Picking Up My Tab: Understanding and Mitigating Synchronized Token Lifting and Spending in Mobile Payment

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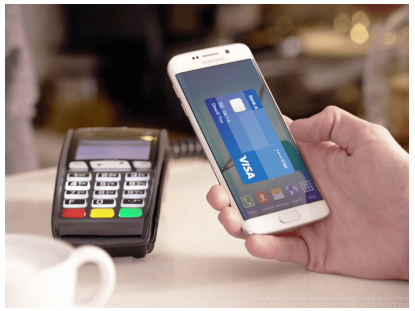
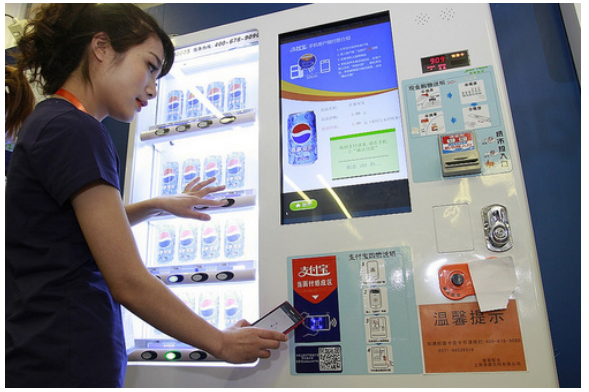
Mobile Payment – A Convenient Life Style

- Mobile payment is everywhere.
- Over 5 Trillion US Dollar Transactions.



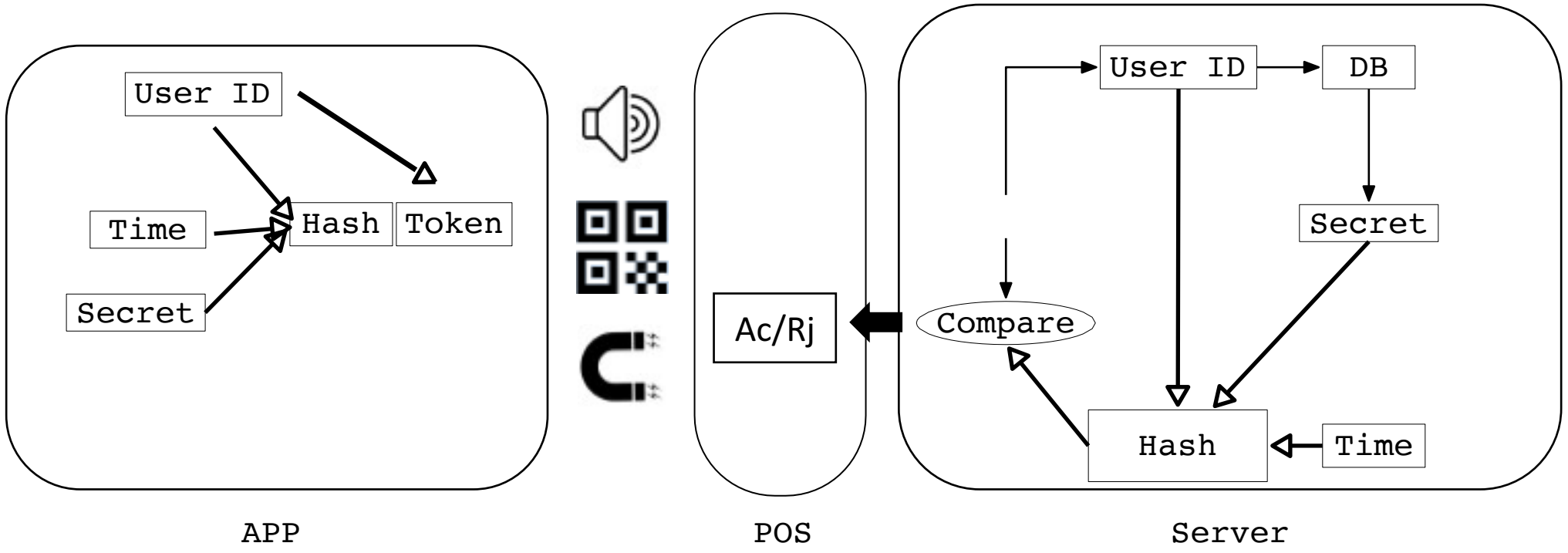


Offline Mobile Payment

- A Mobile Payment Method Without Network.
  - Mobile phone does not need network.
  - POS machine must be connected.
- Advantages.
  - Short delay.
  - Avoid poor network connection inside rooms.
- Simple to use.
  - No need to enter password
  - Simple approach a phone to POS.

Offline Mobile Payment Working Flow

- Hash value inside token.
- Security based on the synchronized secret key.

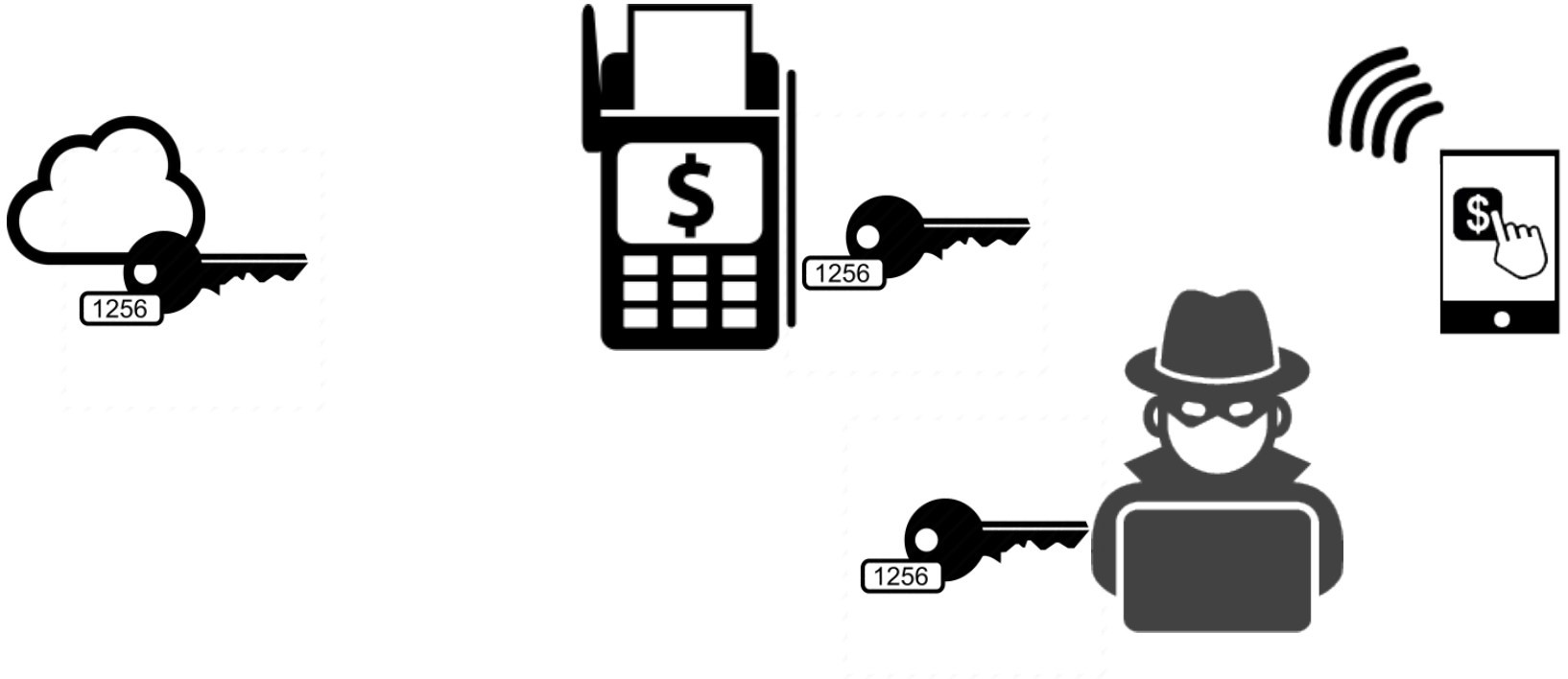


Security Guarantees

- Through hashing, a token is bonded to
  - The time when being generated.
  - The user ID.
  - It cannot be **forged** without the synchronized secret.
- Tokens are hard to sniff.
  - Token transportation is designed to be distance bonded.
- Even if a token is sniffed.
  - A token, once received by the provider, is invalidated immediately.
  - A token is only valid in a short period of time.

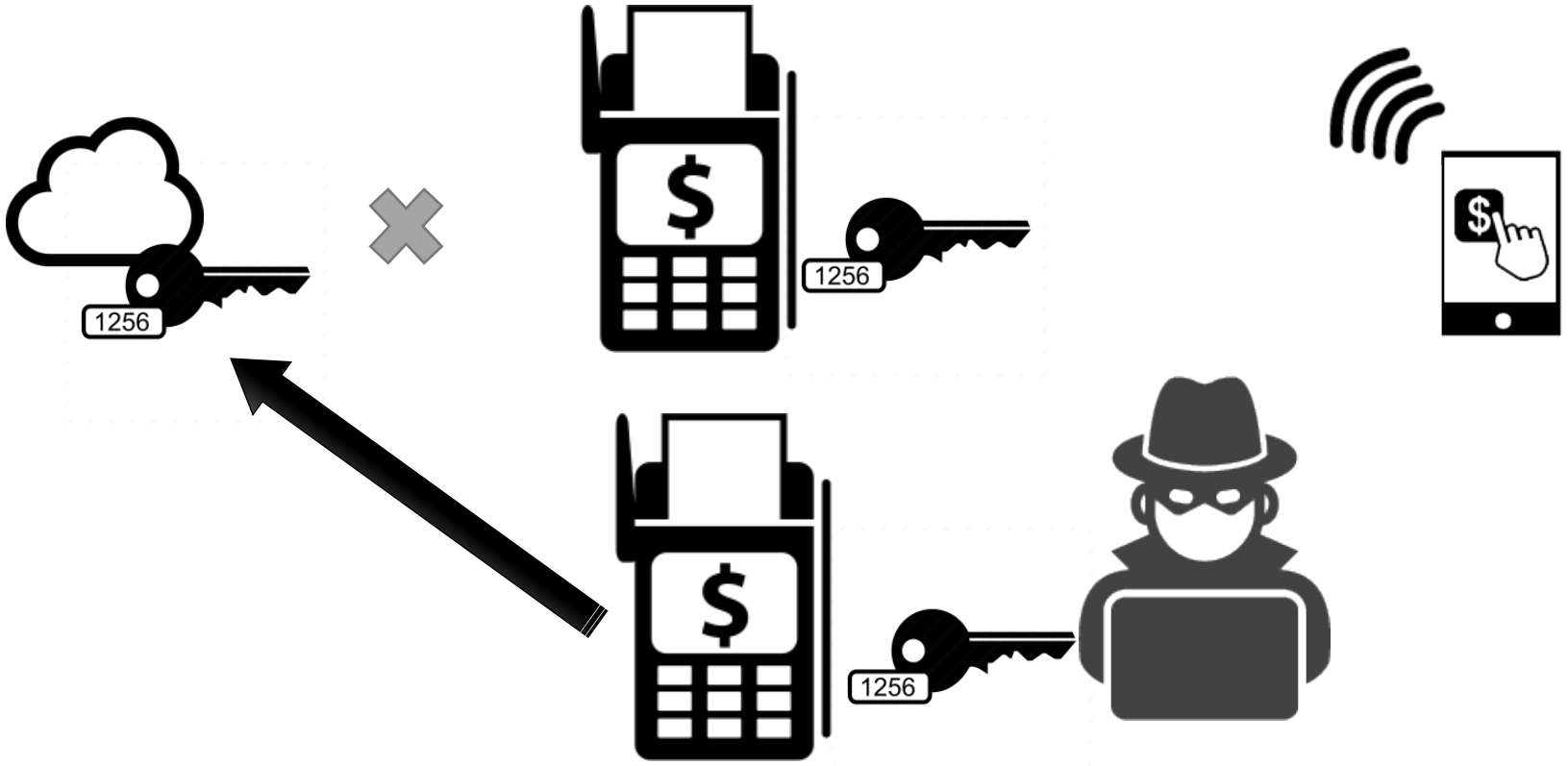
Assumption: Passive Adversaries

- Passive attackers are already defended, because tokens, once sniffed, are also received by the provider, is invalidated immediately.



Break it with an active adversary

- But it is vulnerable to an active adversary!

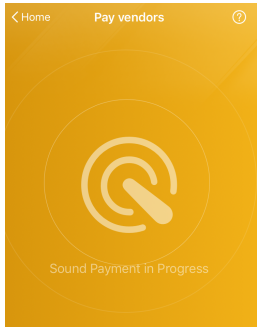


Attacks against Offline Payment

- STLS Attacks.
  - Synchronized Token Lifting and Spending.
- Steps
  - Acquire a live token.
  - Prevent it from being legally used.
  - Spend it at another place, before it expires.
- Targets

SAMSUNG pay

Alipay™



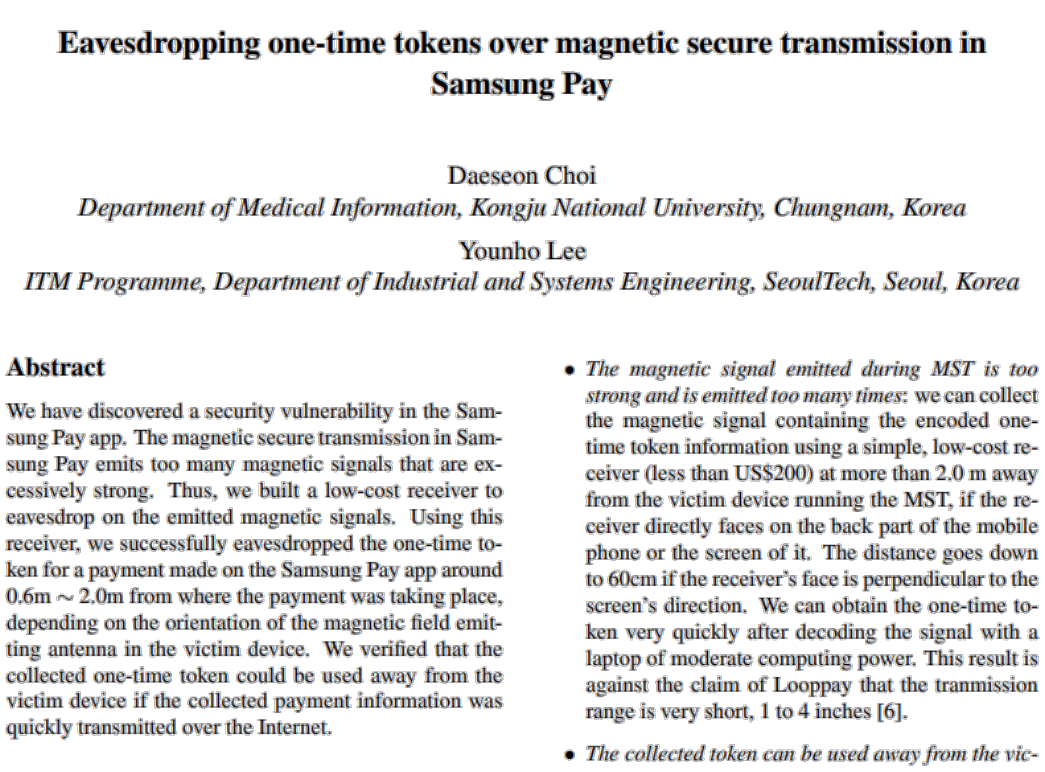
Samsung Pay

SAMSUNG pay

Pay SAMSUNG pay

Known Attacks against Samsung

- Previous paper sniffing and replaying Samsung pay tokens.
  - Assumption: Passive attackers.
- Legal transaction is not interrupted.
- The sniffed token is not alive.
- Users are still enough secure.



Eavesdropping one-time tokens over magnetic secure transmission in Samsung Pay

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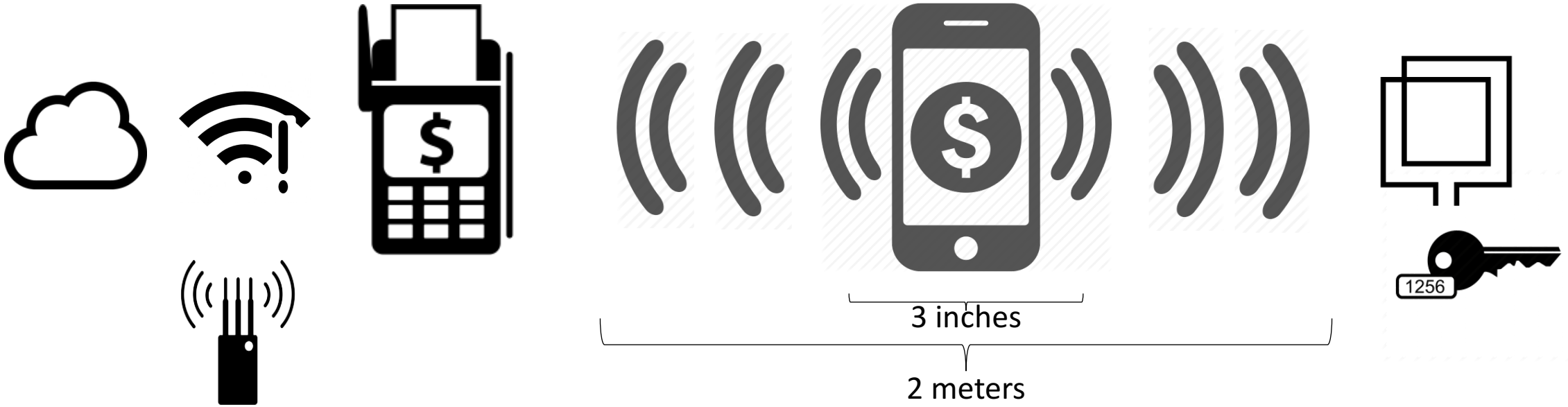
Abstract

We have discovered a security vulnerability in the Samsung Pay app. The magnetic secure transmission in Samsung Pay emits too many magnetic signals that are excessively strong. Thus, we built a low-cost receiver to eavesdrop on the emitted magnetic signals. Using this receiver, we successfully eavesdropped the one-time token for a payment made on the Samsung Pay app around 0.6m ∼ 2.0m from where the payment was taking place, depending on the orientation of the magnetic field emitting antenna in the victim device. We verified that the collected one-time token could be used away from the victim device if the collected payment information was quickly transmitted over the Internet.

- *The magnetic signal emitted during MST is too strong and is emitted too many times*: we can collect the magnetic signal containing the encoded one-time token information using a simple, low-cost receiver (less than US$200) at more than 2.0 m away from the victim device running the MST, if the receiver directly faces on the back part of the mobile phone or the screen of it. The distance goes down to 60cm if the receiver's face is perpendicular to the screen's direction. We can obtain the one-time token very quickly after decoding the signal with a laptop of moderate computing power. This result is against the claim of Looppay that the tranmission range is very short, 1 to 4 inches [6].
- *The collected token can be used away from the vic-*

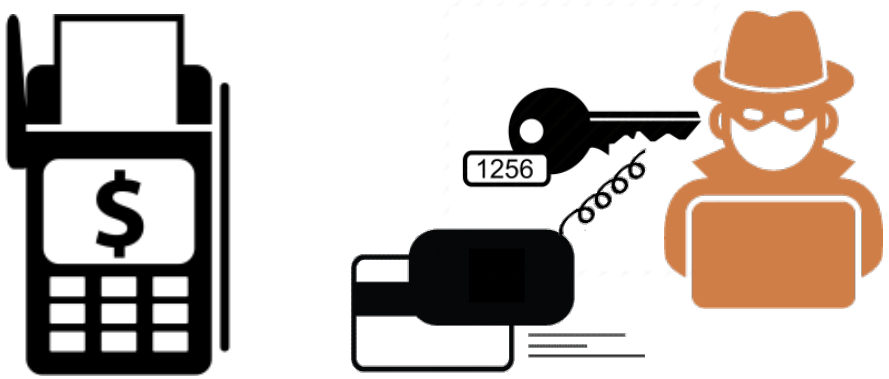
STLS Attack against Samsung Pay

- Assumption: Active Attackers.
- Standing close to the POS, can jam the network.

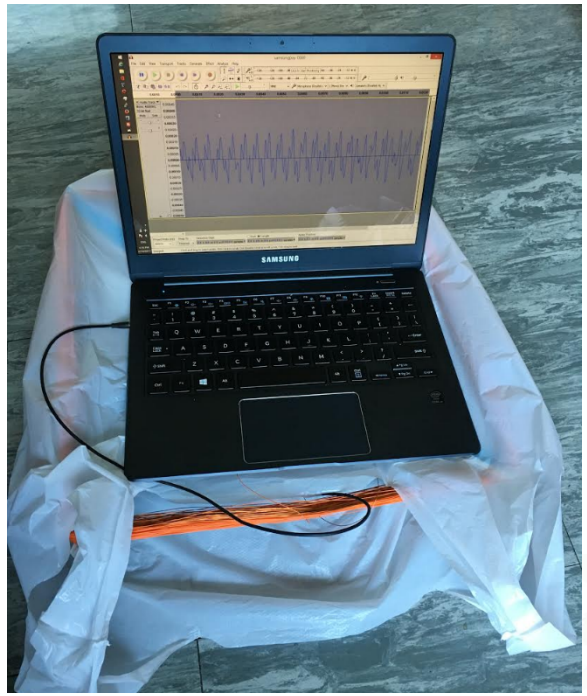


STLS Attack against Samsung Pay

- Token replay.

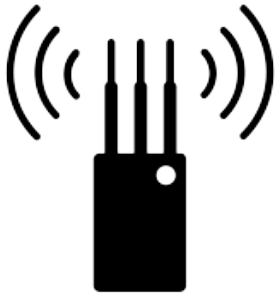


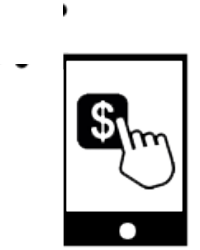
Devices to launch the attack



Sound Pay

Attacking Sound Pay – Adversary Model





Attacking Sound Pay –Sniffing and Jamming

Attacking Sound Pay – Colluder Side

STLS Attacks – QR Pay

- An extremely popular payment method.
- Payment Mode
  - B2S mode: A phone scans QR code on a paper to pay.
  - B2L mode: A phone presents QR code under POS scanner to pay.

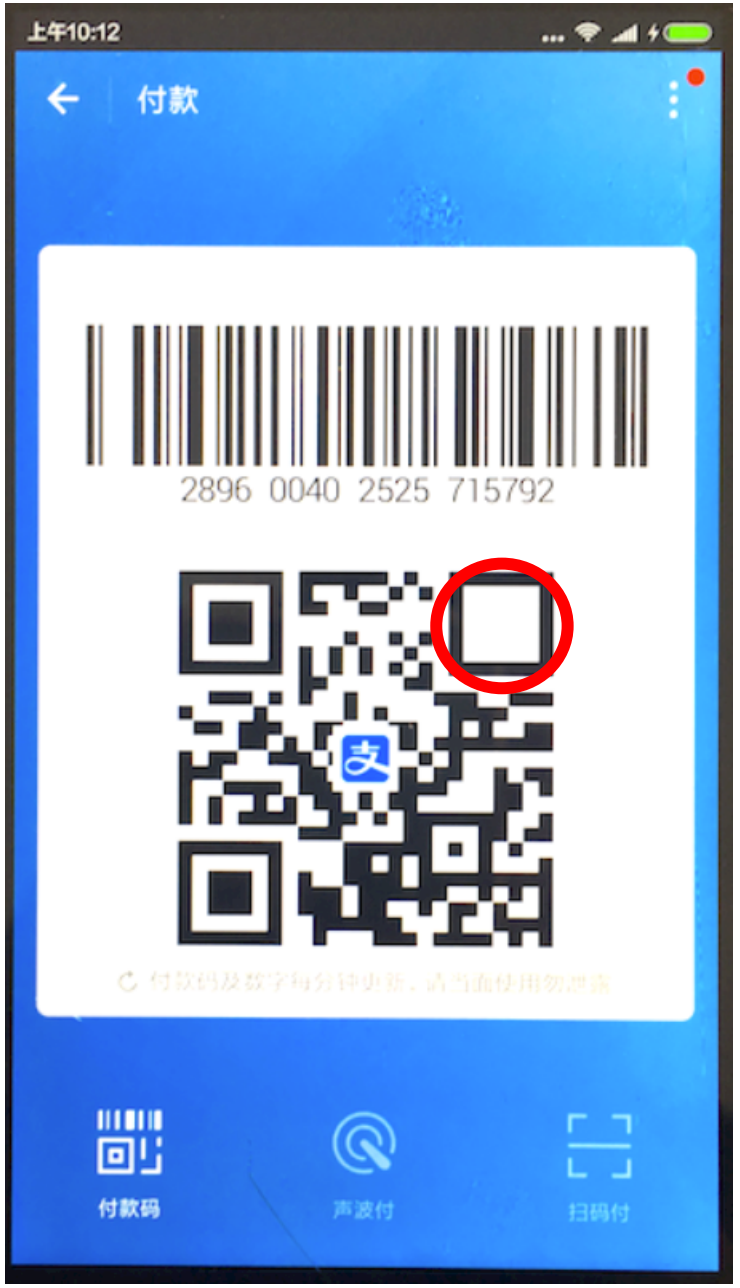
Adversary Model – QR Pay

- Payer’s phone is infected with attacker’s malware.
- The malware has the front camera privilege.
  - For sniffing.
- The malware can display a floating window.
  - To prevent tokens from being legally used.

STLS Attacks – QR Code Sniffing

Prevent Legal Scanning

- A malware a draw a white block.
- To prevent the code from legally recognized.
  - Positioning mark is critical for decoding.
  - POS machine can no longer decode the QR code.
- The sniffed QR code token is kept alive.
  - Attackers spend the token during the period.



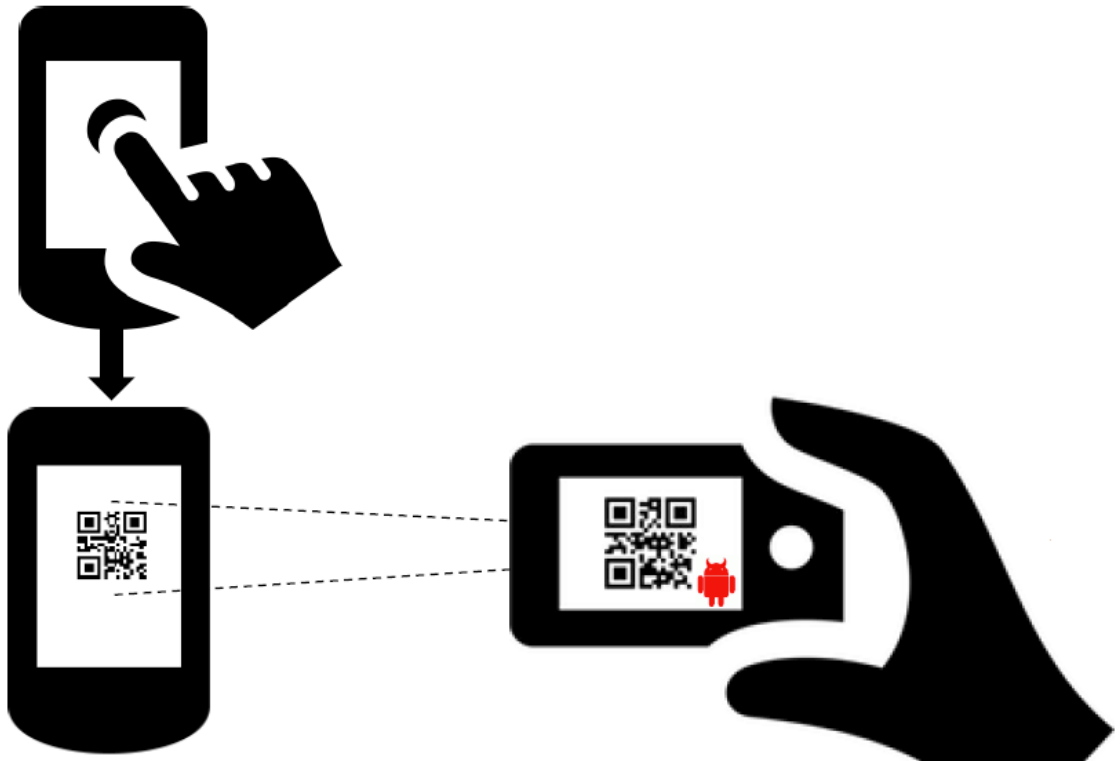
P2P Mode Attacks

- What if you use iPhone instead of Android Phone?
  - iPhone does not support background front camera photo shooting.
- What if your phone is not infected?
- P2P mode: A phone scans QR code on another phone to pay.
- The QR code can also be used in B2L mode to pay to the merchants.

P2P Mode Attack Adversary Model

- The victim (payee) is not infected.
- The payer is infected with attacker’s malware.
  - Has an exactly same UI with legal payment app.
  - Will be used to sniff the QR code token.
- The victim has turned on the Bluetooth.
  - Can be exploited by attacker to keep the token alive.

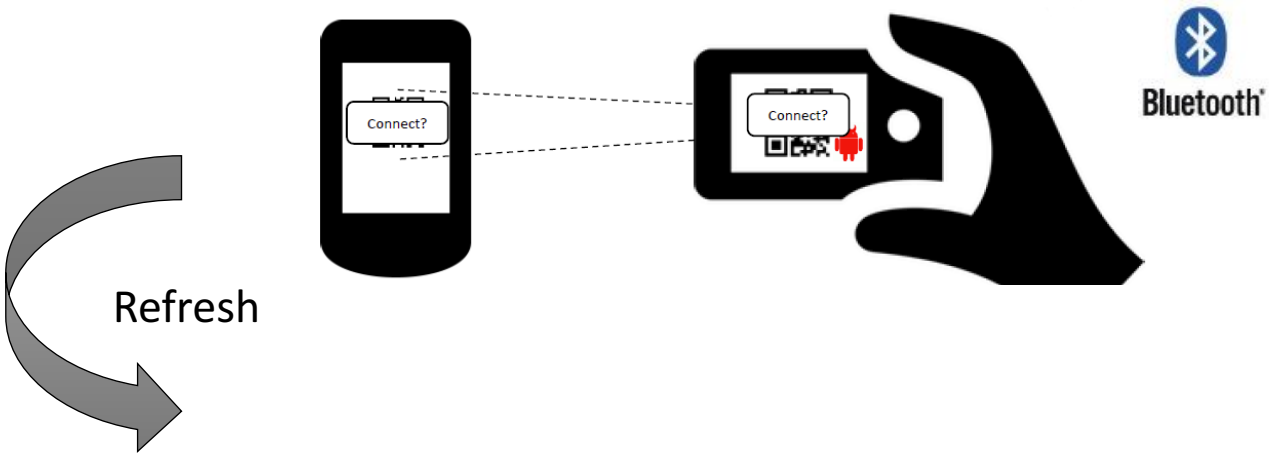
STLS Attacks – QR Code Sniffing



Payee

Payer (infected)

Preventing sniffed QR code from legal scan



Payee

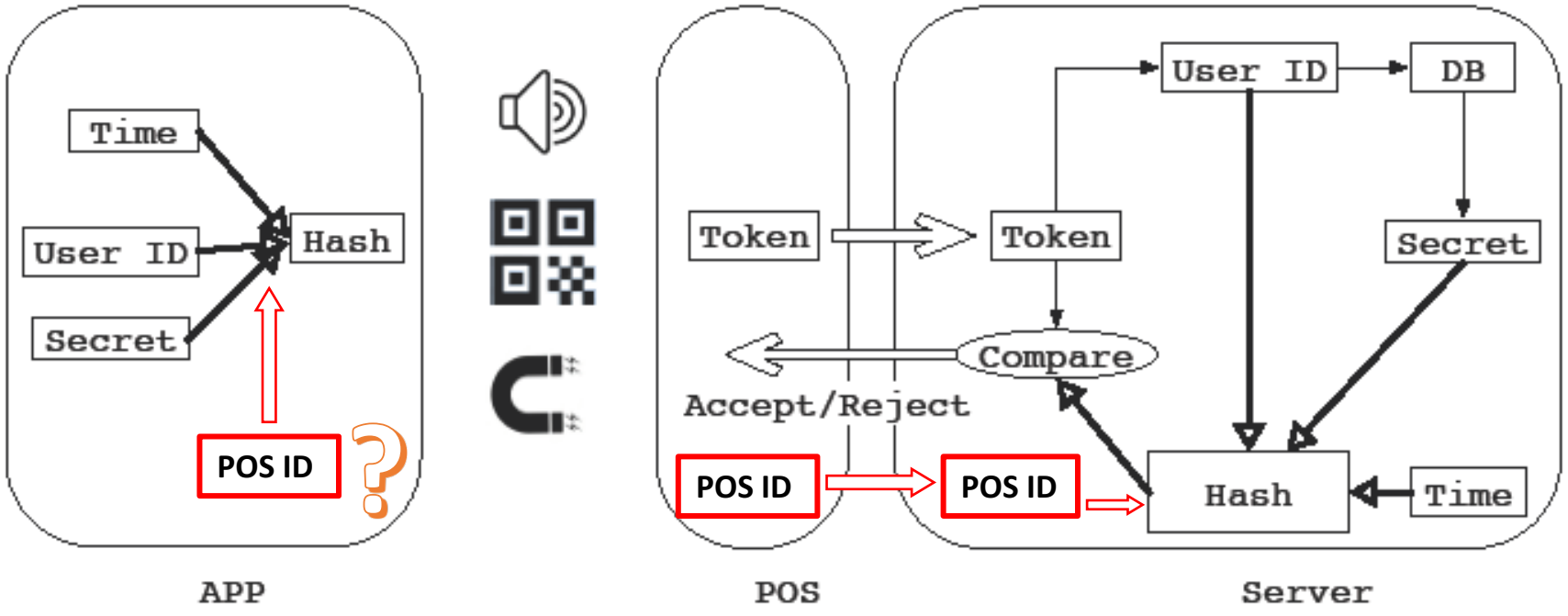
Payer (infected)

STLS Attacks – Alipay's Action

- Alipay ceased P2P transfer through QR code in this Feb.
- Face to face money transfer moved to printed QR code.
  - Users get an exclusive QR code for receiving money after application.

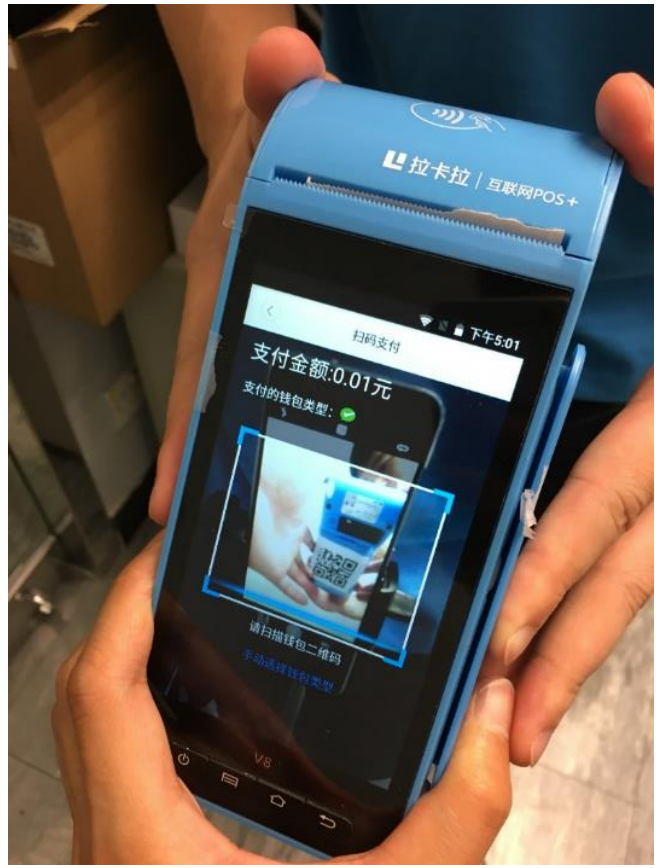
POSAUTH, restrict the use of sniffed tokens

- Live token can be spent at anywhere, with the upper bound amount.
- Sniffed token cannot be spent remotely, once bonded to the POS ID.



POSAUTH

- Get the POS ID
  - By a front scan.
  - Hash it into token.
  - Token is bonded.
- No hardware upgrade.



Q&A

- Offline payment schemes only considered passive attackers.
- Active attackers can keep the sniffed token alive by interrupting the transaction.
- Attackers can spend the token before it expires.

Security Vulnerabilities

- A token is bond to
  - The time when being generated.
  - The user ID.
  - But **not** a specific transaction (Amount, Merchant ID, etc.).
- A live token can be spent by the attacker, once sniffed.
  - At anywhere.
  - With the upper bound amount.

STLS Attacks – B2L Mode Attacks

- The white block prevents QR code from being legally recognized.
- The font camera captures a picture containing the QR code.
- The background app can decode the QR code to get the token.
- The token can be spent at another place.