Telecommunication Infrastructure of Bangladesh: Architecture, Performance Evaluation, and Future Perspectives

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Abstract : Telecommunication infrastructure plays a vital role in supporting modern communication services, including mobile networks, fixed-line telephony, Voice over Internet Protocol (VoIP), and broadband data transmission. As Bangladesh continues its digital transformation, a reliable and efficient telecommunications network has become essential for economic development and nationwide connectivity. This paper presents a comprehensive overview of the telecommunication infrastructure of Bangladesh, focusing on its hierarchical network architecture and operational framework. The study describes the functions and interconnections of the International Gateway (IGW), Interconnection Exchange (ICX), Access Network Service (ANS), and the regulatory responsibilities of the Bangladesh Telecommunication Regulatory Commission (BTRC). In addition, the end-to-end routing mechanisms for both domestic and international voice calls are explained to illustrate the flow of communication across the national network. To complement the architectural analysis, the paper discusses key network performance indicators, including the Answer-Seizure Ratio (ASR) and Average Call Duration (ACD), which are widely used to assess call completion efficiency, service quality, and network reliability. The study also highlights current challenges facing Bangladesh's telecommunication sector and outlines future directions toward next-generation networks, intelligent traffic management, and 5G-enabled communication systems. This work provides a concise reference for researchers, students, and telecommunications professionals seeking an understanding of Bangladesh's evolving telecom infrastructure and its performance evaluation metrics.

IndexTerms **– Telecommunication Infrastructure, Bangladesh Telecom Network, International Gateway (IGW), Interconnection Exchange (ICX), Access Network Service (ANS), Bangladesh Telecommunication Regulatory Commission (BTRC), Answer-Seizure Ratio (ASR), Average Call Duration (ACD), Quality of Service (QoS), Network Performance Evaluation, Voice Traffic, Call Routing.**

INTRODUCTION

Telecommunication has become one of the most essential components of modern society, enabling the transmission of voice, data, video, and multimedia services across local, national, and international networks. It plays a vital role in economic development, digital transformation, education, healthcare, e-commerce, and public administration by providing seamless connectivity among individuals, organizations, and governments [1].

At its core, telecommunications relies on the transmission of information through electrical or electromagnetic signals, commonly known as carrier waves. These signals are modulated using analog or digital techniques to convey voice, text, images, and multimedia data between communication endpoints [2]. The rapid growth of mobile broadband, cloud computing, the Internet of Things (IoT), and fifth-generation (5G) communication technologies has significantly increased the demand for reliable, scalable, and high-capacity telecommunication networks [3].

To efficiently manage increasing communication traffic, modern telecommunication systems employ hierarchical network architectures that separate local access, inter-network routing, and international connectivity. Such architectures improve network scalability, routing efficiency, traffic management, and service reliability while ensuring interoperability among different communication networks [4].

Bangladesh has experienced remarkable growth in its telecommunication sector during the last two decades. The expansion of mobile communication services, broadband Internet, fiber-optic backbone networks, and government-led digital initiatives has transformed telecommunications into one of the country's most important infrastructures [5]. According to the Bangladesh Telecommunication Regulatory Commission (BTRC), the national telecommunication network consists of several interconnected entities, including Access Network Service (ANS) operators, Interconnection Exchange (ICX) operators, and International Gateway (IGW) operators, all operating under a comprehensive regulatory framework [6].

Within this architecture, ANS operators provide communication services directly to end users, ICX operators facilitate interconnection among domestic operators, and IGW operators manage international voice traffic by connecting the national network with global telecommunication carriers [7]. This layered framework enables efficient routing of both domestic and international voice calls while supporting secure and reliable communication across different service providers.

The performance of telecommunication networks is commonly evaluated using Quality of Service (QoS) indicators. Among these, the Answer-Seizure Ratio (ASR) and Average Call Duration (ACD) are two of the most important performance metrics for voice communication networks. ASR represents the percentage of successfully established calls relative to the total number of call attempts, whereas ACD indicates the average duration of completed calls. Higher ASR and ACD values generally reflect better network performance, routing efficiency, and user experience [8]. Additional performance indicators, including Call Setup Success Rate (CSSR), Post Dial Delay (PDD), Call Drop Rate (CDR), latency, jitter, and network availability, are also widely used to evaluate the operational quality of modern telecommunication systems [9].

Although previous studies have investigated mobile communication technologies, network evolution, and Quality of Service (QoS) evaluation, a comprehensive overview of Bangladesh's telecommunication infrastructure that integrates network architecture, regulatory framework, call routing mechanisms, and performance evaluation metrics remains limited. Therefore, this paper presents a comprehensive overview of the telecommunication infrastructure of Bangladesh by describing the operational roles of ANS, ICX, IGW, and BTRC, illustrating domestic and international call routing mechanisms, and discussing important network performance indicators such as ASR and ACD. The study also highlights current challenges and future directions toward intelligent network management, artificial intelligence-assisted traffic optimization, and next-generation 5G communication systems [10].

BANGLADESH TELECOMMUNICATION NETWORK TOPOLOGY

The telecommunication infrastructure of Bangladesh is based on a regulated three-tier hierarchical switching architecture that ensures efficient traffic routing, regulatory compliance, lawful interception, and reliable communication across both domestic and international networks. As shown in Figure 1, the lowest tier comprises Access Network Service (ANS) operators, including mobile network operators and fixed-line service providers, which provide direct communication services to end users through technologies such as GSM, CDMA, and the Public Switched Telephone Network (PSTN). To avoid complex direct interconnections among multiple operators, all inter-operator voice traffic is routed through the Interconnection Exchange (ICX) layer. Acting as a centralized switching platform, the ICX efficiently manages domestic call routing between different ANS operators while forwarding international voice traffic to the International Gateway (IGW). The IGW serves as the interface between the national telecommunication network and international carriers, facilitating cross-border voice communication through both Time Division Multiplexing (TDM) and IP-based transmission technologies. In addition, the Bangladesh Telecommunications Company Limited (BTCL) continues to play an important role by providing fixed-line communication services and supporting interconnection functions within the national network. The entire telecommunication ecosystem is regulated by the Bangladesh Telecommunication Regulatory Commission (BTRC), which is responsible for spectrum management, licensing, interconnection policies, Quality of Service (QoS) monitoring, and the prevention of illegal telecommunications traffic, thereby ensuring secure, efficient, and reliable nationwide communication services.

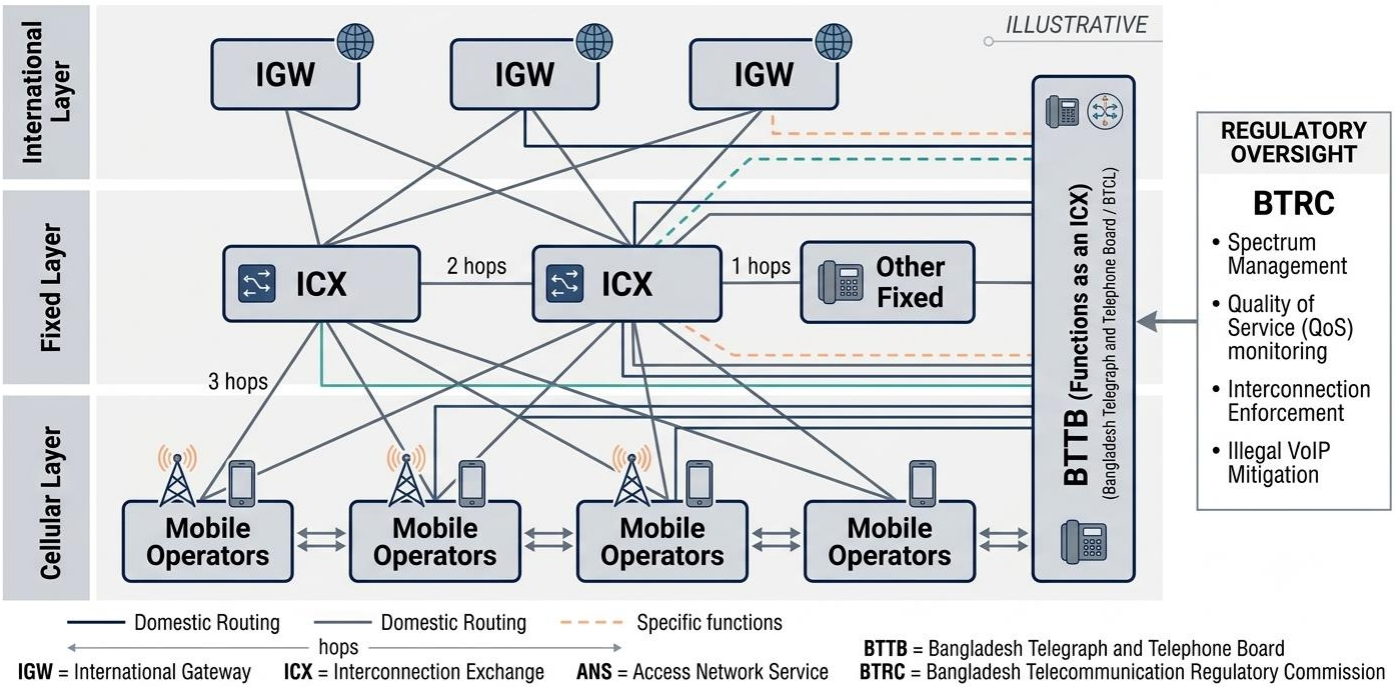

Figure 1. Hierarchical architecture of the Bangladesh telecommunication network.

3.1 The Role of International Gateway (IGW) in International Connectivity

The International Gateway (IGW) serves as the primary interface between Bangladesh's national telecommunication network and international telecommunications carriers. It is responsible for handling all incoming and outgoing international voice traffic, thereby enabling seamless communication between domestic subscribers and overseas networks. As the gateway for international call routing, the IGW receives outbound voice traffic from the Interconnection Exchange (ICX) and forwards it to foreign carriers, while inbound international calls are received from global operators and routed back to the appropriate ICX for delivery to the destination Access Network Service (ANS) operator.

To support efficient and reliable international communication, the IGW maintains connectivity with international carriers through both Internet Protocol (IP)-based and Time Division Multiplexing (TDM) transmission technologies, depending on the interconnection agreements and network infrastructure. Within the national telecommunication network, the connection between the IGW and ICX is primarily established using TDM-based links to ensure stable and secure transport of international voice traffic. By acting as the exclusive gateway for international call exchange, the IGW plays a crucial role in maintaining service quality, facilitating international interoperability, ensuring regulatory compliance, and supporting the secure operation of Bangladesh's telecommunications network under the supervision of the Bangladesh Telecommunication Regulatory Commission (BTRC).

3.2 The Role of Interconnection Exchange (ICX) in Telecommunication Connectivity

Interconnection Exchange (ICX) plays a vital role in establishing seamless connectivity among different telecommunication entities. It acts as a bridge between International Gateway (IGW) operators and Access Network Services (ANS), enabling efficient exchange of voice traffic and communication services. In addition, ICX facilitates interconnection between different ANS operators, ensuring smooth communication among subscribers of various networks. The entire connectivity infrastructure of ICX is supported through Time Division Multiplexing (TDM)-based connectivity, which provides reliable and organized transmission of voice and signaling traffic. Therefore, ICX serves as a central interconnection platform that enhances network interoperability, improves service accessibility, and maintains efficient communication flow within the telecommunication ecosystem.

3.3 The Role of Access Network Service (ANS) in End-User Connectivity

Access Network Service (ANS) serves as the primary interface between telecommunication operators and end users by providing direct access to voice and communication services. It includes mobile operators as well as fixed-line telephone service providers that establish connectivity with subscribers. ANS networks utilize various access technologies, including GSM and CDMA, to enable wireless communication services, while fixed telephony systems support traditional wired communication. Through electronic mobile devices, fixed telephone sets, and other telecommunication terminals, consumers can access the services provided by ANS operators. Therefore, ANS plays a crucial role in ensuring last-mile connectivity, enabling reliable communication access, and connecting end users with the broader telecommunication network infrastructure.

3.4 The Role of Bangladesh Telecommunication Regulatory Commission (BTRC) in Ensuring a Sustainable Telecommunication Ecosystem

The Bangladesh Telecommunication Regulatory Commission (BTRC) serves as the principal regulatory authority responsible for the governance, supervision, and development of the telecommunication and information and communication technology (ICT) sector in Bangladesh. Established under the Bangladesh Telecommunication Regulation Act, 2001 (Act No. 18 of 2001) and becoming operational on January 31, 2002, BTRC operates as an independent statutory organization to ensure the efficient management and sustainable growth of the country's telecommunication infrastructure. The commission provides regulatory frameworks for cellular networks, fixed-line services, internet connectivity, satellite communication, and broadcasting systems, while ensuring compliance with national policies and international standards.

A major responsibility of BTRC is to formulate and enforce regulatory policies, licensing frameworks, and technical guidelines for key telecommunication entities, including Access Network Services (ANS), Interconnection Exchanges (ICX), and International Gateways (IGW). Through effective regulatory supervision, BTRC ensures proper interconnection among operators, efficient utilization of network resources, and uninterrupted communication services for end users. Moreover, the commission manages national radio frequency spectrum resources by allocating and monitoring spectrum bands for different generations of mobile technologies, including 2G, 3G, 4G, and 5G, to support technological advancement and network expansion.

In addition, BTRC plays a significant role in maintaining service quality and protecting consumer interests by monitoring key Quality of Service (QoS) parameters, such as call completion rates, call drop rates, Answer Seizure Ratio (ASR), and data service performance. The commission also implements regulatory measures to prevent unauthorized telecommunication activities, including illegal VoIP bypass, and ensures adherence to security and lawful interception requirements. Furthermore, BTRC regulates tariff structures and promotes fair competition among telecom operators to establish a transparent and consumer-friendly market environment.

Overall, BTRC acts as the backbone of Bangladesh's telecommunication ecosystem by providing effective regulatory governance, ensuring fair market competition, improving service quality, and facilitating the adoption of emerging communication technologies. Through its continuous monitoring and policy interventions, BTRC contributes significantly to the expansion, reliability, and sustainable development of the national telecommunication infrastructure.

CALL FLOW MECHANISM IN BANGLADESH TELECOMMUNICATION NETWORK

The telecommunication network architecture of Bangladesh follows a structured and regulated call routing mechanism to ensure efficient connectivity among domestic and international subscribers. The overall call flow is governed by the regulatory framework established by the Bangladesh Telecommunication Regulatory Commission (BTRC), where different network entities, including Access Network Services (ANS), Interconnection Exchanges (ICX), and International Gateways (IGW), perform specific roles in the communication process. According to the regulatory model, ANS operators, including mobile, Public Switched Telephone Network (PSTN), IP Telephony, and WiMAX providers, are not permitted to establish direct physical connectivity with International Gateways (IGW) or other ANS operators. Instead, all inter-operator and international voice traffic must be routed through authorized Interconnection Exchange (ICX) platforms to ensure transparency, proper traffic management, and regulatory compliance.

4.1 Domestic Call Routing Mechanism

For domestic communication between subscribers of different ANS operators, the call follows a regulated interconnection pathway. Initially, the calling subscriber originates the call through their respective ANS network using a communication terminal, such as a mobile handset or fixed telephone set. The originating ANS processes the call request and forwards the traffic to the designated ICX node through established interconnection links. The ICX functions as a centralized switching platform that identifies the destination network and manages the routing process. After processing the signaling and traffic information, the ICX forwards the call to the corresponding destination ANS operator, which subsequently delivers the call to the intended subscriber. This mechanism enables seamless communication between different network operators while maintaining interoperability and service reliability.

4.2 International Call Routing Mechanism

The routing process for international calls involves additional network elements to establish connectivity beyond national boundaries. When a subscriber initiates an international call, the originating ANS collects the call request and transfers the traffic to the authorized ICX platform. The ICX then forwards the call to the designated International Gateway (IGW), which acts as the primary interface between the national telecommunication network and international carriers. The IGW transmits the call through international communication infrastructures, including submarine optical fiber cable systems and satellite-based VSAT links, depending on the available connectivity route. Subsequently, the international carrier receives the call traffic and completes the connection with the destination international subscriber.

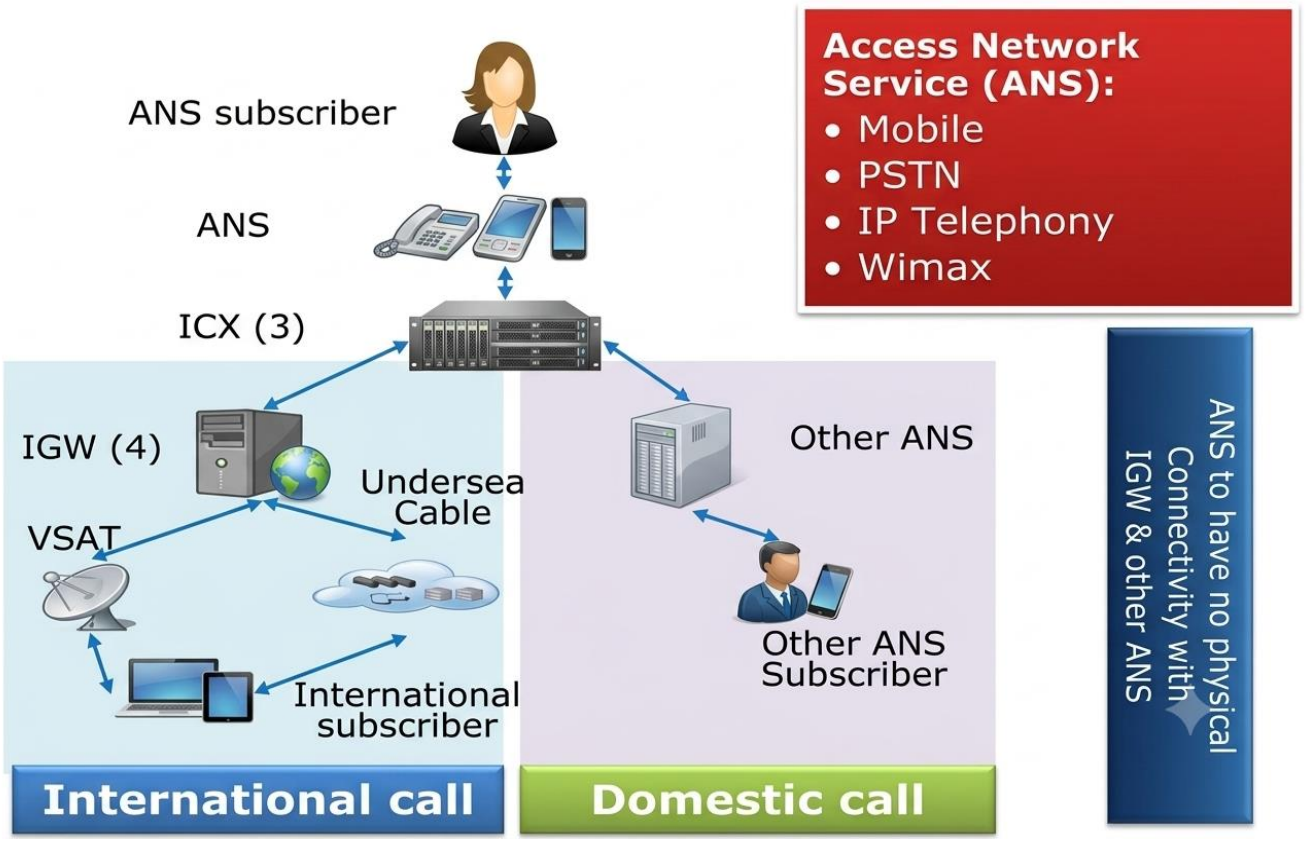

Figure 2. Call Flow Architecture Analysis of Bangladesh Telecommunication Networks: Domestic and International Connectivity Perspective.

ANALYSIS OF KEY PERFORMANCE INDICATORS FOR DOMESTIC AND INTERNATIONAL CALL ROUTING: ASR AND ACD EVALUATION

In modern telecommunication networks, effective monitoring of voice traffic performance is essential to ensure reliable communication services. Network operators and regulatory authorities continuously evaluate call quality, routing efficiency, and interconnection performance using several Key Performance Indicators (KPIs). Among these indicators, Answer Seizure Ratio (ASR) and Average Call Duration (ACD) are considered two of the most important parameters for analyzing call completion success and overall network health.

In the context of Bangladesh's telecommunication infrastructure, where Access Network Service (ANS) operators, Interconnection Exchange (ICX) operators, and International Gateway (IGW) operators are interconnected under regulatory supervision of the Bangladesh Telecommunication Regulatory Commission (BTRC), ASR and ACD provide valuable insights into domestic and international voice traffic performance. These KPIs help identify routing problems, signaling failures, congestion issues, and abnormal traffic patterns.

5.1 Definition and Measurement of ASR

Answer Seizure Ratio (ASR) represents the percentage of successful call connections compared to the total number of call attempts initiated through a particular network route. It is one of the primary indicators used to evaluate the effectiveness of call setup procedures, signaling performance, and interconnection reliability.

A higher ASR value generally indicates that a greater proportion of users are successfully connected with their intended destinations, while a lower ASR suggests possible problems in network availability, routing configuration, congestion, or signaling communication.

The ASR can be calculated using the following formula:

$$ASR(\%) = \frac{Number\ of\ Succesful\ Calls}{Total\ Number\ of\ Call\ Attempts} * 100\%$$

Here, a call attempt or seizure refers to any call setup request generated within the network, regardless of whether the call is answered, rejected, busy, or unsuccessful. An answered call refers to a successfully established communication session where the destination responds with an Answer Message.

The quality of a voice route can be assessed by analyzing the ASR value. Generally, higher ASR values represent efficient routing and reliable network operation.

Table 5.1: ASR Performance Classification and Network Quality Assessment

ASR Range	Performance Level	Typical Network Condition
Above 65–70%	Excellent	Direct routes, stable signaling, low congestion
50–60%	Acceptable	Normal domestic inter-operator traffic
30–45%	Poor	International congestion, routing issues, or high failure rate
Below 30%	Critical	Route failure, illegal bypass, or major network outage
Above 65–70%	Excellent	Direct routes, stable signaling, low congestion

For domestic traffic, especially direct operator-to-operator communication, higher ASR values are commonly observed due to shorter routing paths. However, international traffic may experience comparatively lower ASR because of multiple network elements, longer signaling paths, and international routing dependencies.

5.2 Definition and Importance of ACD

Average Call Duration (ACD) represents the average conversation time of successfully connected calls within a specific route, operator, or network segment. Unlike ASR, which evaluates call establishment success, ACD focuses on the quality and stability of the established communication session.

ACD is widely used to evaluate voice quality, customer engagement, route reliability, and possible abnormal traffic behavior.

The ACD is calculated as:

$$ACD = \frac{Total\ Duration\ of\ Successful\ Calls}{Total\ Number\ of\ Answered\ Calls}$$

Only successfully answered calls are included in ACD calculation. Failed or unanswered call attempts are excluded.

Table 5.2: ACD Performance Classification and Network Quality Assessment

Traffic Type	Typical ACD Range	Characteristics
Domestic Mobile/PSTN Calls	2–4 minutes	Normal interpersonal communication
International IGW Traffic	3–6 minutes	Longer conversations due to distance and purpose
Automated/Robocall Traffic	Less than 10–30 seconds	Short-duration, high-volume calling behavior
Domestic Mobile/PSTN Calls	2–4 minutes	Normal interpersonal communication

A healthy network usually maintains a stable ACD value. A sudden reduction in ACD may indicate poor voice quality, call drops, or abnormal traffic generation.

5.3 Combined Analysis of ASR and ACD

ASR and ACD provide complementary information when evaluating network performance. While ASR indicates the success rate of call establishment, ACD reflects the stability and quality of completed calls. Therefore, analyzing both parameters together provides a more accurate understanding of network behavior.

Table 5.3: ASR–ACD Matrix for Call Routing Performance Evaluation

ASR Condition	ACD Condition	Possible Network Interpretation
High ASR	High ACD	Healthy route with reliable signaling and good voice quality
High ASR	Low ACD	Calls are connected but voice quality problems may exist
Low ASR	High ACD	Connection problems exist, but successful calls remain stable
Low ASR	Low ACD	Severe routing failure, congestion, or abnormal traffic condition

A combined evaluation of ASR and ACD trends allows operators and regulators to distinguish between normal traffic variations and serious network problems. Therefore, these KPIs play a vital role in maintaining a reliable, efficient, and transparent telecommunication ecosystem.

5.4 Performance Analysis of ASR and ACD Relationship

The relationship between Answer-Seizure Ratio (ASR) and Average Call Duration (ACD) across different telecommunication network tiers is presented in Figure 3 [2]. The results show a strong positive correlation between ASR and ACD, indicating that higher call completion rates generally contribute to longer and more stable communication sessions. The linear regression analysis shows a high correlation (R^2 = 0.9798), confirming the significant relationship between successful call establishment and voice communication performance.

The IGW operators demonstrate ASR values ranging from approximately 53% to 68%, with ACD increasing from 3.4 to 4.9 minutes. This indicates that efficient international routing and reliable carrier connectivity positively influence voice service quality. Similarly, the ICX operators show improved performance with ASR values of 61%–69% and ACD values of 4.0–5.1 minutes, highlighting the importance of effective interconnection management in domestic voice traffic exchange.

The ANS operators achieve comparatively higher ASR and ACD values, where Grameenphone, Robi, and Banglalink show better performance than Teletalk in the evaluated dataset. These variations may be related to differences in network coverage, infrastructure capacity, traffic management, and operational optimization.

Overall, the analysis confirms that ASR and ACD are important indicators for evaluating voice network performance. Higher ASR reflects improved call accessibility, while higher ACD indicates better call stability and user engagement. Therefore, continuous monitoring of these parameters is essential for optimizing routing efficiency and maintaining Quality of Service (QoS).

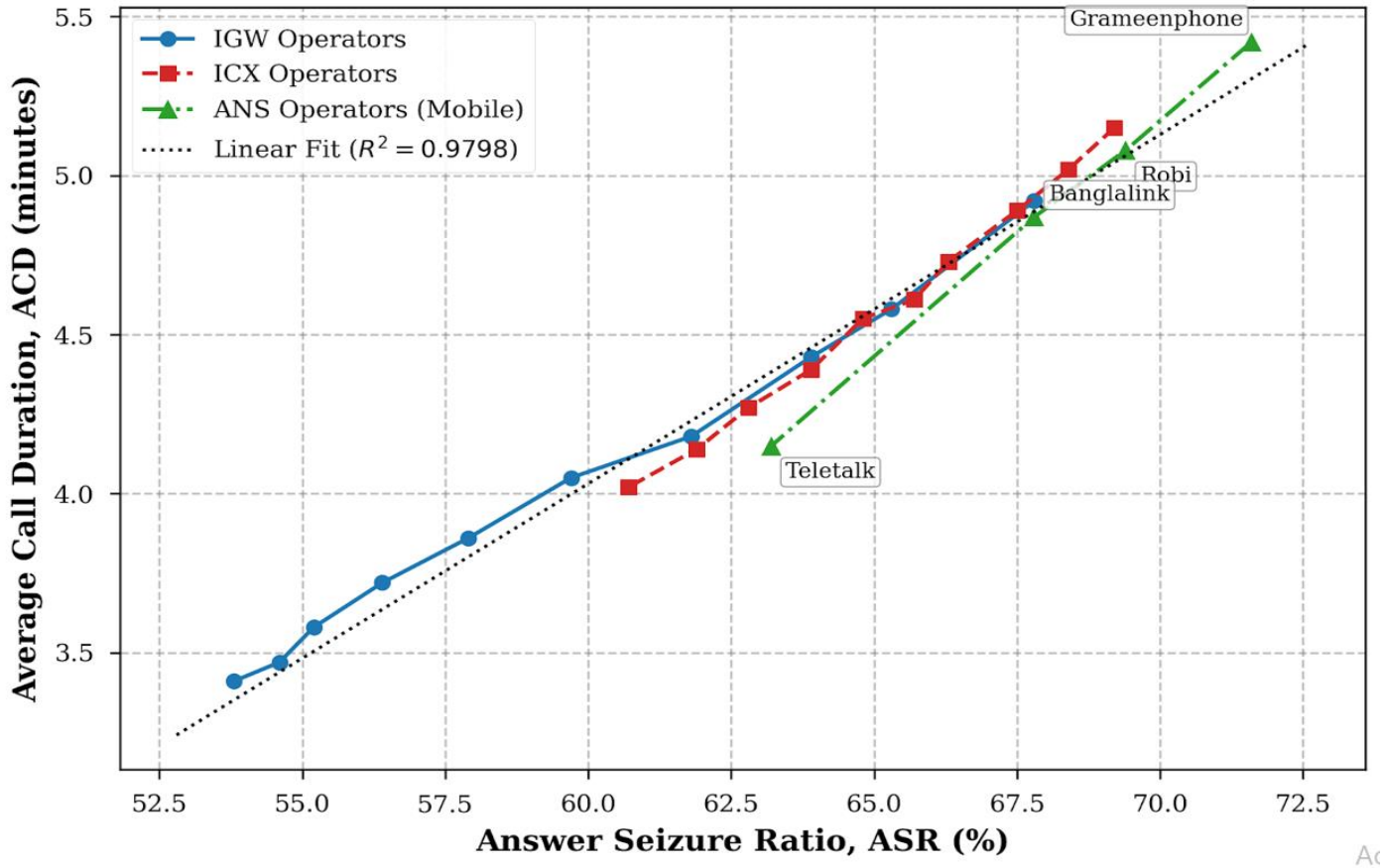

Figure 3. Relationship between Answer-Seizure Ratio (ASR) and Average Call Duration (ACD) across different telecommunication network tiers.

CONCLUSION

This paper presents a comprehensive overview of the telecommunication infrastructure of Bangladesh, focusing on its hierarchical network architecture, operational framework, and voice traffic performance evaluation. The study explains the functional roles of

Access Network Service (ANS), Interconnection Exchange (ICX), and International Gateway (IGW) in managing domestic and international communication services under the regulatory supervision of the Bangladesh Telecommunication Regulatory Commission (BTRC). The layered architecture enables efficient traffic routing, inter-operator connectivity, and reliable communication across national and international networks. The performance analysis based on key voice quality indicators, including Answer-Seizure Ratio (ASR) and Average Call Duration (ACD), demonstrates a strong relationship between successful call establishment and communication stability. The observed correlation between ASR and ACD highlights the importance of effective routing mechanisms, interconnection efficiency, and network optimization in maintaining Quality of Service (QoS). The analysis also emphasizes the significant role of IGW, ICX, and ANS operators in ensuring seamless voice communication and improving overall network performance. With the continuous growth of mobile connectivity, broadband services, and emerging technologies such as 5G, IoT, and artificial intelligence-based network management, Bangladesh's telecommunication infrastructure requires continuous modernization and optimization. Future development should focus on intelligent traffic management, advanced QoS monitoring, infrastructure sharing, and efficient utilization of network resources. This study provides a structured reference for understanding the current telecommunication framework of Bangladesh and highlights potential directions for developing a more resilient, efficient, and future-ready communication ecosystem.

I. ACKNOWLEDGMENT

The authors would like to acknowledge the support of artificial intelligence (AI)-based language assistance tools, including ChatGPT and Gemini, which were used to improve language clarity, grammatical accuracy, and the overall readability of this manuscript. The authors remain fully responsible for the research content, analysis, interpretations, and final version of the paper.

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