CSE 127: Computer Security

Security Concepts

Kirill Levchenko

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Computer Security

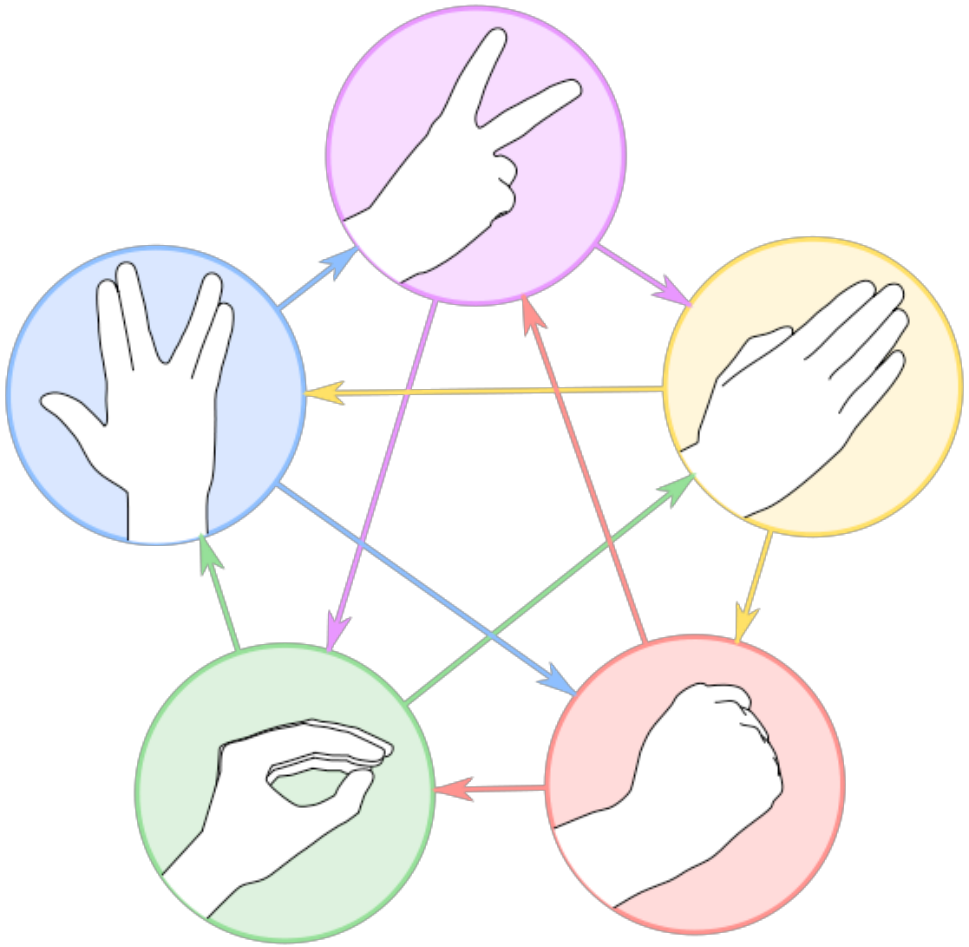
- Protection of systems against an **adversary**
- **Secrecy:** Can't *view* protected information
- **Integrity:** Can't *modify* protected information or process
- **Availability:** Can't deny access to system for other users

Adversary

- An **adversary** is someone who seeks an outcome detrimental to your interests
  - An *adversarial setting* involves implicit or explicit conflict
- An adversary is *rational* if he acts to maximize his payoff
  - We usually assume an adversary is rational

Adversarial Setting

- **Example:** Games
- Structured adversarial setting
- Opposing objectives well-defined



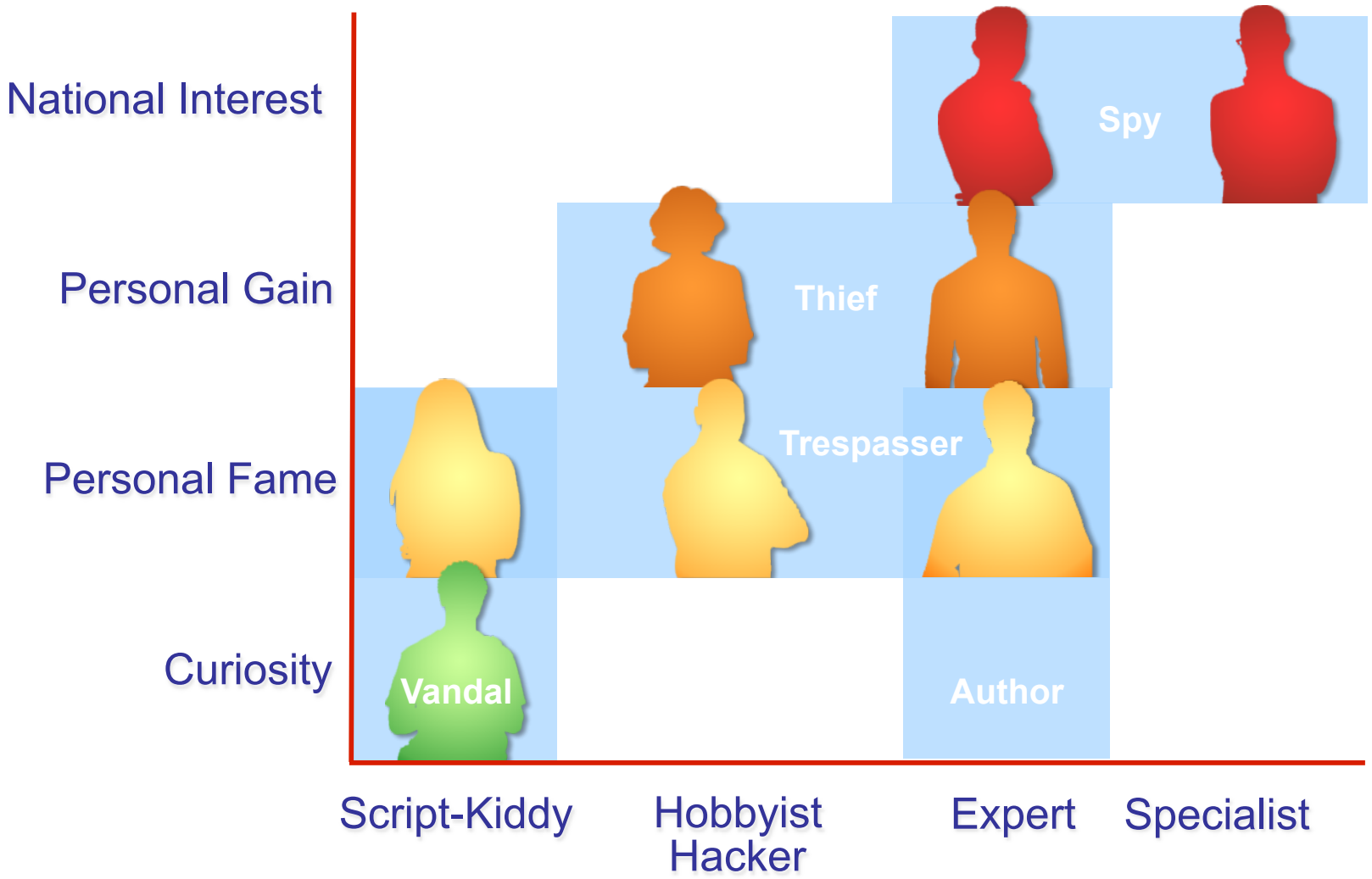
Adversary or *Attacker?*

- An adversary becomes an **attacker** when he *acts* in a way that is detrimental to your interests
- **Adversary** is a term often used in cryptography
- **Attacker** is a term often used in computer security
- Technical distinction not hugely important
  - Both ultimately mean “bad guy”

Adversaries and Attackers

- Defined by **motives** and **resources**
- **Motives:**
  - Curiosity
  - Fame
  - Money
  - National interest
- **Resources:**
  - Time, money, and training

Classes of Attackers



From David Aucsmith, Microsoft.

Computer Security

- **Our definition:** Analysis and protection of computer systems in an adversarial setting
- **Traditional definition:** Protection of information against unauthorized access

Orange Book Definition

Fundamental Computer Security Requirements

Any discussion of computer security necessarily starts from a statement of requirements, i.e., what it really means to call a computer system "secure." In general, secure systems will control, through use of specific security features, access to information such that only properly authorized individuals, or processes operating on their behalf, will have access to read, write, create, or delete information. Six fundamental requirements are derived from this basic statement of objective: four deal with what needs to be provided to control access to information; and two deal with how one can obtain credible assurances that this is accomplished in a trusted computer system.

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Security specialists (e.g., Anderson [6]) have found it useful to place potential security violations in three categories.

1) Unauthorized information release: an unauthorized person is able to read and take advantage of information stored in the computer. This category of concern sometimes extends to "traffic analysis," in which the intruder observes only the patterns of information use and from those patterns can infer some information content. It also includes unauthorized use of a proprietary program.

2) Unauthorized information modification: an unauthorized person is able to make changes in stored information—a form of sabotage. Note that this kind of violation does not require that the intruder see the information he has changed.

3) Unauthorized denial of use: an intruder can prevent an authorized user from referring to or modifying information, even though the intruder may not be able to refer to or modify the information. Causing a system "crash," disrupting a scheduling algorithm, or firing a bullet into a computer are examples of denial of use. This is another form of sabotage.

Authorization

- What is **authorized**?
- **Authorized:** allowed by the operator of the system
- Clear when there is a central authority and explicit policy
  - **Example:** Department of Defense time-sharing systems
- Can be awkward to apply in some settings
  - **Example:** Click fraud malware on your smart phone

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Secrecy

- **Prevent unauthorized access to information**
- Also called *confidentiality* in the literature
  - *However:* some authors use *confidentiality* to mean an "obligation to protect secrets." (Anderson Ch. 1)
  - I will use the term *secrecy* in this class
- What are some scenarios where you want secrecy?
- What are some scenarios involving computers?

Integrity

- **Prevent unauthorized modification of information, process, or function**
- **Example:** Changing your bank account balance without depositing money
- **Example:** Getting snacks from vending machine without paying for them
- What are some other examples?

Information Integrity

- The focus of traditional computer security has been protection of information
- What about control or function of system?
  - In a digital computer system everything is information
  - Why not just say integrity is “protection of information?”

Authenticity

- **Prevent impersonation of another principal**
- Some authors call this *origin integrity*
- **Example:** Getting money from someone else's bank account using their credentials
- Does integrity include authenticity?
- What are some other examples?

Availability

- **Prevent unauthorized denial of service to others**
- **Example:** Physically rendering ATM unusable
- **Example:** Network denial of service attacks
- What are other examples of denial of service?


Insert Here
VISA
VISA
CLEAR
ENTER

Examples

- Which security property is violated if someone …
- … unplugs your alarm clock while you're sleeping?
- … change the time on your alarm clock?
- … Installs a camera in your room?

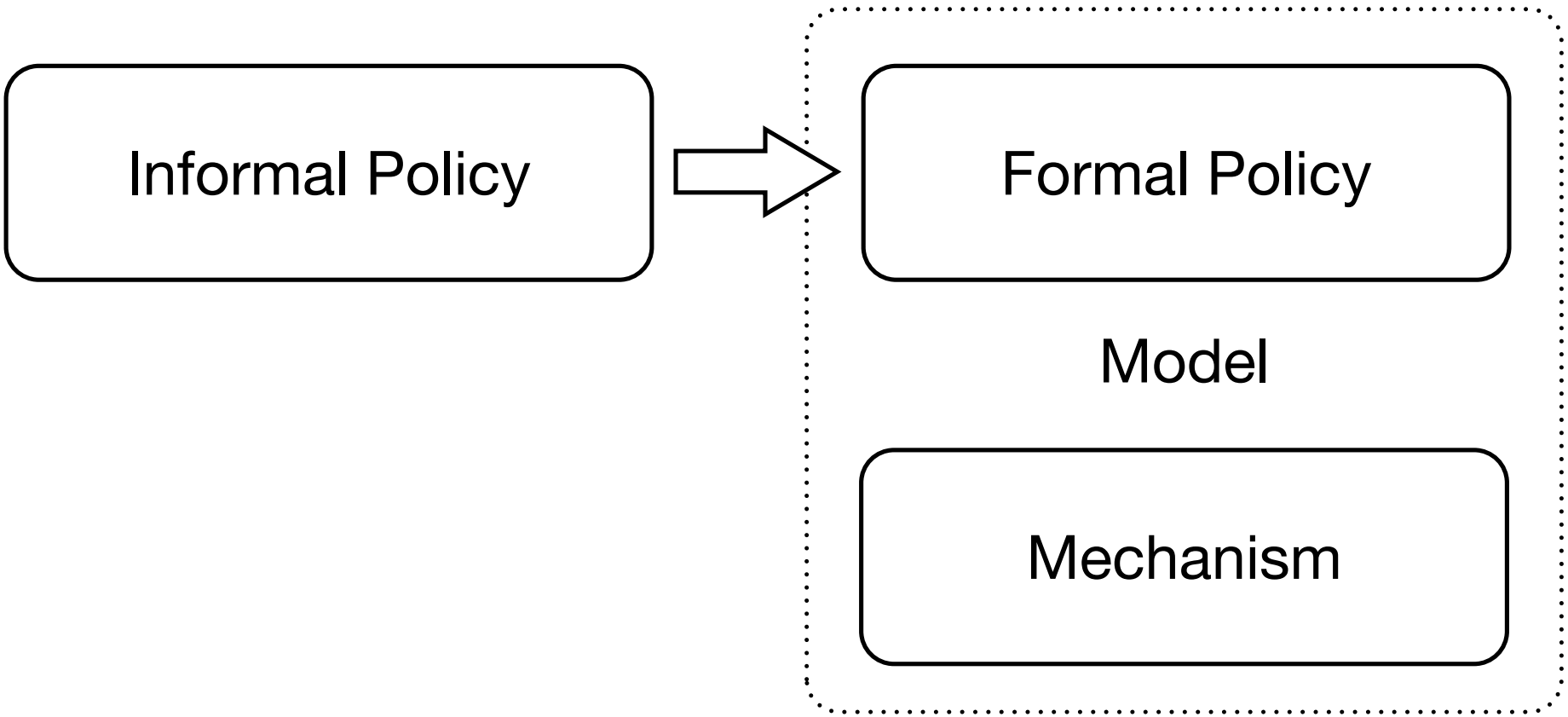
Privacy

- **Privacy:** A person's right or expectation to control the disclosure of his/her personal information
- What is the difference between **privacy** and **secrecy**?

Security Policy

- **Security policy:** Set of allowed actions in a system
- **Security mechanism:** Part of system responsible for implementing the security policy
- **Security model:** Abstraction used by security mechanism
  - We will study several models in the next two lectures
  - Policy may be formulated using model

Policy, Mechanism, Model



Assurance

- **Assurance:** Procedures ensuring that policy is enforced
- **Examples:** Testing, code audits, formal proofs
- Assurance is what justifies our *trust* in a system

Trust

- **Trust:** Belief that system or component will perform as expected or required
- **Trusted:** *assumed* to perform as expected or required
  - *Anderson:* component whose failure compromises security
- **Trustworthy:** *will* perform as expected or required
  - Some authors use *trustworthy* to mean that “there is sufficient credible evidence” that system or component will perform as expected or required

Trusted Computing Base

- **Trusted Computing Base (TCB):** Part of the system assumed to function as required
- Malfunction in TCB can lead to loss of protection
- Assurance gives us confidence of our trust of TCB

Trusted Computing Base

- **In Unix:** CPU, memory, boot disk, operating system kernel, operating system utilities (e.g. `passwd`)
- On a Web server?
- At a store?
- What assurance do we have for above?
  - How do we know TCB will work as required?

Incentives and Deterrents

- **Incentive:** Promise of reward for desirable action
- **Deterrent:** Threat of punishment that discourages undesirable action
- **Examples:**
  - UCSD punishes violation of academic integrity policy
  - Gun ownership believed to deter criminals
  - Reward for information about lost pet
- Other examples?

Incentives and Deterrents

- Attacker's equation:
  (expected gain) > (cost of attack)
- Defender's equation:
  (cost of protection) < (expected loss)

Incentives and Deterrents

- Attacker's equation:
  (expected gain) > (cost of attack) + (expected punishment)
- Defender's equation:
  (cost of protection) < (expected loss)

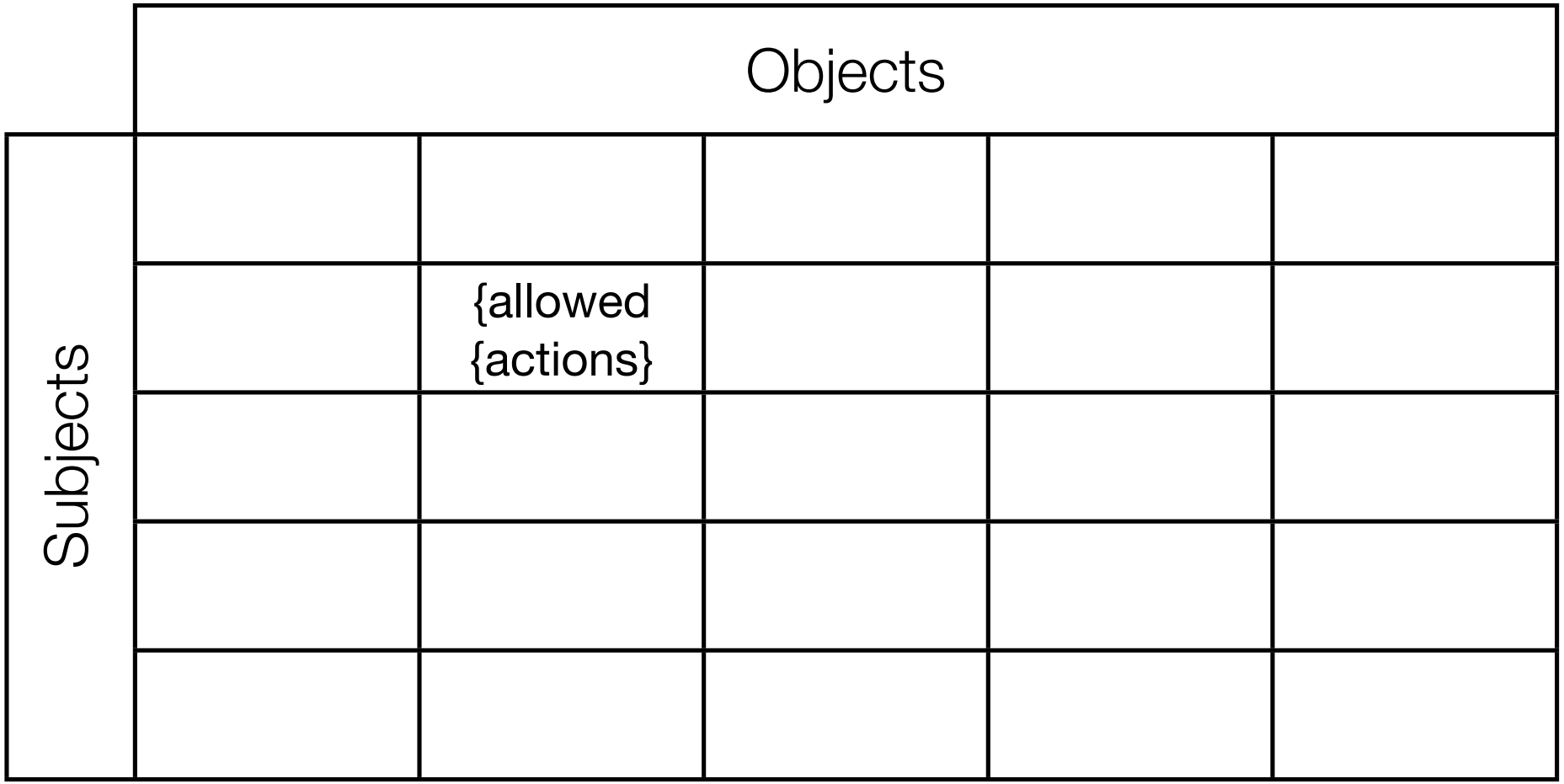
Accountability

- **Accountability:** Ability to attribute actions to individuals
- Why is accountability necessary?
- System must be amenable to forensic analysis after something goes wrong
- **Audit log:** record of all security-relevant events in system
  - Availability and integrity of audit log is critical
  - What about secrecy?

Security Model

- **Subjects:** Individuals or processes acting on their behalf
- **Objects:** Protected information or function
  - Objects often also include subjects
- Subjects operate on objects
  - System mediates and facilitates subject-object interaction
- **Policy:** what *action* is *subject* allowed to do with *object?*
  - And who can introduce new subjects and objects into system?
- Nearly all security models built on this idea

Access Control Matrix



Access Control Matrix

	Broccoli	Fruit from Tree of Life	Fruit from Tree of Knowledge
Adam	*{see, eat}*	*{see, eat}*	*{see}*
Eve	*{see, eat}*	*{see, eat}*	*{see}*

Access Control Lists (ACLs)

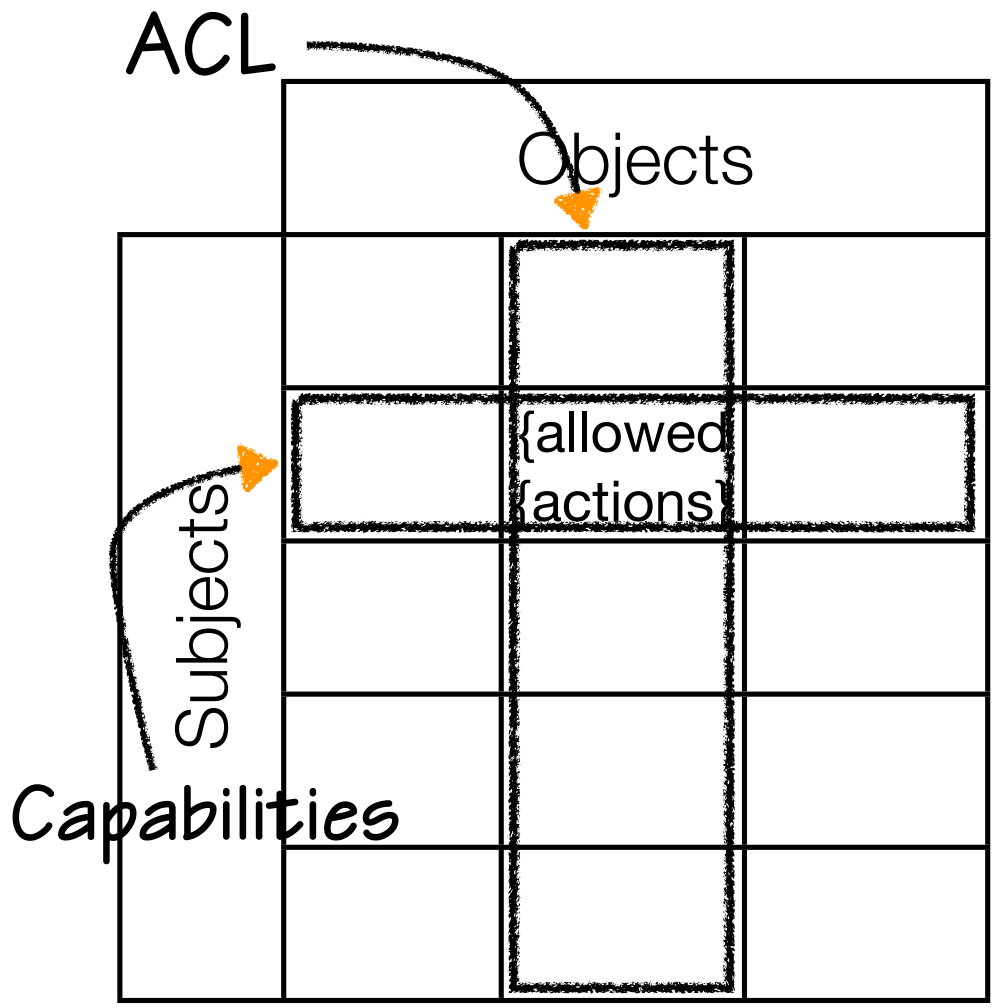
- An **access control list** of an object identifies which subjects can access the object and what they are allowed to do
- ACLs are object-centric: access control is associated with objects in the system
- Each access to object is checked against object's ACL
- **Example:** guest list at a night club

Capabilities

- A **capability** grants a subject permission to perform a certain action
  - Unforgeable
  - Usually transferrable
- Capabilities are subject-centric: access control is associated with subjects in the system
- **Example:** car key

ACLs & Capabilities

- Columns of the Access Control Matrix define objects' *ACLs*
- Rows of the Access Control Matrix define users' *capabilities*



Unix File System Sec. Model

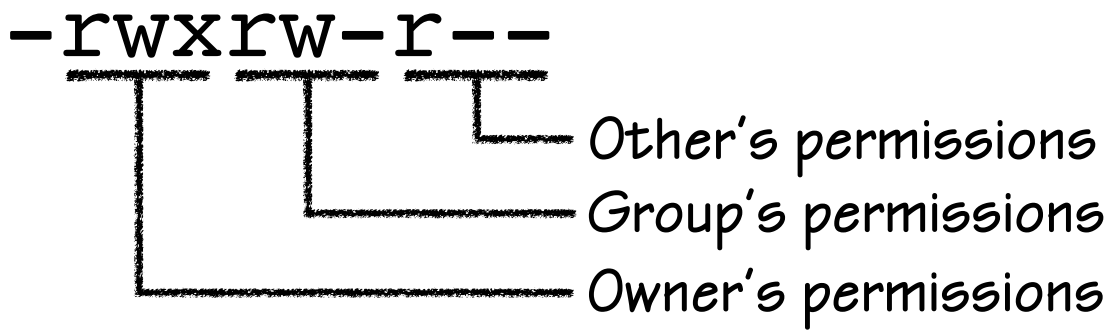
- *Subjects:* Users
- *Objects:* Files and directories
- *Actions:* read, write, execute
  - Execute a file means can call `exec()` on file
  - Directory “execute” means user can *traverse* it
- Unix is a simplified ACL system
  - Arbitrary ACLs not possible in traditional Unix
  - Modern Unix operating systems allow arbitrary ACLs

Unix Superuser

- **Superuser** allowed do anything that is possible
- Called `root` and mapped to user id 0
- A superuser is a *role* rather that a particular user
- System administrators assume the superuser role to perform privileged actions
  - Good practice to assume superuser role only when necessary

Permissions

- Each file has an **owner** and a **group**
  - **Group:** named set of users
- File permissions specify what owner, group, and other (neither owner nor group) is allowed (read, write, exec)



Permissions

- Only owner and superuser can change permissions
- Only superuser can change owner
- Only owner and superuser can change group
  - Owner can only change to group she belongs to
- User's allowed actions on file are:
  - Owner's permissions if the user is the owner,
  - Group's permissions if the user is in the group,
  - Other's permissions otherwise

Permissions

- Users interact with system via processes acting on their behalf
- When you interact with system via terminal, command shell acts on your behalf
- Each process is associated with a user

Login

- When user connects to system via physical terminal, system runs `login` process as `root` to start session
  - Authenticates user using username and password
  - Changes its user id and group id to that of user
    - This is possible because superuser allowed to do anything
  - Executes user's shell
- `sshd` performs similar actions
- *Critical:* dropping privileges from `root` to regular user

Changing Privilege

- Superuser can drop privilege to become regular user
- Want way to elevate privilege in controlled manner
- How?

Elevating Privilege

- Executable files have a `setuid` and `setgid` bit
- If `setuid` is set, files is executed with privilege of owner
  - `ruid` is that of executing user, `euid` and `suid` that of owner
- The `setgid` bit does same for group
  - But supplementary groups remain that of executing user
- The `passwd` command is `setuid` and owned by `root`
  - Executes as superuser (`root`) — why?

Unix Security Model

- What do you like about the Unix security model?
- What do you dislike about it?
- Is it a good model?