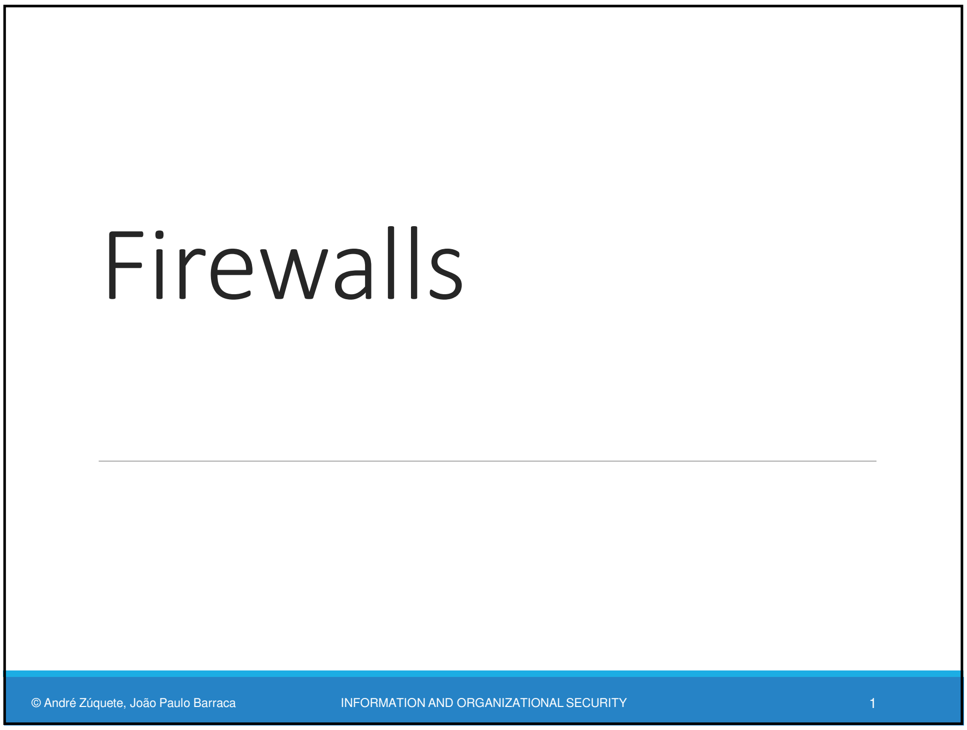
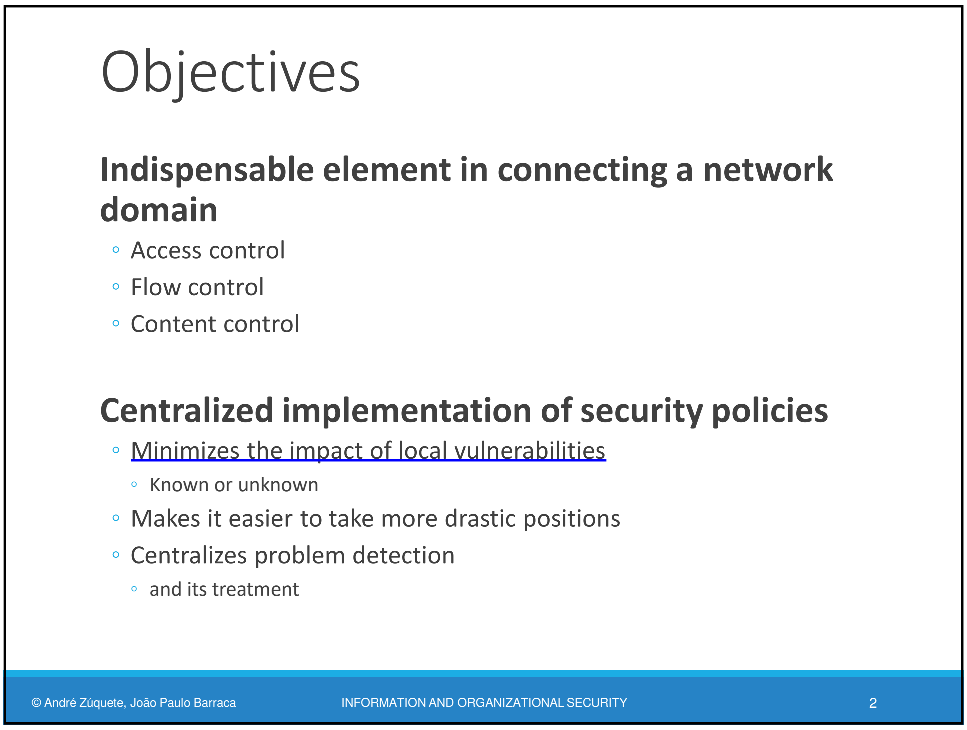


Firewalls



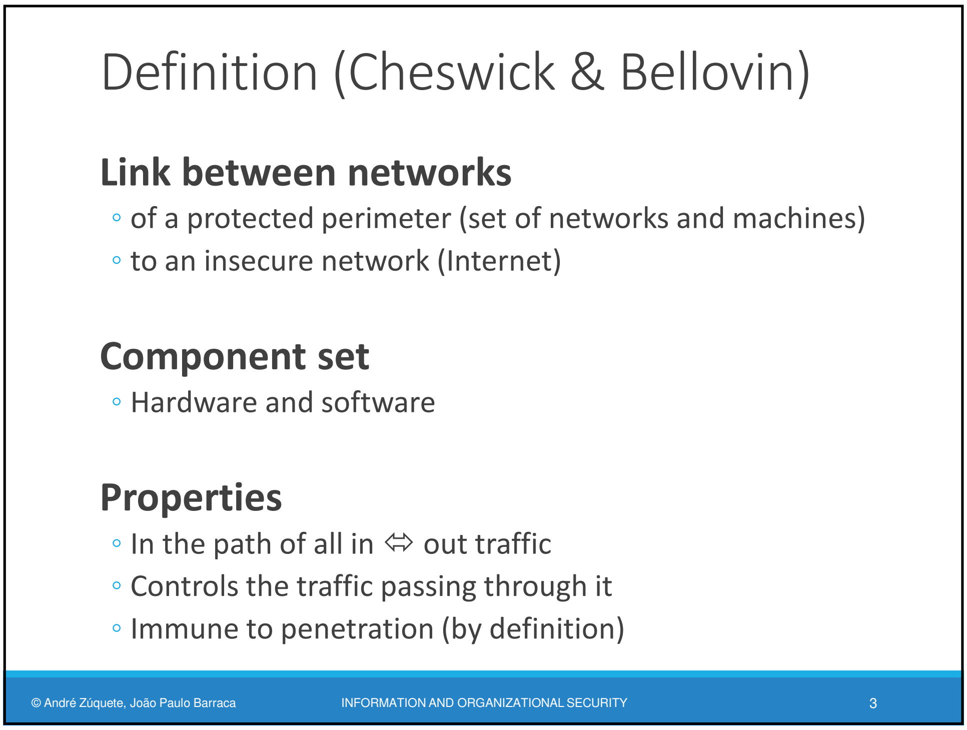
Objectives

Indispensable element in connecting a network domain

- Access control
- Flow control
- Content control

Centralized implementation of security policies

- Minimizes the impact of local vulnerabilities
  - Known or unknown
- Makes it easier to take more drastic positions
- Centralizes problem detection
  - and its treatment



Definition (Cheswick & Bellovin)

Link between networks

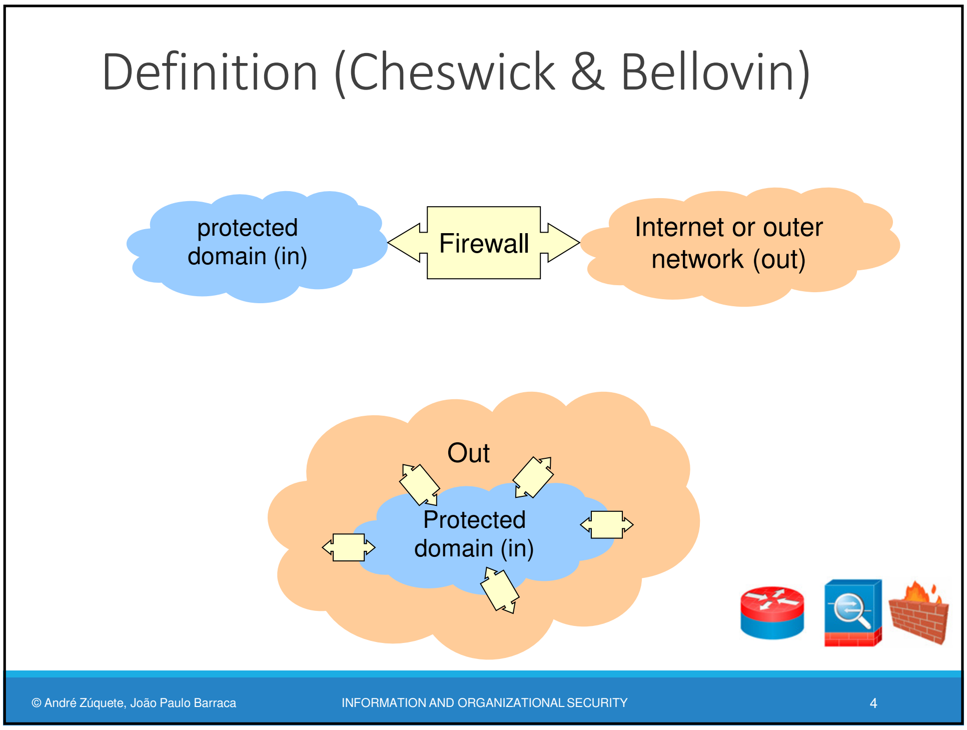
- of a protected perimeter (set of networks and machines)
- to an insecure network (Internet)

Component set

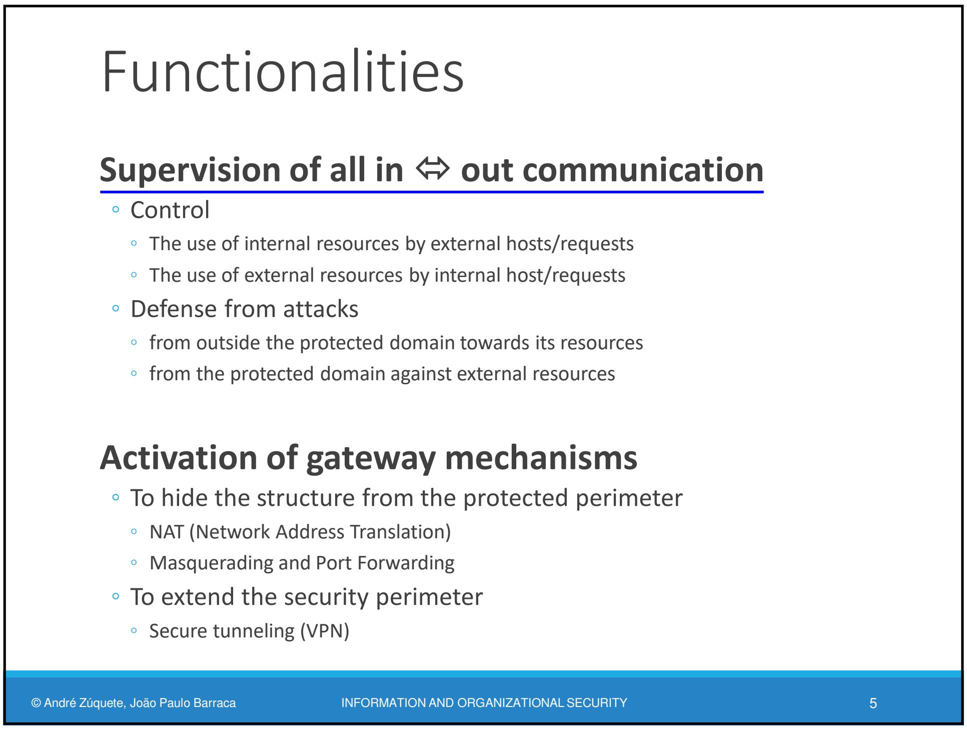
- Hardware and software

Properties

- In the path of all in ⇔ out traffic
- Controls the traffic passing through it
- Immune to penetration (by definition)



Definition (Cheswick & Bellovin)



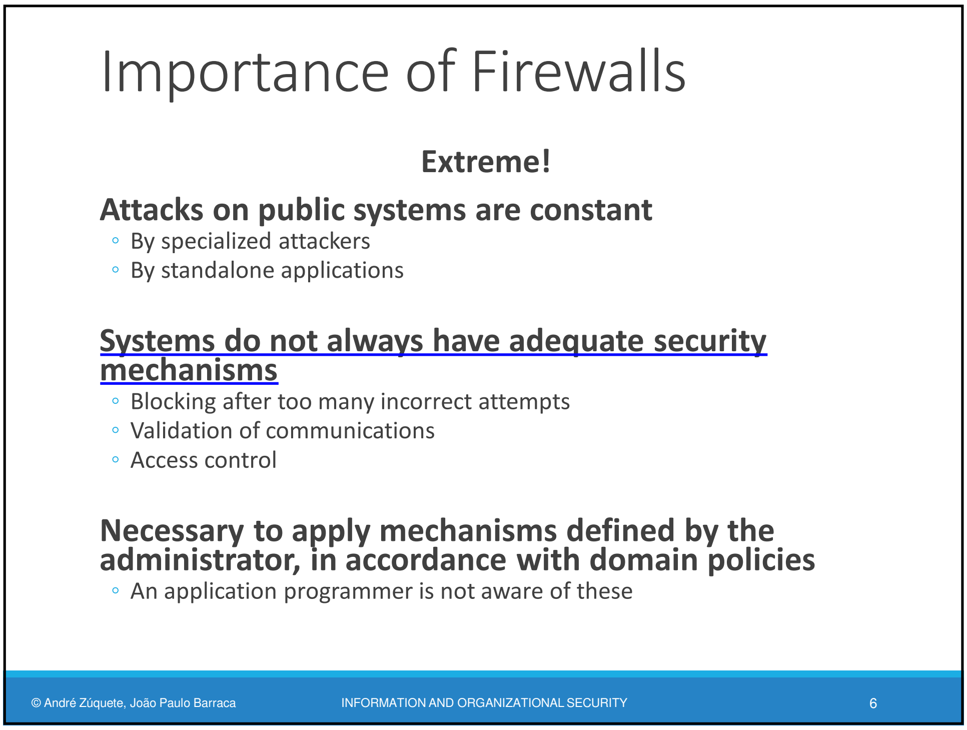
Functionalities

Supervision of all in ⇔ out communication

- Control
  - The use of internal resources by external hosts/requests
  - The use of external resources by internal host/requests
- Defense from attacks
  - from outside the protected domain towards its resources
  - from the protected domain against external resources

Activation of gateway mechanisms

- To hide the structure from the protected perimeter
  - NAT (Network Address Translation)
  - Masquerading and Port Forwarding
- To extend the security perimeter
  - Secure tunneling (VPN)



Importance of Firewalls

Extreme!

Attacks on public systems are constant

- By specialized attackers
- By standalone applications

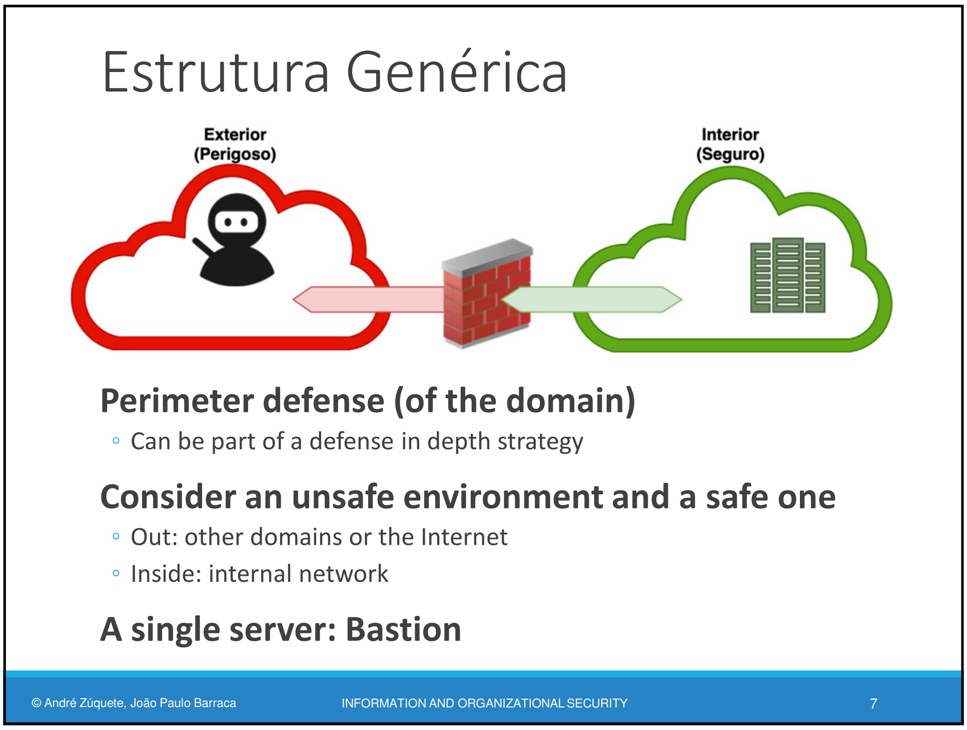
Systems do not always have adequate security mechanisms

- Blocking after too many incorrect attempts
- Validation of communications
- Access control

Necessary to apply mechanisms defined by the administrator, in accordance with domain policies

- An application programmer is not aware of these

Firewalls servem como



Estrutura Genérica

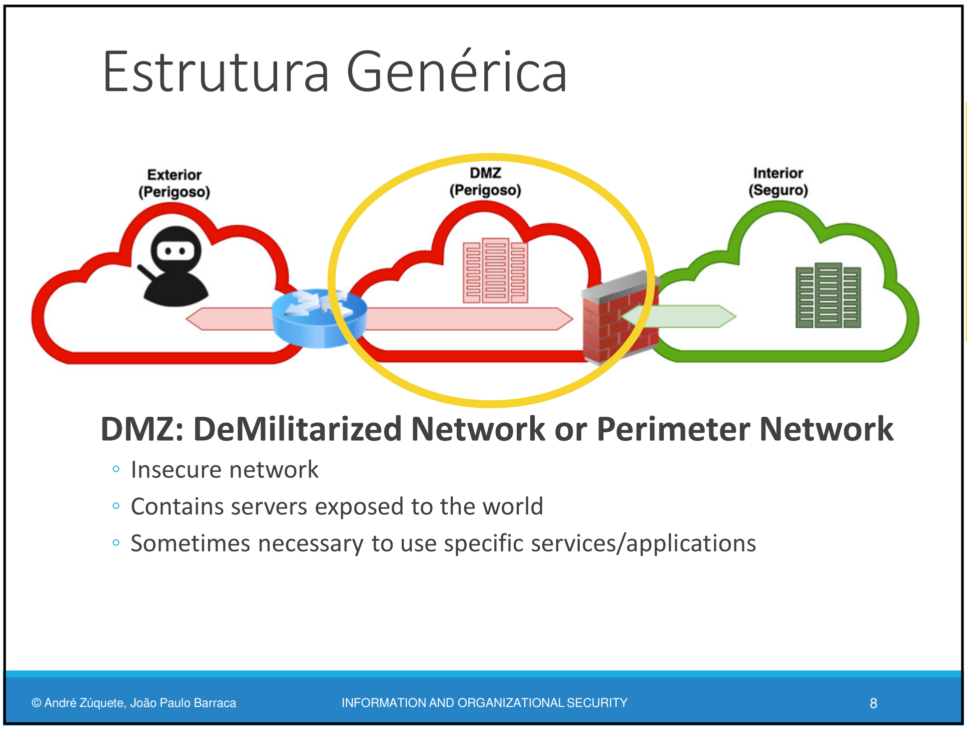
Perimeter defense (of the domain)

- Can be part of a defense in depth strategy

Consider an unsafe environment and a safe one

- Out: other domains or the Internet
- Inside: internal network

A single server: Bastion



Estrutura Genérica

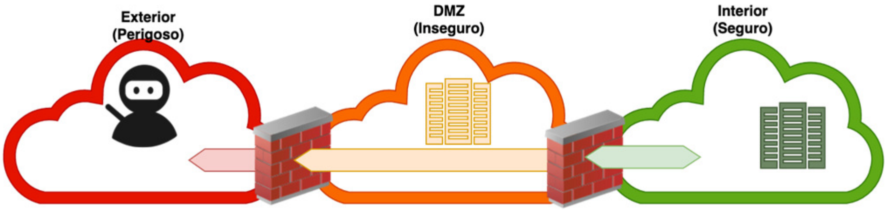
DMZ: DeMilitarized Network or Perimeter Network

- Insecure network
- Contains servers exposed to the world
- Sometimes necessary to use specific services/applications

É uma rede configurada de forma a permitir que alguns serviços sejam acessados a partir da Internet, enquanto mantém outros serviços e recursos protegidos na rede interna.

Fornecee uma camada adicional de proteção contra ameaças externas, como ataques cibernéticos. Isso é feito, em parte, por meio da implementação de firewalls

Estrutura Genérica



DMZ may have some protection

- System of two Firewalls with different rules

External firewall: quite permissive

- Control access to all networks

Internal firewall: more restricted

- Control access to the internal network

Types: packet filters

Reject unauthorized interactions based on the content of IP datagrams

- IP addresses (source and/or destination)
- IP/transport header options
- Transport protocols and ports (origin and/or destination)
- Directions for creating virtual circuits
- Data sent via transport protocol
- Datagram size

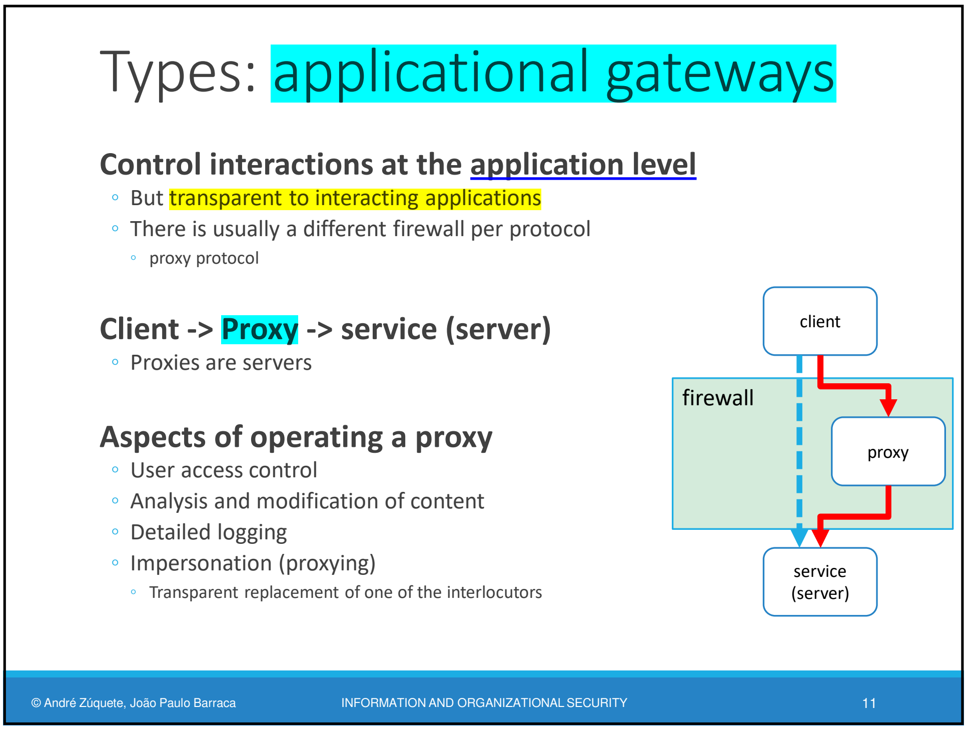
Can analyze flow behavior

- Example: detect port scans (with nmap)

Typically supported by core OS components

- Example: iptables, ipfw, pf

Proxies podem controlar o acesso dos usuários, analisar e modificar o conteúdo das comunicações, manter registros detalhados e até mesmo se fazer passar por um dos interlocutores.



Types: applicational gateways

Control interactions at the application level

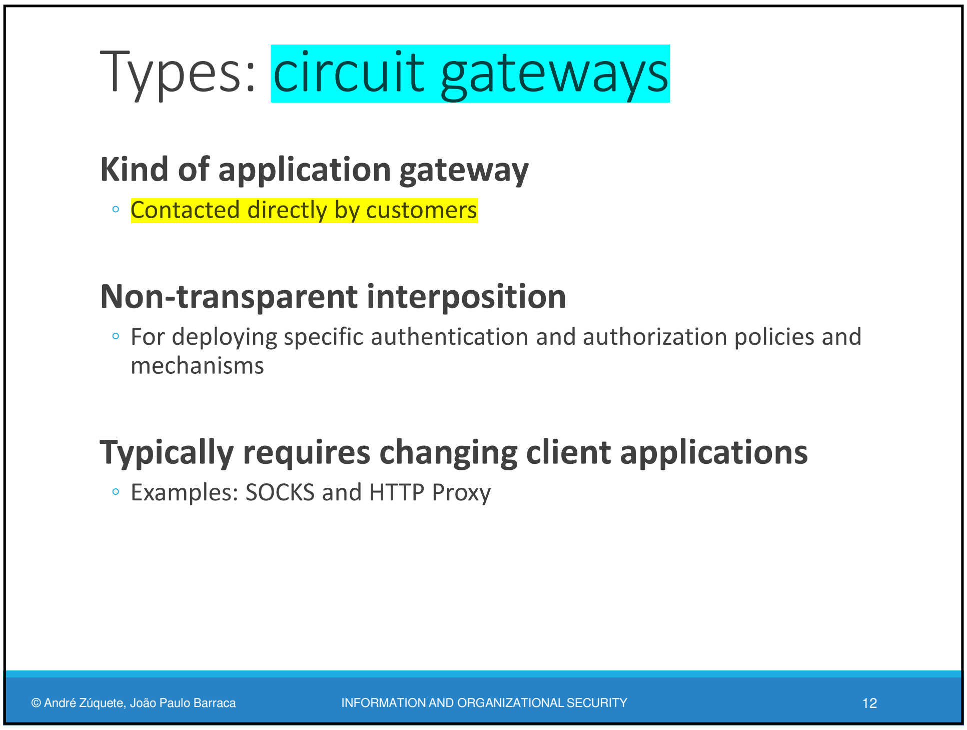
- But transparent to interacting applications
- There is usually a different firewall per protocol
  - proxy protocol

Client -> Proxy -> service (server)

- Proxies are servers

Aspects of operating a proxy

- User access control
- Analysis and modification of content
- Detailed logging
- Impersonation (proxying)
  - Transparent replacement of one of the interlocutors



Types: circuit gateways

Kind of application gateway

- Contacted directly by customers

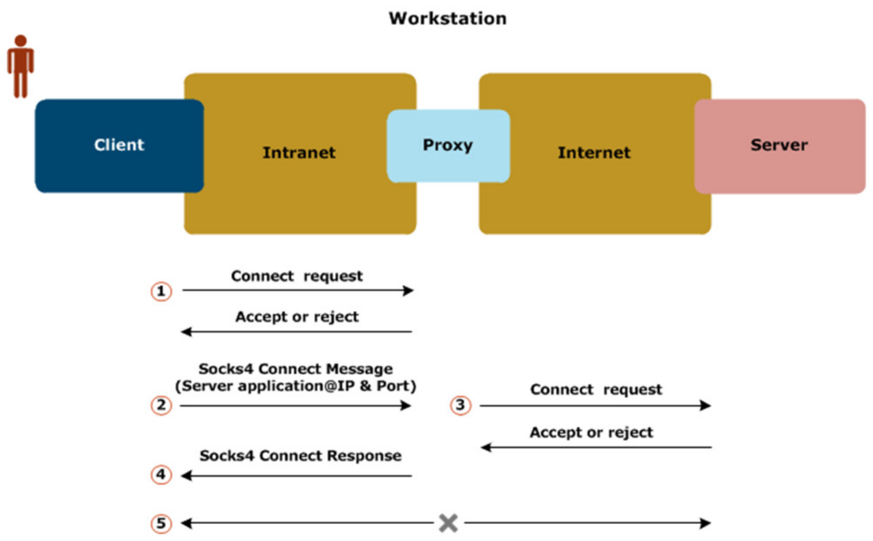
Non-transparent interposition

- For deploying specific authentication and authorization policies and mechanisms

Typically requires changing client applications

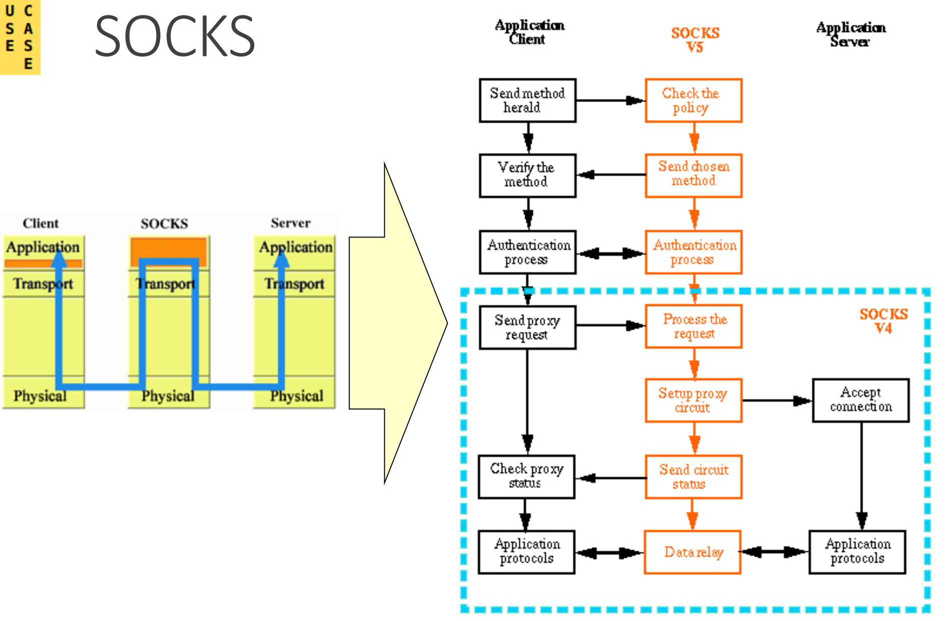
- Examples: SOCKS and HTTP Proxy

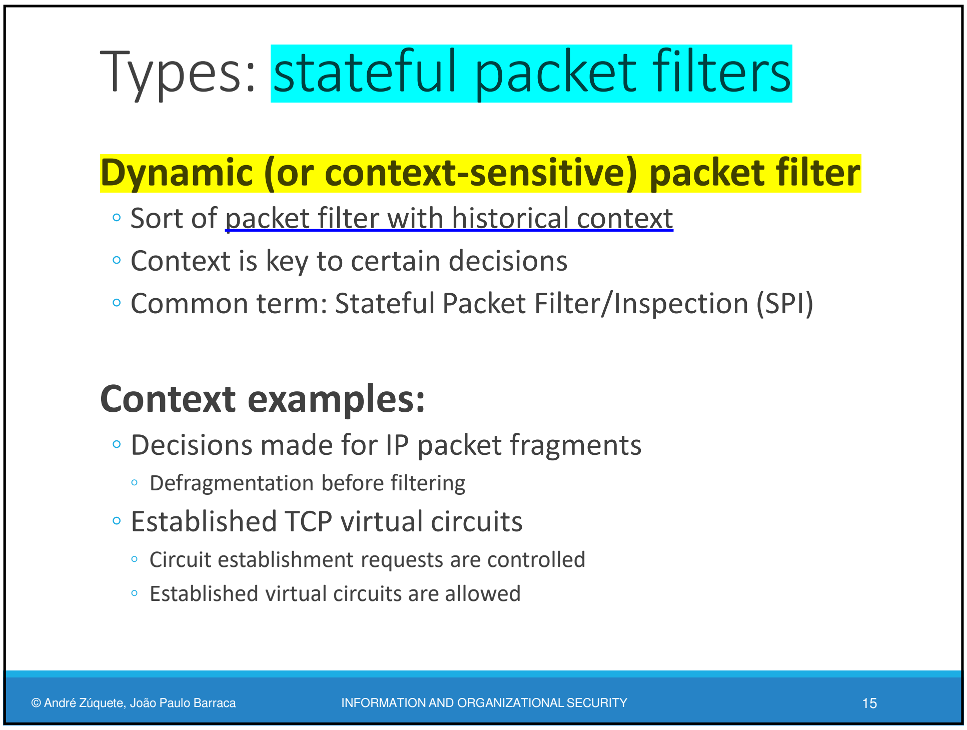
Types: SOCKS4 circuit gateways



USE CASE

SOCKS





Types: stateful packet filters

Dynamic (or context-sensitive) packet filter

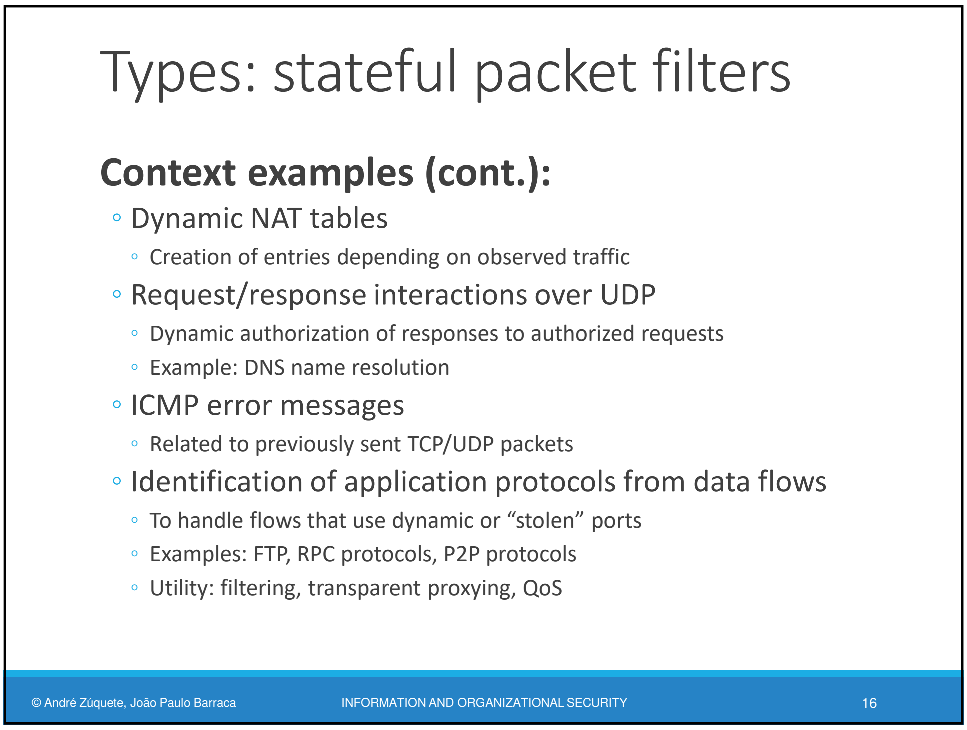
- Sort of packet filter with historical context
- Context is key to certain decisions
- Common term: Stateful Packet Filter/Inspection (SPI)

Context examples:

- Decisions made for IP packet fragments
  - Defragmentation before filtering
- Established TCP virtual circuits
  - Circuit establishment requests are controlled
  - Established virtual circuits are allowed

São um tipo de firewall que vai além da filtragem simples de pacotes de rede.

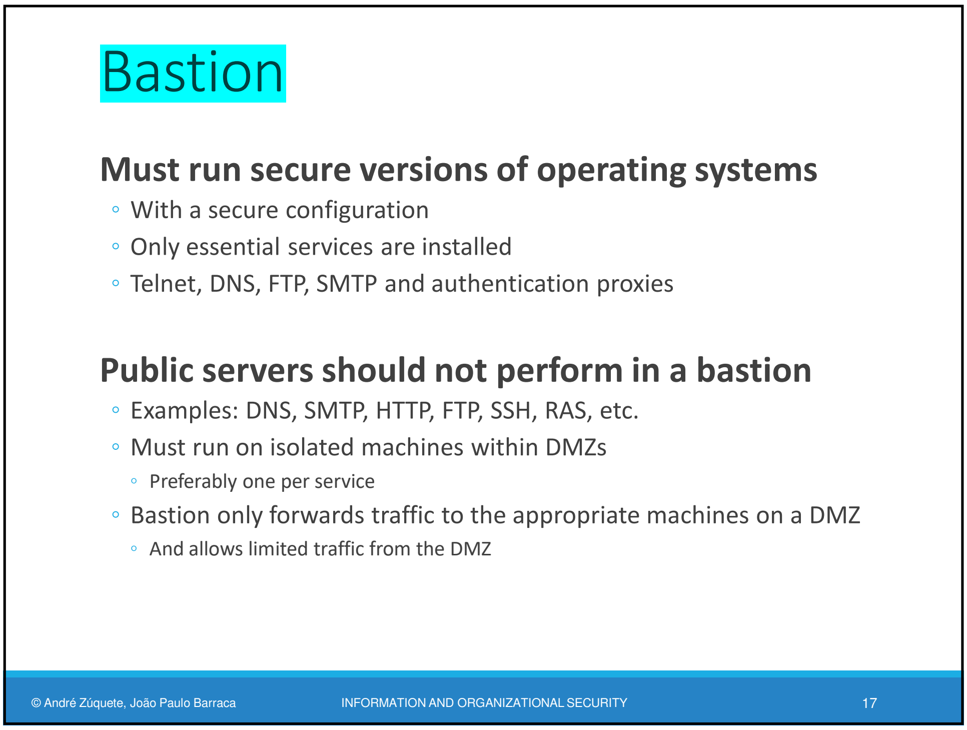
Eles são capazes de tomar decisões com base em informações contextuais e históricas sobre o tráfego de rede.



Types: stateful packet filters

Context examples (cont.):

- Dynamic NAT tables
  - Creation of entries depending on observed traffic
- Request/response interactions over UDP
  - Dynamic authorization of responses to authorized requests
  - Example: DNS name resolution
- ICMP error messages
  - Related to previously sent TCP/UDP packets
- Identification of application protocols from data flows
  - To handle flows that use dynamic or “stolen” ports
  - Examples: FTP, RPC protocols, P2P protocols
  - Utility: filtering, transparent proxying, QoS



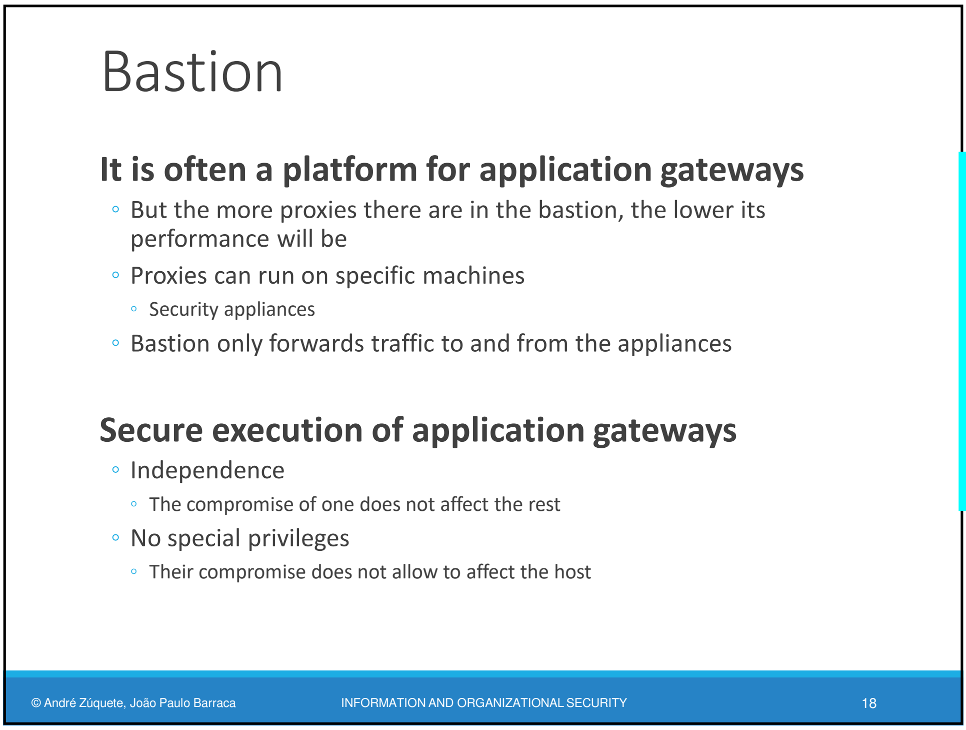
Bastion

Must run secure versions of operating systems

- With a secure configuration
- Only essential services are installed
- Telnet, DNS, FTP, SMTP and authentication proxies

Public servers should not perform in a bastion

- Examples: DNS, SMTP, HTTP, FTP, SSH, RAS, etc.
- Must run on isolated machines within DMZs
  - Preferably one per service
- Bastion only forwards traffic to the appropriate machines on a DMZ
  - And allows limited traffic from the DMZ



Bastion

It is often a platform for application gateways

- But the more proxies there are in the bastion, the lower its performance will be
- Proxies can run on specific machines
  - Security appliances
- Bastion only forwards traffic to and from the appliances

Secure execution of application gateways

- Independence
  - The compromise of one does not affect the rest
- No special privileges
  - Their compromise does not allow to affect the host

Servindo como pontos de entrada seguros e protegendo a rede interna contra ameaças externas.

Eles são executados em sistemas operativos seguros e são cuidadosamente configurados para garantir que apenas o tráfego autorizado passe por eles.

Além disso, eles podem atuar como plataformas para aplicação de gateways, desde que se mantenha um equilíbrio entre segurança e desempenho.

Topology: Dual-homed (w/ or w/o DMZ)

DeMilitarized Network

Architecture

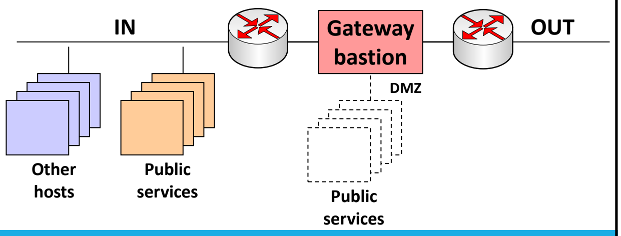
- A single machine
- Gateway bastion
- A pair of additional routers
  - To isolate the bastion of direct addressing
- Internal and public servers

Problems

- Bastion compromise disables firewall
- The firewall processing load is all on the bastion
- Public services are within the protected network

Benefits

- Simplicity
- Resource savings



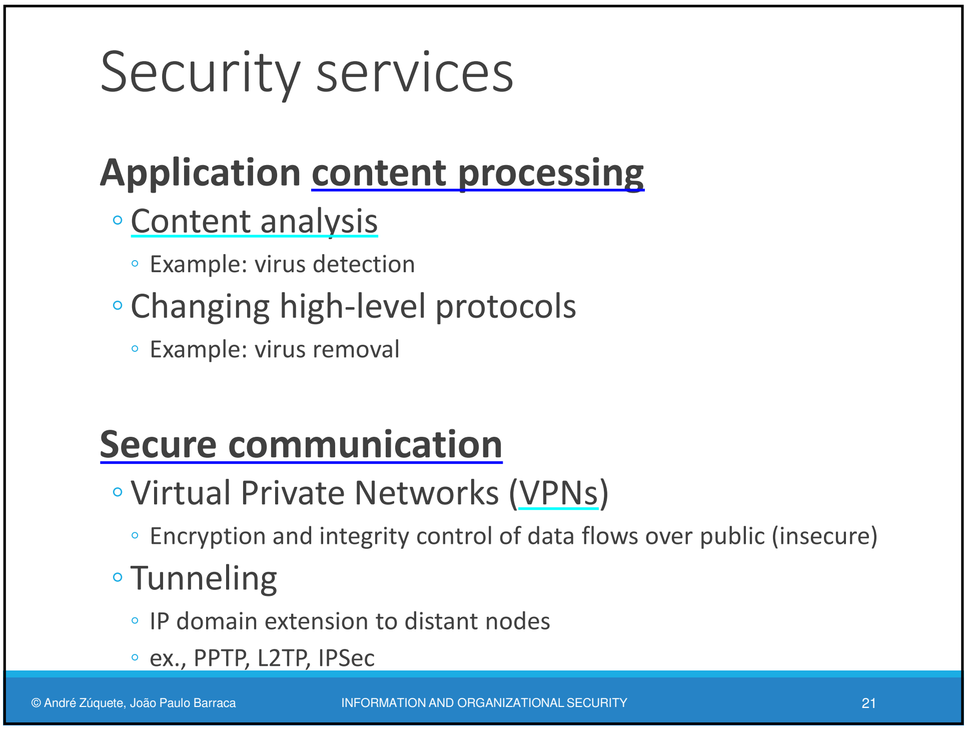
Security services

Authorization

- From data streams (packet filters)
  - Transport or network level
- Users (application gateways / circuits)

Traffic Redirection

- For dedicated hosts
  - Local services (e.g., mail, www, ftp, etc.)
  - Proxies in security appliances
- Proxying
  - Explicit (e.g., circuit gateways)
  - Transparent (e.g., NAT address translations)



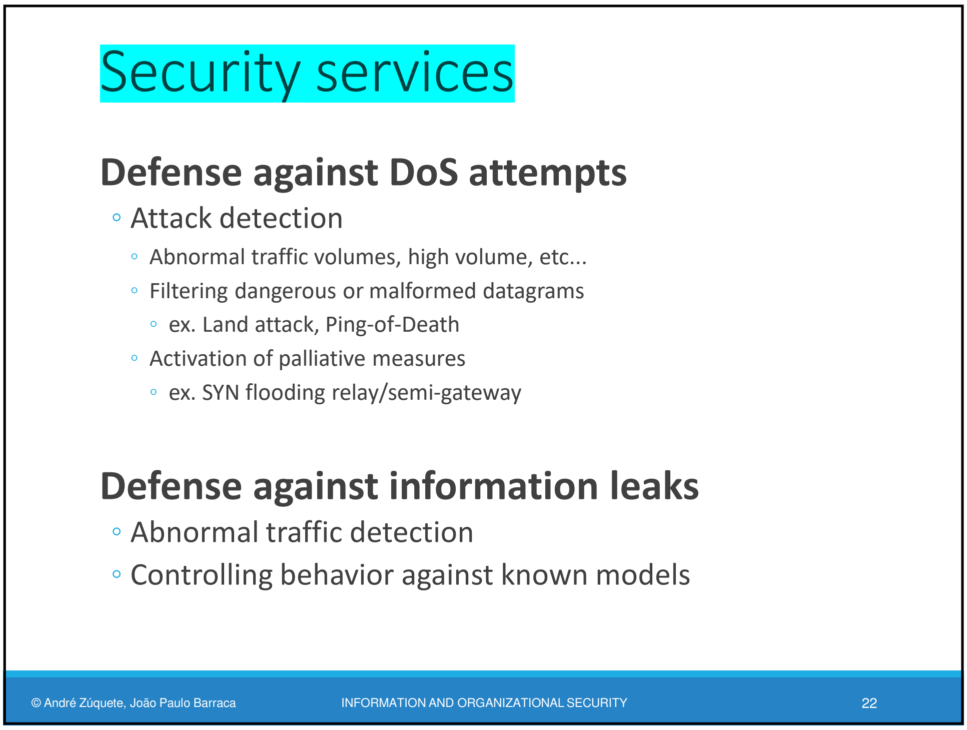
Security services

Application content processing

- Content analysis
  - Example: virus detection
- Changing high-level protocols
  - Example: virus removal

Secure communication

- Virtual Private Networks (VPNs)
  - Encryption and integrity control of data flows over public (insecure)
- Tunneling
  - IP domain extension to distant nodes
  - ex., PPTP, L2TP, IPSec



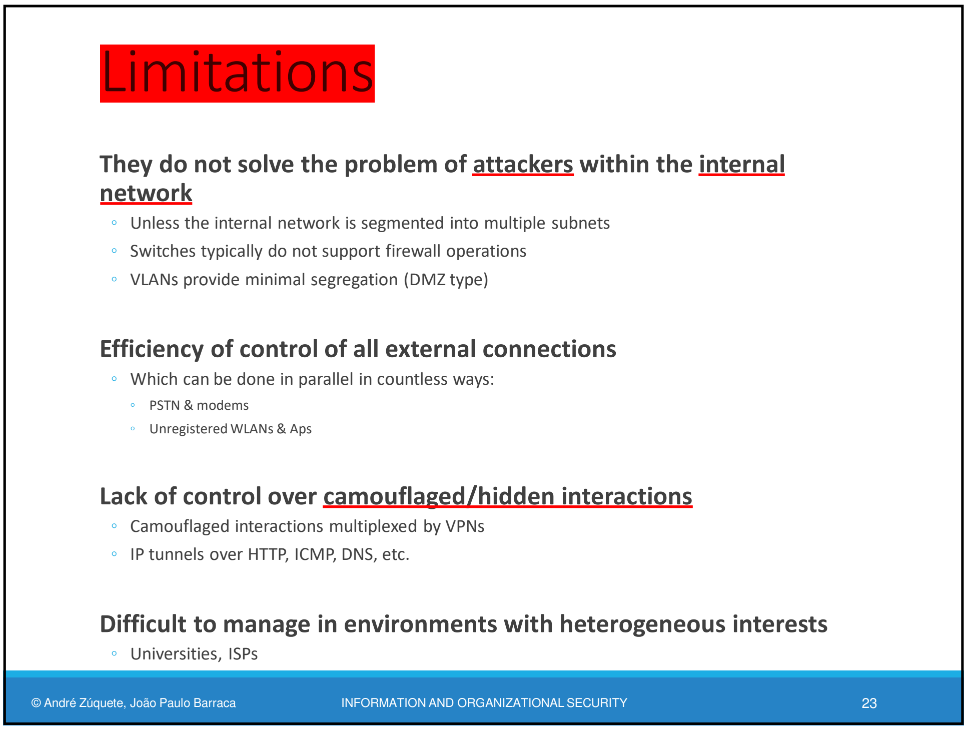
Security services

Defense against DoS attempts

- Attack detection
  - Abnormal traffic volumes, high volume, etc...
  - Filtering dangerous or malformed datagrams
    - ex. Land attack, Ping-of-Death
  - Activation of palliative measures
    - ex. SYN flooding relay/semi-gateway

Defense against information leaks

- Abnormal traffic detection
- Controlling behavior against known models



Limitations

They do not solve the problem of attackers within the internal network

- Unless the internal network is segmented into multiple subnets
- Switches typically do not support firewall operations
- VLANs provide minimal segregation (DMZ type)

Efficiency of control of all external connections

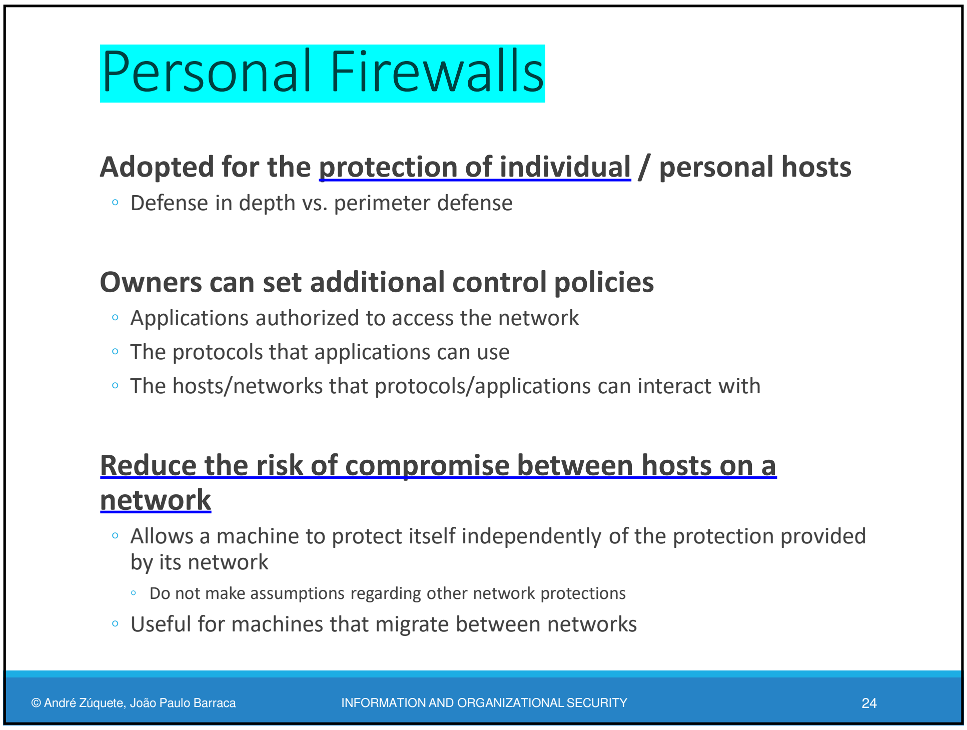
- Which can be done in parallel in countless ways:
  - PSTN & modems
  - Unregistered WLANs & Aps

Lack of control over camouflaged/hidden interactions

- Camouflaged interactions multiplexed by VPNs
- IP tunnels over HTTP, ICMP, DNS, etc.

Difficult to manage in environments with heterogeneous interests

- Universities, ISPs



Personal Firewalls

Adopted for the protection of individual / personal hosts

- Defense in depth vs. perimeter defense

Owners can set additional control policies

- Applications authorized to access the network
- The protocols that applications can use
- The hosts/networks that protocols/applications can interact with

Reduce the risk of compromise between hosts on a network

- Allows a machine to protect itself independently of the protection provided by its network
  - Do not make assumptions regarding other network protections
- Useful for machines that migrate between networks

Personal firewalls: issues

Normal users are not network security experts

- They don't normally understand how IP networks work
  - IP addresses, transport ports, transport protocols, etc.
- They do not know how to assess whether a given interaction is normal, acceptable, etc.
- They don't know the basic security policies they should apply

Blocking suspicious interactions may nullify functionality

- Network communication is currently commonplace
- Applications do not inform users of their communication needs

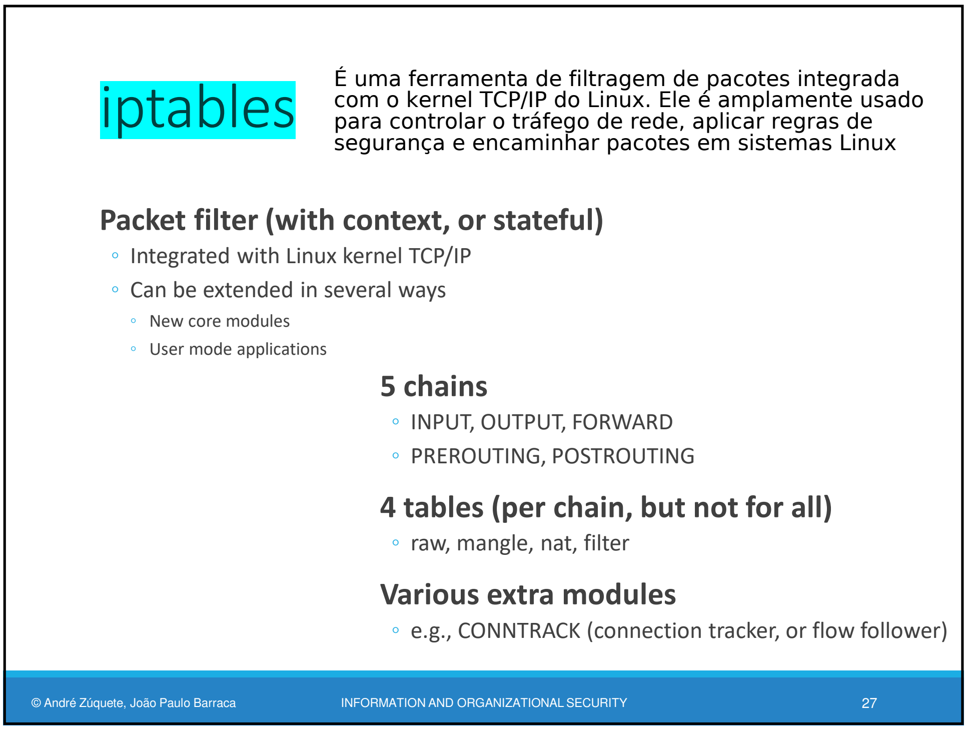
Personal firewalls: issues

Operational complexity

- Different operating environments → different policies
- Different network interfaces → different policies

The combination of operational scenarios, network interfaces and acceptable interactions for each case leads to a huge number of rules

- Confusion, incoherence → difficult to detect vulnerabilities



iptables

É uma ferramenta de filtragem de pacotes integrada com o kernel TCP/IP do Linux. Ele é amplamente usado para controlar o tráfego de rede, aplicar regras de segurança e encaminhar pacotes em sistemas Linux

Packet filter (with context, or stateful)

- Integrated with Linux kernel TCP/IP
- Can be extended in several ways
  - New core modules
  - User mode applications

5 chains

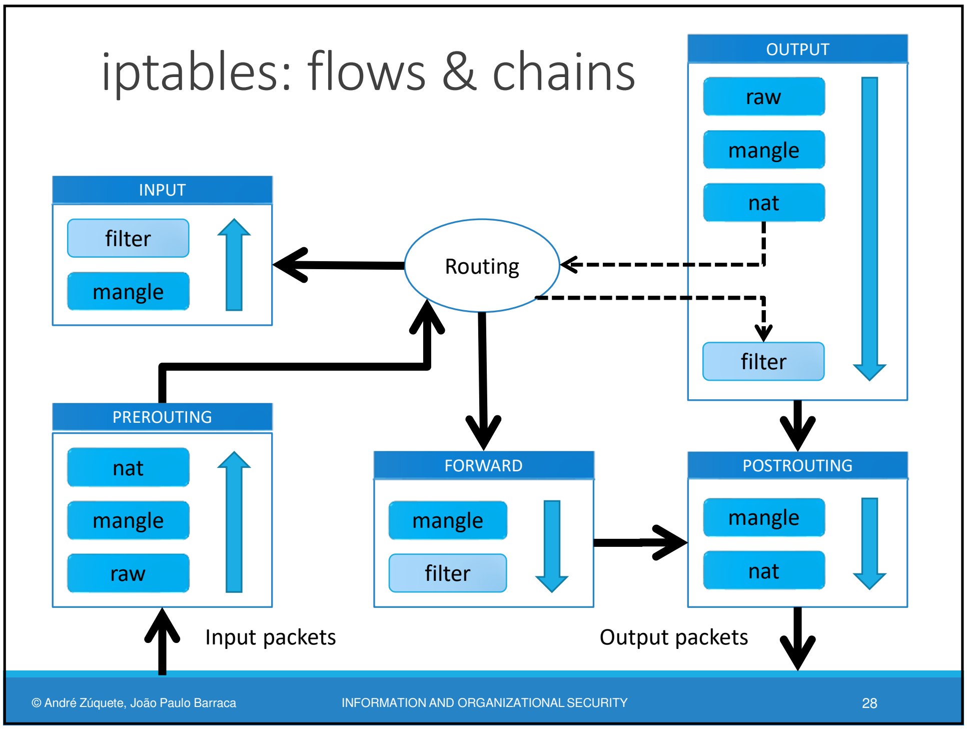
- INPUT, OUTPUT, FORWARD
- PREROUTING, POSTROUTING

4 tables (per chain, but not for all)

- raw, mangle, nat, filter

Various extra modules

- e.g., CONNTRACK (connection tracker, or flow follower)



iptables: flows & chains

OUTPUT: raw, mangle, nat, filter

INPUT: filter, mangle

Routing

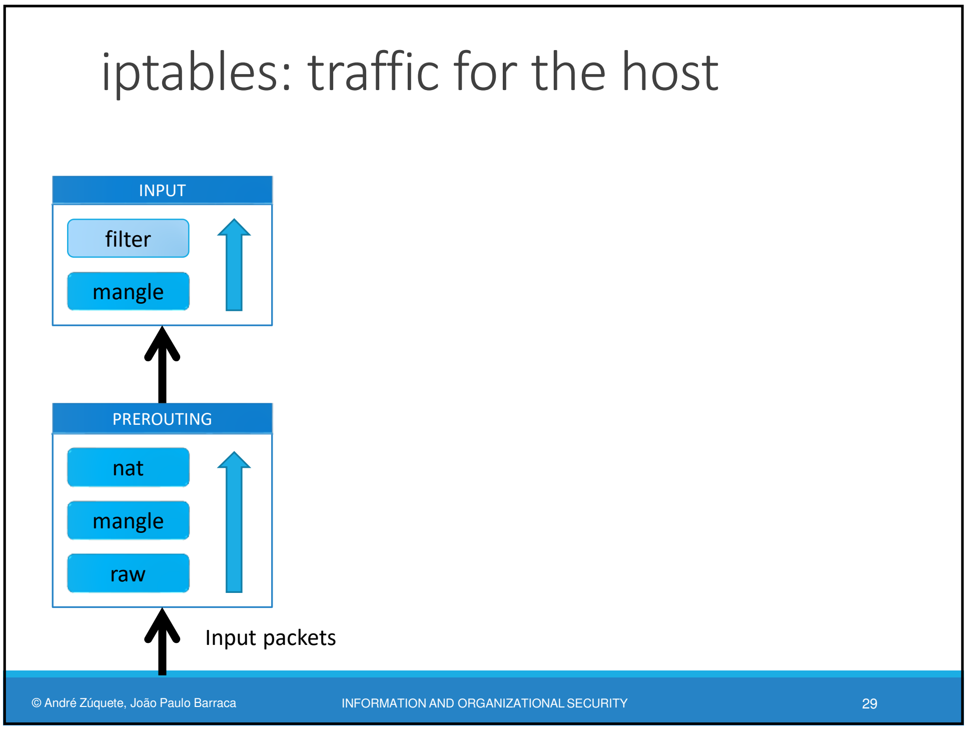
PREROUTING: nat, mangle, raw

FORWARD: mangle, filter

POSTROUTING: mangle, nat

Input packets

Output packets



iptables: traffic for the host

INPUT

filter

mangle

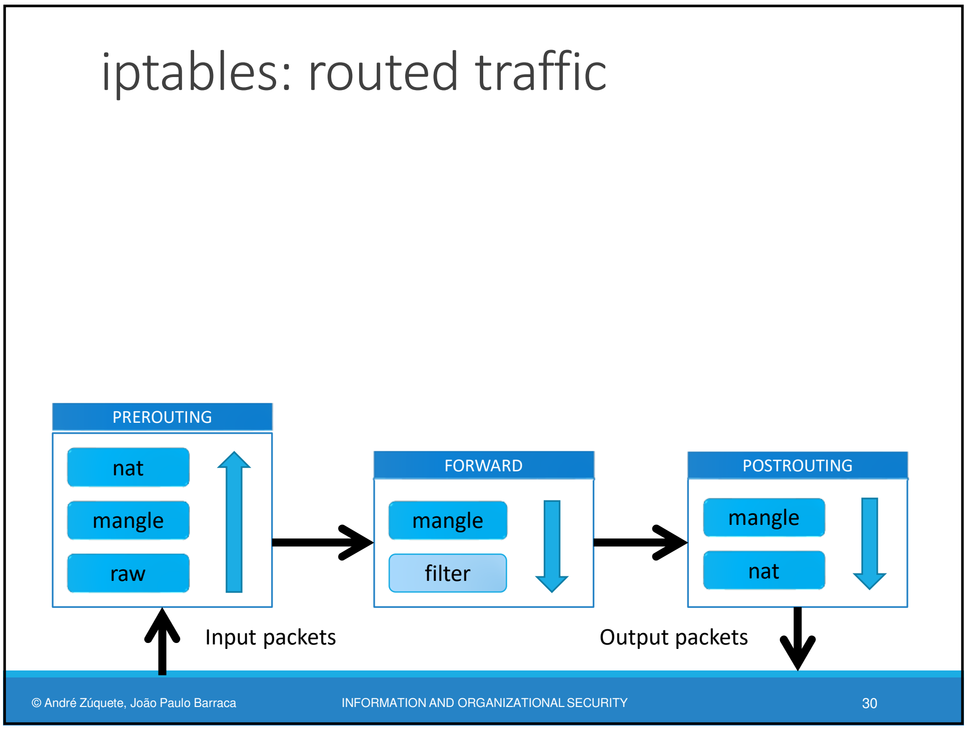
PREROUTING

nat

mangle

raw

Input packets



iptables: routed traffic

PREROUTING

nat

mangle

raw

FORWARD

mangle

filter

POSTROUTING

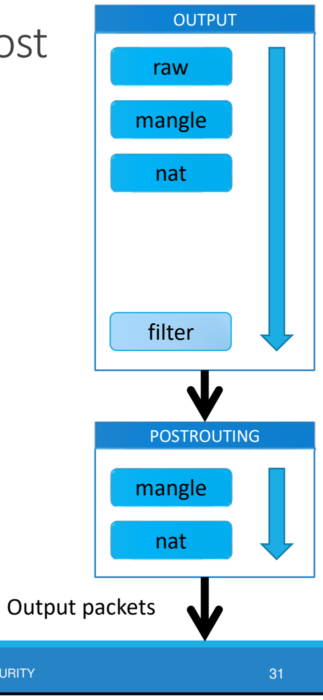
mangle

nat

Input packets

Output packets

iptables: traffic from the host



iptables: decisions

Basic decisions

- ACCEPT
  - Let the package continue
- DROP
  - Discard the package
- CONTINUES
  - Use decisions from other rules

Reusable Decisions

- New chains
- Jump to a new chain
  - The name of the chain is the decision
- RETURN
  - Leave the current chain

Other decisions

- LOG
- MARK
  - With internal label
  - Useful for making coherent decisions across different chains
- REJECT
  - Rejection with error message
- SNAT, MASQUERADE
  - Source NAT (masquerading)
- DNAT, REDIRECT
  - Destination NAT (port forwarding)
- Actions by applications
  - QUEUE

USE CASE

Iptables exploitation: fail2ban

Agent that observes records, comparing them with patterns

- Can prevent some DoS, brute force attacks (SSH), scans
- Reactive: Does not prevent the attack from starting
  - May not prevent attacks with few interactions
- Can be used with any service that creates records

Jail: a context composed of several rules

- Defines what to observe and what action to take
- Action: Implement a specific response
  - example: block communications on the firewall
  - Can use a local or remote firewall

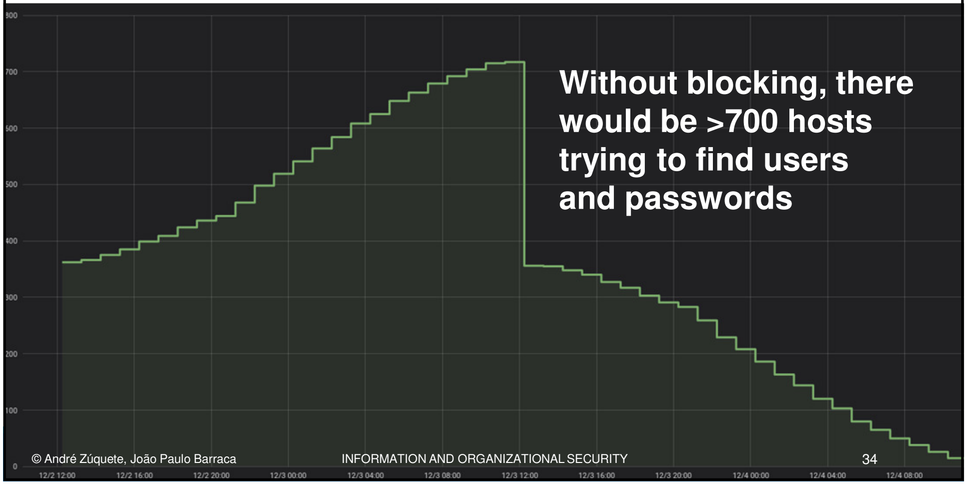
Filter: a set of regexps that signal anomalous behavior

- Composed of expressions to consider and ignore (white list)

USE CASE

Iptables exploitation: fail2ban

“Anonymous” server, without content
# of IPs blocked due to SSH access attempt



Without blocking, there would be >700 hosts trying to find users and passwords