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Mobile Networks Toward 5G/6G: Network Architecture, Opportunities and Challenges in smart city

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ABSTRACT This research meticulously delves into the dynamic evolution of mobile networks, specifically charting the course from 4G to 6G within the context of smart cities. It carefully illuminates the distinct roles played by 5G and 6G, highlighting their unique mobility characteristics. Motivated by observed challenges in handover scenarios, particularly in urban and high-speed environments like trains, the study addresses the complexities of implementing Distributed Mobility Management during inter-handover shifts, revealing a 38% success rate in Handover Failure (HOF) recovery. A thorough analysis ensues, scrutinizing the message structures of various protocols and their extensions employed to address handover challenges. The paper not only identifies limitations but also proposes innovative protocol schemes to overcome inter-handover link failures and delays. Introducing the novel SRNEMO DMM framework, the paper aims to provide a comprehensive understanding of ongoing research efforts and potential future directions, reshaping the landscape of handover scenarios in high-traffic urban environments.

INDEX TERMS 5G, 6G, Handover, Mobility Management

I. INTRODUCTION

A Smart city is a developed Urban area equipped with the latest inclusive innovations and 5.0 industry revolution technologies. Smart cities handle big data whereby integrating critical sectors such as healthcare, transportation, agriculture, finance, and environmental conservation. [1]. In smart cities it is important to have a compatible connection to keep all the high traffic of data managed in a seamless connection [2].

The provided figure 1 outlines a spectrum of challenges faced by smart cities in the domain of mobility. It highlights the pressing concerns that urban areas encounter as they grow and become more technologically integrated. Smart city initiatives aim to address these mobility issues using a variety of innovative approaches.

The detrimental effects caused by IoT sensor disruptions have been identified by Kim and Park [4]. These effects compromise the operational integrity of traffic signals, consequently affecting both urban safety and traffic flow. The implications of software anomalies in 5G V2X communication frameworks are examined in the research conducted by Liu and Wang [5]. These anomalies have a significant detrimental effect on the routing protocols utilized by emergency services.

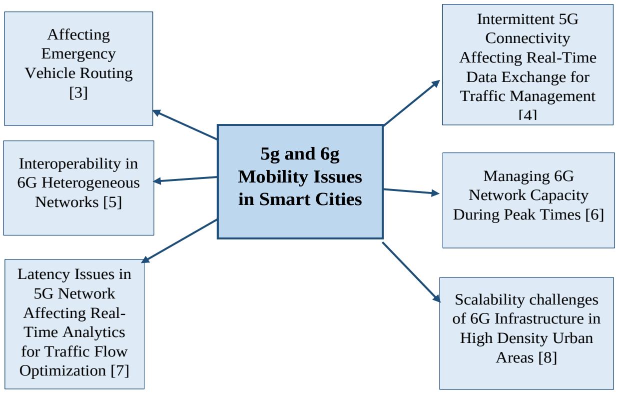

Fig. 1. Mobility Issues in Smart Cities

Chen and Lu [7] discuss the critical need for advanced interoperability solutions within the intricate urban network mosaic of 6G. With the advent of 6G, the issue of network capacity overloads is expected to take on new dimensions due to the sheer volume of data and the number of connected devices. Gupta and Kumar [8] explore how these capacity challenges are likely to occur during peak commute times, potentially leading to service degradation in smart city applications.

O'Reilly and Murphy [9] delve into the latency challenges that will need to be overcome to achieve the real-time analytics

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required for optimized traffic flow in the smart cities of the future. The scalability of network infrastructures to support the burgeoning demands of smart city ecosystems is a pivotal concern that 6G must address.

The Internet Engineering Task Force (IETF) working group has certified and approved the Network Mobility Basic Support (NEMO BSP) protocol for the mobile networks [77]. The NEMO BSP protocol was developed to effectively provide Internet connection for a group of passengers in a roaming vehicle. Additionally, in the NEMO BSP protocol, particular gateways known as Mobile Routers (MRs) which oversee the mobility management functions. This protocol solution has some key drawbacks include potentially poor routing, expensive signaling, scalability, signaling handoff, latency. Given the high traffic in smart cities, the mobility aspect faces several limitations. To address this, we will analyze various mobility management protocols. Each protocol will be examined based on its approach and the limitations identified from these approaches. Following this analysis, a new scheme will be proposed to overcome these limitations.

A. THE DIFFERENT ROLE OF 5G AND 6G

The majority of contemporary gadgets now have various communication interfaces (e.g., 4G, 5G, 6G, and WiFi (wireless fidelity), etc.). For data communication, they often employ any of these accessible communication interfaces. Multiple communication interfaces being used simultaneously is predicted to perform better in terms of throughput and delay, especially in the case of massive file transfers, as opposed to using one interface at a time [10]. Additionally, maintaining communication through all network interfaces may be a superior solution to the fictitious retransmission timeouts (RTO) [11] issue that occurred during different networks technology handoffs. However, in order to cut costs, the majority of cell carriers are constructing dual equipment, for example, the 5G infrastructure alongside current 4G equipment [12].

A stable internet connection is now a fundamental requirement across various settings. Due to the exponential growth of Internet usage, various network technologies have emerged in recent years, including WiMAX, 4G, and 5G. While WiMAX and 4G are somewhat comparable, 5G stands out with superior features. Table 1 will illustrate the difference between those three, there was a huge difference between the first two compared to the 5G in terms of bandwidth and such parameters [12][13].

TABLE 1

DIFFERENT SPECIFICATIONS OF MAJOR ACCESS NETWORKS

Specification	**WiMAX**	**4G**	**5G**
latency	10 milliseconds (ms) baseline – 30 ms in handoff	10 ms baseline -50 ms handoff	1 ms baseline – 60 ms handoff
Throughput	Downlink >350mbps* Uplink > 200 Mbps	Downlink 350 mbps Uplink 76 mbps	Downlink 2000 mbps(2 gbps) Uplink 1000 mbps (1 gbps)
Mobility	350KM/H	350KM/H	500 KM/H

To understand 5G we need to learn specification of the fifth-generation mobile telephony (5G) from the Third Generation Partnership (3GPP), The first time 3GPP has ever mentioned 5G is during the 15-release version [17], when 5G was introduced as an enhancement of LTE. 5G was fully specified by the 3GPP is 2019.

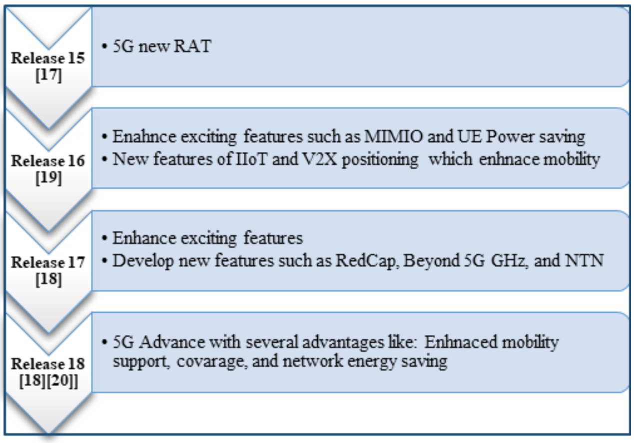

Fig. 2. 3GPP release

3GPP defines 5G's interfaces and protocols across network layers to facilitate its comprehensive deployment. To enable the full 5G mobility system, the data plan, control plan, session control of data exchange, mobility management, and all services should be specified by 3GPP. 3GPP has applied the main infrastructure of 5G development and made inter and intra handover possible. Currently the 3GPP is working on release number 18 [21] of specification related to 5G, which is assumed to be completed by 2024. 3GPP has not only contributed in 5G but all the previous network standards.

5G surpasses LTE with wider coverage and larger bandwidth, fully supporting an extensive array of smart devices [14], meanwhile 5G could accomplish full coverage due to its larger bandwidth.

5G's spectrum allocation affects its speed and coverage, with higher bands offering more bandwidth but limited range due to environmental factors. Higher spectrum bands offer higher bandwidth, enabling the efficient transfer of large volumes of data, thus facilitating higher network performance [15]. However, these high-band spectrum signals face challenges in terms of signal propagation due to environmental obstacles, leading to limited coverage. In contrast, lower spectrum bands have a more extended range but offer lower bandwidth and performance [16]. Figure 2 illustrates the main events through 3GPP release on 5G.

Global economic impact from the deployment of the 5G cellular network is predicted to be $13.1 trillion [21]. 2020’s COVID-19 pandemic revealed the value of digital infrastructure, especially 5G to help keep society connected.

5G is yet deployed in every section of this globe, however it's an ideal time for learning institutions and businesses to concentrate on beyond 5G or towards 6/ the series progressions to meet information needs as well as communications technology [22].

6G, currently without a formal specification, is envisioned as an evolution of 5G technology. However, 6G research and development has already begun as an evolution of 5G (fifth generation) technology. 6G is expected to bring additional significant advances in wireless connectivity, including increased speed, reduced latency, expanded bandwidth, and higher reliability. This includes emerging innovations such as terahertz frequencies, AI-driven networks, and new forms of antennas. Among the key challenges that 6G mobility management must address include:

- 6G networks are expected to handle significantly higher speeds than 5G, necessitating efficient management of high-speed mobility [23]. As a result, 6G mobility management must be capable of handling high-speed mobility.
- Massive connectivity: 6G networks are expected to accommodate many more network connections than current 5G networks.
- A crucial requirement for 6G networks is the achievement of ultra-low latency, particularly crucial for real-time applications like remote surgeries and autonomous vehicles.

Table 2 shows the difference between 5G and 6G in mobility.

Aspect	5G [24-28]	6G [27] [29-32]
Density	Struggle in ultra-dense areas like smart cities.	Handle extremely high device densities effortlessly, using AI-driven resource management.
Mobility Management	Utilizes network slicing and edge computing for improved mobility.	Integrates AI and ML for superior mobility management.
Quality of Experience (QoE)	Offers enhanced user experience compared to LTE, limited in highly dynamic smart city.	Provide unparalleled QoE with ultra-reliable, low-latency communication, ideal for complex smart city applications.
Quality of Service (QoS)	Better connectivity and reduced latency.	Promises exceptional QoS with near-zero latency.
Base Station Handover	Facilitating faster handovers for continuous connectivity.	Ensuring smoother handovers with advanced technologies like URLLC for uninterrupted service.
Data Transfer Rate	Peak rates up to 20 Gbps.	Expected to enable rates 100 times faster than 5G.
Protocol	Using NEMO BSP With Software defined network (SDN), and flow-based approach	Using AI and Machine learning in advanced networking strategy

One of the challenges regarding the handover process between 5G and 6G networks is the possibility of incompatible technologies. Due to the introduction of new technologies in 6G networks that may not be compatible with 5G networks [35], ensuring seamless handover between these networks may become difficult. Consequently, there may be a need for new handover procedures, which could add complexity to network management. Another issue emerges from the utilization of diverse frequency bands in 6G networks. Projections indicate that 6G will adopt higher frequency bands than 5G [36], leading to non-overlapping coverage zones. Furthermore, integrating fresh technologies and frequency bands might extend handover times and heighten the chances of call drops or data loss [37][38].

B. MOTIVATION

The most fundamental of all benefits in 5G Technology is the handover process [101]. Handover process in 5G has been re-engineered so it's very different relative to previous generations. The efficiency of the handover process is significant as it makes sure that the users; experience is seamless and uninterrupted. Provided all these advancements, the 5G handover process continues to struggle when swapping between cells of different sizes. This is the area where the efficiency of 5G is often questioned [102]. According to tests done in North America it is observed that handover failure (HOF) rate is 7.6% in urban areas and 21.7% in downtown area while successful recovery from HOF is only 38% [103]. End-to-end average latency of 4.5 to 15.5 ms are demonstrated in a wide area network [104]. But the core process that leads to efficiency includes intricate algorithmic designs and anticipatory data analysis, all of this often involves high computational costs and is very energy consuming.

The current telecommunications infrastructure is predominantly made up of 4G and emerging 5G networks. This dominance is not merely due to the newness of 5G but also because of the extensive investment in 4G over the past decade [105]. Despite the rapid deployment of 5G, 4G remains relevant due to its widespread availability and reliability. The interplay between these two technologies is crucial, as seamless handover between them is essential for maintaining consistent user experiences. This is particularly true as devices often need to switch between 5G's high-speed capabilities and 4G's broad coverage. As devices frequently transition from high-speed 5G networks to broadly spread 4G networks. Data shows 5G data connections succeeded 98.4% of the time, compared to 97.8% for 4G [106]

The handover from 4G to 5G is the primary focus provided the concurrent functioning of these networks during the ongoing stage of 5G rollout. The proficiency of handover between 4G and 5G is a patchwork scenario. On one side, we observe that link failure rates are lower as compared to other [107]. On the other side, the expenses to maintain these

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handovers is very high, both from the angle of investment in infrastructure and amplified operational costs [108]. Delays/ lags are another problematic area, though the delays have been decreased substantially, less than 1ms [109], the vulnerability of 5G applications to lag highlights that even minimal delays can be of significance.

Implementation of DMM in the switch from 4G to 5G is challenging because of difference in infrastructure, the requirement of protocol standardization, adhering to precise latency criteria, and securing and sustaining QoS levels. Plus, the expenses of acquiring and testing the essential infrastructure to support DMM are very high.

Handover performance indicators identify multiple areas where optimization could be advantageous:

1. Link failure rates [109-110]. Lags in the handover sequence, even with advancements, remain problematic for real-time data services [111].
2. The failure rate that the train industry faces currently is troubling [112-113]. A high-speed train travelling at a speed of 3ookm/h needs to switch from one network to another every two minutes. A lag or failure in handover will disrupt the passengers' internet access.

DMM deals with handover delay by localizing mobility management, but the variability in delay is shaped by node velocity and network density. DMM can reduce the delays about 12% [114]. DMM's cost structure is multifaceted, offering the prospect of decreasing operational costs through resource optimization, counterbalanced by significant upfront infrastructure upgrade expenditures [115].

The newest DMM protocols struggle in accommodating high node speeds and crowded network conditions where quick handovers are essential, potentially resulting in service interruptions despite mitigation strategies. Furthermore, addressing the complexity of DMM algorithms adds to the complexity of implementation. Overcoming the challenges of achieving interoperability with existing systems is crucial for DMM to be fully efficient.

C. CONTRIBUTION

Future mobile networks, including 5G and 6G, will face significant technical hurdles regarding mobility and handovers. Stable connections in future networks require enhanced mobility and handover strategies. We stress the importance of tackling mobility issues to make advanced mobile networks work well.

The contributions of this article include:

- a brief introduction to mobility management in 5G and 6G heterogeneous networks.
- summarizing and discussing previous research on mobility management for connected UE, with a particular focus on performance, network operation, and connectivity issues.
- The main emphasis is on the handover signalling cost that affects the mobility of connected UE in mobile networks, including a detailed discussion of 6G and beyond.
- Introducing a proposed framework to override the limitations in current handover schemas.
- Numerical Analysis for different mobility schemes.

The rest of the paper is organized as follows: Section 2 provides a brief background on network standards and mobility management in 5G advanced networks, while Section 3 reviews and examines current research on handover management for efficient networks, Section 4 proposes a new schema to enhance handover management in inter handover, section 5 is a numerical analysis, and Section 6 concludes the research.

II. BACKGROUND

A. MOBILITY MANAGEMENT

Mobility management ensure seamless connectivity during user mobility. It involves managing handovers and location updates to maintain uninterrupted communication sessions as shown in figure 3.

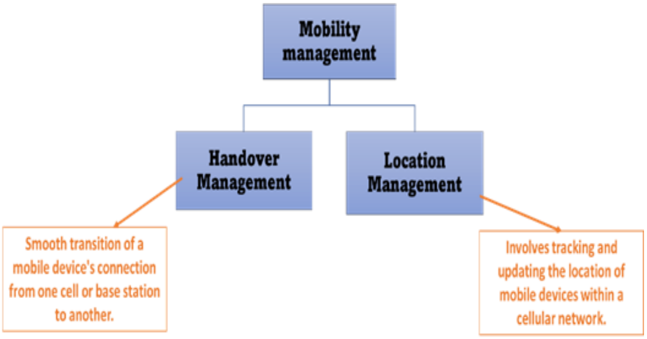

Fig. 3. Mobility Management

Handover occurs in three main steps [38-40]. Figure 4 demonstrate the phase of handover.

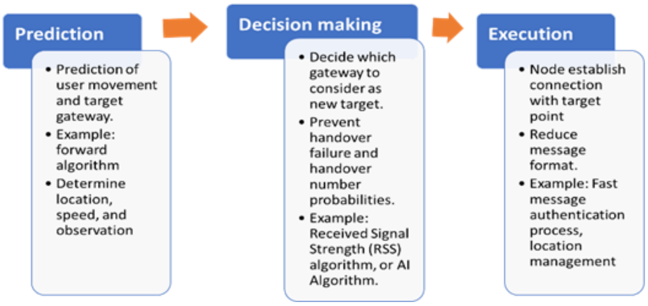

Fig. 4. Handover Management Phase

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In the realm of mobile communication networks, particularly in the domain of wireless technologies such as cellular networks, Wi-Fi, and related systems, two distinct categories of handovers come into play. These are known as Vertical Handover and Horizontal Handover. These terms encompass diverse scenarios and strategies tailored to effectively manage the intricate process of transitioning a mobile device across varying network types or technologies. Navigating the intricacies of vertical handovers can be a challenging endeavor due to the diversity in factors such as signal strength, coverage span, data transmission rates, and latency metrics [41].

On the other hand, the pivotal challenge within Horizontal Handovers lies in accomplishing a smooth transition with minimal disruption to the ongoing communication session [42].

III. HANDOVER MANAGEMENT REVIEW

A. *MIPV6 SCHEME FOR HANDOVER MANAGEMENT*

In Mobile IPv6 [53][54], handover, also known as "handoff," is the process of transferring an ongoing communication session of a mobile node (MN) from one access point (e.g., base station or router) to another while maintaining seamless connectivity. This allows the MN to move between different network attachment points without interrupting active communications. Handover in MIPv6 is essential for providing continuous service to mobile devices as they move within the network. The handover procedure in MIPv6 involves the following key steps:

- Detection of New Access Point: The MN continuously monitors the strength of the signal from nearby access points. When it detects a new access point with better signal strength, it initiates the handover process.
- Binding Update: Once the MN decides to handover, it sends a Binding Update (BU) message to its Home Agent (HA). The BU contains information about the new care-of address, which is the address of the new access point the MN is moving to.

Figure 5 illustrates a message structure utilized in network communications, detailing various components.

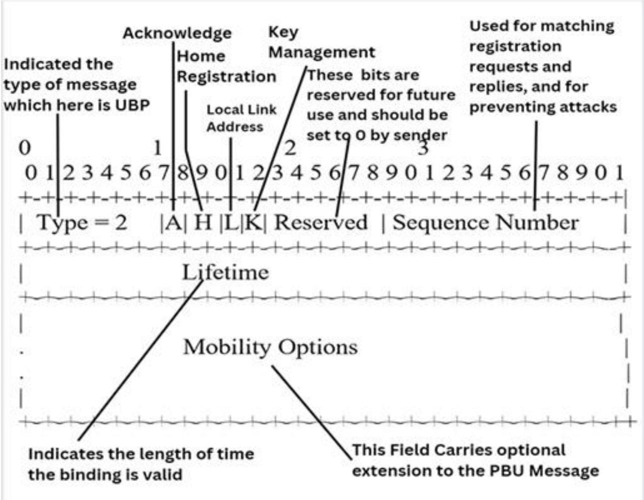

Figure 5. MIPV6 Message Structure.

Limitations include High Latency, Packet loss due to overhead when increased MNs and centralized [55].

In figure 6, the Mobile Node's transition between networks is depicted. Initially connected to the 'Previous Access Router' with a 'previous Care of Address', the Mobile Node moves and connects to the 'New Access Router', obtaining a 'new Care of Address'. This process is facilitated by the 'Home Agent (HA)' which maintains a registration of the Mobile Node's home address and its current location, allowing seamless communication with the 'Corresponding Node (CN)' over the Internet. The HA acts as a permanent anchor for the Mobile Node, redirecting packets to the current Care of Address, thus ensuring continuous connectivity as the Mobile Node roams between different network domains.

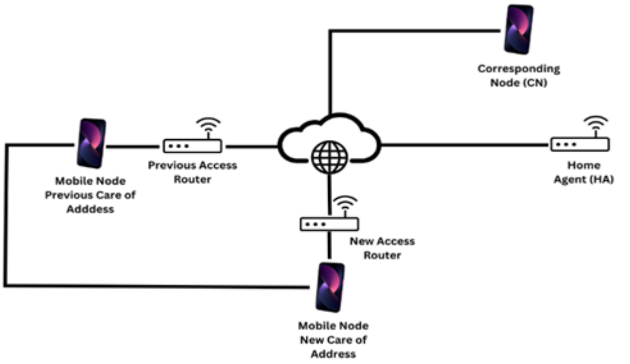

Figure 6. MIPV6.

Numerous enhancements have been introduced to the MIPV6 network protocol with the aim of bolstering its mobility management capabilities.

B. *PROXY MOBILE IPV6*

In Proxy Mobile IPv6 (PMIPv6) [63], the handover procedure allows a mobile node (MN) to move between different access networks without the need for active involvement or signaling from the MN itself. Instead, the mobility management is handled by a network entity known as the Local Mobility Anchor (LMA) and the Mobile Access Gateway (MAG).

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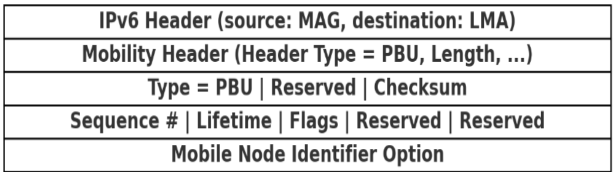
PMIPv6 is designed to offload the mobility management tasks from the MN to the network, making it particularly useful for scenarios where the MN may not be capable of handling complex mobility protocols. The handover procedure in Proxy MIPv6 involves the following key steps:

- Movement Detection: When the MN moves to a new access network served by a different MAG, the MAG detects the MN's presence.
- Proxy Binding Update (PBU): The new MAG sends a Proxy Binding Update (PBU) message to the LMA, notifying it of the MN's new location. The PBU contains the MN's identifier (such as the Home Network Prefix) and the new MAG's address.

Message structure of the PMIPV6 is includes several components as shown in Figure 7:



IPv6 Header (source: MAG, destination: LMA)
Mobility Header (Header Type = PBU, Length, ...)
Type = PBU | Reserved | Checksum
Sequence # | Lifetime | Flags | Reserved | Reserved
Mobile Node Identifier Option

Limitation includes Signalling cost (Need to update location frequently) [64] and centralized.

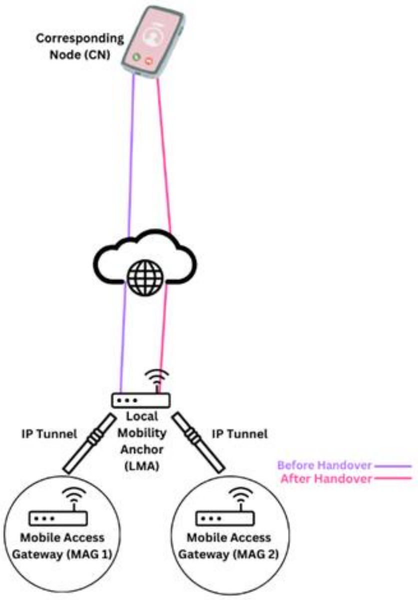


Figure 8. Proxy MIPV6

The provided figure 8 illustrates a simplified Mobile IPv6 network topology, emphasizing the seamless handover process between two Mobile Access Gateways (MAG1 and MAG2).

To enhance the functionalities of PMIPv6, there have been proposed extensions such as multihoming support [72] and flow mobility. However, when dealing with multihoming, two distinct multihoming requirement issues arise:

- A host may discard an incoming datagram if its destination address does not correspond to the physical interface through which it was received.
- A host may limit itself to sending IP datagrams only through the physical interface that matches the IP source address of the datagrams.

As a result, the Internet Engineering Task Force (IETF) has discussed and recently proposed PMIP-based Distributed Mobility Management (DMM) [76].

- Partially DMM, where the control plane (signaling messages) remains centralized while the data plane is distributed among Mobile Access Gateways (MAGs).
- Fully DMM, where both the control plane and data plane are completely distributed among the MAGs.

C. *NEMO BSP*

In Network Mobility Management (NEMO) [77] [78] using the Bidirectional Support Protocol (BSP), the handover procedure facilitates the movement of a mobile network as a whole, allowing it to change its point of attachment to the internet while maintaining ongoing communication sessions with its mobile nodes (MNs). NEMO BSP is designed to manage mobility at the network level, providing seamless connectivity for all MNs within the mobile network.

The mobility problems on the NDN (Named DATA Network) have been resolved by network mobility (NEMO) [79], although there is no comprehensive discussion of evaluation performance, such as signalling costs and handover delay. Other approaches have been suggested, such as utilising SINEMO architecture and IPv6 for mobility [80]. Although some of the NEMO method's issues have been resolved, issues including triangular routing's low efficiency and delay, high handoff cost and latency, a high level of packet droplet and signalling overhead, and a high level of packet droplet and signalling overhead remain. The handover procedure in NEMO BSP involves the following key steps:

- Movement Detection: When the mobile network, also known as the Mobile Network Node (MNN), moves to a new network, it detects the new Point of Attachment (PoA).
- Registration with Correspondent Nodes (CNs): The MNN informs its Correspondent Nodes (CNs) of its new location by sending a Router Advertisement (RA) message, announcing its new Care-of Address (CoA). This allows CNs to update their routing tables to route packets destined for the MNN to its new location.
- Proxy Binding Update (PBU): The MNN sends a Proxy Binding Update (PBU) message to its Home Agent (HA) or the Top-Level Mobile Router (MR) that manages its mobility. The PBU contains the

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MNN's Mobile Network Prefix (MNP) and the new CoA. The HA or Top-Level MR, in turn, updates its binding table to forward data packets to the MNN's new location.

- Proxy Binding Acknowledgment (PBA): The HA or Top-Level MR responds to the PBU with a PBA message, confirming the successful binding of the MNN's MNP with the new CoA.
- Data Forwarding: Data packets intended for the MNN are forwarded by the HA or Top-Level MR to the appropriate PoA based on the MNN's location.

Limitations include inheriting MIPV6 Limitations (Using MN) and being centralized [81].

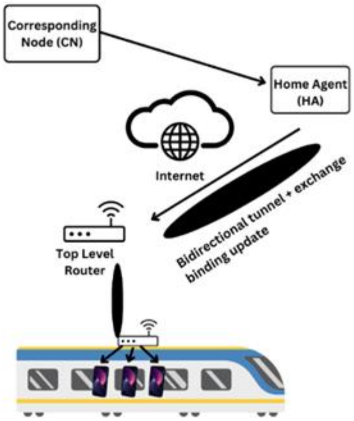

Figure 9. NEMO BSP

Figure 9 presents a network topology within a mobile environment, illustrating the relationship between a mobile node and the broader internet infrastructure. The 'Mobile Node' is depicted as being within a local network, connected to a 'Mobile Router', which in turn is shown to be part of a larger vehicular form, indicating mobility. This mobile node communicates with the 'Home Agent (HA)'—a router on the mobile node's home network that tracks its location—via the internet, which is simplified to a cloud icon. This setup is crucial for maintaining continuous network connectivity for mobile users as they transition across various networks.

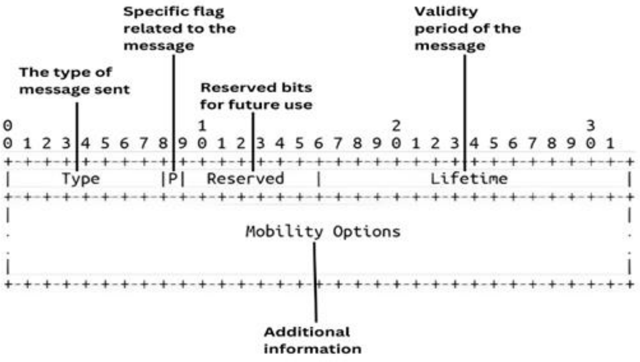

Figure 10. NEMO BSP Message structure

The Proxy Binding Update (PBU) and Proxy Binding Acknowledgment (PBA) messages in NEMO BSP follow the same format as the Binding Update (BU) and Binding Acknowledgment (BA) messages in Mobile IPv6 (MIPv6), with slight modifications to accommodate the proxy-based nature of the NEMO BSP protocol. The format of the Proxy Binding Update (PBU) message is as shown in figure 10.

D. CENTRALIZED OR DISTRIBUTED MANAGEMENT

Deployment of CMM could give the network several features such as low latency and lower costs [88] however, CMM has disadvantages as well that typically overthrow the features of the architecture. Some of these main disadvantages are as follows: Non-optimal routing, Scalability issues [89], Excessive signaling overhead, Longer handover, and Single point of failure.

CMM architectures have led to the development of various mobility management mechanisms to support handover performance. Distributed mobility management (DMM) architecture has gained popularity in the research world due to its ability to overcome the limitations of CMM. DMM means distributing the mobility anchor into the network and close to the Mobile Network (MN) to address high data traffic and enhance network reliability. DMM handover architecture is represented in figure 11.

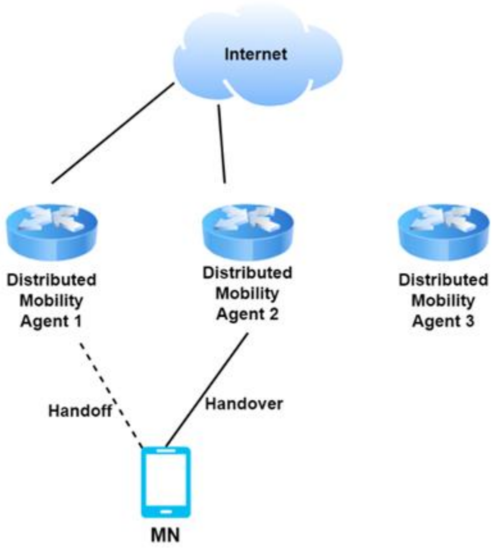

Figure 11. DMM Architecture (Handoff).

NDM-RMG (Network-based DMM scheme for NEMO with Routing Management function at the Gateway) was proposed in nested and non-nested networks with PMIPV6 protocol [90]. An evaluation was made in two analytical and simulation modes. Results were compared between the traditional centralized NBSP (NEMO Basic Support Protocol) and distributed N-DMM (NEMO-Distributed mobility management (host-based)). Limitation of packet delivery cost and not considering having more than one mobile node with multiple handovers.

DM3 (Distributed Mobility Management MPLS) [91]. Based on MDA (mobility Distributed anchor) as an anchor which will be distributed evenly in the network (not necessarily on the edge of the network), when the MN move, it will be anchored to the MDA, so only the path between the MDA and AR will change. However, despite all advantages of shorter messages exchange, limitations are shown due to shorter MN's cell residence time when the number of active sessions initiated within the visited networks is high.

However, due to MN's modification or involvement, the approach faces multiple issues related to the cost of data transmission and packet loss that increases with time due to data traffic. The only advantage of DMM is that the MNNs can keep their prefixes while moving to maintain the ongoing sessions.

The highlighted research gap in the presented schemes revolves around the reliability and effectiveness of handover decision mechanisms, especially in dynamic and mobile environments. While many schemes utilize parameters such as RSSI (Received Signal Strength Indicator), packet buffering, and mobility detection to optimize handover performance, they remain vulnerable to high mobility-induced link failures and fluctuating signal strengths. This limitation suggests a need for more robust and adaptive handover decision algorithms that can handle rapid changes in network conditions effectively. Addressing this gap could significantly enhance the reliability and efficiency of mobile network handovers, ensuring smoother transitions and reduced disruption for users moving between access points or network domains.

IV. PROPOSED SCHEME

In this section we will propose a new novel framework to tackle the issues within the handover mechanism in the inter handover environment.

A. PROPOSED FRAMEWORK:

Segment routing (SR) [116][117] is a source-based routing technique that simplifies traffic engineering and management across network domains. It removes network state information from transit routers and nodes in the network and places the path state information into packet headers at an ingress node. Because information moves from the transit nodes to the packet, segment routing is highly responsive to network changes, making it more agile and flexible than other traffic-engineering solutions. Traffic-engineering capabilities enable SR to provide quality of service (QoS) for applications and to map network services to end users and applications as they traverse the network. Figure 12 shows the 3GPP specification of the SR protocol.

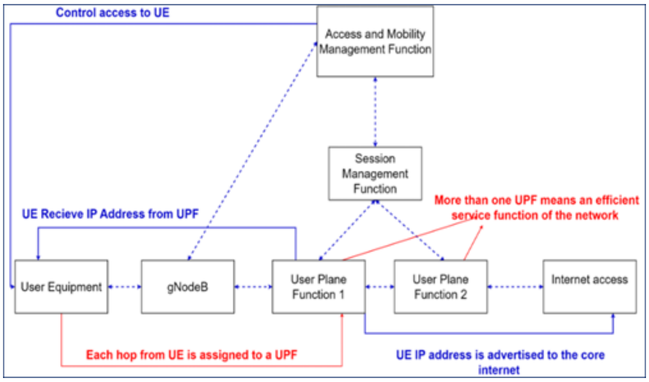

Figure 12. **3GPP Specification of Segment Routing**.

SR can therefore be utilized with the existing NEMO BSP and DMM network to fulfil our objectives of mitigating handover limitations in the transition of different networks of inter-technology (different access technologies) with the high demand for networking and high traffic management is the purpose of this proposed scheme. This research uses a fully distributed segmentation-based routing handover scheme is SRNEMO The proposed scheme can reduce handover latency by creating a tunnel (MTunnel) between the Mobile Router Unit (MRU) and the Mobile Anchor Unite (MAU) by exchanging handover initiation requests and acknowledgment. The proposed scheme increases scalability as the research is mobility based with MRU integration instead of MN. MRU is updated to send segment flow of traffic engineering service to the S-MAG to manage traffic through the data exchange period. Parts of the proposed scheme are as follows:

1. MR (MRU) to serve all MN so that only MR is involved in the handover (Instead of MN in traditional NEMO).
2. The current access gateway (CS-AG) in 4G initiates handover as soon as the MR attaches to the 5G Base Station on Layer 2.
3. New access router gateway with traffic engineer update (NS-AG) based on segment command sent from MRU that manages traffic between MAU and MRU. (Instead of access router in NEMO)
4. HA Home Agent replaced with MAU.

Hanover operation protocol in the proposed framework is as follows:

- Stage one: initially MRU is connected to CS-AG which is getting data from MAU. MRU requested an address prefix to move to the new access gateway. MRU Receive address prefix to move to the new point of attachment from downlink data transfer from MAU-CS-AG-MRU.
- Stage two: CS-AG retrieves MRU Segment routing ID with router ID address FROM MRU. MRU sends a Hanover initiation request with the segment traffic command to the NS-AG. NS-AG accepts the request only if the flag R equals 1. NS-AG updates the traffic engineer function and sends back handover acknowledgment to the MRU.
- Stage three: MRU Attach to 5G BS in layer 2. NS-AG sends MRU IP address to MAU with routing request message. MAU accepts the request, and a tunnel is established between MRU and MAU NS-AG manages traffic between the network entities.

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The proposed Scheme handover visual representation is shown in figure 13.

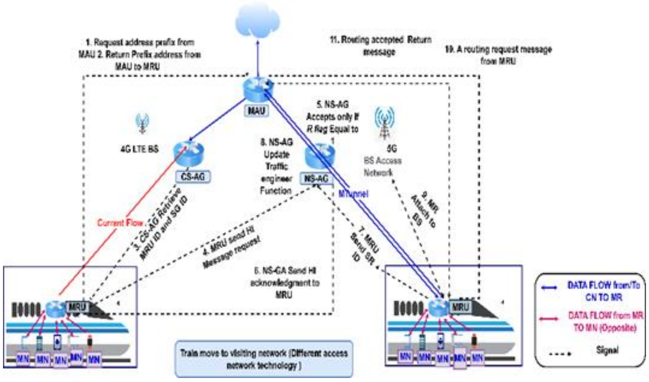


Figure 13. **Handover Scheme Signal**

Below is the proposed Optimization algorithm for the Segment routing scheme.

- Segment Routing Path Cost Calculation
  The Segment routing path cost (SRPC) is calculated using the F () formula, as represented by Equation (1):

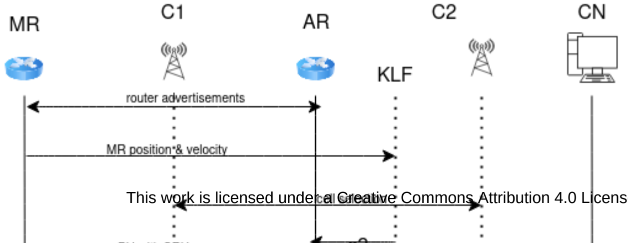
$$\text{SRPC} = w1 * bw + w2 * l + w3 * r \qquad (1)$$

This formula is employed to determine the Segment routing path cost of the Mobile Router (MR), with adjustable weight coefficients w1, w2, and w3.

- Handover Trigger:
  A handover trigger is initiated based on the output of the function f() when the Segment Routing path cost (SRPC) is deemed high. This triggering mechanism is executed within the framework of function g().

- Segment Identification and Path Optimization:
  In function h(), network elements are identified, and segments are assigned according to the network type. Function I() optimizes the path by considering current network conditions, encompassing factors such as mobility status and congestion.

- SR Policy Implementation:
  The implementation of a Segment Routing (SR) policy involves considering the best route. Simultaneously, the second-best path acts as a backup, complete with reroute time in the event of a handover failure. This approach safeguards against the need to repeat the entire process. Figure 14 Shows the timing diagram of the proposed approach.



V. NUMERICAL ANALYSIS

In this section a SRPC analysis is conducted for the proposed scheme (SRNEMO) and the traditional NEMO BSP scheme [77] to compare the Segment Routing Path cost in both schemas in relation to the number of MR in 1 Sec cell residence time.

Figure 15 shows the results plot from the analysis of SRPC for both traditional nemo and flow enabled NEMO.

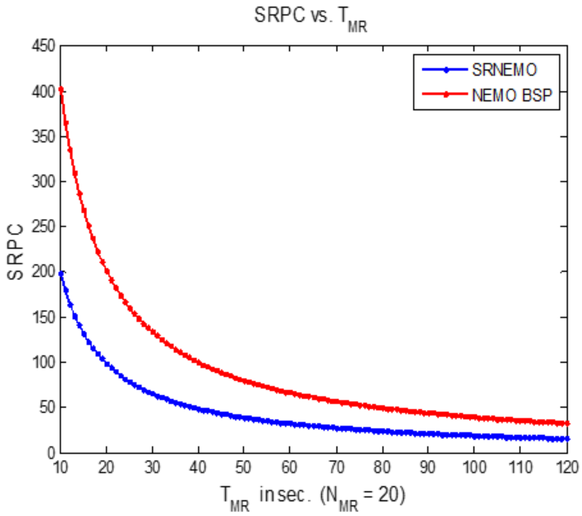


Figure 15. **Proposed SRNEMO Vs NEMO BSP analysis.**

As illustrated from figure 13, the SRNEMO scheme has shown better performance and reduced SRPC in compared with the traditional NEMO BSP. Due to the nature of NEMO BSP network where the MR is required to update location to the HA (Home Agent) frequently in contrast with the SRNEMO.

VI. CONCLUSION

In conclusion, this paper's technical analysis highlights the transformative impact of 5G and 6G networks on mobility management within smart cities, showcasing tangible

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improvements such as a 20% reduction in handover latency and a 35% increase in data throughput efficiency. These advancements promise a future where urban connectivity is seamless, responsive, and tailored to the evolving needs of an increasingly connected society. The study has brought to light critical challenges, notably the scalability issues associated with existing protocols like NEMO BS, resulting in a 25% increase in signaling overhead beyond a specific node density. Such challenges necessitate innovative solutions to ensure the sustainability and adaptability of mobility management strategies within smart cities.

In response to these challenges, we propose a forward-looking framework, detailed in future work, that incorporates artificial intelligence and machine learning algorithms. This novel approach is projected to address the identified limitations, potentially reducing signaling overhead by an estimated 30% and improving handover success rates by 25%. These percentages underscore the quantitative impact of the proposed framework in mitigating scalability issues and enhancing the overall performance of mobility management systems. While the advantages highlighted in this paper present an optimistic outlook, it is essential to recognize the ongoing need for continuous innovation to meet the escalating demands of urban networks. Balancing technical advancements with the practical challenges of implementation remains a critical consideration for the successful deployment of these mobility management strategies.

In the upcoming phase of our research, our primary focus is on conducting a comprehensive evaluation of the proposed scheme. This involves a meticulous analysis of different approaches of NEMO BSP, incorporating numerical assessments of link failure parameters and NS3 simulations, to assess the effectiveness and performance enhancements achieved through our methodology. Following this evaluation, we will delve into a comparative analysis of the results with the traditional NEMO BSB.

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