart devices are embedded with various sensors and actuators that transmit and receive data that can be processed on the main controlling unit and do not

need any human-to-human or human-to-computer interaction. In layman terms, this technology enables users to run diagnostic tests on connected devices and interact with the devices in real time in order to execute certain actions (SM, Biju and Alex, 2017).

IoT service providers now offer smart home solutions that enable users to monitor and control various aspects of the home such as lighting, security system and even kitchen devices such as refrigerators and washing machines. For instance, Philips Hue range of lights enables users to personalise and change light settings according to time of day and mood. Whirlpool offers a smart washing machine that can intimate users when it runs low on detergent. From the absurd to the practical, the many applications of IoT and its impact on our daily lives is rather profound, and it is only just the beginning.

### B. How did it get here?

The emergence of IoT is a result of the convergence of various technologies, most notably micro-electromechanical systems supported by proliferation of high speed broadband internet across the globe. Micro-electromechanical systems (MEMS) are devices that are fabricated using integrated circuit (IC) batch processing at the micro level. These systems are a unique combination of mechanical and electrical components that synergize to sense, control, and actuate at the micro level to influence functioning of systems at the macro level. MEMS are integrated in devices that find application in industries ranging from automotive to defence. Their seemingly endless applications across the length and breadth of industries is mainly attributed to the system being a culmination of designs and manufacturing techniques that incorporate expertise from areas of material sciences, mechanical engineering, electrical engineering, optics, fluid engineering, and optics, among various others. Some of the everyday examples of devices integrated with these systems are air bags, ink jet printheads, smartphones, optical switches, biosensors, to name a few. MEMS essentially function as the eyes and ears of IoT systems.

## II. MAJOR GROWTH DRIVERS FOR THE TECHNOLOGY

- Increasing penetration of low-cost high-speed broadband, especially in developed economies

- According to Goldman, Sachs & Co. (2014, September), cost of bandwidth decreased 40X over the last decade
- Advent of nanotechnology allows for development of smaller devices, in turn allowing for easier integration with other devices
- Smartphones serve as monitoring and primary input devices for IoT and thus, proliferation of smartphones argues well for market growth
  - Over 2.1 billion smartphone users in 2016 (Statista)
- Plummeting costs of internet-connected sensors allow for production of cost-effective IoT systems
  - Over 50% drop in prices of sensors, with average price plummeting to 60 cents from US\$ 1.30 over the last decade (Goldman Sachs, 2014)
- Rampant economic growth in emerging economies in Asia Pacific and Latin America and economic recovery in Europe and North America is in turn leading to higher discretionary income worldwide. This translates into higher spending power on high-end products such as IoT-integrated products.
- As per stats released by Forbes (2015), data generated over the last two years surpasses all data created since the evolution of man. Burgeoning growth in generation of big data, in turn requires smart solutions for effective analysis of data for effective decision making. IoT enables real-time monitoring and analysis of data.
- Advent of IPv6 is expected to provide IoT a very stable platform that is a touted to be future-ready to accommodate the projected 25 billion connected devices by 2020 (Cisco, 2011). More importantly, it allows for

end-to-end encryption that ensure secure communication between connected devices.

- Sensing the highly lucrative growth opportunities in the field, major software players are focusing on increasing investments in development of IoT solutions.
  - In January 2014, Google acquired Nest Labs—a provider of smart home solutions—for US\$ 3.2 billion
  - In March 2014, Intel acquired Basis Science—a manufacturer of smart devices—for around US\$ 100 million
  - In 2014, Electric Imp—an IoT cloud-platform provider—and Zuli—a manufacturer of smart plugs—collectively received funding of over US\$ 70 million
- In 2015, the Indian government set up a roadmap for development of 100 Smart Cities, which has since been increased to 109 cities across the country. The development of these connected cities would involve integration of IoT systems across various levels.

Unlike other new technologies that are rather disruptive, IoT can be integrated in most existing platforms with minor modifications, as opposed to a complete overhaul. Increasing research activities, especially in the field of nanotechnology are further expected to allow for a smooth transition from conventional systems to those integrated with IoT. Moreover, increasing number of players entering into the market is expected to create a highly conducive scenario for market growth and in turn, would drive prices down in the near future. IoT, in conjunction with various novel technologies is transforming various industries and resulting in high productivity and efficiency.

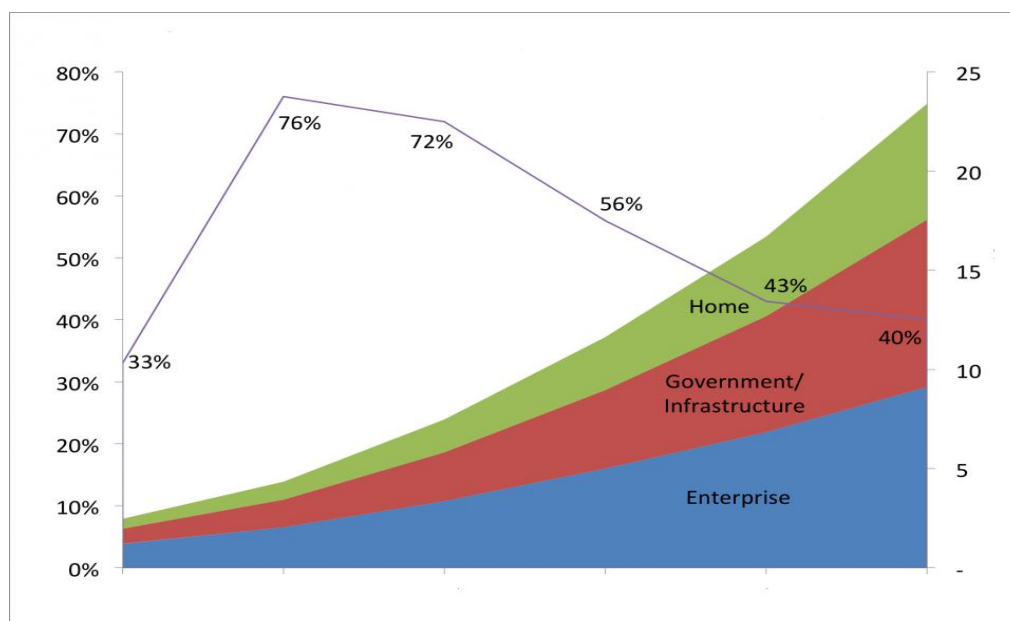


Figure 1. Usage of IoT in various sectors.

#### A. Agriculture

Burgeoning growth in population is projected to put additional burden on the already far stretched agricultural infrastructure worldwide, with a projected 70% increase in

production necessary to meet global demand by 2050. Unseasonal and insufficient rains are leading to frequent drought conditions, further aggravating the situation. Smart farming or precision farming helps alleviate the situation and

allows for efficient use of resources and also helps significantly improve crop yields. IoT helps track and store data related to soil-mapping, weather tracking, and fertilizer application, among other factors. This data is then analyzed and fed into a decision support system (DDS) that helps optimize various process to improve yield.

#### B. Automotive

Application of IoT is especially high in the automotive sector. Increasing consumer inclination towards high-end vehicles, implementation of stringent safety standards by various governments regarding automobile safety, and rising disposable income are factors that argue favourably for growth in integration of advanced features such as IoT in automobiles. As per a report by Gartner, over 250 million vehicles are expected to ply on roads across the globe by 2020. Driver assist technologies have been extensively used in the recent past, with automakers now focusing on development of autonomous cars and vehicles that can communicate amongst themselves as they ply on the roads to enhance safety. Google is deeply vested in development of Waymo—its version of smart self-driven cars, while Uber launched its self-driving car service in San Francisco in December 2016. Apart from this, a major application of IoT is in fleet management. Telematics enables real-time monitoring analysis of data related to the fleet, and helps ensure pre-emptive maintenance, improves efficiency across the supply chain logistics, monitors drivers, improves safety, and significantly reduces operational costs

#### C. Healthcare

Increasing prevalence of diseases and rapidly aging global population necessitate speedy and effective treatment options. While the incidence of various chronic diseases is increasing, the healthcare infrastructure across the globe has not been able to keep pace with it. The issue has further been amplified by a serious dearth of doctors. Remote patient monitoring offers a perfect solution to addressing this burning issues plaguing the global healthcare industry. These systems enable healthcare professionals to monitor real-time statistics of patients, without the need for constant monitoring in person. What makes this an even more effective tool is the fact that it can be deployed in a non-clinical setting, which in turn results in better results and lower healthcare costs as compared to conventional methods.

#### D. Industrial

The integration of automation has led to significant reduction in production time and improvement in efficiency across various industrial processes. This has further been complemented by integration of IoT to form smart factories. The highly scalable nature of the technology is rapidly witnessing its integration across the length and breadth of industries. Deployment of IoT in the telecommunications sector helps track cell towers in real time and allows for pre-emptive maintenance of machinery that drastically reduces downtime. Development of *smart grids* has led to virtually uninterrupted and highly efficient power supply with minimal wastage during transition. Mazak Corporation—an advanced solutions provider based in Japan—announced the launch of

the Mazak iSMART Factory concept in November 2014. The company's press release states, 'The Mazak iSMART Factory™ uses advanced manufacturing cells and systems together with full digital integration to achieve free-flow data sharing in terms of process control and operation monitoring. In the Mazak iSMART Factory™, the MTConnect® open communications protocol works with process support software and provides connectivity and the capability to monitor then harvest data from all the different production floor machines, cells, devices and processes.'

#### E. Consumer Electronics and FMCG

Smart homes are no longer restricted to the overzealous imagination of die-hard fans of Marvel Comics' Tony Stark and his alter ego Iron Man! In December 2016, Mark Zuckerberg unveiled his smart home, complete with his own iteration of Jarvis—an AI virtual assistant. The smart home handles most daily tasks such as setting reminders and making phone calls, and even prepares breakfast and even gets you suited up. While such an advanced and integrated IoT home is still a long way off, the market is teeming with various smaller products such as Philips Hue (smart lighting) and LG talking washing machine and refrigerator based on LG's HomeChat System give a feel of things to come. Popular rum brand, Malibu, too teased consumers in August 2016, by releasing 40,000 limited edition bottles that allowed consumers access to exclusive content on their smartphone by simply tapping the bottle with the device.

### III. RESTRAINTS

Much like any revolutionary technology, IoT is not without its limitations and a sizeable number of detractors. Here's looking at some of the pitfalls of the technology.

#### A. Security Concerns

IoT-enabled devices are connected on a network and allow users to interact with these wirelessly through a connected monitoring device such a smartphone. This convenience though, comes at a price, as it leaves these devices susceptible to being remotely hacked. There are various vulnerabilities in the security of such devices, which are actively exploited with malicious intent. One such major incident was a series of IoT Distributed Denial of Service (DDoS) attacks in the U.S. on October 21, 2016. While this caused major confusion and greatly affected internet connectivity in the country, it exposed the number of unsecured IoT devices and highlighted the urgent need to address these concerns. Manufacturers and software developers are increasing focusing on improving security features of connected devices, with various security patches being released periodically to ensure continued protection.

#### B. Cost of Implementation

One of the major factors that inhibits widespread adoption of IoT devices is their high costs. Though costs of sensors have decreased by as much as fifty percent since the turn of the century, most manufacturers of consumer goods position IoT-based products in the premium category, mainly to recover high costs involved in research and development.

However, with IoT becoming the mainstay in the industry and rampant competition in the market is expected to lead to major price wars that would in turn lead to significant drop in prices of IoT devices. Players across various industries now realize that the benefits offered by IoT far outweigh the initial capital investment involved in deployment of these devices.

#### C. Relatively Weak Internet Infrastructure in Emerging Economies

While there is no denying that the world has witnessed proliferation of the internet over the last decade, the internet infrastructure in most under developed nations such as China, India, and Brazil is still very much in the nascent stage of development. High speed connectivity being one of the key elements for integration of IoT, this pegs back integration of the technology in these regions. However, the scenario is expected to change drastically in the near future, with favourable government initiatives such as launch of Digital India initiative in 2015 and strong economic growth in these countries set to place these on the fast track towards integration of IoT. While North America is currently the largest market for IoT, Asia Pacific, spearheaded by India is expected to dislodge the region from its mantle over the following decade.

#### IV. CONCLUSION

It wouldn't be farfetched to say that we've only just uncovered the tip of the massive iceberg that IoT is, with its applications limited only by one's imagination. While consumer electronics seems like the obvious choice for implementation of IoT, its integration would serve more as a value added service than a breakthrough invention. IoT integration in healthcare and defence seem like the next frontier, which can potentially disrupt the very way in which these sectors function. A prototype of a revolutionary real-time glucose monitoring device that discreetly monitors glucose levels, uploads the data onto the cloud and as required injects insulin into the user's body via an attached insulin pump, without any human intervention at any stage is but just a glimpse of the revolution that is just breaking through the surface now. Monitoring of troops spread across vast regions and deployment of missiles autonomously on detection of a potential threat are some of the applications of IoT that are being tested in the field across various major armies across the globe. The future looks extremely promising for IoT, which would pretty much be a part of our daily lives ensuring just the perfect temperature for a peaceful sleep to monitoring our vital stats and taking precautionary measures to help avoid a medical emergency.

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