

# Computer Networks CS555

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www.cs.wmich.edu/gupta/teaching/cs555/spring2005/  
Source: Guizani book, Kurose and Ross book, Internet

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## Chapter 2 Network Applications

### Learning objectives

- Basic understanding of Internet, Client / Server architecture, browsers and servers.
- HTML, Java, JavaScript, VBScript, PHP, Java servlet programming.
- Website Designing.
- Understanding of various protocols.

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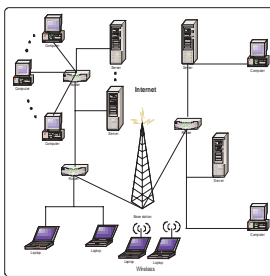
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## Internet

- Internet is an inter-network that has a worldwide collection of networks, routers, gateways, servers and clients, that uses a common set of protocols.
- WWW is an arena of documents that are linked to each other using hyperlinks
- The WWW is a system of Internet Servers through which several Internet protocols can be accessed using a user agent called a Browser
- W3C-World wide Web Consortium defines WWW as "The world wide web is the universe of network accessible information, an embodiment of human knowledge"



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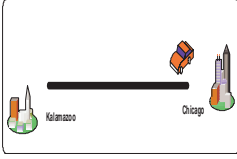
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### Analogy for WWW

- WWW is an information highway and the users use browsers to access different documents
  - cities : WWW documents
  - highway : WWW
  - car : browser
- Each city is identified using a unique zip code.
- Each web document in the Internet is uniquely identified using its address. These addresses are called *URL (Uniform Resource Locator)*. Browsers use this address to reach the particular web document.



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### URL-Uniform Resource Locator

PROTOCOL ://	HOSTNAME /	DIRECTORY PATH
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- A URL is used to give the address of any resource on the WWW.
- The Protocol can be any of the following, *http: hypertext transfer protocol, ftp: file transfer protocol, gopher: gopher protocol, mailto: electronic mail address, news: USENET News, telnet: Terminal emulation session, WAIS: Wide area information services*
- A host name is the name of the server where the resource resides, discussed in the next section.
- A directory path identifies the path of the directory in the server where the resource resides.

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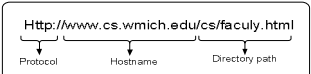
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### Example - URL

`Http://www.cs.wmich.edu/cs/faculy.html`



- In this example `http://` is the protocol part of the URL.
- `www.cs.wmich.edu` is the hostname where the web document resides.
- `cs/faculy.html` is the directory path where the html file resides.

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## Client/Server Architecture

```

    graph LR
      User[User] -- "Request  
http://www.ctmu.com" --> Server[Web server of CTMU]
      Server -- "Response  
Display the web page" --> User
  
```

- *Client*-The host that requests a service is called client
- *Server*-The host that services the request

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## Browsers & Cookies

- A *Browser* is a software application that allows users to navigate through the web, display web pages that consist of links, text, pictures, and other media
- Browsers can be roughly classified into two types:
  - Text Browsers
    - Render only text and ignore all images and multimedia elements
    - Example: Lynx
  - Graphical Browsers
    - Visual browsers-Render text, images, colors, graphs and other multimedia elements
    - Example: Microsoft Internet Explorer, Netscape, Mozilla, Mosaic and Opera
- *Cookies* are text only information generated by a web server that is stored in the user's computer, ready for future access
- Cookies undergo a two-stage process
  - First stage: The cookie is stored in the user's computer without their consent or knowledge
  - Second stage: The cookie is automatically transferred from the user's machine to the server

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## Servers

- A Server is a computer or device on a network that manages network resources
- A *web server* is a program that runs on a computer connected to the Internet
- Popular Web Servers are Apache web server, Microsoft Internet Information Server (IIS), and Netscape Enterprise Web Server.
- Need for Web server**
  - website development / deployment
  - Build an *Intranet*
    - Features of Intranet are:
      - Speed: Broad bandwidth
      - Security: Private internal network (LAN/WAN), is protected from Internet users by a firewall
      - Control: Enterprise network management to ensure reliability

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## Servers contd..

- **Application Server**
  - Application servers, a type of middleware occupying a large chunk of computing territory between database servers and the end user: often connect the two.
- **Mail Server**
  - Mail server is defined as a networked computer that is dedicated to support electronic mail
  - Users access mail messages through **mail agents**
  - Popular agents are **pine, Netscape Messenger, Outlook**, etc

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## Internet Discovery tools

- Search engine is a tool that enables users to locate information on the World Wide Web
- Types of search engines
  - **Crawler-Based Search Engines**
    - "crawl" or "spider" the web, then users search through what they have found –Example Google
  - **Human-Powered Directories**
    - A human-powered directory, such as the Open Directory, depends on humans for its listings. Users should submit a short description to the directory for entire site
  - "Hybrid Search Engines" Or Mixed Results
    - a hybrid search engine will favor one type of listings over another.

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## Search engines

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### Google

- Google is coined from a mathematical term called "Googol" which means "1 followed by 100 zeros"
- Technology used in Google
  - "PageRank" technology
  - "hypertext-matching" analysis

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### Google Contd..

- "PageRank" technology
  - PageRank interprets a link from Page A to Page B as a "vote" by Page A for Page B
  - PageRank assesses a page's importance by the number of votes it receives
- "hypertext-matching" analysis
  - Full content on each web page and factors in fonts, subdivisions, and the precise location of each word
  - Google also analyzes the content of neighboring web pages to ensure the results returned are the most relevant to a user's queries

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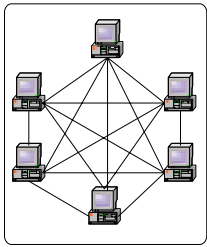
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### Peer to Peer Networking

- Peer-to-peer is a style of networking in which a group of computers communicate directly with each other, rather than through a central server



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## P2P applications

- A P2P application has a simple user interface runs outside of the browser and supports both file serving and downloads
- Kazaa
  - Kazaa is an extremely popular P2P system used for music, freeware and other file sharing over the Internet
  - The peer-to-peer searches occur through users with fast connections, called Super nodes. Once located, the file is sourced for downloading directly from the user who has it.
- Kazaa lite
  - Kazaa Lite is a spin-off of the Kazaa application. Kazaa Lite contains no ads, a built in privacy firewall called PeerGuardian, and other features intended to improve on the original Kazaa.

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## ISP and CGI

- **Internet Service Provider (ISP)** is a company that provides Internet connection to home and business customers. There are three levels of ISPs: National ISPs, Regional ISPs, and Retail ISPs.
- **Common Gateway Interface (CGI)** is a set of rules that describe how a web server communicates with another piece of software (CGI program) and vice versa

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## Markup Languages

A Sample HTML File - Hello World

```
<HTML>
<BODY>
Hello World!
</BODY>
</HTML>
```

- The Hyper Text Markup Language (HTML) is a widely used presentation protocol on the World Wide Web (WWW).
- '<' and '>' are tag delimiters.
- Every HTML page begins with a <HTML> tag and ends with a matching </HTML>.
- The <BODY> tag lets the browser that interprets this HTML knows that whatever follows below the tag until the matching closing tag of </HTML> encompasses the BODY of the page.
- HTML tags are not case sensitive.

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## More HTML tags

```

<HTML>
<BODY>
<imgsrc="/images/myimage.gif">
<BR> Above is an image
<br> <a
  href="http://www.yahoo.com">Visit
  Yahoo! </a>
</BODY>
</HTML>

```

```

<HTML>
<BODY>
<B>Hello World!</B><BR>
<CENTER> This text will be centered
</CENTER><BR>
<FONT FACE="Arial" SIZE="12px">
This text uses the Arial Font
</FONT>
</BODY>
</HTML>

```

- <IMG> - specify an image source.
- <A> - hyperlink tag
- <BR> - line break.
- <CENTER> - text enclosed in between will be centered
- <FONT> - font in which the text should be displayed.

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## More HTML tags

```

<table border=2>
<tr>
<td>Cell A</td>
<td>Cell B</td>
<td>Cell C</td>
</tr>
<tr>
<td>Cell D</td>
<td>Cell E</td>
<td>Cell F</td>
</tr>
</table>

```

```

<HTML>
<BODY>
<H1>This is heading1 </H1><br>
<H2>This is heading2 </H2><br>
<H3>This is heading3 </H3><br>
<HR> <!--Horizontal Rule -->
<h1 align="left"> This is left aligned text </H1>
<p> This is paragraph one </p>
<p> This is paragraph two </p>
<b> Bold Text </b><br>
<i> Italic Text </i><br>
<u> Underline </u><br>
</BODY>
</HTML>

```

- <TABLE> - Table tag  
border=n, n is the width of the border in pixels
- <TR> - Row
- <TD> - Cell
- Heading tags (H1, H2, H3)
- Horizontal rule tag (hr)
- Alignment tags (h1 align)
- Paragraph (P)
- Text formatting tags (B, I, U).

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## More HTML tags

```

<HTML>
<BODY>
<FORM METHOD=POST
ACTION="submitform.php">
Your Name: <input type="text"
name="mytextbox" size="10"><br>
Your Favorite Color: <br>
<input type="checkbox" name="favcolor"
value="red"> Apples<br>
<input type="checkbox" name="favcolor"
value="blue"> Oranges<br>
Your Favorite Color: <br>
<input type="radio" name="favcolor1"
value="red"> Red<br>
<input type="radio" name="favcolor1"
value="blue"> Blue<br>
<textarea name="body" cols="35"
rows="4"></textarea>
<input type="submit" name="submit">
</FORM>
</BODY>
</HTML>

```

- The name attribute tag specifies a unique identifier for the field.
- A scripting language can read the value in the field.
- The submit button is used to submit the values in the form.
- It must be noted that the <input> tags always appear within the <FORM> tag.
- The form tag specifies the method of submission, which can be either, POST or GET Name Attribute

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## XHTML

- XHTML-Combination of HTML and XML
- XML-Describe data / content
- HTML-Display data

```

<HTML>
<HEAD>
<TITLE> This is bad HTML</TITLE>
<BODY>
<h1>Bad HTML
</BODY>

```

- The code above works fine even if it doesn't follow the HTML tags

Example of XHTML Document

```

<!DOCTYPE html
PUBLIC "-//W3C//DTD XHTML 2.0
Strict/EN"
"http://www.w3.org/TR/xhtml1/DTD/x
html1-strict.dtd">
<html>
<head>
<title>simple document</title>
</head>
<body>
<p>a simple paragraph</p>
</body>
</html>

```

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## Java

```

graph LR
    A["Java program  
(byte code)"] --> B["Compiler  
(JDK)"]
    B --> C["Class file  
(byte code)"]
    C --> D["JVM  
(JRE)"]
    D --> E["OS  
(Windows, Linux, Mac OS)"]

```

- java object oriented
- Architecture independent
- java virtual machine (JVM)
- java data types
  - java is a strongly typed language
  - byte, short, int, long, float, double, boolean, char

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## A sample java code

```

Class Example {
/* This is a simple Java program
Example.java
*/
public static void main (String args [])
{
//Prints My first java program
System.out.println("My First Java
Program");
}
}

```

- Line 1: *Class Example* / Keyword *Class* - declare a new class. *Example* - identifier, the name of the class.
- Line 2: */\** - multi-line comment statement.
- Line 4: *\*/* - end of multi-line comment statement
- Line 5: *public static void main (String args[])* The keyword *static* -allows *main ()* to be called without having to instantiate a particular instance of the class. The key word *void* -"*main*" does not return any value. *String args []* - declares a parameter named *args*
- Line 6: *// Prints My first java program* Single line comment statement.
- Line 7: *System.out.println("My First Java Program");* *println()* - displays the string. *System* - predefined class. *Out* - output stream

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### Java operators and control structures

- Arithmetic operators  
+, -, \*, /, %, ++, --, +=, -=
- Logical operators  
~, &, ||
- Relational operators  
=, >, <, !=
- Bitwise operators  
<<, >>
- Control statements in java are similar to the control statements in C/C++  
if, switch, for, while, do, break, return, continue

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### Java classes and packages

- java.lang
- java.io
- java.net
- java.util
- java.applet
- java.awt

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### Java and the Internet

- Java has a technology that allows small programs known as "applets" to be embedded in web pages.
- Line 1 and Line 2 imports AWT (Abstract Window Toolkit) package and Applet package.
- Line 4 *paint()*- applet redisplay its output.
- Line 6 *drawString()*  
**Void drawstring(String Message, int x, int y)**  
In a Java window 0,0 refers to the upper left corner location.

An Applet Example

```
import java.awt.*;
import java.applet.*;
public class FirstApplet extends Applet{
    public void paint(Graphics g)
    {
        g.drawString("My First Applet",20,20);
    }
}
```

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### Java and the Internet (contd..)

```

<HTML>
<HEAD>My First
  Applet</HEAD>
<BODY>
<appletcode="First Applet"
  width=200 height=60>
</applet>
</BODY>
</HTML>
    
```

- Execution of applet: Web browser and HTML file with appropriate applet tag
- Width and height specify the dimensions of the display area used by the applet

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### Client side scripting

```

<html>
<body>
<script type="text/javascript">
document.write("My First
JavaScript!")
</script>
</body>
</html>
    
```

- Line 1: <html>
- Line 2: <body>
- Line 3: <script type="text/javascript">
- Indicates the scripting language used in the HTML page. Code follows is a JavaScript code.
- Line 4: document.write ("My First JavaScript")
- Write an output to the HTML page.
- Line 5: </script>
- To close script tag
- Line 6: </body>
- Line 7: </html>
- To close HTML tags

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### Client side scripting (Contd..)

```

<html>
<body>
<script type="text/vbscript">
dim st
st="My first VBScript that displays today's
Date and Time"
document.write(st)
document.write("<br />")
document.write("Date: " & date())
document.write("<br />")
document.write("Time: " & time())
</script>
</body>
</html>
    
```

- Line 1: <html>
- Line 2: <body>
- Line 3: <script type="text/vbscript">
- Indicates the scripting language used in the HTML page.
- Line 4: dim st
- Declares a variable st
- Line 5: st=" My first VBScript that displays today's Date and Time"
- Assigns a value to the variable
- Line 6: document.write (st)
- write an output to the HTML page .
- Line 7: document.write("<br />")
- Line 8: document.write ("Date: " & date())
- Line 9: document.write("<br />")
- Line 10: document.write("Time: " & time())
- Two built-in functions namely date() and time() that displays the current date and time.
- Line 11: </script>
- Line 12: </body>
- Line 13: </html>
- To close script and HTML tags.

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## Server side scripting

- Server side scripting languages run on the machine that is serving the website
- PHP, ASP, JSP and PERL are some of the server side scripting languages
- Advantage - you can hide the code from the users who are accessing the web page

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## PHP (Hypertext Preprocessor)

```

<?php
$title = "My First Script";
$greeting = "Welcome to my first
script.";
?>
<html>
<head>
<title><?php echo($title) ?></title>
</head>
<body>
<h1><?php echo($title) ?></h1>
<p><?php echo($greeting) ?></p>
</body>
</html>

```

- Line 1: <?php  
A PHP scripting block starts with <?php and ends with ?>
- Line 2: \$title = "My First Script";
- Line 3: \$greeting = "Welcome to my first script.";
- PHP variables start with a special character \$.
- Line 4: ?>  
This line is used to close the PHP tag
- Line 5: <html>
- Line 6: <head>
- Basic HTML tags.
- Line 7: <title><?php echo(\$title) ?></title>  
Displays the string "My First Script" in the title. echo is a basic output statement in PHP
- Line 8: </head>
- Line 9: <body>
- Basic HTML tags
- Line 10: <h1><?php echo(\$title) ?></h1>
- Line 11: <p><?php echo(\$greeting) ?></p>
- The above lines show how echo is used in different tags
- Line 12: </body> and Line 13: </html> close the body and html tags respectively.

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## Perl Scripting (Practical Extraction and Report Language)

```

#!/usr/bin/perl
$title = "My first Script";
$greeting = "Welcome to my first
script.";
print "Content-type: text/html\n\n";
print <<EOF;
<html>
<head>
<title>$title</title>
</head>
<body>
<h1>$title</h1>
<p>$greeting</p>
</body>
</html>
EOF

```

- Line 1: #!/usr/bin/perl  
Every Perl program starts with #!/usr/bin/perl. It tells the program where to find the Perl interpreter so that the script can run.
- Line 2: \$title = "My first Script";
- Line 3: \$greeting = "Welcome to my first script.";
- Lines 2 and Line 3 assigns values to the variables. Variables in Perl are always preceded by the \$ sign
- Line 4: print "Content-type: text/html\n\n";  
Line 4 tells the browser that the content will be in text/html and skips a line
- Line 5: print <<EOF;  
... EOF  
This print command tells the program to print the HTML code until it finds the word EOF. Line 6 to Line 14 act in the same way as in PHP scripting

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## JavaServlet

- A Servlet is a Java class
- Executed in a Java VM –Servlet engine
- The Servlet engine loads the Servlet class the first time the Servlet is requested, or optionally already when the Servlet engine is started
- The Servlet then stays loaded to handle multiple requests until it is explicitly unloaded or the Servlet engine is shut down.

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## JavaServlet

```

import java.io.*;
import javax.servlet.*;
public class
HelloServlet extends GenericServlet {
public void service (ServletRequest request,
ServletResponse response)
throws ServletException, IOException {
response.setContentType("text/html");
PrintWriter pw = response.getWriter();
this.MyContentHere(pw);
pw.close();
}
public void MyContentHere(PrintWriter pw) {
String title = "My First Script";
String greeting = "Welcome to my first script.";
pw.println("<html>");
pw.println("<head>");
pw.println("<title>" + title + "</title>");
pw.println("</head>");
pw.println("<body>");
pw.println("<h1>" + title + "</h1>");
pw.println("<p>" + greeting + "</p>");
pw.println("</body>");
pw.println("</html>");
}

```

•Line 1: import java.io.\*;  
 •Line 2: import javax.servlet.\*;  
 These lines import io and servlet package that contains classes and methods necessary for the execution of servlets.  
 •Line 3: public class HelloServlet extends GenericServlet {  
 This line declares the class HelloServlet that extends GenericServlet class  
 •Line 4: public void service (ServletRequest request,ServletResponse response) throws ServletException, IOException {  
 Service() method is responsible for handling requests made to the Servlet  
 •Line 5: response.setContentType("text/html");  
 This method sets the Content-Type header to the "text/html" MIME type, which tells the Web browser to expect an HTML Web page  
 •Line 6: PrintWriter pw = response.getWriter();  
 The standard Java I/O class for outputting plain text data is java.io.PrintWriter.  
 •Line 7: this.MyContentHere(pw);  
 This line calls a user defined function called MyContentHere() which accepts an argument of type PrintWriter

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## JavaServlet

- Line 1: import java.io.\*;
- Line 2: import javax.servlet.\*;
- Line 3: public class HelloServlet extends GenericServlet {
- Line 4: public void service (ServletRequest request,ServletResponse response) throws ServletException, IOException {
- Line 5: response.setContentType("text/html");
- Line 6: PrintWriter pw = response.getWriter();
- Line 7: this.MyContentHere(pw);

These lines import io and servlet package that contains classes and methods necessary for the execution of servlets.  
 This line declares the class HelloServlet that extends GenericServlet class  
 Service() method is responsible for handling requests made to the Servlet  
 This method sets the Content-Type header to the "text/html" MIME type, which tells the Web browser to expect an HTML Web page  
 The standard Java I/O class for outputting plain text data is java.io.PrintWriter.  
 This line calls a user defined function called MyContentHere() which accepts an argument of type PrintWriter

we can output lines of text to the Web browser with the println method of our pw object as shown in the following lines

```

pw.println("<html>");
pw.println("<head>");
pw.println("<title>" + title + "</title>");
pw.println("</head>");
pw.println("<body>");
pw.println("<h1>" + title + "</h1>");
pw.println("<p>" + greeting + "</p>");
pw.println("</body>");
pw.println("</html>");

```

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## Development Tools

- Allows users to develop WebPages without knowledge of HTML
- Web authoring software generate the markup languages in the background while the novice user can concentrate on the layout of the page

Some development tools....

- Netscape composer
- Microsoft Frontage
- Macromedia Dreamweaver

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## Development Tools

- Netscape composer
  - Tool that is used to create HTML based documents
  - Uses fonts, styles, paragraphs, and lists, and includes an integrated spelling checker
- Microsoft FrontPage
  - A product of Microsoft that helps in designing, building and maintaining websites
  - A user-friendly and relatively powerful WYSIWYG webpage editor
- Macromedia Dreamweaver
  - Fully-featured professional web development tool
  - HTML code editing, advanced table editing, site management tools, built in FTP client, support for animation, DHTML and third-party tags, including ASP, Apache, Cold Fusion, Tango, and many others

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## Protocols

- Established ways of transferring information
- Provides
  - Formulas for passing messages
  - Specify the details of message formats
  - Describe how to handle error conditions

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## HTTP

- Hyper Text Transfer Protocol
- Web clients communicate with web server using HTTP protocol
- HTTP is based on a Request/Response Model
- HTTP uses a TCP connection through well-known port 80
- HTTP - a stateless protocol

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## HTTP contd..

- HTTP Client side communication  
GET /myfile.htm HTTP/1.0  
  \r\n
- HTTP Server side communication  
HTTP/1.0 200 OK  
Date: Wed, 18 Sep 1996 20:18:59 GMT  
Server: Apache/1.0.0  
Content-type: text/html  
Content-length: 1579  
Last-modified: Mon, 22 Jul 1996 22:23:34 GMT

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## HTTP contd..

- HTTP/1.0 uses non-persistent connections
  - each time a TCP connection is opened and closed for an object
- HTTP/1.1 uses persistent connections
  - The server leaves the TCP connection open after sending the response.
  - Subsequent requests and responses between the same client and same server can be sent over the same connection

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## HTTP Message format

- Request message

method	sp	URL	sp	Version	cr	lf	Request line
Header field name		value	cr	lf	Header lines		
Header field name		value	cr	lf			
cr	lf	Entity body					

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## HTTP Message format

- Response Message

version	sp	Status code	sp	phrase	cr	lf	Status line
Header field name		value	cr	lf	Header lines		
Header field name		value	cr	lf			
cr	lf	Entity body					

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## FTP

- FTP is an acronym for File Transfer Protocol.
- A protocol for transferring files over the network from one computer to another
- The well-known port 20 is used for the data connection and well-known port 21 is used for the control connection

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### FTP contd..

The diagram illustrates the FTP architecture. On the client side (labeled 'CLIENT'), there are three components: 'USER INTERFACE', 'CONTROL PROCESS', and 'DATA TRANSFER PROCESS'. On the server side (labeled 'SERVER'), there are two components: 'CONTROL PROCESS' and 'DATA TRANSFER PROCESS'. A 'CONTROL CONNECTION (PORT 20)' connects the client's control process to the server's control process. A 'DATA CONNECTION (PORT 21)' connects the client's data transfer process to the server's data transfer process. Bidirectional arrows indicate communication between the client and server components.

- FTP uses two parallel TCP connections
  - control connection and data connection to transfer a file
- The client side consists of a client user interface, a control process, and a data transfer process
- The server side consists of a server control process and a server data transfer process

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### FTP contd..

- The three basic files
  - ASCII (American Standard Code for Information Interchange) file
  - EBCDIC (Extended Binary Coded Decimal Interchange Code) file
  - Image File
- An FTP address looks like a HTTP address, or website address except it uses the prefix ftp:// instead of http://
  - Example: ftp://ftp.FTPplanet.com
- FTP Client software
  - WS\_FTP Pro is Windows-based FTP client software
  - "Fetch" is the FTP client software used in the Macintosh systems
- Anonymous FTP
  - Anonymous FTP allows users to have access on files of a remote host without having an account on that machine.
  - The username for anonymous FTP is "anonymous" and the password is the user's email address.

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### TFTP

- TFTP (**T**rivial **F**ile **T**ransfer **P**rotocol) is a very simple protocol for transferring files
- Lacks most features of FTP
- Allows users to read and write files from remote host to local machine and vice versa
- uses UDP as its underlying protocol and operates on a well-known port 69

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### TFTP Messages

- Five different types of TFTP messages
  - RRO: Read Request
  - WRQ: Write Request
  - DATA
  - ACK: Acknowledgement
  - ERROR

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### TELNET

- TELNET is an acronym for Terminal Network
- A text-only protocol that allows users to connect to a remote computer and use programs and data as if the users were sitting in front of the computer
- TELNET uses the TCP connection and the server uses a well-known port 23 for communication

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### Architecture of TELNET

```
graph LR; Terminal[Terminal] <--> TelnetClient[Telnet Client]; TelnetClient <--> Internet((Internet)); Internet <--> TelnetServer[Telnet server];
```

- A user sends a bunch of keystrokes to a terminal driver in his/her local operating system
- The characters are sent to a telnet client which transforms the characters to a universal character set called Network Virtual Terminal (NVT) characters and delivers them to the local TCP/IP stack
- These NVT characters travel through the Internet and arrive at the TCP/IP stack of the remote machine and given to telnet server which converts the character to an understandable form by the remote computer

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## TELNET contd..

- Modes of operations
  - Telnet implementations operate in three different modes
    - Default mode
    - Character mode
    - Line mode
- Client software
  - Typical GUI applications for Telnet include: TeraTerm and EWAN for Windows and NCSA Telnet for the Macintosh

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## Rlogin

- **Rlogin** is a remote login protocol provided by the BSD UNIX
- The “rlogin” protocol requires the use of TCP
- The contact port is 513
- Rlogin performs remote connections and terminal emulations between two UNIX machines
- Rlogin uses only one TCP connection – special character FF base 16 is used to distinguish between the data and command

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## SNMP

- Simple Network Management Protocol (SNMP) is protocol that facilitates the exchange of management information between network devices
- SNMP uses UDP (User Datagram Protocol) as its underlying protocol on two well-known ports 161 and 162
- Versions of SNMP are
  - SNMPv1
  - SNMPv2c
  - SNMPv3

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### Architecture of SNMP

```

    graph TD
      NMS[NMS] --- M1[Agent]
      NMS --- M2[Agent]
      NMS --- M3[Agent]
      M1 --- MB1[Management base]
      M2 --- MB2[Management base]
      M3 --- MB3[Management base]
      MB1 --- MB2
      MB2 --- MB3
  
```

- **Network device:** A network device or the “Managed Object” is a network component that requires some form of monitoring and management.
- **Agent:** An agent is a mediator between the manager and the device
- **Manager:** A manager or management system is a separate entity that manages the agents from a remote place

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### Components of SNMP

- **The protocol-** defines the functioning of the basic operations of SNMP
- **Structure of Management Information (SMI)-** a set of rules used to specify the format for defining managed objects or the devices that are accessed using SNMP
- **Management Information Base (MIB)-** a collection of definitions, which define the properties of the managed object or the device

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### SNMP contd..

- Basic operations
  - Retrieving data
  - Altering variables
  - Receiving unsolicited messages
- SNMP tools
  - “WhatsUP”
  - CiscoWorks Simple network management solution (SNMS)

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### DNS (Domain name Service)

- Domain Name Service (DNS) provides the translation between hostname and IP address.
- DNS uses the UDP protocol and port 53
- Domain name space (tree) is divided into three different sections. generic domains, country domains and inverse domains

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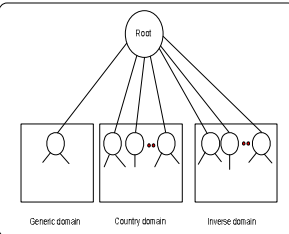
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### DNS contd..



- Generic domains define registered hosts according to their generic behavior
  - com- Commercial organization
  - edu-Educational institutions
  - gov-Government institutions
  - int-International organization
  - mil-Military groups
  - net-Network support centers
  - org-Nonprofit organizations
- Country domains uses two character country abbreviations
  - us for United States
  - in for India
- The inverse domain is used to map an address to a name

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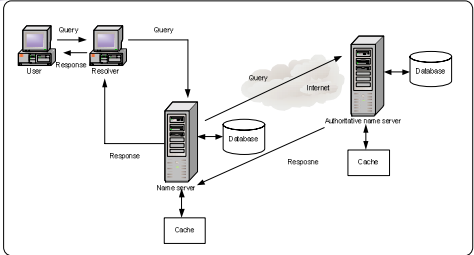
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### How does DNS works?



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## DNS Records

- DNS records are stored as RR records (resource records)
- RR fields- Name, Value, Type, and TTL
- type=A - name is a hostname and the value is the IP address of the hostname
- type=NS - value contained is a name server
- type=CNAME- value is an alias for a hostname

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## DNS Message format

Identification	Flags	
Number of questions records	Number of answer records	↑ 12 bytes ↓
Number of authoritative records	Number of Additional records	
Questions (Variable number of questions)		Name, type fields for a query
Answers (Variable number of resource records)		RRs in response to query
Authority (Variable number of resource records)		Records for authoritative servers
Additional Information (Variable number of resource records)		Additional "helpful" information

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## SMTP

```

    graph LR
        User[USER] <--> Client[SMTP CLIENT]
        FS1[FILE SYSTEM] <--> Client
        Client -- "SMTP COMMANDS, REPLIES and MAIL" --> Server[SMTP SERVER]
        Server <--> FS2[FILE SYSTEM]
    
```

- Simple Mail Transfer Protocol (SMTP), documented in RFC 821, is Internet's standard host-to-host mail transport protocol and traditionally operates over TCP, port 25
- SMTP uses a style of asymmetric request-response protocol

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### How does SMTP works?

- Client SMTP (running on sending mail server host) has to establish a TCP connection on port 25 to the Server SMTP (running on the receiving mail server host).
- Once the TCP connection is established, the client and server perform some application level handshaking.
  - Handshaking phase,
    - SMTP client indicates the email address of the sender and the receiver.
    - After the handshaking phase, the client sends the message.
    - The client uses TCP, a reliable protocol to send the message to the server without any error.
- When the session gets completed, the client closes its connection.

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### Example SMTP Session

```
Client:HELO mymachine
Server:250 - Pleased to meet you mymachine
Client:MAIL FROM: sender@wmich.edu
Server:250 - Sender OK
Client:RCPT TO: webmaster@wmich.edu
Server:250 - Recipient OK
Client:DATA
Client:Subject: This is a test message
Client:Hello, this is a test
Server:250 Message Accepted for delivery
Client:quit
Server:Closing connection
```

- MAIL command - sender identification.
- RCPT commands follows giving the receiver information.
- DATA command gives the mail data.
- The end of the mail data indicator confirms the transaction

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### Mail Message Formats

- SMTP is designed to carry text messages using 7-bit ASCII codes
- MIME is an acronym for **M**ultipurpose **I**nternet **M**ail **E**xtensions
- MIME provides a way for non-text information to be encoded as text.
- This encoding is known as base 64

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## MIME

- MIME Header

```
MIME-VERSION:1.0
From:Webmaster@wmihc.edu
To:Webmaster@cmich.edu
Subject:ApplicationLayer Slides
Content-
type:multipart/mixed;boundary=gc0p4ya2s4m2p3
v9ui
```

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## MIME

- Seven MIME types
  - **Text:** Contains textual information either formatted or unformatted.
  - **Image:** Contains image data. Examples for image types are JPEG, GIF, etc.
  - **Audio:** Contains audio information that requires an audio output device.
  - **Video:** Contains video information that needs hardware/software to display video images.
  - **Application:** Contains uninterpreted binary data particular for specific applications.
  - **Multipart:** Contains at least two different entities using independent data types.
  - **Message:** Contains encapsulated messages

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## Mail Access Protocols

- SMTP delivers messages from sender Mail Server to Receiver Mail Server
- Mail access protocols
  - POP3
  - IMAP

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## POP3

```

    graph LR
      Client[Client] --- SMTP1[SMTP Server]
      SMTP1 --- SMTP2[SMTP Server]
      SMTP2 --- receiver[receiver]
      POP3[POP3] --- SMTP2
    
```

- The Post Office Protocol 3 (POP3) is a standard protocol for retrieving e-mail
- The client opens a TCP connection to the mail server on port 110
- The POP3 protocol has three states, authentication, transaction, and update

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## POP3 contd..

- Authentication phase
  - The client sends the username, password, and authenticates itself to the POP3 Server
  - POP3 Server acquires an exclusive lock on the Mail drop to prevent messages from being modified or removed before the session enters the update state
- Transaction phase
  - The client retrieves the messages from the server and client can mark and unmark the messages for deleting
- Update phase
  - The mail server deletes the messages marked for deletion and closes the connection with the client

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## IMAP

- IMAP (Internet Message Access Protocol) is a method of accessing electronic mail or bulletin board messages that are kept on a (possibly shared) mail server
- POP3, a message is downloaded locally on the client's computer and will not be available on a different computer
- IMAP provides a mechanism to store messages remotely in folders which can be accessed from anywhere with an IMAP client

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 **IMAP contd..**

- Non authenticated state
  - The client specifies the username and password
- Authenticated state
  - The client must select a mailbox to access before sending commands that affects messages
- Selected state
  - Mailbox is selected and the client can issue commands that affect a particular message during this state
- Logout state
  - The Client Server session is terminated

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