ANALYSIS OF A 3G NETWORK QoS IN URBAN AND RURAL AREA IN MALAYSIA

MohdFadzli bin Hashim
2010600654
Faculty of Electrical Engineering
UniversitiTeknologi MARA Malaysia
40450 Shah Alam, Selangor, Malaysia
E-mail:fadzlihashim87@gmail.com

Abstract- **This work is an investigation on mobile QoS(Quality-of-Service) of a 3G network in an urban and rural area. The investigation was done by analyzing raw data acquired through drive tests carried out in the different areas. There were three main parameters of network QoS that were focused on in the analysis. They are availability, dependability and reliability. Availability is determined through analyzing RSCP(Received Signal Code Power) values meanwhile dependability is determined through analyzing blocked call events and reliability is determined through analyzing Ec/No(Received Energy Per Chip divided by power) values and dropped call events. The results of the analysis were used to determine the impact of different terrain and population density in urban and rural areas on a 3G network QoS. Handover failures and packet data performance will also be analyzed.**

Keywords-QoS, RSCP, Ec/No,blocked call,dropped call,handover failure

I. INTRODUCTION

Cellular mobile services in Malaysia have experienced massive growth in the past decade or so. Mobile service providers are competing to bring the best quality of service into the market. Mobile QoS is defined as the totality of characteristics of a telecommunicatios service that bear on its ability to satisfy stated and implied needs of the user of the service[1].The Malaysian Communication And Multimedia Commission sets the standard for Malaysian service providers to give consumers clear and specific standards where through these standards the QoS of a service provider can be gauged[2][3]. The three main parameters of the QoS that will be assessed in this work are availability, dependability and reliability. To asses these parameters there are a number of crucial KPI's(Key Performance Indicator) that were analyzed. These KPI data can be obtained through RF drive testing. The drive tests were carried out in two different areas having different topographic and demographic conditions(urban and rural) to study the impact of terrain and population density on a 3G network QoS.

Availability

Availability is defined as the ability of an item to be in a state to perform a required function at a given instant of time or at any instant of time[1]. Network availability is a network's ability to respond to requests made by users accessing the network.

KPI for Availability:

i. RSCP(Received Signal Code Power)

RSCP is defined as the power measured by a receiver on a particular communication channel. The 3G network coverage performance is determined through analyzing this KPI. It is expressed in dBm (mW on a logarithmic scale).The figure below shows the range of ideal RSCP value for a 3G network.

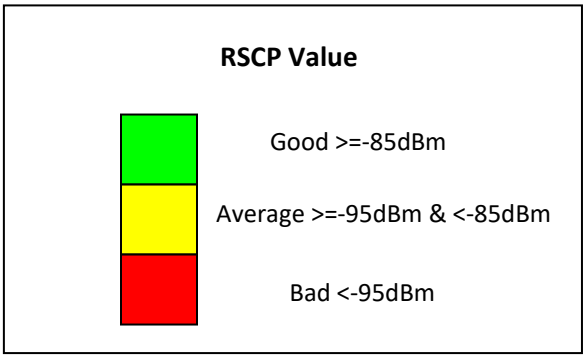

Figure 1:RSCP range of values in dBm.

Dependability

Dependability is defined a performance criterion that describes the degree of certainty (or surety) with which the function is performed regardless of speed or accuracy, but within a given observation interval[4].

KPI for Dependability:

i. Blocked Call Event.

Blocked call is defined as a call which is not connected because there is no free channel to serve a call attempt or due to other network related problems [5].Blocked call rate is calculated based on the percentage of number of blocked call over total number of call attempt. Blocked call can be caused by one of 3 main reasons that are poor RF conditions (Ec/No,RSCP), a problem in the UTRAN(UMTS Terrestrial Radio Access Network), or it can occur because of core network issues.

Reliability

Reliability is defined as the probability that an item can perform a required function under stated conditions for a given time interval [6].To asses this part of the QoS, two KPI's were analyzed.

KPI for Reliability:

i. Ec/No

Ec/No is defined as the received energy per chip divided by the power density in the band. It is identical to RSCP/RSSI. It is measured in dB and is always negative.

$$\frac{Ec}{No} = \frac{RSCP(dBm)}{RSSI(dBm)} \qquad (1)$$

$$\frac{Ec}{No} = RSCP - RSSI\ (dB) \qquad (2)$$

Since received energy per chip is always smaller than total received power, Ec/No value will always be negative. This KPI will affect the cell dominance. Figure 2 shows the ideal range of Ec/No for a 3G network.

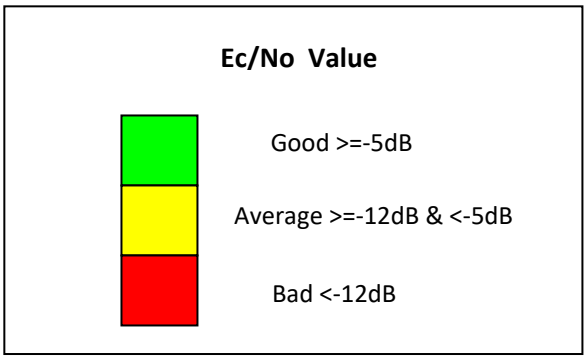

Figure 2:Ec/No range of values in dB

ii. Dropped Call Event.

Dropped call event occurs when a connection is established, but is disconnected due to abnormal call release [5]. In terms of reliability, dropped call events is arguably the most crucial KPI of a 3G network. Dropped call events can occur due to the same reasons as blocked call events.

Besides voice QoS the packet data QoS performance were also analyzed. The KPI's analyzed for packet data QoS are:

i. Packet Data Session Completion.
ii. Packet data Switching Network Access Delay.
iii. Packet dropped.
iv. Throughput.

II. METHODOLOGY

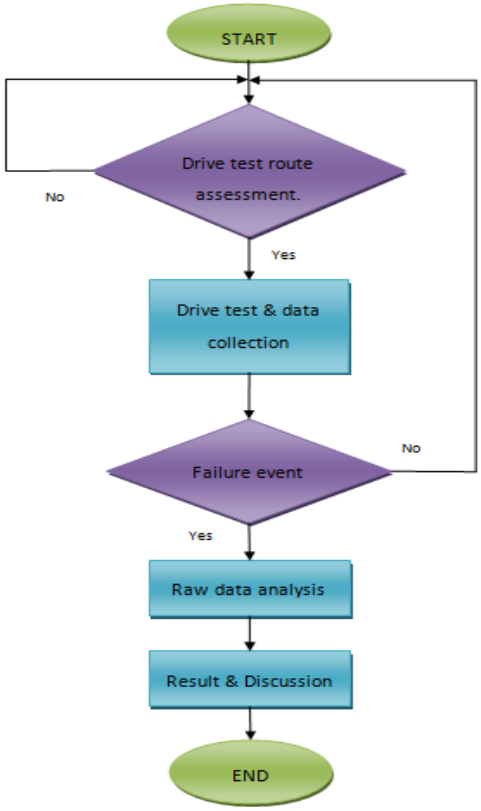

Figure 3: Flow chart for the analysis of a 3G network QoS.

A. Drive testing.

Drive tests are a means of gauging the performance of a mobile network by collecting data on specific KPIs. The software used for collecting the raw data was Nemo Outdoor software. The setup for the drive tests is shown in Figure 4. This setup was used for all the drive tests carried out for this work.

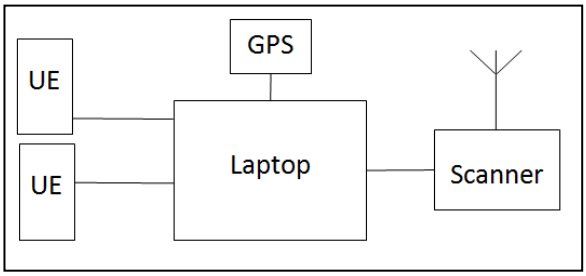

Figure 4: Drive test equipment setup.

The first area of interest is Ipoh. The urban city is located in the northern part of Malaysia. The city has an urban population of 813,603[10]. The city consists of mainly buildings and it is surrounded by limestone hills at certain more sub-urban parts of the city. The drive test in Ipoh was carried out for about 6 hours 22 minutes. This is in compliance with the standards for drive testing set by the MCMC[2]. The test was carried out from 10:50 PM and was completed at approximately 5:12 AM the next day.

The second area for the drive test was in mostly rural parts of east Malaysia in Tuaran, Sabah. The population for Tuaran is 105,435 with population density of just 90 people/km^2[11] Tuaran is mostly covered by forest trees and hills with some small sub-urban communities. The drive test in Tuaran was completed in less time because there were less traffic volume in Tuaran compared to Ipoh thus, making it easier to complete the drive test in less time. The test took about 3 hours and 30 minutes to be completed. It was carried out at 2:10 PM and completed at approximately 5:40 PM.

B. Data analysis.

The raw data were collected using Nemo Outdoor software and then transferred to the Nemo Analyzer software to generate the logfiles. The KPIs data were then extracted as excel files to be analyzed using MATLAB and Excel.

The data consists of:

i. Ec/No best active set.
ii. RSCP best active set.
iii. Failure Events.
iv. Layer 3 and RRC (Radio Resource Controller) signaling.
v. Packet data KPI.

A MATLAB script was created to form a scatter plot for the RSCP vs Ec/No to determine the overall RF conditions of the 3G network both in Ipoh and Tuaran. Pie charts were used to show the distribution of the KPI values according to the respective areas.

C. R.F.C.O.N.A.N (Radio Frequency Conditions Analyzer)

For ease of viewing, R.F.C.O.N.A.N (pronounced as 'refconan') is a GUI(Graphical User Interface) that was created using MATLAB software where users can assess the overall RF conditions in the areas involved by literally a push of a button. The assessment is done by analyzing three KPIs. They are Ec/No, RSCP and RSCP vs Ec/No.

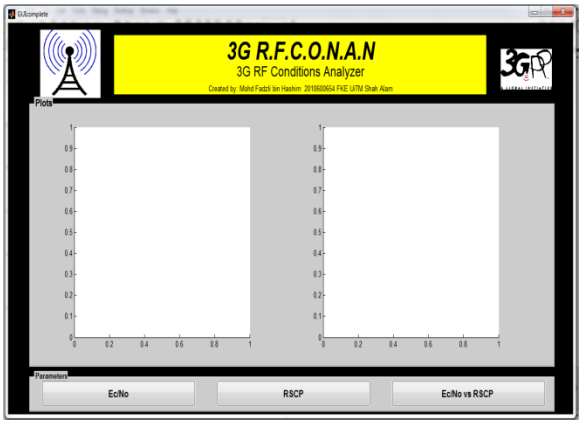

Figure 5: The R.F.C.O.N.A.N interface before pushing a button.

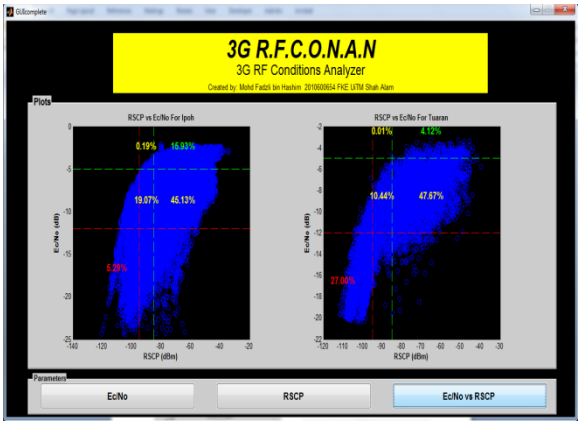

Figure 5: Scatter plot using the R.F.C.O.N.A.N after user clicks a push button.

Through the creation of this GUI, ease of viewing and repeatability of the RF conditions overall assessment of other areas are possible.

III. RESULT AND DISCUSSION

A. RSCP

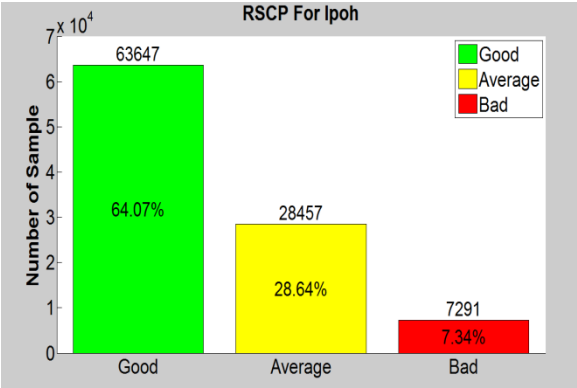

Figure 7:Sample value distribution according to RSCP value for Ipoh.

The coverage for Ipoh was recorded having 64.07% of the samples in the range of more than -85dBm. Only 7.34% of the samples had low coverage problems of RSCP below than -95dBm meanwhile 28.64% of the samples had average coverage.

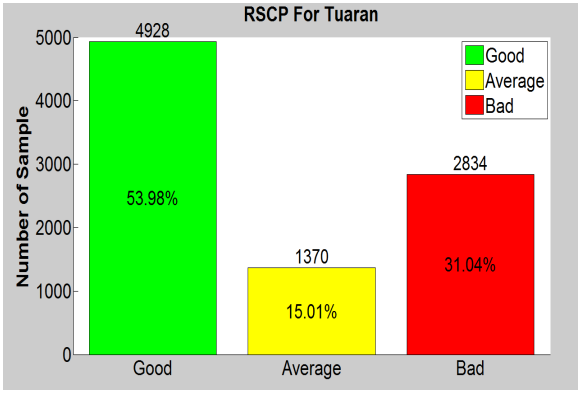

Figure 8:Sample value distribution according to RSCP value for Tuaran.

The most distinct finding of the data in Tuaran is 31.04% of the samples were below acceptable level of -95dBm.About 54% of the samples were in good coverage range.A number of 1370 samples or 15% of the samples had average coverage compared to 29% of Ipoh RSCP values.

B. Ec/No.

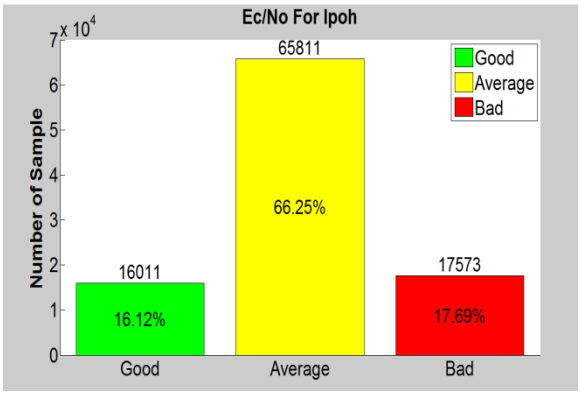

Figure 5:Sample value distribution according to Ec/No value for Ipoh.

It is observed that a majority of the samples in Ipoh were in the average range of -12dB≤Ec/No<-5dB with 66.25%. 17.69% of the samples were in the lower range of Ec/No. A number of 16,011 samples out of 99,395 or 16.12% were observed to have Ec/No values of more than -5dB.

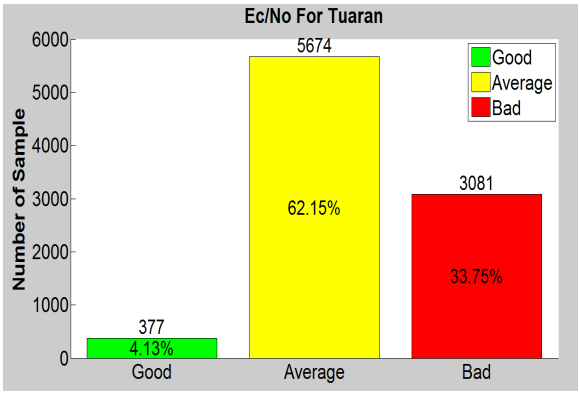

Figure 6:Sample value distribution according to Ec/No value for Tuaran.

Compared to the urban Ipoh, Tuaran recorded a total of just 9,132 samples and 62.15% of them were recorded having the value of -12dB≤Ec/No<-5dB. Despite having a higher percentage of samples above the average value of Ec/No, only 4.13% of the samples in Tuaran had good cell dominance of Ec/No over -5dB. The distribution for samples having very low values of Ec/No were almost two times higher compared to Ipoh with Tuaran recording 33.75% having Ec/No values below -12dB.

C. RSCP vs Ec/No

Good RF conditions means that a network has to have good cell dominance to maintain reliability and avoid dropped calls or handover failures. Aside from having good cell dominance, a network needs to have good coverage not only for the network service to reach users but to establish a good RF condition when combined with good cell dominance. The scatter plot is used to give a clear view of the overall performance of the 3G network in both areas.

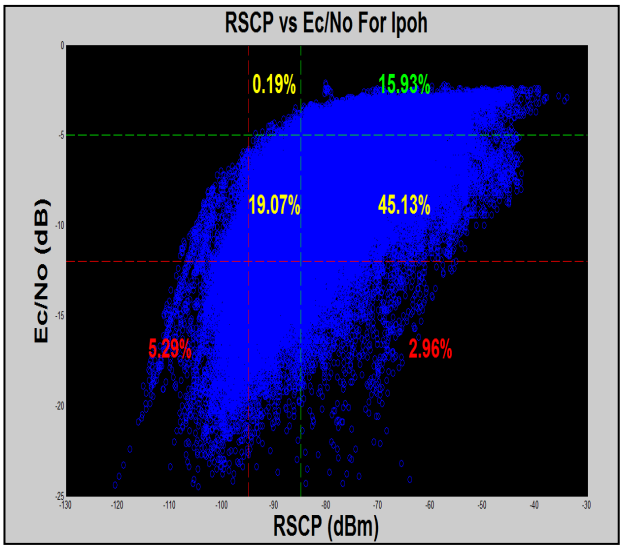

Figure 9:RSCP vs Ec/No scatter plot for Ipoh.

From the scatter plot above, it is observed that 15.9% of the samples in Ipoh were in the best RF condition of Ec/No≥-5dB and RSCP≥-85dBm. About 64.4% of the samples were in the acceptable range of cell dominance and coverage with 0.2% having average coverage and good dominance meanwhile 45.1% of the sample having good coverage but average dominance. Approximately 5.3% of the samples had below acceptable levels of RF condition. Approximately 3% of the samples had good coverage but very low dominance. This will increase interference in the area. Unacceptable RF condition is when the Ec/No value is below -12dB while at the same time having RSCP value less than -95dBm. This condition increases the probability of failure events such as dropped calls, blocked calls and handover failures.

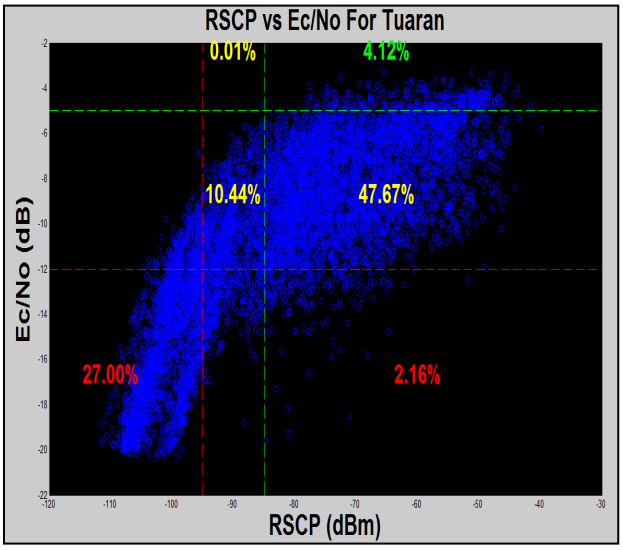

Figure 10: RSCP vs Ec/No scatter plot for Tuaran.

With the scatter plot in Figure 10, it can be seen that the overall RF condition in Tuaran is less ideal for a good 3G network QoS compared to Ipoh. Only 4.12% of the samples had good dominance(Ec/No>-5dB) and coverage(RSCP>-85dBm). About 58.12% of the samples had acceptable RF conditions compared to 64.4% in Ipoh. About 27% of the samples had unacceptable RF conditions compared to Ipoh's 5.3%. There was a 1% reduction in interference compared to Ipoh.

Good RF conditions are crucial to the QoS of a mobile network. Failure events such as dropped calls, blocked calls and handover failures mostly occur in bad RF conditions. This will affect the availability, dependability and reliability of the network thus, directly affecting the QoS performance. Through the figures above it is shown that Ipoh as an urban city has an overall better RF conditions compared to mostly rural Tuaran. This might be due to the fact that Tuaran has more natural 'blocking' elements such as trees and hills compared to Ipoh. Most of these elements are comparable to and some of them are even larger than the buildings of urban Ipoh. There was a slight interference reduction in Tuaran and this is due to the fact that base stations are usually further apart in rural areas therefore reducing interference. Although Ipoh has a tremendously larger population and higher population density compared to Tuaran, it remains to be seen if the demographic factor affects the overall RF conditions in Ipoh severely. Through this technique of scatter plot, a systematic approach can be utilized when trying to assess the overall RF conditions of any area. This step can be repeated for other areas by merely changing the raw data source file.

D. Failure events.

Event	Time	System	Serving band	Network cause
Soft handover failure	00:45:27	UMTS FDD	2100	Invalid configuration
RRC connection dropped	01:20:09	UMTS FDD	2100	undefined
GSM/UMTS call dropped (ETSI)	01:20:14	UMTS FDD	2100	undefined
GSM/UMTS call attempt failure	01:58:04	UMTS FDD	2100	undefined
Handover failure	03:14:35	UMTS FDD	2100	Physical channel failure

Figure 11: Failure events for Ipoh drive test.

There were 5 failure events in the Ipoh drive test. Two dropped calls, one blocked call, one SHO(Soft handover) failure and one HO(hard handover) failure. One blocked call and one drop call were caused by poor RF conditions and the remaining three failures were caused by issues in Layer 3(network layer).

Event	Time	System	Serving band	Nemo status
GSM/UMTS call dropped (ETSI)	14:16:28	UMTS FDD	2100	Dropped call (i.e. network release)
GSM/UMTS call attempt failure (I	14:21:12	UMTS FDD	2100	Timeout before connection
GSM/UMTS call dropped (ETSI)	14:34:13	UMTS FDD	2100	Dropped call (i.e. network release)
GSM/UMTS call attempt failure (I	15:49:59	UMTS FDD	2100	Timeout before connection
GSM/UMTS call dropped (ETSI)	16:01:51	UMTS FDD	2100	Dropped call (i.e. network release)

Figure 12: Failure events for Tuaran drive test.

There were 5 failure events in the Tuaran drive test. All of them were caused by poor RF conditions. There were two blocked calls and three dropped calls that occur through the drive test.

Table 1: Comparison between Ipoh and Tuaran failure events caused by poor RF conditions.

Failure events	**Ipoh**	**Tuaran**
Blocked calls due to RF conditions	2%	4.2%
Dropped calls due to RF conditions	2%	5%

The table above shows the comparison between Ipoh and Tuaran failure events. The failure events cause can be identified through the NEMO status message and network cause message. The comparison is only done on failures caused by RF conditions because failure events caused by other than poor RF conditions might be affected by the time of day the drive tests were carried out where time of day is not the parameter we are interested in. Through the failure events, it is proven that Tuaran which has less ideal RF conditions caused more failures in terms of blocked calls and dropped calls. This is because the voice channel is directly affected by the dominance and coverage conditions of the network.

E. Packet data QoS

Table 2: Packet data Qos in Ipoh

Packet data QoS KPI	KPI Value for Ipoh
Packet data session completion	100%
Packet data switching network access delay	99.39% of samples<=7sec
Packet dropped	10.87%
Average throughput	1549.64kbps

The table shows the packet data network performance in Ipoh where a perfect session completion was achieved but 10.87% packet was dropped during the drive test. This might be due to best effort services experiencing poor RF conditions.

Table 3: Packet data Qos in Tuaran

Packet data QoS KPI	KPI Value for Ipoh
Packet data session completion	100%
Packet data switching network access delay	99.39% of samples<=7sec
Packet dropped	10.87%
Average throughput	1549.64kbps

Only 80% of the packet data sessions in Tuaran were completed and about 20% of the packet data had delay of more than 7 seconds. 15% packet data were dropped.

IV. CONCLUSION

In this work, it is observed that in terms of reliability, Ipoh as an urban area has better coverage with 93% of the RSCP value in the drive test in Ipoh is well above -95dBm compared to Tuaran with only 69%. In terms of dependability and reliability, Ipoh had 3 failure events due to bad RF conditions with two dropped calls, one blocked call. Meanwhile Tuaran had 5 failure events caused by poor RF conditions with two blocked calls and three dropped calls. In terms of Ec/No, Tuaran had the most percentage having values below the acceptable -12dB with approximately 34%. Therefore in the context of this work, it is concluded that Ipoh as an Urban area had better 3G network QoS compared to Tuaran as a rural area. In this global era, as people are becoming more and more dependent on mobile services for information on the go, personal and business use, the level of QoS of a network becomes even more important. Technological advancement is good but unequal opportunity to experience it will prove to be detrimental to a country's overall ability to compete on the world stage as information availability is the key to boost intellectual and economic prowess of a country. The R.F.C.O.N.A..N can be utilized to assess the overall RF conditions of other areas. This study can be improved by increasing the number of sites to increase the number of samples and thus, coming up with a more definitive conclusion. It is hoped that with this study, a better and understanding can be given on how the different topographic and demographic conditions of an area affects the availability, dependability and the reliability of a 3G network thus, the QoS of the network.

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