Authentication

Dr. Yeonjoon Lee

Outline

- Concepts and basic authentication
- Strong authentication
- Authentication and Key Exchange

Authentication

Concepts and basic authentication

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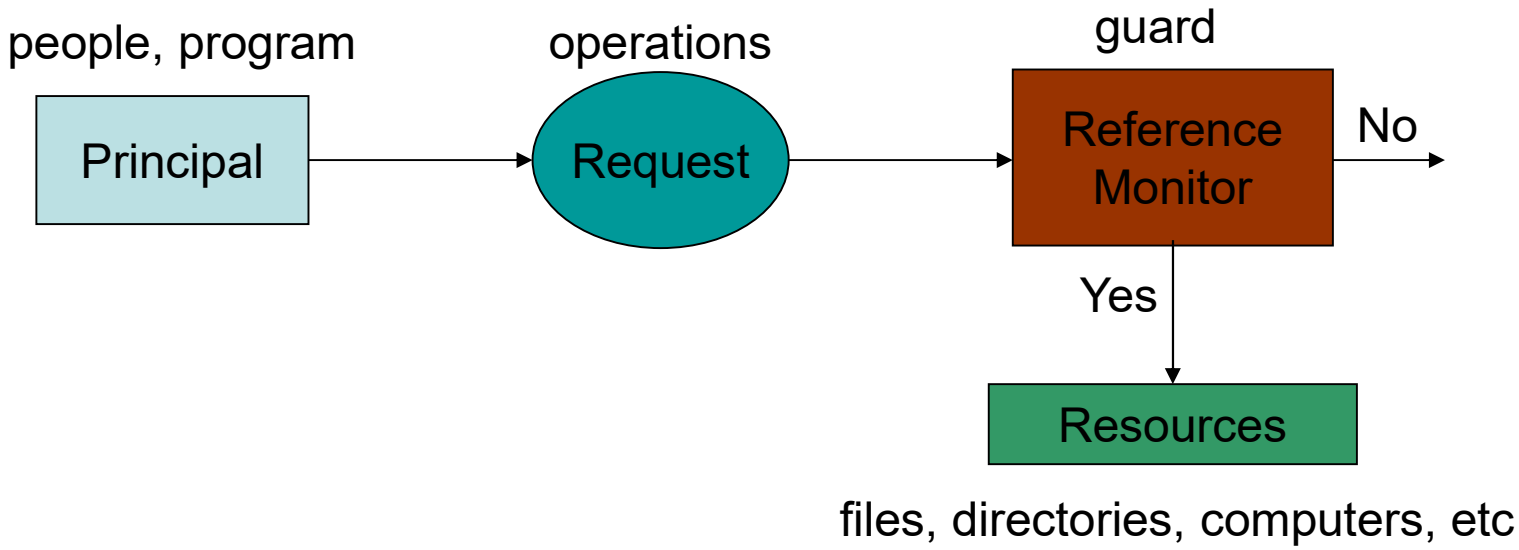
Authentication (from Wikipedia)

Authentication (Greek: *αυθεντικός*, from 'authentes'='author') is the act of proving an assertion, such as the identity of a computer system user. In contrast with identification, the act of indicating a person or thing's identity, authentication is the process of verifying that identity. It might involve validating personal identity documents, verifying the authenticity of a website with a digital certificate.

Authentication, authorization and access control

- Authentication: determining who makes the request
- Authorization: determining who is allowed to access resources
- Access control: how to make the decision and control the access



Authentication model

From the textbook (computer security: principles and practice)

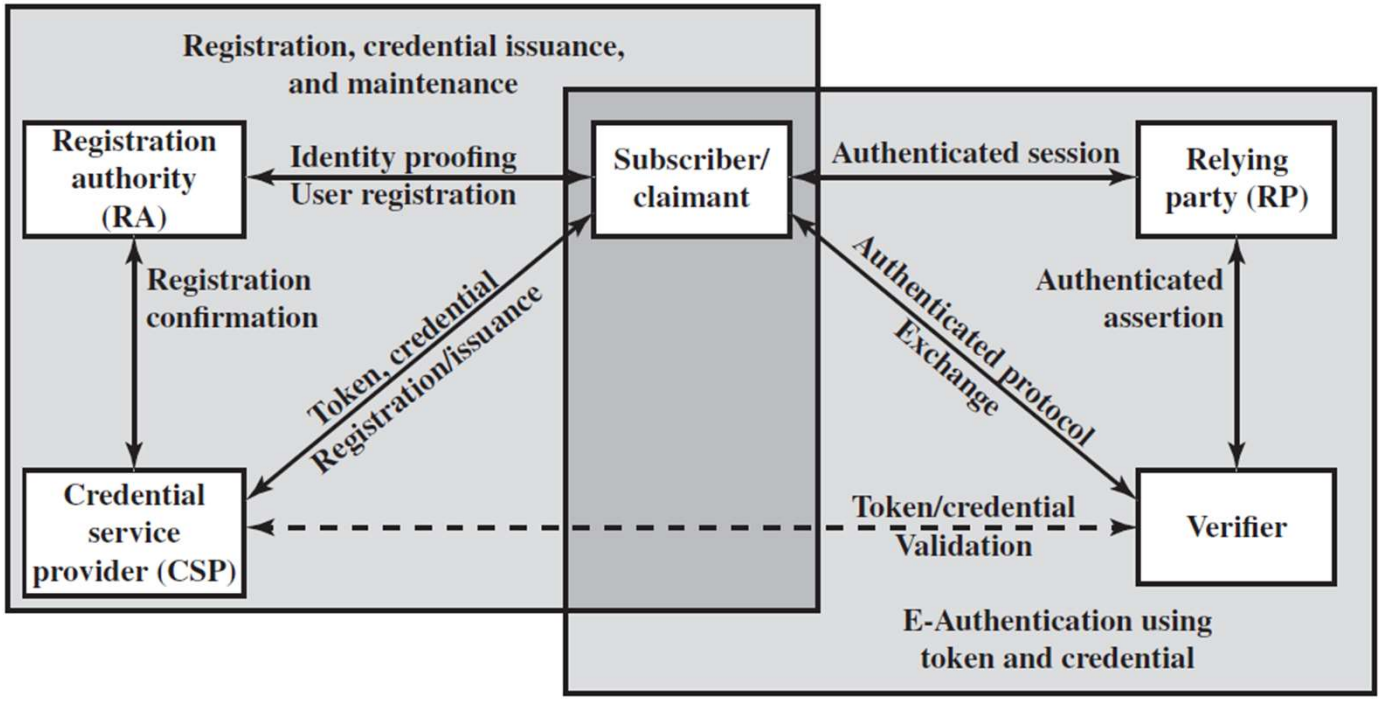


Figure 3.1 The NIST SP 800-63-2 E-Authentication Architectural Model

Means of user authentication

- User authentication is based on knowledge shared by a computer and a user

- Four types of knowledge
  - Something the user knows: password, PIN, questions, etc.
  - Something the user has: credit card, debit card, etc.
  - Something the user is: fingerprint, DNA, etc
  - Something the user does: voice pattern, handwriting, typing rhythm, etc.

Password authentication

- Password: a mutually agreed-upon secret code between a computing system and a user

- Authenticate a user on the basis of ⟨user, password⟩ pair

Attacks on passwords

- Guess: online or offline (obtaining password file)
  - Try common passwords
  - Personalized guesses
  - Password reuse

- Steal: examples
  - Workstation hijacking
  - User mistakes
  - Electronic monitoring

Weak passwords

- Morris and Thompson studied the password distribution in 79
  - 2 letters: 2%; 3 letters: 14%; 4 letters 14%; 5 letters: 22%; words in dictionaries: 15%
- British online bank Egg found users still choosing weak passwords in 02
  - Family member names: 50%

How to crack a weak password

- No password
- The same as the user ID
- Derivable from user ID
- Common word lists (“password”…) plus patterns (“asdfg”…)
- Look up words in online dictionary
  - One contains 80,000 words, and trying all takes only 80s
- Add capitalization (“PaSsWorD”…)
- Add substitution (0 for o …)

More password cracking

- Use more power hardware
  - AMD can try XX passwords every second
- Use better algorithms
  - Model relations between letters with hidden Markov chain
- Leverage exposed passwords
  - SQL injection on RockYou.com exposes 32 million passwords

Reasons for using password authentication

- Easy to deploy
  - Alternatives are more expensive and more complicated to deploy
- Robust
  - Approaches like single-sign-on create a single point of failure.
- Flexible
  - Automatic password managers are hard to synchronized across devices

Choose a strong password

- Use characters other than A-Z
- Choose long passwords
- Avoid actual names or words
- Choose an unlikely password
- Change the password regularly
- Do not write it down
- Do not tell anyone else

Password selection strategies

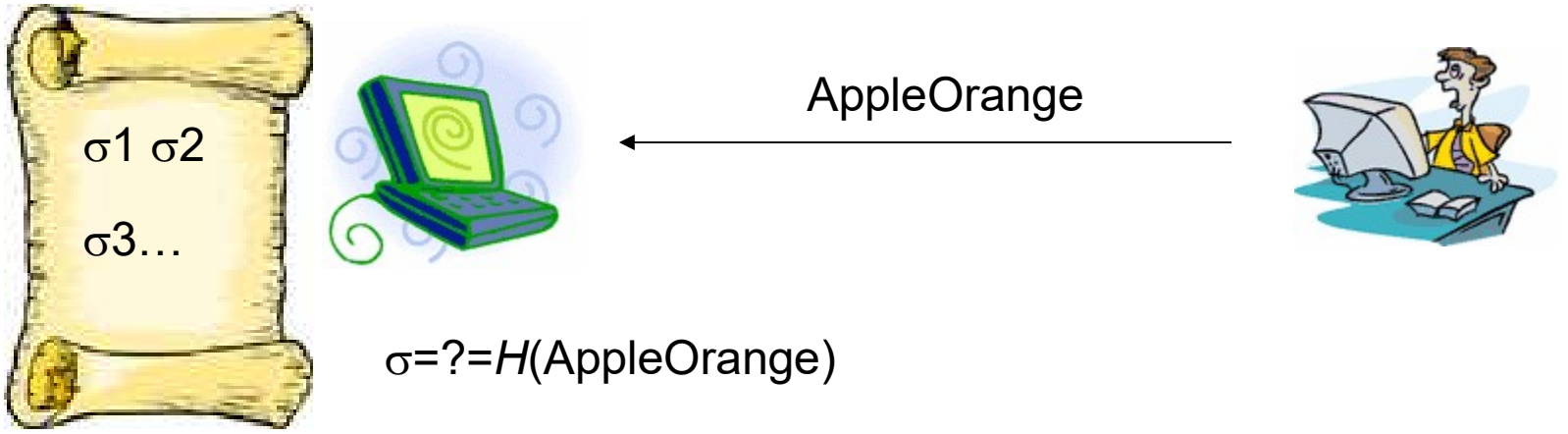
- User education
- Computer-generated passwords
- Password checking
- Password policy

How to store the password list?

- Obvious solution: keeping it on the server in plaintext
- But, if cracker gets into the server, somehow…

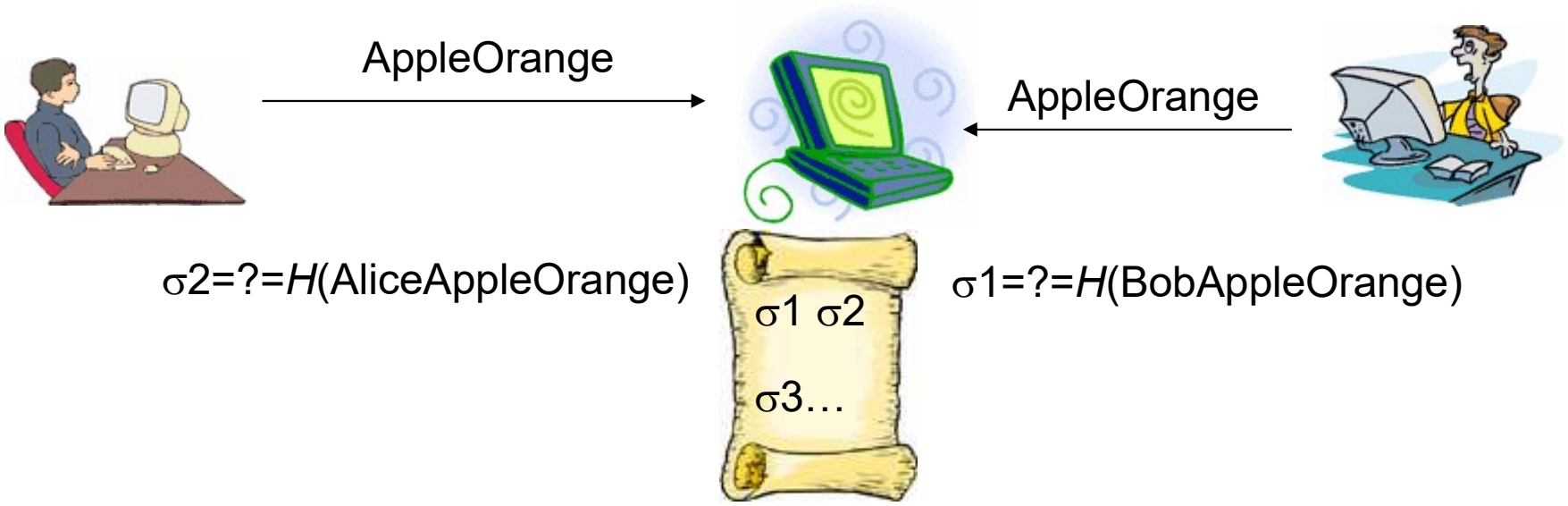
Store password list

- Keep only the fingerprints of the passwords



Store password list (cont'd)

- What happens if two choose the same password?



- In Unix, $\sigma = H(\gamma, \text{paswd})$ and the computer keeps (γ, σ)

UNIX password storage and protection

- Stored in shadow password file
  - Protected by system privilege
- Threats to the password file
  - Hacking
  - Breaking in less protected systems of the same user
  - Backup devices carry password file
  - Network sniffing

Authentication

Strong user authentication

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Problems of password authentication

- An adversary may tap the network wire to steal your password
- Your passwords might get lost or stolen

Memory card and smart card

- Memory card
  - Credit card, bank card with magnetic stripe
  - Some further protected by PIN
  - Weaknesses: special reader, risk of token loss, usability
- Smart card
  - Include a microprocessor
  - User interface: keyboard and display
  - Electronic interface: contact or NFC
- Authentication protocol
  - User => card => computer
  - One-time password
  - Challenge-response

Smart card/reader exchange

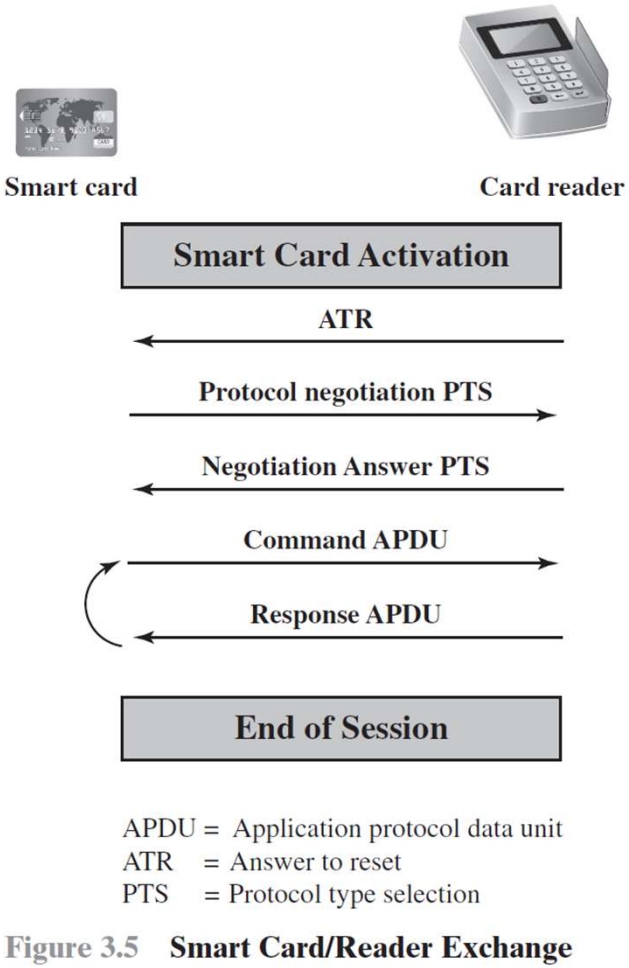
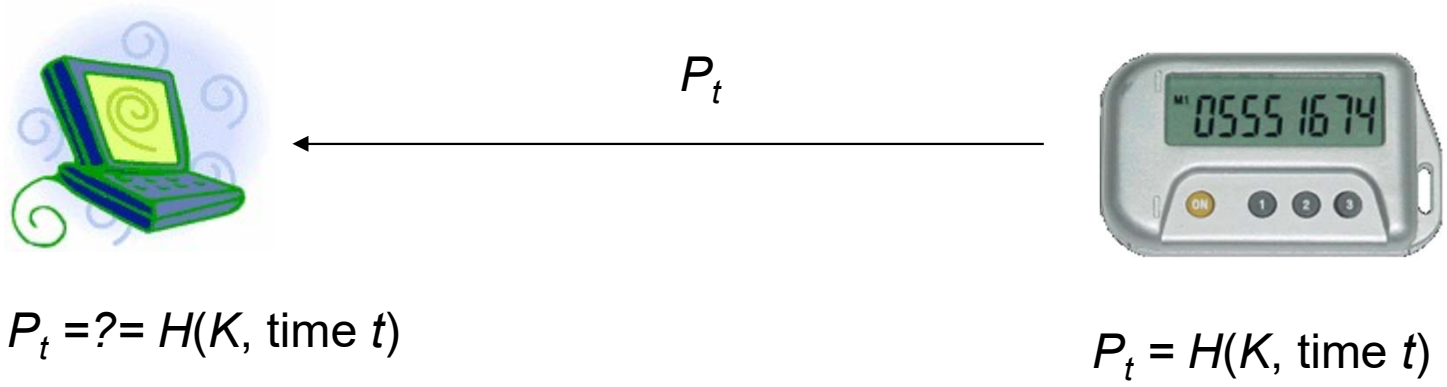


Figure 3.5 **Smart Card/Reader Exchange**

One-time password

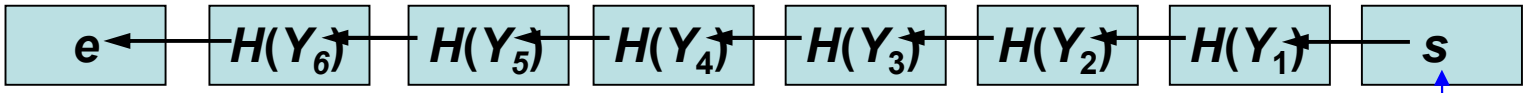
- Password good for one-use only
- Password token
  - A device that generates unpredictable password
  - Synchronous token
    - Change password every minute
    - Time alignment between the token and the computer
    - Need to adjust alignment periodically

How to design a one-time password token



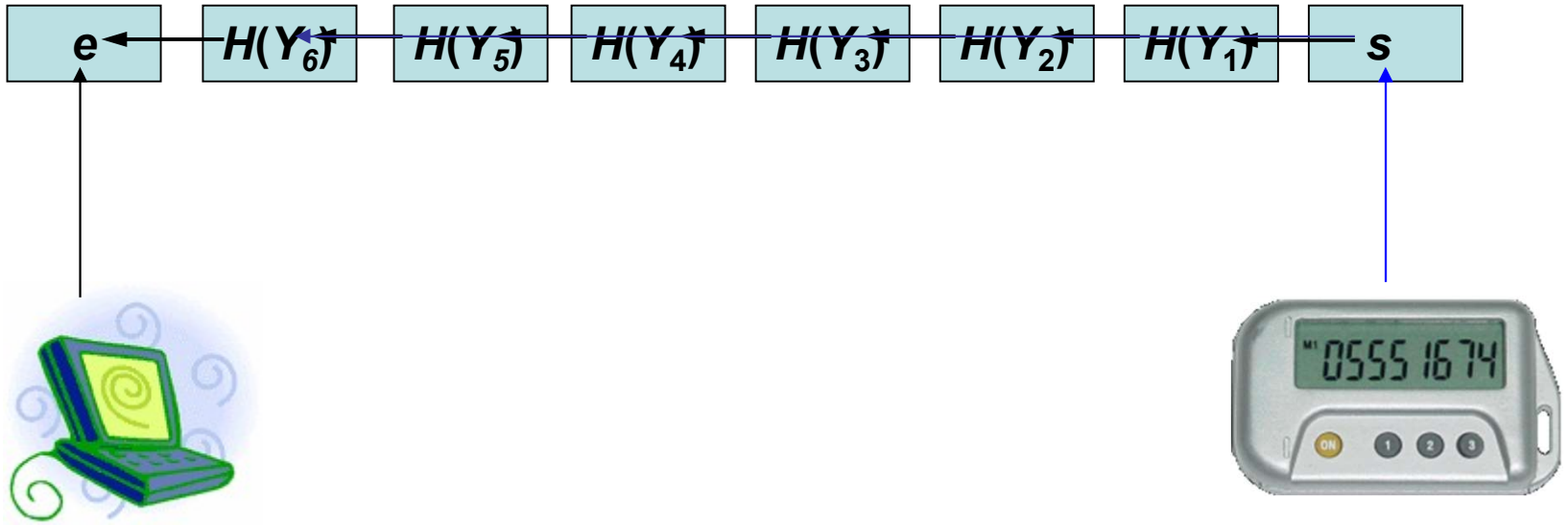
- Token only calculates hash once
- But, it needs to keep synchronization with the computer

How to design a password token (cont'd)



- Hash-chain approach
- This approach works against eavesdropper, why?
- This approach does not need synchronization between token and computer
- But token has to perform many hash operations

How to design a password token (cont'd)



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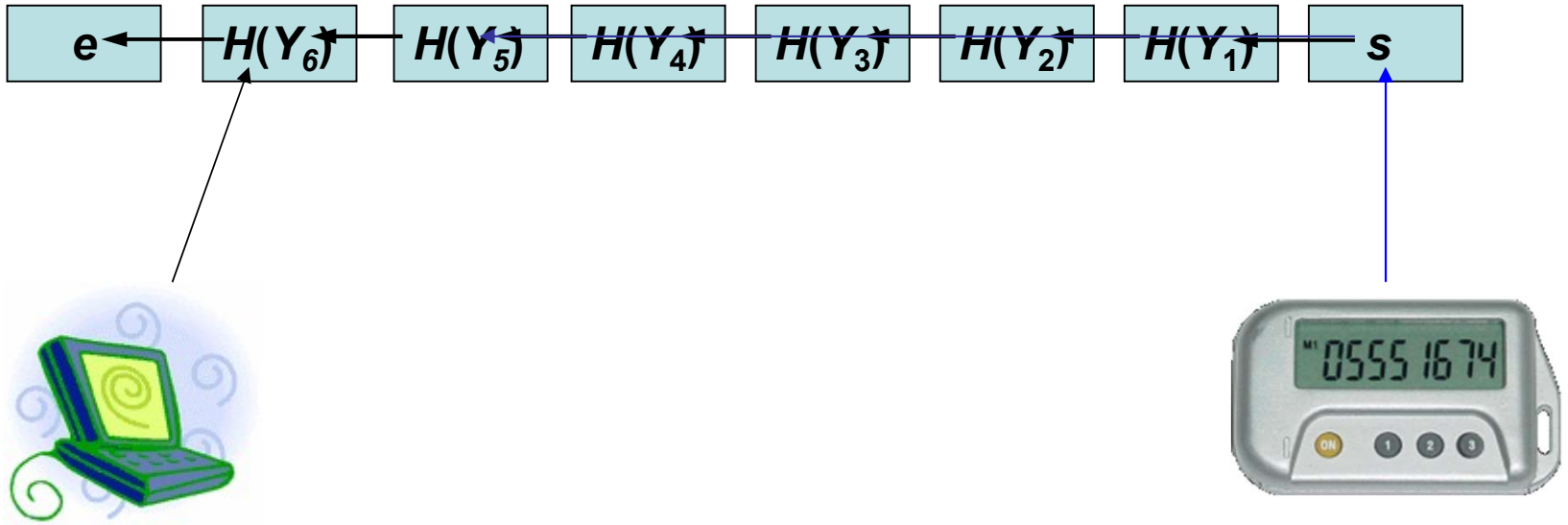

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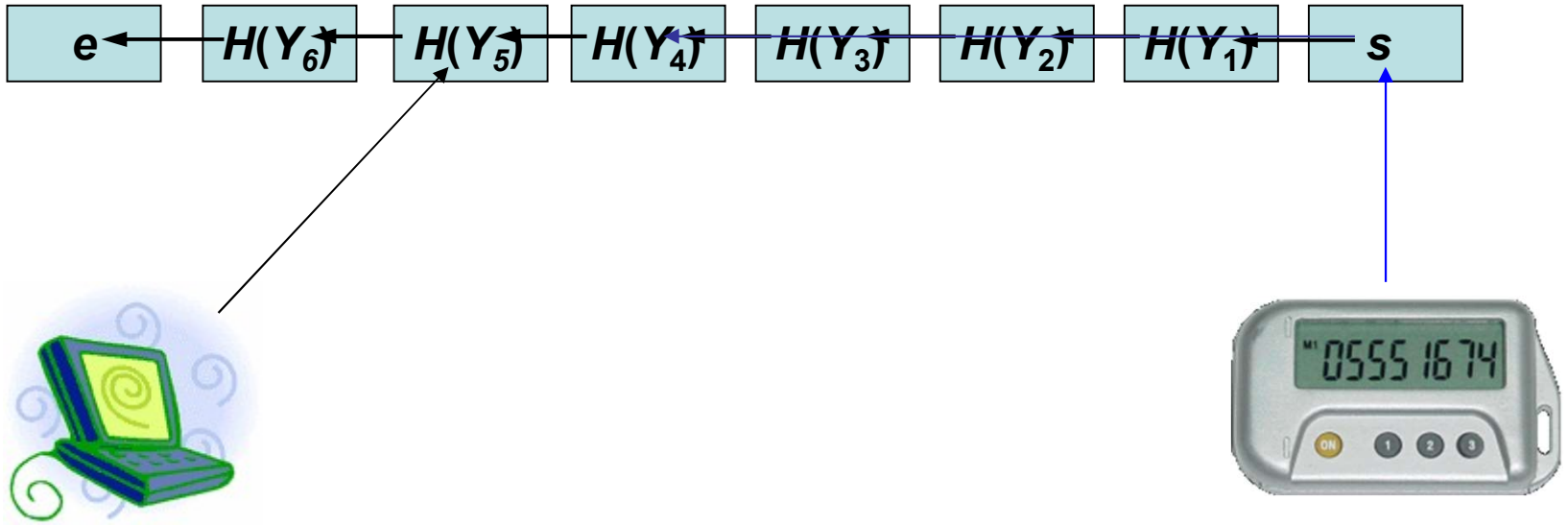

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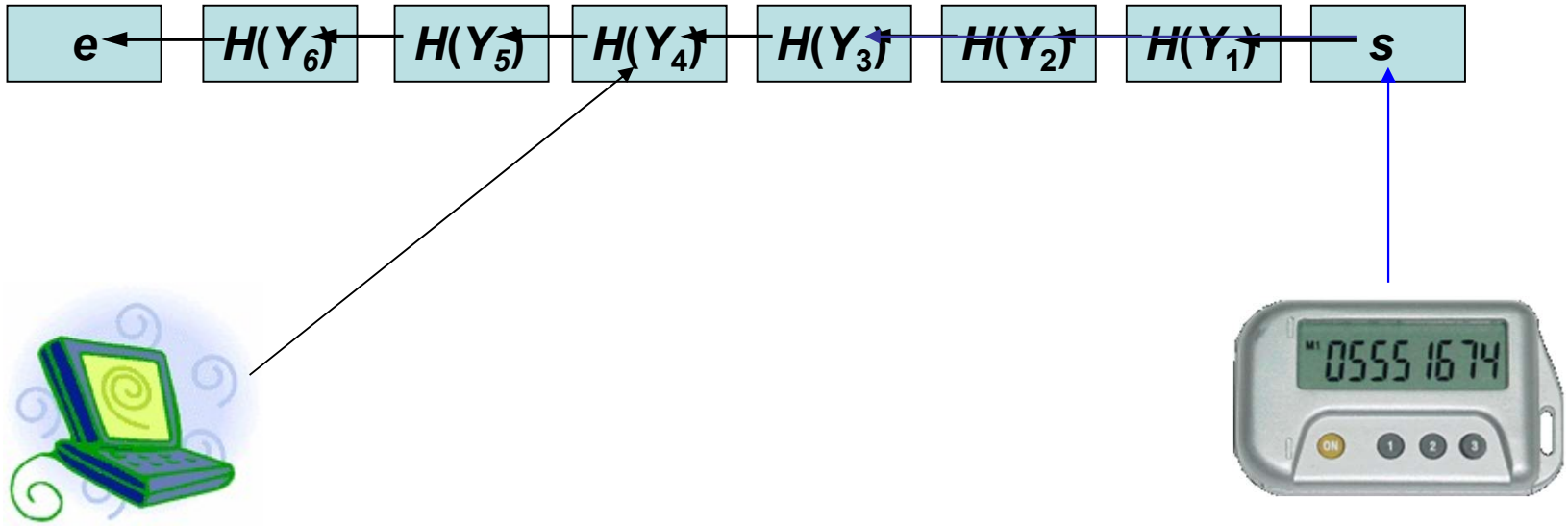

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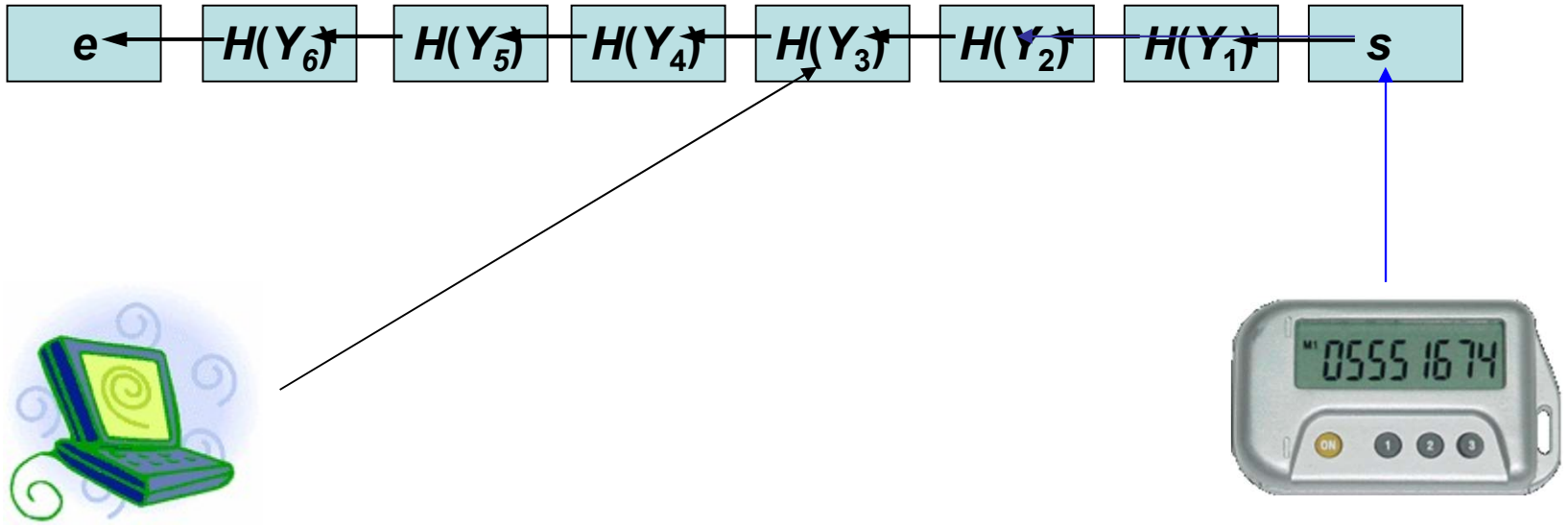

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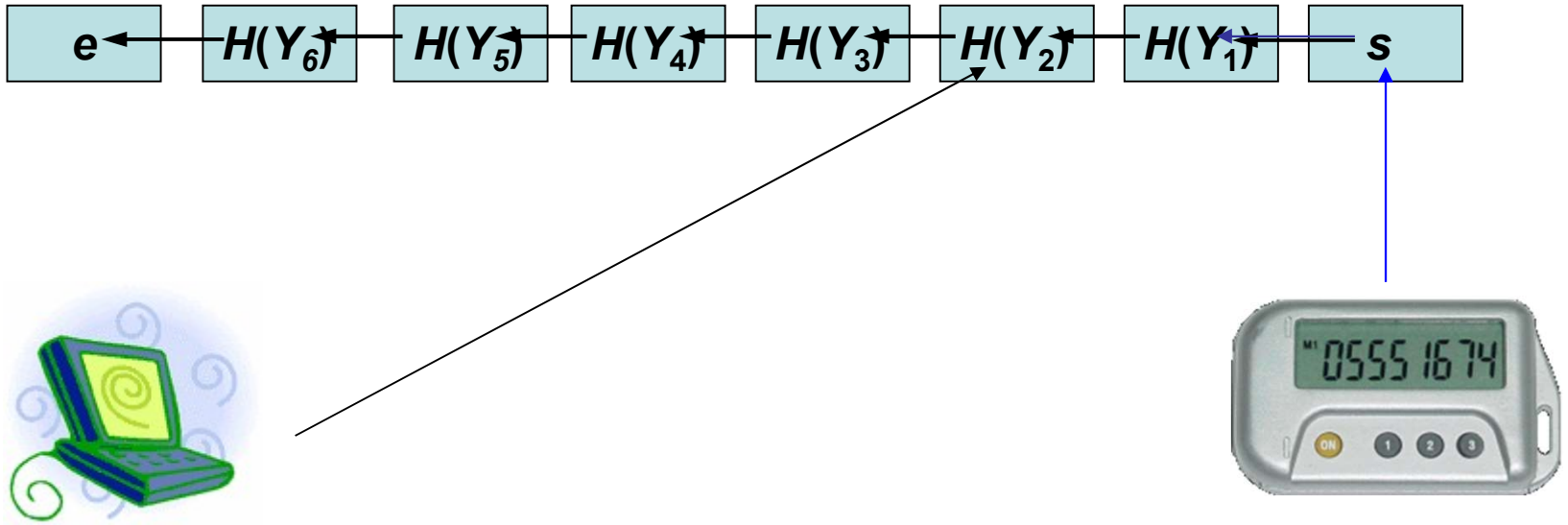

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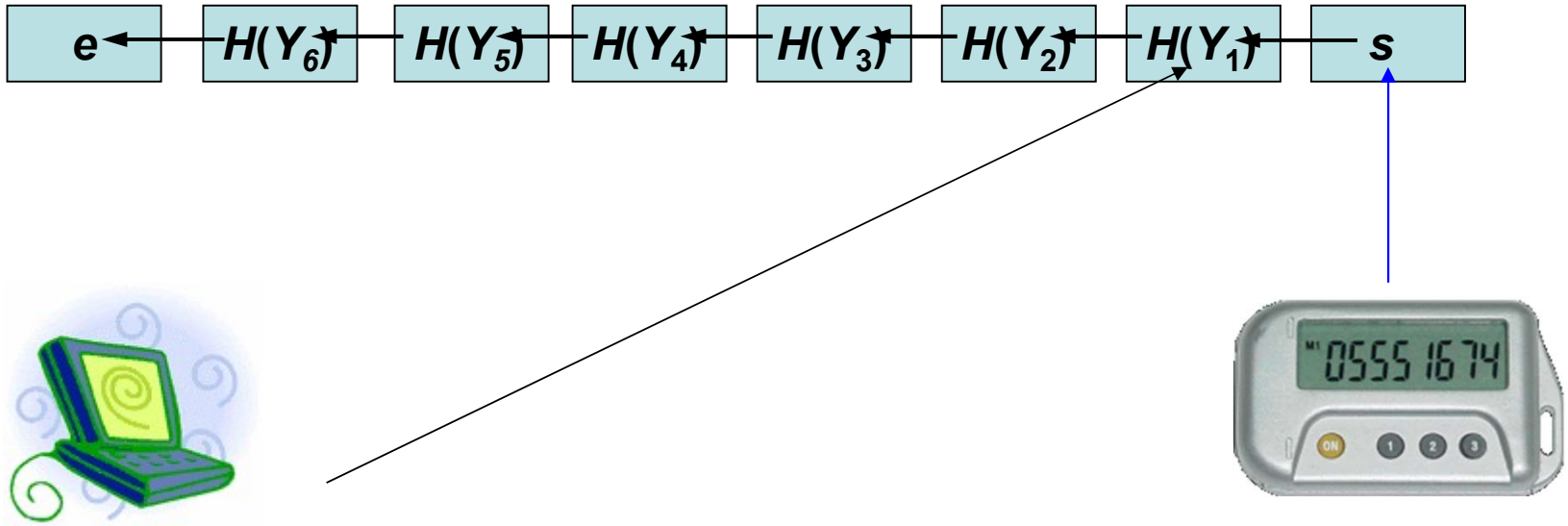

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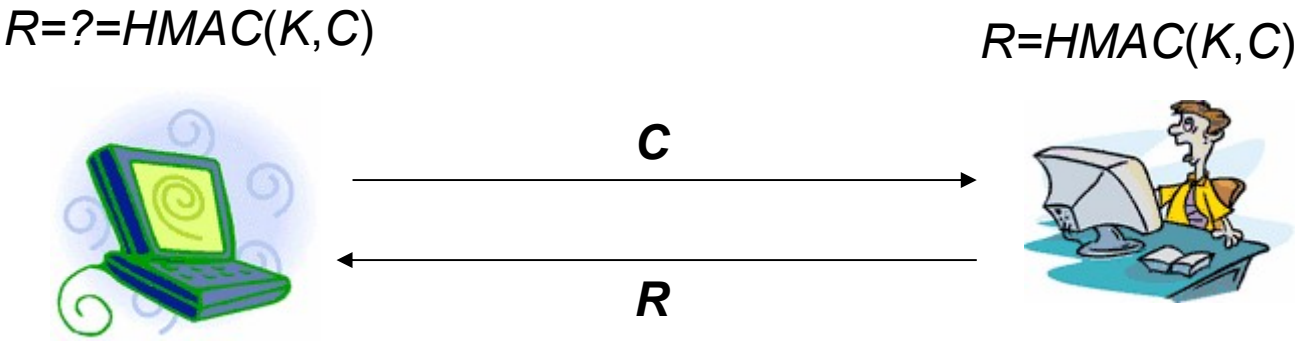
Challenge and response



- Use one-way function and a shared secret, a client can authenticate a server even in the presence of eavesdropper

Tell human and computers apart

- Sometimes, one only needs to prove that he is a human
  - Many security problems caused by “zombies”, computers controlled by virus, worms

- How to tell human and computer apart
  - Human being can understand some fuzzy concepts while computers cannot
  - Can we design a trapdoor one-way function with human cognition capability as key?

CAPTCHA

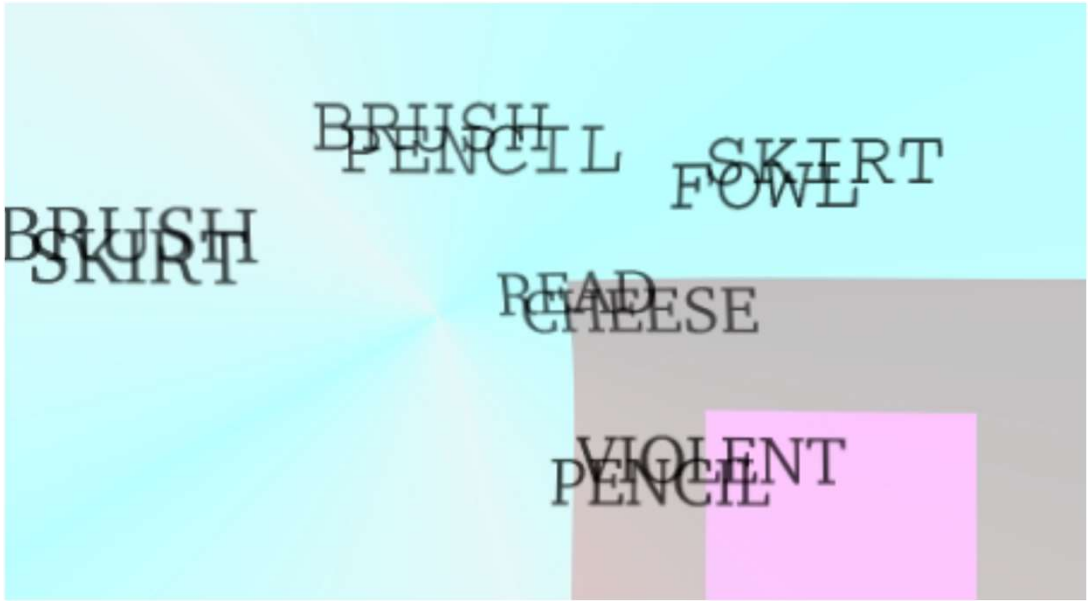
- Turing test: a test of a machine's capability to perform human-like conversation.

- CAPTCHA: ***c***ompletely ***a***utomated ***p***ublic ***T***uring test to tell ***c***omputers and ***h***umans ***a***part
  - CAPTCHA is a one-way function to computer
  - CAPTCHA is not a one-way function to human being
  - http://www.captcha.net/captchas/

CAPTCHA used by gmail

- This approach is no longer secure: some pattern-recognition problem can automatically detect the characters

A more secure example



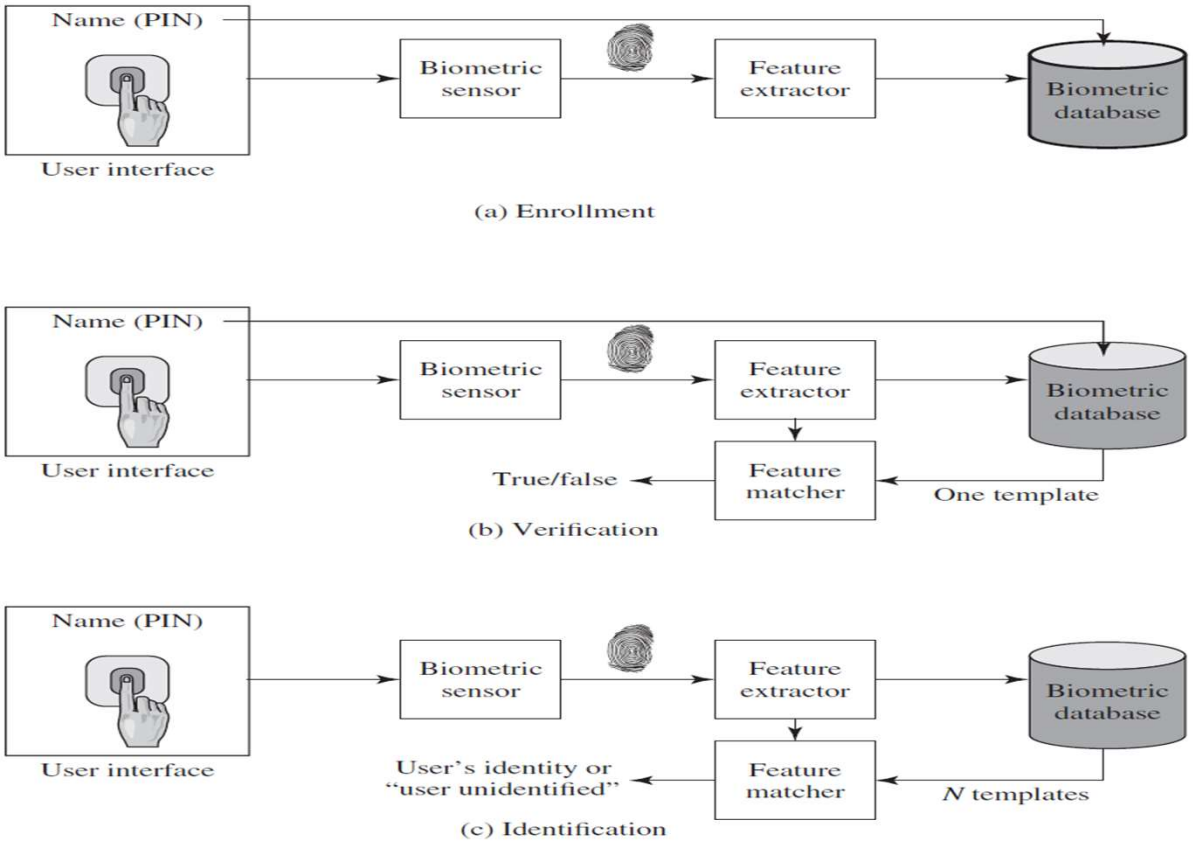
Another example

Choose a word that relates to all the images.

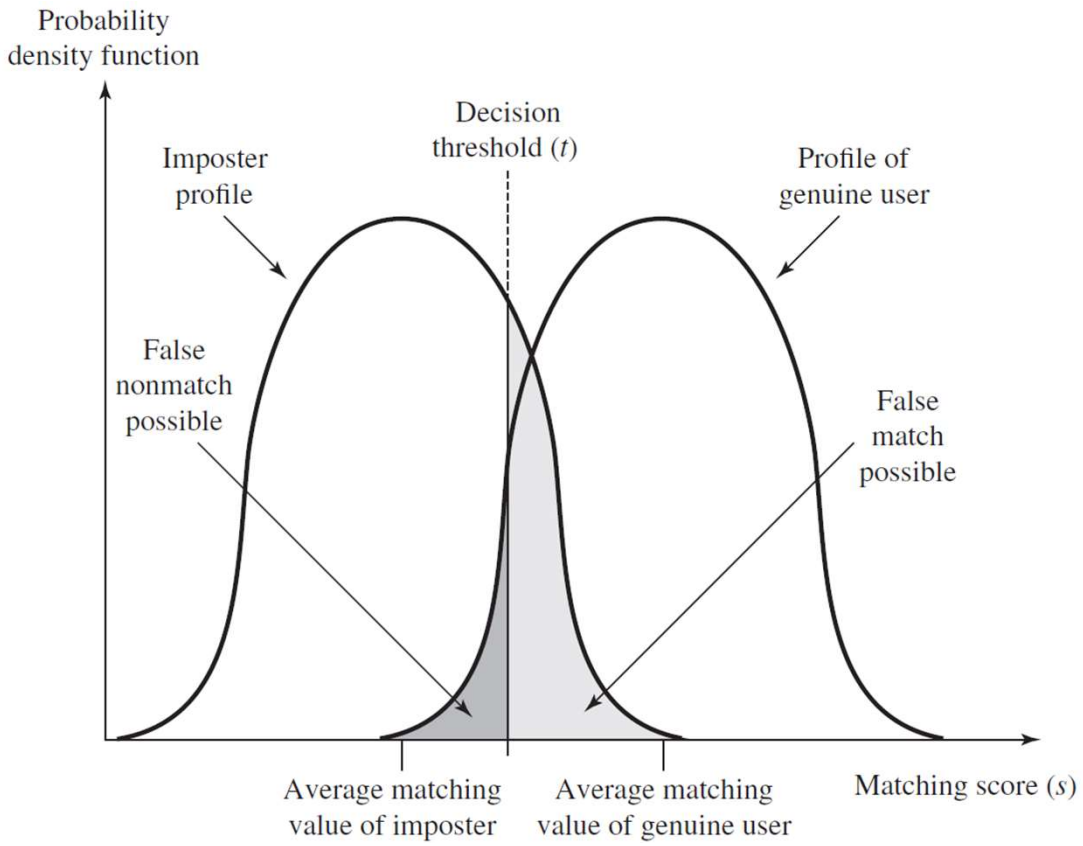
Biometric authentication

- Handwritten signatures
- Keystroke dynamics
- Face recognition
- Hand geometry
- DNA
- Fingerprints
- Iris code
- Retina pattern
- Voice

Biometric system: operations



Biometric accuracy



Problems of biometrics

- Limitation of technologies
  - DNA typing has a high rate of false positives
- Environmental factors
  - Noise, dirt, vibration, and unreliable lighting conditions
- Forgery
  - Fingerprints planted by villains
  - The age of a fingerprints
- Challenge: more usable biometrics technologies
  - E.g, meet bank's goal of 1% fraud rate and 0.01% insult rate

Mutual authentication

- Man-in-the-middle attack
- Server also needs to authenticate itself to user
  - Simple authentication: last login time
  - Mutual Challenge-and-Response authentication

Other Authentication

- Two factor authentication
- Single Sign On

Authentication

Authentication and key exchange protocols

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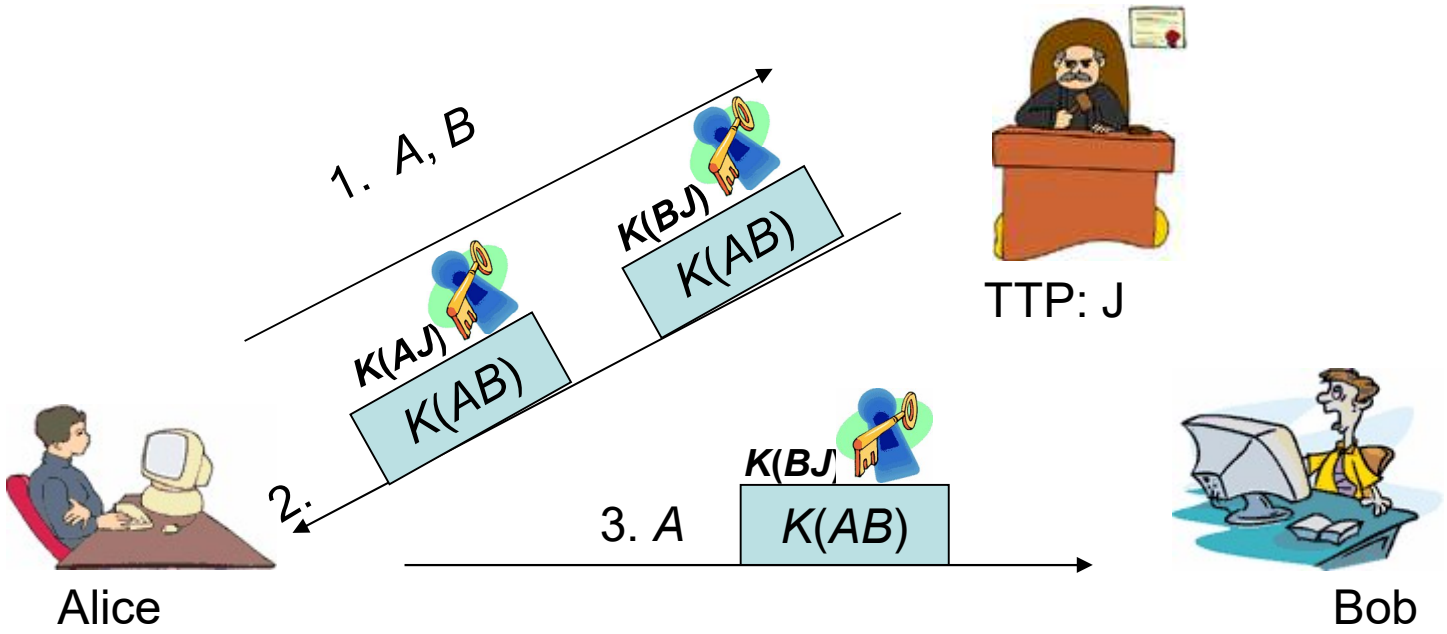
Key exchange

- Authentication between two agents
  - One agent gains confidence in the other's identity
  - E.g., computer to computer, software to software
- Establish session key
  - Authentication is coupled with the distribution of a session key
  - Session key is used to protect authenticity, confidentiality and integrity of later communication

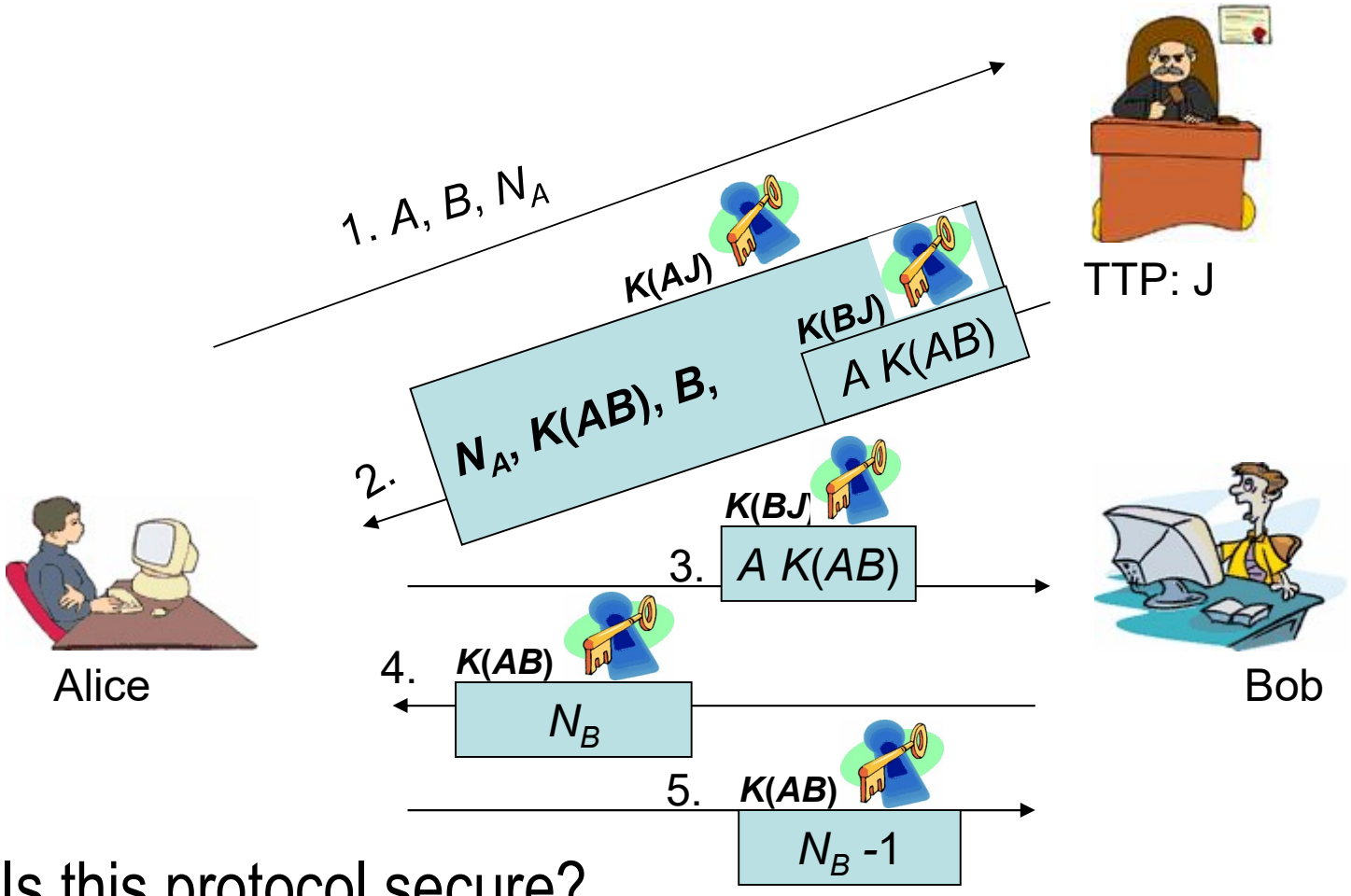
A simple key exchange protocol

K*(*AB*): a secret key of *A* and *B
K*(*BJ*): a secret key of *B* and *J
K*(*AJ*): a secret key of *A* and *J



- Is this protocol secure?
  - How could Bob know whom he is talking to?

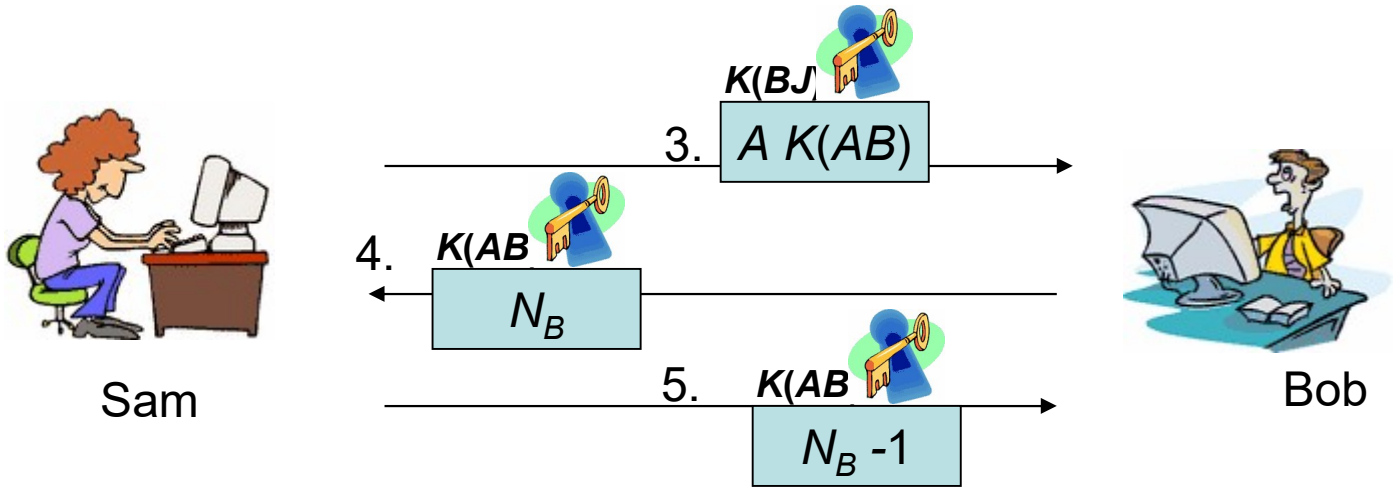
The Needham-Schroeder protocol



- Is this protocol secure?

Denning-Sacco replay attack

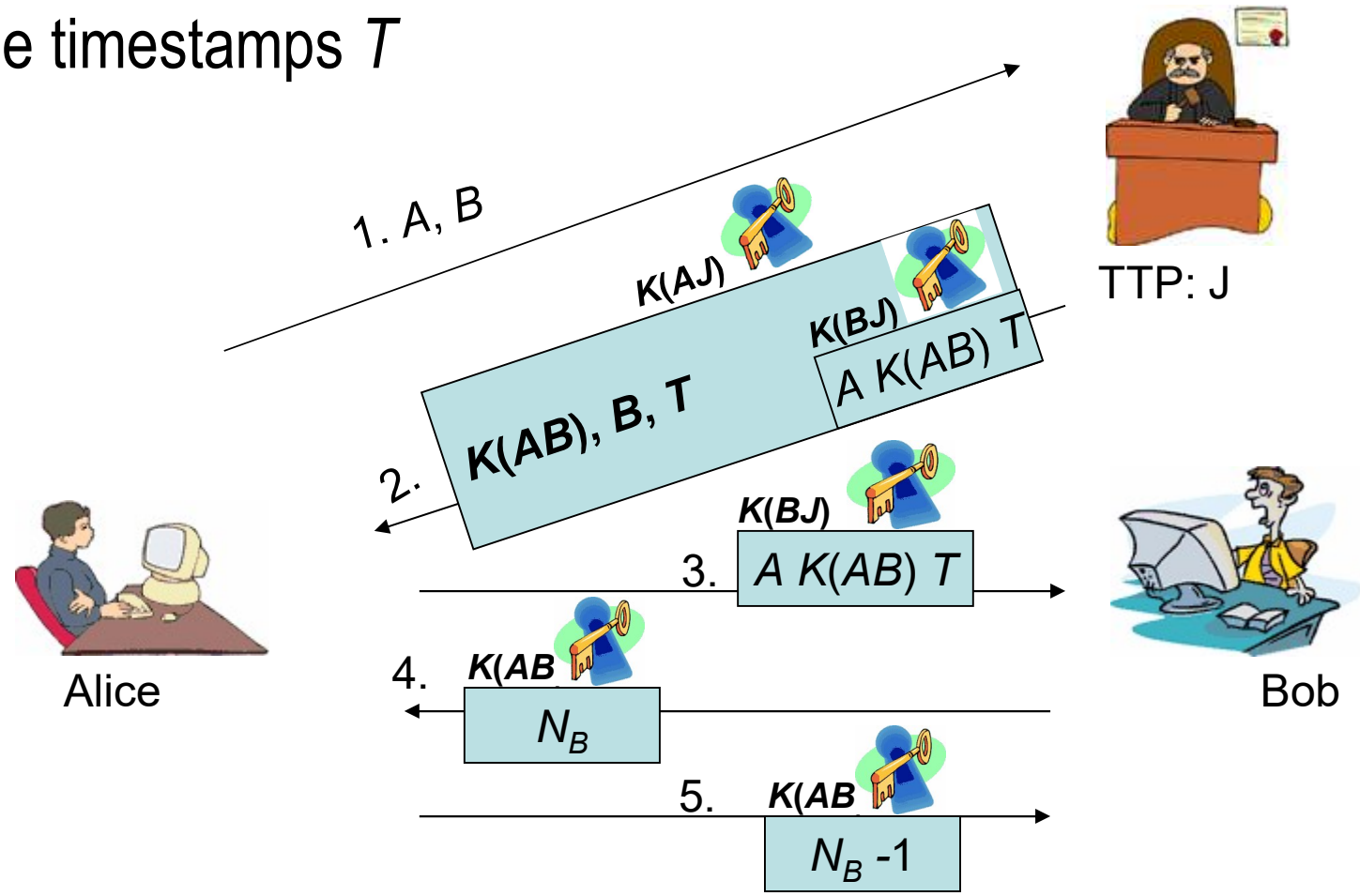
- If Sam stole the session key of last session, *K*(*AB*), he can play the following game



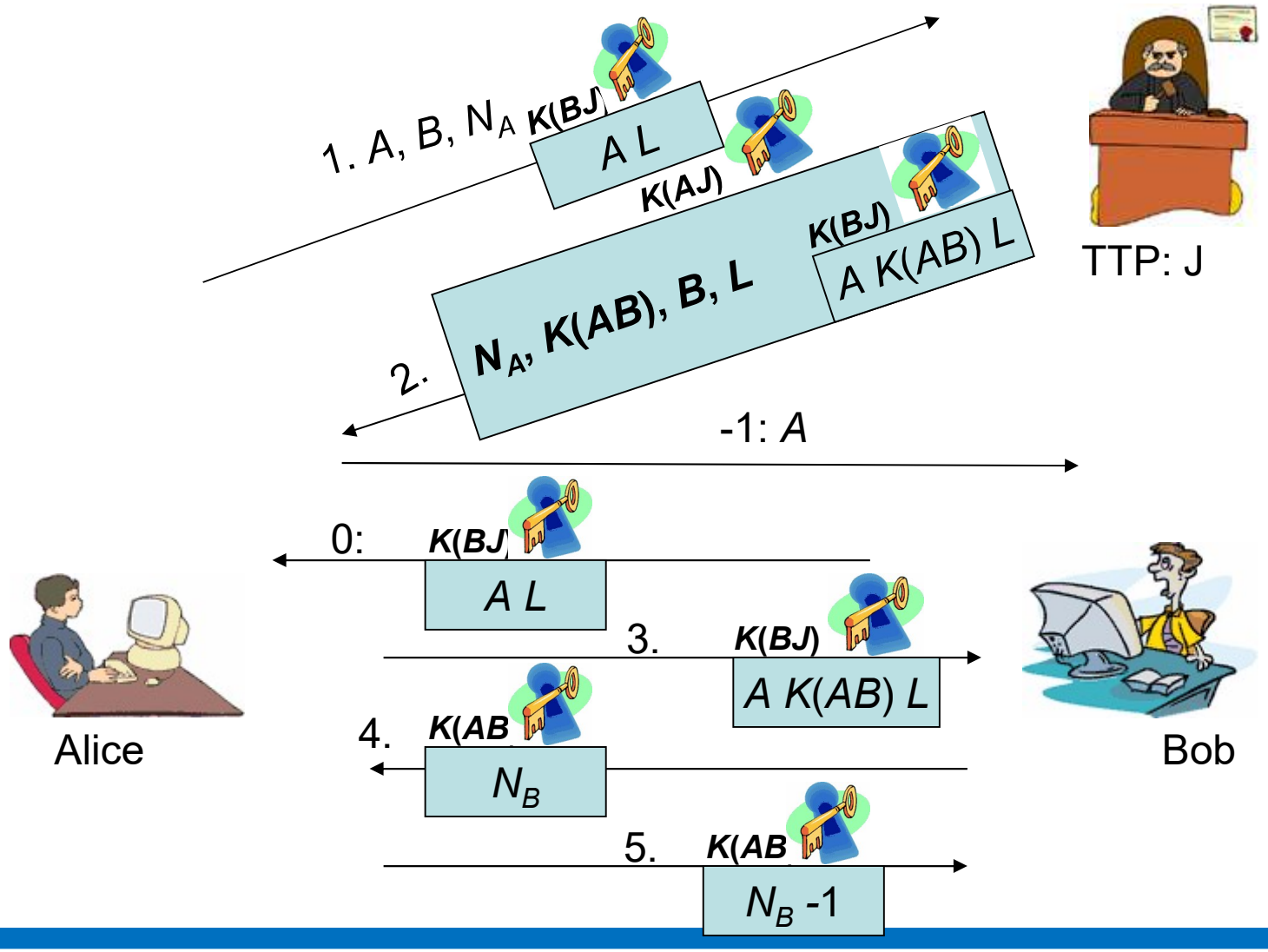
- Sam can replay 3 to 5, to impersonate Alice

Denning-Sacco fix

- Use timestamps *T*

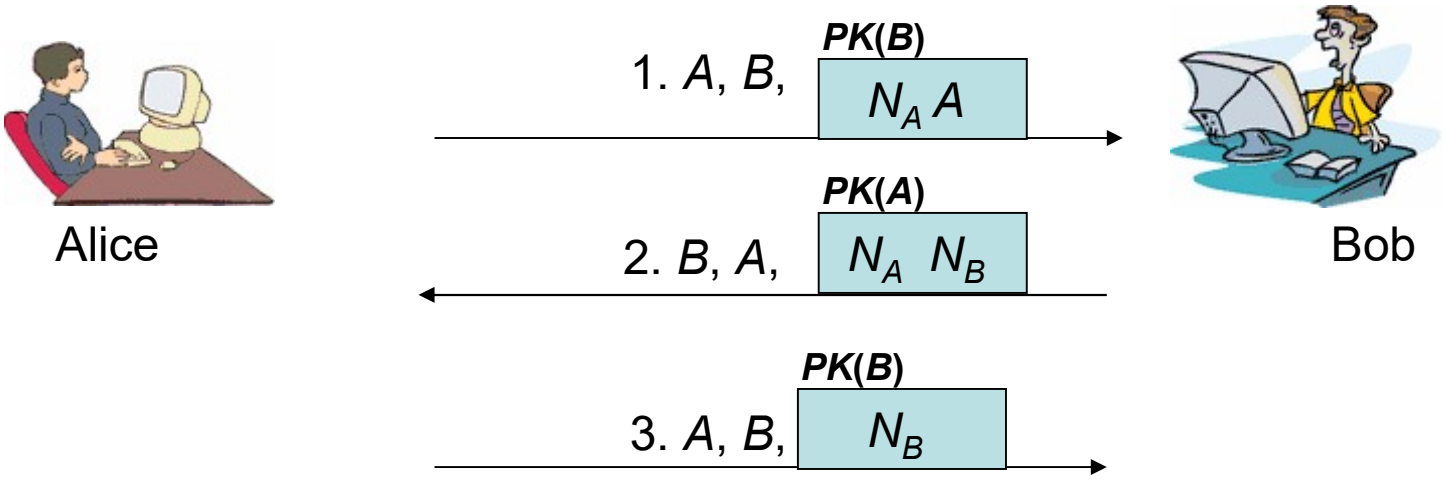


Needham-Schroeder fix



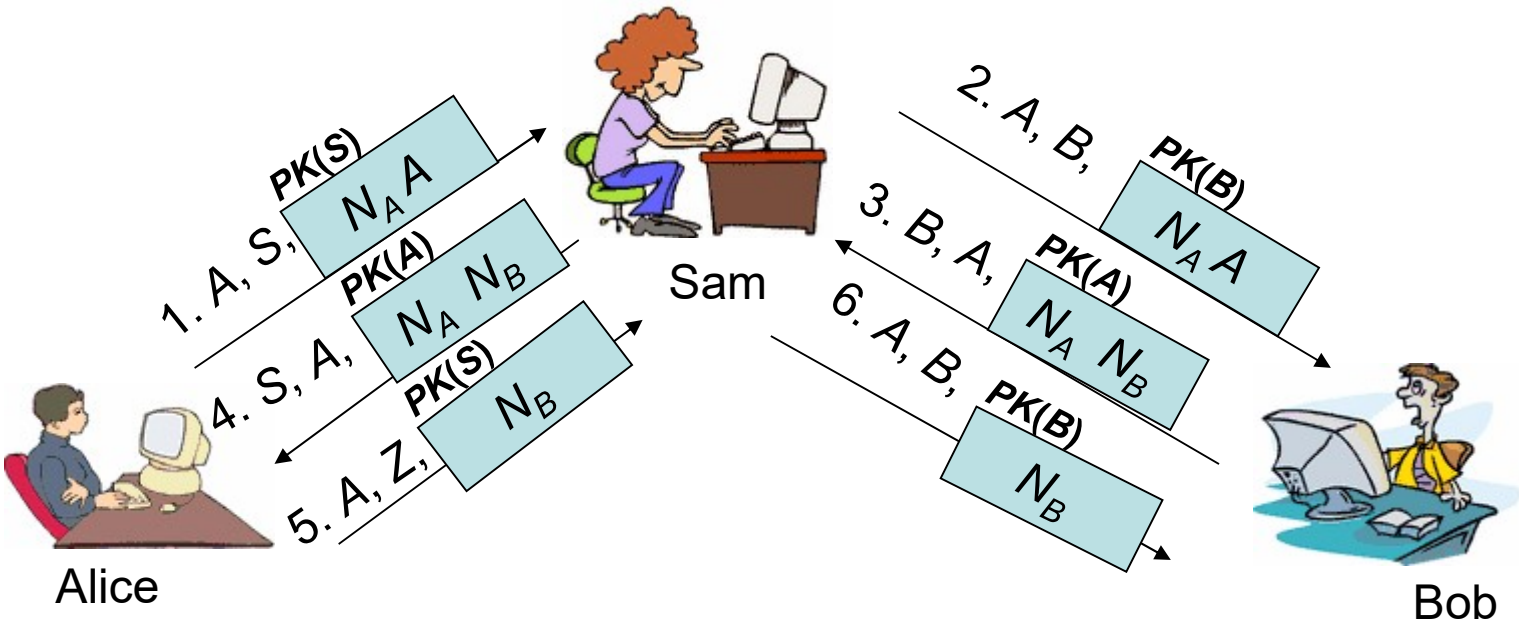
Needham-Schroeder public key authentication

PK*(*A*): a public key of *A
PK*(*B*): a public key of *B



- Any problem in this protocol?

Man-in-the-middle attack



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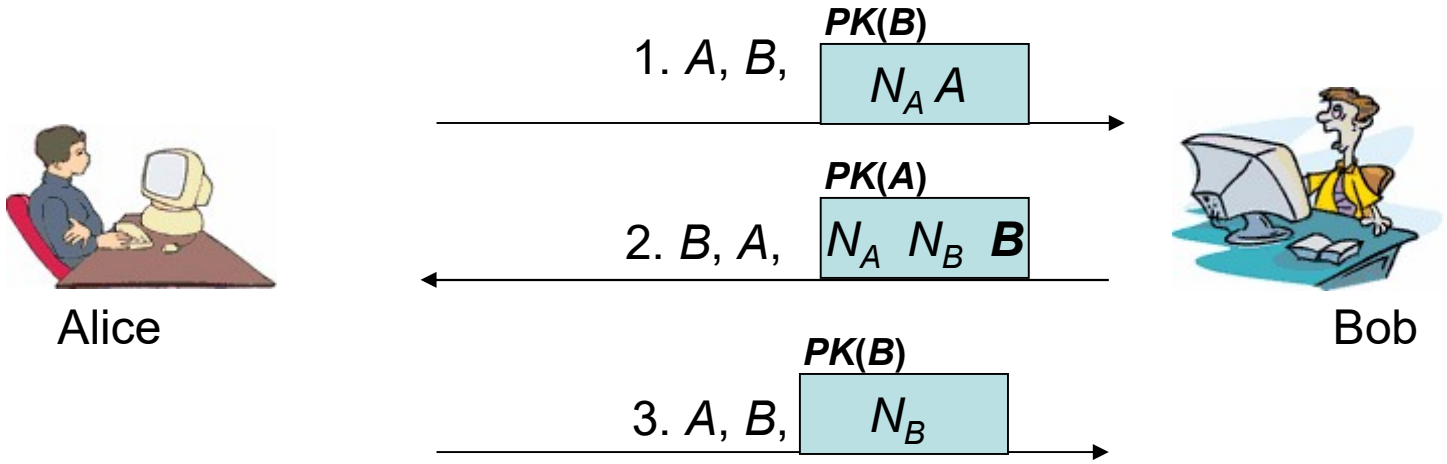
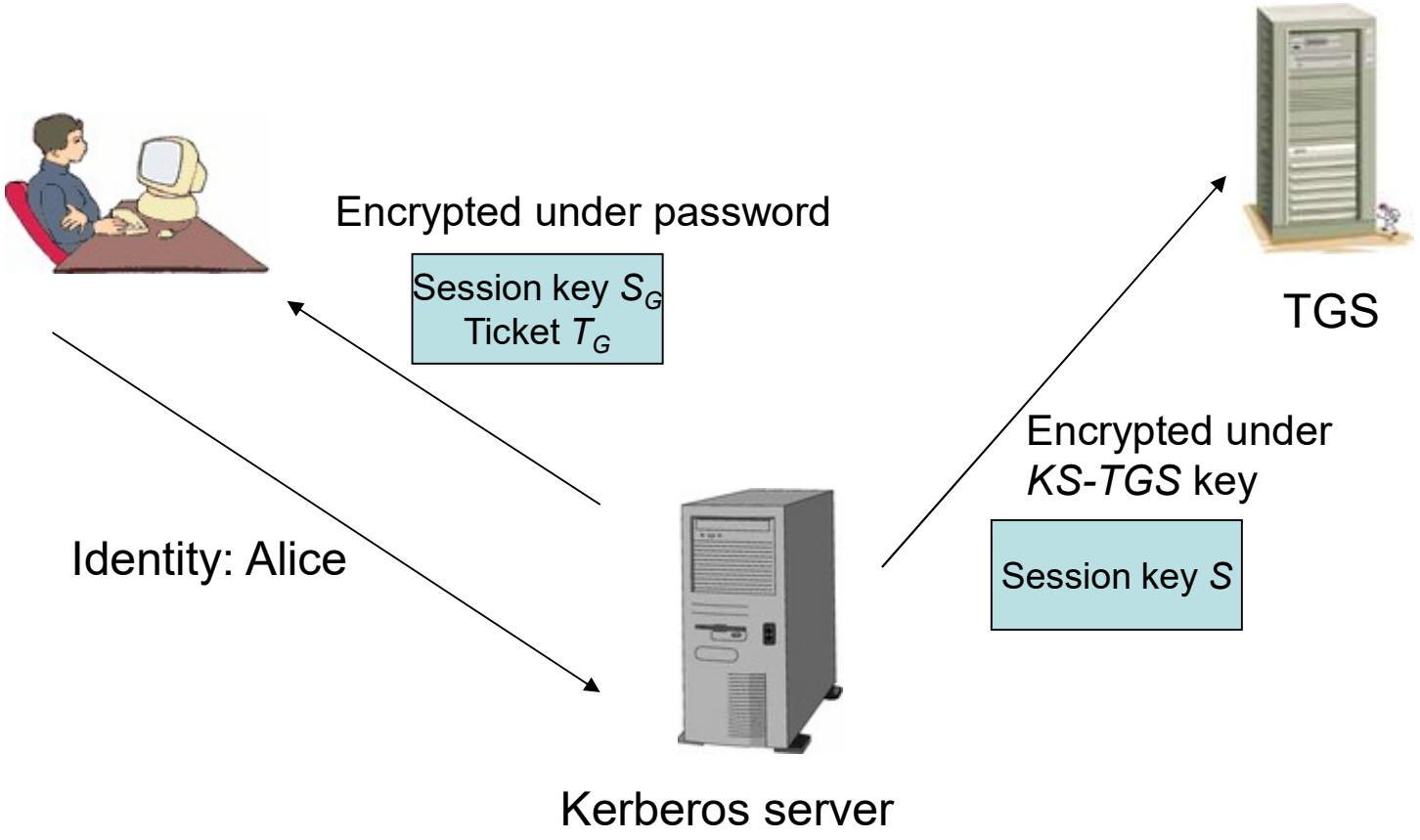


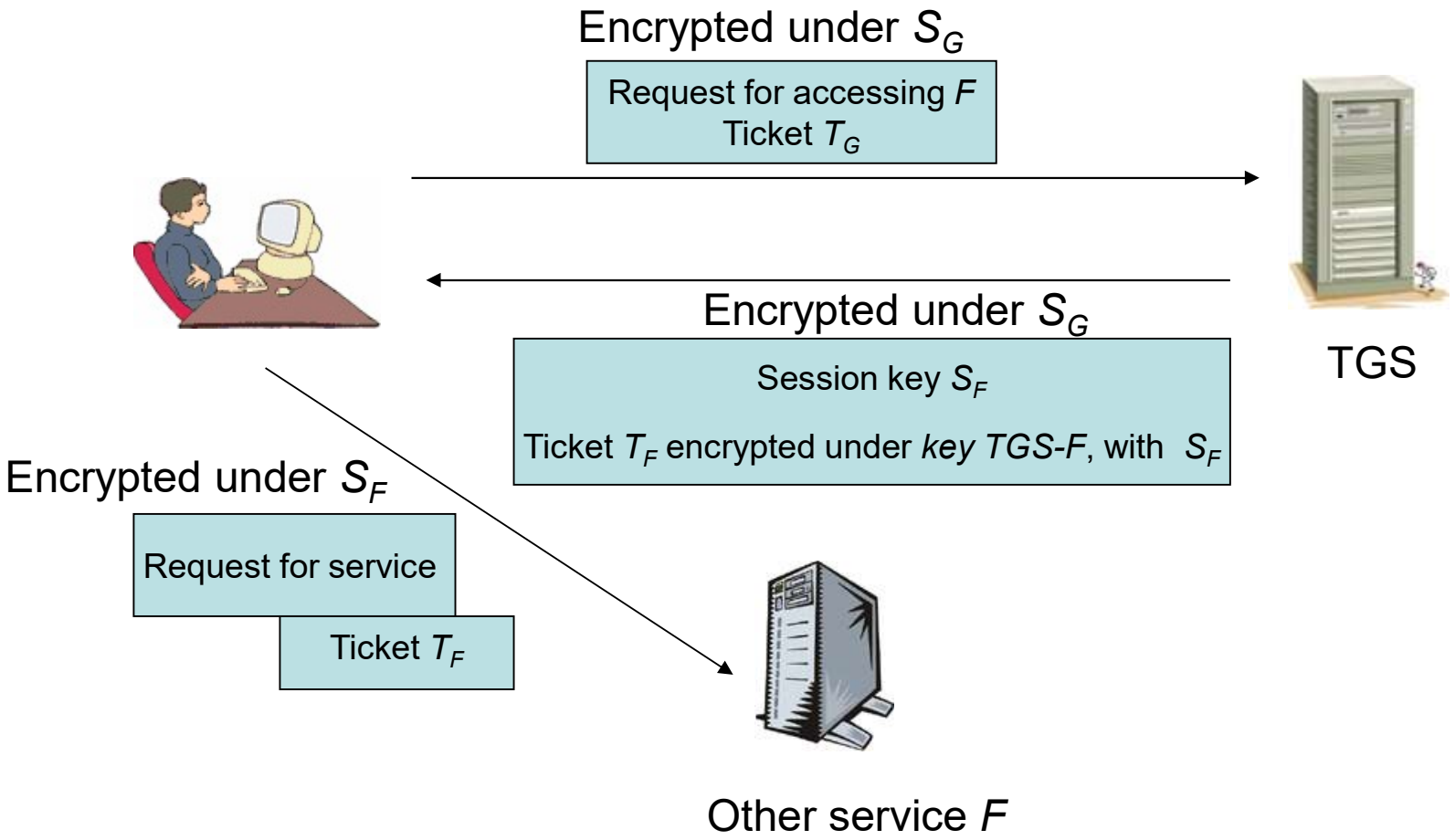
Kerberos

- Trusted 3rd party authentication protocol designed for TCP/IP networks
  - Based on Needham-Schroeder + timestamp
- Kerberos ticket
  - An authentication/access control token with username, service, time and control information
- Actors in Kerberos system
  - Clients
  - Kerberos server
  - Ticket-Granting Server (TGS)
  - Other servers

Initiating a Kerberos session



Obtain a ticket to access a service



Security strength of Kerberos

- No passwords passing on the network
- Protection against spoofing
- Limited period of validity
- Timestamps to prevent replay attacks
- Mutual authentication
  - 1+user's timestamp

Kerberos Vulnerabilities

- Require continuous availability of a trusted TGS
- Require a trusted relation between TGS and *F*
- Require timely transactions
- A subverted workstation saves passwords
- Password guessing works
- Kerberos does not scale well