

# Chapter 1: INTERconnected NETwork: Internet

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# 1.1 Internet: The Giant Wide Area Network

- ▶ Early computers were expensive and isolated.
- ▶ A good idea is to share resources, information and facilitate communication.
  - ▶ The networking became important.
- ▶ In 1969, ARPANET started as a federally funded research project.
  - ▶ Initiated by the Advanced Research Project Agency (ARPA) and the US Department of Defence (DoD).
  - ▶ The experiment linked researchers with remote computers centers, allowing them to share hardware and software resources such as computer disk space and databases.
  - ▶ Later, it was renamed the Internet.

# 1.1 Internet: The Giant Wide Area Network

- ▶ The inter-network operated with a technique called packet switching.
  - ▶ Digital data is transmitted in small bundles called packets.
- ▶ ARPANET used the Transmission Control Protocol (TCP) and Internet Protocol (IP) for communication.
- ▶ INTERconnected NETwork (Internet) is an arbitrary collection of physical networks interconnected by routers to provide host-to-host packet delivery service.
- ▶ The Internet is defined as the globally distributed network of networks that consists of millions of private, public, academic, business, and government networks, which are linked by an extensive range of electronics, wireless, and optical networking technologies.

# 1.1 Internet: The Giant Wide Area Network

- ▶ The networks can primarily be classified either based on:
  1. Transmission media used (wired and wireless)
  2. Layout of the network;
    - ▶ Point-to-point (PTP)
    - ▶ Multi-access (ring, star, or bus)
    - ▶ Application centric architecture (Peer-to-peer or client-server)
- ▶ LANs, MANs, WANs
  - ▶ LANs – limited in size, typically spanning a few hundred meters; it is fast, with speeds from 10Mbps to 10Gbps.
  - ▶ MANs – optimized for a larger geographical area than a LAN, ranging from 5 to 50 km diametrically; it is fast as LANs but requires high-speed connections, such as fiber optics
  - ▶ WANs – covers a large geographic area such as country, continent or even whole world. Internet is the giant WAN.

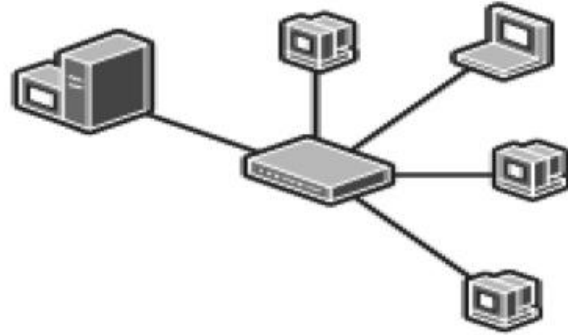
# 1.1 Internet: The Giant Wide Area Network

- ▶ Another classification of networks focuses on the roles of the networked computers.
  1. Peer-to-Peer network.
  2. Client/Server network.
- ▶ Client/server network:
  - ▶ Clients initiate a communication session by sending request to servers
  - ▶ Servers respond to clients by acting on request and returning results.
  - ▶ One server generally supports numerous clients.
  - ▶ Refer to Figure 1.1

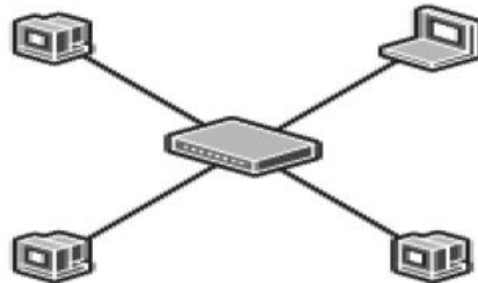
# 1.1 Internet: The Giant Wide Area Network

- ▶ Peer-to-peer (P2P):
  - ▶ All end systems have equivalent capabilities and responsibilities.
  - ▶ Either party can initiate a communication session
  - ▶ No central location for authenticating users, storing files, or accessing resources
  - ▶ Inexpensive, easy to install and limited in space
  - ▶ Refer to Figure 1.2

# 1.1 Internet: The Giant Wide Area Network



**FIGURE 1.1**  
Client/server network.



**FIGURE 1.2**  
Peer-to-peer network.



# 1.1 Internet: The Giant Wide Area Network

- ▶ Two types of P2P networks; **Pure P2P** and **Hybrid P2P** network.
- ▶ Pure P2P network:
  - ▶ P2P system that has no central service of any kind.
  - ▶ Examples: Workgroups in Microsoft Windows Network, Gnutella, Freenet
- ▶ Hybrid P2P network:
  - ▶ Depends partially on central servers or allocates selected functions to a subset of dedicated peers.
  - ▶ Central servers act as central directories
  - ▶ Dedicated peers directly control information among other peers
  - ▶ Examples: Skype, BitTorrent



# 1.2 Communicating over the Internet

- ▶ Two popular models to deal with aspects of network abstractly:
  1. Open Systems Interconnection (OSI) reference model.
  2. TCP/IP model.
- ▶ OSI reference model:
  - ▶ Became the international standard for communication architecture in 1984.
  - ▶ Considered as the primary architectural model for inter-computer communications.
  - ▶ Describe how information/data made its way from application programs through a network medium to another application program located on another network.
  - ▶ Divides into seven smaller and manageable layers (Figure 1.4)

# 1.2 Communicating over the Internet

- ▶ OSI reference model:
  - ▶ The lower four layers (transport, network, data link, and physical—Layers 4, 3, 2, and 1) are concerned with the flow of data from end to end through the network.
  - ▶ The upper three layers of the OSI model (application, presentation, and session—Layers 7, 6, and 5) are oriented more toward services to the applications.
- ▶ Note:
  - ▶ The OSI model was a generic, protocol- independent standard.
  - ▶ TCP/IP model provided an application viewpoint of the network.
  - ▶ The OSI model conceptually defined the services, interfaces, and protocols.
  - ▶ The TCP/IP (Internet) model provided its successful implementation (Figure 1.5).

# 1.2 Communicating over the Internet

7. Application: Application programs using the network
6. Presentation: Data representation
5. Session: Inter-host communication
4. Transport: End-to-End connections; error detection and correction
3. Network: Handling of data grams-routing and congestion
2. Data link: Access to media
1. Physical: Binary transmission

**FIGURE 1.4**

OSI reference model.

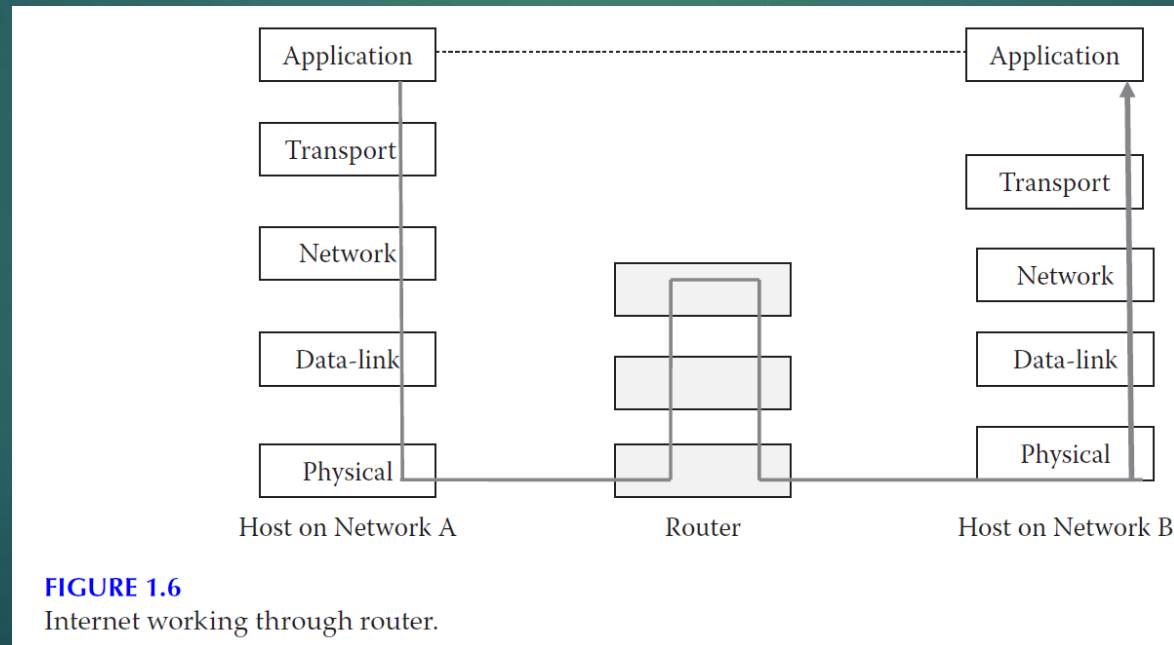
OSI reference model	TCP/IP conceptual layers
7. Application ( <i>DNS, FTP, HTTPS, POP3, SMTP, Telnet</i> )	4. Application
6. Presentation ( <i>JPEG, MPEG, TIFF</i> )	
5. Session ( <i>ZIP, SQL</i> )	
4. Transport ( <i>TCP, UDP</i> )	3. Transport
3. Network ( <i>ICMP, IGMP, IPSec, IPV4, IPV6</i> )	2. Internet (network)
2. Data link ( <i>ATM, PPP, Frame relay</i> )	1. Network interface
1. Physical ( <i>Bluetooth, Ethernet, DSL, ISDN, 802.11, Wi-Fi</i> )	

**FIGURE 1.5**

OSI versus TCP/IP model.

# 1.2.1 Protocol Layering

- To communicate using the Internet system, a host must implement the layered set of protocols comprising the Internet protocol suite (Figure 1.6).



# 1.2.1 Protocol Layering

- ▶ The protocol layers used in the Internet architecture are as follows (Figure 1.7).

User application program (FTP, SMTP, HTTP, Telnet, DNS) <i>{Represents data to user and takes care of encoding}</i>
Transmission control protocol (TCP) <i>{Supports communication between diverse devices across diverse networks}</i>
Internet protocol (IP) <i>{Determines the best path through the network}</i>
Network interface (Ethernet) <i>{Controls hardware devices and media that make up the network}</i>
Hardware (Physical connection)

**FIGURE 1.7**

Internet protocol stack.

# 1.2.1 Protocol Layering

- ▶ The role of each layer is as follows:
  - ▶ **Application layer**: two categories of application layer protocols: **user protocols** that provide service directly to users, and **support protocols** that provide common system functions.
  - ▶ The most common Internet user protocols are:
    - ▶ Telnet (remote login),
    - ▶ FTP (file transfer),
    - ▶ SMTP (electronic mail delivery),
    - ▶ HTTP (web).
  - ▶ The Support protocols, used for host name mapping, booting, and management include:
    - ▶ Simple Network Management Protocol (SNMP),
    - ▶ Bootstrap Protocol (BOOTP),
    - ▶ Trivial File Transfer Protocol (TFTP),
    - ▶ Domain Name System (DNS) protocol.

# 1.2.1 Protocol Layering

- ▶ ***Transport layer:***

- ▶ Responsible for reliable source-to-destination (end-to-end) delivery of the entire message.
- ▶ Two primary Transport Layer protocols at present: TCP and User Datagram Protocol (UDP).
- ▶ TCP is a reliable connection-oriented protocol whereas UDP is a connectionless (datagram) protocol.



# 1.2.1 Protocol Layering

## ▶ **Internet layer:**

- ▶ IP is a connectionless or datagram Internetwork service, providing no end-to-end delivery guarantees.
- ▶ IP datagrams may arrive at the destination host damaged, duplicated, out of order, or not at all.
- ▶ The Internet Control Message Protocol (ICMP) is a control protocol that is considered an integral part of IP, although it is architecturally layered upon IP—it uses IP to carry its data end- to-end.
- ▶ ICMP provides error reporting, congestion reporting, and first-hop router redirection.
- ▶ The Internet Group Management Protocol (IGMP) is an Internet layer protocol used for establishing dynamic host groups for IP multicasting.

# 1.2.1 Protocol Layering

- ▶ **Link layer (network interface):**

- ▶ To communicate on a **directly connected network**, a host must implement the communication protocol used to interface to that network.
- ▶ The Link Layer protocol provides this interface.
- ▶ It specifies how to organize data into frames and how to deliver a frame over a network.
- ▶ Its responsibility is the correct delivery of messages.

# 1.2.1 Protocol Layering

- ▶ ***Physical layer:***

- ▶ Provides physical interface for transmission of information.
- ▶ Defines rules by which bits are passed from one system to another on a physical communication medium.
- ▶ It covers all the **mechanical, electrical, functional, and procedural** aspects for physical communication.

# 1.2.2 Internet Addressing

- ▶ An IP address is a unique global address for a network interface.
- ▶ It is a 32-bit logical address.
- ▶ The address consists of four 8-bit fields known as octets.
- ▶ The IP address is represented in "dotted decimal notation" by grouping the four octets.
- ▶ Each octet represents a decimal number ranging from 0 to 255 (0-255 is the range for 8-bit binary numbers).
- ▶ The format of an IP address is xxx.xxx.xxx.xxx, where each xxx is a number from 0 to 255.
- ▶ These IP addresses are unique and controlled by an address registry.
- ▶ For instance, the IP address for [www.apple.com](http://www.apple.com) is 17.112.152.32.
- ▶ For [www.amazon.com](http://www.amazon.com), it is 54.239.26.128.

# 1.2.2 Internet Addressing

- ▶ IP addresses have a prefix for the network and a suffix for specific computers.
- ▶ Each network gets a unique number, and each computer on the network gets a unique suffix.
- ▶ IP addresses ensure unique computer addresses globally and coordinate network number assignments globally.
- ▶ URLs specify Internet addresses for files and use DNS to convert to numeric addresses.
- ▶ DNS acts like the "phone book" of the Internet, matching names to numbers.
- ▶ URLs are sensitive to spelling, spaces, and letter case.

# 1.2.2 Internet Addressing

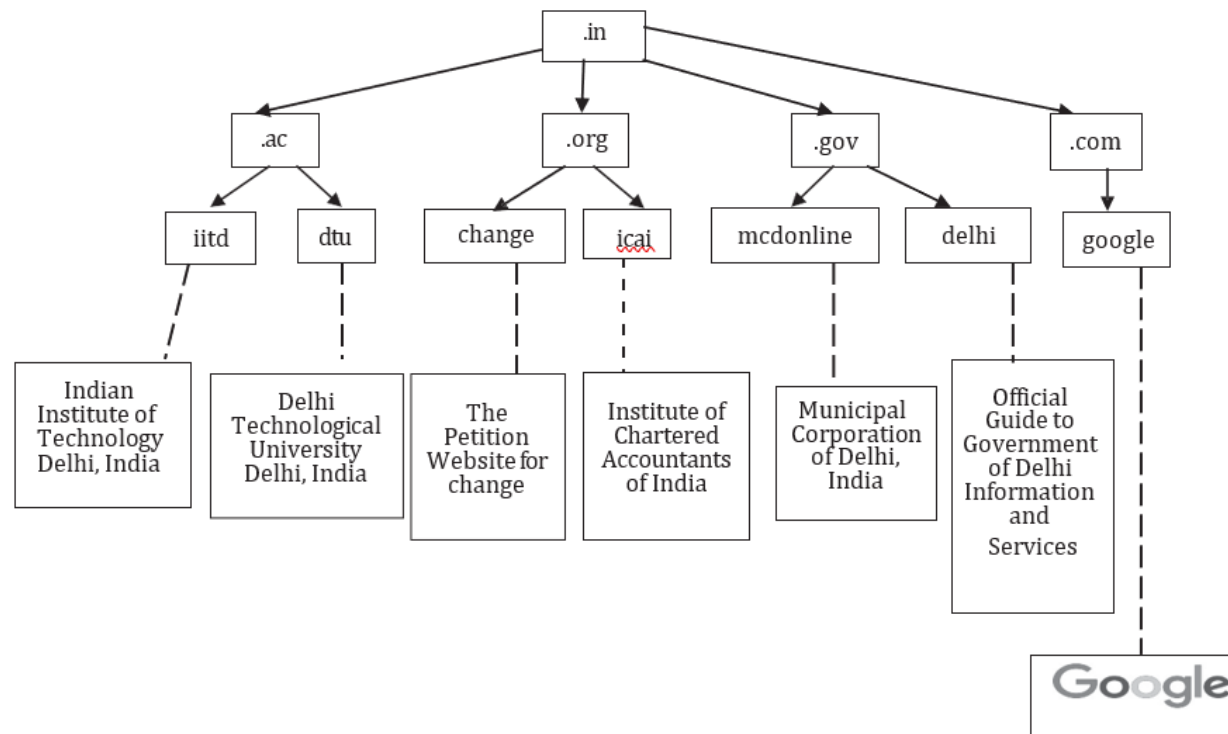
- ▶ A URL consists of several parts, with a generic structure of protocol, domain name, path, and filename.
- ▶ Protocol specifies the transfer method, like HTTP or FTP.
- ▶ Domain name includes www (optional), second-level name (e.g., dtu.ac), and top-level name (indicating organization or geographic region).
- ▶ Path denotes the server directory or folder, specifying the resource location.
- ▶ File name identifies the specific file in that directory with extensions like htm or php.
- ▶ Example: `http://www.dtu.ac.in/Academics/antiragging.php`.

# 1.2.2 Internet Addressing

- ▶ The DNS is a distributed system with a hierarchical structure, represented as a tree, where each node is a DNS name (Figure 1.9).
- ▶ Each branch in the DNS tree is a DNS domain, which can contain hosts or sub-domains.
- ▶ The top-level domains are at the root of the tree, followed by sub-domains in a top-down hierarchy.
- ▶ A URL is now considered a subset of Uniform Resource Identifier (URI), which is a string identifying resources on the Internet.
- ▶ A URI can identify a resource by location, name, or both, making it more general than a URL.
- ▶ URL and URN (Uniform Resource Name) are specializations of URI.



# 1.2.2 Internet Addressing



**FIGURE 1.9**  
Sample DNS hierarchy.

# 1.2.2 Internet Addressing

- ▶ Every URL is a URI, but every URN is also a URI, and they are not interchangeable.
- ▶ A URL provides information about fetching a resource from its location, starting with a protocol (e.g., http) and including the host name and document path.
- ▶ A URN uniquely identifies a resource by a name and starts with the prefix urn.
- ▶ URNs can represent ideas and concepts, not just documents, and can be translated into URLs by a resolver for document retrieval.
- ▶ A URI encompasses URLs, URNs, and other resource identification methods.
- ▶ In the analogy, a URN is like a unique name (e.g., ISBN for a book), a URI is an identifier representing the contents of the book, and a URL is the location of the book (e.g., its web address).

# 1.3 Accessing the Internet

- ▶ The Internet is composed of numerous connected computing devices called hosts or end systems.
- ▶ These hosts are linked together via communication links, but not directly to each other.
- ▶ Intermediate switching devices called routers are used to indirectly connect hosts.
- ▶ Routers are responsible for forwarding data packets.
- ▶ This structure is often referred to as the "Nuts and Bolts" view of the Internet.
- ▶ Further details about the Internet's structural configuration can be found in Section 1.3.1.

# 1.3.1 Internet Configuration

- ▶ Computers access the Internet through Internet Service Providers (ISPs).
- ▶ ISPs may connect to Network Service Providers (NSPs), forming the Internet Backbone.
- ▶ Internet Backbone is a network of routers connected by high-speed networks.
- ▶ Network Access Points (NAPs) are where backbones meet and exchange traffic.
- ▶ ISPs can connect directly to a backbone or through a larger ISP.
- ▶ Internet's basic building blocks include ISPs, backbones, NAPs, regional networks, and POPs.
- ▶ A Point of Presence (POP) is a machine connected to the Internet.
- ▶ ISPs offer dial-up or direct access to POPs, providing connections to subscribers.

# 1.3.1 Internet Configuration

- ▶ The Internet access structure is hierarchical, with Tier-1, Tier-2, Tier-3 ISPs at different levels.
- ▶ Tier-1 ISPs have national/international coverage, Tier-2 ISPs are often regional, and Tier-3 ISPs are the closest to end systems.

# 1.3.1 Internet Configuration

- ▶ ISPs offer Internet accounts with various connection options: dial-up, high-speed, and wireless access.
- ▶ Dial-up access uses analog modems over phone lines, establishing the Point-to-Point Protocol (PPP).
- ▶ High-speed access includes options like DSL, ISDN, leased lines, and cable Internet connections, each suitable for specific needs.
- ▶ Wireless access is available through Wi-Fi technology, allowing devices to connect to the Internet when within range of a wireless network.
- ▶ Different access methods cater to the diverse connectivity preferences and requirements of users.

## 1.3.2 Web Browser

- ▶ A web browser is a software program for retrieving, presenting, and navigating information on the Web.
- ▶ The primary function of a browser is to use a URL to locate and retrieve information resources.
- ▶ A URL is a four-part addressing scheme that informs the browser about:
  1. The transfer protocol for transporting the file.
  2. The domain name of the computer where the file is hosted.
  3. The pathname of the folder or directory on that computer.
  4. The name of the file.
- ▶ These components enable the browser to access and display web pages accurately.



## 1.3.2 Web Browser

- ▶ Major web browsers allow users to access multiple information resources in different windows or tabs.
- ▶ They include features like pop-up blockers to prevent unwanted windows from opening.
- ▶ Some well-known web browsers include Internet Explorer, Netscape Navigator, Mozilla Firefox, Opera, Google Chrome, Safari, and more.
- ▶ The basic functions of a web browser involve interpreting HTML markup and presenting documents visually.
- ▶ They support hyperlinks in HTML documents, enabling users to navigate between web pages.
- ▶ Browsers use HTML forms and the HTTP protocol to send requests, retrieve data from web applications, and maintain and manage cookies.

# 1.4 Internet Organizations

- ▶ No one owns or controls the entire Internet; it's a concept relying on a physical infrastructure connecting networks.
- ▶ The Internet is governed by a variety of loosely coupled organizations.
- ▶ These organizations lack a strict hierarchy in overseeing the Internet's development.

# 1.4 Internet Organizations

- ▶ Internet Society (ISOC) coordinates long-term Internet development.
- ▶ Internet Engineering Task Force (IETF) is an international community of network professionals, producing technical documents to enhance Internet quality.
- ▶ Internet Corporation for Assigned Names and Numbers (ICANN) handles IP address allocation, gTLDs, ccTLDs, DNS management, root server system, and protocol identifiers.
- ▶ Internet Assigned Numbers Authority (IANA) manages responsibilities now under ICANN, including TLDs, protocol numbers, IP addresses, and AS numbers.
- ▶ Internet Architecture Board (IAB) oversees Internet architecture, protocol development, scalability, and openness of standards.

# 1.4 Internet Organizations

- ▶ Internet Engineering Steering Group (IESG) manages technical aspects of IETF activities and Internet standards.
- ▶ Internet Research Task Force (IRTF) conducts research on protocols, applications, architecture, and technology.
- ▶ Internet Research Steering Group (IRSG) oversees and supports research carried out by IRTF.
- ▶ World Wide Web Consortium (W3C) develops web technology standards, not directly related to other Internet organizations.
- ▶ Regional Internet Registries (RIRs) manage and allocate Internet number resources, including IP addresses and AS numbers.

# 1.5 Cyber Ethics

- ▶ Cyber Ethics encompasses responsible behavior on the Internet, including basic Netiquettes.
- ▶ Users must follow ethical conduct and adhere to societal and cyberspace laws.
- ▶ Netiquette involves respecting privacy, avoiding plagiarism, and showing responsible human behavior.
- ▶ Essential elements include respect for others' time and bandwidth, prohibiting spam, viruses, and hoaxes, fostering a culture of safe, ethical, and responsible Internet use.

# 1.5 Cyber Ethics

► Cyber Ethics includes:

1. Positive and responsible contribution to e-society.
2. Being respectful and courteous in communication.
3. Avoiding harm to others by not spreading harmful content, viruses, gossip, or using others' information.
4. Sharing network resources and maintaining honesty and trustworthiness.
5. Respecting property rights and copyrights, not downloading copyrighted material, and giving proper credit for intellectual property.

# 1.5 Cyber Ethics

- ▶ The growth of the Internet with e-business, e-commerce, and more users has heightened the importance of cyber laws.
- ▶ Cyber law governs legal issues related to the use of interconnected information technology.
- ▶ It deals with the legal aspects of computers and the Internet.
- ▶ Cybercrime is a darker aspect of technology, and cyber laws play a crucial role in combating it.



# Review Questions

1. Answer the following:

- i. \_\_\_\_\_ network is optimized for a larger geographical area than a LAN, ranging from several blocks of buildings to entire cities, typically covering an area ranging from 5 to 50 km diametrically.
- ii. In the Internet Protocol stack \_\_\_ layer is responsible for reliable source-to-destination delivery of the entire message.
- iii. BitTorrent is an example of \_\_\_\_\_ network architecture.
- iv. \_\_\_\_\_ is a 32-bit logical address, composed of four 8-bit fields, called octets.
- v. \_\_\_\_\_ offers Internet accounts to configure the network connections either by using a dial-up access, high-speed access or wireless access.
- vi. \_\_\_\_\_ is a software program that retrieves, presents, and traverses information resources on the web.
- vii. W3C is the acronym for \_\_\_\_\_.
- viii. \_\_\_\_\_ refers to the code of responsible behavior on the Internet.
- ix. \_\_\_\_\_ develops standards for the Internet.
- x. URL consists of three parts. They are \_\_\_, \_\_\_\_\_ and \_\_\_\_\_.

# Review Questions

2. The terms “Internet” and “Web” are synonymous and can be used interchangeably. Comment.
3. What is the “Hourglass” Architecture of the Internet?
4. Differentiate between the following
  - i. LAN, WAN, MAN
  - ii. Client/Server architecture and Peer-to-Peer architecture
  - iii. URI, URN, URL
5. How are the concepts of IP addressing, URL, and DNS associated?
6. In what ways can an Internet Service Provider (ISP) configure network connections?
7. What are the basic functions of a web browser? Name any four web browsers.
8. List a few Netiquettes that should be practiced in order to become a good “cyber citizen.”



# Thank You

See you in the next chapter