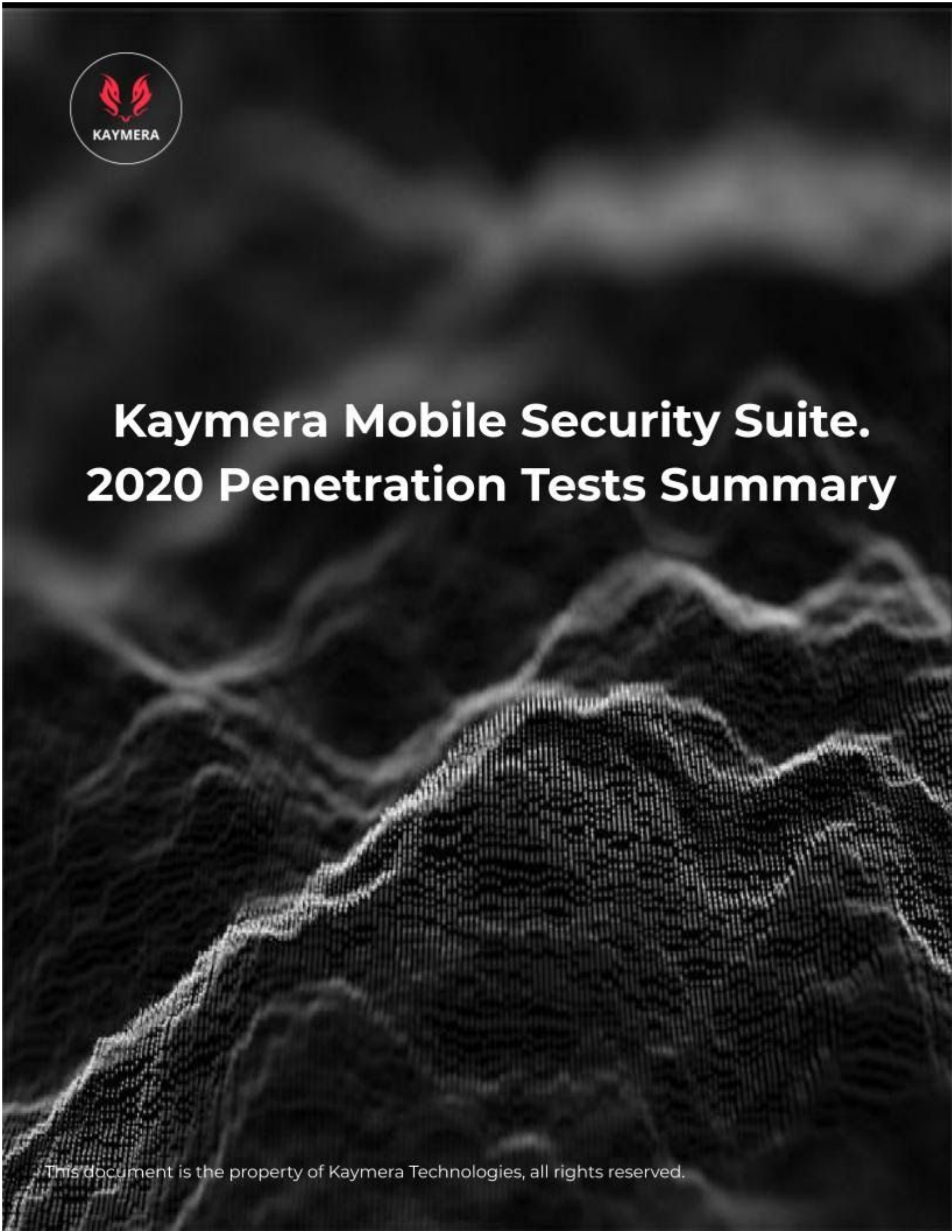


Kaymera Mobile Security Suite. 2020 Penetration Tests Summary

Table of Contents

Reference Context & Objectives

Objective of this initiative is to perform a security assessment of Kaymera Mobile Security Solution to verify the security baseline of supporting infrastructure and identify targeted security mitigations both on mobile devices and infrastructure.

The **aim** of this document is to describe activities performed during multiple penetration tests by different organizations, and design possible mitigations to implement to improve the security level of Kaymera Solution.

Executive Summary

The assessment activity was using the following modes:

- Penetration Test from Internet on Kaymera infrastructure
- Penetration Test on mobile device
- Penetration Test from Tester's network on Kaymera infrastructure
- App Installation & Execution Analysis

Efforts were placed on the identification and exploitation of security weaknesses that could allow a remote attacker to gain unauthorized access to organizational data.
No faults were found with network devices or configuration, and host operating systems and services were found to be well patched and configured. There were no vulnerabilities found that could be rated as critical.
The activity was divided in different phases:

- **Cyber Threat Landscape**: Analysis of the solution, hardware and software specs, features, input/output communications. This activity led to identification of Point of Attacks for target solution.
- **Penetration Test from Client's network on Kaymera infrastructure:** Evaluation of security exposure on infrastructure from Intranet.
- **Penetration Test on mobile device**: Evaluation of security exposure on Kaymera device.
- **Penetration Test from Internet on Kaymera infrastructure**: Evaluation of security exposure on infrastructure from Internet.
- **App Installation & Execution Analysis:** Identification of methodology to bypass whitelist/blacklist measures to install malicious apps.
- **Remediation Plan:** Definition of a Remediation Plan to address possible mitigations identified during the analysis

Cyber Threat Landscape Analysis

Cyber Threat Landscape analysis was performed on target solution through the following phases:

- **Functional and behavioral analysis:** includes identification and evaluation of hardware and software specs and device features through legit interactions.
- **Physical interaction analysis:** includes identification and evaluation of hardware components to directly or indirectly interact, such as USB ports, serial connectors, debug ports or touch-screen.
- **Communication flows analysis:** includes identification and evaluation of input/output communication flows. Specifically, it includes Wi-Fi, LTE, Bluetooth and NFC. LTE channel analysis was not considered because of legal issues related to the assets required to perform the activity.

Based on obtained information, it has been identified a list of possible Points of Attack which have been leveraged in the attempt to perform a valuable exploit on target solution.

Points of Attack identification

Using the information obtained from previous analysis, the following Points of Attack have been identified:

- **Public Infrastructure:** this Point of Attack does not require any specific pre-requirement, because the infrastructure exposed on the Internet is public by definition.
- **Client's Infrastructure:** this Point of Attack requires the attacker to be inside Client's network.
- **Physical device:** this Point of Attack requires proximity to the mobile device or physical access for the attacker.

From this Points of Attack, a list of activities has been identified to perform an assessment aiming to the identification of the overall level of vulnerability of the target system. Specifically:

- Penetration Test from Internet on Kaymera infrastructure
- Penetration Test on mobile device
- Penetration Test from Client's network on Kaymera infrastructure
- App Installation & Execution Analysis

The following describes the results of specified activities performed in the security assessment.

Penetration Test from Internet on Kaymera infrastructure

The Penetration Test activity from the Internet on Kaymera infrastructure aims to identify exposed services, software versions, unsecure configurations and possible vulnerabilities.

Scope

The activity scope includes the hosts exposed on the Internet by TEST and PRODUCTION environments.

TEST ENVIRONMENT:

- IP 151.XX.XXX.XX (st-Client's-msk-kontroller.Client's.com)
- IP 151.XX.XXX.XX (st-Client's-msk-fs.Client's.com)
- IP 151.XX.XXX.XX (st-Client's-msk-vpn.Client's.com)
- 151.XX.XXX.XX (st-Client's-msk-ts.Client's.com)

PRODUCTION ENVIRONMENT:

- 151.XX.XXX.XX (Client's-msk-kontroller.Client's.com)
- 151.XX.XXX.XX (Client's-msk-fs.Client's.com)
- 151.XX.XXX.XX (Client's-msk-vpn.Client's.com)
- 151.XX.XXX.XX (Client's-msk-ts.Client's.com)

Point of Attack

All the activities were performed from the Internet using a Kali machine with source IP “52.XX.XX.XXX”.

Methodology

The methodology used for Penetration Test from Internet on the infrastructure was structured in the following phases:

1. **Intelligence Gathering**: detect and collect publicly available data related to Client’s asset and individuals.
2. **Service Discovery**: identify services exposed from targets in scope.
3. **Vulnerability Analysis & Exploitation**: identify security issues on targets through direct/indirect interaction; these vulnerabilities were leveraged to execute Proof-of-Concepts of public/ad-hoc exploits which guarantee the repeatability of performed tests.
4. **Post Exploitation**: retrieve information (e.g. password, configurations, details) on compromised systems to be used for future attacks, gain higher privileges (i.e. privilege escalation) or perform lateral movement to attack other systems from exploited ones.

Tools

In the following a non-exhaustive list of the tools used to perform the activity:

- Shodan
- Censys
- Tenable Nessus
- Burp Suite Professional
- Nmap
- TLSSled
- Metasploit Framework
- SipVicious
- Nikto

Intelligence Gathering

The only public information identified for targets in scope are related to the following hosts: 151.XX.XXX.XX (st-Client's-msk-kontroller.Client's.com), 151.XX.XXX.XX (Client's-msk-kontroller.Client's.com). On these hosts, a “nginx” server (TCP/XXX) with untrusted certificate (CA.Client's.com) was detected.

Public Information on 151.XX.XXX.XX

Toggle screen reader support

Find and replace

Find

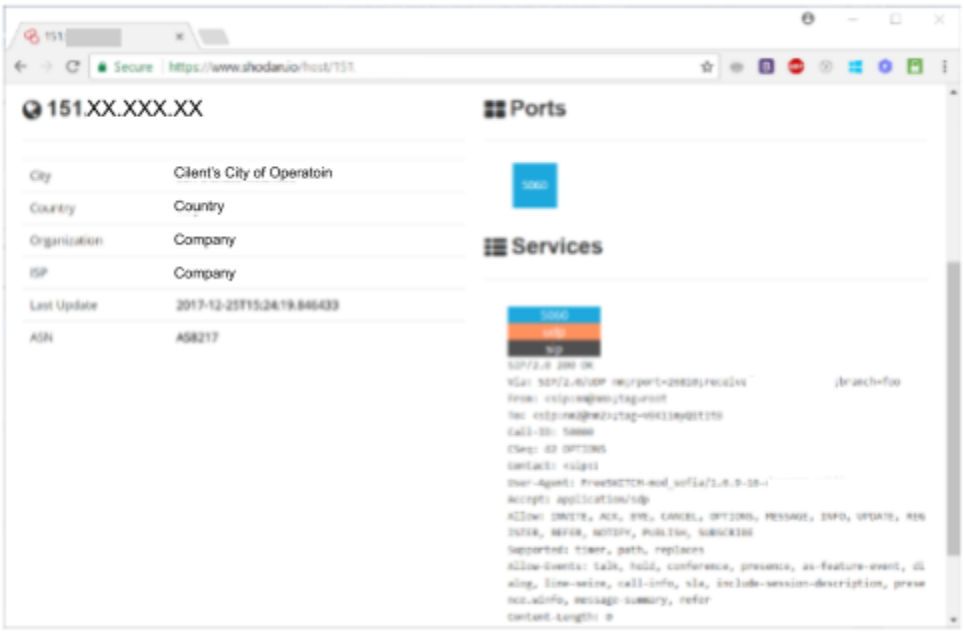
7 of 59

Context:

.Client's.com) an exposed SIP service (udp/XXX) wa

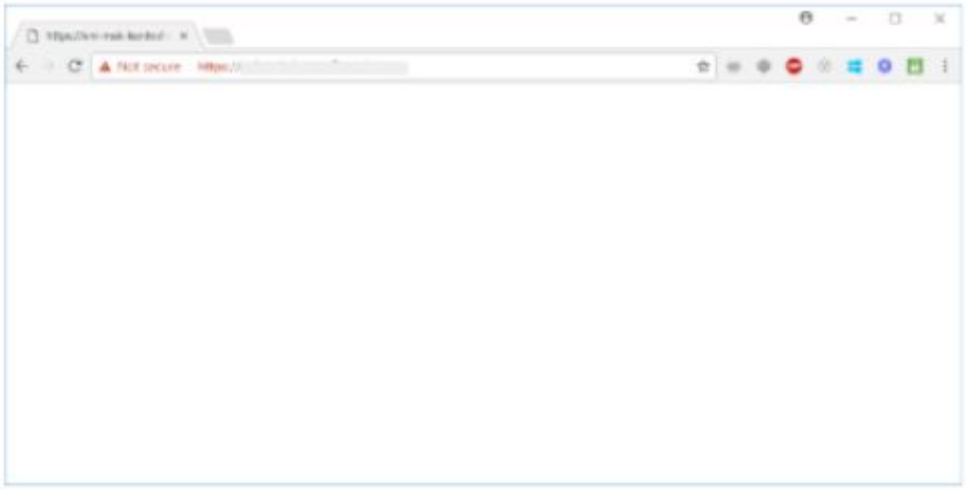
Public Information on 151.XX.XXX.XX

On TEST host 151.XX.XXX.XX (st-Client's-msk-fs.Client's.com) an exposed SIP service (udp/XXX) was also detected. On the other hand, the PRODUCTION counterpart (151.XX.XXX.XX/Client's-msk-fs.Client's.com) does not seem to expose this service.



Public Information on 151.XX.XXX.XX

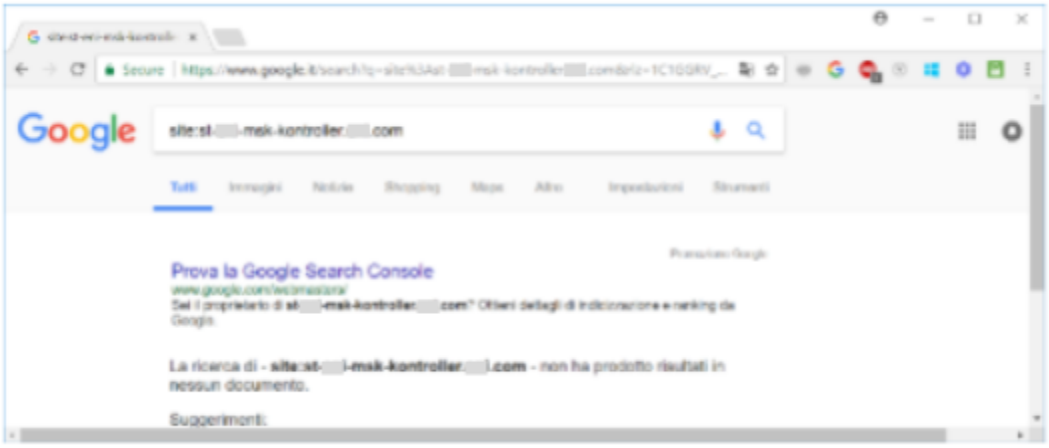
Both using DNS names or IPs, it is not possible to access or browse on web applications exposed from hosts st-Client's-msk-kontroller.Client's.com and Client's-msk-kontroller.Client's.com on port TCP/XXX. Even in this case, the certificate could not be trusted because it was released by an unknown CA (CA.Client's.com).



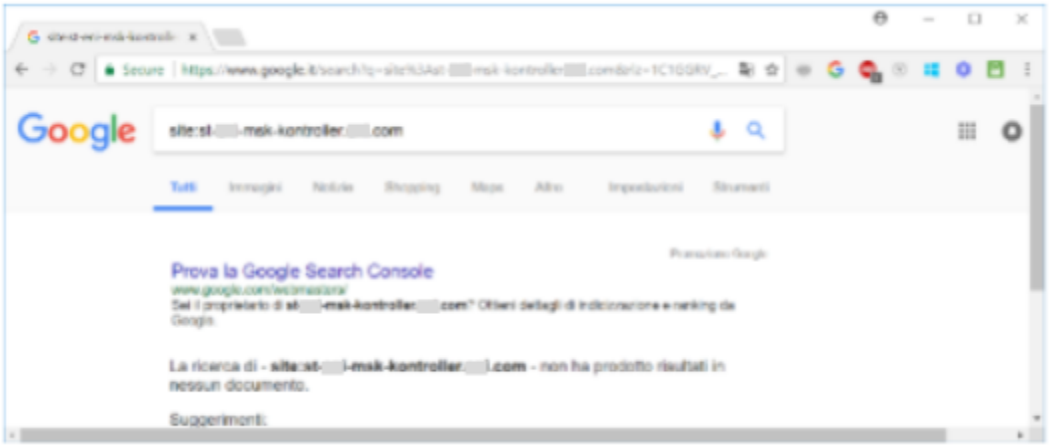
Client's-msk-kontroller.Client's.com Web Application

st-Client's-msk-kontroller.Client's.com Web Application

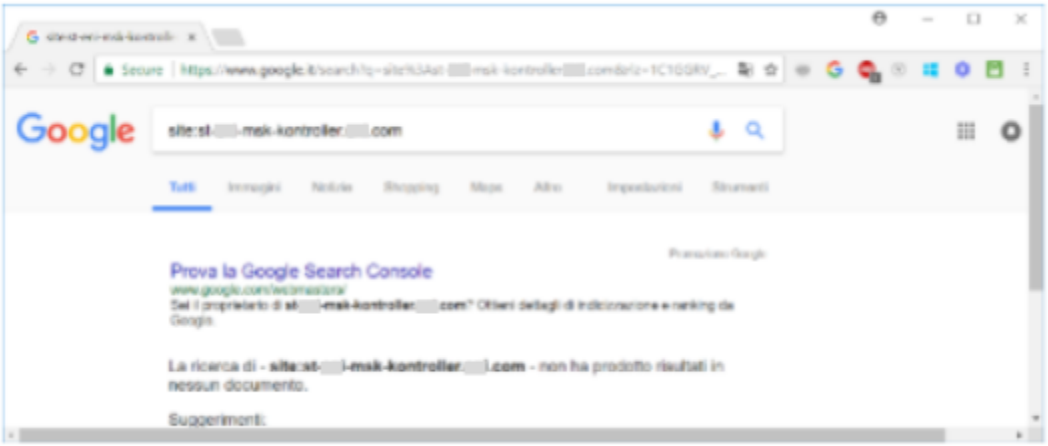
No pages indexed by Google were detected for TEST and PRODUCTION hostnames.



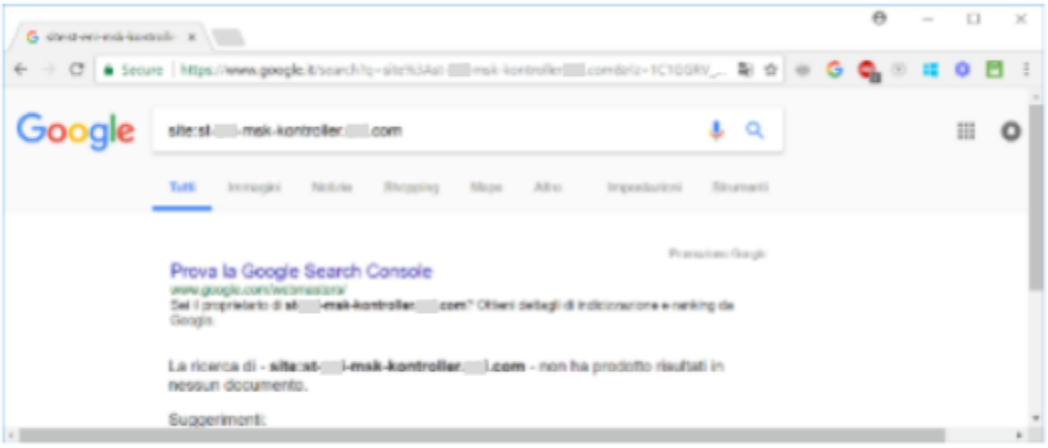
st-Client's-msk-kontroller.Client's.com Google results



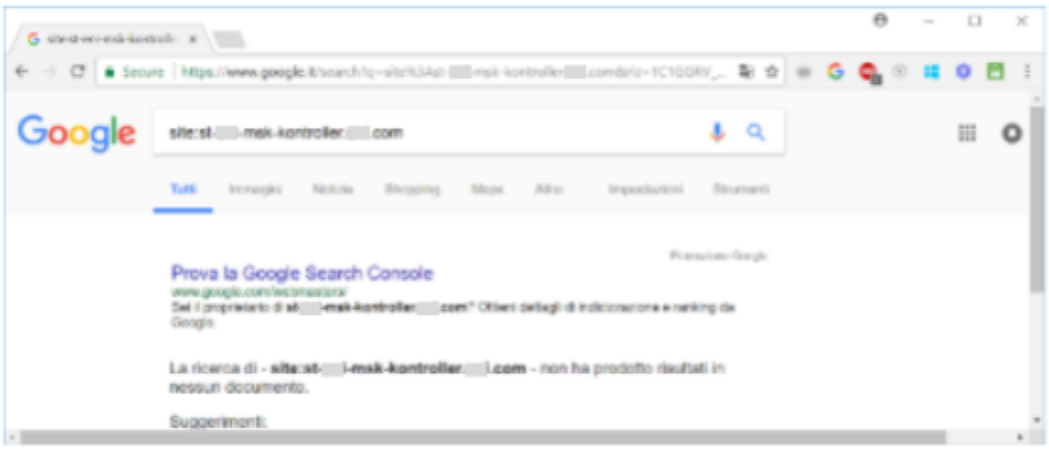
st-Client's-msk-fs.Client's.com Google results



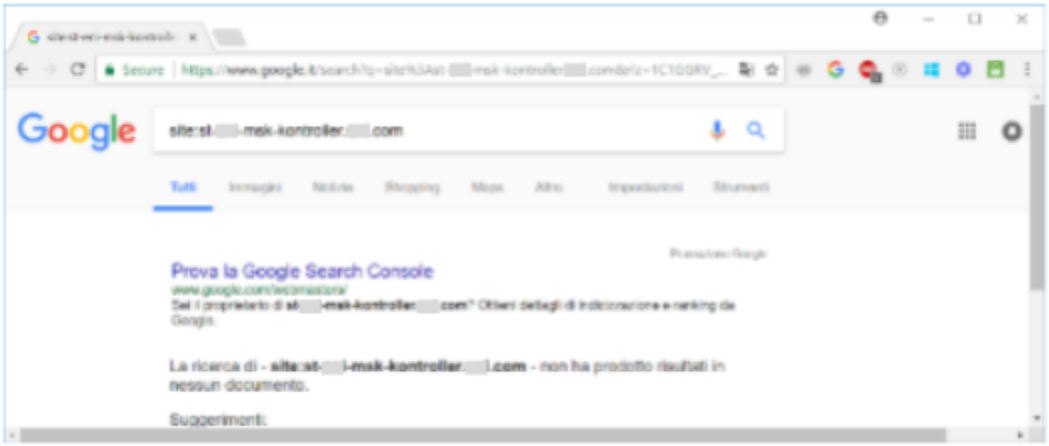
st-Client's-msk-vpn.Client's.com Google results



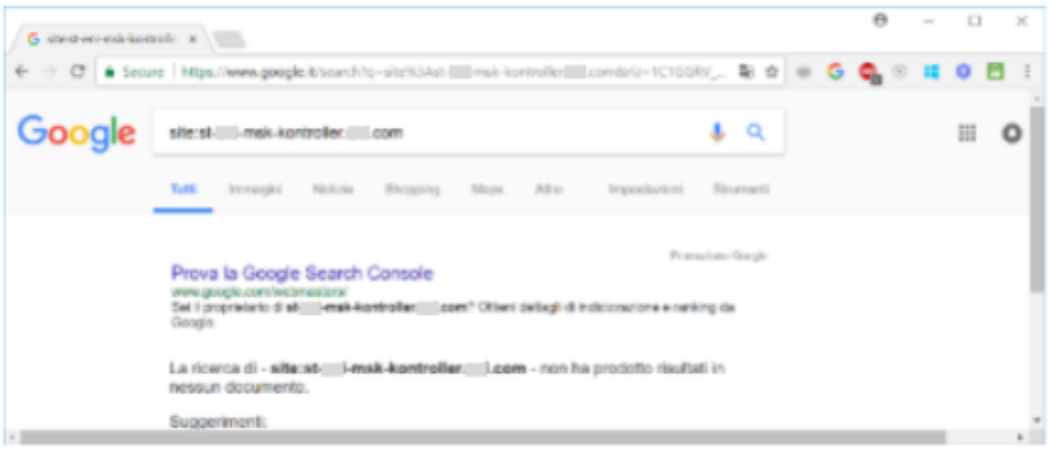
st-Client's-msk-ts.Client's.com Google results



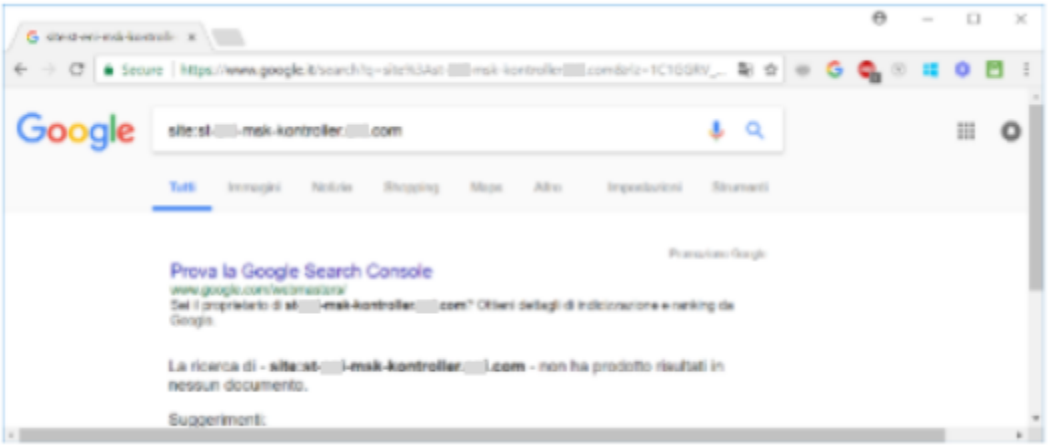
Client's-msk-kontroller.Client's.com Google results



Client's-msk-fs.Client's.com Google results



Client's-msk-vpn.Client's.com Google results



Client's-msk-ts.Client's.com Google results

Service Discovery

Active port analysis on target hosts identified multiple exposed services:

IP/HOSTNAME	PORT	SERVICE
151.XX.XXX.XX/st-Client's-msk-kontroller.Client's.com	TCP/XXX	HTTPS
151.XX.XXX.XX/st-Client's-msk-fs.Client's.com	udp/XXX	SIP
151.XX.XXX.XX/st-Client's-msk-fs.Client's.com	TCP/XXXX	SSL (commonName=st-Client's-msk-fs.Client's.com)
151.XX.XXX.XX/st-Client's-msk-fs.Client's.com	TCP/XXXX	sip-proxy, FreeSWITCH mod_sofia 1.6.9-16-d574870~64bit
151.XX.XXX.XX/st-Client's-msk-fs.Client's.com	TCP/XXXX	SSL (commonName=st-Client's-msk-fs.Client's.com)
151.96.248.53/st-Client's-msk-vpn.Client's.com	TCP/XXXX	OpenVPN
151.XX.XXX.XX/st-Client's-msk-ts.Client's.com	TCP/XXXX	Coturn TURN server
151.XX.XXX.XX/Client's-msk-kontroller.Client's.com	TCP/XXX	HTTPS
151.XX.XXX.XX/Client's-msk-fs.Client's.com	udp/XXX	SIP
151.XX.XXX.XX/Client's-msk-fs.Client's.com	TCP/XXXX	SSL (commonName=Client's-msk-fs.Client's.com)
151.XX.XXX.XX/Client's-msk-fs.Client's.com	TCP/XXXX	sip-proxy, FreeSWITCH mod_sofia 1.6.9-16-d574870~64bit

151.XX.XXX.XX/Client's-msk-fs.Client's.com	TCP/XXXX	SSL (commonName=Client's-msk-fs.Client's.com)
151.XX.XXX.XX/Client's-msk-vpn.Client's.com	TCP/XXXX	OpenVPN
151.XX.XXX.XX/Client's-msk-ts.Client's.com	TCP/XXXX	Coturn TURN server

Table 1: Exposed services from Internet

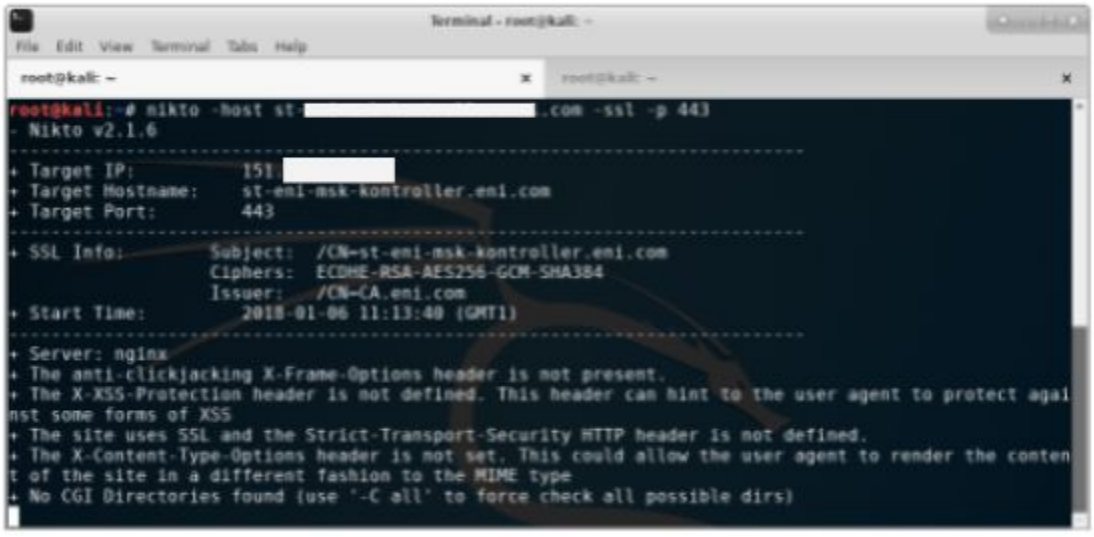
Vulnerability Analysis & Exploitation

Based on exposed services, different types of analysis were performed to identify possible issues, wrong configurations and vulnerabilities.

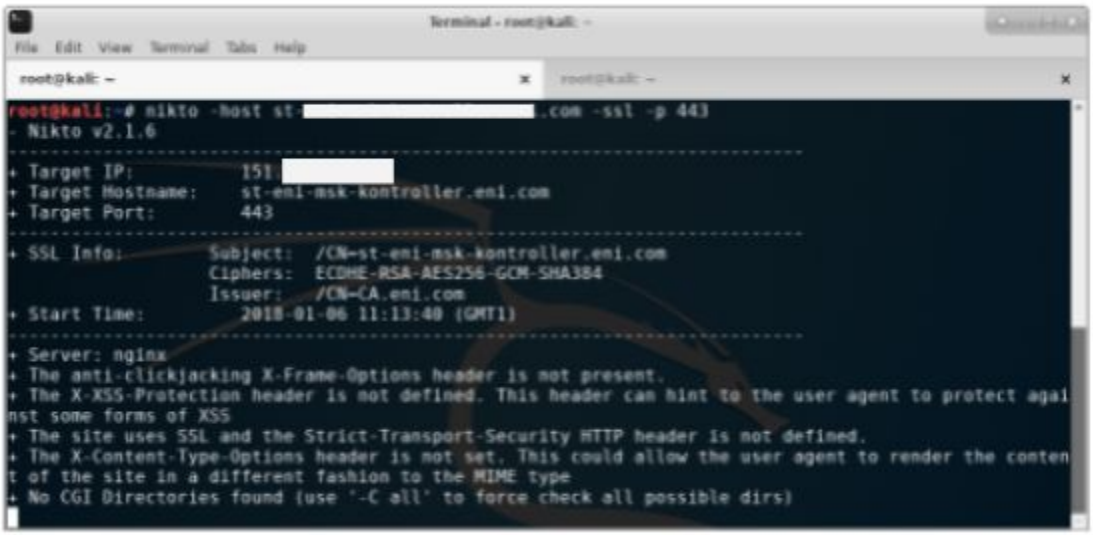
HTTP/HTTPS service attack

Both on TEST (151.XX.XXX.XX/st-Client's-msk-kontroller.Client's.com) and PRODUCTION (151.XX.XXX.XX/Client's-msk-kontroller.Client's.com) environment was detected a “Nginx” web server on port TCP/XXX.

A brute force attack was executed to identify directories, known files and publicly available admin pages. No relevant results have been obtained by the activity.



Web Server analysis on st-Client's-msk-kontroller.Client's.com



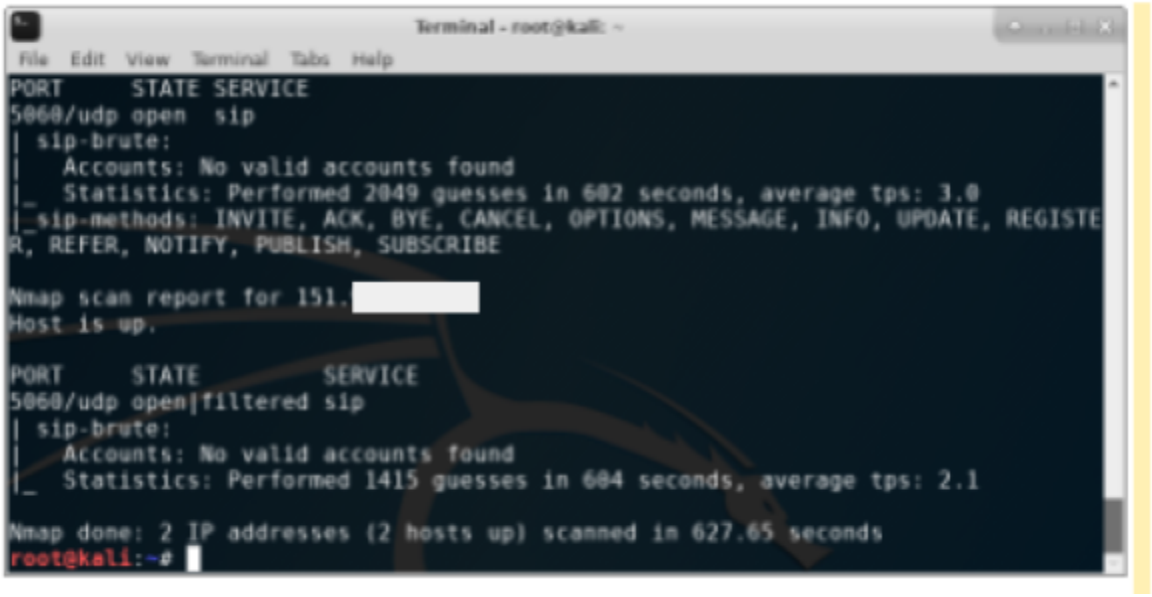
Web Server analysis on Client's-msk-kontroller.Client's.com

SIP service attack

Both on TEST (151.XX.XXX.XX/st-Client's-msk-fs.Client's.com) and PRODUCTION (151.XX.XXX.XX/Client's-msk-fs.Client's.com) environment a SIP server was detected with filtered port udp/XXX. Detected version on the TEST server is “FreeSWITCH mod_sofia 1.6.9-16-d574870~64bit”.

FreeSwitch banner

On both servers, a brute force attack was performed to identify existing SIP users. However no users were retrieved. In addition, on TEST server (151.XX.XXX.XX/st-Client's-msk-fs.Client's.com) the following active methods were detected: INVITE, ACK, BYE, CANCEL, OPTIONS, MESSAGE, INFO, UPDATE, REGISTER, REFER, NOTIFY, PUBLISH e SUBSCRIBE.



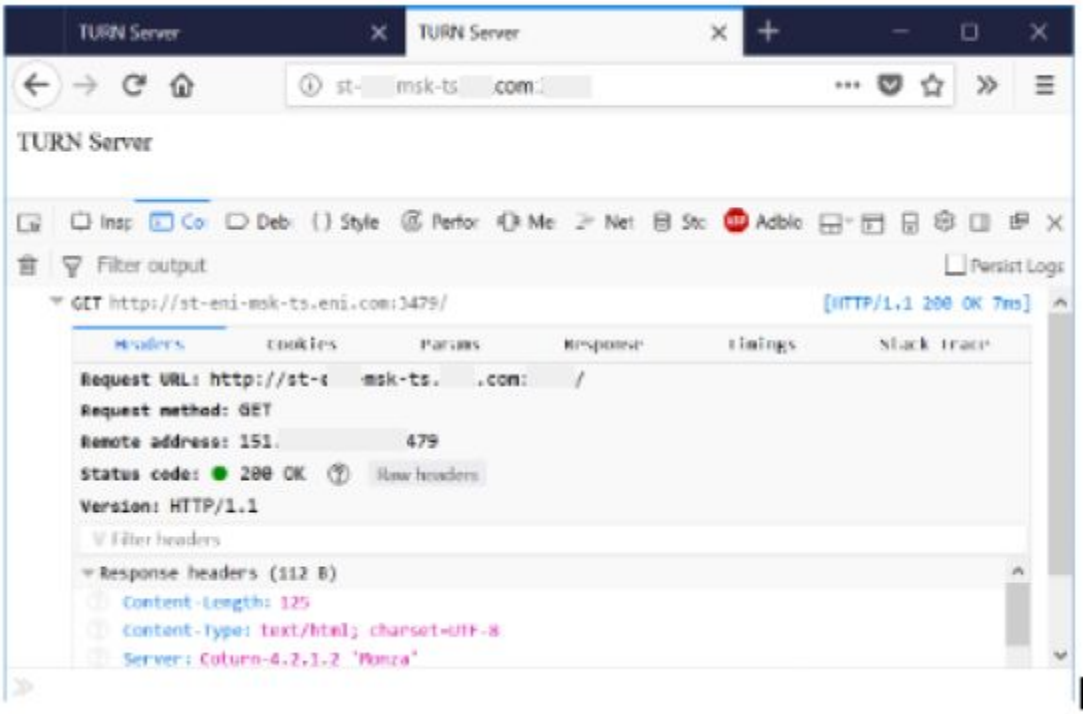
SIP users brute force

TURN service attack

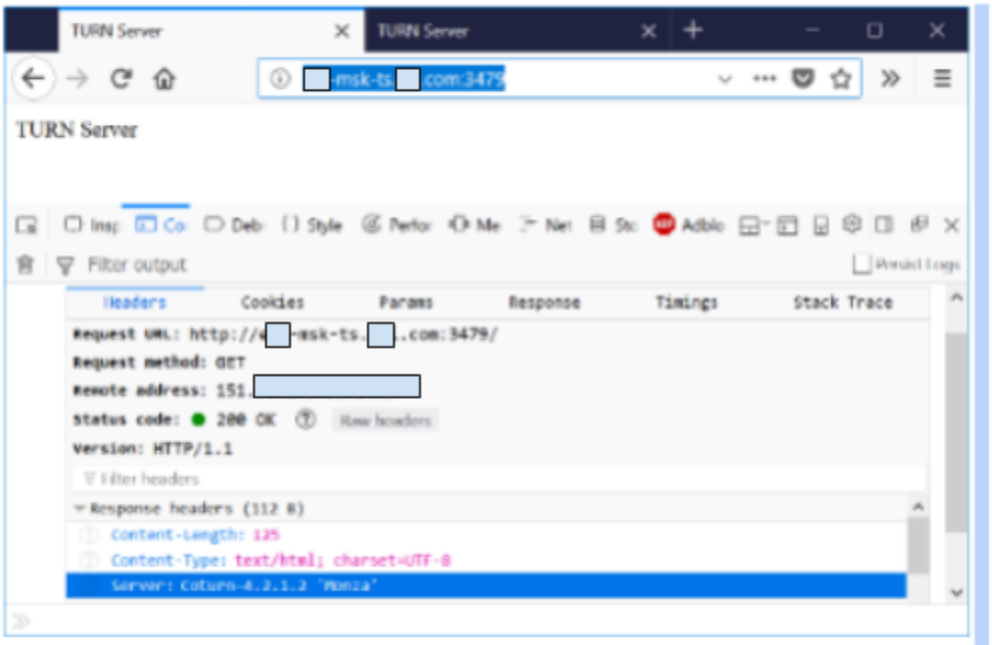
Both on TEST (151.XX.XXX.XX/st-Client's-msk-ts.Client's.com) and PRODUCTION (151.XX.XXX.XX/Client's-msk-ts.Client's.com) environment was detected by a TURN server web application. Detected versioni is “Coturn TURN server 4.X.X.X”.

TURN Server on host 151.XX.XXX.XX/st-Client's-msk-ts.Client's.com

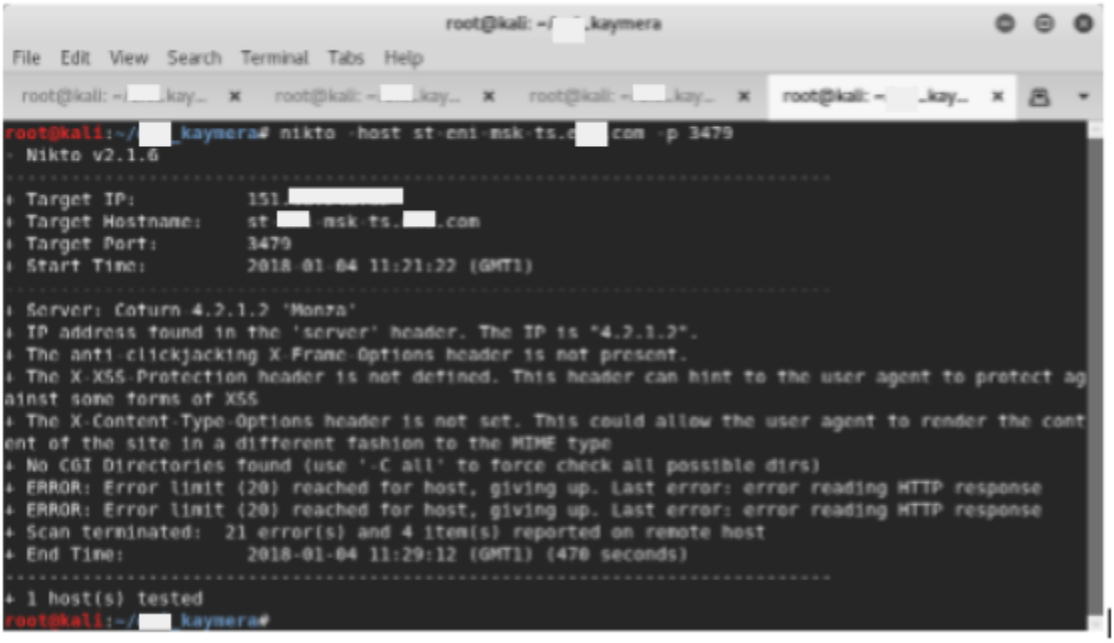
TURN Server on host 151.XX.XXX.XX/Client's-msk-ts.Client's.com



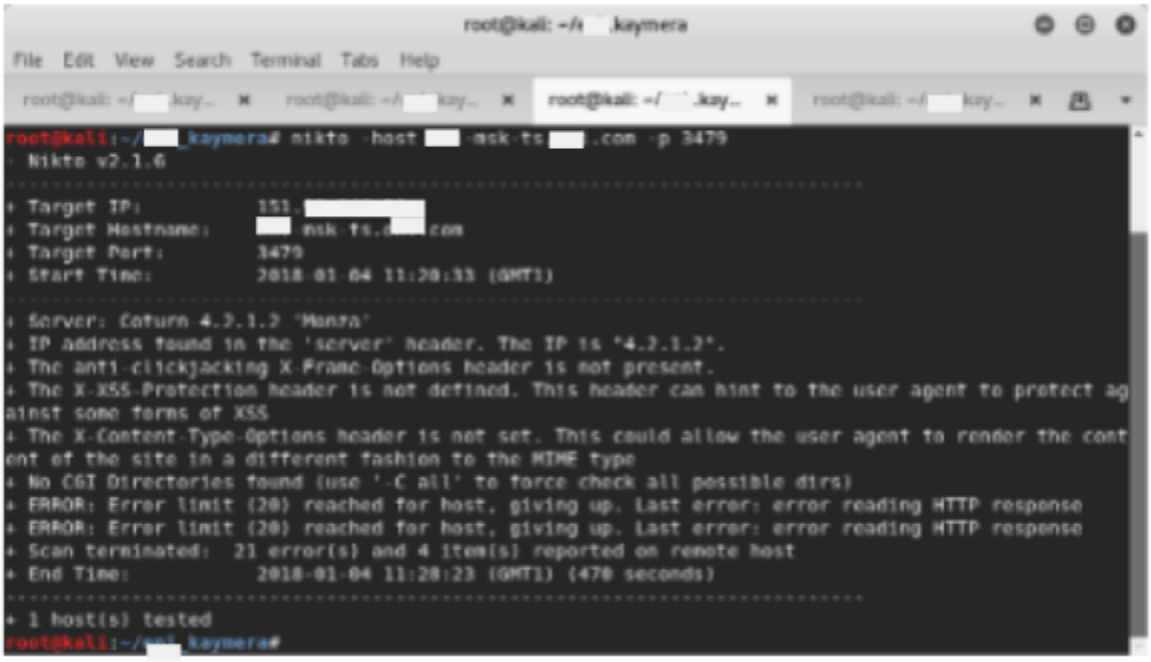
Coturn 4.2.1.2 Banner



Coturn 4.2.1.2 Banner



Info on 151.XX.XXX.XX/st-Client's-msk-ts.Client's.com



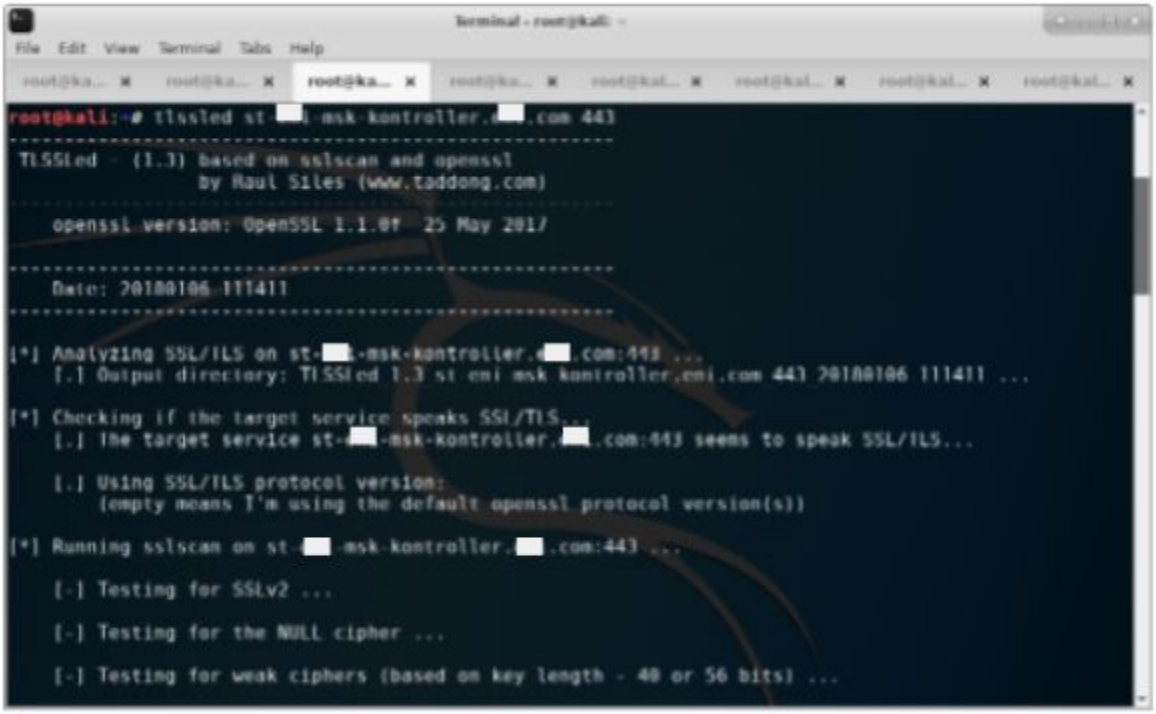
Info on 151.XX.XXX.XX/Client's-msk-ts.Client's.com

During the activities, although multiple test runs have been executed, some significant delay was detected in replies from the server which could have partially invalidated this test.

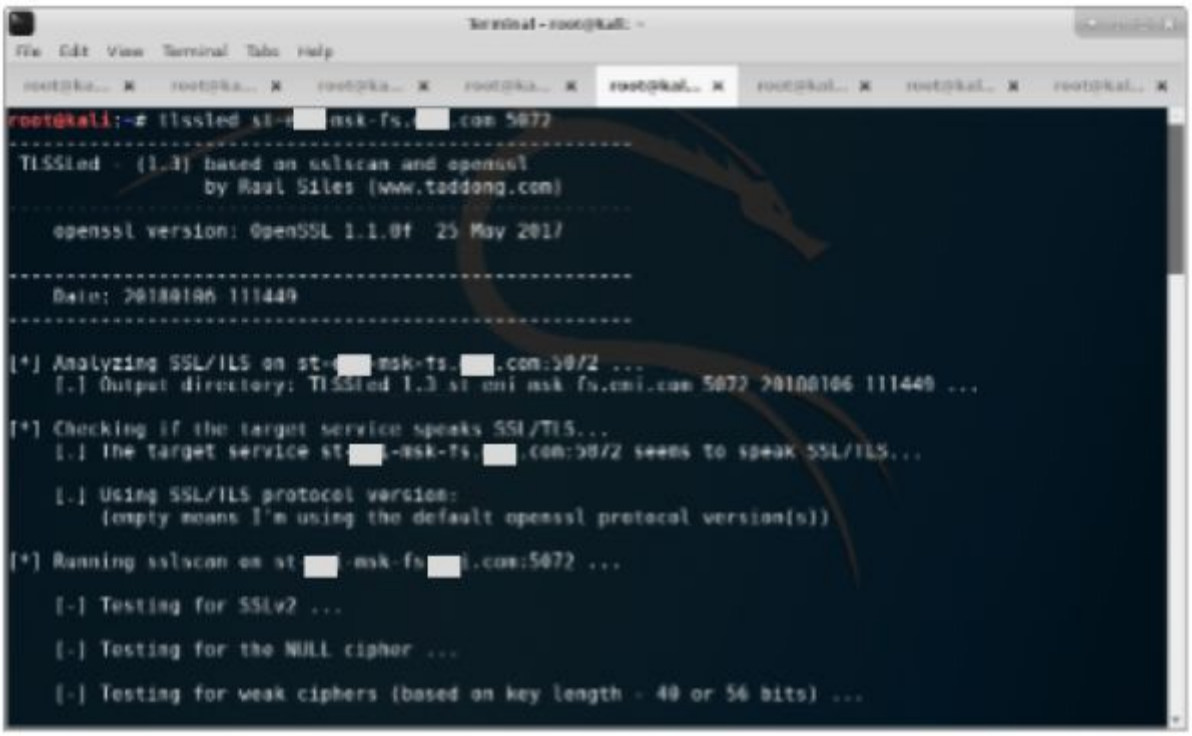
SSL service attack

It was executed a drill-down analysis of SSL services exposed from the following servers: 151.XX.XXX.XX/st-Client's-msk-kontroller.Client's.com (TCP/XXX), 151.XX.XXX.XX/st-Client's-msk-fs.Client's.com (TCP/XXXX, TCP/XXXX), 151.XX.XXX.XX/Client's-msk-kontroller.Client's.com (TCP/XXX), 151.XX.XXX.XX/Client's-msk-fs.Client's.com (TCP/XXXX, TCP/XXXX).

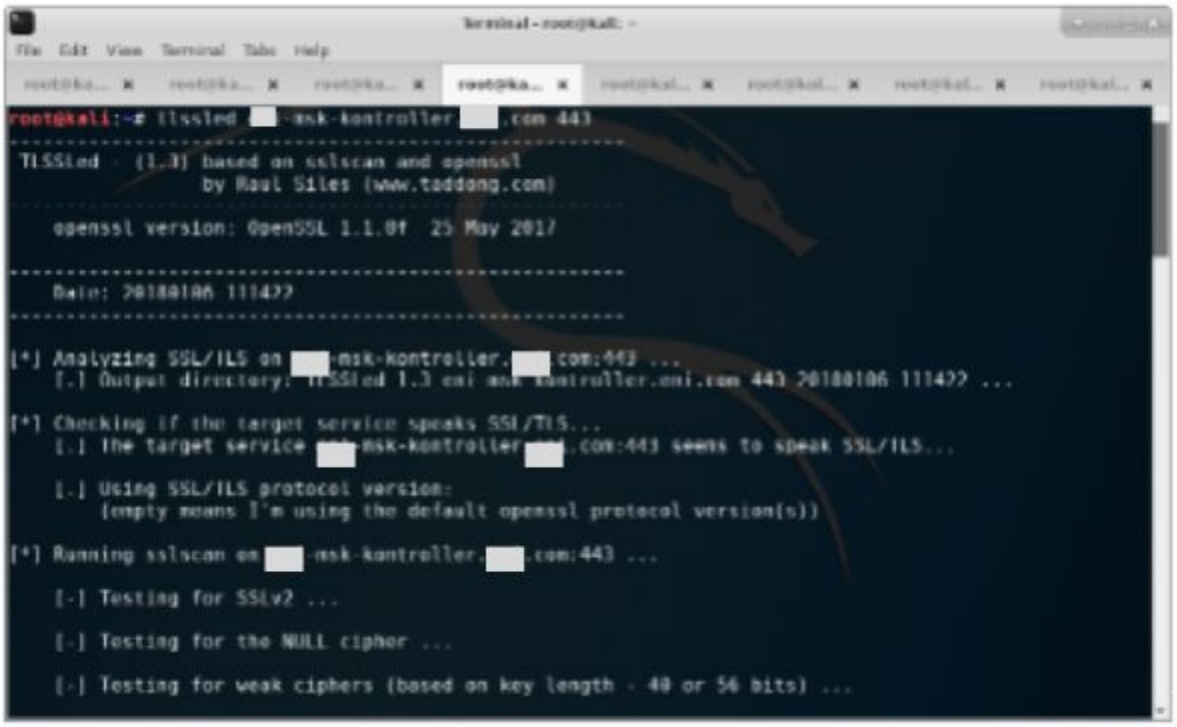
On 151.XX.XXX.XX/st-Client's-msk-kontroller.Client's.com (TCP/XXX), 151.XX.XXX.XX/st-Client's-msk-fs.Client's.com (TCP/XXXX), 151.XX.XXX.XX/Client's-msk-kontroller.Client's.com (TCP/XXX) and 151.XX.XXX.XX/Client's-msk-fs.Client's.com (TCP/XXXX) hosts no unsecure cipher or deprecated hash mechanisms were detected.



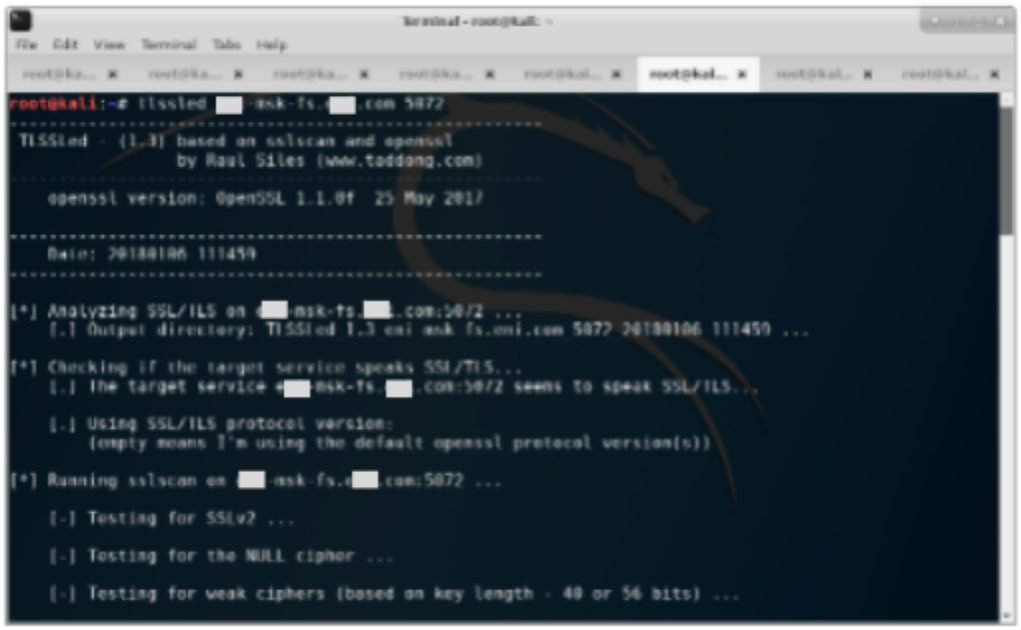
SSL analysis on st-Client's-msk-kontroller.Client's.com (port XXX)



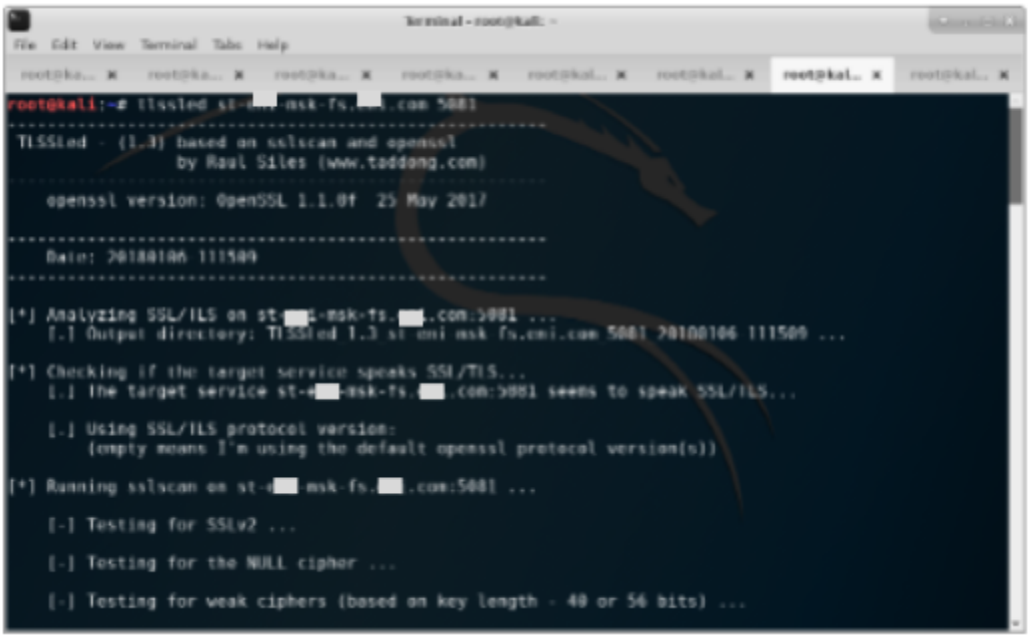
SSL analysis on st-Client's-msk-fs.Client's.com (port XXXX)



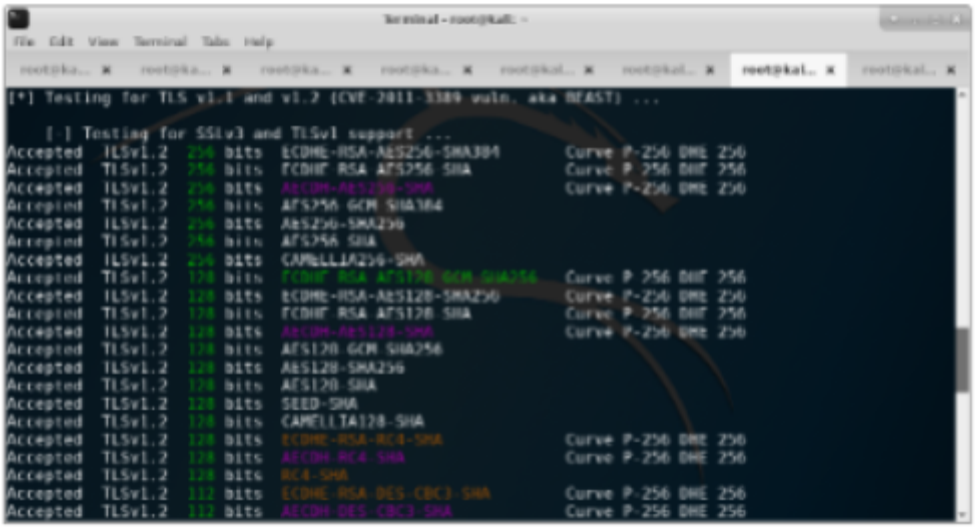
SSL analysis on Client's-msk-kontroller.Client's.com (port XXX)



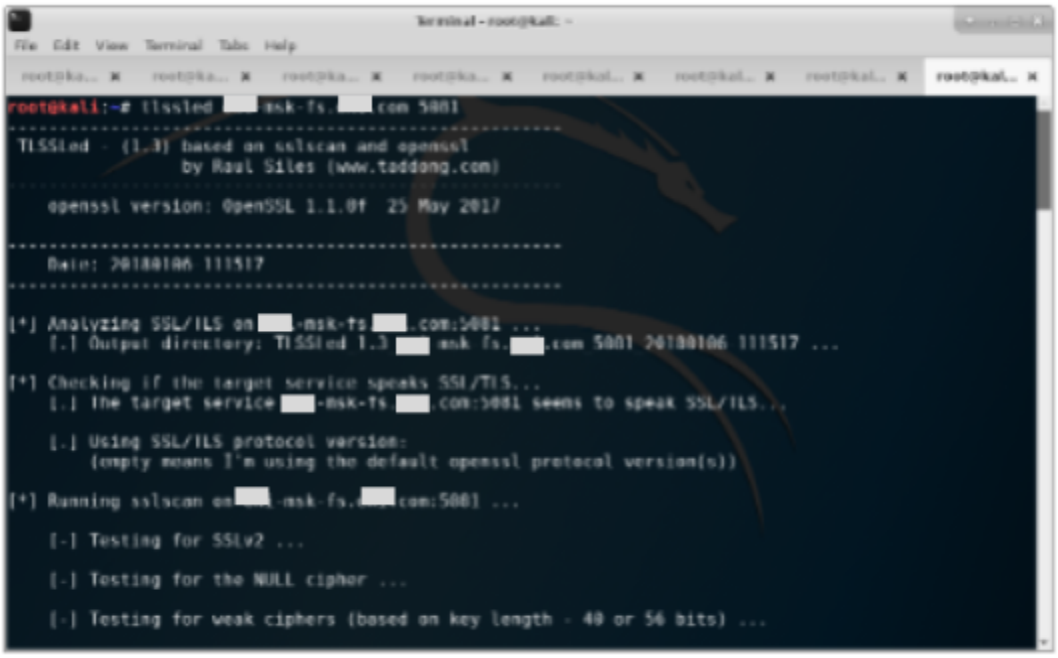
SSL analysis on st-Client's-msk-fs.Client's.com (port XXXX)



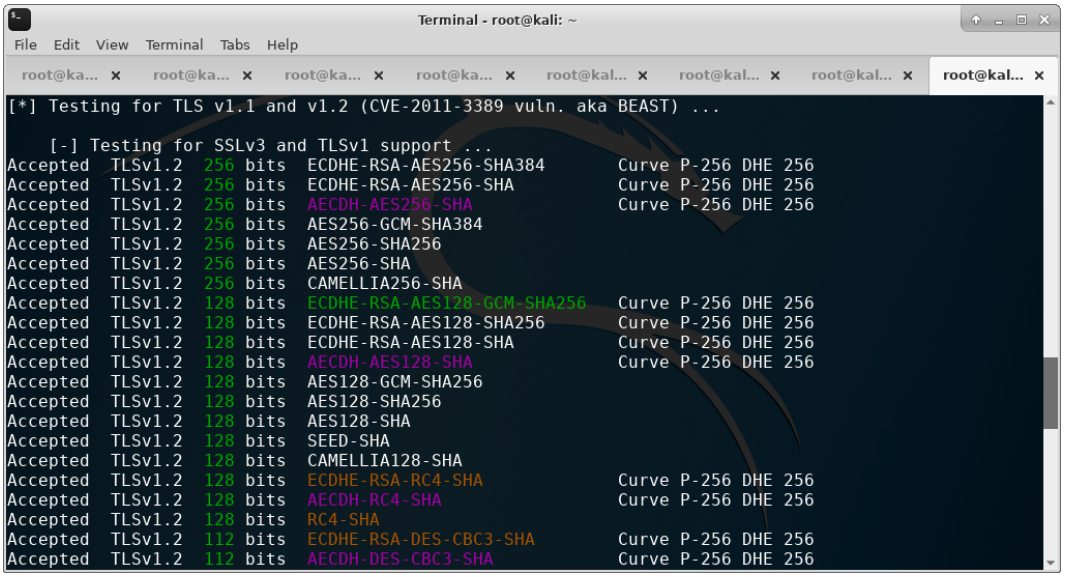
SSL analysis on st-Client's-msk-fs.Client's.com (port XXXX)



Unsecure hash mechanisms supported by st-Client's-msk-fs.Client's.com (port XXXX)



SSL analysis on Client's-msk-fs.Client's.com (port XXXX)



Unsecure hash mechanisms supported by Client's-msk-fs.Client's.com (port XXXX)

Penetration Test on mobile device

Penetration Test activity on mobile devices aims to identify exposed services, used software versions, wrong/unsecure configurations and possible vulnerabilities.

Scope

The activity scope includes the following areas:

- USB
- NFC
- WiFi

Point of Attack

All the activities were performed from 2 Kaymera devices with a supporting Kali Linux machine.

Methodology

Used methodology was divided into different phases:

1. USB analysis
2. NFC analysis
3. Wi-Fi analysis

Support Instruments

In the following a non-exhaustive list of the tools used to perform the activity:

- Tenable Nessus
- Burp Suite Professional
- Nmap
- TLSSled
- WiFi Pineapple
- Metasploit Framework
- SipVicious
- Bettercap
- Nikto
- Hcitool
- Ubertooth One
- ADB

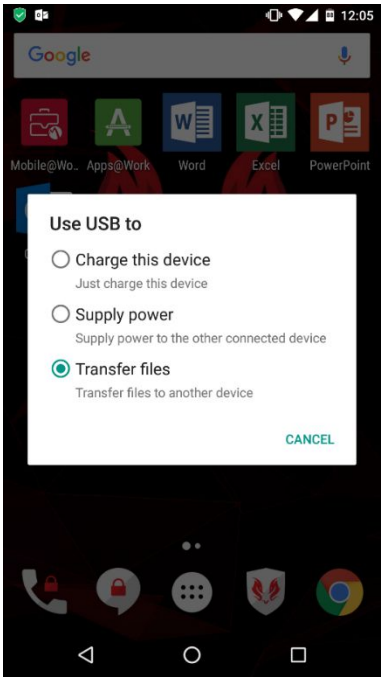
USB analysis

Physical ports analysis led to identification of a single USB type-C. This port can be used for:

- device charging
- power supply
- file transfer

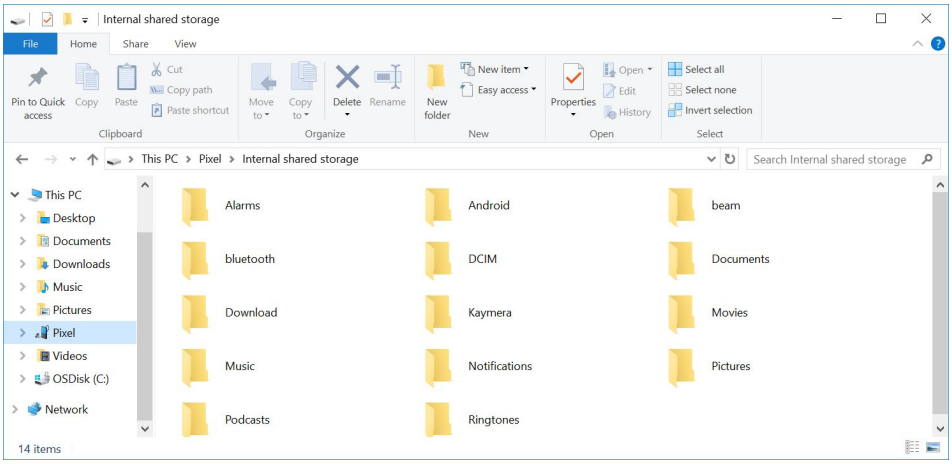
File transfer

File transfer feature is not inhibited, so that an attacker with device physical access could obtain its data after lock-screen bypass.



File transfer

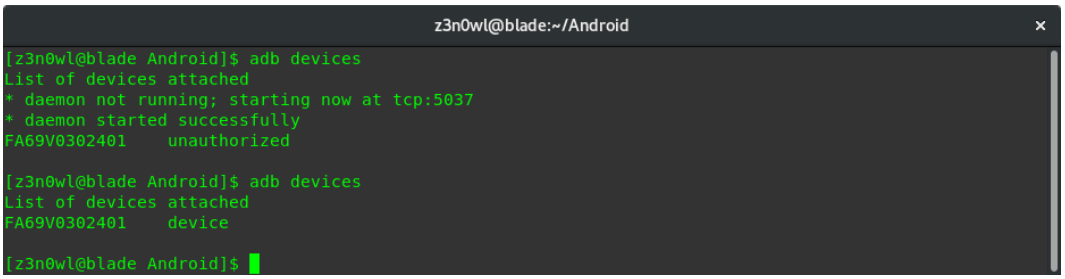
File transfer feature allows mounting and browsing of device memory. In particular, it is possible to transfer screenshots, video or pictures.



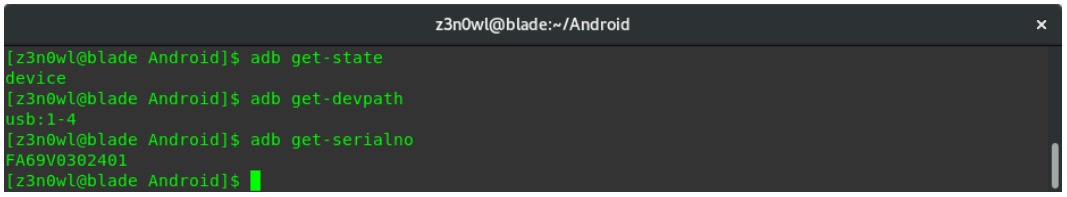
Device memory from external OS

1.1.1 Android Debug Bridge (ADB)

Debug feature is enabled by default as honeypot. At first connection, the device requires the user to grant access to the connected computer.



ADB enabling

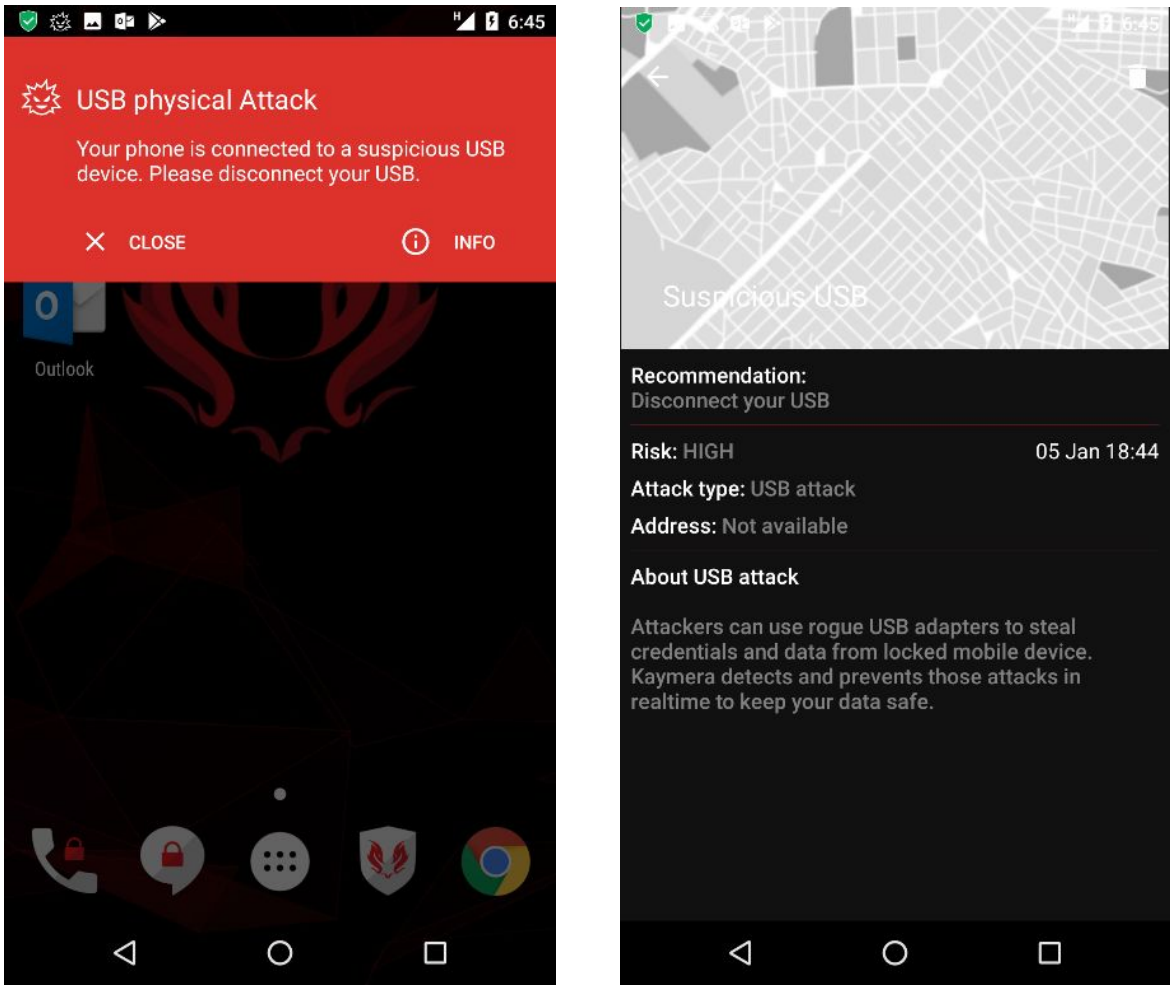


ADB get-* commands

Every attempt to use ADB with not “get-*” commands are intercepted and blocked by the device.

ADB other commands

The device shows a warning pop-up in case of detected unauthorized ADB command.



ADB access detected & blocked

No root/unlock attempt was performed because of this security configuration.

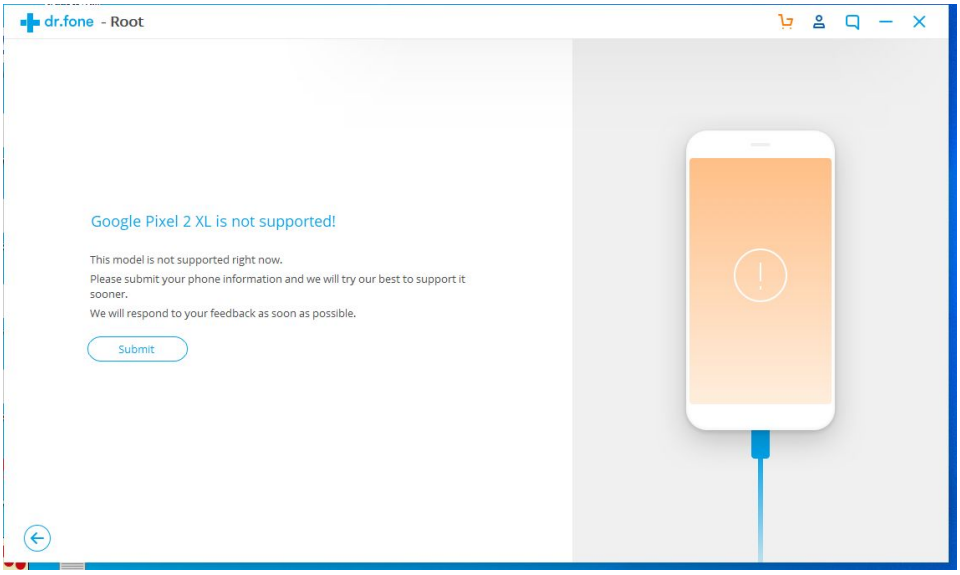
Rooting Procedure Analysis

The rooting process of a device, in this case a customized android OS, is performed taking in consideration the following points:

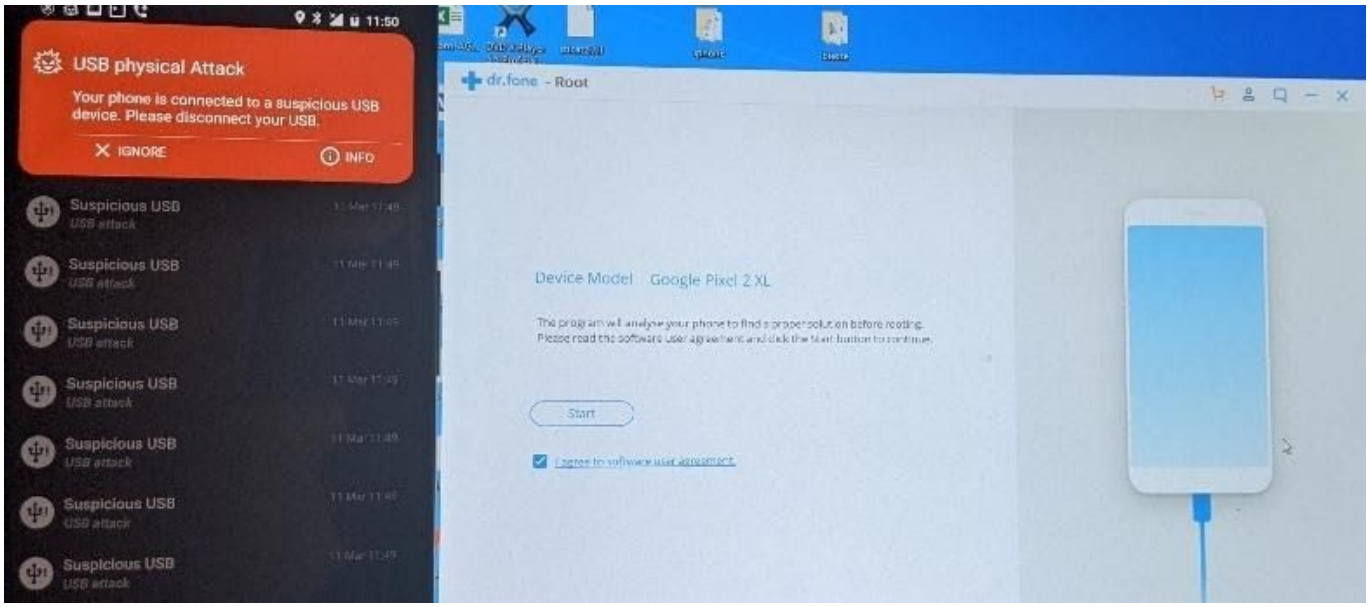
- I/O device's interfaces (WIFI, USB, Bluetooth)
- Camera input interpretation
- Unprotected services
- Android OS internals (vendor's configuration files, setuid scripts, android kernel version)
- Vulnerable installed binaries (toybox, busybox)

The first rooting attempt was performed using the USB data transfer feature. The android version installed in the analyzed device was not supported by the rooting software available in the market.

The following picture shows the result of the rooting attempt using the USB interface:



It is important to highlight that during the rooting attempt, the ***Kaymera Centralized Security Center*** was able to recognize the malicious use of the USB interface, and a warning message was shown as in the following picture.

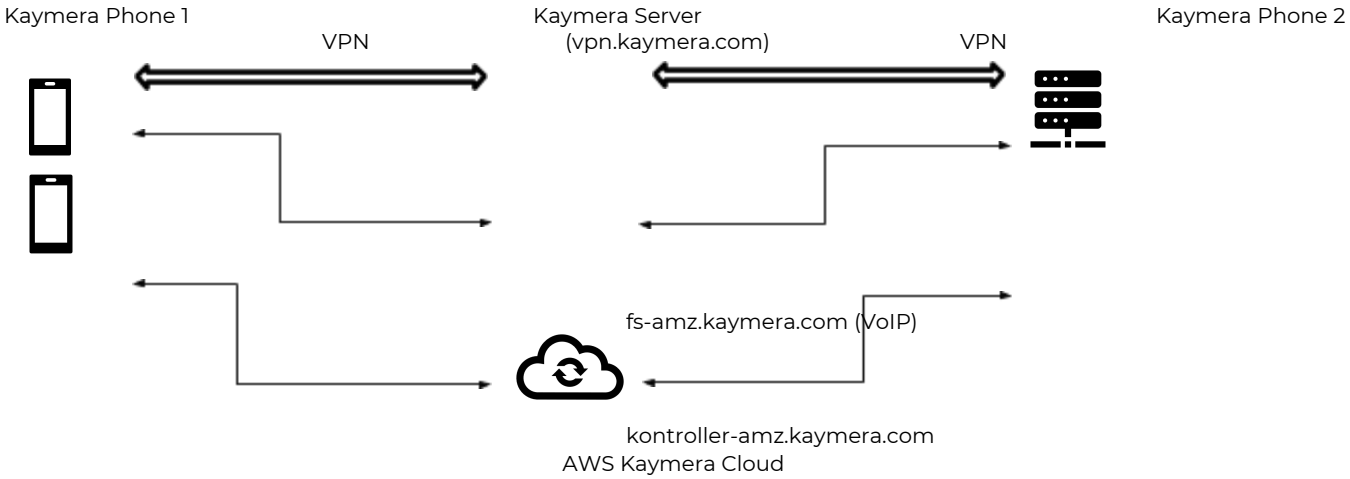


During the test, it was not possible to activate the android developer options which does not allow to perform further rootkitting attempts (recovery mode, or adb packet installation).

Communication Analysis

The architectural solution provided by the vendor includes two calling methods (“Secure Call” and “Semi-Secure Call”) and a cryptographically protected messaging called “Encrypted Conversation”.

Secure Call:



The secure call is established among two kaymera secure phones where applications are installed: **Kaymera Secure Communications App** (call & msg app) and **Kaymera Centralized Security Center** (Management, VPN, IDS, etc). During the test, the traffic generated performing a secure call was captured.

The phone devices (terminal) expose the VOIP service (sip/tls) on port XXXX/tcp. This allows to establish a VoIP connection directly with the phones.

 # netstat -ntap

Active Internet connections (servers and established)

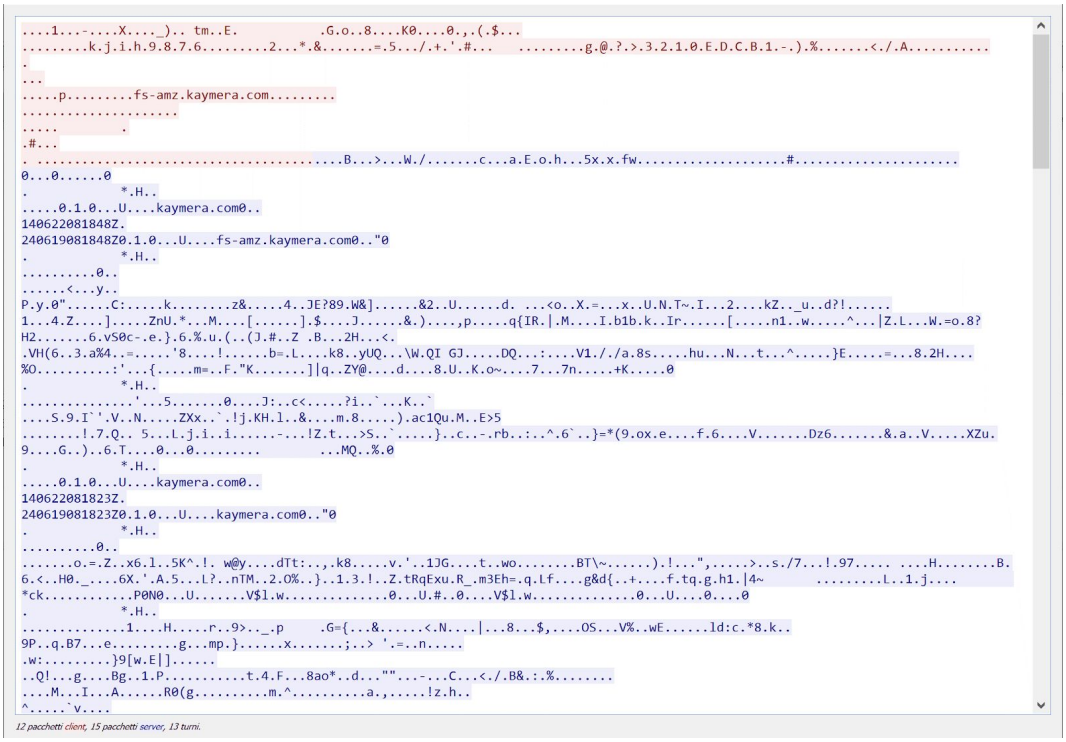
Proto	Recv-Q	Send-Q	Local Address	Foreign Address	State	PID/Program name
tcp	91	0	0.0.0.0:XXXXX	0.0.0.0:*	UNKNOWN(138)	-
tcp	91	0	0.0.0.0:XXXXX	0.0.0.0:*	UNKNOWN(138)	-
tcp	91	0	0.0.0.0:XXXXX	0.0.0.0:*	UNKNOWN(138)	-
tcp	91	0	0.0.0.0:XXXXX	0.0.0.0:*	UNKNOWN(138)	-
tcp	92	0	0.0.0.0:XXXXX	0.0.0.0:*	UNKNOWN(138)	-
tcp	91	0	0.0.0.0:XXXXX	0.0.0.0:*	UNKNOWN(138)	-
tcp	0	0	127.0.0.XXXXX	0.0.0.0:*	LISTEN	-
tcp	91	0	0.0.0.0:XXXXX	0.0.0.0:*	UNKNOWN(138)	-
tcp	91	0	0.0.0.0:XXXXX	0.0.0.0:*	UNKNOWN(138)	-
tcp	0	0	**0.0.0.0:**XXXXX	**0.0.0.0:***	**LISTEN**	**-**

The phone terminal, in order to establish the secure call, opens several connections. The stream of such connections is shown below:

Server: Kontroller-amz.kaymera.com
IP: 34.XX.XX.XXX:XXX/tcp (TLS 1.2)

The connection is TLS protected. Therefore, it was not possible to read packets content.

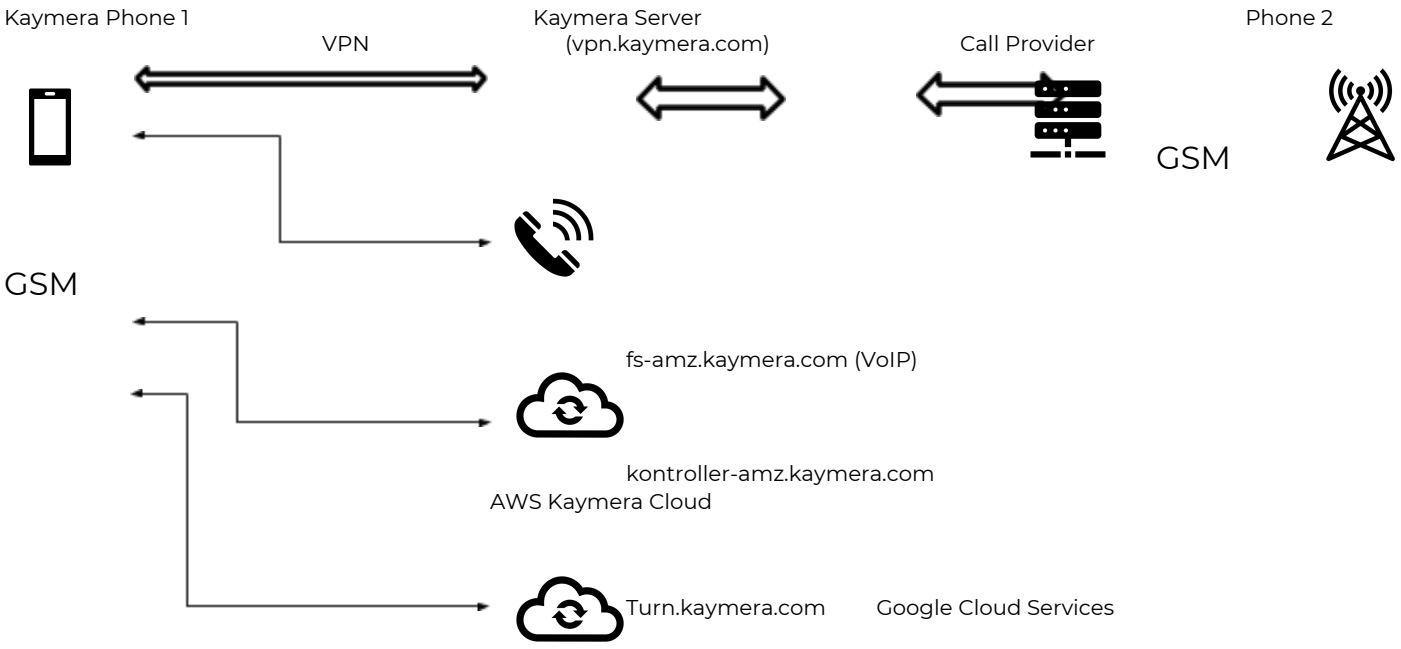
Server: fs-amz.kaymera.com
IP: 104.XXX.XX.XXX:XXXX/tcp (VoIP sip/tls)



Server: vpn.kaymera.com
IP: 35.XXX.XX.XXX:XXXX/udp (VPN)

No other connections were detected during this test.

Semi-Secure Call:

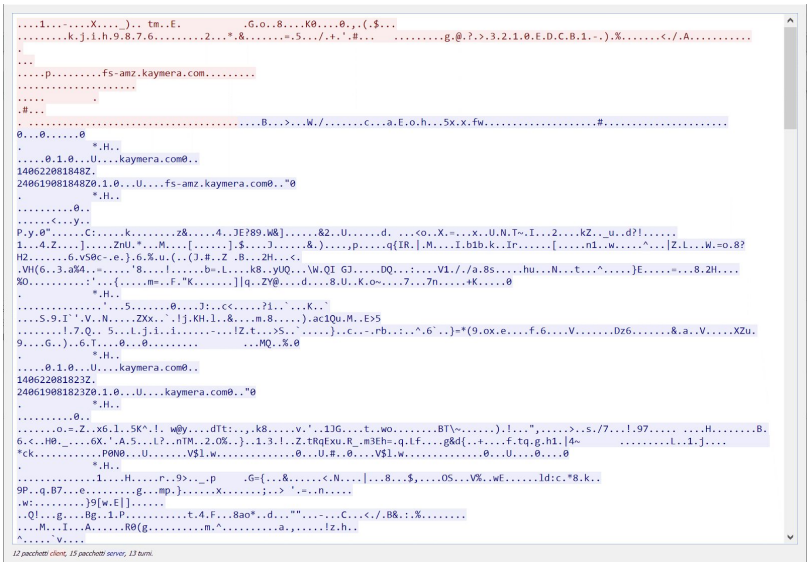


The phone terminal, in order to establish a semi secure call, opens several connections.

Server: kontroller-amz.kaymera.com
IP: 34.XX.XX.XXX:XXX/tcp (TLS 1.2)

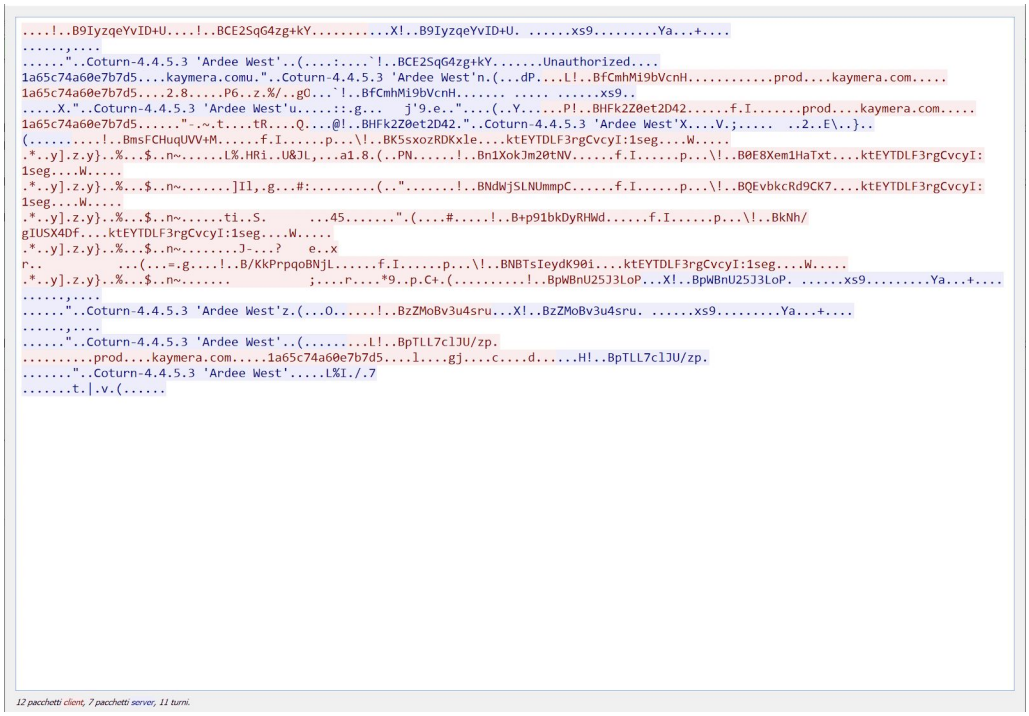
The connection is TLS protected. Therefore, it was not possible to read packets content.

Server: fs-amz.kaymera.com
IP: 104.XXX.XX.XXX:XXXX/tcp (VoIP sip/tls)



Server: vpn.kaymera.com
IP: 35.XXX.XX.XXX:XXXX/udp (VPN)

Server: turn.kaymera.com
IP: 104.XXX.XX.XXX (Traversal using Relay NAT)

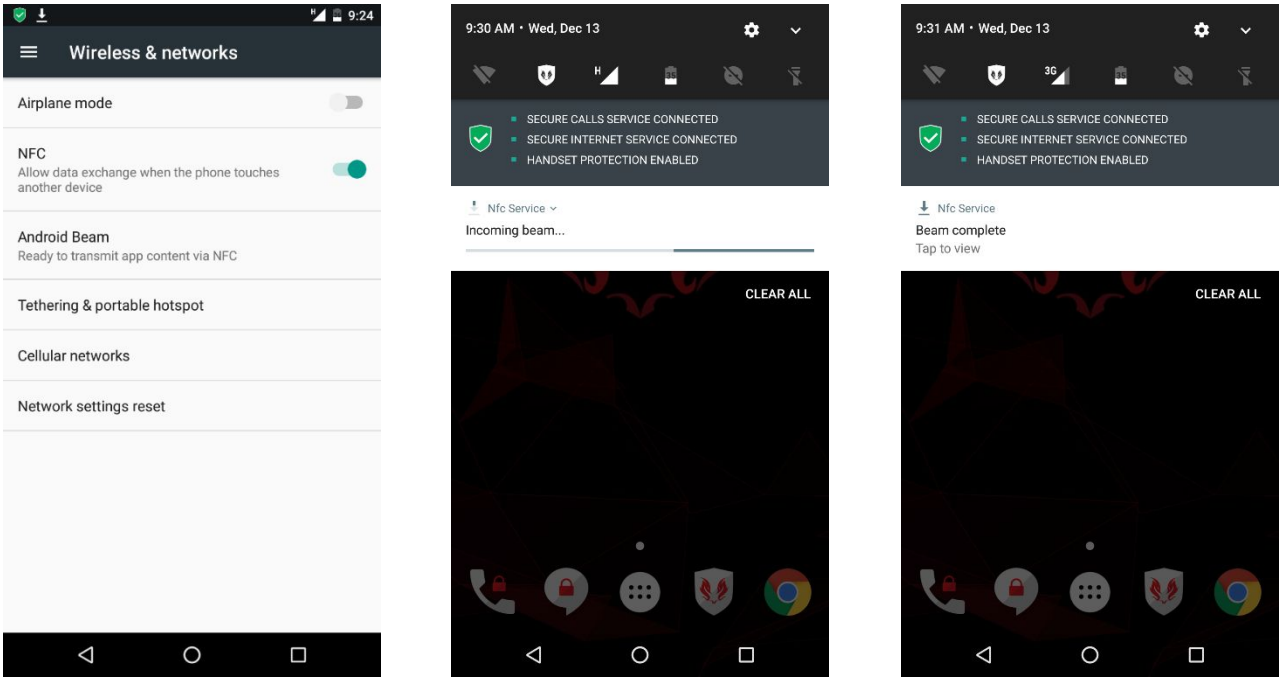


NFC analysis

NFC analysis was executed to understand if the device offers protection from file transfer and offers specific protection countermeasures.

1.1.2 File transfer

File transfer feature is not inhibited, so that data can be moved even between non-Kaymera devices.



File transfer through NFC

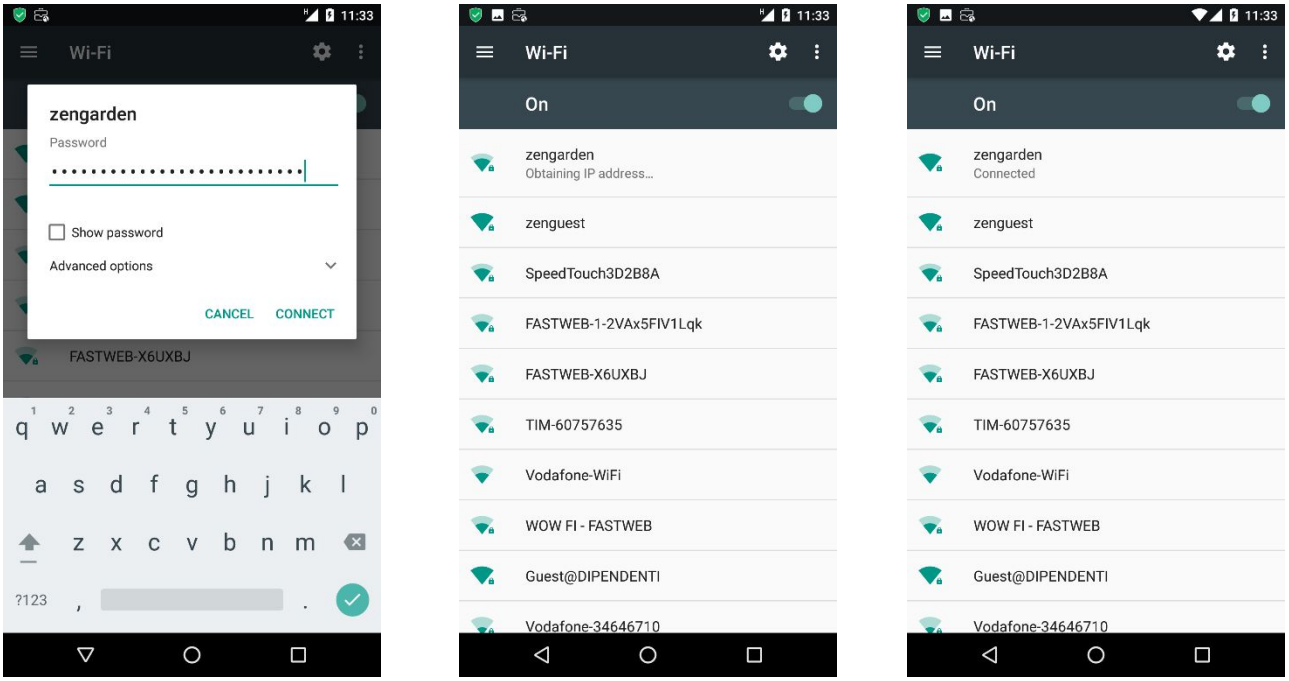
Transferred image through NFC

WiFi analysis

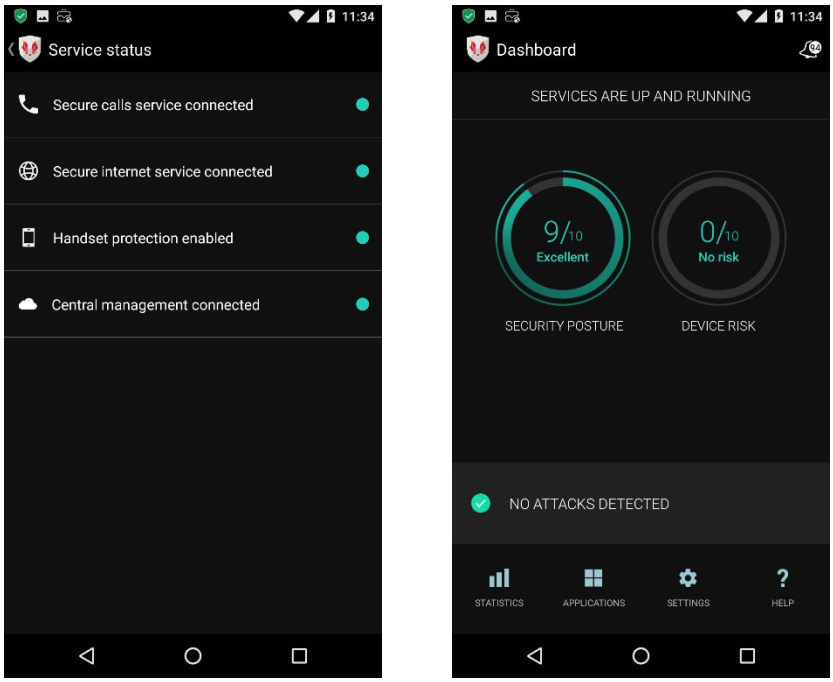
Wi-Fi analysis was made to understand if the device offers protection mechanisms against FakeAP (e.g. RogueAP, Evil Twin) and Man-in-the-Middle attacks. In addition, services exposed by mobile devices were analyzed.

Untrusted AP access

From performed analysis, the device allows connection to a Wi-Fi network with untrusted SSID. Specifically, even connecting to an untrusted AP, the device manages to connect with Central Management and enable Secure Call, Secure Internet and Handset Protection services.



Untrusted network access



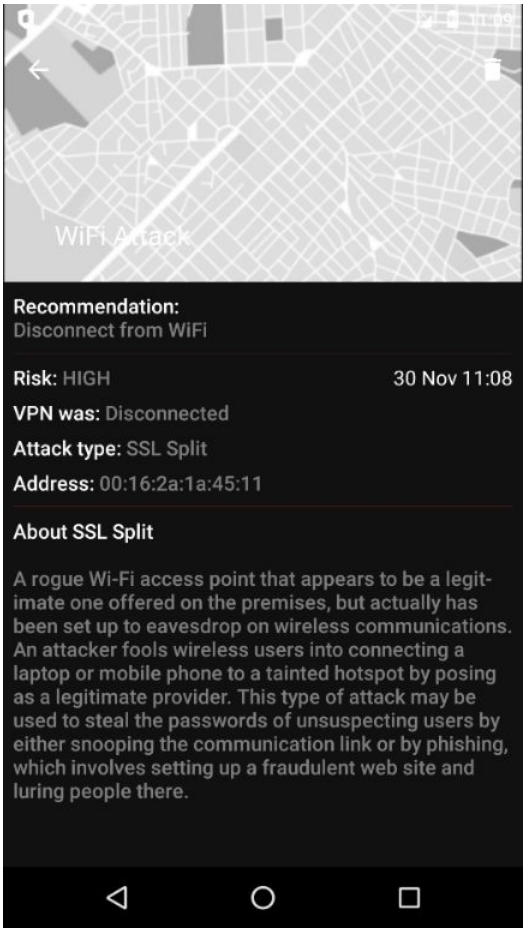
Service enabling on untrusted network

Fake AP

The analysis resulted in the change of impersonating a network already saved on the device. Specifically, pre-configured Wi-Fi SSID (Client's-cert) was cloned on an external AP not owned by Client's and the device correctly connected to it even with a different authentication method – certificate for Client-cert and WPA for cloned AP. Using a Fake AP it is possible to intercept all clear text content transmitted and received from the device without being detected by its own security mechanisms.

Man-in-the-Middle with SSL Splitting

The device is able to detect a MitM attempt only in case of usage of untrusted certificates, needed to perform SSL splitting attack and decode encrypted traffic towards/from legit websites. In case of detection, mobile device automatically disconnect from Wi-Fi networks.



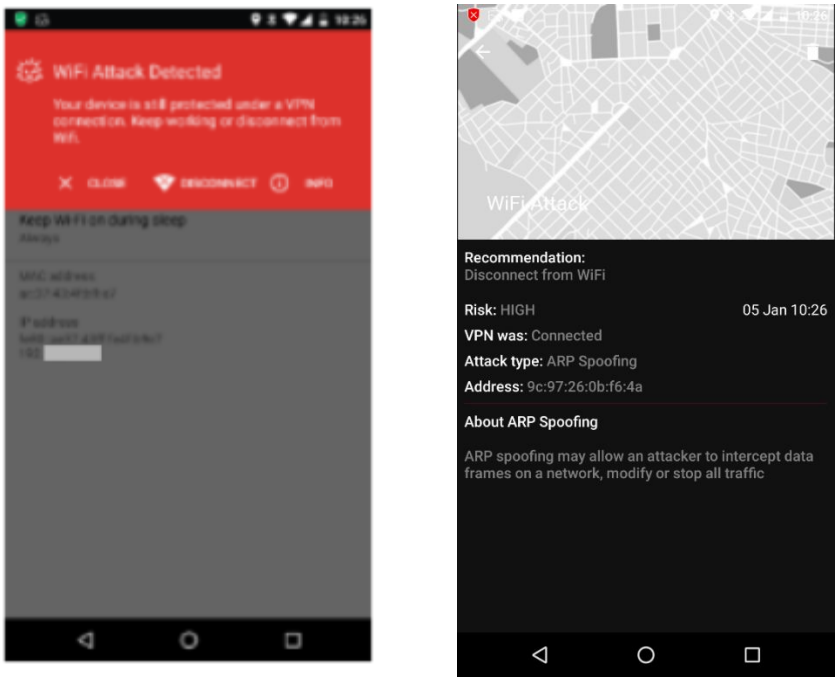
Detected SSL Split

Man-in-the-Middle with ARP Spoofing

It was evaluated as a chance to execute a Man-in-the-Middle attack through ARP Spoofing using a notebook connected to the same device network.

MitM setup

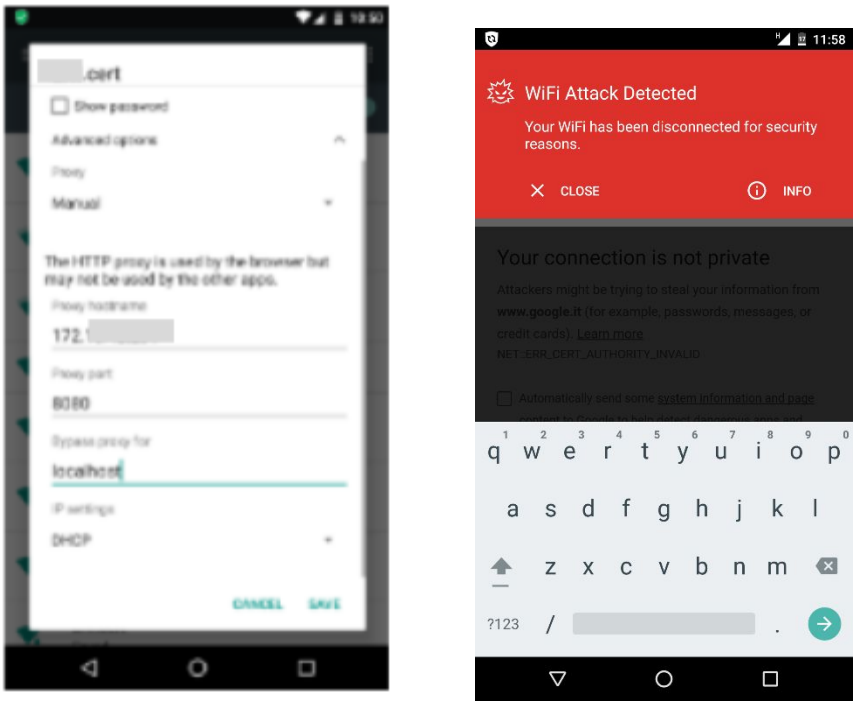
In this case, the device detects the MitM attempt through ARP Spoofing.



ARP Spoofing detection and block

Man-in-the-Middle with Malicious SSL Proxy

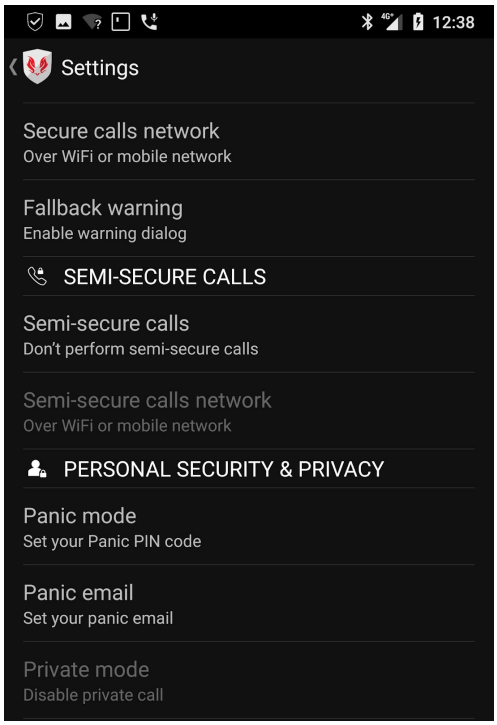
Even installing a Proxy SSL certificate on the device, it is still able to detect a MitM attack, disconnecting it from the Wi-Fi network.

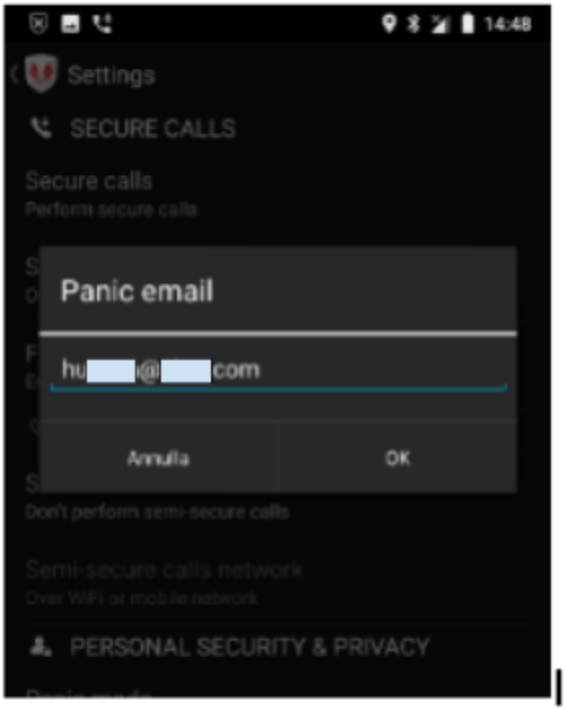


MitM Proxy settings

Panic Mode Analysis

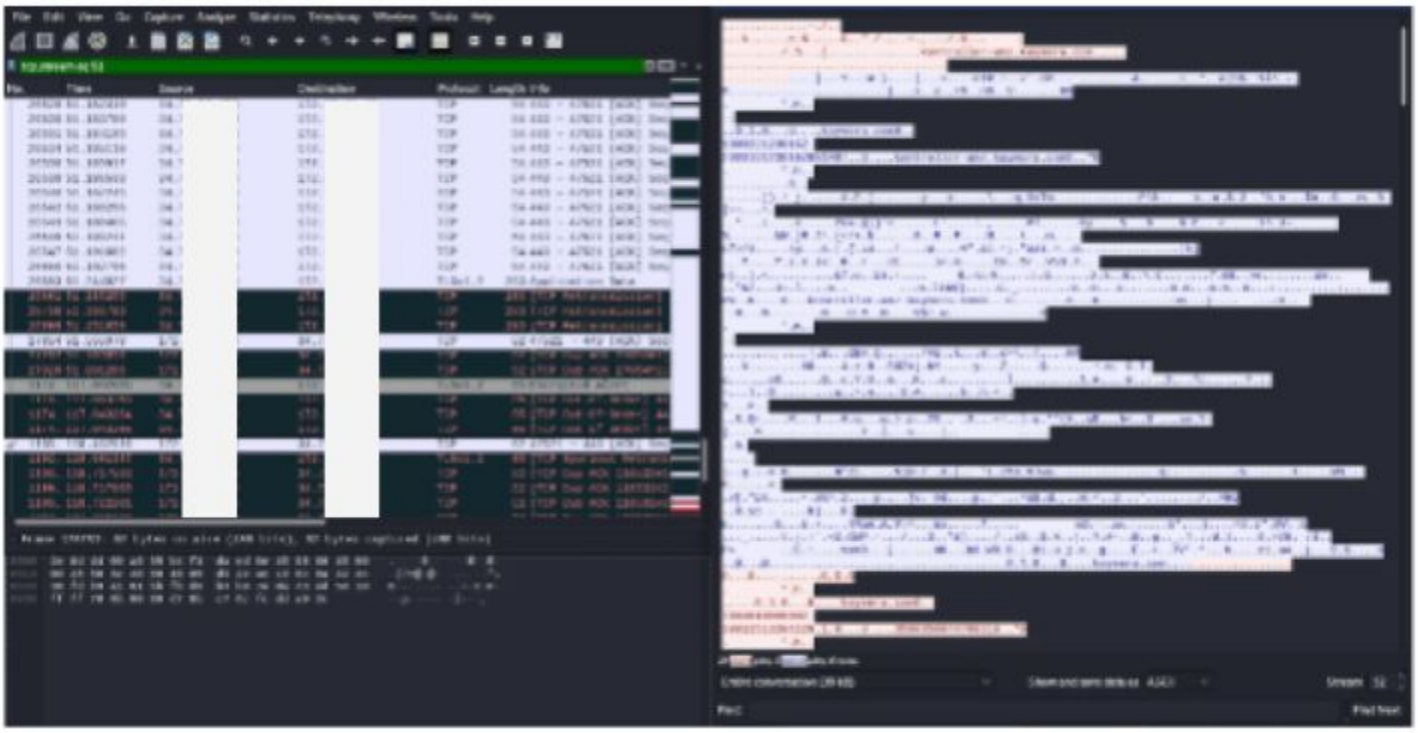
The Kaymera Secure Start Phone has a feature called “Panic Mode” which allows to modify the phone standard environment under attack. Using the Dashboard app (management app) it is possible to configure a Panic device PIN and an email address.



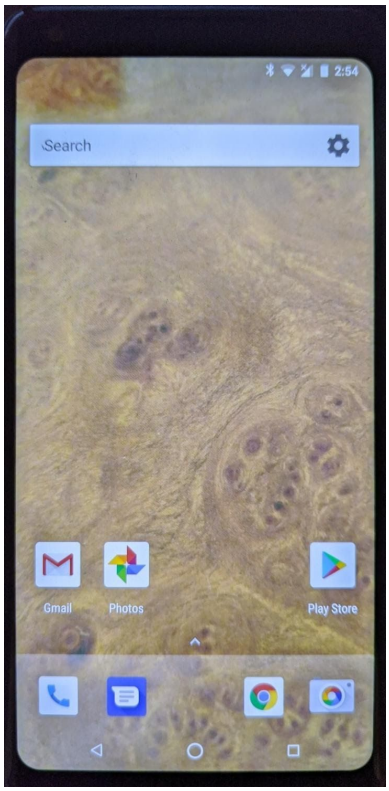


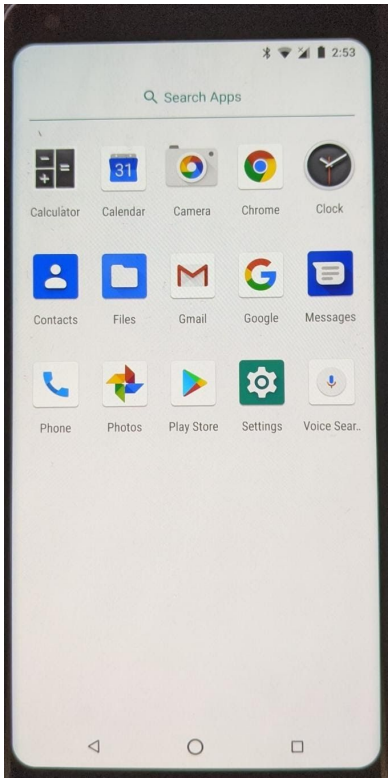
In case the final user is under attack, he/she will be able to unlock the phone with the PIN code specified in the Dashboard application. At this point, the device behaves as a standard android device in terms of android theme, launcher and installed applications. At the same time, the device starts to send its current GPS position, photos from both cameras and audio/video to the pre-configured email address.

The data is sent via HTTPS through the Kaymera Management Server. Follows an example of such traffic where the *xxxxx-xxx.kaymera.com* server was contacted.



Standard android launcher and applications:

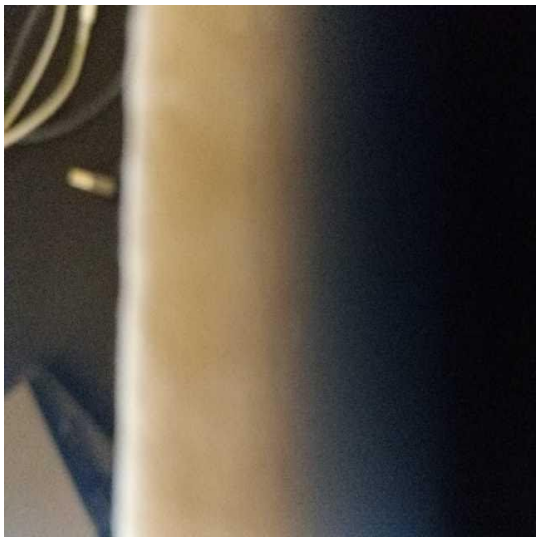




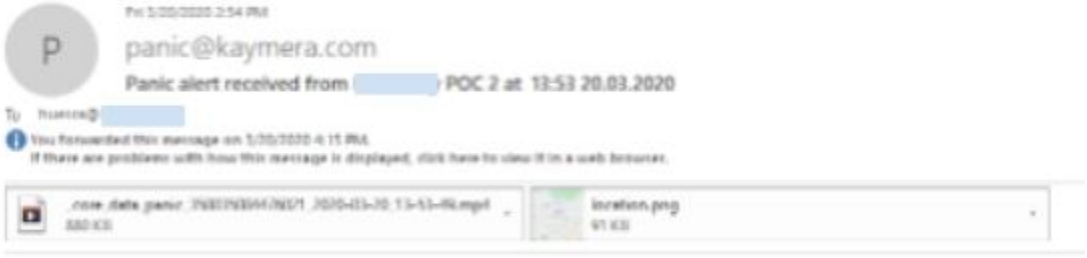
Panic Mode Active Notification via Email address.

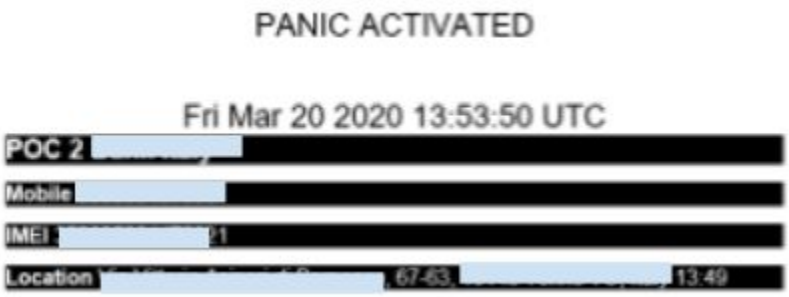
The first email contains the device's GPS location together with a picture from the rear and front device's camera.

Front and rear cameras:



The second received email contains a front camera video in MPEG-4 (.mp4) format and an upgrade of the device's GPS location.





Update of the device's GPS Location:

During Panic Mode no unauthorized traffic or connection establishment was out of the Kaymera environment, such as towards third party servers (information trackers, etc).

Penetration Test from Client's network on Kaymera infrastructure

The Penetration Test activity from the Internet on Kaymera infrastructure aims to identify exposed services, software versions, unsecure configurations and possible vulnerabilities.

Scope

The activity scope includes the hosts exposed on the Internet by TEST and PRODUCTION environment.

TEST ENVIRONMENT:

- 10.XXX.XXX.XX
- 10.XXX.XXX.XX
- 10.XXX.XXX.XX
- 10.XXX.XXX.XX
- 10.XXX.XXX.XX
- 10.XXX.XXX.XX

PRODUCTION ENVIRONMENT:

- 10.XXX.XXX.XX
- 10.XXX.XXX.XX
- 10.XXX.XXX.XX
- 10.XXX.XXX.XX
- 10.XXX.XXX.XX
- 10.XXX.XXX.XX
- 10.XXX.XXX.XX
- 10.XXX.XXX.XX
- 10.XXX.XXX.XX

Point of Attack

All the activities were performed from internal network through Virtual Desktop provided by Client's with IP address 10.XXX.XXX.XX/W10REVCU1101.ad00.Client's.intranet. This machine (OS: Windows 10), not allowing virtual machines execution or usage/installation of some required tools (e.g. Kali, Metasploit), limited the level of detail of the analysis described in the document.[1]

[1] *The constraint was dictated by the temporal needs for the provision of the Kaymera solution by the Top management. .*

To reach targets from this Point of Attack and execute the tests, it was required to authenticate through Juniper Firewall (with Client's domain credentials). Specifically, the following URLs were used: https://auth-gdc-sb-a.Client's.com, https://auth-gdc-sb-b.Client's.com, https://auth-gdc-sb-c.Client's.com, https://auth-gdc-sb-d.Client's.com.

Methodology

The methodology used for Penetration Test from Internet on the infrastructure was structured in the following phases:

5. **Intelligence Gathering**: detect and collect publicly available data related to Client's asset and individuals.
6. **Service Discovery**: identify services exposed from targets in scope.
7. **Vulnerability Analysis & Exploitation**: identify security issues on targets through direct/indirect interaction; these vulnerabilities were leveraged to execute Proof-of-Concepts of public/ad-hoc exploits which guarantee the repeatability of performed tests.
8. **Post Exploitation**: retrieve information (e.g. password, configurations, details) on compromised systems to be used for future attacks, gain higher privileges (i.e. privilege escalation) or perform lateral movement to attack other systems from exploited ones.

Tools

In the following a non-exhaustive list of the tools used to perform the activity:

- Tenable Nessus
- Burp Suite Professional
- Nmap
- Nikto

Service Discovery

Active port analysis on target hosts identified multiple exposed services:

IP	PORT	SERVICE
10.XXX.XXX.XX	TCP/XX	ssh OpenSSH 6.7p1 Debian 5+deb8u3 (protocol 2.0)
10.XXX.XXX.XX	UPD/XXX	rpcbind 2-4 (RPC #100000)
10.XXX.XXX.XX	UPD/XXX	ntp NTP v4 (secondary server)
10.XXX.XXX.XX	UPD/XXX	SNMPv1 server (public)
10.XXX.XXX.XX	TCP/XXXX	http Coturn TURN server http admin 4.2.1.2
10.XXX.XXX.XX	TCP/XXXX	tcpwrapped
10.XXX.XXX.XX	TCP/XXXXX	status 1 (RPC #100024)
10.XXX.XXX.XX	TCP/XX	ssh OpenSSH 6.7p1 Debian 5+deb8u3 (protocol 2.0)
10.XXX.XXX.XX	UPD/XXX	rpcbind 2-4 (RPC #100000)

10.XXX.XXX.XX	UPD/XXX	ntp NTP v4 (secondary server)
10.XXX.XXX.XX	UPD/XXX	SNMPv1 server (public)
10.XXX.XXX.XX	TCP/XXXXX	postgresql PostgreSQL DB 9.4.9
10.XXX.XXX.XX	TCP/XXXX	tcpwrapped
10.XXX.XXX.XX	TCP/XXXXX	status 1 (RPC #100024)
10.XXX.XXX.XX	TCP/XX	ssh OpenSSH 6.7p1 Debian 5+deb8u3 (protocol 2.0)
10.XXX.XXX.XX	UPD/XXX	rpcbind 2-4 (RPC #100000)
10.XXX.XXX.XX	UPD/XXX	ntp NTP v4 (secondary server)
10.XXX.XXX.XX	UPD/XXX	SNMPv1 server (public)
10.XXX.XXX.XX	TCP/XXXX	tcpwrapped
10.XXX.XXX.XX	TCP/XX	ssh OpenSSH 7.2 (protocol 2.0)
10.XXX.XXX.XX	TCP/XXXX	Openvpn OpenVPN
10.XXX.XXX.XX	TCP/XXXX	tcpwrapped
10.XXX.XXX.XX	TCP/XXXX	http nginx
10.XXX.XXX.XX	TCP/XX	ssh OpenSSH 6.7p1 Debian 5+deb8u3 (protocol 2.0)
10.XXX.XXX.XX	UPD/XXX	rpcbind 2-4 (RPC #100000)
10.XXX.XXX.XX	UPD/XXX	ntp NTP v4 (secondary server)
10.XXX.XXX.XX	UPD/XXX	SNMPv1 server (public)
10.XXX.XXX.XX	udp/XXX	sip-proxy FreeSWITCH mod_sofia 1.6.9-16-d574870~64bit
10.XXX.XXX.XX	TCP/XXXX	ssl/ayiya
10.XXX.XXX.XX	TCP/XXXX	sip-proxy FreeSWITCH mod_sofia 1.6.9-16-d574870~64bit
10.XXX.XXX.XX	TCP/XXXX	ssl/sdl-ets
10.XXX.XXX.XX	TCP/XXXX	tcpwrapped
10.XXX.XXX.XX	TCP/XXXX	ftp-proxy
10.XXX.XXX.XX	TCP/59217	status 1 (RPC #100024)
10.XXX.XXX.XX	TCP/XX	OpenSSH 6.6.1p1 Ubuntu 2ubuntu2.8 (Ubuntu Linux; protocol 2.0)
10.XXX.XXX.XX	TCP/XX	http nginx
10.XXX.XXX.XX	UPD/XXX	rpcbind 2-4 (RPC #100000)
10.XXX.XXX.XX	UPD/XXX	ntp NTP v4 (secondary server)
10.XXX.XXX.XX	UPD/XXX	SNMPv1 server (public)
10.XXX.XXX.XX	TCP/XXX	ssl/http nginx
10.XXX.XXX.XX	TCP/XXXX	ssl/http nginx
10.XXX.XXX.XX	TCP/XXXX	tcpwrapped
10.XXX.XXX.XX	TCP/XXXX	rtsp
10.XXX.XXX.XX	TCP/38345	status 1 (RPC #100024)
10.XXX.XXX.XX	TCP/XX	ssh OpenSSH 6.7p1 Debian 5+deb8u3 (protocol 2.0)
10.XXX.XXX.XX	UPD/XXX	rpcbind 2-4 (RPC #100000)
10.XXX.XXX.XX	UPD/XXX	ntp NTP v4 (secondary server)
10.XXX.XXX.XX	UPD/XXX	SNMPv1 server (public)
10.XXX.XXX.XX	TCP/XXXX	tcpwrapped
10.XXX.XXX.XX	TCP/XXXX	mongodb MongoDB 2.5.1 or later
10.XXX.XXX.XX	TCP/XX	ssh OpenSSH 6.7p1 Debian 5+deb8u3 (protocol 2.0)
10.XXX.XXX.XX	UPD/XXX	rpcbind 2-4 (RPC #100000)
10.XXX.XXX.XX	UPD/XXX	ntp NTP v4 (secondary server)

10.XXX.XXX.XX	UPD/XXX	SNMPv1 server (public)
10.XXX.XXX.XX	TCP/XXXXX	postgresql PostgreSQL DB 9.4.9
10.XXX.XXX.XX	TCP/XXXX	tcpwrapped
10.XXX.XXX.XX	TCP/XXXX	status 1 (RPC #100024)
10.XXX.XXX.XX	TCP/XX	ssh OpenSSH 6.7p1 Debian 5+deb8u3 (protocol 2.0)
10.XXX.XXX.XX	TCP/XXXX	rpcbind 2-4 (RPC #100000)
10.XXX.XXX.XX	UPD/XXX	ntp NTP v4 (secondary server)
10.XXX.XXX.XX	UPD/XXX	SNMPv1 server (public)
10.XXX.XXX.XX	TCP/XXXX	http Coturn TURN server http admin 4.2.1.2
10.XXX.XXX.XX	TCP/XXXX	tcpwrapped
10.XXX.XXX.XX	TCP/XXXX	status 1 (RPC #100024)
10.XXX.XXX.XX	TCP/XX	Ssh OpenSSH 6.7p1 Debian 5+deb8u3 (protocol 2.0)
10.XXX.XXX.XX	UPD/XXX	rpcbind 2-4 (RPC #100000)
10.XXX.XXX.XX	UPD/XXX	ntp NTP v4 (secondary server)
10.XXX.XXX.XX	UPD/XXX	SNMPv1 server (public)
10.XXX.XXX.XX	UDP/775	rpcbind
10.XXX.XXX.XX	TCP/XXXX	http Coturn TURN server http admin 4.2.1.2
10.XXX.XXX.XX	TCP/XXXX	tcpwrapped
10.XXX.XXX.XX	TCP/XXXX	status 1 (RPC #100024)
10.XXX.XXX.XX	TCP/XX	ssh OpenSSH 6.7p1 Debian 5+deb8u3 (protocol 2.0)
10.XXX.XXX.XX	UPD/XXX	rpcbind 2-4 (RPC #100000)
10.XXX.XXX.XX	UPD/XXX	ntp NTP v4 (secondary server)
10.XXX.XXX.XX	UPD/XXX	SNMPv1 server (public)
10.XXX.XXX.XX	TCP/XXXXX	rpcbind
10.XXX.XXX.XX	TCP/XXXX	tcpwrapped
10.XXX.XXX.XX	TCP/XXXX	mongodb MongoDB 2.5.1 or later
10.XXX.XXX.XX	TCP/XX	ssh OpenSSH 7.2 (protocol 2.0)
10.XXX.XXX.XX	TCP/XXXXX	domain NLNet Labs Unbound
10.XXX.XXX.XX	UPD/XXX	ntp NTP v4 (secondary server)
10.XXX.XXX.XX	TCP/XXXX	openvpn OpenVPN
10.XXX.XXX.XX	TCP/XXXX	tcpwrapped
10.XXX.XXX.XX	TCP/XXXX	http nginx
10.XXX.XXX.XX	TCP/XX	ssh OpenSSH 6.7p1 Debian 5+deb8u3 (protocol 2.0)
10.XXX.XXX.XX	UPD/XXX	rpcbind 2-4 (RPC #100000)
10.XXX.XXX.XX	UPD/XXX	ntp NTP v4 (secondary server)
10.XXX.XXX.XX	UPD/XXX	SNMP
10.XXX.XXX.XX	TCP/XXXX	tcoflashagent
10.XXX.XXX.XX	TCP/XXXX	ssl/ayiya
10.XXX.XXX.XX	TCP/XXXX	sip-proxy FreeSWITCH mod_sofia 1.6.9-16-d574870~64bit
10.XXX.XXX.XX	TCP/XXXX	ssl/sdl-ets
10.XXX.XXX.XX	TCP/XXXX	tcpwrapped
10.XXX.XXX.XX	TCP/XXXX	ftp-proxy (Cluecon)
10.XXX.XXX.XX	TCP/XXXX	status 1 (RPC #100024)
10.XXX.XXX.XX	TCP/XX	ssh OpenSSH 6.6.1p1 Ubuntu 2ubuntu2.8 (Ubuntu Linux; protocol 2.0)

10.XXX.XXX.XX	TCP/XX	smtp Postfix smtpd
10.XXX.XXX.XX	TCP/XX	http nginx
10.XXX.XXX.XX	UPD/XXX	rpcbind 2-4 (RPC #100000)
10.XXX.XXX.XX	UPD/XXX	ntp NTP v4 (secondary server)
10.XXX.XXX.XX	UPD/XXX	snmp SNMPv1 server (public)
10.XXX.XXX.XX	TCP/XXX	ssl/http nginx
10.XXX.XXX.XX	TCP/XXXX	ssl/http nginx
10.XXX.XXX.XX	TCP/XXXX	tcpwrapped
10.XXX.XXX.XX	TCP/XXXX	rtsp
10.XXX.XXX.XX	TCP/XX	ssh OpenSSH 6.7p1 Debian 5+deb8u3 (protocol 2.0)
10.XXX.XXX.XX	UPD/XXX	rpcbind 2-4 (RPC #100000)
10.XXX.XXX.XX	UPD/XXX	NTP v4 (secondary server)
10.XXX.XXX.XX	UPD/XXX	SNMPv1 server (public)
10.XXX.XXX.XX	TCP/XXXX	tcpwrapped
10.XXX.XXX.XX	TCP/XXXX	mongodb MongoDB 2.5.1 or later

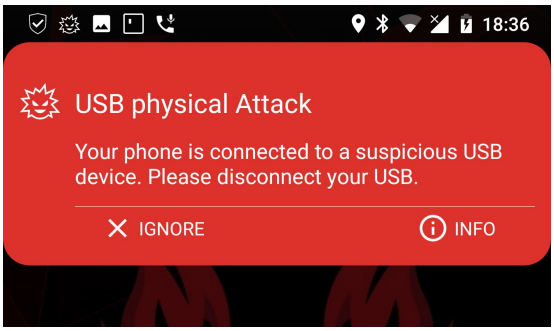
Table 5: Exposed services from Client's Intranet

Attacks detection Analysis and Management Controller Overview

The Kaymera Secure Smartphones were under attack during the Penetration Testing operation. The vendor's application Dashboard was able to detect some attacks such as the ones shown below:

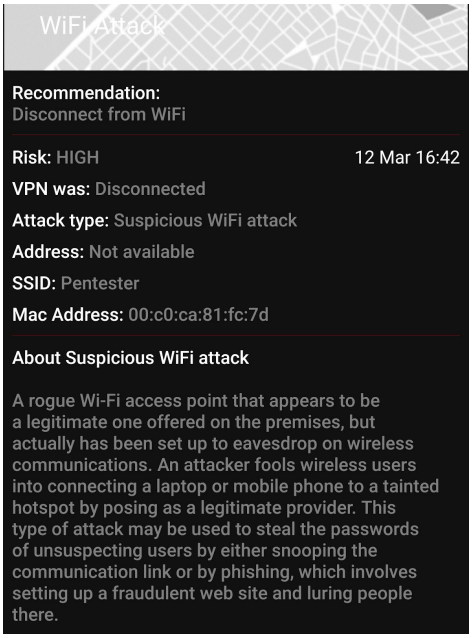
USB attack – rooting procedure:

During the rooting procedure the Dashboard application was able to detect the malicious use of the USB interface.



WIFI attack - Rogue AP:

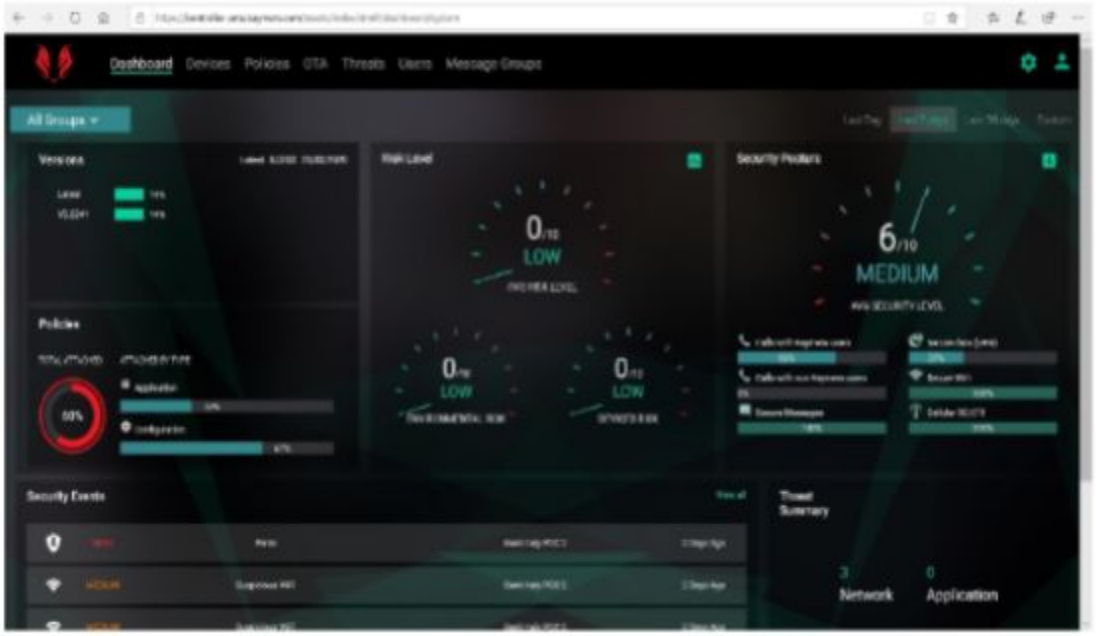
During the Penetration Test activity, the Dashboard application was able to detect a Rogue AP to which the phone was connected. In this case the malicious AP was used for some attacks such as man-in-the-middle and to obtain an interactive shell in the device.



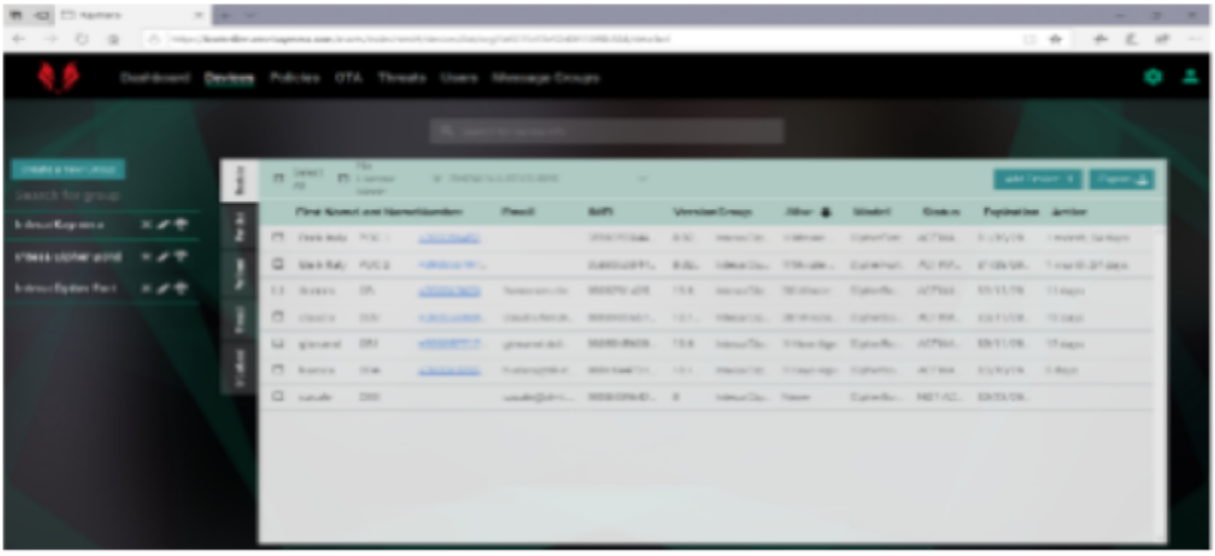
The Vendor provides an online administrative console “Kaymera Kontroller Console” from which an administrative client user is able to customize the Kaymera environment Kaymera Secure Communications App , Kaymera Encrypted Smartphone, etc) in order to satisfy his organization requirement.

URL: https://kontroller-amz.kaymera.com/assets/index.html#/dashboard/system

The administrative console uses a robust authentication method composed by the use of an X509 certificate in combination with a username and password authentication mechanism. It also implements a second authentication factor via OTP sent via SMS to the administrative client user. Following the kaymera controller console dashboard.

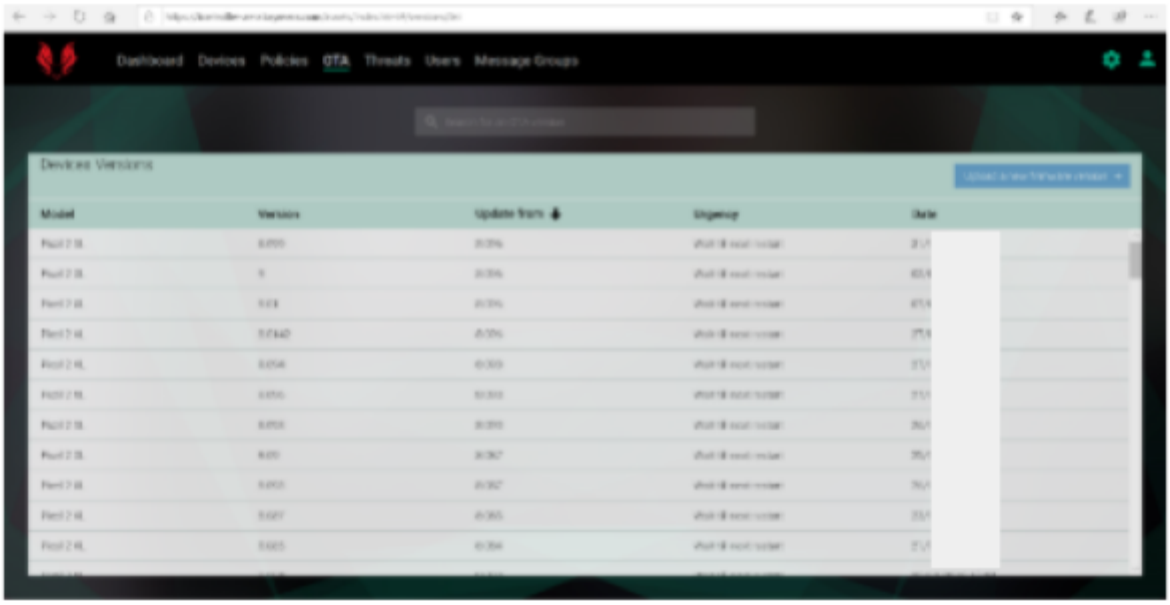


Registered devices with client’s phone private information “IMEI, email, phone number, etc”.

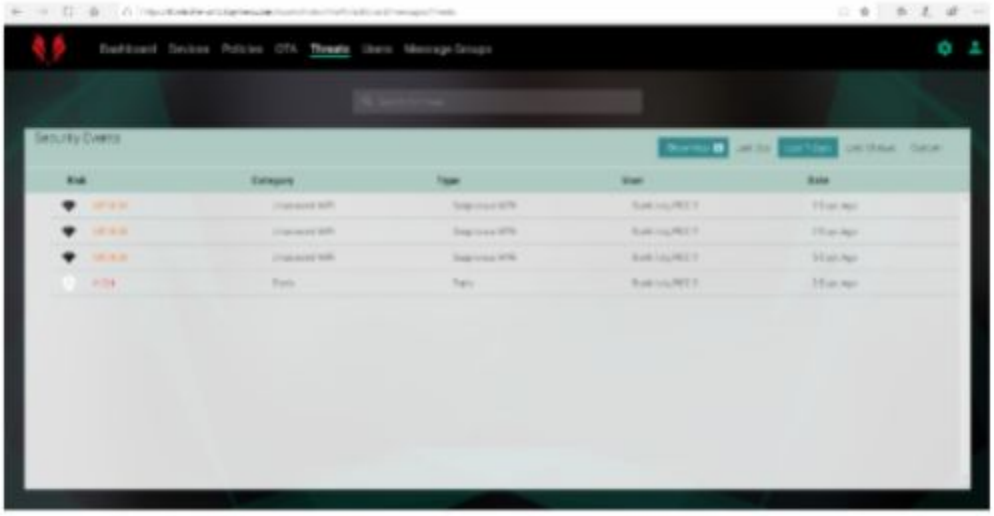


The Kaymera console allows to apply specific policies for each device or each group of devices:

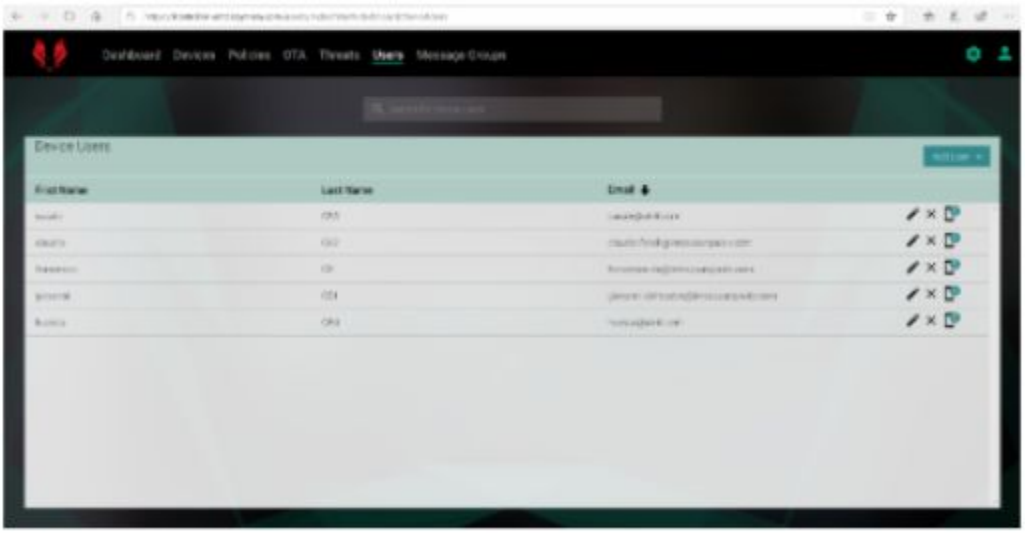
Following the vendor's software-firmware updates for each devices "Over The Air":



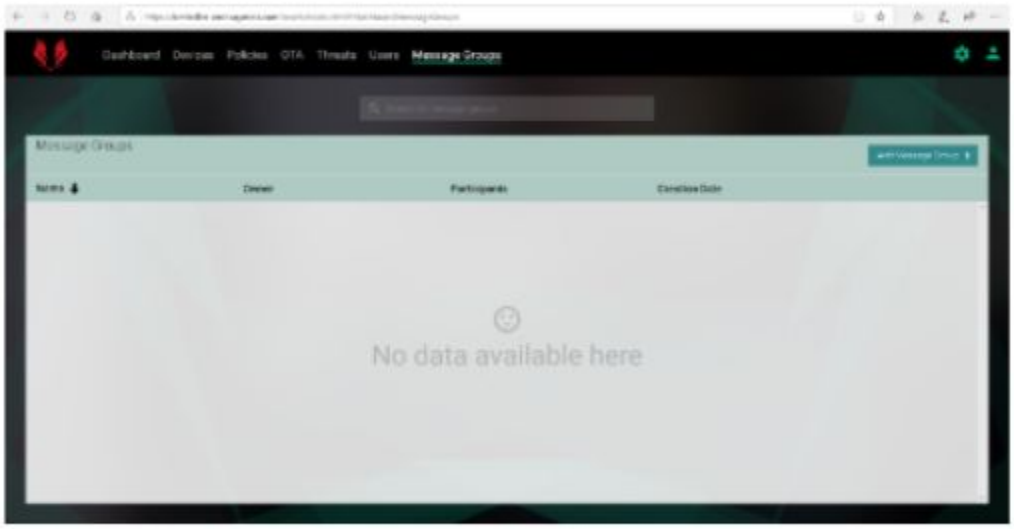
Security Events detected on the devices:



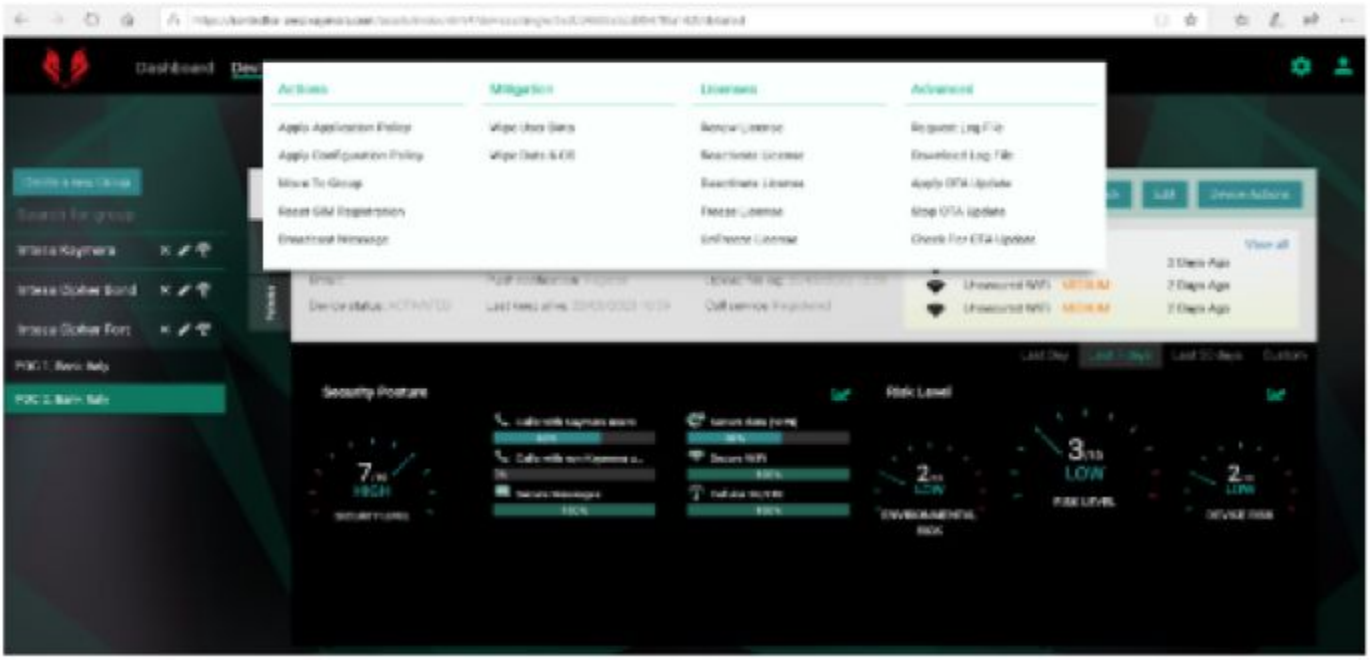
Registered users for each device:



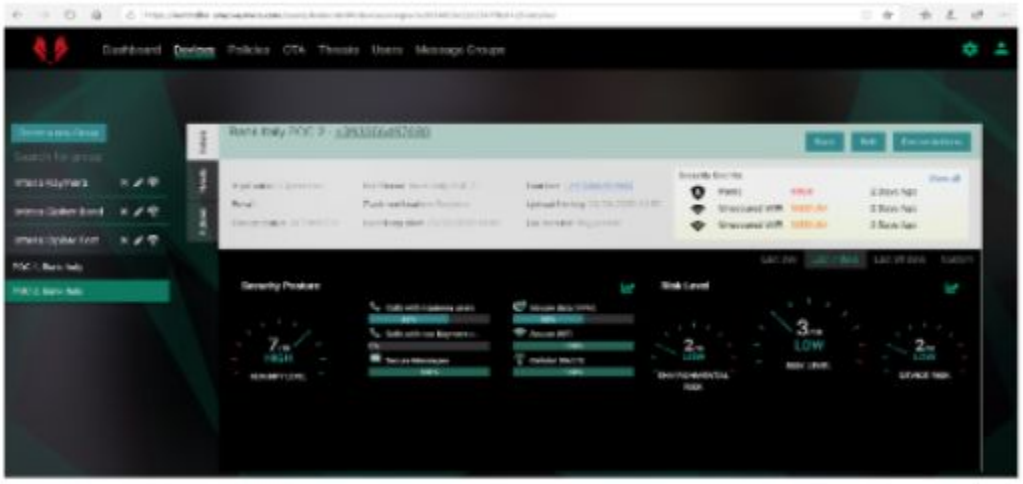
The Kaymera administrative console allows to send broadcast SMS using the “Message Group” feature:



Following some of the most important operations that an administrative user is able to perform remotely on the kaymera devices.



Some related information for a specific device:



App Installation & Execution Analysis

App Installation & Execution Analysis aims to analyze app whitelist mechanisms, to evaluate the chance to bypass it and install custom apps to access software/hardware features and data on mobile devices.

Scope

The activity scope includes the following areas:

- App removal
- App download
- App installation

Point of Attack

All the activities have been performed through direct access to 2 Google Pixel (Kaymera) devices and using a supporting Kali Linux machine.

Methodology

Used methodology was divided into different phases:

1. Installed app analysis
2. Security measures bypass

Tools

In the following a non-exhaustive list of the tools used to perform the activity:

- WiFi Pineapple
- Bettercap
- Hcitool
- Ubertooth One
- ADB

Installed app analysis

In the following, the list of apps installed on the device. This list includes apps that are surely included into whitelist, but does not include any possible allowed apps not yet installed at device delivery.

Vendor	Software	Versione	Tipologia

Google	Android Keyboard (AOSP)	7.1	Software Keyboard
Google	Calculator	7.1	Calculator
Google	Calendar	7.1	Calendar
Google	Camera	2.0.002	Camera Management
Google	Chrome	62.0.3202.84	Browser
Google	Clock	4.5.0	Clock
Google	Contacts	1.4.22	Contact Management
Kaymera	Dashboard	296.5dcd244	Kaymera Console
Google	Email	7.1	Email Management
Microsoft	Excel	16.0.8730.2050	Document Elaboration
Google	Files	7.1	File Management
Google	Gallery	1.1.40030	Picture Management
Google	Gmail	7.11.5.177402951.release	Email Management
Google	Google	7.16.19.21.arm64	Google Profile Management
Google	Google Play services	11.9.51 (440-177350961)	Google Services
Google	Google Play services for Instant Apps	2.7-release-179555567	Google Services
Google	Google Play Store	8.5.39.W-all [0] [PR] 178322352	Google Store
Google	Launcher3	7.1	Launcher
Kaymera	Messages	296.5dcd244	Messages Management
MobileIron	MobileIron	9.5.1.1.1R	Device Management
Google	Music	7.1	Audio Management
9Folders Inc.	Nine	4.1.1b	Email Management
Microsoft	Outlook	2.2.74	Email Management
Kaymera	Phone	3.00.00	Call Management
Microsoft	PowerPoint	16.0.8730.2050	Document Elaboration

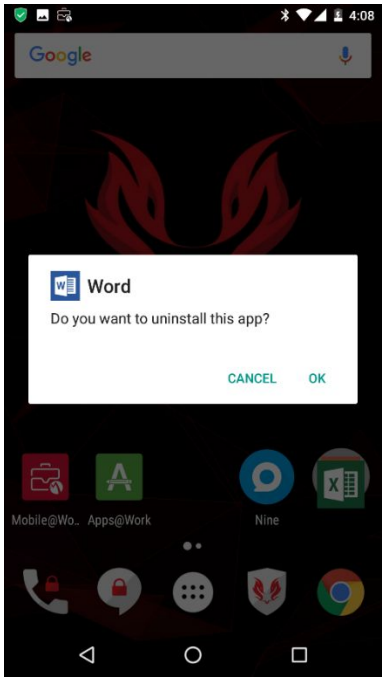
Google	Settings	7.1	Device Settings
Google	SIM Toolkit	7.1	SIM Management
Microsoft	Word	16.0.8827.2054	Document Elaboration
Client's	App@Work	n.a.	Client's Store
Microsoft	Skype for Business	6.17.0.7	Corporate Chat

Table 7: Device Kaymera Softwares

Security measures bypass

App removal

It tested the possibility to uninstall pre-configured apps from the device. Test was performed on the "Microsoft Word" app. No protection mechanism against app removal was detected.



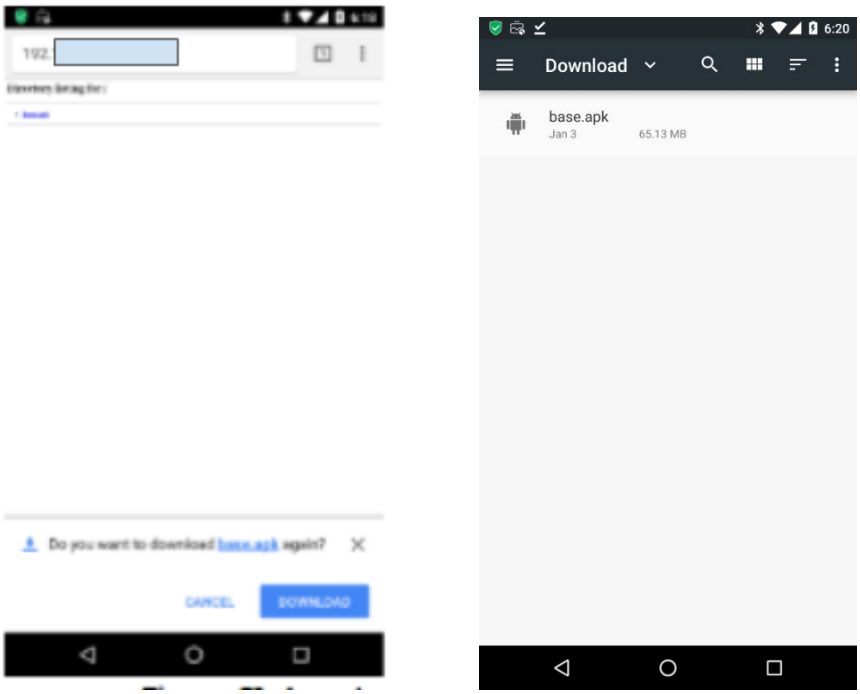
Whitelisted app removal

App download from alternative sources

It tested the possibility to download an app from the browser instead of the official Google Store. Specifically, an app was deployed on a temporary web server on the same device network and it was executed as a download attempt from a mobile device. No protection mechanism was detected against app download from browser.

```
root@kali:~/Desktop/PythonFolder# python -m SimpleHTTPServer 3000
Serving HTTP on 0.0.0.0 port 3000 ...
192.[redacted] - - [05/Jan/2018 19:34:01] "GET /base.apk HTTP/1.1" 200 -
```

Web Server creation for browser download

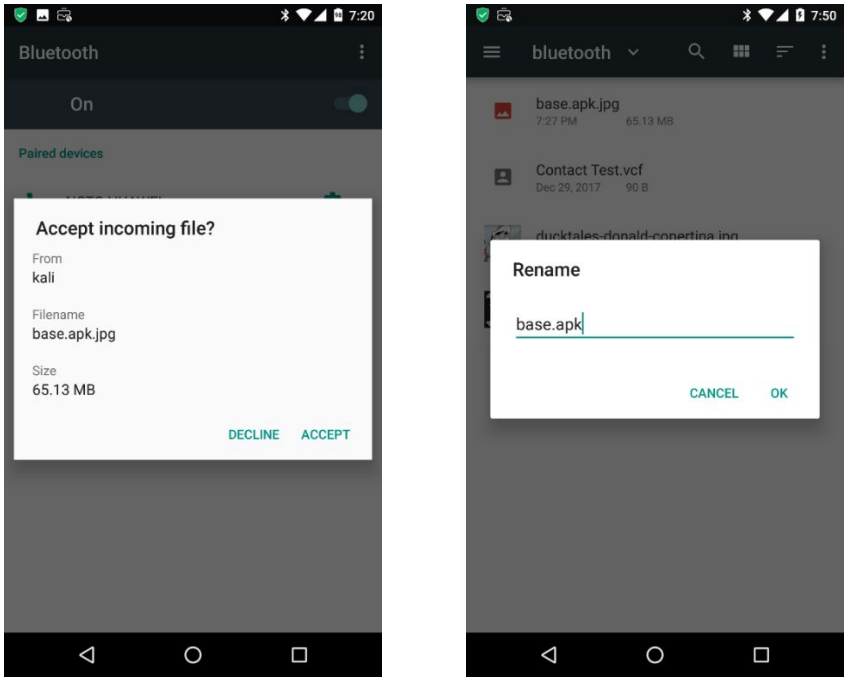


App download on device

It tested the possibility to receive an app through Bluetooth. Specifically, the app was sent from a Kali server on the same network of mobile devices using Bluetooth channel. No protection mechanism was detected against app download from Bluetooth, even if file renaming was needed to allow app sending.

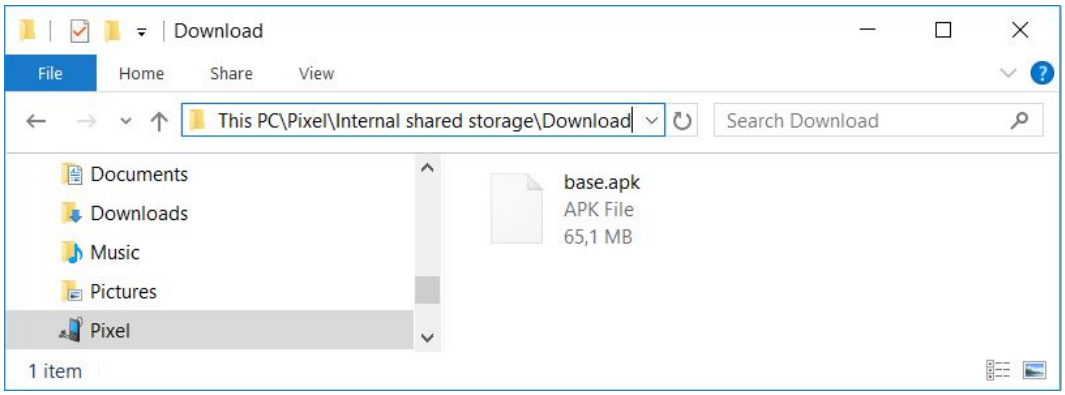
```
root@kali:~/Desktop/PythonFolder# bluetooth-sendto --device=AC:37:43:89:66:A6 ~/
Desktop/PythonFolder/base.apk.jpg
Gtk-Message: GtkDialog mapped without a transient parent. This is discouraged.
```

App sending through Bluetooth

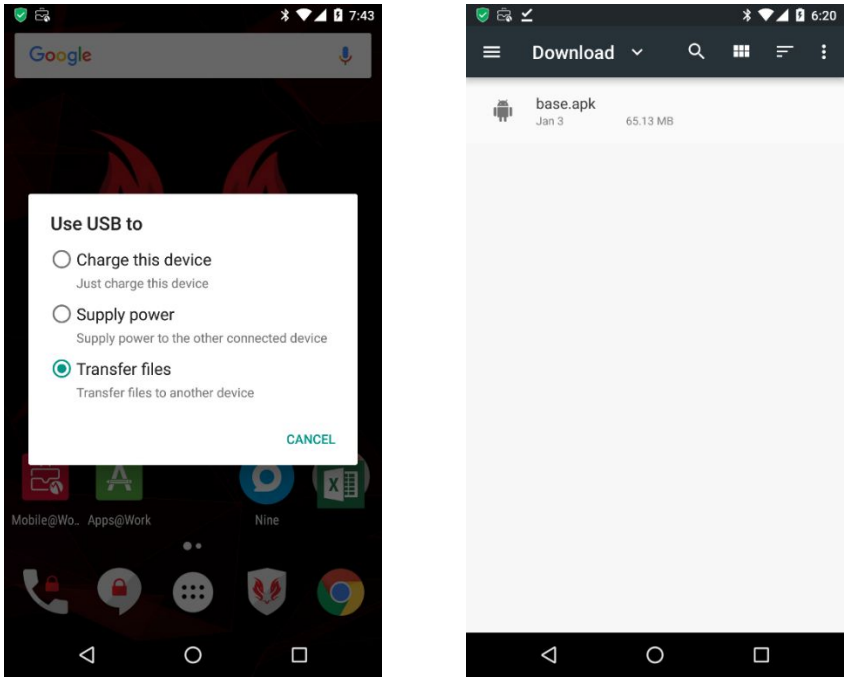


App download on device through Bluetooth

It tested the possibility to receive an app through USB transfer. Specifically, the app was transferred from a laptop directly connected to the device through USB. No protection mechanism was detected against app transfer through USB.

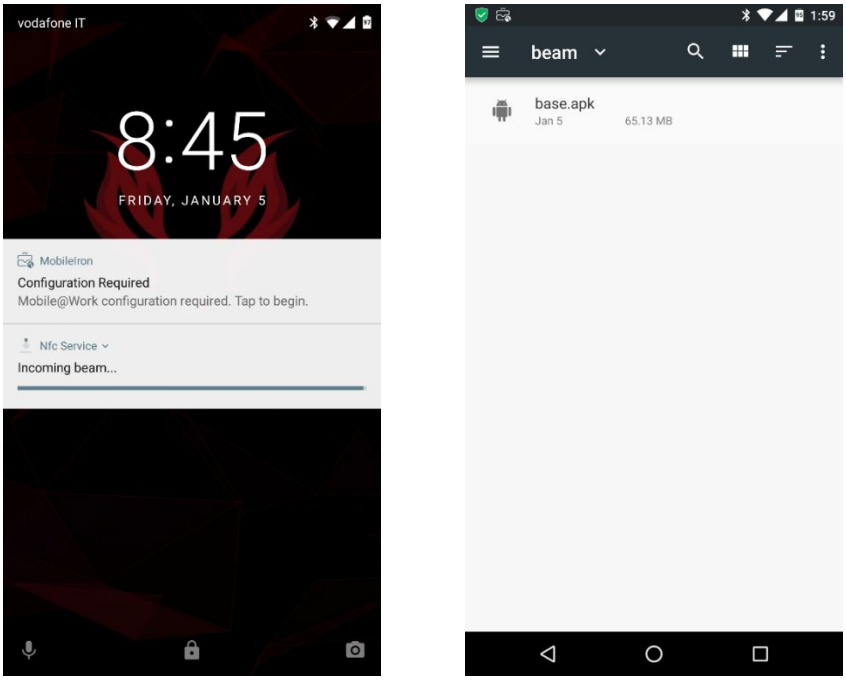


Device memory



App download on device through USB

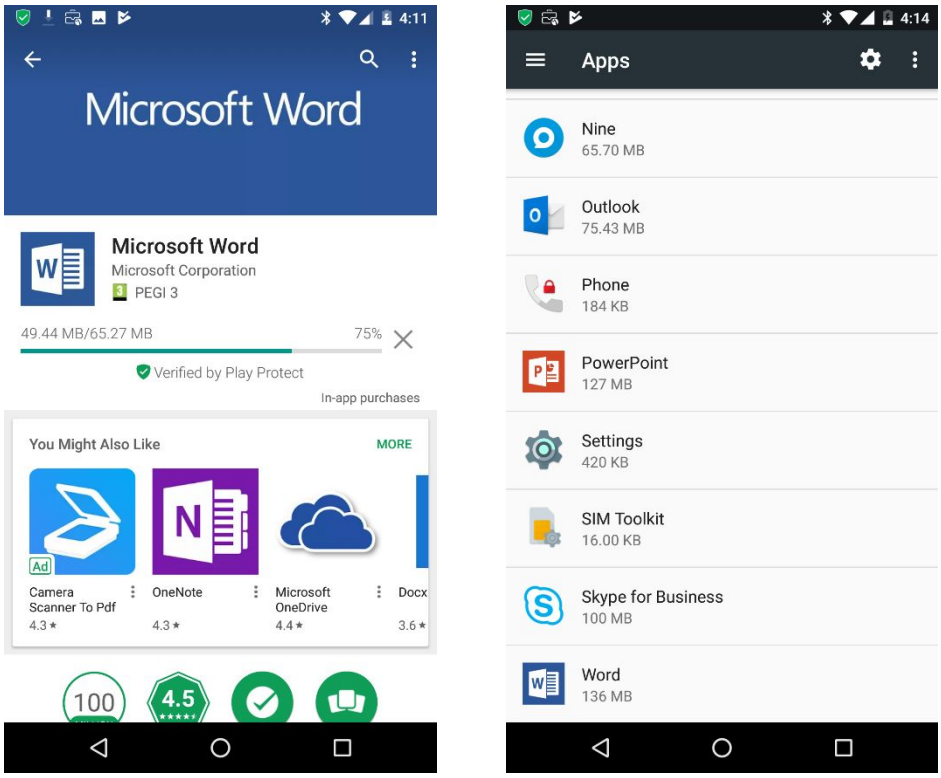
The possibility to receive an app through NFC was tested. Specifically, the app was sent through NFC from a device next to the target device. No protection mechanism was detected against app transfer through NFC.



App download on device through NFC

Whitelisted app installation from Google Store

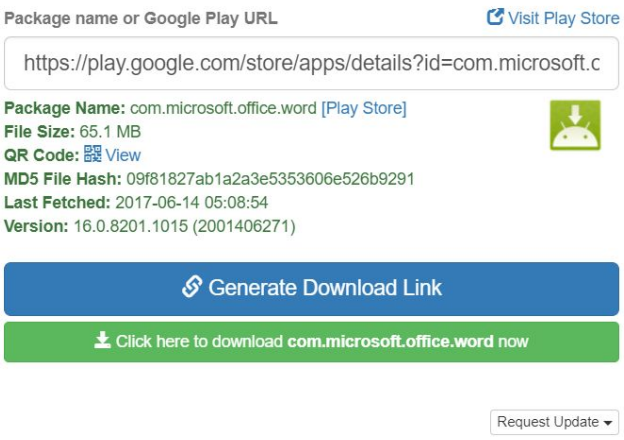
It was tested the possibility to install a whitelisted app – previously removed – from the official Google Play Store. No issue was detected.



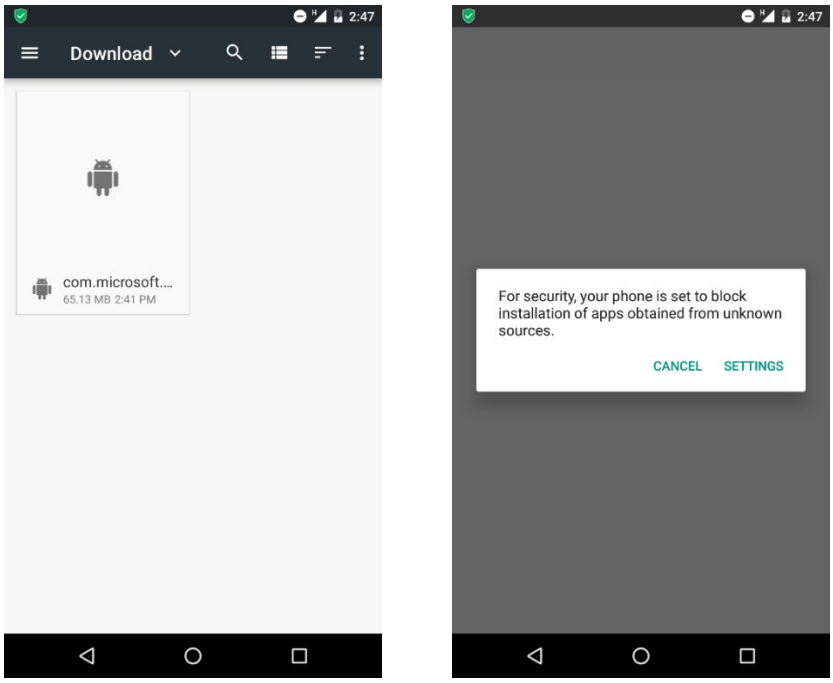
Whitelisted app installation from Google Store

Whitelisted app installation from alternative sources

To verify the possibility to install a whitelisted app from File Explorer instead of the official Google Play Store, the apk of “Microsoft Word " (com.microsoft.office.word.apk) was downloaded and later transferred on Kaymera device. However the installation through File Explorer failed because the apk was not recognised as originated from a known source.

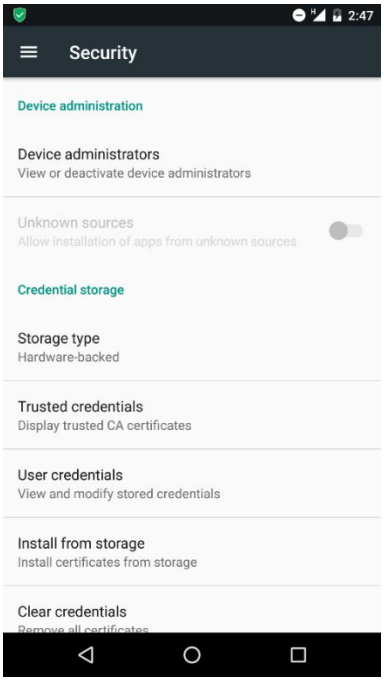


MS Word apk download



App installation attempt

To install the app it was tried to disable “Unknown sources” configuration from device GUI. This was not possible because the device inhibits the enabling of this feature from the settings menu.



“Unknown Source” enabling attempt

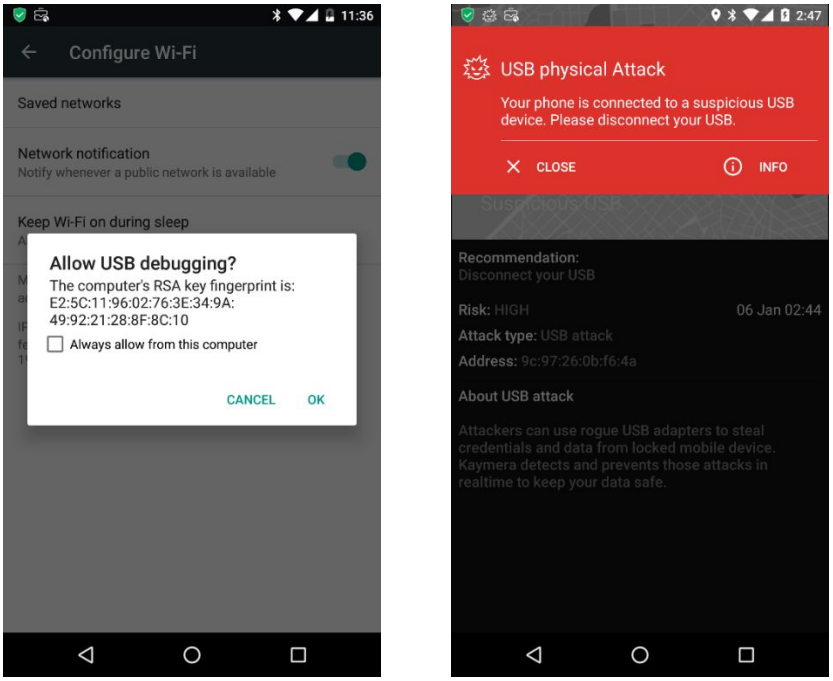
We also tried to enable “Unknown sources” setting through adb. This configuration allows app installation even if not directly downloaded from Google Play Store. However, ADB command was intercepted and blocked by the device.

```
C:\Users\PC-NotoAnonimo>adb devices
List of devices attached
FA69R0300969    unauthorized


C:\Users\PC-NotoAnonimo>adb devices
List of devices attached
FA69R0300969    device


C:\Users\PC-NotoAnonimo>adb shell settings put global install_non_market_apps 1
error: closed
```

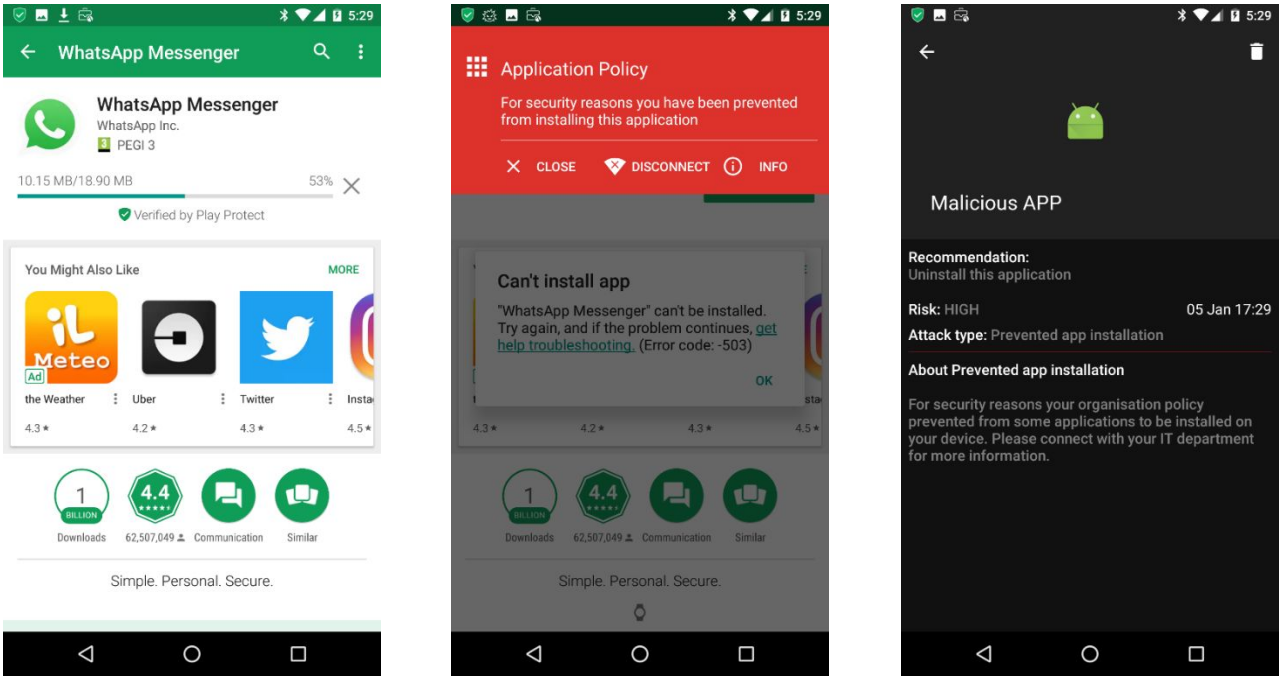
ADB feature enabling



ADB interception and block

Non-whitelisted app installation from Google Store

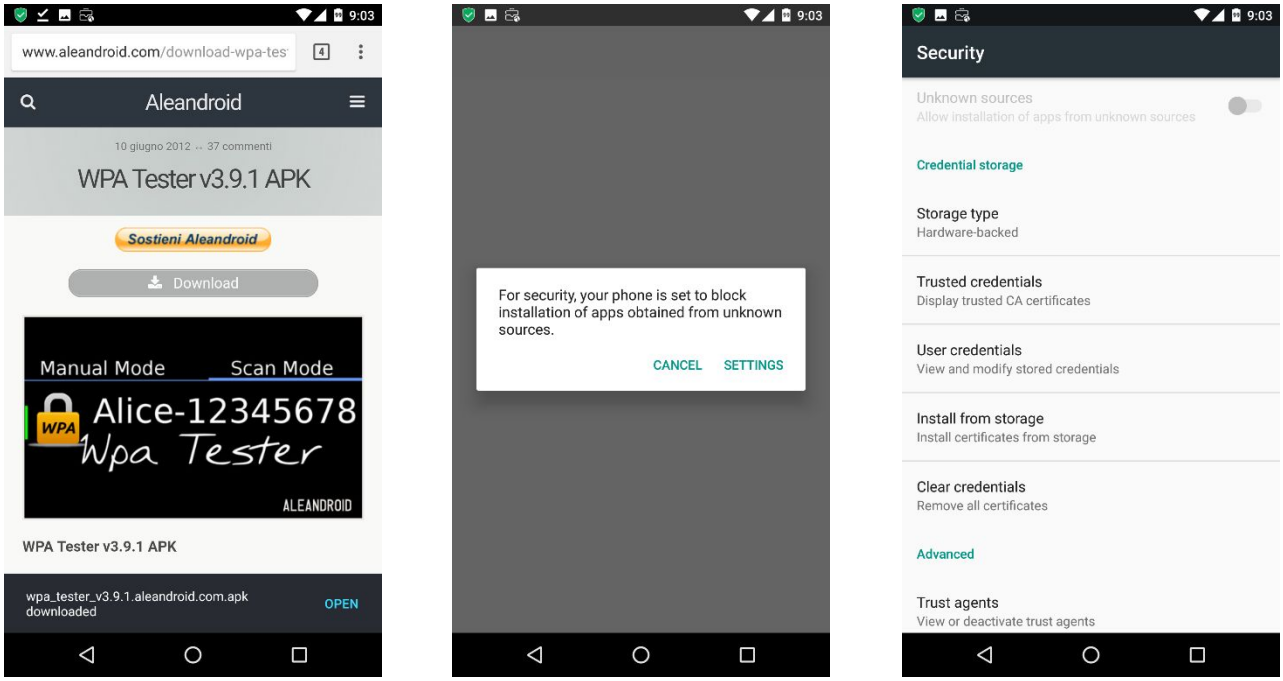
It was tested the possibility to install a not-whitelisted app from different sources. Even if the app is correctly downloaded (e.g. “WhatsApp” in our test), installation attempts are detected and blocked by mobile device.



Non-whitelisted app installation from Google Store

Non-whitelisted app installation from alternative sources

Non-whitelisted app download from a repository different from Google Play Store is allowed, but, at installation submission, the device is able to detect the “Unknown source” nature of the file and blocks installation attempts.



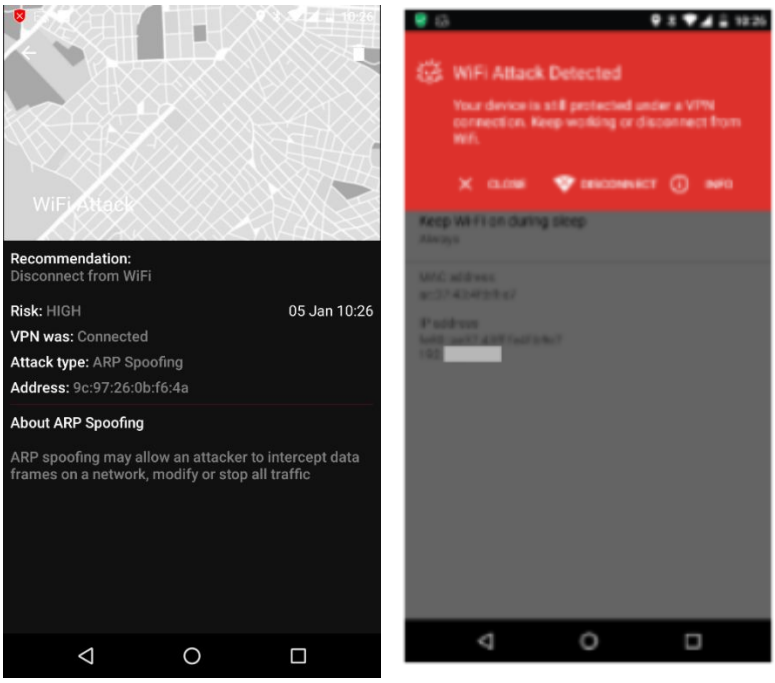
Non-whitelisted app installation from alternative sources

Google Play Store interception

It was verified the chance to install an app through Man-in-the-Middle attack between device and official Google Play Store ufficiale, intercepting downloaded file and exchanging it with an alternative malicious file. Specifically, the attack was executed through ARP spoofing and requires device and attacker notebook to be in the same network.

MitM with Google Play Store

Malicious apk cannot be installed because MitM ARP spoofing is detected and blocked.



ARP Spoofing detection and block

Vulnerabilities

Performed analysis didn't identify any change to bypass current whitelist/blacklist configurations.