

Figure 2. Internet of Things growth (data from [Number of IoT devices 2015-2025 | Statista](#))

II. POTENTIAL APPLICATION DOMAINS OF IOT

When we say potential application domains, we are not talking about numbers only, but we have to consider the other factors of daily life for example of individuals. In line with [4], the applications of IoT cover broad areas including smart cities and smart environments out of more others.

A. Smart Cities

If we are talking about Smart cities, we can offer internet of things opportunities to use data to handle and manage traffic, better usage of city infrastructure and let the people inside the city healthy / Safety at the same time it will keeps the city clean. Now we will discuss some positions and their impact.

A.1 Smart infrastructure: cities must be built to accommodate with ongoing development with digital technologies, so infrastructure of the buildings must be planned more efficiently. Smart Cities must use technologies to save and usage the energy efficiently as well as the environment infrastructure friendly. One of the factor impacts is the smart lighting should only provide the light once and when it required, and not only the light working but also the performing of the brightness level, all of this function must be tracked daily to know how to save the power.

A.2 Traffic Management: One of the most and biggest issue to the big smart cities is to optimize the traffic, so implementing the internet of things to help road objects to send real time updates of the traffic flow to a traffic control point for data analysis and adjust traffic lights immediately. It uses historical data to predict and prevent issues without any human factor.

A.3 Smart Waste Management: This solution will help to optimize the efficiency of waste collection and re-use, as well as reduce the operation costs. Waste containers or chutes will have

sensors to report to the control unit which can send notifications to Truck system or drivers smartphones when the containers reach to the specified threshold.

B. Smart Environments

Internet of things allows people to check and measure the quality of the air inside the environment by controlling several parameters. To clear that point we are talking about air pollution which means the amount of Sulfur Dioxide, Nitrogen Dioxide and Carbon Monoxide in the air. The Air quality measures it can show the amount and types if gases in the air which can determined as pollutants Like PM10, PM2.5, NO2, SO2, CO). when the concerned objects are connected to internet of things can measure the air quality will be in which category (Good, Satisfactory, Moderate, Poor, Very Poor and severe) as it shown below in Fig. 3. By using the Internet of things in the smart environments it will be helping to improve Cities, farms, and factories, at the same time can be mandatory for industrial cities to make sure that they are following the environmental regulations. Information about the air can give an advantage for the people to avoid any respiratory pathologies. [5]

AQI CATEGORY	PM10 (24HR)	PM2.5 (24HR)	NO2 (24HR)	O3 (8HR)	CO (8HR)	SO2 (24HR)	NH3 (24HR)
Good (0-50)	0-50	0-30	0-40	0-60	0-10	0-40	0-200
Satisfactory (51-100)	51-100	31-60	41-80	51-100	11-20	41-80	201-400
Moderately polluted (101-200)	101-250	61-90	81-160	101-168	21-30	81-160	401-800
Poor (201-300)	251-350	91-120	161-280	169-208	10-17	161-300	801-1200
Very poor (301-400)	351-430	121-250	281-400	209-348	17-34	301-600	1201-1800
Severe (401-500)	430+	250+	400+	348+	34+	600+	1800+

Figure 3. Pollutants and Health Breakpoints

C. Healthcare

Many healthcare systems in many countries are inefficient and, slow. IoT application can offer in health care is tracking patients, staff, and objects, identifying, moreover and authenticating, individuals by auto gathering knowledge and sensing. Hospital operations flow will be improved when patients flow is tracked for example. On the other hand, authentication and identification can reduce incidents errors or lose tracking of patients, record maintenance. Auto data collection is significant in operation automation, reduction time consuming, as well as medical inventory management. [6].

When we talk about domains in this sector will; having the ability to measure a patient's compliance with prescriptions, and warning for patients. So, sensors will be applied to outpatient and inpatient patients, also dental Bluetooth devices may give information about the health of the tooth. All of this will enhance measurement and monitoring techniques of functions such as

pressure, temperature, heart rate, blood sugar, cholesterol levels, and so many others.

D. Retail and Logistics

IoT in retail Management has different benefits. include observing storage supply chain, tracking of products to enable payment processing based on the locations or activity during transportation phases, and others. Inside the retail, IoT can be applied to enhance fast payment processes as auto checking out, detecting stock shortage, controlling the rotation of products on shelves as well as warehouses to automate the stock management procedures [7].

IoT objects can be used in this by using, wireless sensor networks and radio frequency identification. Currently use of SAP (Systems Applications and Products), in logistics there are some examples like, item location, storage incompatibility issues. Application of IoT also can assist in maintenance and repair as these systems can be put in place to check and maintain equipment malfunctions and auto schedule maintenance services before any failure in the equipment. This can be achieved by installing sensors inside equipment to monitor functionality and send reports accordingly.

E. Smart Business

There are so many things that are being important part in the smart business, but the more attractive part is the Radio-frequency identification (RFID) technology usage to introduces the main concept of smart businesses as well as the inventory control management system. Tracking and monitoring here will be the main target for the goods with the help of RFID technology. Not only that with RFID assistance, we will be able to check the product stock availability in real time and also it will lead to inventory management help. After tracking, monitoring, availability and manage the inventory we will be able to check the quality of products when we combine the RFID and bio sensors together. At the end when we use the IoT we will be able to enhance the business productivity by the quality of our products.

F. Social Networking

Social networking it can be defined as the use of Internet-based social media sites to stay connected. Also, the social networking will have a social purpose, a business purpose, or both. With the previous definition social networking are used for sharing the information as well as the values between each other. On the same time, it provides us platform for communication in better way. And when we try to find the relation to the concept of IoT and social networking we will find so many applications which being able to connect the people in a unique way. On the other hand, there is another concept is important and it can play a main role in the social networking enhancement like the concept of the web of things.

G. Security and Surveillance

When we are thinking about integration phase or part between different technologies within the same single management system, the security will be an important factor. Internet of Things will try to provide more secure enjoyment globally by using its enhanced technologies. In part of the security, you will find homes security, buildings security, shops security as well as car parking security are now can be managed easily with the assistance of IoT. When it comes to countries governments and military armies you will find some many applications of internet of things which can enhance the control model and there are numerous applications of IoT through which we can better control the battlefield by using the sensors.

III. RESEARCH CHALLENGES

For all the above applications domains of Internet of things. Internet of things has many challenges must be sorted out for Internet Of things evolution. These challenges have two factors the metrics which they are heterogeneous technologies that are used in sensing, collection and sorting the date, with the second factor is all of that require more attention in different research areas [8]. On the other hand, many surveys of the Internet of things include a section of research challenges, so I have tried to consolidate their results here for our target.

A. Privacy and data protection:

The Internet of Things is known to be "an international network infrastructure, linking physical and virtual objects through the exploitation of information capture and communication capabilities. This infrastructure includes existing and involving web and network developments. it will provide specific object-identification, sensing element and association capability because the basis for the event of freelance cooperative services and applications. These are going to be defined by a high degree of autonomous information capture, event transfer, network property and ability." This ends up in a variety of new (as well as already known) potential risks regarding data security and each privacy and information protection, that should be thought about. The severity and probability of every risk can rely on the circumstances during which every IoT application / system is deployed.

We have identified some major challenges and issues about privacy & data protection and information security. One of the most important challenge is continuity and availability of IoT-based services ensuring, challenge is to make sure accessibility and continuity within the provision of those services, and to avoid any potential operational failures and interruptions. If we considered that any attacker could re-programmed smart home power service, it will be very difficult to resume the facility offer

to the home, which suggests that some functions could impact the availability of the grid. Another challenge is a question, is the design consider IoT technologies? in fact privacy and data protection must be assigned systemically at design layer. But on the ground that not happened, and it have been added later.

On the same time IoT objects does not have enough resources to implement all relevant security functionalities. Another challenge is the risks are context-aware and situational, more persons are participated in this process, most of privacy and policies being context-aware and situational, which it makes the identification and assess very difficult. For example, applications like smart homes, how you can assure that some principles of data and privacy protection like informed consent can be survive in that open environment? One more challenge is violation of the individual's data and privacy protection. Nature of operation process of IoT depends on devices, sensors, readers, and applications which can all these sectors' data being collected about individual through the targeted environments. This information collected might be for people habits, interests, location, and some other personal information, by these combinations one example can be found in the implementation of the contactless credit card which the name and card number can be read without any authentication. With this data it opens gateway for the attackers to use the cards or bank account of the card owner.

B. Data Management.

Data management is one of the challenges, as the information Centric Networking (ICN) offers efficient aid in the rich content retrieval as well as accessing to the services. This it appears as valuable as provide access, transferring and managing. Here the challenge starts by question, how to extend the ICN paradigm competently over the fixed network edge? How ICN functionality on resource with cell phones connected with IoT [9].

C. IoT understanding.

The issue is how to increase number of people who they able to understand the changes and the implications more clearly. "The pace of change has exceeded the rate of human capability to absorb, the cup is already full" said Jeff Kavanaugh VP and Senior partner in High Tech and Manufacturing for Infosys. IoT is going beyond of calling it by early stage as connected devices to be smart, immersive, and converting the data it collected to valuable data about object, operation, or individual person. The fast expedition and IoT learning will lead to down sensor costs, enabling more business cases that was very expensive in the past.

Other factors need to be mentioned here related to social, legal, and ethical issues keys mentions: The key social, legal, and ethical issues facing the IoT, as discussed by the Oxford Internet

Institute [10] are: Global misinformation systems, big data problems, public attitudes, opinions, and behavior, tightly coupled systems, Quality of service issues, new forms of risk, and linking the IoT to work on responsible innovation.

D. Universal Standards:

Universal standard is required to different devices communication from different environments. European Telecommunications Standards Institute (ETSI) and Internet Engineering Task Force (IETF) both are working to develop the standards which are related to IoT but still the unified standard for the communication one of the IoT research challenge.

E. Interoperability:

Usually with regards to the internet, compatibility is always being to be the most basic essential value due to the first precondition in Internet connectivity requirements of that "connected" systems to have the ability to "communicate in the same language" in terms of encodings or decoding and protocols as well. On the other hand, nowadays, many industries using so many standards to support their applications. So, it is very important and significant for the applications to be within organizational because the large amount as well as the types of data, and different devices, are using standard interfaces in different entities, with consideration of the wide range of system limitations. Here it comes to, the IoT systems straight forward being designed to handle all higher degrees of computability.

F. General Research challenges of IoT:

Generally, IoT gives us the new model or an example to the society so in this case definitely there are requirements to changes in the laws as per this new age of this technology. So, must be a sanction in case of any threats or violations for these roles. Globally cooperation required to work together and share the same responsibilities when it comes to the legal factors of using this new technology. We need a dedicated chain or series for devices to be able to communicate effectively with each other as the IoT in this case will handle or deal with a large number of sensors. More a standard sequence for that series management will be also required. Other challenges in IoT are that the complexity of the large number of devices will be related to each other's but it will not be only connection it will also sharing information between them. And because of processing that amount of data, the devices will consume huge amount of energy. Which will affect the devices live time when it be used for any of IoT field. In this case we need to generate some mechanisms which it can help us in reduce the energy consuming by these devices, when we use the green technology in IoT field for further efficient energy usage. All these are some of the challenges that need more focus in the future to achieve the aim from IoT in the implementation in our real world.

We will start with describe of the future application for IoT then we will describe some of the technologies.

Data Store Reliability

Nowadays we are using to keep our own or organizational data in the cloud. With edge computing which allows any connected devices to share, analyze and keep them data locally. So, the edge computing with its nature as kind of hybrid approach to data processing which will participate in reshaping the future of IoT. With the spreading of IoT in many areas in our lives, we have to make sure that all connected systems functionality is up and running smoothly. Also, the need for the security will make the data store when it comes to related to sensitive systems are required. To clarify, for example whenever a person enters a dangerous area in the organization, machinery must stop immediately. Here where edge computing can take place. While it will allow the system to divide the data and take critical decisions quick, and at the same time making sure that the system is working correctly without any faults or drops.

Voice-Controlled Devices

The question here is touching things left and right is the best idea? Nowadays we can confirm that not the best idea due to ongoing COVID pandemic. Not only for this reason but also for the general convenience we can shift towards the voice-controlled interfaces. Starting from ATMs non touchable to the voice control panels in our industrial fields, for sure voice technology is already changing the way of our interaction with some of objects around us. But as usual there is hazard here, voice-controlled devices raise privacy and security challenges. Some of the main concerns here is related to the voice payments or any financial transactions will use this facility. This point will take us back to the one of the major IoT trends, which is the enhanced IoT security. IoT systems will be more secure in the near future to give us the right time to explore new possibilities.

Internet of Medical Things

From this headline Internet of Medical Things, we can come up with slogan "The power to save lives". The development of medicine is going with cooperation with the technological progress at the same time. IoT and its future may bring more positive changes to the healthcare field. The whole world had already need to reevaluate the importance of remote healthcare specially with the ongoing COVID pandemic. Security and safety are essential requirements in the clinical environment, but with present of IoT it can helps by improving the monitoring and processing patient data. Shortly patients and doctors will not even be required to be meet face to face, which will be the most useful during the lockdown, in such it happens again. We can confirm that shortly, IoT trends will get more great influence in the healthcare field, with all the smart medical devices becoming more popular.

We can say that the functions of e-Health devices can include the following:

- *Monitoring:* which it gives the ability to the devices to be able to monitor your heart rate, blood pressure, and other health markers.
- *Emergency response:* With this option for the devices will be able to send you an alarm as well as recommendations in case of a health emergency and/or call you an assistance.
- *Fitness assistance:* with this option for the devices will be able to offer some general assistance as well as advice during the physical training.
- *Reporting:* with this option for the devices will be able to collect data about your condition and send it to your doctor.

All the above was only just the tip of the mountain in showing how the new technology will change the way we are dealing with health. Hopefully in the current or coming decades we can see how the nanotech devices can collect data about our conditions, report the same to doctors, as well as assistance in healing us as we go. We can assuming that the future of the Internet of Things and we need to be ready for it.

Vehicle-to-everything (V2X) connectivity & autonomous driving:

One of the expected trends in 2021 is the development of V2X connectivity, so it might be a good period to have a look into it. for the proper functionality of the autonomous cars for example the V2X will be mandatory or essential for that. As it will allow the vehicle to be able to connect to devices and vehicles around the target vehicle as well as collecting information from them, for the situation analysis on the road. We will all thanking this technology for assisting cars in predicting roads situations, selecting the best routes as well as driving at optimal speed to be able to save fuel. On the other hand, autonomous cars are not yet ready for bulk usage. By using the internet of Vehicles, we will be able to make V2X-controlled cars more and better safer than human-controlled cars. But the biggest challenge here for autonomous cars currently is the presence of the human-driven cars on the streets. Security concerns as well as hazard will be present during the current situation of the cohabitation of autonomous and traditional vehicles on the roads, and also many numbers of legal ramifications must be resolved in the near future will assist in the same further.

In this part we will try to describe the technologies which will get an important role in Internet of Things applications.

5G and IoT.

5th Generation 5G technology will be main component of the next network society. 5G will help a lot of connected devices to meet the expected real time, reliability communication needs for application performance. 5G will also provide wireless connection for so many applications and use cases, including smart cities, smart homes. It will also accelerate the development cycle of the internet of things. 5G will be leader of

the global IoT. Main features of the new 5G technology are reviewed and presented in [11].

Massive IoT

Massive IoT means the services typically expanding relying on a huge number of devices, sensors, and actuators. Sensors are low cost and very low energy consuming. But in fact, generated data by each sensor will be small, and very low latency. While actuators are also low cost, they will have varying energy footprints ranging from very low to moderate energy consumption. Here we will show Vertical markets for Massive IoT tech, figure 4 shows the massive IoT applications. [12]



Figure 4. The Massive IoT applications

Critical IoT

Critical IoT means applications like traffic safety/control, control of infrastructure and wireless connectivity for industrial processes. These applications require high reliability and availability when we talk about wireless connectivity, as well as low latency. On the other hand, Devices low cost and energy consumption but not important as it for Massive IoT applications. Also, the amount of data transported from and to devices not large, wide instantaneous bandwidths are useful in order to meet capacity and latency requirements. Figure 5 shows the critical IoT.[13]

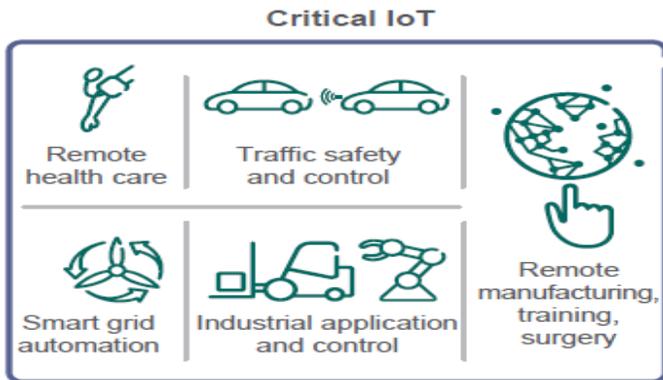
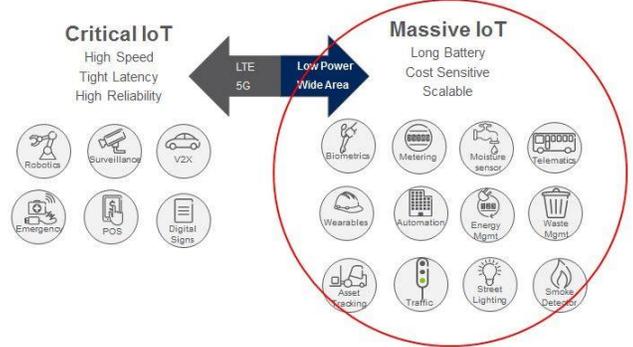


Figure 5. Critical IoT

Figure 6 shows the differences between the critical and massive IoT.



V. CONCLUSION

Internet of things can be defined as complex network system, will be continuing to enhance the new forms of the system/software engineering and many others in next coming years. The application areas of IoT are diverse to serve many users, with different needs. The technology can help users, individuals, communities, and organizations. As discussed in the application section of this research paper, the IoT will have positively impact millions of lives worldwide. Reference to [14], this has become more evident, as different governments around the world have an interest in the IoT concept by providing more funding for further research. more research studies already in place, new dimensions to the IoT processes, technologies involved and objects which can be connected, opening the great gate for the functionalities of IoT. On the other hand, IoT is expansive and affects practically all areas of lives, makes it a good research topic for studies in various related fields like information technology and computer science. This paper spotted on many potential application domains for the IoT, some of future applications and other some research challenges.

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