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Analysis of Multimedia Applications in WiMAX Femtocells

Q. KHUHAWAR[++], S. ABBASI, F. KHUHAWAR*

Institute of Information and Communication Technology, University of Sindh,Jamshoro, Sindh, Pakistan

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Abstract: The recent advances in wireless access technologies has opened new opportunities for multimedia applications such as High-Definition (HD)On-Demand video. Moreover, interest and demand have raised to massive level for multimedia applications access over wireless networks. The applications such as video streaming, IPTV, Mobile TV, video calls, and peer-to-peer video sharing have brought the emergence of WiMAX (Worldwide Interoperability for Microwave Access) technology. The multimedia applications are by nature delay sensitive and in our work we analyze the performance of WiMAX Femtocell backhaul and the hunt parameters that affect the Quality of Service (QoS). The deep analysis helped us discover that the size and number of Femtocells play important role in optimizing the performance and it varies with type of multimedia application being used. To have deep insight, we extensively study the performance of WiMAX Femtocells using OPNET simulator and deduce some interesting results.

Keywords: Femtocells, Throughput, WiMAX, Multimedia, QoS

1. INTRODUCTION

The domain of wireless communication has become popular and interest towards research and development is increasing day by day. When talking about wireless scenario, Femtocell is said to be the next happening thing (Prasad and Baruah, 2009). Personal low power cell towers at every home sounds delightful possession to the users. The global market has developed communication standards with the start of technologies (pingYeh, *et al.,* 2008), (Prasad and Baruah, 2009) like 3G, WiMAX and now 4G. WiMAX Femtocells are a micronization of cellular networks and are vehicle to increase indoor coverage. Moreover, the deployment of WiMAX Femtocells will enhance user experience for greater QoS. The concept of five-bar coverage can be achieved through WiMAX Femtocells due to its reduced interference. Hence, more users can be packed into a given area in the same region of spectrum, thus increasing the area spectral efficiency (Alouini and Goldsmith, 1997).To reduce multi-access interference, Femtocells perform synchronization to align received signals, and ensure a tolerable carrier offset. Synchronization is also required so that macrocell users can handoff to a Femtocell or vice versa (picoChip: flexible wireless, 2008), (Andrews, *et al.,* 2007). Furthermore, it is also important to have efficient synchronization between Femtocells so as to coordinate in between forward and reverse link transmission on fixed phases and also to bound the timing drift as well and to cut the traffic bottleneck.

WiMAXprovides pervasive distribution of wireless broadband communication for fixed as well as mobile users (Lelescu, *et al.,* 2008), (Huang, *et al.,* 2008). A wide varity of multimedia applications have been supported by IEEE 802.16 standard. IEEE 802.16 also defines different types of service flows for WiMAX, such as UGS, rtPS, ertPS, nrtPS and BE. Each of these service flows come with unique QoS requirements. Hence each of these mentioned five flow services must have unique scheduling mechanism (ping Yeh, *et al.,* 2008), (Prasad and Baruah, 2009).

The paper is organized as following.The related work is discussed in Section2. Section 3 presents the proposed model and design. The results and discussion are highlighted in Section4. Finally, we conclude the work in Section5.

2. RELATED WORK

The"Home Base Station" technology was introduced by group of Motorola engineers in 2002. Later to promote femtocell usage, a Femtocell Forum was introduced by a group of vendors. Home based 2G Femtocell model was released by Sprint Nextel in 2008 and it was built by Samsung Electronics to work with Sprint handsets. 3G standard based Femtocell network service was rolled out by Vodafone and Verizon in 2009. Most of the companies like Starhub, O2, Softbank, TeliaSonera and AT&T started practicing Femtocells and announced testing in Raleigh and Charlotte.

[++]Corresponding Author Email: quratulain.faheem@gmail.com; Tel.: +92-333-2789328

* Department of Telecommunication, Mehran UET, Jamshoro, Sindh, Pakistan

Boundary limits for indoor coverage problems can be mitigated using Femtocells. Its other benefits may include reduced operational/capital cost, traffic load and power requirements. Hence, the increase in revenue per user and it has deployment in licensed (operator-owned)spectrum (Sahin, *et al.,* 2009). Furthermore, according to WHO fact sheet, Femtocellscomply with the guidelines for human exposure toelectromagnetic emissions issued by the InternationalCommission on Non Ionizing Radiation Protection (ICNIRP) regulatory authority. Femtocell is considered to have same level ofradio frequency (RF) exposure risk as WiFi access point's do, which are normally used in homes and offices (WHO, n.d.).

It has been estimated that by 2011, there will be around 32 million access points worldwide containing 102 millions of Femtocell users (Research Report, 2007). Femtocell operate in licensed spectrum and may share the same spectrum with Marcocell. Unlike WiFi, Femtocells are owned by mobile operators. Hence, there is the possibility of RF interference to happen between neighboring Femtocells as well as between Femtocells and Macrocells. Therefore, the spectrum has to be efficiently allocated in the Femtocell network in order to mitigate the interference problems.The authors in (Chandrasekhar and Andrews, 2007) have developed strategies to avoid interference in coexisting environment of Femtocells and Macrocells. To ease the process of installation, configuration and management, Femtocells are expected to operate in a plug and play fashion. Methods for self-optimization andauto-configuration as a Consumer Premise Equipment (CPE) have been investigated in (Ho and Claussen, 2007), (Holger Claussen, 2007) to optimize the coverage of Femtocells and minimize the impact on Macrocell network.

The prime concern of operators is to integrate the existing network and services with the Femtocells or to extend the operator's cellular network in to home network. Thus, enabling high data-rate services. IMS, GAN and UMTS based Femtocell solutions have been discussed on different Femto forums.

The recent development in the field of mobile applications have led to the emergence of mobile broadband platforms to support the capacity that these applications need.MIMO systems compatible antenna configurations for Femtocell applications have been presented (Ndikumasabo, 2009) to achieve a two-fold capacity increase as compared to SISO architecture.

3. SYSTEM DESIGN SETUP

The design phase includes WiMAX system with two WiMAX Base Stations called BS_A and BS_B. These BS's are connected to the core network, which consist of routers and VoIP as well as Videoconference servers.Each BS has a low powerhome base station called Femtocell and has eight usersthat are connected via WLAN access point (AP). AP is connected to WiMAX base station and the purpose of this system designis to analyze the performance of the multimedia applications while users are in Femtocell environment. For this reason, the user's profile has been configured to avail the VoIP and VideoConference services (Kalhoro, *et al.,* 2010). Some basic configuration features have been set, such as: Each WiFi hot-spot is connected to thenetwork using WiMAX connections and auto-addressing IP. WLAN nodes are also manually configured to have BSS ID values on all WLAN access points and their corresponding WLAN clients. The network uses RIP on all routing devices(including WiMAX) to perform routing through the network. WiMAX flows on Bronze Best Effort WiMAX serviceclass, 64 kbps. Mapped to IP ToS Best Effort (0) (used by VoIP application), Silver rtPS WiMAX service class, 384kbps. Mapped to IP ToS Excellent Effort (3) (used by Video Conferencing application). Further details of some defaultparameters are shown in **(Table 1.and 2)**.

3.1 Set of values for BS's

Antenna gain= 15dBi, maximum transmission power (w) = 0.05, MAC address BS_A= 22, MAC address BS_B=33, maximumnumber of SS (subscriber stations) supports = 100, minimumpower density= -90, maximum power density = -60, all CDMAcodes set to eight *i.e.* (number of initial ranging codes, number of HO (Handover)ranging codes, number of periodic ranging codes, number of bandwidth request). Back off ranging is set to2.

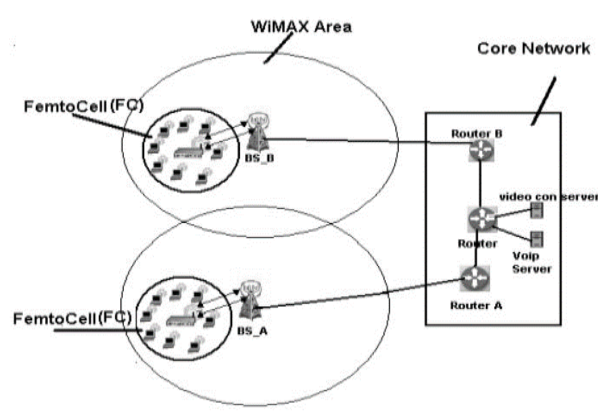

Fig.1 Femtocells using Multimedia Applications

3.2 Set of values for Subscriber's

Femtocell users have Wi-Fi LAN card with 11Mbps data transition and the default parameters of WLAN system are shown in **(Table.1).**The total number of users are 16, from which half of them are served by video conference server and the rest by VoIP server.

Table 1 : Default Parametets of WLAN System

#	Default Parameters	Values Set
1	Data Rate (bps)	11 Mbps
2	Transmit Power (W)	0.005 W
3	Packet Received Power Threshold	-95
4	CTS to Self Option	Enable
5	Short Relay	7
6	Long Relay	4
7	AP Beacon Interval	0.02
8	Max. Received Life-Time	0.5
9	Buffer Size	256000
10	Large Packet Processing	Drop

3.3 WLAN Access Point's Configuration Set

Wi-Fi Access point use CTS (Clear to Send) option and backhaullink is connected with BTs (Base Transceivers).

Table 2 : Femtocell Parameters

#	Default Parameters	Values Set
1	Antenna Type	Omni direction
2	Max. Transmit Power (W)	15 dB
3	Pilot Power	4 dB
4	Queue Length	3
5	Traffic Model	Multimedia
6	Long Relay	4
7	Max. Received Life Time	0.5
8	Buffer Size	256000

4. RESULTS AND DISCUSSION

The designed system is simulated using OPNET and the performance of multimedia (video and voice) has been analyzed.

The performance parameter like packet delay, packet variation, jitter, queuing delay, system throughput are chosen. Further the impact of increasing Femtocells on system throughput are analyzed as well.

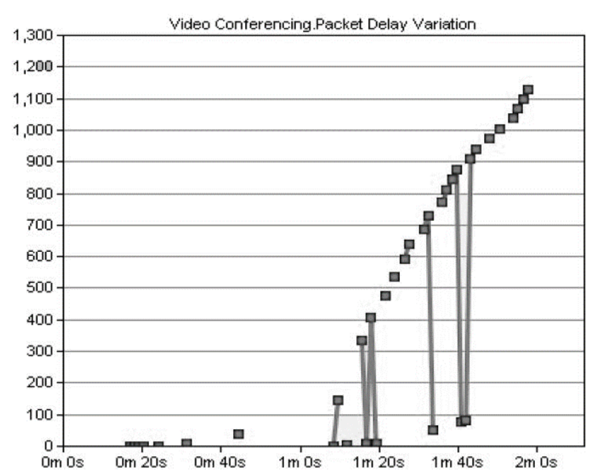

Fig.2 : Packet Variation Delay in Video Conference

4.1 Video Conferencing

To analyze the performance of video conferencing feature, we have chosen two parameters (Packet Variation and End-to-End Packet Delay) and the results of analysis are shown in **(Fig.)**, and **(**

Fig.).

The results show that the performance of Video Conferencing decrease with the increase in number of Femtocells as well as number of events due to the variation/increase in packet delay. Hence resulting in poor video conferencing performance.The equation evaluate packet delay can be described as,

$$f^p \partial\vartheta(t) = f\partial^p(t) - f\partial_n(t-1)\partial o \qquad \text{(I.)}$$

Where $f\partial^p(t)$ is delay of current packet, $f\partial_n(t-1)$ is the delay of previous packet and ∂o is kept regular interval for generating packets.

$$f_o^p \partial\vartheta(t) = \sum_{i=1}^{N} (f\partial^p(t) - f\partial_n(t-1)\partial o)_n \qquad \text{(II.)}$$

Where $f_o^p \partial\vartheta(t)$ is the delay of all the packets, and $f\partial_n(t-1)$ is the delay of previous packet. $\partial o$is kept regular interval for generating packets.

4.2 VoIP

(Fig.4) **(Fig.5)** and **(Fig.6)** shows jitter, packet variation and end-to-end packet delay in VoIP service, observed by Femtocell user. It is seen that the variation in time between packets raises to jitter can be due to network congestion, timing drift, route changes, increasing number of Femtocells in a system as well as limited buffer size. Where buffer is kept at least 2*J*R bit, where R is connection inbit/secand a worst case jitter of J seconds, with zero indicating that no jitter is present.

(Fig.4)shows that initially system has zero jitter but later it increases when Femtocells and number of events are increased and hence the system becomes dense. This results in inadequate performance of VoIP service. It has been observed that it reaches up to 0.054 seconds, and these results of packet variations are verified using Equation IV as shown in **(Fig.5),**

The results show thatend-to-end packet delay variation in VoIP service is extremely high. Similarly, end-to-end delay has shown to reach its peak value as well due to increase in Femtocells in WiMAX system.

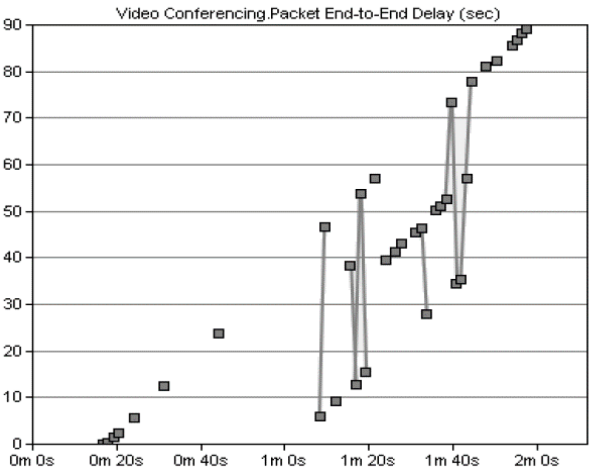

Fig.3: Overall Packet Delay in Video Conference

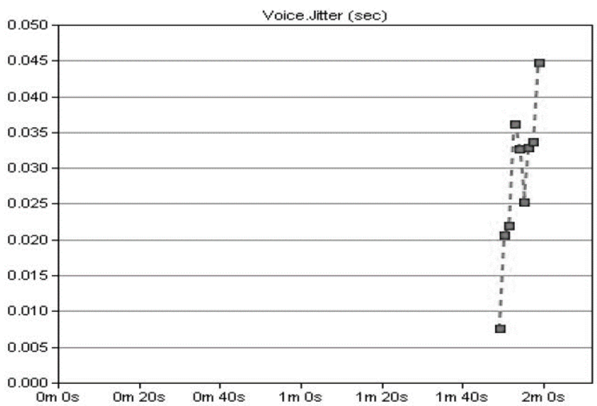

Fig.4 : Jitter in VoIP

Eventually, the probability of data loss is shown to increase due to increase in jitter, end-to-end packet delay and packet variation as shown in **(Fig.7)**

The reason for this behaviour is due to the fact that VoIP packets are required to reach on proper time due to its real time nature. However, voice jitter, voice packet delay variation and voice end-to-end delay increases chances of packet destruction.

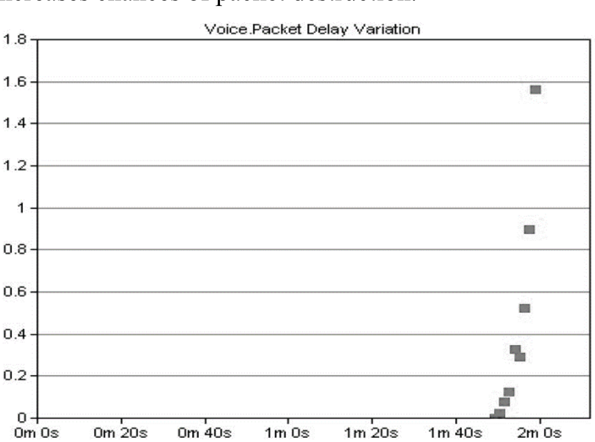

Fig. 5 : VoIP packet delay variation

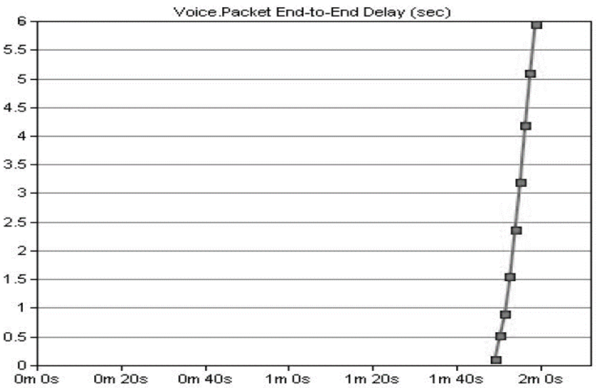

Fig.6 : VoIP end-to-end delay

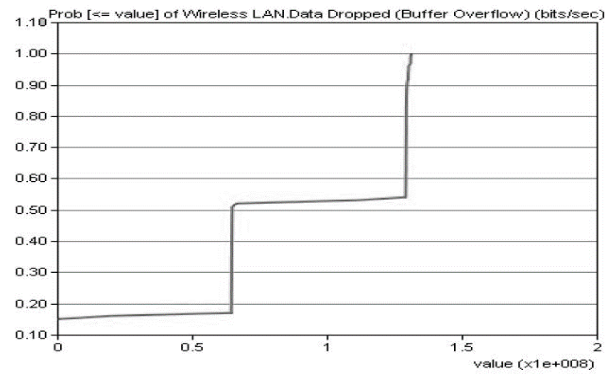

Fig.1 : Data loss in Femtocells due to buffer overflow

4.3 Servers

Video conferencing and VoIP servers are busy serving users. However, as the number of requests made by users increase, the concept of priority gets involved. Hence, we have used rtPS scheduling scheme, as it is used for real time service. Hence, implementation of rtPS scheduling scheme has shown to give priority to VoIP packets. **(Fig. 8 and (Fig. 9)** demonstrate the power of rtPS scheduling mechanism.

With respect to queuing delay (towards the server), the video conferencing feature is shown to relatively have more queuing delay as compared to VoIP service.

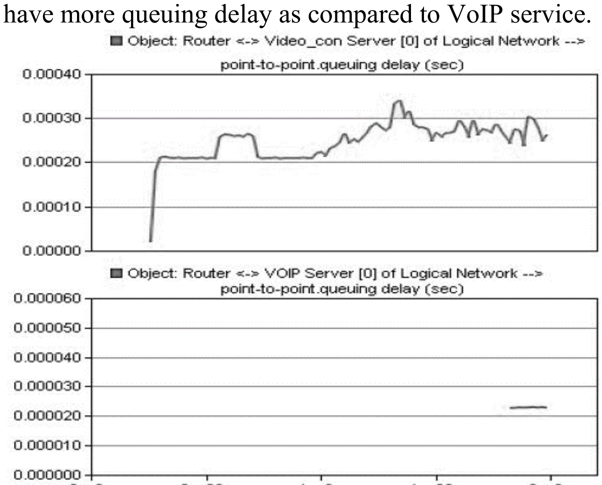

Fig. 8: Point-to-Point queuing delay of both servers

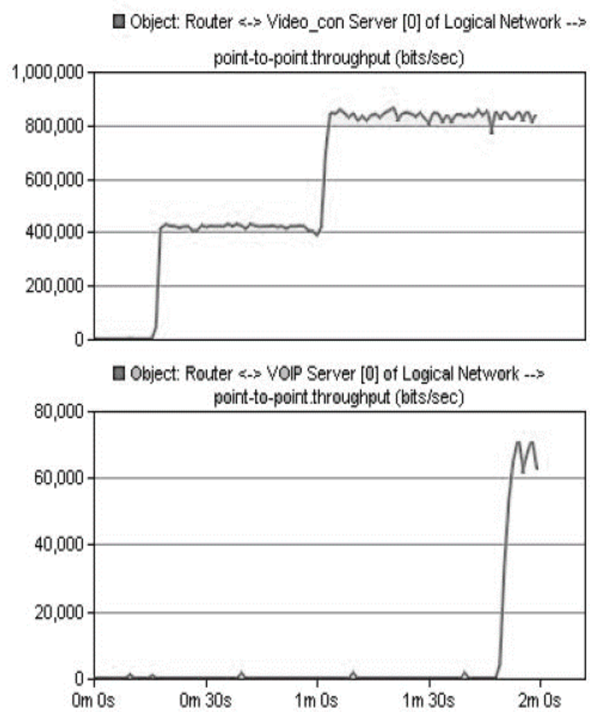

Fig.9 : Point-to-Point throughput of both servers

It has also been observed that the point-to-point clients that use video conferencing feature face more queuing delay. The possible reason for this behaviour is due to the fact that there is single scheduling scheme available for WiMAX technology and the need to introduce separate protocol for video packets is required, as rtPS is not full filling requirements of VoIP services.

4.4 Justification

We try to build system model through set of equations. We have observed that the performance of WiMAX technology decreases with the increase in number of Femtocells.

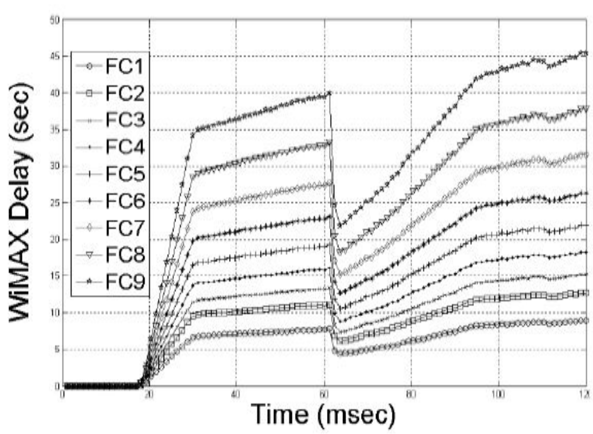

Fig.10 : WiMAX delay

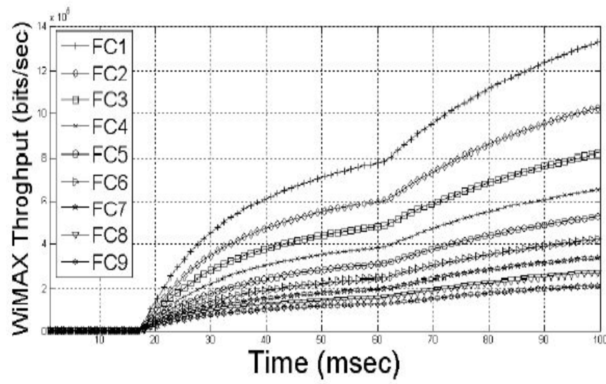

Fig.11 : Average WiMAX throughput

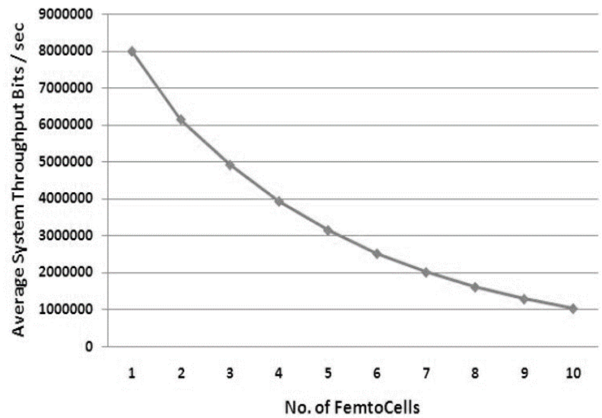

Fig.12 : Average throughput versus Femtocells

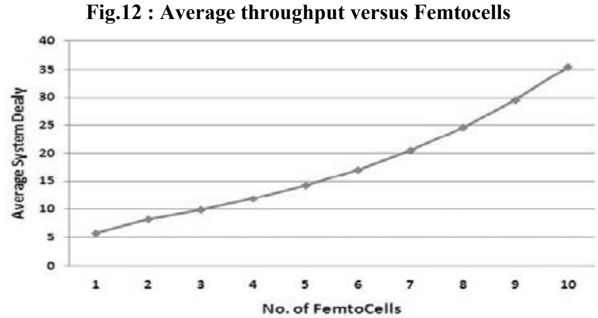

Fig.13 Average system delay versus Femtocells

$$S = \sum_{c=1}^{k} f^{c} \qquad \text{(III.)}$$

Where f^c is Femtocell and S is the system model which contains Femtocells. The throughput of the desired system can be calculated as;

$$S_{th} = w_{max-th} + \sum_{th-c=1}^{l} f^{th-c} \qquad \text{(IV.)}$$

Where f^{th-c} is the Femtocell throughput and S_{th} is the system model throughput.**(**

Fig.) shows the average system throughput via following mathematical relationship.

$$S_{th} = w_{max-th} + \sum_{th-c=1}^{l} \frac{f^{th-c}}{l} \qquad \text{(V.)}$$

The results show that the increase in number of Femtocells negatively impact on average system performance.

(Fig.11) and **(Fig.12)** represent the WiMAX system performance in terms of over all system throughput and delay. We can clearly observe that the average system throughput decreases with the increase in number of Femtocells. Similarly, an increase in average over all system delay is observed as well.

5. CONCLUSION

The study has come up with the conclusion that the Femtocell environment for VoIP service is compromising the Quality of Service (QoS) asrtPSis giving more priority to the video packets as shown in **(Fig.10)** and **(Fig.11).** The performance of WiMAX system decreases with the increase in number of Femtocells. Moreover, the variation in number of Femtocellshas a direct impact on end-to-end delay as well as data loss.Hence, there is a need to develop a new scheduling scheme that can enhance the performance for real time application in Femtocells.

In future work, we plan to further investigate whether implementing a new scheduling mechanism will solve the problems highlighted in this work.

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