Applying Relay Attacks to
Google Wallet

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Outline

- Introduction
  - Relay Attack
  - Software-based Relay Attack
- Google Wallet
- Google Wallet Relay Attack
  - Test Setup
  - Limitations & Improvements
  - Workarounds
- Google‘s Response
Relay Attack

- Smartcard
- Smartcard Reader
- Mole (Relay Reader)
- Proxy (Card Emulator)
- Smartcard Reader
Relay Attack

- Cannot be prevented by application layer cryptography
  - Simple range extension of contactless communication channel

- Typical countermeasures:
  - Shielding of contactless interface with Faraday cage
  - Physical activation and deactivation
  - Two-factor authentication (e.g. PIN/password in addition to card)
  - Distance bounding protocols
Software-based Relay Attack

- Relay attack: Mole requires **close physical proximity** to device-under-attack

- Software-based Relay Attack:
  - Secure element access through application processor
  - App (software) replaces physical mole
  - App needs access to secure element and network interface(s)
  - Secure element access typically through privilege escalation
Software-based Relay Attack

NFC-enabled Mobile Phone

Application Processor
- Secure Element API
- Relay Software
- Network API

Secure Element

Card Emulator

Card Emulator Software

Network API

Card Emulation API

NFC hardware capable of card emulation

NFC/RFID link

Point-of-Sale Terminal
Software-based Relay Attack

**Diagram Description:**

1. **C-APDU** arrives at the **Secure Element**.
2. **R-APDU** is processed by the **Secure Element** and then
   - **(3) C-APDU** is sent to the **Network API**.
   - **(4) Relay Software** and **Network API** exchange C-APDU.
   - **(5) C-APDU** is sent back to the **Secure Element**.
3. **C-APDU** is again processed and
   - **(6) R-APDU** is generated and sent back to the **Network API**.
4. **R-APDU** is sent to the **Network API** and then
   - **(7) R-APDU** is sent to the **Secure Element**.
5. **Secure Element** processes **R-APDU** and
   - **(8) Relay Software** and **Network API** exchange R-APDU.
6. **(9) R-APDU** is sent back to the **Secure Element**.
7. **Secure Element** processes **R-APDU** and
   - **(10) NFC Emulator** and **Card Emulator API** exchange data.
8. **(11) R-APDU** is sent to the **Point-of-Sale Terminal**.
9. **Point-of-Sale Terminal** responds with **R-APDU**.
10. The cycle repeats.

**References:**

- **Applying Relay Attacks to Google Wallet, NFC 2013**
- **© Michael Roland**
- **www.mroland.at**
Google Wallet

- Container for
  - Payment cards
  - Gift cards
  - Reward cards
  - Special offers

- Android app
  - User interface

- Java Card applets on secure element
  - Secure data storage
  - Interface with POS terminals
Analysis of Google Wallet

- Focus on communication between
  - Android app and secure element
  - POS terminal and secure element

- Secure element contains
  - Google Wallet on-card component
    - Manages access to payment cards, ...
  - Google MIFARE access applet
    - Provides access to secure element’s MIFARE 4K memory
  - EMV-compliant proximity payment application
Google Wallet’s PIN

- Unlocks access to
  - User interface (Google Wallet app)
  - EMV payment cards

- Issues
  - PIN is verified by Google Wallet app
    - Known attack on PIN hash exists!
  - On-card component does not verify the PIN
    - Unlock command: \texttt{80 E2 00 AA 00}
    - PIN is not necessary to unlock Google Wallet → Send unlock command instead!
Google Prepaid Card

- EMV-compliant
- MasterCard PayPass
- EMV Mag-Stripe protocol
  - with dynamic CVC3
EMV Mag-Stripe Transaction

- **POS**: Select Proximity Payment System Environment (PPSE)
  - **SE**: Confirm and return list of available EMV payment applications

- **POS**: Select MasterCard Google prepaid card
  - **SE**: Confirm selection and return application details

- **POS**: Request processing options of the payment system
  - **SE**: Return processing options (Mag-Stripe mode only, online transactions only, no cardholder verification, etc.)

- **POS**: Request Mag-Stripe data file
  - **SE**: Return Mag-Stripe data of track 1 and track 2

- **POS**: Request computation of cryptographic checksum (CVC3) for a given random number
  - **SE**: Return transaction counter and dynamic CVC3 for track 1 and track 2
Relay Attack on Google Wallet

- Relay app
  - Android app
  - Unlock/lock Google Wallet on-card component
  - Forward APDUs to secure element

- Card emulator
  - Python application
  - ACR 122U
  - Notebook computer

- POS terminal
  - Hypercom Artema Hybrid
  - ViVOtech ViVOpay 5000

Relayed payment transaction successful
Limitations & Improvements

- Relay app needs access to secure element
  - Root privileges
  - Privilege escalation exploits

- Transaction limits
  - In Austria: € 25 for contactless transactions
  - Google Wallet: $ 100 possible according to user reports
  - Build “bot network” of wallets
    → Distribute payments to many wallets

- Slow relay communication (5 commands + 5 responses)
  - Only checksum computation contains dynamic data
    → 1 command + 1 response
Workarounds

- Timeouts of POS terminals
  - Now: 20 seconds with many POS terminals
  - Benchmark target of EMV specification: 500 ms
  - Problem: Cloud-based EMV applications use same principle as relay attack

- PIN verification
  - Now: PIN is only verified by Google Wallet app
  - PIN could be verified by on-card component
  - PIN could be verified at POS terminal

- Disable internal mode for payment applets
  - Modern secure elements can distinguish between external and internal mode communication
  - Rules can be setup on per-applet or per-APDU basis
  - Problem: Payment applets cannot be used for future on-device payment applications (e.g. payment in mobile phone’s web browser)
Google’s Response

- April 2012: Reported to Google
- June 2012: New installations no longer vulnerable
- September 2012: Existing users are forced to install update
- New version:
  - Blocks all access to payment applet from application processor (internal mode disabled)
  - PIN is still only verified by Wallet app
Demo available at
http://youtu.be/hx5nbkDy6tc
http://youtu.be/_R2JVPJzuDg

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