IMPROVING HANDOFF IN MOBILE COMMUNICATION SYSTEMS USING BIT ERROR RATE OPTIMIZATION

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ABSTRACT
In the concept of handoff performance in mobile communication, Bit Error Rate (BER) was not fully considered, hence this dissertation focused on Mobility Management Scheme (MMS) in mobile communication using BER as sensitive parameter as well as throughput, media access delay and call drop. Multilinks Nigeria was used as the research test bed. A Multilink base station (mast) of height 32m with ID number HT/SE/NE/008 located at longitude N06^{0}27'53.2" and E007^{0}33'09.6 Emene Enugu (Enugu State Nigeria) with transmission power (TX power) 35dBw and transmission frequency 881.25MHz was used. A BER implementation model, MATLAB Simulink was developed while showing the validation results. The Gaussian Minimum Shift Keying (GMSK) modulator was used in the model to provide spectrally efficient modulation scheme which leads to a good BER performance and self-synchronizing capability. Empirical Mode decomposition (EMD) was used further to process the signals. The validated result showed that at signal to noise ratio (SNR) of 5, BER of the existing model was 0.006 and the proposed model was 3 at the same BER which resulted to a coding gain of 2dB. This showed that the proposed system performs better than the existing one; therefore the system achieved a good reliability as a transceiver over the existing system. Also, an empirical study on the Quality of Service (QoS) metrics for micro and macro mobility was achieved with much improvement in micro mobility compared with macro mobility.

Keywords: Handoff, Bit Error Rate, Quality of Service, Signal to Noise Ratio.

1.0 INTRODUCTION
Recent activity in mobile computing and wireless networks strongly indicates that mobile computers and their wireless communication links will be an integral part of future internetworks. Communication over wireless links is characterized by limited bandwidth, high latencies, sporadic high bit-error rates and temporary disconnections that network protocols and applications must deal with. In addition, protocols and applications have to handle user mobility and the handoffs that occur as users move from cell to cell in cellular wireless networks [1]. Handoff is a process of transferring a mobile station (MS) from one base station (BS) or Channel to another. The channel change due to handoff may be through a time slot, frequency band, code-word, or combination of these for Code-Division Multiple Access (CDMA). Efficient mobility management techniques are critical to the success of next-generation wireless systems. Mobility management enables systems to locate roaming terminals in order to deliver data packets (location management) and maintain connections with them when moving into new subnet (handoff management). Handoff management, which is one of the functions of mobility management, has become more critical in fourth generation (4G) wireless networks which support multimedia services [2].

Call Drop Out is one of the most annoying problems in Mobile Communications. A call is said to be drop when the active phone call is unexpectedly terminated. The main causes for call drop are handover (Handoff) failure, network congestion, high bit error rate, co-channel and adjacent channel interference and lack of coverage in the particular area [3]. It is one of the most important Quality of Service indicators for a mobile carrier. Over the years, many strategies have been proposed to solve the problem of call drop out. But the problem is still prevalent. One of the important reasons for call drop outs is high Bit Error Rate (BER). In general, many existing wireless systems set a threshold BER before a call is dropped [2].

Consequently, improving handoff in mobile communications using Bit Error Rate (BER) optimization is the main focus of this work (reduce the call drop out due to high BER). Planning of wireless networks is vital if operators wish to make full use of the existing investments. The proposed model used data collected from the testbed as input signal, GMSK Modulation and EMD for the signal processing to improve the BER and thereby improve the end-to -end performance of the system. The aim of the optimization is to allow seamless roaming and service continuity across various access networks. The system was simulated using MatLab and its BER was measured.

2.0 RELATED WORK

Mohanty [4] explained that an inter-system handoff between heterogeneous networks may arise in the following scenarios: (i) when a user moves out of the serving network and enters an overlying network, (ii) when a user connected to a network chooses to handoff to an underlying or overlaid network for his/her service requirements, (iii) when the overall load on the network is required to be distributed among different systems.

In Yokota et al [5], a low-latency handoff algorithm for a WLAN was proposed that uses access points and a dedicated medium access control (MAC) bridge. Seamless handoff architecture for Mobile IP, called S-MIP is presented in Hsieh et al [6] that combines a location tracking scheme with the HMIP handoff.

A vertical handoff mechanism between IEEE 802.11 (WLAN) and IEEE 802.16e (Mobile WiMAX) networks in a wireless mesh backbone is proposed in Zhang [7].
In Dutta et al [8], a media-independent pre-authentication scheme was proposed. The authors noted that the delay in Mobile IP handoff was contributed by two elements: (i) the delay in movement detection of the MN, and (ii) delay due to signaling for registration. The proposed mechanism reduces the movement detection delay. It has two parts: (i) handoff for the forward direction (i.e. mobile-terminated data) and (ii) handoff for the reverse direction (i.e. mobile-originated data).
Harini [9] proposed an enhanced Hierarchical Mobile IPv6 (E-HMIPv6) architecture based on a novel cross-layer/cross protocol design approach. Using simulation results, the work show that, the handoff delay and packet loss are reduced in (E-HMIPv6) based handoff, when compared with the standard HMIPv6 based handoff.

The work of Wei and Jung [10], considered handover operations while focusing on the modification of hierarchical Mobile IPv6 to support fast handoff by reducing the influence of duplication address detection (DAD). Through their investigations, the work then proposed a Stealth-time HMIP (SHMIP) which can reduce the effect of the DAD time on the handoff delay thus reducing the handoff time significantly. To further reduce packet losses, the work adopt pre-handoff notification to request previous MAP to buffer packets for the mobile node. By simulations, it was shown that the proposed scheme can realize low handoff delays and low packet losses during macro mobility.

In Chiranjeev and Rajeev [11], the authors proposed a new preemptive handoff scheme in integrated mobile communication environment. Analytical models and simulation results were generated which showed that their proposed system offers a degree of protection to data calls from pre-emption unlike previous preemptive schemes.

The authors in Alagu and Meyyappan [12] analyzed the different traffic schemes for handoff handling and call blocking attempts in mobile cellular networks. The work then analyzed various Handoff schemes for multiple traffic system and simulates an Asynchronous Transfer Mode (ATM) based wireless Personal Communication Network to implement the non-preemptive Measurement Based Prioritization Scheme (MBPS). Call Blocking (Total number of calls blocked / Total number of calls processed), Handoff failures (Total number of handovers not assigned channels / Total number of calls processed) and Throughput ((TSC + TSH) / Total number of calls processed) are the simulated metrics for the study. Where, TSC = Total number of calls that have been assigned channels and backbone links. TSH=Total number of handovers that have been assigned channels and backbone links.

The work of Goswami and Swain [13] developed an effective and efficient handoff scheme using mobile controlled handoff and fractional guard channel techniques, where mobile station measures the signal strength from surrounding base stations and interference level on all channels. Two models are proposed to calculate the blocking probability of new calls and the dropping probability of handoff calls, using call admission control scheme in a cellular system. Numerical analyses of both the models are carried out to investigate the impact on performance of the parameters and comparisons with conventional channel reservation schemes.

Li and Samuel [14], presented a comprehensive performance analysis of fast handover for Hierarchical Mobile IPv6 (F-HMIPv6) using the fluid-flow and random walk mobility models. In their work, location update cost, packet delivery cost and total cost functions were formulated based on the proposed analytical models. In this work, the impact of several wireless system factors such as user velocity, user density, mobility domain size, session-to-mobility ratio was discussed also.

The work of Saied et al [15], proposed an enhanced packet scheduling scheme to favour user equipment (UEs) that experienced handover (HO) in wireless mobile networks. At the scheduler level, a Packet Scheduler based-Handover Class (PS-HOC) scheme makes use of the elapsed time of HO connections to classify the HO requests into prioritized HO and non-prioritized HO calls. Further, PS-HOC sorts the connections based on their delay sensitivity and their channel quality. The performance of the proposed scheme is compared with delay driven scheduler (DDS) scheme in terms of average packet delay, average queue size and average packet dropping rate. Their simulation results show the effectiveness of the proposed scheme.

3.0 METHODOLOGY

Improving the network platform for NGWN (Next Generation Wireless Network) meet it specific requirements in terms of BER (Bit Error Rate) optimization, three steps are considered:

1. **Real-time system drive test methodology**: This is a method of measuring and assessing the coverage, capacity and Quality of Service (QoS) of a mobile radio network. Also, it is the process of manual collection of radio interface performance information in the geographical area of interest. In this work, a preliminary visit to understudy handoff procedures was achieved. At the outset of this work, several network operators thriving on 3G services were visited, while finally using Multilinks Nigeria for the research test-bed. A multilink base station (mast) of height 32m with ID number HT/SE/NE/008 located at longitude N06^{0}27’53.2” and E007^{0}33’09.6 Emene Enugu (Enugu state Nigeria) with transmission (TX) power 35dBw and transmission frequency 881.25MHz was considered.
2. **Empirical Decomposition methodology**: Empirical Mode Decomposition is a non-linear technique for analyzing and representing non-stationary signals in handoff mobility management systems. This is data-driven and is used to decompose a signal in the time domain, into a complete and finite set of adaptive basis functions which are defined as Intrinsic Mode Functions (IMFs). It involves the use of Fourier and the Wavelet Transforms. The motivation behind the EMD is to perform a procedure on a signal and then to iterate on the residual low frequency parts.
3. **Modeling and simulation methodology with MATLAB Simulink and OPNET software**: Model representation (or model specification) is the process of describing system behaviour and in-so-doing converting the model that exists in the mind(s) of the system designer(s) such as conceptual model(s) – into a model that can be communicated to others i.e. communicative model. The primary role assigned specification in the development of software is to enunciate what the system is to do as separate from how it is to be done- This representation is most often accomplished via a specification language or tool.

3.1 Physically Proposed Model for Peer to Peer Mobility

The model of handoff mobility reengineered for efficient QoS application integration will address physical channel communication, network scalability, BER scaling, and packets traffic control. The model will address possible user-centric issues such as call drops, throughput effects, and media delays during micro and macro mobility. Figure 1 shows the flow diagram.

The Model is described below [2]:

The burst builder is used to model the user equipment source which performs the Cyclic Redundancy Check (CRC) in an ongoing call. Traffic generation undergoes convolutional encoding. The bernoulli binary generator block also generates binary numbers (traffic source). The traffic optimization bank comprises of the convolutional encoder (which encodes the binary numbers or user data), the inter-leaver and the modulator array. The CRC generator library block generates and appends the CRC bits information. These CRC bits are used to detect errors in the data frame at the receiver. These CRC bits are used to detect errors in the data frame at the receiver. The Convolutional encoder library block also encodes the traffic against channel errors.

The GMSK reshape optimizer bank further enhances error reduction at the transmitting station. Space time diversity encoder sends the same data over independent fading paths (channel).

These independent paths are combined in some way such that the effect of fading on the resultant signal is reduced. The GMSK transmitter is to split the high- traffic rate data stream and transmit simultaneously over the channel. After data is modulated by GMSK modulator, the traffic is passed through the GMSK transmitter. This data traffic is passed through the channel. In the channel, we used AWGN effects. This channel produces some errors in the transmitter traffic data. At receiver, the transmitted data is recovered. AWGN Channel block adds white Gaussian noise to each symbol of the bipolar data. This noise represents the random error in the demodulation of the symbol. The AWGN Channel subsystem implements the propagation through multiple paths of a Rayleigh fading channel [2].

The Mobile Station Transmitter GMSK was used to provide spectrally efficient modulation scheme which leads to a good BER performance and self-synchronizing capability. The receiver section of the system is responsible for the recovery of the data symbols transmitted on the traffic channel. The operations performed in this section include receiver filtering, the GMSK correlation, the GMSK demodulation, and descrambling.

The Receive filter block performs gain amplification filtering on the received sample streams with a filter that is matched to transmit to maximum in-band signal-to-noise ratio. The decoded information bits and the CRC bits are provided to the predictor traffic quality detector block. The GMSK receiver computes symbol duration correlations for the traffic data and pilot symbols with its gain factor. The predictor block compares the information bits to the bits generated at the source. Finally, the resultant bit and frame error rates are displayed.

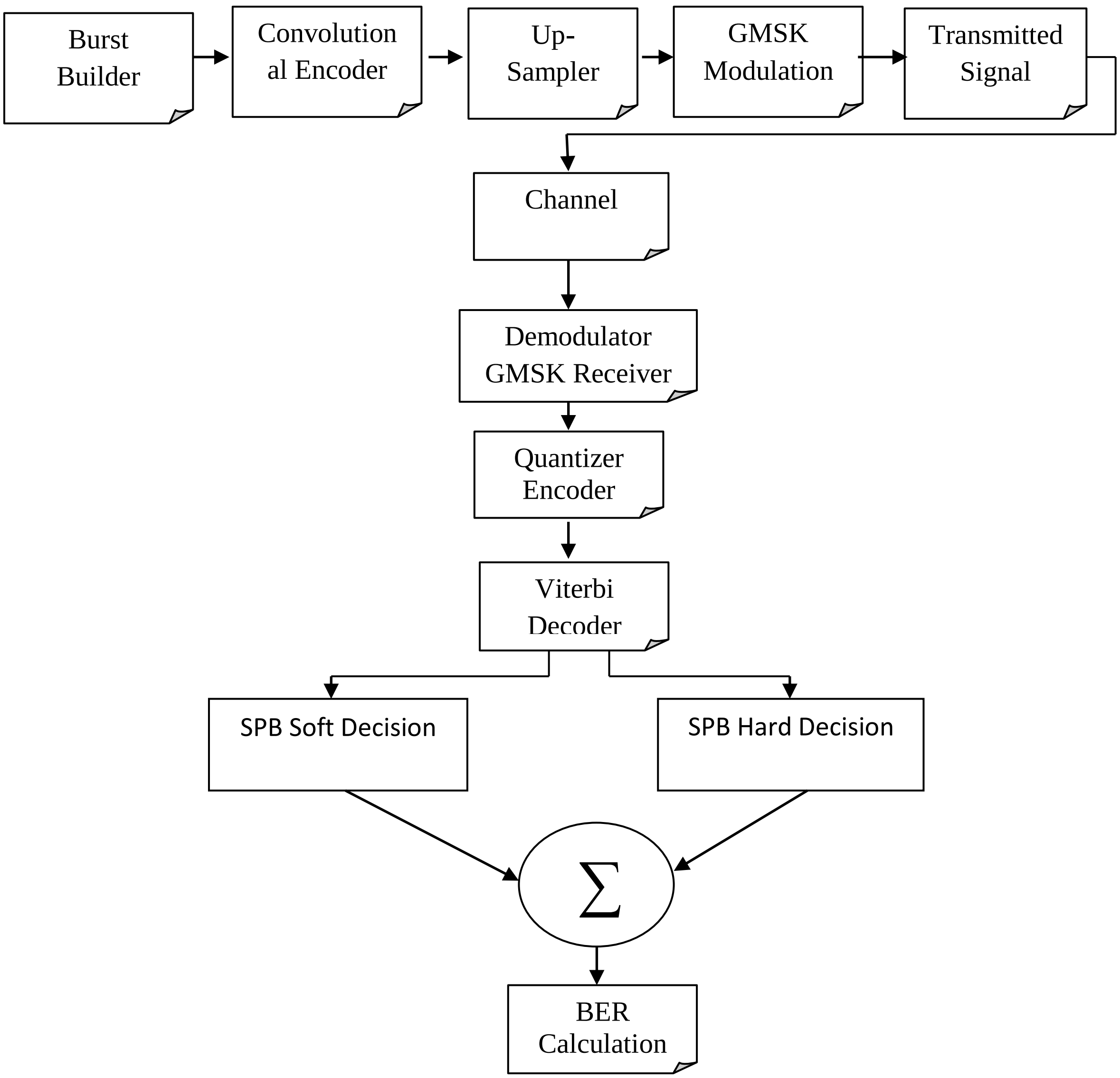

Figure 1: *System Flow diagram [2]*

Mobility Prioritization Scheme with Guard channels

In the proposed network, if all channels of a cell are occupied, calls originating within that cell are simply blocked and the handover requests to that cell are queued based on their priority This follows a non-preemptive dynamic priority discipline. The handover area are the regions marked by different ranges of values of power ratio, corresponding to the priority levels such that the highest priority belongs to the MS whose power level is closest to the receiver threshold. On the other end, MS that has just issued a handover request has the least priority. Obviously the last comes at the end of the queue. A queued MS gains higher priority as its power ratio decreases from the handover threshold to the receiver threshold. The MS‘s waiting for channels in the handover queue are sorted continuously according to their priorities [2]. When a channel is released, it is granted to the MS with the highest priority.

Predictor Unit

This unit predicts and displays the bit error rate (BER) and Signal to Noise ratio, etc for both soft and hard decisions in the mobility peer to peer system. Both of these error rates show the effects of MS to MS communication via the channel as well as the received signal strengths captured at optimal frequencies. The prediction output decouples the multipath fading intensity and additive noise in the system. The GMSK Space-Time Diversity Decoder /Combiner, GMSK transmitter/Receiver, Channel and the Predictor are the key subsystems of system. This paper used Minimum Shift Keying (MSK) for modeling the Peer to Peer micro mobility system.

GMSK Modulator

The ultimate goal of a modulation technique is to transport the SMS signal through a radio channel with the best possible quality while occupying the least amount of radio spectrum. Since voice is the main payload of cellular network, the model is described by

$$X[n] = S[n] + t[n] \quad (1)$$

Where, *X[n]* is the noisy speech signal, *S[n]* is the original call speech *and t[n]* is the noise source. At micro-mobility, the noise reduction block is placed at the demodulator of the MS receiver of the peer to peer system.

Now, for the GMSK modulator used, the mathematical model is derived below. Since the mobility baseband signals are generated at low rates, these signals are now modulated on an RF carrier for transmission. The baseband signal s(t) is a complex function represented by

$$s(t) = a(t)e^{j\theta(t)} \quad (2)$$

Where $a(t)$ = Amplitude and $\theta(t)$ is the phase.

The Fourier transform of *S(t)* is given by

$$S(f) = \int_{-\infty}^{\infty} s(t)e^{-j2\pi ft}dt \quad (3)$$

A functional block diagram of a generic modulation procedure for signal *S(t)* is given by

$$x(t) = \text{Real}\ \{s(t)\ A_c\, e^{ej2\pi fc^{t}}\} = A_c a(t)\cos[2\pi f_c t + \theta(t)] = A_c a(t)\cos\ \omega(t) \quad (4)$$

$$x(t) = A_c.a(t)\cos\theta(t)\cos(2\pi f_c t) - A_c.a(t)\text{Sin}\theta(t)\text{Sin}(2\pi f_c t) \quad (5)$$

The BER performance of GMSK with coherent detection under AWGN conditions is given by

$$P_e = \text{Xfc}\ \left(\sqrt{2\beta \frac{E_b}{N_0}}\right) \quad (6)$$

Where β is a degradation factor due to pre-modulation filter.

$\beta = 1$ corresponds to the performance of index of GMSK

The BER under Rayleigh channel condition is given by

$$P_e = 1 - \frac{1}{\sqrt{1 + \frac{1}{\beta({E_0}/{N_0})_{avg}}}} \quad (7)$$

Where $({E_b}/{N_0})$avg = Avg. Value.

Again, for the burst message:

D(t) *(t) = Acos(wt+θ)* *Channel*. (8)

Where *D(t)* is the message, *Acos(wt+θ)* is the modulation. Modulation is done by varying the amplitude *(A)*, phase *(θ)*, or frequency *(wt)* of a high frequency carrier in accordance with the amplitude of the message signal [2].

4.0 RESULT

Mobility QoS Model Validations

Figure 2 shows the decreasing signal strength in a macromobility scenario. As the distance from the BS increases, the signal strength shows a recursive degradation which affects the quality of service even at higher BER. This is a very conspicuous behavior as seen in today's networks offering 2.5 and 3G services. In a NGWN, this behaviour is expected not to affect QoS index at large considering the BER also [2].

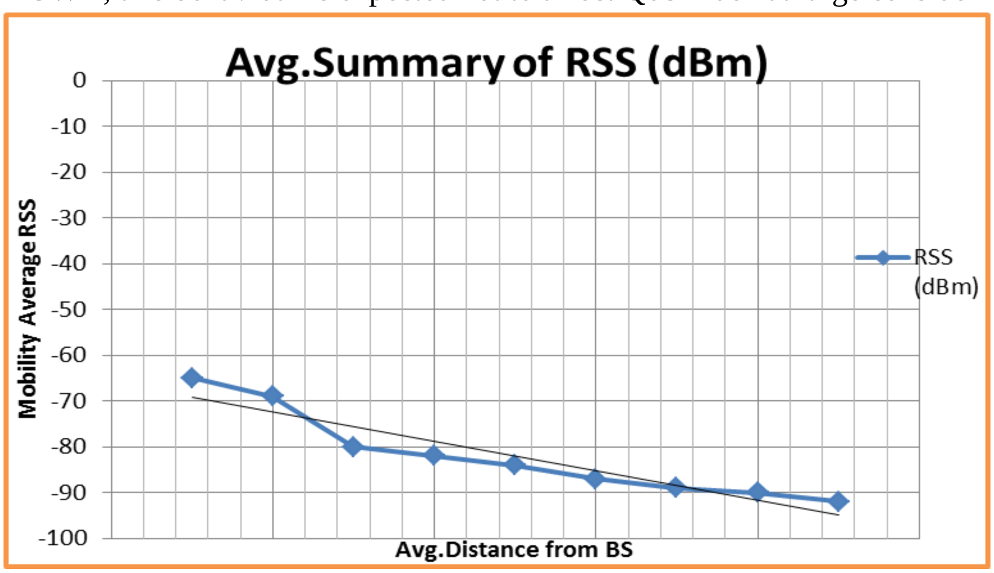

Figure 2: *A Plot of Summarized Avg.RSS with Distance*

Bit error rate (BER) performance of the proposed model

From the graph, for higher values of SNR, the BER is low

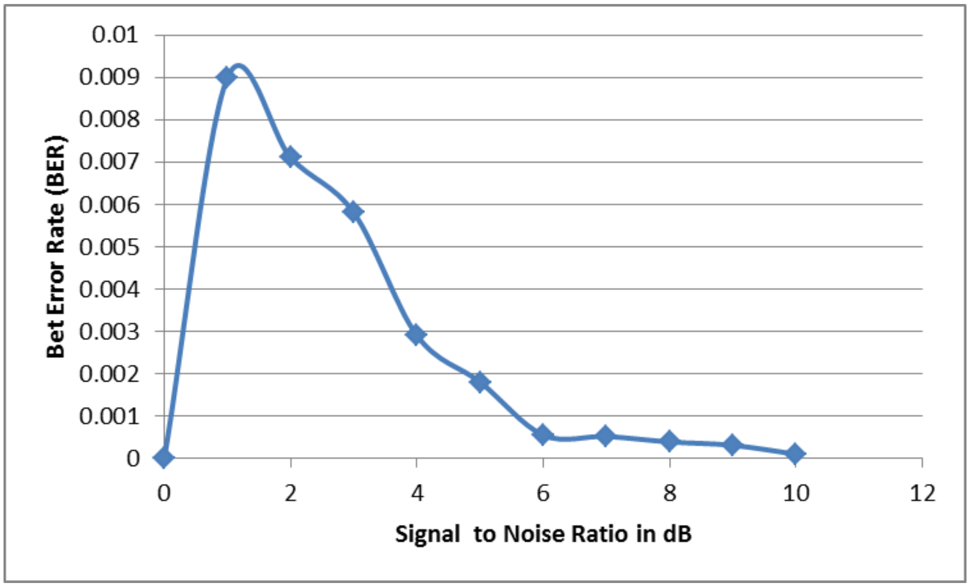

Figure 3: *BER Vs SNR graph for the proposed model [2].*

Comparison of the Result of Existing Work with the Proposed Work

Table 1: Shows the results for the BER at different values of Eb/N_0. The 'BER Simulated' in the table gives the BER without the SPB

Eb/N0 in dB	-5	-4	-3	-2	-1	0	1	2	3	4	5
BER Theory	.19	.17	.146	.122	.098	.076	.055	.037	.023	.01	.005
BER Simulated	.22	.18	.158	.130	.102	.079	.056	.039	.024	.01	.006

Theory gives the theoretical values, using equation $P_b = Q(\sqrt{2Eb/N_0})[1-2Q(\sqrt{2Eb/N_0}]$ and BER Simulated gives the simulated values for different Eb/N_0. It was observed that a coding gain of approximately 0.02 dB is obtained.

The previous work and the proposed work, at the same BER = 0.006, SNR of the previous work is 5 and SNR of the proposed work is 3, therefore coding gain is = 5-3 = 2dB, therefore the system achieved a good reliability as a transceiver over the existing system.

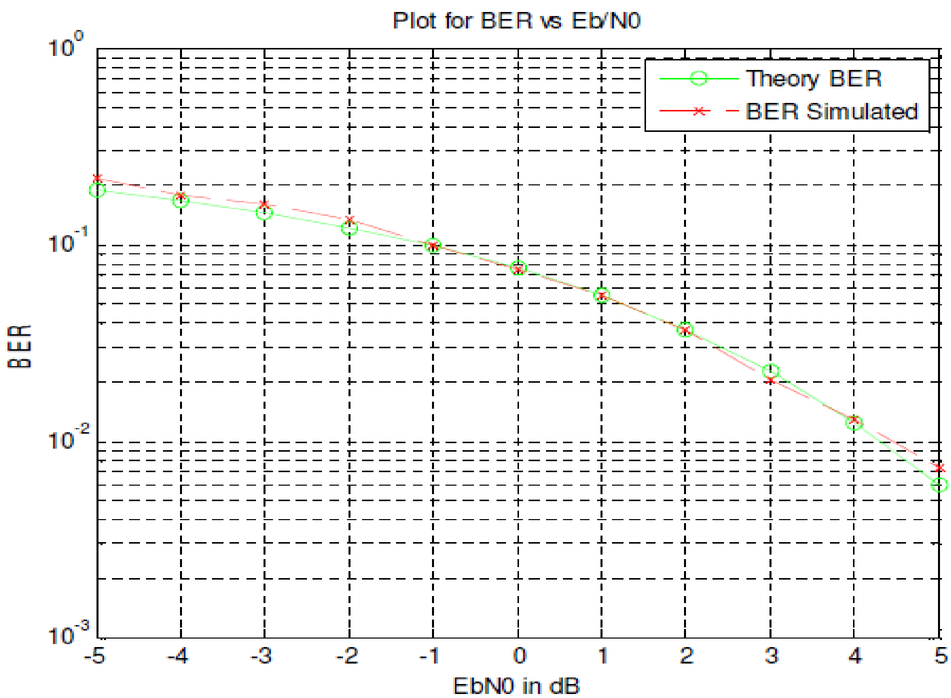

Figure 4: *Theoretical and simulated comparison curve [2]*

CONCLUSION

This work used an investigative research approach to show how improvement of handoff scheme in mobile communications can be achieved in the context of Mobility management for NGWN. The work proposed a mobility management architecture that can guarantee seamless roaming and service continuity for real-time applications using details from field study. MATLAB Simulink was used to develop an experimental model for BER analysis considering handoff scenarios while making deductions on their effects on sensitive metrics, such as delay and packet loss applications.

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