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)

```
 ---------------------------------------------------
|  Error Detect  |      Data        |    Header      |
|  (Check Sum)   |                  |  (Addresses)   |
  ---------------------------------------------------
```

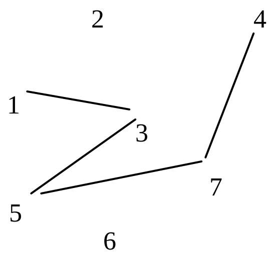
Computer Node Addresses:

- 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)
```

- TCP (Transmission Control Protocol):
- Send Site: Breaks message into packets
- Receive Site: Collects & Reassembles packets in proper order

"Best" routing is chosen using Routers



Domain Names

- Synonyms for IP Addresses
- bingsuns.binghamton.edu

```
      |                  |
  individual          largest
  machine             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

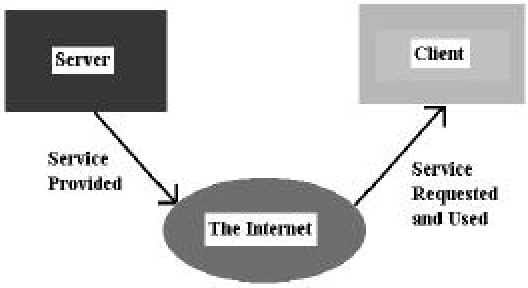
The .NET Dns Class

- In System.Net namespace
- **Dns**: a static class that retrieves information about a specific host from the DNS
  - Info returned in an instance of the IPHostEntry class
  - If the specified host has more than one entry in the DNS database, IPHostEntry contains multiple IP addresses and aliases
  - Dns.GetHostByName(string hostName) method
    - Returns an IPHostEntry object containing host information for the address specified in *hostName*
    - That object's AddressList property can be used to set up an array of IPaddresses that corresponds to the hostnames
- 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 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: remote logon service
  - ftp: file transfer service
  - 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)

Telnet Client

- A remote logon client
- You need an account on remote machine
- Starting Windows Telnet client (from command prompt):

  telnet
  - You'll be prompted for a domain name or IP address
  - Then can look at commands by entering 'help'
- Another way of starting telnet:

  telnet domain-name or IP-address
    - You provide logon ID & password
    - Starts a session with the remote machine
- Also available in BU's BUICK Suite

FTP--File Transfer Protocol

- Many "anonymous" ftp servers
  - provide access to public or password-protected files
  - Usually used to transfer files between computers
- Starting Windows ftp client (from DOS command prompt):

```
ftp  domain-name or IP-address
```

- Response:

```
ftp> User:
Ftp> Password:
```

- Getting help:

```
ftp> help
```

- WS_FTP GUI version available in BU's BUICK Suite

Network Communication Between Computers

•Applications running on different computers can communicate with each other

–Server App: Waits for other apps on other computers to open a communication connection

–Client App: 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

Socket Stream

- Basic object used to perform network communication
- Used to read/write messages going between applications
  - (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 sockets, networking is viewed like file I/O
    - Read from or write to a socket connection as easily as to a file

Making a Socket Connection to a Process Running on Another Computer

- Specify the IP Address of computer where 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
  - Like telephone communication: (Dial number and extension)
  - Can be any number from 0 to 65535
    - But numbers 0 to 1023 may be used by the operating system
    - So use numbers greater than 1023

Details of Establishing a Simple Server (Using Socket Streams)

1. Create a TcpListener class object
   - TcpListener myListener= new TcpListener(5000);
     - Parameter is port number to which to bind the server on the machine it's running on
2. Call TcpListener object's Start( ) method
   - myListener.Start( );
     - Waits indefinitely (listens on specified port) for connection requests
3. Use TcpListener's AcceptSocket( ) to make connection between server and client when request is received
   - Socket myConnection = myListener.AcceptSocket( );
     - Blocks until connection is attempted and then 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 Socket Stream Connection

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

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

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

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

   – Reads a line of text from the stream (sent by the client)

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

   – Writes the string to the 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 Socket Streams)

1. Create a TcpClient class object

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

2. Try to connect to a server
   - Call 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

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

     - "localhost" = "loopback" = 127.0.0.1 means same machine as server
     - Will throw an exception if no Server available

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

Using the Client Socket Stream Connection

4. Create BinaryReader and BinaryWriter objects for transferring data across the 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 stream (sent by the server)

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

   - Writes the string to the 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 Sections 19.1-19.4 in your Deitel text book
  - Also the ChatServer and ChatClient example program code on the CS-360 Sample Programs web pages
- 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
- The communication is done through socket 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 socket's NetWorkStream( ) method to get a socket stream
    - Creates binary reader and writer to read/write data over the socket stream connection
    - Enters into a do/while loop that continually uses the binary reader to read a string from the socket 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 socket 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 get a socket stream
    - Creates a binary reader and a binary writer to read/write data over the socket stream connection
    - Enters into a do/while loop that continually uses the binary reader to read a string from the socket 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 app is closed using the Application.Exit( ) method
- Input text box's KeyDown handler
  - Write the text in the input box to the socket stream using its binary writer as in the ChatServer app
- For both the server and the client, it would be much better to use Try/Catch blocks, as in the examples on the website