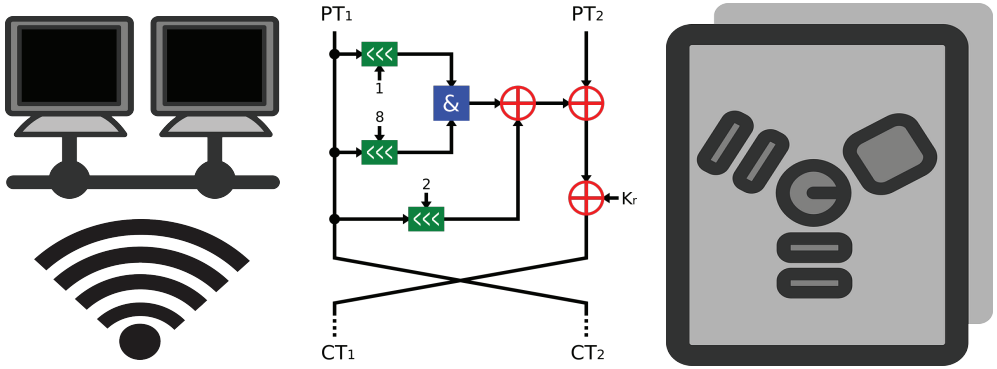
CSE 40567 / 60567: Computer Security



Security Basics 4 / Cryptography 1

My office hours will be held in
182D Fitzpatrick going forward

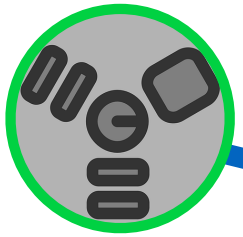
Homework #1 has been released. It is due Tuesday, Jan. 28th at 11:59PM

See **Assignments Page** on the course website for details

Course Roadmap

Basics

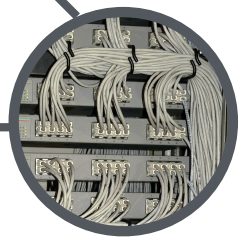
(weeks 1 & 2)



3 Core Areas

(weeks 3 - 6)

(weeks 6 - 10)



(weeks 11 - 15)

The Web

(weeks 15 & 16)

The history of computing and cryptography are intimately intertwined

- Turing served as a cryptanalyst at Bletchley Park during WWII
  - Designed the electromechanical "Bombe" to decipher Enigma codes
- Colossus Mark 1
  - First programmable, electronic, digital computer
  - Designed to break the Lorenz cipher

Contemporary Cryptography

- Support security protocols that must operate in the presence of motivated attackers
    - Hackers
    - Criminals
    - Corporations
    - Governments
- Ensure that algorithms are themselves resistant to direct attack by cryptanalysis leveraging vast computational resources
- Design algorithms that run in realtime (even on embedded hardware)

What is the focus of this unit?

- The development of protocols that serve as the building blocks for system, network, web and mobile security
- Practical implementations and best practices for algorithms considered to be secure today
  - We'll leave the proofs for CSE 40622/60622
- Real-world attacks, and how they can be mitigated

Introduction to Protocols

Eavesdropping revisited

Larger keyspaces supporting longer passwords and pin numbers are good, right?

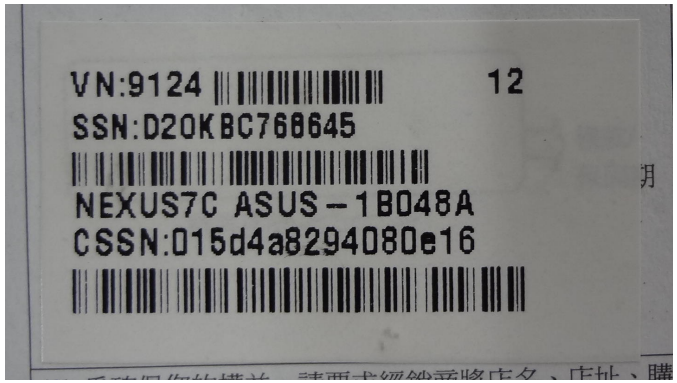
128 bit key → `4rch4304str0n0my`

256 bit key → `m4ryh4d4l1ttl3l4mbl1ttl3l4mbwh0z`

Doesn't affect the "shoulder surfing" attack

Eavesdropping revisited

Master passwords based on a serial number provide a convenient fallback

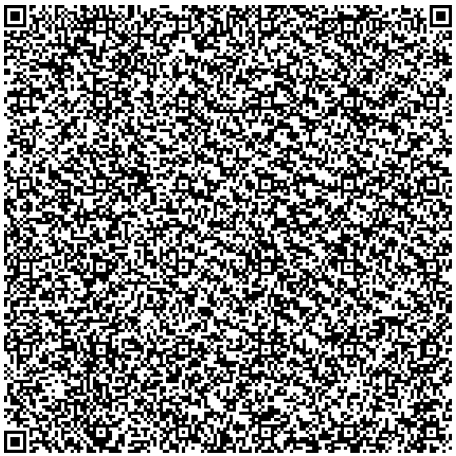


Nexus7C BY-SA 3.0 Solomon203

Serial numbers are rarely protected. (Mechanics, service technicians, janitors, etc. have access to them)

Eavesdropping revisited

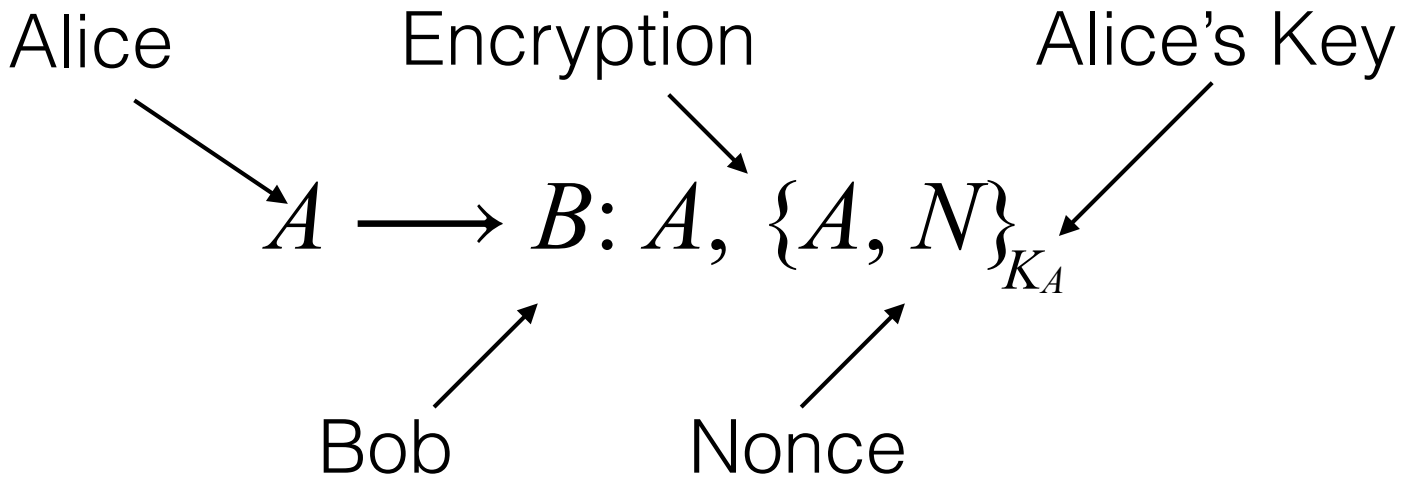
What about a physical token?



Potential for replication if an attacker can gain access to it

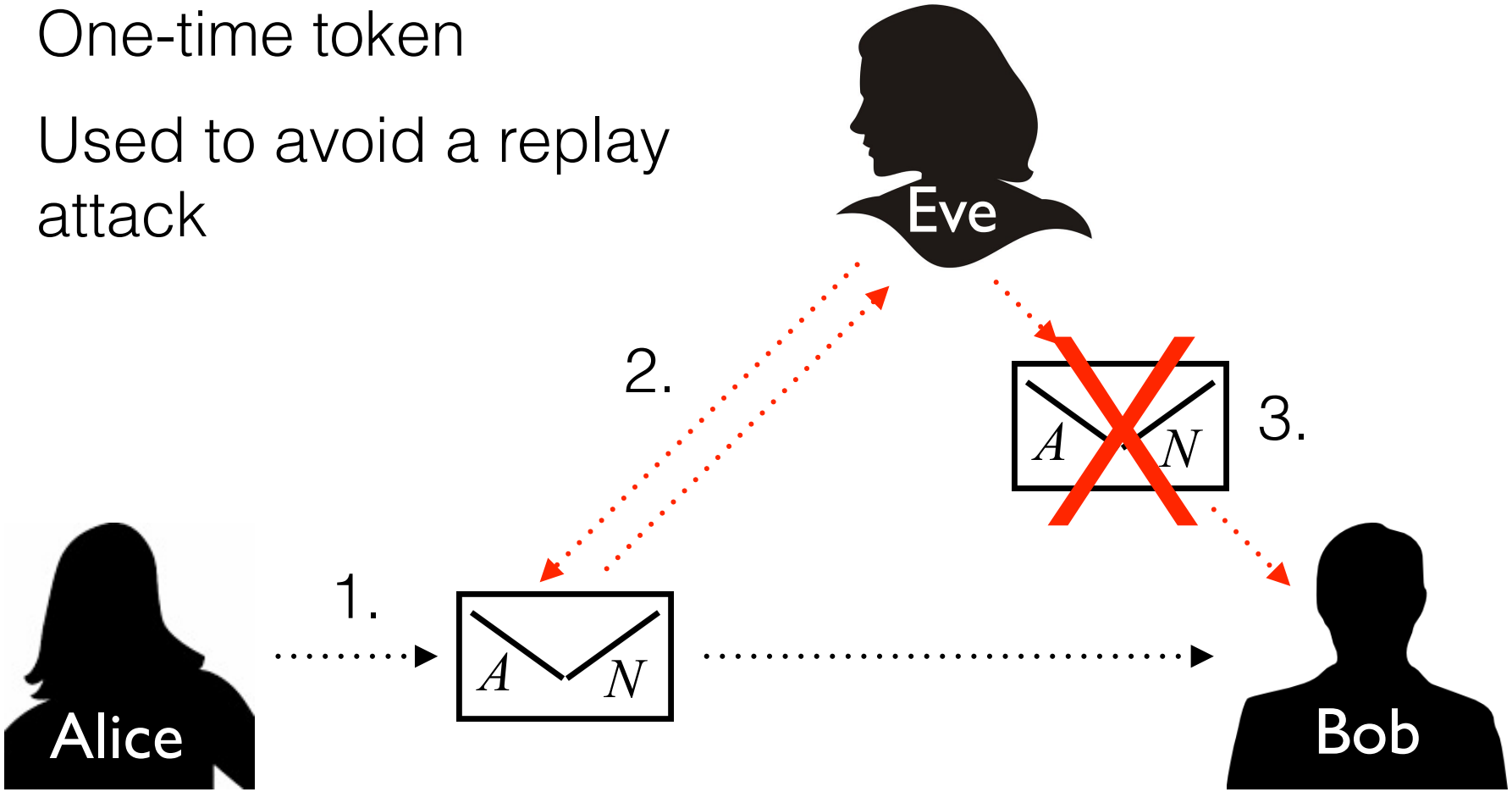
Simple Authentication

Scenario: Alice wants to gain access to her workstation, but needs to authenticate via Bob



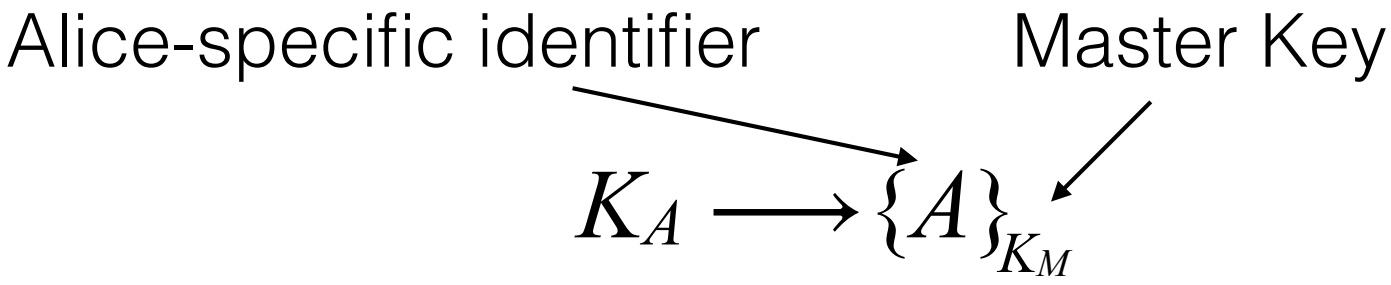
Nonce (N)

- One-time token
- Used to avoid a replay attack



Key diversification

Where does Alice's key come from? One possibility:



Pros:

+ Simple key management

Cons:

- Length of identifier may limit usable keyspace
- Master key needs to be shared

Challenge-Response Protocols

- Problem with one-way authentication schemes: no guarantee messages make it to the intended recipient
- This can be solved with a two-way protocol
  1. Alice initiates an authentication session
  2. Bob responds with proof that he received Alice's message
     - Alice validates Bob's message

Two-step challenge and response protocol

1. $A \longrightarrow B: N$
2. $B \longrightarrow A: \{B,N\}_K$

Shared Key

- In this scheme, Alice can decrypt the message from Bob, expecting to see the nonce she sent him
- The shared key guarantees the integrity of the protocol
  - But how is the shared key distributed?

Two-factor Authentication

Let's formalize two-factor authentication as a challenge-response protocol

S = Server; P = Password Generator;
PIN = Personal Identification Number

1. $S \longrightarrow A: N$
2. $A \longrightarrow P: N, PIN$
3. $P \longrightarrow A: \{N, PIN\}_K$
4. $A \longrightarrow S: \{N, PIN\}_K$

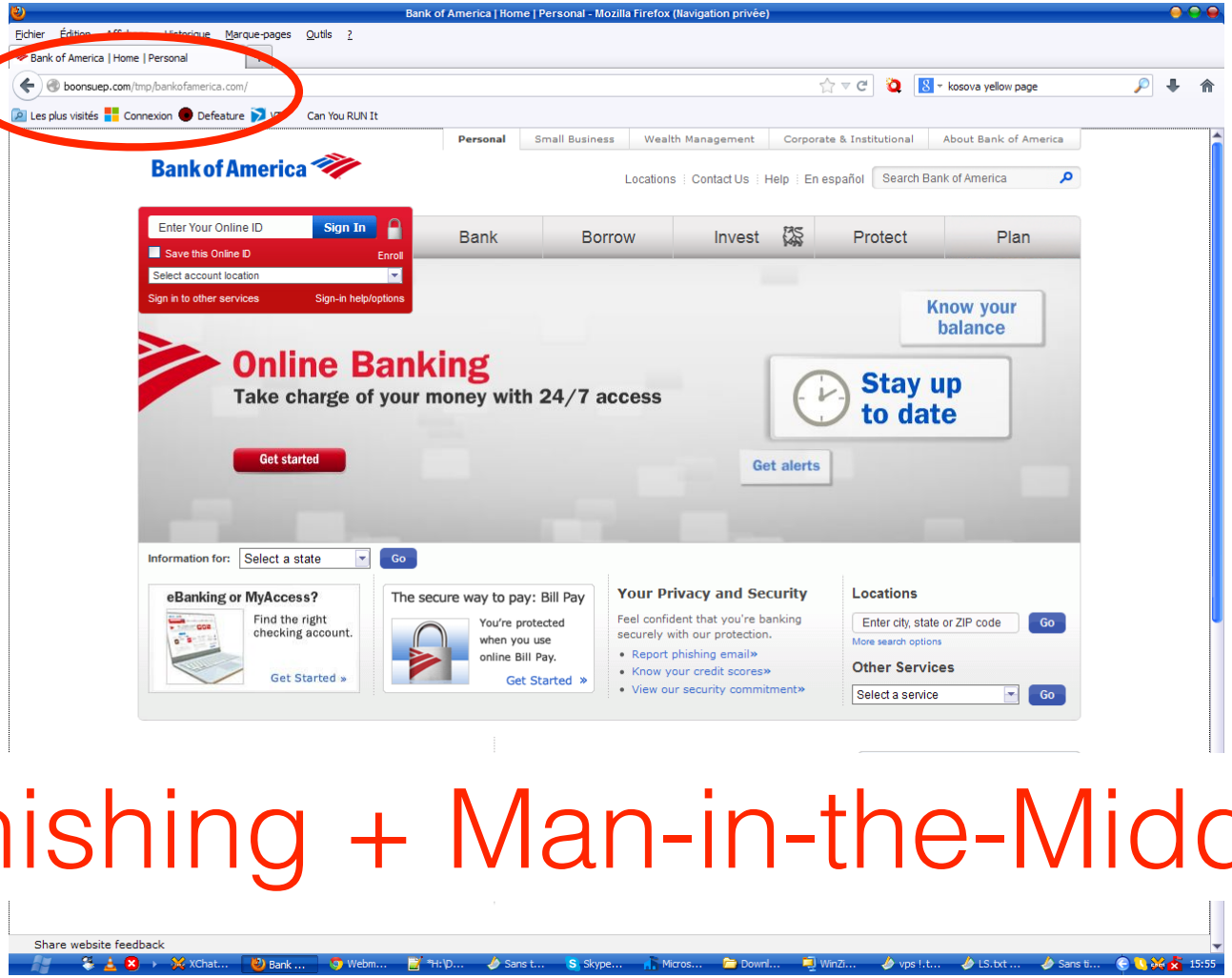
Chip + Pin

U.S. Chip-enabled Payment Cards CC BY-SA 2.0 tales of a wandering youkai

Calculator uses bank card to perform crypto

1. Calculator is loaded with card
2. Asks for user's PIN
3. For card transaction: computes response code based on a counter
4. For two-step logon: computes a challenge

How can two-factor authentication be attacked?



Phishing + Man-in-the-Middle

Image credit: http://www.xylibox.com/2013/04/phish-phisher.html

How can two-factor authentication be attacked?

1. Attacker installs Trojan program on Alice's computer
2. When Alice logs into her bank, attacker piggybacks on that transaction with the Trojan

"…the horse which once Odysseus led up into the citadel as a thing of guile"

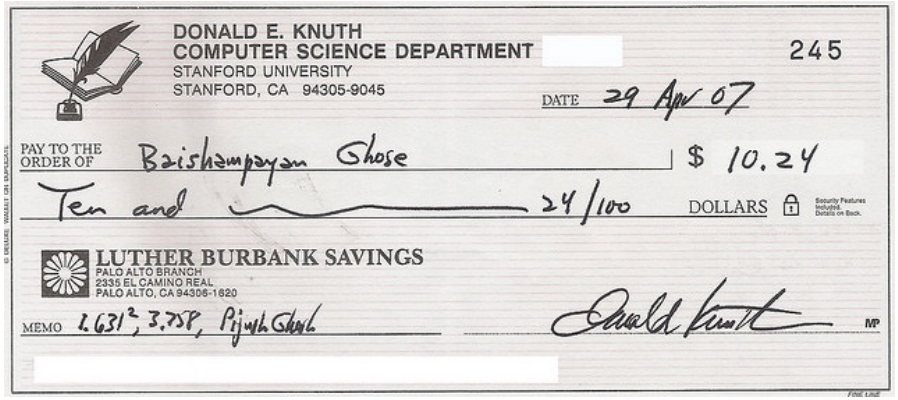
B. Schneier, "Two-Factor Authentication: Too Little, Too Late," Schneier on Security, 2005

Defense against Man-in-the-Middle and Trojan Horses?

- For the banking scenario, derive the authentication code from:
  - Transaction amount
  - Payee account number
  - Transaction sequence number
- This prevents an attacker from crafting their own transaction

Impact on usability

- Time-consuming: minutes instead of seconds
- Complicated: entry of a lot of information, including long strings of digits
    - Customers may revert to physical branches, call-centers and paper checks
        - Loss of cost savings of online banking


DONALD E. KNUTH
COMPUTER SCIENCE DEPARTMENT
STANFORD UNIVERSITY
STANFORD, CA 94305-9045

245

DATE 29 Apr 07

PAY TO THE ORDER OF Baishampayan Ghose $ 10.24

Ten and 24/100 DOLLARS

LUTHER BURBANK SAVINGS
PALO ALTO BRANCH
2335 EL CAMINO REAL
PALO ALTO, CA 94306-1620

MEMO $1.631^2, 3.758, \pi, i, \ln 1$

A reward from Sir Donald Knuth

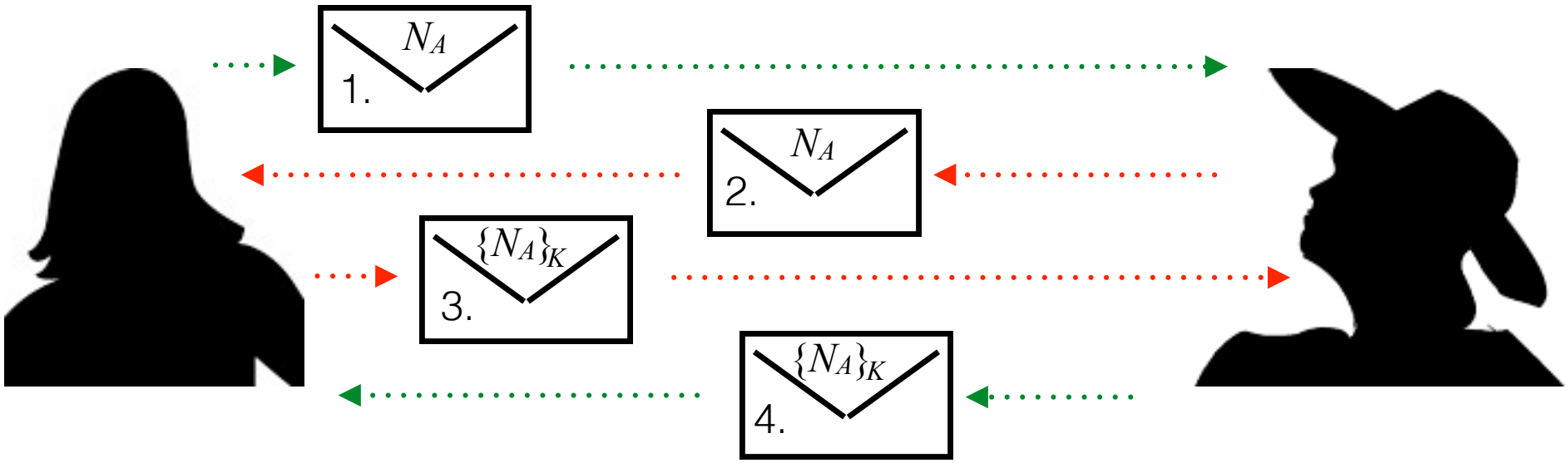
Mutual Authentication

Alice and Bob need to identify each other:

1. $A \longrightarrow B: N_A$
2. $B \longrightarrow A: N_B$
3. $A \longrightarrow B: \{N_B\}_K$
4. $B \longrightarrow A: \{N_A\}_K$

What is the weakness in this protocol?

Reflection Attacks



Stopping reflection attacks

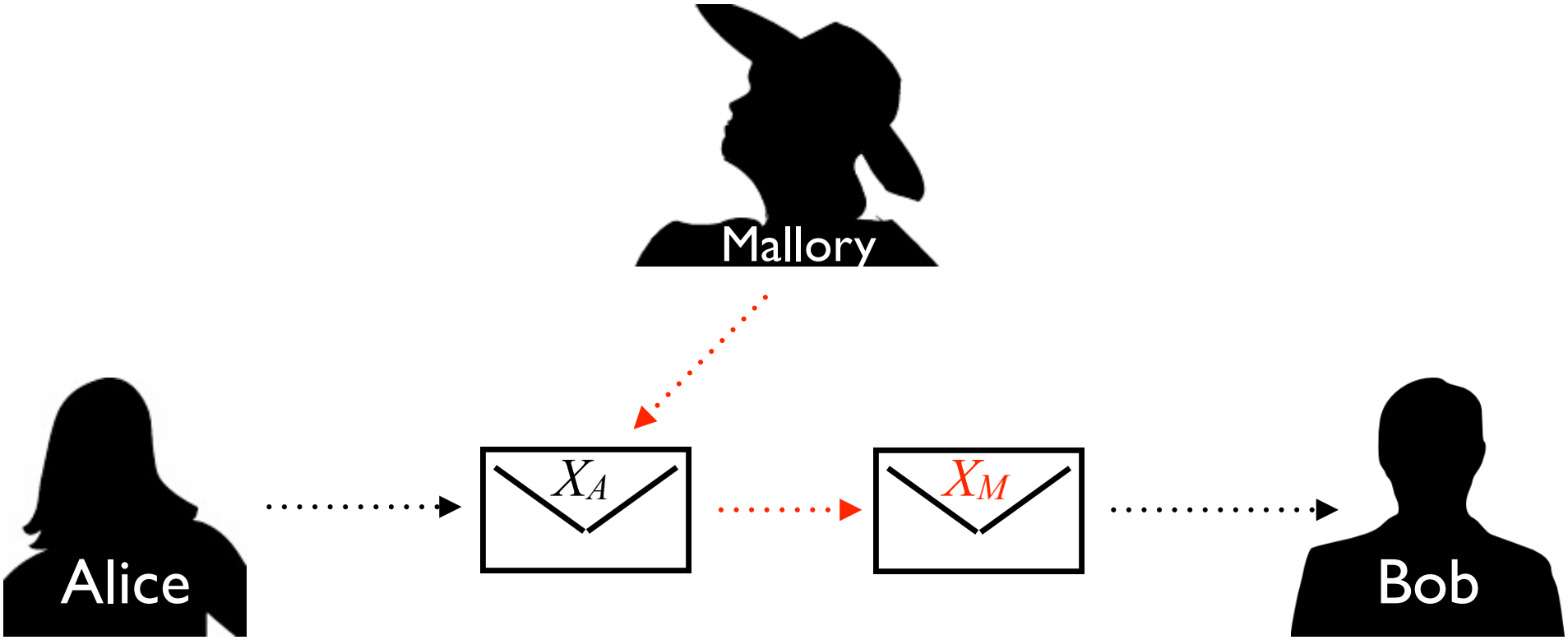
Alice and Bob need to identify each other; include IDs in the transaction:

1. $A \longrightarrow B: N$
2. $B \longrightarrow A: \{B, N\}_K$

ID is tied to a specific actor

- IDs can be checked with known actors
- If known actor didn't send, reflection attack is detected

Manipulating the message



Changing the environment

Original ATM

A Triton brand ATM with a dip style card reader and a triple DES keypad

- End-to-end encryption

Switch to Cheaper ATM

- Doesn't treat info on magnetic strip as secret
- Assumes operation in a trustworthy environment

Chosen Protocol Attack

Given some target protocol:

Design a new protocol that will attack the target protocol if users can be persuaded to reuse information

- Token
- Crypto Key

Chosen Protocol Attack

Protocols share elements

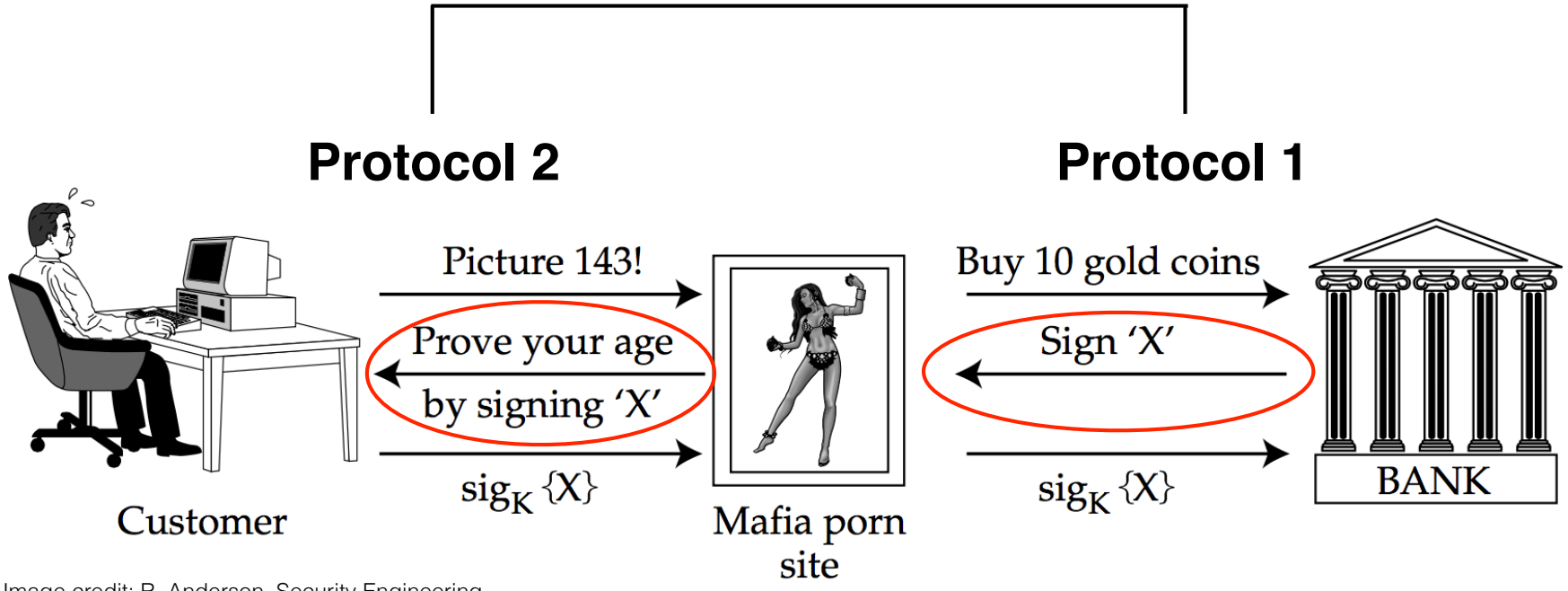


Image credit: R. Anderson, Security Engineering

Ways to mitigate chosen protocol attack

- Do not allow crypto keys to be used by more than one application
- Do not let other people bootstrap their own application security off of yours
    - Be aware of security dependencies