Global Mobility: The Key Enabler for Next Generation Networks (NGN)

Mani Shekhar, *Member, IACSIT*, Krishan Kumar, and Sandeep Kumar

***Abstract*—Global Mobility is one of the invigorating issue for Next Generation Networks (NGNs). To facilitate user roaming over NGNs, there must be an effective and efficient Global Mobility Management mechanism, so that the mobile connection with its current serving network is handoff to its target network to maintain service continuity without the need to disconnect and reconnect. Therefore, we propose a novel architecture that can be deployed in NGNs. Second we propose a predictive and adaptive Network Switching Decision Mechanism (NSDM) that optimizes the switching initiation time as well as selection of the most optimal network. The proposed NSDM considers the technology type as well as the signal to Interference Ratio (SIR) and user preferences as the most important factors to make network switching decision.**

***Index Terms*—Global mobility, next generation networks, network switching decision mechanism, network admission control, heterogeneous network.**

I. Introduction

The future networks must be able to coordinate services within a diverse network environment. To interconnect many heterogeneous networks [1] in a seamless fashion, lot of technical issues needed to be faced such as those associated with heterogeneous architectures, seamless switching and secure global mobility. Therefore, the major requirements that must be achieved by NGN [2] can be summarized as below:

- *Access freedom*: In NGN, the MN will move from one integrated access network to another freely and transparently without risk of connection disruption.
- *Efficient bandwidth utilization*: NGN is designed to offer efficient bandwidth utilization especially for the constraining applications in order to satisfy the QoS requirements and improve the network performances.
- *Secure access*: The NGN should guarantee and maintain the same level of security services to the users when they roam across different access networks.
- *Low blocking Probability*: The switching mechanisms should be managed to maintain good network performances which include a near–zero switching blocking probability and a near-zero call blocking probability.

The NGN Global mobility management is expected to meet continuously increasing requirement of users and multimedia services [3], [4]. Thus to satisfy these requirements, it is necessary to make interworking different access network in such a way to have one or more criteria of QoS satisfy with each technology such as minimum switching latency, efficient bandwidth, less packets loss rate etc.

The performance requirements of user are measured in terms of quality of service (QoS) and grade of service (GoS). QoS is packet-level factor which includes packet loss rate packet delay and throughput rate. GoS is a call-level factor which includes new call blocking probability (NCBP), hand-off call blocking probability (HCBP), handoff call dropping probability (HCDP) and connection forced termination probability (CFTP). In terms of network admission control (NAC) at a call level, we are more concerned with NCBP and HCDP as GoS measures.

The main objective of our work is three-fold. First, we proposed novel configuration architecture for interworking the heterogeneous access networks. This novel NGN architecture integrates intelligent network components that can achieve global mobility management scheme. Second, we consider the signal quality and user preferences as decision making in internetworking in heterogeneous network. In final stage the simulation results shows that the reduction of unnecessary handoffs proposed in our network switching decision mechanism (NSDM).

II. Background and Related Work

The technology for NGN would be about "ubiquitous computing", that is, having the ability to access the applications from any platform, anywhere, any time. To create such an environment, one needs to integrate various applications, emerging from various engineering practices. Global mobility is gaining a tremendous interest among scientists all over the world.

Internet users and wireless access networks are increasingly being installed to enable mobile usage. Internet mobility requires solutions to move between access networks with maintained network connectivity. Global mobility in NGN networks requires new level of mobility support as compared to traditional mobility.

A. Global Mobility Defined

From a user point of view the listed properties required to achieve global mobility.

- Switching automation from one access network to another access network on criteria like signal to interference ratio, user preference, etc.
- Complete application session persistence while out-of-range, out-of-approach, and when delay is involved in Accessing new network or setting up tunnel to home network.

Manuscript received March 8, 2012; revised May 20, 2012.

M. Shekhar and K. Kumar are with Electronics and Communication Engg. Department, PSIT, Kanpur, U.P, India (e-mail: mi_sr87@yahoo.com, krishan_rathod@nitham.ac.in).

S. Kumar is with Communication Engineering Department, NIT Hamirpur, Hamirpur, H. P, and India (e-mail: sandeep_rgec@ymail.com).

- Transparency in network at IP layer: The mobile user should be able to attach to the new target network without any user intervention.
- Delay minimization during switching: when switching off between two subnets or different access networks, the protocol related delay needs to minimize if there is no problem of radio coverage.

In the case of wireless network access it is common for the mobile user to lose the network due to bad link, poor signal of strength or to go out of coverage of an access point or base station. In such type of situation the applications (for which user is registered to its home network) should not time out, causing the applications to be restarted. Also, most IP mobility technology requires a finite amount of time (a few seconds to a minute) to switch between networks while they setup a tunnel to their old network.

B. Switching in Next Generation Networks (NGN)

Switching schemes have been thoroughly researched and deployed in cellular system. Switching simply means that mobile station connection is transferred from one frequency to another during a communication. This may occur due to many reasons (distance, RSS, mobile node velocity etc).The switching process includes three main stages: the measurement process, the switching decision and the switching execution.

The performance of the employed switching procedure is critical to the overall performance of wireless network. A network switching decision mechanism (NSDM) is required to preserve connectivity of mobile devices anywhere and at anytime. Therefore, switching in NGN must exhibit low latency, sustain minimal amounts of data loss, as well as scale to large networks.

1) NGN Switching Requirements

In NGN networks, an efficient switching algorithm can achieve global mobility and many desirable features by trading off different operating characteristics.

2) Interference Prevention

A switching algorithm should avoid high interference. Intra-cells interference is caused by devices transmitting on the same cell. Inter-cell interference is caused by devices transmitting on cells using the same frequency. Both intra and inter cells interference may severely limit the transfer rates of a wireless network.

3) Seamlessness

A switching algorithm should be fast so that the user does not experience service degradation or interruption. Service degradation may be due to a continuous reduction in signal strength or an increase in co-channel interference (CCI). Service interruption may be caused by hard handoff approach being exercised in the network [5].

4) Performance Improvement

There should be minimum number of unnecessary handoff. Excessive horizontal or vertical handoffs lead to heavy handoff processing loads on network and poor QoS. In a handoff scenario, the more handoff attempts, the greater chance that a call will be denied access to a channel, resulting in a higher handoff calls dropping probability [6].

5) Reliability

An algorithm for switching should be reliable. This means that the call should have good quality after switching. Many parameter help in determining the potential QoS of a user base station. Few of these parameters are bit error rate (BER), Signal to Noise ratio (SNR), Signal to Interference ratio (SIR).

III. NGN and NSDM Architecture

The main challenges in designing NSDM scheme lie in the network heterogeneity. In addition, a network can have its specific switching policy, switching matrices and decision making algorithms. For this reason the internetwork switching needs more study than switching executed in same technology.

A. Design Issues and Goals

The main goals in design of NSDM scheme in next generation networks are summarized as follows:

- *Data rates*: Different networks support different data rates. For example the WLAN technology has high data rates; so it is preferable to have each MN connected to the WLAN technology only if the signal from the WLAN is not usable [7].
- *Range discovery*: WLAN and WPAN offer limited coverage and higher data access rates, while wireless wide area network (WWAN) provides geographically wide area coverage but lower access bandwidth.
- *Switching decision*: The switching decision between NGN networks would appear to be more complex to manage. It should be based on application–specified policies and user quality of service requirements as well as periodic measurements of quality of the underlying network connectivity.
- *Security*: Security [8] mechanism should guarantee that only corresponding parties have knowledge about the key and MN identity. Also, the user would maintain same security level when roam across NGN networks.

The design goals of NSDM are listed as:

- Small buffer required for switching in NGN networks
- Low network loss
- Efficient use of resources.

B. Proposed NGN Configuration

The network interoperability is done to achieve different purpose such as acquiring high bandwidth, minimum power consumption and minimum interference. These purposes can be determined by user preference, the application requirements or the terminal capabilities. Thus we deploy a Centralized Access Control Unit (CACU) which serves as bridge between the integrated networks and it can assure several functionalities depending upon the required QoS parameter. It enables integration of networks in NGN.

It plays the role of operation providing protocol interoperability and provides abstracted service to pair of different access technologies. The CACU may support multiple base stations which provide wireless link-layer connectivity.

In intelligent network (IN) architecture, the switches are called Network Switching Points (NSPs) and there are also dedicated nodes for network control called Network Control

Points (NCPs). NSPs and NCPs are connected via signalling system No 7(SS7) network and the dialog between them is based on Intelligent Network Application Protocol (INAP).

In this context, in order to support heterogeneous networks, global mobility management function has to be added to these IN principle. As depicted by Fig. 1, the Network Switching Point (NSP) detect any report from a mobile node and communicates with the Network Control Point(NCP), which is node containing the service execution logic, to obtain an information on how to execute network switching. The NCP may ask the NSP to send the MN as a recorded message and can also collect a response from the MN and send it to the NCP for processing. The NCP function may be located in the NSP node or it may be a standalone node. In the proposed architecture (as depicted in Fig. 1), the NSP is typically located in the access point and NCP is located in Centralized unit.

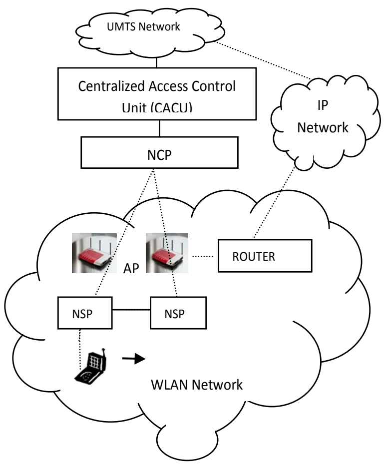

Fig. 1. UMTS-WLAN integrated architecture.

C. Proposed RSS Model for Decision Making

In this subsection, we will study the WLAN RSS model as we are interested to keep the MN connected to the WLAN network as long as possible to experience better performance with higher data rates.

Indeed, from the basic path loss model, the RSS is expressed as a function of the distance between the MN and the access point (AP):

$$RSS(d) = P_T - L - 10n\log(d) + f(\mu,\sigma) \text{ dBm} \tag{1}$$

where P_T is the transmitted power, L is a constant signal power loss, n is path loss exponent that usually has values between 2 and 4, and $f(\mu,\sigma)$ represents shadow fading modelled as zero mean Gaussian random variable with mean μ and standard deviation σ with values between 6 and 12 dB depending on the environment.

Consequently, different averaging mechanisms are used to reduce the effect of signal variation due to these fluctuations. In the discrete problem, the WLAN RSS is sampled at every T sampling; hence it can be shown as

$$RSS[t] = \mu RSS[t] + N[t] \text{ dBm} \tag{2}$$

where t is time index, $\mu RSS[t] = P_T - L - 10n\log(d[t])$, $d[t]$ is the distance between the MN and the WLAN access point(AP) at instant t, and $N[t] = f(\mu,\sigma)$. Therefore, the distance from the AP is the main parameter that affects the WLAN RSS.

D. Proposed NSDM Algorithm

Repeat
Working in WLAN
If *($SIR_{WLAN} < SIR_{req\_application}$)* ***then***
If *required QoS_{UMTS} is satisfied*
Then
Start adaptive dwell timer
If *condition satisfy until timer expires*
Then
Execute handoff to the UMTS network
Else
Reset dwell timer
End if

Else
Trigger passive or active WLAN network scanning
If *Detection of new AP with ($SIR_{new\text{-}AP} > SIR_{present\text{-}AP}$)*
Then
Start adaptive dwell timer expires
If *condition satisfy until timer expires*
Then
Execute switching to the new AP
Else
Reset dwell timer
End if
End if
End if
End if
End Repeat

In this section, we propose an effective switching procedure that guarantees low handoff blocking probability, low switching overhead and low packet loss during switching in the considered WLAN-UMTS heterogeneous architecture. Moreover, the proposed Network Switching Decision Mechanism (NSDM) takes in to consideration the main switching characteristics of next generation networks (NGN).

1) Forward Switching Decision Process and Algorithm

The forward switching means switching from a small network cell with high data rates to a larger network cell with lower data rates. Because the priority of switching is to high data rate (the switching priority is given for WLAN) and received signal power from the attachment point of different networks are incomparable.

We prefer to use threshold SIR to determine the switching decision. A node currently associated to the WLAN network evaluates the Signal to Interference Ratio value to detect when switching is needed. Upon noticing degradation in the SIR which not satisfies the SIR required by the application, the WLAN adapter checks if the QoS parameters offered by the UMTS network satisfy the required session QoS. Then switching to UMTS is trigged if the condition is satisfied during the dwell timer. Otherwise, the WLAN adapter starts scanning for detecting the presence of another access point with an SIR greater than the SIR of the current one.

For switching we have taken following considerations:

- SIR_{WLAN} : the measured SIR for WLAN network.
- QoS_{WLAN} : the QoS parameters for WLAN network.
- SIR_{UMTS} : the measured SIR for UMTS network.
- QoS_{UMTS} : the QoS parameters for UMTS network.

Algorithm 1 NSDM when the MN is currently in WLAN Network

In our proposed Forward Switching Decision Algorithm, we use the dwell timer which will start to work when a specified condition is first satisfied. If the condition persists during the dwell time; the MN performs the next action after the dwell timer is expired. Otherwise the MN reset the dwell timer. Consequently, a MN does not perform switching until the target network becomes stable which enhance the QoS and network performance.

2) Reverse Switching Decision Process and Algorithm

The reverse switching means switching from a large network cell with low data rates to a smaller network cell with higher data rates. In this, we design the algorithm on a switching from UMTS to WLAN technology. In this algorithm, the terminal power is taken as decision making parameter.

Indeed, if the terminal power is critical, a switching process to the WLAN is triggered if the SIR measured in WLAN satisfies the SIR required by the application and the QoS parameters offered by WLAN are satisfactory. Thus and the condition persists until the dwell timer expires. Otherwise the MN stays in the current network. We suppose that the switching from the UMTS to WLAN is a desirable switching process and it improves the network performance by reducing the interference level.

Repeat
Working in UMTS
If *(Terminal Power < P_T)* ***then***
If *(SIR_{WLAN} > $SIR_{required\ application}$) and*
If *required QoS_{WLAN} is satisfied*
Then
Start adaptive dwell timer
If *condition satisfy until timer expires*
Then
Execute handoff to the WLAN network
Else
Reset dwell timer
End if
Else
Stay connected in current network
End if
End if
End if
End Repeat

Algorithm 2 NSDM when the MN is currently in UMTS Network

In our proposed Reverse Switching Decision Algorithm, we have considered that the switching to WLAN network represent an optimal solution for the MN with a critical power status to maintain the active connection because the UMTS sensibility is higher than the WLAN sensibility. Therefore, the power consumption in the UMTS technology is higher than the WLAN technology.

IV. Simulation and Analyses

It is important and challenging issue to achieve global mobility in next generation networks (NGN). We used the simulation analysis to test the performance of the system. The simulation goals are to focusing the influence of WLAN-UMTS switching admission priority on switching blocking probability, switching overhead, and packet loss rate in UMTS.

1) Simulated Network and Description

The global mobility management is the process by which a user keeps its connection active when it moves from one network to another. However, seamless support of network switching in NGN is still an open issue. Therefore, we address performance of NSDM for proposed NGN architecture.

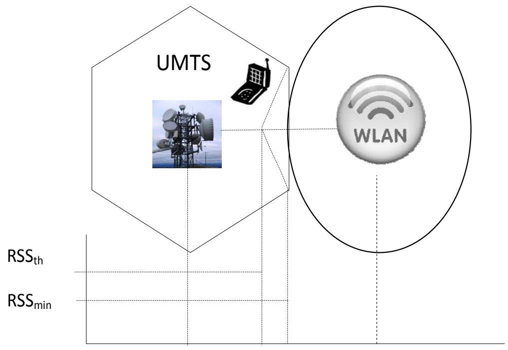

Fig. 2. Analysis of switching process

2) Results and Analysis

This sub-section is dedicated to describing the results in terms of performance and benefit of the proposed NSDM scheme. The following notations are defined with reference to Figure 2 that shows the switching from the current network referred as UMTS to the future network referred as WLAN.

RSS_{th}: The threshold value of the received signal strength (RSS) initiate the switching process of NGN. This implies, when the RSS of UMTS goes below RSS_{th} Service of registration procedures are initiated for switching of mobile terminals (MTs) to the WLAN.

RSS_{min}:The minimum value of RSS required for successful communication between MT and UMTS network.

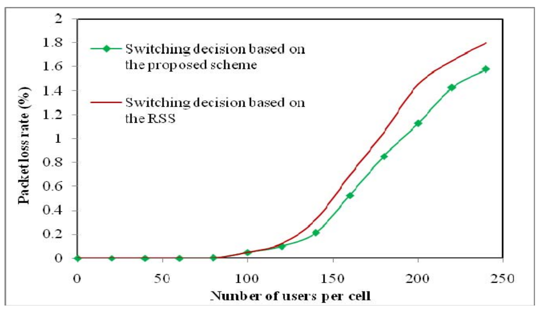

Fig. 3. Packet loss rate

From the Fig. 3 it is clear that the packet loss rate increases when the number of admitted user increases. We note also that the NSDM guarantees a packet loss rate less than the traditional decision based on the RSS. We justify this decrease in the packet loss rate by the improvement resulting in considering the network conditions, the applications and terminal performances while making the switching decision to target network.

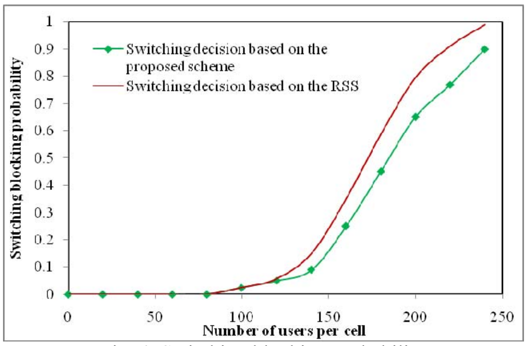

Fig. 4. Switching blocking probability

Fig. 4 shows the variation of values obtained for switching blocking probability, assuming that the number of users in UMTS varies from 0 to 250. It is clear that switching blocking probability increase when the number of users increases. This can be explained by the increase of the number of admitted users, while the recourses for switching are kept unchanged.

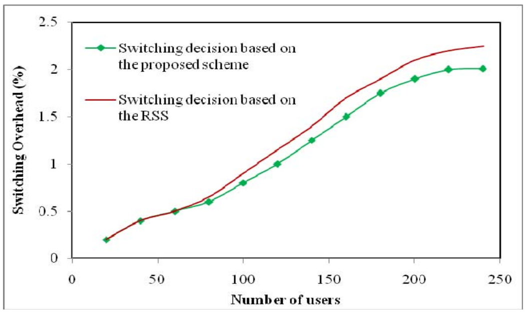

Fig. 5. Switching overhead

In Fig. 5 shows the variation in switching overhead, assuming that the number of UMTS users varies from o to 250. Switching overhead increases when number of users increases. This can be explained by increase of number of switching attempts and as a result the increase of the number of signalling messages.

V. Conclusions

This issue studied network switching in NGN and a case study of WLAN and UMTS integration. We first introduced the proposed NGN architecture. Then two algorithms for triggering the switching action have been discussed, where the SIR, the application requirements and the terminal capabilities are considered. To verify the proposed WLAN to UMTS algorithm, a new global mobility analysis approach (NSDM) has been introduced. The simulation results show the proposed Network Switching Decision Mechanism reduces the switching blocking probability, the packet loss rate and switching overhead which improves the performances of network.

Acknowledgment

The authors would like to thank the anonymous reviewers for their constructive remarks and suggestions.

References

[1] Q. Li and P. Zhang, "A Novel Mobility Management Architecture based on GLL in Configurable Networks," in *proc. IEEE 6th International Conference on ITS Telecommunications*, New York, pp.70-73, 2006.

[2] S. Mohanty, "Architecture and Cross-Layer Mobility Management Protocols for Next-Generation Wireless Systems," Ph.D. dissertation, *Dept. Elect. Eng. Georgia Institute of Technology*, pp. 34-41, 2005.

[3] M. Ali, T. Voigt, and Z. A. Uzmi, "Mobility Management in Sensor Network," in *proc. IEEE 2th Conference on Distributed Computing in Sensor Systems*, Jun. 2006.

[4] R. M. Kibria and A. Jamalipour, "On Designing Issues of the Next Ge-neration Mobile Network," *IEEE Trans. on Network*, pp. 6-13, 2007.

[5] C. Kappler, P. Pöyhönen, M. Johnsson, and S. Schmid, "Dynamic Network Composition for Beyond 3G Networks: A 3GPP Viewpoint," *IEEE Trans. Network Computing*, pp. 47-52, 2007.

[6] V. Srivastava and M. Motani, "Cross-Layer Design: A Survey and the Road Ahead (Periodical style)," *IEEE Trans. Communications*, pp. 112-119, 2005.

[7] V. Kawadia and P. R. Kumar, "A Cautionary Perspective on Cross Layer Design," *IEEE Trans. Wireless Communications*, vol.12, no. 1, pp. 3–11, 2005.

[8] S. Shakkottai and P. C. Karlsson, "Cross-Layer Design for wireless Networks," in *Proc. IEEE Communication*, vol. 41, pp. 74-80, 2003.

Mani Shekhar was born in Kanpur, India in 1987. He obtains his engineering degree from Dr. KNMIET College in India in 2009, and master degree from NIT Hamirpur, in, 2011, in India. He is working as Assistant Professor in Electronics and Communication Engineering Department, PSIT Kanpur, India. His research is concern the Seamless and Secure Mobility Management for Next Generation Networks.

Krishan Kumar was born in Haryana, India in 1980. He obtains his engineering degree from MDU Rohtak, in 2002, and master degree from NIT Kurushetra, 2005, in India. He is working as Assistant Professor in Electronics and Communication Engineering Department, NIT Hamirpur, India. His area of research is communication systems.

Sandeep kumar was born in Delhi, India in 1988. He obtains his engineering degree from RGEC College in India in 2009. He is research scholar in Communication systems and networks. His research is concern the OFDM optimization in wireless system.