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ASSESSMENT OF HIGH NETWORK LATENCY ON BROADBAND POWERLINE COMMUNICATION

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***Abstract* - This paper focuses on the evaluation of broadband power line communication taking in terms of data transmission and the delayed measured and compared to theoretical values. The utilization of communication systems has expanded rapidly. However, there is a need to deploy new telecommunication systems and transmission technologies that can carry more data and allows faster transmission at a minimal cost. Due to this, the effect of high latency, noise and interference in communication networks is one major challenge that pose great danger to faster and successful data transmission. We use data obtained from the software tool (ICMP) which recorded the ping statistics and (SPSS) in data coding and analysis. Broadband power line communication may be seen as complementary or alternative solutions to traditional fixed line networks and wireless networks according to existing network architectures with PLC bandwidths set to increase**

Index Terms - Latency, Broadband Power line Communication (BPLC), National grid, Power Line Technology (PLT).

I. INTRODUCTION

The crowded wireless spectrum and its high demand have driven researchers to look for more sustaining and lower cost communication alternatives. In order for information to be transmitted from one point to another such transmission mediums such as optical fiber, coaxial cables, satellite microwave etc. have been deployed to carry enormous bandwidth and stand the test of time.

Over the years , power line technology were known for voice transmission using single carrier narrowband technology operating with low frequency band and also allows the provision of data rate in few kilobits per seconds (Kbps)[1][2][3].

Power-line Technology (PLT) is another form of wired networking that uses the existing Alternating Current (AC) source transmission medium within buildings as a communication channel[4]. It also referred to as broadband over power line[5]–[7]. However, instead of using telephone network cables laid directly to your homes and offices, it transmits the broadband internet access over the existing national grid power cables and this is done by demultiplexing the electricity and internet service into different wavelength. Its uses existing power lines as a medium of transmission to provide a high data speed over power lines. This is achieved by superimposing a modulated signal or by coupling a radio frequency energy over a power line on definite carrier frequencies onto a power line and helps to avoid using expensive transmission medium such as fiber optics and microwave [8].

The technology under study can be categorized into either broadband or narrow band technology. In narrowband, lower frequencies are typically in the range of (1 KHz-1 MHz) whereas broadband are deployed for the range of frequencies (1-30 MHz). Power line communication technology find itself in the applications of smart grids[4], [9]–[13]. Broadband power line technology allows frequencies within the range of 150 kHz to 34 MHz having a theoretical maximum speed of 200Mbps [14]. The technology is less time consuming to deploy because of the existence of AC power outlet within virtually, every building. Services such as broadband Internet, Voice, data, and a variety of value-added services can be run through this medium [15]

Broadband power line technology is one of the technologies that has being deployed for few years now to carry broadband internet services to various destinations (homes and offices). It uses power cables as a medium of transmission to carry data and exchange over existing power cables[16][17].

BPL systems work by combining radio frequency energy with current power lines. The orthogonal Frequency Division

Multiplexing (OFDM) modulation method is used to deliver high-speed data communication to clients. Data transmission is produced configurable to guarantee that download and upload speeds are customer-specific[18].

The system is capable of working within the (10-30 MHZ) frequency band in the midst of harmonics and distortions in online supply so that noise and power quality issues do not occur. In any case, the signal strength should not be less than 30 dB across the network. Home linked to electrical power lines can be part of the BPL communication network and use digital broadband communication facilities by simply plugging into a computer-connected BPL modem or any other appropriate communication device to access high-speed internet and enjoy voice and data communication[16][17], [19].

II. RESEARCH DESIGN MODEL

Research design is a procedure in which valid data is collected and analysed, obtaining from different sources. This help to react towards the respective relevant scope and research problems aiming in getting the cause of delay in some network parameters while achieving some levels of accuracy with value of information aligned in reference to all levels of accuracy with structural maximization. According to Groenewald (2004), research design has been noted as an advanced set of decisions that creates the master plan for the determined methods as well as proceedings for the collection of data and analysis of the same. Detailed Research design is the types of approaches meant for both research and implementation of the research work. Measuring of variables is key and mostly concentrated while collecting data using software tools is carried out. A notable strategy in preparing the sample of the selected measured data is outlined while making way for analysing the data collected. A successful research design as defined by many scholars is about comparing: design of exploratory, purposive, evaluating research ethics, develop of data plan through analysis, which includes tables, determining of data by fixing research problems as identified and identifying the parameters that is affecting network performance. It is important to maintain necessary caution in order to avoid defining symptom instead of underlying problem [20] .

III. DATA ANALYSIS METHOD AND TOOLS

The author used content analysis, because of its advantages in qualitative and quantitative analysis. The analysis was used to develop questions in relation to the chosen samples. The qualitative procedure was use in coding the data into manageable content. The author coded for specific patterns which depict the questions. The gathered information is being simplified and reduced while the provided results can be measured using quantitative approach [21]. Content analysis is a tool authors use to structure qualitative research data collected which support and satisfy the research objectives and the data samples that could generalized to answer key questions.

The main disadvantage of content analysis is the high level human errors/ high human interaction, this can lead to misinterpretation of data and findings making the process unreliable conclusions[22]. The network reading is in raw data, the data are coded in numeric, and this coding is done according to how the software accept input to indicators variables. SPSS is a computer software that use in data analysis, this tool will be use in addition to Microsoft Excel. The results will be display in graphs, charts and in tables after analyzing.

IV. MATHEMATICAL MODEL

Measure of central tendency is a value that represent a typical/central entry of a data set and the most common measures of central tendency are: Sample mean (Average) and the sum of all the data entries divided by the number of entries as captured by the software tool. The frequency of repeated readings is observed.

$$\underline{X} = \frac{\Sigma x}{n} \quad (1)$$

$$S = \sqrt{\frac{\Sigma(x-\underline{x})^2}{n-1}} \quad (2)$$

Equation 1 is the sample mean and equation 2 is the sample standard deviation. Standard deviation measures consistency and viability of the sample. Good consistency is an advantage while less variation is better.

Correlating the variables using Kendall coefficient. The model is use in determining the level of association between multiple sets of ranking of individual or even objects as well as data. A situation where only two variables are involved, spearman coefficient of correlation is applicable as follows.

$$W = \frac{S}{K^2\left(\frac{N^3-N}{12}\right)} \quad (3)$$

Where S = $\Sigma(R_j - R_j)^2$ and N is the number of objects ranked, K number of sets ranked, R ranks assigned by K and R_j absolute mean of ranks.

$$R_{11} = \frac{\Sigma W}{AN} \quad (4)$$

Relative importance index where W is the weight given to each factor by the respondent ranging from 1-5, A highest weight and N total number of respondent.

V. SOURCE OF DATA

In order to achieve the main aim of the study, data was obtained from the software tool Internet Control Message Protocol (ICMP) which recorded the ping statistics and trace route. The parameters and their readings, which were captured, are Internet Protocol (IP) address, time-to-live (TTL), Bytes, and the time in milliseconds (ms). Both transmit and received data were updated and recorded. The ping statistics for IP address

192.168.1.2 on local area network are: packets sent (1000), received packets (1000), lost packet (0), and the maximum approximate roundtrip of time is averaged to (7ms). Ping statistics for IP address 197.251.230.38 on broadband power line are: sent packets (1049), received packets (939), lost packets (110), maximum and minimum approximated roundtrip of time in milliseconds are 834ms and 31ms respectively and averaged to 143ms.

VI. Results Analysis and Discussion

This study conducts a survey on the excessive delay on broadband power line communication relative to Local Area Network (LAN). The measured parameters are IP address, time to live, bytes and the transmission time in milliseconds. Internet control message protocol (ICMP) with pings and trace route is employed for data capturing while Microsoft Excel and the Statistical Package for Social Scientists (SPSS) are computer software's generally use in data coding and analysis, these tools are employed in analysing the data while making meaning to the displayed graphs, charts and tables. The results and discussions are skewed toward the research objectives of the study. The results and analysis are inferred while comparing literature to establish relevance.

TABLE I. NETWORK READING ON BROADBAND POWER LINE COMMUNICATION

Local Area Network Reading on roundtrip				
IP Address	**Bytes**	**Time in milliseconds (ms)**	**TTL**	**Average time(ms)**
192.168.1.2	32	1 1 1 1 1 2	128	1.167
192.168.1.2	32	1 1 1 2 1 1	128	1.167
192.168.1.2	32	1 1 1 4 1 1	128	1.5
192.168.1.2	32	4 1 5 1 1 1	128	2.167
192.168.1.2	32	1 3 1 1 1 1	128	1.333
192.168.1.2	32	4 1 2 1 1 4	128	2.167
192.168.1.2	32	1 1 1 1 1 1	128	1
192.168.1.2	32	1 1 1 1 1 1	128	1
192.168.1.2	32	4 1 1 1 1 4	128	2
192.168.1.2	32	1 1 1 1 1 1	128	1
192.168.1.2	32	1 3 4 1 2 1	128	2
192.168.1.2	32	1 1 1 1 1 1	128	1
192.168.1.2	32	1 4 1 1 1 2	128	1.667
192.168.1.2	32	1 1 1 1 1 1	128	1
192.168.1.2	32	1 1 1 1 1 1	128	1
192.168.1.2	32	1 1 1 1 1 1	128	1
192.168.1.2	32	1 1 1 1 1 1	128	1
192.168.1.2	32	1 1 1 1 1 1	128	1
192.168.1.2	32	1 1 1 1 1 1	128	1
192.168.1.2	32	1 1 1 1 1 1	128	1
192.168.1.2	32	1 1 1 1 1 1	128	1
192.168.1.2	32	1 1 1 1 1 1	128	1
192.168.1.2	32	1 1 1 1 1 1	128	1
192.168.1.2	32	1 1 1 1 1 4	128	1.5
192.168.1.2	32	1 1 1 1 1 1	128	1
192.168.1.2	32	1 1 1 1 3 1	128	1.333
192.168.1.2	32	1 1 1 1 1 1	128	1
192.168.1.2	32	1 1 1 1 1 1	128	1
192.168.1.2	32	1 3 1 1 1 1	128	1.333
192.168.1.2	32	3 1 1 1 2 1	128	1.5
192.168.1.2	32	1 1 1 1 1 1	128	1

Table 1 consists of the IP address, Bytes, Time in milliseconds, Time to Live (TTL) and the average time. The IP address is a number assigned to each computer active on a network supporting the internet protocol; this distinguishes each network from every other network interface on the network. Each IP address is carried by a sequence of eight bits to represent one character and processed as single unit of information. The time taken for every information to make a roundtrip is recorded in milliseconds with the corresponding Time to Live (TTL). The average time taken is also recorded for the same IP address as shown in Table 4.2. Ping statistics for IP address 192.168.1.2 on local area network are: packets sent (1000), received packets (1000), lost packet (0), and the maximum approximate roundtrip of time is averaged to (7ms).

TABLE II. " BROADBAND POWER LINE

IP Address	TTL	Frequency	Average Time (ms)
197.251.230.38	58	2	140
197.251.230.38	58	1	134.8
197.251.230.38	58	1	135.33
197.251.230.38	58	1	131
197.251.230.38	58	1	143
197.251.230.38	58	1	135.61
197.251.230.38	58	1	142.83
197.251.230.38	58	1	134.5
197.251.230.38	58	1	139.33
197.251.230.38	58	1	130.5

TABLE III. " LOCAL AREA NETWORK

IP Address	TTL	Frequency	Average Time (ms)
192.168.1.2	128	5	1
192.168.1.2	128	5	1
192.168.1.2	128	5	1
192.168.1.2	128	5	1
192.168.1.2	128	5	1
192.168.1.2	128	5	1.33
192.168.1.2	128	4	1.5
192.168.1.2	128	2	1.68
192.168.1.2	128	5	1
192.168.1.2	128	5	1.33

VII. TABLES OF PLOTTED VALUES AND GRAPHS

Table 4.3 and 4.4 represent the tables used to generate graphs for analysing and discussions. The frequency represents how many time a value occurs in the recorded data. IP address with high frequency shows consistency in a roundtrip of delay, meaning a value occurring several times within the acceptable range. Broadband power line shows an irregular parting with values recording just one occurrence and very high average delay of time in milliseconds while the local area network recorded relatively high values of frequency with low average delay time in milliseconds. The roundtrip for the IP address of the local area network also recorded low values of delay as shown in the above tables.

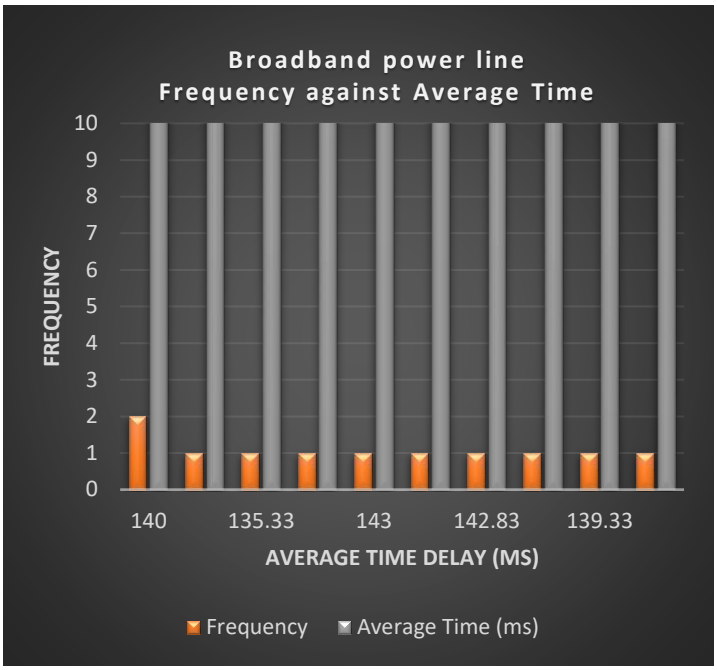

Figure 1. Broadband Power Line Delay

The figure depicts the average delay of broadband power line communication. The highest value of 143milliseconds with a frequency of one (1) are recorded while 140 recorded the highest frequency of two (2), 142.83 and 139.33 also recorded the second and third highest value of delay with same frequency value of one (1). The maximum delay difference is 12.5milliseconds with an average frequency of one (1). The frequency value shows how often a delay occur for every roundtrip, the graph further reveals the high values of delay recorded in broadband power line communication peaking a little above research finding. [23] in their recent publication of vehicular delay analysis on power line communication recorded a maximum delay of 100milliseconds which is lower than the 145milliseconds recorded but within the generalized range. The total delay difference between the maximum and the minimum falls within 12.5milliseconds which differ but good in relative to 18 milliseconds as reported in the above publication.

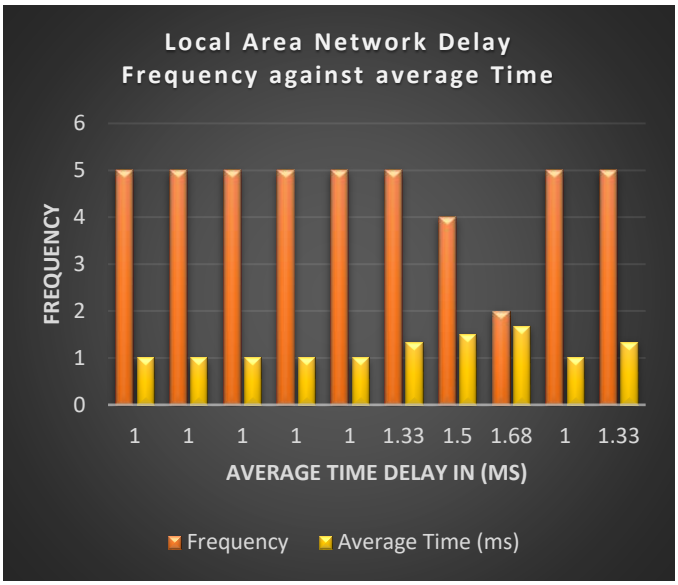

Figure 2. Local Area Network Delay Relative to Broadband power line communication

The figure represents a local area network transmission delay. The highest delay recorded is 1.68milliseconds with a frequency of two (2) while the second highest value of 1.33milliseconds recorded a frequency of five (5) and 1.5milliseconds recorded four (4). The remaining delay recorded a frequency of five (5) and the lowest delay recorded is 1milliseconds and a maximum of 1.68milliseconds with a difference of 0.68milliseconds. The higher the frequency, the more acceptable and consistent the delay occur, the delay is considered to be within the acceptable range. [24] publication on transmission propagation and recently updated in 2018 reported a delay of (1-3)/milliseconds which is in line with this thesis and findings.

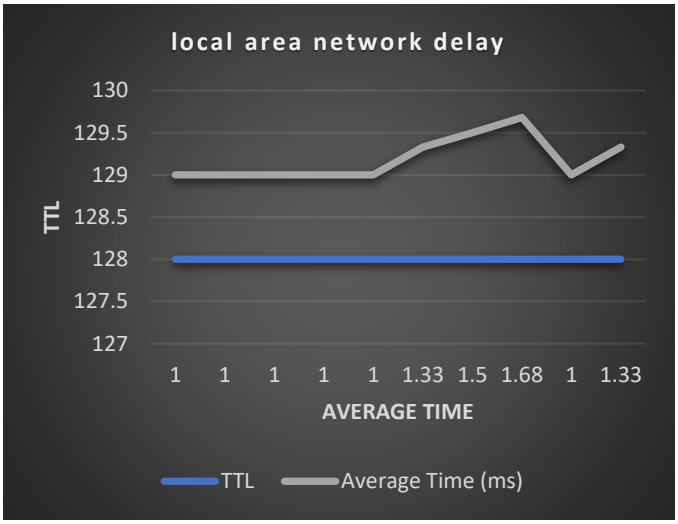

Figure 3. TTL to Average delay of Local area network

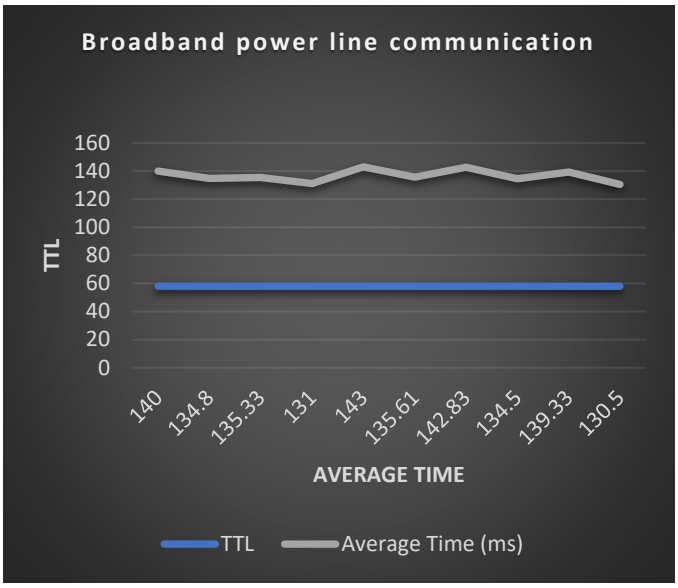

Figure 4. TTL to Average delay of broadband power line communication.

The figure represents broadband power line communication delay, as the time to live value remains the same as 58, the average time keeps varying and reaches a peak value of 143milliseconds and 142.83ms before a low value of 130.5ms. The average time is recorded to be far high than the TTL value as shown the figure above. The graph is in line with research findings.

VIII. CONCLUSION

Broadband power line communication may be seen as complementary or alternative solutions to traditional fixed line networks and wireless networks according to existing network architectures with PLC bandwidths set to increase.

Analysis of the data reveals high delay of transmission in broadband power line communication as compared to local area network. A maximum delay value of 142ms and a minimum of 130.5ms has been recorded in broadband power line as compared to a maximum value of 1.63ms and a minimum value of 1ms in local area network.

The high delay recorded is analysed to have resulted from harmonics as revealed in the non-linearity of the averaged transmission time. Network nonlinearities from loads and flux distortion in synchronous systems (high-voltage and direct-current power conversion and transmission) as well as ripples in the voltage of the transmission power is identified to have significantly contributed the high losses leading to the delay. The recorded data delay never repeated readings in a roundtrip for IP address 197.251.230.38 with TTL value of 58 and a 32bytes while IP address 192.168.1.2 with TTL value of 128 and a 32bytes recorded several repeated low in delay values, which further reveals consistency than the address of 58 TTL.

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