Internet of Things (IoT) : Is IoT a Disruptive Technology or a Disruptive Business Model?

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Abstract

The purpose of this paper was to describe how the newly emerging "Internet of Things" (IoT) will provide unprecedented opportunities to penetrate technology and automation into everything we do, and at the same time, provide a huge playing field for businesses to develop newer business models to capture market share. The information available on the Internet today is mostly constrained by the number of users generating the content. Internet users have grown from several thousand a few years ago to 2.8 billion in 2014 and is estimated to grow to 6.5 billion in 2020. Imagine a situation where we augment the effort of today's data collection method by using "Things with sense – called Sensors" to automatically collect, store, and analyze data. With the advancements in hardware, wireless networking, and cloud computing, this data can be stored, analyzed, and used. The number of sensors is projected to grow from 7 billion in 2014 to over 50 billion in 2020, with each person on earth carrying an average of seven devices. This explosion in the "things" used and subsequently, the data being collected will not only impact major service providers like semiconductor, networking, and device manufacturers, but will also redefine the current product offering and branding strategies. There will be a huge opportunity for businesses to provide a variety of customized products and services, the prominent ones being automobiles, healthcare, home control systems, environment protection, and manufacturing.

Keywords: **internet of things (IoT), sensors, gateway, cloud computing, consumers, disruptive, technology, business model, manufacturing, healthcare, automobile, home automation**

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In this year's budget, our Prime Minister, Shri Narendra Modi, has committed to enabling 100 "Smart Cities" in India. This massive promise, all encapsulated in two words, has reignited the push for automation and cloud computing, ultimately segueing in on the "Internet of Things" platform. Strangely, out of the three words, the seemingly naïve "things" here is the most revealing about the sheer magnitude of the task. All smart devices like mobile phones, tablets, electronic sensor devices come under this huge umbrella of "things". The objective would be to connect them like never before and exchange information between devices, networks, and possibly, sectors of business. This goal will push us to automate everything we do and reduce manual processing.

Information and communication technology plays a significant role in enabling quick data gathering, storing, predictive analysis, and initiating quick actions to improve the quality of living. Imagine a situation wherein you meet with an accident, the car dials an ambulance, and the hospital has all your vital statistics even before you are wheeled into the emergency-room (Bhandari, Kasturi, & Chopade, 2014). Think through how useful this data can be to the doctors in ensuring correct diagnosis. Also, consider situations where your smart refrigerator automatically orders the items needed to be replenished into your online shopping cart. You do not have to be concerned about missing out your favorite ice-cream while ordering your groceries. All these would be possible by

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putting some sense into the "things" and letting the things manage your requirements automatically, without any human intervention.

The Internet is a conglomeration of networks that is mostly used as a source of information today. Over the last 15 years, the number of Internet users has grown from a few thousands to 2.8 billion in 2014 (Wikipedia, Global Internet Usage, n.d.), with a projected growth of over 6.5 billion users in 2020 (Internet Stats Today, 2013). With increasing number of users getting hooked onto the web through a plethora of devices, nearly all of the information on the Internet today is generated and managed by human beings. The data gets stored in some servers and is made available to others through standard networking and security protocols. The amount and quality of data are constrained only by the bandwidth of the people using the Internet. At the same time, any error arising in the data is also only due to human interventions. What if we eliminate this "error" and let the *things* create and manage the data themselves? In a lighter vein, what if we could drill some sense into these devices? These devices can continuously monitor and capture data at frequent intervals, eliminating human errors. Large amount of data can then be collected and stored as a result of this automation.

Business Opportunities

The usage model with this new technology is limited only by our imagination. The increasing investment and usage of technology will create a spiraling need for innovative business offerings for both products and services. While the large players define the standards for IoT technology - like the manufacturers of sensors, gateways, and servers, the network providers plan on capitalizing their investments, the service providers - like cloud and data analytics - stand to gain a large market in IoT. IoT also offers other small and medium businesses opportunities in positioning their products and creating a constant revenue stream.

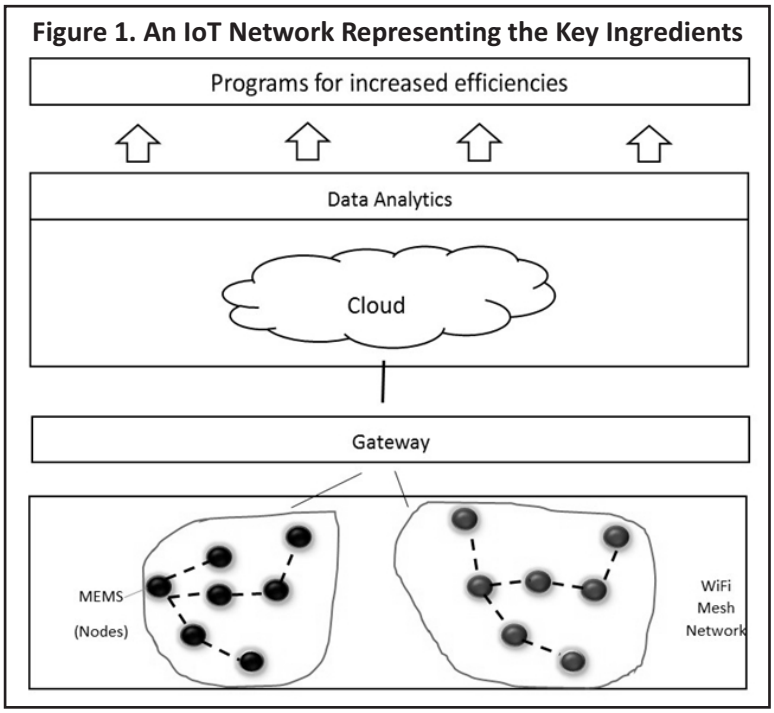
While everyone has an opening to develop a business opportunity in IoT, it is a challenge to define a niche for a particular business offering in this space. IoT is a conglomeration of various entities, and no single player can have a dominant position in this market. The key in IoT is collaboration. Several companies have to bring their products and services together and create unique market segments. For example, the car manufacturers who plan to place sensors in the car should partner with the sensor manufacturers, with the wireless providers for data transmission, with cloud for data storage and analysis, and with all their service partners for fixing issues in the car. The model should encapsulate pricing, revenue sharing, and should clearly define the responsibilities of each provider in this partnership.

In this paper, we will briefly describe what Internet of Things (IoT) means, and compare and contrast IoT as a disruptive technology and/or a disruptive business model.

What is Internet of Things (IoT) ?

Kevin Ashton in 2009 (Wikipedia, Internet of Things) first coined the term Internet of Things (IoT). His idea was to connect every *thing* to the Internet and put some sense into the things to gather, store, transmit, and understand data. Depending upon the consumer's choice, the *thing* can also perform certain pre-determined actions.

Let us take an example of a real-time implementation of IoT. Silver Spring Networks (Silver Spring Networks, 2014) headquartered in California provides advanced metering infrastructure, whereby they have connected several million customers by a grid, which enables automatic meter reading and fault detection. The automated meter reading system also helps the company to offer various service plans to customers. The meters themselves act as "things" with in-built sensors to collect and transmit the data. The meters are connected to each other in a WiFi mesh network topology, and the data of several meters at once is loaded into the cloud through a gateway. Silver Spring Networks provides the data to utility providers to track and monitor usage.



IoT Components

IoT in itself consists of a set of smart "things" called nodes. These nodes, also called MEMS (micro-electro mechanical systems) are low power computing devices that can collect the data. The MEMS themselves are connected in a WiFi mesh network. The network is dynamic, allowing sensors to get in and out of the network at any time. The collective data within the network is then transmitted to a "gateway" or a "router". A gateway is a computing device which is connected to the Internet (or Cloud).

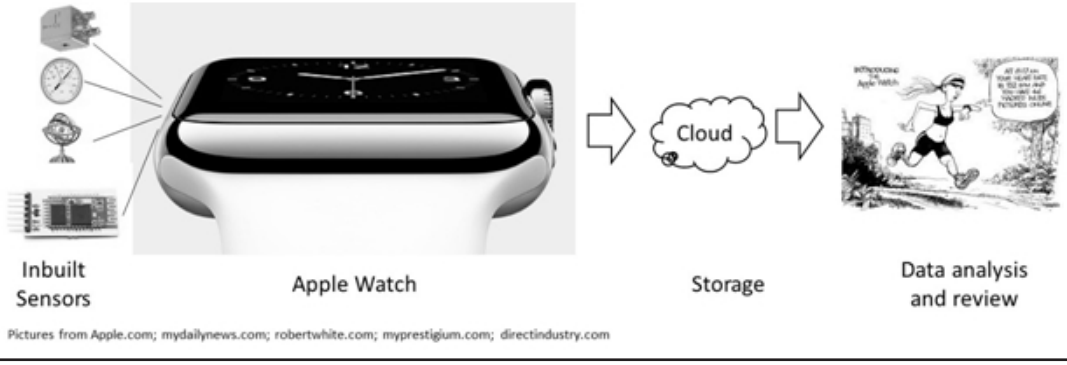
The Figure 1 is a schematic representation of IoT components. The data that is collected in the cloud is used for data analysis. Companies offer various services to their clients based on the data collected and analyzed. For example, if IoT is used to collect the heart rate periodically, the system can automatically call an ambulance if the heart rate goes below the normal acceptable thresholds.

In our example of a car accident, the sensor mounted in the car will collect the crash statistics, and upon determining that it is a crash, dials a specified number for ambulance (Raymond James and Associates, 2014). The sensors mounted on the passengers will continue to collect critical data of their health. This data is transmitted to the cloud. The sensors continue to send data to the cloud through the ambulance network during transit. As the patients are wheeled into the emergency room, the data is already available to the doctors. This availability of the data helps to improve the accuracy of the diagnostics and also the number of patients attended to in a given time.

Is IoT a Disruptive Technology ?

↳ **The Technology Already Exists :** The technology and concept of IoT have been in existence for over 10 years. RFIDs connected to a wireless network are already being used in manufacturing plants, inventory tracking, and warehouse management (Girish, 2012). These RFIDs are wireless devices, which can continuously send the location data, helping track the movement of goods in a plant or a warehouse. The data from RFIDs are stored and analyzed for optimizing the plant inventories, reduce wastage or loss, and increase workflow efficiencies. However, the technology was limited to specific segments. Sensors were custom-built for requirements. Privately

Figure 2. Apple Watch Containing Various Sensors Used for Health and Fitness Monitoring



owned networks and warehousing equipment required large-scale investments and were not easily reproducible. The entire implementation was custom designed and was not scalable across other units.

↳ **Why is IoT a Disruptive Technology? :** Disruptive technologies have a significant impact on our lifestyles, increase the quality of living, and redefine the way we live and work. Manyika, Chui, Bughin, Dobbs, Bisson, and Marrs (2013) listed 12 technologies that will significantly impact our lives, one of them being IoT. IoT is discussed as a change catalyst that will be used significantly in everything we do. Remote monitoring and data collection & control will have a huge impact across various segments, including healthcare, manufacturing, electricity, urban infrastructure, security, resource extraction, agriculture, retail, vehicles, and will help increase retail sales.

Increased use of connected sensors to collect data and store them in centralized servers will also drive additional business models and create a plethora of service offerings to customers. This, in turn, will drive new technologies and concepts to enrich people's lives. Large technology houses who have realized the importance of IoT are encouraging promising start-ups from within to infuse fresh ideas to accelerate disruptive technology penetration.

A case in point being the recent announcement of Apple Watch by Apple Inc. introducing a wearable watch with several embedded sensors. The Figure 2 illustrates the collective usage of an Apple Watch. The watch has a built-in heart rate sensor to track heart rate, an accelerometer, gyroscope, and barometer to measure fitness activities and body movements like running, cycling, and walking; photosensors and LEDs to detect pulse rate; phone call capability; browsing, GPS, and video; retina display to capture users' touches; all these in addition to providing the standard watch functions. Apple has closely connected its communication devices like iPhone with this new technology. By bundling multiple sensors into one device, Apple has successfully created a device using IoT to cater to a large set of consumer requirements and thereby provide enriched user experience.

↳ **Increased Use of Technology Drives Further Technology Innovations :** In the example of the Apple Watch, the entire ecosystem around wearables has started to innovate. The Watchkit SDK allows developers across the world to come up with creative applications to increase the user experience of Apple Watch customers.

Competition has started providing similar rich features on their products. Basis is offering a watch called Basis Peak, shown in Figure 3, to track fitness and sleep cycles (Basis, n.d.). The watch automatically detects sleeping, walking, running, and biking. It tracks the heart rate, skin temperature, and perspiration levels. The sleep cycles, including REM and deep sleep patterns are captured, including the toss & turn and interruptions in sleep. This helps the users to monitor their sleep patterns, and take corrective actions for sleep-related issues.

To reiterate, the entire ecosystem is increasingly offering new and innovative technological solutions to augment IoT capabilities. The sensor manufacturers are packaging more features into their products to enhance the capabilities of the products. They are bundling more sensors to reduce the size and add more features. The mesh networks are becoming sophisticated to enable roaming. Sensors can be added or removed from the network in real time. The gateways are not just a simple computing device to transmit data. They are becoming more intelligent to

Figure 3. Basis Peak – Fitness and Sleep Tracker

Source: Basis (n.d.)

filter the data for noise, thus reducing the amount of data they transmit. Data storage and analysis is becoming cheaper due to advancements in server technologies like virtualization and efficient power management systems.

Current Gaps and Improvements Needed in IoT Technology

- **MEMS or Nodes:** The micro-electromechanical systems, also called "nodes" are low power computing devices that have an inbuilt sensor to collect and transmit data. The existing MEMS will have to be optimized for power & performance. Further reduction in size of sensors will allow multiple sensors to be bundled into a single unit, thereby reducing the size of the overall device, allowing more data to be collected for various features.

- **Wireless Mesh Network:** The network has to be improved to detect collisions and transmission losses. The IP protocol IPv4 that is the current standard cannot scale to this estimated usage. The next version of IPv6 protocol should be made standard and all devices need to embrace the new standards.

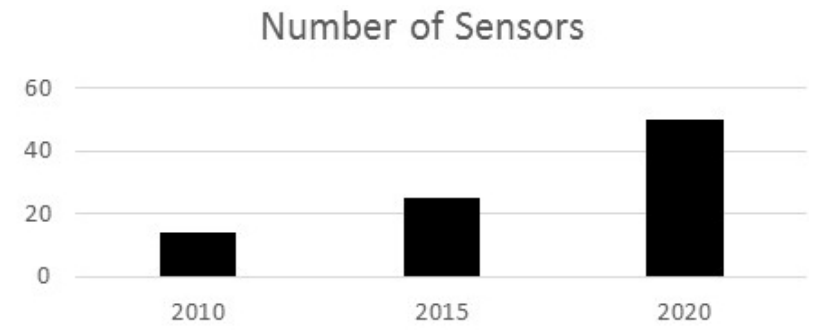
- **Gateway & Cloud:** Even though gateways are the connectors to transmit data to a wide area network (WAN), they are a single point of failure between the MEMS and WAN. The gateway and cloud should be made fail safe and intelligent enough to scrub the data before forwarding. Their capacity should be increased according to the increased usage of data transmission.

- **Analytics:** We need faster processing of data for timely interaction with the MEMS. Newer techniques like artificial intelligence and linear programming should be used for predictive data analysis. Needless to say, data should be made available to the users in an easy to use format. A study conducted by International Data Corporation revealed that diverse data types and connections combined with new analytics and new users/insights at the right time yield 60% greater data dividend (Vesset, Morris, & Gantz, 2014).

- **Converged Standards and Processes:** Currently, the MEMS, gateways, and cloud use a wide variety of standards for data gathering, transmission, storage, and retrieval. Each manufacturer will bring in their standards, and device inter-operability is impacted. There has to be a universal set of standards for MEMS to interact in the Mesh networks, without which the concept of plug-and-play is defeated.

- **Security:** Data security on the Internet is still evolving. Since IoT brings in a lot of personal data, the data security and protocols should be standardized.

Figure 4. Forecasted Number of *Things* Connected to the Internet



Source : Manyika et al. (2013)

IoT technology exists today in a skeletal form, but is going through massive improvements to cater to the increasing demand and implementation. We need common standards and protocols across all pieces of technologies to enable IoT usage for mass implementation.

Is IoT a Disruptive Business Model?

IoT is becoming ubiquitous. The number of *things* connected to the Internet by 2020 is predicted at 50 billion (Cisco Systems, 2014), which averages to over seven things connected to the net per person. This huge increase in the number of IoTs will cause a tremendous stress on the ecosystem.

With the estimated large-scale migration of people from rural to urban areas by 2050, the usage of IoT will increase substantially. The existing business volumes will increase by five folds. According to a survey by McKinsey (Manyika, Chui, Bughin, Dobbs, Bisson, Marrs, 2013), the estimated business from IoT by 2025 will be between $2.7 trillion and $6.2 trillion annually, as shown in the Figure 4.

IoT is redefining the business playing field by opening up vast opportunities for all businesses who can define their unique product and service offerings that impact customers positively. Over the next few years, IoT will be in most of the customer products and services, even if the customers are technology agnostic. According to a report from the Economist Intelligence unit, an important factor contributing to the business adoption of IoT is the falling cost of the underlying technology. Increased use of IoT would drive further technical development, which in turn will bring opportunities for new products and service offerings (Witchalls, 2013).

Applications of IoT

IoT offers a ubiquitous business opportunity across all domains. It is a sector poised nicely to provide us with the next big moment in technology. Manyika et al. (2013) stated that the common applications for IoT are in the areas of healthcare, manufacturing, electricity, urban infrastructure, security, resource extraction, agriculture, retail, vehicles, and other potential areas like climate prediction and home appliances. The opportunities to introduce new products and services in these segments is limitless. A recent example is the introduction of IoT in the restroom at Heathrow Airport, London wherein sensors monitor the number of people using the restroom, before alerting the housekeeping staff for cleaning. The IoT technology can also point the users to the next nearby restroom in case of clogs or breakdowns.

- **Healthcare :** Quality healthcare depends on timeliness and accuracy of data availability. Most hospitals have automated the process of storing patient data in centralized database servers. However, the limitation is in the data

generation processes. Most of the data is collected during clinical tests and sometimes by patients themselves monitoring their blood pressure, sugar levels, and heart rate.

IoT can play a significant role in automating the collection, storage, and analysis of patient data. Wearables like Apple Watch are used to collect patients' data automatically. The frequency can be set depending on the requirement and condition of the patient. The data that gets stored in the cloud can be retrieved by the hospitals for review and patient care. The system can also send messages to the hospitals, patients, and their relatives in case of an emergency. For example, the system can dial an ambulance based on the severity of the patient's health data.

Automobiles : IoT is picking up steam in the automobile sector. It allows the automobile manufacturers to use sensors to monitor the health of the parts. It is estimated that the automotive industry will lead the IoT revolution by 2020 (Witchalls, 2013). The opportunities include monitoring the health of all the critical accessories in an automobile real time, and also providing other services like emergency calling, theft tracking, and insurance renewals. Imagine your mechanic having all the data of your car when you bring your car for service or better yet, imagine your car getting serviced at your door step remotely without having to wheel the car to the service garage. The service mechanics can actually monitor the health of the car remotely and even adjust most of the electronic circuitry in the car for fixes.

Environment Monitoring : IoT is increasingly being used to monitor the environment. Increased use of IoT can be seen in flood forecasting, monitoring, and control of water levels in dams and canals. IoT is also being used in monitoring air and water quality.

Home Automation : Imagine that you are watching your favorite channel in your living room and as you move from your living room to your bedroom, the lights and TV in the living room automatically turn off, while the lights in your bedroom turn on. The TV in your bedroom will start playing the same channel you were watching in the living room earlier. This is possible through home automation using IoT.

IoT offers a chance to programmatically control all the home appliances like TVs, music system, air conditioning, security, lighting, refrigerator, microwave, and so forth. This will help to decrease the amount of energy consumed, while increasing the user experience of creating the right mood and living conditions at home.

Business Opportunities : With the increased volume of production, the cost of the MEMS, gateway, and cloud infrastructure will go down. The MEMS cost is expected to go down by 90% in the next 5 years. The money is not in the actual production and distribution of devices, but it is in the entire eco-system - a combination of hardware, software, network, and service. It is not possible for any one player to have a dominant position in IoT. There will be acquisitions, mergers, and partnerships from various players wanting to benefit out of IoT. Software as a service (SaaS) will gain prime importance.

Business Considerations

Even though IoT concepts have existed, the usage of IoT is increasing, and it is now considered as a disruptive technology that is increasingly getting accepted as part of our daily lives. However, businesses planning to monetize on IoT have to consider various factors and plan for potential risks, since the changing technology can also impact the products and services severely, many times making them redundant in a short span of time.

Consumer Needs : Advancement in technology pushes consumer expectations higher. It is important to understand what the consumers' want and how the products and services cater to the emotional and functional needs of the consumer. Bundling of products and services, ease of use, and meeting customer expectations opens up new business opportunities.

- **Market Size :** The combination of increased penetration of the Internet and fast paced growth of technology is changing the needs and buying patterns of consumers. With over 50% of India's population being under 25 years of age and 65% being under 35 years of age, the Gen Y and Gen Z who have grown up with technology are heavily influenced by the rapid development of the Internet. They are adept in using the latest gadgets and web-based services online 24x7 right throughout the year. They easily accept new technologies like IoT and can potentially be the early adopters of most newest technologies.

- **Competition and Barriers to Entry :** Several large companies like Intel, Cisco, ARM, IBM are investing into IoT. Small and medium businesses must understand their limitations in being able to compete in this space. The opportunities are unlimited, which allow all businesses to create a niche offering in the market for themselves.

- **Technical Feasibility :** Most importantly, businesses have to decide on the patents and innovations they will develop in-house against leveraging third party patents. Cost vs. value has to be evaluated for the products and services being offered.

- **Cost & Schedule :** Clear estimations of the return on investment is a must. The breakeven point has to be understood. The linkage between cost, schedule, and quality has to be understood and defined.

- **Manufacturing and Supply Chain :** Businesses should identify the source of their products and services. Process to deliver the selected products and services should be documented and explained to the customers.

A Case Study: IoT Used to Monitor Pressure and Temperature of Tires in Real-Time

Mahindra Group bought a major share in Reva Electric Car Company in May 2010 to form Mahindra Reva Electric Vehicles Private Limited. The electric car named e2o can accommodate four passengers and can drive up to 120 km for each recharge. The lithium-ion battery used in the car takes about 5 hours to charge. The car has made extensive use of IoT technology (Roy, 2014). The car can be remotely locked/unlocked, the car's air conditioner can be started using a mobile app or laptop, and can run a complete diagnostic check on all the vital parameters of the car. The car also sends an SMS for suspected theft and break-ins. The car's fuel gauge system continually informs the customers on the amount of charge left in the batteries and the distance they can drive with the current charge. This will stop all surprises of the car stalling on the road due to a dead battery. Mahindra has also signed up with Schrader International to implement a snap-in valve sensor on Reva's tires to implement tire pressure monitoring systems (TPMS) ("Schrader wins global business from India’s Mahindra Reva Electric Vehicles Pvt. Ltd.," 2013) . This technology will collect the tire pressure and temperature through electronic sensors and transmit the same to the instrument panel. Frequent monitoring of tire pressure will result in reduced tire bursts, and increased fuel efficiency.

Research Implications

Our paper illustrates the disruptions in technology due to the evolution of IoT. Non-tech companies will be benefited by our research in understanding how the influx of IoT can impact their business models. It is important that they start thinking about winning in a collaborating environment, since IoT spans across multiple providers of various technologies. It is difficult for any one company to have a dominant position across all IoT technologies and application areas. Even the tech savvy companies will be benefited by the technological content and the data

provided by this study.

Academic institutes can dissipate the knowledge of IoT amongst students. Our initial conversation with reputed institutions revealed that academic institutions don't have a good curriculum on this rapidly evolving technology. Business schools should focus upon specific areas to further research on the opportunities IoT can provide. They should explore the models that companies should follow to take advantage of the explosive markets resulting from IoT implementation.

Conclusion

IoT is becoming ubiquitous. Since IoT requires a combination of hardware, software, networking, cloud computing, analytics and supply-chain management, it is very unlikely we will see dominant players in this space who can provide a complete solution. The ecosystem will force partnerships, expanding into other business domains, and consolidation of weak players. The question we should ask ourselves is: Are the players positioning themselves appropriately to take the best advantage of this explosive growth? It is not just mobile phones and tablets anymore; it's the entire compute continuum. As all the pieces of technology become affordable, the penetration of IoT will accelerate. We will then start seeing bundling and consolidation of various technologies like cloud, data services, the Internet, mobile communications, and so forth. The increased consumption of IoT will drive innovations in newer technologies and business offerings, spiraling further investment and increased penetration. Thus, IoT is both a disruptive technology and a disruptive business model, each one spiraling the development and consumption of the other.

Limitations of the Study and Scope for Further Research

IoT offers huge opportunities for research across every application area. For the scope of our research, we conducted several interviews across various IoT application areas, but we did not conduct a deeper probe in any specific area. We made corporate contacts, predominantly in Bengaluru, which is cosmopolitan and has a diverse set of population in terms of race, beliefs, ethics, and cultural background. The variations in data, especially from tier 2 and 3 cities were not considered. While the penetration of IoT is increasing, the alignment on common standards and communication protocols is not progressing at the same rate. We limited the scope of our research to broad technology and business concepts and did not do a deeper dive on the need for common security protocols in implementation of IoT.

There is potential to take a deeper probe into each of the functional areas. IoT implementation is gaining momentum across every possible functional area, thus providing larger opportunities for further study and analysis. The validity of this research has to be expanded and tested across other functional areas and in cities outside of Bengaluru. Security and interoperability are the key for IoT's success. Due to the lack of common standards for IoT in industries, most of the implementations of IoT are severely customized. There is an ample scope to align on common standards and protocols for IoT implementation, which will drive the cost down and increase IoT penetration in industries.

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