CS458/CS558 Introduction to Computer Security

Access Control

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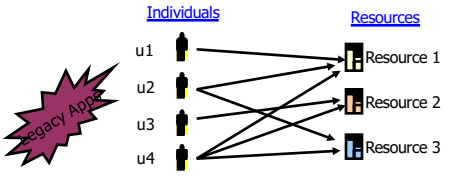
Discretionary Access Control

- Restricts access to objects based solely on the identity of users who are trying to access them.
- The owner of a resource decides who can access to the resource and what privileges they have.



http://csrc.nist.gov/rbac/alvarez.ppt

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Discretionary Access Control Example

- Linux uses discretionary access control
- ls –l

```
-rw-r--r--  1 pyang pyang   17446 Mar  6 11:28 a
drwx------ 21 pyang pyang   4096 Jun 10  2010 b
lrw-r--r--  21 pyang pyang    13 Mar 15  2011 c -> /var/run
```

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```

- Bit 1:
  - -: normal file, d: directory, l:link pointing to a file
- Bits 2 – 4: r (read), w (write), and x (execution) permissions for owner.
- Bits 5 – 7: r, w, and x permissions for group.
- Bits 8 – 10: r, w, and x permissions for others.

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Discretionary Access Control Example (Cont.)

```
-rw-r--r--  1 pyang pyang   31399 Mar  6 11:32 t.c
```

```
> chmod 700 t.c
```

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Discretionary Access Control Example (Cont.)

```
-rw-r--r--  1 pyang pyang   31399 Mar  6 11:32 t.c

> chmod 700 t.c
-rwx------  1 pyang pyang   31399 Mar  6 11:32 t.c
```

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Discretionary Access Control Example (Cont.)

```
-rw-r--r--  1 pyang pyang   31399 Mar  6 11:32 t.c

> chmod 700 t.c
-rwx------  1 pyang pyang   31399 Mar  6 11:32 t.c

> chmod g+r t.c
```

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Discretionary Access Control Example (Cont.)

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> chmod g+r t.c
-rwxr-----  1 pyang pyang   31399 Mar  6 11:32 t.c
```

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Mandatory Access Control

- Assign a security level to each object
  - Reflects sensitivity of information in that object
- Assign a security clearance to each user
  - Reflects his trustworthiness
- Security level/clearance:
  - Top Secret (TS)
  - Secret (S)
  - Confidential (C)
  - Unclassified (U)

TS > S > C > U

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Mandatory Access Control

- No Read-up: A user A can read only those objects whose security level <= the security level of A
- No Write-down: A user A can create only objects whose security level >= the security level of A.
- Example:

  Security clearance: (u1, TS), (u2, C),

  Security level: (o1, TS), (o2, S), (o3,C), (o4,U)

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  u1 can read o1, o2, o3, o4

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  u1 can read o1, o2, o3, o4

  write o1

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Mandatory Access Control

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- No Write-down: A user A can create only objects whose security level >= the security level of A.
- Example:

  Security clearance: (u1, TS), (u2, C),

  Security level: (o1, TS), (o2, S), (o3,C), (o4,U)

  u1 can read o1, o2, o3, o4

  write o1

  u2 can read o3, o4

  write o1, o2, o3

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Role-Based Access Control (RBAC)

- Users are assigned to appropriate roles; Permissions are associated with roles.

  - Role: typically associated with a function or position in an organization, e.g., doctor, nurse, patient.
  - Permission = (operation, resource).
  - A user has a permission if he is a member of some role with that permission.

http://csrc.nist.gov/rbac/sandhu-ferraiolo-kuhn-00.ps

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Role-Based Access Control (RBAC)

- Benefits
  - Greatly reduces redundancy: permissions are associated with roles, not users. E.g.

Discretionary (10000 rules):

$(u_1, f_1), \ldots, (u_1,\ldots,f_{10})$

……

$(u_{1000},f1), \ldots, (u_{1000}, f_{10})$

Role-based (1000+10 rules):

$(u_1$, Student), …, $(u_{1000}$, Student)

(Student, f_1), …, (Student, f_{10})

  - Easy to administer: roles reflect organizational structure and change less frequently.

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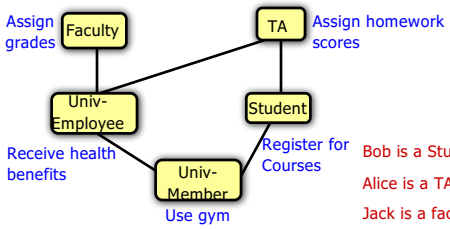
RBAC: Role Hierarchy

- $r_1 \geq r_2$: r_1 inherits from r_2, r_1 is senior to r_2.
  - Permission flows up, Membership flows down.
    - Every member of r_1 is a member of r_2.
    - Members of r_1 have all the permissions that members of r_2 have.



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RBAC: Separation of Duty

- Prevent a single user from garnering too much authority.
- Two types
  - Static Separation of Duty (SSD)
  - Dynamic Separation of Duty (DSD)

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Static Separation of Duty

- Constraints on assignment of user to role.
- If user is member of one role, it gets no membership for other role.

Example:

(DeptChair, Dean) ∈ SSD

A user cannot be in both Deptchair and Dean roles

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Dynamic separation of Duty

- User cannot act simultaneously in both roles,

Example:

(Supervisor, Cashier) ∈ DSD

A user cannot invoke both Supervisor and Cashier roles at the same time

Cashier

Closes Cashier Role session

Opens Supv Role session

Supervisor

Accounting Error

Correct Error

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Database Access Control

http://www.fsl.cs.sunysb.edu/~swam/cse590/papers/db-sec-concepts.pdf

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System R Authorization Model

- Most commercial database management systems (DBMS) adopt DAC
- System R model: one of the first authorization models for relational database management system.
- Database table (relation)

FirstName	LastName	Email	Phone
John	Smith	John.Smith@yahoo.com	626 222-2222
Steven	Goldfish	goldfish@fishhere.net	323 455-4545
Paula	Brown	pb@herowndomain.org	416 323-3232
James	Smith	jim@supergig.co.uk	416 323-8888

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System R Authorization Model

- Current discretionary authorization models for relational DBMS are based on the System R authorization model.
- Access privilege:
  - SELECT: retrieve data from a database
  - INSERT: insert new records in a database
  - DELETE: delete records from a database
  - UPDATE: update records in a database

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System R Authorization Model

- Based on ownership administration with administration delegation
- When a user creates a table, becomes the owner of that table.
  - Authorized to exercise all access modes on the table
- Owner can delegate privileges to other subjects using GRANT option.

  Bob: GRANT select, insert ON Employee TO Ann
- If a privilege is granted with the grant option, the user receiving it cannot only exercise the privilege, but can also grant it to other users

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System R Authorization Model

- Subject, to whom the administration right on a given table has been granted and then revoked, may have granted to another subject an authorization to access the table.

  Bob: GRANT select, insert ON Employee TO Ann

  Ann: GRANT select ON Employee TO Jim

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System R Model: Revocation

- Revoke: take back to the authorizations from a subject
- Recursive revocation: removes all authorizations for the table from the revokee
- Non-cascading revocation
  - Authorization granted by user from whom the authorization is being revoked are not revoked
- Periodic Authorization
  - Users given access authorization to data only for the time periods in which they need data

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Content-Based Access Control

- Access control decisions based on data contents
- Example
  - Table employee: records information about employees of a company
  - Access control Requirement: A manager can only access the information of employees who work in the project that he manages.
  - When a manager issues a query, the system returns only the tuples related to the employees who are working in the project managed by this manager.

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View based Access Control

- Suppose we want to authorize user Ann to access only the employees whose salary is lower than 20000:

```
CREATE VIEW AnnView AS
SELECT * FROM Employee
WHERE Salary < 20000;
GRANT Select ON AnnView TO Ann;
```

Ann: `SELECT * FROM AnnView`

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Query Modification

- Example: suppose we want authorize user Ann to access only the employees whose salary is lower than 20000:

Ann: `SELECT * FROM Employee`

After query modification:

```
SELECT * FROM Employee
        WHERE Salary < 20000
```

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Chapter 18
Intrusion Detection

Intrusion

- Unauthorized intrusion into a computer system/network is one of the most serious threats to computer security.
- Intrusion detection systems (IDS): detect unusual patterns of activity or patterns of activity that are known to correlate with intrusions.
  - Host based: monitors systems calls or logs
  - Network based: monitors the flow of network packets
  - Provide early warning of an intrusion so that defensive action can be taken to prevent or minimize damage.

Intruders

- A significant issue for networked systems is hostile or unwanted access by users or software
  - User trespass:
    - Unauthorized logon to a machine
    - Acquisition of privileges or performance of actions beyond those that have been authorized
  - Software trespass: Virus, worm, or Trojan horse
  - These attacks relate to network security.
  - However, these attacks are not confined to network-based attack.
    - E.g. virus may be introduced into a system by means of a diskette.

Three Classes of Intruders

- Masquerader (outsider): an individual who is not authorized to use the computer and who penetrates a system's access controls to exploit a legitimate user's account.
- Misfeasor (insider): a legitimate user who accesses data, programs, or resources for which such access is not authorized, or is authorized but misuses his/her privileges
- Clandestine user (outsider/insider): an individual who seizes supervisory control of the system and uses this control to evade auditing and access controls or to suppress audit collection.

Intruders

- May seem benign, but still cost resources – may slow performance for legitimate users
- However, there is no way in advance to know whether an intruder will be benign or malign.
- May use compromised system to launch other attacks
- Example: attack occurred at Texas A&M, 1992
  - The computing center was notified that one of its machines was being used to attack computers at other location
  - Several outside intruders involved – obtained hundreds of passwords, including some of the major and supposedly security servers.
  - One machine was set up as a hacker bulletin board.

Two Levels of Hackers

- High level: sophisticated users with thorough knowledge of the technology
- Low level: foot soldiers who merely used the supplied cracking programs with little understanding of how they worked.
- Team work combined these two: sophisticated knowledge of how to intrude and a willingness to spend countless hours "turning doorknobs" to probe for weaknesses.

Intrusion Techniques

- Aim to gain access and/or increase privileges on a system - key goal often is to acquire passwords
- Typically, a system must maintain a file that associates a password with each authorized user. If such a file is stored with no protection, then it is easy to access it and learn password.

Intrusion Techniques

- Aim to gain access and/or increase privileges on a system - key goal often is to acquire passwords
- Typically, a system must maintain a file that associates a password with each authorized user.
- Protecting password
  - One-way function: the system stores only the value of a function based on the user's password.
    - When the user presents a password, the system transforms that password and compares it with the stored value.
  - Access control: access to the password file is limited to one or a very few accounts.

Password Guessing

- Attacker knows a login (from email/web page etc)
- Then attempts to guess password for it
- Weak passwords

Password Guessing

- Attacker knows a login (from email/web page etc)
- Then attempts to guess password for it
- Weak passwords
  - Short password (eg. sdgw@)
  - Contains only small-case letters (e.g. absdrsgs)
  - Contains only capital letters (e.g. SIRLSOFN)
  - Contains only digits (e.g. 12389506)
  - Contains dictionary words (e.g. helloworld)
  - Contains only adjacent keys (e.g. sdfghjkl)

Password Guessing

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Password Guessing

- Attacker knows a login (from email/web page etc)
- Then attempts to guess password for it
  - Exhaustively try all short passwords (1-3 characters)
    - The system can simply reject any login after 3 password attempts
  - The default passwords used with standard accounts
  - Common word searches: try words in the system's online dictionary or a list of likely passwords
  - Collect information about users: variations on names, birthday, phone, common words/interests

Password Guessing

- Guessing attacks are highly effective when a large number of guesses can be attempted automatically and each guess verified without the guessing process being detected
- Use a Trojan horse to bypass restrictions on access
  - A low-privilege user produces a game program and invite the system administrator to use the program.
  - The program indeed plays the game, but in the background it also copies the password file (unencrypted, but access protected).
  - Because the game was running under the administrator's high-privilege mode, it was able to gain access to the password file.
  - Trojan horse can be very difficult to counter

Password Capture

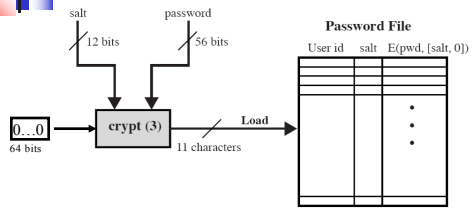
- Watching over shoulder as password is entered
- Using a trojan horse program to collect password
- Monitoring an insecure network login
  - eg. telnet, FTP, web, email

Password Management

Unix Password Management

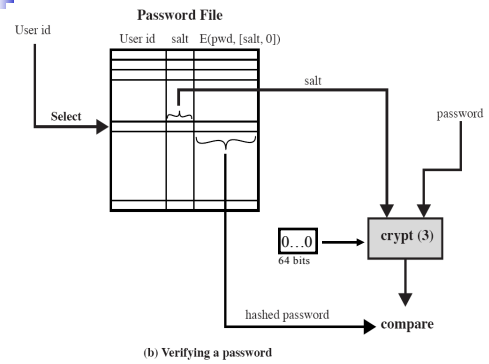
- The user selects a password
- The password is converted into a 56-bit value that serves as the key.
- The encryption routine is known as crypt(3), which is based on DES
- http://en.wikipedia.org/wiki/Shadow_password

Loading a New Password



- 12-bit salt: the time at which the password is assigned to the user
- Encrypt a 64-bit block of zeros 25 times
- The resulting in 64-bit output is translated into 11 character sequence

Verifying a password



(b) Verifying a password

Managing Passwords - Education

- Studies have shown that many people use short passwords or guessable passwords
- Need some approach to counter this
- Educate on importance of good passwords
  - Give guidelines for good passwords
    - Minimum length (>6)
    - Require a mix of upper & lower case letters, numbers, punctuation
    - Not dictionary words

Managing Passwords - Computer Generated

- Let computer create passwords

Managing Passwords - Computer Generated

- Let computer create passwords
  - If the passwords are quite random in nature, users will not be able to remember them.
  - Even if the password is pronounceable, the user may have difficulty remembering it.
  - Have history of poor user acceptance

Managing Passwords - Computer Generated

Forgot Password

- Forgot password
  - If the user has provided an alternative email address, then
    - email the password to the user (not secure)
    - email a link to the user which enables the user to change the password
      - The link should not contain ID of the user
      - The link should expire shortly, e.g. within 2 days

Forgot Password

- Forgot password
  - If the user has provided a phone number, then
    - send the password to the phone (not secure)
    - Send a token to the phone; the user needs to enter the token in order to change the password
      - The token should be randomly generated
      - The token should expire after short time e.g. within 2 days

Forgot Password

- Forgot password
  - If the user has provided security questions and answers, then prompt the user security questions
  - The answer to a good security question is:
    - Safe: cannot be guessed or researched
    - Stable: does not change over time
    - Memorable: can remember
    - Simple: is precise, easy, consistent
    - Many answers: has many possible answers

Forgot Password

- Forgot password
  - If the user has provided security questions and answers, then prompt the user security questions
    - It is difficult to find questions that meet all five criteria
      - People share so much personal information on social media, blogs, and websites, that it is hard to find questions that meet the criteria above.
      - Many questions are not applicable to some people; for example, what is your oldest child's nickname – but you don't have a child.

Forgot Password

- Forgot password
  - If the user provides neither email, phone, nor security questions
    - Ask user to provide e.g.
      - Name, birthday etc
      - When was the account created
      - The last date when the user logs onto the account
      - Three contacts
      - Three email subjects
      - IP address

Intrusion Detection

Intrusion Detection

- Intrusion detection system
  - Block if detected quickly. The sooner the intrusion is detected, the less the amount of damage and the more quickly that recovery can be achieved.
  - Act as deterrent
  - Collect info to strengthen the intrusion prevention facility

Intrusion Detection

- Assume intruder will behave differently from a legitimate user
  - But there is an overlap in these behaviors.
  - A loose interpretation of intruder behavior will lead to a number of false positives
  - A tight interpretation of intruder behavior will lead to an increase in false negatives or intruders not identified as intruders.
  - An element of compromise in the practice of intrusion detection

Statistical Anomaly Detection

- Collect of data relating to the behavior of legitimate users over a period of time.
- Statistical tests are applied to observed behavior to determine with a high level of confidence whether the behavior is not legitimate user behavior.

Statistical Anomaly Detection

- Threshold detection
  - Defines thresholds for the frequency of occurrence of various events - independent of users
    - Count occurrences of specific event over time
    - If exceed reasonable value assume intrusion
    - Alone is an ineffective detector: may generate a lot of false positive or a lot of false negative

Statistical Anomaly Detection

- Profile based
  - A profile of the activity of each user is developed and is used to detect changes in the behavior of individual accounts.
    - Characterize past behavior of users
    - Detect significant deviations from this

Rule-Based Detection

- Rule-based detection: attempt to define a set of rules that can be used to decide that a given behavior is that of an intruder.
  - Rules identify known penetration, weakness patterns or suspicious behavior
  - Compare audit records or states against rules
  - Quality depends on how well this is done

Example: Rule-Based Detection

- Uses heuristic rules to assign degrees of suspicion to activities
  - Users should not read files in other users' personal directories
  - Users must not write other users' files
- Audit records are examined, and they are matched against the rule base.
- If a match is found, then the user's suspicion rating is increased.
- If enough rules are matched, then the rating will pass a threshold that results in the reporting of an anomaly.

Audit Records

- Fundamental tool for intrusion detection
- Native audit records
  - Part of all common multi-user OS
  - Advantage: no additional collection software is needed
  - Disadvantage: may not contain the needed information or may not contain it in a convenient form.
- Detection-specific audit records
  - Created specifically to collect wanted info
  - At cost of additional overhead on system

Audit Records

- The audit records developed by Dorothy Denning
  - Subject: initiators of actions – a terminal user or a process acting on behalf of users or groups of users.
  - Object: e.g. files, programs, etc.
  - Action: operation performed by the subject on or with an object, e.g. read, login, execute.
  - Exception-condition: which exception condition is raised on return
  - Resource-usage: e.g. number of records read or written, processor time, etc.
  - Time-stamp: identify when an action took place.

Audit Records

- Most user operations are made up of a number of elementary actions
  - E.g. file copy
    - Access validation
    - Read from one file
    - Write to another file
- Consider the command copy game.exe to <Library> game.exe issued by Smith.

smith	execute	<Library>copy.exe	0	CPU=00002	11058721678
smith	read	<smith>game.exe	0	CPU=00020	11058721679
smith	write	<Library>game.exe	write-vio	CPU=00005	11058721680

Base-Rate Fallacy

- Practically an intrusion detection system needs to detect a substantial percentage of intrusions with few false alarms
  - If too few intrusions detected ➔ false security
  - If too many false alarms ➔ waste time
- This is very hard to do
- Existing systems seem not to have a good record