Security of Near Field Communication: Does My Phone Need A Tinfoil Hat?

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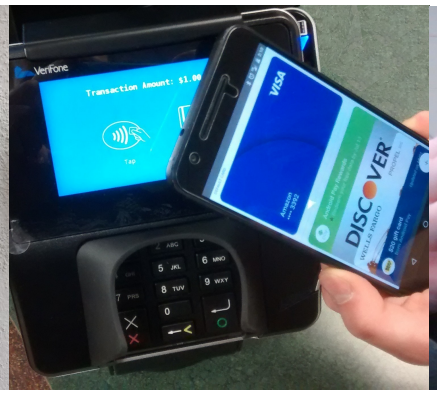
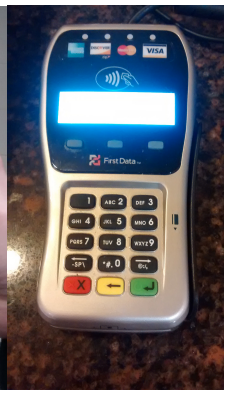
University of Minnesota, Morris

April 30, 2015

Have you used NFC?

Note: The communication standard used in UCard was not verified

Definition

Near Field Communication or *NFC*

is a short-range contactless communication technology.

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is a short-range contactless communication technology.

- 1 meter range
- Quick setup
- Line of sight not required

Motivation

Questions about NFC

- What is NFC and how does it work?
- Is it secure and should I trust it?
- Is NFC the future?

Outline

Background

Introduction to RFID

- NFC is based on *radio frequency identification* (RFID) technology

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- Range depends on frequency, size of antenna, power, and interference

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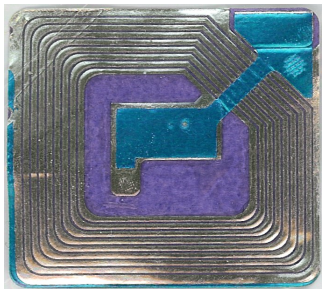
- Range depends on frequency, size of antenna, power, and interference
- Communication happens between tags and readers

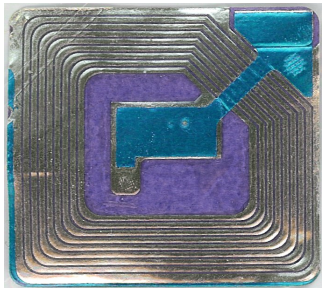
Tags & Readers



Tag

- A tiny circuit with an antenna coil
- Stores limited information
- Can be powered or passive
- Passive tags are smallest and cheapest

Tags & Readers



Tag

- A tiny circuit with an antenna coil
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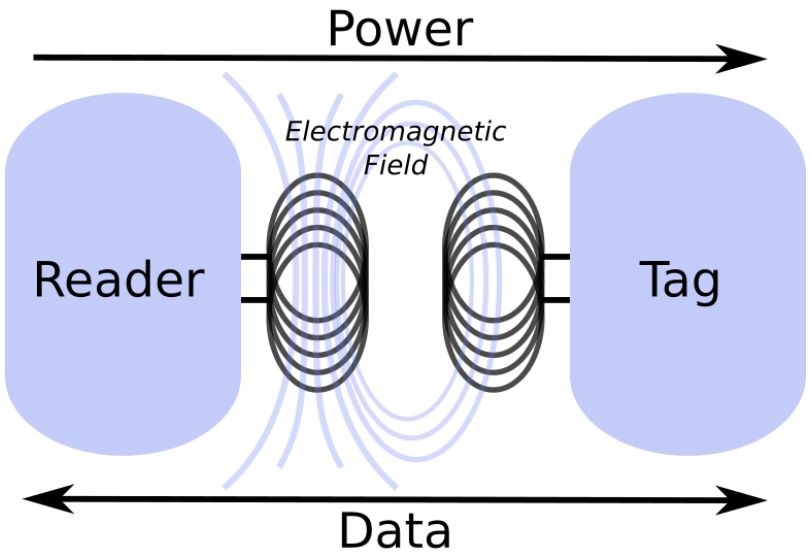
Reader

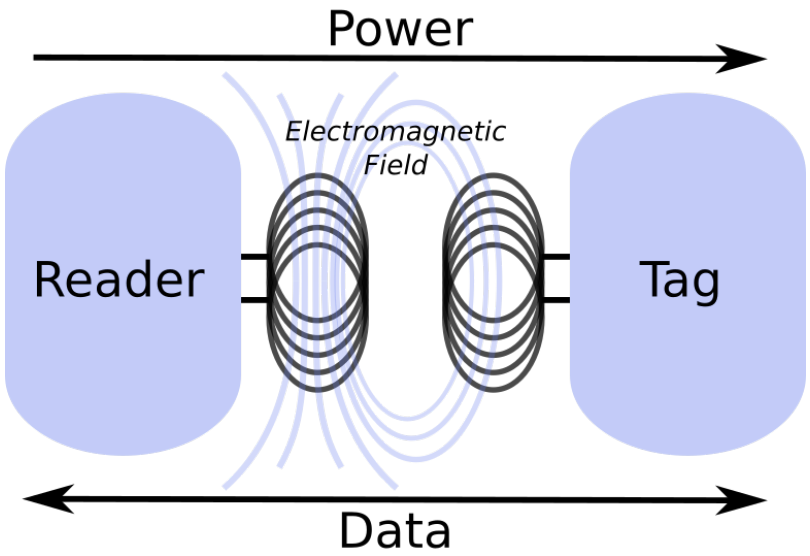
- Reader generates an electromagnetic field using an antenna coil
- The tags coil receives power from the field
- Initiates communication

Contactless Communication



RFID Communication

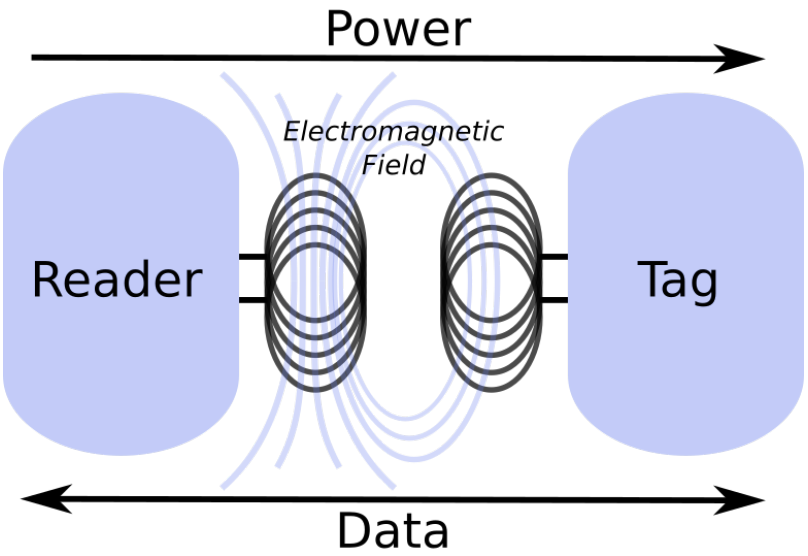
Contactless Communication



RFID Communication

1. Reader generates a field

Contactless Communication



RFID Communication

1. Reader generates a field
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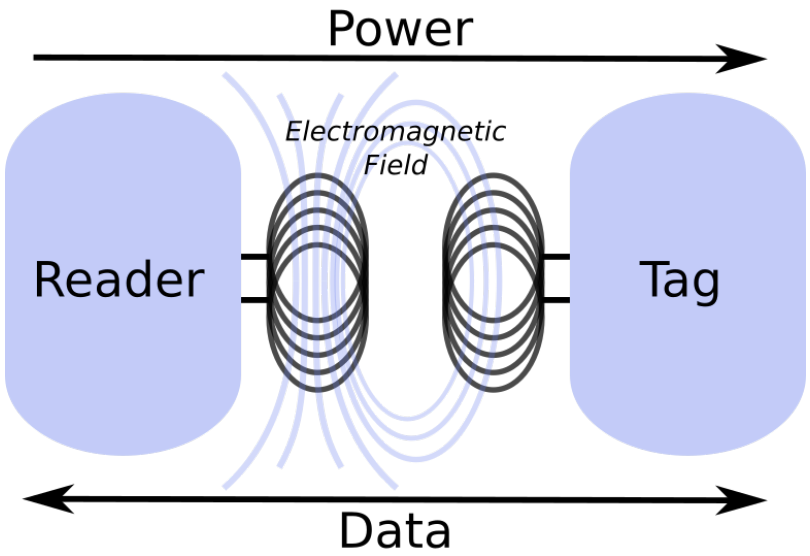

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2. Tag is activated by induced power
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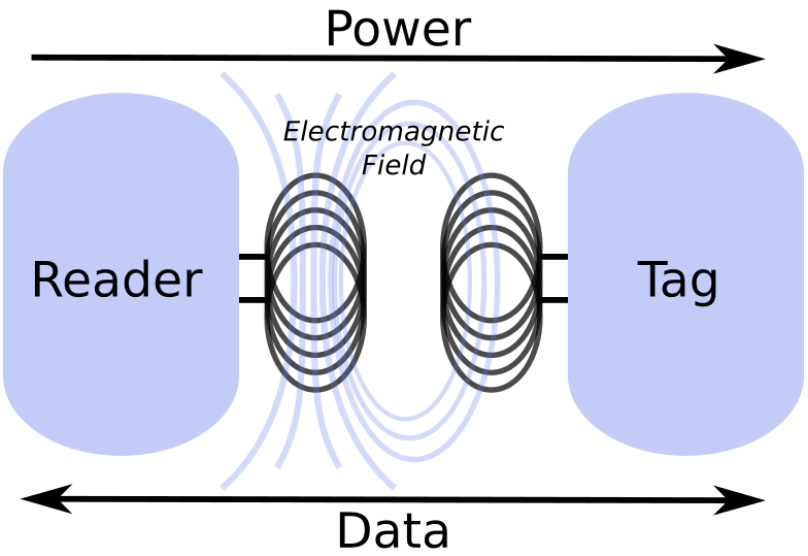

RFID Communication

1. Reader generates a field
2. Tag is activated by induced power
3. Reader runs discovery protocol, selecting tag by unique ID
4. Communication ensues

NFC on Mobile Phones

NFC extends RFID:

1. Phones can act as readers
2. Phones can emulate tags
3. Phones can communicate peer-to-peer

NFC on Mobile Phones

1 Phones can act as readers

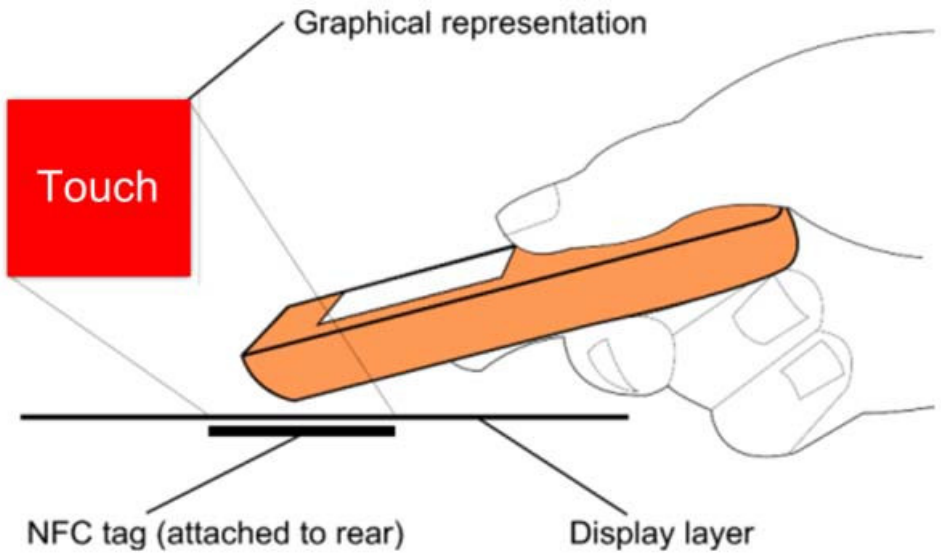

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Image from Hardy 2010

NFC on Mobile Phones

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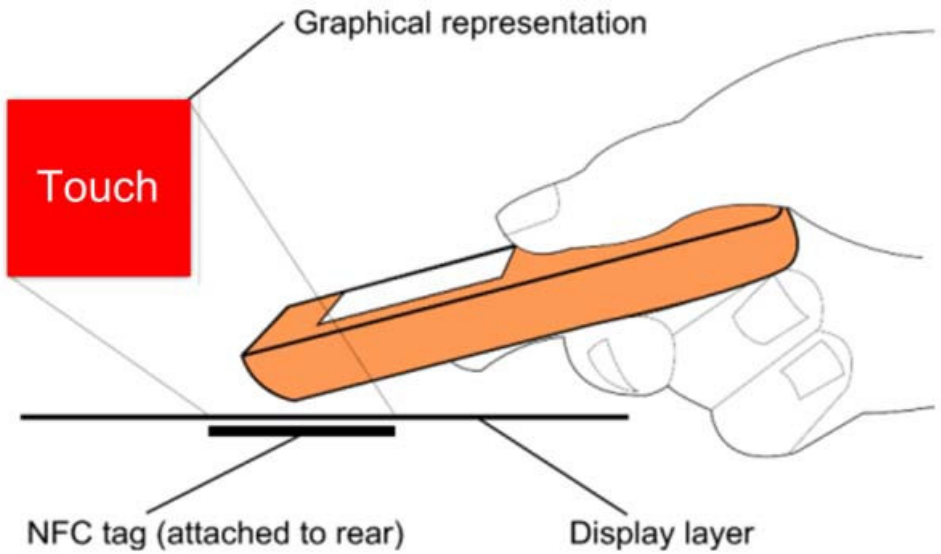

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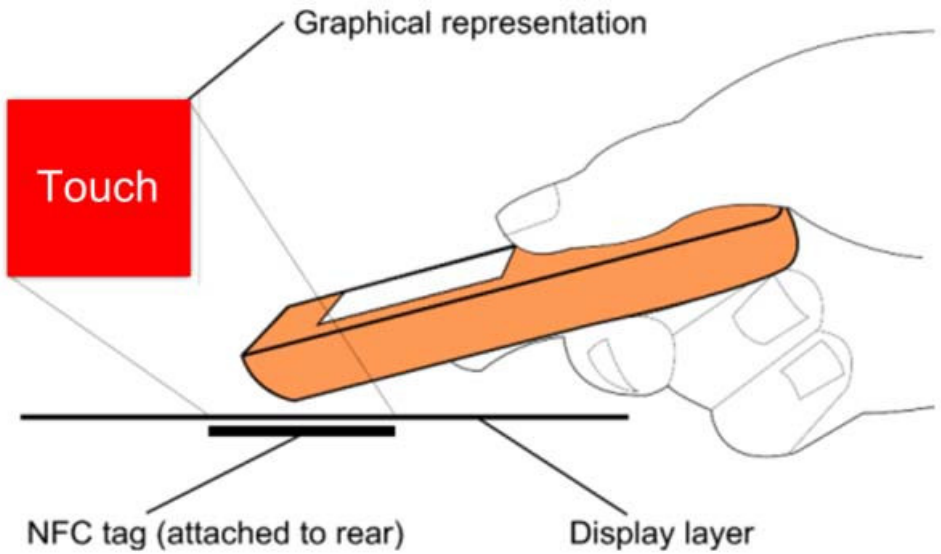

- Phones read NFC tags as if they were QR codes
- Touching a tag mounted to a map could bring up tourist information
- Research into using tags as a user interface

Image from Hardy 2010

NFC on Mobile Phones

2 Phones can emulate tags

- Phones acts as if it were a passive tag

Image Note: Thank you Evan

NFC on Mobile Phones

2 Phones can emulate tags

- Phones acts as if it were a passive tag
- A possibility for payments or ticketing applications

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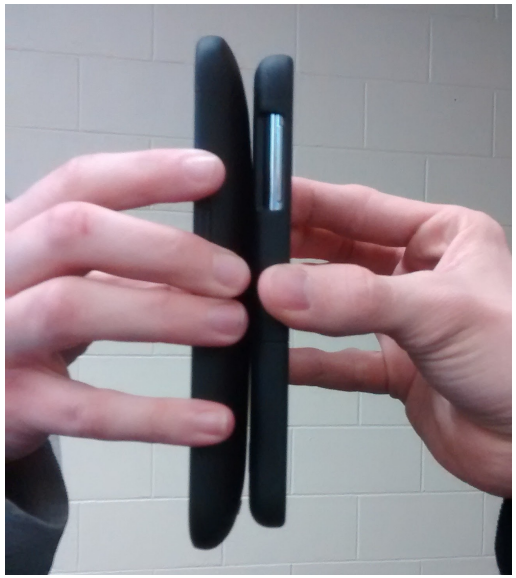
Phones can communicate peer-to-peer

3 Phones can communicate as peers



- Phones take turns switching between reader and tag-emulation mode

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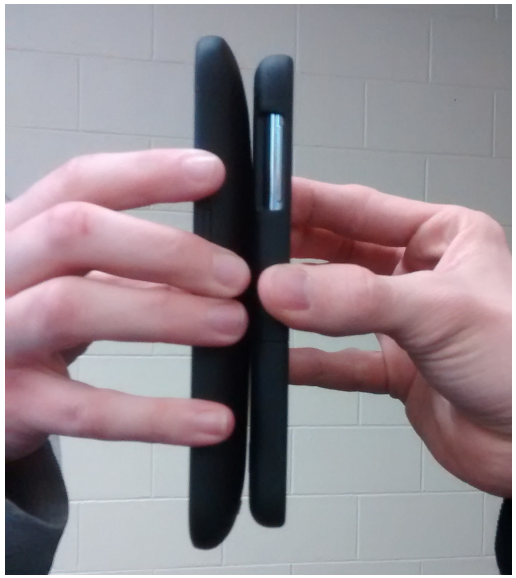

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- Highest NFC communication throughput

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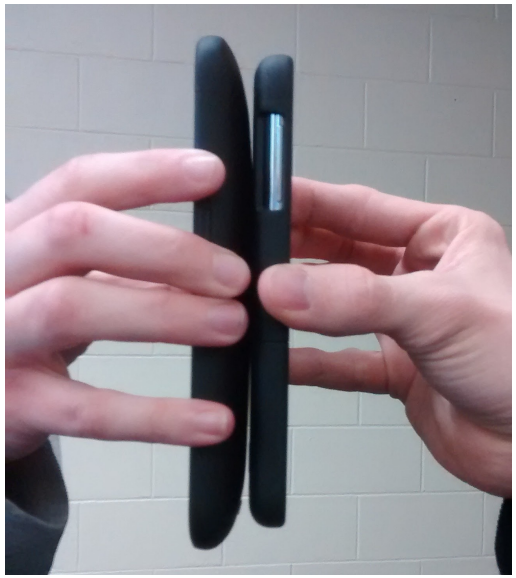

- Phones take turns switching between reader and tag-emulation mode
- Highest NFC communication throughput
- Can be used as a basis for stronger security or file transfers

Image Note: Thank you Jacob and Maggie

Security for NFC

NFC is not inherently secure

1. NFC's limited range makes attacks difficult, but not impossible
2. Features like confidentiality, integrity, and authentication need to be implemented as an extension of NFC

Contactless Credit Cards

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- Some credit cards contain passive NFC tags

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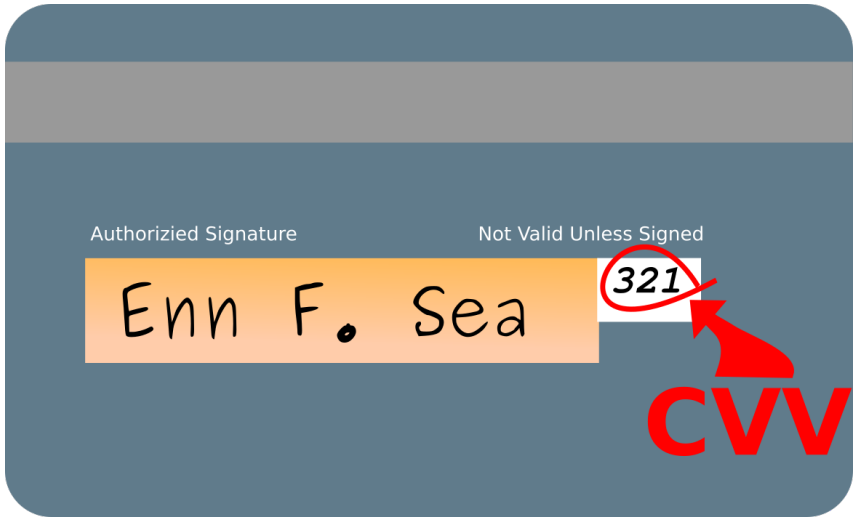
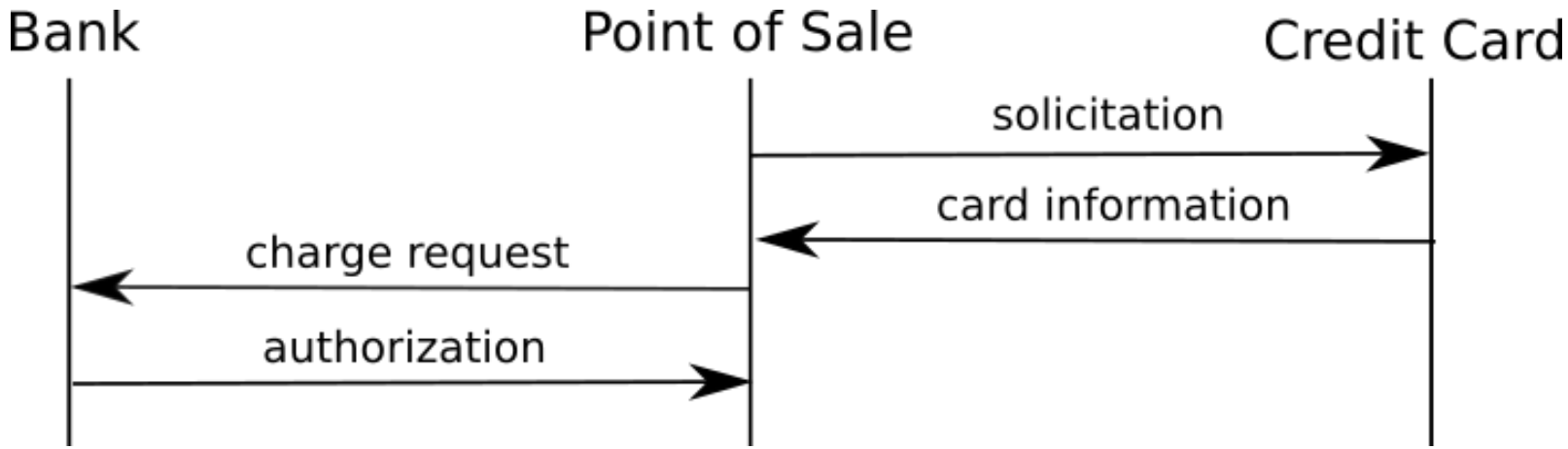
- We focus on Jensen, Gouda, and Qiu's [1] work on securing such cards in this section
- Security solutions must be computationally inexpensive to run on passive tags

Contactless Credit Cards

- Card generates a pseudo-random *Dynamic Card Validation Value* (iCVV) for each transaction
- The iCVV is sent to point of sale and then validated by bank



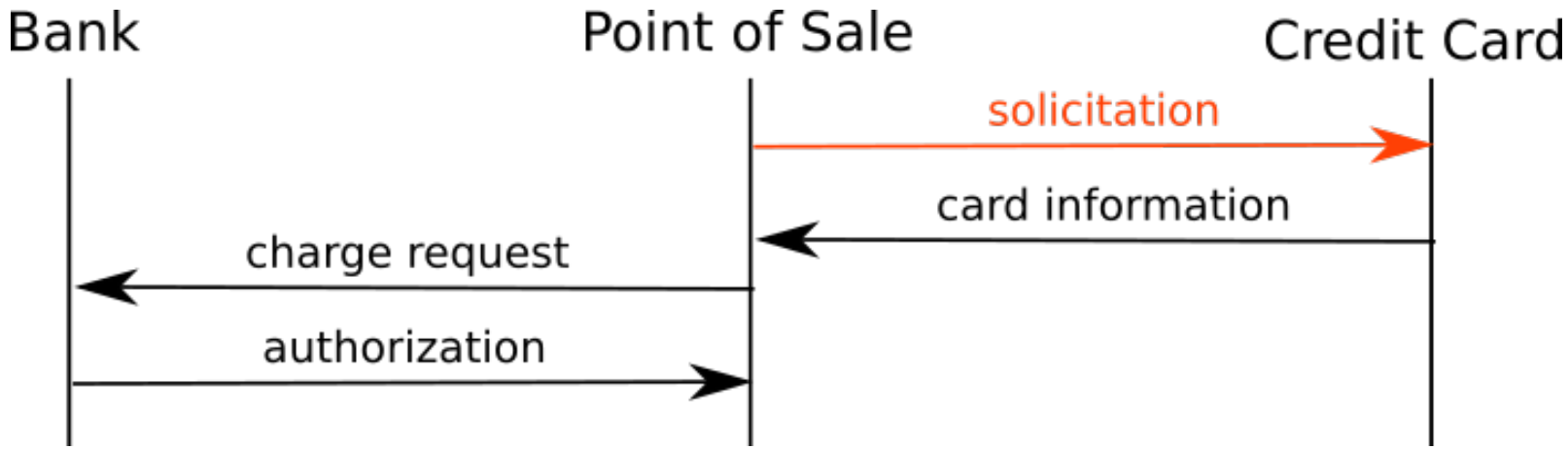
Current Credit Protocol



Security depends upon

- Each transaction's card generated iCVV
- The limited range of NFC

Current Credit Protocol



Solicitation

- Point of Sale and Credit card exchange static messages
- For example, card may identify itself as `VISA CREDIT`

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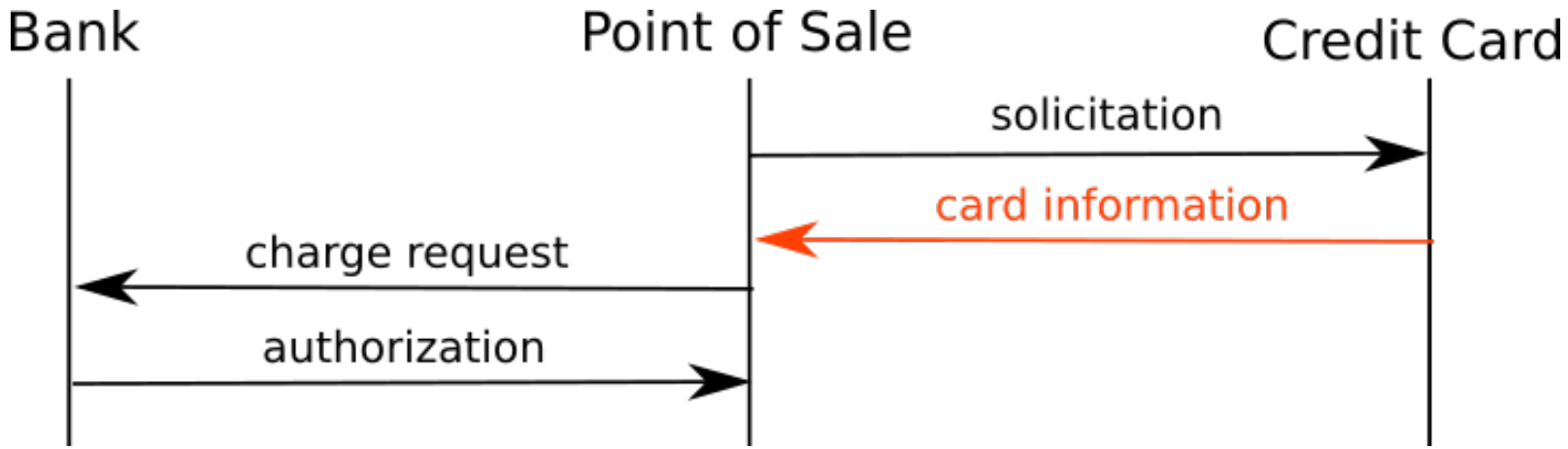
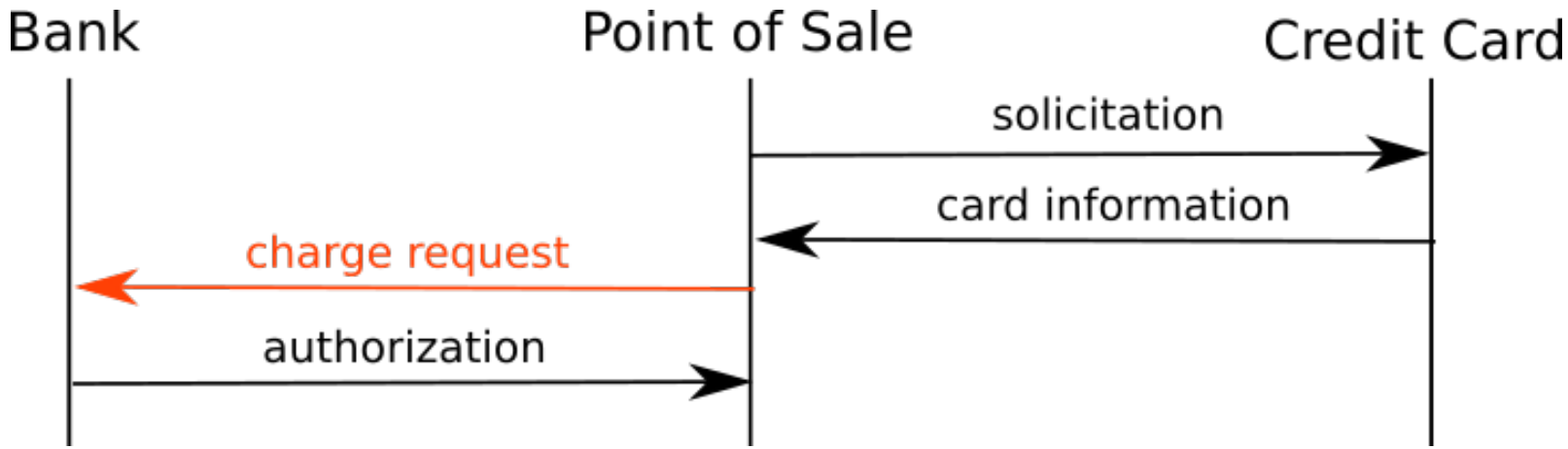


Card Information

- Credit card transmits card information, including: **card number, expiration, bank name, and iCVV**
- Unfortunately, this transmission is in plain text

Current Credit Protocol



Charge request

- Card number, expiration, and iCVV are sent to the indicated bank

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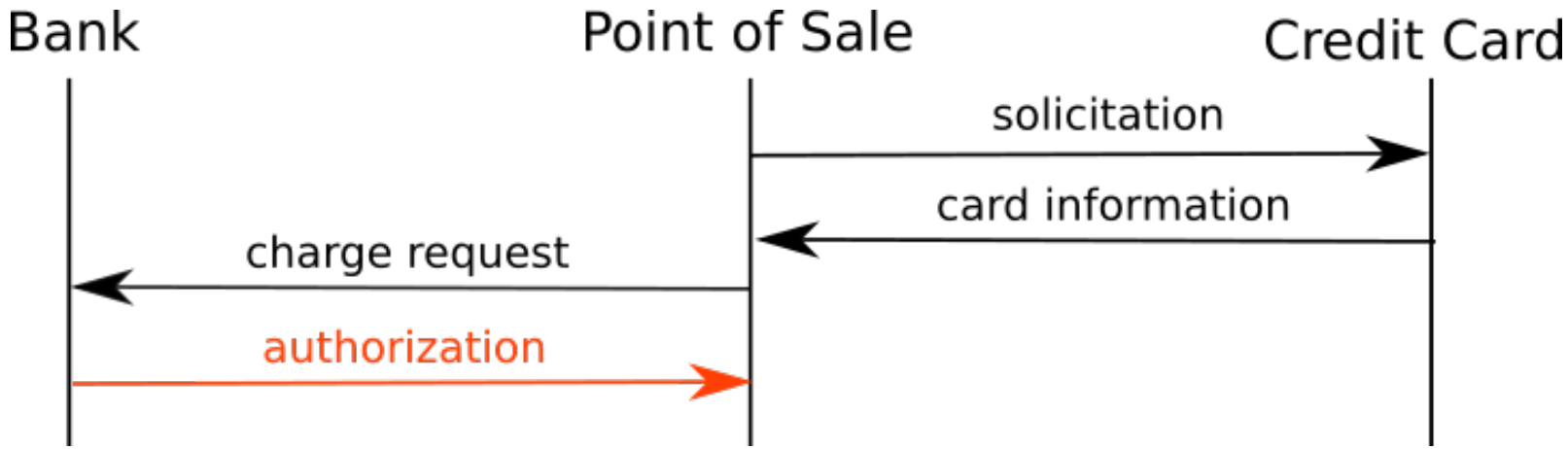

Authorization

- Bank verifies transaction by checking iCVV, location information, and other bank information

Eavesdropping

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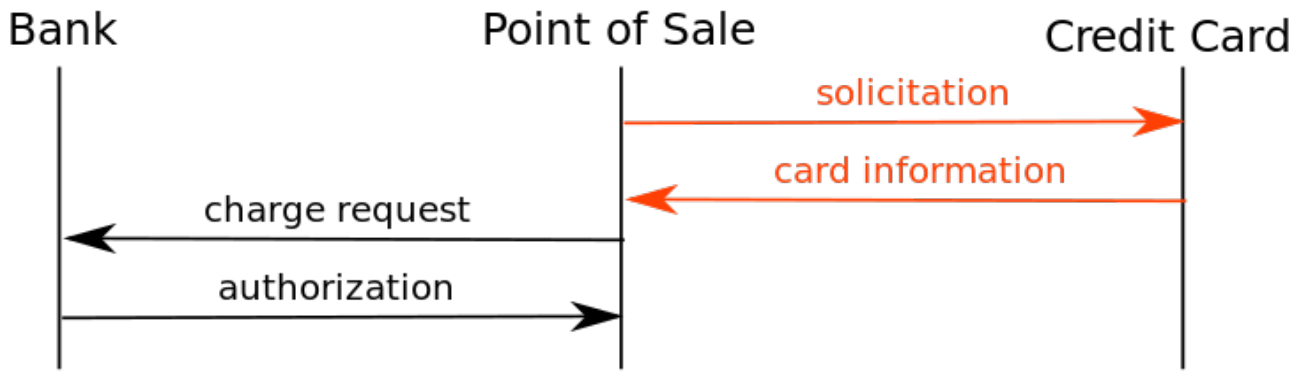
- A third party captures sensitive information sent between Point of Sale and Credit Card



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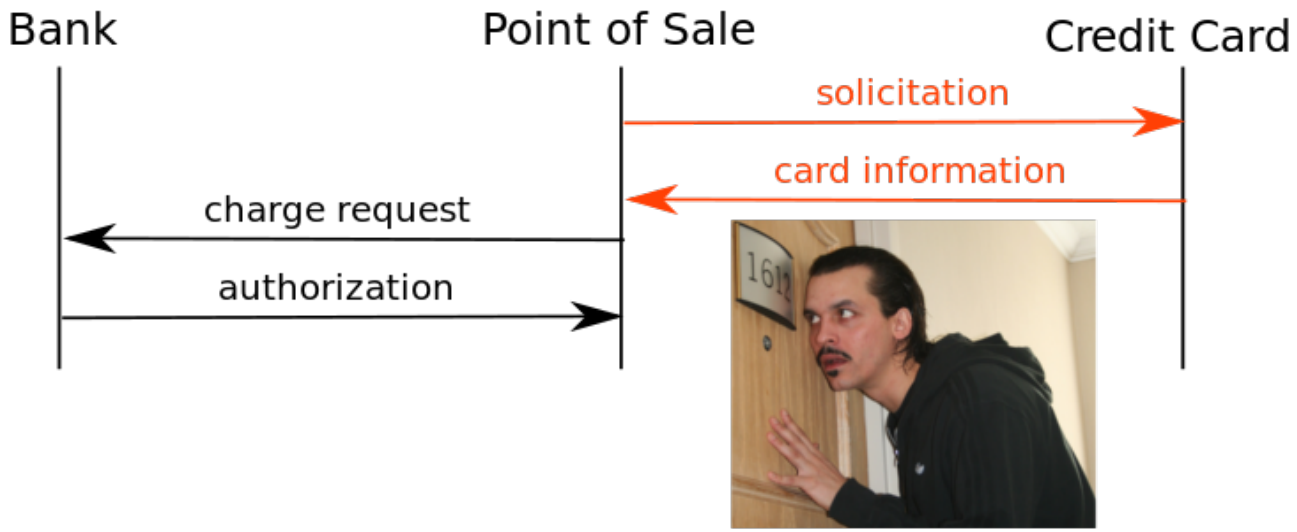

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Eavesdropping

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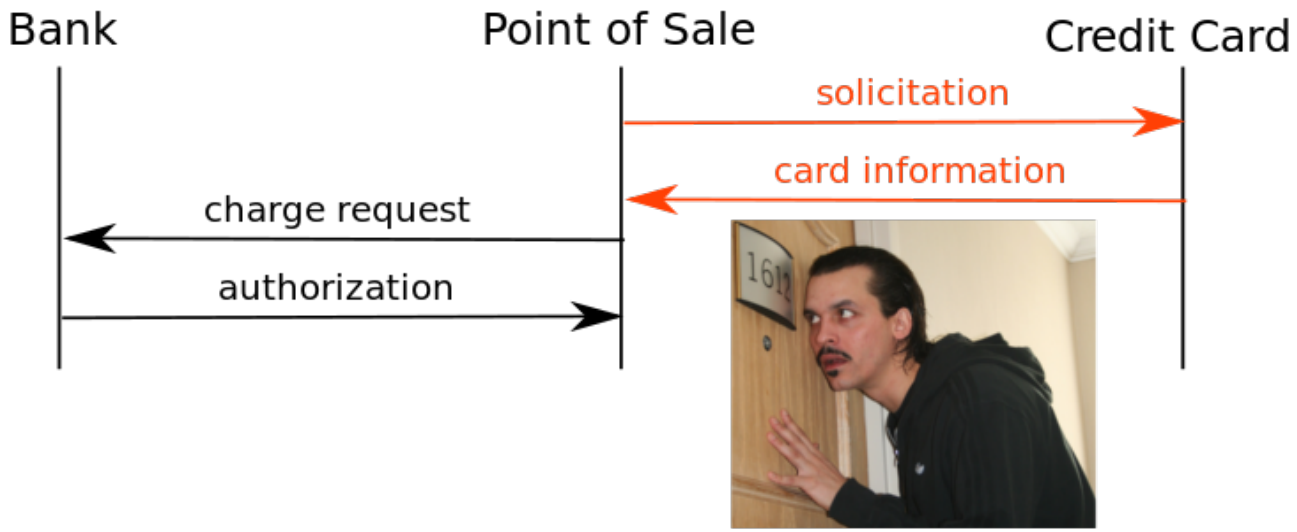
- Card number, expiration, bank name, and *used* iCVV can be obtained



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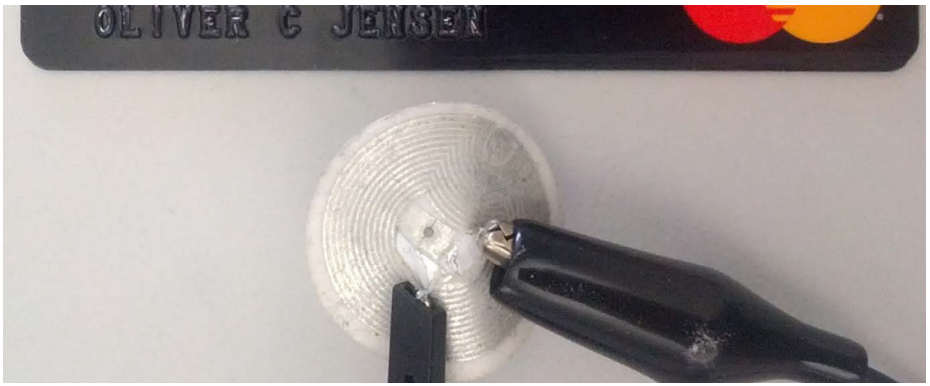
Eavesdropping

The eavesdropping attack is feasible, requiring only an inexpensive tag and radio



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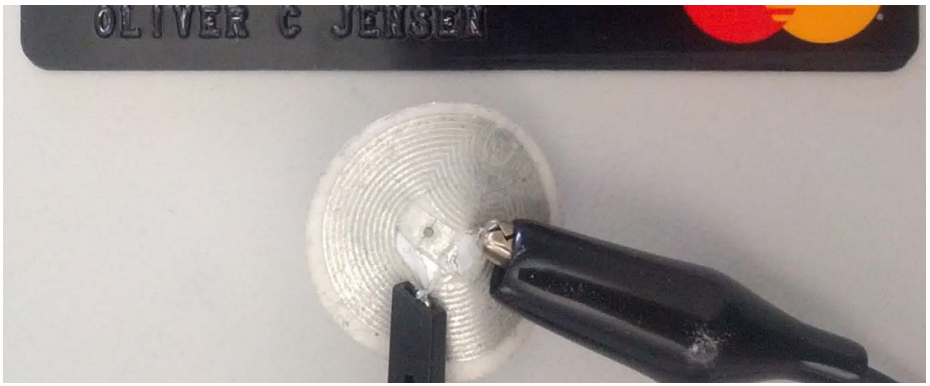
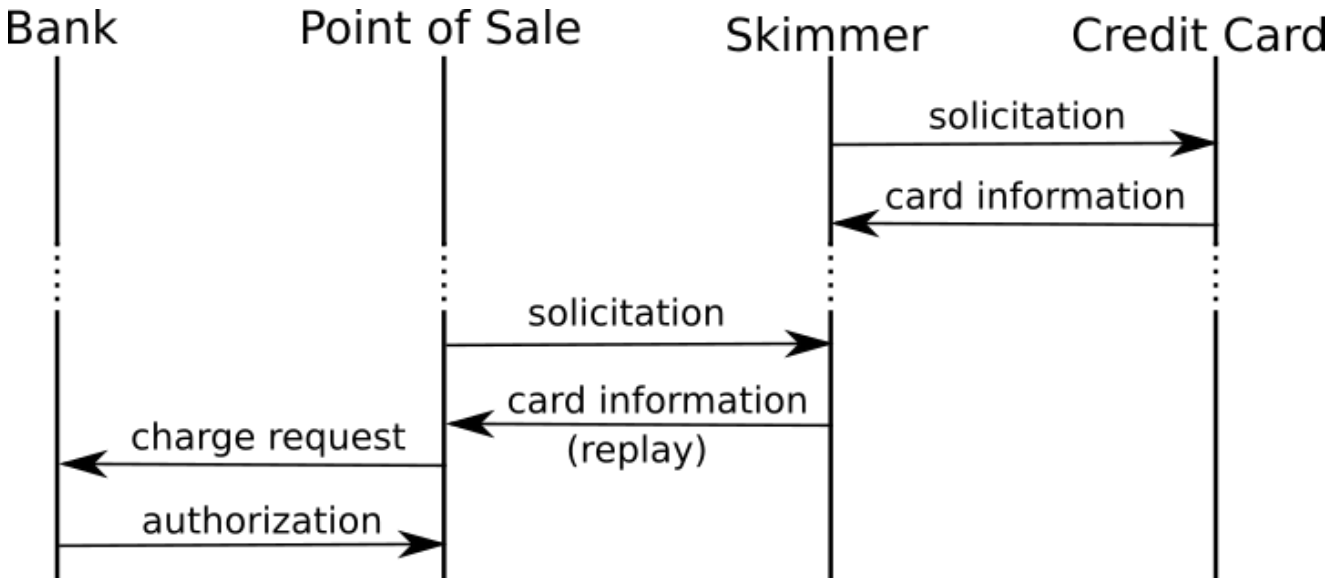


- A small antenna could easily be concealed near a terminal

Skimming & Relay Attacks



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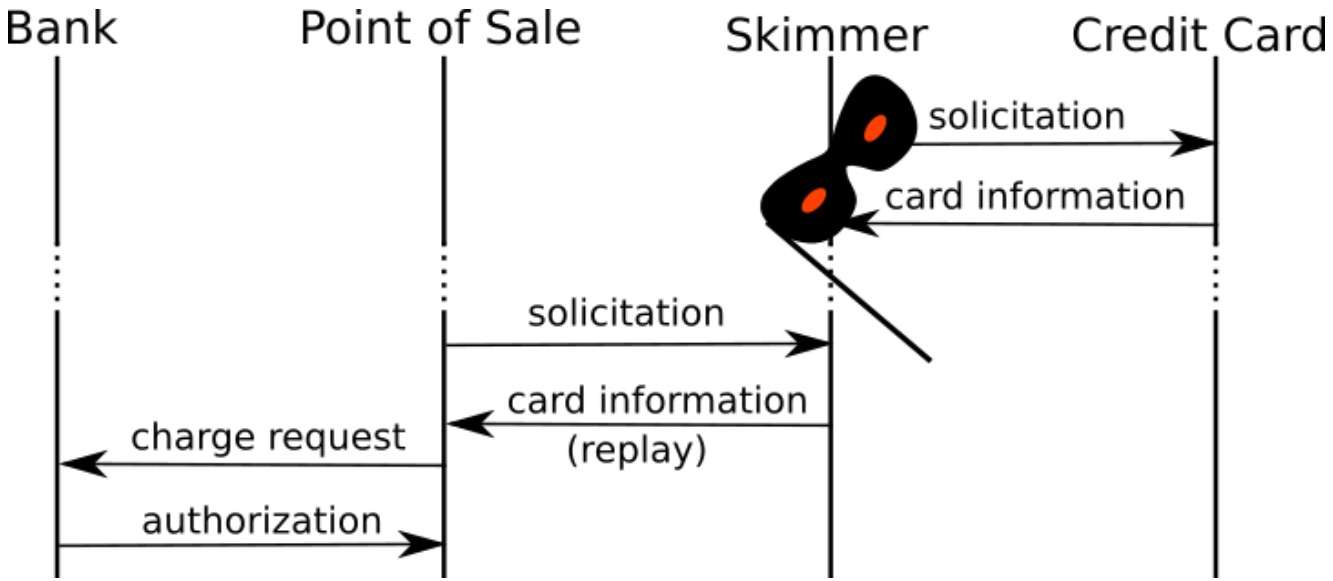

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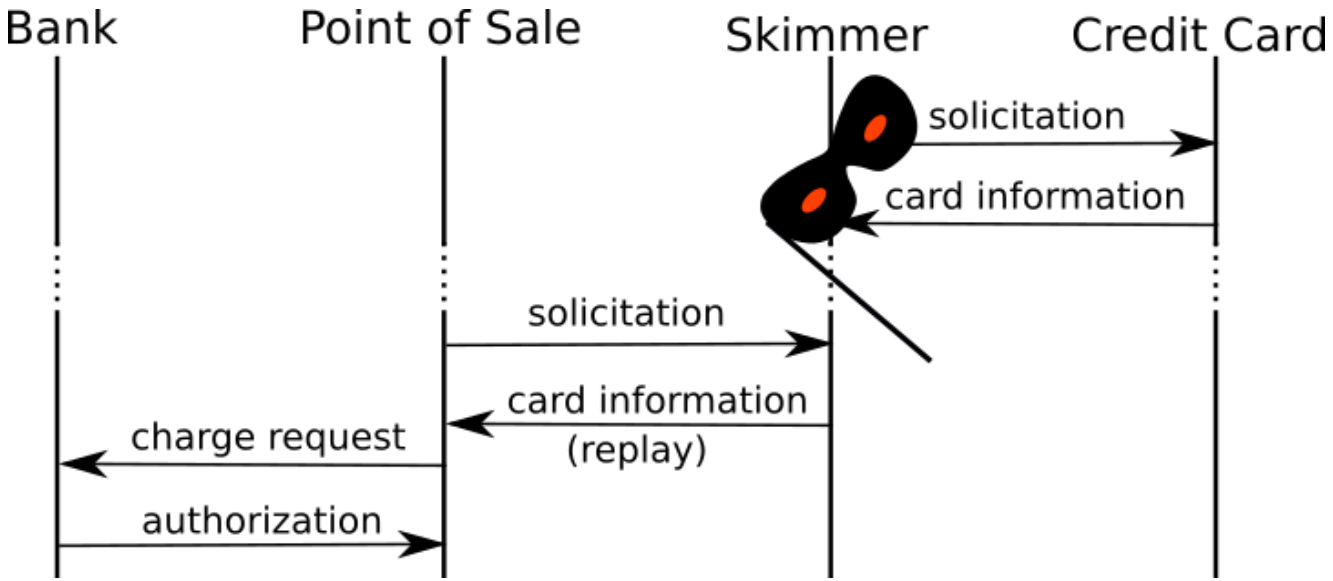

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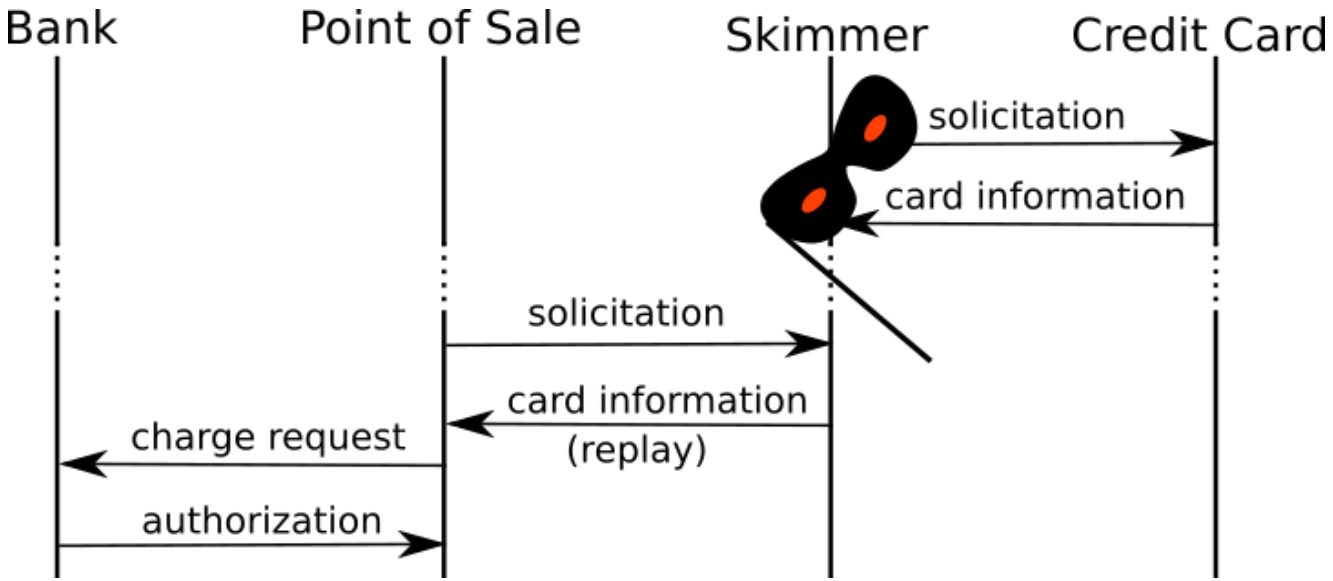

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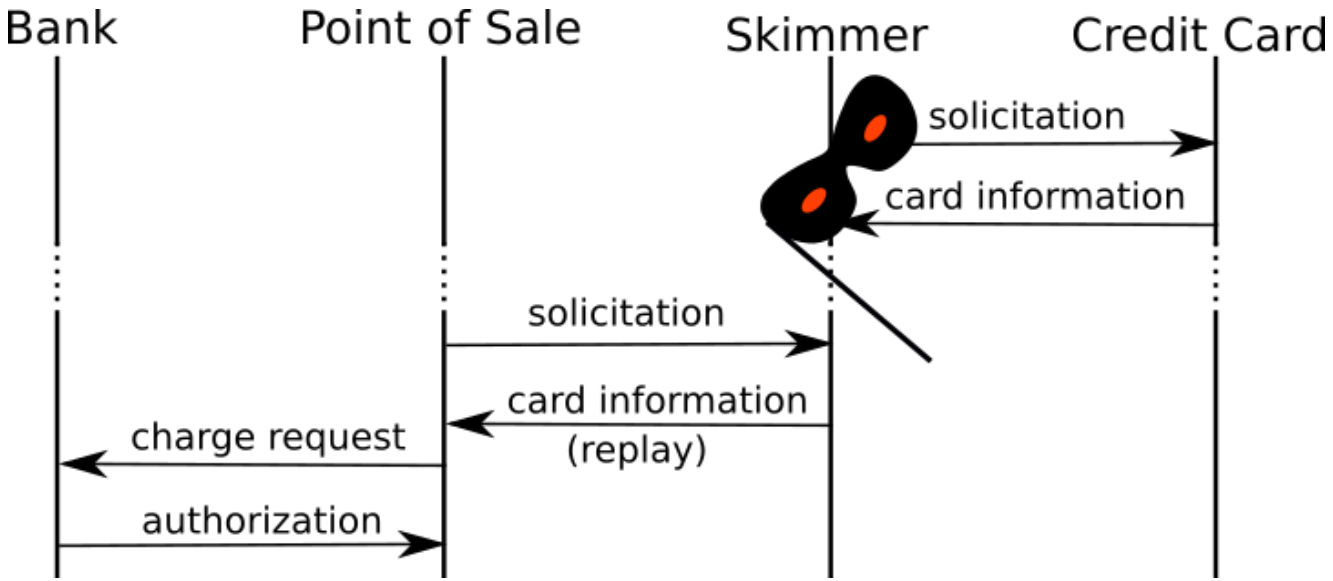

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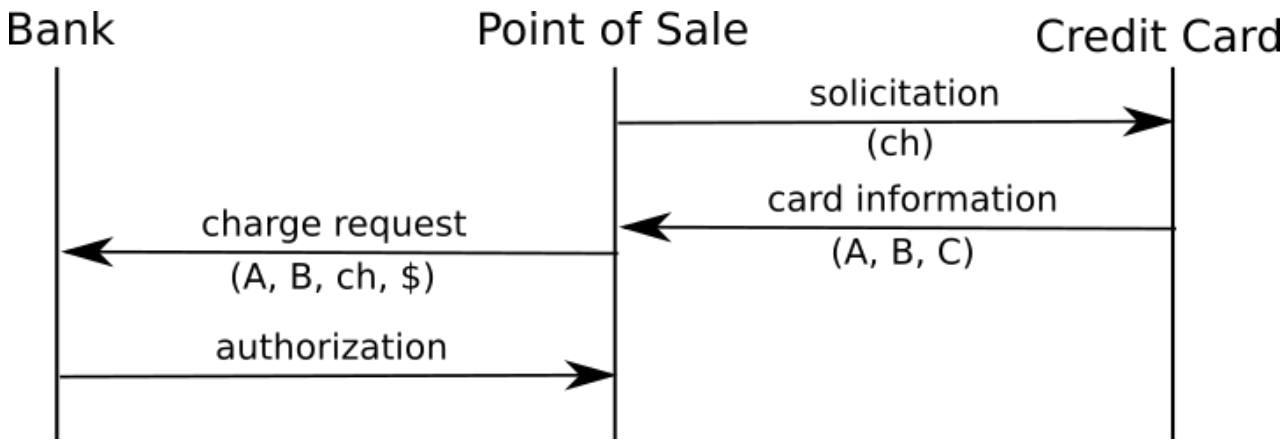
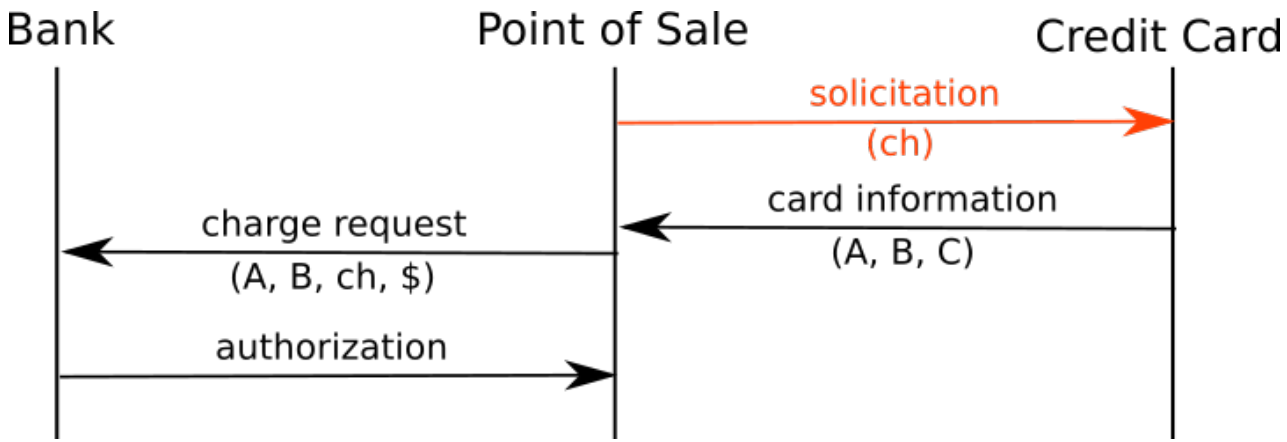
- In a relay attack, two devices execute the skimming attack in concert

Proposed Secure Credit Protocol



A credit card protocol restructured

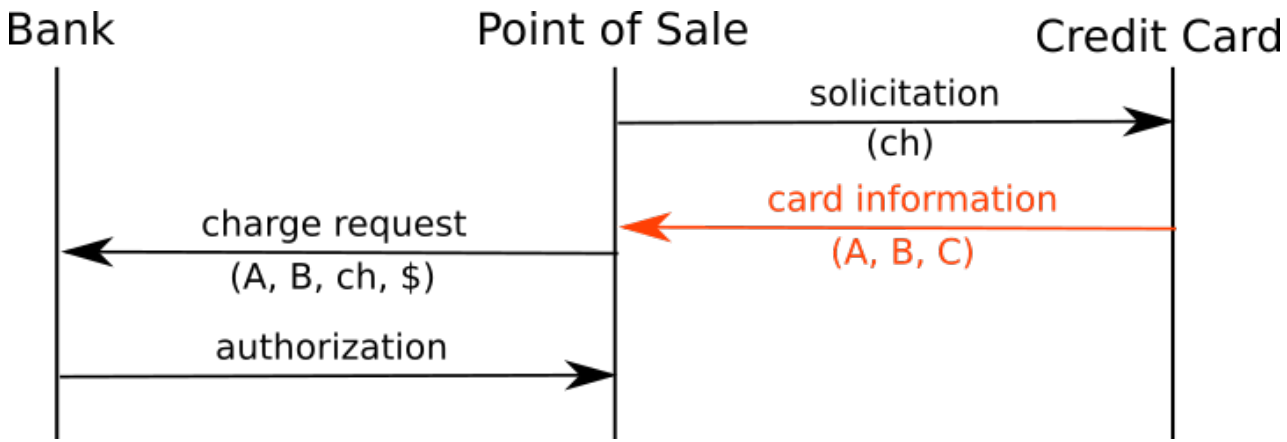
Proposed Secure Credit Protocol



Solicitation

- Point of Sale now sends a challenge

Proposed Secure Credit Protocol



Restructured Card Information

(A) ***UUID***, a static Universally Unique Identifier is used to identify the credit card.

(B) ***H(card info, ch, iCVV)*** is a hash-like function used to authenticate the card's identity.

(C) ***bank name*** is used to route the charge request.

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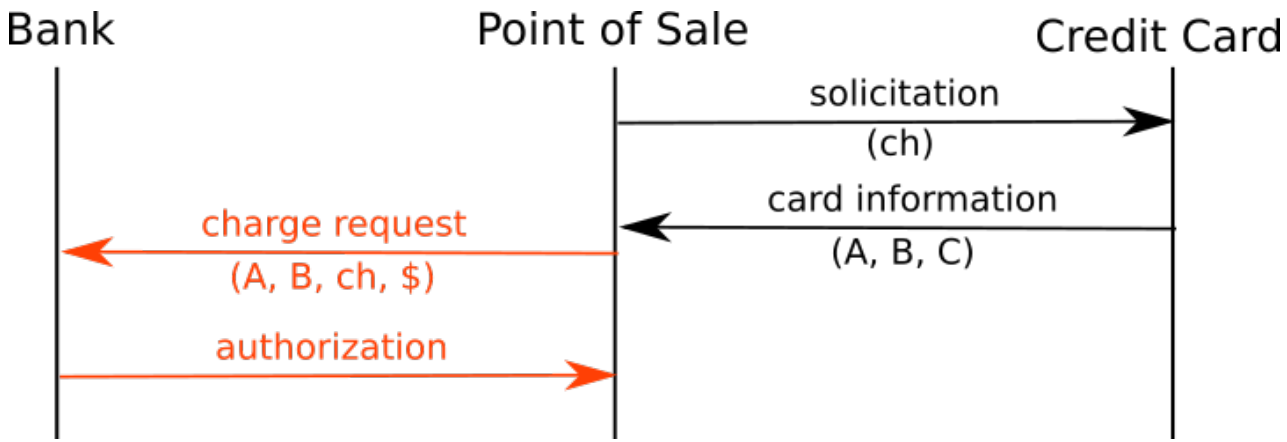

Charge request

- Card information is sent to the indicated bank

Authorization

- Bank verifies transaction

Hash-like function H

Requirements of H

1. **Output appears random**
2. **Output cannot be used to derive components**

So that attackers cannot

- Glean useful information
- Build a new hash output using the components and a new challenge

Hash-like function H

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Bank-generated hash	1011 0110
Challenge	1110 1110
Values kept when ch=1	1010 0111

Hash-like function H

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Bank-generated hash	1011 0110
Challenge	1110 1110
Values kept when ch=1	1010 0111
iCVV	1010 1010
Result of XOR	0000 1101

NFC and Mass Transit Ticketing

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- Presently, contactless cards widely used for mass transit ticketing
- Three Nokia reseachers investigate NFC phone based ticketing
- Tamrakar, Ekberg, and Asokan's [2] work is the focus of this section
- Their goal is to build a secure ticketing scheme while keeping transaction time below the 300ms industry standard

Proposed Ticketing Protocol

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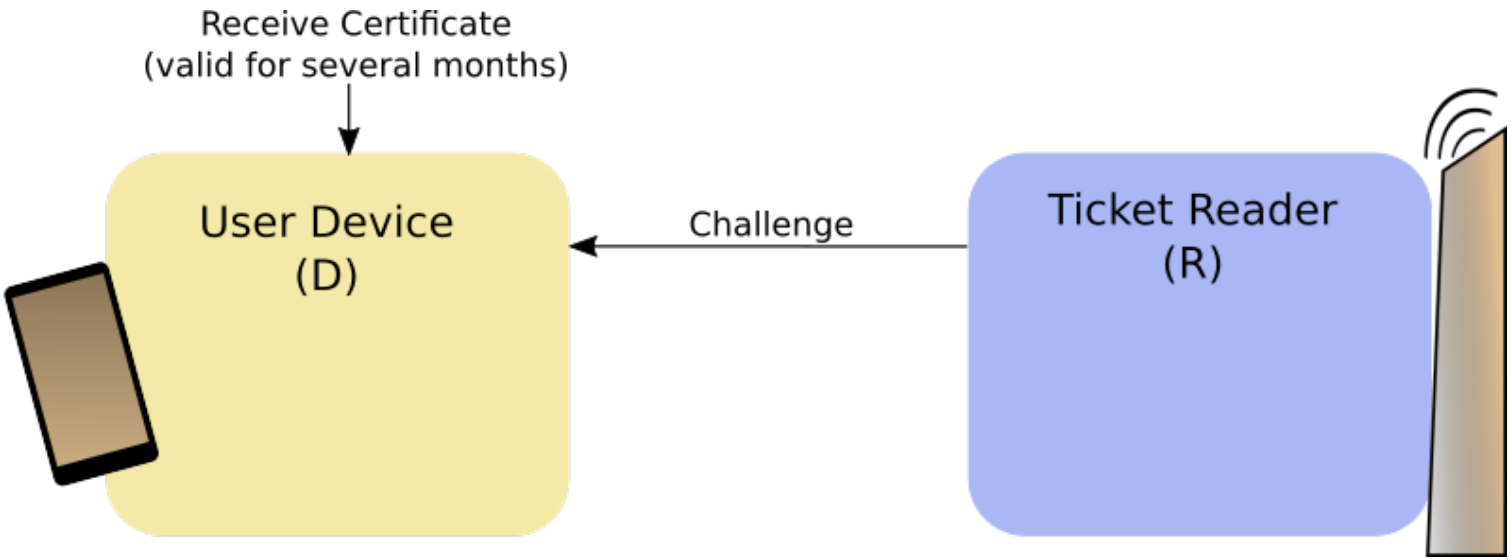

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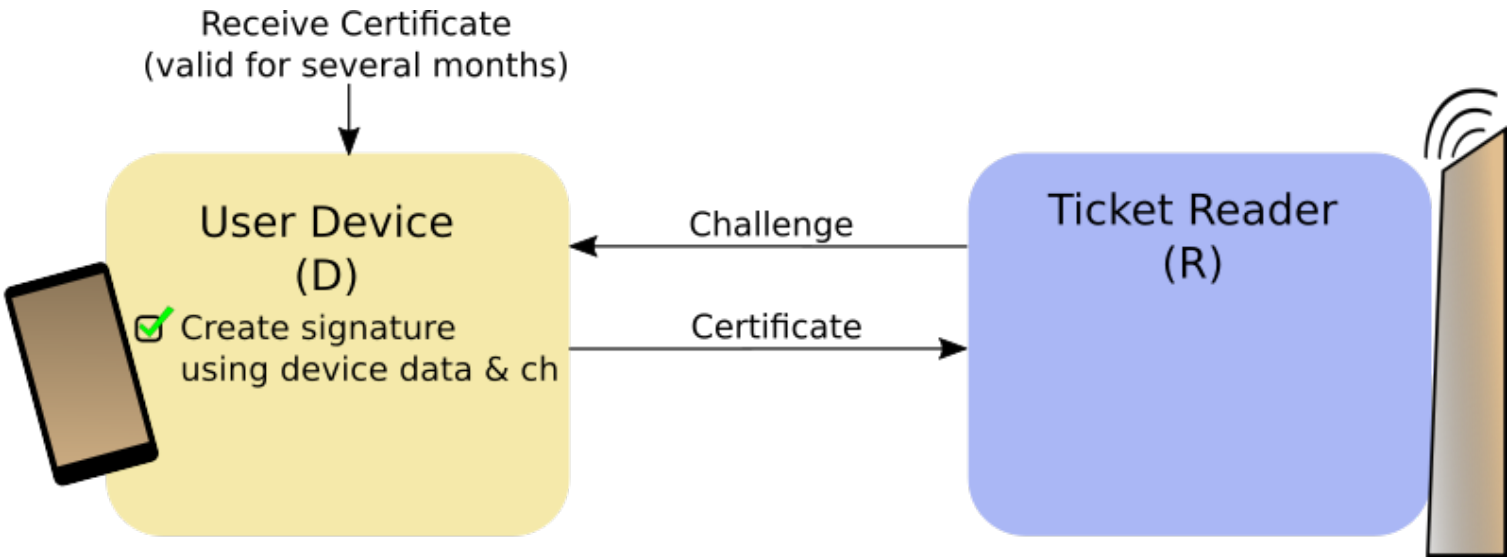

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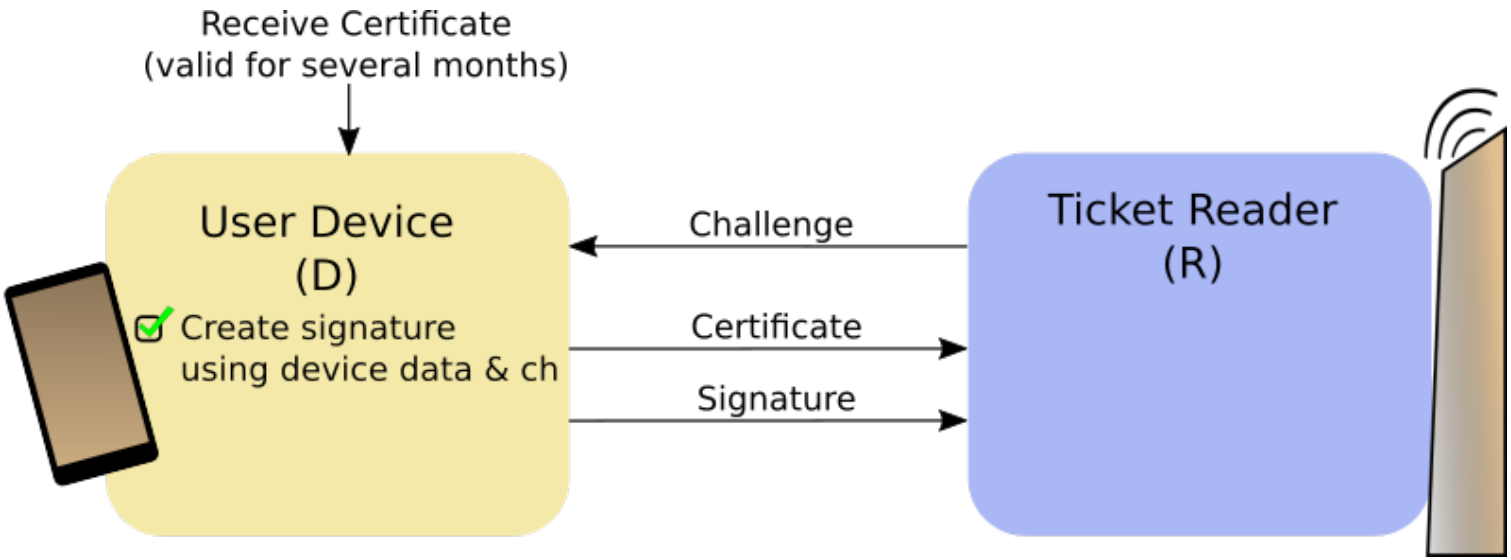

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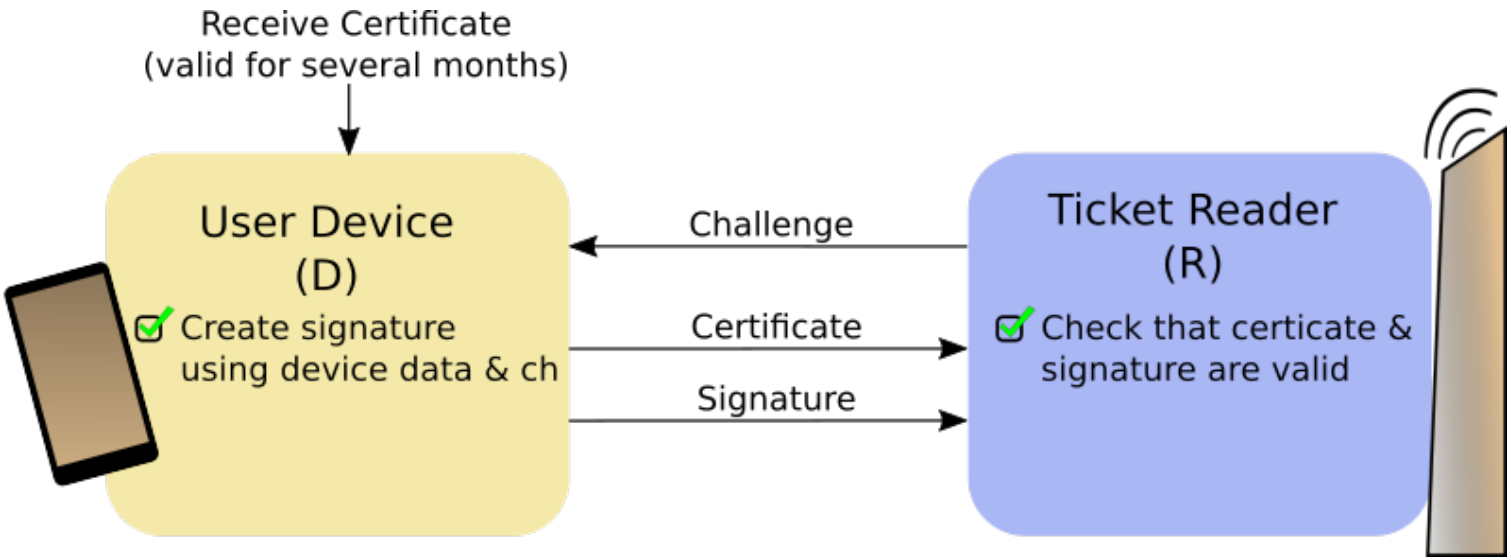

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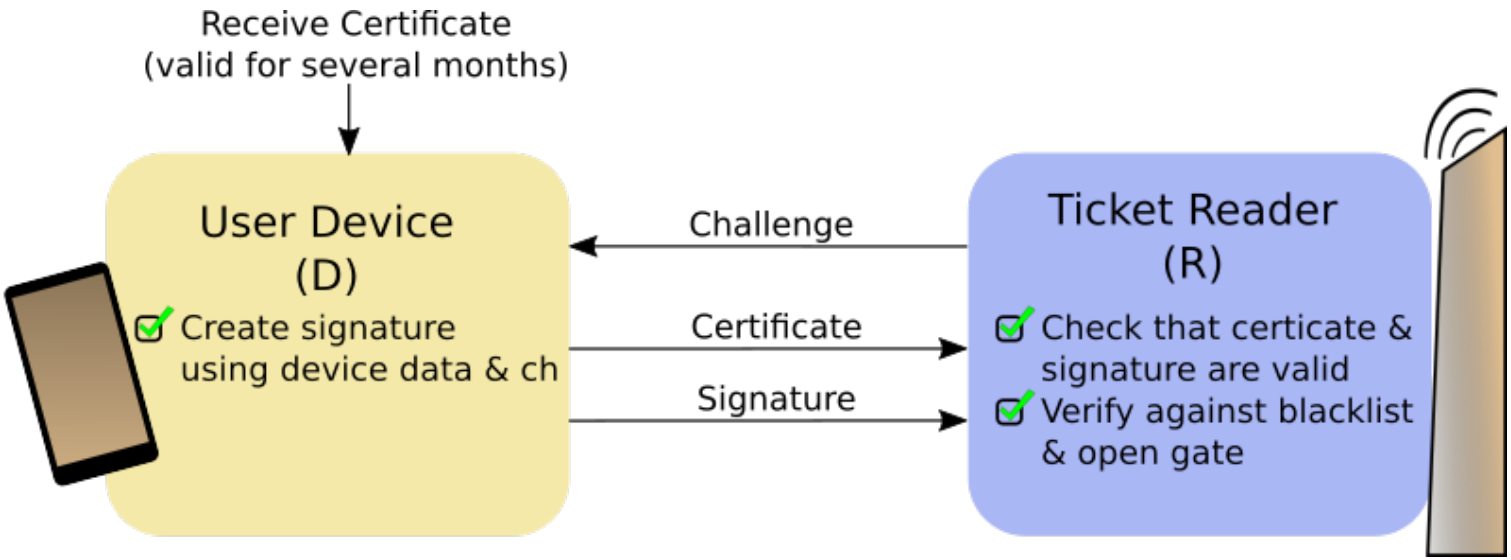

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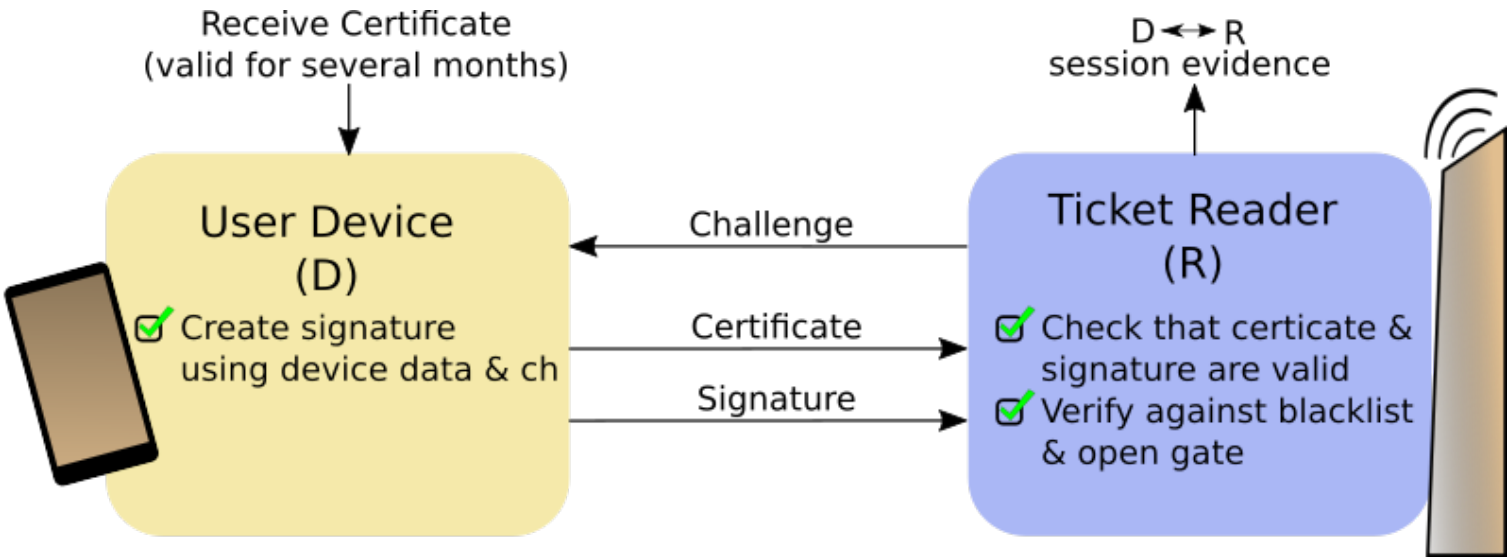

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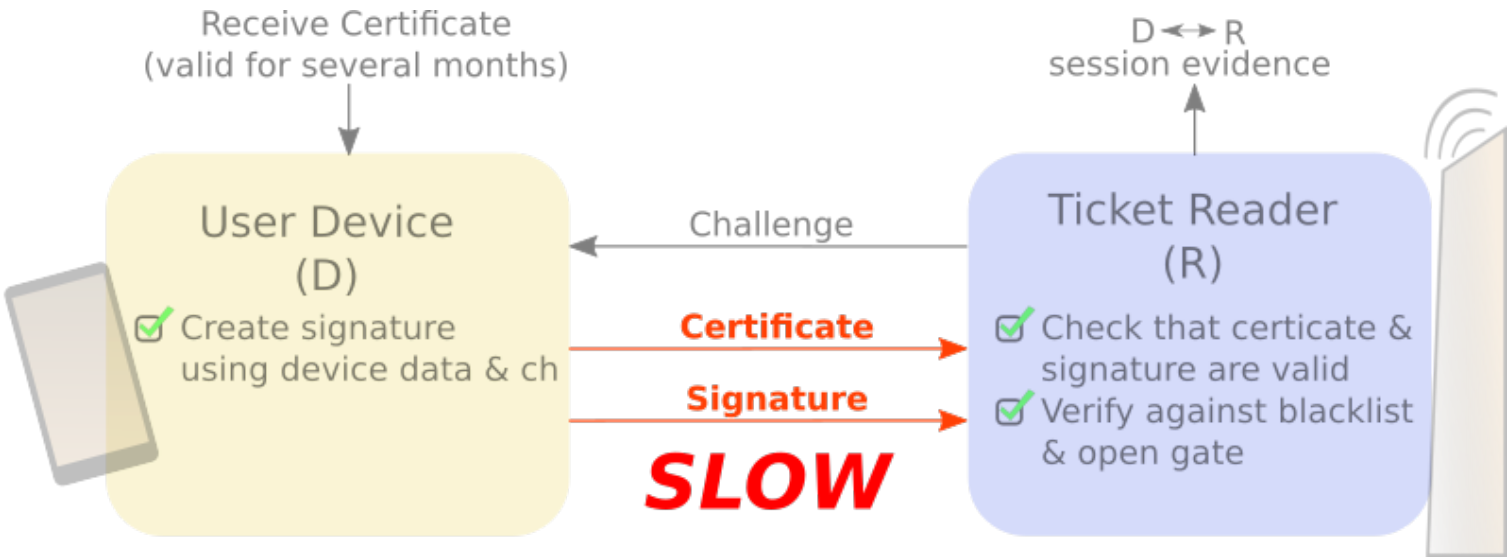

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Use tokens instead of certificates

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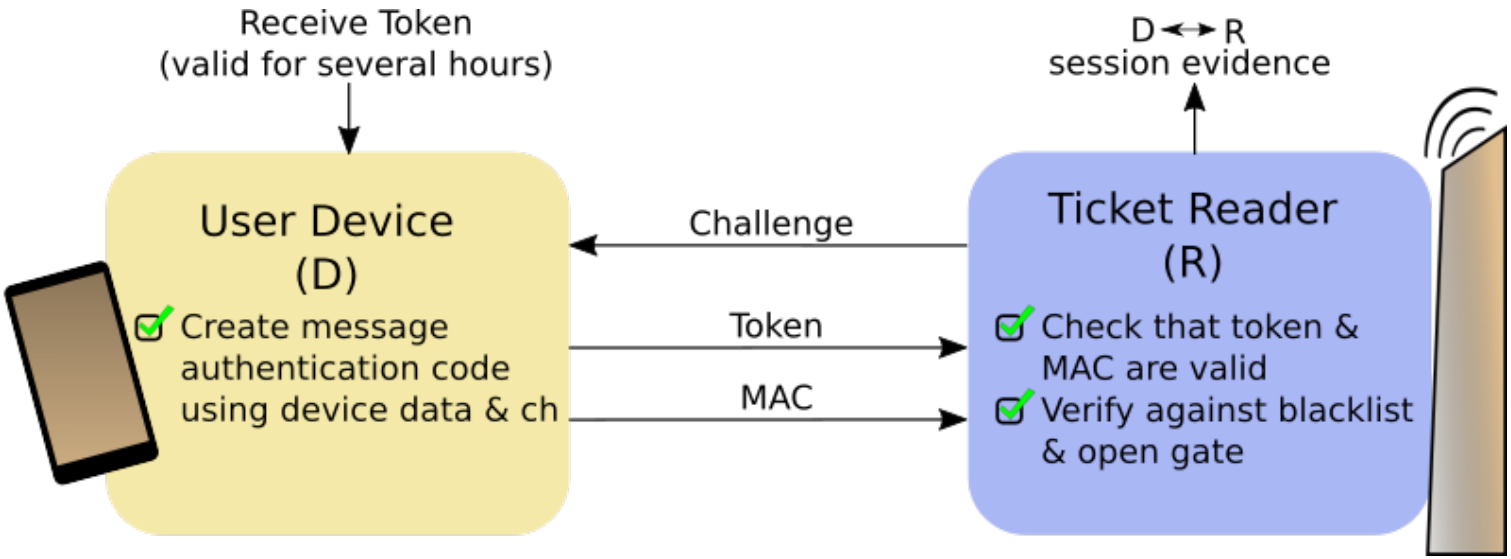
Use a lighter authentication method

- Switching from a signature to a MAC (*message authentication code*) substantially reduces overhead

Use tokens instead of certificates

- Send a small token that the reader can validate
- For security, the token should be refreshed often

Protocol Variant 1



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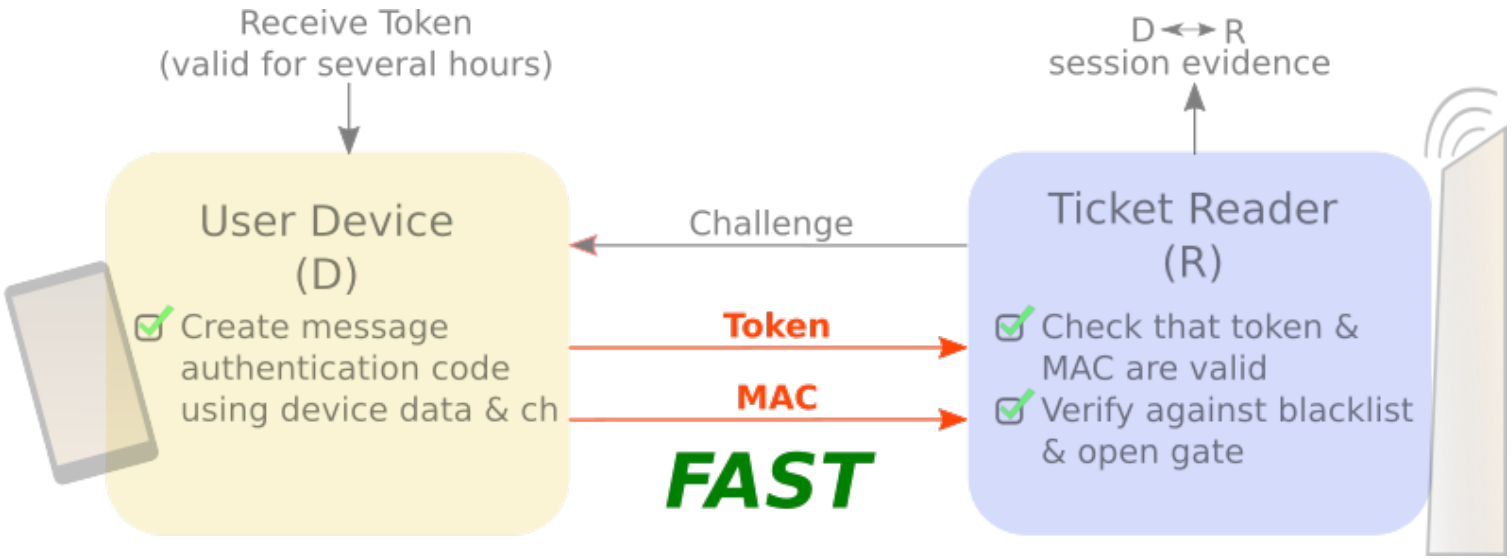

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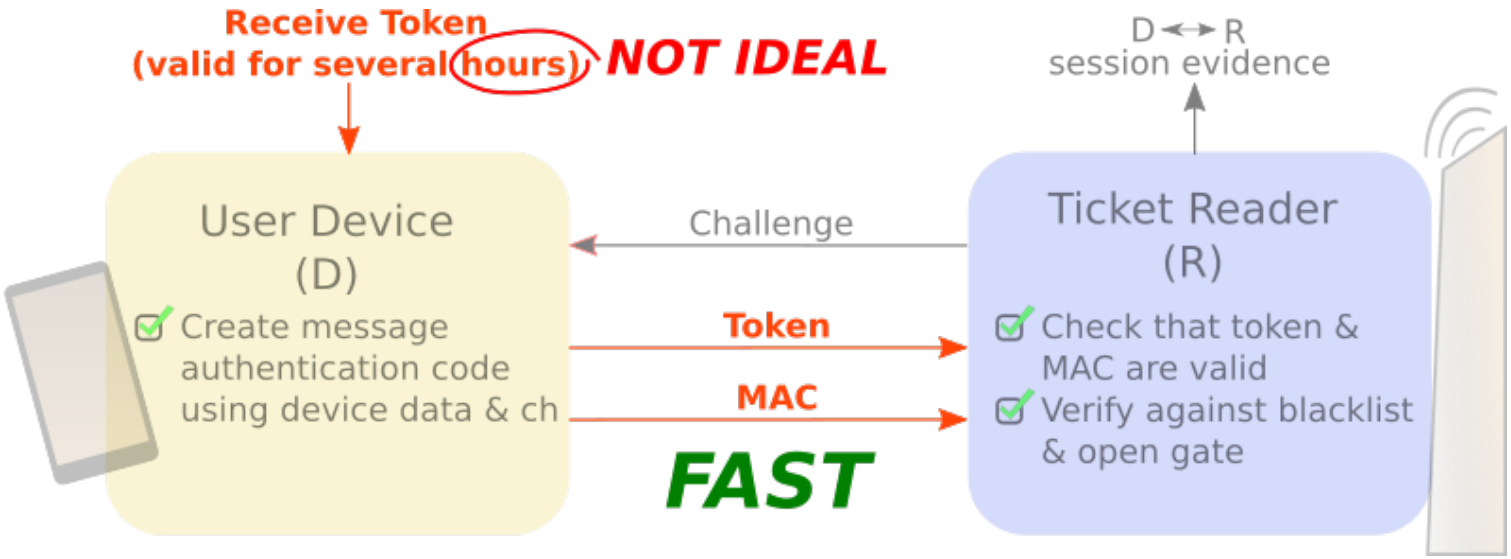

Protocol Variant 2

Use small, timely tokens AND a long-term certificate

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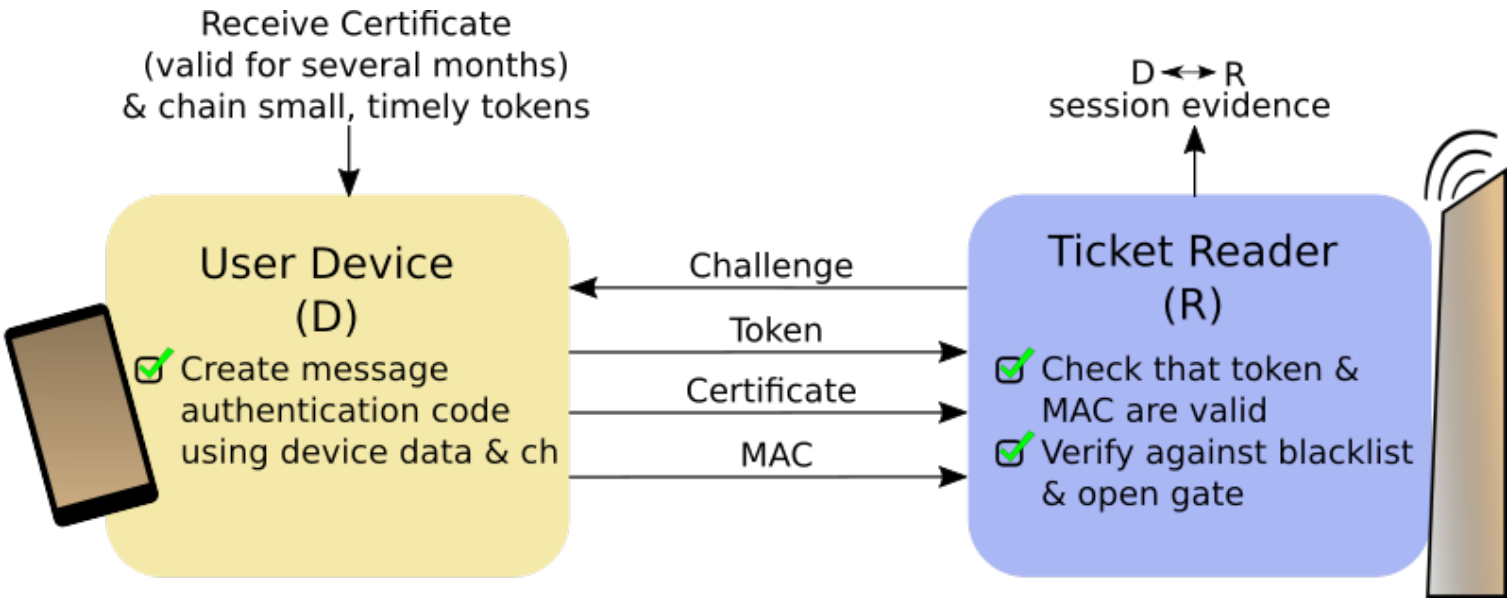
Use small, timely tokens AND a long-term certificate

- This is implemented using a reverse hash chain



Viability of Mobile Ticketing

Viability of Proposed Protocols

Encryption Key Size	Standard	Variant 1	Variant 2
1024 bits	296 ms	164 ms	182 ms
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- The Nokia researchers grant that relay attacks are possible in all protocols, but that there is a short opportunity windows and low monetary gain
- The researchers state that these protocols are meets performance and security needs better than the current contactless card system
- While mobile ticketing is an imperfect, it is valid path forward that offers value

EnGarde: Physical NFC Security

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- Gummeson et al's [3] work on the EnGarde prototype is the focus of this section

EnGarde Prototype

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- Software can be updated to combat current and future threats

EnGarde Expectations

EnGarde should defend against all NFC modes

- Malicious tags
- Malicious readers
- Malicious peers
- Malicious software installations

NFC Decoding and Jamming

How does EnGarde detect and stop unwanted transmissions?

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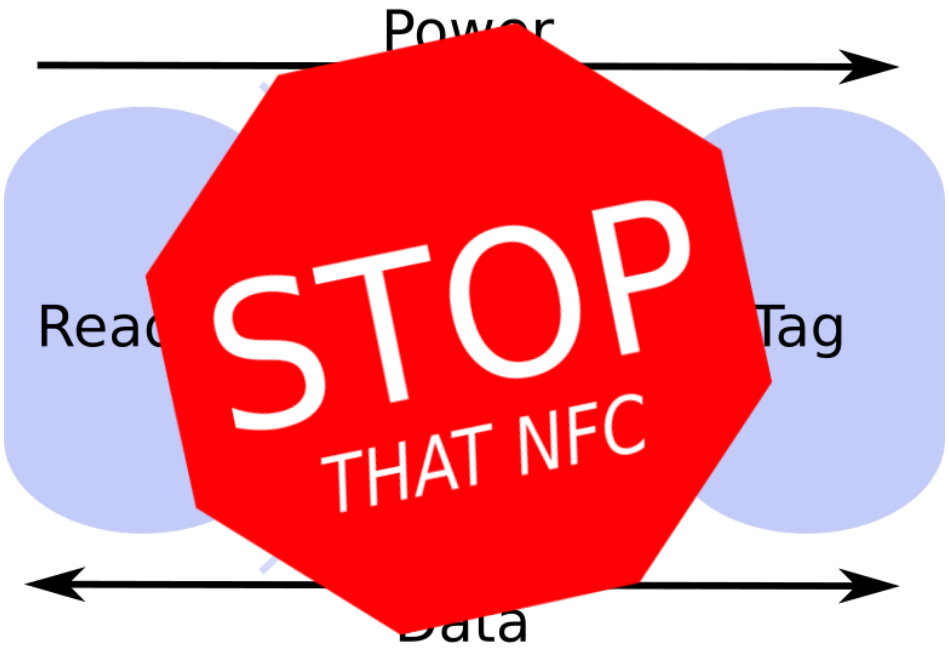

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- The blocking rules can be updated for robust handling of current and future attacks

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Experimental Evaluation of EnGarde

Results

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- EnGarde was able to successfully block all malicious test cases using one of the jamming methods
- Decoding was also successful in decoding a malicious tag to the URL *http://www.malware*
- EnGarde's defense seems strong, but we note that its defense is only as strong as the blocking rules it has

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- Now we have a better idea of how NFC works. Is it secure? Is it the future?
- Clever solutions can mitigate security concerns
- NFC data transfer speed appears to be the biggest bottleneck
- NFC is young and will likely act as platform for future applications
- In the end, security relies on vigilance and on understanding risks

Questions

Questions?

Stop by the NFC enabled pop machine near the bookstore for a neat demonstration.

Sources

Primary Research Sources

1. Oliver Jensen, Mohamed Gouda, and Lili Qiu. 2016. A secure credit card protocol over NFC. In Proceedings of the 17th International Conference on Distributed Computing and Networking (ICDCN '16). ACM, New York, NY, USA, Article 32 , 9 pages.
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