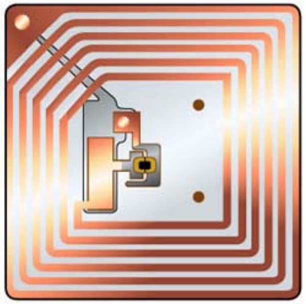
On the Security of RFID

Hung-Min Sun
Information Security Lab.
Department of Computer Science
National Tsing Hua University

What is RFID?

- Radio-Frequency Identification Tag



Reference

http://glossary.ippaper.com

Roles of RFID applications

Tags Reader Server(Database)

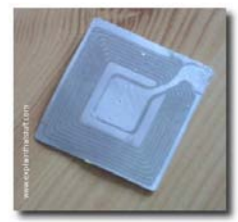
Barcode v.s. RFID

Barcode

1 30092 68125 9

- require a direct line of sight to the printed barcode
- have no read/write capability
- cheap

RFID



- can be read at much greater distances
- unique object id
- more expensive

Reference

www.cs.utexas.edu/~shmat/

Where Are RFID Used?

- Physical-access cards
- Inventory control
  - Gillette Mach3 razor blades, ear tags on cows, kid bracelets in waterparks, pet tracking
- Logistics and supply-chain management
  - Track a product from manufacturing through shipping to the retail shelf
- Gas station and highway toll payment
  - Mobile SpeedPass

Reference

www.cs.utexas.edu/~shmat/

Commercial Applications of RFID

- RFID cost is dropping dramatically, making it possible to tag even low-value objects
  - Around 5c per tag, $100 for a reader
- Logistics and supply-chain management is the killer application for RFID
  - Shipping, inventory tracking, shelf stocking, anti-counterfeiting, anti-shoplifting
- Massive deployment of RFID is in the works
  - Wal-Mart pushing suppliers to use RFID at pallet level, Gillette has ordered 500,000,000 RFID tags

Reference

www.cs.utexas.edu/~shmat/

Future Applications of RFID

- Location Awareness
- Health Care
- Apparel
- Smart Shelf

Reference

http://www.rfidjournal.com/

RFID Tag Power Sources

- Passive (this is what mostly used now)
  - Tags are inactive until the reader's interrogation signal "wakes" them up
  - Cheap, but short range only
- Semi-passive
  - On-board battery, but cannot initiate communication
    - Can serve as sensors, collect information from environment: for example, "smart dust" for military applications
  - More expensive, longer range
- Active
  - On-board battery, can initiate communication

Reference

www.cs.utexas.edu/~shmat/

RFID Frequency Ranges

- Low frequency (LF): (100~500KHz) 125 kHz, 135 kHz
  - Shortest read range < 50 cm, slowest read speed
  - Strong ability to read a tag on objects with liquid or metal components, Physical Access Control, Animal Identification
- High frequency (HF): (10~15 MHz), 13.56MHz
  - Read range < 1.5 meter, cheapest tag
  - Smart cards, smart shelves, health care
- Ultra-high frequency (UHF): (860 to 960) MHz
  - Read range 3~10m, faster read speed
  - EPC tags, supply chain systems
- Microwave: (> 1GHz), 2.45GHz, 5.8GHz
  - Read range 3~10m, fast read speed, most expensive
  - Supply chain systems, airline baggage tracking

Security Problems of RFID

- Eavesdropping
- Hot-listing
  - Attacker has special interests in certain items
- Replay attack
- Cloning
- Tracing
- Data forging
- Denial of Service

Fundamental problem:

Lack of mutual authentication

Challenges of RFID

- Low-cost tag costs US$0.05
- Limited computational ability and storage
  - Cannot implement common cryptographic functions on the tags
- Goal: Lightweight computation approaches for securing RFID
  - Lightweight mutual authentication protocols

However, RFID tag …

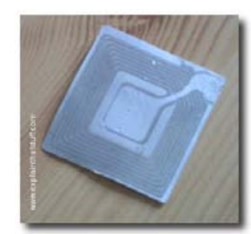
- No or very limited power
- Little memory
  - Static 64- or 128-bit identifier in current 5-cent tags
- Little computational power
  - A few thousand gates at most
  - Static keys for read/write access control
- Not enough resources to support public- or symmetric-key cryptography
  - Cannot support modular arithmetic (RSA, DSS), elliptic curves, DES, AES; hash functions are barely feasible
- Is resettable
  - Passive tag resets when power off

EPCglobal Class 1 Generation 2

- Most popular in long-range RFID applications
- Frequency: 860-960 MHz
- Reading range: 10-20 Feet
- ISO 18000-6C

Reader

RFID tag



Query →

← RN16 (16-bit random number)

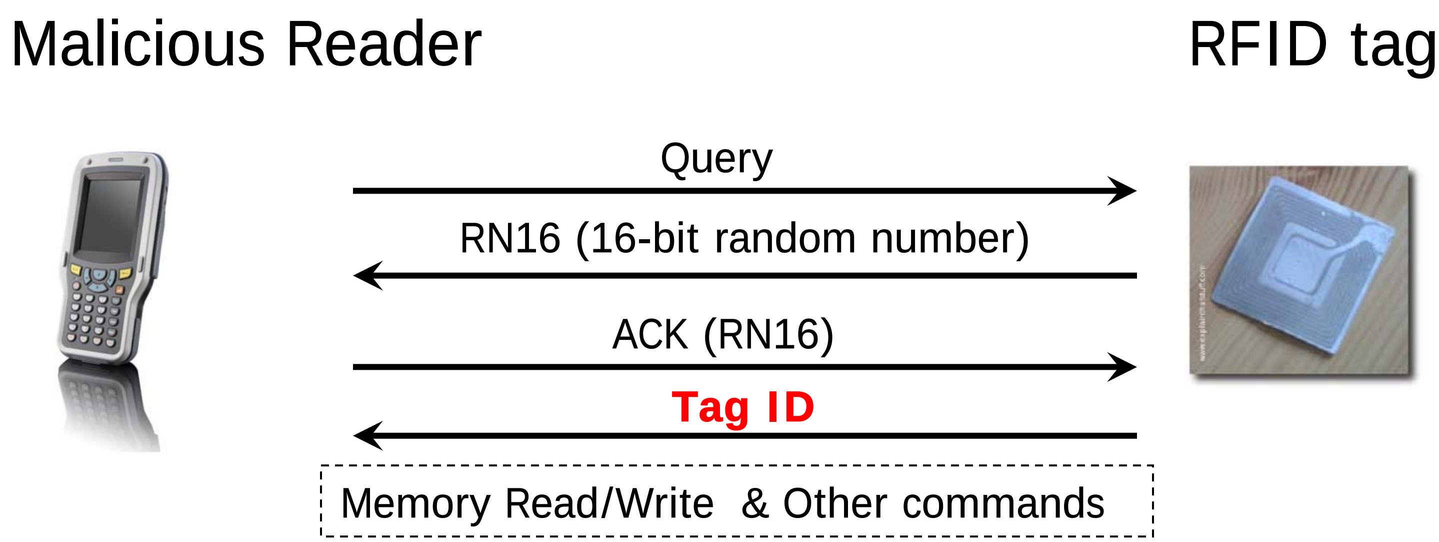
ACK (RN16) →

← Tag ID

Memory Read/Write & Other commands

Problems in EPCglobal C1G2

- Long reading range
- A naïve protection:
  - Use of 16-bit random number
- Tag ID is transmitted in plaintext
- Lack of "reader-to-tag" authentication



Secure Protocols for RFID

Secure RFID Protocols

Hash-based Approaches

- [1] S. Weis, “Security and Privacy in Radio-Frequency Identification Devices,” master’s thesis, Massachusetts Inst. of Technology (MIT), Massachusetts, USA, May 2003.
- [8] M. Ohkubo, K. Suzuki, and S. Kinoshita, “Cryptographic Approach to “Privacy-Friendly” Tags,” RFID Privacy Workshop, MIT, Massachusetts, USA, Nov. 2003.
- [9] T. Dimitriou, “A Lightweight RFID Protocol to protect against Traceability and Cloning Attacks,” Proc. 1st IEEE Conf. Security and Privacy for Emerging Areas in Comm. Networks (SecureComm ’05), Sep. 2005.
- [12] G. Tsudik, “YA-TRAP: Yet Another Trivial RFID Authentication Protocol,” Proc. 4th IEEE Int’l Conf. Pervasive Computing and Comm. (PerCom’06), Mar. 2006.
- [13] G. Avoine and P. Oechslin, “A Scalable and Provably Secure Hash Based RFID Protocol,” Proc. 3rd IEEE Int’l Workshop Pervasive Computing and Comm. Security (PERCOMW ’05), Mar. 2005.
- [14] D. Henrici and P. M¨ uller, “Hash-Based Enhancement of Location Privacy for Radio-Frequency Identification Devices Using Varying Identifiers,” Proc. First IEEE Int’l Workshop Pervasive Computing
- and Comm. Security (PerSec ’04), Mar. 2004.
- [36] Ohkubo, M., Suzuki, K., and Kinoshita, "RFID privacy issues and technical challenges," Commun. ACM 48, 9 (Sep. 2005).

Secure RFID Protocols

Lightweight Approaches

- [23] A. Juels, “Strengthening EPC Tags Against Cloning,” Manuscript, RSA Laboratories, Mar. 2005.
- [24] Y.C. Chen, W.L. Wang, and M.S. Hwang, “RFID Authentication Protocol for Anti-Counterfeiting and Privacy Protection,” Proc. 9th IEEE Int’l Conf. Advanced Comm. Technology (ICACT ’07), Feb. 2007.
- [25] A. Juels, “Minimalist Cryptography for Low-Cost RFID Tags,” Proc. 4th Int’l Conf. on Security in Comm. Networks (SCN ’04), Sep. 2004.
- [26] Y.Z. Li et al., “Security and Privacy on Authentication Protocol for Low-cost RFID,” Proc. Int’l Conf. Computational Intelligence and Security (CIS ’06), Nov. 2006.
- [27] P. Peris-Lopez et al., “M2AP: A Minimalist Mutual-Authentication Protocol for Low-Cost RFID Tags,” Proc. 3rd Int’l Conf. Ubiquitous Intelligence and Computing (UIC-06), Sep. 2006.
- [29] H.Y. Chien, “SASI: A New Ultralightweight RFID Authentication Protocol Providing Strong Authentication and Strong Integrity,” IEEE T. Dependable Secure Comput., vol. 4, no. 4, pp. 337–340, 2007.
- [32] D.N. Duc et al., “Enhancing Security of EPCglobal Gen2 RFID Tag against Traceability and Cloning,”
- Proc. 3rd Conf. Symp. Cryptography and Inf. Security (SCIS’06), Jan. 2006.
- [35] A. Juels and S. Weis, “Authenticating Pervasive Devices with Human Protocols.” Crypto, Aug. 2005.

Security Analysis of RFID Protocols

	Hash-based Protocols							Lightweight Protocols							
	[1]	[8]	[9]	[12]	[13]	[14]	[36]	[23]	[24]	[25]	[26]	[27]	[29]	[32]	[35]
Tracing	‡	—	‡	‡	—	‡	—	‡	‡	—	$O(l^2)$	‡	‡	‡	‡
Skimming	‡	—	—	—	—	—	—	‡	‡	—	‡	‡	$O(2^{2l})$	$O(2^{16})$	‡
Spoofing	‡	—	‡	—	—	—	—	$O(q_J)$	$O(2^l)$	$O(2^{2L})$	‡	‡	‡	‡	‡
Cloning	‡	—	—	—	—	—	—	$O(q_J)$	$O(2^l)$	$O(2^{3kLm})$	‡	‡	$O(2^{2l})$	$O(2^{32})$	‡

q_J	size of PINSET	—	not possible	‡	constant time
l	bit length of pseudonym	m	security parameter		
L	bit length of one-time pad	k	number of pseudonyms		

So…
How to design a secure protocol for low-end RFID Tag?

Hung-Min Sun and Wei-Chih Ting,

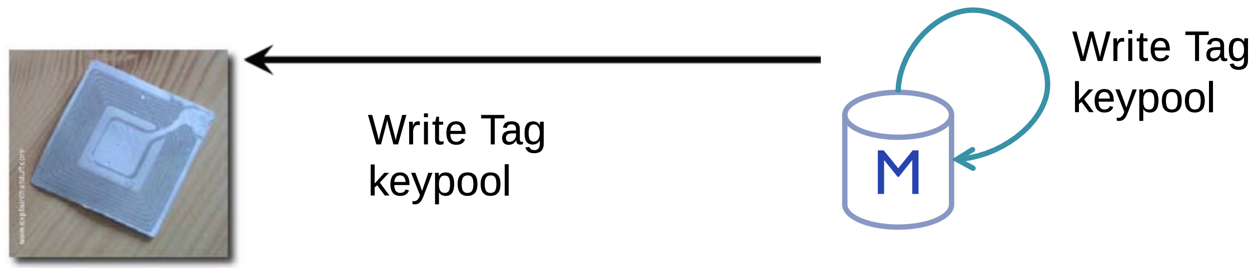
"A Gen2-based RFID Authentication Protocol

for Security and Privacy," *IEEE Transactions on Mobile Computing*, Vol. 8, No. 8, pp. 1052-1062,

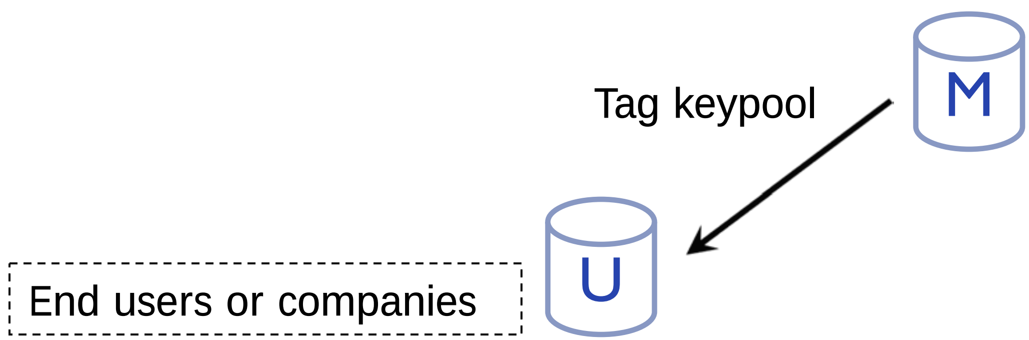
2009.

Gen2+

- Setup at manufacturer

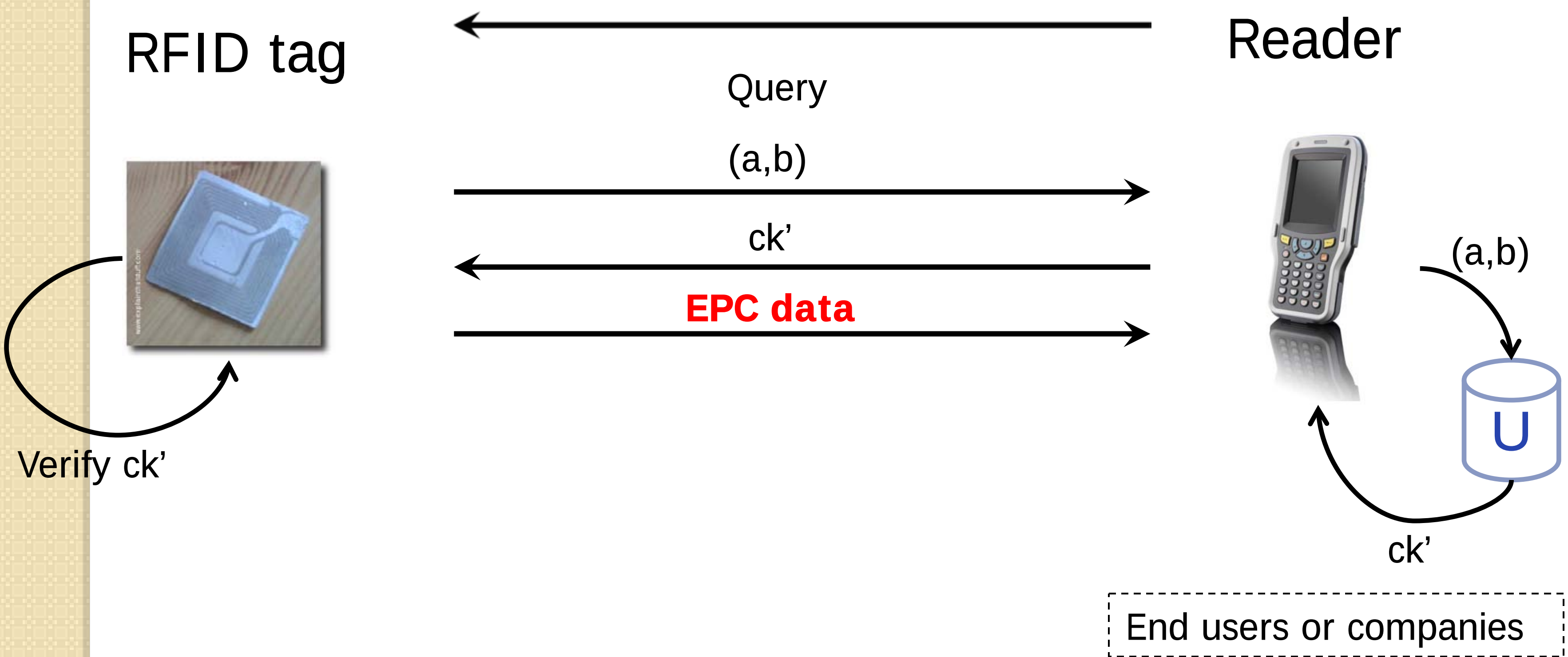


- After sold

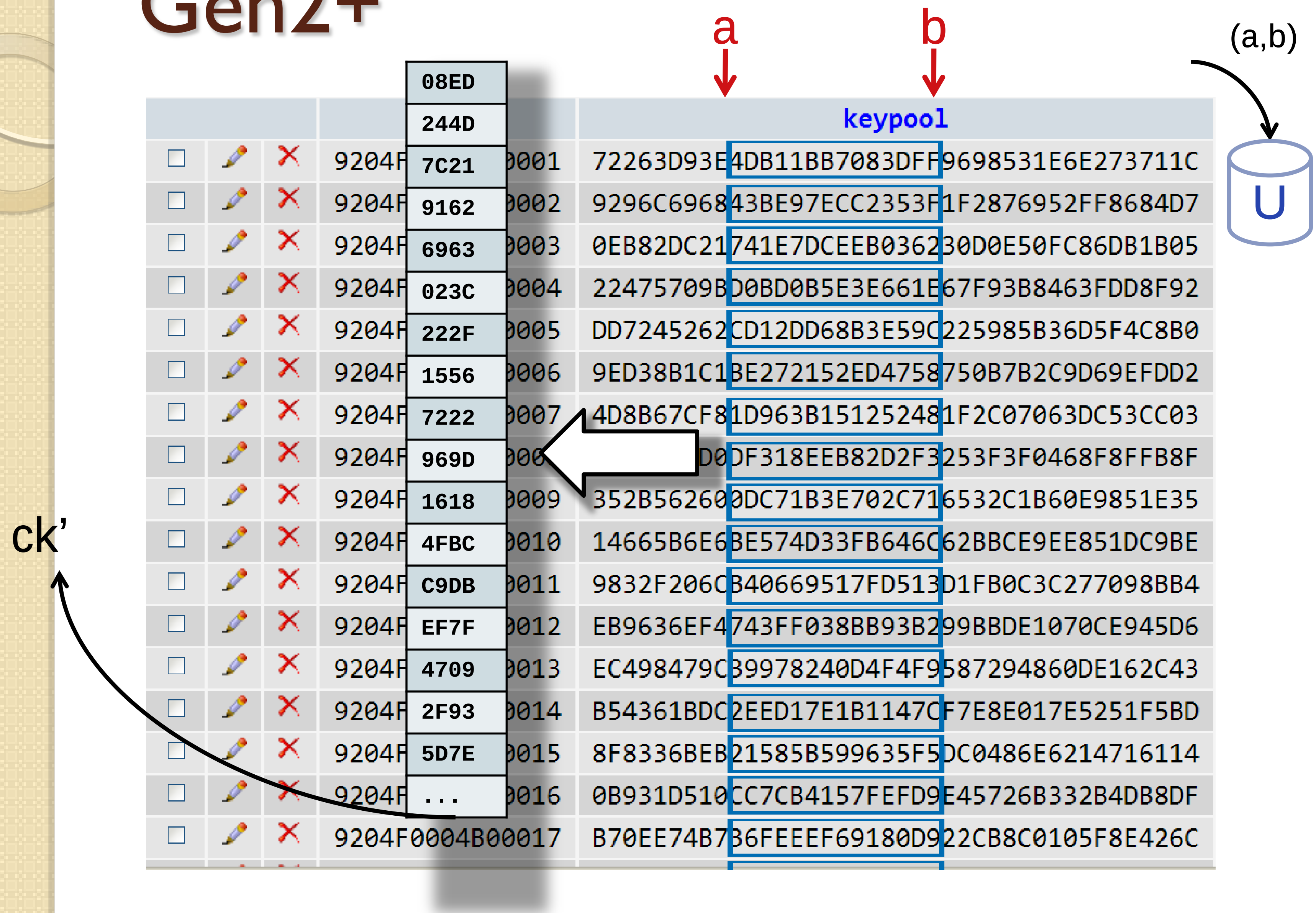


Gen2+

- In use


RFID tag
Reader
Query
(a,b)
ck'
EPC data
Verify ck'
(a,b)
U
ck'
End users or companies

Gen2+


a
b
(a,b)
U
ck'
keypool
08ED
244D
7C21
9162
6963
023C
222F
1556
7222
969D
1618
4FBC
C9DB
EF7F
4709
2F93
5D7E
...
9204F0004B00017
72263D93E4DB11BB7083DFF9698531E6E273711C
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0B931D510CC7CB4157FEFD9E45726B332B4DB8DF
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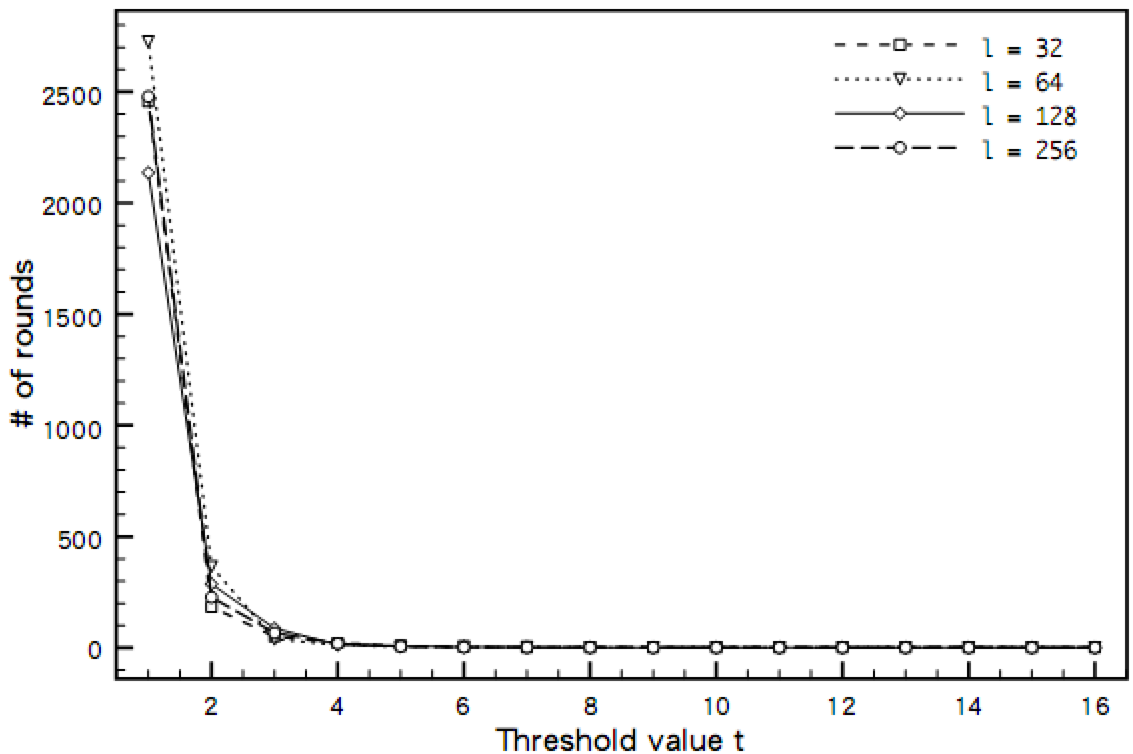
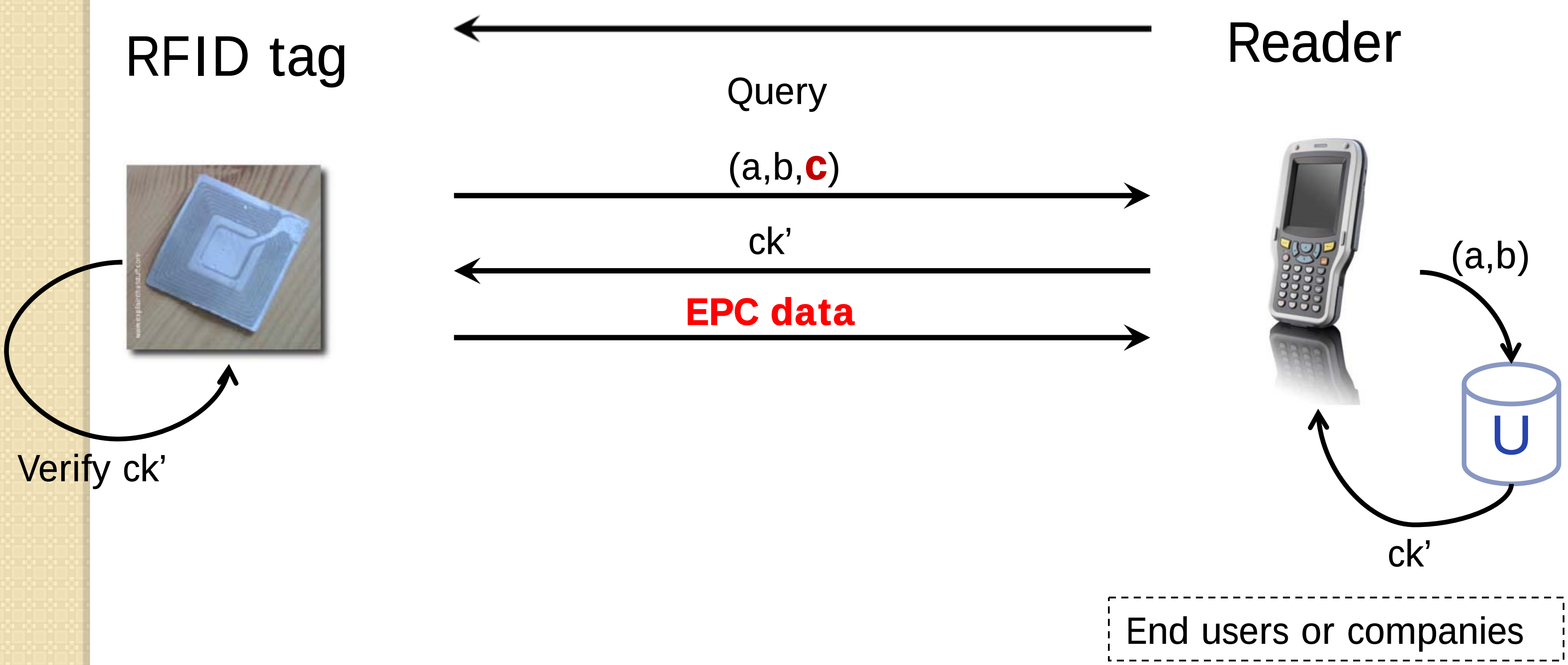
Gen2+

- Results before enhancement



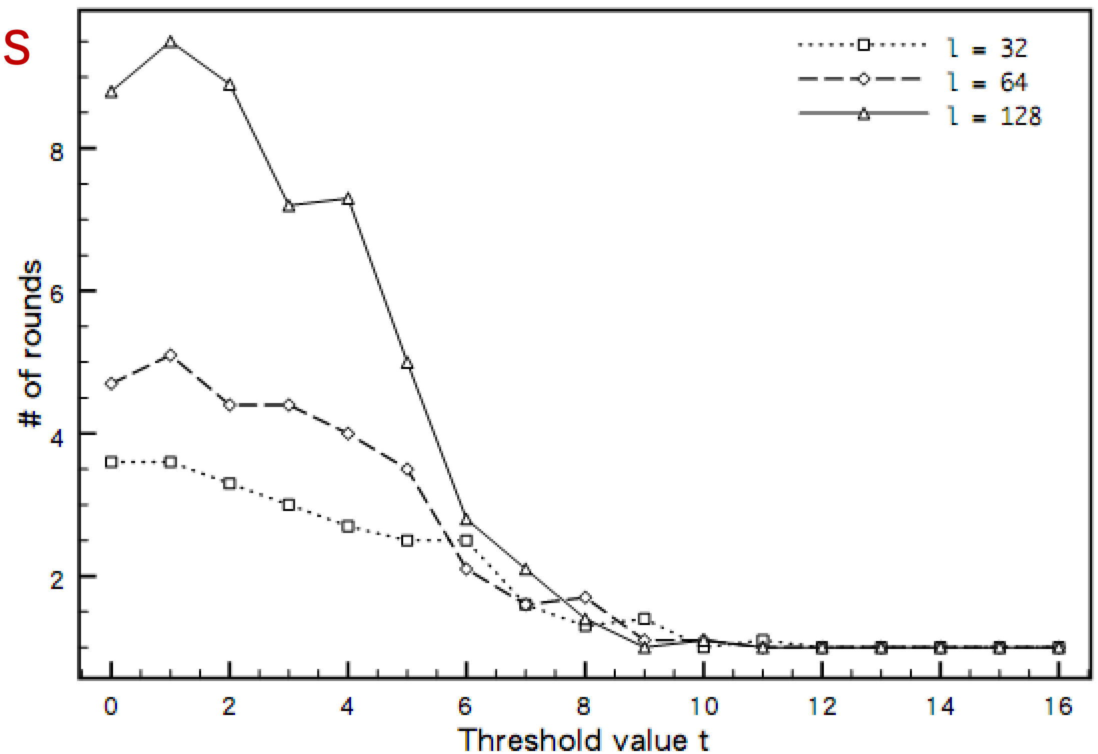
Gen2+

- In use


RFID tag
Reader
Query
(a,b,**c**)
ck'
EPC data
Verify ck'
(a,b)
U
ck'
End users or companies

- Results **after** enhancement

< 10 rounds



Thank You
Q & A