

**Quality of service (QoS) analysis & performance
enhancement of mobile communication in Bangladesh**

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THESIS ABSTRACT:

Quality of Service (QoS) is very important in mobile communication system & its measures the performance of the system. Different parameters involve in enhancing QoS such as effective handover, adaptive modulation, advance antenna system, antenna diversity, relay technique, effective channel coding, organized interleaving & frequency hopping, increasig base stations. We have analyzed theses parameters & proposed effective solution to some of the enforcing problem.

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1.0.Cellular Mobile Telecom Service (CMTS)

There has been a phenomenal growth in cellular mobile telecom services in Bangladesh in the recent past and this service has overtaken PSTN services in terms of number of connections. This trend of extremely rapid growth witnessed in mobile telecommunication services is likely to continue. Thus ensuring the QoS standards by the service provider is very critical for smooth and orderly growth in the services as well as satisfaction of customers at large. In this context, QoS benchmarks for CMTS adopted by some of the countries of this region are given in Annex. 1. The QoS parameters for cellular mobile telecom service can be categorized in 6 categories, namely provision time,complaints/fault incidence and repair, network performance, Customer care/assistance, billing complaints, network management and security and customer perception of service. While first five are put under Objective Parameters and will be covered in this chapter, the sixth is covered under SubjectiveParameters.

- 1.1. Quality of Service (QoS) is the main indicator of the performance of a telecom network and of the degree to which the network conforms to the stipulated norms and standards specified by the regulator or any other agency designated for the same. The subscriber's perception of the Quality of Service (QoS) is determined by a number of

performance factors. The purpose of laying down Quality of Service Parameters is to:

1.2. To make the QoS parameters more comprehensive, it was decided to sub-divide the QoS parameters into following four broad categories:

- Network Performance
- Fault Incidence and Repair
- Billing Complaints and Redressal
- Customer Perception regarding the Services

Each of the above categories for both the services, viz. Core Telecom Services, and Internet Services, is being discussed in the following paragraphs.

2. Work Performance:

Network Performance is the most important QoS parameter for measurement of quality of a Telecom Operator. Poor performance of a telecom network would induce customer complaints and faults, thereby leading to customer dissatisfaction towards the operator. The Network Performance parameter can further be subdivided into the following:

- Service Access Delay
- Call Completion Ratio
- Call Set-up Success Rate
- Network Congestion
- Call Drop Ratio (generally applicable to wireless networks)

- Grade of Service
- Point of Interconnection (PoI) Congestion

2.1 Service Access Delay:

Service Access Delay can be defined as *"the time between the last dialed digit and getting the ring back tone"* for the fixed line basic telephones and as *"the time between the pressing of send button and getting ring back tone"* for the WLL and Mobile networks. In view of the fact that the ring back tone is received immediately after completion of dialing in case of wireline networks, this parameter has little relevance. Hence it has been recommended to delete it for the wire line services.

This parameter defines the time taken from pressing the send

button of Mobile Set (MS) to getting the ring back tone. It consists of the following components:

- a) Time to connect call: This means that call setup command has been passed to the called network after authentication. This normally should happen within 4 seconds.
- b) Time to confirm instructions to connect: This is the maximum time from initiating call setup command to when this is acknowledged to the user. This is concurrent to the time to connect call.

c) Time to alert mobile set: The maximum time from when the mobile network receives a call for a mobile set to when the alert is energized. This time period is generally 4 to 15 seconds.

Based on above, the benchmark for Service Access Delay should be **<15 seconds**.

2.2. Call Completion Ratio:

Call Completion Ratio (CCR) is defined as *"the ratio of number of completed calls to the number of call attempts"*. Not all attempts result in effective calls i.e. called party answer. A variety of reasons such as called party busy, no answer and congestion in the network as well as subscriber behaviors like premature release, wrong dialing are also responsible for failure. Thus, the CCR is quite dependent on the human behavior which can vary from one subscriber to another, one place to another etc. and hence, may not reflect true picture of the performance of the telecom networks. Hence, the Authority decided that another parameter that is more indicative of the network performance of an operator, viz. i.e. "Call Set up Success Rate" be included in its place for wireless networks. It was also discussed if similar other parameter more indicative of the network performance of the wire line network could be put in place. There were suggestions that a parameter termed Seizure to Bid Ratio could be introduced, and this would represent the network performance, without taking into account the scenarios like called party busy, no answer, and congestion in the network. It was noted that majority of Regulators have continued the usage of Call Completion Ratio in their QoS documents. After the discussion the Authority agreed that it was not an appropriate substitute. Thus, the Authority felt that for the present, CCR may be continued to be used for the fixed wire-line networks.

Call Setup Success Ratio (CSSR) is defined as *"the ratio of established calls to call attempts"*. Established calls means the following events have happened in call set up:

Call attempt is made within the service area and call is routed to the onwards path from the concern switch (MSC in case of wireless networks). Call Setup Success Rate is a ratio of Established Calls to Call Attempts. The established calls are those calls where Traffic Channel (TCH) is allocated. In accordance with ITU-T E600 (03/93), the call attempt is defined as "an attempt to achieve a connection to one or more devices attached to a telecommunication network.. Established calls means the following events have happened in call set up.

- i. Attempt is made
- ii. The TCH is allocated, and
- iii. The call is routed to the outward path of the concerned MSC.

Thus established calls is a process which includes complete signaling in the call set up and does not measure the performance of the called exchange or that of the Point of Interconnection. This is defined as under:

Call set up success rate (TCH success rate = $\text{Total no. of all successful TCH Assignments} \times 100 / \text{Total no. all TCH Assignment Attempts}$).

It is proposed to keep the benchmark for this parameter as:

- i) Short term < 92%**
- ii) Long term < 95%**

2.3.Call Drop Ratio:

Call Drop Ratio is defined as *"the ratio of calls lost after establishment to all established calls"*. This includes calls dropped due to failure of handover, radio

loss and network congestion. This parameter is applicable to the wireless networks (WLL/Mobile) only.

This parameter is a measure of uninterrupted quality of call during the entire length of conversation i.e. once the Traffic Channel has been assigned, the call should not drop. This parameter measures failure in coverage, problem with the quality of signal, network congestion and network failure. As per ETSI EG 202 057-3 v 1.1.1 (2005-04), Dropped Call Ratio is "the percentage of calls which, once they have been correctly established and therefore have an assigned TCH, are interrupted prior to their normal completion by the user, the cause of the early termination being within the operator's network.

The call drops in the network could be mainly due to following reasons:

- a. Interference: Frequency Interference caused by either co-channel or adjacent channels.
- b. Handover: If handover between two sectors is not well defined.
- c. Antenna down-tilts are wrong.
- d. Antenna on one sector pointing in different directions.
- e. Antenna is obstructed.

The benchmark for this parameter is proposed as **< 3%**

2.4. Grade of Service:

Grade of Service (GoS) is defined as *"the probability of call failure over the junctions between two switches due to non availability of junctions"*. This parameter is generally applicable to the PSTN network. This parameter is not included in the existing QoS parameters for the PSTN licensee. To facilitate better junction planning and hence better QoS to the customers, the Authority decided for the inclusion of this parameter.

This parameter is defined as probability of loss of a call between originating switch and terminating switch. The proposed benchmark for this parameter $\leq 4\%$ i.e. upto 4% calls should be lost between the originating switch, their interconnections and terminating switch during TCBH.

2.5.Block Call Rate:

This parameter denotes congestion in the network either due to no availability of signaling channel known as Standalone Dedicated Control Channel (SDCCH) in respect of GSM network or paging channel in respect of CDMA network, or due to non-availability of Traffic Channel (TCH) itself. In other words, blocked call means a call that is not connected because there is

no free channel to serve a call attempt. The benchmarks for these parameters are proposed as below:

starting at the same time each day for which the average traffic of resource group is greatest over the days under consideration". ITU recommends analysis of 90 days to establish TCBH. Further, the above parameters are to be measured by the operators within their own network (within a single exchange in case of wire line networks). In view of the variety of different systems in use at the different exchanges, it has also been recommended that for the present time, measurements of all the parameters for the wire line networks shall be limited to the Parent Exchanges alone. To judge the inter-operator performance as well as

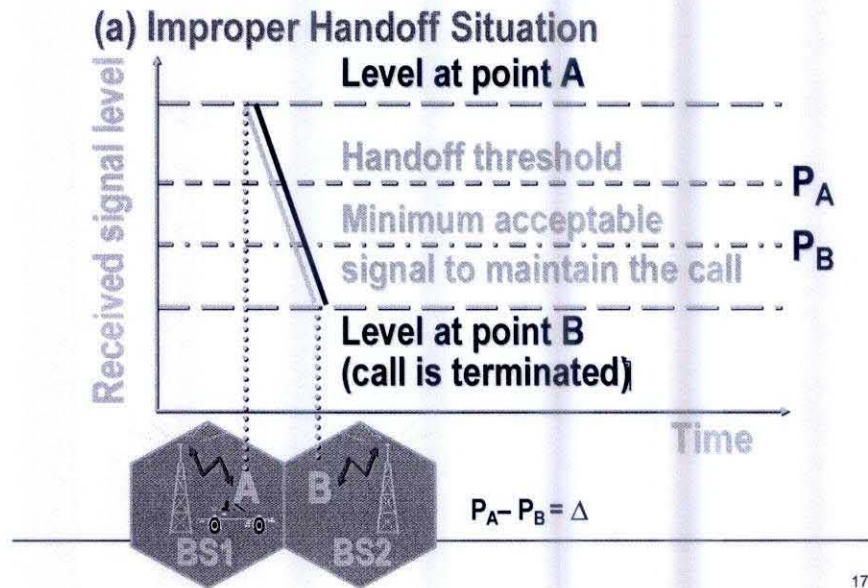
inter-exchange performance of PSTN/ wire-line networks, parameters like Pol congestion and GoS have been defined.[1 ,2]

2.5.HANDOVER

- Required when
 - a subscriber travels between cells during a conversation
 - interference occurs on current channel, hence call must be assigned to new channel
- MSC must handoff call/control from old channel in base station in old cell to new channel in base station in new cell
- MSC must
 - identify the new cell
 - determine available channels in the new cell
 - perform handoff seamlessly
- Unnecessary handoffs need to be avoided

FIGURE2.6:IMPROPER HANDOFF

Handoff Scenario



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Handoff Timing

$$P_A - P_B = \Delta$$

Δ should not be too large or too small

Δ too large:

too many handoffs

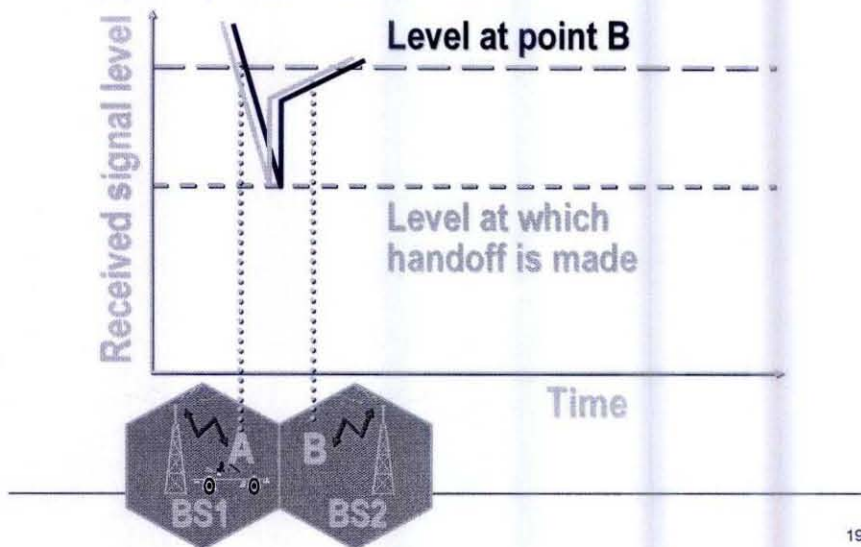
Δ too small:

chance of call being lost

FIGURE 2.6: PROPER HANDOFF

Handoff Scenario (cont'd)

(b) Proper Handoff Situation



Hard and Soft Handoffs

■ Hard handoff

- ☐ MSC breaks mobile's connection to base station in old cell
- ☐ makes makes new connection using new channel in new cell
- ☐ seamless transfer that goes unnoticed by user

■ Soft handoff

- ☐ Mobile always retains same channel across the system
- ☐ MSC compares signals from neighbouring base stations to determine the strongest
- ☐ MSC selects between instantaneous signals received from a number of base stations
- ☐ This is method used in CDMA Spread Spectrum systems

Other Types of Handoff

■ Mobile-Assisted Handoff (MAHO):

- ☐ Every mobile measures the received power from surrounding base stations, and continuously reports results to serving base station
- ☐ Faster hand-off rate than with the MSC-controlled type
- ☐ Particularly suited for micro-cell environments

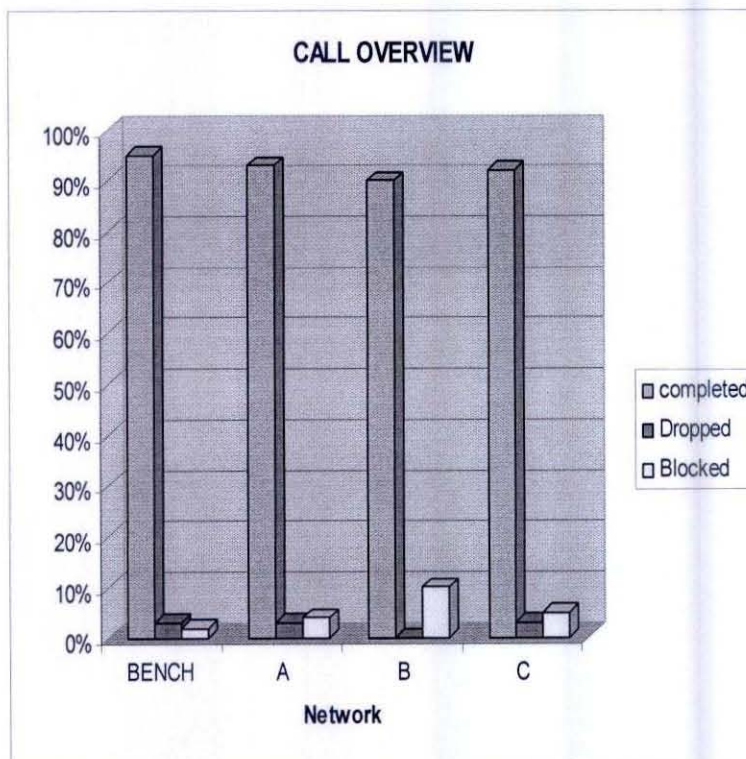
■ Inter-system Handoff:

- ☐ One cellular system to a different cellular system[3]

3. CALL STATISTICS:

	Network	completed	Dropped	Blocked
BENCH	<u>95%</u>	<u>3%</u>	<u>2%</u>	
A	<u>93%</u>	<u>3%</u>	<u>4%</u>	
B	<u>90%</u>	<u>0%</u>	<u>10%</u>	
C	<u>92%</u>	<u>3%</u>	<u>5%</u>	

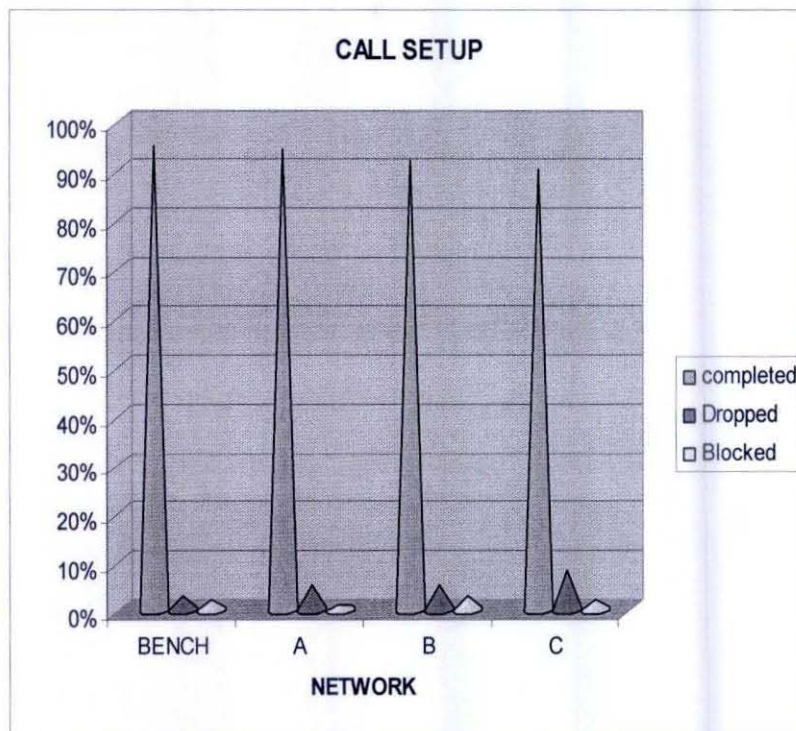
3.1 TABLE:CALL OVERVIEW



GRAPH:3.2:CALL OVERVIEW

3.3.TABLE:CALL SET-UP

Network	completed	Dropped	Blocked
BENCH	95%	3%	2%
A	94%	5%	1%
B	92%	5%	3%
C	90%	8%	2%

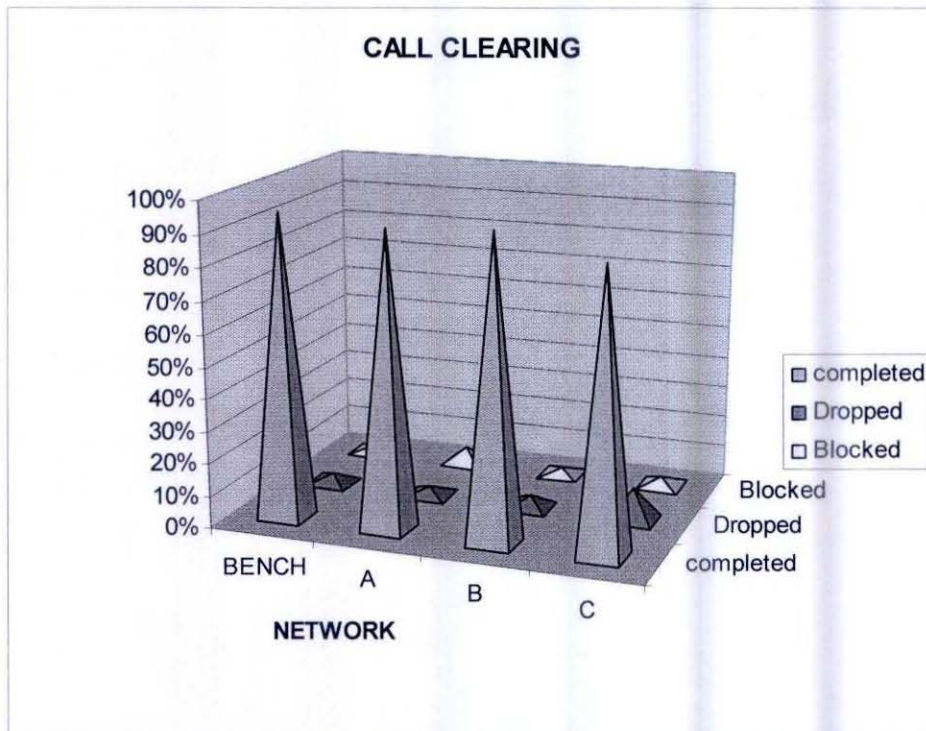


GRAPH:3.4 CALL SET-UP

3.5. TABLE CALL CLEARING

Network	completed	Dropped	Blocked
BENCH	95%	3%	2%
A	92%	3%	5%
B	94%	4%	2%
C	87%	10%	3%

TABLE:3.5

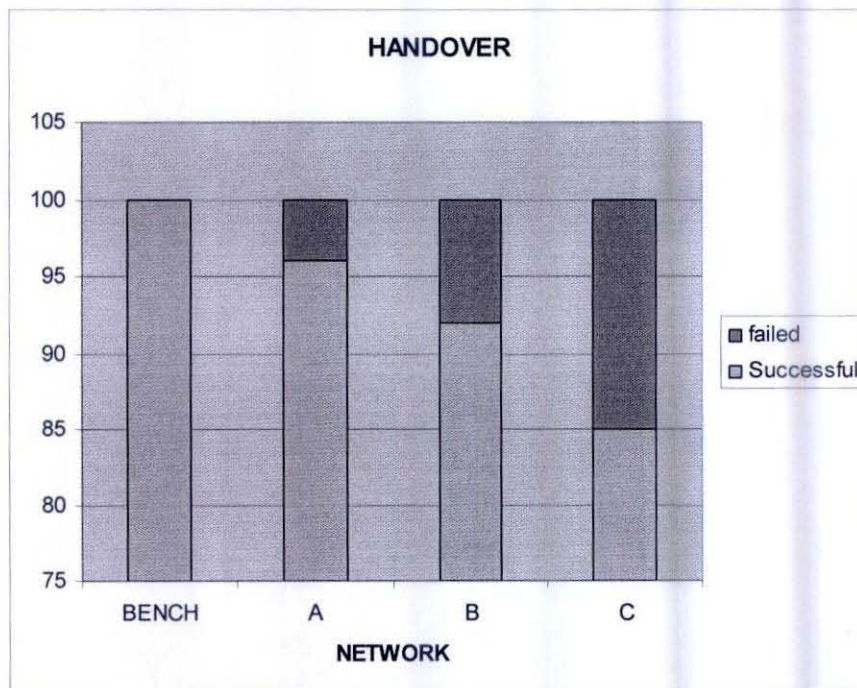


3.6GRAPH:.CALL CLEARING

HANDOVER STATISTICS

3.7TABLE: HANDOVER

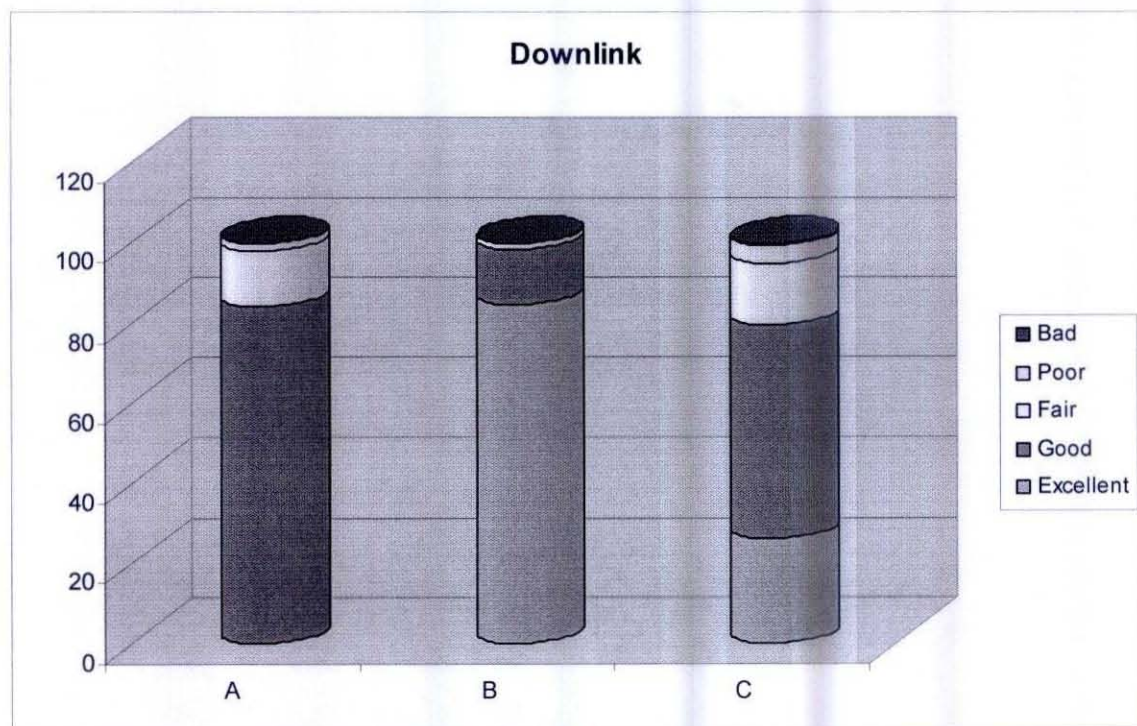
State	BENCH	A	B	C
Success	99	96	92	85
Block	1	4	8	15



GRAPH:3.8:HANDOVER

TABLE:3.9_SPECH QUALITY (DOWNLINK):

Network	Excellent	Good	Fair	Poor	Bad
A	0	83.94	14.16	1.73	0.17
B	84.39	14.04	1.4	0.18	0
C	26.35	53.07	15.52	4.33	0.72

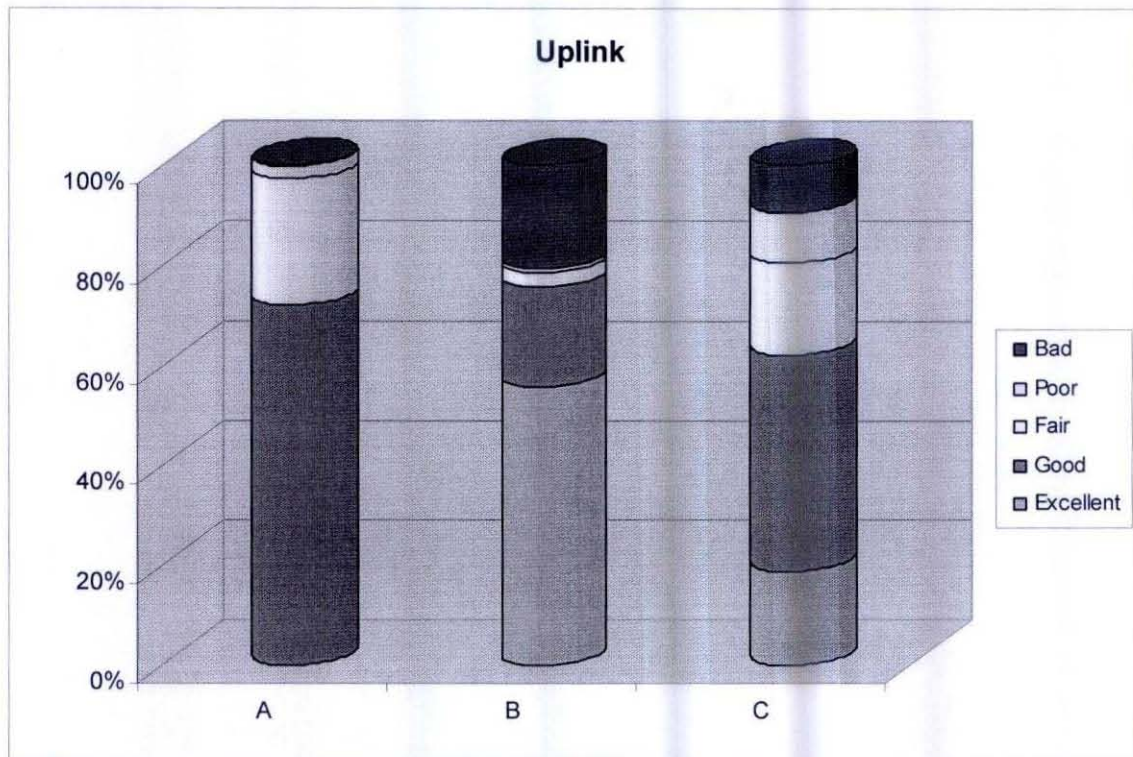


GRAPH:3.10_SPECH QUALITY (DOWNLINK)

3.11_SPECH QUALITY (UPLINK)

Network	Excellent	Good	Fair	Poor	Bad
A	0	72.03	25.29	2.49	0.19
B	55.75	19.69	2.92	0.78	20.66
C	18.76	43.51	18.16	10.18	9.38

TABLE:3.12SPECH QUALITY (UPLINK)



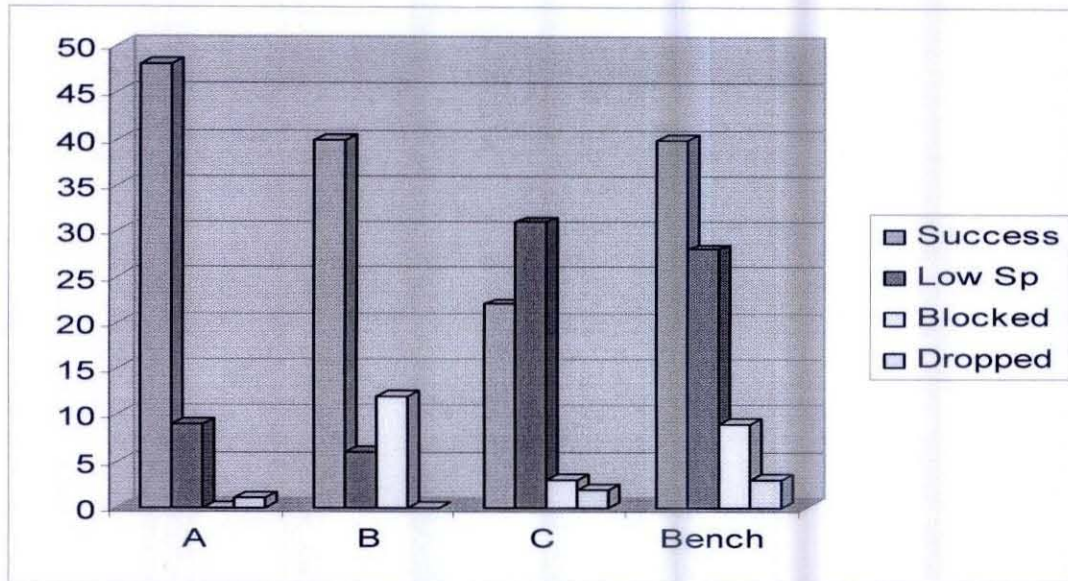
CALL RECORD QoS:TABLE.3.13

Setup			Setup			Setup		
A ID	time	state	B ID	time	STATE	C id	time	STATE
1	6.89	S	1	9.72	S	1	7.31	S
2	6.99	S	2	9.4	S	2	7.25	S
3	7	L	3	10.05	S	3	7.44	S
4	7.4	S	4	9.89	S	4	7.99	L
5	6.76	L	5	9.68	S	5	7.9	L
6	7.37	S	6	10.31	S	6	6.88	S
7	6.62	S	7	9.78	S	7	7.65	L
8	6.61	L	8	9.53	S	8	6.85	L
9	7.21	S	9	9.24	S	9	7.95	L
10	6.98	S	10	9.83	S	10	8.03	S
11	6.8	S	11	10.93	S	11	6.87	L
12	6.98	S	12	10.18	S	12	7.48	S
13	7.01	D	13	9.86	S	13	8.22	L
14	7.19	S	14	9.82	S	14	8.1	L
15	7.28	S	15	9.29	S	15	8.26	S
16	8.12	S	16	9.66	S	16	7.28	L
17	6.87	S	17	9.64	S	17	6.79	S
18	6.9	S	18	9.33	S	18	7.36	S
19	7.3	L	19	10.9	S	19	7.68	S
20	7.72	S	20	9.64	S	20	7.87	L
21	6.99	S	21	9.34	S	21	7.84	L
22	6.82	S	22	0	B	22	7.27	L
23	6.87	S	23	0	B	23	6.94	L
24	6.8	L	24	0	B	24	7.85	L

25	6.78	S	25	0	B	25	7.72	L
26	6.86	S	26	0	B	26	0	B
27	7.09	S	27	0	B	27	10.42	L
28	6.75	S	28	9.68	S	28	7.33	L
29	6.92	S	29	9.41	S	29	8.02	L
30	7.13	S	30	9.11	S	30	7.77	L
31	7.22	L	31	9.9	S	31	6.83	S
32	6.96	S	32	9.49	S	32	7.38	L
33	7.65	S	33	9.11	S	33	7.11	D
34	6.85	S	34	9.8	S	34	7.52	L
35	7.01	S	35	9.55	S	35	7.56	S
36	6.62	S	36	10.1	S	36	7.41	L
37	6.91	S	37	9.83	S	37	7.97	L
38	7.4	S	38	9.49	S	38	7.53	L
39	7.16	S	39	10.12	S	39	9	L
40	6.86	S	40	9.87	S	40	8.36	S
41	7.61	S	41	9.53	S	41	7.13	L
42	7.45	S	42	9.23	S	42	7.77	L
43	14.25	S	43	8.96	S	43	7.59	S
44	7.62	L	44	9.59	S	44	7	D
45	6.72	S	45	9.32	S	45	0	B
46	7.17	S	46	10.11	S	46	0	B
47	6.82	S	47	9.59	L	47	8.29	S
48	6.83	L	48	9.43	L	48	7.19	S
49	6.53	S	49	10.01	L	49	7.28	L
50	6.95	S	50	9.6	L	50	7.08	S
51	7.07	S	51	9.4	L	51	7.11	S
52	7.52	S	52	10	L	52	7.78	S
53	7.36	S	53	9.62	L	53	7	S
54	6.87	S	54	10.33	L	54	7.77	L
55	6.75	S	55	10.09	L	55	6.85	S

56	6.76	L	56	9.75	L	56	7.43	S
57	6.96	S	57	9.42	L	57	7.54	L
58	6.68	S	58	10.05	L	58	7.61	L
Total			Total			Total		
sec	415.57		sec	505.51		sec	417.41	
Avg			Avg			Avg		
value	7.165		value	8.716		value	7.197	

NETWORK	Success	Low Sp	Blocked	Dropped
A	48	9	0	1
B	40	6	12	0
C	22	31	3	2
Bench	40	28	9	3



GRAPH:3.14 :CALL RECORD QoS

We have already discussed about the problem due to increasing bit error rate, Equipment, voltage wave standing ratio, transmission problem, handover, antenna down.

For solving these problem, we have to discuss about adaptive antenna modulation, Antenna diversity, MIMO (multiple input multiple output), smart antenna.

4.Antenna diversity:

Antenna diversity, also known as space diversity, is any one of several wireless diversity schemes that use two or more antennas to improve the quality and reliability of a wireless link. Often, especially in urban and indoor environments, there is not a clear line-of-sight (LOS) between transmitter and receiver. Instead the signal is reflected along multiple paths before finally being received. Each of these bounces can introduce phase shifts, time delays, attenuations, and even distortions that can destructively interfere with one another at the aperture of the receiving antenna. Antenna diversity is especially effective

at mitigating these multipath situations. This is because multiple antennas afford a receiver several observations of the same signal. Each antenna will experience a different interference environment.

Antenna Techniques

Antenna diversity can be realized in several ways. Depending on the environment and the expected interference, designers can employ one or more of these methods to improve signal quality. In fact multiple methods are frequently used to further increase reliability.

- Spatial Diversity – Spatial diversity employs multiple antennas, usually with the same characteristics, that are physically separated from one another. Depending upon the expected incidence of the incoming signal, sometimes a space on the order of a wavelength is sufficient. Other times much larger distances are needed. Cellularization or sectorization, for example, is a spatial diversity scheme that can have antennas or base stations miles apart. This is especially beneficial for the mobile communications industry since it allows multiple users to share a limited communication spectrum and avoid co-channel interference.

- Pattern Diversity – Pattern diversity consists of two or more co-located antennas with different radiation patterns. This type of diversity makes use of directive antennas that are usually physically separated by some (often short) distance. Collectively they are capable of discriminating a large portion of angle space and can provide a higher gain versus a single omnidirectional radiator.

- Polarization Diversity – Polarization diversity combines pairs of antennas with orthogonal polarizations (i.e. horizontal/vertical, $\pm$ slant 45° , Left-hand/Right-hand CP etc). Reflected signals can undergo polarization changes depending on the media. By pairing two complementary polarizations, this scheme can immunize a system from polarization mismatches that would otherwise cause signal fade. Additionally, such diversity has proven valuable at radio and mobile communication base stations since it is less susceptible to the near random orientations of transmitting antennas.

- Transmit/Receive Diversity – Transmit/Receive diversity uses two separate, collocated antennas for transmit and receive functions. Such a configuration eliminates the need for a duplexer and can protect sensitive receiver components from the high power used in transmit.

- Adaptive Arrays – Adaptive arrays can be a single antenna with active elements or an array of similar antennas with ability to change their combined radiation pattern as different conditions persist. Active electronically scanned arrays (AESAs) manipulate phase shifters and attenuators at the face of each radiating site to provide a near instantaneous scan ability as well as pattern and polarization control. This is especially beneficial for radar applications since it affords a signal antenna the ability to switch among several different modes such as searching, tracking, mapping and jamming countermeasures.

Applications

A well-known practical application of diversity reception is in wireless microphones, and in similar electronic devices such as wireless guitar systems. A wireless microphone with a non-diversity receiver (a receiver having only one antenna) is prone to random drop-outs, fades, noise, or other interference, especially if the transmitter (the wireless microphone) is in motion. A wireless microphone or sound system using diversity reception will switch to the other antenna within microseconds if one antenna experiences noise, providing an improved quality signal with fewer drop-outs and noise. Ideally, no drop-outs or noise will occur in the received signal.

Another common usage is in Wi-Fi networking gear and cordless telephones to compensate for multipath interference. The base station will switch reception to one of two antennas depending on which is currently receiving a stronger signal. For best results, the antennas are usually placed one wavelength apart. For microwave bands, where the wavelengths are under 100 cm, this can often be done with two antennas attached to the same hardware. For lower frequencies and longer wavelengths, the antennas must be multiple meters apart, making it much less reasonable.

Mobile phone towers also often take advantage of diversity - each face of a tower will often have three antennas; one is transmitting, while the other two perform diversity reception.

The use of multiple antennas at both transmit and receive results in a multiple-input multiple-output (MIMO) system. The use of diversity techniques at both ends of the link is termed space-time coding.

Antenna diversity for MIMO

Diversity Coding is the spatial coding techniques for a MIMO system in wireless channels. Wireless channels severely suffer from fading phenomena, which causes unreliability in data decoding. Fundamentally, diversity coding sends multiple copies through multiple transmit antennas, so as to improve the reliability of the data reception. If one of them fails to receive, the others are used for data decoding.

5. MIMO

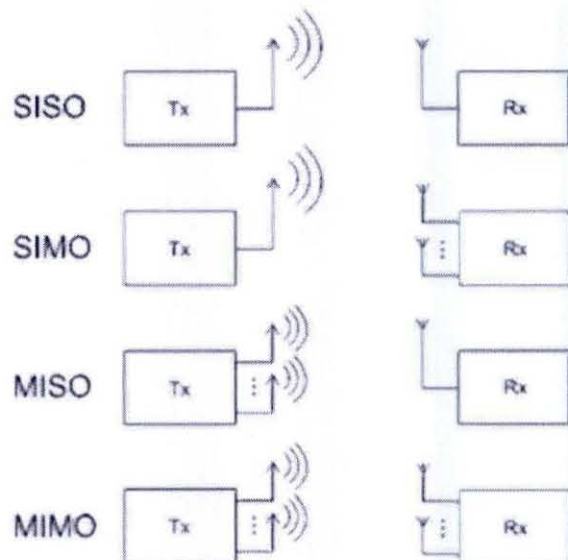


FIGURE 5.1.MIMO

In radio, multiple-input and multiple-output, or MIMO (pronounced *my-moh*), is the use of multiple antennas at both the transmitter and receiver to improve communication performance. It is one of several forms of smart antenna technology.

MIMO technology has attracted attention in wireless communications, since it offers significant increases in data throughput and link range without additional bandwidth or transmit power. It achieves this by higher spectral efficiency (more bits per second per hertz of bandwidth) and link reliability or diversity (reduced fading). Because of these properties, MIMO is a current theme of international wireless research. (Refer to: Research trends in MIMO literature)

Functions of MIMO

MIMO can be sub-divided into three main categories, precoding, spatial multiplexing or SM, and diversity coding.

When the receiver has multiple antennas, the transmit beamforming cannot simultaneously maximize the signal level at all of the receive antenna and precoding is used. Note that precoding requires knowledge of the channel state information (CSI) at the transmitter.

Multi-antenna types

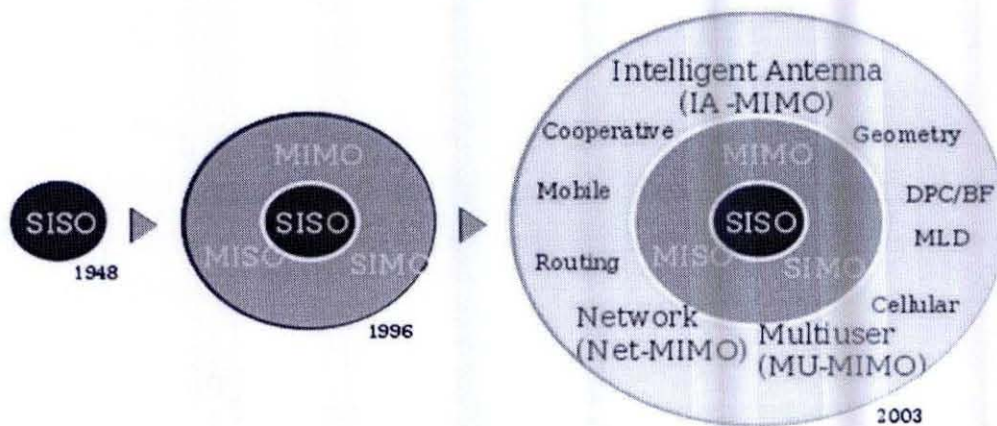


FIGURE 5.2. MIMO communications

Up to now, multi-antenna MIMO (or Single user MIMO) technology has been mainly developed and is implemented in some standards, e.g. 802.11n (draft) products.

- SISO/SIMO/MISO are degenerate cases of MIMO
 - Multiple-input and single-output (MISO) is a degenerate case when the receiver has a single antenna.
 - Single-input and multiple-output (SIMO) is a degenerate case when the transmitter has a single antenna.
 - single-input single-output (SISO) is a radio system where neither the transmitter nor receiver have multiple antenna.

Multi-user types

Recently, the research on multi-user MIMO technology is emerging. While full multi-user MIMO (or network MIMO) can have higher potentials, from its practicality the research on (partial) multi-user MIMO (or multi-user and multi-antenna MIMO) technology is more active.

- Multi-user MIMO (MU-MIMO)
 -

Applications of MIMO

Spatial multiplexing techniques makes the receivers very complex, and therefore it is typically combined with Orthogonal frequency-division multiplexing (OFDM) or with Orthogonal Frequency Division Multiple Access (OFDMA) modulation, where the problems created by multi-path channel are handled efficiently. The IEEE 802.16e standard incorporates MIMO-OFDMA. The IEEE 802.11n standard, which is expected to be finalized soon, recommends MIMO-OFDM.

6. Smart antennas

The analog cutoff is now less than one year away, and with that change will come new reception issues for terrestrial broadcast viewers. Although the FCC has sought to replicate analog service in its digital channel allocation plan, most broadcasters will have a digital channel assignment different from their analog one. Inherently, this means that the RF field conditions at the viewer's location will be considerably different from those of the analog service. Smart antennas offer a convenient way to minimize the impact on the viewer.

Because terrestrial television receivers must potentially receive signals from various locations, a fixed antenna cannot provide optimum reception across the available channels. In addition, community antennas using the same transmitting site may cause receivers to experience different multipath reception conditions across different channels. While indoor antenna re-aiming may not affect an analog viewer — or the viewer simply tolerated a lower SNR on some channels — re-aiming an antenna for optimum digital service could be quite burdensome.

Electronically steerable smart antennas that automatically optimize the preferred signal direction for each particular broadcast emission were developed years ago for military applications and are increasingly being used in cellular telephone base stations. This optimization can take into account various signal quality factors, such as signal strength, multipath energy and BER.

Digital signal reception varies widely

Terrestrial television reception is subject to many transmission path impairments, including multipath interference, where delayed echos of the transmitted signal can arrive at the antenna because of reflections off large objects in the receiving space. Moderate to severe multipath can lead to an increase in BER, which could compromise video and audio or, in the worst case, result in no reception at all.

While this situation can often be remedied by physically re-aiming the receiving antenna, this adjustment may not be ideal for all received stations because of their different transmission powers, frequencies and locations.

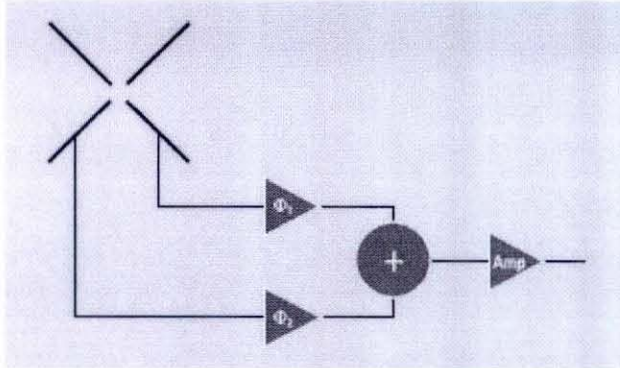


Figure 6.1. Simple smart antenna system, with selectable element phase and overall gain

[Click on image to enlarge.](#)

These difficulties are compounded because of the cliff effect, wherein the BER increases catastrophically below a certain C/N ratio or D/U interference ratio. As such, antenna adjustment can be problematic under many reception conditions. The situation is equally inconvenient with outdoor antennas (requiring a rotator) or indoor ones (requiring frequent trips to the television).

It is now practical to use this same technology for consumer digital television reception. By providing an automatic mechanism to adjust the antenna, the direction and gain (amplification) of the antenna can be electronically changed, with no need for user intervention or physical adjustment of the antenna. This type of antenna functions by changing the relative gain and phase (delay) of the internal elements. While offering a high degree of optimization for both signal capture and interference rejection, this kind of adaptive antenna is somewhat complex and hence expensive to implement.

Practical smart antennas

An alternate type of smart antenna is the so-called switched beam antenna system. In this system, multiple fixed elements within the antenna are selectively used so that a primary receiving direction is favored. At the same time, strong sources of multipath can be negated. An optimization algorithm can perform a trade-off between the two factors. The user simply plugs the antenna in to a suitably equipped DTV receiver or converter box, and the receiver automatically adjusts the antenna for optimal reception of each DTV station.

One example of such a system is shown schematically in Figure 1. The optimization algorithm is typically executed by the CPU in the receiving device and is done once during initial setup. In addition to selecting different azimuth directions, units can operate with different levels of RF amplification. This is useful in areas of high signal strength to avoid overload of the receiver front end, which could otherwise result in high intermodulation distortion.

Selecting an antenna direction and gain setting for optimum signal reception involves assessing the signal quality over the operating extent of the antenna. Various parameters of the received signal can be evaluated and weighed, including signal strength, mean squared error of the channel equalizer, spectral flatness and unwanted interference.

Depending on the system architecture, this optimization process can be tightly integrated with the demodulator or implemented separately. The combination of direction and gain can also be used in a more sophisticated algorithm that anticipates third-order intermodulation interference from strong UHF taboo channels, or from the $n \pm 1$, two-channel pairs where tuner RF selectivity may be minimal.

A standardized smart antenna interface

While a smart antenna can be an option to the consumer, it will only function if the appropriate interface is available at the receiver. Such an interface has been developed

and standardized by the Consumer Electronics Association, and is known as CEA-909A, "Antenna Control Interface."

This standard describes how a compliant receiver can operate with any compliant antenna, regardless of manufacturer. The standard also specifies the data format used, the connection standards and other requirements.

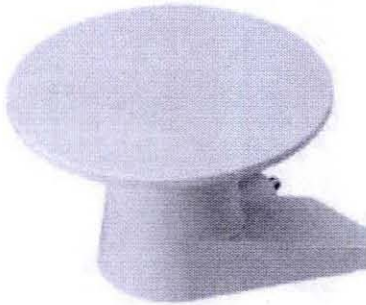


Figure 6. 2. A smart antenna can be a small, attractive and affordable solution.

The antenna configuration is neither specified nor implied, leaving specific design considerations to the manufacturer. As such, an elaborate system can even be designed using a full-blown antenna farm. The more practical design allows for the realization of an affordable, attractive antenna with a small form factor, as seen in Figure 2.

Smart antennas (also known as adaptive array antennas, multiple antennas and recently MIMO) are antenna arrays with smart signal processing algorithms used to identify spatial signal signature such as the direction of arrival (DOA) of the signal, and use it to calculate beamforming vectors, to track and locate the antenna beam on the mobile/target. The antenna could optionally be any sensor.

Smart antenna techniques are used notably in acoustic signal processing, track and scan RADAR, radio astronomy and radio telescopes, and mostly in cellular systems like W-CDMA and UMTS.

Extension of smart antennas

- Smart antenna systems are also a defining characteristic of MIMO systems, such as the proposed IEEE 802.11n standard. Conventionally, a smart antenna is a unit of a wireless communication system and performs spatial signal processing with multiple antennas. Multiple antennas can be used at either the transmitter or receiver. Recently, the technology has been extended to use the multiple antennas at both the transmitter and receiver; such a system is called a multiple-input multiple-output (MIMO) system. As extended Smart Antenna technology, MIMO supports spatial information processing, in the sense that conventional research on Smart Antennas has focused on how to provide a beamforming advantage by the use of spatial signal processing in wireless channels. Spatial information processing includes spatial information coding such as Spatial multiplexing and Diversity Coding, as well as beamforming.[6,7,8]

7.Adaptive modulation techniques:

Adaptive modulation techniques have the potential to substantially increase the spectrum efficiency and to provide different levels of service to users, both of which are considered important for third-generation cellular systems. In this work, we propose a general framework to quantify the potential gains of such techniques. Specifically, we study the throughput performance gain that may be achieved by combining adaptive modulation and power control.

We apply codes to adaptive modulation in fading channels. Adaptive modulation is a powerful technique to improve the energy efficiency and increase the data rate over a fading channel. The adaptive method exhibits a power savings of up to 20 dB.[10]

Phase-shift keying (PSK) is a digital modulation scheme that conveys data by changing, or modulating, the phase of a reference signal (the carrier wave).

Any digital modulation scheme uses a finite number of distinct signals to represent digital data. PSK uses a finite number of phases, each assigned a unique pattern of binary bits.

Usually, each phase encodes an equal number of bits. Each pattern of bits forms the symbol that is represented by the particular phase. The demodulator, which is designed specifically for the symbol-set used by the modulator, determines the phase of the received signal and maps it back to the symbol it represents, thus recovering the original data. This requires the receiver to be able to compare the phase of the received signal to a reference signal — such a system is termed coherent (and referred to as CPSK).

Alternatively, instead of using the bit patterns to *set* the phase of the wave, it can instead be used to *change* it by a specified amount. The demodulator then determines the *changes* in the phase of the received signal rather than the phase itself. Since this scheme depends on the difference between successive phases, it is termed differential phase-shift keying (DPSK). DPSK can be significantly simpler to implement than ordinary PSK since there is no need for the demodulator to have a copy of the reference signal to determine the exact phase of the received signal (it is a non-coherent scheme). In exchange, it produces more erroneous demodulations. The exact requirements of the particular scenario under consideration determine which scheme is used.

There are three major classes of digital modulation techniques used for transmission of digitally represented data:

- Amplitude-shift keying (ASK)
- Frequency-shift keying (FSK)
- Phase-shift keying (PSK)

All convey data by changing some aspect of a base signal, the carrier wave (usually a sinusoid), in response to a data signal. In the case of PSK, the phase is changed to represent the data signal. There are two fundamental ways of utilizing the phase of a signal in this way:

- By viewing the phase itself as conveying the information, in which case the demodulator must have a reference signal to compare the received signal's phase against; or

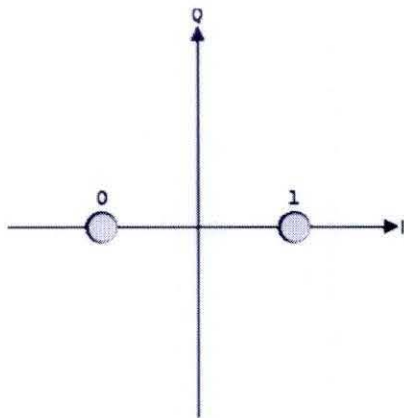
- By viewing the *change* in the phase as conveying information — *differential* schemes, some of which do not need a reference carrier (to a certain extent).

A convenient way to represent PSK schemes is on a constellation diagram. This shows the points in the Argand plane where, in this context, the real and imaginary axes are termed the in-phase and quadrature axes respectively due to their 90° separation. Such a representation on perpendicular axes lends itself to straightforward implementation. The amplitude of each point along the in-phase axis is used to modulate a cosine (or sine) wave and the amplitude along the quadrature axis to modulate a sine (or cosine) wave.

Applications

Owing to PSK's simplicity, particularly when compared with its competitor quadrature amplitude modulation, it is widely used in existing technologies.

7.1. Binary phase-shift keying (BPSK)



Constellation diagram for BPSK.

BPSK (also sometimes called PRK, Phase Reversal Keying) is the simplest form of PSK. It uses two phases which are separated by 180° and so can also be termed 2-PSK. It does not particularly matter exactly where the constellation points are positioned, and in this figure they are shown on the real axis, at 0° and 180° . This modulation is the most robust

of all the PSKs since it takes the highest level of noise or distortion to make the demodulator reach an incorrect decision. It is, however, only able to modulate at 1 bit/symbol (as seen in the figure) and so is unsuitable for high data-rate applications when bandwidth is limited.

In the presence of an arbitrary phase-shift introduced by the communications channel, the demodulator is unable to tell which constellation point is which. As a result, the data is often differentially encoded prior to modulation.

Implementation

Binary data is often conveyed with the following signals:

$$s_0(t) = \sqrt{\frac{2E_b}{T_b}} \cos(2\pi f_c t + \pi) = -\sqrt{\frac{2E_b}{T_b}} \cos(2\pi f_c t) \quad \text{for binary "0"}$$

$$s_1(t) = \sqrt{\frac{2E_b}{T_b}} \cos(2\pi f_c t) \quad \text{for binary "1"}$$

where f_c is the frequency of the carrier-wave.

Hence, the signal-space can be represented by the single basis function

$$\phi(t) = \sqrt{\frac{2}{T_b}} \cos(2\pi f_c t)$$

where 1 is represented by $\sqrt{E_b}\phi(t)$ and 0 is represented by $-\sqrt{E_b}\phi(t)$. This assignment is, of course, arbitrary.

The use of this basis function is shown at the end of the next section in a signal timing diagram. The topmost signal is a BPSK-modulated cosine wave that the BPSK modulator would produce. The bit-stream that causes this output is shown above the signal (the other parts of this figure are relevant only to QPSK).

Bit error rate

The bit error rate (BER) of BPSK in AWGN can be calculated as:

$$P_b = Q\left(\sqrt{\frac{2E_b}{N_0}}\right) \text{ or } P_b = \frac{1}{2}\text{erfc}\left(\sqrt{\frac{E_b}{N_0}}\right)$$

Since there is only one bit per symbol, this is also the symbol error rate.[11]

7.2. Quadrature phase-shift keying (QPSK)

Sometimes known as quaternary or quadriphase PSK, 4-PSK, or 4-QAM, QPSK uses four points on the constellation diagram, equispaced around a circle. With four phases, QPSK can encode two bits per symbol, shown in the diagram with Gray coding to minimize the BER — twice the rate of BPSK. Analysis shows that this may be used either to double the data rate compared to a BPSK system while maintaining the bandwidth of the signal or to maintain the data-rate of BPSK but halve the bandwidth needed.

As with BPSK, there are phase ambiguity problems at the receiver and differentially encoded QPSK is used more often in practice.[12]

7.3. Digital QAM

Like all modulation schemes, QAM conveys data by changing some aspect of a carrier signal, or the carrier wave, (usually a sinusoid) in response to a data signal. In the case of QAM, the amplitude of two waves, 90 degrees out-of-phase with each other (in

quadrature) are changed (*modulated* or *keyed*) to represent the data signal. Amplitude modulating two carriers in quadrature can be equivalently viewed as both amplitude modulating and phase modulating a single carrier.

Phase modulation (analog PM) and phase-shift keying (digital PSK) can be regarded as a special case of QAM, where the magnitude of the modulating signal is a constant, with only the phase varying. This can also be extended to frequency modulation (FM) and frequency-shift keying (FSK), for these can be regarded as a special case of phase modulation.

Interference/noise QAM app

In moving to a higher order QAM constellation (higher data rate and mode) in hostile RF/microwave QAM application environments, such as in broadcasting or telecommunications, interference (via multipath) typically increases. Reduced noise immunity due to constellation separation makes it difficult to achieve theoretical performance thresholds. There are several test parameter measurements which help determine an optimal QAM mode for a specific operating environment. The following three are most significant.

- Carrier/interference ratio: characterizes the ability to cope with interference when operating at nominal levels. This metric defines in-band and out-of-band channel performance.
- Carrier/noise ratio: defines the minimum amount of carrier power above noise power required for an acceptable bit error ratio (BER). This metric does not measure interference. Increasing QAM order requires increased carrier power to get acceptable BERT. If the noise floor remains unchanged then this metric is improved with QAM mode.
- Threshold/interference ratio: characterizes allowable interference that can be tolerated when operating at threshold.[13]

8.0.Methodology:

1.As the solution of previous problem of mobile communication, we have discussed, where adaptive modulation is the one of the solution,

Bit error rate reduces with increasing modulation techniques.And how efficiency different techniques can be used to ensure a standard bit error rate. consequently if we use BPSK,QPSK,16 QAM for getting data from far distance to close distance respectively, then error will be reduce but data flow will be very slow. For getting fast data rate with reduced error ,we have to use antenna diversity.

2.ANTENNA DIVERSITY: Antenna diversity use two or more antennas to improve the quality and reliability of a wireless link. Bit error rate significantly reduced with the increasing number of transmitter and receiver.

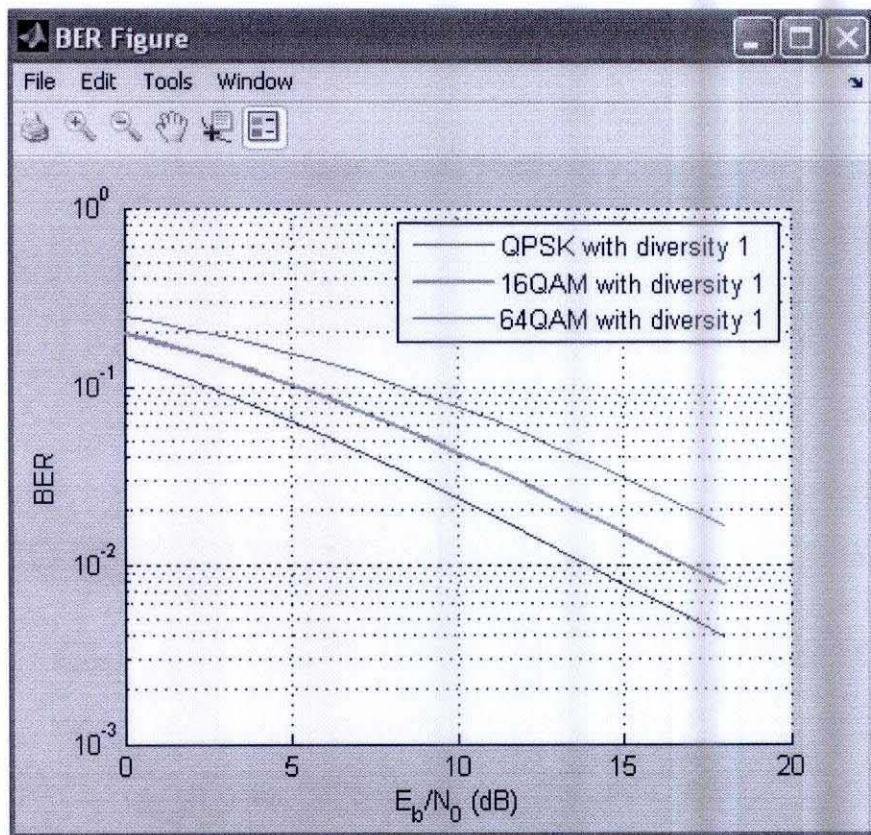
3.HANDOVER TECHNIQUES: Soft handover

For managing Frequency hopping and interleaving techniques enhancement , soft handover is more efficient than hard handover.

Mobile always retains same channel across the system. MSC compares signals from neighbouring base stations to determine the strongest. MSC selects between instantaneous signals received from a number of base stations. This is method used in CDMA Spread Spectrum systems

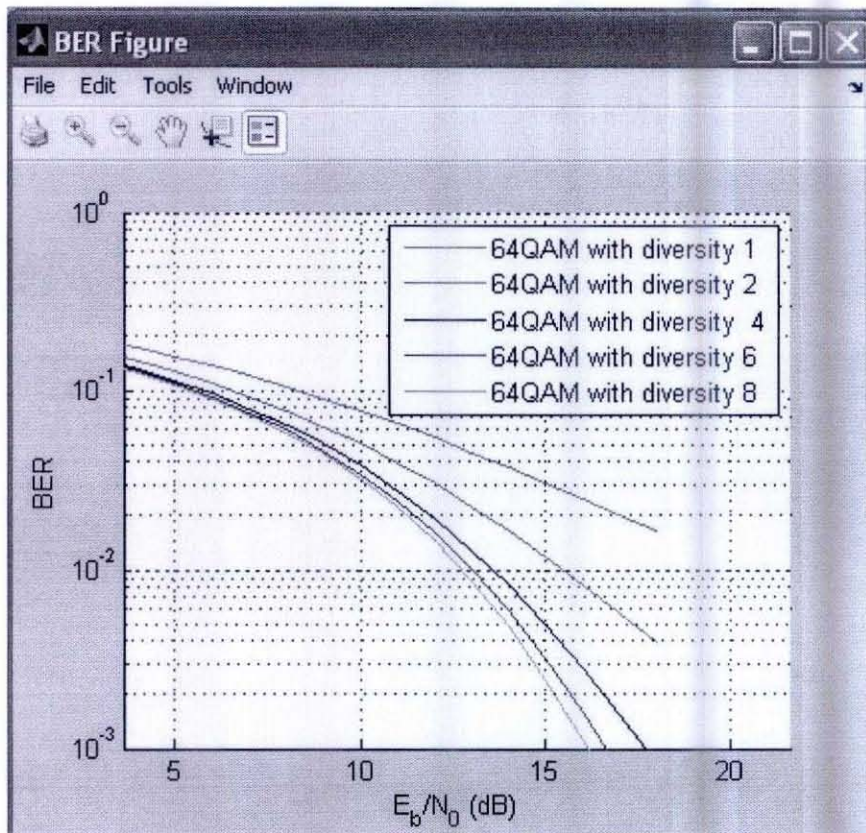
SIMULATION RESULT:

1.



9.1.FIGURE 1

In this figure we can see 3 different line of QPSK, 16 QAM, 64 QAM . All this modulation techniques are with diversity 1. where bit error rate are in db form.



9.2.BER FIGURE2

In this figure only 64 QAM with antenna diversity 1, 2, 4, 6, 8 are we used to show how bit error are reduced to using different antenna diversity. here antenna diversity 8 gives less bit error than antenna diversity 6. like this similarities 64 QAM with diversity 1 gives more bit error than diversity 2. so if we increase antenna diversity then bit can be reduced. so for antenna diversity 8 mean we need 8 receiver and transmitter. Which are costly.

- **Conclusion**

Using adaptive modulation techniques we can significantly reduce the bit error rate. By using antenna diversity, smart antenna and MIMO we can increase the data rate of flow by decreasing the error. The Smart Antennas has focused on how to provide a beamforming advantage by the use of spatial signal processing in wireless channels. Spatial information processing includes spatial information coding such as Spatial multiplexing and Diversity Coding, as well as beamforming. The use of multiple antennas at both transmit and receive results in a multiple-input multiple-output (MIMO) system. The use of diversity techniques at both ends of the link is termed space-time coding. Thus, if one antenna is experiencing a deep fade, it is likely that another has a sufficient signal. Collectively such a system can provide a robust link. While this is primarily seen in receiving systems (diversity reception), the analog has also proven valuable for transmitting systems (transmit diversity) as well. Inherently an antenna diversity scheme requires additional hardware and integration versus a single antenna system but due to the commonality of the signal paths a fair amount of circuitry can be shared. Also with the multiple signals there is a greater processing demand placed on the receiver, which can lead to tighter design requirements. Typically, however, signal reliability is paramount and using multiple antennas is an effective way to decrease the number of drop-outs and lost connections. In antenna diversity, though need to use multiple antenna, so the amount of cost increase which is the only disadvantage of antenna diversity.

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