Asset Analysis

Asset Analysis -I

- It discovers the assets that result in an impact (a loss for the organization) if successfully attacked
- It should discover which ICT resources an organization needs to work in an efficient way
  1. Discover the fundamental business processes
  2. Critical ICT resources for these processes
  3. The impact for the organization if
     - A business process is stopped (resource integrity or availability)
     - The resource has to be rebuilt ex novo (integrity)
     - The attacker discovers the information in the resource (confidentiality)

Asset Analysis -II

- Physical and Logical Resources
  - Databases
  - Applications to access the database and compute the outputs of interest (may be even more important than the database i.e. application using pubblic data)
  - Computational power
  - Communication bandwidth

The cost of malicious cyberactivies in USA (Feb. 2018)

- Malicious cyber activity cost between $57 and $109 billion in 2016.
- Malicious cyber activity directed at private and public entities manifests as denial of service attacks, data and property destruction, business disruption for collecting ransoms, theft of proprietary data, intellectual property, and sensitive financial and strategic information.
- Damages from cyberattacks and cyber theft may spill over from the initial target to economically linked firms, magnifying the damage to the economy
- Firms share common cyber vulnerabilities, causing cyber threats to be correlated across firms. The limited understanding of these common vulnerabilities impedes the development of the cyber insurance market.
- Scarce data and insufficient information sharing impede cybersecurity efforts and slow down the development of the cyber insurance market.
- Lax cybersecurity imposes negative externalities on other economic entities and on private citizens. Failure to account for these externalities results in underinvestment in cybersecurity by the private sector relative to the socially optimal level of investment.

The cost of malicious cyberactivies in USA (Feb. 2018)

Attackers

a) **Nation-states**: Russia, China, Iran, and North Korea. These groups are well funded and often engage in sophisticated, targeted attacks.

b) **Corporate competitors**: Firms that seek illicit access to proprietary IP, including financial, strategic, and workforce-related information on their competitors.

c) **Hacktivists**: Private individuals or groups with a political agenda and seek to carry out high-profile attacks. Attacks help hacktivists distribute propaganda or to cause damage to opposition organizations for ideological reasons.

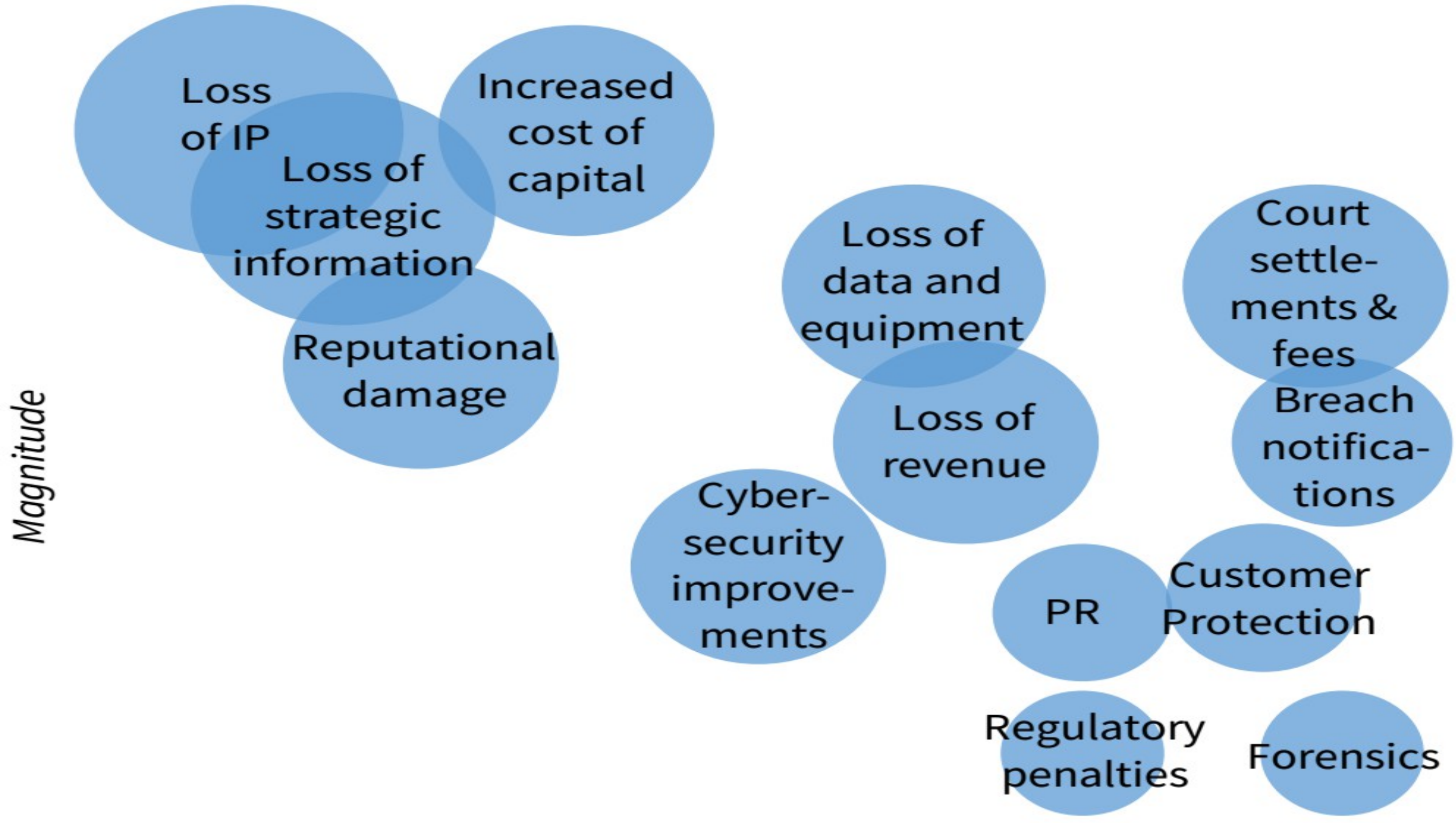
d) **Organized criminal groups**: These are criminal collectives that engage in targeted attacks motivated by profit seeking.

e) **Opportunists:** Usually amateur hackers driven by a desire for notoriety.

f) **Company insiders**: These are typically disgruntled employees or ex-employees

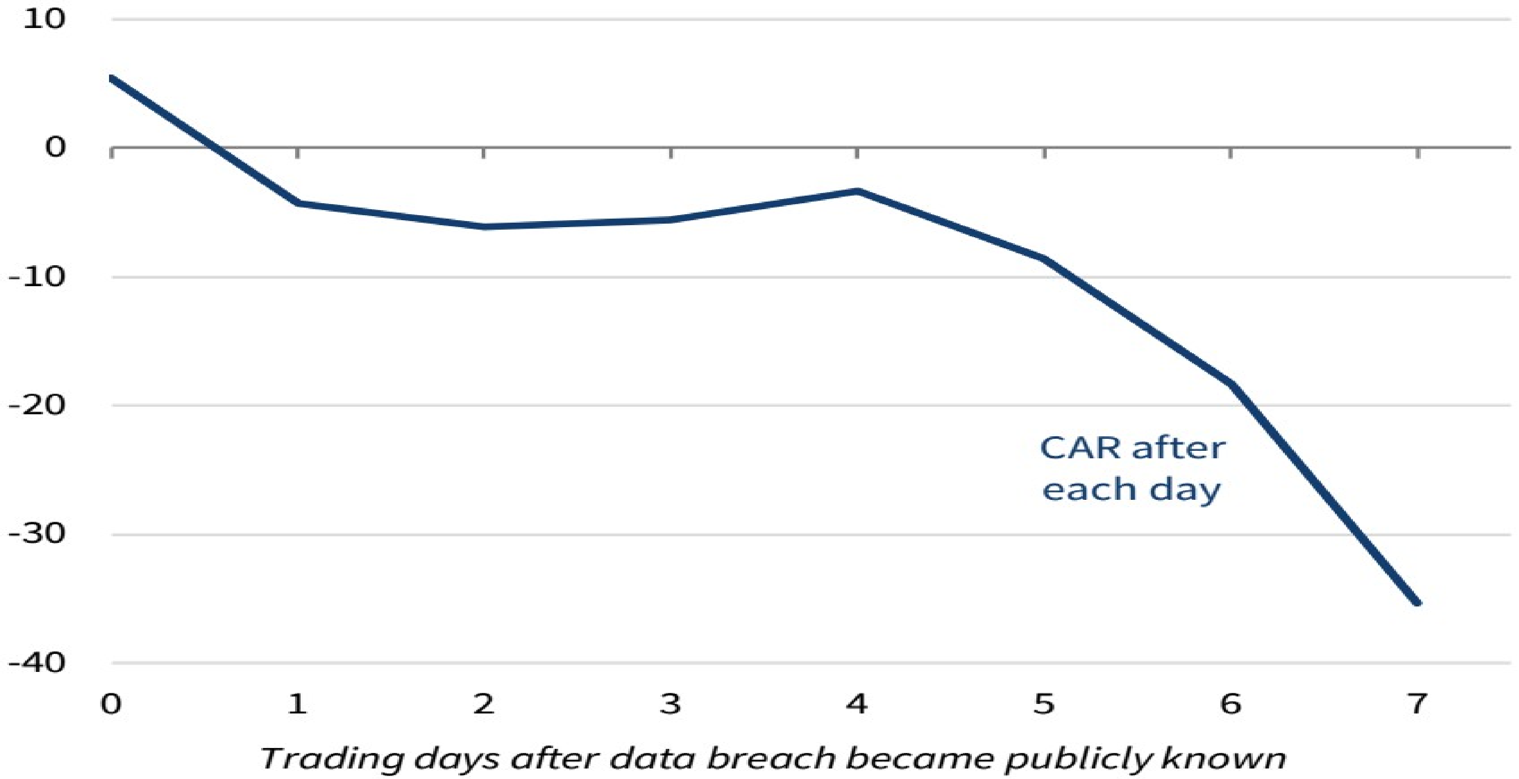
The cost of malicious cyberactivies in USA (Feb. 2018)

Figure 1. Cost Components of an Adverse Cyber Event


Loss of IP
Increased cost of capital
Loss of strategic information
Reputational damage
Loss of data and equipment
Court settle-ments & fees
Breach notifica-tions
Loss of revenue
Cyber-security improve-ments
PR
Customer Protection
Regulatory penalties
Forensics
Magnitude

The cost of malicious cyberactivies in USA (Feb. 2018)

Figure 5. SolarWorld's Cumulative Abnormal Return After Its Data Breach Became Publicly Known
(CAR, percent)



Asset Analysis -III

- In general it is rather complex to approximate the value of a resource
- A possible heuristics consider the cost of rebuilding the resource if it disappears
- An asset analysis is useful non only for security reasons but also to be aware of which resources do exist and how they are used (catalogue of resources)
- The first of any set of principles to evaluate and manage ICT risk always requires to build an inventory of all the resources in the system to be protected

Security Policy

Security Policy

A set of rules that an organization adopts both to minimize the risk and to define the goals of security

- Defining the goal of security = the assets and the resources to be protected to protect the assets
- Defining the correct behavior of all the users
- Forbidding dangerous behaviors and components
- It implies the definition of
  - System architecture
  - Catalogue of components and of application
  - Users (rights and constrains)
  - Administrators (rights and constrains)
  - Legal use of the resources
  - Who has to verify that the policy is applied
  - What happens if the policy is violated

Security Policy

- It is critical because it defines
  - The goals and the assets of an organization
  - Legal behaviour for each class of users
  - Whether components can still have some vulnerabilities and how they should be used
  - Rules to manage both human and ICT resources
  - Roles and responsibility
- The security policy cannot violate the legislation that concerns ICT systems

Subject and object

- A more abstract definition of a policy represents user and resources in an abstract way in terms of objects to define some operations that users can apply
- A subject is any entity that can invoke the operations defined by an object
- An object that invokes some operations defined by other objects is both a subject and an object
- The implementation of subjects and objects depends upon the implementation level (e.g. the VM) of interest

Subject = user, application, program, process, thread, instruction …

Object = instance of an abstract data type, procedure or function, variable, logical or physical resources

Rights

- A subject entitled to invoke an operation of an object owns a right on this object
- Rights are directly or indirectly deduced from the security policy
  - Direct = S can read the file F then
    S owns a read right on F
  - Indirect = since S can read F then a program P then any program that S execute can read the memory segment MS that stores a record of F then
    P owns a read rights on MS

    = the right of P on MS is deduced from those of S on F

Objects, operations and types

- The specification of an object with the operations it defines (implements) defines a data type
- A type system can be used to allow only those invocations of an operation on an object that are entitled by the policy
- However *dynamic controls cannot be avoided* due to vulnerabilities in the compiler or in the run time support that result in run time behavior that differs from the expected one as defined by the specification

Security Policies: a first important classification

- Default allow = it defines forbidden behaviours and *allows anything that it does not define* = enumerating badness
- Default deny = it defines legal behaviors and *forbids anything it does not define* eg anything else
- Default allow is very dangerous =anytime we forget to enumerate a bad behavior enumerating badness does not work

An analogy

- Default allow = defines a set S by describing those elements that do not belong to S = the complement of S

- Default deny = defines a set by describing the elements that belong to S

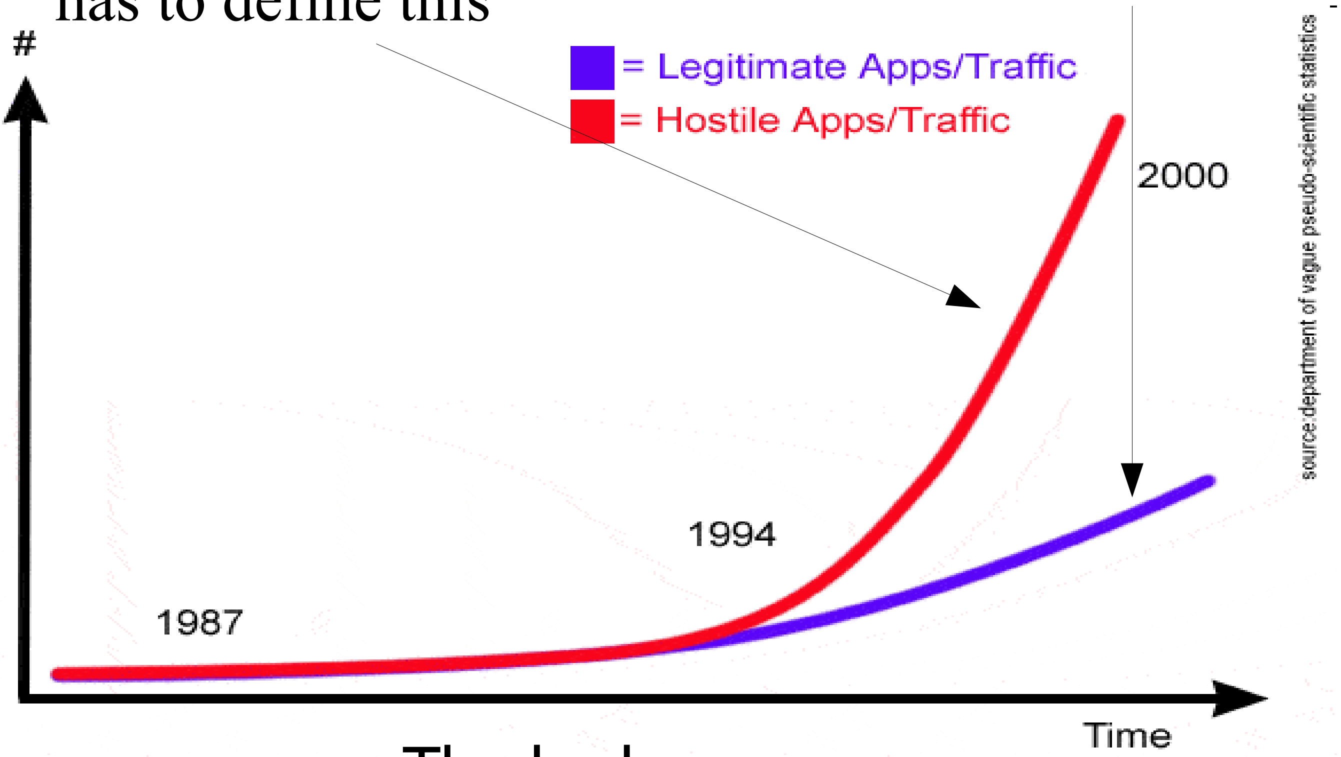
The Six Dumbest Ideas in Computer Security (M.Ranum)

1. **Default Permit (default allow)**
2. **Enumerating Badness**
3. **Penetrate and Patch**
4. **Hacking is Cool**
5. **Educating Users**
6. **Action is Better Than Inaction**

Enumerating Badness

A default allow policy has to define this

A default deny policy defines this



source:department of vague pseudo-scientific statistics

The badness gap

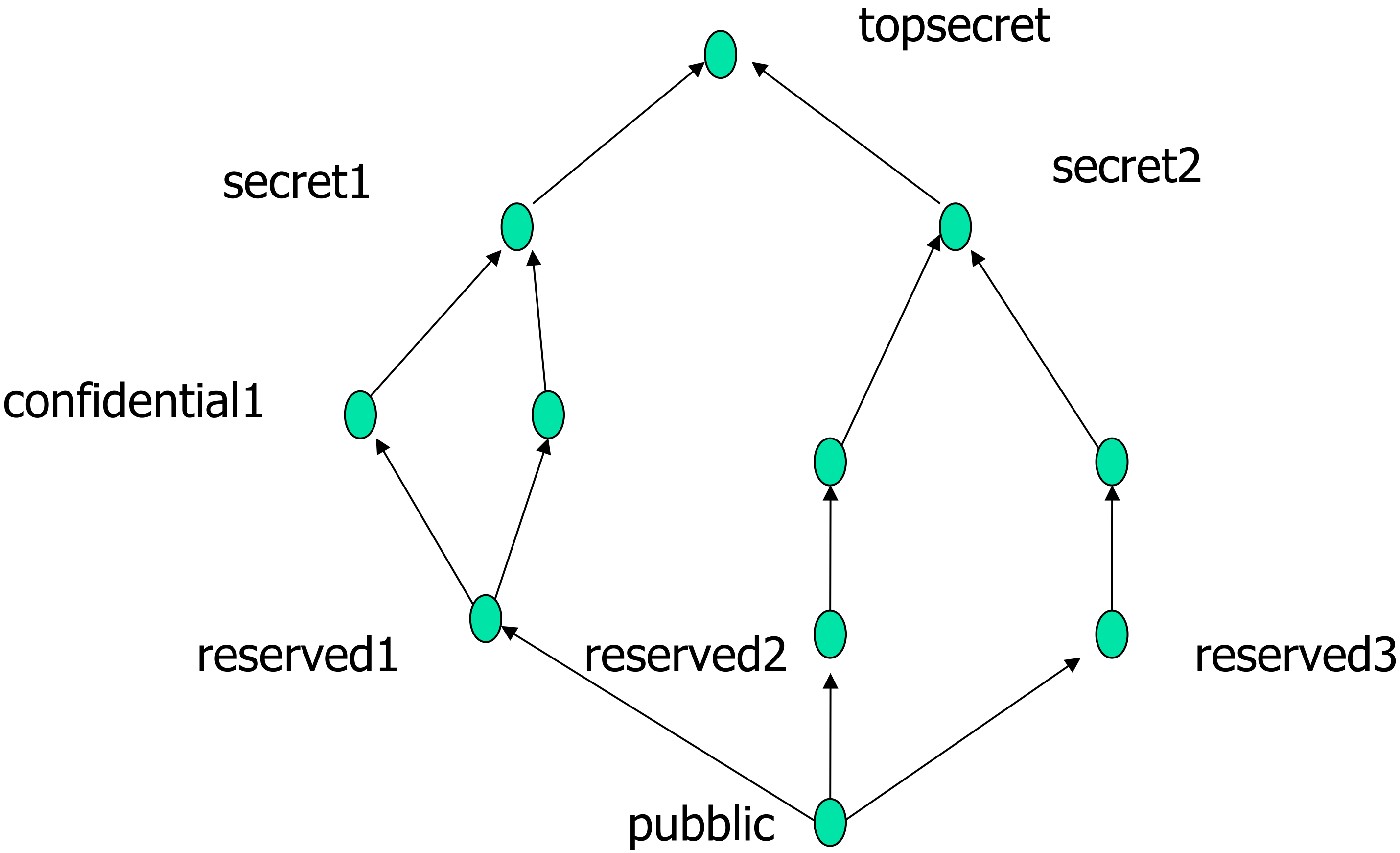
Classes of security policy

- Discretionary access control
  - An owner exists for each object
  - The owner defines (has the right and the burden of defining)
    - The subjects can operate on the object (need to access)
    - The rights for each subject
- Mandatory access control
  - There is an owner but there are some system wide rules it has to satisfy = it cannot violate

Mandatory Access Control

- All the objects are partitioned into classes
- All the subjects are partitioned into classes
- The same classes for object and subjects (not strictly required but it simplifies everything)
- All the classes are partially ordered
- A subject may be granted the right to invoke an operation only if the classes of the subject and of the object satisfy a predefined condition

Partial Order



MAC information flow - I

- Object = file
- Operations = read/write/append
- A subject in a class C may be enabled to
  - Read any file with a class lower than or equal to C
  - Write any file with a class equal to C
  - Append a record to a file with a class larger than C
  - The owner of the file can grant the rights provided that the previous rules are satisfied

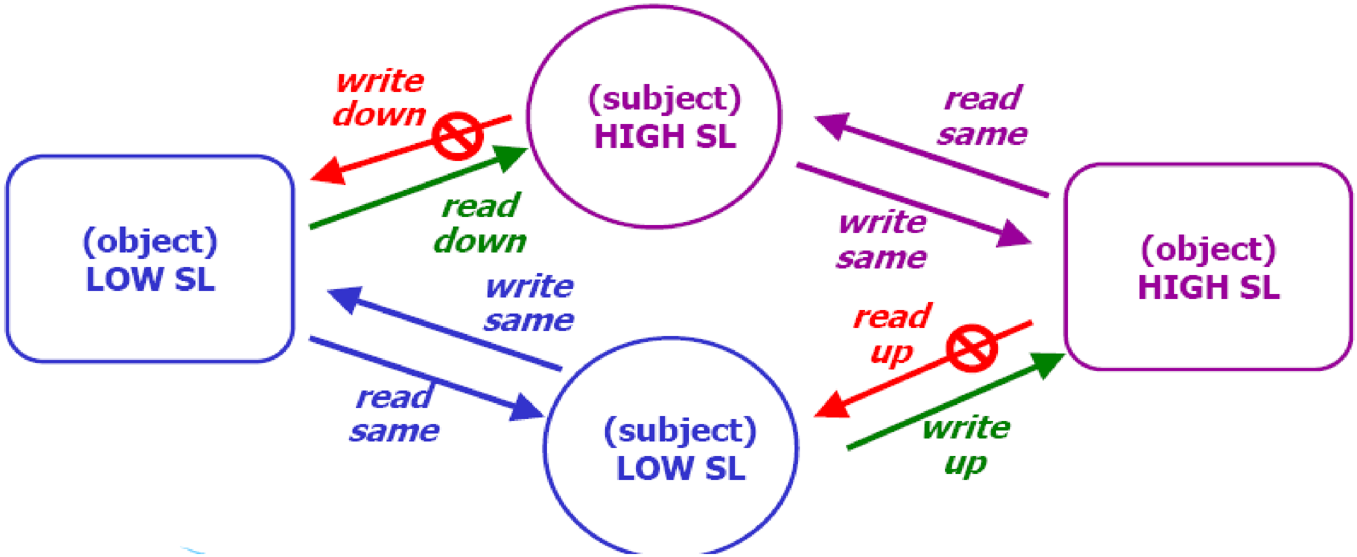
This policy prevents loss (leaks) of information (No write down)

no write down

- Prevents an information flow from an high level object to those with a lower level
- Guarantee confidentiality of information
- As a counterpart, the amount of information with a higher level increases because the information level cannot decrease
- A further operation is required to periodically desecretate information to the lower levels

Mandatory Access Control - I

- Bell-LaPadula Policy (multilevel security)
  - access control attributes:
    - hierarchical security level
    - set of non hierarchical categories
  - fixed rules: "no read up, no write down"



MAC information flow - II

- Object = file
- Operation= read/write
- A subject in class C may be enabled to
  - Write any file with a class lower than or equal to C
  - Read any file with a class larger than or equal to C

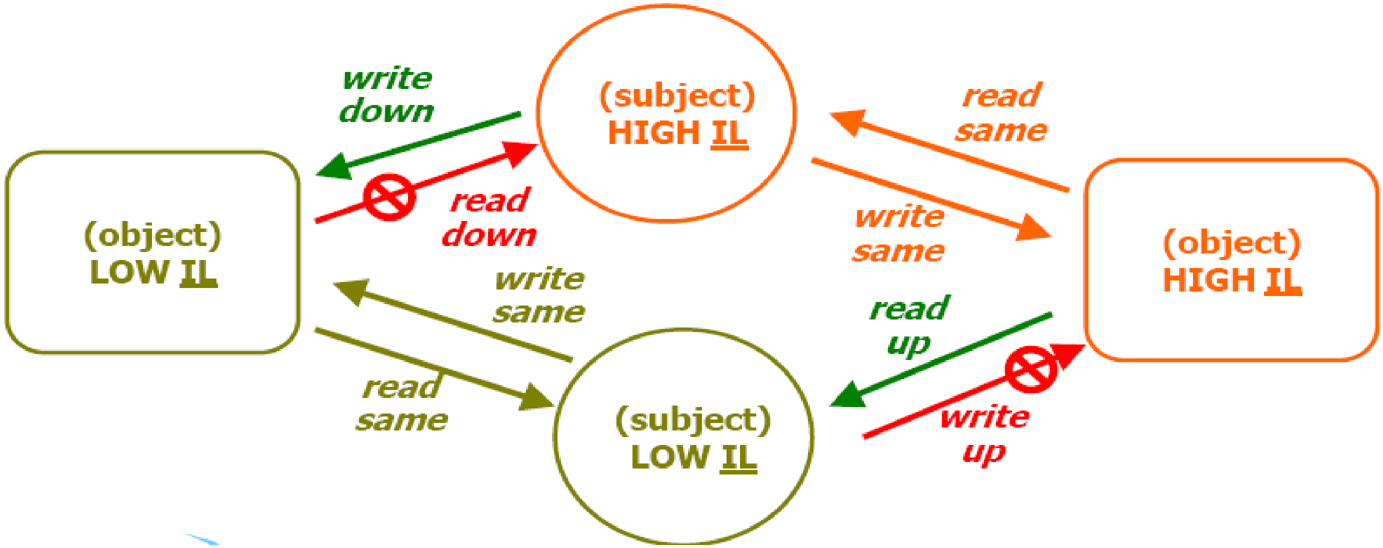
Integrity is privileged (No write up)

No write up

- A low integrity subject cannot update an highly integrity object
- Integrity is privileged at the expence of confidentiality

Mandatory Access Control - II

- Biba Integrity model (multilevel security)
  - access control attributes:
    - hierarchical integrity level
    - set of non hierarchical integrity categories
  - fixed rules: "no write up, no read down"
    - exact opposite of BLP/multilevel security



Watermark

- The level of a subject is not fixed but it is a function of the objects it has worked on
- To protect confidentiality, the level increases has the subject reads critical information
- Monotonic increase, after a given level has been reached no decrease is possible
- Time dependent MAC policy
- Introduced to prevent the flowing of information at higher levels

No interference

- Each object and each subject is paired with a label that defines the corresponding level
- An object label is updated at run time according to both
  - the operations that are invoked
  - the level of the subject invoking the operations
- A system satisfies the *no interference principle* if the labels paired with an object do not change even after removing subjects with a lower or an higher level from the system (Bell-LaPadula/Biba)
- No information
  - leakes from the higher levels
  - can affect objects with a higher level

Clark -Wilson -1

- A policy in this class defines
  - A set of consistency contrains on a subset of the objects
  - Some sequences of operations on some objects (well formed transactions) that do preserve any consistency constrains
- If only these sequences are invoked, then the system evolution can navigate only across states that satisfies the consistency constrains

Clark -Wilson -2

- Each well formed transaction is atomic, either is completed or it is undone
- Atomicity may be implemented by a backup copy of involved objects
- It is the user responsibility to prove that each transaction is well formed, e.g. it does not violate the consistency constrains

CW- Example

- Objects = Bank accounts
- Constrain

  1. If money is moved betwen two accounts, their sum does not change = we add to an account the amount we withdraw from the other
  2. We record the amount of money cashed, the one that has been withdrawned and the accounts
  3. At the end of each day

  sum of the accounts in 2. = (cashed) - (withdrawals) +
  (sum of the accounts in 2. at the beginnging of the day)

- Any transaction must be atomic

Chinese Wall

- Objects are partioned into classes
- As soon as a subject invokes an operation on an object
  - cannot invoke operations on objects in distinct classes
  - can only invokes operation on objects in the class
- Avoid conflict of interest
- Time dependent
- Can be integrated with a MAC/DAC policy

Overall Policy – I

- A real policy can merge several of the previous policy
- As an example
  - No write down
  - Chinese wall
- We have rules that define which objects can be read and other that forbid the access to some other objects

Overall Policy – II

- Distinct policies can be applied to the same object/subject
- There are two levels for a subject, one for confidentiality and one for integrity
  - Some objects consider the confidentiality level (no write down)
  - Some objects consider the integrity level (no write up)

Trusted Computing Base

- TCB includes any component that is involved in the implementation of the security policy
- These components are highly critical because any bug in a TCB component is, almost always, a vulnerability
- Any system needs to trust all the TCB components
- Assurance of these components is very important
- They should be carefully controlled

Size of the TCB

- The security level of a system and the trust in it increases as the size of the TCB decreases
- Correctness of a small TCB can be proved by applying formal method and this results in a high assurance level
- An important criteria to select among alternative implementation of the same policy

All together now …

- We can define important resources by looking at process of the organization
- We can define subjects and objects in terms of these resources
- We can define rules on the resource usage and map them into rights
  - Default allow
  - Default deny
- Rights can be defined in one of two framework
  - Mac (system wide constrains)
    - Integrity
    - Confidentiality
    - Static or watermark
  - Dac (no global constrain)
- Data Types + Run time check = Trusted Computing Base
  - Size important for security