Next-Generation Routing Paradigms: A Technical Exploration of 5G and 6G Wireless Networks

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Abstract: ***Routing is a critical component in the architecture of 5G and 6G networks, playing a pivotal role in achieving the high data transmission rates and advanced features anticipated in the forthcoming wave of wireless communication. This article explores the developments and methodologies being integrated into 6G, focusing on key technologies such as Machine Learning (ML) and Deep Learning (DL) to enhance routing efficiency. These technologies enable routing algorithms to be intelligent, adapting in real-time to network conditions for optimal data transmission, reduced latency, and efficient resource utilization. The study also examines the role of dynamic network slicing, edge computing, and enhanced security measures, highlighting how these emerging technologies work in tandem to improve routing paths. By analyzing current research trends and technological advancements, this survey provides insights into how 6G networks will evolve beyond previous generations. It offers a vision of how 6G will address routing challenges, fostering a more interconnected, secure, and responsive communication framework that supports the growing demands of future digital ecosystems.***

Keywords: 6G Networks, Machine Learning, Deep learning, Routing Algorithm, Wireless Communication

1. Introduction

The rapid increase in mobile data traffic, driven by globalization and the rise of new technologies like IoT, AI, blockchain, and connected devices, is pushing the limits of current mobile networks. According to the International Telecommunication Union's Radio communication (ITU-R) sector, global mobile data traffic is projected to skyrocket from 158 Exabytes (EB) per month in 2022 to 5016 EB per month by 2030[1], with individual users expected to consume 257 GB of data each month by 2030. This growth reflects a surge in mobile internet usage, with an estimated 70% of the global population relying on mobile services by 2025. To meet these increasing demands, 5G technology has been deployed globally, providing faster data speeds and lower latency. However, as automation and data-driven innovations continue to evolve, 5G may not be sufficient. Enter 6G technology, which promises ultra-fast speeds, minimal latency, and vast coverage to handle the explosion of data traffic. 6G will connect the digital, biological and physical realms through the use of AI and ML; this will pave the way for innovations like smart cities, driverless cars, and holographic communication in real time. 6G will lay the foundation for future technologies, offering the connectivity needed for a highly integrated, data-intensive world.

1.1 The Progression of Telecommunication Technology: From 1G to 6G

The era of telecommunication began in the early 1980s and has witnessed extensive growth in the later decades, with significant advances in data speeds, connectivity, and efficacy [2-3]. The evolution of telecommunication technology is presented in Figure 1.

The first stage of mobile wireless technology, known as 1G, was mostly based on analog methods and started in the 1980s. Data transfer speeds were low, and the sound quality was bad. Introduced in the 1990s, 2G mobile communications networks allowed users to send and receive Short Messages Service (SMS) and, to a lesser extent, email. Several examples include Global System for Mobile Communications (GSM), Code Division Multiple Access (CDMA), and others in the field of mobile communications.

The third-generation (3G) networking that emerged in the 2000s allowed for more rapid data transfers, online browsing, and the support of multimedia messages. Some examples are Enhanced Data Rates for GSM Evolution (EDGE), CDMA2000, and Wideband CDMA (WCDMA). In the 2010s, fourth-generation (4G) networks enabled online gaming, video conferencing, and High Definition (HD) streaming of video by improving network coverage and data transfer rates. Technologies like WiMAX and Long-Term Evolution (LTE) are a few examples. The IoT, smart city and the fourth industrial century are anticipated to be set up by the 5G networks, which were released in 2018. With AI integrated into the network infrastructure at every level, 6G mobile networks provide unprecedented coverage, lightning-fast data transfers, and incredibly low latency. These networks will utilize all terahertz (THz) conversation, ultra-massive Multiple-Input Multiple-Output (MIMO), AI, ML, quantum communication, etc.

1.2 Development of 6G Technology

The current terrestrial network is insufficient for 6G worldwide coverage, necessitating a comprehensive network that integrates non-terrestrial networks for diverse applications. The 6G architecture will be expansive, devoid of

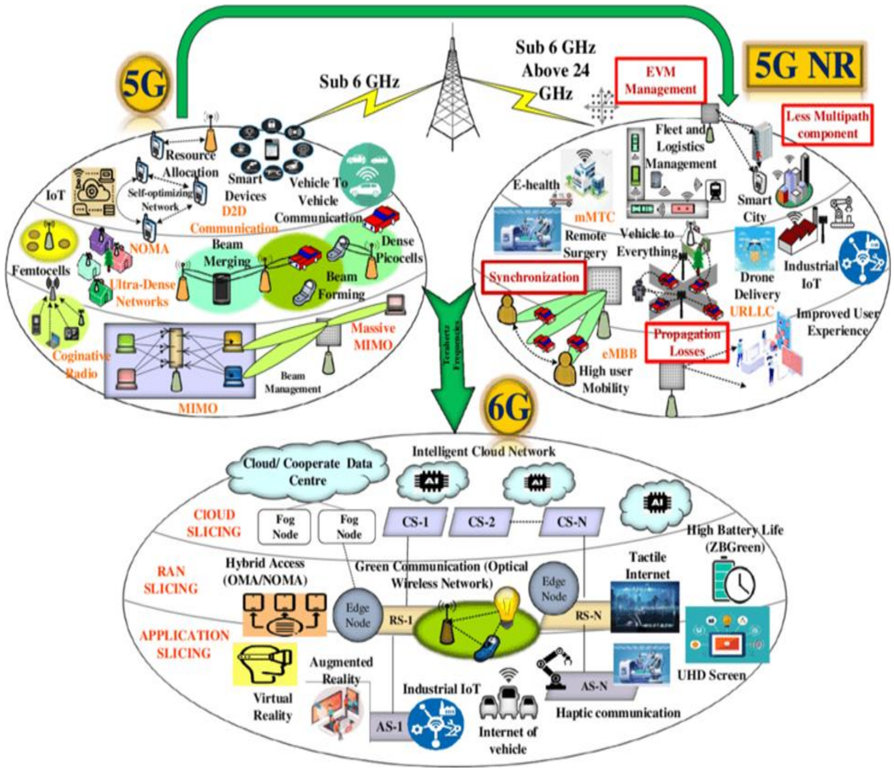

Figure 1: 6G Mobile Technology

cells, and structured into four tiers: space, air, terrestrial, and marine [4], as depicted in Figure 1.

The space network tier will provide broadband internet access in space, and the expansion of 6G coverage using THz frequency bands will be accomplished by the terrestrial layer data transfer.

On the other hand, the 6G network will get more crowded and path loss will grow. 5G will enable the Internet of Things network concept to progress into real-time monitoring; the Tactile Internet will center on the identification, control, access, and modification of virtual items in real-time. For a wide variety of uses, photonic solutions are on the horizon; for example, photonic heterodyne mixing will pave the way for the easy integration of wireless and fiber communications. An essential component of 6G networks, Visible Light Communication (VLC) systems function between 400 and 800 THz [5]. Light-Emitting Diodes (LEDs) and also image sensors are the backbone of VLC's transceiver communication, which outperforms Radio Frequency (RF) technology in interplanetary applications like nautical and aviation.

1.3 Characteristics of 6G Networks

According to popular belief, 6G wireless networks will significantly outperform 5G in a number of key areas. Compared to 5G, the upcoming 6G wireless network is said to feature ten times greater spectrum and network efficiency, fantastic coverage, ultra-low latency, an enhanced user experience with AI and VR, and data transfer speeds exceeding 10 Tbps. They will also enable over 1 million connections, a hundredfold increase compared to current 5G networks, and offer high-energy efficiency, resulting in extended battery life and enhanced sustainability [6]. Achieving efficient communication across many systems is made possible by integrating 6G networks with various technologies such as the IoT, cloud computing, etc. The results of 4G, 5G, and 6G technologies are compared in Table 1. [7].

6G networks can facilitate services like robotic surgery, VR, Unmanned Aerial Vehicles (UAVs), IoT, Vehicle-to-Everything (V2X), and machine-to-machine collaboration [8]. They require broad connectivity, ultra-reliable and low delay, increased energy efficiency, enhanced security and privacy, resource optimization, and global coverage [9]. They are expected to be deployed around 2030, with the potential to emerge earlier in specific regions. Chinese telecom giants China Mobile, Huawei, and ZTE are among those investigating 6G possibilities [10]. The US Federal Communications Commission (FCC) has launched the "THz wave" to test future standards [11], with research being spearheaded by LG and the University of Oulu in Finland. Though 6G technology has great potential, it may be some time before it comes to fruition.

1.4 Routing Protocol in 6G Networks

Future communication systems will need routing protocols for 6G networks that can handle extremely low latency, extremely high bandwidth, extremely mobile users, and extremely connected devices. Unlike previous generations, 6G networks incorporate cutting-edge technologies like AI/ML-based optimization, blockchain for security, and quantum communication for enhanced performance. Listed below are a few important features and possible 6G routing systems.

1) AI-Driven Routing Protocols
- AI/ML models analyze real-time data to optimize routing decisions.

- Use Reinforcement Learning (RL) to select optimal paths dynamically.

Example: Deep Q-Learning for packet routing in dynamic topologies.

2) Quantum-Assisted Routing

Table 1: Evaluation of 6G, 5G, and 4G Networks

Performance indicators	*4G*	5G	6G
Prominent frequency	6 GHz	90 GHz	10 THz
Maximum data transmission speed	1 Gbps	10 Gbps	1 Tbps
Service level	Video	VR	Tactile
Efficient use of the spectrum	15 bps/Hz	30 bps/Hz	100 bps/Hz
Coverage %	< 70%	80%	> 99%
Efficiency in energy usage	< 1000x related to 5G	1000x related to 4G	> 10x related to 5G
AI	No	Partial	Completely
The density of connections	2000devices/ km^2	1 million devices/ km^2	> 10 million devices/ km^2
Low delay	100 ms	1 ms	0.1 ms
Precise positioning	Meter level (50 m)	Meter level (20 m)	Centimeter level
Transmission of Haptic	No	Partial	Completely
End to End reliability	99.9%	99.999%	99.9999%
Structure	MIMO	Massive MIMO	Smart surface
Sensitivity of the receiver	~ -100dBm	~ -120dBm	~ -130dBm
Virtual world expansion	No	Partial	Completely
Providing support for mobility	350 km/h	500 km/h	≥ 1000 km/h
Combination of satellites	No	No	Completely
Autonomous vehicle	No	Partial	Completely
THz transmission	No	Limited	Extensively

- Quantum communication leverages quantum entanglement for secure and efficient routing.
- Quantum Internet integration can enable protocols that utilize Quantum Key Distribution (QKD) for highly secure data transfers.

3) Blockchain-Based Routing
- Uses blockchain to enhance trust and security in multi-hop routing.
- Decentralized systems prevent data tampering during routing.
- Useful in securing communication for autonomous systems and IoT devices.

4) SDN-Based Routing
- Centralized control over routing using SDN controllers.
- Dynamic allocation of resources based on network requirements.
- Compatible with Network Function Virtualization (NFV) for flexible and programmable networks.

5) 6G-Specific Ad Hoc Routing Protocols
- Designed for dynamic environments like UAV swarms, V2X, and mobile edge networks.

Example: Optimized Link-State Routing (OLSR) with machine learning for predictive maintenance.

6) Edge-Enabled Routing
- Utilizes edge computing to make routing decisions closer to the data source.
- Reduces latency by minimizing the need for backhaul communication with central servers.

7) Cluster-Based Routing Protocols
- Devices are grouped into clusters to optimize communication.

Example: Optimized Cluster-based Protocols (OCP) using evolutionary algorithms like Genetic Algorithms or Walrus Optimization Algorithm (WOA).

1.5 Applications

- Smart Cities: Routing protocols in 6G need to handle massive IoT deployments for real-time traffic management, energy optimization, and smart utilities.
- Autonomous Vehicles: Low-latency and reliable routing for V2X communication in autonomous systems.
- Telemedicine: Real-time data transfer and routing for high-definition holographic communications in remote surgeries.

1.6 Challenges in Current Routing Protocols

6G intends to address a number of issues that present routing systems encounter, despite the improvements in 5G.

- The existing conventional routing protocols lack flexibility. They cannot handle dynamic networks as required by modern applications causing inefficiency in resource utilization and high latency at tuned traffic or node mobility. [12]
- When more devices join, extreme latency and congestion during rush hours affect the routing protocols that are challenged to maintain quality, particularly in critical applications [13].
- Current routing protocols are not easily scalable as more devices are connected and this results in creating bottlenecks and degradations in performances [14].

The below sections are prepared as follows: Section 2 reviews routing techniques in 6G- networks and Section 3 concludes this study and suggests future enhancements in the 6G era.

2. Survey on Different Routing Techniques in 5G and 6G Networks

A framework was created to facilitate interaction between UAVs and their various participants as they exit the communication zone, enabling connectivity with Low-Earth-Orbit (LEO) satellites. Incentive functions were applied based on the urgency of user information and the transfer linkages among UAV participants. They also evaluated constantly altering parameters to make accurate decisions based on historical errors via the QL scheme.

A method to improve UAV networks' energy efficiency was proposed by Duhayyim et al. [16]; it is called Energy Aware Data Collection with Route Planning for 6G-enabled UAV communication (EDACRP-6G) and it is based on 6G-enabled UAV communication. To choose the best Cluster Heads (CHs) and organize clusters, EADCRP-6G uses the Improved Red Deer Algorithm-based Clustering (IRDAC) system, and to find the best routes, it uses the Artificial Fish Swarm-based Route Planning (AFSRP) system. This two-pronged strategy overcomes issues like inefficient routing and excessive power consumption in environments with limited resources by efficiently collecting data from clusters and selecting the best possible paths for data transmission in 6G-enabled UAV networks.

To achieve extremely low latency communication in a 6G Wide Area Network (WAN), Das et al. [17] developed a Hybrid Fibre Optic-Wireless (FiWi) architecture, which combines fiber optics with wireless technology. Using a local wireless network, messages were directed from a source node to the closest access point on the network of backbones in this architecture. From there, the message was quickly and efficiently sent to an access point that was geographically close to the last node by means of the backbone network. The message was sent to its destination via a local wireless connection from this access point.

In order to obtain great energy efficacy and resilience for B5G/6G networks, Mesodiakaki et al. [18] created a Robust heuristic algorithm (P-HEUR) to handle customer organization, BH traffic routing, and the switch of BS and BH links. The PHEUR method consisted of three phases. Initially, the process connected user equipment (UEs) and solved Backhaul (BH) traffic routing without considering uncertainties. Then, it aimed to improve energy efficiency by deactivating base stations (BSs) and BH links while adjusting connections and routes. Finally, it accounted for demand uncertainties and deactivations, adjusting the solution to ensure constraints were met.

Duong et al. [19] have proposed a Routing protocol in 6G named Intelligent Routing Algorithm based on ML (IRSML) in software defined wireless networking. It is used in Software - Defined Wireless Networking (SDWN). Routing in SDWN is usually done by Integer Linear Programming Problem (ILP). It focuses on efficient routing standards by providing rejection ratio, minimized end –to end delay (EED), maximizing network throughput. IRSML is a combination of RL and Supervised Learning.

For 6G networks, Marinho et al. [20] introduced Coverage Area Increased Network (CAIN), an AI system that is both intelligent and energy-aware when boosting coverage regions. In order to increase the network's coverage area, the CAIN sent out several messages to nodes that were farther away from an Access Point (AP), based on the node's connection to the AP. If a node lacked an AP connection, the CAIN would choose an adjacent node with an AP connection to send the message. Additionally, in the absence of an adjacent AP connection, the node would choose an adjacent node to transmit the message until it reaches the AP. This CAIN was enhanced by AI algorithms like RL, Federated Learning (FL), and DNN.

Gururaj et al. [21] suggested a Collaborative Energy-Efficient Routing Protocol (CEERP) for viable transmission in 5G/6G WSNs. First, they collected the information at the sink node. The RL grouped the network's nodes and selected the CH for improved data transfer based on the remaining energy. Then, the CEERP was applied with a Multi-Objective Improved Seagull Algorithm (MOISA) to improve the network’s performance.

A load-balancing routing algorithm based on Deep Q-Networks (DQNs) was applied to Low Earth Orbit (LEO) satellites by Dong et al. [22]. This algorithm used Deep Reinforcement Learning (DRL) for optimizing routing selections for 6G Space-Air-Ground Integrated Networks (SAGIN). The routing decisions were made by a source node in the Iridium constellation structure, which required randomly creating pairs of starting and ending nodes. Arrival at the final destination node marked the end of the route and the result of the routing process.

By utilizing AI, Haseeb et al. [23] developed a Multi-Hop Optimization Framework that includes a trustworthy routing algorithm for autonomous systems. 6G technology ran on the higher level, between the network's edge and sink nodes. To safeguard communications, the protocol guaranteed authentication and data secrecy, and optimization techniques were used in the routing process.

Luetal. [24] has proposed a Routing protocol in 6G named Graph SAGE – Path-diverse reliable routing algorithm for Wireless Mesh Networks. Graph SAGE creates a strategy to generate network labels for supervised training. Network labels and Graph SAGE learns graph features to obtain values of Optimization of shortest path performance. After assessing network conditions, the optimal route with the highest performance is chosen for data transmission.

To improve the efficiency of path discovery in 6G networks, Tilwari et al. [25] created the Multi-Criteria Aware Integrated Decision-Making (MCAIDeM) routing protocol. This protocol unifies various criteria into a single approach for IoT communication. The protocol evaluated the levels of congestion in the network's data traffic using a Modified Back Pressure (MBP) method. When choosing a path, it took into account things like mobility, link quality, queue duration, and node residual energy.

Swetha et al. [26] designed a novel routing protocol tailored for 6G networks, addressing challenges such as ultra-dense networks, dynamic traffic patterns, and diverse communication needs. This protocol, called Network Extension and Security Routing Protocol (NEXUS), utilized advanced AI techniques, including Supervised Learning (SL), RL and Graph Neural Networks (GNN), to optimize routing paths and manage network resources efficiently. NEXUS enhanced coverage and ensured secure routing by adhering to 6G requirements like ultra-low latency, high throughput, and energy efficiency. It also supported ad-hoc communication in disaster scenarios, overcoming limitations posed by fixed base stations, ensuring seamless 6G-era operations.

Tshakwanda et al. [27] developed a 6G network management system using a two-tiered AI/ML framework involving Speed Optimized Long Short-Term Memory (SPLSTM) and RL. The SP-LSTM approach was applied for initial predictive analytics in routing, while RL dynamically managed routing applications. Qlearning, an RL technique, utilized network topology elements such as Massive MIMO, mmWave communications, network slicing, edge computing, SDNs, and VNFs. Open Shortest Path First (OSPF) implemented Dijkstra's shortest path algorithm to optimize data transmission paths, thereby enhancing network management.

Mageswaran et al. [28] deployed a Data Transmission Rate Allocation (DTRA) method. To enhance data transmission for efficient nodes, a Residual Energy Cluster Head (RECH) method was implemented. Additionally, reliability and speed in the 6G network were improved using the Dynamic Multipath Routing Protocol (DMRP), which also mitigated channel defects. Lastly, in 6G communication networks, Quality of Service (QoS) was ensured by optimizing the transmission rate of user equipment through low energy consumption, and enhancing channel quality through the DTRA method.

A Query-Driven Clustering (QDC) methodology was suggested by Gong et al. [29] to enhance WSN energy efficiency. There are four consecutive sections to the proposed QDC. Partitioning a large-scale WSN into multiple smaller sub-networks using 5G infrastructure is the first step in a size-balanced a system partitioning algorithm. Second, minimization of energy consumption during centralized sub-network maintenance of information is the goal of an estimation-based mechanism. The third step is to reduce the massive amount of energy needed to cluster nodes worldwide by implementing centralized query-driven clustering techniques in each sub-network to group those query targets. Lastly, a load-balanced and energy-efficient routing system was created for each sub-network's inter-cluster routing.

The IMIMO-5G based BEE protocol, which stands for Intelligent Multiple Input Multiple Output and Balanced Energy Efficiency, was suggested by Dogra et al. [30] for use in WSN intra- and inter-clustering. This protocol lays out the methods for multihop routing's CH selection, intra- and inter-clustering formation, and more. Next, select two CHs to house the sensors and manage energy consumption; doing so will extend the network's lifespan and enhance its coverage area through the usage of long-distance inter-cluster transmission. An IMIMO-5G-based BEE will initially partition the network into intra- and inter-clusters in order to distribute the energy consumption among the CHs. Data will be transmitted from the sensors to the CHs, which will in turn transfer the information towards the BS. With the help of clustering and multihop structure, the nodes communicate with one another to reduce reaction time by exchanging data from source to destination, and clusters closer to the BS has a smaller radius.

Data transmission along the chosen path is improved by an energy-efficient routing protocol suggested by Arya et al. [31] that is based on Deep Belief Networks (DBNs). Since this is the case, the PDR is enhanced. Starting with a network-wide clustering of nodes, this architecture uses a RL method to reward nodes that are part of each cluster. After that, the appropriate CH for efficient data transfer is selected using an MRFO method. The data is transmitted to the sink node via the selected CH using an efficient deep learning algorithm. Finally, the proposed deep network-based routing protocol is evaluated using a number of metrics. Lifespan of the network, power consumption, amount of live nodes, and pace of packet delivery are all examples of such measures.

According to Jothikumar et al. [32], a hierarchical routing technique can be advantageous for Internet of Things applications in 5G environments and beyond. which improves energy efficiency and network longevity. The k-means method and the multihop method are utilized by the Optimal-CBR protocol for node clustering and chain routing, respectively. The data transmission continues with the chaining phase after the clustering phase ends when two-thirds of the node have died. During the cluster phase, all nodes are grouped together using the standard k-means algorithm. The CH is selected as the one with the greatest energy node that is geographically closest to the centroid. The CH acts as a relay, gathering packets sent by its members and sending them on to the BS. Because there aren't enough live nodes to cluster through the chaining phase, the surviving nodes use multihop routing to generate chaining and send data to the BS.

The centralized non-uniform clustering routing method (C-EEUC) was introduced by Chen et al. [33] and is based on communication expenses and residual energy. As the process defines a weight matrix P, it considers all nodes to be potential cluster leaders for the clustering stage. Included in the values of the matrix elements are the following: the basis chosen by the cluster head, the residual energy of the nodes, and the communication expense between the nodes and the cluster head. When choosing a cluster head, every time the most heavily loaded node is chosen, all the other nodes in the competition range stop trying to outdo each other and the set of potential cluster heads is updated.

An intelligent routing method for 6G-enabled WSNs was created by Zhang [34]. Given the non-uniformity and overlap of areas in network transmission, an energy prediction-based approach for node coverage and scheduling is suggested. As a second point, has been figured out how to make wireless sensor networks use less energy by predicting their use using a clustering technique. Incorporating energy characteristics into the actual prediction computation as influencing elements, the operating state model of the network sensor is set up. Lastly, intelligent routing uses a clustering mechanism and the Particle Swarm Optimization Algorithm (PSO) to aid in path selection, which in turn increases the wireless network's fault tolerance while dealing with massive volumes of dynamic data.

The above-discussed routing techniques for 5G and 6G communication networks are evaluated in terms of their advantages, drawbacks, and performance metrics in Table 2.

Table 2: Comparison of Different Routing Techniques in 5G and 6G-Empowered Communication Networks

Ref. No.	*Techniques*	*Merits*	*Demerits*	*Performance Metrics*
[15]	A delay-aware QL-based routing (XiA)	It reduces delay effectively.	It needs to integrate multiple ground-level APs to further improve the network performance.	Data rate (For Bandwidth in range of 100 − 500 GHz) = 15 Tbps; Bit Error Rate (BER) =10dBm
[16]	EADCRP-6G	It lengthens the life of the network and decreases its energy usage.	Delay and throughput were not satisfactory.	Energy consumption for 100 UAVs = 159mJ; Network lifetime for 100 UAVs = 4490 rounds; Throughput for 100 UAVs = 0.63Mbps; Mean delay for 100 UAVs = 6.88s
[17]	Mailbag routing	Because of this, 5G and 6G technologies can meet their requirements for extremely low latency.	To improve the distribution of message traffic and reduce queue delay at intermediary routers, a concentric circle of optical fibers should replace the Manhattan grid architecture in the backbone.	Average routing time = 46-79 µs, Average E2E delay for a packet of size 1KB = < 380μs
[18]	P-HEUR	Very Low Execution Time	Could not cope with uncertainty	With 40% deviation, Γ = 5, EC =1800000 bits/J, Execution time =0.1s, Price of Robustness = 48%; Mean Constraint Violation; Probability = 0.4%, Mean unsatisfied user probability = 0.1%. All the results are taken at 6th hour of the day
[19]	IRSML	Optimizes multiple objectives, improves QoT, reduces EED, enhances throughput.	High computational complexity, training time, reliance on accurate data.	Packet Delivery Ratio (PDR) = 93.94%, Average throughput = 289.36Mbps.
[20]	CAIN	It increases the network coverage and reduces storage overhead efficiently.	The mean number of messages reaching the CHs was low.	Mean communication delay for 100 devices = 2e-09s; Mean communication distance for 100 devices = 0.32m; Mean No. of messages reaching the CHs for 100 devices = 1.6; Mean storage overhead for 100 devices = 7 Kbyte
[21]	CEERP	It increased network lifetime and energy efficiency.	Routing overhead was high. Also, it needs to incorporate optimization schemes with more sophisticated data transfer.	Throughput = 90%;Energy consumption = 90%; Network lifetime = 95%;Packet permission = 85%; Routing overhead = 95%;Transmission speed = 92%
[22]	DQNLLRA	It reduced a mean queue utilization and achieved a robust load-balancing ability.	Making the most efficient routing selections also requires thinking about things like network dependability, congestion stage and energy consumption.	Path delay for 100 test flows = 90s; Path maximization queue utilization for 100 test flows = 0.76%; Path average queue utilization for 100 test flows = 0.31%
[23]	Multi-Hop Optimization	Low energy consumption	Computation overhead is high	Data Delivery Ratio for 500 nodes = 88%;Nodes overhead for 500 nodes = 12%;Energy consumption for 500 nodes= 0.13J;Latency for 500 nodes = 3.2s; Computational cost for 500 nodes = 10%
[24]	Graph SAGE	Reliable transmission, congestion reduction, improved throughput	High complexity, training overhead, scalability issues	Average end-to-end delay = 48.8ms, Packet loss rate = 46.75%, Throughput = 54.3 packet/s
[25]	MCAIDeM	It provided significant insights for the design of real-time implementation systems based on diverse network factors.	It needs to select best route by incorporating ML algorithms for future heterogeneous 6G networks.	Throughput for 100 nodes = 25 Kbps; Delay for 100 nodes = 2.7ms; Energy consumption for 100 nodes = 110mAh
[26]	NEXUS	Enhanced coverage, low latency, energy efficiency	Complexity, high computational requirements, scalability challenges	Network Lifetime = 92s, Average throughput = 6Mbps, Energy Consumption = 62 J
[27]	SP-LSTM with RL	It optimally balanced predictive and real-time responses, enriching network performance in varying conditions.	In real-time networks, a single agent in the RL may oscillate between many policies, resulting in instability in routing decisions.	Mean squared error (MSE) = 1.04132e-0.7; Training accuracy = 98.22%; Prediction accuracy = 99.998%,Training Duration =184.34s; Prediction Duration = 22.30s.
[28]	RECH, DMRP, DTRA	Enhances energy efficiency and network lifetime	May require advanced hardware and infrastructure	Throughput = 80.4%; Energy efficiency = 86.8%, Transmission speed = 90.01s; Network Lifetime = 96.3%
[29]	QDC protocol	Load-balanced inter-cluster routing scheme.	Limited scalability in extremely large networks.	Energy Consumption for effective monitoring phase = 296J; Network Lifetime for effective monitoring phase = 2762 rounds; Network Lifetime for non- effective monitoring phase = 511 rounds
[30]	IMIMO protocol	Improved network lifetime with energy balancing	Potential challenges in scalability for large IoT networks	Network Coverage Area = 90m; Transmission delay (100 rounds) =1 sec, Transmission delay (400 rounds) = 0.1 s
[31]	DBN routing	It enhances network lifetime by	Computationally expensive and	For 200 nodes: Throughput = 0.954s; Energy

	protocol	optimizing data transmission and energy consumption	harder to implement in resource-constrained environments.	consumption = 0.4J; Network Lifetime = 32320s
[32]	Optimal-CBR protocol	The hierarchical routing approach optimizes energy use, enhancing the network's overall energy efficiency.	It can be computationally intensive, especially for large network	Average residual energy at 1200 rounds) = 0.49J; Total alive nodes at the end of 1000 rounds = 278; Energy expenditure of the CH at 200 rounds = 0.13J; PDR = 0.9.
[33]	C-EEUC	Energy-efficient, extended network lifetime, optimized routing.	Complex selection, potential competition inefficiency, scalability issues.	Total live nodes after 1000 rounds is 100
[34]	Intelligent routing using clustering and PSO for WSN	It has better energy efficiency and achieved faster user response.	Number of node failures remained high.	No. of node failures (@ 350 rounds) = 99; Average energy consumption (@ 350 rounds) = 0.8%

3. Performance Evaluation

This section outlines the evaluation of WSN models, focusing on number of live nodes and the Energy consumption as key performance metrics. The protocols were tested under various simulation environments to assess their efficiency in practical applications. Figure.2. displays the results of a protocol-by-node performance analysis for the DBN, Optimal CBR, C-EEUC, and PSO protocols, where the number of rounds and the initially available node are crucial factors. Here, average of nodes and rounds are taken for comparing all methods. Based on the data, it appears that DBN has 40 live nodes, Optimal CBR protocols have 70, C-EEUC has 60, and Cluster-PSO has 100.

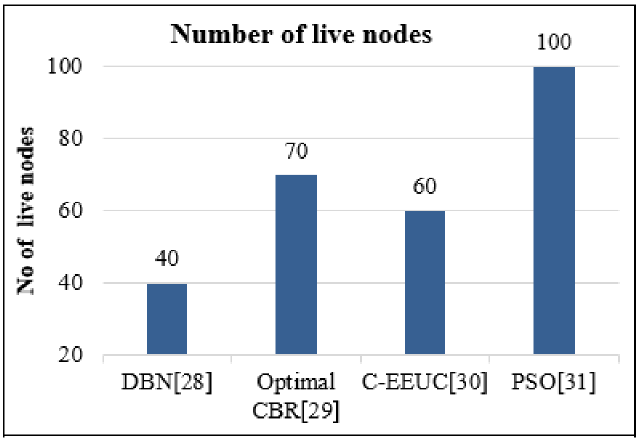

Figure 2: Testing data- load current (amperes)

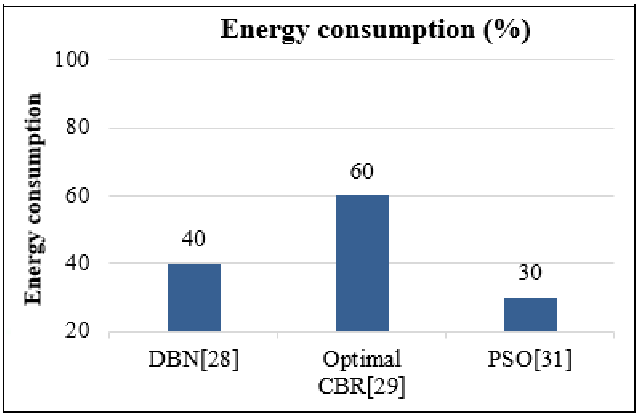

Figure 3: Performance analysis of Protocols based on their Energy Consumption

The comparison results show that the Cluster-PSO have better performance than other models. An analysis of the energy usage of three distinct protocols DBN, Optimal CBR, and PSO is shown in Figure. 3. The average values of each method is calculated based on the number of nodes utilized in the paper. The power consumption of DBN is 40%, Optimal CBR is 60%, and PSO is 30%.

4. Conclusion

The demand for future communication networks with stable and efficient routing mechanisms is increasing rapidly. Designing intelligent routing protocols is critical to optimizing network performance, particularly in the complex, dynamic, and re-source-constrained environment of 6G networks. AI-driven 6G networks offer promis-ing solutions to address these challenges. This paper provides a comprehensive sur-vey of ML and DL algorithms developed to optimize routing protocols in 6G net-works. The advantages, limitations, and performance metrics of these algorithms are summarized in a tabular format to identify existing challenges and research gaps. The study highlights the pivotal role of routing algorithms in developing intelligent, adaptive, and efficient routing protocols for future 6G networks. Ongoing advance-ments in AI techniques are expected to enable 6G networks to achieve enhanced routing reliability, scalability, and adaptability, catering to the diverse requirements of individuals, organizations, and industries. Future research will focus on creating AI-powered routing algorithms that overcome the limitations of traditional ap-proaches, ensuring robust and efficient communication in 6G networks.

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