A STUDY OF UNDERSTANDING THE MANAGEMENT APPROACH TOWARDS IOT (INTERNET OF THINGS) ADOPTION FOR MANUFACTURING COMPANIES IN PUNE

A Thesis

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BY

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UNDER THE GUIDANCE OF

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Undertaking

I, Anushka Rajendra Shembekar - the Ph. D Scholar of Tilak Maharashtra Vidyapeeth in Management subject. Thesis entitled "**A study of understanding the management approach towards IoT (Internet of Things) adoption for manufacturing companies in Pune**" under the supervision of Prof (Dr.) Hemant Keshav Abhyankar. Solemnly affirm that the thesis submitted by me is my own work. I have not copied it from any source. I have gone through extensive review of literature of the related published / unpublished research works and the use of such references made has been acknowledged in my thesis. The title and the content of research is original. I understand that, in case of any complaint especially plagiarism, regarding my Ph.D. research from any party, I have to go through the enquiry procedure as decided by the Vidyapeeth at any point of time. I understand that, if my Ph.D. thesis (or part of it) is found duplicate at any point of time, my research degree will be withdrawn and in such circumstances, I will be solely responsible and liable for any consequences arises thereby. I will not hold the TMV, Pune responsible and liable in any case.

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CERTIFICATE OF THE SUPERVISOR

It is certified that work entitled "A study of understanding the management approach towards IoT (Internet of Things) adoption for manufacturing companies in Pune" is an original research work done by Anushka Rajendra Shembekar.

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- up to the standard in respect of both content and language for being referred to the examiner.

Prof (Dr.) Hemant Keshav Abhyankar

Signature of the Supervisor

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- Dispotronics
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- Forbes Marshall
- Godrej
- GS Labs
- Honeywell
- Indo Schottle
- InfoWorld Consultancy Private Limited
- Kirloskar Brothers Limited
- Kirloskar Ebara Pumps Limited
- Kirloskar Oil Engines
- Konecranes Private Limited
- Maven Systems Private Limited
- OMKAR ENGINEERING
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- Persistent System Limited
- Poona Shims Private Limited
- Praj Industries
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- TATA AutoComp Systems Limited
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- Sigma electric
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Executive Summary

Manufacturing Industry in India has gone through various phases of development over a period of time. India a credible investment destination and presents an attractive opportunity to manufacturers. However to achieve this inclusive growth this sector is facing various challenges. Addition to the challenges, globalization has added one more important parameter of competition to this sector. These various challenges can be addressed with the help of technology. Industrial process automation helps solving most of the problems faced in current scenario.

Industrial production has gone through several revolutions in the last two centuries. The third revolution brought a lot of automation, giving better quality of products, at lesser cost.

With high speed changes in technology, the industry gets transformed. New technology means speed, accuracy, cost reduction and so on.

The extensive use of computers and advent of Artificial Intelligence has brought us to this new revolution. As every machine component is becoming smart and intelligent, they are in a position to anticipate several things, in advance, and if properly programmed, could participate in decision making. This is what is bringing in the fourth industrial revolution; often referred as Industry4.0.

This has become possible, only because of Internet of Things (IoT).

IoT is integration of machine, Person or any physical device that has the ability to transfer data over the network. The whole western world is converting the manufacturing processes using IoT. Indian Industry has to compete the industry world over, for sustainability. Tomorrow the world market may not accept products where IoT is not

used. This has been realized by the Industry and many large scale manufacturing companies are preparing themselves for the adoption of IoT.

Pune is a leading industrial hub of India. It is also known as the Oxford of the East, due to a strong educational set up. It is also a cultural city. The researchers thought it appropriate to check the progress of Industry in Pune, with respect to Industry 4.0 visa-vis its preparedness for implementation of IoT.

IoT is still at an early stage of development, and many problems and research challenges must be solved before it is widely adopted. The industry should know the readiness parameters, challenges and right approach towards IoT initiatives. The check-list for the same will help them for smooth conversion.

During the survey the researcher designed the questionnaire that was based on below five parameters

1. Basic Information
2. Awareness
3. Readiness
4. Adoption
5. Advantages/Limitation/Challenges

With the objective of checking the current adoption stage, IoT awareness status, readiness towards IoT and challenges for adoption, the researcher decided the sample from industry. Researcher conducted one on one interview to collect qualitative data. The research was also supported by experts view and various other research papers.

While discussing with more than 50 plus companies from the selected domain, it has been realized that there is enough awareness about IoT in management. Management has shown readiness required for IoT adoption through various parameters. However many companies are still in the process and have not yet implemented IoT. Considering this state, limitation and various challenges faced by them were studied.

Requirement gathering, understanding and its conversion has been observed as a major reason for failure of IoT initiatives. Expectation of immediate ROI, Business process change, skilled worker/employees was on top of all the challenges listed by several management people from various companies.

Researcher observed that companies see the potential of IoT, but they don't know where to begin to adopt the technology.

Researcher recommend that IT and business group should be in sync to incorporate IoT in the company. Further, for every IoT project to be successful there should be a dedicated team including cross functional team members. This will definitely increase chances of getting better output. The project should have involvement of all the connected functions and departments. The training is required for project team but also as well as for each and every employee around as per requirement.

IoT requires a company to undergo change which should be well thought of while starting the project. This changeover cannot take place without a fundamental cultural and organizational change throughout the entire value chain, including suppliers and clients.

Looking forward, it can be said that IoT will be THE key lever of the ongoing Fourth Industrial Revolution, which is marked by opportunities and paradigm-changing innovations that facilitate entirely new business models.

Key words:- IoT, Industry 4.0, Pune industry, Smart manufacturing , Smart factory, Artificial Intelligence , Digital transformation , Strategy, Resource planning , Skill development, IIoT, Industrial IoT ,Industrial revolution, Technology adoption, Smart Solutions , M2M ,Sensors, Automation , Plant Automation , Smart Grid , Data Analytics, Machine learning, Smart energy, ROI

Tables and Figures

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Chapter - 1

Introduction

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1.1 Indian Manufacturing companies and its development

India is an attractive hub for foreign investments in the manufacturing sector. Several mobile phone, luxury and automobile brands, among others, have set up or are looking to establish their manufacturing bases in the country [1, 2].

Strengths of Manufacturing sector in India [1, 2, 3]:

- Robust Demand - Huge domestic market with a rapidly increasing overall population
- Increasing Investment - Investment in the Indian manufacturing sector has been on the rise, both domestic and foreign. Gross fixed capital formation, which represents net investment in fixed assets, has grown 10.44 percent annually between FY16 and FY18PE.
- Policy Support - Initiatives like 'Make in India' and sector specific incentives to various manufacturing companies, aiming to ‘Make In India’ a global manufacturing hub
- Competitive advantages - Increasing share of young working population in the total population. India can achieve its full manufacturing potential as it looks to benefit from its demographic dividend and a large workforce over the next two or three decades

Manufacturing is crucial for any economy—not only does it raise employment, but it also boosts the economy. Development of the manufacturing sector in India has reduced employment pressure on agriculture [4]. It has brought in much needed foreign exchange. It has expanded trade and commerce. Manufacturing industries have helped in eradication of unemployment and poverty.

Manufacturing Industry in India has gone through various phases of development over a period of time. Since independence in 1947, the domestic manufacturing sector has traveled from building the industrial foundation in 1950’s and early 1960’s, to the license–permit Raj between 1965 and 1980. Then it underwent a phase of liberalization of 1990’s and finally to the present phase of global competitiveness.

The Indian Manufacturing sector currently contributes 16-17% to GDP and gives employment to around 12% (2014) of the country’s workforce. Various studies have

estimated that every job created in manufacturing has a multiplier effect in creating 2–3 jobs in the services sector. In a country like India, where employment generation is one of the key policy issues, this makes this sector a critical one to achieve inclusive growth.

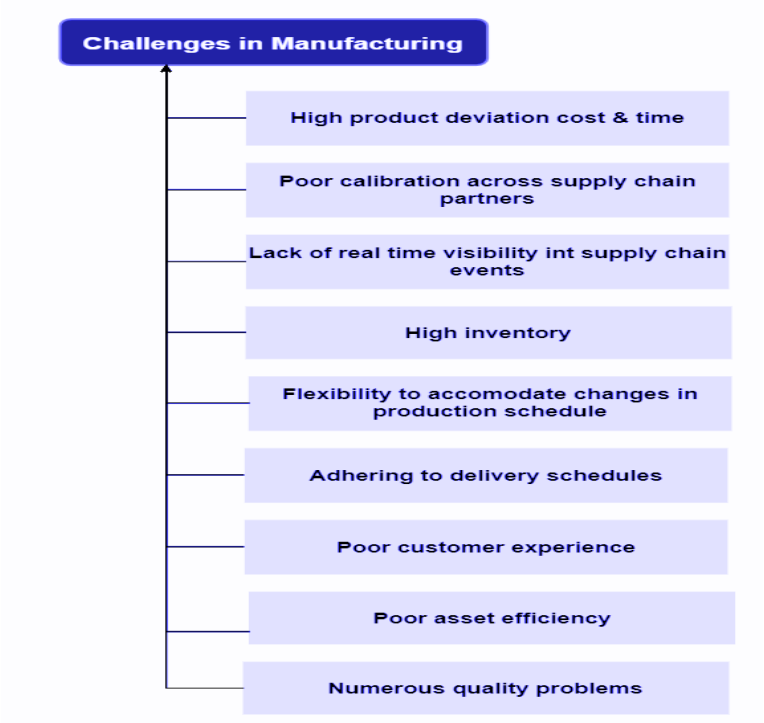
While a number of factors like robust domestic demand, a growing middle class, a young population and a high return on investment, makes India a credible investment destination and presents an attractive opportunity to manufacturers. However to achieve this inclusive growth this sector is facing various challenges.

1.1.1 Challenges faced by manufacturing companies [3]:

- Enabling greater sales, production and service agility
- When it comes to enhancing productivity, ensuring that manufacturing workforces have the information they need to be successful is crucial.
- Better supply chain visibility and collaboration to improve performance and drive down costs.
- Compliance reporting, quality management systems and reducing the time spent preparing for audits
- Equipment Maintenance and Upkeep to reduce unplanned downtime and its impact on manufacturing productivity.
- Getting more value out of machine data and enabling greater manufacturing intelligence.
- The complexity of manufacturing continues to increase, yet the availability of skilled workers entering the industry is declining.
- Usability of systems.
- Ensuring workforce safety
- Inappropriate Equipment: The right manufacturing equipment is integral to successfully empowering the workforce. Often, however, this equipment is complex and creates major complications during common employee changeovers. The age of the equipment can also inhibit its ability to promote productivity. Occasionally, equipment is routinely used for a task separate from its intended purpose, slowing down production with every use.

Addition to the challenges, globalization has added one more important parameter of competition to this sector. These various challenges can be addressed with the help of technology. Industrial process automation helps solving most of the problems faced in current scenario.

Figure 1.1: Challenges in Manufacturing



1.1.2 Globalization , competitiveness and its impact

In India, the process of economic reforms during the last two and a half decades have increased competitive pressures on firms resulting in adoption of a variety of strategies for their survival and growth. The competitive and intense manufacturing market and global economic recession have prompted many manufacturing companies to re-evaluate and reconstruct the process they undertake to design and manufacture a new product. Rapid changes in technology are changing the basis of competition throughout the world.

According to PwC's 18thAnnual Global CEO Survey, global CEOs of industrial manufacturing firms are recognizing the significance of 3DP, robotics, and other

technological advances. They regard using mobile technologies for engaging customers (73%), cyber security (72%), and data mining and analysis (70%) as strategically important. Indeed, among those CEOs who plan to form new alliances or joint ventures this year, 60% plan to do so in order to gain access to new technologies [1, 6].

1.2 Industrial Revolution , Industry 4.0 and Industrial IoT

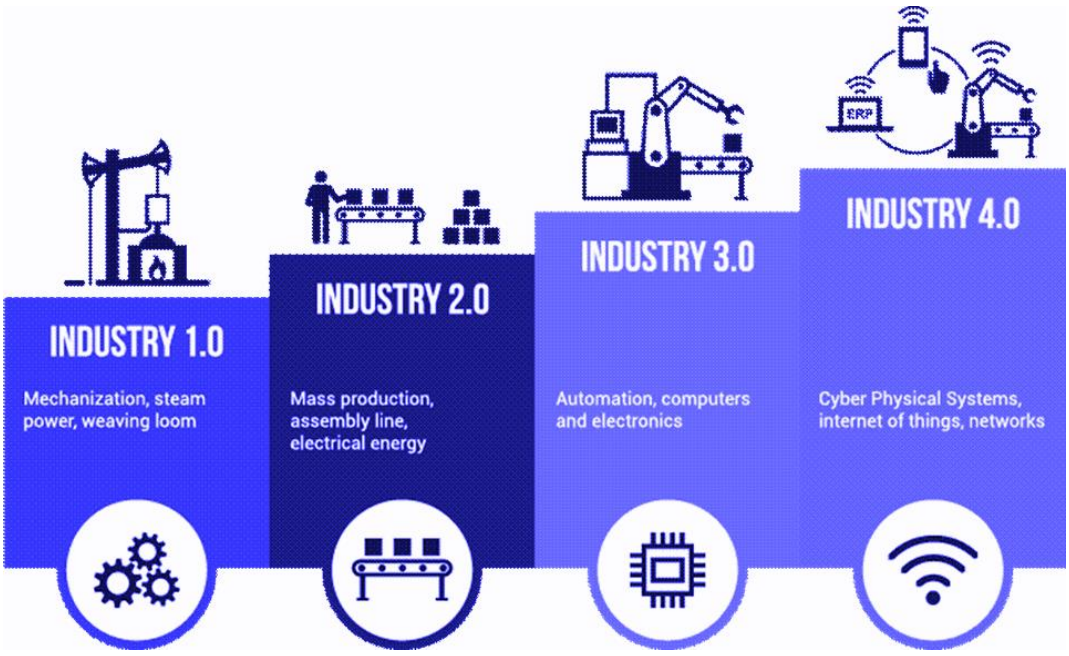
An industry is a sector that produces goods or related services within an economy.

The Industrial Revolution is one of the most significant events in human history and had a profound effect on many nations throughout the world. While the Industrial Revolution first began in Britain in the 18th century, and took place throughout the centuries that followed, its impacts can still be seen in our lives today. As an event, the Industrial Revolution had both positive and negative impacts for society [5].

The Industrial Revolution was a time when the manufacturing of goods moved from small shops and homes to large factories. This shift brought about changes in culture as people moved from rural areas to big cities in order to work.

The Industrial Revolution began in the 18th century, when agricultural societies became more industrialized and urban. The transcontinental railroad, the cotton gin, electricity and other inventions permanently changed society [5].

Figure 1.2: Industrial Revolution



1.2.1 First Industrial Revolution

In Britain, an industrial revolution (now known as the first industrial revolution) introduced machines into production by the turn of the 18th century (1760-1840). This included a move away from human/animal powered production and toward the use of steam and water as the primary sources of energy. This helped agriculture greatly and the term “factory” became popular. Textile industry was a large part of the British economy at the time and it benefited greatly from this revolution. [3, 5]

1.2.2 Second Industrial Revolution

Systems such as telegraphs and railroads were introduced into industries at the beginning of the last quarter of the 19th century; this marks the start of the second industrial revolution. Mass production became the predominant means of manufacturing in this period and factory electrification greatly contributed in making this possible. Abundant steel production fueled an increase in railway infrastructure and that then helped with mass production of consumer goods. Synthesis of artificial dye and other advances in chemistry also happened in this period. World-War-I put an abrupt end to this revolution but the idea

of mass production persisted after the war and is now common place in the manufacturing industry [3, 5].

1.2.3 Third Industrial Revolution

The third industrial revolution is perhaps the most familiar to people living in the early parts of the 21st century. The roots of this revolution date back to the period between 1950 - 1970. This revolution, also known as Digital Revolution, is marked by a shift from analog/mechanical systems to digital systems. The main driver behind the third revolution was the huge development in computers and information and communication technology and hence it is sometimes referred to as “Information Age” [3, 5].

1.2.4 Fourth Industrial Revolution (Industry 4.0)

The fourth industrial revolution, which started with the beginning of the 21st century, introduces customized and flexible mass production technologies into automated manufacturing. This means that machines will operate independently, and/or cooperate with humans to create a customer-oriented production field that constantly works on maintaining itself.

The machine becomes an autonomous/semi-autonomous entity that is able to collect data, analyze it, and act upon it. This is achieved by various advance technologies for self-optimization, self-cognition, and self-customization into the industry. The manufacturers now become machine communicators rather than machine operators.

Industry 4.0 refers to a new phase in the Industrial Revolution (Fourth Industrial Revolution) that focuses heavily on interconnectivity, automation, machine learning, and real-time data.

The industrial internet of things (IIoT) is a term used to describe the IoT applied in the industrial context. Both concepts have the same main characteristics of availability,

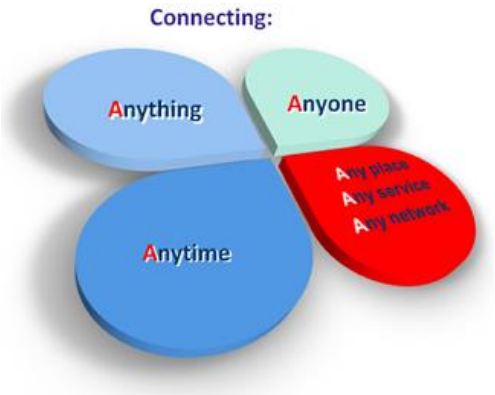
intelligence and connectedness. The only difference between those two is their general usage.

New inventions and new technology are big contributors for businesses to grow and develop during the Industrial Revolution

Internet of Things is a technology, advancing at warp speed, and most manufacturers struggle to keep up. [3, 5].

1.3 Internet of Things (IoT)

Figure 1.3: Concept of IoT



The term “Internet of Things” was coined by Kevin Ashton in 1999 during his work at Proctor and Gamble. Ashton, who was working in supply chain optimization, wanted to attract senior management’s attention to a new exciting technology called RFID (Radio Frequency Identification). Because the internet was the hottest new trend in 1999, he called

his presentation “Internet of Things”. The idea of connected devices has been around since the 1970s. Back then, the idea was usually termed as “embedded internet” or “pervasive computing”. [7,8]

The Internet of Things (IoT) is a term that has been introduced around the beginning of the 21st century to define objects/devices that are able to connect to and transfer data via the internet. In other words, IoT is defined as one object communicating to another object over internet connectivity.

In the phrase IoT, ‘Thing’ refers to these connected objects that send data to and receive data from other objects.

Devices that can be considered as IoT objects are many: cars, CCTV cameras, kitchen appliances, biometric readers and industrial machinery. An IoT device is connected through an IP network to the internet. The devices connect to the net either through Ethernet — wired or wireless — or Bluetooth.

Where IoT devices differ from traditional internet-capable equipment like laptops, computers and smartphones is that they have a very limited user interface and are considered to be more of an instrument that is used to measure and relay data rather than serve as a direct interface to the Internet.

The data that is produced by these IoT devices can be accessed with ease from anywhere in the world, provided they are connected to the Internet. As objects can interact with another object without human intervention, a lot of data generation happens from diverse locations that are aggregated very quickly, thereby increasing the need to better index, store and process such data.

Another term M2M (Machine-to-Machine) entails the transfer of information from one device to another. The term basically refers to point-to-point communication between the two devices. In contrast with M2M, IoT is a broader term that refers to a network of connected devices supporting data integration with a specific application; it involves multi-level communication and flexible responses. The total number of IoT devices that are currently active and online is already massive and it continues to grow at a rapid rate.

In an active move to accommodate new and emerging technological innovation, the UK Government, in their budget, allocated £4 crore towards research into the Internet of Things [2].

Currently the development project “smart cities” is using IoT which will be applied to the things which can help us reduce waste and improve efficiency for things such as energy use; this helps us understand and improve how we work and live [10].

In manufacturing domain, it has an identity as Industry 4.0 /Smart factory/ Smart Manufacturing.

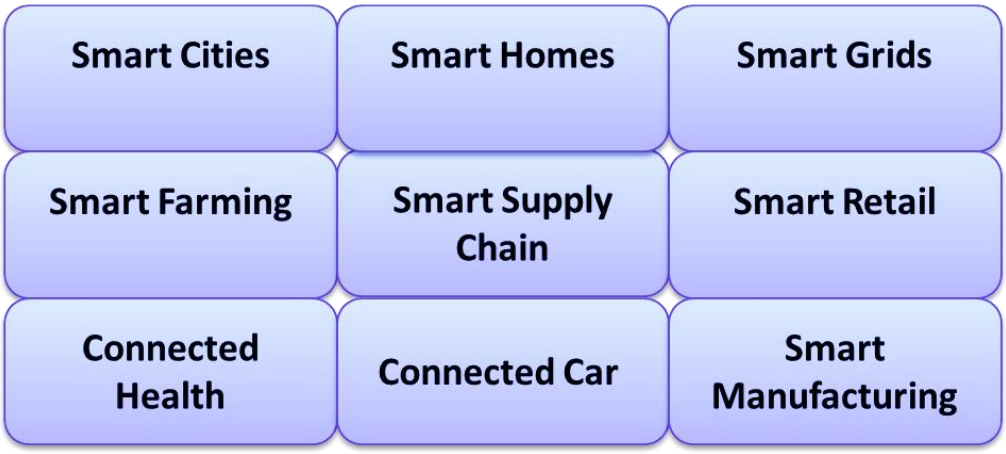
Many top companies have started exploring this technology at various levels, few companies are in the process of implementation and few are planning to implement.

IoT will have widespread and beneficial effects by mid 2020s and it is now estimated that the total global IoT market will reach $1,567B by 2025. There are multiple forces which are driving the growing need for both technologies and more and more industries, governments, engineers, scientists and technologists have started to implement it in manifold circumstances; IoT has become the hottest technological trend in recent times.[9]

1.4 Applications of IoT

IoT has a lot of different applications. These are used in process automation, home automation, smart cars, decision analytics, smart grids etc.. The list of IoT applications will grow as technology evolves in the years ahead.

Figure 1.4: Area of applications in IoT



1.4.1 Smart Cities[5,10,11,12]

Borrowing a definition from Wikipedia, A Smart city is an urban area that uses different types of sensors to collect data and then use this data to manage the resources efficiently. This includes data collected from people, devices, and assets that are processed and analyzed to monitor and manage traffic and transportation systems, water supply, power plants, waste management, crime detection, information systems, hospitals, schools, libraries, and other services.

Use of IoT technologies at city wide scale can help us reduce waste and improve efficiency for things such as energy use; this helps us understand and improve how we work and live. Smart city development is gaining in popularity among municipal governments and in published literature.

Barriers/Challenges

- Lack of cooperation and coordination between a city's operational networks and on how IT management can be effectively imposed on the development of the smart cities
- Awareness amongst citizens

1.4.2 Smart Homes [7,11]

Smart home technology, also often referred to as home automation, provides homeowners security, comfort, and convenience. It helps in energy efficiency by allowing them to control smart devices, often with smart phone apps. A part of the internet of things (IoT), smart home systems and devices often operate together, sharing consumer usage data among themselves and automating actions based on the homeowners' preferences. In geographies with increasing number of smart home automation devices, daily lives are becoming well-organized and comfortable. This desirability has created a lot of buzz about IoT in the IT industry. The idea of smart homes has been around for decades but it is only in recent years that the technology to perform mundane tasks has gained widespread acceptance due to ubiquitous internet connectivity and reduced costs.

Products and services associated with home automation, smart, and connected homes have changed the perception of technological innovation amongst customers. Homes are now altered into a connected and personalized ecosystem of services. With the arrival of IoT,

technologies such as Wi-Fi, Bluetooth are enabling many devices to communicate with each other making the home smarter. With the decrease in prices of sensors, smart devices are becoming affordable.

Barriers/Challenges

- In some geographies, it is still cost ineffective to adopt these technologies
- With lot of automation, the complexity of use can quickly rise leading to negligence/maintenance
- As with all IoT based services, data security is an important barrier. This is particularly crucial in home automation as people are careful about their privacy at home
- Interoperability and compatibility of various home automation systems and devices

1.4.3 Connected Health [13]

Healthcare industry has been rapidly adopting Internet of Things (IoT) and Artificial Intelligence (AI) to improve access and outcomes. IoT could be used from remote monitoring equipment to smart sensors to equipment integration. It has the potential to improve how physicians deliver care and also keep patients safe and healthy. Patients can gain personalized attention to their health through the use of devices in the form of wearable like fitness bands and other wirelessly connected devices like blood pressure and heart rate monitoring cuffs, glucometer etc. These can be tuned to remind calorie count, exercise check, appointments, blood pressure variations and much more.

Through the use of connected IoT devices, patients can spend more time interacting with doctors, boosting patient engagement and satisfaction in the process. IoT promises to revolutionize healthcare providing economical solutions for both the patient and healthcare professional.

In India, some of the impediments to the healthcare system's growth include an ageing and burgeoning population, a lack of adequate infrastructure and shortage of medical professionals, poor accessibility to quality healthcare in remote and rural areas, increasing incidence of chronic disease and rising cost of care.

To improve this ailing healthcare system into an integrated, efficient and patient-centric system, IoT and connectivity is a promising solution. IoT based monitoring can greatly help in changing from the current focus of curative care toward a preventative healthcare model. Through the integration of medical IoT devices, smart sensors, mobile health monitoring apps, artificial intelligence (AI) ,the possibilities are endless.

IoT is being used to track the progression and treatment of diseases, to monitor patients' health conditions and accordingly alter their medication levels, to track medicines usage data to ensure adherence to treatment plans, and to provide real-time information on symptoms.

The healthcare space in India is conducive to IoT adoption. The factors that are helping this include a talent pool of doctors, scientists, mathematicians, engineers and designers converging to achieve improved health outcomes for citizens. Technology adoption in the Indian healthcare sector is promising to be a game changer in the delivery of healthcare services and is poised for substantial growth.

Barriers/Challenges

- Data security & privacy
- Data overload & accuracy
- Cost
- Community acceptance
- Competence of the users
- Interoperability
- Slow growth adaptation from the policy makers

1.4.4 Connected Car[11,12]

Digital communication technologies have made rapid inroads in vehicles bringing in a transformation in the industry over the last decade.

The idea of connected transportation is gaining traction worldwide. It is based on providing enhanced connectivity, for example, vehicles-vehicle (V2V) communication broadcasting their presence:

- **V2I** "*Vehicle to Infrastructure*": The technology captures data generated by the vehicle and provides information about the infrastructure to the driver. The V2I technology communicates information about safety, mobility or environment-related conditions.
- **V2V** "*Vehicle to Vehicle*": The technology communicates information about speed and position of surrounding vehicles through a wireless exchange of information. The goal is to avoid accidents, ease traffic congestion and have a positive impact on the environment.
- **V2C** "*Vehicle to Cloud*": The technology exchanges information about and for applications of the vehicle with a cloud system. This allows the vehicle to use information from other, though the cloud connected industries like energy, transportation and smart homes and make use of IoT.
- **V2P** "*Vehicle to Pedestrian*": The technology senses information about its environment and communicates it to other vehicles, infrastructure and personal mobile devices. This enables the vehicle to communicate with pedestrians and is intended to improve safety and mobility on the road.
- **V2X** "*Vehicle to Everything*": The technology interconnects all types of vehicles and infrastructure systems with another. This connectivity includes cars, highways, ships, trains and airplanes.

This communication enables a variety of services such as real time street updates, smart routing and tracking, roadside assistance in case of accidents, automatic toll transactions, automatic parking/parking management, on-board entertainment, and much more.

Connected car technology involves a wide network of sensors, embedded software, antennas, and related infrastructures that assist the vehicle in navigating our complex world. Making decisions with consistency, accuracy, and speed are part of the responsibility of this system while maintaining its reliability. These requirements will become even more critical for fully autonomous vehicles.

Leading automotive manufacturers, suppliers, and dealers have started investing heavily in Internet of Things and are gaining returns in the form of ultra-efficient inventory management, real time promotions that grow sales, reduced operational expenses and increase in revenue. They are beginning to change their business processes and recognize that, in time, IoT will touch every area of automotive operations and customer engagement.

Barriers/Challenges

- Connected cars require long development times.
- Car dealerships need to be more tech savvy as they need to spend more time with their customers showing them the advanced technology in their new vehicles.
- Automakers will need to define, establish, and enforce standard practices for connectivity — such as communications, data processing, sensor suites, and other tech.

1.4.5 Smart Retail [14]

Retail operations are now using IoT solutions across a number of applications in order to improve store operations, increasing purchases, reducing theft, enabling inventory management, and enhancing the consumer's shopping experience. Physical retail stores can better compete with online rivals through the use of IoT. They can regain their lost market share and attract consumers into the store, and in the process, save money and hold better shelf inventory.

Barriers/Challenges

- The gap between what retailers are currently offering and what is technologically possible.
- Retailers are failing to meet customers on the platforms the customer prefers, and instead, spend lot of time trying to convince customers to join them on "their platform".

1.4.6 Smart Grids [5]

Smart grids are another area with huge IoT potential. A smart grid basically promises to extract information on the behavior of consumers and electricity suppliers in an automated fashion to improve the efficiency, economics, and reliability of electricity distribution.

Barriers/Challenges

- Availability and integrity are the most important security objectives in the smart grid from the perspective of system reliability.
- Consumer's level of understanding and awareness is low
- Policy makers and regulators are not very clear about the future prospects of Smart Grids.

1.4.7 Smart Farming [4,5]

At times, the usability of IoT in farming is underestimated. However, since a lot of farming operations are remote and farmers can have livestock roaming over a large area, all of this is well suited to be monitored and controlled using IoT techniques. This is what is meant by smart farming; and it has the potential of becoming an important IoT application field, especially in the agricultural-product exporting countries.

Sensors can monitor things like soil moisture, lighting conditions and humidity; this data can then be accessed through the internet anywhere in the world to monitor the farm parameters. Irrigation systems that are connected to IoT interfaces can be automatically switched on or off depending on the requirements of the crop and weather, soil conditions at the farm.

Barriers/Challenges

- There is a lack of awareness in farmers as far as technology-based farming solutions and their applicability are concerned
- Sensors are expensive and may or may not fit into the budget requirements of farmers

1.4.8 Smart Supply Chain

Supply chains have already been getting smarter for a couple of years through solutions to problems like helping suppliers exchange inventory information or tracking of goods while they are on the road or in transit are some of the popular offerings. With sensors embedded in factory equipment, they can communicate data about different parameters, such as

temperature, pressure, and utilization of the machine. An IoT system can continuously monitor a system and adjust parameters to optimize the performance of the system [8].

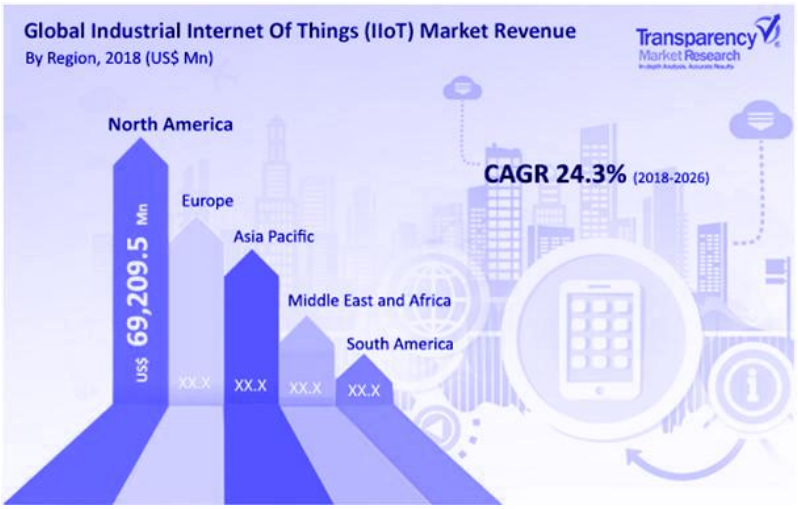
1.4.9 Smart Manufacturing [12,15]

Manufacturing is yet another sector that is seeing benefits by adopting IoT technologies. In fact, global manufacturing is being transformed due to IoT based technologies and Robotics; this renewal is being referred to as 'Fourth Industrial Revolution' or 'Industry 4.0' [7,12]. This is leading to large efficiency and productivity gains are being realized due to cost reductions, quality improvements, customization and a quantum leap in performance. Increasing investment in these technologies is propelling manufacturers ahead among their competition. For instance, expensive PLC (programmable logic controller) modules based on old technologies and needing proprietary software to operate are being replaced by cheaper IoT devices that can perform similar functions with much improved connectivity for operation. With IoT sensors and network capabilities delivered onboard, Automobile OEMs (Original Equipment Manufacturers) will now be able to monitor cars for their health even after the vehicle leaves the showroom and hits the road. Thus, in the case of a manufacturing defect, they can obtain all the operating data on the vehicle as gathered by the IoT sensors and compare them with data logs of the rest of the healthy fleet in order to reach to a quick diagnosis and resolution of the issue. Such a scenario helps the manufacturer to not only assess a problem for their customers more quickly, but it also helps them to strengthen their own manufacturing procedures and ensure that they limit the likelihood of such events occurring in the future. In manufacturing sector IoT applications have scope in various products and services.

India is still in very early stages of adopting digital and IoT technologies. With global competition, Indian manufacturers cannot afford to be left out of this fourth industrial revolution and if India aims at becoming a global manufacturing hub, it must proactively embrace these technologies to achieve it.

1.5 Global Adoption of IoT

Figure 1.5: Global Industrial IoT Market revenue



Global businesses are tossing over digital transformation. They are seeking new technological models to create a connected initiative for merging operational, informational and predictive departments of the industry. This transformation and the emergence of IoT development have played a major role to reduce costs in the industrial sector. It is forecasted to improve the overall production, enhance operational efficiency, improve transparency, and reduce bugs, errors, and complexities of different processes at different stages in the industry.

Intelligent devices are predicted to revolutionize the way customers, enterprises interact with the manufacturing processes. The growth in the smartphone and connected devices penetration has led to the sharing of large volumes of data across multiple platforms, which is expected to drive the overall utilization of IoT in manufacturing processes. The enormous surge in the number of intelligent devices would help manufacturers enhance their business processes.

The major factors driving the growth of the market are the growing need for centralized monitoring and predictive maintenance of manufacturing infrastructure, the advent of latest communication technologies, and the need for agile production and operational efficiency.

IoT in the manufacturing market is segmented on the basis of components (solutions, platforms, and services), application areas, verticals, and regions. IoT in manufacturing services are segmented into managed and professional services [5, 6, 11].

Further, professional services include IoT consulting services, IoT infrastructure services, system design and integration services, support and maintenance services, and education and training services.

North America has two (the US and Canada) developed economies investing heavily in Research and Development (R&D) activities, thereby contributing to the development of new technologies. The number of startups is growing at a significant rate in North America. Due to the early adoption of trending technologies, such as IoT, Big data, DevOps, and Mobility, manufacturers in North America are keen to integrate IoT technologies in their processes. Growing number of SMEs and increasing digitization in manufacturing by large organizations have also aided the growth of the North American IoT in manufacturing market. SMEs are flexible in incorporating new technologies into their existing systems, whereas large manufacturers have heavy budgets for digitization. All these factors are driving the growth of the market in North America. With the technological advancement and increasing adoption of smart grids in the region, the market is expected to grow at a high rate.

Asia Pacific (APAC) has witnessed the advanced and dynamic adoption of new technologies, and it is a lucrative market [12]. The region is expected to grow at the highest CAGR (Compound annual growth rate) during the forecast period in the market, as governments in APAC are investing in R&D of IoT in manufacturing services. Additionally, they are taking aggressive initiatives to enhance the IT infrastructure, enabling commercial users to adopt cutting-edge technology.

The Asia Pacific region is expected to witness the highest CAGR in the global IoT industry and this comes in primarily due to large-scale industrialization in Asian markets like China, India and Japan [16].

Traditionally, Multinational Companies have used Asia (and other markets) for manufacturing due to the availability of cheap labor while maintaining Research and Development (R&D) in the USA and Europe. This status quo is quickly changing as indigenous innovation is being derived from state of the art R&D facilities in Asia [2, 15].

Noticeable in particular is China's shift from being predominantly a manufacturing base to a center of innovation [2].

At present, Asia Pacific is leading the world in IoT adoption with 43% of the companies in the region having adopted the technology in a bid to achieve a hyper connected future while companies that resist adoption of IIoT run the risk of being left behind the competition [16, 17].

However, the components of IIoT like AI, robotics, data and M2M technologies are bringing about myriad new or untested legal and regulatory issues that companies need to keep top of mind if they are to move forward in this space.

Reason behind massive adoption of IoT will be successful in Africa are listed as [15, 18, 19]:

- Cheaper cost of sensors and bandwidth
- Cheap processing
- Introduction of Big Data Analytics
- Widespread use of Smartphone
- Ubiquitous Wireless network
- Alternative energy and ultralow power technologies

While this is a promising sign for adoption of IoT, there are still challenges that need to be addressed [18]:

- Inadequacy of Power Supply
- High Poverty Rate

- Network Capacity Constraints
- Illiteracy
- Low Internet Penetration Rate
- Interoperability and Standards
- Data Management
- Security Issues in IoT
- Lack of Local Content

1.6 IoT for manufacturing companies

For manufacturing companies IoT can be used in below various applications [5, 15, 20, 21]:

- Creating and monitoring processes: Business impact of the Internet of Things (IoT) can be measured by offering a powerful way to monitor and control assets and processes.

- Asset performance management: With intelligent sensors, machines can transmit information about a problem to any location or person in a connected factory. In field operations in particular, this efficiency allows technicians to bring the right materials to properly address service calls.

- Safety and security monitoring: The status of individual workers in high-risk positions can be continuously monitored. Customizable sensors can detect any physical or security emergency and respond automatically. Responses can send alerts and call first responders or security personnel. They can also include immediate physical responses such as locking doors, and stopping elevators. Violations of safety procedures trigger alerts before an incident even happens.

- Quality control monitoring: Quality control analytics combined with sensors can test materials and components to make sure they meet specifications. In a factory setting, operational parameters such as pressure and temperature are monitored to avoid subpar production conditions. Products are tested as they are completed with real-time alerts indicating if they have gone outside of specified parameters.

- Inventory management: With the help of IIoT and RFID, manufacturers can outflank the problems bound to the manual methods and gain real-time visibility into their inventory. Various advantages of IoT usage :
    - Automation of inventory tracking and reporting
    - Constant visibility into the inventory items' quantity, location and movements
    - Inventory optimization
    - Identifying bottlenecks in the operations
    - Lead time optimization

- Customer lifecycle enhancement: If products in use are connected, they can report when they're having a problem. Some types of problems can be addressed by remote troubleshooting. This provides a high level of awareness and customer service response.

- Packaging optimization: Smart packaging includes embedded devices that record whether an item has been exposed to temperatures or moisture levels beyond the acceptable limits. Smart packaging also communicates with devices and creates a cost-effective firewall against counterfeit products.

- Logistics and supply chain management: GPS tracking and embedded sensors mean that real-time inventory information is always available. Inventory providers, warehouses, shippers and customers all sign receipts on mobile systems instead of clipboards, keeping everyone in the loop. Order picking processes can also be automated, based on real-time needs.

- Workflow: Automating workflow forms the foundation from which IoT can work in conjunction with artificial intelligence to identify and activate even more nuanced optimization opportunities.

1.7 Importance of IoT Adoption in manufacturing

The adoption of IoT in manufacturing enables the transition of traditional manufacturing systems into modern digitized ones, generating significant economic opportunities through industries re-shaping.

When smart connectivity is introduced into physical products, the industries that manufacture and sell those products will find the technology indispensable.

The end game in manufacturing innovation is improved efficiency. Industrial IoT opens the door to a world of process efficiency tools tailored to transform every aspect of manufacturing production, service, and delivery

The uneasiness centers around changing methods manufacturing companies see as tried and true, thus shaking the foundation of their business.

Extensive proof of ROI before companies rock the boat is expected. If IoT's predictive analytics is used that proof isn't hard to offer. The harder part is starting exploring technology [21].

IoT cannot and will not be mechanically forced into these companies. Especially because one of the fears around implementation is eliminating human touch. IoT help ensure that conversations happen between the right people. No matter how set your employees may be in their work routines, once they experience efficiency and savings first-hand, buy-in is almost guaranteed.

As a younger generation of manufacturing professionals is being handed the baton, they will bring with them their expectations for smart, connected, innovative devices and methods. These expectations will raise the bar for other antiquated areas of the manufacturing business.

Early IoT adopters will enjoy time in the spotlight while most other companies will be filling their pros and cons columns. It is important to note, however, that there is value in building a strategy for IoT and taking the time to set expectations, internally and externally, prior to investment.

1.8 Competitive advantages of IoT in Manufacturing sector

Digital Transformation is creating new opportunities for many industries. Manufacturing and supply chain are leading the path for digital transformation primarily through the adoption of the Internet of Things (IoT) technologies. IoT-enabled devices are growing exponentially and represent opportunities for organizations to manage, interpret and leverage vast sources of data. IoT solutions enable businesses to deliver innovative new services faster and with less risk to their customers, and deliver a true lasting competitive advantage. [8, 22, 23, 24]

1.9 Management Approach towards IoT across industries

There are four key drivers that are transforming businesses through digitization: improving customer engagement; digitizing products and exploring new business models; improving decision making and driving operational efficiencies.

Digital transformation is not only about innovations and emerging technologies. Rather, its main goal is to transform the processes and business models by using digitization as a tool in this process. Organizations need to address multiple requirements if they want to go digital and deliver the intended business outcomes. Simplification and innovation are two fundamental elements for going digital. As a part of this digital transformation, IoT is increasingly becoming part of the picture.

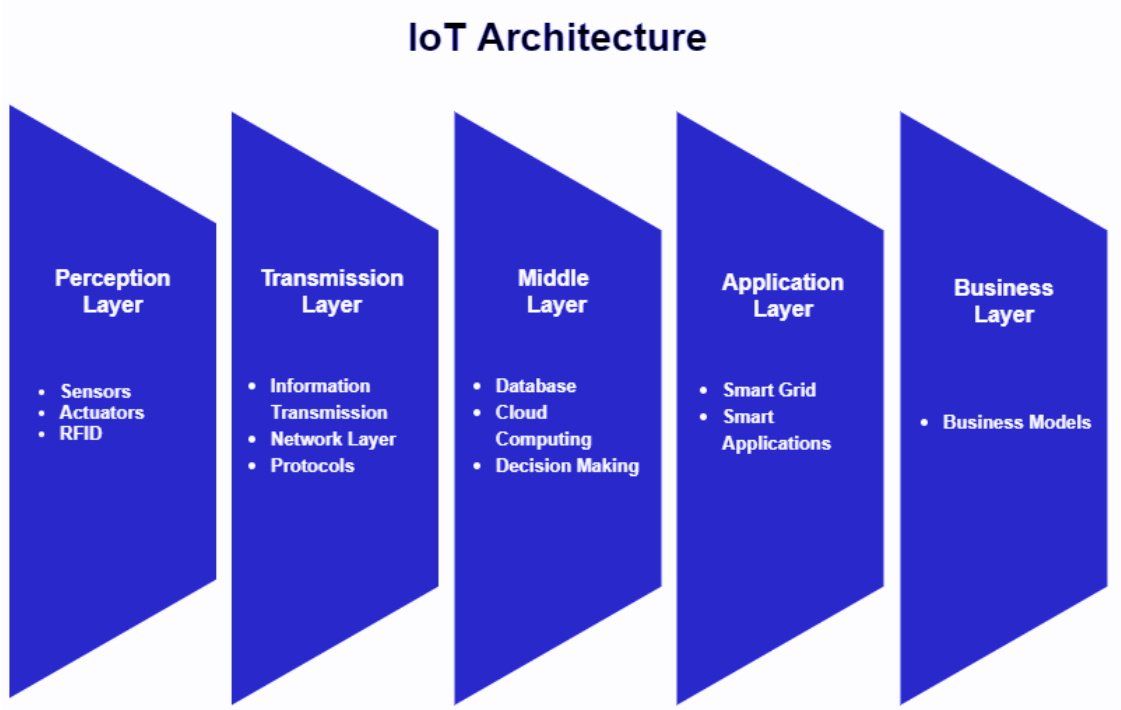
Traditional business models are changing to a customer centric mass-market approach and adapting to this is a big challenge for many businesses. To tackle this, global organizations

are considering IoT to be a strategic tool for business scalability. It is helping enterprises showcase new and innovative user experiences; and innovating customer experience and gaining their acceptance is the starting point of a digital transformation.

1.10 Glossary of various terminologies connected to IoT

1.10.1 Architecture and Key technical Terminologies [5,19]

Figure 1.6: IoT Architecture



1.10.2 The Things

Things are basically any item that can have a sensor attached to it and can be tracked by computers. For e.g. any machine, any vehicle, any gadget etc.

1.10.3 Sensors/Actuators

IoT sensors are the devices that monitor the parameters of a machine (the Thing) of interest so that an action can be taken after applying some decision logic on these parameters. For example, if a sensor sees that the water level in a water tank is too low, an action of turning on a pump can be taken. IoT sensors consist of manual or digital sensors connected to circuit boards or processing units. The circuit boards can be programmed to measure a range of data collected from a sensor device such as carbon monoxide level, temperature, humidity, pressure, vibration, and motion. Arduino or Raspberry Pi is among the popular circuit board choices during the prototyping phase of building an IoT system when a Proof of Concept (POC) is being established.

The IoT sensors (along with the rest IoT architecture) allow seamless control of data through automation by delivering actionable insights. They can be used by businesses for

predictive maintenance, enhanced efficiency, and reducing costs. Main difference between IoT sensors and simple sensors is that they can not only gather data at different physical environments, but also send data to the connected devices.

Simply put, an actuator is a mechanism that turns energy into motion. Based on the energy source used to generate the motion, types of actuators are, Pneumatic (those that use compressed air to generate motion), Electric (those that use electricity) among many others. An actuator requires a control signal that tells it when to start/stop and a source of energy that causes the actual motion. The control signal is relatively low energy and could be in the form of an electric voltage or current, pneumatic or hydraulic pressure, or even human power. It is through an actuator that a control system acts upon an environment [5].

1.10.4 Internet Gateways and Data Acquisition System

Connectivity, a key aspect of IoT, allows devices to communicate with others as well as with the applications and services that are running in the cloud. Due to the sheer volume of connected devices and due to the impact that network design decisions can have at scale, Network design and management are essential skills within IoT.

Cloud gateways facilitate data compression and secure data transmission between field gateways and cloud IoT servers. It also ensures compatibility with various protocols depending on what protocol is supported by gateways [5].

It is through these gateways that the data goes from things to the cloud and vice versa.

A gateway:

- provides connectivity between things and the cloud (a part of the IoT solution explained later in the section),
- enables data preprocessing and filtering before moving it to the cloud (this is done for storage and processing efficiency) and
- transmits control commands going from the cloud to things.

The machines (or things) then execute commands using their actuators leading to a desirable of operation based on the logic embedded into the system.

1.10.5 Edge Computing

Edge computing is a distributed computing paradigm that brings computer data storage and processing closer to the location where data is gathered and action on the machine (the thing) is to be taken. This allows data produced by the internet of things (IoT) devices to be processed closer to where it originates instead of sending it across long routes to data centers or clouds; leading to reduced data transport requirements and thereby saving network bandwidth costs and preventing data storage proliferation. As part of the implementation, Edge computing pushes applications, data and computing power away from the centralized points and toward the locations closer to the user. A Content Distribution Network (CDN) is used for performance and efficiency gain by storing content closer to its users [5].

1.10.6 Device Management

To ensure a well operating system with IoT devices, it is essential to monitor and manage the performance of connected devices. An IoT system that is not managed after its installation is unlikely to perform as expected. Some parts of device management are listed below [25]:

- It is necessary to have some device identification system to establish the identity of the device as genuine with trusted software transmitting reliable data.
- It is required to configure and control the devices to tune them according to the purposes of an IoT system. Some parameters remain fixed (like device ID) while other settings might need regular adjustments based on the desired functionality (for example, the time between sending messages with data).
- Continuous monitoring/diagnosis of the devices is necessary to ensure smooth performance and to identify risks of breakdown.
- Regular software updates are essential to maintain system security, fix bugs and to add new functionality

1.10.7 User Management

User management involves identifying users and matching their roles, access levels and ownership in a system. Typical operations involve things like, adding and removing users, managing user settings, controlling access of various users to certain information, as well as the permission to perform certain operations within a system, controlling and recording user activities and so on [5,25].

1.10.8 Networking Terminologies

Engineering approach of IoT includes sensors and communication protocols to APIs and machine learning [5, 26, 27]

Communication:

RFID - ISO/IEC Standards list

Description: A radio-frequency identification system (RFID) tags (or labels) are attached to the objects for identification. An interrogator or reader is a two-way radio transmitter-receiver that sends a signal to the tag and reads its response. This data is then transmitted by the reader to a computer system running RFID software or RFID middleware. RFID tags can be either passive, active or battery assisted passive. An active tag has an on-board battery and periodically transmits its ID signal. A battery assisted passive (BAP) has a small battery on board and is activated when in the presence of an RFID reader.

Frequency: 120–150 kHz (LF), 13.56 MHz (HF)433 MHz (UHF), 865-868 MHz (Europe)902-928 MHz (North America) UHF, 2450-5800 MHz (microwave), 3.1–10 GHz (microwave)

Range: 10cm to 200m

Examples: Road tolls, Building Access, Inventory

EnOcean - ISO/IEC 14543-3-10 (Alliance)

Description: The EnOcean technology used primarily in building automation systems. It is an energy harvesting wireless technology that also has applications in industry,

transportation, logistics and smart homes. Units based on EnOcean technology combines micro energy converters with ultra-low power electronics and enable wireless communications between battery less wireless sensors, switches, controllers and gateways.[5]

Frequency: 315 MHz, 868 MHz, 902 MHz

Range: 300m Outdoor, 30m Indoors

Examples: Wireless switches, sensors and controls

NFC - ISO/IEC 18092 and ISO/IEC 14443-2, 3, 4, JIS X 6319-4

Description: NFCs (Near-Field Communication) are short-range wireless technologies that require a distance of 10 cm or less for communication. NFC is a part of the RFID technology and operates at 13.56 MHz on ISO/IEC 18000-3 air interface and at rates ranging from 106 kbit/s to 424 kbit/s. NFC involves an initiator and a target; the initiator first generates a Radio Frequency field that can power a passive target. This enables NFC targets to be very simple, such as in the form of tags, stickers, key fobs, or cards that do not require batteries. If both devices are powered, NFC peer-to-peer communication is possible [5].

Frequency: 13.56 MHz

Range: < 0.2 m

Examples: Smart Wallets/Cards, Action Tags, Access Control

Bluetooth (SIG)

Description: For exchanging data over short distances, Bluetooth wireless technology can be used (using short-wavelength radio transmissions in the ISM band from 2400–2480 MHz) from fixed and mobile devices. Bluetooth allows creation of personal area networks (PANs) with high levels of security[5]

Frequency: 2.4GHz

Range: 1-100m

Examples: Hands-free headsets, key dongles, fitness trackers

WiFi (Alliance)

Description: With Wi-Fi technology network devices can exchange data wirelessly (using radio waves) over a computer network allowing for high-speed Internet connections. According to the Wi-Fi Alliance, Wi-Fi is a "wireless local area network (WLAN) product that is based on the Institute of Electrical and Electronics Engineers" [5].

Frequency: 2.4 GHz, 3.6 GHz and 4.9/5.0 GHz bands.

Range: Common range is up to 100m but can be extended.

Examples: Routers, Tablets, etc.

Weightless (SIG)

Description: Weightless plans to be an open standard that uses White space (wavelength radio transmissions in unoccupied TV transmission channels) to exchange data between a base station and many other machines around it with high levels of security [5].

Frequency: Varies with legislation (470 – 790MHz)

Range: Up to 10km

Data Rates: 1kbits/s to 10Mbits/s

Examples: Smart meters, traffic sensors, industrial monitoring

GSM (Association)

Description: GSM (Global System for Mobile communications) is used for transmitting mobile voice and data services. It is an open, digital cellular technology and it already serves 90% of the world's population. In the areas where terrestrial coverage is not available, GSM satellite roaming can instead provide access [5].

Frequency: Europe: 900MHz & 1.8GHz, US: 1.9GHz & 850MHz

Data Rate: 9.6 kbps

Examples: Cell phones, M2M, smart meters, asset tracking

There are many other communication methods available like 3G, 4G LTE, ANT, Dash7, Ethernet, GPRS, PLC / Power line, QR Codes, EPC, WiMax, X-10, Zigbee, IPv4 /IPv6 and many more

Internet Protocol is an identification/location system for computers on networks for routing traffic across the Internet (latest version is v6, IPv6). Before it can communicate with other devices on the internet, every device must be assigned an IP address.

UDP

The User Datagram Protocol (UDP) is one of the core members of the Internet protocol suite (the set of network protocols used for the Internet). With UDP, computer applications can send messages, in this case referred to as datagrams, to other hosts on an Internet Protocol (IP) network without prior communications to set up special transmission channels or data paths.

TCP

The Transmission Control Protocol (TCP) is intended for use as a highly reliable host-to-host protocol between hosts in packet-switched computer communication networks, and in interconnected systems of such networks.

6LoWPAN

6LoWPAN is an acronym of IPv6 over Low power Wireless Personal Area Networks. The 6LoWPAN group has defined encapsulation and header compression mechanisms that allow IPv6 packets to be sent to and received from over IEEE 802.15.4 based networks.

1.10.9 Hardware

- **Wireless SoC (system on chip)**

  Manufacturers like Gainspan, Wiznet, Nordic Semiconductor, TI and others are creating self-contained, RF-certified module solutions that have TCP, UDP and IP on chip. These solutions include built-in security features, can reduce certification time and allow companies to add communication to any microcontroller-based (MCU-based) product with little RF expertise.

- **Prototyping boards and platforms**

  From the Arduino to the Raspberry Pi to the new Beagle Bone Black, there are a large number of community DIY (Do it yourself) and prototyping platforms available that are making it possible to create your own Internet of Things project.

1.10.10Protocols

- **Constrained Application Protocol (CoAP)**

  A software protocol intended to be used in very simple electronics device that allows them to communicate interactively over the Internet. It is particularly targeted for small low power sensors, switches, valves and similar components that need to be controlled or supervised remotely, through standard Internet networks. CoAP is an application layer protocol that is intended for use in resource-constrained internet devices, such as WSN nodes. CoAP is designed to easily translate to HTTP for simplified integration with the web, while also meeting specialized requirements such as multicast support, very low overhead, and simplicity.

- **Representational State Transfer (REST)**

  A style of software architecture for distributed systems such as the World Wide Web. REST has emerged as a predominant web API design model.

- **Message Queue Telemetry Transport (MQTT)**

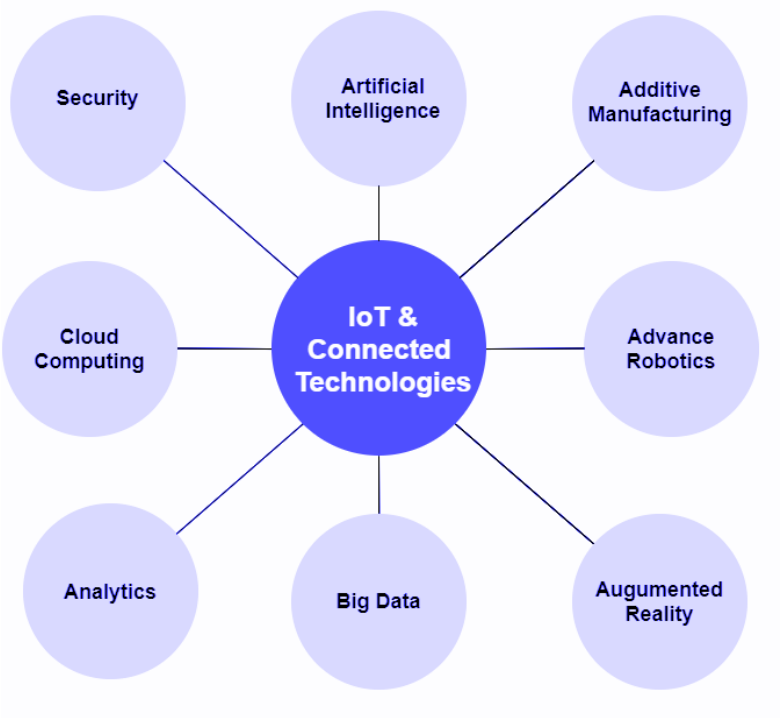
An open message protocol for M2M communications that enables the transfer of telemetry-style data in the form of messages from pervasive devices, along high latency or constrained networks, to a server or small message broker.

- **The Extensible Messaging and Presence Protocol (XMPP)**

  An open technology for real-time communication, which powers a wide range of applications including instant messaging, presence, multi-party chat, voice and video calls, collaboration, lightweight middleware, content syndication, and generalized routing of XML data.

1.10.11Technological Advances and Connected Technology

Figure 1.7: IoT and connected technologies



1.10.11.1 Artificial Intelligence

Artificial intelligence (AI) is an area of computer science that attempts creation of intelligent machines that act like humans and work autonomously (or-semi autonomously) once trained. AI is anticipated to perform a plethora of smart tasks such as voice recognition, face identification, language translation, targeted advertising, and so on without explicit human instructions. AI relies on data to train itself and as a result gains intelligent autonomy to act when faced with a previously unseen data point. As a general rule, the more training data, the better the AI algorithms perform when deployed. Hence, AI has better potential in applications that generate a vast amount of data during their day to day operations. This can be used to gradually train an AI algorithm which can then act either in place of a human operator or enhance system performance by doing tasks that are not well suited for a human. As we have seen, the Internet of Things (IoT) includes a chain of interconnected devices that transfer data over a network. IoT devices have made an entry into our daily lives with the goal of enhancing our comfort. These devices operate on

internet connectivity and generate inconceivable amounts of data that is pertinent to user behaviors, their preferences, choices and their personal information.

Artificial intelligence, in this case, can greatly help by making use of the deluge of data that is moving through the IoT devices. It allows us to analyze the data, make sense out of it and thus AI is predicted to be the chief propellant in initiating the unprecedented growth of the IoT revolution. AI has the capability to provide analytics that is required to extract meaning from Big Data and in the process Big data is a critical knowledge provider for AI to continue to learn and become more intelligent. Enterprises are still unsure as to how to store and process such outsized amounts of data. This is, to an extent, encumbering the growth and potential of IoT.

The types of tasks that AI can perform in an IoT ecosystem can be divided into three broad categories of operation:

- Predictive: This kind of operation is useful with preventative maintenance. Predictive analysis helps to determine when a part of the machinery is most likely to experience a breakdown and hence such a scenario can be avoided through preemptive intervention.
- Prescriptive: Prescriptive analysis offers immediate suggestions that can be instrumental in preventing any kind of disasters or botches.
- Adaptive/Autonomous: Constant data feeds from sensors can help the systems in performing frequent actions autonomously without any human involvement

The collective effect of AI & IoT will be first witnessed when routine and repetitive manual tasks will be automated, thus providing assisted intelligence. As the complexity of decisions in different situations escalates, AI can supplement human decision making, providing augmented intelligence. Finally, when a stage reaches such that machines become able enough to learn about various situations and make consistent and predictable decisions that humans can trust, they shall become autonomous. The potential benefits of both AI and IoT can be obtained when they are combined at the devices end as well as at server. As an example, AI combined with Machine learning can study from the data to analyze and predict the actions necessary in the future in advance, such as order replacements in marketing and preventing failure of equipment in industry before it occurs.

In addition, AI can be used with machine learning in smart-homes to enhance the user experience; for instance, AI techniques combined with IoT can be used to analyze the human behavior via Bluetooth signals, motion sensors, or facial-recognition technology and to make the corresponding changes in lighting and room temperatures [5].

1.10.11.2 Additive Manufacturing (3D printing)

Additive Manufacturing (AM) is a phrase used to describe the technologies that build 3D objects by adding layer-upon-layer of material. In other words, it refers to a process by which digital 3D design data is used to build up a component by depositing material layer after another. The term "3D printing" is increasingly used to mean additive manufacturing. Based on material of choice, there are various kinds of 3D printing, such as those utilizing thermoplastics or other polymeric materials.

Use of 3D printing reduces marketing time by shortening the path from conception of an idea and its first prototype. Integration of 3D printing in IoT product development has become vital in order to achieve progress while gaining temporal as well as monetary advantage as 3D printing is much cheaper than traditional manufacturing. These advantages enable solutions in many industries like: Automotive, Medical, Aerospace, Consumer, and many others.

A Hybrid process refers to the combination of additive and subtractive manufacturing (SM) processes applied sequentially or in integrated fashion, including proper fixturing and orientation control to form the parts. This approach is used both to enhance the dimensional accuracy and to accelerate the overall production process. The inadequacies of fabricating complicated areas, where a single manufacturing process (subtractive or additive) is not sufficient, can be overcome using hybrid techniques.

Having looked at all the benefits of AM, there however is certainly a long way to go to establish a true Internet of Things across the world of additive manufacturing. This will involve developing the tools to implement these concepts, and successfully establishing them as a fundamental part of company cultures. With passage of time as these ideas take hold, we will soon see the smart factories of tomorrow come to fruition [5].

1.10.11.3 Advanced Robotics

Robotics is a field that utilizes ideas from various fields like mechanical engineering, information engineering, electronic engineering, computer science, and so on. In 1954 George Devol invented the first digitally operated and programmable robot called the Unimate. In 1961, the first industrial robot, Unimate, went online in a General Motors automobile factory in New Jersey. Engelberger (known as the father of modern robotics) along with George Devol, licensed, patented and developed “Unimate”, the first industrial robot in the United States [5].

Today, most robots are deployed to perform repetitive or dangerous jobs. For instance, operating inside a toxic environment or doing a simple repeated action on an assembly line. They work in factories to build things like cars, candy bars, and electronics. This is sometimes characterized as the “long tail” of tasks that are allocated to relatively low paying repetitive jobs. These include actual physical robots that can, for instance, manage a warehouse moving boxes around or clean the floor in large plants and of course you have extensive robotics in Manufacturing.

The most advanced humanoid robot to date has been developed by a team of researchers at the University of Tokyo. Named Kengoro, the robot has been made as similar to humans as current technology allows. Kengoro is the most advanced because he is the latest model, they have made two others previously.

Bringing IoT to a factory floor is as much about robots as it is about any other class of device. Regardless, robots are attractive in their own right because labor costs are rising globally. Companies are desperate to address this problem and despite capital costs and limits on the technology, they are increasingly investing in robotics for automation. In turn, those robotic investments are often matched and sometimes melded with investments in smarter, IoT-equipped factories. Although robotics for automation generally focuses on movement and manipulations, IoT and robotics involves a world of devices in the field: devices that depend on electronic sensors and software. The IoT and robotics communities are coming together to create The Internet of Robotic Things (IoRT). The IoRT is a concept in which intelligent devices can monitor the events happening around them, fuse their

sensor data, make use of local and distributed intelligence to decide on courses of action and then behave to manipulate or control objects in the physical world. Both IoT devices and robots depend on sensors to understand the environment around them, quickly process data and determine how to respond. Robots are able to handle anticipated situations, while most IoT applications can only handle well-defined tasks.

1.10.11.4 Augmented Reality

Augmented reality (AR) is a type of interactive, reality-based display environment that makes use of the capabilities of computer generated display, sound, text and effects to enhance the user's real-world experience. As against virtual reality (VR), which replaces your vision, augmented reality adds to it. VR completely covers and replaces your field of vision while AR apps only show up on your smartphone or tablet screen, and even wearable like hololens can only project images in a limited area in front of your eyes [5].

Figure 1.8: Use of Augmented reality

AR changes the existing reality by making it more meaningful as it allows the user to interact with it while enhancing his/her understanding. Hence, augmented reality has a great potential to be used in the classroom as it can change the way students interact with the real world, enhances student engagement, and makes the learning of their subject content fun. In the beginning the personal computer, smartphone and tablet applications for augmented reality focused mostly on games, but the uses of AR are much broader. For

instance, the military uses augmented reality to assist men and women as they make repairs in the field while medical personnel use AR to prepare for surgery. AR is also more widely accessible compared with VR. While VR requires dedicated hardware, anyone can use AR on their phone with the aid of an app that supports AR. Some popular examples of AR apps include AcrossAir, Google Sky Map, Layar, Lookator, SpotCrime, and PokemonGo [5].

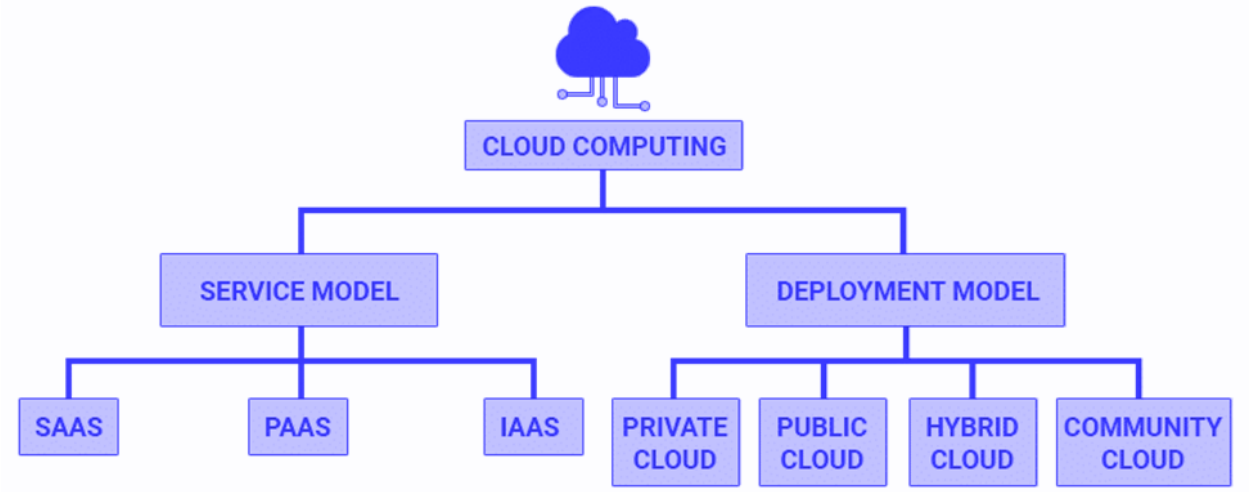
Augmented Reality is acquiring a new dimension with IoT able to connect and utilize digital information from various devices. Using specialized hardware and software, Augmented Reality seamlessly overlays 3D digital content on top of the existing environment while no longer being restricted to the media and entertainment and gaming industries. Through its unique user experience and digital twin, Augmented Reality is enabling enterprises to modernize the entire gamut of business functions from R&D, and customer and employee engagement to manufacturing, production and field services.

1.10.11.5 Cloud Computing

The term “Cloud” originated from a network design that was used by network engineers for representing the location of various network devices and their interconnections.

Today, data storage has become a priority in all fields due to an increase in computer and Mobile user’s activity. Both large and small scale businesses thrive on their data and spend a huge amount of money to maintain it, in the process, requiring a strong IT support and a storage hub. However, not all businesses can afford the high cost of in-house IT infrastructure and back up support services. Here, Cloud Computing comes into the picture as a cheaper solution. Its efficiency in storing data, computation and less maintenance cost has led to attention from the bigger businesses as well.

Figure 1.9: Various models of Cloud computing



As needs of different businesses vary, four main types of cloud computing models are offered [28].

- Private cloud: This type of cloud serves requirements of a single organization. This is typically used for internal work within an organization Where the computing resources can be governed, owned and operated by the same organization.
- Community cloud: As the name suggests, computing resources are shared between organizations or within a community.
- Public cloud: This type of cloud is usually used for Business to Consumer (B2C) type interactions. Here, computing resources are typically owned-governed-operated by city/state/country governments, academic organizations or businesses.
- Hybrid cloud: As necessary, computing resources from different clouds are tied together and this architecture is referred to as a hybrid cloud.

There are three major types of cloud computing offerings

Software as a Service (SaaS)

- SaaS is a model where a customer can access applications/software hosted by a vendor (or service provider) via the internet. As technologies that support web services become mature and recent developmental tools like Ajax became popular, SaaS has become increasingly prevalent model of cloud computing. Since delivered over the internet, users anywhere in the world can access these services.

- Traditionally users purchased a software suit for use at their end. With SaaS, this model is now changing with users being able to subscribe to software on a monthly or yearly basis whether it is a single user, a small group of users or thousands of users in a large corporation.
- It is increasingly used for financial accounting, planning, 3D modeling and so on.

Platform as a Service (PaaS)

- PaaS is a service that is hosted on the cloud and provides the users, via the internet, a platform/environment for building applications and services.
- To understand in simple terms we can use the following analogy. It is like working on an art project where you are provided with all the raw materials and tools needed to accomplish your art piece. You simply have to make use of the right materials and tools to bring your work-piece to fruition.
- Typically, PaaS services are regularly updated with features. It also includes software support and support for management services, storage, networking, deploying, testing, collaborating, hosting and maintaining applications. Professionals that benefit from PaaS services include Software developers, web developers and related business.

Infrastructure as a Service (IaaS)

- Alongside SaaS and PaaS, IaaS is the third fundamental model of cloud computing. It provides access to computing resources in a virtualized environment "the cloud" on the internet. Examples include: virtual server space, network connections, bandwidth, load balancers and IP addresses. Hardware resources needed for the service are pooled together and distributed across numerous data centers providing redundancy and reliability to IaaS.
- IaaS provides a complete computing package. It is attractive to small scale businesses that are looking to cut costs on IT infrastructure as it saves money spent on maintenance and purchase of hardware, network connections, external storage spaces and the like.

In Spite of all the benefits of cloud computing, there are some downsides to it that cannot be overlooked. Currently, privacy presents a strong barrier for users to adopt Cloud Computing. The administrative staff of the cloud computing service could theoretically

monitor the data moving in memory before it is stored. To maintain the confidentiality of this data, administrative and legal controls should be in place. Another way to increase privacy is to keep the data encrypted at the cloud storage site, preventing leakage via unauthorized access through the internet.

1.10.11.6 Big Data :

It refers to a massive amount of data that keeps on growing exponentially with time.

It is so voluminous that it cannot be processed or analyzed using conventional data processing techniques.

It includes data mining, data storage, data analysis, data sharing, and data visualization.

The term is an all-comprehensive one including data, data frameworks, along with the tools and techniques used to process and analyze the data.

Types of Big Data

- Structured

  It refers to highly organized information that can be readily and seamlessly stored and accessed from a database by simple search engine algorithms.

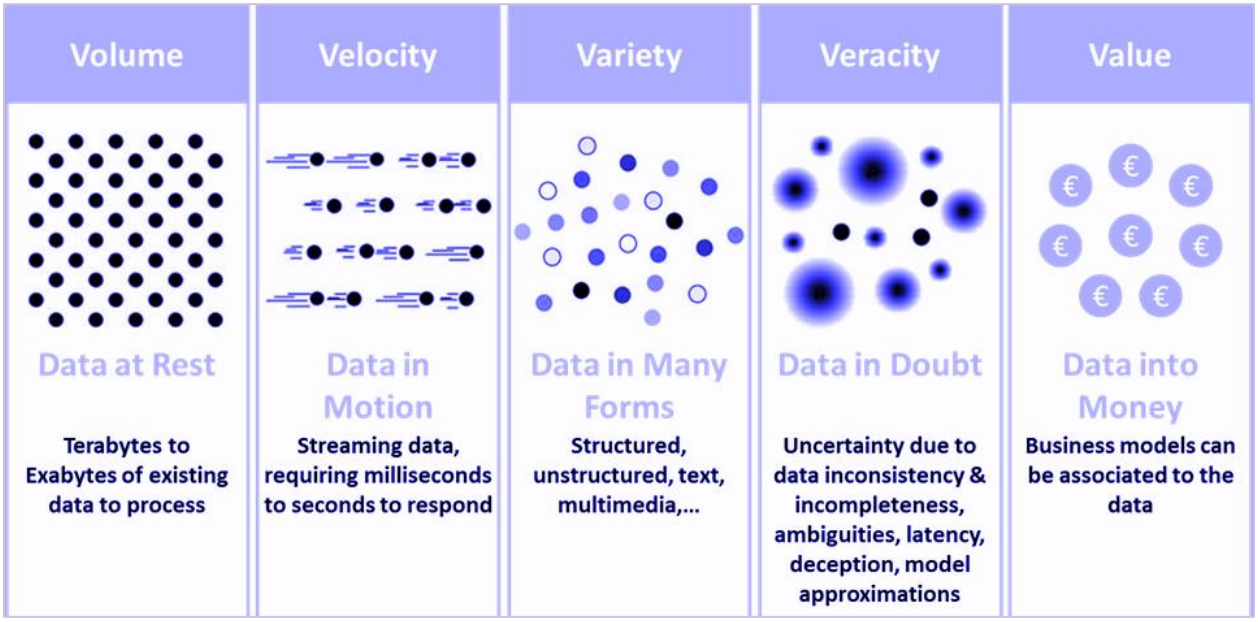
- Unstructured

  Unstructured data refers to the data that lacks any specific form or structure whatsoever. This makes it very difficult and time-consuming to process and analyze unstructured data.

- Semi-structured

  Semi-structured data pertains to the data containing both the formats mentioned above, that is, structured and unstructured data. To be precise, it refers to the data that although has not been classified under a particular repository (database), yet contains vital information or tags that segregate individual elements within the data.

Figure 1.10: Type of Data



Advantages:

- One of the biggest advantages of Big Data is predictive analysis. Big Data analytics tools can predict outcomes accurately, thereby, allowing businesses and organizations to make better decisions, while simultaneously optimizing their operational efficiencies and reducing risks.
- By harnessing data from social media platforms using Big Data analytics tools, businesses around the world are streamlining their digital marketing strategies to enhance the overall consumer experience. Big Data provides insights into the customer pain points and allows companies to improve upon their products and services.
- Being accurate, Big Data combines relevant data from multiple sources to produce highly actionable insights. Almost 43% of companies lack the necessary tools to filter out irrelevant data, which eventually costs them millions of dollars to hash out useful data from the bulk. Big Data tools can help reduce this, saving you both time and money.
- Big Data analytics could help companies generate more sales leads which would naturally mean a boost in revenue. Businesses are using Big Data analytics tools to

understand how well their products/services are doing in the market and how the customers are responding to them. Thus, they can understand better where to invest their time and money.

- With Big Data insights, you can always stay a step ahead of your competitors. You can screen the market to know what kind of promotions and offers your rivals are providing, and then you can come up with better offers for your customers. Also, Big Data insights allow you to learn customer behavior to understand the customer trends and provide a highly 'personalized' experience to them [5].

Challenges in Big Data Integration

- The Uncertainty of Data Management
- Talent Gap in Big Data
- Getting Data into Big Data Structure
- Syncing Across Data Sources
- Extracting Information from the Data in Big Data Integration
- Other challenges like integration of data, skill availability, solution cost, the volume of data, the rate of transformation of data, veracity and validity of data

1.10.11.7 Analytics

Analytics provides many ways to access, organize, and visualize the data according to business needs.

It is concerned with turning raw data into insight for making better decisions. Analytics relies on the application of statistics, computer programming, and operations research in order to quantify and gain insight into the meanings of data. It is especially useful in areas which record a lot of data or information

Analytics often involves studying past historical data to research potential trends, to analyze the effects of certain decisions or events, or to evaluate the performance of a given tool or scenario. The goal of analytics is to improve the business by gaining knowledge which can be used to make improvements or changes.

Sample dashboard in manufacturing sector:

Figure 1.11: Sample analysis graph for wastage in the manufacturing plant

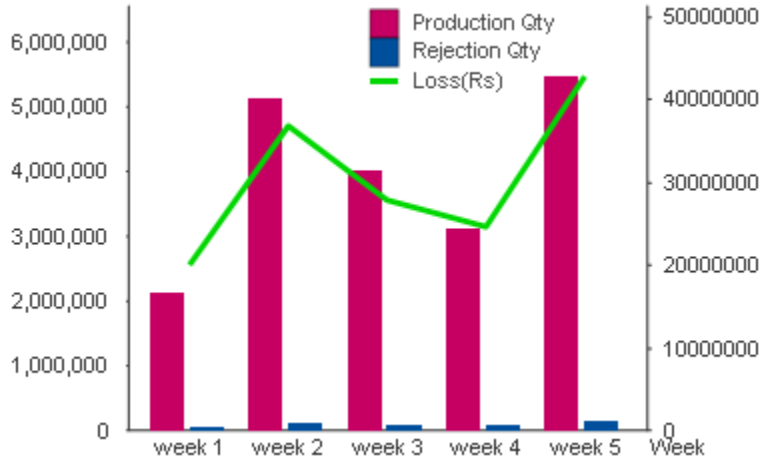
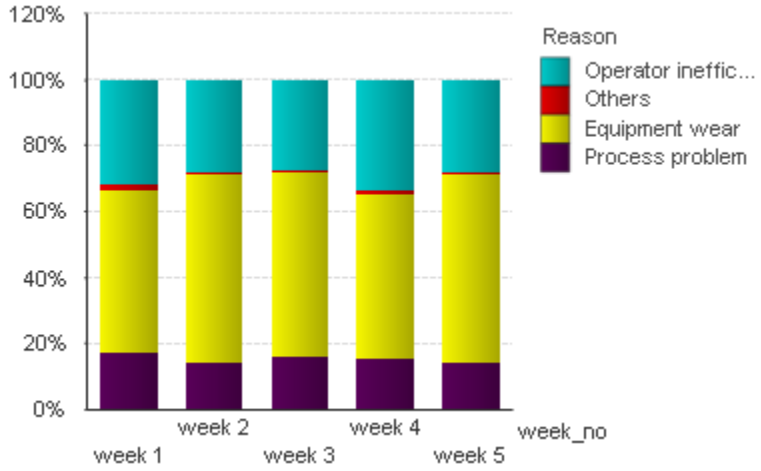


Figure 1.12: Sample analysis graph for downtime reasons in the manufacturing plant



Advanced Analytics is the autonomous or semi-autonomous examination of data or content using sophisticated techniques and tools, typically beyond those of traditional business intelligence (BI), to discover deeper insights, make predictions, or generate recommendations [15].

1.10.11.8 Security Monitoring

Security is one of the important concerns in the IoT ecosystem. All the data produced by connected things must be securely transmitted and protected from cyber-criminals. Another concern is that the things that are connected to the internet can be targets of malicious activity by bad actors. In the worst case scenario, cyber-criminals can get access to the “brain” (logic/operations/controls/command) of the whole IoT system to stall it or operate it undesirably [9].

As a preventative measure, it is necessary to log and analyze the commands sent by control applications to things, monitor the actions of users and store all these data in the cloud. Ensuring such rigor, it is possible to address security breaches at the earliest stages and take measures to reduce their influence on an IoT system.

With smart, Artificial Intelligence (AI) based system, it is also possible to identify patterns of suspicious behavior, and store these samples to compare them against system logs generated in the future. This could prevent potential penetrations and minimize their impact on an IoT system.

1.11 Summary

It has been seen that IoT adoption has started globally. It can be applied in various domains and across multiple applications. It is been considered as a competitive advantage for any company. Its adoption in India at large scale can give major advantages to the manufacturing sector. While exploring this thought below points came forward.

As the technology is new, it is required to know how management is looking at it. Though the technology implementation has started, it is essential to understand their approach towards implementation. Understanding the same will provide companies plan for digital transformation

- Whether IoT is Part of Company's digital transformation?
- Are companies ready with its IoT plan and Journey?
- People interested in pursuing their career in IoT, know how they should share their career in the IoT field?
- Are companies ready for the adoption?
- What is their awareness level about IoT?
- Are companies aware about Advantages and Challenges of IoT?
- Is the eco-system for IoT adoption ready?

These all questions triggered the research in this area. This chapter concludes with the objective of the research work and the problem statement.

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Chapter - 2

Literature Review

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2.1 Introduction

This chapter provides the background about the previous scientific research that has been done with the consideration of various aspects of Internet of Things (IoT), on the basis of IoT application, usage, adoption, connected technologies. For this review we have gone through 28 research papers, manufacturing company website, various articles published by IoT implementers/partners. The research papers not only include papers from academic but also few research papers from Industry.

2.2 About IoT & Manufacturing

Thousands of railway trains are running on multiple routes per day in Rome. Trenitalia (Train transport company, Rome, Italy) which is the primary train operator in Italy shifted its approach from reactive activities to a system that provides the real conditions of each component run time [29].

Referring to the above example, the digital space has witnessed major transformations in the last couple of years & the latest entrant to the digital space is the Internet of Things (IoT) (CII Summit 2018). IoT has the potential to transform India in many ways. The demand for IoT in India is emerging across industries such as utilities, automotive, transportation, logistics and manufacturing. Everyday customers are already using IoT enabled smart devices for health and wellness, tracking devices for personal safety, and also the emerging smart home systems category. And the government, whose flagship initiatives like Digital India & Make in India feature IoT as a key enabler of public utilities and services.

The manufacturing sector has a large footprint in the US economy, producing a gross output of $2.2 trillion in 2016, 11.7% of the total American GDP. To achieve competitive advantages in global markets, modern manufacturing enterprises strive to create new products or services with exceptional features such as adaptation, customization, responsiveness, quality and reliability at unprecedented scales [31].

For industrial enterprises, digital transformation often translates into a phrase called Smart Manufacturing. Smart Manufacturing is not only about digitizing the manufacturing function but also about using digital technologies to unlock new operating efficiencies during product conceptualization, design and manufacture and towards delivering hyper-personalized experiences to customers across the product lifecycle [50].

By enabling continuous delivery and continuous innovation, smart manufacturing has already started to create the outcome economy, where goods are delivered as a service. In addition, according to Accenture (2017) [49], smart manufacturing could unlock between 9% and 48% of additional value, depending on the sector.

Internet of Things (IoT) is one of the critical enabling technologies for smart manufacturing; it is the formation of a global information network composed of large numbers of interconnected "Things". For manufacturing companies, "Things" include machines, robots, materials, sensors, actuators, controllers, human operators, equipment, products, material handling equipment etc. IoT infrastructure provides a unique opportunity to link manufacturing "Things," services, and applications to achieve effective digital integration [31].

IoT is defined in various ways across world [32]:

Definition 1: The networking of physical objects using embedded sensors, actuators, and other devices that can collect or transmit machine information.

Definition 2: IoT is a network of connected objects having a unique identity for every object.

Definition 3: IoT is integration of machine, Person or any physical device has the ability to transfer data over the network

Definition 4: IoT is world of things, internet, and technology platforms. It is integration of all that is commonly used to enable interconnection

Internet of Things (IoT) term represents a general concept where in sensors sense the data which is retrieved through various devices and utilized for analysis as well as to check the trends of data. It includes various machines, objects, environments and infrastructure which are communicating with each other [12].

2.3 About Industry 4.0

At Hanover fair conducted in January 2011, Germany government introduced a new concept as one of its “strategic initiatives” termed as the Industry 4.0 that is adopted as a part of the High Tech strategy 2020 action plan. (ISSN (Online) 2393-8021, 2017). In Germany, a lot of prominent institutions, research and trade actors have joined their hands to work together in order to realize the close vision of Industry 4.0 [33].

IoT is believed to bring the ‘fourth industrial revolution’ widely known as ‘Industry 4.0’ [30].

Industry 4.0 is a common discussion topic for researchers, academicians and industry communities at various occasions in Germany [34].

The main idea is to exploit the potentials of new technologies and concepts such as :

- availability and use of the internet and IoT,
- integration of technical processes and business processes in the companies,
- digital mapping and virtualization of the real world,
- ‘Smart’ factory, ’Smart’ manufacturing including ‘smart’ means of industrial production and ‘smart’ products.

Considering the current state of Industry 4.0, it is important to understand the preconditions that have to be fulfilled so that a new concept can be introduced in the manufacturing system. At least the following has to be fulfilled [34]:

- Stability of the production has to be guaranteed also during the transition phase.
- Stepwise investment should be possible as most of the industrial processes cannot bear big one-time investments.
- A good know-how protection is necessary. Closely connected is the cyber security issue.

2.4 IoT developments

To evaluate the current state of the German organization a study was conducted on the readiness of Germany companies for Industry 4.0. The following six dimensions were evaluated:

- Organization plan, strategy ,Investment and Innovation management
- Smart applications, data capturing and its use for various reports and updates
- Digital modeling with use of IT systems and various equipment
- Integration of various systems ,data storage and application for Smart operation
- Various tagging, virtual identity for components and products
- Data-driven services with predictive analysis and decision making
- Employee skill sets

Although the concept is very comprehensive and complex, three main points can be identified [34]:

- The Industry 4.0 concept is not limited just to the direct manufacturing in the company but it also includes a complete value chain from providers to customers and all enterprise's business functions and services.
- The Industry 4.0 assumes broad support of an entire life cycle of systems, products and series, distributed both spatially and organizationally.
- The smart products continuously provide the data, pre-process, during the manufacturing process and post manufacturing process
- The data is very important for preventive maintenance, troubleshooting, overall analysis, daily dashboards etc.
- It can provide the manufacturer useful information about lifetime and reliability of their products.
- Industry 4.0 is a specialization of the IoT applied to the manufacturing/industrial environment. It assumes a real-time data collection leading to the issue of handling and analyzing big data and cyber security.

After almost 30 years, manufacturing has started taking momentum in the form of Industry 4.0 and IoT. It has the ability to optimize supply chain thereby facilitating the production of high-quality goods at low costs. This, in turn, boosts up the ability of manufacturing plants [30].

Forrester predicts (2018), for the Indian Manufacturing sector- IoT will move from the shop floor and become an essential part of B2B value propositions & pricing models. Providing proactive & predictive maintenance services would become a business model for many companies, to ensure better customer experience.

Real-time data – from people, processes, and devices through sensors is a real revolution. It is really a game changing where we can see innovation in various manufacturing processes and various sub domains of the manufacturing sector. It will provide more visibility across the process [35].

Many companies are thinking that IoT is something very expensive and not for their pocket. Due to this attitude companies are limiting themselves from exploring IoT and its advantages. Any company begins its digital journey by making data available on digital systems and eventually bringing isolated processes & functions to exchange information. Realizing data as an asset and technologies like IoT the medium for simplifying & enabling organizations to capitalize this data, is important. Those who have realized this are the digital leaders of their sector, and the rest will soon follow [35].

2.5 Challenges in Manufacturing companies Vs. IoT Solution

Indian IoT Panel (2017) revealed various problems from Indian Manufacturing companies where IoT can be the solution [19, 38, 45, 88]:

- Frequent machine breakdown causing Production loss, impacting Quality, Shelf life and Revenue
- Excess material in every packaging resulting in to revenue loss
- Higher lead time in instrumentation availability
- Higher test set up template creation time
- Higher cost of measurement equipment and analysis tool
- Lack of portability of the existing solution
- Complaints due to faulty parts being sent to customers
- Problem of defective parts being mixed with good parts
- Need for shift wise rejection scenario to be transparent
- Resources wasted in coordination & walking distance
- Long reaction time for breakdowns
- Increased rejections due to wrong assembly of components
- Increase in Man-movement for checking plunger size and quantity leading
- Non availability of live representation of machine health in shop floor
- Non availability of database of errors for every machine in turns problem in speedy troubleshooting
- Low productivity and OEE
- Increasing cost spent on test benches and minimize noise level
- Increasing cost of operation due to inefficient usage and monitoring of energy
- Difficulty in real time inventory tracking with respect to types
- Dynamic production planning system not available
- No reliable method to track products or raw materials in the production line
- In case of a recall, no accountable method to trace root cause of problem
- Inaccurate inventory reporting causes increased stock

2.6 IoT Benefits and Challenges

As IoT is new technology and being relatively transparent to the users, it is likely that some of the consumers use at least some simple IoT networks without knowing about it (2017). It means that some traditional information technology theories may not be adequate for explaining the adoption of IoT devices and their applications among consumers.

IoT adoption was explored in Danish companies considering various parameters. It says that IoT-enablement can happen on five levels [36]:

- Monitoring
- Control
- Optimization
- Autonomy
- System Autonomy

Danish company respondents exhibit greater belief in IoT than foreign counterparts. However, very few companies have their vision defined about IoT.

All products, devices, facilities, systems, equipment, delivered goods, processes, workflows, and people will coexist in a connected world, interacting and being interdependent. The future with IoT embraces the reality that no product or asset will be an island. IoT systems will act like social networks, socializing connected product data to foster unparalleled knowledge and collaboration [37].

It has been started to build IoT Ecosystem, there are many IoT platform vendors competitive landscape of such vendors' highlights that there is no dominant provider of IoT platforms. In fact, the market is extremely crowded with a very broad range of companies, with a mix of startups, big industrial players, and system integrators and traditional IT companies all competing to provide solutions in space [15].
In addition, a significant number of vendors are adding IoT capabilities to their portfolios, making the landscape unclear.

In order for technology providers to successfully sell IoT, it is imperative to focus on the business value [20].

While conducting the survey in USA for manufacturing companies regarding various benefits below results were seen:

Figure 2.1: IoT benefits in Manufacturing

It has been found that IoT will have a great impact on the economy by transforming many enterprises into digital businesses and facilitating new business models, improving efficiency and increasing employee and customer engagement [29].

Initially, leaders viewed IoT as an immediate solution to all their business problems, however , with small experiment or proof of concepts ,the company leaders got to know that there are many other parameters which need to be checked before going for IoT implementation. The problem statement should be very clear to implement IoT solution [29].

Leaders have started exploring the applications and use cases for which the IoT is best suited as their organizations embarked on their journeys toward digitalization. They are expecting some of these ‘explorers’ to move to the ‘reality’ phase, when proof of concept (POCs) graduate to commercial or production deployment.”

The effective use and implementation of IoT will be beneficial for the large as well as small organizations. IoT by using sensors connect the different devices used throughout the manufacturing unit of the industry. In this way, this cutting edge technology is shifting the entire working scenario of the enterprises by providing better customer service, enhanced processes, and new avenues for business, well-structured insights and better control over others [30].

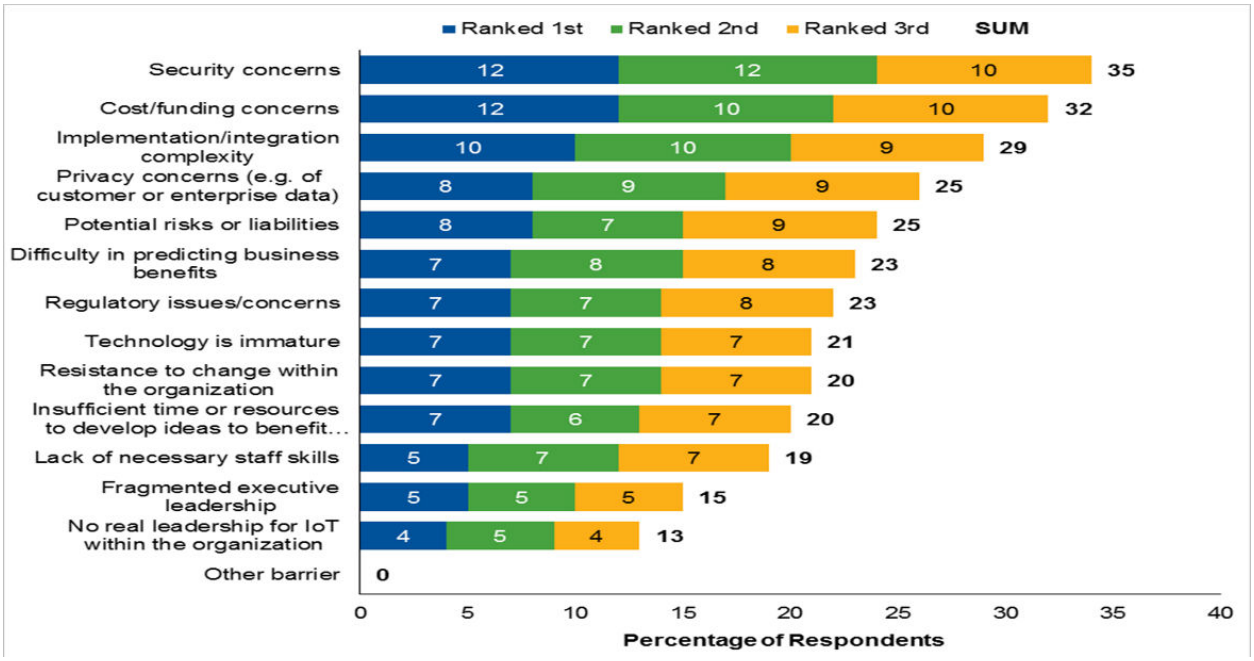
It is been observed that IoT use cases focused on delivering cost savings and indirectly increasing the margins. It is focusing on fuel, energy and labor which often have significant financial impact and shorter payback time frames [29].

Mapping out the best practices for getting an IoT initiative off the ground, including upfront agreement and mapping of the IoT to business objectives, development of use cases and creation of a vision and roadmap, can help you stay on track to deliver on the stated business objectives as your IoT project progresses.

It has been concluded that to move forward with IoT, digital capabilities are all important. Time commitment, patience is very important as a step-by-step approach is required for any project to be successful. But move with deliberate speed, so that you don’t lose the first-mover advantage to competitors [38].

Few Barriers observed to IoT Success [39]:

Figure 2.2: Barriers observed to IoT success



There are few challenges manufacturers are facing in workforce management along two basic components [40]:

- Shortage of expertise. An aging workforce — workers with a significant amount of expertise at or reaching retirement age — as well as stagnant or declining numbers of new graduates in manufacturing- and engineering-related disciplines
- Technology savvy. An incoming workforce that treats technology of all kinds as a natural component of the work process

Lack of digital skills and transformation culture top the list of the challenges identified by survey respondents conducted by PWC (2016) from industrial products companies in 26 countries across Europe, the Americas, Asia Pacific, Middle East and Africa.

Few management challenges were mentioned while studying various challenges [40]:

- Awareness of IoT at all stages
- IoT buying from various leaders across organization

- Communication between stakeholders in organizations and line-of-business (LOB) leaders
- Priorities of functional leaders across engineering, maintenance, manufacturing, supply chain, and services leading to better funding for IoT programs.
- Decreasing trend in hardware, software, and services cost as partners who offer this leverage the economies of scale as more enterprises adopt IoT.

Additionally, despite the deep belief in IoT, Lack of convincing business cases is the most important barrier in Danish companies [36].

Barriers to IoT adoption, ranked according to importance for Danish company respondents

1. Lack of convincing business case
2. Handling new technologies
3. Security
4. Risks associated with change
5. Qualified personnel
6. Privacy
7. Employee resistance

Few more roadblocks were added to IoT challenges [36]:

- A perceived high cost of IoT that holds companies back.
- A challenge of identifying the value capture in a company-specific context - despite an almost unanimous belief in the potential of IoT. A clash between IoT and companies' traditional governance structures, as IoT still presents both uncertainties and a lack of historical precedence.
- that occurs when IoT requires a company to undergo change to a degree that it stifles action.
- Knowledge gap on IoT, especially among top management.

Though IoT adoption has various challenges, it also has various benefits and competitive advantages considering which challenges can be handled.

IoT helps organizations to differentiate themselves in three areas [40]:

- Productivity and efficiency in the factory to manufacture quality products at lower cost by means of proactive and predictive maintenance of the manufacturing equipment.
- For competitive product differentiation by offering new functionalities bundled with software.
- New business models such as a pay-according-to-use model, which were not possible before because of the lack of technology.

Few IoT Applications and Benefits across the Manufacturing Value Chain [21]:

- Complex automation: Rapid, real-time sensing of unpredictable conditions and instantaneous responses.
- Connected supply chain: Stakeholders can understand interdependencies, flow of materials and manufacturing cycle times.
- Tracking: Movement of products.
- Factory visibility: Production line information provided to decision-makers.
- Proactive maintenance
- Safety and efficiency.
- Self-controlled machines.
- Product design: Features embedded within the physical object or kept in the cloud.

With reference to IDC and Cognizant joint research (2015), the key benefits are:

- Increasing reliability and quality through ongoing access to operational intelligence
- Connecting shop-floor decisions with corporate-level objectives, whether they are primarily focused on lowering costs, increasing customer service, or increasing revenue

Smart, connected products enable remote monitoring and remote service that drive both a reduction in the costs of services and an improvement in the level of service [37].

While defining various benefits, Lopez Research (2014) describes various IoT applications in Manufacturing:

It says smart manufacturing systems will link production and business domains such as Material Requirements Planning (MRP), Manufacturing Resource Planning (MRPII) and Manufacturing Execution Systems (MES).

IoT can have an impact on process improvement, for examples [41]:

- Factory visibility
- Automation
- Energy management
- Proactive maintenance
- Connected Supply Chain

IoT will fundamentally change how products are invented, manufactured, shipped and sold. Leading manufacturers are designing for constantly evolving, evergreen products and services. It requires a completely new approach to designing products as well as factories and systems that support a manufacturing process.

2.7 Few Manufacturing case study [42]

- Stanley Black & Decker(Fortune 500 American manufacturer)

RFID tags with WiFi infrastructure being used to get more visibility to track real-time line Productivity

- Airbus (World's largest airliner manufacturer)

Smart tools being used to perform manufacturing processes such as drilling, measuring,tightening, etc. leading to improvement in production efficiency, by regular monitoring of results

- RioTinto (World's largest metals and mining corporations)

Sensors and GPS receivers being used on dump trucks to reduce variability of pre-set Routes

- Sysmex (Medical Electronics)

Remote monitoring of medical equipment to reduce downtime

- Intel (Technology company)

Smart factories enabling visibility into production issues for an integrated view, thereby increasing efficiency and utilization of equipment

- GE (Multinational conglomerate)

Sensors installed on engines to reduce downtime via predictive maintenance

Nowadays, people are united in their need to be connected to the Internet anywhere, anyhow, anytime [43].

Although, the communication is established primarily by using devices, the human users are real “generators” and “consumers” of the input and output information. Thus, the human user has to be considered as a “smart” IoT object, thus he/she should be identified, authenticated, authorized. The main “secret” is hidden behind the digitalization of the user and all of the user-friendly and automated mechanisms. The demand of using internet technologies reflects respectively into all of the users’ devices in one way or another, and they have become mobile and closer to the users than ever. Today, the presence of smart devices providing connectivity to the world at each second is considered as a mandatory part of our life. Thus, the number of connected devices rapidly increases each year. That requires an autonomous device

communication to be created. One of the promising solutions today is known as the Internet of things (IoT). IoT is an informational network that allows the look-up of information about real-world objects interact directly with each other by means of a unique identifier [43]

Users have concerns about their privacy, when personal information is provided, is always a sensitive field which could be a reason for unwillingness of using the system.

KPMG(*Multinational, company that offers professional services) is a multinational professional services network, and one of the Big Four accounting organizations*) attempted to find the readiness index (Term by KPMG) of manufacturing companies based on below parameters [44]

- Leadership
- Governance
- Competency
- Technology
- Value realization
- Financing

However in 2015, the overall readiness of Indian manufacturing enterprises was low with respect to the above parameters

2.8 Current Trends in IoT

IoT is still at an early stage of development, and many problems and research challenges must be solved before it is widely adopted. Many of these are technical, including interoperability and scalability, as billions of heterogeneous devices will be connected, but deciding on how to invest in the IoT is a challenge for business, and there are also major social, legal and ethical challenges, including security and privacy of data collection, which must be resolved [45].

India has a population of 1.2 billion people and its resources are stretched to say the least. However, India has to rework the way it has historically dealt with issues; the world around it is changing. Fourth industrial revolution with IoT is on its way to occupy the world and likely provides large opportunities. Through IoT it is feasible to create a prolonged ecosystem with qualified employees and to bear on India's edge in manufacturing and can orchestrate to large scale customization. Although it is very tough to manage the process centrally, if players in the system apply right levers there will be reinforced effects.
Thus it is imperative to communicate the ideas that players in the government and corporate sector will profit most, if an initiative of Industry 4.0 goes together.
By adopting IoT, we will have a major competitive advantage over global competitors in economy. But first and foremost we need to have the essence of speed in order to capture this opportunity and to achieve our goal [46].

India has a huge task in its dream of being the world's preferred manufacturing destination.

Every company, depending on its applications and types of devices, will have different pain points and business needs for implementing IoT and different expectations for where and how they expect a return on their investment. The reality is that high, measurable cost savings, top line growth, and increased customer satisfaction—which ultimately translate into increased market share—are being realized today by companies across industries that are using IoT, with payback being measured in just months[37].

IoT has been cited as one of the most promising innovations in information technology to date. Experts conclude that it will transform and reinvigorate the consumer brand because it will provide marketers with more direct, personalized contact with consumers. If marketing strategy utilizing IoT is executed properly, this positive experience with the brand can deepen relationships with consumers, enhance loyalty, and increase sales [47].

Global Industry 4.0 Survey (2016) concluded that within the next five years, advanced implementation of Industry 4.0 will become a ‘qualifier to compete’ and is also likely to be seen by investors as a ‘qualifier for funding’ [16, 17].
The business value for a manufacturing enterprise is typically directly proportional to the square number of connected machines, things and people to the system.
Hence in the context of manufacturing, the systemic value of the increased connectedness of things, people and data to the internet called 'information automation' increases the intrinsic business value of the adoption of IoT [16,17].

Today everything is connected to the Internet. Internet of Things (IoT), as one of the disruptive technologies, is rising quickly. The IoT is predicted to be a major IT-enabled business trend over the next 10 years, and their benefits to consumers are significant. Adoption of IoT offers numerous opportunities for an organization such as cost savings, improvements of products and services, and risk mitigation. The adoption of IoT and use is estimated to be more common due to which it will be major components of the Future Internet.

The Internet of Things (IoT) is becoming a buzzing area everywhere because of which it needs significant research attention [32].

There are many research challenges associated with the IoT. These cover the whole field, including the technical challenges of designing, managing and using a multi-national, multi-industry, multi-technology infrastructure, the business challenges of developing IoT business models, and the organizational, political and social challenges of a new technology which promises to change the way we live and work in major ways [45].

Nevertheless, more research needs to explore the capabilities needed to adopt the IoT in the organization. The researcher has tried to identify the factors that affect the acceptance of IoT by users. The future research, researcher recommended to conduct more empirically

studies in this field and to test a new IoT adoption model in different countries and in context [48].

The Government of India has set an ambitious target of increasing the contribution of manufacturing output to 25 percent of Gross Domestic Product (GDP) by 2025, from 16 percent currently (2019) [1].

IoT, being one of the most important aspects of Industry 4.0 for India is expected to capture close to 20 percent share in the global IoT market in the next five years. The IoT market in India is projected to grow at a CAGR (Compound annual growth rate) of more than 28 percent during 2015-2020 [1].

Government of India has taken initiatives such as Green Corridors and 'Make in India'

The current number of IoT devices in India is around 60 million and the number is going to increase to 1.9 billion units by 2020. The IoT market in India is poised to reach $15 billion by 2020, accounting for 5% of the global market, as per a NASSCOM report [23, 42].

Share of young working population in the total population is increasing; India can achieve its full manufacturing potential as it looks to benefit from its demographic dividend and a large workforce over the next two-three decades [1].

2.9 Summary

In summary, various literature surveys are made on research topics like IoT implementation in other countries, adoption in various countries, IoT domains and application, challenges in IoT implementation in India, Industrial revolution and its connection to IoT.

India being a manufacturing hub, it is very important to know the current state of IoT adoption in manufacturing companies.

IoT terminology has been part of various research forums, conferences, seminars and meetings. When IoT adoption has been discussed on such a large scale, it is necessary to understand its awareness and readiness of industry.

Many researchers have studied IoT based on various parameters; however, studying management approach will add value for long term results and returns.

The industry should know the readiness parameters, challenges and right approach towards IoT initiatives. The check-list for the same will help them for smooth conversion.

The expectation of industry leaders, IoT leaders and team should be brought to the same page so that a healthy IoT ecosystem can be created.

Knowing current IoT adoption status in the industry would help to plan the growth suggested by Indian government.

The Research gap is identified while studying various research papers , articles and contributions made in this direction for further studies.

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Chapter - 3

Research Methodology

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3.1 Introduction

This chapter includes the research methodology of the thesis. In this part research strategy, the research method, the research approach, the methods of data collection, the selection of the sample and the research process has been described. However limitations, if any, have also been stated.

3.2 Objectives

- To know the present status of IoT adoption in Industry
- To know the current implementation status of IoT
- To understand the roadmap for companies in this area
- To know the awareness of IoT in industry
- To know the readiness of companies for IoT implementation
- To understand the challenges faced by companies while IoT adoption.

3.3 Statement of the proposed null hypotheses

1. There is no difference in IoT implementation stage in companies
2. There is no enough awareness about IoT in companies
3. The companies do not have required readiness for IoT Adoption
4. There are no competitive benefits if customer satisfaction level is improving because of IoT
5. Risk of misuse of data during exchange of information in IoT projects is nowhere related to Intellectual property

3.4 Research method

Pune is an industrial city with large number of MSMEs, large scale and multinational companies. It is a manufacturing centre for engineering and automotive companies. At the same time it is also a leading IT hub. This is why Pune was selected as a location for research. In order to understand industry interest in adoption of IoT, primary visits and surveys were conducted.

It was realized that only large scale manufacturing companies are inclined to adopt IoT hence the MNCs and large scale companies are considered for research.

To get a 360 degree view on the research objectives, in addition to manufacturing companies, we also collected data from IoT implementers (IoT partners who are working with manufacturing companies for their IoT projects) and various industry forums.

The population and the sample for the research has been discussed later in this chapter

3.5 Questionnaire

Based on the literature review and objectives defined for the research, a questionnaire was set up to get the required information. A pilot survey was conducted using this questionnaire [Annexure B-I].The objective behind this pilot survey was also to verify if the personal can give the information.

With the feedback and suggestion given during pilot survey, the questionnaire was finalized and implemented for the research [Annexure B-II]

3.6 Population of Study

- Companies Identified
  - MNCs, Large engineering manufacturing companies with manufacturing facilities based out of Pune.
- Large scale companies in Pune :
  - Forbes Marshall, Kirloskar Brothers Ltd, Cummins India Limited, Tata Motors Limited ,Bajaj Auto Limited, Honeywell, Total Automation Solutions ,Bharat Forge, Kirloskar oil engines, Thermax, Godrej, Emerson, Aquatech etc.
- Implementing Agencies
  - IoT companies
  - Cloud service provider
- Other Entities/Industry Forum
  - CII
  - IEEE
  - Government
- Beneficiary/Customer
- Interviewee profile should be one of the below: This will help in understanding IoT plans and current status in the company very easily
  - IT leaders in the company
  - Functional leaders in the company
  - Policy makers
  - Top management
  - Marketing head in the company

3.7 Sample selection

During the study it was observed that the companies with Turnover - More than 500Crs are more in sample with respect to IoT adoption.

With this observation during pilot survey we finalized the sample based on below parameters:

- Location - Pune (Hinjavadi, Chinchwad, Kharadi, Bhosari, Shirval, Aundh, Mundawa, Yeravda, Chakan etc.)
- Manufacturing companies (Engineering manufacturing, Electrical, Electronics, Automobile, Auto Ancillaries etc.)
- Turnover - More than 500Crs
- Type - MNC or Industry top
- Unlisted - Public Ltd, BSE Listed - Public Ltd, Private Limited

Based on above various parameters, total population was 97 companies [62].In which 50+ companies were planning for IoT adoption plan (Based on data shared on company website)

In the current study, the sample respondents who are selected have relevant work experience in the field of manufacturing sector and various processes in the same sector. All the sample selected members are decision makers and project heads for IoT initiatives in the respective companies

3.8 Instrument for data collection

We have used 2 types of primary data collection methods which include online survey and one-on-one interviews.

It is the result of a questionnaire based data collection of 51 companies, more than 75 high-ranking IT and business leaders from the IoT domain with extensive knowledge of IoT strategy.

For the purposes of this research, various research papers were reviewed, online surveys were carried out. Conferences and seminars attended have given additional insights while analysis of data. The base for the analysis was the conduction of interviews in depth.

The interviews were one on one. It was only questionnaire based but also response based. This helped in identifying participant's emotions, feelings, and opinions regarding a particular question.

The most important point in this survey is that for all 51 companies the data was collected based on one-on -one interview which was conducted in person. With this an added advantage was that it involved personal and direct contact between interviewees and us. It helped in eliminating non-response rates.

In addition many expert discussions were conducted.

A questionnaire (Annexure B-II) designed by us was used in the study. The content of the instrument was based on the findings of pilot interviews and survey conducted (Annexure B-I) with the manufacturing leaders as well as on the information based on the literature reviewed.

The questionnaire has five sections: A, B, C, D and E:

- Section “A”, is on personal data of the respondents; It has 10 items
- Section “B”, is on the awareness about IoT in company which has 5 items
- Section “C”, contains questions on readiness of companies with respect to various management parameters. It has 18 items;
- Section “D”, collect information about adoption approach in manufacturing, which has 19 items;
- Finally, section “E”, is on Advantages/Limitation/Challenges and overall IoT adoption plan of company which is made up of 18 items

The instrument was structured in the modified Likert fashion; Subjects were then instructed to respond to their degree of agreement with the statements contained in the instrument.

Level of Agreement:

1 – Strongly disagree
2 – Disagree
3 – Neutral
4 – Agree
5 – Strongly agree

Frequency:
1 – Never
2 – Rarely
3 – Sometimes
4 – Often

5 – Always

Level of Participation:

1 – Definitely No

2 – Probably No

3 – Somewhat

4 – Probably Yes

5 – Definitely Yes

3.9 Source Of Data

- Primary Source
  - Interviews (Personal, Group, Focused, Telephonic)
  - Online surveys
  - Research published in scholarly/academic journals
  - Direct observations

- Secondary Source
  - Company Annual reports
  - Company / Implementation partner websites
  - Papers/case studies published by companies

3.10 Limitations

IoT is been explored across the world in various domains. IoT adoption approach has wide scope for research. However it is difficult to study IoT adoption approach for each domain and each application across world. India being manufacturing hub, manufacturing companies are selected as an area of research.

As a concept is global, area is also infinite and global study is challenging, hence, decided to restrict it to Pune based manufacturing companies.

While preparing questionnaire, got to know that currently SMEs are not inclined to IoT adoption. With this large scale manufacturing companies from Pune region are finalized.

Hence the research does not consider all SMEs and all other large scale industry sectors except manufacturing companies [3.7,Page No:80) of this research document.

This could be stated as a limitation of study

3.11 Remarks

This chapter has outlined and justified the research methodology implemented in this thesis and its validity. The key research tools were questionnaires, supplemented by interviews with all types of connected participants – Decision makers, on project team and students pursuing a career in IoT. The participants were carefully targeted.

The experts' views were taken from various research companies in and outside India.

The major results and findings of this thesis are discussed in the following chapter.

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Chapter - 4

Analysis and Interpretation

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4.1 Background

As the research demands for knowing, management approach, the important aspect of this research was survey of decision makers. One to one interaction with leaders was very important to understand their understanding and approaches. Authentic feedback from the people could analyze the assumptions and could tally it with the research done and then arrived on concrete conclusions to analyze with the facts and truths that were quoted as assumptions. Considering the scope and its limitations, a total of 51 companies were selected from the manufacturing sector in Pune. Various heads from these companies were interviewed in detail and a questionnaire was filled for record purpose. After thorough analysis done various findings came out.

4.2 Questionnaire for the Interviews

Total 70 questions were drafted in the questionnaire [Annexure B-II]. Questionnaire was divided into below 5 sections:

1. Basic Information
2. Awareness
3. Readiness
4. Adoption
5. Advantages/Limitation/Challenges

Excluding the basic information which include name, age, years of experience, education etc., almost all other questions were objective questions. We covered the employees from IT department, Functional people (Manufacturing head, plant head, product head, marketing head etc.) and decision makers. All the findings are multifold viz age wise, educational qualification wise, experience wise, functional area wise, adoption status wise etc.

An Excel file was prepared for data entry and its analysis further. Feedback received was entered in excel sheet and then findings were searched from different angles.

4.3 Data Analysis

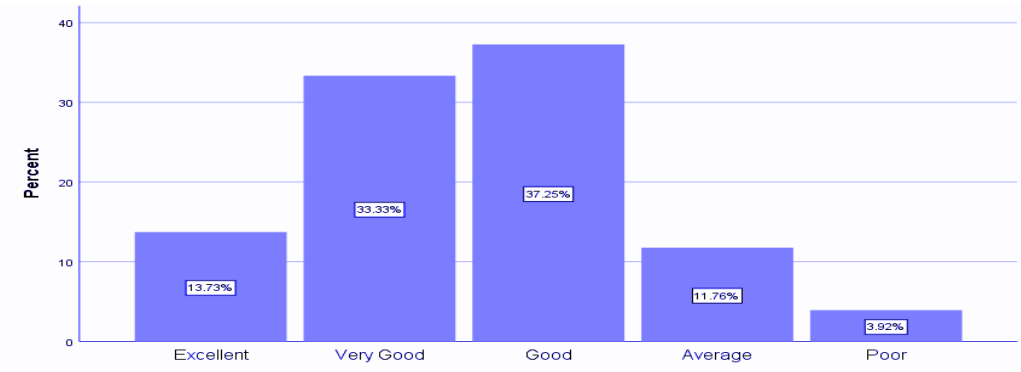
4.3.1 Descriptive Statistics

1. **Question: Awareness level of respondent about IoT**

Table No 4.1: Table showing statistical data about awareness level of respondent about IoT

	Frequency	Percent	Cumulative Percent	Mean	Median	Std. Deviation
Excellent	7	13.7	13.7	2.59	3.00	1.004
Very Good	17	33.3	47.1			
Good	19	37.3	84.3			
Average	6	11.8	96.1			
Poor	2	3.9	100.0			

Figure No 4.1: Bar chart showing awareness level of respondent about IoT



Findings:

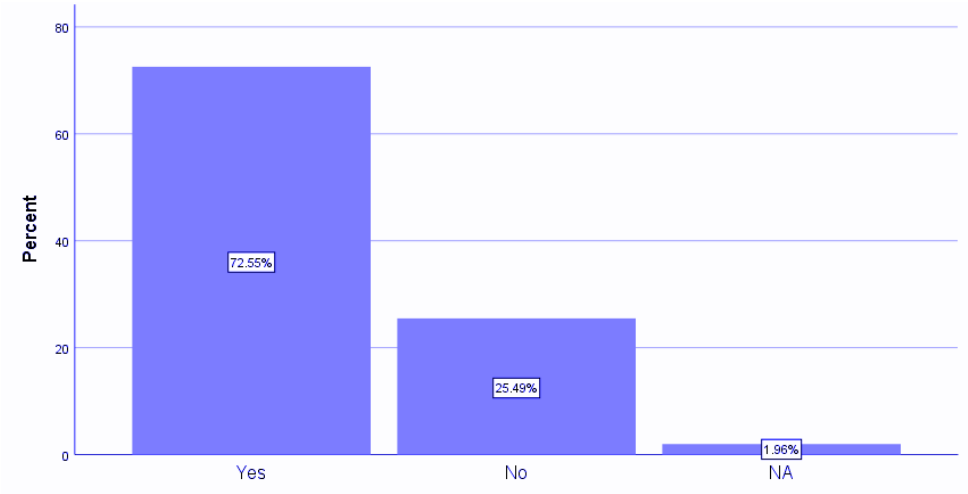
Majority respondent have a good awareness level about IoT. With reference to the above figure, more than 80% of respondents are well aware about IoT.

2. **Question: Conference /seminar attended on IoT by the respondent**

Table No 4.2: Table showing statistical data about Conference /seminar attended on IoT by the respondent

	Frequency	Percent	Cumulative Percent	Mean	Median	Std. Deviation
Yes	37	72.5	72.5	1.29	1.00	0.502
No	13	25.5	98.0			
NA	1	2.0	100.0			

Figure No 4.2: Bar chart showing Conference /seminar attended on IoT by the respondent



Findings:

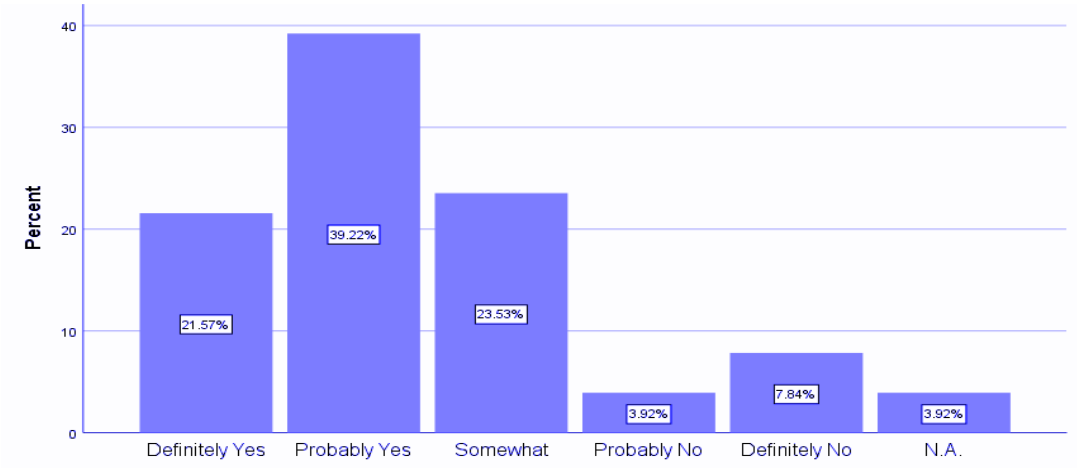
72.55% respondents have attended conference/Seminar held on IoT. There are 10% respondents, though not attended any conference/Seminar on IoT, still are aware about IoT [Q1]

3. **Question: IoT Training or workshop attended by key people of the company**

Table No 4.3: Table showing statistical data about IoT Training or workshop attended by key people of the company

	Frequency	Percent	Cumulative Percent	Mean	Median	Std. Deviation
Definitely Yes	11	21.6	21.6	2.49	2.00	1.317
Probably Yes	20	39.2	60.8			
Somewhat	12	23.5	84.3			
Probably No	2	3.9	88.2			
Definitely No	4	7.8	96.1			
N.A.	2	3.9	100.0			

Figure No 4.3: Bar chart showing IoT Training or workshop attended by key people of the company



Findings:

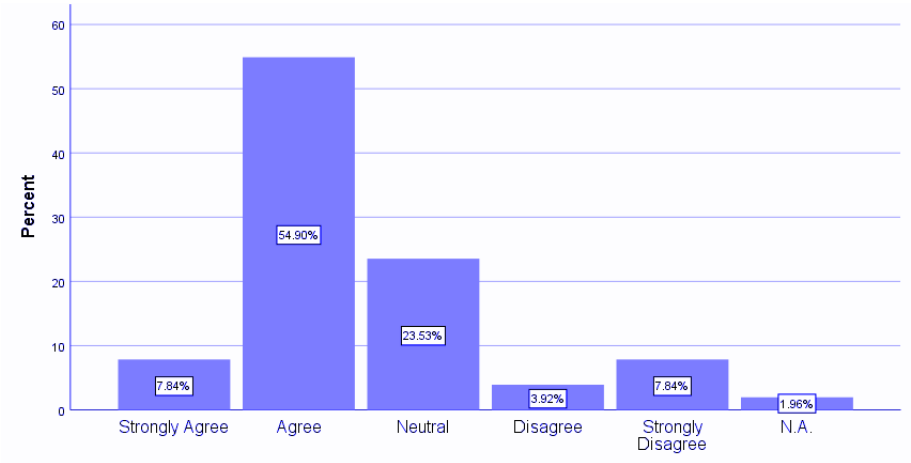
Amongst the population, 60.79% have attended workshop or training.23.53% attended it partially. Hardly 10% of respondents are saying that they have not attended any workshop or training.

4. **Question: There is enough awareness about the current state of technology in IoT in My Company**

Table No 4.4: Table showing statistical data about awareness about the current state of technology in IoT in company

	Frequency	Percent	Cumulative Percent	Mean	Median	Std. Deviation
Strongly Agree	4	7.8	7.8	2.55	2.00	1.101
Agree	28	54.9	62.7			
Neutral	12	23.5	86.3			
Disagree	2	3.9	90.2			
Strongly Disagree	4	7.8	98.0			
N.A.	1	2.0	100.0			

Figure No 4.4: Bar chart showing awareness about the current state of technology in IoT in company



Findings:

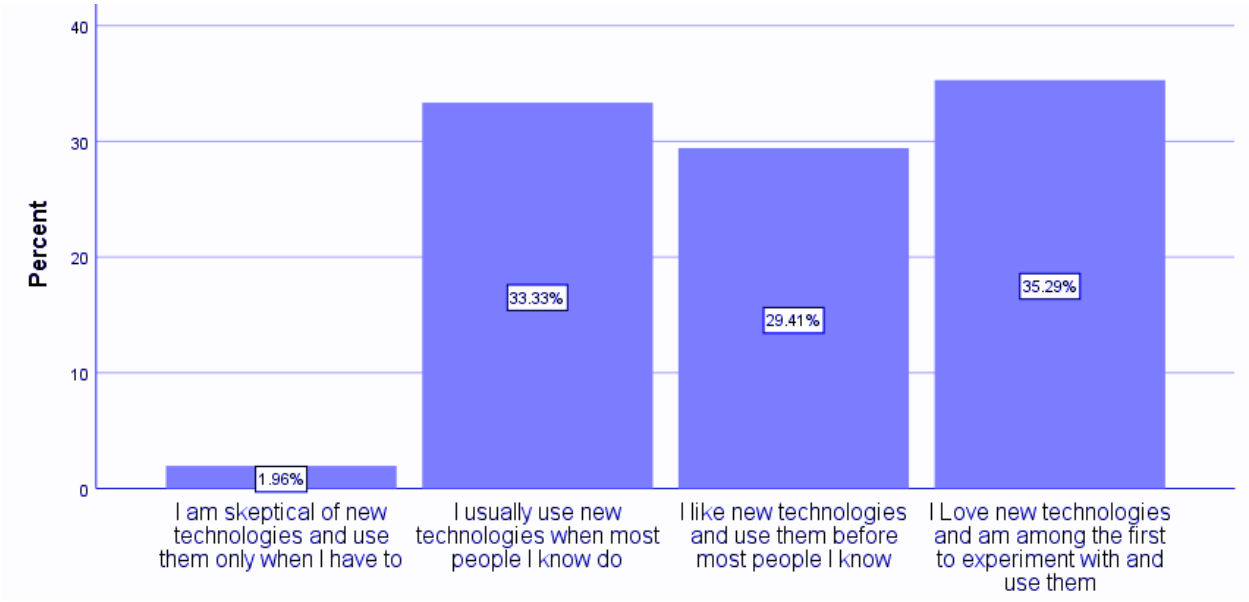
62.74% of respondents agreed that there is enough awareness about IoT in their company; however 23.53% respondents are not sure about the current awareness state of IoT in their company.

5. **Question: When it comes to Technology, what best describes you?**

Table No 4.5: Table showing statistical data about, when it comes to Technology, what best describes you?

	Frequency	Percent	Cumulative Percent	Mean	Median	Std. Deviation
I am skeptical of new technologies and use them only when I have to	1	2.0	2.0	3.96	4.00	0.937
I usually use new technologies when most people I know do	17	33.3	35.3			
I like new technologies and use them before most people I know	15	29.4	64.7			
I Love new technologies and am among the first to experiment with and use them	18	35.3	100.0			

Figure No 4.5: Bar chart showing when it comes to Technology, what best describes you?



Findings:

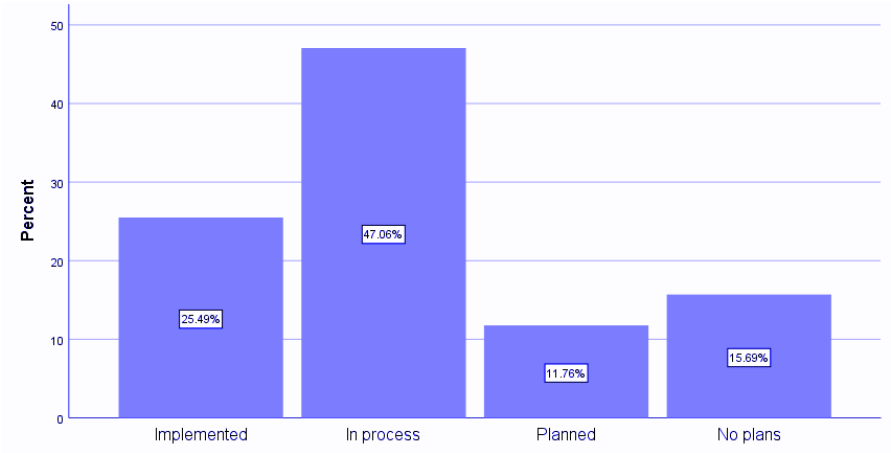
Regarding new technology adoption,35.3% respondents say that they are the first one to experiment and use new technology.2% respondents use it only if they need it.62.74% respondents are relatively open to use new technology if it is being used somewhere.

6. **Question: What is current adoption status of IoT in your company**

Table No 4.6: Table showing statistical data about current adoption status of IoT in company

	Frequency	Percent	Cumulative Percent	Mean	Median	Std. Deviation
Implemented	13	25.5	25.5	2.18	2.00	0.994
In process	24	47.1	72.5			
Planned	6	11.8	84.3			
No plans	8	15.7	100.0			

Figure No 4.6: Bar chart showing current adoption status of IoT in company



Findings:

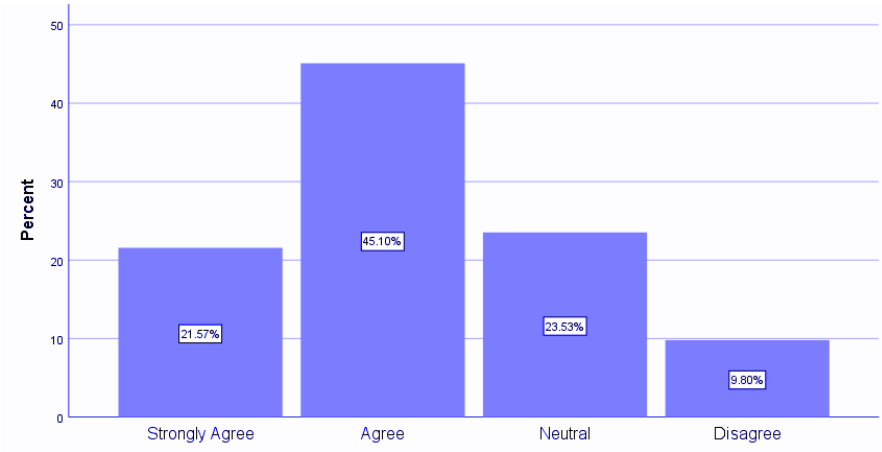
When the respondents talked about the current status of IoT adoption in their company, the majority are in the process of IoT adoption.25.49% of respondents have already implemented IoT in their company.

7. **Question: Respondent readiness for IoT adoption**

Table No 4.7: Table showing statistical data about respondent readiness for IoT adoption

	Frequency	Percent	Cumulative Percent	Mean	Median	Std. Deviation
Strongly Agree	11	21.6	21.6	2.22	2.00	0.901
Agree	23	45.1	66.7			
Neutral	12	23.5	90.2			
Disagree	5	9.8	100.0			

Figure No 4.7: Bar chart showing Respondent readiness for IoT adoption



Findings:

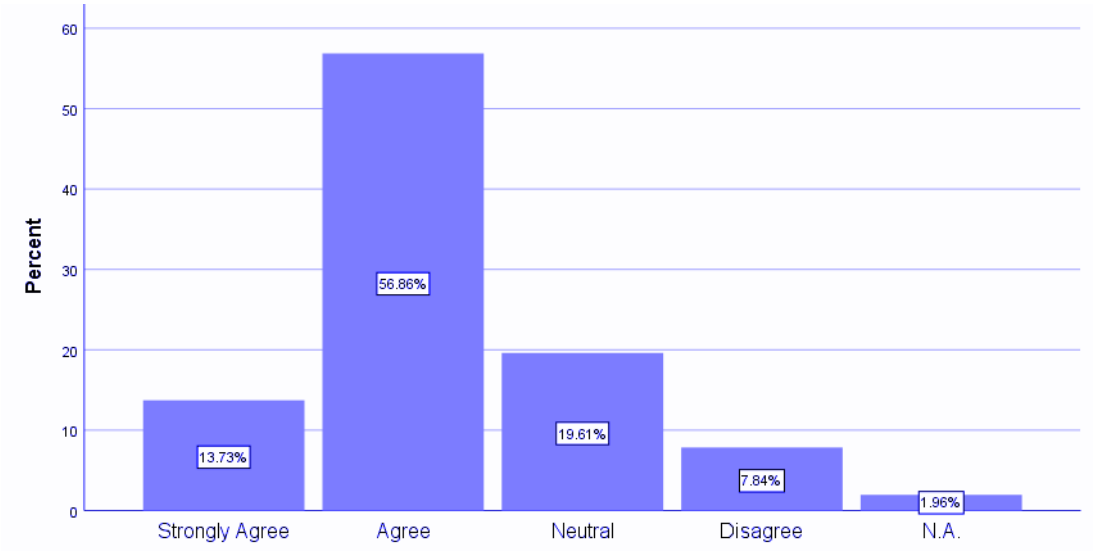
66.61% respondents mentioned that they are ready for IoT adoption; however 10% of the population said they are not ready for IoT Adoption. The individual readiness is more than 50%.

8. **Question: Company readiness about infrastructure**

Table No 4.8: Table showing statistical data about company readiness about infrastructure

	Frequency	Percent	Cumulative Percent	Mean	Median	Std. Deviation
Strongly Agree	7	13.7	13.7	2.29	2.00	0.944
Agree	29	56.9	70.6			
Neutral	10	19.6	90.2			
Disagree	4	7.8	98.0			
N.A.	1	2.0	100.0			

Figure No 4.8: Bar chart showing company readiness about infrastructure



Findings:

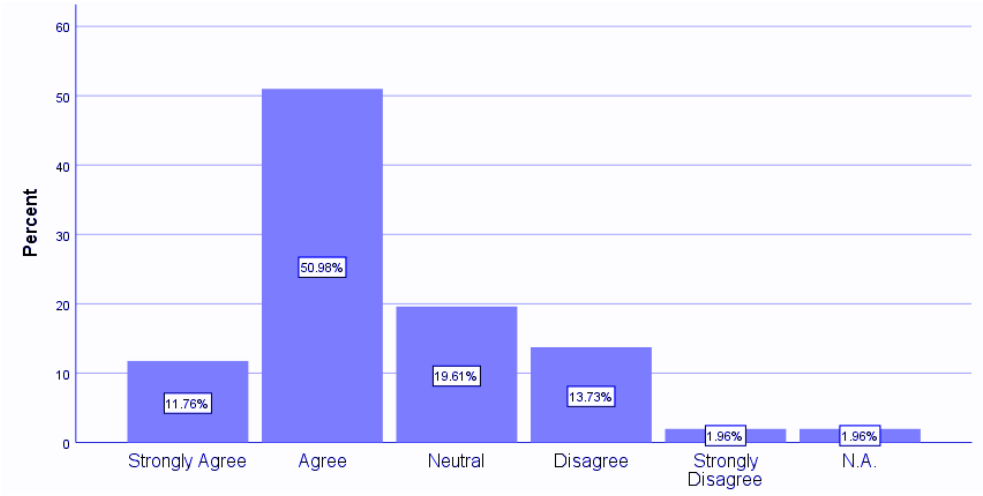
With respect to infrastructure readiness, 70.6% respondents mentioned that they are ready.19.61% are neutral on this parameter of readiness.9.8% are not ready on the infrastructure side for IoT adoption.

9. Question: Company readiness for investment required for IoT

Table No 4.9: Table showing statistical data about company readiness for investment required for IoT

	Frequency	Percent	Cumulative Percent	Mean	Median	Std. Deviation
Strongly Agree	6	11.8	11.8	2.49	2.00	1.065
Agree	26	51.0	62.7			
Neutral	10	19.6	82.4			
Disagree	7	13.7	96.1			
Strongly Disagree	1	2.0	98.0			
Strongly Agree	6	2.0	100.0			

Figure No 4.9: Bar chart showing company readiness for investment required for IoT



Findings:

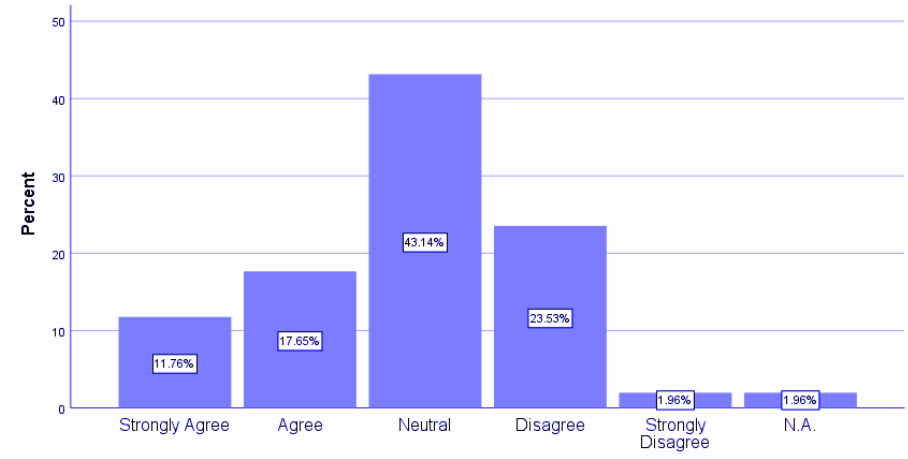
For the investments required in IoT adoption,62.7% respondents say that their companies are ready to invest in IoT.1.56% companies are either already invested or IoT adoption is not yet planned so not ready for investments

10. **Question: My company has the skill set in house which are required for IoT adoption**

Table No 4.10: Table showing statistical data about in house skill set in house required for IoT

	Frequency	Percent	Cumulative Percent	Mean	Median	Std. Deviation
Strongly Agree	6	11.8	11.8	2.92	3.00	1.074
Agree	9	17.6	29.4			
Neutral	22	43.1	72.5			
Disagree	12	23.5	96.1			
Strongly Disagree	1	2.0	98.0			
N.A.	1	2.0	100.0			

Figure No 4.10: Bar chart showing about in house skill set in house required for IoT



Findings:

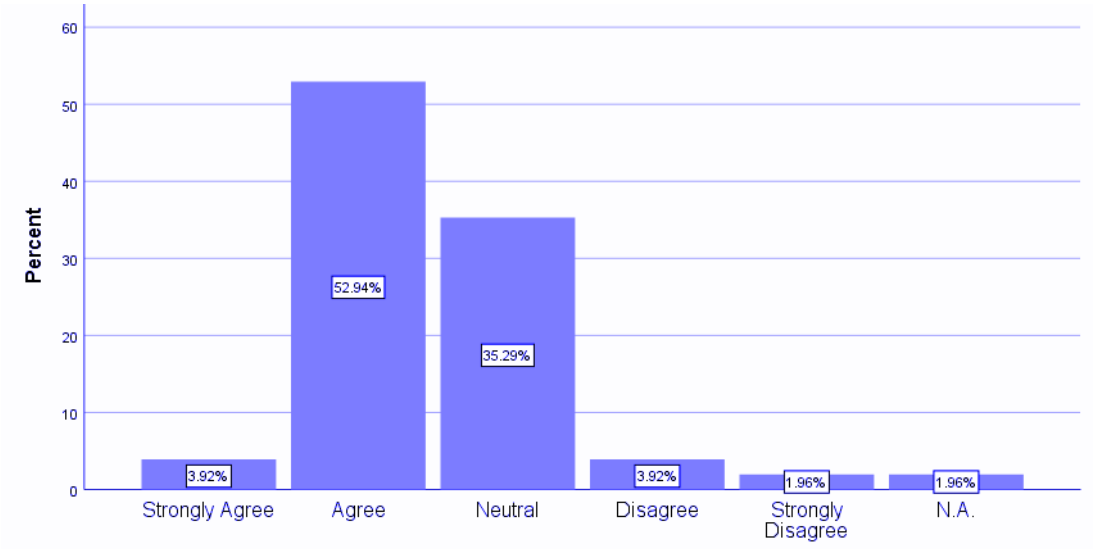
Regarding the Skill Sets required for IoT adoption, very few companies i.e. 29.4% have in-house skill-sets available for IoT.43.14% are not sure if they have required skill set in house.25.52% respondents says they don't have skill set required for IoT adoption within their company.

11. Question: My company is ready to outsource the required skill sets

Table No 4.11: Table showing statistical data about readiness to outsource the required skill sets

	Frequency	Percent	Cumulative Percent	Mean	Median	Std. Deviation
Strongly Agree	2	3.9	3.9	2.53	2.00	0.880
Agree	27	52.9	56.9			
Neutral	18	35.3	92.2			
Disagree	2	3.9	96.1			
Strongly Disagree	1	2.0	98.0			
N.A.	1	2.0	100.0			

Figure No 4.11: Bar chart showing readiness to outsource the required skill sets



Findings:

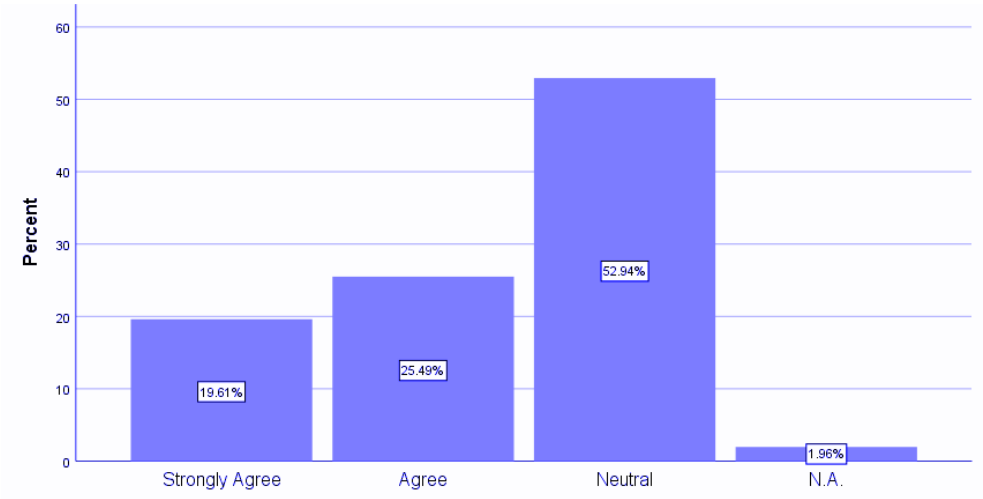
56.86% respondents are saying that they are ready to outsource the required Skill sets however 35.29% are neutral on this decision.

12. Question: My company has identified the need / area for adoption

Table No 4.12: Table showing statistical data about if company has identified the need / area for adoption

	Frequency	Percent	Cumulative Percent	Mean	Median	Std. Deviation
Strongly Agree	10	19.6	19.6	2.41	3.00	0.942
Agree	13	25.5	45.1			
Neutral	27	52.9	98.0			
N.A.	1	2.0	100.0			

Figure No 4.12: Bar chart showing if company has identified the need / area for adoption



Findings:

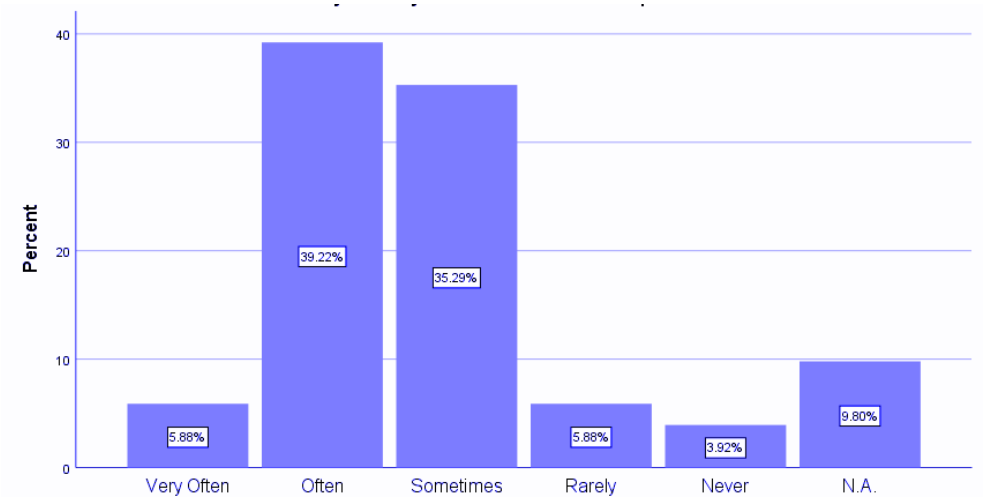
Area of IoT adoption has been identified by 45.1% of the companies.52.94% are on those lines however not identified yet.

13. Question: Are you ready for failures while IoT adoption

Table No 4.13: Table showing statistical data about readiness for failures while IoT adoption

	Frequency	Percent	Cumulative Percent	Mean	Median	Std. Deviation
Very Often	3	5.9	5.9	2.92	3.00	1.324
Often	20	39.2	45.1			
Sometimes	18	35.3	80.4			
Rarely	3	5.9	86.3			
Never	2	3.9	90.2			
N.A.	5	9.8	100.0			

Figure No 4.13: Bar chart showing readiness for failures while IoT adoption



Findings:

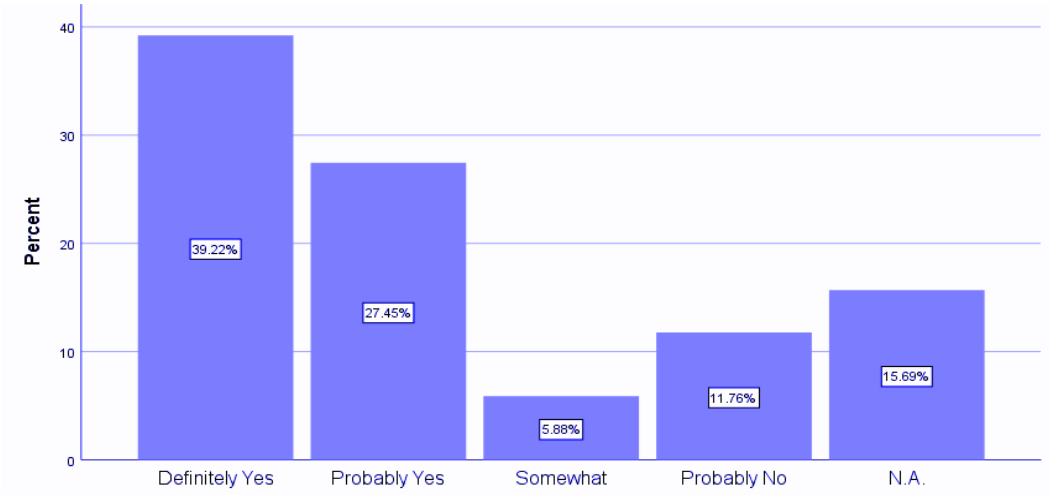
On the scale of accepting failures during IoT Adoption, 90.2% of respondents are ready for the failures during the adoption process at different scales; however 3.92% says that they are not ready for failure

14. Question: Do you want to go for another attempt if you have failed

Table No 4.14: Table showing statistical data about another attempt if company failed for first IoT attempt

	Frequency	Percent	Cumulative Percent	Mean	Median	Std. Deviation
Probably Yes	20	39.2	39.2	2.53	2.00	1.793
Definitely Yes	14	27.5	66.7			
Somewhat	3	5.9	72.5			
Probably No	6	11.8	84.3			
N.A.	8	15.7	100.0			

Figure No 4.14: Bar chart showing data about another attempt if company failed for first IoT attempt



Findings:

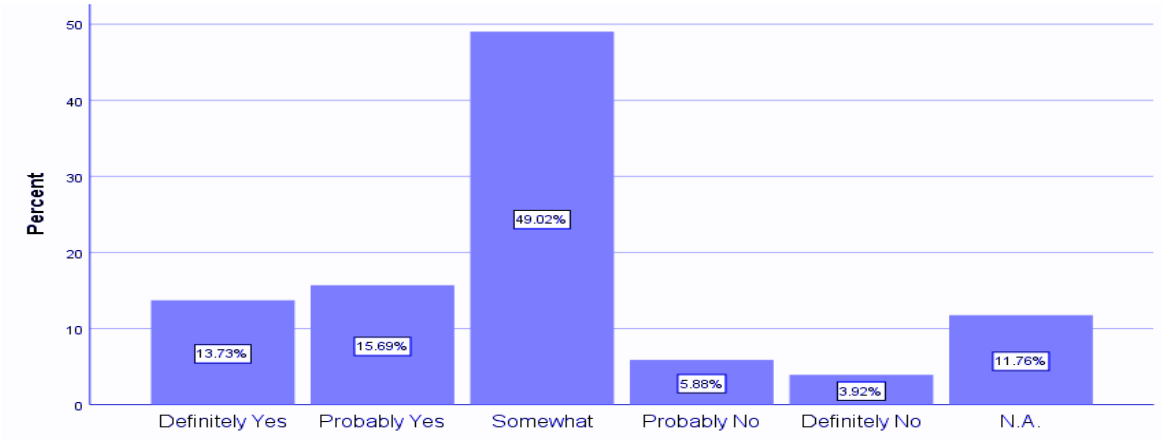
In case of failure 66.7% of the respondents are saying that they want to for another attempt.11.76% of the respondents says that they will not go another attempt. May the respondents who don't have plans for IoT adoption are saying that this is not applicable in their case.

15. **Question: Is the service team an active part of the product development team to plan IoT services before product launch?**

Table No 4.15: Table showing statistical data about if service team an active part of the product development team to plan IoT services before product launch

	Frequency	Percent	Cumulative Percent	Mean	Median	Std. Deviation
Definitely Yes	7	13.7	13.7	3.06	3.00	1.420
Probably Yes	8	15.7	29.4			
Somewhat	25	49.0	78.4			
Probably No	3	5.9	84.3			
Definitely No	2	3.9	88.2			
N.A.	6	11.8	100.0			

Figure No 4.15: Bar chart showing if service team an active part of the product development team to plan IoT services before product launch



Findings:

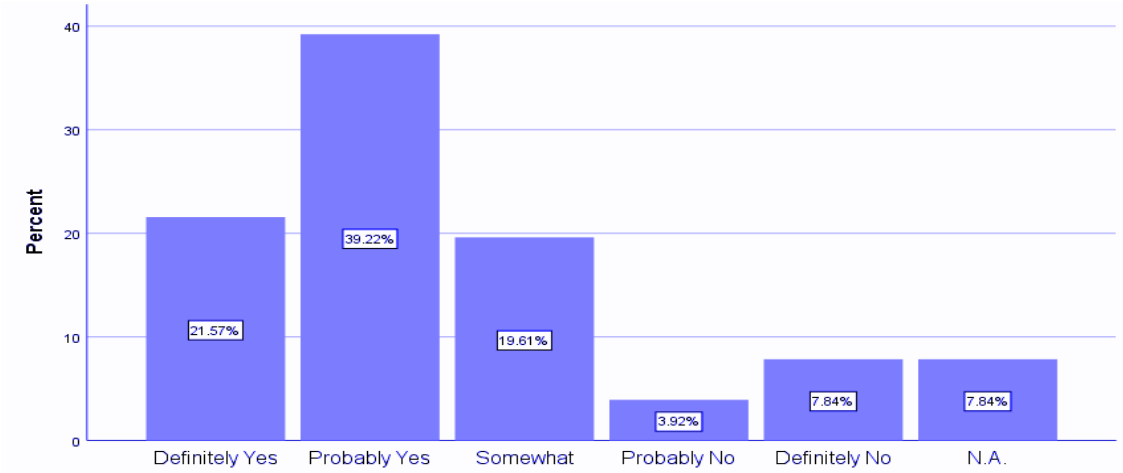
This shows that service team is somewhat part of IoT product development team.13.73% says that service team is active part of their product development team.9.8% respondents say that their service team is not part of their IoT product development team.

16. **Question: Does your IoT infrastructure provide sufficient bandwidth and capacity?**

Table No 4.16: Table showing statistical data about IoT infrastructure sufficient bandwidth and capacity

	Frequency	Percent	Cumulative Percent	Mean	Median	Std. Deviation
Definitely Yes	11	21.6	21.6	2.61	2.00	1.484
Probably Yes	20	39.2	60.8			
Somewhat	10	19.6	80.4			
Probably No	2	3.9	84.3			
Definitely No	4	7.8	92.2			
N.A.	4	7.8	100.0			

Figure No 4.16: Bar chart showing about IoT infrastructure sufficient bandwidth and capacity



Findings:

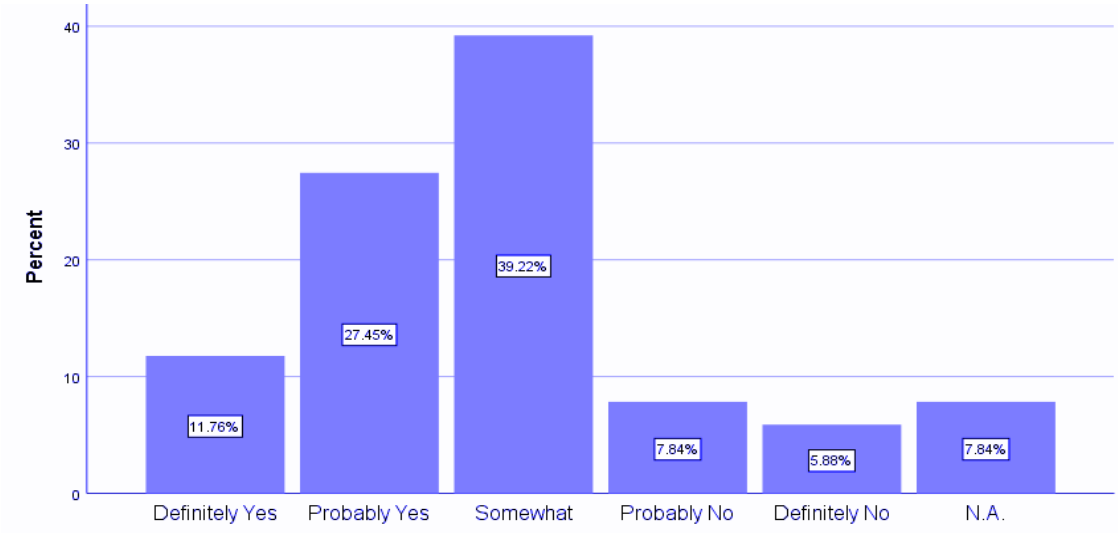
80% of the respondents mentioned that their infrastructure can provide sufficient bandwidth and capacity required for IoT. 11.7% of the respondents says that their companies are not ready for such infrastructure.

17. **Question: Have you selected an IoT platform to support your strategic IoT initiatives?**

Table No 4.17: Table showing statistical data about IoT platform selection

	Frequency	Percent	Cumulative Percent	Mean	Median	Std. Deviation
Probably Yes	6	11.8	11.8	2.92	3.00	1.339
Definitely Yes	14	27.5	39.2			
Somewhat	20	39.2	78.4			
Probably No	4	7.8	86.3			
Definitely No	3	5.9	92.2			
N.A.	4	7.8	100.0			

Figure No 4.17: Bar chart showing IoT platform selection



Findings:

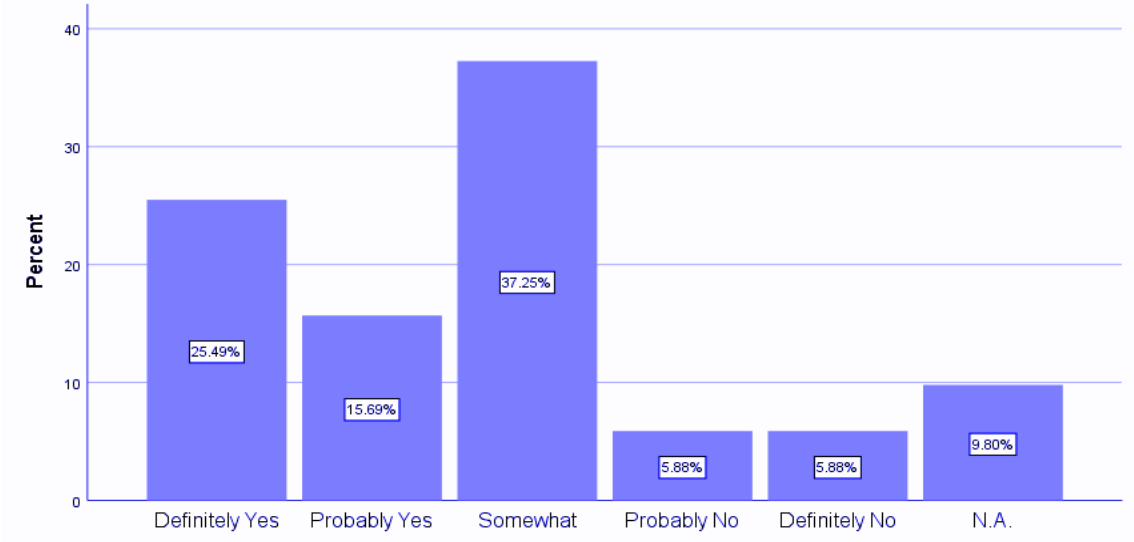
For taking forward IoT initiatives, 78.4% of the respondents say that their company has selected the IoT platform however 39.22% companies are still in the process of finalizing the IoT Platform**.**

18. Question: Does your IT Architecture cater for IoT?

Table No 4.18: Table showing statistical data about IT Architecture cater for IoT

	Frequency	Percent	Cumulative Percent	Mean	Median	Std. Deviation
Definitely Yes	13	25.5	25.5	2.80	3.00	1.536
Probably Yes	8	15.7	41.2			
Somewhat	19	37.3	78.4			
Probably No	3	5.9	84.3			
Definitely No	3	5.9	90.2			
N.A.	5	9.8	100.0			

Figure No 4.18: Bar chart showing if IT Architecture cater for IoT



Findings:

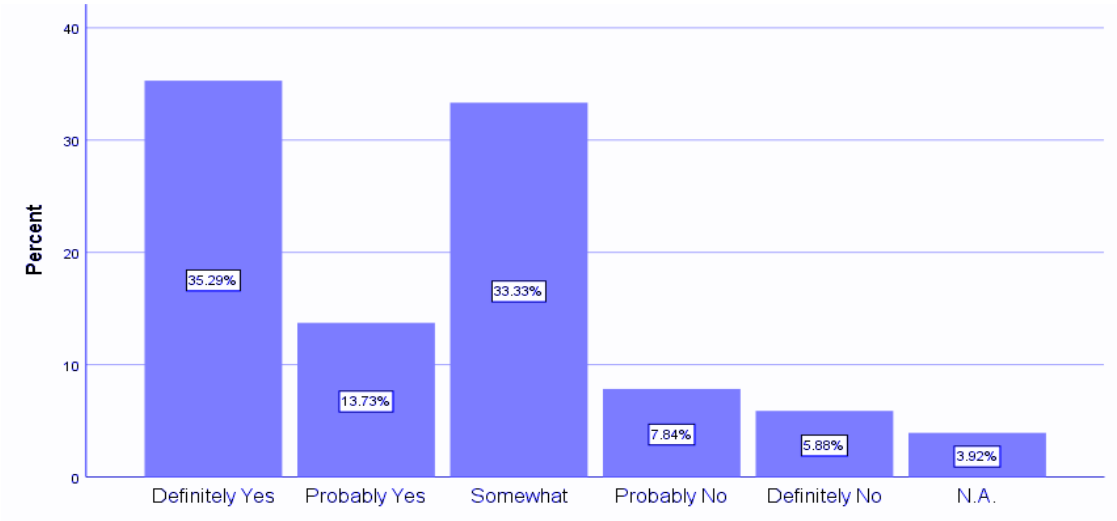
78.4% of the respondents say that their IT architecture caters for IoT however 37.25% are somewhat ready with their IT architecture for IoT initiatives.5.88% respondents expressed that their IT architecture is not ready for IoT.

19. Question: Is your IT company / department well positioned to deal with IoT complexities?

Table No 4.19: Table showing statistical data about company positioning to deal with IoT complexities

	Frequency	Percent	Cumulative Percent	Mean	Median	Std. Deviation
Definitely Yes	18	35.3	35.3	2.47	3.00	1.405
Probably Yes	7	13.7	49.0			
Somewhat	17	33.3	82.4			
Probably No	4	7.8	90.2			
Definitely No	3	5.9	96.1			
N.A.	2	3.9	100.0			

Figure No 4.19: Bar chart showing company positioning to deal with IoT complexities



Findings:

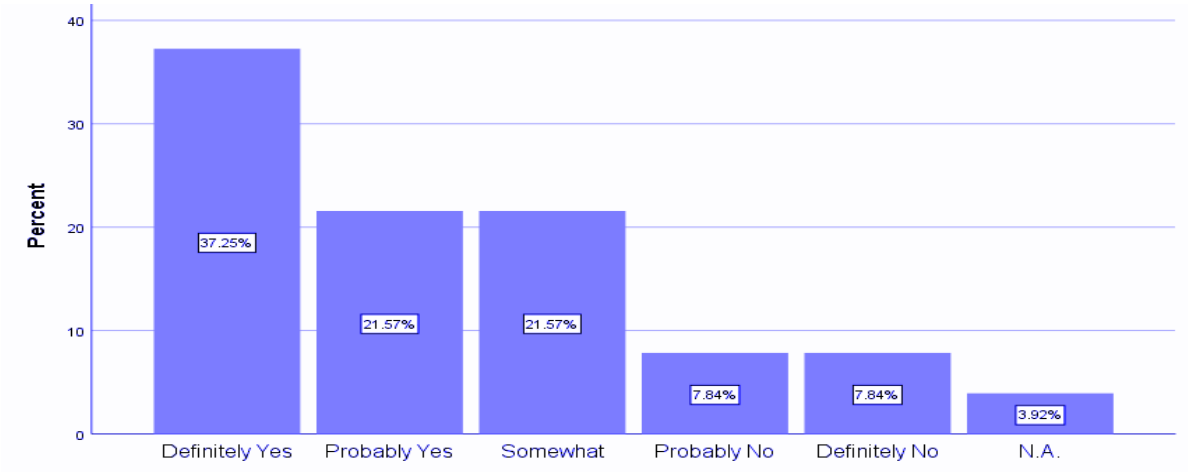
49% of the respondents are saying that their IT Organization (IT Implementers) or IT departments are well positioned to deal with IoT complexities and 33.33% of the respondents are saying that they are somewhat ready .13.72% of the respondents are saying that their IT supporters are not well positioned to deal with IoT complexities.

20. Question: Have you defined who will drive/sponsor the IoT initiatives?

Table No 4.20: Table showing statistical data about IoT initiative sponsor

	Frequency	Percent	Cumulative Percent	Mean	Median	Std. Deviation
Definitely Yes	19	21.6	58.8	2.39	2.00	1.457
Probably Yes	11	21.6	80.4			
Somewhat	11	7.8	88.2			
Probably No	4	7.8	96.1			
Definitely No	4	3.9	100.0			
N.A.	2	21.6	58.8			

Figure No 4.20: Bar chart showing trend about IoT initiative sponsor



Findings:

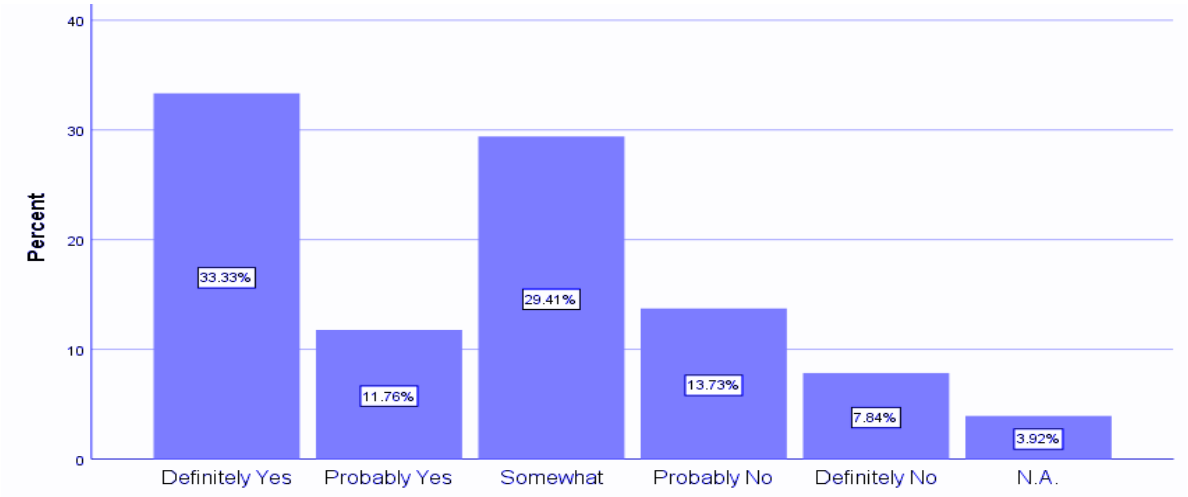
Regarding the project drive or sponsor for IoT initiatives 80.4% of the respondents say that they have defined who is going to drive the project, however 21.57% of the respondents say that they have defined it somewhat.15.48% of the respondents say that they have not defined about the sponsor or driving force for IoT initiatives

21. **Question: Have you defined a roadmap to transform your business to IoT enabled services?**

Table No 4.21: Table showing statistical data about roadmap to transform business to IoT enabled services

	Frequency	Percent	Cumulative Percent	Mean	Median	Std. Deviation
Definitely Yes	17	33.3	33.3	2.63	3.00	1.469
Probably Yes	6	11.8	45.1			
Somewhat	15	29.4	74.5			
Probably No	7	13.7	88.2			
Definitely No	4	7.8	96.1			
N.A.	2	3.9	100.0			

Figure No 4.21: Bar chart showing trend about roadmap to transform business to IoT enabled services



Findings:

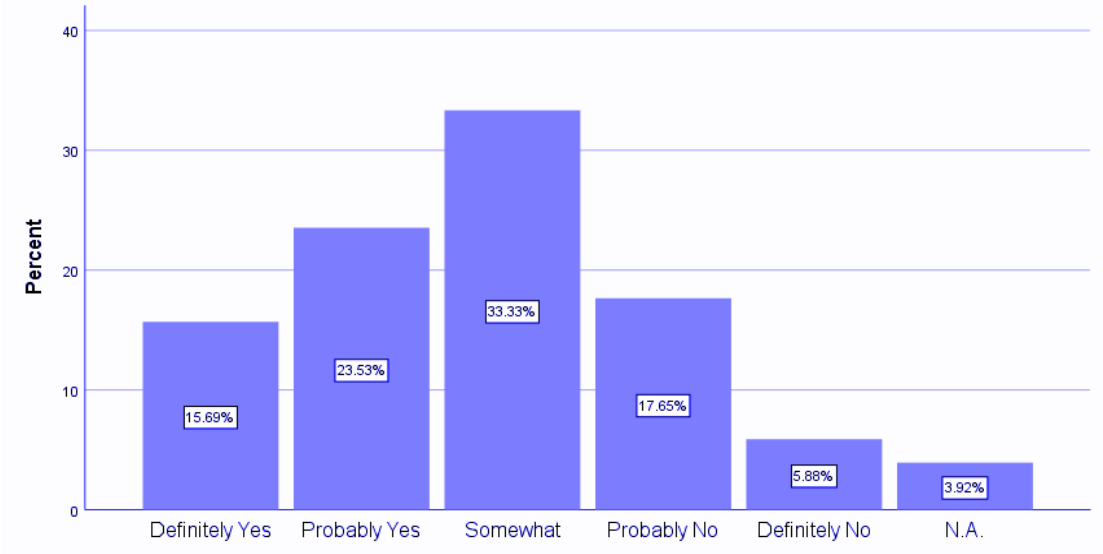
74.5% of the respondents say that they have defined a roadmap to transform their business to IoT enabled services. However 21.57% of the respondents have not decided anything on similar lines.

22. Question: Does your IT strategy and roadmap include IoT capabilities

Table No 4.22: Table showing statistical data about IT strategy and roadmap

	Frequency	Percent	Cumulative Percent	Mean	Median	Std. Deviation
Definitely Yes	8	15.7	15.7	2.86	3.00	1.281
Probably Yes	12	23.5	39.2			
Somewhat	17	33.3	72.5			
Probably No	9	17.6	90.2			
Definitely No	3	5.9	96.1			
N.A.	2	3.9	100.0			

Figure No 4.22: Bar chart showing trend about IT strategy and roadmap



Findings:

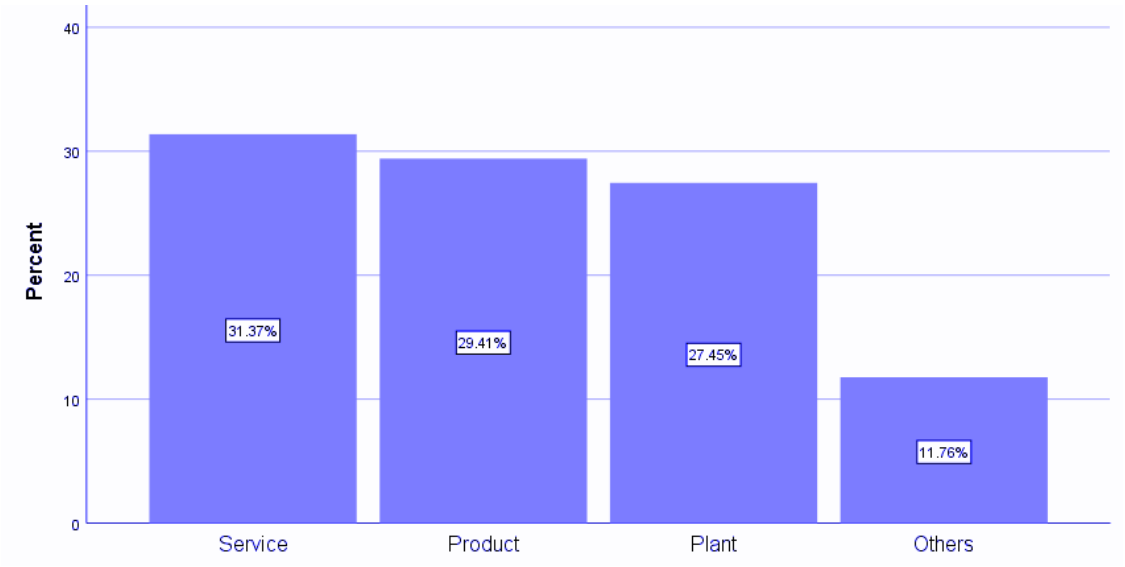
72.5% of the respondents say that their IT strategy and roadmap include IoT capabilities however 23.53% of the respondents say that their IT strategy and roadmap does not include IoT capabilities

23. Question: Where have you used IoT?

Table No 4.23: Table showing statistical data about application of IoT

	Frequency	Percent	Cumulative Percent	Mean	Median	Std. Deviation
Service	16	31.4	31.4	2.20	2.00	1.020
Product	15	29.4	60.8			
Plant	14	27.5	88.2			
Others	6	11.8	100.0			

Figure No 4.23: Bar chart showing application of IoT



Findings:

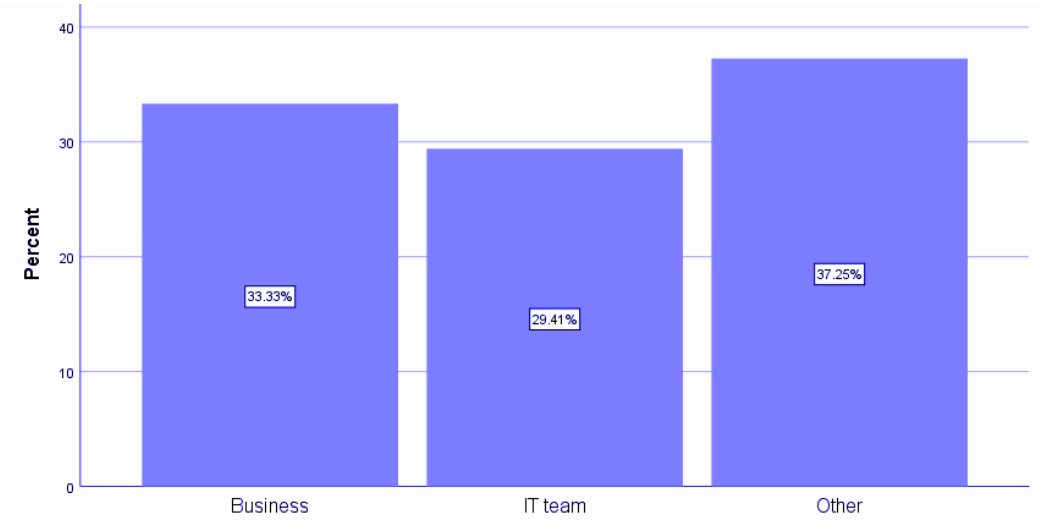
While checking on application of IoT, 31.37% of respondents have used it or planned to use it for services, 29.41% have used it or planned to use it for product, 27.45% of the respondents have used it or planned to use it in their manufacturing plant.

24. Question: IoT initiative came from

Table No 4.24: Table showing statistical data about IoT initiatives

	Frequency	Percent	Cumulative Percent	Mean	Median	Std. Deviation
Business	17	33.3	33.3	2.71	3.00	1.285
IT team	15	29.4	62.7			
Other	19	37.3	100.0			

Figure No 4.24: Bar chart showing IoT initiatives



Findings:

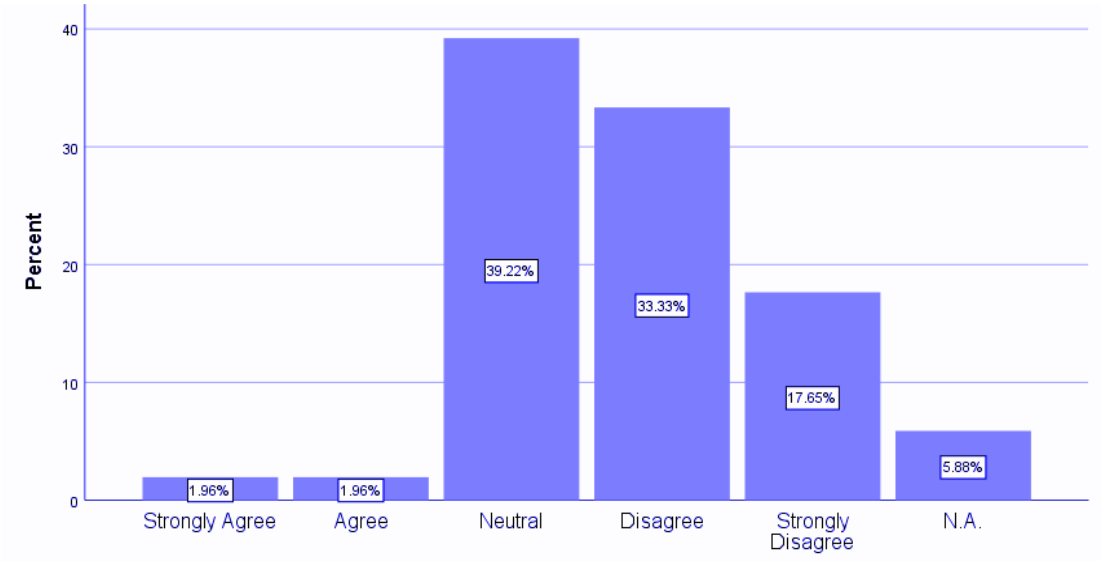
In most of the companies, i.e. 33.33% of the respondents say IoT initiative has come from the Business team and 29.41% of the respondents say it has come from IT team. 37.25% say the sources of IoT initiatives are different than these two.

25. **Question: There is a Lack of vision and leadership for this initiative in my company**

Table No 4.25: Table showing statistical data about vision and leadership for IoT initiative

	Frequency	Percent	Cumulative Percent	Mean	Median	Std. Deviation
Strongly Agree	1	2.0	2.0	3.80	4.00	1.020
Agree	1	2.0	3.9			
Neutral	20	39.2	43.1			
Disagree	17	33.3	76.5			
Strongly Disagree	9	17.6	94.1			
N.A.	3	5.9	100.0			

Figure No 4.25: Bar chart showing vision and leadership for IoT initiative



Findings:

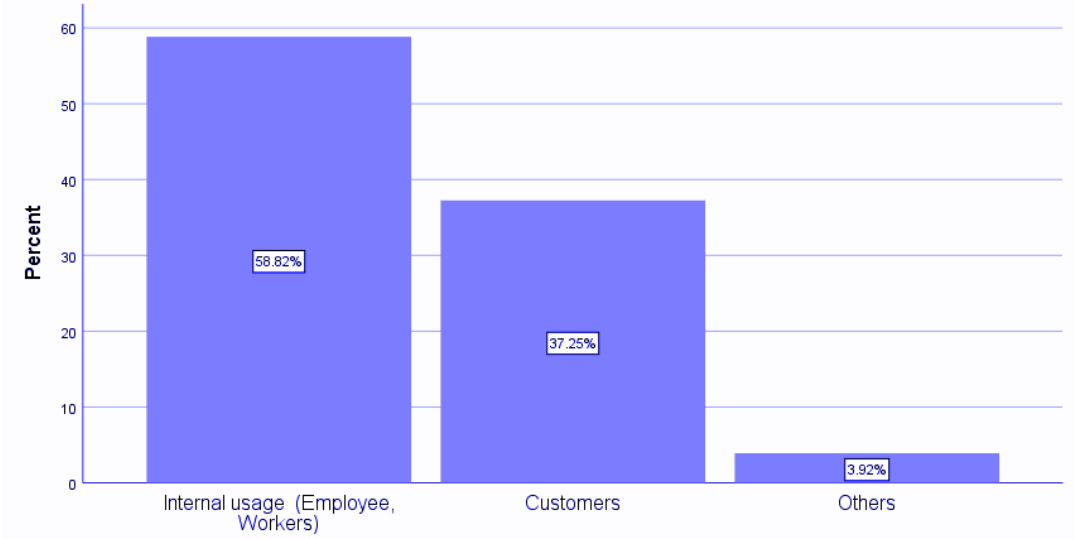
Most of the respondents say that they are neutral while talking about lack of vision and leadership for IoT initiatives

26. Question: Who is the target audience for IoT implementation

Table No 4.26: Table showing statistical data about target audience for IoT implementation

	Frequency	Percent	Cumulative Percent	Mean	Median	Std. Deviation
Internal usage (Employee, Workers)	30	58.8	58.8	1.49	1.00	0.703
Customers	19	37.3	96.1			
Others	2	3.9	100.0			

Figure No 4.26: Bar chart showing inclinations for target audience for IoT implementation



Findings:

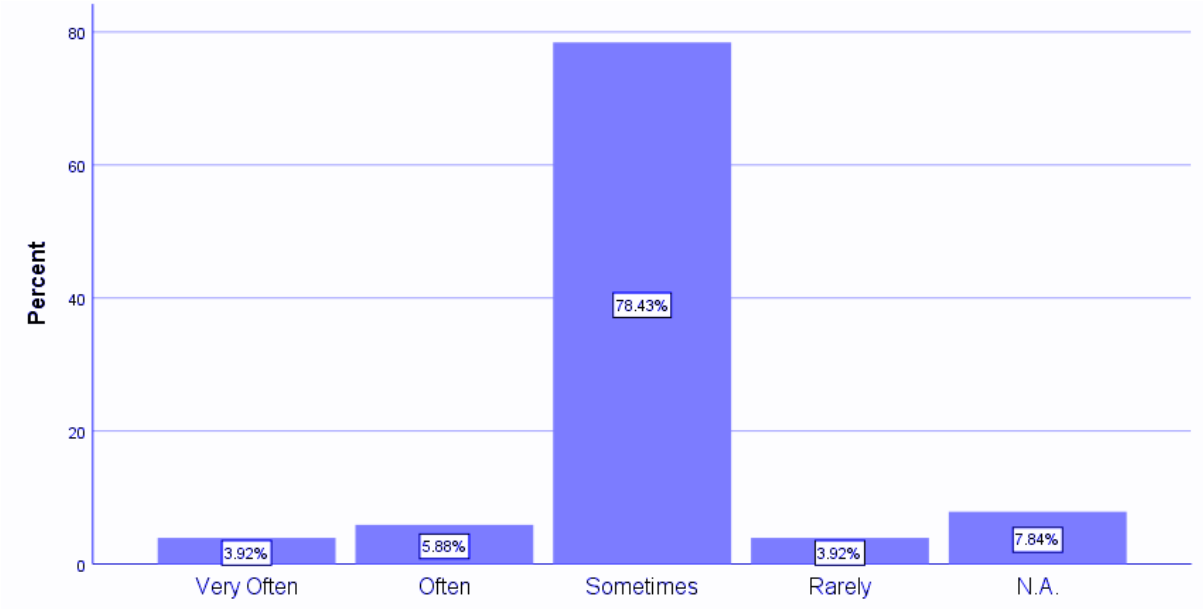
Mainly, Employees/ workers are the majority Target audience for companies for IoT solutions. With the speed of IoT implementation, Customer audience count is gearing up.

27. Question: Have you experience failure during adoption / POC

Table No 4.27: Table showing statistical data about failure frequency

	Frequency	Percent	Cumulative Percent	Mean	Median	Std. Deviation
Very Often	2	3.9	3.9	3.14	3.00	0.980
Often	3	5.9	9.8			
Sometimes	40	78.4	88.2			
Rarely	2	3.9	92.2			
N.A.	4	7.8	100.0			

Figure No 4.27: Bar chart showing failure frequency



Findings:

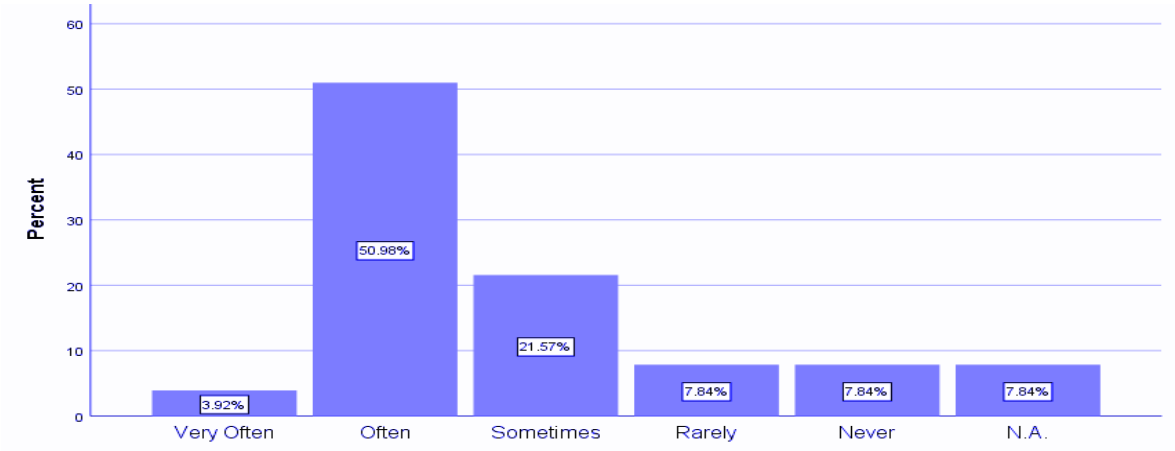
Percentage of failure during adoption/POC is very rare .However 78.43% have experiences the failure sometimes at the time of adoption or proof of concept (POC)

28. Question: Is understanding of requirement the reason for IoT failure

Table No 4.28: Table showing statistical data about reason for failure: Understanding of requirement

	Frequency	Percent	Cumulative Percent	Mean	Median	Std. Deviation
Very Often	2	3.9	3.9	2.88	2.00	1.336
Often	26	51.0	54.9			
Sometimes	11	21.6	76.5			
Rarely	4	7.8	84.3			
Never	4	7.8	92.2			
N.A.	4	7.8	100.0			

Figure No 4.28: Bar chart showing trends about reason for failure: Understanding of requirement



Findings:

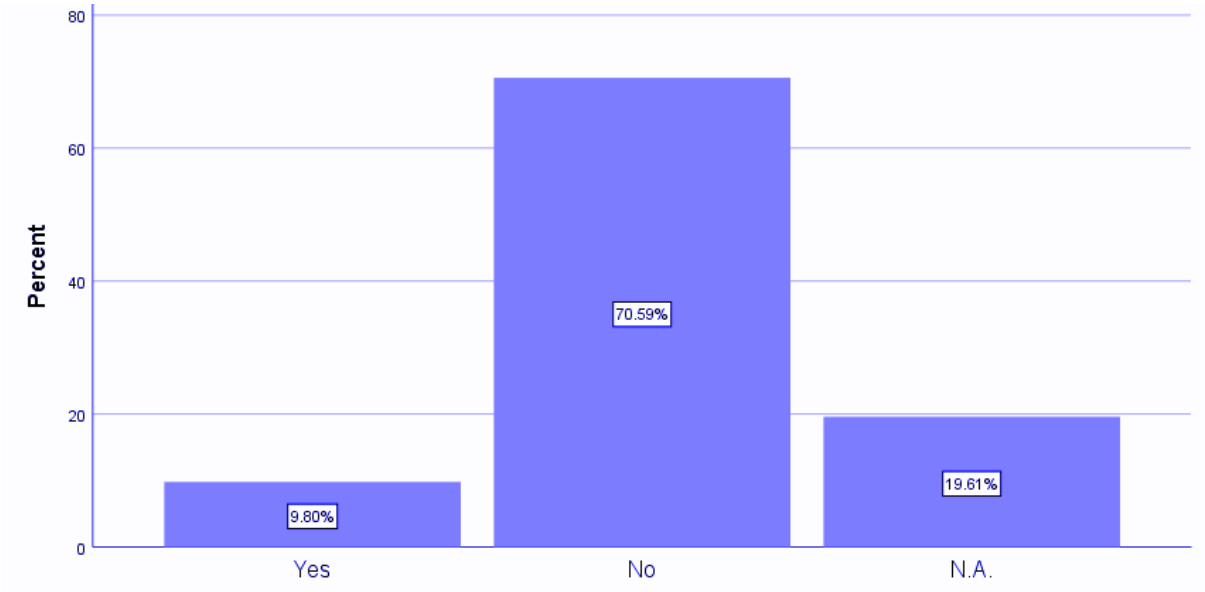
Almost half of the time, the requirements are not conveyed in the proper way, or the understanding of requirements is not proper.54.9% of respondents say that the understanding of requirement is often the reason for IoT failure

29. Question: Have you done any Audit for IoT

Table No 4.29: Table showing statistical data about IoT Audit

	Frequency	Percent	Cumulative Percent	Mean	Median	Std. Deviation
Yes	5	9.8	9.8	2.10	2.00	0.539
No	36	70.6	80.4			
N.A.	10	19.6	100.0			

Figure No 4.29: Bar chart showing experience about IoT Audit



Findings:

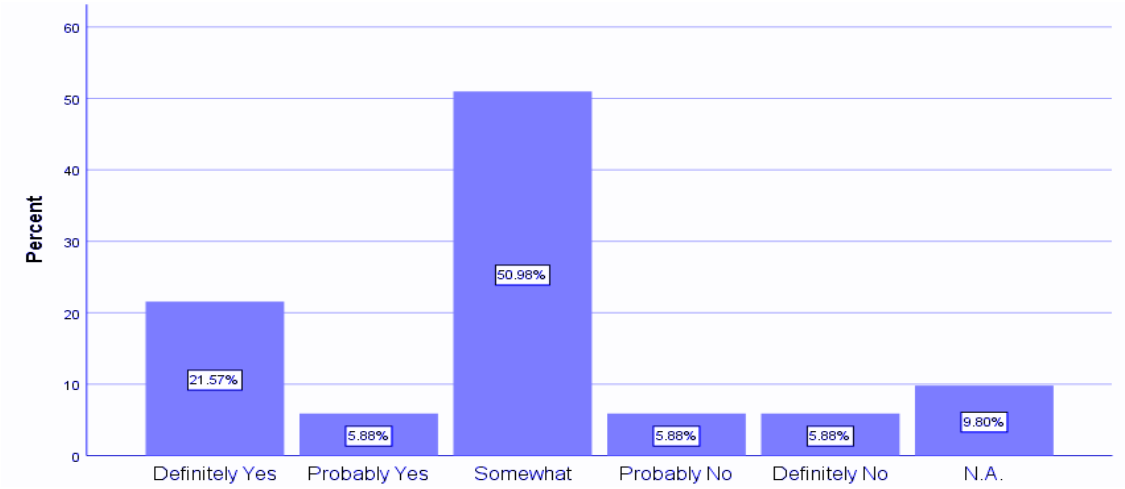
More than 70 % of the companies have not done any audit for IoT after the POC (Proof Of concept/implementation

30. **Question: Are your customers willing to share the machine generated data with you?**

Table No 4.30: Table showing statistical data about customers willing to share the machine generated data

	Frequency	Percent	Cumulative Percent	Mean	Median	Std. Deviation
Definitely Yes	11	21.6	21.6	2.98	3.00	1.463
Probably Yes	3	5.9	27.5			
Somewhat	26	51.0	78.4			
Probably No	3	5.9	84.3			
Definitely No	3	5.9	90.2			
N.A.	5	9.8	100.0			

Figure No 4.30: Bar chart showing customers willing to share the machine generated data



Findings:

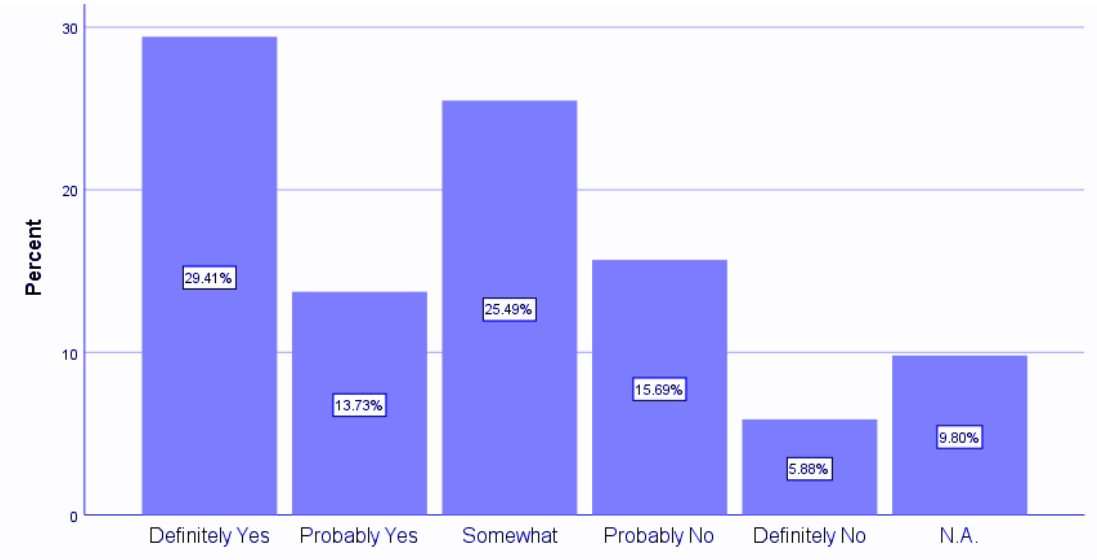
While sharing the machine generated data 78.4% of the respondents says their customers are ready for sharing the data however 11.76% of the respondents say their customer are reluctant to share machine generated data.

31. **Question: Has your company involved customers in defining what data needs to be collected?**

Table No 4.31: Table showing statistical data about customer involvement for data collection

	Frequency	Percent	Cumulative Percent	Mean	Median	Std. Deviation
Definitely Yes	15	29.4	29.4	2.84	3.00	1.617
Probably Yes	7	13.7	43.1			
Somewhat	13	25.5	68.6			
Probably No	8	15.7	84.3			
Definitely No	3	5.9	90.2			
N.A.	5	9.8	100.0			

Figure No 4.31: Bar chart showing customer involvement for data collection



Findings:

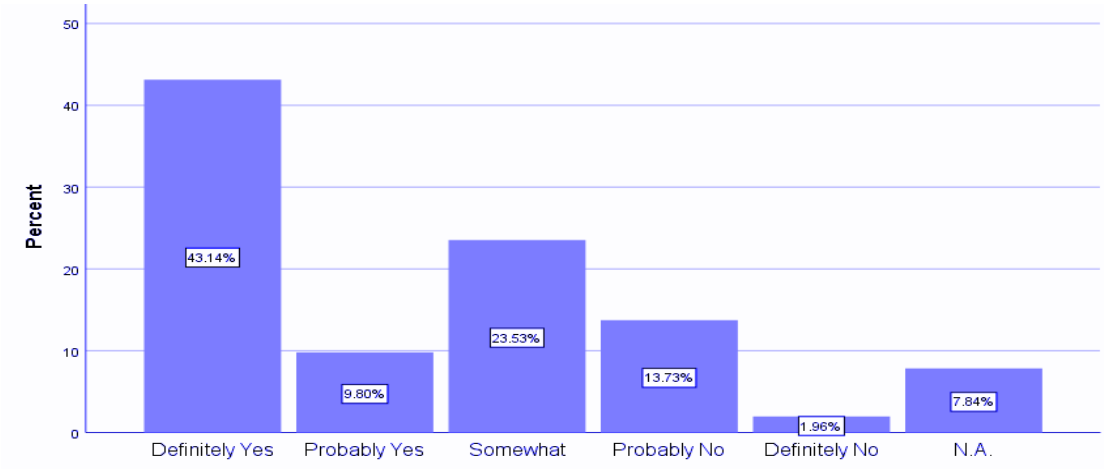
43.1 % companies say that they have involved their customer while defining the exact need of the data, while 15.68% of the companies have not involved their customer regarding this parameter.25.49% companies have involved their customer partially

32. **Question: Have you introduced updated security policies to meet the IoT requirements?**

Table No 4.32: Table showing statistical data about security policies for IoT requirements

	Frequency	Percent	Cumulative Percent	Mean	Median	Std. Deviation
Definitely Yes	22	43.1	43.1	2.45	2.00	1.579
Probably Yes	5	9.8	52.9			
Somewhat	12	23.5	76.5			
Probably No	7	13.7	90.2			
Definitely No	1	2.0	92.2			
N.A.	4	7.8	100.0			

Figure No 4.32: Bar chart showing security policies for IoT requirements



Findings:

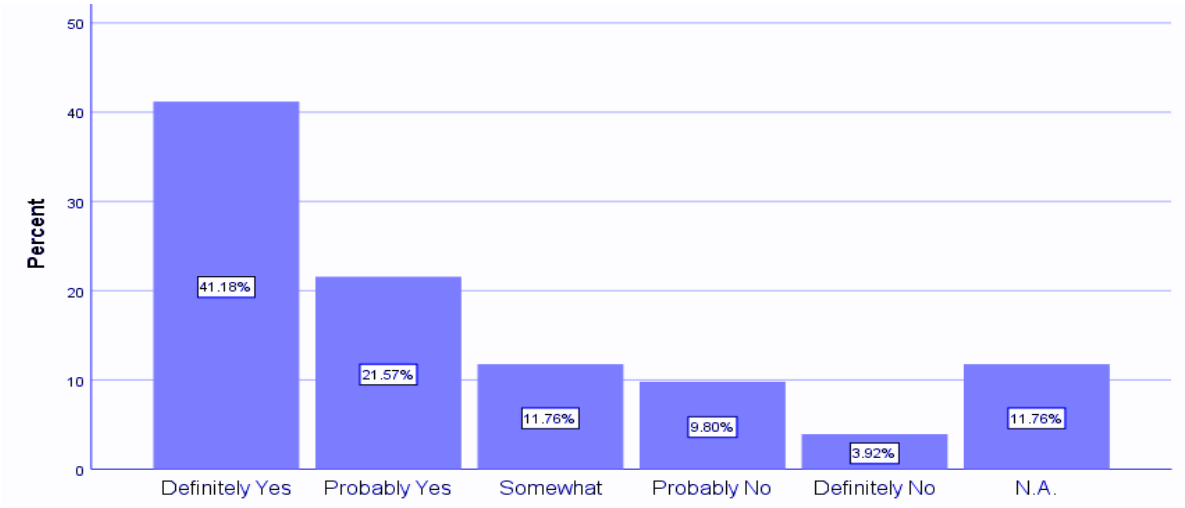
52.9% of the respondents say that they have updated security policies to meet IoT requirements however 23.53% say that they have done it at some stage

33. Question: Have you considered Artificial Intelligence to facilitate prediction capabilities?

Table No 4.33: Table showing statistical data about AI consideration in IoT project

	Frequency	Percent	Cumulative Percent	Mean	Median	Std. Deviation
Definitely Yes	21	41.2	41.2	2.49	2.00	1.725
Probably Yes	11	21.6	62.7			
Somewhat	6	11.8	74.5			
Probably No	5	9.8	84.3			
Definitely No	2	3.9	88.2			
N.A.	6	11.8	100.0			

Figure No 4.33: Bar chart showing trends about AI consideration in IoT project



Findings:

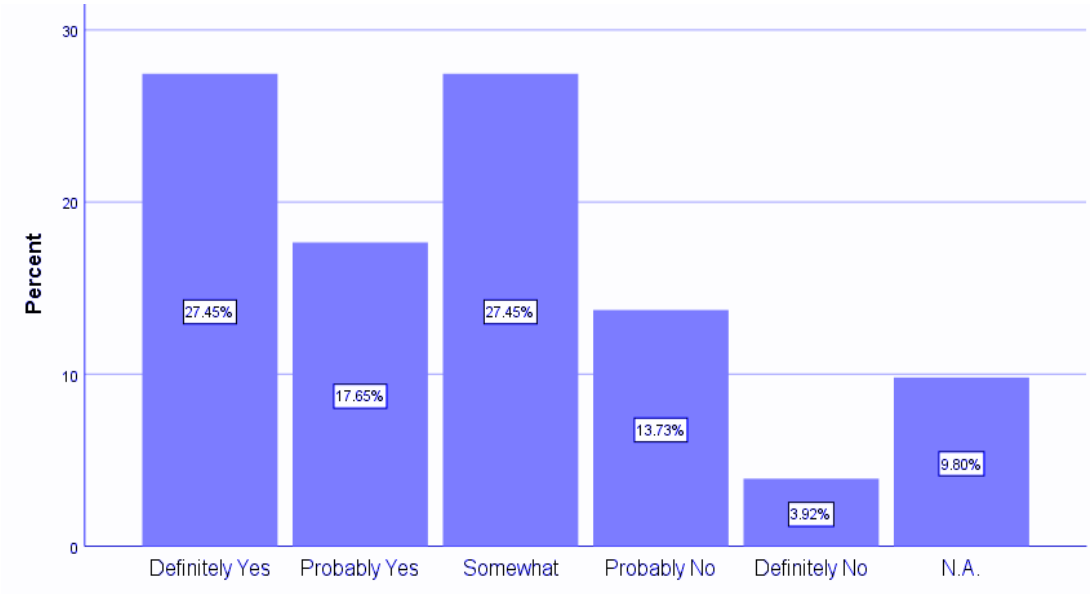
Regarding Artificial Intelligence, 74.5% of the respondents say that they have considered AI in the plan of IoT Adoption.

34. Question: Are the key stakeholders actively supporting the IoT initiatives?

Table No 4.34: Table showing statistical data about stakeholders support in IoT initiatives

	Frequency	Percent	Cumulative Percent	Mean	Median	Std. Deviation
Definitely Yes	14	27.5	27.5	2.78	3.00	1.566
Probably Yes	9	17.6	45.1			
Somewhat	14	27.5	72.5			
Probably No	7	13.7	86.3			
Definitely No	2	3.9	90.2			
N.A.	5	9.8	100.0			

Figure No 4.34: Bar chart showing stakeholders support in IoT initiatives



Findings:

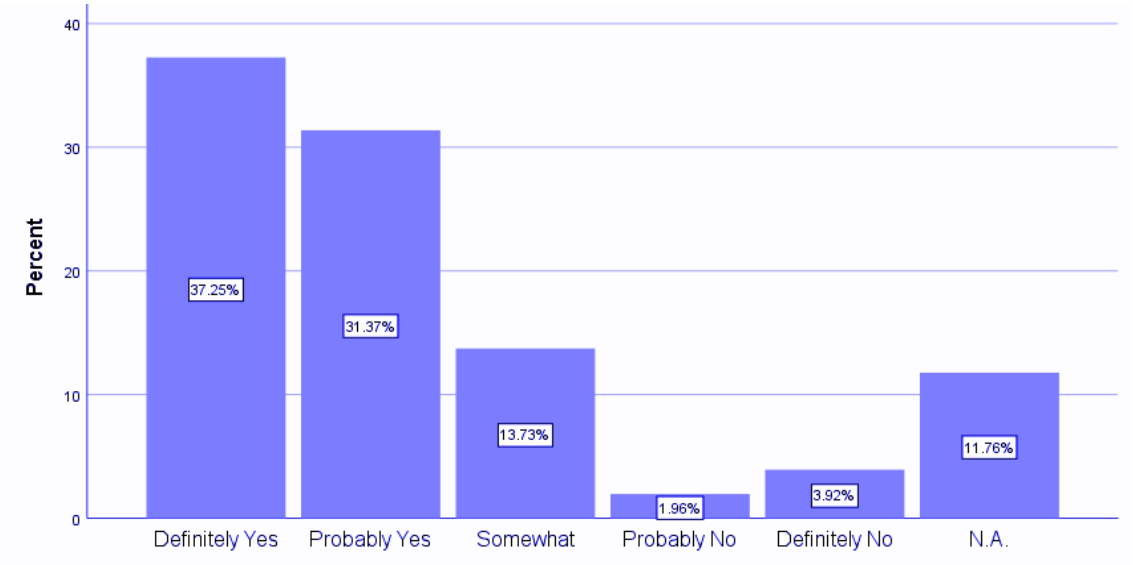
45.1 % of the respondents say that IoT initiatives have been supported by key stakeholders in the company however 45.1% of the respondents say that stakeholders are not very active in supporting IoT initiatives.

35. Question: Are your newly produced products connected or connectable?

Table No 4.35: Table showing statistical data about new products

	Frequency	Percent	Cumulative Percent	Mean	Median	Std. Deviation
Definitely Yes	19	37.3	37.3	2.39	2.00	1.650
Probably Yes	16	31.4	68.6			
Somewhat	7	13.7	82.4			
Probably No	1	2.0	84.3			
Definitely No	2	3.9	88.2			
N.A.	6	11.8	100.0			

Figure No 4.35: Bar chart showing trends about new products



Findings:

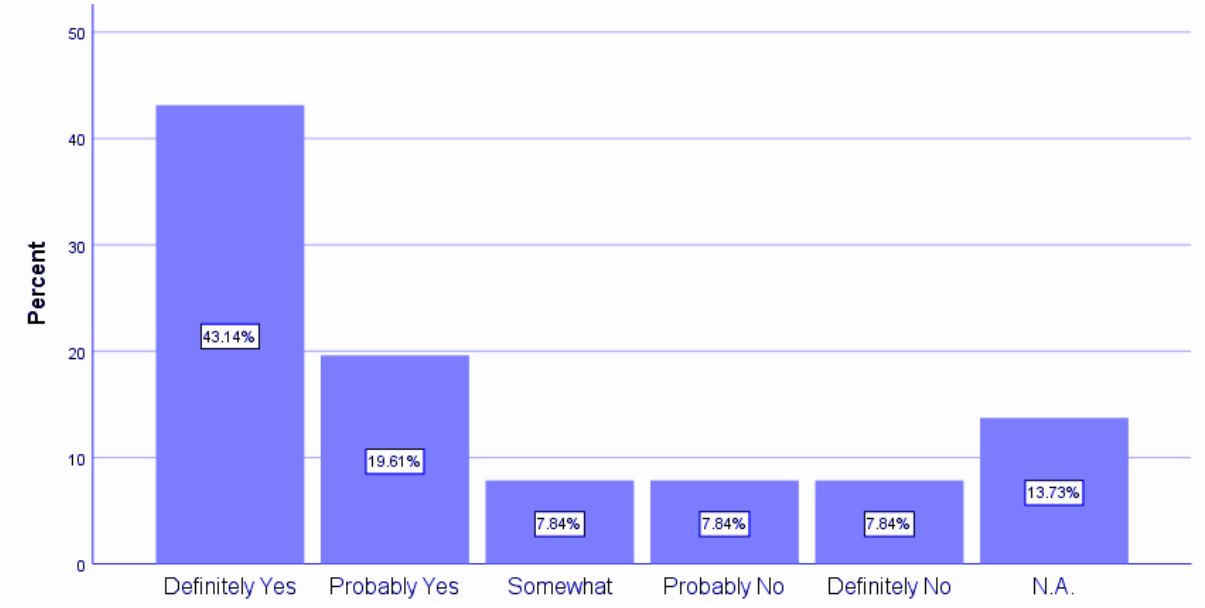
68.6% of the respondents say that their newly produced products would be connected or connectable.13.72 % of the respondents says they may be connected or connectable.

36. Question: Do you offer IoT enabled services to your customers?

Table No 4.36: Table showing statistical data about offering of IoT enabled services to customer

	Frequency	Percent	Cumulative Percent	Mean	Median	Std. Deviation
Definitely Yes	22	43.1	43.1	2.59	2.00	1.857
Probably Yes	10	19.6	62.7			
Somewhat	4	7.8	70.6			
Probably No	4	7.8	78.4			
Definitely No	4	7.8	86.3			
N.A.	7	13.7	100.0			

Figure No 4.36: Bar chart showing about offering of IoT enabled services to customer



Findings:

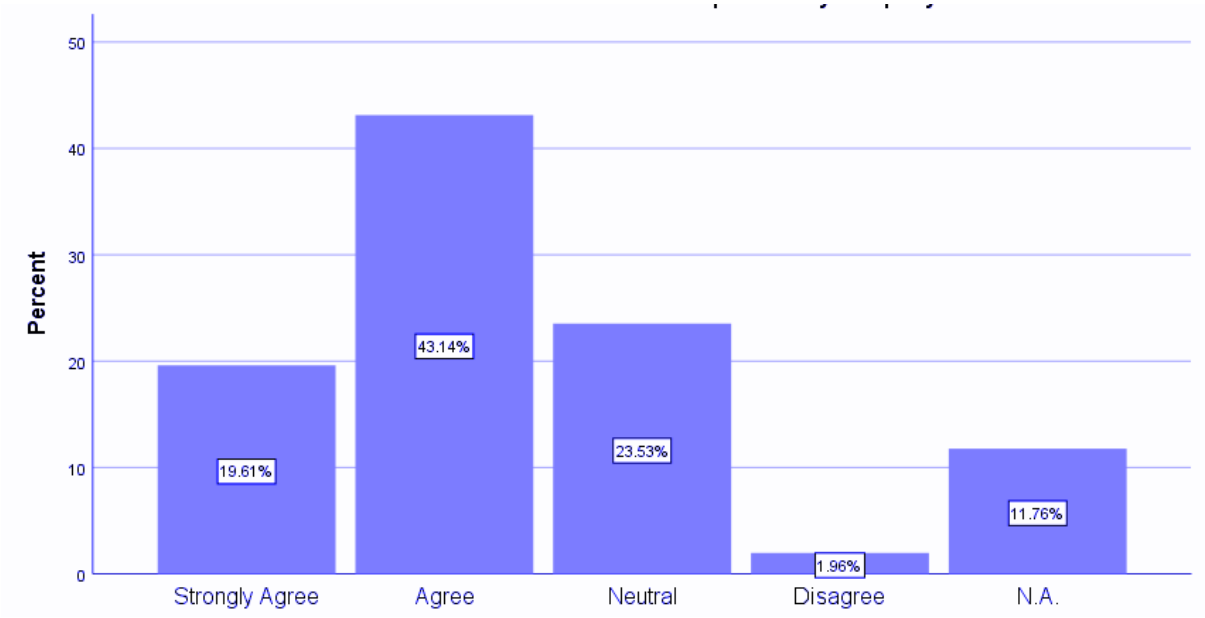
Regarding IoT enabled services, 70.6% of the respondents say they offer it to customer however 15.68 % of the respondents say they don't offer IoT enabled services to their customers

37. Question: There is Return on Investment for IoT adoption in my company

Table No 4.37: Table showing statistical data about ROI on IoT

	Frequency	Percent	Cumulative Percent	Mean	Median	Std. Deviation
Strongly Agree	10	19.6	19.6	2.55	2.00	1.460
Agree	22	43.1	62.7			
Neutral	12	23.5	86.3			
Disagree	1	2.0	88.2			
N.A.	6	11.8	100.0			

Figure No 4.37: Bar chart showing trends of ROI on IoT



Findings:

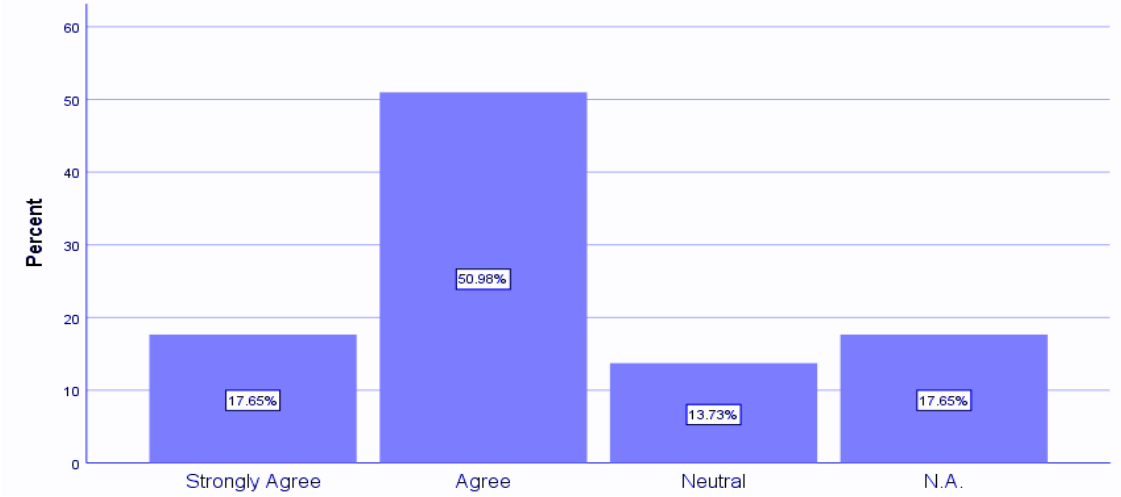
62.7% of the respondents think that there is Return On Investment (ROI) for IoT adoption, 23.53% respondents are neutral on ROI for IoT adoption.

38. Question: Plant efficiency is observed

Table No 4.38: Table showing statistical data about Plant efficiency

	Frequency	Percent	Cumulative Percent	Mean	Median	Std. Deviation
Strongly Agree	9	17.6	17.6	2.67	2.00	1.657
Agree	26	51.0	68.6			
Neutral	7	13.7	82.4			
N.A.	9	17.6	100.0			

Figure No 4.38: Bar chart showing Plant efficiency



Findings:

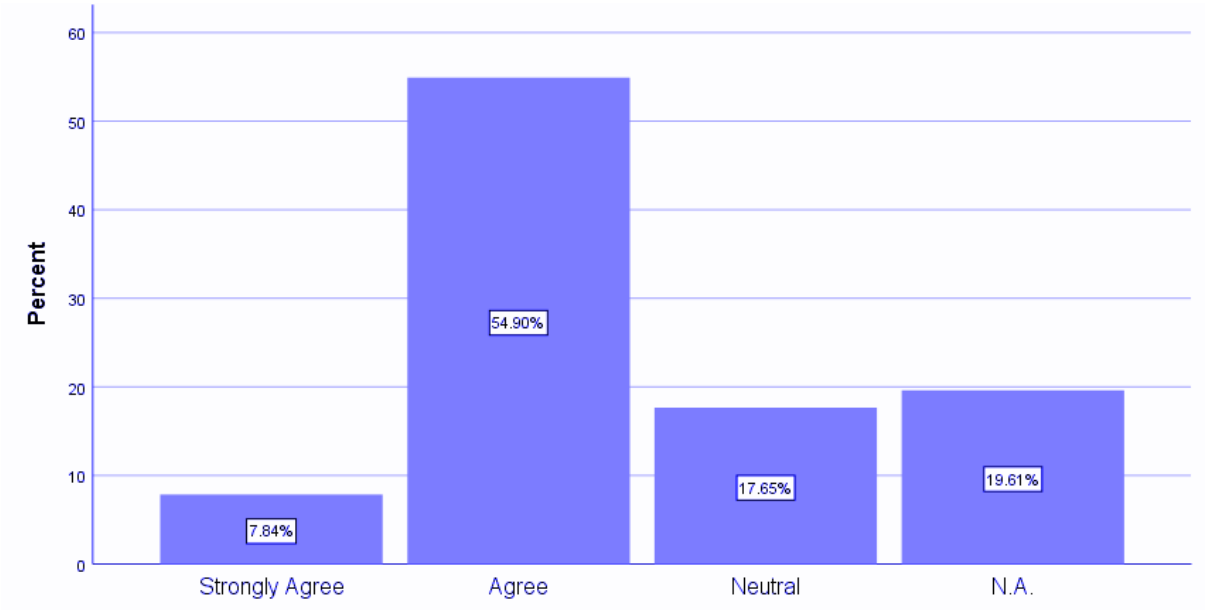
51 % of people agree that plant efficiency is observed and 18% of the people strongly agreed to the same.

39. Question: There is improvement in worker's productivity

Table No 4.39: Table showing statistical data about improvement in worker's productivity

	Frequency	Percent	Cumulative Percent	Mean	Median	Std. Deviation
Strongly Agree	4	7.8	7.8	2.88	2.00	1.633
Agree	28	54.9	62.7			
Neutral	9	17.6	80.4			
N.A.	10	19.6	100.0			

Figure No 4.39: Bar chart showing improvement in worker's productivity



Findings:

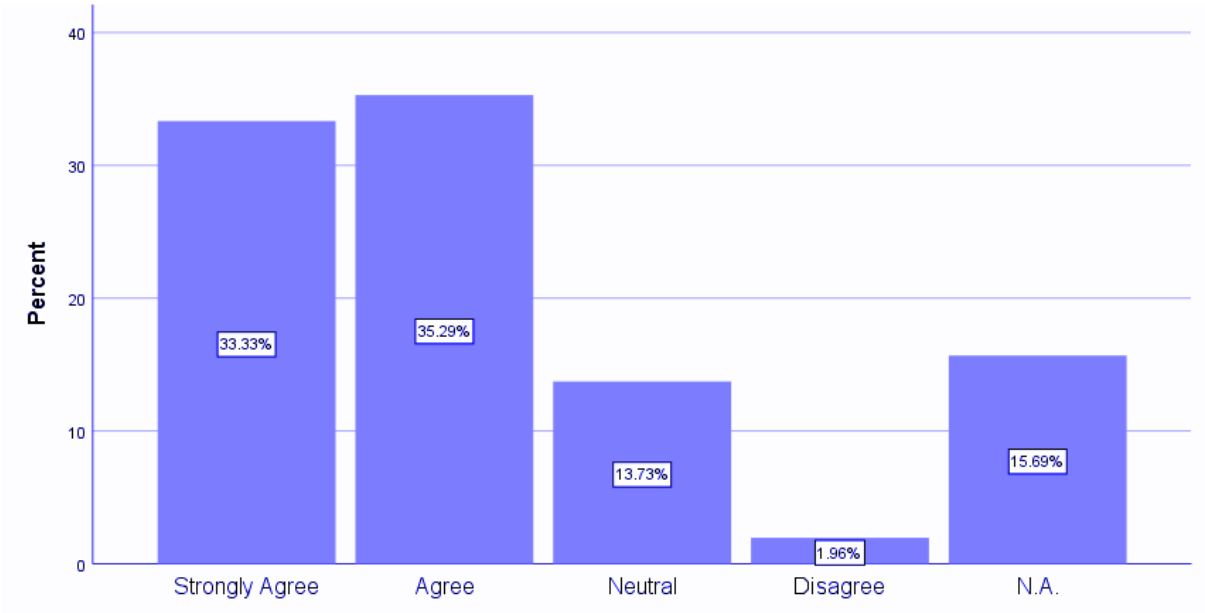
55 % of the people agree that there is improvement in worker's productivity and 18 % of the people are neutral over it.

40. Question: Plant up-time is observed

Table No 4.40: Table showing statistical data about Plant up-time

	Frequency	Percent	Cumulative Percent	Mean	Median	Std. Deviation
Strongly Agree	17	33.3	33.3	2.47	2.00	1.701
Agree	18	35.3	68.6			
Neutral	7	13.7	82.4			
Disagree	1	2.0	84.3			
N.A.	8	15.7	100.0			

Figure No 4.40: Bar chart showing opinion about plant up-time



Findings:

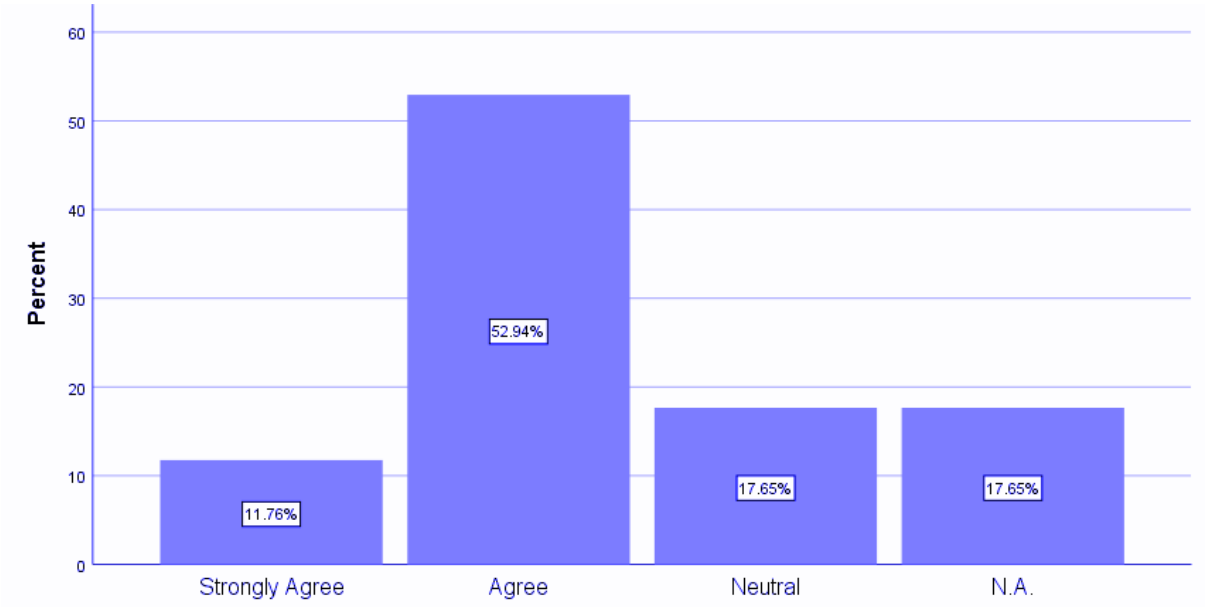
Very few that are nearly 2 % of the people disagree with the Plant up-time is observed otherwise nearly 69 % of the people Agreed/Strongly agreed to the plant up-time is observed.

41. Question: There is growth in productivity

Table No 4.41: Table showing statistical data about growth in productivity

	Frequency	Percent	Cumulative Percent	Mean	Median	Std. Deviation
Strongly Agree	6	11.8	11.8	2.76	2.00	1.607
Agree	27	52.9	64.7			
Neutral	9	17.6	82.4			
N.A.	9	17.6	100.0			

Figure No 4.41: Bar chart showing growth in productivity



Findings:

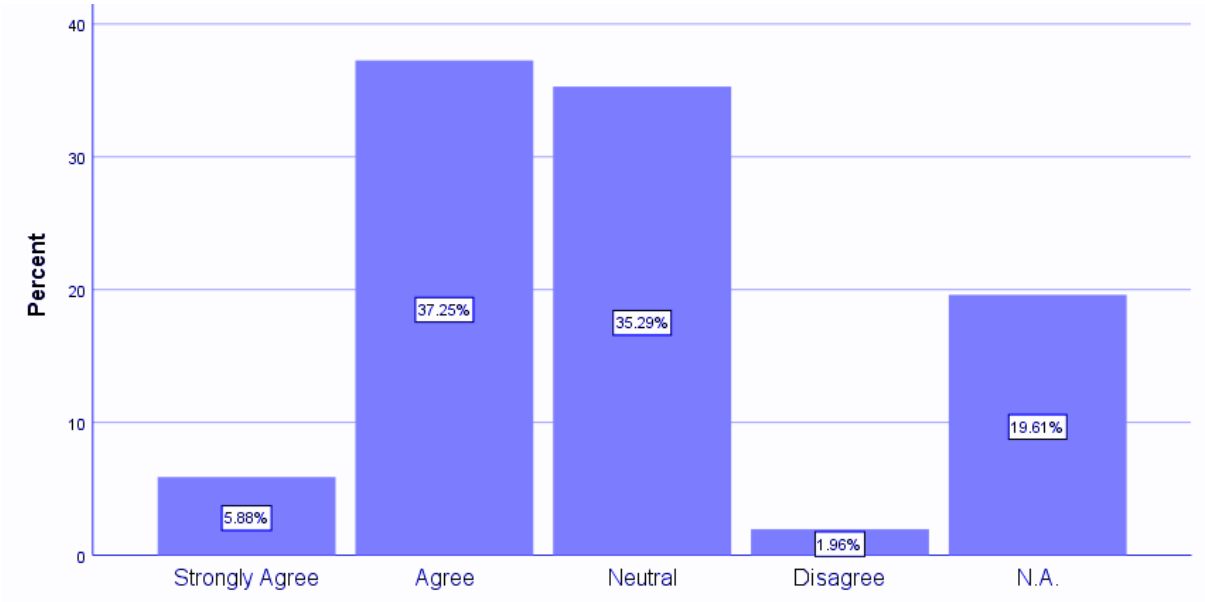
There is growth in productivity according to 53 % of the people and 12 % of the people strongly agreed to the growth in productivity.

42. Question: There is growth in sales

Table No 4.42: Table showing statistical data about growth in sales

	Frequency	Percent	Cumulative Percent	Mean	Median	Std. Deviation
Strongly Agree	3	5.9	5.9	3.12	3.00	1.558
Agree	19	37.3	43.1			
Neutral	18	35.3	78.4			
Disagree	1	2.0	80.4			
N.A.	10	19.6	100.0			

Figure No 4.42: Bar chart showing growth in sales



Findings:

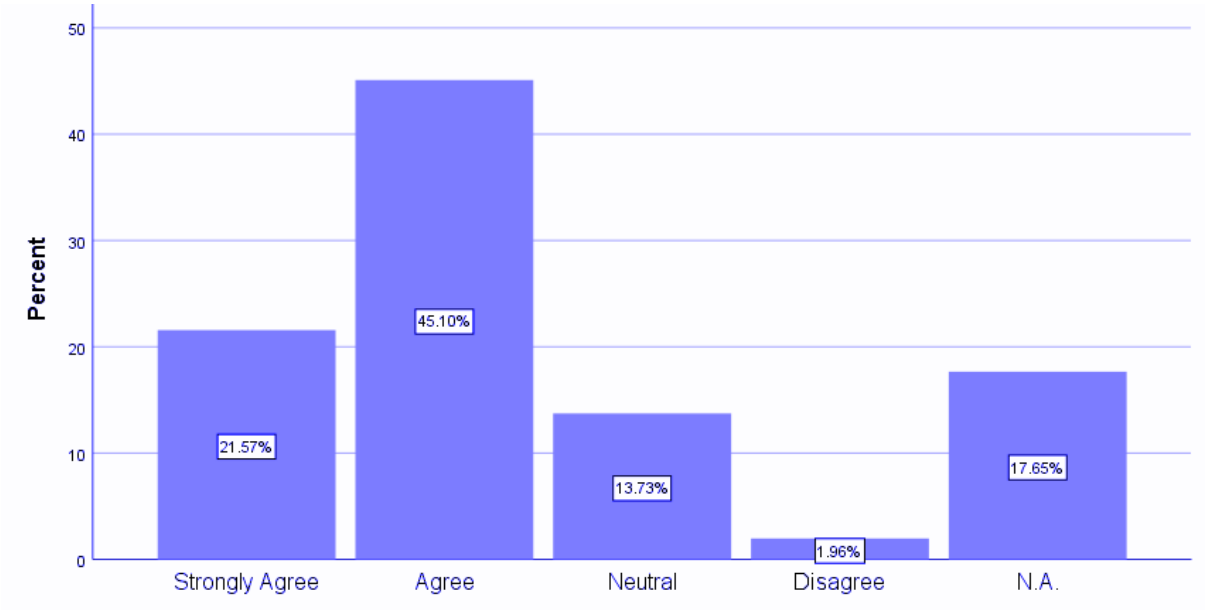
Sales are improving according to 43 % of the people who are agreed/strongly agreed. At the same time 35 % of the people are neutral to there is growth in sales.

43. Question: There is improvement in customer satisfaction level

Table No 4.43: Table showing statistical data about improvement in customer satisfaction level

	Frequency	Percent	Cumulative Percent	Mean	Median	Std. Deviation
Strongly Agree	11	21.6	21.6	2.67	2.00	1.693
Agree	23	45.1	66.7			
Neutral	7	13.7	80.4			
Disagree	1	2.0	82.4			
N.A.	9	17.6	100.0			

Figure No 4.43: Bar chart showing improvement in customer satisfaction level



Findings:

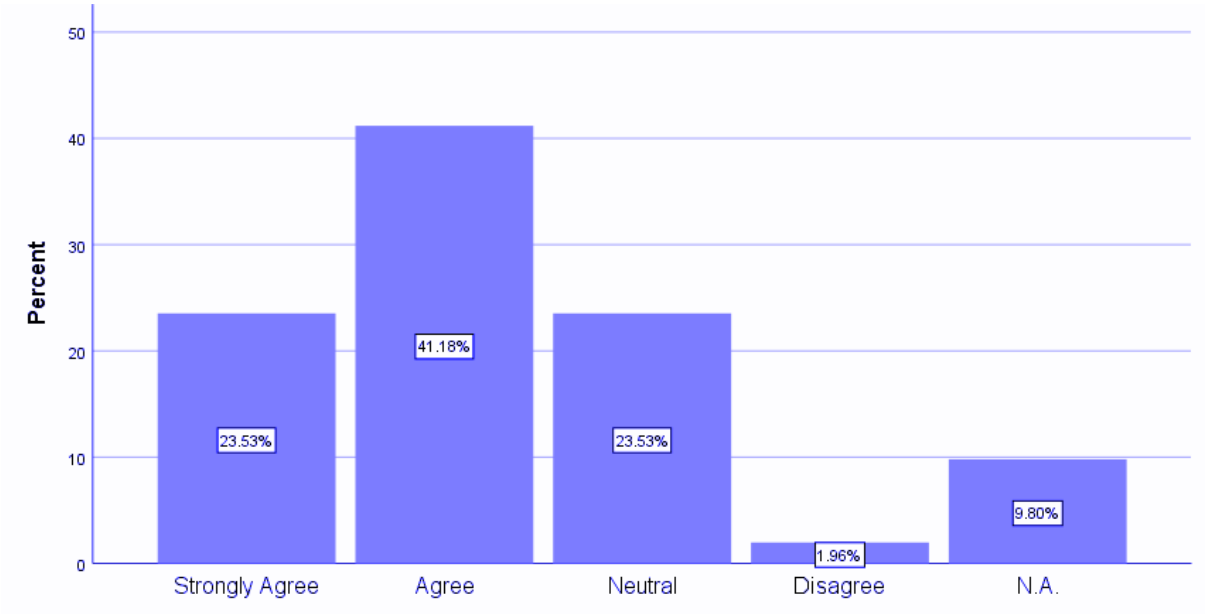
On IoT adoption 66.7% of respondents say there is improvement in customer satisfaction level.

44. Question: Do you find IoT adoption as a competitive benefit?

Table No 4.44: Table showing statistical data about IoT adoption as a competitive benefit

	Frequency	Percent	Cumulative Percent	Mean	Median	Std. Deviation
Strongly Agree	12	23.5	23.5	2.43	2.00	1.404
Agree	21	41.2	64.7			
Neutral	12	23.5	88.2			
Disagree	1	2.0	90.2			
N.A.	5	9.8	100.0			

Figure No 4.44: Bar chart showing opinion about IoT adoption as a competitive benefit



Findings:

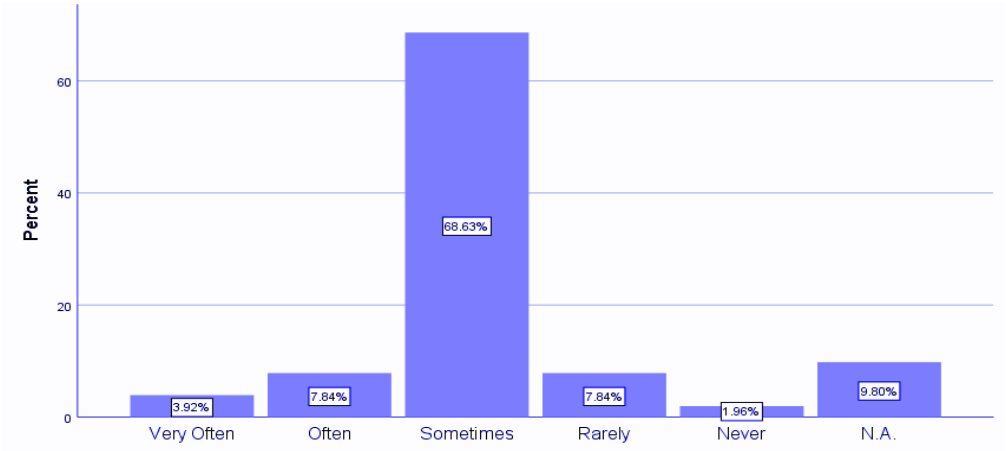
With respective IoT as a competitive benefit, 64.7% of the respondents agreed to the statement however 23.53% are still neutral about it.

45. Question: Does "Legacy equipment in use" is the showstopper for IoT Adoption?

Table No 4.45: Table showing statistical data about Legacy equipment in use during IoT Adoption

	Frequency	Percent	Cumulative Percent	Mean	Median	Std. Deviation
Very Often	2	3.9	3.9	3.25	3.00	1.111
Often	4	7.8	11.8			
Sometimes	35	68.6	80.4			
Rarely	4	7.8	88.2			
Never	1	2.0	90.2			
N.A.	5	9.8	100.0			

Figure No 4.45: Bar chart showing opinion about Legacy equipment in use during IoT Adoption



Findings:

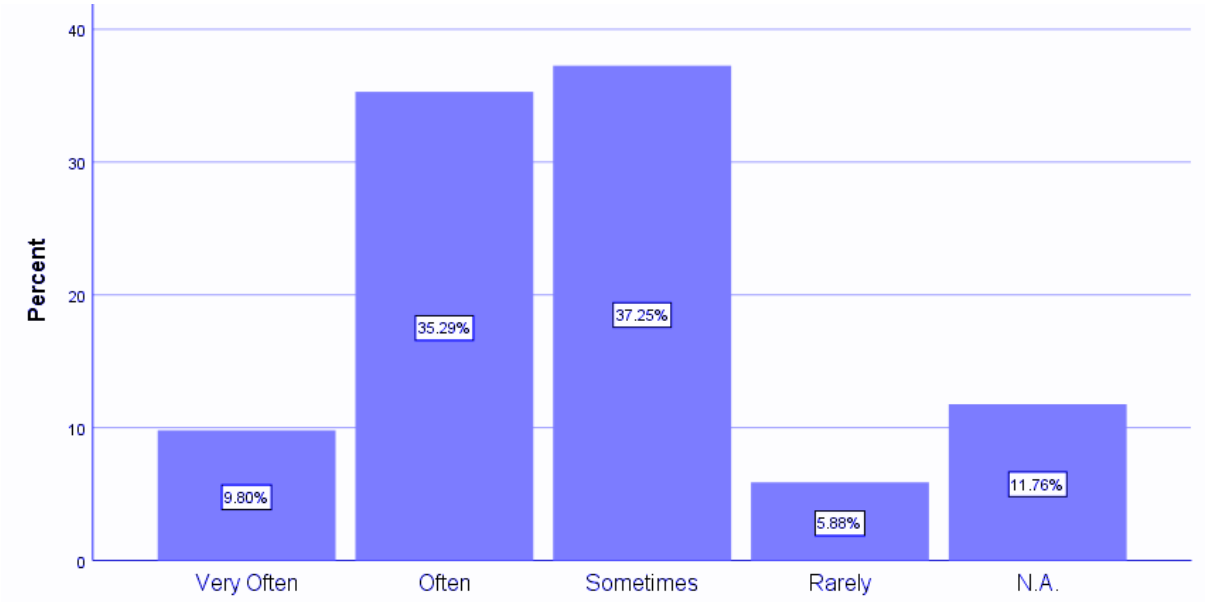
80.4% of the respondent says that “Legacy equipment in use” is the showstopper for IoT Adoption, however 1.96% of the respondents say they never faced any problem related to legacy equipment in use

46. Question: Do you find any requirement for retro-fitting for IoT usage? What kind of machines/products

Table No 4.46: Table showing statistical data about requirement for retro-fitting

	Frequency	Percent	Cumulative Percent	Mean	Median	Std. Deviation
Very Often	5	9.8	9.8	2.86	3.00	1.371
Often	18	35.3	45.1			
Sometimes	19	37.3	82.4			
Rarely	3	5.9	88.2			
N.A.	6	11.8	100.0			

Figure No 4.46: Bar chart showing requirement for retro-fitting



Findings:

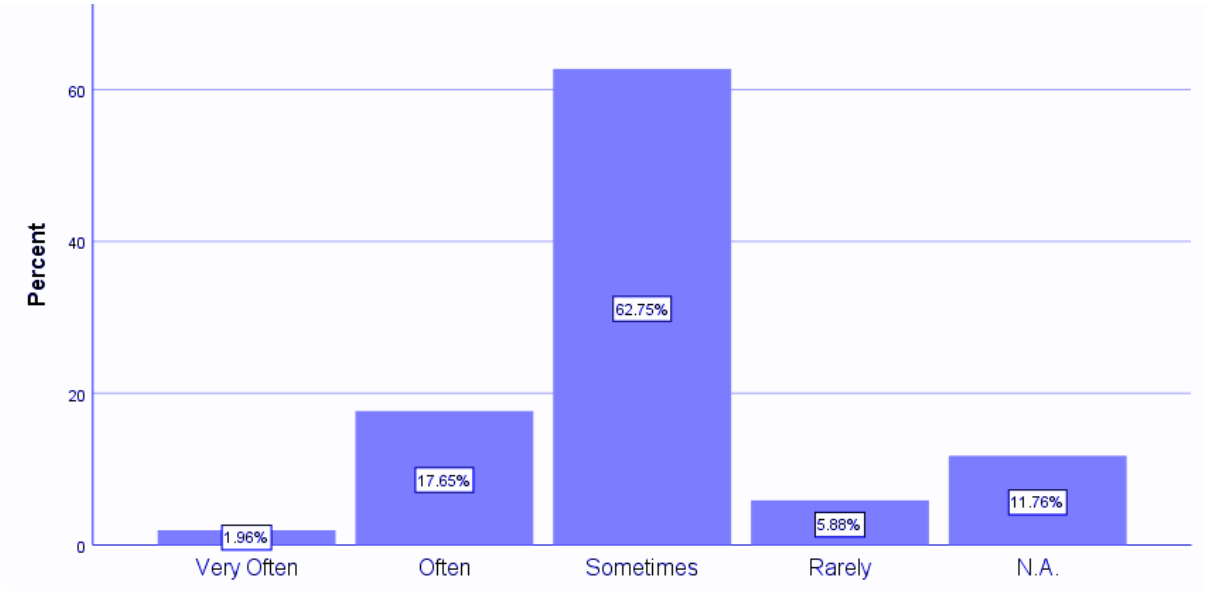
While checking for requirement of retrofitting during IoT implementation 82.4% of the respondents says that there is need of retrofitting for IoT usage.5.88% says rarely there is need of retrofitting. However it seems that in majority scenario retrofitting is required.

47. Question: Do you find any limitations for implementation?

Table No 4.47: Table showing statistical data about limitations for IoT implementation

	Frequency	Percent	Cumulative Percent	Mean	Median	Std. Deviation
Very Often	1	2.0	2.0	3.20	3.00	1.167
Often	9	17.6	19.6			
Sometimes	32	62.7	82.4			
Rarely	3	5.9	88.2			
N.A.	6	11.8	100.0			

Figure No 4.47: Bar chart showing trends about limitations for IoT implementation



Findings:

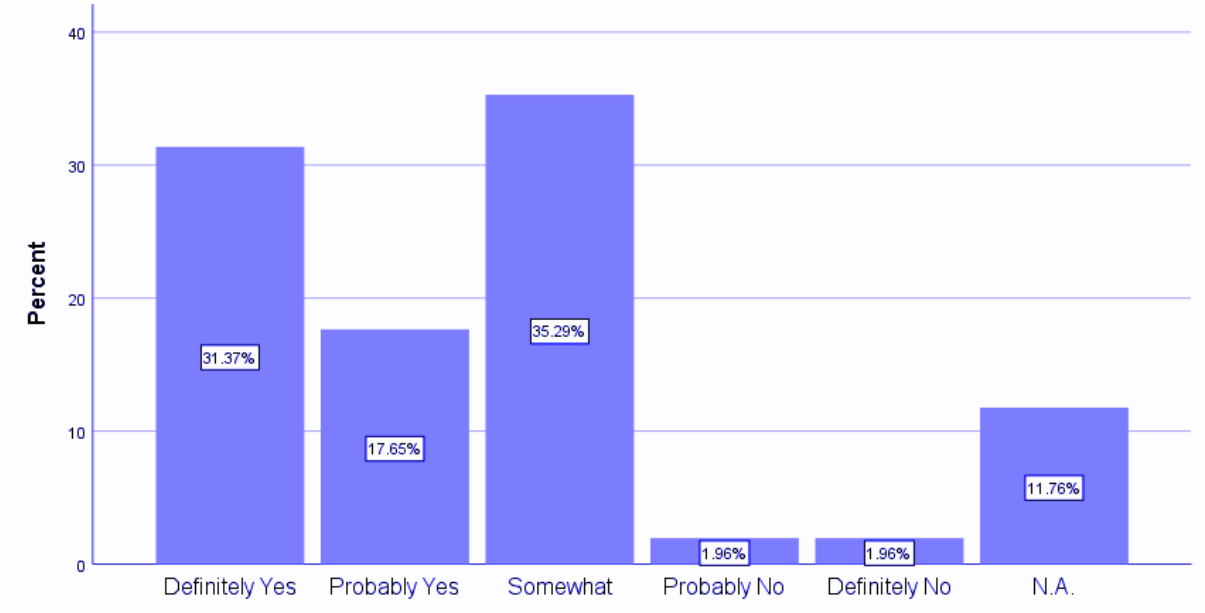
When asked about limitations in IoT implementation, 62.75% of the respondents say that sometimes there are limitations; however 5.88% of the respondents say rarely there are limitations.19.61% says rarely they feel there are limitations.

48. Question: Do you find any Privacy concerns with respect to data for adoption in your company?

Table No 4.48: Table showing statistical data about Privacy concerns

	Frequency	Percent	Cumulative Percent	Mean	Median	Std. Deviation
Definitely Yes	16	31.4	31.4	2.61	3.00	1.576
Probably Yes	9	17.6	49.0			
Somewhat	18	35.3	84.3			
Probably No	1	2.0	86.3			
Definitely No	1	2.0	88.2			
N.A.	6	11.8	100.0			

Figure No 4.48: Bar chart showing opinions about Privacy concerns



Findings:

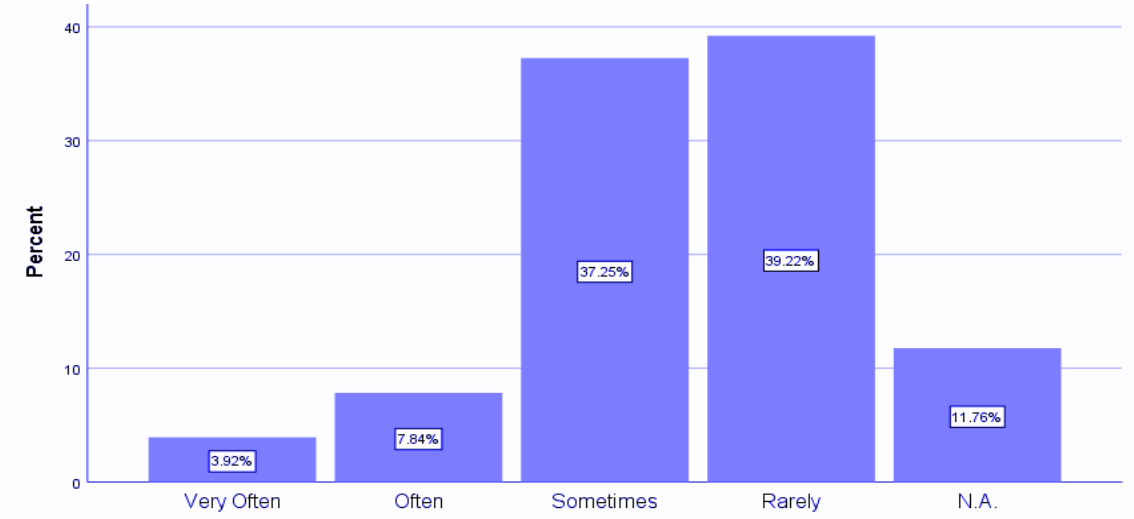
84.3 % of the respondents have concern with respect to privacy for data adoption in their company.

49. Question: Do you feel that there is risk of misuse of data during exchange of information with partners

Table No 4.49: Table showing statistical data about is risk of misuse of data during exchange of information with partners

	Frequency	Percent	Cumulative Percent	Mean	Median	Std. Deviation
Very Often	2	3.9	3.9	3.59	4.00	1.169
Often	4	7.8	11.8			
Sometimes	19	37.3	49.0			
Rarely	20	39.2	88.2			
N.A.	6	11.8	100.0			

Figure No 4.49: Bar chart showing is risk of misuse of data during exchange of information with partners



Findings:

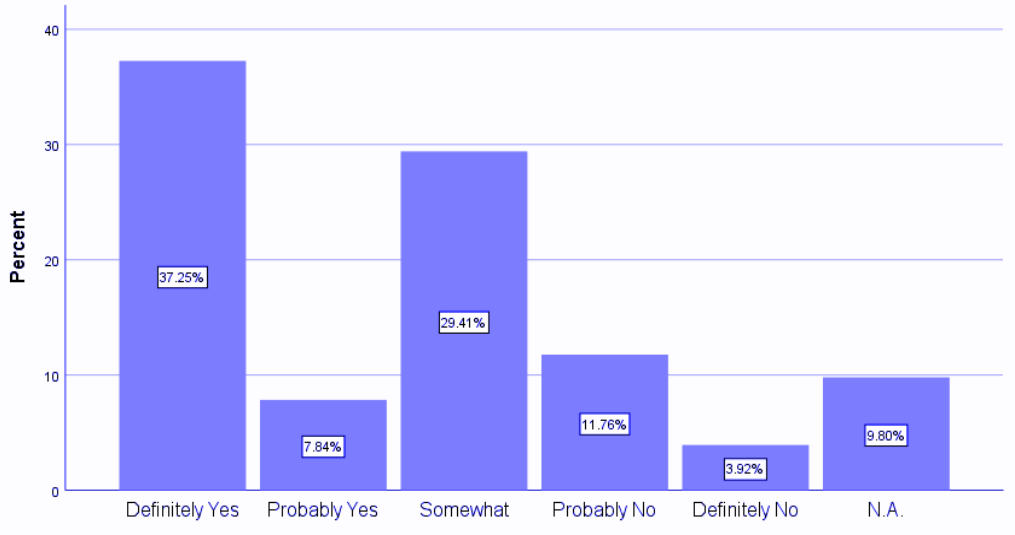
The majority respondents expressed that the risk of misuse of data during information exchange is very less, 37.25% says the risk is sometimes and 39.22% says rarely there is risk of misuse of data during exchange of information with partners

50. Question: Do you see any concern with respect to intellectual property due to IoT adoption

Table No 4.50: Table showing statistical data about views on intellectual property due to IoT adoption

	Frequency	Percent	Cumulative Percent	Mean	Median	Std. Deviation
Definitely Yes	19	37.3	37.3	2.67	3.00	1.633
Probably Yes	4	7.8	45.1			
Somewhat	15	29.4	74.5			
Probably No	6	11.8	86.3			
Definitely No	2	3.9	90.2			
N.A.	5	9.8	100.0			

Figure No 4.50: Bar chart showing views on intellectual property due to IoT adoption

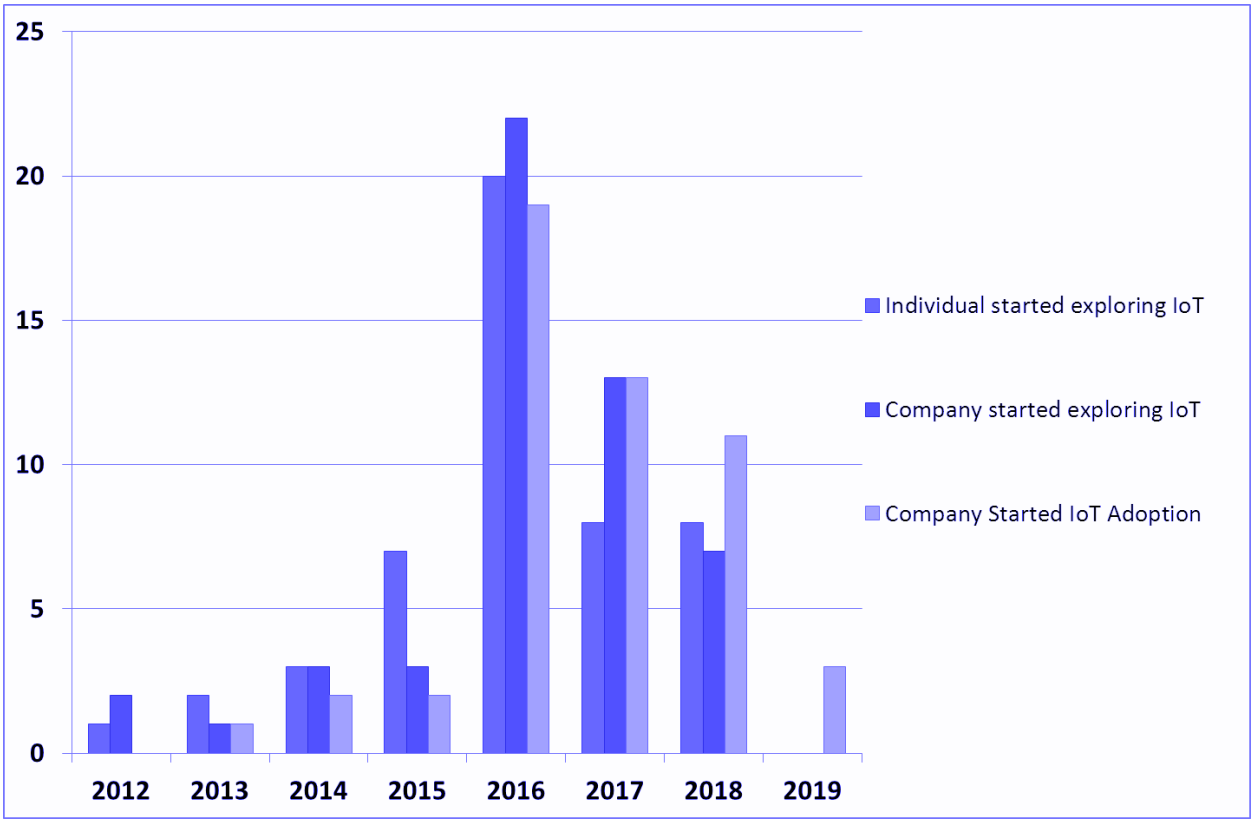


Findings:

Regarding intellectual property due to IoT Adoption,74.5% of the respondents have concern. 15.68% of the respondents did not find any concern with respect to intellectual property

4.3.2 Trend Analysis : IoT Adoption trends

Figure No 4.51: Bar chart showing trends of IoT Adoption



Findings:

The trend of IoT exploration as an individual was highest in Year 2016 amongst the respondents. The conversion from exploring to actual adoption also started in 2016 though the knowing about IoT started long back in 2012. After 2014, there is drop in year 2015, where again the adoption rate was lower however after 2016 there is no break in IoT adoption

4.3.3 Correlation- Analysis

1. If the respondents have attended the conference/ seminar, are their department /company well positioned to deal with IoT complexities?
2. If the respondents have attended the training / workshop, are their department /company well positioned to deal with IoT complexities?

3. If the company doesn't have sufficient skill sets in house, are they ready to outsource the required skill sets or do they have a roadmap which includes IT capabilities?

Figure No 4.52: Chart showing correlations in various awareness parameters

Correlations

			Conference or seminar attended by the respondent	Training or workshop attended by key people of the organization	My organization has the skill set in house which are required for IoT adoption	My organization is ready to outsource the required skillsets	Is your IT organization / department well positioned to deal with IoT complexities?	Does your IT strategy and roadmap include IoT capabilities
Spearman's rho	Conference or seminar attended by the respondent	Correlation Coefficient	1.000	.166	.259	.109	.345*	.213
		Sig. (2-tailed)	.	.245	.067	.448	.013	.133
		N	51	51	51	51	51	51
	Training or workshop attended by key people of the organization	Correlation Coefficient	.166	1.000	-.128	-.144	.394**	.118
		Sig. (2-tailed)	.245	.	.370	.314	.004	.408
		N	51	51	51	51	51	51
	My organization has the skill set in house which are required for IoT adoption	Correlation Coefficient	.259	-.128	1.000	.307*	.179	.365**
		Sig. (2-tailed)	.067	.370	.	.029	.209	.008
		N	51	51	51	51	51	51
	My organization is ready to outsource the required skillsets	Correlation Coefficient	.109	-.144	.307*	1.000	.119	.204
		Sig. (2-tailed)	.448	.314	.029	.	.406	.150
		N	51	51	51	51	51	51
	Is your IT organization / department well positioned to deal with IoT complexities?	Correlation Coefficient	.345*	.394**	.179	.119	1.000	.329*
		Sig. (2-tailed)	.013	.004	.209	.406	.	.018
		N	51	51	51	51	51	51
	Does your IT strategy and roadmap include IoT capabilities	Correlation Coefficient	.213	.118	.365**	.204	.329*	1.000
		Sig. (2-tailed)	.133	.408	.008	.150	.018	.
		N	51	51	51	51	51	51

*. Correlation is significant at the 0.05 level (2-tailed).

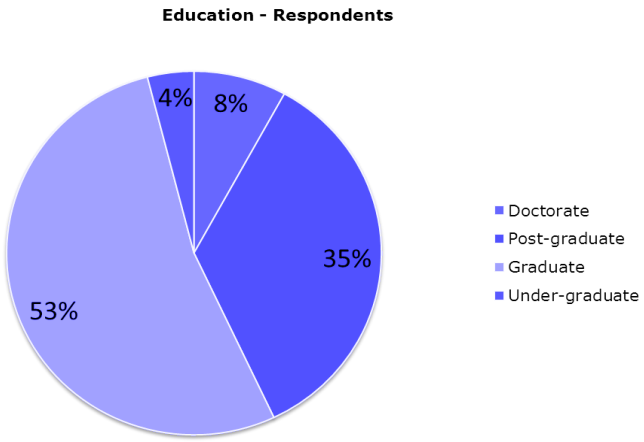
**. Correlation is significant at the 0.01 level (2-tailed).

Findings:

From the above table it can be seen that there is a significant relationship between attending conference/seminar/training/workshop on IoT and company position in dealing with IoT complexities. The companies where their employees are trained on IoT are confident that they would be able to handle IoT complexities. Additionally if the required skill sets are not available in the company, either companies are ready to outsource it or they have planned for those skill sets in their IT roadmap or IT strategy.

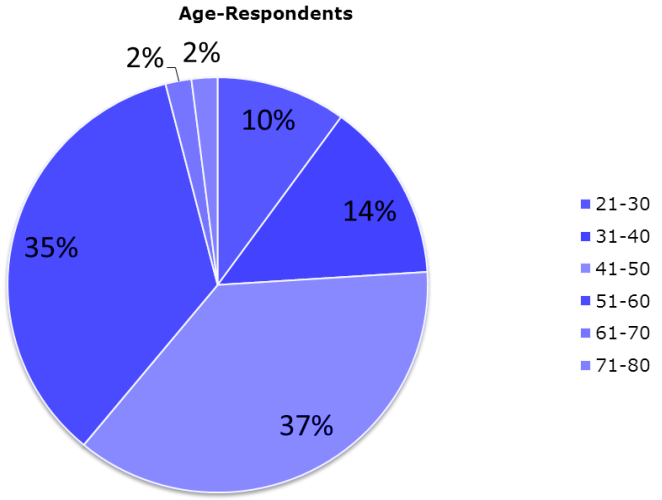
4.3.4 Demographic Analysis

Figure No 4.53: Pie Chart showing educational division amongst respondents



Remarks: 35% respondents are post-graduate and 8% of the respondents are Ph.D. holders.

Figure No 4.54: Pie Chart showing age wise division amongst respondents



Remarks: Majority of respondents are in between 41-60 of their age.

4.4 Hypotheses

4.4.1 Research Question no 1: Is there any significant difference in IoT implementation stage in companies?

Hypothesis 1:

Null Hypothesis -H0: There is no difference in IoT implementation stage in companies

Alternate Hypothesis -H1: There is difference in IoT implementation stage in companies

Statistical Test: T-Test

Level of Significance (α) =0.05

Test Table:

T-Test					
		V		p	
QA_4		1326.000		< .001	
Note. Wilcoxon signed-rank test.					

Conclusion:

Since the p value is less than the level of significance (0.05) the null hypothesis is rejected. Hence it is concluded that all companies have not yet implemented IoT in their companies. There is a difference in the IoT implementation stage of companies.

In order to find out where the differences lies we refer to the descriptive table, which is mentioned below:

Descriptive table:

Descriptive				
	N	Mean	SD	SE
QA_4	51.000	2.176	0.994	0.139

The mean value indicates that most of the companies are in the process of IoT implementation.

4.4.2 Research Question no 2: Is there enough awareness about IoT in companies?

Hypothesis 2:

Null Hypothesis -H0: There is no enough awareness about IoT in companies

Alternate Hypothesis -H1: There is enough awareness about IoT in companies

Statistical Test: Friedman Chi-square Test

Level of Significance (α) =0.05

Test Statistics Table:

Test Statistics	
N	51
Chi-Square	117.035
df	4
Asymp. Sig.	.000

Observation: X^2 (4) =117.035, P=0.000, N=51

Conclusion:

Since the p value is less than the level of significance (0.05) the null hypothesis is rejected. Hence it is concluded that there is enough awareness about IoT in companies.

In order to find out where the differences lies we refer to the rank table, which is mentioned below:

Ranks	
	Mean Rank
Awareness about IoT of the respondents	3.23
Conference or seminar attended by the respondent	1.33
Training or workshop attended by key people of the organization	3.01
There is enough awareness about the current state of technology in IoT in My Company	2.95
When it comes to Technology, what best describes you?	4.48

Regarding various training/conference/workshop/training also the variation is less. From the rank table it has been seen that there is a high variation about the respondents describing themselves when it comes to Technology.

4.4.3 Research Question no: Does the companies have required readiness for IoT Adoption?

Hypothesis 3:

Null Hypothesis -H0: The companies do not have required readiness for IoT Adoption

Alternate Hypothesis -H1: The companies have required readiness for IoT Adoption

Statistical Test: Friedman Chi-square Test

Level of Significance (α) =0.05

Test Statistics Table:

Test Statistics	
N	51
Chi-Square	54.309
df	15
Asymp. Sig.	.000

Observation: X^2 (15) =54.309, P=0.000, N=51

Conclusion

Since the p value is less than the level of significance (0.05) the null hypothesis is rejected. Hence it is concluded that companies have the readiness required for IoT Adoption.

In order to find out where the differences lies we refer to the rank table, which is mentioned below:

Ranks	
	Mean Rank
What is current adoption status of IoT in your organization	6.79
Do you feel that you are ready for IoT adoption	7.01
My organization is infrastructure wise ready for investment	7.26
My organization is ready for investment required for IoT	8.30
My organization has the skill set in house which are required for IoT adoption	10.08
My organization is ready to outsource the required skill sets	8.54
My organization has identified the need / area for adoption	8.25
Are you ready for failures while IoT adoption	9.72
Do you want to go for another attempt if you have failed	7.75
Is the service team an active part of the product development team to plan IoT services before product launch?	10.46
Does your IoT infrastructure provide sufficient bandwidth and capacity?	8.46
Have you selected an IoT platform to support your strategic IoT initiatives?	10.10
Does your IT Architecture cater for IoT?	9.18
Is your IT organization / department well positioned to deal with IoT complexities?	7.95
Have you defined who will drive/sponsor the IoT initiatives?	7.46
Have you defined a roadmap to transform your business to IoT enabled services?	8.69

From the rank table it has been seen that there is very low variation about the respondents when it comes to current adoption status of IoT. Similarly about company readiness for adoption low variation is observed.

4.4.4 Research Question no 4: Is there competitive benefit if customer satisfaction level is improved because of IoT

Hypothesis 4:

Null Hypothesis -H0: There are no competitive benefits if customer satisfaction level is improving because of IoT

Alternate Hypothesis -H1: There are competitive benefits if customer satisfaction level is improving because of IoT

Statistical Test: Spearman Rank Order Correlation

Level of Significance (α) =0.05

Pair	Spearman's rho (ρ)	P-value	Result
There is improvement in customer satisfaction level AND Do you find IoT adoption as a competitive benefit?	0.653	0.01	Significant

Conclusion:

From the above table it can be seen that there is a significant relationship between improvement in customer satisfaction level and IoT adoption as a competitive benefit. As the $p<0.05$, we can conclude that we can reject the null hypothesis and accept the alternate hypothesis, which says that there is competitive benefits if customer satisfaction level is improving because of IoT.

4.4.5 Research Question no: If there is risk of misuse of data during exchange of information in IoT projects with partners is it because of Intellectual property

Hypothesis 5:

Null Hypothesis -H0: Risk of misuse of data during exchange of information in IoT projects is nowhere related to Intellectual property

Alternate Hypothesis -H1: Risk of misuse of data during exchange of information in IoT projects is related to Intellectual property

Statistical Test: Spearman Rank Order Correlation

Level of Significance (α) =0.05

Pair	Spearman's rho (ρ)	P-value	Result
Do you feel that there is risk of misuse of data during exchange of information with partners AND Do you see any concern with respect to intellectual property due to IoT adoption	0.362	0.01	Significant

4.5 Conclusion:

From the above table it can be seen that there is a significant relationship between risk of misuse of data during exchange of information with vendor and concern with respect to intellectual property. As the $p<0.05$, we can conclude that we can reject the null hypothesis and accept the alternate hypothesis, which says that Risk of misuse of data during exchange of information in IoT projects is related to Intellectual property. Companies are concern about their data exchange as they feel it may impact on their intellectual property.

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Chapter - 5

Conclusions and Recommendations

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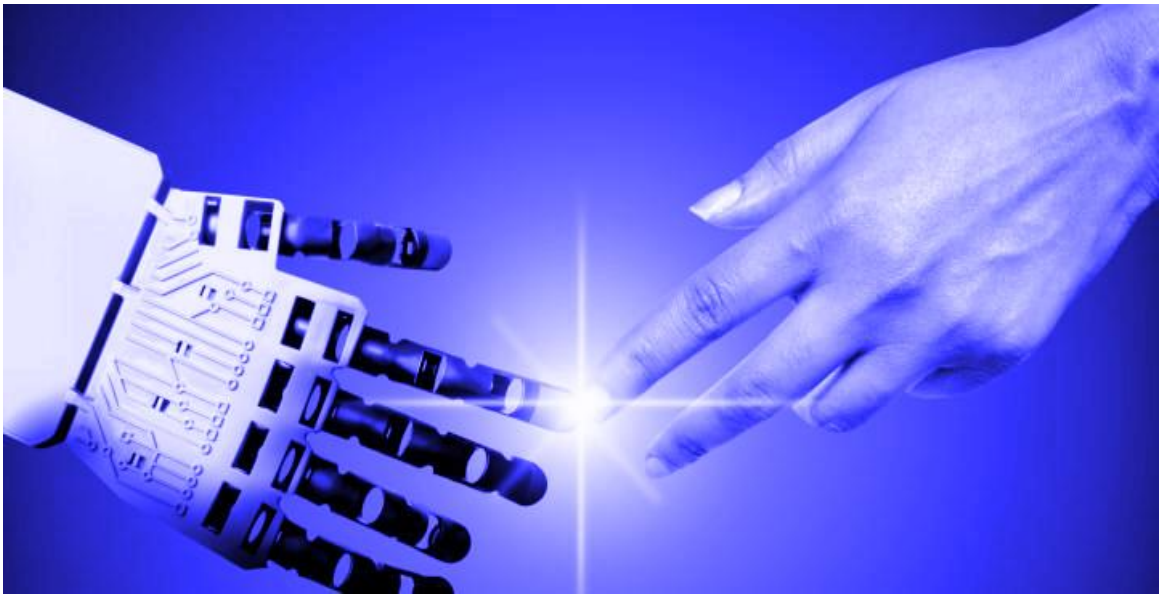
5.1 Background

IoT is not about just machines replacing humans. It is about how we can achieve our production and quality goals better through an optimum collaboration between humans and machines. It is not machines vs. humans!

Figure No 5.1: Collaboration between humans and machines



The 'replacement' is not going to be across the entire spectrum of activities. The 'Smart Factory' paradigm is going to free up human operators' time from having to monitor certain parameters 24/7. It is going to reduce errors, when the operators have already been on the shop-floor for many hours and prone to mistakes. It is going to keep them safe, by integrating mistake-proofing ('Poka-yoke') mechanisms using connected sensors. It is not about diminishing the role of the human operators, but rather elevating it to a smart custodian of the production and quality, helped by minions made of steel and silicon.

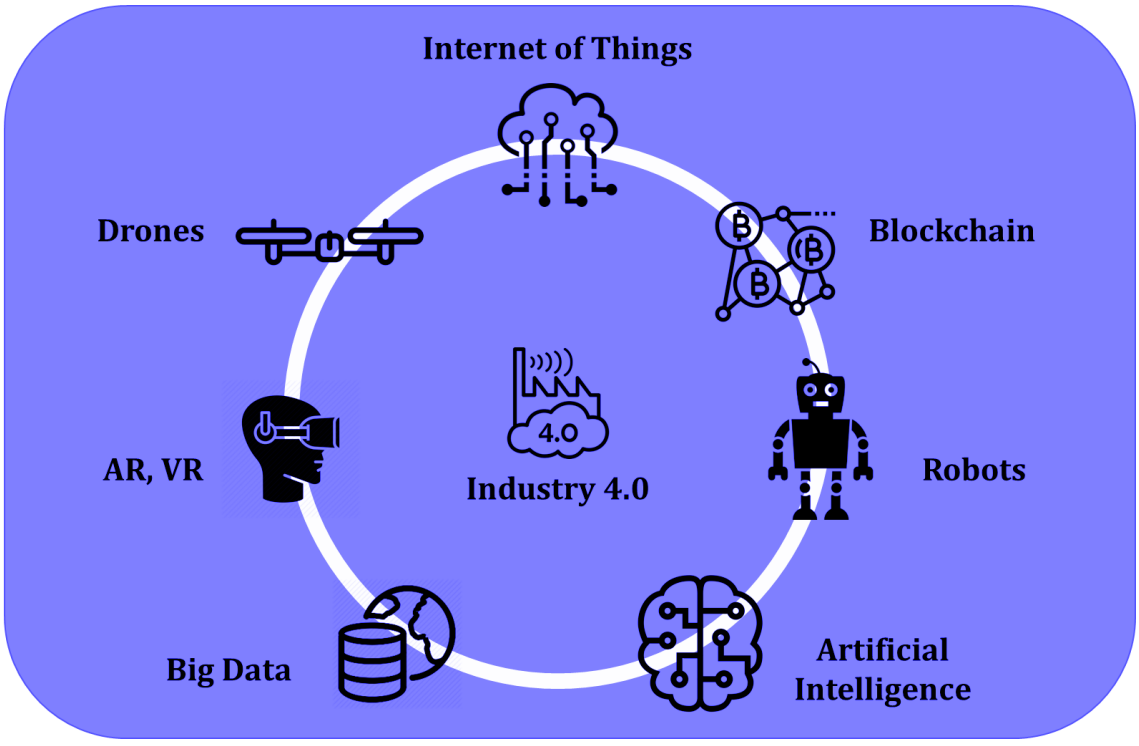
As we see, the activities most susceptible to being replaced by robots and machines are predictable physical work (e.g. job-work being replaced by automatic CNC machines), data collection and processing (e.g. data entry and preliminary processing replaced by connected sensors and machine-learning algorithms).

This past decade has seen a barrage of new technical terms (some rejuvenated from research going on since decades) – like Artificial Intelligence, Machine Learning, Big Data, Deep Learning, Blockchain, IoT (Internet-of-Things), and Augmented Reality (AR).

This soup of technical terms can seem confusing and disorienting. But, these are not disparate and irrelevant technologies. They do have a common thread. In a nutshell, all of them are about improving what humans can do by themselves, by aiding them with tools to make faster and better decisions.

Success of any of these technologies depends on the people as well! The change management has to be smartly done. Judicious use of technology, like anything else, will be the only way out.

Figure No 5.2: Use of technology



Traditional 'cloud computing' is being heavily complemented by the edge computing paradigm, forming an entirety of a single, symbiotic solution.

Cloud computing is not the end stage of decentralized computing; increasingly the ‘edge computing’ paradigm is taking over.
On-the-edge, local, point-of-use computing allows a fast, decentralized approach and can be spread across huge geographical regions.

The “hype cycle” is a graphical presentation developed by the American research & advisory firm Gartner, for representing the maturity, adoption and social application of specific technologies. The hype cycle provides a graphical and conceptual presentation of the maturity of emerging technologies through five phases.
As far as multiple components of IoT are concerned, we are near the Peak of Expectation and will soon be entering the Trough of Disillusionment.
This is the stage where there is a lot of early publicity resulting in some quick adapters achieving initial success. Slowly, a number of success stories come out—often accompanied by scores of failures. Some companies take action; most don't.
This phase will belong to those who take decisive action! At this stage, starting small isn’t a crime – not starting at all will prove to be.

Figure No 5.3: Expectations Vs Time

5.2 Important Findings

After the analysis and interpretation, below important findings are listed:

- Management approach towards IoT does include the vision particular company has defined. Middle management or functional heads were reluctant to talk about leadership vision on IoT initiatives (chapter 4:Q25).
- Education trends say that people who have done masters or doctorate are more aware about IoT and connected things.
- People are keen to do new things with respect to technologies, which may boost IoT Adoption (chapter 4:Q5).
- In the manufacturing industries, Management has started exploring IoT and identifying areas of adoption (chapter 4:Q12).However there is a gap of almost 2 years in exploring IoT and the actual start of the project.
- Many companies are making initial IoT investments because they see their competitors exploring this area
- Most of the time, these initiatives have come from either the IT department or business (chapter 4:Q24).
- The companies who have implemented IoT or are in the process of implementation have majorly started the adoption in their manufacturing plant. The companies, who have already implemented IoT, have below automation tools already implemented in their company.
    - DCS-Distributed Control System
    - SCADA-Supervisory Control and Acquisition
    - PAC-Programmable Automation Controller
    - ANN-Artificial neural network
    - PLC-Programmable Logic Controller Instrumentation
    - Robotics
- Management has their roadmap for IoT enabled products and services that can be offered to customers (chapter 4:Q21, Q36).

- Management is exploring various IoT platforms for IoT implementation (chapter 4:Q17). Whenever management is thinking about IoT initiatives, it does consider AI as a part of it (chapter 4:Q33).
- Management is not very sure about handling IoT complexities by their IT team or their IoT partner(chapter 4:Q19).However though the companies don't have skill set available within the company, management is ready to outsource the required skill set(chapter 4:Q11)
- Management agree that there will be return on investment for IoT adoption(chapter 4:Q37).They mention that there are multiple advantages by implementing IoT(chapter 4:Q42)
- Management mentioned about various benefits about IoT implementation where in below points were stated by majority: Better planning and controlling, Customer Value, Faster time to market, Improved quality, Individualization of products, Risk minimization, More efficient division of labour, Improved asset utilization, competitive edge to product, Improvement in services.
- Requirement gathering, understanding and its conversion has been observed as a major reason for failure of IoT initiatives (chapter 4:Q28).Security is a concern raised by many companies in the process of IoT implementation (chapter 4:Q50).The percentage of service team being part of IoT product development team is very low (chapter 4:Q15).Many times there is a requirement for retro-fitting during IoT implementation. That’s why ,while planning IoT projects especially in plants, the investment and integration of legacy equipment should be taken into consideration(chapter 4:Q46).As the majority of the companies have not done any IoT audit after POCs/implementation, Doing audit may add a few more guidelines for further implementation and can bring failure rate down(chapter 4:Q29).
- When management is ready to accept failure, there is a high chance that projects will move fast within the company. IoT implementations may get advantage of this management approach (chapter 4:Q13).
- It has been seen that there is enough awareness about IoT in management. Management has shown readiness required for IoT adoption through various parameters. However many companies are still in the process and have not yet

implemented IoT. Considering this state limitation and various challenges faced by them were studied.

- Expectation of immediate ROI ,Business process change, Skilled worker/employees were on top of all the challenges listed by various management people from various companies

5.3 Additional comments provided by management of various companies[Annexure B-II:14,43,62,70]:

- In Industry 4.0, the integration of IT (Information Technology) with the OT (Operational technology) is challenging to achieve since there is a technology gap between them.
- IT and business group should be in sync to incorporate IoT in the company
- IT is quite mature with well-defined policies, but OT is an upcoming trend and has not traditionally been a networked technology. So, quite often it gets difficult to align manufacturing processes with IT systems.
- Companies see the potential of IoT, but they don't know where to begin to adopt the technology.
- IoT has many dimensions with respect to its usage in industry. It would help in building new revenue streams for manufacturing companies
- For heavy machineries, Plants, high temperature sites, it is very important to have standard IoT gadgets in place. Standardization and Certification for electronic gadget and sensors should be in place is very important
- For every IoT project to be successful there should be a dedicated team including cross functional team members. This will definitely increase chances of getting better output.
- Organizations struggle with assessing the financial impact of IoT investments and quantifying ROI remains difficult.

5.4 Testing of Hypotheses[Chapter 4, 4.4]

- **There is a difference in the IoT implementation stage of companies.**

  It has been proved that currently various companies are in various stages of IoT implementation. Most of the companies are “in process” of IoT implementation however not yet implemented.

- **There is enough awareness about IoT in companies.**

  It has been proved that the required awareness is already available in industry with respect to IoT. When ask about IoT in the company most of them said that they know about IoT. The company key people have gone through various training sessions and workshops. Additionally they have attended conferences and seminars to understand the current trends of IoT in the industry.

- **Companies have the readiness required for IoT Adoption**

  It has been proved that companies have enough readiness for IoT Adoption. Various parameters with respective to readiness justify the same. Companies are ready with respect to infrastructure and IT requirements. Though they don't have in house skills, they are ready to outsource it. Management has decided about project sponsor within the company. They are partially ready with the plan and roadmap.

- **There is competitive benefits if customer satisfaction level is improving because of IoT**

It has been proved that after providing IoT services to customers, their satisfaction level has started improving. Customers are extremely happy which has resulted in competitive benefits.

- **Risk of misuse of data during exchange of information in IoT projects is related to Intellectual property.**

  It has been seen that management in the manufacturing sector is worried about data leakage .They expressed concern about the risk of misuse of data if they are sharing the data with IoT partner. The management also mentioned their data privacy concerns. Management feels that this may have an impact on their intellectual properties. Management was reluctant to share their data outside the organization

5.5 Conclusion

Looking forward, it can be said that IoT will be THE key lever of the ongoing Fourth Industrial Revolution, which is marked by opportunities and paradigm-changing innovations that facilitate entirely new business models[Chapter4:Q36,37 38,39,40,41,42,44, Annexure B-II:Q70].

Seizing these opportunities requires a comprehensive business strategy to guide IoT efforts. Companies should start small and scale fast, advancing to prototyping based on the first minimum viable assignment as quickly as possible. Executives must also help their employees embark on this journey, because any IoT project changes the way the company does business which impacts people's mindset and work. Sustainable impact is created only when people believe in the opportunities ahead and don't reject them [Chapter4:Q21, 22, 25, 30, Annexure B-II: Q61, 70].

The right set of talent will be the key to IoT success [Chapter4:Q10, 11, 19]. The availability of adequate talent – both at a strategic leadership level as well as on the factory floor – can prove to be a significant challenge for India manufacturing companies on its way to IoT maturity. It is very essential to build leaders who can successfully navigate their companies in the digital age. Up-skilling the workforce, investment and collaboration from all stakeholders will be key pointers for the IoT roadmap [Chapter4:Q34, Annexure B-II:Q70]. This will require significant planning from the beginning.

5.6 Recommendations

1. IoT benefits[Chapter4:Q44, Annexure B-II:Q61,70]:

- Technology can easily be molded to suit any kind of requirements that should be noticed by businesses.
- Many times companies are looking at the vast possibilities IoT can bring to them through a keyhole which should be avoided.
- Adopting IoT or Industry 4.0 is an initiative to take the manufacturing industry forward through a complete digitalization of the manufacturing process.
- Realizing data as an asset and technologies like IoT the medium for simplifying & enabling organizations to capitalize this data, is important.

2. IoT Skill-sets[Chapter4:Q10,11]:

- It is not possible to have all required IoT skills in house considering IoT architecture. Companies should have small IoT labs in house for Skill developments. Quick training or workshops should be arranged for all management people (Lower management, middle management and top management).This will improve IoT adoption within the company.
- This should include all the connected functions and departments. The training should be conducted, not only for project team but also for each and every employee at various intensity

  For e.g. HR recruitment teams should be trained to conduct interviews for IoT projects, Finance people should know how the budgeting and returns should be decided for IoT projects , plant head should know what kind of machinery he should plan in future, where retrofitting requirements are there etc.

3. IoT ,Team building and Change Management[Chapter4:Q15,24, Annexure B-II:Q66]:

- It is essential to involve various teams while planning IoT projects for particular functions in the company. Many times the IT team independently decides the requirement and implementation process. This may result in gaps in the requirements and ultimately failure of the project.
- While building a team for IoT projects, cross functional team building, their buying for projects and their training is required.
- Role clarity and interconnection amongst departments for IoT projects should be very clear.
- IoT requires a company to undergo change which should be well thought of while starting the project. This changeover cannot take place without a fundamental cultural and organizational change throughout the entire value chain, including suppliers and clients.

4. Few critical steps to get started with IoT [Chapter4:Q13,27,28,44, Annexure B-II:Q62,70]:

- Appoint dedicated leadership to drive IoT momentum
- Evaluate value captures within the company. Competitive analysis is also good option for evaluating the same
- Research, value addition and competitive benefits are very important before freezing the plan.
- Create IoT adoption plan, categorizing projects into Simmer, Pilot, and Scale
- Exploring partnerships to fast track adoption

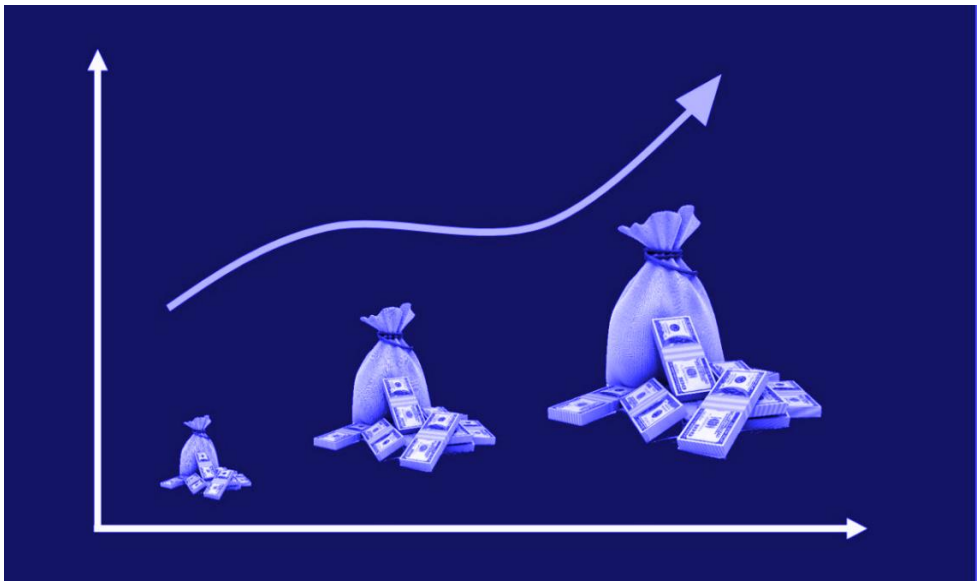
5. Approach towards IoT projects[Chapter4:Q44, Annexure B-II:Q15,16,33]:

- Before starting IoT initiative, doing readiness audits in the company will help in reducing the challenges faced during project execution.
- While selecting the project, if low hanging fruits are targeted the chances of success in the first go are more.
- There are various stages to reach the maturity level of IoT. Companies need capabilities to climb the earlier stage of the continuum in order to be able to reach subsequent stages. Some companies skip earlier stages entirely if those stages do not deliver the value they are looking for.
- The continuum does not imply that all companies should focus on reaching the last stage. Instead, a company decides which features will deliver real value to customers relative to its costs.
- It is not a case that the company at first level is 'immature'; instead it serves to demonstrate the scale of the IoT opportunity remaining, even when the first steps have been taken.

6. IoT and expectations[Chapter4:Q44,Annexure B-II:Q61,62,70]:

- Value from IoT can come from both internal efficiency gains, e.g. within supply chain and production, and companies' customer offerings.
- IoT Solution cannot be the same for all, so none of the companies can be exempted from the project management process.
- There's an IoT solution for every pocket: the challenge is going to be in picking out the right initial project to work on, as a proof-of-concept/ pilot project.

Figure No 5.4: IoT for all pockets



- The non-linearity of outcome means the returns do not follow a linear path with the investment made. Initially, small investments don't always lead to any real Return-on-Investment (RoI). For an initial project, if the problem statement is incorrectly chosen or ill-defined, the IIoT implementation will not produce any RoI, and will result in loss of faith in taking it forward. Therefore, a smartly chosen PoC problem is important [Chapter4:Q37]!
- Industry 4.0 is not the end. It is going to be followed by Industry 5.0 – which is the so-called 'Uber-isation' of Manufacturing: on-demand, customized, low-volume manufacturing as a service. You will get what you want without owning any piece of equipment.
- IoT is not just for companies in developed economies; but for businesses of all sizes and categories, spread across the globe! [Annexure B-II:Q62,70]
- IoT is often associated with the required hardware and software; the technical adaptations needed for leveraging IoT are just one part of the picture. The challenge of adapting IoT is not only IT. A complete digital transformation entails a fundamental rethinking and repositioning of the way business is done. [Annexure B-II:62,66]

5.7 Scope for future research

1. IoT for Small and Medium Scale Industries (SMEs)

IoT is for all pockets however it is important to find out the approach of small and medium scale companies towards IoT adoption. It is essential to find the reasons behind reluctance of SMEs towards IoT.

2. Various sectors of IoT

In this research our target industries were mainly engineering manufacturing companies. There are other industries where it is important to check the management approach

3. IoT ecosystem

In the process of IoT project execution there are various units that plays vital role. These units are generally with respect to IoT architecture .Understanding this ecosystem and identifying the gaps within the eco-system will add value in IoT project management.

4. IoT Start-ups

There are various start-ups working into the IoT domain. Studying these companies, its working, success rate and strategies applied will give better view in overall IoT project working.

5. Vendor Evaluation for IoT projects

It is been observed that Large scale companies are doing IoT POCs with startups however while implementation they are executing the projects with large IT companies. The process of vendor evaluation and selection for IoT initiatives could be very interesting way.

6. Success measures for IoT initiatives

Finding the reasons behind the success for the companies where 1st IoT project has been successfully implemented and they are going for next IoT project

7. IoT investments

IoT start-up investment and funding, investments happening at IoT product development and investment happening at deployment side could be a financial study with respect IoT market value

8. Change Management for IoT

During the research process most of management team mentioned that change management is very challenging in overall IoT adoption. The detail analysis of change management issues may help in faster IoT implementation.

9. IoT Vs. Skill Development

Government has various initiatives on skill development. It also has policy named "National Policy for Skill Development and Entrepreneurship, 2015" .To study if IoT skill development is part of this policy and how it will add value to overall nation development

10. Impact Analysis

To study impact of IoT adoption and doing it analysis with respect to various parameters may give different dimension to overall digital transformation

Annexure A

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Annexure B-I

Questionnaire

Sr.No	Questions
1	Company/User Details
2	Any Automation used
3	Are you aware about IoT
4	Is it the part of your digital transformation strategy
5	IoT initiative came from (Business / Marketing / IT)
6	Current Adoption status/stage (Implemented / In process / Planned / no plans)
7	Do you feel there is a Lack of vision and leadership for this initiative in your company? (Yes/ No/ N.A.)
8	Do you think there is enough awareness about the current state of technology in IoT in your company? (Yes/ No/ N.A.)
9	What are the biggest challenges or inhibitors you see for IoT Adoption?
10	What all benefits do you see after adoption?
11	Do you see Return on investment after IoT adoption?
12	Do you find any limitation for adoption?

Annexure B-II

Questionnaire

1.Name	
2.Age	
3.Educational qualification	
4.Total work experience	
5.Total experience with manufacturing company	
6.Current Company Name	
7.Designation	
8.Company location	
9.Type of company	Software(cloud) / IoT Gadget / Manufacturing / Others
10.Your area of work in current company	IT / Functional / Decision maker / Plant / Marketing / R&D
11.Awareness level about IoT	Excellent / Very Good / Good / Average / Poor
12.Have you attended any conference /seminar on IoT	Yes / No / N.A.
13. Have the key people from your organization have undergone any trainings/workshops?	Definitely Yes / Probably Yes / Somewhat / Probably No / Definitely No / N.A.
14.What is your definition of IoT (2-lines)	
15.There is enough awareness about the current state of technology in IoT in my company	Strongly Agree / Agree / Neutral / Disagree / Strongly Disagree / N.A.

16. Tick the automation used in your company	ANN- Artificial neural Network, DCS - Distributed Control System, HMI - Human Machine Interface, SCADA -Supervisory Control and Data Acquisition, PLC - Programmable Logic controller, PAC - Programmable Automation controller Instrumentations, Motion Control, Robotics, All
17. When it comes to technology, what best describes you? Tick the one from list	1. I am skeptical of new technologies and use them only when I have to 2. I am usually one of the last people I know to use new technologies 3. I usually use new technologies when most people I know do 4.I like new technologies and use them before most people I know 5.I love new technologies and am among the first to experiment with and use them
18.What is current adoption status of IoT in your organization	Implemented / In process / Planned / no plans
19.Do you feel that you are ready for IoT adoption	Strongly Agree / Agree / Neutral / Disagree / Strongly Disagree / N.A.
20.My organization is infrastructure wise ready for investment	Strongly Agree / Agree / Neutral / Disagree / Strongly Disagree / N.A.
21.My organization is ready for investment required for IoT	Strongly Agree / Agree / Neutral / Disagree / Strongly Disagree / N.A.
22.My organization has the skill set in house which are required for IoT adoption	Strongly Agree / Agree / Neutral / Disagree / Strongly Disagree / N.A.
23.My organization is ready to outsource the required skillsets	Strongly Agree / Agree / Neutral / Disagree / Strongly Disagree / N.A.
24.My organization has identified the need /area for adoption	Definitely Yes / Probably Yes / Somewhat / Probably No / Definitely No / N.A.

25.Are you ready for failures while IoT adoption	Very often /Often / Sometimes / Rarely / Never / N.A.
26.Do you want to go for another attempt if you have failed	Definitely Yes / Probably Yes / Somewhat / Probably No / Definitely No / N.A.
27. Is the service team an active part of the product development team to plan IoT services before product launch?	Definitely Yes / Probably Yes / Somewhat / Probably No / Definitely No / N.A.
28. Does your IoT infrastructure provide sufficient bandwidth and capacity?	Definitely Yes / Probably Yes / Somewhat / Probably No / Definitely No / N.A.
29. Have you selected an IoT platform to support your strategic IoT initiatives?	Definitely Yes / Probably Yes / Somewhat / Probably No / Definitely No / N.A.
30. Does your IT Architecture cater for IoT?	Definitely Yes / Probably Yes / Somewhat / Probably No / Definitely No / N.A.
31. Is your IT organization/ department well positioned to deal with IoT complexities?	Definitely Yes / Probably Yes / Somewhat / Probably No / Definitely No / N.A.
32. Have you defined who will drive/sponsor the IoT initiatives?	Definitely Yes / Probably Yes / Somewhat / Probably No / Definitely No / N.A.
33. Have you defined a roadmap to transform your business to IoT enabled services?	Definitely Yes / Probably Yes / Somewhat / Probably No / Definitely No / N.A.
34.Does your IT strategy and roadmap include IoT capabilities	Definitely Yes / Probably Yes / Somewhat / Probably No / Definitely No / N.A.
35.Year when you started exploring IoT concept	
36.Year when your company started exploring IoT concept	
37. Year when you started adoption of IoT	
38. Where you have used it?	Service/ Product / Plant / Other
39.IoT initiative came from	Business / Marketing team / IT team / Other
40.There is a Lack of vision and leadership for this initiative in my company	Strongly Agree / Agree / Neutral / Disagree / Strongly Disagree / N.A.

41.Who is the target audience for IoT implementation	Internal usage (Employee ,workers) / Customers / Dealers / Other
42.Have you experience failure during adoption/ POC	Very often /Often / Sometimes / Rarely / Never / N.A.
43. In your opinion ,What are the reasons for failure	
44.Is understanding of requirement is the failure	Very often /Often / Sometimes / Rarely / Never / N.A.
45.Have you done any Audit for IoT	Yes / No / N.A.
46. Are your customers willing to share the machine generated data with you?	Definitely Yes / Probably Yes / Somewhat / Probably No / Definitely No / N.A.
47. Has your company involved customers in defining what data needs to be collected?	Definitely Yes / Probably Yes / Somewhat / Probably No / Definitely No / N.A.
48. Have you introduced updated security policies to meet the IoT requirements?	Definitely Yes / Probably Yes / Somewhat / Probably No / Definitely No / N.A.
49. Have you considered Artificial Intelligence to facilitate prediction capabilities?	Definitely Yes / Probably Yes / Somewhat / Probably No / Definitely No / N.A.
50. Are the key stakeholders actively supporting the IoT initiatives?	Definitely Yes / Probably Yes / Somewhat / Probably No / Definitely No / N.A.
51. Are your newly produced products connected or connectable?	Definitely Yes / Probably Yes / Somewhat / Probably No / Definitely No / N.A.
52. Do you offer IoT enabled services to your customers?	Definitely Yes / Probably Yes / Somewhat / Probably No / Definitely No / N.A.
53. There is Return on investment for IoT adoption in my company?	Strongly Agree / Agree / Neutral / Disagree / Strongly Disagree / N.A.

54. Plant efficiency is observed	Strongly Agree /Agree / Neutral /Disagree / Strongly Disagree / N.A.
55. There is improvement in worker's productivity	Strongly Agree / Agree / Neutral / Disagree / Strongly Disagree / N.A.
56. Plant up-time is observed	Strongly Agree / Agree / Neutral / Disagree / Strongly Disagree / N.A.
57. There is growth in productivity	Strongly Agree / Agree / Neutral / Disagree / Strongly Disagree / N.A.
58.There is growth in sales	Strongly Agree /Agree / Neutral /Disagree / Strongly Disagree / N.A.
59.There is improvement in customer satisfaction level	Strongly Agree / Agree / Neutral / Disagree / Strongly Disagree / N.A.
60. Do you find IoT adoption as a competitive benefit?	Strongly Agree / Agree / Neutral / Disagree / Strongly Disagree / N.A.
61. What all other benefits do you see after adoption?	Better planning and controlling / greater flexibility in manufacturing / Improved quality / Improved asset utilization / Faster time to market / Others
62. What change do you expect after IoT Adoption?	
63. Does "Legacy equipment in use" is the showstopper for IoT Adoption?	Very often / Often / Sometimes / Rarely / Never / N.A.
64. Do you find any requirement for retro-fitting for IoT usage? What kind of machines/product	Very often / Often / Sometimes / Rarely / Never / N.A.
65. Do you find any limitation for implementation?	Very often / Often / Sometimes / Rarely / Never / N.A.
66. What are the biggest challenges or inhibitors you see for IoT Adoption	Capital investment / Business process change / Skilled workers / High cost of sensors / Vendor finalization/ Expectation of ROI / Others

67. Do you find any Privacy concerns with respect to data for adoption in your company?	Definitely Yes / Probably Yes / Somewhat / Probably No / Definitely No / N.A.
68. Do you feel that there is a risk of misuse of data during exchange of information with partners	Very often / Often / Sometimes / Rarely / Never / N.A.
69. Do you see any concern with respect to intellectual property due to IoT adoption	Definitely Yes / Probably Yes / Somewhat / Probably No / Definitely No / N.A.
70. What cumulated benefits from IoT implementation do you expect in next 3 years	