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Emerging Technologies and Applications of IoT: Current and Future Perspectives

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Abstract:- This article presents an in-depth analysis of the current and future Internet of Things (IoTs) technologies and applications. A brief overview of the significance of the current state of IoT technologies is discussed. The article examines emerging technologies and techniques such as 5G, edge computing, and AI, that will continue to transform ongoing IoT applications. The article explores the applications of IoT in various industries such as healthcare, transportation, smart cities, and agriculture. The article highlights the security and privacy concerns and solutions to IoT applications in different domains. This article offers some unique predictions on IoT growth in the next 5–10 years and a final discussion on the roles of IoT technologies in enabling Industry 4.0.

***Keywords**:- Internet of Things (IoT), 5G, Edge computing, Artificial Intelligence (AI), Healthcare, Smart Cities, Agriculture, Security, Privacy, Predictions.*

I. INTRODUCTION

The Internet of Things (IoT) is an emerging technology that has gained significant attention in recent years. It is a network of physical objects, devices, vehicles, and other items embedded with sensors, software, and connectivity to enable them to collect and exchange data with each other and humans. The IoT is transforming various industries, such as healthcare, transportation, smart cities, and agriculture, by improving efficiency, reducing costs, and enhancing the user experience.

A. Definition of IoT and its Importance

The definition of the "Internet of Things" has evolved over time, but it can be broadly defined as a network of interconnected devices that are capable of exchanging data with each other and with the cloud. According to Gartner, Inc., the IoT is a network of physical objects that contain embedded technology to communicate, sense, or interact with their internal states or the external environment. These objects range from consumer devices such as smartphones and smart watches to industrial equipment such as turbines and pipelines.

The importance of the IoT lies in its ability to collect and analyze vast amounts of data from various sources, enabling businesses and individuals to make more informed decisions. For example, IoT can help healthcare providers monitor patients remotely and collect data on their vital signs and medication adherence, leading to more personalized and effective treatments. In transportation, IoT can improve safety and efficiency by enabling real-time monitoring of vehicles and traffic flow, leading to reduced congestion and emissions. In smart cities, IoT can improve energy efficiency and reduce waste by enabling intelligent management of public infrastructure such as lighting, water, and waste management systems.

Furthermore, the IoT has the potential to create new business models and revenue streams. For example, companies can use data collected from IoT devices to develop new products and services, such as personalized health monitoring or predictive maintenance for industrial equipment. The IoT can also enable new ways of interacting with customers, such as using smart speakers or chatbots to provide personalized recommendations or support.

B. A Brief History of IoT

IoT has its roots in the early days of networking when the first interconnected computer systems emerged in the 1960s and 1970s. However, it wasn't until the early 1980s that the first example of an IoT device was created. In 1982, a group of students at Carnegie Mellon University in Pittsburgh, Pennsylvania, connected a Coca-Cola vending machine to the internet, making it one of the first internet-connected devices. The machine was equipped with sensors that could detect when drinks were running low or when the temperature inside the machine was too high or too low. By connecting the machine to the internet, the students were able to monitor its status remotely and ensure that it was always stocked with drinks that were at the right temperature (Atzori, Iera, & Morabito, 2010).

Despite this early example of IoT, it wasn't until the 1990s that the term "Internet of Things" was coined. Kevin Ashton, a British technology pioneer, first used the term in a presentation to describe a system in which objects could be identified and tracked using radio-frequency identification (RFID) technology. However, it wasn't until the early 2000s that advances in technology, such as wireless networking and low-cost sensors, made IoT more practical and feasible (Al-Fuqaha et al., 2015).

One of the first major IoT applications was the introduction of smart home technology, such as the Nest thermostat, in 2011. This marked the beginning of the IoT era, with companies investing heavily in IoT research and development. Today, IoT is a multi-billion-dollar industry with countless applications and use cases (Gubbi, Buyya, Marusic, & Palaniswami, 2013).

The growing accessibility of cloud computing and big data analytics in recent years has fueled the growth of the IoT. The ability to store and analyze vast amounts of data in real-time has enabled businesses to derive valuable insights and make data-driven decisions. The emergence of 5G networks has also created new opportunities for IoT, with faster and more reliable connectivity enabling the deployment of new applications and use cases (Kranenburg, 2014).

C. Significance of the IoT

The Internet of Things (IoT) has significant implications for a wide range of industries, including healthcare, transportation, energy, manufacturing, and agriculture. IoT technologies offer new ways to collect, analyze, and utilize data, allowing organizations to optimize their operations, reduce costs, and enhance the customer experience (Zanella et al., 2014).

One of the most significant applications of IoT is in the healthcare industry. IoT devices such as wearable sensors and remote patient monitoring systems can be used to collect and analyze real-time health data, enabling healthcare providers to monitor patients remotely and provide personalized treatment plans (Alam et al., 2020). For example, IoT-enabled devices can be used to monitor vital signs, detect falls, and track medication adherence, improving patient outcomes and reducing healthcare costs (Bassi, Horn, Kourtellis, & Nikaein, 2018).

In the transportation industry, IoT technologies can be used to improve safety and efficiency. Connected vehicles can share data with each other and with infrastructure, allowing for real-time traffic monitoring and optimization (Taleb et al., 2017). IoT-enabled systems can also be used to monitor vehicle performance and predict maintenance needs, reducing downtime and improving overall vehicle reliability (Hermann, Pentek, & Otto, 2016).

In the energy sector, IoT technologies can be used to optimize energy consumption and reduce costs. Smart grid systems, which utilize IoT sensors and analytics to monitor and manage energy usage, can help utilities better manage their resources and reduce waste (Chen, Wan, Li, & Li, 2020). IoT-enabled devices can also be used to monitor energy usage in buildings, enabling more efficient heating and cooling systems and reducing energy consumption (Baldini, Castro, Chang, & Jara, 2019).

In manufacturing, IoT technologies can be used to optimize production processes and improve quality control. IoT sensors can be used to monitor machine performance, detect faults, and predict maintenance needs, reducing downtime and improving overall efficiency (Bai, Yang, Chen, & Chen, 2021). IoT-enabled systems can also be used to improve quality control by enabling real-time monitoring and analysis of production data to identify and address issues (Boulanger & Chioukh, 2021).

In general, IoT technologies have the potential to transform a wide range of industries, enabling organizations to collect, analyze, and utilize data in new and innovative ways. As IoT technologies continue to advance, they will become increasingly important in enabling organizations to remain competitive and meet the evolving needs of their customers.

D. Motivation for the research paper

The Internet of Things (IoT) has become a critical technology for businesses and governments alike. Its potential to revolutionize the way we live, work, and interact with the world is immense (Zanella et al., 2014). However, despite the rapid growth of the IoT in recent years, there are still many challenges that need to be addressed to fully realize it's potential.

One of the main challenges facing the IoT is its security. As more and more devices are connected to the internet, the risk of cyber-attacks increases. According to a report by the Identity Theft Resource Center (2020), the number of data breaches in the United States increased by 17% in 2019, with over 1,400 reported breaches. This highlights the need for stronger security measures to protect IoT devices and the data they collect.

Another challenge facing the IoT is the interoperability of devices from different manufacturers. The lack of standardization among IoT devices makes it difficult for them to communicate with each other. This can lead to a fragmented ecosystem where devices cannot be integrated into larger systems, limiting their functionality and usefulness (Shi et al., 2016).

The exponential rise in IoT devices has also generated a vast amount of data that needs to be processed and examined right away. This calls for substantial computing power and storage capacity, which can be costly and energy-intensive (Gubbi et al., 2013).

Despite these challenges, the potential benefits of the IoT are enormous. IoT has the potential to optimize business operations, improve public safety, and enhance the quality of life for individuals. For example, IoT can be used in smart cities to monitor traffic flow, reduce energy consumption, and improve public safety. In healthcare, IoT can be used to monitor patients remotely, improve drug adherence, and prevent medical errors (Al-Fuqaha et al., 2015).

Given the immense potential of IoT, it is essential to address the challenges facing its widespread adoption. This research paper aims to explore current and future trends in IoT, including the challenges and opportunities presented by the technology. By doing so, we hope to contribute to the ongoing discussion on how best to harness the potential of IoT for the benefit of society.

II. CURRENT STATE OF IOT

The rapid growth of smart devices and the use of various technologies in the IoT lay the foundation for countless research opportunities. Smart homes integrate various domains, including home automation, which enables the residents to control home appliances like air conditioners, fans, washing machines, refrigerators, toasters, coffee makers, personal computers, smartphones, etc. remotely using the internet (Barodawala, Makwana, Punjabi, & Bhatt, Jan. 2018). Clients can utilize all characteristics of the smart home system and screen the appliances through the smart system platform operated on Android and advanced Internet of Things-based security. (Abdulla et al., 2020) caution for Smart Home: when nobody is available there so as to identify an intruder or some strange event at home, the IOT system begins without client intervention, and furthermore, it dynamically passes an email to the proprietor if any threats are found, and the proprietor takes the required action;

Both smart gardening and indoor air quality monitoring allow for remote plant monitoring as well as recurrent nutrient and watering applications (Min & Park, 2018). Smart gardening improves both the mental health of the building's occupants and the quality of the air in the surrounding area. To provide notifications, analytics, visualization, and real-time updates on IAQ levels, modern monitoring systems must include smart applications (Saini, Dutta, & Marques, 2020). An indoor air quality detector (IAQD) can be used in a variety of communication scenarios, including wired communication, short-range wireless network communication, long-distance communication to a cloud platform, and mixed applications (Zhao, Wu, & Li, 2019).

Smart home occupants are safe and secure thanks to the integration of sensors, human-computer vision techniques, video intercoms, and security cameras that are integrated into the system and controlled via a virtual private network (VPN), as well as IoT technology that can detect anomalies and intruders and send out real-time alerts (Froiz-Miguez, Fernández-Caramés, Fraga-Lamas, & Castedo, 2018). The IOT surveillance system works without client intervention and dynamically sends an email to the proprietor if any threats are found; the proprietor then takes the required action (Abdulla et al., 2020).

The ability to remotely monitor patients has improved healthcare services and extended elderly people's average life expectancy thanks to developments in biomedical sensors, wearable technology, the Internet of Things (IoT), and smart sensors (Kumar, Wang, Poongodi, & Imoize, 2021). Despite all the IoT advancements, IoT device reliability incorporates conventional reliability metrics into IoT-centric solutions. Assuming that the failure structures of IoT devices follow a specific probability distribution, a probabilistic model for measuring reliability in connected IoT devices was used to calculate reliability, failure rate, availability, and MTTR (Zin et al., 2016).

Challenges and opportunities of the IoT include the development and implementation of context-aware middleware due to the particular characteristics of devices and contexts, such as the limited resources of smart devices and the dynamic nature of contexts; the development of frameworks for efficient and optimized energy consumption at smart homes due to the increased amount of energy costs and demands; and the improvement of security in smart homes due to the increased number of new technologies (Almusaylim & Zaman, 2018). According to Nord, Koohang, and Paliszkiewicz (2019), IOT challenges according to the theoretical framework were: integration of new technologies into existing technologies was a challenge; managing complexity: protocol proliferation; bringing data from the edge: networking challenges; there are too few best practices in the evolving area of IoT. User security and privacy are significant problems, and the generation of reliable outputs from extensive, complex databases using machine learning algorithms allows for predicting and detecting vulnerabilities in IoT-based systems (Whaiduzzaman et al., 2022).

There is a need to secure IoT applications through the use of energy- and memory-aware lightweight security algorithms; security mechanisms should consist of fewer calculations, increase battery capacity, and use natural resources such as solar and wind energy, which also require upgrades to hardware and special skills (Swamy & Kota, 2020).

III. EMERGING TECHNOLOGIES IN IOT

According to Whaiduzzaman et al. (2022), Smart City 5.0 can harmoniously balance all aspects of life and the opposing interests of many city stakeholders since it blends human cooperation and artificial intelligence; Smart cities rely on the latest innovation in cloud, fog, and edge computing to conduct data analytics as close as feasible to the point of data creation; fog and edge computing were created as extensions to cloud networks; As the amount of acquired data increases, machine learning techniques are employed to enhance an application’s intelligence and capabilities. To address security concerns, machine learning (ML) techniques that embed intelligence in IoT devices and networks have to be employed. IoT in our daily lives, such as AI-powered IoT for consumers to listen to music on smartphones while driving or performing other tasks, Headphones with the Internet of Things sensors can track heart rates and use artificial intelligence to predict emotions; the smartphone may select the world's best song from those stored. Smart devices can modify or automate a state or behavior based on knowledge, which is considered a critical component of an IoT solution.

Machine learning techniques are used to create a prediction model of resource localization by incorporating actual task scheduling. IOT's primary aim in agriculture is to automate all agricultural operations and methods to maximize productivity.

5G design (Mahmood et al., 2021) and evolution address a multitude of use cases across multiple industries and even allow multiple IoT segments to coexist to serve a single vertical industry. Industrial wireless demands can broadly be grouped into three IoT segments: massive, broadband, and critical. Massive IoT (mIoT) targets a massive number of connected low- to medium-end industrial devices; Broadband extends high data rate (i.e., eMBB) services to data-intensive applications and provides additional IoT-related features such as low latency and enhanced battery-saving, coverage, and uplink data rates; Critical IoT is for time-critical industrial use-cases with a demanding requirement set of latency (1 ms with a 0.001% packet error rate) and reliability and covers use-cases such as collaboration and control of machines, robots, and processes, mobile robots, real-time human-machine interaction (HMI), automated guided vehicles, autonomous cars, and AR/VR applications.

In order to achieve massive data exchange at various frequencies, near-instant, reliable broadband connectivity must be provided. However, to implement 6G technology, several challenges need to be overcome, which include new spectrum allocation, network densification, inter-cell interference suppression, and distributed massive MIMO antenna technology (Sharma, Chehri, & Fortier, 2020).

IV. APPLICATIONS OF IOT

The applications of IoT are diverse, and they span across various industries, including healthcare, transportation, agriculture, and smart cities. These industries benefit from the technology's capability to improve efficiency, increase productivity, and enhance safety. In this section, we will discuss how the IoT is transforming these industries.

A. IoT in the Healthcare Industry

The healthcare industry has shown significant growth and innovation with the integration of IoT technology. IoT-enabled medical devices, wearables, and mobile apps are being widely used in healthcare to provide remote monitoring, and personalized treatment, and improve patient outcomes.

IoT technology has the potential to revolutionize the healthcare industry by transforming traditional healthcare practices into more patient-centric and proactive approaches. One of the significant advantages of IoT in healthcare is that it allows healthcare providers to monitor patients' vital signs and health conditions in real time, leading to early detection and timely intervention of health problems. This reduces hospital readmissions and emergency room visits, thereby lowering healthcare costs.

Moreover, IoT in healthcare has facilitated the development of wearable devices that can track patient health data, such as heart rate, blood pressure, oxygen saturation, and glucose levels, among others. These devices have improved the accuracy and frequency of patient health monitoring, resulting in better diagnoses and personalized treatment plans.

IoT in healthcare has also led to the development of telemedicine, which allows healthcare providers to remotely monitor and communicate with patients. This is especially important in rural or remote areas where healthcare access is limited. Telemedicine has also enabled healthcare providers to provide consultation services to patients who are unable to physically visit healthcare facilities.

Finally, the IoT in healthcare has enabled the development of electronic health records (EHRs), which improve patient outcomes by providing healthcare providers with access to a patient's complete medical history. EHRs have also enhanced data sharing among healthcare providers, leading to better collaboration and improved patient care.

Several studies have shown the positive impact of IoT on healthcare, including improved patient outcomes, reduced healthcare costs, and enhanced patient satisfaction (Dorsey et al., 2020; Mastellos et al., 2020). Therefore, it is imperative for the healthcare industry to continue to leverage IoT technology to improve patient care and outcomes.

B. IoT in the Transportation Industry

The transportation industry has significantly benefited from IoT technology, and its use has been gaining momentum in recent years. IoT in the transportation industry involves the integration of various devices, sensors, and platforms that enable real-time communication, data sharing, and decision-making processes. This technology has revolutionized the way transportation services are provided, leading to increased efficiency, safety, and reduced costs.

One of the most notable applications of IoT in the transportation industry is logistics and supply chain management. IoT sensors and devices are used to monitor the movement and location of goods in transit, enabling companies to track the progress of their shipments in real-time (Al-Fuqaha et al., 2015). This allows for better planning and scheduling of deliveries, reducing delays and ensuring on-time delivery of goods.

The field of public transportation is also changing as a result of the IoT. Cities are using IoT-enabled sensors and devices to monitor traffic flow, predict congestion, and adjust traffic signals in real-time to improve traffic flow (Gubbi et al., 2013). This has the potential to reduce congestion, air pollution, and travel time for commuters. In addition, IoT is also being used to monitor the performance of public transportation vehicles, ensuring they are running efficiently and minimizing breakdowns (Hussain & Salah, 2019).

IoT-based solutions can also help reduce the maintenance costs of transportation vehicles. The use of sensors and predictive analytics can help monitor the health of vehicle components and identify potential issues before they become major problems (Lee & Lee, 2015). This proactive approach to maintenance can reduce the downtime of the vehicles and improve the overall efficiency of the transportation system.

Another significant application of IoT in the transportation industry is the use of autonomous vehicles. Autonomous vehicles rely on IoT-based solutions for communication and decision-making. They use sensors and machine-learning algorithms to analyze the environment and make real-time decisions. Since human error is a major factor in most accidents, using autonomous vehicles can greatly reduce the number of collisions on the road.

The use of IoT in the transportation industry is not limited to land-based transportation. According to Zanella et al. (2014), IoT technology is being used in the aviation industry to monitor aircraft performance, enabling real-time monitoring of fuel consumption, engine performance, and maintenance requirements. This ensures that aircraft are running efficiently, reducing fuel consumption, and minimizing downtime due to maintenance issues.

In general, IoT technology is transforming the transportation industry, leading to increased efficiency, safety, and reduced costs. Its applications are vast, and there is potential for further development and innovation in this field.

C. IoT in Smart Cities

A "smart city" is a concept that aims to integrate various technologies, including IoT, to improve the quality of life for its residents, enhance urban services, and promote sustainable development. Smart cities leverage data from connected devices to improve infrastructure, transportation, public safety, and more. IoT plays a crucial role in the development of smart cities by providing real-time data to help city planners make informed decisions (Bai et al., 2021).

IoT in smart cities can be seen in various applications, such as smart transportation, smart parking, smart lighting, and smart waste management systems. For instance, IoT-enabled sensors in street lights can help detect the presence of pedestrians and vehicles and adjust lighting accordingly, leading to reduced energy consumption and increased safety. Similarly, IoT sensors in waste bins can detect the level of waste and optimize garbage collection schedules, resulting in reduced fuel consumption and better utilization of resources (Al-Fuqaha et al., 2015).

In addition to these examples, IoT is also used in various other applications in smart cities, including smart buildings, smart grids, and environmental monitoring. Smart buildings leverage the IoT to optimize energy consumption and reduce costs by collecting data from various sensors, such as temperature, humidity, and occupancy. Smart grids use IoT to manage energy distribution, monitor power quality, and reduce outages (Min & Park, 2018).

IoT in smart cities has the potential to revolutionize the way cities operate by making them more sustainable, efficient, and livable. By leveraging data from connected devices, city planners can make data-driven decisions to improve public services, enhance citizen engagement, and foster innovation (Zanella et al., 2014). However, as with any technology, IoT in smart cities also presents various challenges, such as data privacy and security concerns, interoperability issues, and the need for a robust infrastructure to support IoT devices.

To overcome these challenges and maximize the potential of IoT in smart cities, it is crucial to have a holistic approach that considers the entire ecosystem, including infrastructure, policies, and regulations. Collaboration between various stakeholders, including city governments, technology providers, and citizens, is also crucial to the successful implementation of IoT in smart cities (Zanella et al., 2014).

D. IoT in Agriculture

IoT has numerous applications in agriculture, enabling farmers to optimize crop yields, reduce waste, and increase efficiency. Smart farming technology allows for real-time monitoring of crops, soil, and weather conditions, providing farmers with valuable data to make informed decisions.

One application of IoT in agriculture is precision farming, which involves the use of sensors and mapping tools to gather data on crop yield, soil moisture, and other variables (González-de-Soto et al., 2020; Wang et al., 2021). This data is then analyzed to optimize fertilizer and water usage, leading to reduced costs and increased crop yields. For example, the use of IoT technology in vineyards has been shown to increase grape quality and yield while reducing water usage (Hosseini et al., 2021).

Another application of IoT in agriculture is smart irrigation, which uses sensors to measure soil moisture and weather conditions to optimize irrigation schedules (Han & Wang, 2021). This technology reduces water waste and lowers costs while also improving crop yields. A study by Ramrez-Hernández et al. (2020) found that the use of smart irrigation systems increased crop yield by up to 25% while reducing water usage by up to 30%.

In addition to precision farming and smart irrigation, IoT technology can also be used for livestock monitoring. Smart sensors can be attached to livestock to monitor their health, behavior, and location in real-time. This data can help farmers identify potential health issues and optimize feeding schedules, resulting in better animal health and increased efficiency (Cavalcante et al., 2020; Li et al., 2021).

All in all, the use of IoT in agriculture has the potential to revolutionize the way farmers manage their crops and livestock. By using IoT devices and sensors to collect and analyze data, farmers can optimize crop yield, reduce water usage, and improve the overall efficiency of agricultural supply chains.

V. SECURITY AND PRIVACY CONCERNS IN THE IOT

Since IoT is able to connect a large number of heterogeneous devices, a unified architecture or middleware is needed to implement it (Sobin, 2020). Interoperability is another challenge where authentication is key and the user's identity must not be revealed. During communication between devices, user data must not be tapped. Data confidentiality is a challenge because of the constant change in terminologies and the requirements of end-users. Identification technology challenges map a unique identifier to an entity to make it without ambiguity identifiable and retrievable; Internet of Things Architecture: Technology becomes imperative for the providers and requesters to communicate meaningfully with each other, irrespective of their heterogeneous nature; Establishment of communication technology challenges like proper deployment, Constraint-free mobility of items, cost, heterogeneity, and communication modality overcome the existing network dynamically to change the continuous evolution of things so that they can feature varying degrees of autonomy; Correct identification of data and further signal processing Standards are to be designed so that they support a wide range of applications and address the common requirements of all the possible applications that are interrelated to the IoT. Security threats in IoT-based healthcare systems (Ferrag, Shu, & Choo, 2021): Replay Attack (provide replay attacking resistance in epidemic situations), Impersonation Attack, Denial-of-Service Attack, Stolen Smart Card Attack, Man-in-the-Middle (MITM) Attack, Tampering Attack, De-Synchronization Attack, Privileged-Insider Attack, False Data Injection Attack, Ephemeral Secret Leakage Attack, Attacks Against Block chain-Based Solutions, Sybil Attack, and Botnet Attack.

Ho-Sam-Sooi, Pieters, & Kroesen (2020) show that high-level descriptions of security and privacy risks, through hacking, and in the real world, people may (wrongfully) assume that IoT products have built-in security; The main security threats in precision agriculture are: sensors being vulnerable to eavesdrop, steal, and inject malicious data due to signal loss from their long-distance deployment strategy and harsh environment; location tampering of outdoor sensors and actors resulting in agricultural facility failure and abnormal operation; 5G (Yang et al., 2021) is vulnerable to security threats like interception of node communication, network attacks, authenticity, integrity, and confidentiality.

To enhance the security and privacy of smart agriculture, user authentication systems should ensure the following security and performance requirements: resilience to various attacks, device anonymity, session key agreement, mutual authentication, and unlinkability; The proposed spatial spectrum framework supports reuse and truthfulness, including a cryptographic authority, multiple bidders, and an auctioneer; (Yang et al., 2021) To provide traceability and trust in the agrifood supply chain, a security solution deployed over the Ethereum blockchain network is proposed. To ensure confidentiality with end-to-end security guarantees, a clustered and distributed key management framework based on group-based keys is proposed. Intrusion detection systems based on machine learning and data mining algorithms are proposed.

VI. PREDICTIONS OF IOT GROWTH IN THE NEXT 5–10 YEARS

The Internet of Things (IoT) has witnessed tremendous growth in recent years, and this trend is expected to continue in the next 5–10 years. The current IoT market is valued at $250 billion, and it is projected to reach $1.6 trillion by 2025 (McKinsey & Company, 2020). The growth of IoT can be attributed to several factors, such as the increasing adoption of smart devices, the availability of low-cost sensors, and the proliferation of wireless networks. The use of IoT will become more widespread, not only in developed countries but also in developing countries, where businesses will begin to invest in IoT solutions to increase productivity and efficiency.

One of the key drivers of IoT growth is the increasing adoption of smart devices. Smart devices such as smartphones, smart watches, and smart home devices have become an integral part of our lives. According to Statista (2021), there are currently 4.5 billion active internet users globally, and this number is expected to reach 6 billion by 2022. As the number of internet users increases, the demand for smart devices will also increase, thereby driving the growth of the IoT.

In addition, the availability of low-cost sensors has also played a significant role in the growth of the IoT. Sensors are used in IoT devices to collect data, and the cost of sensors has decreased significantly in recent years. According to IoT Analytics (2020), the cost of sensors has decreased by 50% in the last decade, making it more affordable for companies to incorporate sensors into their IoT devices. This has led to an increase in the number of IoT devices in use, thereby driving the growth of IoT.

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One of the main drivers of IoT growth in the next 5–10 years is the increasing demand for automation and the adoption of Industry 4.0 technologies. IoT can help optimize industrial processes, reduce waste, and increase productivity. As a result, more companies will invest in IoT to improve their supply chain management, quality control, and predictive maintenance processes. In addition, the growth of wireless networks such as 5G has also played a significant role in the growth of the IoT. 5G networks offer faster data speeds, low latency, and higher device connectivity. This makes it possible for more devices to be connected to the internet, thereby enabling the growth of the IoT. According to Ericsson (2020), there will be 3.5 billion 5G subscriptions by 2026, which will enable the growth of new IoT use cases. The combination of IoT and 5G will also open up new opportunities for IoT applications, such as remote healthcare, autonomous vehicles, and smart cities.

IoT growth is expected to be significant in various industries. In the healthcare industry, IoT devices are being used to monitor patients remotely, which has become more important due to the COVID-19 pandemic. According to Markets and Markets (2021), the healthcare IoT market is projected to grow from $72.5 billion in 2020 to $188.2 billion by 2025. In the transportation industry, IoT devices are being used to track and manage vehicles, which has led to increased efficiency and reduced costs. According to Business Insider Intelligence (2020), the transportation and logistics IoT market is expected to grow from $10.4 billion in 2020 to $17.9 billion by 2024.

Therefore, the growth of IoT in the next 5–10 years is expected to be significant, driven by factors such as the increasing adoption of smart devices, the availability of low-cost sensors, and the growth of wireless networks such as 5G. The growth of IoT is expected to be significant in various industries, including healthcare and transportation. As the demand for IoT devices continues to increase, companies that incorporate IoT into their products and services will have a competitive advantage in the market.

VII. IMPACTS OF THE IOT ON SOCIETY

The Internet of Things (IoT) is a rapidly growing phenomenon that is transforming the way we live, work, and interact with each other. While the IoT has the potential to revolutionize our lives and bring about significant benefits, it also raises important questions about its impact on society. This section examines the positive and negative impacts of the IoT on society, the ethical considerations of the IoT, and how it will shape our future.

A. Positive and negative impacts of the IoT on Society

The IoT has the potential to have significant positive impacts on society. One of the most significant benefits of the IoT is its ability to improve efficiency and productivity in various industries. For instance, in the healthcare sector, IoT devices can be used to monitor patients' health remotely, enabling doctors to provide better and timelier care. Similarly, in the transportation industry, IoT sensors can be used to optimize traffic flow and reduce congestion, leading to more efficient transportation networks (Duffy, 2021). Moreover, the IoT has the potential to transform the way we live our daily lives. Smart homes equipped with IoT devices can help us manage our energy consumption, improve our home security, and provide us with more personalized experiences. Additionally, IoT devices can help us stay connected to the world around us, whether it be through wearable technology or smart cities that improve our quality of life (Rahmani et al., 2021).

While the IoT has the potential to have significant positive impacts, it also has the potential to cause harm. One of the most significant concerns about the IoT is its impact on privacy and security. With the increasing number of IoT devices, the risk of data breaches and cyber-attacks is increasing, putting our personal information at risk. The use of IoT devices also raises issues with data ownership and control because businesses are able to gather and use our data without our permission (Kshetri, 2021). Additionally, job displacement and income inequality may be brought on by the IoT. Particularly in sectors that rely heavily on manual labor, the automation of various tasks through the use of IoT devices may result in job losses. This may result in income inequality and a growing wealth disparity (Bughin et al., 2021).

B. IoT ethical considerations

The IoT has significant ethical issues that need to be addressed if we want to make sure it is used responsibly and ethically. The problem of consent is one of the biggest ethical issues. We must have control over how our data is used and who has access to it as IoT devices continue to gather more and more information about us. There are more moral issues to take into account, especially when it comes to data security and privacy. IoT devices' massive data collection has the potential to compromise personal privacy and make sensitive data accessible to third parties. The use of IoT devices also raises concerns about surveillance and the potential for abuse by governments and other organizations (Barnes, 2020).

The issue of bias is a crucial ethical point to remember. IoT device algorithms are only as effective as the data they are trained on. The devices themselves will be biased if the data used to train these algorithms is biased, which will produce discriminatory results (Kshetri, 2021).

C. Discussion of How IoT will shape our future

The Internet of Things is expected to have a significant impact on our future, both in terms of how we live our lives and how we interact with one another. One of the most significant implications of the Internet of Things is the potential for a more connected and efficient world. We can expect to see advancements in areas such as transportation, healthcare, and energy consumption as the number of IoT devices grows (Rahmani et al., 2021). Furthermore, the Internet of Things has the potential to transform the way we work, with the automation of various tasks increasing productivity and efficiency. Furthermore, there are fears that the widespread adoption of IoT will result in job displacement and exacerbate existing economic inequalities. Automation of previously performed tasks by human workers may result in job losses, particularly in industries such as manufacturing, logistics, and transportation.

Despite these concerns, the IoT is poised to shape our future in profound ways. With the increasing number of connected devices, the amount of data generated will continue to grow exponentially, providing unprecedented opportunities for data analysis and insights. This has the potential to revolutionize a wide range of industries, from healthcare to agriculture, and improve efficiency and productivity in ways that were previously unimaginable.

In general, the IoT has the potential to significantly impact our lives in both positive and negative ways. While it offers numerous benefits, there are also ethical and societal concerns that must be addressed. As we continue to move towards an increasingly connected world, it is important that we carefully consider the implications of this technology and work towards ensuring that it is used in a responsible and ethical manner.

VIII. CONCLUSION

In conclusion, this research paper has discussed the emerging technologies and applications of the Internet of Things (IoT) and their current and future perspectives. IoT technology has come a long way and continues to grow rapidly. The potential benefits of IoT technology are immense, but they come with significant challenges and risks. IoT has the potential to revolutionize many industries and impact society positively and negatively.

The limitations of this research paper include the limited scope of the topic, as there are many areas of IoT that could not be covered in depth due to time and space constraints. Additionally, the rapidly evolving nature of IoT technology means that some of the information discussed in this paper may become outdated relatively quickly.

Future research directions could include a deeper exploration of the ethical and social implications of IoT technology, particularly in regard to privacy and security. Additionally, further research could investigate the potential of the IoT to address global challenges such as climate change and sustainability.

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