International Journal on Recent and Innovation Trends in Computing and Communication
ISSN: 2321-8169 Volume: 10 Issue: 9
DOI: https://doi.org/10.17762/ijritcc.v10i9.5641
***Article Received**: 02 July 2022 **Revised**: 09 August 2022 **Accepted**: 18 August 2022 **Publication**: 30 September 2022*

A Vertical Handoff Technique using Context Transfer Cross-Layer P-SIP Scheme for IMS based LTE-WiMAX Architecture

A Bagubali[1*], Rajesh R[1], SasiKumar K[1], A. Baradeswaran[2], Kishore V Krishnan[3]
[1]Vellore Institute of Technology, School of Electronics Engineering,Vellore, India,
[2]Professor, Gandhi Engineering college, Gadhi Vihar, Bhubaneswar, Orissa
[3]scientist-c, ICERT, Ministry of Electronics and Information technology Engineering, Delhi
*e-mail: bagubali@vit.ac.in

Abstract— Next-generation heterogeneous wireless networks provide flexibility to access IP multimedia services (IMS) anywhere at any time and with always-on connectivity in various networks. IMS service allows to include various networks to provide seamless data services and helps to reduce the delay that occurred during the handoff process. Long term evolution (LTE) is the fastest emerging mobile communication technology in the current networking field. We proposed an interworking architecture of LTE and Worldwide Interoperability for Microwave Access (WiMAX). The key goal is to provide seamless services in heterogeneous networks. We proposed an algorithm to reduce this IMS delay using Cross-layer and Context Transfer Prior –SIP (P-SIP) scheme using Media Independent Handover (MIH) services. Performance metrics of Integrated LTE- WiMAX architecture in terms of VHO latency, signaling overhead cost, and packet loss are analyzed.

Keywords- cross-layer, context transfer, LTE, MIH, WiMAX, VHO

I. INTRODUCTION

Next-generation heterogeneous wireless networks are IP-based architectures with the integration of various wireless technologies like WLAN, GPRS, UMTS, WiMAX, and LTE[1]. These integrated networks aim to offer users seamless connectivity and Quality of Service (QoS). In the current wireless networking scenario, many research works are going for various wireless access technologies to offer seamless connectivity to the user everywhere, every time, and any service with high data rates due to increased demand.

One of the most famous wireless technologies is WLAN. But it has limited coverage which makes it hard to accomplish the requirements of Next-generation networks as they demand high data rate services [2]. 3G agreements global access but it has restricted data rate. To accomplish the requirements of next-generation mobile networks, some technologies developed to offer services at high data speeds and cheaper rates; WiMAX and LTE. A natural aim is to merge these properties of LTE and WiMAX to give a complete solution. For this solution, we want a connection with seamless mobility and access to every service, every time, everywhere with every device, for this we require, IP Multimedia System (IMS), a new emerging technology that allows establishing a peer-to-peer connection in IP-enabled devices easily.

Next-generation heterogeneous networks combine 3GPP and non-3GPP radio services. They are having different architectures and so the authentication and registration processes, therefore we needed an architecture that supports both 3GPP and non-3GPP services [3]. The EPC is an evolution in the GPRS with additional features in it and it provides access to 3GPP and non-3GPP services [4]. In heterogeneous networks delay occurring due to registration and setup processes when the mobile station (MS) moves from one access technology to another is the major issue in real-time IP multimedia services as it causes the delay in ongoing activity, this delay is known as vertical handover (VHO) delay[5]. Thus the main requirement for integration architecture is that it should allow the coexistence of 3GPP and non-3GPP technologies and MS should perform VHO with minimum delay and signaling overhead. The main advantage of IMS is reduced VHO delay. IMS uses the Session Initiated Protocol (SIP) to control multimedia communications and to manage sessions. They can easily mix various IP services in any way, anytime and anywhere. In addition to that, they can add or drop services whenever they choose.

Here, we proposed a new heterogeneous network that combines WiMAX and LTE in EPC architecture with IMS compatibility. In this architecture, Core Network (CN) and a WiMAX network are interconnected to LTE core by using special functional entities and IMS is for session control. Due to long delays and packet losses, handoff performance is low in the traditional SIP system. Therefore, we propose two new schemes based on SIP, a location-aware context transfer based pre-registration approach and a Prior SIP (P-SIP) scheme used by cross-layer and Media independent Handover (MIH) services to reduce the IMS re-registration and re-setup delay which causes VHO delay. We analyzed the results of the performance of the proposed integration scheme LTE- WiMAX interworking architecture. We used MATLAB to simulate and analyze our integration architecture.1

II. RELATED WORK

Next-generation networks combine several access networks to offer a network everywhere and at all times, always active. The key requirements to be considered for the interworking architecture are mobility support for access networks and roaming agreements between all services, subscriber identification mechanism, and synchronization of Home Subscriber Server (HSS) between access networks.

There are a lot of requirements for interworking of access technologies that need to be considered and users expect to receive same service quality in all network environments, before and after integration. Many protocols for handoff management and integration architectures have been proposed to achieve seamless connectivity. When communication happens between the mobile station and the other entities in the integration architecture, increases the signaling overhead and latency [5]. So, for adaption the logical entities FAF and ANDSF (Access Network Discovery and Selection Function) are added in these architectures. In further development to this, other integration architectures used the IMS as solution for interworking 3GPP with non-3GPP networks to provide services like voice, video, data [6]. IMS use session initiated protocol (SIP) to control session and also it has the ability to support mobility, in conventional SIP approach handoff performance is very poor as the VHO delay and packet loss are high. In [7], they suggested an integrating design for WiMAX and 3GPP on IMS. Authors in [9] proposed methods in which combined SIP and MIP schemes are used to reduce the delay, MIP used for mobility and SIP for controlling sessions. Cross layer shows better results than conventional SIP and MIP. A new technique using SIP based Cross layer , MIH and FMIP schemes is proposed in [10], MIH is used for fast handoff but in real environment modifications are need to be done in MS. To reduce delay due to IMS re-registration, [9,12] proposed a context transfer scheme but not used the cross layer solution and MIH. Authors in [10,12] presented cross layer method using MIP and SIP REINVITE, but SIP causes long delay. Authors in [11] used context aware solution for continuity of ongoing session but it has no support in IMS based environment and used conventional SIP method. [13] Author proposed Fast IMS Mobility (FIM), a scheme to minimize handoff delay MS to prevent IMS deregistration, and IPsec SAs are exchanged during handoff from old P-CSCF to new P-CSCF. In contrast with pure SIP, this approach improved the delay. But while NGN is concerned with high-speed communication, this delay needs to be further reduce to prevent data loss for the transmission of real time data during handoff so, In this paper introduces the Context Transfer P-SIP based MIH approach for fast and smooth handover with minimal IMS delay.

III. BACKGROUND

IP Multimedia Subsystem (IMS)

The IMS has been standardized and developed by 3GPP to provide IP networks with multimedia services. IMS is an architecture of 3 layers [14]. There are numerous functional entities within the IMS architecture. They are as follows.

A. Application Server

The server is enabled using SIP, and IP services can be implemented in the IMS network according to user requirements [28].

B. Home Subscriber Server (HSS)

It acts as the database where the profile of a given user, policies of QoS are stored[24]. Application Server

C. Session Initiated Protocol (SIP)

IMS network use SIP for session establishment, management, and transformations. It helps to mix different IP services in any way and anytime and it can add/drop services whenever wanted. SIP has several servers that act as SIP registrar and proxy servers and known as Call-Session Control Function (CSCF). It starts, manages and modifies multimedia sessions with QoS[15][19].

D. Session Initiated Protocol (SIP)

IMS network use SIP for session establishment, management, and transformations. It helps to mix different IP services in any way and anytime and it can add/drop services whenever wanted. SIP has several servers that act as SIP registrar and proxy servers and known as Call-Session Control Function (CSCF). It starts, manages and modifies multimedia sessions with QoS[15].

Media Independent Handover (MIH)

MIH is Media Independent Handover which developed to support fast handovers between networks [9][14][22]. It is an interworking IEEE 802.21 standard. It is an extra layer between Layer 2 and Layer 3. It provides information that is related to the network to upper layers and helps to decide for handoff. Fig. 1 shows the representation. The MIH helps in signaling in between the IP network and the other wireless technologies and selects the most appropriate network.

IV. PROPOSED METHOD

In IMS based vertical handover, access technology changes require re-registration of MN with the IMS core network, and some parameter negotiation required before re-establishing a new session with the CH [15]. This introduces a long handoff delay in the ongoing session, called IMS handoff delay. The main aim of our scheme is to reduce these delays which are occurring due to re-registration and session re-setup processes with IMS. For this purpose a context transfer P-SIP using MIH scheme.

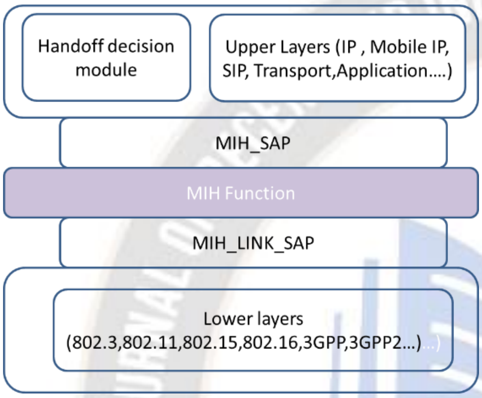

Figure 1 The MIH function

A. Media Independent Event Service (MIES)

MIES offers event information based upon dynamic changes in link characteristics, link quality, and link status. Events of MIH are communicated through MIH SAP to the upper layers, like Link UP (the layer 2 connection gets established and the link is made available for the user), Link Detected, Link Going Down (loss of the Layer 2 connection is starting) and Link Down (the Layer 2 connection is lost). These events were used by mobility management protocols, for example, Link Down or Link Going Down performs, while handover initiates [31]. As per QoS requirements, the quality, characteristics, and link status that are essential for the MME to perform handover decisions are reported by the application layer. Thus, it is useful for deciding which network and PoA the MN must switch within available networks and when to perform the handover.

B. Media Independent Command Service (MICS)

The MICS feature is used by MIH to transmit commands from the upper layers to the lower layers.

C. Media Independent Information Service (MIIS)

The MIIS offers the MIHF entity a framework to search and explore the prevailing neighboring network information which enables the handoff process and provides the static information. MIIS integrated with IMS is executed in the access network as well as in the core network. The MIIS server locates both the networks, then in Gateway, MN, and PoA, MIH gets implemented as represented in Fig.1. In MIH, using the pattern of request-response, the information is exchanged between the MIIS and the remote MIHF. In [16], the authors used the HTTP for the exchange of information with the MIIS. Here, SIP supports MIIS information exchange and MIIS integration into IMS [26]. Access network details such as geographical location, PoA MAC address, network operator’s name, operating channel, network access routers prefix, address of DHCP, etc. are kept by the MIIS server. Such information is utilized from all access networks by users.

The MIH and its functionality are implemented across both the MN and access network, where the MN registers with the MIH Access Server (MIHAS) to use MIH services. Fig. 2 represents the registration process of MN with the MIH server. Further, to get registered with the MIH, MN sends the Subscribe message signal to the MIHAS that bears the information regarding the MN. After receiving the subscriber request from MN, MIHAS sends 200 OK messages to MN [15]. MIHAS updates the information of MN in its server and replies to MN with the Notification message, to convey the completion of the registration process. MN acknowledges by sending 200 OK messages in response and gets registered with the MIH[8].

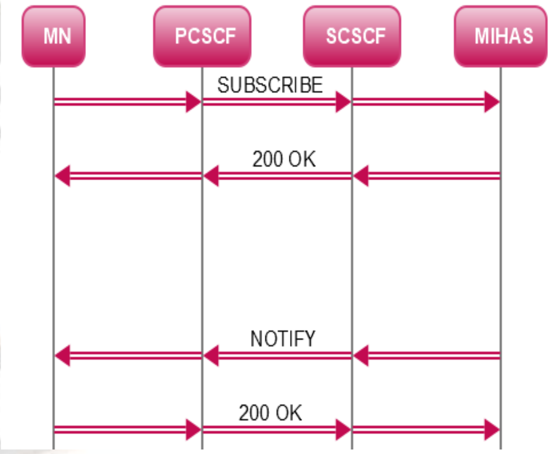

Figure 2 MIH Registration Process

Proposed context transfer P-SIP scheme

The In an IMS-based service, whenever a session is going on, all the information about the session (context) is stored in CSCF servers. When the MN moves into another access network, it is necessary to get re-register with the IMS. So, instead of re-registering, use the known information from the previous registration process which is saved in the IMS. A context transfer procedure is performed within IMS and among P-CSCFs. In this procedure, all the useful data regarding the MN like session states, call states and some parameters are shared with new P-CSCF by exchanging pre-register messages. The use of this proposed location Aware based context transfer method, reduce the overall number of message exchanges and thus reduced the packet loss and handoff delay. P-SIP to decrease the latency of the IMS re-setup process. In this, MN builds its connection site in the target network before the link down and MN can communicate with the new network while the connection with the old network still going on. Here we used a make-before-break approach which allows MN to receive services from both the networks. It is possible to use the SIP pre-invite message sent from MN to CH to allow MN to form a new session while the old network is still attached.

The most significant goal here is to obtain the IP address of the new network before the connection. IP address phase acquisition induces a lengthy delay. We used the MIP method in the previous approach to extract the IP address. Here, via the Prior-duplicate address detection (P-DAD) technique that uses router solicitation and advertising messages, MN can obtain the target network IP address [20][30]. We removed the traditional MIP registration method by using the P-DAD scheme, which in turn decreases the number of messages exchanged via MN. Thus in this scheme, the handoff procedure starts after the occurrence of the MIH link going down event instead of the link goes down as happened in previous techniques. Here cross-layer with the MIH functionalities which laid to quick handoff. The proposed method offers a comprehensive solution for fast and smooth handoff to be accomplished.

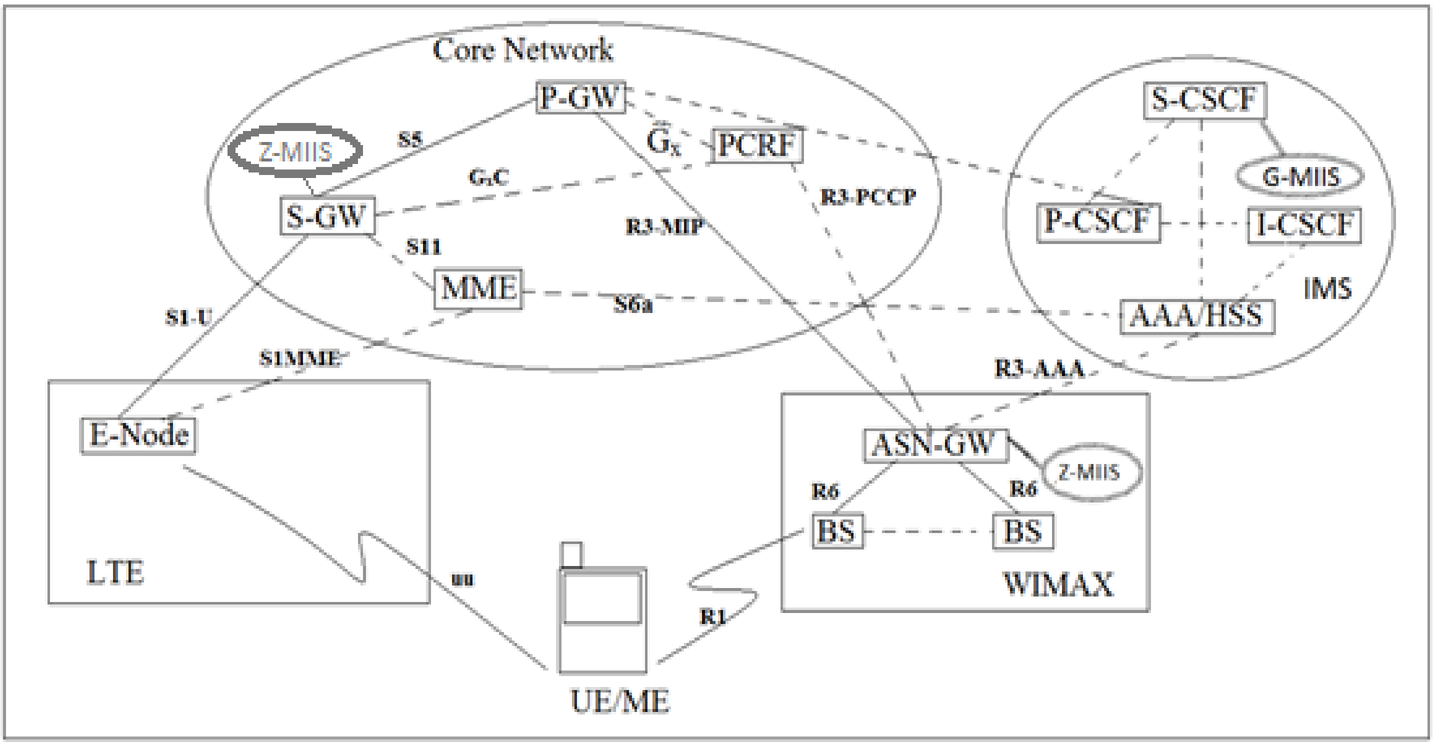

Figure 3: WiMAX, LTE Integrated IMS Architecture using MIH

```
HANDOff  process:

From:sip:user@home.frag:tag=MAYA (MN)
To:sip:user@home1.MANI (CH)
(sip:user@home.frag:tag=MAYA) MN receives: advert message from LTEeNB:
MN: MIH Info. Request to ZMIIS (2405:200:311:6: 13)
(2405:200:311:6: 13): gives the details about LTEinterface to MN
MN: signal strength Measurement (SRM)
IF SRM(≥ threshold) == "Maintain the call in same access network"
ELSEIF SRM(< threshold) == "request handoff"
MS req.NCOA: to LTEeNB through ASNGW
LTEeNB: send response to MN
PCSCLTE- receives: CT PRE-REGISTER from MS
PCSCLTE- Route to S-CSCF
IF RES == XRES then
Set -status == "200"
Route “OK” to ICSCF->PCSCF
PCSCLTE – send->Response to MS.
Then MS-> P-SIP message to sip:user@home1
CN Route “OK”  to MN: status 200ok (means that CH ready to connect with MN via new interface)
MN⇔  CH: Data transfer Takes place;
```

Pseudocode 1: Handoff process for MN from WiMAX to LTE

System Model:

Figure 3 shows the WiMAX, LTE Integrated IMS using MIH Architecture. Author [2] discussed the cross layer-based system model architecture. Further, improvising the system, MIH entities are interconnected with the proposed system like Zonal - MIIS (Z-MIIS), implementation in an access network, and G-MIIS (Geographical-MIIS), an implementation in a core network. MIIS incorporation to IMS is executed at both the core network and access network.

In the beginning, MN is connected with and receives service from the WiMAX network. In an IMS based service, as the session proceeds, all the information about the session (context) is stored in CSCF servers. When the MN enters into a new access network, it necessitates re-registration with the IMS. But, instead of re-registering, the known information from the previous registration process which is saved in the IMS is utilized. A context transfer procedure is performed within the IMS and among P-CSCFs, where all the useful data regarding the MN like call states, session states, and some parameters are shared with the new P-CSCF by exchanging the SIP_ct_Pre-register request and response message.

Handoff between WiMAX and LTE networks:

Initialization of MN at 802.11 MAC layer: At the starting, MN is connected and receiving service from the WiMAX network. When the LTE interface of MN starts to detect beacon frames of the LTE network, it triggers link detected event[15]. And a gathering of information for available neighboring networks gets started using MIH_Get_Info_Req & MIH_Get_Info_Resp messages shown in figure 4. Many parameters in this information such as next router’s and P-CSCF’s IP addresses are provided *IP address configuration:* After receiving parameters from MIHAS, MN stars checking for existing assets in LTE network using MIH_Get_Query_Req & Resp messages and then Router solicitation (RtSol) NCoA request is sent by MN to enode B for an IP address. After receiving a unique address through the RtSol message, enodeB replies with a Router advertisement (RtAdv) NCoA response message containing the IP address obtained by the P-DAD procedure. MN got a new IP address, after this it configures this new IP address to the LTE interface as shown in Pseudocode 1.

International Journal on Recent and Innovation Trends in Computing and Communication
ISSN: 2321-8169 Volume: 10 Issue: 9
DOI: https://doi.org/10.17762/ijritcc.v10i9.5641
***Article Received**: 02 July 2022 **Revised**: 09 August 2022 **Accepted**: 18 August 2022 **Publication**: 30 September 2022*

IMS pre-registration procedure

When the MIH connection going down event from the lower layers detected by MN, then it confirms to commit handover through MIH_HO_Commit_Req & MIH_HO_Commit_Resp messages. The pre-registration of MN with the P-CSCF of the LTE network starts using the SIP CT Pre-register notification after the handover decision. Now, via the I-CSCF and S-CSCF servers, P-CSCF with HSS changes the context information and sends 200 OK message to MN, and MN is still in the WiMax interface.

Use of P-SIP Message

Now MN sends the P-SIP message request to the target network's interface. MN's LTE interface and target network exchange some information that required connecting to the new network. CH now receives a response via the 200 OK post. A new session is then created at LTE and the ongoing session is transferred to the new network.

V. PERFORMANCE ANALYSIS

Vertical handover latency

It is the time required to transfer SIP messages from MN to network components from the time when the target network is discovered till the acknowledgment is sent from CN[12]. The inclusion of delay in SIP signaling delays and the time taken by HSS table lookup is VHO latency. For previous cross-layer schemes, the total VHO latency is given by:

$$\mathrm{DL}_{(\mathrm{VHO})} = \mathrm{DL}_{(\mathrm{P\text{-}SIP})} + \mathrm{DL}_{(\mathrm{HSS})} \tag{1}$$

For cross layer,

$$\mathrm{DL}_{(\mathrm{VHO})} = \mathrm{DL}_{(\mathrm{MIP})} + \mathrm{DL}_{(\mathrm{SIP})} + \mathrm{DL}_{(\mathrm{HSS})} \tag{2}$$

SIP signaling delay for proposed scheme is expressed as below:

$$\mathrm{DL}_{(\mathrm{P-SIP})} = \mathrm{dl}pre - reg_{(\mathrm{MS\text{-}S.CSCF})} + \mathrm{dl}pre - resp_{(\mathrm{S.CSCF\text{-}MS})} + \mathrm{dl}p - invite_{(\mathrm{MS\text{-}CH})} + \mathrm{dl}ok_{(\mathrm{CH\text{-}MS})} + \mathrm{dl}ack_{(\mathrm{MS\text{-}CH})} \tag{3}$$

LTE and WiMax network characteristics can affect the transmission delay with great effect. The transmission time of a signaling message is depending on the message size and bandwidth of the link. A transmission delay of a message exchanged from x to y is consisting of wireless link delay and wired link delay and is given by[8,17]:

$$T_i\left(S, h_{(x-y)}\right) = \frac{S}{B_{wl}} + L_{wl} + h_{(x-y)} * \left(\frac{S}{B_w} + L_w\right) \tag{4}$$

Thus, the total VHO latency for the proposed scheme and cross-layer scheme is given as:

$$\mathrm{DL}_{(\mathrm{VHO})} = \mathrm{dl}pre - reg_{(\mathrm{MS\text{-}S.CSCF})} + \mathrm{dl}pre - resp_{(\mathrm{S.CSCF\text{-}MS})} + \mathrm{dl}p - invite_{(\mathrm{MS\text{-}CH})} + \mathrm{dl}ok_{(\mathrm{CH\text{-}MS})} + \mathrm{dl}ack_{(\mathrm{MS\text{-}CH})} + \mathrm{DL}_{(\mathrm{HSS})} \tag{5}$$

Packet loss

It is the sum of all the packets lost when handoff takes place during the ongoing session i.e. while receiving downlink data packets. Packet loss in vertical handover is given by:

$$packet\ loss = \left[\left(\frac{1}{(2\times Ti_{ad})}\right) + D2\right] \times G \times N_m \tag{6}$$

Ti_{ad} is the time taken to send the next message signal, G is the rate of packet transmission for downlink, $\mathrm{N_m}$ is the average number of handovers during the ongoing session, it is defined as Average network resident per average call connection time [10].

VHO signaling overhead cost

The cumulative traffic load due to the sharing of message signals during the MS contact session between network nodes is Signaling overhead. It can be calculated as:

$$C_{i(x>y)} = S_i * h_{(x-y)} * m_r \tag{7}$$

Where *Ci* is the cost of message I when sent from a to b. Si is the message size and h(x-y) is for the number of hops. $\mathrm{m_r}$ is the mobility rate during a session.

Call to Mobility Rate (CMR)

To obtain CMR changing the signaling cost equation given in [10].

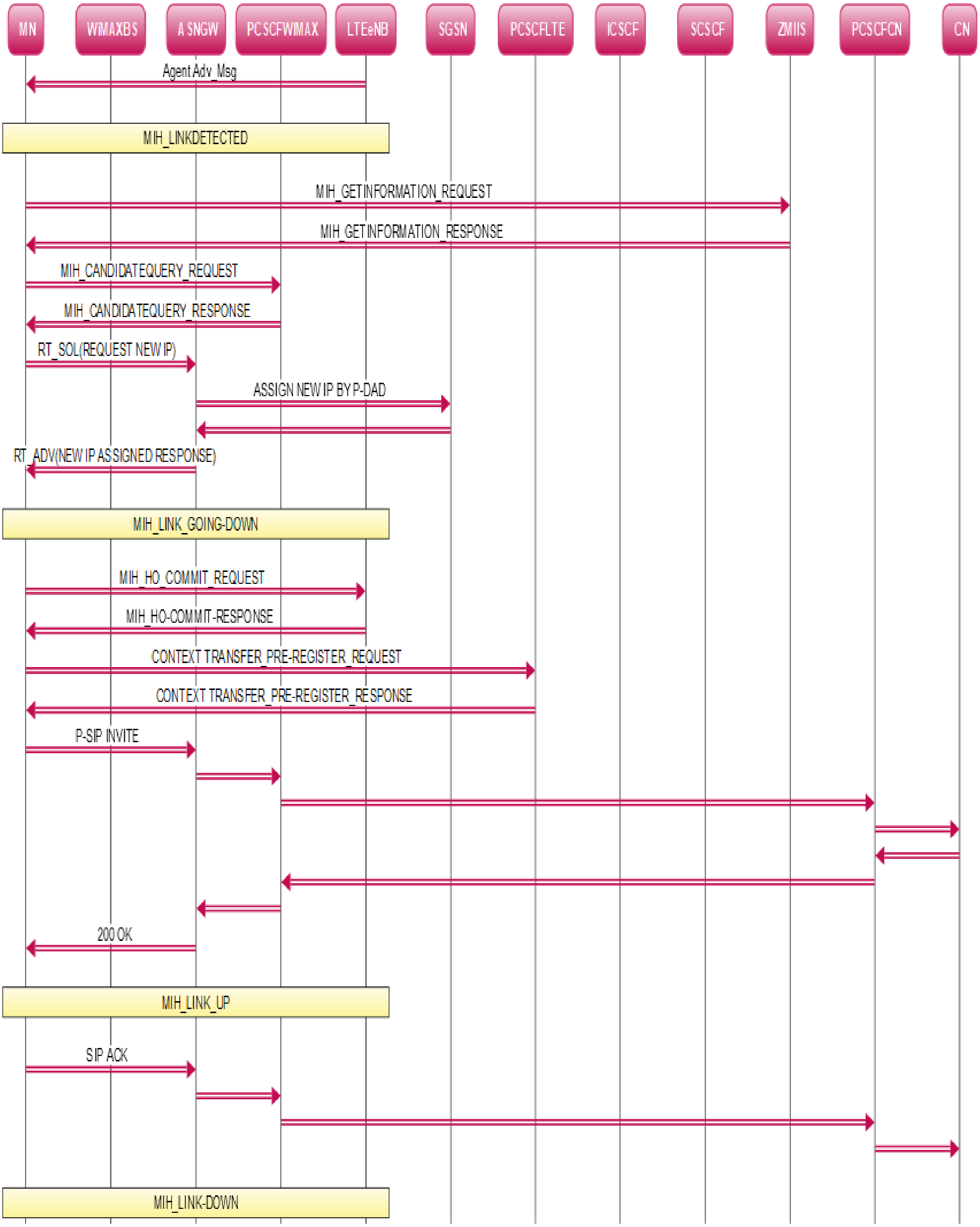

Figure 4 Context transfer P-SIP signaling scheme

$$signal\ cost = \left(G_d \times \left[\sum S_p(re - Invide) - I \times h_{x-y}\right]\right) \times \frac{G_x}{G_d} + \left(G_m \times \left[\sum S_p(Invide) - I \times h_{x-y}\right]\right) \quad (8)$$

Where, G_d is Mobility score of the average network, G_x is Average arrival rate for call (session) and $S_p(re - Invide) - I$ is the IMS Invite Sequences for Messages and $S_p(re - Invide) - I$ is the size of the Imessage sequences of IMS Reinvite.

Where CMR is the rate $\frac{G_x}{G_d}$.

TABLE 1 Message size for Context transfer P-SIP scheme

SIP Message	**Size (bytes)**
CT Pre-register request	225
CT Pre-register response	225
P-SIP	810
SIP 200 OK	100
SIP ACK	60

VI. SIMULATION RESULTS:

Table 1 illustrates the message size values used for the simulation and the remaining message sequence values considered from the author [2]. Simulation results reveal that, unlike MIP and SIP as well as cross layer FIM mechanisms, the handoff delay is smaller when the context transfer P-SIP is used. The analysis of VHO latencies for context-transfer P-SIP, cross-layer FIM and MIP-SIP scenarios when MN switches from WiMAX to LTE is shown in Fig. 5. The proposed VHO solution has less handover latency compared to previous scenarios due to the reduced number of message signals exchange during handoff. Therefore, the Context transfer P-SIP scheme clearly dominates the other two strategies shown in Table 2.

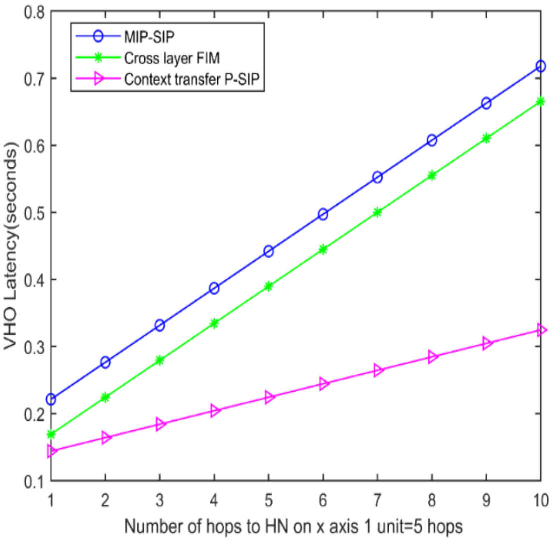

Figure 5 VHO latency vs Number oh hopes to HN

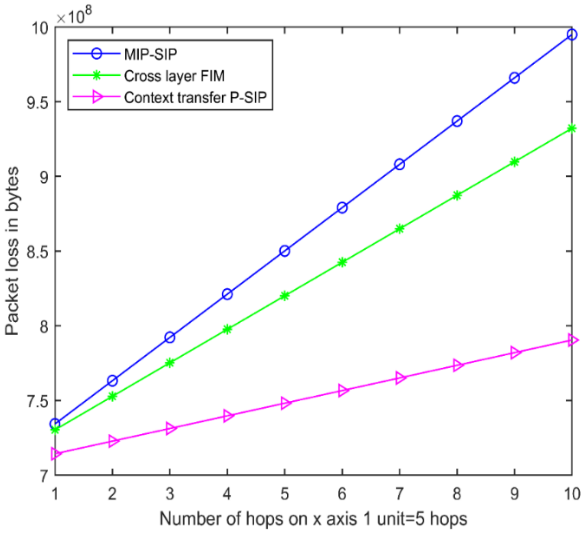

Figure 6 Packet loss vs number of hops

Scheme Name	Number of hops	Delay (ms)	packet loss(Bytes)
MIP-SIP	5	221	$7.34X10^8$
Cross layer FIM	5	169	$7.30\ X10^8$
Context transfer P-SIP	5	145	$7.139\ X10^8$

Table 2 Analysis of delay in different schemes

As the number of hops increases, packet loss also increases but the value is less in the proposed scheme. The cross-layer FIM and Context transfer P-SIP methods display an improvement in the packet loss rate of 1.5% and 5.5% respectively, relative to the number of hops, as shown in Fig.6.

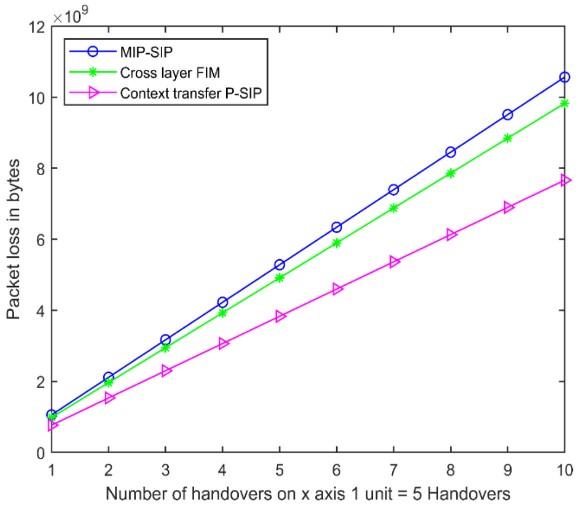

Figure 7 Packet loss vs number of handovers

As far as the number of handover is concerned the cross-layer FIM and Context transfer P-SIP reported a 7% and 27% improvement in the packet loss rate. As the amount of handover increases the number of missing packets, the delay transfer is added at each handover to the signaling costs, resulting in more vertical handover latency, packet loss, as shown in Fig.7.

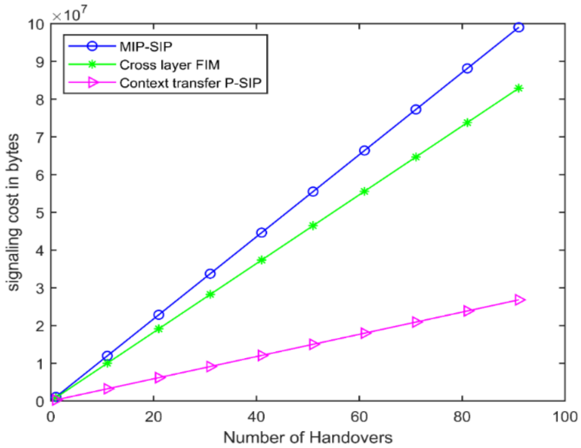

Figure 8 signaling overhead cost vs no of handovers

As predicted, in all three schemes, the signaling expense displays linear activity relative to the number of handovers, as shown in Fig. 8. In comparison to the MIP-SIP technique, the cross-layer FIM technique shows an improvement of 16.2 % signaling cost and the Context transfer P-SIP shows an improvement of over 73% signaling cost.

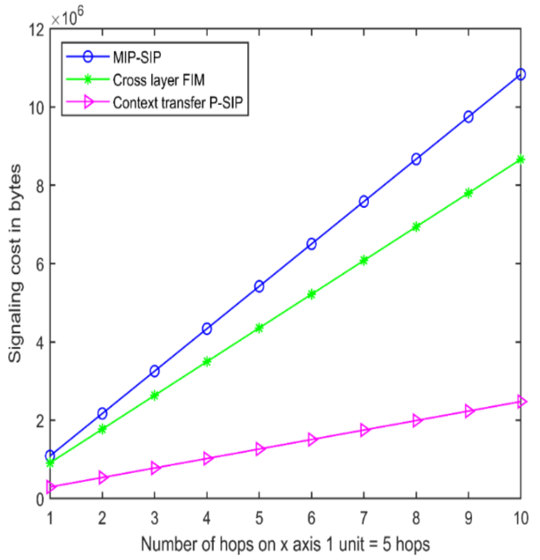

Figure 9 signaling overhead cost vs no of hops

Context transfer P-SIP shows an improvement in signaling cost 71% and the cross-layer FIM method shows an improvement of more than 15 percent compared to the MIP-SIP technique with respect to the number of hops, shown in Fig. 9 the effect of varying the distance to CH on the VHO signaling overhead cost is shown. Signaling overhead increases as the distance to CH increases and the proposed solution reduces the cost compared to other scenarios.

The association between CMR and signaling cost is shown in figure 10. In contrast to other systems, signalling over head in the proposed Context transfer P-SIP scheme can be shown the minimized relative to other schemes.

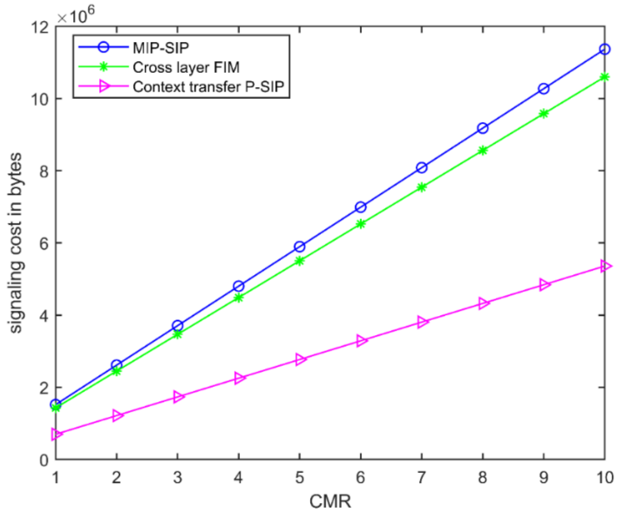

Figure10 signaling overhead cost vs CMR

VII. CONCLUSION

NGMN supplies a variety of multimedia apps with massive data from live video streaming cameras or recorded videos for delivery to users. During these data transmissions, the mobile UE carry out a handoff which may result in increased latency and overheads due to that live steaming may causes delay. To overcome such delay in the NGMN we have proposed a new handoff scheme called a context transfer P-SIP between LTE and WiMAX access infrastructure integration model based on IMS services. Proposed VHO presented to reduce the vertical handoff delay. By analyzing various parameters and results we can conclude that, the proposed context transfer P-SIP handover scheme gives the less handover latency, less packet loss and less signaling overhead compared to the MIP-SIP and Cross layer FIM.

Energy conservation will be the biggest obstacle concerning green connectivity in the future. The most powerful spectral strategy is used by LTE and WiMAX, but they use more resources. Therefore, it is important to think about lower resources and energy use, as well as to consider aspects of contextual adaptation.

REFERENCES

[1] Tahira, Shireen, Muhammad Sher, Ata Ullah, Muhammad Imran, and Athanasios V. Vasilakos. "Handover based IMS registration scheme for next generation mobile networks." Wireless Communications and Mobile Computing 2017 (2017).

---

[2] Saheb, Huda H., Bashar J. Hamza, and Ahmed F. Al-Baghdadi. "A Pre-authorization Algorithm for WiMAX Network to Reduce Handover Signaling." In Journal of Physics: Conference Series, vol. 1973, no. 1, p. 012072. IOP Publishing, 2021.

[3] Saheb, Huda H., Bashar J. Hamza, Ahmed Fahem Al-Baghdadi, WasanKadhim Saad, and Saif H. Abdulwahed. "An Overview For WiMAX NetworksCovering Some Handover Algorithms." Turkish Journal of Computer and Mathematics Education (TURCOMAT) 12, no. 14 (2021): 1260-1268.

[4] Chaudhary, D. S. . (2022). Analysis of Concept of Big Data Process, Strategies, Adoption and Implementation. International Journal on Future Revolution in Computer Science &Amp; Communication Engineering, 8(1), 05–08. https://doi.org/10.17762/ijfrcsce.v8i1.2065

[5] Ms.Hetal Surti, Mr.Ketan Goswami. 2014. “Optimization Handoff in Mobility Management for the Integrated Macrocell Femtocell LTE Network”. International Journal on Recent and Innovation Trends in Computing and Communication 2 (1):63-67.

[6] Rodriguez, Joswill Victor Pajaro, and Amir Esmailpour. "Integrated QoS provisioning for unified LTE-WiMAX networks." In 2016 International Conference on Computing, Networking and Communications (ICNC), pp. 1-6. IEEE, 2016.

[7] Rao, K. Prabhakara, and P. V. Sridevi. "An integrated cross layer approach for throughput improvement in wireless sensor networks." In 2016 10th International Conference on Intelligent Systems and Control (ISCO), pp. 1-6. IEEE, 2016.

[8] N. A. Libre. (2021). A Discussion Platform for Enhancing Students Interaction in the Online Education. Journal of Online Engineering Education, 12(2), 07–12. Retrieved from http://onlineengineeringeducation.com/index.php/joee/article/view/49

[9] Tang, Yuliang, Chun-Cheng Lin, Guannan Kou, and Der-Jiunn Deng. "Cross-layer handover scheme for multimedia communications in next generation wireless networks." EURASIP Journal on Wireless Communications and Networking 2010 (2010): 1-10.

[10] K.S. Munasinghe, A. Jamalipour, Interworked WiMAX-3G cellular data networks: an architecture for mobility management and performance evaluation, IEEE Transactions on Wireless Communications 8 (2009) 1847–185.

[11] Romanov, O. I., M. M. Nesterenko, L. A. Veres, and Y. S. Hordashnyk. "IMS: Model and calculation method of telecommunication network's capacity." In 2017 International Conference on Information and Telecommunication Technologies and Radio Electronics (UkrMiCo), pp. 1-5. IEEE, 2017.

[12] Chawla, A. (2022). Phishing website analysis and detection using Machine Learning. International Journal of Intelligent Systems and Applications in Engineering, 10(1), 10–16. https://doi.org/10.18201/ijisae.2022.262

[13] Zhang, Li Jun, and Samuel Pierre. "An enhanced fast handover with seamless mobility support for next-generation wireless networks." Journal of network and computer applications 46 (2014): 322-335.

[14] Selvi, M. Phemina, and S. Sendhilnathan. "Minimizing handover delay and maximizing throughput by heterogeneous handover algorithm (HHA) in telecommunication networks." Appl. Math 11, no. 6 (2017): 1737-1746.

[15] Bagubali, A., V. Prithiviraj, and P. S. Mallick. "Performance analysis of IMS based LTE and WIMAX integration architectures." Alexandria Engineering Journal 55, no. 4 (2016): 3229-3238.

[16] Edward, E. Prince, and V. Sumathy. "Performance analysis of a context aware cross layer scheme for fast handoff in IMS based integrated WiFi–WiMax networks." Pervasive and Mobile Computing 17 (2015): 79-101.

[17] Shahwaiz Afaqui, M., Cristina Cano, Vincent Kotzsch, Clemens Felber, and Walter Nitzold. "Implementation of the 3GPP LTE-WLAN Interworking Protocols in NS-3." arXiv e-prints (2019): arXiv-1901.

[18] Bhuvaneswari, M., and P. Seethalakshmi. "A Survey on QoS Enhancement in Mobile Multimedia Services using Cross-Layer Design in 4G Wireless Networks." International Journal of Computer Applications 19, no. 4 (2011): 14-18.

[19] Bagubali, A., Ankit Agarwal, V. Prithiviraj, and P. S. Mallick. "Performance Analysis of Inter and Intra IMS Network." Journal of Green Engineering 4, no. 3 (2014): 175-194.

[20] Akkari, Nadine. "An IMS-based integration architecture for WiMax/LTE handover." Computer Networks 57, no. 18 (2013): 3790-3798.

[21] Mohammed, M. M., Viktor, Z., Yurii, K., Lyubov, B., Konstiantyn, P., & Turovsky, O. L. (2022). Methods for assessing the impact of bandwidth of control channels on the quality of telecommunications networks in the transmission of data packets of different types. International Journal of Communication Networks and Information Security (IJCNIS), 13(2).

[22] Avhankar, Madhavi S., Dr. Janardan A. Pawar, Snehankita Majalekar, and Suwarna Kedari. 2022. “Mobile Ad Hoc Network Routing Protocols – Using OPNET Simulator”. International Journal on Recent and Innovation Trends in Computing and Communication 10 (1):01-07.

[23] P. Pal et al., "Vertical Handoff in Heterogeneous Mechanism for Wireless LTE Network - An Optimal Approach," 2020 International Conference on Emerging Trends in Communication, Control and Computing (ICONC3), 2020, pp. 1-5.

[24] Malathy, E. M., and Vijayalakshmi Muthuswamy. "State of art: vertical handover decision schemes in next-generation wireless network." Journal of Communications and Information Networks 3, no. 1 (2018): 43-52.

[25] Alhusenat, A. Y., Alma’aitah, A. Y., & Hayajneh, K. F. (2022). Matching Subcarrier Resource Allocation and Offloading Decision. International Journal of Communication Networks and Information Security (IJCNIS), 13(2).

[26] Pal, Pushparaj, Taranpreet Kaur, Dinesh Sethi, Anil Kumar, Sanjay Kumar, Anil Lamba, and Umang Rastogi. "Vertical handoff in heterogeneous mechanism for wireless lte network-an optimal approach." In 2020 International Conference on Emerging Trends in Communication, Control and Computing (ICONC3), pp. 1-5. IEEE, 2020.

[27] Praptodiyono, Supriyanto, Teguh Firmansyah, Mudrik Alaydrus, M. Iman Santoso, Azlan Osman, and Rosni Abdullah. "Mobile IPv6 vertical handover specifications, threats, and mitigation methods: A survey." Security and Communication Networks 2020 (2020).