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Intelligent Handover Techniques In 6g Networks

Abstract:

Due to the rapid advancement of smart infrastructures and terminals, along with the development of applications such as augmented and virtual reality, holographic projection, and remote surgery, modern networks (forthcoming 5G and 4G networks) are likely to be inadequate in meeting the swiftly increasing traffic demands. Similarly, initiatives from both the scholarly and academic domains have been rigorously evaluated about 6G systems. Recently, artificial intelligence (AI) has been extensively used as an alternative perspective for the design and advancement of 6G systems with a significant level of sophistication. The paper advocates for AI-enhanced architectural engineering for 6G systems to facilitate information discovery, intelligent service provisioning, mechanical system adjustment, and smart resource management, with the network architecture divided into four layers: smart application layer, intelligent control layer, information search and logic layer, and intelligent sensing layer. The article further surveys and examines the applications of AI techniques for 6G organizations and elaborates on how to effectively and efficiently implement AI procedures to optimize network operations, including intelligent spectrum management, handover management, intelligent mobility, and AI-enhanced mobile edge computing. The report emphasizes essential future research topics and potential solutions for 6G networks, including energy management, hardware advancement, algorithm resilience, and computational efficiency.

Keywords— 6G networks, Artificial Intelligence, Remote networks, device-to-device (D2D) technologies, and massive machine-type communications (mMTC)

Introduction

From the initial generation of wireless networks, known as 1G, to the most recent iteration, known as 5G, wireless networks have advanced by concentrating on elements such as data throughput, end-to-end latency, dependability, energy efficiency, coverage, and spectrum use.

There are three key use scenarios that have been identified by the International Telecommunication Union (ITU) for 5G networks. These scenarios include enhanced mobile broadband (eMBB), ultra-reliable low latency communication (URLLC), and massive machine-type communications (mMTC), all of which support a range of applications [1, 2]. In this context, technologies like as millimeter-wave (mmWave), massive multiple-input multiple-output (MIMO), and device-to-device (D2D) are deployed to improve the quality of service (QoS) and quality of experience (QoE) that customers get, as well as to optimize the performance of the network. Quality of service (QoS) is a measure of how well a service performs as a whole, while quality of experience (QoE) evaluates

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how satisfied or dissatisfied a device is with the interactions it has with a service.

Both industry professionals and academics are already focusing their attention on research concerning 6G networks, which are expected to proficiently facilitate high-quality services, novel applications (such as virtual and augmented reality, remote surgery, and holographic projection), and limitless connectivity for a wide variety of smart devices. This is happening at the same time that 5G networks are being implemented. The roadmap for 6G networks was investigated in references [3] and [4], which included a discussion of the needs, enabling methodologies, and designs.

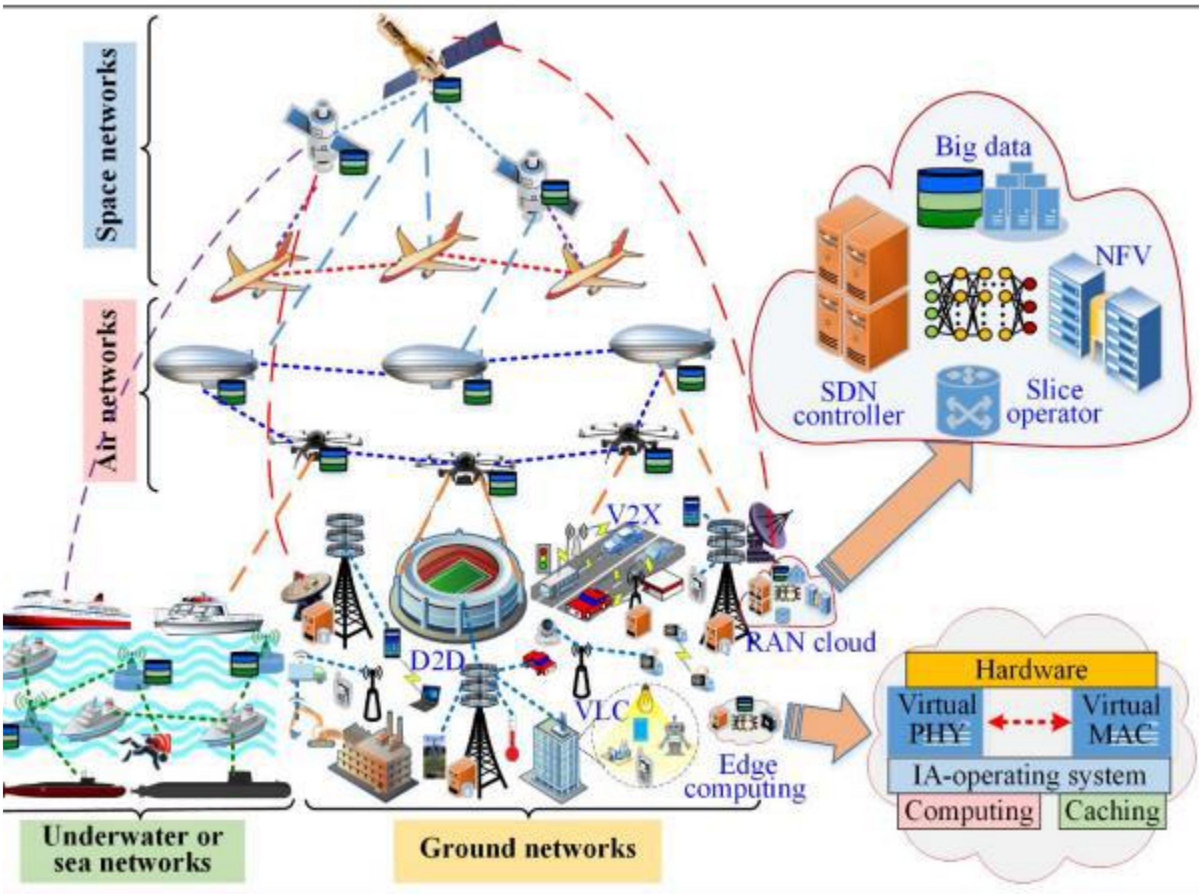

Figure 1: Architecture of 6G Network

6G networks, in contrast to networks of previous generations, are required to undergo a transformation in order to achieve intelligence that satisfies the more stringent standards and expectations of the intelligent information society of 2030. These standards and expectations include the following (three to six): ultrahigh data rates, with a peak data rate of no less than one terabit per second and a user-experienced data rate of one gigabit per second; ultralow latency, which is characterized by an end-to-end delay of less than one millisecond, with the possibility of reaching as low as ten to one hundred microseconds; ultrahigh reliability, which is approximately one to ten joules per second; high energy efficiency (EE), which is approximately one joule per second; very high mobility, which can reach up to one thousand kilometers per hour; massive connectivity, which can accommodate up to ten thousand devices per kilometer and a traffic capacity of up to one gigabit per second; extensive frequency bands (for example, 1 THz-3 THz); and integrated intelligence with artificial intelligence capabilities.

Literature Survey

Wireless systems have evolved from the 1G framework to the forthcoming 5G systems, including diverse factors such as spectrum usage, coverage, energy efficiency, dependability, end-to-end latency, and data throughput. 5G systems include three primary categories of use cases: ultra-reliable low-latency communication (URLLC) to support various essential services (Letaief et al., 2019). Consequently, device-to-device (D2D) technologies, massive multiple-input multiple-output (MIMO), and millimeter-wave (mmWave) technologies are used to provide clients with improved quality of service (QoS) and quality of experience (QoE), while also augmenting network efficiency. Alex Mathew, International Journal of Computer Science and Mobile Computing, Volume 10, Issue 3, March 2021, pages 26-31 Copyright 2021, IJCSMC All Rights Reserved Twenty-seven Despite the deployment of 5G systems, stakeholders from both industry and academia have concentrated on the exploration of 6G networks, which are anticipated to deliver superior services, accommodate emerging technologies (including virtual and augmented reality, remote scientific regulations, and holographic projections), and support an extensive array of intelligent terminals (Manogaran et al., 2020). For instance, addressed guidance for 6G networks, including requirements, enabling architecture, and methodologies.

Distinct from previous generation systems, 6G networks must adapt by assimilating knowledge to fulfill the stringent requirements of the intelligent data society of 2030, which encompasses: extensive frequency bands, traffic capacity of up to 1 Gbs/m2, support for up to 107 devices/km2, massive connectivity, exceptionally high mobility, superior energy efficiency (EE), ultrahigh reliability, an end-to-end delay of less than 1 ms, a peak data rate of no less than 1 Tb/s, and a user-experienced data rate of 1 Gb/s, alongside ultrahigh data rates and ultralow latency (Orange et al., 2020).

Based on prior development strategies of systems, the first 6G networks will fundamentally rely on contemporary 5G systems, such as the frameworks of NFV and SDN. In contrast to 5G systems, 6G networks need the enhancement of the aforementioned stringent requirements, including ultrahigh data speeds, ultralow latency, ultrahigh reliability, and seamless connectivity (Pouttu 2018). The progression of 6G systems entails significant complexity, variety, and dynamic characteristics. All these difficulties need networks that are very dynamic, adaptive, and intelligent (Basar et al., 2019). Artificial intelligence (AI), with robust learning capabilities, exceptional cognitive abilities, and astute recognition skills, enables the design of 6G systems to intelligently adapt and support diverse applications without human intervention.

Overview of Handover Issue and Related Work

The mobility handover procedure may substantially impair performance in cellular networks. Consequently, standardization organizations like as the Third Generation Partnership Project (3GPP) and the Internet Engineering Task Force (IETF) have established several defined handover techniques to enhance the quality of service for end-users. [16].

To facilitate mobility in cellular networks, 3GPP has established the General Packet Radio Service (GPRS) Tunneling Protocol (GTP), which roots user plane and control plane traffic at designated core entities. In 5G networks, the User Plane Function (UPF) anchors user plane traffic, while the Access and Mobility Management Function (AMF) anchors control plane traffic [18]. Handover in 5G networks may be executed in two methods. The first way involves the Xn interface, which creates a direct link between gNBs. Alternatively, changeover may occur via the N2 interface between the gNB and the AMF when an Xn handover is impractical, such as owing to altered radio circumstances, load balancing, or absence of Xn access to the destination gNB, among other reasons.

The serving gNB determines the initiation of the handover procedure. This procedure consists of three separate phases: handover preparation, execution, and completion. The serving gNB assesses the need of a handover based on measurement reports from the MN, which include indications of the radio signal strength of both the serving and adjacent cells, as experienced by the MN. During a handover executed over the Xn interface, the serving gNB transmits downlink packets to the target gNB using this interface to prevent packet loss during the handover process [20], [21].

The IETF has introduced the Proxy-Based Fast Mobile IPv6 Protocol (PFMIPv6), an enhancement of Proxy Mobile IPv6 (PMIPv6) [22], in which the Local Mobility Anchor (LMA) serves as the primary topological anchor for the mobile node's home network prefix(es). In PFMIPv6, the Mobile Access Gateway (MAG) is tasked with detecting the movements of Mobile Nodes (MNs) to and from the access link, as well as managing binding registrations to the MNs' Local Mobility Anchor (LMA).

During the handover process, a bidirectional tunnel is established between the serving MAG and the target MAG to facilitate the transfer of packets designated for the MN [23]. The primary drawback of PFMIPv6 is that the tunneling expenses increase significantly when configuring several handover destinations. The authors of this research previously shown that an IP-over-ICN design may mitigate these expenses [14], [24]. These research specifically shown how the IP-over-ICN design may eliminate tunneling via a permanent anchor point, hence enhancing overall network efficiency. The solution presented in this study expands upon this notion by using flexible multicast and handover prediction to address the shortcomings of previous systems, as detailed in subsequent sections.

The preceding discussion clearly indicates a continued need for innovative handover solutions capable of ensuring high quality of service for end-users. A significant number of research initiatives concentrate on using Software Defined Networking (SDN) for mobility management [25].

Nevertheless, the majority of these SDN methodologies are inapplicable to large-scale networks since mobile flow inputs must be evaluated against matching rule fields at each OpenFlow switch along the route. This incurs substantial expenses in mobile flow management. In [26], the authors provide a software-defined seamless handover technique using passive wireless connection quality measures. This solution employs a handover management algorithm that includes decision-making and execution mechanisms to enhance mobility and facilitate make-before-break handovers. In [27], an approach for estimating mobility and available resources based on SDN is introduced to facilitate smooth changeover.

This system employs a Markov chain formulation to evaluate the transition probability of mobile nodes between neighboring base stations and their resource availability probabilities. This technique enables the selection of the most appropriate target base stations and their virtual assignment to the mobile nodes. All connections are then formed with OpenFlow tables. Reference [28] proposes a Software-Defined Networking (SDN) based 5G core, which adheres to the standard 3GPP 5G architecture. The objective of the effort is to foster flexibility, streamline administration, and eradicate vendor reliance inside the network. All aforementioned efforts need the modification of OpenFlow rules in each SDN router along the user's path and demand a distinct rule for every mobile node. This would result in flow-table depletion in conventional large-scale implementations.

AI-Enabled Intelligent 6G Networks

The advancement of 6G networks will be extensive, multi-faceted, exceedingly intricate, dynamic, and diverse. Moreover, 6G networks must provide uninterrupted connection and ensure varied Quality of Service (QoS) needs for the vast array of devices, while also managing substantial data created from physical settings. AI techniques endowed with robust analytical, learning, optimization, and intelligent recognition capabilities can be utilized in 6G networks for performance optimization, knowledge discovery, advanced learning, structural organization, and complex decision-making. Utilizing AI, we provide an AI-enabled intelligent architecture for 6G networks, which is primarily segmented into four layers: the intelligent sensing layer, the data mining and analytics layer, the intelligent control layer, and the smart application layer, as seen in Fig. 2. This four-layer bottom-up design effectively functions as a transparent conduit between the physical realm (encompassing generic physical and virtual entities, items, resources, etc.) and the social sphere (including human needs, social behaviors, etc.). We will initially present many prevalent AI approaches as follows. AI approaches include multi-disciplinary methodologies, including machine learning (supervised, unsupervised, and reinforcement learning), deep learning, optimization theory, game theory, and meta-heuristics [9]. Machine learning and deep learning are the most prevalent subfields of AI, extensively used in wireless networks.

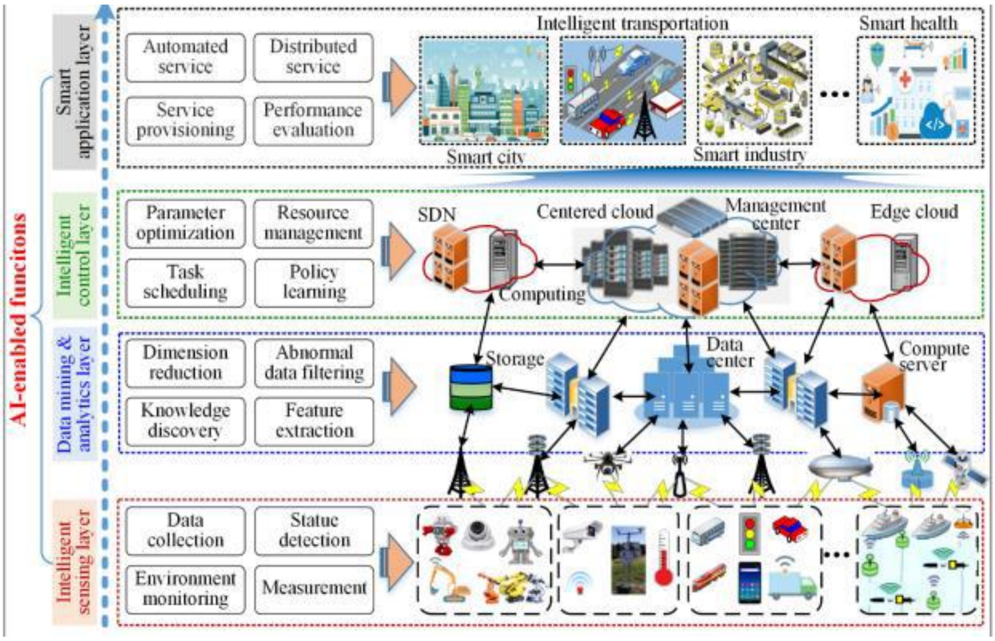

Figure 2: Methodology for 6G Networks

Deep Learning is an artificial intelligence function that emulates the human brain's ability to comprehend data representations and generate patterns using artificial neural networks. It has many layers of neurons, and the learning model may be supervised, semi-supervised, or unsupervised. Traditional deep learning techniques include deep neural networks (DNN), convolutional neural networks (CNN), recurrent neural networks (RNN), and long short-term memory networks (LSTM).

Intelligent Sensing Layer

Sensing and detection are fundamental functions of 6G networks, which aim to intelligently perceive and identify data from physical surroundings via a multitude of devices (e.g., cameras, sensors, cars, drones, and smartphones) or large groups of individuals. AI-enabled sensing and detection can intelligently gather extensive, varied, and scalable data by directly interacting with the physical environment, primarily encompassing radio-frequency utilization identification, environmental monitoring, spectrum sensing, intrusion detection, and interference detection. Highly precise, real-time, and robust sensing are of significant relevance, since 6G networks must provide ultra-reliable and ultra-low latency communication services. Moreover, changing 6G networks result in ambiguity about spectrum characteristics, posing significant challenges for robust and precise sensing. Artificial intelligence methodologies can facilitate precise, real-time, and resilient spectrum sensing. Fuzzy Support Vector Machines (SVM) and nonparallel hyperplane SVM exhibit robustness against environmental uncertainties. Convolutional Neural Network (CNN)-based cooperative sensing enhances accuracy while maintaining low complexity. The integration of K-means clustering with SVM enables real-time sensing through the training of low-dimensional input samples. Additionally, Bayesian learning effectively addresses large-scale heterogeneous sensing challenges by managing heterogeneous data fusion.

Methodology

The expansion of 6G systems will be extensive, multifarious, dynamic, highly complicated, and diverse. Furthermore, 6G systems need the provision of reliable networks and the guarantee of diverse Quality of Service (QoS) requirements for various devices, as well as the processing of substantial volumes of data generated from real-world environments (Sheth et al., 2020). Artificial intelligence techniques with strong evaluation capabilities, learning abilities, optimization potential, and astute recognition skills can be integrated into 6G networks to intelligently enhance performance, facilitate data discovery, refine learning, organize structures, and support complex decision-making (Chowdhury et al., 2020). Utilizing AI, the study introduces an AI-enhanced technique for 6G systems, primarily divided into four layers: smart application layer, intelligent control layer, analytics layer, and intelligent sensing layer.

The methodology for 6G Networks encompasses several AI techniques, including meta-heuristics, game theory, optimization theory, deep learning, as well as supervised, unsupervised, and machine learning approaches. Among these strategies, deep learning and machine learning are the most prevalent AI methodologies widely used in wireless systems (Viswanathan and Mogensen 2020).

The objective of unsupervised learning is to identify hidden patterns and derive important insights from unlabeled data, and it is categorized into clustering and dimensionality reduction. Grouping aims to consolidate a collection of tests into distinct categories based on their similarities, mostly via K-means clustering and hierarchical clustering methods (Giordani and Zorzi 2020). The reduction of measurement transforms a higher-dimensional information space into a lower-dimensional framework without sacrificing essential data. Isometric mapping (ISOMAP) and Principal Component Analysis (PCA) are two primary dimensionality reduction approaches. Typically, detection and recognition are the most basic tasks in 6G networks, which adeptly gather extensive data from real-world environments via various devices, including smartphones, drones, automobiles, sensors, and cameras (Yang et al., 2019). AI-enabled detection and recognition systems may collect dynamic, reliable, and adaptive information by interacting with the physical environment, primarily via radiofrequency identification, environmental monitoring, spectrum sensing, intrusion detection, and obstacle recognition.

Algorithms

The elevated data transmission capacity and minimal idleness of 5G networks have significantly enhanced the VR/AR experience for 5G users (Zhang et al., 2019). Nevertheless, significant challenges remain in the implementation of obstructive VR in 5G networks, which must be addressed in 6G networks. Cloud VR/AR services may provide immersive experiences for users; nevertheless, latency is a significant concern, and the resulting unpredictability leads to further complications (Chowdhury and Jang et al 2019). Delivering VR/AR via cloud services enhances accessibility and compactness; nevertheless, due to 5G transmission rates, images must be compressed, necessitating the advent of 6G networks for the real-time transmission of substantial volumes of lossless images or videos.

In 6G systems, the immersive experience of virtual and augmented reality will be enhanced. Diverse sensors will be used to collect tactile data and provide feedback to users. Consequently, the XR in 6G systems is likely to integrate traditional Ultra-Reliable Low Latency Communications (URLLC) with enhanced Mobile Broadband (eMBB), which may be characterized as Mobile Broad Bandwidth and Low Latency (MBBLL) (Dang et al., 2020). The exceptional security and protection challenges associated with eMBB and URLLC in multisensory XR applications include malicious behavior, access control, and internal communication.

Results

The cutting-edge wireless correspondence framework will comprise enormous self-healing and self-organizing robots. Collectively, these AI robots need high calculation power. The requirement for energy will be expanding with the expansion in savvy robots. Conventional GPUs are not gathering the energy productivity necessities of cutting-edge remote network correspondence systems. In such a situation, an energy-proficient and adaptable, insightful organization configuration will be required. The business has shifted towards the IoTs, IoBTs, and EVs. The sensors are conveyed all over the place. In the entryway, there is a sensor in the forced-air system, in-vehicle, on the TV, in the fridge, in workplaces. Every one of these sensors needs energy-productive correspondence.

Through the expansion in the number of linked gadgets, the higher limit channels and back-pulling demand expanded. An exceptionally thick sent sensor system creates more than tara bytes (TB) of information regularly. This information creation needs a high limit back-pulling channel to oblige the traffic. In the past remote ages (1G-to-5G), remote conventions are intended for some particular frameworks. With the improvement of mMTC and IoTs, there is demand to have force-productive and cost-effective gadgets to be planned. This Internet of Things (IoT) correspondence prompts the advancement of vehicular correspondence, for example, self-ruling driving named V2X (vehicle-to-foundation). The vehicle needs to associate with others vehicle, with people on foot, and numerous sensors introduced in the vehicle. Jointly, this correspondence should be amazingly dependable and with relatively lower inertness and safety. Modern robotization is another model where many sensors are conveying and creating a colossal measure of information. The base area traffic capacity for 6G is about 1000Mbps/m

Technology enabler	**Pros**	**Cons**	**Use cases**	**Research initiatives**
Quantum Communication (QC) and QML (72.75)	Faster High-performance processing Power	Costly Complex	Drug industry Radar industry Mathematics	D-Wave Systems Inc. IBM Corporation Intel Corporation Cambridge Quantum Computing Limited
Blockchain 161. ZZ Z8.80	Distributed Stability Integrity Immutability Traceability	Inefficient High storage Privacy concerns Decentralize	Supply-chain Voting Healthcare Security Digital identity	IBM Alibaba Group (China) Fujitsu (Japan) Mastercard ING Groep (Dutch banking firm)
Reconfigurable Intelligent Surfaces (RIS)s [55.50)	Low complexity Power efficient Low cost	Difficulty in phase configuration	Comm. and Defense industry	-World-wide

Conclusion

For the purpose of supporting a variety of services, enhancing network performance, and delivering dependable availability, this research suggests the use of AI-driven knowledge engineering for 6G systems. This is accomplished via the application of AI methodology. The research has shown a wide range of applications that are powered by artificial intelligence (AI) in order to address many elements of the supply of 6G systems. These applications include AI-enabled flexible edge processing, intelligent spectrum management, handover management, smart mobility, and cognitively enhanced mobile edge computing. In the end, the research highlights a number of intriguing prospective routes for inquiry and potential solutions for 6G networks.

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