

# Attacks on wireless localization

## The case of PKES

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Introduction

Key systems

Relay attacks

Proposed Solutions

Summary & Literature

# Terms

PKE system

**p**assive **k**eyless **e**ntry system

CID

**C**ustomer **I**dentification **D**evice

# Mechanical keys

- ▶ Mechanical key & lock systems
- ▶ Immobilisers

# Remote key Systems

- ▶ Button to open
- ▶ Operate at RF
- ▶ Physical key to ignite engine

# Passive keyless entry systems

- ▶ Car opens when CID is in range
- ▶ Engine can be ignited if the key is in the vehicle
- ▶ Physical backup key

# PKES in detail

1. Pulling handle transmits a LF-signal
2. CID wakes up and responds in RF
3. If response is correct, the vehicle opens
  - ▶ Same holds for ingiting the engine
  - ▶ Usually enhanced by RFID

# Introduction

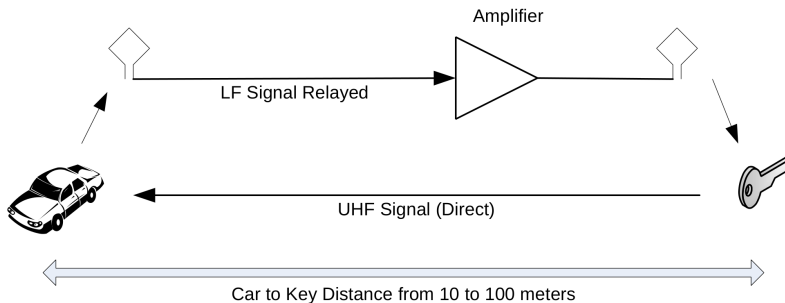
- ▶ Relocating signal emission & reception
- ▶ Underlying problem: proper localization in wireless networks
- ▶ Circumvents higher level authentication



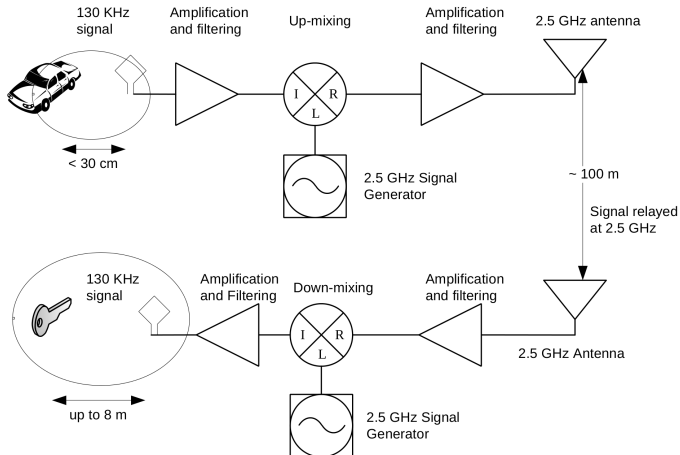
# Two thieves

- ▶ Thief 1 next to the vehicle
- ▶ Thief 2 near the CID
- ▶ Relay between both thieves

# Relay over the cable



# Relay over the wire



# This works in practice

- ▶ Simple & inexpensive
- ▶ Tested by Francillon, Danev, and Capkun [2011]
- ▶ All ten systems vulnerable

# Results of tests

Car model	Maximum Delay		Key Response (std dev)		Key Response Time Spread	
1	500	μs	1782	μs ( $\pm 8$ )	21	μs
2	5000	μs	11376	μs ( $\pm 15$ )	47	μs
4	500	μs	-	-	-	-
5	1000	μs	5002	μs ( $\pm 4$ )	11	μs
6	10000-20000	μs	23582	μs ( $\pm 196$ )	413	μs
7	620	μs	1777	μs ( $\pm 12$ )	25	μs
8	620	μs	437	μs ( $\pm 70$ )	162	μs
9	2000	μs	1148	μs ( $\pm 243$ )	436	μs
10	35	μs	2177	μs ( $\pm 8$ )	12	μs

**Table:** Experimentally tested maximum delay, key response time and spread per model, from Francillon et al. [2011]

# Results of tests

- ▶ Attack works on all systems
- ▶ For “convenient” attack, amplification is required
- ▶ Relay can be established over long distances

# Scenarios

- ▶ Supermarket
- ▶ Office

# Implications

- ▶ Steal the car



# Implications

- ▶ Steal the car
- ▶ Access to the vehicle
  - “Experimental Security Analysis of a Modern Automobile” by Koscher et al. [2010]

short term

- ▶ Fall back to mechanical keys

short term

- ▶ Fall back to mechanical keys

long term

- ▶ Highlight action on the CID

short term

- ▶ Fall back to mechanical keys

long term

- ▶ Highlight action on the CID

long term

- ▶ Multi channel [Stajano et al., 2010]
- ▶ Distance bounding protocols [Brands and Chaum, 1994]

# Multichannel communication

- ▶ Use two frequencies or types of media
- ▶ Makes relaying more difficult
- ▶ More difficult to implement

# Distance bounding protocols

- ▶ Be quick
- ▶ Be strict on timing
- ▶ Has vulnerabilities

# Distance bounding protocol

1. A generates a nonce
2. A sends nonce in reverse bitorder to B and starts timer
3. B will respond with the xored nonce in correct bit order
4. A stops timer upon receiving of the correctly xored nonce
5. A deduces distance from time-of-flight

# Summary

- ▶ PKE systems are vulnerable to relay attacks
- ▶ Attacks can be performed easily
- ▶ Solutions are at hand, but not free from vulnerabilities



# Literature

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# Questions?

# Thank you!

Thank you for your attention!