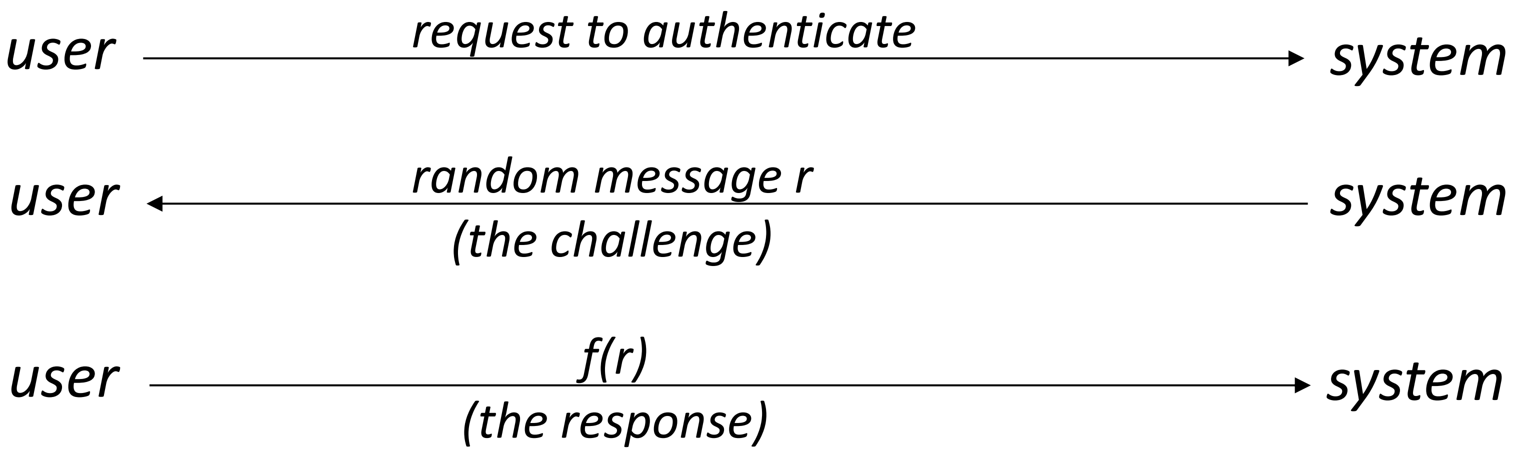
Lecture 12
October 23, 2023

Challenge-Response

User, system share a secret function *f* (in practice, *f* is a known function with unknown parameters, such as a cryptographic key)



user → *request to authenticate* → *system*

user ← *random message r (the challenge)* ← *system*

user → *f(r) (the response)* → *system*

One-Time Passwords

- Password that can be used exactly *once*
  - After use, it is immediately invalidated
- Challenge-response mechanism
  - Challenge is number of authentications; response is password for that particular number
- Problems
  - Synchronization of user, system
  - Generation of good random passwords
  - Password distribution problem

S/Key

- One-time password scheme based on idea of Lamport
- *h* one-way hash function (SHA-256, for example)
- User chooses initial seed *k*
- System calculates:

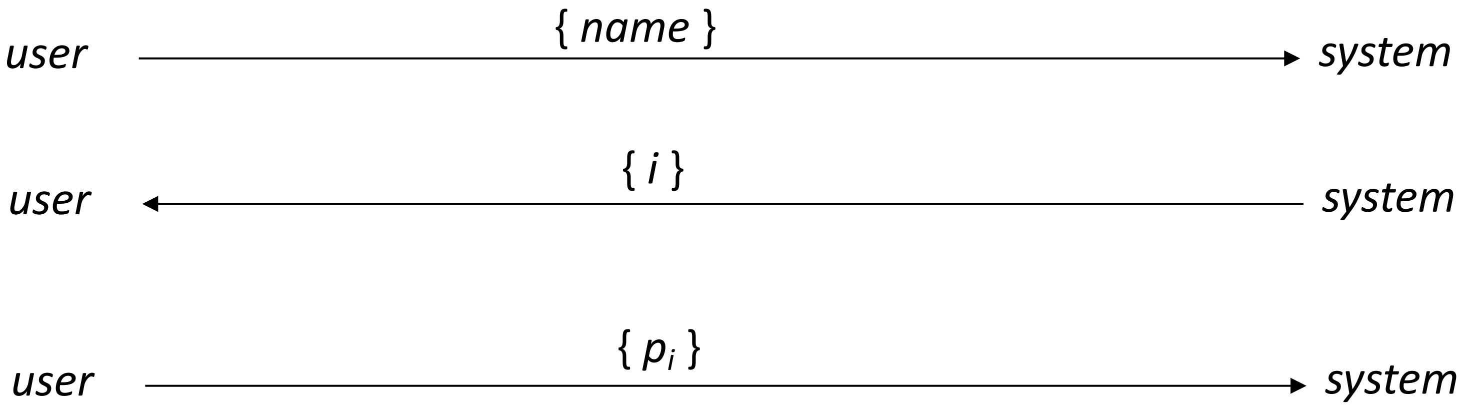
$$h(k) = k_1,\ h(k_1) = k_2,\ \ldots,\ h(k_{n-1}) = k_n$$

- Passwords are reverse order:

$$p_1 = k_n,\ p_2 = k_{n-1},\ \ldots,\ p_{n-1} = k_2,\ p_n = k_1$$

S/Key Protocol

System stores maximum number of authentications n, number of next authentication i, last correctly supplied password p_{i-1}.



user $\xrightarrow{\{\ name\ \}}$ system

user $\xleftarrow{\{\ i\ \}}$ system

user $\xrightarrow{\{\ p_i\ \}}$ system

System computes $h(p_i) = h(k_{n-i+1}) = k_{n-i} = p_{i-1}$. If match with what is stored, system replaces p_{i-1} with p_i and increments i.

Hardware Support

- Token-based
  - Used to compute response to challenge
    - May encipher or hash challenge
    - May require PIN from user
- Temporally-based
  - Every minute (or so) different number shown
    - Computer knows what number to expect when
  - User enters number and fixed password

Biometrics

- Automated measurement of biological, behavioral features that identify a person
  - Fingerprints: optical or electrical techniques
  - Voices: speaker verification or recognition
  - Eyes: patterns in irises unique
  - Faces: image, or specific characteristics like distance from nose to chin
  - Keystroke dynamics: believed to be unique

Location

- If you know where user is, validate identity by seeing if person is where the user is
  - Requires a device saying where the user is, like a smart phone

Multi-Factor Authentication

- Example: “where you are” also requires entity to have LSS and GPS, so also “what you have”
- Can assign different methods to different tasks
  - As users perform more and more sensitive tasks, must authenticate in more and more ways (presumably, more stringently) File describes authentication required
    - Also includes controls on access (time of day, *etc*.), resources, and requests to change passwords
  - Pluggable Authentication Modules

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Identity

- *Principal*: a unique entity
- *Identity*: specifies a principal
- *Authentication*: binding of a principal to a representation of identity internal to the system
  - All access, resource allocation decisions assume binding is correct

Files and Objects

- Identity depends on system containing object
- Different names for one object
  - Human use, *eg*. file name
  - Process use, *eg.* file descriptor or handle
  - Kernel use, *eg*. file allocation table entry, inode

More Names

- Different names for one context
  - Human: aliases, relative *vs*. absolute path names
  - Kernel: deleting a file identified by name can mean two things:
    - Delete the object that the name identifies
    - Delete the name given, and do not delete actual object until *all* names have been deleted
- Semantics of names may differ

Example: Names and Descriptors

- Interpretation of UNIX file name
  - Kernel maps name into an inode using iterative procedure
  - Same name can refer to different objects at different times without being deallocated
    - Causes race conditions
- Interpretation of UNIX file descriptor
  - Refers to a specific inode
  - Refers to same inode from creation to deallocation

Example: Different Systems

- Object name must encode location or pointer to location
  - *SSH* style: *host*:*object*
  - URLs: *protocol*://*host*/*object*
- Need not name actual object
  - *SSH* style may name pointer (link) to actual object
  - URL may forward to another host

Users

- Exact representation tied to system
- Example: UNIX/Linux systems
  - Login name: used to log in to system
    - Logging usually uses this name
  - User identification number (UID): unique integer assigned to user
    - Kernel uses UID to identify users
    - One UID per login name, but multiple login names may have a common UID

Multiple Identities

- UNIX systems again
  - Real UID: user identity at login, but changeable
  - Effective UID: user identity used for access control
    - Setuid changes effective UID
  - Saved UID: UID before last change of UID
    - Used to implement least privilege
    - Work with privileges, drop them, reclaim them later
  - Audit/Login UID: user identity used to track original UID
    - Cannot be altered; used to tie actions to login identity

Groups

- Used to share access privileges
- First model: alias for set of principals
  - Processes assigned to groups
  - Processes stay in those groups for their lifetime
- Second model: principals can change groups
  - Rights due to old group discarded; rights due to new group added

Roles

- Group with membership tied to function
  - Rights given are consistent with rights needed to perform function
- Uses second model of groups
- Example: DG/UX
  - User *root* does not have administration functionality
  - System administrator privileges are in *sysadmin* role
  - Network administration privileges are in *netadmin* role
  - Users can assume either role as needed

Naming and Certificates

- Certificates issued to a principal
    - Principal uniquely identified to avoid confusion
- Problem: names may be ambiguous
    - Does the name “Matt Bishop” refer to:
        - The author of this book?
        - A programmer in Australia?
        - A stock car driver in Muncie, Indiana?
        - Someone else who was named “Matt Bishop”

Disambiguating Identity

- Include ancillary information in names
  - Enough to identify principal uniquely
  - X.509v4 Distinguished Names do this
- Example: X.509v4 Distinguished Names
  - /O=University of California/OU=Davis campus/OU=Department of Computer Science/CN=Matt Bishop/

    refers to the Matt Bishop (CN is *common name*) in the Department of Computer Science (OU is *organizational unit*) on the Davis Campus of the University of California (O is *organization*)

CAs and Policies

- Matt Bishop wants a certificate from Certs-from-Us
  - How does Certs-from-Us know this is “Matt Bishop”?
    - CA’s *authentication policy* says what type and strength of authentication is needed to identify Matt Bishop to satisfy the CA that this is, in fact, Matt Bishop
  - Will Certs-from-Us issue this “Matt Bishop” a certificate once he is suitably authenticated?
    - CA’s *issuance policy* says to which principals the CA will issue certificates

Example: Verisign CAs

- Class 1 CA issued certificates to individuals
  - Authenticated principal by email address
    - Idea: certificate used for sending, receiving email with various security services at that address
- Class 2 CA issued certificates to individuals
  - Authenticated by verifying user-supplied real name and address through an online database
    - Idea: certificate used for online purchasing

Example: Verisign CAs

- Class 3 CA issued certificates to individuals
  - Authenticated by background check from investigative service
    - Idea: higher level of assurance of identity than Class 1 and Class 2 CAs
- Fourth CA issued certificates to web servers
  - Same authentication policy as Class 3 CA
    - Idea: consumers using these sites had high degree of assurance the web site was not spoofed