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OPay: an Orientation-based Contactless Payment Solution Against Passive Attacks

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Introduction

- Contactless payment is growing
- It is **vulnerable** to Passive Relay attacks
- Passive Relay attacks are increasing because:
  - Contactless limit
  - Mobile Point of Sale (mPoS) terminals

https://sumup.co.uk/

Introduction

- Passive Relay attack:
  - NFC Reader
  - Wireless Link
  - Remote Card Emulator
  - Remote Terminal
- mPoS-based Passive attack:
  - mPoS Terminal

https://sumup.co.uk/

https://www.zettle.com/

https://squareup.com/

Introduction-Thread Model

- **mPoS-based Passive Attacks**
- mPoS terminal holder: **malicious**
- Current **countermeasures**:
  - Beep sound: can be muted
  - Tracing bank account: not easy [1]

https://www.betabrand.com/

[1] : Ross Anderson. 2020. Security engineering: a guide to building dependable distributed systems. John Wiley & Sons

Introduction-Existing Solutions

Distance-bounding Protocols

- **Assumption:** card and terminal are far apart
- **Ineffective** solutions

Ambient-sensor-based

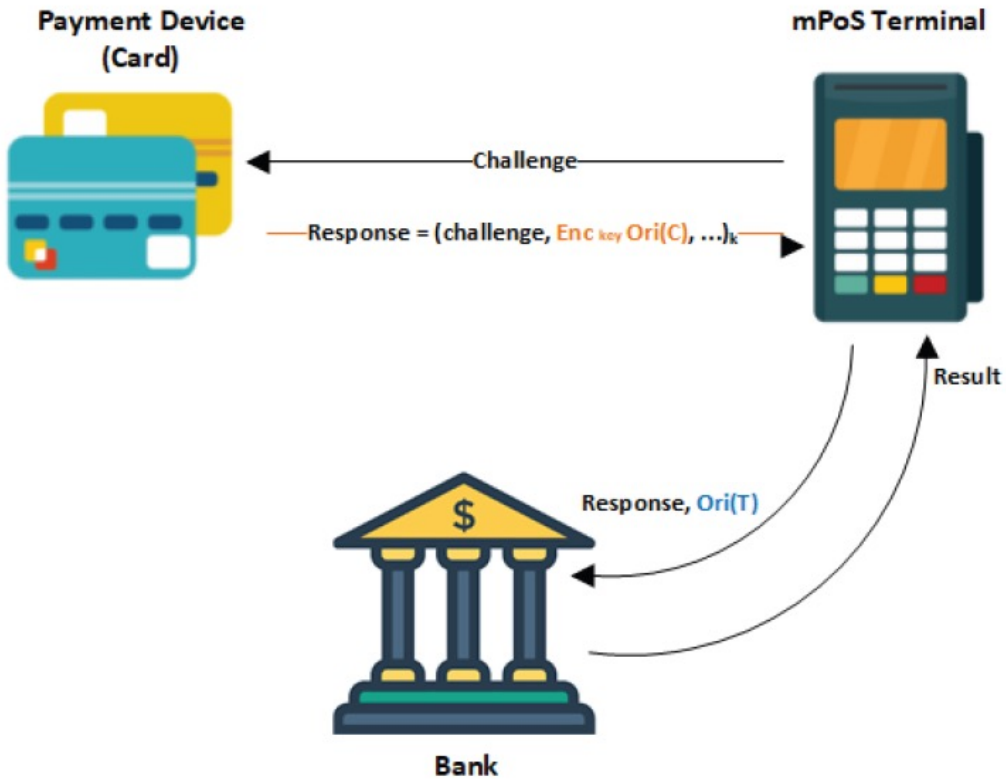
- Do **not change the usage model**
- **Can't prevent** attacks in the same environment

User Activation

- **Can prevent** attacks in the same environment
- **Change the usage model**

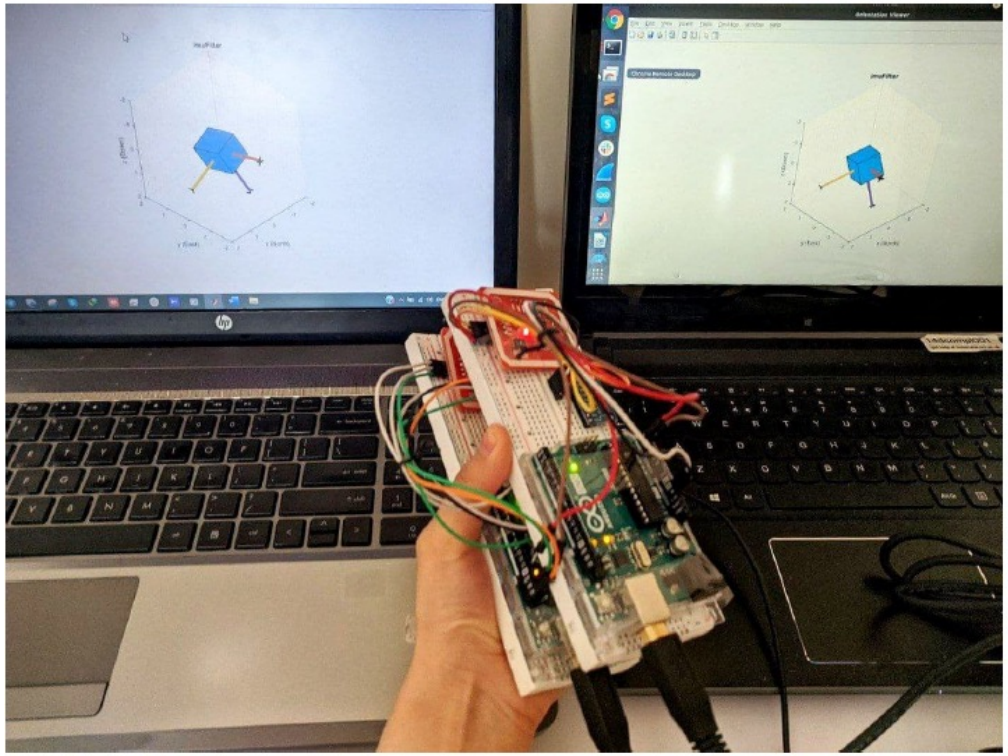
OPay-overview

- OPay: Orientation-based Payment Solution
- **Main Idea:** using orientation data of payment device and mPoS terminal to approve/deny a transaction based on the similarity comparison



OPay-overview

- Proof-of-concept **prototype** includes:
  - **Arduino Uno** Boards
  - **PN532**: NFC RFID Module
  - **MPU-9250** Module: Accelerometer and Gyroscope



OPay-Orientation Estimation

- **Orientation**: a **rotation** that takes a quantity in a parent reference frame to a child reference frame, represented in unit **Quaternions.**

- Distance between two unit-quaternions:
  - **Dot-product**
  - **Angle of rotation**

- **Correlation** between the dot-product and angle of rotation

Evaluation-Data Collection

Demographic	Participants(%)
Gender	
Male	12 (60%)
Female	8 (40%)
Age	
18-25	5 (25%)
26-35	9 (45%)
36-45	4 (20%)
46-55	2 (10%)
Occupation	
University Students	9 (45%)
University/Industry Employee	7 (35%)
Unemployed	4 (20%)

Participant demographics (N = 20)

a) OPay payment setup; b) random guessing attack; c) targeted guessing attack

Evaluation-Performance

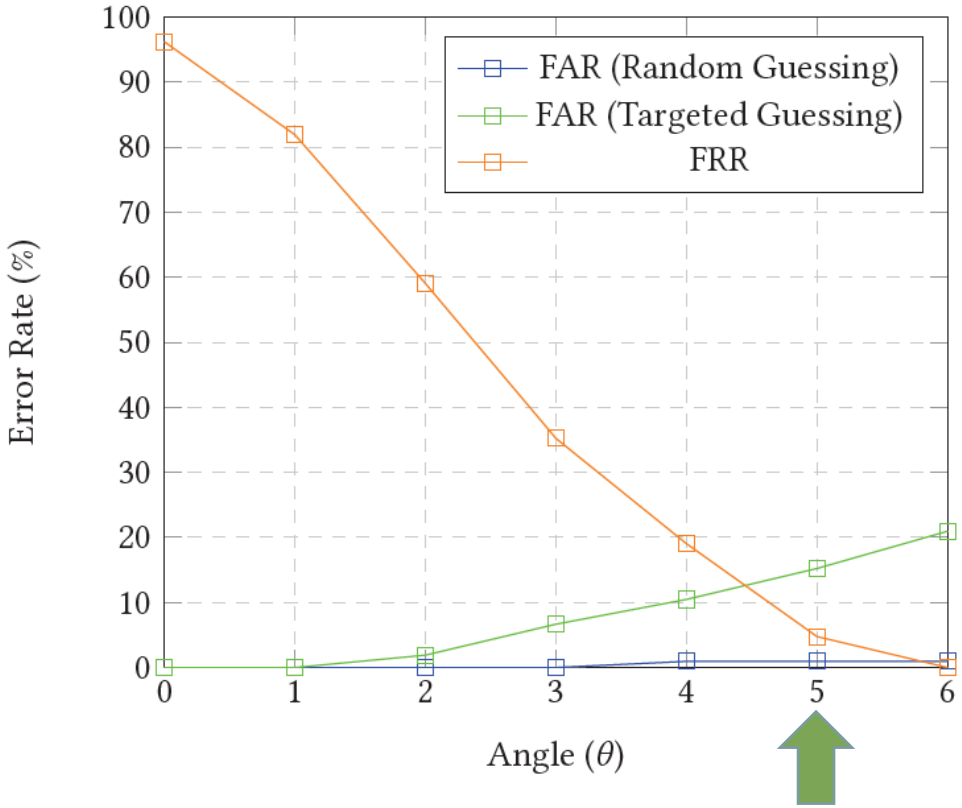
- Timing:

Code	Total Time (s)	% Time
Read Sensor Data	0.132	58.1%
Sensor Data Fusion	0.082	36.2%
Orientation Calculation	0.014	5.7%
Total	**0.228**	**100%**

Targeted Guessing Attack:
EER=12%
FAR=15.24%
FRR=4.76%

Random Guessing Attack:
EER=1%
FAR=0.96%
FRR=4.76%

- Error Rate:



Evaluation-Usability

- System Usability Scale (SUS) framework

Questions	Normal Score	OPay Score	Questions	Normal Score	OPay Score
1. I think I would like to use this system frequently	4.25	4.45	2. I found the system unnecessarily complex	1.5	1.8
3. I thought the system was easy to use	4.52	4.5	4. I think that I would need the support of a technical person to be able to use this system	1.55	1.9
5. I found the various functions in this system were well integrated	4	4.15	6. I thought there was too much inconsistency in the system	1.9	1.85
7. I would imagine that most people would learn to use this system very quickly	4.55	3.85	8. I found the system very cumbersome to use	1.55	2.05
9. I felt very confident using this system	3.95	4.35	10. I need to learn a lot of things before I could get going with this system	1.55	1.75

- Normal SUS Score: **83**
- OPay SUS Score:**78.62**

Evaluation-Comparison

Papers	Required Sensor(s)	Duration (s)	FRR (%)	FAR (%)	Preserves existing usage model	Prevents same env/location attacks
Czeskis et al. [5]	Accelerometer	1	0	0	No	Yes
Gurulian et al. [16]	Force Resistors	Seconds	0.1	0.1	No	Yes
Mehrnezhad et al. [23]	Accelerometer	0.6–1.5	9.99	9.99	No	Yes
Gurulian et al. [17]	Infrared sensor	0.5	0.5	0.5	Yes	No
Gurulian et al. [15]	AAE Sensors	0.5	1.72	18.06	Yes	No
Ma et al. [22]	GPS	10	67.5	67.5	Yes	No
Halevi et al [18]	Audio	1-2	0	0	Yes	No
	light	1-2	5	6.5	Yes	No
Shrestha et al. [25]	HA	Instant	7.93	9.85	Yes	No
	HGA	Instant	5.30	6.83	Yes	No
	THGA	Instant	2.96	5.81	Yes	No
OPay	Accelerometer, Gyroscope	0.228	4.76	0.96-15.24	Yes	Yes

Conclusion

- OPay is the **first** solution that:
  - Reduce the fraud success rate by **85-99%**
  - Supports fast transactions; **228ms** (under 500ms)
  - Does **not** change contactless payment usage model
- Future works:
  - Feasibility of OPay for other vulnerable payment devices

https://www.tovisorga.com/

Thank you!

Thank you for your attention. Feel free to ask questions.

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