Cryptography and Network Security

UNIT-V

Fifth Edition

by William Stallings

Intruders

- significant issue for networked systems is hostile or unwanted access
- either via network or local
- can identify classes of intruders:
  - masquerader
  - misfeasor
  - clandestine user
- varying levels of competence

- A significant security problem for networked systems is hostile, or at least unwanted, trespass by users or software.

- User trespass can take the form of unauthorized logon to a machine or, in the case of an authorized user, acquisition of privileges or performance of actions beyond those that have been authorized.

- Software trespass can take the form of a virus, worm, or Trojan horse.
- All these attacks relate to network security because system entry can be achieved by means of a network.
- However, these attacks are not confined to network based attacks.
- A user with access to a local terminal may attempt trespass without using an intermediate network.

- A virus or Trojan horse may be introduced into a system by means of an optical disc.
- Only the worm is a uniquely network phenomenon.
- Thus, system trespass is an area in which the concerns of network security and computer security overlap.

- One of the two most publicized threats to security is the intruder (the other is viruses), often referred to as a hacker or cracker. In an important early study of intrusion, Anderson [ANDE80] identified three classes of intruders:
  - **Masquerader:** 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:** A legitimate user who accesses data, programs, or resources for

    which such access is not authorized, or who is authorized for such access but

    misuses his or her privileges
  - **Clandestine user:** An individual who seizes supervisory control of the system and uses this control to evade auditing and access controls or to suppress audit collection
- The masquerader is likely to be an outsider; the misfeasor generally is an insider; and the clandestine user can be either an outsider or an insider.

- Intruder attacks range from the benign to the serious.
- At the benign end of the scale, there are many people who simply wish to explore internets and see what is out there.
- At the serious end are individuals who are attempting to read privileged data, perform unauthorized modifications to data, or disrupt the system.

Examples of Intrusion

- remote root compromise
- web server defacement
- guessing / cracking passwords
- copying viewing sensitive data / databases
- running a packet sniffer
- distributing pirated software
- using an unsecured modem to access net
- impersonating a user to reset password
- using an unattended workstation

Intrusion Techniques

- aim to gain access and/or increase privileges on a system
- often use system / software vulnerabilities
- key goal often is to acquire passwords
  - so then exercise access rights of owner
- basic attack methodology
  - target acquisition and information gathering
  - initial access
  - privilege escalation
  - covering tracks

- The objective of the intruder is to gain access to a system or to increase the range of privileges accessible on a system.
- Most initial attacks use system or software vulnerabilities

that allow a user to execute code that opens a back door into the system.

- Alternatively, the intruder attempts to acquire information that should have been protected.
- In some cases, this information is in the form of a user password.
- With knowledge of some other user's password, an intruder can log in to a system and exercise all the privileges accorded to the legitimate user.
- 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 an easy matter to gain access to it and learn passwords. The password file can be protected in one of two ways:

• **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. In practice, the system usually performs a one-way transformation (not reversible) in which the password is used to generate a key for the one-way function and in which a fixed-length output is produced.

• **Access control:** Access to the password file is limited to one or a very few accounts.

Techniques for learning passwords

1. Try default passwords used with standard accounts that are shipped with the system. Many administrators do not bother to change these defaults.
2. Exhaustively try all short passwords (those of one to three characters).
3. Try words in the system's online dictionary or a list of likely passwords. Examples of the latter are readily available on hacker bulletin boards.
4. Collect information about users, such as their full names, the names of their spouse and children, pictures in their office, and books in their office that are related to hobbies.
5. Try users' phone numbers, Social Security numbers, and room numbers.
6. Try all legitimate license plate numbers for this state.
7. Use a Trojan horse (described in Chapter 21) to bypass restrictions on access.
8. Tap the line between a remote user and the host system.

Other Intrusion Techniques

- Other intrusion techniques do not require learning a password. Intruders can get access to a system by exploiting attacks such as buffer overflows on a program that runs with certain privileges.
- Privilege escalation can be done this way as well.

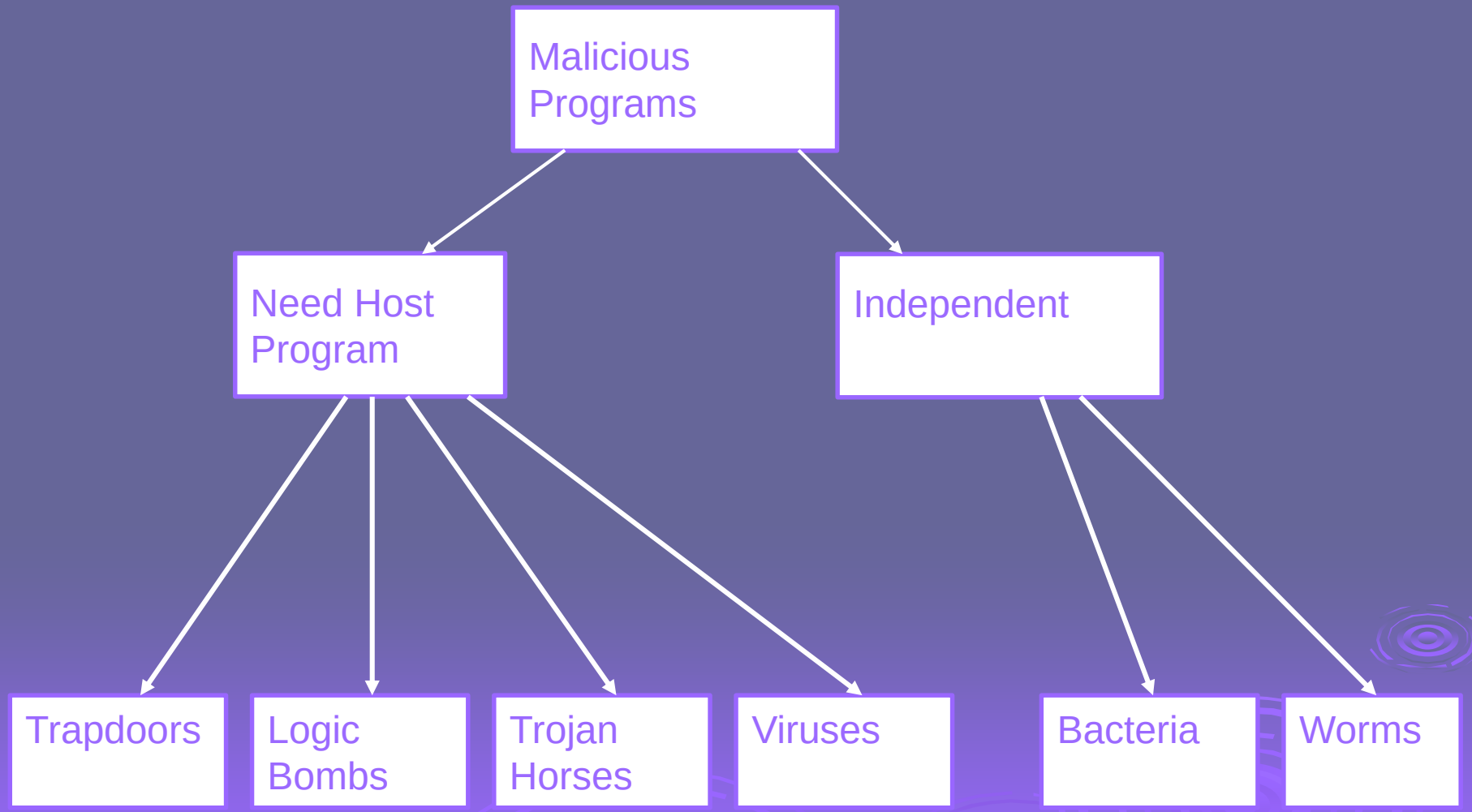
- We turn now to a discussion of the two principal countermeasures: detection and prevention.
- Detection is concerned with learning of an attack, either before or after its success.
- Prevention is a challenging security goal and an uphill battle at all times.

Viruses and ”Malicious Programs”

- Computer “Viruses” and related programs have the ability to replicate themselves on an ever increasing number of computers. They originally spread by people sharing floppy disks. Now they spread primarily over the Internet (a “Worm”).

- Other “Malicious Programs” may be installed by hand on a single machine. They may also be built into widely distributed commercial software packages. These are very hard to detect before the payload activates (Trojan Horses, Trap Doors, and Logic Bombs).

Taxanomy of Malicious Programs



Definitions

- Virus - code that copies itself into other programs.
- A "Bacteria" replicates until it fills all disk space, or CPU cycles.
- Payload - harmful things the malicious program does, after it has had time to spread.
- Worm - a program that replicates itself across the network (usually riding on email messages or attached documents (e.g., macro viruses).

Definitions

- Trojan Horse - instructions in an otherwise good program that cause bad things to happen (sending your data or password to an attacker over the net).
- Logic Bomb - malicious code that activates on an event (e.g., date).
- Trap Door (or Back Door) - undocumented entry point written into code for debugging that can allow unwanted users.
- Easter Egg - extraneous code that does something "cool." A way for programmers to show that they control the product.

Virus Phases

- **Dormant phase** - the virus is idle
- **Propagation phase** - the virus places an identical copy of itself into other programs
- **Triggering phase –** the virus is activated to perform the function for which it was intended
- **Execution phase** – the function is performed

Virus Protection

Have a well-known virus protection program, configured to scan disks and downloads automatically for known viruses.

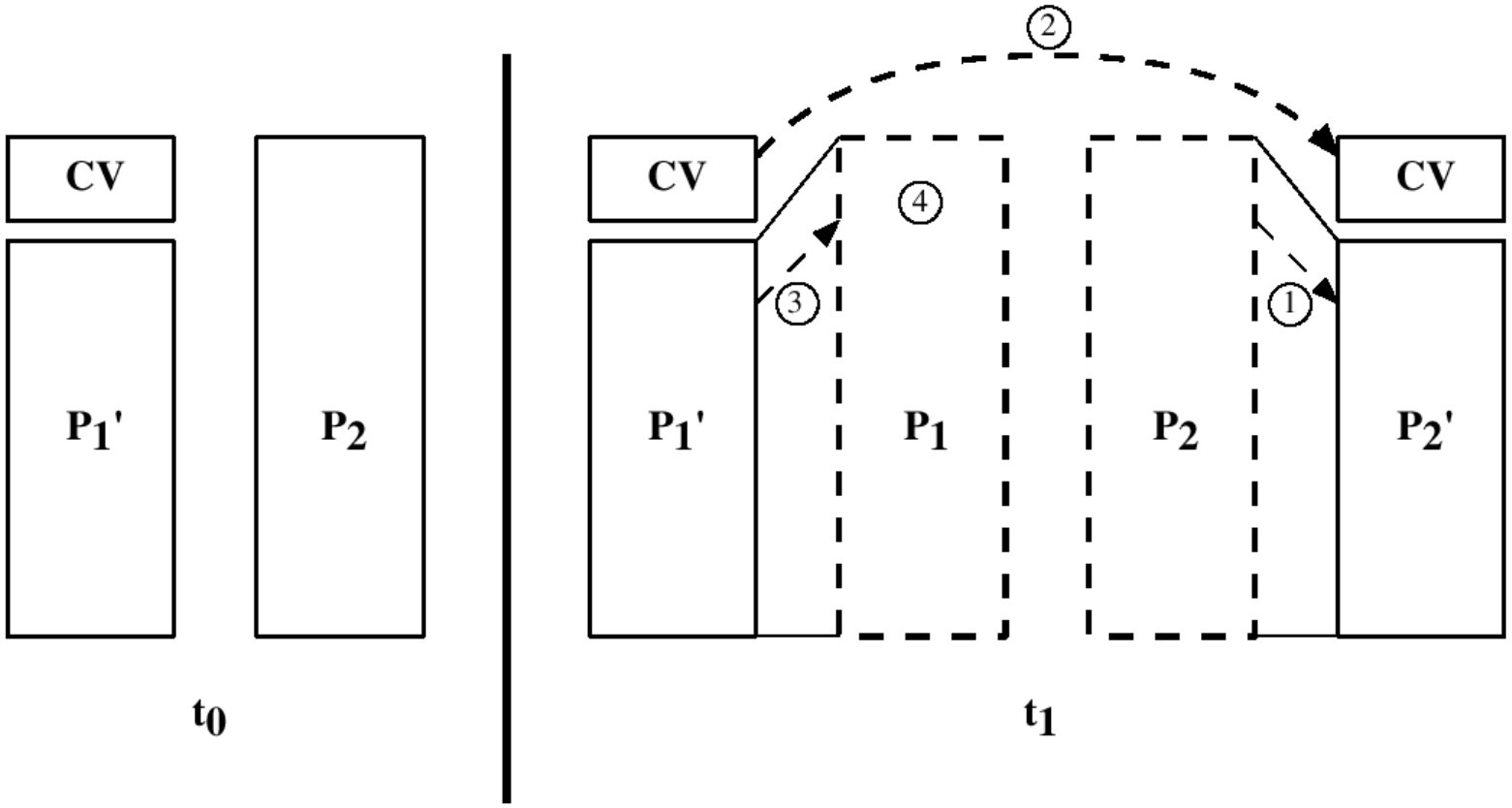
Do not execute programs (or "macro's") from unknown sources (e.g., PS files, Hypercard files, MS Office documents,

Avoid the most common operating systems and email programs, if possible.

Virus Structure

```
        program V :=

{goto main;
        1234567;

            subroutine infect-executable :=
                {loop:
                file := get-random-executable-file;
                if (first-line-of-file = 1234567)
                        then goto loop
                        else prepend V to file; }

            subroutine do-damage :=
                {whatever damage is to be done}

            subroutine trigger-pulled :=
                {return true if some condition holds}

main:       main-program :=
                {infect-executable;
                if trigger-pulled then do-damage;
                goto next;}

next:

}
```

A Compression Virus



Types of Viruses

- **Parasitic Virus** - attaches itself to executable files as part of their code. Runs whenever the host program runs.
- **Memory-resident Virus -** Lodges in main memory as part of the residual operating system.
- **Boot Sector Virus -** infects the boot sector of a disk, and spreads when the operating system boots up (original DOS viruses).
- **Stealth Virus** - explicitly designed to hide from Virus Scanning programs.
- **Polymorphic Virus** - mutates with every new host to prevent signature detection.

Macro Viruses

- Microsoft Office applications allow “macros” to be part of the document. The macro could run whenever the document is opened, or when a certain command is selected (Save File).
- Platform independent.
- Infect documents, delete files, generate email and edit letters.

Outline

- Firewall Design Principles
  - Firewall Characteristics
  - Types of Firewalls
  - Firewall Configurations
- Trusted Systems
  - Data Access Control
  - The Concept of Trusted systems
  - Trojan Horse Defense

Firewalls

- Effective means of protection a local system or network of systems from network-based security threats while affording access to the outside world via WAN`s or the Internet

Firewall Design Principles

- Information systems undergo a steady evolution (from small LAN`s to Internet connectivity)
- Strong security features for all workstations and servers not established

Firewall Design Principles

- The firewall is inserted between the premises network and the Internet
- Aims:
  - Establish a controlled link
  - Protect the premises network from Internet-based attacks
  - Provide a single choke point

Firewall Characteristics

- Design goals:
  - All traffic from inside to outside must pass through the firewall (physically blocking all access to the local network except via the firewall)
  - Only authorized traffic (defined by the local security police) will be allowed to pass

Firewall Characteristics

- Design goals:
  - The firewall itself is immune to penetration (use of trusted system with a secure operating system)

Firewall Characteristics

- Four general techniques:
- Service control
  - Determines the types of Internet services that can be accessed, inbound or outbound
- Direction control
  - Determines the direction in which particular service requests are allowed to flow

Firewall Characteristics

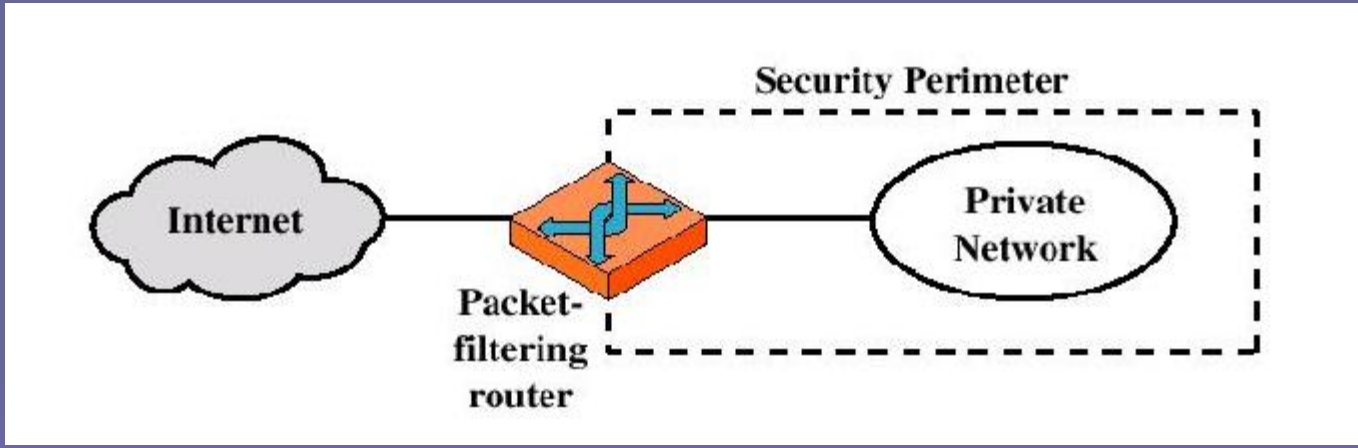
- User control
  - Controls access to a service according to which user is attempting to access it
- Behavior control
  - Controls how particular services are used (e.g. filter e-mail)

Types of Firewalls

- Three common types of Firewalls:
  - Packet-filtering routers
  - Application-level gateways
  - Circuit-level gateways
  - (Bastion host)

Types of Firewalls

- Packet-filtering Router



Types of Firewalls

- Packet-filtering Router
  - Applies a set of rules to each incoming IP packet and then forwards or discards the packet
  - Filter packets going in both directions
  - The packet filter is typically set up as a list of rules based on matches to fields in the IP or TCP header
  - Two default policies (discard or forward)

Types of Firewalls

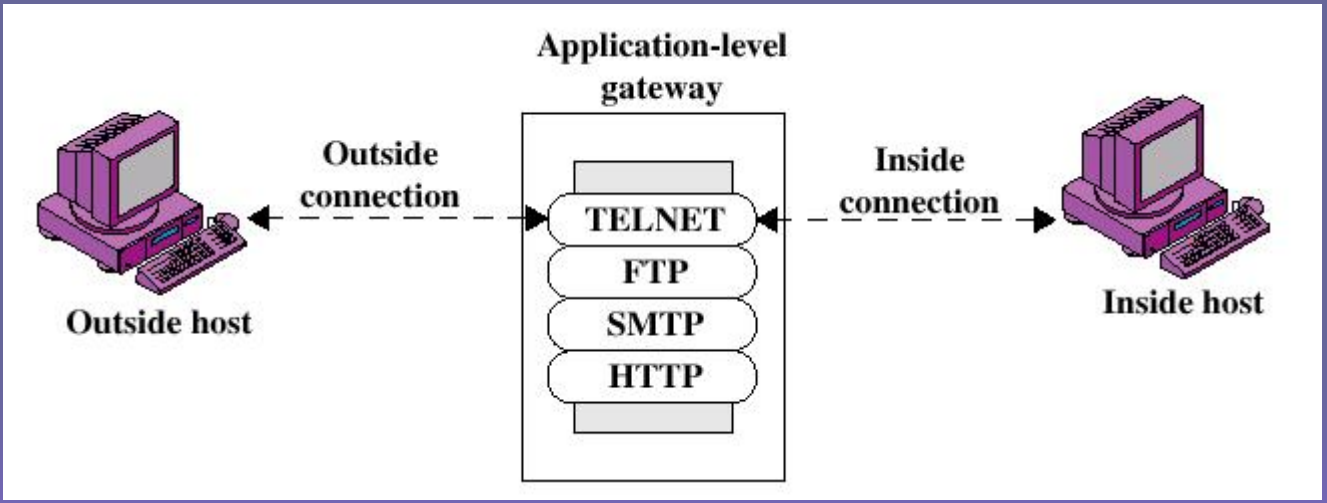
- Advantages:
  - Simplicity
  - Transparency to users
  - High speed
- Disadvantages:
  - Difficulty of setting up packet filter rules
  - Lack of Authentication

Types of Firewalls

- Possible attacks and appropriate countermeasures
  - IP address spoofing
  - Source routing attacks
  - Tiny fragment attacks

Types of Firewalls

- Application-level Gateway



Types of Firewalls

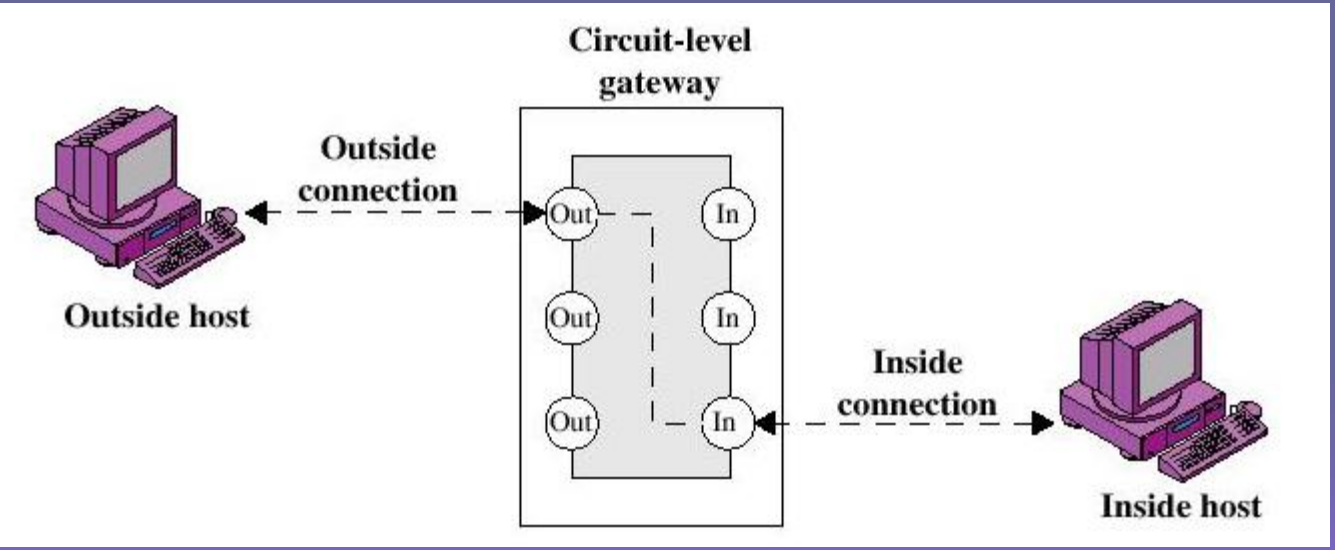
- Application-level Gateway
  - Also called proxy server
  - Acts as a relay of application-level traffic

Types of Firewalls

- Advantages:
  - Higher security than packet filters
  - Only need to scrutinize a few allowable applications
  - Easy to log and audit all incoming traffic
- Disadvantages:
  - Additional processing overhead on each connection (gateway as splice point)

Types of Firewalls

- Circuit-level Gateway



Types of Firewalls

- Circuit-level Gateway
  - Stand-alone system or
  - Specialized function performed by an Application-level Gateway
  - Sets up two TCP connections
  - The gateway typically relays TCP segments from one connection to the other without examining the contents

Types of Firewalls

- Circuit-level Gateway
  - The security function consists of determining which connections will be allowed
  - Typically use is a situation in which the system administrator trusts the internal users
  - An example is the SOCKS package

Types of Firewalls

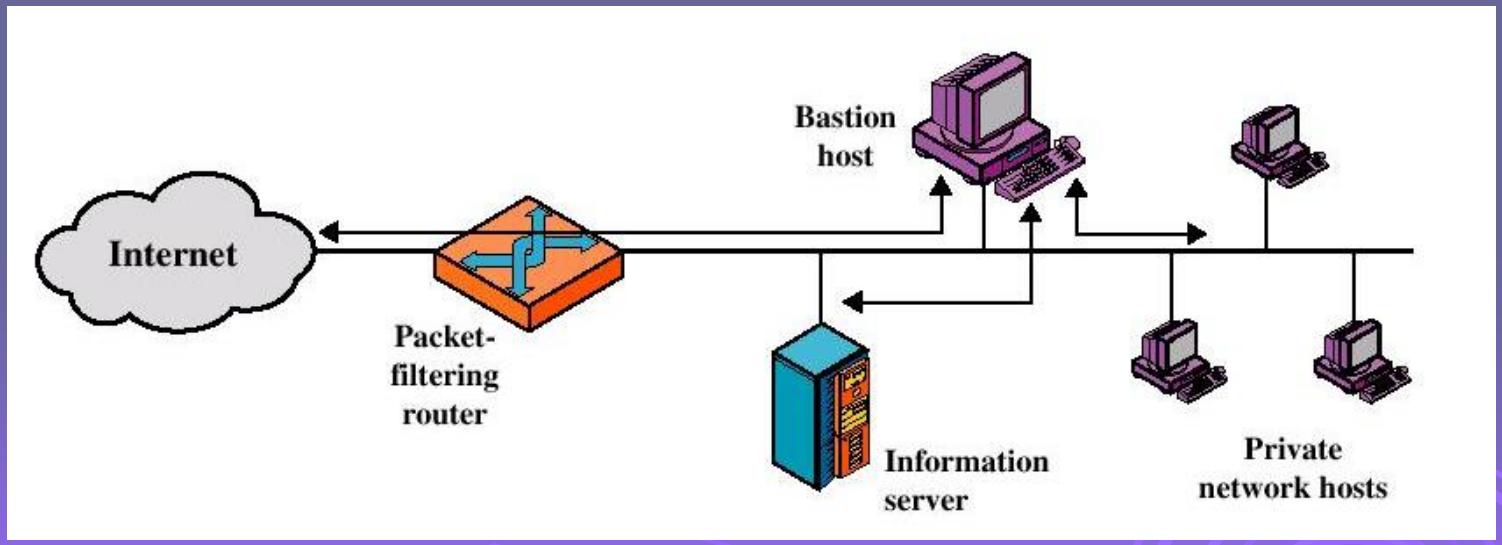
- Bastion Host
  - A system identified by the firewall administrator as a critical strong point in the network´s security
  - The bastion host serves as a platform for an application-level or circuit-level gateway

Firewall Configurations

- In addition to the use of simple configuration of a single system (single packet filtering router or single gateway), more complex configurations are possible
- Three common configurations

Firewall Configurations

- Screened host firewall system (single-homed bastion host)



Firewall Configurations

- Screened host firewall, single-homed bastion configuration
- Firewall consists of two systems:
  - A packet-filtering router
  - A bastion host

Firewall Configurations

- Configuration for the packet-filtering router:
  - Only packets from and to the bastion host are allowed to pass through the router
- The bastion host performs authentication and proxy functions

Firewall Configurations

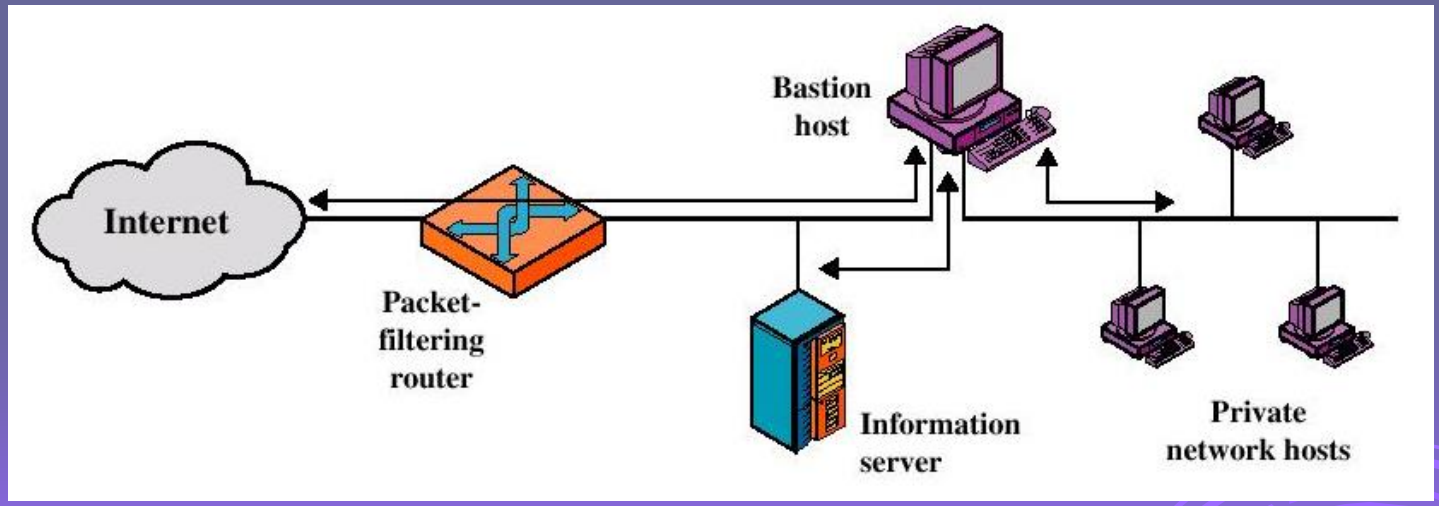
- Greater security than single configurations because of two reasons:
  - This configuration implements both packet-level and application-level filtering (allowing for flexibility in defining security policy)
  - An intruder must generally penetrate two separate systems

Firewall Configurations

- This configuration also affords flexibility in providing direct Internet access (public information server, e.g. Web server)

Firewall Configurations

- Screened host firewall system (dual-homed bastion host)

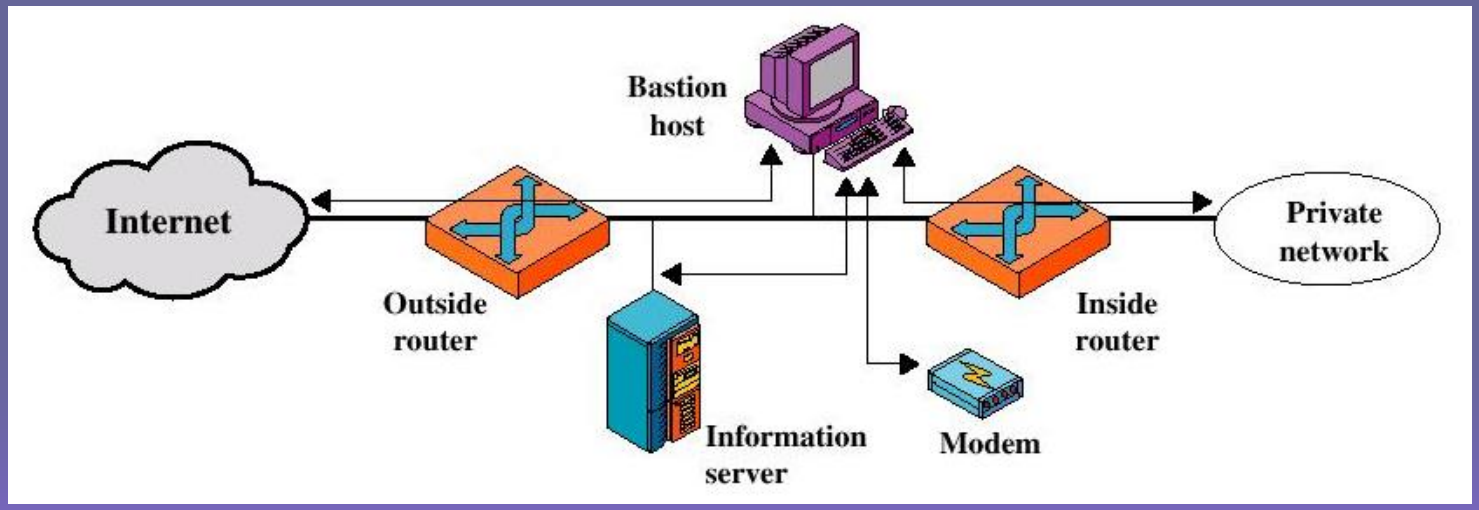


Firewall Configurations

- Screened host firewall, dual-homed bastion configuration
  - The packet-filtering router is not completely compromised
  - Traffic between the Internet and other hosts on the private network has to flow through the bastion host

Firewall Configurations

- Screened-subnet firewall system



Firewall Configurations

- Screened subnet firewall configuration
  - Most secure configuration of the three
  - Two packet-filtering routers are used
  - Creation of an isolated sub-network

Firewall Configurations

- Advantages:
  - Three levels of defense to thwart intruders
  - The outside router advertises only the existence of the screened subnet to the Internet (internal network is invisible to the Internet)

Firewall Configurations

- Advantages:
  - The inside router advertises only the existence of the screened subnet to the internal network (the systems on the inside network cannot construct direct routes to the Internet)

Trusted Systems

- One way to enhance the ability of a system to defend against intruders and malicious programs is to implement trusted system technology

Data Access Control

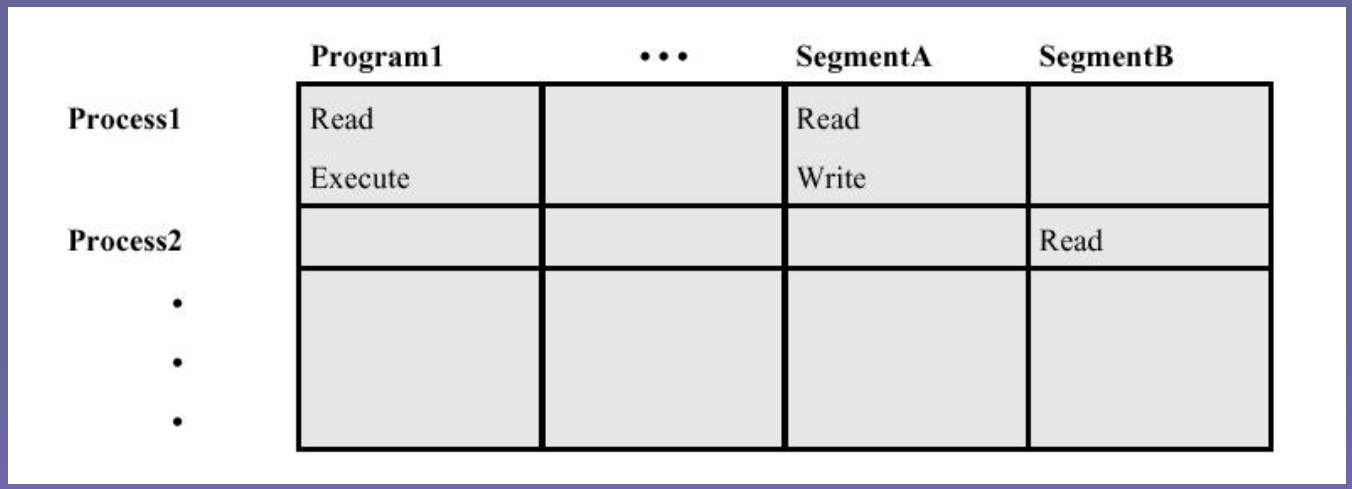
- Through the user access control procedure (log on), a user can be identified to the system
- Associated with each user, there can be a profile that specifies permissible operations and file accesses
- The operation system can enforce rules based on the user profile

Data Access Control

- General models of access control:
  - Access matrix
  - Access control list
  - Capability list

Data Access Control

- Access Matrix



	Program1	• • •	SegmentA	SegmentB
Process1	Read Execute		Read Write	
Process2				Read
•				
•				
•				

Data Access Control

- Access Matrix: Basic elements of the model
  - Subject: An entity capable of accessing objects, the concept of subject equates with that of process
  - Object: Anything to which access is controlled (e.g. files, programs)
  - Access right: The way in which an object is accessed by a subject (e.g. read, write, execute)

Data Access Control

- Access Control List: Decomposition of the matrix by columns

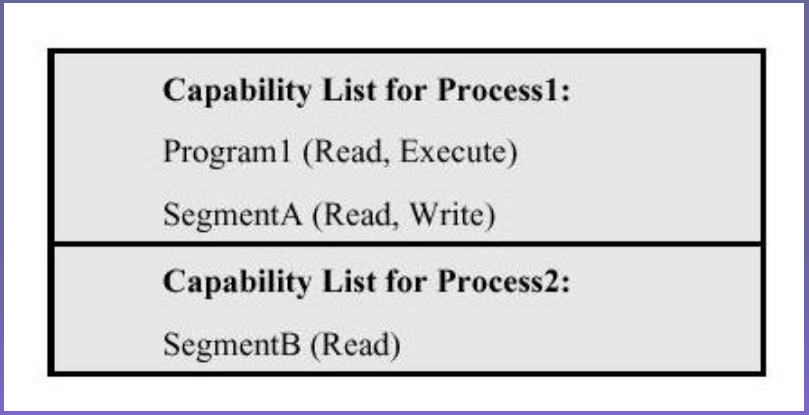
Access Control List for Program1: Process1 (Read, Execute)
Access Control List for SegmentA: Process1 (Read, Write)
Access Control List for SegmentB: Process2 (Read)

Data Access Control

- Access Control List
  - An access control list lists users and their permitted access right
  - The list may contain a default or public entry

Data Access Control

- Capability list: Decomposition of the matrix by rows



Data Access Control

- Capability list
  - A capability ticket specifies authorized objects and operations for a user
  - Each user have a number of tickets

The Concept of Trusted Systems

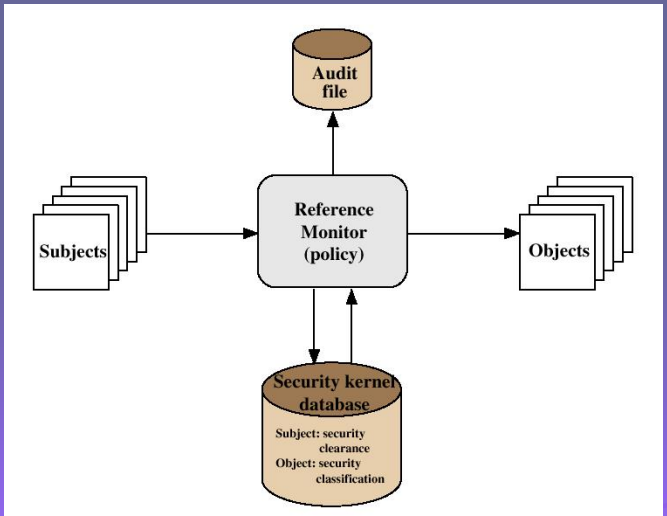
- Trusted Systems
  - Protection of data and resources on the basis of levels of security (e.g. military)
  - Users can be granted clearances to access certain categories of data

The Concept of Trusted Systems

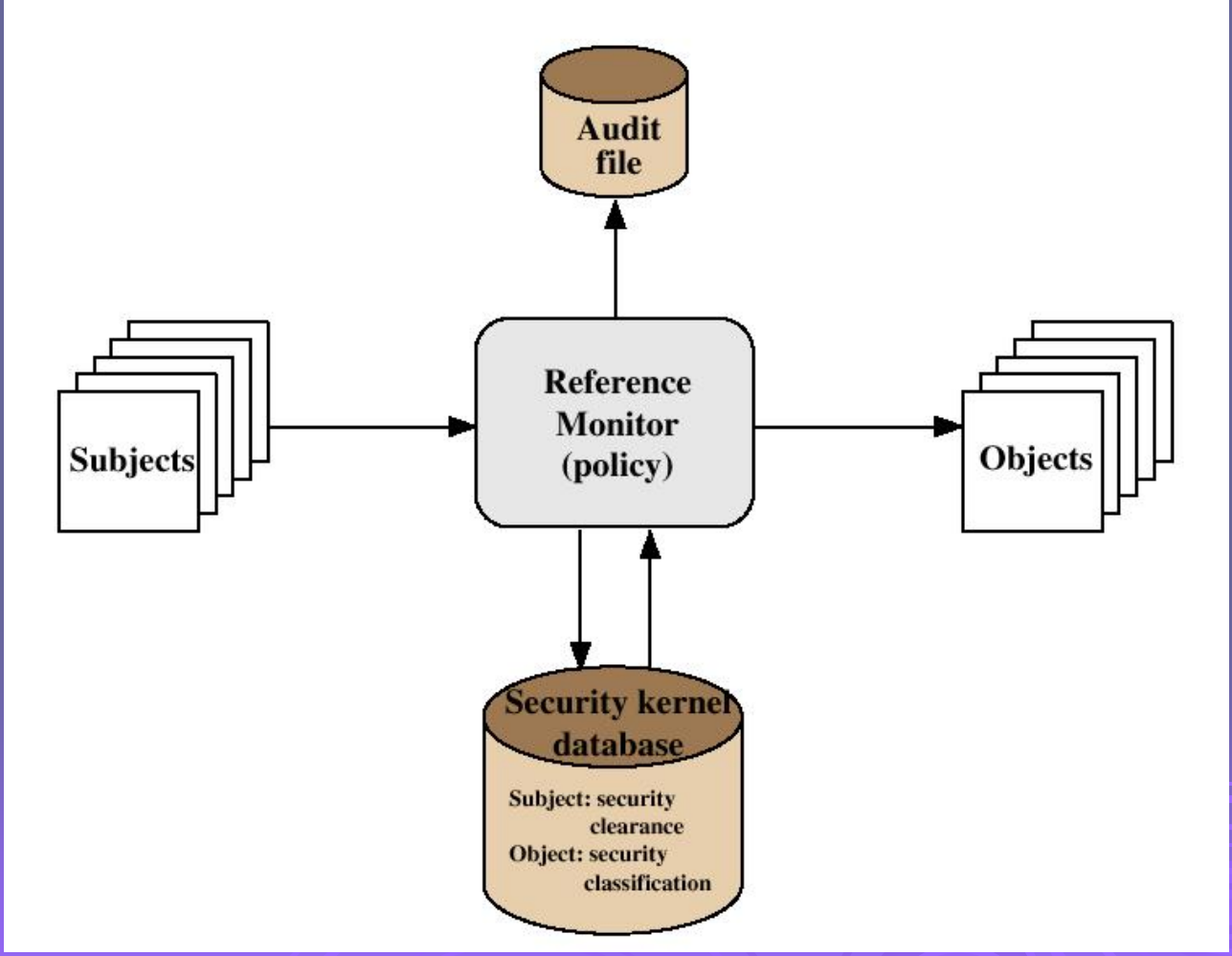
- Multilevel security
  - Definition of multiple categories or levels of data
- A multilevel secure system must enforce:
  - No read up: A subject can only read an object of less or equal security level (Simple Security Property)
  - No write down: A subject can only write into an object of greater or equal security level (*-Property)

The Concept of Trusted Systems

- Reference Monitor Concept: Multilevel security for a data processing system



The Concept of Trusted Systems



The Concept of Trusted Systems

- Reference Monitor
  - Controlling element in the hardware and operating system of a computer that regulates the access of subjects to objects on basis of security parameters
  - The monitor has access to a file (security kernel database)
  - The monitor enforces the security rules (no read up, no write down)

The Concept of Trusted Systems

- Properties of the Reference Monitor
  - Complete mediation: Security rules are enforced on every access
  - Isolation: The reference monitor and database are protected from unauthorized modification
  - Verifiability: The reference monitor's correctness must be provable (mathematically)

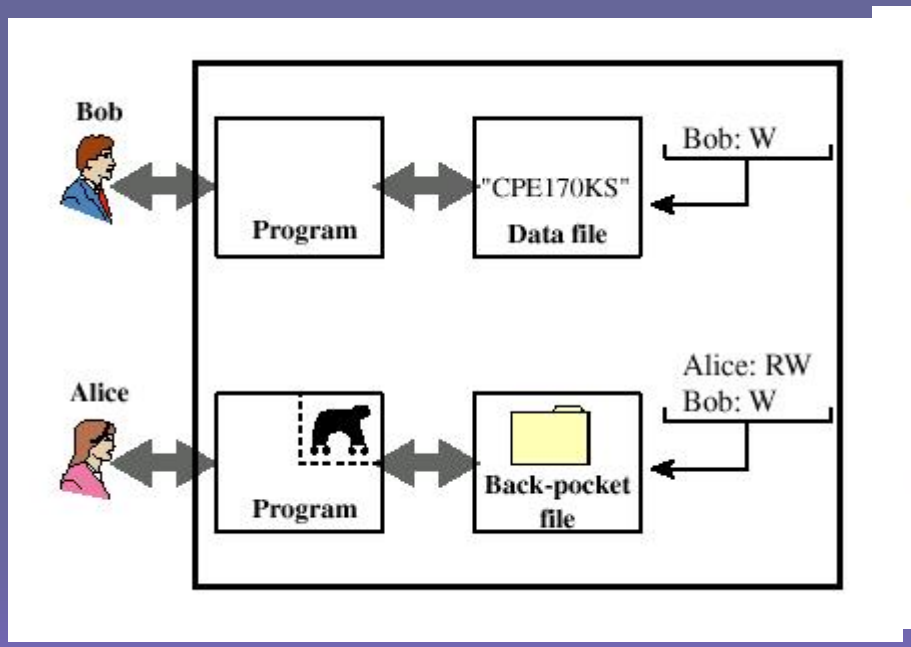
The Concept of Trusted Systems

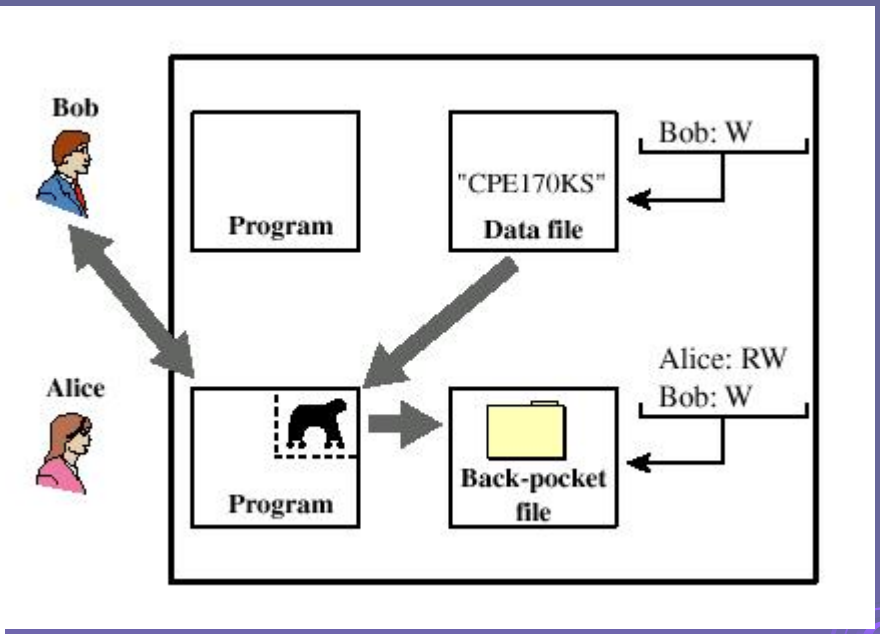
- A system that can provide such verifications (properties) is referred to as a trusted system

Trojan Horse Defense

- Secure, trusted operating systems are one way to secure against Trojan Horse attacks

Trojan Horse Defense





Trojan Horse Defense