

# Cryptography and Network Security Chapter 20

Fourth Edition  
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Lecture slides by Lawrie Brown

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# Chapter 20 – Firewalls

*The function of a strong position is to make the forces holding it practically unassailable*

**—On War, Carl Von Clausewitz**



# Introduction

- seen evolution of information systems
- now everyone want to be on the Internet
- and to interconnect networks
- has persistent security concerns
  - can't easily secure every system in org
- typically use a **Firewall**
- to provide **perimeter defence**
- as part of comprehensive security strategy



# What is a Firewall?

- ❑ a **choke point** of control and monitoring
- ❑ interconnects networks with differing trust
- ❑ imposes restrictions on network services
  - only authorized traffic is allowed
- ❑ auditing and controlling access
  - can implement alarms for abnormal behavior
- ❑ provide NAT & usage monitoring
- ❑ implement VPNs using IPSec
- ❑ must be immune to penetration

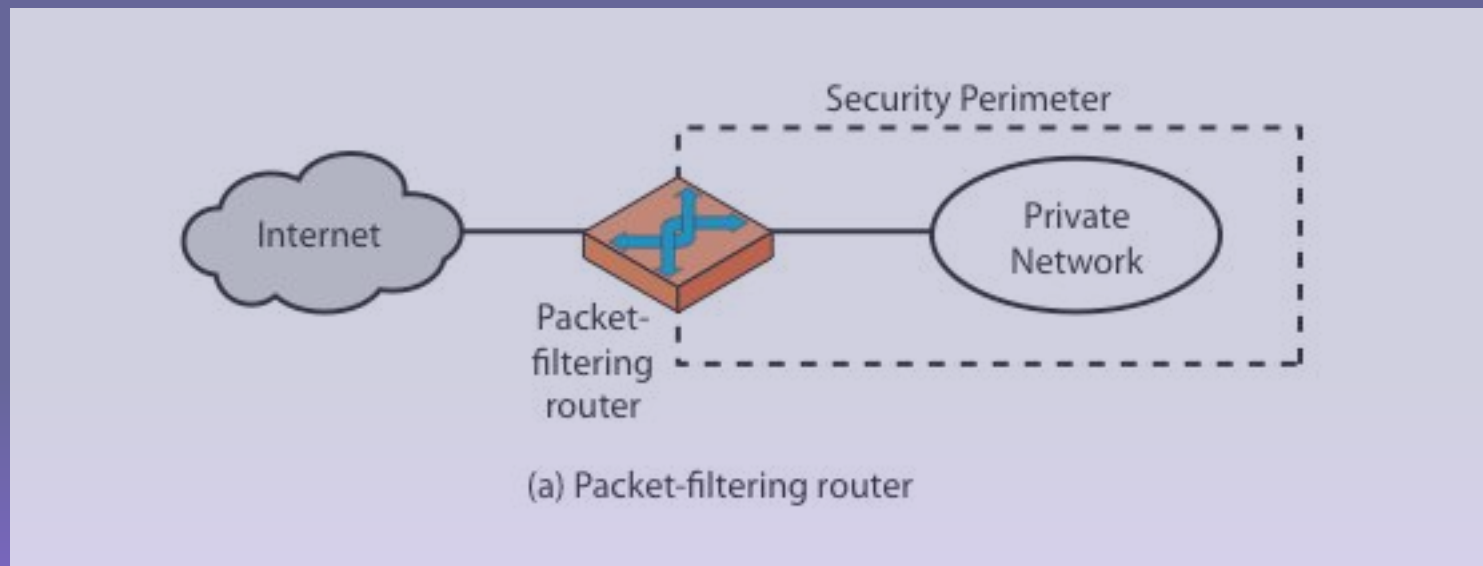
# Firewall Limitations

- ❑ cannot protect from attacks bypassing it
  - eg sneaker net, utility modems, trusted organisations, trusted services (eg SSL/SSH)
- ❑ cannot protect against internal threats
  - eg disgruntled or colluding employees
- ❑ cannot protect against transfer of all virus infected programs or files
  - because of huge range of O/S & file types

# Firewalls – Packet Filters

- simplest, fastest firewall component
- foundation of any firewall system
- examine each IP packet (no context) and permit or deny according to rules
- hence restrict access to services (ports)
- possible default policies
  - that not expressly permitted is prohibited
  - that not expressly prohibited is permitted

# Firewalls – Packet Filters



# Firewalls – Packet Filters

Table 20.1 Packet-Filtering Examples

A	action	ourhost	port	theirhost	port	comment
	block	*	*	SPIGOT	*	we don't trust these people
	allow	OUR-GW	25	*	*	connection to our SMTP port

B	action	ourhost	port	theirhost	port	comment
	block	*	*	*	*	default

C	action	ourhost	port	theirhost	port	comment
	allow	*	*	*	25	connection to their SMTP port

D	action	src	port	dest	port	flags	comment
	allow	{our hosts}	*	*	25		our packets to their SMTP port
	allow	*	25	*	*	ACK	their replies

E	action	src	port	dest	port	flags	comment
	allow	{our hosts}	*	*	*		our outgoing calls
	allow	*	*	*	*	ACK	replies to our calls
	allow	*	*	*	>1024		traffic to nonservers



# Attacks on Packet Filters

- ❑ IP address spoofing
  - fake source address to be trusted
  - add filters on router to block
- ❑ source routing attacks
  - attacker sets a route other than default
  - block source routed packets
- ❑ tiny fragment attacks
  - split header info over several tiny packets
  - either discard or reassemble before check

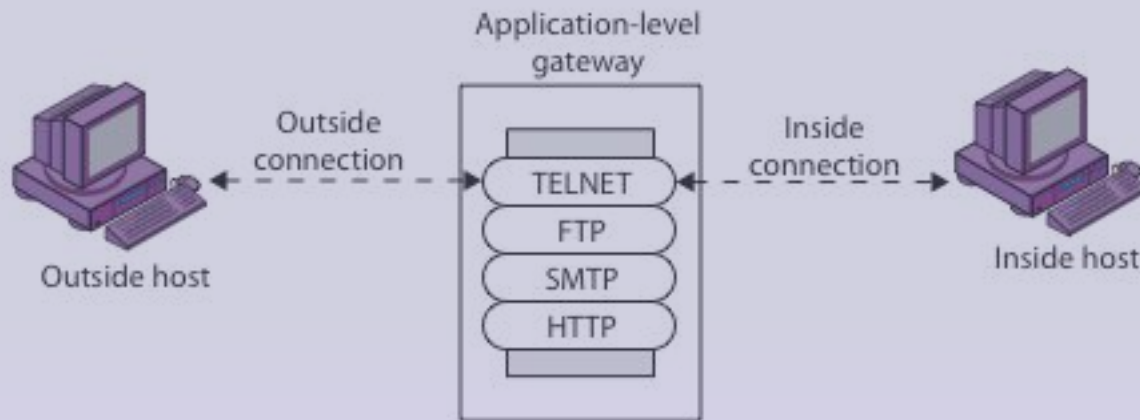
# Firewalls – Stateful Packet Filters

- ❑ traditional packet filters do not examine higher layer context
  - ie matching return packets with outgoing flow
- ❑ stateful packet filters address this need
- ❑ they examine each IP packet in context
  - keep track of client-server sessions
  - check each packet validly belongs to one
- ❑ hence are better able to detect bogus packets out of context

# Firewalls - Application Level Gateway (or Proxy)

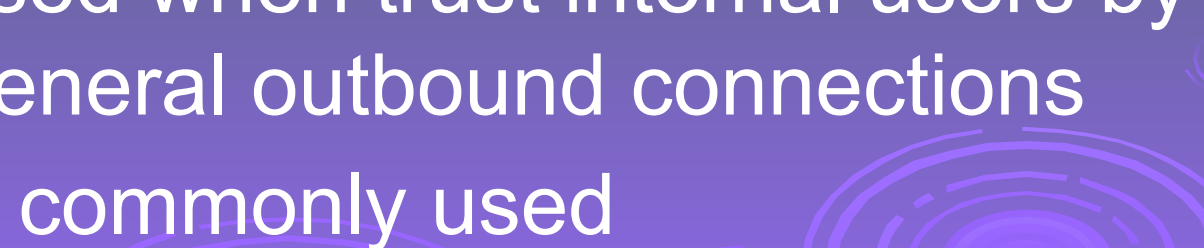
- have application specific gateway / proxy
- has full access to protocol
  - user requests service from proxy
  - proxy validates request as legal
  - then actions request and returns result to user
  - can log / audit traffic at application level
- need separate proxies for each service
  - some services naturally support proxying
  - others are more problematic

# Firewalls - Application Level Gateway (or Proxy)

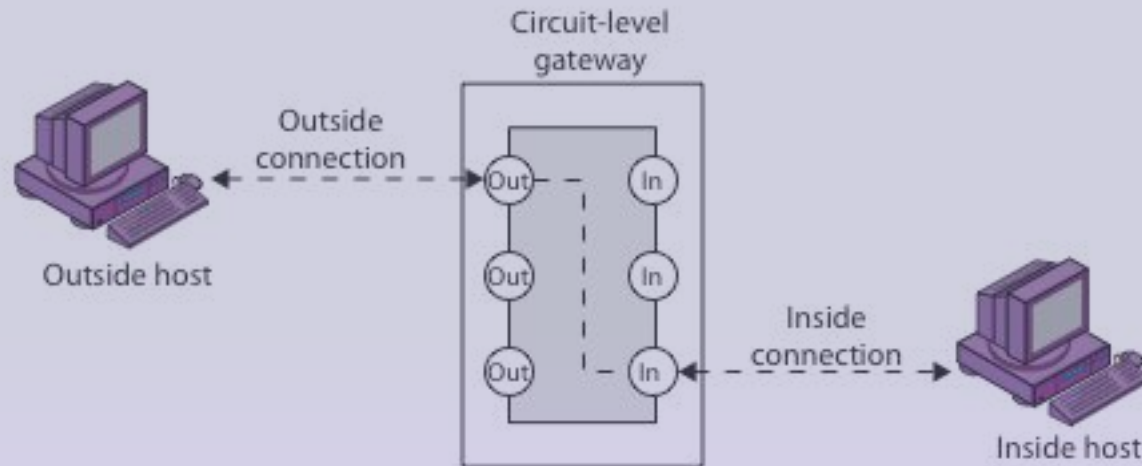


(b) Application-level gateway

# Firewalls - Circuit Level Gateway

- ❑ relays two TCP connections
  - ❑ imposes security by limiting which such connections are allowed
  - ❑ once created usually relays traffic without examining contents
  - ❑ typically used when trust internal users by allowing general outbound connections
  - ❑ SOCKS is commonly used
- 
- The bottom right corner of the slide features several decorative concentric circles in a light blue color, resembling ripples in water. These circles are of varying sizes and are positioned in the lower right quadrant, partially overlapping the bottom edge of the text area.

# Firewalls - Circuit Level Gateway

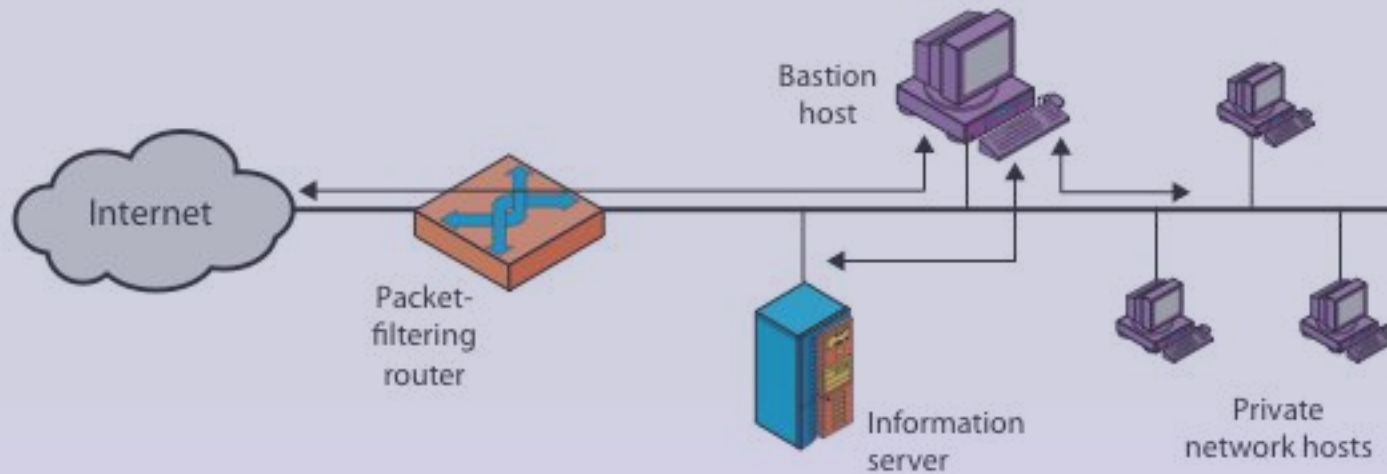


(c) Circuit-level gateway

# Bastion Host

- ❑ highly secure host system
- ❑ runs circuit / application level gateways
- ❑ or provides externally accessible services
- ❑ potentially exposed to "hostile" elements
- ❑ hence is secured to withstand this
  - hardened O/S, essential services, extra auth
  - proxies small, secure, independent, non-privileged
- ❑ may support 2 or more net connections
- ❑ may be trusted to enforce policy of trusted separation between these net connections

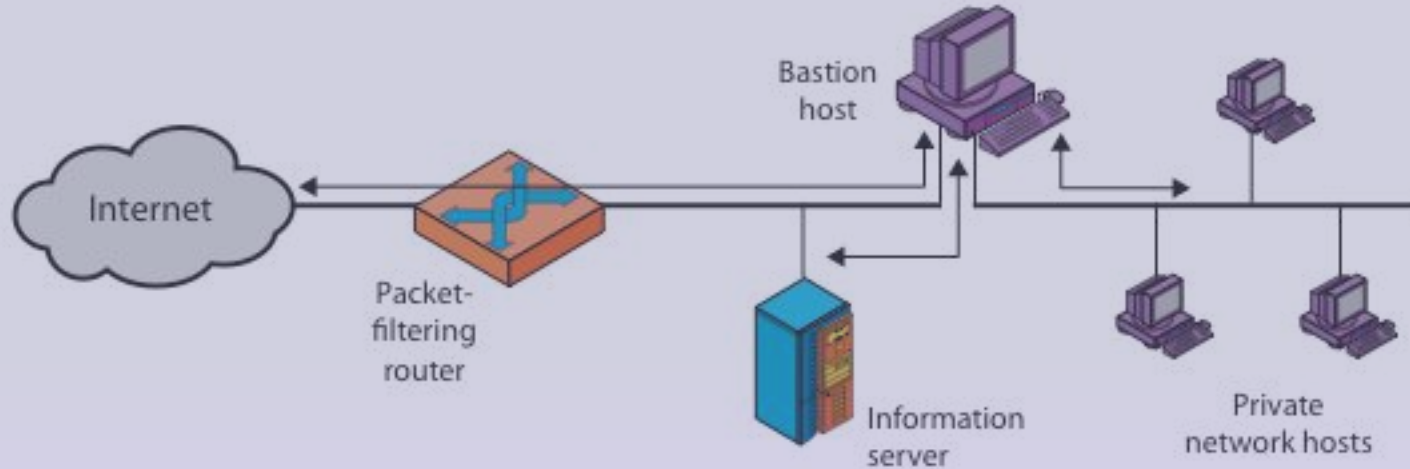
# Firewall Configurations



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

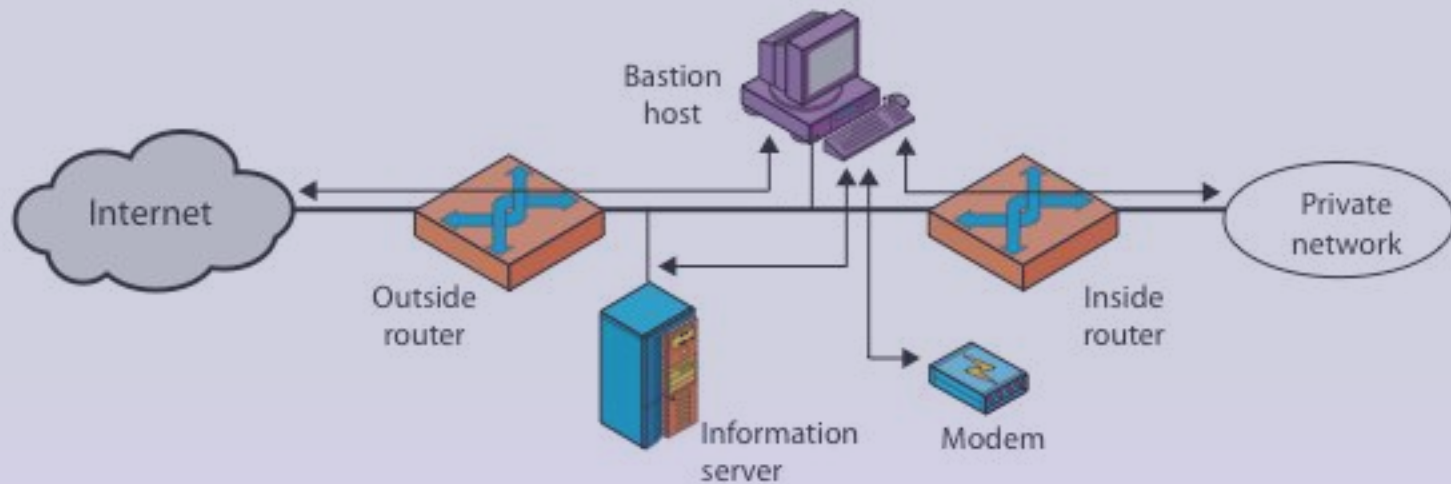


# Firewall Configurations



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

# Firewall Configurations



(c) Screened-subnet firewall system

# Access Control

- given system has identified a user
- determine what resources they can access
- general model is that of access matrix with
  - **subject** - active entity (user, process)
  - **object** - passive entity (file or resource)
  - **access right** – way object can be accessed
- can decompose by
  - columns as access control lists
  - rows as capability tickets

# Access Control Matrix

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

(a) Access matrix

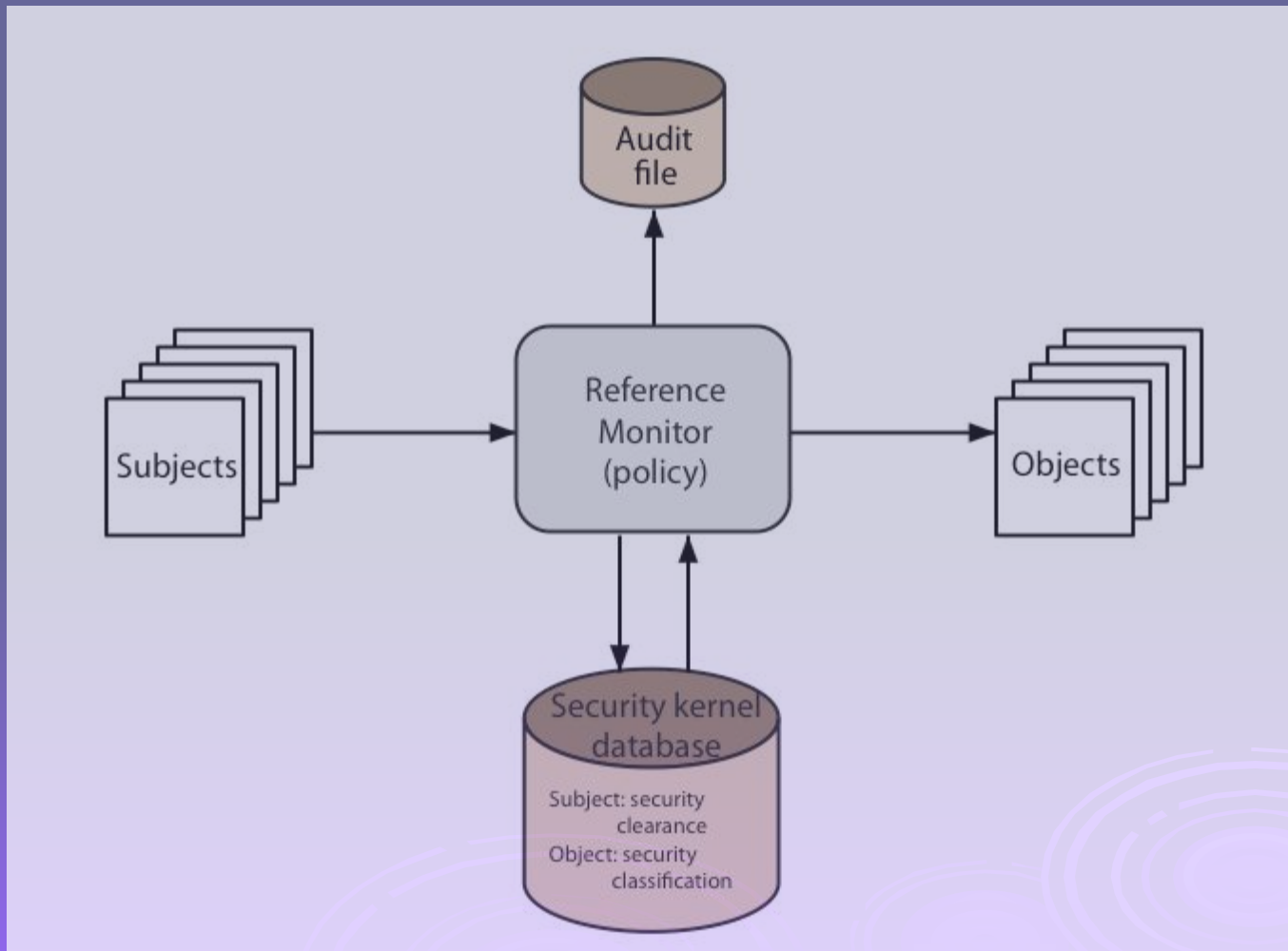
# Trusted Computer Systems

- ❑ information security is increasingly important
- ❑ have varying degrees of sensitivity of information
  - cf military info classifications: confidential, secret etc
- ❑ subjects (people or programs) have varying rights of access to objects (information)
- ❑ known as multilevel security
  - subjects have **maximum** & **current** security level
  - objects have a fixed security level **classification**
- ❑ want to consider ways of increasing confidence in systems to enforce these rights

# Bell LaPadula (BLP) Model

- one of the most famous security models
- implemented as mandatory policies on system
- has two key policies:
- **no read up** (simple security property)
  - a subject can only read/write an object if the current security level of the subject dominates ( $\geq$ ) the classification of the object
- **no write down** (\*-property)
  - a subject can only append/write to an object if the current security level of the subject is dominated by ( $\leq$ ) the classification of the object

# Reference Monitor



# Evaluated Computer Systems

- governments can evaluate IT systems
- against a range of standards:
  - TCSEC, IPSEC and now Common Criteria
- define a number of “levels” of evaluation with increasingly stringent checking
- have published lists of evaluated products
  - though aimed at government/defense use
  - can be useful in industry also



# Common Criteria

- ❑ international initiative specifying security requirements & defining evaluation criteria
- ❑ incorporates earlier standards
  - eg CSEC, ITSEC, CTCPEC (Canadian), Federal (US)
- ❑ specifies standards for
  - evaluation criteria
  - methodology for application of criteria
  - administrative procedures for evaluation, certification and accreditation schemes

# Common Criteria

- defines set of security requirements
- have a Target Of Evaluation (TOE)
- requirements fall in two categories
  - functional
  - assurance
- both organised in classes of families & components



# Common Criteria Requirements

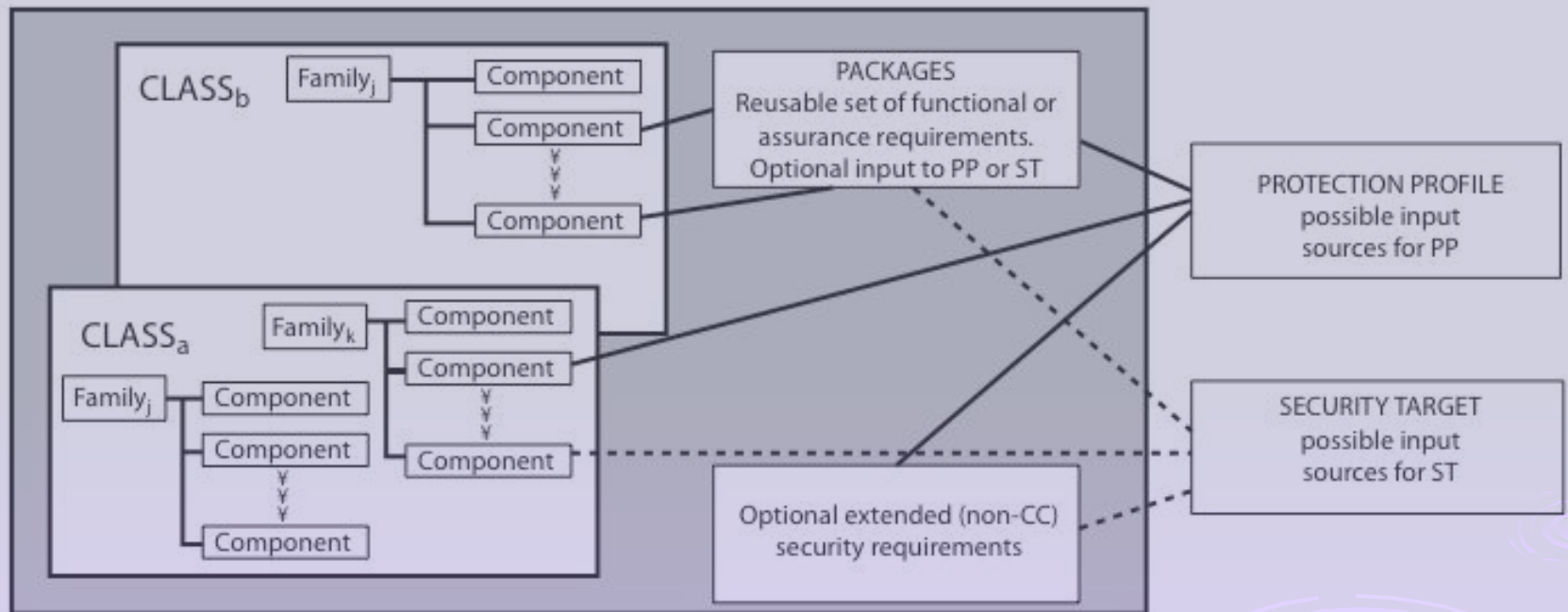
## □ Functional Requirements

- security audit, crypto support, communications, user data protection, identification & authentication, security management, privacy, protection of trusted security functions, resource utilization, TOE access, trusted path

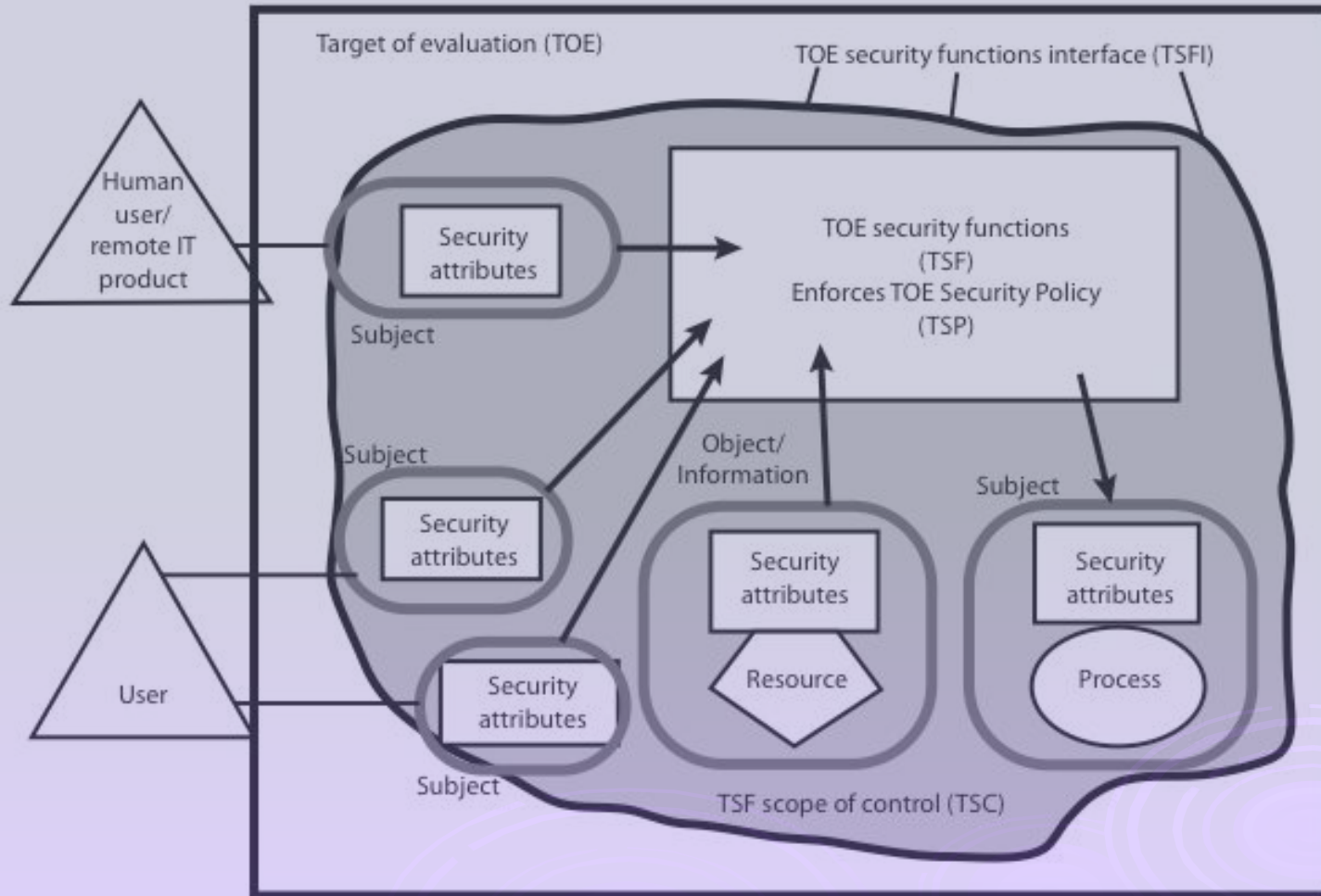
## □ Assurance Requirements

- configuration management, delivery & operation, development, guidance documents, life cycle support, tests, vulnerability assessment, assurance maintenance

# Common Criteria



# Common Criteria



# Summary

- have considered:
  - firewalls
  - types of firewalls
  - configurations
  - access control
  - trusted systems
  - common criteria

