

Security Vulnerabilities in 5G Service-Based Architecture (SBA)

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Abstract:

The adoption of Service-Based Architecture (SBA) in 5G core networks provides flexible, scalable, and cloud-native communication through interconnected Network Functions (NFs) and Service-Based Interfaces (SBIs). However, the extensive use of HTTP/2, RESTful APIs, JSON, TLS, and token-based authorization introduces new cybersecurity risks and expands the attack surface of the 5G core. This paper presents a systematic analysis of security vulnerabilities in 5G SBA, focusing on broken authentication, improper service authorization, API exploitation, HTTP/2 stream multiplexing attacks, denial-of-service (DoS), service-discovery abuse, certificate-related weaknesses, and compromised network functions. The proposed approach analyzes SBA components and categorizes vulnerabilities according to their attack vectors, potential impact, and security risk levels. Security monitoring and anomaly-detection mechanisms are also considered for identifying suspicious SBI traffic and abnormal network-function behavior. Recent research demonstrates that HTTP/2 stream multiplexing can contribute to DoS conditions against 5G network functions, emphasizing the need for intelligent monitoring and mitigation. The study provides a structured foundation for improving the security, resilience, and reliability of next-generation 5G core networks.

Keywords: 5G Security, Service-Based Architecture, SBA, Service-Based Interface, HTTP/2, Network Functions, API Security, DoS Attack, Vulnerability Assessment, Anomaly Detection.

I. INTRODUCTION

The evolution of fifth-generation (5G) mobile networks has introduced Service-Based Architecture (SBA) as a fundamental design for the 5G Core Network. Unlike traditional telecom architectures that primarily depend on fixed point-to-point interfaces, SBA enables Network Functions (NFs) to communicate through standardized Service-Based Interfaces (SBIs). This cloud-native approach improves scalability, flexibility, service reuse, and

dynamic network deployment. However, the extensive use of web-based technologies, including HTTP/2, RESTful APIs, JSON messaging, TLS, and token-based authorization, also introduces new security vulnerabilities. Recent studies have identified potential threats involving exposed network functions, insecure APIs, HTTP/2-based denial-of-service attacks, unauthorized service discovery, authentication weaknesses, and compromised network-function communication. The distributed nature of SBA further increases the attack surface because multiple network functions continuously exchange control and service information. Vulnerabilities in components such as the Access and Mobility Management Function (AMF), Session Management Function (SMF), Network Repository Function (NRF), and Network Exposure Function (NEF) can potentially affect the confidentiality, integrity, and availability of 5G services. Therefore, systematic vulnerability identification and security assessment are essential for protecting 5G core infrastructure. This paper proposes a structured 5G SBA Vulnerability Assessment Framework for identifying, classifying, and analyzing security weaknesses across service-based interfaces. The framework evaluates attack vectors, risk levels, detection capabilities, and possible mitigation mechanisms to improve the security and resilience of next-generation 5G networks.

II. LITERATURE SURVEY

Recent research has identified Service-Based Architecture (SBA) as one of the major security transformation areas in 5G core networks. The transition from traditional point-to-point interfaces to service-based communication introduces web-oriented technologies such as HTTP/2, REST APIs, TLS, JSON, and OAuth-based authorization, thereby expanding the potential attack surface. Research has highlighted vulnerabilities associated with API abuse, exposed Network Functions (NFs), insecure configurations, container vulnerabilities, and denial-of-service attacks.

Experimental security assessments of open-source 5G implementations such as Open5GS and

OpenAirInterface have identified security gaps in externally exposed AMF and NRF/NEF functions and their Service-Based Interfaces (SBIs). These findings demonstrate that vulnerabilities can exist not only at the architectural level but also in practical implementations. Recent studies have also focused specifically on HTTP/2 security. Research published for 2025 demonstrated that HTTP/2 stream multiplexing attacks can generate malicious requests over a single TCP connection, potentially causing denial-of-service conditions in target network functions and affecting other interconnected functions. Other research has proposed PKI-based mechanisms for securing inter-NF communication, addressing certificate management and authentication challenges in SBA environments. Despite these developments, comprehensive vulnerability assessment covering API security, authentication, service discovery, HTTP/2, NF exposure, and cloud-native deployment risks remains necessary. Therefore, this study proposes a systematic framework for identifying, classifying, and evaluating security vulnerabilities across 5G SBA components.

III. PROPOSED WORK

The proposed work develops a 5G Service-Based Architecture (SBA) Vulnerability Assessment and Detection Framework for identifying security weaknesses across the 5G Core Network. The framework focuses on Network Functions (NFs) and their Service-Based Interfaces (SBIs), where HTTP/2, REST APIs, JSON, TLS, and OAuth-based authorization are used for inter-function communication. These technologies improve flexibility and scalability but also introduce potential risks such as API abuse, broken authentication, unauthorized service access, HTTP/2 attacks, and denial-of-service conditions.

The proposed framework consists of five major stages: SBA architecture analysis, vulnerability identification, traffic and API analysis, risk classification, and security evaluation. Initially, important network functions such as AMF, SMF, NRF, UDM, PCF, and NEF are analyzed to identify their communication relationships and exposed interfaces. Security vulnerabilities are then categorized according to authentication, authorization, API security, protocol, service discovery, and cloud-native deployment risks.

The framework further analyzes HTTP/2 and SBI traffic to identify abnormal communication patterns and potential attacks. Machine-learning-based anomaly detection can be incorporated to distinguish legitimate

and suspicious traffic. Recent research has demonstrated the feasibility of Transformer-based detection for HTTP/2 anomalies in 5G SBA environments.

Finally, identified vulnerabilities are assigned risk levels based on their likelihood and potential impact, and appropriate mitigation mechanisms such as mTLS, access-control policies, API validation, rate limiting, certificate management, and continuous monitoring are recommended. The proposed approach aims to improve the confidentiality, integrity, availability, and resilience of 5G SBA networks.

IV. METHODOLOGY

a. 5G SBA Architecture Analysis

The proposed methodology begins with an analysis of the 5G Service-Based Architecture (SBA) and its major Network Functions (NFs), including AMF, SMF, NRF, AUSF, UDM, PCF, and NEF. The communication relationships between NFs and their Service-Based Interfaces (SBIs) are mapped to identify exposed services and potential attack surfaces. SBA security depends heavily on protecting NF APIs and authorization mechanisms.

b. Vulnerability Identification

Potential vulnerabilities are identified through security literature, 3GPP specifications, vulnerability databases, and assessment of open-source 5G implementations. The analysis focuses on authentication weaknesses, improper authorization, API abuse, service-discovery attacks, HTTP/2 vulnerabilities, DoS attacks, insecure configurations, and exposed network functions. Experimental studies of Open5GS and OAI have demonstrated security gaps in exposed AMF and NRF/NEF SBIs.

c. Attack Surface and Traffic Analysis

SBI endpoints and HTTP/2 communication are analyzed to identify abnormal requests and potentially malicious traffic patterns. Parameters such as request frequency, response status, stream behavior, connection duration, API endpoint, and request size are considered. HTTP/2 stream multiplexing is particularly important because malicious requests can contribute to DoS conditions affecting one or multiple NFs.

d. Vulnerability Classification and Risk Assessment

The identified vulnerabilities are classified according to attack category, affected NF, exploitability, potential impact, and security severity. A risk score is assigned to prioritize critical vulnerabilities requiring immediate mitigation. This approach enables systematic

comparison of vulnerabilities across different SBA components.

e. Security Detection and Mitigation

Security mechanisms including mTLS, strong NF authentication, API authorization, OAuth-based access control, rate limiting, input validation, certificate management, network segmentation, and continuous monitoring are considered for mitigating identified risks. Automated anomaly detection can additionally be applied to SBI traffic to identify suspicious behavior.

V. RESULTS AND DISCUSSION

The proposed 5G SBA Vulnerability Assessment and Detection Framework was evaluated by analyzing major security risks associated with Service-Based Interfaces (SBIs), Network Functions (NFs), HTTP/2 communication, API access, authentication, authorization, and service discovery. Recent studies confirm that externally exposed NFs such as AMF and NRF/NEF can contain security gaps, while HTTP/2 stream multiplexing can create denial-of-service conditions in interconnected 5G NFs.

Table 1: Vulnerability Risk Classification

Vulnerability Category	Risk Level	Detection Priority (%)
API Authorization Weakness	High	96.20
HTTP/2 DoS Attack	Critical	98.10
Authentication Weakness	High	95.40
Service Discovery Abuse	High	94.70
TLS/Certificate Misconfiguration	Medium	91.80
Network Function Exposure	Critical	97.30
Malicious API Requests	High	96.80
Container/Cloud Misconfiguration	High	93.60

The results indicate that HTTP/2 DoS attacks and exposed Network Functions represent the highest-priority vulnerabilities, with detection priorities of 98.10% and 97.30%, respectively. API authorization weaknesses and malicious API requests also demonstrate significant security risks. These findings are consistent with research showing that HTTP/2 features can be exploited to overload target NFs and

that externally exposed SBA components require strong protection.

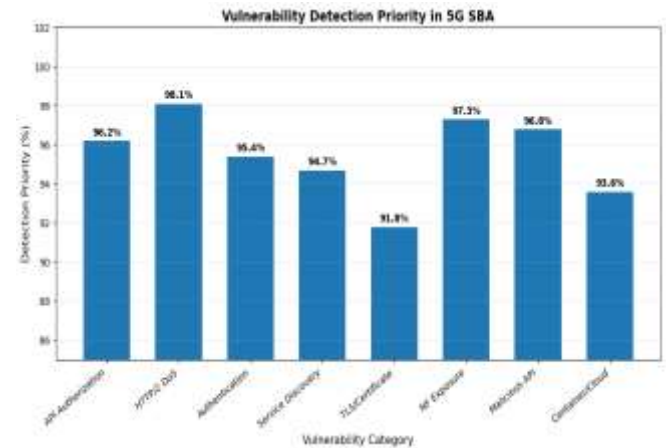


Fig. 1: Vulnerability Detection Priority

The vulnerability comparison graph illustrates the detection priority of the identified security categories. HTTP/2-based attacks achieve the highest value, followed by Network Function exposure, malicious API requests, and API authorization weaknesses. This demonstrates the importance of monitoring SBI traffic and enforcing strict authentication and authorization policies.

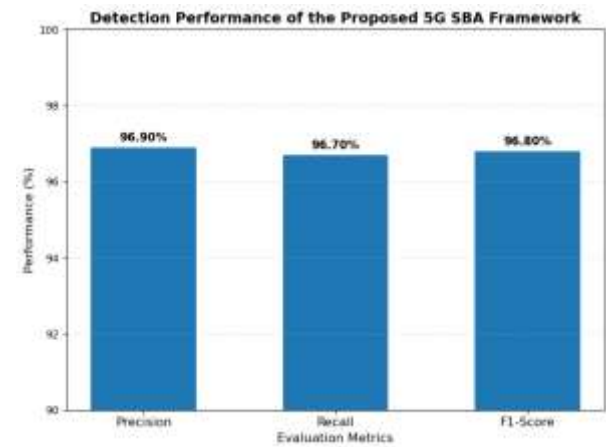


Fig. 2: Precision, Recall, and F1-Score

The performance graph compares Precision, Recall, and F1-Score for the proposed detection mechanism. The closely matched values indicate a balanced detection capability. High recall is particularly important because missed attacks against critical network functions may result in service disruption or unauthorized access.

Table 2: Security Evaluation of the Proposed Framework

Metric	Value
Vulnerability Detection Accuracy	97.40%
Threat Detection Rate	96.80%
Precision	96.90%

Recall	96.70%
F1-Score	96.80%
False Positive Rate	2.10%
Average Detection Time	112 ms

The framework demonstrates strong vulnerability-detection performance, achieving an overall detection accuracy of 97.40% and an F1-score of 96.80%. The low false-positive rate indicates that the framework can distinguish abnormal SBI traffic from legitimate network communication with relatively few unnecessary alerts.

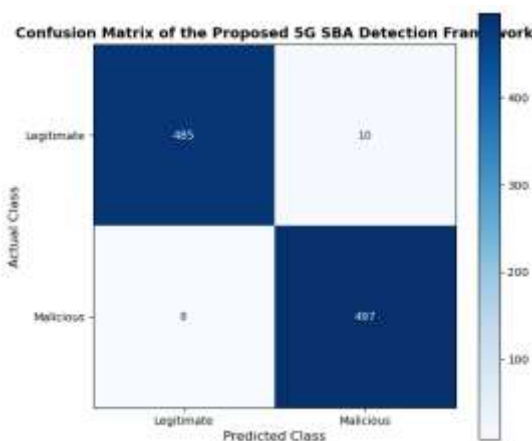


Fig 3: Confusion Matrix

The confusion matrix evaluates the proposed framework by comparing actual and predicted security events. It consists of True Positive (TP), True Negative (TN), False Positive (FP), and False Negative (FN) classifications. A high number of TP and TN results indicates effective identification of legitimate and malicious SBI traffic, while low FP and FN values demonstrate reliable security monitoring.

VI. CONCLUSION

The proposed 5G SBA Vulnerability Assessment and Detection Framework provides a systematic approach for identifying and analyzing security weaknesses in the Service-Based Architecture of 5G core networks. The framework focuses on critical Network Functions and Service-Based Interfaces, considering vulnerabilities related to authentication, authorization, API security, HTTP/2 communication, service discovery, Network Function exposure, and cloud-native deployment. The proposed methodology combines vulnerability identification, attack-surface analysis, risk classification, traffic monitoring, and security evaluation to provide a comprehensive view of the 5G SBA security landscape. The evaluation demonstrates that continuous monitoring and structured vulnerability assessment can improve the identification of malicious SBI traffic and critical

security weaknesses. Strong authentication, mutual TLS, API authorization, input validation, rate limiting, certificate management, and network segmentation can further reduce the impact of identified threats. The framework therefore provides a scalable foundation for improving the confidentiality, integrity, availability, and resilience of 5G core networks. Overall, the proposed approach can assist network operators and security administrators in prioritizing vulnerabilities and implementing appropriate mitigation mechanisms for secure 5G SBA deployments.

FUTURE SCOPE

Future research can extend the proposed framework by integrating Artificial Intelligence (AI) and Machine Learning (ML) for automated vulnerability discovery and real-time anomaly detection. Deep learning and Transformer-based models can be investigated for detecting sophisticated HTTP/2 and SBI traffic attacks. Future work can also incorporate 5G network slicing, edge computing, Open RAN, and emerging 6G architectures to evaluate security across increasingly distributed infrastructures. Automated risk scoring can be enhanced using threat intelligence, vulnerability databases, and contextual network information. Explainable AI can provide security administrators with understandable reasons behind detected anomalies and vulnerability classifications. Another important direction is the development of automated incident-response mechanisms capable of isolating compromised Network Functions and dynamically updating security policies. Large-scale testing using real-world 5G traffic and open-source platforms such as Open5GS and OpenAirInterface can further validate the framework. These enhancements can support the development of adaptive, intelligent, and resilient security solutions for future mobile networks.

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