Lecture for January 20, 2016

ECS 235A

UC Davis

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Overview

- Access control lists
- Capability lists
- Rings-based access control
- Policies
- Trust
- Nature of Security Mechanisms
- Policy Expression Languages

Access Control Lists

- Columns of access control matrix

	file1	*file2*	*file3*
Andy	rx	r	rwo
Betty	rwxo	r	
Charlie	rx	rwo	w

ACLs:

- file1: { (Andy, rx) (Betty, rwxo) (Charlie, rx) }
- file2: { (Andy, r) (Betty, r) (Charlie, rwo) }
- file3: { (Andy, rwo) (Charlie, w) }

Default Permissions

- Normal: if not named, *no* rights over file
  - Principle of Fail-Safe Defaults
- If many subjects, may use groups or wildcards in ACL
  - UNICOS: entries are (*user*, *group*, *rights*)
    - If *user* is in *group*, has rights over file
    - '*' is wildcard for *user*, *group*
      - (holly, *, r): holly can read file regardless of her group
      - (*, gleep, w): anyone in group gleep can write file

Abbreviations

- ACLs can be long … so combine users
  - UNIX: 3 classes of users: owner, group, rest
  - rwx rwx rwx

    rest

    group

    owner
  - Ownership assigned based on creating process
    - Most UNIX-like systems: if directory has setgid permission, file group owned by group of directory (Solaris, Linux)

ACLs + Abbreviations

- Augment abbreviated lists with ACLs
  - Intent is to shorten ACL
- ACLs override abbreviations
  - Exact method varies
- Example: IBM AIX
  - Base permissions are abbreviations, extended permissions are ACLs with user, group
  - ACL entries can add rights, but on deny, access is denied

Permissions in IBM AIX

```
attributes:
base permissions
  owner(bishop):  rw-
  group(sys):     r--
  others:         ---
extended permissions enabled
  specify         rw-   u:holly
  permit          -w-   u:heidi, g=sys
  permit          rw-   u:matt
  deny            -w-   u:holly, g=faculty
```

ACL Modification

- Who can do this?
  - Creator is given *own* right that allows this
  - System R provides a *grant* modifier (like a copy flag) allowing a right to be transferred, so ownership not needed
    - Transferring right to another modifies ACL

Privileged Users

- Do ACLs apply to privileged users (*root*)?
  - Solaris: abbreviated lists do not, but full-blown ACL entries do
  - Other vendors: varies

Groups and Wildcards

- Classic form: no; in practice, usually
  - UNICOS:
    - holly : gleep : r
      - user holly in group gleep can read file
    - holly : * : r
      - user holly in any group can read file
    - * : gleep : r
      - any user in group gleep can read file
  - AIX: base perms gave group sys read only

    ```
    permit      -w-      u:heidi, g=sys
    ```

    line adds write permission for heidi when in that group

AIX ACL Algorithm

1. Determine what set *S* of permissions the user has from the base permissions.
2. If extended permissions are disabled, stop. The set *S* is the user's set of permissions.
3. Get the next entry in the extended permissions. If there are no more, stop. The set *S* is the user's set of permissions.
4. If the entry has the same user and group as the process requesting access, determine if the entry denies access. If so, stop. Access is denied.
5. Modify *S* as dictated by the permissions in the entry.
6. Go to 3.

Conflicts

- Deny access if any entry would deny access
  - AIX: if any entry denies access, *regardless or rights given so far*, access is denied
- Apply first entry matching subject
  - Cisco routers: run packet through access control rules (ACL entries) in order; on a match, stop, and forward the packet; if no matches, deny
    - Note default is deny so honors principle of fail-safe defaults

Handling Default Permissions

- Apply ACL entry, and if none use defaults
  - Cisco router: apply matching access control rule, if any; otherwise, use default rule (deny)
- Augment defaults with those in the appropriate ACL entry
  - AIX: extended permissions augment base permissions

Revocation Question

- How do you remove subject's rights to a file?
  - Owner deletes subject's entries from ACL, or rights from subject's entry in ACL
- What if ownership not involved?
  - Depends on system
  - System R: restore protection state to what it was before right was given
    - May mean deleting descendent rights too …

Windows 7 NTFS ACLs

- Different sets of rights
  - Basic: read, write, execute, delete, change permission, take ownership
  - Generic: no access, read (read/execute), change (read/write/execute/delete), full control (all), special access (assign any of the basics)
  - Directory: no access, read (read/execute files in directory), list, add, add and read, change (create, add, read, execute, write files; delete subdirectories), full control, special access

Accessing Files

- User not in file's ACL nor in any group named in file's ACL: deny access
- ACL entry denies user access: deny access
- Take union of rights of all ACL entries giving user access: user has this set of rights over file

Example

- Paul, Quentin in group *students*
- Quentin, Regina in group *staff*
- ACL entries for *e:\stuff*
    1. *staff,* create files/write data, allow
    2. Quentin, delete subfolders and files, allow
    3. *students*, delete subfolders and files, deny
- Regina can create files or subfolders (1)
- Quentin cannot delete subfolders and files
    - Even with 2; Quentin in *students*, and explicit deny in 3 overrides allow in 2

More Example

- Regina wants to create folder *e:\stuff\plugh* and set it up so:
  - Paul doesn't have delete subfolders and files access
  - Quentin has delete subfolders and files access
- How does she do this?

How She Does It

Inherited from *e:\stuff*:

staff, create files/write data, allow

Quentin, delete subfolder and files, allow

~~*students*, delete subfolder and files, deny~~

Paul, delete subfolders and files, deny

Capability Lists

- Rows of access control matrix

	file1	*file2*	*file3*
Andy	rx	r	rwo
Betty	rwxo	r	
Charlie	rx	rwo	w

C-Lists:

- Andy: { (file1, rx) (file2, r) (file3, rwo) }
- Betty: { (file1, rwxo) (file2, r) }
- Charlie: { (file1, rx) (file2, rwo) (file3, w) }

Semantics

- Like a bus ticket
  - Mere possession indicates rights that subject has over object
  - Object identified by capability (as part of the token)
    - Name may be a reference, location, or something else
  - Architectural construct in capability-based addressing; this just focuses on protection aspects
- Must prevent process from altering capabilities
  - Otherwise subject could change rights encoded in capability or object to which they refer

Implementation

- Tagged architecture
  - Bits protect individual words
    - B5700: tag was 3 bits and indicated how word was to be treated (pointer, type, descriptor, *etc*.)
- Paging/segmentation protections
  - Like tags, but put capabilities in a read-only segment or page
    - EROS does this
  - Programs must refer to them by pointers
    - Otherwise, program could use a copy of the capability—which it could modify

Implementation (*con't*)

- Cryptography
  - Associate with each capability a cryptographic checksum enciphered using a key known to OS
  - When process presents capability, OS validates checksum
  - Example: Amoeba, a distributed capability-based system
    - Capability is (*name*, *creating_server*, *rights*, *check_field*) and is given to owner of object
    - *check_field* is 48-bit random number; also stored in table corresponding to *creating_server*
    - To validate, system compares *check_field* of capability with that stored in *creating_server* table
    - ***Vulnerable if capability disclosed to another process***

Amplifying

- Allows *temporary* increase of privileges
- Needed for modular programming
  - Module pushes, pops data onto stack

    ```
    module stack … endmodule.
    ```
  - Variable *x* declared of type stack

    ```
    var x: module;
    ```
  - *Only* stack module can alter, read *x*
    - So process doesn't get capability, but needs it when *x* is referenced — a problem!
  - Solution: give process the required capabilities while it is in module

Examples

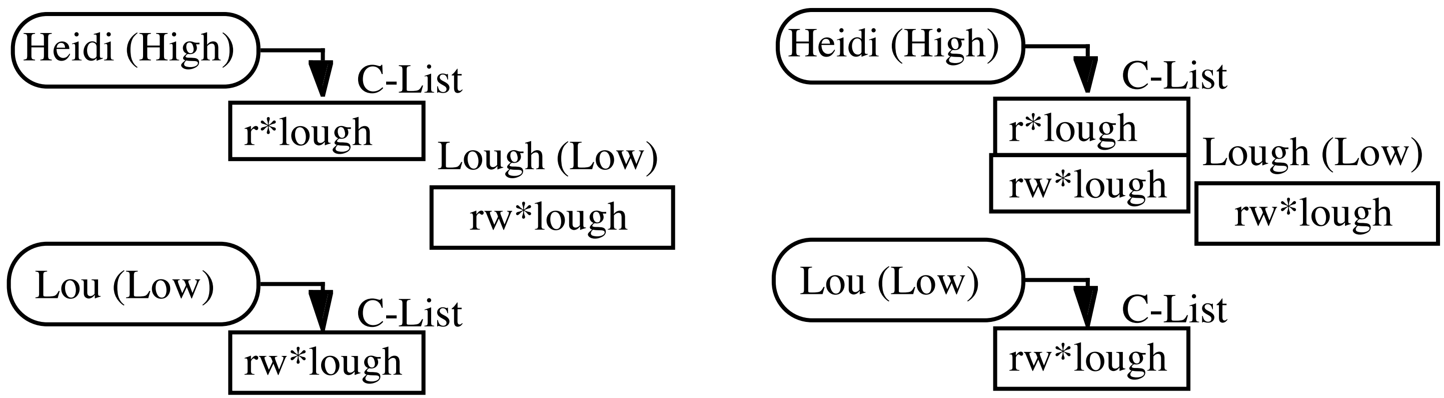
- HYDRA: templates
  - Associated with each procedure, function in module
  - Adds rights to process capability *while the procedure or function is being executed*
  - Rights deleted on exit
- Intel iAPX 432: access descriptors for objects
  - These are really capabilities
  - 1 bit in this controls amplification
  - When ADT constructed, permission bits of type control object set to what procedure needs
  - On call, if amplification bit in this permission is set, the above bits or'ed with rights in access descriptor of object being passed

Revocation

- Scan all C-lists, remove relevant capabilities
  - Far too expensive!
- Use indirection
  - Each object has entry in a global object table
  - Names in capabilities name the entry, not the object
    - To revoke, zap the entry in the table
    - Can have multiple entries for a single object to allow control of different sets of rights and/or groups of users for each object
  - Example: Amoeba: owner requests server change random number in server table
    - All capabilities for that object now invalid

Limits

- Problems if you don't control copying of capabilities



The capability to write file *lough* is Low, and Heidi is High so she reads (copies) the capability; now she can write to a Low file, violating the *-property!

Remedies

- Label capability itself
  - Rights in capability depends on relation between its compartment and that of object to which it refers
    - In example, as as capability copied to High, and High dominates object compartment (Low), write right removed
- Check to see if passing capability violates security properties
  - In example, it does, so copying refused
- Distinguish between “read” and “copy capability”
  - Take-Grant Protection Model does this (“read” and “take”)

ACLs vs. Capabilities

- Both theoretically equivalent; consider 2 questions
  1. Given a subject, what objects can it access, and how?
  2. Given an object, what subjects can access it, and how?
  - ACLs answer second easily; C-Lists, first
- Suggested that the second question, which in the past has been of most interest, is the reason ACL-based systems more common than capability-based systems
  - As first question becomes more important (in incident response, for example), this may change

Privileges

- In Linux, used to override or add access restrictions by adding, masking rights
  – Not capabilities as no particular object associated with the (added or deleted) rights
- 3 sets of privileges
  – Bounding set (all privileges process may assert)
  – Effective set (current privileges process may assert)
  – Saved set (rights saved for future purpose)
- Example: UNIX effective, saved UID

Trusted Solaris

- Associated with each executable:
  - *Allowed set* (*AS*) are privileges assigned to process created by executing file
  - *Forced set* (*FS*) are privileges process must have when it begins execution
  - $FS \subseteq AS$

Trusted Solaris Privileges

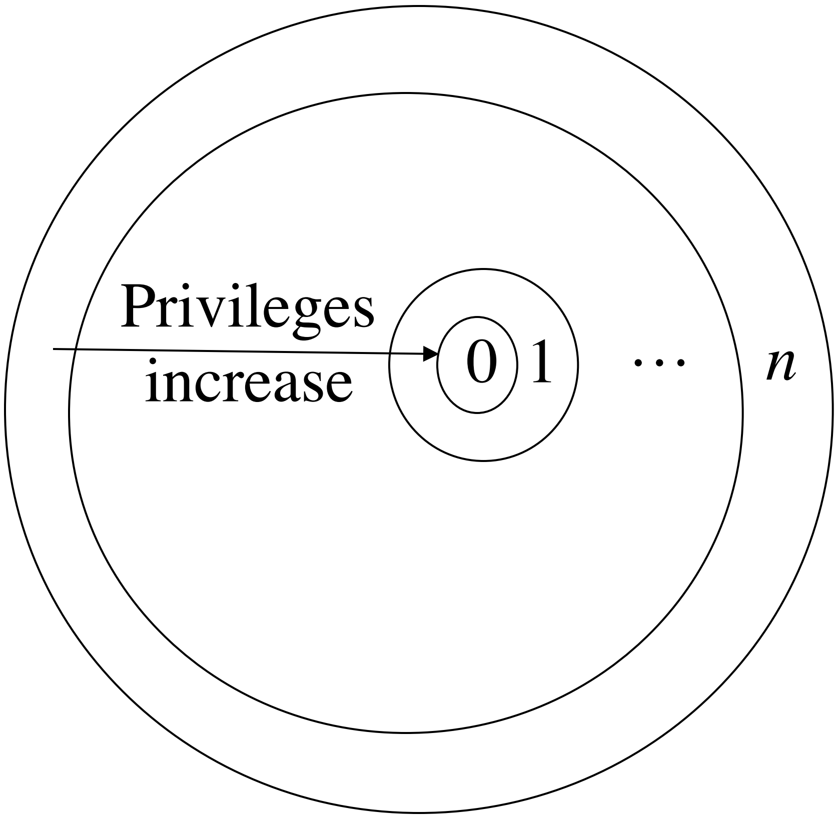
Four sets:

- *Inheritable set* (*IS*): privileges inherited from parent process
- *Permitted set* (*PS*): all privileges process may assert; defined as $(FS \cup IS) \cap AS$
  - Corresponds to bounding set
- *Effective set* (*ES*): privileges program requires for current task; initially, *PS*
- *Saved set* (*SS*): privileges inherited from parent process and allowed for use; that is, $IS \cap AS$

Bracketing Effective Privileges

- Process needs to read file at particular point
- *file_mac_read*, f*ile_dac_read* ∈ *PS*, *ES*
- Initially, program deletes these from *ES*
  - So they can't be used
- Just before reading file, add them back to *ES*
  - Allowed as these are in *PS*
- When file is read, delete from *ES*
  - And if no more reading, can delete from *PS*

Ring-Based Access Control



- Process (segment) accesses another segment
  - Read
  - Execute
- *Gate* is an entry point for calling segment
- Rights:
  - *r* read
  - *w* write
  - *a* append
  - *e* execute

Reading/Writing/Appending

- Procedure executing in ring r
- Data segment with *access bracket* (a_1, a_2)
- Mandatory access rule
  - $r \le a_1$ allow access
  - $a_1 < r \le a_2$ allow r access; not w, a access
  - $a_2 < r$ deny all access

Executing

- Procedure executing in ring r
- Call procedure in segment with *access bracket* (a_1, a_2) and *call bracket* (a_2, a_3)
  - Often written (a_1, a_2, a_3)
- Mandatory access rule
  - $r < a_1$ allow access; ring-crossing fault
  - $a_1 \le r \le a_2$ allow access; no ring-crossing fault
  - $a_2 < r \le a_3$ allow access if through valid gate
  - $a_3 < r$ deny all access

Versions

- Multics
  – 8 rings (from 0 to 7)
- Intel’s Itanium chip
  – 4 levels of privilege: 0 the highest, 3 the lowest
- Older systems
  – 2 levels of privilege: user, supervisor