Computer Security: Principles and Practice

Fourth Edition

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Chapter 3

User Authentication

NIST SP 800-63-3 (*Digital Authentication Guideline*, October 2016) defines digital user authentication as:

"The process of **establishing confidence in user identities** that are presented electronically to an information system."

Table 3.1 Identification and Authentication Security Requirements (SP 800-171)

	Basic Security Requirements:
1	Identify information system users, processes acting on behalf of users, or devices.
2	Authenticate (or verify) the identities of those users, processes, or devices, as a prerequisite to allowing access to organizational information systems.
	Derived Security Requirements:
3	Use multifactor authentication for local and network access to privileged accounts and for network access to non-privileged accounts.
4	Employ replay-resistant authentication mechanisms for network access to privileged and non-privileged accounts.
5	Prevent reuse of identifiers for a defined period.
6	Disable identifiers after a defined period of inactivity.
7	Enforce a minimum password complexity and change of characters when new passwords are created.
8	Prohibit password reuse for a specified number of generations.
9	Allow temporary password use for system logons with an immediate change to a permanent password.
10	Store and transmit only cryptographically-protected passwords.
11	Obscure feedback of authentication information.

(Table can be found on page 65 in the textbook)

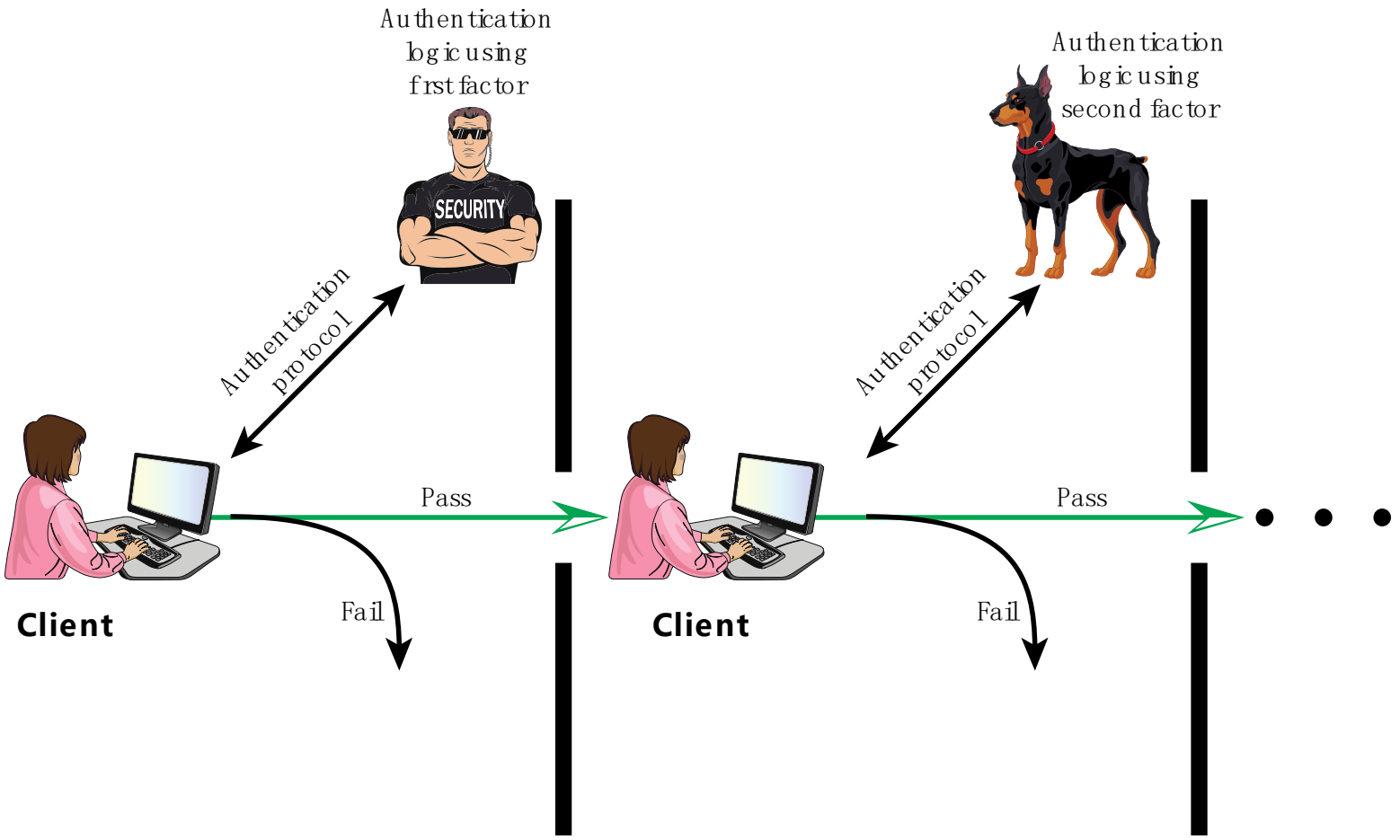


Figure 3.2 Multifactor Authentication

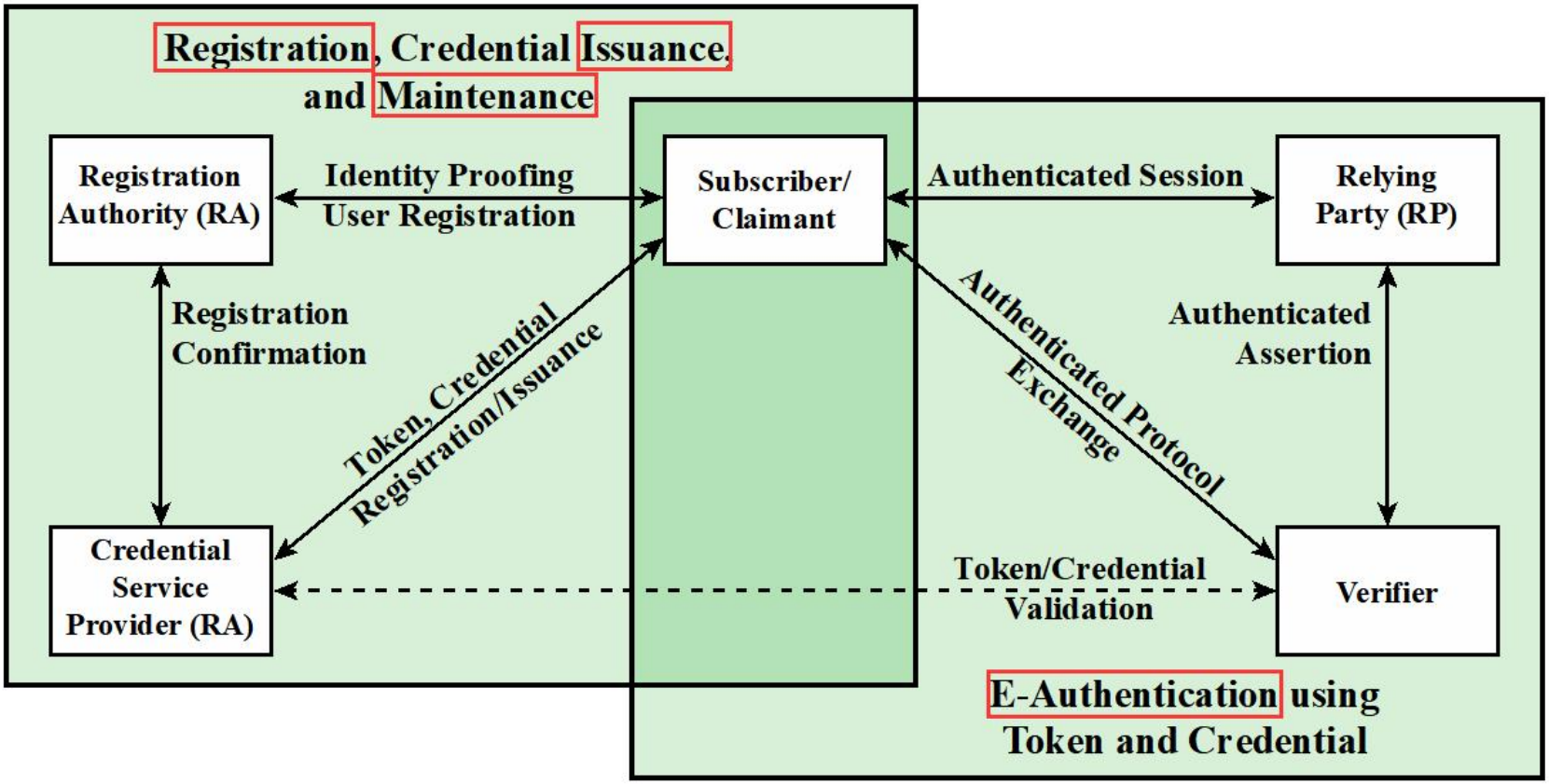


Figure 3.1 The NIST SP 800-63-2 E-Authentication Architectural Model

The four means of authenticating user identity are based on:

Something the individual knows

- Password, PIN, answers to prearranged questions

Something the individual possesses (token)

- Smartcard, electronic keycard, physical key

Something the individual is (static biometrics)

- Fingerprint, retina, face

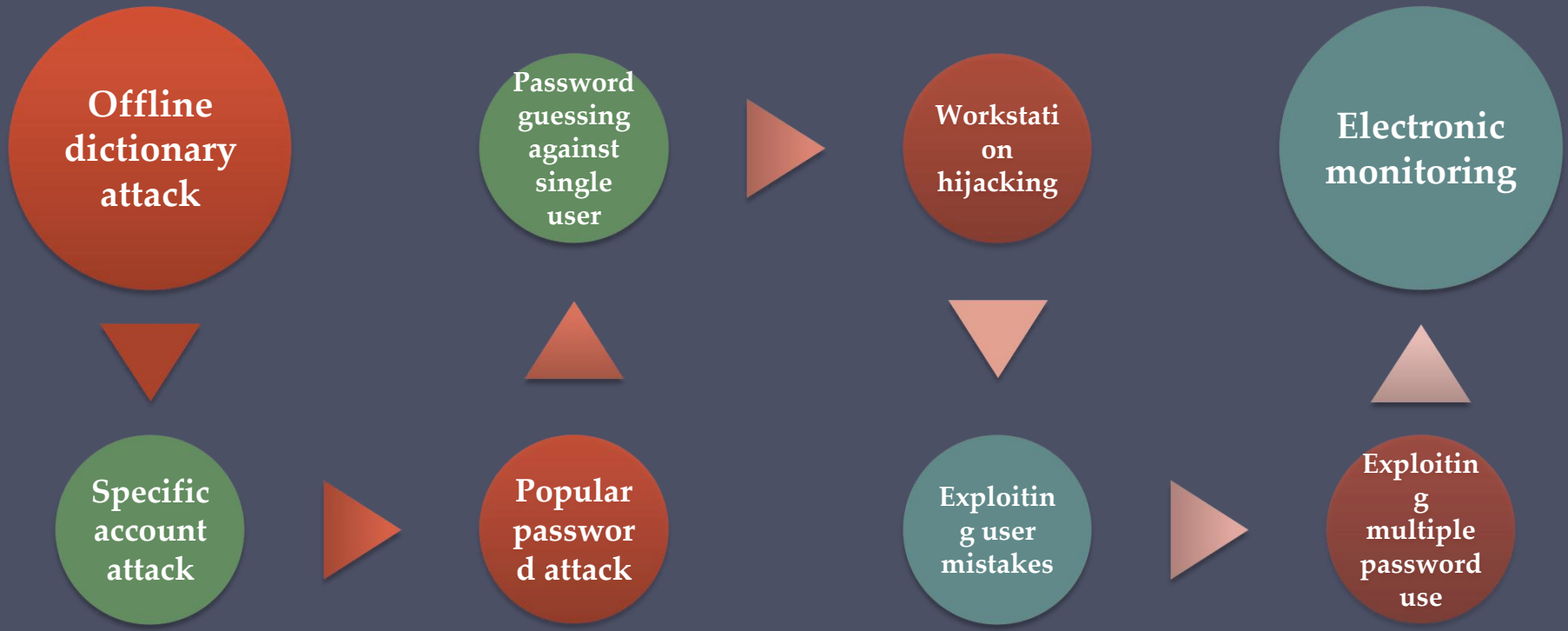
Something the individual does (dynamic biometrics)

- Voice pattern, handwriting, typing rhythm

Password-Based Authentication

- Widely used line of defense against intruders
  - User provides **name/login** and **password**
  - System **compares password** with the one stored for that specified login
- The user ID:
  - Determines that the user is **authorized** to access the system
  - Determines the **user's privileges**
  - Is used in **discretionary access control**

Password Vulnerabilities



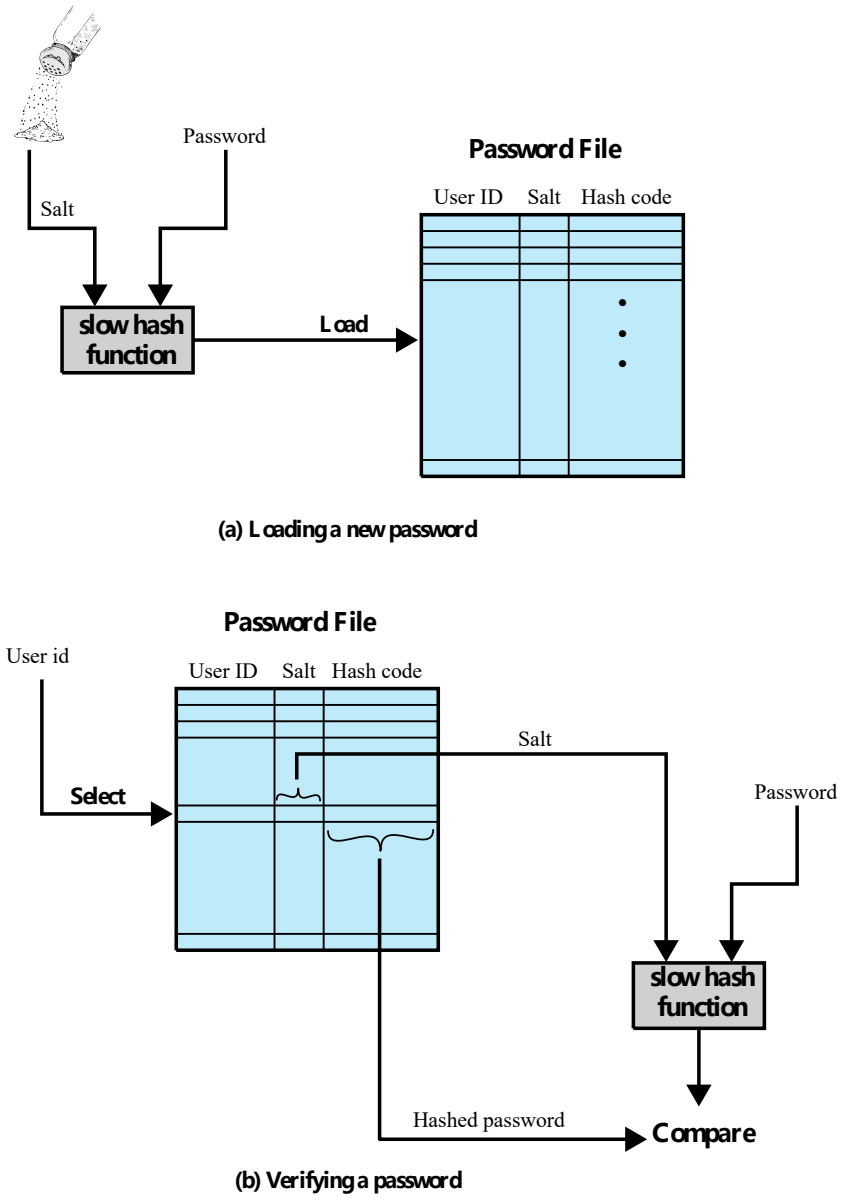


Figure 3.3 UNIX Password Scheme

Password Cracking

Dictionary attacks

- Develop **a large dictionary of possible passwords** and try each against the password file
- **Each password** must be hashed using **each salt value** and then compared to **stored hash values**

Rainbow table attacks

- Pre-compute **tables of hash values for all salts**
- A mammoth table of hash values
- Can be **countered** by using **a sufficiently large salt value** and **a sufficiently large hash length**

Password crackers exploit the fact that people choose **easily guessable passwords**

- **Shorter** password lengths are also easier to crack

John the Ripper

- **Open-source password cracker** first developed in 1996
- Uses a **combination of brute-force and dictionary** techniques

Modern Approaches

- Complex password policy
  - Forcing users to pick **stronger passwords**
- However **password-cracking techniques** have also improved
  - The **processing capacity** available for password cracking has increased dramatically
  - The use of **sophisticated algorithms** to generate potential passwords
  - Studying **examples and structures** of actual passwords in use

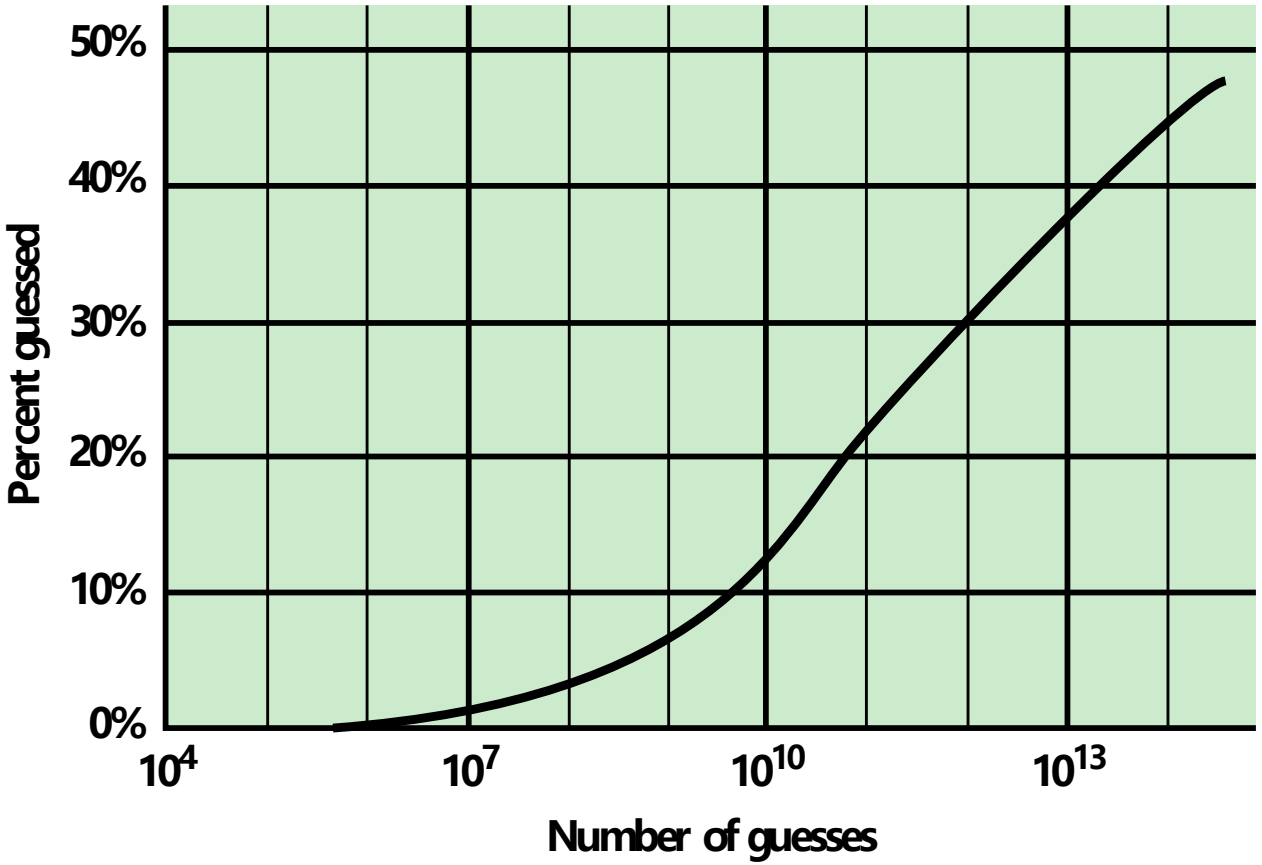


Figure 3.4 The Percentage of Passwords Guessed After a Given Number of Guesses

Password File Access Control

Can block offline guessing attacks by **denying access to encrypted passwords**

- Make available only to privileged users
- Shadow password file

Vulnerabilities

- **Weakness** in the OS that allows access to the file
- **Accident** with permissions making it readable
- **Users with same password** on other systems
- Access from **backup media**
- **Sniff passwords** in network traffic

Password Selection Strategies

User education

Users can be told the importance of using hard to guess passwords and can be provided with guidelines for selecting strong passwords

Computer generated passwords

Users have trouble remembering them

Reactive password checking

System periodically runs its own password cracker to find guessable passwords

Complex password policy

User is allowed to select their own password, however the system checks to see if the password is allowable, and if not, rejects it

Goal is to eliminate guessable passwords while allowing the user to select a password that is memorable

Table 3.3

Card Type	Defining Feature	Example
Embossed	Raised characters only, on front	Old credit card
Magnetic stripe	Magnetic bar on back, characters on front	Bank card
Memory	Electronic memory inside	Prepaid phone card
Smart Contact Contactless	Electronic memory and processor inside Electrical contacts exposed on surface Radio antenna embedded inside	Biometric ID card

Types of Cards Used as Tokens

Memory Cards

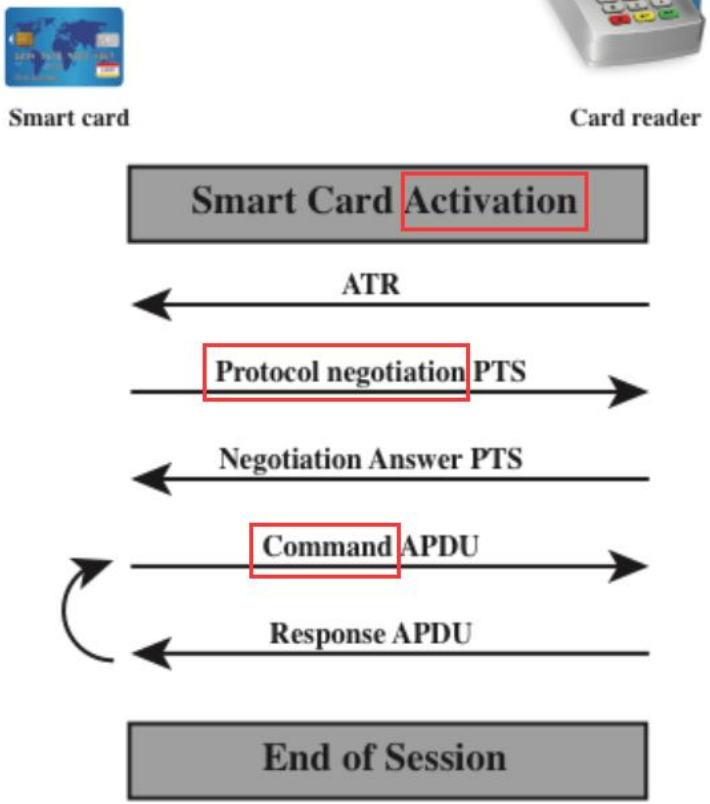
- Can **store** but do **not process** data
- The most common is the **magnetic stripe card**
- Can include an **internal electronic memory**
- Can be used alone for **physical access**
  - Hotel room
  - ATM
- Provides significantly greater security when **combined with a password or PIN**
- **Drawbacks** of memory cards include:
  - Requires a **special reader**
  - **Loss** of token
  - User **dissatisfaction**

Smart Tokens

- Physical characteristics:
  - Include an **embedded microprocessor**
  - A smart token that looks like a bank card
  - Can look like calculators, keys, small portable objects
- User interface:
  - Manual interfaces include a **keypad** and **display** for human/token interaction
- Electronic interface
  - A smart card or other token requires an **electronic interface** to communicate with a compatible reader/writer
  - **Contact** and **contactless** interfaces
- Authentication protocol:
  - Classified into three categories:
    - **Static**
    - **Dynamic password** generator
    - **Challenge-response**

Smart Cards

- **Most important category of smart token**
  - Has the **appearance of a credit card**
  - Has an **electronic interface**
  - May use any of the **smart token protocols**
- Contain:
  - An **entire microprocessor**
    - Processor
    - Memory
    - I/O ports
- Typically include **three types of memory**:
  - **Read-only** memory (ROM)
    - Stores data that does not change during the card's life
  - **Electrically erasable programmable** ROM (EEPROM)
    - Holds application data and programs
  - **Random access memory** (RAM)
    - Holds temporary data generated when applications are executed



APDU = application protocol data unit
ATR = Answer to reset
PTS = Protocol type selection

Figure 3.6 Smart Card/Reader Exchange

Electronic Identity Cards (eID)

Use of a smart card as a **national identity card** for citizens

Can serve the same purposes as other national ID cards, and similar cards such as a driver's license, for **access to government and commercial services**

Can provide **stronger proof of identity** and can be used in a wider variety of applications

In effect, is a smart card that has been **verified by the national government** as valid and authentic

Most advanced deployment is the **German card** *neuer Personalausweis*

Has **human-readable data** printed on its surface

- Personal data
- Document number
- Card access number (CAN)
- Machine readable zone (MRZ)

Function	Purpose	PACE Password	Data	Uses
ePass (mandatory)	Authorized offline inspection systems read the data	CAN or MRZ	Face image; two fingerprint images (optional), MRZ data	Offline biometric identity verification reserved for government access
eID (activation optional	Online applications read the data or acess functions as authorized	eID PIN	Family and given names; artistic name and doctoral degree: date and place of birth; address and community ID; expiration date	Identification; age verification; community ID verification; restricted identification (pseudonym); revocation query
	Offline inspection systems read the data and update the address and community ID	CAN or MRZ		
eSign (certificate optional	A certification authority installs the signature certificate online	eID PIN	Signature key; X.509 certificate	Electronic signature creation
	Citizens make electronic signature with eSign PIN	CAN		

Table 3.4

Electronic Functions and Data for eID Cards

CAN = card access number
MRZ = machine readable zone
PACE = password authenticated connection establishment
PIN = personal identification number

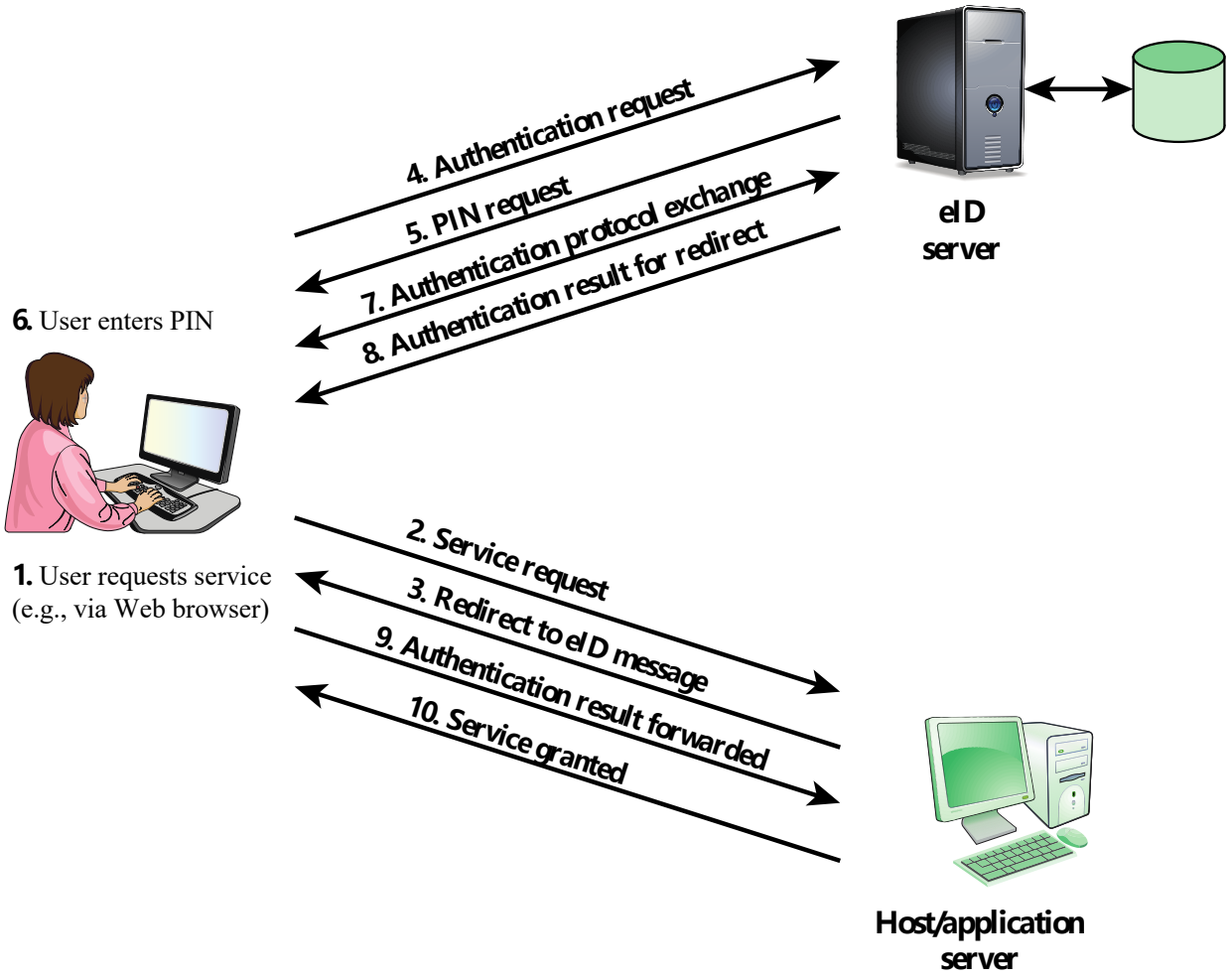


Figure 3.7 User Authentication with eID

Password Authenticated Connection Establishment (PACE)

Ensures that the contactless RF chip in the eID card cannot be read without explicit **access control**

For online applications, access is established by the user entering the **6-digit PIN** (which should only be known to the holder of the card)

For offline applications, either the **MRZ** printed on the back of the card or the six-digit card access number (**CAN**) printed on the front is used

Biometric Authentication

- Attempts to authenticate an individual based on unique **physical characteristics**
- Based on **pattern recognition**
- Is technically complex and expensive when compared to **passwords** and **tokens**
- Physical characteristics used **include**:
  - Facial characteristics
  - Fingerprints
  - Hand geometry
  - Retinal pattern
  - Iris
  - Signature
  - Voice

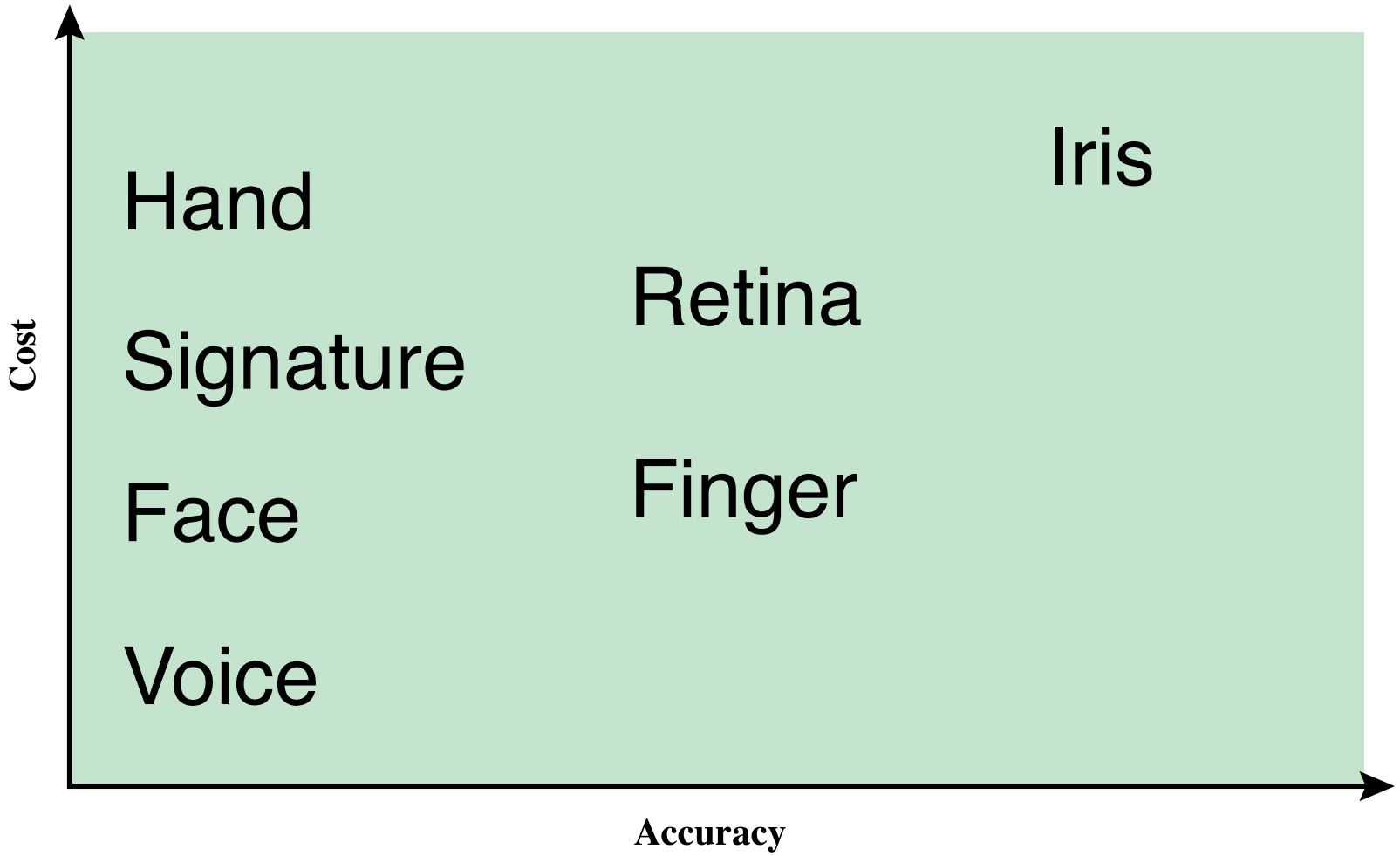


Figure 3.8 Cost Versus Accuracy of Various Biometric Characteristics in User Authentication Schemes.

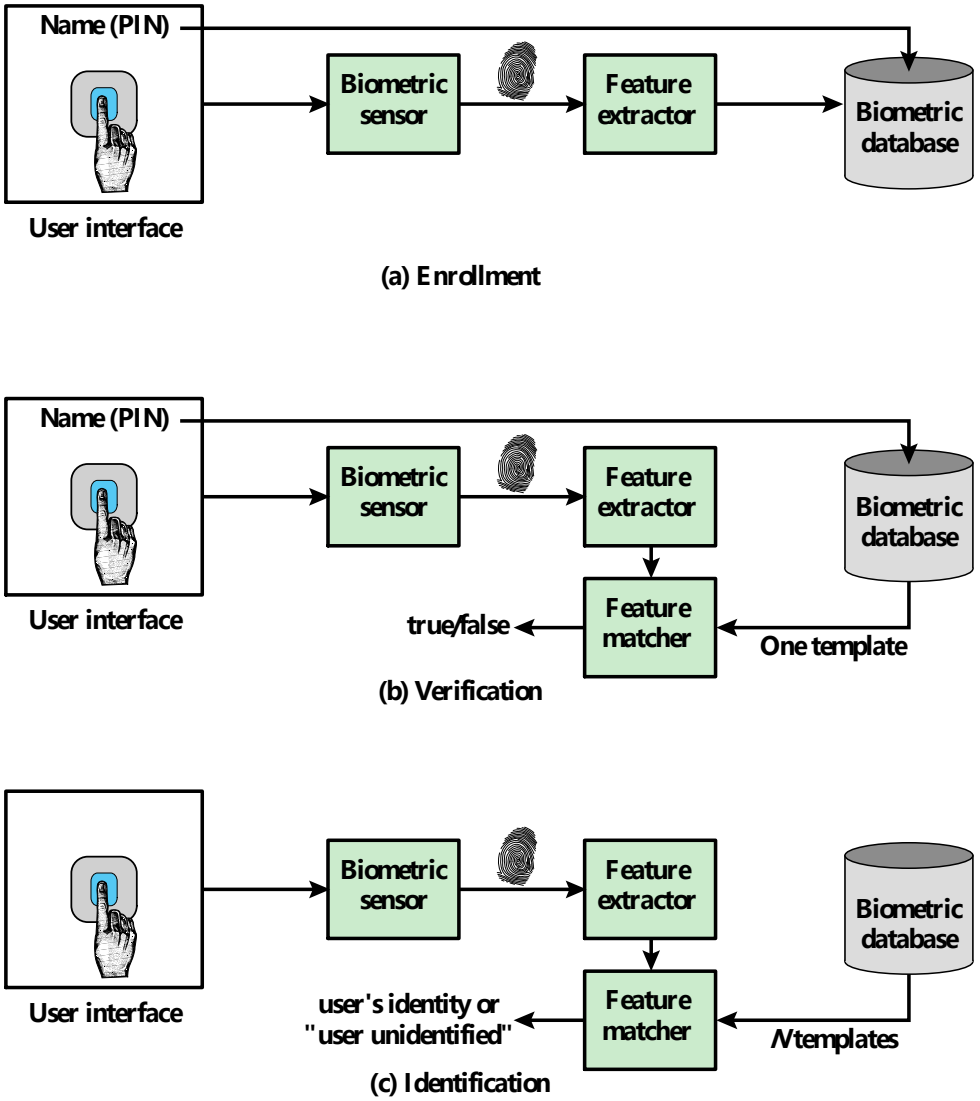
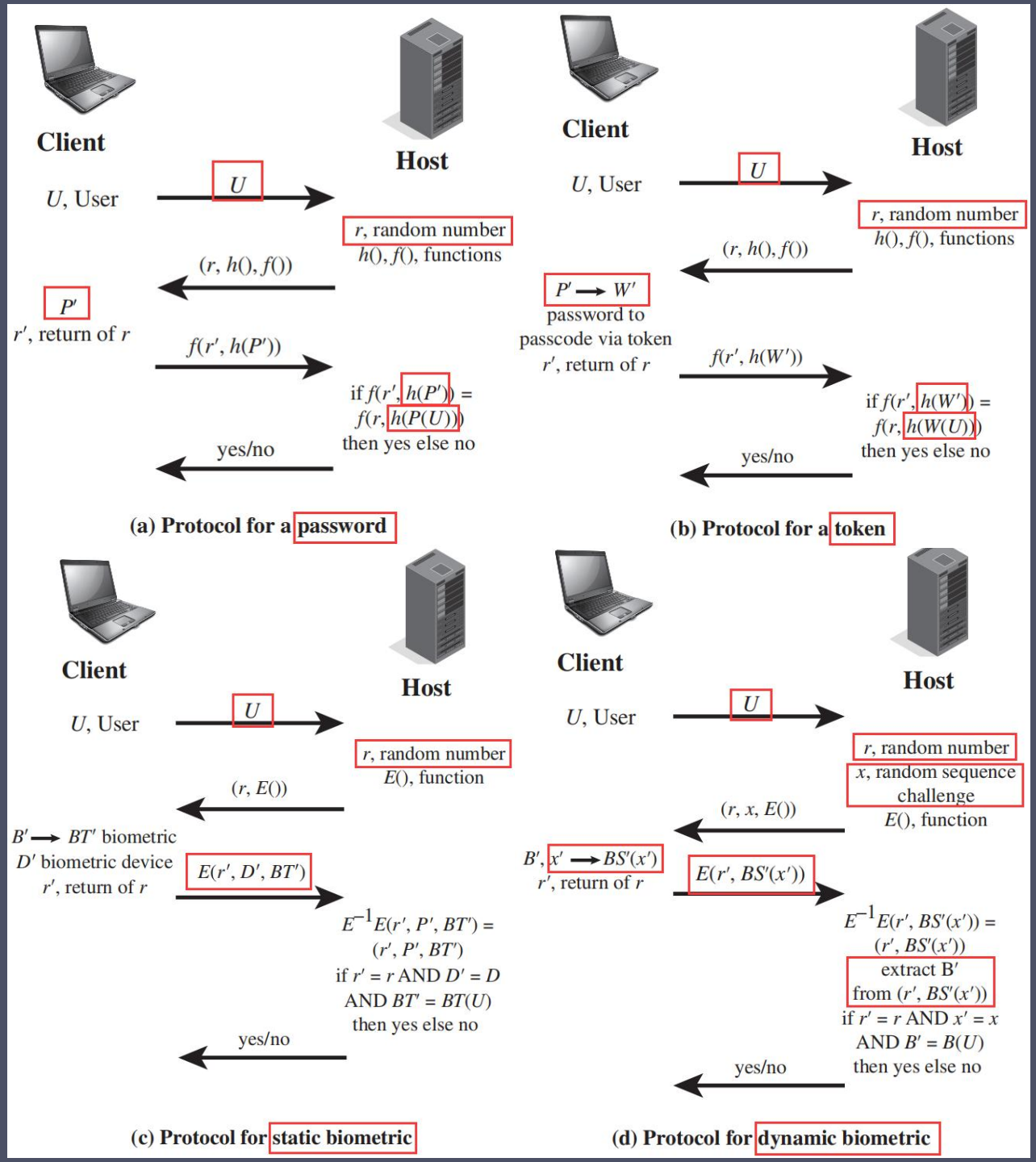


Figure 3.9 A Generic Biometric System. Enrollment creates an association between a user and the user's biometric characteristics. Depending on the application, user authentication either involves verifying that a claimed user is the actual user or identifying an unknown user.

Remote User Authentication

- Authentication over a network, the Internet, or a communications link is more complex
- **Additional security threats** such as:
  - **Eavesdropping**, **capturing** a password, **replaying** an authentication sequence that has been observed
- Generally rely on some form of a **challenge-response protocol** to counter threats

Figure 3.13 Basic **Challenge-Response** Protocols for **Remote User Authentication**



Attacks	Authenticators	Examples	Typical defenses
Client attack	Password	Guessing, exhaustive search	Large entropy; limited attempts
	Token	Exhaustive search	Large entropy; limited attempts, theft of object requires presence
	Biometric	False match	Large entropy; limited attempts
Host attack	Password	Plaintext theft, dictionary/exhaustive search	Hashing; large entropy; protection of password database
	Token	Passcode theft	Same as password; 1-time passcode
	Biometric	Template theft	Capture device authentication; challenge response
Eavesdropping, theft, and copying	Password	"Shoulder surfing"	User diligence to keep secret; administrator diligence to quickly revoke compromised passwords; multifactor authentication
	Token	Theft, counterfeiting hardware	Multifactor authentication; tamper resistant/evident token
	Biometric	Copying (spoofing) biometric	Copy detection at capture device and capture device authentication
Replay	Password	Replay stolen password response	Challenge-response protocol
	Token	Replay stolen passcode response	Challenge-response protocol; 1-time passcode
	Biometric	Replay stolen biometric template response	Copy detection at capture device and capture device authentication via challenge-response protocol
Trojan horse	Password, token, biometric	Installation of rogue client or capture device	Authentication of client or capture device within trusted security perimeter
Denial of service	Password, token, biometric	Lockout by multiple failed authentications	Multifactor with token

Table 3.5

Some Potential Attacks, Susceptible Authenticators, and Typical Defenses

(Table is on page 96 in the textbook)


AUTHENTICATION SECURITY ISSUES
Eavesdropping
Adversary attempts to learn the password by some sort of attack that involves the physical proximity of user and adversary
Host Attacks
Directed at the user file at the host where passwords, token passcodes, or biometric templates are stored
Denial-of-Service
Attempts to disable a user authentication service by flooding the service with numerous authentication attempts
Replay
Adversary repeats a previously captured user response
Trojan Horse
An application or physical device masquerades as an authentic application or device for the purpose of capturing a user password, passcode, or biometric
Client Attacks
Adversary attempts to achieve user authentication without access to the remote host or the intervening communications path

Summary

- Digital user authentication principles
  - A model for digital user authentication
  - Means of authentication
  - Risk assessment for user authentication
- Password-based authentication
  - The vulnerability of passwords
  - The use of hashed passwords
  - Password cracking of user-chosen passwords
  - Password file access control
  - Password selection strategies
- Token-based authentication
  - Memory cards
  - Smart cards
  - Electronic identity cards
- Biometric authentication
  - Physical characteristics used in biometric applications
  - Operation of a biometric authentication system
  - Biometric accuracy
- Remote user authentication
  - Password protocol
  - Token protocol
  - Static biometric protocol
  - Dynamic biometric protocol
- Security issues for user authentication

作业

- 英文教材（第四版）P124-125
- Questions 3.1, 3.3
- Problems 3.1, 3.2, 3.8