Network Security & Attacks – Part II

COMP90073
Security Analytics

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Outline

- More Network Attacks
- Network Security Systems
- Case Study – Network Attack Traffic Analysis

More Network Attacks

- Spoofing Attacks & BGP Hijacking Attack
- Password Attacks
- Wireless Attacks
- Key Patterns for Well-Known Attacks

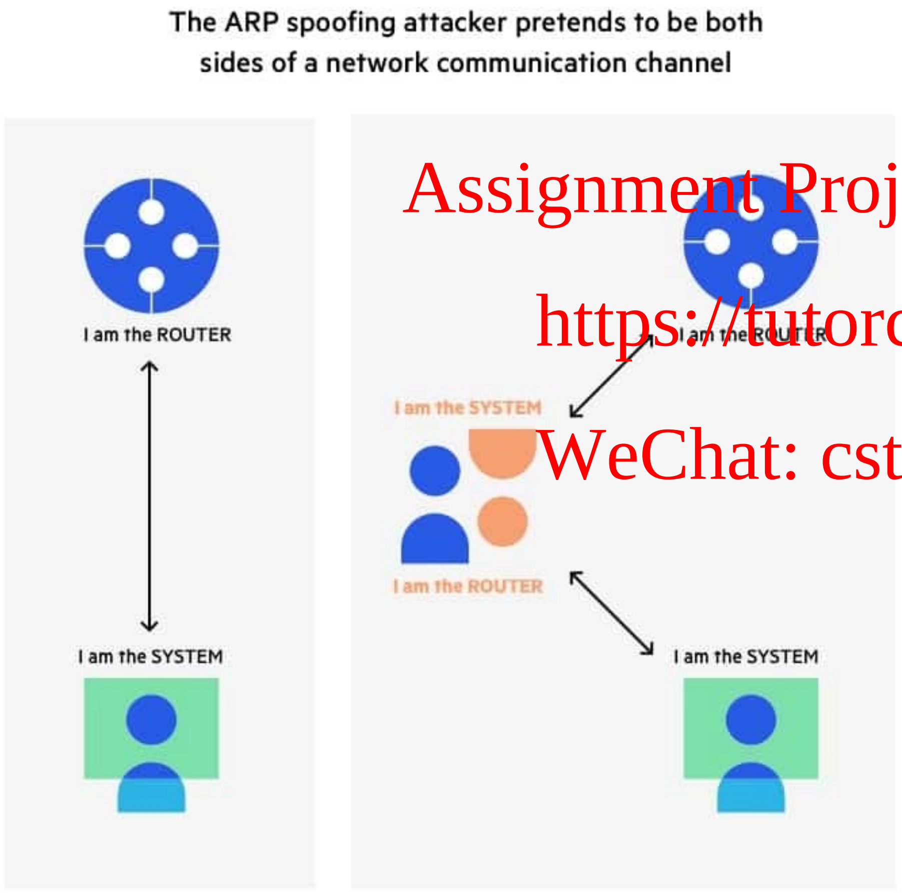
Spoofing Attacks & BGP Hijacking Attack

- **Spoofing attack:** an attacker impersonates another device to execute an attack
  - **IP address spoofing attack**: The attacker sends IP packets from a fake source address in order to disguise itself. DDoS attacks typically use IP spoofing to make the packets appear to be from legitimate source IP addresses
  - **ARP spoofing attack**: The attacker sends spoofed ARP packets across the Layer 2 network in order to link the attacker's MAC address with the IP address of a legitimate host
  - **DNS server spoofing attack**: The attacker modifies the DNS server in order to reroute a specific domain name to a different IP address. DNS server spoofing attacks are typically used to spread malware

- **BGP hijacking attack:** a common router manipulation attack, can be launched by an attacker by configuring or compromising an edge router to announce prefixes that have not been assigned to his or her organization, to reroute victim's traffic to the attacker

Spoofing Attacks & BGP Hijacking Attack

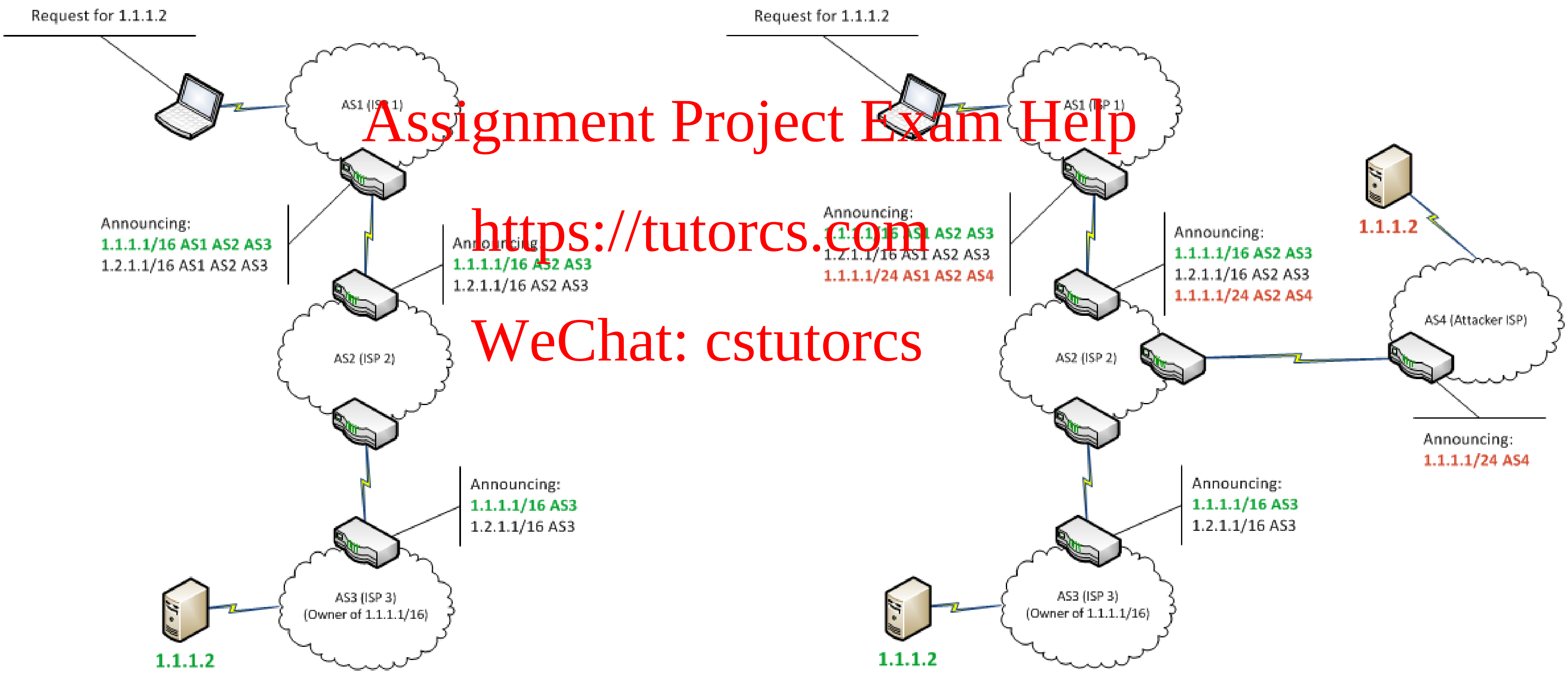
ARP spoofing



https://www.imperva.com/learn/wp-content/uploads/sites/13/2020/03/thumbnail_he-ARP-spoofing-attacker-pretends-to-be-both-sides-of-a-network-communication-channel.jpg.webp

Spoofing Attacks & BGP Hijacking Attack

- BGP Hijacking



https://labs.bishopfox.com/tech-blog/2015/08/an-overview-of-bgp-hijacking

Password Attacks

- **Password-guessing attack**: This is the most common type of password attack, but some of these techniques may be very inefficient. Threat actors can guess passwords locally or remotely using either a manual or automated approach

- **Password-resetting attack**: In many cases, it is easier to reset passwords than to use tools to guess them. Several cracking tools just attempt to reset passwords. In most cases, the attacker boots from a USB or CD-ROM to get around the typical Windows protections

Password Attacks

- **Password cracking**: These attacks work by taking a password hash and converting it to its original plaintext. In this case, the attacker needs tools such as extractors for hash guessing, rainbow tables for looking up plaintext passwords, and password sniffers to extract authentication information

- **Password sniffing**: The threat actor just sniffs authentication packets between a client and server and extracts password hashes or enough authentication information to begin the cracking process

- **Password capturing**: This is typically done by using key loggers or Trojan horses

Wireless Attacks

- **Installing a rogue access point**: The attacker basically installs an access point and can create a backdoor and obtain access to the network and its systems

- **Jamming wireless signals and causing interference**: The purpose of this attack is to cause a full or partial denial-of-service condition in the wireless network

- **Evil twin attack**: This is done when the attacker is trying to create rogue access points so as to gain access to the network or steal information, *e.g.,*
  - *the attacker purchases a wireless access point, plugs it into the network, and configures it exactly the same as the existing network*

Wireless Attacks

- **War driving**: This is a methodology used by attackers to find wireless access points wherever they may be. The term war driving is used because the attacker can just drive around and get a very huge amount of information over a very short period of time

- **Bluejacking**: The attacker sends unsolicited messages to another device via Bluetooth

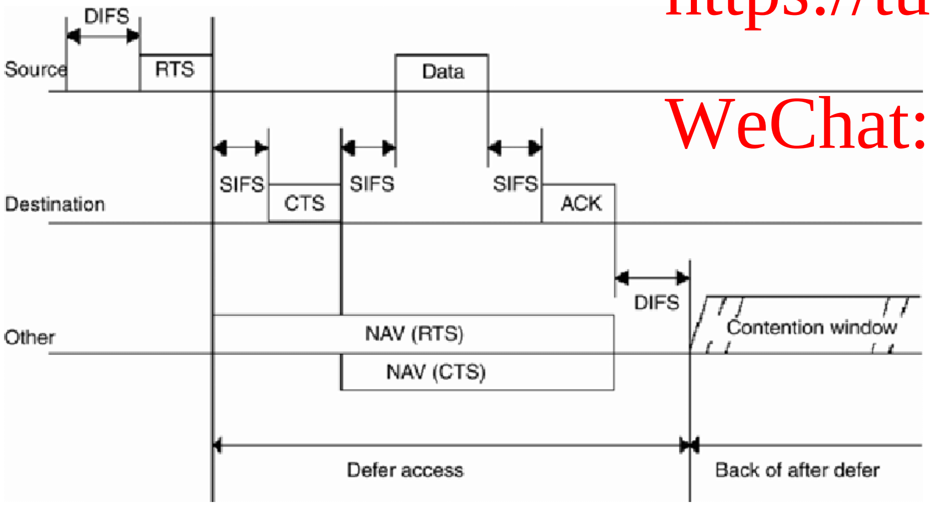
- **IV attack**: The attacker can cause some modification on the Initialization Vector (IV) of a wireless packet that is encrypted during transmission. The goal of the attacker is to obtain a lot of information about the plaintext of a single packet and generate another encryption key that then can be used to decrypt other packets using the same IV

- **WEP/WPA attack**: WEP and several versions of WPA are susceptible to different vulnerabilities and are considered weak

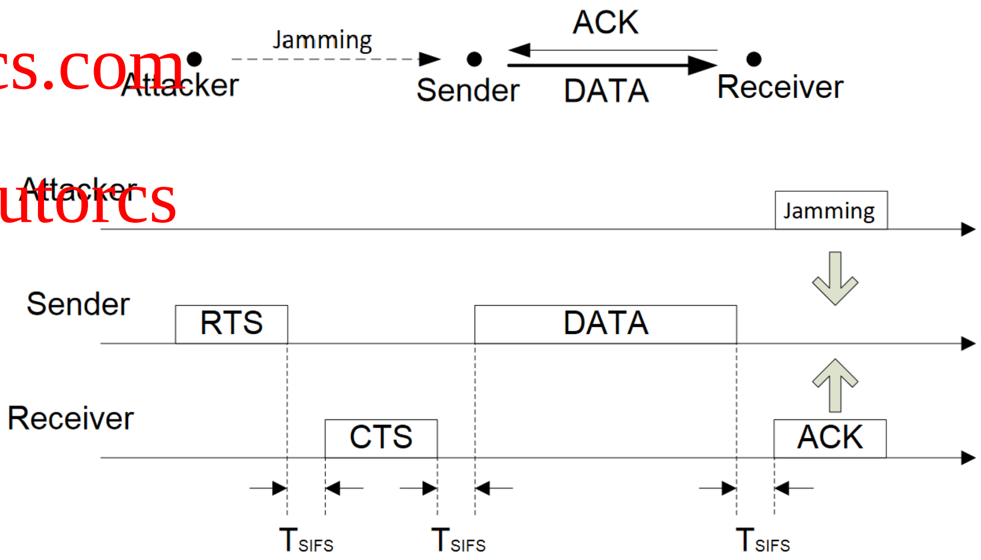
- **WPS attack**: This attack is carried out with WPS password-guessing tools to obtain the WPS passwords and use them to gain access to the network and its data

Wireless Attacks (Jamming)

- RTS/CTS
- Jamming attacks [3]:
  - Constant jamming
  - Reactive jamming
  - Random and periodic jamming

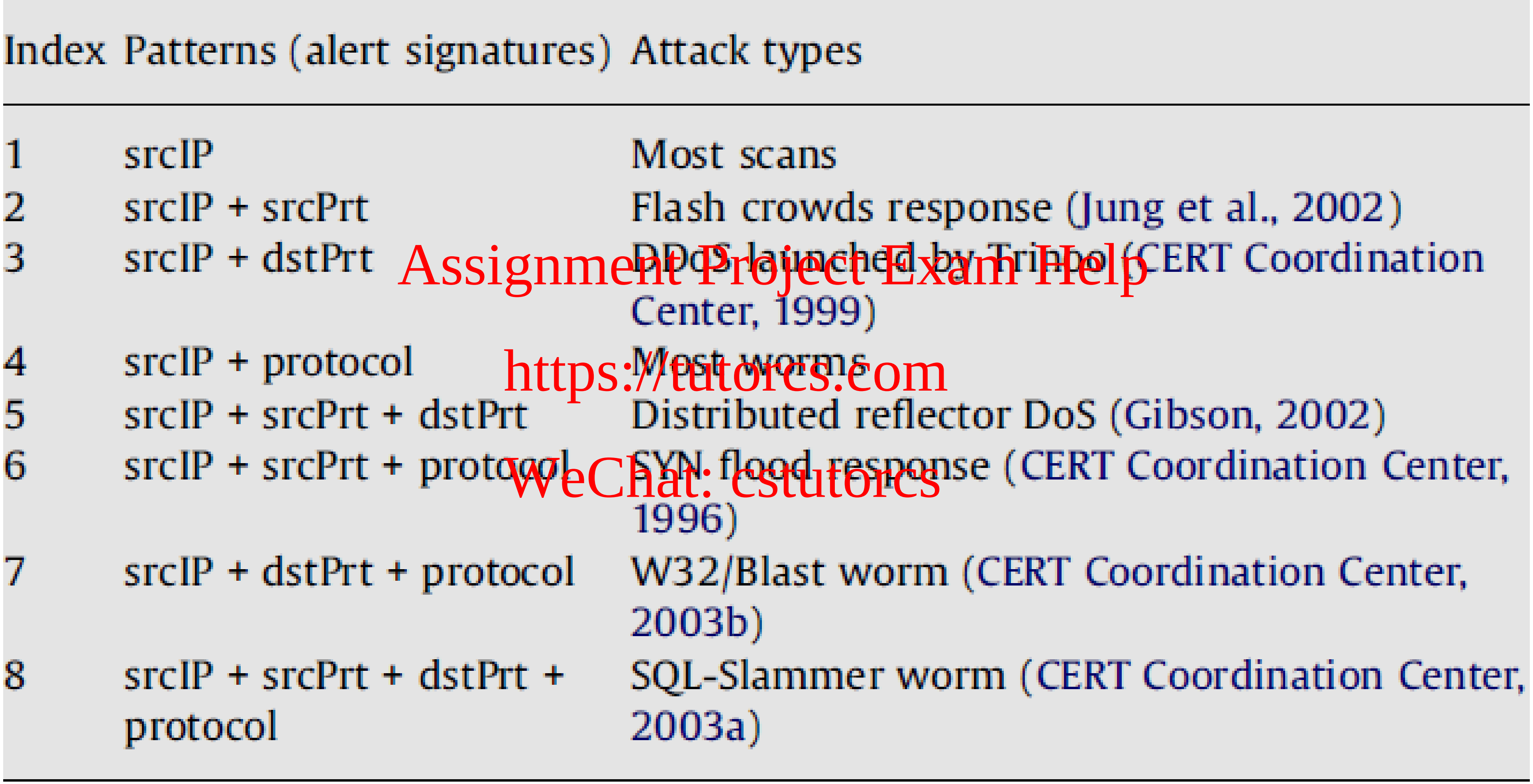


RTS/CTS



Reactive jamming

Key Patterns for Well-Known Attacks



Index	Patterns (alert signatures)	Attack types
1	srcIP	Most scans
2	srcIP + srcPrt	Flash crowds response (Jung et al., 2002)
3	srcIP + dstPrt	DDoS launched by Trinoo (CERT Coordination Center, 1999)
4	srcIP + protocol	Most worms
5	srcIP + srcPrt + dstPrt	Distributed reflector DoS (Gibson, 2002)
6	srcIP + srcPrt + protocol	SYN flood response (CERT Coordination Center, 1996)
7	srcIP + dstPrt + protocol	W32/Blast worm (CERT Coordination Center, 2003b)
8	srcIP + srcPrt + dstPrt + protocol	SQL-Slammer worm (CERT Coordination Center, 2003a)

Patterns and their corresponding attack activities (Source: [2])

Key Patterns for Well-Known Attacks

- **Pattern 1** consists of a single feature - source IP address (srcIP). In most large scale scan scenarios, a common source IP address can be observed across different network domains, since attackers try to map the whole network at once

- **Pattern 2** consists of the combination of source IP address and source port (srcIP + srcPrt). For example, during a flashcrowd (a huge number of hosts create excessive connections to unintentionally overwhelm a server) on a webserver, there are a large number of responses from this webserver that will be sent out in reply to the flashcrowd requests. Consequently, it can be observed that there are many HTTP (srcPrt = 80) traffic flows from this web server(srcIP)

- **Pattern 3** consists of the combination of source IP address and destination port (srcIP + dstPrt). For example, this pattern can be observed when a master controller instructs its daemons or slave hosts (on destination port 27444) to launch a denial of service attack against a target system

Key Patterns for Well-Known Attacks

- **Pattern 4** consists of the combination of source IP address and protocol (srcIP + protocol). In most worm attacks when an infected system tries to spread itself to others, this pattern can be observed across different subnetworks

- **Pattern 5** consists of the combination of source IP address, source port, and destination port (srcIP + srcPrt + dstPrt). For example, this pattern can be observed during a distributed reflector DoS attack

- **Pattern 6** consists of the combination of source IP address, source port and protocol (srcIP + srcPrt + protocol). For example, if a target is undergoing a large-scale SYN flood attack, there will be a large number of SYN-ACK packets sent by the target in reply to the attack sources. From the perspective of the subnetworks that contain the attack sources, they will see many SYN-ACK packets (protocol = TCP) arriving where there is no ongoing transaction, sent by a target system on a certain port (srcIP)

Key Patterns for Well-Known Attacks

- **Pattern 7** consists of the combination of source IP address, destination port and protocol (srcIP + dstPrt + protocol). For example, this pattern was observed during the W32/Blaster worm outbreak

- **Pattern 8** consists of the combination of source IP address, source port, destination port and protocol (srcIP + srcPrt + dstPrt + protocol). For example, this pattern can be observed across different network domains when an infected system tries to spread itself to others during SQL-Slammer worm outbreak

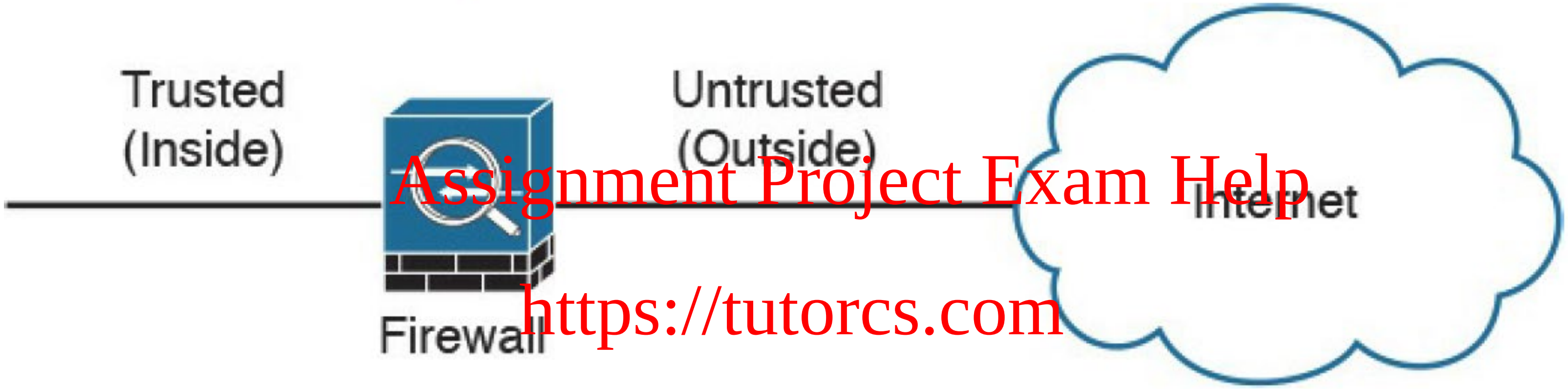
Network Security Systems

- Traditional and next-generation firewalls

- Intrusion detection systems (IDSs) & intrusion prevention systems (IPSs)

Traditional & Next-Generation Firewalls

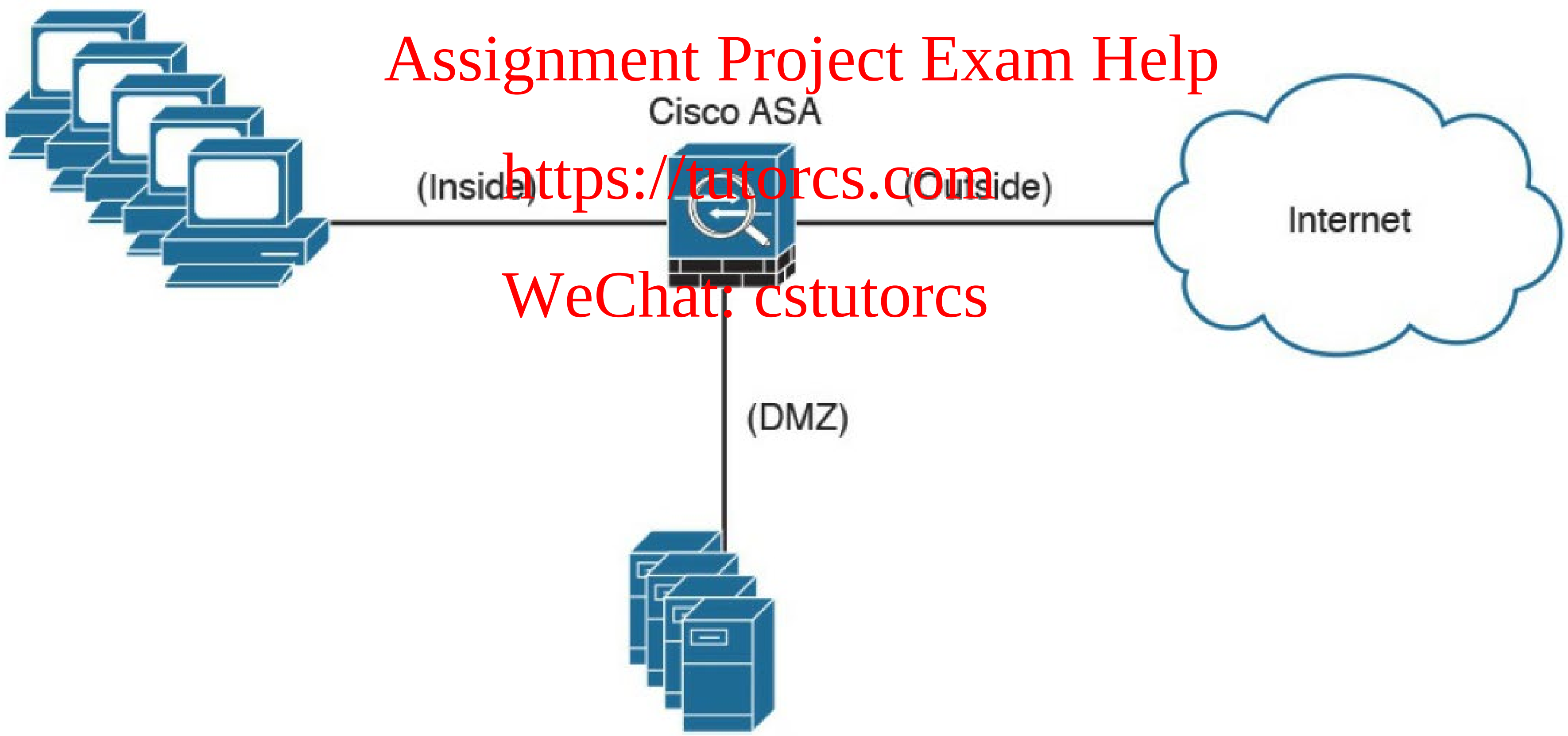
- Firewalls: devices placed between a trusted and an untrusted network



- Network-based firewalls
  - Provide key features used for perimeter security
  - Primary task is to deny or permit traffic that attempts to enter or leave the network based on explicit preconfigured policies and rules

Traditional & Next-Generation Firewalls

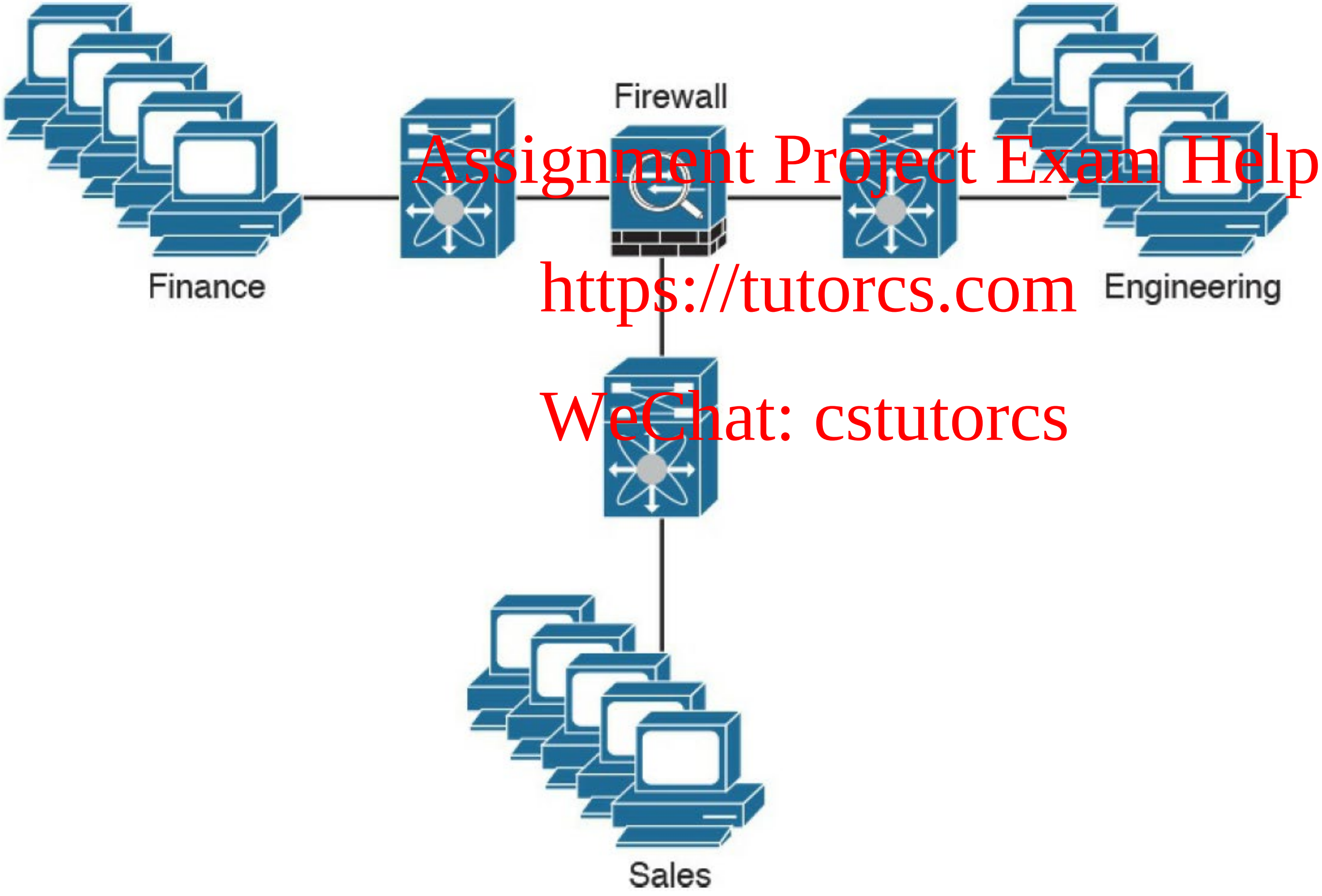
- Demilitarized zones (DMZ): provide security to the systems that reside within them with different security levels and policies between them, *e.g.*,



DMZ (Source: [1])

Traditional & Next-Generation Firewalls

- Firewall provides **network segmentations** while enforcing policy between those segments, *e.g.*,



Network segmentations (Source: [1])

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Traditional & Next-Generation Firewalls

- How do firewalls allow or block traffic:
  - Packet-filtering techniques
  - Application proxies
  - Network address translation (NAT)
  - Stateful inspection firewalls
  - Next-generation context-aware firewalls

Packet-filtering Techniques

- Purpose: to control access to specific network segments by defining which traffic can pass through them

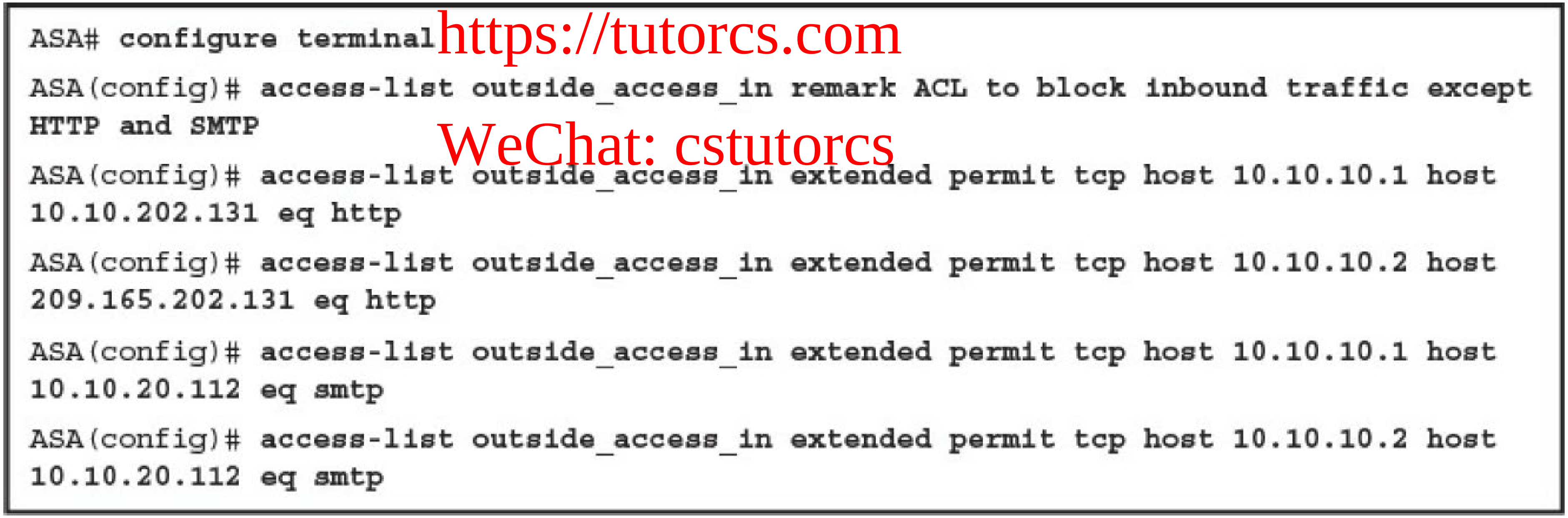
- ACL (Access Control List): a set of predetermined rules
  - Configured in firewalls, routers, switches, wireless access controllers, and etc
  - ACE (Access Control Entry): each entry of an ACL, it inspects OSI Layer 2 – 4 headers
    - Layer 2 protocol information such as EtherTypes
    - Layer 3 protocol information such as ICMP, TCP, or UDP
    - Layer 3 header information such as source and destination IP addresses
    - Layer 4 header information such as source and destination TCP or UDP ports

Packet-filtering Techniques

- ACL common practices
  - When a new ACE is added to an existing ACL, it is appended to the end of the ACL
  - When a packet enters the firewall, the ACEs are evaluated in sequential order. Hence, the order of an ACE is critical
  - Implicit deny at the end of all ACLs
  - Return traffic for TCP/UDP is automatically allowed since the connections are considered established and bidirectional
  - Return traffic for other protocols such as ICMP is automatically denied since the connections are considered unidirectional

Packet-filtering Techniques

- ACL configuration example on Cisco ASA
  - First two ACEs allow HTTP traffic destined for 10.10.202.131 and 209.165.202.131 from the two client machines
  - Last two ACEs allow SMTP access to 10.10.20.112 from both machines



```
ASA# configure terminal
ASA(config)# access-list outside_access_in remark ACL to block inbound traffic except
HTTP and SMTP
ASA(config)# access-list outside_access_in extended permit tcp host 10.10.10.1 host
10.10.202.131 eq http
ASA(config)# access-list outside_access_in extended permit tcp host 10.10.10.2 host
209.165.202.131 eq http
ASA(config)# access-list outside_access_in extended permit tcp host 10.10.10.1 host
10.10.20.112 eq smtp
ASA(config)# access-list outside_access_in extended permit tcp host 10.10.10.2 host
10.10.20.112 eq smtp
```

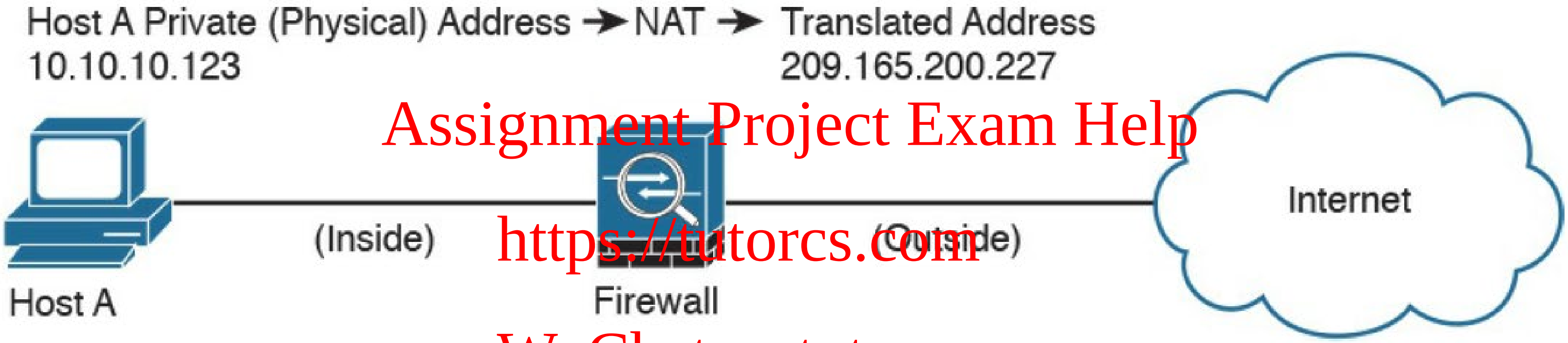
ACL configuration example (Source: [1])

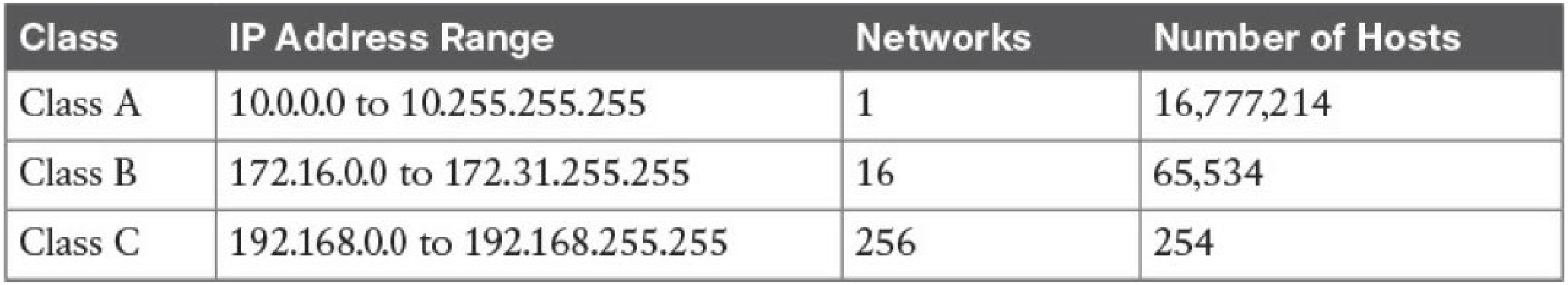
Application Proxies

- Operate as intermediary agents on behalf of clients that are on a private or protected network
- Clients on the protected network send connection requests to the application proxy to transfer data to the unprotected network or the Internet
- Application proxy (or web proxy) sends the request on behalf of the internal client
- Work at OSI Layer 7
- Most proxy firewalls can cache information to accelerate their transactions

Network Address Translation (NAT)

- NAT: translate the internal host’s private (or real) IP addresses to a publicly routable (or mapped) address, *e.g.*,



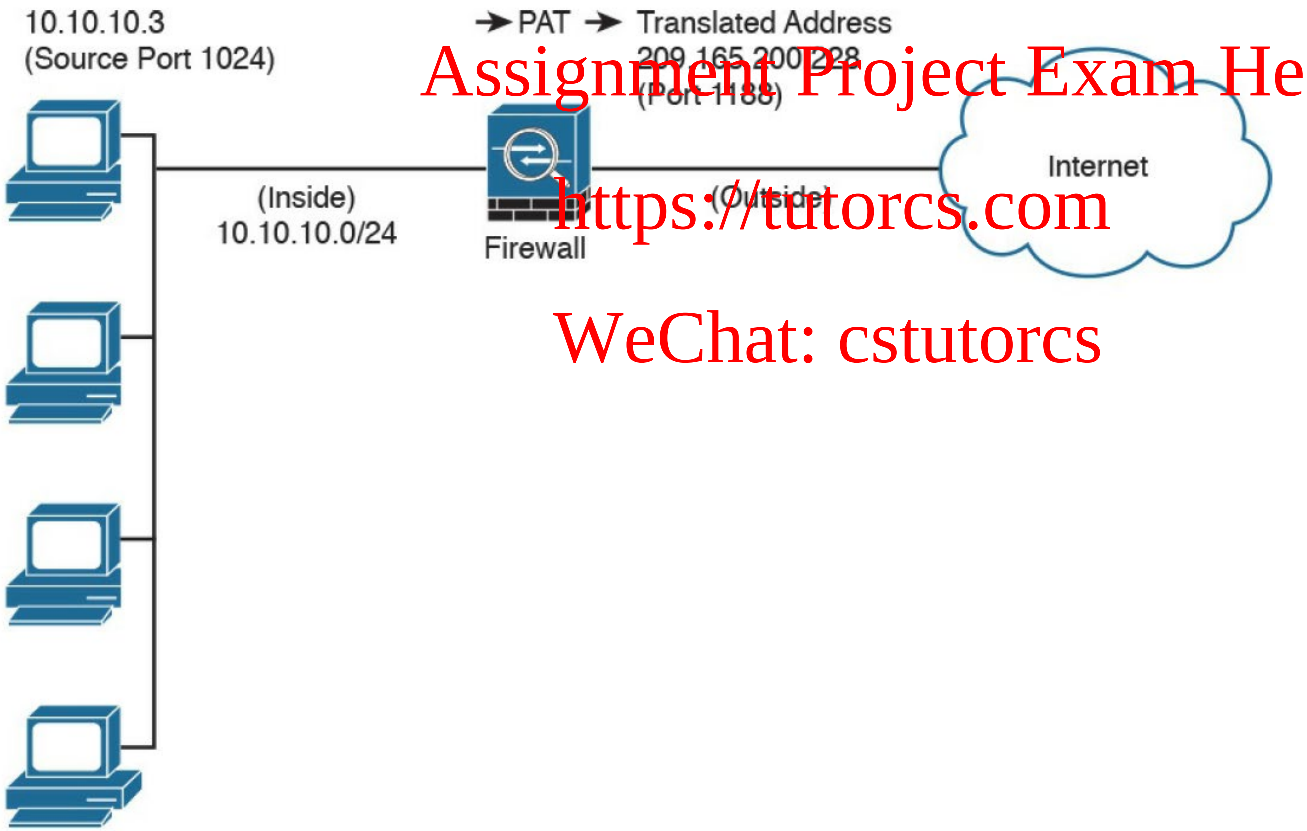


Class	IP Address Range	Networks	Number of Hosts
Class A	10.0.0.0 to 10.255.255.255	1	16,777,214
Class B	172.16.0.0 to 172.31.255.255	16	65,534
Class C	192.168.0.0 to 192.168.255.255	256	254

RFC 1918 Private Address Ranges (Source: [1])

Network Address Translation (NAT)

- Port Address Translation (PAT): a subset of NAT, it allows many devices on the internal protected network to share one IP address by inspecting the Layer 4 information on the packet, *e.g.,*



PAT (Source: [1])

Stateful Inspection Firewalls

- Track every packet passing through their interfaces by ensuring that they are valid, established connections.

- Examine not only the packet header contents but also the application layer information within the payload

- Different rules can be created on the firewall to permit or deny traffic based on specific payload patterns

- State table: database of the state of the connection detailing whether such a connection has been established, closed, reset, or is being negotiated

Next-Generation Firewalls

- Context-aware firewalls: be aware of not only the applications and users accessing the infrastructure but also the device in use, the location of the user, and the time of day

- Provide granular control of applications, comprehensive user identification, and location-based control

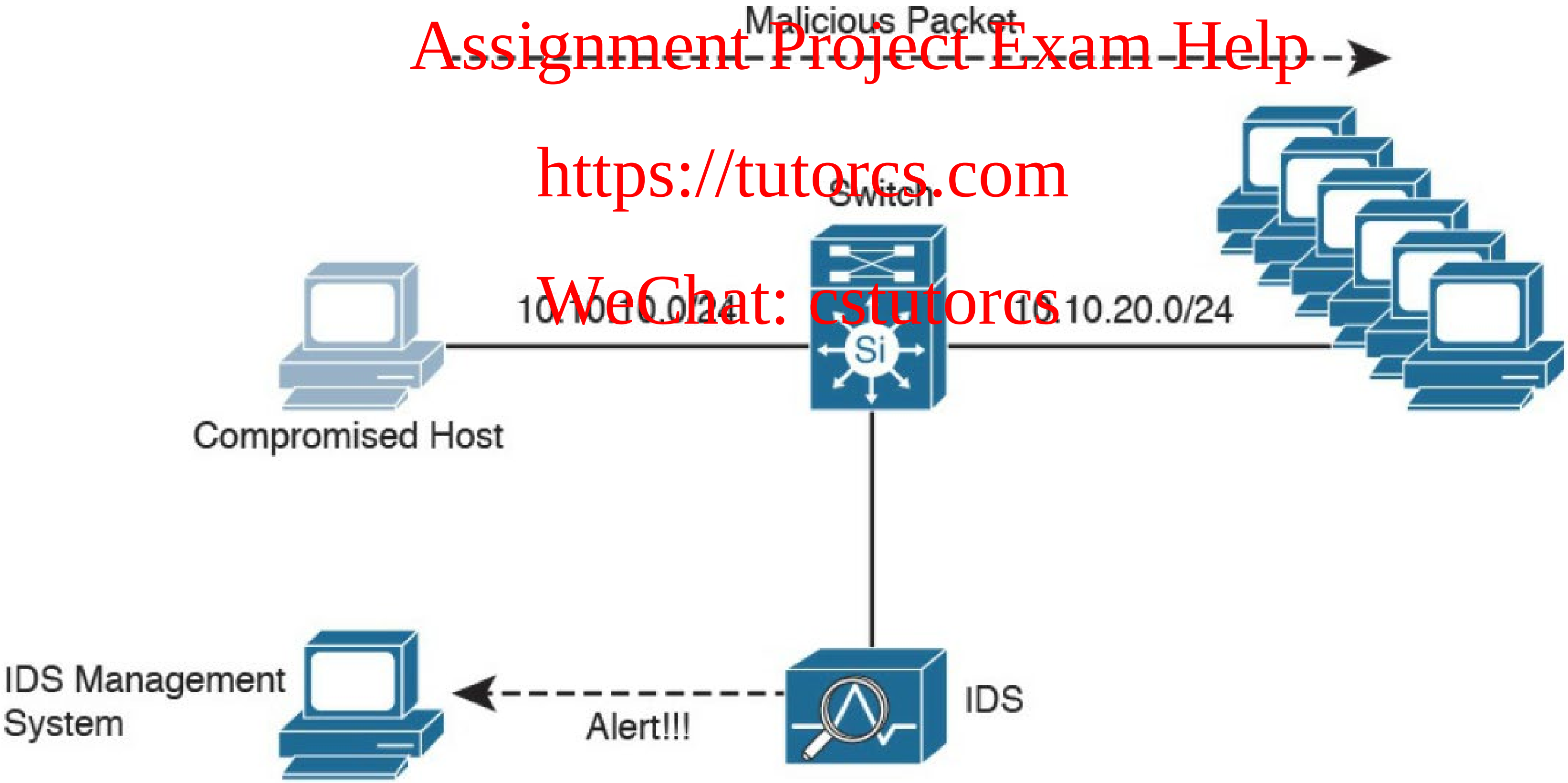
Network Security Systems

- Traditional and next-generation firewalls

- Intrusion detection systems (IDSs) & intrusion prevention systems (IPSs)

IDSs & IPSs

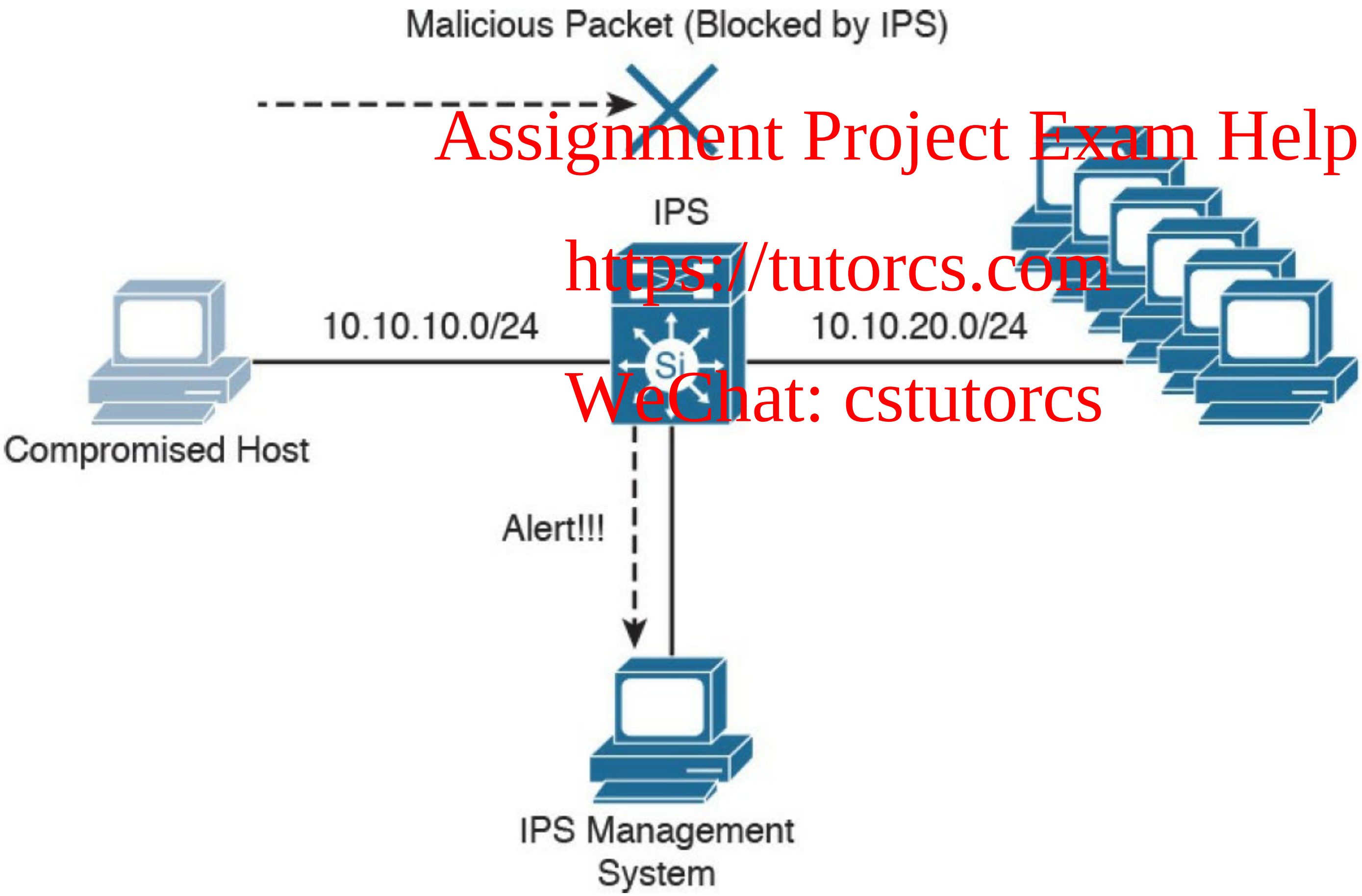
- IDSs: Devices that detect attempts from an attacker to gain unauthorized access to a network or a host, to create performance degradation, or to steal information, *e.g.*,



IDS (Source: [1])

IDSs & IPSs

- IPSs: Devices that are capable of not only detecting all security threats, but also dropping malicious packets inline, *e.g.*,



IPS (Source: [1])

IDSs & IPSs

- Detection methodologies
  - Pattern matching and stateful pattern-matching recognition
  - Protocol analysis
  - Anomaly-based analysis

Pattern Matching

- Search for a fixed sequence of bytes within the packets traversing the network

- Uses the concept of signature - a set of conditions that point out some type of intrusion occurrence, *e.g.,*
  - *"TCP packet has a destination port of 1234 and its payload contains the string ff11ff22"*

- Pros:
  - Direct correlation of an exploit
  - Trigger alerts on the pattern specified
  - Can be applied across different services and protocols

- Cons:
  - High false positives
  - High false negatives if attack pattern alters

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Stateful Pattern-Matching Recognition

- Dictate that systems performing this type of signature analysis must consider the chronological order of packets in a TCP stream, i.e., judge and maintain a stateful inspection of such packets and flows

- Pros:
  - The capability to directly correlate a specific exploit within a given pattern
  - Supports all non-encrypted IP protocols

- Cons:
  - Uncertain rate of false positives
  - Possibility of some false negatives
  - Resource intensive (Memory & CPU)

Protocol Analysis

- Decode all protocol or client-server conversations, and identify the elements of the protocol and analyse them while looking for an infringement

- Look at explicit protocol fields within the inspected packets, or more sophisticated techniques such as examination of the length of a field within the protocol or the number of arguments, e.g.,
  - *Examine specific commands and fields in SMTP protocol such as HELO, MAIL, RCPT, DATA, RSET, NOOP, and QUIT*

- Pros:
  - Low false positives if the protocol being analysed is properly defined and enforced

- Cons:
  - High false positives if the protocol definition is ambiguous or tolerates flexibility in its implementation

Anomaly-Based Analysis

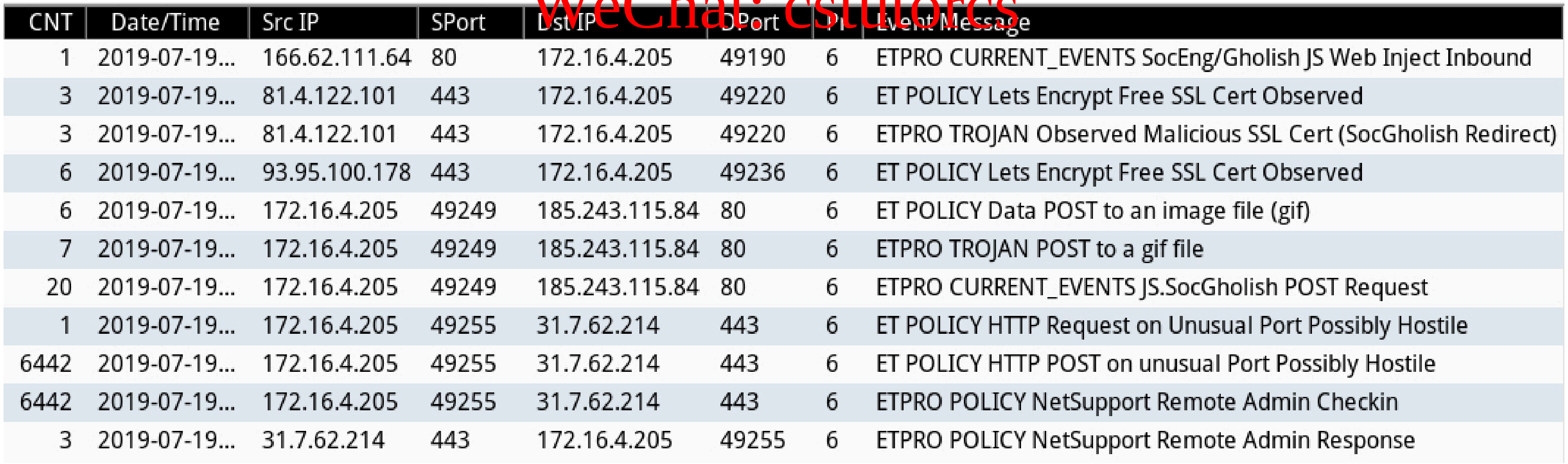
- Keep track of network traffic that diverges from “normal” behavioural patterns

- Limitation: what is considered to be normal must be defined

- Challenges: to classify a specific behaviour as normal or abnormal based on different factors below:
  - Negotiated protocols and ports
  - Specific application changes
  - Changes in the architecture of the network

Case Study – Network Attack Traffic Analysis

- LAN segment data:
  - LAN segment range: **172.16.4.0/24**
  - Domain: **mind-hammer.net**
  - Domain controller: **172.16.4.4** (Mind-Hammer-DC)
  - LAN segment gateway: **172.16.4.1**
  - LAN segment broadcast address: **172.16.4.255**
- IDS alerts triggered:

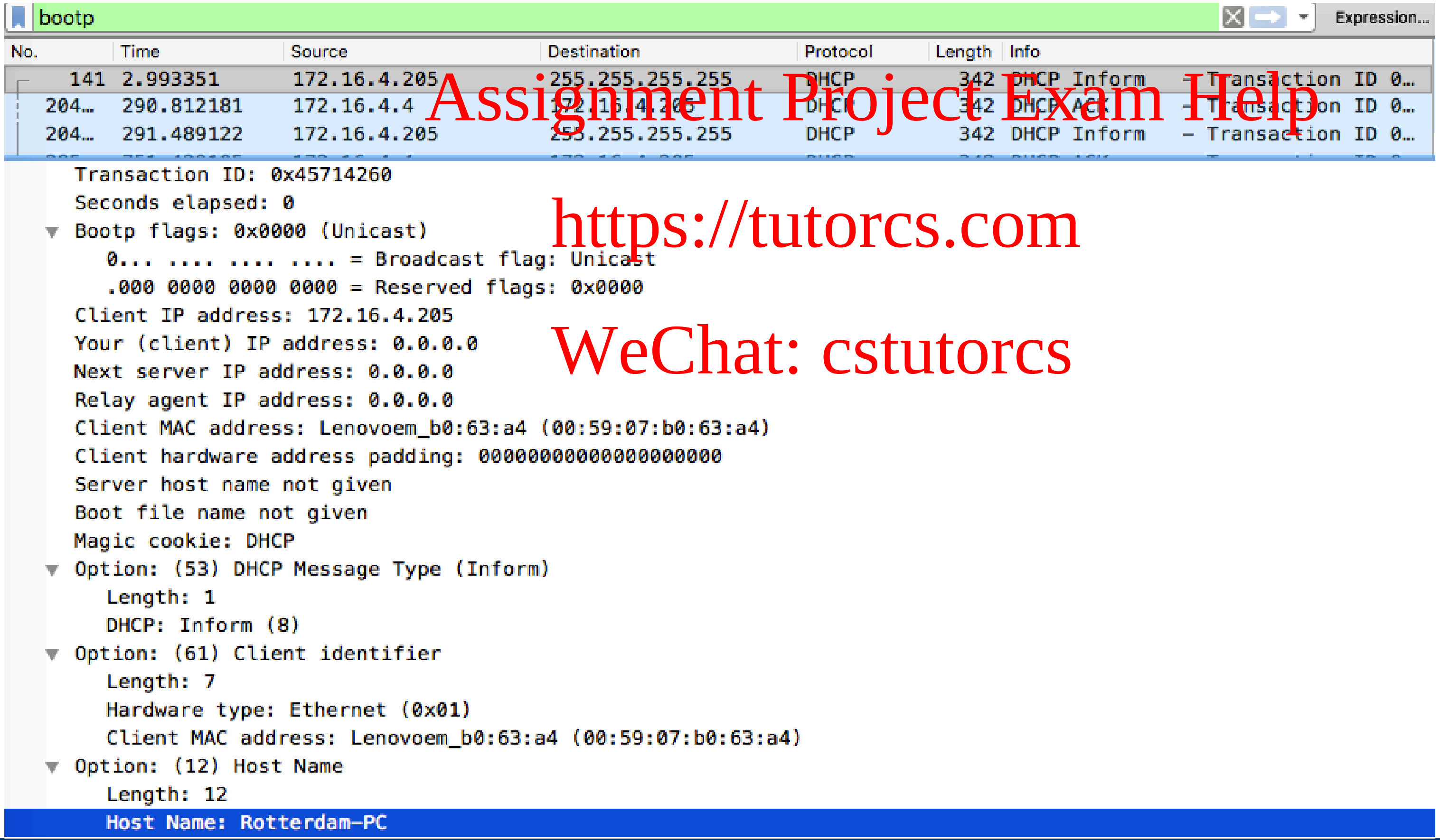


CNT	Date/Time	Src IP	SPort	Dst IP	DPort	Pr	Event Message
1	2019-07-19...	166.62.111.64	80	172.16.4.205	49190	6	ETPRO CURRENT_EVENTS SocEng/Gholish JS Web Inject Inbound
3	2019-07-19...	81.4.122.101	443	172.16.4.205	49220	6	ET POLICY Lets Encrypt Free SSL Cert Observed
3	2019-07-19...	81.4.122.101	443	172.16.4.205	49220	6	ETPRO TROJAN Observed Malicious SSL Cert (SocGholish Redirect)
6	2019-07-19...	93.95.100.178	443	172.16.4.205	49236	6	ET POLICY Lets Encrypt Free SSL Cert Observed
6	2019-07-19...	172.16.4.205	49249	185.243.115.84	80	6	ET POLICY Data POST to an image file (gif)
7	2019-07-19...	172.16.4.205	49249	185.243.115.84	80	6	ETPRO TROJAN POST to a gif file
20	2019-07-19...	172.16.4.205	49249	185.243.115.84	80	6	ETPRO CURRENT_EVENTS JS.SocGholish POST Request
1	2019-07-19...	172.16.4.205	49255	31.7.62.214	443	6	ET POLICY HTTP Request on Unusual Port Possibly Hostile
6442	2019-07-19...	172.16.4.205	49255	31.7.62.214	443	6	ET POLICY HTTP POST on unusual Port Possibly Hostile
6442	2019-07-19...	172.16.4.205	49255	31.7.62.214	443	6	ETPRO POLICY NetSupport Remote Admin Checkin
3	2019-07-19...	31.7.62.214	443	172.16.4.205	49255	6	ETPRO POLICY NetSupport Remote Admin Response

Source: www.malware-traffic-analysis.net

Case Study – Network Attack Traffic Analysis

- Q: What is the IP address, MAC address, and host name of the infected Windows host?
- A: **172.16.4.205, 00:59:07:b0:63:a4, ROTTERDAM-PC**



```
No.    Time         Source          Destination       Protocol   Length  Info
  141  2.993351     172.16.4.205    255.255.255.255   DHCP          342  DHCP Inform   – Transaction ID 0…
204…   290.812181   172.16.4.4      172.16.4.205      DHCP          342  DHCP ACK      – Transaction ID 0…
204…   291.489122   172.16.4.205    255.255.255.255   DHCP          342  DHCP Inform   – Transaction ID 0…
```

```
    Transaction ID: 0x45714260
    Seconds elapsed: 0
  ▼ Bootp flags: 0x0000 (Unicast)
       0... .... .... .... = Broadcast flag: Unicast
       .000 0000 0000 0000 = Reserved flags: 0x0000
    Client IP address: 172.16.4.205
    Your (client) IP address: 0.0.0.0
    Next server IP address: 0.0.0.0
    Relay agent IP address: 0.0.0.0
    Client MAC address: Lenovoem_b0:63:a4 (00:59:07:b0:63:a4)
    Client hardware address padding: 00000000000000000000
    Server host name not given
    Boot file name not given
    Magic cookie: DHCP
  ▼ Option: (53) DHCP Message Type (Inform)
       Length: 1
       DHCP: Inform (8)
  ▼ Option: (61) Client identifier
       Length: 7
       Hardware type: Ethernet (0x01)
       Client MAC address: Lenovoem_b0:63:a4 (00:59:07:b0:63:a4)
  ▼ Option: (12) Host Name
       Length: 12
       Host Name: Rotterdam-PC
```

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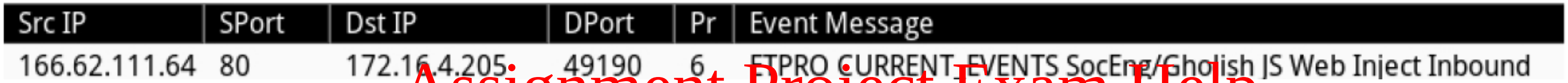
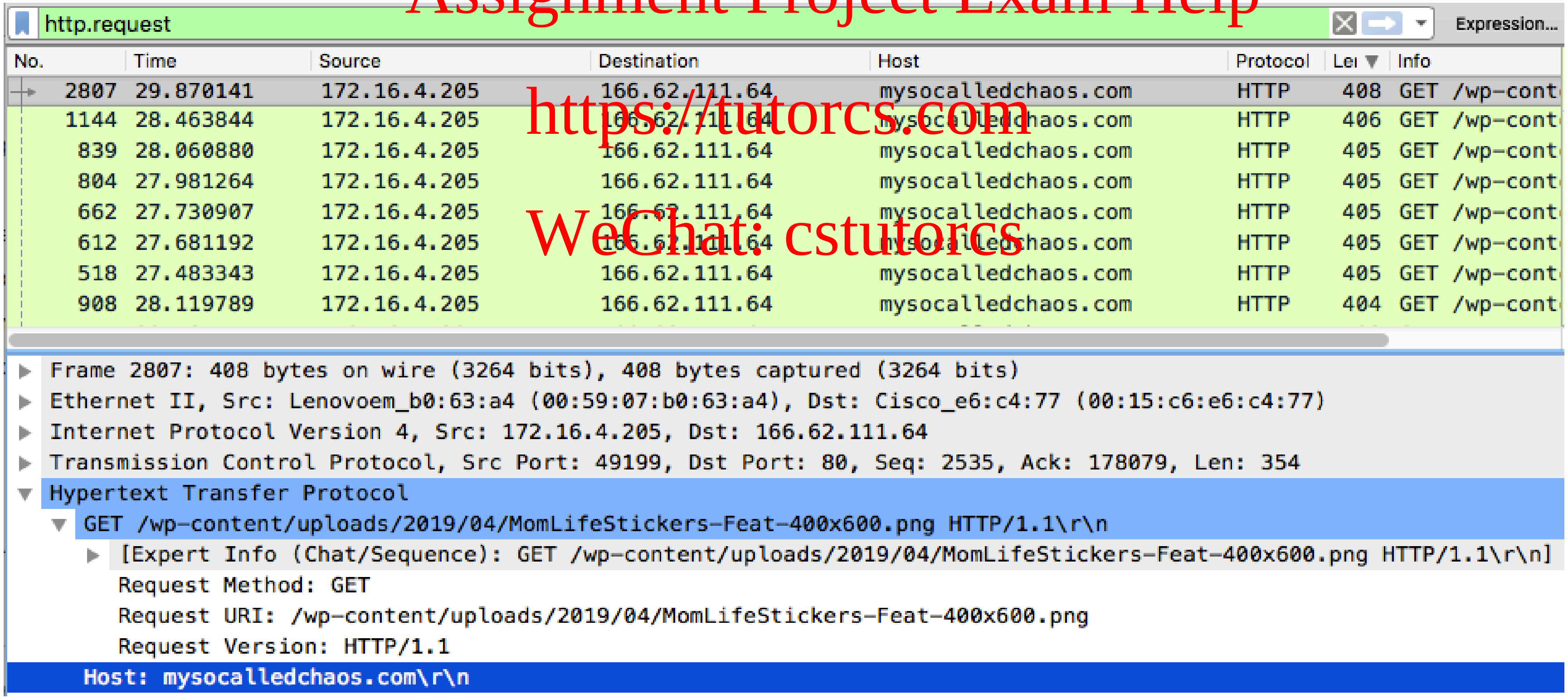
Case Study – Network Attack Traffic Analysis

- Q: Based on the alerts what is the name of the campaign that delivered the malware?
- A: **SocGholish** also known as **FakeUpdates**



Src IP	SPort	Dst IP	DPort	Pr	Event Message
166.62.111.64	80	172.16.4.205	49190	6	ETPRO CURRENT_EVENTS SocEng/Gholish JS Web Inject Inbound

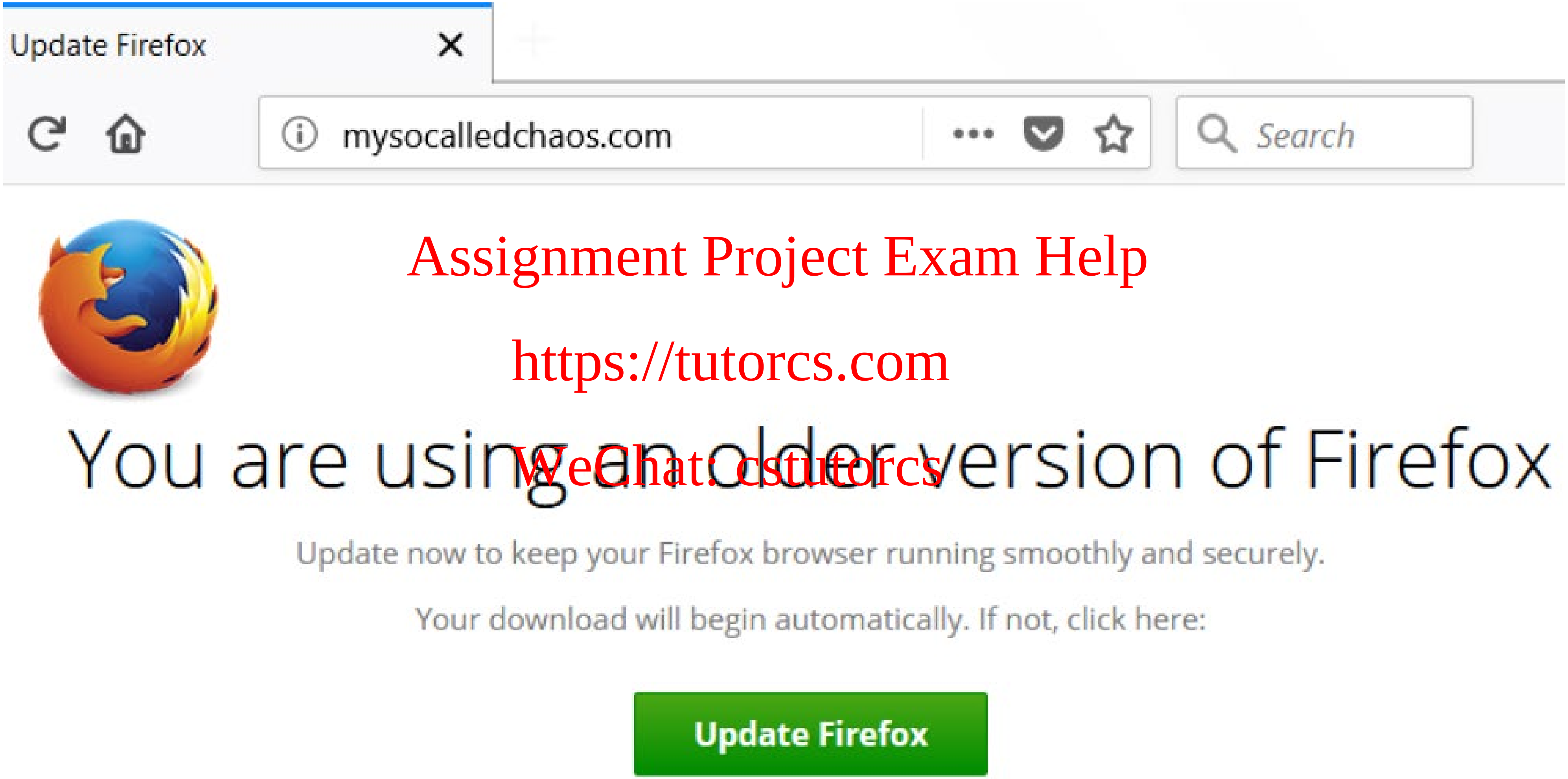


http.request

No.	Time	Source	Destination	Host	Protocol	Le	Info
2807	29.870141	172.16.4.205	166.62.111.64	mysocalledchaos.com	HTTP	408	GET /wp-cont
1144	28.463844	172.16.4.205	166.62.111.64	mysocalledchaos.com	HTTP	406	GET /wp-cont
839	28.060880	172.16.4.205	166.62.111.64	mysocalledchaos.com	HTTP	405	GET /wp-cont
804	27.981264	172.16.4.205	166.62.111.64	mysocalledchaos.com	HTTP	405	GET /wp-cont
662	27.730907	172.16.4.205	166.62.111.64	mysocalledchaos.com	HTTP	405	GET /wp-cont
612	27.681192	172.16.4.205	166.62.111.64	mysocalledchaos.com	HTTP	405	GET /wp-cont
518	27.483343	172.16.4.205	166.62.111.64	mysocalledchaos.com	HTTP	405	GET /wp-cont
908	28.119789	172.16.4.205	166.62.111.64	mysocalledchaos.com	HTTP	404	GET /wp-cont

```
▶ Frame 2807: 408 bytes on wire (3264 bits), 408 bytes captured (3264 bits)
▶ Ethernet II, Src: Lenovoem_b0:63:a4 (00:59:07:b0:63:a4), Dst: Cisco_e6:c4:77 (00:15:c6:e6:c4:77)
▶ Internet Protocol Version 4, Src: 172.16.4.205, Dst: 166.62.111.64
▶ Transmission Control Protocol, Src Port: 49199, Dst Port: 80, Seq: 2535, Ack: 178079, Len: 354
▼ Hypertext Transfer Protocol
  ▼ GET /wp-content/uploads/2019/04/MomLifeStickers-Feat-400x600.png HTTP/1.1\r\n
    ▶ [Expert Info (Chat/Sequence): GET /wp-content/uploads/2019/04/MomLifeStickers-Feat-400x600.png HTTP/1.1\r\n]
      Request Method: GET
      Request URI: /wp-content/uploads/2019/04/MomLifeStickers-Feat-400x600.png
      Request Version: HTTP/1.1
    Host: mysocalledchaos.com\r\n
```

Case Study – Network Attack Traffic Analysis



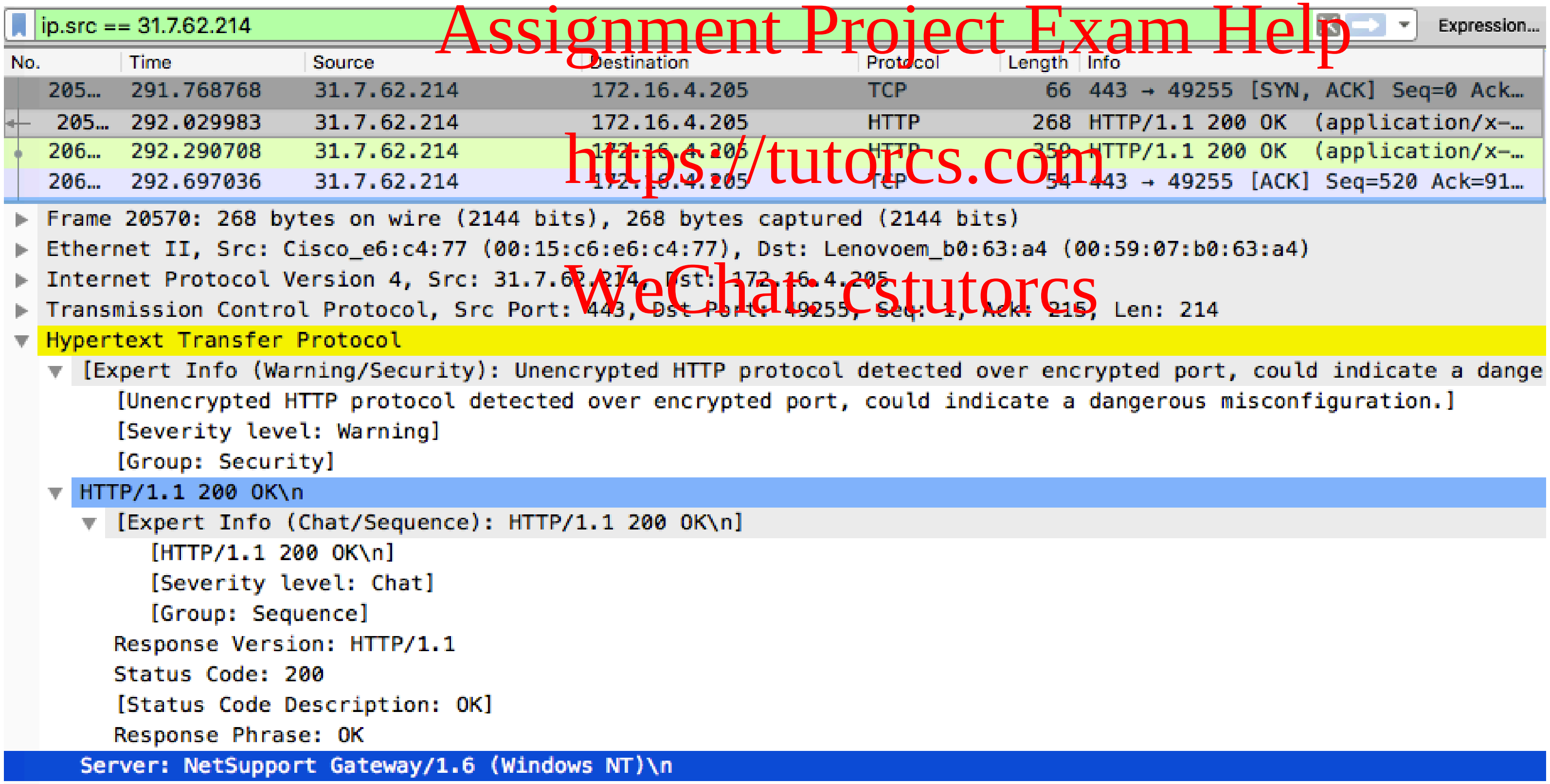
You are using an older version of Firefox

Update now to keep your Firefox browser running smoothly and securely.

Your download will begin automatically. If not, click here:

Case Study – Network Attack Traffic Analysis

- Q: Based on the alerts, what is the final malware that infected the Windows host?
- A: **NetSupport Manager RAT**. The alerts say "NetSupport Remote Admin Checkin" and "NetSupport Remote Admin Response”



ip.src == 31.7.62.214

```
No.     Time          Source          Destination     Protocol  Length  Info
205…    291.768768    31.7.62.214     172.16.4.205    TCP           66  443 → 49255 [SYN, ACK] Seq=0 Ack…
205…    292.029983    31.7.62.214     172.16.4.205    HTTP         268  HTTP/1.1 200 OK  (application/x-…
206…    292.290708    31.7.62.214     172.16.4.205    HTTP         350  HTTP/1.1 200 OK  (application/x-…
206…    292.697036    31.7.62.214     172.16.4.205    TCP           54  443 → 49255 [ACK] Seq=520 Ack=91…

▶ Frame 20570: 268 bytes on wire (2144 bits), 268 bytes captured (2144 bits)
▶ Ethernet II, Src: Cisco_e6:c4:77 (00:15:c6:e6:c4:77), Dst: Lenovoem_b0:63:a4 (00:59:07:b0:63:a4)
▶ Internet Protocol Version 4, Src: 31.7.62.214, Dst: 172.16.4.205
▶ Transmission Control Protocol, Src Port: 443, Dst Port: 49255, Seq: 1, Ack: 215, Len: 214
▼ Hypertext Transfer Protocol
  ▼ [Expert Info (Warning/Security): Unencrypted HTTP protocol detected over encrypted port, could indicate a dange
      [Unencrypted HTTP protocol detected over encrypted port, could indicate a dangerous misconfiguration.]
      [Severity level: Warning]
      [Group: Security]
  ▼ HTTP/1.1 200 OK\n
    ▼ [Expert Info (Chat/Sequence): HTTP/1.1 200 OK\n]
        [HTTP/1.1 200 OK\n]
        [Severity level: Chat]
        [Group: Sequence]
      Response Version: HTTP/1.1
      Status Code: 200
      [Status Code Description: OK]
      Response Phrase: OK
    Server: NetSupport Gateway/1.6 (Windows NT)\n
```

Summary

- More Network Attacks
  - Compare different types of attacks
  - Understand how network attacks work
  - Describe examples of different types of attacks
  - Select key patterns to detect well-known attacks

- Network Security Systems
  - Traditional and next-generation firewalls
    - Explain DMZ and network segmentation
    - Describe ACL and its common practices
    - Explain NAT & PAT process
    - Understand stateful inspection firewalls
  - IDSs & IPSs
    - Compare the difference between IDS and IPS
    - Understand different detection methodologies

- Case Study
  - Understand the network attack traffic analysis process
  - Apply the analysis process to other network attacks

Reference

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- [2] C.V.Zhou, et al., 2009, *Decentralized multi-dimensional alert correlation for collaborative intrusion detection*, Journal of Network and Computer Applications
- [3] Hossein Pirayesh, Huacheng Zeng. Jamming Attacks and Anti-Jamming Strategies in Wireless Networks: A Comprehensive Survey. Available from: https://arxiv.org/pdf/2101.00292.pdf