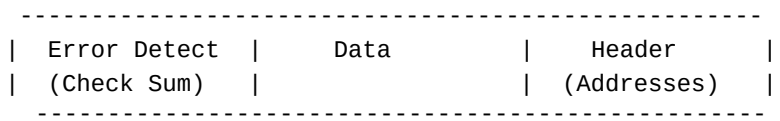
The Internet: Networking with Stream-based Sockets

The Internet

- A Global Network of Networks
- ARPANet: SRI, Utah, UCLA, UCSB, (1969)
  - Defense Dept. Advanced Research Projects Agency (DARPA)
  - Stanford Research Institute (Doug Engelbart)
  - Designed to survive bomb attacks
  - Distributed control, Expandable
- Ethernet
  - Global standard for interconnecting computers
  - Xerox PARC (Early 70s)
  - Client/Server architecture
- Exponential Growth
  - Tens of Millions of Computers
  - Hundreds of millions of Users

The Internet

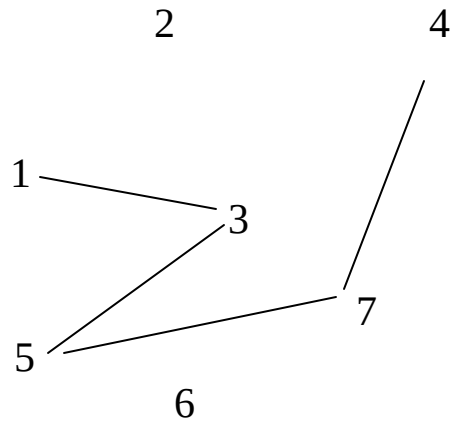
- A Packet Switched Network
  - Like Postal System
  - Messages broken up into packets (like envelopes)



Computer Node Addresses:

- IP (Internet Protocol)
  - 32 bit numeric address in four 8-bit fields:
  - 128.226.6.4 (bingsuns IP Address)
    | |
    network computer
    (city/state) (street/number) <-- postal analogy
  - Called the IP Address
- TCP (Transmission Control Protocol):
- Send Site: Breaks message into packets
- Receive Site: Collects & Reassembles packets in proper order

“Best” path between computers is chosen using Routers



Domain Names

- Synonyms for IP Addresses
- bingsuns.binghamton.edu

individual machine	largest domain

  – Synonym for 128.226.6.4
- Internet Domain Name Server (DNS) software maps domain names to IP addresses

Common High-Level Domain Names

- com: commercial
- edu: educational
- gov: government
- mil: military
- org: other organization
- net: network resources
- --: country name
  - e.g., ca = Canada

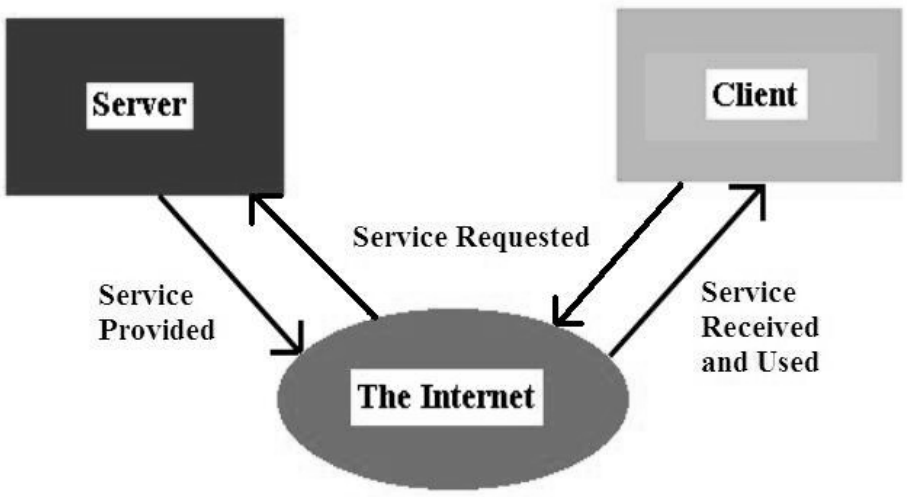
The .NET Dns Class

- In System.Net namespace
- **Dns**: a class that has methods that retrieve information about a specific host from the Domain Name Server
  - Dns.GetHostByName(string hostName) and Dns.GetHostByAddress(string hostIPaddress) static methods
  - Both return an IPHostEntry object containing host information
    - For GetHostByName(hostName) it gives access to the IP address(es) corresponding to the DNS name specified in *hostName*
      - That object's AddressList property can be used to set up an array of IPaddresses that correspond to the hostname
    - For GetHostByAddress(hostIPaddr) it gives access to domain name/aliases for the specified IP address
      - That object's Aliases property is an array of domain names
  - See GetIPAddress example program

Networking Software

- Client/Server Model
  - Client Program -- seeks a service from remote computer
  - Server Program -- provides a service to a client running on a remote computer
  - Computers are usually connected over a network
  - Examples
    - Print Server
    - File Server
    - Information Server

Client/Server Model



Information Servers

- Program handles requests for information
- Some examples
  - e-mail: electronic mail service
  - telnet/Rlogin/SSH: remote logon services
  - ftp/SSH: file transfer service
  - Some older text-based information servers:
    - gopher: net browsing service (text based)
    - archie/veronica: automated net search services
    - WAIS: automated file content search service
    - Net News: network bulletin board service
  - WWW: hypermedia access to internet (Web page service)

Network Communication Between Computers

- Applications running on different computers can communicate with each other
  - Server Application: Waits for other applications on other computers to open a communication connection
  - Client Application: Attempts to open a connection
- When connection is established, data can be exchanged
- Either can close the communication
- Connections:
  - Two programs running on different computers that are communicating with each other form a connection
  - Data is sent and received along the connection

Network Socket Stream

- Basic object used to perform network communication
- Used to read/write messages going between apps
  - (Like a file stream in file I/O)
- A Socket is a communication "endpoint“
  - There's a socket at each end of the connection
- Windows support for sockets: in the Winsock API
  - MFC encapsulates this in the CAsyncSocket base class
    - Provides complete, event-driven socket communications
    - Lowest level support -- Notes at: www.cs.binghamton.edu/~reckert/360/17b_sockets_f03.html
    - Higher level support from derived classes like CSocket
- .NET encapsulates socket support in:
  - System.Net.Sockets namespace
  - With .NET sockets, networking is viewed like file I/O
    - Read from /write to a socket stream as easily as from/to a file stream

Making a Socket Connection to a Process Running on Another Computer

- Specify the IP Address of computer where the other application is running
  - Identifies a machine
- Also specify the Port the application is listening on
  - Identifies the program that should handle the communication
    - e.g. port 80 is reserved for web document transfer
- IP Address/Port are like number/extension in telephone communication
  - Port can be any number from 0 to 65535
    - Numbers 0 to 1023 may be used by the operating system
    - So use numbers greater than 1023

Details of Establishing a Simple Server (Using TCP/IP Network Socket Streams)

1. Create a TcpListener class object
   - TcpListener myListener = new TcpListener(5000);
     - Parameter: port # to bind the Server to on the machine it's running on
2. Call TcpListener object's Start( ) method to start listening for connection requests
   - myListener.Start( );
3. Use TcpListener's AcceptSocket( ) to accept an incoming request and establish the connection
   - Socket myConnection = myListener.AcceptSocket( );
     - Returns a Socket object
       - » Socket object will be null if connection was not made
       - » Its Connected property will be true after socket is connected
4. Create a NetworkStream associated with the socket
   - NetworkStream myNetStream = new NetworkStream(myConnection);
     - This will be used to do the reading and writing as in File I/O

Using the Server Network Stream Connection

5. Create BinaryReader and BinaryWriter objects for transferring data across the network stream

```
BinaryWriter myWriter = new BinaryWriter(myNetStream);
BinaryReader myReader = new BinaryReader(myNetStream);
```

6. Use BinaryReader/BinaryWriter methods to read/write data, e.g.:

```
string receiveStr, sendStr;
receiveStr = myReader.ReadString( );
```

   - Reads a line of text from the network stream (sent by the Client)

```
myWriter.Write(sendStr);
```

   - Writes the specified string to the network stream (to the Client)

7. When done, close readers, writers, network stream, and connection socket

```
myReader.Close( );   myWriter.Close( );
myNetStream.Close( );   myConnection.Close( );
```

Details of Establishing a Simple Client (Using Network Streams)

1. Create a TcpClient class object

```
TcpClient myClient = new TcpClient( );
```

2. Try to connect to a Server
   - Call Client object's Connect(IP address, port) method
     - Specify IP address (or domain name) of machine Server is running on and Server's port number in the two parameters
     - If successful, an underlying socket will be created for communications and a positive integer is returned
     - Will throw an exception if no Server is available at that address & port

```
myClient.Connect("localhost", 5000);
```

     - "localhost" = "loopback" = 127.0.0.1 means same machine as server

3. Get a NetworkStream associated with the TcpClient

```
NetworkStream myNetStream = myClient.GetStream( );
```

   - This will be used to do the reading and writing as in File I/O
   - An underlying socket will be created

Using the Client Network Stream Connection

4. Create BinaryReader and BinaryWriter objects for transferring data across the network stream

```
BinaryWriter myWriter = new BinaryWriter(myNetStream);
BinaryReader myReader = new BinaryReader(myNetStream);
```

5. Use BinaryReader/BinaryWriter objects to read/write data

```
string receiveStr, sendStr;
receiveStr = myReader.ReadString( );
```

   - Reads a line of text from the network stream (sent by the Server)

```
myWriter.Write(sendStr);
```

   - Writes the specified string to the network stream (to the Server)

6. When done, close readers, writers, network stream, and TCP Client

```
myReader.Close( );   myWriter.Close( );
myNetStream.Close( );   myClient.Close( );
```

Using Threads with Sockets

- Whenever we try to establish and use a connection, the thread we do it in blocks until the connection is established
  - Blocking also takes place when reading or writing data
- To avoid the entire application from freezing, run this code in a separate thread

A Network Chat Client/Server System

- A Server and a Client Application
  - See Chapter 23 in your Deitel text book
- ChatServer application waits for a Client application to connect to a specified port on its computer
- ChatClient application attempts to connect to that port on that machine
- Both ChatServer and ChatClient have a single-line "input" text box and a multi-line "display" text box
- When a connection is established, either can type text in its input text box and the text will appear in the other's display text box when user hits <Enter> key
- The communication is done through network streams

ChatServer Application

- Form's constructor starts a new thread to accept Client connections
  - Thread's RunServer( ) method does the work (executes when thread starts)
  - Creates and starts a TcpListener on port 5000
  - Listens for a connection attempt from a Client
    - Connection is made (socket obtained) with listener's AcceptSocket() method
    - Uses new socket's NetWorkStream( ) method to get a network stream
    - Creates binary reader & writer to read/write data over the network stream connection
    - Enters into a do/while loop that continually uses the binary reader to read a string from the network stream
      - Any string read is added to the text displayed in the "display" text box
      - Do/While loop continues until the socket is disconnected or a ">>CLIENT TERMINATE" string is received
    - After do/while loop exits, the reader, writer, network stream, and socket are closed
- Input text box's KeyDown handler:
  - Writes the text in the input text box to the network stream using its binary writer whenever the user types <Enter> as long as the connection is valid
    - If the text entered is "TERMINATE", closes the connection socket
- An event handler for the form's "Closing" event is added
  - Calls System.Environment.Exit(System.Environment.ExitCode) to close the app
    - Exit( ) method of Environment class closes all threads associated with the app

ChatClient Application

- Same overall structure as the ChatServer
- Form's constructor starts a new thread to connect to the Server
  - Thread's RunServer( ) method does the work
    - Instantiates a TcpClient and run its Connect("localhost", 5000) method
      - Connects to the Server on the same machine
      - This call blocks until connection request is accepted
    - Uses TcpClient's GetStream( ) method to create a network stream
    - Creates a binary reader and a binary writer to read/write data over the network stream connection
    - Enters into a do/while loop that continually uses the binary reader to read a string from the network stream and display it in the form's "Display" text box
    - After do/while loop exits, the reader, writer, NetWorkStream, and TcpClient are all closed and application is closed using the Application.Exit( ) method
- Input text box's KeyDown handler
  - Write the text in the input box to the network stream using its binary writer as in the ChatServer application
- For both the Server and the Client, it would be much better to use Try/Catch blocks