A Seamless Adaptive Mobility Management Scheme for 4-G Network

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Summary
The evolution of IPVv6 -Core based Mobile communication system is conceptualized with various factors of scalabilities, convergence and availability in true sense, which is the goal of fourth generation (4G) mobile network. One of the main objectives of 4G network is to bring a convergence of Internet domain and telecommunication with better quality of service (QoS) provisioning to all its mobile users. Therefore design of an adaptive protocol for seamless handoff synchronized with non linear mobility pattern is an active research issue. This paper introduces a novel scheme called Reduced Registration Time Care-of Mobile IP (RRTC: MIP). RRTC: MIP introduces architecture of adopting care-of address of home network in more optimized way in order to reduce the registration time, which in turn reduces the handoff latency. The proposed scheme is simulated in discrete time simulator OMNeT++. The performance parameters like network Registration time, Handoff -latency versus mobility is evaluated and compared with the existing MIPv6. The efficiency of proposed RRTC: MIP is found better than MIPv6.
Key words:
IPv6, 4G Network, Handoff,

1. Introduction

The need for advanced mobile communication systems have mainly increased as the user requirements have accelerated exponentially. Many organizations such as IEEE, Electronics and Telecommunications Research Institutes, Korea University etc have been working towards 4G networks to provide Seamless Connectivity anywhere anytime. The 4G networks would be heterogeneous in nature where there would be multiple service providers, equipped with varied technologies offering varied services for the benefit of the users. A simple 4G network is shown in Fig. 1. It is very clear from Fig. 1 that a user could utilize multiple services offered by multiple providers enabling seamless connectivity. In 4G networks a mobile node in network could access services and bandwidth offered by other service providers without pre registration or pre subscription.

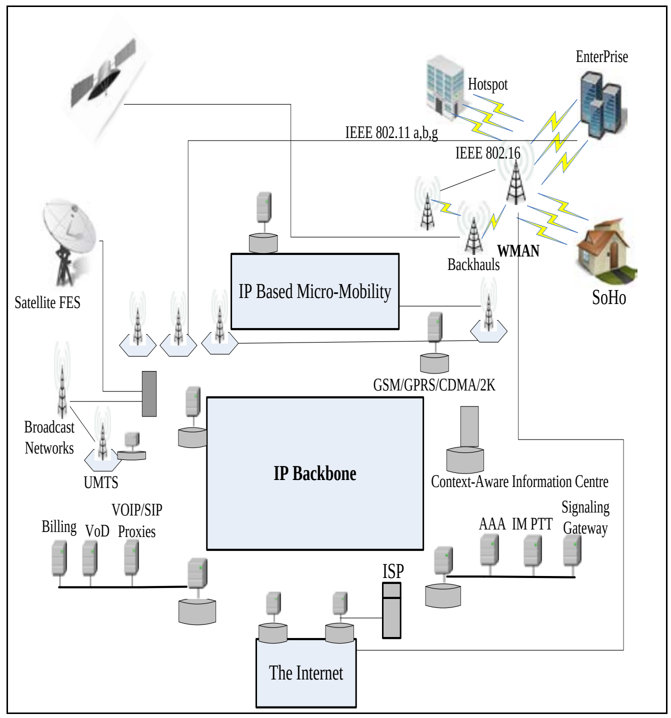

Figure 1: Architecture of 4G Network

To enable such diverse mobility options there is a need for an interface management technology which not only provides convergence of the varied services offered but also provides service provider coordination based on MIPv6 core architecture. It may so happen that some additional components may be necessary to monitor the spectrum or shared spectrum. Security becomes a major concern when multiple interfaces are involved in communication.
The interfaces have varied transmission rates, varied technologies, varied services and varied spectrum allocation. Thus, it is very necessary for the user to have compatible devices to enjoy such connectivity [1].The mobile node should also be capable of auto configurability without the user intervention. A very critical aspect is to

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design a Business Model that combines the offerings of service providers, efficient sharing of resources and allocation of services. Resourceful Mobility Management would be a key area for 4G networks. Handoff Management is an integral element of Mobility Management [2]. In this paper, network interface switching, decision making within services offered and connectivity management are studied.

2. Related Work

4G network architecture designs have been extensivelystudied. A basic 4G network which has a IP Core[20][21][22] is as shown in Fig. 2.

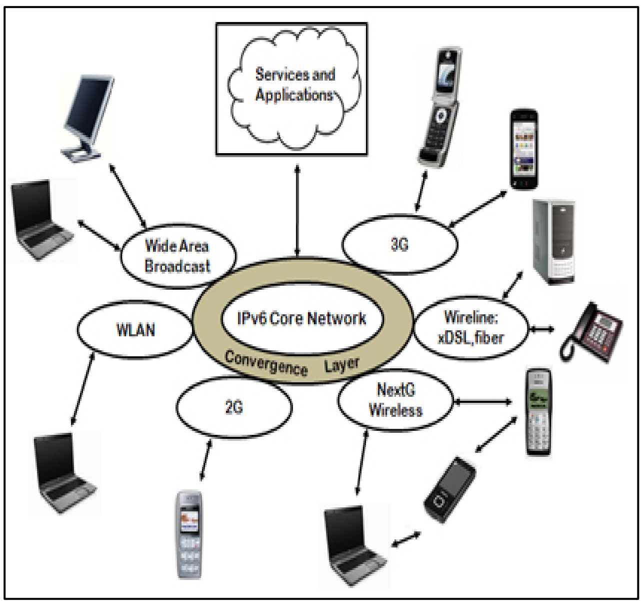

Figure 2. 4G network integrated over a IP core

The Open Wireless Architecture and Open Access Spectrum [3] architecture propose that multiple service providers would have to converge and offer services. Many issues still remain with respect to the implementation of such networks [4].4G networks consist of multiple access technologies whose convergence could be established over an IP core network efficiently. Based on our study, it is very clear that the IP Core would be a very eminent part of the 4G network. We envision an IP Core network offering varied services over varied interfaces in our architecture put forth in this paper. As studied from the research conducted by NGMC forum, Korea and CJK collaboration [5] [6] on 4G implementation, it is very evident that the 4G architecture would incorporate an IP core network for communication. We consider a 4G network converged over the MIPv6 core. MIPv6 is a layer 3 protocol, well defined by RFC3775 [7]. The usage of MIPv6 is advantageous as it provides better mobility support and better addressing schemes [8].

To provide seamless connectivity handoff management is a very important criterion to be considered in 4G Network architecture design. [9]. Handoffs are differentiated into various categories [10]. In our research presented through this paper we consider handoffs across diverse networks that are available for data transactions. Handoff is a process in which an ongoing data transaction or an ongoing call is transferred from one interface to another interface without neglecting the fact that the terminal is mobile. The interfaces are interconnected through the core IP network. There are many terms associated with handoff management like Hand off latency, interface association time and connection reestablishment time. Handoff latency is the time between the last data transmission and the next data transmission after the interfaces over which the data transmissions were taking place have been changed. Handoff latency [20] could be represented as shown in Eq. (1)

Handoff Latency = Interface Association Time + Connection Reestablishment Time (1)

Handoff occurs across interfaces. The time taken to get association with the new interface is known as the Interface Association Time. Once the interface is established, the time taken to restore the previous data transmission is known as connection reestablishment time. Handoffs based on the networks involved can be of two kinds: Horizontal handoffs and vertical handoffs.

Horizontal handoffs occur between identical network technologies whilst Vertical handoff occurs between different network topologies. A good deal of research is being done towards the implementation of Handoff mechanisms. Handoff management involves several challenges like Quality of Service (QoS), communication cost, Received Signal Strength (RSS), service type, end user preference etc. Many approaches exist to provide efficient handoff techniques which consider a few parameters or a combination of these parameters for decision making. WLAN to CDMA2000 and vice versa handoff management schemes based on RSS and end user preference have been realized using IP/MIP connectivity [11]. Soft Handoff using MIP has been considered as a robust mechanism across data communication involving multiple interfaces. Multiple Interface handoff pose a major security threat [12]. A key based handoff mechanism [13] could be considered as a secure option. This scheme introduces additional packet transactions to provide security. SIP based handoff management techniques are easy to implement and efficient but suffer long handoff delays which could be negated by using node tracking techniques [14]. The node tracking technologies could be considered as an additional network management cost.

Terminals of the next generation networks are envisioned to demand high bandwidth with superior QoS. RSS measure has been considered as a parameter for superior QoS provision. Many algorithms have been developed to handle handoff based on the RSS measure which assure superior QoS [15] IP based Protocols have been developed to manage handoff. An IP based protocol which incorporates buffering scheme [16] was found effective. Not only did this protocol effectively reduced data loss but also exhibited reduced delays in handoffs. Another Fast Handoff Mechanism over MIPv6 was effective due to the Candidate Access Router Discovery [17] mechanism incorporated into the network to manage handoffs. It is very apparent that IP based solutions prove effective for handoff management. Handoff Management Architectures implemented through Handoff Servers have been also proposed by many researchers [18]. These Handoff Servers maintain connectivity with the nodes over IP Tunnels [19]. We have used one such server based approach in our research. There is still lot of issues to be addressed while considering realization of 4G networks. Many organizations are working towards the realization of seamless connectivity. In this paper we propose a MIPv6 based architecture, capable of handling handoffs across various interfaces providing varied services.

3. Proposed System

As stated earlier, each access point receives Mobile anchor point option messages from high-layer Mobile anchor points every Δ period of time. In proposed system, we consider the inclusion of information on instant loads of Mobile anchor points in the Mobile anchor point option messages. Examples of parameters that can define a Mobile anchor point load are memory size, CPU processing power, and used bandwidth. For simplicity, we denote the load of the i^{th} Mobile anchor point, as shown in its kth downstream node, at the nth time slot as $M_i \rightarrow k[n]$ and define it as the integer part of the percentage of the ratio of the number of packets that is processed on the link that connects the i^{th} Mobile anchor point to its k^{th} downstream node to the total number of packets that the Mobile anchor point can process on the same link during the computation period of time $([n.\Delta, (n + 1).\Delta])$, i.e.,

$$M_{i\rightarrow k}[n] = \left[\frac{\left(p_{i\rightarrow k[n]}\right) + W.q_{i\rightarrow k}[n]}{c_{i\rightarrow k.\Delta}}.100 \right] \quad (2)$$

Where $C_{i\rightarrow k}$ denotes the data processing speed of the ith Mobile anchor point on the link to its k^{th} downstream node. Note that a network element along the communication path can function as either a Mobile anchor point or a mere router. The former case concerns packets that are destined to MNs and are registering with the network element as their Mobile anchor point, whereas the latter case relates to packets that are destined to nodes with other network elements as Mobile anchor points. Similarly, $p_{i\rightarrow k}[n]$ and $q_{i\rightarrow k}[n]$ denote the total number of data packets that are forwarded by the i^{th} Mobile anchor point to its k^{th} downstream node as a mere router and the number of data packets that are destined to MNs registered with the i^{th} Mobile anchor point, respectively, at the n^{th} time slot. Intuitively, the computational loads that is required by a mere router to forward a data packet and that required by a Mobile anchor point to transmit a data packet to a node registered with it are different. W is a weight factor for reflecting the difference in these two computational loads. It is assumed that access points have prior knowledge on the two parameters $C_{i\rightarrow k}$ and W for each i^{th} Mobile anchor point and for each respective k^{th} downstream node. Upon computing their loads, Mobile anchor points notify access points of this information via the 7 bits of the reserved (RES) field carried in the packet header of Mobile anchor point option messages, as we will explain later. Having a potential number of MNs that is connected to the same Mobile anchor point for communication may likely lead to congesting the Mobile anchor point in question and result in an inefficient distribution of the network traffic. To avoid congesting Mobile anchor points with traffic, ARs should advise newly arriving MNs with the most appropriate Mobile anchor point. Mobile anchor points should, thus, be aware of the ongoing dynamics in network conditions and should reflect these dynamics in the signaling messages that they send to ARs. Based on these dynamics, ARs sort Mobile anchor points according to their availability, i.e., their loads with respect to the ARs, and advise newly arriving MNs with the most optimum Mobile anchor point.

To notify ARs of possible changes in network conditions, Mobile anchor points use the EMA method to predict possible future transitions in their loads. The underlying reason beneath the choice of EMA consists of the EMA being a cut-and-dry approach for analyzing and predicting performance. The EMA is also easy to implement and requires minimal computational load. As we have mentioned earlier, the traffic load is periodically measured every Δ period of time in the proposed scheme. Let $M_{i\rightarrow k}[n]$ and $E_{i\rightarrow k}[n]$ denote the measured load value and the EMA value of the i^{th} MOBILE ANCHOR POINT load with respect to its k^{th} downstream node at the nth time slot, respectively. By definition, $E_{i\rightarrow k}[n]$ is expressed as follows:

$$E_{i\to k}[n] = \frac{\sum_{k=0}^{\infty} \left((1-r)^k M_{i\to k}[n-k] \right)}{\sum_{k=0}^{\infty} (1-r)^k}$$

Where r is the exponential smoothing constant ($0 < r < 1$).

Considering that $\left(\sum_{k=0}^{\infty} \theta^k = 1/(1-\theta)\right)$, $E_{i\to k}[n]$ can easily be computed in a recursive manner as follows:

$$E_{i\to k}[n] = rM_{i\to k}[n] + (1-r)E_{i\to k}[n-1] \quad (3)$$

To give more weight to the latest data, r is set to 0.9 throughout this paper. The key idea behind the proposed method is to use the EMA value to predict the transition tendency of the Mobile anchor point load on each available link. This prediction is based on the comparison between the two values $E_{i\to k}[n]$ and $M_{i\to k}[n]$ for each i^{th} Mobile anchor point and each respective k^{th} downstream node. In case ($E_{i\to k}[n] < M_{i\to k}[n]$ the load of the i^{th} Mobile anchor point on the link to its k^{th} downstream node has more tendency to increase [i.e., the load increase (LI) tendency], whereas in the case of ($E_{i\to k}[n] < M_{i\to k}[n]$), the Mobile anchor point load on the same link may likely decrease [i.e., the load decrease (LD) tendency]. Upon predicting their load transitions, Mobile anchor points notify ARs of this information via the 7 bits of the RES field carried in the packet header of Mobile anchor point option messages. We used 1 bit of the RES field as a flag to indicate the load transition tendency of the Mobile anchor points:1 for LI and 0 for LD. The remaining 6 bits are used to indicate the Mobile anchor point loads. A Mobile anchor point i sets the 6 bits of the RES field (of the Mobile anchor point option message that is destined to its k^{th} downstream node) to null if its load is smaller than 36%.2 Otherwise, it set

s the 6 bits of the RES field to the integer part of the difference between the load and 36% as follows:

$$RES_{val} = Max(0, [M_{i\to k}[n] - 36]) \quad (4)$$

Based on this information, ARs decide the most appropriate Mobile anchor points for future visiting mobile users. This operation is performed following two stages. When the network is not over- loaded, the selection of Mobile anchor points is conducted based on distance as in HMIPv6 . In a particular domain, Mobile anchor points with loads that are less than a predefined threshold β are sorted. The parameter β indicates the level of congestion that a network operator can tolerate. Unless otherwise specified, β is set to 80% throughout this paper. The farthest Mobile anchor point among the sorted Mobile anchor points is selected first, similar to the traditional distance-based selection scheme of HMIPv6 . This operation is repeated until the loads of all Mobile anchor points exceed the threshold. At this stage, the selection of Mobile anchor points is based on the estimation of the Mobile anchor point load transition using the EMA method. High-hierarchy Mobile anchor points with LD tendencies are preferably selected as Mobile anchor points for communications. In case of multiple Mobile anchor points with LD tendencies, the Mobile anchor point router at the highest hierarchy is chosen. This aims at creating large Mobile anchor point domains for MNs so that their future handoffs can locally be handled. This process ultimately minimizes the handoff signaling cost. In the case where all high-hierarchy routers have LI tendencies, ARs select the high-hierarchy Mobile anchor point router with the minimum traffic load, i.e., the lowest value of RES_{val}.

In the proposed scheme, information on load transition is sent to ARs every Δ time interval. In the simulations that were conducted so far, Δ was set to 1 s. To investigate the effect of Δ on int the proposed system performance, we plot the number of packets processed by inter- Mobile anchor point links for different values of Δ. The figure demonstrates that setting Δ to higher values results in a poor distribution of network traffic among Mobile anchor points. The choice of Δ is a compromise between enhancing the traffic distribution and reducing the frequency of Mobile anchor point option messages. Indeed, small values of Δ would efficiently distribute the data traffic on the network, whereas large values of Δ would reduce the number of Mobile anchor point option messages that are sent over the communication time. For more clarity, evaluation index, and to develop a signal processing method for the reduction of level quantization errors.

$$\phi = 1 - \frac{\sum_{i=1}^{N} |\alpha_i - \overline{\alpha}|}{2\overline{\alpha}(N-1)} \quad (5)$$

where α_i is the number of packets that were processed by the i^{th} link, and N is the number of inter- Mobile anchor point links. is the average value of $\{\alpha_i, i = 1, \ldots, N\}$. Φ captures the efficiency of traffic distribution over the network and ranges from zero to one. Low values of Φ represent a poor distribution of network traffic and lead to significant packet drops. Graphs the value of Φ for different values of Δ and demonstrates that setting Δ to values that are larger than 30 s degrades the traffic distribution over the network. On the other hand, results based on that the system overhead remains minimal when we set Δ to 1s. Note that similar experiments were conducted, considering different traffic mobility patterns, and identical results were obtained. To conclude, (Δ = 1s) represents a good tradeoff between an efficient distribution of data traffic and a reduced frequency of Mobile anchor point option packets.

Implementation and Results

The proposed system is experimented on standard 32 bit Windows OS on OMNeT++. The OMNeT++ Integrated Development Environment is based on the Eclipse platform, and extends it with new editors, views, wizards, and additional functionality. OMNeT++ adds functionality for creating and configuring models, performing batch executions, and analyzing simulation results, while Eclipse provides C++ editing, SVN/GIT integration, and other optional features (UML modeling, bug tracker integration, database access, etc.) via various open-source and commercial plug-ins. The proposed scheme operates as follows. Similar to HMIPv6, proposed system adopts the dynamic mobile anchor point discovery approach. Each AR receives mobile anchor point option messages from high layer mobile anchor points every Δ period of time. Unless otherwise specified, Δ is set to 1 s. using the information that is included in mobile anchor point option messages and based on a given computational model; each AR selects the optimum mobile anchor point for communication.

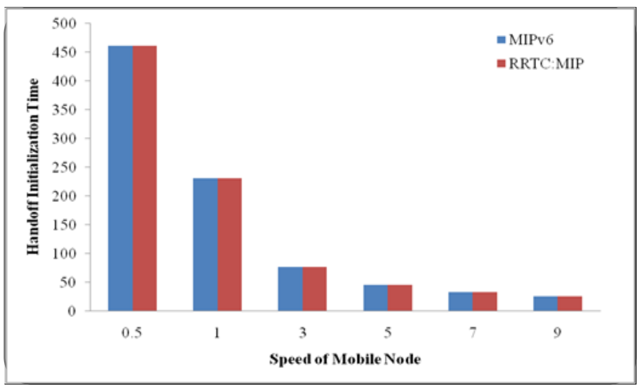

Figure 3: Speed of Mobile Node of Handoff Initialization Time

The handoff intilalization time with respect to $MIPV6$ is response to the $RRTC$. The speed of mobile node will increased the Handoff intialization time is decline.

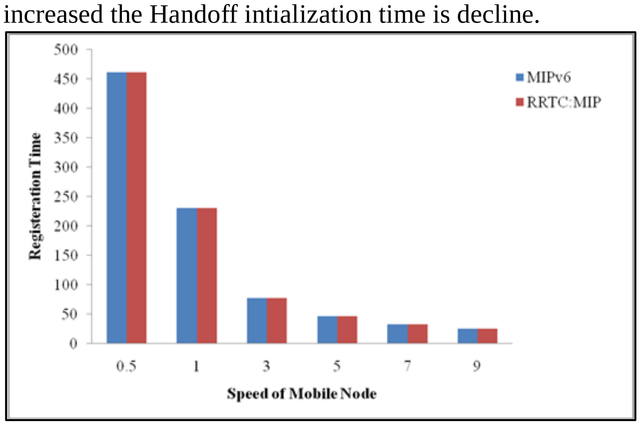

Figure 4 : Speed of Mobile Node of Registeration Time

The registeration time with respect $MIPV6$ is response to the $RRTC$. The speed of mobile node will increased the registeration time is decline.

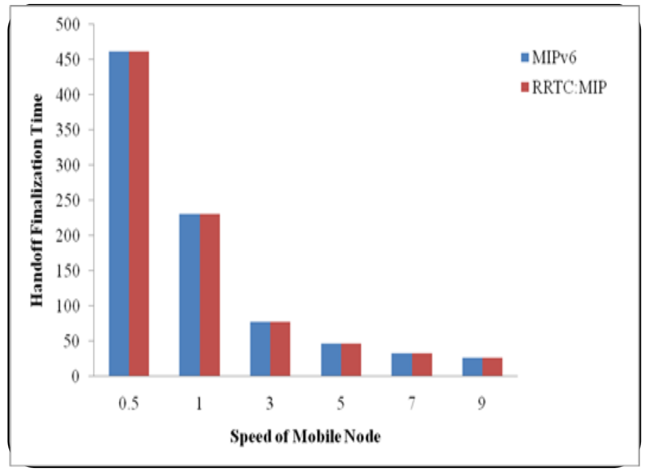

Figure 5 : Speed of Mobile Node of Handoff FinalizationTime

The handoff finalization time with respect $MIPV6$ is response to the $RRTC$. The speed of mobile node will increased the registeration time is decline.

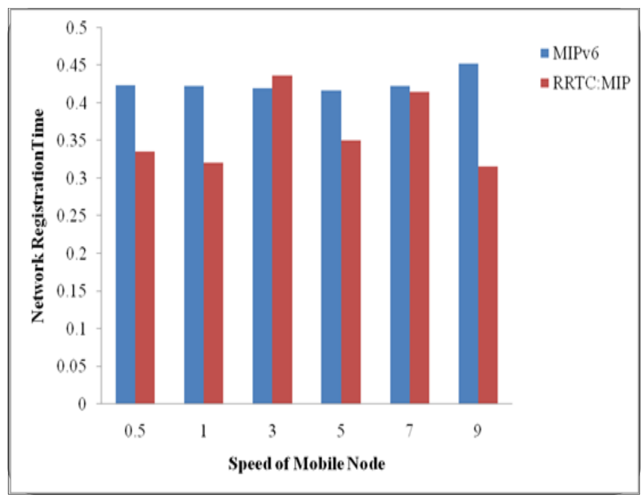

Figure 6 : Speed of Mobile Node of Network Registeration Time

The networkregisteration time with respect $MIPV6$ is response to the $RRTC$. The network registeration time of $MIV6$ will increased network registeration time of $RRTC$ is decline.

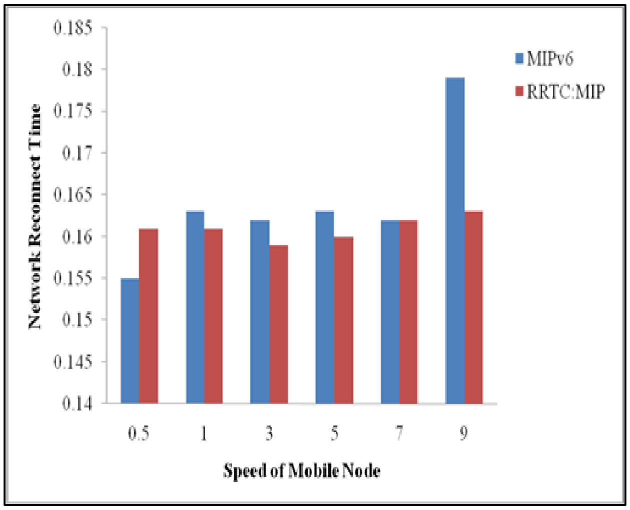

Figure 7 : Speed of Mobile Node of Network Reconnect Time

The network reconnect time with respect $MIPV6$ is response to the $RRTC$. While increasig the speed of mobile node, the network reconnect time of $MIV6$ will increased network reconnect time of $RRTC$ is decline.

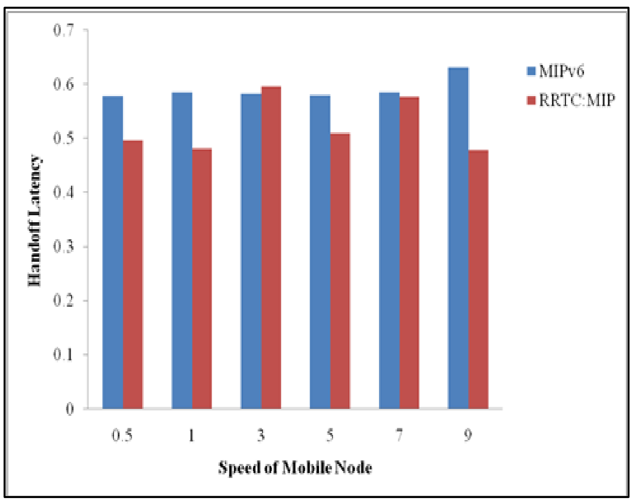

Figure 8 : Speed of Mobile Node of Handoff Latency

The handofflatency with respect $MIPV6$ is response to the $RRTC:MIP$. While increasig the speed of mobile node, the kandoff latency of $MIV6$ will increased. In the same time handoff latency time of $RRTC$ is decline.

Conclusion

In this paper, we have proposed a method that significantly improves the performance of HMIPv6 in large mobile networks. In such large networks, operators may need to deploy a set of Mobile anchor points over a given domain. The proposed scheme has provided a reliable balanced traffic load among these Mobile anchor points. Although most of the strategies that were proposed earlier in the literature attempt to solve the macro-mobility issues and provide fast transition performance, they create a complex landscape for network traffic management. Some routers are overly congested with packets, whereas others are underutilized. Extensive simulation results have demonstrated that the proposed scheme has the potential of substantially improving the average communication delay, reducing the number of losses, and making better utilization of the network resources. All of these achievements are highly important for implementing integrated or differentiated services (DiffServ) architectures to support QoS over mobile IP networks. This achievement represents a major goal of the research that was carried out in most of the IETF Working Groups.

References

[1] “4G Terminals: How we are going to Design them?”Jan Craninckx and stephane Donnay IMEC, Kapeldreef 75, Belgium.

[2] “Efficient Mobility Management for Vertical Handoff between WWAN and WLAN” QianZhang, ChuanxiongGuo, ZihuaGuo, and WenwuZhu, Wireless and Networking Group Microsoft Research Asia, IEEE Communications Magazine, Speaker, QijinChen

[3] “Open Wireless Architecture-The Core to 4G Mobile Communications”. Willie W. Lu, Jenny H.U, U.S Center for Wireless Communications. Stanford University.

[4] “Guest Editorial: 4G Wireless Systems” IEEE JOURNAL ON SELECTED AREAS IN COMMUNICATIONS, VOL. 24, NO. 3, MARCH 2006

[5] “Introduction of 4G Activities in Korea” Donsung Oh, Daesik Kim and Seungku Hwang Mobile Telecommunications Research Division, ETRI Gajong-Dong, Yusung-Gu, Taejon 305-350, Korea.

[6] “4G- A NEW ERA IN WIRELESS TELECOMMUNICATION”, Piyush Gupta, Priyadarshan Patil,Magister Program in S/W Engineering, Malardalen University

[7] “Mobility support in IPv6. RFC 3775, June, 2004.

[8] “Optimization of GSM-UMTS Core Network forIP Convergence in 4G through Mobile IPv6” I. Szekely, T.Balan, F. Sandu*, D. Robu, Sz. Cserey,"Transilvania" University / Department of Electronics and Computers, Brasov.

[9] “Hand-Off Evolution with Multiple Interface” Ching-Lun Lin and Chih-Hsiang Ho, Institute for Information Industry, Taiwan, Jen-Yi Pan, National Chung Cheng University, Taiwan, IT Pro September/October 2008 published by the IEEE Computer Society

[10] “Handoffs in Fourth Generation Heterogeneous Networks”,Nidal Nasser, University of Guelph Ahmed Hasswa and Hossam Hassanein, Queen’s University,IEEE Communications Magazine • October 2006

[11] “A Client-based Vertical Handoff Approach for Seamless Mobility in Next Generation Wireless Networks” Yong-Sung Kim,Dept. of Computer Science and

Engineering, POSTECH Korea, Email: freekys@postech.ac.kr; Dong-Hee Kwon, POSDATA Co., LTD.Korea,

[12] “A Survey of Security Threats on 4G Networks”, Yongsuk Park, Member, IEEE, and Taejoon Park, Member, IEEE; Authors are with the Communication and Networking Lab, Samsung ,Advanced Institute of Technology, Korea Workshop on Security and Privacy in 4G Networks

[13] “Securing roaming and vertical handover in fourth generation networks” by Neila KRICHENE and Noureddine BOUDRIGA, University of Carthage, Tunisia,2009 Third International Conference on Network and System Security

[14] “A SIP-based Seamless-handoff (S-SIP) Scheme for Heterogeneous Mobile Networks” Department of Electrical & Computer Engineering, The University of British Columbia, Vancouver, Canada 2Department of Computing, The Hong Kong Polytechnic University, HongKong, China Emails: zhangj@ece.ubc.ca, cshchan@comp.polyu.edu.hk and vleung@ece.ubc.caatter IEEE publication in the WCNC 2007 proceedings.

[15] “Vertical Handoff Algorithms with QoS Guarantee for 4G Networks” Leandro Bento Sena Marques, Project Office, Ventures Innovation & Technology Center,Campinas, Brazil Email:leandro.marques@venturus.org.br, Shusaburo Motoyama,School of Electrical and Computer Engineering State University of Campinas UNICAMP,Campinas, Brazil Email: motoyama@dt.fee.unicamp.br

[16] “IDMP based fast handoff and paging in IP based 4G Mobile Networks”, Archan Misra, IBM T. J. Watson Research Center,Subir Das, Ashutish Dutta, and Anthony McAuley, Telcordia Technologies,Sajal K. Das,University of Texas at Arlington, IEEE Communications Magazine • March 2002

[17] “Service-oriented FMIPv6 Framework for Efficient Handovers in 4G Networks” Yun Zhou, Jun Yuan, Ying Wang, Ping Zhang,Wireless Technology Innovation Institute Beijing University of Posts and Telecommunications, Beijing, China.

[18] “Universal Seamless Handoff Architecture in Wireless Overlay Networks”, Ling-Jyh Chen, Tony Sun, Benjamin Cheung, Duke Nguyen, Mario Gerla,{cclljj, tonysun, bcheung, duke, gerla}@CS.UCLA.EDU,UCLA Computer Science Department, Los Angeles, CA 90095, USA

[19] “USHA: A Practical Vertical Handoff Solution”, Ling-Jyh Chen, Tony Sun, and Mario Gerla ,Computer Science Department. UCLA.

[20] "Handoff Management Architecture for 4G Networks over MIPv6",Prakash.S,C.B.Akki,Kashyap Dhruve.IJCSNS International Journal of Computer Science and Network Security.No.2,February 2010. pp :267-274

[21] "Trusted Convergence Operator – A Conciliate Solution to Accounting, Charging and Unified Billing in 4G Networks",Prakash.S,C.B.Akki,Kashyap Dhruve.International Journal of Computer and Electrical Engineering.Vol 3 Issue 5 2011. pp: 663-669

[22] "Unified Billing-Realization of convergent architecture for charging and billing in 4G networks", Prakash.S,C.B.Akki,Kashyap Dhruve.ACEEE International Journal on Information Technology.Vol 1 Issue 3, 2011 pp : 26 - 32