

Original Research Article

Tropospheric Influence on Call Setup in Mobile Networks

Abstract

The dependency of mobile network operators on the troposphere for signal transmission without pre-evaluation and characterization of the region where the signals are transmitted. This research investigates the effects of weather variables (relative humidity, windspeed, rainfall and temperature) on call setup for four mobile networks (MTN, Airtel, Globacom and 9mobile) in Calabar, Nigeria. Six years data of weather variables collected from the Nigerian Meteorological Agency (NIMET), Calabar and six years Call Setup Success Rate (CSSR) data obtained from the telecommunications regulatory body, Nigerian Communication Commission (NCC), was used for this study, both spanning from January 2015 to December 2020. From the collected data, graphs were plotted and, in each case, the CSSR was the dependent variable while the tropospheric variables were the independent variables. Also, regression models were obtained to forecast the CSSR of each network, provided the tropospheric variable at each given period is known. Finally, the variables were correlated to give a picture of how each tropospheric variable related to the CSSR of the networks. For MTN network, a low negative correlation was obtained for temperature and relative humidity, a low positive correlation was obtained for rainfall while an increase in windspeed led to a corresponding decrease in CSSR. For Airtel network, a moderately positive correlation exist between CSSR and windspeed/rainfall while low positive relationship existed for temperature. However, an increase in relative humidity led to more successful call setup. For Globacom network an increase in relative humidity, windspeed, and temperature moderately led to a decrease in the number of successful call setup while rainfall had a very low effect on call setup. Finally, for 9mobile network, an increase in temperature led to a moderate increase in call setup. Relative humidity and windspeed had a negligible effect on call setup while a moderately negative relationship existed between rainfall and call setup. This result will be very useful to mobile network planners and the network operators.

1. Introduction

A call setup is an exchange of signaling information in the call process that leads to Traffic Channel (TCH) seizure [1]. In telecommunications, a call setup is evaluated using the Call Setup Success Rate (CSSR) which is the number of unblocked call attempts to the number of seizures resulting in a successfully established call [2]. CSSR depicts the percentage of

attempts to initiate a call that results in a connection to the dialed number [3]. It is measured in percentage and given a threshold level of 98% by the Nigerian Communication Commission (NCC) [4][5].

A successful call setup consists of an immediate assignment procedure and an assignment procedure. The former is used in creating a signaling connection between the Mobile Station (MS) and the network while the latter is used to occupy a speech channel [6]. High CSSR depicts better cell performance and is obtainable when Traffic Channel (TCH) allocation and Standalone Dedicated Control Channel (SDCCH) seizures are accessed to setup a call [7]. When there is a call setup failure, it means that the user's request is not served due to problems on the resource allocation of a signaling channel in which the negotiation for the actual traffic is performed [8]. A major cause of call setup failure or poor CSSR is low signal strength [3] which is sometimes caused by weather and this is one major reason for constant optimization [9].

The cellular network comprises of a Mobile Station (MS) that connects to the Base Transceiver Station (BTS) via air interface [10]. In addition to other hardware, BTS contains the equipment called Transceiver (TRX), which is responsible for the transmission and reception of several radio frequency (RF) signals to and fro the end user [11][12]. There are three main components that are required to setup a communication system; the transmitter, the receiver and the channel between the two. The signal which passes through this channel crosses the tropospheric layer of atmosphere of earth [13]. In this region, signals, usually transmitted as radio waves [14][15], are affected by varying conditions during propagation and when a radio wave is interrupted by bad weather, signal quality reduces and this can cause signal losses [16][17][18][19].

Studies shows that when signals are transmitted, they interact with tropospheric variables like rain fall, wind speed, relative humidity, temperature, sand and dust storms [20-25]. When the transmitted signals interact with the tropospheric variables, the signals undergo absorption, interference, refraction, scattering, reflection, fading and attenuation [8][26-32]. This introduces distortions to terrestrial communication systems [33], causing transmission error and affecting signal quality [34-35].

In Nigeria, network operators rely on transmitting signals through the troposphere without pre-evaluation and characterization of the troposphere and this is the reason for poor QoS [23]. To describe the reliability of networks, one needs to know which weather parameters affect the propagation of signal and the changing weather conditions, which may cause severe degradation in system performance [36]. To forecast, simulate, and design high performance communication systems, exact transmission characteristics of radio waves in various environments have to be known [22]. Mobile network providers need planning and optimization of their networks. They need to find a compromise between radio coverage in different environments, the QoS and the operation of the network [34].

The QoS of a mobile network can be improved by eliminating the factors that affect KPIs performance both from external and internal sources [37], accurate prediction of radio frequency signal coverage in a terrain is required [38].

Several researchers have investigated technical factors affecting poor QoS [39][40]. These has led to the frequent expansion of their base stations and capacities but the problem of poor call qualities persists [41]. To the best of our knowledge, no researcher has studied the impact of weather on CSSR. Bearing in mind that weather parameters affect signals and one of the causes of poor CSSR is low signal strength, we may assume that weather affects CSSR, hence, this research. The crucial part of this research is to detect the dependencies of CSSR on rainfall, wind speed, temperature and relative humidity.

2. METHODOLOGY

This work investigates how relative humidity, wind, rainfall and temperature affects call setup in mobile networks. Four mobile networks are investigated in this study. They are MTN network, 9mobile network, Glo network and Airtel network. The research is carried out in the city of Calabar, Nigeria. 72 months radiosonde data for Calabar, obtained from the Nigerian Meteorological Agency (NIMET), Calabar, is used for this study. These data contain monthly data of relative humidity, wind speed, rainfall and temperature, spanning from January 2015 to December 2020.

Furthermore, 72 months data of CSSR was obtained from the Nigerian Communication Commission. These data spans from January 2015 to December 2020. The CSSR data are obtained during busy hours across base stations in Calabar. Whenever there is signal transmission, CSSR are measured through sophisticated counters embedded in the base station of mobile networks in Calabar.

The obtained tropospheric and CSSR data is then subjected to statistical analyses to obtain a relationship between both variables. A correlation analysis is done to obtain the degree of relationship between the variables investigated while a regression analysis was done to establish a relationship between the variables investigated, as well as to enable us predict and forecast when to expect call setup success or not.

3. RESULTS AND DISCUSSION

This section is divided into four parts. We shall first analyze the effect of relative humidity on call setup for the four networks, followed by the effect of wind speed, rainfall on finally, temperature.

3.1 Effects of Relative Humidity on Call Setup

In this part, figure 1 shows a graph of CSSR against relative humidity, plotted for MTN network. A weak negative correlation value of -0.07 was obtained. A regression model to predict possible call setup was obtained as $C = -0.01R + 100.13$ for MTN users. A graph of CSSR against relative humidity for Airtel network was revealed in figure 2. A strong positive correlation value of 0.82 was developed with a regression model $C = 0.05R + 94.70$ for Airtel users to forecast when it is accurate to make calls. Figure 3 sets forth a graph of CSSR against rainfall for Globacom network. A regression equation, $C = -0.09R + 105.75$ and a moderately negative correlation value, -0.34 were obtained. A graph of CSSR against relative humidity for 9mobile network is presented in Figure 4, with weak correlation value of -0.14 and regression equation of $C = -0.01R + 100.29$. In each regression model developed, C depicts CSSR while R stands for relative humidity. Therefore, at a known value of relative humidity, it is possible to predict the probability of having a successful call setup.

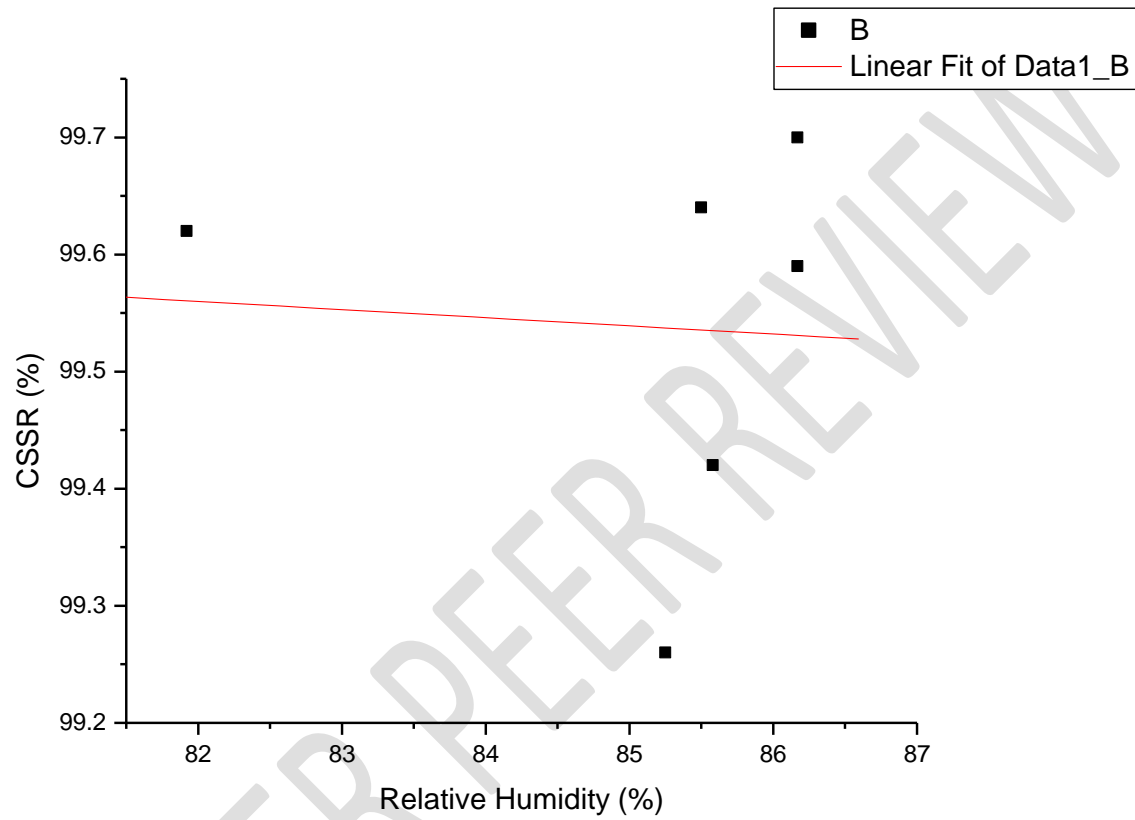


Figure 1: Graph of CSSR against Relative Humidity for MTN Network

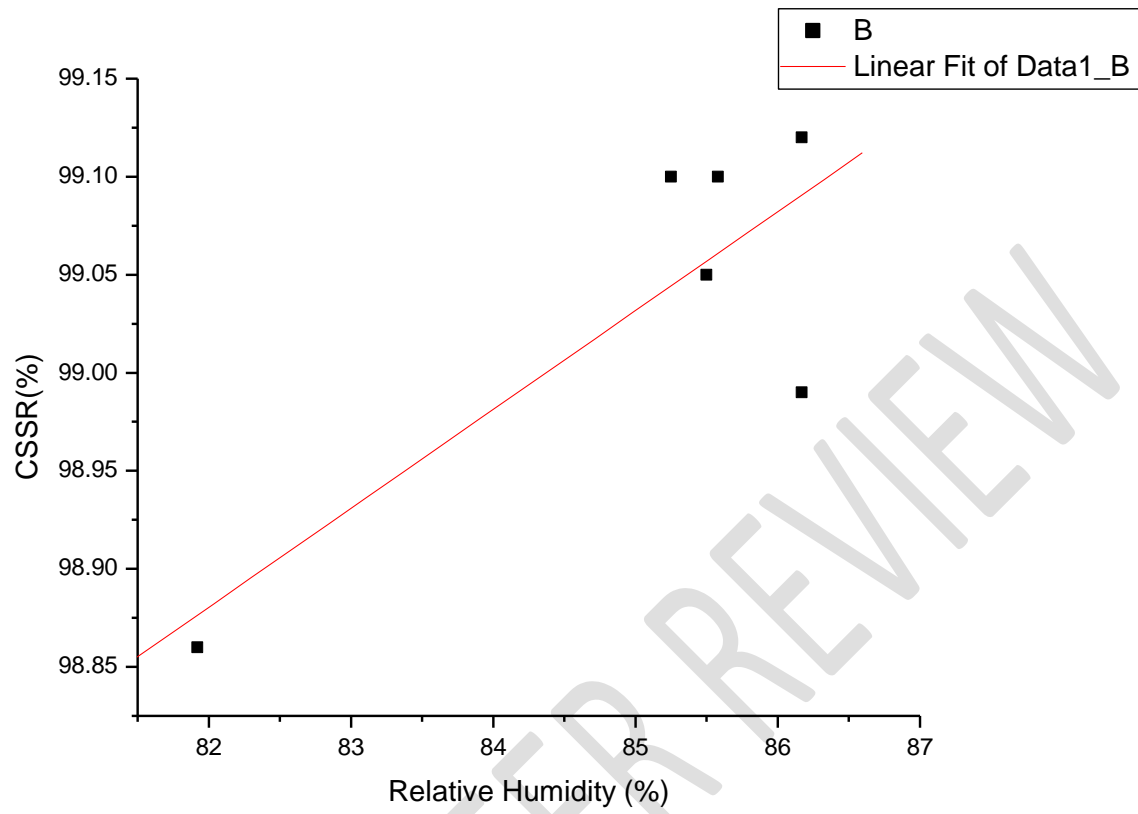


Figure 2: Graph of CSSR against Relative Humidity for Airtel Network

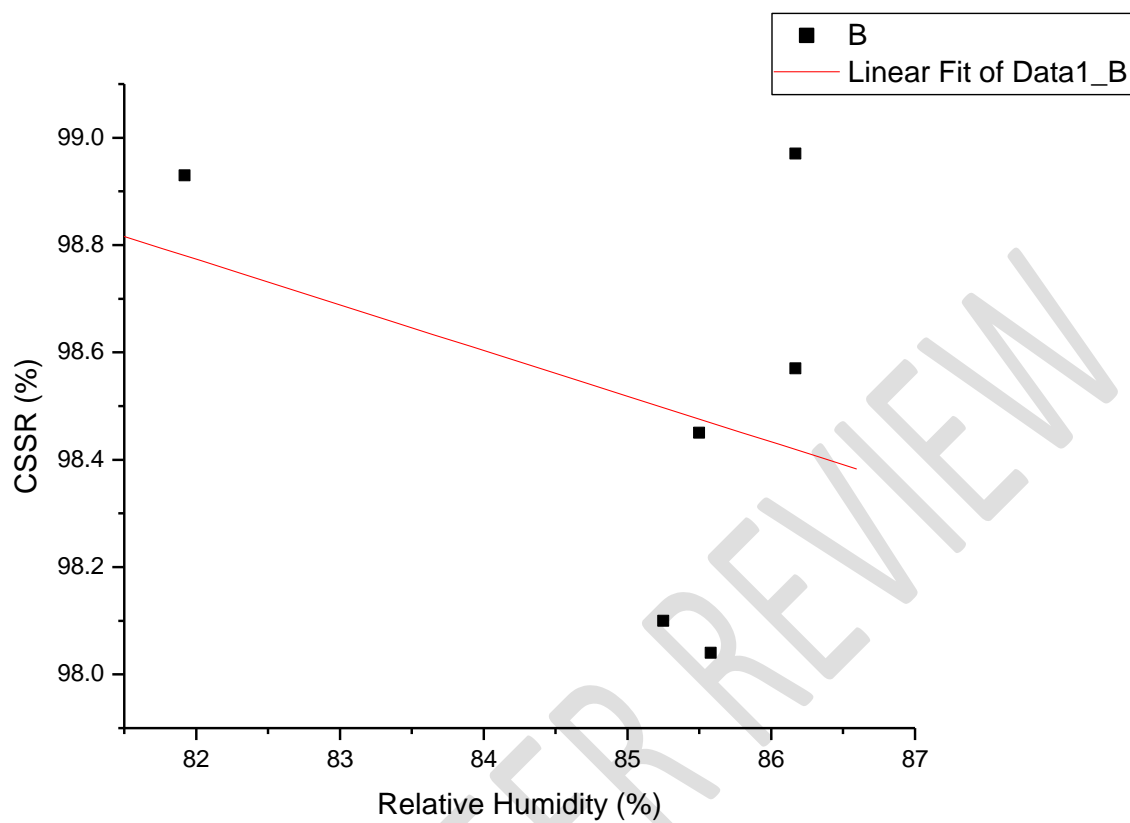


Figure 3: Graph of CSSR against Relative Humidity for Globacom Network

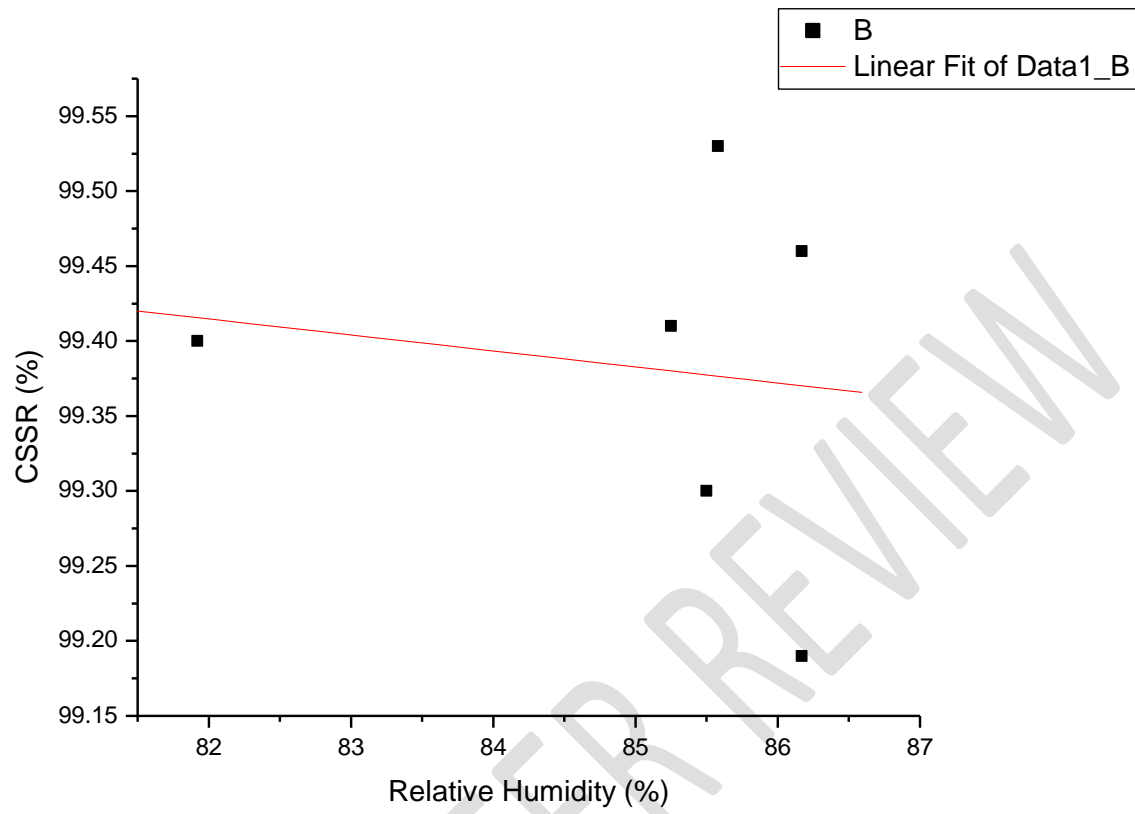


Figure 4: Graph of CSSR against Relative Humidity for 9Mobile Network

3.2 Effects of Wind Speed on Call Setup

In this section, figure 5 to 8 flaunt graphs of CSSR against windspeed for MTN, Airtel, Globacom and 9mobile network respectively. For MTN network, a high negative correlation of – 0.95 was obtained with regression equation $C = - 0.03W + 101.28$. A regression model $C = 0.01W + 98.68$ and a moderately positive correlation value of 0.33 was obtained for Airtel network. For Globacom network, a moderately negative correlation of – 0.69 was obtained with a derived regression equation $C = - 0.06W + 101.54$. For 9mobile network, a regression model $C = 0.01W + 99.09$ along with a weak correlation value of 0.22 was obtained. In each case, C represents CSSR while W represents the windspeed.

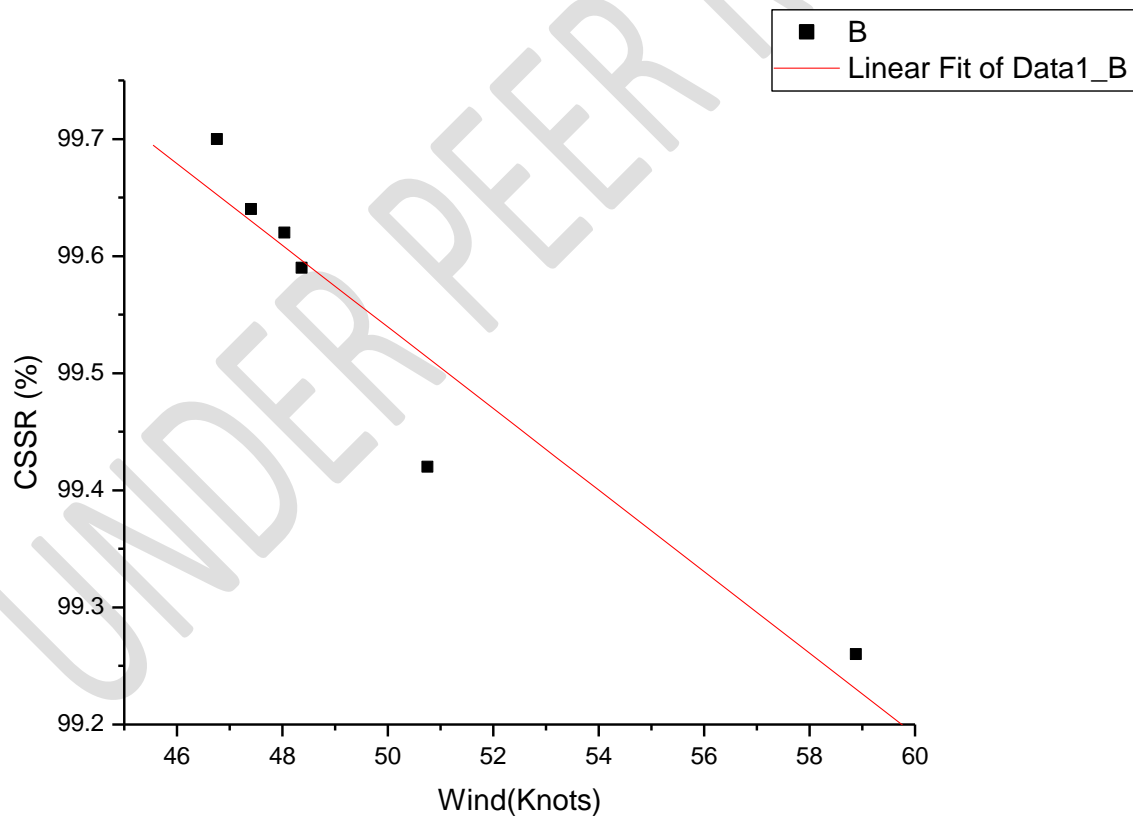


Figure 5: Graph of CSSR against Wind Speed for MTN Network

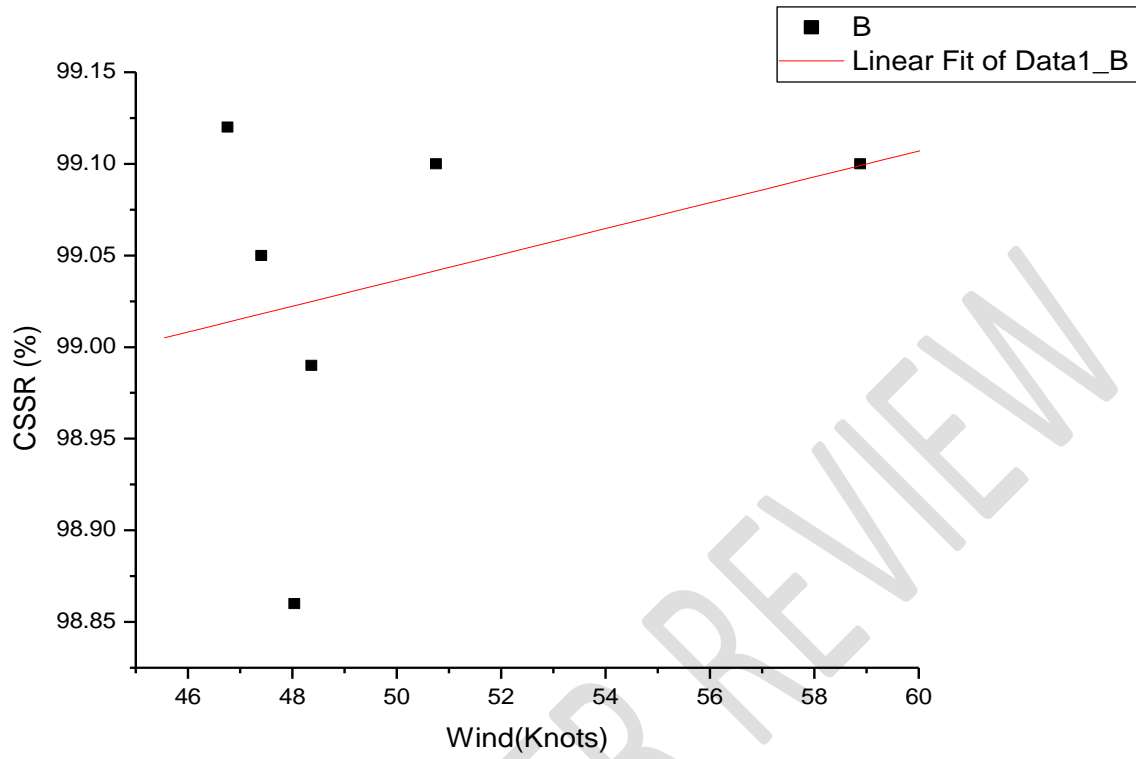


Figure 6: Graph of CSSR against Wind Speed for Airtel Network

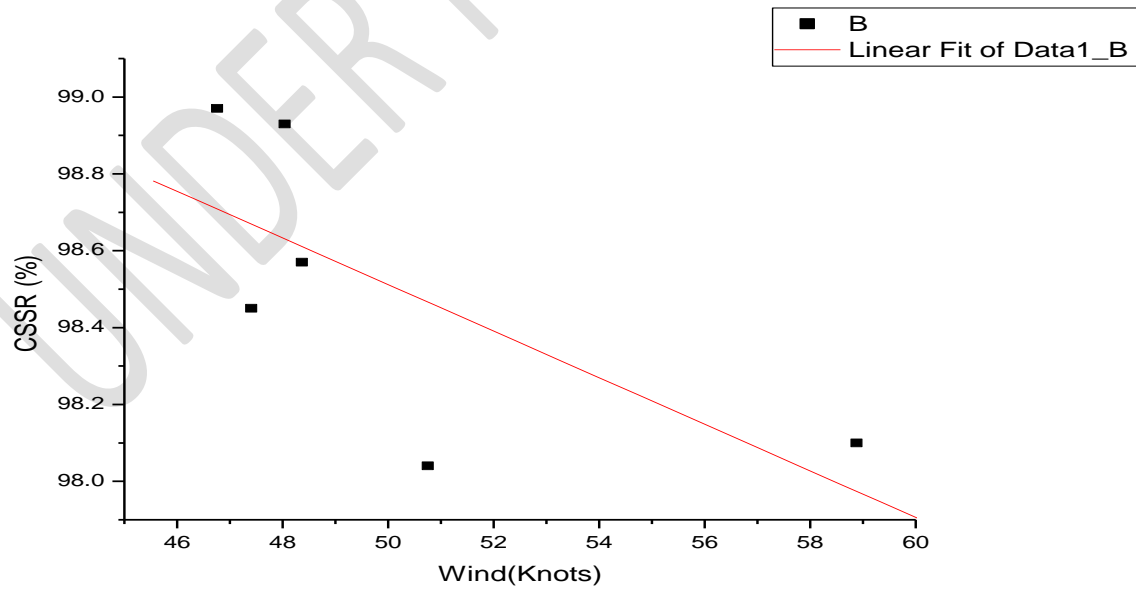


Figure 7: Graph of CSSR against Wind Speed for Globacom Network

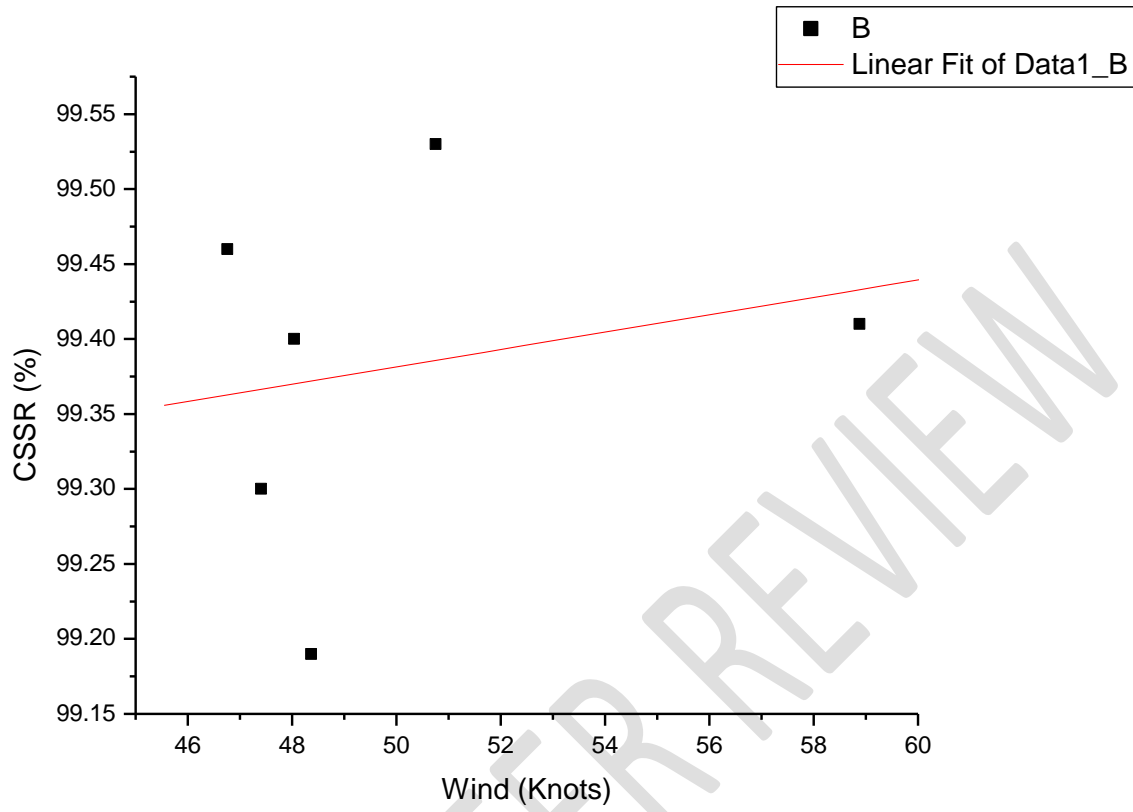


Figure 8: Graph of CSSR against Wind Speed for 9Mobile Network

3.3 Effects of Rainfall on Call Setup

Here, figure 9 to 12 present graphs of CSSR against rainfall for MTN, Airtel, Globacom and 9mobile network respectively. A weak positive correlation of 0.10, a moderately positive correlation of 0.49, a weak positive correlation of 0.16 and a moderately negative correlation of -0.32 was obtained for MTN, Airtel, Globacom and 9mobile network, respectively. Furthermore, regression models were obtained for the four networks: $C = 5.12RF + 99.41$ for MTN network, $C = 0.01RF + 98.66$ for Airtel network, $C = 0.01RF + 98.02$ for Globacom network and $C = 0.01RF + 99.69$ for 9mobile network. Again, C represents CSSR while RF represents rainfall.

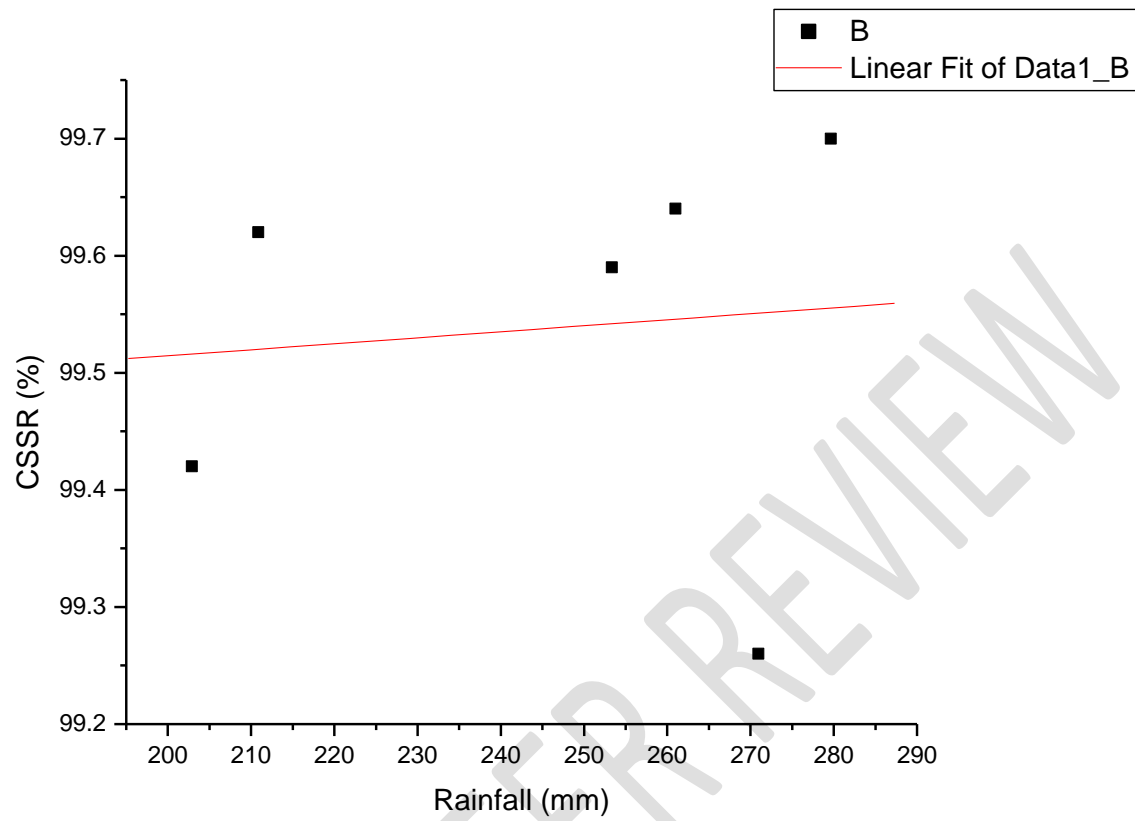


Figure 9: Graph of CSSR against Rainfall for MTN Network

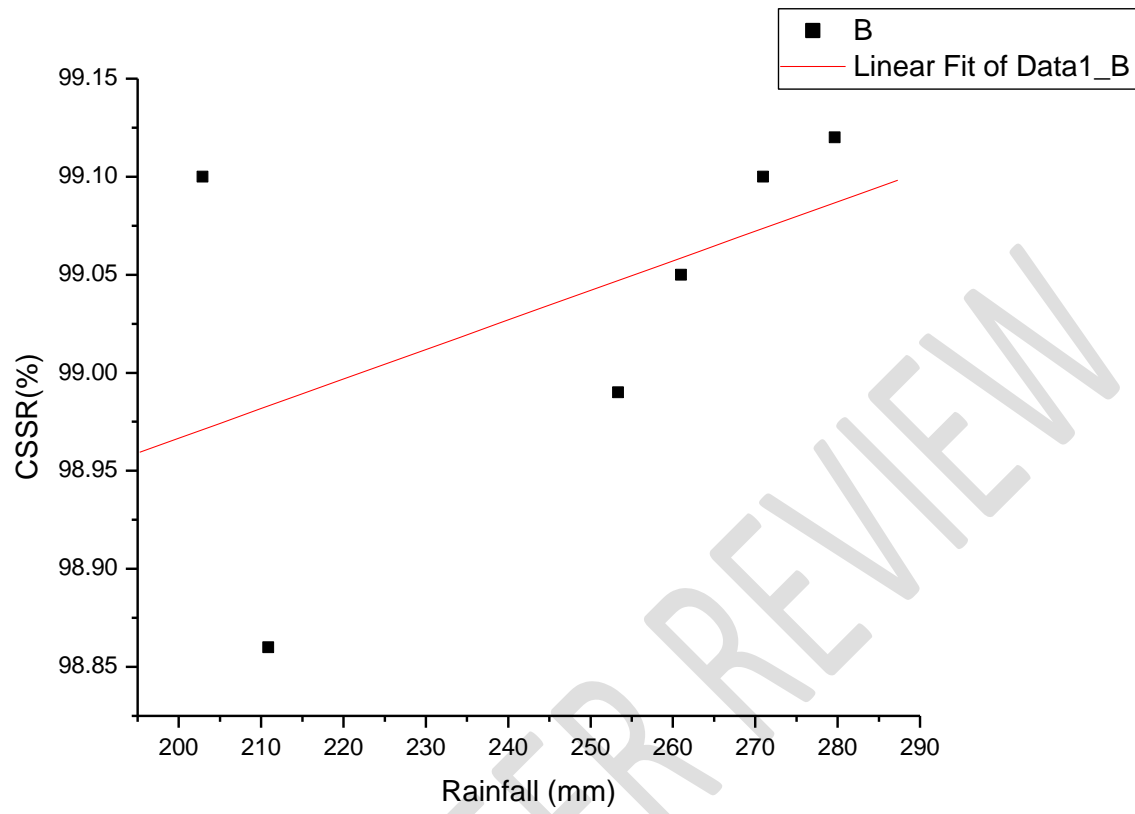


Figure 10: Graph of CSSR against Rainfall for Airtel Network

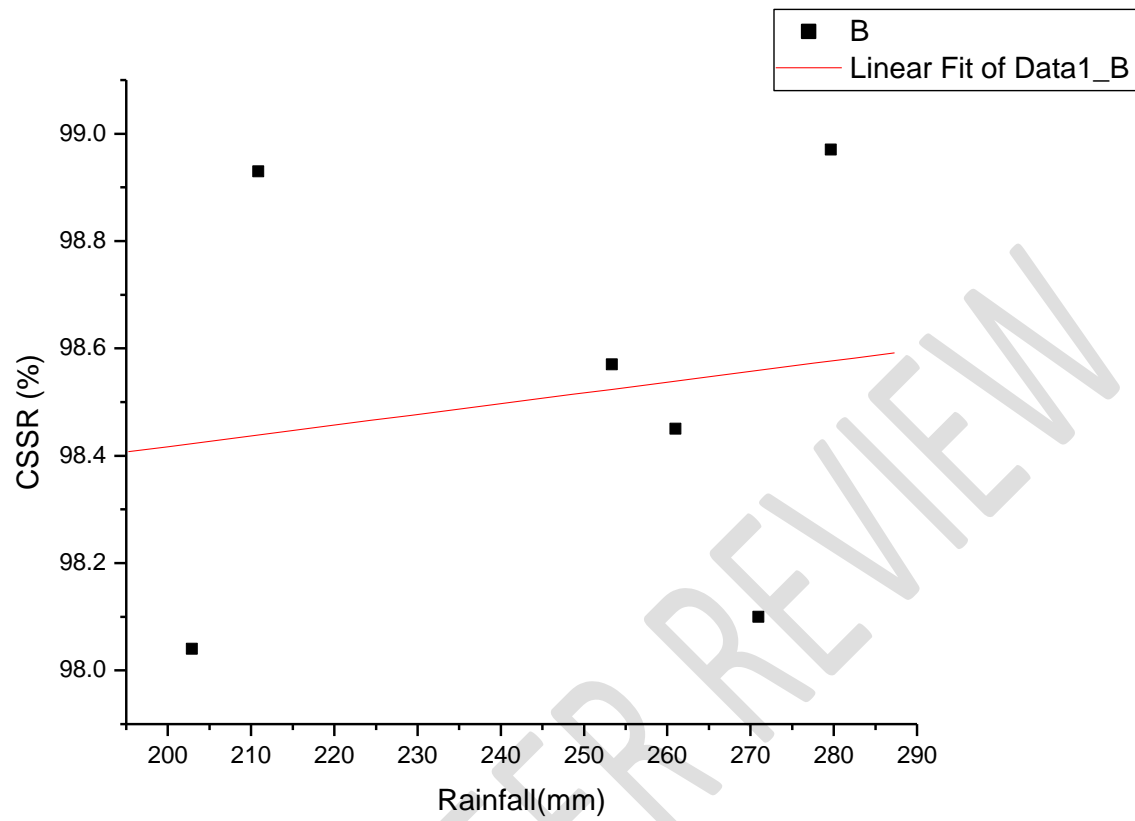


Figure 11: Graph of CSSR against Rainfall for Globacom Network

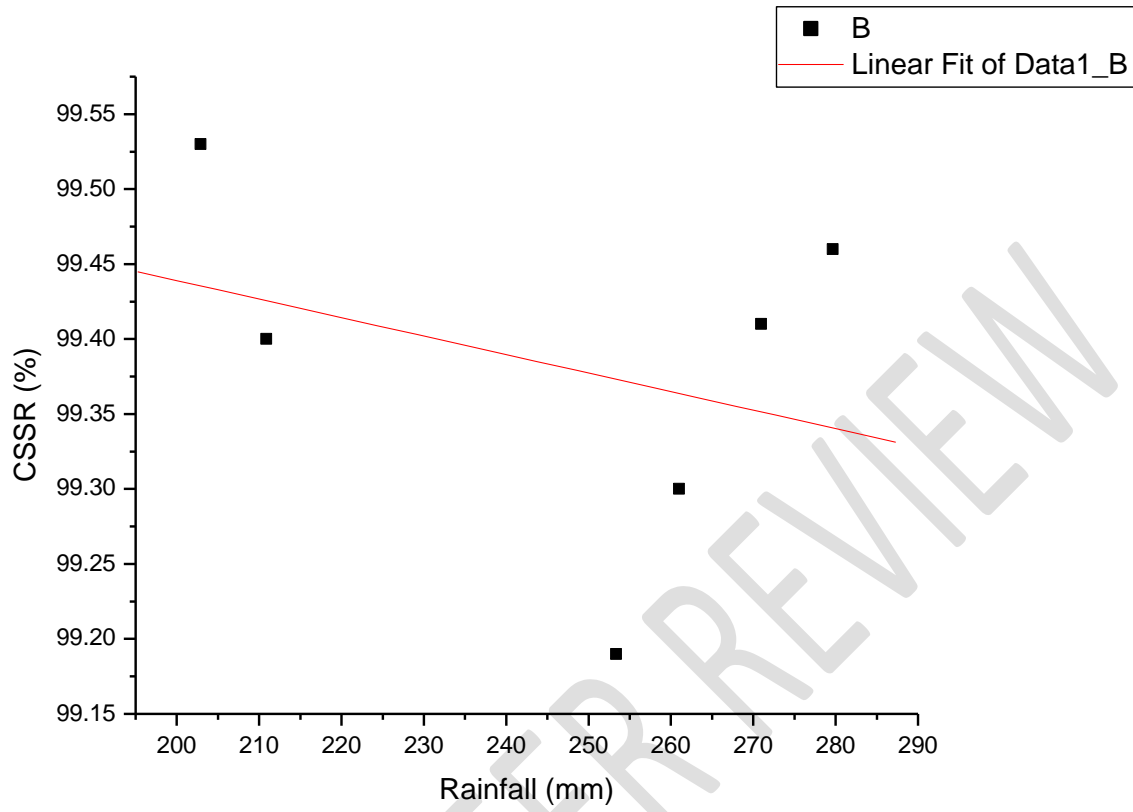


Figure 12: Graph of CSSR against Rainfall for 9Mobile Network

3.4 Effects of Temperature on Call Setup

Lastly, figures 13 to 16 unveil graphs of CSSR against temperature for the four networks under study. A low negative correlation value of -0.10 was obtained for MTN network, a low positive correlation value of 0.14 was realized for Airtel network, a moderately negative correlation value of -0.38 was obtained for Globacom network and a moderately positive correlation of 0.51 was obtained for 9mobile network. Again, regression equations $C = -0.02T + 100.14$, $C = 0.02T + 98.49$, $C = -0.18T + 104.26$ and $C = 0.07T + 97.02$ were obtained for MTN, Airtel, Globacom and 9mobile networks. Here, C stands for CSSR while T represents temperature.

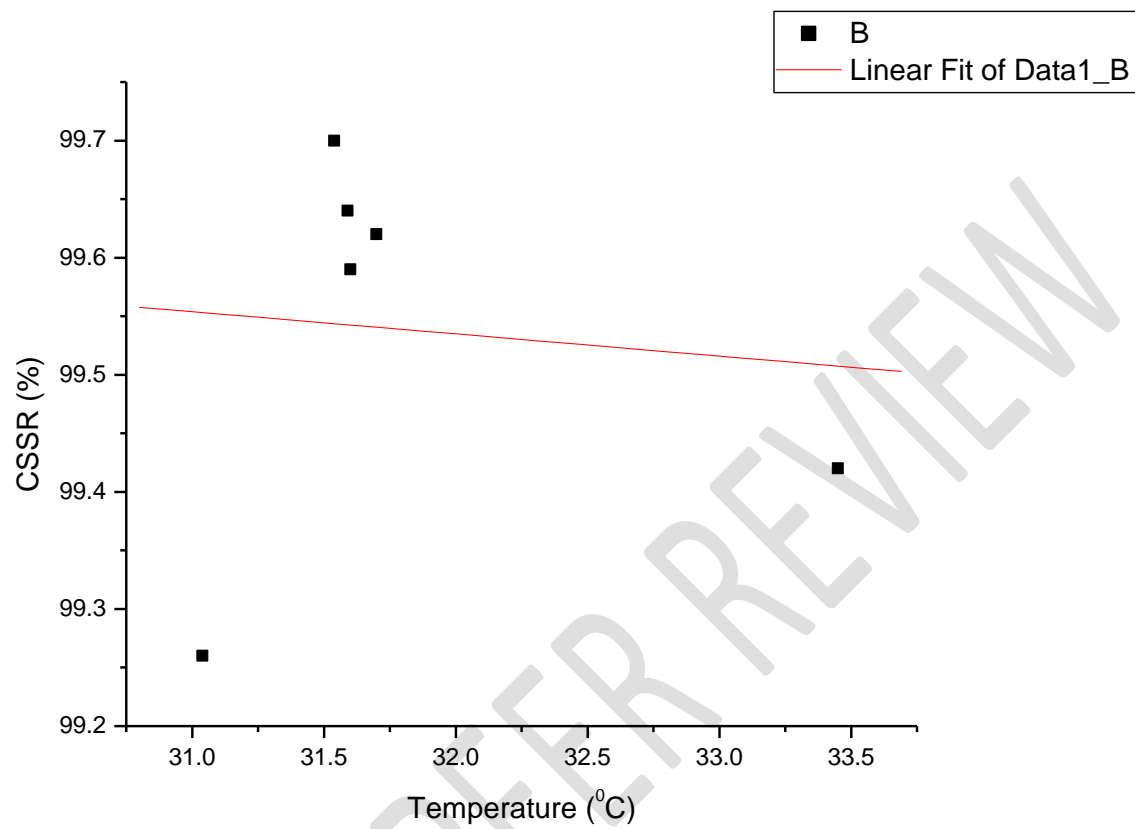


Figure 13: Graph of CSSR against Temperature for MTN Network

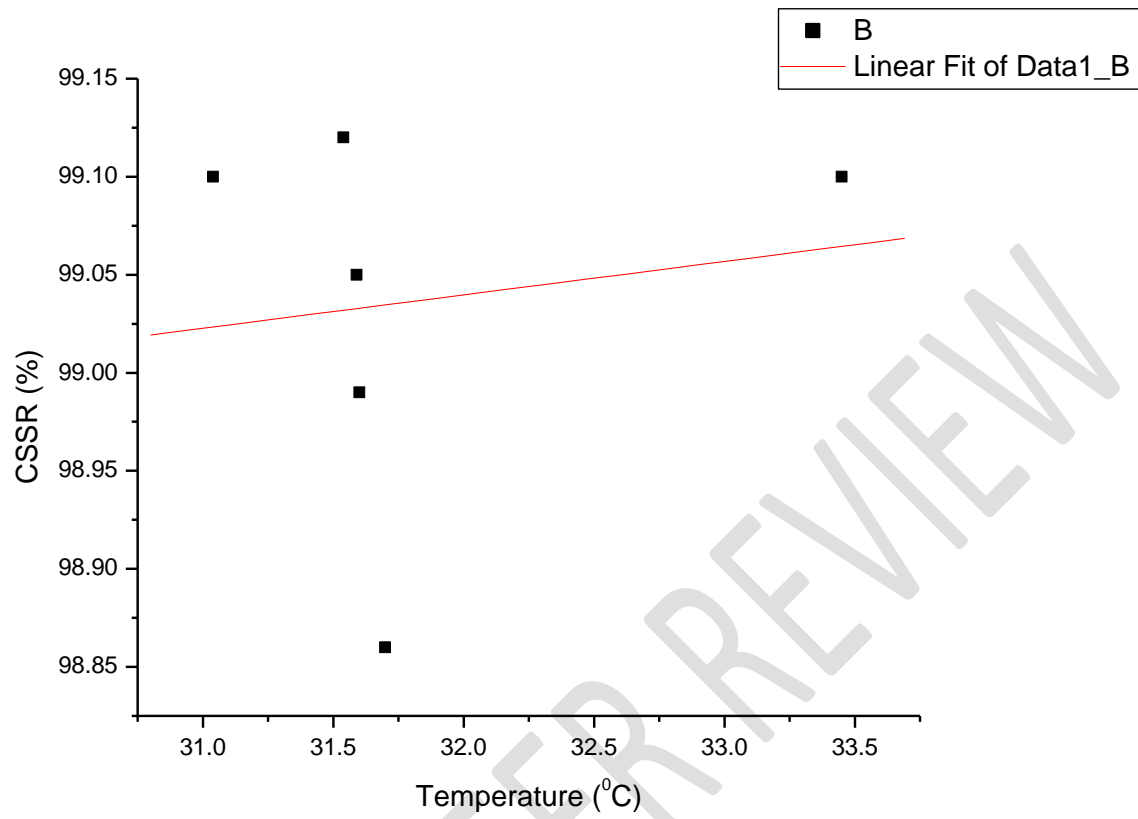


Figure 14: Graph of CSSR against Temperature for Airtel Network

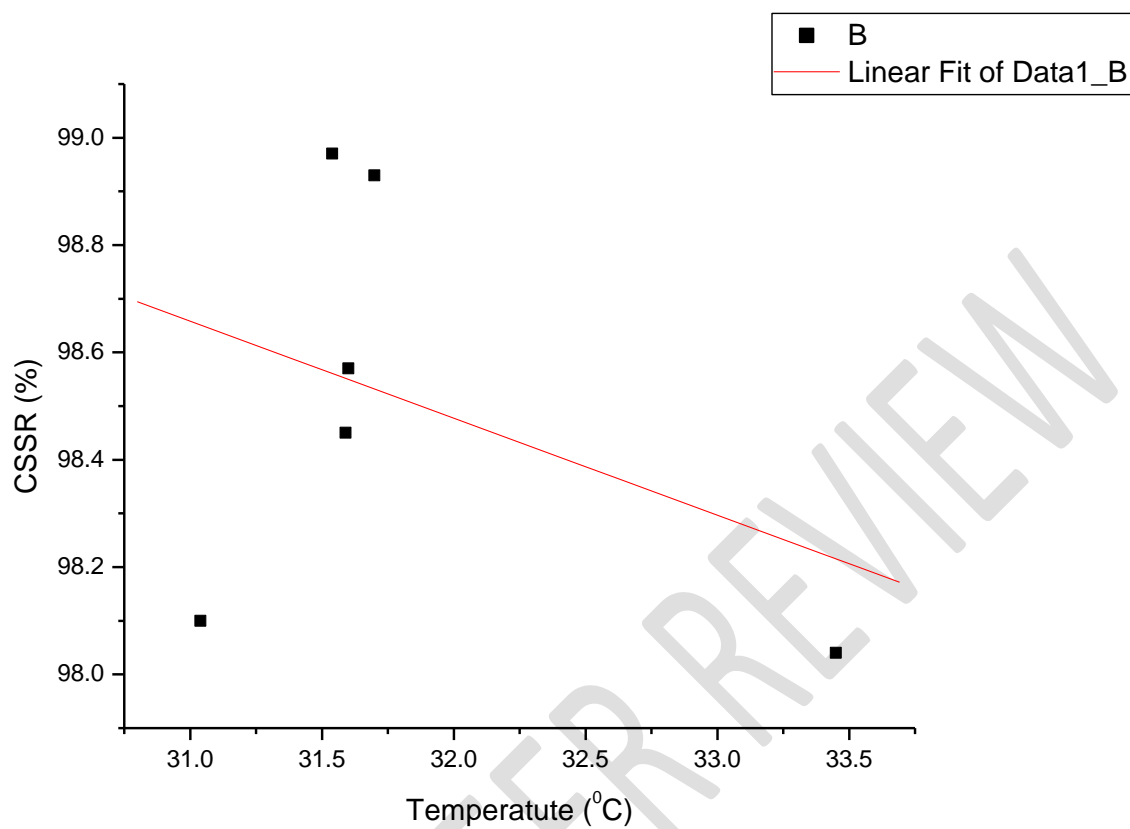


Figure 15: Graph of CSSR against Temperature for Globacom Network

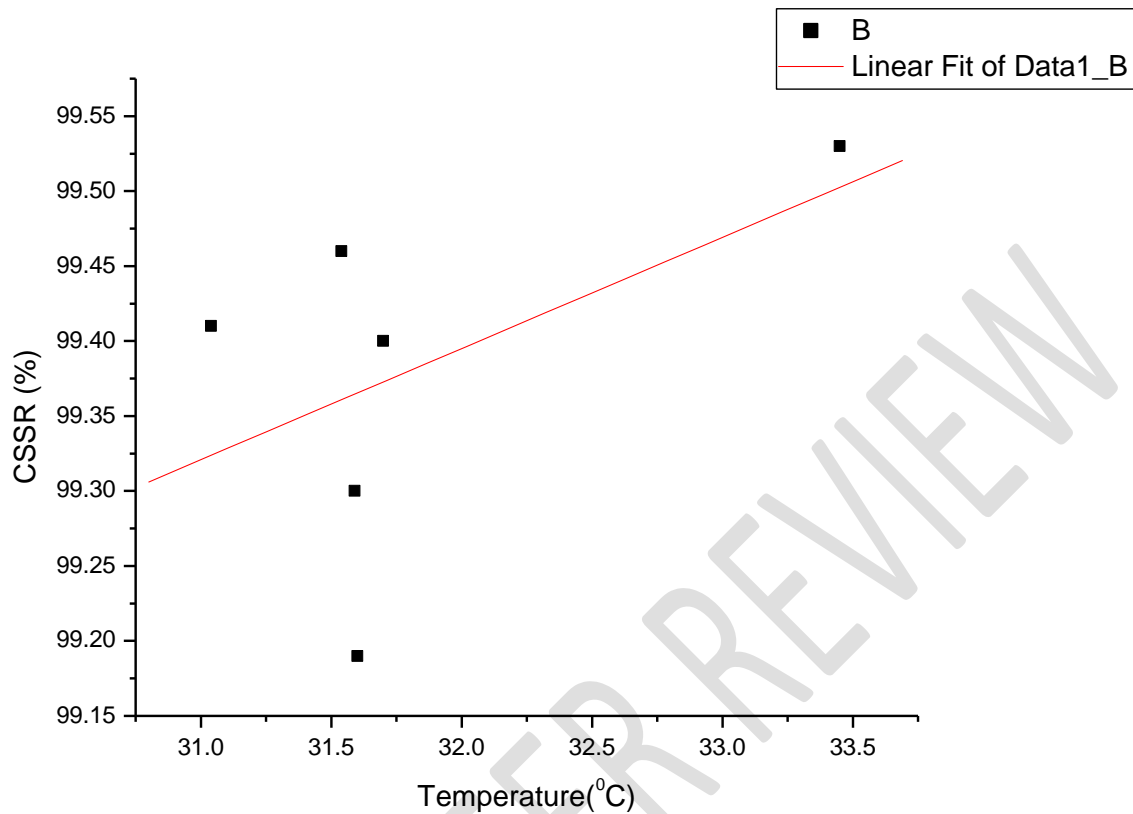


Figure 16: Graph of CSSR against Temperature for Graph Network

Conclusion

The influence of relative humidity, windspeed, rainfall and temperature on call setup for four mobile networks operating in Calabar have been studied. The call setup of the four networks under study varied with tropospheric variables in an irregular pattern. Results showed an irregular pattern, but on the average, we can conclude that weather variables have low significance on CSSR.

COMPETING INTERESTS DISCLAIMER:

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation

but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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