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5G Core Operate Through Quarterly Update (Q4-2022)

Summary

This report summarizes information on vulnerabilities associated with the 5G network, that potentially could be employed or leveraged by an untrusted network operator, in support of the Under Secretary of Defense for Research and Engineering (OUSD R&E) 5G Operate Through Program. The information in this report is based on open-source material published or made available between 1 June and 31 August 2022.

5G Network Vulnerabilities for Operate Through

The vulnerabilities in this section were obtained from the National Institute of Standards and Technology (NIST) National Vulnerability Database (NVD) for this reporting period. Vulnerabilities that are of direct interest for the Operate Through program, as well as 5G-related vulnerabilities of potential general interest, are included.

Vulnerabilities Listed in NIST NVD

No new pertinent vulnerabilities were identified.

Literature Review of 5G Vulnerabilities for Operate Through

The following section summarizes open-source literature focused on 5G-related vulnerabilities that either directly pertain to 5G Operate Through or are of potential general interest.

Hacking Mobile Networks Has Gotten a Lot More Interesting With 5G and Open RAN

8 August 2022

https://www.srlabs.de/bites/5g-security

Assessment: The red team of Security Research Labs, Berlin, has identified several configuration settings for Docker Containers running on Kubernetes that can break out of one container/tenant and take over the entire Kubernetes cluster. Authors report several instances of observing this behavior in cloud-based network systems in an article published in IEEE Spectrum, as referenced below in Related Information. Some of these vulnerabilities, e. g., HostPID, can lead to taking down the entire system by using the "kill host process" hacking vector. Other hacking vectors such as "inject into host process," "Search for passwords and tokens in config and history files," and "add SSH key" are shown to be able to run malicious code, view/encrypt data, and take down the entire system.

Adopting Docker-based best practices for 5G Standalone (5G SA) and even 5G Non-standalone (5G NSA) is a necessity for 5G because the Radio Access Network (RAN), 5G Core, and Multi-access Edge Computing (MEC) are leaning toward or have already leaned toward cloud-native deployments. Additionally, it is also important to measure cloud security levels in each of these cloud-based 5G network elements to achieve secure and reliable communications.

Contents:

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Abstract: This article discusses 5G network vulnerabilities in terms of the cloud environment: can a hacker break out of one container/tenant to compromise others, or even compromise the underlying infrastructure? Security Research Labs' red team assessments on 5G telcos and other cloud-native infrastructures regularly come across configuration settings for Docker containers running on Kubernetes that allow precisely this scenario.

Related Information: *https://spectrum.ieee.org/5g-virtualization-increased-hackability*

How To Hack Mobile Communications Via Unisoc Baseband Vulnerability

4 August 2022

https://resources.infosecinstitute.com/topic/how-to-hack-mobile-communications-via-unisoc-baseband-vulnerability/

Assessment: This is a blog by Mr. Pedro Travares on the Infosec website discussing a vulnerability that arises in android devices, smart televisions, etc., that can allow a mobile device to cause a Denial-of-Service (DoS) attack, provided the targeted device is equipped with a chip manufactured by a Chinese Semiconductor device manufacturer named Unisoc. This blog does not provide any evidence or cite references to indicate if DoS vulnerabilities have been seen in the 5G SA or NSA environment while using this chip in any UE device. 5G (SA and NSA) are radically different from LTE in its security architecture for the network infrastructure, including UE. This case may be relevant to LTE when Android UEs equipped with Unisoc chip are used for mobile communications, but it may not be relevant to the Operate Through scenario.

Abstract: The Chinese company UNISOC, founded as Spreadtrum, is one of the world's largest chipmakers and the biggest in China over the last 20 years. The firm produces low-cost chipsets for Android devices compatible with 2-5G technology, smart TVs, and other products. Because researchers have not tested their products before, the CheckPoint team decided to analyze part of the protocol messages used, known as Network Access Stratum (NAS), and found a vulnerability (CVE-2022-20210) that can be abused to disrupt the device's radio communication via a malformed packet, causing a DoS condition. This vulnerability allows attackers to neutralize communications in a specific location.

5G Core Network Security Issues and Attack Classification from Network Protocol Perspective

31 May 2020

https://www.semanticscholar.org/paper/5G-core-network-security-issues-and-attack-from-Kim/7aaa0ecf29ffaed17f3794198c4c0e8f3975b00e

Assessment: This paper discusses the following possible attacks on a 5G network: 1) Distributed Denial-of-Service (DDoS) attacks caused by security vulnerabilities in IoT devices, 2) RAN failure and small cell security management owing to heterogeneous wireless network access and coverage expansion, 3) visibility for security monitoring and expansion of the protection target owing to the decentralized mobile network structure, 4) dynamic security management and access control caused by the sharing of physical hardware equipment regarding virtualization platform and network slicing technology, and 5) security issues related to third-party applications and API reliability and connection paths to internal mobile communication networks, which are caused by applying MEC. It is of general interest but not specific to the Operate Through scenario.

Abstract: 5G technology services commercialized in 2019 have not only provided voice and data communication but have also undergone significant structural changes in mobile networks to accommodate IoT devices, sensitive to latency and reliability. These changes came about by adopting the latest information and communication technologies, such as software-defined networking/network function virtualization, MEC, and network slicing. However, this technological evolution poses new security challenges (e.g., creation of new access paths) owing to its complex inter-operation structures, security downgrading, and limitations in security visibility. In this paper, the authors analyzed five new security issues for each 5G section, relative to 5G technical advantages, by reviewing previous studies. In addition, they classified cyber-attacks against nine network protocols primarily used in the 5G core network.

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Effective Feature Selection Methods to Detect IoT DDoS Attack in 5G Core Network

1 May 2022

https://www.semanticscholar.org/paper/Effective-Feature-Selection-Methods-to-Detect-IoT-Kim-Kim/40cc9460b2726e6ea80d4b9af2f4ce640c90e9e8

Assessment: This paper discusses detection of DDoS attacks on 5G mobile networks by IoT devices with weak security. It is of general interest, but not specific to the Operate Through scenario.

Abstract: 5G networks aim to realize a massive IoT environment with low latency. IoT devices with weak security can enable Tbps-level DDoS attacks on 5G mobile networks. Accordingly, interest in automatic network intrusion detection using machine learning (ML) technology in 5G networks is increasing. ML-based DDoS attack detection in a 5G environment should provide ultra-low latency. To this end, utilizing a feature-selection process that reduces computational complexity and improves performance by identifying features important for learning in large datasets is possible. Existing ML-based DDoS detection technology mostly focuses on DDoS detection learning models on the wired Internet. In addition, studies on feature engineering related to 5G traffic are insufficient. This study performed feature selection experiments to reduce the time complexity of detecting and analyzing large-capacity DDoS attacks in real time based on ML in a 5G core network environment. The results of the experiment showed that the performance was maintained and improved when the feature selection process was used. In particular, as the size of the dataset increased, the difference in time complexity increased rapidly. The experiments show that the real-time detection of large-scale DDoS attacks in 5G core networks is possible using the feature selection process. This demonstrates the importance of the feature selection process for removing noisy features before training and detection.

Related Information: https://www.sdxcentral.com/articles/analysis/is-5g-network-slicing-a-cybersecurity-attack-vector/2022/06/; https://www.theprojectcounselgroup.com/2022/06/12/the-emerging-cyber-threat-attacking-5g-via-network-slices-and-metadata/

An Emerging Threat: Attacking 5G Via Network Slices

7 June 2022

https://www.darkreading.com/threat-intelligence/an-emerging-threat-attacking-5g-via-network-slices

Assessment: Of general interest, but not specific to the Operate Through scenario.

Abstract: A high-level discussion about using network slices as potential points of access to, and jumping off points for, lateral movement into other slices of the 5G core network. This technique, which is analogous to a form of container escape in a cloud environment, was successfully tested by researchers from Deloitte and Virginia Tech. The initial compromise of the first network slice could be achieved by exploiting open ports and vulnerable protocols, for example. While pivoting to a different slice would not be a trivial task, it is technically possible.

Related Information: https://www.sdxcentral.com/articles/analysis/is-5g-network-slicing-a-cybersecurity-attack-vector/2022/06/; https://www.theprojectcounselgroup.com/2022/06/12/the-emerging-cyber-threat-attacking-5g-via-network-slices-and-metadata/

Ericsson, Qualcomm and Thales to Take 5G Into Space

26 July 2022

https://www.zawya.com/en/press-release/companies-news/ericsson-qualcomm-and-thales-to-take-5g-into-space-aacalsg7

Assessment: While not currently pertinent to the Operate Through scenario, INL assesses that space-based 5G communications over an untrusted operator's satellite network infrastructure will be a future arena of pertinent security concern.

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Abstract: Thales and Qualcomm have partnered in an endeavor to bring 5G to non-terrestrial communications (NTN), employing the technology for space-based communications. If successful, this could open the door to enabling 5G smart phones to communicate from anywhere on the globe.

Related Information: *https://www.esa.int/Applications/Telecommunications_Integrated_Applications/Space-enabled_5G_links_Japan_and_Europe*

Wild Networks: Exposure Of 5G Network Infrastructures to Adversarial Examples

4 July 2022

https://arxiv.org/pdf/2207.01531.pdf

Assessment: As 5G networks are deployed and more devices begin to use these networks to move traffic, the current methods of managing network packets no longer hold up. To solve this problem researchers noted that many carriers are planning to use ML models that can sort, classify, and prioritize packets. These ML models are the weakness or the weak points for the attack, because the attackers are able to change the classification of packets or prioritization of packets and thus affect the models' forwarding decisions. The researchers suggested that by flooding the network with garbage traffic, a technique known as "myopic attack," they can take down a 5G mobile setup. The basic idea behind myopic attack lies in making slight changes to data sets, i.e., modifying the datasets that ML algorithms use to train and test, thus compromising the accuracy of the prediction of the model.

The 5G paradigm enables a new class of harmful adversarial ML attacks with a low entry barrier which cannot be formalized through existing adversarial barriers. Such vulnerabilities must be proactively assessed. Some of these myopic attacks can be launched from the adversaries' own devices without compromising any segment of the 5G network. Adversarial ML will seriously impact 5G SA, as well as 5G NSA networks. This is applicable to Operate Through.

Abstract: 5G networks must support billions of heterogeneous devices while guaranteeing optimal Quality of Service (QoS). Such requirements are impossible to meet with human effort alone, so ML represents a core asset in 5G. ML, however, is known to be vulnerable to adversarial examples; moreover, as this paper shows, the 5G context is exposed to yet another type of adversarial ML attack that cannot be formalized with existing threat models. Proactive assessment of such risks is also challenging due to the lack of ML-powered 5G equipment available for adversarial ML research. To tackle these problems, the authors proposed a novel adversarial ML threat model that is particularly suited to 5G scenarios and is agnostic to the precise function solved by ML. In contrast to existing ML threat models, these attacks do not require any compromise of the target 5G system while still being viable due to the QoS guarantees and the open nature of 5G networks. Furthermore, the authors proposed an original framework for realistic ML security assessments based on public data. They proactively evaluated their threat model on six applications of ML envisioned in 5G. The authors' attacks affect both the training and the inference stages, can degrade the performance of state-of-the-art ML systems, and have a lower entry barrier than previous attacks.

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Active Foreign Commercial 5G Standalone Networks

Table 1 lists foreign network operators that claim to have launched 5G SA commercial mobile services as of 31 August 2022.[a]

Table 1. Foreign 5GSA Commercial Networks

Country	Operator	5GSA Launch	Remarks
Australia	Optus[1] TPG Telecom[2]	November 2021 November 2021	Optus provides 5G services via the 3500 MHz, 2300 MHz, and 2100 MHz spectrum bands.TPG's 5GSA core network runs on TPG's 700 MHz spectrum holdings. Note that TPG now incorporates Vodafone Australia.[3]
Bahrain	STC Bahrain	May 2022	STC Bahrain launched the country's first 5GSA network using Huawei equipment. The network supports eMBB, URLLC, and massive Machine-Type Communications (mMTC) services.[4]
Brazil	TIM Brasil Claro Brasil Vivo	July 2022 July 2022 July 2022	All three of Brazil's wireless providers activated 5G SA commercial services in July 2022 in the capital of Brasilia in the 3500 MHz band (TIM soft-launched its 5G SA services in April to select users).[5,6] 5G services in the 26 GHz band, primarily aimed at hotspot coverage for industrial applications or point to point solutions, are also planned.[7]
Canada	Rogers Communications[8]	March 2022	Rogers' 5G SA network is Canada's first. The company's 5G services operate in the 600, 1700, and 2500 MHz bands.[9] The company expanded its spectrum to the 3500 MHz band in June 2022.[10]
China	China Mobile[11] China Telecom China Unicom	November 2020[12] November 2020[13] November 2020	As of early 2021, these three operators had deployed over 700,000 5GSA base stations; China Mobile commissioned 5GSA services in all prefectures and cities across China; and China Telecom and China Unicom jointly built the world's largest shared 5GSA network covering 300 cities.
Finland	Telia Company[14]	November 2021	Telia was the first commercially available 5GSA network in the Nordic and Baltic regions. The company offers 5G services in the 700 and 3500 MHz and has also acquired spectrum in the 26 GHz band. The company is working on rolling out 5G services to all of its markets across the Nordic and Baltic countries.[15]
Germany	Deutsche Telekom[16] Vodafone[17]	April 2022 March 2022	As of early 2022, Deutsche Telekom's network had 5,000 antennas operating in the 3600 MHz spectrum, providing coverage to over 200 urban centers and cities. Vodafone had over 4,000 antennas supporting 5G SA services, operating in the 3600, 1800, and 700 MHz spectra and is projected to reach nationwide coverage by 2025.
Italy	Linkem[18]	October 2021	Linkem's 5G SA network is Italy's first and operates in the 3500 MHz band.
Japan	SoftBank Corp.[19]	October 2021	Supporting SoftBank Air Terminals, SoftBank provides coverage in the 3.9-4.0 GHz and 29.1-29.5 GHz ranges.[20]
Kuwait	STC Kuwait[21]	May 2021	STC's 5G services were launched in the 3500 Mhz band and the company expanded its services into the 2100 MHz band, as well.[22]
Philippines	Smart Communications[23]	October 2021	Smart launched the first 5G SA network in the Philippines in Makati City. Based on available information, the company's 5G services appear to mainly be in the 700 and 3500 MHz bands, although 5G carrier aggregation tests have also been carried out using the 2600 and 3500 MHz bands.[24]
Saudi Arabia	Zain KSA[25] STC Saudi Arabia[26,27]	February 2022 August 2021	At launch, Zain's network comprised 5,000 towers and covered 51 cities. The provider operates 5G in the 2600 and 3500 MHz bands.[28] STC's 5GC supports both 5GNSA and 5GSA services. STC's 5GC supports both 5GNSA and 5G SA services.

[a] This list does not include commercial 5GSA fixed wireless or private networks, or operators engaged in testing or trials.

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Country	Operator	5GSA Launch	Remarks
Singapore	M1 Limited[29] StarHub Mobile[30] Singtel[31]	July 2021 July 2021 September 2021	M1 and StarHub Mobile engaged in a joint venture to build their 5G SA network; both the M1/StarHub and the Singtel networks were commissioned in the 3500 MHz spectrum.
South Africa	Rain[32]	July 2020	South Africa's Rain launched the first 5G SA network in Africa in partnership with Huawei. Rain secured bandwidth in the 700 MHz and 2600 MHz bands,[33] although it applied for spectrum in the 800 and 3500 MHz bands, as well.[34]
South Korea	KT[35]	July 2021	KT is the first provider in South Korea to launch 5G SA services. In 2018, KT secured 5G spectrum in the 3500-3600 MHz and 26.5-27.3 GHz bands.[36]
Spain	Vodafone[37]	December 2021	Vodafone's initial 5G SA commercial rollout in Spain was for the businesses in the Almeria Science and Technology Park.
Taiwan	Taiwan Mobile Co.[38]	October 2021	Taiwan Mobile 5G services operate in the 700 MHz and 700 MHz + 3500 MHz/28 GHz (low+high) bands. The company also operates 4G/5G EUTRA-NR EN-DC in the 700 MHz, 1800 MHz, 2100 MHz, 3500 MHz, and 28 GHz bands.[39]
Thailand	AIS[40]	July 2020	AIS launched 5G SA services in July 2020,[41] and by August 5G SA had reportedly extended services to all 77 provinces in the country.[42] AIS 5G operates in the 700 MHz, 2600 MHz, and 26 GHz bands.[43]

Projected Growth of 5G Global Connections

Figure 1 illustrates the projected growth of 5G global connections[b] from 2021 through 2030 based on data from GSMA, divided by Combatant Command.[c]

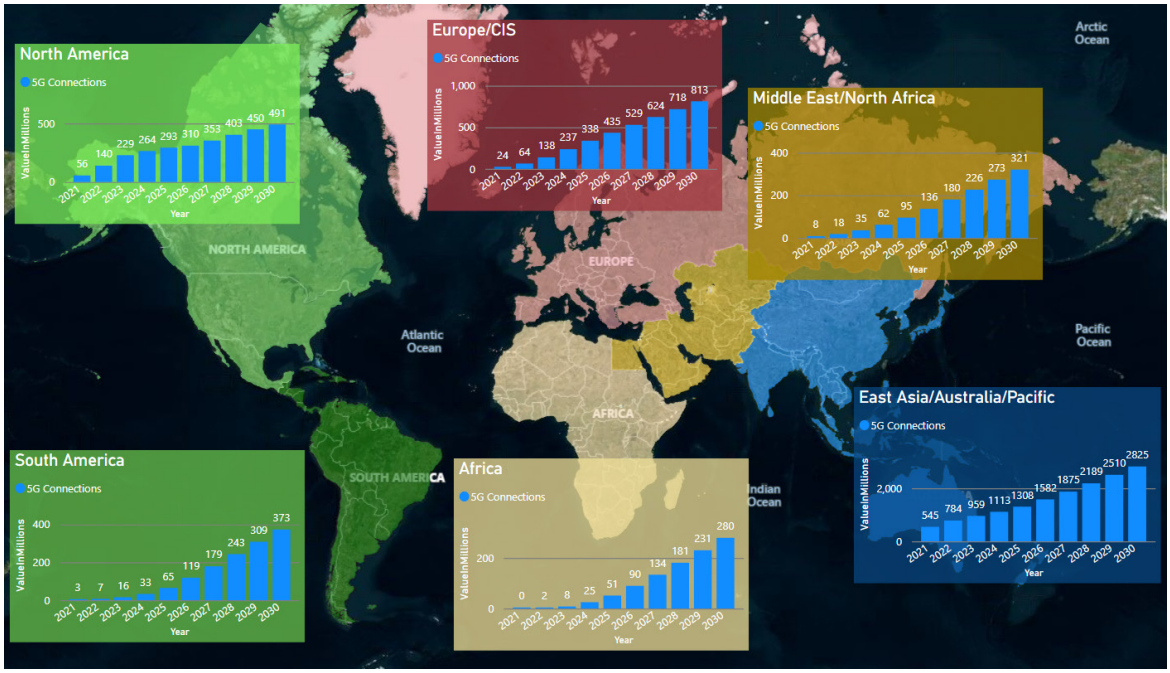

Figure 1: *Growth Projections for Global 5G Connections (GSMA)*

[b] Each connection is defined as being associated with a unique SIM. Note also that the statistics for connections include estimates for devices that use multiple SIMs.

[c] This graphic will be updated periodically to reflect any significant changes in trend projections.

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