Keep it Like a Secret:
When Android Apps Contain Private Keys

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CERT/CC

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Legal

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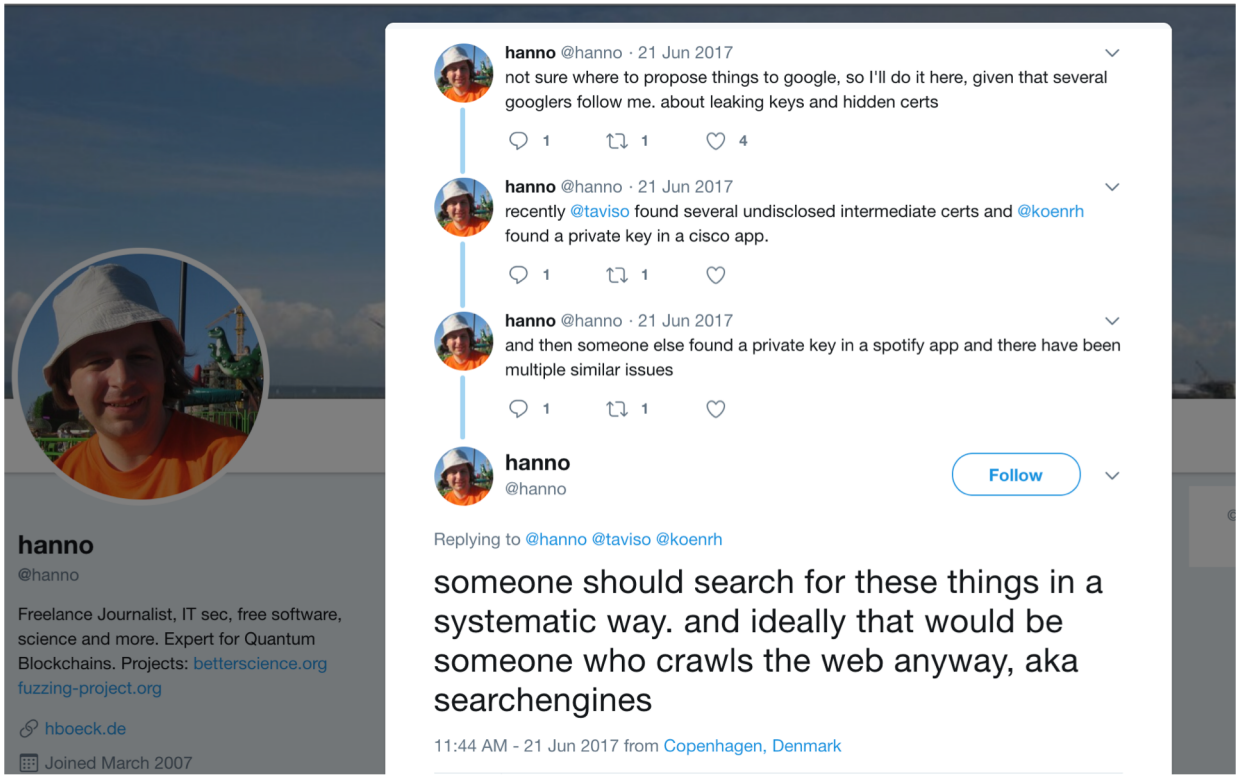
DM18-0416

Background

The Inspiration



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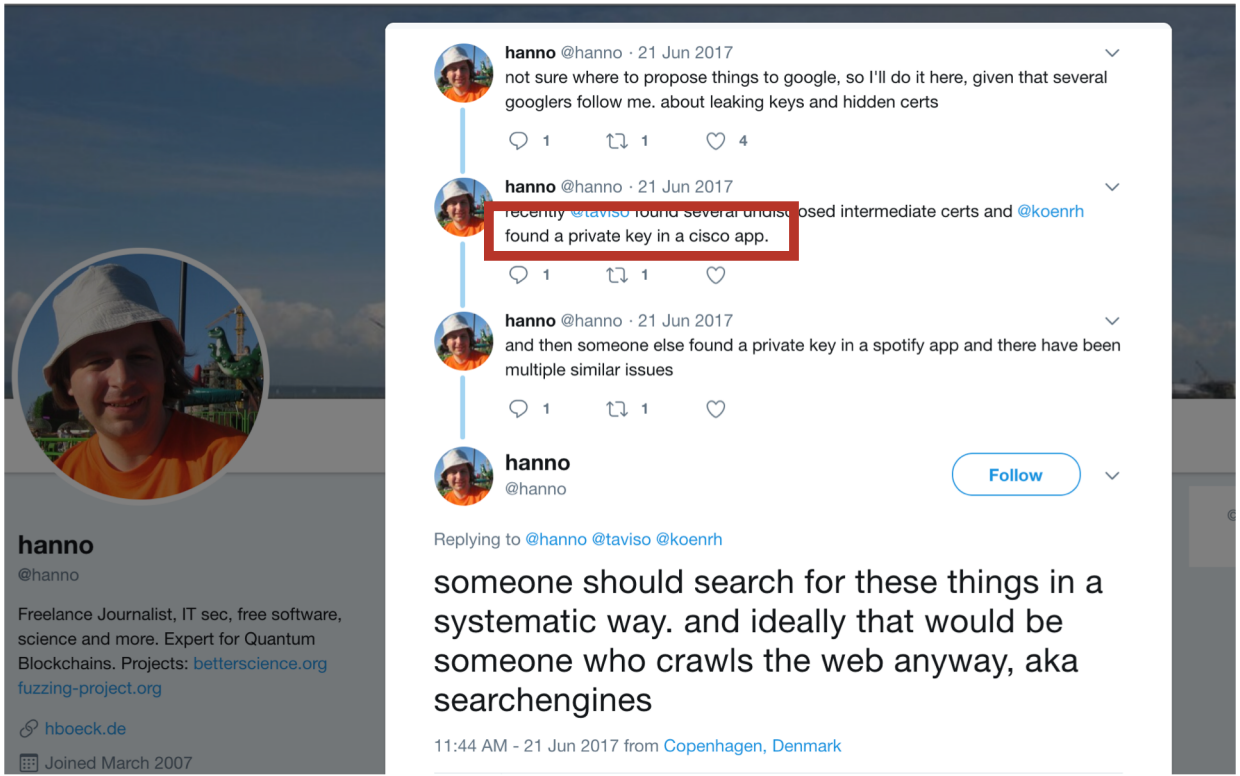

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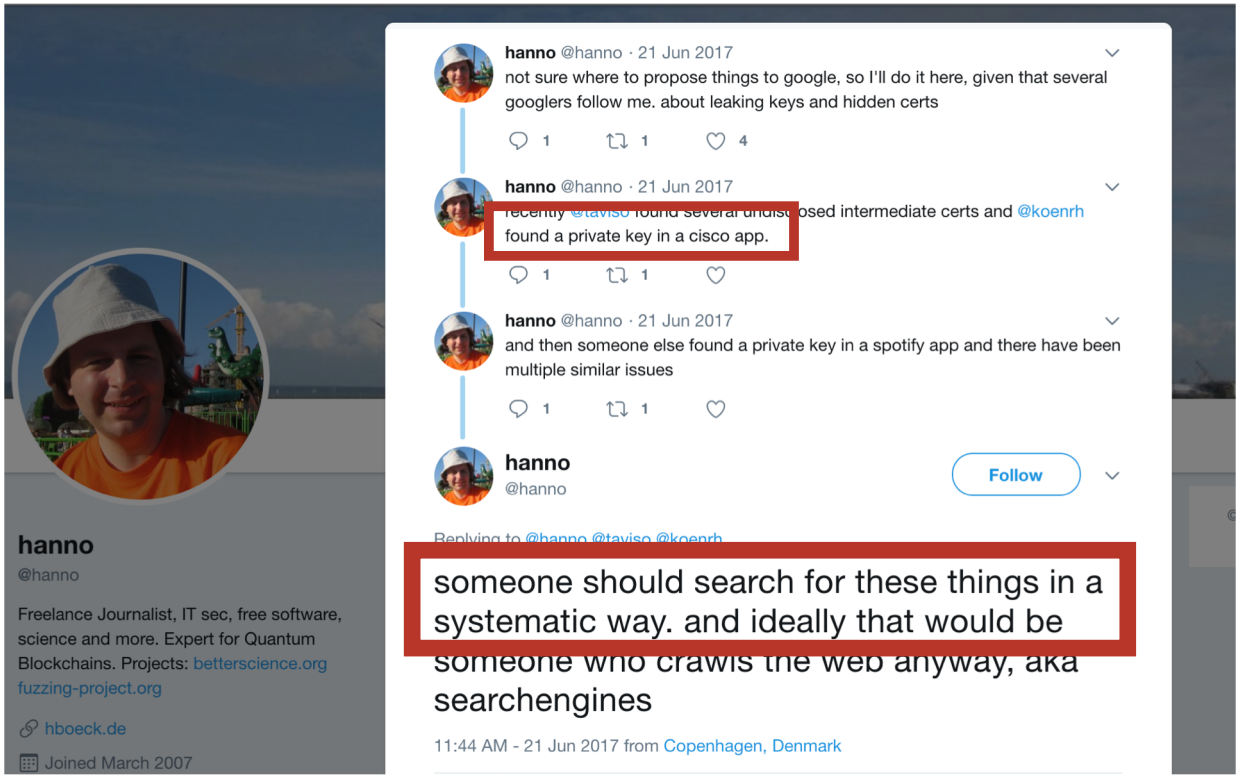

Prior Android Work

#RSAC

The Numbers

	Total	Percent
Free Apps Tested	1,000,500	Most?
Vulnerable Apps Discovered	23,667	2.4%
Vulnerable App Authors Notified	23,301	98.5%
Email responses	1,593	6.8%
Email responses with fix details	25	0.1%

"There are now 1 million apps in the Google Play store."
July 24, 2013

http://mashable.com/2013/07/24/google-play-1-million/

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RSAConference2015

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Why Private Keys Matter

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Private key files can be used for a number of purposes, including:

- Signing Android Applications
- Signing IOS Applications
- Encrypting HTTPS traffic
- More!

Getting Android Apps

Downloading APK Files

```
while true; do
   cat /usr/share/hunspell/*.dic | sed 's/\/[^/]*$//' | shuf \
      | xargs -n1 python apkspider.py -k
   echo "Download stopped!?"
   sleep 60
done
```

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https://github.com/matlink/gplaycli
https://github.com/androguard/androguard

Learning from mistakes

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by_sha256/c9/ab/34/
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Picking out Key Files

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Answer: Leverage your sqlite database.

```
select file from files where apkpath = ? and (
file like '%.key' or
file like '%.pem' or
file like '%.der' or
file like '%.p12' or
file like '%.bks' or
file like '%.pfx' or
type like '%key%')
```

Key File Formats

PKCS#1

```
-----BEGIN RSA PRIVATE KEY-----
MIIBOwIBAAJBANxtmQ1Kccdp7HBNt8zgTai48Vv617bj4SnhkcMN99sCQ2Naj/sp
... (snip) ...
NiCYNLiCawBbpZnYw/ztPVACK4EwOpUy+u19cMB0JA==
-----END RSA PRIVATE KEY-----
```

- RSA only
- Not password protected

https://github.com/kjur/jsrsasign/wiki/Tutorial-for-PKCS5-and-PKCS8-PEM-private-key-formats-differences

PKCS#5 - Protected

```
-----BEGIN RSA PRIVATE KEY-----
Proc-Type: 4,ENCRYPTED
DEK-Info: DES-EDE3-CBC,E83B4019057F55E9

iIPs59nQn4RSd7ppch9/vNE7PfRSHLoQFmaAjaF0DxjV9oucznUjJq2gphAB2E2H
... (snip) ...
y5IT1MZPgN3LNkVSsLPWKo08uFZQdfu0JTKcn7NPyRc=
-----END RSA PRIVATE KEY-----
```

- RSA only
- Encryption details included (mode, seed)

https://github.com/kjur/jsrsasign/wiki/Tutorial-for-PKCS5-and-PKCS8-PEM-private-key-formats-differences

PKCS#8 - Plain

```
-----BEGIN PRIVATE KEY-----
MIIBVAIBADANBgkqhkiG9w0BAQEFAASCAT4wggE6AgEAAkEA6GZN0rQFKRIVaPOz
... (snip) ...
LaLGdd9G63kLg85eldSy55uIAXsvqQIgfSYaliVtSbAgyx1Yfs3hJ+CTpNKzTNv/
Fx80EltYV6k=
-----END PRIVATE KEY-----
```

- Multiple algorithms
- Not password protected

https://github.com/kjur/jsrsasign/wiki/Tutorial-for-PKCS5-and-PKCS8-PEM-private-key-formats-differences

PKCS#8 - Protected

```
-----BEGIN ENCRYPTED PRIVATE KEY-----
MIIBpjBABgkqhkiG9w0BBQ0wMzAbBgkqhkiG9w0BBQwwDgQIU9Y9p2EfWucCAggA
... (snip) ...
IjsZNp6zmlqf/RXnETsJjGd0TXRWaEdu+XOOyVyPskX2177X9DUJoD31
-----END ENCRYPTED PRIVATE KEY-----
```

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DER Encoding

Key files can be PEM (base64) or DER (binary) encoding

```
openssl asn1parse -inform der -in KEYFILE
```

If "`prim: OBJECT`" is in the results, and openssl returns with exit code 0, you have a DER-encoded key.

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- Password-protection is optional
- A password causes container-level encryption
- You won't know if a protected PKCS12 file contains a private key until **after** you crack it

Java KeyStore

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- **No** container-level encryption is used
- Private keys share the same password as the container by default
- BKS-V1 keystores use only 16 bits for container-level integrity
  https://insights.sei.cmu.edu/cert/2018/03/the-curious-case-of-the-bouncy-castle-bks-passwords.html

Key File Deception

MIME Magic to the Rescue

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- `/assets/ic_launcher-web.png`

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Password Cracking

Why crack passwords?

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- The impact of a key leak is related to its protection

GPU hardware

GPUs are massively parallel, which is a great match for password cracking.

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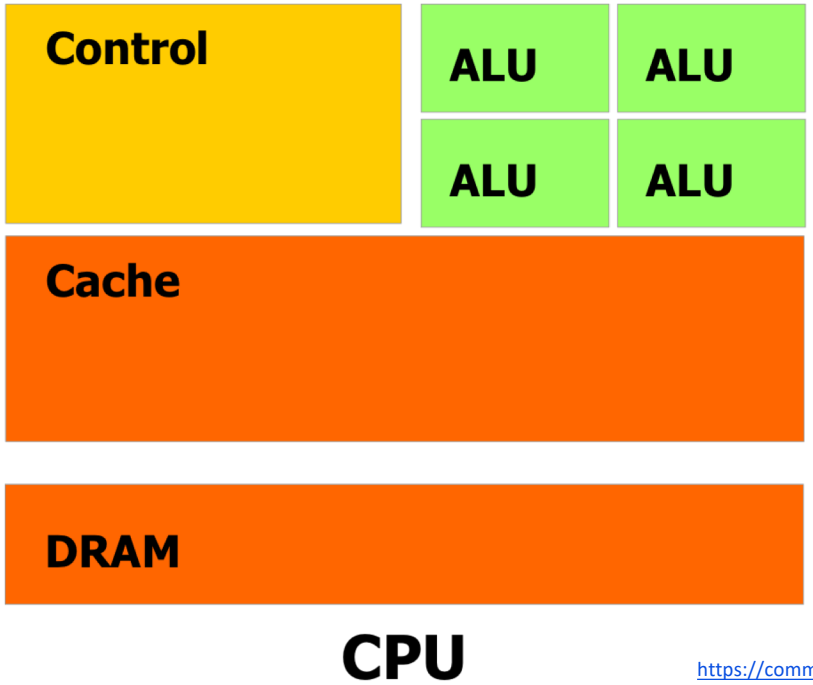

https://commons.wikimedia.org/wiki/File:Cpu-gpu.svg

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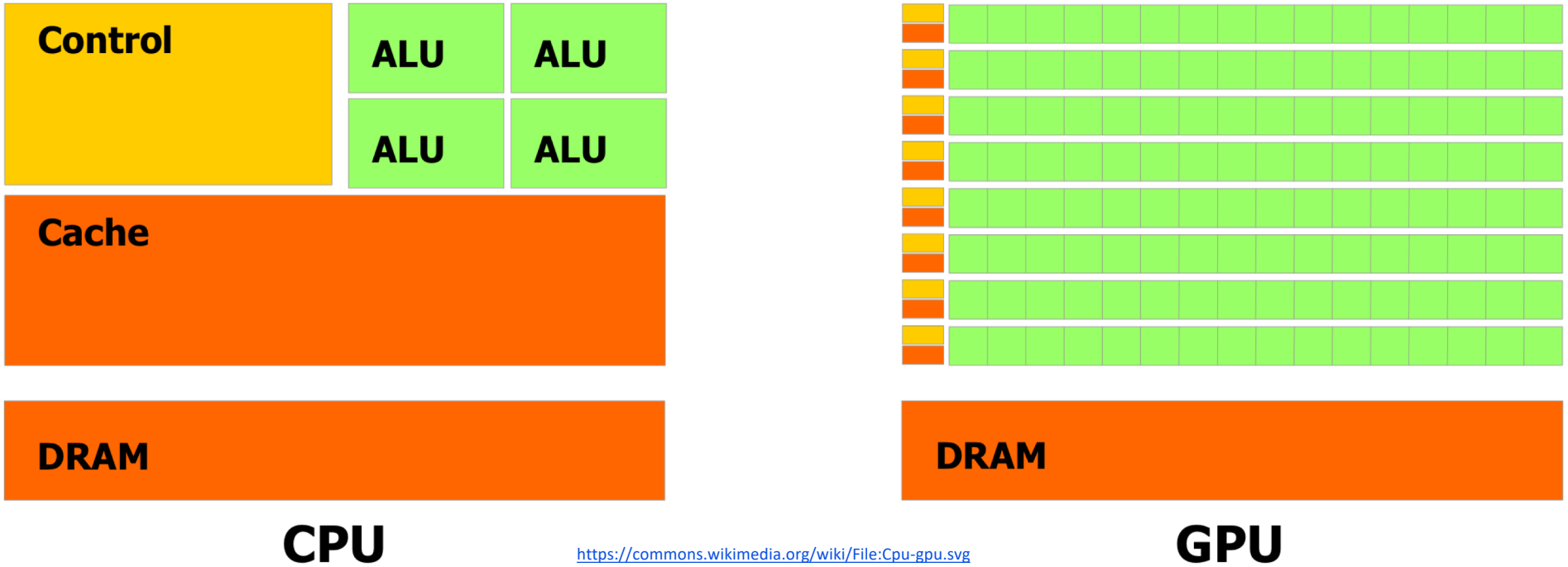

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Password-cracking software

John the Ripper

https://github.com/magnumripper/JohnTheRipper

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Hashcat

https://hashcat.net/hashcat/

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Password Strength

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- Charset size
- Length

Password strength example

Symbols used: digits 0-9 (Charset size:10)

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Length: 1

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Length: 1
Total passwords: 10 (10^1)

Password strength example

Symbols used: digits 0-9 (Charset size:10)

Length: 1
Total passwords: 10 (10^1)

Length: 2

Password strength example

Symbols used: digits 0-9 (Charset size:10)

Length: 1
Total passwords: 10 (10^1)

Length: 2
Total passwords: 100 (10^2)

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Increasing password length grows password strength **exponentially**!

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Total passwords: 1000 (10^3)

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Real-world password cracking times

Password	Charset size	Length	Crack Time
TMAE	26	4	1 second
66aK	62	4	2 seconds
tcdely	26	6	2 seconds
v4lz6o	36	6	27 seconds
>^	32	2	162 seconds
dcgkrnel	26	8	186 seconds
8C;e	84	4	407 seconds (7 mins)
QFsRe7	62	6	1022 seconds (17 mins)
147wyf7g	36	8	9569 seconds (3 hours)

Random passwords found via MD5 with John the Ripper incremental mode on 64 CPU cores

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:@(	32	3	16459 seconds (5 hours)
QLvD:	74	5	59861 seconds (17 hours)
KDJCTFWY	26	8	279959 seconds (3 days)
ahpcwckjq	26	9	472538 seconds (5 days)
{~>[	22	4	475956 seconds (5 days)
lavyovfass	26	10	619300 seconds (7 days)
ob13zgx33	36	9	796192 seconds (9 days)
fqmRDnGY	52	8	1874245 seconds (22 days)

Random passwords found via MD5 with John the Ripper incremental mode on 64 CPU cores

Example Passwords

Which passwords are good?

Rules of the game:

Given an example password, tell me if the password is **weak** or **strong.**

Weak or Strong?

Password:
`changeit`

Weak or Strong?

Password:
`changeit`

Answer:
WEAK

Weak or Strong?

Password:
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Answer:
WEAK

Reason:
Present in “rockyou” password list

https://github.com/danielmiessler/SecLists/tree/master/Passwords

Weak or Strong?

Password:
`7y6t5r4e`

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- Numbers and symbols at end
- Hashcat rules target human nature

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Cracked by hashcat “naïve” strategy

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Password:
`delaunay55`

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Answer:
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Reason:
Author left a note.

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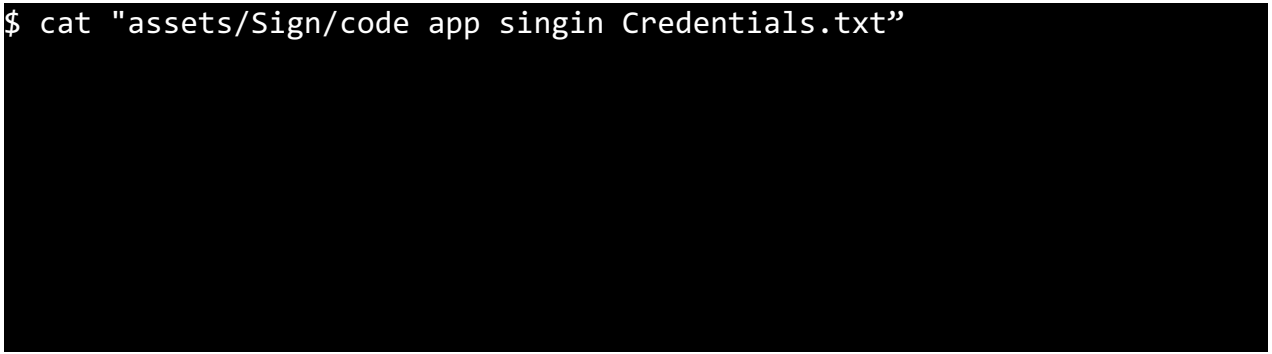

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WEAK

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```
$ cat "assets/Sign/code app singin Credentials.txt"
   signingConfigs {
        config {
            keyAlias 'codehospitality'
            keyPassword 'delaunay55'
            storeFile file('C:/Users/Al/keystores/codehospitality.jks')
            storePassword 'delaunay55'
        }
    }
```

Weak or Strong?

Password:
`SamSam1cooke!`

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Answer:
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```
$ cat /assets/www/config/README.txt
The apple developer credentials are:
[redacted]@[redacted]
[redacted]


The Google Play credentials are:
[redacted]@[redacted]
[redacted]

The password for the sean.p12 file:
SamSam1cooke!
```

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```
$ cat res/values/strings.xml
…
<string
name="lyfpay_certificate_password">yXPZ1gzxFkV68NKquIpa93BLeHiC7Yjd
</string>
…
```

Weak or Strong?

Password:
`305P6N2cEl4nkH!T$1q*`

Weak or Strong?

Password:
`305P6N2cEl4nkH!T$1q*`

Answer:
WEAK

Weak or Strong?

Password:
`305P6N2cEl4nkH!T$1q*`

Answer:
WEAK

Reason:
It’s in the application.

Weak or Strong?

Password:
`305P6N2cEl4nkH!T$1q*`

Answer:
WEAK

Reason:
It's in the application.

```
$ cat decompiled/com/[redacted]/security/SecurityUtil.java
```

Weak or Strong?

Password:
305P6N2cEl4nkH!T$1q*

Answer:
WEAK

Reason:
It's in the application.

```
$ cat decompiled/com/[redacted]/security/SecurityUtil.java
public class SecurityUtil {
    private static final char[] certPass;

    static {
        SecurityUtil.certPass = new char[]{'3', '0', '5', 'P', '6',
'N', '2', 'c', 'E', 'l', '4', 'n', 'k', 'H', '!', 'T', '$', '1', 'q',
'*'};
    }
```

Weak or Strong?

Password:
gaypark@lespark#gzxyindex.php

Weak or Strong?

Password:
`gaypark@lespark#gzxyindex.php`

Answer:
WEAK

Weak or Strong?

Password:
`gaypark@lespark#gzxyindex.php`

Answer:
WEAK

Reason:
It’s in the application.

Weak or Strong?

Password:
`gaypark@lespark#gzxyindex.php`

Answer:
WEAK

Reason:
It's in the application.

Decompiled `liblespark.so` in IDA:

Weak or Strong?

Password:
gaypark@lespark#gzxyindex.php

Answer:
WEAK

Reason:
It's in the application.

Decompiled `liblespark.so` in IDA:

```
EXPORT
Java_com_redwolfama_peonylespark_util_jni_PasswordUtil_getSSLPassword
Java_com_redwolfama_peonylespark_util_jni_PasswordUtil_getSSLPassword
PUSH            {R3,LR}
LDR             R3, [R0]
LDR             R1, =(aGayparkLespark - 0x11FE)
LDR.W           R3, [R3,#0x29C]
ADD             R1, PC  ; "gaypark@lespark#gzxyindex.php"
BLX             R3
POP             {R3,PC}
; End of function
Java_com_redwolfama_peonylespark_util_jni_PasswordUtil_getSSLPassword
```

Weak or Strong?

Password:
gaypark@lespark#gzxyindex.php

Answer:
WEAK

Reason:
It's in the application.

Decompiled `liblespark.so` in IDA:

```
EXPORT
Java_com_redwolfama_peonylespark_util_jni_PasswordUtil_getSSLPassword
Java_com_redwolfama_peonylespark_util_jni_PasswordUtil_getSSLPassword
PUSH            {R3,LR}
LDR             R3, [R0]
LDR             R1, =(aGayparkLespark - 0x11FE)
LDR.W           R3, [R3,#0x29C]
ADD             R1, PC  ; "gaypark@lespark#gzxyindex.php"
BLX             R3
POP             {R3,PC}
; End of function
Java_com_redwolfama_peonylespark_util_jni_PasswordUtil_getSSLPassword
```

Weak or Strong?

Password:
`T.G-8~KvkNwvB&7g`

Weak or Strong?

Password:
`T.G-8~KvkNwvB&7g`

Answer:
STRONG

Weak or Strong?

Password:
`T.G-8~KvkNwvB&7g`

Answer:
STRONG

Reasons:

- It is long enough
- It uses a large character set
- It has no patterns recognizable by a cracker

Keys used by apps

If a private key is contained within and used by an application...

Keys used by apps

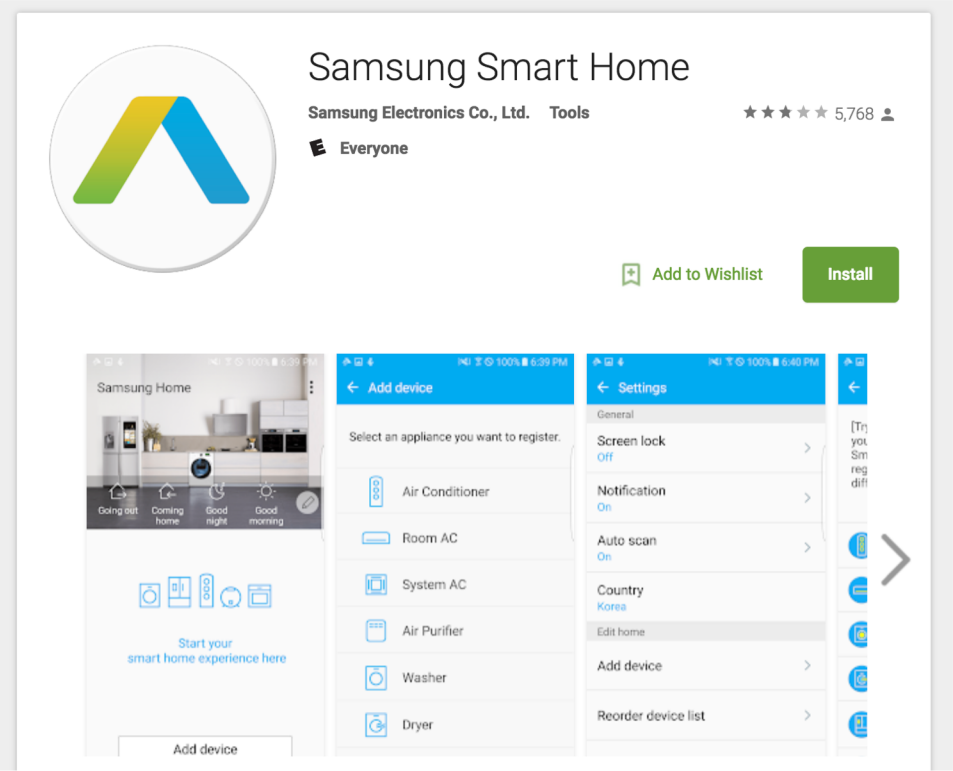
If a private key is contained within and used by an application...

it doesn’t matter how strong you’ve made it!

Keep it Like a Secret: When Android Apps Contain Private Keys

Case Study: Samsung SmartHome

Samsung SmartHome



Samsung SmartHome

ADDITIONAL INFORMATION

Updated
February 5, 2018

Installs
1,000,000 - 5,000,000

Current Version
3.1072.19.203

Requires Android
4.0 and up

Content Rating
Everyone
Learn more

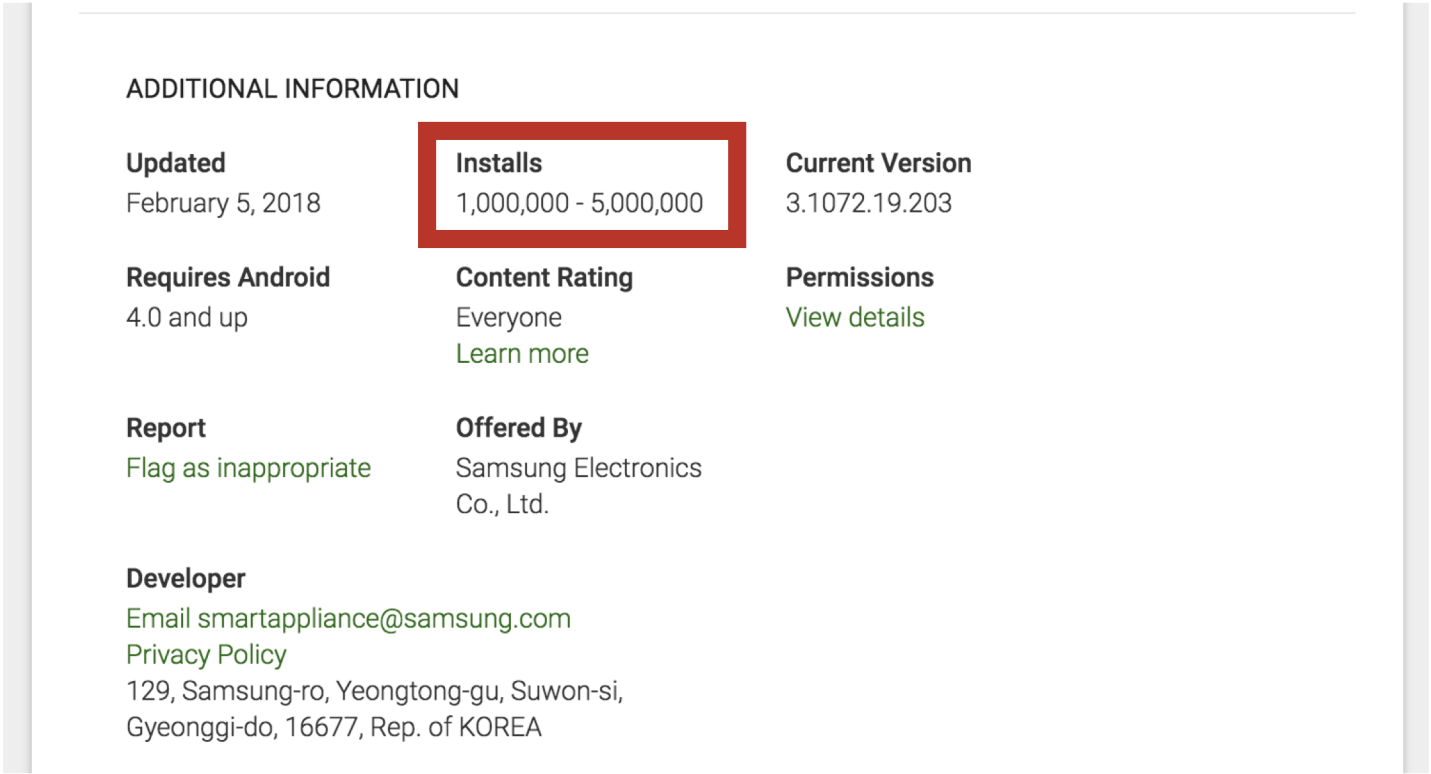
Permissions
View details

Report
Flag as inappropriate

Offered By
Samsung Electronics Co., Ltd.

Developer
Email smartappliance@samsung.com
Privacy Policy
129, Samsung-ro, Yeongtong-gu, Suwon-si, Gyeonggi-do, 16677, Rep. of KOREA

Samsung SmartHome



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Privacy Policy
129, Samsung-ro, Yeongtong-gu, Suwon-si, Gyeonggi-do, 16677, Rep. of KOREA

Finding a private key used by a popular app

```
sqlite> select file, keyused, dlcount from keys inner join apks on keys.appname = apks.appname
where file like '%COMMON14K_M_priv%' order by apks.dlcount desc;
```

Finding a private key used by a popular app

```
sqlite> select file, keyused, dlcount from keys inner join apks on keys.appname = apks.appname
where file like '%COMMON14K_M_priv%' order by apks.dlcount desc limit 10;
keys/com.samsung.smarthome/assets/certificates/COMMON14K_M_priv.pem|0|1000000
keys/com.samsung.smarthome.refrigerator/assets/certificates/COMMON14K_M_priv.pem|1|10000
keys/com.samsung.smarthome.dvm/assets/certificates/COMMON14K_M_priv.pem|0|10000
keys/com.samsung.dacorsmarthome/assets/certificates/COMMON14K_M_priv.pem|0|500
sqlite>
```

Finding a private key used by a popular app

```
sqlite> select file, keyused, dlcount from keys inner join apks on keys.appname = apks.appname
where file like '%COMMON14K_M_priv%' order by apks.dlcount desc limit 10;
keys/com.samsung.smarthome/assets/certificates/COMMON14K_M_priv.pem|0|1000000
keys/com.samsung.smarthome.refrigerator/assets/certificates/COMMON14K_M_priv.pem|1|10000
keys/com.samsung.smarthome.dvm/assets/certificates/COMMON14K_M_priv.pem|0|10000
keys/com.samsung.dacorsmarthome/assets/certificates/COMMON14K_M_priv.pem|0|500
sqlite>
```

Finding the reference to the private key

```
$ grep -rl COMMON14K_M_priv.pem .
```

Finding the reference to the private key

```
$ grep -rl COMMON14K_M_priv.pem .
decompiled/com/samsung/smarthome/refrigerator/SmartHomeLauncherActivity.java
smali/com/samsung/smarthome/refrigerator/SmartHomeLauncherActivity.smali
original/META-INF/MANIFEST.MF
original/META-INF/CERT.SF
strings.txt
$
```

Finding the reference to the private key

```
$ grep -rl COMMON14K_M_priv.pem .
decompiled/com/samsung/smarthome/refrigerator/SmartHomeLauncherActivity.java
smali/com/samsung/smarthome/refrigerator/SmartHomeLauncherActivity.smali
original/META-INF/MANIFEST.MF
original/META-INF/CERT.SF
strings.txt
$
```

Finding the reference to the private key

```
$ cat decompiled/com/samsung/smarthome/refrigerator/SmartHomeLauncherActivity.java
…
 String[] v0_1 = new String[4];
        v0_1[0] = "DHE-RSA-AES128-SHA";
        v0_1[1] = "DHE-RSA-AES256-SHA";
        v0_1[v4] = "AES128-SHA";
        v0_1[3] = "AES256-SHA";
        SSLswitch.setServerCiphers(v0_1);
        SSLswitch.setClientCiphers(v0_1);
        SSLswitch.setRunSSL(this.getApplicationContext(), true);
        SSLswitch.setShp_certificates("ca-certificates_20151109.crt");
        SSLswitch.setCertChain("CertChain.pem");
        SSLswitch.setMyCert("COMMON14K_M_CertChain.pem");
        SSLswitch.setPrivateKey("COMMON14K_M_priv.pem");
        SSLswitch.setPassword("KKJSB04XvDQMC0rm2LHTHhAyK3iBVfpHBuQCXwKEYN4=");
        SSLswitch.setDHParam("dh_param_1024.pem")
```

Finding the reference to the private key

```
$ cat decompiled/com/samsung/smarthome/refrigerator/SmartHomeLauncherActivity.java
…
 String[] v0_1 = new String[4];
        v0_1[0] = "DHE-RSA-AES128-SHA";
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        v0_1[3] = "AES256-SHA";
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        SSLswitch.setRunSSL(this.getApplicationContext(), true);
        SSLswitch.setShp_certificates("ca-certificates_20151109.crt");
        SSLswitch.setCertChain("CertChain.pem");
        SSLswitch.setMyCert("COMMON14K_M_CertChain.pem");
        SSLswitch.setPrivateKey("COMMON14K_M_priv.pem");
        SSLswitch.setPassword("KKJSB04XvDQMC0rm2LHTHhAyK3iBVfpHBuQCXwKEYN4=");
        SSLswitch.setDHParam("dh_param_1024.pem")
```

Finding the reference to the private key

```
$ echo 'KKJSB04XvDQMC0rm2LHTHhAyK3iBVfpHBuQCXwKEYN4=' | base64 -D
```

Finding the reference to the private key

```
$ echo 'KKJSB04XvDQMC0rm2LHTHhAyK3iBVfpHBuQCXwKEYN4=' | base64 -D
(RN4

      J+2x U G _ `
```

Finding the reference to the private key

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 String[] v0_1 = new String[4];
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        SSLswitch.setCertChain("CertChain.pem");
        SSLswitch.setMyCert("COMMON14K_M_CertChain.pem");
        SSLswitch.setPrivateKey("COMMON14K_M_priv.pem");
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Decoding the key password

```
$ cat decompiled/com/sec/smarthome/framework/security/SSLswitch.java
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Decoding the key password

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$ cat decompiled/com/sec/smarthome/framework/security/SSLswitch.java
…

public static void setPassword(String arg1) {
    SSLswitch.password = PswGenerator.decryptPBE(arg1);
}
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```

Decoding the key password

```
$ cat decompiled/com/sec/smarthome/framework/security/PswGenerator.java
// Decompiled by JEB v2.3.10.201802032133

package com.sec.smarthome.framework.security;

…

public static String decryptPBE(String arg9) {
        String v0_5;
        byte[] v1_1;
        String v4 = null;
        int v3 = 0;
        byte[] v6 = PswGenerator.createKey(PswGenerator.salt, PswGenerator.key_data);
…
```

Decoding the key password

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…
```

VERY COMPLICATED

Decoding the key password

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$ cat decompiled/com/sec/smarthome/framework/security/PswGenerator.java
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        byte[] v1_1;
        String v4 = null;
        int v3 = 0;
        byte[] v6 = PswGenerator.createKey(PswGenerator.salt, PswGenerator.key_data);
…
```

VERY COMPLICATED

... but it doesn't matter!

Using the existing code

```
$ cat PswGenerator.Java.diff
--- PswGenerator.orig.java  2018-02-16 14:20:53.930636617 -0500
+++ PswGenerator.java   2018-02-20 13:17:30.717678481 -0500
@@ -1,8 +1,8 @@
 // Decompiled by JEB v2.3.10.201802032133

…



+
 public class PswGenerator {
+
+  public static void main(String[] args)
+  {
+    String pw;
+    System.out.println("Attempting to decode 'KKJSB04XvDQMC0rm2LHTHhAyK3iBVfpHBuQCXwKEYN4='...");
+    pw = PswGenerator.decryptPBE("KKJSB04XvDQMC0rm2LHTHhAyK3iBVfpHBuQCXwKEYN4=");
+    System.out.printf("\nDecoded password: %s\n", pw);
+   }
+
```

Using the existing code

```
$ cat PswGenerator.Java.diff
--- PswGenerator.orig.java  2018-02-16 14:20:53.930636617 -0500
+++ PswGenerator.java   2018-02-20 13:17:30.717678481 -0500
@@ -1,8 +1,8 @@
 // Decompiled by JEB v2.3.10.201802032133

…


+
 public class PswGenerator {
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+    String pw;
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+    pw = PswGenerator.decryptPBE("KKJSB04XvDQMC0rm2LHTHhAyK3iBVfpHBuQCXwKEYN4=");
+    System.out.printf("\nDecoded password: %s\n", pw);
+   }
+
```

Running their code to get the password

```
$ javac PswGenerator.java
```

Running their code to get the password

```
$ javac PswGenerator.java
$ java PswGenerator
```

Running their code to get the password

```
$ javac PswGenerator.java
$ java PswGenerator
Attempting to decode 'KKJSB04XvDQMC0rm2LHTHhAyK3iBVfpHBuQCXwKEYN4='...

Decoded password: 1%^t[redacted]
$
```

Running their code to get the password

```
$ javac PswGenerator.java
$ java PswGenerator
Attempting to decode 'KKJSB04XvDQMC0rm2LHTHhAyK3iBVfpHBuQCXwKEYN4='...

Decoded password: 1%^t[redacted]
$
```

Running their code to get the password

```
$ javac PswGenerator.java
$ java PswGenerator
Attempting to decode 'KKJSB04XvDQMC0rm2LHTHhAyK3iBVfpHBuQCXwKEYN4='...

Decoded password: 1%^t[redacted]
$
```

Password is 16 characters and complicated

Decrypting the key

```
$ openssl pkey -in assets/certificates/COMMON14K_M_priv.pem -passin pass:1%^t
```

Decrypting the key

```
$ openssl pkey -in assets/certificates/COMMON14K_M_priv.pem -passin pass:1%^t
-----BEGIN PRIVATE KEY-----
MIIEvQIBADANBgkqhkiG9w0BAQEFAASCBKcwggSjAgEAAoIBAQCq48EeXQVO31cA
YIHHYrIB4dAepFvvmWAI1lN1v214Hhq1X+0hhXE8iNX7Kn1kGkBLfiu3nxTvb+fB
tL5ZifIJDbBY2ZoXwq4pfb6cwkAlLgZ1grZ4BY7LZp5eMtQwOdbPCL8ySjrmDca8
YW70qZAZlGWY+1NGV4ydGih3t6OwGSOopwt6dptX0lzV+euKsy5pAJNIJ7JgkR/d
uMcNNK4tYaPyAHVdmcxxJw+e33AdcWCZIGGFbfbAVuNl+05B93lxZHF3jM/uhL0l
/ei3uG8febIDb73mEWD8g3obVeaImU6+cm7KyFCP1Pwlw3xjAV90jqJkIrNXfk92
zqSll0XfAgMBAAECggEAQDqKAxeDPznCQWoEXSRDM2HkDyBHTa6f4bJse/0O7+6g
…
jmbxYeD9BQKBgQDP6gT3G3lju+rVTzvLoYl6DJ3urI2j8QlZ7y/koqiKnSnbu5a7
Y2hq0lVsHMdbjX+roVphrbAEUmoDpxO5KaJrfW2VKMcYSAvjXR/JAH1NPneSjDgp
srgog/yrJvMXAXIEIe245KcC4UKqbDGV8GP7/XZJYE+W33Yls8d81Y2vRQKBgEoc
s0I0WYMQtzK0qTZzPpv6XmfSnTmxi6Lyre/Xl3q1QELsWGXrt1S9Ge7t8Ie0tNPT
5d/50tSgWED4hLv59yV8gVNu0bLlfSQbbU0+PG4aeeO7mMJU+khjccvhB03Sbk8R
7yWlSImPF8a2mbA6OPsOyILycVKYYprI6MeOJP6pAoGAD38lqdZk5azOnuu0/mC9
KT2GmbdlUENz3FIfnjzdE1a766+dovDEnfZxXCAXi/Ycy87ABX/kwroD8zpec6tl
oxfi+WwlI3dAJgemYpe71po/HJaNBV3V2rLyZ5ur7vI8Ya/d36ldg4vea5dXzK5d
yzkb0/Odq8A00aztCY1eWgU=
-----END PRIVATE KEY-----
```

Getting the public key from the private key

```
$ openssl pkey -in assets/certificates/COMMON14K_M_priv.pem -passin pass:1%^t[redacted] -pubout
```

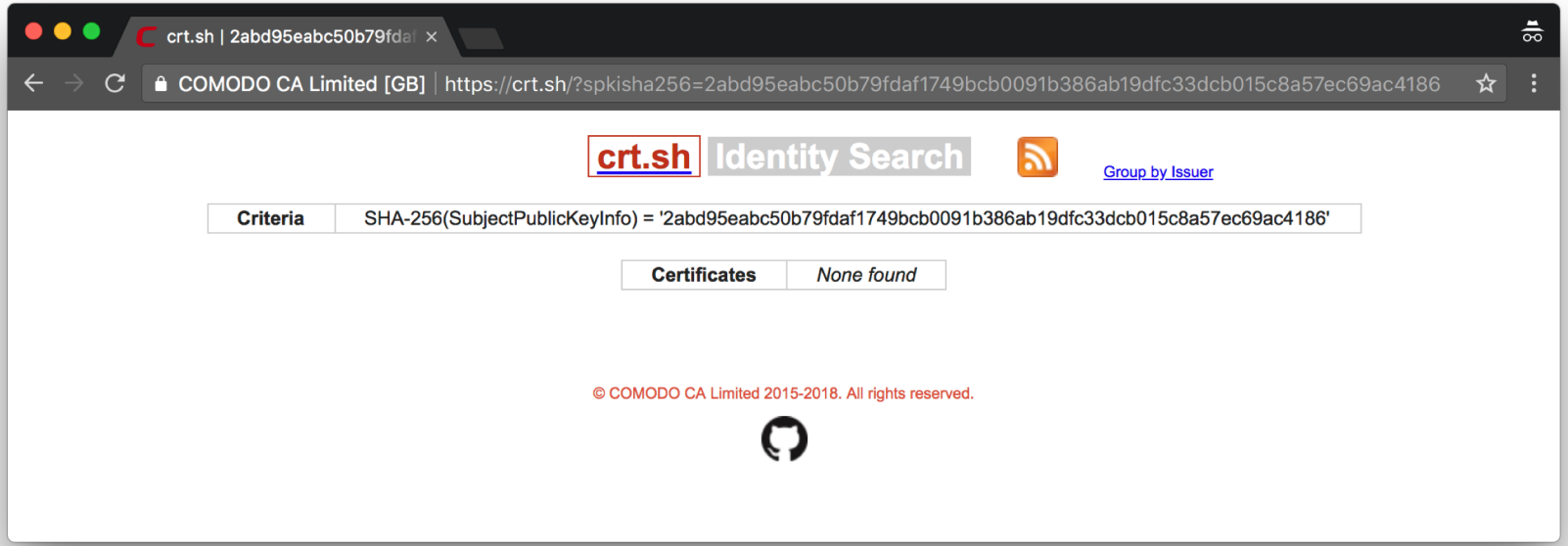
Getting the public key from the private key

```
$ openssl pkey -in assets/certificates/COMMON14K_M_priv.pem -passin pass:1%^t          -pubout
-----BEGIN PUBLIC KEY-----
MIIBIjANBgkqhkiG9w0BAQEFAAOCAQ8AMIIBCgKCAQEAquPBHl0FTt9XAGCBx2Ky
AeHQHqRb75lgCNZTdb9teB4atV/tIYVxPIjV+yp9ZBpAS34rt58U72/nwbS+WYny
CQ2wWNmaF8KuKX2+nMJAJS4GdYK2eAWOy2aeXjLUMDnWzwi/Mko65g3GvGFu9KmQ
GZRlmPtTRleMnRood7ejsBkjqKcLenabV9Jc1fnrirMuaQCTSCeyYJEf3bjHDTSu
LWGj8gB1XZnMcScPnt9wHXFgmSBhhW32wFbjZftOQfd5cWRxd4zP7oS9Jf3ot7hv
H3myA2+95hFg/IN6G1XmiJlOvnJuyshQj9T8JcN8YwFfdI6iZCKzV35Pds6kpZdF
3wIDAQAB
-----END PUBLIC KEY-----
```

Getting the public key hash

```
$ openssl pkey -in assets/certificates/COMMON14K_M_priv.pem -passin pass:1%^t[redacted] -pubout
-outform der | sha256sum
2abd95eabc50b79fdaf1749bcb0091b386ab19dfc33dcb015c8a57ec69ac4186  -
```

Checking if public key hash is in crt.sh



Comparing the Private Key Modulus to the Public one

```
$ openssl pkey -in assets/certificates/COMMON14K_M_priv.pem -passin pass:1%^t[redacted] \
| openssl rsa -noout -modulus | openssl sha256
```

Comparing the Private Key Modulus to the Public one

```
$ openssl pkey -in assets/certificates/COMMON14K_M_priv.pem -passin pass:1%^t[redacted] \
| openssl rsa -noout -modulus | openssl sha256
(stdin)= 1c03a8197edd52063a9694ee76d789ca2a53fc6962638831e3af2f0ff281405a
```

Comparing the Private Key Modulus to the Public one

```
$ openssl pkey -in assets/certificates/COMMON14K_M_priv.pem -passin pass:1%^t[redacted] \
| openssl rsa -noout -modulus | openssl sha256
(stdin)= 1c03a8197edd52063a9694ee76d789ca2a53fc6962638831e3af2f0ff281405a
$ openssl x509 -noout -modulus -in assets/certificates/COMMON14K_M_CertChain.pem \
| openssl sha256
```

Comparing the Private Key Modulus to the Public one

```
$ openssl pkey -in assets/certificates/COMMON14K_M_priv.pem -passin pass:1%^t[redacted] \
| openssl rsa -noout -modulus | openssl sha256
(stdin)= 1c03a8197edd52063a9694ee76d789ca2a53fc6962638831e3af2f0ff281405a
$ openssl x509 -noout -modulus -in assets/certificates/COMMON14K_M_CertChain.pem \
| openssl sha256
(stdin)= 1c03a8197edd52063a9694ee76d789ca2a53fc6962638831e3af2f0ff281405a
```

Comparing the Private Key Modulus to the Public one

```
$ openssl pkey -in assets/certificates/COMMON14K_M_priv.pem -passin pass:1%^t[redacted] \
| openssl rsa -noout -modulus | openssl sha256
(stdin)= 1c03a8197edd52063a9694ee76d789ca2a53fc6962638831e3af2f0ff281405a
$ openssl x509 -noout -modulus -in assets/certificates/COMMON14K_M_CertChain.pem \
| openssl sha256
(stdin)= 1c03a8197edd52063a9694ee76d789ca2a53fc6962638831e3af2f0ff281405a
```

Comparing the Private Key Modulus to the Public one

```
$ openssl pkey -in assets/certificates/COMMON14K_M_priv.pem -passin pass:1%^t[redacted] \
| openssl rsa -noout -modulus | openssl sha256
(stdin)= 1c03a8197edd52063a9694ee76d789ca2a53fc6962638831e3af2f0ff281405a
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| openssl sha256
(stdin)= 1c03a8197edd52063a9694ee76d789ca2a53fc6962638831e3af2f0ff281405a
```

Comparing the Private Key Modulus to the Public one

```
$ openssl pkey -in assets/certificates/COMMON14K_M_priv.pem -passin pass:1%^t[redacted] \
| openssl rsa -noout -modulus | openssl sha256
(stdin)= 1c03a8197edd52063a9694ee76d789ca2a53fc6962638831e3af2f0ff281405a
$ openssl x509 -noout -modulus -in assets/certificates/COMMON14K_M_CertChain.pem \
| openssl sha256
(stdin)= 1c03a8197edd52063a9694ee76d789ca2a53fc6962638831e3af2f0ff281405a
```

The modulus hashes match, so the certificate is for the private key!

Getting certificate details

```
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Certificate:
    Data:
        Version: 3 (0x2)
        Serial Number: 10 (0xa)
    Signature Algorithm: sha1WithRSAEncryption
        Issuer: C=KR, O=Samsung Electronics, CN=RemoteAccessCA(CE)
        Validity
            Not Before: Jan  1 00:00:00 1960 GMT
            Not After : Jan  1 00:00:00 2060 GMT
        Subject: C=KR, O=Samsung Electronics, CN=COMMON14K_M/emailAddress=COMMON14K_M@samsung.com

…

            X509v3 Basic Constraints:
                CA:TRUE
            X509v3 Subject Alternative Name:
                DNS:samsung.com, DNS:localhost
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Samsung private key conclusions

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- A private key for a certificate authority (CA) is included in multiple Android apps
- The certificate for said key can also be used to identify both “localhost” and “samsung.com” hosts

Don’t worry too much, as the certificate isn’t trusted by OS/browser versions I’ve seen.

Private Key Details From Samsung

- Older appliances and low-end Android devices do not have a trusted execution environment (TEE), such as TrustZone. This required that the key be included in the Android application.

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- Newer devices use SmartThings, which uses a trusted execution environment (TEE, Secure Element, or Artik) to protect keys securely.
- Samsung also implemented their IoT services in accordance with the common IoT standard, based on device unique certificates and Mutual SSL.

Things App Authors Say

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```
I left this file (res/raw/clientv01.bks) in the actual app only to confuse a potential hacker who
would try to hack my app.
```

Things App Authors Say

```
Indeed, there is a static certificate saved in the app code. However, the reason for this is that
the app is a *honeypot* and the key is needed for emulating a "valid" HTTPS connection.
```

Things App Authors Say

```
Hola, muchas gracias por su correo.

Tengo alguna pregunta que espero pueda responderme:

1) Mi aplicación es muy sencilla, se basa en html + Jquery y está compilada con
Phonegapp. No esoty seguro de tener los conocimientos como para poder
solucionar el problema. ¿Cómo podría arreglar el problema que usted me está
reportando?
2) Si no consigo arreglar el el problema ¿Van a retirar la app de la PlayStore?

La app es gratuita y sin publicidad, es un recurso de lectura, un trabajo
cultural sin ánimo de lucro.
```

Things App Authors Say

```
The keys you refer to were not place by design by me -
they were added by default by the program used - Appinventor.
```

Things App Authors Say

```
The key included in "SSH Server" application is our intention.
This key is for consistence host key verification when user upgrades the app.
```

Things App Authors Say

Things App Authors Say

```
Good Morning,

Thank you very much for your interest in our [REDACTED]

Good luck with your outdated initiatives!
```

Things App Authors Say

```
Thank you so much and Good Job CERT Coordination Center.
```

Private Key Statistics

File Type Counts

File Type	Count
APK (Android applications)	1,701,930

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APK (Android applications)	1,701,930
PKCS#1/5	549

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Openvpn (OVPN)	103

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Openvpn (OVPN)	103 (64 unique)

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PGP Private	10

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Apple iPhone Enterprise private keys	68

PKCS#12 Password Cracking Statistics

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Total	2119	100%

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rockyou.txt password list	870	41.4%

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Strings from app code	729	34.4%
Manual analysis	18	0.8%

Java Keystore Password Cracking Statistics

Strategy	Count	Percent
Total	3215	100%

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Strings from app code	35	1.1%
hashcat-naive	1714	53.3%

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Conclusions

If an application includes a private key, it:

- might be an accident.
- might not have the best design, if it is not an accident.
- has an impact that depends on what the key is used for.

Recommendations for Google and Apple

If an application includes a private key:

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Result: Fewer Mistakes

Contact Information

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