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Research Paper

Optimize Transmission of Image over Integrated Mobile WiMAX and WiLAN Network

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Abstract

The problem of multiuser downlink resource allocation in Mobile WiMAX system was studied. Three different network scenarios considered for the transmission of image data. Resource allocation is done using Active Set Optimization and Genetic Algorithm, for all the three network scenarios. Simulation results show that information fed back and association among subcarriers play vital role to improve system performance. As compared to reduced complexity, resource allocation using Active Set Optimization and Genetic Algorithm seems especially attractive as the number of users increases for Image Data. It is observed through simulation that the System using Genetic Algorithm performs better than Active Set. Linear Resource Allocation in terms of significantly decreasing the computational complexity and achieve higher capacities, while being applicable to a more general class of systems. As Genetic Algorithm follows constraints of Stochastic processes it didn't give results highest in all Experiment Conducted. It is also observed that for Integer-Binary Objective function Performance of Genetic Algorithm is not that much satisfied because of its stochastic processing. Also processing time required to reach final optimize variables values is too much.

Keywords: *Integrated Mobile WiMAX, resource allocation, Genetic Algorithm, Active-Set optimization.*

1. Introduction

The problem of multiuser downlink resource allocation in Mobile WiMAX system was studied in last semester. Simulation results showed that information fed back and association among subcarriers play vital role to improve system performance. As compared to reduced complexity resource allocation Active Set Optimization and Genetic Algorithm seems especially attractive as the number of users increases. It is observed through simulation that the System using Genetic Algorithm performs better than Active Set, Linear Resource Allocation and Root Finding in terms of significantly decreasing the computational complexity and achieve higher capacities, while being applicable to a more general class of systems. As Genetic Algorithm follows constraints of Stochastic processes it didn't give results highest in all Experiment Conducted. It is also observed that for Integer-Binary Objective function Performance of Genetic Algorithm is not that much satisfied because of its stochastic processing. Also processing time required to reach final optimize variables values is too much.

As in WiMAX latency period is too important because Base Station have to allot the resources in short span of time to its active users, GA fails to reach Optimize variables value within that period and took too much time. So we came to the conclusion that for such type of Networks Active-Set Optimization is best suited instead of Genetic Algorithm though the fitness functions value is greater than the results obtained by Active-Set Optimization Technique. Some related signal processing techniques are presented in [9]-[13].

2. Bitmap packet formations

Step 1: Input Image with 256 X 256 size used for Transmission using 100 Subcarriers with 64 QAM symbol size is 8 Bits hence (256*256=65536) symbols required to transmit our Image.

Table 1: Properties of image

Sr. No.	Attribute	Value
1	File Name	Antenna256.bmp
2	Mode	Grayscale
3	Resolution / size (Pixel)	256 X 256
4	Depth	8 Bit
6	Compression	RLE

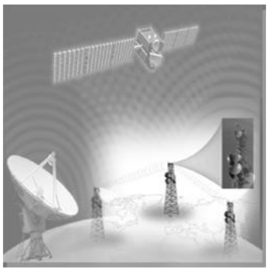

Fig. 1: Image for experiment resolution

Total Number of Symbols for Total 100 Subcarriers
$= \frac{65536}{100} = 655.36$
Total Number of Frames required to transmit 656 Symbol Data
$= \frac{655.36}{48} = 13.65$
Hence 13.65 ≈ 14 Frames required to Transmit above mentioned Image. If channel is good then time required to Transmit above Image for our Experiment is:
64KB=256*256*8bits=524288Bits = 14 * 5ms = 70 ms
524288 Bits transmitted in 70ms hence within 1 Sec we can transmit 7489828.5 bits.
Bits per with Bandwidth Requirement is = 100(Subcarriers) * 10.94 KHz (subcarriers Spacing) =1094 KHz = 1.094 MHz.
Means,

Table 2: Data rate for three modulation schemes

Time Required to transmit	No. of Frames Required	Band width	Transmitted Bits	Transmitted Bits (KB)
1Sec	14	1.094 MHz	7489828.5	914.2857KB => 9.14MB
Capacity for(64QAM)	6.84 Bits/Sec/Hz			
QPSK	55	1.094 MHz	1906501.8	232.7KB
Capacity	1.74 Bits/Sec/Hz			
16QAM	28	1.094 MHz	3744914.2	457.14KB
Capacity	3.423 Bits/Sec/Hz			

Step 2: Sample Image Matrix
For simplicity we consider 8 x 8 Image, after reading image file we get Matrix in MATLAB with ASCII values in between 0 to 255. E.g. 144 Represents value of first pixels value of Inputted Image.

144	154	160	164	159	159	153	150
182	189	193	196	194	193	183	181
216	222	226	231	113	222	213	200
139	111	125	122	109	83	69	48
16	57	71	116	119	111	15	54
38	71	37	90	96	86	92	51
40	36	11	49	41	44	4	60
26	3	28	27	27	57	2	10

Step 3: Conversion of Base for QPSK:
For QPSK we have to change its base from 8 bit to 2 bits per symbol after changing Base of Inputted Image we can calculate following Matrix for 1st row only:

144	**154**	**160**	**164**	**159**	**159**	**153**	**150**
0	**2**	0	0	3	3	1	2
0	**2**	0	1	3	3	2	1
1	**1**	2	2	1	1	1	1
2	**2**	2	2	2	2	2	2

Step 4: Data Mapping (Data on 100 Subcarriers)

Sub Carrier number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
	0	0	1	2	2	2	1	2	0
	3	3	2	1	1	3	3	1	2
	3	2	0	0	1	0	3	0	1

Sub Carrier number→	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
	0	2	2	0	1	2	2	3	3
	2	3	1	1	3	2	1	3	0
	2	2	0	0	3	2	0	0	1

Step 5: DPSK data table

2	1	4	2	4	1	1	1	1	1	4	4	1
2	1	1	4	2	3	2	3	1	1	2	2	1
1	4	3	1	3	2	1	4	3	3	1	3	2
4	2	3	1	4	2	4	4	4	1	3	3	2

4	4	2	3	4	2	1	2	1	2	3	2
1	2	4	2	3	3	3	1	4	3	1	3
4	4	1	1	3	4	4	2	1	3	2	3
3	2	1	1	4	4	4	2	4	2	2	1

Step 6: Apply output from Step 5 to IFFT to achieve time domain wave

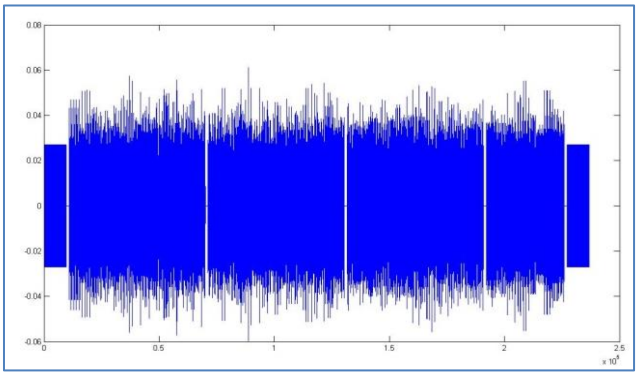

Fig. 2: Time Domain Representation of Frame of 5ms

3. Simulation experiment–1

3.1. Single User Scenario

Aims:

1. Vary Image size by keeping SINR constant and Measure Quality of Received Image.
2. Change Modulation Scheme and Measure SNR.

3. Change Modulation Scheme for Appropriate SNR Range.

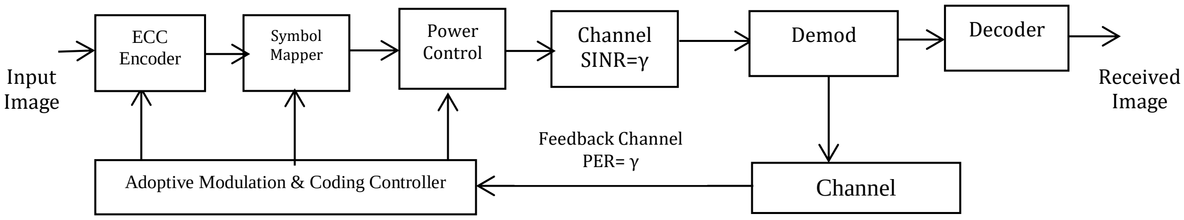

Fig. 3: Single user scenario

Table 3: Parameters considered

Sr. No.	Parameter		Value
1	IFFT size		1024
2	Data Subcarrirers		720
3	Guard Subcarriers		184
4	Pilot Subcarriers		120
5	Cyclic Prefix		1/8
4	Symbol Size	BPSK	1
		QPSK	2
		16QAM	4
		64QAM	6
5	Symbol Per Frame for 5ms Duration		48
6	Channel Bandwidth		10MHz
7	Subcarrier frequency spacing		10.94KHz
8	Symbol Time		91.4μs
9	Guard time assuming (12.5%)		11.4 μs
10	OFDM Symbol Duration		102.9 μs

A block diagram of system is given in Fig. 3. For simplicity, we first consider a single-user system attempting to transmit as quickly as possible through a channel with a variable SINR—for example, due to fading. The goal of the transmitter is to transmit data from its queue as rapidly as possible, subject to the data being demodulated and decoded reliably at the receiver. Feedback is critical for adaptive modulation and coding: The transmitter needs to know the "channel SINR γ, which is defined as the received SINR γr divided by the transmit power Pt, which itself is usually a function of. The received SINR is thus γr= γ. Pt.

WiMAX systems use adaptive modulation and coding in order to take advantage of fluctuations in the channel. The basic idea is quite simple: Transmit as high a data rate as possible when the channel is good, and transmit at a lower rate when the channel is poor, in order to avoid excessive dropped packets. Lower data rates are achieved by using a small constellation, such as QPSK, and low-rate error-correcting codes, such as rate convolutional or turbo codes. The higher data rates are achieved with large constellations, such as 64 QAM, and less robust error correcting codes; for example, rate convolutional, turbo, or LDPC codes. In all, 52 configurations of modulation order and coding types and rates are possible, although most implementations of WiMAX offer only a fraction of these. These configurations are referred to as burst profiles.

Following table shows Received Images for various SNR with QPSK modulation on 100 Subcarriers. As SNR increases Received Quality of Image improves. We found that above SNR=7 image's received SNR reaches to Infinity.

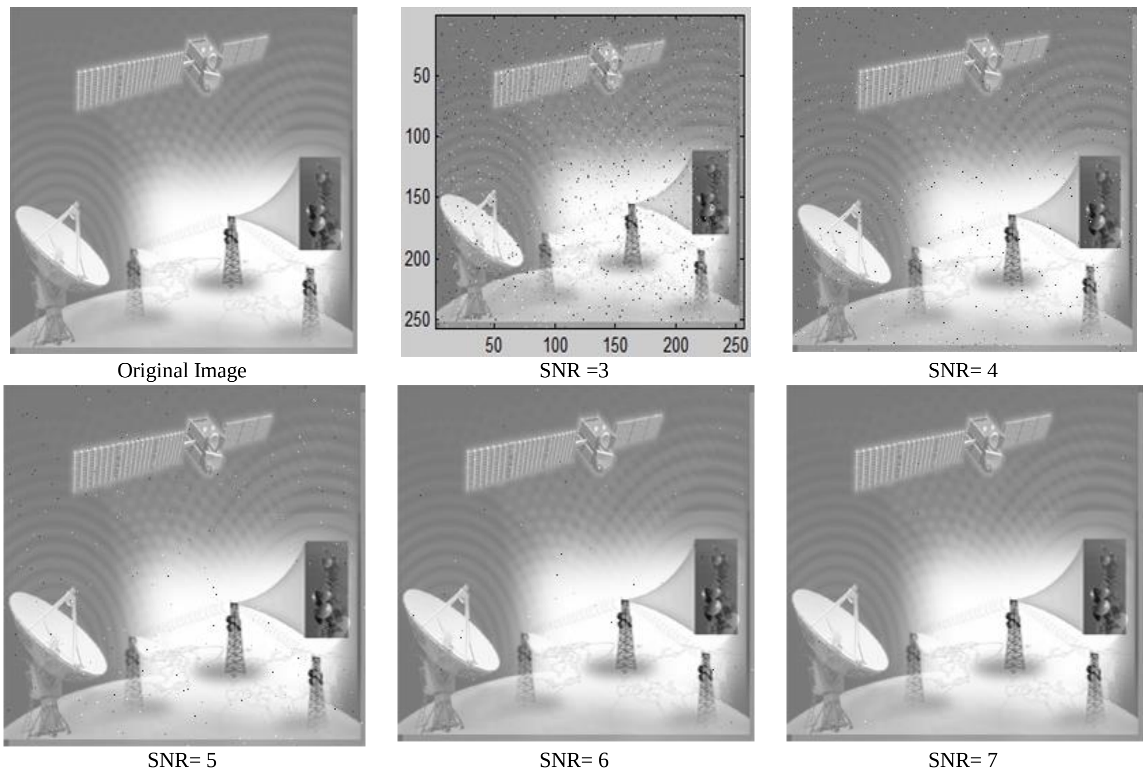

Fig.4: Images received using QPSK on 100 Subcarriers for SNR>3 and SNR<7

Similarly we carried out same experiment for 16QAM modulation scheme for different SNR. Following table shows Image Quality for different SNR for the same parameters set as above.

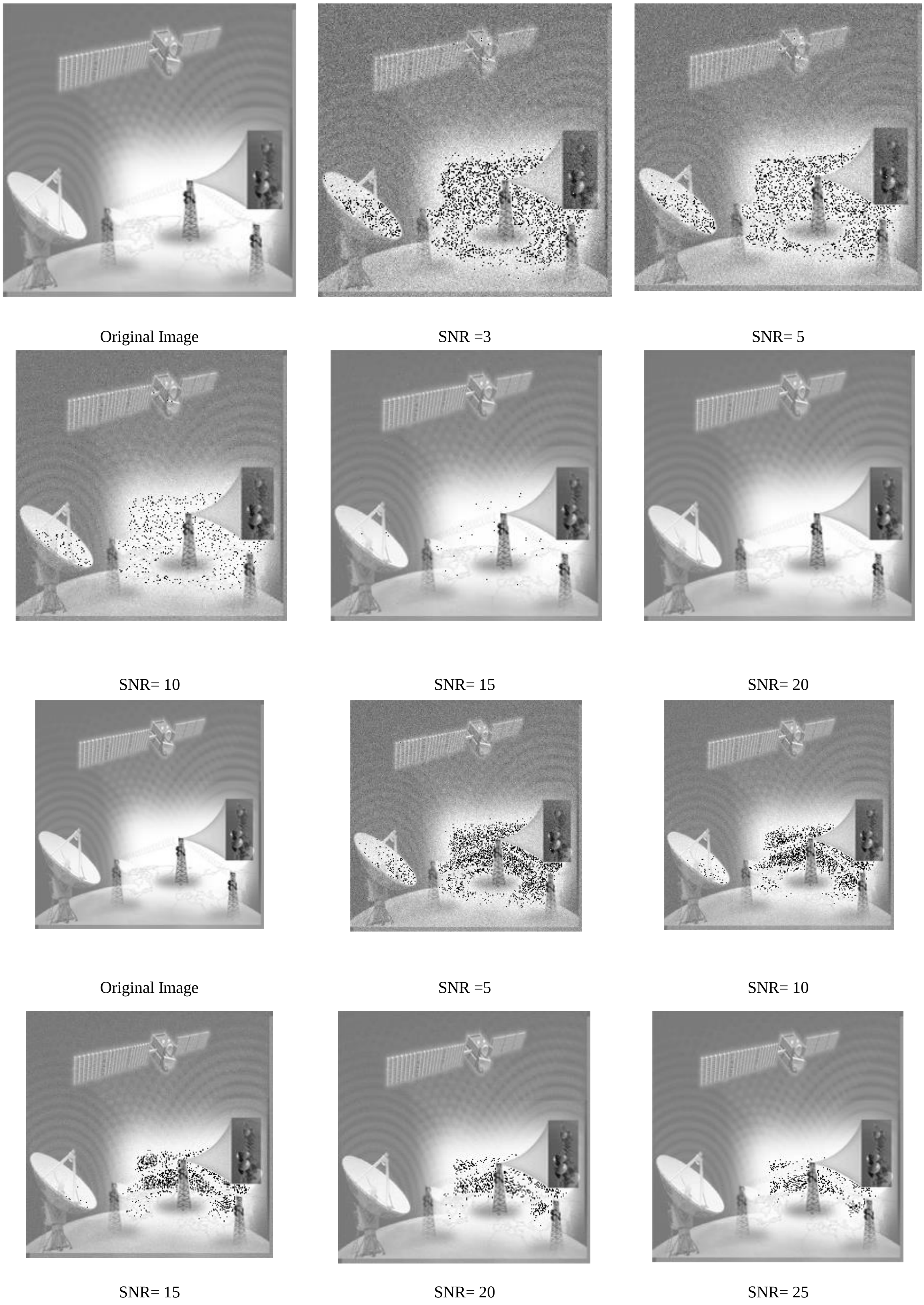

Fig. 5: Images received using 16 and 64 QAM on 100 subcarriers for SNR>3 and SNR<25

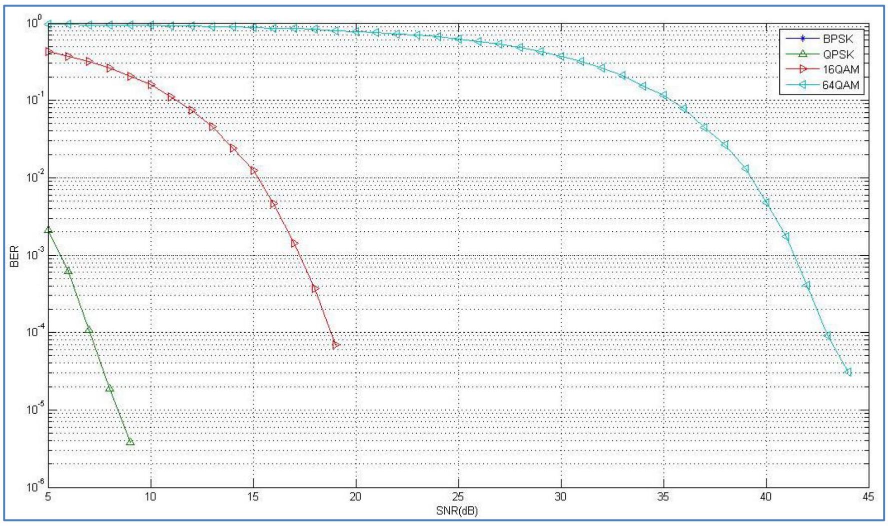

Fig. 6: BER versus SNR for various modulation schemes

3.2. Policy for AMC controller:

A key challenge in AMC is to efficiently control three quantities at once: transmit power, transmit rate (constellation), and the coding rate. This corresponds to developing an appropriate policy for the AMC controller. Although reasonable guidelines can be developed from a theoretical study of adaptive modulation, in practice, the system engineer needs to develop and fine-tune the algorithm, based on extensive simulations, since performance depends on many factors. There are a number of ways to take advantage of multiuser diversity and adaptive modulation in OFDMA systems. Algorithms that take advantage of these gains are not specified by the WiMAX standard, and all WiMAX developers are free to develop their own innovative procedures.

3.3. Ideal distance for various burst profiles

Table 4: Ideal distance for various modulation schemes

Modulation Scheme	Recommended Distance(km)
64QAM ¾	0.2
64QAM 2/3	0.4
16QAM	0.7
QPSK	0.7 to 1.5

4. Simulation experiment–2

4.1. Two users' scenario

In this experiment we add one more active user on the network. Both users see channel differently also their QoS requirement is different. Base Station sense QoS for each user and allot Subcarriers and available Transmit Power. Following Table shows details of parameters set for both Users.

Table 5: Two users scenario

Parameter Setting	User 1	User 2
SNR	5	30
Modulation	QPSK	64QAM
Word Size	2	6
Subchannels Allotted	96/24➔4	192/24➔8
Power Allocation	0.1/3➔0.033	0.2/3➔0.067
Ifft size	1024	1024

4.2. Results: Bit error rate versus channel allotted

In this experiment, we use 24 subcarriers to represent one Subchannel. For User 1 Subchannel allocation is 4, means information transmitted to User 1 is over 96 Subcarriers, Similarly for User 2, 192 Subcarriers allotted for 8 Subchannels. Total Transmit Power assumed is 0.1; here we scaled down 20W of power to 0.1 and accordingly calculations are done. Also it is assumed that User 2 is having more QoS requirement as compared to User 1 hence obviously more power allocation to that User.

Table 6: BER per user versus subchannels allotted

	USER 1 (BER)			USER 2 (BER)	
Sub channel s Allotted	Proportio-nal Resource	Active Set Optimizat ion	Sub channels Allotted	Proportion al Resource	Active Set Optimizat ion
4	0.001541	0.001782	8	0.25577	0.25418
5	0.004921	0.004993	9	0.28238	0.28703
6	0.010654	0.010464	10	0.31012	0.30769
7	0.018578	0.018608	11	0.33356	0.32907
8	0.027546	0.02747	12	0.34923	0.34642
10	0.050415	0.050671	15	0.40385	0.40227
12	0.07476	0.075645	17	0.43161	0.42813

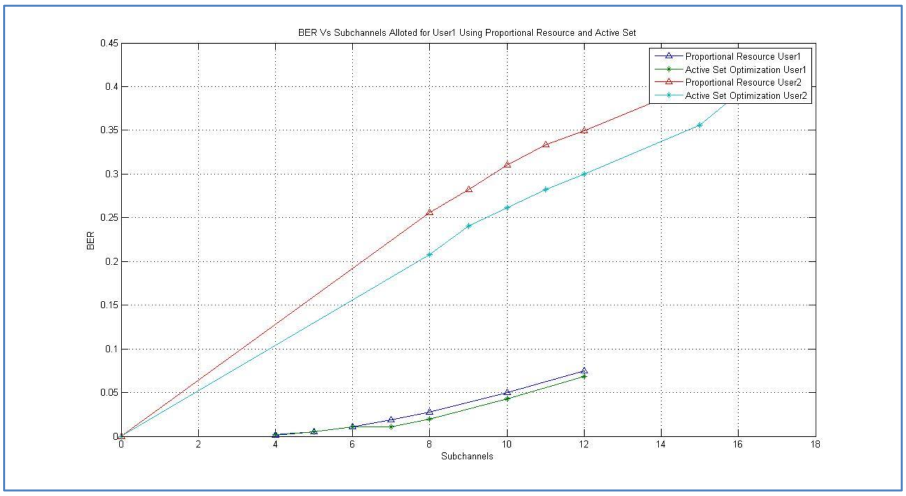

Fig.7: Bit error rate versus subchannels Allotted for both users using PR and AS algorithms.

Table 7: RMS phase error versus subchannels allotted

	USER 1 (RMS Phase Error)			USER 2 (RMS Phase Error)	
Subchannels Allotted	Proportional Resource	Active Set Optimization	Subchannels Allotted	Proportional Resource	Active Set Optimization
4	14.0121	14.0531	8	0.61995	0.61841
5	15.7029	15.783	9	0.65205	0.65947
6	17.3645	17.3386	10	0.6926	0.68753
7	18.84	18.838	11	0.72696	0.72147
8	20.1903	20.1713	12	0.75373	0.748
10	22.8855	22.9309	15	0.84279	0.84362
12	25.3447	25.4312	17	0.89581	0.89031

Fig. 7 shows results of Bit Error Rate Versus Number of Subchannels allotted for both users using Proportional Resource and Active Set Optimization. It's seen from fig. 7 as Number of Subchannels increases Bit Error Rate is also Increases. This is because here we keeping channel parameters constant. If channel is poor and Base station in going to increase Subchannels then obviously it will affect Information bits and tends to increase Errors per packet per frame. Hence we suggest that in poor channel conditions Base Station should allot fewer subchannels with burst profile like QPSK so that Reliability of Information transmission would increase with compromising constraint on Bit Rate or Spectral Efficiency. It's also observed that BER is less using Active Set Optimization as compared to proportional resource. This is only because of Constraints fulfilled by Active Set Optimization to provide more power on Received Effective Subchannel SNR as compared to Proportional Resource.

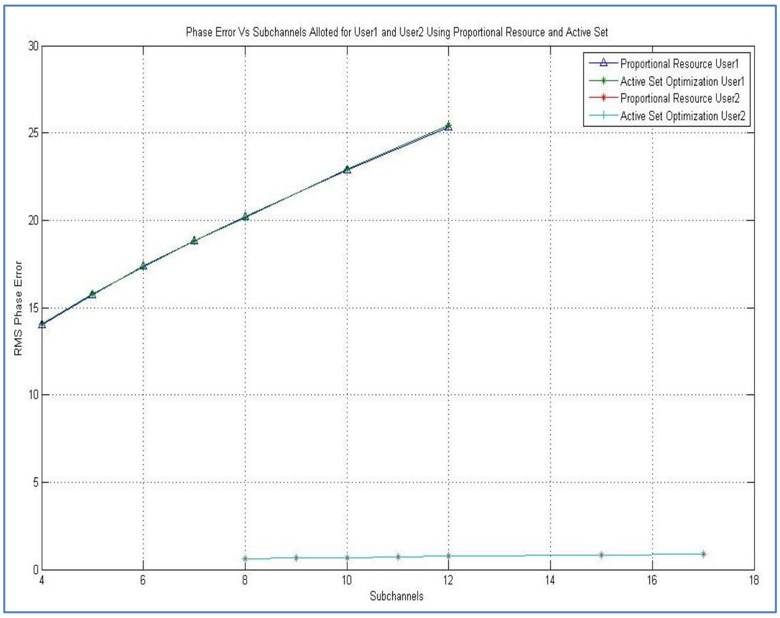

Fig. 8: Subchannels versus RMS phase error

Fig. 8 Shows graph of Subchannels allotted per user Versus RMS Phase error using Active Set Optimization and Proportional Resource Algorithm. It is observed that there is slight change in RMS Phase error in the Received Signal for Both the algorithms. Also RMS Phase error is very low for 64 QAM Modulation scheme but it is too large for QPSK modulation scheme. Also RMS Phase error recorded using Active Set Optimization is slightly less than Proportional Resource Algorithm.

4.3. Normalize Euclidian distance

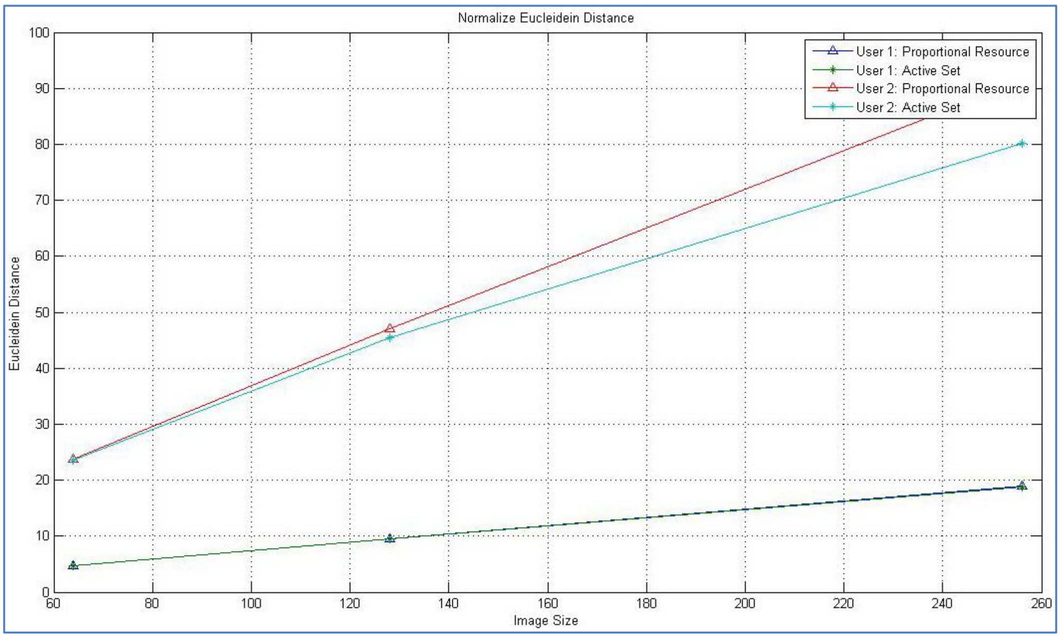

Fig. 9: Euclidian distance versus image size

$$Euclidian\ distance = \frac{\sqrt{OriginalImage(i,j)^2 - ReceivedImage(i,j)^2}}{\sum_{i,j=1}^{imax,jmax} \sqrt{OriginalImage(i,j)^2}}$$

Table 8: Euclidian distance for received image for both users

Normalize Euclidian Distance			
User 1 [SNR=5] [Subchannels: 4]		User2 [SNR=30] [Subchannels: 16]	
Proportional Resource	Active Set Optimization	Proportional Resource	Active Set Optimization
4.6942	4.6942	23.7446	23.6589
9.451	9.4497	47.1168	45.401
18.896	18.8034	91.4451	80.1199

For Poor, Average and Moderate Channel Conditions, Active Set Optimization Performs better than Proportional Resource. For Good channel Conditions Both Provide Similar Results as compared to Euclidian Distance. But Capacity achieved is More Using Active Set Optimization. From Fig.11 we can conclude that as per Quality of Received Image using Active-Set Optimization is good as compared to Proportional Resource. Hence reliability of Transmitted Bits increases while Using Active Set Optimization rather than Proportional Resource Algorithm.

5. Simulation experiment-3

5.1. System Model

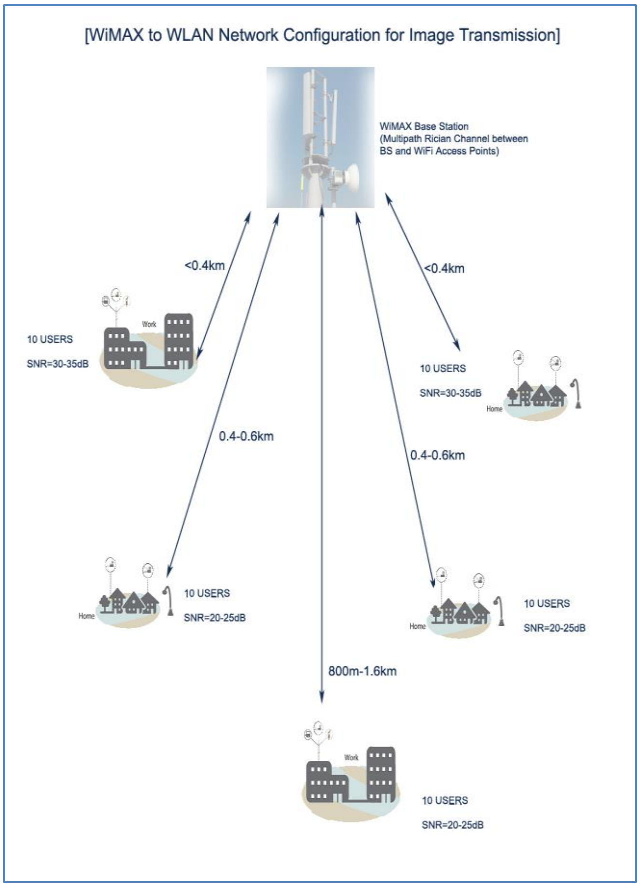

Fig. 10: WiMAX-WLAN network scenario

Fig. 10 shows system model where one WiMAX Base Station providing Service to five Wireless Local Area Network. It is assumed that each Wireless Local Area Network comprised of 10 Users with different QoS requirement. Also Each WLAN is situated at various distances from Main WiMAX Base Station. With respect to distance and QoS requirement WiMAX Base Station allot different number of Subchannels to those WLAN also Power Allocation is also done by Base Station. Within this network we integrate our Three Algorithms i.e. Proportional Resource, Active-Set Optimization and Genetic Algorithm.

5.2. Network Parameters

Following table shows Parameters Considered for Simulation for WiMAX and WLAN networks.

Table 8: WiMAX parameters considered

Sr.No.	Parameter		Value
1	IFFT size		1024
2	Data Subcarrirers		720
3	Guard Subcarriers		184
4	Pilot Subcarriers		120
5	Cyclic Prefix		1/8
4	Symbol Size	BPSK	1
		QPSK	2
		16QAM	4
		64QAM	6
5	Symbol Per Frame for 5ms Duration		48
6	Channel Bandwidth		10MHz
7	Subcarrier frequency spacing		10.94KHz
8	Symbol Time		91.4μs
9	Guard time assuming (12.5%)		11.4 μs
10	OFDM Symbol Duration		102.9 Ms

Table 9: Wireless LAN parameters considered

Sr. No.	Parameter		Value
1	IFFT size		1024
2	Number of Users		10
3	Modulation	64QAM	6
4	Channel Bandwidth		20MHz
5	Number of Spatial Streams		1

It is assumed that, WLAN network 1 is situated at longer distance i.e. in between 800m-1.6km, WLAN Network 2 and 4 are situated above 400m and below 800m and WLAN Network 3 and 5 are situated below 400m distance. Hence after sensing their distance and QoS requirement WiMAX Base Station decides to allot highest QoS Resources for WLAN Network 2 and 4 with 64QAM , for WLAN 1 and 3 Base Station provides burst profile with 16 QAM and for WLAN Network 1 Base Station uses Burst Profile with QPSK.

5.3. Results : Individual capacity of the network

Table 10: Capacity of the network

Network	Modulation	Capacity(bits/Sec/Hz)
WiFi1	QPSK	3.5149
WiFi2	16QAM	5.5997
WiFi3	64QAM	6.7133
WiFi4	16QAM	5.8042
WiFi5	64QAM	7.8808

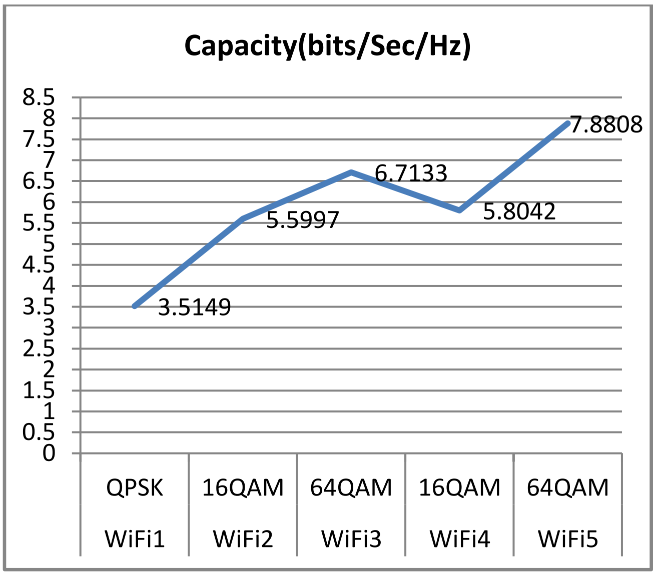

Fig. 11: Individual WLAN network capacity

Fig. 11 shows Individual WLAN capacity, it is quite obvious that for 64QAM, capacity or bit rate is more as compared to 16QAM and QPSK modulation schemes. Hence WLAN nearer to Base Station receives more data rates and WLAN at distant places receives data at lower rates. Also to combat BER Base station use robust modulation schemes for Remote WLAN so that data reliably travel through channel.

5.4. Individual Channel Capacity for WLAN

Table 11: Individual capacity for WLAN

		Capacity(bits/Sec/Hz)	
Network	Modulation	Proportional Resource	Active Set Optimization
WiFi1	QPSK	3.5149	3.6003
WiFi2	16QAM	5.5997	10.7364
WiFi3	64QAM	6.7133	26.0336
WiFi4	16QAM	5.8042	11.5842
WiFi5	64QAM	7.8808	27.1639

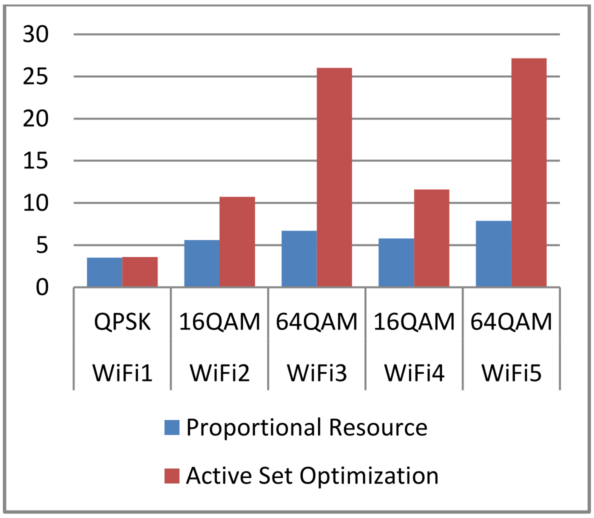

Fig. 12: Individual Network Capacity for PR and AS Algorithms

Fig. 12 Shows bar chart for Channel Capacity for Individual WLAN as it is seen, capacity achieved for each WLAN is more in case of Active Set Optimization. This is only because of more power allocation for higher priority allocation for WLAN 3 and WLAN 5. Moderate power is been allotted to WiFi2 and WiFi4 hence capacity achieved for them is less than WiFi3 and WiFi5 but more than WiFi1.

5.5. Overall channel capacity

Simulation is performed using the same parameters used as for Proportional Resource and Active Set algorithm. Experiment is conducted only for 50 users under 5 WLAN. From the results it is been observed that capacity is maximum for WiMAX system using Active Set Optimization. Capacity is increases as number of WLAN increases on the network this is because of Multiuser Diversity Gain.

Table 12: Overall capacity

		Capacity(bits/Sec/Hz)	
Network	Modulation	Proportional Resource	Active Set Optimization
WiFi1	QPSK	3.5149	3.6003
WiFi2	16QAM	4.5573	7.16835
WiFi3	64QAM	5.2759	13.45676667
WiFi4	16QAM	5.408025	12.988625
WiFi5	64QAM	5.90258	15.82368

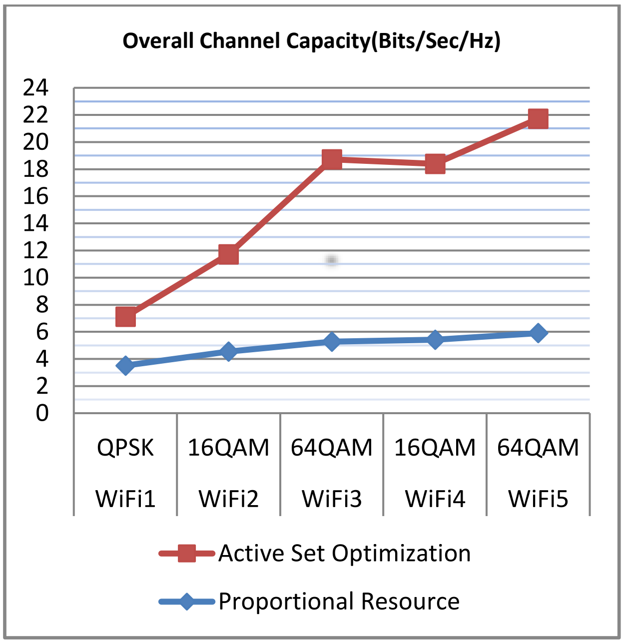

Fig.13: Overall channel capacity achieved using PR & AS Algorithms

5.6. Bit error rate for various WLAN only for proportional resource

Fig.14 shows BER for various WLAN for proportional resource scheme.

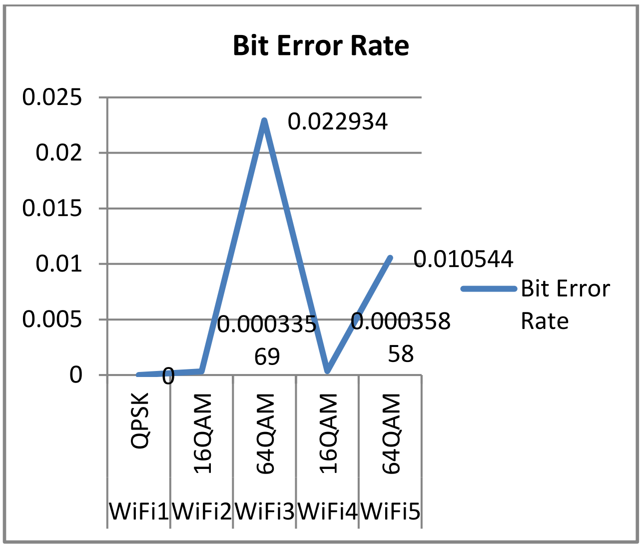

Fig. 14: BER for individual WLAN networks

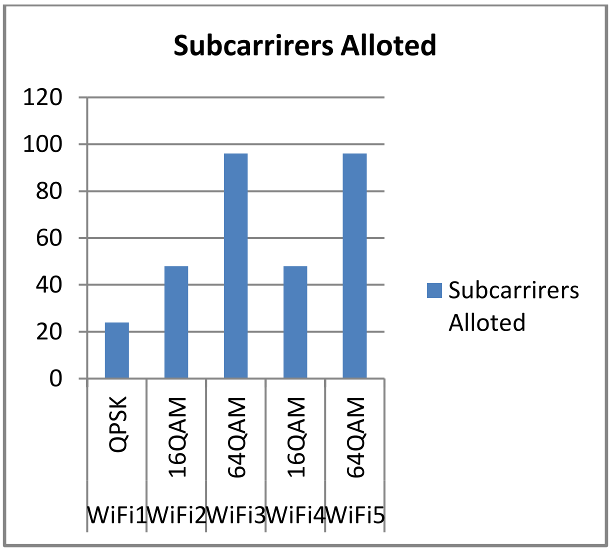

Fig. 15: Subcarrier allocation scheme adopted by WiMAX base station

5.7. Number of errors in received symbols

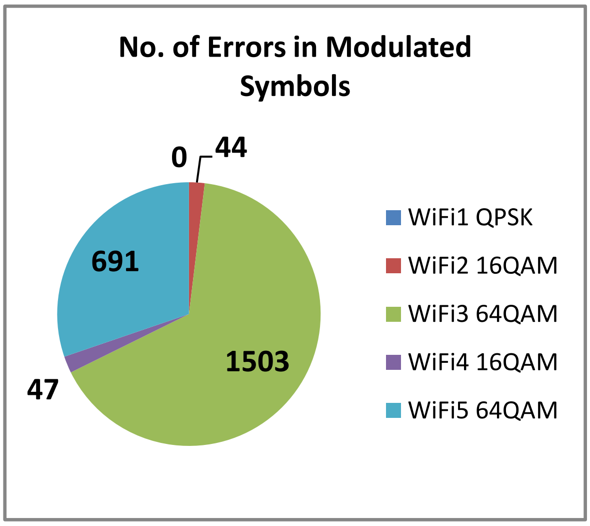

Fig. 16: Number of errors in received modulated words for various WLAN

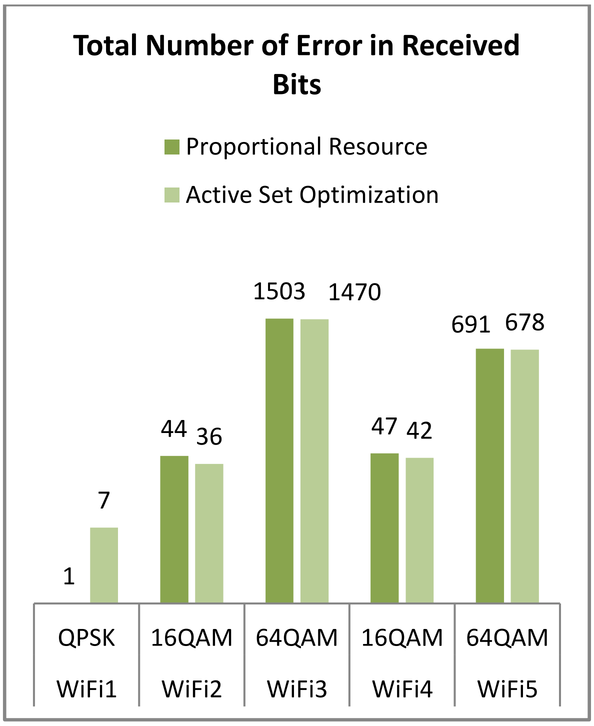

Fig.17: Number of errors in received symbols using PR and AS algorithms

6. Conclusion

The problem of multiuser downlink resource allocation in Mobile WiMAX system was studied. Simulation results show that information fed back and association among subcarriers play vital role to improve system performance. As compared to reduced complexity resource allocation Active Set Optimization and Genetic Algorithm seems especially attractive as the number of users increases for Image Data. It is observed through simulation that the System using Genetic Algorithm performs better than Active Set, Linear Resource Allocation in terms of significantly decreasing the computational complexity and achieve higher capacities, while being applicable to a more general class of systems. As Genetic Algorithm follows constraints of Stochastic processes it didn't give results highest in all Experiment Conducted. It is also observed that for Integer-Binary Objective function Performance of Genetic Algorithm is not that much satisfied because of its stochastic processing. Also processing time required to reach final optimize variables values is too much.
As in WiMAX latency period is too important because Base Station have to allot the resources in short span of time to its active users, GA fails to reach Optimize variables value within that period and took too much time. It is also observed that as number of subcarriers increases beyond 72 Genetic Algorithm couldn't find unknown variables values. So we come to the conclusion that for such type of Networks Active-Set Optimization is best suited instead of Genetic Algorithm though the fitness functions value is greater than the results obtained by Active-Set Optimization Technique.

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