Lecture 13
October 19, 2022

Access Control Mechanisms

- Access control lists
- Capability lists
- Ring-based access control

Access Control Lists

- Columns of access control matrix

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

ACLs:

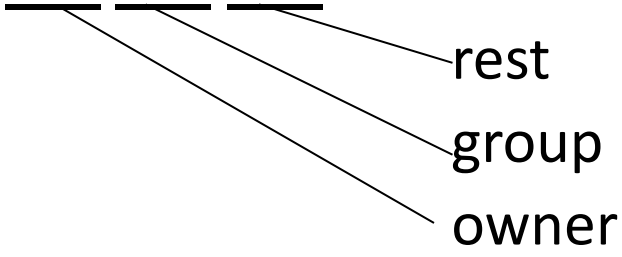
- file1: { (Andy, rx) (Betty, rwxo) (Charlie, rx) }
- file2: { (Andy, r) (Betty, r) (Charlie, rwo) }
- file3: { (Andy, rwo) (Charlie, w) }

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



  - 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: Extended permissions (Linux, FreeBSD, others)
  - Minimal ACLs are abbreviations, extended ACLs give specific users, groups permissions
  - Extended ACL entries give rights provided those rights are in mask

Minimal and Extended ACL

user *heidi*, group *family* owns file with permissions:

```
user::rw-
user:skyler:rwx
group::rw-
group:child:r--
mask::rw-
other::r--
```

- *heidi* can read, write file (first line)
- *matt*, not in group *child*, can read file (last line)
- *skyler* can read, write file (second line masked by fifth line)
- *sage*, in group *family*, can read, write the file (third line masked by fifth line)
- *steven*, in group *child*, can read file (fourth line masked by fifth line)

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

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 …

Capability Lists

- Columns 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

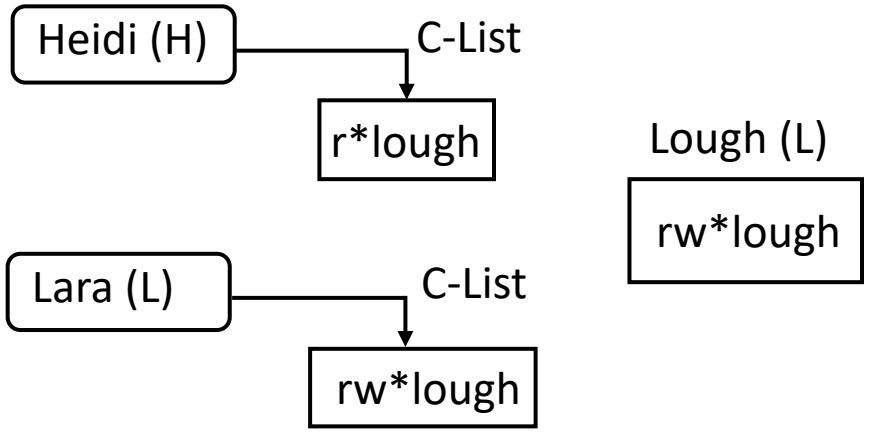
- HYDRA: templates
  - Associated with each procedure, function in module
  - Adds rights to process capability *while the procedure or function is being executed*
  - Rights deleted on exit
- Intel iAPX 432: access descriptors for objects
  - These are really capabilities
  - 1 bit in this controls 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

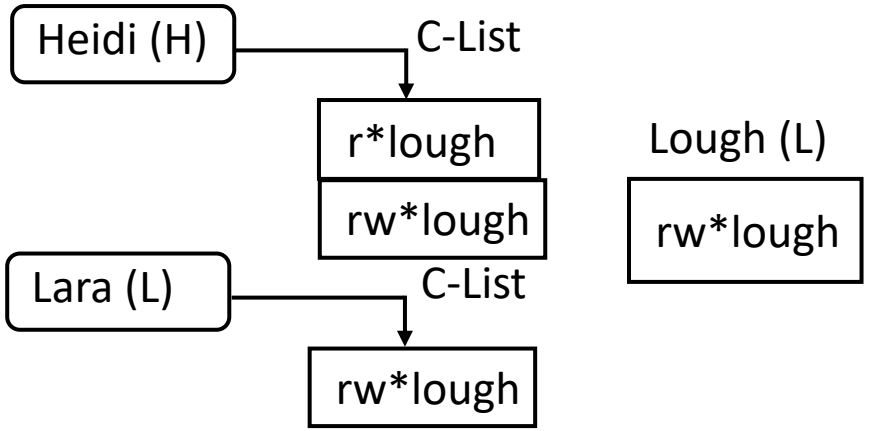
Revocation

- 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

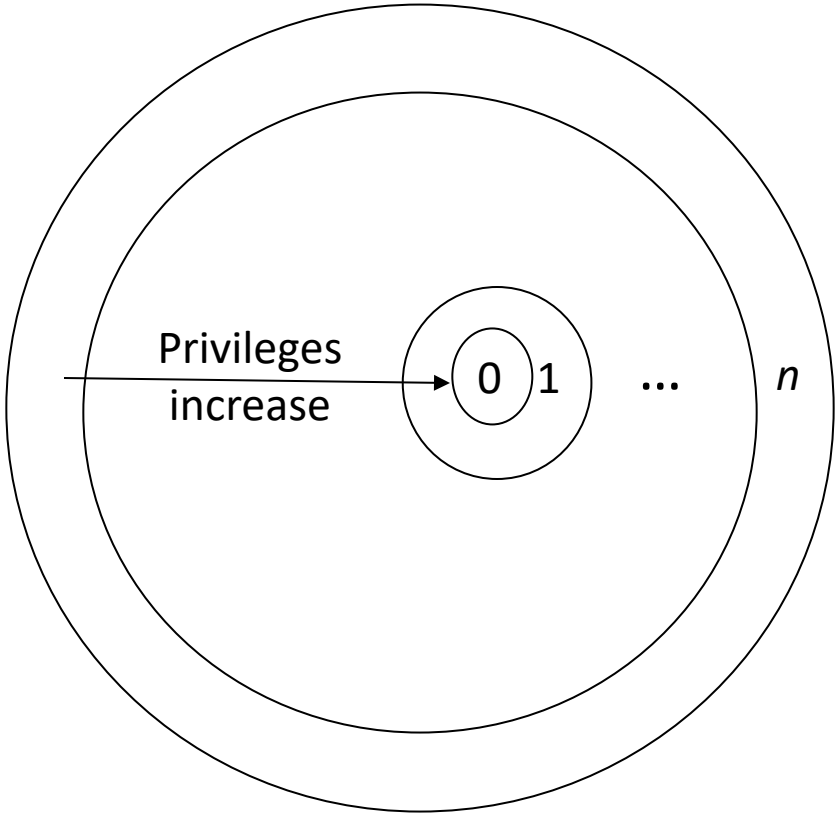
Four sets:

- *Inheritable set* (*IS*): privileges inherited from parent process
- *Permitted set* (*PS*): all privileges process may assert; (*FS* ∪ *IS*) ∩ *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* ∩ *AS*

Bracketing Effective Privileges

- Process needs to read file at particular point
- *file_mac_read, file_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 (data)
  - execute (routine)
- *Gate* is an entry point for calling segment
- Rights:
  - *r* read
  - *w* write
  - *a* append
  - *e* execute