Preliminaries II
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Agenda

• Homework #1
  - HTTP basics
  - Windows sockets
HTTP Basics

- General URL format:
  - Optional elements shown in square brackets
    
    \[scheme://[user:pass@]host[:port][/path][?query][#fragment]\]

- No need to parse username/password in this homework, but you must strip off the fragment and extract the port number from the host
  - If the path is not present, must use root “/” in its place

- HTTP request is [/path][?query]

<table>
<thead>
<tr>
<th>URL</th>
<th>Request</th>
</tr>
</thead>
<tbody>
<tr>
<td><a href="http://google.com">http://google.com</a></td>
<td>/</td>
</tr>
<tr>
<td><a href="http://tamu.edu?test=1/blah">http://tamu.edu?test=1/blah</a></td>
<td>/?test=1/blah</td>
</tr>
<tr>
<td><a href="http://tamu.edu?tes:t=1/blah">http://tamu.edu?tes:t=1/blah</a></td>
<td>/?tes:t=1/blah</td>
</tr>
</tbody>
</table>
HTTP Basics 2

• HTTP request
  - Begins with the **method** line, followed by (field: value) pairs
  - Ends with an empty line

• Methods in hw1
  - GET and HEAD, same syntax

• HTTP responses
  - Status line begins with HTTP/
  - Status codes are 3-digit integers

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**minimal request**

```
METHOD request HTTP/version\r\n\r\n```

**GET /courses/ HTTP/1.0\r\nHost: irl.cs.tamu.edu\r\nConnection: close\r\n\r\n**

```
GET /courses/ HTTP/1.0
Host: irl.cs.tamu.edu
Connection: close
\r\n```

**HTTP/1.0 200 OK\r\nCache-Control: private\r\nContent-Type: text/html\r\nServer: Microsoft-IIS/7.0\r\nX-Powered-By: ASP.NET\r\nMicrosoftOfficeWebServer: 5.0_Pub\nMS-Author-Via: MS-FP/4.0\nDate: Thu, 17 Jan 2013 09:22:34 GMT\r\nConnection: close\nContent-Length: 16367\r\n\r
```html
<head>
<meta http-equiv="Content-Language" content="en-us">
<meta http-equiv="Content-Type" content="text/html; charset=windows-1252">
...```

---

**status line**

**HTTP header**

**empty line**

**object**
Agenda

- Homework #1
  - HTTP basics
  - Windows Sockets
Windows Sockets

• Sockets are interfaces to the TCP/IP protocol stack
  - More on TCP and IP later in the semester
  - HTTP (hw1) uses TCP
  - Sockets identified by their handle

• Communication using sockets is accomplished by a set of system calls to **Winsock**
  - Winsock is the Windows implementation of sockets
  - Parts are identical to Berkeley sockets on Unix

• TCP sockets can be used in two modes:
  - Client (socket actively establishes outgoing connections)
  - Server (socket listens for incoming connections)
Windows Sockets 2

• **IP address**: uniquely identifies the host to be contacted
  - 4-byte number written with a dot between each byte
  - How to assign IP 128.194.135.60 to an integer in C++?

• **Localhost** has IP address 127.0.0.1

• What if multiple network applications need to be run simultaneously on one host?

• **Solution: ports**
  - Each socket is bound to unique port
  - Socket = OS handle, port = externally visible identifier
  - The OS forwards incoming messages to sockets based on ports they are bound to
Windows Sockets 3

- Ports are 2-byte unsigned integers
  - Port 0 reserved, 1-1023 are system; 1024-65535 user
- Some well-known ports
  - HTTP: 80 (sometimes also 8000 or 8080)
  - Telnet: 23
  - SSH: 22
  - SMTP: 25 (encrypted SMTP on 465, 587)
- See http://www.iana.org/assignments/port-numbers
- When issuing a connect, the OS implicitly binds the socket to the next available port
  - Clients do not need to worry about their port numbers
  - But explicit binding is mandatory for servers
Example (Windows)

- Use “netstat –a” to see open ports on your host

<table>
<thead>
<tr>
<th>Proto</th>
<th>Local Address</th>
<th>Foreign Address</th>
<th>State</th>
</tr>
</thead>
<tbody>
<tr>
<td>TCP</td>
<td>viper:echo</td>
<td>viper:0</td>
<td>LISTENING</td>
</tr>
<tr>
<td>TCP</td>
<td>viper:discard</td>
<td>viper:0</td>
<td>LISTENING</td>
</tr>
<tr>
<td>TCP</td>
<td>viper:daytime</td>
<td>viper:0</td>
<td>LISTENING</td>
</tr>
<tr>
<td>TCP</td>
<td>viper:qotd</td>
<td>viper:0</td>
<td>LISTENING</td>
</tr>
<tr>
<td>TCP</td>
<td>viper:chargen</td>
<td>viper:0</td>
<td>LISTENING</td>
</tr>
<tr>
<td>TCP</td>
<td>viper:epmap</td>
<td>viper:0</td>
<td>LISTENING</td>
</tr>
<tr>
<td>TCP</td>
<td>viper:microsoft-ds</td>
<td>viper:0</td>
<td>LISTENING</td>
</tr>
<tr>
<td>TCP</td>
<td>viper:netbios-ssn</td>
<td>viper:0</td>
<td>LISTENING</td>
</tr>
<tr>
<td>TCP</td>
<td>viper:3713</td>
<td>imap.cs.tamu.edu:pop3</td>
<td>TIME_WAIT</td>
</tr>
<tr>
<td>TCP</td>
<td>viper:3717</td>
<td>google.com:http</td>
<td>ESTABLISHED</td>
</tr>
<tr>
<td>TCP</td>
<td>viper:3718</td>
<td>google.com:http</td>
<td>ESTABLISHED</td>
</tr>
</tbody>
</table>

TCP   | viper:38209   | dsl-113-77-11-99.chinanet.cn:12876 | ESTABLISHED    |

P2P application (skype, BitTorrent) or possibly hacker
Winsock requires initialization (unlike Unix)
- This should be done **before** any other winsock calls
- Once per program execution

```c
#include <windows.h>
WSADATA wsaData;
WORD wVersionRequested = MAKEWORD(2,2);
if (WSAStartup(wVersionRequested, &wsaData) != 0)
{
    printf("WSAStartup error %d\n", WSAGetLastError());
    exit(-1);
}
```
Agenda

• HTTP basics
• Windows sockets
  - Clients
Steps to writing a TCP client:
- Open a socket
- Determine the IP address of the server in URL
- Initiate connection with the server
- Send request
- Receive response
- Close socket

Task 1: open/close a TCP socket
- Sockets are initially unbound (i.e., no port associated)

```c
SOCKET sock = socket(AF_INET, SOCK_STREAM, IPPROTO_TCP);
if (sock == INVALID_SOCKET)
{
    printf("socket() error %d\n", WSAGetLastError());
    exit(-1);
}
...
closesocket (sock);
```
Task 2: determine the IP address of the server in URL

First assume the server is specified by an IP address
- Try converting to 4-byte int using `inet_addr(host);`

If this fails, then the server is given by its hostname
- Use the domain name system (DNS)
- DNS resolves fully-qualified domain names (FQDN) such as `www.tamu.edu` to their IP addresses (165.91.22.70)

DNS lookup performed through a system call
- `struct hostent* remote = gethostbyname(host);`
- Returns 4-byte IP addresses inside the structure
Clients 3

• **Task 3**: connect socket to server on given port

```c
struct sockaddr_in server;
server.sin_family = AF_INET; // IPv4
server.sin_addr = ... // from inet_addr or gethostbyname
server.sin_port = ... // port #

if (connect (sock, (struct sockaddr*) &server,
    sizeof(struct sockaddr_in)) == SOCKET_ERROR)
{
    printf ("Connection error: %d\n", WSAGetLastError());
    return;
}
```

• Main caveat is that all numbers must be in **network byte order** (MSB first)
  - Forward (host-to-network): `htons()`, `htonl()`
  - Reverse (network-to-host): `ntohs()`, `ntohl()`

• `inet_addr` and `gethostbyname` internally perform this, so usually only port # needs explicit conversion
**Clients 4**

- **Task 4**: send request conforming to correct protocol

```c
char *sendBuf = new char [requestLength];
// place request into buf
if (send (sock, sendBuf, requestLen, 0) == SOCKET_ERROR) {
    printf ("Send error: %d\n", WSAGetLastError());
    return;
}
```

- **Task 5**: receive response into recvBuf
  - Data arrives in chunks from function recv(), needs to be appended to a character buffer
  - Size of message and each chunk is unknown a-priori
    - Recv() must be called repeatedly until it returns 0 bytes
    - Use a pointer that moves along receive buffer
    - Buffer starts from 4-8 KB and is resized dynamically to accommodate longer messages