Measurement of 3G (WCDMA) Radio Statistics in Sub Urban Region of South-Western Ethiopia

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Abstract*: The aim of this paper is to study and analysis of the WCDMA (Wideband Code Division Multiple Access) based 3G network in Sub Urban Region of Ethiopia.3G network parameters in term of RSSI (Received signal strength indicator), RSCP (Received signal code power), and Signal Quality (E_C/I_O) has been evaluated around different site location by drive test. Plotted graph of signal levels Cumulative Distribution Function (CDF) shows that 41.7% of the total coverage area have poor signal strength. Drive test measurements were conducted on main route of Mettu city via shore river to the Mettu University (Ethiopia). Samsung (Galaxy A20) smartphones with "Android 7+" operating system and "Net-Monitor" software was used during the observations and measurements. All collected data were taken at the sampling interval of 15 seconds in 18 sessions for 49215 reports. The result and conclusion obtained from this experiment can be utilized as a supporting platform in network optimization process by Ethio-telecom.*

Keywords: WCDMA, RSSI, Fade Margin, Signal Quality**,** RSCP.

1. Introduction

The wireless air interface that is used by Ethio-Telecom in Ethiopia for third generation (3G) cellular system is Wideband Code Division Multiple Access (WCDMA/U2100). In order to provide better services to the customers, portability's with advance coming technologies or within existing technologies, optimization of network is needed. Health performance of WCDMA network is regularly measured by Network statistic (key performance indicators), Field measurements (Drive test), End users' feedback etc. Network statistics are collected from different network elements but Key Performance Indicators (KPI) provides information of the network's health traditionally. KPI play a vital role in quality setup but it becomes failure at small or very small statistical information. Other than Ethiopia, where several telecom operators are there, KPI's are also limited. Advancement in existing features of network, need new KPI's and counters. Therefore, modification in KPI's and counters are needed regularly and it gives extra burden to the operator. The work in [1]-[4] also measure the signal strength but in GSM cellular system. Here external environmental factor and methodology is different. Hence, derive test is the most straightforward approach to monitor the network's health and its performance.

1.1 South-Western Part of Ethiopia

Illuba bore Zone(Oromia region) and entire Gambella region is located in south-western part of the Ethiopia and covered by humid broadleaved forest and low land evergreen forest [5]-[7].The Sub urban region around Mettu town, Nikemte, Badelle, Jimma, Gore, Gimbi,Arba Minch and some small towns in Gambella region have almost same geographical challenge in sense of physical barriers (Hilly terrain, Long Trees ,etc.) wherein 3G network performance must be investigated to improve the grade of services(GOS) In this south-western region, the Mettu City (Fig-1) is considered for the study because it is the capital of illuba bore zone. This region also offers a pathloss of 7 dB/km to 27dB/km at 15 GHz (UHF band signal) because of foliage [5].

In a cellular system, if population density of mobile user is not equiprobable around the base station then high directional sectored antenna is pointed in particular direction of heavy traffic to ensure best coverage area. Transmitted electromagnetic waves (EM-Waves) arrive at the receiver either via direct path (Line of Sight path) or through in-direct path (different paths) due to surrounding objects (buildings, mountains, trees etc.). These surrounding objects may experience reflection, scattering and diffraction [5],[8]. The received electric field strength of EM-Wave varies as a result. This phenomenon is known as multipath fading [8]. So, received signal in mobile radio environment experiences slow fading due to topographical changes and fast fading due to multipath propagation [8].

2. Quality Parameters and its Study

2.1 Received Signal Strength Indicator (RSSI) Level

In telecommunication, RSSI is the measurement of power present in received radio signal. Higher value of RSSI indicates stronger signal. In order to improve the RSSI value, Tower Mount Amplifier (TMA) is used along with antenna at tower. The standard value of RSSI is almost same for 2G (GSM) and 3G (LTE/WCDMA/EVDO) cellular generations as it is shown in table -1.

2.2 Received Signal Code Power (RSCP)

It shows the received power of a particular physical communication channel, which is known as Common Pilot Channel (CPICH), it is regularly transmitted by WCDMA base station (Node-B). Its standard value with description is shown in table-2.

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Table 1: RSSI Specifications

Standard RSSI value for 3G	Signal Strength	Description for Services
> -70 dBm	Excellent	Strong signal with Maximum data speed
-70 dBm to -85dBm	Good	Strong signal with average data speed
-86 dBm to -100 dBm	Fair	Fair signal with reliable data speed
< -100 dBm	Poor	Performance will drop
-110 dBm	No signal	Disconnected

Table 2: RSCP Specifications

Standard RSCP value for 3G	Signal Strength	Description for Services
-60 to 0 dBm	Excellent	Strong signal with Maximum data speed
-75 dBm to -60dBm	Good	Strong signal with average data speed
-85 dBm to -75 dBm	Fair	Fair signal with reliable data speed
-95dBm to -85dBm	Poor	Performance will drop
-124 dBm to -95 dBm	Very poor	Disconnected

Table 3: Signal Quality (E_C/I_O) Specifications

EC/I_O value for 3G	Signal Strength	Description for Services
0 to -6dBm	Excellent	Strong signal with Maximum data speed
-7 to -10dBm	Good	Strong signal with good data speed
-11 to -20dBm	Fair	Reliable data speed may possible but close to -20 performance will drop

2.3 Signal Quality (Ec/Io)

It measures the downlink carrier to interference ratio. Ec/Io is a negative dBm values. Values closer to 0 are stronger signals. Standard recommended range of Ec/Io for 3G cellular is listed in table no-3 with respective description.

2.4 WCDMA Signal Level CDF

The plotted graph of Cumulative Distribution Function of the signal level indicates that how much percentage of coverage areas are below the standard signal level. Actually, it gives the statistical measurement of coverage areas with its associated RSSI levels

3. Drive Test and Measurement

3.1 Drive Test (DT) and its Confinement in Investigated Area

In this study, Signal parameters as explained in section-2 were measured in month of November 2019 at Ethio-telecom sites. Drive test was conducted for 93 minutes in the range of 100 meters to the 1500 meters around the base station, along the 10 km route path on main highway of shore river to Mettu university. Total 429 samples have been taken at the interval of 10 seconds to observe the statistical variation of RSSI levels. Signal Strength details were measured with operator's MCC-MNC Id, LAC Id (identify connected cell number), CID (Indicates Connected sector number), RNC number and ARFCN (Absolute radio frequency number) details. In order to get exact data at respective locations, GPS of phone was turned on. Those localities, which are situated in the basin of rift valley are not investigated because of their different case.

3.2 Derive Test Observation:

Measured value of RSSI's with respect to the time at interval of every 15 sec is plotted on graph by net monitor and shown in figure-2(a ,b ,c ,d, e &f).These graph, figure out the signal strength in coverage area of 3G (WCDMA) network. It varies from -51dBm to -88dBm within the range of 100 meters to 1.5 km from the base station (except steep rift valley). Practically, all major localities are found to be covered by an average signal strength in range of -70dBm to -80dBm.The range of RSCP lies in between -60dBm to -85dBm in whole measurement. The observed value of RSSI level and RSCP level(fig-3) suggest that the signal quality lies in range of -8dBm to -15dbm.Consequence of DB statistics (fig-4) based on 18 sessions and 49215 reports, result CDF graph (fig-5) for investigate area and remarks that 41.7% ,22.2% and 3.3% of the total coverage are getting the signal strength below -70dBm, -75dBm, and -80dbm respectively.

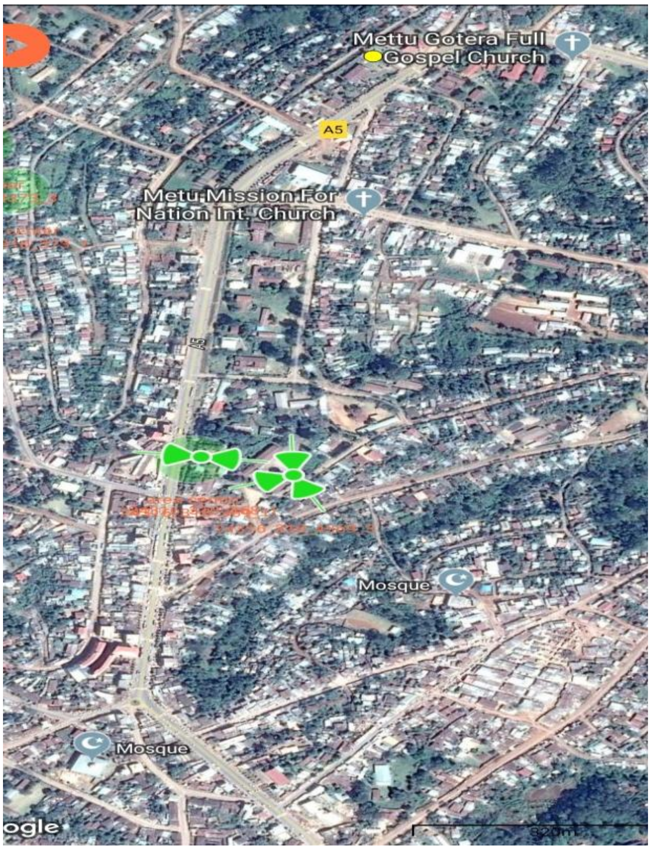

Figure 1: Mettu City (Place of Drive Test)

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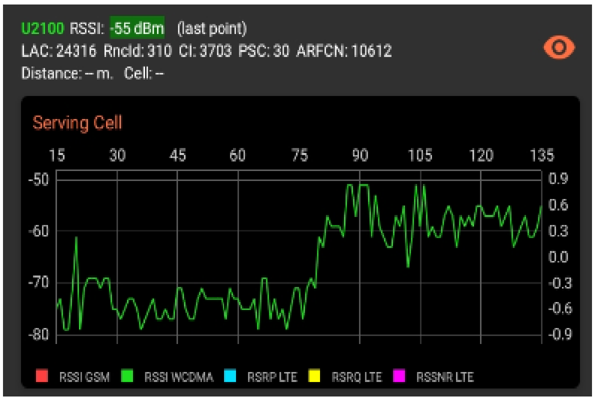


Figure 2 (a): RSSI Graph

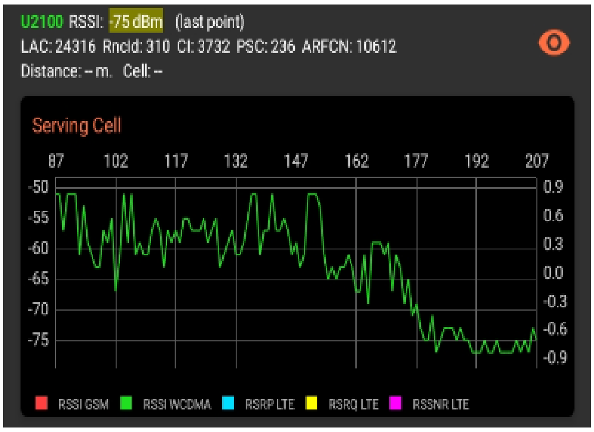


Figure 2 (b): RSSI Graph

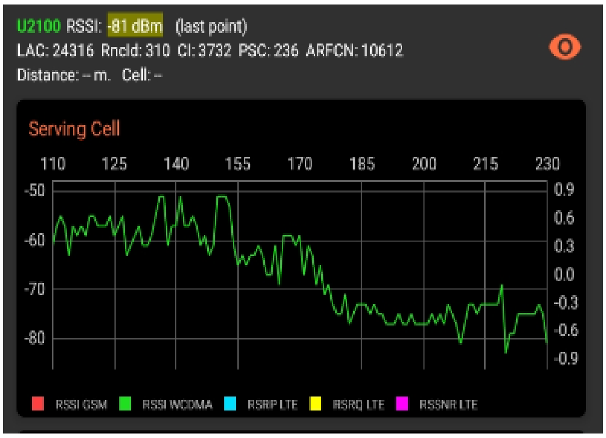


Figure 2 (c): RSSI Graph

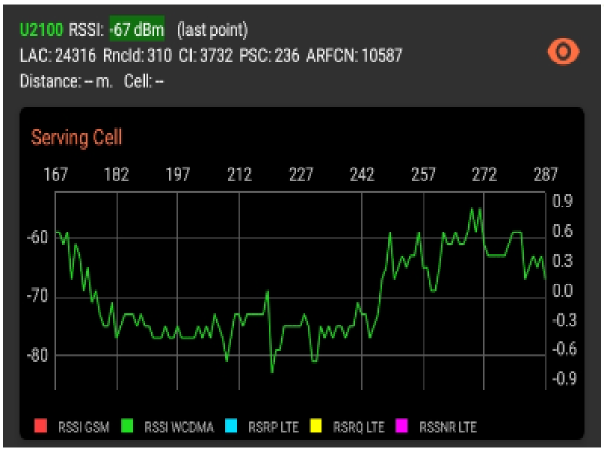


Figure 2 (d): RSSI Graph

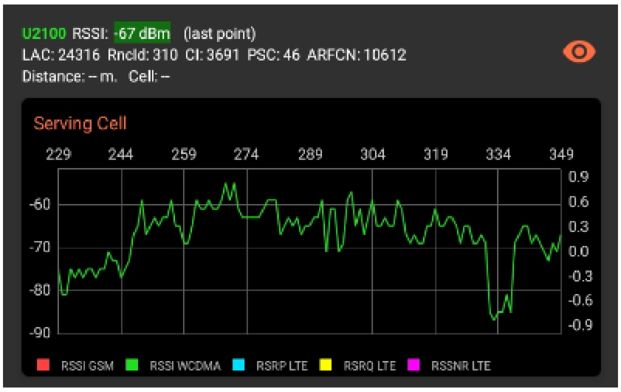


Figure 2 (e): RSSI Graph

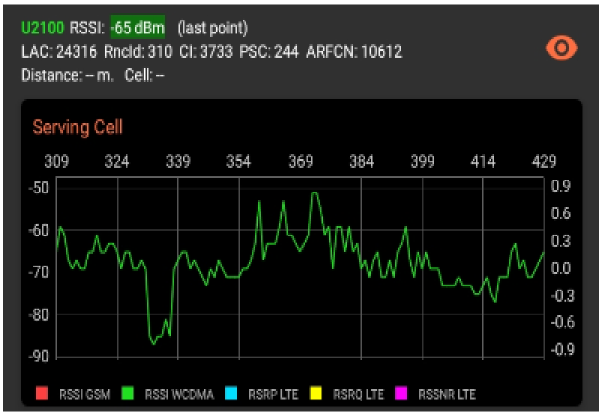
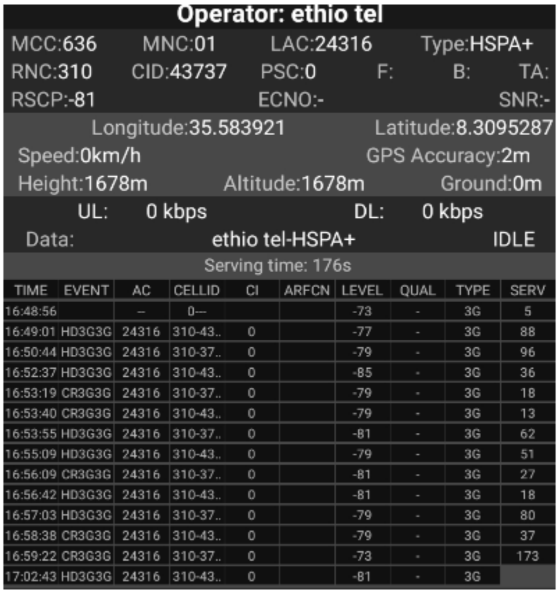


Figure 2 (f): RSSI Graph


Operator: ethio tel
MCC:636 MNC:01 LAC:24316 Type:HSPA+
RNC:310 CID:43737 PSC:0 F: B: TA:
RSCP:-81 ECNO:- SNR:-
Longitude:35.583921 Latitude:8.3095287
Speed:0km/h GPS Accuracy:2m
Height:1678m Altitude:1678m Ground:0m
UL: 0 kbps DL: 0 kbps
Data: ethio tel-HSPA+ IDLE
Serving time: 176s

TIME	EVENT	AC	CELLID	CI	ARFCN	LEVEL	QUAL	TYPE	SERV
16:48:56		--	0---			-73	-	3G	5
16:49:01	HD3G3G	24316	310-43..	0		-77	-	3G	88
16:50:44	HD3G3G	24316	310-37..	0		-79	-	3G	96
16:52:37	HD3G3G	24316	310-43..	0		-85	-	3G	36
16:53:19	CR3G3G	24316	310-37..	0		-79	-	3G	18
16:53:40	CR3G3G	24316	310-43..	0		-79	-	3G	13
16:53:55	HD3G3G	24316	310-37..	0		-81	-	3G	62
16:55:09	HD3G3G	24316	310-43..	0		-79	-	3G	51
16:56:09	CR3G3G	24316	310-37..	0		-81	-	3G	27
16:56:42	HD3G3G	24316	310-43..	0		-81	-	3G	18
16:57:03	HD3G3G	24316	310-37..	0		-79	-	3G	80
16:58:38	CR3G3G	24316	310-43..	0		-79	-	3G	37
16:59:22	CR3G3G	24316	310-37..	0		-73	-	3G	173
17:02:43	HD3G3G	24316	310-43..	0		-81	-	3G	

Figure 3: Sample of "RSCP Measurement"

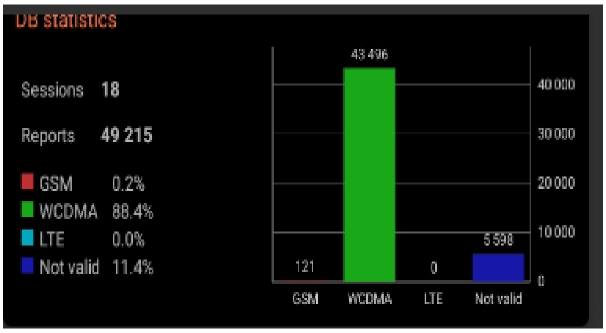


Figure 4: Data base Statistics for 49215 recorded data

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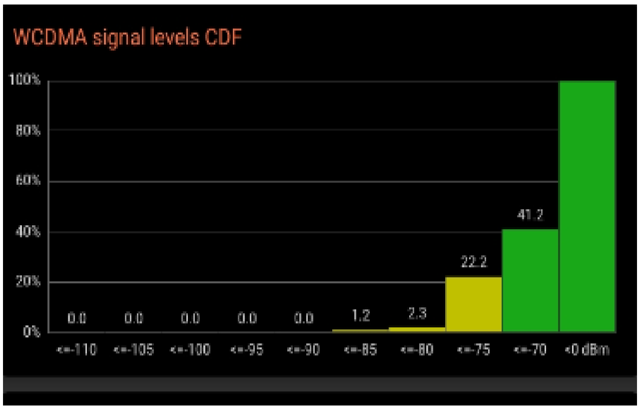

Figure 5: CDF Plot for WCDMA Coverage Area

4. Result and Analysis

The detail observation in the drive test (DT) bring the following result as

4.1 Proportion of location within coverage area.

On the basis of [8] it can be derived that, if mobiles are uniformly distributed within the cell area of L (1.5 km) radius and receiving the signal above threshold w_0 (assume here -70dBm). Let μ be proportion of mobiles receiving a signal above threshold within defined area and prob($w \geq w_0$) be the probability that w exceeds w_0 within infinitesimal area dA. Therefore, desired proportion μ is the probability prob($w \geq w_0$) averaged over the total circular area [8]. Hence,

$$\mu = \frac{1}{A}\int prob(w \geq w_0)dA$$

Where $A = \pi L^2$ and $dA = ldld\theta$. Thus

$$\mu = \frac{1}{\pi L^2}\int_0^L\int_0^{2\pi} prob(w \geq w_0)ldld\theta$$

$$\mu = \frac{2}{\pi L^2}\int_0^L prob(w \geq w_0)ldl$$

So, under the investigated drive test circumstances (0≤L≤1.5 km), above equation is modified as,

$$\mu = \frac{2}{\pi L^2}\int_0^L prob(w \geq -70dbm)ldl$$

4.2 Value of outdoor pathloss index (n)

Based on Log-normal shadow model for line of sight (LOS) consideration, received power at two different distance can be calculated as [8]

$$W(D) = W(D_0) - 10nlog(\frac{D}{D_0})$$

$Here, W(D) = Received\ power\ at\ distance\ D\ in\ dBm,$
$W(D_0) = Received\ power\ at\ distance\ D_0\ in\ dBm$

Thus, as per drive test observation W(1.5km) = -88dBm and W(0.1km) = -51dBm.Therefore, from above equation, value of pathloss index(n) becomes 3.14.

4.3 Fade margin and Quality of Service

RSSI statistics repeatedly reveal that the average level of received signal(-70dBm) follow log-normal distribution with time and location up to certain distance. Here shadow fading changes slowly, so called slow fading. To reduce the impact of shadow fading and ensure certain edge coverage probability "Slow fading margin" should be introduced. In this research work, a fade margin of -10dbm to -15dbm is found experimentaly.in addition to it, the observations from the drive test show that 41.7% and 22.2 % of the total coverage areas are getting the poor and very poor benefit of 3G(WCDMA) services because of low signal strength. The radio coverage in this area is dump due to irregular nature of steep valleys and foliage. Hereof it results the call drops during the mobility.

5. Conclusion

In this work, quality parameters of radio signal for 3G (WCDMA) network were measured and verified. Furthermore, drive test results were compared with its standard values as tabulated in tables (1,2,3). This comparison shows a good agreement. In case of high data rate services, the network performance is strongly dependent on the location of mobile users. So, in order to achieve high data rate in such environment low return loss antennas [9]-[12] should be used in mobile systems. Finally, it is concluded that these subs urban region based on south-western part of Ethiopia offer a path loss component of 3.14 with standard deviation (log-normal shadowing) of -10dBm to -15 dBm at radio frequency of 2100MHz.

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Author Profile

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