Network Performance Analysis and Optimization of LTE-Advanced Systems

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Abstract: This work focuses on the optimization of an LTE-Advanced network through a comprehensive performance analysis framework. The study involves the collection, processing, and evaluation of network statistical data and measurement reports obtained from the network management system. To assess network performance and identify potential issues, several Key Performance Indicators (KPIs), including traffic measurement counters, service drop rates, and other quality-of-service metrics, are analyzed. Furthermore, common fault localization and troubleshooting techniques are applied to diagnose network inefficiencies and improve overall system performance. The analysis is conducted using data acquired from the Huawei M2000 network management platform, enabling a detailed evaluation of network behavior and optimization opportunities.

Keywords: Long Term Evolution (LTE), Generation (G), Key Performance Indicators (KPIs), Mobile, Network, Optimization.

1. INTRODUCTION

Mobile communication refers to the exchange of information between users and devices without requiring a physical wired connection. The early generations of cellular systems, particularly GSM, introduced the fundamental principles of mobile communication, including circuit-switched voice services and mobility support [1]. This was followed by UMTS, which extended cellular capabilities by enabling higher data rates and supporting early mobile broadband services, marking a significant step in the evolution of wireless networks [1].

Over time, cellular systems evolved into high-capacity communication networks capable of supporting voice, data, and multimedia services with improved reliability and seamless mobility. This evolution was driven by the introduction of LTE, which significantly enhanced spectral efficiency, system capacity, and overall user experience [2]. LTE-Advanced further improved network performance through advanced techniques such as carrier aggregation, enhanced MIMO configurations, and improved interference management mechanisms [3].

The continuous evolution toward fifth-generation (5G) mobile networks introduced new capabilities designed to support ultra-low latency, massive device connectivity, and enhanced reliability for emerging applications such as IoT, autonomous systems, and mission-critical communications [4-5]. The standardization of 5G New Radio (NR) was introduced in 3GPP Release 15, which also defined the initial architectural framework for LTE–NR interworking and dual connectivity [6]. However, the deployment of 5G has occurred gradually, resulting in a prolonged coexistence between LTE/LTE-Advanced and 5G NR networks. In particular, E-UTRA–NR dual connectivity (EN-DC) enables LTE and NR to operate simultaneously, ensuring service continuity and efficient spectrum utilization during mobility scenarios [7-8]. This architecture represents a key enabler of heterogeneous multi-RAT deployments in modern mobile networks.

Prior to and during early 5G deployment, LTE remained the dominant mobile broadband technology, addressing increasing traffic demand. LTE-Advanced improved system performance through advanced radio technologies such as MIMO and carrier aggregation [2], [3]. Practical implementation and optimization of these technologies are supported by operator training and vendor-specific engineering guidelines, particularly in commercial LTE deployments [9-10].

Modern mobile networks therefore operate as heterogeneous multi-radio access technology (multi-RAT) environments in which LTE/LTE-Advanced and 5G NR coexist and complement each other. Within this

framework, LTE continues to provide wide-area coverage, mobility support, and service continuity, while dual connectivity mechanisms enable coordinated operation between LTE and NR layers [6-8].

From this perspective, the LTE-Advanced measurements analyzed in this study, including the operational data collected in June 2021, represent an empirical assessment of an established LTE network during a period of increasing 5G deployment [9-12]. The objective is not to position LTE-Advanced as a competing technology to 5G NR, but rather to assess whether the LTE layer maintains adequate accessibility, E-RAB establishment, service continuity, and mobility performance within an evolving multi-generation network environment. Maintaining the performance of this layer is particularly important in heterogeneous networks where LTE and 5G NR coexist and where users may experience mobility and coverage transitions between different radio-access technologies. Therefore, LTE-Advanced optimization remains relevant in the 2021–2026 timeframe as part of the broader evolution toward heterogeneous 4G/5G mobile networks.

To ensure efficient network operation and maintain Quality of Service (QoS), LTE networks rely on standardized Key Performance Indicators (KPIs) defined under 3GPP performance management specifications. These KPIs provide quantitative measures of network accessibility, retainability, mobility, and traffic performance within the E-UTRAN system [13-15]. Continuous monitoring of these indicators enables operators to detect performance degradation and apply optimization strategies. In LTE-Advanced networks, KPI-based performance analysis is essential because network behavior is influenced by radio conditions, traffic load, configuration parameters, and mobility patterns. Accessibility KPIs such as RRC connection setup success rate and E-RAB establishment success rate evaluate service accessibility, while retainability KPIs such as drop rates measure service continuity. Mobility KPIs such as handover success rate assess seamless user movement across cells. Together, these KPIs provide a comprehensive representation of network performance [2], [3], [13].

The aim of this work is to optimize an LTE-Advanced network through a comprehensive performance analysis framework. The study involves the collection, processing, and evaluation of network statistics and measurement reports obtained from the network management system. To assess network performance and identify potential issues, several KPIs are analyzed, including accessibility, retainability, and mobility indicators. In particular, RRC setup performance, E-RAB establishment success, call drop behavior, and handover performance are examined to identify areas of network degradation and potential optimization opportunities. Traffic measurement counters, service drop rates, and fault localization techniques are also investigated to support the identification of network inefficiencies. The analysis is conducted using operational performance data collected from the Huawei M2000 network management platform [9-12]. The dataset provides cell-level measurements that enable the evaluation of LTE-Advanced network behavior under real operational conditions. By relating Huawei performance counters to the corresponding KPIs, the study provides a systematic approach for identifying performance limitations and evaluating the effectiveness of network optimization activities. The results therefore contribute to a practical understanding of LTE-Advanced performance management and demonstrate the continued value of KPI-driven optimization in heterogeneous mobile networks during the ongoing transition from LTE toward 5G.

2. LTE-ADVANCED OPTIMIZATION

In this section, the selected Key Performance Indicators (KPIs) are evaluated using performance counters collected from the network management system. These counters constitute the basis for KPI calculations and provide essential information for assessing network performance, identifying bottlenecks, and diagnosing operational issues. Furthermore, KPI definitions and threshold values should be continuously refined based on operational experience from commercial network deployments and radio network optimization practices.

The KPIs analyzed in this work are classified according to their performance objectives.

Accessibility is evaluated through the RRC Connection Establishment Success Rate and the E-RAB Establishment Success Rate, which measure the ability of users to successfully access network services.

Retainability is assessed using the Call Drop Rate (CDR), reflecting the network's capability to maintain ongoing connections.

Mobility performance is evaluated through the Handover Success Rate (HSR), which indicates the effectiveness of user mobility management between neighboring cells. Together, these KPIs provide a comprehensive assessment of network performance and Quality of Service (QoS). All measurement data and performance statistics used in this analysis were collected from the Huawei M2000 network management platform.

2.1 Mathematical Formulation of LTE-Advanced Performance KPIs

The LTE-Advanced optimization performance is evaluated using KPIs derived from Huawei network performance counters. To ensure reproducibility, the mathematical relationships between the raw counters and the reported KPIs are explicitly defined below.

- **E-RAB Establishment Success Rate**

The E-RAB Setup Success Rate represents the proportion of E-RAB establishment attempts that are successfully completed. It is calculated as:

$$ERAB\ Setup\ Success\ Rate(\%) = \frac{ERABSetup_Attempt - ERAB\ Setup\ Failure}{ERABSetup_Attempt} \times 100 \quad (1)$$

where ERABSetup_Attempt is the number of E-RAB establishment attempts and E-RAB Setup Failure is the number of unsuccessful E-RAB establishment procedures.

- **Call Drop Rate (CDR)**

The CDR evaluates abnormal termination of established E-RAB sessions. The Huawei measurements include the total abnormal E-RAB release triggered at the eNodeB level.

$$N_{AbRel} = LE - RAB.AbnomRel.eNBTot$$

This includes specific failure sub-counters, such as:

$N_{HOFail} = LE - RAB.AbnomRel.HOFailure$
(Abnormal releases caused by handover failures)

$N_{HOOut} = LE - RAB.AbnomRel.MME.HOOut$

(Abnormal releases related to MME/S1 outgoing handovers)

The CDR is calculated according to the Huawei KPI definition as:

$$\text{CDR}(\%) = \frac{N_{AbRel}}{\text{Total E-RAB Releases}} \times 100 \quad (2)$$

- **Handover Success Rate (HSR)**

The HSR measures the percentage of handover attempts successfully completed:

$$\text{HSR}(\%) = \frac{N_{Successful\ Handover}}{N_{Handover\ Attempts}} \times 100 \quad (3)$$

where the numerator and denominator correspond to the Huawei handover-success and handover-attempt counters reported in the handover performance dataset.

A higher HSR indicates improved mobility robustness and a lower probability of service interruption during inter-cell mobility.

- **RRC Setup Success Rate**

For completeness, the RRC Setup Success Rate is calculated from the corresponding Huawei RRC connection counters:

$$\text{RRC Setup Success Rate}(\%) = \frac{N_{RRC\ Success}}{N_{RRC\ Attempt}} \times 100 \quad (4)$$

The service and signaling procedures are evaluated separately using their corresponding RRC counters.

Together, these formulations establish a consistent relationship between the Huawei raw performance counters and the LTE-Advanced optimization KPIs reported in the study.

A. Accessibility Performance in LTE Networks:

In LTE networks, a User Equipment (UE) must first perform the Random Access (RA) procedure before accessing network services such as service requests, location updates, or responses to paging messages. The RA procedure initiates communication between the UE and the network and enables the establishment of a control-plane connection with the Mobility Management Entity (MME).
The control-plane connection comprises two components: the Radio Resource Control (RRC) signaling connection over the Uu interface between the UE and the eNodeB, and the S1 signaling connection between the eNodeB and the MME. Once the control-plane connection has been successfully established, the MME may trigger the setup of an Evolved Radio Access Bearer (E-RAB) for service delivery. The eNodeB is responsible for the establishment, modification, and release of E-RABs through radio bearer management procedures.
Network accessibility, a key LTE performance metric, is commonly assessed by analyzing failures occurring during the access procedure. These failures are generally

classified into four categories: Random Access (RA) failures, RRC connection setup failures, authentication failures, and E-RAB setup failures. Monitoring and analyzing these events are essential for identifying performance bottlenecks, diagnosing network issues, and improving overall service accessibility and Quality of Service (QoS).

➢ **RRC measurement data:**

Table 1 represents data and statistics exported from M2000.

An RRC connection setup failure is observed when the eNodeB successfully sends the RRC Connection Setup message but fails to receive the corresponding RRC Connection Setup Complete message from the UE before the expiry of the relevant RRC timer. Consequently, the RRC connection establishment procedure is aborted, and the allocated radio resources are released.

The possible causes may be caused by one or more of the following factors:

- Soft device instability or software hang condition
- Mismatch between installed hardware and licensed capacity/features
- Hardware failure affecting baseband or radio units
- Degradation or failure in the transmission network

Regarding the corrective actions, these may include:

- Resetting or replacing the affected card
- Resolving hardware–license mismatches
- Performing PRB expansion where required
- Applying traffic balancing between the serving cell and neighboring cells
- Verifying and correcting the transmission path

As an operational observation, a soft card reset was performed. Following the soft reset of the affected card, the number of RRC Connection Success signaling events shown in Table 2 decreased. However, the RRC Setup Success Rate improved because the relationship between successful RRC connections and the corresponding connection attempts became more favorable. Therefore, the observed improvement should be assessed based on the RRC Setup Success Rate rather than the absolute number of successful signaling events alone. Consequently, the cell listed in Table 2 was identified as requiring optimization and was subsequently optimized.

Furthermore, Figure 1 shows a distinct capacity-related intervention between 14/06 and 15/06. The measurements recorded on 14/06 represent the pre-intervention condition, characterized by an E-RAB Setup Success Rate of approximately 50% and a high level of congestion. On 15/06, the first post-intervention measurements show a substantial improvement following the implementation of the PRB expansion and activation of the associated capacity licenses. Thus, the transition between 14/06 and 15/06 represents the operational intervention point associated with the observed change in network performance.

The PRB expansion increased the radio resources available for scheduling in the affected cell. Before the intervention, the available PRB resources were constrained relative to the offered traffic and service demand, resulting in increased resource contention and a higher probability of unsuccessful E-RAB establishment. Following the capacity expansion and activation of the associated licenses, a larger pool of schedulable radio resources became available, allowing more simultaneous users and E-RAB establishment requests to be accommodated. Consequently, the E-RAB Setup Success Rate increased from approximately 50% on 14/06 to approximately 90% on 15/06, while the congestion level decreased to nearly zero. The close temporal correspondence between the capacity intervention and the KPI transition indicates that the removal of the radio-resource constraint was a major contributor to the observed performance improvement.

Therefore, the results demonstrate a direct relationship between the resource-level intervention and the measured KPI response: increasing the available PRB capacity reduced radio-resource congestion, increased the probability of successful E-RAB establishment, and consequently improved the accessibility performance of the optimized cell.

Table 1 RRC measurement data (All RRC events (raw counts))

eNodeB Name	Cell Name	LocalCell Id	Availability	RRC Setup Success Rate (Service)	RRC Setup Success Rate (Signaling)	RRCConnection_Attempt_service	RRCConnection_Success_signaling
UL_Hlifaya_40652	40652O	3	79%	97,4558	99,049	3223	1979
UL_TABACOOP_23639	23639T	23	100%	99,0134	96,3054	16522	15666
UL-RN_Ouargla_Ghardaia (GOR_5)_3060	30606M	1	100%	99,0506	95,2802	316	323
UL_MERS_EL_HADJADJ_31736	31736T	23	100%	99,1476	97,375	16777	2708
UL_El_garta_7729	07729R	21	100%	99,158	97,9508	1544	478

Table 2 RRC measurement data for unique cell (RRC events grouped per cell identity)

eNodeB Name	Cell Name	Availability (%)	RRC Setup Success Rate (Service) (%)	RRC Setup Success Rate (Signaling) (%)	RRC Connection Attempts (Service)	RRC Connection Successes (Signaling)	RRC Congestion Rate (%)	RRC Setup Failure (Other Causes)
UL_Hlifaya_4	406520	100	99.9323	99.8978	4430	1933	0	0
UL_Hlifaya_4	406520	100	99.8706	99.8534	3090	1724	0	0
UL_Hlifaya_4	406520	100	99.6019	99.8527	4270	1711	0	0
UL_Hlifaya_4	406520	79	97.4558	99.049	3223	1979	0	0
UL_Hlifaya_4	406520	100	100	99.6849	2556	1898	0	0
UL_Hlifaya_4	406520	100	99.9575	99.7224	2352	1796	0	0

Table 3 e-RAB measurement data

eNodeB Name	Cell Name	Local Cell Id	LTE ERAB Congestion Rate (%)	ERAB setup Attempts	LTE ERAB Setup Success Rate (%)	ERAB Setup Failure (times)	L.E-RAB FAILEst NoradioRes
UL_In_Gazem_ville_11678	11678M	1	46.1322	212110	53.8339	97923	97851
UL_In_Gazem_ville_11678	11678S	22	44.894	40188	55.0637	18059	18042
UL_In_Gazem_ville_11678	11678SN	2	44.6339	110145	55.3044	49230	49162
UL_In_Gazem_ville_11678	11678O	3	43.481	151680	56.4478	66060	65952
UL_In_Gazem_ville_11678	11678R	21	43.4303	103718	56.4936	45124	45045
UL_In_Gazem_ville_11678	11678T	23	42.1359	65545	57.7985	27661	27618
UL_EL_ALIA_7502	07502N	2	40.6935	17972	59.2312	73087	72952
UL_EL_ALIA_7502	07502O	3	40.4456	159157	59.4897	64475	64372
UL_EL_ALIA_7502	07502M	1	40.3973	224978	59.5569	90988	90885
UL_EL_ALIA_7502	07502S	22	39.2774	54110	60.6653	21284	21253
UL_EL_ALIA_7502	07502R	21	38.1547	66600	61.7297	25488	25411
UL_EL_ALIA_7502	07502T	23	37.5807	70648	62.2565	26665	26550

Table 4 PRB Utilization

eNodeB Name	LocalCell Id	DL_PRB_Utilization(%)	UL_PRB_Utilization(%)	L.Traffic.User.Max	Cell Traffic Volume_DL(Gbit)	Cell Traffic Volume_UL(Gbit)
UL_In_Guezam_Ville_11678	23	93,0551	43,5785	55	20,6615	4,3915
UL_In_Guezam_Ville_11678	21	92,8607	51,0067	66	32,6026	7,3321
UL_In_Guezam_Ville_11678	1	98,3897	45,6222	201	140,6988	13,8957
UL_In_Guezam_Ville_11678	2	97,7045	35,7676	141	95,5701	9,0634
UL_In_Guezam_Ville_11678	3	98,3451	48,3146	129	64,925	10,0653
UL_In_Guezam_Ville_11678	22	91,9261	36,576	45	27,1854	3,4617
UL_In_Guezam_Ville_11678	3	98,6369	46,764	132	73,1288	9,4527
UL_In_Guezam_Ville_11678	23	92,044	39,7628	63	24,1379	2,3767
UL_In_Guezam_Ville_11678	2	98,5363	40,5232	144	104,4836	9,6568
UL_In_Guezam_Ville_11678	22	93,2112	41,0706	55	28,7545	2,2607
UL_In_Guezam_Ville_11678	1	98,3582	36,8521	214	154,8308	11,5435
UL_In_Guezam_Ville_11678	21	92,7324	54,0758	70	34,3734	7,5048

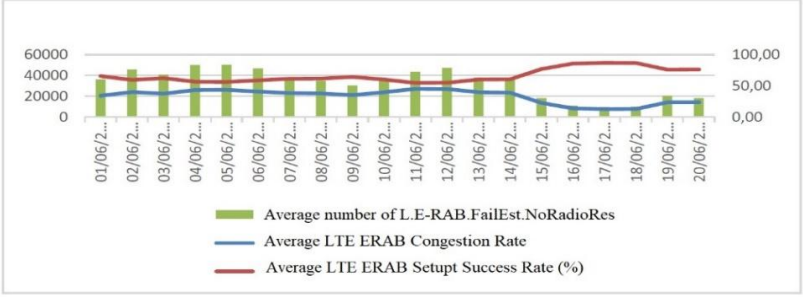


Fig. 1 e-RAB Success Rate.

➢ **e-RAB Traffic measurement data**

Table 3 represents e- RAB measurement data and statistics. An E-RAB connection setup failure is observed when the eNodeB sends the E-RAB Setup message but does not receive the corresponding E-RAB Setup Complete message within the expected time, resulting in a failed bearer establishment procedure. The issue may be caused by one or more of the following:

- Hardware failures (e.g., baseband or radio cards)
- Insufficient PRB availability or resource constraints
- Transmission network degradation or failure
- Traffic congestion due to limited network resources

In this case, a hardware-related issue was identified. Therefore, the PRB utilization counter was analyzed, as shown in Table 4.

Figure 1 represents e-RAB Success Rate vs. Congestion Rate during 20 days of the cell UL_In_Guezam_Ville. It is evident that resource congestion was reduced following the addition of PRB expansions and the associated licenses, as illustrated in Figure 1, leading to an improvement in LTE E-RAB accessibility.

B. Retainability:

Retainability KPIs are used to evaluate the network's ability to maintain services requested by a user for the desired duration once the user is connected. These counters can be calculated per cell or per cluster. Retainability KPIs are important for assessing whether the system can sustain the required level of service quality.

➢ **CDR Traffic measurement data:**

Service drops are monitored through traffic measurements in commercial networks. The service drop rate and the number of service drops are used to detect and analyze faults. The traffic measurement results are exported from the M2000. Table 5 presents the CDR measurement data and statistics obtained from the M2000.

According to the definition of the traffic measurement counter on the eNodeB, if abnormal releases are counted in the L.E-RAB.AbnormRel.HOFailure counter, service drops are attributed to handover failures. Service drops associated with a cause value of "handover failure" is typically due to an abnormal release resulting from a failed handover from the serving cell. In this case, use inter-cell outgoing handover counters to identify the target cell with the highest service drop rate, optimize handover relationships, including handover parameters and neighbor relations, and verify whether the related counters improve after optimization. As observation, both sites highlighted in yellow color exhibited an issue with the same neighbor relation. A newly deployed site has the same Physical Cell Identity (PCI) as the serving cell, leading to PCI confusion. The proposed solution is to modify the PCI and perform a delete/recreate of the neighbor relation.

After applying the proposed solution, it was observed that the CDR decreased and met the target of less than 1.5%, as shown in Table 6. Therefore, the issue was resolved, and the two cells were successfully optimized.

C. Mobility:

Mobility KPIs are used to evaluate the performance of E-UTRAN mobility, which is critical to the customer experience. Several categories of mobility KPIs are defined based on handover types, including intra-frequency and inter-frequency handovers.

➢ **Intra-frequency measurement data:**

Table 7 presents the intra-frequency handover measurement data and statistics exported from the M2000 system.

Low intra-frequency handover success rates and very low intra-frequency handover execution rates may be caused by missing neighbor relations, incorrect neighbor configuration, PCI conflicts, improper handover event parameter settings, or EPC handover preparation failures. To address these issues, neighbor relations and ANR configurations should be verified, EPC authentication and security configurations should be checked, and eNodeB alarms and basic configuration parameters should be reviewed. In this case, the issue was caused by the introduction of the LTE 2100 MHz frequency layer, where some handover-related parameters between neighboring cells were incorrectly configured, resulting in degraded intra-frequency handover performance.

After performing an audit, the incorrect parameter settings were corrected, resulting in an improvement in handover performance. As shown in Table 8, the Intra-Frequency Handover Success Rate increased and reached the target value of greater than 98%. Therefore, the issue was resolved, and the cell was successfully optimized.

Table 5 CDR Traffic measurement data (Number of CDR events generated (Event/signaling load))

eNodeB Name	Cell Name	Call Drop Rate (All)(%)	L.E-RAB.Abnorm Rel.eNBTot	L.E-RAB.Abnorm Rel.HOFailure	L.E-RAB.Abnorm Rel.MME.HO Out
UL_05529	05529N	7,3582	2038	598	1136
Champ de tir- M doukal_05	05561S	7,1231	790	0	18
UL_Sidi_salemll_23704	23704N	5,8628	18202	13643	11539
UL_3G_31171	31171O	4,8577	1329	5	28
UL_OUED_JEMAA_48202	48202N	4,5806	2607	1	9
UL_3G_31171	31171S	4,5685	1215	0	10
UL_3G_31171	31171N	4,5567	1764	2	11

Table 6 CDR measurement data (Usage extracted from CDRs (Traffic / consumption))

eNodeB Name	Cell Name	Call Drop Rate (All)(%)	Date	eNodeB Name	Cell Name	Call Drop Rate (All)(%)
UL_05529	05529N	7,3582	2021-06-04	_Sidi_salemll_23	23704N	5,8628
UL_05529	05529N	9,6333	2021-06-05	_Sidi_salemll_23	23704N	0,7872
UL_05529	05529N	4,5768	2021-06-06	_Sidi_salemll_23	23704N	0,6891
UL_05529	05529N	0,3291	2021-06-07	_Sidi_salemll_23	23704N	0,7175
UL_05529	05529N	0,3151	2021-06-08	_Sidi_salemll_23	23704N	0,7641
UL_05529	05529N	0,2448	2021-06-09	_Sidi_salemll_23	23704N	0,8162
UL_05529	05529N	0,2802	2021-06-10	_Sidi_salemll_23	23704N	0,4212
UL_05529	05529N	0,18	2021-06-11	_Sidi_salemll_23	23704N	0,0513

Table 7 Intra-frequency measurement data Ho exec (Total executed intra-frequency handovers (Raw event count))

eNodeB Name	Cell Name	Integrity	Intra-frequency Handover Success Rate(%)	L.HHO.IntraFreq.NoData.ExecAttOut	L.HHO.IntraFreq.NoData.ExecSuccOut
UL_Sidi_salemll_23704	23704N	100%	54,0919	10538	5602
UL_Sidi_salemll_23704	23704O	100%	68,9411	2689	1901

Table 8 Intra-frequency measurement data Ho for unique cell (HO activity normalized per cell identity (Cell-level filtered view))

eNodeB Name	Cell Name	Intra-frequency Handover Success Rate(%)	L.HHO.IntraFreq.NoData.ExecAttOut	L.HHO.IntraFreq.NoData.ExecSuccOut
UL_Sidi_sale	23704O	68,9411	2689	1901
UL_Sidi_sale	23704O	75,3004	2304	1818
UL_Sidi_sale	23704O	74,7967	2328	1853
UL_Sidi_sale	23704O	76,2133	2424	2015
UL_Sidi_sale	23704O	74,6523	2186	1731
UL_Sidi_sale	23704O	77,566	2589	2096
UL_Sidi_sale	23704O	94,0904	2445	2345
UL_Sidi_sale	23704O	99,932	1853	1853

Table 9 Inter-frequency measurement data Ho Success Rate (% of successful inter-frequency HO attempts (Performance KPI (ratio)))

eNodeB Name	Cell Name	LocalCell Id	Integrity	Inter-frequency Handover Success Rate(%)
UL_ARZEW_2_31695	31695N	2	100%	53,0303
UL_BTLELIS_31115	31115N	2	100%	57,8171
UL_31585	31585O	3	100%	58,2492
UL_BTLELIS_31115	31115N	2	100%	59,3838
UL_ARZEW_2_31695	31695N	2	100%	62,4309
UL_AIN_EL_BEIDA_31718	31718R	21	100%	62,5
UL_Belghaid_LPA_EXTENSI	31764N	2	100%	66,6667
UL_HAI_ISTIKLAL_BOUTLEL	31551N	2	100%	68,6275
UL_Ras_Kalouche_26710	26710N	2	100%	68,75
UL-HAI_ESSALAM_31670	31670O	3	100%	69,2308

Table 10 Inter-frequency measurement data Ho for unique cell (Inter-frequency HO activity per distinct cell (Structural / normalized count))

eNodeB Name	Cell Name	Integrity	Inter-frequency Handover Success Rate(%)
UL-HAI_ESSALAM_31670	31670O	100%	100
UL-HAI_ESSALAM_31670	31670O	100%	69,2308
UL-HAI_ESSALAM_31670	31670O	100%	100
UL-HAI_ESSALAM_31670	31670O	100%	92,8571
UL-HAI_ESSALAM_31670	31670O	100%	100
UL-HAI_ESSALAM_31670	31670O	100%	100
UL-HAI_ESSALAM_31670	31670O	100%	100
UL-HAI_ESSALAM_31670	31670O	100%	100

Table 9 represents Inter-frequency measurement data and statistics obtained from M2000.

A low inter-frequency handover success rate may be caused by missing neighbor relations, incorrect neighbor configuration, PCI conflicts, improper handover event parameter settings, or EPC handover preparation failures. To resolve these issues, the neighbor relations and ANR configuration should be verified, EPC authentication and security settings should be checked, and eNodeB alarms and configuration parameters should be reviewed. In this case, the issue was caused by the introduction of the LTE 2100 MHz frequency layer, where some inter-frequency handover relation parameters were incorrectly configured, resulting in poor handover performance.

After performing an audit, the incorrect parameter settings were corrected, resulting in an improvement in handover performance. As shown in Table 10, the Inter-Frequency Handover Success Rate increased and reached the target value of greater than 98%. Therefore, the issue was resolved, and the cell was successfully optimized.

3. CONCLUSION

This work highlights the continuous evolution of mobile communication systems, where successive generations have been developed to provide enhanced network performance, improved Quality of Service (QoS), and support for emerging applications through advanced architectures, access techniques, and standardized releases. A fundamental aspect of this evolution is the use of KPIs, which serve as essential metrics for evaluating and monitoring LTE network performance.

The analysis presented in this work demonstrates the importance of KPI-based assessment, supported by traffic measurement counters and network performance statistics, for identifying network issues and ensuring efficient operation. The KPI formulas and corresponding counters used in the evaluation are detailed throughout the study. The obtained results confirm that continuous network monitoring, performance analysis, and optimization are critical for maintaining service quality and achieving reliable LTE network operation.

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