Information and Network Security Journal

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Implementing Substitution and Transposition Ciphers

Aim: To study and implement the Substitution and Transposition Ciphers

Theory:

Substitution Cipher:
The Substitution Cipher is one of the simplest and oldest methods of encrypting messages. It falls under the category of symmetric key encryption, meaning the same key is used for both encryption and decryption. In a Substitution Cipher, each letter in the plaintext (original message) is replaced by another letter or symbol to create the ciphertext (encrypted message). This method is called substitution because each letter is substituted with another according to a predetermined rule.

Caesar Cipher:
One of the most famous examples of a Substitution Cipher is the Caesar Cipher, named after Julius Caesar, who is believed to have used this method to protect his confidential correspondence. The Caesar Cipher involves shifting each letter in the plaintext by a fixed number of positions in the alphabet.

For example, with a shift of 3, the letter 'A' is substituted with 'D', 'B' with 'E', 'C' with 'F', and so on. This process wraps around the alphabet, so 'X' becomes 'A', 'Y' becomes 'B', and 'Z' becomes 'C'. The shift value is often referred to as the key, and it determines the mapping from plaintext to ciphertext.

Encryption Process:
To encrypt a message using the Caesar Cipher, follow these steps:

Choose a shift value (key) for the cipher.
Take the plaintext message and, for each letter:

a) Determine its position in the alphabet.
b) Shift the position by the key value.
c) Map the new position back to a letter in the alphabet.
d) Replace the original letter with the mapped letter to obtain the ciphertext.

For example, with a shift of 3, the plaintext "HELLO" would become "KHOOR" in ciphertext.

Decryption Process:
To decrypt a message encrypted with the Caesar Cipher, the recipient needs to know the shift value (key) that was used. The decryption process is the reverse of the encryption process:

Obtain the ciphertext message.
For each letter:

a) Determine its position in the alphabet.
b) Shift the position back by the key value (subtract the key).
c) Map the new position back to a letter in the alphabet.
d) Replace the original letter with the mapped letter to obtain the plaintext.

Using the same shift of 3, the ciphertext "KHOOR" would be decrypted as "HELLO".

Transposition Cipher:
The Transposition Cipher is another type of encryption method that operates by rearranging the characters or blocks of characters in the plaintext to form the ciphertext. Unlike the Substitution Cipher, which substitutes each letter with another, the Transposition Cipher preserves the original letters but changes their order. One of the well-known examples of a Transposition Cipher is the Railfence Cipher.

Railfence Cipher:
The Railfence Cipher is a basic form of a Transposition Cipher that rearranges the letters of the plaintext by writing them in a zigzag pattern along a set number of "rails." The rails are imaginary horizontal lines on which the plaintext characters are placed.

Encryption Process:
To encrypt a message using the Railfence Cipher, follow these steps:

a) Choose the number of rails (often referred to as the key) for the cipher.
b) Write the plaintext message diagonally along the rails from top to bottom and left to right.
c) Once the last rail is reached, reverse the direction and continue writing diagonally upwards until the first rail is reached again.
d) Read the characters in the zigzag pattern from left to right and from top to bottom to obtain the ciphertext

Decryption Process:
To decrypt a message encrypted with the Railfence Cipher, the recipient needs to know the number of rails (key) used during encryption. The decryption process is the reverse of the encryption process:

a) Write the ciphertext diagonally along the rails, just as it was done during encryption.
b) Read the characters from left to right and from top to bottom to obtain the plaintext.

Code: Python code for implementing Caesar Cipher

```
#A python program to illustrate Caesar Cipher Technique
def encrypt(text,s):
        result = ""

        # traverse text
        for i in range(len(text)):
                char = text[i]

                # Encrypt uppercase characters
                if (char.isupper()):
                        result += chr((ord(char) + s-65) % 26 + 65)

                # Encrypt lowercase characters
                else:
                        result += chr((ord(char) + s - 97) % 26 + 97)
        return result
#check the above function
text=input(" Enter the text to encrypt ")
s = 3
print("Text : " + text)
str(s)
print( "Cipher: " + encrypt(text,s))
```

Code: Java code for implementing Railfence Cipher

```
public class railfence {
    public static void main(String args[])
    {
        String input = "ismile";
        String output = "";
        int len = input.length(),flag = 0;

        System.out.println("Input String : " + input);
        for(int i=0;i<len;i+=2) {

            output += input.charAt(i);
        }
        for(int i=1;i<len;i+=2) {

            output += input.charAt(i);
        }
        System.out.println("Ciphered Text : "+output);
    }
}
```

Code: Python code for implementing Railfence Cipher

```
string = input("Enter a string: ")

def RailFence(txt):
   result = ""
   # First rail: characters at even indices
   for i in range(len(txt)):
      if i % 2 == 0:
         result += txt[i]
   # Second rail: characters at odd indices
   for i in range(len(txt)):
      if i % 2 != 0:
         result += txt[i]
   return result
print("Encrypted:", RailFence(string))
```

Click on the following link or scan QR for video demonstration of the given practical

https://youtu.be/1txPRg0qIbg	https://youtu.be/zcGqbAWWv-Q	https://youtu.be/W31HhqLQLRI
Railfence Cipher JAVA	Caesar Cipher	Railfence Cipher Python

RSA
Encryption and Decryption

Aim: To study and implement the RSA Encryption and Decryption

Theory:

RSA (Rivest-Shamir-Adleman) Algorithm:

RSA is a widely used asymmetric encryption algorithm that provides secure communication over untrusted networks. It is based on the mathematical problem of factoring large prime numbers, which is computationally difficult and forms the foundation of RSA's security.

Key Generation:

The RSA algorithm involves the generation of a public-private key pair. The key generation process consists of the following steps:

a) Select two distinct prime numbers, p and q.
b) Compute the modulus, N, by multiplying p and q: $N = p * q$.
c) Calculate Euler's function, $\phi(N)$, where $\phi(N) = (p - 1) * (q - 1)$.
d) Choose an integer, e, such that $1 < e < \phi(N)$ and e is coprime with $\phi(N)$. This means that e and $\phi(N)$ should have no common factors other than 1.
e) Find the modular multiplicative inverse of e modulo $\phi(N)$, denoted as d. In other words, d is an integer such that $(d * e) \% \phi(N) = 1$.
f) The public key consists of the modulus, N, and the public exponent, e. The private key consists of the modulus, N, and the private exponent, d.

Encryption Process:

To encrypt a message using RSA encryption, follow these steps:

a) Obtain the recipient's public key, which includes the modulus, N, and the public exponent, e.
b) Represent the plaintext message as an integer, M, where $0 \leq M < N$.
c) Compute the ciphertext, C, using the encryption formula: $C = M^e \bmod N$.

Decryption Process:

To decrypt a message encrypted with RSA encryption, the recipient uses their private key. Follow these steps:

a) Obtain the recipient's private key, which includes modulus, N, and the private exponent, d.
b) Receive the ciphertext, C.
c) Compute the plaintext, M, using the decryption formula: $M = C^d \bmod N$.

Security Considerations:

RSA encryption relies on the difficulty of factoring large prime numbers. The security of RSA is based on the assumption that factoring large numbers is computationally infeasible within a reasonable time frame. Breaking RSA encryption requires factoring the modulus, N, into its constituent prime factors, which becomes exponentially more difficult as N grows larger.

To ensure the security of RSA, it is essential to use sufficiently large prime numbers for key generation and to protect the private key from unauthorized access.

Code: Python code for implementing RSA Algorithm

```
from Crypto.PublicKey import RSA
from Crypto.Cipher import PKCS1_OAEP
import binascii

keyPair = RSA.generate(1024)

pubKey = keyPair.publickey()
print(f"Public key:  (n={hex(pubKey.n)}, e={hex(pubKey.e)})")
pubKeyPEM = pubKey.exportKey()
print(pubKeyPEM.decode('ascii'))

print(f"Private key: (n={hex(pubKey.n)}, d={hex(keyPair.d)})")
privKeyPEM = keyPair.exportKey()
print(privKeyPEM.decode('ascii'))

#encryption
msg = 'Ismile Academy'
encryptor = PKCS1_OAEP.new(pubKey)
encrypted = encryptor.encrypt(msg)
print("Encrypted:", binascii.hexlify(encrypted))
```

Click on the following link or scan QR-code for video demonstration of the given practical

https://youtu.be/b9RYoJ4y9Cs

Message Authentication Codes (MAC)

Aim: To study and implement the Message Authentication Code for ensuring the message intergrity and authenticity

Theory:

Message Authentication Code (MAC):

MAC is a technique used to ensure the integrity and authenticity of messages exchanged between two parties. It involves the use of a secret key and a cryptographic hash function to generate a tag or code that can be appended to the message. The receiver can verify the integrity and authenticity of the message by recomputing the MAC using the same key and hash function and comparing it with the received MAC.

MAC can be implement using various algorithms, we consider MD5 and SHA1

MD5 Algorithm:
MD5 (Message Digest Algorithm 5) is a widely used cryptographic hash function. Although it has been widely used historically, it is now considered to have vulnerabilities and is not recommended for security-critical applications. Nonetheless, it serves as an educational example for understanding MAC and cryptographic hash functions.

MAC Generation Process:
To generate a MAC using the MD5 algorithm, follow these steps:

a) Both the sender and receiver must agree on a secret key, K, which is known only to them.
b) Concatenate the message, M, and the secret key, K: ConcatenatedData = M || K (|| denotes concatenation).
c) Apply the MD5 algorithm to the ConcatenatedData to obtain the MAC: MAC = MD5(ConcatenatedData).
d) MAC Verification Process:

To verify the integrity and authenticity of a received message using the MAC, follow these steps:

a) Receive the message, M, and the MAC, MAC.
b) Concatenate the received message, M, with the secret key, K: ConcatenatedData = M || K.
c) Apply the MD5 algorithm to the ConcatenatedData to compute the recalculated MAC: RecalculatedMAC = MD5(ConcatenatedData).
d) Compare the RecalculatedMAC with the received MAC. If they match, the message is considered authentic and intact.

Security Considerations:
MD5 is no longer considered secure for cryptographic purposes due to vulnerabilities that have been discovered. It is susceptible to collision attacks, where two different inputs produce the same hash value. Therefore, it is recommended to use stronger hash functions, such as SHA-256 or SHA-3, for MAC generation in real-world applications.

Additionally, the security of MAC relies on the confidentiality and integrity of the secret key. If an attacker gains access to the secret key, they can generate valid MACs and forge messages.

SHA1 (Secure Hash Algorithm):
SHA is a family of cryptographic hash functions designed by the National Security Agency (NSA) in the United States. It provides secure one-way hashing and is widely used for various security applications. Examples include SHA-256 and SHA-3, which are stronger and more secure than MD5 or SHA-1.

MAC Generation Process:
To generate a MAC using the SHA algorithm, such as SHA-256, follow these steps:

a) Both the sender and receiver must agree on a secret key, K, which is known only to them.
b) Concatenate the message, M, and the secret key, K: ConcatenatedData = M || K (|| denotes concatenation).
c) Apply the SHA algorithm (e.g., SHA-256) to the ConcatenatedData to obtain the MAC: MAC = SHA-256(ConcatenatedData).
d) MAC Verification Process:

To verify the integrity and authenticity of a received message using the MAC, follow these steps:

a) Receive the message, M, and the MAC, MAC.
b) Concatenate the received message, M, with the secret key, K: ConcatenatedData = M || K.
c) Apply the SHA algorithm (e.g., SHA-256) to the ConcatenatedData to compute the recalculated MAC: RecalculatedMAC = SHA-256(ConcatenatedData).
d) Compare the RecalculatedMAC with the received MAC. If they match, the message is considered authentic and intact.

Security Considerations:
The security of MAC relies on the confidentiality and integrity of the secret key. If an attacker gains access to the secret key, they can generate valid MACs and forge messages. Therefore, it is crucial to employ strong key management practices to protect the secret key.

Additionally, the security of the MAC depends on the security of the underlying hash function. Strong hash functions like SHA-256 are designed to resist collision attacks and other cryptographic vulnerabilities.

Code: Python code for implementing MD5 Algorithm

```
import hashlib
result = hashlib.md5(b'Ismile')
result1 = hashlib.md5(b'Esmile')
# printing the equivalent byte value.
print("The byte equivalent of hash is : ", end ="")
print(result.digest())
print("The byte equivalent of hash is : ", end ="")
print(result1.digest())
```

Code: Python code for implementing SHA Algorithm

```
import hashlib
str = input(" Enter the value to encode ")
result = hashlib.sha1(str.encode())
print("The hexadecima equivalent if SHA1 is :  ")
print(result.hexdigest())
```

Click on the following link or scan QR-code for video demonstration of the given practical

https://youtu.be/SYe3sNQydIg

MD5

https://youtu.be/rWO6ajImQIg

SHA 1

Digital Signatures

Aim: To study and implement the Digital Signature algorithm

Theory:

Digital Signature:

Digital signatures provide a means of ensuring message integrity and authenticity in secure communication. A digital signature is a cryptographic technique that uses asymmetric encryption algorithms, such as RSA (Rivest-Shamir-Adleman), to bind the identity of the signer with the content of a message. It allows the recipient to verify the integrity of the message and authenticate the signer's identity.

RSA Algorithm:

RSA (Rivest-Shamir-Adleman) is an asymmetric encryption algorithm widely used for secure communication. It is based on the mathematical problem of factoring large prime numbers, which is computationally difficult. RSA consists of a key pair: a public key for encryption and a private key for decryption and digital signing.

Digital Signature Generation Process:

To generate a digital signature using RSA, follow these steps:

a) The signer generates a key pair: a private key (d) and a public key (e, N).
b) The signer computes the hash value of the message using a cryptographic hash function, such as SHA-256, to ensure data integrity.
c) The signer applies a mathematical function to the hash value using their private key (d) to generate the digital signature.

Digital Signature Verification Process:

To verify the authenticity and integrity of a received message using a digital signature, follow these steps:

a) The recipient obtains the signer's public key (e, N).
b) The recipient computes the hash value of the received message using the same cryptographic hash function.
c) The recipient applies a mathematical function to the received digital signature using the signer's public key (e, N).
d) The recipient compares the computed signature with the received digital signature. If they match, the message is considered authentic and intact.

Security Considerations:

The security of digital signatures relies on the following considerations:

1. Key Management: The private key used for generating the digital signature must be kept confidential and securely stored. Unauthorized access to the private key could compromise the security of the digital signature.
2. Hash Function Security: The choice of a secure cryptographic hash function is critical for ensuring the integrity of the message and preventing hash function vulnerabilities.
3. Key Length: The security of RSA is directly related to the key length used. Longer key lengths offer higher security against brute-force attacks.
4. Certificate Authorities: In real-world scenarios, digital signatures are often used with X.509 certificates issued by trusted certificate authorities (CAs). CAs validate the identity of the signer and bind it to the public key, providing a trusted mechanism for digital signature verification.

Digital signatures, based on asymmetric encryption algorithms like RSA, provide a powerful mechanism for ensuring message integrity and authenticity in secure communication. Understanding the principles of digital signatures, including the key generation process and verification steps, is crucial for undergraduate students studying practical cryptography. Additionally, awareness of key management, hash function security, and the role of trusted certificate authorities enhances the understanding of real-world digital signature implementations.

Code: Python code for implementing SHA Algorithm

```
from Crypto.Signature import PKCS1_v1_5
from Crypto.Hash import SHA256
from Crypto.PublicKey import RSA
from Crypto import Random

def generate_signature(private_key, message):
    # Load the private key
    key = RSA.importKey(private_key)

    # Generate SHA-256 hash of the message
    hashed_message = SHA256.new(message.encode('utf-8'))

    # Create a signature using the private key
    signer = PKCS1_v1_5.new(key)
    signature = signer.sign(hashed_message)

    return signature

def verify_signature(public_key, message, signature):
    # Load the public key
    key = RSA.importKey(public_key)

    # Generate SHA-256 hash of the message
    hashed_message = SHA256.new(message.encode('utf-8'))

    # Verify the signature using the public key
```

```
    verifier = PKCS1_v1_5.new(key)
    return verifier.verify(hashed_message, signature)


# Generate RSA key pair
random_generator = Random.new().read
key_pair = RSA.generate(2048, random_generator)

# Extract public and private keys
public_key = key_pair.publickey().export_key()
private_key = key_pair.export_key()

# Example usage
message = "Hello, World!"

# Generate a digital signature
signature = generate_signature(private_key, message)
print("Generated Signature:", signature)

# Verify the digital signature
is_valid = verify_signature(public_key, message, signature)
print("Signature Verification Result:", is_valid)
```

Click on the following link or scan QR-code for video demonstration of the given practical

https://youtu.be/zggIfS5sNtg

Key Exchange using Diffe-Hellman

Aim: To study and implement the Diffe-Hellman key exchange algorithm for secure exchange of keys between two entities.

Theory:

Key Exchange:
Key exchange is a fundamental concept in cryptography that allows two parties to securely establish a shared secret key over an insecure communication channel. The shared key can then be used for symmetric encryption to ensure confidentiality, integrity, and authenticity of the communication. One widely used key exchange algorithm is the Diffie-Hellman algorithm.

Key Exchange Techniques:
Key exchange techniques enable secure key establishment between two parties. There are two main types of key exchange techniques:

1) Symmetric Key Exchange
2) Asymmetric Key Exchange

Symmetric Key Exchange:
In symmetric key exchange, both parties share a pre-established secret key. This key is typically distributed using a secure out-of-band method. Once the secret key is shared, it can be used for secure communication. However, this approach requires prior key sharing and becomes impractical for scenarios where a large number of participants need to securely communicate

Asymmetric Key Exchange:
Asymmetric key exchange, also known as public key exchange, overcomes the limitations of symmetric key exchange by using asymmetric encryption algorithms. It allows two parties who have never communicated before to establish a shared secret key without any prior key sharing. Asymmetric key exchange is based on the concept of public and private key pairs, where the public key is widely known and the private key is kept secret.

Diffie-Hellman Algorithm:

The Diffie-Hellman algorithm is a widely used asymmetric key exchange algorithm. It enables two parties to securely establish a shared secret key over an insecure communication channel.

High-level working explanation of the Diffie-Hellman algorithm:

a) Select a large prime number, p, and a primitive root modulo p, g. These values are publicly known.
b) Each party, Alice and Bob, generates a private key, a and b, respectively.
c) Both Alice and Bob calculate their public keys:
d) Alice: $A = g^a \bmod p$
e) Bob: $B = g^b \bmod p$
f) Alice and Bob exchange their public keys over the insecure channel.

Key Generation:

a) Alice calculates the shared secret key using Bob's public key:
b) Secret Key: $K = B^a \bmod p$
c) Bob calculates the shared secret key using Alice's public key:
d) Secret Key: $K = A^b \bmod p$

Key Agreement:

Both Alice and Bob have calculated the same shared secret key, K, independently.
They can now use K as the shared secret key for symmetric encryption algorithms to ensure secure communication.

Security Considerations:

The security of the Diffie-Hellman algorithm relies on the following considerations:

1) Large Prime Numbers: The security of the algorithm is based on the difficulty of the discrete logarithm problem. Using large prime numbers ensures the security of the shared secret key.
2) Public Key Distribution: The public keys exchanged during the key exchange process should be authenticated to prevent man-in-the-middle attacks. Techniques like digital signatures or certificate authorities can be used for authentication.
3) Key Length: Longer key lengths provide stronger security against brute-force attacks. It is important to use an appropriate key length for the prime number to ensure the desired security level.

Conclusion:

Key exchange techniques play a crucial role in establishing secure communication channels between parties. The Diffie-Hellman algorithm, as an example of asymmetric key exchange, allows two parties to securely establish a shared secret key over an insecure channel. Understanding the principles of key exchange, including the Diffie-Hellman algorithm and its security considerations, is essential for undergraduate students studying practical cryptography..

Code: Python code for implementing Diffie-Hellman Algorithm

```
from random import randint
if __name__ == '__main__':

    P = 23
    G = 9

    print('The Value of P is :%d'%(P))
    print('The Value of G is :%d'%(G))

    a = 4
    print('Secret Number for Alice is :%d'%(a))

    x = int(pow(G,a,P))

    b = 6
    print('Secret Number for Bob is :%d'%(b))

    y = int(pow(G,b,P))

    ka = int(pow(y,a,P))

    kb = int(pow(x,b,P))

    print('Secret key for the Alice is : %d'%(ka))
    print('Secret Key for the Bob is : %d'%(kb))
```

Click on the following link or scan QR-code for video demonstration of the given practical

https://youtu.be/LYtbQiy7OzM

Click on the following link or scan QR-code for a simple animated video to explain the working of Diffie-Hellman Algorithm

https://youtu.be/ozjG1CtP-1c

IP Security (IPsec) Configuration

Aim: To configure IPsec on network devices to provide secure communication and protect against unauthorized access and attacks.

Theory:

IPSec
IPSec (Internet Protocol Security) is a suite of protocols designed to ensure secure communication over IP networks. It operates at the network layer, and it provides:

1. Confidentiality (Encryption)
2. Integrity (Data not altered)
3. Authentication (Sender verification)
4. Anti-replay protection

IPSec Protocol Components:

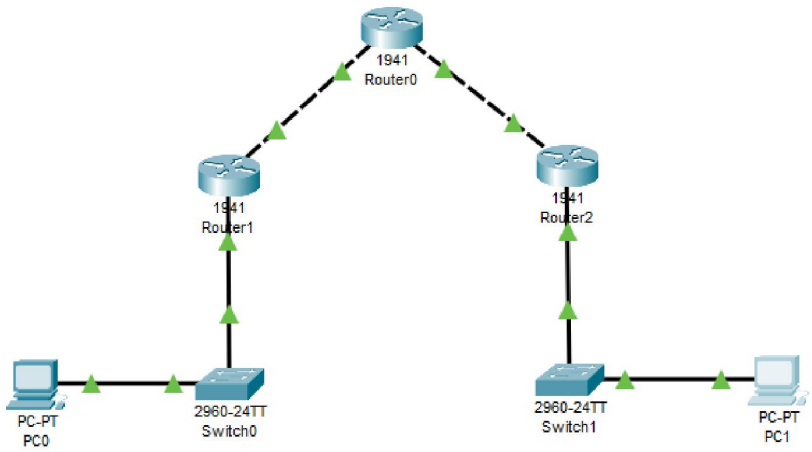
1. AH (Authentication Header) – provides data integrity and authentication.
2. ESP (Encapsulating Security Payload) – provides confidentiality, integrity, and authentication.
3. IKE (Internet Key Exchange) – negotiates and manages security associations (SAs).

Modes of Operation:

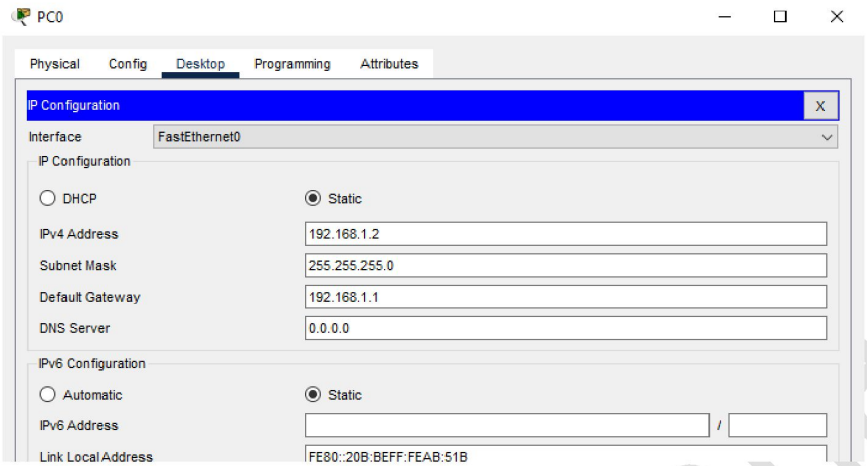
1. Transport Mode – Only the payload of the IP packet is encrypted or authenticated.
2. Tunnel Mode – The entire IP packet is encrypted and a new IP header is added.

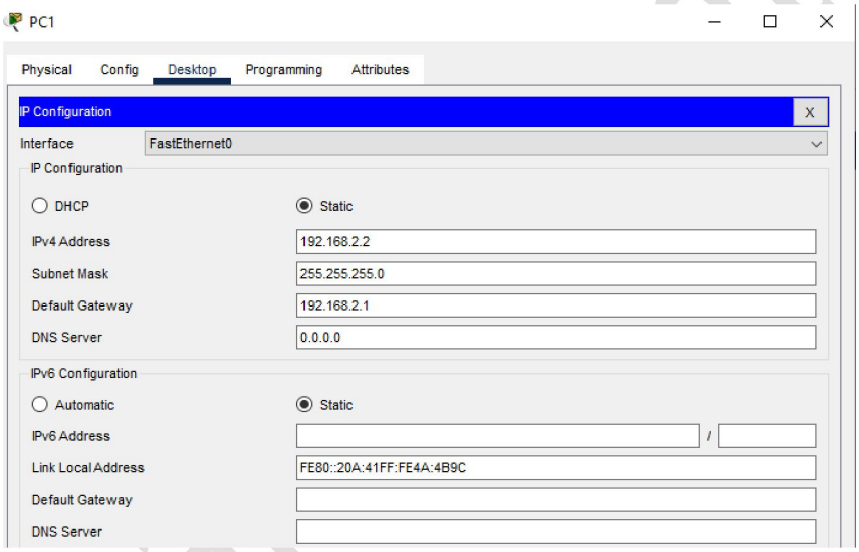
Topology:

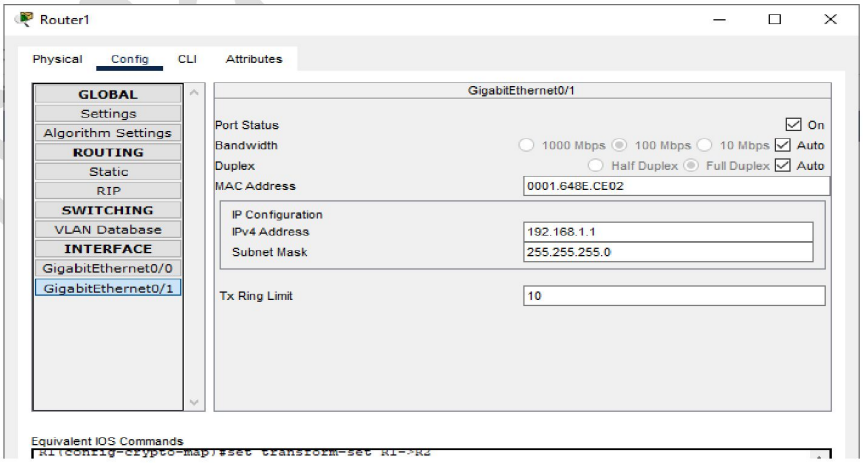
We use the following topology



We configure the interfaces as follows


PC0
Physical
Config
Desktop
Programming
Attributes
IP Configuration
Interface
FastEthernet0
IP Configuration
DHCP
Static
IPv4 Address
192.168.1.2
Subnet Mask
255.255.255.0
Default Gateway
192.168.1.1
DNS Server
0.0.0.0
IPv6 Configuration
Automatic
Static
IPv6 Address
Link Local Address
FE80::20B:BEFF:FEAB:51B


PC1
Physical
Config
Desktop
Programming
Attributes
IP Configuration
Interface
FastEthernet0
IP Configuration
DHCP
Static
IPv4 Address
192.168.2.2
Subnet Mask
255.255.255.0
Default Gateway
192.168.2.1
DNS Server
0.0.0.0
IPv6 Configuration
Automatic
Static
IPv6 Address
Link Local Address
FE80::20A:41FF:FE4A:4B9C
Default Gateway
DNS Server


Router1
Physical
Config
CLI
Attributes
GLOBAL
Settings
Algorithm Settings
ROUTING
Static
RIP
SWITCHING
VLAN Database
INTERFACE
GigabitEthernet0/0
GigabitEthernet0/1
GigabitEthernet0/1
Port Status
On
Bandwidth
1000 Mbps
100 Mbps
10 Mbps
Auto
Duplex
Half Duplex
Full Duplex
Auto
MAC Address
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IP Configuration
IPv4 Address
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Subnet Mask
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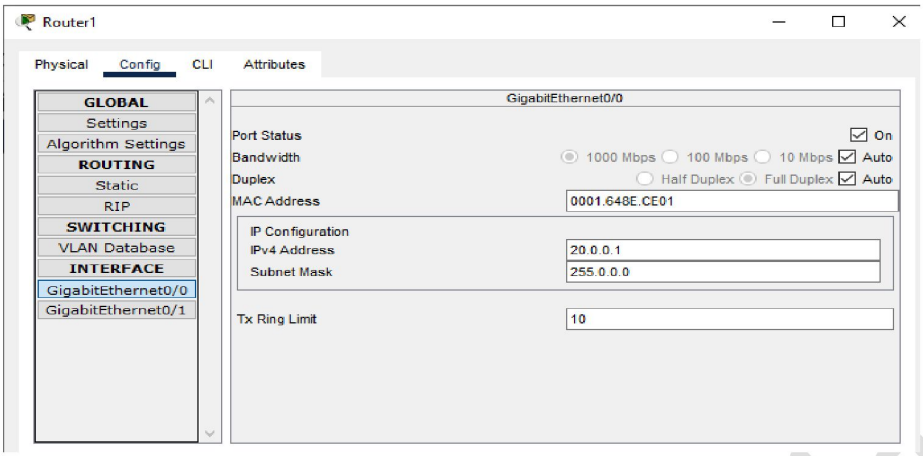
Tx Ring Limit
10
Equivalent IOS Commands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GLOBAL
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Algorithm Settings
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Static
RIP
SWITCHING
VLAN Database
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GigabitEthernet0/1
GigabitEthernet0/0
Port Status
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1000 Mbps
100 Mbps
10 Mbps
Auto
Duplex
Half Duplex
Full Duplex
Auto
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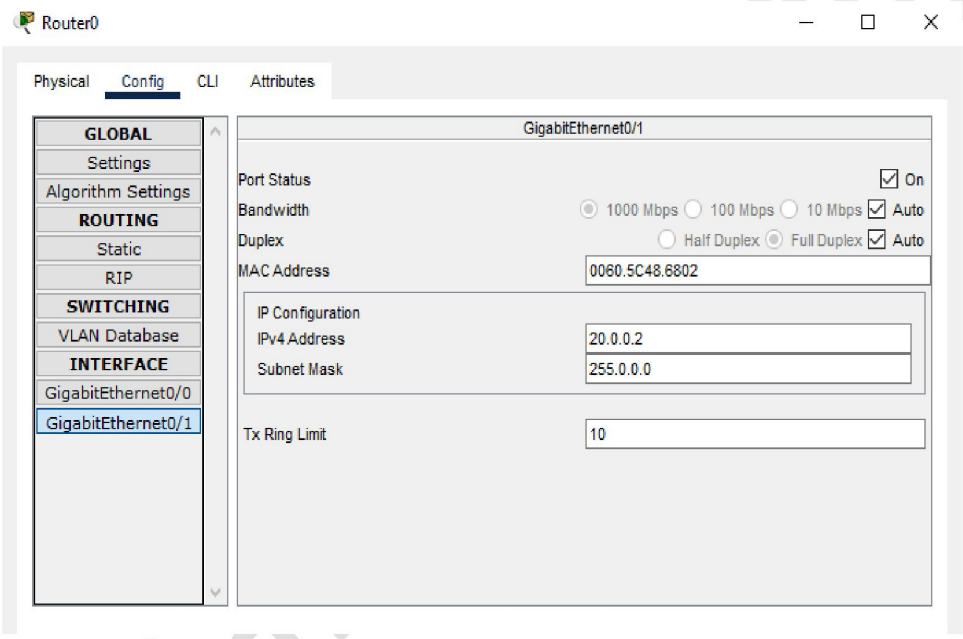
Tx Ring Limit
10


Router0
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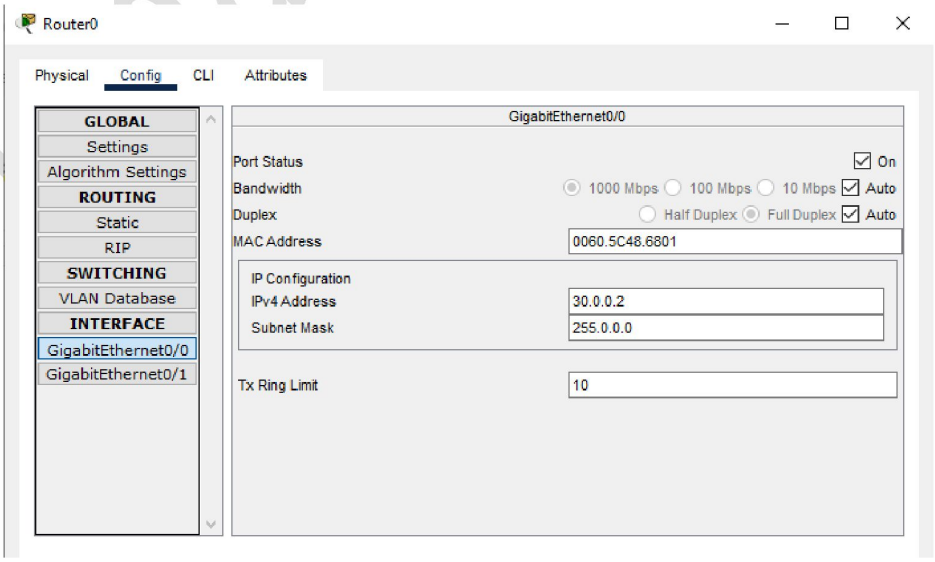
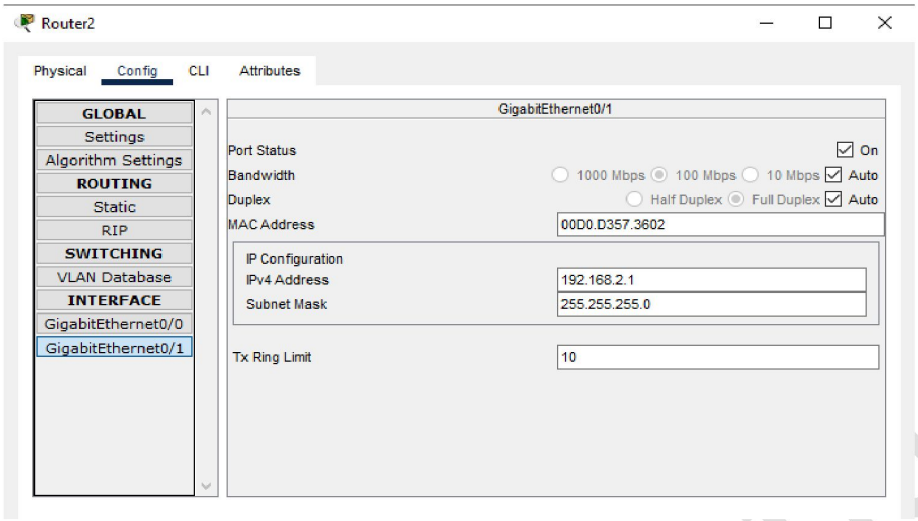
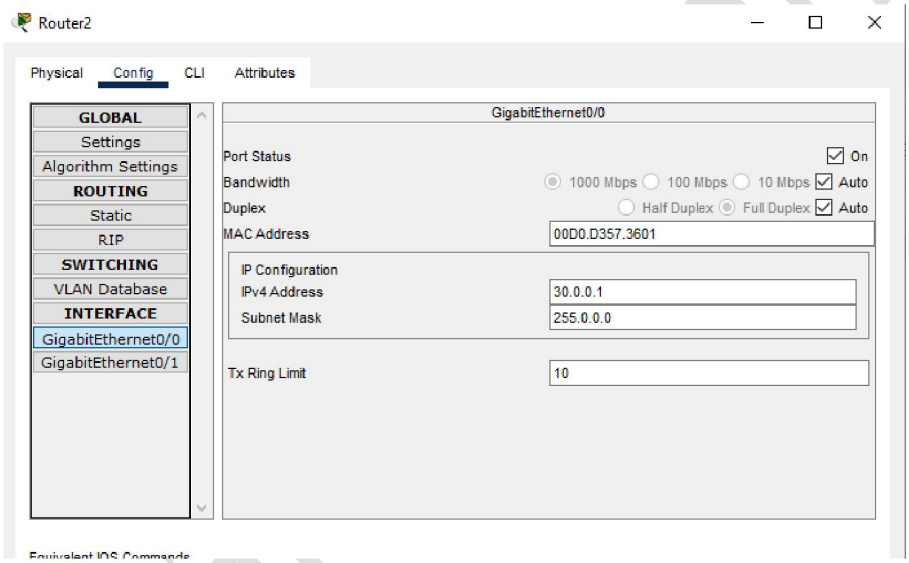
Attributes
GLOBAL
Settings
Algorithm Settings
ROUTING
Static
RIP
SWITCHING
VLAN Database
INTERFACE
GigabitEthernet0/0
GigabitEthernet0/1
GigabitEthernet0/1
Port Status
On
Bandwidth
1000 Mbps
100 Mbps
10 Mbps
Auto
Duplex
Half Duplex
Full Duplex
Auto
MAC Address
0060.5C48.6802
IP Configuration
IPv4 Address
20.0.0.2
Subnet Mask
255.0.0.0
Tx Ring Limit
10


Router0
Physical
Config
CLI
Attributes
GLOBAL
Settings
Algorithm Settings
ROUTING
Static
RIP
SWITCHING
VLAN Database
INTERFACE
GigabitEthernet0/0
GigabitEthernet0/1
GigabitEthernet0/0
Port Status
On
Bandwidth
1000 Mbps
100 Mbps
10 Mbps
Auto
Duplex
Half Duplex
Full Duplex
Auto
MAC Address
0060.5C48.6801
IP Configuration
IPv4 Address
30.0.0.2
Subnet Mask
255.0.0.0
Tx Ring Limit
10





Configuring R1 for IPSec

```
R1>
R1>enable
R1#
R1#configure terminal
R1(config)#
R1(config)#access-list 100 permit ip 192.168.1.0 0.0.0.255 192.168.2.0 0.0.0.255
R1(config)#
R1(config)#crypto isakmp policy 10
R1(config-isakmp)#
R1(config-isakmp)#encryption aes 256
R1(config-isakmp)#
R1(config-isakmp)#authentication pre-share
R1(config-isakmp)#
R1(config-isakmp)#group 5
R1(config-isakmp)#
```

```
R1(config-isakmp)#exit
R1(config)#
R1(config)#crypto isakmp key ismile address 30.0.0.1
R1(config)#
R1(config)#crypto ipsec transform-set R1->R2 esp-aes 256 esp-sha-hmac
R1(config)#
R1(config)#crypto map IPSEC-MAP 10 ipsec-isakmp
R1(config-crypto-map)#set peer 30.0.0.1
R1(config-crypto-map)#set pfs group5
R1(config-crypto-map)#
R1(config-crypto-map)#set security-association lifetime seconds 86400
R1(config-crypto-map)#
R1(config-crypto-map)#set transform-set R1->R2
R1(config-crypto-map)#
R1(config-crypto-map)#match address 100
R1(config-crypto-map)#exit
R1(config)#inter
R1(config)#interface g0/0
R1(config-if)#cr
R1(config-if)#crypto map IPSEC-MAP
```

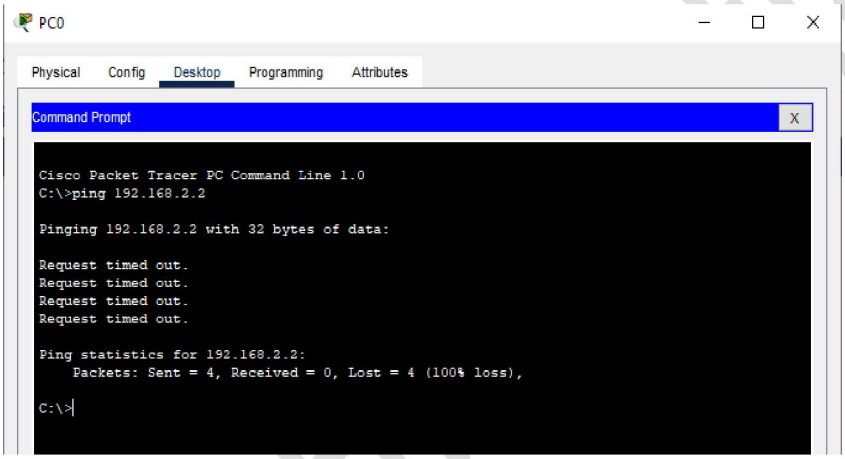
Configuring R1 for IPSec

```
R2>en
R2#
R2#
R2#configure terminal
R2(config)#
R2(config)#
R2(config)#access-list 100 permit ip 192.168.2.0 0.0.0.255 192.168.1.0 0.0.0.255
R2(config)#
R2(config)#crypto isakmp policy 10
R2(config-isakmp)#
R2(config-isakmp)#encryption aes 256
R2(config-isakmp)#
R2(config-isakmp)#authentication pre-share
R2(config-isakmp)#group 5
R2(config-isakmp)#exit
R2(config)#
R2(config)#crypto isakmp key ismile address 20.0.0.1
R2(config)#
R2(config)#crypto ipsec transform-set R2->R1 esp-aes 256 esp-sha-hmac
R2(config)#
R2(config)#exit
R2(config)#crypto map IPSEC-MAP 10 ip
R2(config-crypto-map)#set peer 20.0.0.1
R2(config-crypto-map)#set pfs group5
R2(config-crypto-map)#
R2(config-crypto-map)#set security-association lifetime seconds 86400
```

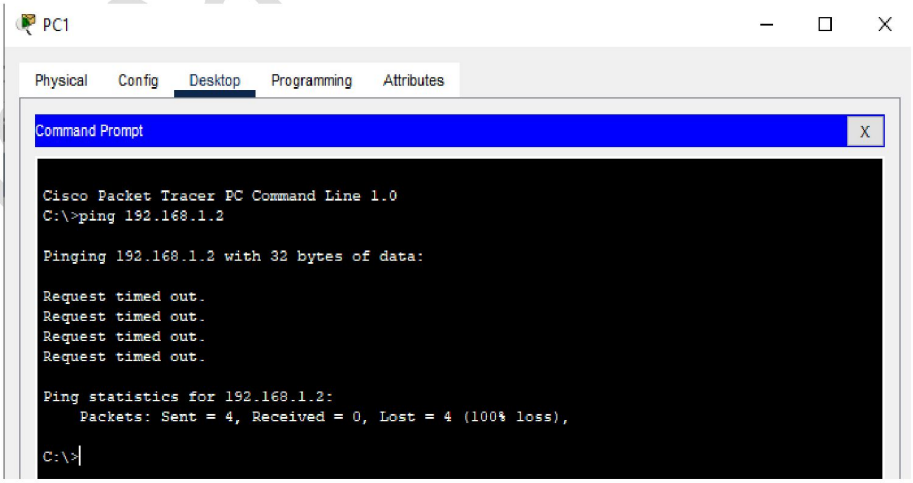
```
R2(config-crypto-map)#
R2(config-crypto-map)#set transform-set R2->R1
R2(config-crypto-map)#
R2(config-crypto-map)#match address 100
R2(config-crypto-map)#exit
R2(config)#
R2(config)#interface g0/0
R2(config-if)#
R2(config-if)#crypto map IPSEC-MAP
```

We verify the working as follows

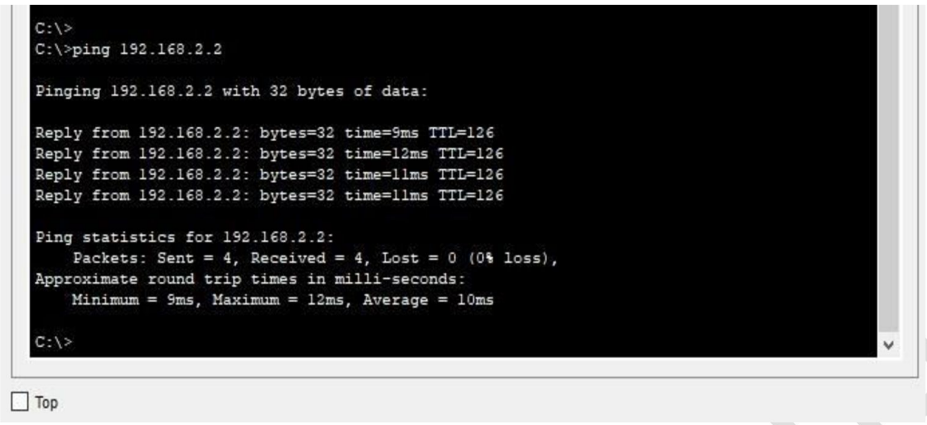
Pinging PC0:



Pinging PC1:



Pinging PC2:



Click on the following link or scan QR-code for video demonstration of the given practical

https://youtu.be/QHR6cbvB6X0

Firewall Configuration and Rule-based Filtering

Aim: To configure and test firewall rules to control network traffic, filter packets based on specified criteria, and protect network resources from unauthorized access.

Theory: Windows Firewall is a network security system that monitors and controls incoming and outgoing network traffic based on predetermined security rules. It helps protect your computer from unauthorized access and potential cyber threats.

Key concepts:

1. Port Blocking: Prevents communication through specific network ports used by certain applications.
2. Program Blocking: Stops a specific application from accessing the network.
3. Website Blocking: Restricts access to specific websites using IP or domain name rules.

Requirements:

1. Windows 10/11 operating system
2. Administrative privileges
3. Target program, port number, and website URL for testing

Procedure:

1. Opening Windows Firewall
   a. Press Windows + R, type control, and press Enter.
   b. Navigate to: System and Security → Windows Defender Firewall.

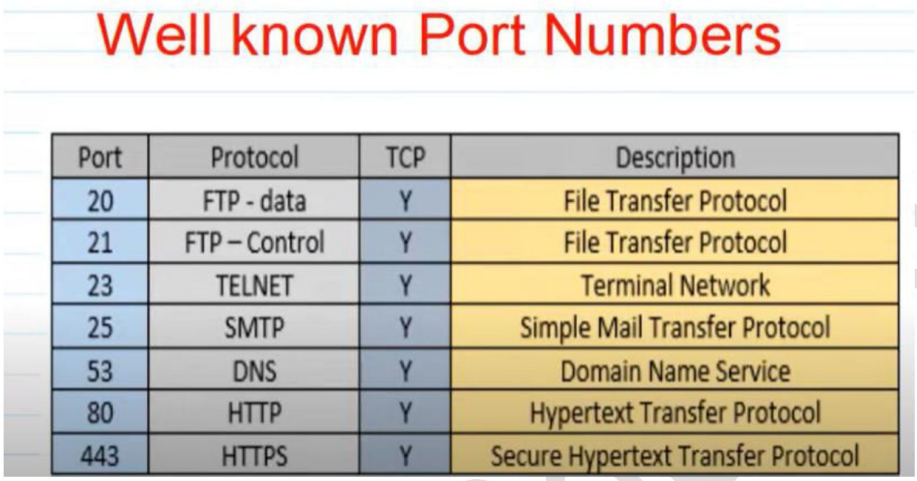
2. Blocking a Port
   a. Click Advanced settings on the left panel.
   b. Select Inbound Rules → New Rule.
   c. Choose Port and click Next.
   d. Select TCP or UDP (as required) and enter the port number (e.g., 80 for HTTP).
   e. Select Block the connection and click Next.
   f. Apply to all profiles (Domain, Private, Public).
   g. Give the rule a name (e.g., Block Port 80) and click Finish.

3. Blocking a Program
   a. In Advanced settings, go to Outbound Rules → New Rule.
   b. Select Program and click Next.
   c. Browse and select the executable file (.exe) of the program to block.
   d. Select Block the connection and click Next.
   e. Apply to all profiles and name the rule (e.g., Block Chrome).

4. Blocking a Website
   a. Find the IP address of the website by using ping command in Command Prompt: nslookup abcd.com
   b. Note the ipv4 and ipv6 addresses
   c. In Advanced settings, go to Outbound Rules → New Rule.

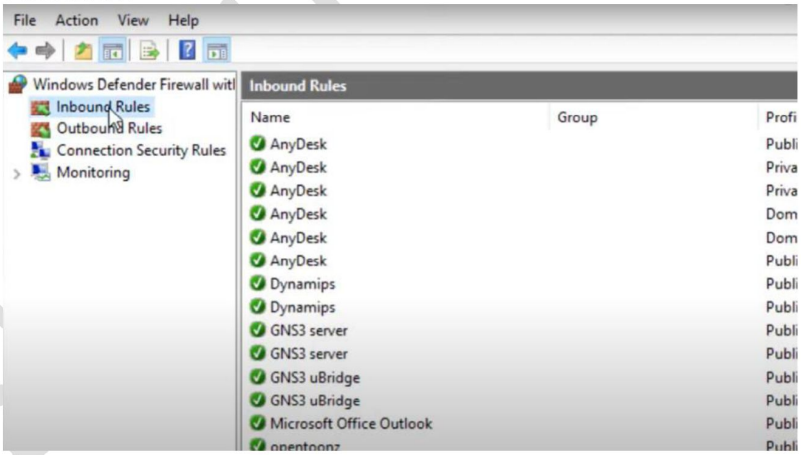
d. Choose Custom and click Next.

e. Under Which remote IP addresses does this rule apply to choose These IP addresses and add the website's IP.
f. Select Block the connection and finish the setup.

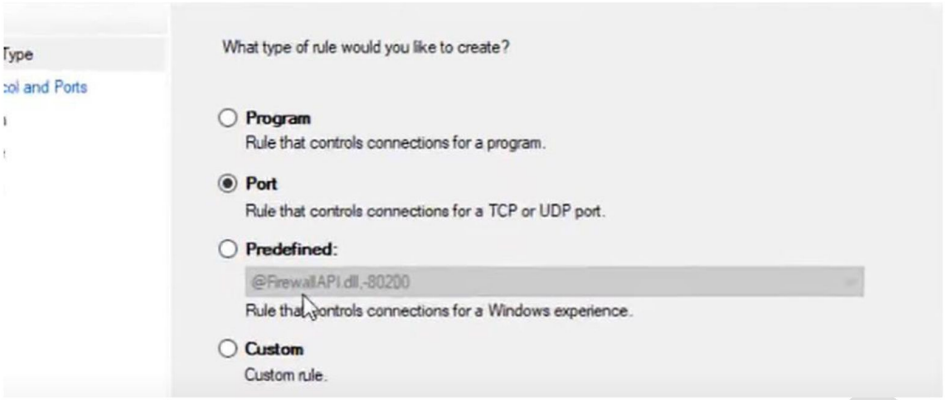


Blocking a port: We do the following steps

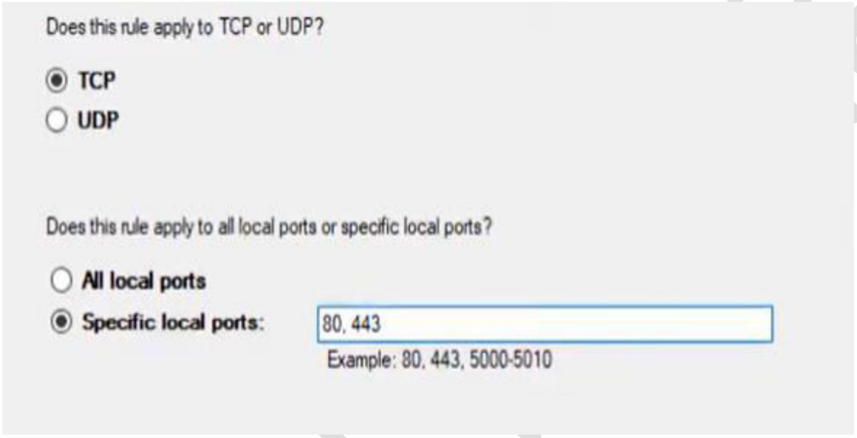
We click on Inbound Rules:



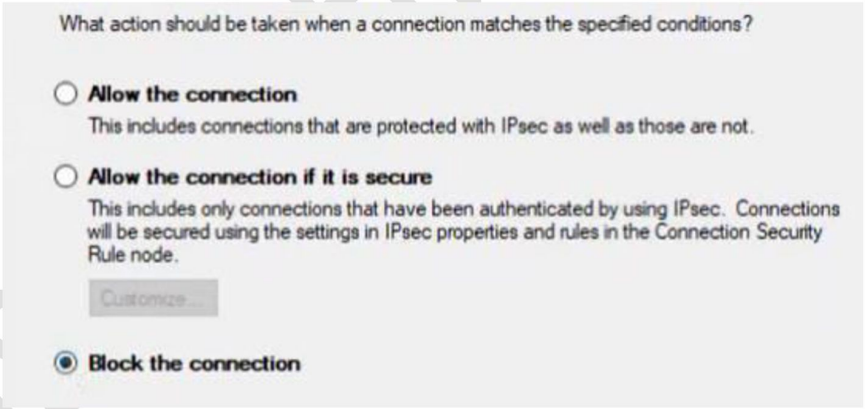
Next select the PORT



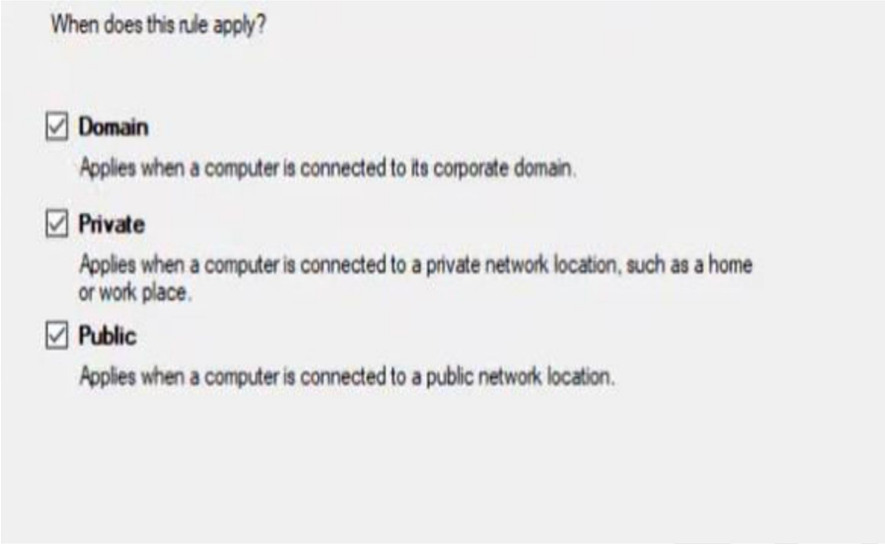
Select TCP option and Specify the Ports which are to be blocked



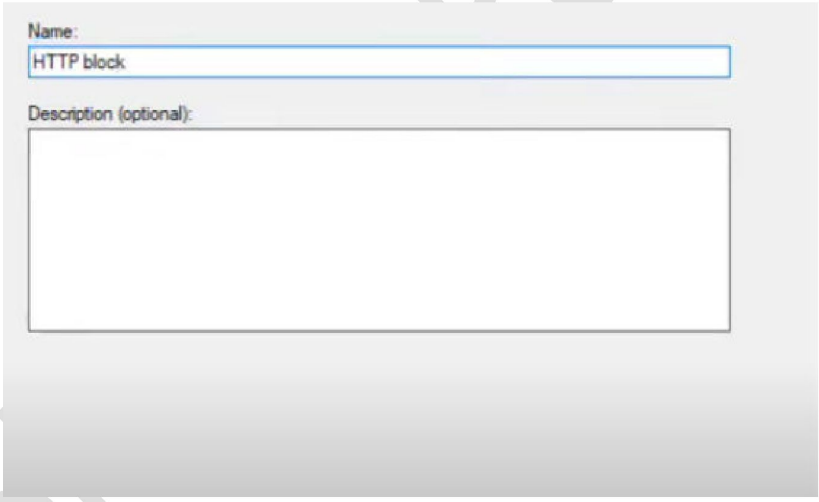
Block the connection:



Apply the rule:

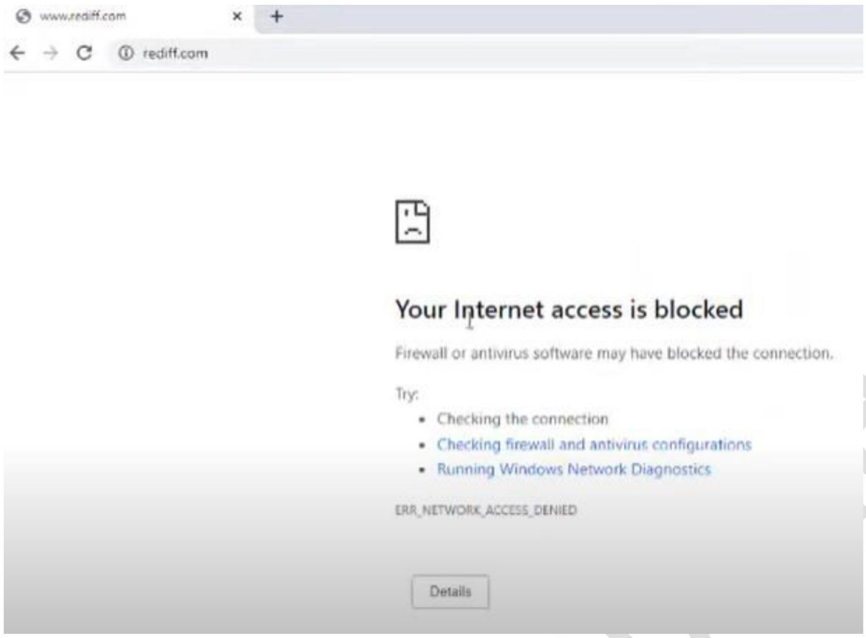


Name the Rule:



Repeat the above for outbound rule.

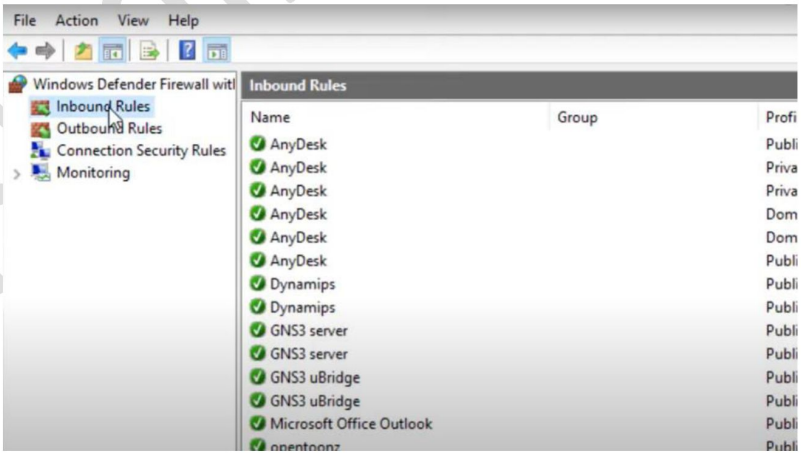
Test the rule



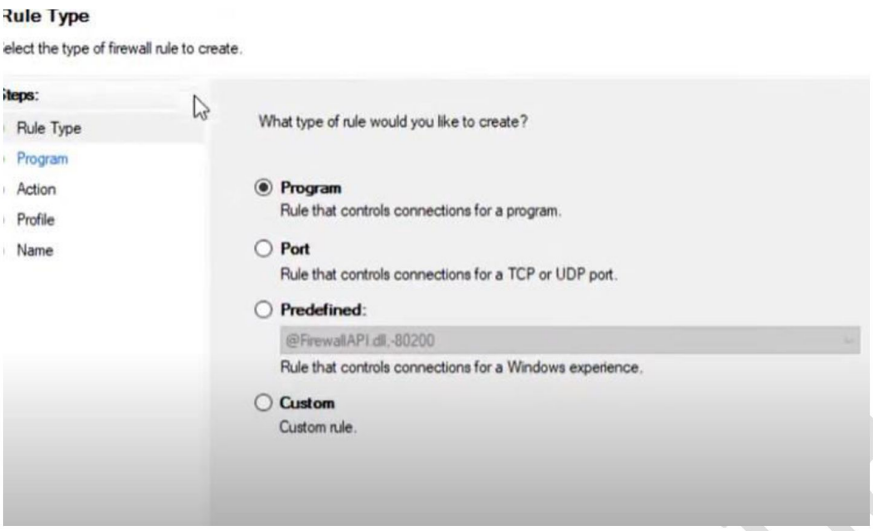
Hence we see that the rule works well and the port 80, 443 which is http and https is blocked

Blocking a program: We do the following steps

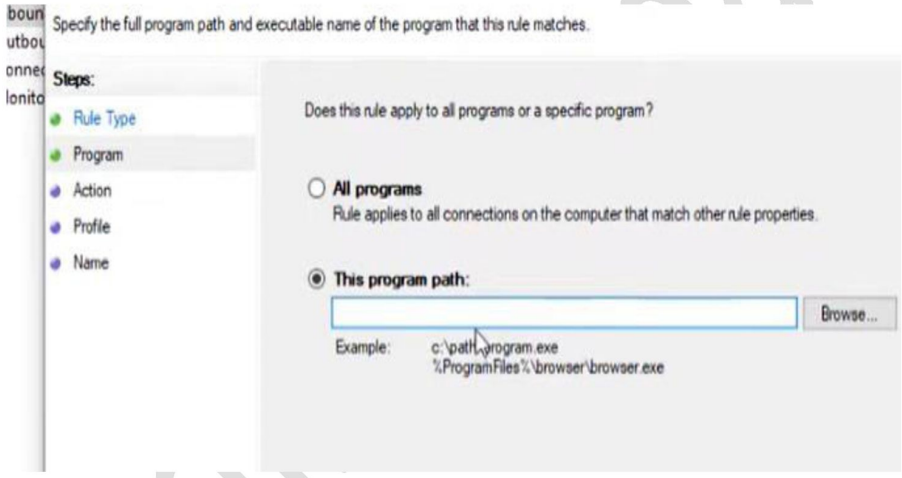
We click on Inbound Rules:

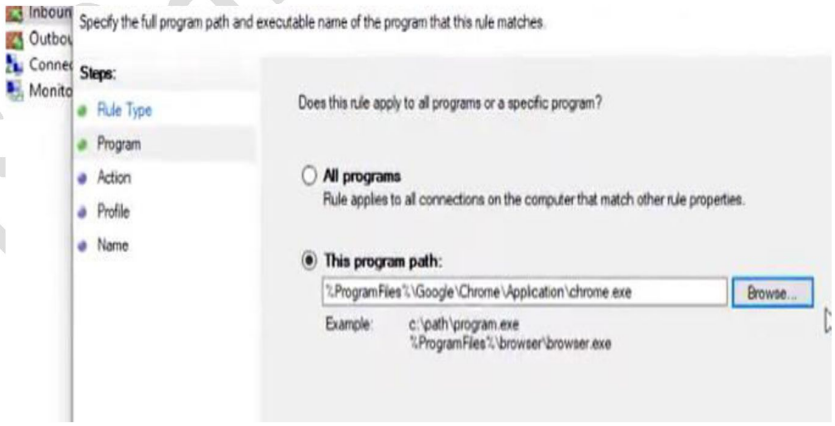


Select the Program option:

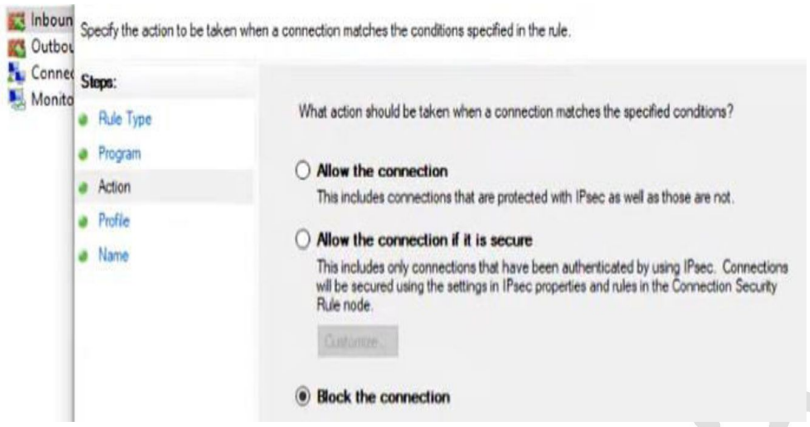


Provide the program path:

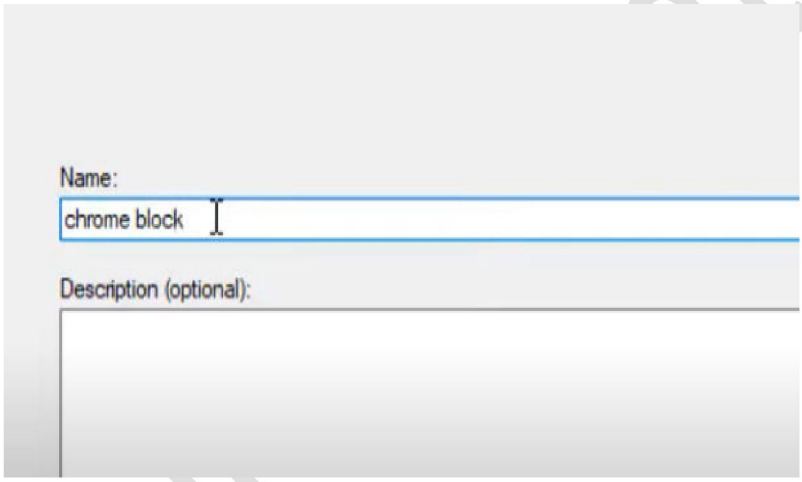




Block the connection:

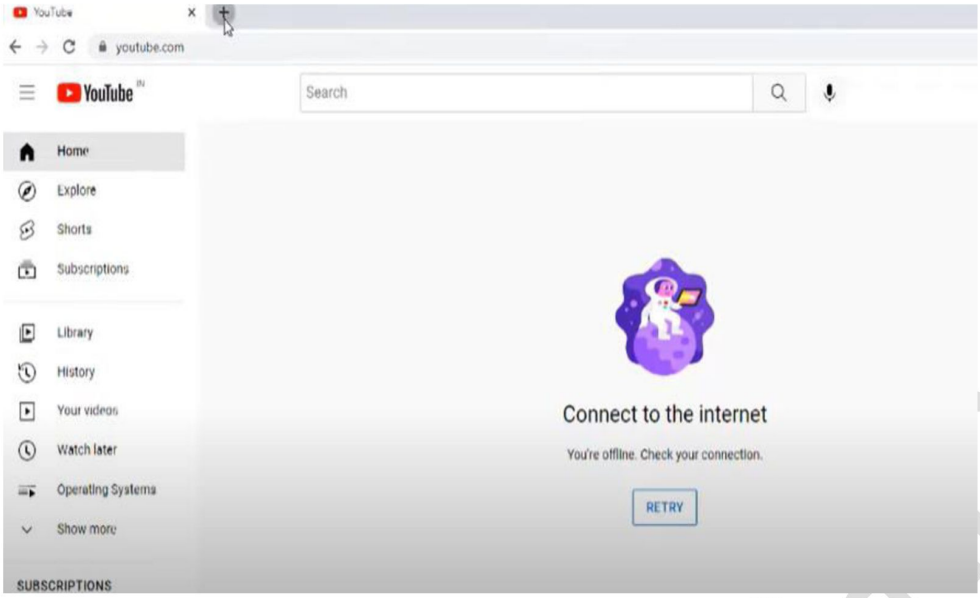


Specify the name of the rule:



Repeat the above for outbound rule.

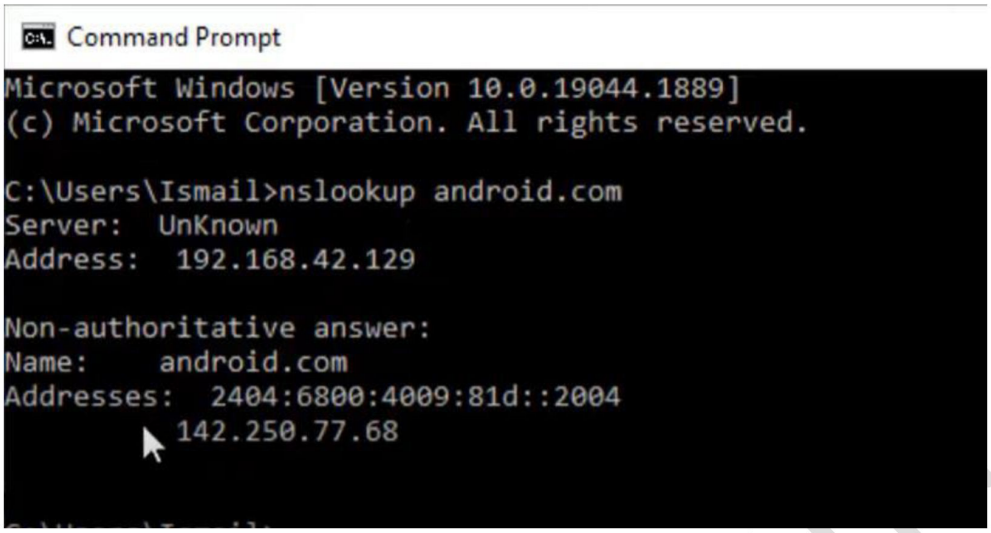
Test the rule



Hence we see that the rule works well and the browser is blocked

Blocking a website: We do the following steps

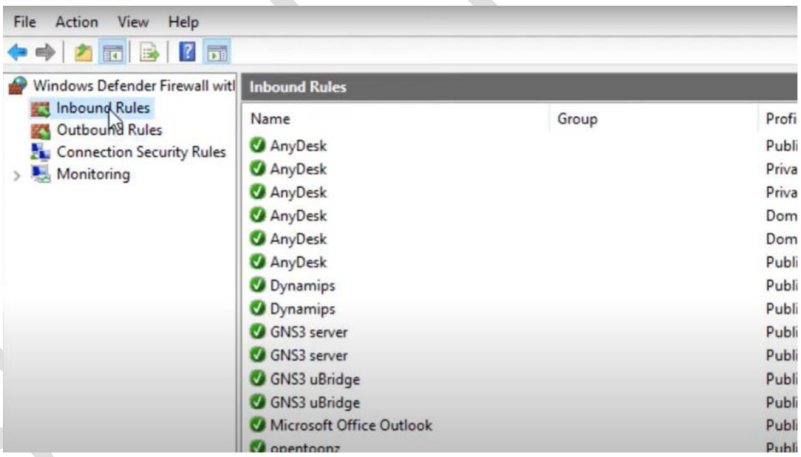
Assuming we want to block the website www.android.com (only for educational purpose), we first find the ip addresses of the server hosting it using the command prompt



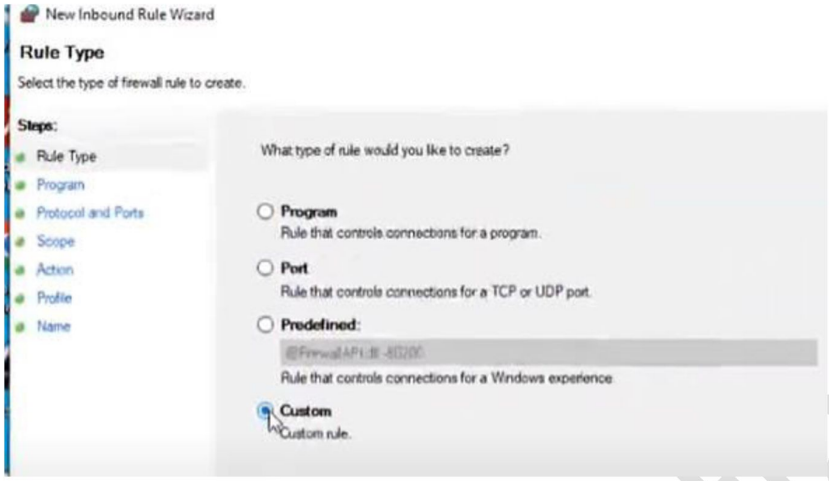
We note the ip addresses (both ipv4 and ipv6)

2404:6800:4009:81d::2004
142.250.77.68

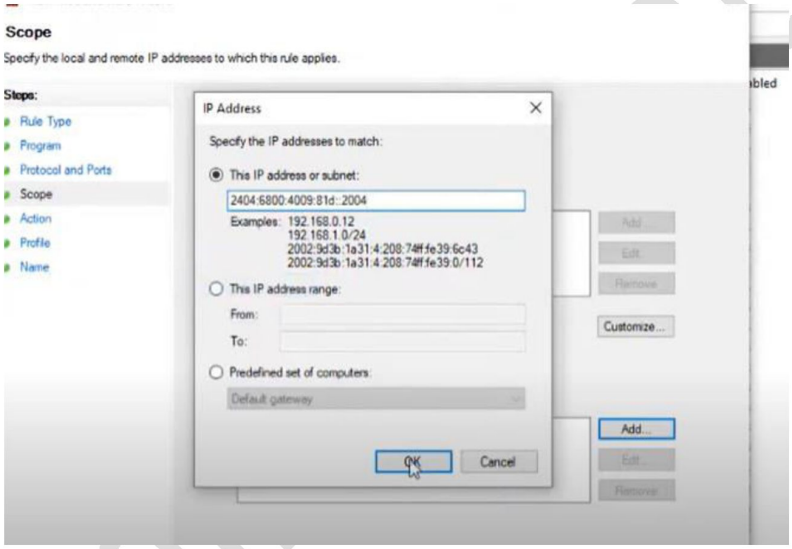
We click on Inbound Rules:



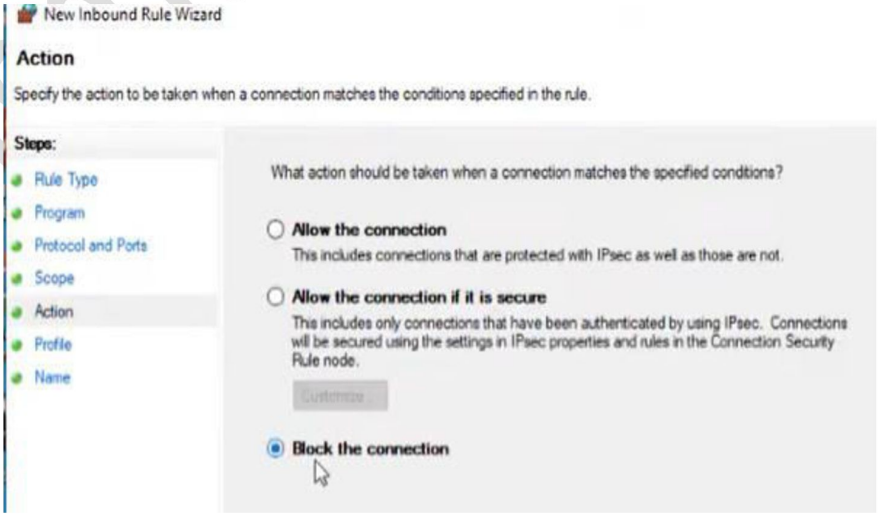
Click on custom option



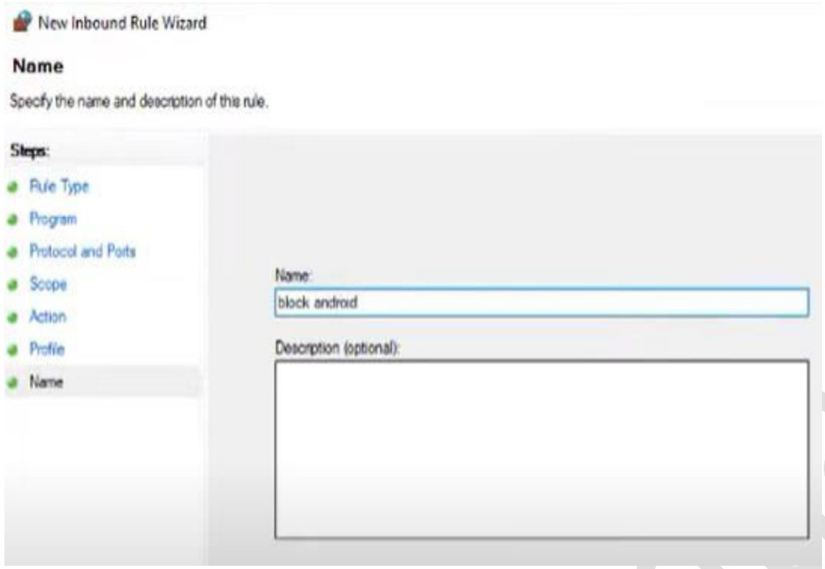
Insert the ipv6 address



Block the connection

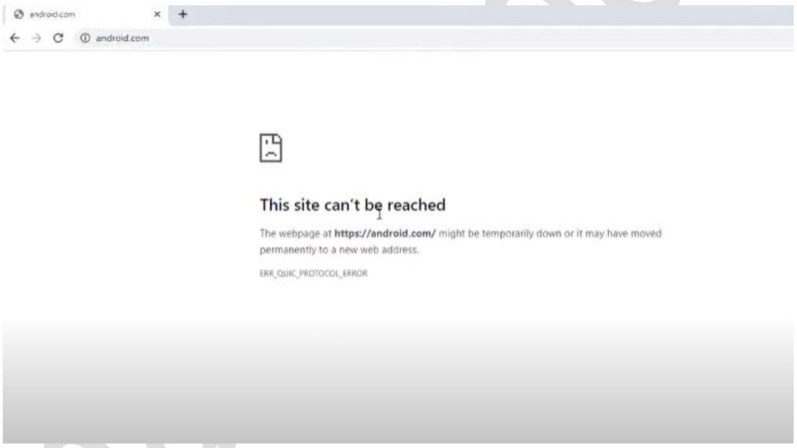


Name the rule



Repeat the above steps for IPv4 address

Test the rule:



We see that the website is blocked

Click on the following link or scan QR-code for video demonstration of the given practical

https://youtu.be/94Pi87vrZfo

Malware Analysis and Detection

Aim: To do Detect and Analyse Malware (Clean Samples)

Theory:

Malware, short for "malicious software," refers to a broad category of software programs or code specifically designed to infiltrate, damage, disrupt, or gain unauthorized access to computer systems, networks, and digital devices. Malware is created with malicious intent, often to steal sensitive information, gain control over systems, extort money, or cause harm to users or organizations. There are various types of malware, each with distinct characteristics and purposes. Some common types of malware include:

1. Viruses: Viruses are malicious programs that attach themselves to legitimate files or programs and spread by infecting other files. When infected files are executed, the virus replicates and spreads further, potentially causing damage to data and systems.

2. Worms: Worms are standalone programs that replicate and spread across computer networks without needing to attach themselves to other files. They often exploit security vulnerabilities to self-propagate and can cause network congestion and data loss.

3. Trojans: Trojans are deceptive programs that disguise themselves as legitimate software, tricking users into installing them. Once installed, Trojans can perform a variety of malicious activities, such as stealing sensitive information, opening backdoors, or launching attacks.

4. Ransomware: Ransomware encrypts a user's files or entire system and demands a ransom payment in exchange for providing the decryption key. It can lead to data loss and significant disruption if not properly managed.

5. Spyware: Spyware is designed to secretly gather information from a user's device, such as browsing habits, passwords, and personal data. This information is then sent to a remote attacker or entity.

6. Adware: Adware is software that displays unwanted advertisements, often in the form of pop-ups or banners, on a user's device. While not as malicious as other types of malware, it can be disruptive and invasive.

7. Keyloggers: Keyloggers record a user's keystrokes, allowing attackers to capture sensitive information like passwords, credit card numbers, and other confidential data.

8. Botnets: Botnets are networks of compromised computers or devices, known as "bots" or "zombies," controlled by a central attacker. Botnets are often used to launch coordinated attacks, distribute spam, or carry out other malicious activities.

9. Rootkits: Rootkits are designed to hide malicious activities from the user and security software. They can modify or replace core system files to gain unauthorized access and control over a system.

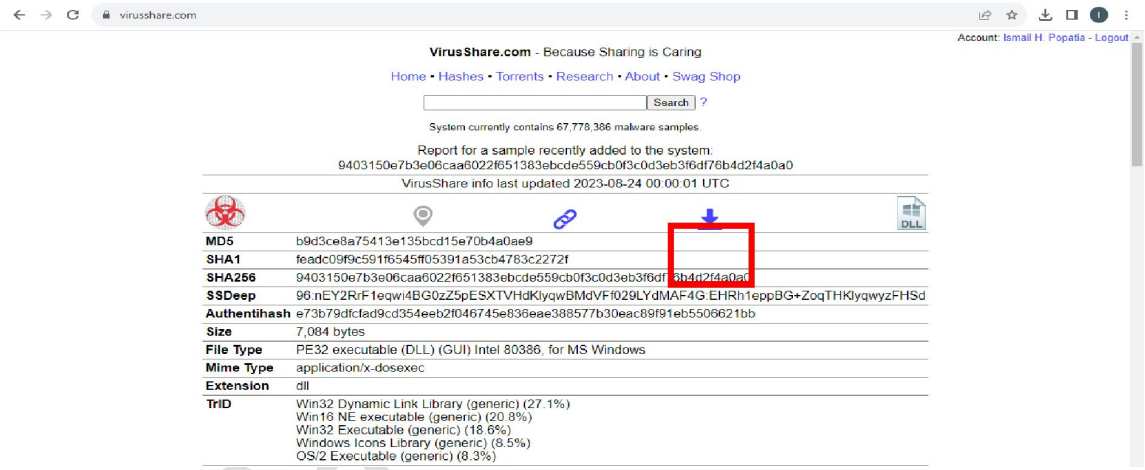
10. Backdoors: Backdoors provide unauthorized access to a compromised system. They can be used by attackers to maintain control over a system, often allowing them to return even after the initial breach is resolved.

Malware can enter systems through various vectors, including malicious email attachments, compromised websites, infected software downloads, and even through physical devices like infected USB drives. To protect against malware, it's essential to maintain strong cybersecurity practices, including using reputable antivirus and anti-malware software, keeping software up-to-date, avoiding suspicious links and downloads, and practicing safe browsing habits.

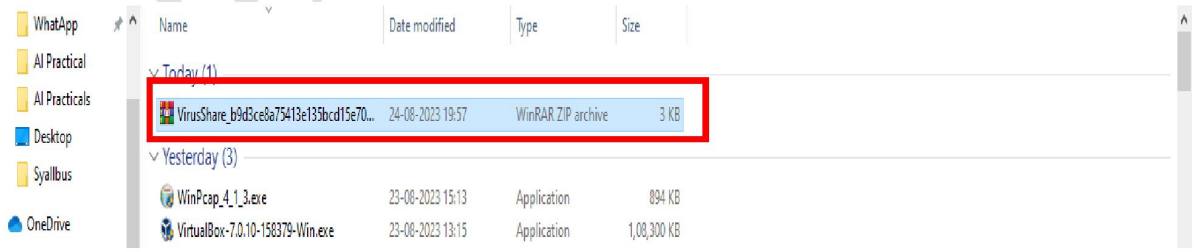
Analysis:

For analysing the Malware, we need one. A clean sample of the Malware needs to be downloaded from a trusted website, the downloading and analysis is demonstrated by the following steps

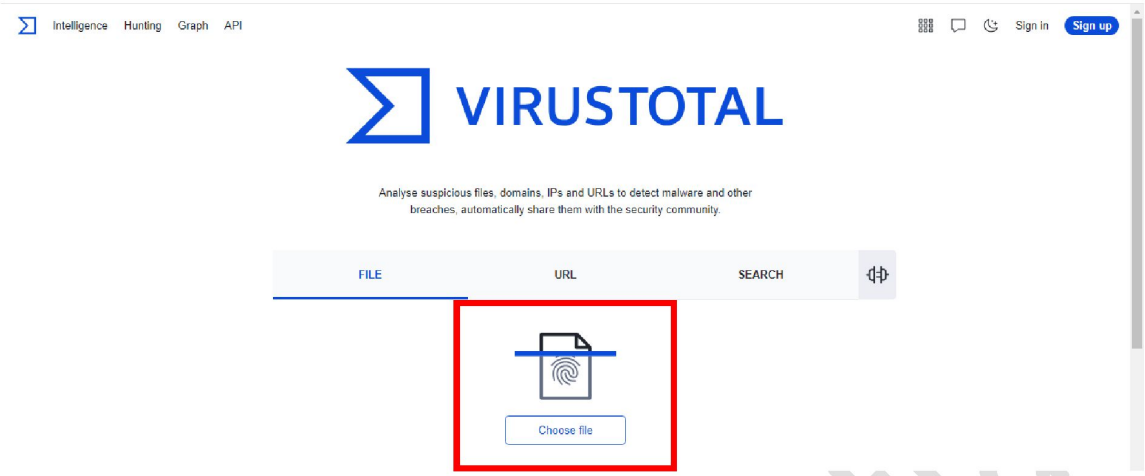
1) We select the website www.virusshare.com for downloading the clean sample of Malware (an account needs to be created for the same). Any other source can be selected to download the Malware (clean sample and authorised site)



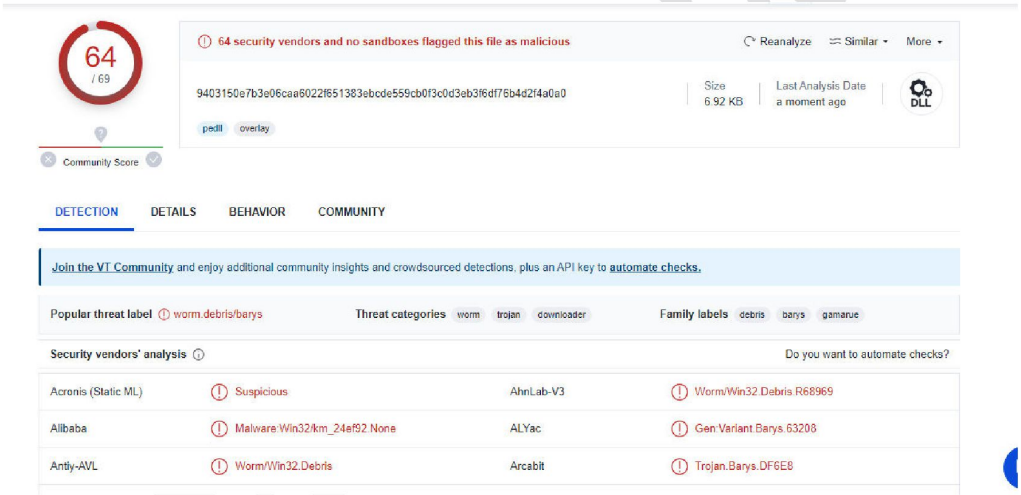
2) By clicking the above download icon the Malware gets downloaded in ZIP format.



3) For unzip the password is “infected”, there is no need to unzip the file, we create a folder “Malware” on desktop and save the file in the folder
4) In order to analyse the Malware, we select the website www.virustotal.com

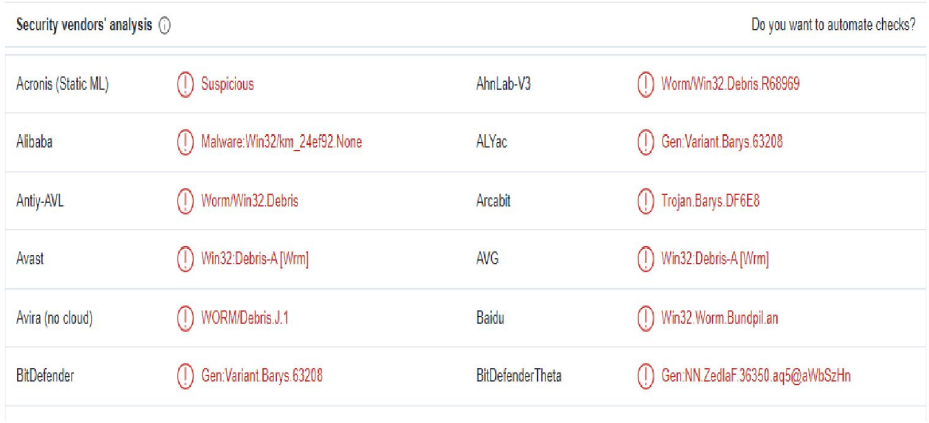


5) Click on “Choose File” and select the file from the location (ZIP file will do, if asks for password enter infected)
6) We get the following after the upload is complete



We interpret the following findings

a) 64 security vendors out of 69 flagged this file as malicious
b) The detection tab shows the threats-type which were flagged by the vendors for e.g



c) The details tab gives the following information
    i. Basic properties
    ii. History
    iii. Compiler products
    iv. Header
    v. Sections
    vi. Imports
    vii. Exports
    viii. Overlays
d) The Behaviour tab gives the following information
    i. Activity summary
    ii. MITRE ATT&CK Tactics and Techniques
    iii. Behaviour Similarity Hashes
    iv. Process and service actions

Countermeasures: Countermeasures are strategies, actions, or precautions taken to prevent or mitigate various risks, threats, or undesirable events. In the context of cybersecurity and dealing with potential malware, viruses, and other online threats, here are some common countermeasures you can take:

1. Use Antivirus and Anti-Malware Software: Install reputable antivirus and anti-malware software on your devices. Keep the software updated to ensure you have the latest protection against known threats.

2. Keep Operating Systems and Software Updated: Regularly update your operating system, web browsers, plugins, and other software. Updates often include security patches that address vulnerabilities.

3. Use Strong and Unique Passwords: Use complex passwords that combine upper and lower case letters, numbers, and symbols. Avoid using common or easily guessable passwords. Consider using a password manager to securely store your passwords.

4. Enable Two-Factor Authentication (2FA): Whenever possible, enable two-factor authentication for your online accounts. This adds an extra layer of security by requiring a second form of verification in addition to your password.

5. Be Cautious with Email and Attachments: Be wary of unsolicited emails, especially those with attachments or links. Don't open attachments or click on links from unknown or suspicious sources. Verify the sender's authenticity before taking any action.

6. Use a Firewall: Enable firewalls on your devices and network. Firewalls help block unauthorized access and protect your system from external threats.

7. Regular Backups: Regularly back up your important data to an external source or a cloud storage service. In case of a malware attack or data loss, you'll have a copy of your important files.

8. Educate Yourself and Others: Stay informed about common online threats, phishing techniques, and best practices for online safety. Educate your family, friends, and colleagues about cybersecurity hygiene.

9. Secure Wi-Fi Networks: Secure your home or office Wi-Fi network with a strong password and encryption. Avoid using public Wi-Fi networks for sensitive activities.

10. Use Ad-Blockers and Script Blockers: Install browser extensions that block ads and potentially malicious scripts. This can help prevent drive-by downloads and malvertising.

11. Disable Macros: Disable macros in office documents unless you're certain they are safe. Malicious macros are often used to deliver malware.

12. Download Software from Official Sources: Only download software from reputable and official sources. Be cautious of downloading software from unfamiliar websites.

13. Regularly Scan for Malware: Perform regular scans of your devices using reputable antivirus and anti-malware tools.

14. Use Virtual Private Networks (VPNs): When connecting to the internet, especially on public networks, use a VPN to encrypt your internet connection and enhance your privacy.

15. Implement Security Policies: If you're managing a network or a business, establish and enforce security policies for employees, including guidelines for safe browsing, email practices, and device usage.

16. Monitor Financial and Personal Information: Regularly monitor your bank accounts, credit card statements, and other financial accounts for any suspicious activities.

Remember that cybersecurity is an on going effort. Threats evolve over time, so it's important to stay vigilant and adapt your countermeasures as needed. No single countermeasure can provide complete protection, but a combination of these practices can significantly reduce your risk exposure.

https://youtu.be/H2agWcwaqvM