Towards Independent Measurement of End to End Bit Error Rate in GSM Network

S. A. Gbadamosi[1], A. M. Aibinu[2], E.N Onwuka[3] O.K Ugweje[4]
[1,3,4]*Telecommunication Engineering Department,*
[2] *Mechatronics Engineering Department,*
Federal University of Technology, Minna
Nigeria
[1]g_safiu.its@futminna.edu.ng,[2]maibinu@gmail.com

***Abstract*— This article introduces the trends of measuring bit error rate of GSM network independently of the service providers using a PC Based Software System. This paper further reveals the role of software defined radio (SDR) in achieving reception and transmission of signals at any carrier frequency using any standard and protocol which can be reprocessed immediately with the aid of the subject software operation of a PC. The results obtained from the reception and transmission of signals can used to estimate the Bit Error of the signal at that frequency. Thus the possibility and mechanisms of independent measurement of End to End Bit Error Rate have been presented in this paper**

***Keywords*—** Bit Error rate, Carrier frequency, PC based software, Protocol, Software Defined Radio

I. INTRODUCTION

The most widely used wireless system is Global System for Mobile Communication (GSM) and it belongs to the second generation (2G) wireless systems [1]. The growing importance of the Wireless system has brought much attention towards the performance measure of these Wireless systems. This performance can be measured in terms of Bit Error Rate (BER) which is one of the most important factor affecting call Drop [2-3]. Call drop is one of the key performance indicators (KPI) for a mobile carrier [3]. Several strategies proposed to solve the problem of call drop prove insufficient as the problem is still prevalent in some parts of the world. Among the solutions adopted was the introduction of Call Admission Control Algorithms to decide at the time of call arrival whether or not a new call should be admitted into the network. Some of the call admission control schemes adopted were; the Guard channel schemes, Queuing priorities schemes and Dynamic channel Assignment schemes. But in any digital communication systems, the quality of service (QoS) requirement for voice users is usually expressed as BER less than 10^{-3}; which is a figure of merit for a complete digital interconnect Link (including active and passive components). Probability of error (BER) usually defined as the probability that the transmitted symbol is detected in error. These errors become significant only when we wish to sustain an adequate signal–to-noise ratio in the presence of distorted transmission through electronic circuitry [4] and the propagation medium. Whenever the value of BER is higher than the set value, there will be call drop. Unless the BER is improved, the problem of call drop cannot be reduced [3]. In-depth analysis of BER has shown that it is a problem associated with air interface, greatly affected by atmospheric turbulence, distortion,[5] bit synchronization issue, Interference, attenuation problem, multipath fading in wireless network and so on which leads to channel fading [6-7],. This fading can be analyzed using models such as Rayleigh and K-distribution models by measuring the receiver's sensitivity [7]. Higher BER affect several factors of GSM networks such as the bandwidth, signal –to- noise Ratio (S/N) and the performance of the transmitter and the receiver. Previous effort to reduced BER was based on three methods which were; Diversity, Channel Coding and Channel Equalization. Lots of work has been done in the improvement of BER but little attention has been paid towards measuring this parameter independently of the mobile provider domain.

Critical examination of a complete wireless communication systems as depicted Fig. 1 have indicated that BER measurement can be conducted by measuring the receiver's sensitivity in various radio propagation conditions and testing of interference sensitivity of the receiver [4],[8]. BER can be classified into two groups namely; intrinsic and extrinsic BER as depicted in Fig 2.

The effect of this extrinsic BER cannot be over emphasized as this error distorts the signal greatly depending on the modulation techniques used. Two methods have been proposed for measuring BER namely; the Drive Test Measurement and the PC Based Bit Error Measurement.

Drive Test is time consuming whereas PC Based BER measurement (PC based Software) can be conducted through the use of Data acquisition card and a BER

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Software (radio based software). The radio based software was produced through the combined effort of both commercial and non-commercial establishments. The ultimate goal of this software defined radio was the actualization of an agile radio that receives and transmits signals at any carrier frequency using any communication protocols, all of which is reprogrammable immediately. These systems places keen request on the limits of processors and data converter since it involves real-time inclination of Giga-samples of data produced by direct conversion of wireless signals into digital data [9].

The rest sections described: the related work that can be used for measuring bit error rate; basic concept of bit error rate; working principle of software defined radio and conclusion.

II. RELATED WORK

In [10] a user configurable system capable of generating and evaluating test pattern simultaneously over three channels with data rates of up to 3Gb/s per channel was developed. It was used to test AC couple interconnect on a low orbit satellite using a FPGA based systems. In [9] more attention was focused on the flexibility of the software radio receiver using high precision A/D converter with an integrated precision down conversion and a general purpose computer platform. The ultimate goal of the work was the realization of an intelligent radio that can convey and obtain signals at any carrier frequency using any protocol, all of which can be reprogrammed virtually instantaneously. An inclusion of BER calculator makes this system a perfect BER measuring system. Since it will just compare and calculate the bit transmitted against the received bits. In [5] a broad explanation on possible solutions of interoperable problem between systems operating at different frequency bands using different standards was elucidated. The paper gave an insight into how signal processing of the digitized antenna output is done by speedy logic circuits and high velocity microprocessors which bring to mind multi-terminal/multi-frequency operation. The solution uses a PC data acquisition card and software written in Borland Delphi to measure bit error rate [5]. The modulation scheme uses a VHF carrier which is frequency modulated (i.e. Gaussian frequency shift keying GFSK).

III. BASIC CONCEPT OF BIT ERROR RATE

Error Rate (BER) can be expressed as the amount of bit error divided by total number of bits (be it received, transmitted, or processed over a fixed period) [13].

$$BER = \frac{bit \quad error}{total \quad number \quad of \ bits} \qquad 1$$

Bit error often occurs when a system fails to identify the correct logic level of the received bit. BER depends on probability, which represents the actual BER of the link only if the number of transmitted bits approaches infinity [10],[13-14], . The GSM standardization committees defined test-modes for measuring the receiver characteristics of a BTS (Technical Specification "3GPP TS 11.21"). The major characteristic of a receiver is its sensitivity, which in digital systems is determined through the Bit Error Rate (BER). The signal at the receiver end is a mixture of noise and data. The basic principle of the BER test modes is simple, send a data stream and compare the output to the input as it passes through the system [2]. A radio communication tester (CMU 200) can be used to describe the scenario as depicted in fig 3 below. A data stream can be sent to the mobile from the tester, which then sends it back to the tester (loop). The tester compares the sent and received data streams to determine the number of bit errors [8].

IV. SOFTWARE DEFINED RADIO

The approach to software defined radio (SDR) involves obtaining a real time PC receiver based with the aid of a workstation which converts the inbound signals to digital form that is near to the antenna. This method has been deployed by many other researchers in this field [15-17], . The advancement in technology of workstations with high speed circuit and computing architecture has made workstation a powerful and inexpensive hardware platform to use [9]. These software radios are constituent of a wireless network systems which have parameters and operational modes that can be modified or adjusted via software. The software is a total package that consist of transceiver (i.e. transmitter and receiver) in which the operating parameters of frequency range, utmost power output (either radiated or conducted), modulation type, Line coding, channel coding, bit rate, symbol rate, etc are contained in. The operating system in the workstation that must be adopted should guarantee maximum accessibility to all the resources of the workstation as well as drivers for the input/output operations. The SDR based 900MHz can support real time Gaussian minimum shift keying (GMSK) reception and Advance mobile phone system (AMPS) [10]. Fig 4 and Fig 5 depicts the sample receiver architecture and block diagram of the GSM-like software receiver.

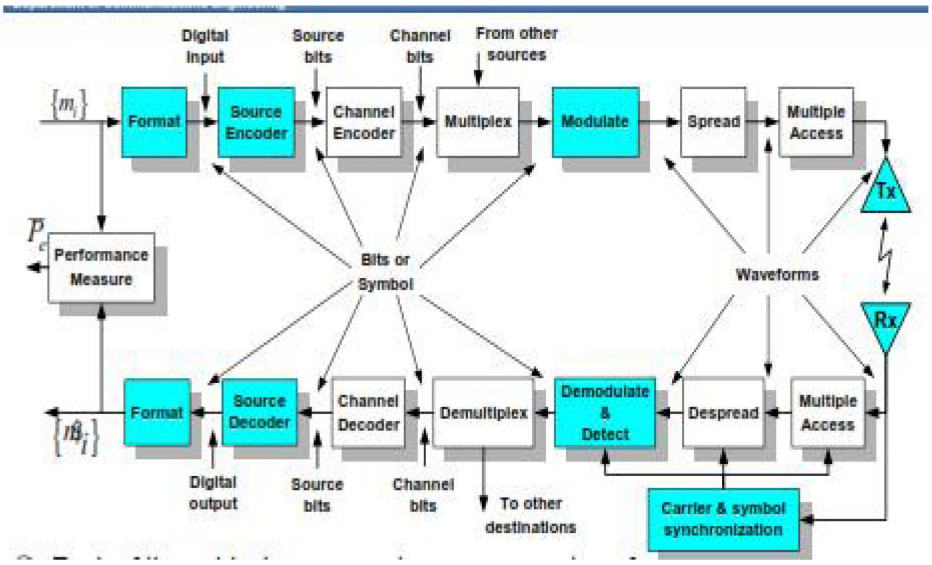

Fig 1: A complete wireless communication system (source: Ugweje lecture note 2014)

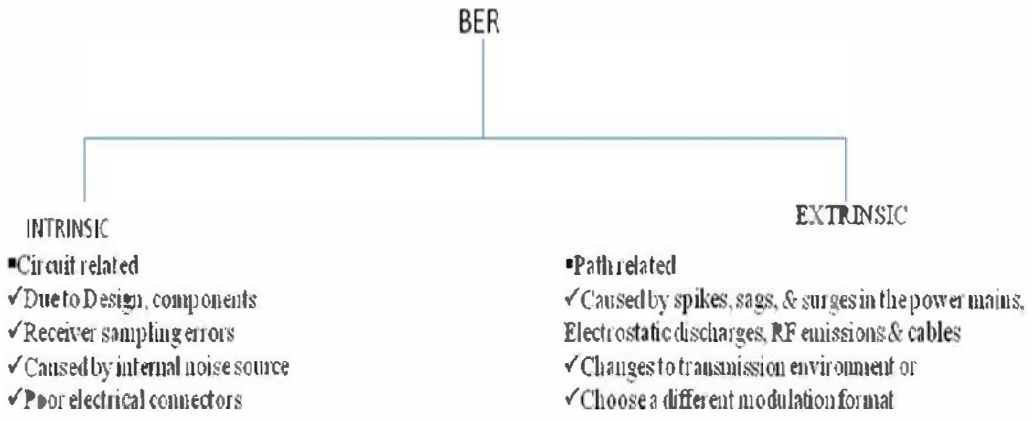

Fig 2: Classification of bit error rate in wireless network

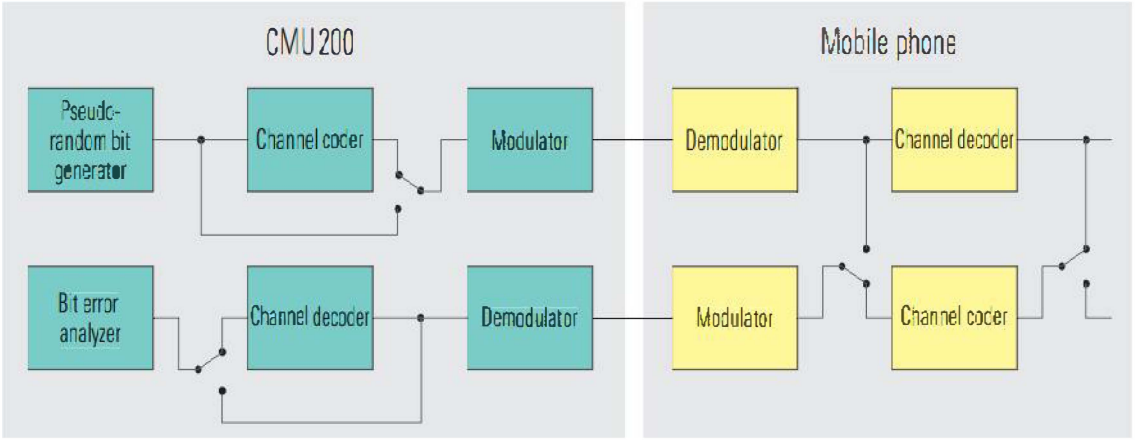

Fig 3: The radio communication tester (CMU 200) (source: Universal Radio Communication Tester CMU 200)

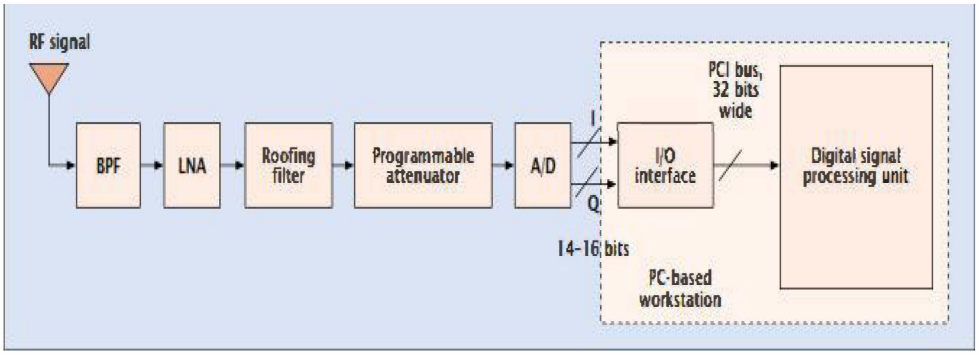

Fig 4: Sample receiver architecture (source: Massimiliano Laddomada, Politecnico di Torino: 2001)

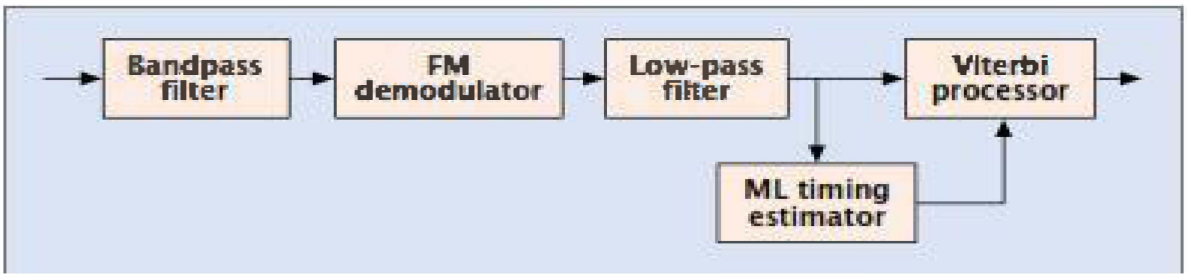

Fig 5: The block diagram of GSM-like software receiver, (source: Massimiliano Laddomada, Politecnico di Torino,2001)

V. CONCLUSION

A Bit error rate measurement system can be developed using the technology behind the software radio and the swiftness of high precision A/D converter with a ground purpose computer platform. Thus this paper gave an insight on how a bit error rate measuring systems can be developed.

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