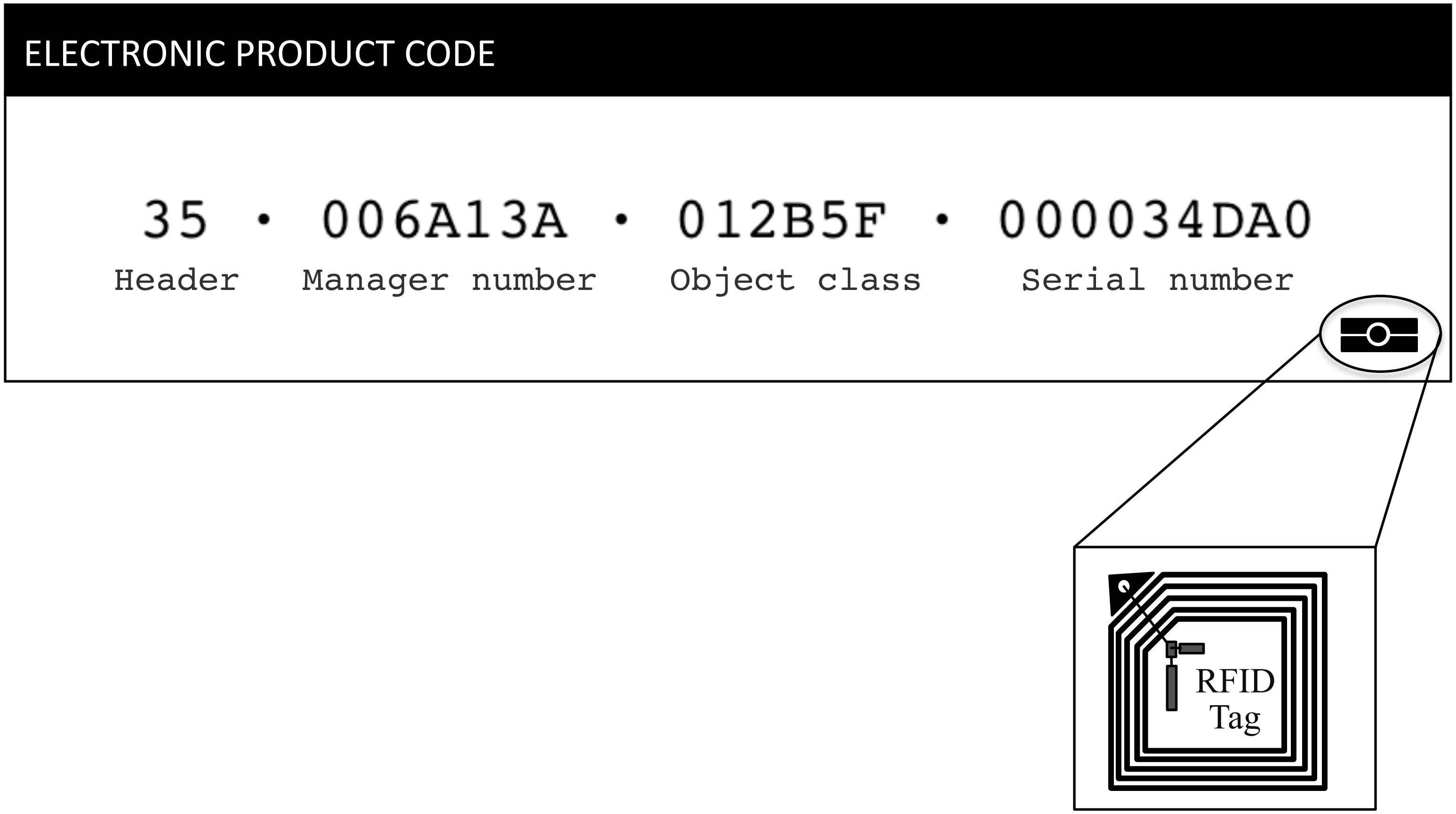
RFID Tags

- Radio frequency devices that transmit information (e.g., serial numbers) to compliant readers in a contactless manner

- Classified in the literature as:
  - Passive: transmission power is derived from reader
  - Active: energy comes from on-board battery
  - Semi-passive: battery powered chips, but transmission powered by reader

- Electronic Product Code (EPC) tags
  - Main kind of low-cost tags in use on today's RFID supply chain applications
  - Passive UHF RFID tags
  - EPCglobal inc: Main organization controlling EPC development

Sample representation of an EPC number

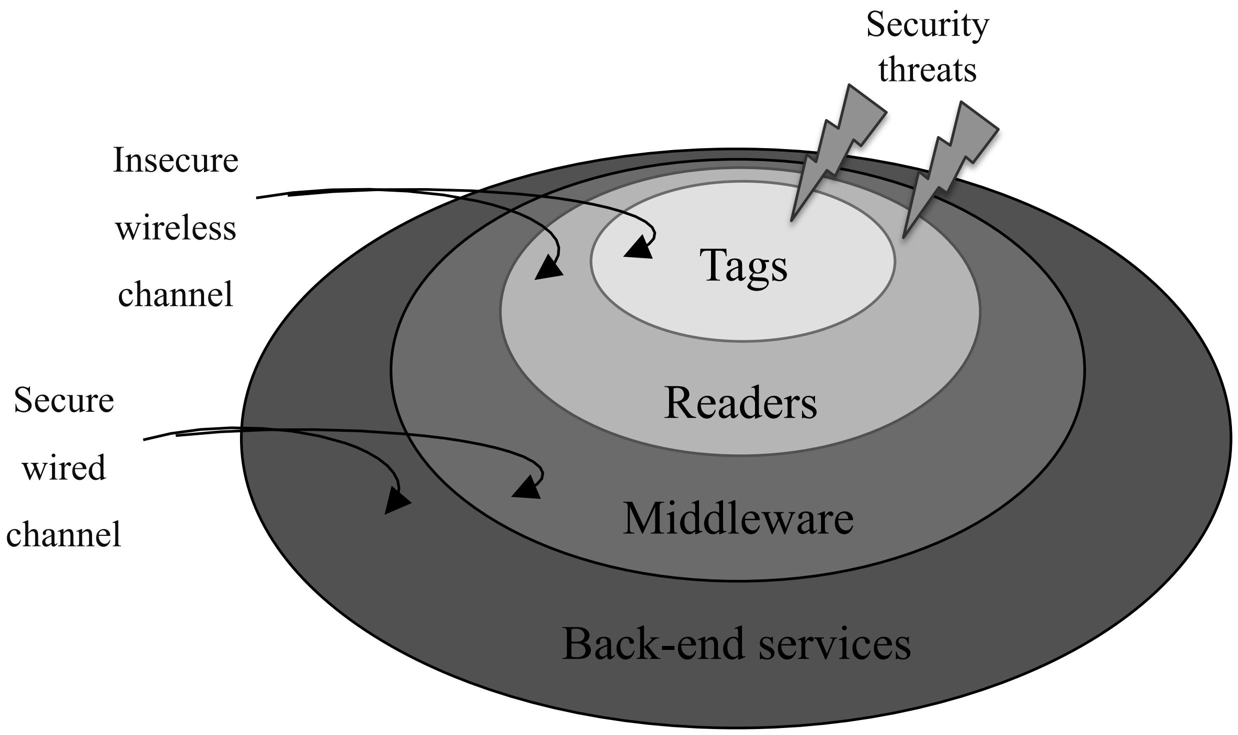


ELECTRONIC PRODUCT CODE

35	006A13A	012B5F	000034DA0
Header	Manager number	Object class	Serial number

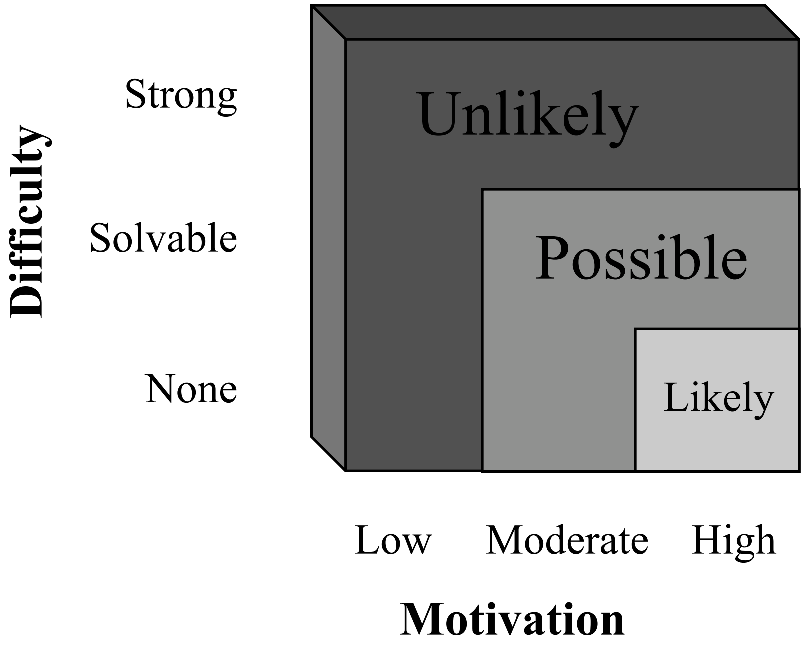
Security Problems

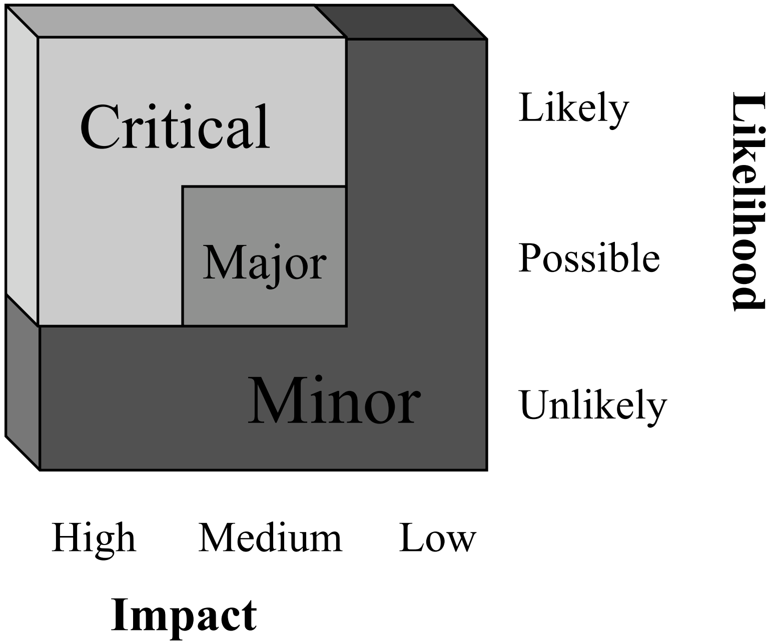
- Threats to and from front-end components (i.e., tags and readers)
- Privacy concerns during the receiving of information
  - Lack of authentication between readers & tags
  - Necessity of a fine grained access control for the interaction of principals



Threat Analysis Methodology

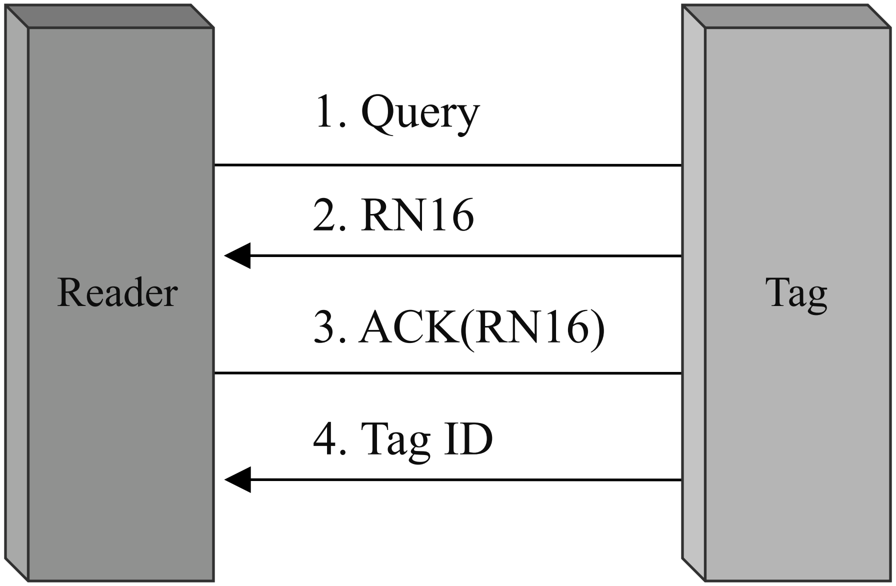
- Based on a methodology proposed by the European Telecommunications Standards Institute (ETSI)
  - Risk Factors: Likelihood of threat occurrence & Impact on user or system
  - Likelihood Assessment Factors: Motivation of attacker & Technical difficulty
  - Overall Risk Assessment: Critical, Major, Minor





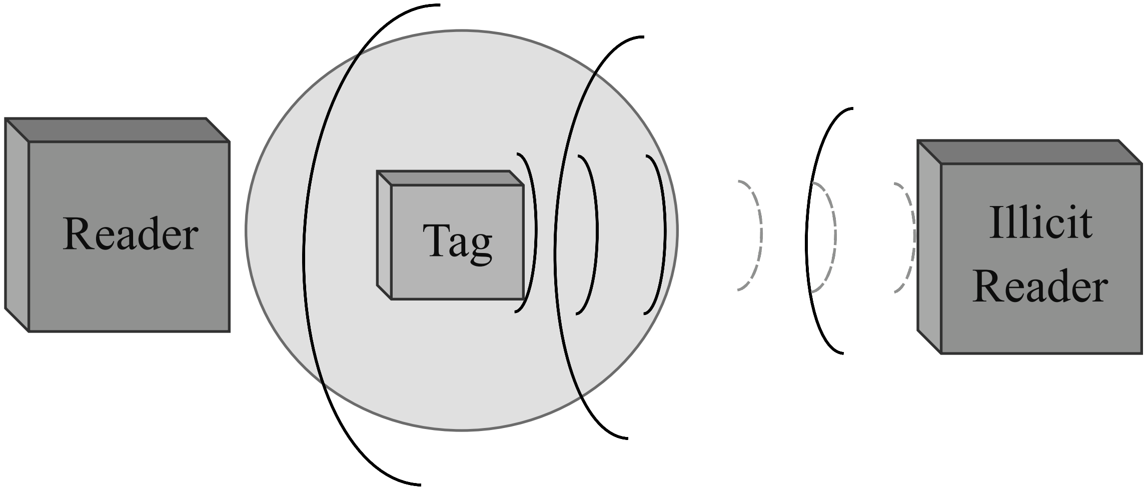
EPC Inventory Protocol

- Lack of authentication between readers & tags
  - 16-bit random sequences (denoted as RN16) to acknowledge the process
- Any compatible reader can obtain the code
  - Illicit readers can impersonate legal readers



Rogue Scanning

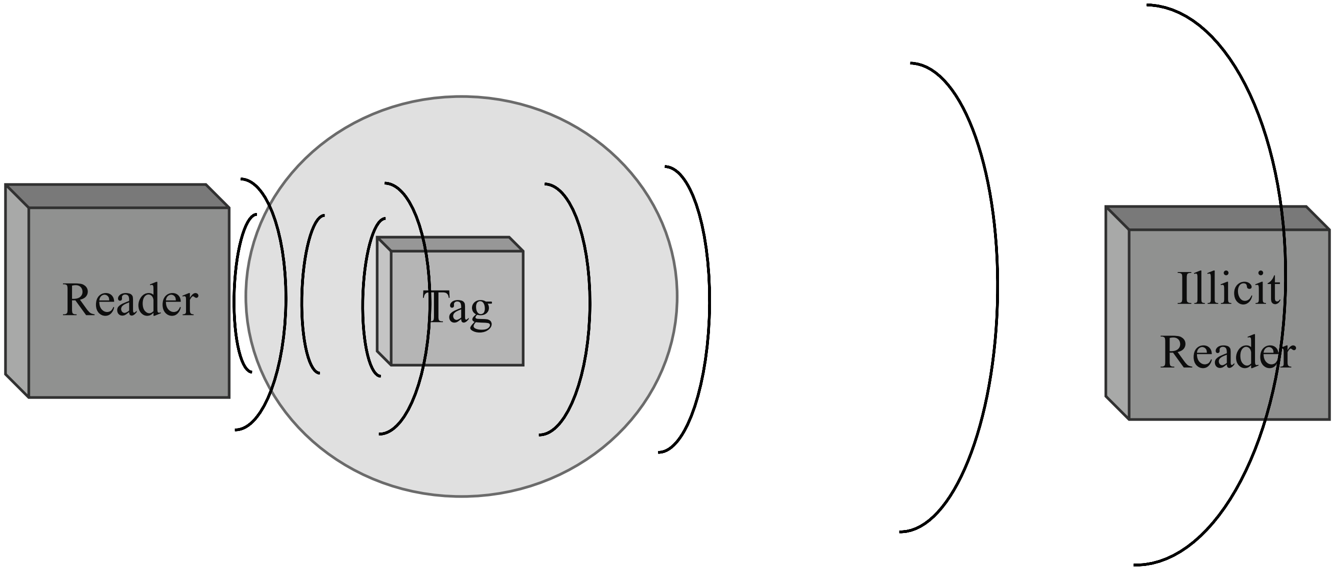
- Powering the tag to obtain tag ID
  - The use of special hardware (e.g., highly sensitive receivers and high gain antennas) can ease the attack.



Motivation	Difficulty	Likelihood	Impact	Risk
High	*Solvable*	*Possible*	*High*	*Critical*

Eavesdropping Reader Channel

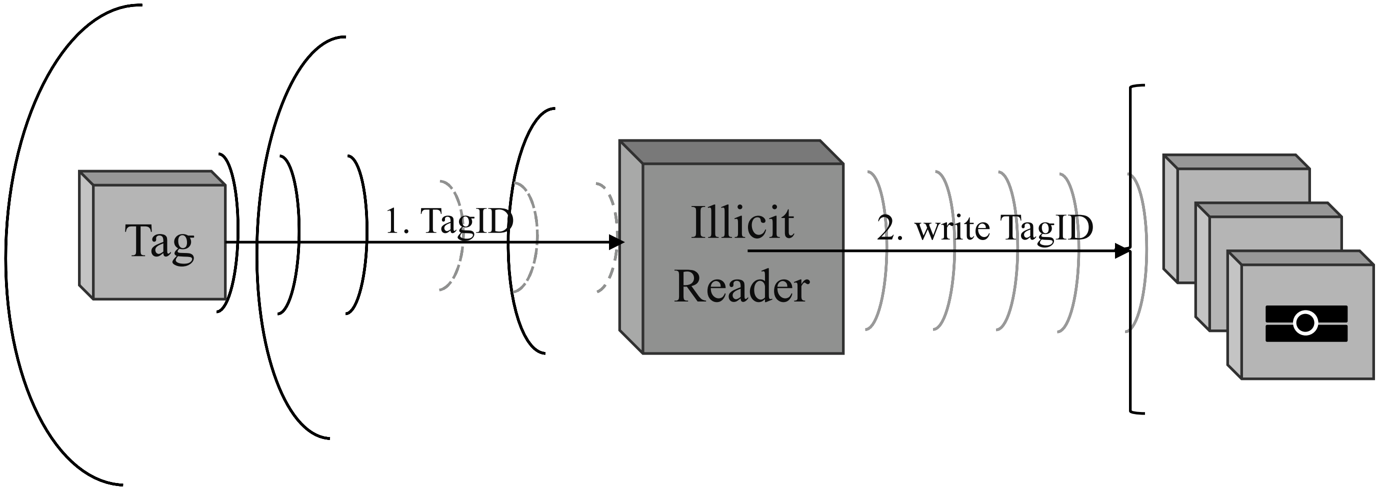
- Passive observation or recording of the communication
  - The distance at which an attacker can eavesdrop the signal of an EPC reader can be much longer than the operating environment of the tag.
  - Some data items (e.g., 16-bit random sequences) can be eavesdropped at long distances.



Motivation	Difficulty	Likelihood	Impact	Risk
High	*Solvable*	*Possible*	*High*	*Critical*

Cloning of Tags

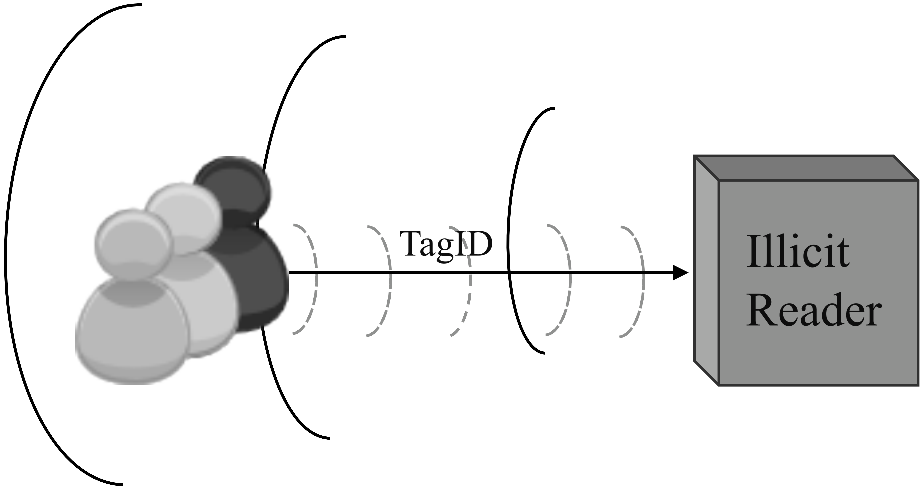
- Using the codes eavesdropped or scanned, an attacker may successfully clone the tags



Motivation	Difficulty	Likelihood	Impact	Risk
Moderate	*Solvable*	*Possible*	*Medium*	*Major*

Location Tracking

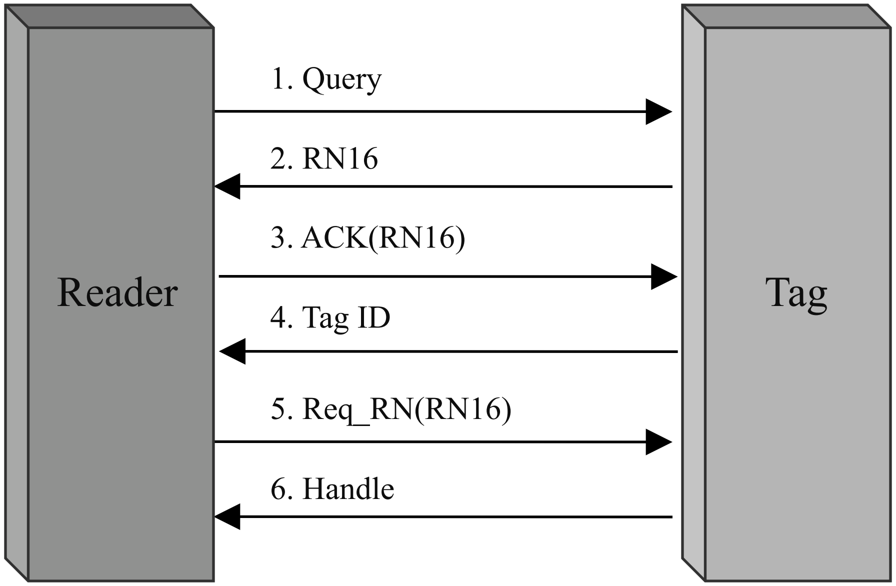
- Adversaries can distinguish any given tag by just getting the EPC
- Correlating reader's position, adversary can trace location of bearers
- It can also provide useful data for fingerprinting and profiling



Motivation	Difficulty	Likelihood	Impact	Risk
Moderate	*Solvable*	*Possible*	*Medium*	*Major*

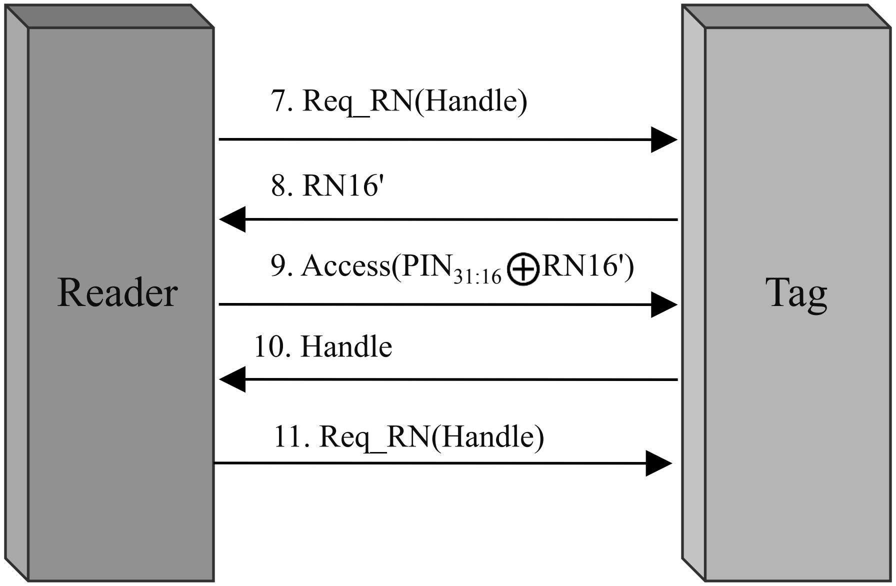
Tampering of Data (1/3)

- Gen2 tags are required to be writable
- Although this feature can be protected with a 32-bit password, bypassing the protection is solvable



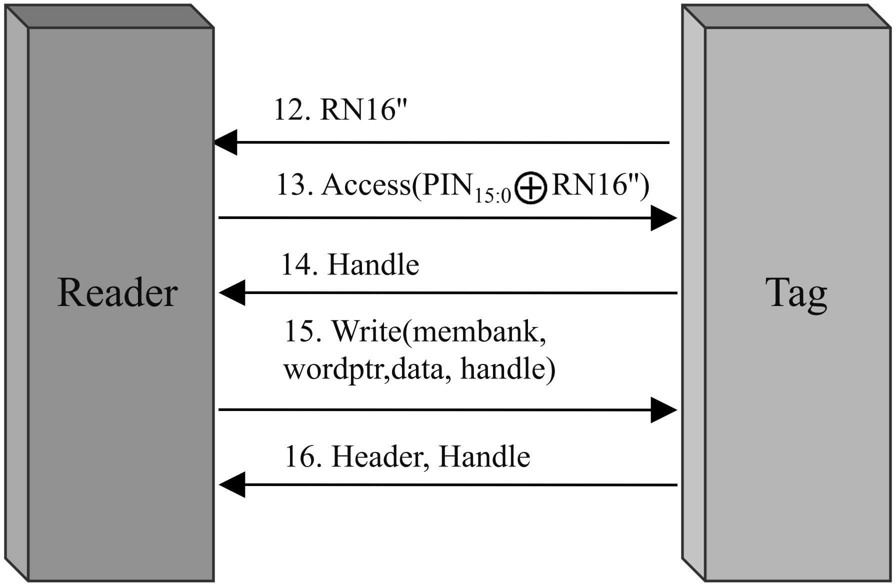
Tampering of Data (2/3)

- Gen2 tags are required to be writable
- Although this feature can be protected with a 32-bit password, bypassing the protection is solvable



Tampering of Data (3/3)

- Gen2 tags are required to be writable
- Although this feature can be protected with a 32-bit password, bypassing the protection is solvable

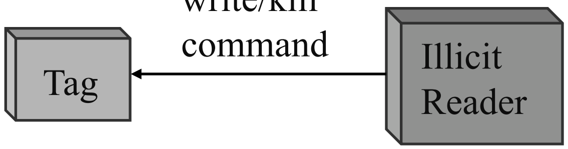

Reader
Tag
12. RN16"
13. Access(PIN$_{15:0}$ ⊕ RN16")
14. Handle
15. Write(membank, wordptr,data, handle)
16. Header, Handle

Motivation	Difficulty	Likelihood	Impact	Risk
Moderate	*Solvable*	*Possible*	*High*	*Critical*

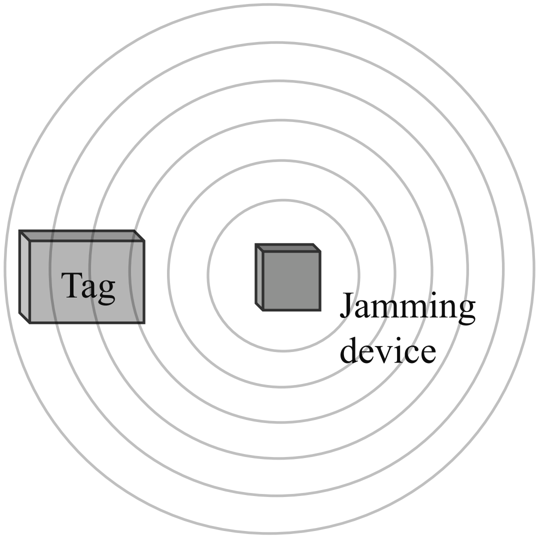
Denial of Service

- Tag data destruction or interference by attacks such as (1) attacks targeting writing or self-destruction routines and (2) use of jamming or strong electromagnetic pulses.

(1)



(2)



Motivation	Difficulty	Likelihood	Impact	Risk
Moderate	*Solvable*	*Possible*	*Medium*	*Major*

Evaluation of Threats (Summary)

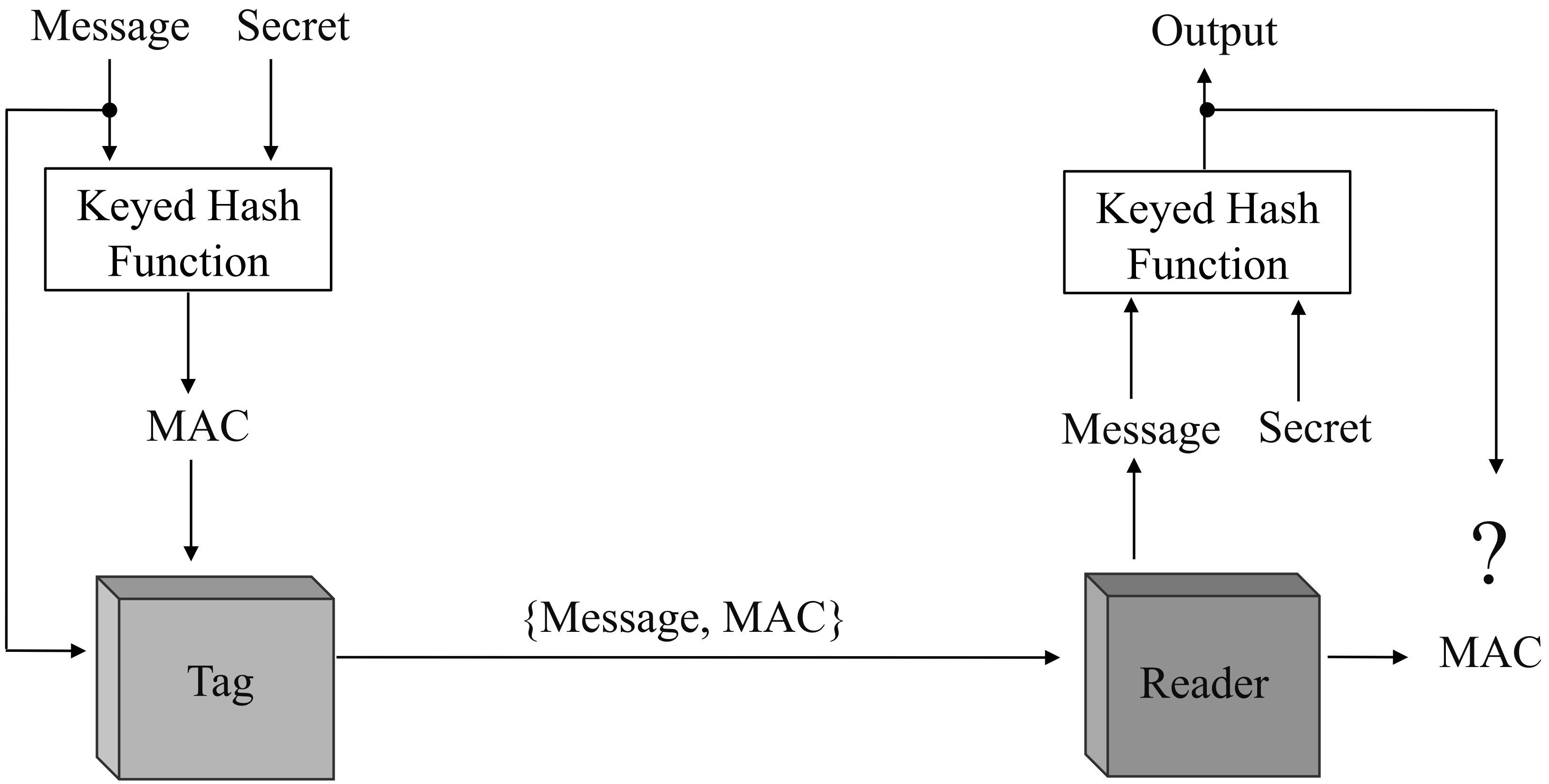
Threats	Motivation	Difficulty	Likelihood	Impact	Risk
Eavesdropping, Rogue Scanning	*High*	*Solvable*	*Possible*	*High*	*Critical*
Cloning of Tags, Location Tracking	*Moderate*	*Solvable*	*Possible*	*Medium*	*Major*
Tampering of Data	*Moderate*	*Solvable*	*Possible*	*High*	*Critical*
Destruction of Data, Denial of Service	*Moderate*	*Solvable*	*Possible*	*Medium*	*Major*

How to deal with these threats ?

- Shielding or jamming the signal
  - It may work on some other RFID applications, but not on EPC setups
- Third party blockers or guardians
  - Requires the management of new components
- Use of lightweight countermeasures, such as:
  - Message Authentication Codes
  - Lock-based Access Control Schemes
  - Random Pseudonyms
  - Threshold Cryptography
  - Physically Unclonable Functions

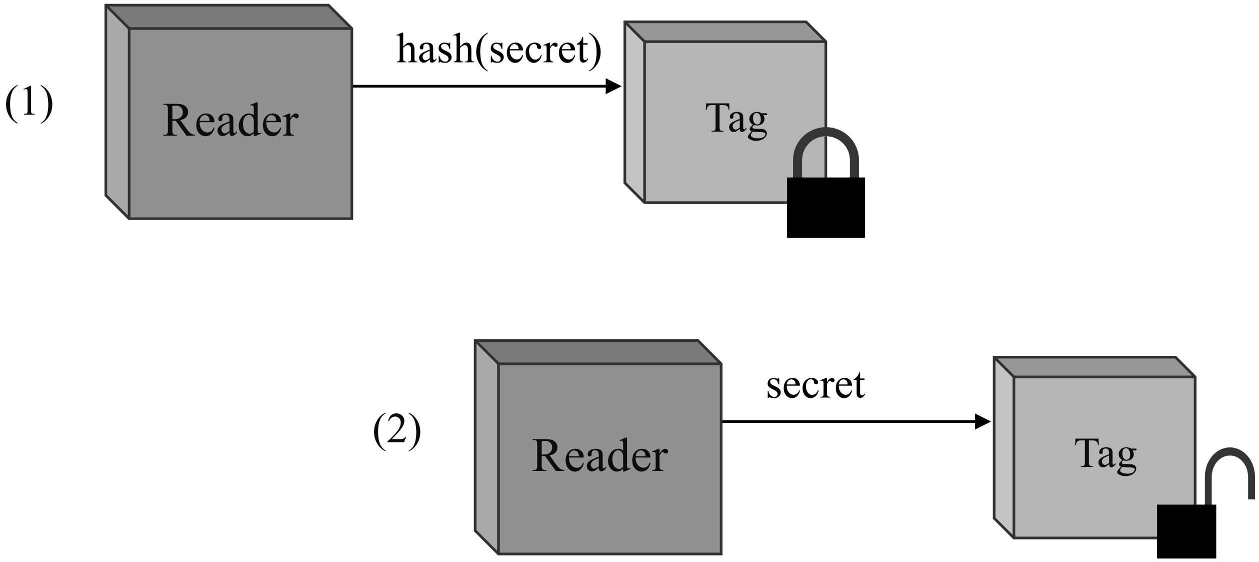
Message Authentication Codes

- Tags & readers share a secret that allows the verification of the integrity and authenticity of exchanged messages



Lock-based Access Control Schemes

- Simplified Scheme:
  - Readers and tags share a common secret
  - When a tag receives a proof ownership of the secret (e.g., a hash of it), it locks itself → when interrogated, it only answers with this pseudo ID
  - Tag unlocks itself when it receives the secret

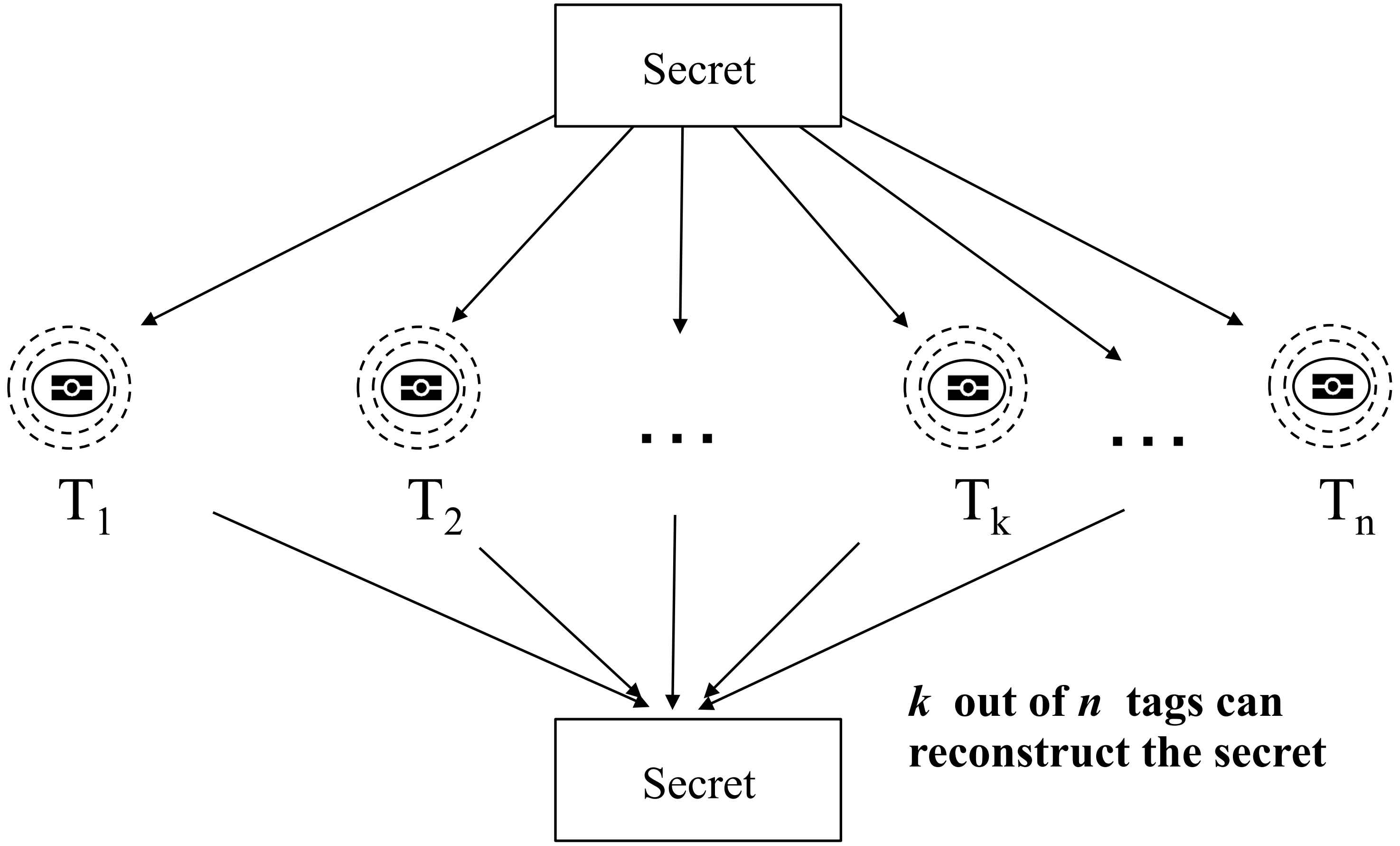


Random Pseudonyms

- Tags storing a pseudonym, or a list of pseudonyms, instead of the real object or tag identifier (i.e., EPC number)
- To handle the location tracking threat, pseudonyms must be generated at random and they must change frequently
- Authorized readers must know how to match the pseudonyms to the real tag identifiers

Threshold Cryptography

- Exploit the natural movement of tag populations on the supply chain to distribute secrets and enforce privacy

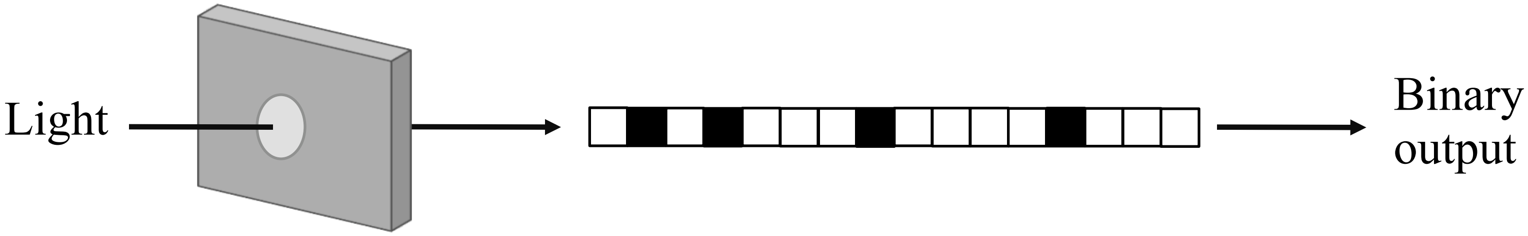


***k* out of *n* tags can reconstruct the secret**

Physically Unclonable Functions (1/2)

- Originated from optical mechanisms for generating unique secrets in the form of physical variations

- E.g.:



Physically Unclonable Functions (2/2)

- Promising for the implementation of challenge-response protocols in low-cost EPC tags.

- Optical designs have been improved towards new schemes exploiting other physical random variations
  - Delays of wires and logic gates of integrated circuits
  - SRAM startup values as origin of randomness

- Can be used to handle the authentication threat, as well as the cloning and location tracking threats