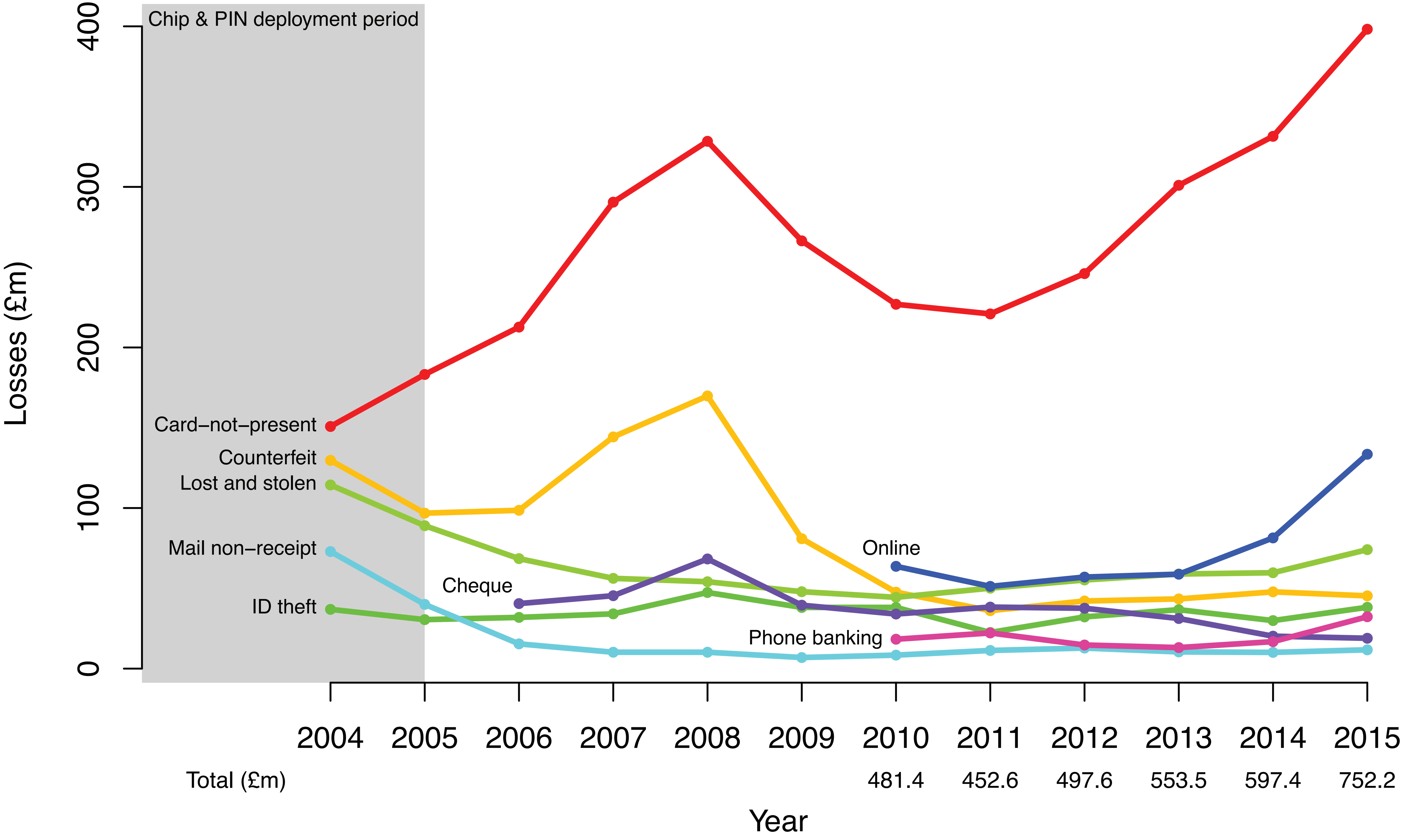
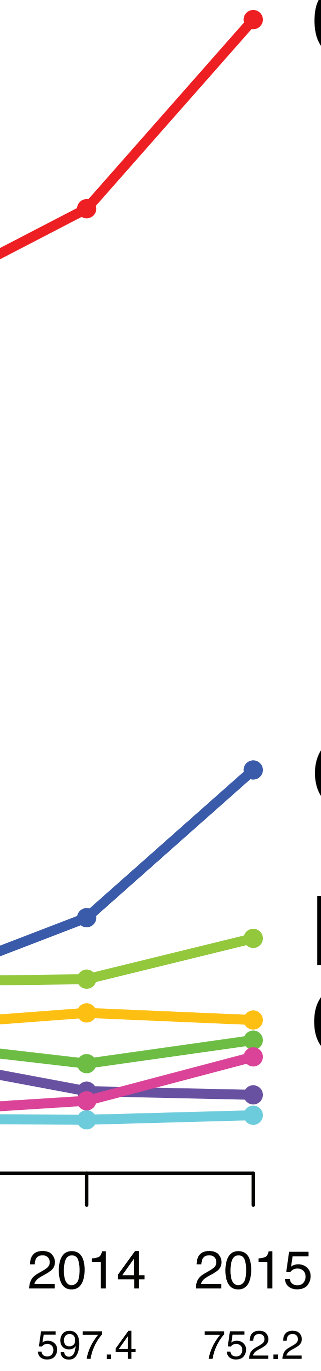
Payment Security: Attacks & Defences

Dr Steven J Murdoch
University College London

UK fraud is going up again



…even types of fraud Chip and PIN was supposed to prevent



Card-not-present: up 20% to £398.2m

Online banking: up 64% to £133.5m

Lost and stolen: up 24% to £74.1m

Counterfeit: down 5% to £45.3m

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Card-not-present: up 20% to £398.2m

Lost and stolen: up 24% to £74.1m

Counterfeit: down 5% to £45.3m

within total fraud figures (£567.5m)

Fraud in UK: up 16% to £379.8m

Fraud abroad: up 25% to £187.7m

Chip and PIN transactions have three main stages

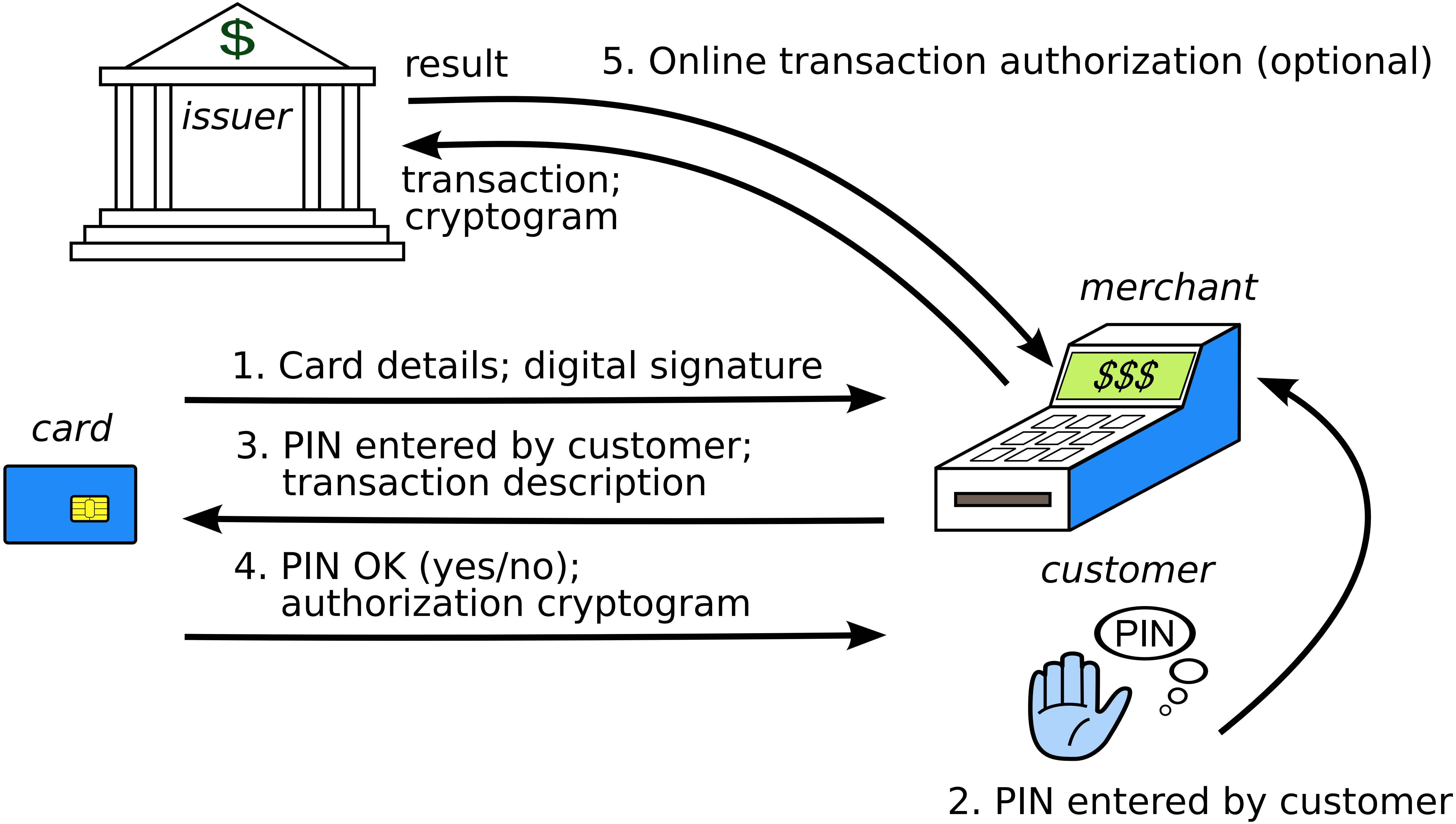
- **Card authentication**
  card proves it is real through providing a digital signature that the terminal can verify

- **Cardholder verification**
  card and terminal check that legitimate cardholder is present (normally by card verifying the PIN)

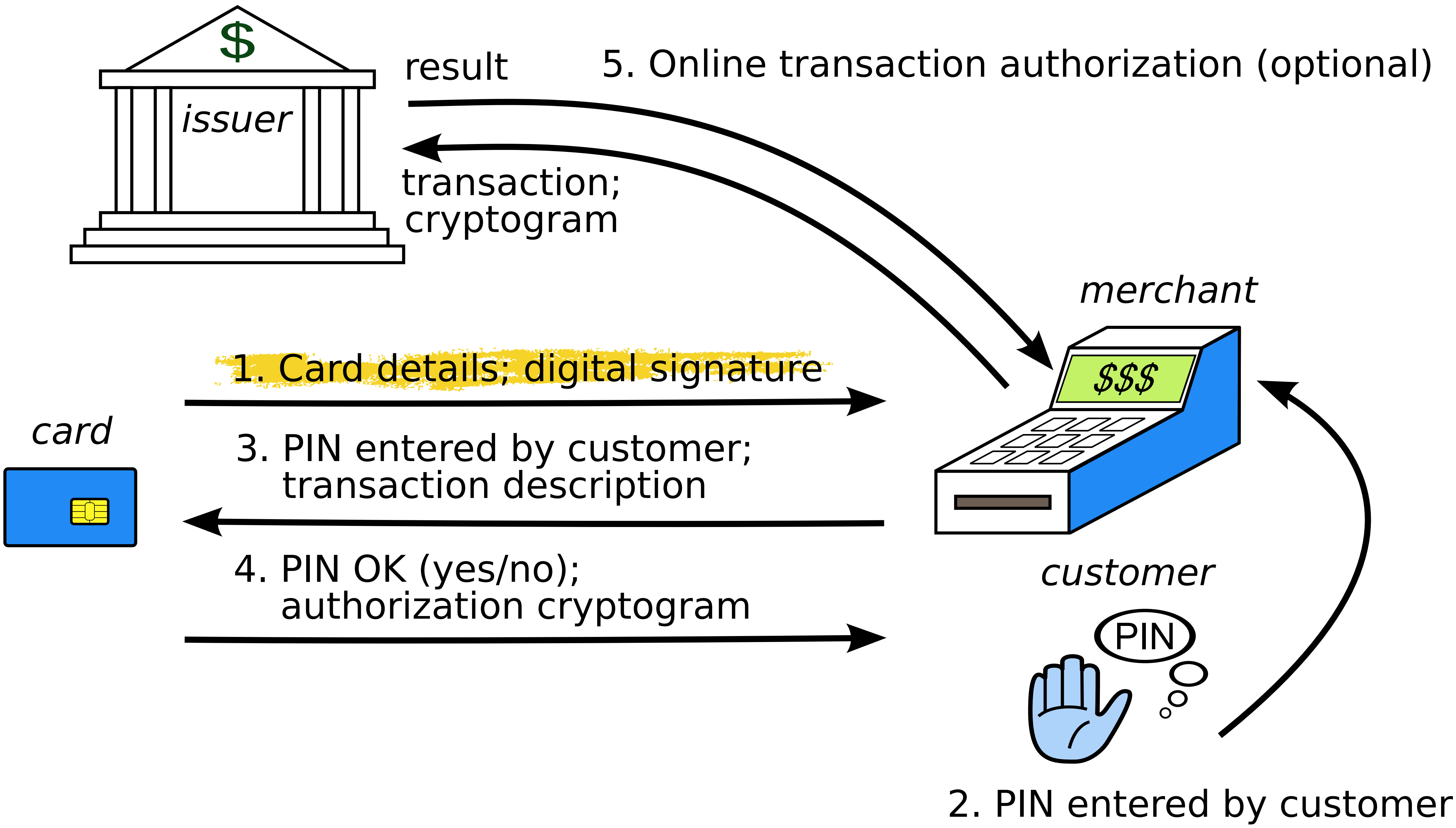
- **Transaction authorisation**
  terminal checks with bank that previous steps have been followed and the transaction should proceed

EMV protocol

- **Card authentication**
- **Cardholder verification**
- **Transaction authorisation**


$
issuer
result
5. Online transaction authorization (optional)
transaction;
cryptogram
merchant
$$$
1. Card details; digital signature
card
3. PIN entered by customer;
transaction description
4. PIN OK (yes/no);
authorization cryptogram
customer
PIN
2. PIN entered by customer

Card authentication



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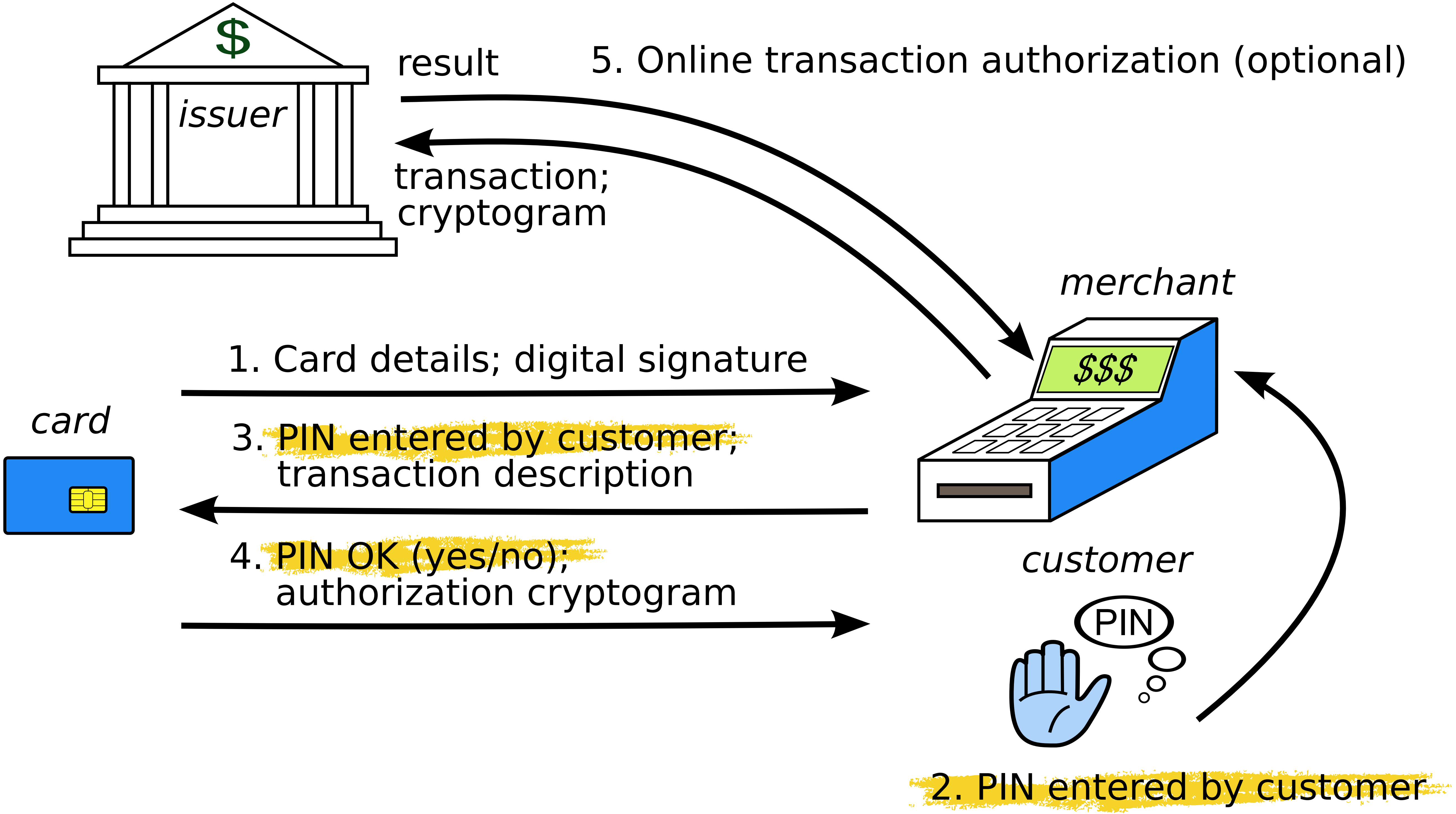
Cardholder verification



issuer

result

5. Online transaction authorization (optional)

transaction;
cryptogram

merchant

1. Card details; digital signature

card

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transaction description

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authorization cryptogram

customer

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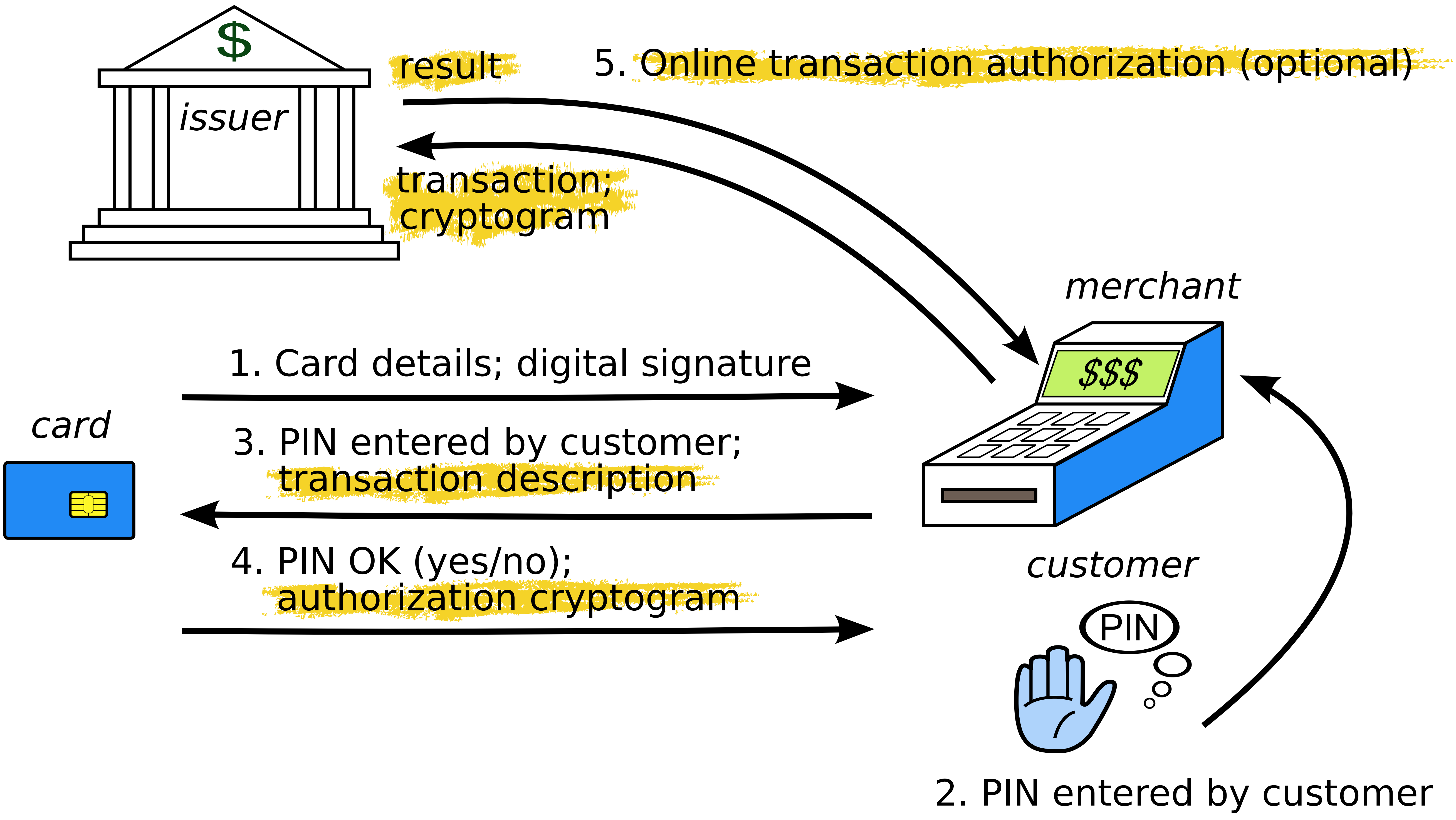
Transaction authorisation



result

5. Online transaction authorization (optional)

transaction;
cryptogram

1. Card details; digital signature

3. PIN entered by customer;
transaction description

4. PIN OK (yes/no);
authorization cryptogram

2. PIN entered by customer

Criminals have successfully bypassed Chip & PIN

Obtain static data as a result of flawed tamper resistance in Chip & PIN terminals

then

Bypass card authentication through exploiting backwards compatibility mode

Counterfeit

Steal cards

then

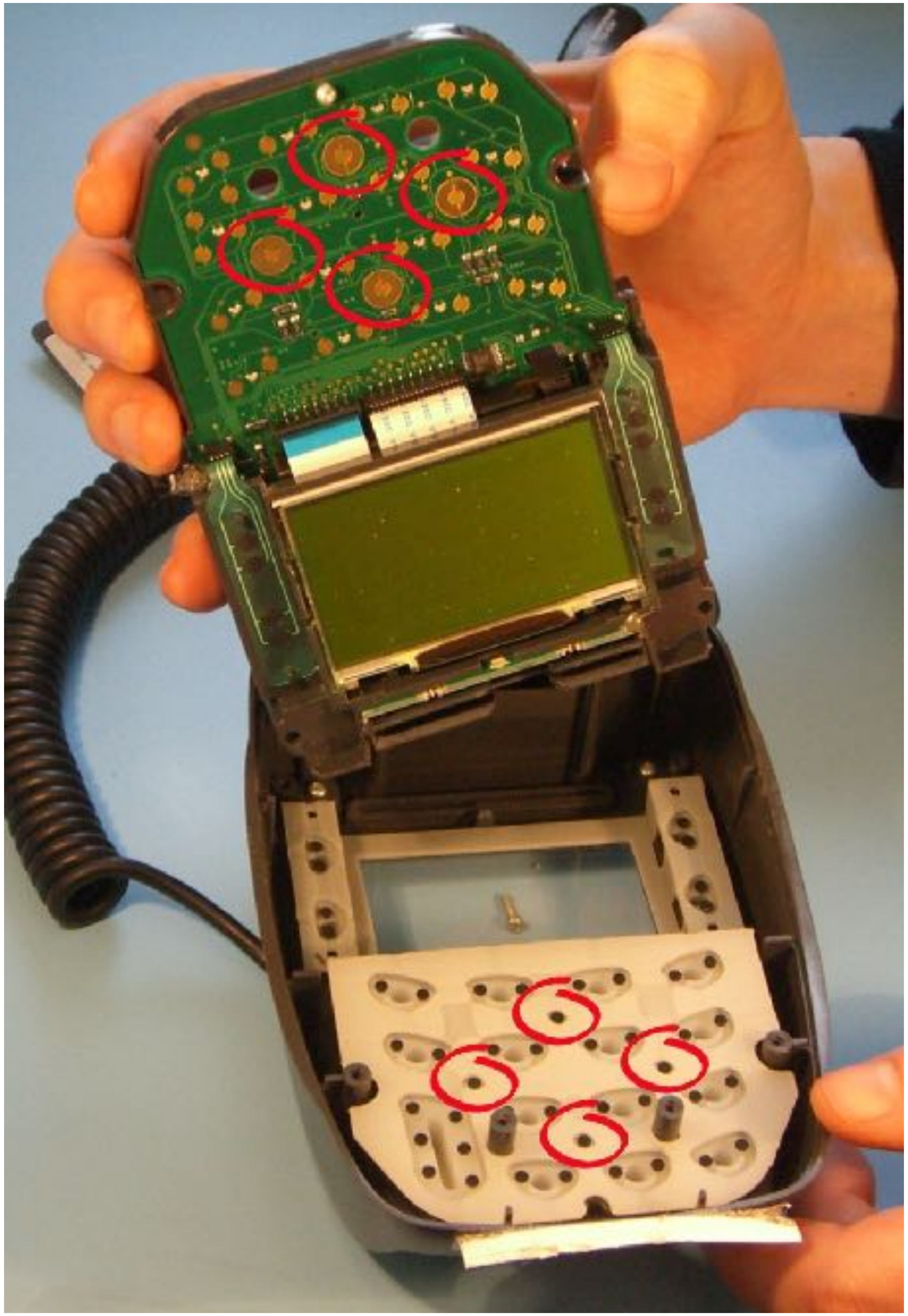
Bypass cardholder verification by exploiting Chip and PIN protocol flaws

Lost and Stolen

Sensitive data is sent unencrypted between the card and the terminal

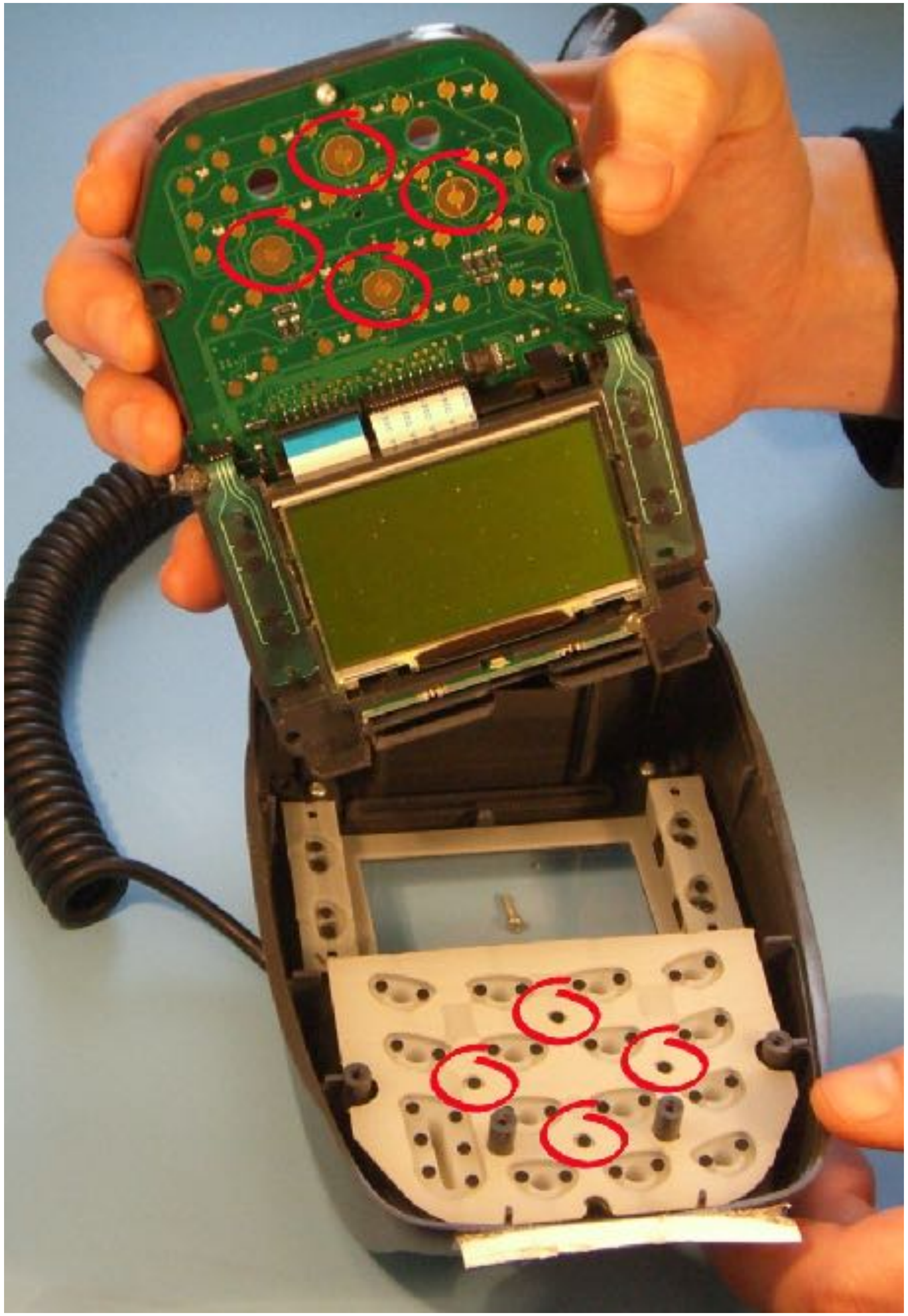
- Card number, expiry date, cardholder name …
- Copy of magnetic stripe including CVV (for some cards)
- PIN to be checked by card

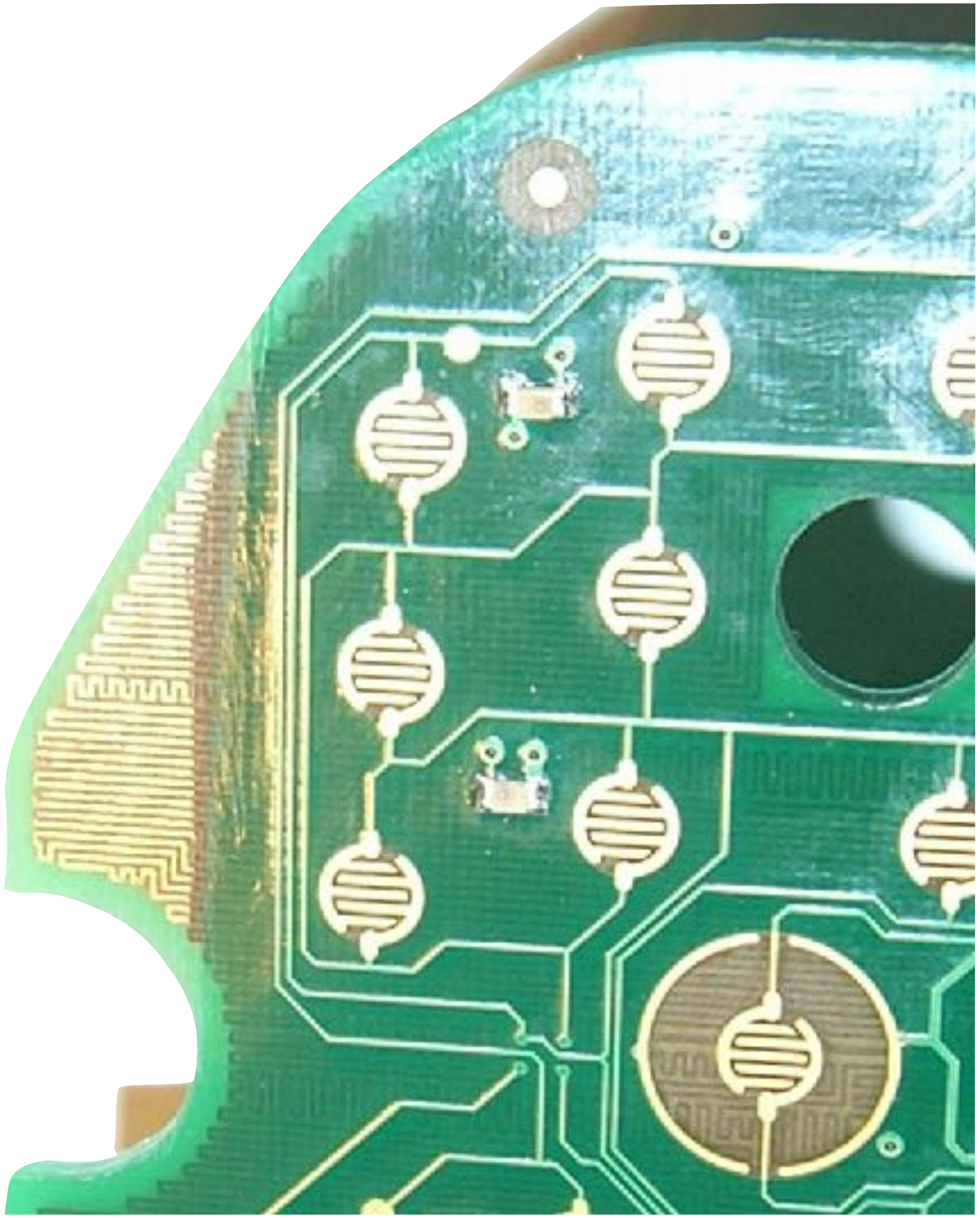
Chip and PIN terminals are supposed to protect this information against being recorded: **tamper resistance**

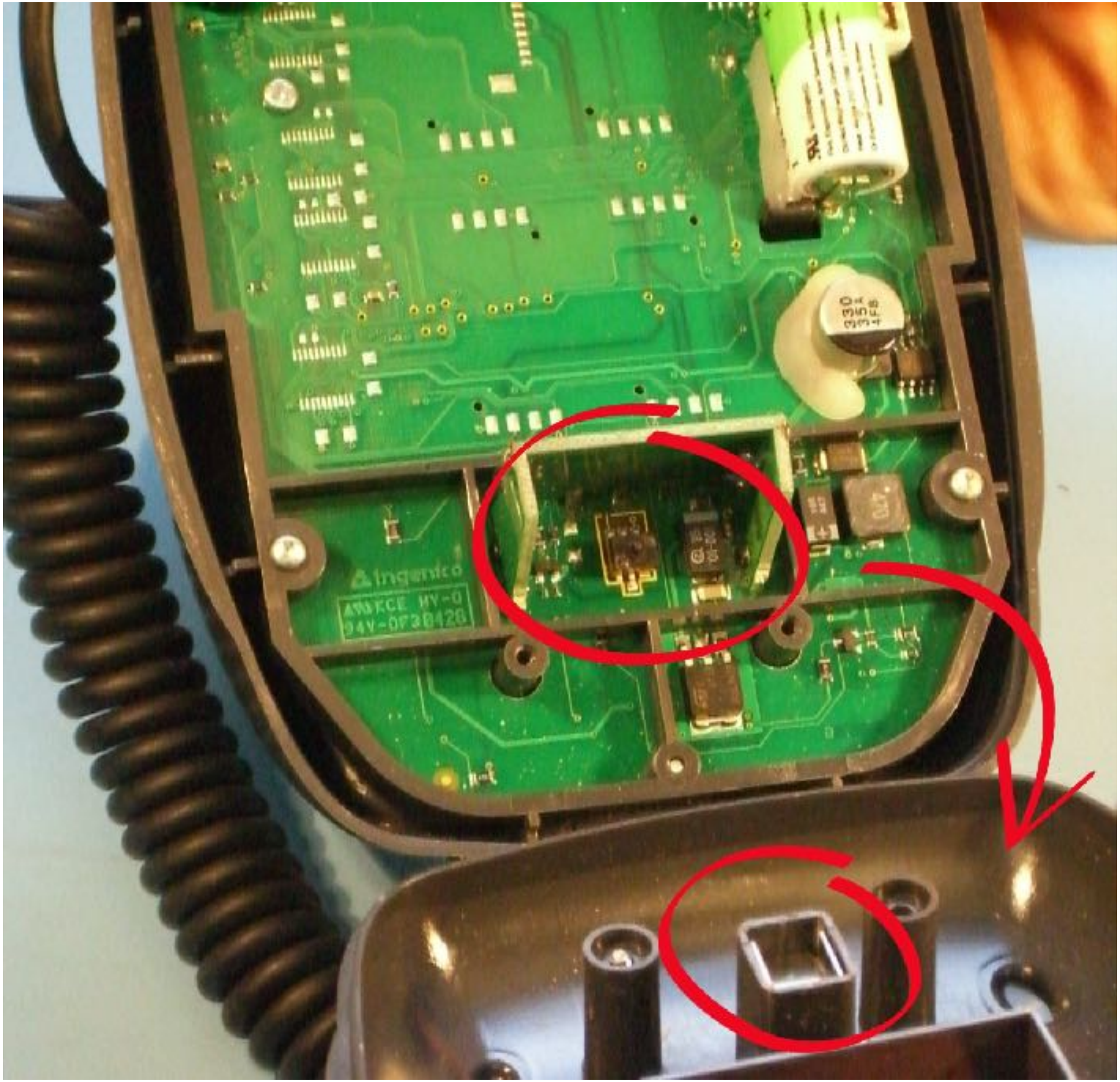


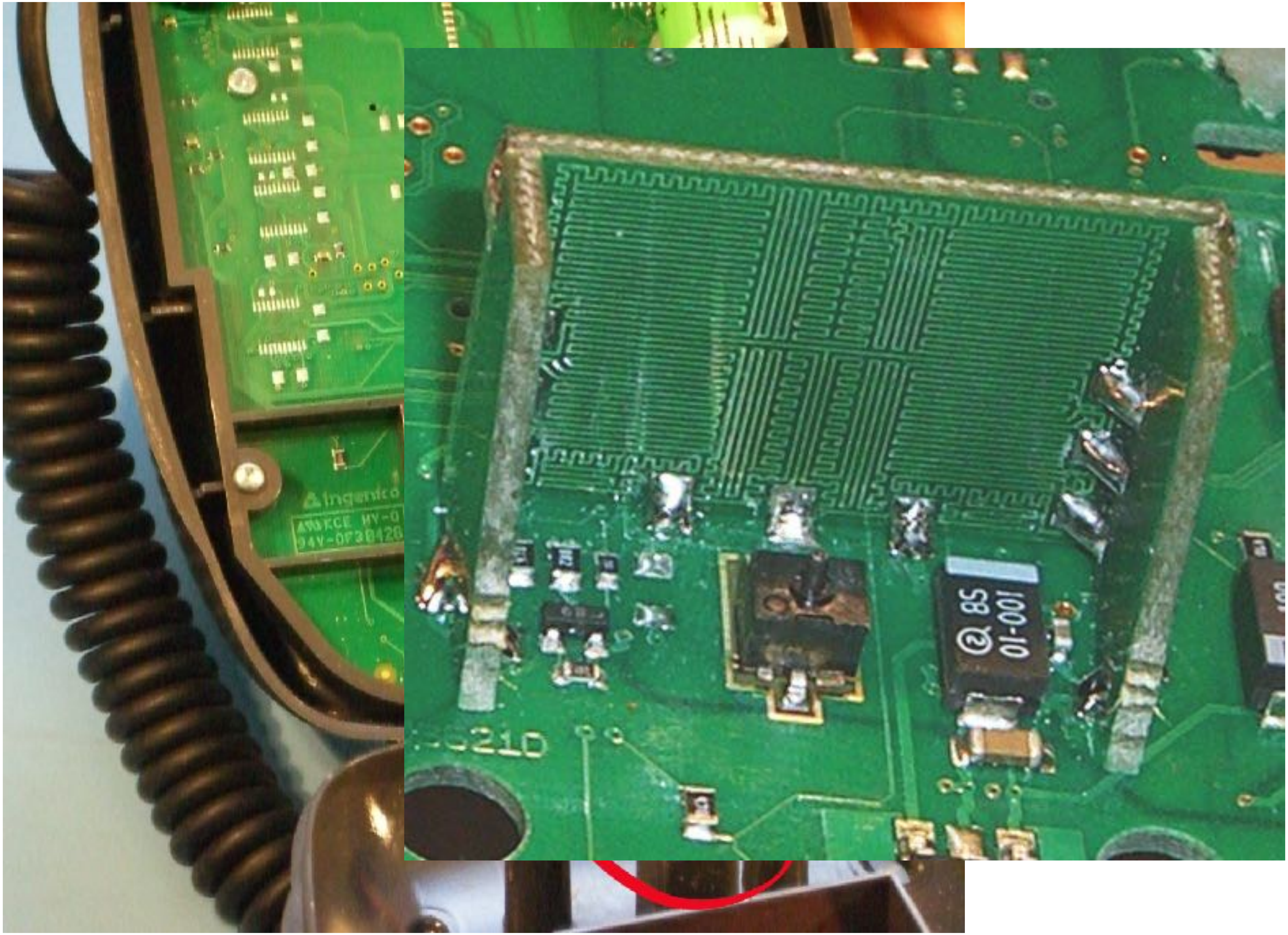
Tamper switches

Tamper mesh






ingenico
KCE HY-0
94V-0F3B128
330
35V


ingenico
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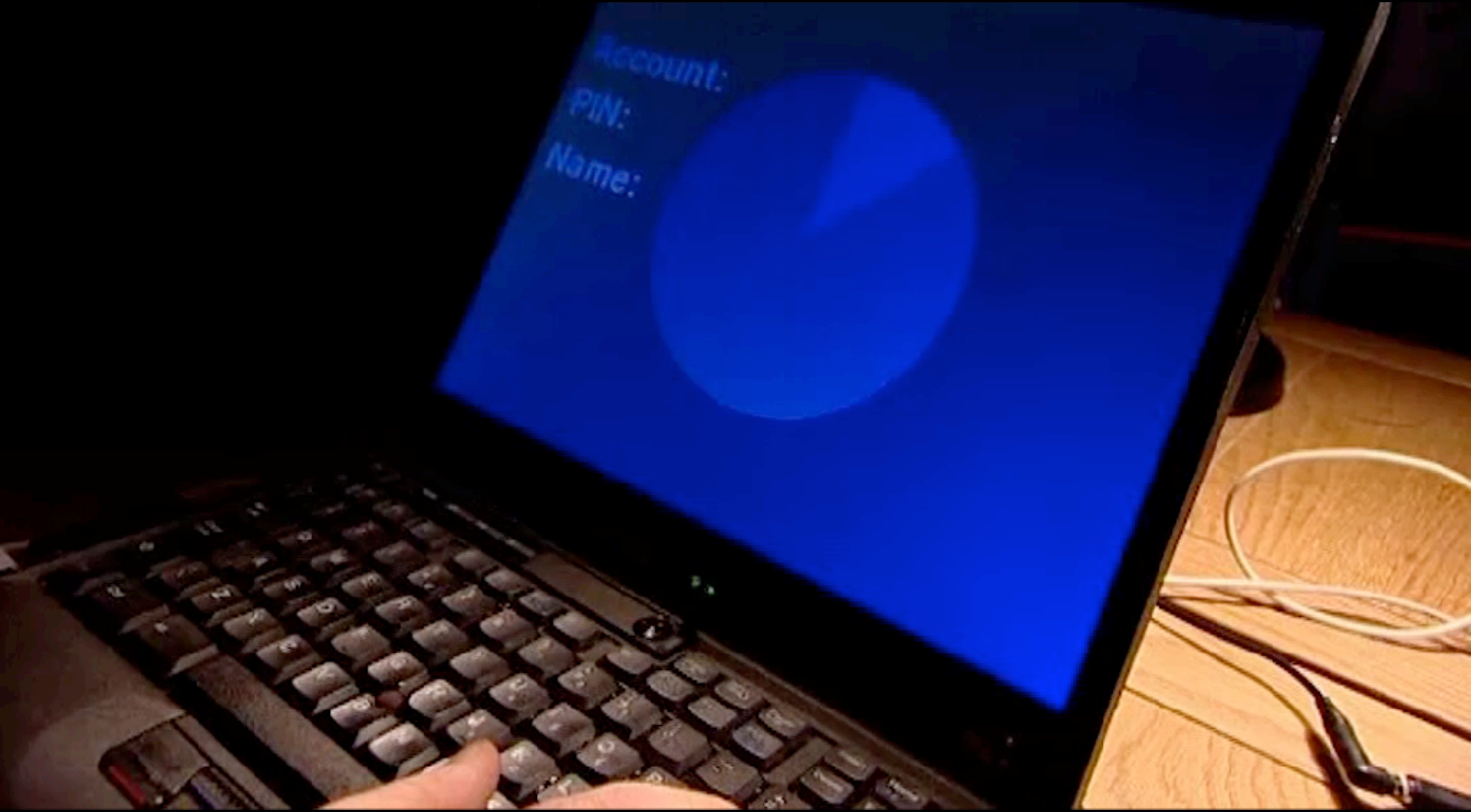
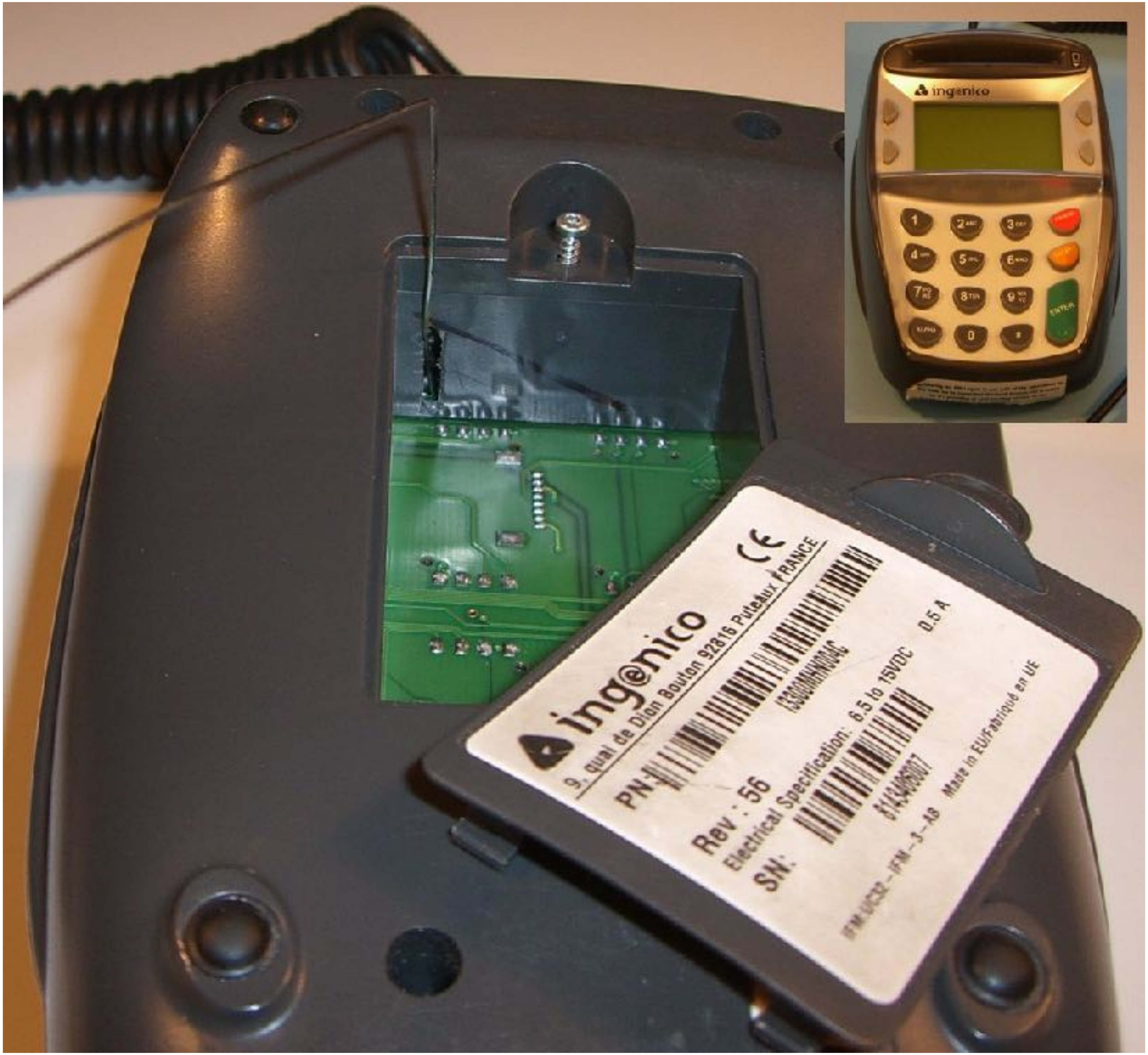
85
100-10
0210


Account:
PIN:
Name:


ingenico
1
2
3
4
5
6
7
8
9
0
ENTER
ingenico
9, quai de Dion Bouton 92816 Puteaux FRANCE
CE
PN:
Rev : 56
Electrical Specification: 6.5 to 15VDC 0.5 A
SN:
IFM-UC32-IFM-3-A8 Made in EU/Fabriqué en UE

Criminal gets all that is needed to make a magnetic stripe card

- Card number, expiry date
- CVV
- Cardholder’s PIN

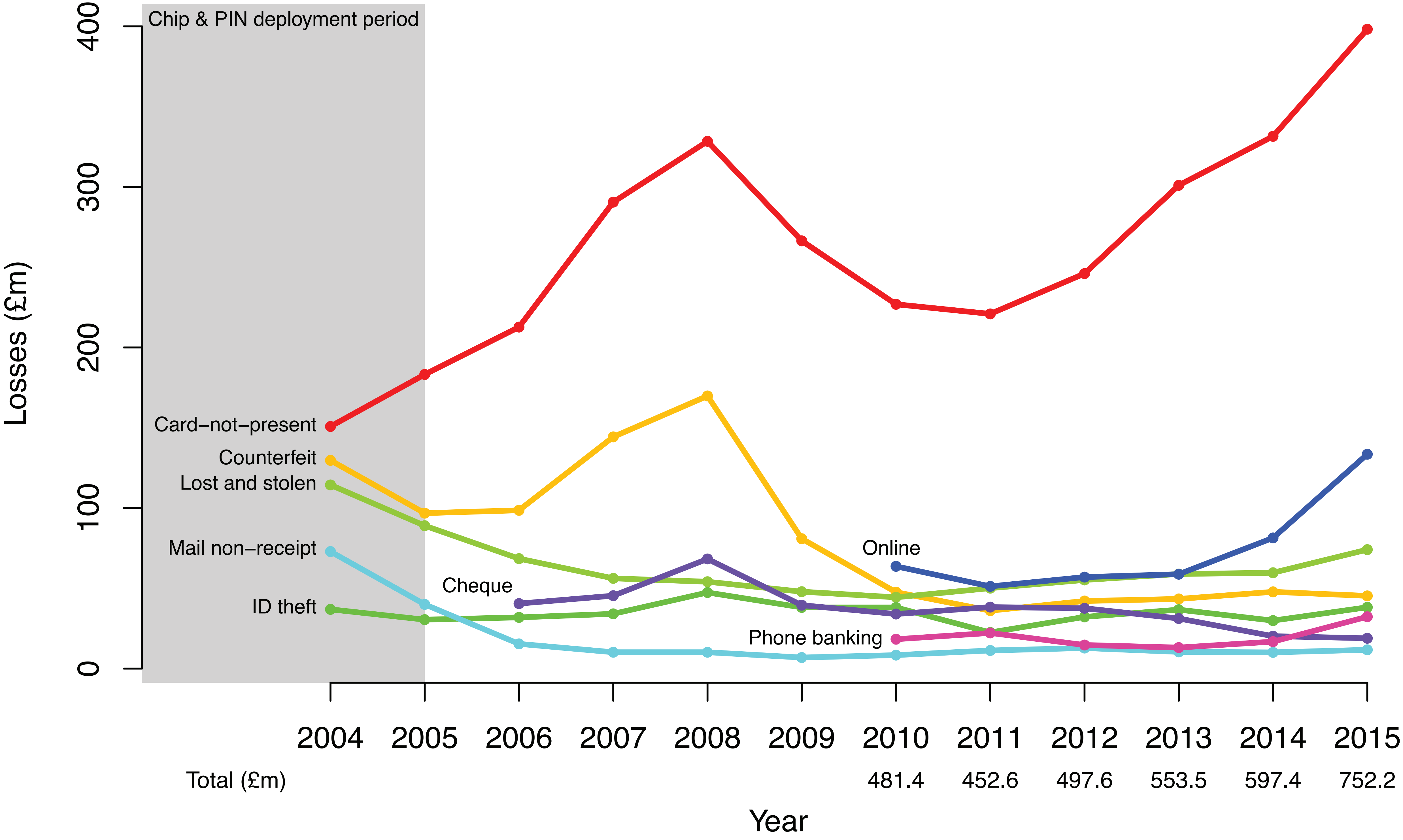
Compromising a shop terminal now gives criminals enough information to make ATM withdrawal

Criminal gets all that is needed to make a magnetic stripe card

- Card number, expiry date
- CVV
- Cardholder's PIN

CASH

Chip and PIN led to increase in counterfeit fraud



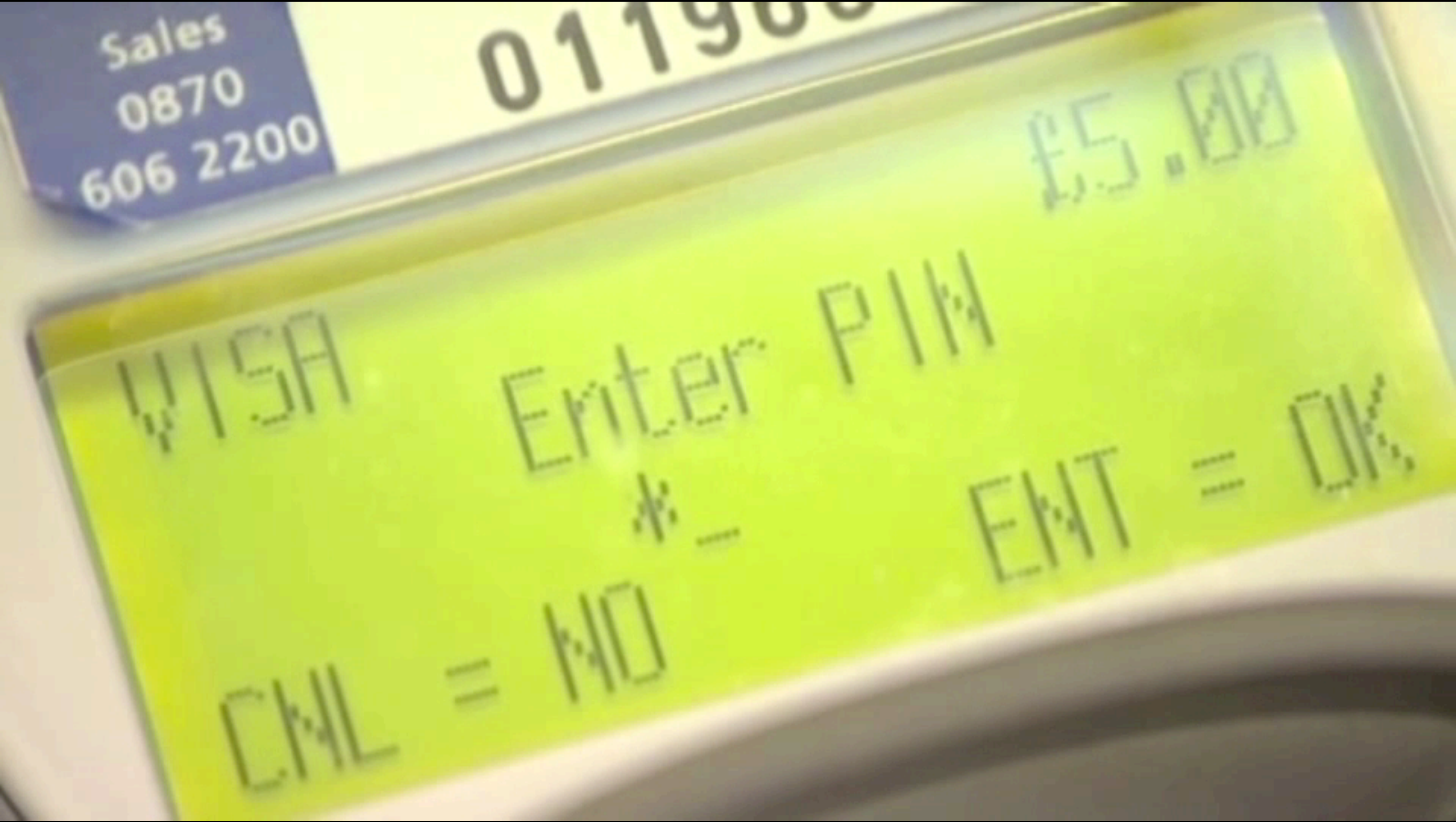
Card is responsible for cardholder verification

- Card states ways by which cardholder verification can be performed and the preference (e.g. first PIN, then signature)

- If PIN used, terminal sends PIN to card and card checks if correct

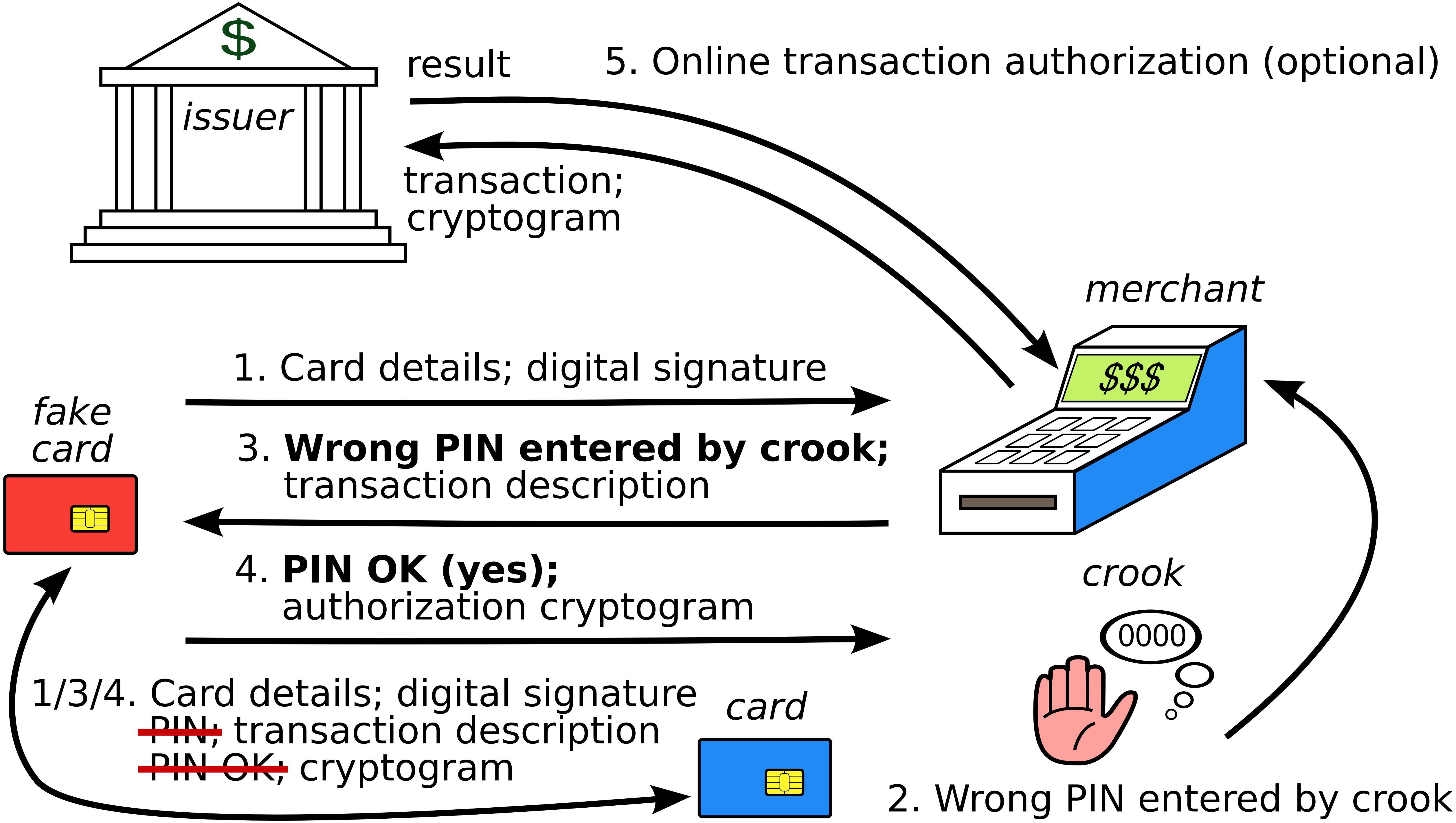
- PIN sometimes encrypted

- Response **not encrypted or authenticated**



```
VISA                £5.00
      Enter PIN
        *_      ENT = OK
CNL = NO
```

The no-PIN attack



result

5. Online transaction authorization (optional)

transaction;
cryptogram

merchant

fake
card

1. Card details; digital signature

3. **Wrong PIN entered by crook;**
transaction description

4. **PIN OK (yes);**
authorization cryptogram

crook

1/3/4. Card details; digital signature
~~PIN;~~ transaction description
~~PIN OK;~~ cryptogram

card

2. Wrong PIN entered by crook

Response from industry

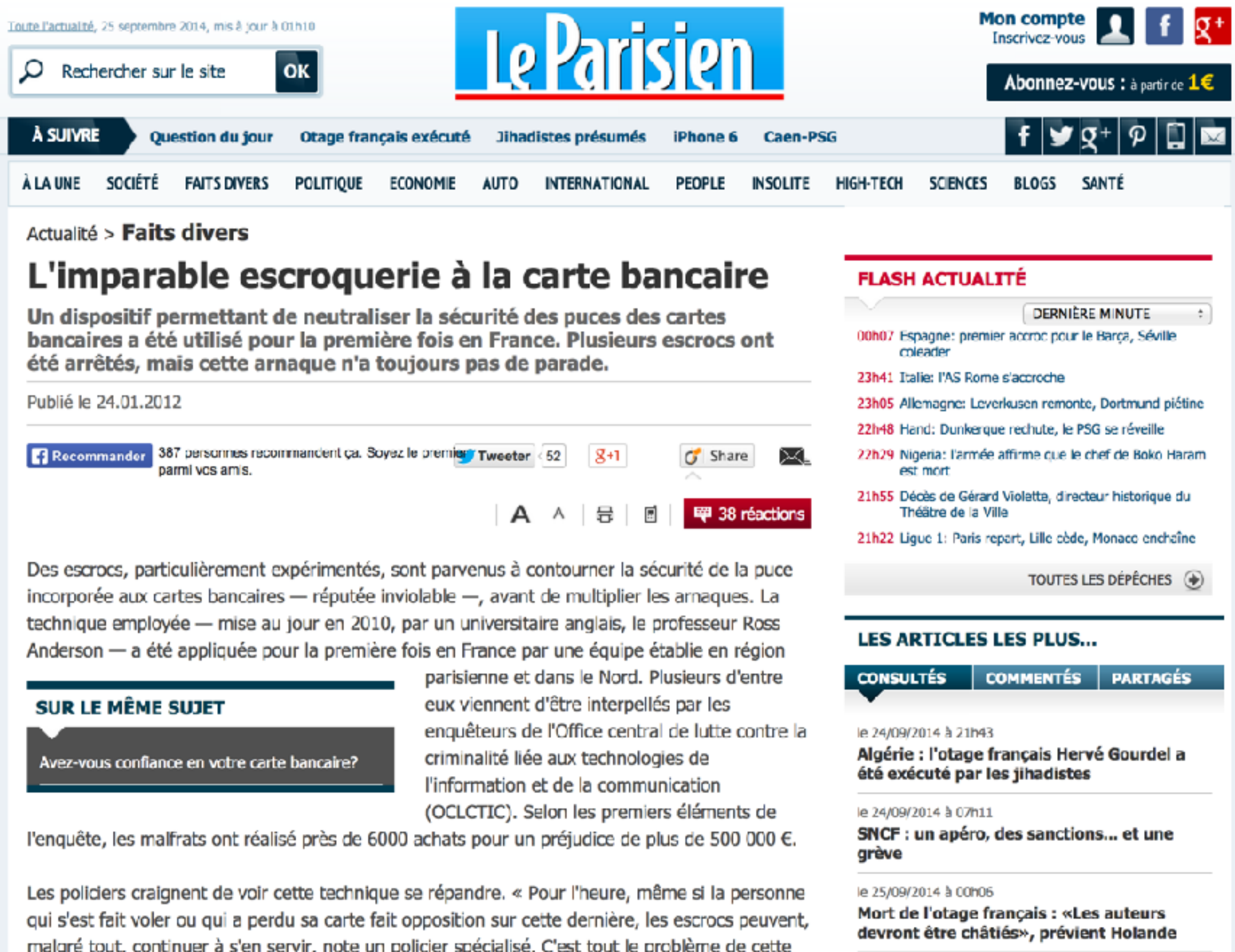
> What is more, at this stage, the observations are the result of scientific research whose transposition outside laboratory conditions is complex since it would necessitate the use of highly sophisticated material.

— Le GIE des Cartes Bancaires (January 2010)

> Neither the banking industry nor the police have any evidence of criminals having the capability to deploy such sophisticated attacks.

— UK Cards Association (February 2010))

Response from criminals



Actualité > **Faits divers**

L'imparable escroquerie à la carte bancaire

Un dispositif permettant de neutraliser la sécurité des puces des cartes bancaires a été utilisé pour la première fois en France. Plusieurs escrocs ont été arrêtés, mais cette arnaque n'a toujours pas de parade.

Publié le 24.01.2012

Des escrocs, particulièrement expérimentés, sont parvenus à contourner la sécurité de la puce incorporée aux cartes bancaires — réputée inviolable —, avant de multiplier les arnaques. La technique employée — mise au jour en 2010, par un universitaire anglais, le professeur Ross Anderson — a été appliquée pour la première fois en France par une équipe établie en région parisienne et dans le Nord. Plusieurs d'entre eux viennent d'être interpellés par les enquêteurs de l'Office central de lutte contre la criminalité liée aux technologies de l'information et de la communication (OCLCTIC). Selon les premiers éléments de l'enquête, les malfrats ont réalisé près de 6000 achats pour un préjudice de plus de 500 000 €.

SUR LE MÊME SUJET

Avez-vous confiance en votre carte bancaire?

Les policiers craignent de voir cette technique se répandre. « Pour l'heure, même si la personne qui s'est fait voler ou qui a perdu sa carte fait opposition sur cette dernière, les escrocs peuvent, malgré tout, continuer à s'en servir, note un policier spécialisé. C'est tout le problème de cette

FLASH ACTUALITÉ

00h07 Espagne: premier accroc pour le Barça, Séville coleader

23h41 Italie: l'AS Rome s'accroche

23h05 Allemagne: Leverkusen remonte, Dortmund piétine

22h48 Hand: Dunkerque rechute, le PSG se réveille

22h29 Nigeria: l'armée affirme que le chef de Boko Haram est mort

21h55 Décès de Gérard Violette, directeur historique du Théâtre de la Ville

21h22 Ligue 1: Paris repart, Lille cède, Monaco enchaîne

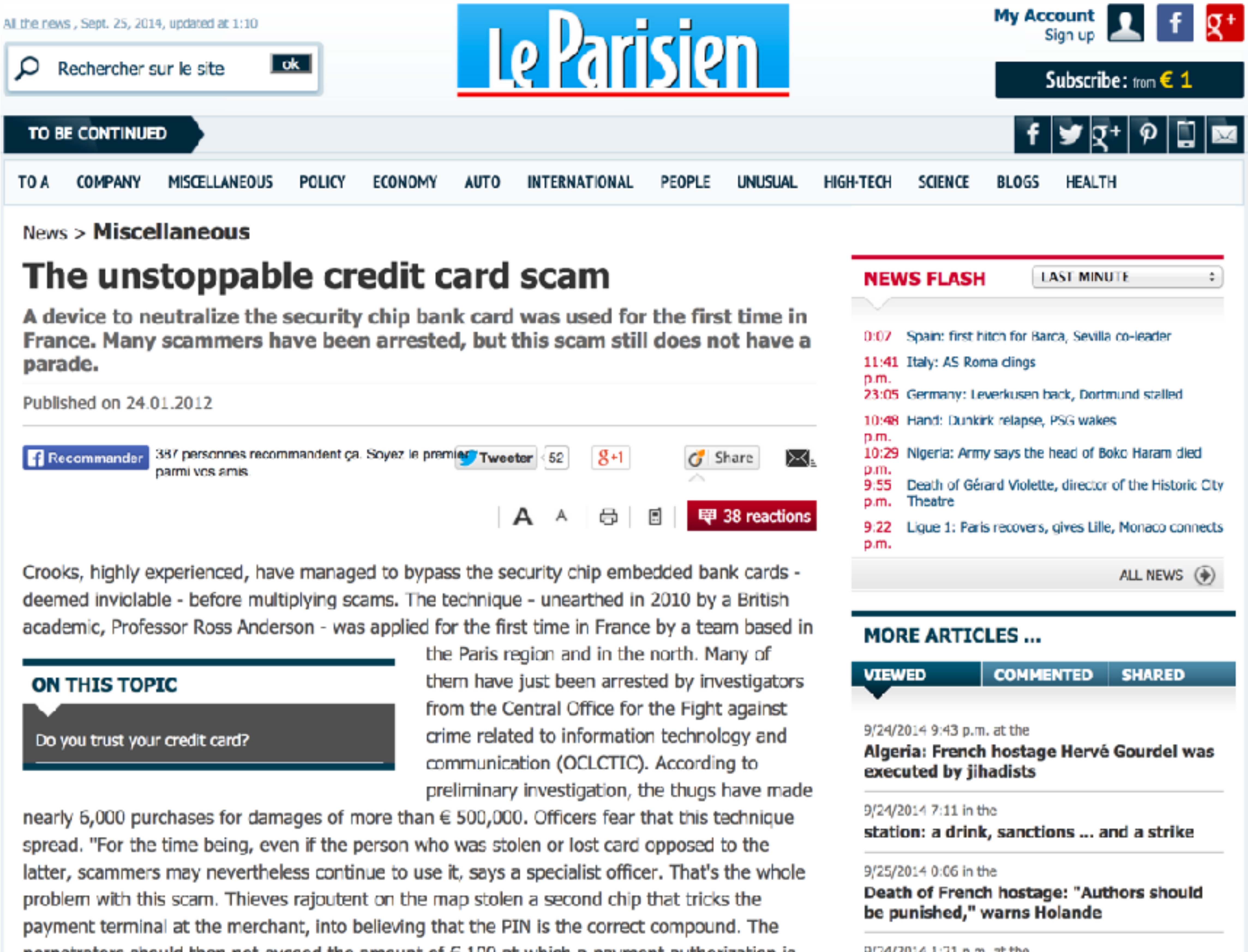
LES ARTICLES LES PLUS...

le 24/09/2014 à 21h43
Algérie : l'otage français Hervé Gourdel a été exécuté par les jihadistes

le 24/09/2014 à 07h11
SNCF : un apéro, des sanctions... et une grève

le 25/09/2014 à 00h06
Mort de l'otage français : «Les auteurs devront être châtiés», prévient Holande

Response from criminals



The unstoppable credit card scam

A device to neutralize the security chip bank card was used for the first time in France. Many scammers have been arrested, but this scam still does not have a parade.

Published on 24.01.2012

Recommander
387 personnes recommandent ça. Soyez le premier parmi vos amis.
Tweeter
52
+1
Share
A
A
38 reactions

Crooks, highly experienced, have managed to bypass the security chip embedded bank cards - deemed inviolable - before multiplying scams. The technique - unearthed in 2010 by a British academic, Professor Ross Anderson - was applied for the first time in France by a team based in the Paris region and in the north. Many of them have just been arrested by investigators from the Central Office for the Fight against crime related to information technology and communication (OCLCTIC). According to preliminary investigation, the thugs have made nearly 6,000 purchases for damages of more than € 500,000. Officers fear that this technique spread. "For the time being, even if the person who was stolen or lost card opposed to the latter, scammers may nevertheless continue to use it, says a specialist officer. That's the whole problem with this scam. Thieves rajoutent on the map stolen a second chip that tricks the payment terminal at the merchant, into believing that the PIN is the correct compound. The perpetrators should then not exceed the amount of € 120 at which a payment authorization is

ON THIS TOPIC

Do you trust your credit card?

NEWS FLASH LAST MINUTE

0:07	Spain: first hitch for Barca, Sevilla co-leader
11:41 p.m.	Italy: AS Roma clings
23:05	Germany: Leverkusen back, Dortmund stalled
10:48 p.m.	Hand: Dunkirk relapse, PSG wakes
10:29 p.m.	Nigeria: Army says the head of Boko Haram died
9:55 p.m.	Death of Gérard Violette, director of the Historic City Theatre
9:22 p.m.	Ligue 1: Paris recovers, gives Lille, Monaco connects

ALL NEWS

MORE ARTICLES ...

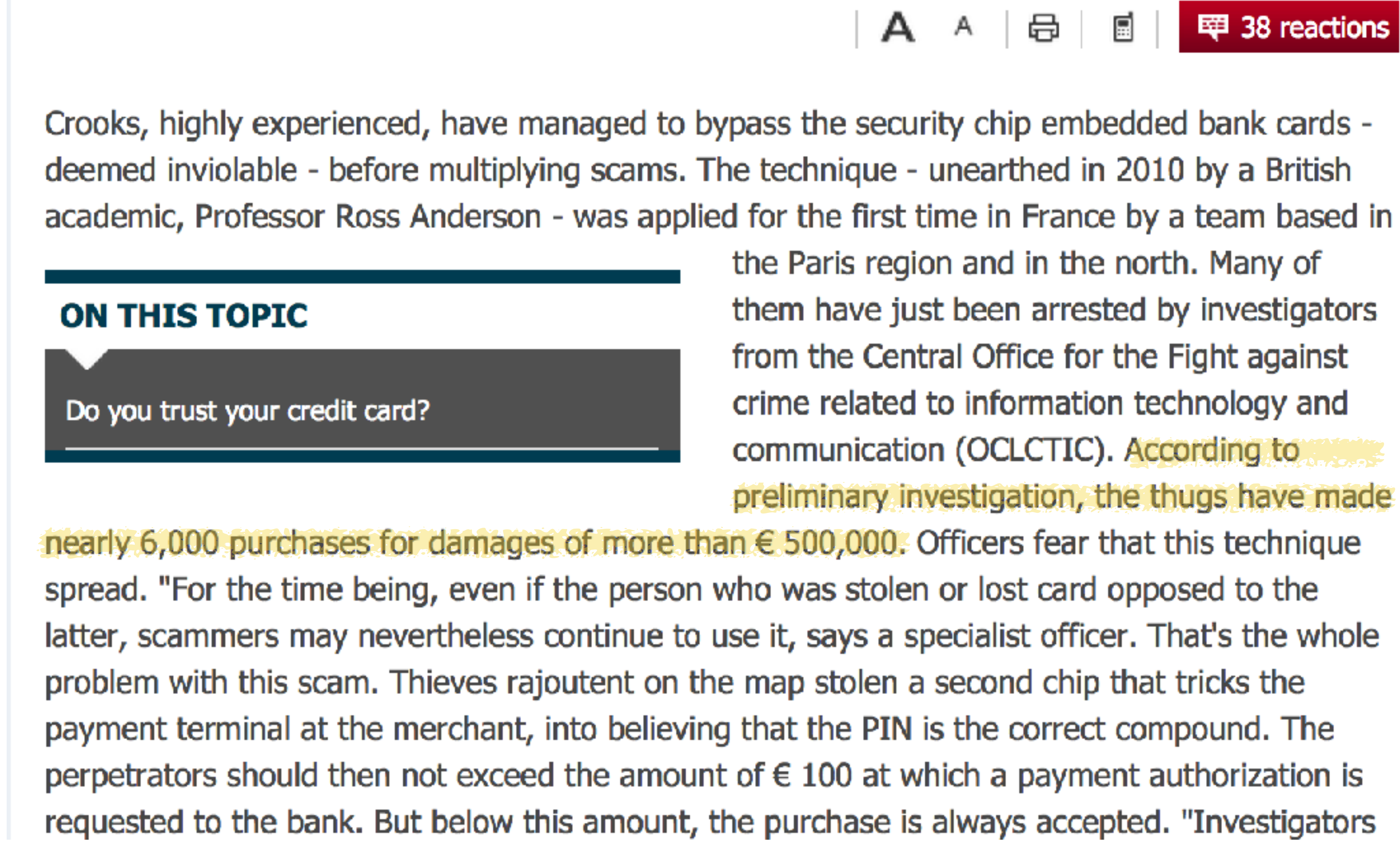
VIEWED | COMMENTED | SHARED

9/24/2014 9:43 p.m. at the
Algeria: French hostage Hervé Gourdel was executed by jihadists

9/24/2014 7:11 in the
station: a drink, sanctions ... and a strike

9/25/2014 0:06 in the
Death of French hostage: "Authors should be punished," warns Holande

9/24/2014 1:21 p.m. at the



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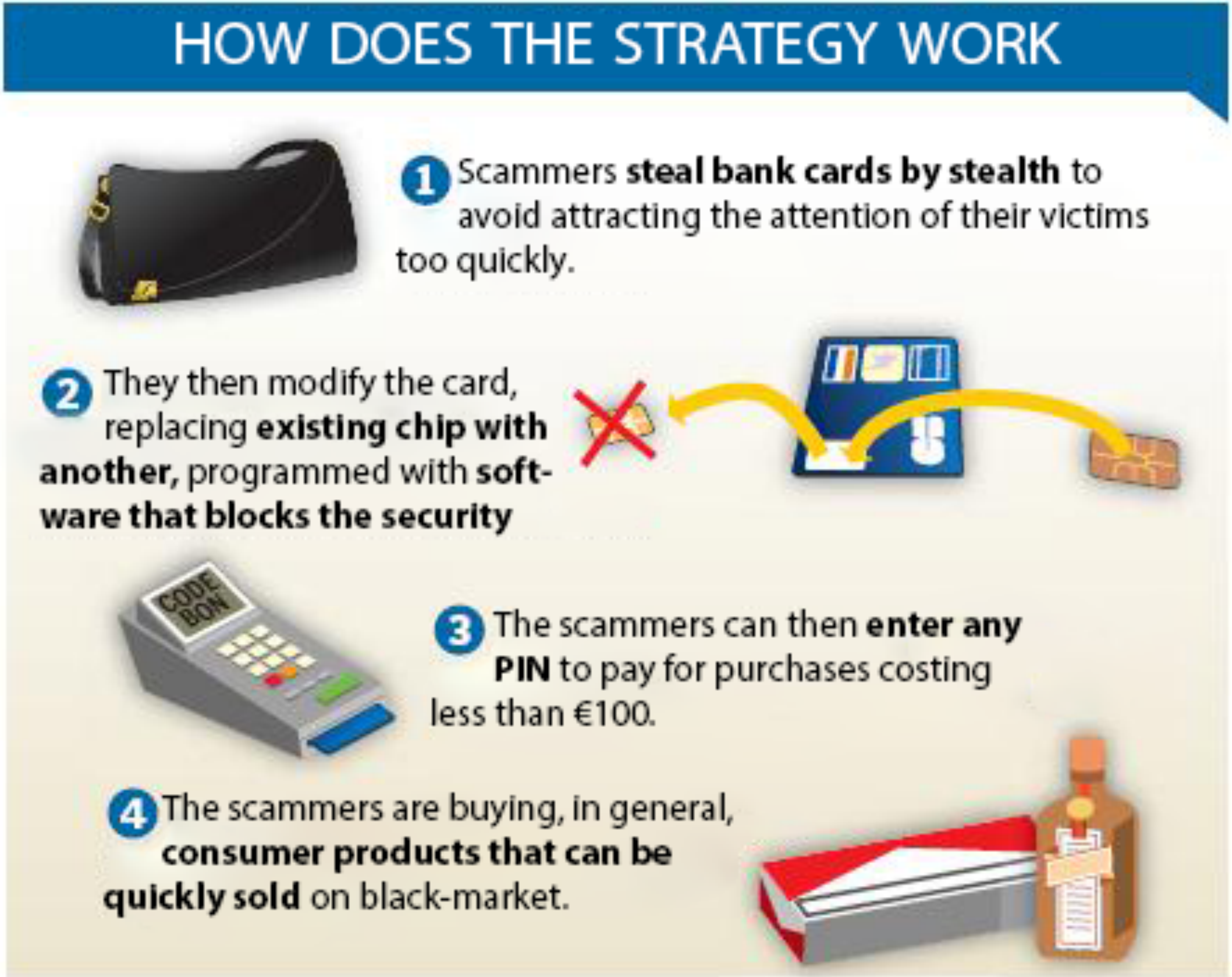
ON THIS TOPIC

Do you trust your credit card?



HOW DOES THE STRATEGY WORK

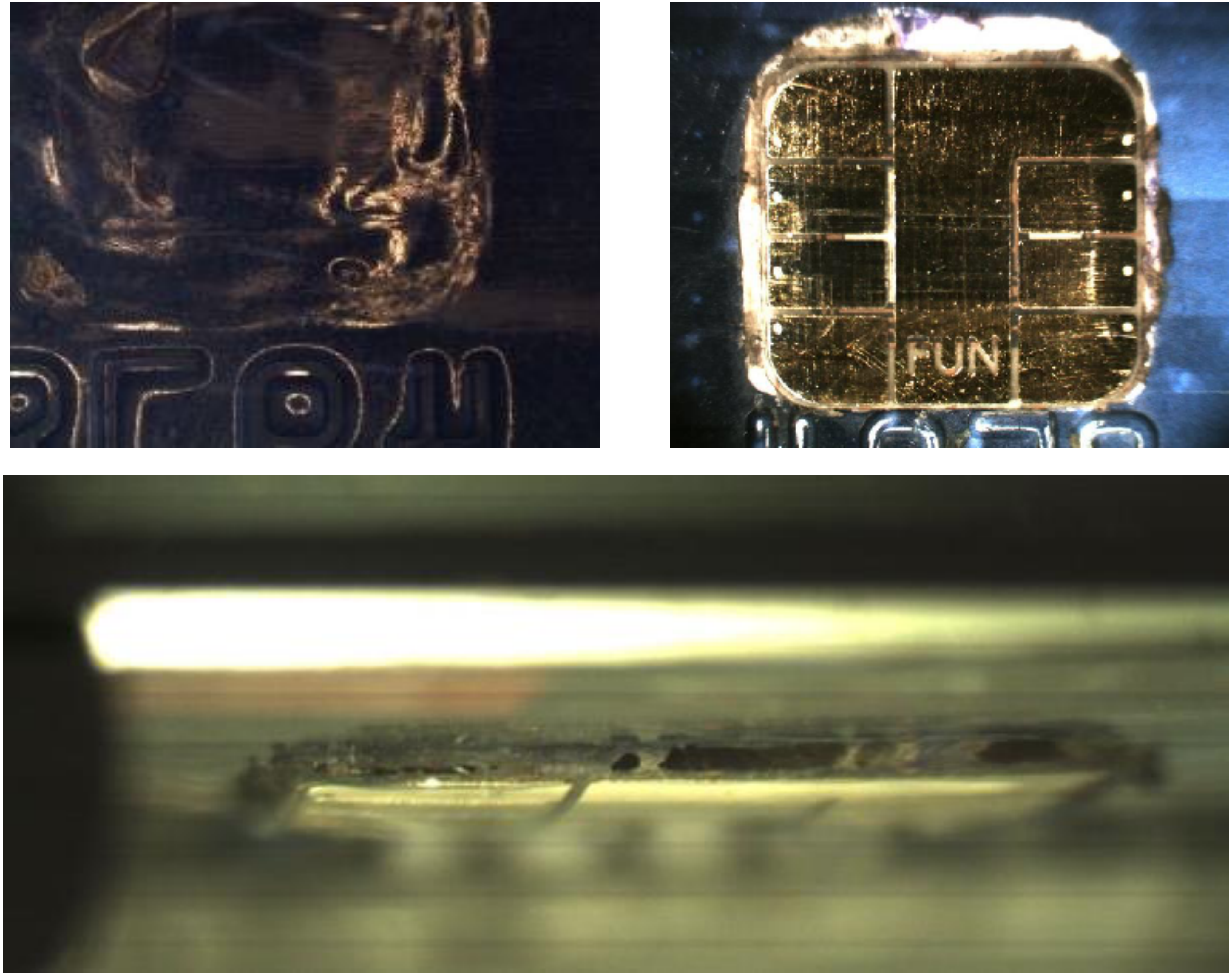
1 Scammers **steal bank cards by stealth** to avoid attracting the attention of their victims too quickly.

2 They then modify the card, replacing **existing chip with another,** programmed with **software that blocks the security**

3 The scammers can then **enter any PIN** to pay for purchases costing less than €100.

4 The scammers are buying, in general, **consumer products that can be quickly sold** on black-market.

Response from criminals



Ferradi et al. “When Organized Crime Applies Academic Results – A Forensic Analysis of an In-Card Listening Device”, Cryptology ePrint Archive: Report 2015/963.

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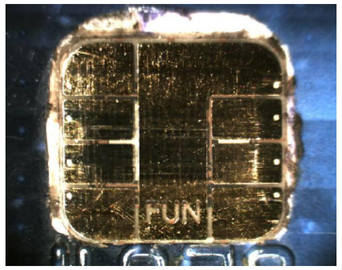

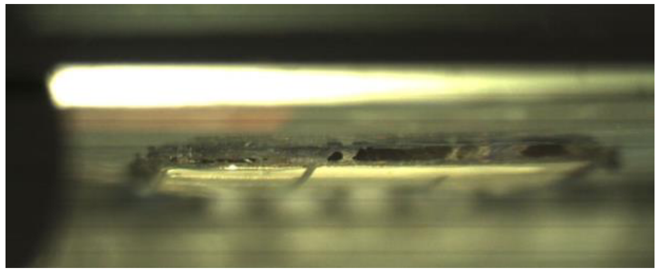

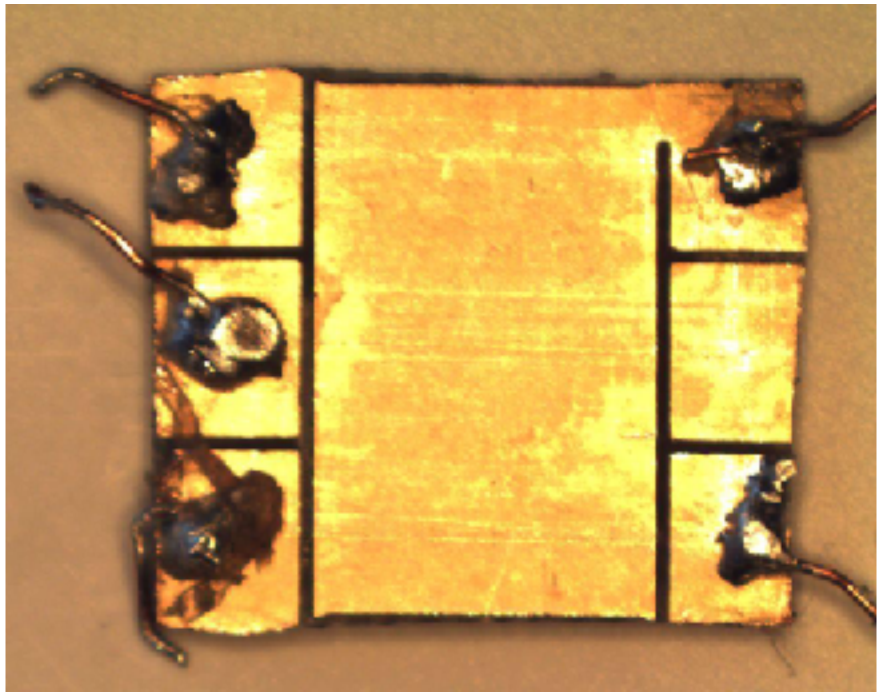

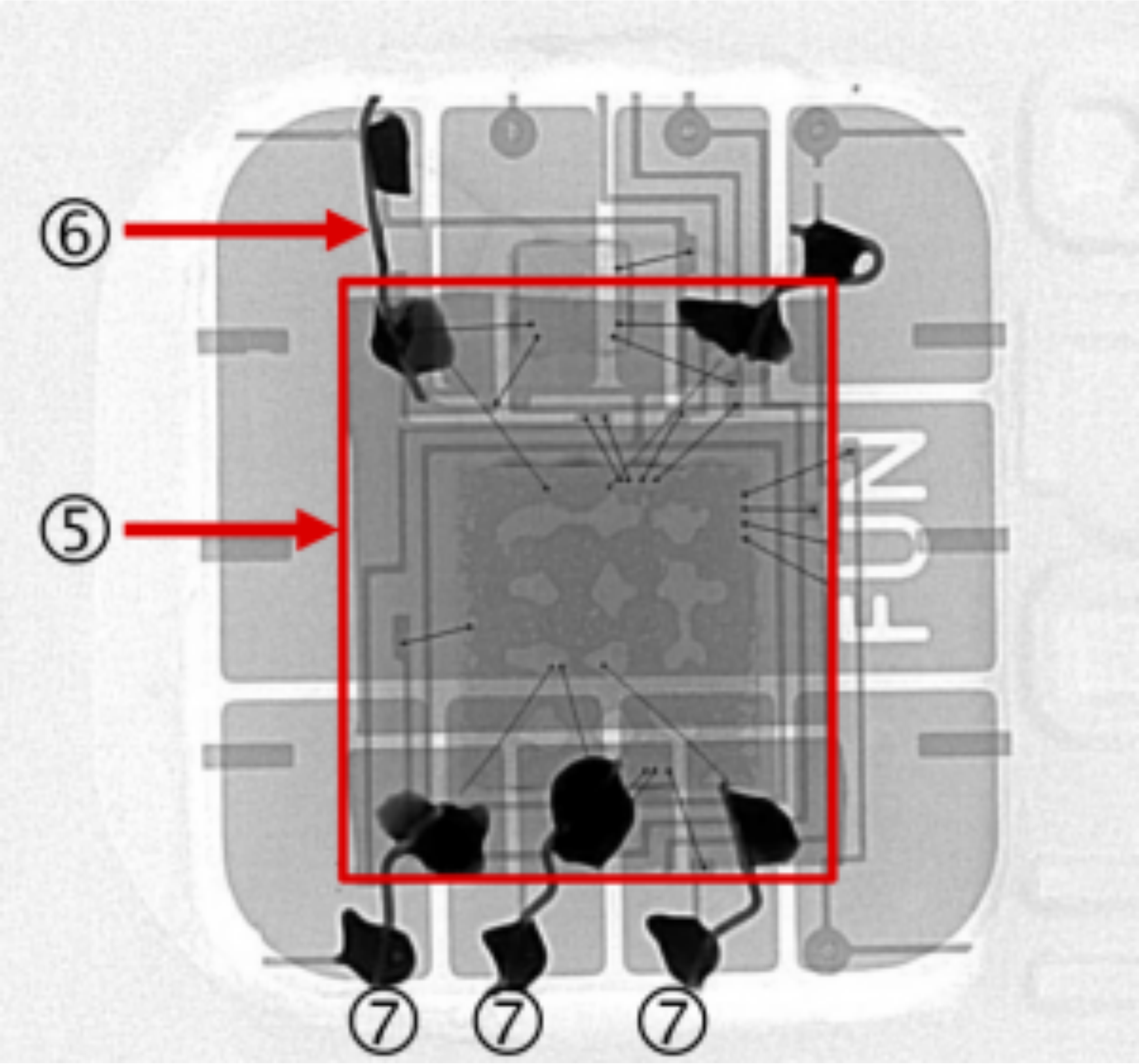

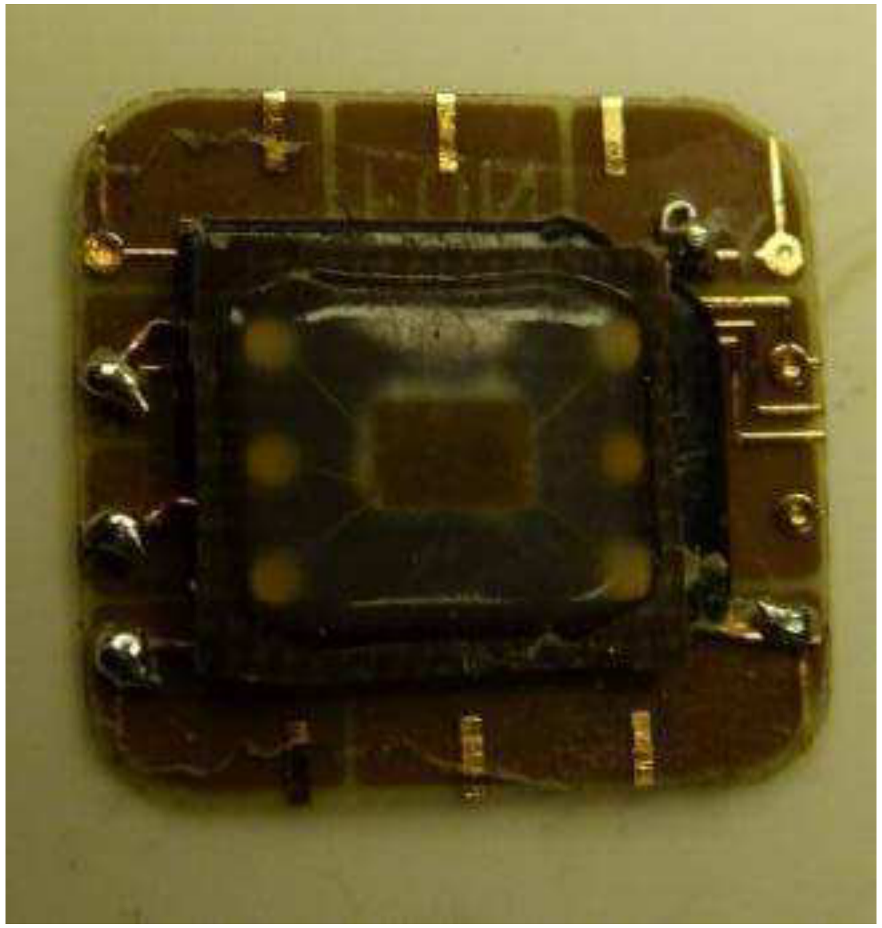

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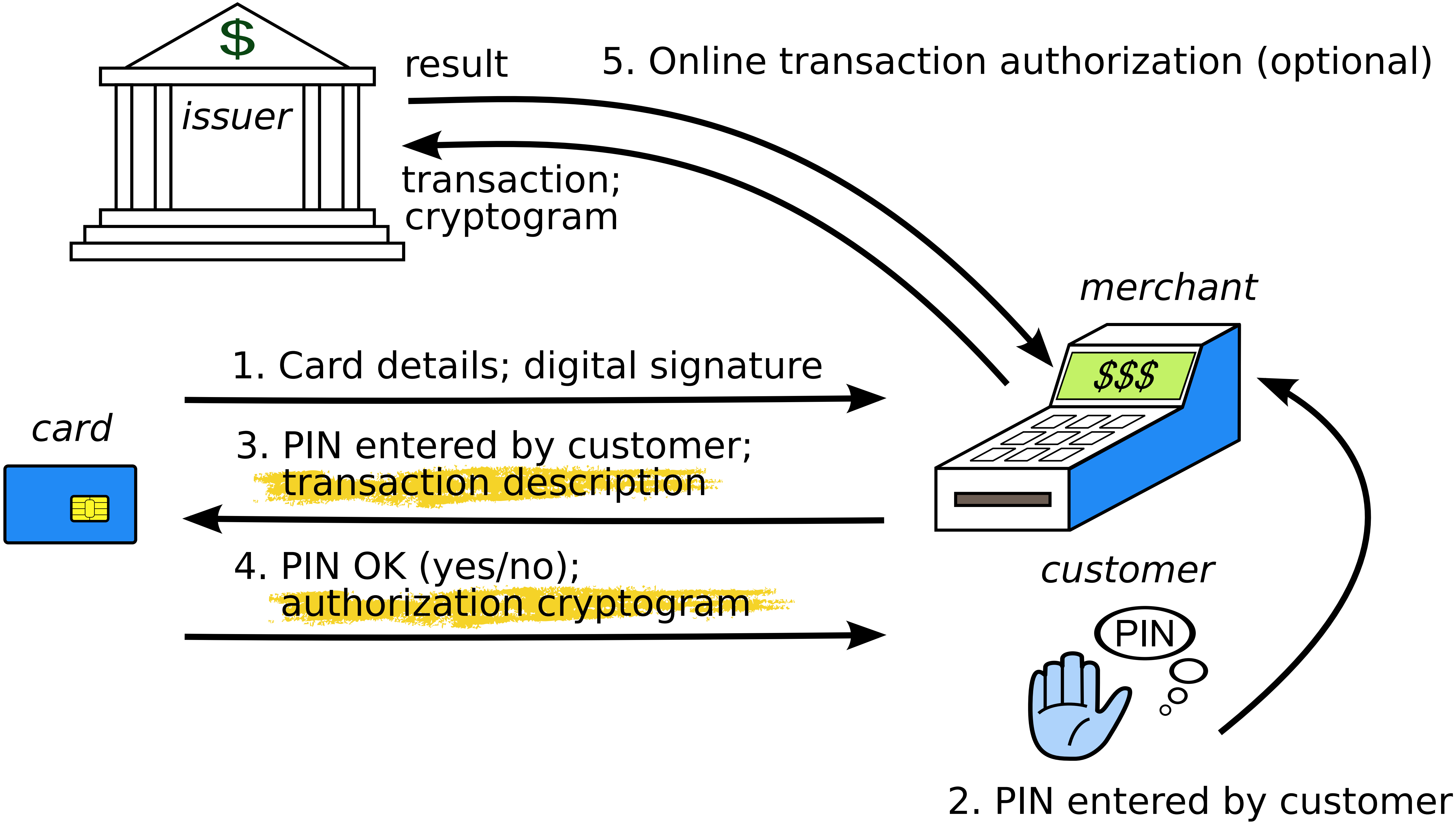
Unpredictable numbers are essential to prove that real card is present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customer
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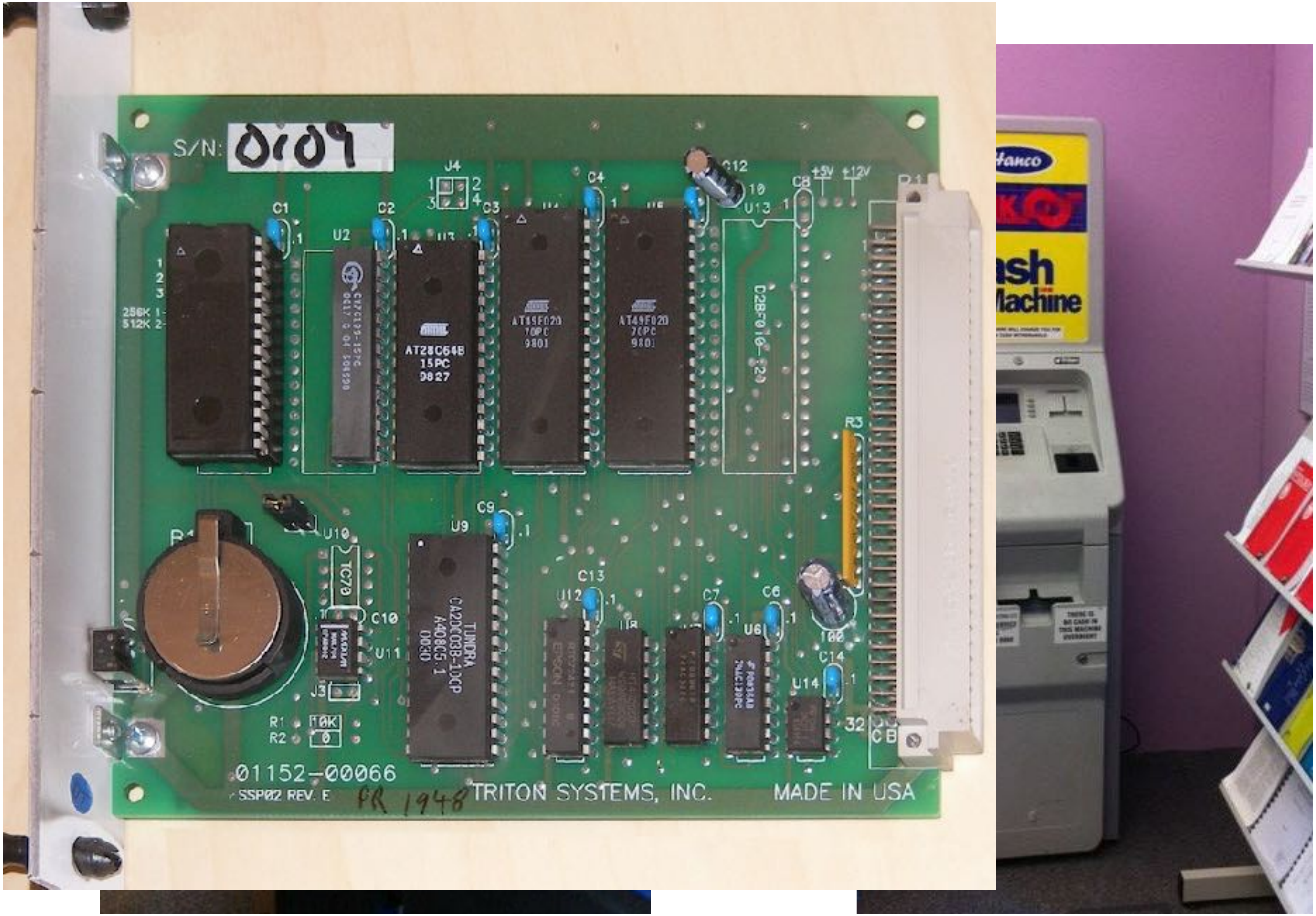
Random numbers?

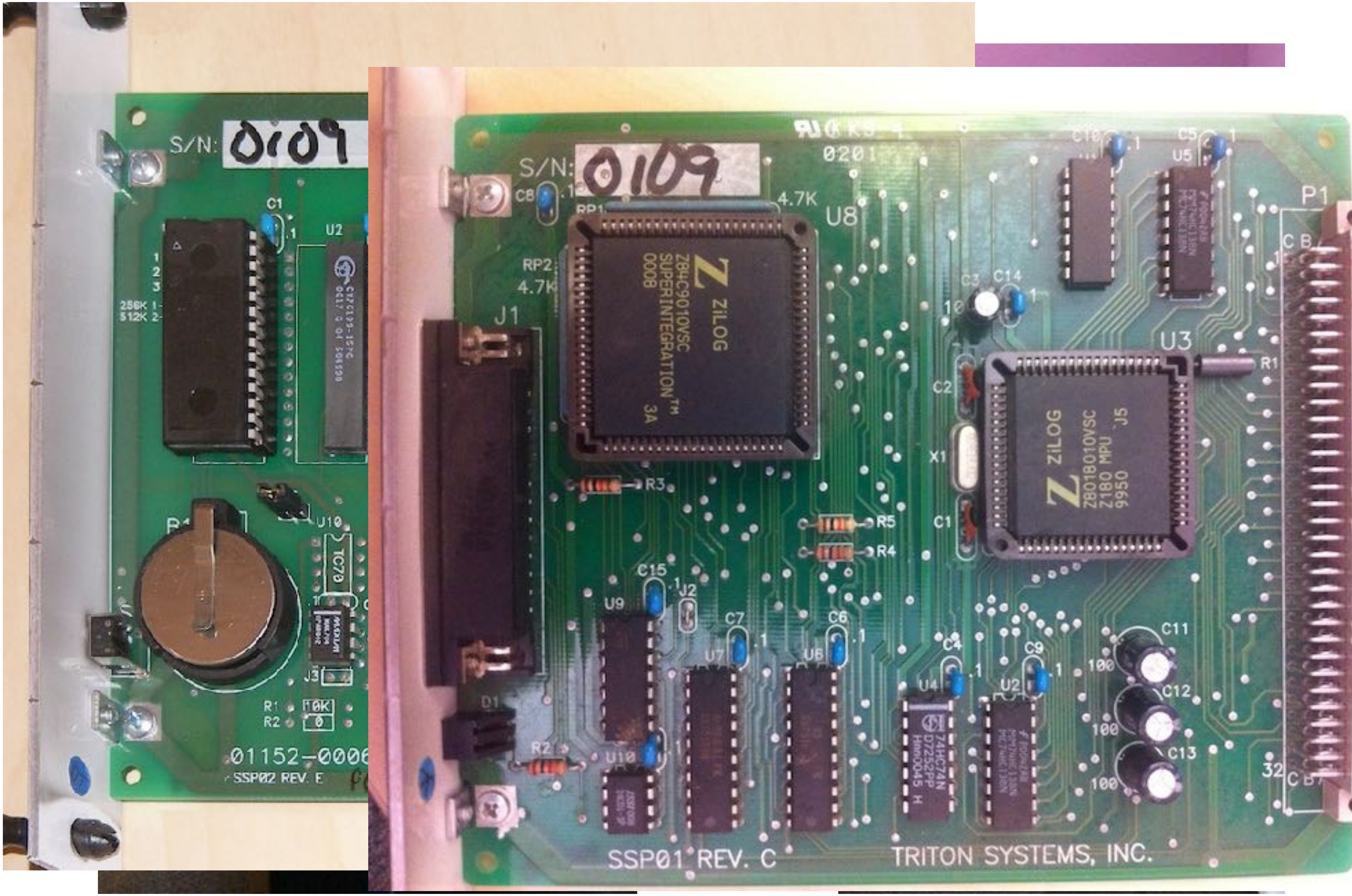
Date	Time	UN
2011-06-29	10:37:24	F1246E04
2011-06-29	10:37:59	F1241354
2011-06-29	10:38:34	F1244328
2011-06-29	10:39:08	F1247348

Reverse engineering

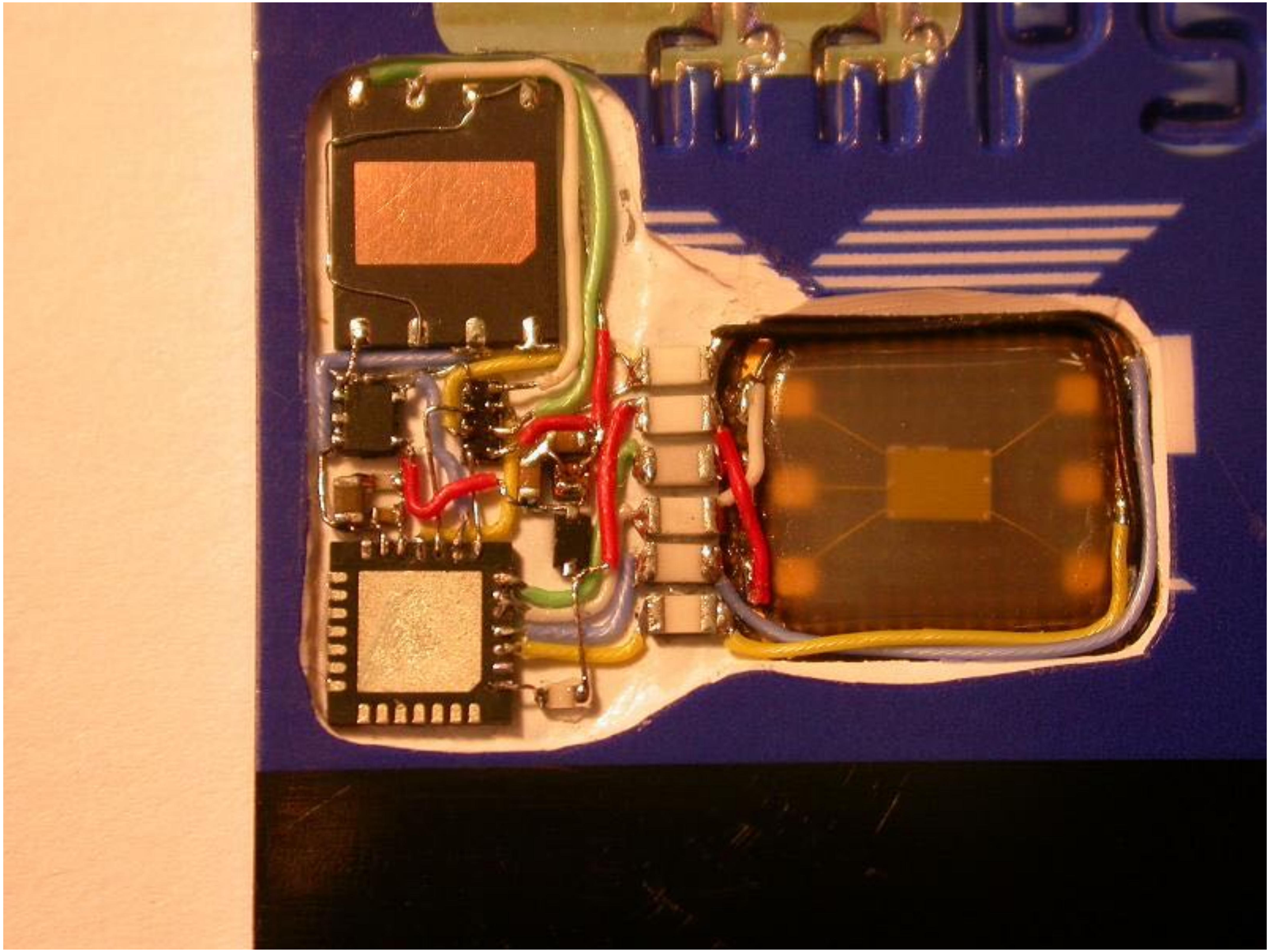
Reverse engineering



Reverse engineering



Surveying the problem



Exploiting the vulnerability

- Pre-play card: load with cryptograms for expected UNs
- Malware attack: tamper with ATM or POS terminal to produce predictable UNs
- Tamper with ATMs or POS in supply chain
- Collusive merchant, modifies software
- Tamper with communications

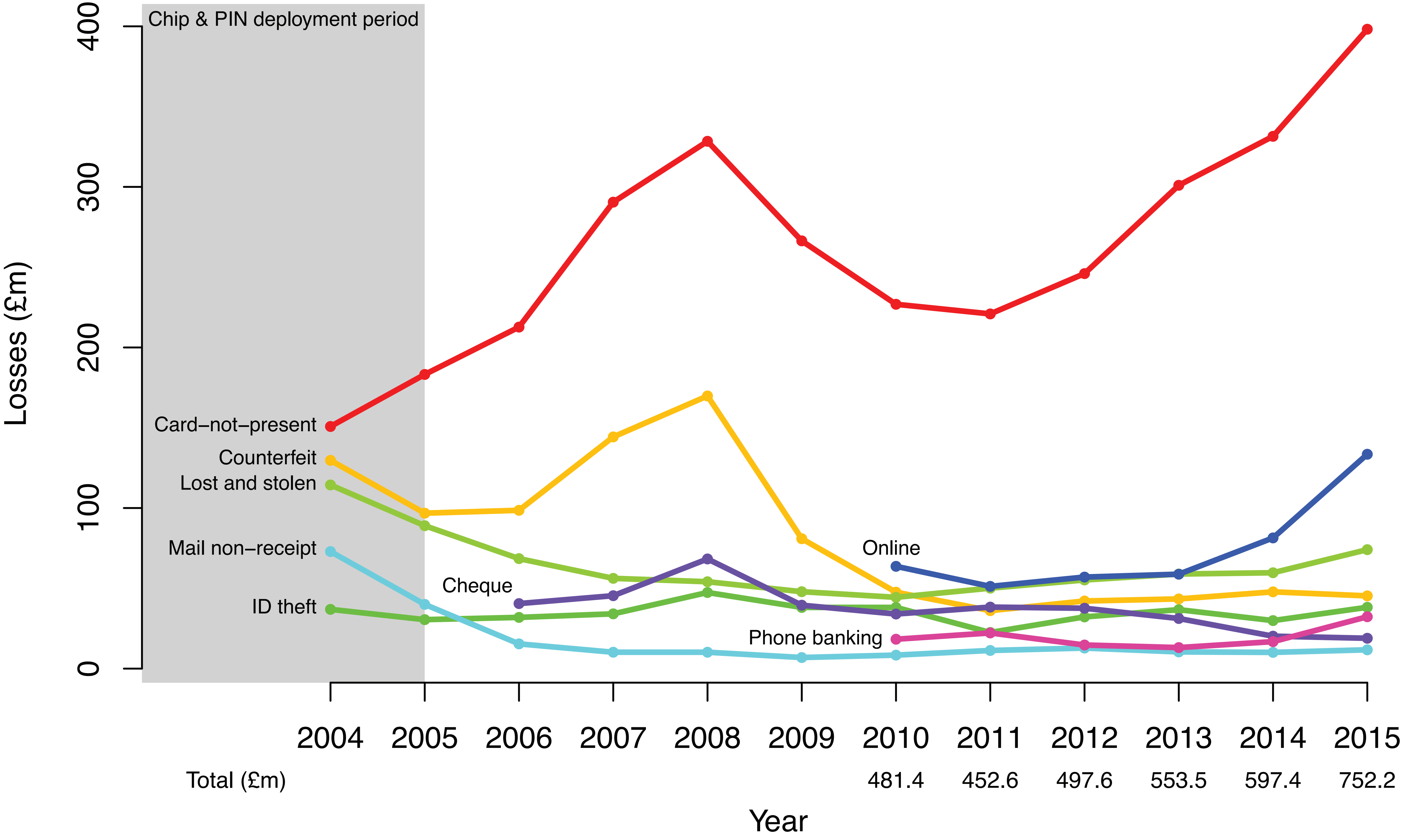
Response from industry

> While Cambridge scientists have identified a theoretically potential, but technically complicated, type of card fraud, there is absolutely no evidence of this being undertaken in the real world.
>
> — UK Cards Association (September 2014)

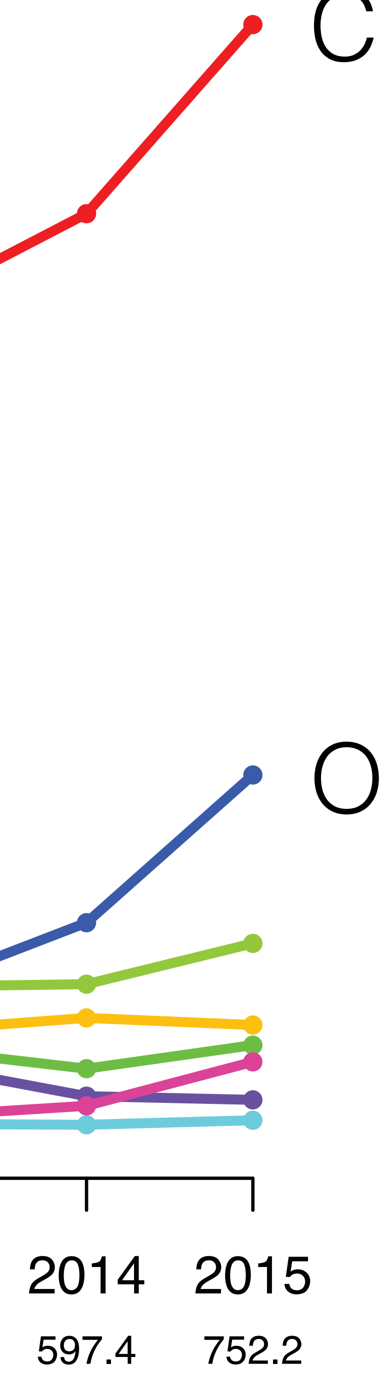
Quiz

- Please visit **kahoot.it** using smartphone, tablet or computer and enter PIN which will be shown next
- You may play individually or in a team
- Responses are anonymous (unless you choose to use your real name)
- You have 20 seconds to answer each question, and the faster you answer the more points you get
- Does not count towards module assessment

What about online fraud



Up as well



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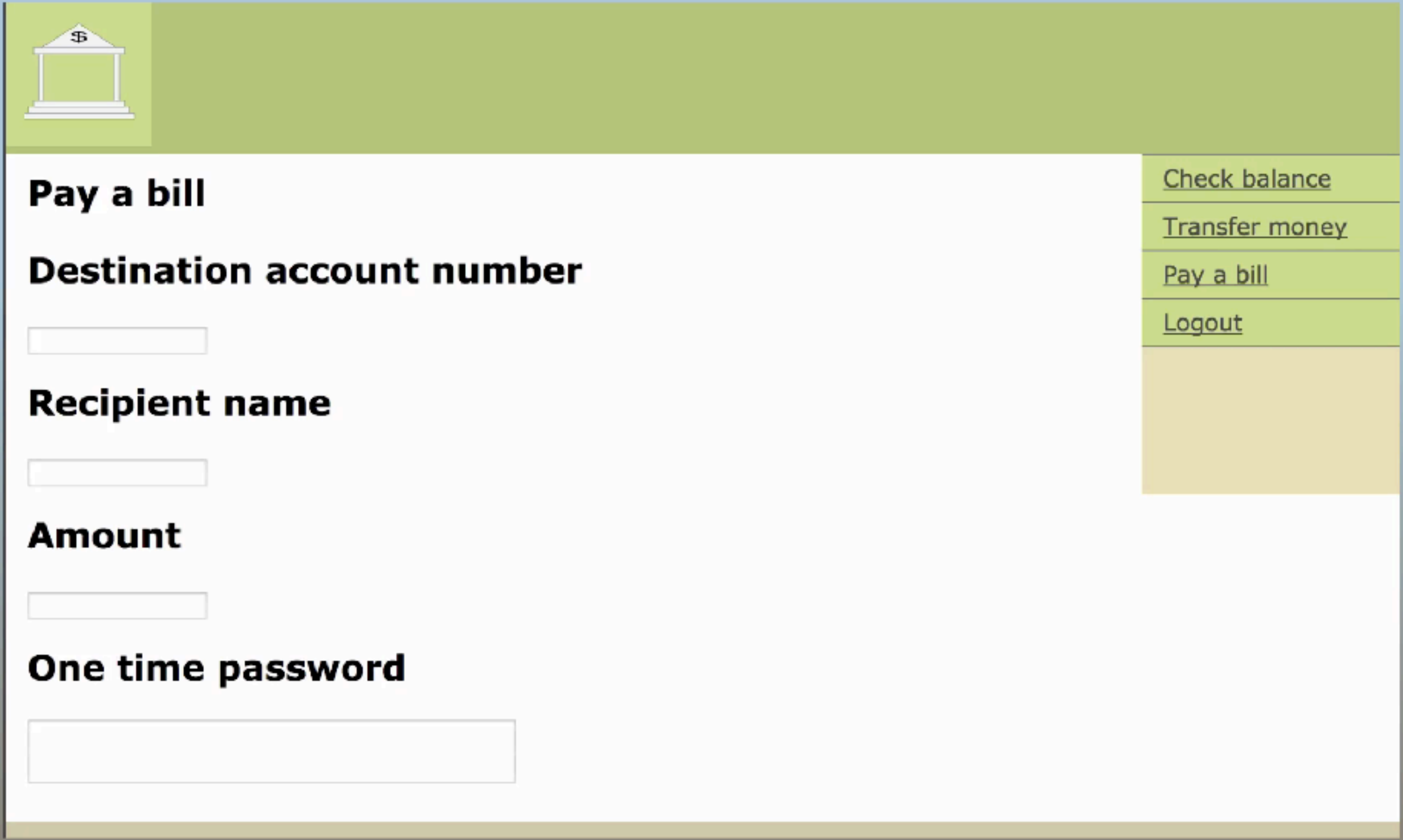


Pay a bill

Destination account number

Recipient name

Amount

One time password

EMV-CAP in the UK

EMV CAP’s weakness: attacker controls user experience

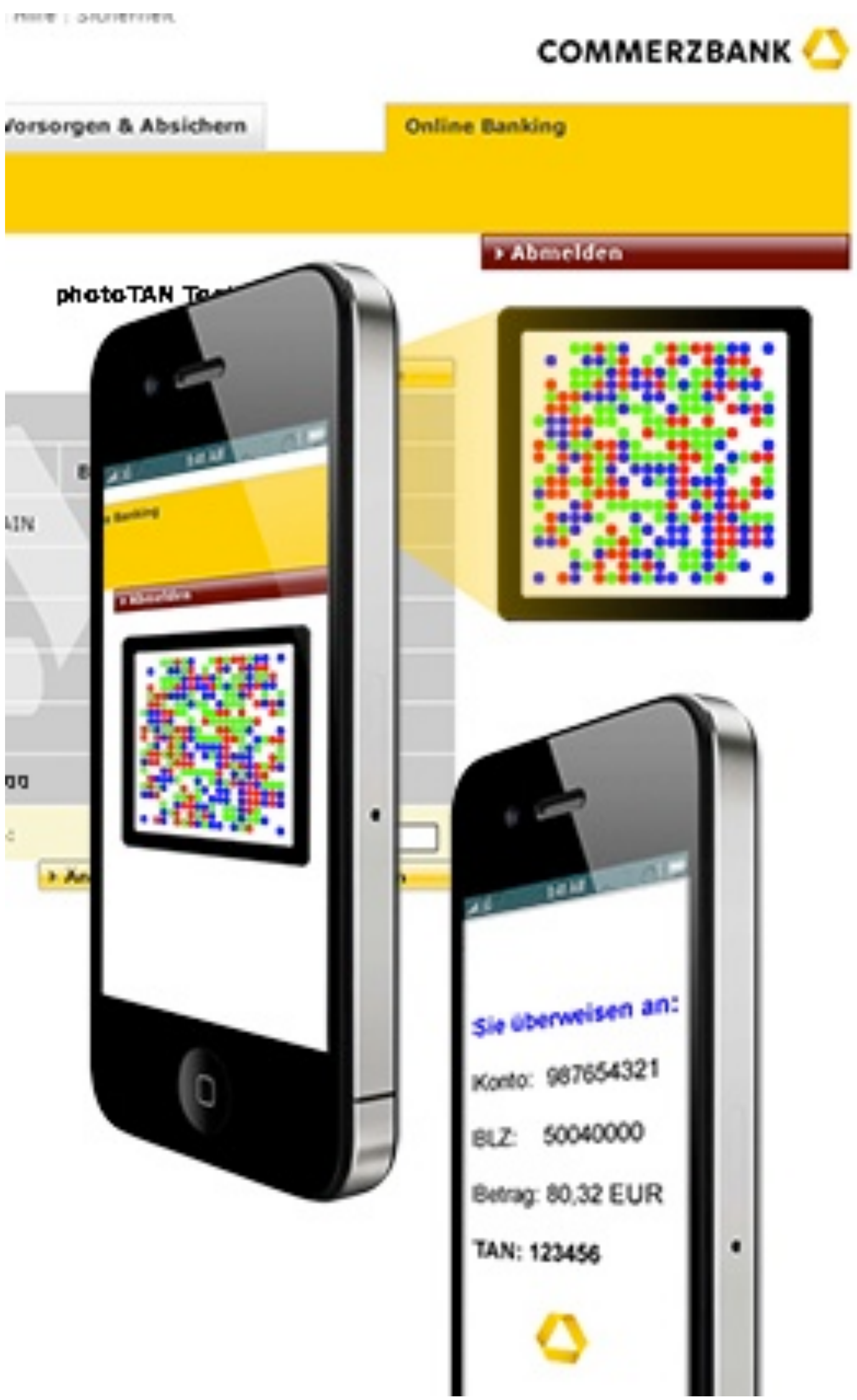
- User thinks they are typing random challenge but it is really part of an account number

- User thinks it’s OK that details on device don’t match those they entered on the computer

- User thinks they are performing a POS transaction but really it’s online banking

Connect
VISA
Debit

Usability is a security requirement



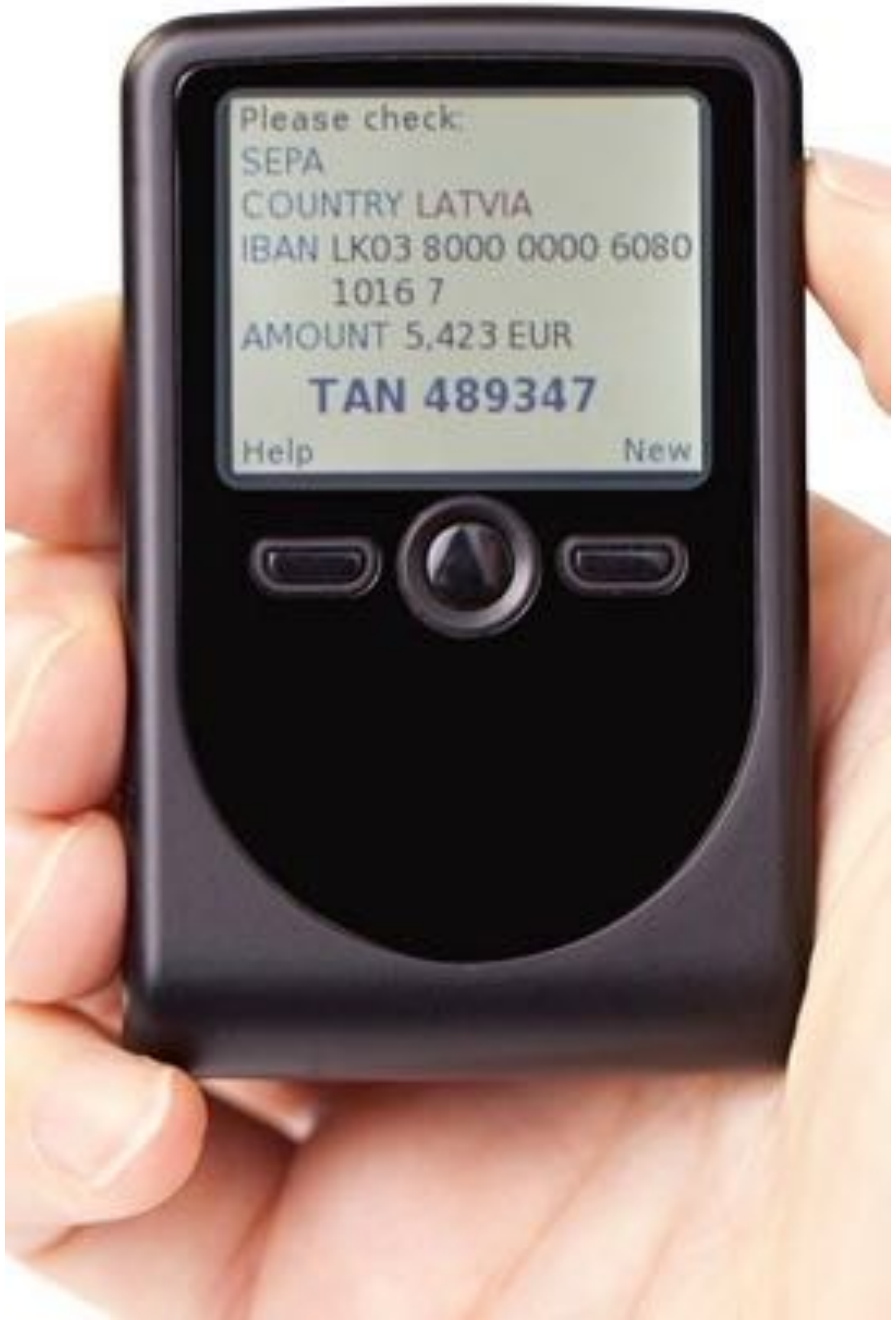
Sie überweisen an:

Konto: 987654321

BLZ: 50040000

Betrag: 80,32 EUR

TAN: 123456



Please check:
SEPA
COUNTRY LATVIA
IBAN LK03 8000 0000 6080
1016 7
AMOUNT 5,423 EUR
TAN 489347

If something goes wrong do you get your money back?

- In the US, very likely yes (Regulation E & Z)
- In the EU, it's more complicated (Payment Services Directive) …
  - Banks are permitted to refuse a refund for fraudulent transaction if customer has been "grossly negligent" in complying with bank terms and conditions
- What is considered "grossly negligent" and is this definition fair?

Example T&C (HSBC UK)

“You must take **all reasonable precautions … including** but are not limited to:

…

not choosing security details that may be **easy to guess**

…

Never writing down or otherwise recording your PIN and other security details in a way that can be understood by someone else

…

keeping your security details **unique to your accounts with us**

…

not allowing anyone else to have or use your card, security devices, PINs, or any of your security details”

Over $^1/_3$ of customers have 3 or more PINs

	0	1	2	3	4	5	6	7	8	9	mean
4 digits	1	88	65	41	31	8	5	1	1	0	2.28
5 digits	233	5	3	0	0	0	0	0	0	0	0.05
6 digits	228	8	4	1	0	0	0	0	0	0	0.08

Almost half of PINs are used once per month or less frequently

	4-digit PINs								
	#1	#2	#3	#4	#5	#6	#7	#8	Sum
Every day	34	0	0	1	0	0	0	0	35
Several times a week	117	30	3	3	0	0	0	1	154
Once per week	59	35	12	3	0	0	0	0	109
Once per month	21	37	24	8	3	0	0	0	93
Several times per year	6	24	24	12	2	2	1	0	71
Once per year or less	1	14	10	10	4	1	0	0	40
Never	2	12	14	9	6	4	1	0	48

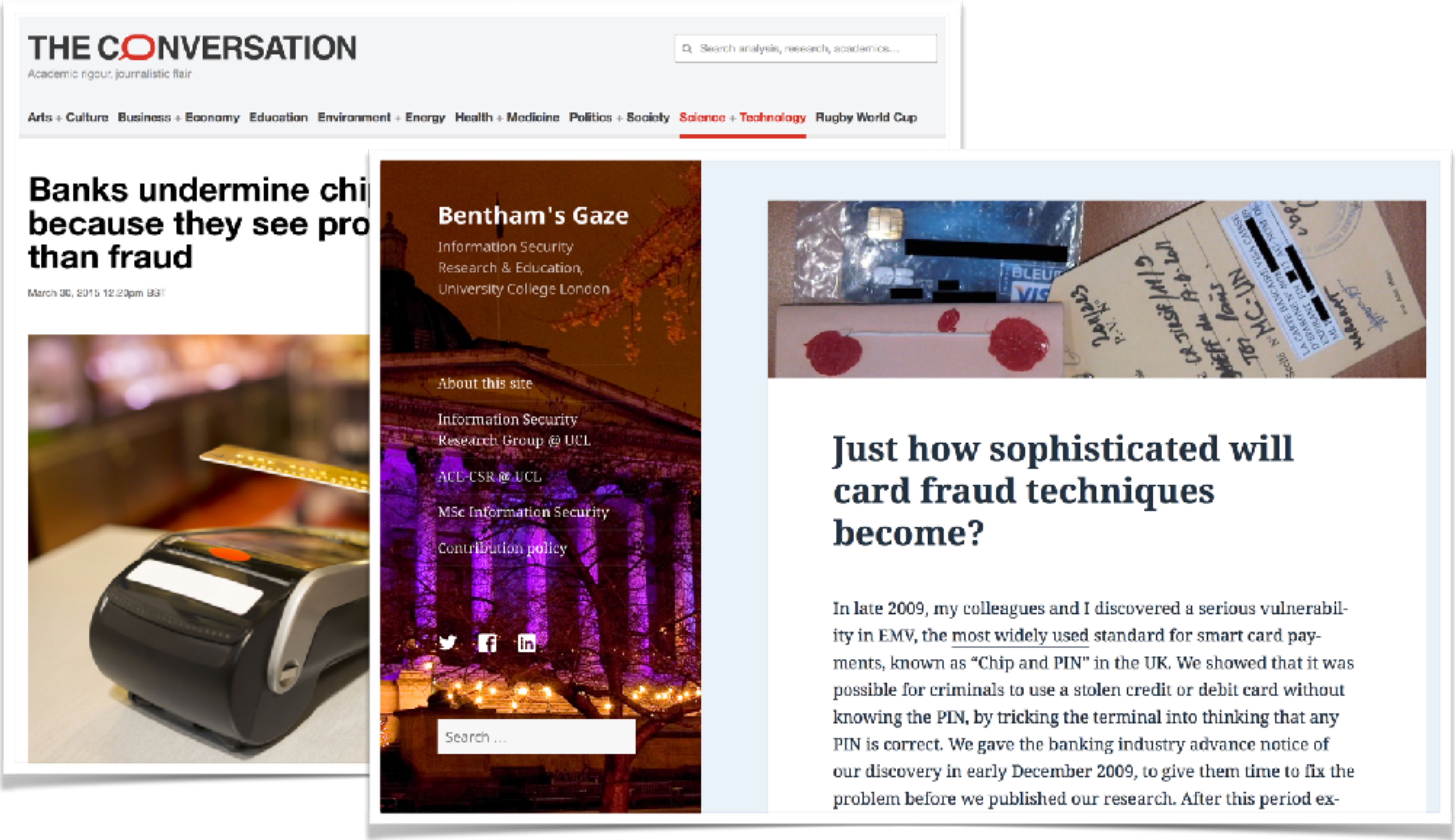
Customers find ways to manage this otherwise impossible task

- About $^1/_3$ of customers write down their PIN and keep it with the card (e.g. in a wallet, diary, phone)
- About $^1/_4$ of customers use their PIN elsewhere (mainly mobile phone)
- About $^1/_2$ of customers share their PIN with someone else (mainly spouse/partner or other family members)
- **These actions are treated as gross negligence if there is no other more likely explanation for fraud**
- Is this fair? What can be done about it? Our work is ongoing

Conclusions

- Don’t underestimate criminals
- Better statistics are needed
  - Outside of UK
  - Customer losses
- Usability is a security requirement, especially when it comes to online payments

More information



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Just how sophisticated will card fraud techniques become?

In late 2009, my colleagues and I discovered a serious vulnerability in EMV, the most widely used standard for smart card payments, known as "Chip and PIN" in the UK. We showed that it was possible for criminals to use a stolen credit or debit card without knowing the PIN, by tricking the terminal into thinking that any PIN is correct. We gave the banking industry advance notice of our discovery in early December 2009, to give them time to fix the problem before we published our research. After this period ex-

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