THE ROLE OF NETWORK SECURITY AND 5G COMMUNICATION IN SMART CITIES AND INDUSTRIAL TRANSFORMATION

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PREFACE

In the ever-evolving landscape of technology, the intersection of network security and 5G communication stands at the forefront of driving significant transformations in our societies. As we navigate the era of smart cities and the industrial revolution, the integration of these two crucial elements plays a pivotal role in shaping the future of connectivity, efficiency, and innovation. "The Role of Network Security and 5G Communication in Smart Cities and Industrial Transformation" delves into the intricate relationship between the security of our digital infrastructure and the revolutionary capabilities of fifth-generation (5G) communication technologies. This preface serves as a gateway to understanding the complex dynamics at play and exploring the challenges and opportunities that arise in the context of smart cities and industrial metamorphosis.

Smart cities are emerging as hubs of interconnected technologies, where data-driven decision-making, automation, and connectivity are redefining urban living. The synergy between 5G communication and network security becomes paramount in ensuring the seamless operation of diverse applications, ranging from smart grids and intelligent transportation systems to healthcare and public safety. This preface sets the stage for an in-depth exploration of how robust network security becomes the bedrock upon which the promises of 5G in smart cities can be fully realized. Simultaneously, as industries undergo a profound transformation with the advent of Industry 4.0, characterized by the fusion of digital technologies, the role of network security becomes even more critical. The deployment of 5G communication networks in industrial settings promises unprecedented gains in efficiency, productivity, and flexibility. However, this also introduces new vulnerabilities that require meticulous attention to safeguard critical infrastructure, intellectual property, and sensitive data. This preface aims to articulate the delicate balance required to harness the potential of 5G in industrial applications while fortifying digital defenses against evolving cyber threats.

As we embark on this exploration, the preface provides a roadmap for readers, outlining the key themes, objectives, and significance of the ensuing chapters. It encourages a holistic understanding of the intricate interplay between network security and 5G communication in the context of smart cities and industrial transformation. Together, these elements converge to shape a future where connectivity is not only ubiquitous but also secure, empowering societies to embrace the transformative potential of technology while safeguarding against the challenges that accompany progress.

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INTRODUCTION

In the dynamic landscape of technology and urban development, the synergy between network security and 5G communication stands as a linchpin for transformative change. This book, titled "The Role of Network Security and 5G Communication in Smart Cities and Industrial Transformation," embarks on a comprehensive exploration of the intricate relationship between these two pillars, unraveling the profound impact they wield in shaping the future of our cities and industries. As we navigate the era of unprecedented technological advancements, the concept of smart cities emerges as a beacon of innovation. Smart cities represent a holistic integration of digital technologies, data-driven insights, and intelligent infrastructure, promising to revolutionize the way we live, work, and interact with our urban environments. At the same time, industries are experiencing a paradigm shift with the advent of Industry 4.0, where automation, connectivity, and data analytics converge to redefine traditional manufacturing processes. Both of these revolutions are underpinned by the transformative potential of 5G communication networks.

This book serves as a guide to unravel the symbiotic relationship between network security and 5G communication in the context of smart cities and industrial transformation. The deployment of 5G networks brings forth unparalleled connectivity, enabling faster data speeds, lower latency, and the ability to connect a multitude of devices simultaneously. However, this newfound connectivity also presents novel challenges in terms of cybersecurity, privacy, and the integrity of critical systems. The pages of this book unfold the critical role of network security in mitigating these challenges, ensuring that the promises of 5G can be harnessed securely and responsibly.

The primary aim of this book is to provide a nuanced understanding of the key themes and challenges within the realm of network security and 5G communication. The objectives include:

Smart Cities and Urban Dynamics: Delving into the impact of 5G and network security on the development of smart cities, exploring the challenges and opportunities that arise in creating intelligent, responsive urban environments.

Industrial Evolution with 5G: Investigating the transformative potential of 5G in industrial settings, uncovering how network security becomes paramount in ensuring the reliability and security of interconnected industrial systems.

Cybersecurity Challenges: Identifying and dissecting the cybersecurity challenges inherent in the 5G landscape, offering insights into proactive measures and best practices to safeguard against evolving threats.

Ethical and Responsible Implementation: Advocating for the ethical and responsible implementation of 5G technologies, considering the implications for privacy, data protection, and the overall well-being of individuals and communities.

The book endeavors to provide readers with a comprehensive framework for understanding the intertwined dynamics of network security and 5G communication. By doing so, it aims to equip professionals, researchers, policymakers, and enthusiasts alike with the knowledge necessary to navigate the complexities of our evolving digital landscape while fostering a secure and resilient future for smart cities and industrial realms alike.

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CHAPTER 1

Sustainability in Smart Cities: A 5G Green Network Approach

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Abstract: The rapid urbanization and technological advancements of the 21st century have propelled the evolution of smart cities, aiming to enhance efficiency, connectivity, and overall quality of life. As cities strive to address environmental challenges, this research investigates the integration of a 5G Green Network as a pivotal component of smart city sustainability. The study explores the intersection of 5G technology and environmentally conscious practices, aiming to understand their collective impact on urban development. The literature review underscores the current landscape of smart cities, sustainability, and the emergent role of 5G networks. Highlighting gaps in existing research, the paper establishes the need for an in-depth examination of the potential environmental benefits and challenges associated with deploying 5G technology in smart city infrastructures. A conceptual framework is proposed, delineating the key components of a 5G Green Network and its seamless integration into smart city infrastructure. The methodology section outlines research design, data collection methods, and analytical tools employed to assess the sustainability implications of 5G technology. The paper examines the various facets of smart city infrastructure and elaborates on how 5G Green Networks can positively impact energy efficiency, reduce carbon emissions, and enhance overall sustainability. Drawing on case studies and examples, the research presents successful instances of cities implementing 5G Green Networks and analyzes the lessons learned. This research aims to provide valuable insights for policymakers, urban planners, and technologists alike, fostering a deeper understanding of the potential of 5G Green Networks in advancing the sustainability agenda within the context of smart cities.

Keywords: IoT, Green technology, Green communication, Smart cities, 5G Network.

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INTRODUCTION

In the midst of an era characterized by rapid urbanization and burgeoning technological innovation, the concept of smart cities has emerged as a transformative paradigm for urban development. Smart cities leverage cutting-edge technologies to enhance efficiency, connectivity, and overall livability, aiming to create urban ecosystems that respond intelligently to the needs of their inhabitants. This evolution towards smart urbanization, however, is not without its challenges, and one of the paramount concerns is the imperative of sustainability. Sustainability in the context of smart cities goes beyond mere ecological considerations; it encompasses a holistic approach that integrates environmental responsibility, economic viability, and social inclusivity. The need for sustainable urban development has become increasingly urgent in the face of climate change, resource constraints, and the burgeoning global population. As we strive to construct cities that endure, fostering a harmonious coexistence between humanity and the environment becomes paramount.

This research paper embarks on an exploration of the interplay between sustainability and smart cities, with a specific focus on the transformative potential of 5G green networks. The research problem at the heart of this inquiry lies in understanding how the deployment of 5G technology, coupled with environmentally conscious practices, can contribute to the sustainable development of smart cities. As traditional telecommunication networks pave the way for 5G, a convergence of connectivity and environmental responsibility presents itself as an opportunity to reshape the urban landscape. The importance of incorporating 5G Green Networks in smart city infrastructure cannot be overstated. Beyond the anticipated advancements in communication speeds and data capacity, 5G networks hold the promise of reduced energy consumption and a diminished carbon footprint. This paradigm shift from conventional networks to green, energy-efficient alternatives underscores the potential for 5G technology to be a catalyst for environmental sustainability within the urban context.

Literature Review

The literature on smart cities elucidates the multifaceted nature of urban development, emphasizing the integration of information and communication technologies (ICTs) to enhance the efficiency and quality of urban services. Scholars such as Caragliu, A., Del Bo, C., & Nijkamp, P [1]. and Hollands [2] have extensively examined the concept, highlighting the potential for smart cities to improve resource allocation, environmental sustainability, and overall urban governance. Sustainability in urban development has been a recurring theme in the literature, with researchers emphasizing the need to balance economic growth with environmental responsibility and social equity. Works by Beatley [3] and Newman and Jennings [3] underscore the importance of creating cities that are resilient, resource-efficient, and inclusive, considering the ecological impact of urbanization. Recent studies exploring the integration of 5G technology into urban environments have primarily focused on the anticipated advancements in communication speeds and data capacity. Notable contributions by Zhang *et al.* [4] and Misra *et al.* [5] provide insights into the technical aspects of 5G deployment, emphasizing its potential to revolutionize connectivity and enable new applications across various sectors. Despite the wealth of literature on smart cities, sustainability, and 5G technology, a critical analysis reveals discernible gaps that necessitate further exploration. First and foremost, the intersection of sustainability, smart cities, and 5G networks remains underexplored. Few studies have comprehensively addressed the potential environmental impact of 5G technology in the broader context of urban sustainability. This research is poised to bridge these gaps by providing a holistic examination of the integration of 5G Green Networks in smart cities. By weaving together insights from the realms of smart cities, sustainability, and 5G technology, this study aims to contribute a nuanced understanding of the potential environmental benefits and challenges associated with 5G deployment in urban contexts.

Conceptual Framework

The conceptual framework provides a structured basis for the subsequent analysis and discussion of the research findings, offering a visual representation of the interdependencies that define the integration of 5G Green Networks in the broader context of smart city sustainability shown in Fig. (**1**) [6].

The fundamental key terms associated with the framework is as follows:

- **Smart Cities:** Smart cities leverage information and communication technologies (ICTs) to enhance urban infrastructure, services, and the overall quality of life for residents. This includes the integration of data-driven solutions for efficient governance, sustainable resource management, and improved connectivity.
- **Sustainability:** Sustainability in the context of urban development refers to the balanced integration of economic, environmental, and social considerations. It involves creating cities that meet the needs of the present without compromising the ability of future generations to meet their own needs [7].
- **5G Technology:** 5G technology represents the fifth generation of mobile networks, characterized by significantly faster data transfer speeds, lower latency, and increased capacity compared to previous generations. It forms the

CHAPTER 2

The Effective Cost-Reduction Plan for Particle Swarm Optimization-Based Mobile Location Monitoring in 5G Communications

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Abstract: The focus on cost reduction within mobile communication networks has become a key subject of attention due to its significant proportion of the overall cost utilization structure of information and communication technology (ICT). This research digs into the area of 5G networks, which include a heterogeneous mix of mega cells and small cells with a clear demarcation between data and control planes. The paper considers two categories of information or data. There are two categories of data flow or traffic: high-rate traffic for data and low-rate data congestion. Large-scale cellular base stations, or MBSs, are responsible for controlling and regulating signals in the conventional architecture for separation. In contrast, a small cell base station (SBS) controls data transmission at both low and high rates. An MBS manages control signals and- the pace of data flow within the modified separation architecture under consideration, whereas an SBS controls a high-speed data flow. An efficient energy-saving method is presented to improve the cost-effectiveness of base stations (BSs). The amount of user equipment (UEs) seeking high-rate data traffic and the number of UEs present within overlapping areas that are generally covered by the considered BS and neighboring BSs are used to establish the operational state of a BS. To implement this cost-cutting method, Particle swarm optimization (PSO) finds an application to create a problem related to optimizing something and find its answer. The findings unequivocally demonstrate that the suggested energy-saving approach, as implemented within the redesigned split network design, surpasses the energy efficiency achieved by traditional energy-efficient techniques, Both of them have distinct network structures that are basic and customized. Additionally, this suggested plan significantly reduces cumulative latency, offering a highly promising strategy for enhancing overall network efficiency.

Keywords: Cellular mobile systems, Location management, Particle swarm optimization (PSO), 5G networks.

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INTRODUCTION

An essential concern associated with the issue of global warming is the steadily rising amount of energy that is consumed [1], and diminishing cost utilization. The use of mobile networks for communication has drawn attention because it accounts for a significant portion of the whole cost of technology for information and communication (ICT). The mobile communication network cost will be more crucial in the future with increasing traffic load in the upcoming networks with 5G [2, 3]. According to reference [4], in mobile communication networks, a base station (BS) is the main source of cost usage, and the BS's cost utilization is influenced by traffic load, which varies according to the geographical location.

Significant effort has been made to increase the energy savings of a BS to lower the cost use of mobile communication networks. The primary idea of work to lower the cost usage of a BS is to turn off as many BS components as feasible once they are no longer required [4]. For instance, the Base Station (BS) can enter a slumber mode through deactivating power to most of its components when they are not in active use. As depicted in Fig. (**1**), if the BS experiences minimal traffic and neighboring BSs can adequately cover the traffic, it can be powered off to achieve significant energy savings [5].

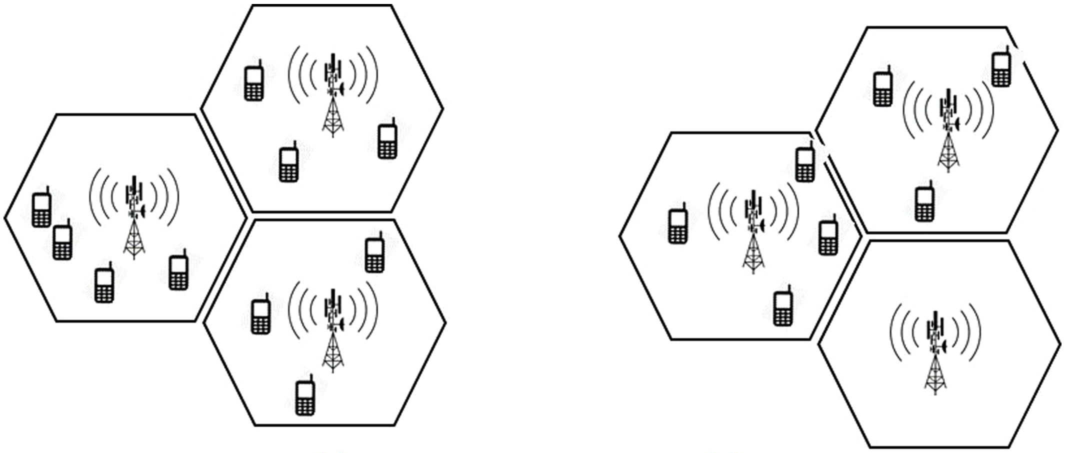

Fig. (1). (Base station (BS) activation and deactivations). (**a**) Activation; (**b**) deactivation [1].

Contextual information, such as dynamic changes in demand and channel for traffic conditions within a setting at which the Base Station (BS) and User Equipment (UE) connections are ever-changing, is used to determine the operational status of the BS. In a prior study [6], two schemes known as "greedy-on" and "greedy-off" were introduced. These schemes change the BS state to either on or off. It was found that the “greedy” strategy demonstrated improved energy efficiency provided certain conditions were met. In another study [7], various methods for reducing the number of active BSs were presented, and a traffic-intensity-aware multi-cell cooperation scheme was introduced. In this scheme, the BS state is adjusted to the off state based on its traffic density, which is categorized into peak-hour traffic and off-peak traffic, depending on the UE's traffic demand. Furthermore, coverage gaps are addressed by neighboring BSs that remain in one state. The cell zooming approach is also presented [8] as an alternative to the BS activation and deactivation procedures [4, 7], which adjusts the coverage area of BSs to allow cells to zoom in and out in response to changes in traffic load and channel conditions, as shown in Fig. (**2**).

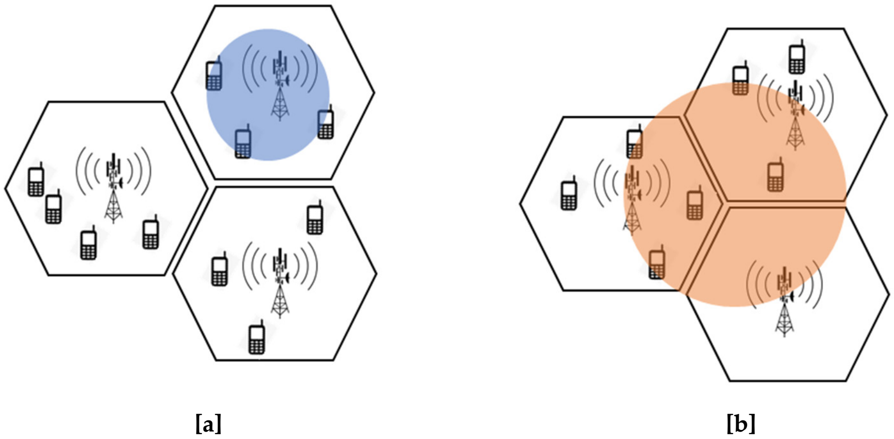

Fig. (2). Cell zooming can be done in two ways: (**a**) zooming in; (**b**) zooming out [2].

A BS that is busy and experiencing high traffic loads will zoom in, while nearby BSs will zoom away to prevent any possible coverage gaps. A BS zooms out while nearby BSs zoom in when they are not busy and have little traffic. Cell zooming allows the Base Station (BS) that is zoomed in to go into a sleep state to save energy and lower operating expenses. In this case, the region that the dormant BS had formerly serviced is covered by nearby BSs.By reducing the cost associated with active base stations, the cell zooming system aims to balance traffic distribution to enhance the system's overall energy effectiveness. To oversee the data coming from the switched-off BSs, active BSs must fill up any coverage gaps and work with neighboring BSs [9].

CHAPTER 3

Smart Cities with 5G and Edge Computing in 2030

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Abstract: The emergence of smart cities represents a paradigm shift in urban development, harnessing technological advancements to address pressing challenges and improve quality of life for citizens. As we look towards the year 2030, the convergence of 5G and edge computing technologies promises to revolutionize the landscape of urban environments, unlocking unprecedented levels of connectivity, efficiency, and sustainability. This paper explores the transformative potential of integrating 5G and edge computing in shaping the smart cities of the future. Firstly, it delves into the foundational principles of smart cities, emphasizing the need for interconnectedness, data-driven decision-making, and citizen-centric design. Building upon this framework, it examines the distinct capabilities offered by 5G networks, such as ultra-low latency, high bandwidth, and massive device connectivity, and elucidates how these attributes facilitate the proliferation of IoT devices, autonomous systems, and immersive experiences within urban contexts. Moreover, the paper discusses key challenges and considerations associated with the deployment of 5G and edge computing infrastructures in urban environments, such as cybersecurity risks, regulatory frameworks, and equitable access. It advocates for collaborative efforts among stakeholders, including governments, industries, and communities, to address these challenges and ensure the responsible and equitable implementation of smart city technologies.

Keywords: Autonomous vehicles, IoT (Internet of Things), Real-time data processing, Smart infrastructure, Smart cities 2030, 5G networks.

INTRODUCTION TO SECURITY IN SMART CITIES

In today's rapidly advancing era of 5G and the Internet of Things (IoT), where technology is evolving at an unprecedented pace, the concept of building secure cities has emerged as a topic of paramount importance [1 - 5]. With the advent of 5G, which promises lightning-fast connectivity and the ability to support a massive number of devices simultaneously, and the widespread integration of IoT devices into our daily lives, cities are presented with both incredible opportunities

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and significant challenge [6 - 8]. As urban centres continue to evolve and progress, becoming increasingly interconnected and digitally integrated, it is evident that the potential benefits that can be derived from this transformation are truly immense. This paradigm shift holds the promise of enhancing efficiency, sustainability, and overall quality of life for the residents of these urban areas [9]. However, it is important to note that as technology continues to advance and become more integrated into our daily lives, it also brings with it a multitude of security challenges that cannot be ignored. These challenges must be addressed in a comprehensive manner to ensure the safety and privacy of citizens, the smooth functioning of critical infrastructure, and the overall resilience of the urban environment [10 - 12]. It is crucial that we take these challenges seriously and implement effective measures to mitigate any potential risks that may arise. By doing so, we can embrace the benefits of technological advancements while also safeguarding the well-being of our society [13 - 23].

Kho and Jeong [24] proposed a Hazard Analysis and Critical Control Points (HACCP)-based cooperative model for smart factories in South Korea. HACCP is a systematic approach to identifying and mitigating risks in manufacturing processes. This model integrates 5G connectivity to enable real-time monitoring and control, enhancing the safety and quality of products in smart manufacturing environments.

The seamless integration of 5G networks and Internet of Things (IoT) devices has revolutionised the way smart cities operate. By harnessing the power of these advanced technologies, cities are now able to collect and analyse massive volumes of data in real-time [25, 26]. This influx of data has paved the way for more intelligent decision-making processes across various sectors, including urban planning, traffic management, energy consumption, healthcare, and much more. With the advent of 5G networks, smart cities have gained unprecedented connectivity and speed, enabling them to handle the vast amounts of data generated by IoT devices [27]. These devices, ranging from sensors and cameras to smart metres and wearables, are embedded throughout the city's infrastructure, creating a network of interconnected devices that constantly gather and transmit data [28, 29]. One of the key benefits of this integration is the ability to enhance urban planning. By analysing real-time data on population density, traffic patterns, and environmental factors, city planners can make informed decisions to optimise the allocation of resources and improve the overall quality of life for residents. For example, they can identify areas with high traffic congestion and implement intelligent traffic management systems to alleviate the problem [30 - 32]. Moreover, the integration of 5G and IoT enables cities to monitor and manage energy consumption more efficiently. Smart metres installed in buildings can provide real-time data on energy usage, allowing for better energy management and the identification of areas where energy efficiency can be improved. This not only reduces costs but also contributes to As we delve deeper into the realm of connectivity, we find ourselves presented with a myriad of exciting opportunities that have the potential to revolutionise the way we live, work, and interact with the world around us [33, 34].

Temesvári *et al.* [35] provide a review of mobile communication technologies and their applications in the manufacturing sector. The paper discusses the role of 5G in supporting various manufacturing processes, including predictive maintenance, supply chain management, and flexible production. Understanding the impact of 5G on manufacturing is essential for industries seeking to leverage its benefits.

However, it is important to acknowledge that this newfound connectivity also brings with it a set of challenges and risks that we must navigate carefully. One of the foremost concerns that arise from this interconnectedness is the increased vulnerability to cyberattacks. With more devices and systems being connected to the internet, the potential for malicious actors to exploit vulnerabilities and gain unauthorised access to sensitive information becomes a pressing issue [36]. This can lead to devastating consequences, ranging from financial losses to compromised personal data and even threats to national security. Furthermore, the risk of data breaches looms large in this interconnected landscape. As more data is generated, stored In order to effectively establish secure cities within this ever-evolving landscape, it is imperative to adopt a comprehensive and multifaceted approach that encompasses a wide range of measures [37]. These measures should not only focus on technological advancements, but also take into consideration the organisational and regulatory aspects of city security. Technological measures play a crucial role in enhancing the security of cities. The implementation of advanced surveillance systems, such as high-definition cameras and facial recognition software, can significantly bolster the ability to monitor and detect potential threats. Additionally, the integration of smart technologies, such as Internet of Things (IoT) devices, can provide real-time data and analysis, enabling authorities to respond swiftly to any security breaches shown in Fig. (**1**). However, it is important to recognise that technology alone cannot guarantee the safety of a city.

These challenges encompass threats such as vulnerabilities introduced by network slicing, which is a key feature of 5G networks. The authors also propose innovative solutions, including enhanced authentication methods, to address these challenges. This source is valuable for gaining insights into the dynamic landscape of 5G security [38].

CHAPTER 4

5G and Smart Cities: Smarter Solutions for a Hyperconnected Future

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Abstract: The integration of 5G technology into the fabric of smart cities heralds a new era of urban development, promising unprecedented levels of connectivity, efficiency, and innovation. This paper explores the transformative potential of 5G networks in shaping the future of smart cities, where hyperconnectivity serves as the cornerstone for smarter solutions to address pressing urban challenges. Beginning with an overview of the fundamental principles underlying smart cities, this paper highlights the imperative of leveraging advanced technologies to create more sustainable, resilient, and livable urban environments. It then examines the unique capabilities of 5G networks, including ultra-fast data transmission, ultra-low latency, and massive device connectivity, and explores how these features enable a diverse array of smart city applications across various sectors. Furthermore, the paper delves into the specific ways in which 5G technology enhances existing smart city infrastructures and enables the development of novel solutions to urban challenges. From intelligent transportation systems and autonomous vehicles to remote healthcare services and augmented reality experiences, the hyperconnectivity facilitated by 5G networks empowers cities to deploy innovative solutions that improve quality of life for residents and enhance urban efficiency.Moreover, the paper discusses the challenges and opportunities associated with the deployment of 5G networks in urban environments, including infrastructure requirements, regulatory considerations, and privacy concerns. It emphasizes the need for collaboration between governments, industries, and communities to address these challenges and ensure the responsible and equitable deployment of 5G technology in smart cities.

Keywords: Edge computing, Hyperconnected networks, IoT (internet of things), Network slicing, Smart cities, Urban innovation, 5G technology.

INTRODUCTION

Throughout the span of approximately every decade, a novel surge of wireless mobile telecommunications technology arises, characterised by the application of

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inventive frequency bands, elevated data speeds, and the inception of brand-new services. This advancement propels us nearer to accomplishing the smooth connectivity of almost every aspect of our tangible world.

The inaugural phase, known as 1G, made its debut in the early 1980s. It was distinguished by its capacity to transmit speech using analogue technology. While exemplifying noteworthy advancement for its era, 1G had constraints. Significantly, it lacked data services to transform voice into digital signals, displayed below-average voice quality, and had not yet provided global roaming services.

In this comprehensive review, the (Digital 2020) report provides detailed insights into global digital trends. It covers a wide range of digital indicators, including internet penetration, social media usage, and e-commerce trends, offering a holistic view of the digital landscape that can inform discussions on technology adoption.

The ensuing era, 2G, emerged in the tardy 1990s, signifying the onset of digital technology. 2G brought improvements in vocal clarity and data transfer capability. In this period, the Worldwide System for Mobile Communications (WSMC) acted as the digital norm, integrating characteristics such as Brief Communication Assistance (BCA), Multimedia Communication Assistance (MCA) enabled by devices with vivid screens, and Wireless Application Protocol (WAP) enabling internet connectivity services on portable gadgets. Notwithstanding the energy-intensive characteristic of these multimedia applications, a noteworthy benefit of 2G mobile devices was their prolonged battery life, attributable to the minimal power usage of radio signals [1].

The third stage, 3G, surfaced in the latter portion of the 2000s. It introduced authentic wireless data connectivity, granting users extensive internet access. Significantly, 3G technology brought about heightened data transmission velocities, enabling the evolution of advanced multimedia applications. Moreover, the incorporation of new frequency ranges and positioning data allowed for functionalities previously unavailable to portable devices. This included endeavours like web surfing, electronic mail entry, TV streaming, visual assembly, and even the application of global positioning system (GPS) technology. This expansive assortment of applications made the 3G era remarkable for the consumer market. Nevertheless, it additionally resulted in a surge in expenditures for 3G gadgets and amplified power usage. For instance, 3G devices require more power compared to the majority of 2G models due to their expanded capabilities [2].

The fourth stage of wireless mobile telecommunications technology, recognised as 4G, surfaced in 2010 and persists to be employed presently. This era is constructed upon Internet Protocol (IP) and strives to offer exceptional, safeguarded, economical services, multimedia, and internet connectivity *via* IP, presenting notably elevated data speeds in comparison to its forerunners. Precisely, 4G introduces pervasive high-speed wireless broadband, unleashing the potential of portable video streaming and advanced services like interactive amusement, high-definition streaming, and three-dimensional television [3].

As utilities increasingly turn to drones for inspections and maintenance, a review like [4] can provide insights into the adoption and impact of drone technology in the utility sector.

Currently, 4G provides consumer data speeds in the magnitude of megabytes, latency within the millisecond spectrum, and sustains a device density of approximately 2000 connected devices per square kilometre worldwide. This has enabled the execution of the Internet of Things (IoT). Nevertheless, owing to an escalating requirement and the advent of innovative cellular communication breakthroughs, the 4G epoch is anticipated to pave the way for the subsequent iteration, 5G, at the onset of the forthcoming decade [5].

The forthcoming 5G epoch is ready to introduce network and service capabilities formerly unreachable. It assures improved durability, intensified data speeds, decreased delay, backing for extensive simultaneous links, and worldwide network reach even in demanding situations like high mobility (*e.g.*, in trains) and densely packed or thinly populated areas (*e.g.*, stadiums, marketplaces). Furthermore, 5G will have a crucial function in facilitating an authentic Internet of Things (IoT), offering a groundwork to link a vast assortment of detectors and effectors with an emphasis on energy effectiveness and transmission constraints.

Motivated by an unparalleled upsurge in interconnected gadgets, mobile data traffic, and the constraints of 4G technology in tackling this substantial data requirement, both industry and academia are concentrated on delineating the specifications for 5G services, signifying the commencement of the 5G epoch. A contraption equipped with 5G will possess the ability to sustain network connectivity consistently and universally, unleashing the potential to interconnect all contraptions within the network. To accomplish this objective, the fundamental plan of the 5G system is expected to endorse up to a million simultaneous connections per square kilometre, enabling the actualization of a plethora of inventive concepts within the domain of Internet of Things (IoT) amenities [6].

The Internet of Things embodies a modern digital communication paradigm, where everyday objects interact with each other and users through the World

CHAPTER 5

5G–Enabled Smart Healthcare System with the Integration of Blockchain Technology

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Abstract: Among the most crucial jobs in the digitization era is to track the data in real-time for a wide network of healthcare systems. Blockchain technology introduces us to the new age of sharing information in an authorized way using different consensus algorithms to connect the data blocks in chains, along with the help of Hash-keys making it safer. In blockchain technology, any entrance of malicious data replacing the original data cannot be encouraged because the distributed ledgers have the same data in an encrypted manner, and changing the same data in such a huge network is merely impossible, this enhances the security of the user's information. Smart healthcare systems on a higher basis use Health Information Exchange(HIE), to decentralize the previous health records of the patient between organizations and frequently update them. Smart healthcare systems make it viable for decentralization of patient data, the number of drugs consumed, and statistics of different diseases as 5G plays a major role here because of its distributed implementation, its connectivity with IoTs and IIoTs that help in the easy update of information with the patient's access given. With the advent of 5G-NR, using the modulation techniques of QAM, variable Bandwidth, and the NOMA, it has enhanced higher data rates and high networking capacities. Mobile Edge Computing (MEC) of 5G technology helps in storing and computing data in a decentralized manner with the help of distributed Mobile Cloud Centres(MCC). Over time, many private blockchain technologies have been suggested, which involve only a few organizations and transact data only between them unlike the public blockchain technology thereby increasing the reliability and security. In this chapter, we emphasize smart health sectors, the necessity of blockchain, the different blockchain designs for healthcare applications, and the different proposed algorithms based on 5G, and the chapter concludes with recent advances in 5G networks, the challenges, and potential solutions.

Keywords: Blockchain, Cloud computing, MEC, Smart healthcare, 5G-NR.

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INTRODUCTION

Evolution of Block-Chain

There has been a tremendous change in technologies within the last 30 years of period, the rise in the software industry has taken the service sector into a golden period which has a lot of things to deal with such as network chain, information, availability, security, transaction of information, statistics on purchases, *etc.* The above domains have revolutionized each and every sector such as automobile, internet, wireless communication, business, banking, health, education, *etc.* Before, several different industries carried out all of these tasks, but there were numerous flaws and challenges, including: a) disturbance and lack of integrity in the network chain because of the centralized system. b) Information should always be retrieved when needed from servers which then takes a lot of power and eats up In-memory. c) Disruption of the chains because of lack of rules and gathering all the confidential information of a person or an organization by creating breaches or corrupting them by adding viruses in the software or websites through which we cite. d) Centralized transaction of information with different rules and restrictions of different entities. e) In the field of AI, statistics is the most important for data to be asserted, even though there are a lot of information transactions made in all sectors, with the inclusion of software, there is no proper update of data from time to time to perform proper models to predict further developments for the future. There are still many problems that can be addressed like remote area access with these technologies and that is when everyone started looking for new technologies that can optimize all these problems and increase performance and the new solutions are solved using the technologies shown in Fig. (**1**). This paved the way for the significance of Block-chain that was first introduced in 2008 with an application of bitcoin by SatoshiNakamoto in his paper for building a trusted model for transactions that do not rely on financial and third party organizations with an idea of distributed ledger network with an end to end connection. With the tremendous growth of Block-chain in recent time periods, this technology has no leaps and bounds in its framework which can go from public to private, for its algorithms that can even run on IoTs, which helps in remote connectivity, for its distributed network that has information of every transaction made by a peer from time to time, the update of information is a strength in this technology, and the main reason we are foreseeing this technology as a future lead in networking domain is its security which is in the hands of every peer and sophisticated rule to chain a block. The minimal use of third parties is a default advantage of blockchain. The Blockchain in tech improvements are going to make this world of technology a secure place for the functioning of operations on the surplus amount of information that is being produced for every second.

This technology will be used as a communicating platform between devices in an authorized manner which is seen as a better service provided in every sector.

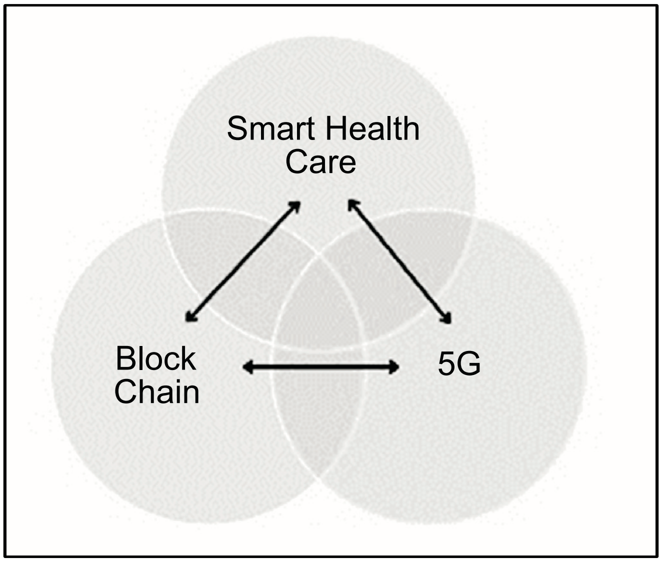

Fig. (1). Venn representation of blockchain.

Block-Chain

The innovations considering both upcoming and existing programs in Blockchain can project the existing technology in a peculiar and efficient manner. Blockchain is a shared and connected immutable ledger that records transactions and updates them in a frequent manner. The sailors of the technology are eagerly exploring this island intermixing with all other techs such as IoTs, IoMTs, IIoTs, finance, banking, healthcare, and AI which gives us untapped possibilities in an efficient manner. Although Block-chain was introduced as a financial manager to save the clients having trust issues and third-party organizations, this is seen as the front-liner of every network communication because of its security. Before getting into the very enlarged and flexible domain, let us understand its basics as shown in Fig. (**2**).

Block is a basic unit of a Block-chain, which contains three essential things for its connectivity 1) data is the information we want to transact. 2) Hash-key of the block is the fingerprint through which we can access the information of the block (32 bit,64 bit,128 bit,256 bit). 3) Previous Hash is the hash-key value of the previous block that's implemented in the chain as [1]. There are some crucial points to be noted about a block such as, the information in a block is immutable or intangible and it can hold the info of user choice, the chains in the block are introduced so that no other malicious block enters in between the chain and

CHAPTER 6

Edge Computing for Analysis in Health Care Industry using 5G Technology

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Abstract: In today's world, ailments have increased due to increased stress and an unhealthy way of living among other reasons. This demands proper and effective monitoring of an individual's health for early prevention. Among the various ailments, heart-related issues have become a significant concern. The increased risk of heart-related problems can be tackled by the use of technology, which provides a route for effective monitoring, therefore various ways pertaining to technologies have been explored. Extensive research has been conducted in the fields of smart textiles and sensors, with Textile Electrocardiogram being one of the major developments. Electrocardiography (ECG) is a popular technique for monitoring the heart rate and other parameters in order to alert the individual of any risk if present. However, real-time monitoring is crucial for reliable and effective analysis. This analysis can further be converted into reports for proper diagnosis by certified medical professionals or doctors. Adequate and efficient analysis of this data requires enormous resources and computing power, which implies that mobile phones are not suited for the same. This leads to the necessity for customized hardware to achieve this task. In view of this, an architecture has been developed to interface the sensors wirelessly using 5G protocols for faster and secure communication to the custom Hardware *i.e.* edge device to generate reports on demand. In this chapter, we will discuss the recent advances in various technologies that can be used at the communication, encryption and edge computing levels, the challenges, and potential solutions.

Keywords: Edge computing, Edge device, Smart healthcare, Textile electrocardiogram, 5G communication.

INTRODUCTION

A distributed computing paradigm is known as edge computing [1]. Many issues, such as the longevity of a battery's charge limitations, response time requirements,

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bandwidth, cost, and data security and privacy, could be resolved *via* edge computing. Some of the challenges in edge computing include security and privacy, resource management, and programming models. Edge computing allows for the low-cost implementation of improved performance systems, which can be applied to newer fields. Edge computing represents a dynamic and evolving ecosystem, characterized by fragmentation. Moreover, both standards and business models are presently evolving and reaching a phase of maturity.

Edge computing applications are vastly supported by the introduction of 5G communication systems [2], which provide high bandwidth, low latency, and massive connectivity. Technology will play a bigger part in healthcare in future, and 5G-based smart healthcare networks will be essential to enabling cutting-edge medical applications. These networks do, however, also present a of security difficulties.

Integrating 5G connectivity into the IoT systems introduces the risk of connectivity and reliability issues as many devices can be connected to the same network at some time. The impact of 5G on healthcare extends beyond just faster internet [3]. 5G networks present numerous benefits for healthcare applications, positioning themselves as a promising technology in the field. With their high data transfer rates and minimal latency, 5G networks facilitate real-time communication and swift data transmission, essential for efficient healthcare services. These networks facilitate the seamless transmission of high-resolution medical imaging data, enabling remote diagnosis and consultation [4, 5].

The emergence of 5G technology enhances the existence of a highly interconnected Internet of Things, primarily through Massive Machine Type Communication (mMTC). This demands robust network capacity to handle numerous connected devices within each cell, thereby generating the need for effective communication with control centers [6]. 5G network ecosystem facilitates seamless connectivity between medical sensors, actuators, and the cloud, offering exceptional high-speed and extensive bandwidth support [7].

Edge computing, by relocating computation and storage closer to the data origin, facilitates quicker analysis and decision-making, a critical aspect in healthcare applications [8]. The development of numerous technologies that interface sensors wirelessly using 5G protocols has been made possible by notable advancements in wireless sensors for wearable electronics in recent years [9]. The integration of wearable sensor arrays for in situ perspiration analysis allows for large-scale application. This integration allows for complex signal processing and wireless transmission, connecting the technological disparity between signal transduction, conditioning, processing, and wireless communication in wearable biosensors [10].

The significant enhancement of application performance and the processing of extensive real-time data are enabled by the interconnected technologies of 5G and edge computing. Speeds are increased up to ten times by 5G compared to 4G, while latency is reduced by mobile edge computing, as it brings computing functionalities nearer to the final user within the network. The use of edge computing and 5G in healthcare applications comes with challenges [10, 11].

This chapter will cover the growth of edge computing, its growth since the arrival of 5G communication technology, and its impact on the health sector. Each of these concepts and their impacts on the society will be discussed.

OBJECTIVES OF EDGE COMPUTING WITH 5G

Leveraging edge computing within 5G technology profoundly amplifies the efficacy of wearable devices like ECG devices. This integration empowers real-time analysis, swift responses, and streamlined data transmission, fundamentally advancing the oversight and control of cardiac health for individuals.

Fig. (**1**) illustrates the five objectives of edge computing in 5G for healthcare application considering an example of Textile Electrocardiogram.

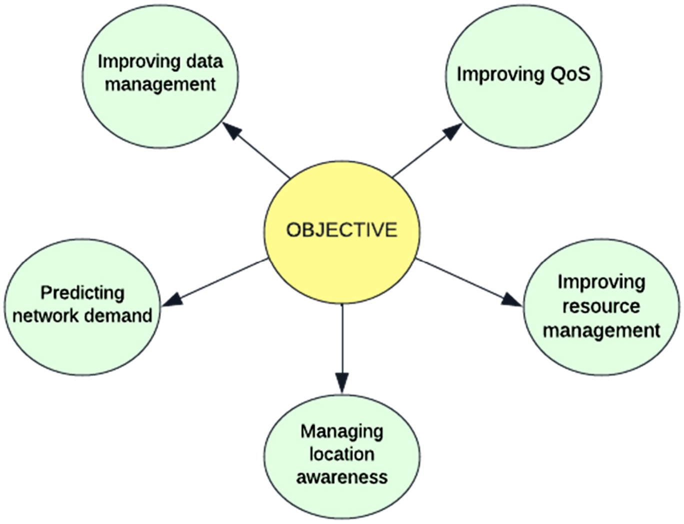

Fig. (1). The objectives of Edge computing with 5G.

CHAPTER 7

Big Data Analytics and Machine Learning for Secure and Flexible Mobile Service towards Smart Utilities

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Abstract: The proliferation of smart utilities has revolutionized the way we manage essential services such as energy, water, and transportation. Mobile technologies play a pivotal role in delivering these services efficiently. However, the sheer volume of data generated by these systems poses significant challenges in terms of security, flexibility, and overall performance. This research explores the synergy of Big Data Analytics and Machine Learning (ML) to address these challenges. We investigate how these technologies can enhance the security of mobile service infrastructures in smart utilities, ensuring the protection of sensitive data and safeguarding against cyber threats. Moreover, we explore the potential of ML algorithms to adapt and optimize mobile service delivery, ensuring flexibility in response to changing demands and environmental conditions. The study leverages real-world data from smart utility deployments, applying advanced analytics techniques to extract valuable insights and patterns. These insights enable the development of proactive security measures and the creation of flexible, adaptive mobile service models. By harnessing the power of Big Data Analytics and ML, we aim to create a foundation for smarter, more secure, and highly responsive mobile services in the context of smart utilities, ultimately contributing to the sustainable development of smart cities and communities.

Keywords: Cybersecurity, Big data analytics, DL, ML, 5G.

INTRODUCTION

In an era where technological advancements continue to reshape our world, the convergence of big data analytics, machine learning, and mobile services stands as a pivotal force, particularly in the realm of smart utilities. As our dependence on efficient and sustainable utility services grows, so does the need for innovative

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solutions that enhance their security, flexibility, and overall performance. This introduction sets the stage for exploring the profound impact of big data analytics and machine learning for secure and flexible mobile service towards smart utilities [1, 2].

The Era of Smart Utilities

The dawn of smart utilities marks a transformative shift in how we manage, distribute, and consume essential resources. From electricity and water to waste management, the integration of advanced technologies promises to make these services more intelligent, responsive, and tailored to the needs of a dynamic society. At the heart of this evolution lies the synergy between big data analytics, machine learning, and mobile services [3].

Significance of Mobile Services in Smart Utilities

Mobile services play a crucial role in connecting and optimizing various components of smart utility systems. From monitoring and control to real-time data acquisition, mobile platforms facilitate the seamless operation of utility infrastructure. However, as these services become more integral, the challenges of ensuring their security and flexibility become increasingly complex [4].

Triumvirate of Big Data, Machine Learning, and Mobile Services

Big data analytics serves as the backbone, empowering utilities to extract meaningful insights from vast datasets. Machine learning algorithms, in turn, enable utilities to predict and adapt to changing conditions, optimizing operations and resource allocation. The amalgamation of these technologies with mobile services creates a dynamic ecosystem capable of responding intelligently to the needs of both providers and consumers [5].

Security Imperatives in Smart Utilities

As the connectivity and interdependence of smart utilities intensify, so does the need for robust security measures. Cyber threats loom large, making secure mobile services an imperative. Encryption, authentication, and proactive security measures become essential components in safeguarding critical utility infrastructure [6].

Flexibility for Dynamic Environments

Smart utility operations are inherently dynamic, influenced by factors ranging from weather conditions to user demand. Machine learning algorithms, when integrated with mobile services, enable a level of adaptability that ensures utilities can respond nimbly to changing circumstances, optimizing efficiency and resource utilization. This exploration into big data analytics and machine learning for secure and flexible mobile service towards smart utilities will unfold across chapters, each delving into specific aspects of this intricate ecosystem. From laying the foundations of big data analytics and machine learning to dissecting case studies demonstrating their real-world impact, the following pages will offer insights into the challenges, opportunities, and ethical considerations inherent in this transformative journey [7, 8].

THE FOUNDATIONS OF BIG DATA ANALYTICS

In the landscape of smart utilities, big data refers to the vast volume, velocity, and variety of data generated by various components within the utility infrastructure. These components include sensors, smart meters, control systems, and other IoT devices that continuously produce a torrent of information. Big data in smart utilities encompasses structured and unstructured data, offering insights into the consumption patterns, operational performance, and overall health of utility systems. The three key dimensions of big data – volume, velocity, and variety – are particularly pronounced in the context of smart utilities. The sheer volume of data generated on a real-time basis, the rapid velocity at which it is produced, and the diverse formats it takes present unique challenges and opportunities. Big data in smart utilities becomes a strategic asset when harnessed effectively, providing a comprehensive view of the entire utility ecosystem [8, 9].

Big data analytics plays a pivotal role in transforming raw data into actionable insights, thereby optimizing utility operations and decision-making processes. By leveraging advanced analytics tools, utilities can gain a granular understanding of consumer behavior, equipment performance, and system vulnerabilities. This, in turn, enables utilities to enhance operational efficiency, reduce downtime, and proactively address potential issues. The utilization of big data in smart utilities extends to predictive analytics, allowing for the anticipation of equipment failures or fluctuations in demand. With these predictive capabilities, utilities can implement preventive measures, schedule maintenance more efficiently, and ultimately reduce costs. Additionally, big data-driven decision-making enables utilities to respond dynamically to changing conditions, fostering a more adaptive and resilient infrastructure discussed in Table **1** [9 - 11].

These examples illustrate how big data analytics empowers utilities to extract actionable insights from the massive volumes of data they generate. By harnessing the potential of big data, smart utilities can achieve operational excellence, make informed decisions, and ultimately provide more reliable and efficient services to consumers.

CHAPTER 8

An Overview of Computational Intelligence and Big Data Analytics for Smart Healthcare

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Abstract: Smart healthcare, propelled by technological advancements, is witnessing a paradigm shift in the way healthcare services are delivered. This paper explores the transformative impact of Computational Intelligence (CI) and Big Data Analytics on smart healthcare systems. Computational Intelligence encompasses artificial neural networks, fuzzy logic, genetic algorithms, and expert systems, while Big Data Analytics involves the processing and analysis of large datasets to extract meaningful insights. This integration aims to enhance the efficiency, accuracy, and personalized nature of healthcare delivery. The application of CI in smart healthcare includes disease diagnosis through medical image analysis and predictive analytics for identifying high-risk patients. Moreover, CI facilitates personalized medicine by tailoring treatment plans based on individual characteristics. On the other hand, Big Data Analytics contributes to clinical decision support, population health management, and real-time monitoring of patients. The combination of CI and Big Data Analytics enables the development of predictive models, decision support systems, and efficient utilization of data from Internet of Things (IoT) devices and sensors. However, the adoption of these technologies in smart healthcare is not without challenges. Privacy and security concerns surrounding patient data, interoperability issues, and ethical considerations demand careful attention. Establishing standards for data interoperability and addressing ethical concerns related to consent and algorithmic biases are imperative for the successful implementation of CI and Big Data Analytics in healthcare.

Keywords: Analytics, Bigdata, Clinical strategies, Computational intelligence, Healthcare.

INTRODUCTION

The healthcare landscape is undergoing a revolutionary transformation driven by technological advancements that promise to redefine patient care, optimize resou-

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rce utilization, and enhance overall healthcare outcomes. At the forefront of this evolution are Computational Intelligence (CI) and Big Data Analytics, two pillars of innovation that synergistically contribute to the concept of smart healthcare. Smart healthcare leverages cutting-edge technologies to create a connected and intelligent ecosystem, enabling healthcare providers to deliver more personalized, efficient, and effective services. Computational Intelligence (CI) encompasses a suite of advanced algorithms inspired by human intelligence, including artificial neural networks, fuzzy logic, genetic algorithms, and expert systems. These computational techniques empower healthcare systems to analyze complex datasets, identify patterns, and make informed decisions, mirroring the cognitive processes of human professionals. Big Data Analytics, on the other hand, involves the systematic extraction of meaningful insights from vast and diverse datasets. In the context of healthcare, this includes clinical data, patient records, and real-time monitoring information. By harnessing the power of Big Data Analytics, healthcare practitioners can uncover valuable patterns, trends, and correlations that were previously obscured by the sheer volume and complexity of the data.

The integration of CI and Big Data Analytics in the healthcare domain holds the promise of addressing longstanding challenges and unlocking new possibilities. From early and accurate disease diagnosis to personalized treatment plans, and from real-time patient monitoring to predictive modeling, these technologies are reshaping the way healthcare is conceptualized, delivered, and experienced. This paper provides an in-depth overview of how Computational Intelligence and Big Data Analytics are being harnessed in the realm of smart healthcare. We explore their individual contributions, collaborative applications, and the transformative impact on patient care and healthcare management. Additionally, we delve into the challenges and considerations that must be addressed to ensure the ethical and secure implementation of these technologies in the complex and sensitive healthcare ecosystem. As we embark on this journey through the landscape of smart healthcare, it becomes evident that the fusion of computational intelligence and big data analytics is not merely a technological evolution; it is a pivotal revolution with the potential to redefine the future of healthcare delivery.

LITERATURE SURVEY

The adoption of Fourth Industrial Revolution technologies, particularly artificial intelligence, and big data has presented significant challenges for industries across various sectors [1]. In the healthcare industry, the adoption of these technologies has brought both immense benefits and numerous challenges. One of the major benefits is the ability to utilize artificial intelligence and big data analytics for smart healthcare. These technologies enable the analysis of vast amounts of healthcare data, including electronic health records, medical imaging, and genomics data, to extract valuable insights and support decision-making in healthcare settings. Furthermore, the combination of artificial intelligence and big data has the potential to revolutionize clinical practice by enabling predictive modeling, personalized medicine, and real-time monitoring of patients [2].

This advancement in technology allows for more accurate diagnoses, early detection of diseases, and the development of personalized treatment plans. The use of computational intelligence and big data analytics in smart healthcare has the potential to improve patient outcomes, enhance efficiency in healthcare delivery, and reduce healthcare costs. Additionally, the integration of these technologies allows for remote monitoring and telemedicine, expanding access to healthcare services for underserved populations. In summary, the integration of artificial intelligence and big data analytics in smart healthcare is expected to bring significant innovations by improving accuracy in diagnosis, enabling predictive modeling for patient outcomes, and enhancing the overall efficiency of healthcare delivery. Furthermore, the use of computational intelligence and big data analytics in smart healthcare can also contribute to the early detection of epidemics and disease outbreaks, as well as improve population health management by identifying trends and patterns in large-scale health data.

Overall, the adoption of artificial intelligence and big data analytics in smart healthcare has the potential to revolutionize the industry by improving patient care, expanding access to healthcare services, and driving cost savings. The integration of artificial intelligence and big data analytics in smart healthcare has the potential to revolutionize the industry by improving patient outcomes, enhancing efficiency in healthcare delivery, and reducing costs [3]. By leveraging the power of computational intelligence and big data analytics, healthcare providers can make more accurate diagnoses, personalize treatment plans, and improve patient outcomes. Furthermore, the real-time monitoring and analysis of patient data can lead to early detection of diseases and timely interventions. This can ultimately result in improved population health management and overall healthcare quality [4].

ROLE OF COMPUTATIONAL INTELLIGENCE IN SMART HEALTHCARE

Computational intelligence plays a significant role in the development and implementation of smart healthcare. It involves the use of various techniques and algorithms, such as machine learning, deep learning, and natural language processing, to analyze large volumes of data from different sources [5 - 7]. These intelligent systems can learn from the data and make predictions, recommendations, and decisions to support healthcare providers in their decision-

CHAPTER 9

Identification and Interconnection of Symptoms of Hypertension using Interpretive Structural Model: A Qualitative Survey

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Abstract: Hypertension (HTN) is one of the major global public health maladies. Equally, the impact on the incidence of hypertension in smart cities is increasing due to the abundant use of electromagnetic fields like 5G. HTN may not have any warning indications so the interconnection of its symptoms is crucial for early diagnosis and management. Thus, in order to examine a set of symptoms and how they relate to one another in HTN, the authors employed interpretive structural model (ISM). In the first stage, the authors identified a total of 18 symptoms of hypertension by review. After an interview with the expert panel, 17 additional symptoms were found in the second stage. In the third stage, expert panel members were asked to rate the symptoms with a score 1 to 4. The authors used an ISM in the fourth stage to develop a causality rule-base for the diagnosis of hypertension. Any combination of symptoms, such as 1. Dizziness followed by a) Chest pain + Palpitation + Transient chest pain after exertion /or, b) Headache + Fainting. 2. Headache followed by a) Chest pain + Palpitation + Transient chest pain after exertion /or, b) Dizziness + Fainting. 3. Fainting followed by a) Chest pain + Palpitation + Transient chest pain after exertion, /or, b) Dizziness + Headache, may be used to identify hypertension. It was discovered that the presence of nosebleed symptoms did not contribute to the hypertension diagnosis. Data analytics is a common tool used by smart cities to enhance healthcare facilities. By contributing insights into the early detection of hypertension throughout smart cities, the ISM model can support data-driven decision-making and enhance the healthcare system.

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Keywords: Hypertension symptoms, Hypertension management, Interpretive structural model (ISM), Qualitative survey study, Qualitative research methods, Symptom interconnection.

INTRODUCTION

Hypertension (HTN) is one of the silent killers, contributing to cardiovascular diseases and early death worldwide. Uncontrolled hypertension results in a number of prevalent complications, such as coronary heart disease, peripheral vascular disease, congestive heart failure, renal insufficiency, and stroke [1, 2]. Equally, the impact on the incidence of hypertension in smart cities is increasing due to the abundant use of electromagnetic fields like 5G. As hypertension may not have any warning indications, the majority of people with the condition are unaware of the issue. The early detection of hypertension and the interrelation of its symptoms are therefore crucial for the timely diagnosis and management of HTN [2]. ISM, which stands for Interpretative Structural Modeling, the ISM technique, Warfield first developed in 1974, was created to handle complex challenges [3]. It allows the development of a map of intricate connections within several factors of convoluted conditions by either an individual or group of experts, that can be utilized to gain fresh perspectives and devise renewed solutions to the present problem [4, 5]. To create a visual representation of the scenario, ISM uses concept synthesis, transitive logic, and pair-wise comparison [6]. Many famous organizations, including NASA, have utilized this approach to resolve challenging problems [7]. Thus, in order to examine a set of symptoms and how they relate to one another in hypertension, the authors employed interpretive structural modelling (Fig. **1**).

First Stage: Screening and Identification of HTN Symptoms

To identify HTN symptoms, a literature review of modern literature, medical textbooks, and databases including Scopus, Science Direct, Web of Science, PubMed, Research Gate, Google Scholar, and Shodhganga was conducted. And so, after doing an extensive review, the authors identified a total of 18 symptoms, including blood in your urine (hematuria), blurred or unclear vision, headache, dizziness, fatigue, nosebleed, chest pain, shortness of breath, mental confusion, fainting, heart palpitations, nausea and/or vomiting, tinnitus (ringing in ears), sleepiness, insomnia, confusion, excess sweating, and sometimes patients are asymptomatic [8 - 19].

Second Stage: Confirmation and Verification of HTN Symptoms

Symptoms identified in the first stage by the extensive review were again confirmed and verified by an interview with ten expert panel members having eligibility for a minimum of i) Ten years of teaching/ research experience at the college/university/ industries OR ii) Ten years of experience as a practitioner. Thus, the authors from the expert panel members identified a total of seventeen new symptoms, including projectile vomiting, giddiness, tiredness, weakness in limbs, convulsions, unconsciousness, transient chest pain after exertion, chest pain relief after rest, oliguria, pain at epigastric region, generalized anasarca, swelling on face, swelling on eyelids, swelling on hand, swelling on abdominal wall, swelling on legs and swelling of vulva.

METHOD:

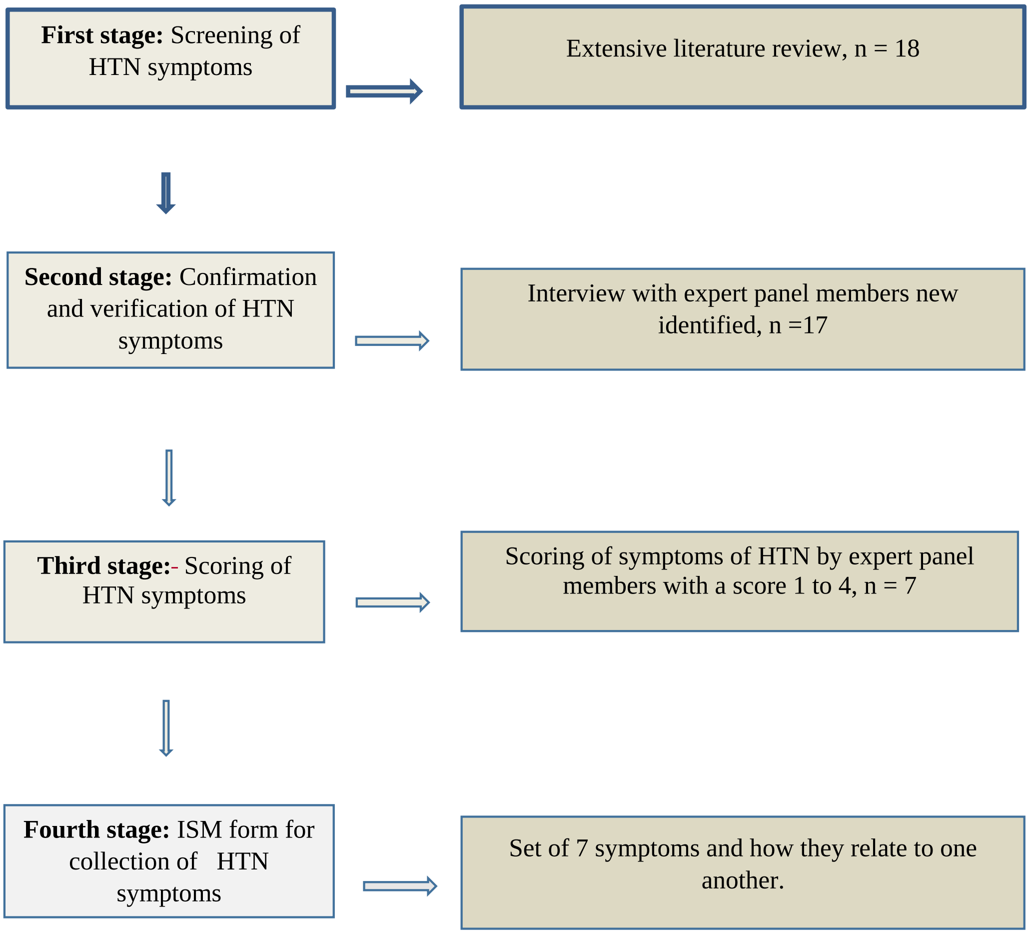

Fig. (1). The study was carried out by the use of four-stage technique.

CHAPTER 10

Health Terminology Standards: A Comparative Study for the Patient Complaint Translation System

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Abstract: When providing an acceptable diagnosis, health terminology helps with the right usage of language to describe illnesses, ailments, and symptoms in patients. There could be serious repercussions for the healthcare industry if this specification is unclear. Uniformity in medical terminology becomes essential when discussing the integration of automation and artificial intelligence into the scenario. The International Standards Organization (ISO) states that terminologies should be formal groupings of concepts that are linguistically unconnected, with a preferred name, suitable synonyms, and links between the concepts clearly expressed for each concept. To assist decision support systems, data sharing between health information systems, epidemiological analysis, research to support health services research, administrative task management, and other activities, standard terminology should be utilized in an electronic health record (EHR). This study examines ten popular clinical terminologies, including LOINC, NDC, and SNOMED Clinical Terms (SNOMED- CT), along with their histories, purposes, kinds, and structures. They also consist of CDT, CPT, RxNorm, HCPCS-Level II, and ICD-10, as well as ICD-10-CM, ICD-10-PCS, and ICD-10. Each criterion's advantages and disadvantages will be considered in this investigation. A comparative analysis is conducted by analyzing multiple terminologies to identify the advantages and disadvantages of each one separately.

Keywords: CPT, CDT, Data transmission, Electronic health records, HCPCS-Level II, ICD-10, LOINC, NDU, RxNORM, SNOMED-CT, Terminology.

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INTRODUCTION

The objective of this research is to analyze health terminologies and create a comparison table that summarizes each according to several factors, such as owner, purpose, applications, area of use, *etc.* Which one is more appropriate for clinical terminology is determined by that finding.

Due to the current COVID-19 situation, a pandemic has been declared by the World Health Organization (WHO). In this pandemic situation, the healthcare industry is being revived in many aspects. The field is undergoing technology intervention with the realization of the importance of data in an appropriate form, systematic handling of data sources such as EHRs (Electronic Health Records), sensors, and other sources like medical ontology. Healthcare organizations want to digitize processes but do not unnecessarily disturb established clinical workflows. Therefore, we now have as much as 80 percent of data unstructured and of poor quality. This brings us to a pertinent challenge of data extraction and utilization in the healthcare space through natural language processing (NLP).

This data is as it is today and given the amount of time and effort it would need for humans to read and reformat it, thus, we cannot yet make effective decisions in healthcare through analytics because of the unstructured form of available data. Therefore, there is a higher need to leverage this unstructured data as we shift from a fee-for-service healthcare model to value-based care. NLP, or natural language processing, is useful in such a scenario. Automatic computational processing of human languages is referred to as “natural language processing” (NLP). This includes both algorithms that receive a real person-written text as input and algorithms that produce natural-looking text as outputs. NLP-based chatbots already possess the capabilities of well and truly mimicking human behavior and executing a myriad of tasks. When it comes to implementing the same on a much larger use case, like a hospital it can be used to parse information and extract critical strings of data, thereby offering an opportunity for us to leverage unstructured data (Alarsh Tiwari, 2020) [1]. Interoperability in information technology refers to linking many systems and effectively exchanging data between them. Every healthcare organization keeps its patients' medical records in accordance with either local or globally recognized standards. By preventing duplications and delays, these data and health message standards support their system's ability to communicate data and make it interoperable (Benson and Grieve, 2016) [2]. This study focuses on translating patients’ chief complaints in the Marathi language into relevant medical terminology. For this, we need to analyze various standard health terminologies.

Clinical terminologies come in a variety of forms and are used in healthcare services. In this study, the most used ten clinical terminologies will be examined. The ICD-10 Procedure Coding System, Current Procedural Terminology (CPT), Logical Observation Identifiers Names and Codes (LOINC), Nomenclature for Properties and Units (NPU), and SNOMED Clinical Terms (SNOMED CT), ICD-10; RxNORM; NDU; and CDT are defined in the introduction and the remaining section of this paper is structured as follows: The background is given in Section II . Section III includes a table summarizing the ten most crucial health language standards, with associated terms. The discussion is presented in part IV, and a conclusion is provided in section V based on a study of the literature and a comparison of ten different clinical terminologies.

BACKGROUND

Both nationally and internationally, the necessity for standardized terminology in the healthcare industry has long been acknowledged. The International Statistical Institute first used the International Statistical Classification of Diseases (ICD) to classify causes of mortality in 1893 [3]. The ICD was expanded to cover morbidity in 1948, when the World Health Organization took over management of it following World War II [4]. In the same year that all countries agreed to adopt the 6th Decennial Revision of the International Lists of Diseases and Causes of Death, the suggestion to create national committees was made to assist in addressing "...statistical problems in the fields of health and vital statistics for study by national technicians as a preliminary step in the international development of standards and methods." [5]. To accomplish this in the United States, the National Committee on Vital and Health Statistics (NCVHS) was established in 1949. Numerous organizations, including the Institute of Medicine (IOM; now the National Academies of Sciences, Engineering, and Medicine), have studied the healthcare sector over the past 30 years and reported on the importance of adopting standardized terminologies and vocabularies for enhancing the delivery and quality of healthcare. The IOM revised and updated its 1991 recommendations regarding the computer-based patient record in 1997, noting that vocabulary standards were required to guarantee the integrity of clinical data in electronic health records (EHRs), as well as its retrieval, interpretation, and exchange, and that progress in improving health care would be difficult to achieve without an increase in the scope, use, and automation of the patient record [6].

Since the inception of Medicare and Medicaid, the use of standardized terminology for reporting and payment in healthcare settings in the United States has developed (enacted 1965). It took longer than anticipated to produce the nationwide standardized billing and claim forms used by the programmes, as well

SUBJECT INDEX

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