University of BRISTOL

Access Control

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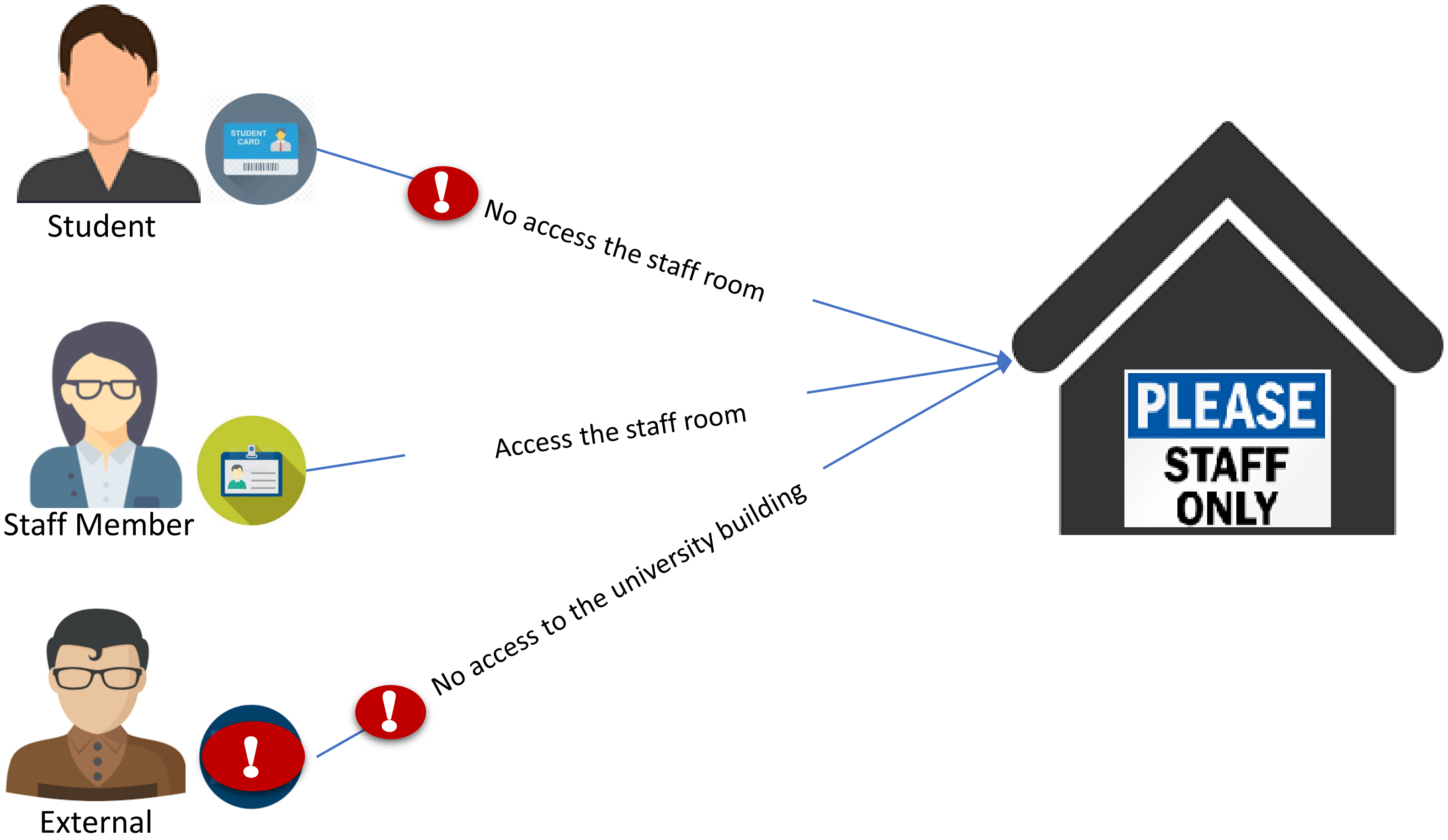
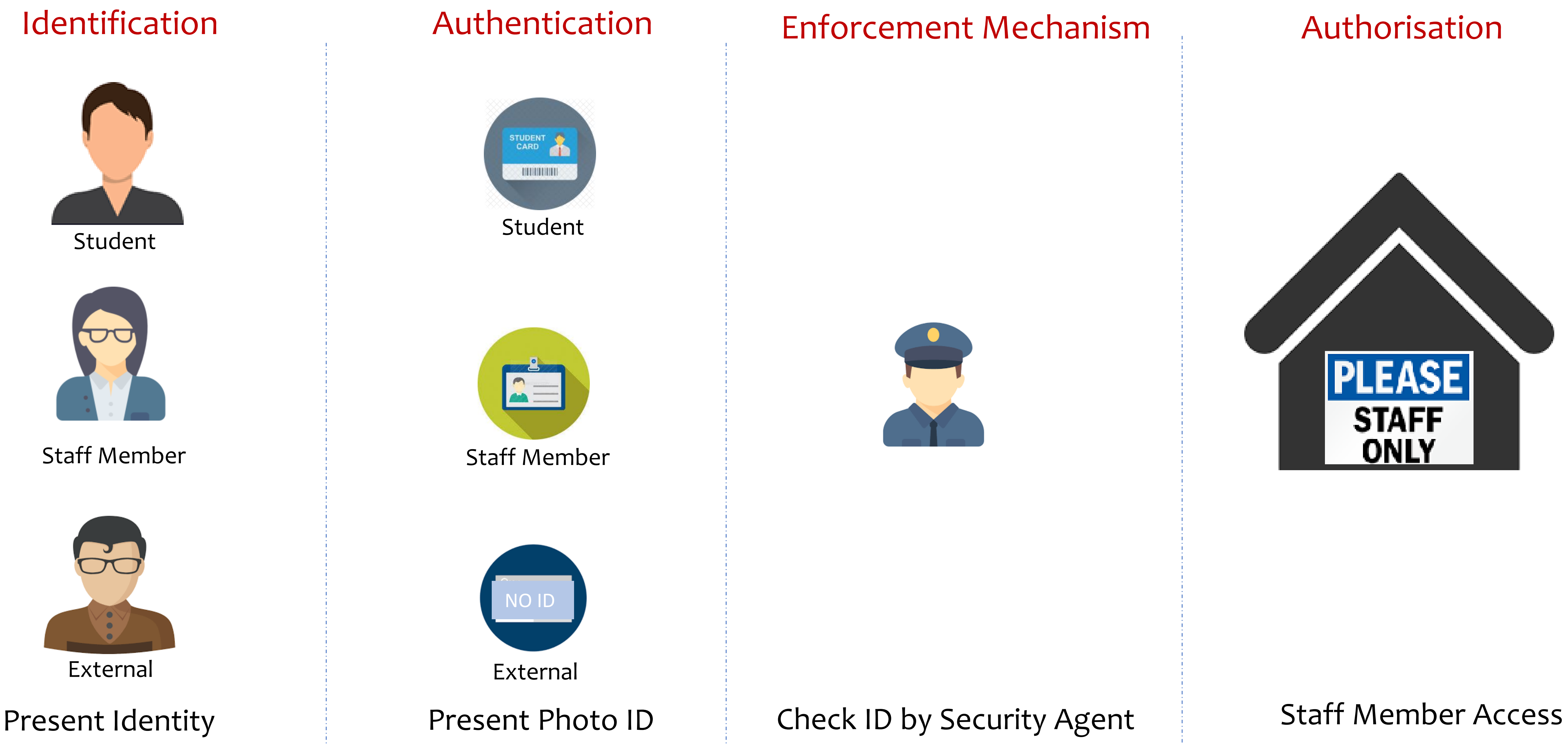
Access Control Example



Access Control Example



Identification

Student

Staff Member

External

Present Identity

Authentication

Student

Staff Member

External

Present Photo ID

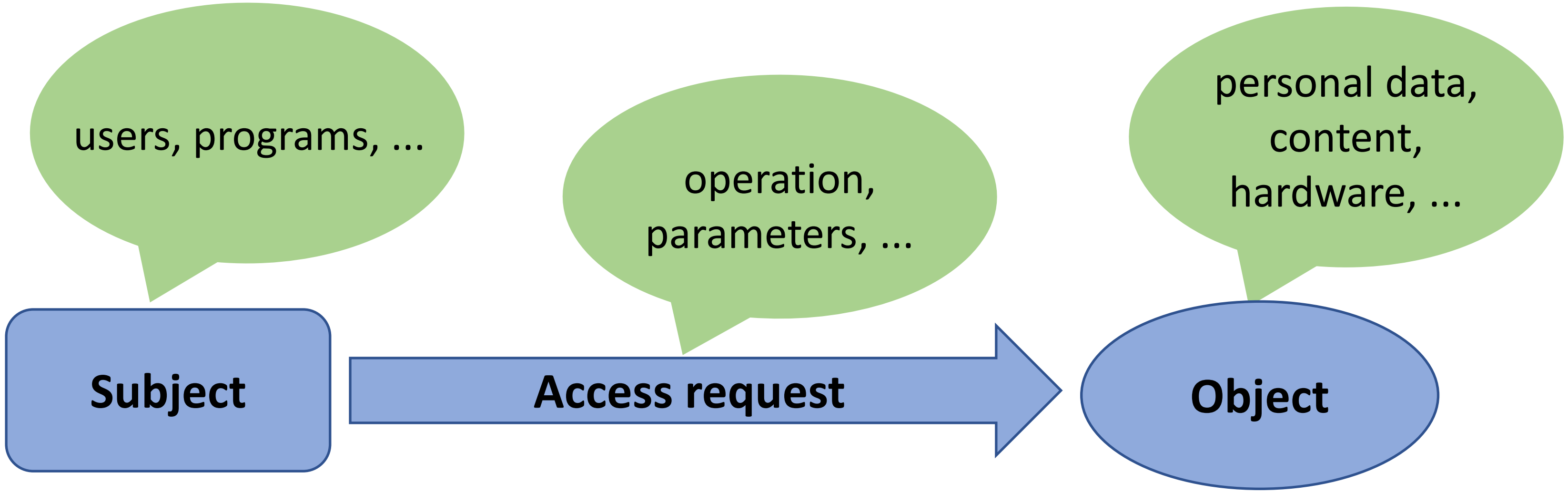
Enforcement Mechanism

Check ID by Security Agent

Authorisation

Staff Member Access

What is Access Control


users, programs, ...
operation, parameters, ...
personal data, content, hardware, ...
Subject
Access request
Object

- The ability to allow only authorized users, programs or processes system or resource access
- The granting or denying, according to a particular security model, of certain permissions to access a resource
- An entire set of procedures performed by hardware, software and administrators, to monitor access, identify users requesting access, record access attempts, and grant or deny access based on pre-established rules.

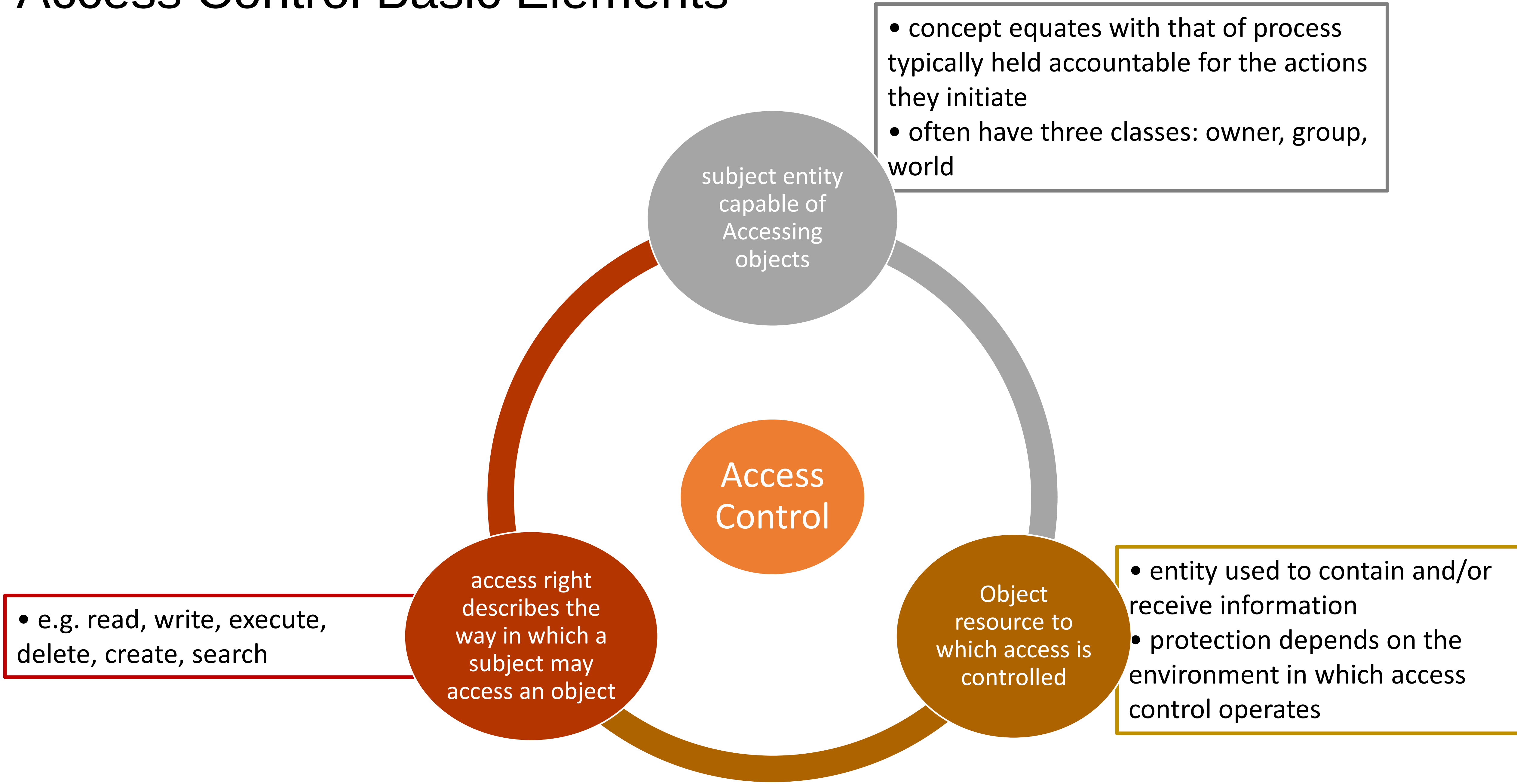
Vocabulary

- Objects. Stuff (resources/files) we want to protect
- Subjects. Stuff (users/processes) that does things to objects
- Principals. Subjects that set the policies
- Domains. What a principal is allowed to set policies about
- Policies. Rules about how subjects and objects interact

Access Control: Domains and Applications

- Social Networks
- Web Browsers
- Operating Systems
- Firewalls

Access Control Basic Elements



Access Control

subject entity capable of Accessing objects

- concept equates with that of process typically held accountable for the actions they initiate
- often have three classes: owner, group, world

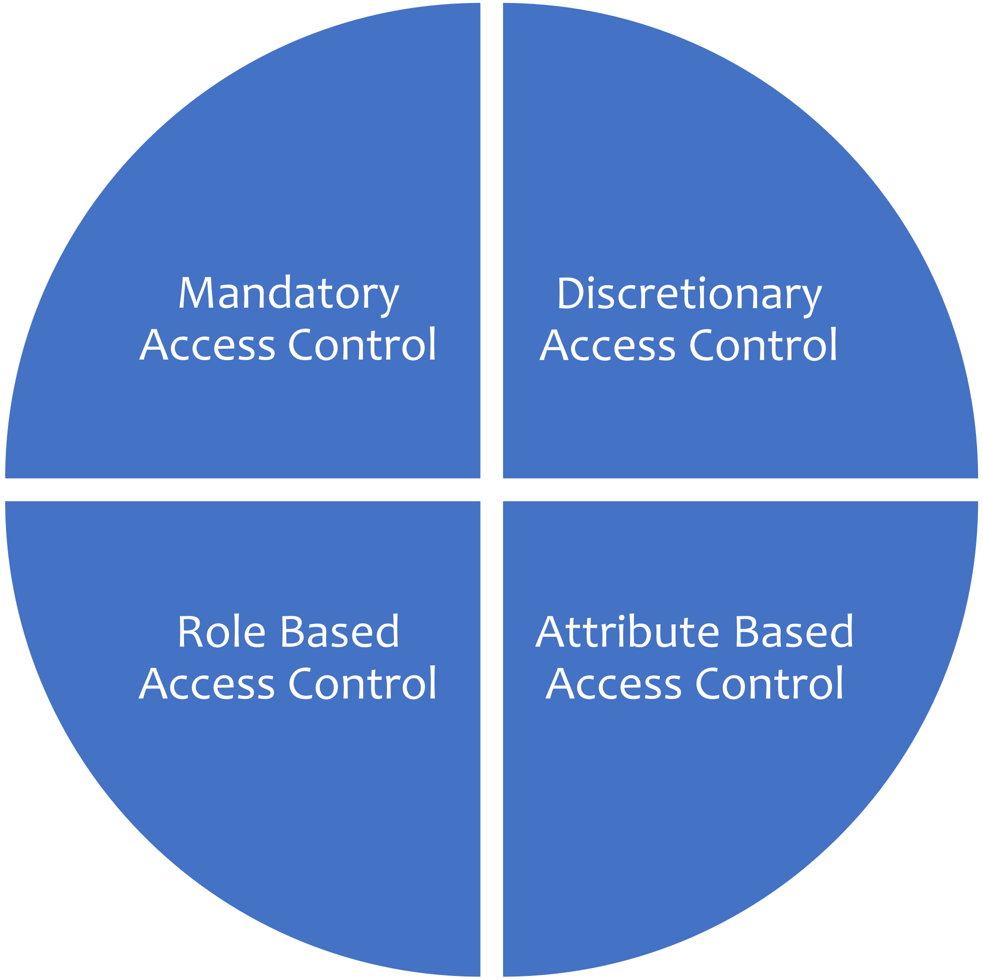
Object resource to which access is controlled

- entity used to contain and/or receive information
- protection depends on the environment in which access control operates

access right describes the way in which a subject may access an object

- e.g. read, write, execute, delete, create, search

Access Control Methods


Mandatory Access Control
Discretionary Access Control
Role Based Access Control
Attribute Based Access Control

Multiple Access Control Policies. DAC, MAC, RBAC are not mutually exclusive.
A system may implement two or even three of these policies for some or all types of access.

Access Control Matrix

- ACM is a matrix of all principals and objects.
- The matrix entries describe the permissions for Subjects, Objects, and operations
- Can determine
  - Who can access an object
  - What objects can be accessed by a subject
  - What operations a subject can perform on an object

- Problem: maintaining such a matrix can be difficult.
- If the matrix is corrupted then all controls is lost.

Access Control Matrix

- Suppose the private key file for J is object O1: Only J can read
- Suppose the public key file for J is object O2: All can read, only J can modify
- Suppose all can read and write from object O3

- What's the access matrix?

	O1	O2	O3
J	R	R, W	R, W
S2	N	R	R, W
S3	N	R	R, W

Least Privilege

- The Principle of Least Privilege states that a subject should be given only those privileges needed for it to complete its task.
- If a subject does not need an access right, the subject should not have that right.

- Limit permissions to those required and no more
- Consider three processes for user J
- Restrict privilege of the process J1 to prevent leaks

	O1	O2	O3
J	R	R, W	N
S2	N	R	R, W
S3	N	R	R, W

Access Control Matrix

- Elaborate the Access Control Matrix for the following example:

  Accountant Ltd is a financial institutions, their access control policies have been designed by Adam who is a security consultant. Adam identified 3 objects (Operating System, Accounting Data and Audit Trial), and 4 subjects.

  - The manager is allowed read and modify two objects: Operating System, Accounting Data, and can only read the Audit Trial.
  - The Audit Trial can be read by all subjects but only the Auditor can modify it.
  - The accounting data can only be read, and modified by Manager and Accounts Programs, however all other subjects can access them.
  - The System Admin can read, write and execute the operating system but can ready only Accounting Data and Audit Trial.

Permissions: x: execute, r: read, w: write

Access Control Matrix

	Operating System	**Accounting Data**	**Audit Trial**
Alice (manager)	R,W	R,W	R
Bob (auditor)		R	R, W
Accounts Program		R,W	R
Sam (sys admin)	R, W, X	R	R

Access Control Lists (ACLs)

- We do not want to store one massive matrix.
- Instead we can store each column of the matrix with the object it refers to.
- For example:

(O2,(J,RW), (S2,R), (S3,R))

	O1	O2	O3
J	R	R, W	R, W
S2	N	R	R, W
S3	N	R	R, W

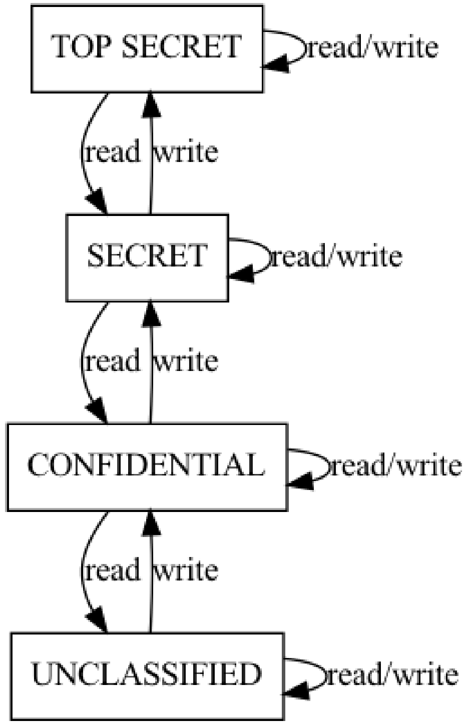
Access Control Lists (ACLs)

- Write the ACL for Audit Trial:

(Audit Trial, (Manager, R), (Auditor, RW), (Account Program, R), (System Admin, R))

Bell LaPadula Model

- Model of access control developed in the US Department of Defense based on *multi-level security.*
- All objects and subjects have a security clearance
- Two rules about the system:
  - *Simple security property:* You cannot read something with more clearance than you. (**No read up**) (preserves secrecy)
  - *property:* You cannot write to something with less clearance than you (**No write down**) (prevents leaking)
  - *Strong★-property:* You can only write to something with the same level of clearance as you (prevents influencing people with more clearance)



Discretionary Access Control (DAC)

- scheme in which an entity may enable another entity to access some resource
- often provided using an access matrix
  - one dimension consists of identified subjects that may attempt data access to the resources
  - the other dimension lists the objects that may be accessed
- each entry in the matrix indicates the access rights of a particular subject for a particular object

Mandatory Access Control (MAC)

- Systems administrator sets the policy as to who can access what
- Typical implementations of you might see:
  - SELinux: NSA’s patches for Linux to add a MAC. Complex but powerful.
  - AppArmour: Canonical’s simplified MAC system based on paths
  - TOMOYO: another simplified system based on paths
- Policies can be applied to more than just files

For example: “*The web browser can access files in the downloads folder ONLY”*

MAC vs. DAC

- BLP is a mandatory access control system, as distinguished from a discretionary system.
- Mandatory Access Controls (MAC): rules are enforced on every attempted access, not at the discretion of any system user;
- Discretionary Access Controls (DAC): rule enforcement may be waived or modified by some users.

Role-Based Access Control

- Role-based access control (RBAC) is a widely used security framework claimed to be especially appropriate for commercial settings.
- Unlike access control policies that assign permissions to subjects, RBAC associates permissions with functions/jobs/roles within an organization.
- A role is a collection of job functions. Roles within a bank might include: president, manager, trainer, teller, auditor, janitor, etc.

Role-Based Access Control

Associate permissions with job functions

  - Each job defines a set of tasks
  - The tasks need permissions
  - The permissions define a role

- Bank Teller:
  - Read/Write to client accounts
  - Cannot create new accounts
  - Cannot create a loan
- Role defines only the permissions allowed for the job

Role-Based Access Control

An individual has:

- a set of authorized roles, which it is allowed to fill at various times;
- a set of active roles, which it currently occupies.

Roles have an associated set of transactions, which are the activities that someone in that role is permitted to carry out.

- The set of transactions can be organization specific: open an account, cash a check, transfer funds, etc.

Role-Based Access Control

- The following are the three primary RBAC rules:
  - Role assignment: A subject can execute a transaction only if the subject has an active role.
  - Role authorization: A subject’s active role must be an authorized role for that subject.
  - Transaction authorization: A subject can execute a transaction only if the transaction is authorized for one of the subject’s active roles.
- Note that a subject can have multiple roles. For example, a bank president might also act as a teller.

Attribute-based Access Control

- In the attribute-based access control mechanism, access rights are defined upon attributes.
- The users' identities are not used anymore to define access rights.
- In ABAC, in order to get access, users need to prove their possession of the required attributes. Thus, users are authenticated to the server to prove their rights.
- ABAC is an extension of RBAC where users' roles are more generalized.
- User access rights are expressed using a set of attributes.

Traditional UNIX File Access Control

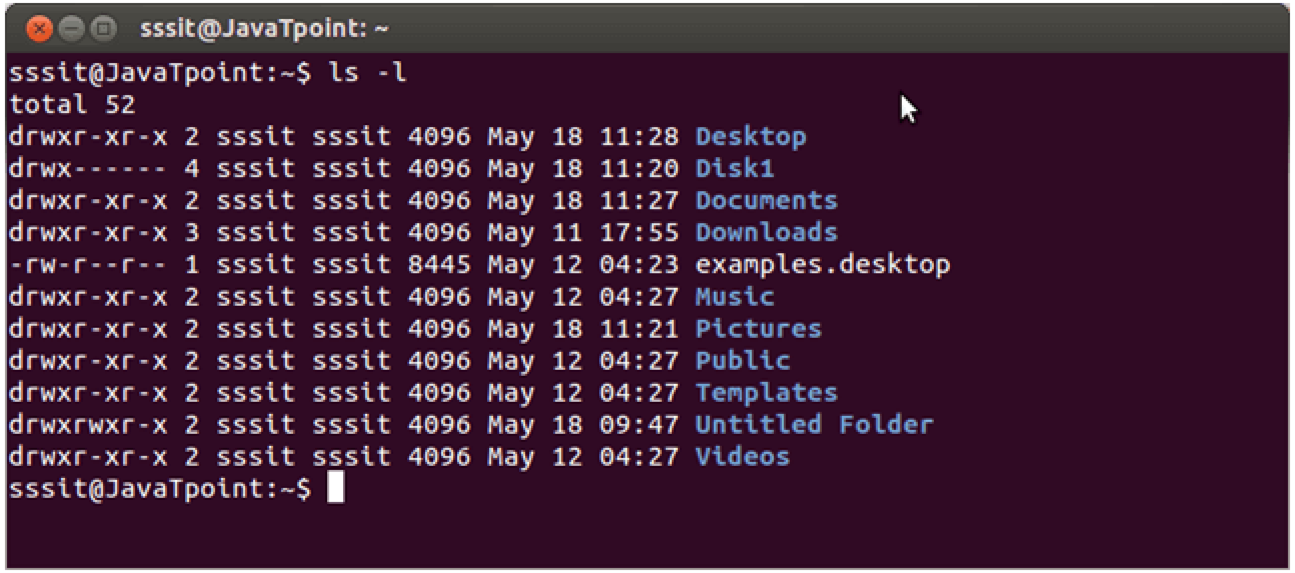
- “set user ID”(SetUID)
- “set group ID”(SetGID)
  - system temporarily uses rights of the file owner / group in addition to the real user’s rights when making access control decisions
  - enables privileged programs to access files / resources not generally accessible
- superuser
  - is exempt from usual access control restrictions
  - has system-wide access

Access Control Lists (ACLs) in UNIX

- modern UNIX systems support ACLs: FreeBSD, OpenBSD, Linux, Solaris
- FreeBSD
  - Setfacl command assigns a list of UNIX user IDs and groups
  - any number of users and groups can be associated with a file
  - read, write, execute protection bits
  - a file does not need to have an ACL
  - includes an additional protection bit that indicates whether the file has an extended ACL
- when a process requests access to a file system object two
- steps are performed:
  - step 1 selects the most appropriate ACL: owner, named users, owning / named groups, others
  - step 2 checks if the matching entry contains sufficient permissions

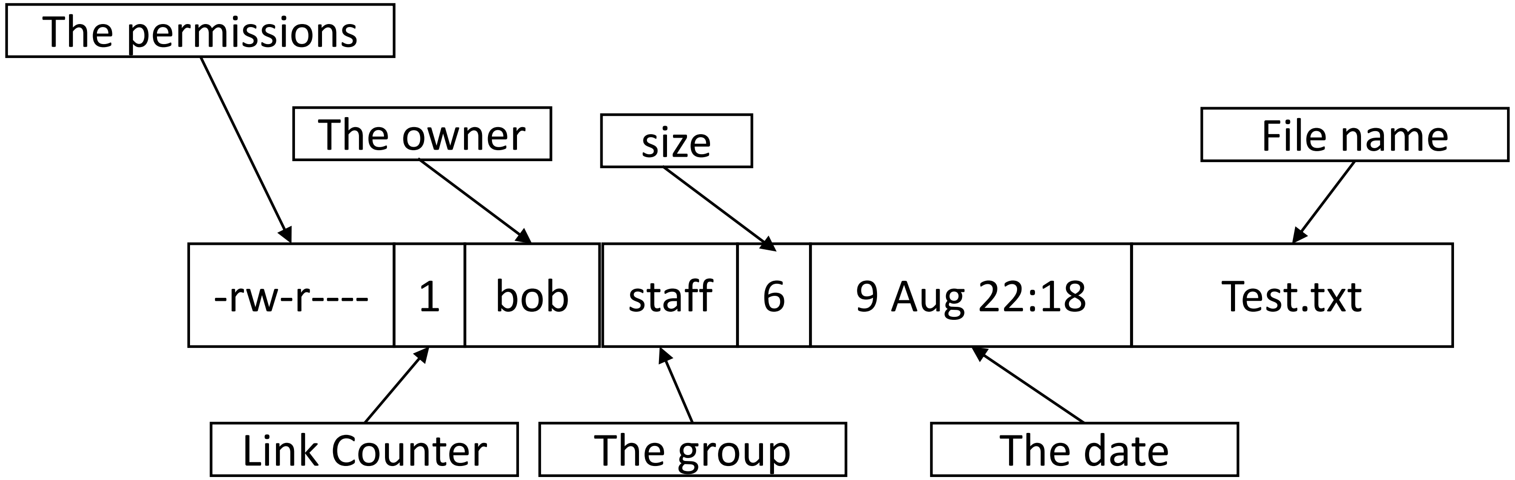
Access Control in Unix/Linux

- Unix/Linux/Mac use ACL, with groups.
- “uid” set when you log on.
- Linux Kernel then dynamically enforces the ACLS.
- ls –l displays files with their ACL
- `root` owns everything (“get root” = control the system)



```
sssit@JavaTpoint:~$ ls -l
total 52
drwxr-xr-x 2 sssit sssit 4096 May 18 11:28 Desktop
drwx------ 4 sssit sssit 4096 May 18 11:20 Disk1
drwxr-xr-x 2 sssit sssit 4096 May 18 11:27 Documents
drwxr-xr-x 3 sssit sssit 4096 May 11 17:55 Downloads
-rw-r--r-- 1 sssit sssit 8445 May 12 04:23 examples.desktop
drwxr-xr-x 2 sssit sssit 4096 May 12 04:27 Music
drwxr-xr-x 2 sssit sssit 4096 May 18 11:21 Pictures
drwxr-xr-x 2 sssit sssit 4096 May 12 04:27 Public
drwxr-xr-x 2 sssit sssit 4096 May 12 04:27 Templates
drwxrwxr-x 2 sssit sssit 4096 May 18 09:47 Untitled Folder
drwxr-xr-x 2 sssit sssit 4096 May 12 04:27 Videos
sssit@JavaTpoint:~$
```

The UNIX Access Control List



-rw-r----	1	bob	staff	6	9 Aug 22:18	Test.txt

The permissions

The owner

size

File name

Link Counter

The group

The date

UNIX File Permissions

- Permissions:

  r: read permission

  w: write permission

  x: execution permission

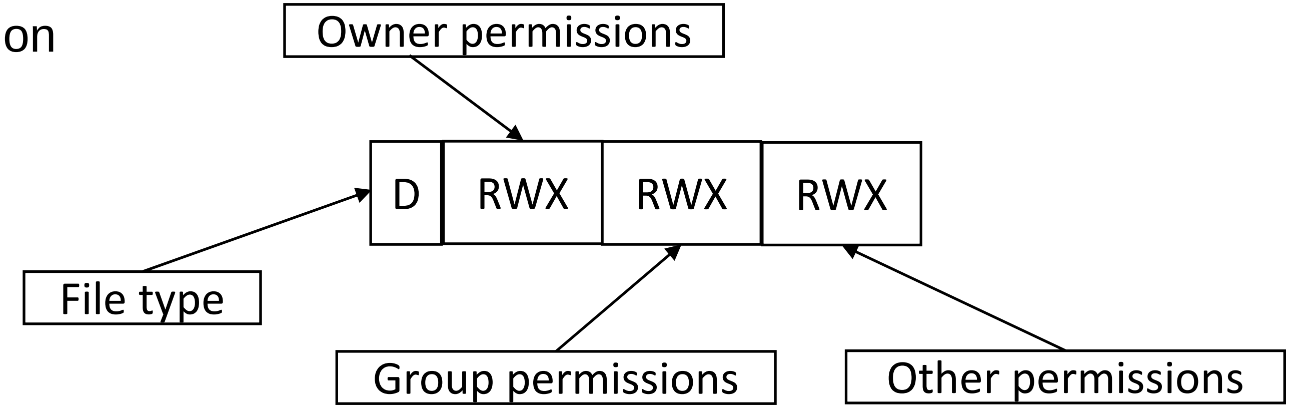
  -: no permissions

- File Type:

  - : file

  d : directory

  b/c: device file



Access Control for Directories

- For directories:
  - “r” is read only for directory contents
  - “x” is permission to traverse, e.g. switch to, run.
  - No “x”: I can’t run any commands inside the directory
  - No “r”: I can’t list the files in the directory

Access Control for Process

-r-sr-xr-x	1	root	wheel	8	7 Sept 22:18	passwd

- The “x” permission controls who can run a process

– in the case of `passwd`: anyone.

- The “s” permission indicates that the process runs with the permission of its owner.

Sandbox

Sandboxing is defined as the process of operating a safe and isolated environment that is decoupled from the surrounding infrastructure and OS, with the objective of testing code and analyzing malware.

Sandboxing is a cybersecurity procedure in which you run code, analyze it, and code in a secure, enclosed environment on a system that resembles end-user working environments. It is intended to prevent the potential threat from entering the network and is commonly used to scrutinize unknown or non-secure code.

Running Untrusted Code

We often need to run buggy/untrusted code:

–programs from untrusted Internet sites: toolbars, viewers, codecs for media player

–old or insecure applications

–legacy software

=> Goal: if application “misbehaves,” kill it.

Features of Sandbox

- User friendly It can detect unknown viruses with a minimal risk of false alarms.
- Provides a platform to test malware and other risky piece of codes.

Much of the code your devices run every day is already sandboxed for your protection

Examples

Web Pages: Your browser essentially sandboxes the web pages it loads. Web pages can run JavaScript code, but this code can not do anything it wants — if JavaScript code tries to access a local file on your computer, the request will fail.

PDFs and Other Documents: Adobe Reader now runs PDF files in a sandbox, preventing them from escaping the PDF viewer and tampering with the rest of your computer. Microsoft Office also has a sandbox mode to prevent unsafe macros from harming your system.

Examples

Mobile Apps: Mobile platforms run their apps in a sandbox. Apps for iOS, Android, and Windows 8 are restricted from doing many of the things standard desktop applications can do. The sandbox disconnects the applications, stopping them from interfering with one another.

Windows Programs: User Account Control functions as a bit of a sandbox, essentially restricting Windows desktop applications from modifying system files without first asking you permission. User Account Control just restricts access to system files and system- wide settings.

Benefits of Sandboxing

- Prevents zero-day attacks**:**

Zero-day threats exploit unknown security flaws. They are highly hazardous because manufacturers cannot issue patches unless they fully comprehend the exploited vulnerability.

Sandboxing software performs admirably in isolating these menaces. Though there is no assurance that it will prevent zero-day manipulations, sandboxing most often works for damage limitation by distancing the potential danger from the remainder of the network.

- Enhances other security programs

Sandboxing is an excellent complement to specific other security software, ranging from action monitoring programs to antivirus programs. Conversely, sandboxing software shields against spyware strains that your virus protection may struggle to detect.

Benefits of Sandboxing

- Helps examine presumably malicious programs for threats

If you’re dealing with new vendors or untrustworthy software sources, you can try out a new application for threats before incorporating it.

- Allows rigorous software tests before they are released

Software changes should be thoroughly tested before they are released to the public. Sandboxing can be used to test new code for possible risks before it officially launches. Therefore, it has a vital role to play in application security.

How To Sandbox Any Program

- **Virtual Machines:** A virtual machine program like VirtualBox or VMware creates virtual hardware devices that it uses to run an operating system.

- This entire operating system is essentially sandboxed, as it does not have access to anything outside of the virtual machine.

- **Using other tools:** Sandboxie, Bufferzone

Types Of Application Sandboxes

Type A: OS enhancement based: Sandboxie, Buffer Zone Pro etc.

Type B: Master/slave model: Adobe ReaderX, Chrome browser

Types Of Application Sandboxes

TYPE A Examples: Sandboxie: BufferZone

- Custom kernel driver modifies Windows behavior, so that change to protected system components is prevented
- Use cases: Most of such sandboxes are used for controlled execution of applications

TYPE B Example: Google Chrome, Adobe Reader

- Slave is confined using OS access control facilities
- Master mediates access to resources
- Use case: protect the application from exploitation

Reading references

[1] Stallings, W., Cryptography and Network Security: Principles and Practice, 7th ed., 2017, Pearson.

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