ST25TB series NFC tags for fun in French* public transports

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**maybe elsewhere too*

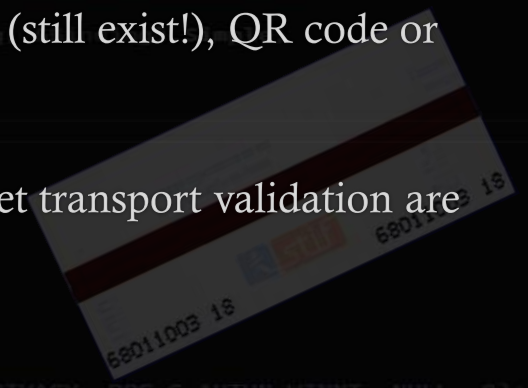
Mandatory notice

- This presentation is not intended to help to fraud in public transports ;
- There is no hack, no CVE, no bypass of intended security features ;
- All this presentation is about normal behavior of ST25TB and SRx cards and their reading system ;
- Research about ST25TB usages was not exhaustive, even in France
  - Can be used elsewhere too (like Brussel, etc.)

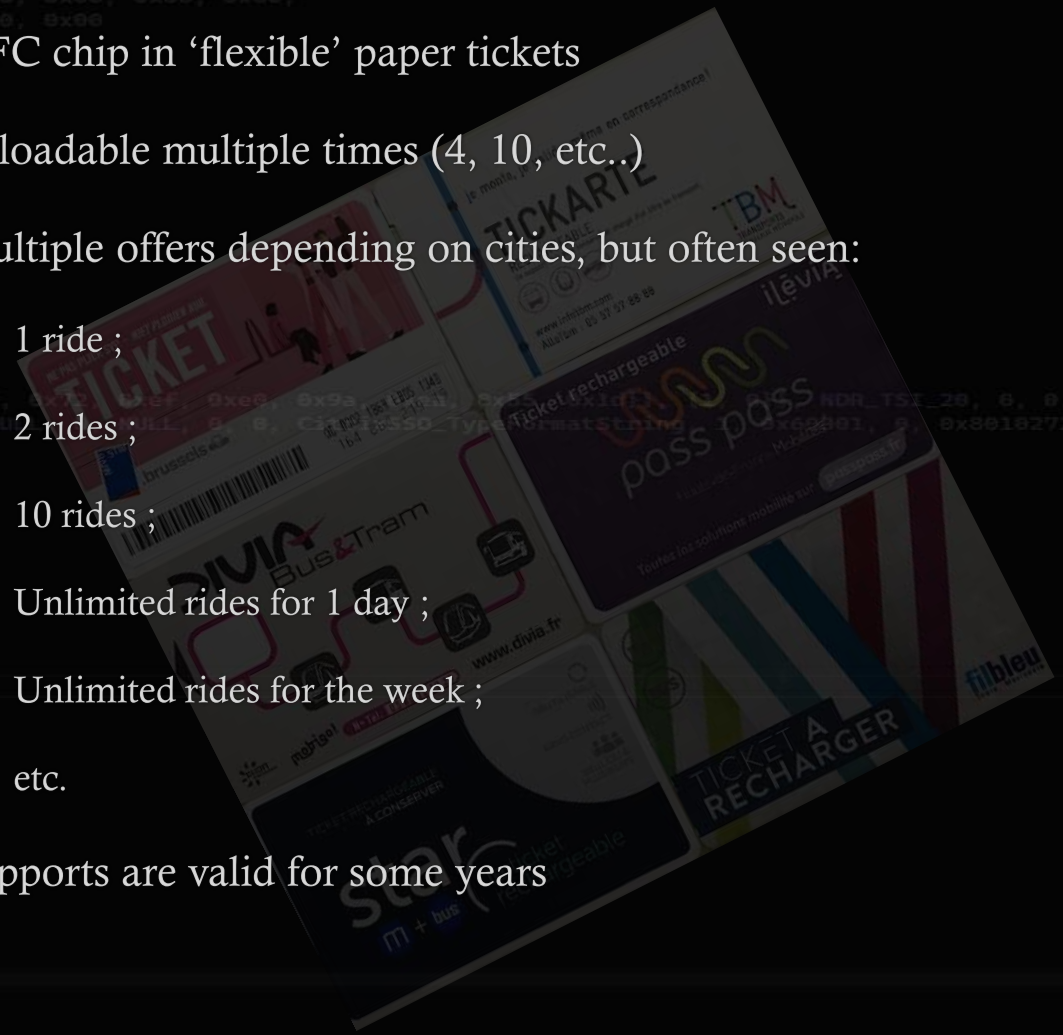
Reloadable convenience tickets

- This is NOT about season tickets
  - Usually, in France, Calypso (Innovatron) or Desfire (NXP) related technologies are used
    - but not only!
  - The card/chip is far more secure, but also more expensive
    - Not always usable for convenience tickets, even reloadable

- This is NOT about magnetic tickets (still exist!), QR code or payment at usage with debit cards
  - Good news, debit cards for ticket transport validation are more and more common



- This is about convenience tickets, usually:
  - NFC chip in ‘flexible’ paper tickets
  - Reloadable multiple times (4, 10, etc..)
  - Multiple offers depending on cities, but often seen:
    - 1 ride ;
    - 2 rides ;
    - 10 rides ;
    - Unlimited rides for 1 day ;
    - Unlimited rides for the week ;
    - etc.
  - Supports are valid for some years



ST25TB series NFC tags

- The ST25TB series of RFID tags are compatible with the ISO14443 standard, so support applications such as public transport and event ticketing.
- They provide state-of-the-art RF performance and include a counter able to count more than 4 billion events.
  - ISO14443-2 Type B with Proprietary Protocol
  - 512-, 2K-, and 4K-bit EEPROM with write protect
  - Two 32-bit counters with anti-tearing feature
  - OTP bytes with conditional erased features

From official ST25TB documentation

ST25TB512-AT

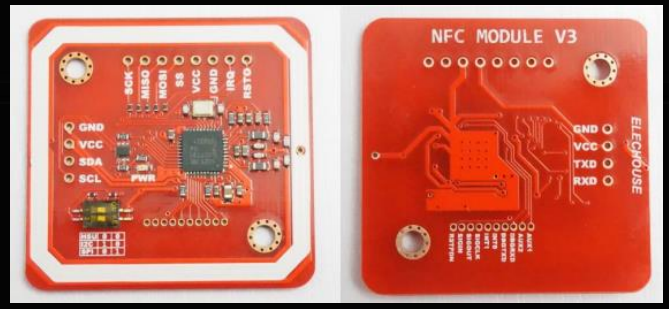
The ST25TB series, and its ancestor SRx, has multiple products available

- SR* – obsolete (~2002/2003…)
  - SR176 (176 bits) - *the most basic one (never seen)*
    - memory area with configurable bits locks
  - SRI512, SRIX512, SRI2K, SRI4K, SRIX4K (for 512 bits, 2 Kbits and 4Kbits)
    - memory area with configurable locks bits
    - resettable one-time programming areas
    - 2 x count down counters, with anti tear down, one counter can be used to reload some OTP part
    - *SRIX* have « France Telecom proprietary anti-clone function », only cards of the series supporting authentication (challenge/response)*
  - **SRT512** (for 512 bits)
    - memory area with configurable locks bits
    - 2 x count down counters, with anti tear down
    - **Designed for transports**
- ST25TB* (~2016…)
  - ST25TB512-AC, ST25TB02K-AC, ST25TB04K-AC
    - Replacement for SRI*
    - No (public ?) traces for a SRIX replacement
  - **ST25TB512-AT**
    - Replacement for SRT*

Addr	32 bits block	Description
0	User area	Lockable EEPROM
1		
2		
3		
4		
5	32 bits binary counter	Count down counter
6	32 bits binary counter	Count down counter
7	User area	Lockable EEPROM
8		
9		
10		
11		
12		
13		
14		
15		
255	OTP_Lock_Reg, 1, ST Reserved	System OTP bits
UID0	64 bits UID area	ROM
UID1		

How to read them?

- Nearly all 14B capable readers can read (and write) to them, this include:
  - The infamous ACS - ACR122U
  - Proxmark3
    - (now that we understand some PCB problems, even the RDV4 ;)))
  - DL533N
  - etc.



- Usually, all NXP PN53x based readers are compatible (but ST and TI chipsets are also in the game)

How to read them?
libnfc : nfc-st25tb

```
c:\security>nfc-st25tb
|mode    : info
Reader   : NXP / PN533 - via pn53x_usb:bus-0:\\.\libusb0-0255--0x04cc-0x2533
  ...wait for card...
Target   : ISO/IEC 14443-2B ST SRx (106 kbps)
UID      : d5 b4 fb 7d 78 33 02 d0
Manuf    : 0x02 - STMicroelectronics
ChipId   : 0x33 - ST25TB512-AT
Serial   : 0x787dfbb4d5
|blk sz : 32 bits
|nb blks: 16
|sys idx: 255

[0x00] 11 01 00 00
[0x01] 24 00 00 25
[0x02] 8e 06 80 15
[0x03] 00 01 43 39
[0x04] 00 00 c0 85
[0x05] 02 00 00 0a
[0x06] fe ff ff ff
[0x07] 00 00 00 00
[0x08] 00 00 00 00
[0x09] 00 00 00 00
[0x0a] 5a 17 00 00
[0x0b] 00 00 00 00
[0x0c] 00 00 00 00
[0x0d] 00 00 00 00
[0x0e] 00 00 00 00
[0x0f] d4 4e bc e4
[0xff] ff ff ff ff
  | ST reserved  : 111111111111111
  | b15          : 1 - not OTP (?)
  | OTP_Lock_Reg : 1111111111111111
```

How to read them?
libnfc : `nfc-st25tb`

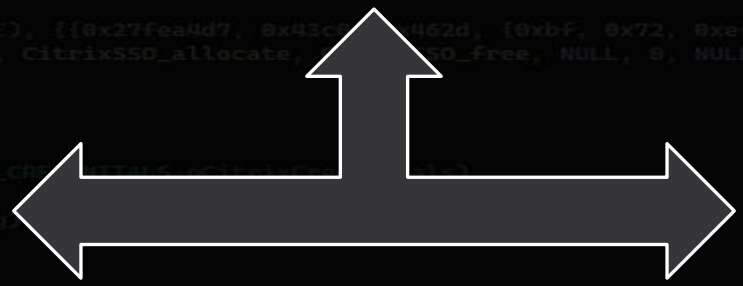
```
c:\security>nfc-st25tb -h

Usage:

  nfc-st25tb [-i]

  nfc-st25tb -b N -r

  nfc-st25tb -b N [-r] -w ABCD[EF01]

  nfc-st25tb -h

Options:

  -i               (default) information mode - will try to dump the tag content and display informations

  -b N             specify block number to operate on (tag dependent), needed for read (-r) and write (-w) modes

  -r               read mode - will try to read block (specified with -b N parameter)

  -w ABCD[EF01]    write mode - will try to write specicied data (2 or 4 bytes depending on tag) to block (specified with -b N parameter)

  -h               this help

Examples:

  nfc-st25tb -i

        Display all tag informations

  nfc-st25tb -b 0x0e -r

        Read block 0x0e (14) of the tag

  nfc-st25tb -b 0x0d -w 0123abcd

        Write block 0x0d (13) of the tag with hexadecimal value '01 23 ab cd'

  nfc-st25tb -b 0x0c -r -w 0123abcd

        Read, then write block 0x0c (12) of the tag with hexadecimal value '01 23 ab cd'

Warnings:

  Be careful with: system area, counters & otp, bytes order.
```

How to read them?
Proxmark3

```
[usb] pm3 --> hf 14b info
[+]  UID: D0 02 33 78 7D FB B4 D5
[+]  MFG: 02, ST Microelectronics SA France
[+] Chip: 0C, SRT512
[usb] pm3 --> hf 14b dump --ns
[+] found a SRT512 tag
[=] reading tag memory from UID D00233787DFBB4D5
[=] ................
[+] SRT512 tag
[=]  block#  | data        |lck| ascii
[=] ---------+-------------+---+----------
[=]   0/0x00 | 11 01 00 00  |   | ....
[=]   1/0x01 | 24 00 00 25  |   | $..%
[=]   2/0x02 | 8E 06 80 15  |   | ....
[=]   3/0x03 | 00 01 43 39  |   | ..C9
[=]   4/0x04 | 00 00 C0 85  |   | ....
[=]   5/0x05 | 01 00 00 0A  |   | ....
[=]   6/0x06 | FD FF FF FF  |   | ....
[=]   7/0x07 | 00 00 00 00  |   | ....
[=]   8/0x08 | 00 00 00 00  |   | ....
[=]   9/0x09 | 00 00 00 00  |   | ....
[=]  10/0x0A | 5A 17 00 00  |   | Z...
[=]  11/0x0B | B8 08 D3 B6  |   | ....
[=]  12/0x0C | 64 80 B3 C2  |   | d...
[=]  13/0x0D | 30 85 3D 04  |   | 0.=.
[=]  14/0x0E | DA DD 00 C1  |   | ....
[=]  15/0x0F | D4 4E BC E4  |   | .N..
[=] 255/0xFF | FF FF FF FF  |   | ....
[=] ---------+-------------+---+----------
```

How to understand them?

```
[0x00] 11 01 00 00
[0x01] 24 00 00 25
[0x02] 8e 06 80 15
[0x03] 00 01 43 39
[0x04] 00 00 c0 85
[0x05] 02 00 00 0a
[0x06] fe ff ff ff
[0x07] 00 00 00 00
[0x08] 00 00 00 00
[0x09] 00 00 00 00
[0x0a] 5a 17 00 00
[0x0b] 00 00 00 00
[0x0c] 00 00 00 00
[0x0d] 00 00 00 00
[0x0e] 00 00 00 00
[0x0f] d4 4e bc e4
[0xff] ff ff ff ff
```



```
[0x00] 11 01 00 00
[0x01] 24 00 00 25
[0x02] 8e 06 80 15
[0x03] 00 01 43 39
[0x04] 00 00 c0 85
[0x05] 01 00 00 0a
[0x06] fd ff ff ff
[0x07] 00 00 00 00
[0x08] 00 00 00 00
[0x09] 00 00 00 00
[0x0a] 5a 17 00 00
[0x0b] b8 40 d2 b6
[0x0c] 64 80 b3 c2
[0x0d] 24 85 bc 04
[0x0e] 11 12 00 41
[0x0f] d4 4e bc e4
[0xff] ff ff ff ff
```

Example in Lille, other layouts are available, and used

How to understand them?

- Intercode & **Intertic** @ AFNOR
  - *Intercode*
    - *NF P99-405-1, NF P99-405-2, NF P99-405-3, NF P99-405-4, NF P99-405-5 & XP P99-405-6*
  - **Intertic**
    - *NF P99-410*
    - **FD P99-416 - E-ticketing for the transportation sector - Interoperability rules for the codification of e-ticketing data - Contactless tickets - FD INTERTIC - 597,12 € HT**
      - **Chapitre 9. SRT512 - ST25TB512-AT**

How to understand them?

(a very old draft is available on the internet)

[DISTRIBUTION DATA]
0x250 = FR
Company/City, Version, End of ticket validity, Tariff, etc.

COUNTER1(CNT1)
0x000001 ride left

COUNTER2(CNT2)
?

? CERTIFICATE ?

DATA CERTIFICATE

```
[0x00] 11 01 00 00
[0x01] 24 00 00 25
[0x02] 8e 06 80 15
[0x03] 00 01 43 39
[0x04] 00 00 c0 85
[0x05] 01 00 00 0a
[0x06] fd ff ff ff
[0x07] 00 00 00 00
[0x08] 00 00 00 00
[0x09] 00 00 00 00
[0x0a] 5a 17 00 00
[0x0b] b8 40 d2 b6
[0x0c] 64 80 b3 c2
[0x0d] 24 85 bc 04
[0x0e] 11 12 00 41
[0x0f] d4 4e bc e4
[0xff] ff ff ff ff
```

[SEDENTARY BLOCK]
ProductID, Key information, etc.

RELOADING1(RLD1)
0x0a reloading left

RELOADING2(RLD2)
?

[USAGE DATA]
Validation information, timestamp, etc.

DISTRIBUTION CERTIFICATE

Example in Lille, other layouts are available, and used

How to understand them?

- `CERTIFICATE` parts are ~a signature on the card data with an external key
  - usually on an external SAM card in vending & validating machines
  - 2 to 4 keys can exist:
    - `DISTRIBUTION`
      - Create signature – (normally) only on vending/loading machines
      - Validate signature
    - `USAGE`
      - Create signature
      - Validate signature
- `CERTIFICATE` are UID dependent
  - An exact copy on another (full) card will not have valid `CERTIFICATE` validation – UID is not the same

What can we do to play with?

- Reload a dump of a full card on the original card?

Saved dump before usage

```
[0x00] 11 01 00 00
[0x01] 24 00 00 25
[0x02] 8e 06 80 15
[0x03] 00 01 43 39
[0x04] 00 00 c0 85
[0x05] 02 00 00 0a
[0x06] fe ff ff ff
[0x07] 00 00 00 00
[0x08] 00 00 00 00
[0x09] 00 00 00 00
[0x0a] 5a 17 00 00
[0x0b] 00 00 00 00
[0x0c] 00 00 00 00
[0x0d] 00 00 00 00
[0x0e] 00 00 00 00
[0x0f] d4 4e bc e4
[0xff] ff ff ff ff
```

```
[0x00] 11 01 00 00
[0x01] 24 00 00 25
[0x02] 8e 06 80 15
[0x03] 00 01 43 39
[0x04] 00 00 c0 85
[0x05] 01 00 00 0a
[0x06] fd ff ff ff
[0x07] 00 00 00 00
[0x08] 00 00 00 00
[0x09] 00 00 00 00
[0x0a] 5a 17 00 00
[0x0b] 00 00 00 00
[0x0c] 00 00 00 00
[0x0d] 00 00 00 00
[0x0e] 00 00 00 00
[0x0f] d4 4e bc e4
[0xff] ff ff ff ff
```

- **No**: counters cannot be refilled at same values (new value is > to current one)
  - `0x0a000002` is > to `0x0a000001`
  - `0xfffffffe` is > to `0xfffffffd`

What can we do to play with?

- Reload counters like a reloading machine?

```
[0x00] 11 01 00 00
[0x01] 24 00 00 25
[0x02] 8e 06 80 15
[0x03] 00 01 43 39
[0x04] 00 00 c0 85
[0x05] 01 00 00 0a
[0x06] fd ff ff ff
[0x07] 00 00 00 00
[0x08] 00 00 00 00
[0x09] 00 00 00 00
[0x0a] 5a 17 00 00
[0x0b] b8 40 d2 b6
[0x0c] 64 80 b3 c2
[0x0d] 24 85 bc 04
[0x0e] 11 12 00 41
[0x0f] d4 4e bc e4
[0xff] ff ff ff ff
```

```
[0x00] 11 01 00 00
[0x01] 24 00 00 25
[0x02] 8e 06 80 15
[0x03] 00 01 43 39
[0x04] 00 00 c0 85
[0x05] 02 00 00 09
[0x06] fd ff ff ff
[0x07] 00 00 00 00
[0x08] 00 00 00 00
[0x09] 00 00 00 00
[0x0a] 5a 17 00 00
[0x0b] b8 40 d2 b6
[0x0c] 64 80 b3 c2
[0x0d] 24 85 bc 04
[0x0e] 11 12 00 41
[0x0f] d4 4e bc e4
[0xff] ff ff ff ff
```

- **No**
  - counters refill are *OK*, because the new `RELOADING1 (0x09xxxxxx)` part is < to previous `RELOADING1 (0x0axxxxxx)`
  - but `CERTIFICATE` part(s) are now **KO – will not validate**, because the signature is invalid / were not recalculated

What can we do to play with?

- Reload a dump of a full card on a new ST25TB512-AT card?

Saved dump before usage

```
[0x00] 11 01 00 00
[0x01] 24 00 00 25
[0x02] 8e 06 80 15
[0x03] 00 01 43 39
[0x04] 00 00 c0 85
[0x05] 02 00 00 0a
[0x06] fe ff ff ff
[0x07] 00 00 00 00
[0x08] 00 00 00 00
[0x09] 00 00 00 00
[0x0a] 5a 17 00 00
[0x0b] 00 00 00 00
[0x0c] 00 00 00 00
[0x0d] 00 00 00 00
[0x0e] 00 00 00 00
[0x0f] d4 4e bc e4
[0xff] ff ff ff ff
```

UID: d00233787dfbb4d5

New blank/full card

```
[0x00] ff ff ff ff
[0x01] ff ff ff ff
[0x02] ff ff ff ff
[0x03] ff ff ff ff
[0x04] ff ff ff ff
[0x05] ff ff ff ff
[0x06] fe ff ff ff
[0x07] ff ff ff ff
[0x08] ff ff ff ff
[0x09] ff ff ff ff
[0x0a] ff ff ff ff
[0x0b] ff ff ff ff
[0x0c] ff ff ff ff
[0x0d] ff ff ff ff
[0x0e] ff ff ff ff
[0x0f] ff ff ff ff
[0xff] ff ff ff ff
```

```
[0x00] 11 01 00 00
[0x01] 24 00 00 25
[0x02] 8e 06 80 15
[0x03] 00 01 43 39
[0x04] 00 00 c0 85
[0x05] 02 00 00 0a
[0x06] fe ff ff ff
[0x07] 00 00 00 00
[0x08] 00 00 00 00
[0x09] 00 00 00 00
[0x0a] 5a 17 00 00
[0x0b] 00 00 00 00
[0x0c] 00 00 00 00
[0x0d] 00 00 00 00
[0x0e] 00 00 00 00
[0x0f] d4 4e bc e4
[0xff] ff ff ff ff
```

UID: d00233abcdefabcd

- **No**: all data are **OK**, but signature verification will fail: **UID is not the same**

What can we do to play with?

- Reload a dump of a full card on a new ST25 magic card?

Saved dump before usage

```
[0x00] 11 01 00 00
[0x01] 24 00 00 25
[0x02] 8e 06 80 15
[0x03] 00 01 43 39
[0x04] 00 00 c0 85
[0x05] 02 00 00 0a
[0x06] fe ff ff ff
[0x07] 00 00 00 00
[0x08] 00 00 00 00
[0x09] 00 00 00 00
[0x0a] 5a 17 00 00
[0x0b] 00 00 00 00
[0x0c] 00 00 00 00
[0x0d] 00 00 00 00
[0x0e] 00 00 00 00
[0x0f] d4 4e bc e4
[0xff] ff ff ff ff
```

UID: d00233787dfbb4d5

```
[0x00] ff ff ff ff
[0x01] ff ff ff ff
[0x02] ff ff ff ff
[0x03] ff ff ff ff
[0x04] ff ff ff ff
[0x05] ff ff ff ff
[0x06] fe ff ff ff
[0x07] ff ff ff ff
[0x08] ff ff ff ff
[0x09] ff ff ff ff
[0x0a] ff ff ff ff
[0x0b] ff ff ff ff
[0x0c] ff ff ff ff
[0x0d] ff ff ff ff
[0x0e] ff ff ff ff
[0x0f] ff ff ff ff
[0xff] ff ff ff ff
```

magic card ?

```
[0x00] 11 01 00 00
[0x01] 24 00 00 25
[0x02] 8e 06 80 15
[0x03] 00 01 43 39
[0x04] 00 00 c0 85
[0x05] 02 00 00 0a
[0x06] fe ff ff ff
[0x07] 00 00 00 00
[0x08] 00 00 00 00
[0x09] 00 00 00 00
[0x0a] 5a 17 00 00
[0x0b] 00 00 00 00
[0x0c] 00 00 00 00
[0x0d] 00 00 00 00
[0x0e] 00 00 00 00
[0x0f] d4 4e bc e4
[0xff] ff ff ff ff
```

UID: d00233787dfbb4d5

- **OK**: all data are **OK**, and signature verification will **validate**, UID are the same
  - But for real, **KO** – this kind of card still not exist, and the form factor is incompatible with ticket controller (human)

What can we do to play with?

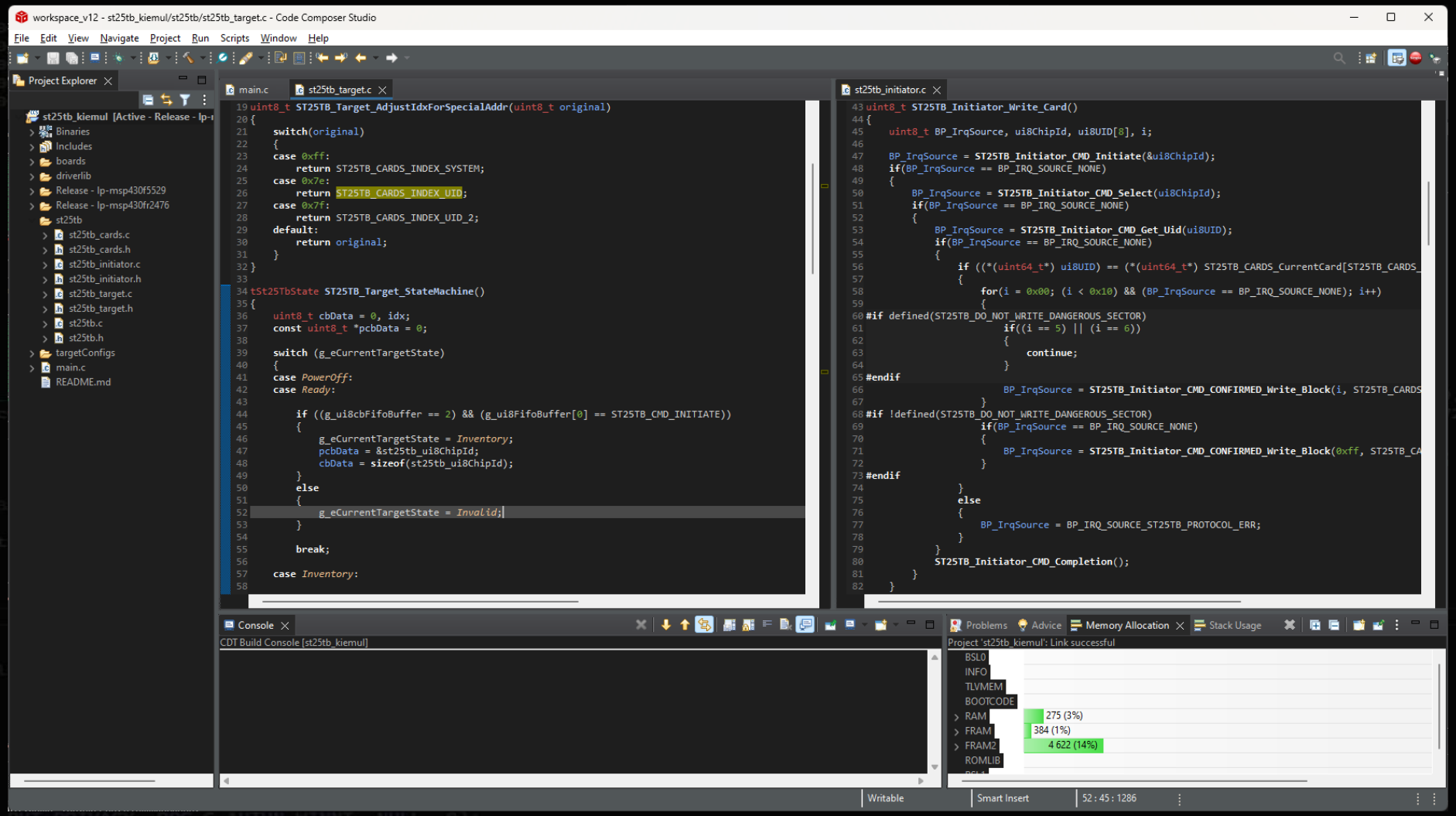
the good idea is here

- Why this is possible ? (in theory)
  - The reader does not **authenticate** the card
  - …and the card does not **authenticate** the reader, so we can dump all its data

- So what ?
  - We can **emulate** (via a potential magic card), or dedicated hardware the ST25TB system
    - Let’s create one!
      - Soon a standalone module for the Proxmark3 RDV4 ?
  - Then write the result to the real card
  - … then loop

What can we do to play with?

st25tb_kiemul



What can we do to play with?

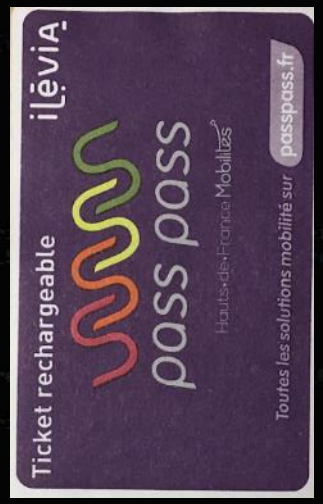
st25tb_kiemul

- Why Texas Instruments ?
  - I don’t know lots of components to do NFC and emulate
    - NXP PN532, very simple to emulate 14A (with some UID limitations)
    - STM ST25R3916(B), very efficient to emulate 14A *(the one in HydraNFCv2 and Flipper Zero)*
      - Seems possible to do other things like 14B, but not ‘natively’
    - nRF 52840 (and friends), good to emulate 14A *(the one in Chameleon Ultra)*
      - even not able to read :’)
  - TI ?
    - TI TRF7970A *(the one in HydraNFCv1)*
      - not a very good one to be honest, lots of errata and things to do yourself but…
      - “[…] In the case of the TRF7970A, **it is possible to emulate both Type 4A and Type 4B** tags concurrently. This feature is a differentiator when compared to static tags that typically offer a single tag type platform. Card emulation for Type 4A uses ISO/IEC 14443A technology at a baud rate of 106 kbps. Card emulation for Type 4B uses ISO/IEC 14443B technology at a baud rate of 106 kbps. After technology selection for either mode has been completed, the higher layers are the same […]”

What can we do to play with?

st25tb_kiemul

original card




```
[0x00] 11 01 00 00
[0x01] 24 00 00 25
[0x02] 8e 06 80 15
[0x03] 00 01 43 39
[0x04] 00 00 c0 85
[0x05] 02 00 00 0a
[0x06] fe ff ff ff
[0x07] 00 00 00 00
[0x08] 00 00 00 00
[0x09] 00 00 00 00
[0x0a] 5a 17 00 00
[0x0b] 00 00 00 00
[0x0c] 00 00 00 00
[0x0d] 00 00 00 00
[0x0e] 00 00 00 00
[0x0f] d4 4e bc e4
[0xff] ff ff ff ff
```

(r) learn

What can we do to play with?

st25tb_kiemul

original card


```
[0x00] 11 01 00 00
[0x01] 24 00 00 25
[0x02] 8e 06 80 15
[0x03] 00 01 43 39
[0x04] 00 00 c0 85
[0x05] 02 00 00 0a
[0x06] fe ff ff ff
[0x07] 00 00 00 00
[0x08] 00 00 00 00
[0x09] 00 00 00 00
[0x0a] 5a 17 00 00
[0x0b] 00 00 00 00
[0x0c] 00 00 00 00
[0x0d] 00 00 00 00
[0x0e] 00 00 00 00
[0x0f] d4 4e bc e4
[0xff] ff ff ff ff
```

virtual card


```
[0x00] 11 01 00 00
[0x01] 24 00 00 25
[0x02] 8e 06 80 15
[0x03] 00 01 43 39
[0x04] 00 00 c0 85
[0x05] 02 00 00 0a
[0x06] fe ff ff ff
[0x07] 00 00 00 00
[0x08] 00 00 00 00
[0x09] 00 00 00 00
[0x0a] 5a 17 00 00
[0x0b] 00 00 00 00
[0x0c] 00 00 00 00
[0x0d] 00 00 00 00
[0x0e] 00 00 00 00
[0x0f] d4 4e bc e4
[0xff] ff ff ff ff
```

What can we do to play with?

st25tb_kiemul

original card


```
[0x00] 11 01 00 00
[0x01] 24 00 00 25
[0x02] 8e 06 80 15
[0x03] 00 01 43 39
[0x04] 00 00 c0 85
[0x05] 02 00 00 0a
[0x06] fe ff ff ff
[0x07] 00 00 00 00
[0x08] 00 00 00 00
[0x09] 00 00 00 00
[0x0a] 5a 17 00 00
[0x0b] 00 00 00 00
[0x0c] 00 00 00 00
[0x0d] 00 00 00 00
[0x0e] 00 00 00 00
[0x0f] d4 4e bc e4
[0xff] ff ff ff ff
```

virtual card


```
[0x00] 11 01 00 00
[0x01] 24 00 00 25
[0x02] 8e 06 80 15
[0x03] 00 01 43 39
[0x04] 00 00 c0 85
[0x05] 02 00 00 0a
[0x06] fe ff ff ff
[0x07] 00 00 00 00
[0x08] 00 00 00 00
[0x09] 00 00 00 00
[0x0a] 5a 17 00 00
[0x0b] 00 00 00 00
[0x0c] 00 00 00 00
[0x0d] 00 00 00 00
[0x0e] 00 00 00 00
[0x0f] d4 4e bc e4
[0xff] ff ff ff ff
```

(r) expose

What can we do to play with?

st25tb_kiemul

original card


```
[0x00] 11 01 00 00
[0x01] 24 00 00 25
[0x02] 8e 06 80 15
[0x03] 00 01 43 39
[0x04] 00 00 c0 85
[0x05] 02 00 00 0a
[0x06] fe ff ff ff
[0x07] 00 00 00 00
[0x08] 00 00 00 00
[0x09] 00 00 00 00
[0x0a] 5a 17 00 00
[0x0b] 00 00 00 00
[0x0c] 00 00 00 00
[0x0d] 00 00 00 00
[0x0e] 00 00 00 00
[0x0f] d4 4e bc e4
[0xff] ff ff ff ff
```

virtual card


```
[0x00] 11 01 00 00
[0x01] 24 00 00 25
[0x02] 8e 06 80 15
[0x03] 00 01 43 39
[0x04] 00 00 c0 85
[0x05] 01 00 00 0a
[0x06] fd ff ff ff
[0x07] 00 00 00 00
[0x08] 00 00 00 00
[0x09] 00 00 00 00
[0x0a] 5a 17 00 00
[0x0b] b8 40 d2 b6
[0x0c] 64 80 b3 c2
[0x0d] 24 85 bc 04
[0x0e] 11 12 00 41
[0x0f] d4 4e bc e4
[0xff] ff ff ff ff
```

(w) values

What can we do to play with?

st25tb_kiemul

original card


```
[0x00] 11 01 00 00
[0x01] 24 00 00 25
[0x02] 8e 06 80 15
[0x03] 00 01 43 39
[0x04] 00 00 c0 85
[0x05] 02 00 00 0a
[0x06] fe ff ff ff
[0x07] 00 00 00 00
[0x08] 00 00 00 00
[0x09] 00 00 00 00
[0x0a] 5a 17 00 00
[0x0b] 00 00 00 00
[0x0c] 00 00 00 00
[0x0d] 00 00 00 00
[0x0e] 00 00 00 00
[0x0f] d4 4e bc e4
[0xff] ff ff ff ff
```

virtual card

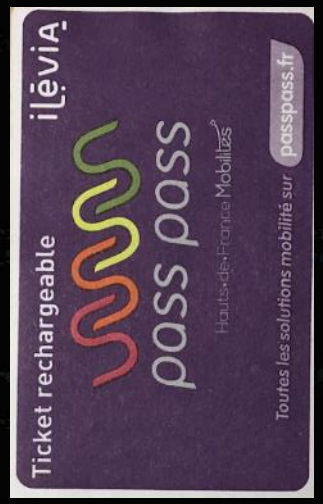

```
[0x00] 11 01 00 00
[0x01] 24 00 00 25
[0x02] 8e 06 80 15
[0x03] 00 01 43 39
[0x04] 00 00 c0 85
[0x05] 01 00 00 0a
[0x06] fd ff ff ff
[0x07] 00 00 00 00
[0x08] 00 00 00 00
[0x09] 00 00 00 00
[0x0a] 5a 17 00 00
[0x0b] b8 40 d2 b6
[0x0c] 64 80 b3 c2
[0x0d] 24 85 bc 04
[0x0e] 11 12 00 41
[0x0f] d4 4e bc e4
[0xff] ff ff ff ff
```

Beep!

What can we do to play with?

st25tb_kiemul

original card




```
[0x00] 11 01 00 00
[0x01] 24 00 00 25
[0x02] 8e 06 80 15
[0x03] 00 01 43 39
[0x04] 00 00 c0 85
[0x05] 01 00 00 0a
[0x06] fd ff ff ff
[0x07] 00 00 00 00
[0x08] 00 00 00 00
[0x09] 00 00 00 00
[0x0a] 5a 17 00 00
[0x0b] b8 40 d2 b6
[0x0c] 64 80 b3 c2
[0x0d] 24 85 bc 04
[0x0e] 11 12 00 41
[0x0f] d4 4e bc e4
[0xff] ff ff ff ff
```

(w) values

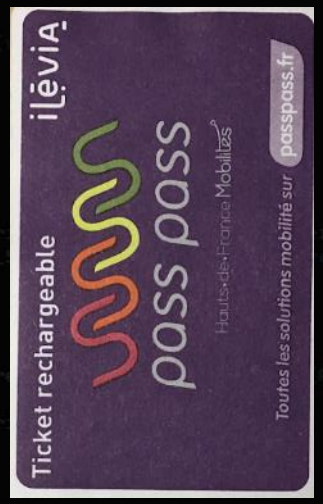
virtual card

```
[0x00] 11 01 00 00
[0x01] 24 00 00 25
[0x02] 8e 06 80 15
[0x03] 00 01 43 39
[0x04] 00 00 c0 85
[0x05] 01 00 00 0a
[0x06] fd ff ff ff
[0x07] 00 00 00 00
[0x08] 00 00 00 00
[0x09] 00 00 00 00
[0x0a] 5a 17 00 00
[0x0b] b8 40 d2 b6
[0x0c] 64 80 b3 c2
[0x0d] 24 85 bc 04
[0x0e] 11 12 00 41
[0x0f] d4 4e bc e4
[0xff] ff ff ff ff
```

What can we do to play with?

st25tb_kiemul

original card




```
[0x00] 11 01 00 00
[0x01] 24 00 00 25
[0x02] 8e 06 80 15
[0x03] 00 01 43 39
[0x04] 00 00 c0 85
[0x05] 01 00 00 0a
[0x06] fd ff ff ff
[0x07] 00 00 00 00
[0x08] 00 00 00 00
[0x09] 00 00 00 00
[0x0a] 5a 17 00 00
[0x0b] b8 40 d2 b6
[0x0c] 64 80 b3 c2
[0x0d] 24 85 bc 04
[0x0e] 11 12 00 41
[0x0f] d4 4e bc e4
[0xff] ff ff ff ff
```

valid for control

virtual card

```
[0x00] 11 01 00 00
[0x01] 24 00 00 25
[0x02] 8e 06 80 15
[0x03] 00 01 43 39
[0x04] 00 00 c0 85
[0x05] 01 00 00 0a
[0x06] fd ff ff ff
[0x07] 00 00 00 00
[0x08] 00 00 00 00
[0x09] 00 00 00 00
[0x0a] 5a 17 00 00
[0x0b] b8 40 d2 b6
[0x0c] 64 80 b3 c2
[0x0d] 24 85 bc 04
[0x0e] 11 12 00 41
[0x0f] d4 4e bc e4
[0xff] ff ff ff ff
```

What can we do to play with?

st25tb_kiemul

original card


```
[0x00] 11 01 00 00
[0x01] 24 00 00 25
[0x02] 8e 06 80 15
[0x03] 00 01 43 39
[0x04] 00 00 c0 85
[0x05] 01 00 00 0a
[0x06] fd ff ff ff
[0x07] 00 00 00 00
[0x08] 00 00 00 00
[0x09] 00 00 00 00
[0x0a] 5a 17 00 00
[0x0b] b8 40 d2 b6
[0x0c] 64 80 b3 c2
[0x0d] 24 85 bc 04
[0x0e] 11 12 00 41
[0x0f] d4 4e bc e4
[0xff] ff ff ff ff
```

virtual card


```
[0x00] 11 01 00 00
[0x01] 24 00 00 25
[0x02] 8e 06 80 15
[0x03] 00 01 43 39
[0x04] 00 00 c0 85
[0x05] 02 00 00 0a
[0x06] fe ff ff ff
[0x07] 00 00 00 00
[0x08] 00 00 00 00
[0x09] 00 00 00 00
[0x0a] 5a 17 00 00
[0x0b] 00 00 00 00
[0x0c] 00 00 00 00
[0x0d] 00 00 00 00
[0x0e] 00 00 00 00
[0x0f] d4 4e bc e4
[0xff] ff ff ff ff
```

Reset to original

What can we do to play with?

st25tb_kiemul

original card


```
[0x00] 11 01 00 00
[0x01] 24 00 00 25
[0x02] 8e 06 80 15
[0x03] 00 01 43 39
[0x04] 00 00 c0 85
[0x05] 01 00 00 0a
[0x06] fd ff ff ff
[0x07] 00 00 00 00
[0x08] 00 00 00 00
[0x09] 00 00 00 00
[0x0a] 5a 17 00 00
[0x0b] b8 40 d2 b6
[0x0c] 64 80 b3 c2
[0x0d] 24 85 bc 04
[0x0e] 11 12 00 41
[0x0f] d4 4e bc e4
[0xff] ff ff ff ff
```

virtual card


```
[0x00] 11 01 00 00
[0x01] 24 00 00 25
[0x02] 8e 06 80 15
[0x03] 00 01 43 39
[0x04] 00 00 c0 85
[0x05] 02 00 00 0a
[0x06] fe ff ff ff
[0x07] 00 00 00 00
[0x08] 00 00 00 00
[0x09] 00 00 00 00
[0x0a] 5a 17 00 00
[0x0b] 00 00 00 00
[0x0c] 00 00 00 00
[0x0d] 00 00 00 00
[0x0e] 00 00 00 00
[0x0f] d4 4e bc e4
[0xff] ff ff ff ff
```

(r) expose

What can we do to play with?

st25tb_kiemul

original card


```
[0x00] 11 01 00 00
[0x01] 24 00 00 25
[0x02] 8e 06 80 15
[0x03] 00 01 43 39
[0x04] 00 00 c0 85
[0x05] 01 00 00 0a
[0x06] fd ff ff ff
[0x07] 00 00 00 00
[0x08] 00 00 00 00
[0x09] 00 00 00 00
[0x0a] 5a 17 00 00
[0x0b] b8 40 d2 b6
[0x0c] 64 80 b3 c2
[0x0d] 24 85 bc 04
[0x0e] 11 12 00 41
[0x0f] d4 4e bc e4
[0xff] ff ff ff ff
```

virtual card


```
[0x00] 11 01 00 00
[0x01] 24 00 00 25
[0x02] 8e 06 80 15
[0x03] 00 01 43 39
[0x04] 00 00 c0 85
[0x05] 01 00 00 0a
[0x06] fd ff ff ff
[0x07] 00 00 00 00
[0x08] 00 00 00 00
[0x09] 00 00 00 00
[0x0a] 5a 17 00 00
[0x0b] b8 08 d3 b6
[0x0c] 64 80 b3 c2
[0x0d] 30 85 3d 04
[0x0e] da dd 00 c1
[0x0f] d4 4e bc e4
[0xff] ff ff ff ff
```

(w) values

What can we do to play with?

st25tb_kiemul

original card


```
[0x00] 11 01 00 00
[0x01] 24 00 00 25
[0x02] 8e 06 80 15
[0x03] 00 01 43 39
[0x04] 00 00 c0 85
[0x05] 01 00 00 0a
[0x06] fd ff ff ff
[0x07] 00 00 00 00
[0x08] 00 00 00 00
[0x09] 00 00 00 00
[0x0a] 5a 17 00 00
[0x0b] b8 40 d2 b6
[0x0c] 64 80 b3 c2
[0x0d] 24 85 bc 04
[0x0e] 11 12 00 41
[0x0f] d4 4e bc e4
[0xff] ff ff ff ff
```

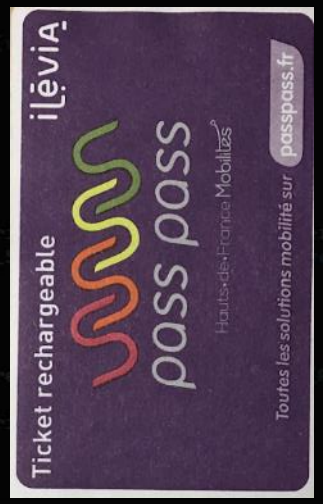
virtual card


```
[0x00] 11 01 00 00
[0x01] 24 00 00 25
[0x02] 8e 06 80 15
[0x03] 00 01 43 39
[0x04] 00 00 c0 85
[0x05] 01 00 00 0a
[0x06] fd ff ff ff
[0x07] 00 00 00 00
[0x08] 00 00 00 00
[0x09] 00 00 00 00
[0x0a] 5a 17 00 00
[0x0b] b8 08 d3 b6
[0x0c] 64 80 b3 c2
[0x0d] 30 85 3d 04
[0x0e] da dd 00 c1
[0x0f] d4 4e bc e4
[0xff] ff ff ff ff
```

What can we do to play with?

st25tb_kiemul

original card




```
[0x00] 11 01 00 00
[0x01] 24 00 00 25
[0x02] 8e 06 80 15
[0x03] 00 01 43 39
[0x04] 00 00 c0 85
[0x05] 01 00 00 0a
[0x06] fd ff ff ff
[0x07] 00 00 00 00
[0x08] 00 00 00 00
[0x09] 00 00 00 00
[0x0a] 5a 17 00 00
[0x0b] b8 08 d3 b6
[0x0c] 64 80 b3 c2
[0x0d] 30 85 3d 04
[0x0e] da dd 00 c1
[0x0f] d4 4e bc e4
[0xff] ff ff ff ff
```

(w) values

virtual card

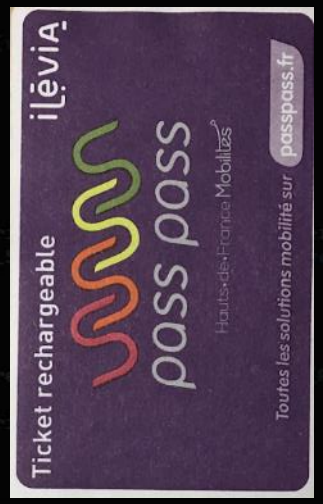
```
[0x00] 11 01 00 00
[0x01] 24 00 00 25
[0x02] 8e 06 80 15
[0x03] 00 01 43 39
[0x04] 00 00 c0 85
[0x05] 01 00 00 0a
[0x06] fd ff ff ff
[0x07] 00 00 00 00
[0x08] 00 00 00 00
[0x09] 00 00 00 00
[0x0a] 5a 17 00 00
[0x0b] b8 08 d3 b6
[0x0c] 64 80 b3 c2
[0x0d] 30 85 3d 04
[0x0e] da dd 00 c1
[0x0f] d4 4e bc e4
[0xff] ff ff ff ff
```

Write is allowed because new values are NOT > to previous ones

What can we do to play with?

st25tb_kiemul

original card




```
[0x00] 11 01 00 00
[0x01] 24 00 00 25
[0x02] 8e 06 80 15
[0x03] 00 01 43 39
[0x04] 00 00 c0 85
[0x05] 01 00 00 0a
[0x06] fd ff ff ff
[0x07] 00 00 00 00
[0x08] 00 00 00 00
[0x09] 00 00 00 00
[0x0a] 5a 17 00 00
[0x0b] b8 08 d3 b6
[0x0c] 64 80 b3 c2
[0x0d] 30 85 3d 04
[0x0e] da dd 00 c1
[0x0f] d4 4e bc e4
[0xff] ff ff ff ff
```

valid for control

virtual card

```
[0x00] 11 01 00 00
[0x01] 24 00 00 25
[0x02] 8e 06 80 15
[0x03] 00 01 43 39
[0x04] 00 00 c0 85
[0x05] 01 00 00 0a
[0x06] fd ff ff ff
[0x07] 00 00 00 00
[0x08] 00 00 00 00
[0x09] 00 00 00 00
[0x0a] 5a 17 00 00
[0x0b] b8 08 d3 b6
[0x0c] 64 80 b3 c2
[0x0d] 30 85 3d 04
[0x0e] da dd 00 c1
[0x0f] d4 4e bc e4
[0xff] ff ff ff ff
```

What can we do to play with?

st25tb_kiemul

original card


```
[0x00] 11 01 00 00
[0x01] 24 00 00 25
[0x02] 8e 06 80 15
[0x03] 00 01 43 39
[0x04] 00 00 c0 85
[0x05] 01 00 00 0a
[0x06] fd ff ff ff
[0x07] 00 00 00 00
[0x08] 00 00 00 00
[0x09] 00 00 00 00
[0x0a] 5a 17 00 00
[0x0b] b8 08 d3 b6
[0x0c] 64 80 b3 c2
[0x0d] 30 85 3d 04
[0x0e] da dd 00 c1
[0x0f] d4 4e bc e4
[0xff] ff ff ff ff
```

virtual card


```
[0x00] 11 01 00 00
[0x01] 24 00 00 25
[0x02] 8e 06 80 15
[0x03] 00 01 43 39
[0x04] 00 00 c0 85
[0x05] 02 00 00 0a
[0x06] fe ff ff ff
[0x07] 00 00 00 00
[0x08] 00 00 00 00
[0x09] 00 00 00 00
[0x0a] 5a 17 00 00
[0x0b] 00 00 00 00
[0x0c] 00 00 00 00
[0x0d] 00 00 00 00
[0x0e] 00 00 00 00
[0x0f] d4 4e bc e4
[0xff] ff ff ff ff
```

Reset to original

etc.

What can we do to play with?

st25tb_kiemul only ?

- **Proxmark3** also supports 14B', SR*
  - very well for RDV4 since 08/28/2023 ;)
  - And standalone modules…

  - **Can be implemented very quickly, if not already existing in private repositories**

- ***Flipper Zero uses ST25R3916***
  - *Not supporting **natively** 14B emulation*
  - It doesn't mean it will be unavailable forever

Where is it used ?

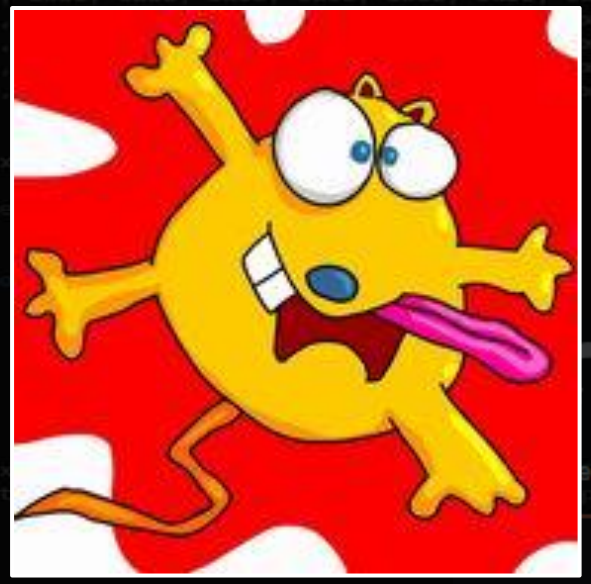
in France

- Not exhaustive…
  - **For sure: Lille, Reims, Dijon, Strasbourg, Bordeaux, Rennes, Tours, Annecy**
  - Maybe (but ~sure): Amiens, Le Havre, Metz, Valenciennes, Besançon, Clermont-Ferrand, Avignon, Aubagne, Caen, Aix-en-Provence, Bayonne, Blois, Perpignan, Pau, Saint-Malo, Cherbourg-Octeville, Lens, Nîmes
  - *?: Montbéliard, Lorient, Chambéry, Châlons-en-Champagne, Bourg-en-Bresse, Boulogne-sur-Mer, Alençon, Chauny, Verdun*
  - …

What to do ?

- Stop using ST25TB* / SR* technologies for convenient transport tickets
- Continue to deploy cEMV / Account-Based Ticketing (ABT)
  - with payment card & smartphone support!
- …or use authenticated methods (like Mifare Ultralight EV1, …)

Questions ?



- @gentilkiwi
- benjamin@gentilkiwi.net
- https://github.com/gentilkiwi
  - `st25tb_kiemul` firmware: https://github.com/gentilkiwi/st25tb_kiemul

References

- ST25TB series NFC tags: https://www.st.com/en/nfc/st25tb-series-nfc-tags.html
- ST25TB512-AT (nearly SRT512): https://www.st.com/en/nfc/st25tb512-at.html
- libnfc (nfc-st25tb): https://github.com/nfc-tools/libnfc/
- proxmark3: https://github.com/RfidResearchGroup/proxmark3
- AFNOR – FD P99-416: https://www.boutique.afnor.org/en-gb/standard/fd-p99416/eticketing-for-the-transportation-sector-interoperability-rules-for-the-cod/fa203907/339737
- TI TRF7970A: https://www.ti.com/product/TRF7970A

Pictures

Because it sounds too easy to make otherwise