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SIGNAL TO NOISE RATIO ESTIMATION OF QAM AND QPSK MODULATION TECHNIQUE AT 910MHz AND 2116.4 MHz USING MEASURED DATA

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Abstract:

Estimation of signal to noise ratio for the received signal is an important task in communication systems. The knowledge of the SNR is a requirement on many systems in order to perform efficient signal detection and link adaptation. In adaptive modulation system we need a way to decide which modulation level is best suited for the present channel condition, in this paper we decided to use the estimated SNR of the link as a channel metric to decide the switching levels. The channel estimation using two digital modulation technique (QAM and QPSK) are considered in W-CDMA environment, as we increase the range of communication, we step down to lower modulation (QPSK) but as we reduce the communication range means we are closer to the base station; we can utilize higher order modulation (QAM) for increase in throughput thus allowing the system to overcome multipath fading and other interferences. The results shows that the values of signal to noise ratio (SNR) from 10-12dB, the modulation scheme that yielded the desired BER of 10^{-3} is QPSK modulation technique while SNR values greater than 18dB, QAM modulation technique can be used doubling the capacity compared with QPSK modulation technique

Key Words: SNR, QPSK, QAM & W-CDMA Network

Introduction:

W- CDMA offers many advantages which include jam resistance, privacy and flexibility. CDMA has been considered and recognized as a viable alternative to both FDMA and TDMA [1]. W-CDMA schemes have many advantages over FDMA and TDMA but these advantages are hindered by the increasing interference caused by other active terminals, since all signals in the W-CDMA system share the same transmission bandwidth. Blocking occurs when the tolerance limit to interference is exceeded, hence in W-CDMA, the level of interference is a limiting factor [2]. Consider a receiver and two terminals (transmitters) with one closer to the receiver and the other farther away. If they transmit simultaneously at equal powers, then the receiver will receive more power from the nearer transmitter. Since one's transmitted signal is the other's noise, the signal-to-noise ratio (SNR) for the farther transmitter is much lower. If the nearer transmitter transmits a signal of magnitude higher than the farther transmitter, then the SNR for the latter may be below detect ability and may as well not transmit. This effectively jams the communication channel. This problem is commonly solved by dynamic modulation and dynamic output power adjustment of the transmitters [2]. That is, the nearer transmitter uses less power and higher order modulation techniques so that the SNR for all transmitters at the receiver is roughly the same

Related Work:

Modulation Schemes in Wireless System:

Quadrature Phase Shift Keying (QPSK) Modulation: Quadrature Phase Shift Keying (QPSK) is the digital modulation technique. Quadrature Phase Shift Keying (QPSK) is a form of Phase Shift Keying in which two bits are modulated at once, selecting one of four possible carrier phase shifts (0, Π/2, Π, and 3Π/2). QPSK perform by changing the phase of the In-phase (I) carrier from 0° to 180° and the Quadrature-phase (Q) carrier between 90° and 270°. This is used to indicate the four states of a 2-bit binary code. Each state of these carriers is referred to as a Symbol [3]. QPSK perform by changing the phase of the In-phase (I) carrier from 0° to 180° and the Quadrature-phase (Q) carrier between 90° and 270°. This is used to indicate the four states of a 2-bit binary code. Each state of these carriers is referred to as a Symbol. Quadrature Phase-shift Keying (QPSK) is a widely used method of transferring digital data by changing or modulating the phase of a carrier signal. In QPSK digital data is represented by 4 points around a circle which correspond to 4 phases of the carrier signal. These points are called symbols. Fig 2.1 shows this mapping.

M-ary Quadrature Amplitude Modulation (QAM): The Modulation equation for QAM is a variation of the one used for PSK. The generalized PSK allows changing the Amplitude and the Phase. In PSK all points lie on a circle so the I and Q values are related to each other.PSK signals are constant envelop because of this; all points have the same amplitude [3]. If we allow the phase and amplitude to change from symbol to symbol, then we get a modulation called quadrature amplitude modulation (QAM) .It can be considered a linear combination of two DSB-SC.so it is an AM and a PM modulation at same time.

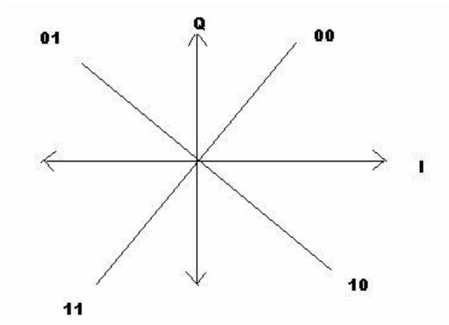


Figure 1: QPSK diagram showing how four different binary codes transmitted

$$s_{m}(t) = \sqrt{2E_S/T_S}\cos(\theta(t))\cos(2\pi f_c t) - \sqrt{2E_S/T_S}\sin(\theta(t))\sin(2\pi f_c t) \quad \text{------2.1}$$

This equation can be used to create an hybrid type of modulation that varies both in amplitude and the phase. When M=16, we have 16 symbols, each representing a four bit word. We can lay these out in a circle but they would be too close an error rate is likely to be high. In 16QAM, we vary not just the phase of the symbol but also the amplitude. In PSK, all symbols sat on a circle so they all had the same amplitude.

BER Expressions for AWGN: The mathematical expression for the BER performance of BPSK, QPSK and square 16-point QAM, assuming perfect clock and carrier recovery, in a Gaussian channel are given in [4] as

$$P_{BPSK}(\gamma) = Q(\sqrt{2\gamma}) \quad \text{-------------2.2}$$

$$P_{QPSK}(\gamma) = Q(\sqrt{\gamma}) \quad \text{---------------2.3}$$

$$P_{16QAM}(\gamma) = \frac{1}{4}Q\left[\left(\sqrt{\frac{\gamma}{5}}\right) + Q\left(3\sqrt{\frac{\gamma}{5}}\right)\right] + \frac{1}{2}Q\left(\frac{\gamma}{5}\right) \quad \text{----------2.4}$$

In equation 2.2, 2.3 and 2.3, (γ) is the SNR and Q(--) is the Q-function which is defined as

$$Q(x) = \frac{1}{\sqrt{2\pi}}\int_{x}^{\infty} exp\left\{-\frac{x^2}{2}\right\}dx \quad \text{---2.4}$$

BER Expressions for Rayleigh Fading Channel: The mathematical expression for the BER performance of BPSK, 4-QAM and square 16-point QAM over a Rayleigh fading channel are given [4] as

$$P_{BPSK}(\gamma) = \frac{1}{2}\left\{1 - \sqrt{\frac{\gamma}{1+\gamma}}\right\} \quad \text{------------------------------------2.5}$$

$$P_{4\text{-}QAM}(\gamma) = \frac{1}{2}\left\{1 - \sqrt{\frac{\gamma}{2+\gamma}}\right\} \quad \text{------------------------------------2.6}$$

$$P_{16\text{-}QAM}(\gamma) = \frac{1}{4}\left[\left\{1 - \sqrt{\frac{\gamma}{10+\gamma}}\right\} + \left\{\frac{9\gamma}{10+9\gamma}\right\}\right] \quad \text{----------2.8}$$

According to [5], their work presents a mathematical technique for determining the optimum transmission. The throughputs defined as the number of bits per second correctly received. Trade-offs between the throughput and the operation range are observed, and equations are derived for the optimal choice of the design variables. These parameters are SNR dependent and can be adapted dynamically in response to the mobility of a wireless data terminal. They also looked at the joint optimization problem involving all the design parameters together. They found that not all the three parameters (data rate 'b', SNR, Length of packet) need to be adapted simultaneously: in the received SNR per symbol stays at some rate so that the received SNR per symbol stays at some preferred value. They also varied received power by changing the distance between the transmitter and receiver. Finally, they gave a characterization of the optimal parameter values as functions of received SNR.

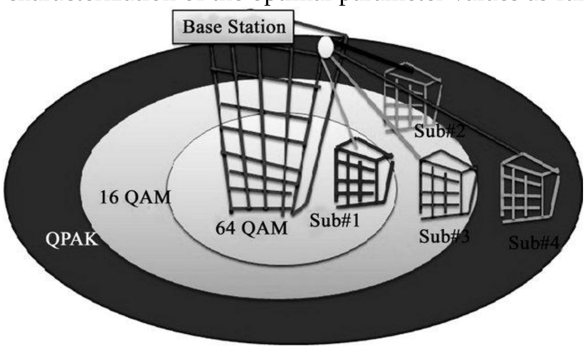
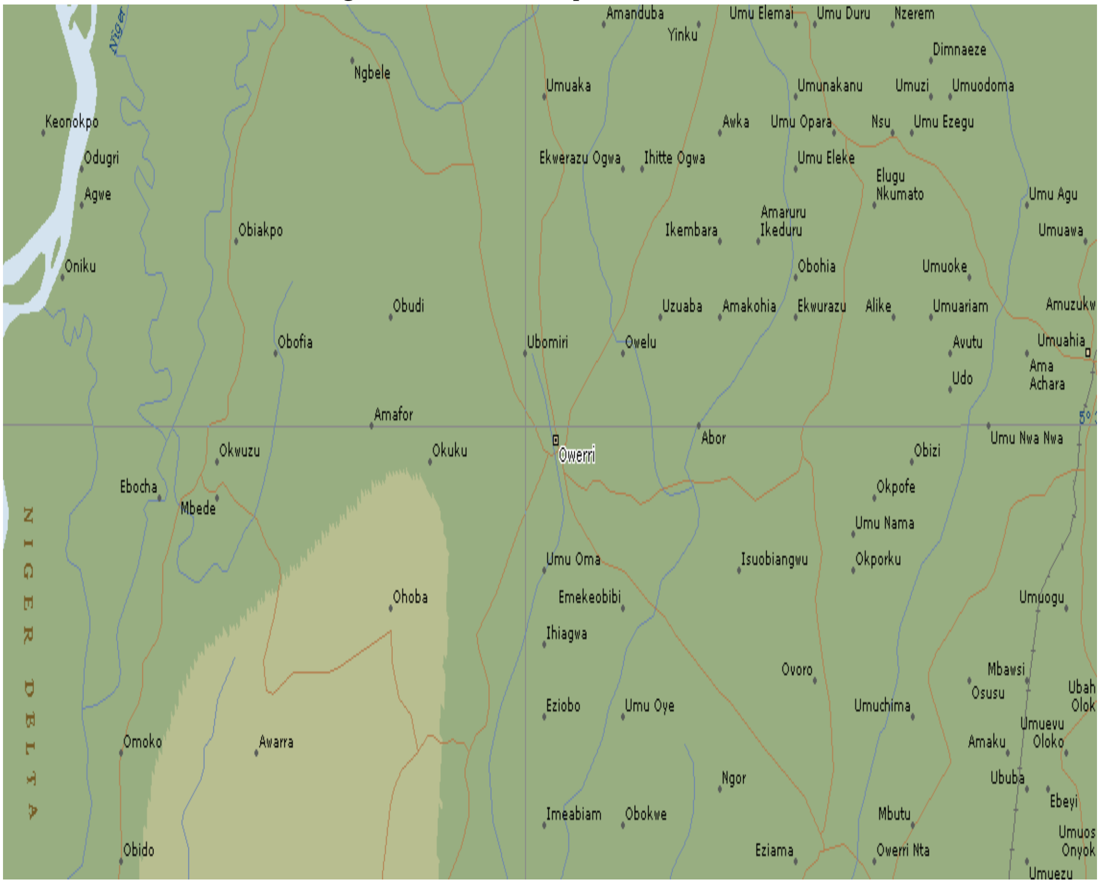


Figure 2: Adaptive Modulation

Measurements Environment Description: This section presents all steps towards the actual model design from field measurement. Two Base Stations were visited and Measurement were taken, Since Sub-Urban Prediction Models are required, the selection of the two (2) representative sites was done in such a way to accommodate the environment scenarios in and around Owerri , Imo State in Nigeria.

Figure 3: Shows the map of the visited sites



Determination of Pathlosses Characterization for Category B:

Table 1: Average Pathloss for Category B, using QAM Modulation Technique

D (KM)	ANTENNA TILT	QAM MODULATION MEDIAN Rx dBm	Pt (dBm)	MEDIAN PL (dbm)
0.1	4	-51	44.1	95
0.2	4	-53	44.1	97
0.3	4	-57	44.1	102
0.4	4	-58	44.1	102
0.5	4	-65	44.1	109
0.6	4	-67	44.1	113
0.7	4	-69	44.1	113
0.8	4	-70	44.1	114
0.9	4	-72	44.1	116
1.0	4	-74	44.1	118
1.1	4	-79	44.1	123
1.2	4	-82	44.1	126
1.3	4	-86	44.1	130
1.4	4	-88	44.1	132
1.5	4	-94	44.1	138

Table 2: Average Pathloss for Category B, QPSK Modulation Technique

D (KM)	ANTENN A TILT	QPSK MODULATION MEDIAN Rx dBm	Pt (dBm)	MEDIAN PL (dbm)
0.1	2	-62	19	81
0.2	2	-64	19	83
0.3	2	-65	19	84

0.4	2	-66	19	85
0.5	2	-67	19	86
0.6	2	-67	19	86
0.7	2	-68	19	87
0.8	2	-69	19	88
0.9	2	-71	19	90
1.0	2	-72	19	91
1.1	2	-77	19	96
1.2	2	-78	19	97
1.3	2	-79	19	98
1.4	2	-77	19	96
1.5	2	-79	19	98

Estimation of Signal to noise Ratio (SNR) from the Measured Data:

SNR is defined as the ratio of average signal to average noise power. SNR can be expressed in dB as [5].

$$SNR_{(dB)} = 10\log SNR$$

$$SNR = P_{t-} P_{L(d)-} S_r$$

Where P_t is the transmitted power in dBm , 44dBm for W-cdma and 43dBm for Gsm, $P_{L(d)}$ is the path loss model and S_r is the receiver sensitivity in dBm (-110dBm). Equation 3.1 and 3.2 were used to calculate the SNR of the environment under study Sub-Urban Area respectively and Matlab program were written to plot the SNR against distance of the test bed. Table 3.3 to 3.4 show the average path loss and average SNR_{dB} appendix E2 and E3 show the matlab codes used. TABLE 3.3 Average Pathloss and SNR (dB) For Category B QAM Modulation Technique (Sub-Urban)

D (KM)	Average Path Loss	SNR (dB)
0.1	95	17.72
0.2	97	17.57
0.3	102	17.17
0.4	102	17.17
0.5	109	16.54
0.6	113	16.13
0.7	113	16.13
0.8	114	16.03
0.9	116	15.81
1.0	118	15.58
1.1	123	14.93
1.2	126	14.49
1.3	130	13.80
1.4	132	13.44
1.5	138	12.07

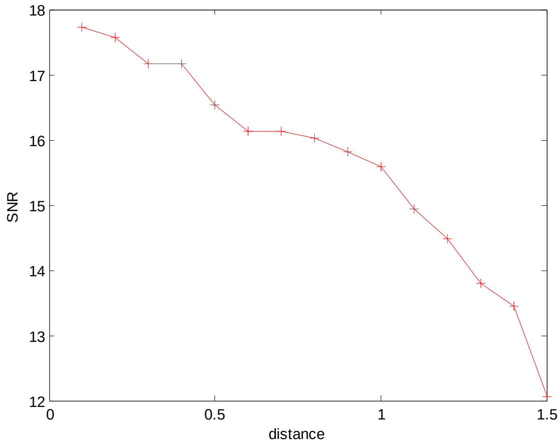


Figure 4: Plot showing the average SNR of QAM modulation techniques against distance for Sub-urban

Table 4: Average pathloss and SNR for category B QPSK modulation technique (Sub- Urban)

D (KM)	Average Path Loss	SNR(dB)
0.1	81	18.64
0.2	83	18.52

0.3	84	18.45
0.4	85	18.39
0.5	86	18.33
0.6	86	18.33
0.7	87	18.23
0.8	88	18.20
0.9	90	18.07
1.0	91	18.00
1.1	96	17.64
1.2	97	17.56
1.3	98	17.49
1.4	96	17.64
1.5	98	17.49

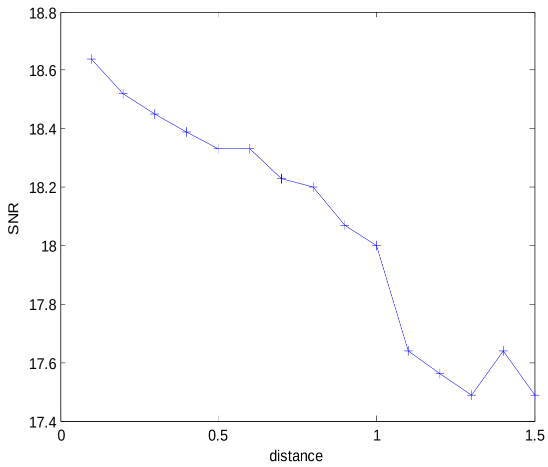


Figure 5: Plot showing the average SNR of QPSK modulation techniques against distance for Sub-urban

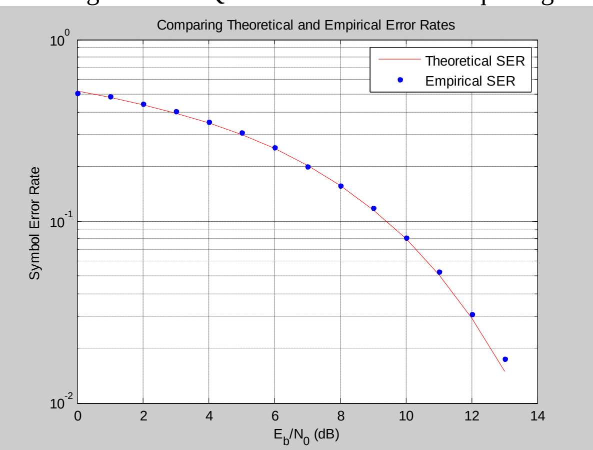


Figure 6: Plot showing the average Empirical Symbol error rate and Theoretical symbol error rate against SNR for the Environment under study

Conclusion:

The necessity of these graphs is to show the relationship of average SNR with distance, it was observed that the SNR and path loss depends on the distance and measurement environment. In this experiment, the channel or the link is very good, since the theoretical symbol error and empirical symbol error are nearly the same, thus no bit error. the results shows that the values of signal to noise ratio (SNR) from 10-12dB, the modulation scheme that yielded the desired BER of 10^{-3} is QPSK modulation technique while SNR values greater than 18dB, QAM modulation technique can be used doubling the capacity compared with QPSK modulation technique

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