HTTP fuzzing in Smart Card Web Server

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http://secinfo.msi.unilim.fr

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Introduction

- Smart cards are essentials:
  - Payment: credit card, moneo, etc.
  - Transport: ticketing in public transport, etc.
  - Insurance: Health Care card, etc.
  - Telephony: SIM card (mobile), etc.

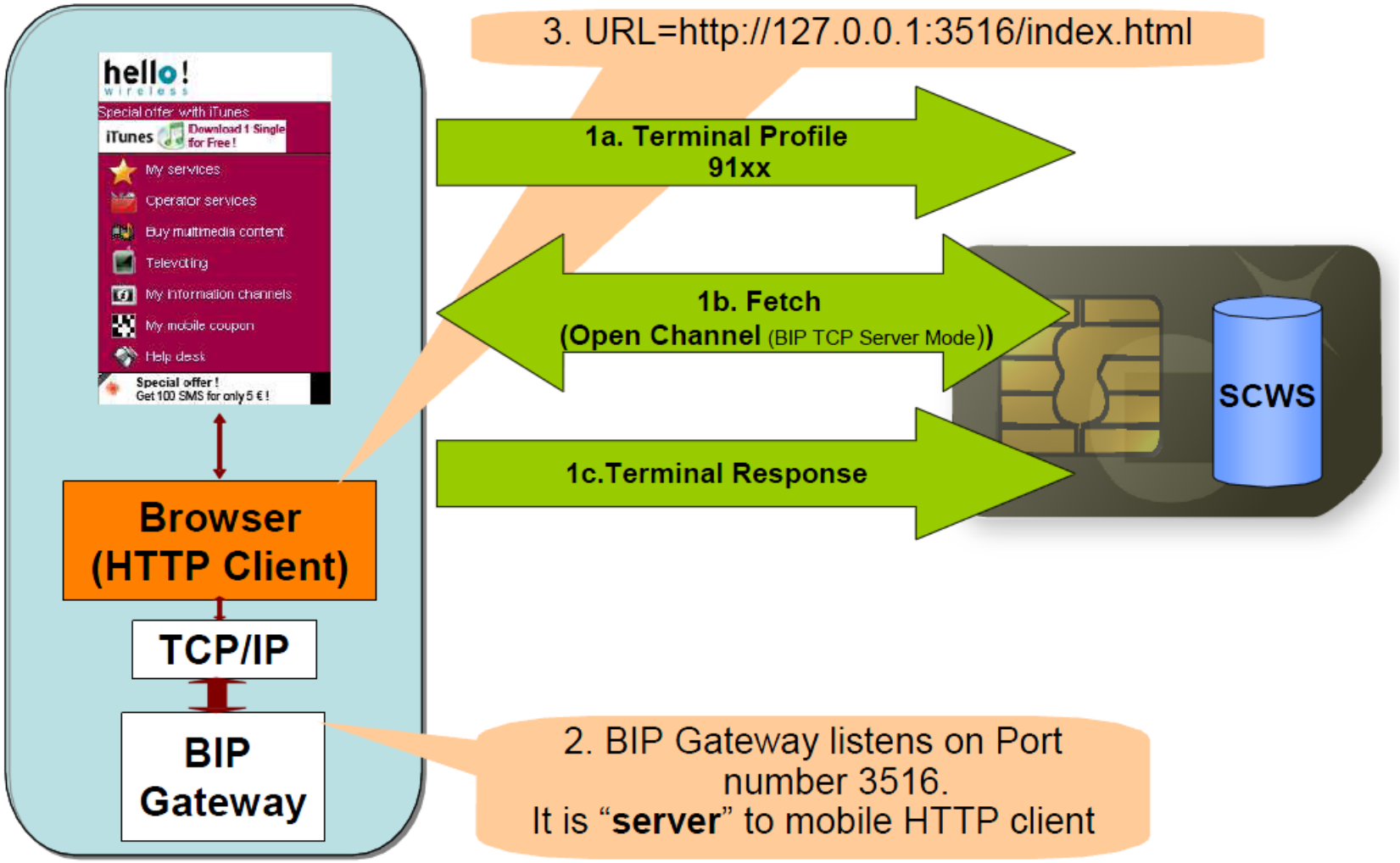
- Hyper Text Transfer Protocol (HTTP) is a new implemented technology in smart card world.

- Problem:
  - How to ensure the HTTP implementation robustness?

State of the art > SCWS / BIP

- mNFC JavaCard 2.2 Smart Card Web Server (SCWS)
- `http://127.0.0.1:3516`
- Short-range wireless technologies (- 10 cm)
- SCWS is both a server and a client application:
  - In server mode, SCWS is used by the subscriber using a WAP browser implemented in his handset.
  - In client mode, SCWS is used by the Card Issuer in order to administrate the SCWS from a server.
- In our case, we use the SCWS in server mode.
- SCWS communicates with BIP commands

State of the art > SCWS / BIP



State of the art > The HTTP protocol

- We can access the SCWS in:
  - Remote to administrate the SCWS
    - Administrative commands : add a user, change a password, etc.
    - The Access Control Policy (ACP) is stocked in the card
  - Local to communicate with the SCWS

Method	Supported	Additional comments
OPTIONS	Optional	
GET	Mandatory	Mandated for HTTP 1.1 server implementations
HEAD	Mandatory	Mandated for HTTP 1.1 server implementations
POST	Mandatory	Support for forms in user interface
PUT	Mandatory	Support for remote administration
DELETE	Mandatory	Support for remote administration
TRACE	Optional	
CONNECT	Optional	

State of the art > The HTTP protocol

- HTTP request representation:

```
GET /index.html HTTP/1.1 \r\n
Host: 127.0.0.1:3516 \r\n
…\r\n
\r\n
```

- Creation of an interactive HTTP Backus Normal Form (BNF)

State of the art > The fuzzing

- It is a software testing technique
- It provides invalid, unexpected or random data to the inputs of a computer program, protocol implementation, … in order to crash it.
- Fuzzing is used to find security flaws in software or computer systems.
- There are two types of fuzzer:
  - *Mutation based fuzzer*: mutates existing data samples to create test data
  - *Generation based fuzzer*: defines new test data based on data models and state models

State of the art > The fuzzing

- Advantages / Drawbacks of fuzzer types:
  - Mutation
    - Limited
    - Fast to implement
    - Slow execution because of cases number
  - Generation
    - Full
    - Implementation is time consuming
    - Slow execution because of cases number

The fuzzing > Aims

- We verify the correctness implementation of the smart card HTTP protocol
- Work in black box without knowledge of the system
- Have a generic data model, usable anywhere (not only on smart card)
- Accurate results analysis:
  - Determine if the smart card has a not expected behavior
  - We analyze the card return value.
- Choose the type of mutation:
  - Mutate all possible values or only part of them?

The fuzzing > HTTP features

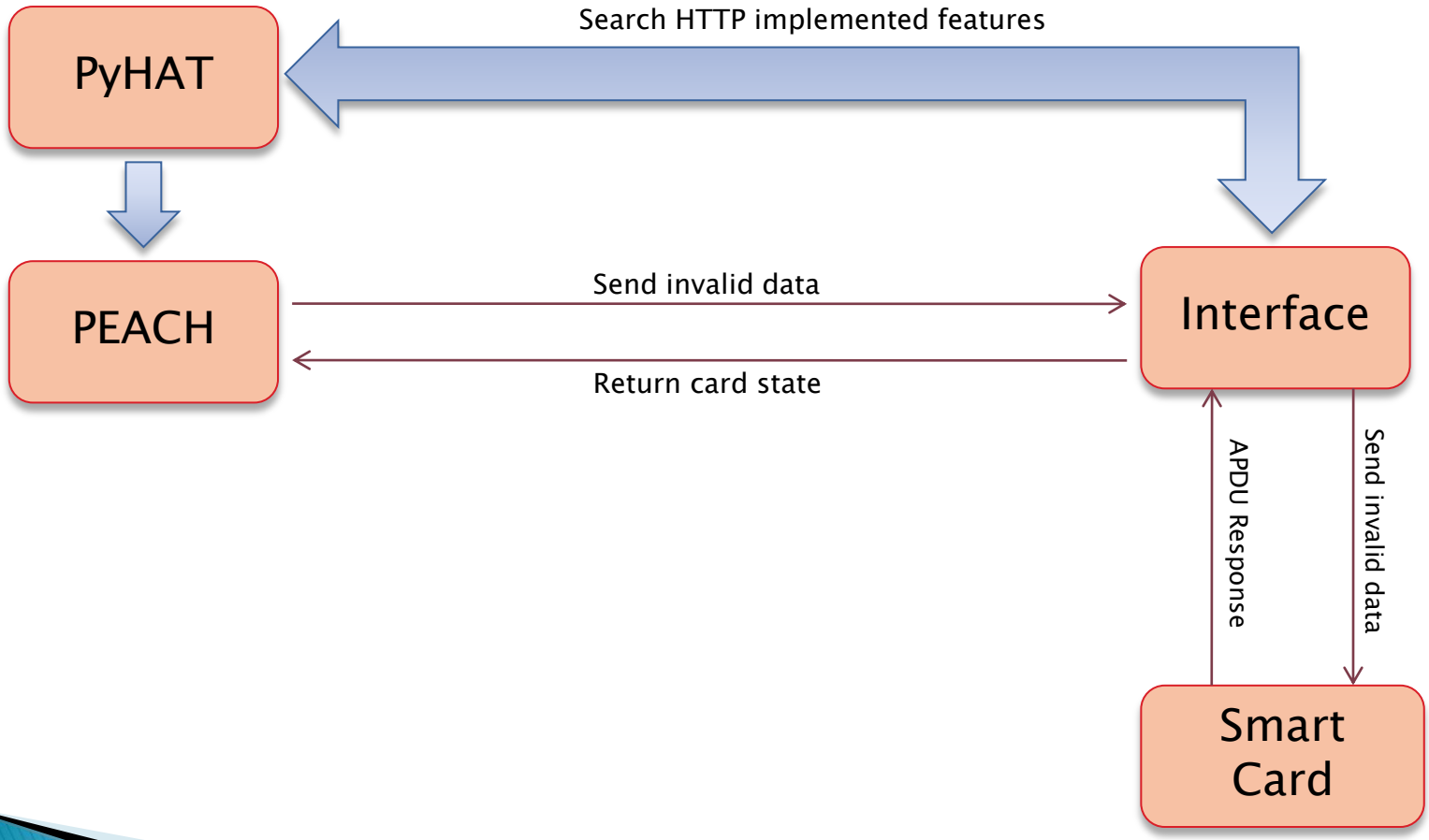
- How to know the SCWS implemented features ?
- We developed PyHAT!
- Which reduces the amount of methods to fuzz

The fuzzing > HTTP features

```
************************************************************
* ooooooooo            ooooo ooooo      o   ooooooooooo *
* 888    888 oooo   oooo 888   888      888  88  888  88 *
* 888ooooo88   888   888  888ooo888     8  88     888     *
* 888          888 888   888   888    8ooooo88    888     *
* 888            8888   o888o o888o o88o  o888o o888o    *
*             o8o888                                     *
************************************************************
* 1. SmartCard Web Server                                  *
* 2. Other Web Server                                      *
* 3. Quit                                                 *
************************************************************
* Your choice : 1



* Transferring data to 127.0.0.1 on port 3516

* List of implemented HTTP methods
** HEAD
** TRACE
** GET
...

* List of supported HTTP versions
** HTTP/0.9
** HTTP/1.0
** HTTP/1.1

* List of supported encoding
** gzip
** compress
** deflate
** identity

* List of parsed headers
** Cache-Control
** Connection
** Date
...
```

```
************************************************************
* ooooooooo            ooooo ooooo      o   ooooooooooo *
* 888    888 oooo   oooo 888   888      888  88  888  88 *
* 888ooooo88   888   888  888ooo888     8  88     888     *
* 888          888 888   888   888    8ooooo88    888     *
* 888            8888   o888o o888o o88o  o888o o888o    *
*             o8o888                                     *
************************************************************
* 1. SmartCard Web Server                                  *
* 2. Other Web Server                                      *
* 3. Quit                                                 *
************************************************************
* Your choice : 2
* Host : secinfo.msi.unilim.fr
* Port [80] :

* Transferring data to secinfo.msi.unilim.fr on port 80

* List of implemented HTTP methods
** HEAD
** TRACE
** GET
...

* List of supported HTTP versions
** HTTP/0.9
** HTTP/1.0
** HTTP/1.1

* List of supported encoding
** gzip
** compress
** deflate
** identity

* List of parsed headers
** Cache-Control
** Connection
** Date
...

* List of web pages on secinfo.msi.unilim.fr
** /xmlrpc.php
** /wp
** /
```

The fuzzing > Test generation



The fuzzing > Logging

- During the fuzzing step, we need to:
  - Log each test
  - To find some implementation errors
- A log file is created for each fuzzed method
- The request sent is saved with the full APDU command

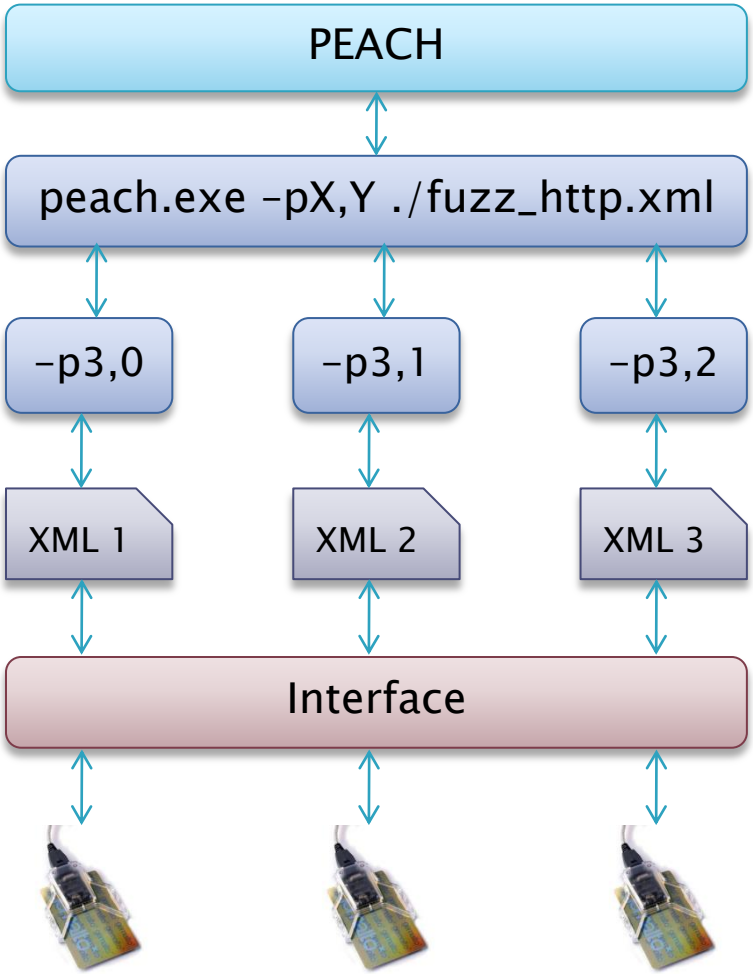
The fuzzing > Logging

```
----- RECEIVE DATA TERMINAL RESPONSE -----
TRANSMIT (total): 80 14 00 00 44 01 03 01 42 01 02 02
  82 81 03 01 00 36 81 32 47 45 54 20 2F 74 65 73 74
  31 2E 68 74 6D 6C 20 48 54 54 50 2F 31 2E 31 0D 0A
  48 6F 73 74 3A 20 31 32 37 2E 30 2E 30 2E 31 3A 33
  35 31 36 0D 0A 0D 0A 37 01 00
TRANSMIT (request only):
GET /test1.html HTTP/1.1
Host: 127.0.0.1:3516
RESPONSE (total):
STATUS WORD : 91 FE
```

The fuzzing > Logging

```
----- SEND DATA -----
TRANSMIT (total): 80 12 00 00 FE
RESPONSE (total): 48 54 54 50 2F 31 2E 31 20 32 30
  30 20 0D 0A 43 6F 6E 74 65 6E 74 2D 4C 65 6E 67 74
  68 3A 31 33 37 0D 0A 45 54 61 67 3A 20 22 30 30 30
  33 22 0D …
RESPONSE (request only):
HTTP/1.1 200
Content-Length:137
ETag: "0003"
Content-Encoding: gzip
Content-Type: text/html
STATUS WORD : 90 00
```

The fuzzing > Parallelization



The fuzzing > Experimental results

- No HTTP card response when "`\r\n\r\n`" is not in the request but there is a correct Status Word (`90 00`).
- SCWS does not compress in GZIP
- PUT method permits to overwrite existing webpages

The fuzzing > Experimental results

```
----- RECEIVE DATA TERMINAL RESPONSE -----
TRANSMIT (total): 80 14 00 00 3F 01 03 01 42 01 02 02
  82 81 03 01 00 36 81 2D 47 45 54 … 0A 0D 0A 37 01 00
TRANSMIT (request only): GET /index.html HTTP/1.1
                         Host: 127.0.0.1
RESPONSE (total):
STATUS WORD : 91 B1
----- FETCH (SEND DATA) -----
TRANSMIT : 80 12 00 00 B1
RESPONSE (request only):      HTTP/1.1 200
                              Content-Length:85
                              ETag: "059B"
                              Content-Type: text/html

<html><head><title>Hello World</title></head>
<body><h1>Hello World</h1></body></html>
STATUS WORD : 90 00
```

The fuzzing > Experimental results

----- RECEIVE DATA TERMINAL RESPONSE -----

TRANSMIT (total): 80 14 00 00 C0 01 03 01 42 01 02 02
82 81 03 01 00 36 81 AE 50 55 54 20 … 6C 3E 37 01 00

TRANSMIT (request only):

```
PUT /index.html HTTP/1.1
Host: 127.0.0.1
Content-Length:85
Content-Type: text/html

<html><head><title>AAAAAAAAAAA</title></head>
<body><h1>BBBBBBBBBB</h1></body></html>
```

RESPONSE (total):

STATUS WORD : 91 20

----- FETCH (SEND DATA) -----

TRANSMIT : 80 12 00 00 20

RESPONSE (request only):

HTTP/1.1 204

STATUS WORD : 90 00

The fuzzing > Experimental results

```
----- RECEIVE DATA TERMINAL RESPONSE -----
TRANSMIT (total): 80 14 00 00 3F 01 03 01 42 01 02 02
  82 81 03 01 00 36 81 2D 47 45 54 … 0A 0D 0A 37 01 00
TRANSMIT (request only):      GET /index.html HTTP/1.1
                              Host: 127.0.0.1
RESPONSE (total):
STATUS WORD : 91 B1
----- FETCH (SEND DATA) -----
TRANSMIT : 80 12 00 00 B1
RESPONSE (request only):      HTTP/1.1 200
                              Content-Length:85
                              ETag: "059C"
                              Content-Type: text/html

<html><head><title>AAAAAAAAAAA</title></head>
<body><h1>BBBBBBBBBB</h1></body></html>
STATUS WORD : 90 00
```

Conclusions

- First results of fuzzing have shown non-conformance of the HTTP specification
- These results can only be discovered through fuzzing
- Fuzzing is possible on smart cards

Any Questions ?

?

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