Review of Networking Concepts

Part 2: Protocols and Services

Layered Protocol Architectures
Network Services
OSI Reference Model

Summary of Topics

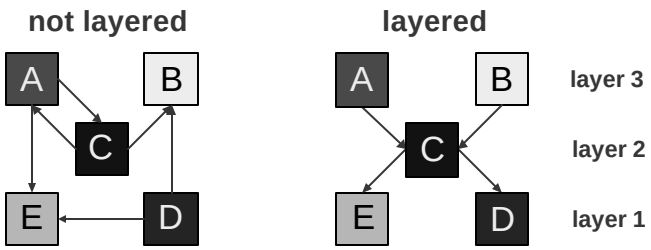
- Protocol, Layers, Encapsulation
- Services
- Protocol Architecture
- OSI Reference Model

Communications Architecture

- **Protocols are a set of rules and conventions**. By enforcing that communicating parties adhere to a common protocol, communication is made possible
- The complexity of the communication task is reduced by breaking it up in several layers of smaller tasks:
  - Each layer is responsible for a specific subtask
  - Each layer has its own protocols
- A structured set of layered protocols is called a layered communications architecture or protocol suite

Layered Network Architecture

- In a **Layered Network Architecture**, the services are grouped in a hierarchy of layers
  - Layer N uses services of layer N-1
  - Layer N provides services to layer N+1
- Example: Network Architecture

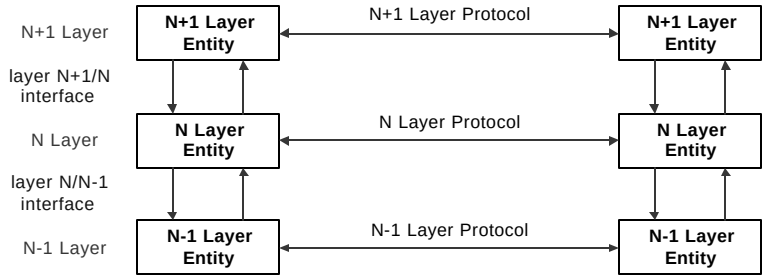


Layered Communications

- A communication layer is completely defined by
  (a) A **peer protocol** which specifies how entities at layer-N communicate
  (b) The **service interface** which specifies how adjacent layers at the same system communicate

- **Note:** When talking about two adjacent layers,
  (a) the higher layer is a **service user**, and
  (b) the lower layer is a **service provider**

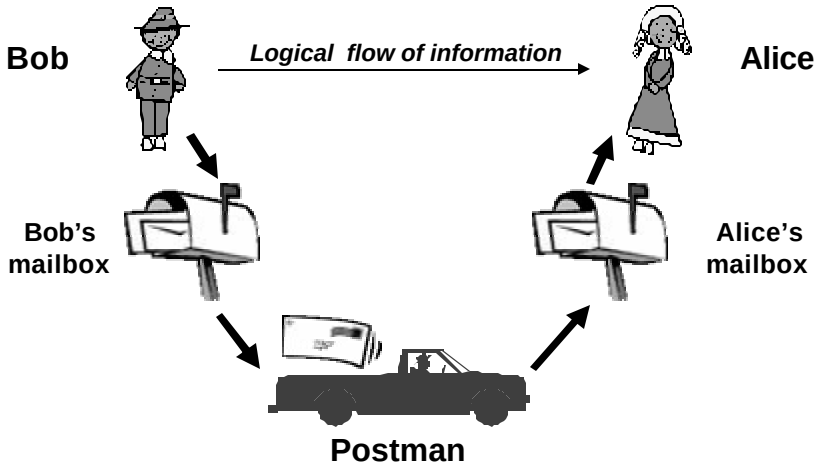
Layered Communications



- Important:
  – The communication between entities at the same layer is logical
  – The physical flow of data is vertical

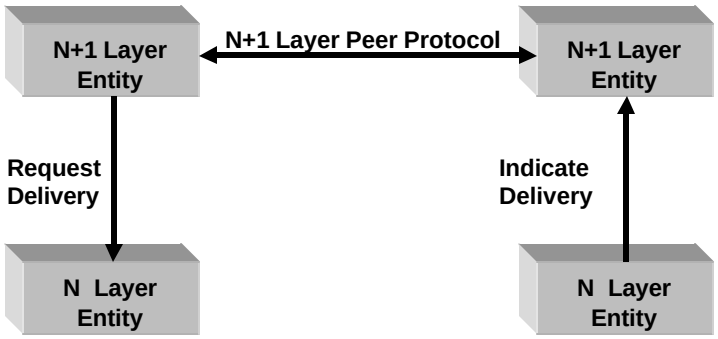
Example: Sending a Letter

- Bob sends a letter to Alice



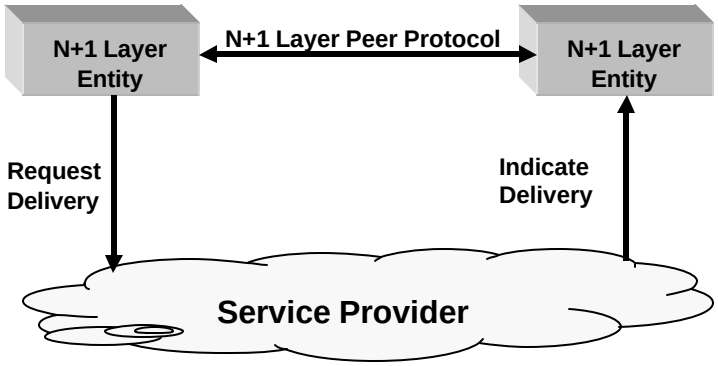
Service Primitives

Communication services are invoked via function calls. The functions are called **service primitives**



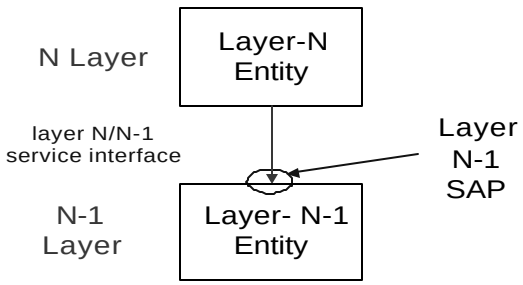
Service Primitives

Recall: A layer N+1 entity sees the lower layers only as a service provider



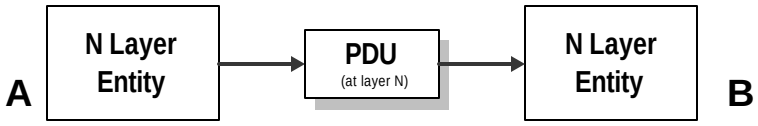
Service Access Points

- A service user accesses services of the service provider at Service **Access Points (SAPs)**
- A SAP has an address that uniquely identifies where the service can be accessed



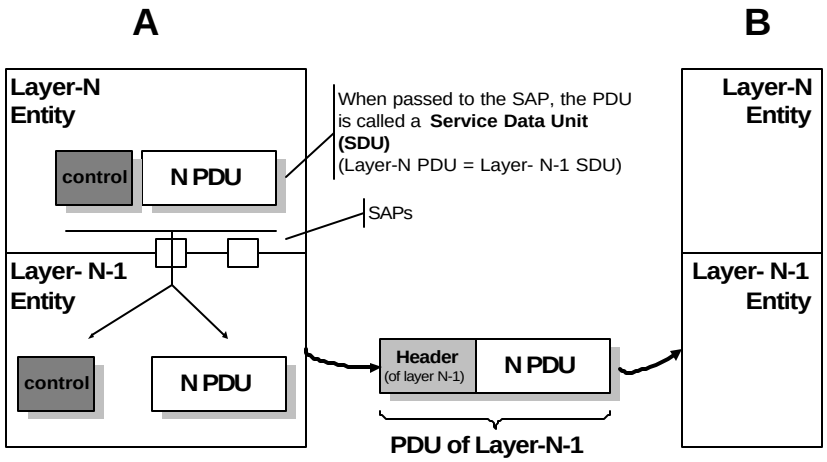
Exchange of Data

- Assume a layer-N entity at A wants to send data to a layer-N peer entity to B
- The unit of data send between peer entities is called a **Protocol Data Unit (PDU)**
- For now, let us think of a PDU as a single packet



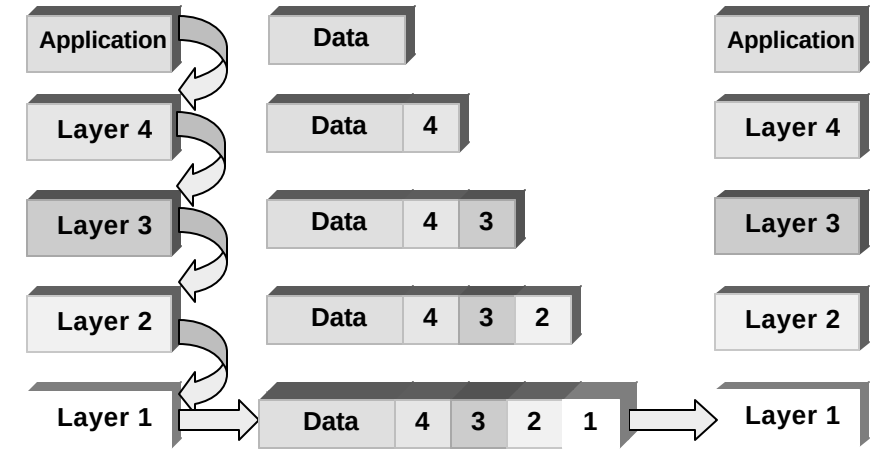
- What actually happens: Layer N passes the PDU to one of A's SAPs at layer N-1
- The layer N-1 entity (at A) then constructs its own PDU which it sends to the layer N-1 entity at B
- Note: PDU at layer N-1 = Header + PDU at layer N

Exchange of Data



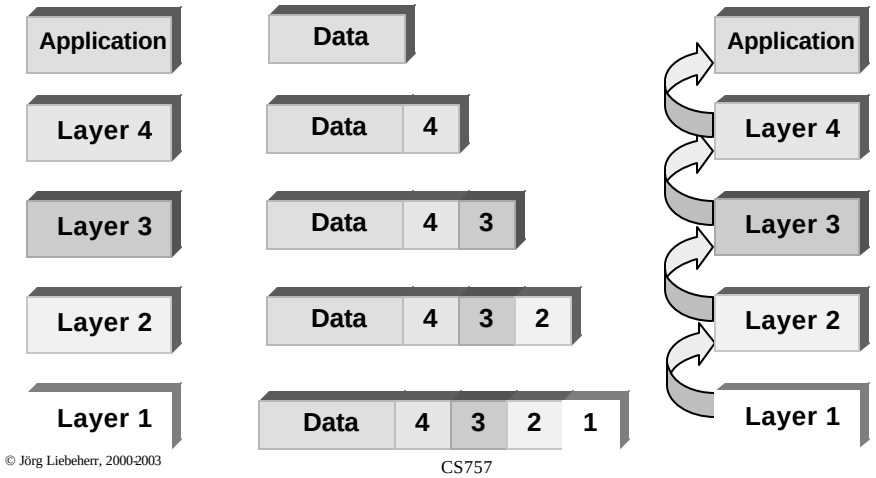
Layering and Encapsulation

- At the sending site, each layer adds a header to the PDU (encapsulates) from the higher layer



Layering and Encapsulation

- At the receiving site, the headers are removed by the corresponding layers



Protocol Architectures

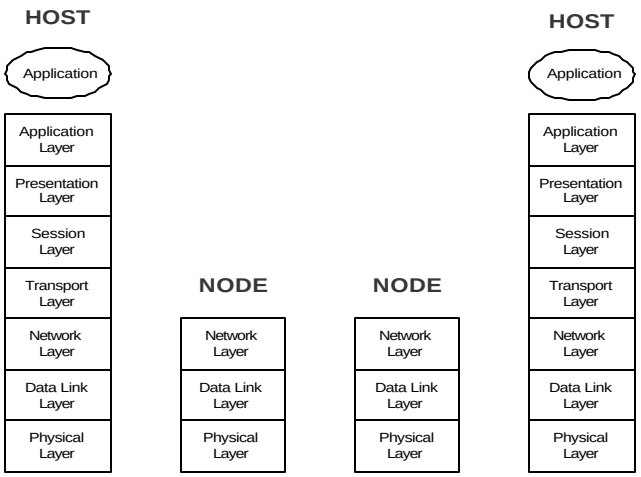
- The following protocol architectures are relevant today:
  - **OSI Reference Model**
    - Defined as a big effort in the 1970's by ISO to specify a comprehensive set of protocols for networking.
    - The effort failed, in that the defined protocols are not widely used. However, the concepts and terminology defined in the OSI model are the *lingua franca* of many networkers
  - **TCP/IP Protocols Suite**
    - The Internet protocol architecture is not the result of a design effort, but has evolved over several decades
  - **ATM Protocol Stack**
    - An example that protocols can be designed by a committee. Future relevance will depend on the success of ATM

OSI Reference Model

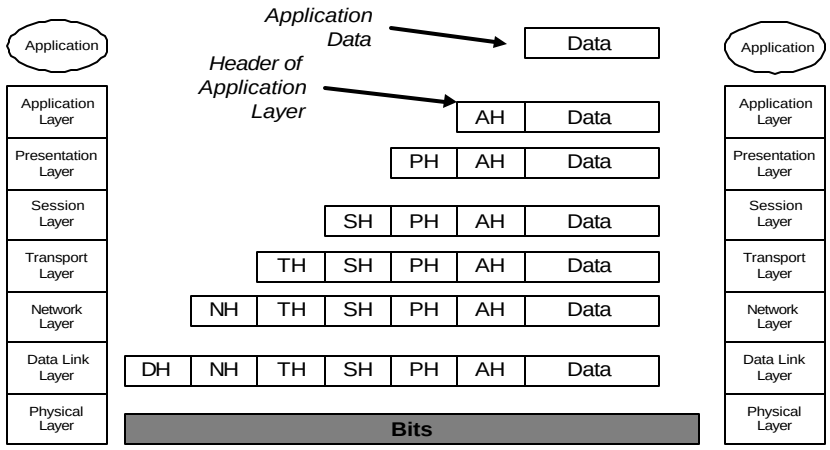
- In 1977 the International Standardization Organization (ISO) developed a model for a layered network architecture
- This effort was completed in 1983 and is known as the Open Systems Interconnection (OSI) Reference Model
- The OSI model defines seven layers:

  Layer 7: Application Layer
  Layer 6: Presentation Layer
  Layer 5: Session Layer
  Layer 4: Transport Layer
  Layer 3: Network Layer
  Layer 2: Data Link Layer
  Layer 1: Physical Layer
  (Layer 0: Interconnection Media)

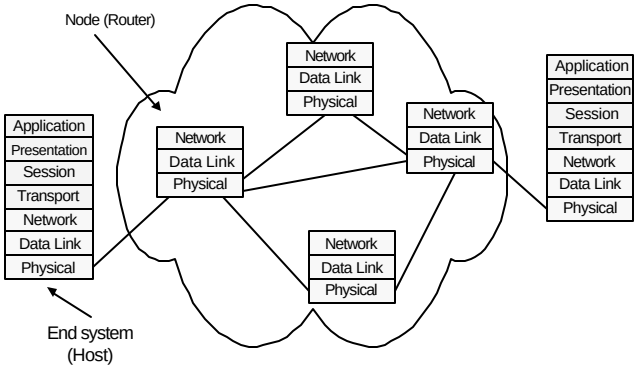
OSI Layers



OSI Layers and Encapsulation



OSI Model in a Switched Communication Network



- Only end systems have all layers
- Nodes only have the lower 3 layers

Physical Layer (Layer 1)

Service:	Transmission of a raw bit stream over a communication channel
Functions:	Conversion of bits into electrical or optical signals
Examples:	X.21, RS-232-C

Data Link Layer (Layer 2)

Service: Transfer of frames over a single link

Functions: synchronization, error control, flow control

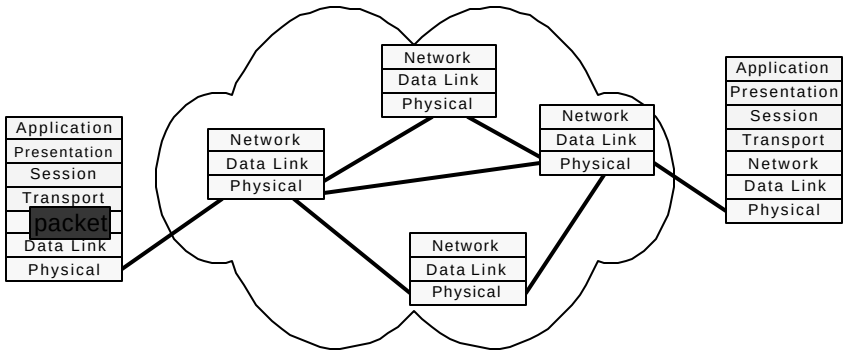
Examples: PPP, SLIP, HDLC, CCITT LAP-D

Network Layer (Layer 3)

Service: End-to-end delivery of packets

Functions: Routing, Addressing, Switching, Congestion Control.

Examples: IP, X.25, CLNP

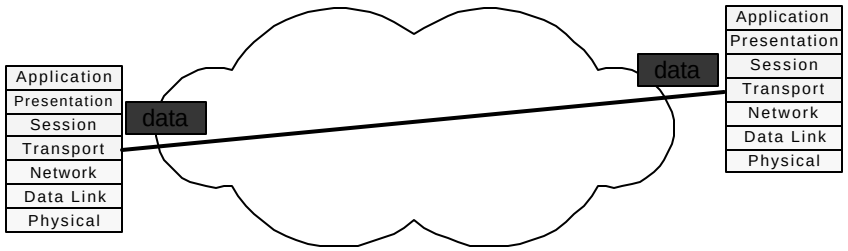


Transport Layer (Layer 4)

Service: Delivery of data between end systems.

Functions: Connection establishment/management/termination, Error Control, Flow Control, Multiplexing.

Examples: TCP, UDP, ISO TP0 - TP4.

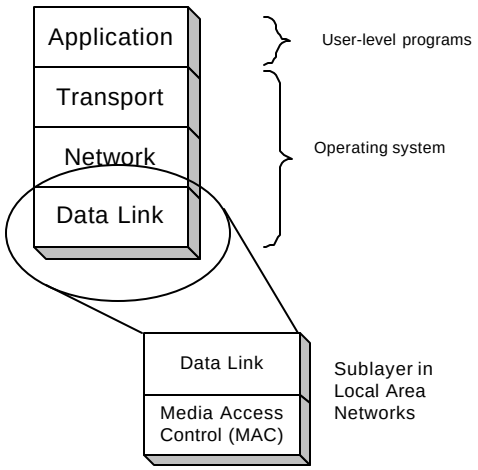


"Higher Layers" of the OSI Reference Model

- **Session Layer (Layer 5):**
  - **Service:** Support the dialog between cooperating application programs
  - **Functions:** Session establishment/management/termination, Synchronization, Recovery
  - **Examples:** ISO session protocol, RPC
- **Presentation Layer (Layer 6):**
  - **Service:** Provides freedom from compatibility problems
  - **Functions:** Virtual device support, syntax conversion, encryption
  - **Examples:** ISO presentation protocol
- **Application Layer (Layer 7):**
  - **Service:** Provides network access to application programs
  - **Functions:** Everything is application specific
  - **Examples**: File Transfer, Electronic Mail

TCP/IP Protocol Suite

- The TCP/IP protocol suite is the protocol architecture of the Internet
- The TCP/IP suite has four layers: Application, Transport, Network, and Data Link Layer
- End systems (hosts) implement all four layers. Gateways (Routers) only have the bottom two layers.

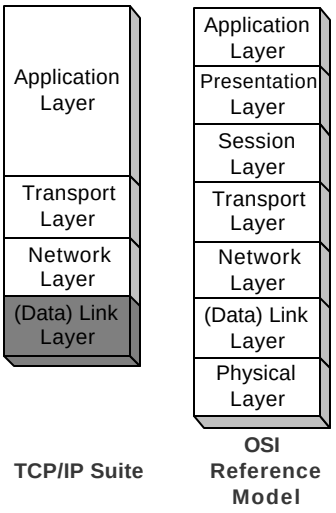


Functions of the Layers

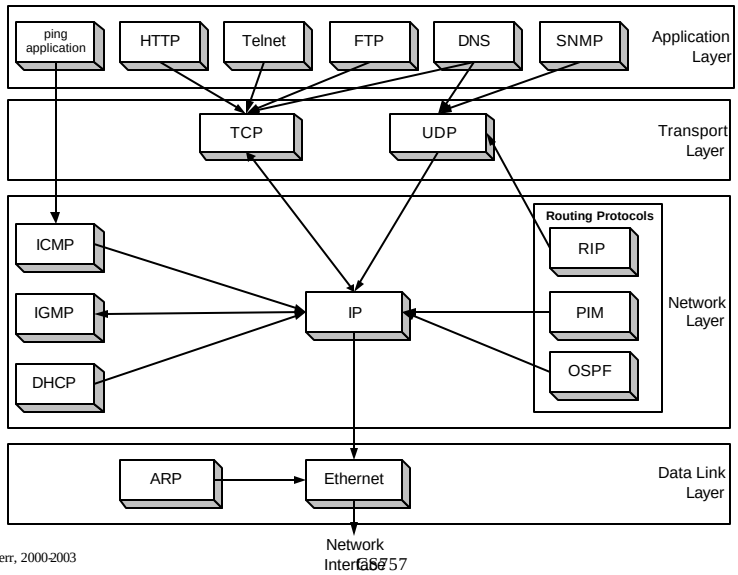
- Data Link Layer:
  - Service: Reliable transfer of frames over a link
Media Access Control on a LAN
  - Functions: Framing, media access control, error checking
- Network Layer:
  - Service: Move packets from source host to destination host
  - Functions: Routing, addressing
- Transport Layer:
  - Service: Delivery of data between hosts
  - Functions: Connection establishment/termination, error control, flow control
- Application Layer:
  - Service: Application specific (delivery of email, retrieval of HTML documents, reliable transfer of file)
  - Functions: Application specific

TCP/IP Suite and OSI Reference Model

The TCP/IP protocol stack does not define the lower layers of a complete protocol stack

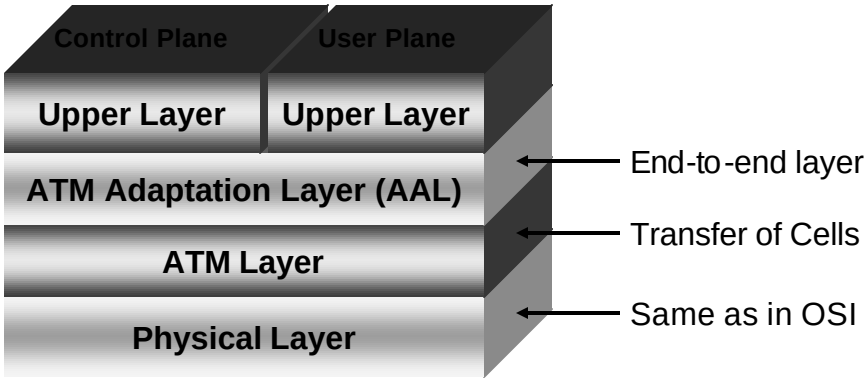


Assignment of Protocols to Layers

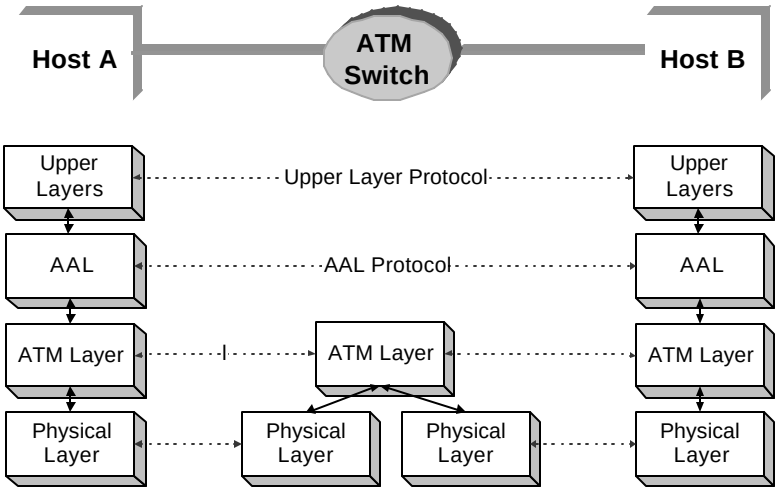


The B-ISDN ATM Reference Model

- ATM technology has its own protocol architecture



Layers of ATM



ATM Layer

- The ATM Layer is responsible for the transport of 53 cells across an ATM network
- The ATM Layer can provide a variety of services for cells from an ATM virtual connection:
  - **Constant Bit Rate (CBR)**
    - guarantees a fixed capacity, similar to circuit switching
    - guarantees a maximum delay for cells
  - **Variable Bit Rate (VBR)**
    - guarantees an average throughput
    - can guarantee maximum delay
  - **Available Bit Rate (ABR)**
    - guarantees 'fairness" with respect to other traffic
  - **Unspecified Bit Rate (UBR)**
    - service is on a "best effort" basis