BORDER SECURITY

LAW 371

Fall 2023

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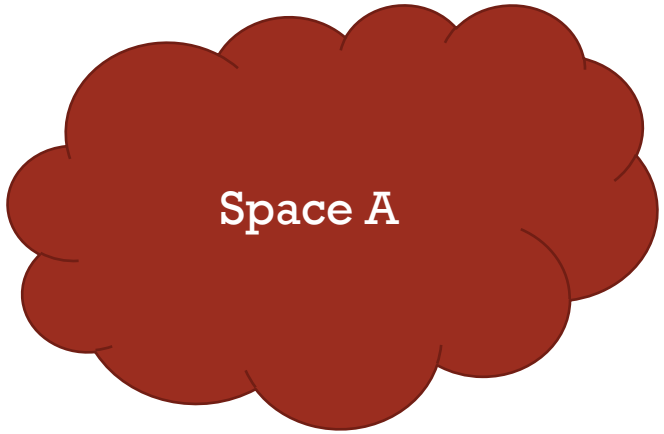
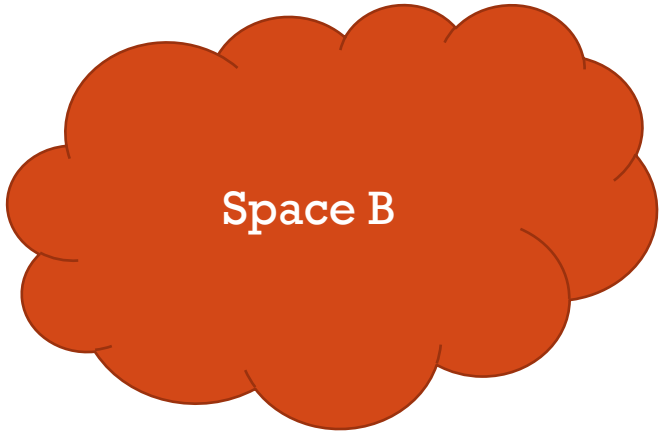
"SPACES"



"Space" is not a technical term.

I use it to represent the concept of separation



MACRO PHYSICAL SPACES

MICRO PHYSICAL SPACES

WHY DO WE SEPARATE PHYSICAL THINGS?

- ***CONTEXT***
- Countries have different
  - Social Models
  - Legal Frameworks
  - Rights and Responsibilities
- Binders, bins, and office "spaces"
  - Importance
  - Meaning

ACCESS

Most physical spaces try to control the flow
from one space to another

CYBER SPACES

- Often tied to a physical space and/or organization
  - All the people, equipment, data, etc. belonging to an entity
  - For example, a corporate network
- But there are far more conceptual spaces
  - Media piracy
  - Hacking communities
- Everything in-between

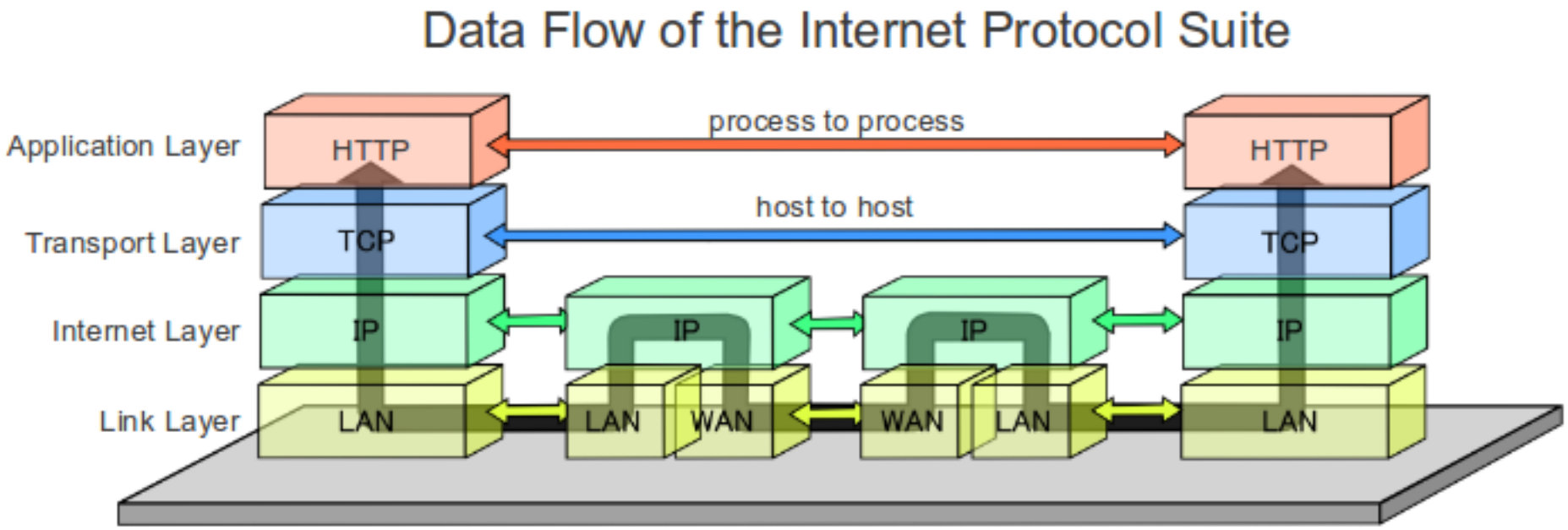
REVIEW: LOCAL AREA NETWORKS

- What is a LAN?
- Generally communicates ***WITHOUT ROUTING***
- This is why it is "local"

LAN'S AS NATURAL SPACES

- LAN's have *historically* created cyber spaces very naturally
- Typically tied to an entity, the LAN is
  - Hosted by the entity **in physical space**
  - Provides resources on behalf of the entity in cyber space
- Access controls are typically related to physical entity
  - Insiders have increased access to resources across the LAN
  - Outsiders have limited access to specific servers/resources

LAN'S CREATE "BORDERS" ON THE INTERNET

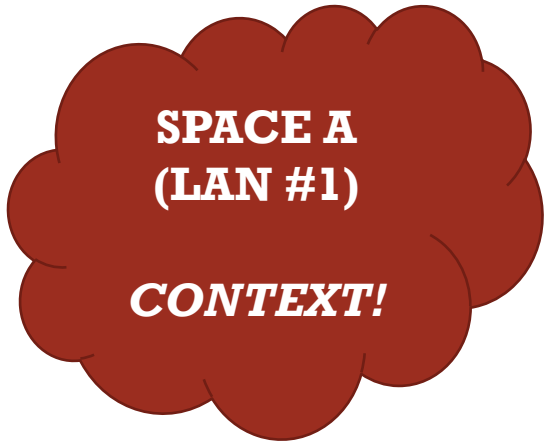


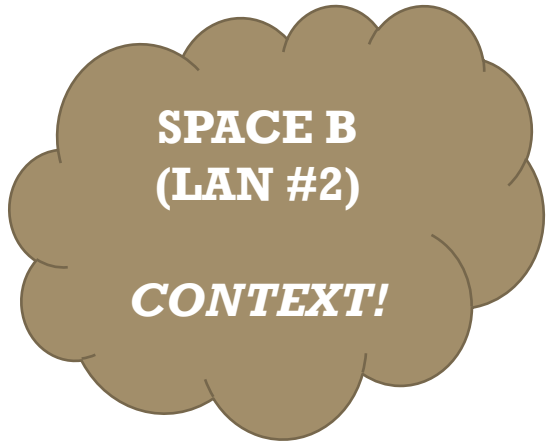
LAN #1 **ROUTER (Gateway)** **ROUTER (Gateway)** **LAN #2**

GATEWAYS: NATURAL BARRIERS

- Outside data can only get into a LAN via router
- We call the routers at the "edges" of a LAN ***gateways***
- Gateways are, therefore, ***natural chokepoints for data***

GATEWAYS: SPACE TRANSITION





CONTEXT IS EVERYTHING

- Security is all about ***context*** (REPEAT AFTER ME!)
- Security has no meaning without context
- What is secure in one context may not be in another
- Outside data is *assumed* to have a different context
- Reasonable and natural to examine data changing context

GATEWAYS: CONTEXT CHANGE

FIREWALL: GATEWAY SECURITY

- What is a “firewall”?
- Informally: any security-enforcement on data transit
- (most commonly at the gateway)

FIREWALL MARKETING

- **Juniper**: "control over applications, users, and content to stop advanced cyber-threats"
- **PAN**: "Instantly find and stop attacks with a fully automated platform"
- **Cisco**: "Prevent breaches, get deep visibility to detect and stop threats fast"

IGNORE MARKETING. THINK *ENGINEERING*

- Ross Anderson's framework from ***Security Engineering***
  - Policy: ***WHAT*** you're supposed to achieve
  - Mechanism: ***HOW*** you're supposed to achieve it
  - Assurance: ***RELIABILITY*** of the mechanism
  - Incentives: ***MOTIVES*** of defenders and attackers

CORE CONCEPTS: *POLICY AND MECHANISM*

- This is not a security engineering class
- But we will use it to help us frame how we look at security
- PAY SPECIAL ATTENTION TO ***POLICY*** vs. ***MECHANISM***
  - Policy is WHAT you want
  - Mechanism is HOW you do it

FIREWALLS: POLICY AND MECHANISM

- Firewalls are MECHANISMS for enforcing certain network security POLICIES
  - Borders are natural places to ***want*** a policy
  - Borders are also an easy place to ***enforce*** some policies
  - BUT DON'T CONFUSE THE TWO!

"SECURITY" IS A MEANINGLESS WORD

- Firewalls, like other mechanisms, don't "create security"
- Consider the marketing descriptions
  - What is a "threat"?
  - What does it mean to "block"?
  - What is an "attack"?
- How would you even evaluate these claims?

ENFORCING POLICY

- Firewalls are ONLY useful to the extent they enforce policy
- Corollary: Policies come BEFORE firewalls
- What security policies might you like to have?
- How well do firewall enforce these?

SAMPLE POLICIES

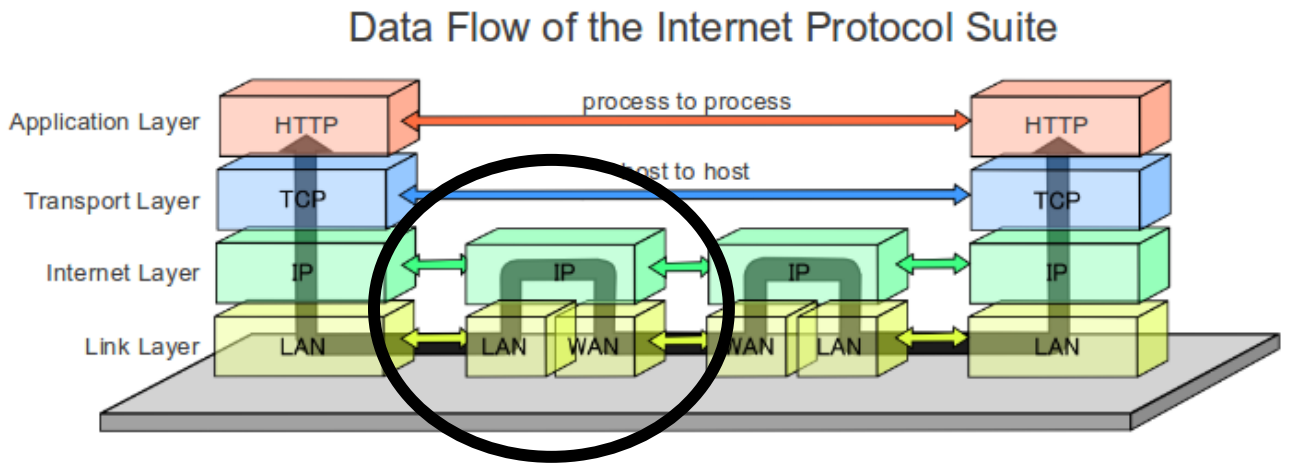
- Policy #1: Only authorized software can enter the network
- Policy #2: Only authorized external network access
- Policy #3: Only authorized published resources
- Policy #4: Authorized resources remain available

- NOTE:
  - External access means LAN user connecting to Internet
  - Published resources means Internet connecting to LAN

EARLY FIREWALLS: LAYER-3 MECHANISMS

- The first firewalls were LAYER 3 (IP level)
- Could only block bad IP addresses!
- Layer-3 filtering can only indirectly enforce
  - Policy #1 by blocking access to ***probably*** dangerous computers
  - Policy #2 by blocking outbound requests to unauthorized IP's
  - Policy #3 by blocking inbound requests to unauthorized servers
  - (Maybe some Policy #4?)

HOW DOES LAYER-3 ENFORCEMENT WORK?



Router/Firewall
-> Has to inspect the IP packet for routing
-> Will drop packets from "bad" addresses

LAYER-4 FIREWALL (PACKET FILTER ONLY)

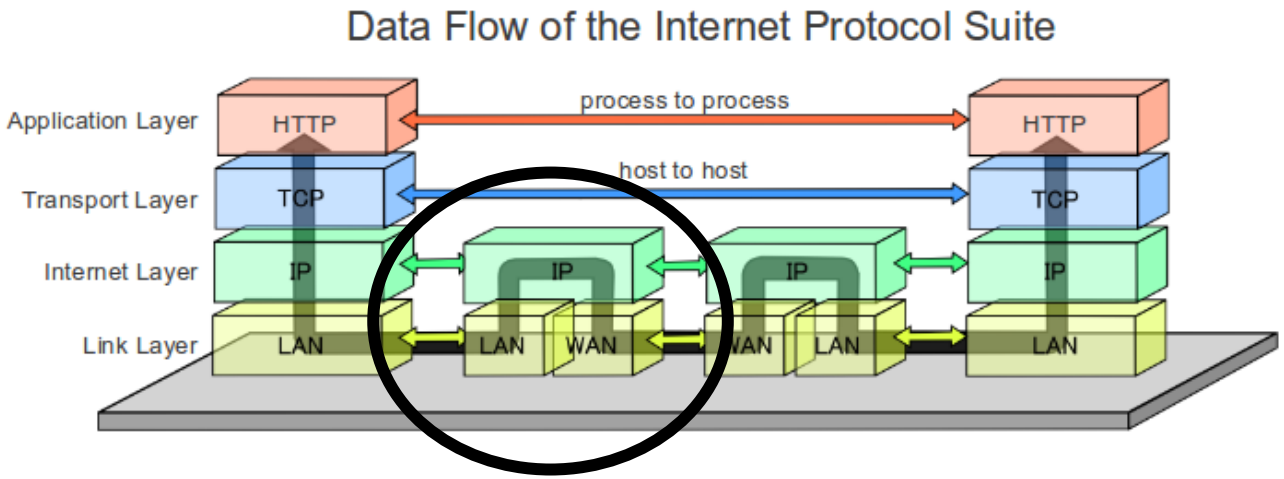
- People quickly realized that IP-layer was weak enforcement
- Examining TCP packets made enforcement better
  - TCP ports ***typically*** represented a specific service
- Policy enforcement mechanism improvements:
  - Policy #2 by blocking access to unauthorized outbound *ports*
  - Policy #3 by blocking access to unauthorized inbound ports

LAYER-4 FIREWALL (STATEFUL)

- Layer-4 packets also reveal *connection state*
- Some malicious packets violate TCP rules, for example
- Layer-4 firewalls could also keep track of TCP sessions
- Better enforcement of policy #4
  - Block malicious network traffic

LAYER-4 STILL LAYER-3 ROUTING

- Important.
- Just because a router is doing L3 routing doesn't mean it cant look at L4 data



Router/Firewall can examine ***any*** data, not just data used for routing

L7 FIREWALLS

- L7 firewalls examine application data
  - Specifically look at data, and not just headers!
  - Can "reassemble" data from more than one packet
- Even more "stateful"

EARLY MOTIVATIONS FOR L7

- Application firewalls go back to 1991!!
- Idea: Firewalls should ***understand*** application traffic.
- Example: File Transfer Protocol
  - Scan FTP data for the logged-in user
  - Scan FTP data for operations (upload/download)
  - Control which users can upload or download
  - Fine-grained application controls

MODERN MOTIVATION FOR L7

- In the past decades, need for L7 scanning has increased
- L3/L4 enforcement is rough guess (e.g., based on IP/port)
- What stops an attacker from using a different port number?
- L7 scanning can block web traffic even on different port
- Can also scan for viruses, malicious data
- (Better for all 4 policies!!!)

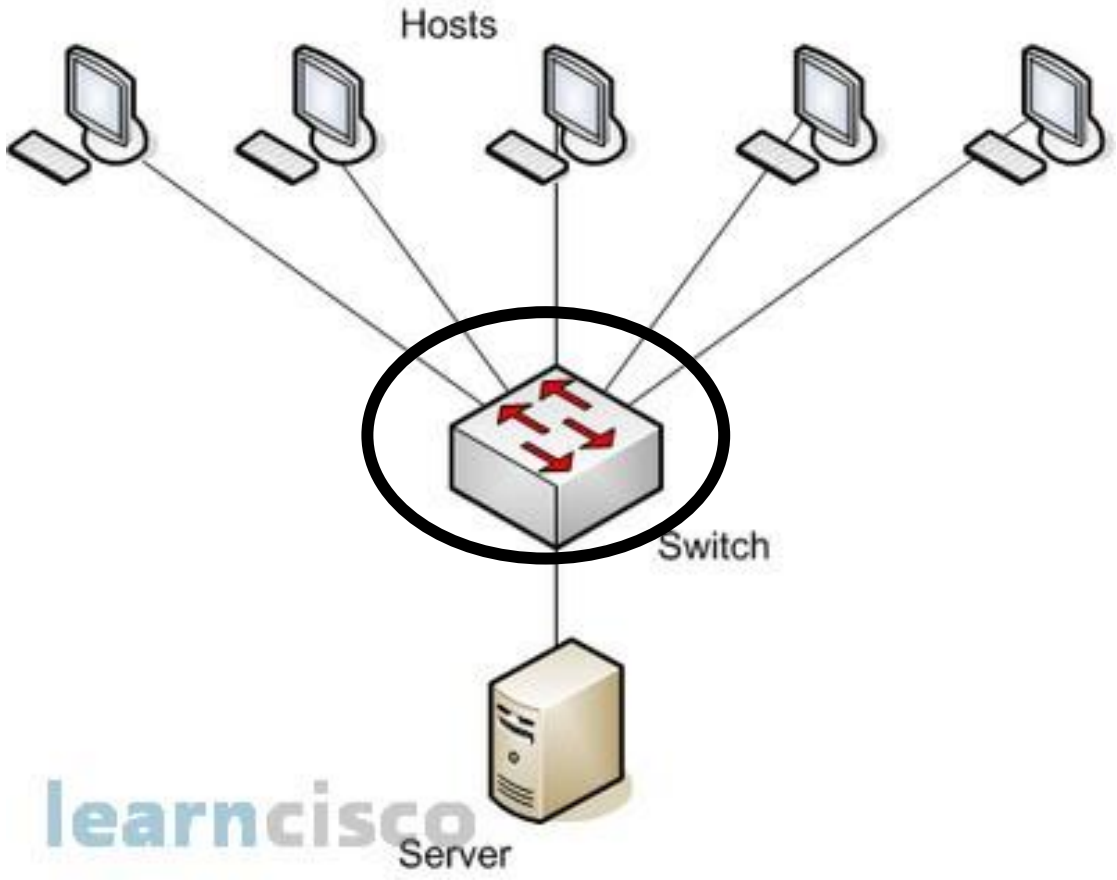
TRACKING USERS

- Since the 90's, firewalls also supported their own services
- Users could log-in to the firewall
- The logging-in process could map a
  - user-name to an IP address (computer)
  - Or even a special connection like VPN

L7 POLICY ENFORCEMENT

- User + Application Scanning even more granular
- Resource access can now be user specific
  - User X can connect to specific external website

YOU CAN ALSO HAVE AN L2 FIREWALL



Firewalls can go here too!

In this case, L2 refers to the routing, not the inspection!

LAYER 2 FIREWALLS

- But this is REALLY confusing
- Has nothing to do with layer used for scanning
- Just refers to scanning in a SWITCH instead of a ROUTER
- Have some neat defensive properties
  - If only a switch, ***HAS NO IP ADDRESS!!! HARDER TO ATTACK!!!***
  - Called "bump in the wire"

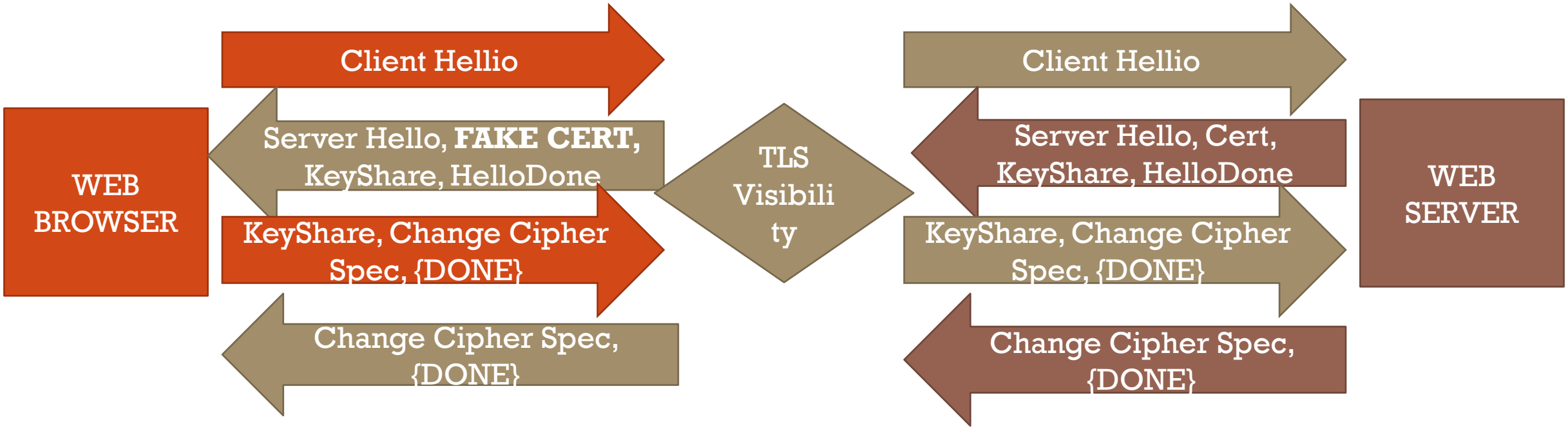
TUNNELS

- In the arms race, bad actors wrap one kind of traffic in another
- Unsurprisingly, HTTP is popular
- Modern firewalls can unpack the tunnel to see what's inside.
- One exception: encrypted tunnels (TLS/SSH)
- Can't see inside without "visibility"

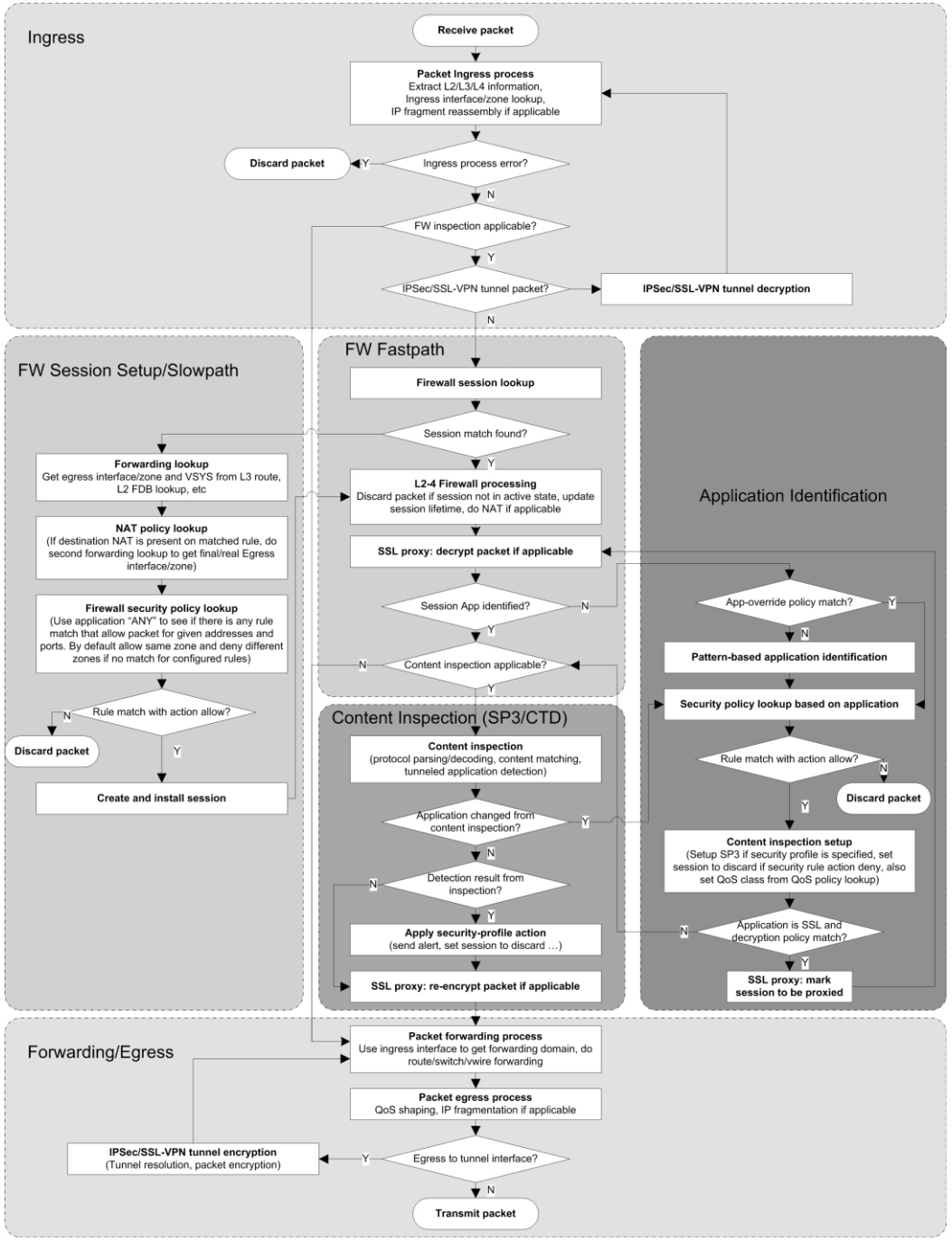
TLS VISIBILITY

- Typically, client MUST have a new root CA installed
- Root CA is a self-signed certificate from the firewall
- Firewall can now generate ANY cert!!!

TLS VISIBILITY HANDSHAKE VISUALIZATION



PALO ALTO NETWORK EXAMPLE



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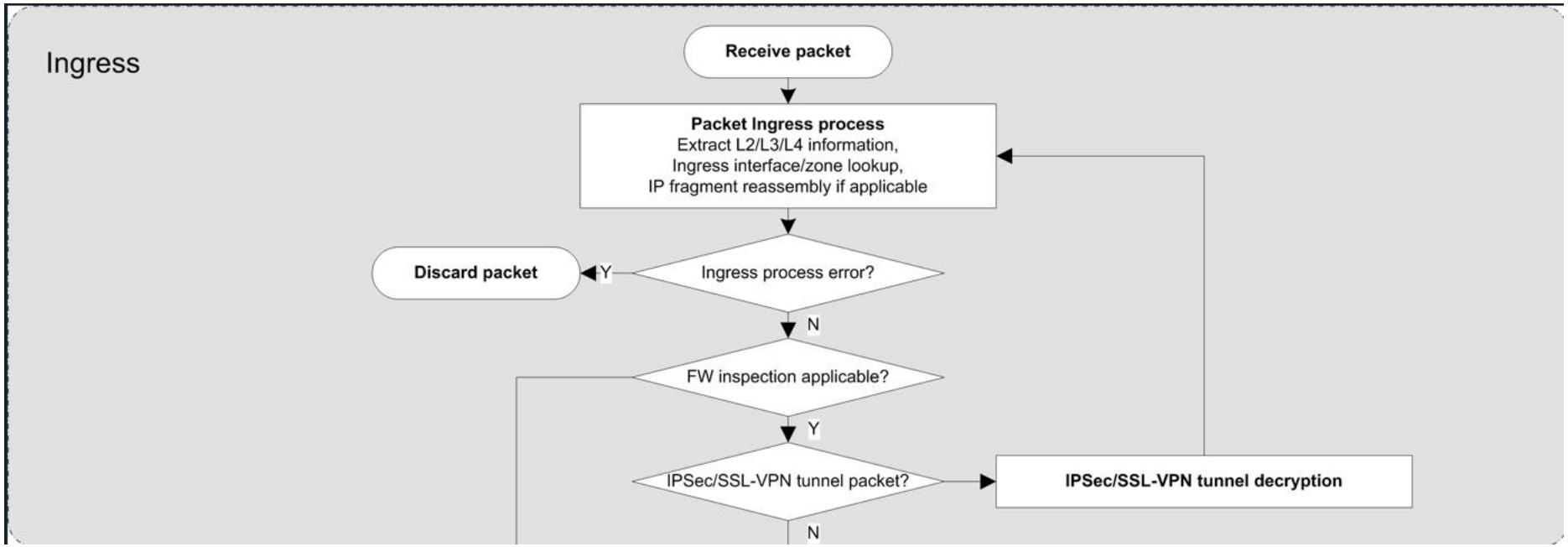

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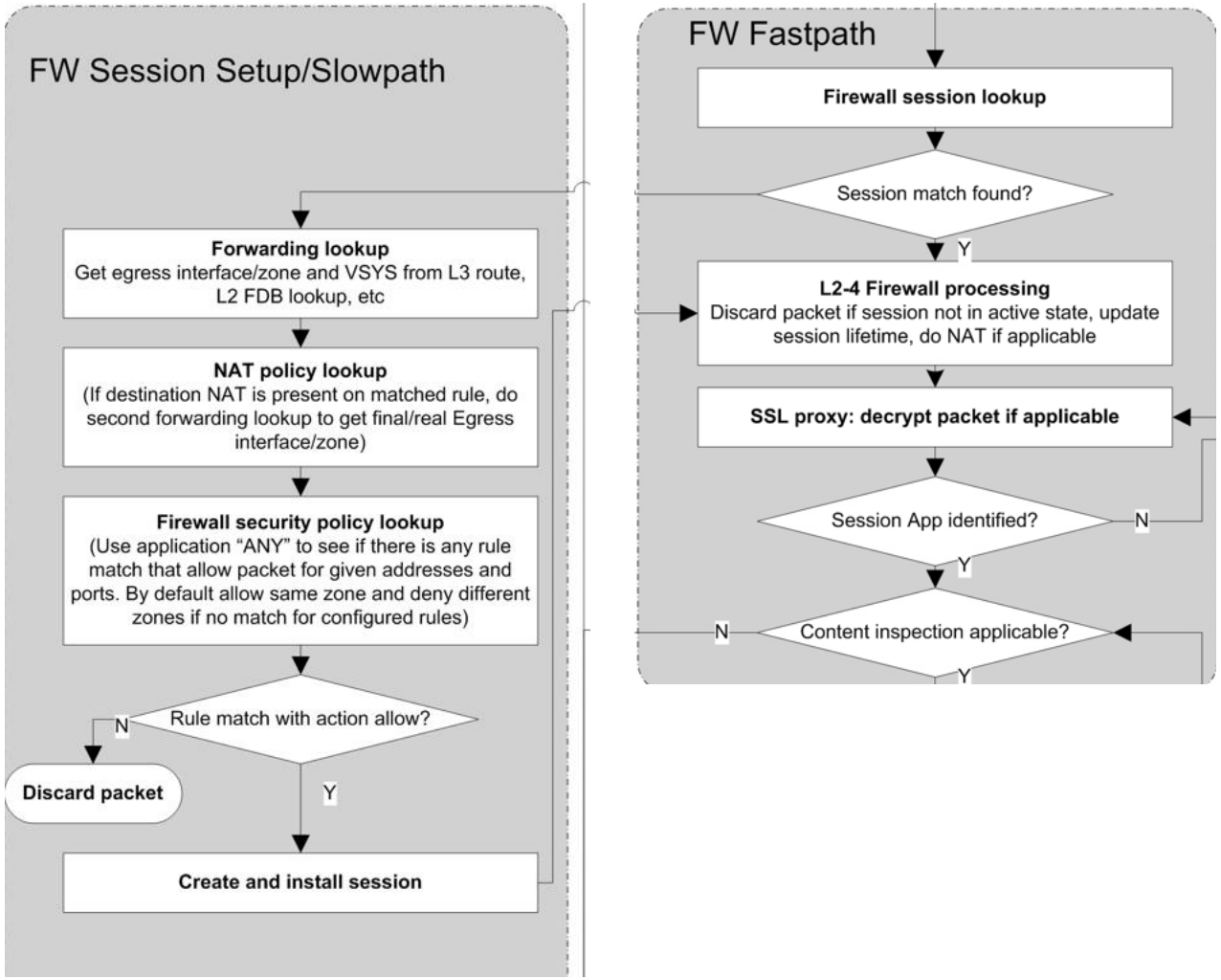

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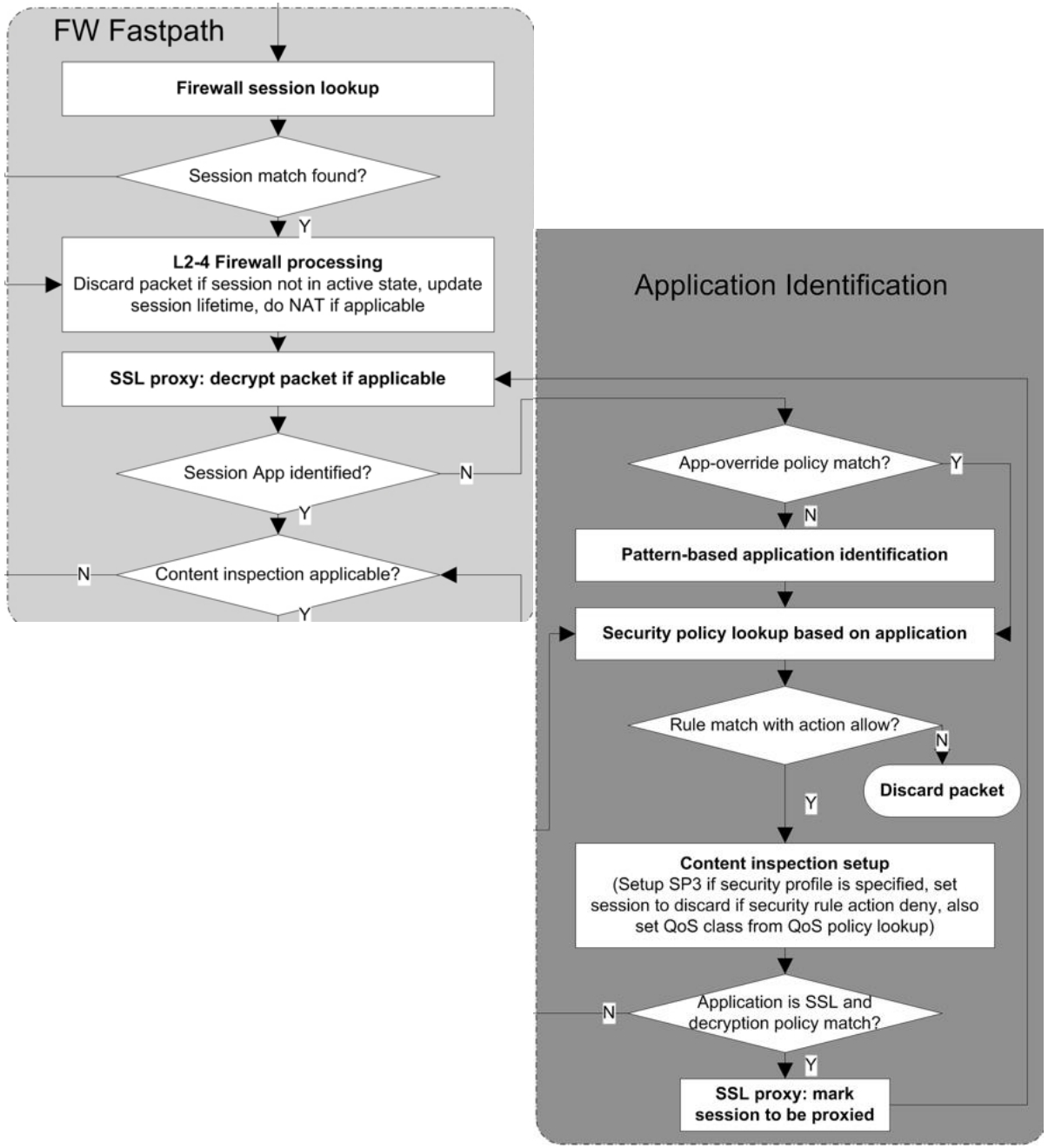

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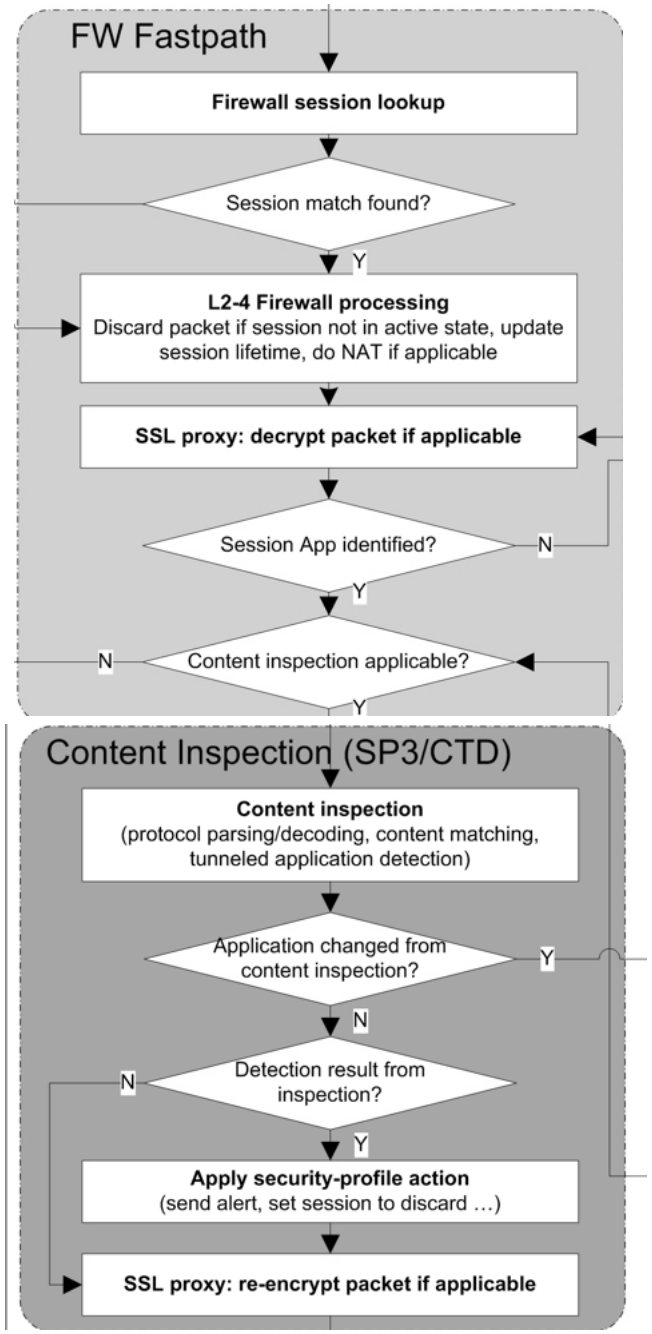

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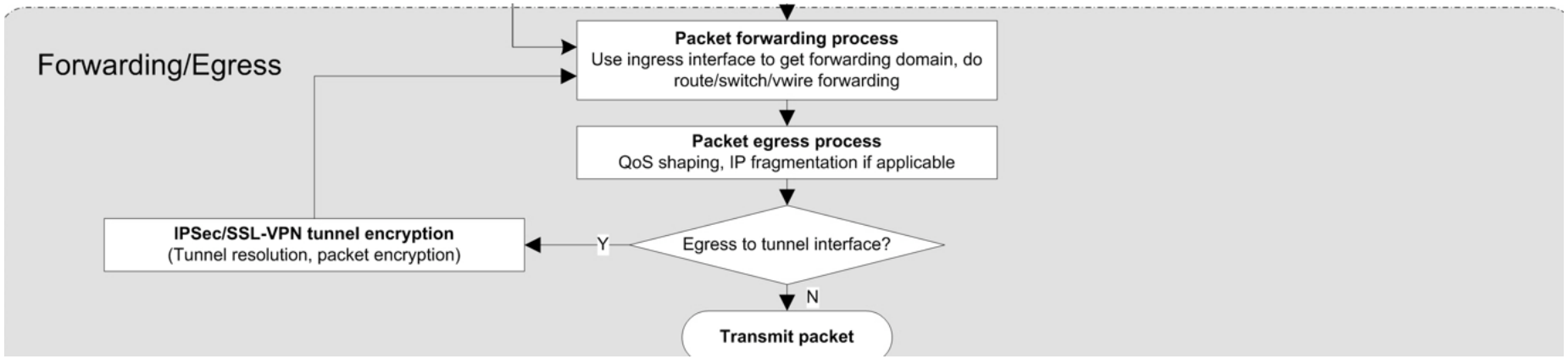
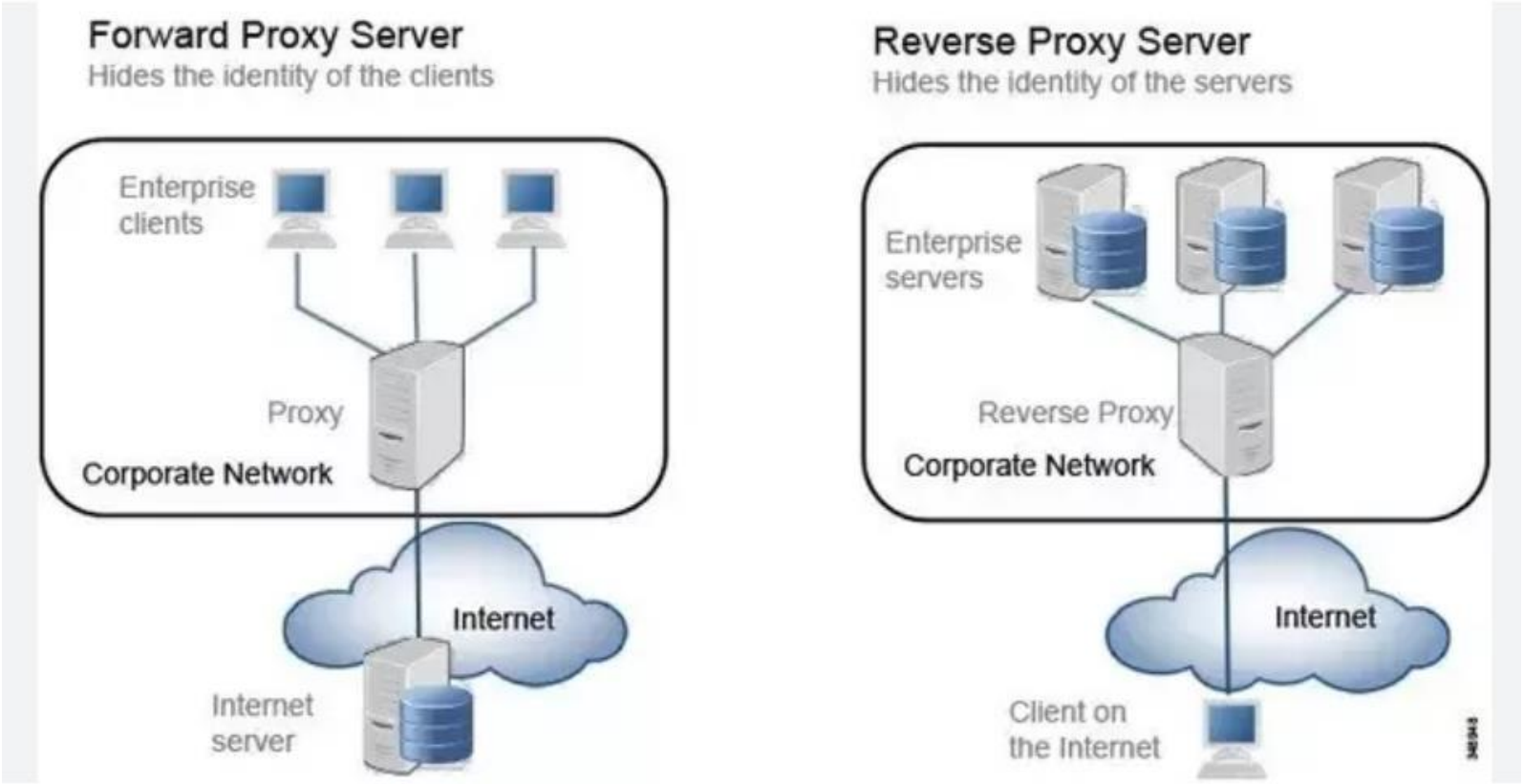


PROXIES


Forward Proxy Server
Hides the identity of the clients
Enterprise clients
Proxy
Corporate Network
Internet
Internet server
Reverse Proxy Server
Hides the identity of the servers
Enterprise servers
Reverse Proxy
Corporate Network
Internet
Client on the Internet

IDS: MITIGATION AND FUTURE PREVENTION

- IDS stands for Intrusion Detection System
- IPS is Intrusion Prevention System
- IDS is far more common because IPS is just too hard (FP/FN)
- IDS assumes the attacker has already won
  - The attacker has already succeeded in his objective and left (forensics)
  - The attacker is in the system, but moving to a higher target (mitigation)

SIGNS OF BAD BEHAVIOR

- Anomalies: unusual network traffic
  - Port scanning (recon)
  - Unusually large data transmissions (buffer overflow, etc)
  - Unexpected traffic between machines
- Surprisingly, this is still very much signature based
- Many attempts to do statistics modeling but usually too noisy

IDS TYPES

- Network Based IDS (NIDS)
  - Monitor traffic on the network (often using the gateways/routers)
- Host Based IDS (HIDS)
  - Monitor traffic received at a host, and the effect thereof
  - Sometimes helpful in simply monitoring the encrypted traffic
- Hybrid systems
  - Deploy host components and network components
  - Report all data back to a central server/dashboard

HONEYPOTS

- An interesting IDS component
- Create a fake system to draw attacker attention
- Introduces components whose entire operation is an anomaly

TYPES OF HONEYPOTS

- Low Interaction – port only, record traffic
  - Purpose: logging
- Medium Interaction – simulated/emulated service
  - Purpose: delay/confuse
- High Interaction – real services on real computers with real OS
  - Purpose: maximum analysis of attacker behavior
- Honeynet – multiple honeypots together on fake network
- Specialized variants:
  - Malware Honeypots
  - Spam Honeypots

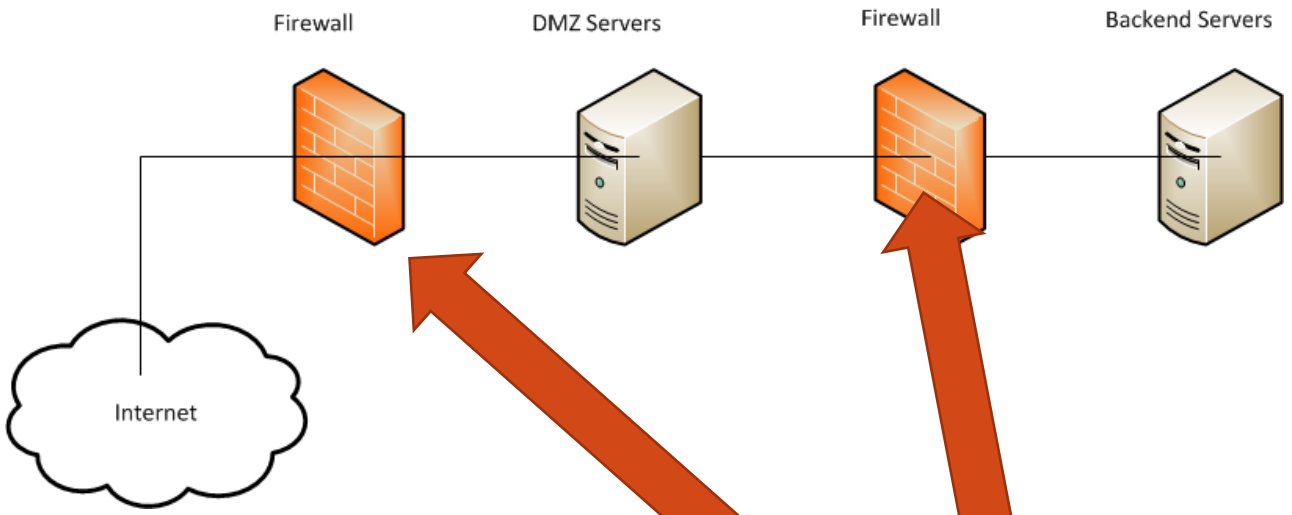
DEPLOYING HONEYPOTS

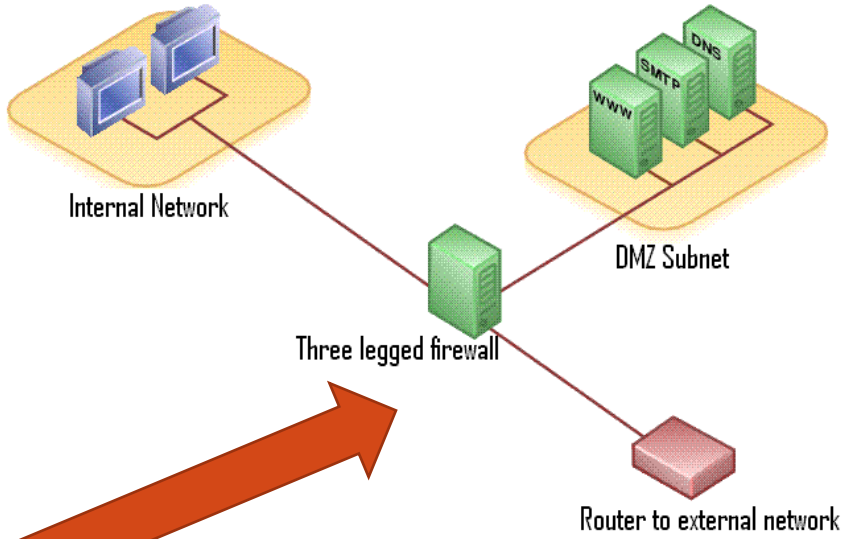
- Now part of larger "Enterprise Deception Operations"
- Entire firms dedicated to setting up fake systems
- Shockingly useful these days… why?
  - Use up attacker time
  - More time to detect attacker
  - More likely to feed false information to attacker

ALL-IN-ONE

- Most "enterprise" firewalls for sale include extras like IDS
- Generally easier to have it all in one

NETWORK ARCHITECTURE: DMZ





POLICY ENFORCEMENT

THE FUTURE

- The future? ***ZERO TRUST NETWORKS***
- Many say that the "Firewall is Dead", "DMZ's are Dead", etc
- I doubt that they die… will probably evolve?