Cross-layer Localized Mobility Management Based on SIP and HMIPv6 in Next Generation Networks

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Abstract —Next Generation Networks (NGNs) are aiming to integrate different access technologies for the accessibility of heterogeneous platform under the control of IP protocol. In such a complex environment, the availability of high data rates, high bandwidth, security, and end-to-end QoS are major challenges. In this paper cross-layer localized mobility management based on Session Initiation Protocol (SIP) and Hierarchical MIPv6 (HMIPv6) is proposed to support the providence of the end-to-end QoS; network and session mobility; reduce latency; and proper bandwidth management. The proposed scheme handles the mobility locally to minimize latency. Further, QoS manager is used for proper management of bandwidth. Performance analysis and numerical results demonstrate the efficiency and feasibility of proposed scheme for real time communication in terms of latency, packet loss, and traffic load.

Index Terms—Next generation networks, hierarchical mobile IPv6, session initiation protocol, End-to-End QoS

I. Introduction

The evolution towards Next Generation Networks underwent different stages starting from first generation (1G) in which only voice communication was possible. Several efforts have been made in second generation (2G) and third generation (3G) to improve IG in terms of providing communication in a digital form [1]. A major development happened to take place when mobile networks started to facilitate the users with the Internet. Users of today want to enjoy having a small size mobile phone with powerful processing and long lasting battery to make full use of the available applications [2], [3]. NGNs are aiming to make possible this dream by providing all-IP based communication [4].

The concept of Next Generation Networks (NGNs) is based on integrating heterogeneous networks such as: fixed networks, mobile communication networks, and the Internet. All these networks having different technologies will be operated under the platform of Internet Protocol (IP) [5]. Due to this heterogeneity, several challenges arise to manage services like multimedia, voice and web in NGNs. These challenges include quality of service (QoS), security, seamless mobility, and successful deployment of NGNs, which need to be addressed.

The major challenge which is considered in NGNs, is quality of service (QoS). It refers to effective mechanism of reserving resources and getting the services of high quality. During the whole process of communication from the start till the end, QoS guarantee less delay and jitter, minimum packet loss, and traffic load. The desired requirements concerning about QoS in NGNs are to provide the seamless QoS, where user can get the diverse services everywhere and any time [6], [7]. In order to meet these requirements, there is a need of end-to-end QoS. In heterogeneous environment like in NGNs, providing end-to-end QoS is a complicated task especially when a user moves frequently from one network to another in real time communication.

In real time applications, the communication can take place using high bandwidth. It is because the real time communication includes audio and video, which is very sensitive to delay and jitter. For this purpose, an efficient approach or architecture is needed that can offer end-to-end QoS capabilities like reservation of resources, admission control, traffic enforcement, assigning priority to the traffic, procedures for bandwidth control, and less delay in an effective manner [8]. To consider these capabilities, end-to-end QoS can be assured using any of the two ways: one is over provisioning a node, and the second one can link bandwidth sharing under connection oriented architecture. The first approach provides an easy way because it has no requirement of QoS architecture but the problem with this approach is it doesn't offer Service Level Agreement (SLAs). It has the suitability where the buffer is used in output router port. The second approach is much complicated because it has the requirement of signaling. Various QoS architectures like Integrated services (IntServ), Differentiated Services (DiffServ), and MPLS can be used for this purpose [9], [10].

Different organizations, including Institute of Electrical and Electronics Engineers (IEEE), Internet Engineering Task Force (IETF), International Telecommunication Union (ITU-T), and European Telecommunications Standards Institute (ETSI) are in the process of developing their standards regarding QoS in NGNs. The problems related to layer-2 are focused by IEEE and Layer-3 problems are under the consideration of IETF. The controlling mechanism and architecture for NGNs are the point of attention by ITU-T and ETSI [11]. The proposed research is an addition to the development that has been made in the domain regarding QoS in NGNs.

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This paper presents the cross-layer localized mobility management based on SIP and HMIPv6 in NGNs. The main contributions of the paper are: i) to handle both session and network mobility locally; ii) to minimize latency, packet loss, and traffic load.

The paper is structured as follows: Literature review is presented in Section II. Statement of the problem is mentioned in Section III followed by the proposed scheme in section IV. Section V describes the performance analysis whereas in Section VI simulation results are presented. At the end in Section VII, the paper is concluded and future works are stated.

II. Literature Review

Improving QoS in NGNs has been focused by many researchers in their work but still a lot of issues need to be addressed regarding the enhancement of the end-to-end QoS especially in real time applications [12].

The research work that has already been done related to QoS in real time applications in NGNs are discussed below. First, some of the implemented projects are mentioned followed by other related research work.

The Multi-Service Access Everywhere (MUSE) [12], based on broadband access is a large integrated R&D project funded by European commission. A QoS approach for Access networks and home IP networks are presented in this project. The consideration is given to edge networks only and core networks are not being focused [13].

The project NETQOS [14] has aimed at enhancing end-to-end QoS and utilization of resources using autonomous policy-based QoS management in both wired and wireless heterogeneous networks. This approach allows the dynamic adaptation to changing requirements of the operational environment, users, internet service providers, and applications. Assuming inter-domain policy and QoS negotiation, no consideration is given to protocol like Session Initiation Protocol (SIP), client-server model communications and NGNs infrastructures [12]. Moreover, no standardize considerations for NGNs have been presented in this project.

The IST (Information Society Technologies) project ENTHRONE has proposed the integrated management solution. It has focused whole audio-visual service distribution chain, including content handling protection, across network's distribution, and response at user terminals [15]. A data model MPEG-21 [15] is used by this project, which provides common support for management and implementation of the resources' functionalities. The negotiation approach for multimedia session like the one in SIP/SDP did not consider in this project [12].

The EUQOS [16] project is mainly focusing on a multi-protocol based QoS model concept for NGNs. They are of the view that it will provide end-to-end QoS having several functionalities for multiple applications. This project has provided QoS for inter domain sessions but the approach used in this has explicitly nothing to do with QoS in core networks of the particular domains [12].

The KING (Key components for the Internet of the Next Generation) [17] project presented an intelligent inter domain QoS routing mechanism for edge networks but assumption has been made that IP core networks has no support of any reliable QoS mechanism [12], [18].

In the following research work the combination of SIP with network mobility protocols are presented.

SIP has been integrated with Fast Mobile IPv6 [19] in 4G networks for real time mobility. This approach also provides end-to-end quality of service. An effort is made to minimize the latency through high-speed handover mechanism. Since binding update is going through core networks which is causing the extra delays. The main reason is that core network or home agent will wait for binding updates from Mobile Node (MN) and then MN will wait for an acknowledgement. This results in half a round trip delay before packets are forwarded. The round trip delay is directly proportional to the distance between MN and core network. There is an additional delay if the MN employs route optimization. Authentication can be done between MN and correspondent node (CN). For this process, 1.5 round trip times will be required in a superlative case scenario [20]. In this approach, the extra burden on QoS manager has been imposed which is to provide the security mechanism, means authentication should be provided by this module.

SIP has been combined with Seamless Mobile IPv6 (SMIPv6) in [21] to improve the QoS. The approach lacks the details and performance analysis regarding how delays will be minimized or any other QoS parameters will be improved.

Architecture has been introduced in [22] which are based on SIP to support QoS and session management by providing a hybrid approach of combining DiffServ and IntServ. It can only work with standard SIP end systems.

Shortly, in some of the above literature study the focus is either on core networks or edge networks. On the other hand, those who have focused both types of networks are resulting high delay and huge burden on QoS manager. The increase in delay and load is due to the flow of both signal and traffic through the core network.

III. Problem Statement

The effect of high delay is considered a major problem in NGNs. It is because of the binding updates which take place through the core network. When MN wants to establish communication with resultant node (RN), the traffic and signals are routed through the core network. Both the core network and RN wait to receive binding updates from MN. In response, MN waits for acknowledgment. If MN and core network is located far away from one another, the increase in delay occurs due to authentication and route optimization. Moreover, it also caused the signaling overhead in the core network.

Another major problem is regarding mobility such as session mobility and network mobility. The researchers have focused on either core network or edge network that affects mobility in NGNs. In real time applications, both core and edge networks need to be focused in order to maintain seamless mobility.

The third problem is the result of massive load on QoS manager in the core network. The consequences due to this reduce the efficiency of QoS manager in managing bandwidth, packet loss, and reserving resources. An effective mechanism is required which can segregate and minimize the load of QoS manager to increase its efficiency while providing end-to-end QoS.

IV. Proposed Scheme

In order to focus the problems stated in Section III, a new scheme named cross-layer localized mobility management based on SIP and HMIPv6 is proposed. This scheme merges two protocols: one is network layer protocol which is HMIPv6 and the second is application layer protocol named SIP [23]. HMIPv6 is hierarchical in structure to handle the signal and traffic locally, and this greatly reduces the latency. Both core and edge networks are focused in proposed scheme. SIP is used to manage session mobility whereas HMIPv6 handles network mobility.

QoS managers in proposed scheme are distributed in two levels such as Regional QoS (RQoS) manager and Core QoS (CQoS) manager. This distribution reduces the burden of QoS manager in the core network. Moreover, in most of the literature, the security is managed through QoS manager. In proposed scheme, it is the responsibility of Mobility Anchor Point (MAP) to handle security. The reduction in load significantly increased the efficiency of QoS manager.

The main objectives which proposed scheme provides are localized management of both session and network mobility to minimize latency, packet loss, and traffic load.

For understanding the proposed scheme effectively, first brief description about HMIPv6, SIP, and QoS manager is presented followed by algorithm, architecture, and signaling flow of the proposed scheme.

A. Hierarchical Mobile IPv6 (HMIPv6)

The access of various networks having multiple radio access methods is provided through mobility protocols in wireless communication. Among the mobility protocols, Mobile IPv6 is the primary protocol. All other protocols such as Fast MIPv6, Seamless MIPv6, and Hierarchical MIPv6 (HMIPv6) are extensions of MIPv6. In MIPv6 during the process of communication, each time messages are exchanged between Mobile Node (MN) and Home Agent (HA) when MN changes its access point. If MN is located far away from HA, the exchange of messages resulting problems like high delay and signaling overhead in the process of updating [24].

Hierarchical Mobile IPv6 (HMIPv6) has been developed to overcome these problems. It is based on the idea of the Internet having various autonomous domains for its efficient management. In the same way, HMIPv6 possess the hierarchical structure to reduce delay and signaling overhead between core network, MN, and Resultant Node (RN) [20]. For the efficiency of this protocol, Mobility Anchor Point (MAP) has been introduced in the updated RFC 5380. The responsibilities of MAP are to act like a local home agent so that mobility can be controlled locally. Two types of addresses including Regional Care of Address (RCoA) and on-Link Care of Address (LCoA) are used by MAP for this local management [20], [24].

LCoA is a temporary address assigned by local router and it is changed when MN is moving inside the same region. This change of LCoA is unknown to both HA and RN and this transparency help a lot in reducing signaling overhead and delay [20], [24], [25]. The RCoA is used when MN moving from one region to another and it is updated with HA so that MN becomes known to HA [20], [21], [24].

Additionally, the mechanism for security management is also provided by MAP in HMIPv6. Before the start of communication MN needs to be authenticated by MAP. For the authentication of MN with MAP, either MN identity or identity of Certification Authority (CA) can be used. Both MAP and MN must be equipped with IKEv2 for this authentication mechanism [20]. Internet Key Exchange version 2(IKEv2) is a protocol which offers secure communication between MN and MAP [20].

B. Session Initiation Protocol (SIP)

SIP is an application layer text based protocol which can support various types of mobility such as service mobility, session mobility, personal mobility, and terminal mobility [22], [26], [27]. Different modules like user agent, redirect server, and proxy server are incorporated in SIP to handle the mobility efficiently [28], [29]. In proposed scheme, SIP server is used to manage mobility when user initiating the handover inside the same region or from one region to another. Two types of mobility are managed in the proposed scheme: pre-call mobility and mid-call mobility. A MN sends REGISTER message to SIP server in respective region local HA for its registration with new IP address, this refers to pre-call mobility. After registration, INVITE message is sent by the RN to SIP server for connection with MN [24]. In reply SIP server forward the address of MN so that RN can directly contact with MN. The MN sends OK message to RN for successful session establishment [19], [24].

During an ongoing session, if any of the nodes initiating handover, it sends re-INVITE message to SIP proxy server. The 200ok message is forwarded to another node by SIP proxy server so that the session can smoothly continue, and this refers to mid call mobility [19].

C. QoS Manager

In NGNs, diverse networks are integrated in a single platform which makes the environment very complicated. For this purpose, an efficient approach is required to manage the QoS in an effective way. Our proposed scheme introduces QoS manager with some modification to handle QoS in such a heterogeneous environment.

QoS manager is used to assign resources like bandwidth, reservation of resources, and network policy implementation [19], [21]. Handovers of different natures are also managed by this module to ensure that resources are provided in advance when MN is in movement [19].

In proposed scheme, QoS managers of two types are used; one is Core QoS (CQoS) manager, which is responsible for QoS management of the core network. The second one is Regional QoS (RQoS) manager to manage resources' region wise and also making coordination with other regions QoS managers. If RQoS manager gets the shortage of resources, it will request CQoS manager to provide the required resources.

In existing approaches related to QoS manager, the security management was also the responsibility of this module. In our proposed scheme, this overload is detached from QoS manager to improve its efficiency regarding minimizing packet loss and traffic load. The task regarding security is assigned to MAP in Combined SIP HMIPv6.

TABLE I: ALGORITHM OF PROPOSED SCHEME

```
BEGIN
NEXT GENERATION NETWORKS (NGNs)
1.  Network A = UMTS
    Network B = WRAN
    Network C = WPAN
    Network D = WIMAX
    Network E = WLAN
    Network F = IP Core Network

2   Nodes = Mobile Node (MN),
    Resultant Node (RN)

3.  Networks (A, B, C, D, E, F)
                =
    MN, MAP, HA, SIP Server, QoS
    Manager, Access Routers (ARs)

4.  MN is communicating with MAP via
    ARs.
    ARs continuously searching the
    MAP and will connect the MN with
    the MAP having   strong signal
    MN binds on-Link CoA with RCoA
    to HA and RN.
    SIP server establish session
    with RN (Pre-call Mobility)
    MN makes movement continuously
    Threshold = value defined for
    the MN and ARs connection.

5. WHILE (strength of signal <
   threshold OR MN wants handover)
     {
     Handover will be initiated
     according to following
      conditions
  a. IF (RN is within same RCoA)
      {
       MN send re-INVITE to RN and
       200ok will be received from RN
       (Mid Call Mobility)
       Communication will continue
       RQoS Manager will manage the
       resources
       IF (RQoS Manager needs
       resources)
      {
       Will contact CQoS Manager for
       resources
       CQoS manager will help in
       resource allocation
       }
       Else
       RQoS manager will allocate
       resources
       }
  b. IF (RN is outside the RCoA AND RN
     belongs to the network of MN)
      {
       MN binds RCoA to HA and RN
       MN send re-INVITE to RN and
       200ok will be received from RN
       (Mid Call Mobility)
       Communication will continue
       RQoS Manager will manage the
       resources

     IF (RQoS Manager needs resources)
       {
        Will contact CQoS Manager for
        resources
        CQoS manager will help in
        resource allocation
        }
       Else
        RQoS manager will allocate
        resources
        }
  c. IF (RN is outside RCoA AND
     belongs to different network)
       {
        MN binds RCoA to HA of that
        network and RN
        MN send re-INVITE to RN and
        200ok will be received from RN
        (Mid Call Mobility)
        Communication will continue
        RQoS Manager will manage the
        resources
     IF (RQoS Manager needs resources)
       {
        Will contact CQoS Manager for
        resources
        CQoS manager will help in
        resources' allocation
        }
        Else
        RQoS manager will allocate
        resources
        }
        }
6. Communication will continue and
   no handover will occur if the
   signal is strong and MN doesn't
   want handover.

END
```

D. Proposed Scheme Algorithm

In the proposed algorithm as shown in Table I, six networks of different types are considered such as UMTS, WRAN, WPAN, WIMAX, WLAN and IP Core Network denoted by A, B, C, D, E, and F respectively. These networks are equipped with various modules like MAP, Home Agent (HA), SIP server, QoS Manager, and Access Routers (ARs). Both MN and RN belong to any type of network can use these modules in order to establish communication. The process of establishing session and managing handover mechanism in proposed algorithm are presented through proposed architecture in Fig. 1.

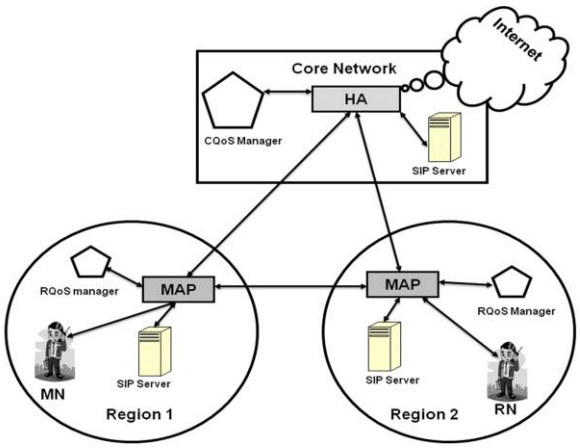

Fig. 1. Architecture of proposed scheme.

In proposed architecture, the information is broadcasted by access routers (ARs) about each MAP, which locates within the range of MN. A MN is connected to MAP having the strong signal through ARs. The connection is made using binding updates in which MN binds LCoA as a temporary address assigned by the access router. MAP binds the RCoA of MN to HA so that if MN wants communication with RN located at any other region, it should be known to HA.

For session establishment, first the pre-call mobility is performed in which MN is registered with SIP server, subsequently connected with RN using INVITE and Ok messages. After successful session establishment, the session will be going on and if MN wants to initiate handover then following three conditions occur:

In first condition, if both MN and RN belong to the same region then only LCoA is changed, and it is updated in MAP using binding updates. There is no need to inform HA and RN about this change of LCoA. Only mid-call mobility is to be performed in which MN sends re-INVITE message to RN. In response, RN sends the 200ok message for continuing the session smoothly. If RQoS manager has the shortage of resources in between an on-going session then it will request CQoS manager to provide the required resources.

In second condition, if RN is outside of MN region and belongs to same network then MAP has to update RCoA of MN with both HA and RN. For the smooth session continuity, mid-call mobility is to be performed. Both RQoS and CQoS mangers coordinate each other for resources management during an on-going session.

In third condition, if MN wants to initiate handover and RN is located at another region and also belongs to different network then MN binds RCoA to HA of that network and RN. In order to continue the on-going session, mid-call mobility is performed and both levels of

QoS managers handle the resources through coordination. The handover signaling flow for the above cases is shown in Fig. 2.

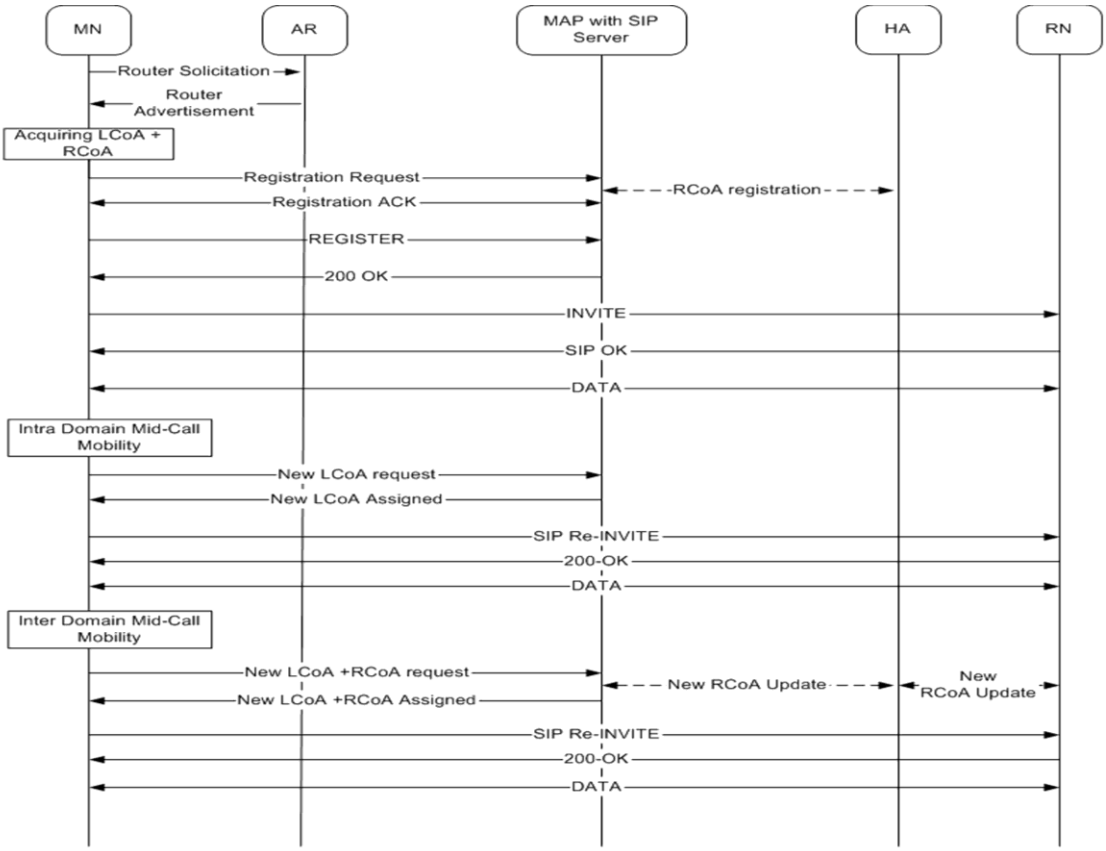

Fig. 2. Handover signaling flow of proposed scheme.

V. Performance Analysis

In this section, the proposed scheme is analyzed and compared with the integration of SIP and FMIPv6.

A. Models for Mobility

For the mobility models hexagonal formation is used as shown in Fig. 3. A MAP region is constructed in the formation having cells enclosed by loops of cells. There are *L* loops of same size in each region. The central cell is numbered with "0" enclosed by loops numbered with "1"and "2" respectively. The assumption is made that each cell is handled by one access router. Following formula in (1) shows the total number of loops in this formation.

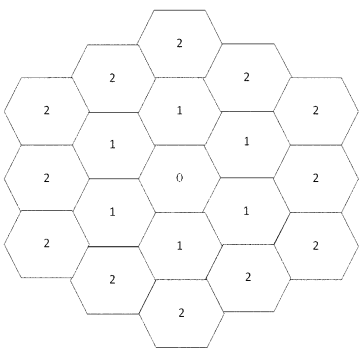

Fig. 3. Hexagonal formation of MAP region with 2 loops in HMIPv6.

$$N(L) = \sum_{l=1}^{L} 6l + 1 = 3L(L+1) + 1 \tag{1}$$

Mobility models of two types including fluid-flow and random-walk [30], [31] are used for the performance analysis of the proposed scheme. The movement of user with unpredictable speed, directions changing, and high mobility are represented by fluid-flow model. Random-walk model is more fitted for the users having mobility of pedestrian type in a small geographical area.

1) Fluid-flow model

In fluid-flow model, the range is kept (0, 2π) for the MN moving inside MAP region. Various notations in (2) and (3) are shown below.

S= Average speed, r = Cell radius, d= User density in a cell, P_a and P_b = Cell parameters and MAP regions inside *L* loops, CR_a and CR_b = Crossing rates of region.

$$CR_a = \frac{d \cdot S \cdot P_a}{\pi} = \frac{d \cdot S(6r)}{\pi} \tag{2}$$

$$CR_b = \frac{d \cdot S \cdot P_b}{\pi} = \frac{d \cdot S(12L+6)r}{\pi} \tag{3}$$

2) Random-walk model

In random-walk model the approaching location of MN is calculated by its preceding location, additionally drawing the value of random variable from an arbitrary

distribution. The assumption is made that MN is located currently in a cell of loop *"l"*. Moreover (4) and (5) showing the probability of MN movement to another cell of loop *"l*+1*"* or its backward movement towards cell of loop *"l*-1*"*.

$$P^{+}(l) = \frac{1}{3} + \frac{1}{6l} \tag{4}$$

$$P^{-}(l) = \frac{1}{3} - \frac{1}{6l} \tag{5}$$

The probability of MN location in existing cell and its movement towards another cell is assumed k and 1-k respectively.

$$P_{l,\,l+1} = (1-k) \text{ if } l = 0,$$

$$P_{l,\,l+1} = (1-k)\left[\frac{1}{3} + \frac{1}{6l}\right] \text{ if } 1 \le l \le L \tag{6}$$

$$P_{l,\,l+1} = (1-k)\left[\frac{1}{3} - \frac{1}{6l}\right] \text{ if } 1 \le l \le L \tag{7}$$

The transition probability from state l to l+1 or l -1 is shown in (6) and (7). It is assumed that $\pi_{l,\,L}$ be a steady-state probability of state l within a MAP region of L loops. The $\pi_{l,\,L}$ is shown in (8) by means of the transition probabilities.

$$\pi_{l,\,L} = \pi_{0,\,L} \prod_{i=0}^{l-1} \frac{P_{i,\,i+1}}{P_{i+1,\,i}} \tag{8}$$

According to the statement of Markov chain property the summation of all the steady-state probabilities is equal to 1, so the $\pi_{0,\,L}$ is represented as:

$$\pi_{0,\,L} = \frac{1}{1 + \sum_{l=1}^{L} \prod_{i=0}^{l-1} \frac{P_{i,\,i+1}}{P_{i+1,\,i}}} \tag{9}$$

B. Handover Latency Analysis

The handover latency refers to the time duration when MN initiating handover and it is unable to send or receive packets. Using the mobility models, the latency analysis of the proposed scheme is compared with the architecture in which SIP has been combined with Fast MIPv6. For the comparison this specific combination is considered because it has provided the base for integrating SIP with network mobility protocols. Integration of SIP with Fast MIPv6 and other related combinations have the prime concept of handling traffic and signal at core network whereas in proposed scheme it is handled locally. The architecture of the proposed scheme in Fig.1 is showing the communication between MN and RN. Following notations are used to express the latency between different entities.

MN and HA = $T_{\text{M-H}}$
MN and MAP = $T_{\text{M-MAP}}$
MAP to MAP = $T_{\text{MAP-MAP}}$
ARs to ARs = $T_{\text{Ar-Ar}}$
MN to RN = $T_{\text{M-R}}$

For the successful communication between MN and RN during the process of handover, the following steps need to be performed.

- Movement recognition (MR) and new CoA configuration ($T_{(\text{MR \& NAC})}$)
- Binding Update (T_{BU})
- Packet Delivery (T_{PD})

The sum of the latency of above steps gives total delay in (10).

$$T_D = T_{(\text{MR \& NAC})} + T_{\text{BU}} + T_{\text{PD}} \tag{10}$$

1) Latency in integration of SIP with FMIPv6

In FMIPv6 the MN movement while entering new subnet is determined through router solicitation or router advertisement. The MN configures its new CoA by means of prefix information in router advertisement. In order to verify new CoA whether it is unique, Duplicate Address Detection (DAD) is used. Following formula represents the delay for movement detection and new CoA.

$$T_{(\text{MR \& NAC})} = T_S + T_{\text{RAdv}} + T_{\text{DAD}}$$

where T_S represent router solicitation delay, T_{RAdv} represent router advertisement delay, and T_{DAD} represent DAD delay.

When new CoA is configured then return routability (RR) for security is performed before binding updates. It requires 1.5 round trip delays between MN and RN [19]. The total BU delay is represented as:

$$T_{\text{BUD}} = T_{\text{RR}} + T_{\text{BU}}$$

where T_{RR} = 3 ($T_{\text{M-H}}$ + $T_{\text{H-R}}$), delay for requesting BU and its reply is T_{BU} = 2 ($T_{\text{M-H}}$ + $T_{\text{H-R}}$), T_{BUD} = 5 ($T_{\text{M-H}}$ + $T_{\text{H-R}}$).

The packet delivery delay is calculated in following formula.

$$T_{\text{PD}} = T_{\text{M-H}} + T_{\text{H-R}}$$

Hence,

$$T_D = T_{(\text{MR \& NAC})} + 5\,(T_{\text{M-H}} + T_{\text{H-R}}) + T_{\text{M-H}} + T_{\text{H-R}},$$
$$T_D = T_{(\text{MR \& NAC})} + 6(T_{\text{M-H}} + T_{\text{H-R}}). \tag{11}$$

2) Latency in proposed scheme

In proposed scheme the traffic and signals are managed locally using MAP in HMIPv6. The delay for new CoA configuration and movement detection is same like the one in integration of SIP with FMIPv6. The delay for binding updates and packet delivery is calculated below.

The problem of round-trip is resolved in HMIPv6 due to local handling of signal and traffic, so the delay for BU is represented as follows:

$$T_{\text{BU}} = 2(T_{\text{M-MAP}} + T_{\text{MAP-R}}).$$

The delay for packet delivery is computed as:

$$T_{\text{PD}} = T_{\text{M-MAP}} + T_{\text{MAP-R.}}$$

Hence,

$$T_D = T_{(MR\ \&\ NAC)} + 2(T_{M\text{-}MAP} + T_{MAP\text{-}R}) + T_{M\text{-}MAP} + T_{MAP\text{-}R},$$

$$T_D = T_{(MR\ \&\ NAC)} + 3(T_{M\text{-}MAP} + T_{MAP\text{-}R}). \quad (12)$$

The above analysis verifies that the proposed scheme reduces the latency to half by handling the signal and traffic locally within region.

VI. Simulation Results

In this section, the numerical results regarding minimizing latency, packet loss, and packet load are obtained using an OPNET simulation tool [32]. The nodes used in the simulation environment are mentioned in proposed architecture. The parameters and values used in the simulations are shown in Table II.

TABLE II: PARAMETERS USED IN SIMULATION

Participating Networks	Core network, TDMA, WiMAX, WLAN , and UMTS
Wired Bandwidth	1 Gb/s
Wireless link bandwidth	100 Mb/s
Packet size	1Kb
Moving speed	5-60 m/s
Radius of wireless cell	100 m
Simulation time	240 sec

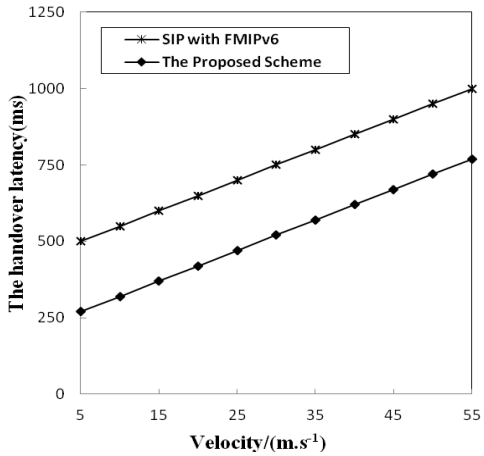

Fig. 4. (a)Handover latency versus velocity (vertical handover).

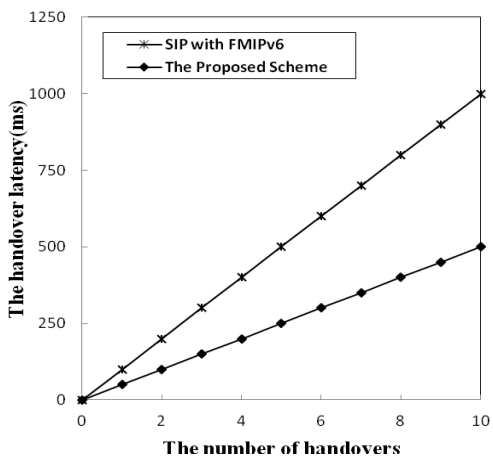

Fig. 4. (b)Handover latency versus number of handovers (vertical handover).

A. Handover Latency

The handover latency is evaluated based on performance analysis and is presented in this sub section. In Fig. 4 the handover latency is shown for vertical handover which means the MN has changed its network. Fig. 4(a) is demonstrating the handover latency versus velocity, whereas in Fig. 4(b) the handover latency versus number of handovers is presented. We can see the proposed scheme minimizes the latency in both cases.

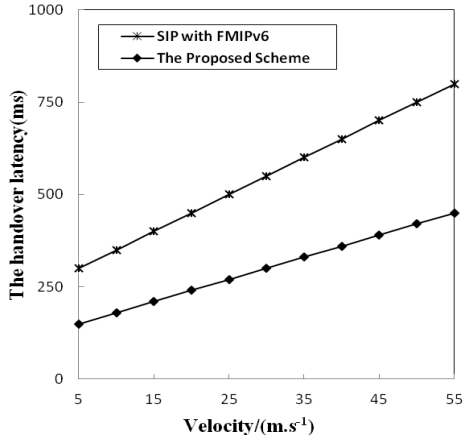

Fig. 5. (a)Handover latency versus velocity (horizontal handover).

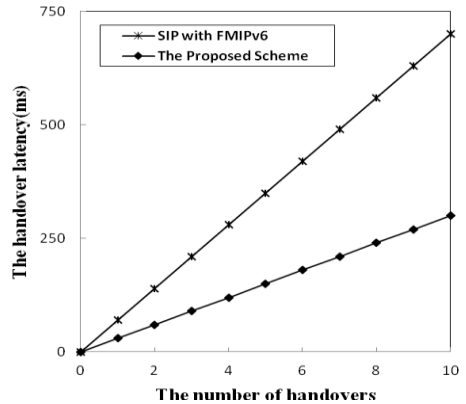

Fig. 5. (b)Handover latency versus number of handovers (horizontal handover).

The horizontal latency is shown in Fig. 5 which means that the MN has initiated handover within the same network. The results for both handover latency versus velocity and handover latency versus number of handovers are presented in Fig. 5(a) and Fig. 5(b) respectively.

B. Packet Loss

During an ongoing session, the loss of packets cannot be ignored which can be happened due to several factors like improper management of bandwidth, frequently handovers, and so on. In our simulations, we evaluated packet loss in terms of MN speed and data transmission rate. In Fig. 6(a) and Fig. 6(b), both cases are shown. We can see the proposed scheme has fewer packets loss than SIP with FMIPv6. When the speed of MN is increased the packets loss reached up to 150 in SIP with FMIPv6, whereas in proposed scheme it is less than 50. Similarly in case of increasing data transmission rate, the packet

loss in SIP with FMIPv6 is 60 whereas in proposed scheme it is below 20.

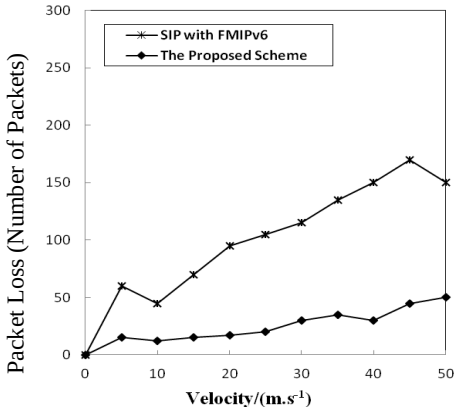

Fig. 6. (a)Packet loss versus velocity.

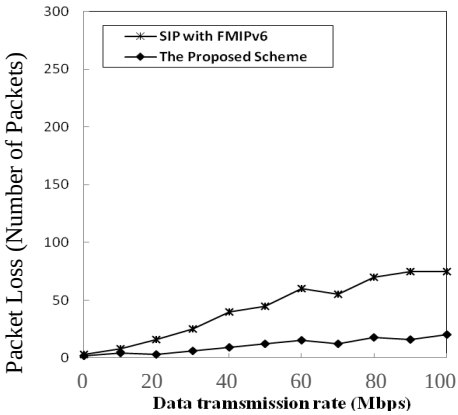

Fig. 6. (b)Packet loss versus data transmission rate.

C. Load

The traffic and signal load is evaluated in both architectures. For analysis, load is compared using packet load versus velocity and packet load versus data transmission rate. Both the comparisons in Figs. 7(a) and (b) show that proposed scheme is efficient than SIP with FMIPv6 regarding signaling and traffic load.

From the performance analysis and numerical results, the proposed architecture seems to be more efficient than SIP with FMIPv6 architecture. Assumptions made in this paper are proven. Both traffic and signals are handled locally which reduce latency, packet loss, and load to the very handsome amount.

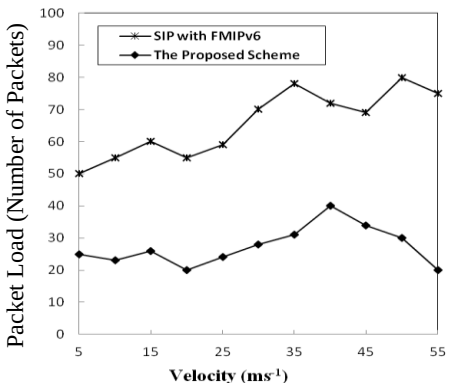

Fig. 7. (a)Packet load versus velocity.

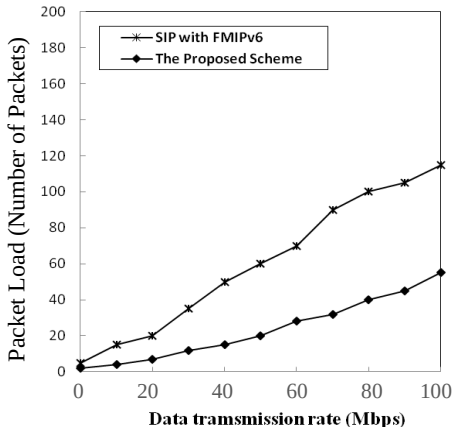

Fig. 7. (b)Packet load versus data transmission rate.

VII. Conclusions and Future Work

The main problem in real time communication in NGNs is to provide maximum QoS. This paper presents the cross-layer localized mobility management based on SIP and HMIPv6. The proposed scheme is toiled with QoS manager to maximize QoS in NGNs. Moreover, it provides end-to-end QoS, less delay, seamless session and network mobility, bandwidth management, resource reservation, minimize packet loss, and traffic load. Analysis showed that the proposed solution provides great impact when managing traffic, both session and network mobility locally because it reduces the latency, packet loss, traffic load, and signaling overhead on the core network. Additionally, it plays a significant role while focusing both core and edge networks.

In future work, we will probe to enhance a security mechanism in proposed architecture and minimize the usage of resources by using sharing of resources' mechanism among different networks.

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