BITS Pilani Presentation

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SSZG575: Ethical Hacking
Session No: 13 (Defense Processes and Tools)

Agenda

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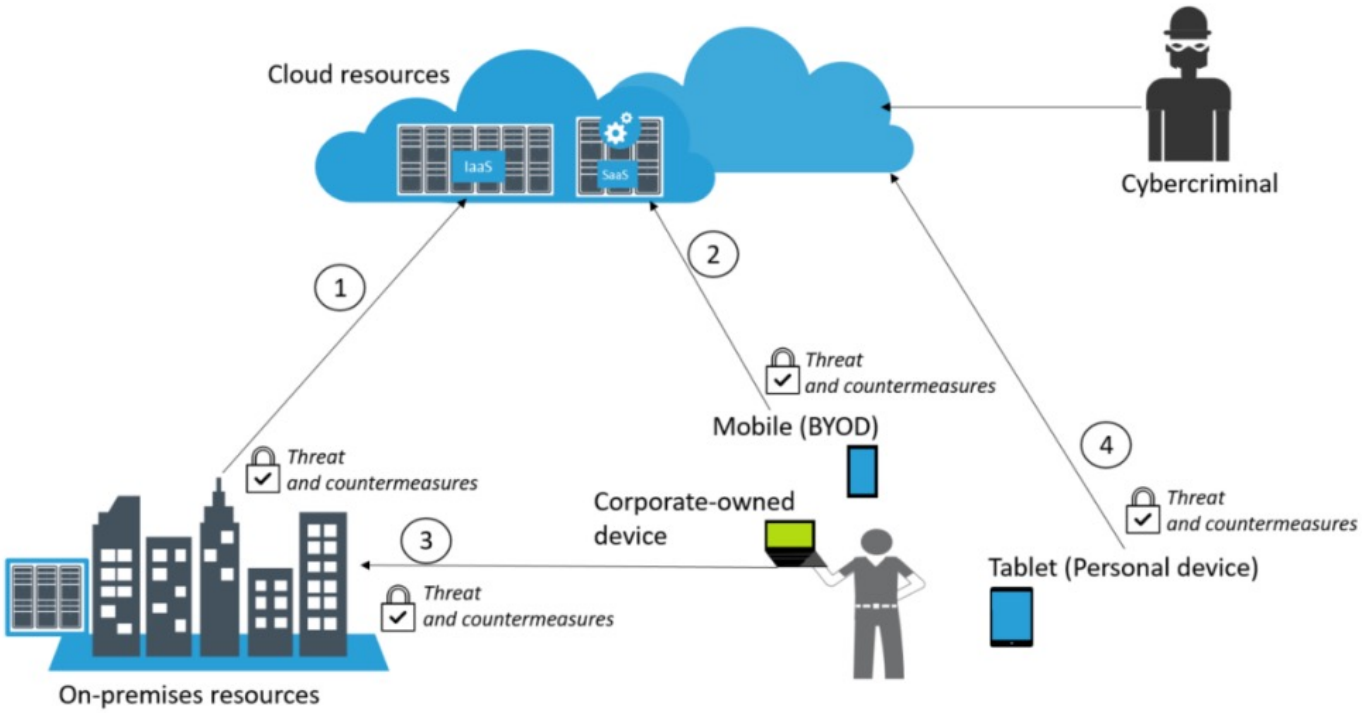
- Attack Entry Points
  - User authentication
  - Data security
  - Continuous security monitoring
- Network Security
- Firewalls
- Honeypots

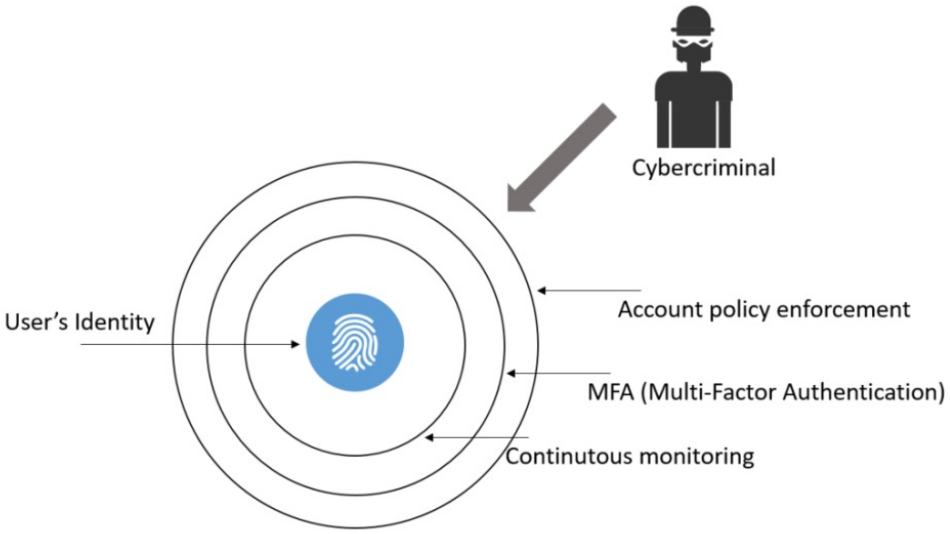
Attack Points

Attack Entry Points



- Connectivity between on-premises and cloud (**1**)
- Connectivity between BYOD devices and cloud (**2**)
- Connectivity between corporate-owned devices and on-premises (**3**)
- Connectivity between personal devices and cloud (**4**)

User Authentication

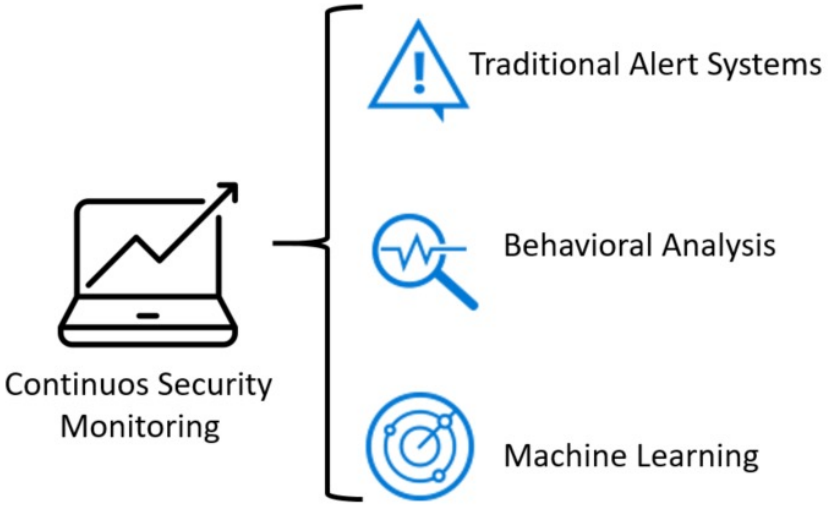


- Multiple layers of protection, starting with the regular security policy enforcement for accounts (strong password requirements, policy of frequent password changes etc)
- Protect user identities using MFA
- Having increased callback feature, where the user initially authenticates using his/her credentials (username and password), and receives a call to enter their pin.
- If both authentication factors succeed, they are authorized to access the system or network

Data Security

State	Description	Threats	Countermeasures	Security triad affected
Data at rest on the user's device.	The data is currently located on the user's device.	The unauthorized or malicious process could read or modify the data.	Data encryption at rest. It could be file-level encryption or disk encryption.	Confidentiality and integrity.
Data in transit.	The data is currently being transferred from one host to another.	A man-in-the-middle attack could read, modify, or hijack the data.	SSL/TLS could be used to encrypt the data in transit.	Confidentiality and integrity.
Data at rest on-premise (server) or cloud.	The data is located at rest either on the server's hard drive located on-premise or in the cloud (storage pool).	Unauthorized or malicious processes could read or modify the data.	Data encryption at rest. It could be file-level encryption or disk encryption.	Confidentiality and integrity.

Continuous Security Monitoring



Defense in Depth

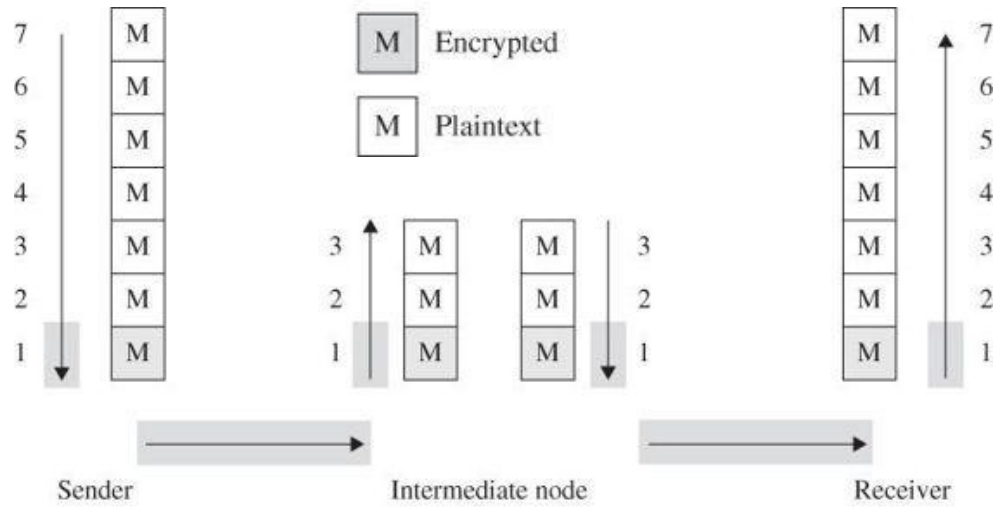
- Network security control
- Antivirus software
- Analyzing data integrity
- Behavioral analysis

Network Security

Network Encryption

- Encryption protects only what is encrypted. At sender or receiver end once data is decrypted, it's exposed to threats
- Encryption algorithm design is work of professionals
- Encryption is no more secure than its key management. Once key is revealed, encryption is of no use
- A flawed system design with super encryption is still a flawed system
- Encryption types:
  - **Link encryption:** Host to Host
  - **End to end encryption:** Application to Application

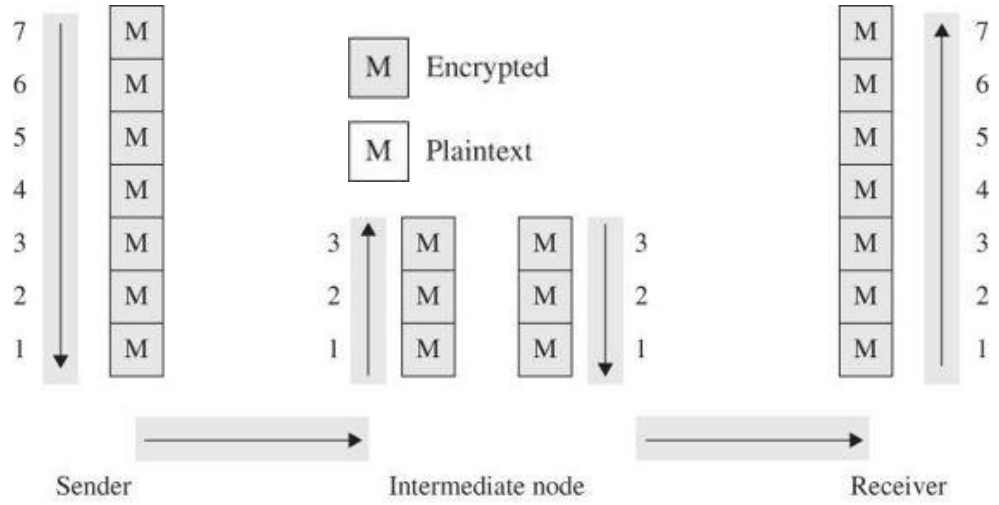
Link Encryption

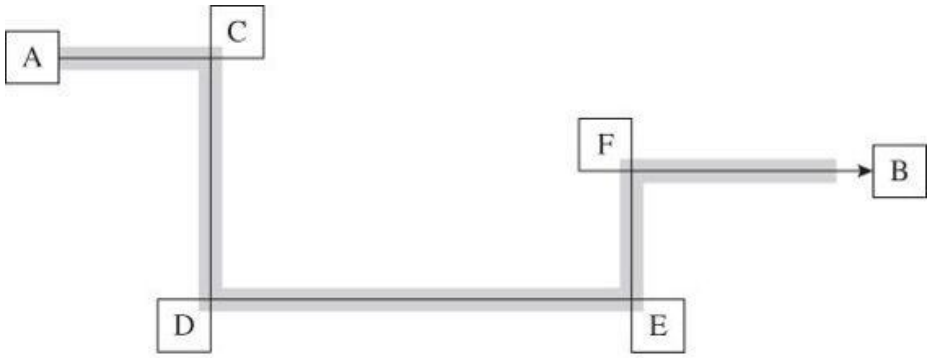


- Data is encrypted just before it's put on the physical network
- Encryption occurs at layer 1 or 2 in OSI network model
- Link encryption covers the communication from one node to next on the path to destination
- Message remains plaintext within the hosts
- Data is in an encrypted state while it travels on its communication path. However, when it reaches a router or another intermediate device, it gets decrypted so that the intermediator knows which way to send it next.

Useful when all hosts are reasonably secure but communication line is not

End to End Encryption





- Encryption is applied between two users
- Encryption is performed at highest level of network layers
- Data confidentiality is maintained even if a lower layer fails or communication passes thru unsecure nodes
- Only the communicating users can read the messages. In principle, it prevents potential eavesdroppers – including telecoms, ISPs and other intermediaries.

Browser Encryption

- Browsers can encrypt data during transmission.
- Browser negotiates with the server an algorithm for encryption
- SSH (Secure Shell):
  - Provides authentication and encryption service to Shell or OS commands
  - Replaces telnet, rlogin, rsh for remote access
  - Protects against spoofing and data modification during transmission
  - Usage algorithm (DES, AES etc) for encryption and (Public keys, Kerberos etc) for authentication
- SSL/TLS (Secure Socket Layer/Transport Layer Security):
  - SSL has 3 version 1.0, 2.0. 3.0. Version 3.1 is known as TLS
  - Implemented at layer 4 (transport layer)
  - SSL operates at application level
  - Provides server authentication, optionally client authentication and encrypted communication channel between client and server

Cypher Suite

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- Cypher suite is client & server negotiated encryption algorithm for authentication, session encryption and hashing
  - Diffie-Hellman
  - DES
  - AES
  - RC4
  - RSA
  - ….
- Server sends a set of records listing cypher suite identifiers it can use
- Client responds with the preferred choices from the shared set

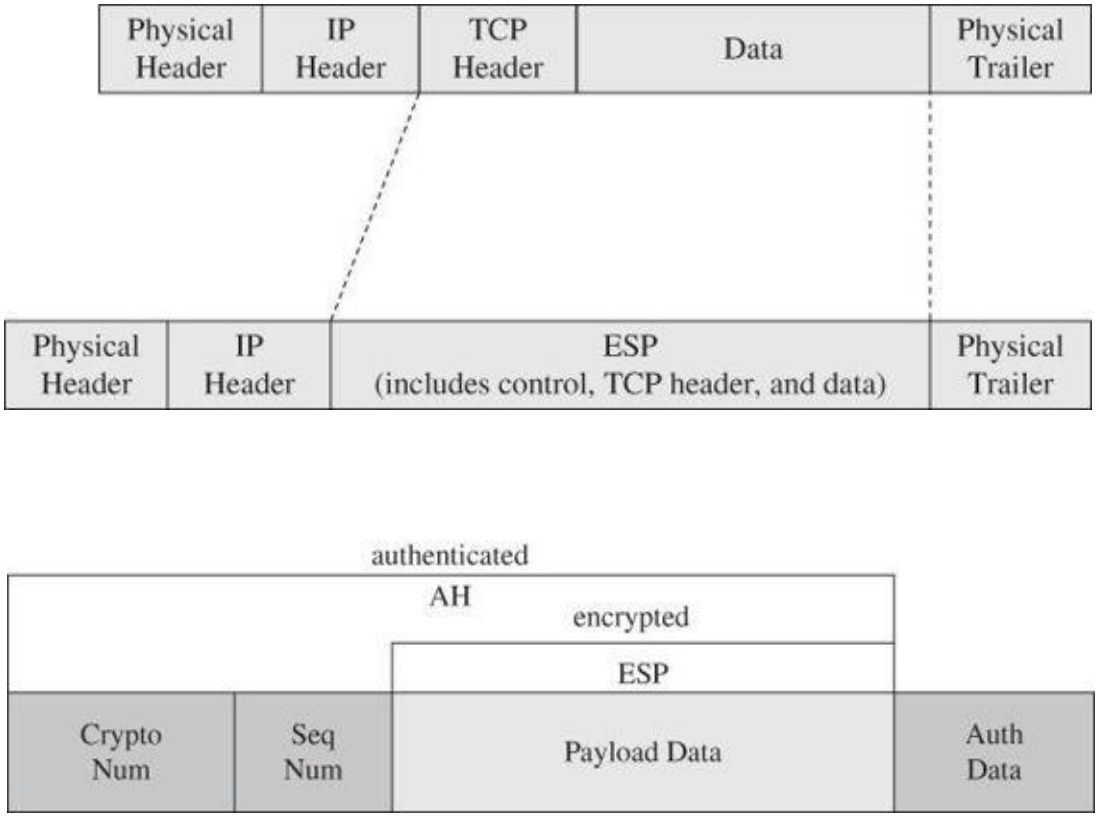
SSL (HTTPS)

- SSL encrypts data that is transmitted across the web.
- Anyone who tries to intercept this data will only see a garbled mix of characters that is nearly impossible to decrypt.
- SSL initiates an **authentication** process called a handshake between two communicating devices to ensure that both devices are really who they claim to be.
- SSL also digitally signs data in order to provide **data integrity**, verifying that the data is not tampered with before reaching its intended recipient.

IP Security (IPSec)

- IPSec implemented at OSI layer 2 (data layer)
- Implements encryption and authentication
- Allows two communicating parties to agree on mutually supported set of protocols
- Security Association (SA): a set of security parameter for a secured communication channel
- SA includes:
  - Encryption algorithm, key and mode
  - Encryption parameters like initialization vector
  - Authentication protocol and key
  - Life span of the SA
  - Address of opposite end of association
  - Sensitivity level of protected data (used for classified information)
- A host (network server or firewall) may have multiple SAs in operation at any given point of time

Headers and Data

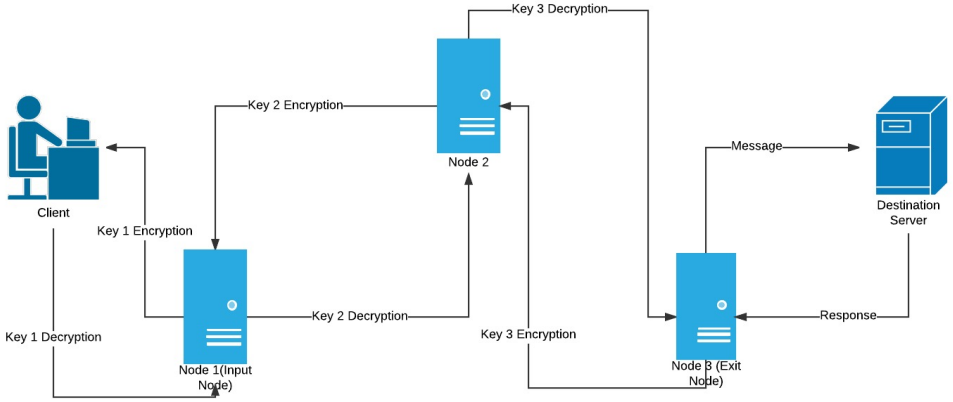


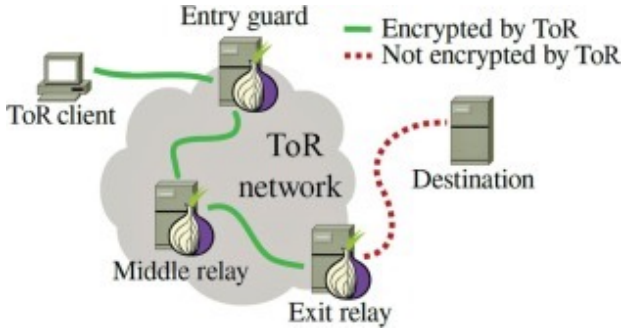
- IPSec has two fundamental data structure:
  - Authentication Header (AH)
  - Encapsulated Security Payload (ESP) – replaces TCP header & data portion of packet
  - Sequence number is incremented by 1 for each packet transmitted
- IPSec encapsulated security payload contains descriptors to tell a recipient how to interpret encrypted content

The Onion Routing (TOR)

- Link & End to end encryption data is encrypted but client & server address remain exposed
- TOR prevents an eavesdropper from learning source, destination, or content of data in transit
- Protection is achieved by transferring communication around a network of computer before delivery to receiver
- Ex: A needs to send a packet to B. It routes it thru X, Y & Z.
  - A encrypts the packet with B's public key and appends a header from Z to B
  - Then A encrypts the result with Z's public key and appends a header from Y to Z
  - Then A encrypts the result with Y's public key and appends a header from X to Y
  - Then A encrypts the result with X's public key and appends a header from A to X
  - Upon receipt of the packet, intermediate nodes only know the previous and next nodes for the packet and not the whole path
- Used in covert mails, private browsing, dark web etc
- Browsers: TOR, Orfox, Epic, Comodo Ics Dragon

The Onion Routing (TOR)





- The client with access to all the encryption keys i.e **key 1, key 2 & key 3** encrypts the message (get request) thrice wrapping it under 3 layers like an onion which have to be peeled one at a time.
- This **triple encrypted message** is then sent to the first server i.e. **Node 1(Input Node).**
- **Node 1** only has the address of **Node 2** and **Key 1**. So it **decrypts** the message using **Key 1** and realises that it doesn't make any sense since it still has 2 layers of encryption so it passes it on to **Node 2**
- **Node 2** has **Key 2** and the addresses of the **input & exit nodes.** So it **decrypts** the message using **Key 2** realises that its still **encrypted** and passes it onto the **exit node**
- **Node 3 (exit node)** peels of the last layer of encryption and finds a **GET request** for youtube.com and passes it onto the **destination server**
- The server processes the request and serves up the desired webpage as a **response.** The response passes through the same nodes in the reverse direction where each node puts on a **layer of encryption** using their specific key
- It finally reaches the client in the form of a **triple encrypted** response which can be decrypted since the client has access to all the keys

Firewalls

What is a Firewall?

- Firewalls are network security devices which protect a subnet (mainly internal) from harm by another subnet (mainly external)
  - Filters traffic between a protected (inside) network and less trustworthy (outside) network
  - Firewall is a traffic cop that permits or block data flow between two parts of a network architecture
  - Firewalls enforce pre-determined rules (security policies) to govern traffic flow
  - Two rules commonly used – default permit and default deny
- Can also be used to separate the sensitive segments of a network i.e. R&D
- Firewalls run on dedicated systems for performance and security reasons
- Firewall system typically doesn't have compilers, linkers, loaders, text editors, debuggers, programming libraries or other tools which an attacker can take advantage of
- CISCO runs its own OS on it's firewalls

How Does Firewall Work?

Rule	Type	Source Address	Destination Address	Destination Port	Action
1	TCP	*	192.168.1.*	25	Permit
2	UDP	*	192.168.1.*	69	Permit
3	TCP	192.168.1.*	*	80	Permit
4	TCP	*	192.168.1.18	80	Permit
5	TCP	*	192.168.1.*	*	Deny
6	UDP	*	192.168.1.*	*	Deny

- **Security Policy:** Set of rules that define what traffic can or can not pass thru the firewall
- Firewalls enforce pre-determined rules (security policies) to govern traffic flow

- **Rule 1:** Allow traffic from any outside host to 192.168.1 subnet on port 25 (mail transfer)
- **Rule 2:** Allow traffic from any outside host to 192.168.1 subnet on port 69 (file transfer)
- **Rule 3:** Allow traffic from 192.168.1 subnet to any outside host on port 80 (web pages)
- **Rule 4:** Allow traffic from any outside host to 192.168.1.18 on port 80 (web server)
- **Rule 5 & Rule 6:** Deny all other traffic (inbound or outbound)

Firewall Rules

- Firewalls can enforce pre-determined rules for:
  - IP Address
  - Domain name
  - Protocols
  - Programs
  - Ports
  - Key words
- Firewall Types
  - Host based (software firewall) - Windows Firewall
  - Network based (hardware+software firewall)

Firewall Categories

- **First Generation:** Packet filtering gateways or screening routers
- **Second Generation:** Stateful inspection firewalls
- **Third Generation:**
  - Application Proxy Firewall
  - Circuit level gateways
  - Guard Firewall
  - Personal firewall
- Network Address Translation (NAT) Firewall
- Next Generation Firewall (NGFW)

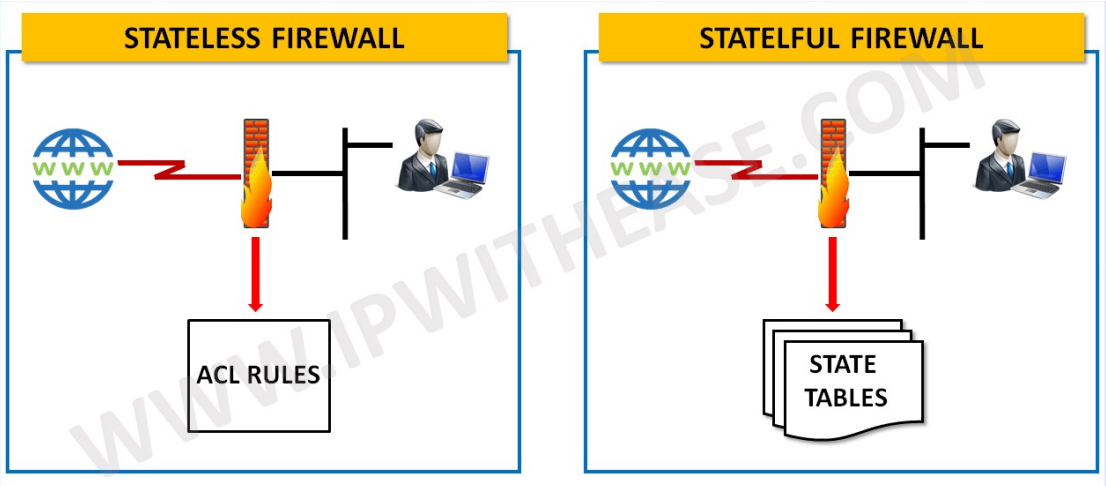
Packet Filtering Firewall

	Source IP	Dest. IP	Source Port	Dest. Port	Action
1	192.168.21.0	--	--	--	deny
2	--	--	--	23	deny
3	--	192.168.21.3	--	--	deny
4	--	192.168.21.0	--	>1023	Allow

1. Incoming packets from network 192.168.21.0 are blocked.
2. Incoming packets destined for internal TELNET server (port 23) are blocked.
3. Incoming packets destined for host 192.168.21.3 are blocked.
4. All well-known services to the network 192.168.21.0 are allowed.

- Simplest form of firewalls
- Controls access based on packet address (source or destination) or specific transport protocol type (HTTP, Telnet)
- Doesn't inspect data inside packet and treats each packet in isolation. It has no ability to judge whether a packet is part of an existing stream of traffic.
- Can detect outside traffic with a forged source header
- Usage separate interface cards for inside and outside
- Can not implement complex rules

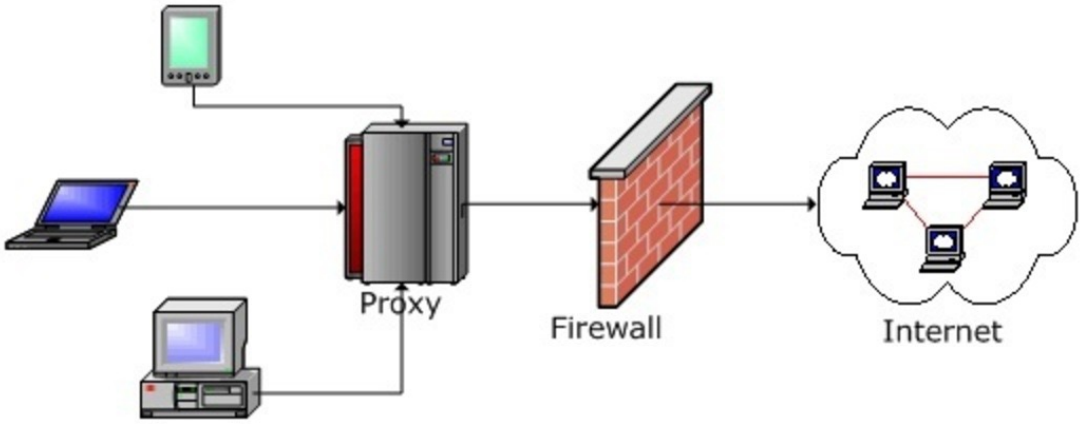
Stateful Inspection Firewall



- Stateful firewalls (performs Stateful Packet Inspection) are able to determine the connection state of packet which makes it more efficient.
- It keeps track of the state of networks connection travelling across it, such as TCP streams.
- Filtering decisions would not only be based on defined rules, but also on packet's history in the state table.

- Stateful inspection firewalls judge traffic based on information from multiple packets
- If someone is trying to scan ports in a short time, firewall will block that host
- Ex: first attempt (port 1) from 10.1.3.1 will be allowed but access time recorded, port 2 allowed, port 3 allowed but at port 4 the abnormal behavior is noticed and dis-allowed

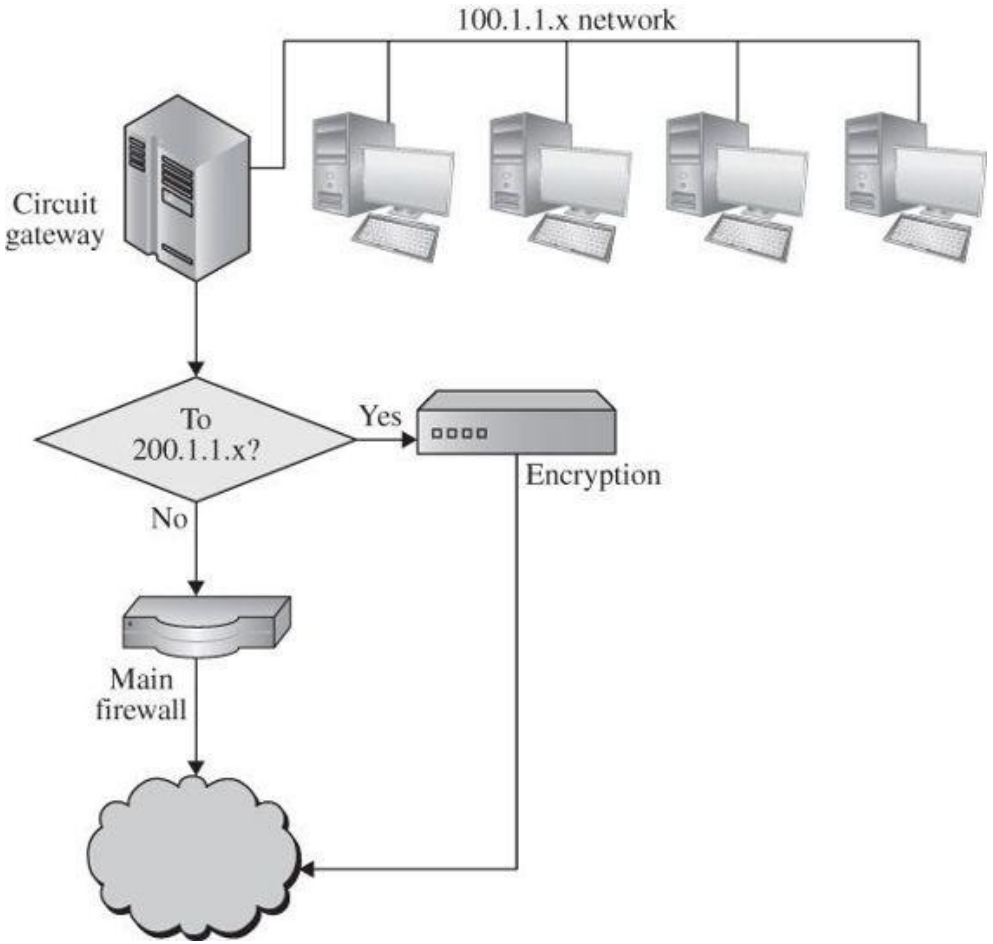
Application Proxy Firewall



- Proxy acts an intermediary between two end systems. Can filter traffic at application level.
- The client must send a request to the firewall, where it is then evaluated against a set of security rules and then permitted or blocked.
- Proxy firewalls monitor traffic for layer 7 protocols (HTTP, FTP etc) and use both stateful and deep packet inspection to detect malicious traffic.

- Application proxy firewall simulates the behavior of a protected application on the inside network, allowing in only safe data
- Application proxy intrudes in the middle of protocol between sender and receiver, similar to man in the middle
- Proxy interprets the protocol stream as an application would and takes control action based on things visible inside the protocol

Circuit Level Gateway



- This firewall allows one network to be extension of another network and functions as a virtual gateway between two networks
- Firewall verifies the circuit at time of creation after which data transfer is normal
- VPNs are implemented thru circuit level gateways

Guard Firewall

- A guard is a proxy type firewall
- A guard implements programmable set of conditions, even if the program conditions become very sophisticated
- Great firewall of China (Golden Shield Program) is a guard firewall. It filters content based on government restrictions/ rules.
  - Initiated, developed, and operated by the Ministry of Public Security (MPS)
  - Blocks politically inconvenient incoming data from foreign countries
  - Web sites belonging to "outlawed" or suppressed groups, such as pro-democracy activists

Personal Firewall

- Personal firewall is program that runs on a single host to monitor and control traffic to that host
- It works in conjunction with support from operating system
- Ex: SaaS Endpoint Protection (McAfee), F-Secure Internet Security, Microsoft Windows Firewall, Zone Alarm, Checkpoint
- Personal firewalls:
  - List of safe/unsafe sites
  - Policy to download code/files
  - Unrestricted data sharing
  - Management access from corporate but not from outside
  - Combine action with anti-virus software

Network Address Translation (NAT)

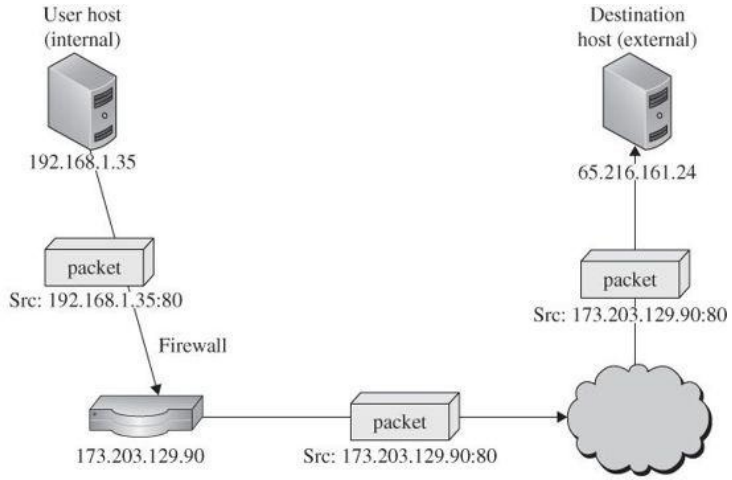


Table of translations performed	
Source	Dest
192.168.1.35:80	65.216.161.24:80

- Allow multiple devices with independent network addresses to connect to the internet using a single IP address, keeping individual IP addresses hidden.
- Hence, attackers scanning a network for IP addresses can't capture specific details, providing greater security against attacks.
- NAT firewalls are similar to proxy firewalls in that they act as an intermediary between a group of computers and outside traffic.

- Every packet between two hosts contains source address & port and destination address & port
- NAT firewall conceals real internal addresses from outsiders who don’t know the real addresses and can not access these real addresses directly
- Firewall replaces source address by its own address and keeps entries of original source address & port and destination address & port in a mapping table.

Next Generation Firewalls (NGFW)

- Combines traditional firewall technology with additional functionality, such as encrypted traffic inspection, intrusion prevention systems, anti-virus etc.
- Has capability to deep packet inspection (DPI). While basic firewalls only look at packet headers, deep packet inspection examines the data within the packet itself, enabling users to more effectively identify, categorize, or stop packets with malicious traffic
- TCP handshake checks
- Surface level packet inspection
- May also include other technologies as well, such as intrusion prevention systems (IPSs) that work to automatically stop attacks against network

Next Generation Firewalls (NGFW)

- According to Gartner, a next-generation firewall must include:
  - Standard firewall capabilities like stateful inspection
  - Integrated intrusion prevention
  - Application awareness and control to see and block risky apps
  - Upgrade paths to include future information feeds
  - Techniques to address evolving security threats
- **Examples:** FortiGate (Fortinet), Cisco ASA, Cisco Meraki MX, Sophos XG, SonicWall TZ, CheckPoint, Palo Alto, Juniper etc

Threat Focused NGFW

- These firewalls include all the capabilities of a traditional NGFW and also provide advanced threat detection and remediation. With a threat-focused NGFW you can:
  - Know which assets are most at risk with complete context awareness
  - Quickly react to attacks with intelligent security automation that sets policies and hardens your defenses dynamically
  - Better detect evasive or suspicious activity with network and endpoint event correlation
  - Greatly decrease the time from detection to clean-up with retrospective security that continuously monitors for suspicious activity and behaviour even after initial inspection
  - Ease administration and reduce complexity with unified policies that protect across the entire attack continuum

NGFW Features

- Breach prevention and advanced security
  - Prevention to stop attacks before they get inside
  - A best-of-breed next-generation IPS built-in to spot stealthy threats and stop them fast
  - URL filtering to enforce policies on hundreds of millions of URLs
  - Built-in sandboxing and advanced malware protection that continuously analyzes file behavior to quickly detect and eliminate threats
  - A world-class threat intelligence organization that provides the firewall with the latest intelligence to stop emerging threats
- Comprehensive network visibility
  - Threat activity across users, hosts, networks, and devices
  - Where and when a threat originated, where else it has been across your extended network, and what it is doing now
  - Active applications and websites
  - Communications between virtual machines, file transfers, and more

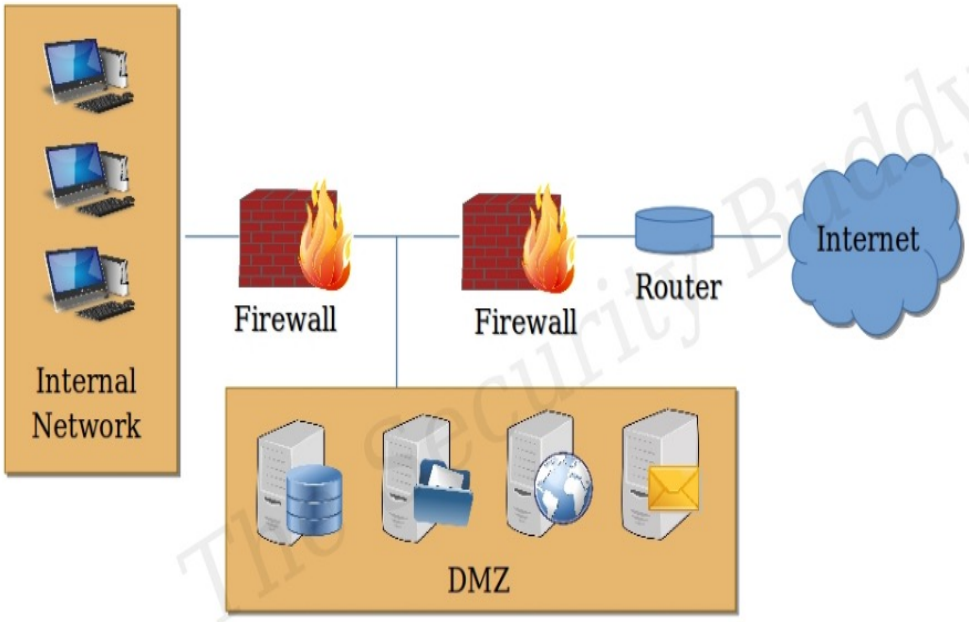
NGFW Features

- Flexible management and deployment options
  - Management for every use case--choose from an on-box manager or centralized management across all appliances
  - Deploy on-premises or in the cloud via a virtual firewall
  - Customize with features that meet your needs--simply turn on subscriptions to get advanced capabilities
  - Choose from a wide range of throughput speeds
- Fastest time to detection
  - Detect threats in seconds
  - Detect the presence of a successful breach within hours or minutes
  - Prioritize alerts so you can take swift and precise action to eliminate threats
  - Make your life easier by deploying consistent policy that's easy to maintain, with automatic enforcement across all the different facets of your organization

NGFW Features

- Automation and product integrations
  - Seamlessly integrates with other tools from the same vendor
  - Automatically shares threat information, event data, policy, and contextual information with email, web, endpoint, and network security tools
  - Automates security tasks like impact assessment, policy management and tuning, and user identification

DMZ (De-Militarized Zone)



- A DMZ Network (De-Militarized Zone) functions as a subnetwork containing an organization's exposed, outward-facing services.
- The goal of a DMZ is to add an extra layer of security to an organization's local area network. A protected and monitored network node that faces outside the internal network can access what is exposed in the DMZ, while the rest of the organization's network is safe behind a firewall.
- A DMZ gives extra protection in detecting and mitigating security breaches before they reach the internal network, where valuable assets are stored.

Firewall Limitations

- Firewall can protect an environment only if the firewall controls entire perimeter
- Firewalls do not protect data outside perimeter
- Firewalls are most visible part of an installation to outsiders and hence most attractive target for attack
- Firewalls must be configured correctly and the configuration must be updated as the internal and external environment changes
- Firewalls are targets for intruders, check firewall logs periodically for evidence of attempted or successful intrusions
- Firewalls exercise only limited control over the content inside packet and hence may not be able to stop malicious code or inaccurate data completely

Data Loss Prevention (DLP)

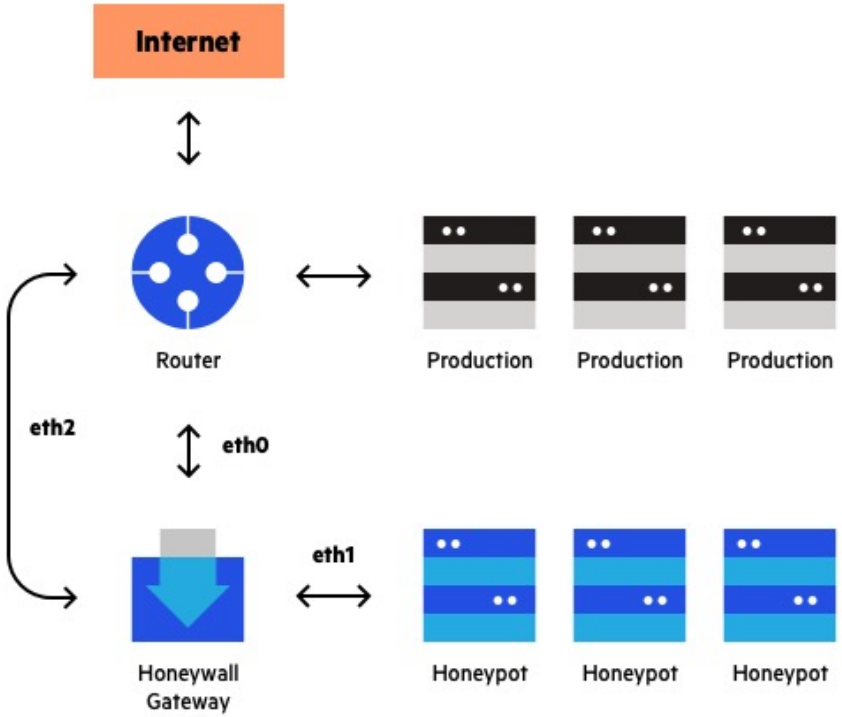
- Set of technologies designed to detect and possibly prevent attempt to send data where it is not allowed to go
- Classified documents, proprietary information, personal information etc in light of Wiki leaks / Edward Snowden scandal
- Two implementation of DLP:
  - **Agent based:** Installed as a rootkit to monitor user behavior like network connections, file access, applications run etc
  - **Application based:** Software agents to monitor email, file transfer etc
- DLP looks for indicators:
  - **Keywords:** set of identified words in the data
  - **Traffic patterns:** bulk file transfer, file sharing, connection to outside email etc
  - **Encoding/encryption:** block outgoing files that they can't decode/decrypt

Leading Enterprise Firewall Products

- Fortinet Fortigate
- Cisco ASA NGFW
- pfSense
- Sophos UTM
- WatchGuard Firebox
- Meraki MX Firewalls
- Juniper SRX
- Palo Alto Network VM-Series

Honeypots

Honeypots



- A cyber honeypot is a baiting trap for hackers.
- It's a sacrificial computer system to attract cyberattacks, like a decoy.
- Honeypots are filled with fabricated information
- Any access to honeypots triggers monitoring and logging actions
- An attack against a honeypot is made to seem successful
- It mimics a target for hackers, and uses their intrusion attempts to gain information about cybercriminals and the way they are operating or to distract them from other targets.

How a Honeypot Works?

- The honeypot looks like a real computer system, with applications and data, fooling cybercriminals into thinking it's a legitimate target.
- Once the hackers are in, they can be tracked, and their behavior assessed for clues on how to make the real network more secure.
- Honeypots are made attractive to attackers by building in deliberate security vulnerabilities.
- Vulnerable ports might be left open to entice attackers into the honeypot environment, rather than the more secure live network.
- A honeypot isn't set up to address a specific problem, like a firewall or anti-virus. Instead, it's an information tool that can help you understand existing threats to your business and spot the emergence of new threats.
- With the intelligence obtained from a honeypot, security efforts can be prioritized and focused.

Level of Interaction

- Low interaction
  - Simple to install
  - Only provides few fake services – port emulation
  - No real operating system that an attacker can operate on
- Medium interaction
  - Provides more interaction
  - Services are still emulated
  - Scripts used to provide more interaction
  - Requires higher skills to deploy
- High interaction
  - Actual operating system in place for interacting with attacker
  - Potential to gather more information
  - Higher risk

Types of Honeypots

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Types

- Email traps
- Database decoys
- Malware honeypot
- Spider honeypot

By monitoring traffic coming into the honeypot system, you can assess:

- where the cybercriminals are coming from
- the level of threat
- what modus operandi they are using
- what data or applications they are interested in
- how well your security measures are working to stop cyberattacks

Products

- KFSensor – High interaction
- Honeyd – Low to Medium interaction
- Back Office Friendly (BOF) – Low interaction
- Argos
- HoneyBOT
- NetBAIT

Demo

- Honeypots

  https://www.youtube.com/watch?v=fQqWe8br2Gw

- Burp Suite Demo

  https://www.youtube.com/watch?v=G3hpAeoZ4ek

- Cisco NGFW Firepower

  https://www.youtube.com/watch?v=e-CtcCPIy04

Thank You