

CISC 7320X - COMPUTER SECURITY

Access Control

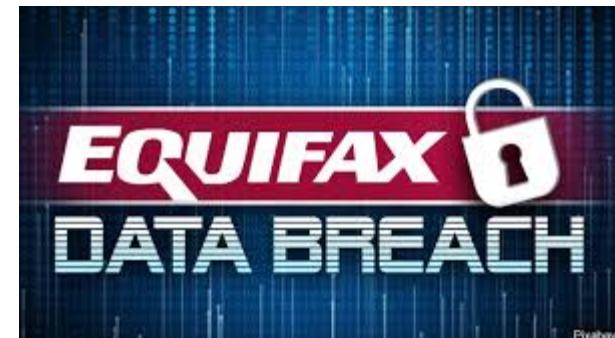
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Topics for today

- Why is security important?
- Authentication mechanisms
- Access control

Why is computer security important?

- Attacks Impact everyone's day-to-day life
 - Millions of compromised computers
 - Millions of stolen passwords
 - Risk of identity theft
- Serious financial damage caused by security breaches



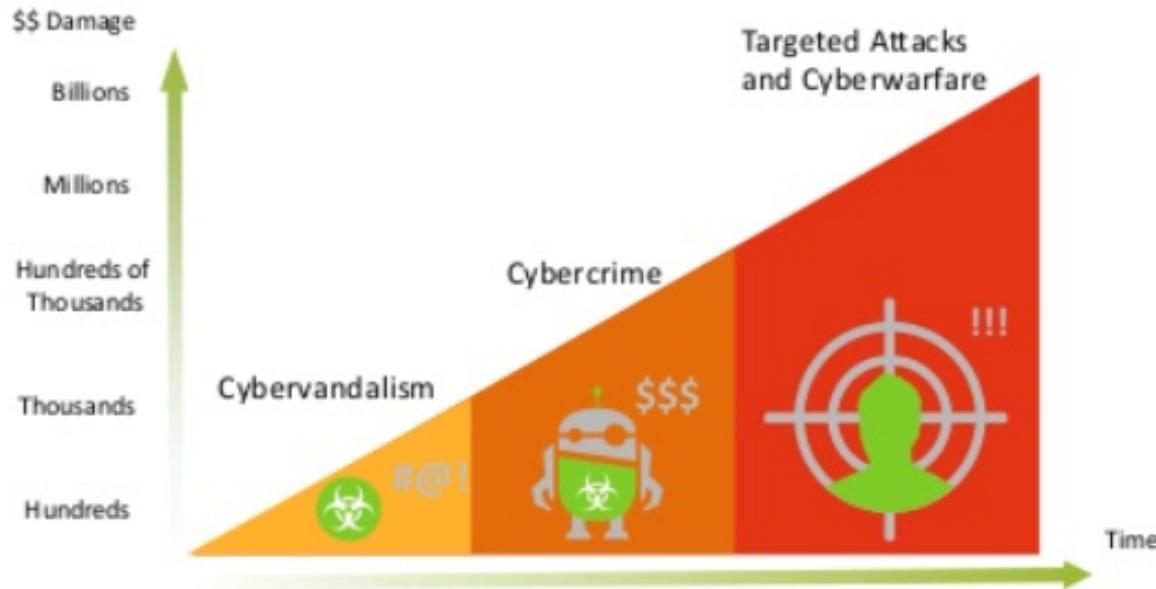
Security Threats History

- 1990's: fewer attacks, attackers gained fame,
 - Some attacks accidental,
- late 2000's: financially motivated
 - pharmaceuticals, credit card theft, identity theft
 - Phishing evolved into spear-phishing
 - More targeted form of attack
 - Uses target personal information to impersonate a trusted source
- 2010's: politically motivated
 - Government actors: Stuxnet, Flame, Aurora
 - Private activism: Anonymous, Wikileaks

Security Threats History

- Threats Have Evolved
 - Attackers have become more sophisticated;
- Arms race between attackers and defenders fuels rapid innovation in malware
- Many attacks aim for profit
 - are facilitated by a well-developed “underground economy” or cyber-crime organizations

Malware Evolution



FAMOUS HACKERS

First Internet Worm



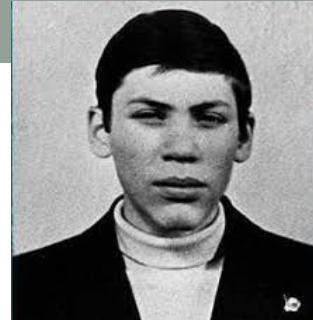
- Robert Tappan Morris was a grad student at cornell in 1988
- Program designed to gauge size of the internet
- Had flows:
 - computers could be infected multiple times
 - each infection caused the computer to slow down more
- Result: 600 computers rendered unusable

KGB Attack on US Computers

- Markus Hess, a German citizen, was recruited by the KGB to break into US army computers
- Used German network to attack 400 US army computers (1980'S)
 - As well as machines in MIT
- Eventually detected by Clifford Stoll
 - a Berkeley astronomer/systems administrator
 - Wrote a book about this, “the Cuckoo egg”
- Hess sentenced to three years in prison



Citibank Hack



- One of the first high-profile financially-motivated hacking
- Vladimir Levin, Russian crime ring leader, gained access to Citibank accounts in 1995
 - Used a computer in London
 - Got access to list of customer codes and pwds
 - Managed to transfer \$3.7 million from these accounts to crime organizations accounts

NASA Attack



- 16 year old Jonathon James hacked into the Marshall Space Flight Center (1999)
- downloaded proprietary software
- Documents stolen were valued at \$1.7 Millions
- Forced NASA to shut down its computer systems for three weeks
 - cost them about \$41,000 to fix

Sarah Palin's Email Hack



- A 20 year old college student, David Kernell obtained access to Palin's email (2008)
 - by looking up biographical details such as her high school and birthdate and using Yahoo!'s account recovery for forgotten passwords
 - posted several pages of Palin's email online
 - Kernell was sentenced to 1 year in prison



Target attack



- Hackers stole data during 2013 holiday season
- Breach hits 40 million payment cards
- Target paid \$18.5 Million multi-state settlement

AUTHENTICATION AND ACCESS CONTROL

CISC 3325 - Information Security

Identification vs. Authentication

- Identities are well known
 - Typically not secret
 - Your email ID appears in your email header
 - Your check has your bank account number
- Authentication, on the other hand, should be reliable.
- Identification asserts your identity
 - Authentication confirms that you are who you purport to be
- Identifiers may be widely known or easily determined
 - Authentication should be private
- If authentication is not strong enough => not secure

Authentication

- The ability to prove that a user or application is genuinely who they claims to be
 - Not just for end-users:
 - For example, a web server and client need to authenticated each other
- Usually the user has no control over the type of authentication



Impersonation

- Pretending to be someone else
 - Attacker may impersonate user, web client or web server
- Authentication can protect against impersonation



Authenticating Users

- How can a computer authenticate the user?
- Authentication basics:
 - Something you **know**
 - Password, pin, etc.
 - Something you **have**
 - House key, ATM card, tokens, etc.
 - Something you **are**
 - Captcha (differentiating humans and computers), fingerprints, face recognition



Something the user knows

- What does the user know?
 - Passwords, pins, etc.
 - Security questions
 - Recognition of an image

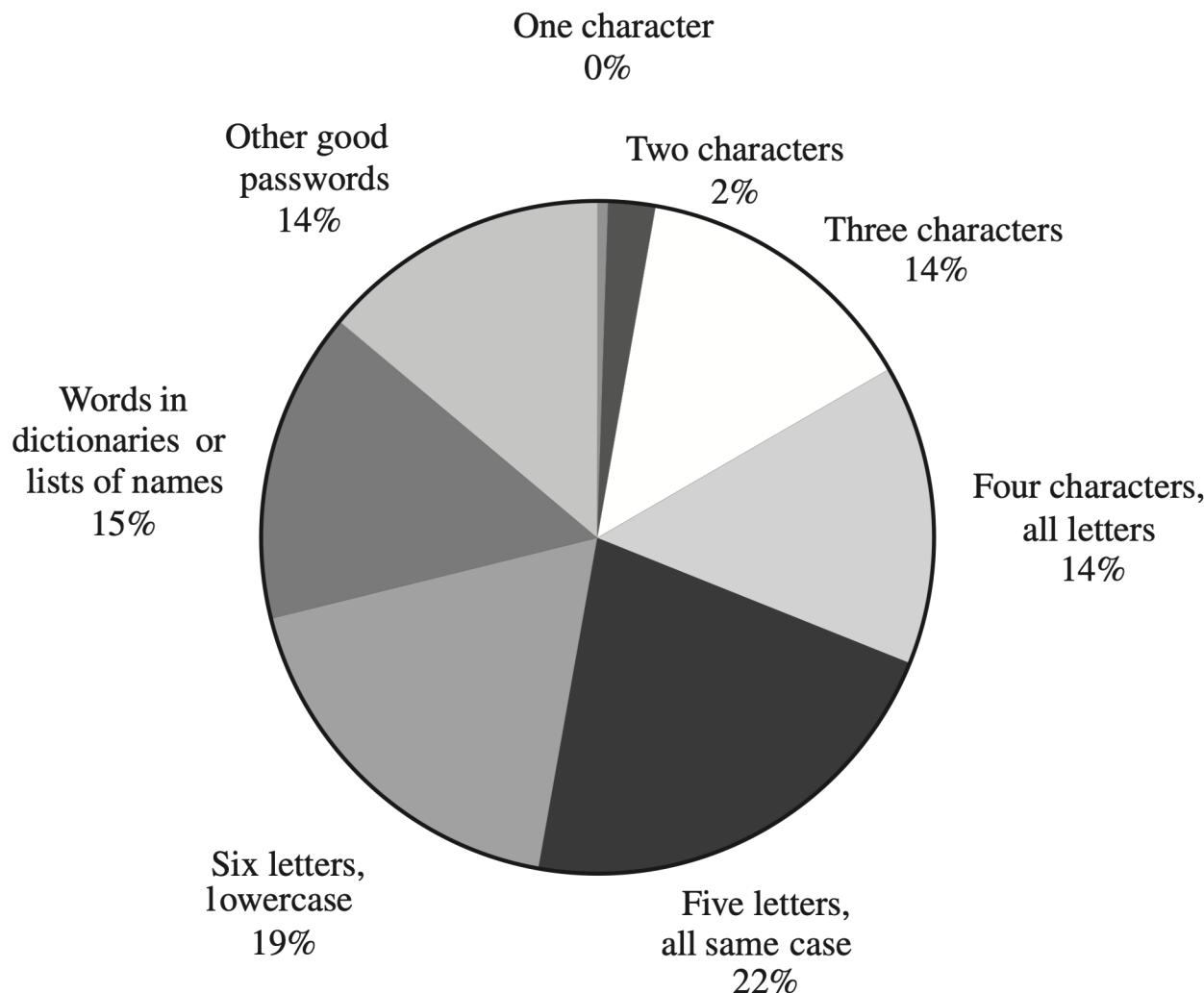
Something the user knows

- Attacks on “something the user knows”:
 - Dictionary attacks
 - Inferring likely passwords/answers
 - Guessing
 - Detecting how a password is stored
 - Defeating concealment
 - Exhaustive or brute-force attack
 - Rainbow tables
 - a precomputed **table** for reversing cryptographic hash functions

What is a good password?

- Many passwords are poorly chosen
- A good password has the following characteristics:
 - At least 8 characters
 - Not a word in several languages
 - Must contain several types of ASCII chars
 - uppercase and lowercase letters, digits, punctuation
 - Try not to begin with an uppercase letter

Distribution of Password Types



Secure Passwords



- Case study: Ashley Madison hack [2015]
- 36 million hashed passwords leaked
 - Some hashed with MD5
 - a relatively weak hashing algorithm
- Researchers cracked passwords
 - Using automated guessing, other attacks
 - Easier passwords easier to crack

Ashley Madison Attack

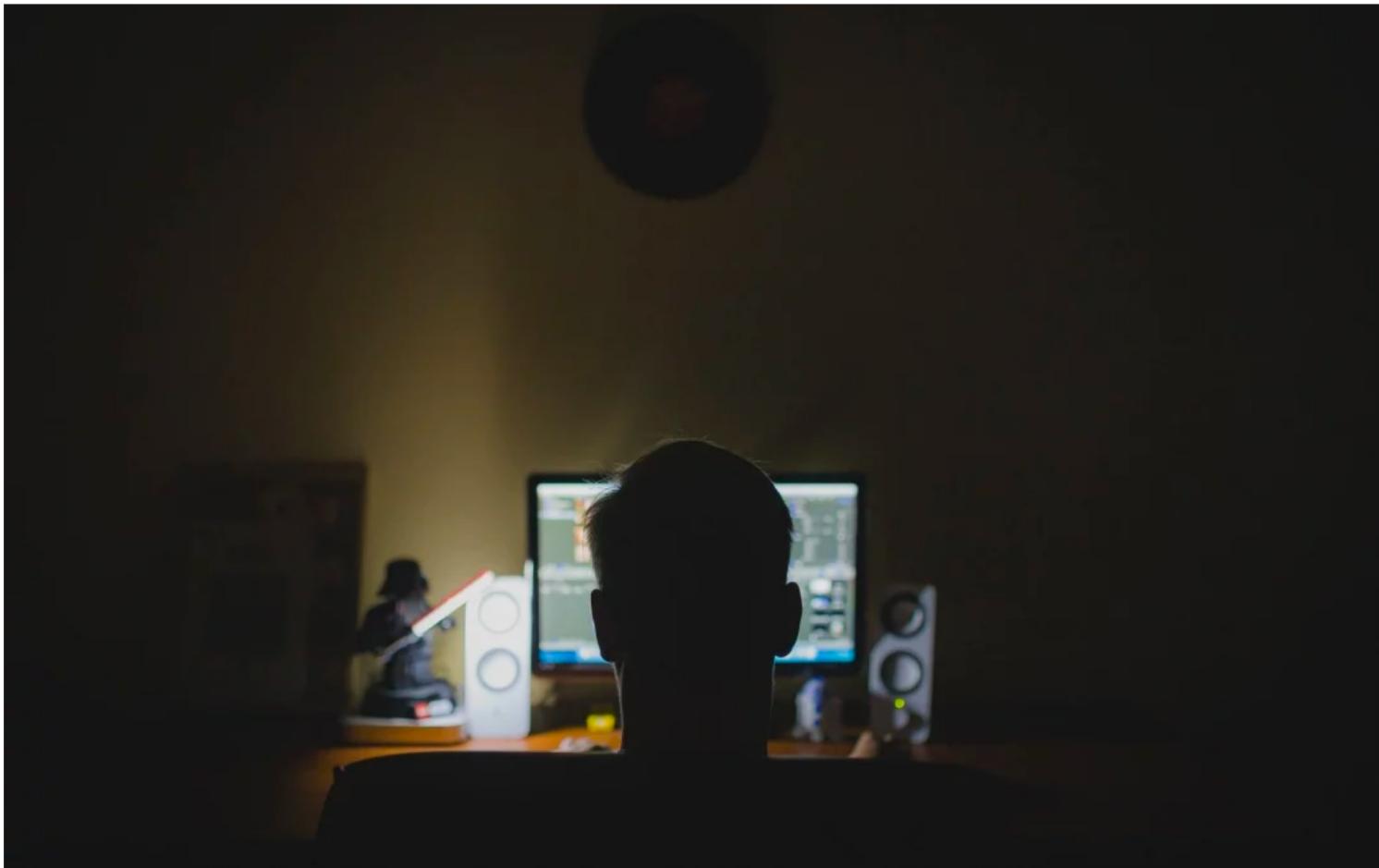
- Most common passwords guessed:



Password	Times used
123456	120,511
12345	48,452
password	39,448
default	34,275
123456789	26,620
qwerty	20,778
12345678	14,172
abc123	10,869

Secure Passwords

- Recent studies reaffirm the users' weak passwords
 - Show that the vast majority of passwords used on the Internet are extremely easy to crack
- Case studies, such as Ashley Madison, showed that a large number of passwords can be detected
 - Using off-the-market cracking tools



63% of Data Breaches Result From Weak or Stolen Passwords

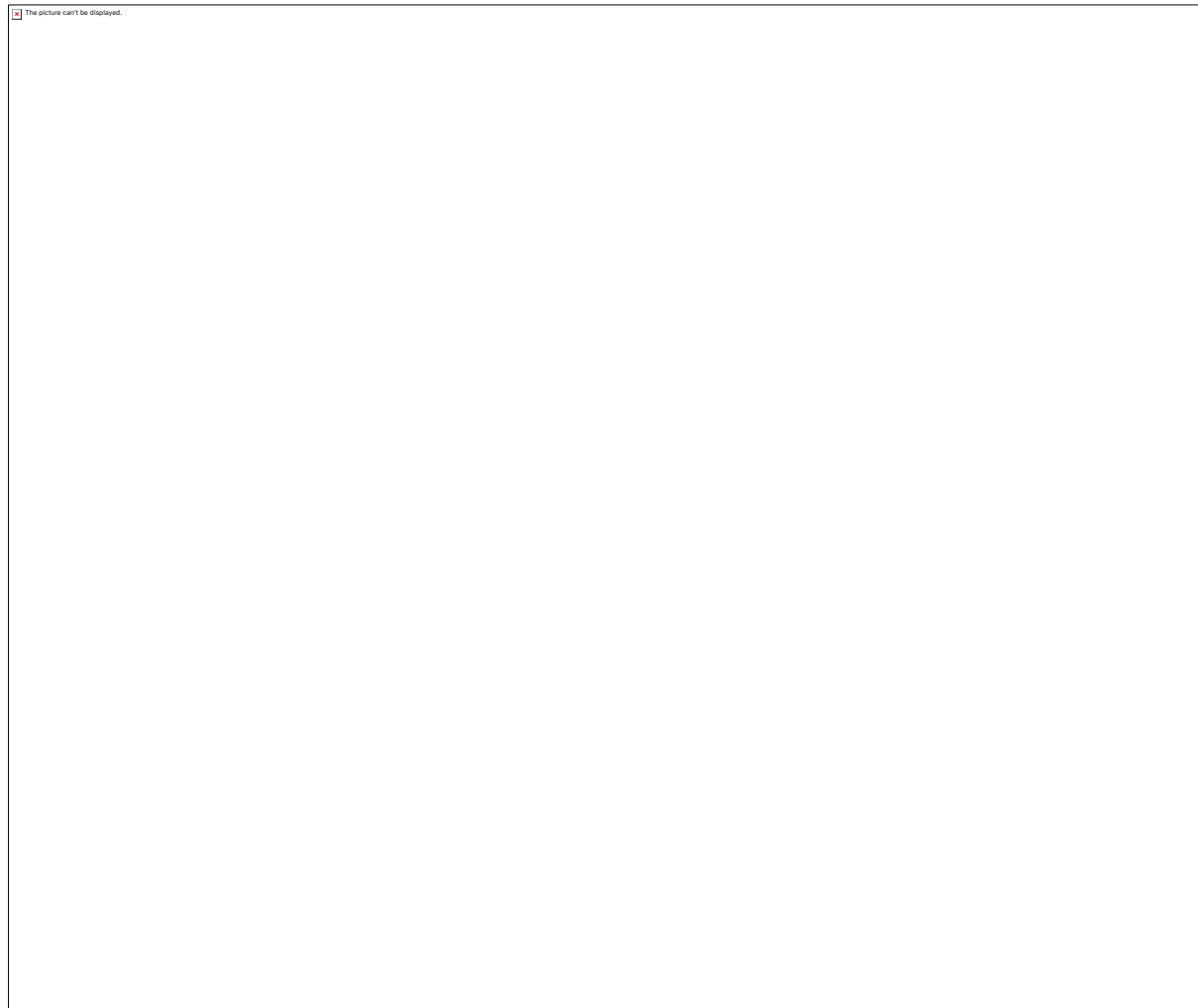
Secure Passwords



- Conclusions:
 - Weak passwords easier to guess
 - Vulnerable even when hashed
 - Many passwords can be guessed
 - by exploiting the predictability in the way most end users choose passwords
 - Password cracking tools significantly improved
 - Passwords should be hashed
 - Using a strong hashing mechanism

BIOMETRICS AND TOKEN-BASED AUTHENTICATION

Biometrics: a physical attribute of the user



Types of biometric authentication

- Fingerprints
- Hand geometry
- Scan of the eye
- Voice
- Handwriting
- Typing style
- Face or facial features

Problems with Biometrics

- Intrusive
- Expensive
- Single point of failure
- Sampling error
- False readings
- Speed
- Forgery

Biometrics Passwords

- Recent advances in smartphones have begun to make biometrics cheaper and easier to use.
- Biometrics are still inadequate for extremely sensitive applications
 - but their convenience makes them a great alternative to weak passwords

Authentication Mechanisms

- Companies are developing authentication methods
 - To be used by third-party applications for authentication
 - So applications do not have to implement it themselves
- Examples: RSA SecureID, Federated Identity Management

Authentication Mechanisms

- RSA Secure ID:
 - Has a code that changes every 60 seconds.
 - Physical possession of the token should be necessary for successful authentication.

RSA Secure ID

- Each token generates a distinct, unpredictable series of numbers that change every minute
 - so the authentication system knows what number to expect from your token at any moment.
- User enters the current number displayed on the token to the authentication application
- Two people can have SecurID tokens, but each token authenticates only its assigned owner
 - Entering the number from another token does not succeed
- The token generates a new number every minute
 - entering number from a previous authentication fails as well

Tokens: Something You Have

Time-Based Token Authentication

Login: mcollings

Passcode: 2468159759

PASSCODE = PIN + TOKENCODE

Token code:
Changes every
60 seconds



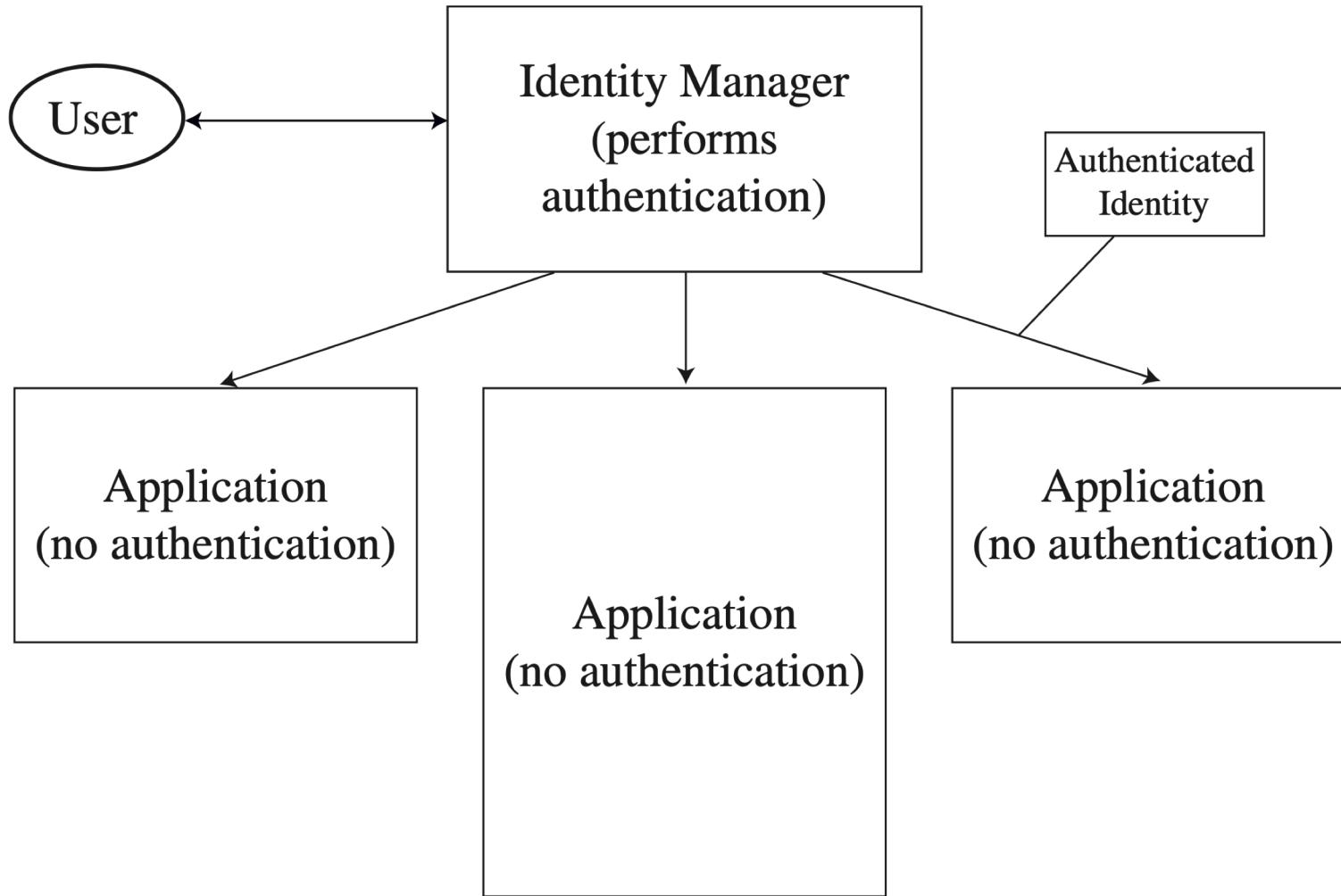
Unique seed

Clock
synchronized to
UCT

Authentication Mechanisms

- Federated Identity Management:
 - A union of separate identification and authentication systems.
 - Authentication is performed in one place,
 - Separate processes and systems determine that an already authenticated user is to be activated.

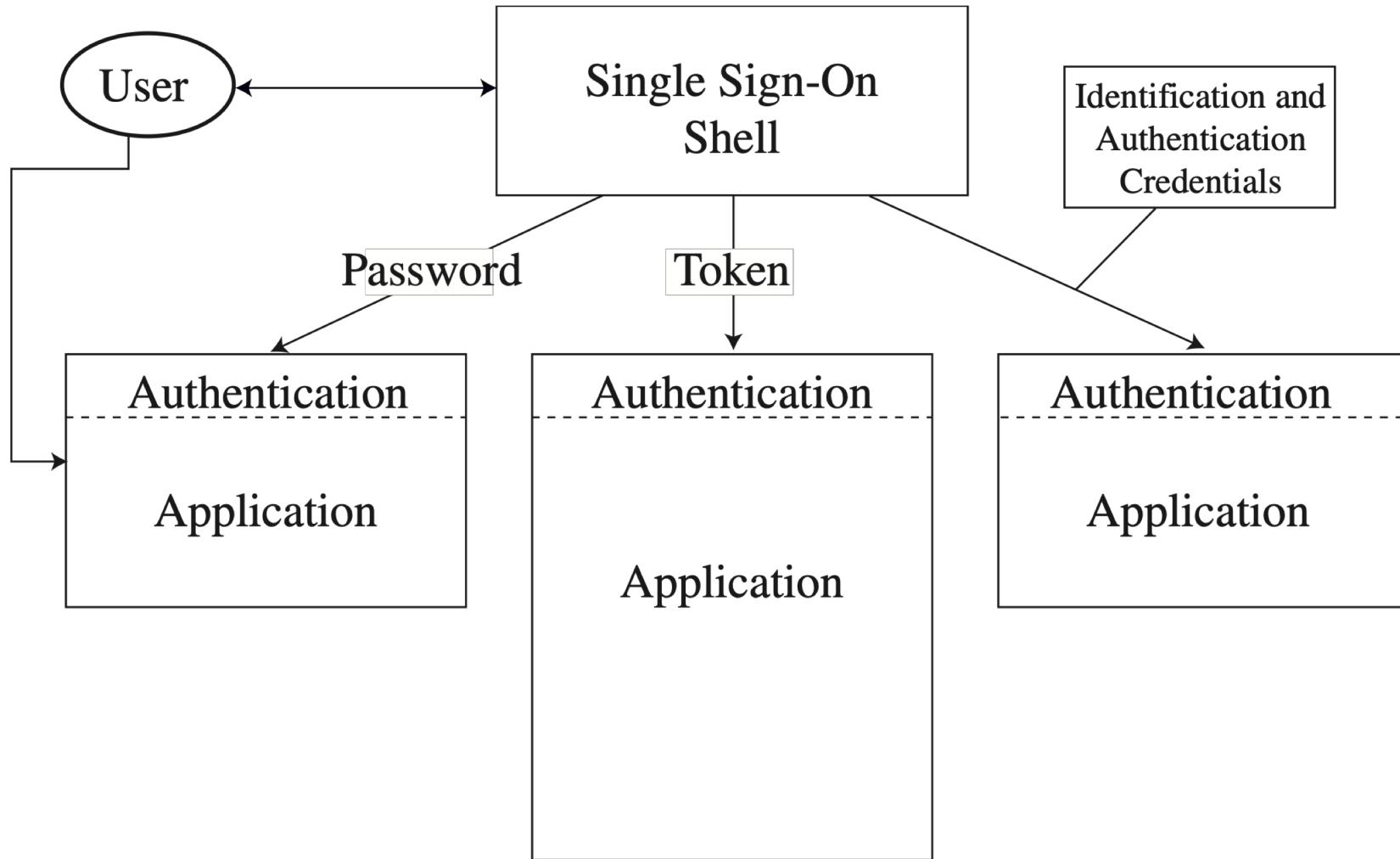
Federated Identity Management



Authentication Mechanisms

- Single sign-on lets a user log on once per session but access many different applications/systems.
 - Often works in conjunction with federated identity management
 - with the federated identity provider acting as the source of authentication for all the applications.

Single Sign-On



Multi-Factor Authentication

- So far we discussed single-factor authentication
- Has some disadvantages:
 - A token works as long as you don't give it away
 - Password can be guessed or eavesdropped on
 - We can compensate by combining both

Multi-Factor Authentication

- Driver license combines two authentication methods:
 - What you have
 - the card itself
 - Who you are
 - Your picture, signature

Multi-Factor Authentication

- Authentication may use more than one factor
 - Two, three, etc.
 - We assume that two are better than one
 - However, usability has to be maintained!
 - Not to cause inconvenience to user

Questions?



Access Control



- Some resources (files, web pages, ...) are sensitive.
 - Need to protect their confidentiality
- How do we limit who can access them?
- This is called the access control problem

Access Control



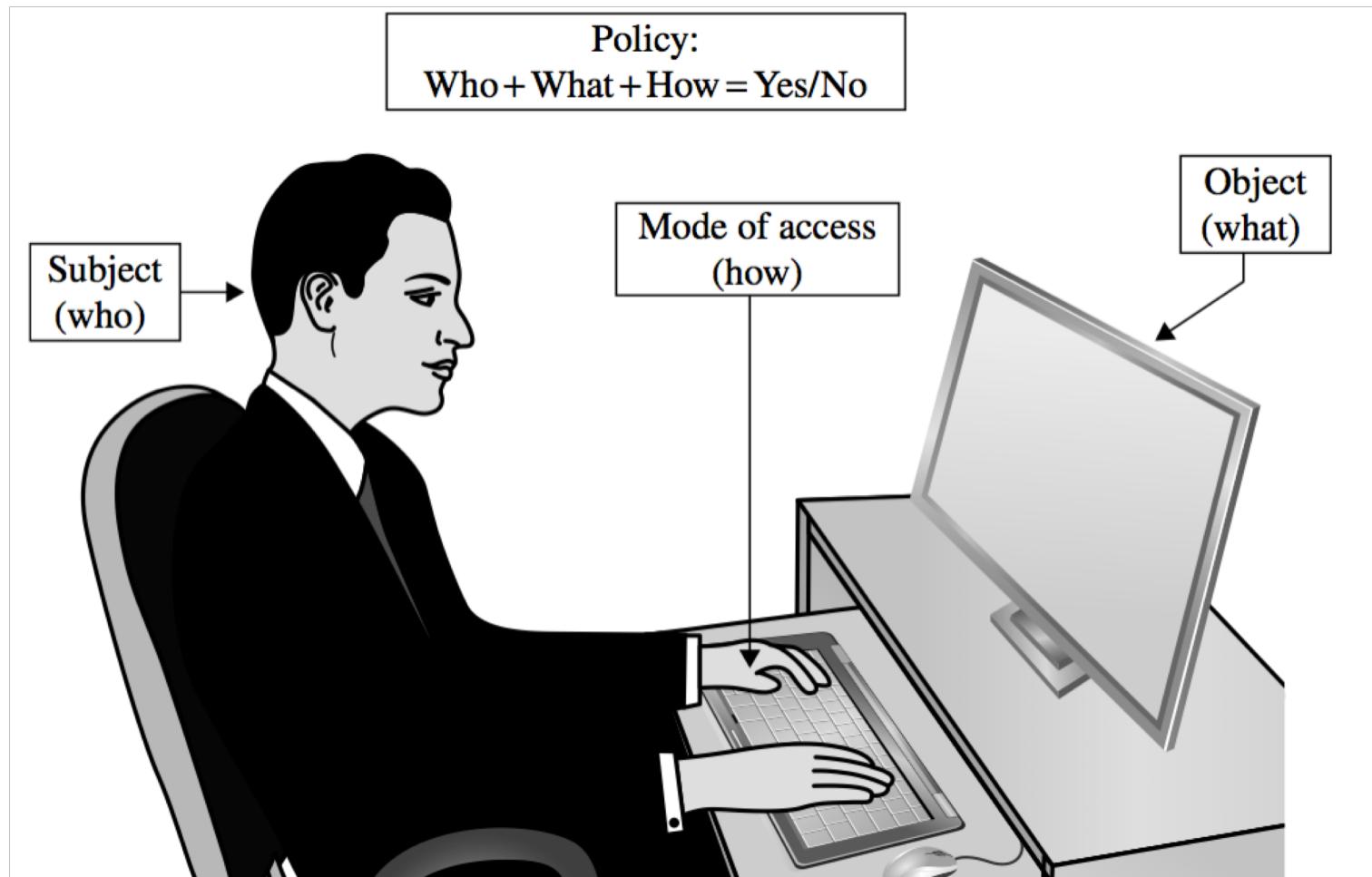
- Basic tasks access control manages:
 - Allow access
 - Deny access
 - Limit access
 - Allowing access to a resource up to a certain point
 - Revoke access
 - Access may change over time

Access Control Fundamentals

- Selective restriction of access to a place or other resource
- The system makes a decision to grant or reject an access request from an already authenticated subject
 - based on what the subject is authorized to access



Access Control



Access Policies

- Goals:
 - Check every access
 - Enforce least privilege
 - Verify acceptable usage
- Track users' access
- Enforce at appropriate granularity
- Use audit logging to track accesses

Access Control Fundamentals

- *Subjects*: entities that can perform actions on the system
- *Objects*: entities representing resources to which access may need to be controlled
- *Policy*: the restrictions we'll enforce
- *Example*:
 $\text{access}(S, O) = \text{true}$ if subject S is allowed to access object O



Principle of Least Privilege



- Minimal user profile privileges is set based on users' job necessities
- Applies to users, user accounts, processes, etc.
 - To allow performing needed functionality
- Example: a teacher should not need access to data internal to a human resource system in order to do their job

Access Control Fundamentals

- Identification and authentication:
 - only legitimate subjects can log on to a system
- Access approval:
 - grant access during operations
 - by associating users with resources they may access
 - based on the authorization policy
- Accountability: identify what a subject did
 - (or all subjects associated with a user)



Questions?

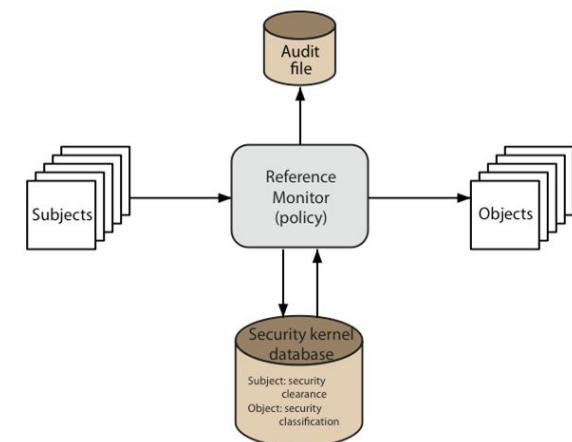


Implementing Access Control

- Reference monitor
- Access control directory
- Access control matrix
- Access control list
- Capability-based security
- Procedure-oriented access control
- Role-based access control

Reference Monitor

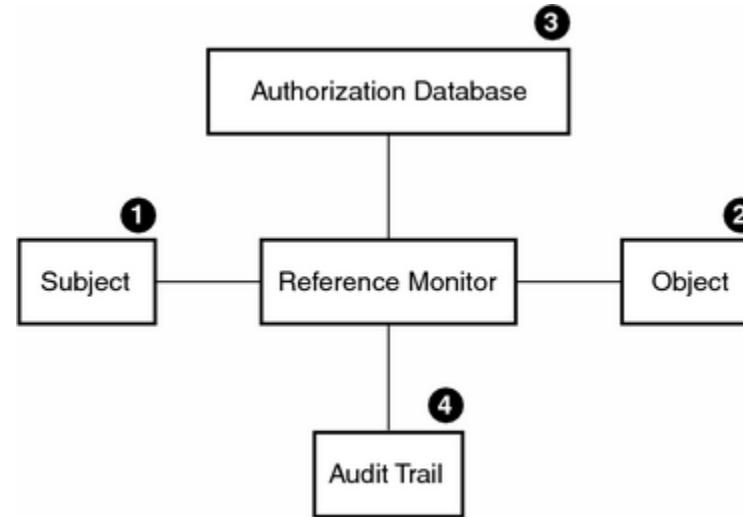
- Defines a set of design requirements on a reference validation mechanism
- Enforces an access control policy over subjects ability to perform operations on objects
 - Subjects, e.g., processes and users
 - Operations, e.g. read and write
 - Objects, e.g. files, etc.



Reference Monitor

- A reference monitor is responsible for mediating all access to data
- Subject cannot access data directly; operations must go through the reference monitor, which checks whether they're OK

Reference Monitor



VM-0994A-AI

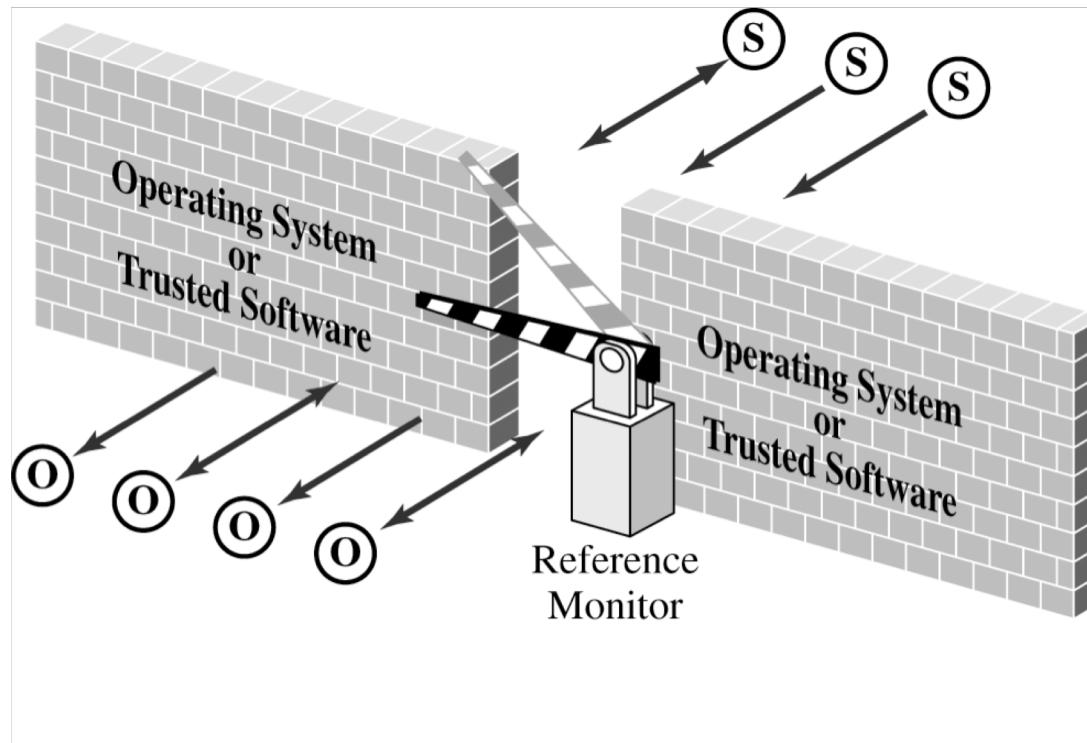
- Authorization Database: Repository for the security attributes of subjects and objects
- Audit trail: Record of all security-relevant events

Criteria for a Reference Monitor

- Ideally, a reference monitor should be:
 - Non-bypassable: mediate every attempt by a subject to gain access to an object
 - Tamper-resistant: Provide a tamperproof database and audit trail
 - that are thoroughly protected from attackers
 - Verifiable: should be simple and well-structured software
 - so that it is effective in enforcing security requirements
 - Unlikely to have bugs

Reference Monitor

- A reference monitor is the primary access control enforcement mechanism of the operating system

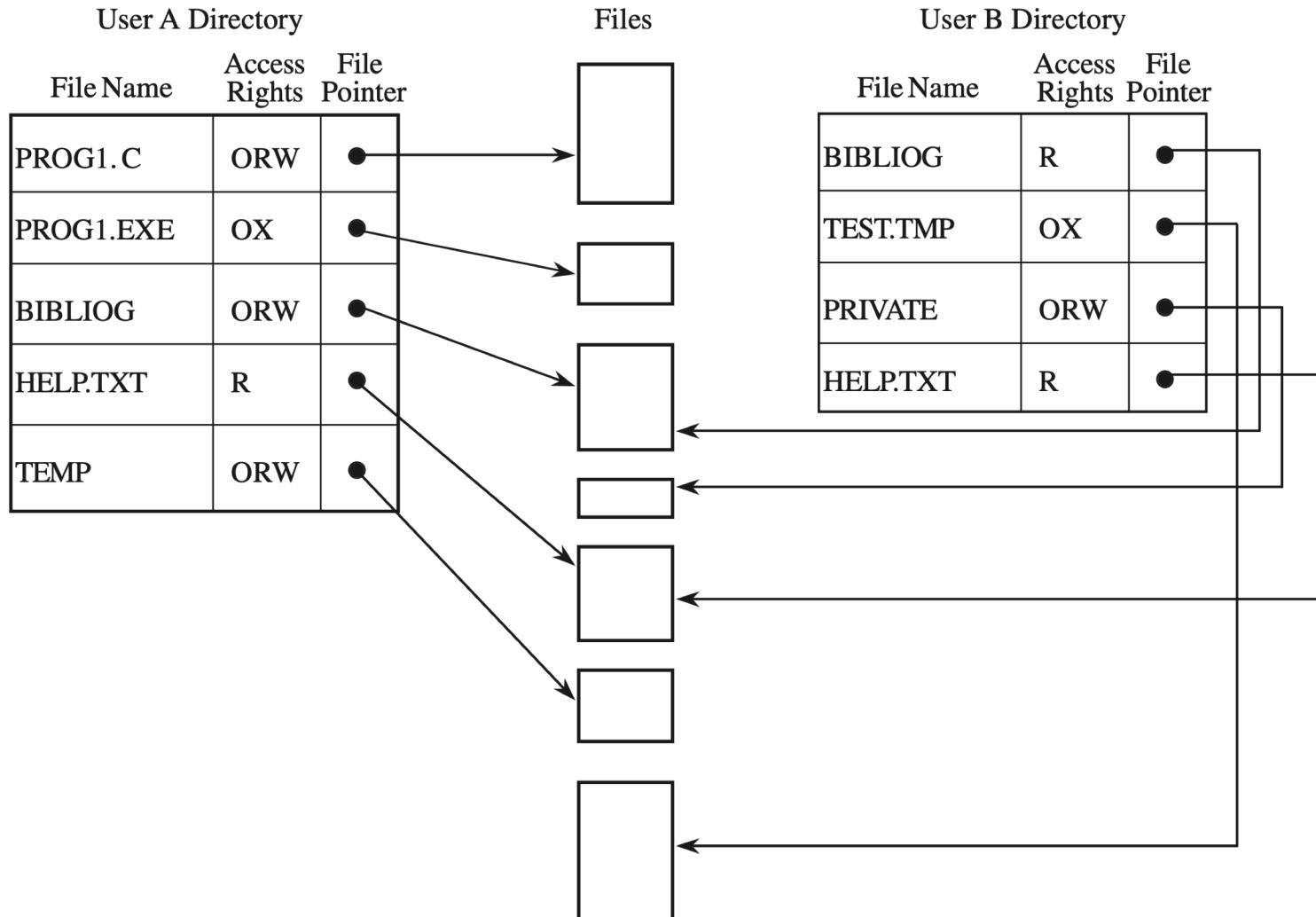


Access Control Fundamentals

- Examples:
- $\text{access}(\text{Alice}, \text{Alice's data}) = \text{true}$
- $\text{access}(\text{Alice}, \text{Bob's data}) = \text{true}$
- $\text{access}(\text{Alice}, \text{Charlie's data}) = \text{false}$



Access Control Directory



Access Control Matrix



- Characterizes the rights of each subject with respect to every object in the system
- Can be written as a rectangular array of cells,
 - one row per subject and one column per object
 - The entry for a particular subject-object pair indicates the access mode
 - that the subject is permitted to exercise on the object
- Each column is an access control list for the object
- Each row is an access *profile* for the subject

Access Control Matrix

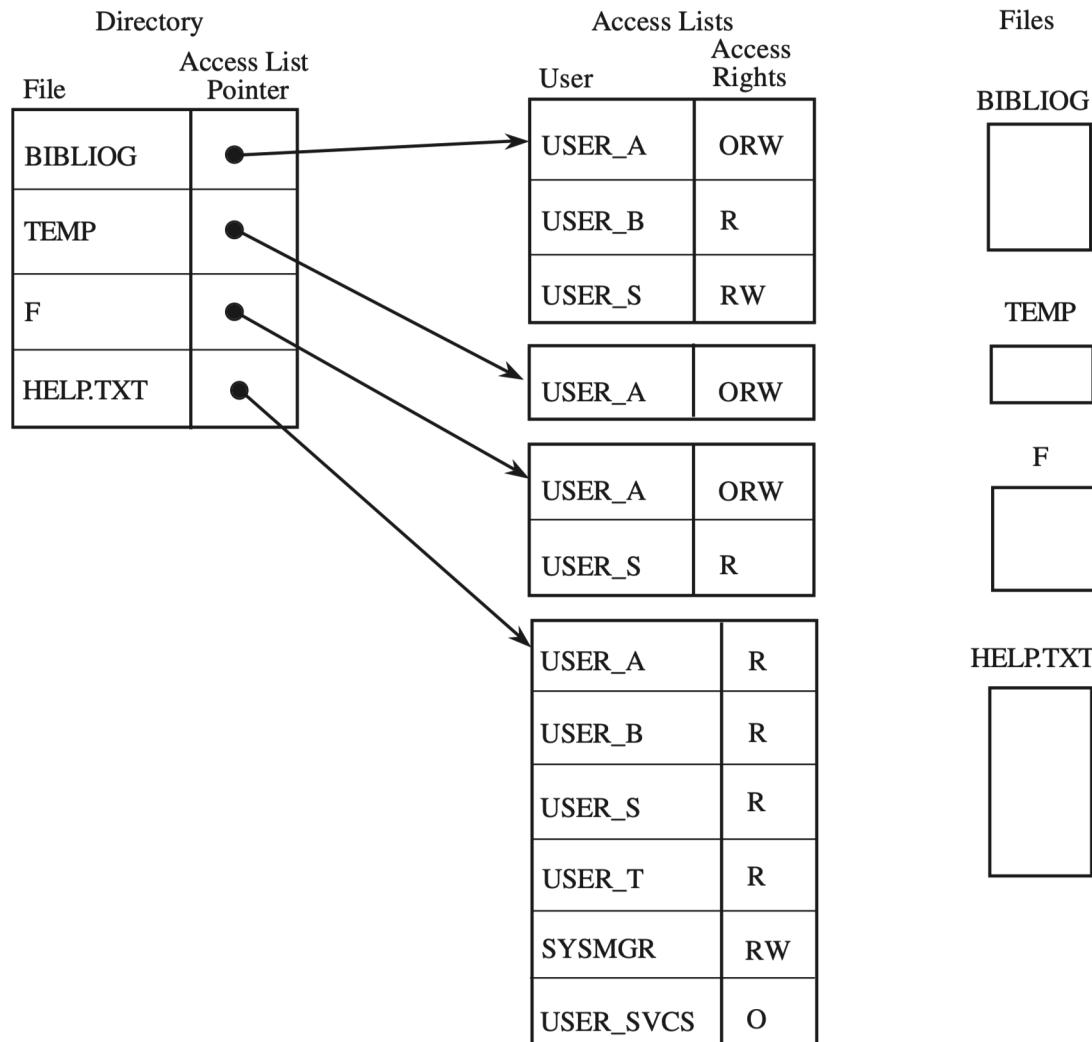
	BIBLOG	TEMP	F	HELP.TXT	C_COMP	LINKER	SYS_CLOCK	PRINTER
USER A	ORW	ORW	ORW	R	X	X	R	W
USER B	R	-	-	R	X	X	R	W
USER S	RW	-	R	R	X	X	R	W
USER T	-	-	-	R	X	X	R	W
SYS_MGR	-	-	-	RW	OX	OX	ORW	O
USER_SVCS	-	-	-	O	X	X	R	W

Access Control List (ACL)



- A list of permissions attached to an object
- An ACL specifies which users or system processes are granted access to objects
 - as well as what operations are allowed on given objects
- Each entry in a typical ACL specifies a subject and an operation
- Example: A file that contains the line:
Alice: admin, Bob: write

Access Control List

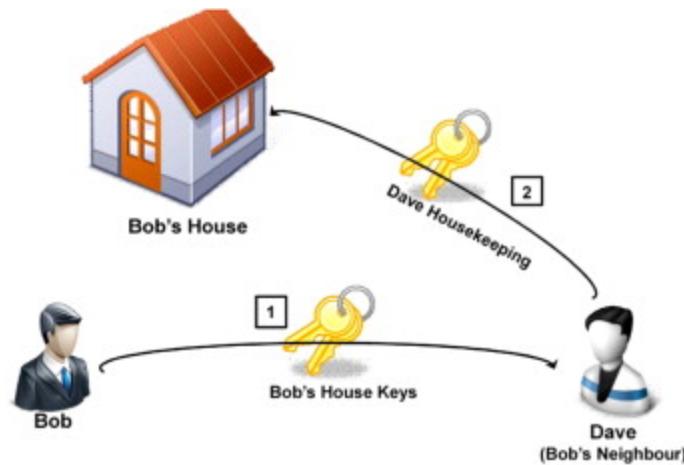


Capability-Based Security

- Oriented around the use of a token that controls an access
- Based entirely on the possession of the token and not who possesses it
- In a capability-based operating system, the capabilities are passed between processes and storage
 - OS maintains the integrity of those capabilities

Capability-Based Security

- Example: Bob gives his key to his neighbor Dave while he goes on vacation.



Procedure-Oriented Access Control

- Provides a more complex access control
- A procedure that controls access to objects
 - for example, by performing its own user authentication to strengthen the basic protection provided by the basic operating system)
- The procedure forms a “capsule” around the object
 - permitting only certain specified accesses

Procedure-Oriented Access Control Example

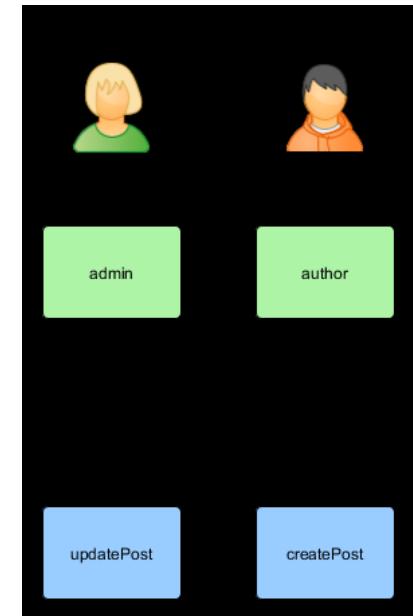
- Procedures can ensure that accesses to an object be made through a trusted interface.
- Example:
 - Neither users nor general operating system routines might be allowed direct access to the table of valid users.
 - The only accesses allowed might be through three procedures:
 - one to add a user
 - one to delete a user
 - one to check whether a particular name corresponds to a valid user.
 - These procedures could use their own checks to make sure that calls to them are legitimate
 - especially add and delete

Procedure-Oriented Access Control

- Implements the principle of information hiding
 - the means of implementing an object are known only to the object's control procedure
- However, this carries a penalty of inefficiency
 - No fast access checking, even if the object is frequently used

Role-Based Access Control (RBAC)

- Access control set by an authority designated for the task
- Access is based on the role each subject has in the system



Summary

- Users can authenticate using something they know, something they are, or something they have
- Systems may use a variety of mechanisms to implement access control

Questions?

