Chapter 1

The Data Communications Industry

Objectives of Chapter 1

- To understand the meaning of data communications
- To study the basic components of data communications as an industry
- To understand standards and regulations
- To have a general idea of the data communications industry challenges and solutions
- The OSI Model

GOAL: Introduce you to the industry of data communications.

What is Data Communication

- Subset of Telecommunications.
- Telecommunications includes radio, telegraphy, television, telephony, data communication, etc.
- It is the encoded transmission of data via electrical, optical, or wireless means between computer or network processors.

The Best way to Approach Data Communications

- Since the field of data communications is in a state of constant change-how can you study data communications and keep your understanding?

LAW: You will never know all there is to know about data communications

- If you accept this law as fact, you will be well on your way to survival in this most exciting and rewarding field.

Data Communications Industry

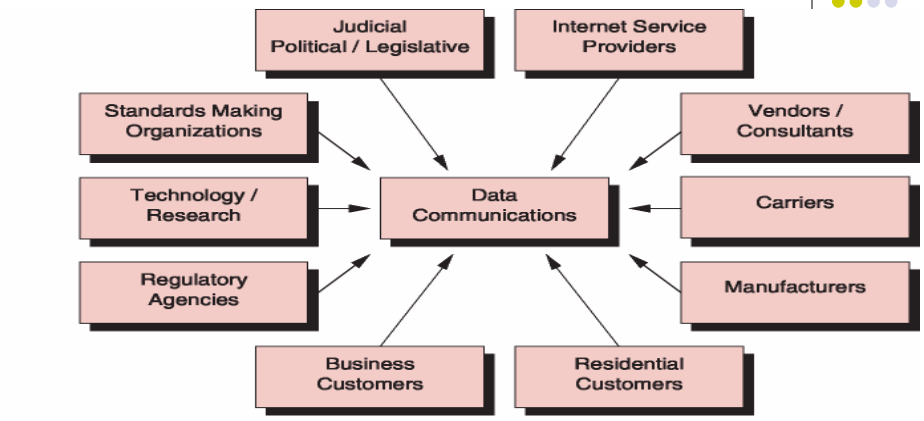


Figure 1-1 The Data Communications Industry: A Series of Interacting Components

- The Data Communications industry has many stakeholders with complex relationships.

Data Communications Industry

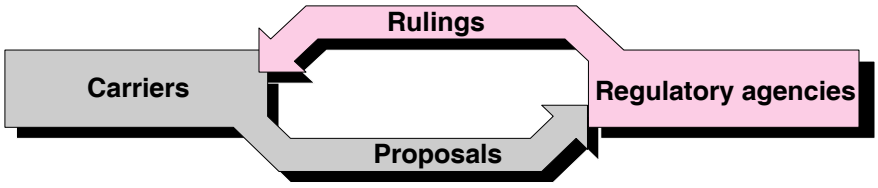
- To be an effective participant in the data communications industry, it is important to understand the industry forces at work behind the scenes.
- Forces that derive the data communication as an industry:
  - The Regulatory Process
  - The Standards Process
  - Manufacturing, Research and Technology

Systems Relationship of Regulatory Agencies & Carriers

- Two tightly dependent components in a constant and ongoing state of change are the **regulatory** and **carrier** components.
- The **regulatory component** represents local, provincial, and national agencies charged with regulating telecommunications.
- The **carrier component** represents companies such as telephone, mobile phones, and cable TV companies that sell transmission services.

Systems Relationship of Regulatory Agencies & Carriers

- This interaction is a rather formal process of a series of proposals, e.g., tariffs.
- Tariffs are submitted to state and governmental regulatory agencies by carriers, and rulings and approvals are issued in return.



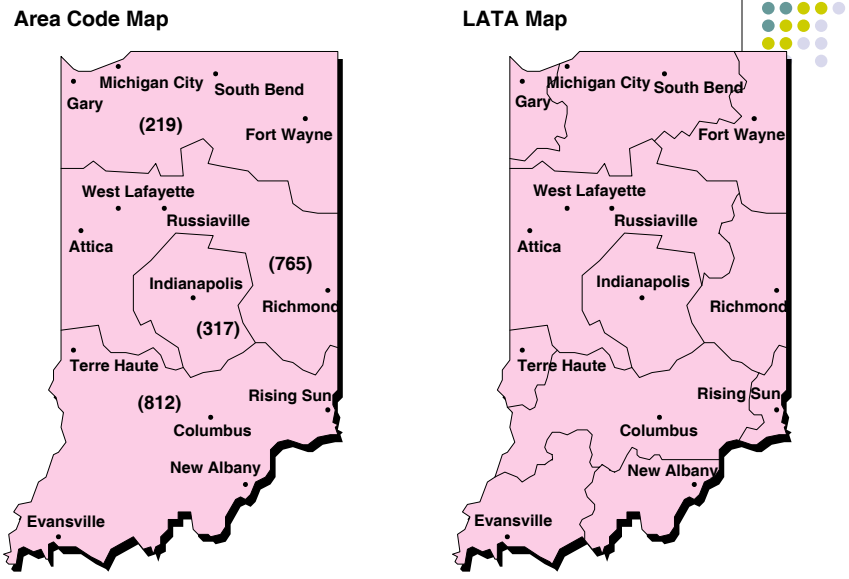
Role of Regulatory Agencies

- The regulating agencies must balance objectives that are sometimes contradictory:
  - Basic phone service must remain affordable enough that all residents of a country can afford it. This guarantee is sometimes known as universal service or universal access.
  - Phone companies must remain profitable to be able to afford to constantly invest in upgrading their physical resources (hardware, cables, buildings, etc.) as well as in educating and training their human resources.

Breakup of AT&T

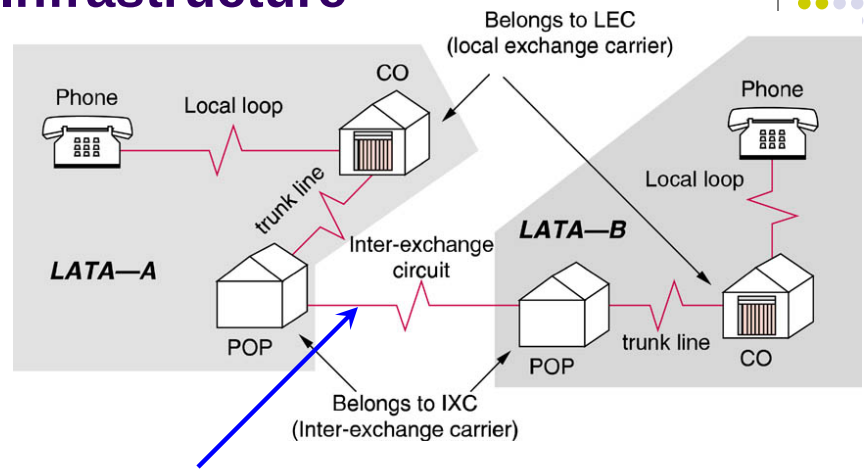
- Till late 1970s & early 80s, there was single company (AT&T) telecommunications industry in US. Hardware and software were supplied by it.
- Homeowners were not allowed to purchase and install their own phones rather rent from AT&T.
- AT&T was declared a monopoly and broken into several smaller companies through a ruling given by the US justice department. (AT&T, Bell Labs, Lucent, NCR)
- Today's competitive telecommunications industry in US is largely the result of this ruling referred to as deregulation.

Area Codes vs. LATAs for the state of Indiana



LATAs do not correspond to area codes

Basic Telecommunications Infrastructure



Inter-exchange circuit – may be via satellite, microwave, fiber optic cable, traditional wiring, or some combination of these media

Basic Telecommunications Infrastructure

- Basic telecommunications infrastructure & the components of PSTN (Public Switched Telephone Network) are:
  - **LATA** (Local Access Transport Areas) – established as a result of the breakup of AT&T to segment long-distance traffic.
  - **LEC** (Local Exchange Carrier) – traffic within a LATA is reserved for the local phone company, i.e, the LEC.
  - **Local loops** – phones connected to the PSTN via circuits
  - **CO** (Central Office) – a facility belonging to local phone company which switches calls to proper destination.
  - **IXC** (Inter-eXchange Carrier) – Phone traffic for locations outside of local LATA must be handed off to the long-distance of the customer choice.
  - **POP** (Point Of Presence) – competing long-distance carriers wishing to do business in given LATA maintain a switching office called POP.

The Importance of Standards

- A **standard** is an agreed upon protocol.
- Thanks to standards, end-users can be confident that devices will operate as specified and will interoperate successfully.
- Without standards, data communications would be nearly impossible.
- Standards allow multiple vendors to manufacture competing products that work together effectively.

Standards Making Organizations

- Standards making organizations for data communications industry fall into two major categories: *officially sanctioned* or *ad hoc*.
- Some officially sanctioned standards making organizations are ***ISO, CCITT, ANSI, IEEE, EIA, IAB, ISOC,*** etc.
- Ad hoc can be by ***task forces, user groups, interest groups, consortiums, forums, institutes,*** etc.

Standardization Process

- Seven steps to make standards:
  1. Recognize the need for a standard
  2. Formation of a committee or task force
  3. Information/recommendation gathering phase
  4. Tentative/alternative standards issued
  5. Feedback on tentative/alternative standards
  6. Final standards issued
  7. Compliance with final standards

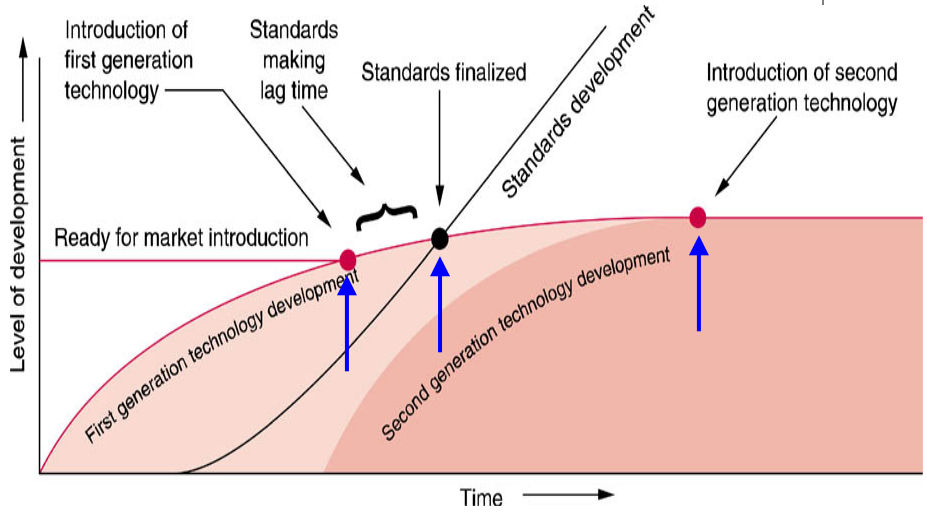
Business Impacts of Standards

- The standard-making process is important for manufacturers. They monitor it closely and participate in it actively.
- The development of new technology most often precedes its standardization.
- To capture early market share and influence the standard-making process, manufacturers often produce and sell equipment before standards are issued-to get their own technology declared as “the standard”.

Technology and Standards Development

- By the time standards are actually adopted for a given technology, the next generation of that technology is sometimes ready to be introduced in the market.
- The development of a standard generally lags the development of the technology.

Technology and Standards Development



Confusion in standards

- Two issues can lead to confusion and might cause bad purchase decisions:
  1. **Standards Extension** -to differentiate their own product offerings, vendors offers "extensions" to a given "standard" which do not necessarily match all the other vendors' "extensions".
  2. **The Jargon Jungle** -competing manufacturers often call similar features or operational characteristics by different names, leaving it to the consumer to sort out the differences.

"There is no data communications police"

Manufacturing, Research and Technology

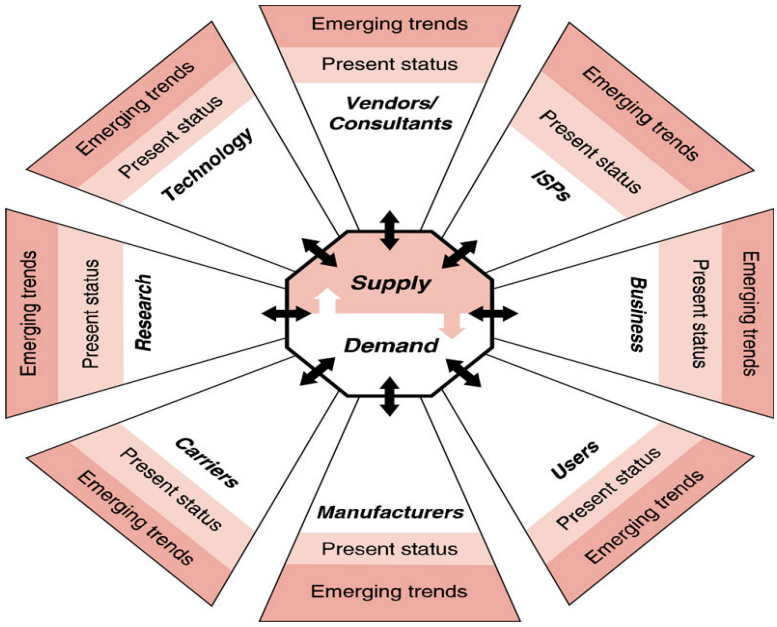
- Supply and demand act as driving forces of data communications.
- Technology push / Demand pull
- **Push** -new technologies may be introduced to the market to initiate innovative uses for this technology and thereby generate demand.
- **Pull** -demand pull causes research and development efforts to accelerate, thereby introducing new technology sooner than it would brought to market.

e.g., Faster transfer of data.

Manufacturing, Research and Technology

- Available technology also plays a key role in the relationship between business and carriers.
- A carrier cannot provide the network services that businesses demand unless the proper technology is available.
- Carriers can afford to invest in new technology only through profitable operations.
- This dynamic relationship can be expressed by:

Business demand + available technology = emerging network services



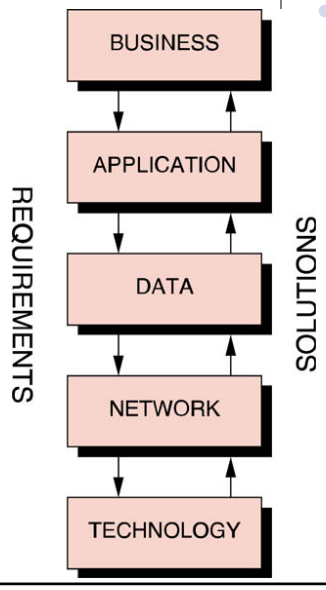
Supply and demand as driving forces of the data communications industry.

Challenges & Solutions to Business Oriented Data Communications

- **Fact** - corporations are not interested in investing in technology merely for the sake of technology.
- Rather, implemented technology must produce measurable impact on business goals and requirements.
- Ensuring and accounting for this technological impact on business goals is a significant challenge.

The Top-Down Approach

- Analysis at upper layers produces requirements that are passed down to lower layers
- While solutions meeting these requirements are passed back to upper layers.
- Hence, business needs/requirements drive solutions.



Business level objectives should be understood first. What is company or individual accomplish by installing this network? Businesses critically reexamine their business processes in an analysis methodology known as business process reengineering (BPR).

After business level objectives are understood, all the applications that will be running on the computer systems attached to these networks, must be understood. Because these applications will be generating the traffic that will travel over the implemented network.

Data that applications generate must be examined, e.g., voice, video, image, fax, in addition to the true data. Also amount of data, its physical location, characteristics, compatibility, etc.

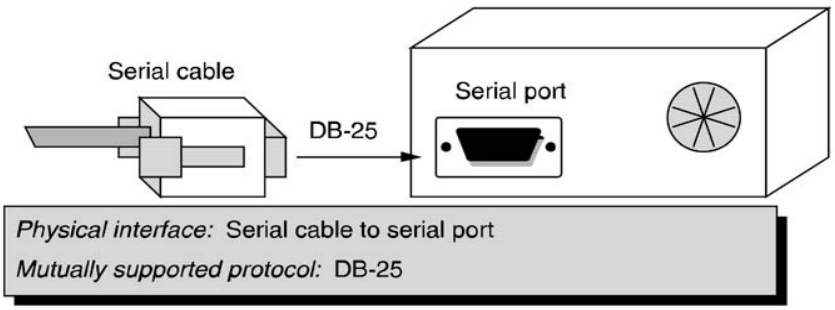
Requirements of network that will possess the capability to deliver this data in a timely, cost-effective manner. A properly designed network supports businesses to respond quickly to customers & rapidly changing market conditions. These requirements called *logical network design.*

This layer determines how various hardware & software components are combined to build a functional network that meets the pre-determined business objectives. The description of required technology is referred to as *physical network design.*

Challenge: Connectivity and Compatibility

- Solving incompatibility problems is at the heart of successful network implementation.
- Compatibility can be thought of successfully bridging the communications gap between two or more technology components (HW or SW).
- This gap is referred to as ***Interface***, it can be HW-to-HW or SW-to-SW or HW-to-SW.

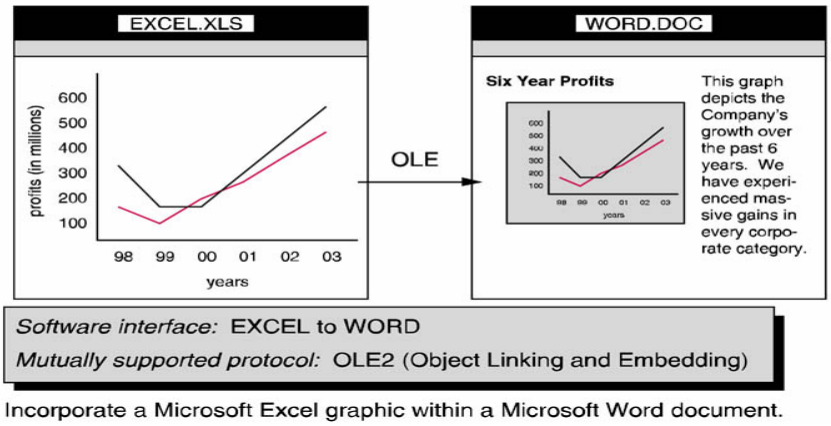
Hardware to Hardware Interface



The serial cable is compatible with the serial port.

- Interfaces may be physical in nature (HW-to-HW). For example:
  - Cables physically connected to serial ports on a computer.
  - A network card physically plugging into the expansion bus inside a computer.

Software to Software Interface

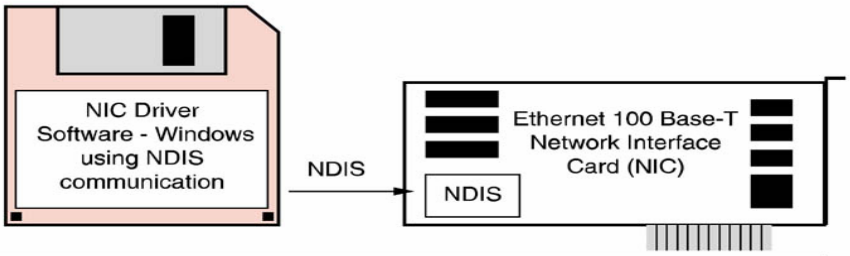


Software interface: EXCEL to WORD
Mutually supported protocol: OLE2 (Object Linking and Embedding)

Incorporate a Microsoft Excel graphic within a Microsoft Word document.

- Interfaces may also be logical or software-oriented (SW-to-SW). For example:
  - A client-based data query tool (MS Excel) gathering data from a large database management system (Oracle).

Software to Hardware Interface



Interface: Network Operating System (NOS) driver to Network Interface Card (NIC)
Mutually supported protocol: Network Driver Interface Specification (NDIS)

- Interfaces may cross the hardware to software boundary (HW-to-SW). For example:
  - A specific piece of software known as a driver that interfaces to an installed network interface card (NIC).
  - A piece of operating system software known as a kernel that interfaces to a computer's CPU chip.

Challenge: Compatibility & Protocols

- Compatibility is possible because of Protocols.
- A **protocol** is a set of rules about how communicating components can talk to each other.
- There are many well-known as well as a few obscure protocols used in telecommunications.
- Protocols may be proprietary (used exclusively by one or more vendors) or open (used freely by all interested parties). Protocols may be officially sanctioned by international standards making bodies, or they may be purely market driven (de facto protocols). A protocol that has become a standard not because it has been approved by a standards organization but because it is widely used and recognized by the industry as being standard is called de facto protocol.

Communications Architecture

- Two of the most popular communications architectures are: *the 7-layer OSI model* and *the 4-layer Internet Suite of Protocols* (or TCP/IP) model.
- The **ISO** (International Standards Organization) has developed a framework for organizing networking technology and protocol solutions known as the **OSI** (Open Systems Interconnection) network reference model.
- The ***OSI Model*** divides the communication between two networked computing devices into 7 layers or categories.

Solution: The OSI Model

- The power of the OSI Model, officially known as ISO Standard 7489, lies in its openness and flexibility.
- It can be used to organize and define protocols involved in communicating between two computing devices located in the same room as effectively as two devices located on opposite sides of the world.
- It is **the reference model** in the world of telecommunications.

Layer	OSI
7	Application
6	Presentation
5	Session
4	Transport
3	Network
2	Data Link
1	Physical

OSI Model

- **Model:** It means that it's only theory! In fact the OSI model is not yet fully implemented in real networks.
- **Open System:** It can communicate with any other system that follows the specified standards, formats, and semantics.
- **Protocols:** give rules that specify how the communication parties may communicate.

The OSI Model

- The bottom layer (layer 1) is concerned with the actual physical connection of two computers or networks.
- Layers 2-6 are not much obvious but represent a sufficiently distinct logical group of functions to connect two computers, as to justify a separate layer.
- The top layer (layer 7) represents services offered to the application programs running on each computer.
- OSI model is not a protocol or group of protocols. It is standardized, empty framework into which protocols can be listed to perform an effective network analysis & design.

Categorizing LAN Architecture: OSI Model

- Consists of 7 layers that loosely group the functional requirements for communication between two computing devices regardless of the software, hardware, or geographical differences between the devices, may be in the same room or opposite sides of the world.
- Each layer relies on lower layers to perform more elementary functions and to offer total transparency to the intricacies (ins and outs) of those functions. At the same time, each layer provides the same transparent service to upper layers.
- First two layers are hardware, other five are software.

The OSI Model

- Network analysts literally talk in terms of the OSI model.
- When troubleshooting network problems, the network analyst starts with the physical layer and ensures that protocols and interfaces are operational at each layer.
- Another benefit of the OSI model is that it allows discussion about the interconnection of two networks or computers in common terms without dealing in proprietary vendor jargon.

Internet Suite of Protocols Model

- Also known as TCP/IP (Transmission Control Protocol/Internet Protocol) protocol suite or TCP/IP architecture.
- Like the OSI model, this is also a layered model in which upper layers use the functionality offered by lower layer protocols.
- Each layer's protocols are able to operate independently from the protocols of other layers. E.g., protocols on a given layer can be updated or modified without having to change the protocols in any other layer.

Internet Suite of Protocols Model

- Either communications architecture can be used to analyze & design communication networks.
- In case of internet suite of protocols model, full functionality of inter-network communications is divided into four layers rather than seven.
- Because of the fewer layers, some network analysts consider the internet suite of protocols model to be more simple and practical than the OSI model.

Layer	OSI	INTERNET	Data Format	Protocols
7	Application	Application	Messages or Streams	TELNET FTP TFTP SMTP SNMP CMOT MIB
6	Presentation			
5	Session	Transport or Host-Host	Transport Protocol Packets	TCP UDP
4	Transport			
3	Network	Internet	IP Diagrams	IP
2	Data Link	Network Access	Frames	
1	Physical			

The OSI model maps to the Internet model and corresponding protocols.

I-P-O (Input–Processing–Output) Model

- Once the protocols are determined for two or more computers to communicate, next step is to determine the technology required to deliver the internetworking functionality.
- To understand the basic function of any networking equipment, one really need to only understand the differences between the characteristics of the data that came in (I) and the data that went out (O). Those differences identified were processed by the data communications equipment (P).
- E.g., Connecting the computer (serial port) to the printer (parallel port).
- Identify and document the process you want to make on the input and what kind of output it should provide.

Layer 1: Physical Layer

- It is responsible for the establishment, maintenance and termination of physical connections between communicating devices, “Point-to-Point data link”.
- transmits and receives a stream of bits (0s and 1s).
- no data recognition at the physical layer.
- operation is controlled by protocols that define the electrical, mechanical, and procedural specifications for data transmission.
- RS232 specification is an example of this layer.

Layer 2: Data-Link Layer

- It is responsible for providing protocols that deliver reliability to upper layers for Point-to-Point connectivity between devices over the physical connections provided by the underlying physical layer.
- It provides reliability to the bit stream by breaking it into chunks called **frames**, or **cells**.
- The key functions are add address, error detection, error correction, flow control.
- To allow the OSI model to closely adhere to the protocol structure, & operation of a LAN, IEEE split Data-Link layer into **two sub-layers**: LLC and MAC.

Data-Link Sublayers

- Media Access Control (MAC): It controls who can use the network when multiple computers are trying to access it simultaneously (i.e. Token passing, Ethernet, etc.). Unique addresses assigned to NICs at the time of manufacture are commonly referred to as MAC addresses.
- Logical Link Control (LLC): It controls frame synchronization, flow control and error checking.
- The advantage of splitting the Data-Link layer & having a single common LLC protocol is that it offers transparency to the upper layers while allowing the MAC sub-layer protocol to vary independently.

Layer 3: Network Layer

- Concerned with the transmission of **packets**.
- Choose the best path to send a packet (**routing**), creating logical paths, known as virtual circuits, for transmitting data from node to node.
- Routing and forwarding are functions of this layer, as well as addressing, internetworking, error handling, congestion control and packet sequencing.
- Two protocols are most widely used:
  - X.25
  - IP

Layer 4: Transport Layer

- Network layer does not deal with lost messages.
- Transport layer ensures reliable service.
- Breaks the message (from session layer) into smaller segments, assigns sequence number and sends them.
- Reliable transport connections are built on top of X.25 or IP.
- It provide end-to-end recovery & flow control.
- It also, provide mechanisms for sequentially organizing network layer packets into a coherent **message.**

Layer 5: Session Layer

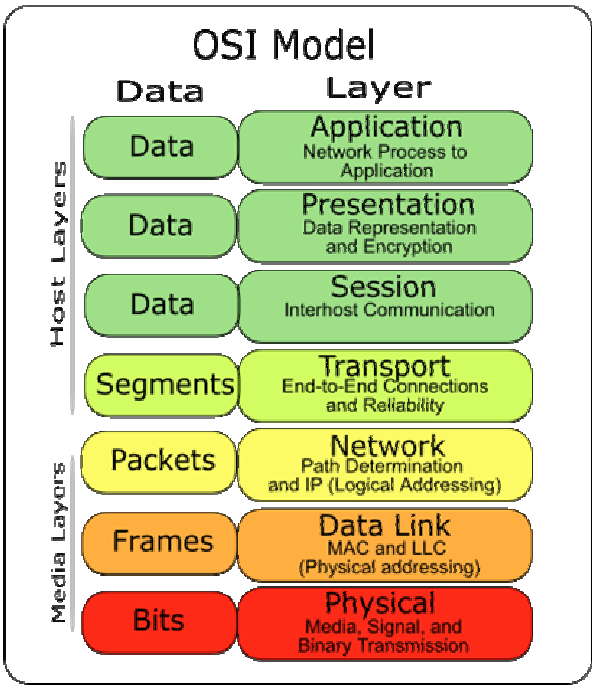
- This layer establishes, manages and terminates connections between applications.
- The session layer sets up, coordinates, and terminates conversations, exchanges, and dialogues between the user application programs at each end.
- It deals with session and connection coordination.

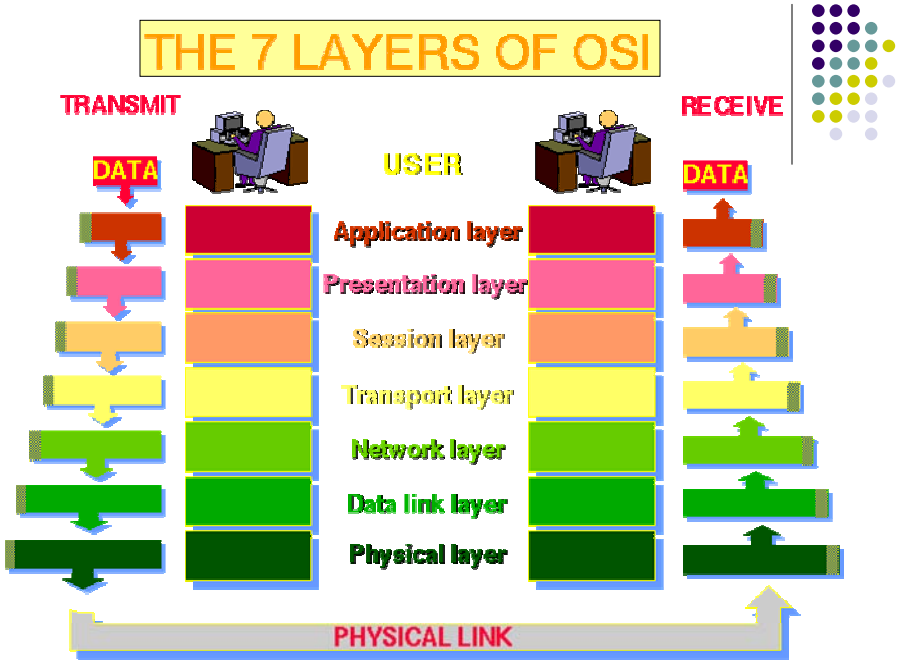
Layer 6: Presentation Layer

- This layer provides an interface between user applications & various presentation-related services required by those applications. An example is data encryption/decryption protocols.
- It is sometimes called the *syntax layer*.

Layer 7: Application Layer

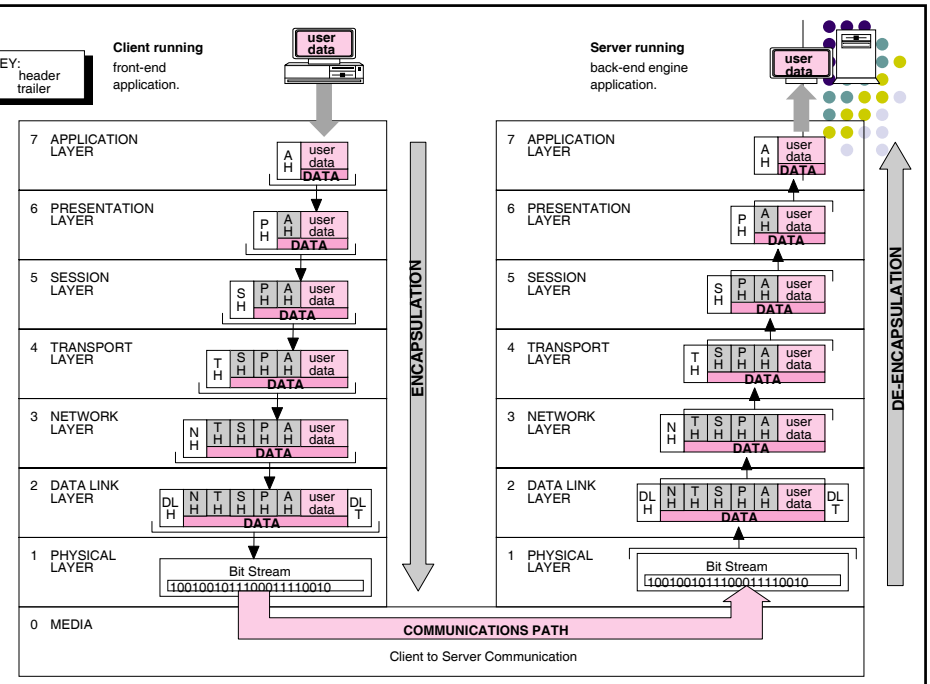
- This layer includes utilities that support end-user application programs but it does not include end-user application programs.
- User authentication and privacy are considered
- Collection of miscellaneous protocols for high level applications.
- It provides application services for Electronic mail, file transfer, connecting remote terminals, etc. E.g., SMTP, FTP, Telnet, HTTP, etc.





Encapsulation/De-encapsulation

- Encapsulation: in this process, each successive layer of the OSI model adds a header (or & trailer) according to the syntax of the protocol that occupies that layer.
- De-encapsulation: in this process, each successive layer of the OSI model removes headers (or & trailer) & processes the data that was passed to it from the corresponding layer protocol on the source client.
- These two processes describe how the various protocol layers interact with each other to enable an end-to-end communications session.



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The Data Communications Profession – Professional Development

- What critical skills are required for data communications professionals. To know the skills you must know the environment in which they will work, which is a knowledge-based economy.
- Data Communications professionals are thought of today more as partners or change agents rather than consultants.

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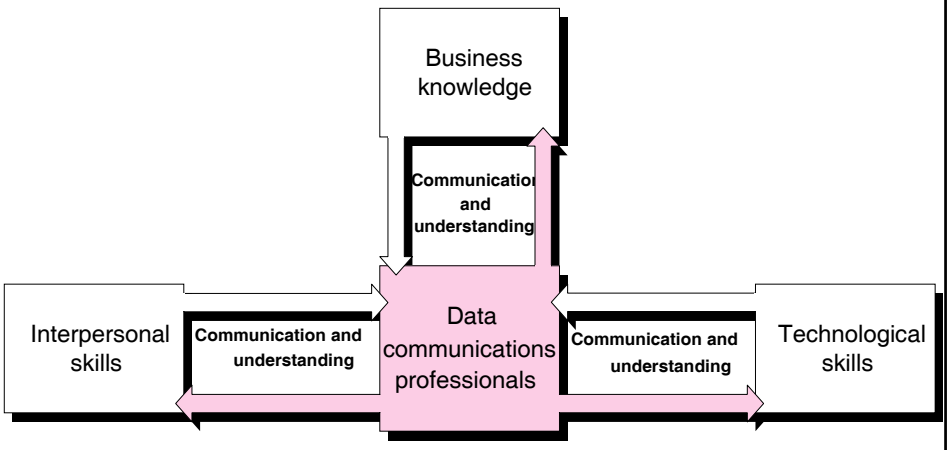
Required Critical Skills for Data Communications Professionals



Required Critical Skills for Data Communications Professionals

- Understand and can speak “business.”
- Demonstrate an ability to own and solve business problems in a partnership rather than consultative role.
- Demonstrate an ability to look outside their own expertise for solutions.
- Exhibit an understanding of the need for lifelong learning.

Required Critical Skills for Data Communications Professionals

- Demonstrate an ability to evaluate technology with a critical eye as to cost/benefit and potential for significant business impact.
- Understand comparative value and proper application of available network services
- Can work effectively with carriers to see that implementations are completed properly and cost effectively.
- Communicate effectively, verbally and orally, with both technically oriented and management personnel.

Professional Certification

- Why seek certification?
  - It is an indication of mastery of a particular vendor's technology, that may be important in some employment situations.
  - There are a number of well known certifications.
- The problem with certification:
  - The amount of material required to earn a certificate
  - The amount of continuing education and experience required to retain this certificate.
  - Vendor-specific certifications do not provide the broad background required for today's multi-vendor inter-networks.