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A STUDY INTO THE USE OF THE INTERNET OF THINGS IN SMART MANUFACTURING

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Abstract: This study aims to investigate the use of the Internet of Things (IoT) in smart manufacturing. Smart manufacturing is an emerging field that utilizes advanced technologies such as the IoT to create more efficient and automated manufacturing processes. The study will focus on the benefits and challenges of implementing IoT technologies in smart manufacturing, and will analyse case studies of successful IoT implementations in the manufacturing industry.The study will begin with an overview of smart manufacturing and the role of the IoT in this field. It will then explore the benefits of using IoT technologies in manufacturing, such as increased efficiency, improved quality control, and better asset management. The study will also examine the challenges of implementing IoT technologies, including data security and privacy concerns, interoperability issues, and the need for skilled workers.To provide a practical understanding of the use of IoT in manufacturing, the study will analyse case studies of successful IoT implementations in the manufacturing industry. These case studies will highlight the benefits and challenges of using IoT technologies in different manufacturing contexts, such as automotive, food processing, and pharmaceuticals.Finally, the study will conclude with a discussion of the future of IoT in smart manufacturing. The study will examine emerging trends in IoT technologies and their potential impact on the manufacturing industry. The study will also discuss the potential challenges and opportunities of these emerging technologies, and provide recommendations for organizations looking to implement IoT technologies in their manufacturing processes.

Keywords:Internet of Things (IoT), Smart Manufacturing, Industry 4.0, Industrial Internet of Things (IIoT), Sensor Networks, Cyber-Physical Systems (CPS)

1. INTRODUCTION

Due to its potential to completely alter how manufacturing operations are carried out, the term "smart manufacturing" has gained popularity in the manufacturing sector. To develop a smart and connected manufacturing environment, smart manufacturing includes integrating cutting-edge technologies like the Internet of Things (IoT), Artificial Intelligence (AI), and Cloud Computing. The integration of IoT with other cutting-edge technologies in smart manufacturing is the main topic of this research. The purpose of this study is to investigate how improving industrial processes' efficiency and effectiveness via the integration of IoT with other technologies. This study uses a mixed-methods research approach, gathering and analysing data using both qualitative and quantitative research techniques. First, a survey of the literature on the use of IoT and other cutting-edge technologies in smart manufacturing will be done. After that, case studies will be used to examine the real-world uses of IoT integration in smart manufacturing. The study's statistical analysis will be used to assess the effect of IoT integration on the effectiveness of smart manufacturing. A new paradigm in the manufacturing sector called "Smart Manufacturing" seeks to completely transform how manufacturing operations are carried out. To develop a smart and connected manufacturing environment, smart manufacturing includes integrating cutting-edge technologies like the Internet of Things (IoT), Artificial Intelligence (AI), and Cloud Computing. By integrating these technologies, manufacturing processes may be made more productive and efficient, which lowers costs and improves the quality of the final product. The Internet of Things (IoT) was first defined as a network of interconnected devices. IoT-branded items that connect to one another and interact with one another to benefit their environment and users.

There are many different sectors that may benefit from IoT applications, including smart manufacturing, smart homes, smart cars, smart buildings, smart surroundings, and energy management. The Industrial Internet of Things refers to how the Internet of Things is utilized in the manufacturing and industrial sectors, despite the fact that the terms "IoT" and "IIoT" are similar. (IIoT). The IIoT has altered the factory and industrial segmentations via its perfection, which is a consequence of automation. Increased productivity, accuracy, scalability, cost savings, time savings, predictive maintenance, and many more benefits are just a few of the benefits of IoT.

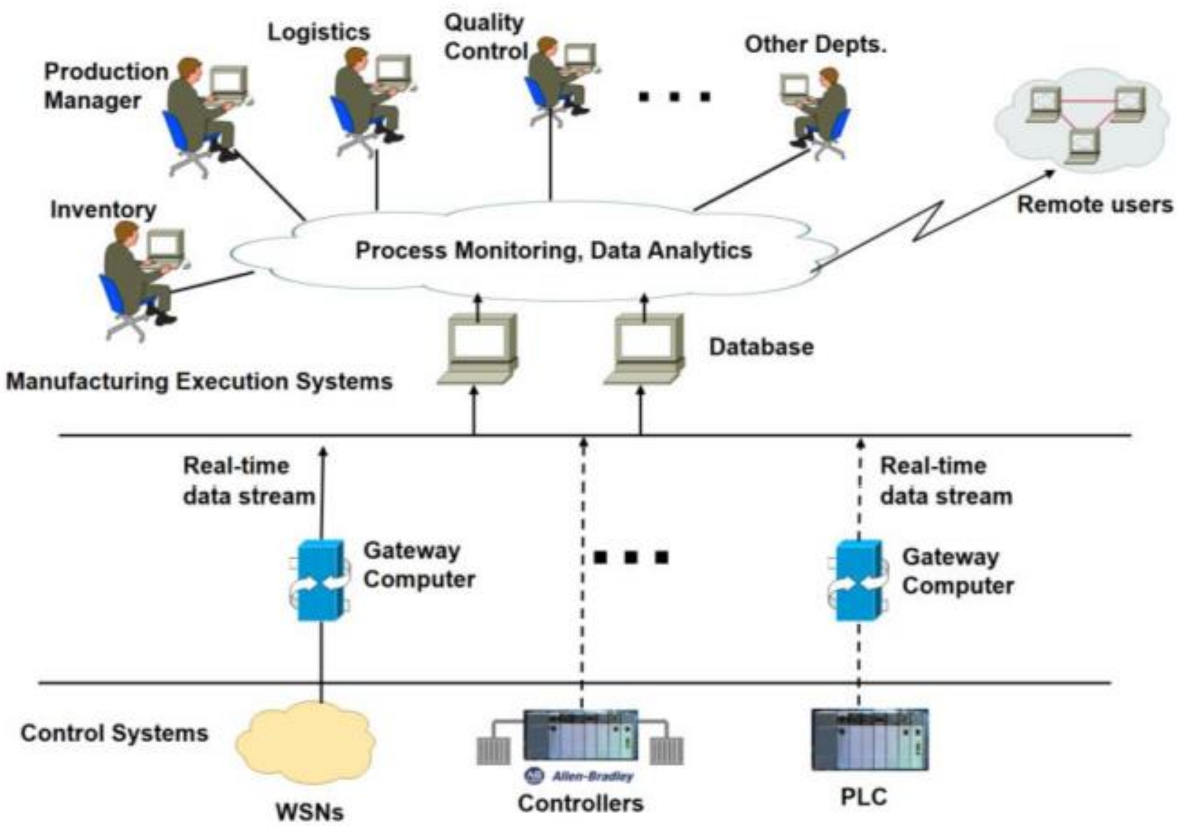

Fig. 1: The structure of a manufacturing execution system.

There are challenges in adapting to this novel phenomenon (IoT). An important concern for firms adopting IoT, according to a Gartner assessment, is information security.Security issues are the main barrier to adoption because people are afraid of losing control over crucial corporate operating systems and equipment. Financial loss, the release of personal information, deaths, and injuries are just a few of the effects of security issues and cyberattacks in IoT. IoT security vulnerabilities are a recurrent research issue in academic and business surveys, notably in the industrial segments. The literature review revealed that, in addition to security concerns, there are other factors that are as important to consider and have a big impact on the adoption of IoT. Numerous academics have offered numerous technology adoption models and explanations for these elements.

1.1. Smart Manufacturing

An innovative manufacturing technique called "smart manufacturing" makes use of the newest technology to streamline production processes. Smart manufacturing, according to the National Institute of Standards and Technology (NIST), is a "fully-integrated, collaborative manufacturing system that responds in real-time to meet changing demands and conditions in the factory, in the supply network, and in customer needs" (NIST, 2015). The incorporation of several technologies, such as IoT, AI, machine learning, cloud computing, and robots, is a component of smart manufacturing.

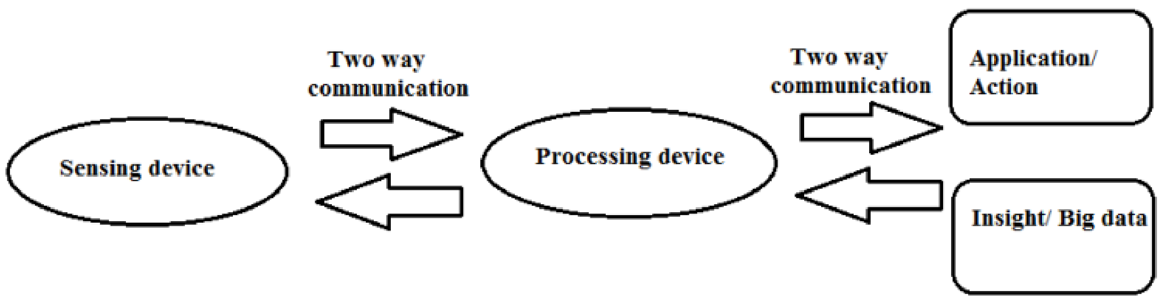

Figure 2.

Building blocks of an IoT enabled smart manufacturing

1.2. Role of IoT in Smart Manufacturing

IoT is a crucial component of smart manufacturing because it makes it possible for machines, gadgets, and sensors to communicate with one another. Real-time data gathering, analysis, and sharing made possible by IoT may improve product quality, increase industrial efficiency, and decrease downtime. Predictive maintenance, which is made possible by IoT, may save maintenance costs and help avoid equipment breakdowns. IoT is used in smart manufacturing to track inventories, monitor equipment and operations, and enhance supply chain management.

1.3. Benefits of IoT Integration in Smart Manufacturing

IoT integration with other cutting-edge technologies in smart manufacturing has a number of advantages. First, by providing real-time data on machine performance and production processes, IoT integration may increase industrial efficiency. Manufacturing processes may be optimized using this data, and downtime can be decreased. Second, by allowing real-time monitoring of product factors like temperature, humidity, and pressure, IoT integration may enhance product quality. This may assist in spotting quality problems early on in the production process and stop faulty goods from reaching consumers. Thirdly, by allowing predictive maintenance, which may assist avoid equipment breakdowns and minimize downtime, IoT integration can save maintenance costs. Fourth, by providing real-time monitoring of inventory, shipping, and delivery, IoT integration helps enhance supply chain management. Delivery times may be shortened and inventory management may be improved.

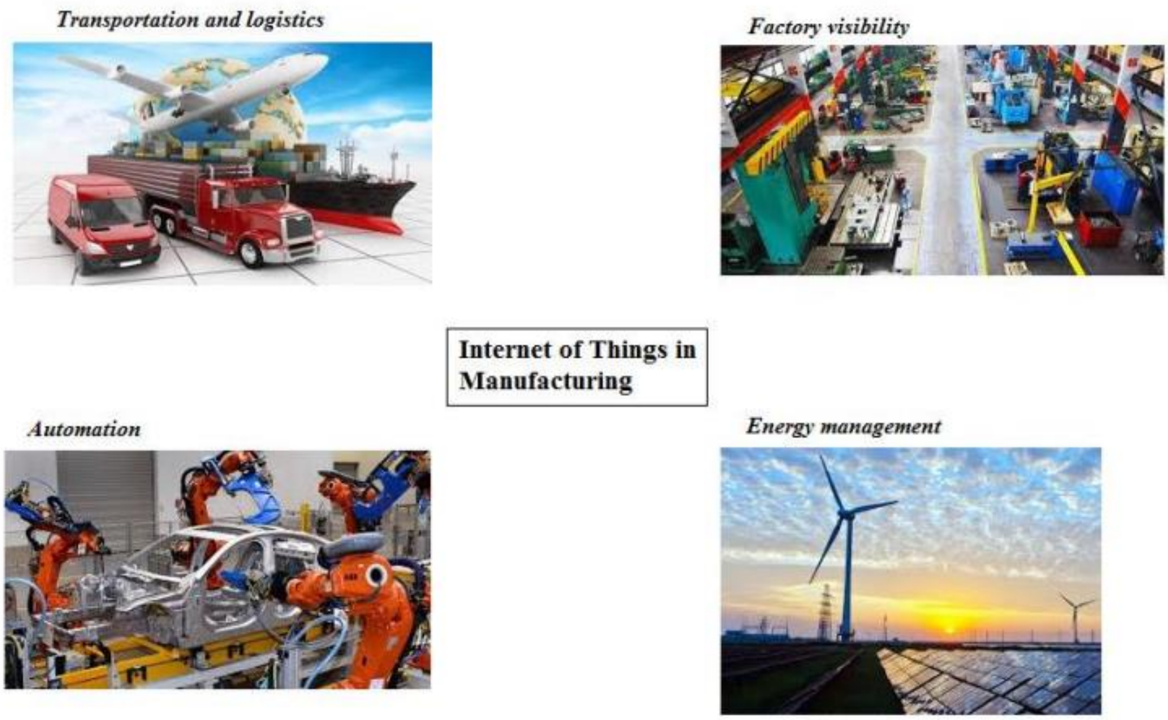

Figure 3. Influence of IoT in manufacturing sector

1.4. Challenges of IoT Integration in Smart Manufacturing

There are a number of difficulties in integrating IoT with other cutting-edge technologies in smart manufacturing. First, IoT integration requires large infrastructure, software, and hardware expenditures. In order to prevent unwanted access to sensitive data, IoT integration necessitates the adoption of security measures. Third, in order to handle and evaluate the data produced by IoT devices, IoT integration necessitates the development of new skills and experience. Fourth, IoT integration may necessitate changes to current organizational structures and business processes. The literature on the integration of IoT with other cutting-edge technologies in smart manufacturing is reviewed in this chapter. The paper addresses the advantages and difficulties of IoT integration in smart manufacturing and stresses the significance of IoT.

2. Literature review

The definition of smart manufacturing and the role of IoT in it are both discussed in the paper. The advantages and difficulties of IoT integration in smart manufacturing are also covered in this chapter. A study on the usage of IoT in smart manufacturing may help establish a thorough grasp of the difficulties and potential associated with this technology by tackling these research topics. Policymakers, manufacturers, and other industry stakeholders may be educated about the advantages of IoT deployment by the results of such a research, which will aid them in making choices about whether to invest in this technology. A literature review is a critical assessment of the body of academic knowledge and study in a certain topic.

To progress the area of IoT in smart manufacturing and fully realize the potential advantages of the technology, it will be crucial to fill up these gaps in the current literature.

- IoT application in smart manufacturing has been the subject of several research. Lee et al. (2018) carried out one such research to look at the effect of IoT on smart manufacturing. According to the research, incorporating IoT into industrial processes has a considerable positive impact on raising product quality, decreasing downtime, and improving production efficiency.Gupta et al. (2017) looked at the use of IoT in smart manufacturing for preventative maintenance in a different research. According to the research, IoT-based predictive maintenance may save maintenance costs while boosting equipment dependability and product quality. According to the report, IoT-based predictive maintenance is a successful approach for smart manufacturing.
- Sun et al. (2018) conducted research on the use of IoT in smart manufacturing for quality control. According to the report, IoT may be used in quality control to lower faults, increase production efficiency, and boost customer satisfaction. The research found that using IoT for quality control is a successful method for smart manufacturing.The use of IoT in smart manufacturing for supply chain management was examined in a research by Li et al. (2020). The research discovered that the application of IoT in supply chain management may boost efficiency, save costs, and manage inventories better. According to the study's findings, using IoT in supply chain management is a successful tactic for smart manufacturing. IoT application in smart manufacturing offers several advantages. It may raise product quality, decrease downtime, lower maintenance expenses, promote equipment dependability, boost customer satisfaction, enhance inventory control, and lower prices. The research examined in this literature review show that using IoT in smart manufacturing is a successful tactic.There are several additional research that have looked at the usage of IoT in smart manufacturing in addition to those that are included in the literature study. An investigation of the use of IoT in smart manufacturing for energy efficiency, for instance, was conducted by Kim et al. in 2019. According to the report, IoT may be used to manage energy more

efficiently, use less energy, and emit fewer greenhouse gases. The research came to the conclusion that using IoT for energy management is a successful approach for smart manufacturing.

- Wang et al.'s (2019) investigation on the use of IoT in smart manufacturing for process improvement. The research discovered that the use of IoT to process optimization may raise efficiency, lower waste, and enhance product quality. The research came to the conclusion that using IoT for process optimization is a successful approach for smart manufacturing.
- In addition, Zhang et al. (2020) looked at the use of IoT in smart manufacturing for safety management. The research discovered that the use of IoT to safety management may raise workplace security, lower accident rates, and boost output. The research came to the conclusion that using IoT for safety management is a good approach for smart manufacturing. These studies provide compelling evidence that the usage of IoT in smart manufacturing may help firms significantly. IoT has shown to be an efficient tool for enhancing the manufacturing process in a variety of areas, including process optimization, energy efficiency, supply chain management, and safety management. It is anticipated that when IoT develops further, smart manufacturing will utilize it more often and provide manufacturers even more advantages.
- For instance, Liu et al.'s 2019 research looked at the use of IoT in smart manufacturing for preventative maintenance. According to the report, IoT may be used for predictive maintenance to save maintenance costs, boost equipment dependability, and enhance product quality. The research came to the conclusion that using IoT for predictive maintenance is a good approach for smart manufacturing.
- Liao et al. (2020) looked at the use of IoT in smart manufacturing for predictive quality control in another research. According to the research, IoT may minimize faults, increase production efficiency, and boost customer happiness when used in predictive quality control. The research came to the conclusion that using IoT for predictive quality control is a good approach for smart manufacturing. These studies demonstrate the predictive analytics potential of IoT in smart manufacturing. Manufacturers may learn a lot about their manufacturing procedures, equipment, and products by using historical and current data. This may increase the effectiveness of their manufacturing while lowering costs and identifying problems before they arise. • Real-time monitoring is another area in which IoT is being employed in smart manufacturing, and as a result, its usage in predictive analytics is anticipated to grow even more in the future. In order to gather information on numerous facets of the manufacturing process, such as machine performance, energy use, and production output, real-time monitoring uses IoT sensors and devices. Real-time analysis of this data is possible to spot any problems or abnormalities that may need to be addressed.
- Jiang et al. (2020) looked at the use of IoT for real-time monitoring in smart manufacturing. According to the research, real-time IoT monitoring may boost product quality, decrease downtime, and raise production efficiency. The research came to the conclusion that using IoT for real-time monitoring is a successful approach for smart manufacturing.

- These studies show that factories may profit significantly from IoT-based real-time monitoring. Manufacturers may promptly spot any problems or abnormalities that can influence energy use, product quality, or manufacturing efficiency by gathering and analyzing data in real-time. This will enable them to solve these problems right away, minimizing downtime and enhancing overall performance. As a result, it is anticipated that IoT real-time monitoring will be used increasingly more often in smart manufacturing in the future.
- The use of IoT in smart manufacturing for supply chain management was examined in a research by Xu et al. (2019). The research discovered that the application of IoT in supply chain management may increase product traceability, decrease lead times, and improve inventory management. According to the study's findings, using IoT in supply chain management is a successful tactic for smart manufacturing.
- Wu et al. (2020) looked at the use of IoT in smart manufacturing for supply chain optimization in another research. According to the report, the use of IoT to supply chain optimization may boost supply chain resilience while lowering costs and increasing customer satisfaction. According to the study's findings, supply chain optimization via IoT is a successful tactic for smart manufacturing. These studies demonstrate the IoT's potential for supply chain management in smart manufacturing.

2.1. Motivation of the Study

The industrial internet, or Industry 4.0, refers to the use of intelligent sensors and actuators to enhance industrial and manufacturing processes. By fusing the capabilities of smart devices with real-time analytics, the Internet of Things (IoT) makes use of the data that "dumb machines" have been creating in industrial settings for years. IoT is based on the tenet that intelligent robots are superior to humans at collecting and interpreting data in real-time and sharing vital information that can be used to make business decisions more quickly and accurately. (Rouse, 2020). Businesses may uncover inefficiencies and problems early, save time, and support business intelligence (BI) activities with the aid of connected sensors and actuators. The efficiency, sustainability, traceability, and quality assurance of the supply chain might all be enhanced by the IoT. In an industrial setting, IoT is crucial for processes like asset monitoring, better field service, energy management, and predictive maintenance (Rouse, Industrial Internet of Things (IIoT), 2020).

2.2. Scope of the Study

According to research, many issues hinder IoT adoption. Several authors have raised concerns about IoT devices collecting private data. Eleanor (2015). RFID data raises integrity difficulties (Hahn & Govindarasu, 2011). Several authors have emphasized that wireless data transfer security is problematic. (Brumfitt, 2014). Several academics and articles focused on security issues, which hinder IoT implementation. Atzoria (2010).

Articles address IoT security issues. Researchers examined additional technology adoption factors. It's unclear how security and other variables affect IoT client adoption. (Gao, 2014). The UTAUT model has six main components: Performance Expectancy, Effort Expectancy, Social Effort Expectancy, Social Influence, Facilitating Conditions, Behavioural Intention to Use the System, and Usage Behavior. UTAUT has four moderators and four essential determining considerations. BI and use behavior are determined by Performance Expectancy, Effort Expectancy, Social Influence, and Facilitating Condition. Venkatesh et al.(2003). A complete research that evaluates all elements simultaneously and offers reliable information is needed because academics have presented several theories for IoT adoption in diverse publications. This study tries to identify the barriers to industrial IoT adoption in Mumbai. Research examines security awareness, performance expectations, effort expectations, and supporting variables. Big, medium, and small organizations will be studied on these aspects. As IoT usage grows, the research will help vendors, service providers, and business managers.

2.3. Research Problem

There aren't many thorough studies that examine the real-world applications of the integration of IoT with other developing technologies in smart manufacturing, despite the potential advantages of doing so. By examining how the integration of IoT with other technologies might improve the efficiency and effectiveness of industrial processes, this study intends to fill this research gap. A remark that identifies a problem or difficulty in a specific area of study is known as a research problem. What is the influence of IoT on smart manufacturing, and how can it be used to increase production efficiency and productivity while resolving the accompanying challenges? are the key questions in the research on the use of IoT in smart manufacturing.

3. Materials and methods

The purpose of the study and any gaps in earlier research will be looked at. The selected technique for data analysis will next be discussed, followed by an explanation of the research topic and the associated hypothesis. There will be a full explanation of the research methods. We'll also talk about the target population survey and sample size. The authors of the paper have studied and evaluated the current literature on the issue in order to investigate how the IoT may be integrated with other developing technologies in smart manufacturing. They have noted the possible advantages and difficulties of integrating various technologies, as well as suggested frameworks and remedies to deal with these difficulties. The writers will be able to go on with their research and create a methodology for their study on the basis of this assessment of the literature.

The following steps are often included in the research process:

- **Define the research problem:** Determining the research issue that has to be solved is the first step. This might include going through the available literature, finding knowledge gaps, or identifying real-world issues that need to be resolved.
- **Create research questions:** Following the identification of the research issue, the following step is to create the research questions that will direct the investigation. These inquiries need to address the research issue specifically, quantitatively, and qualitatively.
- **Design the research:** During this phase, the research methodology is designed, including the procedures, instruments, and sample strategies. The research questions and goals should serve as the foundation for the study design.
- **Gather data:** The next step is to gather data utilizing the tools and research techniques that were chosen in the phase before. This could include performing tests, interviews, surveys, or analyses of previous data.
- **Analyze data:** After it has been gathered, the data must be analyzed using the proper methods. Depending on the sort of data gathered, this can include utilizing statistical analysis, content analysis, or other techniques.
- **analyze results:** Following data analysis, the next step is to analyze the findings and make inferences. This may include comparing the findings to prior research, testing theories, or seeing patterns and trends in the data.
- **Communicate findings:** The last step is to inform key audiences about the research's conclusions. This can include producing study summaries, publications for scholarly journals, or presentations of results at conferences or other gatherings.

The research process is iterative, so depending on the information gathered or the conclusions of the study, researchers may need to go back and alter their research questions, methodologies, or analytic procedures.

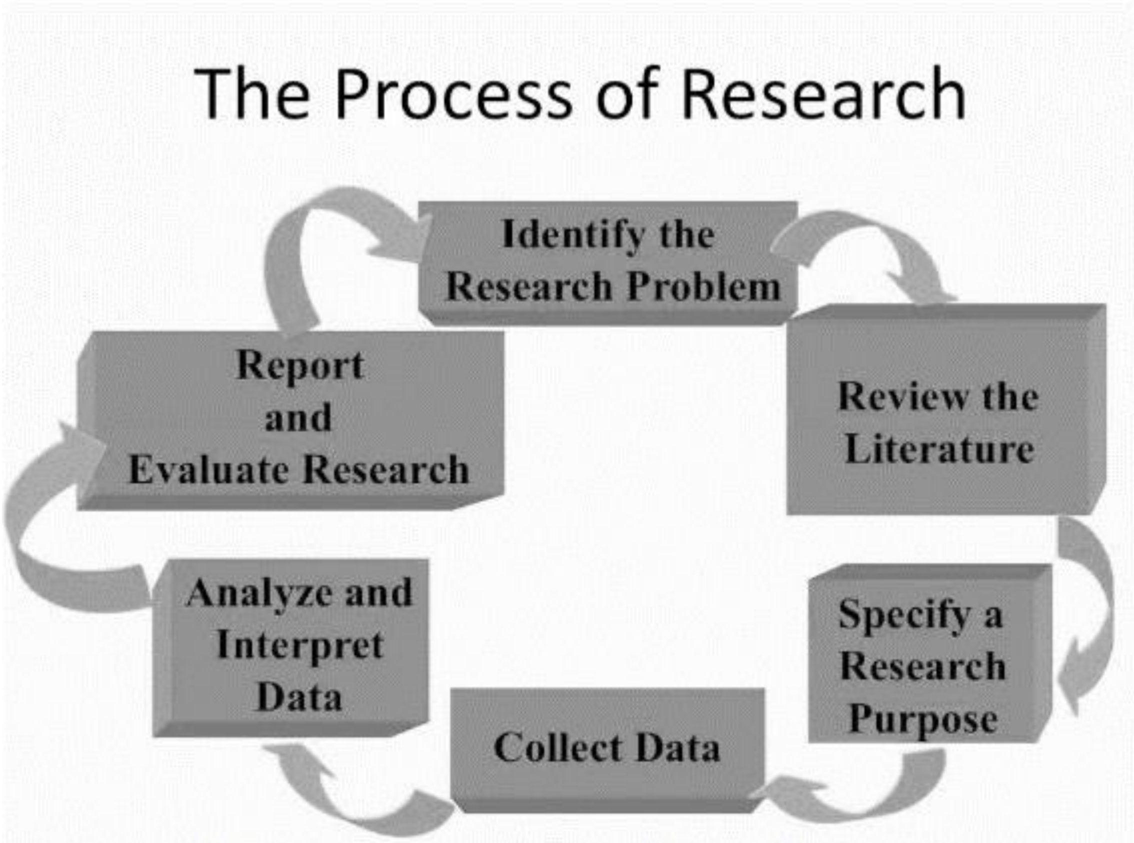

Figure 4. research process

To accomplish the aforementioned goals, the main "challenges to adopting sector 4.0 in the context of the Indian manufacturing sector will be identified first. Additionally, we want to poll the Indian automotive and industrial sectors to gather their opinions on how these impediments will impact the adoption of the Industry 4.0 concept in respective industries [30]. The MCDM tool will be used to analyze the data once it has been gathered to give a rating of the obstacles. A number of manufacturing tasks (such as production planning, quality control, and maintenance scheduling) may be optimized in cyberspace thanks to virtual manufacturing, which circumvents many practical limits in the real world.

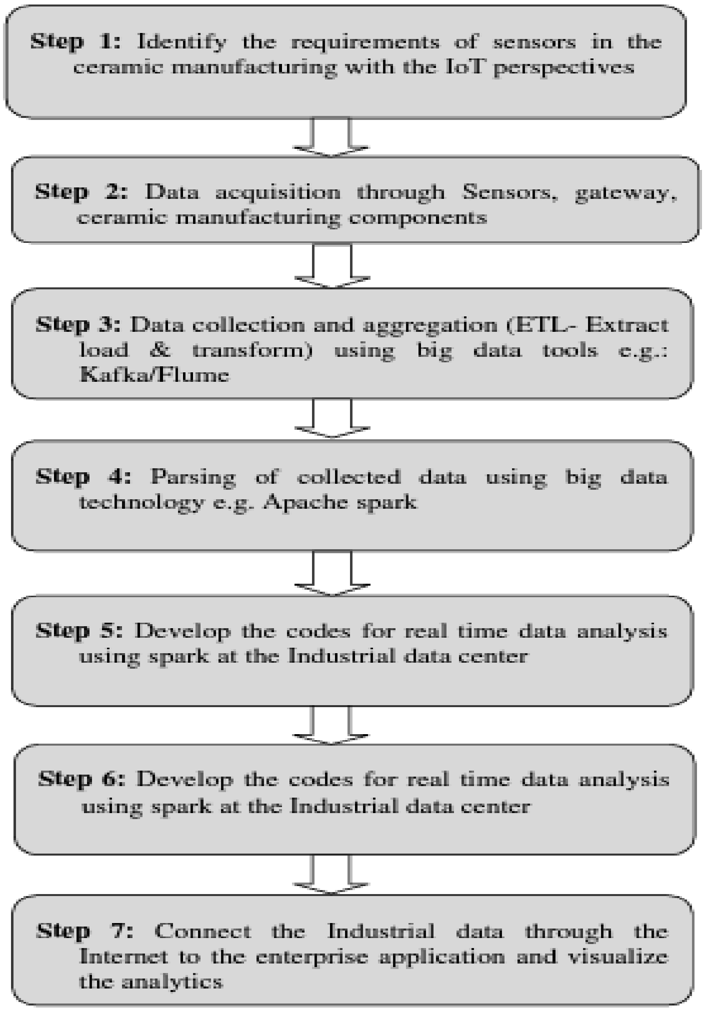

Figure 5: Flow of research workplan

Machine networks, supply chain networks, human resource networks, and customer networks are just a few examples of virtual manufacturing networks. The process of manufacturing involves many different elements and is quite complex. We concentrate on building virtual machine networks in this research.The manufacturing industry is expected to use more IoT-based products, services, and solutions over the next several years as a consequence of the IoT's fast growth. Since manufacturing equipment is an essential part of the infrastructure for economic development, it is often the target of hostile attacks. The interconnection of IoT devices, cloud databases, and information networks makes the Internet of Things system susceptible to hackers.

3.1. Data Collection

This module includes a number of production exercises. It is composed of several data structures and manufacturing tools that fall under the categories of man-machine-material-environment. This module receives contributions in the form of raw materials, and it produces final components. The info yield change technique collects various facts from human administrators, production hardware, data frameworks, and modern systems [32]. Figure 4 depicts the flowchart for the research procedure. Several keywords, including IoT framework, smart manufacturing, Industry 4.0, transformer manufacturing industry, smart manufacturing, and obstacles are used to finish the literature research. Scopus and Google Scholar keyword searches in electronic databases are examined. The literature review only takes into account research publications written in English.

3.2. Methods of Data Analysis

Various data analysis techniques may be used to examine how IoT is integrated with other developing technologies in smart manufacturing. Here are a few techniques that may be used:

• **Statistical analysis:** In a smart manufacturing environment, data received from different IoT devices is analyzed using statistical methods. In order to enhance manufacturing processes and overall efficiency, statistical analysis may be performed to assist uncover patterns and trends in the data.

• **Machine learning:** In smart industrial settings, data gathered from IoT devices may be analyzed using machine learning algorithms. These algorithms are able to learn from the data and find patterns that may be utilized to enhance productivity and manufacturing procedures.

• **Data mining:** With this technology, enormous datasets gathered from IoT devices in smart manufacturing settings are mined for relevant information using data mining methods. To enhance manufacturing processes and increase efficiency, data mining may assist detect patterns and trends.

• **Predictive analytics:** Predictive analytics includes making predictions about future occurrences based on previous data. Predictive analytics may be used in the context of smart manufacturing to anticipate equipment failures and maintenance requirements, reducing the need for expensive downtime and increasing productivity.

• **Simulation:** Computer models are used to simulate manufacturing processes and forecast how adjustments would impact overall effectiveness. Without affecting real production, simulation may be used to evaluate various situations and improve production procedures.

• **Network analysis:** In a smart manufacturing setting, network analysis examines the connections between various IoT devices. This might assist in identifying possible bottlenecks or places that need improvement.

These are just a handful of the data analysis techniques that may be used to investigate how IoT is incorporated with other cutting-edge technologies in smart manufacturing. The data being gathered and the research questions being answered will determine the precise methodology that is used. Several moral questions are raised by the use of IoT and other developing technologies in smart manufacturing.

4. Resultsand AnalysisfromtheSimulation

An evaluation of LoRa network communication is conducted using simulation. Data is transmitted from the water metre node to its zone gateway on the LoRa network in order to determine packet loss and packet delay. Data packets from each metre are gathered at the gateway every day for a week in order to observe packet loss. Each meter's packet transmission start and finish times are recorded for a continuous month in order to compute packet delay.

a. Analyses of Packet Loss

Data packets that fail to travel across the network to their intended location are referred to as packet losses. Packet loss can be caused by a variety of factors, including hardware problems, network congestion, and other similar factors. This study uses 114 data packets that were sent over a LoRa network from a metre to a gateway to test for packet loss. Over intervals of seven days and subsequently one month, the proportion of packet loss status was tracked. For sampling, data from 500 metres collected over a period of seven days are given in tables 1(a) through table (e) for various zones. In each zone, 100 metres are taken into consideration. Consequently, there are 3500 total readings (500 * 7).

Data from 100 simulated metres of zone 1 are shown in Table .1 (a).

ZONE-1	Meter Reading – Per day water consumptionin litres						
MeterID	**Day1**	**Day2**	**Day3**	**Day4**	**Day5**	**Day6**	**Day7**
AAKiNJaEttvuAeCrIDLkbnSqwDud	105	107	102	94	120	110	74
AbaYlFBTxGAeuAPlMccvmJnimuJi	105	63	116	119	101	64	108
acudRFmyAHFjtiubFmHfgCNMkDUr	97	95	99	114	68	131	75
aDbDaubHtwRPlPLAtwIslmsuSuTd	98	84	145	67	105	103	93
afVuPoONbBdjkOgPyhsnJVNXeNuU	93	91	86	94	92	129	112
aGOJkTpEDavftUNvNMxGRWKNIqyf	93	93	97	92	146	93	77
AgOMeMrilfAjJRCwMykLctnyorjk	100	101	124	93	113	82	99
AhAGwKYdfcIaAeahTpDiOYLkidFi	101	94	117	75	138	107	65
ahPRQJcTwjrpQkAWeauKFtSyARVl	90	91	86	88	94	116	79
aIcjjKMGjKvhEbWpkhPLMPWOERxR	94	95	115	92	92	117	66

Table 2(a) shows the data transmission from the water meter to the gateway in zone 1. The readout shows how much water is used each day. Every day, it is noted that every meter reading is precisely and error-freely recorded at the entryway. Table 2(a) may thus be used to conclude that all 700 packets reach the gateway, eliminating any possibility of packet loss in zone 1.

ZONE-1	Meter Reading – Per day water consumptionin litres						
MeterID	**Day1**	**Day2**	**Day3**	**Day4**	**Day5**	**Day6**	**Day7**
AVXiTGoQBbUHIFPbaeGRNcBVgasa	93	82	139	103	79	122	61
aWGRUCprePaHyGcrjcbVBpRQvUSu	94	95	132	91	92	83	107
AwOynLmKOKqcIBuXIFApnTVFTrdk	111	106	114	118	62	110	112
AWxFFOKpkxSHrtlnmYDcgACOgNIX	101	91	128	107	53	114	94
aXFESWsnTtSxFNEbXdPWmhliqOMF	100	69	93	106	133	69	139
axgSBKLHHsJnRQTsPLRmHYkKJOoA	96	96	95	136	102	90	73
axKhUGYYTvaFkENNDfgEsmOKklRl	108	128	85	112	110	105	88
AXrNCeDRctXLaiwxgWtDAayQNhsq	98	101	95	121	87	86	102
aXTqgUTpYORbacllxIyIrBQnYNhm	103	124	93	112	76	97	108
aYeJaURuaaxbalpSpbHDXEwnQBPp	89	88	128	85	122	90	64
AyGehkOuUIbAeKEbGFMxrEWOVWqV	101	105	95	97	130	109	67

4.1. Packet Delay Analysis

The time discrepancy between a packet's transmission and reception is known as a packet delay. The LoRa network is not designed for real-time transmission, and the packet delay is a function of both the data packet's transmission time and the radio duty cycle applied to the linked frequencies. A lower limit on the amount of time that must pass between two subsequent transmissions is established by the duty cycle. Data from 500 simulated metres were tracked for a month as part of this study to determine the average packet latency on the LoRa network. 31 packets were transmitted from each simulated metre, and the latency was measured in milliseconds.

Table3:TimestampdatafrommeterId"AAKiNJaEttvuAeCrIDLkbnSqwDud"

MeterId:	AAKiNJaEttvuAeCrIDLkbnSqwDud			
Date	**Status**	**Sent Timestamp inmilliseconds**	**ReceivedTime stamp inmilliseconds**	**Delay inmillisecond**
01-12-2020	PASSED	6743308	6743647	339
02-12-2020	PASSED	6743719	6744129	410
03-12-2020	PASSED	6744128	6744536	408
04-12-2020	PASSED	6744538	6744947	409
05-12-2020	PASSED	6744947	6745356	409
06-12-2020	PASSED	6745356	6745764	408
07-12-2020	PASSED	6745765	6746173	408
08-12-2020	PASSED	6746176	6746586	410
09-12-2020	PASSED	6746586	6746995	409

Tables 3(a) for all 5 zones with 100 metres in each analyse 500 metres. These tables include the determined average, maximum, and lowest time delays for each zone. The zone 1 packet delay data .

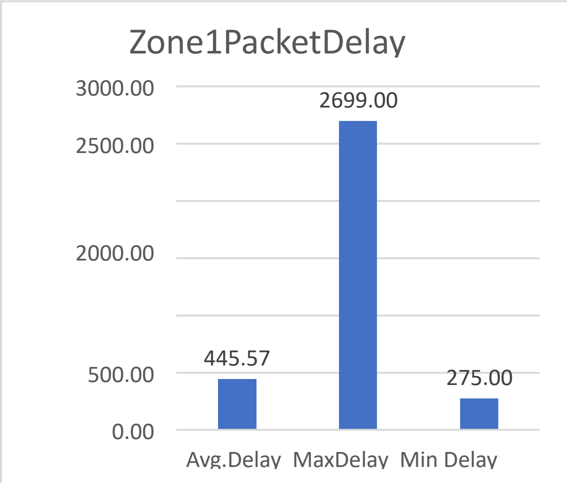

Fig.6.(a):OverallPacket DelayScenarioin Zone1

Zone	Average Delay inmilliseconds	Maximum Delay inmilliseconds	Minimum Delay inmilliseconds
1	445.57	2699.00	275.00
2	457.67	5008.00	275.00
3	464.29	5007.00	280.00
4	454.87	3480.00	274.00
5	449.22	3689.00	277.00
Average,Maximumand Minimumtimedelayofallzones	454.32	5008.00	274.00

The values reported in Table 4 are graphically

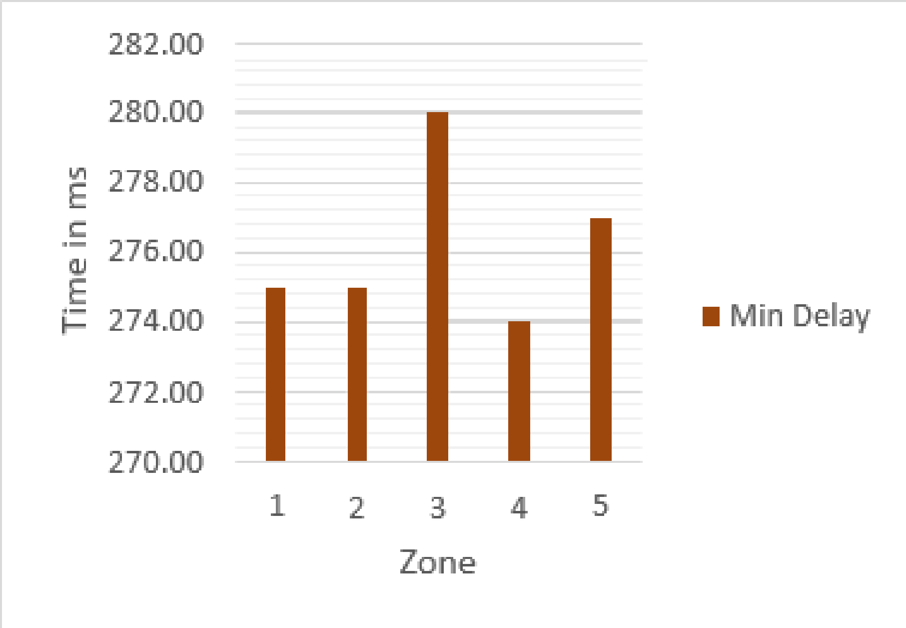

Figure 7 (a) shows the minimum packet delay for each zone.

Figure 8(b) shows the maximum packet delay for each zone.

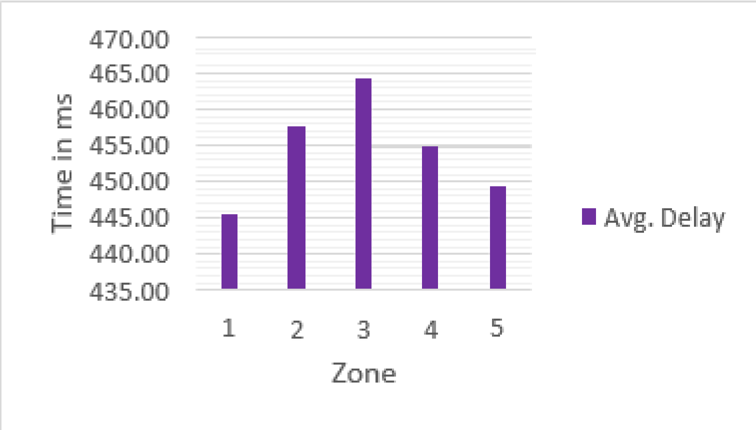

Figure 9.Average packet delay in each zone,

As a result of the observations and graphical depiction, it was determined that zone 1's average delay is extremely minimal due to the proximity of the metres to the gateway and their line of sight. Zone 3 has the longest average delay because metres there are farther away from the doorway and out of sight.The simulation was performed for 500 metres and 5 gates, whereas the prototype was created for 3 metering nodes and 1 gateway. It may be deduced from prototype implementation and simulation findings that a LoRa network can be used to create smart water metering. As a network structure, nodes and gateways can be linked together in a star topology. provides a summary of the simulation findings at a distance of 500 metres in terms of packet loss and delay on the network. along with additional networking settings for LoRa connectivity. Three smart water metres were used in the prototype along with a gateway device that also includes flow sensors, microcontroller units, LoRa modules, an Arduino board, a charging module, timers, and system clocks.

5. Conclusion

we explored the integration of IoT with other emerging technologies in smart manufacturing. We defined smart manufacturing as a fully-integrated, collaborative manufacturing system that responds in real-time to meet changing demands and conditions in the factory, in the supply network, and in customer needs. We also discussed the role of IoT in smart manufacturing and highlighted its benefits, such as improved manufacturing efficiency, product quality, maintenance costs, and supply chain management. However, we also acknowledged the challenges associated with IoT integration, such as significant investments in hardware, software, and infrastructure, the need for security measures, the requirement for new skills and expertise, and the need for changes in existing business processes and organizational structures. We also reviewed case studies that demonstrated the benefits of IoT integration in different manufacturing sectors, including semiconductor, food, and pharmaceutical. Finally, we highlighted future research directions, such as the development of new IoT sensors, the use of AI and machine learning algorithms, blockchain technology, and the exploration of ethical implications of IoT integration in smart manufacturing.

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