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Analysis of Video Surveillance over WiMAX Networks

Final Report

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Abstract

There is a fast growing and wide demand of cost-effective, reliable video surveillance technology in urban areas. With the increasing demand of video surveillance in universities, monitoring street traffic, crime prevention, WiMAX could be the next broadband technology behind these services. An acceptable QoS (Quality of Service) throughput guaranteed by WiMAX as well as its overall positive behaviour with point propagation due to its utilization of multi-path would prove very beneficial to the service providers that provide video surveillance to numerous urban areas. This paper will analyze the feasibility of WiMAX for video surveillance applications through analyzing QoS (Quality of Service) parameters.

1. Introduction

1.1 WiMAX Overview:

With bandwidth and range limitations of Wi-Fi and other wireless technologies, the demand for new wireless technologies are immense. WiMAX can be simply explained as an IP based, wireless broadband access technology that provides performance similar to Wi-Fi (802.11) networks with the coverage and QOS (quality of service) of cellular networks [3].

WiMAX Stand for Worldwide Interoperability for Microwave access also known as IEEE 802.16 which is the IEEE group for wireless MAN (metropolitan area network) air interface specification. This could easily supply the missing link for the 'last mile' connection in wireless metropolitan area networks. WiMAX operates in 10-66GHz band with line of sight and 802.16a standard operates in 2-11GHz band with non line of sight communications. 802.16 operate at up to 124Mbps in the 28MHz channel (in 10-66GHz), 802.16a at 70Mbps in lower frequency, 2-11GHz spectrum [4].

WiMAX is supported by the industry, including companies such as Intel, Dell, Motorola, Fujitsu, AT&T, British Telecom, France Telecom, Reliance Infocomm, Siemens, Sify, PriceWatehouseCoopers and Tata Teleservices – forming an alliance called WiMAX Forum [5].

1.2 WiMAX Advantages:

WiMAX supports higher throughput of 72Mbps, nearly 7 times than IEEE 802.11b and is able to address challenges within a non line of sight (NOLS) environment than Wi-Fi as a result of using the proven technology, OFDM (Orthogonal Frequency Division Multiplexing). WiMAX also has built-in data encryption to prevent eavesdropping on data being transmitted. Unlike other wireless technologies that offer little or no data security WiMAX has a built in data encryption to tighten data security.

Furthermore WiMAX uses scheduling algorithms to provide the necessary QoS for Time sensitive traffic such as video. The five service types that are used to categorize the traffic are Unsolicited Grant Service (UGS), Real-Time Polling Service (rtPSt), Extended Real-Time Polling Service (ertPS), Non-Real-Time Polling Service (nrtPS) and Best Effort (BE) [8].

Service	Description	QoS Parameters
UGS	Support for real-time service flows that generate fixed data packets	Maximum sustained rate Maximum latency tolerance Jitter tolerance
rtPS	Support for real-time service flows that transport variable size data packets on a periodic basis	Minimum reserved rate Maximum sustained rate Maximum latency tolerance Traffic priority
ertPS	Extension of rtPS to support traffic flows such as variable rate VoIP	Minimum reserved rate Maximum sustained rate Maximum latency tolerance Traffic priority Jitter tolerance
nrtPS	Support non real traffic services that require variable size data grants	Minimum reserved rate Maximum sustained rate Traffic priority
BE	Support for best-effort traffic	Maximum sustained rate Traffic priority

Figure 1: QoS Service Classes

As mentioned before, WiMAX uses orthogonal frequency division multiplexing (OFDM) with modulations schemes from QPSK to 64-QAM, which is achievable as a distance from the WiMAX base station. Using a robust modulation scheme such as QPSK, WiMAX can deliver high throughput at long ranges while low order modulation (16 QAM) provides lower throughput at higher range from the same base station [7].

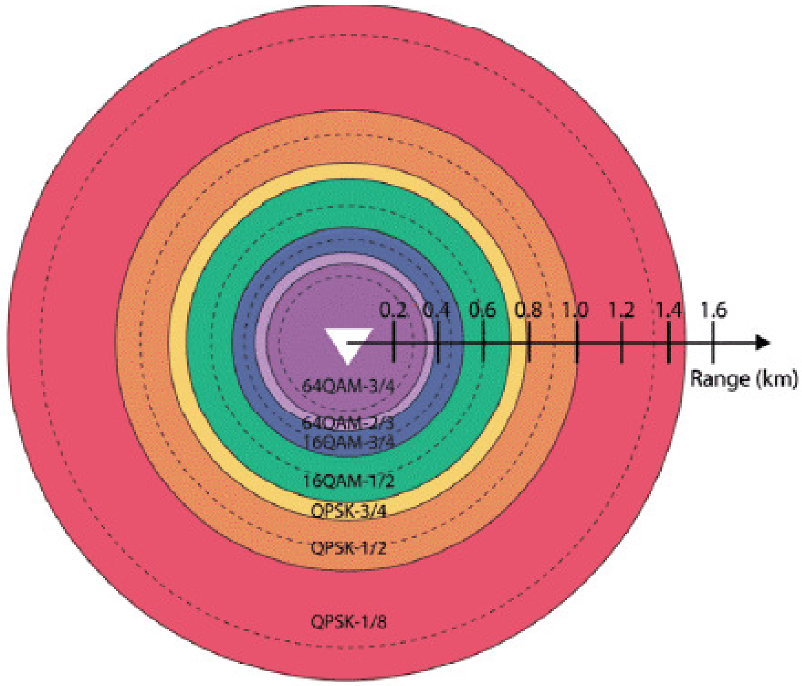


Figure 2: Modulation Scheme [7]

1.3 Video Surveillance Overview:

Initially introduced as a means of security for banks in the 1940s, video surveillance systems have advanced to become one of the most popular security systems today. To address areas like public safety, crime prevention and traffic monitoring, there is a growing demand for cost effective reliable video surveillance systems. United States alone installs 2-3 million surveillance cameras every year and cameras are supposed to sky rocket up to $6.48 billion in 2012, up from $435.8 million in 2005.

Most wireless IP video surveillance systems prevalent in the market are based on IEEE 802.11 due to cost effectiveness of Wi-Fi. Low coverage of Wi-Fi (about 100m) makes it virtually impossible to use it for long distance video surveillance. Furthermore less security standards implemented on Wi-Fi creates uncertainties for applications such as video surveillance making WiMAX a better choice for video surveillance [6].

2. Network construction utilities

This section consists of the various models used by us in order to construct our WiMAX network.

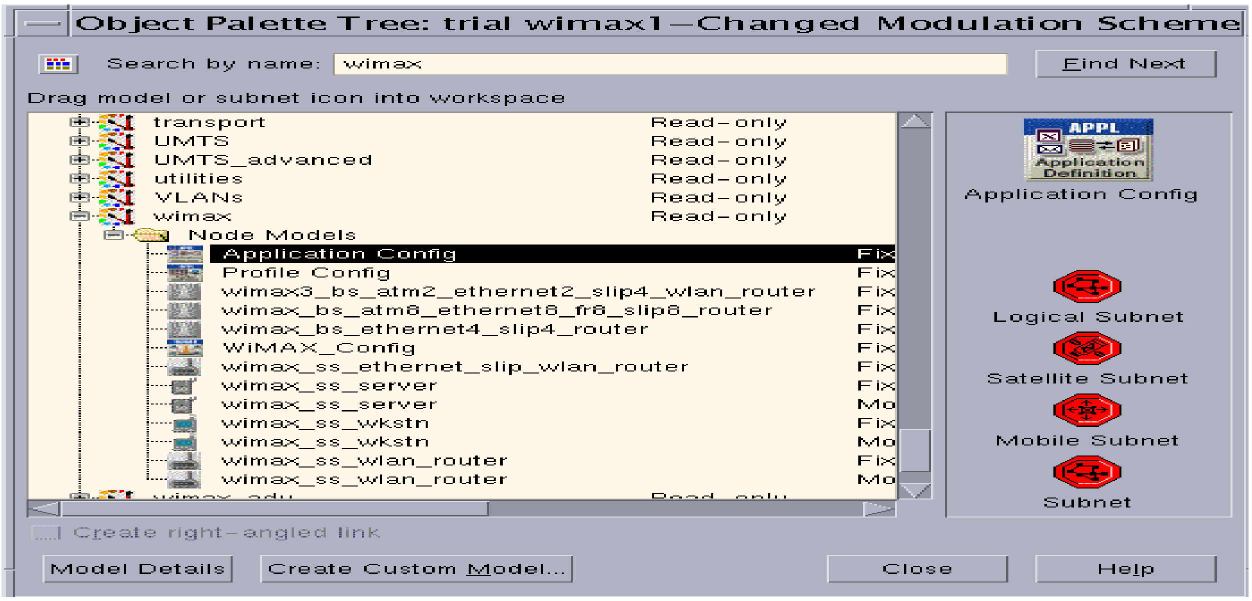
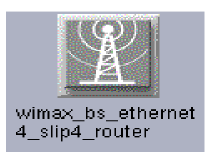


Figure 3: Object Palette showing WiMAX node models

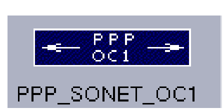
The use of all node models for WiMAX from the Object Palette was readily done on a regular basis. The following were the models used:

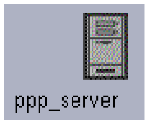
- Application Configuration: 

- Profile Configuration

- WiMAX Base Station: 

- Fixed Subscriber Station: 

- Link Models:  

- Server: 

3. Network Deployment

We used a wireless network deployment wizard in order to deploy a WiMAX network.

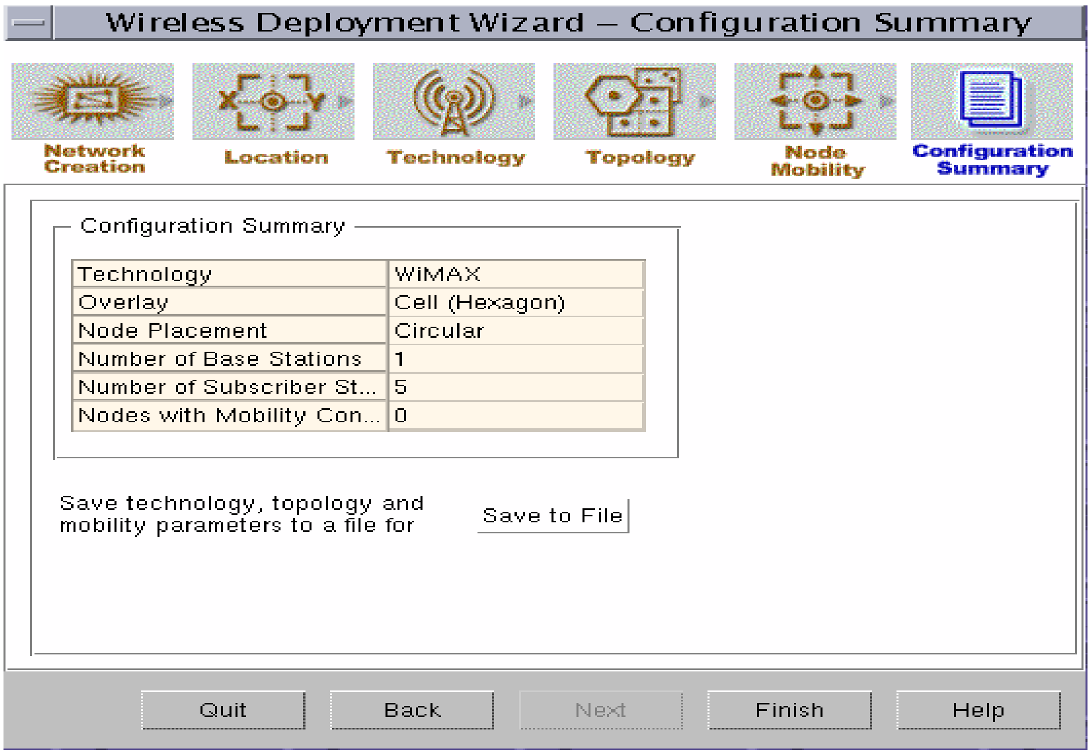


Figure 4: Wireless Network Deployment Wizard

By using the wizard shown above we configured a WiMAX network that consists of a circular placement of nodes in a hexagon with one WiMAX Base Station and 5 Subscriber Stations (Users) which were 1km apart from the Base Station. Also we used fixed nodes as there was no mobility configured. We place the entire WiMAX inside a subnet placed in North America [2].

4. OPNET Model

Our topology consisted of 1 subnet situated in North America within which a Wireless network is deployed.

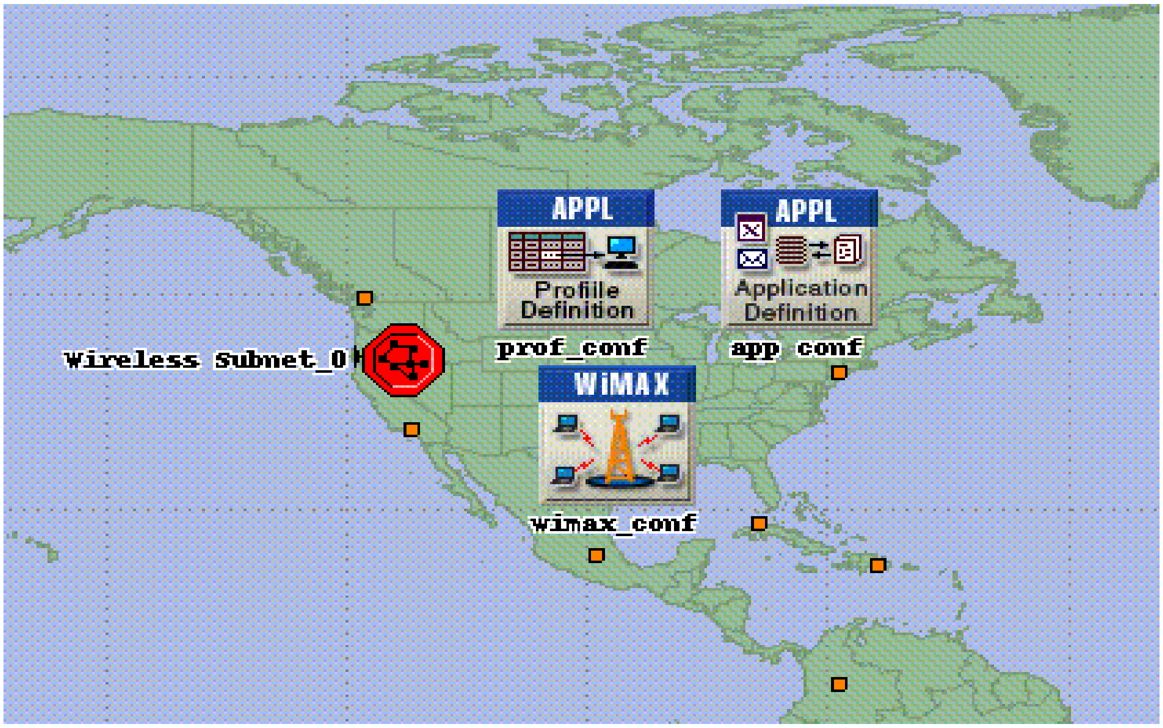
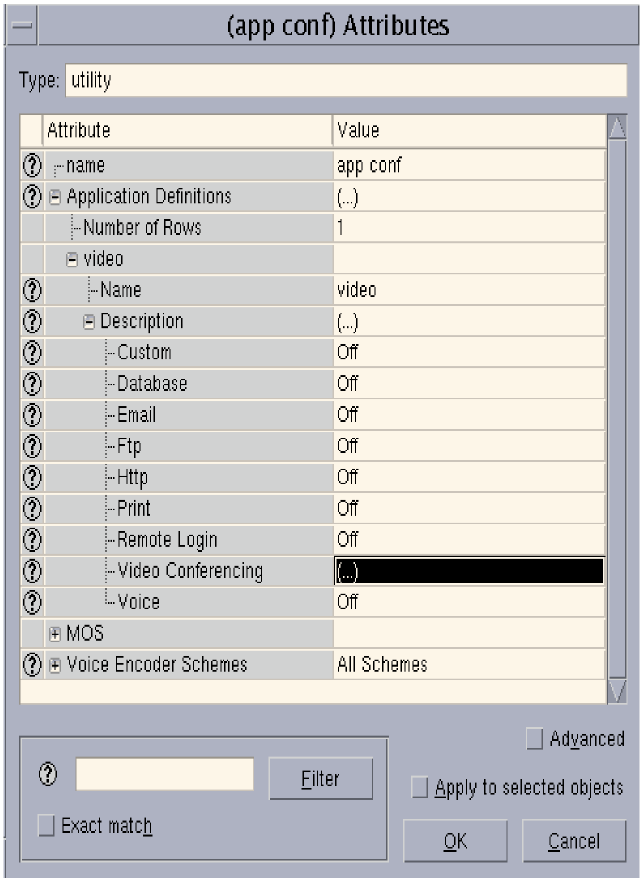


Figure 5: Wireless Topology

4.1 Application/Profile Configuration:

Application configuration specifies which application will be used inside our Wireless topology. Video conference was chosen as the application since that was the only built in application that supported video applications (Figure 4). Furthermore some default attributes inside the application was altered to support high quality video surveillance (30 frames/sec) and the Type of Service was changed to Streaming Multimedia.



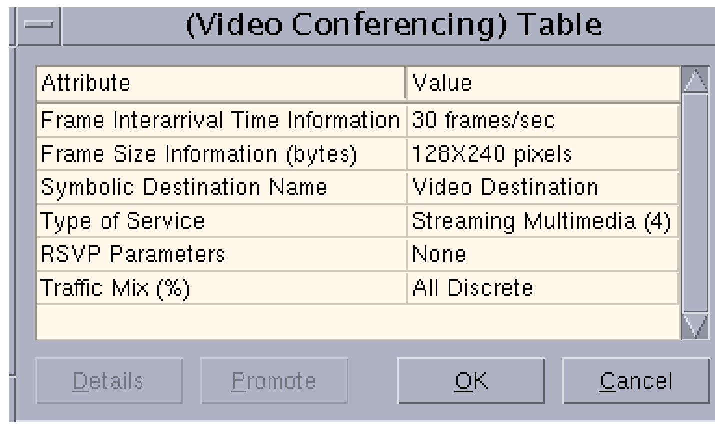
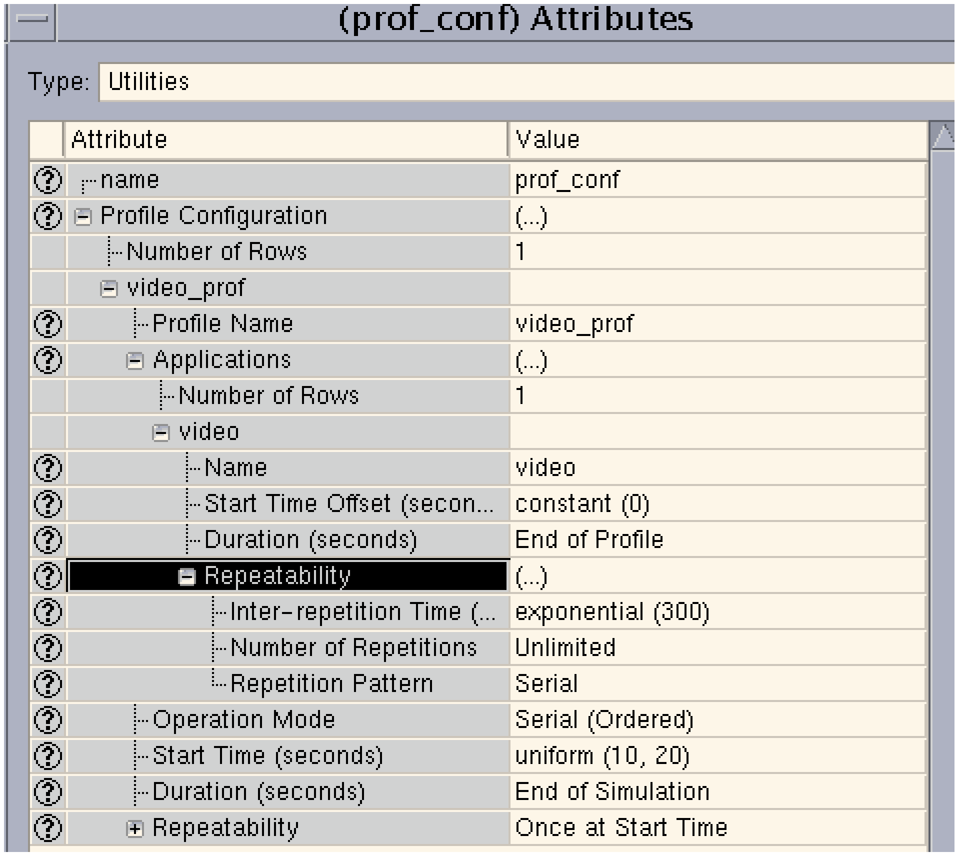


Figure 6: Application Configuration

Figure 7: Video Attributes

Profile Configuration allows to deploy the application generated in the application configuration. Video was added as a profile with no offset and a start time between 10-20 seconds. Furthermore operation mode was selected to be serial (ordered) as only one application is being used.



(prof_conf) Attributes

Type: Utilities

Attribute	Value
name	prof_conf
Profile Configuration	(...)
Number of Rows	1
video_prof	
Profile Name	video_prof
Applications	(...)
Number of Rows	1
video	
Name	video
Start Time Offset (secon...	constant (0)
Duration (seconds)	End of Profile
Repeatability	(...)
Inter-repetition Time (...	exponential (300)
Number of Repetitions	Unlimited
Repetition Pattern	Serial
Operation Mode	Serial (Ordered)
Start Time (seconds)	uniform (10, 20)
Duration (seconds)	End of Simulation
Repeatability	Once at Start Time

Figure 8: Profile Configuration

4.2 WiMAX Configuration:

Efficiency mode was set to Physical layer enabled which includes all WiMAX features except for Mobility and Ranging [9].

A service class groups the QoS requirements of the service flows. Service classes can be defined in the MAC Service class attributes in WiMAX configuration. By default configuration object defines three service classes. Gold, Silver and Bronze. As seen in the figure, only one service class was used (Silver), and the scheduling type was changed to rtPS in order to support real-time traffic with a variable bit rate which can very closely resemble video surveillance traffic. (Figure 1)

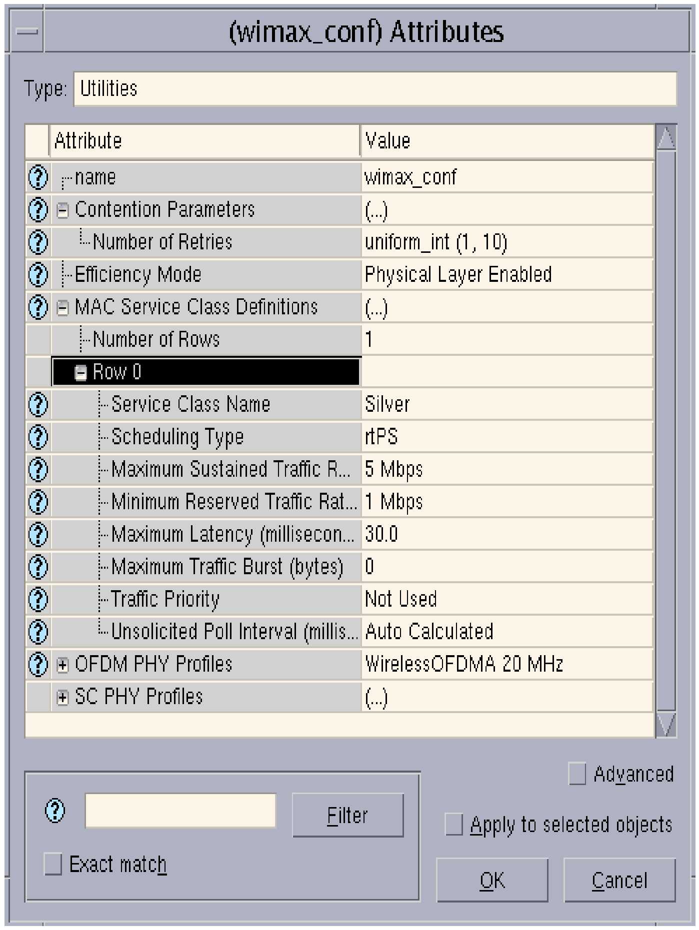


Figure 9: WiMAX Configuration

4.3 Baseline Scenario:

Our baseline consisted of a PPP server (that provides the video surveillance data), an IP backbone and a deployed wireless network within which **only one** user gets video surveillance data [2].

(Links: ppp_sonet_oc1 from server to server backbone, ppp_sonet_oc12 from server backbone to the IP backbone)

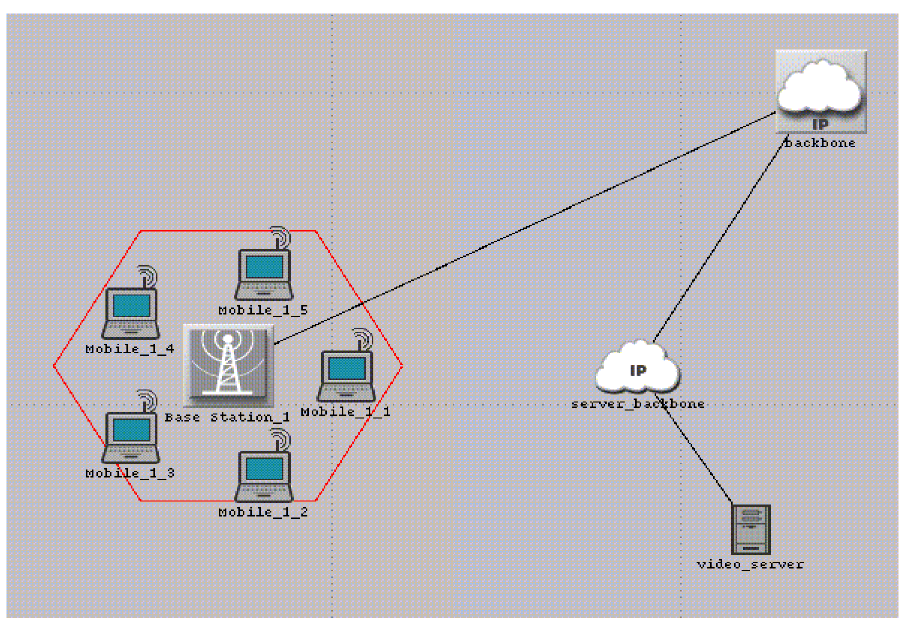
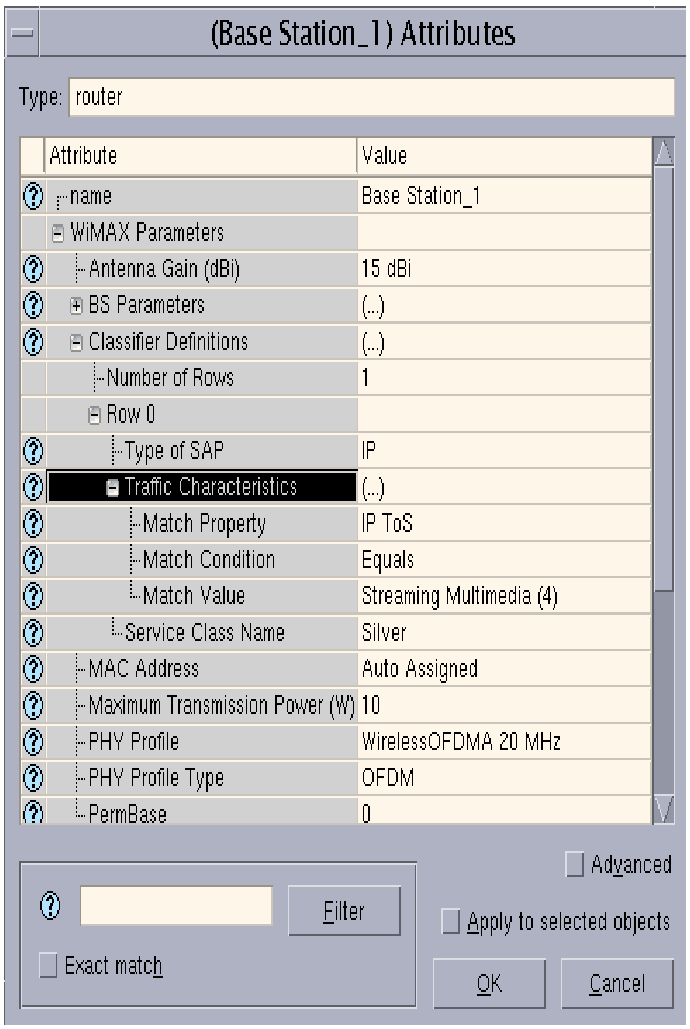


Figure 10: Baseline Scenario (only one work station gets video data)

4.4 Base station/mobile station/Server Configuration:

To support video traffic data received from the IP backbone Traffic Characteristics were set as shown in Figure 9. Match value was set to streaming multimedia to support video data and the service class was set to support silver to support real life traffic. Base station maximum power transmission was changed to 10W. (From default .5W)

Video server was set to support video application which was defined in the application configuration. (Figure 12)



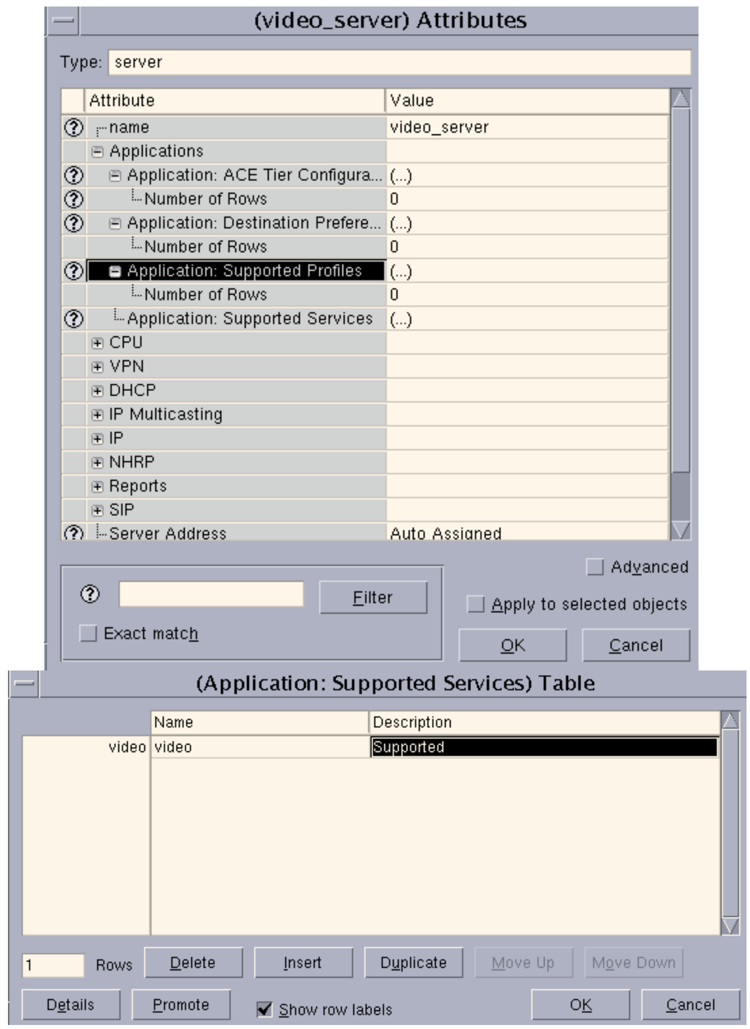


Figure 11: Base station Attributes

Figure 12: Server Attributes

On the mobile station, under classifier definition traffic characteristics were changed as shown below to support real time video traffic (Figure 11). Furthermore under SS parameters Uplink and Downlink traffic was set as shown in Figure 14.

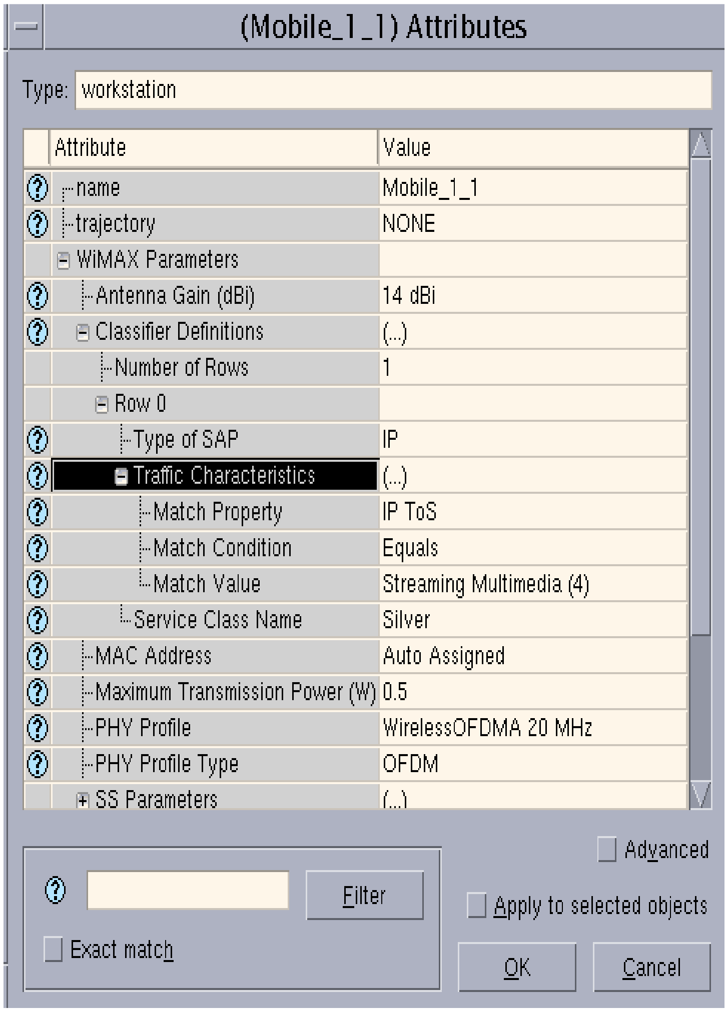


Figure 13: Subscriber station (user) attributes

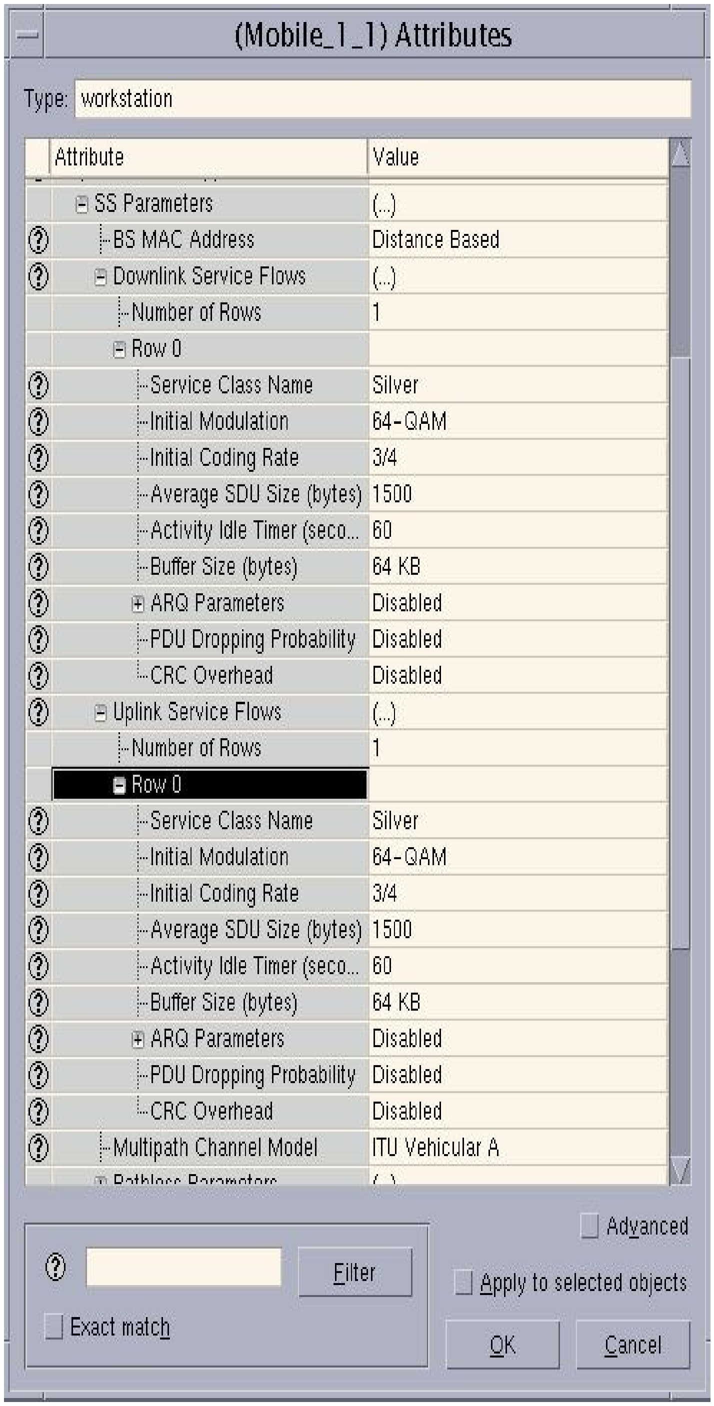


Figure 14: Subscriber station (user) attributes

4.5 Other Scenarios:

1 Base Station and 5 work Stations

The scenario was created to look into how throughput, ETE delay and packet loss changes as the number of subscribers increase.

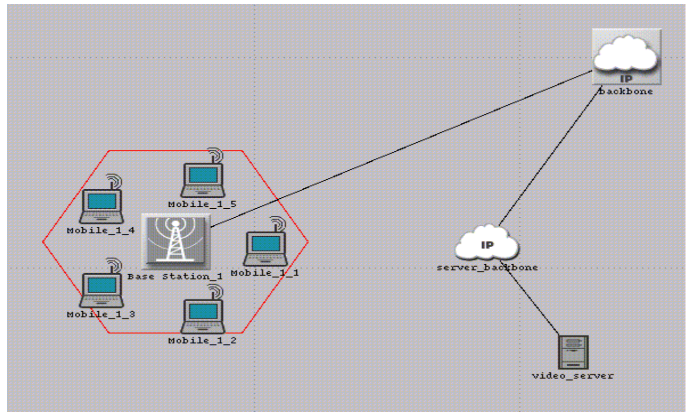


Figure 15: Scenario with 1 Base Station and 5 Subscriber Station

1 work station, 1 base station

(Workstation distance increased from 1km to 30 km)

The scenario was created to look into how throughput, ETE delay and packet loss changes as the number of subscriber distance increases.

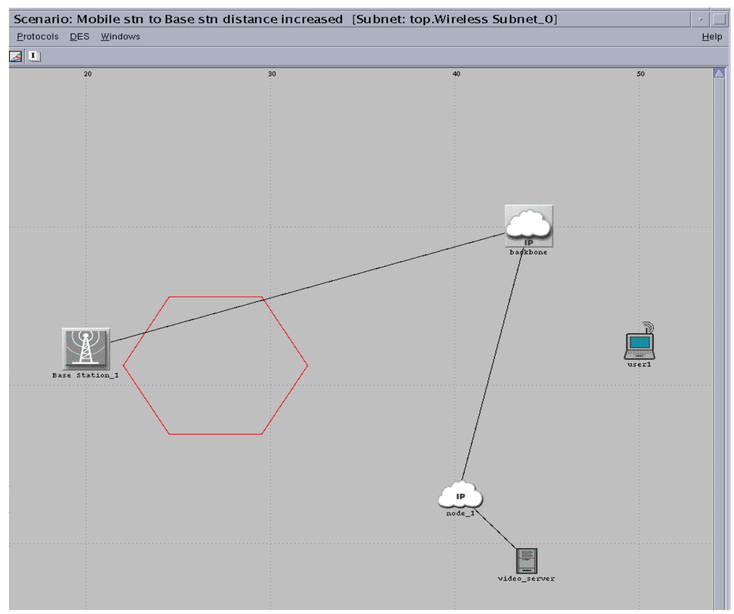


Figure 16: Scenario with 1 work station, 1 base station (Workstation distance increased from 1km to 30km)

1 work station, 1 base station
(Uplink modulation scheme changed from 64 QAM to QPSK 3/4)

The scenario was created to look into how throughput, ETE delay and packet loss changes as the uplink modulation scheme is changed from QAM to QPSK which is a more robust modulation scheme.

5. Mapping the traffic

To successfully map the traffic we deployed the application traffic to the users as shown in the following figure:

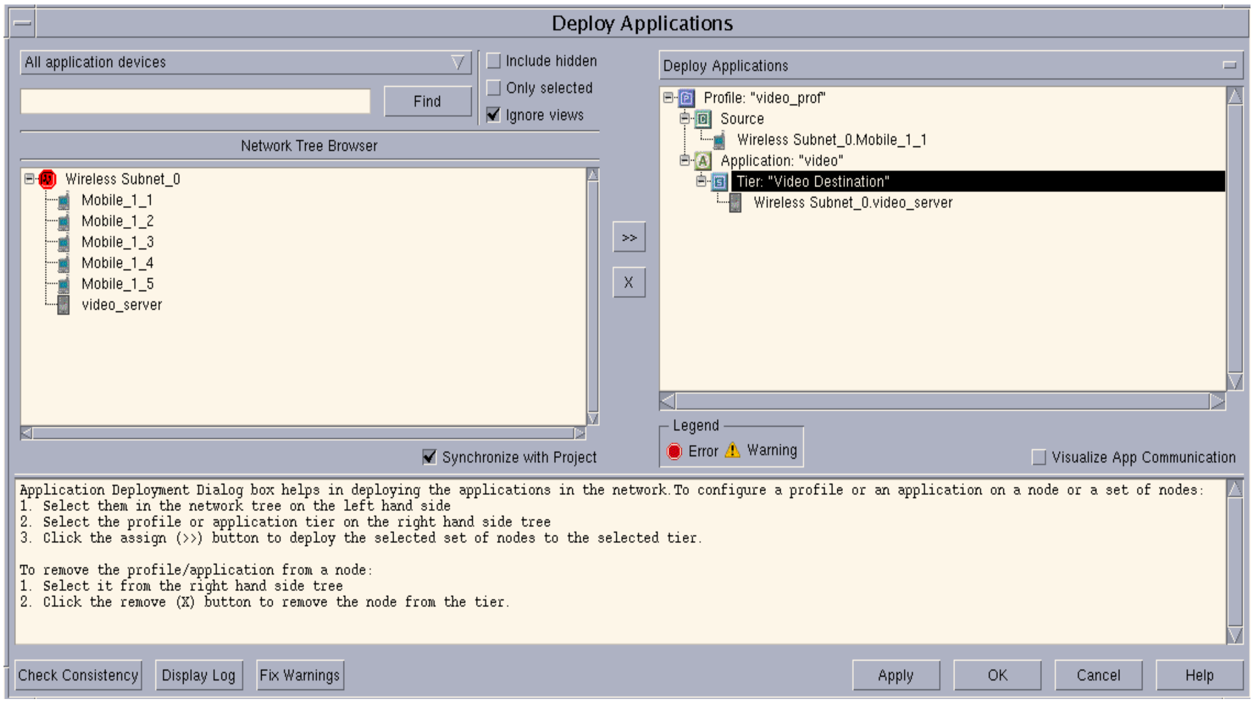


Figure 17: Deploying the Video Surveillance Application

The figure above shows that the source is set to the fixed Mobile Station (user1) and the destination application is set to the Video Server that supports the video surveillance application [2]. This implies that the clients are going to send a request to the server for the application and server would respond accordingly.

6. Simulation and Results

6.1 End-to-end Delay:

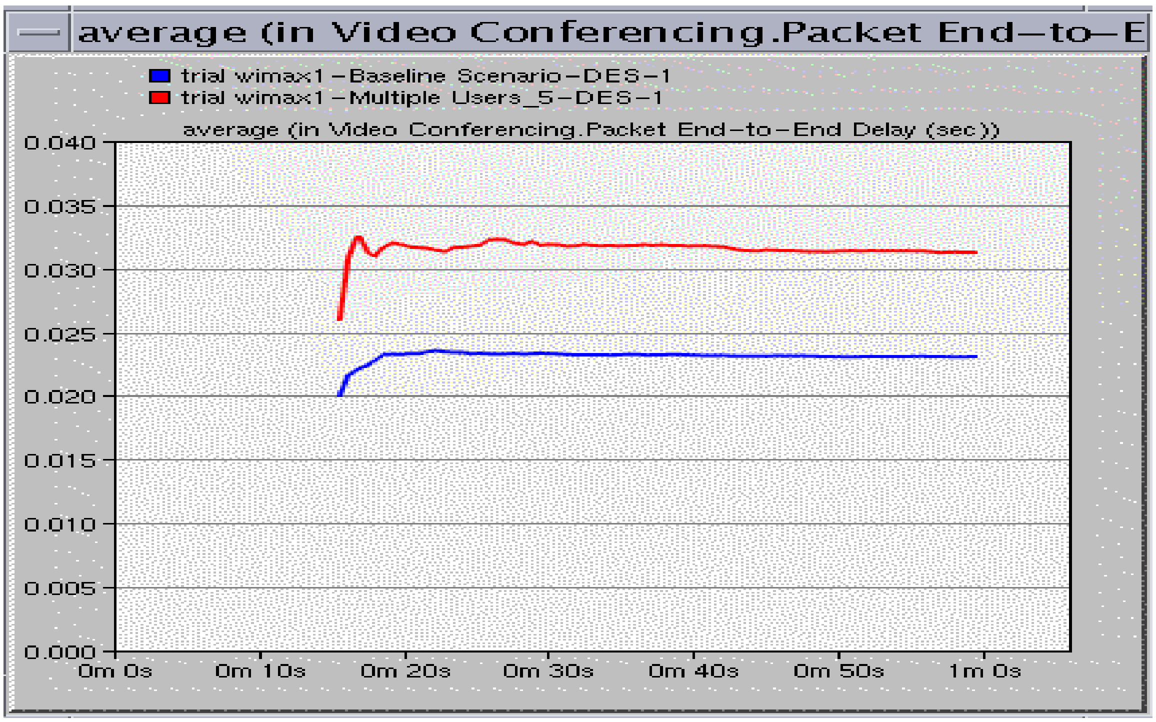


Figure 18: End-to-End Delay for baseline scenario and multiple users' scenario

The graph above depicts the end-to-end delay for the first and second scenario namely with one user and the second with multiple users around the base station. The above graph shows that that the end-to-end delays for the scenario with multiple users (5) as shown by the red curve, is greater than that with one user as depicted by the blue curve. This is expected as delay represents the average time of transit of each packet for more users and in it theory would be more as a lot more traffic is sent for multiple users. In this case, as expected the delay for more the number of users is greater than the delay for single user. The average value for the end-to-end delay is 300ms [1] and in our case the delay is significantly less than that as shown by the blue curve to be 22ms and the red curve to be 32ms.

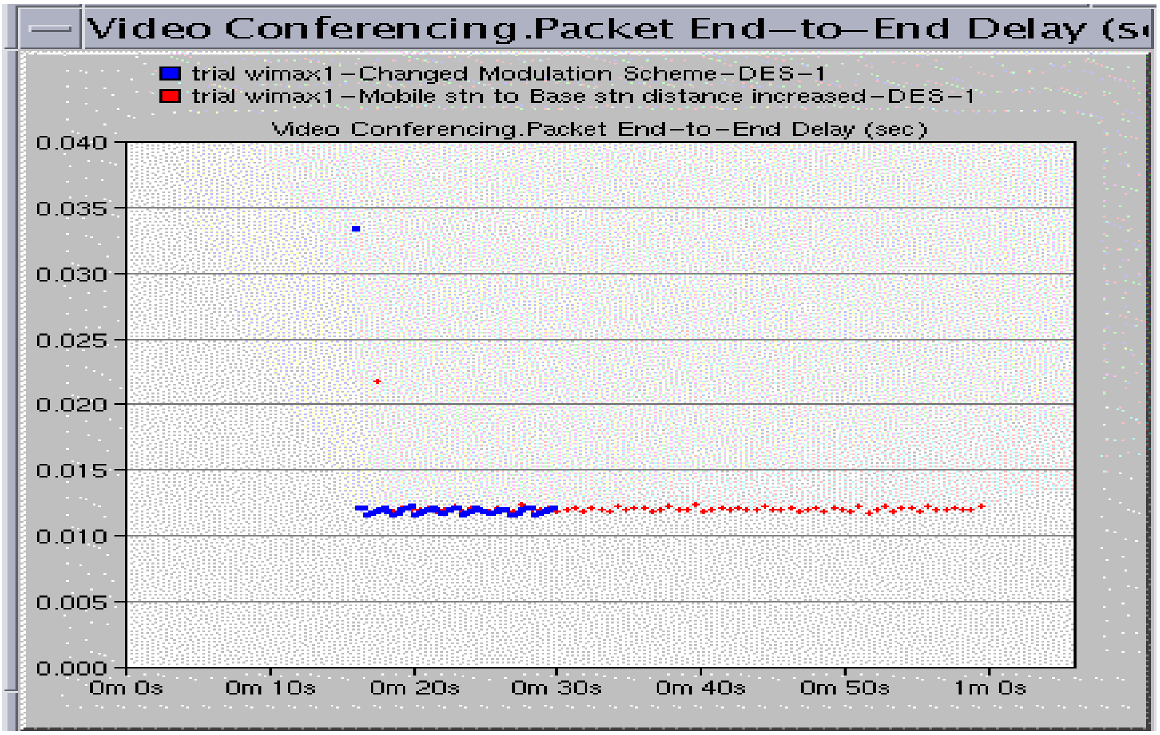


Figure 19: End-to-End Delay for QPSK 3/4

Next we compare the end-to-end delay for the remaining two scenarios where the modulation for the Mobile Station is set to QPSK-3/4 shown by blue curve and the case where the distance of the Mobile Station is increased to 30km from 1km and the modulation scheme is set to QPSK-3/4 shown by the red curve. As we increased the distance to about 30km, the other modulations failed to respond as we were did not obtain any simulation data for the other schemes except the QPSK. After setting the Uplink Data Flow attribute to QPSK-3/4 we observed that the two scenarios had the same delay. This shows us the robustness of the QPSK modulation scheme such that it mitigated the delay caused by such a large distance and gave the same delay as the scenario where we kept the distance of the Mobile Station to be 1km from the Base Station.

6.2 Packets Dropped:

This statistic represents the number of uplink packets dropped. This is also considered as a loss.

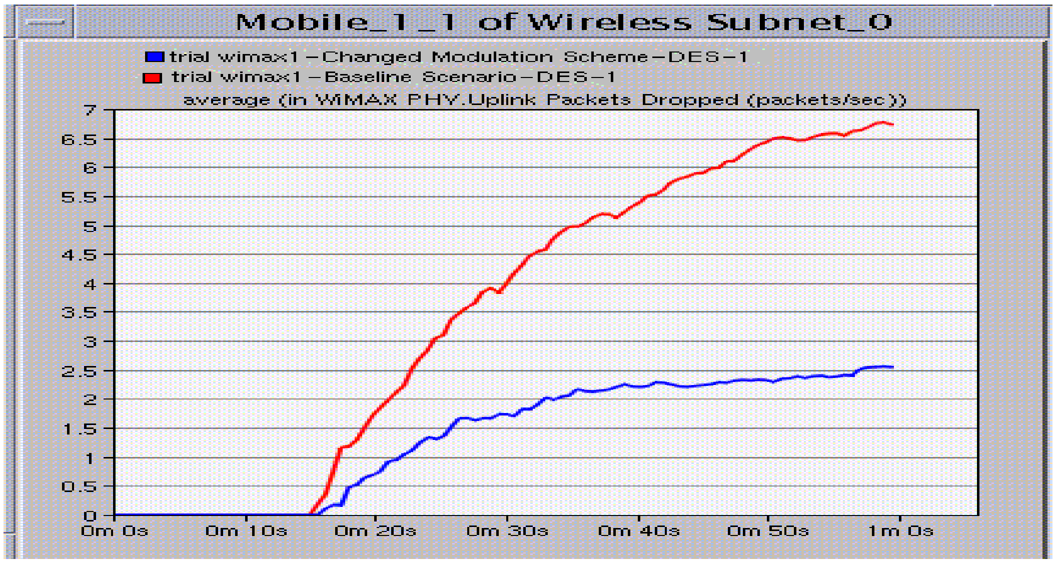


Figure 20: Uplink packets dropped with different modulation schemes

Here we have compared the scenario where we have set the modulation scheme for the uplink data flow to be QPSK to our baseline scenario without any change in any other attributes. As expected from theory, we observe that the QPSK modulation scheme being more robust has its effect on the number of packets dropped. This is shown by the blue line which depicts that the number of packets dropped for the QPSK uplink modulation scheme is less than the 64-QAM modulation scheme. The red curve however, shows that the number of packets dropped for the baseline scenario is fairly large as compared to the other scenario. This shows us the robust nature of the QPSK modulation as compared to the 64-QAM.

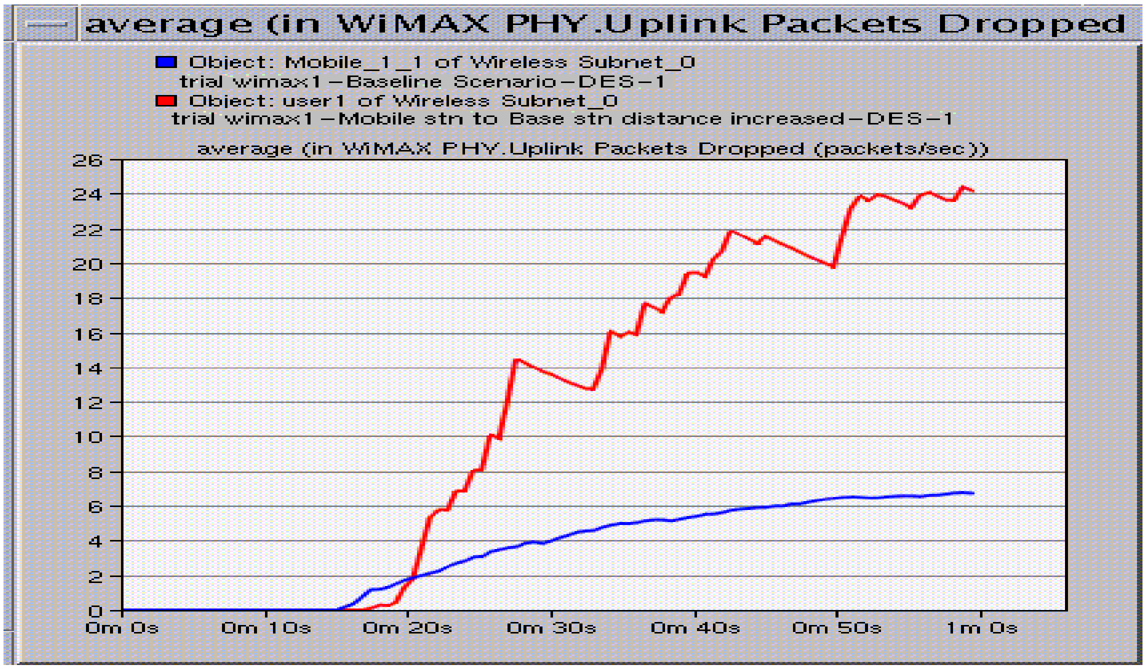


Figure 21: Uplink packets dropped as mobile station to base station distance increased

In the graph shown above we compared the number of packets dropped for the scenario where we increase the distance of the Mobile Station to 30kms from the Base Station and keep the modulation to be QPSK to our baseline scenario where we have 64-QAM as the modulation scheme. Here we observe unexpected results, as QPSK being more robust should compensate for the number of packets dropped as we increase distance. But we observed that QPSK fails to lower the number of packets dropped. The red line indicates that the number of packets dropped for the uplink is more than the number of packets for the baseline scenario having 64-QAM as the baseline scenario. And the blue line indicates that the number of packets dropped for the baseline scenario is fairly less as compared to the other scenario. Therefore, increasing the distance would result in greater packet loss no matter what modulation scheme is used.

6.3 Throughput:

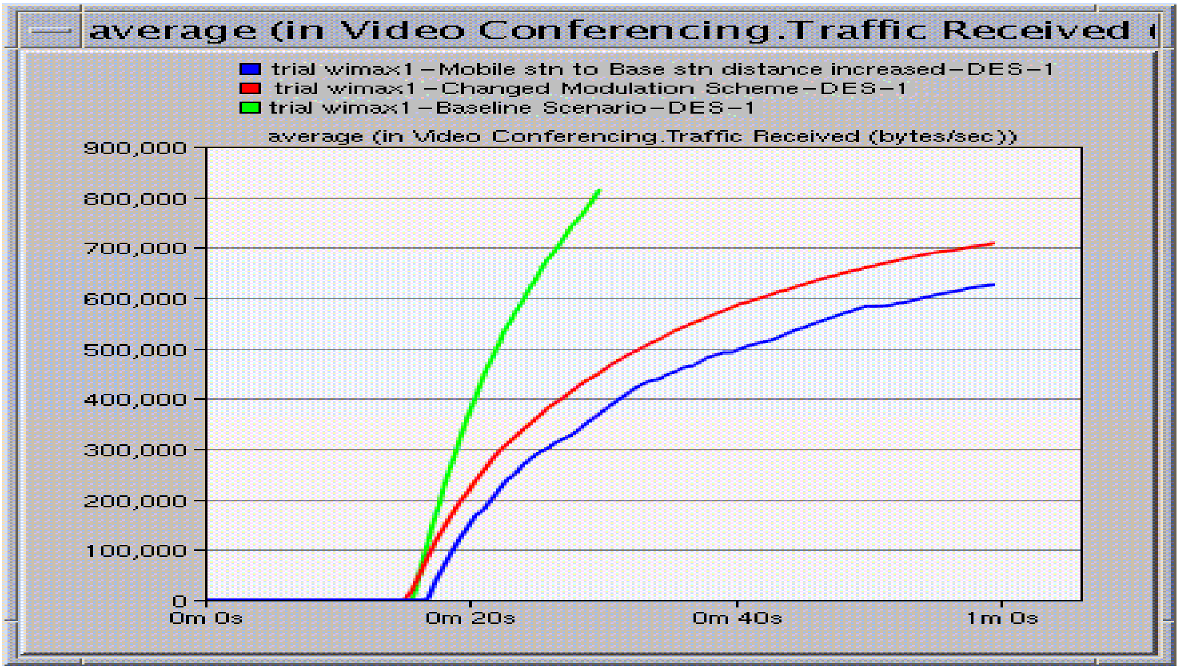


Figure 22: Throughput for all scenarios

We observe that the throughput for all our cases lies in the range required of 10kbps – 5Mbps [1]. This indicates that the throughput for the video surveillance is as expected. The green line is the baseline scenario with the throughput of 0.82Mbps whereas the modulation scheme for the same user is changed from 64-QAM to more robust QPSK this throughput decreases to 0.71Mbps as depicted by the red line. Last but not the least; the blue line depicts a further decrease in the throughput to about 0.61Mbps as the user is move 30kms away from the WiMAX base station and the QPSK uplink modulation scheme is used as opposed to 64-QAM.

6.4 Jitter:

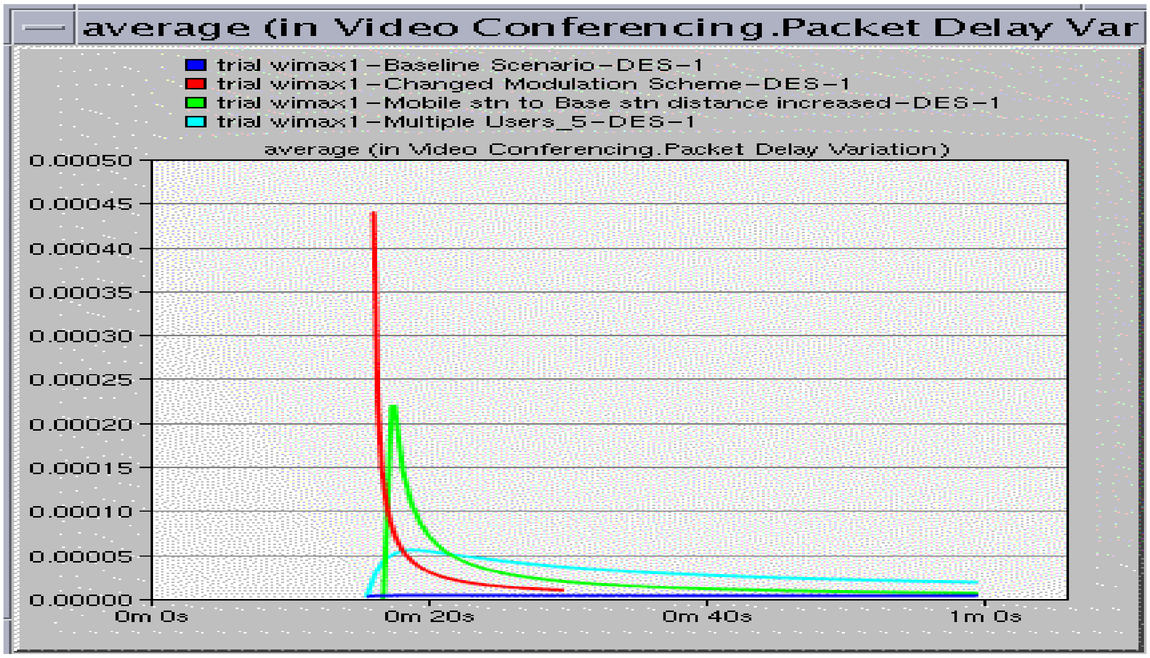


Figure 23: Packet Delay Variation for all scenarios

Jitter is defined as Packet Delay Variation for the video applications. The ideal jitter is less than 2ms [1]. In our case the average jitter value for baseline scenario is 0 as shown by the dark blue curve. The average jitter value for the scenario with multiple users (5) is shown by the light blue curve and is about 0.05ms. The green curve shows the average jitter value of about 0.22ms for the case where the distance of user from the base station is about 30kms and the uplink modulation scheme is QPSK. The red curve depicts the jitter value for of about 0.45ms for the scenario where the distance of the user from the base station is set to default of 1km and the uplink modulation scheme is QPSK. We can observe that the jitter value for all our scenarios is significantly less than the ideal value of 20ms which is considered as a robust statistic.

7. Difficulties and Future work

7.1 Difficulties

One of the major difficulties faced during the project was how to deploy video traffic from our video server to the work stations. Since most of the WiMAX projects carried out in the past has not adequately provided implementation details, a considerably amount of time was spent on deploying traffic. Consequently, we have provided comprehensive details of our topologies, implementing details and traffic deployment which can be used for future work regarding video surveillance applications.

Furthermore significant amount of time was spent on technical difficulties such as disk space issues, Remote login issues which were resolved by the end of the semester.

7.2 Future Work:

The future work on our project would involve further insight on the issue of packets dropped for our video surveillance application. These results in increasing the buffer size for the uplink to 1024kB and to check if the increased buffer size would mitigate the effects of the packets dropped. Since for our application the buffer size of 256kB was not enough to mitigate packet loss. Another scenario can include the terrain and the geographic topography and to see its effect on the video surveillance application in the WiMAX network. Having a mountainous terrain or a lot of barriers in the WiMAX network would include fine tuning of ARQ setting and hence would be a compromise between delay and packet loss. Therefore, including ARQ would be of great benefit in the analysis of any loss in signal.

Since this project was based on choosing video conferencing as the video traffic application (which was the only application that supported video), future work will involve in making a custom application for video surveillance which can closely resemble real time traffic. WiMAX enables mobile video monitoring which can be used authorities to monitor crimes scenes as well as individuals to monitor household security. Future work should focus on analyzing QoS of video surveillance over mobile WiMAX and the drawbacks of using mobile WiMAX.

8. Conclusion

This project analyzes the practicality of WiMAX for video surveillance by analyzing the Quality of Service (QoS) parameters namely throughput, end to end delay, jitter and packet loss. The wireless model was deployed through Opnet14 and simulations were analyzed for different scenarios. Thus all simulations were observed to be as expected for a video surveillance application.

It was observed that end to end delay was clearly affected by the number of users and their distance from the base station, presenting a higher end to end delay for higher number of users and as the base station to workstation distance increased. The role of the uplink modulation scheme was analyzed, by changing the uplink modulation scheme to QPSK ¾ and was observed that end to end delay remained the nearly the same as the distance increased, depicting robustness of the QPSK modulation scheme.

As the modulation changed to a higher scheme it was observed the uplink packets dropped decreased drastically and as the distance from mobile station to base station increased uplink packets dropped increased considerably. The throughput for all scenarios were viewed to lie between 10kbps – 5Mbps and the jitter for all scenarios were observed to be less than .5ms as expected for video surveillance application.

9. References

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10 List of Acronyms

WiMAX: Worldwide Interoperability for Microwave Access

TCP/IP: Transmission Control Protocol/Internet Protocol

MAC: Medium Access Control

QoS: Quality of Service

LoS: Line of Sight

NLoS: Non Line of Sight

QPSK: Quadrature Phase Shift Keying

QAM: Quadrature Amplitude Modulation

ToS: Type of Service

MAN: Metropolitan Area Network

OFDM: Orthogonal Frequency Division Multiplexing

IEEE: Institute of Electrical and Electronics Engineer

ertPS: extended real time Polling Service

rtPS: real time Polling Service

BE: Best Effort

UGS: Unsolicited Grant Service

nrtPS: non-real-time Polling Service