L12: 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*
- Principal
  - A *principal* is a unique *entity*.
  - An *identity* specifies a *principal*
- 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 David Smith 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

- Symantec Certificate Classes
  - VeriSign Certificate Classes (VeriSign's Security Business was acquired by Symantec in 2010)
- Classes 1 – 3 and Class 3 with Extended Validation
- Policies are defined in Certification Practice Statement
  - See http://www.symantec.com/about/profile/policies/repository.jsp#policies

Symantec Certification Classes

- Symantec Trust Network Certificates (Version 3.8.19, March 19, 2015)

Certificate Class	Assurance Level			Usage		
	Low assurance level	Medium assurance level	High assurance level	Signing	Encryption	Client Authentication
Class 1 Certificates	✓			✓	✓	✓
Class 2 Certificates		✓		✓	✓	✓
Class 3 Certificates			✓	✓	✓	✓

Table 1. Individual Certificate Usage

  - Table 1 from "*Symantec Trust Network (STN) Certification Practice Statement, Version 3.8.19, March 19, 2015*"

Symantec Certification Classes

- Symantec Trust Network Certificate Class 3 (Version 3.8.19, March 19, 2015)

	Assurance Level			Usage			
Certificate Class	High with Extended Validation	High with CABF OV Validation	High	Code/ Content Signing	Secure SSL/TLS-sessions	Authen tication	Signing and Encryption
Class 3 Certificates			✓	✓	✓	✓	✓
Class 3 EV SSL Certificates	✓		✓		✓	✓	✓
Class 3 EV Code Signing Certificates	✓		✓	✓		✓	✓
Class 3 OV Certificates		✓	✓		✓	✓	✓

Table 2. Organizational Certificate Usage[7]

  - Table 2 from "*Symantec Trust Network (STN) Certification Practice Statement, Version 3.8.19, March 19, 2015*"

Symantec Assurance Policies

- Low assurance certificates
  - Not for authentication purposes or to support non-repudiation.
  - Modest assurances that the e-mail originated from a sender with a certain e-mail address.
  - Provides no proof of the identity of the Subscriber.
- See "*Symantec Trust Network (STN) Certification Practice Statement, Version 3.8.19, March 19, 2015*"

Symantec Assurance Policies

- Medium assurance certificates
  - For securing some inter- and intra-organizational, commercial, and personal e-mail requiring a medium level of assurances of the Subscriber identity, in relation to Class 1 and 3.
- See "*Symantec Trust Network (STN) Certification Practice Statement, Version 3.8.19, March 19, 2015*"

Symantec Assurance Policies

- High assurance certificates
  - For both individual and organizational certificates
  - Provide a high level of assurance of the identity of the Subscriber in comparison with Class 1 and 2.
- See *"Symantec Trust Network (STN) Certification Practice Statement, Version 3.8.19, March 19, 2015"*

Symantec Assurance Policies

- High assurance with extended validation certificates
  - Class 3 certificates issued by Symantec in conformance with the Guidelines for Extended Validation Certificates.
  - Extended Validation (EV) is an industry standard and standardized by CA/Browser Forum
- See "*Symantec Trust Network (STN) Certification Practice Statement, Version 3.8.19, March 19, 2015*"

Symantec Root Certificates

- 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

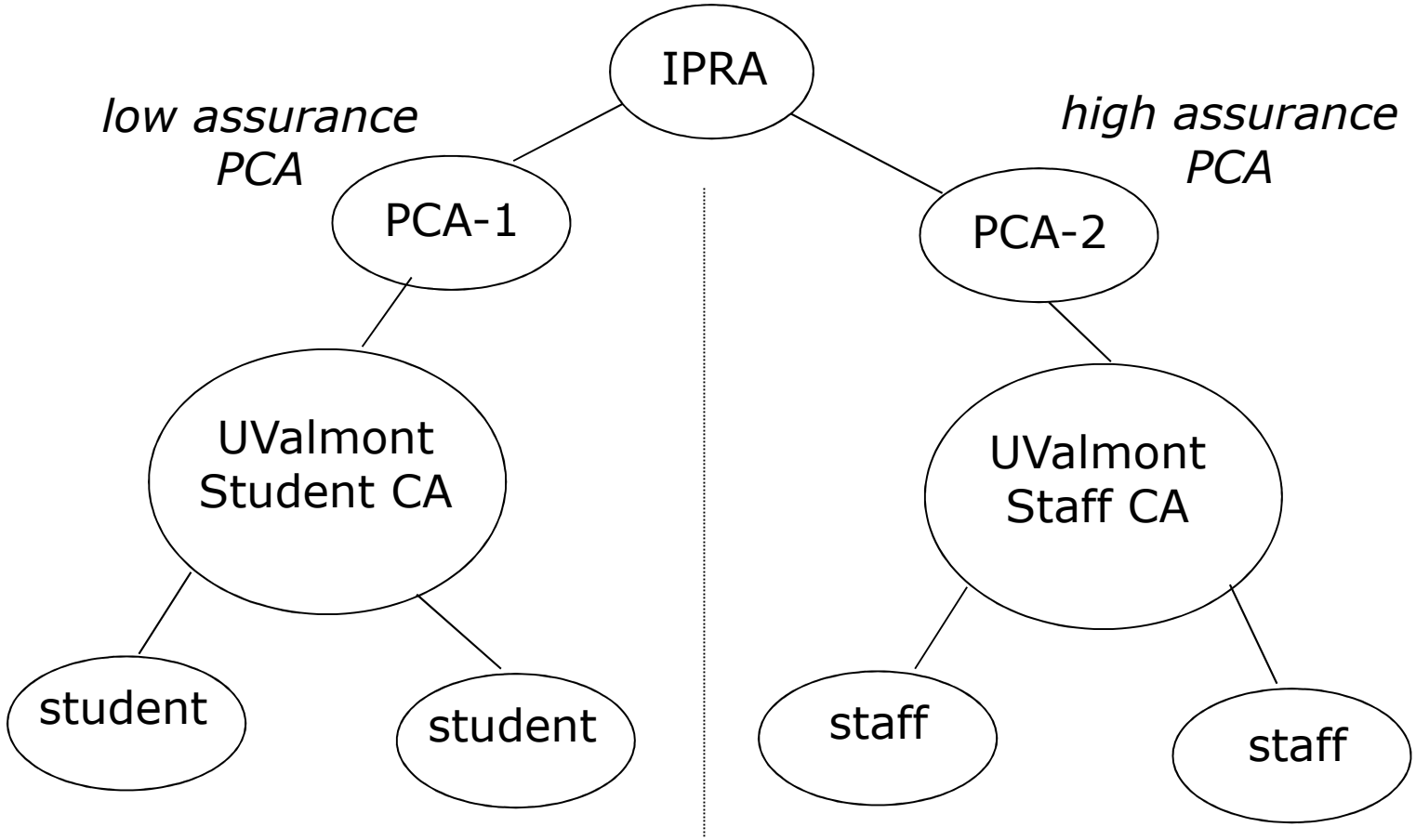
Example

- 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

Example: Whistleblower

- Story of a whistleblower

From: anon108@■■■■■■■■■■
To: Micah Lee
Date: Fri, 11 Jan 2013

Micah,

I'm a friend. I need to get information securely to Laura Poitra
her alone, but I can't find an email/gpg key for her.

Can you help?

From: Laura Poitras
To: Micah Lee
Date: Sat, 12 Jan 2013

Hey Micah,

Thanks for asking. Sure, you can tell this person I can be reached with GPG at: laurapoitras@gmail.com

I'll reply with my public key.

I'm also on jabber/OTR at:
l.p.@jabber.org

I hope all is good with you!

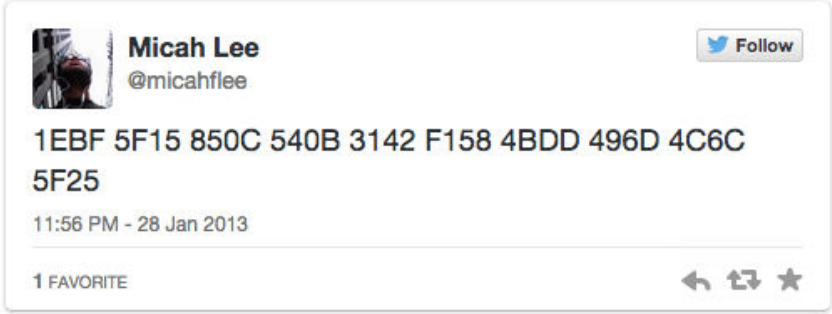
Laura

Example: Whistleblower

- Story of a whistleblower continues

From: 303@riseup.net
To: Micah Lee
Date: Mon, 28 Jan 2013

Hey Micah,
This is Laura Poitras.
Someone is trying to verify my fingerprint to this email. The person has proposed you tweet the fingerprint. Would you be able to tweet this to your acct:
1EBF 5F15 850C 540B 3142 F158 4BDD 496D 4C6C 5F25
Let me know if possible.
Thanks,
Laura



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