Cryptography and Network Security

INTERNET FIREWALLS FOR TRUSTED SYSTEMS

Session Meta Data

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Revision History

Revision Date	Details	Version no.
		1.0

Agenda

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

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

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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)

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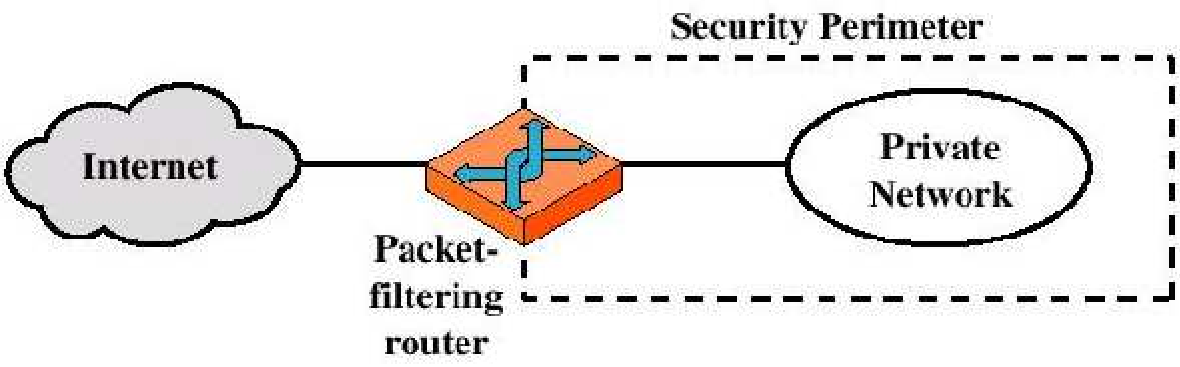
Types of Firewalls

- 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

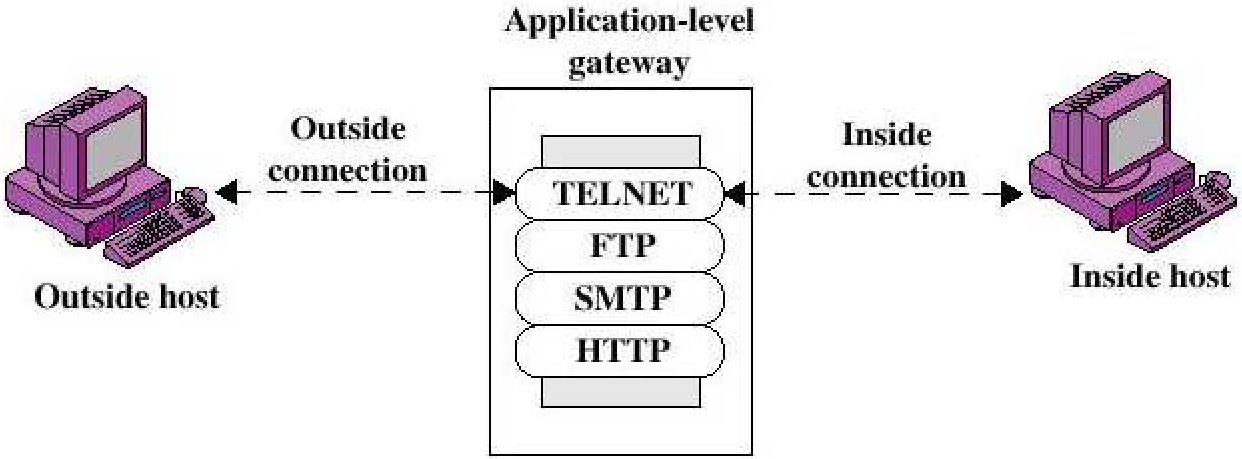
- Advantages:
  - Simplicity
  - Transparency to users
  - High speed
- Disadvantages:
  - Difficulty of setting up packet filter rules
  - Lack of Authentication

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

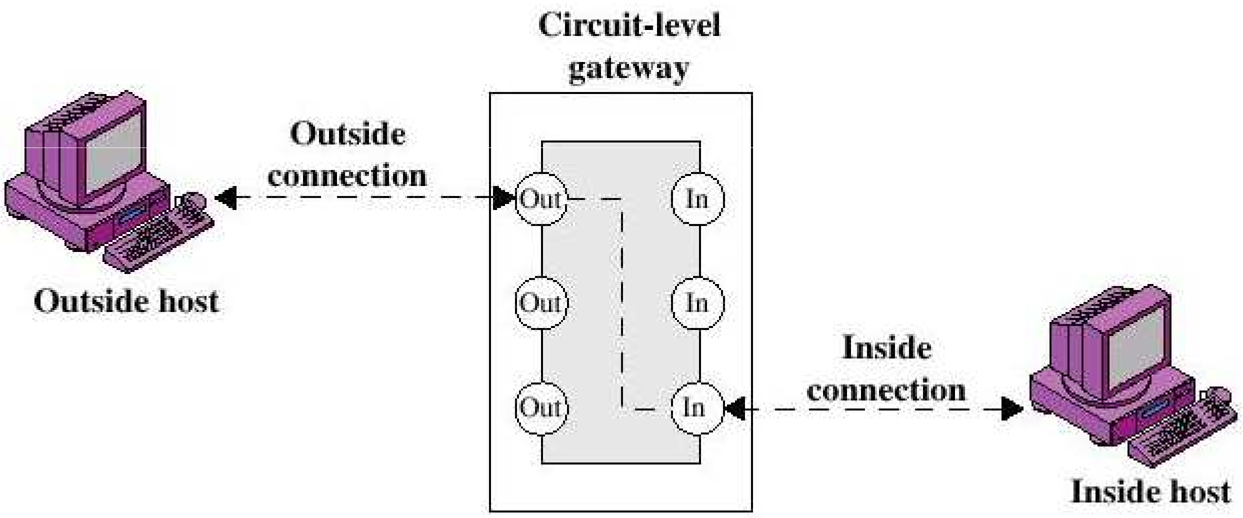
- Application-level Gateway
  - Also called proxy server
  - Acts as a relay of application-level traffic

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

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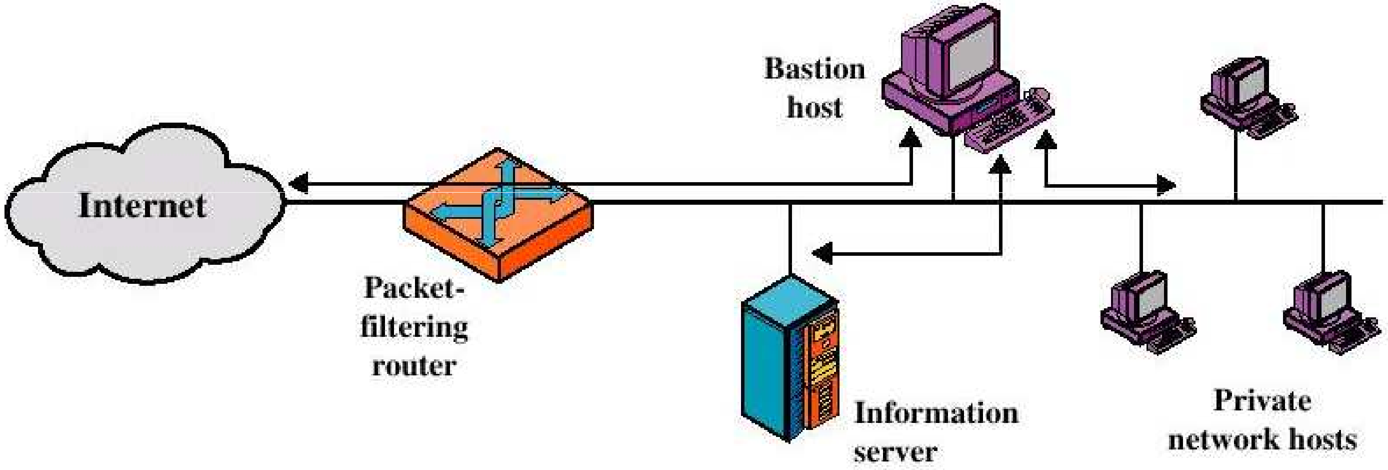
Firewall Configurations

- 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

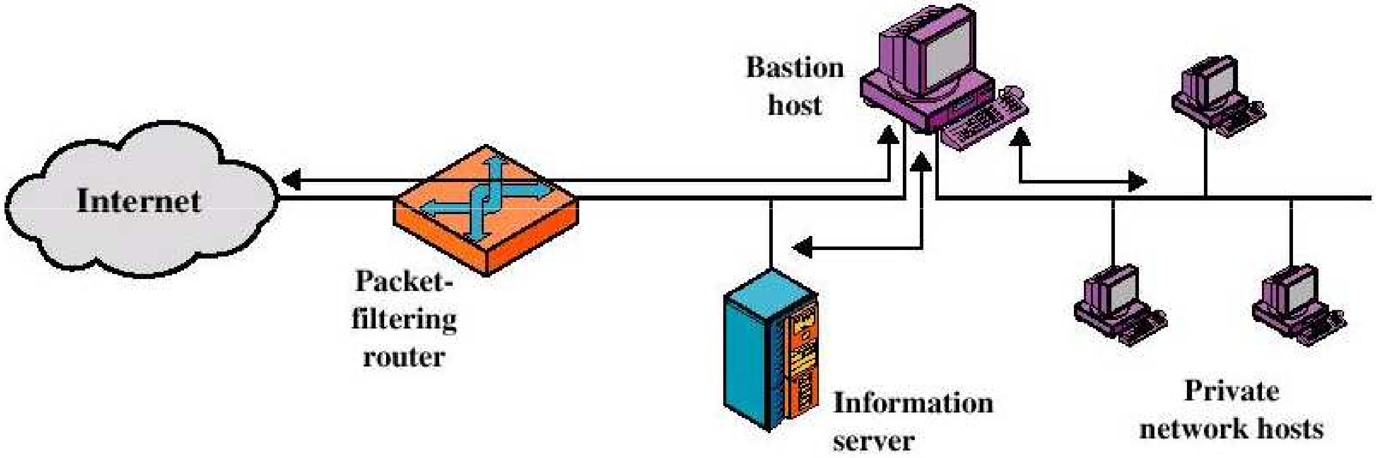
- Greater security than single configurations because of two reasons:
  - This configuration implements both packet-level and application-level filtering (allowing for flexibility in defining security policy)
  - An intruder must generally penetrate two separate systems

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)

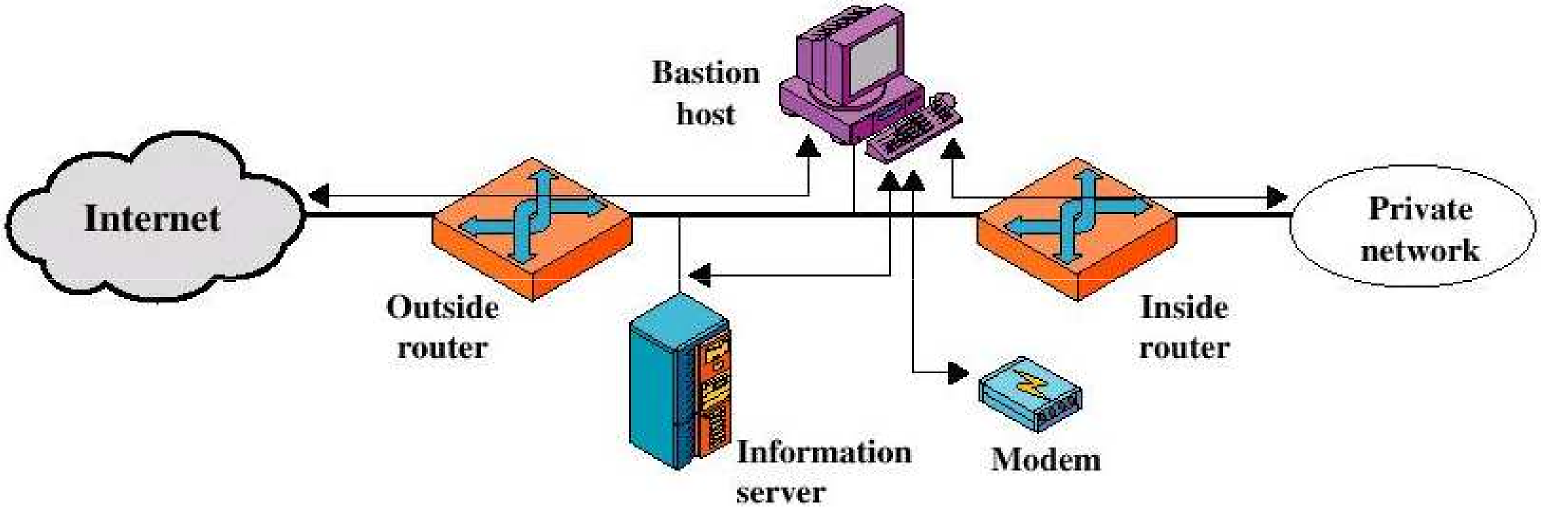


Firewall Configurations

- 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)

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Trusted Systems

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

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Data Access Control

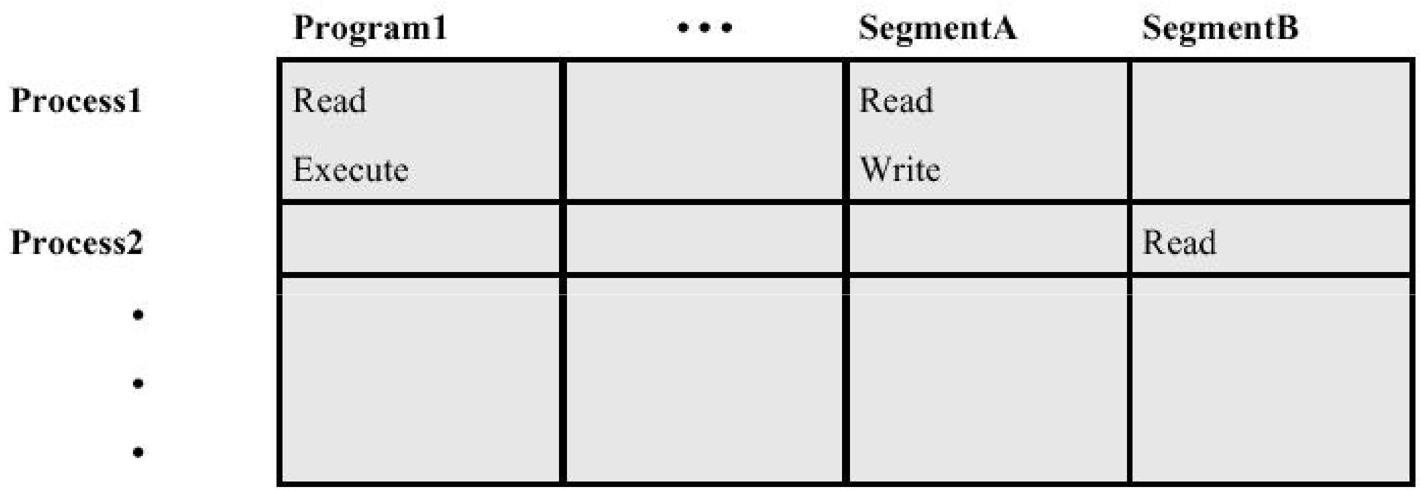
- Through the user access control procedure (log on), a user can be identified to the system
- Associated with each user, there can be a profile that specifies permissible operations and file accesses
- The operation system can enforce rules based on the user profile

Data Access Control

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

Data Access Control

- *Access Matrix*



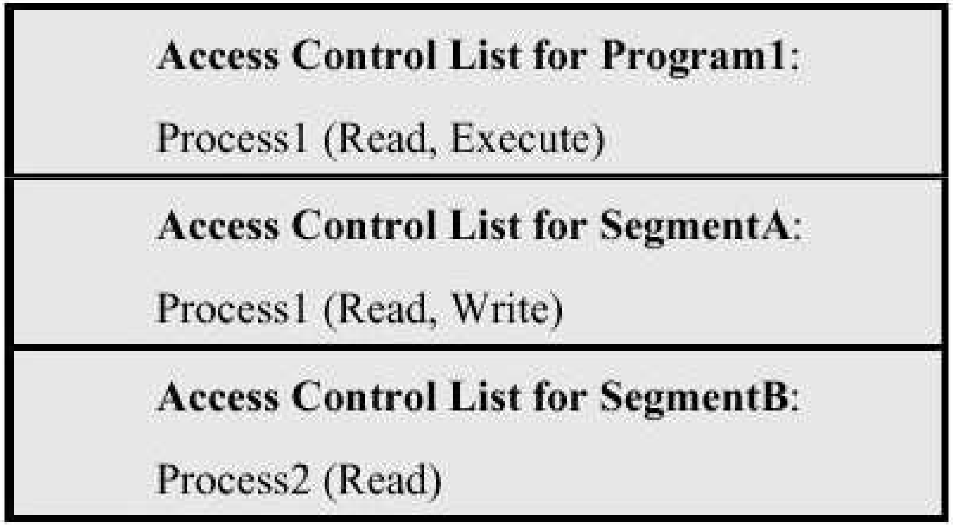
	Program1	• • •	SegmentA	SegmentB
Process1	Read Execute		Read Write	
Process2				Read
• • •				

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:

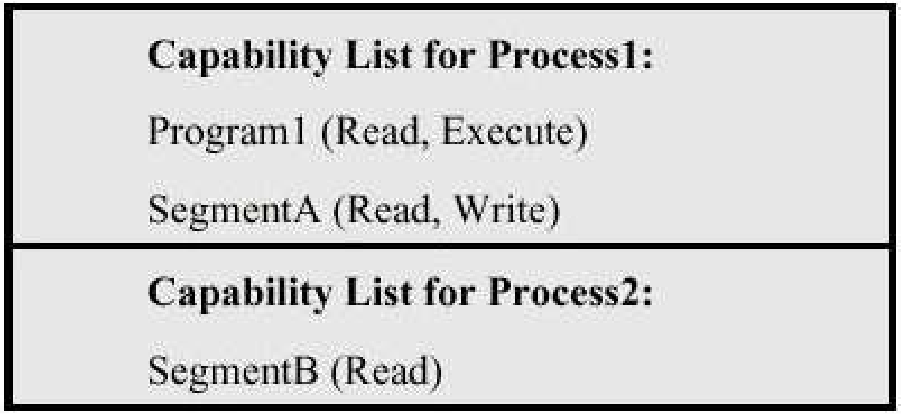
Process2 (Read)

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



Capability List for Process1:

Program1 (Read, Execute)

SegmentA (Read, Write)

Capability List for Process2:

SegmentB (Read)

Data Access Control

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

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The Concept of Trusted Systems

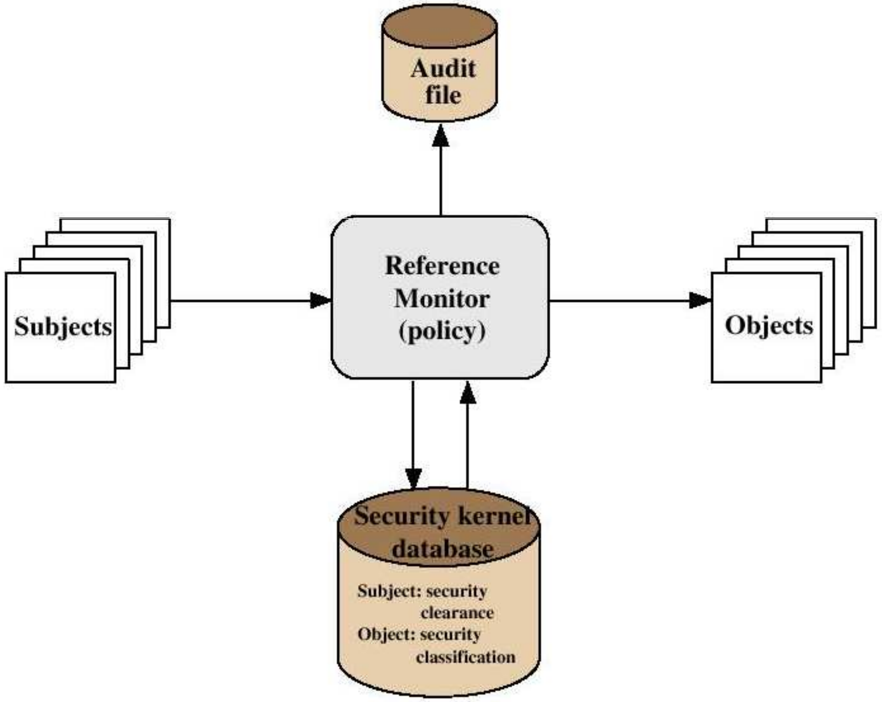
- Trusted Systems
  - Protection of data and resources on the basis of levels of security (e.g. military)
  - Users can be granted clearances to access certain categories of data

The Concept of Trusted Systems

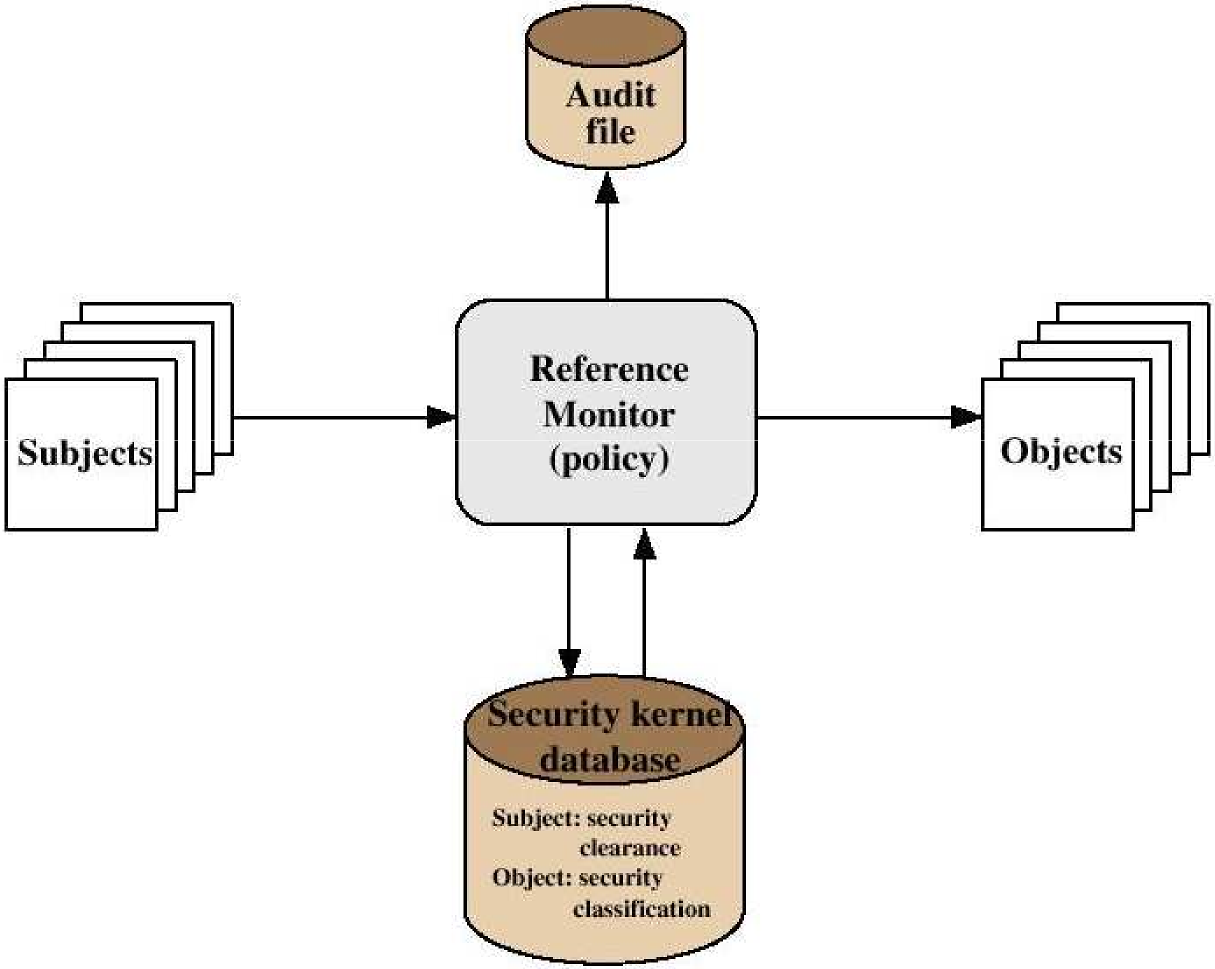
- Multilevel security
  - Definition of multiple categories or levels of data
- A multilevel secure system must enforce:
  - No read up: A subject can only read an object of less or equal security level (Simple Security Property)
  - No write down: A subject can only write into an object of greater or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

The Concept of Trusted Systems

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


Audit file
Subjects
Reference Monitor (policy)
Objects
Security kernel database
Subject: security clearance
Object: security classification

The Concept of Trusted Systems


Audit file
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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

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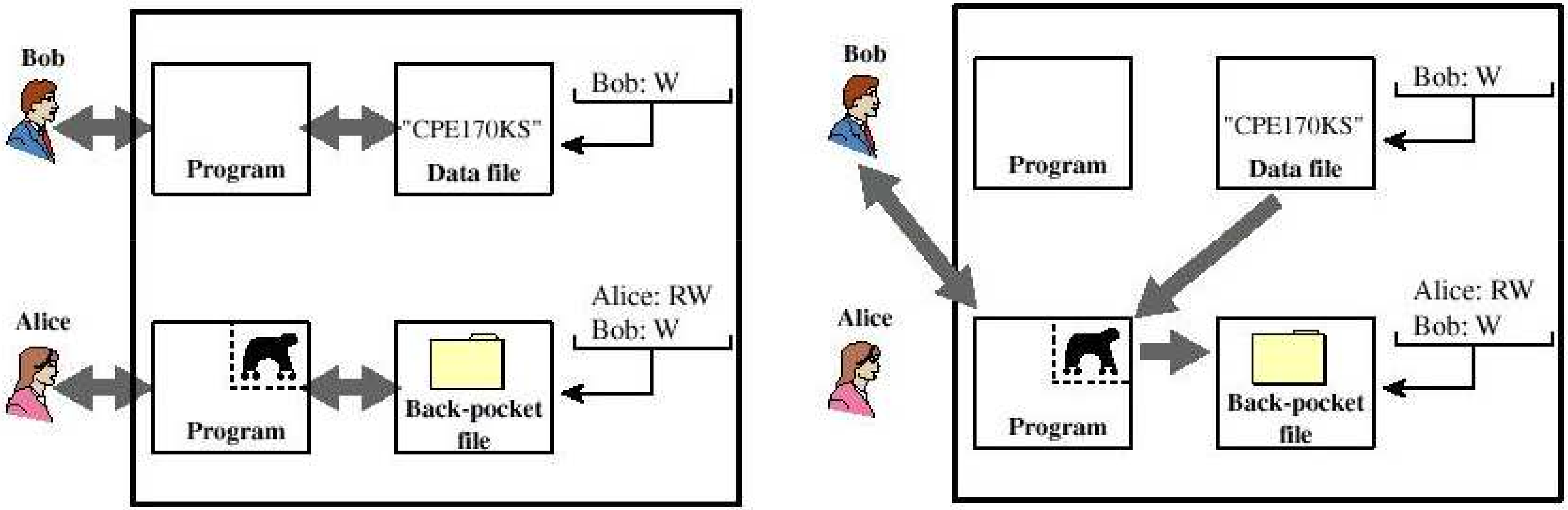
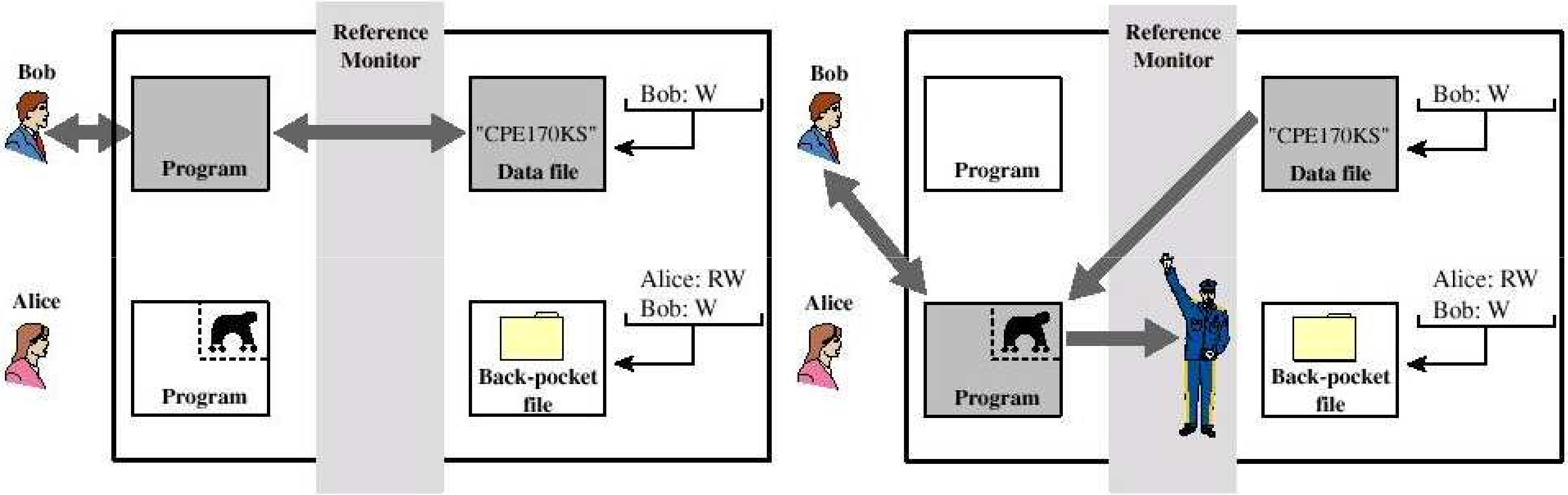
Trojan Horse Defense

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

Trojan Horse Defense



Trojan Horse Defense



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Summary

- have considered:
  - Firewall design principles
  - Trusted systems

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Test your understanding

1) List out the design goals of firewalls.
2) Explain the design principles of firewall.
3) Explain trusted systems.

References

1. William Stallings, Cryptography and Network Security, 6th Edition, Pearson Education, March 2013.
2. Charlie Kaufman, Radia Perlman and Mike Speciner, “Network Security”, Prentice Hall of India, 2002.