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

![Diagram showing not layered and layered network architectures](image_url)
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

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Exchange of Data

- When passed to the SAP, the PDU is called a **Service Data Unit (SDU)**
  (Layer-N PDU = Layer- N-1 SDU)
- The PDU is then passed to the layer N-1 entity at B
- The layer N-1 entity constructs its own PDU (with header) which it sends to layer N at B
Layering and Encapsulation

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

Layer 4
Layer 3
Layer 2
Layer 1

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

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