Digital Financial Services Security Clinic

ITU DFS Security Lab

USSD, STK and Android platform vulnerabilities

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Overview

1. USSD & STK App vulnerabilities tests
2. Android, iOS app security vulnerability tests

Examples of DFS attacks

Source: znet

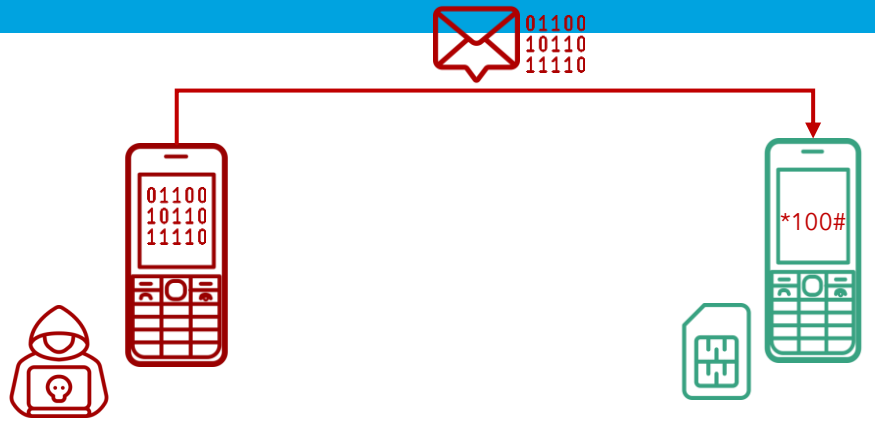
Source: Nairobi News

- March 2021, Times Of India, **2 duped of Rs 82k in SIM swap fraud**
- March 2021, Nairobi News: **Police arrest six Sim-swap fraud suspects in Kasarani**
- The Daily Monitor: **Thieves use 2,000 SIM cards to rob banks**
- Ghana Chamber of Telecommunications: **Mobile Money Fraudsters Now Target Bank Accounts Linked To MoMo Accounts**
- February 2021, CNN: **Police arrest eight after celebrities hit by SIM-swapping attacks**

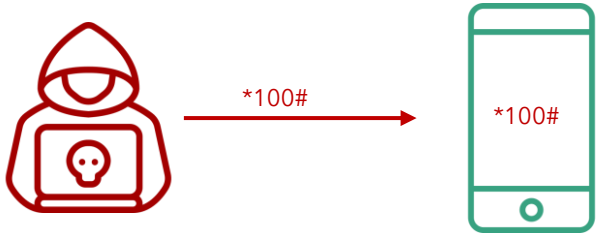
USSD and STK Tests

USSD and STK App Security Tests

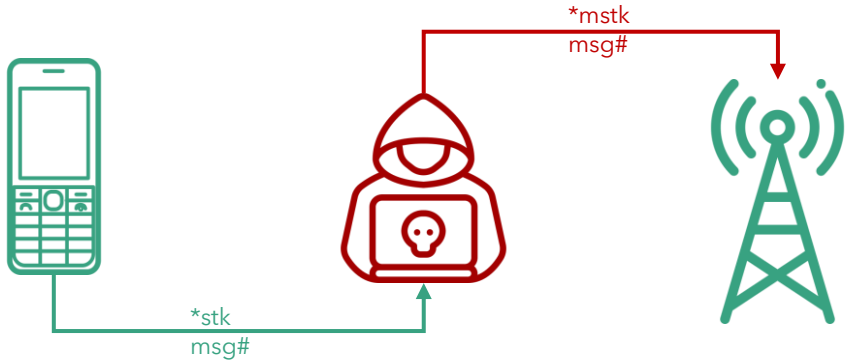
a. **SIM Swap** and **SIM cloning**



b. susceptibility to **binary OTA attacks** (SIM jacker, WIB attacks)

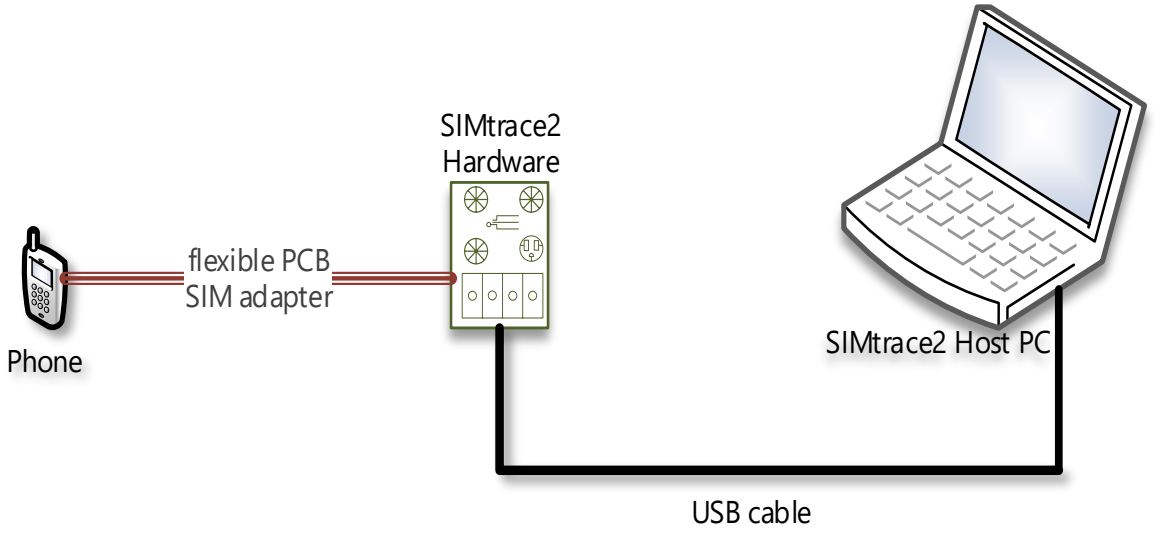


c. **remote USSD** execution attacks



d. **man-in-the-middle attacks** on STK based DFS applications

Man-in-the-Middle attacks on STK based DFS applications



MiTM attack simulation on STK using a SIMtrace

Man-in-the-Middle attacks on STK based DFS applications

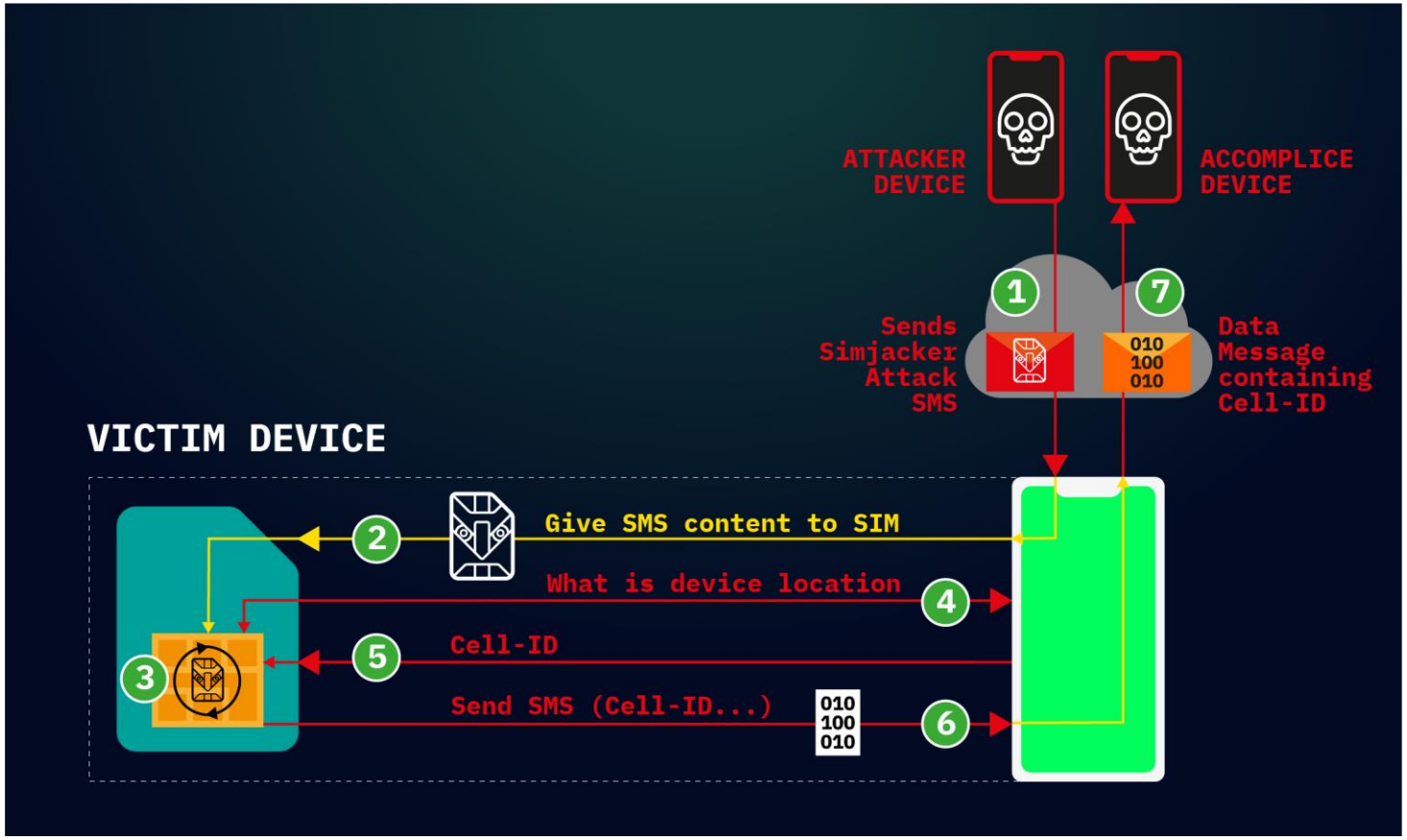
405	125.…	lo…	lo…	GSM …	65	ETSI TS 102.221	STATUS : Terminal should repeat command, Lengt…	38229 (38229),gsmtap (4729)
54	32.8…	lo…	lo…	GSM …	83	ETSI TS 102.221	TERMINAL PROFILE	38229 (38229),gsmtap (4729)
349	85.5…	lo…	lo…	GSM …	77	ETSI TS 102.221	TERMINAL RESPONSE DISPLAY TEXT	38229 (38229),gsmtap (4729)
393	105.…	lo…	lo…	GSM …	77	ETSI TS 102.221	TERMINAL RESPONSE DISPLAY TEXT	38229 (38229),gsmtap (4729)
407	128.…	lo…	lo…	GSM …	77	ETSI TS 102.221	TERMINAL RESPONSE DISPLAY TEXT	38229 (38229),gsmtap (4729)
434	149.…	lo…	lo…	GSM …	77	ETSI TS 102.221	TERMINAL RESPONSE DISPLAY TEXT	38229 (38229),gsmtap (4729)
345	80.2…	lo…	lo…	GSM …	84	ETSI TS 102.221	TERMINAL RESPONSE GET INPUT	38229 (38229),gsmtap (4729)
403	121.…	lo…	lo…	GSM …	84	ETSI TS 102.221	TERMINAL RESPONSE GET INPUT	38229 (38229),gsmtap (4729)
157	33.4…	lo…	lo…	GSM …	81	ETSI TS 102.221	TERMINAL RESPONSE POLL INTERVAL	38229 (38229),gsmtap (4729)
351	86.0…	lo…	lo…	GSM …	87	ETSI TS 102.221	TERMINAL RESPONSE PROVIDE LOCAL INFORMATION	38229 (38229),gsmtap (4729)
409	129.…	lo…	lo…	GSM …	87	ETSI TS 102.221	TERMINAL RESPONSE PROVIDE LOCAL INFORMATION	38229 (38229),gsmtap (4729)
332	62.8…	lo…	lo…	GSM …	80	ETSI TS 102.221	TERMINAL RESPONSE SELECT ITEM	38229 (38229),gsmtap (4729)
336	65.0…	lo…	lo…	GSM …	77	ETSI TS 102.221	TERMINAL RESPONSE SELECT ITEM	38229 (38229),gsmtap (4729)
338	68.3…	lo…	lo…	GSM …	80	ETSI TS 102.221	TERMINAL RESPONSE SELECT ITEM	38229 (38229),gsmtap (4729)
340	71.5…	lo…	lo…	GSM …	80	ETSI TS 102.221	TERMINAL RESPONSE SELECT ITEM	38229 (38229),gsmtap (4729)
396	111.…	lo…	lo…	GSM …	80	ETSI TS 102.221	TERMINAL RESPONSE SELECT ITEM	38229 (38229),gsmtap (4729)
401	116.…	lo…	lo…	GSM …	80	ETSI TS 102.221	TERMINAL RESPONSE SELECT ITEM	38229 (38229),gsmtap (4729)
370	89.9…	lo…	lo…	GSM …	77	ETSI TS 102.221	TERMINAL RESPONSE SEND SHORT MESSAGE	38229 (38229),gsmtap (4729)
428	133.…	lo…	lo…	GSM …	77	ETSI TS 102.221	TERMINAL RESPONSE SEND SHORT MESSAGE	38229 (38229),gsmtap (4729)
121	33.2…	lo…	lo…	GSM …	77	ETSI TS 102.221	TERMINAL RESPONSE SET UP EVENT LIST	38229 (38229),gsmtap (4729)

```
▾ Command details: 012304
    Command Number: 0x01
    Command Type: GET INPUT (0x23)
    Command Qualifier: 0x04
▾ Device identity: 8281
    Source Device ID: Terminal (Card Reader) (0x82)
    Destination Device ID: SIM / USIM / UICC (0x81)
▾ Result: 00
    Result: Command performed successfully (0x…)
▾ Text string: 0435343533
    Text String Encoding: GSM default alphabet, 8 bits (0x04)
    Text String: 5453
Status Word: 911c Normal ending of command with info from proactive SIM
```

PINs on USSD can be intercepted

Analysis of trace packets from SIMtrace device

Testing susceptibility to binary OTA attacks (SIMjacker, WIB attacks)



Source: Adaptive Mobile

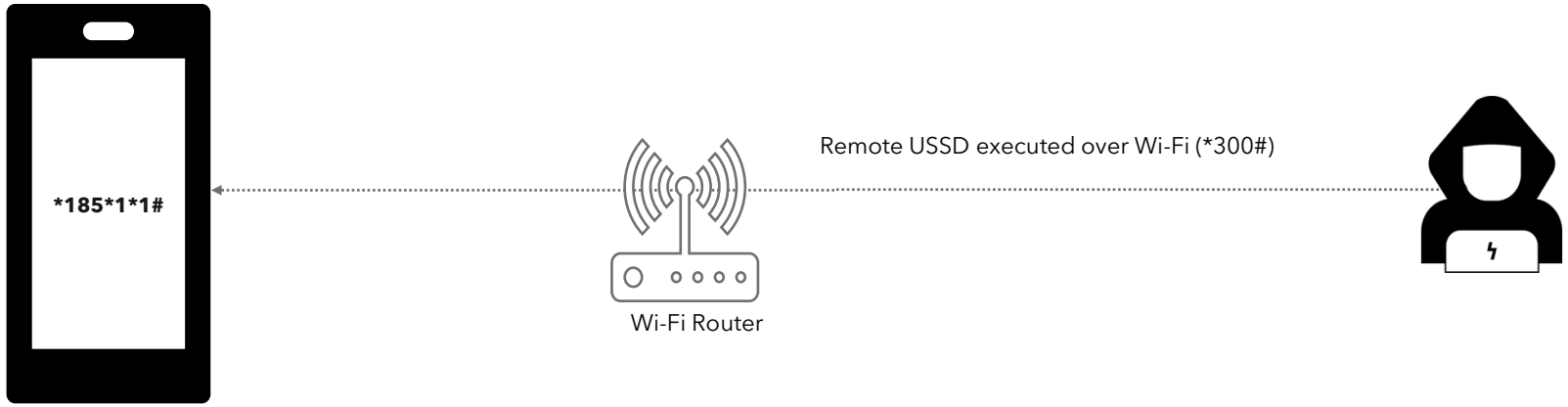
A binary OTA message can instruct the SIM to:

- initiate SS,
- Send SMS
- Initiate a phone call

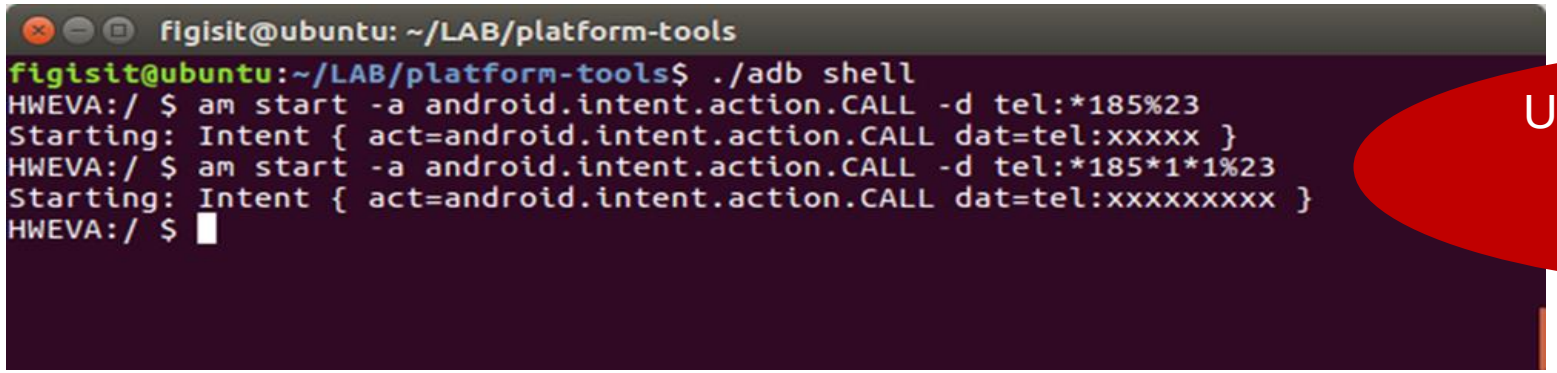
on a vulnerable SIM and will affect both USSD and STK apps.

(see CVE-2019-16256)

Testing remote USSD execution attacks

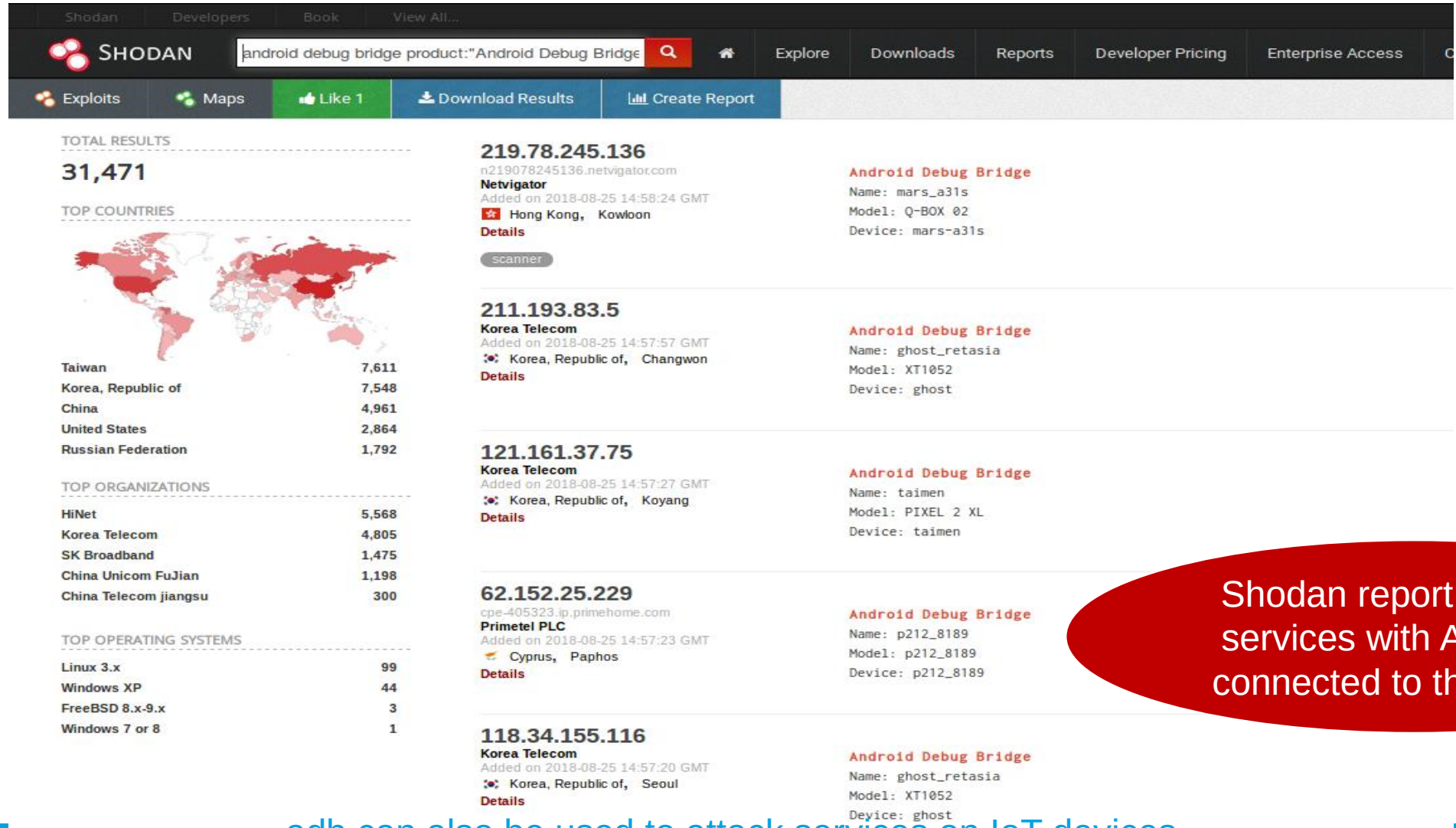


USSD remote attacks through open ADB ports



USSD execution through a terminal for a device connected to Wi-Fi

Remote USSD execution attacks



Shodan report: showing services with ADB open connected to the internet

adb can also be used to attack services on IoT devices

Recommendations

Remote USSD execution on devices

- Disable ADB
- User education
- Discourage use rooted devices

SIM exploitation using binary OTA

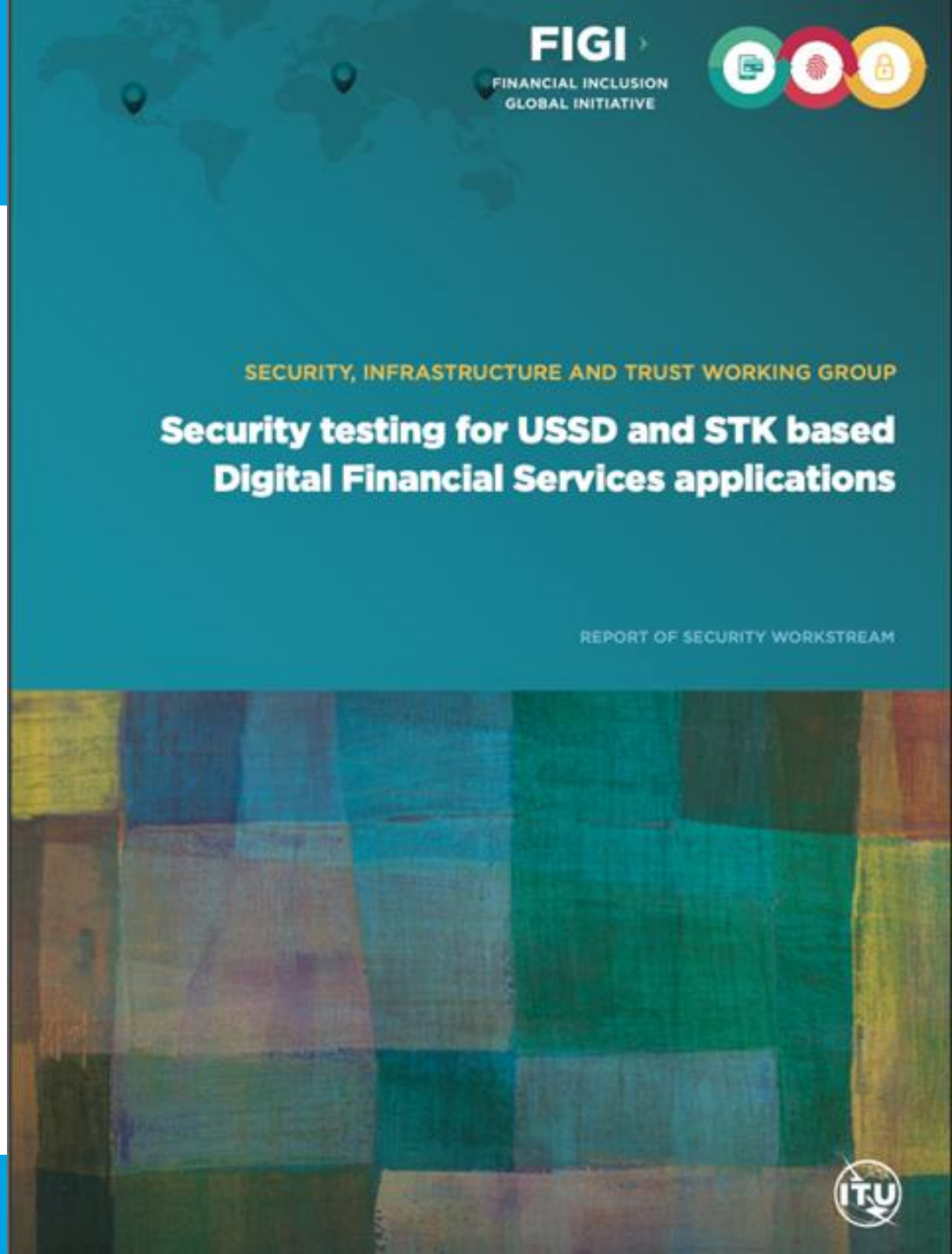
- Binary OTA SMS filtering & blocking.
- SMS home routing.
- SIM card security

Man-in-the-Middle attacks

- Use session timeout
- Secure radio channel communication
- SS7 controls and mitigations

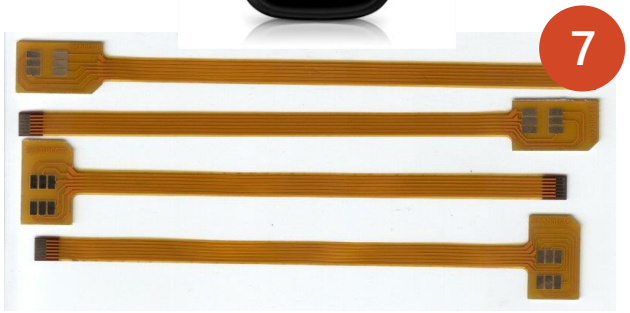
SIM swap and SIM clone attacks

- SIM change detection. (ICCID, IMEI)
- Secure storage of SIM data like IMSI and secret key (KI values)



Hardware for security testing of USSD and STK based DFS

1. Laptop
2. Mobile Android smartphone, Samsung S4
3. Card reader
4. SIM card adapter
5. Mobile featurephone, Samsung 1200
6. Programmable/blank SIMs
7. SIMtrace microSIM & SIM (3FF) FPC Cable
8. SIMtrace2 Hardware Kit
9. Wi-Fi router - Synology RT2600AC



Software for USSD and STK based DFS security testing

i. pySIM: - SIM cloning

ii. SIMtrace: - Man-in-the-middle attacks

iii. SIM tester: - Binary OTA attacks

iv. ADB platform tools: - Remote USSD attack

v. Wireshark: - STK analysis

Android App Security Vulnerabilities and Tests

Introduction

The Open Web Application Security Project

A collaborative, non-for-profit foundation that works to improve the security of web applications

Also works on security of mobile applications.

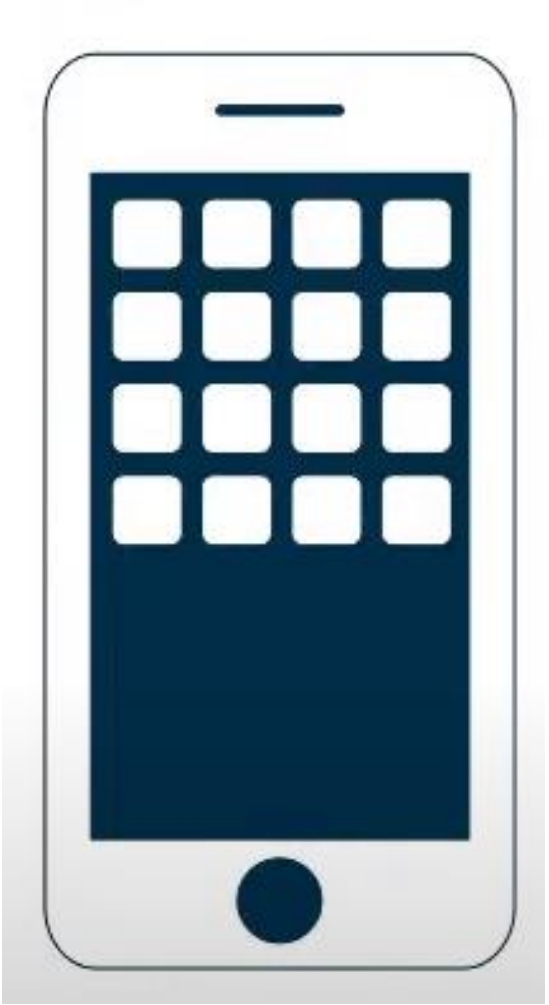
OWASP Mobile Top Ten

OWASP project that aims to identify and document the top ten vulnerabilities of mobile applications

Lab methodology

18 tests organized according to OWASP mobile top ten

Smartphone tests



- Our tests are organized according to the subjects of the OWASP Mobile Top Ten:
  - M1 Improper Platform Usage
  - M2 Insecure Data Storage
  - M3 Insecure Communication
  - M4 Insecure Authentication
  - M5 Insufficient Cryptography
  - M6 *Insecure Authorization*
  - M7 *Client Code Quality*
  - M8 Code Tampering
  - M9 Reverse Engineering
  - M10 *Extraneous Functionality*
- M6, M7, M10 out of scope because they would need access to the source code or require collaboration with the editor

M1 Improper Platform Usage

The application should make correct use of the features of the platform

T1.1 Android:allowBackup

- Backup of the application and its data into the cloud should be disabled

T1.2 Android:debuggable

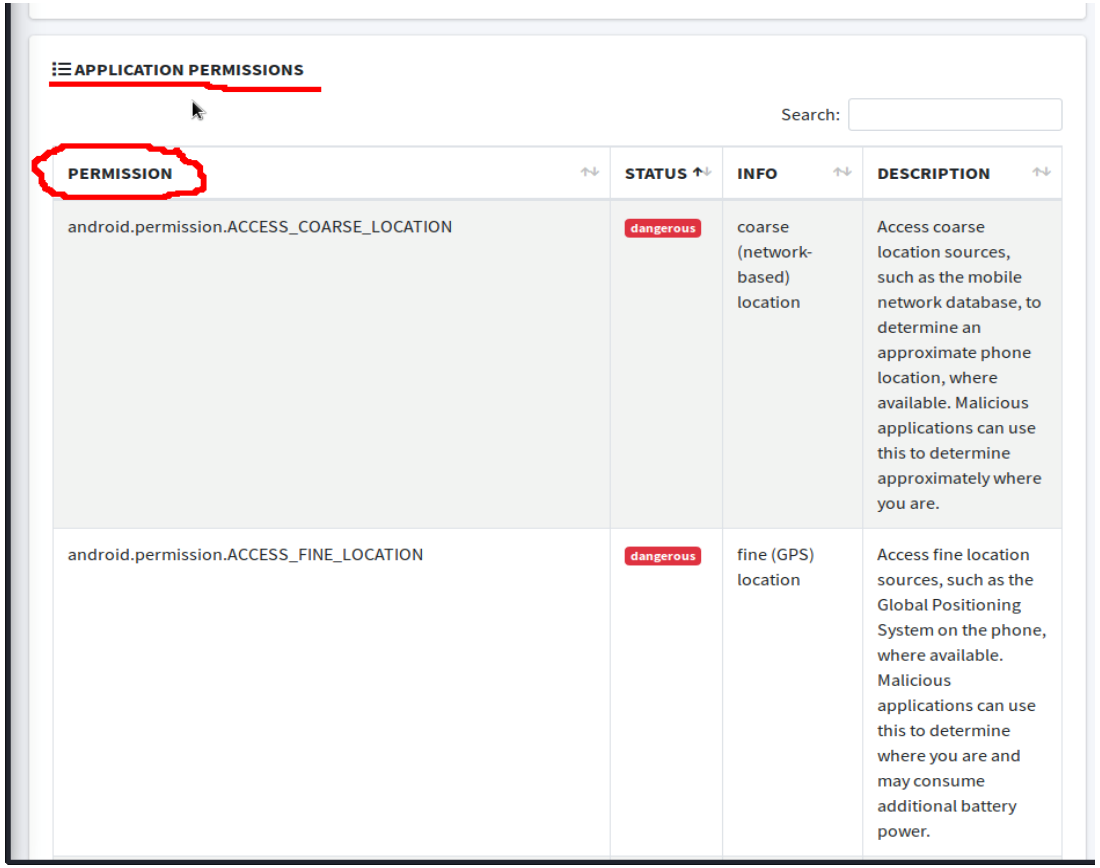
- Debugging features of the application should be disabled

T1.3 Android:installLocation

- The application should be installed in the internal, more secure, memory

T1.4 Dangerous permissions

- The application should not require dangerous permissions, as defined by Android.



M2 Insecure Data Storage

Data should be stored in a way that limits the risks in case of loss or compromise of the phone

T2.1 Android.permission.WRITE_EXTERNAL_STORAGE

- No permission to write to a removable memory card

T2.2 Disabling screenshots

- If not disabled, screen shots are done automatically to generate thumbnails for task switching

M3 Insecure Communication

Protect against eavesdropping and manipulation of traffic

T3.1 Application should only use HTTPS connections

- Test by sniffing traffic

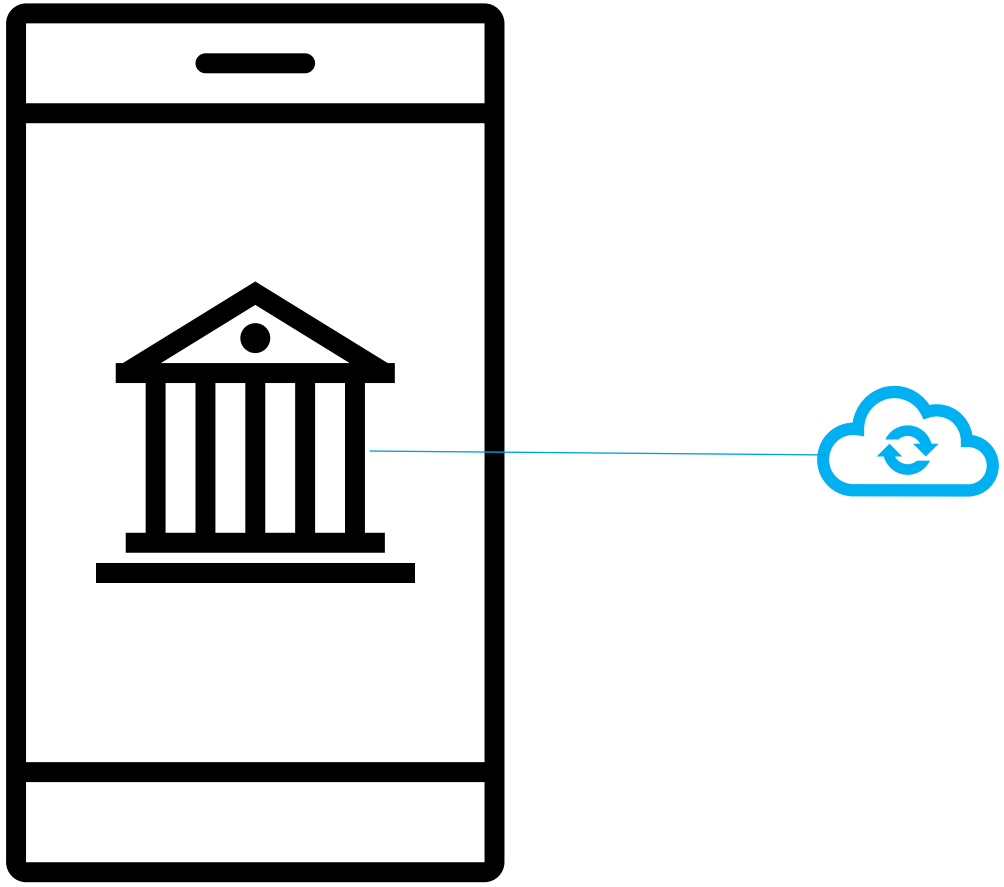
T3.2 Application should detect Machine-in-the-Middle attacks with untrusted Certificates

- Would allow anybody to intercept traffic
- Test by intercepting traffic with proxy

T3.3 Application should detect Machine-in-the-Middle attacks with trusted certificate

- Would allow authorities to intercept traffic
- Test by installing root certificate on phone, intercept with proxy

T3.4 App manifest should not allow clear text traffic



Burp Project Intruder Repeater Window Help Logger++ Backslash

Errors | EsPReSSO | ExifTool | JSON Beautifier | Deserialization Scanner | Logger++ | Paramalyzer | Versions | Software Vulnerability Scanner | Additional Scanner Checks

Dashboard | Target | Proxy | Intruder | Repeater | Sequencer | Decoder | Comparer | Extender | Project options | User options | AuthMatrix | Bypass WAF | CO2

Intercept | HTTP history | WebSockets history | Options

Filter: Hiding out of scope items

#	Host	Method	URL	Params	Edited	Status	Length	MIME type	Extension	Title	Comment	TLS	IP	Cookies	Time
148	https	GET	/iizwlm?_=1594371899392	✓		200	491	JSON				✓			11:04:55
145	https	GET	/iizwlm?_=1594371717242	✓		200	491	JSON				✓			11:01:53
144	https	GET	/iizwlm?_=1594371530169	✓		200	491	JSON				✓			10:58:46
141	https	GET	/P2PPaymentSystem/P2PInterfaceP2PLogin/V4_...	✓		200	576	JSON				✓			10:55:43
139	https	POST	/smartphone/service/v11/privateCustomers/me...	✓		200	1480	JSON				✓			10:55:23
138	https	GET	/smartphone/service/v11/privateCustomers/me...	✓		200	870	JSON				✓			10:55:20
137	https	POST	/P2PPaymentSystem/P2PInterfaceP2PLogin/V4_...	✓		200	805	JSON				✓			10:55:11
136	https	POST	/smartphone/service/v11/orders/p2p/send	✓		200	777	JSON				✓			10:55:09
135	https	GET	/P2PPaymentSystem/P2PInterfaceP2PLogin/V4_...	✓		200	576	JSON				✓			10:55:03
134	https	GET	/P2PPaymentSystem/P2PInterfaceP2PLogin/V4_...	✓		200	576	JSON				✓			10:54:47
133	https	GET	/P2PPaymentSystem/P2PInterfaceP2PLogin/V4_...	✓		200	576	JSON				✓			10:54:17
132	https	GET	/smartphone/service/v11/orders?limit=100&pa...	✓		200	18539	JSON				✓			10:53:47
131	https	POST	/smartphone/service/v11/privateCustomers/me...	✓		200	1480	JSON				✓			10:53:46
130	https	GET	/smartphone/service/v11/privateCustomers/me...	✓		200	870	JSON				✓			10:53:45
129	https	GET	/smartphone/service/v11/orders?since=1970-0...	✓		200	50014	JSON				✓			10:53:45
128	https	POST	/P2PPaymentSystem/P2PInterfaceP2PLogin/V4...	✓		200	1340	JSON				✓			10:53:45

Request | Response

Raw | Params | Headers | Hex | JSON | JSON Beautifier

```
POST /smartphone/service/v11/orders/p2p/send HTTP/1.1
Accept-Encoding: gzip, deflate
Accept: application/json
Accept-Language: fr_CH
X-TWINT-WALLETAPP-LIB-VERSION: 15.3.0.18
Cookie: Navajo=UNBjXYuG2vyu2A3NYol+qgo/M3ThiBT8PhA944Z6Do/24f5NEDkkahF2VEohHy0zNKx2UuZivUg-
Content-Type: application/json; charset=UTF-8
Content-Length: 764
Host: [redacted]
Connection: close
User-Agent: okhttp/3.12.0
ADRUM_1: isMobile:true
ADRUM: isAjax:true

{
  "amount":{
    "amount":20,
    "currency":"CHF"
  },
  "certificateFingerprint":"ef                                417b",
  "moneyReceiver":{
    "firstName"
    "lastName":
  },
  "moneyReceiverMobileNumber":"+4179      ",
  "moneySender":{
    "firstName"
    "lastName":
  },
  "orderUuid":"13976b6e-a57c-448a-8535-51d97f01928d",
  "reservationDate":"2020-07-10T08:55:12",
  "sendMoneyEvenIfCustomerUnknown":true,
  "signature":"gu2DEXJ5pqGx+0c6vQmOcU04MmYqyb+RIHTt8iZ4jHGcul/Jx8iIWVlm6WU64G58oJnnEGH8WArldOmmc61/bZEjOEF3fRXR/2kffAreQNhEOlUc18sJFxx96iAt3Hfe336yHehB0qZ9zTKgtMZwGu8s3tzJNRpvRszio2QCk5X7SIh26AiO4KD047uFmKEPThC
}
```

Clear text traffic in intercepted requests can be manipulated

M4 Insecure Authentication

Prevent unauthorized access to the application

T4.1 Authentication required before accessing sensitive information

- Application must require PIN or fingerprint

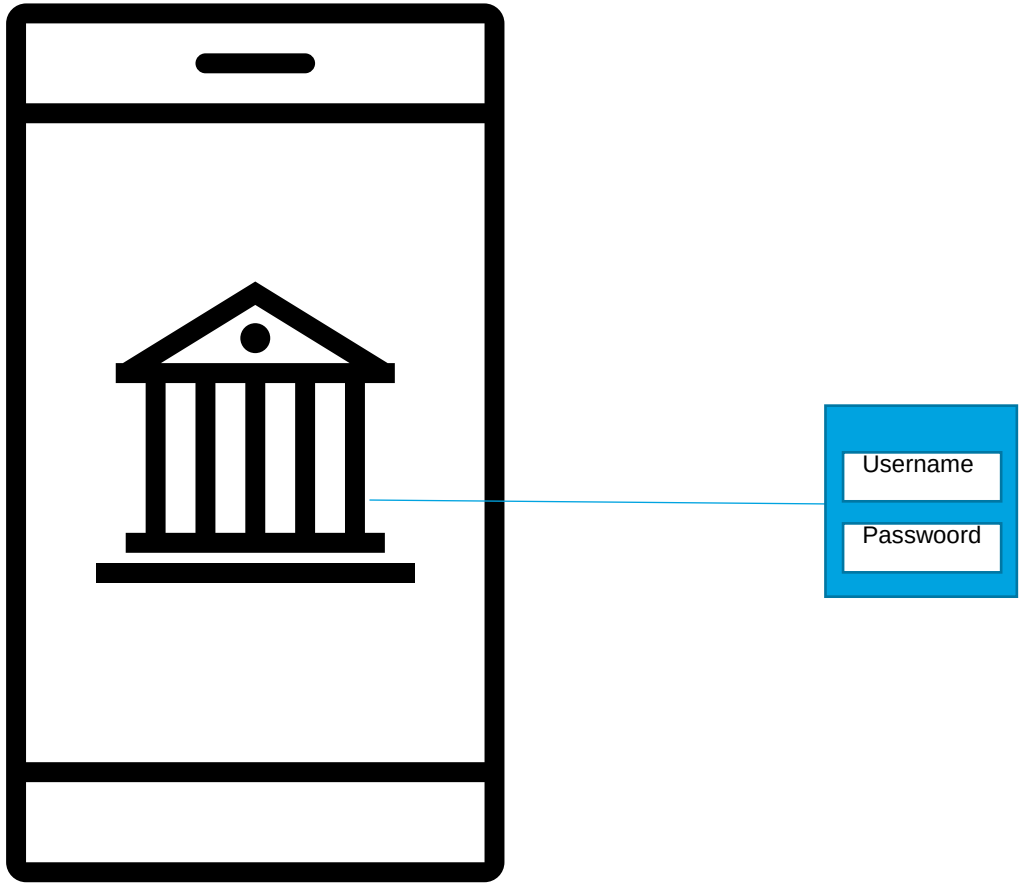
T4.2 The application should have an inactivity timeout

T4.3 If a new fingerprint is added, authentication with fingerprints should be temporarily disabled

- User should provide PIN to enable fingerprints again
- Prevents attacks where an attacker adds their fingerprint to access the application

T4.4 It should not be possible to replay intercepted requests (e.g. a money transfer)

- An attacker intercepting a request for a money transfer could replay it to steal money from the victim.



M5: Insufficient Cryptography

```
"moneyReceiverMobileNumber":"+4179
"moneySender":{
  "firstName"
  "lastName":
},
```

```
112.     }
113.
114.     @TargetApi(8)
115.     public static File b(Context context) {
116.         if (bl.a()) {
117.             return context.getExternalCacheDir();
118.         }
119.         return new File(Environment.getExternalStorageDirectory().getPath()
120.     }
121.
122.     public static String b(String str) {
123.         try {
124.             MessageDigest instance = MessageDigest.getInstance("SHA-1");
125.             instance.update(str.getBytes());
126.             return a(instance.digest());
127.         } catch (NoSuchAlgorithmException unused) {
128.             return String.valueOf(str.hashCode());
129.         }
130.     }
131.
132.     @TargetApi(9)
133.     public static boolean b() {
134.         if (bl.b()) {
135.             return Environment.isExternalStorageRemovable();
136.         }
```

Cryptography can only protect confidentiality and integrity of data if correctly implemented

T5.1 The app should not use unsafe crypto primitives

- E.g., MD5, SHA-1, RC4, DES, 3DES, Blowfish, ECB
- Search for these in the code
- Detection of these primitives does not imply that they are used for protecting critical information!

T5.2 The HTTPS connections should be configured according to best practices

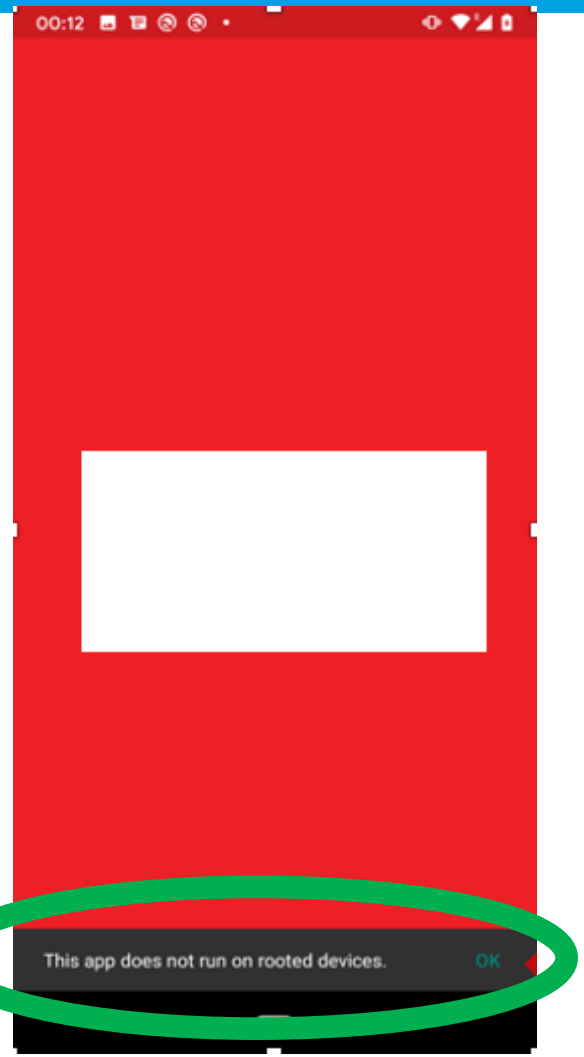
- Watch where the app connects to, use Qualys SSL labs to evaluate configuration, expect a grade of B or more

M8: Code Tampering

Prevent an attacker from tampering the code on the telephone

T8.1 The application should refuse to run on a rooted device

- On a rooted device, users can manipulate the code of the application



M9 Reverse engineering

```
            instance.update(str.getBytes());
            return a(instance.digest());
        } catch (NoSuchAlgorithmException unused) {
            return String.valueOf(str.hashCode());
        }
    }

    @TargetApi(9)
    public static boolean b() {
        if (bl.b()) {
            return Environment.isExternalStorageRemovable();
        }
        return true;
    }

    public Bitmap a(String str) {
        dt<String, Bitmap> dtVar = this.d;
        if (dtVar != null) {
            return dtVar.a(str);
        }
        return null;
    }

    public void a() {
        synchronized (this.g) {
            if (this.c == null || this.c.a()) {
                File file = this.f.c;
                if (this.f.g && file != null) {
                    if (!file.exists()) {
                        file.mkdirs();
```

Prevent attackers from analyzing the logic of the application

T9.1 The code should be obfuscated

- When the code is obfuscated, it is much more difficult to understand the logic of the code
- This makes it more difficult to manipulate the code or to find potential vulnerabilities
- Decompile the code and assess its readability

Android apps tests summary

Application security best practices	Corresponding tests
9.1 Device integrity	T1.2 Android:debuggable T1.4 Dangerous permissions T8.1 The application should refuse to run on a rooted device
9.2 Communication Security and Certificate Handling	T3.1 Application should only use HTTPS connections T3.2 Application should detect Machine-in-the-Middle attacks with untrusted certificates T3.3 Application should detect Machine-in-the-Middle attacks with trusted certificates T3.4 App manifest should not allow clear text traffic T5.1 The app should not use unsafe crypto primitives T5.2 The HTTPS connections should be configured according to best practices T5.3 The app should encrypt sensitive data that is sent over HTTPS
9.3 User authentication	T4.1 Authentication required before accessing sensitive information T4.2 The application should have an inactivity timeout T4.3 If a fingerprint is added, authentication with fingerprints should be disabled T4.4 It should not be possible to replay intercepted requests
9.4 Secure Data Handling	T1.1 Android:allowBackup T1.3 Android:installLocation T2.1 Android.permission.WRITE_EXTERNAL_STORAGE T2.2 Disabling screenshots
9.5 Secure Application Development	T9.1 The code of the app should be obfuscated

What ITU needs to test DFS applications

USSD and STK Tests

- 2 SIM cards of the networks to be tested.
- Active DFS account on each SIM card.
- DFS Wallet PINs
- Prepaid mobile credit on SIM cards – SIM cards must have mobile roaming enabled for Switzerland
- USSD codes for each of the DFS providers.
- Credit on DFS Wallets ($10 to be used for testing)

Android application tests

- In addition to the above requirements,
- Android apps (apk file) must be shared, or links to download the apps from the Play Store.

Questions

Contact: dfssecuritylab@itu.int

www.itu.int