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Signal Tracking and Acquisition Model for Handoff Process in 4G Network

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ABSTRACT

Since network providers must adhere to the Quality of Service (QoS) standard when delivering network services to customers, the focus of this paper is on the development of signal tracking and acquisition models in 4G networks. The Nigerian Communication Commission (NCC) being the regulatory body established some key performance indicators (KPIs) that the network providers must follow in order to determine whether the implemented model will increase mobility and handoff management as well as improve QoS delivery. Within the Base Station (BS) footprint for the one week of Drive Tests, where measurements were made at intervals of 600m radii, the Received Signal Strength (RSSI) in the characterized 4G network demonstrated strong signals in the range of -50dBm to -80dBm. Mathematical calculations using the field experimental data collected and MATLAB SIMULINK show full agreement with NCC benchmark. The Call Drop Rate (CDR) is 14% while NCC benchmark is ≤ 20%. The Grade of Service (GoS) is 1.5%, which is in line with the NCC guideline of 1% to 2%. The proposed model's Handoff Success Rate (HOSR) is 91.2%; the NCC benchmark is 80%.

Keywords: Quality of Service (QoS), Key Performance Indicators (KPIs), Base Station (BS), Received Signal Strength (RSSI), Call Drop Rate (CDR), Grade of Service (GoS)

INTRODUCTION

Wireless communication technology, no doubt, is the highest selling commodity in the world today, there is practically no aspect of life that is optimally driven outside wireless telecommunication system, from educational sector, to banking sector, to sports and games even the local market men/women in the village operates on wireless communication system (Nnebe et al., 2021). For cellular systems particularly, there is a reflection of high interest for mobile broadband capacity systems, namely the universal mobile telecommunication systems (UMTS), known as a third generation (3G) technology (Karim & Othma, 2020). However, it has its own limitations, which necessitated the introduction of long term evolution (LTE) systems received as fourth generation (4G) (Adnan, Hilles, & Yafooz, 2017). LTE systems was introduced in order to handle the lapses in UMTS in terms of better spectrum efficiency, higher data rate, latency, capacity across the cell, better coverage, and better support for mobility (Nnebe et al., 2023). A mobile node in a Fourth Generation (4G) environment will have several interfaces and be able to smoothly switch between heterogeneous networks to ensure the continuation of an active application session. In 4G, the majority of the traffic is data and multimedia as opposed to voice only and through a common wide-area radio access technology and flexible network architecture, LTE has enabled convergence of mobile and fixed broadband networks (Singh & Singh, 2016; Nnebe et al., 2022). Future network devices should be able to roam freely across different access technologies, including wireless local area networks (WLANs), WiMAX networks, cellular systems, etc., in order to enable seamless changeover (Akyildiz, Xie, & Mohanty, 2004). The 4G network has been designed to provide Quality of Service (QoS) features while also offering transmission rates of up to 20 Mbps. Customer satisfaction is a personal feeling of either pleasure or disappointment

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resulting from the evaluation of services rendered by an organization to an individual in relation to expectations (Oliver, 1980; Leisen & Vance, 2001). The aim of 4G is to replace the entire core of cellular networks with a single worldwide cellular network completely standardized based on the Internet Protocol (IP) for video, packet data utilizing Voice over IP (VoIP) and multimedia services. The newly standardized networks would offer uniform video, voice, and data services based solely on IP to the mobile phone or handheld Internet gadget. Software defined radios will be used in the deployment of 4G systems, enabling the equipment to be upgraded to new protocols and services via software updates. It is not an entirely new system, nor does it provide brand-new technical solutions. The main objectives of 4G are integration and convergence. Different wireless network types should be able to seamlessly communicate with the wired backbone thanks to the integration.

Mobility Management in GSM

As with GSM, mobile network mobility management ensures prompt packet delivery to their destinations (Särelä & Hietalahti, 2004). The fundamental prerequisite for this method is a routing protocol. Here, mobility management refers to both the location management and handoff management strategies. Networks can monitor the whereabouts of mobile nodes (MNs) thanks to location management. Location registration and call delivery or paging are the two main sub-tasks of location management. To keep the location database current during the location registration procedure, the MN periodically sends a set of signals to the network informing it of its location. After the location registration is finished, the call delivery operation is started.

The call delivery procedure asks the network for the precise position of the mobile device based on the data that was registered in the network during location registration in order for a call to be successfully delivered. The following concerns must be taken into account when designing a location management system:

(i) Minimizing signaling overhead and latency in the service delivery,
(ii) Ensuring applications receive the guaranteed quality of service (QoS), and
(iii) In a fully overlapping area where multiple wireless networks co-exist, an effective and reliable algorithm must be created to choose the network through which a mobile device should perform registration, decide where and how often the location information should be stored, and how to calculate the exactly where the location information should be stored.

Due to node mobility in ad-hoc networks, finding an efficient path for ad-hoc routing is still a difficult research problem. Node position and neighborhood information, both of which are important for communication, are affected by node mobility. Additionally, it is simple to solve using multi-hop routing discovery. Bhatt et al. (2003) have examined and assessed how node mobility affects the functionality of ad-hoc wireless networks. Additionally, they have merged this method with actual-world scenarios like pedestrian speed estimation (Theus, 2015). It was determined that there are two ways to model the nodes' movement in a simulation.

The first is that node trajectories are calculated in a real network, for example, node positions can be determined using a GPS device, and are then utilized as input to power simulations. The realistic modeling of node mobility makes this method preferable. Utilizing a mobility model, which upholds a set of guidelines for node behavior, is the second option. These methods are insufficient to address these issues because the mobility model only partially captures node behavior. Instead, in order to describe node mobility in simulation, the aforementioned issues must be addressed.

Overview of Handoff

Handoff (or Handover) is the process of transferring the point of attachment of a Mobile Station (MS) to the network from a Base Station (BS) to another BS as the MS moves from the region of coverage of the initial serving BS to the coverage region of the target BS. This is usually required to be seamless and continuous, so that the on-going communication is not dropped, and the user does not experience a poor QoS (Aibinu et al., 2017; Ufoaroh et al., 2021). For the Hierarchical Mobile IPVersion6 (HMIPV6) architecture, handoff (handover) refers to the technique by which a running session is transferred from one Base-Station (BS) to another (Hiussi, Khotimsky, & Krishnan, 2000). Another way to describe it is the process of moving an active call or data session from one core network channel to another (Xie & Wang, 2008). In mobile networking, moving about is unavoidable with cellular deployment spanning many cells, as shown in Figure 1. The serving BS (SBS) changes as a result of mobility. In order to balance the network load, an SBS may alter depending on the load conditions and/or when a Mobile Station (MS) is involuntarily switched to another or a Target BS (TBS). A handoff decision process is therefore a crucial component of a cellular network. Signal strength, signal-to-interference ratio, distance to the BS, velocity, load, etc. could all be factors in the choice to hand off.

In mobile cellular networks, the effectiveness of the handoff mechanism is crucial for maintaining the desired QoS.

When the target signal strength exceeds the serving signal strength or when the serving signal strength drops below a threshold, the handoff decision may be made.

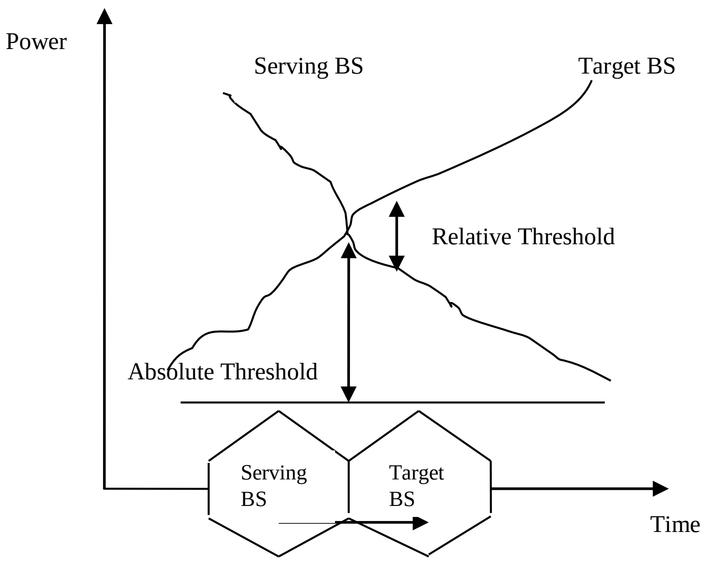

Figure 1: Handoff (Nwalozie et al., 2013)

While location management routing protocol employs the position of the node to improve the performance of routing protocol, handoff management concentrates on the rerouting notion (Nwalozie et al., 2013). When a mobile node switches from one access point to another, it manages the handoff procedure to keep its connection active. The handoff process has three steps. The mobile device, a network agent, or shifting network conditions are what first cause the handoff to start. The second stage is for the generation of a new connection, during which the network must locate fresh assets for the handoff connection and carry out any further routing tasks. The data delivery from the old connection path to the new connection path must be maintained under the data-flow control's control while adhering to the agreed-upon QoS assurances. The type of handoff the mobile device experiences will depend on its movement. In a general sense, handoffs can be divided into two categories:

(i) intra-system handoffs (horizontal handoffs) and
(ii) inter-system handoffs (vertical handoffs).

Intra-system handoffs are the term used to describe handoffs in homogenous networks. When the serving BS's signal strength drops below a predetermined threshold, this form of handoff happens. In the following situations (Särelä & Hietalahti, 2004), an inter-system handoff between heterogeneous networks may occur:

(i) When a user connected to a network chooses to handoff to an underlying or overlay network for his or her service requirements,
(ii) When a user travels from the serving network and enters an overlying network,
(iii) When it is necessary to divide the network's overall load among various systems.

The following challenges must be taken into consideration while designing handoff management systems for next-generation wireless networks built entirely on IP:

(i) signaling overhead and power requirement for processing handoff messages should be minimized,
(ii) QoS guarantees must be made,
(iii) network resources should be efficiently used, and
(iv) Handoff mechanism should be scalable, reliable and robust.

Signal strength degradation and user mobility are the two circumstances under which ongoing calls in handoff management are adjusted. The calls are shifted to new radio channels of the proper strength inside the same cell as a result of the radio channel deterioration, or the connections of the MS are transferred to a neighboring cell during an inter-cell handoff. Inter-cell handoff always occurs as a result of user movement. In each scenario, the connections from the MS can be transferred to the new BS without cutting off communication with the previous BS. It's known as a soft handoff. On the other hand, the procedure is known as a "hard handoff" if connections are broken at the old BS and then restored at the new BS (Nwalozie et al., 2013).

METHODOLOGY

Transverse Electromagnetic Simulator (TEMS) 15.0 was used to create Drive Tests for the Mobile Telecommunication Nigeria (MTN) network. In order to manage handoffs, a hybrid version of mobile assisted handoff, known as h-MAHO, was developed. This Design Method has a more decentralized handoff. The link quality (i.e., RSSI and channel availability) is controlled by both the Mobile Station (MS) and the Base Station (BS). The network requests the MS to measure the signal strength coming from the nearby BSs. However, the network bases its judgment regarding the handoff on the MS's report. The MS measures the RSSI (received signal strength indication) of nearby base stations. The GSM cellular standard employs this handoff mechanism, and the mobile station sends the measurement result to the base station twice every second. The network is remains in charge of deciding when and where to carry out the handoff. This Design Method has a more decentralized handoff. A hybrid MAHO-based handoff technique was created utilizing MATLAB Simulink/graphs and flowchart using the generated model.

Figure 2: TEMS Measurement Tool used for Field gathering of RSSI Data

Although this Project will focus primarily on Handoff and some significant Key Performance Indicator (KPI) indices that improve Mobility Management and QoS delivery in 4G network, the Investigation page displays a variety of information about parameters like Network Frequency, Signal-to-Interference Ratio (SIR), Call Setup, Call Establishment, Call Drops, Uplink and Downlink Physical layer, Throughput, Handoff and Effect of Traffic/Load on Handoff.

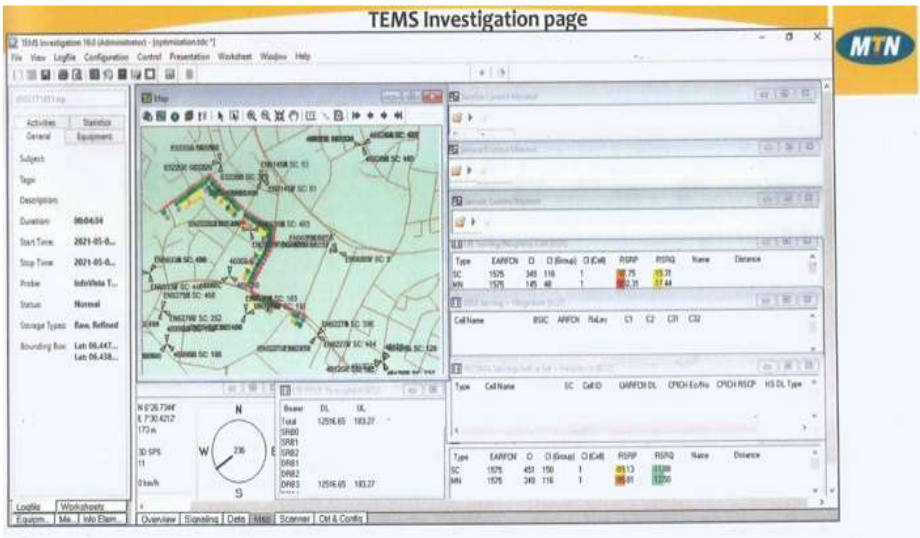

Figure 3: TEMS Investigation Page

In order to cover the given region, a few GSM BTS sites, each with three sectors and varied azimuths, are deployed. For UMTS sites, however, only one Omni-directional antenna per BTS is used. The nearly 600 meter separation between the sites corresponds to the standard configuration for commercial UMTS antennas. A specific GPS-clock is used to synchronize all of the locations. The cell has a diameter of about 350 meters.

RESULTS AND DISCUSSION

In order to acquire data on 4G network KPI, this article used TEM devices to characterize the 4G network and involved MTN site engineers in driving tests. The received signal strength inside metropolitan areas was good during the drive test that was conducted within fifteen (15) working days, or from July 5 to July 23, 2020, with the exception of the week that saw significant rain fall and defective generating sets in some of the thirty (30) BTS of interest. We looked at a cell's call setup success rate, call arrival rate, and number of handoffs in base stations. Call Drop frequently increases as a result of weak RSSI or network downtime. An adaptation of the MAHO approach was created to prevent this situation. By using this method, base station data on the SBS is maintained. The SBS offers details about the load and RSSI of the base station. Before determining which BS to hand off to during handoff, the Mobile Station (Adaptive) took into account the aforementioned two factors. The way in which this strategy was used in this case greatly reduced Call Drops. This is due to the fact that the Handoff in the current MAHO approach is carried out based on RSSI. However, the BTS can have a lot of Handoffs and end up dropping the incoming ones that come after. However, in cases where hybrid MAHO is used, the best BTS is selected and the call transmission proceeds without a break.

Table 1: 4G KPI Statistical Data Averages obtained from 3 Weeks Field Measurement during Drive Test – Rxlev and SIR

WEEK 1	**Time**	**Date**	**Rxlev(dBm)**	**SIR**
Week 1	09:30:07 am	05-07-2021	-65.8	29.2
	09:52:27 am	05-07-2021	-65.8	29.2
	11:01:05 am	05-07-2021	-75.3	19.7
	11:21:15 am	05-07-2021	-75.3	19.7
	04:10:17 pm	05-07-2021	-95.8	0.8
	04:22:21 pm	05-07-2021	-98.8	3.8
	06:01:00 am	06-07-2021	-55.3	39.7
	06:21:17 am	06-07-2021	-70.0	25
	08:30:01 am	06-07-2021	-105.5	0.6
	09:12:27 am	06-07-2021	-98.8	3.8
	10:21:00 am	06-07-2021	-99.3	3.7
	11:00:15 am	06-07-2020	-70.0	25
	08:10:12 am	07-07-2021	-100.8	0.5
	09:02:00 am	07-07-2021	-97.8	3.8
	05:21:05 pm	07-07-2021	-65.3	29.7
	06:00:21 pm	07-07-2021	-110.0	0.4
	07:30:04pm	07-07-2021	-55.0	38.2
	08:18:27pm	07-07-2021	-56.3	39.2
	09:38:06am	08-07-2021	-64.2	24.1
	10:14:18am	08-07-2021	-98.4	30.2
	03:08:27pm	08-07-2021	-99.9	32.3
	03:33:17pm	08-07-2021	-101.9	0.20
	05:12:29pm	08-07-2021	-56.5	33.3
	06:30:13pm	08-07-2021	-100.9	0.52
	09:39:01am	09-07-2021	-50.2	38.8
	09:55:20am	09-07-2021	-55.8	37.2
	11:01:20am	09-07-2021	-72.8	24.0
	11:45:01am	09-07-2021	-76.9	22.0
WEEK 2	**Time**	**Date**	**Rxlev(dBm)**	**SNR**
	09:00:00am	12-07-2021	-64.8	28.9
	09:45:25am	12-07-2021	-62.9	27.5
	10:02:45am	12-07-2021	-104.5	0.43
	11:45:00pm	12-07-2020	-89.2	3.02
	03:15:20pm	12-07-2021	-99.7	2.50
	06:45:00pm	12-07-2021	-98.2	2.90
	08:30:01am	13-07-2021	-92.4	2.60

Week 2	10:45:50am	13-07-2021	-54.4	32.1
	11:01:20am	13-07-2021	-100.8	0.70
	12:32:45pm	13-07-2021	-98.7	2.21
	02:00:00pm	13-07-2021	-72.1	23.22
	09:45:02am	14-07-2021	-75.4	17.90
	11:15:26am	14-07-2021	-98.2	0.31
	01:00:00pm	14-07-2021	-90.4	0.23
	04:30:15pm	14-07-2021	-95.6	0.79
	06:00:00am	15-07-2021	-107.8	0.23
	08:15:10am	15-07-2021	-54.2	36.1
	03:25:12pm	15-07-2021	-55.3	38.3
	06:09:14pm	15-07-2021	-99.2	36.2
	09:15:01am	16-07-2021	-80.2	20.1
	02:15:20pm	16-07-2021	-116.4	0.27
	03:25:15pm	16-07-2021	-98.6	2.90
	05:20:10pm	16-07-2021	-66.1	32.1
	06:25:11pm	16-07-2021	-53.1	36.3
WEEK 3	**Time**	**Date**	**Rxlev(dBm)**	**SNR**
Week 3	09:30:15am	19-07-2021	-94.3	29.2
	10:15:11am	19-07-2021	-91.2	3.80
	12:49:10pm	19-07-2021	-98.5	27.3
	04:20:15pm	19-07-2021	-73.4	18.2
	09:05:15am	20-07-2021	-92.8	0.71
	11:35:20am	20-07-2021	-80.0	19.21
	02:30:21pm	20-07-2021A	-61.2	20.3
	06:45:21am	21-07-2021	-54.1	37.2
	09:15:20am	21-07-2021	-66.2	26.2
	11:55:05am	21-07-2021	-68.1	28.1
	03:30:25pm	21-07-2021	-100.1	0.36
	05:58:10pm	21-07-2021	-99.1	3.00
	03:00:01pm	22-07-2021	-69.9	29.2
	03:55:20pm	22-07-2021	-98.1	3.10
	04:30:15pm	22-07-2021	-99.8	3.03
	06:15:20am	23-07-2021	-101.1	0.37
	08:00:00am	23-07-2021	-96.4	3.10
	10:45:00am	23-07-2021	-97.1	3.01
	05:15:22pm	23-07-2021	-70.2	32.2
	06:45:15pm	23-07-2021	-72.12	27.1

Table 2: 4G KPI Statistical Summary of Effect of Traffic Load on Handoff

	Average Calls Attempted	Average Completed Calls	Average Blocked Calls	Average Answered Calls	Average Unanswered Calls	Average Handover Attempted	Successful Handoff
AWK001	455863	390037	6582	350344	39693	9293	9192
AWK002	419731	234190	18554	194354	39836	6271	6031
AWK003	279830	193839	8599	173932	19907	9289	8728
AWK004	479465	398002	8146	298022	99980	10393	10293
AWK005	53955	40573	1338	34529	6044	3827	3111

AWK006	80208	54058	2615	48293	5765	3634	2989
AWK007	69103	51019	1808	49832	1187	4352	4028
AWK008	132691	106016	2667	93839	12177	8934	8732
AWK009	678566	597331	8123	530728	66603	4723	4273
AWK010	1038491	940585	9790	894032	46553	8373	7832
AWK011	147067	109101	3796	93032	16069	4582	3829
AWK012	108595	87809	2078	78392	9417	3839	3028
AWK013	109534	98231	1276	109634	1011	9278	8713
AWK014	143641	108543	1163	287103	2076	10821	9887
AWK015	176678	254876	1462	264071	11754	2801	2413
AWK016	234987	234869	2374	303109	17010	9476	8501
AWK017	324678	812423	2729	271912	21872	8709	8127
AWK018	412890	79543	2479	38901	29043	7234	6729
AWK019	213456	121845	2712	87293	12003	6903	4417
AWK020	89453	103542	1730	28345	34860	7923	7731
AWK021	79354	304786	910	73192	32876	3489	2989
AWK022	67453	237201	1375	69173	17012	6100	5087
AWK023	54830	564908	1521	39601	39491	3890	2906
AWK024	76987	127512	1073	47145	13009	5189	4781
AWK025	41854	219753	1384	29803	19023	3978	905
AWK026	6751	98419	1747	26309	18723	2758	2703
AWK027	67513	98419	1747	26309	18723	2758	2703
AWK028	87311	319683	1853	41876	16234	3219	1954
AWK029	78613	40725	1638	33809	17609	4156	3840
AWK030	67500	66540	6,00	550370	3678	10750	10750
Average	**210165.03**	**240180.8**	**3539.483**	**172602.8**	**23600.9**	**6329.9**	**5772.7**

Characterization of the 4G Network and Determination of KPIs

The total number of calls made is calculated by adding Call Setups and Blocked Calls. The Call Setup Success Rate is one of the Key Performance Indicators (KPI) that Network Providers use to assess the usability and efficiency of their Networks. As the Call Setup Success Rate (CSSR) increases, the Blocked Call Rate (BCR) or Call Drop Rate (CDR) declines. It is conceivable that this will directly influence/have an impact on how Customers view and evaluate the Services offered by the Network and how it functions. CSSR benchmark set by Nigeria Communication Commission (NCC) is 80%.

Call Setup Success Rate Evaluation

$$\text{CSSR} = \frac{Number\ of\ successful\ calls\ Setup}{Total\ number\ of\ call\ attempts} \quad (1)$$

$$\text{HOSR} = \frac{Number\ of\ successful\ \text{Handoff}}{Number\ of\ attempted\ \text{Handoff}} \text{ x } 100\% \quad (2)$$

$$\text{GoS} = \frac{Number\ of\ \text{lost or blocked}\ calls}{Total\ number\ of\ \text{offered}\ call} \quad (3)$$

From Table 2:

Applying Equation 1: CSSR = $\frac{172602.8}{210165.03}$ = 82.127% or 82% (Round Figure)

Applying Equation 2: HOSR = $\frac{5772.7}{6329.9}$ * 100% = 91.2% or 91% (Round Figure)

Applying Equation 3: GoS = $\frac{3540}{240181}$ = 0.0147 ≈ 0.015 or 1.5%

SIMULINK Simulation Plots of 4G KPI Characterized Network Parameters from the 3 Weeks Conducted Measurements

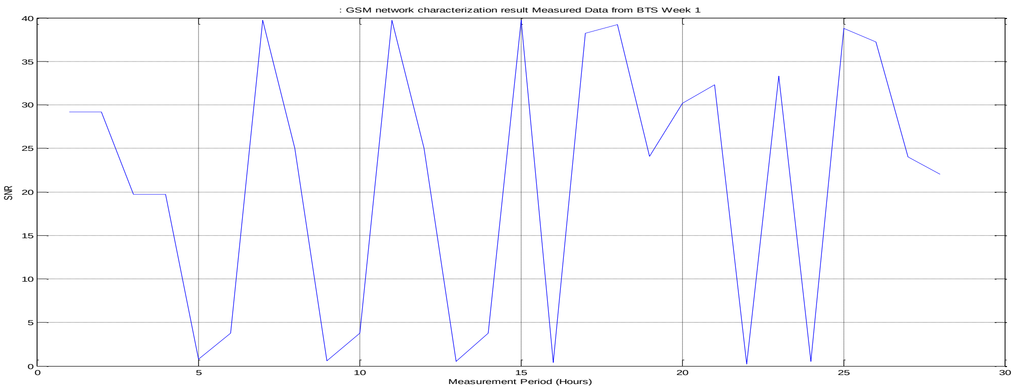

Figure 4: Network Characterization – SNR (Week 1)

From Figure 4 and Table 1, it can be seen that during the test, 4G SNR in good samples within the range -50dBm to -80dBm is observed to be 57.1% in the 1st week with strongest Signal Strength (SNR) at -50.2dBm.

It was discovered that from – 50dBm to – 80dBm the Received Signal Strength can comfortably carry 4G facilities, that is, Voice and Data.

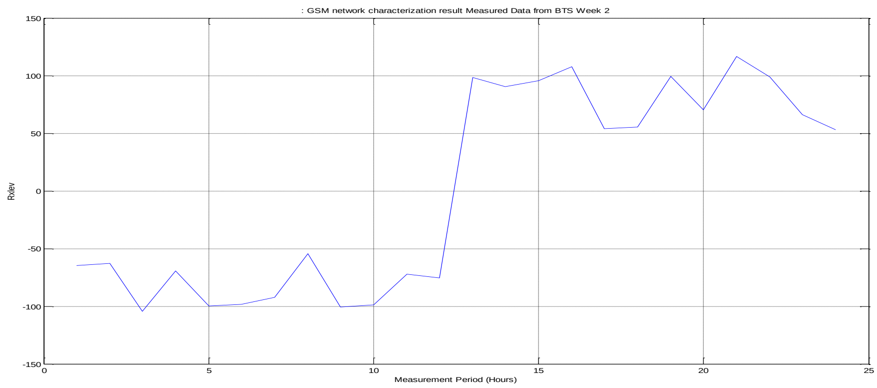

Figure 5: Network Characterization – Rxlev (Week 2)

According to Figure 5 and Table 1 for the second week, the majority of the networked areas that were tested had inadequate radio/antenna signal coverage that was well outside the RSS-required Quality Signal of 80 dBm. Heavy rainfall that was seen during the second week of the test drive is to blame for the poor Signal Quality (62.5%) received by the MS above 80dBm. The Mobile Switching Center (MSC) Logbook also noted that the MSC Standby Generator was defective and required repairs for three days during the measuring period in the second week.

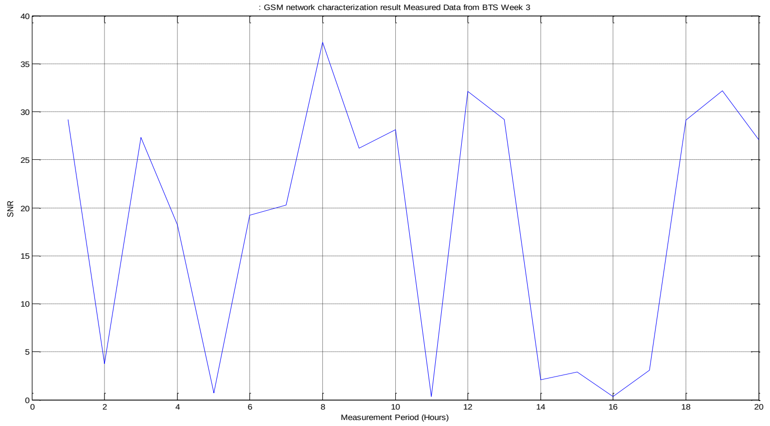

Figure 6: Network Characterization – Rxlev (Week 3)

From Figure 6 and Table 1 in the 3rd week, 45% of the entire tested area on the Network had a good Signal coverage transmitted by the radio/antenna which ranged from -54.1dBm to -80.0dBm, so there was good Sign al Quality received by the MS.

Table 3: Simulated Data of Offered Calls Probability of call blocking Using Hybrid of MAHO (RSSI and Load)

Offered calls	**Probability of call blocking % (Hybrid of MAHO)**
100	0.0000
200	0.0000
300	0.0003
400	0.0016
500	0.0055
600	0.0136
700	0.0270
800	0.0461
900	0.0700
1000	0.0978
1100	0.1281
1200	0.1597
1300	0.1916
1400	0.2232
1500	0.2539
1600	0.2834
1700	0.3116
1800	0.3383
1900	0.3636
2000	0.3874

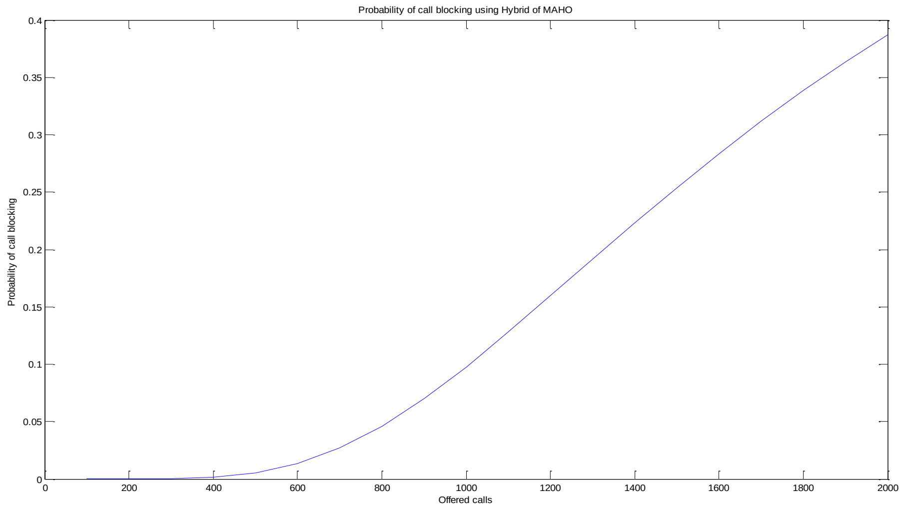

Figure 7: Simulated Data of Offered Calls versus Blocked Call using Hybrid of MAHO

Based only on the simulation results in Figure 7, the mobile station does not hand over to the base station. It also considers the quantity of handoffs on the BS (load). Based on the MAHO decision information – Adaptive, it continues to change at random within the range when choosing the BS to handoff to. For a traffic load of 100, the call blocking probability (Pb) is 0, but it rises as the traffic load does. The number of calls reduced to 0.3% when the traffic load reached 2000. When Hybrid of MAHO was introduced, the call drop rate was on average 0.1%.

Table 4: Comparison of call blocking probability

Offered calls	**Probability of call blocking % (MAHO)**	**Probability of call blocking % (Hybrid of MAHO)**
100	0.0136	0.0000
200	0.1597	0.0000
300	0.3383	0.0003
400	0.4695	0.0016
500	0.5611	0.0055
600	0.6270	0.0136
700	0.6762	0.0270
800	0.7141	0.0461
900	0.7442	0.0700
1000	0.7686	0.0978
1100	0.7888	0.1281
1200	0.8058	0.1597
1300	0.8203	0.1916
1400	0.8328	0.2232
1500	0.8436	0.2539
1600	0.8532	0.2834
1700	0.8616	0.3116
1800	0.8691	0.3383
1900	0.8759	0.3636
2000	0.8820	0.3874

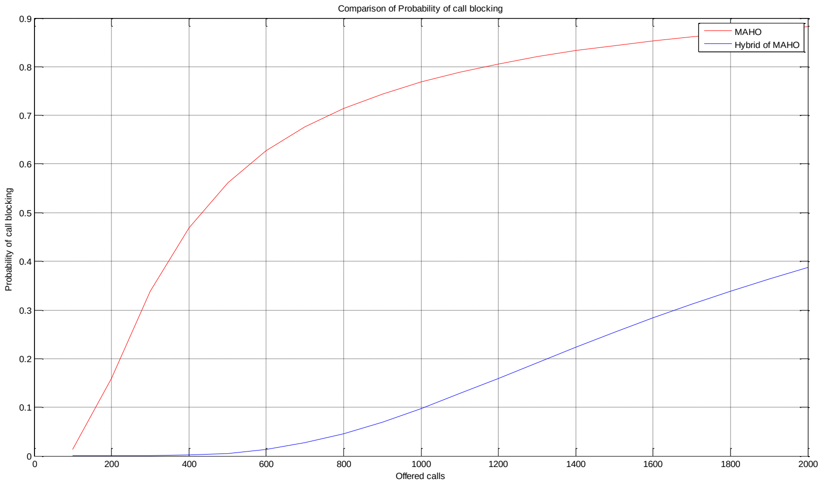

Figure 8: Comparison of call blocking probability with MAHO and Hybrid of MAHO

Based on Handover on the 4G Network, the algorithm's performance is evaluated. The blocking probability using MAHO and the hybrid MAHO handover technique is shown in Figure 4.4a. According to the graph, the call blocking probability is lower with MAHO's hybrid than it is with MAHO. The graph demonstrates that, in comparison to MAHO handover technique, the Hybrid of MAHO handover technique suggested in this paper reduced blocking probability by 0.6%.

Table 5: Handover latency

Handover Latency (MAHO)	Handover Latency (Hybrid MAHO)
260 ms	180 ms

Handover Latency Simulation Result

The network delay experienced when switching from one base station to another base station is known as handover latency. For the network that does not use a handoff prediction table, the handoff latency is shown in Table 5 and Figure 9 to be high. The prediction Table is created using the results of the standard scans in the proposed scheme, and its contents are updated using the Handoff decisions from the Mobile Stations after each successful Handoff (HO) operation. The MAHO prediction Table is kept by the SBS in the suggested manner. With the implementation of the handoff prediction table, all of these requests from different MSs are combined into a single request, preventing network latency.

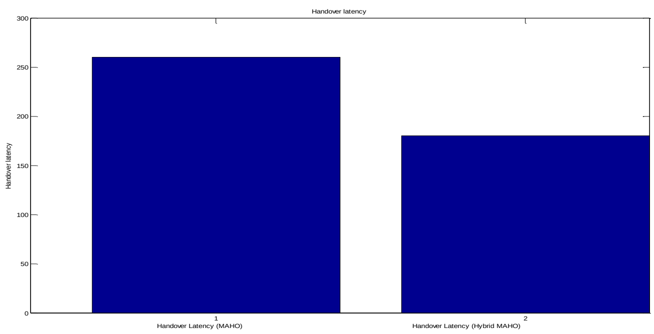

Figure 9: Comparison of Handoff Latency

Figure 9 shows that in terms of Handoff delay, the suggested approach outperforms the MAHO scheme. When hybrid MAHO was employed, it was found that the handoff latency was significantly reduced, going from 260msec to 180msec.

CONCLUSION

As described in this study, hybrid MAHO was used to simulate a system using signal tracking and acquisition to improve seamless handoff management performance in 4G networks. This guarantees that it is possible to migrate data flows transparently across two access points that belong to different heterogeneous technologies and justifies the work done in this research. The design and implementation of an integration architecture that permits vertical handoffs across 4G wireless technologies were given in the research effort. The effort focused on minimizing roaming-related mobility disturbances and lowering latency. The study thus showed that employing a hybrid of the MAHO technique makes it possible to enable transparent mobility, track nodes during sessions, and decrease latency during heterogeneous handoffs. In comparison to the conventional MAHO technique, the proposed h-MAHO technique performs better, with a call setup success rate (CSSR) of 96.3% as opposed to the conventional MAHO model's 94.7%. The proposed model decreased the likelihood of blocking by 0.6%. In comparison to the conventional model's 0.3% call drop probability, simulation of the two models reveals that the suggested model achieves a better result of 0.1%. In terms of handoff latency, the proposed model decreased the time of the conventional model from 260msec to 180msec. Therefore, it is feasible to implement an appropriate architecture that allows seamless mobility in a 4G network utilizing the techniques that were provided and assessed in this research.

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