

Evaluation of the Internet of Things (IoT) as Global Technology and Future Consequence

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Abstract

The Internet of Things (IoT) often refers to the addition of network connectivity to ordinary objects or equipment that was previously not internet enabled. It is about connecting everyday objects to the internet and letting them communicate with each other, including humans. The IoT makes technologies smarter by enabling automation, personalization, and remote control via networks of Internet-connected sensors. At the same time, IoT technologies raise significant privacy concerns, which may hinder their wider adoption. IoT applications range from smart homes and wearable gadgets to industrial automation, agriculture, healthcare, transportation, ecosystem, warfare, business, education, etc. The IoT has the potential and prospects to completely transform our lives by enabling smarter, more connected, flexible, more relaxed, and more efficient systems. IoT has the potential to develop industries' efficiency, increase productivity, and improve our daily lives. IoT will be more global technology, and more things will become internet-connected in the future. It is an analytical paper to evaluate the IoT as a global technology, as well as depict its domains, challenges, and future consequences.

Key Words:

IoT, Security, AI, 5G, 3D printing.

Introduction

The internet of things (IoT) is a catch-all term for a growing number of electronic devices that aren't traditional computers but are linked to the internet to exchange data, information, orders, and instructions. Today, the Internet of Things encompasses a vast array of 'things'. Internet-connected 'smart' versions of standard appliances such as refrigerators, televisions, light bulbs, and gadgets may exist only in an internet-enabled environment (Hossain 2023c&f). Again, internet-enabled sensors are altering manufacturing, healthcare, transportation, distribution centers, the service sector, industry, farms, and other industries (Ann and Tim 2023). IoT, on the other hand, is a term that refers to the increasingly sophisticated ecosystems of online, linked devices with which we share our world. Today, almost any item we use in our homes, businesses, factories, or even wear on our bodies can be online and connected, giving rise to the term internet of things (INNS, 2023). IoT is a trend that is driving the increasing digitalization and datafication of society in many innovative and remarkable ways.

IoT is a new information processing, acquisitional, and evaluation method, and it has been widely used in intelligent transportation, environmental monitoring, efficiency maximization, and other aspects of technologies and devices. Technological effectively integrate the infrastructure resources in communications, connectivity, management, marketing, finance, economy, engineering, medical, power system, environment aspect, and other service and industry-related things by the influenced and effective use of Iota (Liu Hua et al, 2014). So, most of the technologies and devices will be influenced by IoT in the 21st century. Companies and universities all across the world are interested in building Artificial Intelligence (AI) systems, from Apple to Google to Facebook (Hossain 2023d&f). AI is crucial in many engineering fields. Furthermore, 2021 has seen numerous fascinating breakthroughs in the field of AI and machine learning (ML) (Garima 2023). Healthcare devices represent one of the fastest-growing sectors of the IoT market. The value of this sector also known as the Internet of Medical Things (IoMT) is predicted to reach US\$ 176 billion by 2026.

The IoT links physical devices to the internet, enabling data processing and analytics. This entails interacting with the global information network without using a keyboard or a screen. Iota can bring to industrial processes and distribution networks the same efficiency that the internet has long given to knowledge work (Apthorpe 2019). Throughout the world, billions of embedded internets enabled sensors provide an enormous amount of data that businesses can utilize to improve operational safety, track assets, and reduce human operations. Machine data can be used to predict whether equipment will break, giving manufacturers a heads-up and avoiding lengthy periods of downtime (Khaled A A et al, 2023). IoT devices can also be used by researchers to collect data, information, and other intelligence about client preferences and behavior, market demand, future requirements, potential risk, and so on. However, those may be serious implications for privacy and security (Desai 2017). IoT has the potential to develop industries efficiency, increase productivity, and improve our daily lives. At the same time, IoT will influence seriously to other technologies, and in future more things will be internet-connected. Today globally, there are around 17 billion active IoT devices, and more than 85% of firms have boosted their technical efficiency by implementing IoT technology into their products. The IoT has been named 'the next wave of innovation' as its impact on people's day to day lives evolves (Christopher 2016). In fact, IoT is critical for operating large-scale businesses and the service industry in the 21st century.

Furthermore, it was found that IoT has a considerable impact on decision-making and corporate operation management (Gaur 2021). In the future, technological innovation and their extensive use such as IoT, AI, ML, big Data, will also lead to a miracle in every aspect of life, along with long-term gains in user friendly device, efficiency and productivity. Transportation, medical, service and communication costs will drop, logistics and global supply chains will become more available, effective, and the cost of trade will reduced, and all those will allow opening new markets and driving global economic growth (Hossain 2023f&g). It is an analytical paper where author has been taken endeavors to evaluate the IoT as global technologies, as well as illustrate its uses, influences, challenges and future consequences. The leading IoT developments, domains and future IoT market growth has also been predicted in this paper.

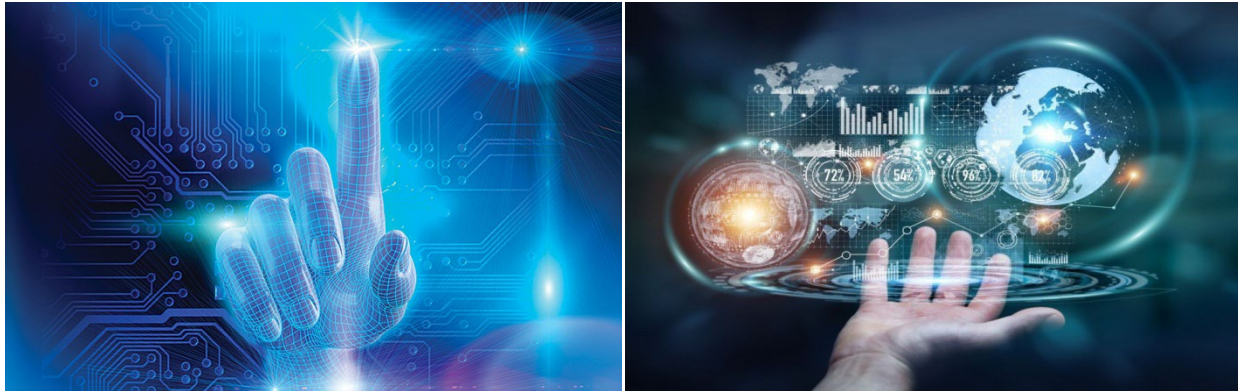


Figure 1. IoT has brought the world in our fingertips and future of Iota (Debra 2022 and Optimize 2023)

2.Domains of IoT as Global Technology

The IoT has its origins in the early 1980s, when the concept of connecting various devices and products to the Internet was first proposed. The term "Internet of Things" was invented in 1999 by Kevin Ashton, a British technology pioneer. The first known IoT-enabled equipment, a Coke machine that could report its inventory and temperature, was invented in the 1980s at Carnegie Mellon University's Computer Science Department. John Romkey developed the first internet-connected device, a toaster that could be turned on and off via the internet, in 1990 (FIA 2021). The advent of wireless communication protocols such as Zigbee, Z-Wave, and Bluetooth enabled IoT devices to have low-power, short-range connections. IPv6 development gave a substantially bigger address space, which was critical for addressing the huge number of IoT devices. With the integration of IoT devices into many sectors such as manufacturing, transportation, and energy, IoT gained popularity in the industry. Machine-to-Machine (M2M) communication has become common, allowing devices to interact and exchange data without the need for human interaction (Hossain 2023f&h).

Thermostats, security cameras, and voice assistants have grown in popularity, providing consumers with greater convenience and control over their living areas. Several organizations and partnerships, like the Industrial IoT Consortium (IIC) and the Open Connectivity Foundation (OCF), worked to define IoT interoperability and security standards (Paul 2016). AI and machine learning (ML) technologies are being integrated into IoT systems, allowing for improved data analytics and predictive capabilities. The expansion of 5G networks enables quicker and more dependable connectivity, boosting the possibilities of IoT even further (Hossain 2023a&f). The Fourth Industrial Revolution (4IR) is the digital revolution that is occurring because of developing technologies such as robotics, IoT, and AI. The 4IR signifies a fundamental shift in how we live, work, and interact with one another (WEFORUM 2016).

4IR is a new chapter in the development of humanity, made possible by unprecedented technological developments comparable to those of the first, second, and third industrial revolutions. These advancements are fusing the physical, digital, and biological worlds in ways that hold enormous promise as well as possible danger. The revolution's pace, breadth, and depth are driving us to reconsider how countries evolve, how organizations create value, and even what it means to be human. The 4IR is about more than simply technological transformation; it is a chance for everyone, including leaders, policymakers, and people from all income levels and nations, to harness converging technologies in order to create an inclusive, human-centered future. Beyond technology, the true opportunity is to create ways to empower the greatest number of people to positively impact their families, companies, and communities (WEFORUM 2016). According to one of the more conservative forecasts by market research firm IoT Analytics, the business would be worth US\$ 1.6 trillion by 2025 (Analytics 2018a). The growth of IoT market and revenue has been shown in figure 4 below (NCTA 2016, IoT Analytics 2022a&b). IoT has the potential to play a big role in achieving a more viable, sustainable, and environmentally friendly future. Three key domains fall under the banner of Iota (Hossain 2023b&f). Interestingly, COVID-19 has substantially expedited the implementation of IoT. Three types of IoT domains and their brief discussion has been given below:

Wearable IoT—

Devices that people can wear as accessories, such as watches, to monitor an individual's activity or vital signs. IoT-enabled wearables are internet-connected devices equipped with various sensors that can be worn as external accessories (for example, watches, glasses, rings, and so on) or embedded in textiles such as smart shoes or jackets. Many commercially available wearables, such as the Fitbit and Apple Watch, are expressly designed for health and fitness tracking (Lee I et al 2015). Sensors gather individuals' movement and vital indicators, such as steps taken, heart rate, and sleep quality, to track activities and assist people in monitoring and improving their wellbeing and physical performance (Haghi M K et al, 2017). Other gadgets, such as Google Glass, aim to assist users monitor their engagement with the world around them by capturing audio and video of their daily lives. The purpose of all wearable technologies is to automatically and unobtrusively record an individual's bodily contact with the surroundings (Motti V G et al, 2015).



Figure 2. Image of impact of IoT on smart city (Nikita 2022 and Smart city 2023)

Household IoT—

Devices that remain in the homes of individuals, such as smart speakers, appliances, and thermostats. A smart house is one that has lighting, heating, air conditioning, security systems, or entertainment systems that interact with one another and work together to improve the occupants' experience and comfort. Smart home gadgets enable remote monitoring and control of home components such as the thermostat, lights, and door locks. Many smart gadgets, such as smart speakers and appliances, aim to improve household convenience and automation (Naeini P E et al, 2017). Using cameras, audio, and fire or water leak sensors, devices can also offer safety and security monitoring. Additional individuals and organizations may be involved in safety monitoring, with information and devices shared with family members, security corporations, or emergency services (Zheng S et al. 2018). The impression of smart home data privacy differs per device. Some information, such as the state of smart lighting or thermostats, is not considered very sensitive. However, video and audio from within the home are typically considered private, and users want strong safeguards against recordings being viewed without their knowledge or permission (Lee H et al, 2016, Hossain 2023f).

2.3 Public IoT

Devices that are used in public locations, such as smart water meters, autonomous vehicles, and Bluetooth beacons. Smart cities and smart buildings have increased the use of IoT technology in public infrastructure. The management and optimization of traditional public services, such as transportation and parking, lighting, ventilation, surveillance and upkeep of public places, and even cultural heritage protection, can all benefit from public IoT infrastructure. The New York City Department of Transportation, for example, incorporated a congestion management system to assess traffic speed at 23 crossings in Midtown Manhattan, reducing travel time by 10% on Midtown's arteries (Hossain 2023e&f). Smart cities and buildings, like smart homes, enable services to monitor the security and safety of areas and people, as well as intelligently automate controls in reaction to the environment. Furthermore, IoT is frequently utilized for resource management, cutting costs by utilizing resources more efficiently and intelligently. For example, the city of Dallas, Georgia, has implemented a smart water meter program that has assisted them in more efficiently detecting water leaks and minimizing water loss. The autonomous car is another developing type of IoT device in the public domain, which is rapidly being used in app-based taxi services (like Uber), home delivery services, and consumer items (e.g., Tesla). Each autonomous car is outfitted with a plethora of sensors to collect data about its surroundings, such as people walking down the street, other vehicles on the road, and adjacent store information (Lee H et al, 2017). Furthermore, drivers and passengers in cars face a considerable quantity of data collection during and after their travel (for example, automobiles may collect information about their daily schedule) (Hossain 2023f&i).

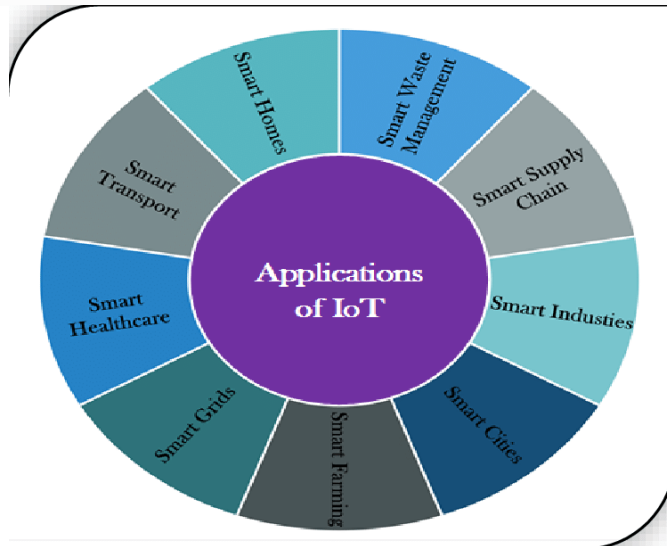


Figure 3. IoT application domains (Rajinderkumar M et al, 2018)

The energy consumption and carbon impact of IoT devices and systems, on the other hand, are becoming serious concerns. Federated learning (FL) is a novel and promising approach that allows numerous devices to train a common model jointly while maintaining individual data on-device. FL is distinguished by the ability to train models with far

less data than centralized learning and to train models on low-power devices. Both federated learning and green/sustainable computing strive to increase the efficiency and sustainability of IoT systems. Federated learning allows numerous devices to learn a common model cooperatively while preserving data on-device, reducing the energy usage and carbon footprint of IoT devices and systems (Hossain 2023f&j). This is due to the fact that FL allows models to be trained on low-power devices with far less data than centralized learning, which can assist to minimize the energy consumption of IoT devices. Integrating Federated learning with green/sustainable computing can potentially open up new IoT use cases and applications. FL, for example, can be used to train models for environmental monitoring, smart cities, and smart grid applications, which can aid in the optimization of energy usage and resource efficiency.

3. Different Technologies Related to IoT

The IoT contains and interacts with a wide range of technologies. We know that artificial intelligence (AI) is a branch of computer science aimed at developing computer systems capable of doing activities that would typically need human intelligence. AI is often used to accomplish tasks such as object recognition, speech transcription, decision making, and so on. Deep neural networks, which require enormous quantities of data to train and work, are currently the most successful kinds of AI. The data acquired by IoT is highly suited for usage by AI, which may then give IoT devices with features such as voice command processing. Again, the cloud refers to computer networks that are accessed remotely rather than locally. It is composed of software, platforms, and infrastructure that are delivered to users on demand. Common cloud services include application execution as well as data storage, processing, and delivery. IoT devices commonly make use of a variety of cloud services. Data collected by IoT devices is frequently stored or processed on cloud platforms, owing primarily to cloud scalability and storage and processing power limitations on small IoT devices, but also because many IoT organizations find additional value in being able to rapidly access data from IoT devices (Hossain 2023f&l).

Internet of Things devices are virtually always linked to the internet or private networks. A variety of businesses require computer hardware and system software to maintain a network, necessitating the usage of network specialists. Wearable, home, and office devices typically link to networks via short-range technologies like Ethernet, Bluetooth, or WiFi, whereas larger IoT ecosystems like those found in cities or farms sometimes employ longer-range technologies like cellular or satellite networks. 5G is a cellular network technology that will eventually replace 4G. 5G will be used to link a new range of IoT devices and applications by delivering more data faster and more securely. Its speed has the ability to support new business models, modify processes, and improve corporate performance. However, few use cases require 5G capabilities today, and most IoT applications are well supported by 4G or lower bandwidth network technology (Telenor, 2023). 5G will bring a few advantages to the Internet of Things, including the ability to connect many more devices at the same time, and the ability to track the location of those devices with significantly greater precision and accuracy (Rocco Di Taranto et al, 2014).

4. Trend of IoT and Future Consequences

In this revolutionary century, physical and virtual dimensions are increasingly intertwined day by day. Advanced technologies such as internet of things, big data and artificial intelligence, augmented reality, mixed reality, virtual reality, blockchain, digital twins, edge computing, metaverse, smart cities, radio frequency identification technologies and smart spaces radically changes in many areas of life including business, industry, education, and service sector. IoT has become a hot topic in the tech-driven world of 21st century. A strong framework of cloud computing, backed up by a seamless blending of sensors and actuators with the environment around us, is making this “network of networks of autonomous objects” a reality. From smart wearables to smart cities, from domestic life to industries, the IoT is expanding itself to different areas. Smart security solutions, smart home automation, smart health care, smart wearables, etc. are in-trend applications of IoT, and by the near future, we expect to see its application to a city's transportation system or smart power grids (Hossain 2023f). We must know the importance of cloud computing, autonomous control, and artificial intelligence in the context of IoT. Augmented reality, high-resolution video streaming, self-driving cars, smart environments, e-health care, and other IoT-centric concepts are becoming commonplace (Fadoua K et al, 2019). Higher data rates, larger bandwidth, expanded capacity, reduced latency, and high throughput are required for these applications. In light of these new principles, IoT has transformed the world by enabling seamless connectivity between disparate networks (Hossain 2023f&l).

4.1 Growth in Data and Devices and increase Human-Device interaction.

Today, about 17 billion devices are actively connected to the Internet and are used for daily tasks. With the arrival of 5G, additional gadgets and data traffic will be possible. We may add to this trend the increased usage of edge computing, which will allow businesses to handle data more quickly and near to the point of action (M Mohageg et al, 2022).

4.2 AI is the Powerful Player in IoT.

Making the most of data, and even comprehending how contemporary infrastructure works on a fundamental level, requires computer support via artificial intelligence. Amazon, Microsoft, and Google are among the main cloud vendors that are increasingly attempting to compete based on their AI capabilities. Several firms aspire to boost their market share by leveraging AI algorithms capable of leveraging machine learning and deep learning, allowing businesses to extract more value from their ever-increasing volumes of data. Artificial intelligence is the key component required to make sense of today's massive amounts of data and boost its business value (Prof. Ahmed 2019). AI will aid IoT data analysis in the following areas: data preparation, data discovery, streaming data visualization, data time series accuracy, predictive and advanced analytics, and real-time geographic and position (logistical data).

4.3 Voice User Interface (VUI) is Now Reality.

It is a competition between industry leaders who want to control the IoT sector at an early stage. Digital assistant devices like as Alexa, Siri, and Google Assistant are the future hubs for the next generation of smart gadgets, and corporations are attempting to build "their hubs" with consumers to make it easier for them to continue adding devices with less trouble and annoyance. Taking a page from science fiction movies, conversing to robots such as R2D2, C-3PO, and Jarvis, etc; accounts for 80% of our daily communications. The use of voice to set up devices, alter settings, provide directions, and receive results will become the norm not only in smart homes, but also in factories but in between like cars, wearables, etc (Hossain 2023f&g). Today, we cannot discuss digitalization without mentioning IoT. It's a technology boon, and in today's world, no firm can flourish without implementing Iota (Antino 2023). IoT has been seamlessly interwoven into many elements of our globalized economy and way of life, ranging from interconnected consumer devices to smart cities.

4.4 IoT Investment is Increases.

The undeniable influence of IoT has attracted and will continue to attract more startup venture capitalists to highly inventive initiatives in hardware, software, and services. IoT spending will reach 1.6 trillion dollars by 2025. IoT is one of the few markets that attract both emerging and conventional venture capitalists. The proliferation of smart gadgets, as well as users' greater reliance on them to do many of their daily chores, will heighten interest in investing in IoT firms. Customers will be looking forward to the next big innovation in IoT, such as smart mirrors that analyze your face and call your doctor if you appear sick, smart ATM machines that incorporate smart security cameras, smart forks that tell you how to eat and what to eat, smart beds that turn off the lights when everyone is sleeping, and smart shoes that will advise you about your health and what to do (Hossain 2023f).

4.5 Real Expansion of Smart IoT like Smart Cities.

Nothing will provide a finer example of IoT connectivity and processing than smart cities, yet smart cities have been in a bit of a holding pattern recently. Smart sensors placed throughout the area will track everything from walking paths to shared automobile use, building occupancy, sewage flow, and temperature preference 24 hours a day, seven days a week, with the goal of creating a place that is comfortable, convenient, safe, and clean for all who live there. Once finalized, the technology might serve as a blueprint for other smart communities and, eventually, smart cities. However, the potential benefits for cities make IoT technology particularly appealing. Cities of various sizes are investigating how IoT may improve efficiency and safety, and this infrastructure is spreading around the world. The auto industry is another area where smart IoT is developing, with self-driving cars becoming commonplace in the coming years (Taeihagh Araz et al. 2019). Many vehicles now include a connected app that displays the most recent diagnostic information regarding the vehicle. This is accomplished through the use of IoT technology, which serves as the linked vehicle's brain. Diagnostic data will not be the sole IoT innovation in the coming year or so (Hossain 2023b&f). Other items that will revolutionize the way we drive are connected apps, voice search, and real-time traffic information.

4.6 Rise of Industrial IoT and Digital Twin Technology.

This new techno-industrial revolution is being driven by a convergence of technologies, with IoT playing a significant role in making production more efficient, less dangerous, and more profitable. Industrial IoT improves efficiency and production by integrating and analyzing data in ways that would not be feasible without a linked manufacturing process. Digital twin technology is another trend that is gaining traction. Organizations can use it to get a clear view of how their IoT devices interact with the manufacturing process. This provides keen businesses with insight into how their machines' life cycles run, allowing them to anticipate improvements that may be required ahead of time. A Gartner poll found that 48% of smart manufacturing adopters want to employ the digital twin concept (Prof. Ahmed 2019).

4.7 Increase movement to the Edge.

Edge computing is a technique that distributes the processing burden and puts it closer to the network's edge (sensors in the case of IoT). The advantages of fog computing are particularly appealing to IoT solution vendors. Some of these advantages include the ability for users to reduce latency, conserve network capacity, operate reliably with quick judgments, collect and secure a wide range of data, and move data to the optimal location for processing with improved analysis and insights of local data. Edge computing has grown in popularity in recent years, but the expanding scope of IoT technologies will amplify this trend. This shift is being driven by two factors: Powerful edge devices in a variety of form factors are becoming less expensive. The importance of centralized infrastructure is growing. Edge computing also makes on-device AI a viable option because it enables businesses to exploit real-time data sets rather than needing to trawl through gigabytes of data in a centralized cloud in real-time. It's likely that in the future years, if not decades, technology will change to a balance of cloud and increasingly distributed edge-powered devices (Cabe 2021). Hardware manufacturers are designing edge infrastructure to be more physically rugged and secure, and security vendors will begin to offer endpoint security solutions to their existing services to prevent data loss, provide insights into network health and threat protection, and include privileged user control and application whitelisting and control, all of which will aid in the rapid adoption and spread of edge computing implementations by businesses (Hossain 2023f).

4.8 Increase Social, Legal and Ethical Issues.

IoT devices are a relatively new and uncontrolled technology. In the foreseeable future, IoT will unavoidably face societal and legal challenges. This is especially true for data acquired by these devices, which may soon fall within the purview of the General Data Protection Regulation (GDPR). The GDPR, a European Union rule on the handling of personal data and privacy, extends its reach beyond the European Union. Any company that wants to operate successfully in the EU must follow the criteria outlined in the 88-page paper. When it comes to the legal control of personal data, security concerns are critical. Development teams can assure the needed level of security and compliance at multiple levels, such as data encryption, active consent, various methods of verification, and other procedures (Hossain 2023d&f). Their purpose is to acquire data legally while limiting its accessibility, processing, and storage to the minimal required by the software product (BBVA 2023).

4.9 Standardization is one of the biggest challenge/problem to growth of IoT.

It is a competition between industry leaders that want to control the IoT sector at an early stage. But we now have a situation of fragmentation. One possible solution is for a small number of vendors to dominate the market, allowing customers to choose one and stick with it for any additional connected devices, similar to how we now have operating systems with Windows, Mac, and Linux, where there are no cross-platform standards. To comprehend the complexity of standardization, we must consider all three areas during the standardization process: Platform, Connectivity, Applications. All three criteria are interconnected, and missing one will break the model and impede the standardization process. Without a strong push from organizations like IEEE or government legislation to create universal standards for IoT devices, there is no way to overcome the fragmentation problem (BBVA 2023).

4.10 Traffic Management.

Modern IoT developments indicate that IoT technology is relevant for addressing global concerns such as traffic and obstruction issues. Many firms are already offering plans and solutions that use IoT-installed technology in traffic systems and automobiles to create more intelligent traffic networks, with the goal of reducing unnecessary traffic and congestion (Hossain 2023e&f). Cities that employ smart-mobility technologies, according to McKinsey, have the potential to reduce commute times by 15 to 20% on average by 2025, with some people benefiting from far greater

reductions. As a result, cities and leaders are finally learning, after a decade of trial and error, that smart-city initiatives cannot be realized without robust technology such as Iota (Thales 2023).

4.11 IoT Security.

According to Statista, the IoT security market will reach 38.7 billion in 2023, up from 4.2 billion in 2022. It's all connected to the growing number of connected devices that demand exceptional security. As a result, security system software will be more important than ever in the coming decade, which is why such IoT device security statistics are unsurprising. As a result, security is an evolving IoT trend, and many firms around the world are developing IoT solutions. When it comes to the extended level of connectivity that we are involved in these days, security is one of the key issues. The rising involvement of technology in people's lives has emphasized the ongoing threat to insecure connected devices (Antino 2023). As a result, security is an evolving IoT trend, with various organizations around the world producing IoT security solutions based on a variety of technologies.

4.12 Metaverse.

The worldwide metaverse market is estimated to reach US\$ 679 billion by 2030, according to Grandview Research. The Internet of Things (IoT) is a fundamental component of the Metaverse system, which depends on it to optimize its possibilities (Antino 2023). The interaction of the Internet of Things and the Metaverse will almost probably open up new opportunities for expansion and growth in the technology industry. Its growth is expected to be propelled by the metaverse's use in a range of businesses, including games, entertainment, media, eCommerce and retailing, training, manufacturing, architecture, engineering, and others (Khurana 2019).

5. Future Growth of IoT Market and its Popularity

Before delving into the data, its necessary delineating what we consider an IoT device and what isn't. In this research, we consider IoT devices as those that were previously not linked to the internet (dumb devices), but are now network connected, allowing for a new set of applications with other consideration. For example, here smart-phones and computers are Internet enabled, those need not classify as IoT devices because they have traditionally been so. But, an internet-enabled toaster oven would be deemed an IoT device because the equipment hasn't generally been connected to a network. With that concept in mind, how quickly is the IoT market expanding has been determined. It may have seemed unthinkable a decade ago that our refrigerators could notify us when we were running low on milk, our doorbells could record our visitors, and our audio speaker system might mistakenly order toys online. Nonetheless, we live in the IoT era, where these types of devices have surged in popularity and are literally everywhere. The IoT has grown dramatically in terms of the number of devices, income earned, and data created, but most forecasts suggest that growth will increase. The number of connected IoT devices has predicted that it will reach 25 billion by 2025; whereas the number of IoT devices was 8.7 billion in 2012. Again, the yearly income from IoT sales is expected to reach US\$ 1.6 trillion by 2025; whereas the IoT sales were US\$ 200 billion in 2012. On the other hand, perhaps most importantly, the volume of data generated by IoT is predicted to reach 2.2 zettabytes by 2025; whereas the volume of data generated was 0.1 zettabytes in 2012 (IoT Analytics 2022a&b; 2018a&b).

There are several competing figures and projections with any market forecast, but all of them imply that growth has been radiating fast and potentially increasing. It has been estimated that, in 2025, there will be more than 25 billion of IoT devices, and that will be producing 2.2 zettabytes of data. As we know that, zettabyte is equal to one trillion gigabytes (Team 2018). Whereas, in comparison with future uses of IoT devices in 2025; it was created only 100 billion gigabytes in 2012. The amount of money to be generated in the IoT sector is similarly astounding, with estimations putting the market's value in 2025 at roughly US\$ 1.6 trillion. According to the NCTA, a trade organization for internet and television providers, the installed base of connected devices is predicted to exceed 50 billion by 2020, representing a nearly 500% growth as compare with 2012 (Team, 2018). Almost every market prediction predicts that the industry will be worth a trillion dollars or more during the next decade. Global connection growth is mostly driven by IoT devices, both on the consumer (like Smart Home) and enterprise/B2B (like connected machinery) sides (Techtarget 2022). However, use of IoT in percentage in different sectors has been shown in figure 5 below (IoT Analytics 2022b). The global IoT market (end-user spending on IoT solutions) is predicted to increase 37% as compared from 2017. Because of the market acceleration for IoT (as stated above), those forecasts have been revised upwards, and the whole market has estimated to reach US\$ 1.6 trillion by 2025 and that has been shown in figure 4 below (IoT Analytics 2022a). Again, forecast of global IoT market in trillion US\$ and active connected in billion has been shown in figure 6 below (IoT Analytics 2018b and 2022b).

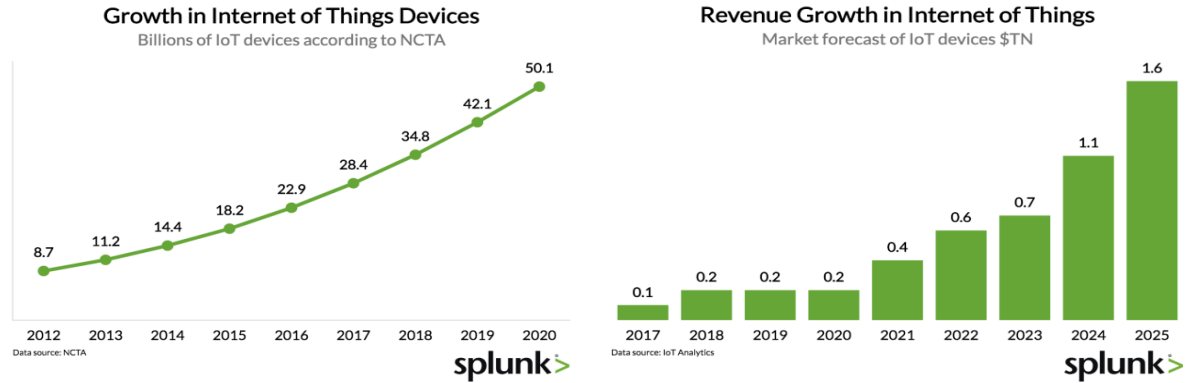


Figure 4. Growth of IoT market (NCTA 2016) and revenue growth of IoT (IoT Analytics 2022a)

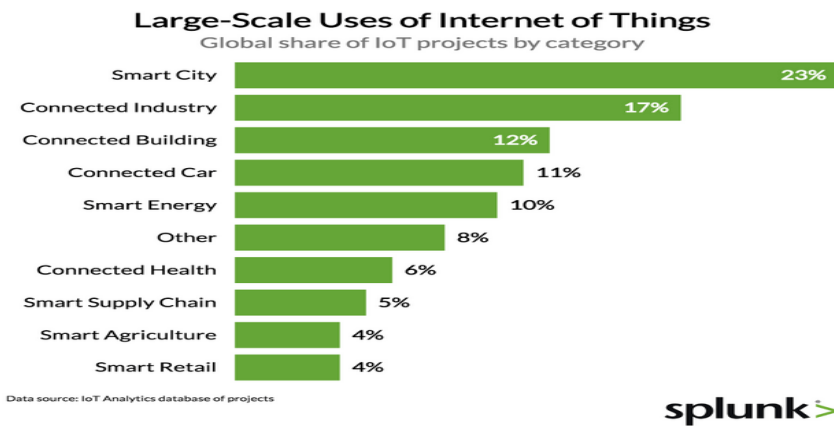


Figure 5. Use of IoT in percentage in different sectors (IoT Analytics 2022b)

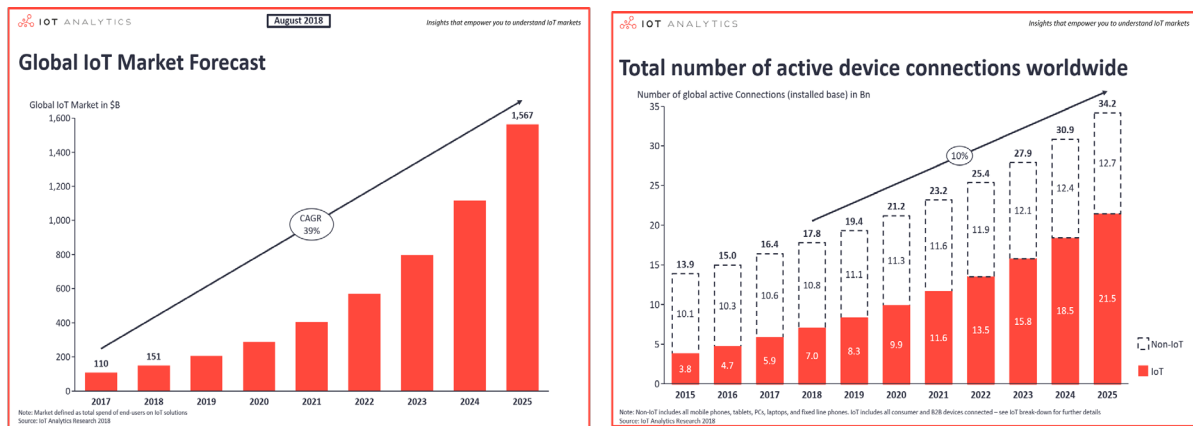


Figure 6. Forecast of global IoT market and active connected with devices (IoT Analytics 2018b)

6. Conclusion

The Internet of Things (IoT) is the unique identification and ‘Internalization’ of common objects. This enables human contact and control of these ‘things’ from anywhere in the world, as well as device-to-device interaction without human intervention. The Internet of Things is predicted to grow rapidly, increasingly linking various elements of our life and blurring the borders between the online and offline worlds. Finally, it is a tool that has the potential to benefit everyone. However, as the Internet of Things expands, additional types of personal information will be acquired, as will the

overall amount of personal information collected. The way this data is used will have a big impact on how much benefit the IoT brings. Traditional approaches for protecting privacy and properly informing individuals about how their personal information is gathered, utilized, and released are incompatible or inadequate for IoT devices. It is possible that new and inventive solutions that can work with gadgets and services that fundamentally form infrastructure will be required. Furthermore, it was found that IoT has a considerable impact on decision-making and corporate operation management including daily personal matters. Nowadays, IoT brings internet connectivity, data processing and analytics to the world of physical objects has become extreme popular. It has been predicted that, by 2025 data use will be 2.2 zettabytes; the value of IoT sates market will be US\$ 1.6 trillion; and IoT device uses will be more than 25 billion.

Traditional methods of safeguarding privacy and adequately educating people about how their personal information is obtained, used, and published are incompatible or inadequate for IoT devices. It is possible that new and inventive solutions that can work with devices, gadgets and services that fundamentally form infrastructure will be required. To gain the benefits of IoT, strong governance, improved accountability, and transparency are also required. Individuals should not have to choose between privacy and the convenience and efficiency of IoT; both should be available to everyone. Again, in the 21st century, we cannot escape from using IoT to manage large-scale businesses and the service industry. Furthermore, it has been found that, IoT has a considerable impact on decision-making and corporate operation management. Smart speakers, which were a small niche a few years ago, are now a ubiquitous presence in homes throughout the world. And, when businesses invest in capital improvements, such assets are increasingly being outfitted with internet connectivity for monitoring, maintenance, and optimization. The IoT revolution has arrived, and it is just growing and that means one massive byproduct of all these linked devices: data. To gain the benefits of IoT, strong governance, improved accountability, and transparency are also required. Individuals should not have to choose between their privacy and the ease and effectiveness of IoT; both should be available to everyone. Again, in the twenty-first century, we cannot escape using IoT to manage large-scale businesses and the service industry. So, companies that design and deploy IoT devices will increasingly have to consider not only how to use IoT devices, but also what to do with the data and how to protect it from threats. As a result, in the 21st century, IoT will govern every sector of business, organization and service sectors along with each element of human life. As a result, we need to utilized such promising and wide useful technology more safely and sustainability by formulation and implementation of necessary roles and regulations.

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