Data Communication

Week 1

What happens in an Internet minute?

And **Future Growth** is **Staggering**

Source: Intel

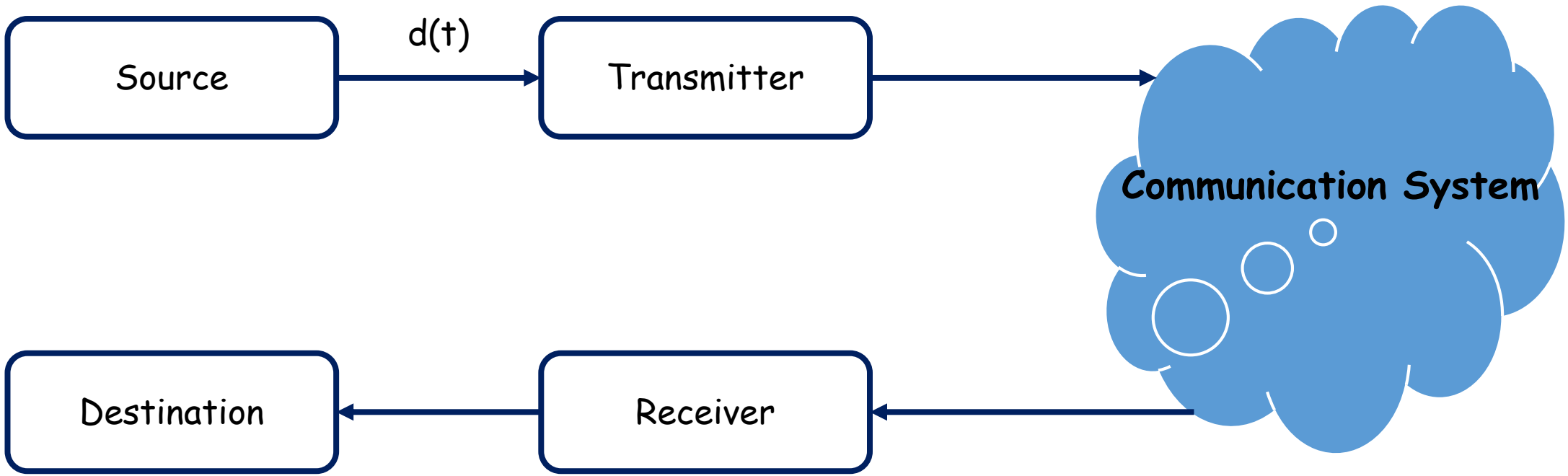
A few more facts

Kevin P. Murphy

We are drowning in information and starving for knowledge. — John Naisbitt.

We are entering the era of **big data**. For example, there are about 1 trillion web pages[1]; one hour of video is uploaded to YouTube every second, amounting to 10 years of content every day[2]; the genomes of 1000s of people, each of which has a length of 3.8×10^9 base pairs, have been sequenced by various labs; Walmart handles more than 1M transactions per hour and has databases containing more than 2.5 petabytes (2.5×10^{15}) of information (Cukier 2010); and so on.

A Simple Data Communication Model



d(t): Data or Message is the information to be communicated

A Simple Data Communication Model

- Source — where the data is originated
  - Source can be a computer, peripheral, or it can be some communication equipment like cell phones, or any system which can send data, which can process data and which can receive data
  - Then we will require a transmitter;
- Transmitter is the device which converts the data sent by the source into a suitable form for transmission through the medium.

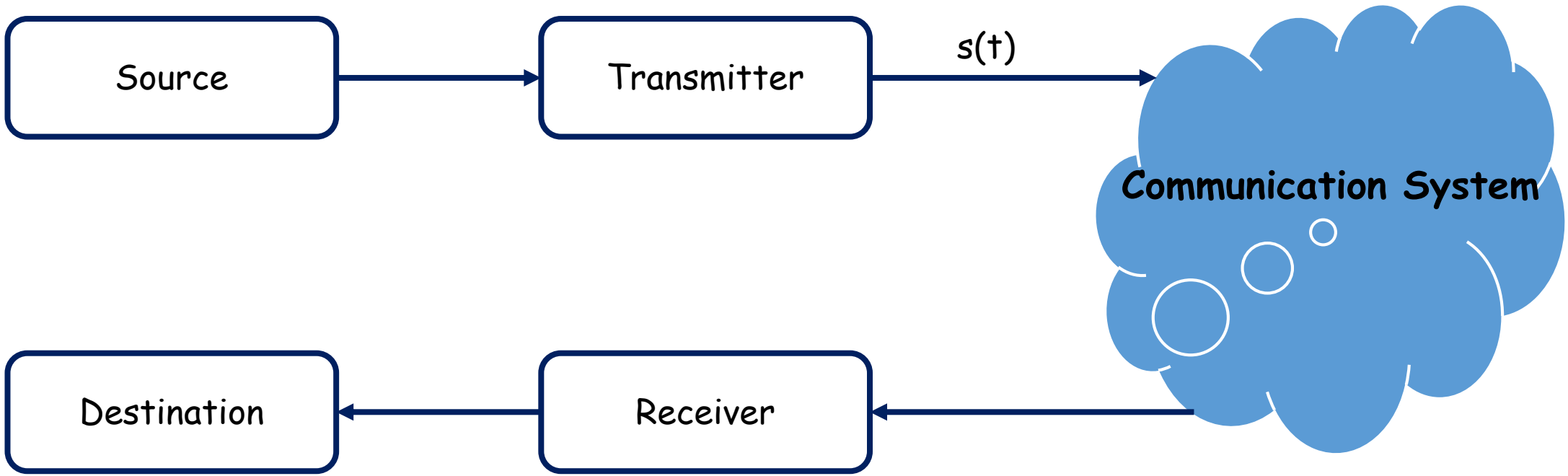
A Simple Data Communication Model

- The source generates data and transmitter will convert it into a suitable form which can be sent through the communication system.
- The communication system; the medium through which the signal is sent.
  - medium can be very simple; a piece of wire or a pair of wire like a coaxial cable, twisted pair of wire or it can be optical fiber or it can be Local Area Network or it can be Wide Area Network.
- So, by communication system we mean that it can be a very simple system like a pair of wire or it can be very complex system like LAN, WAN or internet.

A Simple Data Communication Model

- Receiver — receives the signal and converts it into data or signal
- Destination — where the data is sent

A Simple Data Communication Model



s(t): Signal that can be transmitted through a medium.

A Simple Data Communication Model

- Data is transformed into signal
  - as such the data cannot be sent through the communication system.
- Data has to be converted into some electromagnetic signal which can be transmitted through a medium.
- The signal can be electrical, electronic or optical in nature, which can be sent through the communication system.

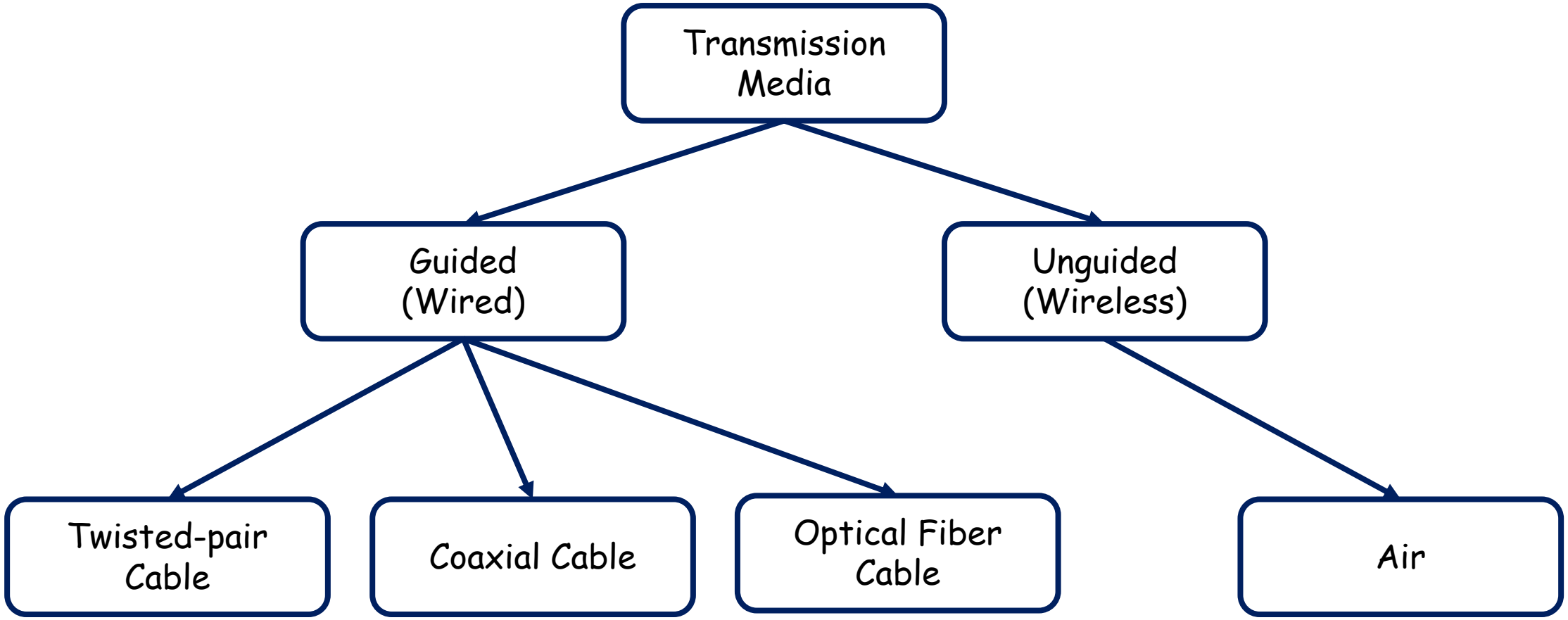
A Simple Data Communication Model

- Signals are two types; analog and digital
- the signal can be periodic in nature, and in fact a signal which is not periodic in nature can be considered as a combination of some periodic signals.
- The signal can have two different types of representation;
  - Time domain representation,
  - Frequency domain representation.

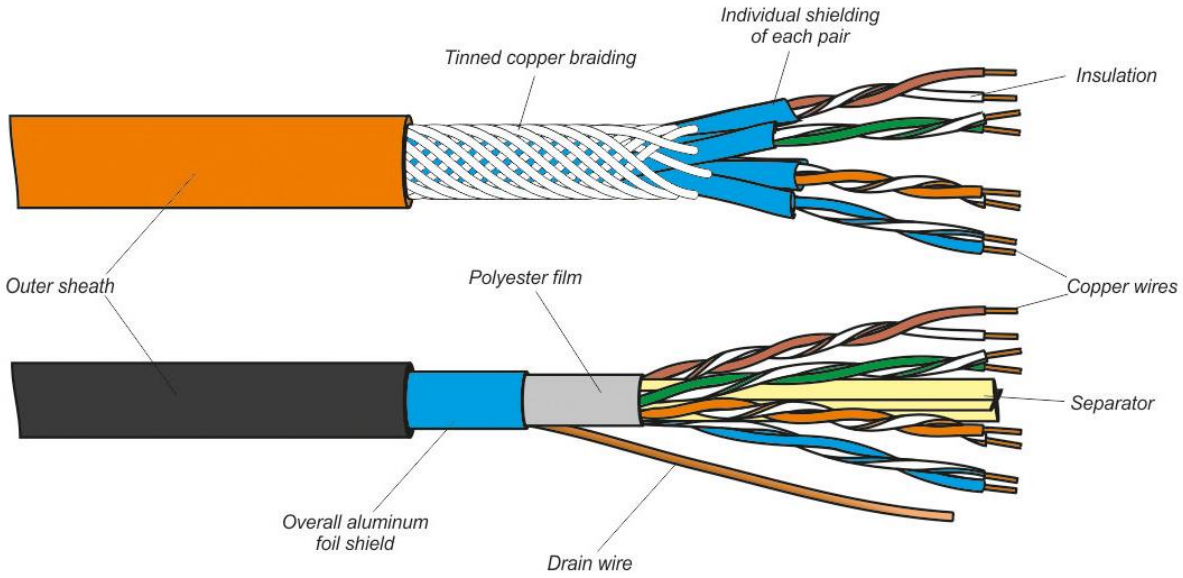
A Simple Data Communication Model

- As the signal passes through the transmission medium, it suffers some impairment and that impairment can be in the form of attenuation.
- Impairments will take mostly for two reasons
  - Attenuation and Distortion
- The distortion will occur in two forms
- These two forms are known as delay distortion and the time distortion
  - these two distortions are to be taken care of at the receiving end.

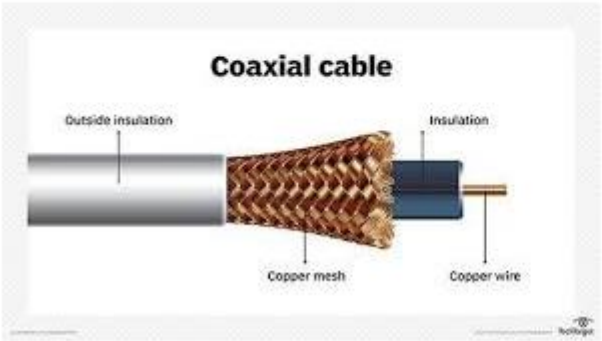
Transmission Media



Transmission Media

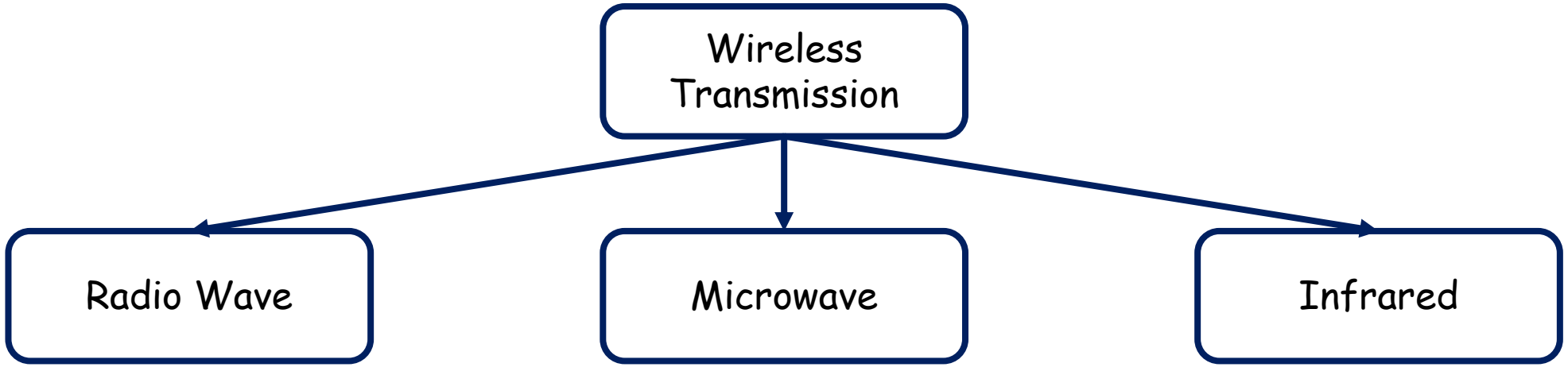


Twisted-pair Cable

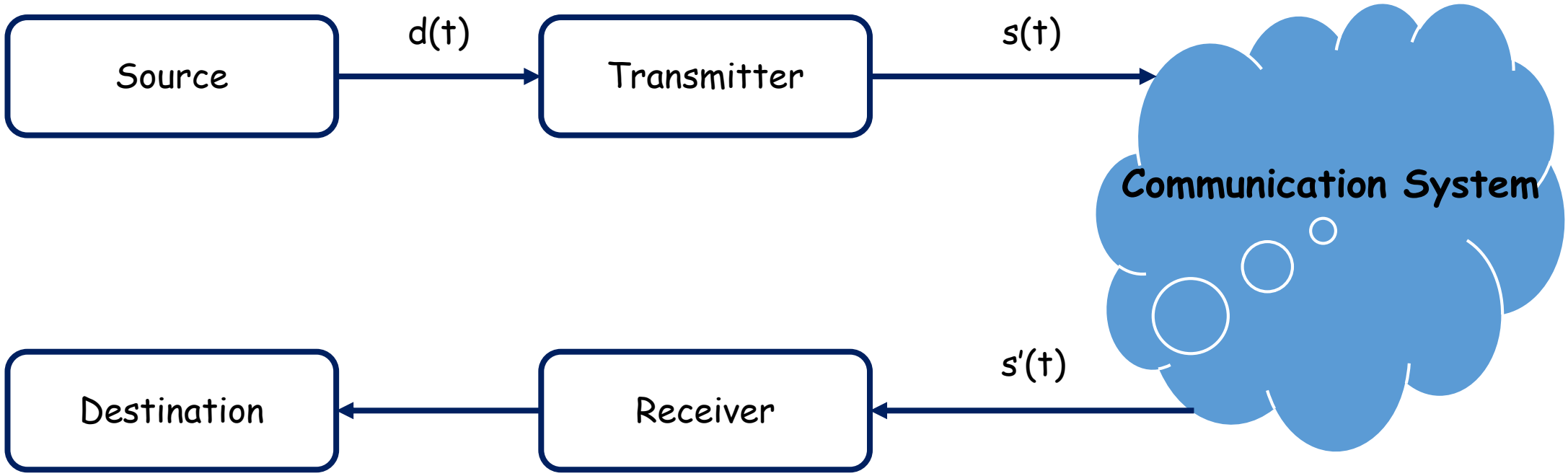


Optical Fiber Cable

Transmission Media



A Simple Data Communication Model



d(t): Data or Message is the information to be communicated

s(t): Signal that can be transmitted through a medium.

A Simple Data Communication Model

- the signal passes through the medium, because of various impairments the signal that is being sent S(t) is not same as it is received by the receiver.
- So, the signal received through the medium is different from what has been sent.
- But what the receiver wants is the same thing.
- Now we have to find out what kind of problem or what is the difference between the original signal and the received signal.

A Simple Data Communication Model

- Interfacing
- Error Detection and Correction
- Flow and Error Control
- Data Link Control

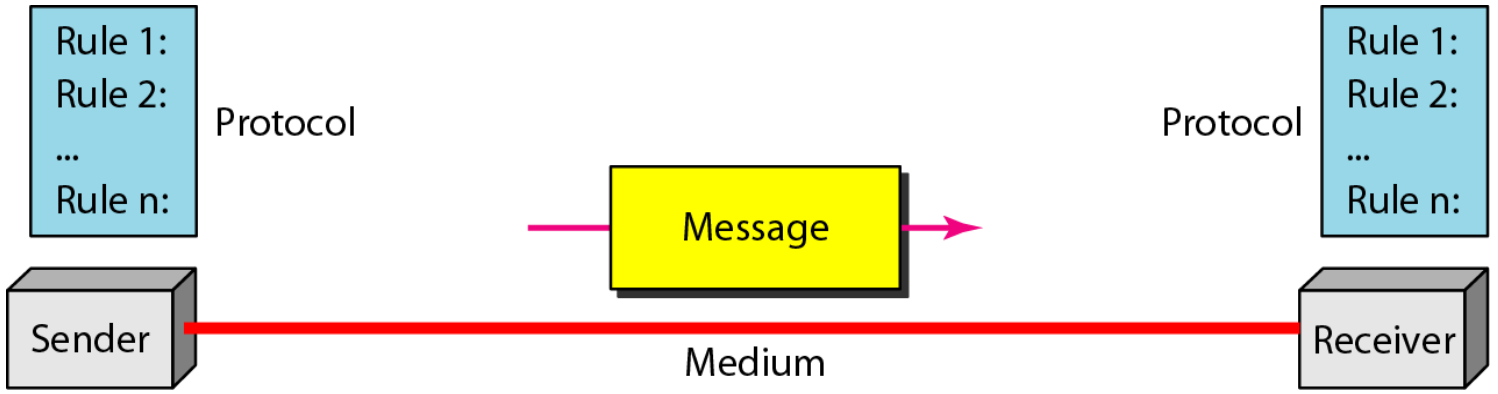
Data Communication (formally defined)

- The term telecommunication means communication at a distance.
- The word data refers to information presented in whatever form is agreed upon by the parties creating and using the data.
- Data communications are the exchange of data between two devices via some form of transmission medium such as a wire cable.

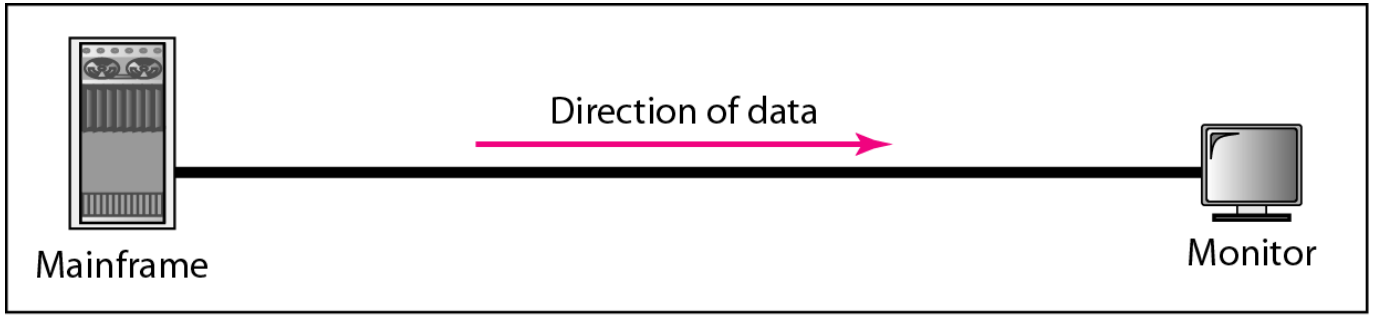
The Effectiveness of a data communication

- Delivery: The system must deliver data to the correct destination.
- Accuracy: The system must deliver data accurately.
- Timeliness: The system must deliver data in a timely manner.
  - delivering data as they are produced
- Jitter: refers to the variation in the packet arrival time. It is the uneven delay in the delivery of audio or video packets.

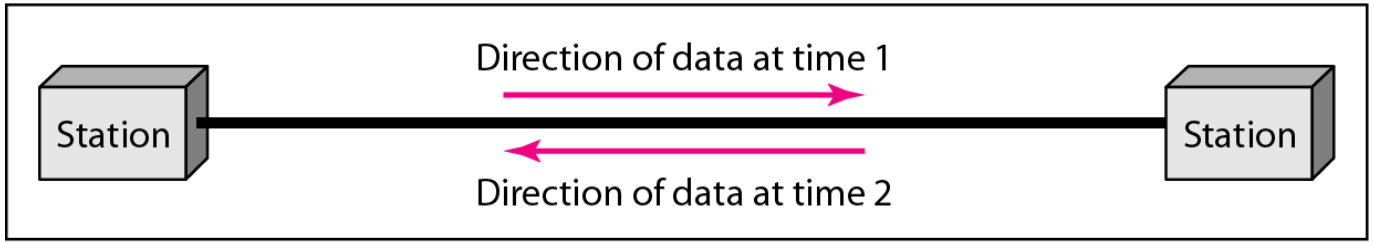
Components of a data communication system



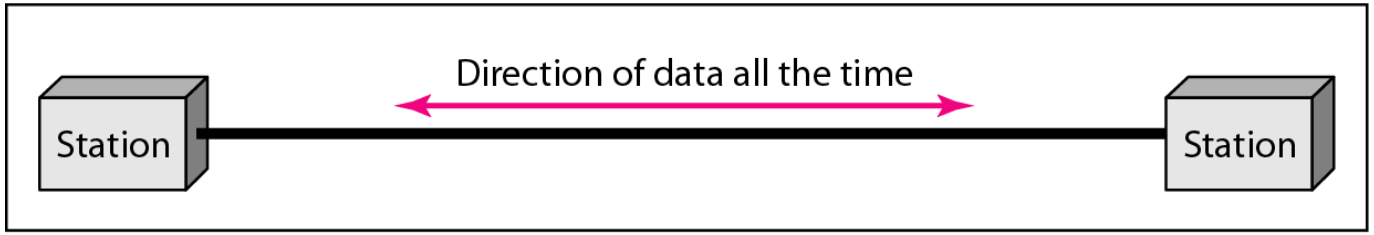
Data flow (simplex, half-duplex, and full-duplex)



a. Simplex



b. Half-duplex



c. Full-duplex

Networks

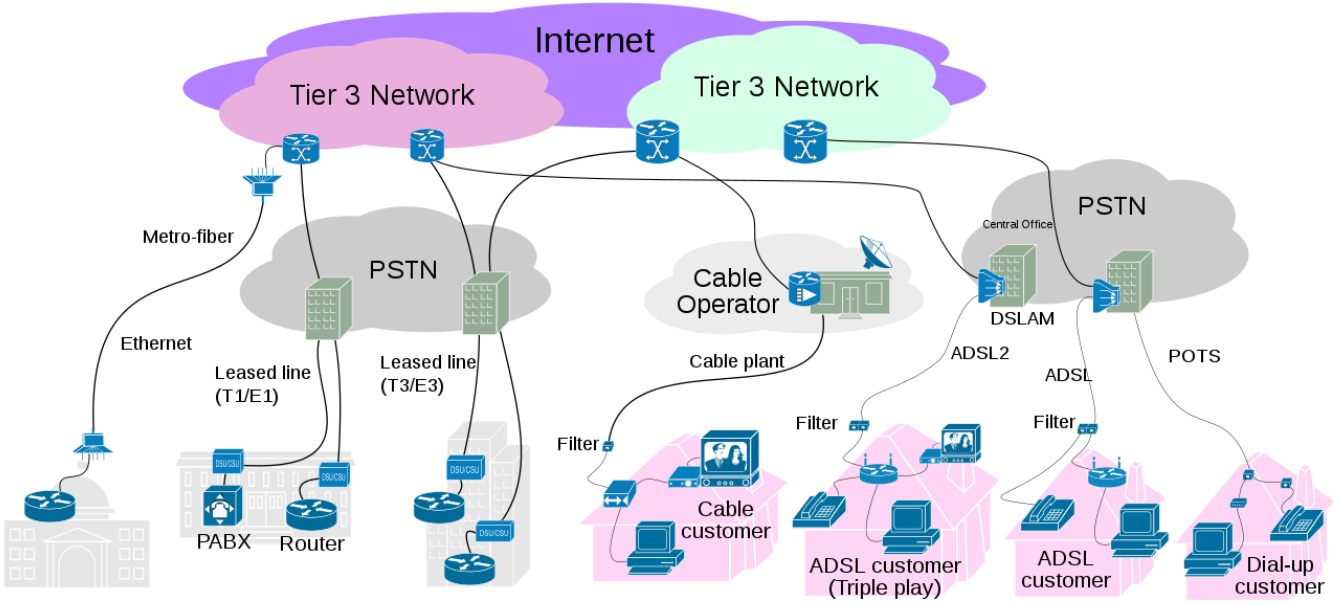
- A network is a set of devices (often referred to as nodes) connected by communication links.
- A node can be a computer, printer, or any other device capable of sending and/or receiving data generated by other nodes on the network.
- A link can be a cable, air, optical fiber, or any medium which can transport a signal carrying information.

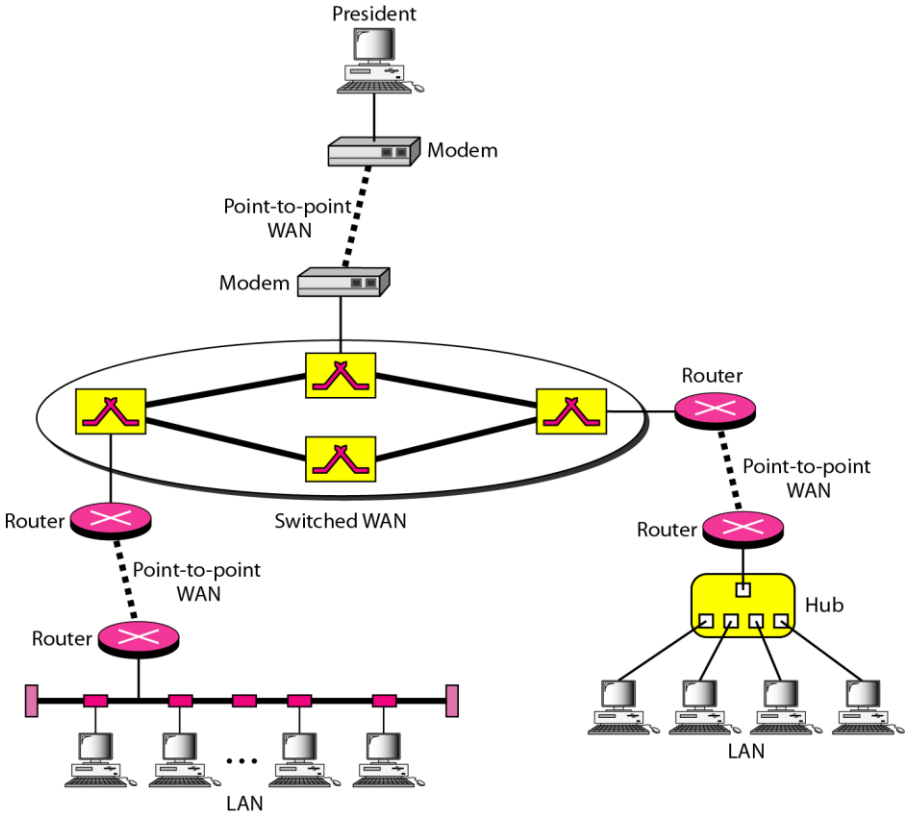
Categories of Networks

- Local Area Networks (LANs)
  - Short distances
  - Designed to provide local interconnectivity
- Wide Area Networks (WANs)
  - Long distances
  - Provide connectivity over large areas
- Metropolitan Area Networks (MANs)
  - Provide connectivity over areas such as a city, a campus

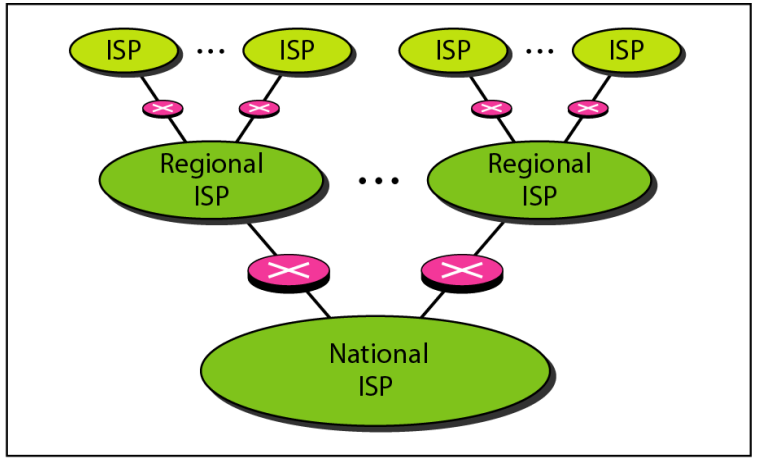
The Internet

- The single virtual network is widely known as internet which is essentially a network of networks.

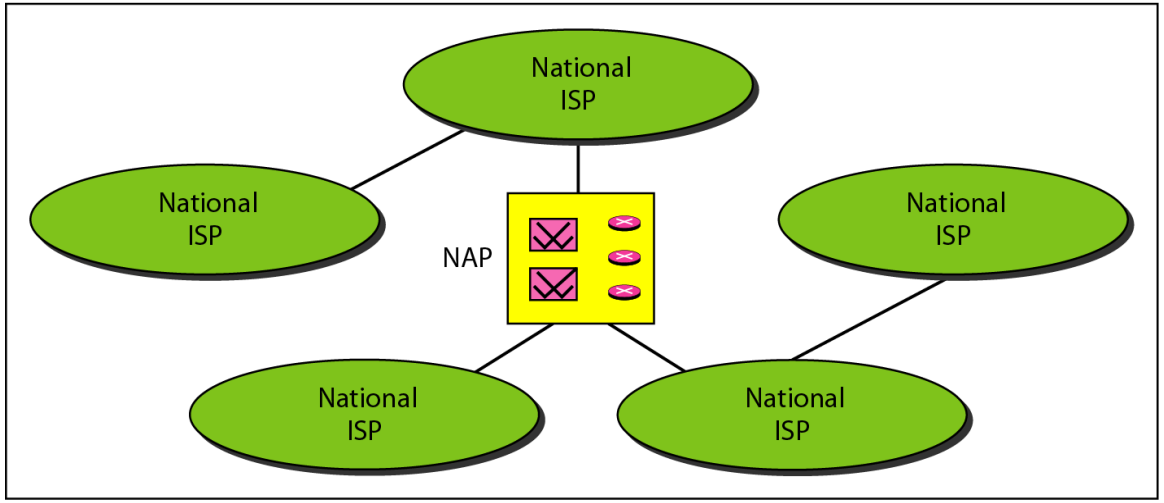




Hierarchical organization of the Internet



a. Structure of a national ISP



b. Interconnection of national ISPs

Basic Concepts

- For successful communication, two systems must follow a common set of rules for generating and interpreting message.
- The set of rules to be followed is very complex
- Layered approach is a viable approach to deal with a complex problem
- The communication functions are partitioned into a hierarchical set of layers.
  - Essentially this layered approach is a divide-and-conquer technique

Layered Approach

- A complex problem is divided into a number of pieces of manageable and comprehensible size
  - each subtask or each piece can be understood easily
- It provides structured modular approach
  - particular module to a particular person then he can develop it and test it independently that is one of the basic principles of layered approach
- Each module can be developed and tested independently
- Allows easy enhancement and implementation of the functions of a particular layer without affecting other layers

Layered Approach — Basic Principles

- Use optimum number of layers
- Put similar functions in the same layer
- Create a layer where there is need for different levels of abstraction
- Allow changes of functions to be made within a layer without affecting others
- Create layer boundaries for each layer with its upper and lower layers
- Choose layer boundaries to minimize information flow across the boundaries

Why it is necessary to create layer boundaries?

- The communication between layers will takes place through the layer boundaries. And, if the layer boundaries are not judiciously defined then the communication may become a problem or information to be communicated will become troublesome.
  - For example, we have to choose layer boundaries to minimize information flow across the boundaries.
- We are decomposing the data communication system into a number of layers.
  - Somewhat similar to multitasking or parallel processing. A particular task is divided into a number of parallel tasks or parallel processes.
- What we want in that situation is minimum inter-process communication.

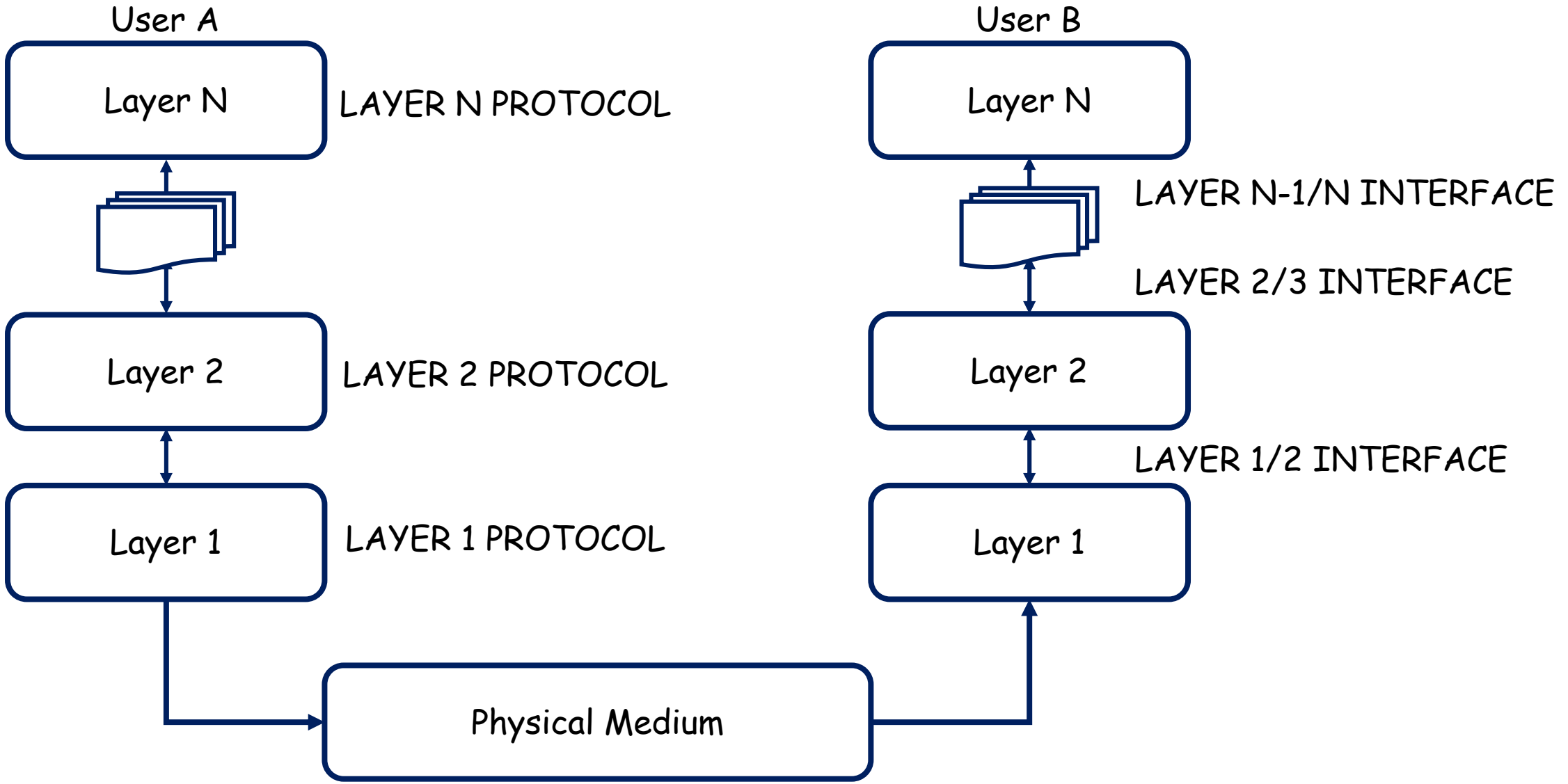
Layers and Interfaces

- System interconnection rules are modularized in terms of series of layers of functions say N layers.
- Each layer contains a group of related functions
- A layer below Layer n and a Layer above Layer n are Layer (n-1) and Layer (n+1), respectively
- Between each pair of adjacent layers there is an interface

Layers and Interfaces

- Interface defines which primitive services the lower layer offers to the upper layer
- Layer n provides services to the Layer (n+1) through service access points
- Each layer adds value to the services provided by the lower layers

Layers and Interfaces



Entity and Protocol

- Data communication occurs between two entities in different systems
- Entity is something which capable of sending, processing or receiving information
- For communication to take place the entities should follow an agreed upon protocol
  - For example, if two persons want to communicate they should use the same language. If one person is speaking in Bengali and another person is speaking in English cannot communicate with each other. They should follow some agreed upon rules, which are known as protocol. So, for communication to take place the entities should follow an agreed upon protocol.

Entity and Protocol

- A protocol is a set of rules that govern data communication
- It defines — what, how and when
- Syntax: Refers to the structure or format of data
  - The data has to be properly formatted so that the other side can interpret it properly
- Semantics: The way the bit patterns are interpreted and actions taken based on the interpretation
- Timing: Specifies when data can be sent and how fast it can be sent

Service Access Points

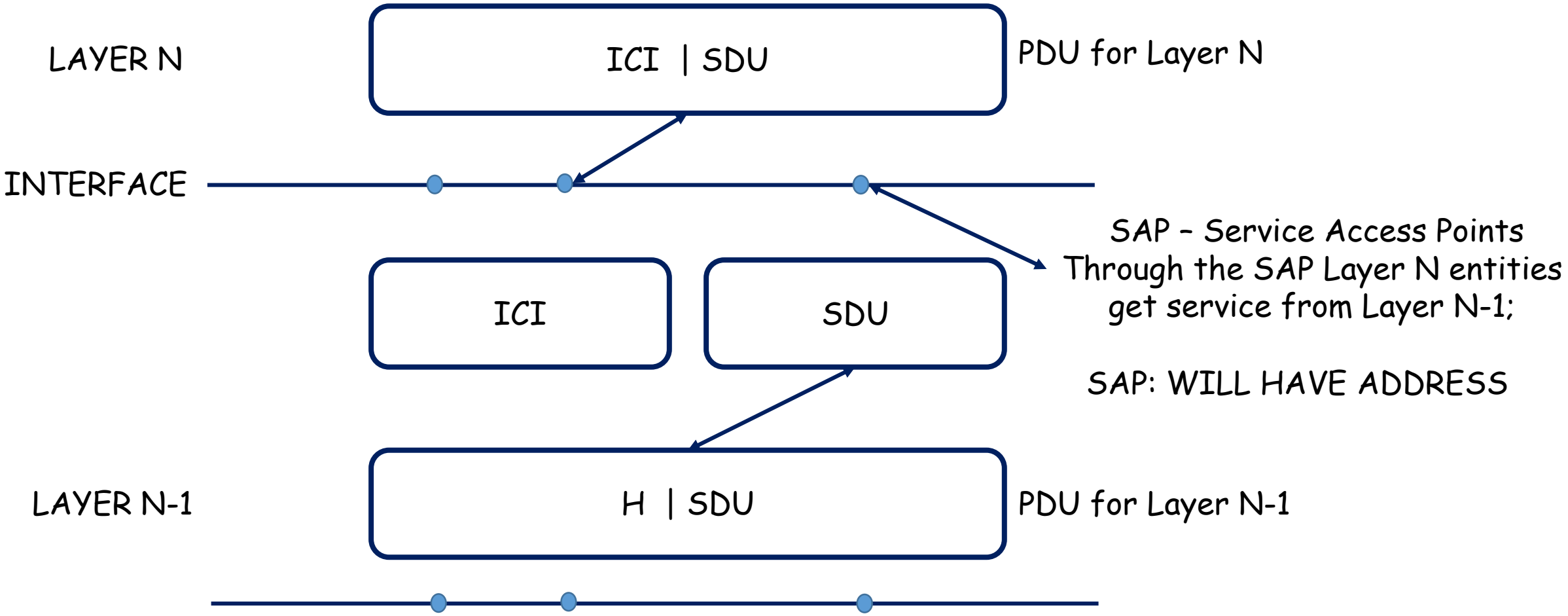
- How the layers communicate with each other through Service Access Points

Service Access Points

PDU – Protocol Data Unit

ICI – Interface Control Information

SDU – Service Data Unit



ISO's Open System Interconnection Architecture

- Application
- Presentation
- Session
- Transport

Responsibility of the Host or Computer

- Network
- Data–Link
- Physical

Responsibility of the network

OSI reference model — Physical Layer

- The physical layer is concerned with the transmission of raw bits over a communication channel.
  - Connected to the transmission medium.
- It decides the mechanical interface that has to be performed between two systems.
  - the connector what will be used, how many pins will it have, what is the length?
- It will have at the electrical part the signal levels, data rate and so on and then
- Physical layer decide whether simultaneous transmission is possible in both directions or not, like simplex
- Physical layer decides the establishing and breaking of connection.
  - This is one of the functions of the physical layer and it deals with the physical transmission medium.
  - That means what particular type of medium to be used, whether we'll be using a guided media like coaxial cable, optical fiber or air as an unguided medium.

OSI reference model — Data-Link Layer

- The function of the Data Link Layer is that this layer transforms the physical layer to a reliable transmission and reception of structured stream.
- Major functions performed:
  - Framing
  - Physical addressing
  - Synchronization
  - Error control
  - Flow control
- Decides whether the transmission will be character oriented or bit oriented

OSI reference model — Network Layer

- Responsible for source to destination delivery by establishing, maintaining and terminating connections
- Deal with logical addressing
- Routing
  - because here it will go through a number of communication systems.
  - examples of routing such as virtual circuits, datagram service etc.
- Assembly and disassembly of messages
- Messages may be assigned priorities and
- It may be necessary to do internetworking, particularly in a heterogeneous network

OSI reference model — Transport Layer

- Responsible for true end to end communication
  - In the previous layer, it was not really concerned with end to end communication but here the transport layer is concerned with end to end communication
  - Particularly, the quality of services required by the upper layer is provided by it
- Port addressing
  - necessary to do multiplexing, to multiplex end user addresses onto network, and also necessary to breakdown a packet into a number of packets and reassemble at the other side.
- The segmentation and reassembly is done by this transport layer
- Then, we have the connection control which monitors the quality of services, end to end error detection and recovery, multiplexing, flow control are the various functions performed in the network layer.

OSI reference model — Session Layer

- The session layer establishes connection and when the data transfer is complete it does the termination.
- It performs dialogue management
  - as part of the dialogue management it will decide who will speak, if you feel somebody will speak and how long they will speak
- The communication can be simplex, half-duplex or full-duplex

OSI reference model — Session Layer

- Whenever the communication is taking place over a long distance, there maybe failure.
- So, to recover from failure in an efficient manner, some check point maybe done which is a part of the session layer.
- It will also do the token management
  - This is necessary when some critical operations are performed by one side.
  - So, the side which has the token will perform the critical operation and that management is done in the session layer.

OSI reference model — Presentation Layer

- Responsible for syntax and semantics of information
- Supports data types, the type of data used,
  - 2's complement number or floating point number we have to use IEEE 754.
- Character codes like ASCII or something else is also decided
- It will also decide about data compression and at the other side decompression like jpeg, mpeg compressions
- Sometimes for secured communication encryption and decryption has to be done

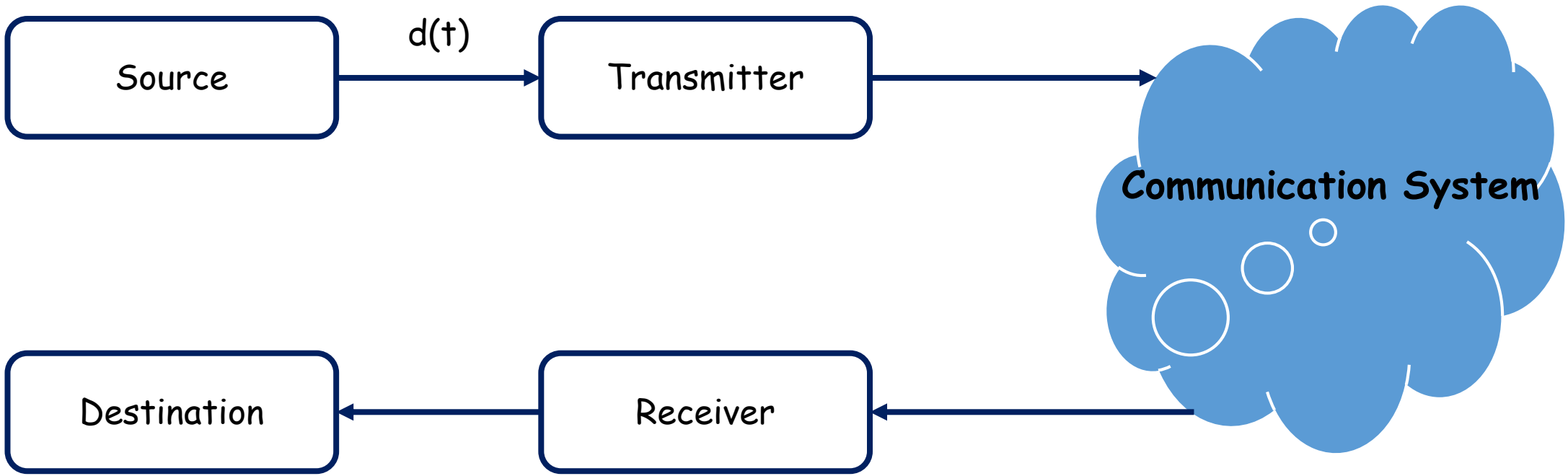
OSI reference model — Application Layer

- Application Layer is concerned with user applications
- There are two types
- Common application service elements (CASE) — login, password checks
- Specific application service elements (SASE) — transfer, access and management, job transfer and manipulation, electronic mail, message handling, document transfer, etc. are within the Application Layer.

The two dominant networking models

- The Open Systems Interconnection (OSI)
  - Theoretical framework
- The Internet Model (TCP/IP)
  - actual model used in today's data communications.
  - which is foundation for the rest of the course

A Simple Data Communication Model



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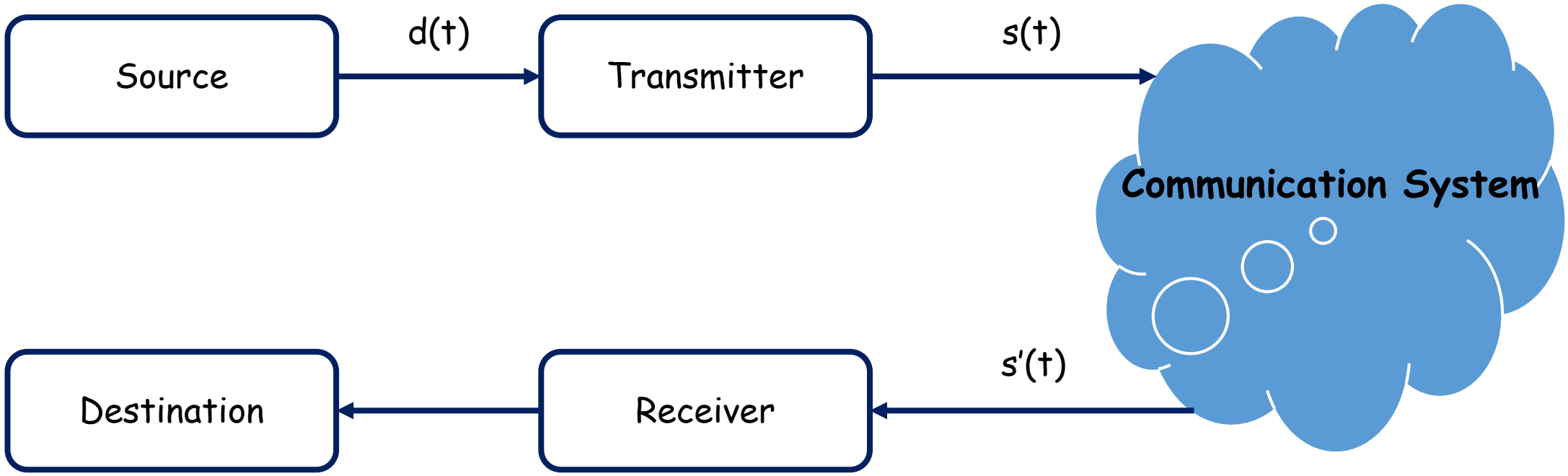

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s(t): Signal that can be transmitted through a medium.

A Simple Data Communication Model

- Interfacing
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- Flow and Error Control
- Data Link Control

- 1. Why is it necessary to have layering in a network?
- 2. How two adjacent layers communicate in a layered network?
- 3. What are the key functions of Data Link Layer?