

The Internet and its Protocols

Protocol Specification & Design

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Friday: 13:30-15:00 (Rm: 101)
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Course Information

- Course conducted in English
- Everything in English

But: This is NOT an English class

- The quality of student's English is not relevant to the course, or to the student's results.

- Interactive Classes
 - Students MUST talk!
- Do not attempt to copy down the contents of the slides,
 - Everything will eventually appear on the Web.
 - Previous years' slides there now

Course Outline (trivia)

- ◊ Introduction to the Subject
 - Teaching Methods
 - Lectures
 - Books
 - Assignments
 - Exams

Course Outline (intro)

- ◇ Introduction to Protocols
 - What is a Protocol?
 - ISO Reference Model
 - Addressing
 - Multiplexing

Course Outline

- ◇ Aspects of Protocol design
 - Correctness
 - Scaling
 - Adaptability
- ◇ Case Studies
 - Internet Protocols

Course Outline (IP intro)

- ◇ Internet Protocol Suite
 - Examples of Internet Applications & their protocol stacks
 - SMTP
 - TFTP
 - HTTP (& SSL)
 - SNMP
 - NFS

Course Outline (Link)

- ◇ Link Layers
- ◇ LAN addressing
- ◇ Unicast, Broadcast, Multicast
- ◇ Repeaters, Bridges, Switches, Routers

Course Outline (IP)

- ◇ IP
 - The IP Header
 - IP Addresses
 - History & Development
 - IPv6, IPv6 Addressing, IPv6 Header

Course Outline (ICMP)

- ◇ ICMP
 - Its Uses
 - ICMPv6
 - ◇ IPv6 Autoconfiguration
 - ◇ DHCP
 - DHCPv6

Course Outline (Forwarding)

- ◇ Packet Forwarding
 - Forwarding Tables
- ◇ ARP (Address Resolution Protocol)
- ◇ Neighbour Discovery (IPv6)
- ◇ Link Layer Limitations

Course Outline (PMTU)

- ◇ PMTU
 - Path Maximum Transmission Unit
- ◇ PMTU Discovery
- ◇ Fragmentation and Reassembly

Course Outline (UDP)

- ◇ Overview of Internet Transport Protocols
 - Transport Addressing
- ◇ UDP (User Datagram Protocol)
 - The Protocol
 - Applications

Course Outline (TCP)

- ◊ TCP (Transmission Control Protocol)
 - Lost Packets
 - Duplicate Packets
 - Erroneous Packets
 - Recovery
 - Acknowledgments
 - Retransmission

Course Outline (TCP2)

- ◊ TCP (continued)
 - Sliding Window
 - One way data flow
 - Two way data flow
 - Network Congestion
 - Detection
 - Recovery

Course Outline (TCP3)

- ◊ TCP (continued)
 - Connection Establishment
 - 3-way handshake
 - Problem of graceful termination
 - Old duplicate packets

Course Outline

- ◇ Review of UDP & its applications
 - Error Recovery
- ◇ T/TCP
- ◇ Review of the underlying protocols

Course Outline (Names)

- ◇ Naming and Addressing
- ◇ The Domain Name System
 - DNS Protocols
 - DNS Name tree
- ◇ Mapping Addresses to Names

Course Outline (Directories)

- ◇ Well Known Names
- ◇ Well Known Ports
- ◇ Service Location
- ◇ Directory Services
 - LDAP (Lightweight Directory Access Protocol)

Course Outline (Apps)

- ◇ Some Internet Applications
 - Brief History of Human Computer Interaction
- ◇ The TELNET Protocol
 - NETASCII
- ◇ FTP
- ◇ SMTP
- ◇ HTTP
- ◇ DHCP
 - Communicating without addresses

Course Outline (RPC)

- ◇ Remote Procedure Calls
 - NFS (Network File System)
 - Associated protocols
- ◇ The Portmapper

Course Outline (Routing)

- ◇ Routing Protocols
- ◇ IGP vs EGPs
 - Interior Gateway Protocols
 - Exterior Gateway Protocols
- ◇ Distance Vector Protocols
 - RIP RIPv2 RIPng
- ◇ Link State Protocols
 - OSPF
- ◇ BGP4
- ◇ Policy Routing

Course Outline (Management)

- ◊ Network Management
 - SNMP - Simple Network Management Protocol
 - MIBs - Management Information Bases

Course Outline (Security)

- ◊ Network Security
 - IPsec
 - SSL
 - HTTP & SSL
- ◊ Public Key Encryption
 - Secure E-Mail
- ◊ Non-security Security mechanisms
 - Reserved Ports

Course Outline (Firewalls)

- ◊ Firewalls
 - Purposes and Limitations
- ◊ Network Address Translation (NAT)
 - Its Limitations
 - Its effects upon the Internet assumptions

Course Outline (Multicast)

- ◇ Multicast IP
 - Multicast Packet Forwarding
 - Multicast Applications
- ◇ Multicast Routing
 - DVMRP
 - PIM
 - Dense Mode
 - Sparse Mode

Course Outline (Conclusion)

- ◇ Summary of the Protocols
- ◇ Overview of Protocol Design
- ◇ Review of the Course

Course Style

- ◇ Take a selected Protocol
- ◇ Find out what it is supposed to do
- ◇ How it does that
 - And why - how it got to be that way
- ◇ How it is specified
 - Why is it specified that way
- ◇ Does it work properly?
 - Always?
- ◇ Is the specification complete?
 - How do we know?
- ◇ What could be improved?
- ◇ Always ask WHY ?

Books

- ◊ W. Richard Stevens
- ◊ TCP/IP Illustrated
 - (3 Volumes, Vols 1 & 3 most relevant)
- ◊ Douglas Comer
- ◊ Internetworking with TCP/IP, Vol 1
 - (Also Vol 2 - variants for ANSI C, BSD, Linux,
 - SvR4, AT&T TLI, Windows, ...)
- ◊ Christian Huitema
- ◊ IPv6, The New Internet Protocol
- ◊ Christian Huitema
- ◊ Routing in the Internet

Books

- ◊ Radia Perlman
- ◊ Interconnections: Bridges, Routers, Switches, and Internetworking Protocols
- ◊ Cheswick & Bellovin
- ◊ Firewalls and Internet Security
- ◊ Kaufman, Perlman & Speciner
- ◊ Network Security: Private Communication in a Public World
- ◊ Mohamed G Gouda
- ◊ Elements of Network Protocol Design

Assessment

- ◊ To be advised later
 - Mid-semester Test (~20%)
 - Final Exam (~50%)
 - Project (assignment) (~30%)
 - ???

Protocols

◊ A mechanism for agreeing HOW to communicate

NOT concerned with
WHAT is to be communicated

BUT different protocols
for different communications

◊ What is data to one protocol is control information to another

Protocols (cont)

◊ Rules for:

◦ How to begin communication

◦ How to carry on communication
▸ Sequencing

◦ Ending communication

Protocol Specification

◊ Text

◦ English, or ...

◊ State Machines

◊ Grammars

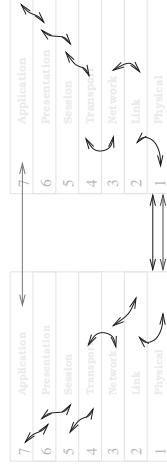
◊ Formal specification methods

ISO Reference Model

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

NOTE: This is a MODEL

Data Exchange Model



Apparent Data Flow
Logical Data Flow
Actual Data Transfer

NOTE: This is a MODEL

The Model Layers: Physical

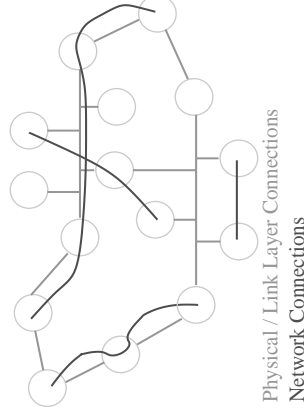
- ◊ Wires (sometimes)
- ◊ Currents & Voltages (sometimes)
- ◊ Plugs and Connectors

The Model Layers: Link

- ◊ Node to Node communications (apparently direct)
- ◊ Uses Physical Layer to move bits
- ◊ May have addressing
- ◊ Usually has error detection
- ◊ Occasionally has error recovery

The Model Layers: Network

- ◊ Node to Node communications (indirect)



The Model Layers: Network

- ◊ Uses Link Layer to transfer bits (usually bytes/octets)
- ◊ Follows Path:
 - From End System
 - (to Intermediate System)
 - ...
 - (to Intermediate System)
 - To End System
- ◊ Always uses addressing
- ◊ Relies upon forwarding
 - Forwarding uses routing
- ◊ Usually has error detection
- ◊ Sometimes has error recovery

The Model Layers: Transport

- ◇ Application to Application
 - ie: a process on one node
 - ▷ to a process on (another) node
- ◇ Always uses addressing
- ◇ Usually has error detection
- ◇ Usually has error recovery
- ◇ Usually has sequencing/duplicate elimination/flow control

The Model Layers: Session

- ◇ Continuous Transport
 - Recovers broken transport connections
- ◇ Multiplexing
 - Multiple sessions on one transport connection
 - Multiple transport connections for one session
- ◇ Connection Recovery
 - checkpoints

The Model Layers: Presentation

- ◇ Data Encoding Rules
 - How are numbers represented
- ◇ Data typing

The Model Layers: Application

- ◇ All the "useful" work
- ◇ The part the users see.

NOTE: All the above is a MODEL

Protocol Specification

- ◇ Text
 - English, or ...
- ◇ State Machines
- ◇ Grammars
- ◇ Formal specification methods

Addresses

- ◇ Identify the location of a node
- ◇ Often contain many levels of information
- ◇ cf: a postal address

Person Name
Number and Street
Town
[Province/State]
Country

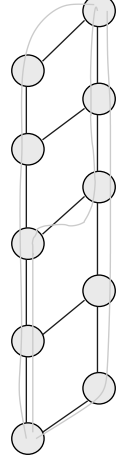
Addresses (cont)

Person Name
Number and Street
Town
[Province/State]
Country

- ◇ Person Name not used by the post office
 - it is not part of the address that they use.
- ◇ The address is hierarchical
 - distant post offices notice only the country
 - nearer ones look at the town as well
 - and even nearer ones, the street
 - delivery person uses street number
- ◇ Not necessarily strictly hierarchical
 - can skip steps

Addresses (cont)

- ◇ Note
 - Distinguish where an address references
 - from the path used to reach the address

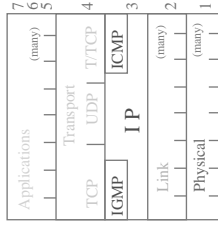


Links
Some Possible Paths

Addresses (cont)

- ◇ Network Addresses
 - represented by bit patterns
 - Not unusual for computer data!
 - Bits usually represented as numbers (decimal or hexadecimal)
- ◇ Different protocols
 - different address forms
- ◇ Different layers
 - different address forms
 - ▷ Often a higher layer uses a lower layer's address
 - ▷ With something extra added

The Internet Protocols



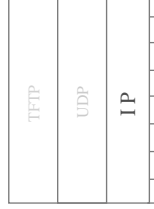
Internet Examples (SMTP)

- ◊ Simple Mail Transfer Protocol
 - RFC821
 - RFC2821



Internet Examples (TFTP)

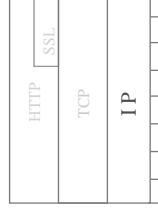
- ◊ Trivial File Transfer Protocol
 - RFC1350



- ◊ Truly a trivial protocol
 - Get me block N of file named X
 - No authentication
 - In fact, nothing...

Internet Examples (HTTP)

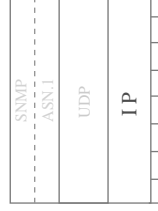
- ◊ Hyper Text Transfer Protocol



- ◊ Optional Secure Socket Layer
 - (Encryption)

Internet Examples (SNMP)

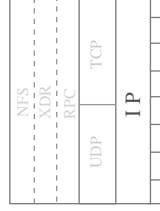
- ◊ Simple Network Management Protocol



- ◊ Anything but simple...
- ◊ Uses Abstract Syntax Notation One (ASN.1)
 - a presentation layer

Internet Examples (NFS)

- ◊ Network File System



- ◊ Uses External Data Representation (XDR)
 - presentation layer
- ◊ Uses Remote Procedure Calls (RPC)
 - session layer
- ◊ Originally used UDP
 - now optionally uses TCP