Business Data Communications and Networking

11th Edition

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Chapter 2

Application Layer

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Chapter 2 Outline

2.1 - Introduction

2.2 - Application Architectures

- Host-Based, Client-Based, Client-Server and Peer-to-Peer Architectures
- Choosing Architectures

2.3 - World Wide Web

- How the Web Works
- Inside an HTTP Request & HTTP Response

2.4 - Electronic Mail

- How E-Mail Works and Inside an SMTP Packet
- Attachments in MIME

2.5 - Other Applications

- Telnet, Instant Messaging, and Videoconferencing

2.6 – Implications for Management

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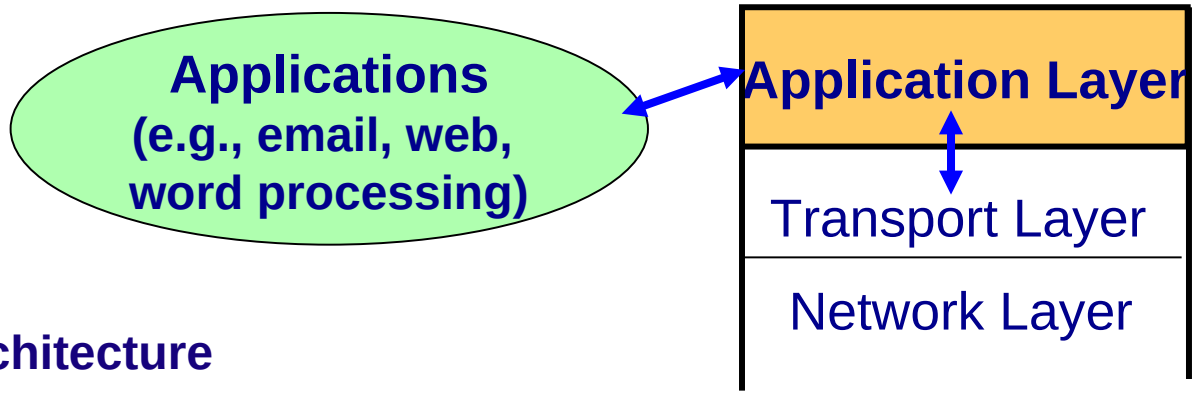
1.1 Introduction



- **Application architecture**
  - **The way in which the functions of the application layer software are spread among the clients and servers on the network**
- **Functions of Application Layer**
  - **Data storage - Storing of data generated by programs (e.g., files, records)**
  - **Data access logic - Processing required to access stored data (often means queries in SQL)**
  - **Application logic - Business logic such as word processors, spreadsheets**
  - **Presentation logic - Presentation of info to user & acceptance of user's commands**

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- **Clients**
  - Personal computer
  - Terminal (monitor and key – contains no CPU)
  - Network computer (designed to communicate, using http, java and other internet based stds)
  - Transaction terminal ie. (ATM)
  - Handheld
- **Servers**
  - Mainframe (large, general use computer)
  - Personal computer
  - Cluster (group of computers that can act as one. Jobs/tasks distributed amongst
  - Virtual server (pc operating as server via s/w and OSs)

2.2 Application Architectures

- **Determined by how functions of application programs are spread among clients and servers**
  - **Host-based Architectures**
    - **Server performs almost all functions**
  - **Client-based architectures**
    - **Client performs most functions**
  - **Client-server architectures**
    - **Functions shared between client and server**

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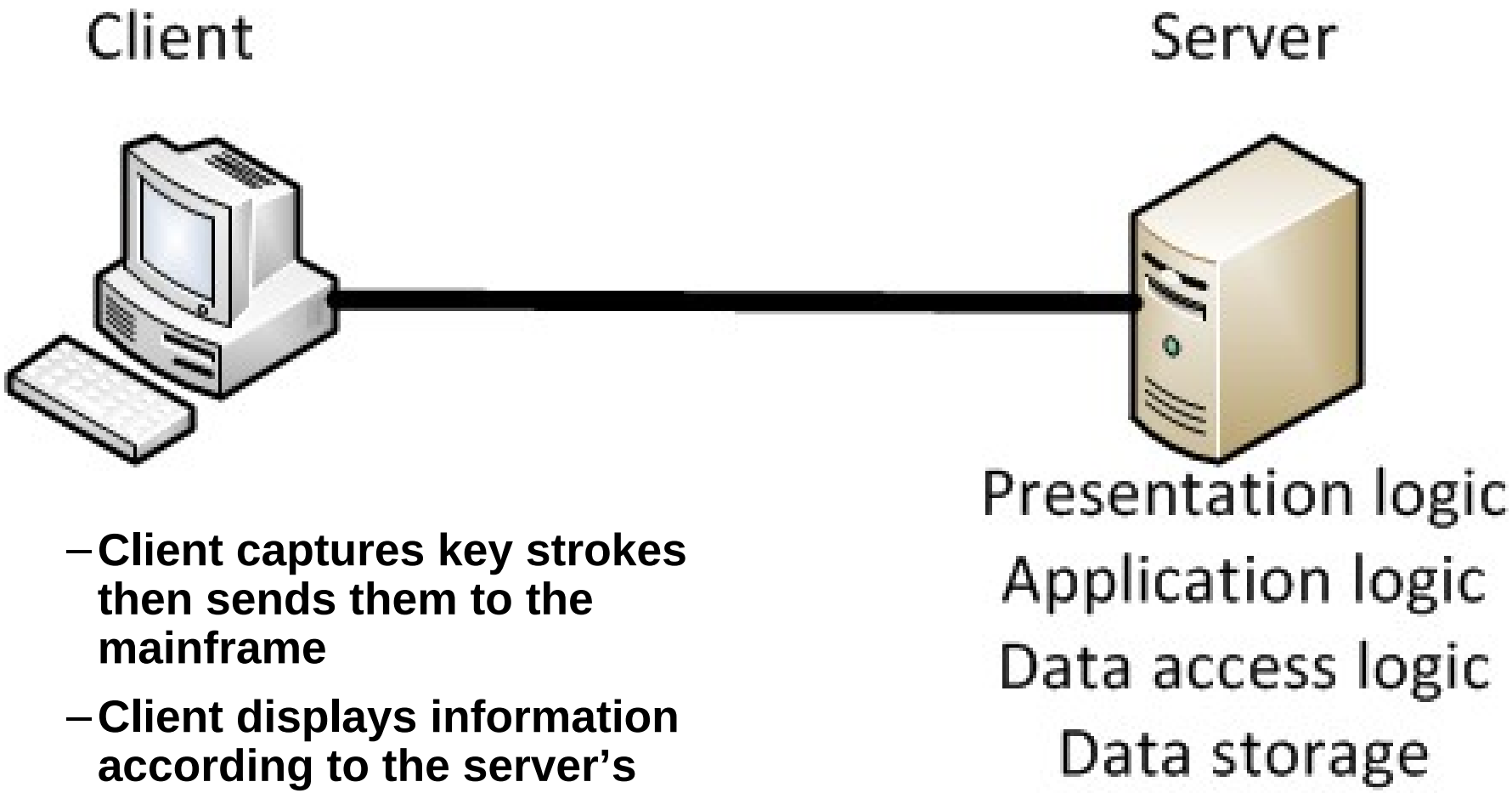
Host-Based Architectures



- **Client captures key strokes then sends them to the mainframe**
- **Client displays information according to the server's instructions**

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Host-based Architecture Problems

- **Host becoming a bottleneck**
  - **Processing done by the host (server), which can severely limit network performance (as demand for more network applications grow)**
- **Host upgrades typically expensive and "lumpy"**
  - **Upgrades come in large increments (ie. 500k)**
  - **Available upgrades require large scale and often costly jumps in processing and memory**
  - **Network demand grows more incrementally than does the host capacity (therefore upgrades needed frequently)**

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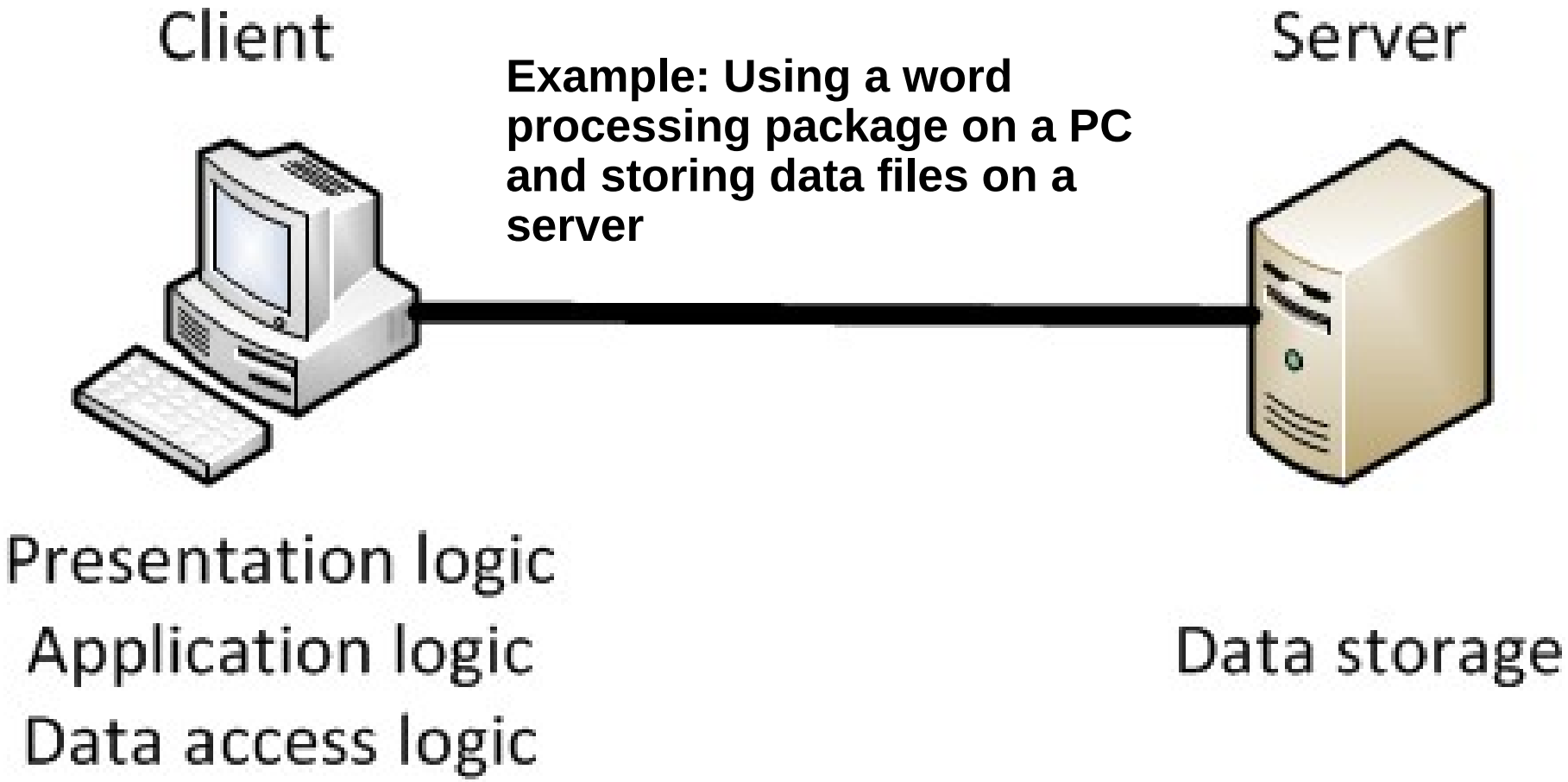
Client-Based Architectures



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Client-Based Architecture Problems

- **Data traffic must travel back and forth between server and client**
  - **Example: when the client program is making a database query, the ENTIRE database must travel to the client before the query can be processed**
  - **Often the large file sizes moving across the LAN can yield a poor result in network performance**

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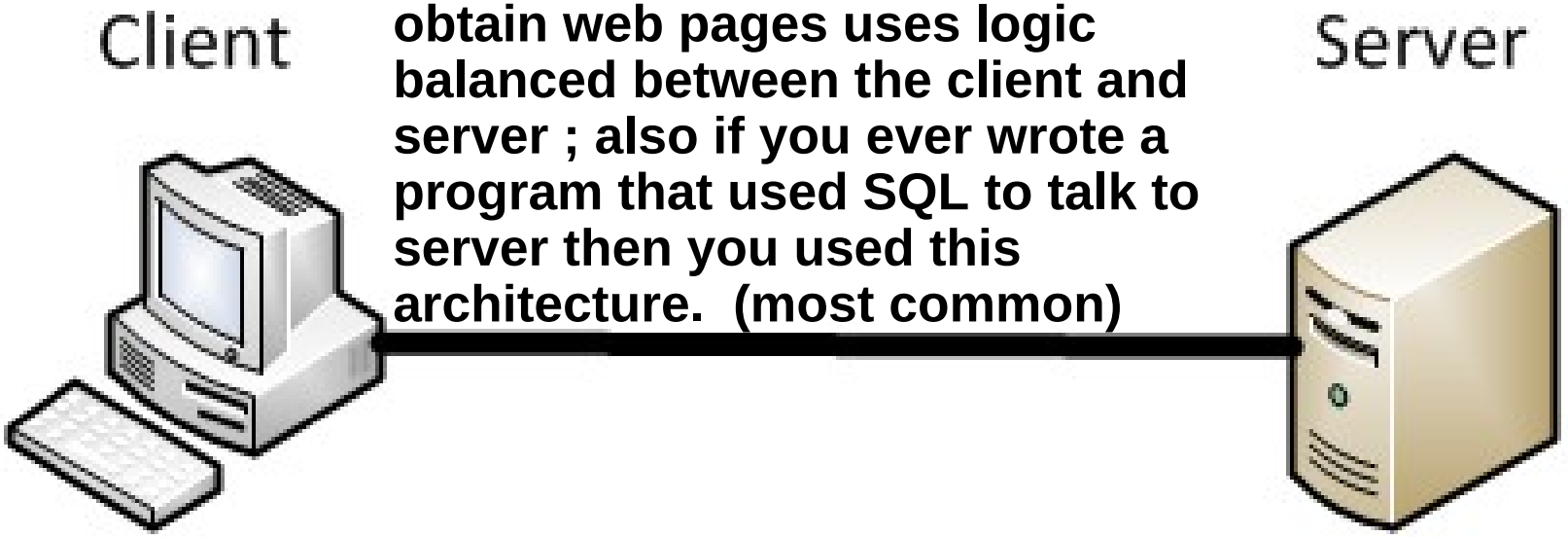
Client-Server Architectures

Example: Using a Web browser to obtain web pages uses logic balanced between the client and server ; also if you ever wrote a program that used SQL to talk to server then you used this architecture. (most common)



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Client-Server Architectures

- **Advantages**
  - **More efficient because of distributed processing**
  - **Allow hardware and software from different vendors to be used together**
  - **Enables cloud computing**
- **Disadvantages**
  - **Difficulty in getting software from different vendors to work together smoothly**
  - **May require Middleware, a third category of software**

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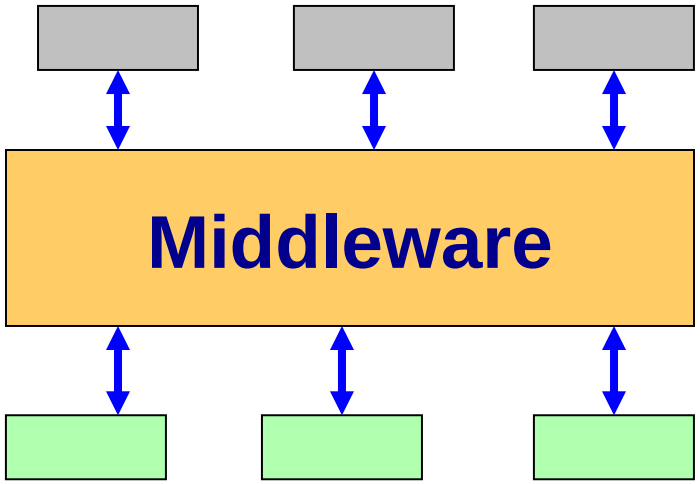
Middleware

client application programs

a standard way of translating between software from different vendors



server application programs

- **Manages message transfers**
- **Insulates network changes from the clients (e.g., adding a new server)**

Example: Open Database Connectivity (ODBC) Open Database Connectivity (ODBC) is Microsoft's strategic interface for accessing data in a heterogeneous environment of relational and non-relational database management systems. Based on the Call Level Interface specification of the SQL Access Group, ODBC provides an open, vendor- neutral way of accessing data stored in a variety of proprietary personal computer, minicomputer, and mainframe databases.

Middleware – cont.
example: ODBC

ODBC alleviates the need for independent software vendors and corporate developers to learn multiple application programming interfaces. ODBC now provides a universal data access interface. With ODBC, application developers can allow an application to concurrently access, view, and modify data from multiple, diverse databases.

ODBC is a core component of Microsoft Windows Open Services Architecture. Apple has endorsed ODBC as a key enabling technology by announcing support into System 7 and up. ODBC is an important industry standard for data access for both Windows and Macintosh applications.

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Multi-tier Architectures

- **Involve more than two computers in distributing application program logic**
  - **2-tier architecture**
    - **Uses clients and servers in a balance, very popular approach in simple LANs**
  - **3-tier architecture**
    - **3 sets of computers involved**
  - **N-tier architecture**
    - **More than three sets of computers used, more typical across complex organizations**
    - **Allows load balancing across servers**

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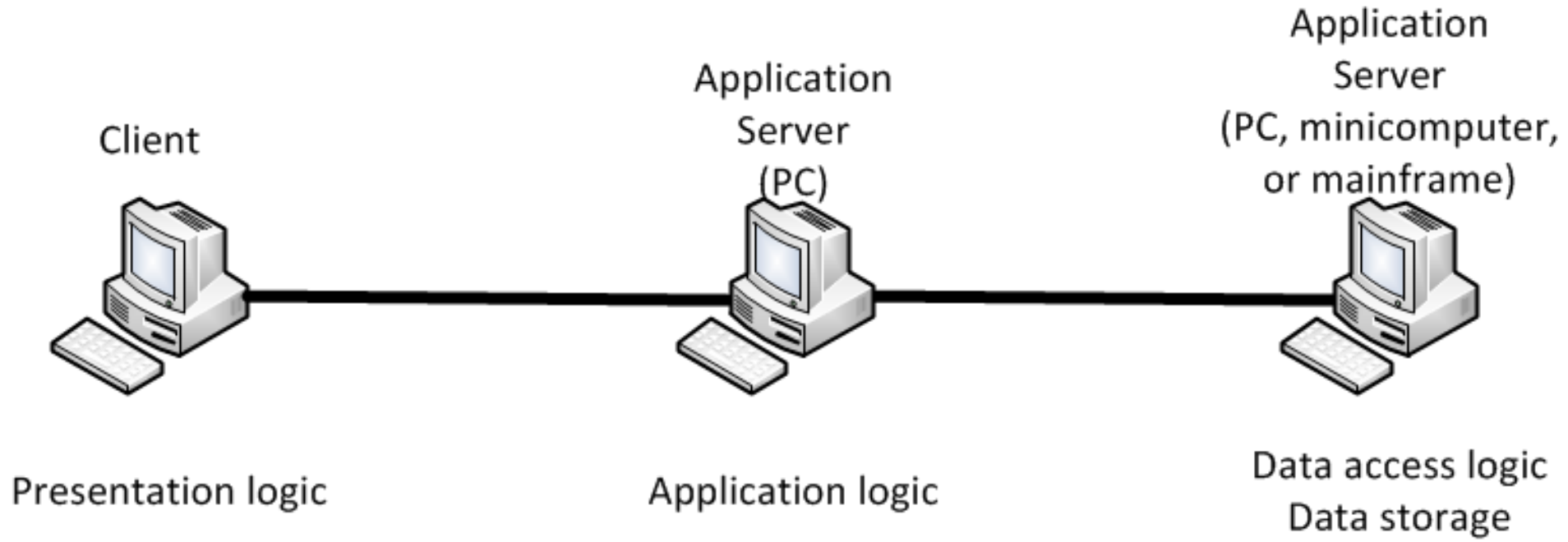
3-tier Architecture



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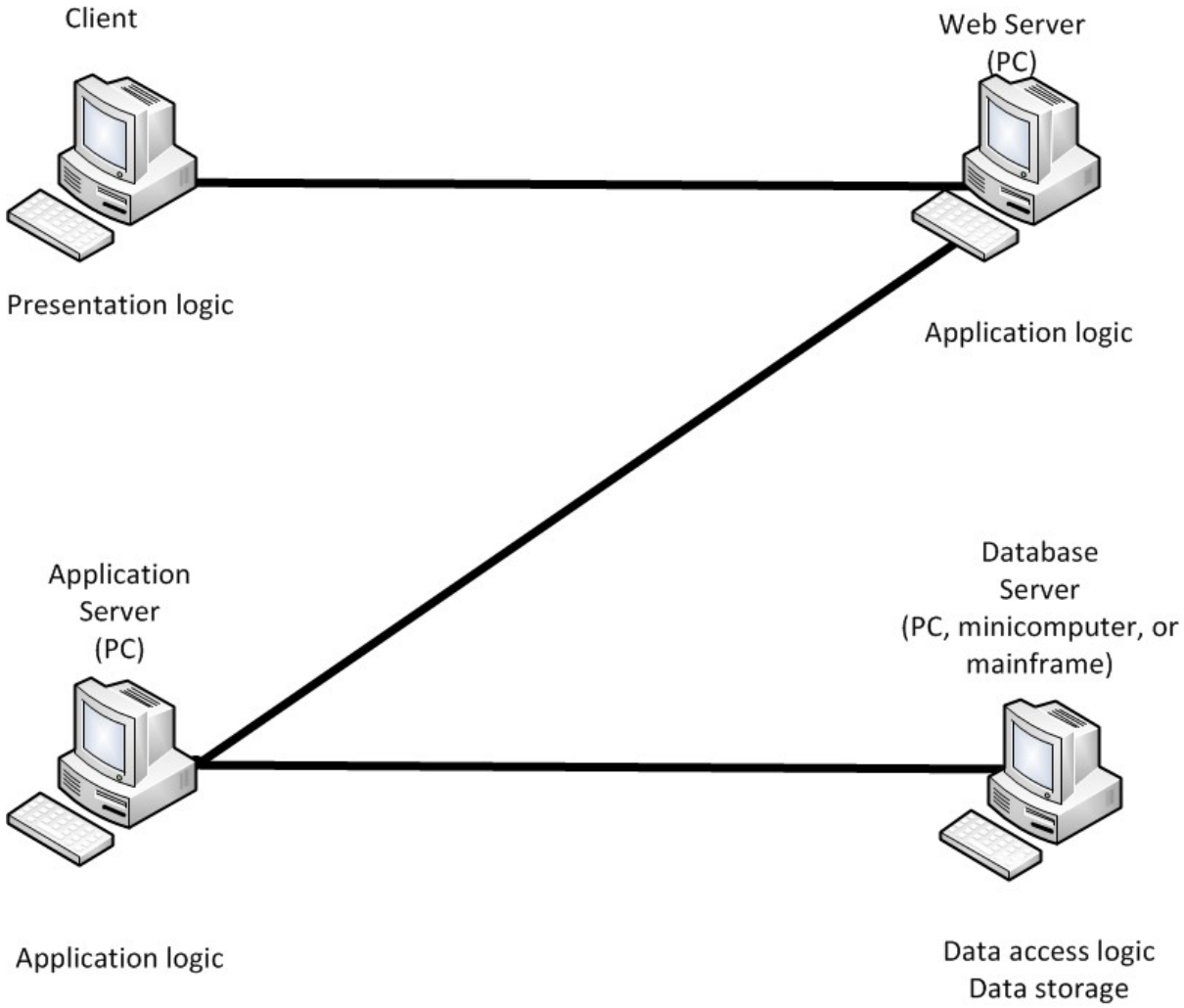
N-tier Architecture



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Multi-tier Architectures

- **Advantages**
  - **Better load balancing:**
    - **More evenly distributed processing. (e.g., application logic distributed between several servers.)**
  - **More scalable:**
    - **Only servers experiencing high demand need be upgraded**
- **Disadvantages**
  - **Heavily loaded network:**
    - **More distributed processing necessitates more data exchanges**
  - **Difficult to program and test due to increased complexity**

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Thin and Thick Clients

- **Classification depends on how much of the application logic resides on the client or server**
- **Thin client:**
  - **Little or no application logic on client**
  - **Becoming popular because easier to manage, (only the server application logic generally needs to be updated)**
  - **The best example: World Wide Web architecture (uses a two-tier, thin client architecture)**
- **Thick client:**
  - **All or most of the application logic resides on the client**

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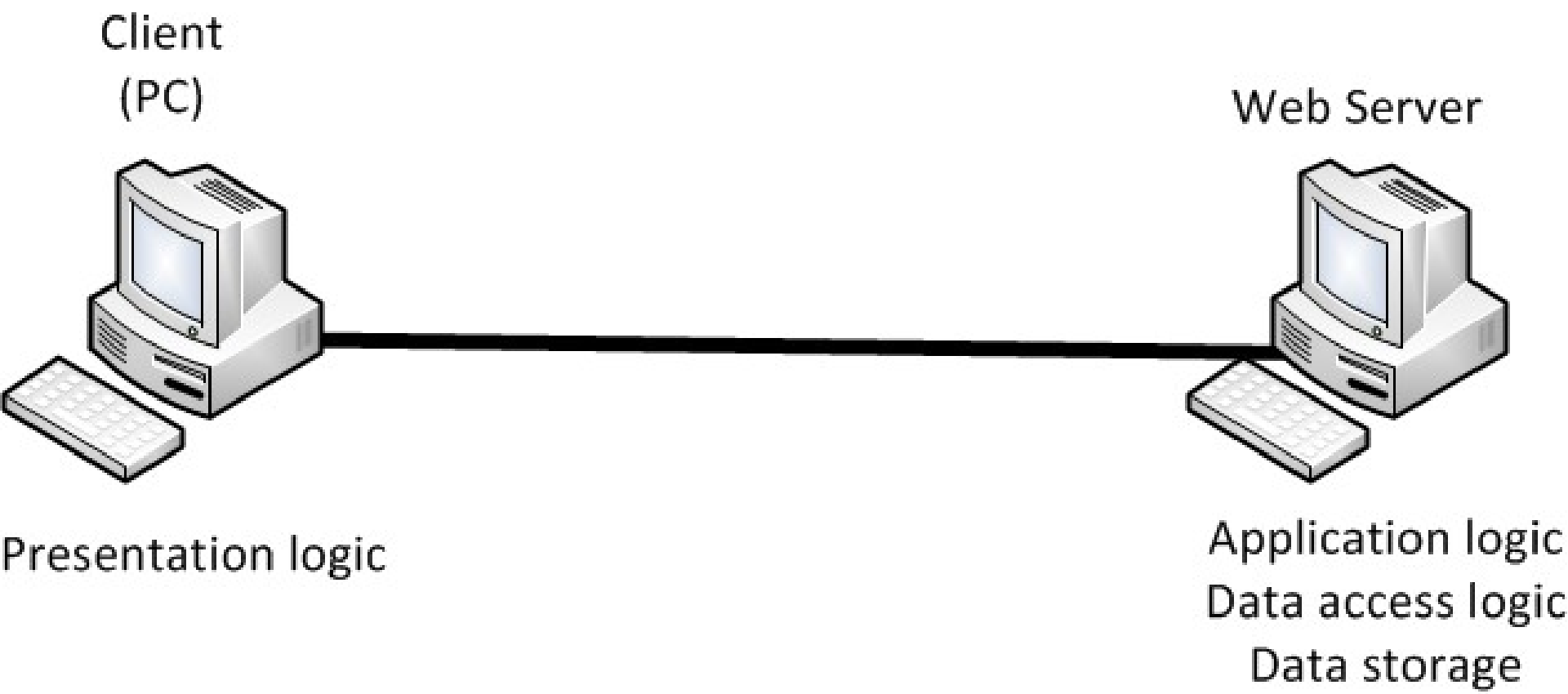
Thin-Client Example: Web Architecture



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Peer to Peer Architecture

- **All computers can serve as a client and a server**
- **Increased popularity in the last decade due to the rise of P2P services such as Napster**
- **Advantages:**
  - **Data can be stored anywhere on the network**
  - **Very resilient to failure**
- **Disadvantages:**
  - **Finding data**
  - **Security**

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Criteria for Choosing Architecture

- **Infrastructure Cost**
  - **Cost of servers, clients, and circuits**
  - **Mainframes: very expensive; terminals, PCs: inexpensive**
- **Development Cost**
  - **Mainly cost of software development**
  - **Software: expensive to develop; off-the-shelf software: inexpensive**
- **Scalability**
  - **Ability to increase (or decrease) in computing capacity as network demand changes**
  - **Mainframes: not scalable; PCs: highly scalable**

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Choosing an Architecture

	Host-Based	Client-Based	Client-Server
Cost of Infrastructure	High	Medium	Low
Cost of Development	Low	Medium	Medium
Scalability	Low	Medium	High

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Applications Layer Examples

- **World Wide Web**
- **E-mail**
- **File Transfer**
- **Videoconferencing**
- **Instant Messaging**

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2.3 World Wide Web

- **Web began with two innovative ideas:**
  - **Hypertext**
    - **A document containing links to other documents**
  - **Uniform Resource Locators (URLs)**
    - **A formal way of identifying links to other documents**
- **Invention of WWW (1989)**
  - **By Tim Berners-Lee at CERN in Switzerland**
- **First graphical browser, Mosaic, (1993)**
  - **By Marc Andressen at NCSA in USA; later founded Netscape**

CERN - Conseil Européen pour la Rechèrche Nucléaire (Berners-Lee, T. (2000) *Weaving the Web*. New York: HarperCollins. P. 4)
NCSA - National Center for Supercomputing Applications

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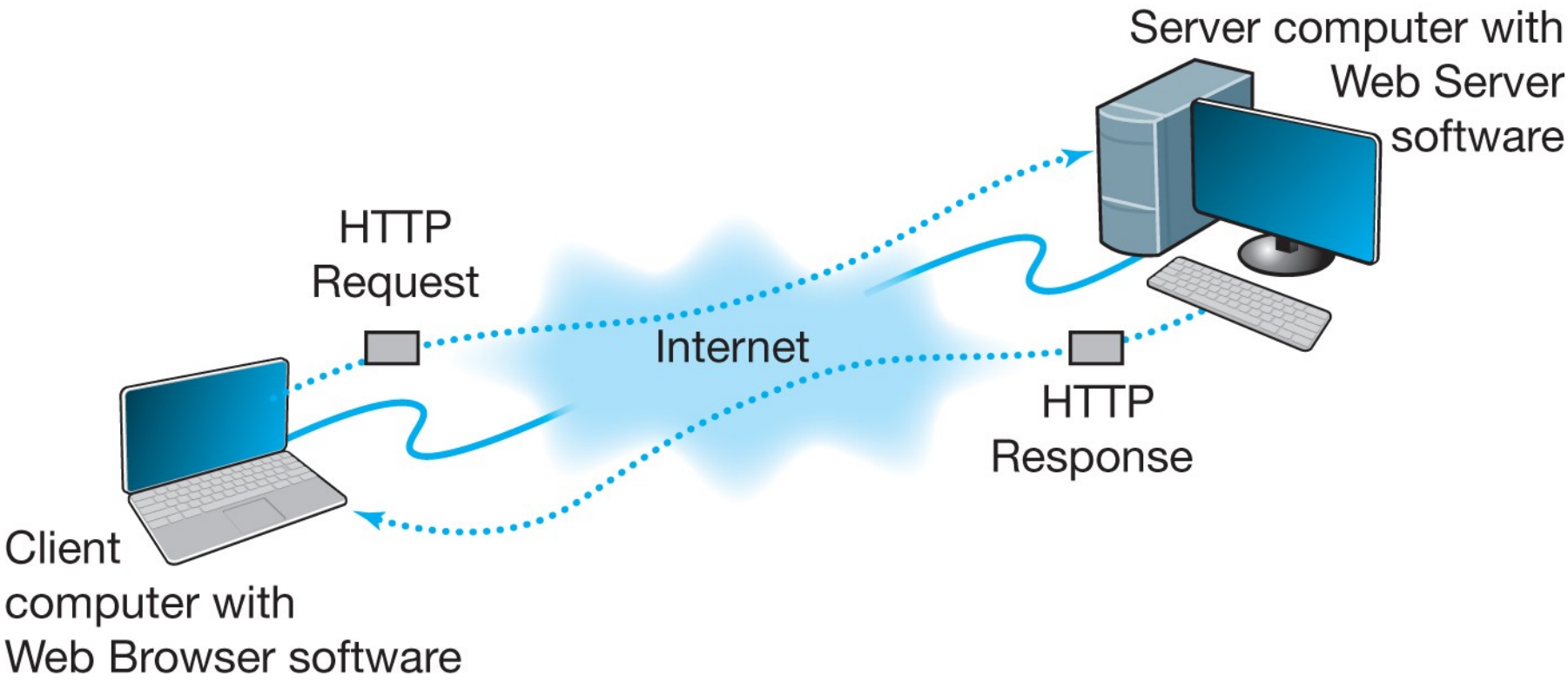
How the Web Works



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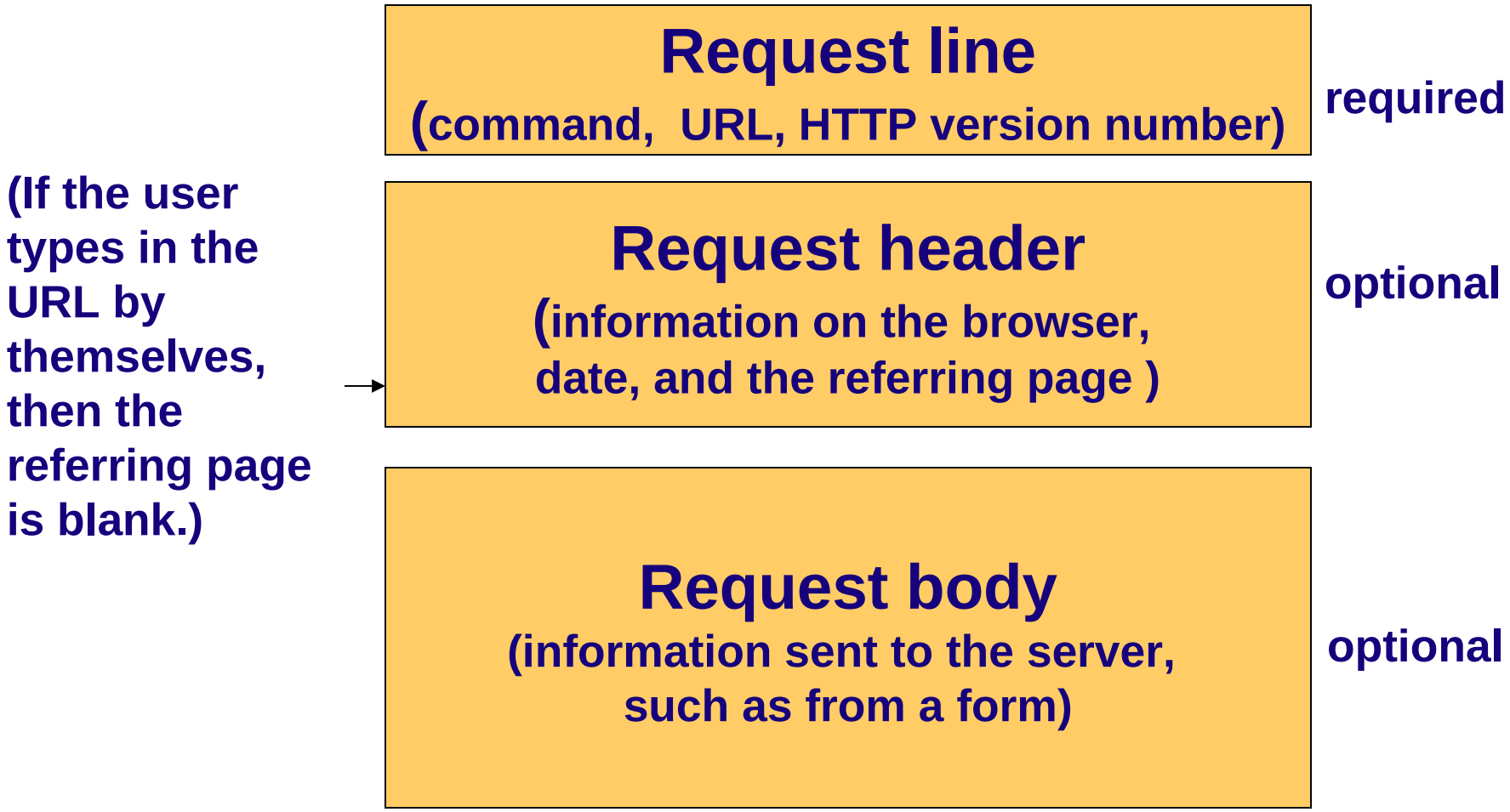
HTTP Request Message



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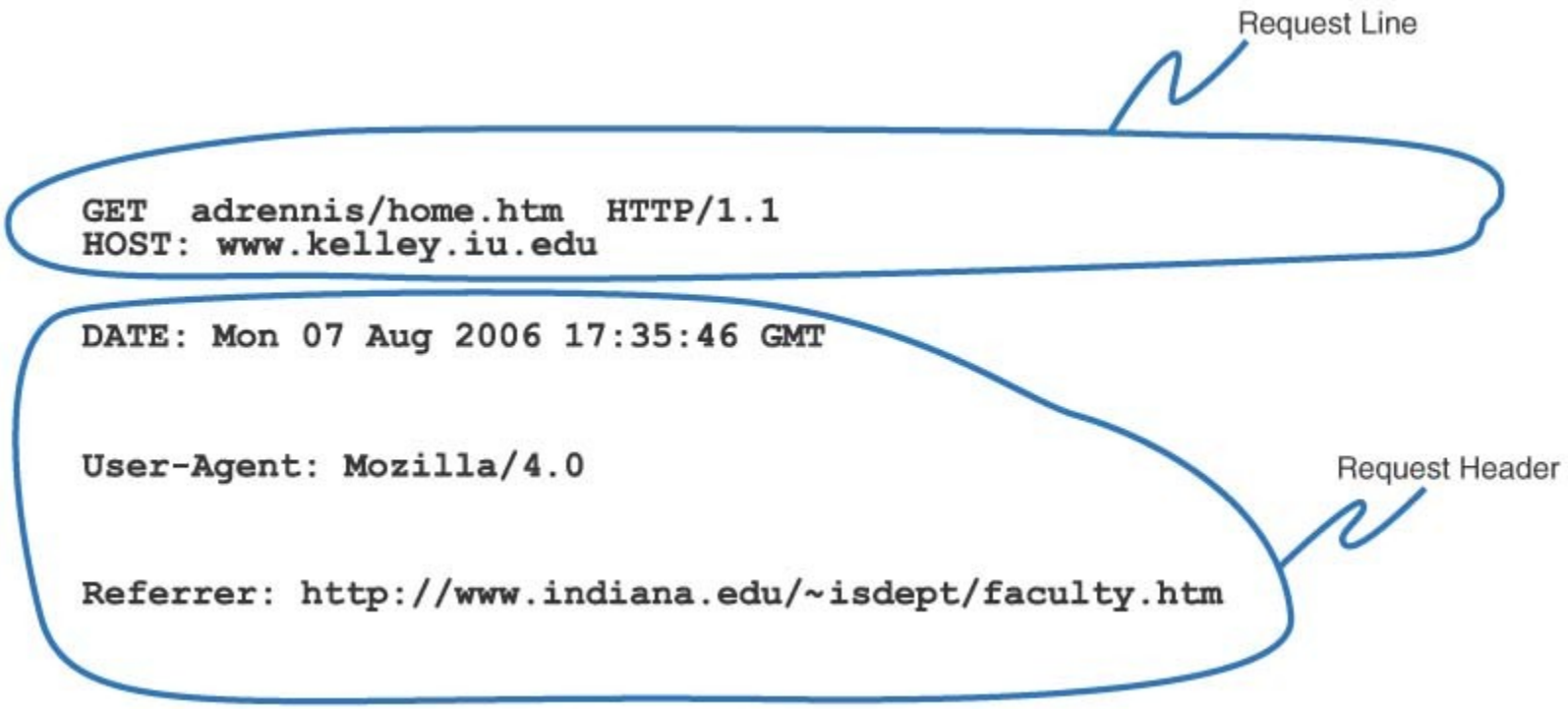
Example of an HTTP Request



Note that this HTTP Request message has no "Body" part.

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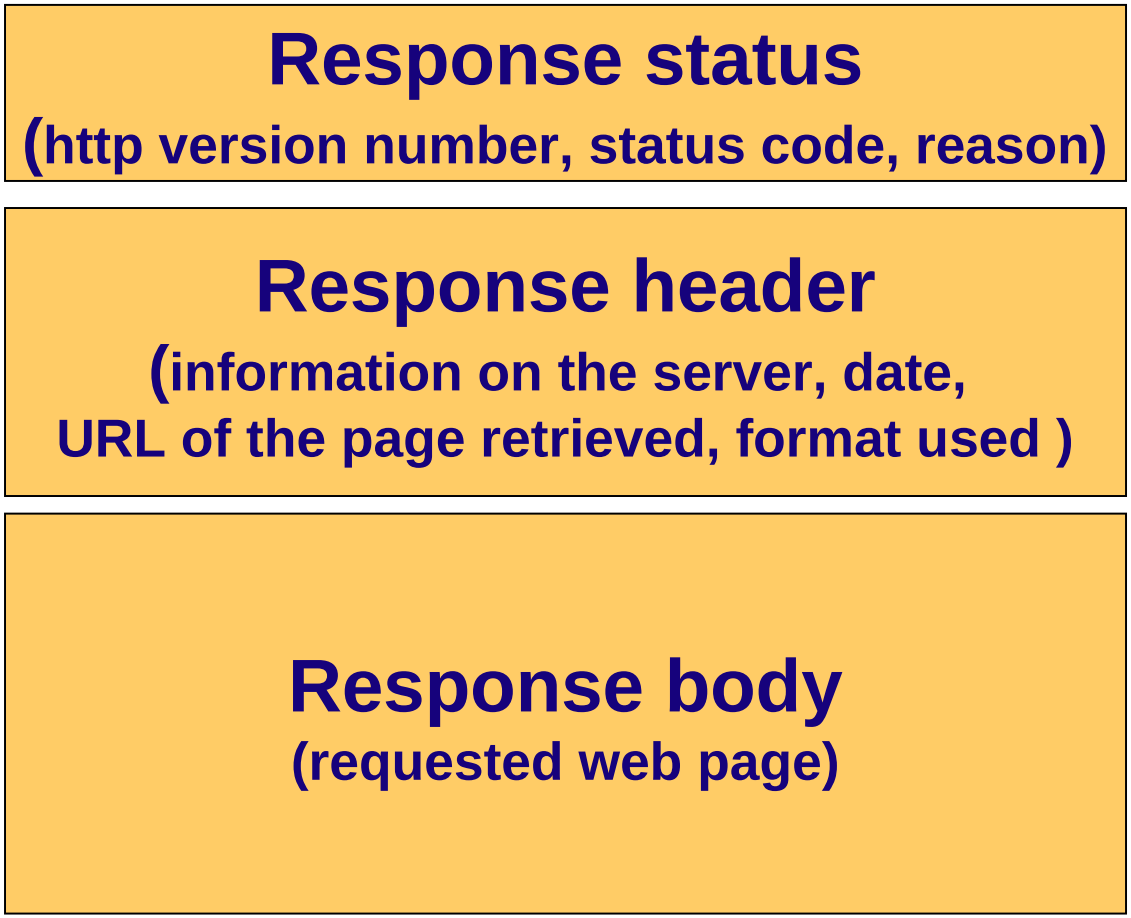
HTTP Response Message



Note: http://www.w3.org/Protocols/rfc2616/rfc2616-sec10.html

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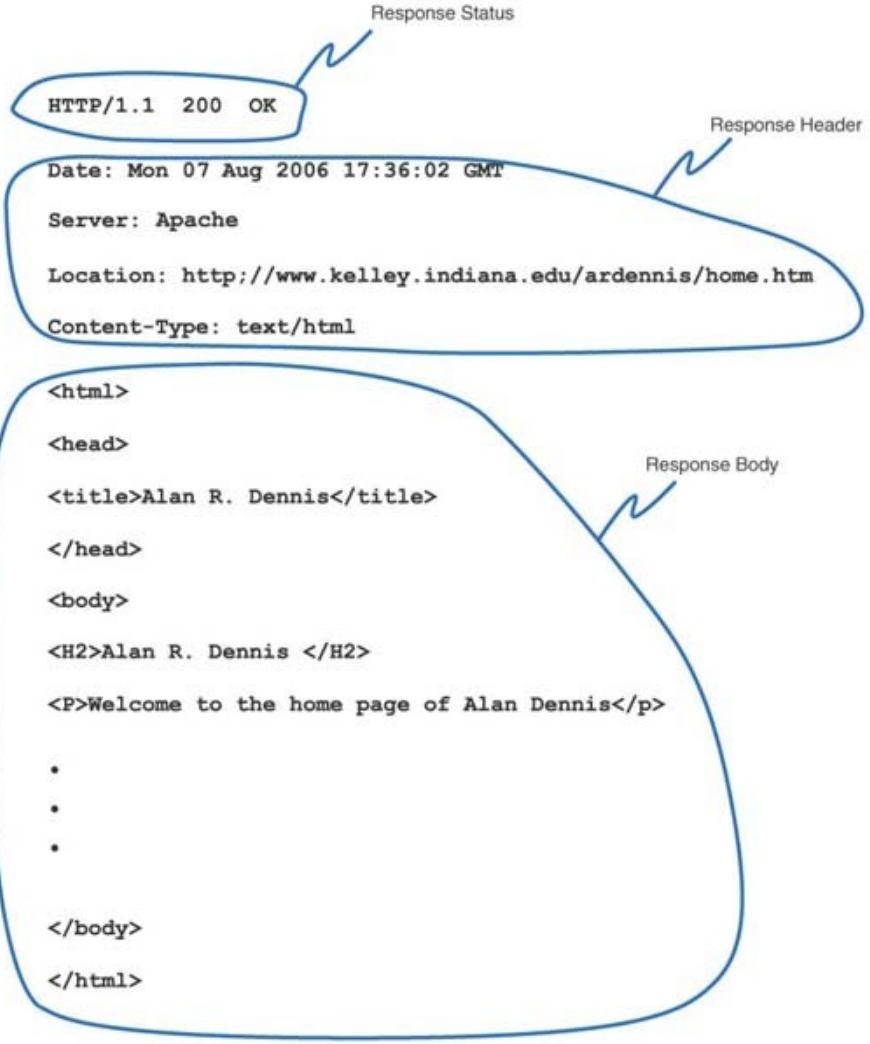
Example of an HTTP Response



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HTML - Hypertext Markup Language

- **A language used to create Web pages**
- **Also developed at CERN (initially for text files)**
- **Tags are embedded in HTML documents**
  - **include information on how to format the file**
- **Extensions to HTML needed to format multimedia files**

Note: http://condor.depaul.edu/hmartch/xmlproj/xml-html.htm

HTML – Hypertext Markup Language

- XML - Extensible Markup Language
  A new markup language becoming popular

XML	HTML
Can be used in various media: The Web Paper CD-ROM Audio	Can be used in one medium: The Web

2.4 Electronic Mail

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E-mail Standards

- **SMTP - Simple Mail Transfer Protocol**
  - **Main e-mail standard for**
    - **Originating user agent and the mail transfer agent**
    - **Between mail transfer agents**
  - **Originally written to handle only text files**
  - **Usually used in two-tier client-server architectures**
- **Post Office Protocol (POP) or**
- **Internet Mail Access Protocol (IMAP)**
  - **Main protocols used between the receiver user agent and mail transfer agent**
  - **Main difference: with IMAP, messages can be left at the server after downloading them to the client**

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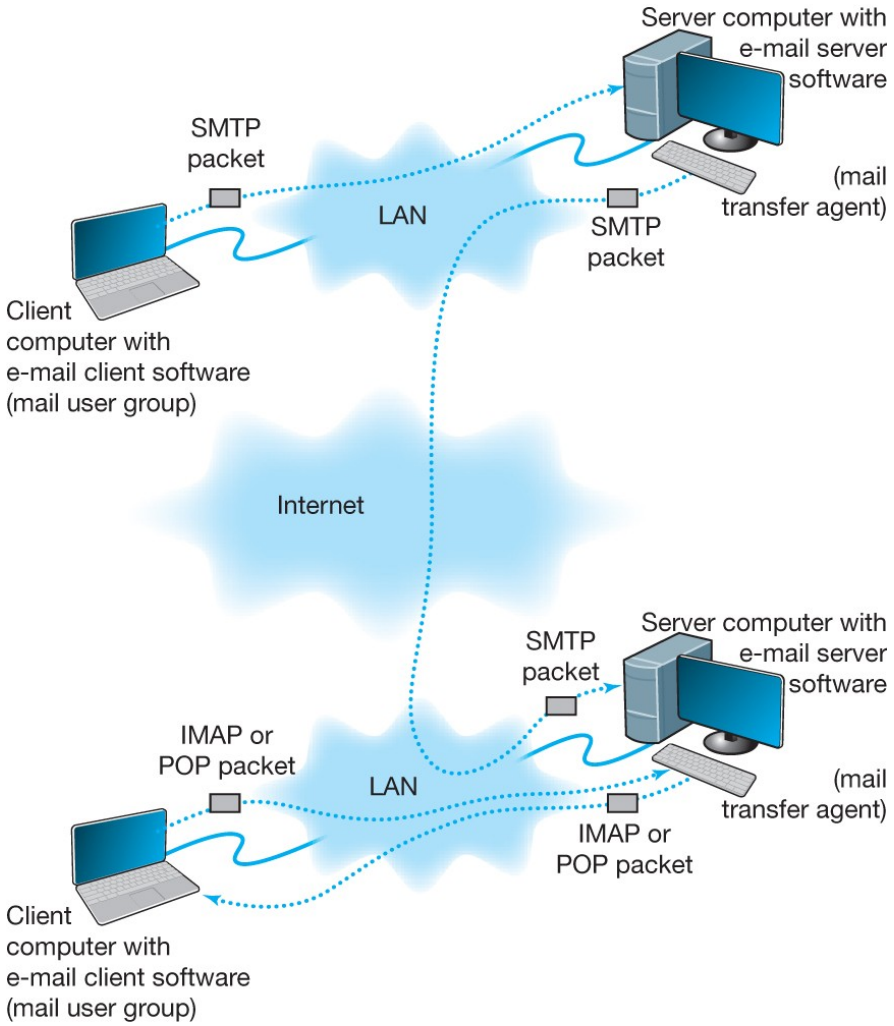
Web-based e-mail



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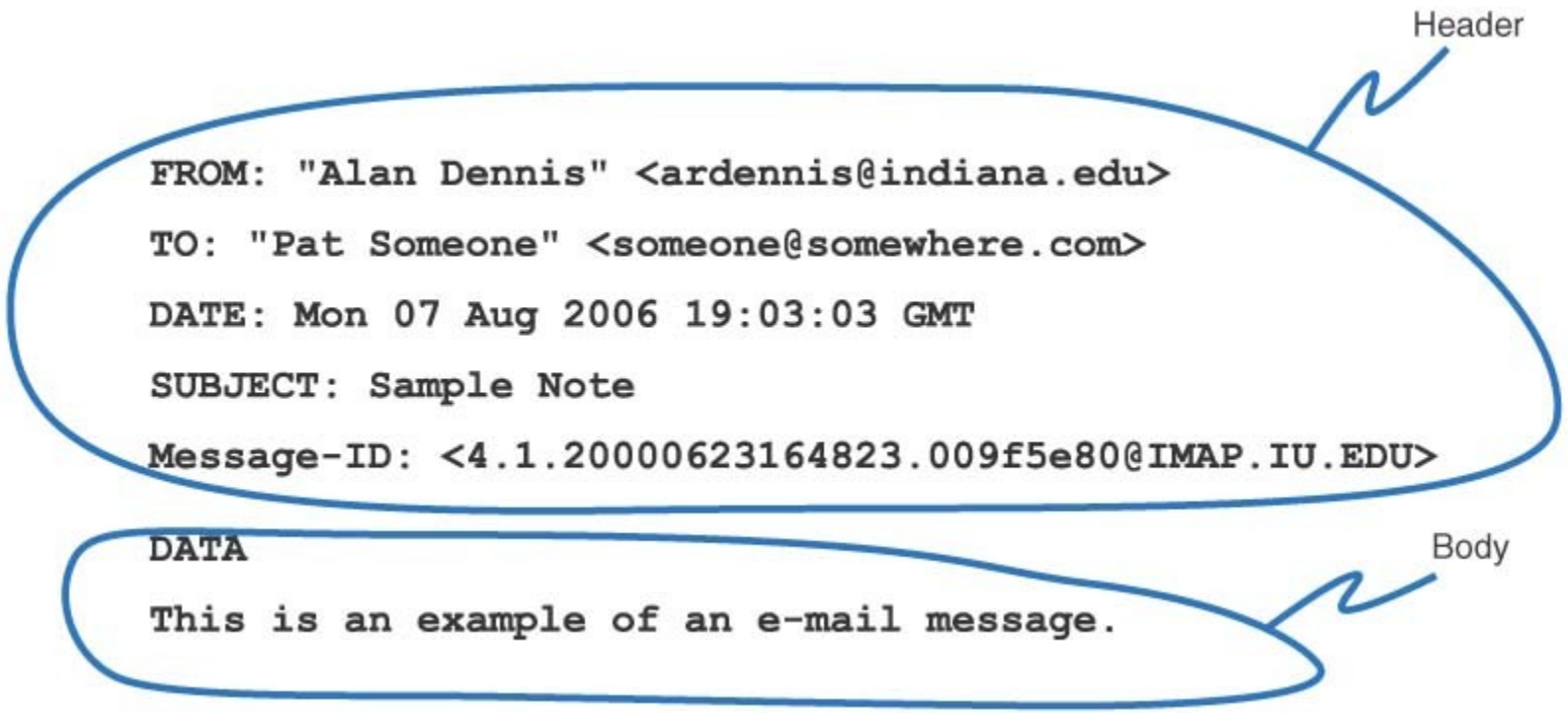
Sample SMTP Message



Note that this SMTP message has no attachments.

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Two-Tier E-mail Architecture

- ***User agent*** **is another word for an e-mail client application**
  - **Run on client computers**
  - **Send e-mail to e-mail servers**
  - **Download e-mail from mailboxes on those servers**
  - **Examples: Outlook, Netscape Messenger**
- ***Mail transfer agent*** **is another word for the mail server application**
  - **Used by e-mail servers**
  - **Send e-mail between e-mail servers**
  - **Maintain individual mailboxes.**

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Host Based e-mail Architectures

- **An old method used on UNIX based hosts**
- **Similar to client-server architecture, except**
  - **Client PC replaced by a terminal, or terminal emulator**
    (Terminal emulation is the ability to make a PC, appear like another, usually older type of terminal so that a user can access programs originally written to communicate with the other terminal type. Terminal emulation is often used to give PC users the ability to log on and get direct access to legacy programs in a mainframe operating system)
    - **Sends all keystrokes to the server**
    - **Display characters received from the server**
  - **All software resides on the server**
    - **Takes client keystrokes and understand user's commands**
    - **Creates SMTP packets and sends them to next mail server**

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MIME

- **Multipurpose Internet Mail Extension**
  - **A graphics capable mail transfer agent protocol (to send graphical information in addition to text)**
    - **SMTP was designed years ago for text transfer only**
  - **MIME software is included as part of an e-mail client**
  - **Translates graphical information into text allowing the graphic to be sent as part of an SMTP message (as a special attachment)**
  - **Receiver's e-mail client then translates the MIME attachment from text back into graphical format**
  - **MIME example (next slide)**

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MIME – CONT.

- MIME Example is a "dummy" MIME type used for documentation purposes only.
- To better understand this, it's important to understand what MIME types and how they are managed by the Internet community.
- MIME (Multipurpose Internet Message Extensions) types were originally created to help email clients understand what type of information an attachment contained so that the appropriate application would be used to open the file. These MIME types are registered with the Internet Assigned Numbers Authority (The Internet Assigned Numbers Authority (IANA) is responsible for the global coordination of the DNS Root, IP addressing, and other Internet protocol resources. www.iana.org)

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MIME – cont.

Sometimes the documentation writers must illustrate their concepts using examples. That's where MIME Example comes into play. Instead of referencing a real MIME type and causing confusion, they use MIME Example to make their point.

The following media subtypes are defined under the MIME Example type:

- application/example
- audio/example
- image/example
- message/example
- model/example
- multipart/example
- text/example
- video/example

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2.5 Other Applications

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Telnet

- **Allows one computer to log into another computer**
  - **Remote login enabling full control of the host**
- **Requires an application program on the client computer and a Telnet server program on the server**
  - **Client program emulates a "dumb" terminal off the server**
- **Most popular Telnet software is PuTTY**
  - **Open source**
  - **Uses SSH encryption for security**
- **Requires account name and password**

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Instant Messaging (IM)

- **A client-server program that allows real-time typed messages to be exchanged**
  - **Client needs an IM client software**
  - **Server needs an IM server package**
- **Some types allow voice and video packets to be sent**
- **Examples include AOL and ICQ**
- **Two step process:**
  - **Telling IM server that you are online**
  - **Chatting**

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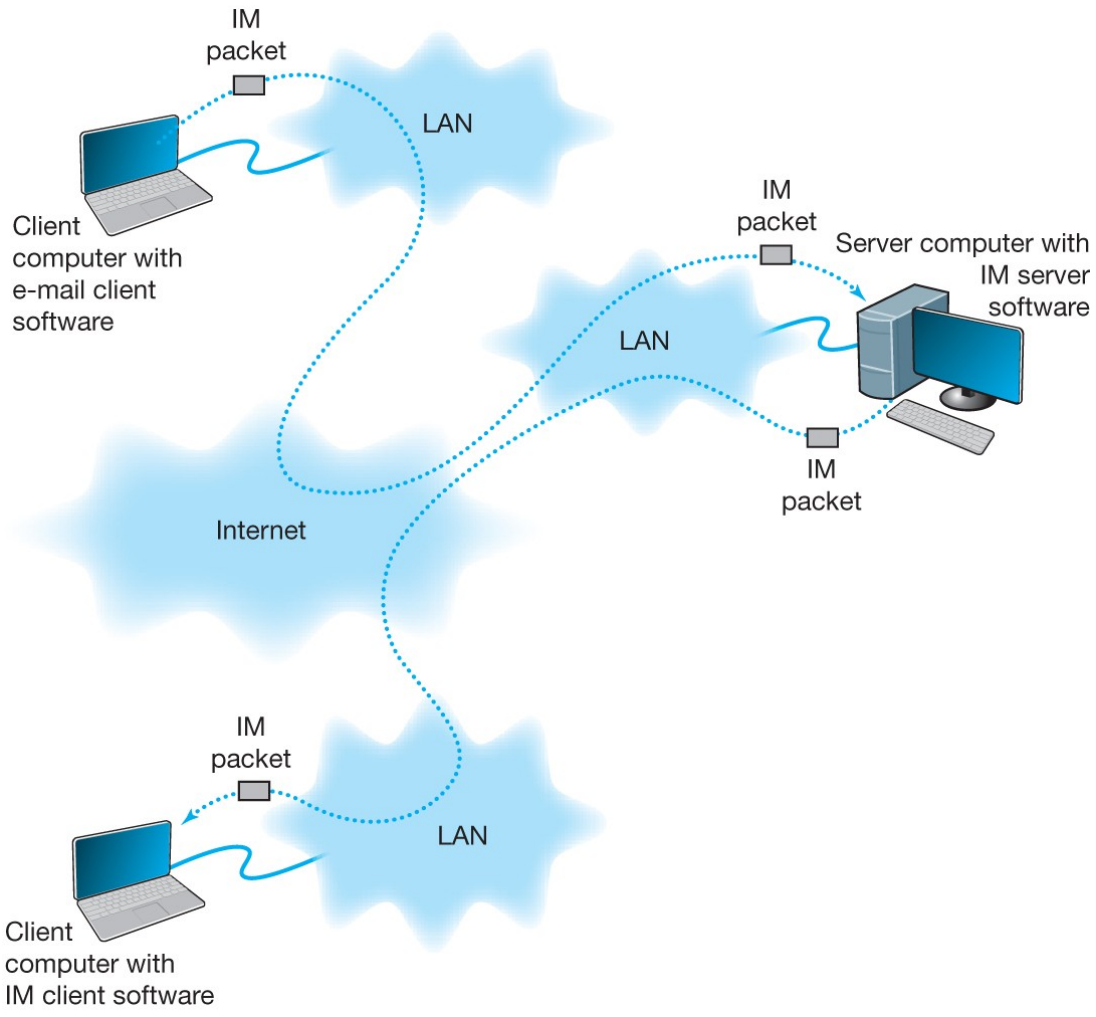
How Instant Messaging Works



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Videoconferencing

- **Provides real time transmission of video and audio signals between two or more locations**
  - **Allows people to meet at the same time in different locations**
  - **Saves money and time by not having to move people around**
  - **Typically involves matched special purpose rooms with cameras and displays**
- **Desktop videoconferencing**
  - **Low cost application linking small video cameras and microphones together over the Internet**
  - **No need for special rooms**
  - **Example: Net Meeting software on clients communicating through a common videoconference server**

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Cisco Videoconferencing



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Image courtesy of Cisco Systems, Inc.

Cisco Videoconferencing



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Image courtesy of Cisco Systems, Inc.

Videoconferencing Standards

- **Proprietary early systems**
- **Common standards in use today**
  - **H.320**
    - **Designed for room-to-room videoconferencing over high-speed phone lines**
  - **H.323**
    - **Family of standards designed for desktop videoconferencing and just simple audio conferencing over Internet**
  - **MPEG-2**
    - **Designed for faster connections such as LAN or privately owned WANs**

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Webcasting

- **Special type of uni-directional videoconferencing**
  - **Content is sent from the server to users**
- **Process**
  - **Content created by developer**
  - **Downloaded as needed by the user**
  - **Played by a plug-in to a Web browser**
- **No standards for webcasting yet**
  - **Defacto standards: products by RealNetworks**

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