Assessment of Available Bandwidth in Heterogeneous 4G Network

Gurumurthy G D[1], Dr K B ShivaKumar[2], Srinidhi G A[3], Dr. H S Shivaram[4]
[1] *Research Scholar, Mewar University, India.*
[2] *Professor, Dept. of TCE, SSIT, Tumkur, India.*
[3] *Asst. Professor, Dept. of TCE SSIT, Tumkur, India.*
[4] *Visiting Professor, Mewar University, India.*

Abstract- The available bandwidth (ABW) of an end-to-end path is its remaining capacity and it is an important metric for several applications. Traffic engineering statistically ensures efficient use of existing network infrastructure based on information of network state through accurate measurement. Unused link capacity, also called available bandwidth (ABW) is one of the parameters used to determine the condition of the network for service providers to efficiently manage resources and services. Active measurement methods proactively shoot probe packets from a source node towards a destination node to estimate various network parameters. In these methods, different probe packet characteristics, such as probe size, number of probes and inter-probe gaps determine the features of the measurement. Proposed algorithm using the active measurement and it creates less self-congestion on the network, and proposed algorithm stand on the bottle neck doubling theory, it uses the less iteration to calculate the available bandwidth and it is well accuracy for available bandwidth measurement.

Keywords—*Self Congestion Networks, Doubling Theory*

I. INTRODUCTION

Traffic engineering statistically ensures efficient use of existing network infrastructure based on information of network state through accurate measurement. Unused link capacity, also called available bandwidth (ABW). ABW is the difference between the link capacity and the traffic load on that link at a given time. Bandwidth is the rate of data transfer, throughput or bit rate measuring in bits per second (bps). Basically the available bandwidth is an important metric for several applications, such as dynamic server selection internet domain path monitoring and path selection. Available bandwidth estimation is considered to be essential for resources management in existing and emerging heterogeneous networks and estimation of available bandwidth for a path is important for high utilization of network resources as well as quality of service guarantee for real time flows.

With the rapid development of the Internet technologies, the demand of the network access selection for consumers is presented as more as possible. As the extension of the general Internet, a variety of mobile and wireless technologies have already been treated as the important developing trend of the Next Generation Internet (NGI). 3G mobile communication networks, Wireless Local Area Networks (WLAN) and Wireless Sensor Networks are deployed around the most of the countries in the world. In daily life, our laptops can access the Internet through the WLAN, and the cell phones can visit the www service by accessing the 3G mobile communication networks. By reason of the increment of mobile subscribers and the development of access technologies, the network service demands of the subscribers are increasingly extended from the general data business to the requirement of Quality of Service (QoS). We focus on ABW measurement. Estimation techniques can be categorized based on their different properties such as measurement process, probe pattern and probing technique. Measurement schemes can be coarsely divided into two types.

- Passive method
- Active Method

Passive measurement methods use ongoing data traffic flows through a measuring node to estimate the network characteristics. Measurement is only possible with the administrative control and the existence of network traffic on the link under measurement. Active measurement methods proactively shoot probe packets from a source node towards a destination node to estimate various network parameters. In these methods, different probe packet characteristics, such as probe size, number of probes and inter-probe gaps determine the features of the measurement. These probes add extra traffic into the network and may affect data traffic when the ABW is small. In addition to this, extra probe load can also affect the measurement process itself.

The proposed algorithm is an active method and it takes less iteration to evaluate the available bandwidth and has more accuracy in calculation. This algorithm basically stand on the bottle neck doubling theory i.e. the probe packet rate is equal to the available bandwidth and there are no differences in output gap at destination. If the rate of transmission is double the available bandwidth then probe packets delay will also be doubled and this theory is known as bottle neck doubling theory.

II. PROPOSED WORK

This section presents the proposed doubling theory for available bandwidth estimation in heterogeneous networks.

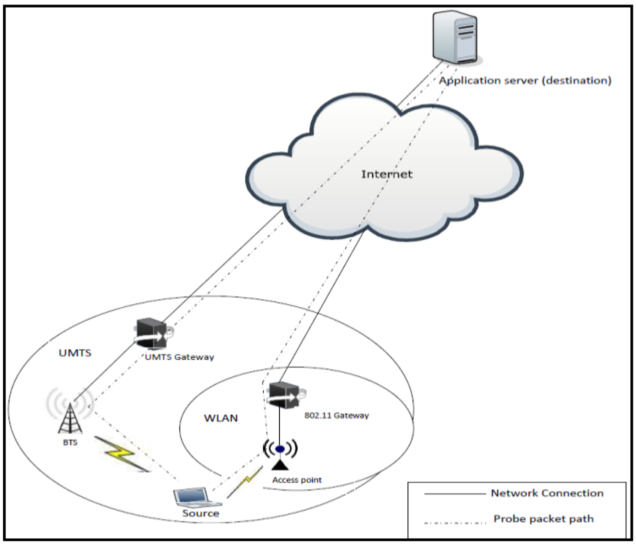


Fig.1: Network Diagram

The work tackles with the bandwidth estimation based on end to end transmission.

A. *Network Environments*

The dotted line in fig.1 shows the probing packet path and non-dotted line shows the physical link. UMTS and WLAN (show as ellipses) are two existing networks overlapped on each other. To calculate the available bandwidth between these two existing networks, mobile devices send probe packets to different network paths and the acknowledgements in reply are used to calculate the available bandwidth using the proposed algorithm. The Mobile device then shifts to the path with higher available bandwidth among the existing ones. This is the agenda of proposed algorithm.

B. *Bottle neck doubling theory*

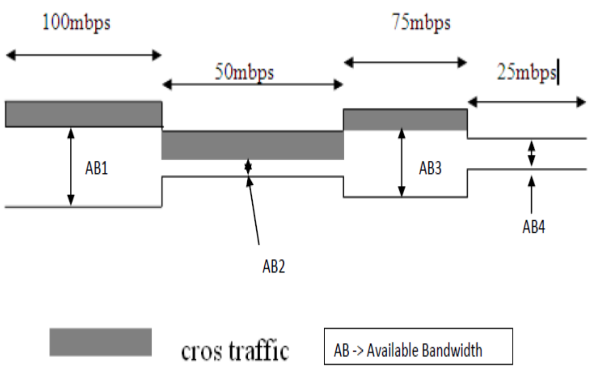


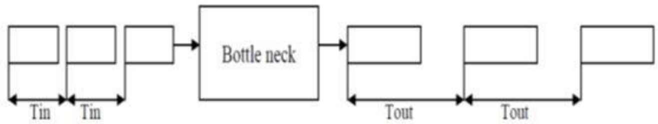
Fig.2: Bottle neck doubling theory

Fig 2 shows the representation of a network path, where each link is represented by a pipe. The link with minimum available bandwidth is called as tight link. The width of each pipe corresponds to the relative capacity of the corresponding link. The shaded area of each pipe shows the utilized part of link's capacity, while the unshaded area shows the spare capacity and the minimum available bandwidth AB2 determines the end-to-end available bandwidth as shown in Fig 2. Bandwidth variation from one link to other link creates bottle neck.

(i) Initial packet gap is equal to the obtained packet gap after bottle neck (Tin==Tout)

Where Tin is the input probing packet gap and Tout is the output probing gap. In this concept, available bandwidth is equal to the rate of transmission of probing packets Here, output probing packet gap is equal to the input probing packet gap (Tin=Tout) and therefore there are no variations at Tout.

(ii) Output probing packet gap is double than the input probing gap (Tout = Tin×2)



In this doubling theory, when we transfer the probe packet at double the rate of the available bandwidth then the output probing gap is exactly equal to the double of the input gap (Tout = Tin×2). The proposed algorithm uses this doubling theory to calculate the available bandwidth of the path.

C. *Available Bandwidth Estimation*

In heterogeneous networks the bandwidth is a measure of available or consumed data communication resources. This available bandwidth is not identical in all heterogeneous networks. In order to research the network bandwidth technologies, a certain number of measurement units that relate to the bandwidth are proposed. In an end to end transmission, the available bandwidth and transmission rate are often regarded as the bottleneck of the transmission. The estimation is made by the use of doubling theory.

Bandwidth Estimation

The capacity and available bandwidth of communication links in heterogeneous network is estimated by sending probe packets on path to the destination. Consider the size of probe packet is p, Rin is the rate of transmission of probe packets so the input probe packet gap is Tin, is defined as,

Tin = p/Rin (1)

The total input probe packet pair gap TIG and the total output probe packet pair gap TOG can be calculated by the following formulas: where 'K' is the number of probe packets and Tout is the output probe packet gap.

TIG = Tin (K-1) (2)

TOG = Tout (K-1) (3)

'V' is the ratio of total output gap and total input gap, it decides the current iteration transmission rate, if the ratio is greater than 2 then current iteration rate reduced to 'V' times of its last iteration rate, and if the ratio is equal to or less than 1 then the iteration rate increases to double of its last iteration rate.

V=TOG/TIG (4)

The total difference between the total output gap and total input gap, D is calculated by the following formula:

D = TOG – TIG (5)

The difference between each probe packet is calculated by the following formulas: where DPP is the difference between each probe packet pair at destination side and PDPP

is the percentage of difference between each probe packet pair at destination side.

DPP = D/(K-1) (6)

PDPP = (DPP*100)/Tin (7)

Unused link capacity, also called available bandwidth (ABW). ABW is the difference between the link capacity and the traffic load on that link at a given time. Bandwidth is the rate of data transfer, throughput or bit rate and is calculated by the following formula:

ABW = Rin - ((PDPP*(Rin/2))/100) (8)

Algorithm

ABW measurement scheme iteratively shoots the fixed size of probe packets from a source node to a destination node at a specific transmission rate and checks the change of probe pair gap at the destination to estimate packet transmission capacity. The change in probe pair gap at the destination end (i.e. the output gap) is affected by the tight-link capacity during the estimation period. If the probe transmission rate is lower than or equal to the ABW, no change in the output gap occurs. To determine the probe rate at each iteration, a proposed algorithm is adopted Fig 3 shows the flowchart for the proposed algorithm ABW measurement scheme. Fig 3 shows a flowchart that describes the ABW measurement scheme. In this scheme, the source node shoots the probe packets towards the destination at random rate. The source node computes the probe pair input gap Tin and destination node computes the probe pair output gap Tout affected by the bottle neck, the output gap results are sent back to the source and compares output gap and input probe pair gap at source. If ratio of the total input gap and total output gap is grater then 2 then reduce the sending probing packet rate to 'V' times of its last iteration rate (Rin/V) where 'V' is the ratio of total input gap and total output probe packet gap, else the ratio of input gap and output probe packet gap less than or equal to 1 and then the probe packet is sent at the rate of "Rin×2". If the probing packet rate is in between 1 & 2 then stop the iteration and go to calculation to check the differences between total output gap and total input gap (D = TOG – TIG) and then it evaluates the difference between pair of packet gap and the percentage of pair of packet gap differences and finally evaluates the available bandwidth calculation "AB = Rin - ((PDPP*(Rin/2))/100)". This proposed algorithm reduces the number of iterations and increases the accuracy.

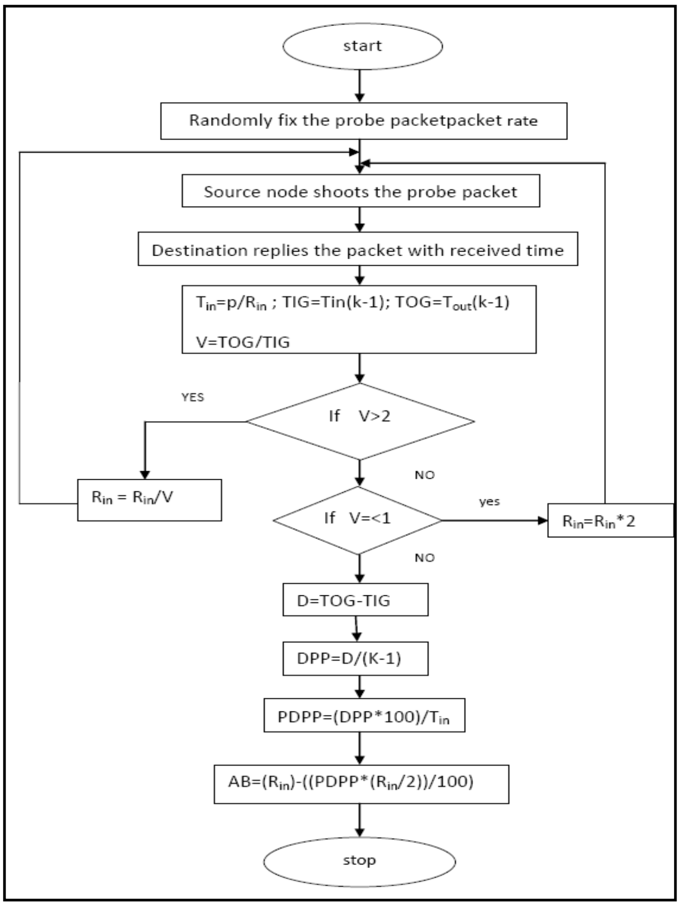
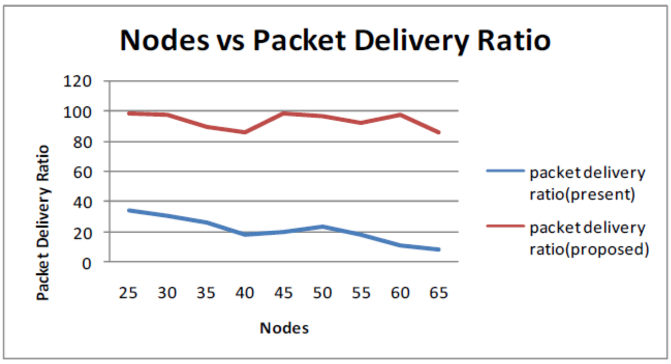


Fig.3: Flowchart to calculate the available bandwidth

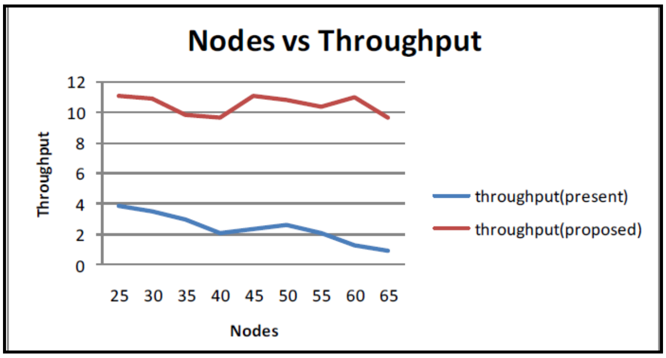
From the graph it is clear that the proposed system with available bandwidth measurement has a steady packet delivery ratio when it is compared with the present system. This is because of the fact that the communication is done only through the nodes with best available bandwidth.

Results and Discussion



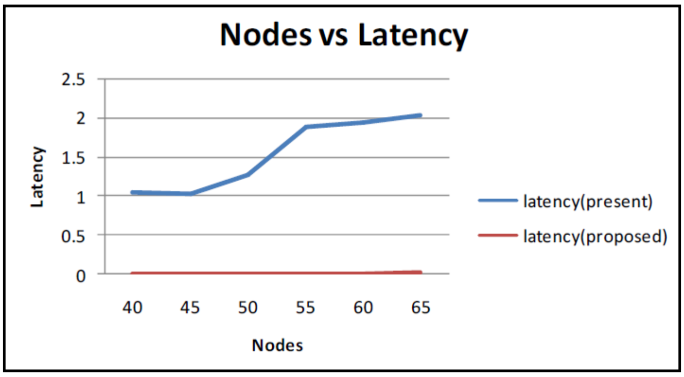
NODES Vs PACKET DELIVER RATIO

NODES Vs THROUGHPUT



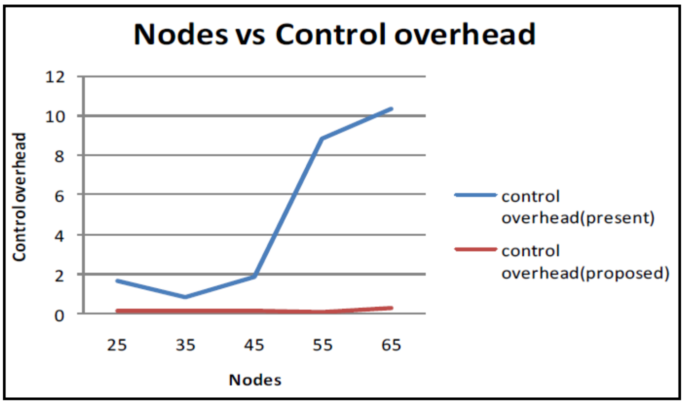
When we consider the node ranging from 25 nodes to 65 nodes for understanding the throughput, the proposed system has a better throughput compared with the present system.

NODES Vs LATENCY



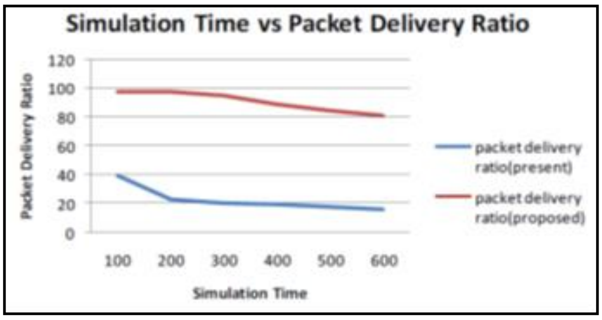
The above graphs shows that the proposed system out performs the present system in terms of latency. This behavior is more noticeable when the number of nodes increases.

NODES Vs CONTROL OVERHEAD



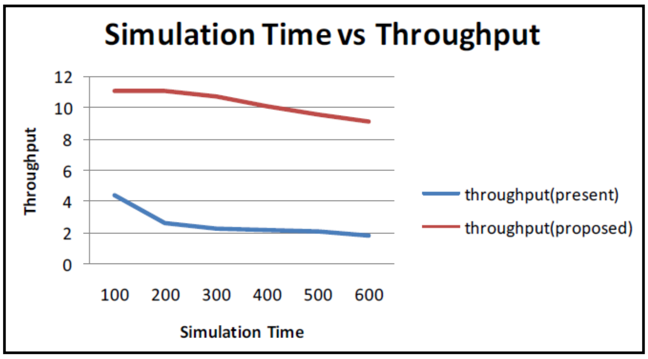
From the above graph we can say that the control overhead of the proposed technique is much lesser than the present technique.

SIMULATION TIME Vs Packet Delivery Ratio



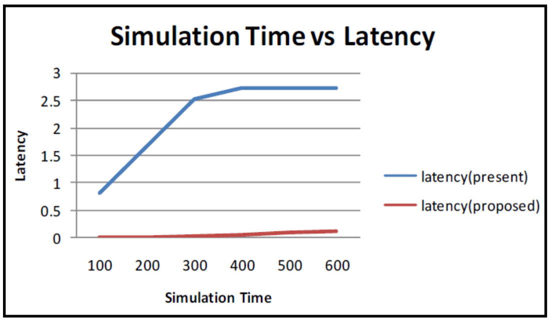
The graph shows the packet delivery ratio (PDR) of the two different modules such as Vertical handoff with ABW calculation and AODV based routing without Handoff.

SIMULATION TIME Vs THROUGHPUT



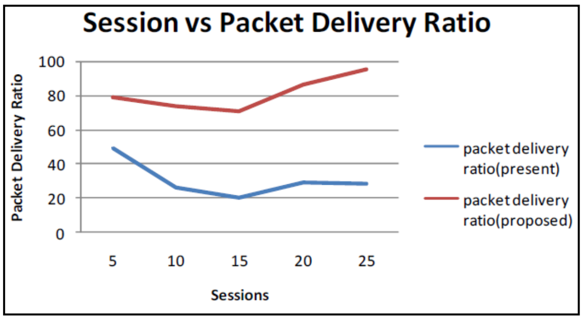
The throughput performance elaborates that the throughput is maintained at a very high level even when the simulation time offered is about 100%.

SIMULATION TIME Vs LATENCY



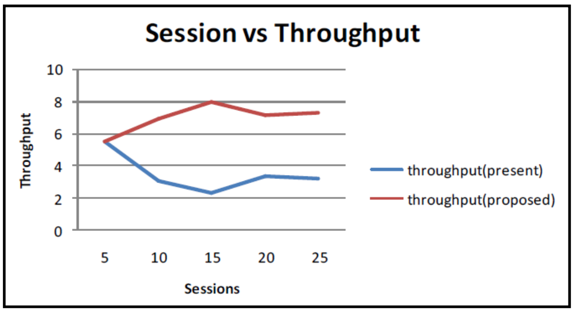
The nodes v/s the latency shows that the latency never shows an upward trend. Occasionally it would go high due to long waiting in the queue in the absence of bandwidth but it improves as soon as the required bandwidth is available.

SESSION Vs PACKET DELIVERY RATIO



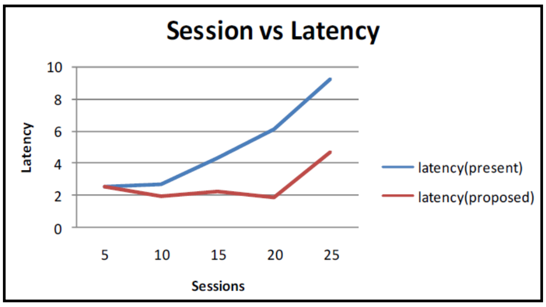
The control overhead is always almost constant. This is due to the stable topology. As the node monitors bandwidth and updates the connection state through vertical handoff, control overhead is optimum due lesser packet transmission in route and neighbor maintenance.

SESSION Vs THROUGHPUT



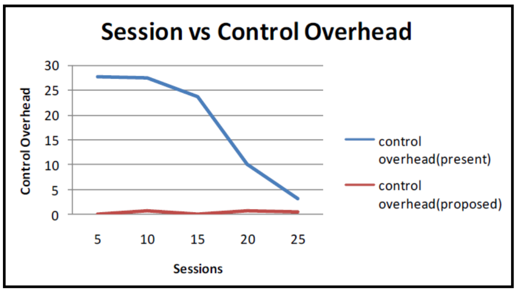
The graph shows the packet delivery ratio (PDR) of the two different modules such as present and proposed technique. We can observe that PDR of proposed technique is better than present technique even though there is an increase in sessions.

SESSION Vs LATENCY



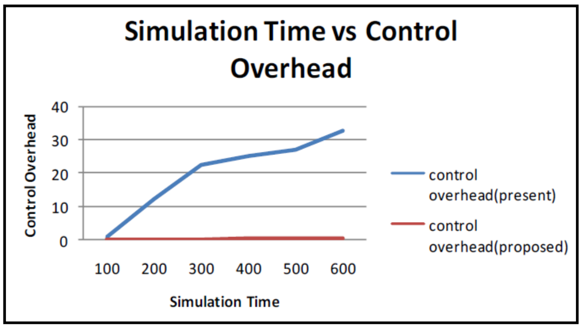
When we consider the session ranging from 5 nodes to 25 nodes for understanding the throughput, the proposed system has a better throughput compared with the present technique.

SIMULATION TIME Vs CONTROL OVERHEAD



The above graphs shows that the proposed technique out performs the present technique in terms of latency. This behavior is more noticeable when the number of sessions increases.

SESSION Vs CONTROL OVERHEAD



From the above graph we can say that the control overhead of the proposed technique is much lesser than the present technique.

III. CONCLUSION

Several bandwidth measurement techniques and bandwidth based routing and scheduling techniques are proposed in the past for different networks. However as QoS in 4G network depends mainly on vertical handoff and vertical handoff decision depends upon availability of constraints prior to transmission or routing. Therefore preemptive solution of bandwidth measurement is a better solution. Performance analysis also ascertain this claim. It is seen from the performance graphs that performance of the proposed system where bandwidth is measured as a round trip function performs better than non-bandwidth based QoS technique as well as delay based QoS technique. Preemptive power loss measurement and the same coupled with bandwith calculation for handoff decision can be thought of a future enhancement of the technique.

IV. REFERENCE

[1] Natsuki Itayaa and Shoji Kasaharab "Dynamic Parameter Adjustment for Available-Bandwidth Estimation of TCP in Wired-Wireless Networks", Computer Communications Volume 27, Pages 976-988 Protocol Engineering for Wired and Wireless Networks 20 June 2004.

[2] Heung Ki Lee, Varrian Hall, Ki Hwan Yum, Kyoung Ill Kim and Eun Jung Kim "Bandwidth estimation in wireless lans for multimedia streaming services", Multimedia and Expo, 2006 IEEE International Conference, Toronto, Ont. pages1181 - 1184 26 December 2006.

[3] Paulo Loureiro, Edmundo Monteiro "What if the end systems knew the bandwidth available in the network?" IEEE Communications Society subject matter experts for publication in the IEEE ", Global Telecommunications Conference, 2008. IEEE GLOBECOM 2008. IEEE New Orleans, LO. Pages: 1 – 6, 08 December 2008.

[4] Hyeong-Min Nam, Kyung-Seok Shin, Jae-Yun Jeong, Seong-Jun Bae, and Sung-Jea Ko "Probing based wireless channel bandwidth estimation and its application to video streaming over wireless networks", Consumer Electronics, 2008. ISCE 2008. IEEE International Symposium, Vilamoura, pages: 1 - 4, 09 July 2008.

[5] Amamra Abdelaziz, Hou Kun Mean "SLOT: A Fast and Accurate Technique to estimate Available Bandwidth in Wireless IEEE 802.11", Computer Modeling and Simulation, 2008. UKSIM 2008. Tenth International Conference, Cambridge, UK. Pages: 46 – 51, 15 April 2008.

[6] Mingzhe Li, Mark Claypool and Robert Kinicki "WBest: a Bandwidth Estimation Tool for IEEE 802.11 Wireless Networks", Local Computer Networks, 2008. LCN 2008. 33rd IEEE Conference, Montreal, Que. pages: 374 – 381, 31 October 2008.

[7] Andreas Johnsson, Mats Björkman "On Measuring Available Bandwidth in Wireless Networks", Local Computer Networks, 2008. LCN 2008. 33rd IEEE Conference, Montreal, Que. pages 861 – 868, 31 October 2008.

[8] Carlos U´ beda Castellanos, Dimas L´opez Villa, Oumer M. Teyeb, Jan Elling, Jeroen Wigard "Comparison of available bandwidth estimation techniques in packet-switched mobile networks", Personal, Indoor and Mobile Radio Communications, IEEE 17th International Symposium, Helsinki, pages 1-5, 11 December 2006.

[9] John Sucec, Kirk Chang, John Lee, Harshad Tanna and Sunil Samtani Larry Muzzelo, Jeffrey Palumbo and Michael Bereschinsky "A resource friendly approach for estimating available bandwidth in secure mobile wireless IP networks", Military Communications Conference, MILCOM, IEEE, Atlantic City, NJ, pages 32 – 38, Vol. 1, 20 March 2006.

[10] Zhenhui Yuan, Hrishikesh Venkataraman and Gabriel-Miro Muntean "Intelligent Probing Technique for Bandwidth Estimation in Wireless Network", School of Electronic Engineering, Dublin City University, Dublin, Ireland 2008.

[11] Samarth H. Shah, Kai Chen, Klara Nahrstedt "Available Bandwidth Estimation in IEEE 802.11-based Wireless Networks", Department of Computer Science University of Illinois at Urbana-Champaign 2004.

[12] Mingzhe Li, Mark Claypool and Robert Kinicki "WBest: a Bandwidth Estimation Tool for Multimedia Streaming Application over IEEE 802.11 Wireless Networks", Computer Science Department at Worcester Polytechnic Institute Worcester, MA, 01609, USA 2007

[13] Hlotomitsii ADACHI Shinji KIKUCHI Tsiineo KATSUYAhlA "NEPRI : Available Bandwidth Measurement in IP Networks", Communications, 2000. ICC 2000. 2000 IEEE International Conference, New Orleans, LA , USA, pages 511 - 515 vol.1, 06 August 2002.

[14] Qiang Liu and Jenq-Neng Hwang "End-to-end available bandwidth estimation and time measurement adjustment for multimedia QOS", Multimedia and Expo, 2003. ICME '03. Proceedings. 2003 International Conference , pages 373-376 vol.3, 18 August 2003.

[15] D. Kiwior, J. Kingston and A. Spratt "PATHMON, A Methodology for Determining Available Bandwidth over an Unknown Network", Advances in Wired and Wireless Communication, 2004 IEEE/Sarnoff Symposium, pages 27 – 30, 04 October 2004.

[16] Jingsha He "On Available Bandwidth Measurement Implementation and Experiment", 29th Annual IEEE International Conference on Local Computer Networks (LCN'04), Tampa, Florida, USA, pages 772-773, 2004.

[17] Nadim Parvez and Ekram Hossain "Improving TCP Performance in Wired-Wireless Networks By Using a Novel Adaptive Bandwidth Estimation Mechanism", Global Telecommunications Conference, 2004. GLOBECOM '04. IEEE, 2760 - 2764 Vol.5, 17 January 2005.

[18] Alessio Botta, Antonio Pescap´e, and Giorgio Ventre "On the performance of bandwidth estimation tools", Systems Communications, 2005. Proceedings, pages 287 – 292, 10 October 2005.

[19] Y Labit, POwezarski, N. Larrieu "Evaluation of Active Measurement Tools for Bandwidth Estimation in Real Environment", IEEE E2EIVON, pages 71-85, 2005.

[20] Alessio Botta, Salvatore D'Antonio, Antonio Pescap´e, and Giorgio Ventre "BET: A Hybrid Bandwidth Estimation Tool", Parallel and Distributed Systems, 2005. Proceedings. 11th International Conference , pages 520 - 524 Vol. 2, 21 November 2005.

[21] Emanuele Goldoni Giuseppe Rossi, Alberto Torelli "Assolo, a New Method for Available Bandwidth Estimation", Internet Monitoring and Protection, 2009. ICIMP '09. Fourth International Conference, Venice/Mestre, pages 130 – 136, 19 June 2009.

[22] Bo Wang, Xiangmin Wen, Yong Sun, Wei Zhen "A Novel Available Bandwidth Measurement Method based on the Pathload", Information Technology and Applications, 2009. IFITA '09. International Forum, Chengdu, pages 652 – 655, 04 September 2009.

[23] Haisheng Jiang, Miao Xue, Ping Dong, Yajuan Qin and Sidong Zhang "Research and implement of dynamic access link selection scheme based on the bandwidth estimation",Communications Technology and Applications, 2009. ICCTA '09. IEEE International Conference, Beijing, pages 115 – 121, 08 December 2009.

[24] K.M. Salehin R. Rojas-Cessa "Combined methodology for measurement of available bandwidth and link capacity in wired packet networks", Communications, IET, Volume 4, pages 240 – 252, 15 January 2010.

Gurumurthy G.D obtained his BE in Electrical & Electronics Engg., In the year 1990 from Mysore University & M Tech in Digital Electronics and Communication Systems in the year 1995 From Mysore University. He is persuing his PhD in Electronics and Communication Engg in Mewar University, Rajasthan. He has 20 years of teaching experience and presently he is working as Assistant Professor, Dept. of E&C, Kalpataru Institute of Technology, Tiptur, Karnataka. His research area is Wireless Networks.

Dr K B ShivaKumar received the BE degree in Electronics & Communication Engineering, ME degree in Electronics, MBA Degree from Bangalore University, Bangalore and M Phil Degree from Dravidian University Kuppam. He obtained Ph.D. in Information and Communication Technology from Fakir Mohan University, Balasore, Orissa. He has got 30 years of teaching experience and has over 60 research publications in National and International conferences and journals. Currently he is working as Professor, Dept. of Telecommunication Engineering, Sri Siddhartha Institute of Technology, Tumkur. His research interests include Signal processing, image processing, Multi rate systems and filter banks, and Steganography.

Srinidhi G A received the BE degree in Telecommunication Engineering, from Visveswaraya Technological University, Belgaum, Karnataka, MTech degree in Sensor Systems Technology from VIT University Vellore, Tamilnadu. He has over 10 research publications in National and International conferences and journals. Currently he is working as Asst Professor, Dept. of Telecommunication Engineering, Sri Siddhartha Institute of Technology, Tumkur. His research interests include Signal processing, image processing, Automotive Sensor systems, MEMS and Steganography.

Dr.H.S.Shivaram procured BE in Electrical Engineering, University of Mysore, 1967, M Tech in Electron Devices Technology, Indian Institute of Technology, Bombay, 1974 & PhD in Electronics /Instrumentation, Indian Institute of Science, Bangalore, 1983. He has more than 43 years of teaching experience & currently he is working as a Research supervisor and Visiting Professor at Mewar University Chittorgarh, Rajasthan, India. He has published 4 International Journals and presented research papers in 5 national conferences. His area of interest being communication Engineering and Networking.