TNE20003 - Internet and Cybersecurity for Engineering Applications

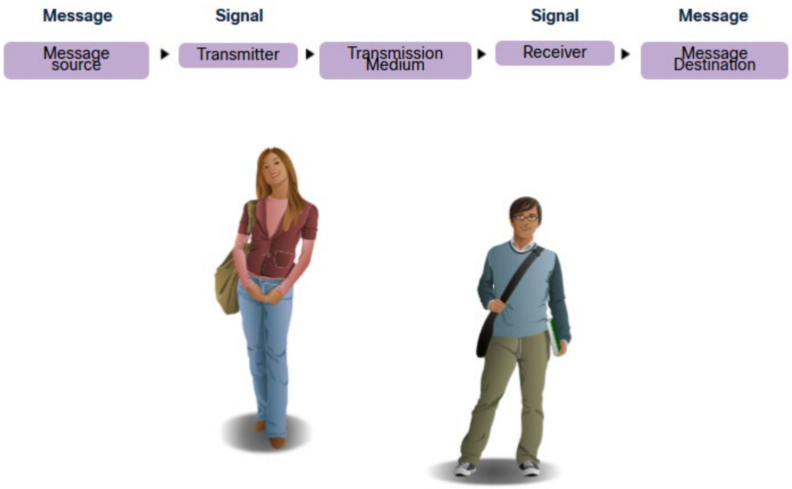
Network Basics – OSI & TCP/IP models & IPv4 Addressing

The Network

- A very complicated combination of various networking devices and infrastructure which allows remote communication
- Was it always this good --- Nooooooooo!
- Today’s networks have evolved over time to deal with many issues such as:
  - Increased usage and new user demand
  - Increased BW requirements due to new and interactive applications
  - Improved hardware capabilities
  - Investment.
- Main function of a working network is to provide “Communication”

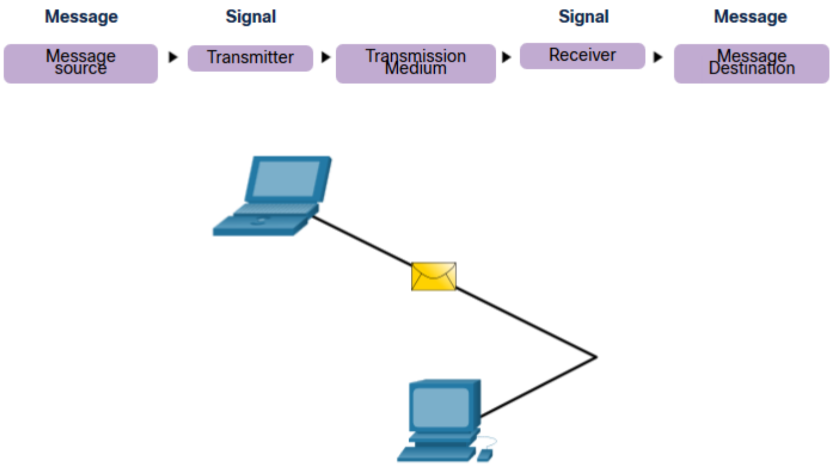
The Network Communications Protocols

- All communications are governed by protocols.
- Protocols are the rules that communications will follow.
- These rules will vary depending on the protocol.



Message → Signal → → Signal → Message

Message source → Transmitter → Transmission Medium → Receiver → Message Destination



Message → Signal → → Signal → Message

Message source → Transmitter → Transmission Medium → Receiver → Message Destination

Communication Standards

A standard is a set of rules that determines how something must be done.

Networking and internet standards ensure that all devices connecting to the network implement the same set of rules or protocols in the same manner.

Using standards, it is possible for different types of devices to send information to each other over the internet.

For example, the way in which an email is formatted, forwarded, and received by all devices is done according to a standard:

- If one person sends an email via a personal computer, another person can use a mobile phone to receive and read the email as long as the mobile phone uses the same standards as the personal computer.

Communication Standards

An internet standard is the end result of a comprehensive cycle of discussion, problem solving, and testing.

These different standards are developed, published, and maintained by a variety of organizations.

When a new standard is proposed, each stage of the development and approval process is recorded in a numbered Request for Comments (RFC) document.

- RFCs for internet standards are published and managed by the Internet Engineering Task Force (IETF).

Other standards organizations that support the internet are shown in the figure.

IEEE
IETF
iana
Internet Assigned Numbers Authority
ICANN
The Internet Corporation for Assigned Names and Numbers
ITU
TIA

Network Communication Models

The Network

- How did it get this good???
  - Development over time from many different companies
- How is this possible?
  - Don’t different companies compete??
    - Yes they do
- Best way to get improvement is to break down the overall network into chunks/layers
  - This allows both big and small companies to try and meet the challenge
  - Work to a world set of standards to ensure compatibility
  - Ensure your layer can communicate effectively with both the layer above and the layer below.

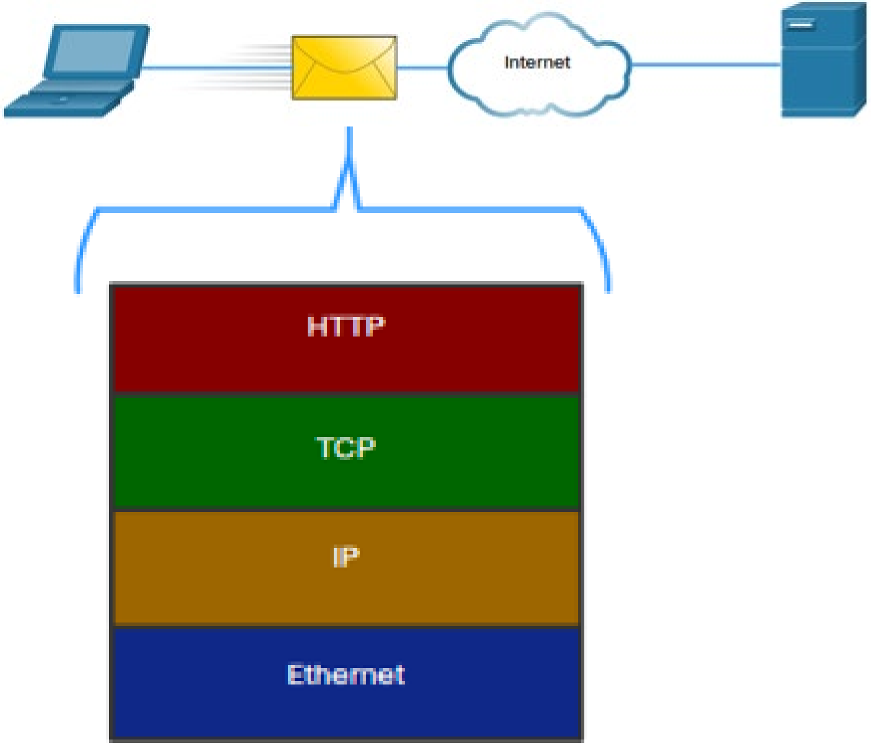
Network Communication Models

- Successful communication requires interaction between a number of protocols.

- This interaction can be done in software and hardware running on each host and networking device, and it can shown as a stack see pic right.

- A stack illustrates the protocols as a layered hierarchy, with each higher-level protocol depending on the services of the protocols shown in the lower levels.

- The separation of functions enables each layer in the stack to operate independently of others



Network Communication Models – the stack

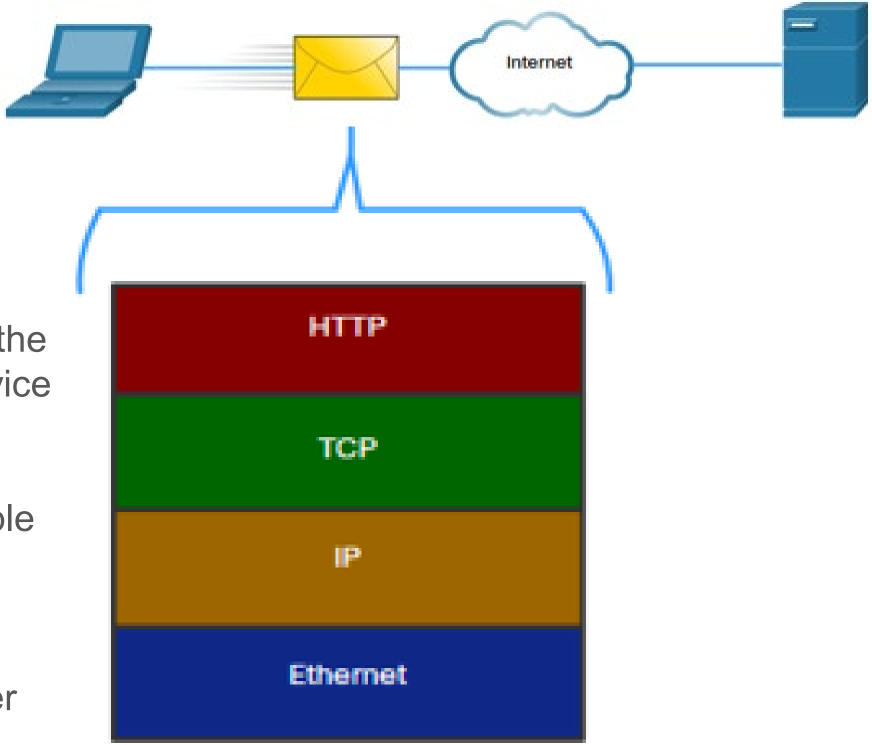
The protocols in the figure are described as follows:

Hypertext Transfer Protocol (HTTP) – This protocol governs the way a web server and a web client interact. HTTP defines the exchange between the client and server.

Transmission Control Protocol (TCP) – TCP is responsible for guaranteeing the reliable delivery of the information and managing flow control between the end device

Internet Protocol (IP) – IP is used by routers to forward the messages across multiple networks between sender and receiver.

Ethernet – This protocol is responsible for the delivery of messages from one Network Interface Card (NIC) to another NIC on the same Ethernet local area network (LAN).



Network Communication Models

A layered model depicts the operation of the protocols occurring within each layer, as well as the interaction with the layers above and below it.

The layered model has many benefits:

- Assists in protocol design, because protocols that operate at a specific layer have defined information that they act upon and a defined interface to the layers above and below.
- Fosters competition because products from different vendors can work together.
- Enables technology changes to occur at one level without affecting the other levels.
- Provides a common language to describe networking functions and capabilities.

TCP/IP Model Layer	Description
Application	Represents data to the user, plus encoding and dialog control.
Transport	Supports communication between various devices across diverse networks.
Internet	Determines the best path through the network.
Network Access	Controls the hardware devices and media that make up the network.

Network Communication Models

OSI Model Layer	Description
7 - Application	The application layer contains protocols used for process-to-process communications.
6 - Presentation	The presentation layer provides for common representation of the data transferred between application layer services.
5 - Session	The session layer provides services to the presentation layer to organize its dialogue and to manage data exchange.
4 - Transport	The transport layer defines services to segment, transfer, and reassemble the data for individual communications between the end devices.
3 - Network	The network layer provides services to exchange the individual pieces of data over the network between identified end devices.
2 - Data Link	The data link layer protocols describe methods for exchanging data frames between devices over a common media
1 - Physical	The physical layer protocols describe the mechanical, electrical, functional, and procedural means to activate, maintain, and de-activate physical connections for a bit transmission to and from a network device.

Upper and Lower Layers of the OSI Model

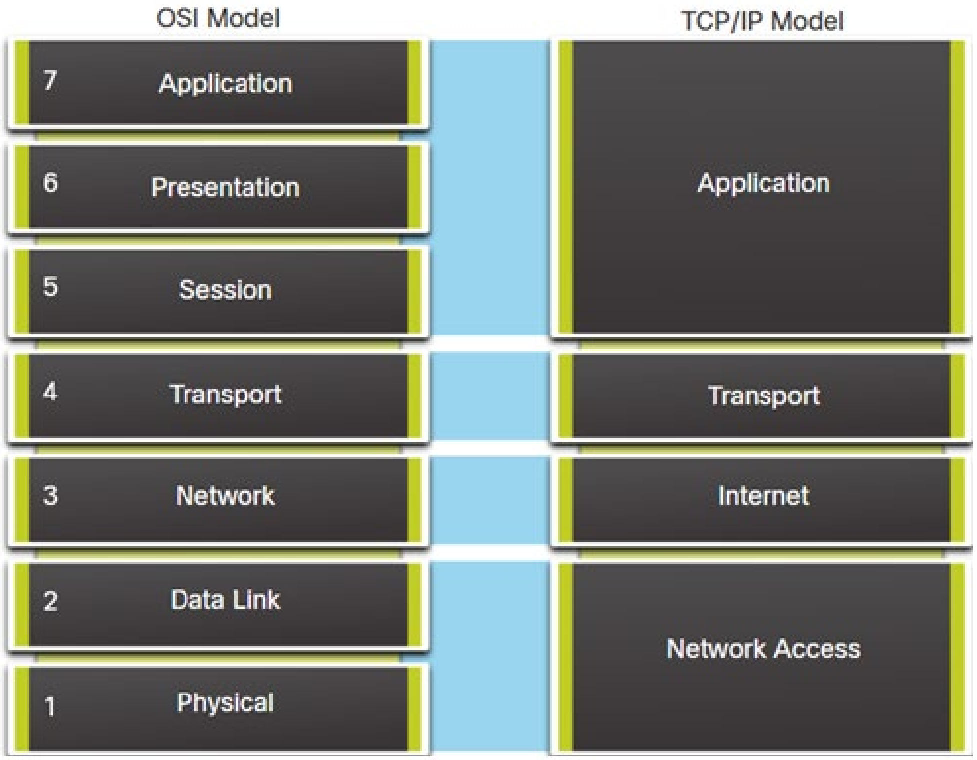
Network Communication Models

Group	Layer Number	Layer Name	Common Network Components Associated with this Layer
Upper Layers	7	Application	• Network aware applications • Email • Web browsers and servers • File transfer • Name resolution
	6	Presentation	
	5	Session	
Lower Layers	4	Transport	• Video and voice streaming mechanisms • Firewall filtering lists
	3	Network	• IP addressing • Routing
	2	Data Link	• Network interface cards and drivers • Network switching • WAN connectivity
	1	Physical	• Physical medium (copper twisted pair, fiber-optic cables, wireless transmitters) • Hubs and repeaters

Network Communication Models

The protocols that make up the TCP/IP protocol suite can be described in terms of the OSI reference model:

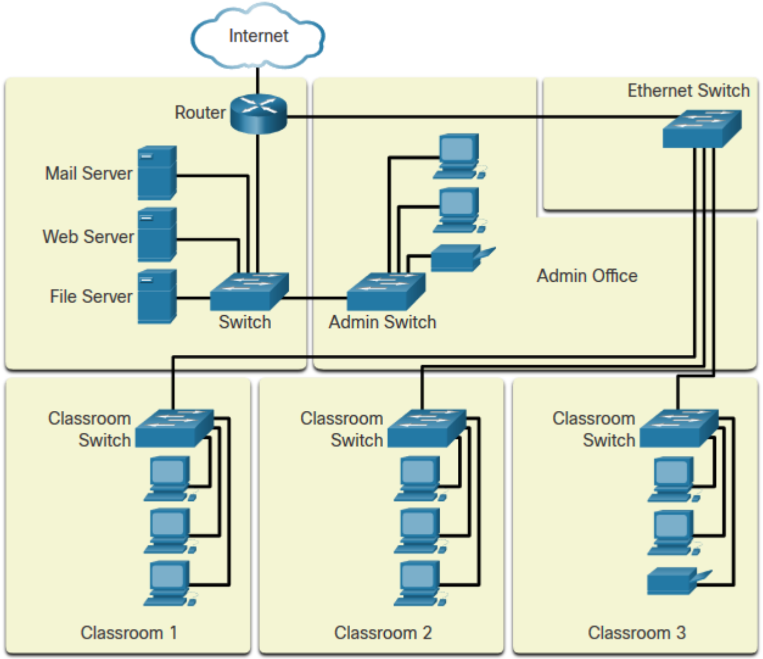
- The functions that occur at the internet layer in the TCP/IP model are contained in the network layer of the OSI Model.
- The transport layer functionality is the same between both models.
- The network access layer and the application layer of the TCP/IP model are further divided in the OSI model to describe discrete functions that must occur at these layers.



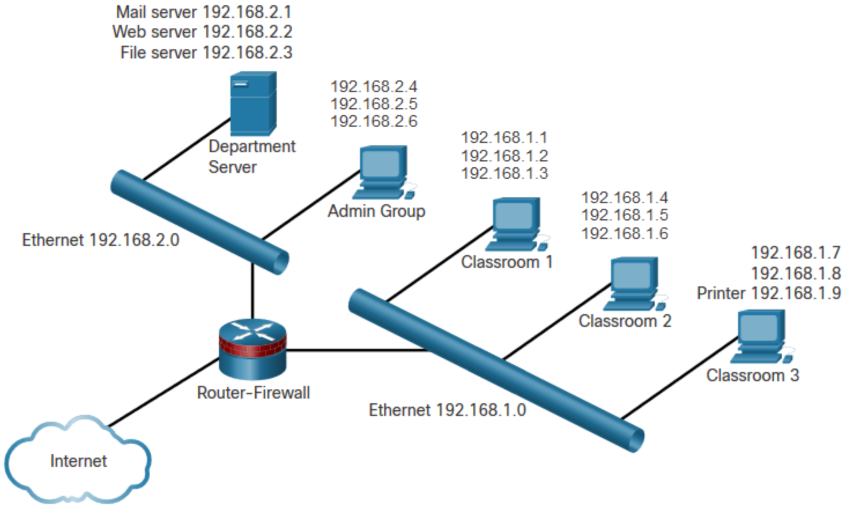
OSI Model		TCP/IP Model
7	Application	Application
6	Presentation	
5	Session	
4	Transport	Transport
3	Network	Internet
2	Data Link	Network Access
1	Physical	

Network Information

A physical topology shows how network devices connect.
A diagram called a logical topology illustrates the relevant network configuration information.



Physical Topology



Logical Topology

Communication between Network Devices

For successful communications, all devices need to know two types of source and destination addresses:

- MAC address, which is unique physical identifier used at layer 2. It is predefined by the equipment provider and is a physical address made up of 48 bits and is usually expressed in Hexadecimal (HEX).

- IP address, which is a unique identifier used at layer 3. It is assigned from a network address which contains many individual IP addresses.

The IPv4 Address

IP Addressing – Legacy Class System

Address Class	Networks Available	Host Per Network
A	**126 ***	**16,777,216**
B	**16,386**	**65,534**
C	**2,097,152**	**254**
D ***multicast***	**N/A**	**N/A**

Address Class	High Order Bits	First Octet Range	Network Bits
A	**0** X X X X X X X	**0 to 126 ***	**8**
B	**1 0** X X X X X X	**128 to 191**	**16**
C	**1 1 0** X X X X X	**192 to 223**	**24**
D ***multicast***	**1 1 1 0** X X X X	**224 to 239**	**28**

* The 127.x.x.x address range is reserved as a loopback address,
used for testing and diagnostic purposes.

IP Addressing Structure

Class	Makeup	Network ID	Broadcast Address
A	N.H.H.H	10.0.0.0	10.255.255.255
B	N.N.H.H	156.15.0.0	156.15.255.255
C	N.N.N.H	203.36.186.0	203.63.186.255

The *Network ID* is the address that has all 0s in the host field.

The *Broadcast Address* is the address that has all 1s in the host field.

When a packet starts out on a network that is using a *broadcast address*, all devices on that network take notice of it.

Remember that the **first** address on each segment is reserved for the **network** id, and the **last** address on each segment is reserved for **broadcasts**.

IP Addressing Structure

Class	Makeup	Network ID	Broadcast Address
A	N.H.H.H	10.0.0.0	10.255.255.255
B	N.N.H.H	156.15.0.0	156.15.255.255
C	N.N.N.H	203.36.186.0	203.63.186.255

All IP Addresses Need a Subnet Mask

(Default Mask)

Class	Makeup	IP Address	Subnet Mask
A	N.H.H.H	10.11.12.13	255.0.0.0
B	N.N.H.H	156.15.16.17	255.255.0.0
C	N.N.N.H	203.36.186.99	255.255.255.0

I have your address, but which part of your address is your street name and which part is your house number ?

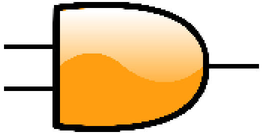
What does the Subnet Mask actually do ?

The subnet mask informs the router how many bits are for the Network and how many for the Host. And what the network ID is.

This is done by using the Boolean AND function.

Example:-

Host:- 192.232.137.125
Mask:- 255.255.255.0
Nw ID:- 192.232.137.0



A	B	X
0	0	0
0	1	0
1	0	0
1	1	1

```
Host:-          11000000.11101000.10001001.01111101
Mask:-          11111111.11111111.11111111.00000000
AND Result:-    11000000.11101000.10001001.00000000
```

This is exactly how the router actually does it !

IPv4 Subnet Mask

Examining the Prefix Length

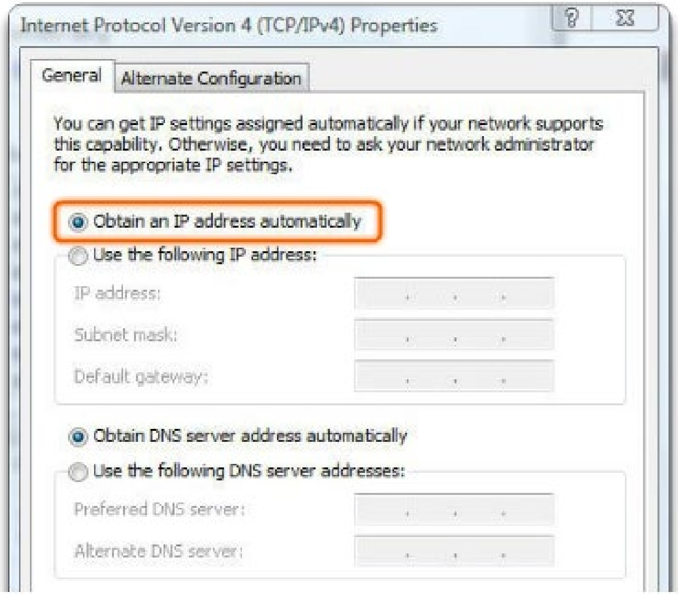
Class	Makeup	IP Address	Subnet Mask
A	N.H.H.H	10.11.12.13	255.0.0.0
B	N.N.H.H	156.15.16.17	255.255.0.0
C	N.N.N.H	203.36.186.99	255.255.255.0

A.B.C.D /N where **N** = Number of Subnet Mask Bits. **32-N=H** where **H** = Host Bits.

Decimal Mask	Binary Mask	CIDR
255.0.0.0	1111 1111 . 0000 0000 . 0000 0000 . 0000 0000	/ 8
255.255.0.0	1111 1111 . 1111 1111 . 0000 0000 . 0000 0000	/ 16
255.255.255.0	1111 1111 . 1111 1111 . 1111 1111 . 0000 0000	/ 24
255.255.255.240	1111 1111 . 1111 1111 . 1111 1111 . 1111 0000	/ 28
255.255.255.252	1111 1111 . 1111 1111 . 1111 1111 . 1111 1100	/ 30

just count the "ones".

Assigning a Dynamic IPv4 Address to a Host



Internet Protocol Version 4 (TCP/IPv4) Properties

General | Alternate Configuration

You can get IP settings assigned automatically if your network supports this capability. Otherwise, you need to ask your network administrator for the appropriate IP settings.

● Obtain an IP address automatically

○ Use the following IP address:

IP address: . . .

Subnet mask: . . .

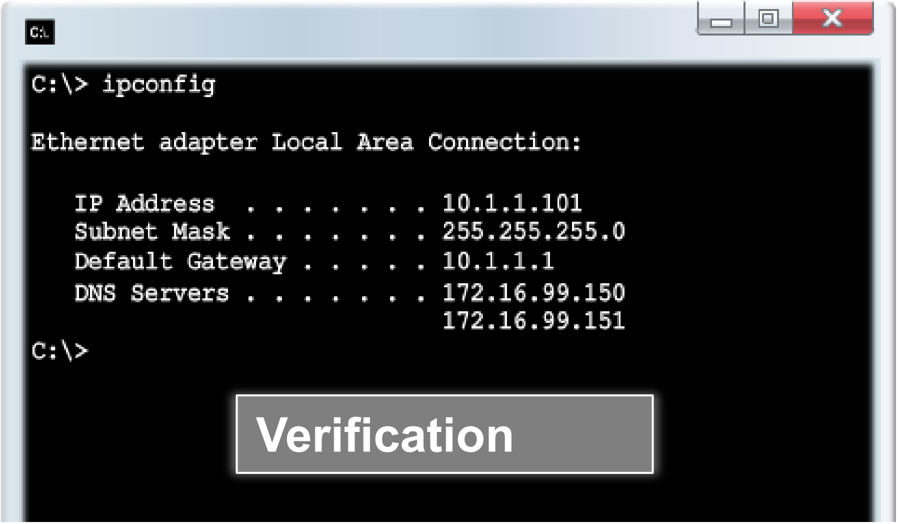
Default gateway: . . .

● Obtain DNS server address automatically

○ Use the following DNS server addresses:

Preferred DNS server: . . .

Alternate DNS server: . . .



```
C:\> ipconfig

Ethernet adapter Local Area Connection:

   IP Address . . . . . . . . 10.1.1.101
   Subnet Mask . . . . . . . . 255.255.255.0
   Default Gateway . . . . . . 10.1.1.1
   DNS Servers . . . . . . . . 172.16.99.150
                               172.16.99.151
C:\>
```

Verification

DHCP – The preferred method of assigning IPv4 addresses to hosts on large networks because it reduces the burden on network support staff and virtually eliminates entry errors.