

The Internet and its Protocols

Protocol Specification & Design

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Monday: 15:00-16:30 (Rm: 201)

Tuesday: 15:00-16:30 (Rm: 201)

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
- ◊ IGPs 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
- ◊ How it is specified
- ◊ Does it work properly?
 - Always?
- ◊ Is the specification complete?
 - How do we know?
- ◊ What could be improved?

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
 - Final Exam
 - Project (assignment)
 - ???

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

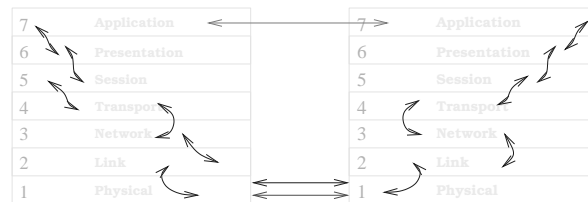
- ◊ Text
 - ◊ English, or ...
- ◊ State Machines
- ◊ Grammars
- ◊ Formal specification methods

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

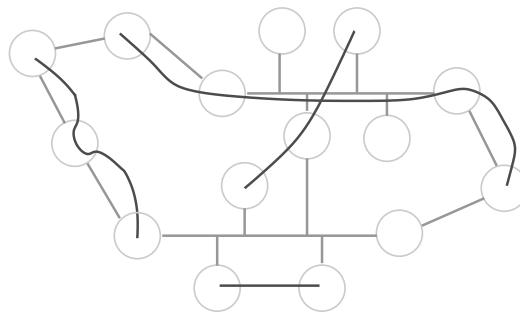
- ◊ Wires (sometimes)
- ◊ Currents & Voltages (sometimes)
- ◊ Plugs and Connectors

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)



Physical / Link Layer Connections
Network Connections

The Model Layers: Network

- ◊ Uses Link Layer to transfer bits (usually bytes/octetets)
- ◊ 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

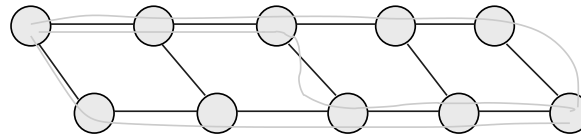
Addresses (cont)

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
 - or parts of steps

Addresses (cont)

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

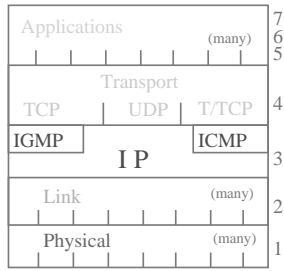


Links
Some Possible Paths

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

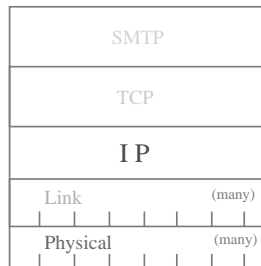
The Internet Protocols



Internet Examples (SMTP)

◊ Simple Mail Transfer Protocol

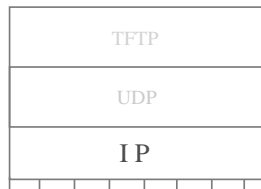
- RFC821
- RFC2821



Internet Examples (TFTP)

◊ Trivial File Transfer Protocol

- RFC1350

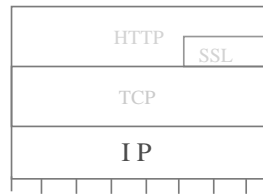


◊ Truly a trivial protocol

- Get me block N of file named X
 - No authentication
 - In fact, nothing...

Internet Examples (HTTP)

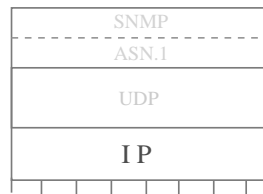
- ◊ Hyper Text Transfer Protocol



- ◊ Optional Secure Socket Layer
 - ◊ (Encryption)

Internet Examples (SNMP)

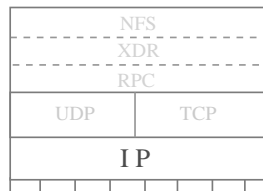
- ◊ Simple Network Management Protocol



- ◊ 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