Technische Universität Braunschweig

IAS | INSTITUTE FOR APPLICATION SECURITY

# Authentication & Access Control

## Vorlesung “Einführung in die IT-Sicherheit”

Prof. Dr. Martin Johns

# Overview

- **Topic of the unit**
  - Authentication and Access Control
- **Parts of the unit**
  - Part #1: Basics of authentication
  - Part #2: Passwords and their problems
  - Part #3: Challenge-response authentication
  - Part #4: Access control techniques

# Authentication

- **Authentication** = binding of an identity to a subject


- **Confirmation of identity by ...**
  - Knowledge factors = what the subject knows
  - Ownership factors = what the subject has
  - Human factors = what the subject is

# Authentication by Knowledge

- **Subject confirms identity by knowledge**
  - e.g. shared secrets, individual knowledge, …


+ **Advantages**
  - Simple deployment without special hardware
  - Replacement of secrets easy in case of compromise

– **Disadvantages**
  - Memory capabilities of human brain limited
  - Confidentiality not guaranteed, e.g. sticky notes

# Authentication by Ownership

- **Subject confirms identity by ownership**
  - e.g. chip cards, security tokens, smartphones, …


\+ **Advantages**
  - Handling similar to physical keys, e.g. Yubikey
  - Cloning and replication usually difficult

– **Disadvantages**
  - Loss and theft of device problematic
  - Often need for special hardware

# Authentication by Biometry

- **Subject confirms identity through human factors**
  - e.g., fingerprint, iris patterns, typing behaviour …

\+ **Advantages**
  - Ideal binding between subject and identity
  - Biometric features naturally available to subject

– **Disadvantages**
  - Replacement of biometric features difficult (⚠ Privacy)
  - Evasion resistance still open research question

# Multi-Factor Authentication

- **Authentication using multiple factors**
  - Example: Scene from the movie “Mission Impossible”

Ethan Hunt needs to

1. … use a stolen chip card (ownership factor)
2. … fake an IRIS scan (human factor)
3. … enter a password (knowledge factor)

# Multi-Factor Authentication

- **Authentication with two factors**
  - No science fiction — we all use it regularly
- **Payment with credit card**
  - Scan of credit card (Ownership)
  - Hand-written signature (Human factor)


- **Payment with debit card**
  - Scan of debit card (Ownership)
  - Input of card PIN (Knowledge)

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# Passwords

- **Password** = information confirming the identity of user
  - Knowledge of a secret word, phrase or number


- **Often combination with (a)symmetric cryptography**
  - e.g. password is mapped to key of symmetric cipher
  - e.g. password protects private key of public-key algorithm
  - ~~Passwords are just great.~~ Wait, it's not that easy…

# Problems with Passwords

- **Password snooping**
  - Eavesdropping of passwords in network traffic
  - Retrieval of passwords from hosts (e.g. via malware)
- **Password guessing** (online) **or cracking** (offline)
  - Dictionary attacks = guessing using dictionary of words
  - Brute-force attacks = guessing using all possible strings
- **Human deficiencies**
  - Weak and often re-used passwords

Let's fix some of these problems

# Password Storage

- **Passwords should never be stored in clear**
  - Application of cryptographic one-way functions
  - Only encoded (hashed) passwords are stored
- **Example:** `$hashed_pw = hash($password);`
  - Simple to validate: `hash($input) == $hashed_pw?`
  - Hard to deduce password from strong hash function
- **Efficient cracking of stored passwords still possible**
  - Brute-force or dictionary attack using hashed strings

# Salted Passwords

- **Encoding of password with random string (salt)**
  - Example: `$hashed_pw = hash($password+$salt);`
  - Salt stored in clear with password `[$salt, $hashed_pw]`

  - **Cracking of multiple passwords more expensive**
    - Same password maps to different hash values
    - Pre-computation of hashes not possible anymore
    - No difference when cracking a single password
- Security depends on quality of password, hash and salt

# Slowing-down Crackers

- **Key stretching**
  - Costly encoding of passwords (e.g. through iterations)
  - Useful for password storage and derivation of keys
  - Direct effect on speed of cracking attempts
- **Some examples**
  - CRYPT: 25 iterations with DES variant and salt
  - PBKDF2: >1000 iterations with PRF (e.g. hash) and salt

```
def simple(password, salt, iter, key=‘’):
                for i in iter:
        key = hash(key + password + salt)
```

# Good Passwords?

- **Testing for insecure passwords is very easy**
  - A laptop can test millions of MD5 hashs per hour
- **Passwords should be very hard to guess**
  - No dictionary words, names, dates and patterns
  - Simple transformations (e.g. reversing) not sufficient
  - Minimum length and diversity of passwords
- **Study by Mazurek et al. (CCS 2013)**
  - ~50% of 25k passwords cracked within one week

# Choosing a Good Password

- **Not that easy**
  - Simple translations well-known (e.g., leet speak)
  - Human memory vs. cracking capabilities
  - Partial solution using password managers
- Hint: **simply pick a phrase instead of a word**
  - "I see dead people." = `iSeeDeadPpl.`
- However: **Avoidance of too common phrases**
  - `2bon2b` found in 4 out of 30 million passwords

# Incident: Rockyou.com

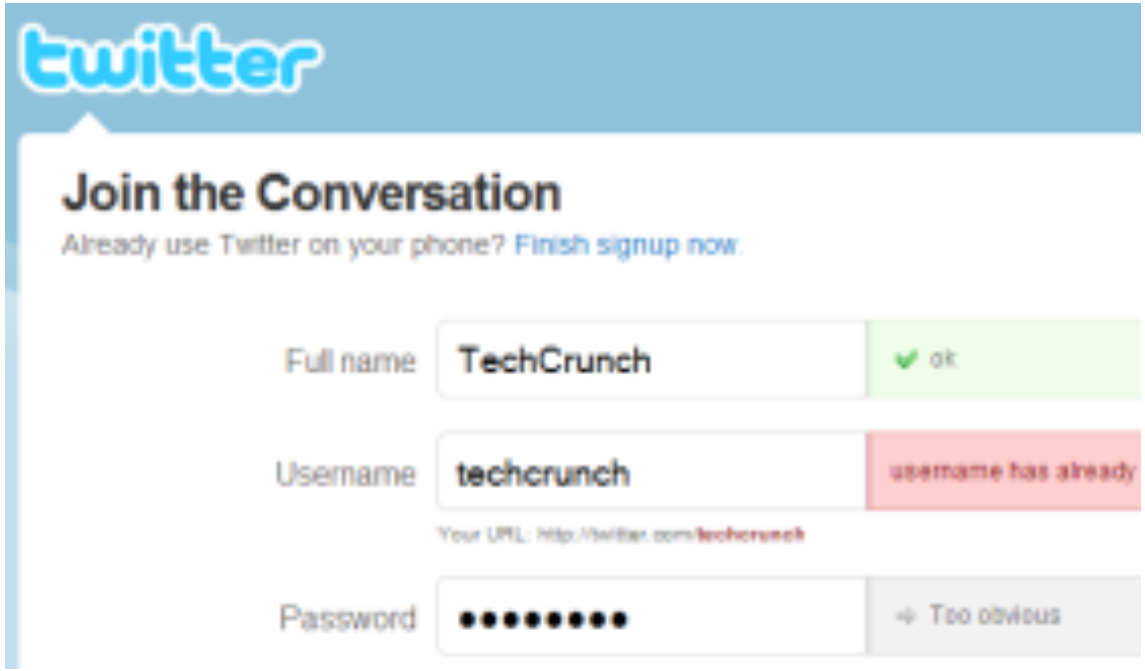
- **The Incident**
  - In December 2009 the website rockyou.com was hacked
  - In this process, more than 32 million (?) passwords were stolen
  - All password were stored by rockyou in **plaintext**

# Incident: Rockyou.com

- **Passwords, so many passwords…**
  - Besides their "own" rockyou.com passwords, the site also stored the users' passwords for external accounts (e.g., Facebook)

# Banned Passwords at Twitter

- Back then Twitter used a blacklist of passwords considered to be “too easy/weak”
- If a user tried to set his/her password to one of these, the attempt was denied



# Banned Passwords at Twitter

- **Examples**
  - password
  - Testing
  - Naked
  - Stupid
  - twitter
  - 123456
  - secret
  - please
  - internet

# Reality Check

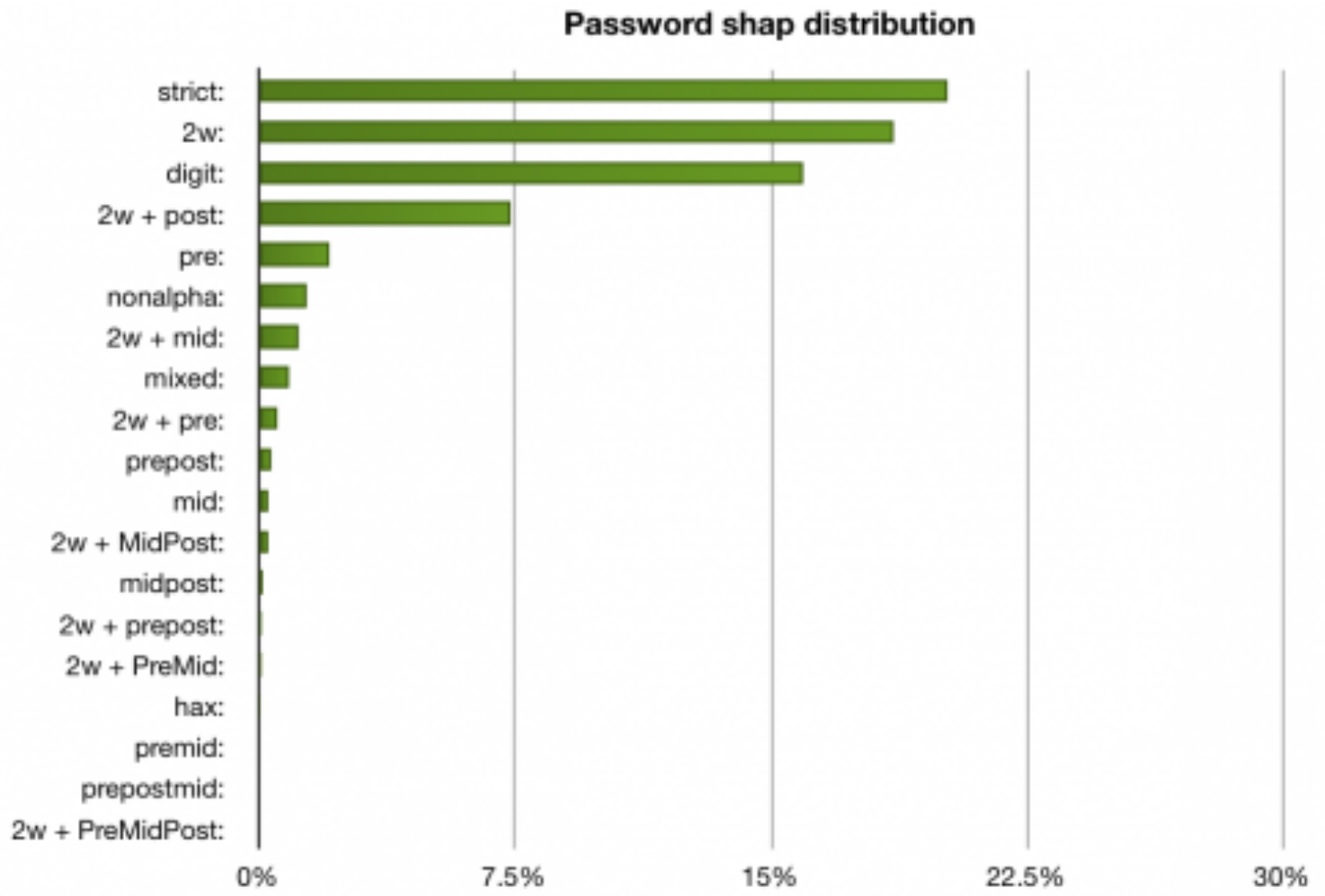
- **Comparison of Twitter's blacklist with the rockyou.com dataset**
  - 100 most frequent passwords from the rockyou data
  - Of these 100 words only **38** were not contained in twitter's list
  - And the remaining 38 were not really any more secure
    - 1234567 (Twitter only checked for 12345)
    - Lovely
    - chocolate
    - … and so on

https://reusablesec.blogspot.com/2009/12/rockyou-32-million-password-list-top.html

# Further analysis of the rockyou.com passwords

- **Elie Bursztein did further statistical analysis of the passwords**
  - Focus: How were the passwords constructed?
- **In particular**
  - How many words
  - Numbers?
  - If so: How many, which and where

# Further analysis of the rockyou.com passwords




http://elie.im/blog/

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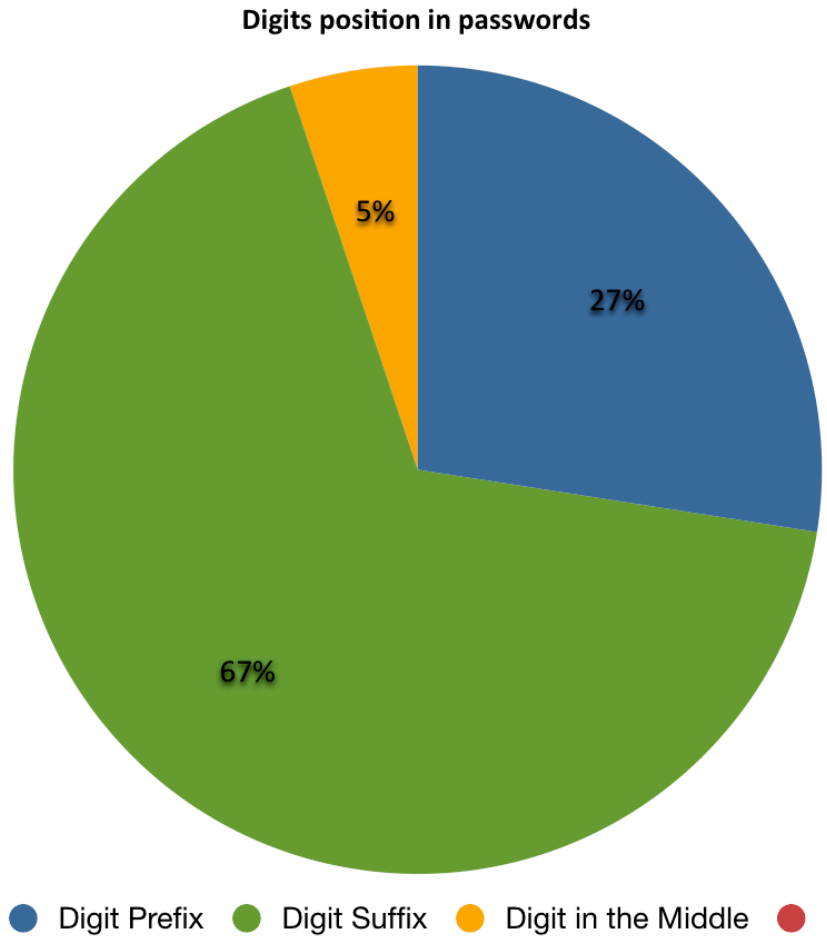


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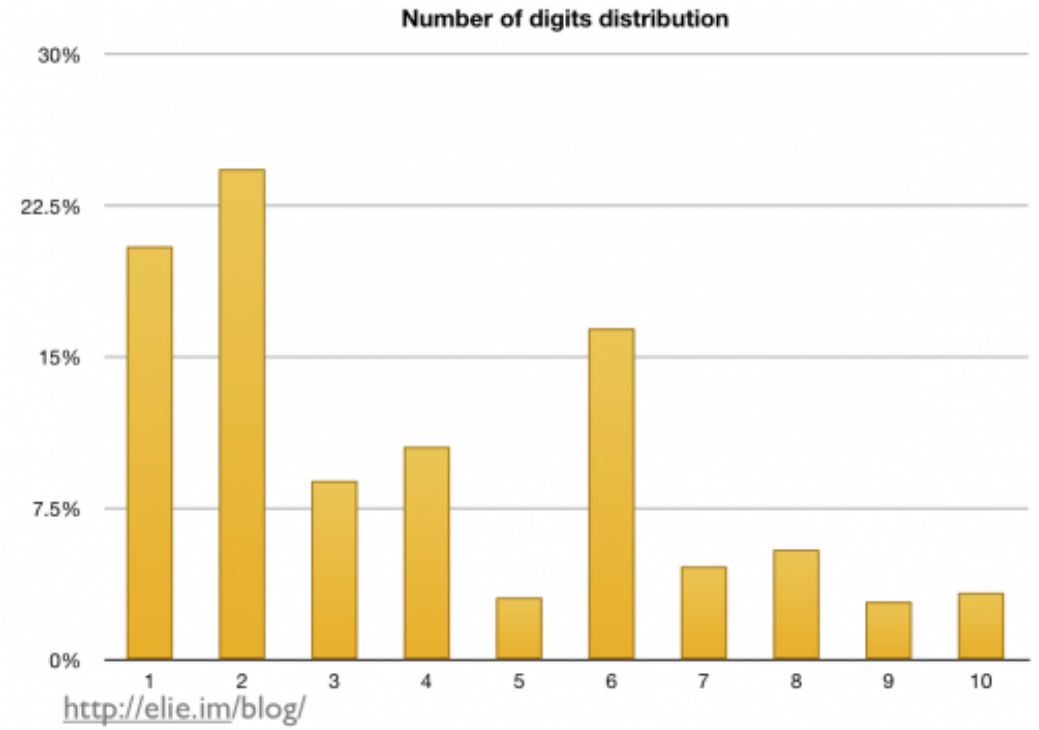


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# One-Time Passwords

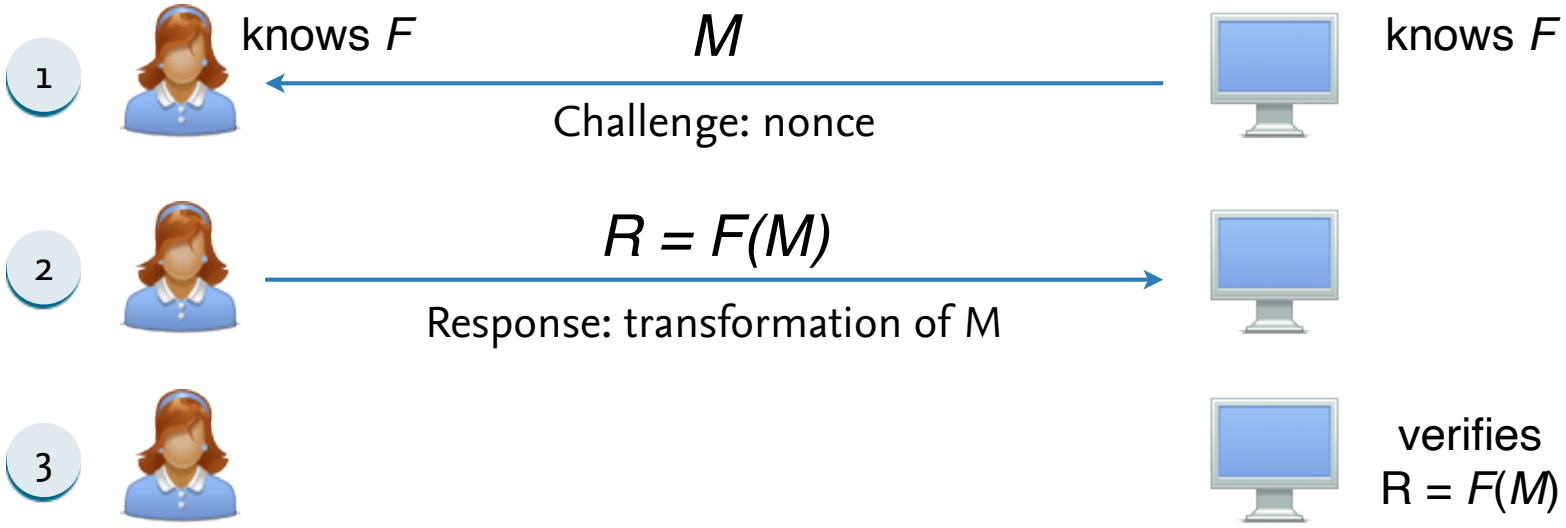
- **Security of passwords "weakens" over time**
  - Password aging = enforced changing of passwords
  - One-time passwords = passwords used exactly once
- Example: **S/KEY Algorithm from the 1980s**
  - User chooses initial key $K_1$
  - Recursive hashing: $H(K_1) = K_2$, $H(K_2) = K_3$, ... $H(K_{n-1}) = K_n$
  - One-time passwords: $P_1 = K_n$, $P_2 = K_{n-1}$, ... $P_n = K_1$
  - Hard to deduce next password $P_i$ from previous $P_{i-1}$

# Example: **RSA SecurID**

- **Security system using two-factor authentication**
  - Factors: knowledge (password) and ownership (device)
  - Device generates authentication code every 60 seconds
  - Authentication using password and displayed code
- **Code Generation**
  - Device initialized for each user with seed (random number)
  - Code computed from seed and current time (~one-time password)

# Challenge-Response Authentication

- **Generic protocol scheme for authentication**
  - System and user share a secret function F
  - Knowledge of function F "challenged" using nonce M
  - Implicit confirmation using response R = F(M)



# Challenge-Response Authentication

- **Secret function often parameterized by password**
  - $F = H(M + P)$ hash function H and password P
  - $F = E_P(M)$ encryption function E and password P
  - Hard to deduce P if F is cryptographically strong
- **Several methods related to challenge-response scheme**
  - One-time passwords
    = challenge (index of password); response (password)
  - RSA SecurID
    = challenge (current time); response (authentication code)

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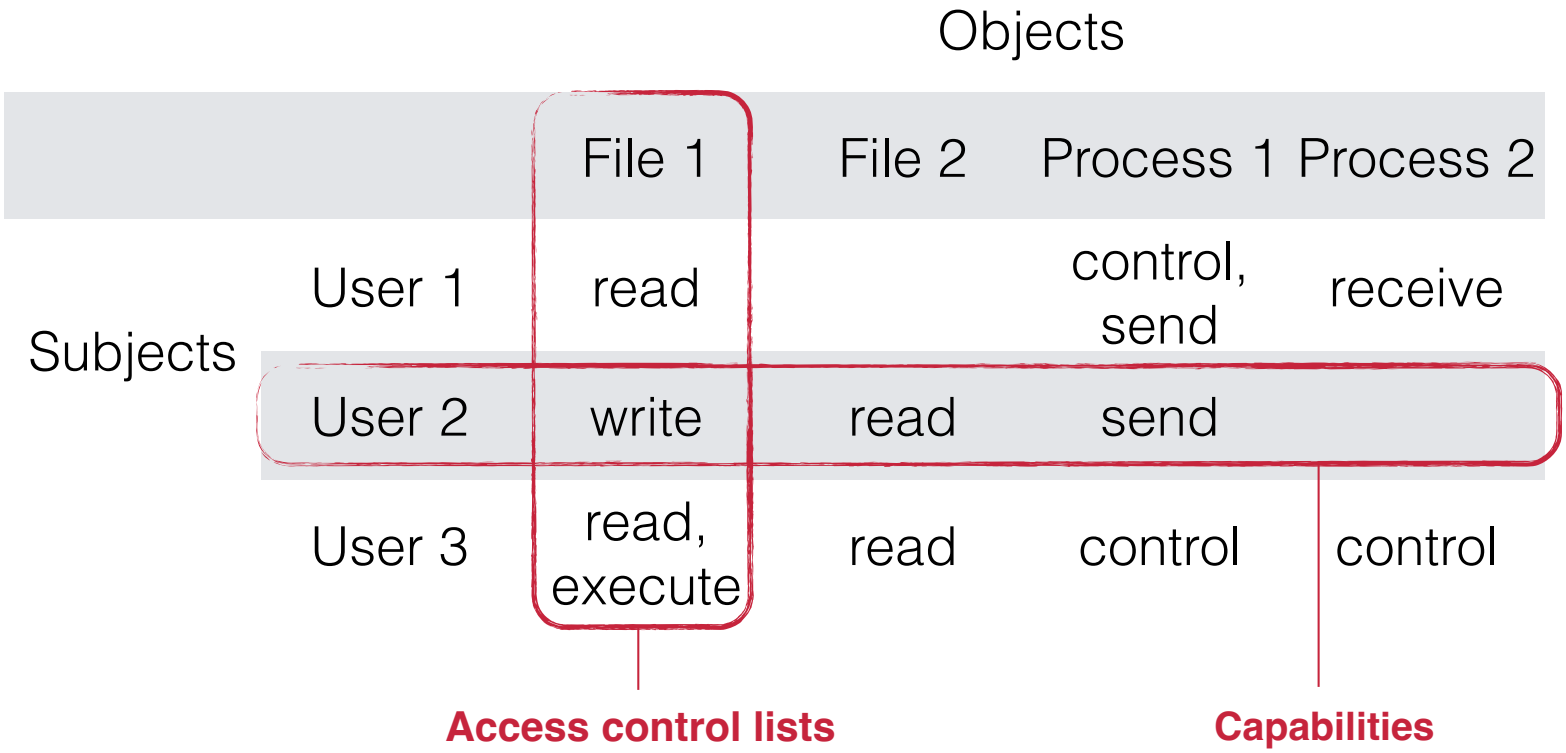
# Access Control


- **Authorization and access control**
  - Control of what a subject is allowed to do
  - Management of permissions and capabilities
  - Often tight coupling with authentication
- **Examples**
  - Execution of programs, reading of files, ...

# Access Control Matrix

- **Classic and simple representation for access control**
  - Mapping from subjects and objects to permissions



# Access Control Models

- **Access control non-trivial in practice**
  - Complex systems ⇝ complex access control models
- **Some characteristics of access control models**
  - Definition of objects and subjects
    e.g. subjects can be users, processes or hosts
  - Representation of permissions
    e.g. columns (access control lists), rows (capabilities)
  - Management of permissions
    e.g. discretionary, mandatory or role-based access control

# Representation: **Access Control Lists**

- **Access control lists (ACL)**
  - Attachment of permissions to objects (columns)
  - \+ Efficient and decentral organization of permissions
  - – Listing of subject permissions very involved
- Example: **OpenBSD packet filter**
  - Deny access to the SSH service from any host
  - → block in quick proto tcp from any to any port ssh

# Representation: **Capabilities**

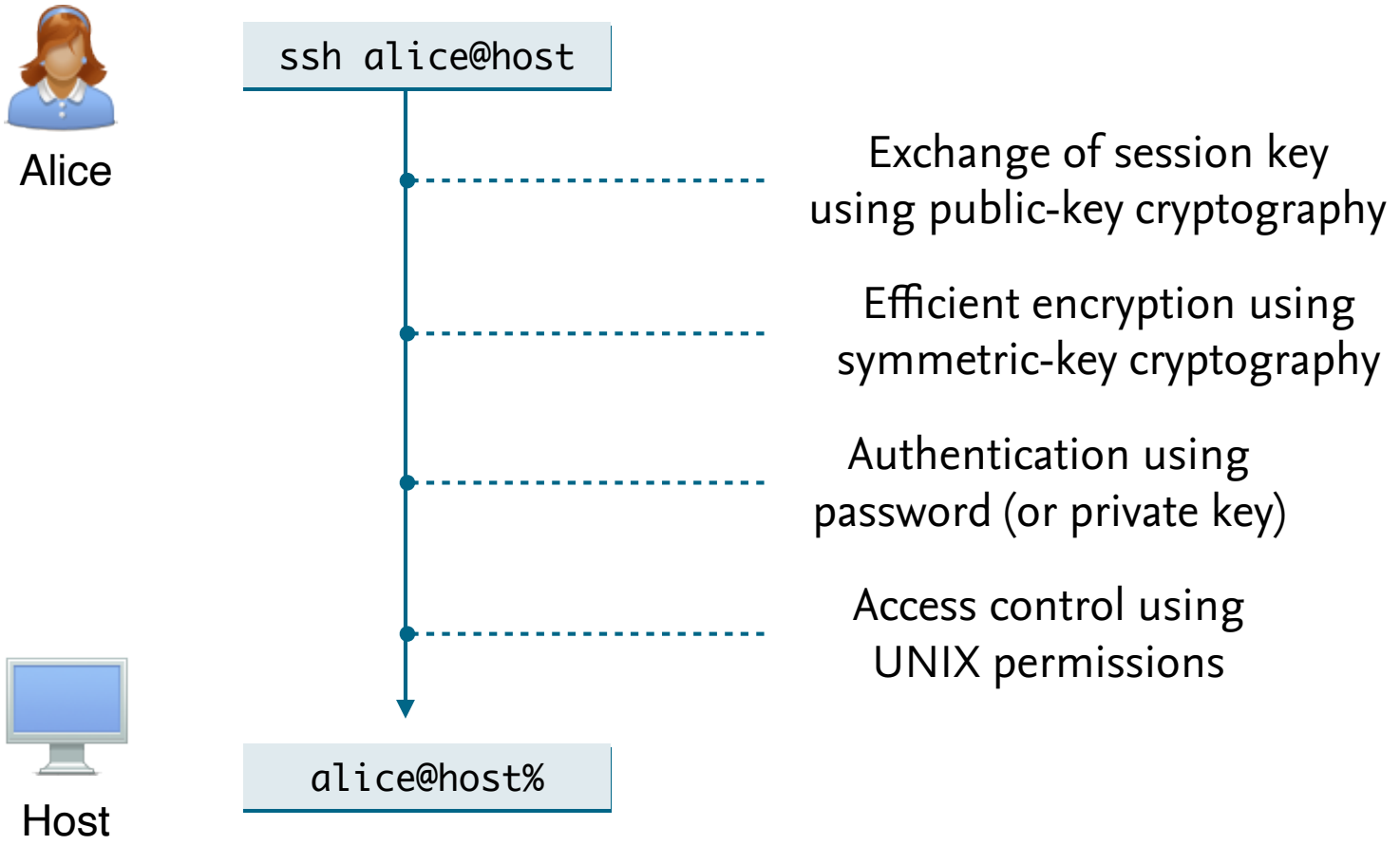
- **Capabilities**
  - Attachment of permissions to subjects (rows)
  - \+ Listing and control of subject permissions simple
  - – Fine-grained permissions difficult to implement
- Example: **Linux capabilities**
  - Restrict permissions to reboot system and load modules
  - → lcap -z CAP_SYS_BOOT CAP_SYS_MODULE

# Management of Permissions

- **Discretionary Access Control (DAC)**
  - Owner of an object controls access
  - Convenient but insecure if object changes owner
- **Mandatory Access Control (MAC)**
  - System globally enforces access control
  - Very secure but tedious to design and operate
- **Role-based Access Control (RBAC)**
  - System enforces access control using roles
  - In-between DAC and MAC models

# Summary

# … putting it together



# Summary

- **Authentication**
  - Key to binding identities to subjects
  - Binding relies on authentication factors
  - Passwords common but weak factor
- **Access Control and Authorization**
  - Definition and management of access control
  - Realizations using ACLs and capabilities