Protocol Architectures and Internet Applications

ITS323: Introduction to Data Communications

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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

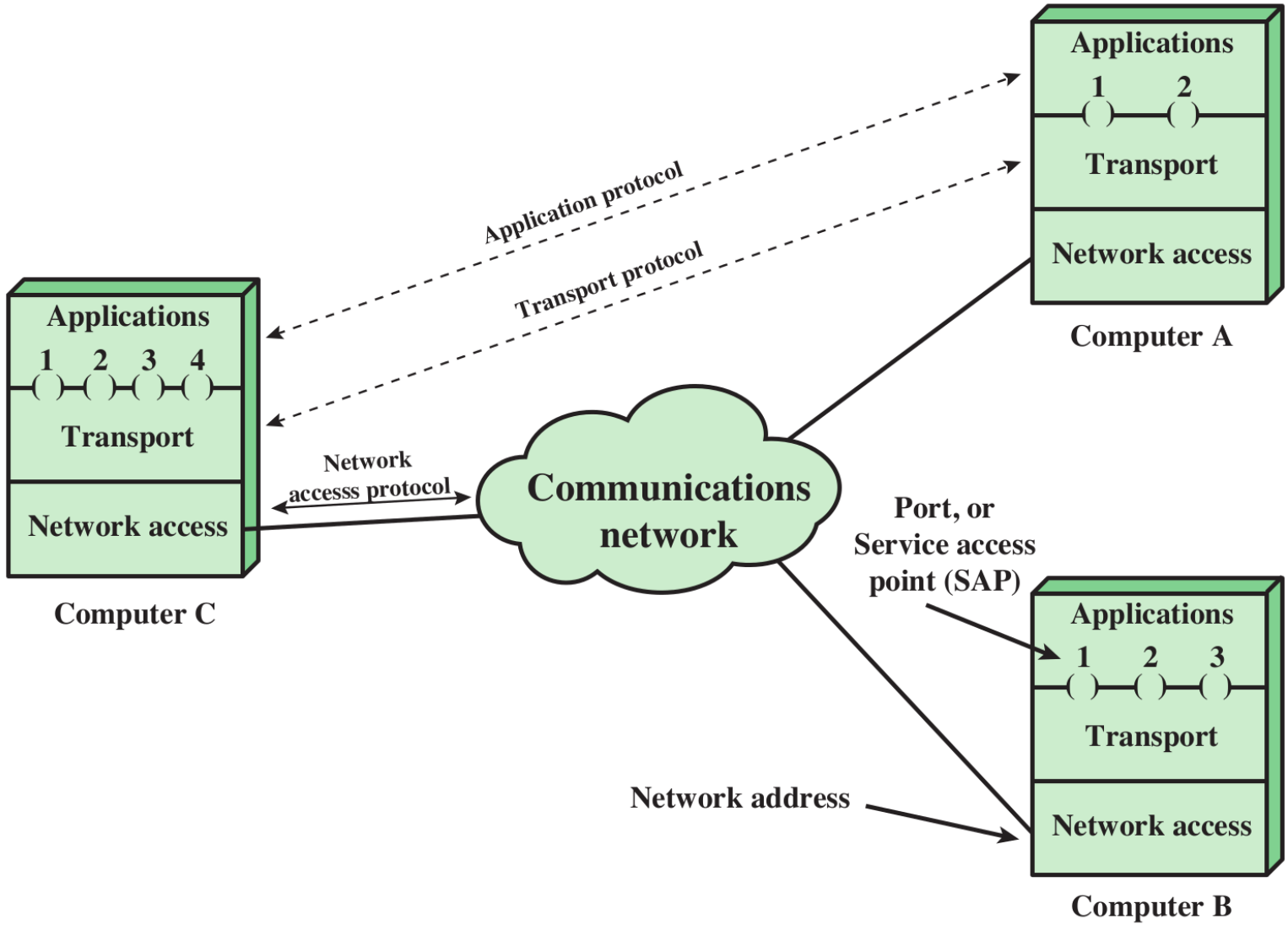
Simple view of data communications

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

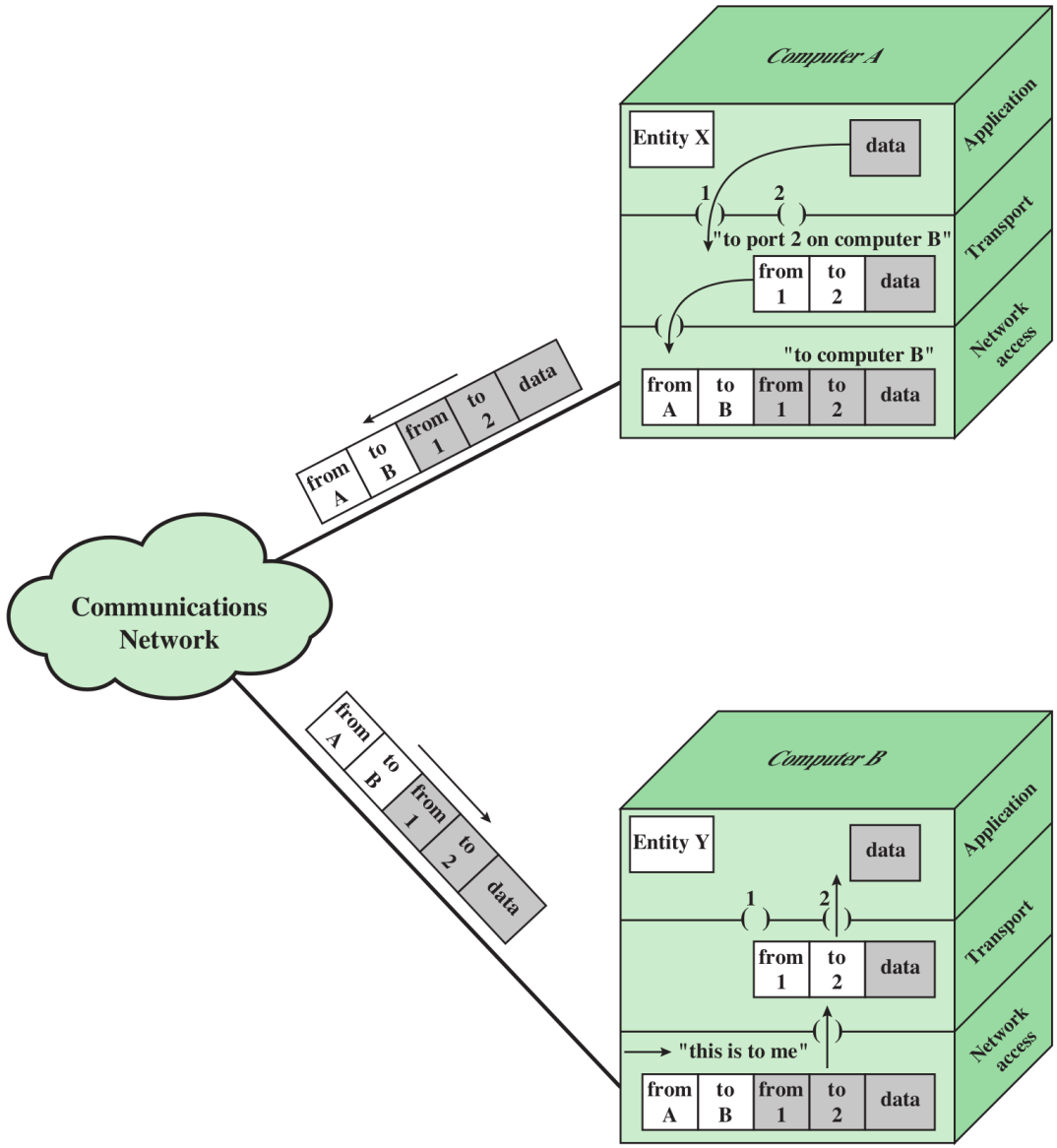
Divide tasks into 3 layers

- 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



Protocols in a Simplified Architecture



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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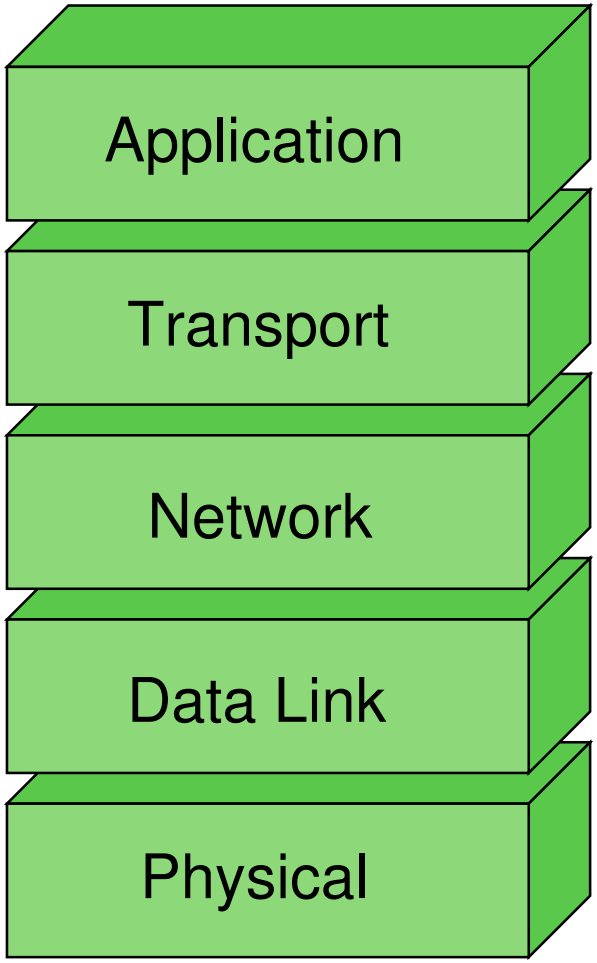
Origins and Terminology

- 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

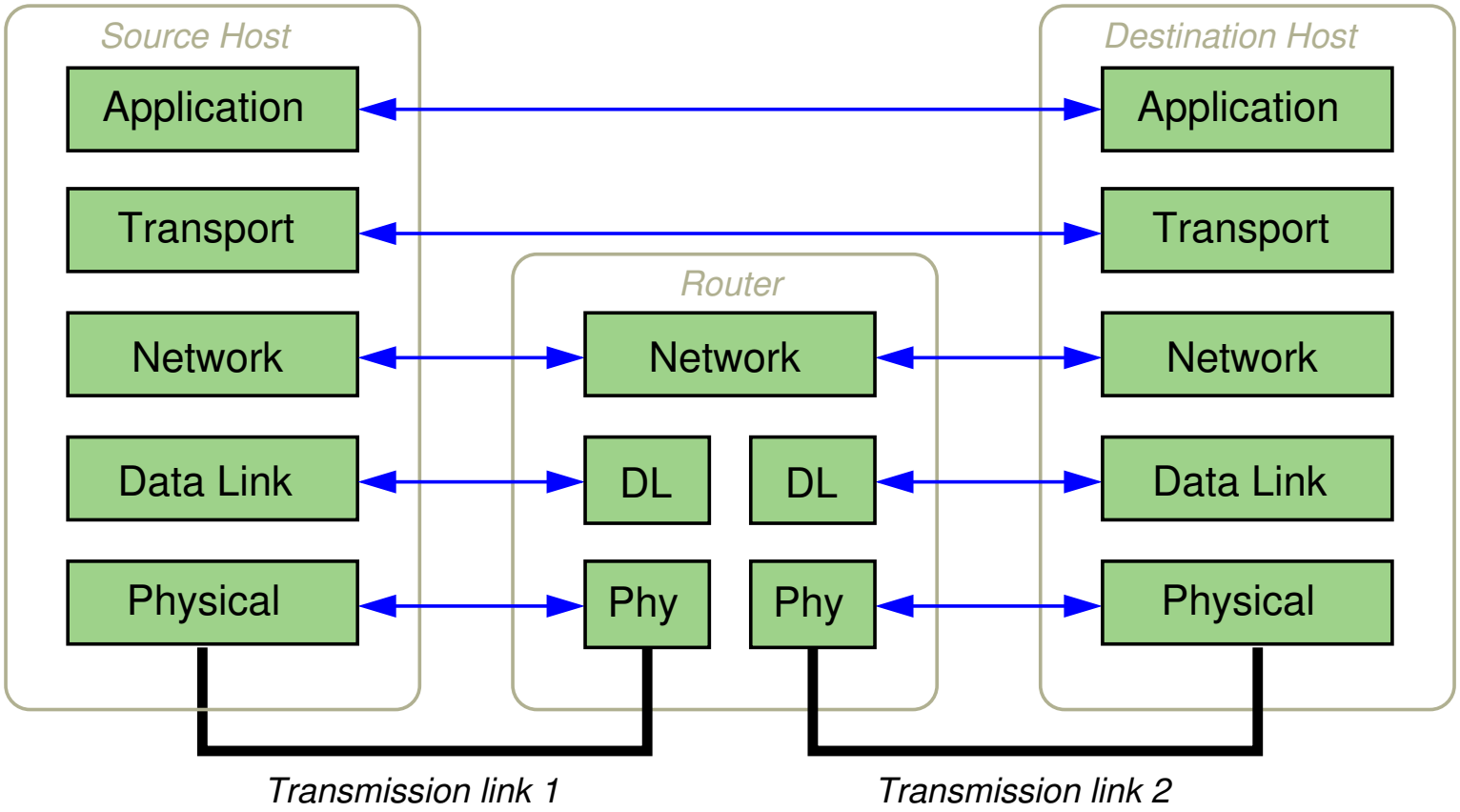
IP ICMP, OSPF, ARP

Ethernet ATM Frame Relay

Wireless LAN SDH PDH

Twisted pair, optical fibre, satellite

TCP/IP Layering Concepts



TCP/IP Layers

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

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`

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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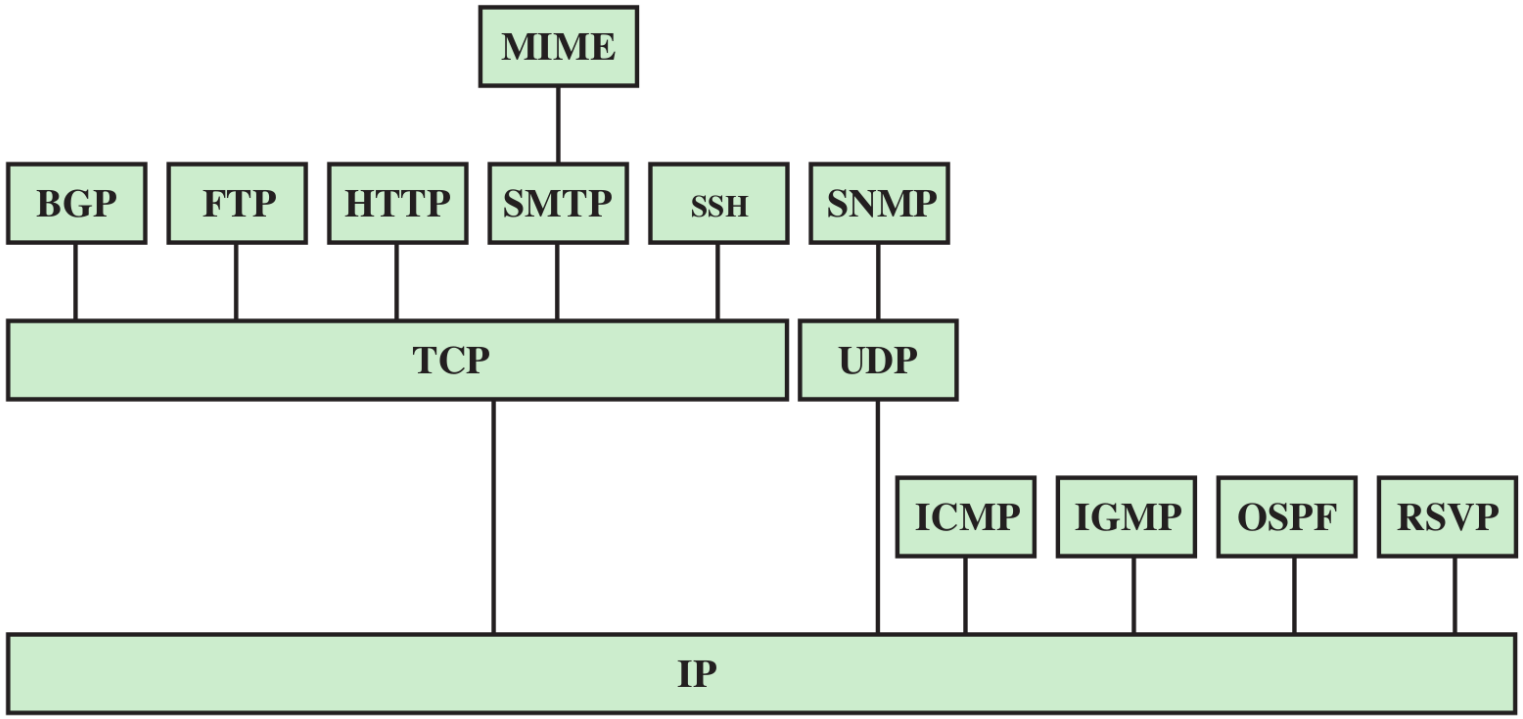
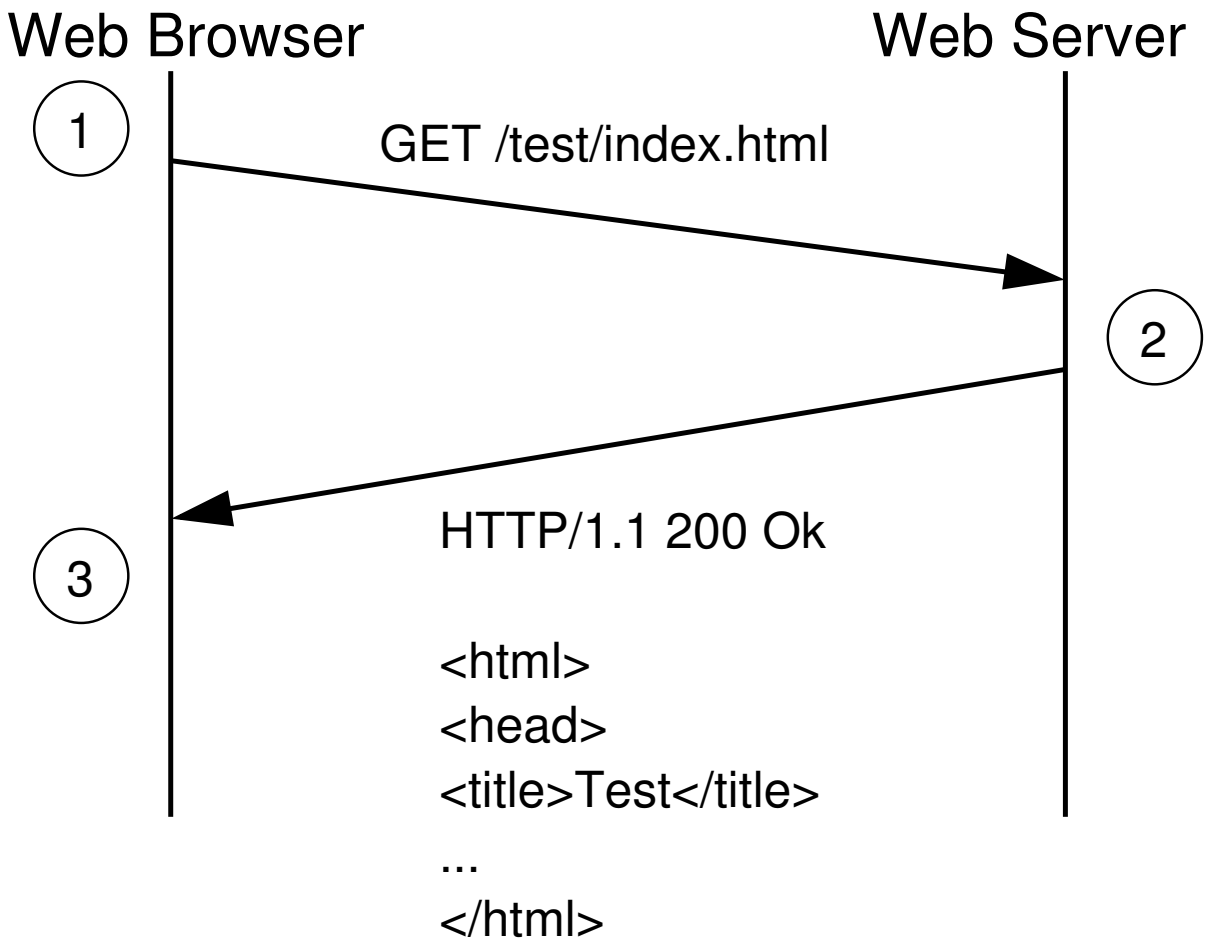
Some Protocols in the TCP/IP Protocol Suite



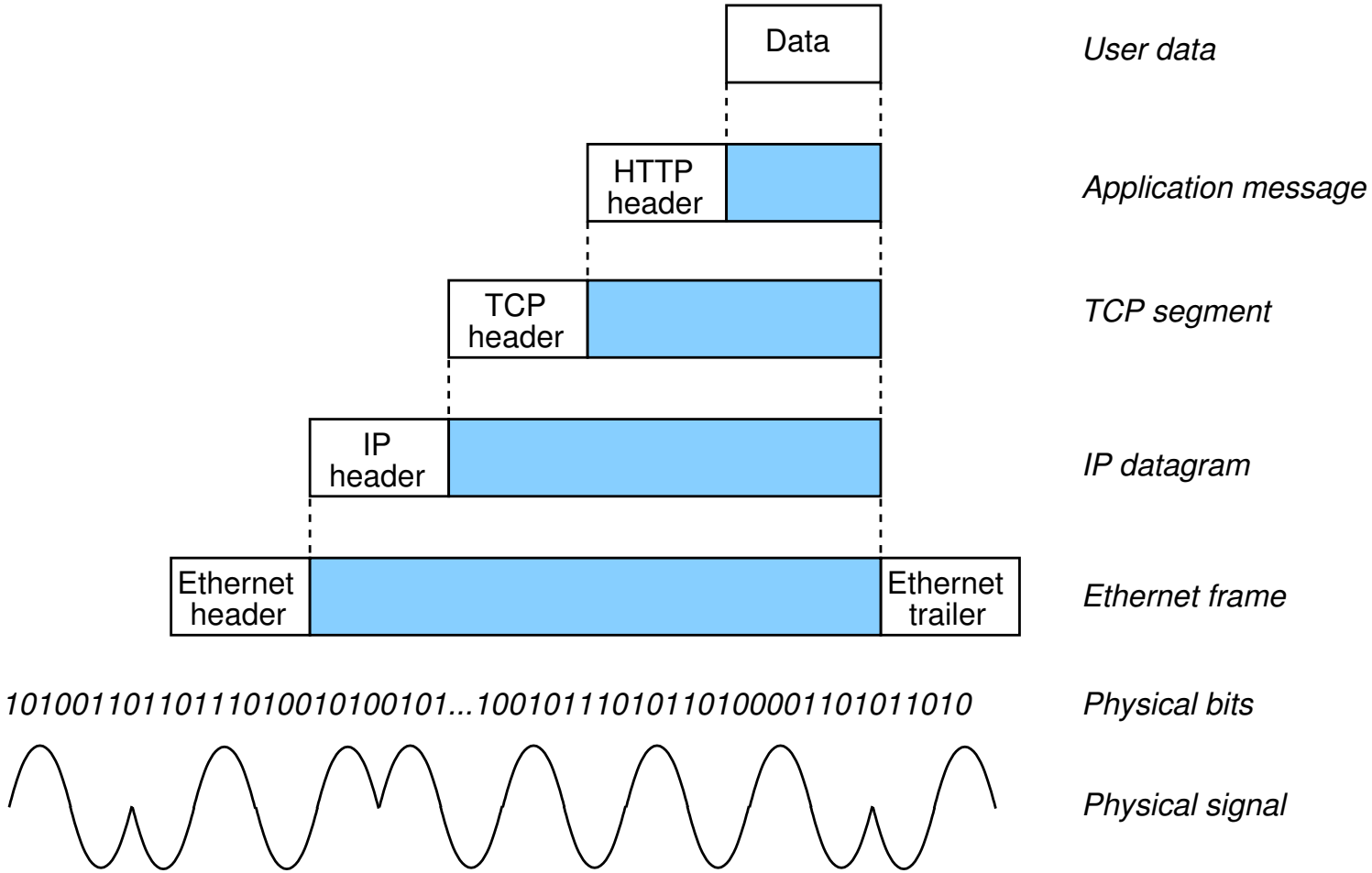
Below IP are the Data Link and Physical layer protocols. These are specific to LAN/WAN technologies.

Example Application: Web Browsing with HTTP

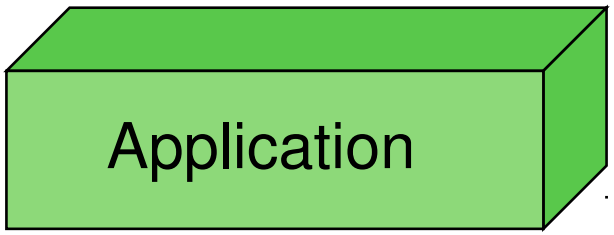


Encapsulation in TCP/IP

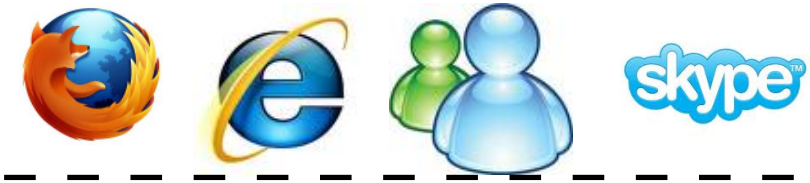
Example: web browser has requested web page from server; server needs to send the page requested back to browser

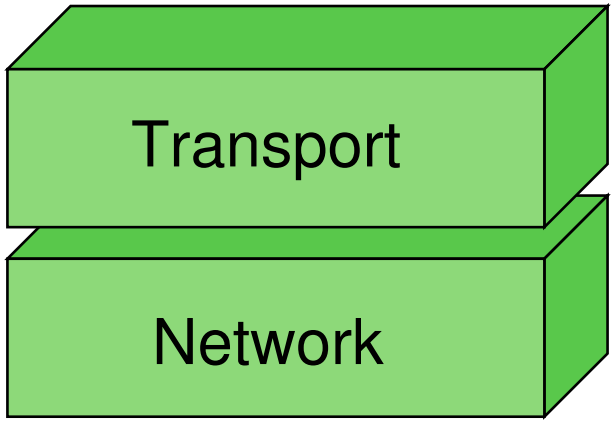


Implementing Layers



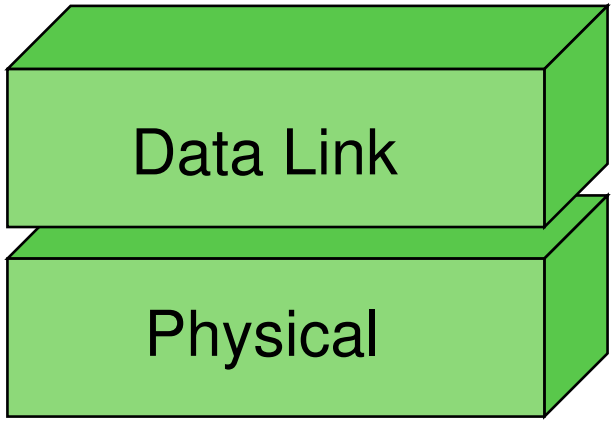
User Processes





Operating System

Windows 7



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