L13: Representing Identity

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Acknowledgement

- Many slides are from or are revised from the slides of the author of the textbook
  - Matt Bishop, Introduction to Computer Security, Addison-Wesley Professional, October, 2004, ISBN-13: 978-0-321-24774-5. Introduction to Computer Security @ VSU's Safari Book Online subscription
  - http://nob.cs.ucdavis.edu/book/book-intro/slides/

Outline

- Concept of identity
- Principal in computer systems
- Identity defined by functions
  - Files and objects
  - Users, groups, and roles
- Identity for certificates: Certificates and names

Identity

- *Identity* is simply a computer's representation of an *entity*
- Principle
  - A *principle* is a unique *entity*.
  - An *identity* specifies a *principle*
- Authentication
  - Authentication binds a principal to a presentation of identity internal to the system
  - All decisions of access and resource allocation assume that the binding is correct

Purposes of Identities

- Accountability
  - Requires an identity that tracks principals so that the principal taking actions can be unambiguously identified
  - Logging and auditing
    - In most systems, logged identity maps to a user account, to a group or to a role
- Access control
  - Requires an identity to determine a specific access (or type of access) should be allowed
    - In most systems, access rights are on the identity of the principal executing process

Principal

- 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

Purposes of Principals

- Accountability
  - Tracks principals across actions and changes of other principals
  - Any actions taken by the principals can then be unambiguously identified
  - Tied to logging and auditing
- Access control
  - Allow or disallow a specific access or a type of access
  - Most systems adopt the *process* model
    - A process executed by a user has a subset of the user's rights where the user is presented by an identity

Identity in Computer Systems

- One would state,
  - User *Alice* can read *Bob*’s files
  - Subject: Alice
  - Object: Bob’s files
- Both subjects and objects require identities
- Be aware of the complexity
  - Multiple names for one thing in different contexts and environments

Files and Objects

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

Multiple Names for an Object

- 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: one file may have multiple names
    - On some systems, “deleting a file” is to mean removing the given file name; while on the others, it is to mean to remove the name and the file object.

Example: Files in Linux/UNIX

- 4 different types of file names

1. *inode*
2. File descriptor
3. File names: absolute path names
4. File names: relative path names

inode

- uniquely identifies a file
- contains file attribute information, e.g., access control permission and owner information
- identifies the specific disk blocks that contains the file’s data

File Descriptor

- Abstracts *inode* into a presentation that a process can read from, write to, and so forth
  - i.e., Processes read and write files using a file descriptor
- Interpretation of Linux/UNIX file descriptor
  - Refers to a specific inode
  - Refers to same inode from creation to deallocation
  - File descriptor cannot rebound to a different file

File Names

- Identity files by describing their positions in the file hierarchy
- Absolute path names
    - Describe the locations of files with respect to the root of the Linux/UNIX file hierarchy
- Relative path names
    - Describe the locations of files with respect to the directory in which the current process is executing
- Processes and uses can use file names to identify files

File Names and inode

- Interpretation of Linux/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

Example: Different Systems

- Object name must encode location or pointer to location
  - rsh, ssh style: host:object
  - URLs: protocol://host/object
    - http://www.vsu.edu/academics/registrar/final-exam-schedule.php
    - where
      - protocol: http
      - host: www.vsu.edu
      - object: /academics/registrar/final-exam-schedule.php
  - Need not to name actual object
    - rsh, ssh style may name pointer (link) to actual object
    - URL may forward to another host

Users

- One would state,
  - User *Alice* can read *Bob*’s files
  - Subject: Alice
  - Object: Bob’s files
- *Identity* tied to a single *entity*
- Exact representation tied to system
- Often as identities of principals executing processes

Example: Linux/Unix 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
    - e.g., the superuser is any user whose UID is 0 regardless of that user's login name
  - One UID per login name, but multiple login names may have a common UID

Multiple Identities for Users in Linux/Unix Systems

- Real UID: user identity at login, but *changeable*
  - see setreuid(2)
- Effective UID: user identity used for access control
  - setuid programs changes effective UID, see setuid(2)
- 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

Further Reading

- Setuid Program Example
  - http://www.gnu.org/software/libc/manual/html_node/Setuid-Program-Example.html
- Mark S. Dittmer and Mahesh V. Tripunitara. 2014. The UNIX Process Identity Crisis: A Standards-Driven Approach to Setuid. In *Proceedings of the 2014 ACM SIGSAC Conference on Computer and Communications Security* (CCS '14). ACM, New York, NY, USA, 1391-1402. DOI=http://dx.doi.org/10.1145/2660267.2660333
- D. Tsafrir, D. D. Silva, and D. Wagner. The murky issue of changing process identity: revising "setuid demystified". *USENIX;login*, 33(3):55--66, June 2008.
- Hao Chen, David Wagner, and Drew Dean. 2002. Setuid Demystified. In *Proceedings of the 11th USENIX Security Symposium*, Dan Boneh (Ed.). USENIX Association, Berkeley, CA, USA, 171-190.

Groups and Roles

- The "*entity*" may be a *set of entities* referred to by a single *identifier*
  - Members of the set must be distinguishable
  - The set may have an identity separate from any its members

Groups

- Used to share access privileges
  - Principals often need to share access to file
  - e.g., all students have access to “StudentActivityPlan.txt”
  - Most systems allow principals to be grouped into sets called *groups*
- 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 as a mechanism for binding cryotgraphic keys to identifiers
  - Certificates issued to a principal
    - Principal uniquely identified to avoid confusion
    - An identifier corresponds to a principal
- Problem: names may be ambiguous
  - Does the name "Matt Bishop" refer to:
    - The author of the textbook?
    - 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.509v3 Distinguished Names do this
- Example: X.509v3 Distinguished Names
  - /O=University A/OU=Department of Computer Science/CN=David Smith/

    refers to the David Smith (CN is *common name*) in the Department of Computer Science (OU is *organizational unit*) at University A (O is *organization*)

Certificate Authorities and Policies

- "David Smith" wants a certificate from Certs-from-Us
  - How does Certs-from-Us know this is "David Smith"?
    - 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, David Smith
  - Will Certs-from-Us issue this "David Smith" a certificate once he is suitably authenticated?
    - CA's *issuance policy* says to which principals the CA will issue certificates

Example: Vendor Defined Certificate Classes

- See http://www.symantec.com/page.jsp?id=roots

Internet Certification Hierarchy

- Tree structured arrangement of CAs
  - Root is *Internet Policy Registration Authority*, or IPRA
    - Sets policies all subordinate CAs must follow
    - Certifies subordinate CAs (called *policy certification authorities*, or PCAs), each of which has own authentication, issuance policies
    - Does not issue certificates to individuals or organizations other than subordinate CAs
  - PCAs issue certificates to ordinary CAs
    - Does not issue certificates to individuals or organizations other than subordinate CAs
  - CAs issue certificates to organizations or individuals

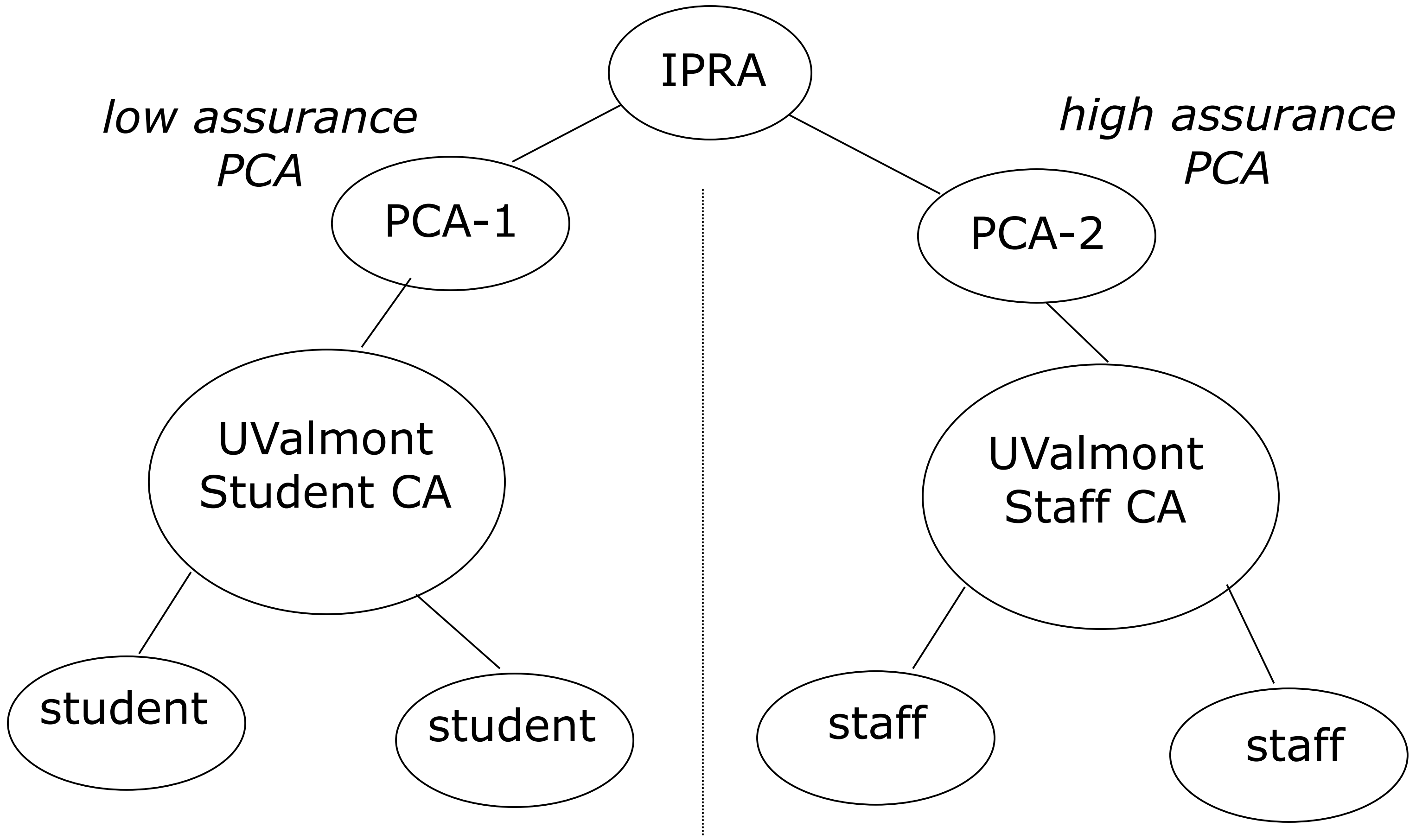
Example

- University of Valmont issues certificates to students, staff
  - Students must present valid registration cards (considered low assurance)
  - Staff must present proof of employment and fingerprints, which are compared to those taken when staff member hired (considered high assurance)

UValmont and PCAs

- First PCA: requires subordinate CAs to make good-faith effort to verify identities of principals to whom it issues certificates
  - Student authentication requirements meet this
- Second PCA: requires use of biometrics to verify identity
  - Student authentication requirements do not meet this
  - Staff authentication requirements do meet this
- UValmont establishes to CAs, one under each PCA above

UValmont and Certification Hierarchy



Certificate Differences

- Student, staff certificates signed using different private keys (for different CAs)
  - Student's signed by key corresponding to low assurance certificate signed by first PCA
  - Staff's signed by key corresponding to high assurance certificate signed by second PCA
- To see what policy used to authenticate:
  - Determine CA signing certificate, check its policy
  - Also go to PCA that signed CA's certificate
    - CAs are restricted by PCA's policy, but CA can restrict itself further

Types of Certificates

- Organizational certificate
  - Issued based on principal’s affiliation with organization
  - Example Distinguished Name

    /O=University of Valmont/OU=Computer Science Department/CN=Marsha Merteuille/
- Residential certificate
  - Issued based on where principal lives
  - No affiliation with organization implied
  - Example Distinguished Name

    /C=US/SP=Louisiana/L=Valmont/PA=1 Express Way/CN=Marsha Merteuille/

Certificates for Roles

- Certificate tied to a role
- Example
  - UValmont wants comptroller to have a certificate
    - This way, she can sign contracts and documents digitally
  - Distinguished Name

    /O=University of Valmont/OU=Office of the Big Bucks/RN=Comptroller

    where "RN" is *role name*; note the individual using the certificate is not named, so no CN

Meaning of Identity

- Authentication validates identity
  - CA specifies type of authentication
  - If incorrect, CA may misidentify entity unintentionally
- Certificate binds *external* identity to crypto key and Distinguished Name
  - Need confidentiality, integrity, anonymity
    - Recipient knows same entity sent all messages, but *not* who that entity is

Persona Certificate

- Certificate with meaningless Distinguished Name
  - If DN is

    /C=US/O=Microsoft Corp./CN=Bill Gates/

    the real subject may not (or may) be Mr. Gates
  - Issued by CAs with persona policies under a PCA with policy that supports this
- PGP certificates can use any name, so provide this implicitly

Example: Whistleblower

- Government requires all citizens with gene Y to register
  - Anecdotal evidence people with this gene become criminals with probability 0.5.
  - Law to be made quietly, as no scientific evidence supports this, and government wants no civil rights fuss
- Government employee wants to alert media
  - Government will deny plan, change approach
  - Government employee will be fired, prosecuted
- Must notify media anonymously

Example: Whistleblower

- Employee gets persona certificate, sends copy of plan to media
  - Media knows message unchanged during transit, but not who sent it
  - Government denies plan, changes it
- Employee sends copy of new plan signed using same certificate
  - Media can tell it's from original whistleblower
  - Media cannot track back whom that whistleblower is

Trust

- Goal of certificate: bind correct identity to DN
- Question: what is degree of assurance?
- X.509v3, certificate hierarchy
  - Depends on policy of CA issuing certificate
  - Depends on how well CA follows that policy
  - Depends on how easy the required authentication can be spoofed
- Really, estimate based on the above factors

Example: Passport Required

- DN has name on passport, number and issuer of passport
- What are points of trust?
  - Passport not forged and name on it not altered
  - Passport issued to person named in passport
  - Person presenting passport is person to whom it was issued
  - CA has checked passport and individual using passport

PGP Certificates

- Level of trust in signature field
- Four levels
  - Generic (no trust assertions made)
  - Persona (no verification)
  - Casual (some verification)
  - Positive (substantial verification)
- What do these mean?
  - Meaning not given by OpenPGP standard
  - Signer determines what level to use
  - Casual to one signer may be positive to another

Summary

- Identity specifies a principal (unique entity)
  - Same principal may have many different identities
    - Function (role)
    - Associated principals (group)
    - Individual (user/host)
  - These may vary with view of principal
    - Different names at each network layer, for example