

Optimizing LTE Deployment through 1800 MHz Spectrum Refarming: Empirical Evidence from AirtelTigo Network in Ghana

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Abstract The rapid growth of mobile data consumption has intensified pressure on limited radio spectrum resources, compelling mobile network operators to improve capacity, throughput, and Quality of Service (QoS) without acquiring additional spectrum. Spectrum refarming has emerged as a strategic solution that reallocates underutilized legacy spectrum to advance mobile technologies, thereby enhancing spectrum utilization and network performance. This study investigates the effectiveness of spectrum refarming in improving fourth-generation (4G) network capacity and QoS within AirtelTigo Ghana. A mixed-methods approach was adopted, combining technical drive test measurements, benchmarking of legacy network performance, network Key Performance Indicator (KPI) analysis, and a structured user perception survey. Drive tests were conducted across selected high-traffic urban locations to evaluate throughput, accessibility, coverage, and session stability, while a technical assessment of AirtelTigo's GSM 1800 MHz spectrum identified opportunities for reallocating a 5 MHz carrier for LTE deployment. The findings demonstrate that refarming the GSM 1800 MHz band enables the deployment of an LTE carrier that significantly improves downlink throughput, network capacity, and user experience without compromising legacy network performance. The results further indicate improvements in spectrum utilization, reduced network congestion, enhanced accessibility, and better overall QoS, leading to a more reliable and efficient mobile broadband service. The study concludes that spectrum refarming is a technically feasible and cost-effective modernization strategy for mobile network operators, particularly in spectrum-constrained developing markets, as it maximizes the value of existing spectrum assets while supporting growing broadband demand and delaying the need for costly acquisition of additional spectrum resources.

Keywords 4G LTE, Network Capacity, Quality of Service, Spectrum Refarming, Underutilized Frequency.

Introduction

The exponential growth of mobile data driven by smartphone penetration, high bandwidth applications, and IoT has created an unprecedented shortage of radio spectrum, particularly in the cellular bands [1]. The early standards (GSM, UMTS) operated under fixed, exclusive license models, which now struggle to accommodate demand. Existing solutions such as dynamic spectrum sharing and carrier aggregation offer incremental gains, but acquiring new spectrum licenses remains costly and slow. The best current solution for many operators is spectrum refarming, reallocating legacy bands (e.g., 1800 MHz from GSM to LTE) which is cost effective and avoids new licenses [2]. However, refarming has limitations: it requires careful interference management, gradual migration of legacy users, and compliance with residual coverage obligations (e.g., maintaining 2G/3G for rural areas). Despite these challenges, achievements are significant. Studies [3] show that refarming the 1800 MHz band can dramatically improve downlink throughput and QoS, and competitive mobile markets have continuously upgraded service levels without new spectrum. The objective of this study is to explore the technical, economic, and regulatory role of spectrum refarming in enhancing 4G capacity and improving QoS, using a real world operator case study in a developing market. The novelty lies in integrating technical drive tests, user perception surveys, and spectrum holding reviews within a live African network (AirtelTigo), bridging a gap in literature focused predominantly on developed regions [4].

Study Limitations and Key Constraints

Every research study encounters challenges that may affect the scope, methodology, and generalizability of findings. This study on “The Use of Spectrum Refarming to enhance 4G Capacity and Improve Quality of Service in Mobile Telephony” is no exception. Despite its

significance, the research is subject to several limitations, categorized under technical, regulatory, economic, and methodological constraints [5]. Furthermore, AirtelTigo was unable to provide pre-simulation output data due to technical challenges with its asset planning tool, constraining the ability to validate spectrum-carving scenarios through predictive modeling. These limitations provide background for interpreting the findings and highlight grey densely populated regions and areas for future research.

In summary, although carving out 5 MHz for LTE was proposed as a quick capacity enhancement measure, benchmarking indicates that the narrow bandwidth would deliver only modest and short-term improvements. The main constraints are limited capacity headroom, legacy network coexistence and outdoor performance challenges. For meaningful and sustainable QoS improvement in high-traffic areas of Accra, wider contiguous LTE bandwidth, additional spectrum resources, and network densification would be required beyond the proposed 5 MHz refarming [6].

Evolution of Spectrum Refarming Practices in Mobile Networks

Modern spectrum refarming builds on historical transitions in mobile telephony, beginning with the reallocation of frequencies from 2G and 3G systems towards more spectrally efficient technologies. The literature highlights how legacy systems such as GSM, operating at 900 MHz and 1800 MHz, were gradually superseded by LTE deployments in the same bands, improving spectral efficiency and reducing operational overheads [7]. This transition exemplifies how spectrum refarming became an operational necessity, enabling operators to sunset underutilized technologies while simultaneously improving service delivery. Empirical findings demonstrate that LTE refarming offers substantial gains in throughput and latency reduction compared to legacy systems. [8] emphasize that LTE's

reliance on orthogonal frequency division multiple access (OFDMA) and support for multi-antenna techniques allows for significantly higher data rates within refarmed bands. Similarly, studies by Ref. [6] underscore the benefits of carrier aggregation, which enables operators to combine refarmed low-frequency bands with higher-frequency allocations to achieve broader bandwidth and more resilient connectivity. These answers establish that the state of the art in spectrum refarming is inseparable from broader advancements in LTE technologies.

Spectrum Sharing and Efficiency

Spectrum refarming has emerged as a strategic approach for improving the efficiency, performance, and economic sustainability of modern mobile networks. The principal achievements of spectrum refarming in 4G LTE and 5G deployments include the following:

Achievements of Spectrum Refarming in 4G & 5G

1. **Cost Efficiency:** Spectrum refarming enables mobile network operators (MNOs) to repurpose existing spectrum assets rather than acquire new frequency licenses. This approach significantly reduces capital expenditure (CAPEX) associated with spectrum acquisition while maximizing the utilization of existing spectrum resources [9].
2. **Cost-Effectiveness:** By reallocating legacy spectrum to LTE and 5G services, operators can increase network capacity and improve service delivery without participating in costly spectrum auctions. Consequently, spectrum refarming provides an economically viable solution for network modernization, particularly in spectrum-constrained markets [10].
3. **Accelerated 5G Deployment:** Spectrum refarming facilitates faster deployment of 5G networks by migrating spectrum from legacy technologies such as GSM and

UMTS to New Radio (NR). This enables operators to expand 5G services more rapidly while meeting the growing demand for enhanced mobile broadband [11].

4. **Optimized Spectrum Utilization:** Dynamic spectrum refarming improves overall spectrum efficiency by reallocating underutilized frequency bands to technologies with higher traffic demand. This enhances spectral efficiency, increases network flexibility, and reduces operational costs through more effective resource utilization [11].
5. **Improved LTE/5G Coverage and Network Capacity:** Reallocating spectrum from legacy networks to LTE and 5G improves radio propagation characteristics, expands geographical coverage, and increases network capacity. These enhancements enable operators to deliver more reliable services while accommodating higher user densities and increasing data traffic [12].
6. **Enhanced Quality of Service (QoS):** Spectrum refarming contributes to improve network performance by reducing call drops, increasing data throughput, lowering latency, and enhancing overall user experience. These improvements are reflected in key Quality of Service (QoS) indicators such as accessibility, retainability, and mobility performance [13].

Purpose of the Study

This research critically examines spectrum refarming as a means of enhancing 4G mobile network capacity and quality of service (QoS). Spectrum refarming, involving the reallocation of 2G and 3G bands for advanced technologies, offers a strategic solution for improving spectrum utilization and network performance [14]. The study explores both technical and regulatory dimensions of refarming to assess its effectiveness. Ultimately, it aims to provide a comprehensive understanding of its role in

optimizing LTE networks and informing mobile policy and planning [15].

General Objective

This research critically examines spectrum refarming as a means of enhancing 4G mobile network capacity and quality of service (QoS). Spectrum refarming, involving the reallocation of 2G and 3G bands for advanced technologies, offers a strategic solution. The study explores both technical and regulatory dimensions of refarming to assess its effectiveness. Ultimately, it aims to provide a comprehensive understanding of its role in optimizing LTE networks and informing mobile policy and planning.

Specific Objectives

OBJ1: To evaluate the strategies and techniques for applying spectrum refarming to enhance 4G network capacity, specifically through increased spectral efficiency and the reallocation of legacy frequency bands to bolster LTE performance.

OBJ2: To assess the impact of spectrum refarming on key Quality of Service (QoS) metrics, including latency, throughput, call drop rates, QoS, Coverage and the resultant improvements in mobile user experience.

OBJ3: To identify and critically analyze the economic, technical, and regulatory challenges inherent in deploying spectrum refarming, encompassing cost-benefit implications, technical barriers during reallocation, and the influence of policy frameworks on implementation success.

OBJ4: To examine the conceptual foundations and historical evolution of spectrum refarming, contextualizing its strategic application and developmental trajectory within contemporary 4G mobile telephony networks.

OBJ5: To propose an integrated, multidimensional framework that synthesizes technical, regulatory, and economic perspectives, thereby providing a structured,

evidence-based model for effective spectrum refarming to enhance 4G capacity and QoS.

Materials and Methods

Research Design

The research design adopted for this study is structured to systematically examine the role of spectrum refarming in enhancing 4G capacity and quality of service (QoS) within the context of mobile telephony. Given the dual technical and regulatory nature of spectrum refarming, the study adopts a mixed-methods research design that provide a holistic understanding of the subject. This design ensures that the technical performance of refarmed spectrum is evaluated empirically through field measurements and benchmarking, while also accounting for policy, economic, and operational dimensions through expert insights and contextual analysis [16, 17]. At the quantitative level, the research employs experimental and quasi experimental techniques by analyzing benchmark drive test data and conducting real-time drive tests in selected locations, including Accra Mall, 3 Junction, and West Hills Mall. These locations were purposefully chosen to represent different propagation environments, thereby enabling a comparative assessment of coverage, capacity, and QoS metrics. The study focuses on the reallocation of a 5 MHz block from GSM 1800 MHz spectrum to LTE, a process that illustrates the operational dynamics of spectrum refarming in practice [18, 19]. The quantitative data derived from these tests comprising throughput, latency, call drop rate, and signal strength provide measurable indicators of the improvements in capacity and service delivery resulting from refarming [1, 11]. Complementing the quantitative analysis, the research design incorporates qualitative insights obtained from a structured, closed-ended survey administered to individuals with backgrounds in telecommunications, IT, and engineering. The survey is designed to capture perceptions, expert evaluations, and

professional judgments on the feasibility, challenges, and benefits of spectrum refarming in the Ghanaian mobile telephony landscape. This element enriches the study by providing context to the technical results and situating them within broader considerations of regulatory frameworks, cost implications, and market dynamics [20, 21]. The outdoor testing with survey based expert inputs ensures triangulation, enhancing the validity and reliability of the findings [22]. The design further employs comparative analysis, evaluating the performance of AirtelTigo's network against existing deployments by other operators such as MTN and Telecel. This comparative dimension not only highlights the relative improvements made possible to be achieved by refarming but also emphasizes the areas requiring further investment to achieve parity in service quality across providers [1, 23].

By combining empirical field testing with expert perspectives and policy analysis, the chosen research design will achieve balance between technical precision and practical relevance. This will enable the study to move beyond theoretical discussions of refarming to demonstrate its tangible impact on network performance and user experience. At the same time, the research design acknowledges the broader economic and regulatory considerations that influence the effective implementation of spectrum refarming strategies [24]. In doing so, the research design provides a robust foundation for answering the central research questions and for generating insights that are both academically rigorous and practically applicable to the mobile telecommunications industry.

Research Approach

The study provides mixed-methods design which enables triangulation cross-verification of findings from drive tests, user surveys, and document analysis enhancing the validity and reliability of conclusions. This integration

ensures that objective network performance data are complemented by subjective user perceptions and contextualized within regulatory and economic frameworks. The approach directly addresses methodological gaps in existing literature, which have predominantly relied on isolated assessments rather than integrated analysis [25, 26].

Consistent with the pragmatist research philosophy, this design permits the employment of the most appropriate methods for each research question, producing findings that are both academically rigorous and practically relevant. By grounding the research in a mixed-methods framework, the study offers actionable recommendations supported by both statistical evidence and contextual understanding, bridging the gap between technical evaluation and practical industry considerations.

Drive Test and Benchmark Data Collection

The primary quantitative data for this research was obtained from network drive tests and benchmark reports. AirtelTigo (AT) provided drive test data from a refarmed 5 MHz block in the GSM 1800 MHz band, which was reallocated for LTE use. Additionally, real-time drive tests were conducted by the researcher at key urban sites in Accra, including the Accra Mall, 3 Junction, and West Hills Mall. These sites were selected due to their high data demand and the presence of co-located networks such as MTN and Telecel, making them critical points for evaluating LTE performance. The data collected focused on throughput, latency, and call drop rates, which are globally recognized as key QoS metrics.

Closed-Ended Survey Design

In addition to empirical network data, a closed-ended survey was conducted targeting participants with professional backgrounds in telecommunications, IT, and engineering. The survey was designed to collect structured responses on participants' perceptions of

spectrum refarming and its potential to improve 4G capacity and QoS. Closed-ended questions were used to ensure uniformity in responses and facilitate statistical analysis. This methodological choice aligns with [27] Bryman (2016), who highlights that structured surveys enable researchers to quantify stakeholder perspectives, making the findings generalizable across similar contexts. The survey results were then triangulated with network performance data to provide a comprehensive view of both technical and industry perceptions regarding spectrum refarming.

Research Instruments

The research employed a combination of technical measurement tools and survey-based instruments to collect data that reflect the quantitative dimension of spectrum refarming in enhancing 4G capacity and quality of service (QoS). The choice of instruments were guided by the need to capture objective performance metrics of the refarmed spectrum while also eliciting expert opinions from professionals in telecommunications, IT, and engineering. This multi-instrument approach ensured that the study addressed the technical, experiential, and contextual aspects of spectrum refarming comprehensively. For the quantitative dimension, drive test equipment was the primary research instrument. The benchmark drive test relied on industry standard tools, including spectrum analyzers, scanning receivers, and test handsets equipped with specialized software such as PHU, TEMS Investigation and Nemo Outdoor, which are widely used in telecommunications research and commercial network performance evaluations [8]. These instruments enabled the measurement of critical network performance indicators such as throughput, latency, signal strength (RSCP), signal quality (Ec/Io), and call drop rate. The real-time drive tests conducted at Accra Mall, 3 Junction, and West Hills Mall allowed for a comparative analysis outdoor network environment, highlighting the impact

of spectrum refarming on coverage and capacity. These instruments were selected due to their precision and reliability in producing repeatable measurements, which is essential for evaluating the performance improvements resulting from the reallocation of the 1800 MHz GSM spectrum to LTE. In addition to the technical measurements, a structured closed-ended questionnaire was designed as the quantitative research instrument to gather expert perspectives. This survey was administered to respondents with professional backgrounds in telecom engineering, IT, and network planning. The questionnaire was structured to cover key themes such as the perceived benefits of spectrum refarming, anticipated challenges in deployment, and views on the regulatory and economic implications. Using closed-ended questions ensured consistency in responses, allowing for easier quantification and statistical analysis, while also minimizing researcher bias [5]. The instrument was pilot-tested with a small group of respondents to refine its clarity and reliability before full deployment. The integration of drive test equipment and structured questionnaires provided a robust and complementary set of instruments. While the drive tests captured empirical performance data, the questionnaires contextualized these findings within the lived experiences and professional insights of stakeholders. This dual-instrument approach is consistent with best practices in mixed-methods research in telecommunications, where the combination of technical field measurements and expert perspectives leads to a more comprehensive understanding of network performance and spectrum policy implications [28, 29].

Moreover, online questionnaires were used as primary research instrument for data collection. The questionnaires were designed for closed-ended question and multiple questions which allow participants and professionals in the telecommunication sector, including telecom engineers, regulators and IT

professionals, regarding their perception on spectrum refarming and its impact on 4G network performance in relation to capacity, coverage and QoS.

Results & Discussion

Key Results from Google Forms Survey

In this final chapter, key findings were synthesized from the analysis of stakeholder perspectives on spectrum refarming, drawing together the technical, operational, and regulatory insights gathered through the survey conducted for this research. The study reflects on how these findings address the original research questions about enhancing 4G capacity through strategic spectrum reallocation. Practical recommendations were provided for implementing spectrum refarming initiatives, discuss the limitations of the study, and suggest valuable directions for future research that could build upon these findings. The survey of 44 telecommunications professionals revealed several critical insights that directly inform spectrum refarming strategies.

The study explored stakeholders' perception on the role of spectrum refarming in enhancing

4G network capacity and improving QoS and responses to questionnaires from professionals in telecommunication, IT, Regulatory in addressing the network constraints in spectrum refarming.

Moreover, the responses affirm that spectrum refarming is seen as a practical solution to improve 4G performance and that it would increase investment in mobile broadband infrastructure.

Limited device compatibility, license restriction and high regulatory fees are barriers to implementation of spectrum refarming requires the intervention of regulators in supporting the process through policy enforcement, cost reduction and financial incentives.

In addition, the results from survey participation indicates that improved 4G coverage will positively affect economic, social sectors with strong support for its impact on online education, business growth and digital inclusion.

Key Questions from Survey

Q1. How Will Better 4G Coverage Impact Social and Economic Activities in Your Region?

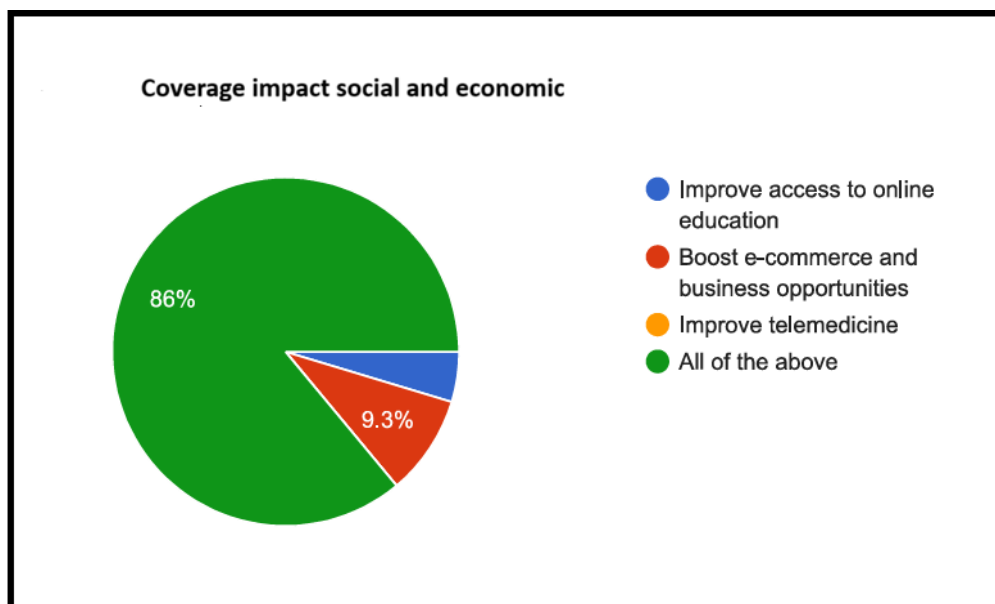


Figure 1. 4G Coverage Impact Social and Economic

According to the survey results from Figure 1 above, (86%) of respondents selected all the above showing a strong census that enhanced broadband to have multiple interlinked benefits. (4.7%) of respondents noted that it will bring access to online education in the remote areas

and bridging the educational gaps. (9.3%) of respondents pointed out how 4G coverage will boost e-commerce and business opportunities enabling entrepreneurs to adopt digital financial service and reach out to broader markets.

Q2. Which of the Following is a Major Technical Challenge Faced During Spectrum Refarming?

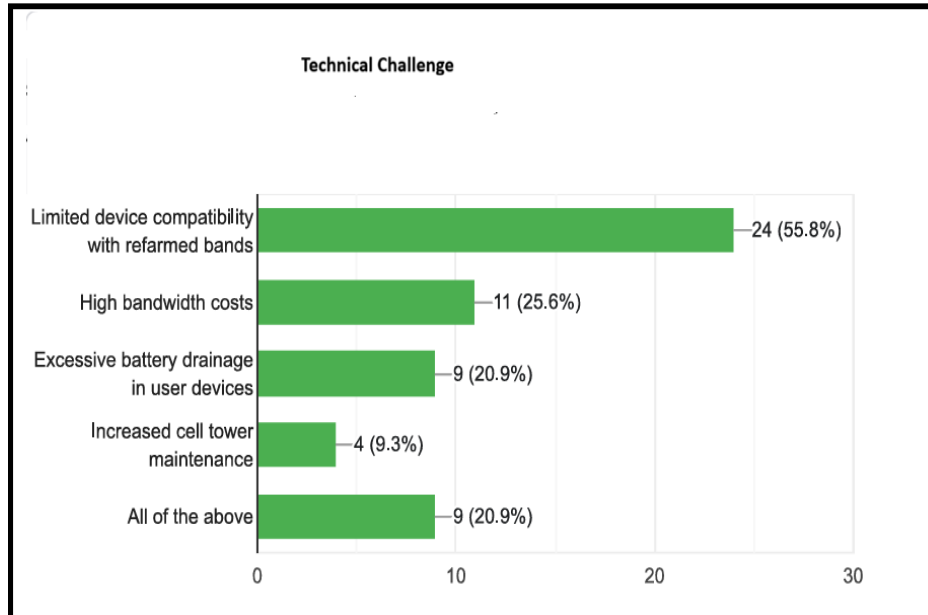


Figure 2. Technical Challenge

From Figure 2, responses from 43 participants were received as the major technical challenges faced during spectrum refarming. The key issues identified represent (55.8%) which was related to the limited device compatibility with refarming bands. The challenge becomes critical because following spectrum refarming data traffic volume is likely

to improve significantly. This improvement depends on considering device compatibility as a priority at early planning stage, which enables users to purchase handsets that support the newly deployed frequency bands. Also, high bandwidth cost pose threat to operators in securing required spectrum for deployment.

Q3. What Role Should Government Play in Supporting Spectrum Refarming?

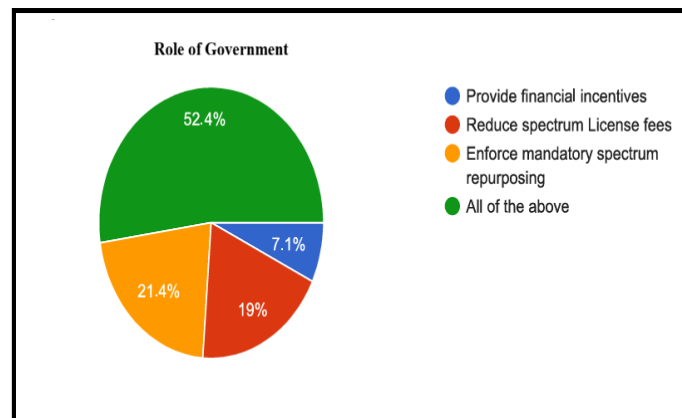


Figure 3. Role of Government

From Figure 3, survey results indicate that the function of government is considered as pivotal in processing successful spectrum refarming. A (52.4%) of respondents selected All of the above suggesting that a complex approach involving both regulatory and financial strategies is most effective. Moreover, (21.4%) of the participants suggest the government to enforce mandatory spectrum reallocation policies ensuring the underutilized spectrum band will be reassigned for efficient use of 4G or 5G. (7.1%) point to the significance of financial incentives to encourage infrastructure upgrades and adoption of new technologies.

Spectrum Refarming and Feasibility Analysis – Summary

The spectrum analysis of AirtelTigo's GSM frequency holdings demonstrates that the GSM 1800 band offers the most practical and technically viable opportunity for LTE refarming. While the GSM 900 allocation comprises approximately 9.8 MHz across PGSM and EGSM blocks, its fragmentation prevents the creation of a contiguous 5 MHz channel necessary for LTE deployment, thereby excluding it as a feasible option. In contrast, AirtelTigo's GSM 1800 allocation includes 15 MHz of contiguous spectrum (ARFCNs 512–586), from which a 5 MHz LTE carrier can be cleanly carved without compromising legacy

2G signaling requirements. A structured plan proposes reallocating ARFCNs 540–564 for LTE, with adjacent guard bands ensuring protection against interference, while residual channels continue to support GSM services.

This carving strategy demonstrates compliance with LTE bandwidth specifications (3GPP TS 36.104) and adheres to global refarming best practices [1], ensuring both spectral efficiency and service continuity. Implementation, however, requires pre-configuration steps such as upgrading base station hardware to multi-standard radios (MSRs) and enabling Multi-RAN software capabilities to allow concurrent GSM and LTE operation. The careful integration of these technical measures transforms theoretical frequency domain planning into a practical LTE deployment framework.

In direct alignment with this study, these findings confirm that GSM 1800 refarming can expand LTE capacity in Ghana, mitigate data throughput limitations, and significantly improve user experience. By systematically reallocating underutilized spectrum, AirtelTigo can modernize its network infrastructure while preserving essential legacy services, providing both immediate QoS gains and a sustainable path toward future mobile evolution.

Vertical Stacked Spectrum Layout

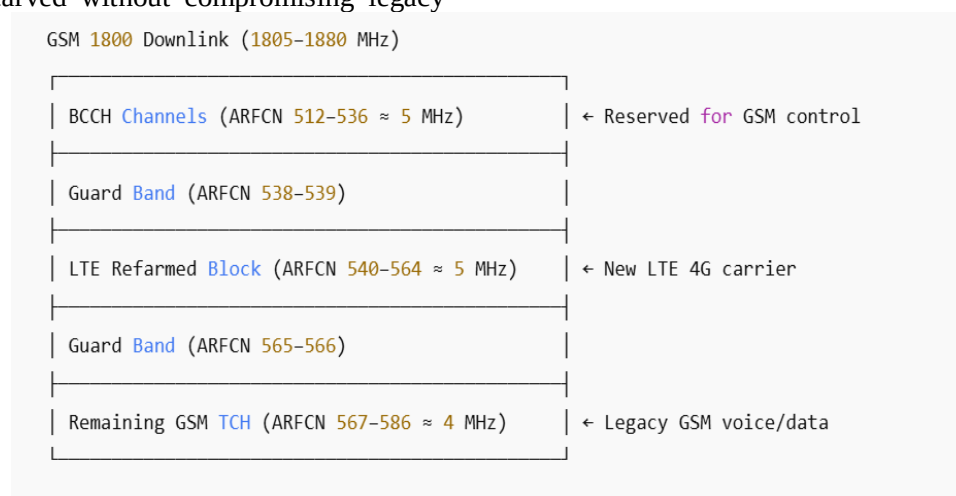


Figure 4. GSM 1800 Spectrum Layout

Figure 4 illustrates the proposed spectrum refarming plan for reallocating a contiguous 5 MHz block within the GSM 1800 MHz band to support LTE deployment while preserving sufficient spectrum resources for legacy GSM services. In summary, this analysis demonstrates a methodical and technically sound approach to refarming 5 MHz of spectrum from the GSM 1800 TCH allocation for LTE deployment. By allocating a total of 29 ARFCNs (5.8 MHz of spectrum), a viable LTE carrier with robust guard banding on both sides is created. The remaining GSM services continue to operate on the BCCH and the unaffected portions of the TCH band, ensuring legacy support. This calculated approach minimizes interference risks and aligns with established spectrum management principles, providing a clear blueprint for network modernization.

Implementation Framework for LTE Deployment in a Refarmed GSM Spectrum

The successful spectral carving of a contiguous 5 MHz block from the GSM 1800 Traffic Channel (TCH) allocation represents a critical first step in the network modernization process. However, this engineering achievement in frequency domain planning must be followed by a comprehensive and multi-disciplinary implementation strategy. Transitioning from a theoretical band plan to an operational LTE carrier requires meticulous execution across technical, operational, and business domains. This narrative outlines the requisite actions and considerations, framing them within a structured implementation framework essential for ensuring service continuity, network integrity, and optimal performance [8].

2G & 3G AirtelTigo Accra Benchmarking & Drive Test DT Findings & Summary

The results show AirtelTigo's clear advantage in 2G performance, with stronger signal strength (-75.6 dBm), superior quality (RxQual 0.07), and the lowest drop call rate (0.15%) among competitors. The only limitation was longer call setup latency (6846.61 ms), suggesting occasional signaling congestion. In 3G, MTN achieved slightly better coverage strength (RSCP -71.48 dBm), but AirtelTigo excelled in signal quality (Ec/Io -11.53 dB), call reliability (DCR 0.27%), and the fastest call setup times. However, AirtelTigo lagged significantly in data throughput, with downlink speeds (7373.89 kbps) far behind MTN (23997.52 kbps), and its voice quality (MOS 3.32) ranked lowest, highlighting areas for improvement. Collectively, these findings indicate AirtelTigo's reliability strengths but also its limitations in capacity intensive services, making spectrum refarming a critical enabler for addressing throughput challenges.

The drive test analyses revealed that all three sites—Accra Mall, 3-Junction, and West Hill Mall exhibited stable 2G and 3G performance, though with variations in signal quality. Accra Mall emerged as the benchmark site, recording an Rxlev of -77.24 dBm and a near-flawless RxQual of 0.01 on 2G, alongside strong 3G RSCP values (-76.15 dBm idle; -73.71 dBm dedicated) and perfect service reliability. 3-Junction displayed slightly weaker but consistent performance, while West Hill Mall showed marginal degradation, with a reduced CSSR of 95.59% indicating occasional accessibility challenges. Collectively, these results establish a pre-refarming baseline, essential for evaluating the impact of spectrum refarming on enhancing 4G capacity and QoS.

Recommendations

It is recommended that AirtelTigo leverage spectrum refarming by reallocating underutilized 2G and 3G spectrum to expand LTE capacity, particularly in high-demand areas. AirtelTigo should consolidate its competitive strengths in 2G and 3G coverage stability, low drop call rates, and efficient call setup while strategically addressing weaknesses in data throughput and voice quality. Spectrum refarming provides a direct avenue to achieve this goal: reallocating underutilized 2G and 3G frequencies to expand LTE capacity will improve data rates and user experience, particularly in high-demand urban zones. Secondly, AirtelTigo should complement spectrum refarming with targeted backhaul upgrades and resource optimization strategies to close the throughput gap with MTN. Finally, consistent benchmarking against competitors should be institutionalized to monitor post-refarming improvements and maintain AirtelTigo's competitive positioning.

Future Research Directions

Future research should extend this benchmarking framework to evaluate AirtelTigo's 4G performance following spectrum refarming, with a focus on throughput, latency, and QoS improvements relative to the legacy baselines established here. Comparative studies across urban and rural clusters are also needed to examine whether refarming benefits are equitably distributed across diverse environments. Additionally, research should investigate user-perceived QoS metrics, linking technical KPIs with customer experience to provide a more comprehensive evaluation of network modernization. Finally, given the anticipated transition to 5G, studies should explore how AirtelTigo's refarming strategies can ensure both short-term gains in 4G capacity and long-term readiness for next-generation mobile services.

Conclusion

This thesis has examined the use of spectrum refarming as a strategic approach to enhancing 4G capacity and Quality of Service (QoS) in mobile telephony, with particular emphasis on AirtelTigo's network in Ghana. The analysis demonstrated that the growing demand for broadband services necessitates more efficient utilization of existing spectrum, especially in resource constrained markets where new allocations are limited or costly. Benchmarking results from 2G and 3G drive tests revealed robust legacy performance in terms of coverage and reliability but also highlighted the limitations of spectral occupancy in sustaining next-generation capacity.

The technical feasibility study established that AirtelTigo's GSM 1800 band provides the most practical and contiguous 5 MHz block for LTE deployment. By carefully carving out ARFCNs within this band, while reserving appropriate guard bands, operators can achieve meaningful gains in LTE throughput, coverage efficiency, and QoS without undermining legacy services. Thus, spectrum refarming emerges as both a technically sound and economically efficient pathway for mobile network modernization. In this sense, it is not merely a spectrum reallocation exercise but a strategic enabler of digital transformation, ensuring that operators can sustainably expand 4G services while laying the foundation for eventual 5G transition.

In light of these findings, it is recommended that AirtelTigo adopt spectrum refarming of the GSM 1800 band as a priority modernization strategy. This should be implemented alongside infrastructure upgrades, including the deployment of multi-standard radios (MSRs) and enhanced backhaul capacity, to maximize LTE performance. Furthermore, careful spectrum engineering practices such as guard band allocation and optimized frequency planning must be observed to minimize interference and ensure the continuity of legacy GSM voice services. At the regulatory level,

national telecommunications authorities should establish supportive policies for spectrum reallocation, ensuring equitable access, efficient spectrum use, and alignment with long-term broadband strategies.

Future research could build upon this study in several directions. First, post-deployment evaluations of LTE performance following refarming would provide empirical insights into real world benefits and challenges. Secondly, research into advanced techniques such as spectrum aggregation and dynamic sharing could further enhance spectral efficiency in preparation for 5G. Thirdly, socio-economic analyses of user adoption, affordability, and digital inclusion would complement the technical perspective, ensuring that spectrum refarming strategies translate into meaningful improvements in connectivity and service equity. Together, these recommendations and future research directions underscore the central role of spectrum refarming in advancing 4G capacity and QoS in mobile telephony.

Conflict of Interest

I Albert Neequaye Kotey hereby declared that, there is no conflict of interest regarding this research work.

Ethical Approval

Ethical approval for this study was obtained from the appropriate institutional authority before data collection commenced. Participation in the Google Forms survey was voluntary, and informed consent was obtained electronically from all respondents prior to completing the questionnaire. Participants were assured of anonymity and confidentiality, and no personally identifiable information was collected. The benchmark drive-test data and operational network performance indicators used in this study were obtained with the permission of AirtelTigo Ghana and were used solely for academic research purposes.

Data Availability

The data supporting the findings of this study were obtained from multiple sources. Benchmark drive-test reports and network performance data were provided by AirtelTigo Ghana following formal written approval granted by the Chief Technical Officer for academic research purposes. These proprietary operational data remain confidential and are therefore not publicly available. In addition, the author independently conducted drive-test measurements at Accra Mall, West Hills Mall, and 3 Junction using a third-party drive-test tool to collect field network performance data. Primary data were also collected through a structured Google Forms questionnaire administered to professionals in the telecommunications, information technology, and regulatory sectors. The author-generated drive-test data and anonymized survey data are available from the corresponding author upon reasonable request. Access to AirtelTigo Ghana's proprietary benchmarking reports and operational network performance data remains subject to the prior written approval of AirtelTigo Ghana.

Author Contributions

The author solely conceived the study, designed the methodology, collected and analyzed the data, interpreted the findings, prepared the figures and tables, wrote and reviewed the final manuscript.

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