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Research Article

Incorporation of Radar Connectivity for Large-scale Internet of Things Services at 6G Speed

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ABSTRACT

Competition to the finish line has been triggered by the launch of the generation of wireless networks known as 6G. In order to find the most efficient answers to the challenges faced by their ancestors, researchers from all around the globe have started their investigations. Several review articles presented their points of view and offered an analytical evaluation of the current state of the art, so presenting the reader with a comprehensive picture of the most recent developments. Even though significant progress has been achieved, most of the initiatives that have been made have been theoretical in nature. These endeavors have focused on the large picture rather than the specific implementation issues that arise when trying to connect the Internet of Things to applications that are used in the real world. The review is approached in a different manner in this article, which covers a number of Internet of Things use cases that are meant to be indicative of the field. The use cases that were selected were selected from the industries that have been the subject of the greatest research and that stand to profit from 6G and associated technologies. The Fourth Industrial Revolution, with its implications for healthcare, smart grids, transportation, and more. We also spoke about some of the difficulties that we encountered in the real world and the important lessons that we learned from putting these use cases into practice. There is a high degree of congruence between the basic requirements of the cases and the primary drivers for the next generation of wireless networks, which is the focus of this inquiry.

Keywords: *Internet of Things (IoT), wireless networks, 6G, healthcare, transportation, smart grid, industry 4.0*

1. Introduction

The networks of the future will be able to support a broad variety of applications and devices that are at the cutting edge of technology. Among the technologies that fall under this category are high-definition television streams that are supplied via the internet and are entirely immersive, intelligent Internet of Things devices, industrial automation, and autonomous vehicles. This technology is projected to meet the requirements of our civilization in the future, and its implementation is anticipated to take place in the year 2030. Because of this, the International Telecommunication Union (ITU-T) has released its vision of the network in the year 2030 and beyond, which identifies the primary drivers for future networks, as seen in Figure 1.

One of the most important motivating factors is the development of high-fidelity holographic society applications that enable communication in real time and bilaterally. In the form of holographic telepresence, which is a kind of holographic communication (HTC), distant individuals are projected as holographic presences at a local site. This makes it possible for local users to participate in remote troubleshooting. The deployment of HTC involves a significant amount of data transmissions. As is the case with video, it is reliant on the colour depth, resolution, and frame rate, but it also needs a far greater amount of material. HTC needs three more "Degrees of Freedom" in order to produce a full image. These "Degrees of Freedom" include the tilt, angle, and position of the observer in relation to the hologram. It is possible that the future of communications may include applications that are based on touch, such as the tactile internet and other touch-based communications. Now, obviously, that is not the purpose at all. The only sense that we have is sight, right? As about the senses of smell and taste? If our goal is to create experiences that are really immersive, it is imperative that we include a number of different sensory modalities into our discourse.[1-3]

The "Connectivity for All Things" phenomenon is the second component, and it refers to an unprecedented expansion in the number of devices that are capable of connecting to the internet. It is possible that the Internet of Things is largely responsible for the anticipated exponential increase in the number of devices that are linked to the internet. One of the primary functions of the Internet of Things is to link billions of different devices. Within the Internet of Things, the majority of machine-to-machine and machine-to-network communications are entirely automated. In a wide range of industries, the Internet of Things has a significant amount of untapped potential for advancement. The healthcare industry (for two examples of its application, see Section 3), smart grids (for an example, see Section 4), transportation systems (for an example, see Section 5), and manufacturing (for an example, see Section 6) are all included there. The number of Internet of Things devices that are expected to be operational by the year 2025 is anticipated to exceed 75 billion. Maintaining a connection that is dependable for such a vast number of devices and the data that they generate is one of the most difficult difficulties that network operators face. Due to the fact that it represented a new paradigm with fundamentally different needs, the Internet of Things (IoT) played a crucial role in the creation of 5G. However, because to the vast number of Internet of Things devices that need to be managed, it is anticipated that this will be a significant problem.[6]

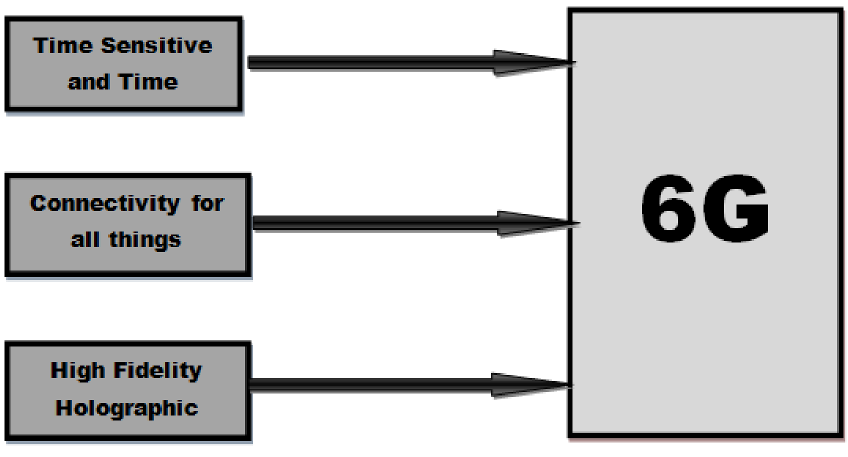

Fig 1. Important variables that will accelerate the development of 6G wireless networks.

The last issue is the increasing significance of time-sensitive applications in sophisticated Internet of Things (IoT) applications like industrial automation and autonomous systems. (IoT) applications are becoming more important. It is far more crucial to consider time in situations when persons are not the primary makers or consumers of data. As a consequence of this, real-time communications will become more significant in the networks of the future.[5]

Within the scope of this article, we adopt a novel approach to reviewing by posing the question of how 6G and the technologies that underpin it could be able to assist in resolving the problems and limitations that have impeded the deployment of analogous use cases in the past. The primary objective of this article is to illustrate the possibilities offered by 6G by shedding light on particular issues that are associated with each of the categories that have been identified. The wider research community, on the other hand, may make use of this information in order to conceptualise and create analogous systems in the same or other fields. Already, there are a great number of works that discuss not just the historical context but also the most current technical advancements. However, we do highlight some of the writers' earlier contributions to cutting-edge Internet of Things use cases that are relevant to the current market. The Internet of Things use examples that have been shown represent just a tiny portion of all the possible implementations of the Internet of Things; nonetheless, they are drawn from four different domains in which the Internet of Things plays an essential role, and they illustrate the wide range of use cases that would be enabled by 6G.[4]

In addition, while research into these applications continues, there is still room for advancement in terms of both their capabilities and the standards that they must meet. The following is the order in which the remaining parts of the paper are presented. The methodology and significant examples that served as the basis for this evaluation are discussed in Section 2. Application of the Internet of Things in the medical field is the topic of discussion in Section 3. In the fourth section, we present a real-world application of the smart grid, namely the energy monitoring system that is used by the hospital. Within the fifth section, we present an application that is associated with transportation. The sixth and last industry, Industry 4.0, is the topic of discussion in Part 6. In the seventh section, a summary of the use cases is presented, along with a discussion of the benefits and drawbacks of 6G. This section provides a summary of the article as well as a conclusion.

2. Research Methodology

The kind of applications that experts predict will make the most of the services and opportunities offered by 6G are the subject of investigation in a number of previous papers in the academic literature. The following are some examples of technologies that fall under this category: holographic tele-presence, remote healthcare (telemedicine), smart cities and environments, autonomous transportation systems, remote learning, and the brain-computer interface. Note that this list is not exhaustive.[7]

We conducted an investigation to see if the environment-signed potential of 6G may help with the industry's present and future communication issues. This was done so that we could better comprehend the value that 6G offers to end customers. This technique was chosen in order to facilitate the investigation of the real-world applications of the promise that 6G holds across a variety of industries. This one-of-a-kind method has two primary goals: (1) to stimulate the public's interest in the potential of 6G technology, and (2) to illustrate the capabilities of 6G core drivers in real-world scenarios by employing examples. The types of industries that have been selected as use cases are those in which technology related to the Internet of Things (IoT) and/or mobile communication are presently being developed and used.

An assortment of use cases that make use of technology related to mobile communication and/or the Internet of Things are shown in the following sections (Figure 2). In the context of 6G and the technologies that accompany it, each paragraph provides an analysis of the use case, the technical specification and requirements, the results (if applicable), the difficulties that were encountered during the execution of the use case, and the prospective remedies. [8][9]

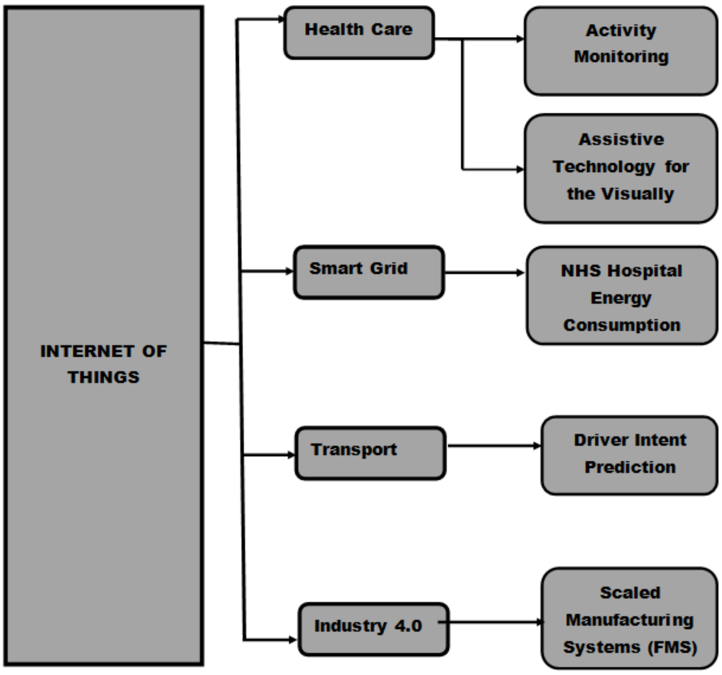

Fig.2. Usage examples that explains the industries and their applicability.

2.1 Healthcare

There is a tremendous deal of concern over the impending conflict that will be caused by an ageing population. During the next fifty years, it is anticipated that the number of persons aged sixty-five and older would rise by about one hundred percent. This has resulted in the development of intelligent systems and technological breakthroughs that may be used in the monitoring of healthcare professionals as well as other parts of everyday life.[9]

By providing proactive, at-home care rather than the conventional, crisis-driven treatment that is offered in hospitals, which has been the norm for quite some time, the Internet of Things (IoT) has been an essential component in promoting a reduction in the amount of stress experienced by medical workers for a considerable amount of time. The probability of epidemics is increased as the population is becoming older.

The Internet of Things (IoT) is being increasingly used in the healthcare industry as a result of pandemics such as COVID-19 and the growing number of individuals who are afflicted with chronic ailments. But the ever-increasing demand begs the question of whether or not the technology that is now available can keep up. It is generally agreed that the sixth generation of mobile communication networks and the technologies that make them possible are the most important parts.[9]

In this part, the authors provide two use examples that illustrate the potential importance of 6G in the healthcare industry. Each of these use cases makes use of a different feature of wireless communication. A hypothetical future in which current technology and the Internet of Things are used to enhance the quality of life of people is represented by each of the scenarios. While the first one addresses the topic of non-invasive activity monitoring via the use of radio frequency (RF) sensing, the second one provides assistance to those who are visually handicapped. As we get to the conclusion of each section, we take a look at the difficulties and constraints that are associated with each use case, as well as the potential role that 6G may play in bridging the gap.

3. Human Activity Monitoring:

3.1 Introduction:

Over the last several years, a number of different fields, such as healthcare, search and rescue, intrusion detection, and others, have shown an increased interest in the capability to detect human movement in both indoor and outdoor settings. All of the human activity detection systems that are now in use depend on ambient sensors, wearables, and cameras, all of which have significant implementation costs and limits. It is also possible that they may create issues over intrusions of privacy, both digital and physical. As can be seen in Figure 3, researchers are continually working to build non-intrusive, deployable, and privacy-preserving systems for detecting large-scale body movement. These systems make use of two or more radio frequency (RF) transceivers. The original radars, which worked by calculating distance, angle, and/or velocity via the use of radio waves, served as the inspiration for this.

When it comes to detecting and identifying potential dangers, the military often use this strategy. The capability of radar detection and identification to be applied to fresh scenarios, such as the categorization of human activity, has been made possible by recent developments in signal processing techniques. As a result of the Doppler effect, the frequency of the echo shifts whenever radar identifies an object that is moving. When referring to the distinctive qualities of the micro-Doppler effect of an object or process, the phrase "micro-Doppler signature" is used. While walking or running, the periodic motion of the arms and legs creates sidebands for the major Doppler frequency that is employed for detection and classification. This results in a micro-Doppler signature that is one of a kind.

We provide a case study on human activity detection utilising ambient radio frequency waves in light of the fact that the next generation of mobile networks, which will be known as 6G, is anticipated to run optimally in radiation environments that are even more powerful than the 5G systems that are now in use. In order to carry out a comprehensive investigation of the detection of human activity inside the home, channel state information (CSI) has been employed in conjunction with Wi-Fi connectivity equipment. For the purpose of capturing CSI data that indicates mobility and activity, wireless devices that are readily accessible and network interface cards operating at 2.4 GHz are employed. In addition, radar-based systems, namely frequency modulated continuous wave (FMCW) and orthogonal frequency division multiplexing (OFDM), have been used in other research projects for the purpose of monitoring occupancy.

On account of the fact that the prior work depended on wireless devices that are commercially accessible and have significant technological restrictions, the subsequent case study will be different from others that have been published in the literature. For instance, a standard network interface card (NIC) that is available off the market only reports thirty subcarriers, despite the fact that the Wi-Fi transmitter sends out fifty-six of them.

In addition, the strength of the transmitter does not change regardless of the actions taken by the individuals who use such transmitters. These little wireless sensors are subject to random noise, which has an effect on the phase information that they acquire. This particular case study used software-defined radios, namely universal software radio peripherals (USRPs), in order to broadcast and receive a N number of OFDM subcarriers. This is in contrast to previous work, which utilised just a restricted number of OFDM subcarriers. Additionally, the technology that was developed specifically for this situation made it possible to make modifications to the power and operating frequency of the transceiver as needed.

Furthermore, it enabled more exact control over the total number of active subcarriers and the use of specifically designed antennas. The case study shows that USRP-based wireless sensing for ordinary activities produces more dependable results than those obtained with commercially available wireless sensors.[10]

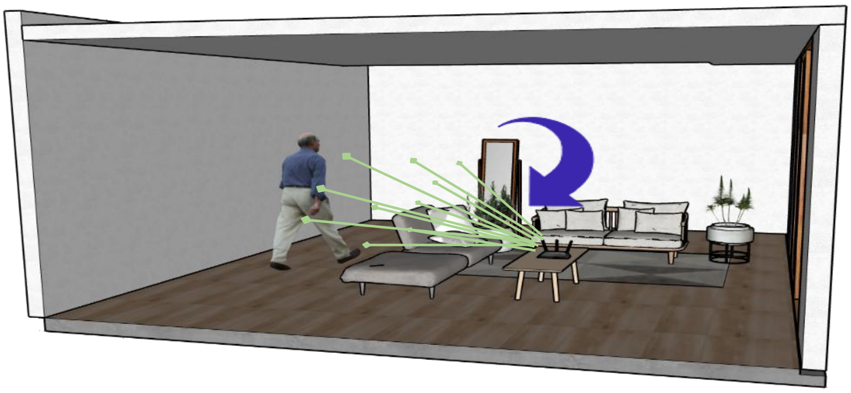

Fig. 3. Activity tracking using ambient RF signals.

3.2 Human Movement Tracking Transmission using Radio Frequency:

MATLAB/Simulink is used to demonstrate how to broadcast a number of OFDM subcarriers, as seen in Figure 4. Utilising an Omni-directional antenna with a gain of three decibels and operating between 2.4 and 2.5 GHz and 4.9 and 5.9 GHz, the USRP is used to transmit data, which is then routed via the antenna. The ability of these Omni-directional antennas to detect human activity in both line-of-sight and non-line-of-sight settings is the key benefit that these antennas provide.

Volunteers of varying ages participated in the experiment that was carried out for this use case. The experiment was carried out in the James Watt Building South of the University of Glasgow. During the course of the project, the objective was to establish the foundation and build a prototype for a system that is capable of monitoring the typical activities of an old person while they remain in the convenience of their own homes. Every single person was put through a series of testing procedures in a laboratory setting that was designed to simulate real-life situations. These procedures included (a) walking, (b) sitting on a chair, (c) standing from a chair, (d) engaging in physical activity, and (e) bending down to pick up an item from the ground. The experiment was conducted out in a room that was 78 square metres (m2) in size and was supplied with standard office equipment such as desks and chairs. Each procedure was carried out 10 times.[11]

Using the K-nearest-neighbor (KNN) method, five different chases were categorised into their respective categories. It was determined that the algorithm's results were as accurate as was practically possible after they were validated against 10 different samples. The study used a total of 755,630 samples for its investigation. There were a total of 270,089 samples that were correctly identified as belonging to the exercising activity, whereas there were 24,423 samples that were incorrectly assigned to one of the other groups. Out of the 24,423 samples that were incorrectly categorised, 13,337 were correctly identified as "picking up an object," 5074 as "sitting down," 2577 as "standing up," and 3435 as "walking." For the purpose of this experiment, the KNN classifier achieved an accuracy rate of 89.73% overall. Comparisons were made between the KNN classifier and many other classification techniques. With an accuracy rate of 81.20 percent, the Decision Tree (DT) classifier produced accurate results. With regard to the other algorithms that were evaluated, discriminant analysis and Naive Bayes performed quite poorly in comparison.

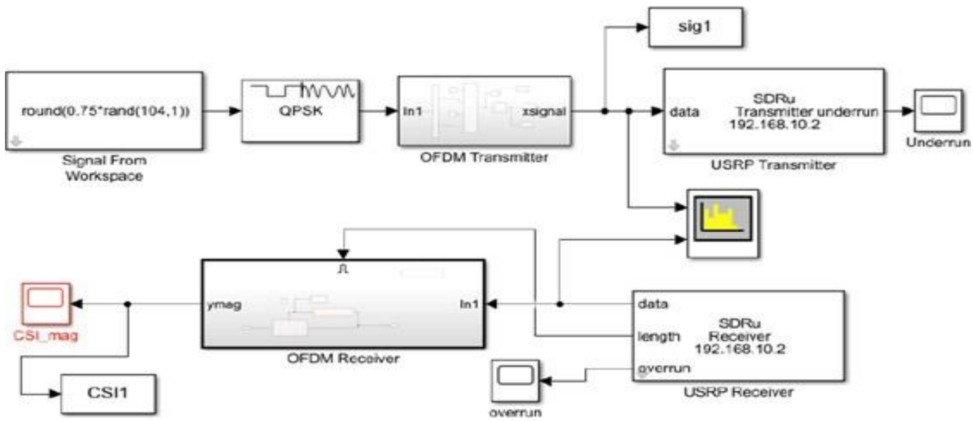

Fig.4. Simulink model for experiments with orthogonal frequency division multiplexing with low complexity.

3.2 Problems and Possible Solutions:

For this case study on activity monitoring utilising dense ambient RF waves, it is possible that future 6G mobile networks will prove to be beneficial. There is a possibility that certain 6G proposals for intelligent reflecting surfaces might be employed to monitor activities that take place inside. As a result of the activity monitoring modules that are built into the 6G radio antennas, this use case is classified as belonging to two of the three primary drivers of 6G: (i) a high-fidelity holographic society, and (ii) time-sensitive and time-engineered applications. It is possible to apply this strategy to a wide variety of circumstances due to the widespread use of 6G technology. Due to the fact that, in addition to the coverage footprint, the monitoring area and its environmental factors need to be considered, the radio planning process becomes more complex when such use cases are adopted. The medical sector is the first area of attention for the potential implementation of this technology. This use case, on the other hand, may have a place in the monitoring of energy consumption, the operations of search and rescue, the physical security of premises, the applications of Industry 4.0, and a great number of other fields where human activity detection is extensively utilized [12].

4. Introduction to Visually Assistive Technology:

For women, the average life expectancy has climbed from sixty years in the early 1900s to ninety-four years in 2016. This is a direct result of advancements in medical technology and improvements in living conditions. The unfortunate reality is that age-related illnesses are pretty frequent, yet there are some elderly people who are fortunate enough to grow up without experiencing any adverse effects. Some kind of vision impairment affects around 2.2 billion individuals throughout the globe, with the majority of those affected being over the age of 50, according to figures provided by the globe Health Organisation.

A greater number of individuals may develop age-related diseases such as age-related macular degeneration (AMD), cataracts, and glaucoma as the average lifespan continues to rise. It is estimated that by the year 2050, there will be 4 million persons in the United Kingdom who have some sort of visual impairment. This represents an increase from the current percentage of 3%, which is approximately 2 million. The costs associated with the management of age-related ailments will grow in tandem with the rise in life expectancy. According to estimates, the yearly expenses for visually impaired individuals in the United Kingdom amount to 15,180 million Euros, while in Germany they amount to 9,214 million Euros, in Italy they amount to 12,069 million Euros, and in France they amount to 10,749 million Euros. Since 2013, the government of the United Kingdom has invested 410 million British pounds on various aids and modifications for people who are visually impaired. Examples of common assistive devices are hearing aids, mobile phones, and wheelchairs. To put it another way, this piece of equipment is unheard of, expensive, and not always available to those who have a need for it. Taking into consideration this circumstance, we provide a solution that is trustworthy, low-maintenance, low-cost, and simple to use in order to assist visually impaired individuals in locating their belongings.

Framework for Real-Time Object Detection Analysis A computer and a smartphone make up the system's central nervous system that supports it. For the purpose of identifying 82 objects from the COCO dataset, the system makes use of machine learning. These items include plates, utensils, fruits, and vegetables. Through the use of their mobile device, users are able to audibly communicate their desire for a product, which may then be sent to their personal computer over the internet. As the user moves the smartphone about to assist with the search, the personal computer begins to receive video from the smartphone. As the user moves the smartphone around, the personal computer evaluates each frame in an effort to establish what the user is after. Figure 5 is an example of how this system operates: when the computer-based 'You Only Look Once' (YOLO V3) algorithm identifies an item of interest, a voice message is sent to the user's smartphone, stating that the user has "found the object of interest."

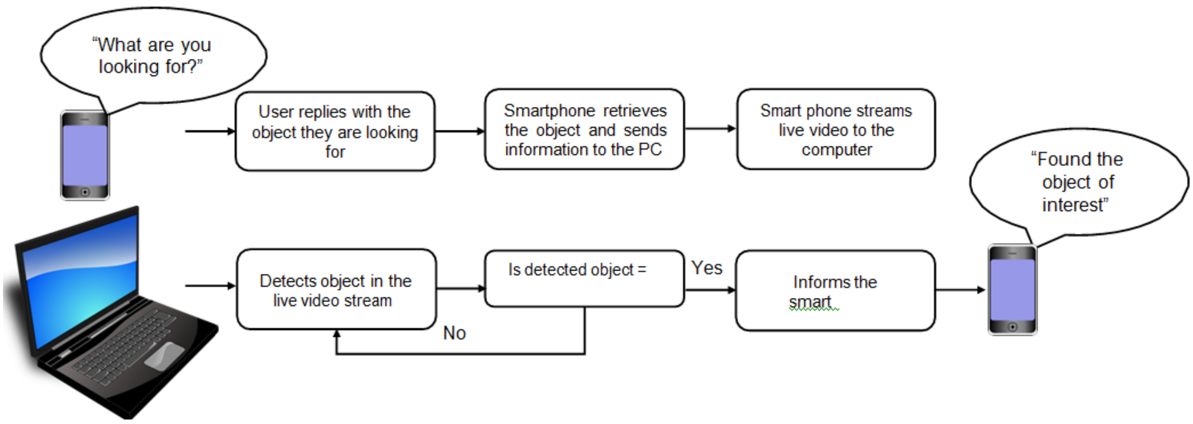

Fig.5. Smartphone and computer task structure [49].

There is a correlation between the effectiveness of the framework and the performance of the machine-learning algorithm. The accuracy of detection is steadily improving as a result of recent developments in computer vision and the availability of data that is freely accessible to the public and is used to train models respectively. Nevertheless, during the process of building this architecture, we were faced with the difficulty of overcoming the computational needs of these systems. When it comes to detecting objects in live-streamed video, we are aware that the majority of users may not own power-packed graphics processing units (GPUs), which are necessary for achieving the highest possible level of performance. Because of this, we were able to improve its performance by adjusting the frames-per-second settings to correspond with the detecting speed.[12]

The first concept that we had for the framework was that it would be a queue. The number of frames per second (fps) in the video would stand for the amount of time that passes between arrivals, and the amount of time that it takes to identify an item would be the service time. Through the use of this technique, we were able to ascertain the optimal frame rate for real-time performance. Through the use of metrics that showed the frequency with which information had been updated, the process of optimisation was directed. In specifically, we evaluated the peak age (PA) of the information, which is the period of time that has passed since the development of the previous piece of data; this is the longest length of time.

Both the inter-arrival time (in frames per second) and the service time (in detection time) are used in the calculation of the PA. Different arrival intervals and service durations are shown in Figure 6, which shows the public address system. The time that passes between arrivals may be within the control of the smartphone, but the central processing unit of the computer is in charge of the service time. In the beginning, the service time, which refers to the amount of time it takes for a computer to identify objects in a video input with a low resolution (160 120), was tested and determined to be 0.31 0.06 seconds (Figure 7a). After conducting an investigation into the distribution of service times with the help of the Fitter software, we found that the vast majority of frames were processed in 0.30-0.31 seconds (Figure 7b).

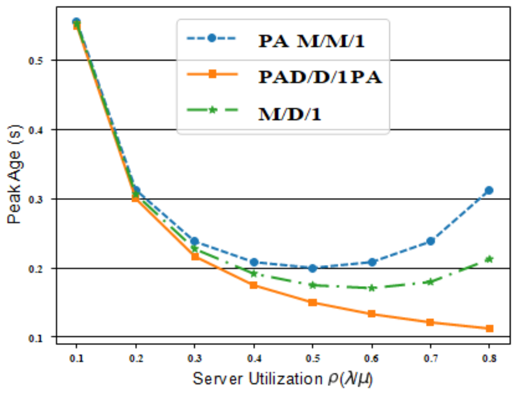

Fig.6. Inter-arrival rate () divided by service rate () is the PA value relative to server utilization.

It is possible to compute an aggregated value for a large number of queues. From one queue to the next, the amount of time spent waiting varies. There is an exponential distribution with regard to the arrival and departure rates in the M/M/1 queues that are seen here. When compared to the M/M/1 queue, which has growing waiting durations but constant processing times, the D/D/1 queue has consistent arrival and service times.

The differences in service time that are shown in Figure 7 are rather limited in quantity. We used an M/D/1 queue as the foundation for our framework. The network delays and inter-arrival durations (which were measured in video frames per second) were expected to follow an exponential distribution, according to our expectations. We utilised the PA expression to reduce the PA from 1402 milliseconds to 130 milliseconds after we had optimised the frames per second.

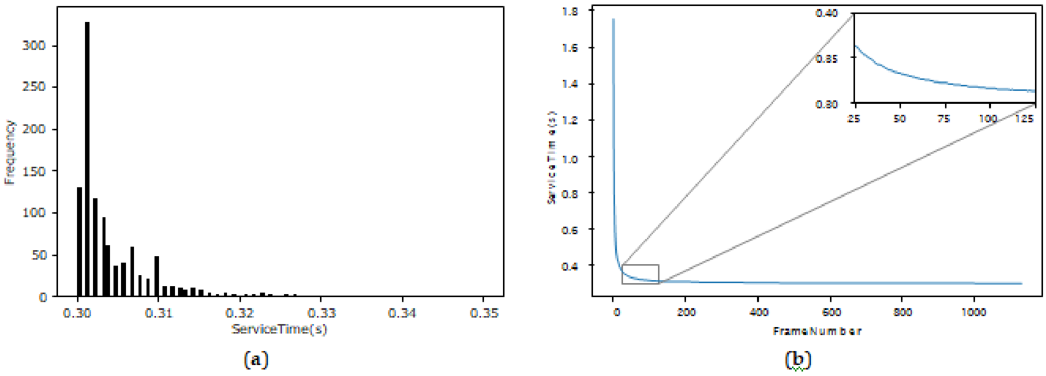

Fig.7. The time it takes to recognise objects in a frame is a statistic used to evaluate service time. (a) A relationship between the number of frames and the length of time required to identify things inside each frame (service time). A histogram of actual time in service (b). The bulk of frames were processed within 0.31 seconds.

5. Smart Grid:

A significant amount of progress has been made towards carbon neutrality by the government of the United Kingdom, notwithstanding the fact that combating climate change is a long-term challenge. The government of the United Kingdom has declared widespread adoption of smart utility monitoring and increased energy-conscious behaviour one of its key priorities by the year 2050. This comes after the government of the United Kingdom became the first major economic leader in the world to pass rules that minimise its contributions to climate change.

University residential complexes, private residences, and hospitals have all been the subject of several studies that have been done with the goal of encouraging energy-conscious behaviour. It has been shown that programmes aimed at changing behaviours may result in immediate energy savings of up to 12 percent; hence, the emphasis is on figuring out how to make use of various forms of smart metering in order to encourage conducting that is energy aware. Smart utility monitoring, on the other hand, is used for a variety of purposes in addition to tenant education. It is also a method for gathering high-resolution energy data that may be utilised in different forecasting models. These models have a broad variety of applications, some of which include load control, energy management, and the guarantee of future energy supply. The fact that this is the case illustrates the widespread interest in high-resolution energy data and the potential role it may play in reducing total consumption in the construction industry.[11]

It is necessary to have a wireless connection and the Internet of Things in order to accurately collect high-resolution energy data, which is necessary for the creation of solutions that are efficient in terms of energy consumption. Several research that investigate Internet of Things-based energy monitoring and management systems have been published since 2011, when the United Kingdom began distributing smart metres. These studies have been published since 2011. When a smart metering system is implemented, the central database will be automatically updated with information about energy use. It is possible that energy providers in the business sector may make use of this information in order to improve their ability to estimate the energy needs of their customers and to alter their monthly price accordingly. The information that is obtained for the purpose of conducting future research may prove to be of great use to many initiatives, including but not limited to load management, demand response studies, and behavioural change programmes.

The three categories that may be used to categorise the key performance indicators (KPIs) of an energy monitoring system are shown in Figure 8. The gathering of data may take place on a daily, hourly, halfhourly (HH), or real-time basis. The first factor to consider is the frequency with which data is collected. In the second division, the emphasis is placed on data loads, regardless of whether they are summarised or broken down into specific individuals. In the third place, the pace at which data is gathered and made accessible to customers is an important factor to consider.

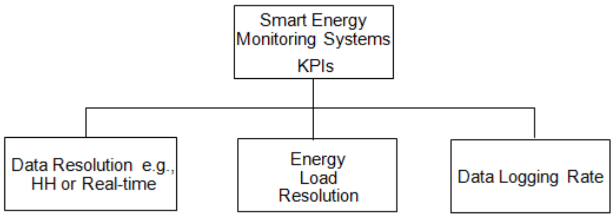

Fig.8. Smart energy monitoring systems have been given a set of KPIs.

The three key performance indicators (KPIs) shown in Figure 8 are very important for the development of Internet of Things-based energy monitoring systems for smart grids and smart cities. An overview of each important performance metric is presented in the following paragraphs:

5.1 Resolution of Energy Data:

In order to successfully resolve this issue, it is essential that the application and utilisation of such data be effective. Data with a higher resolution enables more granular monitoring of consumption as well as the identification of transient spikes in power demand, which makes it valuable for energy modelling. Furthermore, the availability of real-time data makes it possible to conduct time-series analysis of occupancy vs consumption, which may be used to determine which locations need the promotion of energy-conscious behaviour. This is made possible by the fact that the analysis can be performed.

5.2 Reducing the energy load:

What the numbers really indicate in terms of load is another factor that is very important to consider while gathering information. The information obtained from the main cable of a university, for instance, provides an indication of the total electrical consumption of the building. This information is significant, but only at a high level; academics and end users are more interested in much lower resolutions. Mains-level energy monitoring only reveals how users and appliances behave and how efficiently they utilise energy via their usage of the system. Since this is the case, it is of the utmost importance to identify energy sensing that is taking place at a greater resolution inside a structure [11]. The installation of energy-sensing nodes at power outlets and distribution boards is another method that may be employed to ascertain the actual amount of energy that is being consumed at the location where it is being utilised. Sub-metering is one of the options that can be utilised. In a smart city, the integration of this technology with artificial intelligence may handle a wide variety of applications, including but not limited to the monitoring of occupancy, the tracking of senior activities, and the management of buildings that are friendly to the environment. The current technology, on the other hand, makes these issues much more difficult to overcome. The pace at which data is recorded is considered to be one of the most significant metrics and key performance indicators (KPIs) available for any communication system. Data collection is the primary focus of the first two key performance indicators (KPIs), which are designed to ensure that valuable information is obtained. Regarding time-sensitive applications, on the other hand, it is essential that this information be readily available and accessible at all times. There are several uses for high-resolution energy data, including monitoring occupancy and activity, which may be very useful in emergency situations when time is of the essence, such as while an evacuation is taking place. Because of this, it is essential to have data capture and processing done in real time in order to prevent the severe effects that are produced by transmission delays.

Immediately after the establishment of the Key Performance Indicators for energy monitoring systems, it is of the utmost importance to evaluate their actual use, bringing to light both the difficulties and the possibilities for further improvement. We will examine a situation in which persuasive technology was used to persuade people working in a hospital run by the National Health Service (NHS) in the United Kingdom to be more energy careful by giving feedback on their energy use in the next part. A discussion of the system's development, technical requirements, outputs, and restrictions is included in the use case that has been provided. These latter areas are elaborated upon in order to highlight how 6G may be able to fill in the gaps and give higher efficiency while spending less energy. Figure 9 presents a comparison and contrast of two hypothetical energy-saving devices that are intended to impact people's behaviour about the amount of energy they use in their homes.

6. Evaluating the Wireless Electricity Data Logger System: Current Status and Future Directions:

In order to analyse the WEDL deployment at the Medway NHS Hospital, the Key Performance Indicators shown in Figure 8 were employed. The spectrum-like structure that is shown in Figure 12 is a representation of the many technical requirements that are characteristic of a WEDL. The most efficient way for real-time, intelligent, and granular energy monitoring is shown in the last column of Figure 12, which may be found here. The needs of the WEDL that were created and tested at Medway NHS Hospital are shown in Figure 12. These criteria are represented by four green blocks that have black boundaries for themselves. According to the model that was proposed, the system performed admirably in terms of the resolutions of both the data and the energy load. On the other hand, since it was dependent on a GPRS connection, it fell substantially behind in the third key performance indicator, which was Data Logging Rates [12].

More recent versions of mobile devices and the technology that are linked with them make it possible to monitor energy more intelligently, which leads to a society that is more carbon efficient. By way of illustration, the fourth generation of mobile networks has the potential to considerably enhance the performance of WEDL by allowing data speeds of 100 Mbps and, with the most recent version, even 300 Mbps. It is important to note that 5G has the potential to provide speeds that are more than 1 Gigabit per second. The WEDL and other intelligent energy monitoring systems are shown in Figure 12, which shows a possible future version of the WEDL. Think about the impact that 6G may have. On the other hand, the widespread implementation of this use case can run into a variety of obstacles and constraints. It is possible to improve the resolution by physically putting an indefinite number of energy nodes; however, this results in a tremendous demand for bandwidth, which necessitates the development of unique modulation and spectral efficiency measures.

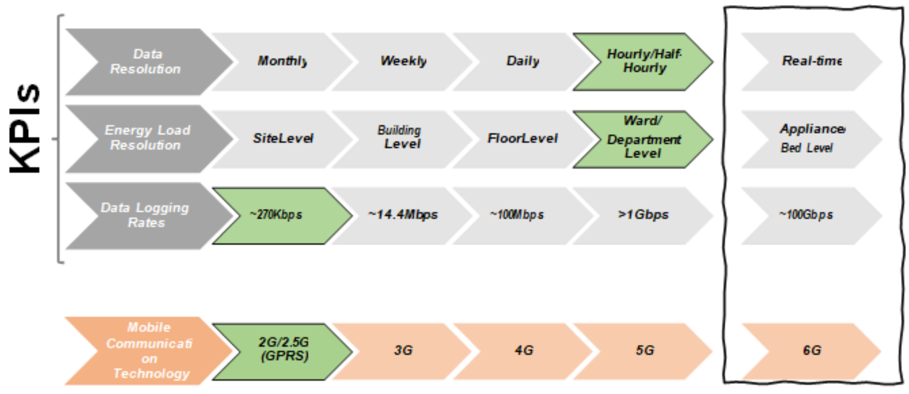

Fig.9. Smart utility monitoring technology's development and assessment within the framework of mobile generational technology.

Sixth-generation wireless networks (G6) are designed to provide a combination of intelligence, high data resolution, an infinite number of energy-sensing nodes that are linked, high data speeds, and low latency. It is anticipated that artificial intelligence (AI) would significantly enhance 6G networks, making it possible to extend a number of features that were not attainable with 5G technology.

Sixth-generation wireless networks have the potential to dramatically enhance the management and arrangement of data acquired from many energy nodes, with a particular emphasis on Service Intelligence (SI). Therefore, the authors are adamant that the utilisation of 6G in energy-saving initiatives will make it possible to develop intelligent systems that are capable of contributing to carbon neutrality. These systems include brain-computer interface-based energy-saving systems, which can be of great assistance in promoting energy-conscious behaviour, which is a key focal point in the plan that the United Kingdom government has devised to achieve the 2050 net zero carbon target. Because there are gaps in the present efforts to monitor energy usage, it is essential to stress that 6G, with a focus on two of its three core drivers, all-things connectivity and time-sensitive applications, has the ability to address these gaps. This is because there are gaps in the existing attempts to monitor energy use.[7]

6.1 Transport:

Transportation is a business that is very necessary to our way of life. As the city's population and the number of automobiles increased, a number of problems, including urban congestion, accidents, pollution, high petrol costs, fuel shortages, and expensive insurance premiums, have gotten more severe. As a consequence of this, several advancements have been made with the objective of lowering the sector's carbon effect while simultaneously raising the level of production and safety. The data shown in Figure 13 demonstrates that researchers are consistently working to improve all aspects of the transportation system, including the infrastructure, automobiles, and public transportation.

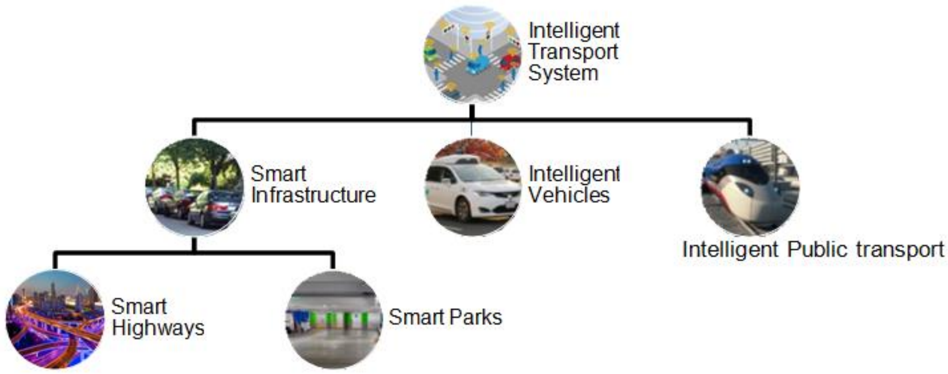

Fig.10. The three main areas of research in intelligent transportation are identified: smart infrastructure, intelligent autos, and intelligent public transportation systems.

A number of advancements in transportation design, including wirelessly controlled traffic signs, intelligent junctions, and infringement detection, have already been implemented in a significant manner all over the world. The Intelligent Public Transportation Systems (IPTS) are being improved by the use of various technologies. Real-time monitoring may be of assistance to passengers in a number of ways, and TIS is one example. We now have the ability to manage transport networks by employing decision-support systems (DSS), which is made possible by recent developments in cutting-edge technology. Whenever we refer to "intelligent vehicles," we refer to a broad variety of capabilities and functions that are available to them. [8]

A vehicle skill-based classification approach that has been developed is shown illustrated in Figure 14. In the first category, there are ordinary vehicles that do not have any advanced features integrated into them. Automobiles that are equipped with driver aid systems fall into the second group. Vehicles that are able to accurately monitor their surroundings and carry out driving activities are categorised as fourth, whilst vehicles that are just able to analyse their surroundings and provide assistance to the driver are categorised as third. A totally autonomous operation in any and all weather and road conditions is the hallmark of the fifth tier, which represents the highest level of automation currently available.

6.2 Industry 4.0:

It is becoming more difficult for manufacturers to meet the demands of their customers, who are increasingly expecting individualised products, and as a result, manufacturers are under increasing pressure to enhance the flexibility of their production environments. Adaptability is becoming more important, and new developments in manufacturing technology are making it possible for us to better meet this need. The term "Industry 4.0" (I4.0) refers to the fourth significant technological advancement in the manufacturing sector. On the one hand, robotics and other forms of automated equipment, and on the other hand, artificial intelligence (AI) and big data acquired via the Internet of Things (IoT) are considered to be the primary motivating forces behind this change. Throughout the course of its development, the sector has gone through four distinct phases, each of which has seen significant advancements in technological capabilities.

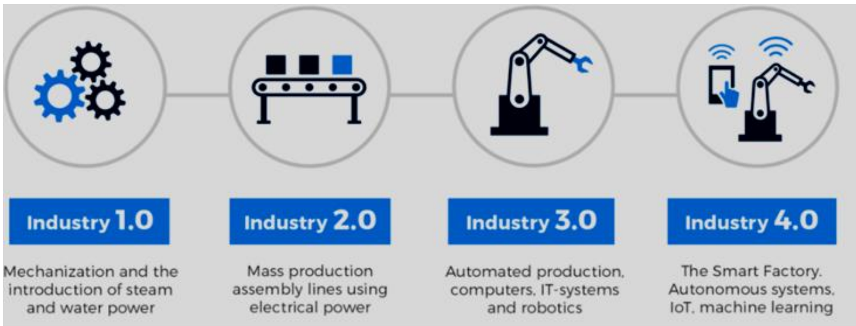

Fig.11. Revolutions in Manufacturing, from the First to the Fourth [99].

There have been a number of different ways in which the term "fourth industrial revolution" has been articulated in the literature; nonetheless, the overarching goal of all of these descriptions is to boost industrial productivity and competitiveness. If you want to achieve many of the requirements of Industry 4.0, one fantastic way is to make use of the technologies that are now available and combine them with a higher degree of connection in order to collect more data throughout a process for real-time analysis [8]. There is a possibility that technologies such as collaborative robots, digital performance monitoring, and remote control may all contribute to the increased automation that Industry 4.0 will bring about.

As a consequence of the implementation of stay-at-home legislation in reaction to the pandemic caused by the corona virus, businesses were compelled to implement a strategy for remote labour, which led to an immediate investment in digital technology. Satya Nadella, the Chief Executive Officer of Microsoft, said that the pandemic was responsible for doing "two years' worth of digital transformation in two months" for the company. In response to the epidemic, 899 firms from a wide range of regions, business sizes, and industries are speeding their digital supply chain and internal processes by three to four years, as shown by the annual survey conducted by McKinsey Global.

Prior to the COVID-19 outbreak, a survey was conducted with 99 industry product leaders from Europe, the Middle East, and Africa. The results of this study give understanding into the future of technologies related to the Internet of Things (I4.0) [8]. The findings demonstrated that artificial intelligence (AI), cloud infrastructure, and the Internet of Things (IoT) are all growing in importance. These technologies complement one another effectively in order to boost connection, which in turn enhances the monitoring of a variety of processes and increases the intelligence and flexibility of the underlying system.

7. Conclusion:

There is a wide range of businesses that stand to gain considerably from the implementation of 6G technology, and widespread adoption is seen as essential to the realisation of the Internet of Things' full potential. There has been much discussion in academic literature over the future of 6G and whether it will be able to meet the ever-increasing demand for connections across all businesses and society. Even though it is not unexpected, literature has begun to conceptualise and identify prospective use cases that will benefit from the sixth generation of mobile networks.

The purpose of this study was to provide a fresh perspective on the literature review of the potential offered by 6G technology, particularly about the Internet of Things (IoT). This technique was studied in relation to five different applications, which included the fields of medicine, engineering, transportation, and industrial production. Identifying the numerous facets of society that may potentially benefit from 6G and the technology that makes it possible was the objective of this approach, which aimed to move beyond the idea of conventional thinking.

The use cases shed light on the many obstacles that future wireless networks will have to overcome to fulfill the varied requirements of various enterprises for a communication channel that is reliable. It is conceivable for academics to make use of these obstacles to push the boundaries of what is presently achievable. Here, we address the most significant issues that have not yet been answered about the primary drivers of 6G and the way technology should be used in each use case. Applications for high-fidelity holographic societies that provide real-time, two-way communication serve as the key push for this development.

Conflict of Interest

The authors declare no potential conflict of interest.

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