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Evaluation of CDMA Microwave Links at Different Environments for VoIP Applications

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ABSTRACT: VoIP is the most important communication technology in the modern communication world. Even though it has became a viable alternative to wired telephony , it is still in development stage in the microwave domain .This paper addresses the challenges faced by VoIP in Microwave domain and tries to establish a relation between Bit Error Rate (BER) with frequency of operation , Transmitted Power and PN Codes in a commercial Microwave VoIP applications using CDMA link by studying their performance in different geographical networks.

Keywords: VoIP, BER, Frequency, Transmitted Power, PN Code, CDMA

I. INTRODUCTION

Voice over IP (VoIP) is one of the most important technologies in the world of communication and due to its cost effectiveness, ease of deployment and enhancements of features; is fast becoming a viable alternative for Public Switched Telephone Networks (PSTN). Even-though VoIP has become very popular and successful in wire-line systems , it is still in infancy in the wireless systems as there are major challenges that needs to be addressed . These challenges includes[1]:

A. *Requirement of High bandwidth*

In VoIP, bandwidth is used to trade-off delay and hence this resource is most valuable in the network and is given major attention by service providers. This is not the case in wireline networks which are generally circuit switched nature

B. *Controlling delay and Jitter*

Wireline systems are having error-free channels and hence don't require re-transmission. However, wireless channels are prone to interferences, resulting in corrupted data packet or bit errors, hence requiring re-transmissions, thereby increasing delay and delay variations and degrading QoS.

C. *Transmission Power & Coverage optimizations:*

More power is required for transmission of Voice packets due to addition of packet overheads resulting in less coverage due to want of transmission power. Further as Microwave communication uses burst mode for packet communication, it requires higher average transmission power and may limit the actual coverage range.

However even though there are limitations in the deployment of microwave communications systems for VoIP applications, in order to reach the locations which don't have access to reliable terrestrial wire-line communication and for fast deployment of connectivity solutions by a service provider, microwave connectivity remains the most viable option.

This had lead to deployment of various microwave solutions by the service providers to reach more and more clientele. Also with the advent of various high bandwidth and real time applications, there has been a tremendous demand of high precision Bit Error Rate (BER), burdening the system designers. More over CDMA is being used extensively for providing connectivity solutions in the microwave domain. Hence a need is felt in the VoIP service providing industry to find out various viable options in order to maintain the very stringent BER and other quality requirements in the commercially operating frequency band which might not interfere with the other signals operating in the vicinity and also help the service providers to achieve good return of their infrastructure investments.

CDMA is considered to be preferred technique to support multimedia services in mobile radio-communications [2], due to its property of efficient utilization of the allocated spectrum by frequency re-use and spreading. Various algorithms and techniques have been researched to improve upon the spectral efficiency of the CDMA with the help of various coding techniques [3-7]. Research has also been carried out in the field of multiple user detection in a given bandwidth and also on improving BER [8-14]. However with exponential growth of microwave link deployment and stringent BER rules, a need is felt to understand the factors influencing the quality of service of the real-time applications like Voice over Internet Protocol (VoIP), Internet etc.

This paper attempts to address the issues faced by the network service providers in the highly used commercial frequency band (2.3 to 2.4 GHz). The approach of the paper is to study and analyze the effects on BER due to change of PN code, frequency and transmitted power. In telecommunication transmission, the BER is the percentage of bits that have errors relative to the total number of bits received in transmission, usually expressed as ten to a negative power. For example, a transmission might have a BER of 10^{-6} meaning that, out of 1,000,000 bits transmitted, one bit was in error. The BER is an indication of how often a packet or other data unit has to be retransmitted because of an error. BER of a microwave link generally provides an insight to the quality and signal carrying capacity of the link under study [15].

This paper is organized in four sections. Section I introduces the motivation and nature of experimental work. Section II presents the experimental set up and the Fade Margin calculations. Observations and inferences are given in section III. Finally the conclusions are drawn in section IV.

II. EXPERIMENTAL SETUP

The study is carried out in three different geographical locations using CDMA based modems of 64 Kbps manufactured by M/s PCOM . The PN Codes used in the modems are pre-set by manufacturer and can be configured from 1 through 8 by external pin settings provided in the modem. The description of each of the setup is given below:

A. *Case –I*

A test bench setup consisting of a pair of radio modems, BER tester, 0dBm antenna and V.35 male-to-male cable to connect the modems to the tester is created. The set up is working on 0dBm power. Fig. 1 shows the snapshot of the test bench. One of the modem is identified as a Master and the other is identified as a Slave (Remote). The transmitted output power is set to 0dBm. The PN codes are set to maximum value ‘8’. The modems are set to a particular frequency value. The 0dBi Omni-directional antennas are connected to each of the radio modem and the modems are powered ON. Bit Error Rate Tester (BERT) is connected to the master modem and loop back is set. The initial readings of the BERT are noted down. Now by keeping the frequency and transmitted power constant, the PN code is decremented and the BER values are noted down. The step is repeated till the PN code value is equal to ‘1’. Next the frequency is changed as per the predefined list and the measurement process is repeated.

B. *Case – II*

Outdoor setup is created in a Central Business District of a etropolitan city .The set up consisted of a pair of radio modems connected to 24 dBi antenna via RF cable. BERT was connected to the modem identified as master. The aerial distance between the two locations is 3 km. The set up is working on 5dBm power. The length of the RF cable is 50mt at one end and 35mt at other end. The test is carried out as per the process defined in case –I above, however the modems are connected to 24dBi antenna via RF cable and the transmitted power is set to 5dBm as the locations are at considerable distance.

C.*Case- III*

Outdoor setup is created in a rural environment . The set up consisted of a pair of radio modems connected to 24 dBi directional antenna via RF cable. The modems are configured as master and slave and are set to a particular frequency. The aerial distance between the two locations is 7 km. The length of RF cable at both the ends is 37.5 m. The transmitted power is set to 5dBm. The PN codes are set to maximum value ‘8’..The modems are now powered ON. BERT is connected to the master modem and loop back is set .The initial readings of the BERT are noted down. The step is repeated till the transmitted power value is equal to maximum (in this case = 20dBm). Next the frequency is changed and the above measurement process is repeated.

Out-door setup shown in Fig.2 is used in both case-II and case-III. Equipments used in both the set-ups shown in Fig.1 and Fig.2 are given below:

1) BERT : Hewlett Packard 37732A Telecom/Datacom Analyzer

2) Radio Modems : CYLINK PCOM 64Kbps SMP Modem operating at 2.3GHz

3) Range of Frequencies : 2.304 GHz to 2.396GHz

4) Connecting Cables : V.35M-M Straight Cable

5) Antennas : Andrew 0dBi for test bench, 24dBi for high power communication. Polarization kept horizontal for maximum range.

6) RF cable : Andrew Corporation’s FSJ4-50B, HELIAX ® Super flexible Foam Coaxial Cable, corrugated copper, 1/2 in, black PE jacket

7) RF Connector : N- Type Male connector (Andrew Corporation’s L4NM connector)

Industry standard pattern of long distance microwave & satellite communication systems, 2^{15} -1 is used for this study. Also the general industry standard BER of 10^{-9} is being evaluated in this research [16].

Fig. 1 : Test Bench Setup

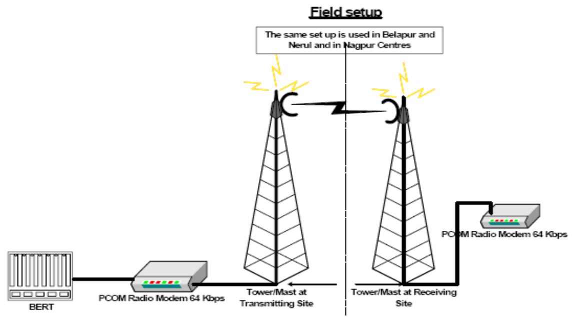

Fig. 2: Field Setup

D. *Calculation of Fade Margin [17]*

To achieve reliable communication, the radio link must have an average received signal level high enough to protect the link against fluctuations in the signal power due to multipath fading and anomalous propagation conditions. This safety factor is referred to as the "*Fade Margin*". The Fade Margin is a measure of how much additional signal attenuation the system can endure without dropping below the required BER level (In this case 10^{-9}).

Mathematically the fade Margin is defined as:

$$\textbf{Fade Margin} = G_{SG} + G_{ANT} - L_{CL} - L_{PL} \qquad \textbf{(1)}$$

Where

G_{SG} is the total system gain measured in dB

G_{ANT} is the total antenna gain of both the antennas measured in dBi

L_{CL} is the total connector cable loss of all cables

measured in dB

L_{PL} is the path loss measured in dB

System Gain (G_{SG}) is the total gain of the radio system, for PCOM microwave systems used in this research G_{SG} = 123 dB. The G_{ANT} in this research is 24dBi per location. The L_{CL} in our case is 0.5dB/m. Path Loss (L_{PL}) is very difficult to calculate as it is dependent on various factors like environment both natural and man-made, geometry of the link, power loss. The loss of power is the major contributor and is equivalent to free space path loss in dB. Generally free space path loss is considered for calculations of L_{PF}. The Fade Margin of 15dB or more is generally recommended in most situations.

Fade Margin calculation for Urban set up: For the urban set up explained in case-II (section B.) antenna gain at either location is 24 dBi. The aerial distance between the two locations is 3 km. The length of the RF cable is 50mt at one end and 35mt at other end.

Hence G_{SG} = 123 dB

G_{ANT} = 24dbi X 2

= 85* 0.5 = 42.5 dB

L_{PL} = 110 dB

L_{CL} = (50+35)* 0.5

Hence Fade Margin = $G_{SG} + G_{ANT} - L_{CL} - L_{PL}$

= 123 + 48 – 42.5 – 110

Fade Margin = 18.5dB

Fade Margin calculation for Rural set up: For the rural set up explained in case-III (section C.) antenna gain at either location is 24 dBi. The aerial distance between the two locations is 7 km. The length of the RF cable is 37.5mt at both the locations.

Hence G_{SG} = 123 dB

G_{ANT} = 24dbi X 2

L_{CL} = (37.5+37.5)* 0.5

= 75* 0.5 = 37.5 dB

L_{PL} = 117 dB

Hence

Fade Margin = $G_{SG} + G_{ANT} - L_{CL} - L_{PL}$

= 123 + 48 –37.5– 117

Fade Margin = 16.5dB

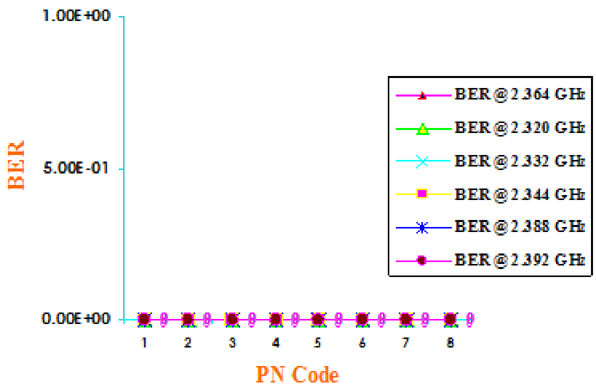

Fig. 3: Test Bench Observations

III. RESULTS & INFERENCES

A. *Test Bench Setup*

Observations of the test bench setup, explained in case-I (section II A.) are shown in fig.3. No change is observed on BER due to change of the PN codes as well as the frequency of operation. Transmitted power is kept constant at 0dBm, as it can't be changed in the test bench.

B. *Results Obtained In Urban Environment*

The fig.4 & fig.5 provides the results obtained in the field set up of an urban city for individual frequencies. It can be seen from fig.5 that the frequency of 2.320 GHz cannot be operated in the locality during the time of experimental set up. It has been observed that the link between the two locations is established by changing the PN code from 8 to 3. No direct relation was found between the BER and change in the frequency of operation. Transmitted power is kept constant at 5dBm. The transmitted power is not increased as the distance is very small and it could interfere with other radio links.

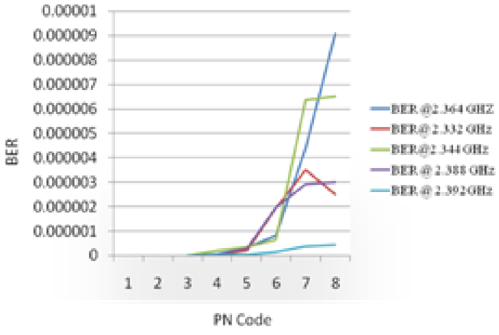

Fig. 4: Urban set up observations

C. *Results obtained in a Rural environment*

The fig.6 & fig.7 provides the results obtained in the field of a rural city for individual frequencies. It can be seen from fig.7, that the frequency of 2.332 GHz cannot be operated in the locality during the time of experimental setup. It has been also observed that the link between the two locations is established by changing the transmitted power from 5 dBm to 15dBm. After the links are synchronized no direct relation was found between the BER and change in the frequency of operation. Also no direct relationship was established between the transmitted power and operating frequency. PN code is kept constant at 7 throughout in this case.

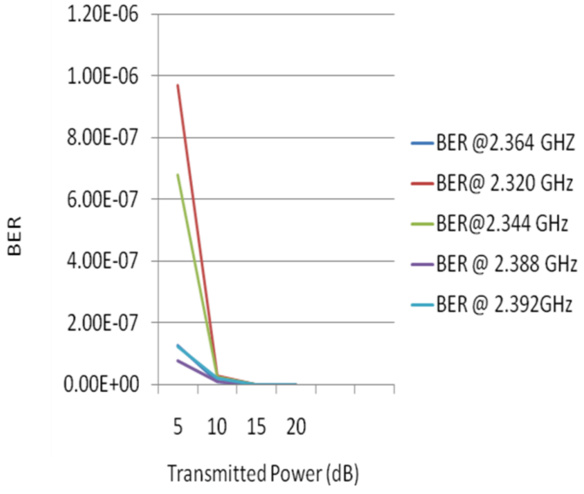

Fig. 6: Rural set up observations

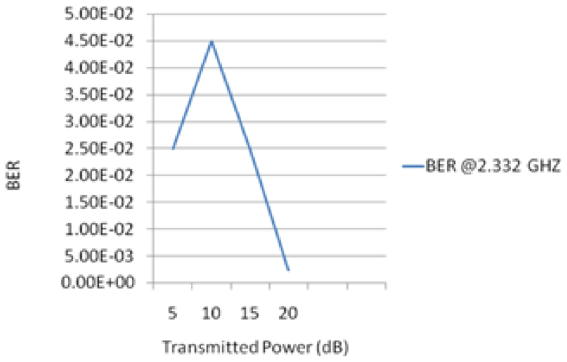

Fig. 7: Rural set up observations

IV CONCLUSIONS

The performance evaluation of the CDMA based point-to point microwave communication link to be used for VoIP application was carried out in 3 different geographical locations. The rate of change of BER with reference to the changes in PN Code, frequency and transmitted power is studied. It may be noted that change of PN code is generally required to obtain an error free communication on the event of errors observed in a synchronized link. The transmitted power is increased to raise the signal strength of the weakly received signal. The frequency is changed in order to achieve initial synchronization of the microwave links. The performance evaluation of the CDMA links can be summarized as follows.

1) If the polarization of the antenna, frequency of operation and the transmitted power are kept constant then the rate of change of BER with PN code is a function of the magnitude of radio interference.
2) If the polarization of the antenna, PN code and synchronization (frequency of operation) of the modems are kept constant. The rate of change of BER with reference to transmitted power is a function of signal strength.
3) No direct relationship was found between rate of change of frequency with PN code/ transmitted power/ BER. However change of frequency was needed in order to establish the microwave links and to achieve synchronization.

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Biography

Manas Ray obtained B.Tech. degree from Dr. Babasaheb Ambedkar Technological University, Maharashtra in 2000. He is the recipient of Dr. Babasaheb Ambedkar Gold Medal for securing first rank in the Electronics and Telecommunication Engineering Department of the University. He has obtained M.E. from Birla Institute of Technology , Jharkhand in 2009.He is persuing PhD. from Birla Institute of Technology ,Mesra, Jharkhand India.. He is a member of IEI India He has worked in the field of Satellite Communication, Long Distance Point-to-Point and Point-to-Multipoint Microwave communication, Optical network, Internet- peering technology. His area of research is Speech Coding , Internet Protocols , CDMA and its applications in the areas of High Speed Data communication networking

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