CSCI 234

Design of Internet Protocols:
Protocol
George Blankenship

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Outline

- Protocol elements
- Protocol functions
- Protocol layers
- Service definitions
- ISO/OSI model
- TCP/IP model

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Key Elements of a Protocol

- Syntax
  - Data formats
  - Signal levels
- Semantics
  - Control information
  - Error handling
- Timing
  - Speed matching
  - Sequencing

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Elements of Standardization

- Protocol specification
  - Operates between the same layer on two systems
  - May involve different operating system
  - Protocol specification must be precise
    - Format of data units
    - Semantics of all fields
    - Allowable sequences
- Service definition
  - Functional description of what is provided
- Addressing

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Protocol Architectures

- Required for devices to communicate
- Vendors have more marketable products
- Customers can insist on standards-based equipment
- Two standards:
  - OSI Reference model (*never lived up to early promises*)
  - TCP/IP protocol suite (*most widely used*)
- Also: IBM Systems Network Architecture (SNA)

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Protocol Functions

- Encapsulation
- Segmentation and reassembly
- Connection control
- Ordered delivery
- Flow control
- Error control
- Addressing
- Multiplexing
- Transmission services

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Encapsulation

- Encapsulation
- Segmentation and reassembly
- Connection control
- Ordered delivery
- Flow control
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- Communication message contains control and data
- Control information
  - Addressing information
  - Error-detection information
  - Dialog control
- Data payload
  - Standard format

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Segmentation and Reassembly

- Encapsulation
- Segmentation and reassembly
- Connection control
- Ordered delivery
- Flow control
- Error control
- Addressing
- Multiplexing
- Transmission services

- Multiplexing and error control require that messages be of a maximum length
- Application messages must be divided into segments that match the transmission criteria
- Application messages that were divided must be reassembled before presented to the destination application

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Connection Control

- Encapsulation
- Segmentation and reassembly
- Connection control
- Ordered delivery
- Flow control
- Error control
- Addressing
- Multiplexing
- Transmission services

- The control component of a PDU is overhead and detracts from throughput.
- The control component of a PDU can be minimized by use of protocol state.
- A protocol state machine is translated into a *connection*.

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Ordered Delivery

✓ Encapsulation
✓ Segmentation and reassembly
✓ Connection control
✓ Ordered delivery
➢ Flow control
➢ Error control
➢ Addressing
➢ Multiplexing
➢ Transmission services

- Messages must be delivered in the order sent
- Alternate routes within a message path allow messages to move at different rates
- Recipient systems must queue received messages for delivery in the proper order

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Flow Control

✓ Encapsulation
✓ Segmentation and reassembly
✓ Connection control
✓ Ordered delivery
✓ Flow control
➢ Error control
➢ Addressing
➢ Multiplexing
➢ Transmission services

- Source and destination systems do not have to be speed matched
- If the source system wishes to send messages slower than the destination's capacity, no action is required
- If the source system wishes to send messages faster than the destination's capacity, back pressure is required

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Error Control

✓ Encapsulation
✓ Segmentation and reassembly
✓ Connection control
✓ Ordered delivery
✓ Flow control
✓ Error control
➢ Addressing
➢ Multiplexing
➢ Transmission services

- Transmission media and transmission systems are not perfect
- Transmission is not impervious to external forces
- Errors introduced by path components or external forces must be identified and removed from the processing path

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Addressing

- Encapsulation
- Segmentation and reassembly
- Connection control
- Ordered delivery
- Flow control
- Error control
- Addressing
- Multiplexing
- Transmission services

- Destination selection is difficult
- Addressing allows the separation of the application-application dialog from the selection process
- Layers allow interim addresses for resilient routing while preserving global application addresses

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Multiplexing

- Encapsulation
- Segmentation and reassembly
- Connection control
- Ordered delivery
- Flow control
- Error control
- Addressing
- Multiplexing
- Transmission services

- Dedicated transmission facility between source and destination are not cost effective
- Ability to use a single facility to service multiple end-systems allows the use of idle cycles and add redundancy
- In order to conserve addresses, lower levels of a protocol architecture will multiplex traffic of the upper levels

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Transmission Services

- Encapsulation
- Segmentation and reassembly
- Connection control
- Ordered delivery
- Flow control
- Error control
- Addressing
- Multiplexing
- Transmission services

- Priority services - ability to place one message before another
- Quality of service (QoS) - ability to select a path based upon needs of the dialog
- Security - ability to secure the information of a dialog
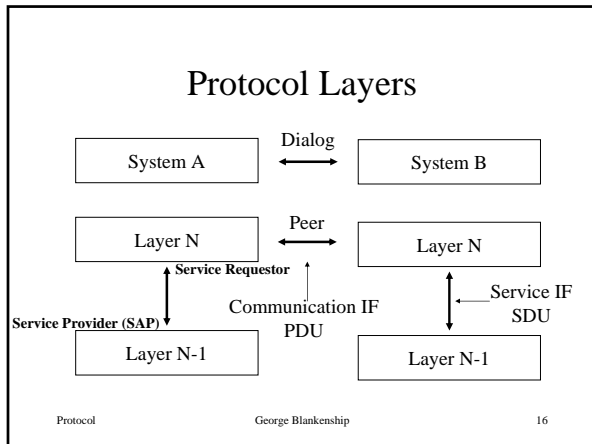
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Protocol Layers

| System A | ← Dialog → | System B |

| Layer N | ← Peer → | Layer N |

Service Requestor

Service Provider (SAP)

Communication IF
PDU

Service IF
SDU

| Layer N-1 | | Layer N-1 |

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Service Definitions

- Confirmed service
  - Requestor receives indication that request has been received (and the operation performed)
  - Request → indication (source to destination)
  - Response → confirm (destination to source)
- Non-confirmed service
  - Requestor has no indication of receipt
  - Request → indication (source to destination)

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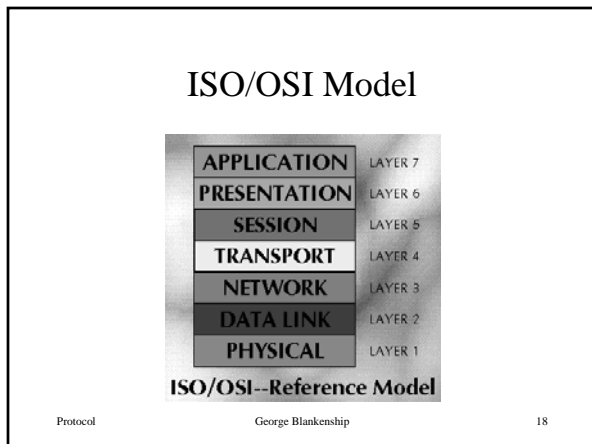## ISO/OSI Model

APPLICATION LAYER 7
PRESENTATION LAYER 6
SESSION LAYER 5
TRANSPORT LAYER 4
NETWORK LAYER 3
DATA LINK LAYER 2
PHYSICAL LAYER 1
ISO/OSI--Reference Model

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OSI Layers

- Layer N services layer N+1
- Layer N+1 access layer N through a service access point (SAP)
- The operation of the SAP is defined by a service definition
- Layer N requests services from layer N-1
- Layer N protocol define by protocol specification

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OSI PDUs

- SPDU (session level PDU) is encapsulated as data in a TPDU (transport level PDU)
- SPDU is moves to (or from) transport layer in a TSDU (transport service data unit)
- TPDU encapsulates transport control and (perhaps) an SPDU
- SPDU is processed by a paired session layer entity

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OSI Routing

- NPDUs are analyzed by the network layer for potential relay
- NPDUs for the local transport are passed up to the transport
- NPDUs for a remote transport are sent back to the data link layer moving the message from one link to another (routing)

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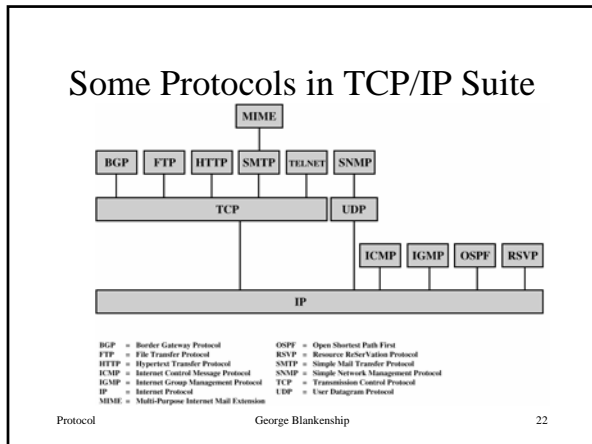
Some Protocols in TCP/IP Suite

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                    MIME

  BGP   FTP  HTTP  SMTP  TELNET  SNMP

      TCP              UDP

                  ICMP  IGMP  OSPF  RSVP

                  IP
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BGP = Border Gateway Protocol
FTP = File Transfer Protocol
HTTP = Hypertext Transfer Protocol
ICMP = Internet Control Message Protocol
IGMP = Internet Group Management Protocol
IP   = Internet Protocol
MIME = Multi-Purpose Internet Mail Extension

OSPF = Open Shortest Path First
RSVP = Resource ReServation Protocol
SMTP = Simple Mail Transfer Protocol
SNMP = Simple Network Management Protocol
TCP = Transmission Control Protocol
UDP = User Datagram Protocol

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TCP/IP Protocol Architecture

- TCP applications (transport layer)
  – Reliable service
  – Ftp, telnet, SMTP, http
- UDP applications (transport layer)
  – Unreliable service
  – DNS, SNMP
- IP applications
  – ICMP, rip, IGMP, OSPF

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TCP/IP Transport

- Reliable and unreliable service design
  – TCP creates reliable transport
  – UDP creates unreliable transport
- Address is port (SAP)
- Sequence number provides lost/duplicate detection (TCP)
- Checksum provides corruption detection

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TCP/IP Network

- Unreliable service design
- Two part address
  - Routing network address
  - Local address (within routing network)
- QoS (quality of service)

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