

Protocol Architectures and Internet Applications

ITS323: Introduction to Data Communications

Sirindhorn International Institute of Technology
Thammasat University

Prepared by Steven Gordon on 8 June 2011
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What is a Protocol?

- ▶ Set of rules that two (or more) peer entities obey in order to communicate
- ▶ Syntax: format of data blocks; types of messages
- ▶ Procedures: set of rules each peer must follow; timing information

The Need for a Protocol Architecture

- ▶ Data communications is complex!
- ▶ Apply divide-and-conquer principle:
 - ▶ Break communication tasks into subtasks
 - ▶ Implement subtasks separately in **layers**
 - ▶ Layers arranged in vertical stack
 - ▶ Layer N uses services of layer $N - 1$
 - ▶ Layer N provides services to layer $N + 1$
 - ▶ Peer layers communicate with a protocol
 - ▶ Combine the layers to get **protocol architecture**

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A Simple Protocol Architecture

Simple view of data communications

- ▶ Applications, e.g. file transfer, email, web browsing, remote login
- ▶ Computers
- ▶ Networks

Divide tasks into 3 layers

- ▶ Application layer: protocols to support each specific application
- ▶ Transport layer: reliability mechanisms for all applications
- ▶ Network access layer: exchange data between computers over network

Protocol Architectures and Networks

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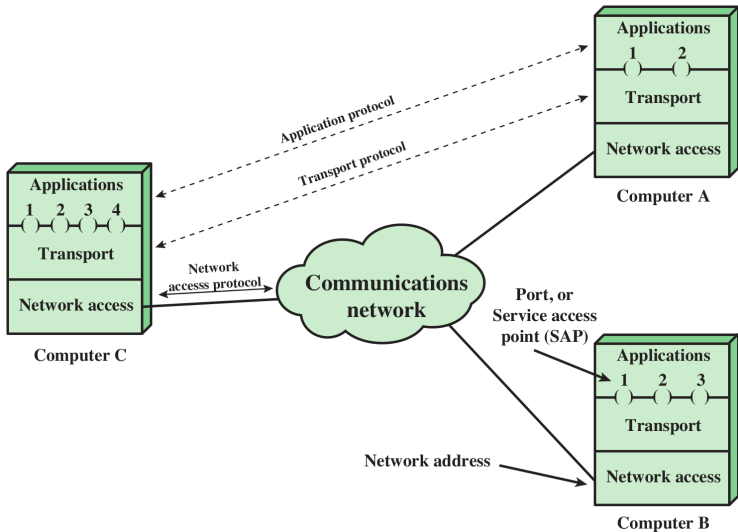
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Protocols in a Simplified Architecture

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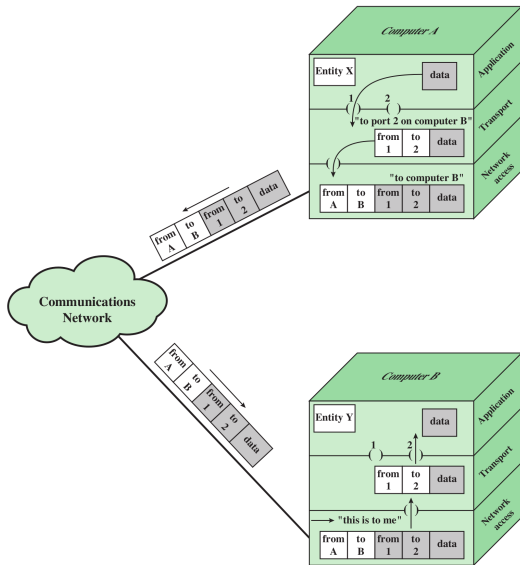
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Common Features of Protocols

- ▶ **Headers** are added to data to carry control information; referred to as **encapsulation**
 - ▶ E.g. source/destination address, sequence number, error-detection code
- ▶ Header + data is called **Protocol Data Unit (PDU)**
- ▶ **Segmentation**: sometimes data must be divided into smaller chunks at source (and re-assembled at destination)

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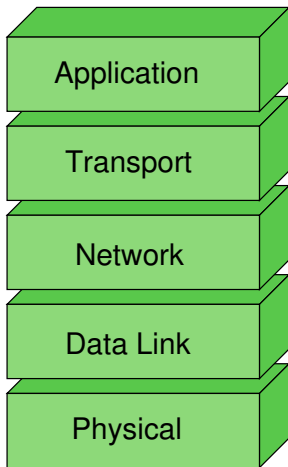
Example of TCP/IP Operation

Internet Applications and Performance

Origins and Terminology

- ▶ ARPANET uses two key protocols, TCP and IP; together (as well as other related protocols) referred to as **TCP/IP protocol suite**
 - ▶ Used in global Internet today
 - ▶ Many protocol standardised by Internet Architecture Board (IAB) and Internet Engineering Task Force (IETF)
 - ▶ No official protocol architecture; generally divided into 5 layers
- ▶ ISO developed Open Systems Interconnection (OSI) protocol architecture in 1970's
 - ▶ Protocol architecture: 7-layer OSI Reference Model
 - ▶ TCP/IP won!
 - ▶ Not used in practice today; principles and terminology still applied

TCP/IP Layers and Example Protocols



HTTP, FTP, SMTP, SSH

TCP, UDP SCTP, DCCP

IP ICMP, OSPF, ARP

Ethernet ATM Frame Relay

Wireless LAN SDH PDH

Twisted pair, optical fibre, satellite

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TCP/IP Layering Concepts

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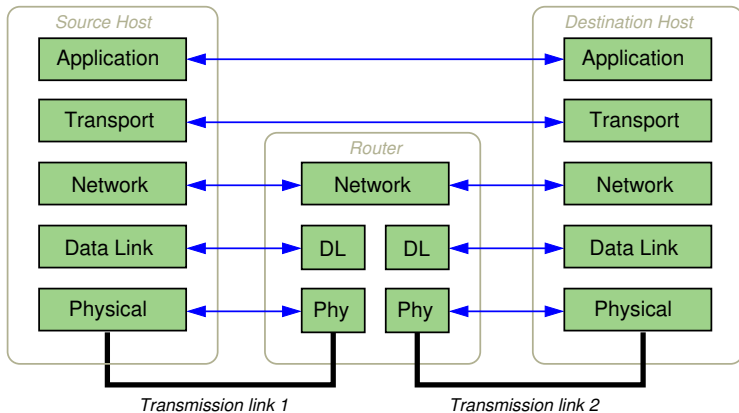
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TCP/IP Layers

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1. Physical Layer

Physical interface between transmission device and medium; how to send bits over transmission medium: data rate, signalling, electrical signals, codecs, modems, . . .

2. Data Link Layer

Transmission of data over link to which the device is attached; addressing scheme of destination device; allows layers above to ignore details of links; may provide reliability; sometimes called: “network Access”, “MAC”, “Link”, “Hardware” layer

TCP/IP Layers

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3. Network Layer

Allows hosts to communicate across different networks; provides routing across the Internet; may provide congestion control, quality of service; sometimes called: “IP”, “Internet” layer

4. Transport Layer

Transfer of data between end-points; connect processes running in OS of host; may provide error control, flow control, congestion control, reliable delivery .

5. Application Layer

Provides functionality needed for various applications

Other Protocol Architectures

- ▶ OSI 7-layer Reference Model
- ▶ Older architectures: IBM SNA, Appletalk, Novell IPX
- ▶ Domain specific architectures: Signalling System 7 (SS7) for telephone signalling; UMTS for 3G mobile telecommunications; . . .

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Protocols and Standards

Protocols

- ▶ Rules that communicating entities follow
- ▶ Implemented in hardware and software on computing devices

Standards

- ▶ Agreed-upon rules; protocols that some organisation has agreed upon
- ▶ Create open and competitive market
- ▶ Allow national and international interoperability

Standard Development Organisations

- ▶ International Organisation for Standardisation (**ISO**): formed from national standards bodies to create global standards
- ▶ International Telecommunication Union(**ITU**): formed from national telecom operators and other organisations to create global standards for telecoms
- ▶ Institute of Electrical and Electronics Engineers (**IEEE**): professional engineering society that develops standards in electronics, radio and electrical engineering
- ▶ Internet Engineering Task Force (**IETF**): develops most standards for the Internet
- ▶ World Wide Web Consortium (**W3C**): develops web based standards (e.g. HTML)
- ▶ Forums and Special Interest Groups: companies working together on specific technologies
- ▶ Regulatory agencies: set regulations on use of communication technologies

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Addressing in TCP/IP: Identifying Computers

- ▶ Computers attach to network via **network interface**
- ▶ Within single network, all computers must use same addressing scheme; referred to as **hardware address** or “physical”, “data link”, “MAC” address
- ▶ Different network technologies may use different, incompatible addressing schemes:
 - ▶ E.g. Ethernet LAN: IEEE 48-bit address; Bluetooth/ZigBee: IEEE 64-bit address; X.25: telephone number style address
- ▶ Separate “logical” address needed to communicate across different network technologies
 - ▶ **IP address**: IPv4 32-bits; IPv6 128-bits
- ▶ Each network interface usually has two addresses: hardware and IP

Addressing in TCP/IP: Identifying Applications

- ▶ Multiple applications may execute on one computer
- ▶ **Port numbers** (or transport address or service access point) used to identify application processes
- ▶ User-friendly and application-specific addresses may also be used
 - ▶ E.g. `www.google.com`, `steve@siit.tu.ac.th`

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Addressing Examples

Try commands `ifconfig`¹, `arp`, `nslookup` and `netstat` on your computer. Find the different types of addresses.

¹`ipconfig` in Windows

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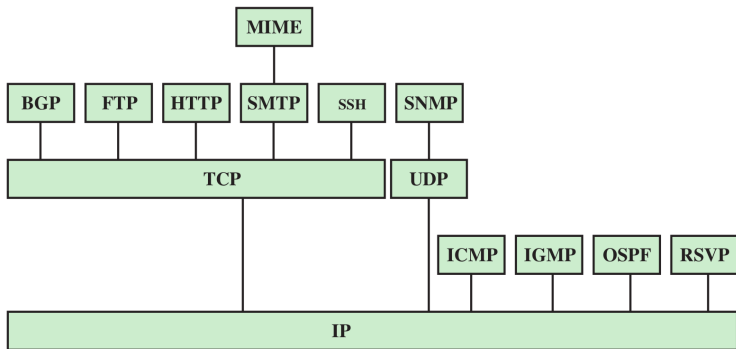
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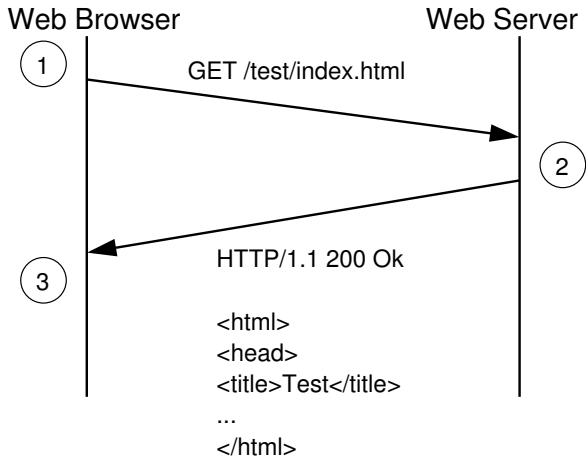
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Some Protocols in the TCP/IP Protocol Suite



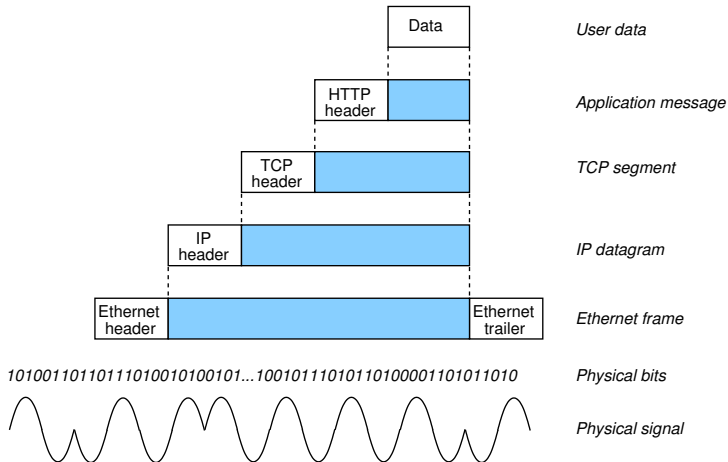
Below IP are the Data Link and Physical layer protocols. These are specific to LAN/WAN technologies.

Example Application: Web Browsing with HTTP



Encapsulation in TCP/IP

Example: web browser has requested web page from server;
server needs to send the page requested back to browser



Implementing Layers

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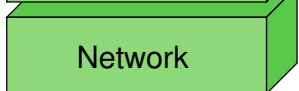
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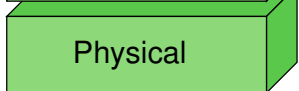
User Processes



Operating System



Network Interface Card



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Internet Applications

Standalone Applications

- ▶ User interface
- ▶ Application logic

Network or Distributed Applications

- ▶ User interface
- ▶ Application logic
- ▶ **Communication mechanisms**

Types of Internet Applications

Traditional Internet-Based Applications

- ▶ File transfer, email, web browsing, remote login, database
- ▶ Accuracy is most important

Multimedia or Real-time Applications

- ▶ Audio/video streaming, voice/video calls, gaming, collaborations
- ▶ Timeliness is most important

Performance Metrics

Bandwidth

- ▶ Range of frequencies a channel can pass
- ▶ Units: Hertz

Data Rate

- ▶ Number of bits a channel or network can transmit
- ▶ Units: bits per second

Throughput

- ▶ Amount of data successfully delivered to destination
- ▶ Units: bits per second

Performance Metrics

Delay

- ▶ Time to transmit data from source to destination
- ▶ Units: seconds
- ▶ Four components:
 1. Transmission delay: time to transmit data on to link
 2. Propagation delay: time for a signal element (or bit) to propagate across link
 3. Processing delay: time for device to process data
 4. Queuing delay: time data spent waiting in queue (memory) inside device

Packet Delay Variation

- ▶ Variance of delay between subsequent packets
- ▶ Units: seconds

Performance Metrics Examples

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