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WSN's IOT Application With 5G Infrastructure

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ABSTRACT

The study provides a state-of-the-art evaluation on 5G and associated technologies in order to answer the demands of industrial stakeholders, particularly those interested in operating WSN networks. It sets out the hurdles and research gaps that must be addressed to accomplish application-specific needs. It offers an overview of some of the challenges that have been addressed or for which there are examples of solutions. It includes new areas such as tactile internet, AI (artificial intelligence) solutions, and distributed ledger technologies, suggesting that having such technologies on board might assist achieve industrial IoT aspirations even more successfully when combined with the availability of 5G capabilities.

Key Words: 5G, WSN, 5G Capabilities, IoT

1. INTRODUCTION

Wired and wireless networks, as well as LTE and 5G migrations, sensors, protocols and the Internet have all been integrated into a new application named WSN (Wireless Sensor Network). The writers of the following articles discuss and contribute to the growing importance of Wireless Sensor Networks (WSNs) in our everyday life. Health care, aided and improved scenarios, industrial and production monitoring and control networks are just a few of the numerous industries where they're finding use. Sensor nodes will be able to join the 'Internet of Things' in the future and utilise it to cooperate and carry out their duties. Nonetheless, "when the WSN is integrated into the Internet, we must thoroughly explore and understand the challenges that arise." To combine the WSN with IoT, several methodologies were attempted and a set of problems were identified.

Sensors in the WSN link to gateways in IP networks to create a global network. This infrastructure is costly to build and maintain. WSN infrastructure is becoming more obsolete as the number of smartphone users rises at an exponential rate each year. The WSN gateway's primary drawbacks in IoT systems are examined. Among them are.

IoT apps deal with data from a variety of devices. The Internet of Things (IoT) can be fully realised only when 5g is in place. In previous generations, IoT devices such as sensors located at the perimeter of the network architecture were thought to be tiny, external hardware with low resources. Assuming this, the IoT devices' primary function was to send data or, at the very least, respond to environmental changes.

One frequent name for the next generation of cellular mobile communication infrastructure is 5G. There are a variety of reasons for this, some of which are directly linked to communications, such as providing high-speed mobile connectivity to densely populated places, and others which are less directly related, such as extending battery life to over 10 years. An increasing need for improved mobile broadband (eMBB), as well as ultra-low latency and critical communication situations (URLLC), as well as the anticipated MMTC, or large IoT (Internet of Things) traffic demands, are among the traffic-related motives.

The industrial Internet of Things (IIoT) will benefit greatly from 5G's ultra-reliable and low-latency connection capabilities. 5G and other future methodologies and technologies are expected to meet the demands of industrial players in this article.

The particular issues of the radio access network are beyond the purview of this research, which focuses on basic solutions inside and outside the core network.

The contributions of this paper are the following.

- 5G and associated technologies are examined in a comprehensive assessment that addresses the demands of industrial stakeholders, including those who want to set up their own private campus networks.

- Research gaps and obstacles are laid out depending on the unique needs of the application in question.

- An overview of various difficulties that have previously been solved or have examples of solutions is provided in this section.

- Tactile internet, AI (artificial intelligence) solutions, and distributed ledger technologies are among the new areas brought into the picture, and it is argued that having these technologies on board may help reach industrial IoT objectives when 5G capabilities are also available.

Beyond the previous comprehensive survey, it covers the IIoT rather than the IoT and delves into the details of how emerging technologies are involved: from production-related issues to mobile edge computing, Edge-Cloud, backend virtualization, security and smart service contracts, as well as artificial intelligence and personal campus networks. Even if the underlying technologies and their outputs have a substantial impact on IIoT applications, smart service contracts and backend virtualization are seldom addressed in the IIoT. Applications based on the Internet of Things. Nonetheless, this study should be studied in order to have a high-level overview of the general IoT-related 5G difficulties (such as architecture, scalability, huge deployments and dense HetNets, interoperability and dense HetNets), as well as the relevant research trends at the moment.

1.1 Sensor Network

Anywhere from the factory floor to the data centre to the medical lab to the wild may be monitored by a sensor network, "which is made up of small battery-powered devices and wireless infrastructure." Data acquired by sensors may be transferred to back-end systems for analysis and usage in applications through the Internet, a business WAN or LAN, or a specialised industrial network.

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In a wireless sensor network, a group of sensors is connected to each other through wireless networks to exchange data from a monitored area in real time. A gateway connects the data to other networks like wireless Ethernet through numerous nodes in the network.

1.1.1 Types of Wireless Sensor Networks

Depending on the environment, the types of networks are decided so that those can be deployed underwater, underground, on land, and so on. Different types of WSNs include:

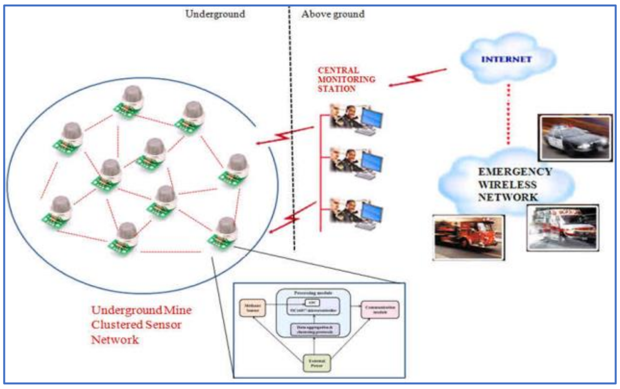
1. Terrestrial WSNs
2. Underground WSNs
3. Underwater WSNs
4. Multimedia WSNs
5. Mobile WSNs

1.1.1.1. Terrestrial WSNs

Unstructured (ad hoc) or structured (preplanned) deployments of hundreds to thousands of wireless sensor nodes are both possible in Terrestrial WSNs. "Sensor nodes are dropped from a fixed plane in an unstructured manner, and their locations are random." The preplanned or structured mode analyses optimum placement, grid placement, and two- and three-dimensional placement models. Battery power is restricted in this WSN, however the battery has solar cells as a backup supply. Low duty cycle operations, delay minimization, and optimum routing are just a few of the ways these WSNs save energy.

1.1.1.2. Underground WSNs

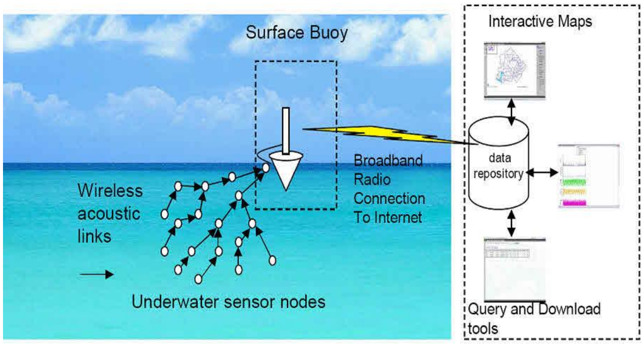
In terms of deployment, maintenance, and equipment costs, subterranean wireless sensor networks are more costly than terrestrial WSNs. Several sensor nodes that are buried in the earth are part of WSNs networks, which monitor subsurface conditions. Additional sink nodes are placed above the ground in order to transfer data from the sensor nodes to the base station.



Recharging the in-ground wireless sensor networks might be a challenge. They're tough to recharge sensor batteries that have a restricted capacity. In addition, the subterranean environment makes wireless communication a problem because of the significant amount of attenuation and signal loss that occurs there.

1.1.1.3. Under Water WSNs

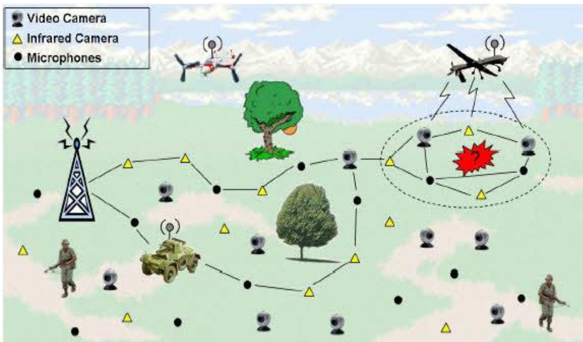
There is more than 70% water on the planet. Sensor nodes and underwater vehicles make up these networks. The sensor nodes' data is collected by autonomous underwater vehicles. Long propagation delays, bandwidth limitations, and sensor failures are among issues that might arise while trying to communicate when submerged.



WSNs submerged in water are powered by a small, non-replaceable battery. The development of underwater communication and networking methods is necessary to address the problem of energy saving for underwater WSNs.

1.1.1.4. Multimedia WSNs

It has been hypothesised that multimedia wireless sensor networks may be used to track and monitor occurrences in the form of multimedia, such as images and video. Sensor nodes equipped with microphones and cameras form the core of these networks. For data compression, retrieval, and correlation, these nodes are linked together wirelessly.



Energy usage, bandwidth needs, data processing, and compression methods are some of the issues associated with multimedia WSNs. Additionally, multimedia material need a large bandwidth in order for the content to be correctly and efficiently transmitted.

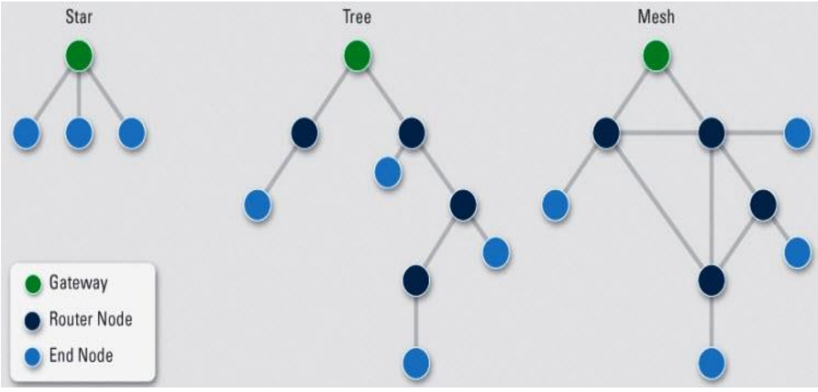
1.1.1.5. Mobile WSNs

An array of sensor nodes may be moved on their own as well as engaged with the actual world. The mobile nodes are able to compute, perceive, and interact with each other.

Compared to the static sensor networks, mobile wireless sensor networks are much more adaptable. More and better coverage, greater energy economy, and more channel capacity are only some of the benefits of MWSNs versus static wireless sensor networks.

1.2 WSN Network Topologies

For radio communication networks, the structure of a WSN includes various topologies like the ones given below.



1.2.1 Star Topologies

Using a star architecture, each node connects directly to a gateway. Messages may be sent or received by a single gateway and then forwarded to several distant nodes. Nodes in star topologies cannot communicate with one another. This enables fast communication between the gateway and the remote node (base station).

It is necessary for the gateway to be within the radio transmission range of all other nodes in the network in order for it to control it. The benefit is that distant nodes' power consumption may be kept to a minimum and easily managed. The number of devices connected to the hub determines the network's size.

1.2.2 Tree Topologies

Cascaded star topology is another name for tree topology. Each node in a tree topology links to a node higher in the tree before connecting to the gateway. This topology's key benefit is that it makes networking expansion and fault detection simple. The bus cable is critical to the network's stability, and if it fails, the whole system would be rendered inoperable.

1.2.3 Mesh Topologies

Within its radio transmission range, Mesh topologies enable data to be sent from one node to the next. Because radio communication ranges are limited, it is necessary for a message to be sent via an intermediary node to the intended recipient. Using a mesh architecture, problems in the network may be easily isolated and detected. The drawback is that the network is extensive and needs a significant investment.

1.2.4 Limitations of Wireless Sensor Networks

1. Possess very little storage capacity – a few hundred kilobytes
2. Possess modest processing power-8MHz
3. Works in short communication range – consumes a lot of power
4. Requires minimal energy – constrains protocols
5. Have batteries with a finite lifetime
6. Passive devices provide little energy

1.3 What is 5G?

In the future, 5G mobile broadband will replace or at least supplement your current 4G LTE service. With 5G, you'll be able to download and upload at much higher rates. Latency, or the amount of time it takes for devices to connect with wireless networks, will also be significantly reduced in the next years.

1.4 How it Works?

In contrast to LTE, 5G utilises three distinct spectrum bands for communication. This may not seem like a big deal, but it will have a significant impact on your day-to-day life.

Low-Band Spectrum It may also be referred to as a spectrum below 1 GHz Carriers in the United States rely heavily on this band for LTE, however available spectrum is running low. There is a huge downside to using low-band airwaves, though: peak data rates are limited to 100Mbps.

T-Mobile is the dominant participant in the low-band spectrum market. In 2017, the FCC auctioned off a significant quantity of 600MHz airwaves, which the carrier is now utilising to rapidly expand its countrywide 5G network.

Mid-Band Spectrum Faster and lower latency than lower band. Low-band spectrum, on the other hand, is more successful in penetrating structures. On mid-band bandwidth, expect speeds of up to 1Gbps. The bulk of the country's mid-band spectrum belongs to Sprint. The carrier is using

Massive MIMO Improve mid-band coverage and penetration. To provide many simultaneous beams for various users, massive MIMO combines several antennas into a single box and a single cell tower, creating multiple antennas for each user. **Beamforming** will also be used by Sprint to enhance its mid-band 5G service. This ensures that each user in the cell receives a consistent signal by sending a single, concentrated signal to them all.

High-Band Spectrum It is what provides the best performance for 5G, but with significant drawbacks. Mm Wave is a common abbreviation for it. Extremely low latency and peak speeds of up to 10Gbps may be achieved with high-bandwidth airwaves. In terms of coverage area and building penetration, high band has a lot of room for improvement.

High-band spectrum is being rolled out by AT&T, T-Mobile and Verizon. The providers will use LTE as a stepping stone to 5G as they build up their countrywide networks. As a result of the trade-off between high speed and building penetration and coverage, high-band spectrum relies on a large number of tiny cells. These are low-power base stations that may be used in conjunction with beamforming to increase coverage in limited geographic regions.

1.5 Advantages of 5G Technology

The above Ericsson picture shows some of the benefits of 5G technology, but there are many more to be found in the following paragraphs.

- *High resolution and bi-directional large bandwidth shaping.*
- *Technology to gather all networks on one platform.*
- *More effective and efficient.*
- *Technology to facilitate subscriber supervision tools for the quick action.*
- *Most likely, will provide a huge broadcasting data (in Gigabit), which will support more than 60,000 connections.*
- *Easily manageable with the previous generations.*
- *Technological sound to support heterogeneous services (including private network).*
- *Possible to provide uniform, uninterrupted, and consistent connectivity across the world.*

1.6 Disadvantages of 5G Technology

In spite of the fact that 5G technology has been studied and envisioned as a solution to all the radio signal challenges and difficulties faced by the mobile world, it contains the following flaws:

- Technology is still under process and research on its viability is going on.
- Because of the lack of technical support in most regions of the globe, this technology seems to be unable to reach the speeds it claims to be capable of.

- Many of the old devices would not be competent to 5G, hence, all of them need to be replaced with new one — expensive deal.
- Developing infrastructure needs high cost.
- Security and privacy issue yet to be solved.

1.7 IoT Requirements—Critical and Mass

Market players' high-level aspirations for 5G are less specific than the recommendations made by the 3GPP. In spite of the fact that the high-level criteria came from several sources, ITU-R M.2083-0 was one of the early standards on the subject. This standard was the first to identify the three categories of critical communication situations: eMBB, URLLC, and MMTC, when expressing the relevance of important capabilities in various use scenarios.

2. LITERATURE REVIEW

Using the LEACH protocol, the CHs are selected at random and the cluster hierarchy is established. LEACH-C is a centralised method that provides a benefit to the system (LEACH-Centralized). Head node assignments are done by chance and the head publicises to neighbouring hubs to join as a member node. Information with available vitality is sent between the cluster's head node and its members. "After a transmission, the nodes in the network go back to sleep mode thanks to time-division multiplexing access (TDMA)." As a result of LEACH-C being a single-hop data transmission system, nodes' vitality levels are merged and sent straight to the sink. As the current round's leader, the node with strength over the threshold transmits its data to the rest of the network. When the hub identification matches the broadcast identity of the same hub, the cluster's head is presented for the duration of that round. Dispersion of vitality usage between the available hubs results in a break-even for LEACH-C. Only the smallest distances can be covered using this protocol, and it cannot be scaled.

It is possible to reduce data propagation delays by using a Chain-Based Hierarchical Routing Protocol (CHIRON), which is referred to as a chain-based routing strategy [8, 9]. In the early stages, the network is divided into fan-shaped sections. Furthermore, each node receives a control message from the BS, and each node determines which group it belongs to. Second, the BS's distant node is activated, resulting in the formation of a chain within the specific group it's in. Gluttonous algorithms are used to connect a node to its nearest neighbour, which then becomes a new node in the next linking phase. Once all group nodes have reached a certain residual energy level, an election takes place to choose a leader. To begin with, the node that is furthest from the base station is deemed to be its head. Remaining energy is found later, and this node will be chosen as the group chain leader. As a starting point, in the fourth phase, data is sent to the chain leader of each group through the chain. In addition, the leaders of the chain send their acquired data to the base station in a leader-by-leader transmission method. Low-energy dissipation may be achieved by this approach, and clustering overhead can be expected in this context.

k-means clustering is an unsupervised clustering method that is the simplest one. "This approach uses the centroid mean value to split a given collection of nodes into k-clusters." K points are randomly chosen to be centroid of k-clusters; the nodes nearest each point are grouped in clusters based on their distance from each point. A new k-cluster is formed by calculating the centroid of each cluster and grouping the nodes closest to it. When there is no change in the clusters, the procedure repeats again. K-means algorithm steps are as follows:(1) Select the k points, where k is the total number of clusters, randomly to be centroids. (2) Form clusters by assigning each node to its nearest centroid based on Euclidean distance. (3) Recalculate each cluster's new centroid (4) Repeat steps 2 and 3 until the centroid of each cluster remains constant.

Support for extending network life is provided by the system. Only by narrowing the sensor's field of view can the performance benefit be maximised.

To increase the network's lifespan, the system makes use of a hierarchical clustering technique called Energy-Aware Unequal Clustering Using the Fuzzy (EAUCF) [11]. The selection of cluster heads in this system is influenced by residual energy as well as the nodes' distances from the BS. The random probability strategy will be used to elect tentative cluster chiefs in the network. The preliminary cluster heads' competition radius will be calculated using the Fuzzy Inference System (FIS). The tentative cluster heads will gather data on the energy remaining in the competition radius from the other tentative cluster heads. The lower-energy nodes will be excluded from the cluster head election if there are more candidates in the competition radius. When selecting the CH, it will not take into account the distance between each node, which might potentially shorten the network's lifetime. There is a delay in data transfer since the system uses energy balancing among the clusters.

Through the use of Hierarchical Power-Aware Routing (HPAR), the network may be divided into several zones [12]. Every zone, which is considered an entity, is made up of a variety of sensor nodes that are particular to that area. As a result, HPAR's first task is to format all the clustered entities (zones). As a further phase, we will complete the hierarchical routing of information across several zones to ensure that the network's life expectancy is increased. Routing a message via a road with the most energy over the other pathways with the least energy is the second stage. Using the Dijkstra algorithm, a route with the lowest energy consumption is first identified as the max-min path in the routing scheme. The max-min ZPmin method then approximates the max-min path. As time goes on, it discovers a new way to boost the network's remaining energy. In addition, the HPAR protocol plays a role in optimising the two fundamental solutions. There is a major advantage to this communication protocol in its focus on the node's transmission energy and the path's lowest possible energy. In addition, it makes use of zones to keep tabs on the vast bulk of the system's sensor nodes. Energy is estimated in this system using the network overhead.

System reduces the distance data travels but does not allow for a wider network to be used at the same time.

As one of the grid-dependent hierarchical algorithms in WSN, the Position-Based Aggregator Node Election Protocol (PANEL) use the node's topographical position to choose its aggregaters. PANEL's greatest asset is its ability to meet the needs of both synchronous and asynchronous systems. The network is divided into several topographical groups using this approach. Nodes provide a reference point for each cluster based on the cluster's lower-left bend position. The node next to the reference point is chosen as the cluster head. Data may be transferred in two ways with this method. Inter-cluster and intra-cluster transmissions are among them. There are several advantages to intracluster transmission, including the fact that the data may be sent across clusters during the process of aggregator selection. In the case of intercluster transmission, information is exchanged between the BSs and distant clusters. Optimized data transit routes minimise energy usage, and nodes' load balancing requirements are reduced.

They also provided and examined an overview of the study's findings on 5G broadband wireless access network energy efficiency issues and viable remedies. In [15–25], there is further 5G-related research. Storage and data transmission expenses are combined to provide an energy-saving issue. Energy-efficient solutions for 5G network resource allocation have also been examined.

'Security Comparison between Dynamic WSN for 5G Networks' authors claimed that Static and Dynamic WSNs are graded in terms of energy consumption, accuracy and routing route length. WSNs may be simulated and implemented using TRMSim-WSN, which is an open-source WSN simulator. The nodes of 100 WSNs were randomly dispersed throughout a 100-square-unit region in this experiment. Of the nodes, requesting a given service 100 times with a specified trust and/or reputation applied. During the experiment, 50 sensors are employed and 100 executions are simulated. Every node only knows its neighbours within its RF range in this scenario. Default settings and simulation parameters are utilised in the experiments. The total number of times this has been done is 100. a total of 100 networks Sensors (percent) Variable; Clients (percent) Variable; Malicious nodes (percent) 20; Plane Units 100; Radio Range 12; Delay between Simulated Networks 0. Threats to security oscillating and colliding with each other 100 times in total. Dynamic networks use less energy than static networks, according to the results. Static networks, on the other hand, are more precise than dynamic networks. Dynamic networks, as opposed to static ones, allow data to travel the shortest distance between origin and destination.

'A survey of clustering techniques in WSNs and consideration of the challenges faced by applying such to 5G IoT scenarios' was the title of a study published in the IEEE Transactions on Wireless Communications. Services supplied by current algorithms are examined in terms of network life span, transmission reliability, latency, and QoE awareness. Findings have been made after this comparison and study. There is only a limited amount of work that can be done to evaluate the network's life expectancy when it comes to network coverage. 2) Clustering does not provide enough assistance for latency awareness and transmission reliability. There has been a lack of focus on user scenario/profile awareness in current clustering studies. Only a little amount of research has been done on clustering in heterogeneous networks with a high degree of diversity.
Proposals have been made for a different network architecture for indoor and outdoor systems. It also touches on the likes of Massive MIMO and visible-light communication. The effect and potential of five technologies have been detailed in a communication magazine article, and they include device-centric architecture, millimetre wave, massive MIMO, smart device, and M2M communication.

The HAP system was utilised to replace the sink node in a WSN application in a 3G cellular network. The following are the two HAPWSN system configurations suggested for distinct purposes:

a. Sensor nodes in the HAP cell transmit directly to HAP.

b. Sensor nodes in HAP cells are grouped together in a cluster, with the cluster head being the node with the highest energy level. Members of a sensor network will gather and transmit data to the cluster head, which in turn will send all of the information to HAP. It was tested in both settings, and the results were recorded and assessed. The Eb/N0 spectral density ratio (Eb/N0) was used as a performance metric. HAP-WSN single-cell scenario's Eb/N0 (Yang and Mohammed, 2008) seems to be bigger than that of HAP-WSN multiple-cell scenario's Eb/N0. For example, replacing sink nodes with the HAP-WSN system provides the following benefits.

a. Reduced complexity of multihop transmission and high energy efficiency

b. Low cost

A novel 5G network coverage detection mechanism was suggested using a WSN. For network coverage detection purposes, the sensor nodes' ability to gather information in real time means they may be used everywhere, and they can meet the demands of network multiple coverage detection throughout the testing and trial phase of a 5G mobile communication network. Based on RSSIs from sensor nodes, the base station antenna is not required to do any additional calculations, making the suggested approach more efficient. The method works well with omnidirectional antennas and smart antennas with changeable beamwidths. Using Kriging interpolation, a coverage detection solution for 5G wireless networks ensures that the network coverage detection region is full. Data collection and processing, Kriging interpolation, and network coverage performance production are the main components of the method. Processing data essentially comprises the selection of target areas, interpolation points, the collecting of RSSI data, and the processing of the data. Most of the interpolation work is done by computing sample data set variations and fitting curves to the variation function values, as well as the RSSIs estimate. Creating the signal contour line of a 5G mobile communication network essentially involves merging the data acquired by the sensor nodes and approximated by the interpolation points. Similar to a contour line in geography, a signal contour line is drawn. This article describes this line as a closed curve that encompasses all points on a topographic map when the signal intensity is identical. A 5G mobile communication network's coverage may be easily shown on a map.

Using Cognitive Radio Wireless Propagation Mode to simulate Smart Home Networks Precoding and Modulation Model for Cognitive Radio Using CRs in smart houses has been shown to be a viable option for addressing the primary issues faced by smart homes, including as interference and wall penetration losses, while maintaining a restricted power budget. Under various scenarios, what power performance can be attained with a CR solution? To address these problems, simulations were conducted. A frequently used SHN is put up against a 5G based on CRs and pre-coded OFDM in these simulations. Power savings of up to 50% are possible using the CR method rather than the more frequent SHN method.

3. SYSTEM RELATED CHALLENGES AND REQUIREMENTS

A well-designed and well-architected system may make it easier to deal with IoT's issues while also making it more convenient to satisfy the criteria.

a) Dust-Fog-Cloud Infrastructure

Efforts have been made to design gateway frameworks to assist the integration of devices and the creation of applications in order to cope with the high level of complexity in IoT. With 5G backhaul support, the Dust-Fog-Cloud architecture [40] has become a popular method for managing the network and collecting data. Dust is a term for the final IoT devices. At its core, fog is an architectural framework that tries to deploy computing resources along the cloud-to-things continuum closer to the end devices. ‘edge’ and ‘fog’ are sometimes used interchangeably. "A massive amount of data is created by the dust, which is very redundant." The cloud to edge data processing and storage pressure may be considerably leveraged by the fog. Fog/edge computing and intelligent resource allocation in IoT systems are still difficult to implement. Another difficult research problem is to make use of and integrate 5G backhaul in order to reduce the deployment costs of IoT infrastructure.

b) Cross Layer Design

To understand the perception layer, you need to think of it as an amalgamation of two separate layers. RFID tags and readers, cameras, GPS sensors, terminals, terminals, and the related wireless infrastructure may all be part of the system. "Communication and data transfer are handled by the networking layer." Conventional design concepts include reliability and energy efficiency. The application layer analyses the obtained data and provides services to end users. The basis of the Internet of Things (IoT) is comprised of the perception and network layers. Together, these two layers provide the IoT system's backbone and core architecture. After determining the application layer design, the architectural design and implementation may be finalised. As soon as one of the three levels of the system (perception, network or application) is unavailable, the whole system is rendered inoperable. While these questions aren't directly related to application development, they do have a significant impact on how and where the system is deployed and what type of data is gathered. Cross-layer architecture is frequently used in networking and communication protocol implementation to increase reliability and energy efficiency. Using the Web of Things idea, lower-layer IoT devices may be accessed with great visibility and performance for the system's end-users. As the name suggests, it seeks to create an appearance of an integrated perceptual and networking layer Layered architectures have been a wonderful success for wired networks, but they may not always be the ideal option for wireless networks.... Cross-layer design, which is based on the idea that different levels of the network may communicate with one other in order to enhance overall network performance, has been suggested and is gaining traction. Cross-layer protocols have lately received a lot of attention in the literature. There are only a limited number of modifications that can be done to the 3GPP-defined 5G cellular network to enable different protocol architectures, despite this. As a result, the key difficulty is how to use current 5G core network components to provide cross-layer implementation. Cross-layer technologies still need additional effort from diverse groups in order to achieve 5G.

c) Middleware

Scientific theory, technical design, and the user experience are all being studied by researchers in academia and business to improve the IoT's development in three primary ways. However, although these activities may improve IoT technology, they also add to the system's complexity when put into practise in the real world. So, the notion of IoT middleware has been proposed, and various solutions are already available, such as Contiki, TinyOS and OpenWSN. It's still unclear what exactly constitutes IoT middleware in a formal sense. All researchers have their own interpretations on the subject matter. Depending on the circumstances, IoT middleware might be compared to an IoT operating system (OS). By integrating and providing interoperability across many applications and services, middleware may streamline and speed the development process. In contrast to service-oriented IoT systems, most current implementations of middleware are focused on wireless sensor networks (WSNs). The need for middleware that can serve a wide range of IoT services was therefore recognised.

Because of the distance between the application layer and lower levels of infrastructure, middleware is typically used. Functional and non-functional needs for middleware service for the Internet of Things may be divided into two areas. Functions like as abstractions and resource management are included in functional requirements. Quality of service (QoS) considerations like energy efficiency and security are included in nonfunctional criteria. 5G-enabled middleware has the potential to improve both functional and non-functional aspects of the network infrastructure when it is used in conjunction with 5G. Middleware and lower network infrastructure haven't been defined clearly. The problem is designing a middleware architecture for 5G-enabled smart interactions and administration.

d) Adaptation to MIMO

Speeds of up to 10 Gbps and latency of 1 millisecond are among the attributes of 5G, which is an enabler for M2M type communication. Quality of experience (QoE) is a major focus of this project. The introduction of MIMO technology is a significant step in achieving the 5G objectives. There are many radio connections made between a mobile phone, a gadget, and several antennas. In terms of communication capabilities and user situations, IoT technology has been suggested with a greater degree of diversification, enabling several real-world applications. Many IoT systems are now using cellular backhaul in order to ensure complete connection. MIMO capabilities are becoming common in IoT devices.

Typically, there are two approaches to improve the user experience on the network. The first thing to do is to increase the amount of bandwidth available. The second option is to provide a larger range of services than simply the best-eort service [65]. Two inelastic tracs and one elastic trac are the three forms of utility functions that have previously been extensively investigated [66]. Utility functions reveal that the networks should provide different sorts of services to accommodate elastic and inelastic tracing. There are several communication interfaces in MIMO, each with its own set of unique qualities, therefore this is a huge benefit. Classifying services is become easier because to MIMO. An improved quality of experience (QoE) may be achieved by categorising and mapping the user's trace to the appropriate network access interfaces.

e) Privacy and Security

If an item is damaged, unauthorised access or theft is prevented by preserving the integrity and confidentiality of its information and making it accessible whenever necessary, then security has been described as a process. For IoT systems, security is just as important as it is for any other computer system. IoT systems acquire a wide range of personal and sensitive information from a wide range of sources. Three major issues with IoT devices and services are security, privacy, and trust. One of the most important quality of service (QoS) elements of IoT systems is privacy and security. More security problems are associated with wireless broadcast transmission, and multihop wireless communication is much worse. Due to the nature of multi-hop distribution, there is no centrally trusted authority to disseminate a public key. 5G infrastructure provides secure transmission, but the end devices and cloud servers remain vulnerable to attack. It is possible that some of the current recommended security measures are only applicable to a single layer of protection. In spite of this, there is still an urgent need for a complete security system that protects all levels. A good cross-layer design and communication is advocated in order to handle security challenges like availability. Large and sophisticated IoT systems, like smart cities, often have a lot of linkages and dependencies. Scalability challenges for security would arise due to the wide variety and quick growth in population and industry of IoT-enabled communication devices. Security vulnerabilities can be handled at each layer, although this is not always possible. Infrastructure at the perception and networking levels, in particular, has to be protected against malicious attacks and intrusive control by unauthorised users. It is critical that authorised users have access to the application layer at all times without interruption from unauthorised users. Using powerful cryptographic primitives and methods like homomorphic encryption, a mutual authentication system would establish confidence, while ensuring privacy and anonymity. The security considerations at the application layer differ from one application to the next.

Every IoT application has privacy and security concerns. Users of AML may have concerns about privacy because of the dissemination of information resulting from power usage habits that might have significant consequences for businesses. As a result, encryption should be used to protect all data transmissions. IoT cloud storage of very sensitive patient data makes Smart Healthcare systems the most major privacy risk for its customers. As a result, cloud storage and computing face the same privacy risks. Wearable IoT devices, on the other hand, are constrained by concerns with battery life, memory, and computational power. The major objective is to build a system that is both lightweight and very secure. When using smart transportation systems, drivers' privacy must be protected from outside observers, who may be privy to their whereabouts, driving habits, and mapped routes. Another factor contributing to the ITS security issue is the sheer number of access points, which renders it open to a wide range of assaults. As a result, the privacy of drivers who do not engage in any authentication activity while operating the cars may be violated. Privacy and security concerns provide a substantial obstacle to 5G technology, and secure communication protocols such as SSL/TLS and IPSec are required.

4. 5G SUPPORTFOR INDUSTRIAL IOT APPLICATIONS UTILIZING ROBOTICS

In today's industrial applications, 5G gives the capabilities that are necessary. It is important to note that robots are required to meet the standards of the URLLC. Here, we evaluate and contrast a number of recent articles on 5G industrial use cases in order to better understand the problems they face.

Industry 4.0

Because of 5G's fundamental capabilities, the fourth industrial revolution is now achievable (support for eMBB, URLLC, and MMTC). According to, industrial automation and data sharing are the hottest topics right now. "Cloud computing, Internet of Things, and cognitive computing are a few of the many topics it focuses on. Industry 4.0 creates a'smart factory'." In modular smart factories, cyberphysical systems monitor physical processes, create a virtual representation of the actual world, and make decentralised decisions. The current limitations of 4G/3G wireless networks are end-to-end latency, power consumption, battery life, and device density. 5G removes these limitations, making previously unavailable use cases possible. For example, time-critical and reliable processes (such real-time monitoring and vision-controlled robots) may be subdivided into three categories: logistical activities involving assets and commodities; quality control and data collecting; as well as remote control of factory processes (remote workers, augmented reality).

When it comes to industrial use cases, such as manufacturing, 5G is an excellent match because of its decreased latency and high data speeds. The research provides an Industrial Demonstration Platform with a mobile robot and ten production modules (IDP). Using 5G in an industrial setting with a broad range of data sources is shown in this research. Wire-free transmission may one day be a thing of the past thanks to the promise of 5G technology.

The authors of this research have uncovered additional advantages of 5G in the context of industrial applications if we look at the benefits from a wider viewpoint. Network virtualization and software-defined networking (SDN) are two of the most important new advances in the field of networking. Infrastructure refurbishment, Mobile robots and Inbound logistics, flexible and modular assembly area plug-and-produce, massive wireless sensor network and process monitoring are all examples of the three key competencies. ' The suggested and integrated communication network architecture for Industry 4.0 and IIoT reference designs may therefore satisfy the demands of the indicated use cases (Industrial Internet Reference Architecture).

According to the authors of this article, the URLLC capabilities of the 5G may be used to construct a distributed robotics control system. A distributed node architecture, such as a cloud server, may be utilised to offload time-critical, computationally heavy activities via 5G URLLC communication between the cloud and the robot. This notion is shown in the actual world by means of a mobile robot.

Digital manufacturing, product lifecycle management and supply chain management are the three pillars of the Productive4.0 collaboration in Europe. In this scenario, the Arrowhead Framework is able to deliver interoperability, integrability, and ergonomic engineering capabilities all at once. According to local automation clouds built on the Arrowhead platform, under challenging conditions, NB-IoT surpasses Cat-3 or Cat-M1 infrastructures, while LTE-based solutions fall short of industrial requirements. Even with QCI-prioritization, a latency of less than 10 milliseconds cannot be achieved (not to mention jitter). There are recent, genuine studies that indicate that even if background traffic takes 50% of the network's capacity, basic (not changed) settings allow devices to interact with less than 5ms end-to-end delay.

5. CONCLUSION

Technology and industry watchers are predicting that 5G will change manufacturing and increase efficiency over time. In order for 5G to be the all-conquering cure for manufacturing, there are several technical issues that must be addressed. There are numerous obstacles to 5G adoption, including spectrum allocation, scaling issues, edge analytics, and security concerns. However, further investigation is needed into the adoption of an unbounded wireless transmission medium in a society that is increasingly aware of data privacy, and that will be a challenge not only for engineers but for standards bodies as well. When weighing the benefits and drawbacks of deploying 5G, keep in mind the unique requirements of each IoT application. The industry as a whole needs a deeper understanding of the data types being transported, their latency sensitivity, and whether or not the data has to be processed alone or in combination with previous information. Whether or if a company must employ 5G topologies in order to carry out a smart manufacturing solution will be heavily influenced by the answers to these and other concerns. Allowing businesses to better adapt to the needs of their consumers, 5G will enable them to be more productive. 5G's introduction is projected to assist manufacturers, whose warehouses, factories, and other facilities will increasingly be fitted with smart technology that take use of faster networks. Taking use of 5G's unprecedented speed and coverage to bring the world closer together than ever before, new industrial opportunities are opening up. Advances in manufacturing technology, including 5G and beyond, will be a boon to any company that can take use of them. Research into the interoperability of wireless technologies in factory environments is needed to reveal reliability, latency, and minimum range of wireless technologies in a factory environment when deployed with 5G, and to evaluate the heterogeneous interoperability of 5G and existing communication protocols currently deployed in manufacturing environments.

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