Optimization and Reliability of Fourth Generation Mobile Device for Heterogeneous Networks

Dr.C. Chandrasekar,
Professor & Head/MCA,
K.S.R College of Engineering,
Tiruchengode – 637 209
Tamil Nadu
E- mail: ccsekar@gmail.com

Dr.A. Krishnan.
Dean,
K.S.R College of Engineering,
Tiruchengode – 637 209
Tamil Nadu
India, E-mail: a_krishnan26@hotmail.com

1. Introduction

This research paper discusses the design, implementation, and analysis of a wireless local area network for high mobility both in wireless LAN (WLAN) and cellular air interfaces. The explosion of radio access technologies [1] and wireless networking devices over recent years has triggered the intensive use of nomadic computing. Mobile devices receive intermittent network access, and alternate between connected and disconnected states. However, the personal gadgets [2] need more networking capabilities. Wireless network coverage is becoming ubiquitous, and always on IP-based [3] services is now closer to reality. An average mobile user may connect to a variety of wireless networks in the course of a day to obtain services, for which they demand operational transparency. It is achieved by fourth generation wireless (4G) networks.

The following [4] are the features of 4G Wireless Network and implementations. Some key features (mainly from the end users' point of view) of 4G networks are stated as follows:

• High usability: anytime, anywhere, and with any technology

• Support for multimedia services at low transmission cost

• Personalization and Integrated services

First, 4G networks are all-IP based heterogeneous networks that allow users to use any system at any time and anywhere. Users carrying an integrated terminal can use a wide range of applications provided by multiple wireless networks. Second, 4G systems provide not only telecommunications services, but also data and multimedia services. To support multimedia services, high-data-rate services with good system reliability will be provided. At the same time, a low per-bit transmission cost will be maintained. Third, personalized service will be provided by this new-generation network. It is expected that when 4G services are launched, users in widely different locations, occupations, and economic classes will use the services. In order to meet the demands of these diverse users, service providers should design personal and customized services for them. Finally, 4G systems also provide facilities for integrated services. Users can use multiple services from any service provider at the same time. Mobility is supported in both cellular phone technologies and WLANs. The present session in cell phones is handed over to other base stations when the user moves from one cell to another without dropping the present call, each cell being the area over which each base station has control over and controls the users. Mobility is also supported among WLANs and the access points in the network, termed as roaming. Although WLANs [5] provide roaming between different access points, the range is limited over which an access point operates 100 meters to 300 meters. One would need an array of access points (cascading) in order to increase the range of network over a wide area. The existing technologies with Mobile IPv6 provide and support to switch between the Wide area networks (Cellular network) and the Local area networks (WLAN) with more time delay.

In this paper we focus on the above inter-working mechanisms, which effectively combine WLANs and Cellular data networks into integrated wireless data networks with very high data rate capabilities in hotspot locations and minimum time delay. A cellular data network can provide relatively low-speed data service over a large coverage area. On the other hand, WLAN provides high-speed data service over a geographically small area. An integrated network combines the strengths of each.

2. Related works

Over the past few years there have been several efforts to support seamless and secured mobility covering multiple administrative domains. Cheng et al., [6] describe a novel approach that achieves smooth handover during handoff, but it assumes foreign agents in the visited network and does not involve heterogeneous access technologies.

Recently, there has been much activity within the Internet Engineering Task Force (IETF) to develop solutions to maintain VPN connectivity while a mobile device changes its IP address. Adrangi et al., [7] describe several scenarios of how a combination of Mobile IP (MIP) and VPN can support continuous security binding as a mobile device changes its IP address. However, it does not address how to support seamless handoff while preserving a VPN and also does not address heterogeneous access technologies. Luo et al., [8] describe a secure mobility gateway that maintains mobility and security association between a mobile and a

VPN gateway, but it does not offer flexible tunnel management techniques and has not explored mechanisms to provide smooth handoff. Birdstep (www.birdstep.com) [9] proposes an approach that uses two instances of MIP to support seamless and secure mobility between an enterprise network and external networks. When a mobile moves to an external network, one instance of MIP is used to ensure that the VPN to the mobile does not break when the mobile changes its IP address. The MIP is used to ensure that packets sent to the mobile's enterprise network can be forwarded to the mobile through the VPN. A key advantage of the Birdstep approach is that it is based completely on existing IETF protocols. It, however, requires that a mobile keeps its VPN always on while the mobile is outside its enterprise network. Furthermore, it is limited to using MIP for mobility management. Luo.H, Z. Jiang et al., [10] provides an alternative approach to seamless mobility using the MIPv6. It does not support soft handover and not considered time delay, Reliability, Throughput.

A.K. Salkintzis, G. Dimitriadis, D. Skyrianoglou, N. Assas [11], discusses seamless interworking of WLAN and 3G cellular networks. The main application considered in this seamless interworking is real time video. The authors do not consider the feasibility of session continuity when a video session needs to be handed over between WLAN and 3G UMTS systems. V.Gazis, N.Alonistioti and L. Merakos [12], looks at future 4G networks, where a mobile user is expected to be connected to the most optimum network at any time, known as always best connected. This concept is investigated within the internetworked WLAN and UMTS systems. But these results are not focusing on the effect of optimum solution.

D. Cavalcanti, C. Cordeiro, D. Agrawa, B. Xie and A. Kumar[13], deals with the integration of different wireless networks, not just the WLAN and cellular systems and identifies research issues that need to be addressed for integration of heterogeneous technologies for next generation wireless mobile networks. It is not proposed any specific approach for the successful integration of heterogeneous networks. O. Song and A. Jamalipour [14], proposes a selection technique between two or more available networks in a heterogeneous environment. This article uses the example of WLAN and UMTS systems as the only available networks, the topic may be extended to multiple network environments. N. Shenoy and P. Mishra [15], looks at a framework to support roaming across cellular and WLAN systems. The proposed framework includes a robust architecture for mobility management for different types of user mobility, QoS provisioning, intersystem message translation and mechanisms to support user subscribed services in the WLAN.

F.G. Marquez. T.R Valladares, L.A. Galindo, M.G. Rodriguez [16], consider a technical contribution to the 3GPP IP multimedia subsystem for provisioning of multimedia services in UMTS. This work analyzes how the interconnection of 3GPP and WLAN networks may be performed in order to support different levels of service interconnection. W.Wu.N. Banerjee, K. Basu and S.K. Das [17], considers Session Initiation Protocol (SIP) for handling mobility management protocols in heterogeneous networks. This work highlights the excessive delay associated with the use of SIP as an application layer protocol and how this would affect the interconnected WLAN and UMTS systems.

Massimo Bernaschi, Filippo, Giulio [18], studies a new approach to the integration of WLAN and cellular networks based on loosely coupled architecture. This model and experimental results on internetworking performance at the network layer are discussed with some ideas on how this performance could be improved.

3. Network time delays in MIPv6

The following are the major criteria [19] to increase latency in Mobile IPv6 (MIPv6).

Detection Period (t_d).

It is the time taken by the mobile terminal to discover the available network(s), using link-layer signaling or the network layer detection mechanism. The Mobile IPv6 generic movement detection mechanism uses the facilities of IPv6 Neighbour Discovery. When the MN is not sending traffic, it listens to IPv6 router advertisements to determine the network prefix. Here the mobile either uses the Router Advertisement or Router Solicitation method to discover the Network.

Configuration Interval (t_c).

This is the interval from the moment a mobile device receives a router advertisement, to the time it takes to update the routing table and assign its new care-of address based on the received network prefix, including the Duplicated Address Detection (DAD) delay. This interval depends on the terminal characteristics (e.g., memory, processing power, etc.). The DAD delay was not significant in the described scenario due to the lack of concurrent mobile hosts roaming simultaneously. In an optimistic case, the DAD delay is very small compared to the other latency components. However, when dealing with more mobile nodes the probability of address collision increases and the DAD delay should be considered. For experimental results on this topic, an environment where the number of mobile nodes moving can be controlled needs to be available.

Registration Time (t_r).

This is the delay between the delivery of the binding update to the home agent and correspondent nodes, and the reception of the first packet at the new interface, with the new care of address as the destination address. This time component increases if the mobile terminal is configured to wait for the binding acknowledgement sent by the correspondent node.

The following figure represents the Network delay for the above three latency time.

For ex. $t_d = 808$ms, $t_c \sim 1$ms, $t_r = 2997$ms, then $t_n = 3806$ms.

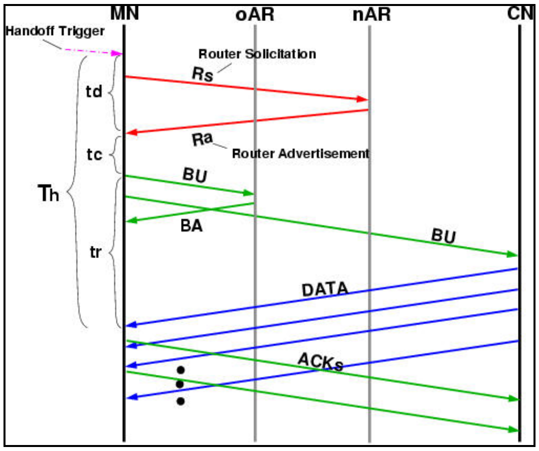


Figure.1 Latency time for mobile during mobility.

3.1 Experiments to evaluate MIPv6 :

* The experiments to evaluate MIPv6 with scenarios WLAN to CDMA cellular network are taken through GloMosim simulator.

* Measurements of MIPv6 performance at the network layer for the above scenario, using ICMP as a test case protocol. Due to the simplicity of this protocol, it is the most appropriate way to measure network layer latency. ICMP does not add too much overhead to the networking process.

WLAN to CDMA (Delay in ms)				
Handoff	**Td**	**Tc**	**Tr**	**Tn**
1	200	.853	2339	2540
2	363	.856	2457	2734
3	453	.858	2563	2945
4	536	.860	2675	3143
5	647	.862	2756	3324
6	757	.866	2867	3534
7	801	.870	2997	3799

Table 1 Total Latency at Network layer for MIPv6.

The overall latency is found by summing the delays to discover the new network (t_d), to build the binding update message using the prefix from the new access router (t_c), and to register the recently formed CoA with the home agent and correspondent nodes (t_r), as shown in the following Equation.

$$T_n = t_d + t_c + t_r$$

WLAN to CDMA (Delay in ms)				
[ms]	**MIN**	**MAX**	**MEAN**	**STD DEV**
Td	200	800	536.57	216.24
Tc	0.853	0.870	0.860	0.058
Tr	2339	2997	2664.86	230.70
Tn	2540	3798	**3145**	444

Table 2 Latency at Network layer for mobility from WLAN to CDMA

4. New Approach for Seamless Mobility:

The cellular networks and the WLAN networks use different technologies. The radio interface of the cellular networks and a WLAN network use different frequencies and technologies and is not interoperable. For data connectivity using these technologies two different data cards (NICs) needs to be used. The mobile node (MN) has been provided that support both IEEE 802.11b and CDMA access technologies.

The handoff [20] between cellular and WLAN networks can be solved in a different way. There are two scenarios under which a handover [21] can take place between the Cellular network and 802.11 networks. That is the device ready to moves from an IEEE 802.11 network to a Cellular network and vice versa. This switching [22] can be based on the signal strength level or when a WLAN access point is detected. In case terminal moves between WLAN and cdma2000, we think about soft handover method that controlled by terminal by Seamless Mobility Gateway (SMG) system.

4.1 Seamless Mobility Gateway (SMG):

The SMG is a special IPsec gateway deployed between the CDMA Cellular network and the corporate intranet. The client is connected to the corporate server through the Seamless Mobility (Seammoby) gateway. The seammoby gateway interconnects the Wireless LAN and CDMA Cellular network. The SMG has two network interface cards: one connected to the CDMA Cellular network and the other to the corporate intranet.

This SMG describes mechanisms to improve the MIPv6 latency and minimize disruptions in the connectivity while roaming the mobile between heterogeneous networks. The following additional methods are implemented with in SMG: RA caching, Seamless Handover, and Client Based Handoff mechanism to improve networking performance and decrease latency.

4.1.1 RA Caching (RAC):

This method aims to eliminate the discovery time (t_d) from the total latency. The main principle behind this optimization is that the mobile node caches every incoming RA, and when it needs to perform a handover because of the loss of coverage, the mobile terminal does not wait for the next incoming RA from the currently available access network, but instead it uses a previously cached RA when possible, reducing (t_d) to zero. This RA Caching details are maintained and updated within SMG. Some time the new router may be busy with additional task, the RA is not immediately sent to the mobile node.

It is important to mention that this optimization is only useful when there is an overlap between the coverage of the old and new access routers.

4.1.2 Seamless Handover (SH):

In hard handover, the MN disconnects (stops listening) from the old interface, and just then starts listening to the new interface. As a result, packets that were already on-the-air, sent by the Enterprise server before it realizes that the MN has moved to another network or those destined to the old network interface, are discarded.

In seamless handover, the mobile node is not entirely disconnected from previous network. Thus, the MN keeps receiving packets from the previous network and meanwhile, it completes the registration process with its new CoA and starts receiving packets through the new interface, which has the CoA assigned. From this seamless handover, the packet losses reduced to ~ ZERO and the latency of t_c and t_r are also reduced to minimum. But it needs overlapping networks between the old network and new network.

4.1.3 Client Based Handoff mechanism (CBH):

This module can identify and select the network either Cellular or WLAN in an efficient manner. The CBH is mainly responsible for creating and maintaining a wireless connection between the user's computer and the corporate network over the best available wireless network. It interacts directly with, and controls, the available wireless interfaces and modems. CBH functions include

- Identifying the best wireless network available,
- Performing hand-off between wireless networks if the current wireless network is no longer the best one available to the user.

The network selection algorithm is implemented within the seamless mobility gateway. The mobile users can choose to use the direct cellular link to communicate with the cellular base station or to communicate with the 802.11 access point from this gateway.

The CBH keeps monitoring the available wireless networks by instructing the wireless modems to scan for available networks and measure Radio Signal Strength (RSS) periodically. This helps the CBH determine whether the current wireless network is still the best available (and thus indicates the need for a hand-off operation). A hand-off may require switching from one wireless modem to another. If the current network is a cellular network, the CBH searches to see if a WLAN (higher speed, lower cost) is available. If the current wireless network is a WLAN and the RSS value is below the threshold, the CBH tries to search for other networks.

4.1.4 Seamless mobility Algorithm:

The newly proposed network selection algorithm is implemented within the seamless mobility gateway. The mobile users can choose to use the direct cellular link to communicate with the cellular base station or to communicate with the IEEE 802.11b access point from this gateway. The mobile device gets connected with corresponding network based on the strength of the radio signal either WLAN or Cellular Network. Again the mobile device continuously transmits the communication through the Seamless Mobility System with the following Algorithm.

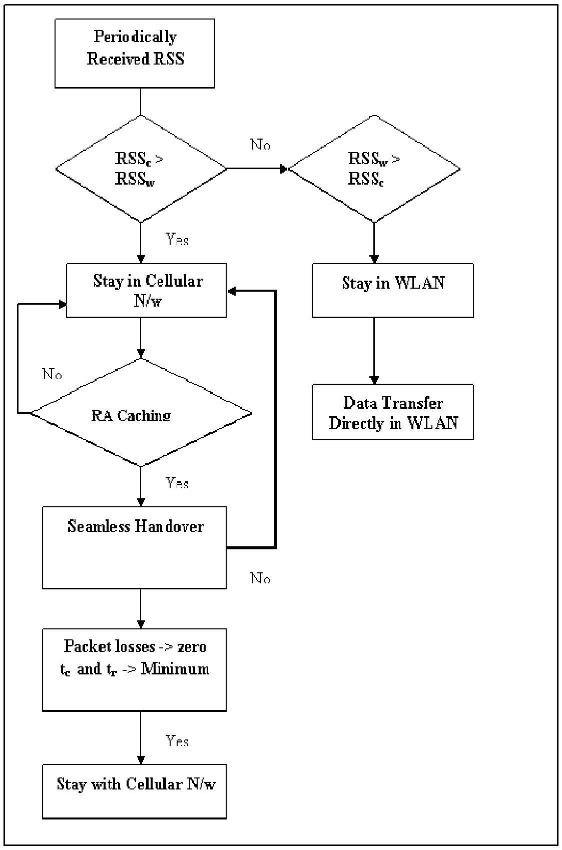


Figure 2. Seamless Mobility Algorithm

5. Experiments and Results

In this section we present simulation results related to Seamless mobility between CDMA Wireless network and WLAN comparing with MIPv6 environments. SMG is designed to offer seamless roaming while MN is moving from one access system such as 802.11b WLAN to another such as CDMA wireless network and vice versa.

Here we are used GloMosim simulator to simulate the environment with proposed system. According to a survey of QoS components in mobile communications [23], the main QoS components in a network are defined as Reliability (α), Latency (β) and Throughput *(γ)*. Bit error rate (BER, λ), and average number of retransmissions per packet (ν) are used to define reliability.

The main parameters, *delay (ζ)* can decide the *latency*.

Our proposed architecture and algorithm reduce the network delay and maintaining seamless mobility in heterogeneous network with high reliability.

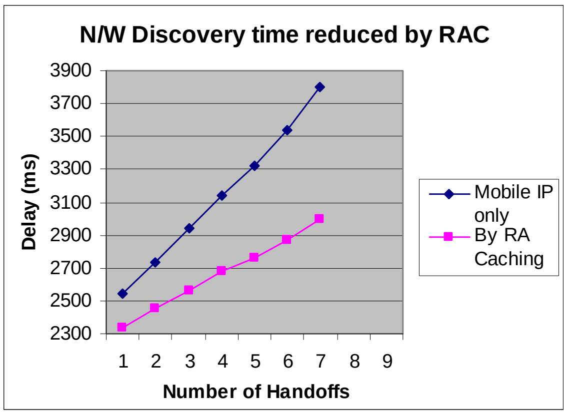


Figure 3. Latency time reduced by RA Caching.

Figure 3 show that the Network Discovery time reduced by RA caching. Figures 4 show that the Latency time is not increased with increasing handoffs for our new proposed system.

The figure 5 and 6 represents the reliability factor of Mobile IP only and new proposed system (SMG). The impact of the reduced latency in new proposed system, figure 7 represents the Throughput also increased with SMG comparing to Mobile IPv6 only environment.

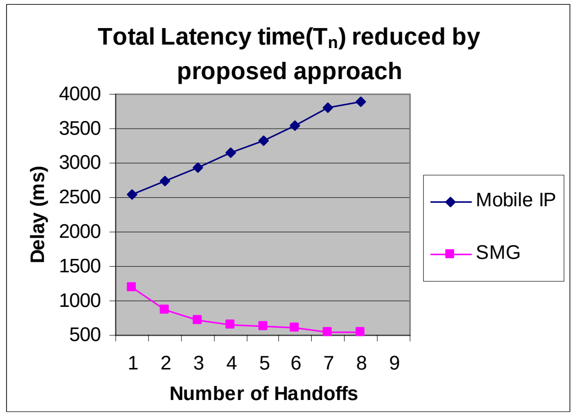


Figure 4 Total Latency time reduced by SMG.

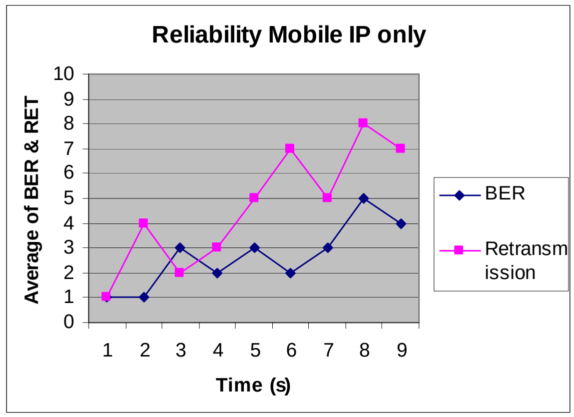


Figure 5. Reliability affected in Mobile IP only

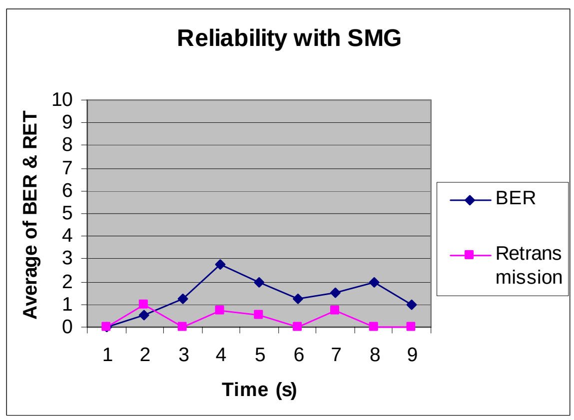


Figure 6. BER and Retransmission reduced by SMG.

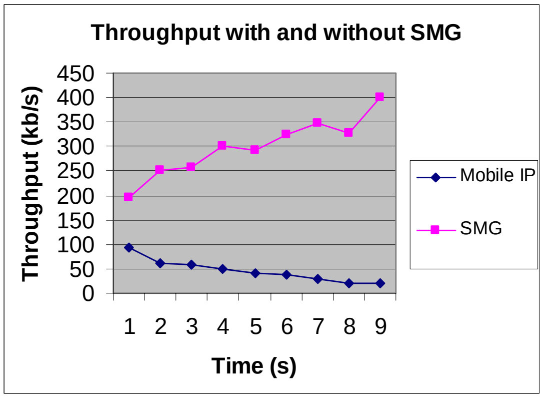


Figure 7. Throughput increased in proposed system

S.No	Number of Handoffs	With Mobile IP only Delay (ms)	With SMG Delay (ms)
1	1	2540	1200
2	2	2734	880
3	3	2945	722
4	4	3143	653
5	5	3324	620
6	6	3534	610
7	7	3799	550
8	8	3900	540
Average (%)		3239.8	721.8 (78%)

Table 3 Optimization of Latency with and without proposed system

The table 3 represents the total latency time 78% reduced by the proposed new Seamless Mobility Gateway system.

The table 4 represents the Bit Error Rate and the number of retransmission minimized by the proposed system. From this result the Reliability of the system is increased and optimized.

The table 5 represents the total Throughput during the seamless mobility is increased with six times better then the MIPv6 system.

6. CONCLUSIONS

Proposed architecture and algorithm reduces the total network delay and maintaining seamless mobility in heterogeneous network with high reliability and Throughput. We have presented a proposed architecture with seamless mobility across heterogeneous radio systems including 802.11b and CDMA-based wireless networks. Seamless mobility between WLAN and Cellular services will benefit both service provider and users. The performance of the system is revealed and results are compared via simulation. Our proposed model can reduce the latency and taking the advantage of high throughput data rate WLAN systems as well as the high reliability of cellular networks.

Time (second)	With Mobile IP only		With SMG	
	BER	Retransmission	BER	Retransmission
1	1	1	0	0
2	4	1	0.5	1
3	2	3	1.25	0
4	3	2	2.75	0.75
5	5	3	2	0.5
6	7	2	1.25	0
7	5	3	1.5	0.75
8	8	5	2	0
9	7	4	1	0
Average= 4.66		2.66	1.36 (70.81%)	0.33 (87.59%)

Table 4 Optimization of Reliability with and without proposed system

S.No	Time (ms)	With Mobile IP	With SMG
1	1	94	196
2	2	60	250
3	3	58	257
4	4	50	300
5	5	40	292
6	6	38	324
7	7	30	348
8	8	20	327
9	9	20	400
Average		45.55	299.3

Table 5 Optimization of Throughput with and without proposed system

The proposed approach is used to evaluate Mobile IPv6 protocol performance in heterogeneous environments, and identify the weaknesses of this protocol to manage seamless roaming between different technologies. The weaknesses time delay (latency time), Throughput and Reliability are successfully maintained by SMG system, Network Selection Algorithm and Seamless mobility Algorithm. In this paper we implemented the inter-working mechanisms, which effectively combine WLANs and cellular data networks into integrated wireless data networks with very high data rate capabilities in hotspot locations. From this new proposed Seamless Mobility Gateway System we can achieve the Enterprise Seamless Mobility Solution for remote server access. The Enterprise Seamless Mobility Solution will mean only one phone to carry, inside or outside the office for mobile enterprise employees and Seamless Mobility from WLAN to CDMA Cellular network and vice versa.

REFERENCES

[1] A. Sanmateu, F. Paint, L. Morand, S. Tessier, P. Fouquart, A. Sollund, E. Bustos, "Seamless mobility across IP networks using Mobile IP", Computer Networks, Edition 2002, pp. 181–190.

[2] N. Tripathi, "Generic Adaptive Handoff Algorithms using Fuzzy Logic and Neural Networks", Ph.D. Thesis, Virginia Polytechnic Institute and State University, August 1997, pp. 262.

[3] J.-E. Berg, R. Bownds, F. Lotse, "Path loss and fading models for microcells at 900 MHz", IEEE 42nd Vehicular Technology Conference, vol. 2, 1992, pp. 666–671.

[4] A. Hatami, P. Krishnamurthy, K. Pahlavan, M. Ylianttila, J. Makela, R. Pichna, "Analytical framework for handoff in non-homogeneous mobile data networks", Proceedings of the 10th IEEE International Symposium on PIMRC,
Osaka, Japan, September 1999, pp. 760–764.

[5] M. Gudmundson, "Correlation model for shadow fading in mobile radio systems", Electronics Letters 27 (23) (1991) pp. 2145–2146.

[6] Ann-Tzung Cheng, et al., "Secure Transparent Mobile IP for Intelligent Transport System", International Conference, ICNSC 2004, Taipei.

[7] F. Adrangi, H. Levkowetz, "Mobile IPv4 Traversal of VPN Gateways", <draft-ietf-mip4-vpn-problem statement 02.txt>, Internet Engineering Task Force (IETF).

[8] Hui Luo et al, "Integrating Wireless LAN and Cellular Data for the Enterprise", IEEE Internet Computing, April 2003.

[9] www.birdstep.com Project about seamless and secure mobility between an enterprise network and external networks.

[10] Luo.H., Z. Jiang, B.Kim, N.K.Shankaranarayanan, and P. Henry, "Integrating Wireless LAN and Cellular Data for the Enterprise", *IEEE Internet Computing*, March 2003.

[11] A.K. Salkintzis, G. Dimitriadis, D. Skyrianoglou, N. Assas, "Seamless Continuity of Real Time Video across UMTS and WLAN Networks: Challenges and Performance Evaluation", IEEE Wireless Communications, June 2005

[12] V.Gazis, N.Alonistioti and L. Merakos, "Towards a Generic Always Best Connected Capability in Integrated WLAN/UMTS Cellular Mobile Networks", IEEE Wireless Communications, June 2005.

[13] D. Cavalcanti, C. Cordeiro, D. Agrawa, B. Xie and A Kumar, "Issues in integrating Cellular Networks", IEEE Wireless Communications, June 2005.

[14] O. Song and A. Jamalipour, "Network Selection in an Integrated Wireless LAN and UMTS Environment using Mathematical Modeling and Computing Techniques, IEEE Wireless Communications, June 2005.

[15] N. Shenoy and P. Mishra, "A Framework for Seamless Roaming across Cellular and Wireless Local Area Networks", IEEE Wireless Communications, June 2005.

[16] F.G. Marquez. T.R Valladares, L.A. Galindo, M.G. Rodriguez "Interworking of IP Multimedia Core Networks between 3GPP and WLAN", IEEE Wireless Communications, June 2005.

[17] W.Wu.N. Banerjee, K. Basu and S.K. Das, "SIP Based Vertical Handoff between WWAN and WLAN", IEEE Wireless Communications, June 2005.
pp. 25-33.

[18] Massimo Bernaschi, Filippo, Giulio, "Seamless Internetworking of WLAN and Cellular Networks: Architecture and Performance issues in a Mobile IPv6 Scenario", IEEE Wireless Communications, June 2005

[19] Jochen Schiller, "Mobile Communications", Pearson Education, Second Edition, 2005

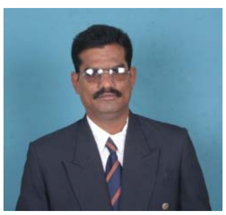
[20] M. Ylianttila, M. Pande, J. Makela, P.Mahonen, "Optimization Scheme for Mobile Users Performing Vertical Handoffs between IEEE 802.11 and GPRS/EDGE networks", IEEE Global Telecomm-unications Conference, 2001, (Globecom01), San Antonio, Texas, USA, vol. 6, Nov. 2001, pp. 3439–3443.

[21] M. Ylianttila, J. Makela, P. Mahonen, "Supporting resource allocation with vertical handoffs in multiple radio network environment", Proceedings of PIMRC 2002, the 13th IEEE International Symposium on Personal, Indoor and Mobile Radio Communications, Lisbon, Portugal, vol. 1, September 2002, pp. 64–68.

[22] S.-E. Kim, J.A. Copeland, "TCP for seamless vertical handoff in hybrid mobile data networks", Proceedings of IEEE Global Telecommunications Conference, 2003 (Globecom03), vol. 2, 1–5 December 2003, pp. 661–665.

[23] D. Chalmers and M. Sloman, "A Survey of Quality of Service in Mobile Computing Environments", IEEE Communication Tutorials and Surveys, http://www.comsoc.org/ pubs/surveys, 2nd qtr. 1999.

Dr. A. Krishnan received his Ph.D. degree in Electrical Engineering from IIT, Kanpur. He is now working as a Dean at K.S.R. College Engineering, Tiruchengode and Research guide at Periyar University, Salem, Anna University, Chennai and Mother Thresa Women's University, Kodaikonal. His research interest includes Control Systems, Digital filters, Power Electronics, Digital Signal Processing, Artificial Intelligence, Neural Networks, Wireless and Mobile Computing. He has been published more than 200 technical papers at various National/ International Conference and Journals.



Dr. C. Chandrasekar received his Ph.D. degree from Periyar University, Salem. He has been working as Professor and Head/MCA at K.S.R College of Engineering, Tiruchengode, Tamil Nadu, India. His research interest includes Wireless networking, Mobile computing, Computer Communication and Networks. He was a Research guide at Anna University Coimbatore, Mother Thresa Women's University Kodaikonal and Periyar University Salem.