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DIMENSIONING MOBILE WIMAX NETWORK: A CASE STUDY

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ABSTRACT

WiMAX is a standard based on wireless technology that provides high throughput broadband connections over long distance. This technology can be used for numerous applications, including “last mile” broadband connections, hotspots and high-speed connectivity for business customers. This research paper has been conducted with cooperation with Palestinian’s Cellular Communication Co (Jawwal). The objective of this study is to propose an approach to design a network on the latest standard of WiMAX namely (IEEE 802.16e) in addition to apply network dimensioning and planning in Nablus city. In this paper a review of WiMAX technology and focusing on 802.16e standard is discussed, A design approach was developed to help network planner in their work, this approach was summarized in a simple flow chart. As a case study, a network based on this technology was designed for Nablus city. The number of subscriber was calculated for each district area and plotted in a clutter map. The Building Penetration Losses for each type of area were modeled using several measurements conducted as a part of this work. The design outcome such as number of base stations and there geographical locations and there corresponding distribution also stated.

Keywords: WiMax, GSM, mobile network.

INTRODUCTION

This paper outlines a mobile Wi-Max network planning and dimensioning process and consider Nablus city as a case study. Mobile network traffic is growing exponentially, and service providers must manage their networks efficiently to meet consumer demand. The technology evolution of radio access networks is limited by the laws of physics, and significant growth in radio frequency (RF) efficiency can no longer be expected. The spectrum available for mobile data applications is limited as being stated in[1]. In the recent years there has been a skyrocket rise in mobile data usage especially due to the large number of smartphones in use. This has led to a rigorous traffic overloading in cellular networks and the trend is expected to continue as stated in [2]. Applying of Wi-Max mobile Network to offload data has been considered as one of the immediate solutions.

In this work, we consider designing a mobile data network in Palestine that promises to bring a new experience to mobile broadband services by offering users high data rates and efficient network access techniques. It provide a design requirements and assumptions (e.g. service quality, link budgets, etc) that should be used for planning Wi-Max Mobile Network Couple; this network design process is outlined keeping in mind that Wi-Max network infrastructure will be stand alone in case if the cellular operators want to upgrade their existing 2.75G; GSM; network to 3G network, the Wi-Max network and infrastructure will work with 3G network in proper way and without much sophistications as being discussed in [3].

This work has two objectives. The first one is to investigate the end-to-end aspects of WiMAX network architecture, and provide a comparison with the existing broadband wireless technologies such as 3G and WiFi. The second objective is to gain an understanding of how to dimension a mobile WiMAX network in the access and core service network.

The access network comprises of the air interface aspects of WiMAX such as radio link budgets, antenna configurations, frequency reuse schemes and so on while the core service part provides the Internet Protocol (IP) connectivity and core network functions the challenges of WiMax has been stated in [4].

The challenge is to improve customer satisfaction with high quality Wi-MAX service, reduce churn, automatically connects mobile handset to the network using without user invention, capacity wholesale by reducing traffic on MNO’s (Mobile Network Operators), service continuity over Wi-MAX, and future location-based applications. Moreover satisfying customers by offering them high data rates and low cost.

LITERATURE REVIEW

Mobile service providers need a strategy to successfully handle mobile traffic demands so they can continue to deliver high-quality mobile experiences to subscribers, attract new customers, and retain happy ones. There are many existing solutions to alleviate the traffic load on cellular networks such as: offloading to femtocells, offloading to WiFi networks, Upgrade the existence infrastructure and Mobile Wi-MAX solution [5],[6].

In this section, we will discuss the related work and what solutions we have and which one is the best for satisfying our target.

Due to the fact that the Palestinian operators still work on GSM/GPRS, so upgrading the existent infrastructure to 3G may be consider as a solution, but this option also has its limitation and constraints. Here we state the possible solutions that have been investigated to cope

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the requirements both FEMTO CELLS and WiFi SOLUTION.

Femto cells [6] originally, the Femtocell technology (i.e., access point base stations) was proposed to offer better indoor voice and data services of cellular networks. Femtocells work on the same licensed spectrum as the macrocells of cellular networks and thus do not require special hardware support on mobile phones as shown in Figure-1. Moreover, customers may need to install short-range base stations in residential or small-business environment, for which they will provide Internet connections. Due to their small cell size, femtocells can lower transmission power and achieve higher signal-to-interference-plusnoise ratio (SINR), thus reducing the energy consumption of mobile phones. Cellular operators can reduce the traffic on their core networks when indoor users switch from macrocells to femtocells.

Even though femtocells offer savings in site lease, backhaul and electricity costs for the operator, they incur strategic investments. Operators will need to aggressively price femtocells despite tight budgets and high manufacturing costs.

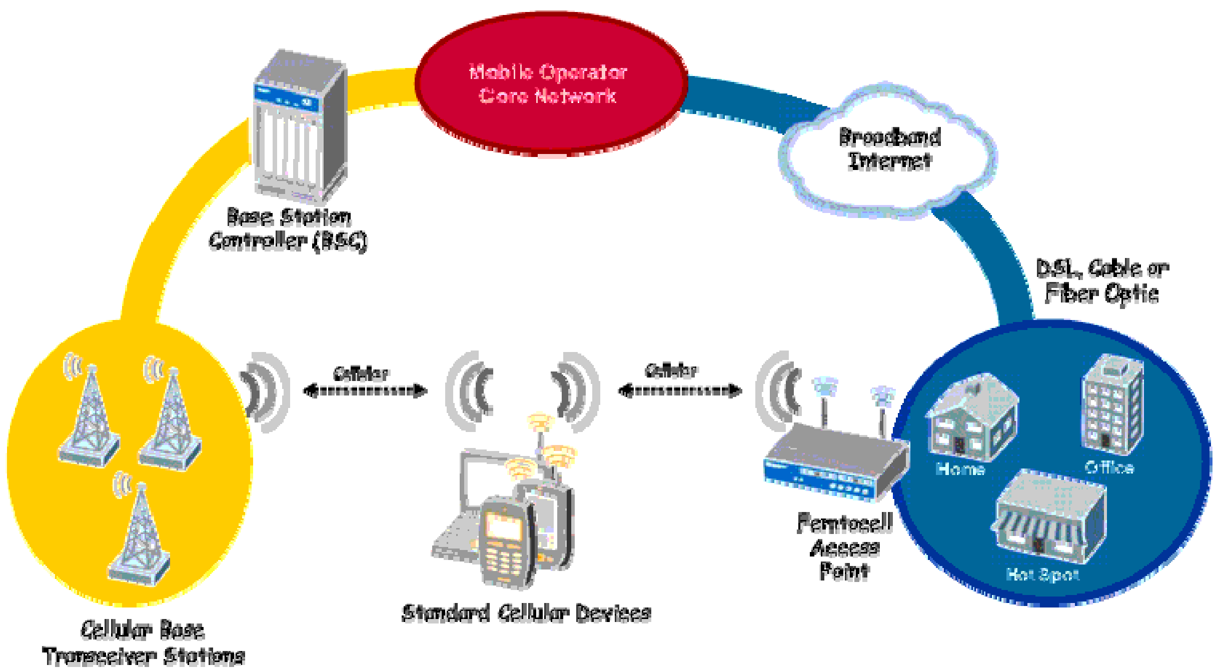

Figure-1. Femtocell access to the core mobile network via broadband internet.

WiFi solution[7]Compared to femtocells, WiFi networks work on the unlicensed frequency bands and thus cause no interference with GSM/GPRS/3G or 4G cellular networks, but it also used unlicensed spectrum which usually used by many other equipment and the interference will be very high in outdoor deployment. Moreover the rang of Wi-Fi is too short in compare with Wi-MAX network. From this point and because Femto cell solution relay on licensed spectrum that's used by existing infrastructures it's expected to have a very high interference and it also usually used for indoor solution, thus it is recommended for the Palestinian network operators to implement this option of Wi-MAX Mobile network in metropolitan cities to successfully handle mobile traffic demands so they can continue to deliver high-quality mobile experiences to subscribers, attract new customers, and retain happy ones.

Candidate technologies

This section presents the comparison of WiMAX with the other broadband wireless technologies, and it can be said that WiMAX offers significant advantages when it comes to deployment. For a given region selected for the deployment, WiMAX allows an operator to select a channel bandwidth from 1.25MHz to 20MHz. This gives the operator some flexibility during the deployment also can select the appropriate channel bandwidth to serve the targeted market segment. Since the target for a broadband wireless technology is to offer high data rates, WiMAX is a better choice for that purpose than 3G and WiFi, as it relies on OFDM and OFDMA technologies. Although WiFi also relies on OFDM technology, it has mobility limitaions.

WiMAX technology incorporated MIMO techniques during its initial design phase, providing it with higher spectral efficiency than 3G [8] systems. 3G systems are implementing MIMO techniques in phases leading into

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low spectral efficiency. For a multicellular deployment, OFDM physical layer technology used by WiMAX gives it an advantage toexploit frequency and multiuser diversity to improve capacity.

When it comes to select the right technology for the broadband wireless access, WiMAX has the potential to become the cost effective technology for the operators who lack 3G infrastructure but can obtain access to either 2.5GHz or 3.5GHz spectrum. WiMAX also provides cost efficient wireless extension to areas without the DSL or wireless infrastructure. For 3GPP operators with limited spectrum, it offers the possibility to provide an alternative broadband wireless access.

Compared to WiFi, WiMAX provides symmetrical bandwidth over a considerable distance with much stronger encryption and less interference. WiMAX spectrum applies over a wide range of the radio frequency (RF) spectrum. On the other hand, for operators with existing GSM and WCDMA technologies, HSPA-LTE is a promising choice as it can be easily integrated with existing radio networks, core networks, networks operations and subscription management. Therefore, HSPA-LTE offers GSM-WCDMA network an evolution path towards the provision of broadband wireless services.

Comparison of broadband wireless networks

WiMax vs. WiFi

The major notable difference between WiFi and WiMAX networks is the coverage area. While WiFi covers a region of up to 300 metres, WiMAX can cover the region of up to 48 kms under NLOS and LOS conditions. Therefore, when it turns to covering large metropolitan area, WiFi network requires an operator to deploy more number of base stations than WiMAX network. This means that it is more costly using WiFi network to provide broadband wireless services that spans over a large area. WiFi network was designed and optimized for indoor use and short range coverage while WiMAX network is designed and optimised for long range coverage and outdoor usage. WiFi serves local area networks whereas WiMAX serves metropolitan area networks (MAN).

WiFi supports fewer users per base station, typically one to ten users with a fixed channel size of 20MHz per base station. WiMAX on the other hand supports one to five hundred users per base station with variable channel size of 1.5MHz to 20MHz WiMAX uses both licensed and unlicensed spectrum whereas WiFi uses only unlicensed spectrum. Operating in the licensed band means WiMAX has the ability to cover long distances and support more number of users by using sub-channelisation. The WiMAX architecture consists of base stations that process requests to send or receive data from terminals, performs access control and allocates the required radio resources to meet the requests that are accepted. In terms of security, WiMAX as opposed to WiFi, is designed with strong security mechanisms in mind with layer upon layer for authentication, authorisation and accounting in place [4], [7].

WiMAX defines a privacy sub-layer at the lower edge of the media access control sublayer of TCP/IP to handle encryption of packets and key management. WiMAX has typically less interference while WiFi suffers from interference in metropolitan areas where there are many users. WiFi access is highly contended and has a poor upload speed between the router and Internet while WiMAX provides connectivity between network endpoints without the need for the direct line of sight. The detailed comparison is stated in Table-1.

Table-1. Comparison matrix WiMax vs. WiFi.

Feature	**WiMax (**802.16a**)**	**Wi-Fi (**802.11b**)**	**Wi-Fi(**802.11a/g**)**
Primary Application	Broadband Wireless Access	Wireless LAN	Wireless LAN
Frequency Band	Licensed/Unlicensed 2 G to 11 GHz	2.4 GHz ISM	2.4 GHz ISM (g) 5 GHz U-NII (a)
Channel Bandwidth	Adjustable 1.25 M to 20 MHz	25 MHz	20 MHz
Half/Full Duplex	Full	Half	Half
Radio Technology	OFDM (256-channels)	Direct Sequence Spread Spectrum	OFDM (64-channels)
Bandwidth Efficiency	<=5 bps/Hz	<=0.44 bps/Hz	<=2.7 bps/Hz
Modulation	BPSK, QPSK, 16-, 64-, 256-QAM	QPSK	BPSK, QPSK, 16-, 64-QAM
Mobility	Mobile WiMax (802.16e)	In development	In development

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Access Protocol	Request/Grant	CSMA/CA	CSMA/CA

- **WiMax Vs. 3G and HSPA**

WiMAX and 3G technologies were initially designed to serve different sectors of the mobile telephone market. This trend will change in the coming years, and both technologies will converge to provide almost the same set of capabilities and services. WiMAX provides high data rates (up to 72Mbps) but provides less mobility. On the other hand, 3G provides smaller data rates (from 384kbps to 3Mbps) than WiMAX but provides users with seamless mobility using existing and evolved cellular mobility protocols and handover mechanisms [9].

Another notable key difference between WiMAX and 3G is the fact that 3G technologies such as HSPA have been the evolution of the existing GSM technology that only require software upgrade, while for the case of WiMAX the whole network has to be built from scratch. The fact that WiMAX requires green field implementation has a consequence on time and cost when deploying the network as compared to the 3G network [10]. 3G systems have fixed channel bandwidth while WiMAX has scalable channel bandwidth from 1.25MHz to 20MHz that allows for a very flexible deployment and high throughput capabilities. Table-5.1 compares the WiMAX and 3G based upon the indicated performance metrics.

General WiMax network planning process

Planning of a wireless network usually involves a number of steps that are essential for a successful business case. The first step is to define the geographic area where the service is expected to be offered. Key metrics to specify for the geographic area are population density, number of households, and number of small and medium businesses. The terrain type also needs to be specified. In order to ensure smooth signal propagation over the wireless networks, flat or moderately hilly terrain is preferred.

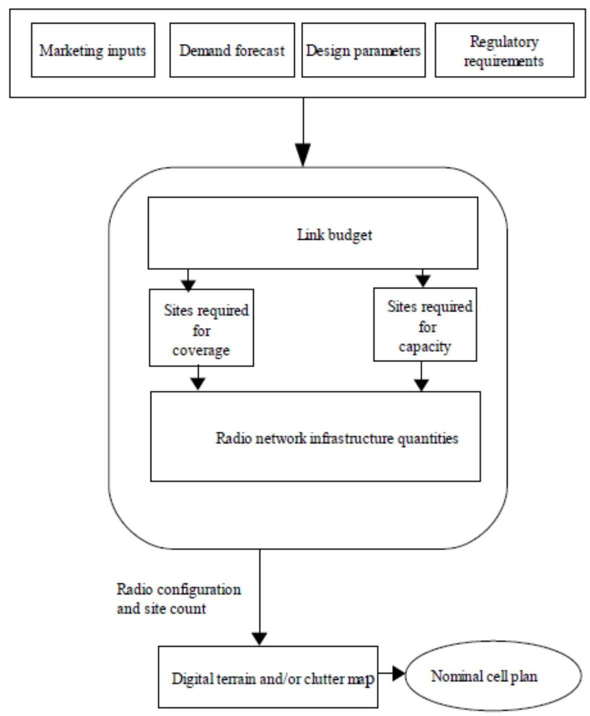
The next step is to determine the spectrum and bandwidth to be used. From the available frequency bands (2.5GHz and 3.5GHz), the selection of either of the frequency band determines the total bandwidth achievable. Depending upon the frequency band chosen, one can decide whether to use channel bandwidth of 1.25MHz, 1.75MHz, 3.5MHz, 5MHz,
8.75MHz, 10MHz, 14MHz or 20MHz.

The step that follows involves determining the technological parameters to calculate range and capacity. Parameters of interest include link budget, spectral efficiency, and antenna configurations (SISO, SIMO, MIMO), frequency reuse factor, which altogether control the coverage area per cell site and the total number of cell sites or base stations needed to cover the desired geography.

In order to achieve end-to-end connectivity, the next step is to dimension and plan the elements that form the core service network. Since WiMAX is an IP- based technology, this involves dimensioning and planning of ASN elements; ASN-GWs and BSs, as well as CSN elements (AAA servers, DHCP/DNS servers, HA, and so on). The choice of ASN and CSN elements and how to configure them is made based upon the type of service that is to be offered, market segment, the available spectrum and topography of the area as reflected in the earlier sections.

Quality of service is another important aspect when planning a mobile Wi-MAX network. This determines the level of service that users will experience when they access the network for voice, data or multimedia communication. Wi-MAX network planning follows the flow of activities as presented in Figure-2.

Table-2. Network dimensioning and planning process.



n order to minimize the interference in Wi-MAX system, there is a need for a careful RF planning. A potential source of interference in Wi-MAX system is the loss in frame synchronization between the base stations using the same channels or when the UL-DL ratio in a TDD system is different for each BS. Wi-MAX supports channel reuse frequency factor of one for operators that have limited amount of spectrum. For a WiMAX system, the downlink coverage is easier to plan than uplink. This is due to the fact that in the downlink, the interference originates from the same location, that is, from aneighboring base station transmitting on the same channel. In network planning, the operator makes assumptions on the data rate, sectorisation, frequency reuse plan, and type of cell (pico, micro or macro cells) to be deployed. The operator also predicts how users will use the services.

Case study

This paper work assumes WiMax deployment in Nablus city with cooperation with Palestinian's Cellular Communication Co (Jawwal). The region classified as dense-urban, urban, suburban and rural areas based on the population density, land area as well as on the scale of existing infrastructure. Based on the total land area of the metropolitan, we determine the number of base stations needed for coverage. From the population of each region, we provide an estimate of the expected number customers and their data density requirements. The number of base stations and the data density required form the key elements in planning end- to-end mobile Wi-MAX network.

Dimensioning WiMAX radio interface

This section presents the dimensioning of the radio network part of the network. Parameters that are considered include estimation of the traffic expectations, population density in the area of deployment, spectrum allocation, link budget analysis, antenna configurations, and frequency reuse scheme. The main outcome out of the dimensioning phase is to come up with an estimate of the number of base stations required to cover a given area, to determine the requirements for the coverage, capacity and quality of service, and to estimate the supported traffic volume per base station.

Table-3. Characteristics of demographic regions, Nablus city.

Characteristic	Area km square
Dens-urban	0.554
Urban	20.77
Sub-urban	6.963
Rural	0.019

Table-3 shows the expected number of customers. The expected number of customers is obtained under the assumption that 45% percent of the subscribers with Jawwal Company are going to subscribe for the service. 50% of them in the dense area, 30% in the urban area, 15% in the suburban area and 5% in the rural area. This is based on the reasoning that customers evolve over time, and in the initial phase, the number of customers is small.

Number of subscribers with Jawwal is around 150000 subscribers. By referring to Table-4 we can see that the total number of expected customers in the first phase is 45000.

Table-4. Expected number of customers.

Metropolitan region.	% of customers in the region.	Expected number of customers.
Dens-urban	50%	22500
Urban	30%	13500
Suburban	15%	6750
Rural	5%	2250

Frequency selection

Link budget analysis

A link budget is the sum of the loss and gain of the signal strength as it travels through different components down the path from the transmitter to the receiver. The link budget allows determining the required transmit power that is able to overcome losses in the transmission medium so that the receive power is adequate for the reception of the signal.

As a result of the link budget, the receive power is sufficiently greater than the noise power, and the targeted bit error rate can be achieved. The link budget determines the theoretical maximum cell radius of each base station and comprises of two types of components [11], the lisnk budget resukts are stated in Table-5:

Required BS: Coverage Deployment:

The Wi-MAX base station is the key network element in connecting the core network to the end user; it determines the coverage of the network and defines the end-user experience. The link budget analysis as presented in the previous section results into determining the cell radius, R, of the base station. Based on the cell radius, we determine the coverage area of a single base station. The coverage area of a single base station leads into determining the total number of base stations required to cover a particular region in a given metropolitan area.

Approximately 30 base stations are needed to cover Nablus city region over the land areas of around 28 square kilometers. Table-6 made using excel sheet to calculate the expected number of base stations required for coverage deployment.

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Table-5. Link budget.

Parameter	Mobile handheld in outdoor scenario		Notes
	Downlink	Uplink	
Power amplifier output power	46.0 dB	24.0 dB	A1
Number of transmit antennas (assuming 2×2 MIMO Base stations)	2	2	A2
Transmit antenna gain	18 dBi	0 dBi	A3
Transmitter losses	3.0 dB	0 dB	A4
Effective isotropic radiated power	61.3 dBm	24.3 dBm	A5 = A1 + $10log_{10}$(A2) + A3 - A4
Channel bandwidth	10MHz	10MHz	A6
Number of subchannels	30	35	A7
Receiver noise level	-104 dBm	-104 dBm	A8 = -174 + $10log_{10}$(A6×1e6)
Receiver noise figure	8 dB	4 dB	A9
Required SNR	0.8 dB	1.8 dB	A10
Subchannelisation gain	0 dB	12 dB	A11 = $10log_{10}$(A7)
Receiver sensitivity (dBm)	-95.2	-110.2	A13 = A8 + A9 + A10 -A11
Receiver antenna gain	0 dBi	18 dBi	A14
System gain	156.5 dB	152.5 dB	A15 = A5 – A13 + A14
Shadow-fade margin	10 dB	10 dB	A16
Building penetration loss	0 dB	0 dB	A17
Link margin	146.5 dB	142.5 dB	A18 = A15 – A16 - A17
Cell radius	Table 7.6		Assuming COST-231 Hata urban model

Required BS: Capacity deployment

On basis of the earlier findings, we can now find how many base stations we need to meet the capacity requirements. Number of subscribers with Jawwal Company in Nablus city is around 15000 subscribers depending on JAWWAL HLR database. Table-7 shows for the capacity deployment around 35 sites is required. Where the required number of sites is the summation of all required sites for DL and UL in each area and also the number of sites in each area is the outcome of the division of the site throughput and required users data density in that area.

Frequency reuse scheme

Frequency planning for the Wi-MAX network involves the use of two common frequency reuse schemes that are available for multi-cellular deployment with 3-sectored base stations. These are the frequency reuse of 1 (universal frequency reuse), denoted as (1,1,3), where all the sectors in a base station use the same channel, and frequency reuse of 3, denoted as (1,3,3) whereby a channel is used only one of every three sectors in a base station. The nomenclature for naming the frequency reuse patterns is (c,n,s) where c stands for the number of base stations, n the number of channels and s the number of sectors per base station site.

With the frequency reuse plan of 3 then each sector is allocated a single 10MHz TDD channel. The overall capacity for (1,1,3) reuse pattern is higher than (1,3,3) reuse pattern since each sector is allocated three channels as opposed to one channel in the case of (1,3,3) reuse. Based on the overall capacity and cost-effectiveness, a universal frequency reuse is preferred for this case study. The frequency reuse of 1 enables better utilization of the assumed spectrum as well as the increase in capacity.

Table-6. Number of BS: coverage deployment.

Characteristic	Area km	Bs for DL	Bs for UL	Bs DL &UL
Dense area	0.554	1	1	2
Urban area	20.77	8	13	21
Suburban area	6.936	2	3	5
Rural area	0.019	1	1	2
Overall Bs required	30			

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Table-7. Number of BS: capacity deployment.

Nablus population	150000		User Profile Kbps per user 5MB/h =		
First Stage (40%)	45000		11.11	Kbps	
Characteristic	Percentage	Subscribers	Users data density kbps	Cell throughputs DL Kbps	Cell throughputs UL Kbps
Dense	50%	22500	249975	25000	6700
Urban	30%	13500	149985	25000	6700
Suburban	15%	6750	74992.5	25000	6700
Rural	5%	2250	24997.5	9000	6700
	Site DL throughputs	Site UL throughputs	# Site DL	# Site UL	# Site
	75000	20100	4	13	17
	75000	20100	2	8	10
	75000	20100	1	4	5
	27000	20100	1	2	3
				#BS for Capacity	35

Frequency reuse distance

Cellular network planning requires that cells using the same frequency be separated by the frequency reuse distance D in order to achieve tolerable signal to interference plus noise ratio. For the frequency reuse distance, D, the following relationship holds: $D = R\sqrt{3N}$ Where *R* is the radius of the cell, and *N* is the number of cells per cluster. This equation is based on the assumption that the cells are hexagons, are equally sized and the same frequency reuse pattern is used for all the cells the universal frequency reuse factor is deployed for all the region of deployment. The frequency reuse distances for the regions of dens, urban, suburban and rural are as indicated in Table-8. With frequency reuse of 1. Where frequency reuse of 1 results into an increase in spectrum efficiency because for a given distance the given frequency can be reused more number of times than in the case of frequency reuse of 3.

Table-8. Frequency reuse.

Region	Cell radius [km]	Reuse distance [km]
Dens-urban	1.18	2.04
Urban	1.18	2.04
Suburban	1.44	2.49
Rural	1.41	2.44

Duplexing method

WiMAX technology uses two types of duplexing methods to separate downlink and uplink transmission and communication of signals. These are TDD and FDD duplexing schemes. TDD uses the same frequency for both downlink and uplink transmission, but the transmission occurs at different time slots. FDD on the other hand uses different pair of frequencies for the downlink and uplink transmission.

For the deployment of mobile Wi-MAX in Nablus city TDD scheme is selected as a duplexing method (10MHz bandwidth channel). Since services offered by mobile Wi-MAX are data centric, typical of Internet access services, this means that the downlink traffic dominates as compared to the uplink traffic. With these types of services, TDD is a suitable duplexing method since it allows the operator to define the percentage of bandwidth to be allocated for both the downlink and uplink. Since TDD method supports downlink to uplink ratio of 1:1 to 3:1, it is expected that the subscribers are bound to experience up to 50 percent increase in downlink data throughput when 3:1 ratio is used in a 10MHz channel [12].

This is because with 3:1 TDD scheme a shared channel is used three quarter of the time for downlink and one quarter of the time for the uplink. Selecting a 10MHz TDD channel for the regions achieves efficient usage of the limited spectrum while at the same time offering the expected quality of service for the mobile Wi-MAX service. Figure-2 shows the gains achieved for 1:1 versus 3:1 downlink to uplink ratio when TDD method is used with various antenna configurations. This justifies the selection of TDD as a duplexing method for the regions.

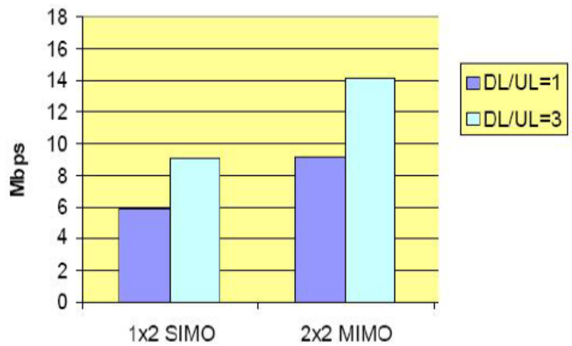

Figure-2. Downlink throughput for TDD with 10MHz channel bandwidth.

Network design

In earlier sections, we show that the required sites for this study are 35 sites, now we have to make a site survey and choose the proper place to install the network equipment to achieve our assumption about data rate and throughput. If there are existence infrastructures then it is better to use these sites and towers to decrease the investment cost. Nablus contains many sites owned by Jawwal Company, and then by using Google earth to locate the coordinates of available sites, Figure 3 shows a portion of Nablus map using Google earth.

Figure-3. Sites in Nablus map based on Google earth.

coordinates of sites that we choose. We concern upon sites having exsictance infrastructure or near to it in order to

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lower the initial investment and we choose the road and high places in order to give the best propagation as shown in Figure-4.

Site	Latitude	Longitude
1	32°13'17.70"N	35°15'42.62"E
2	32°13'34.55"N	35°15'20.23"E
3	32°13'45.85"N	35°15'12.99"E
4	32°13'45.25"N	35°14'59.01"E
5	32°13'55.89"N	35°14'29.22"E
6	32°13'34.97"N	35°14'12.82"E
7	32°13'50.01"N	35°13'56.93"E
8	32°13'5.73"N	35°16'6.87"E
9	32°13'39.81"N	35°12'52.72"E
10	32°13'45.32"N	35°13'19.12"E
11	32°13'20.52"N	35°14'9.01"E
12	32°13'27.01"N	35°14'30.97"E
13	32°13'5.92"N	35°14'29.33"E
14	32°13'40.51"N	35°13'21.92"E
15	32°13'58.69"N	35°14'15.76"E
16	31°59'0.70"N	35°53'24.22"E
17	31°59'15.60"N	35°53'45.67"E
18	31°59'44.90"N	35°53'6.23"E
19	31°59'27.66"N	35°52'5.96"E
20	31°59'38.88"N	35°51'34.14"E
21	31°59'48.55"N	35°50'30.20"E
23	32°13'5.29"N	35°16'14.76"E
24	32°12'35.80"N	35°15'50.86"E
25	32°12'28.86"N	35°14'55.24"E
26	32°15'20.08"N	35°10'42.43"E
27	32°16'15.88"N	35° 8'4.55"E
28	32°15'30.49"N	35° 7'37.24"E
29	32°12'15.35"N	35° 6'53.27"E
30	32°12'8.25"N	35° 7'59.37"E
31	32°11'20.77"N	35° 8'8.82"E
32	32°10'31.71"N	35° 7'38.40"E
33	32°12'44.74"N	35°15'36.07"E
34	32°12'39.26"N	35°16'44.79"E
35	32°12'23.99"N	35°18'0.57"E

Figure-4. Sites coordinates.

By using the RF planning tool that in order to simulate the network and see if our work satisfies the capacity and coverage requirements or a modification has to be done before deploy the network.

Figure-5 shows the DL data rate, while Figure-6 shows the best server signal strength.

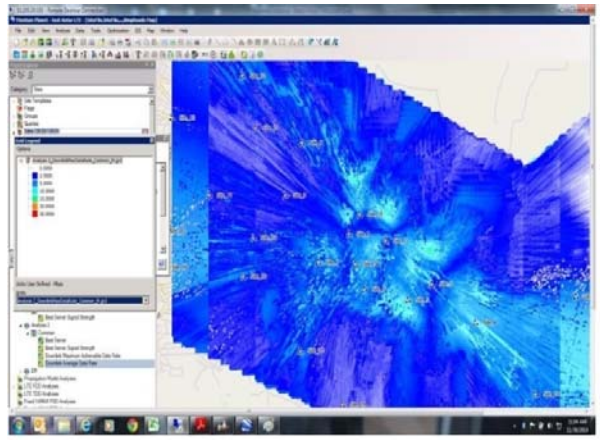

Figure-5. DL data rate.

Figure-6 shows the best server signal strength, which is also, assume to be acceptable.

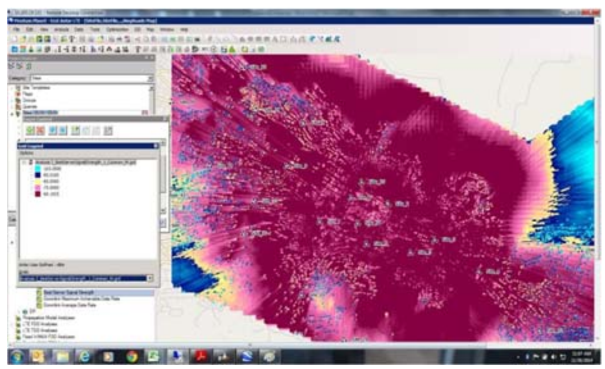

Figure-6. Best server SS.

CONCLUSIONS

Despite the advantages that Wi-Max technology offers during deployment, it requires careful dimensioning and eventually planning in the access and core part of the network so that the estimated downlink data density requirements are fulfilled. Aspects of the access network such as link budget calculation, antenna configurations and frequency reuse schemes, need to be carefully performed. The study showed that by optimizing the link budget parameters such as the number of transmitting antennas and number of sub-channels both for the uplink and downlink, the cell radius is increased leading to few number of base stations. This translates to significant cost savings as base station infrastructure costs amount to a high value on the overall end-to-end investment. Using the universal frequency reuse scheme ensures an effective use of the available spectrum but sacrifices the cell edge performance.

The study showed that, when deploying a mobile Wi-Max network in a low density area such as rural, 1 × 2 SIMO scheme is a good choice. With this scheme, the resulting cell radius leads to fewer base stations needed than in the case of 2 × 2 MIMO scheme. It is also observed that 1 × 2 SIMO and 2 × 2 MIMO schemes are good choices for range limited deployment and as such can be used to get ubiquitous coverage over the metropolitan area. Although 2 × 2 MIMO scheme in dens, urban and suburban resulted into fewer base stations than other regions in such a densely packed environment, upgrades to the base stations configurations with adaptive beamforming technique can help meet the capacity requirement. From the ASN QoS point of view, we observed that mobile Wi-Max provides an operator the flexibility in choosing the QoS model that can suit the type of services that he expects to offer. This allows the operator to deliver the broadband service with an acceptable quality as agreed on the service level agreement.

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