Introduction to Socket Programming

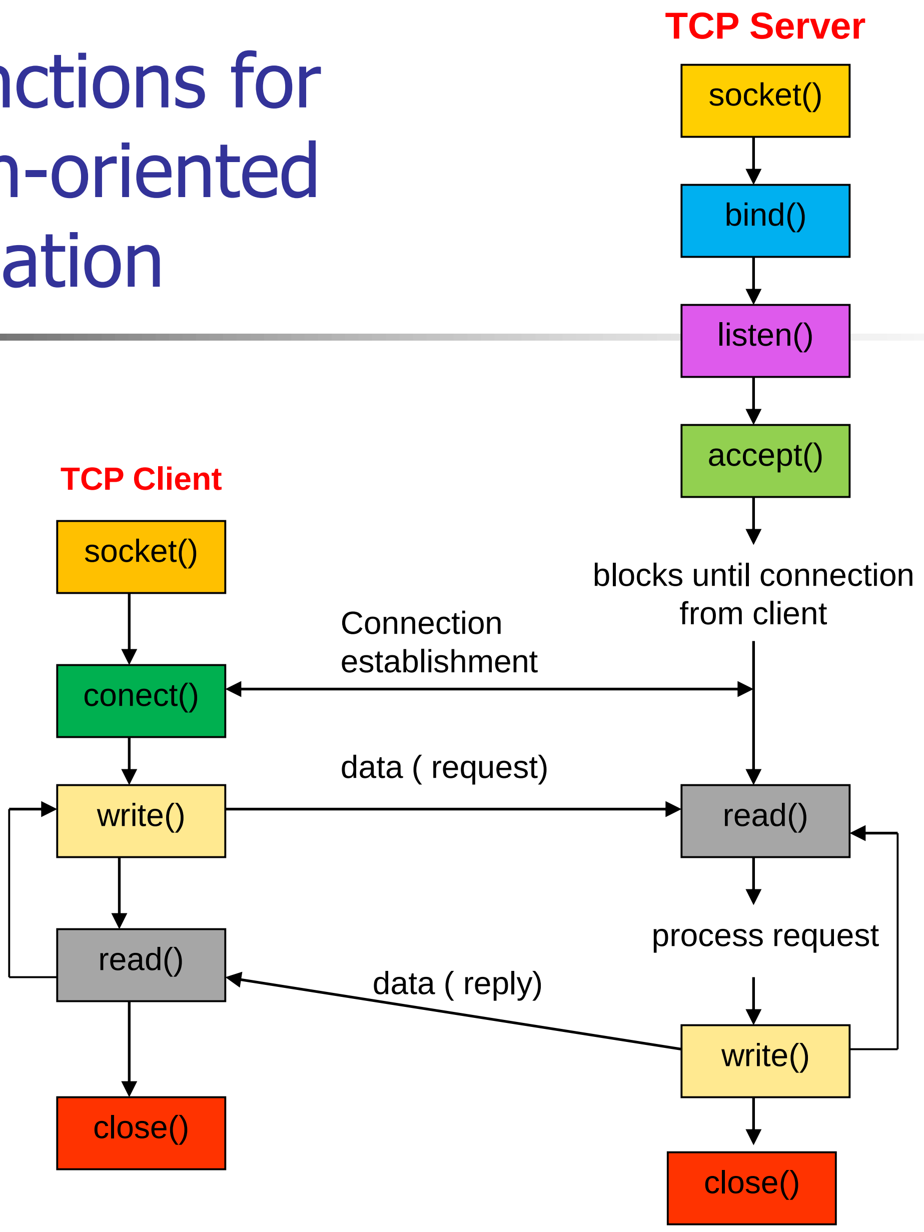
Why Socket Programming?

- To build any network application
  - Web browser
  - FTP

Client – Server model

- Server – provider of information
- Client – seeker of information
- Eg. Apache server – web browser

Socket functions for connection-oriented communication



Data structures

Defined by including the <netinet/in.h> header

```
struct sockaddr
{
unsigned short sa_family;
// address family, AF_xxx

char sa_data[14];
// 14 bytes of protocol
address
};
```

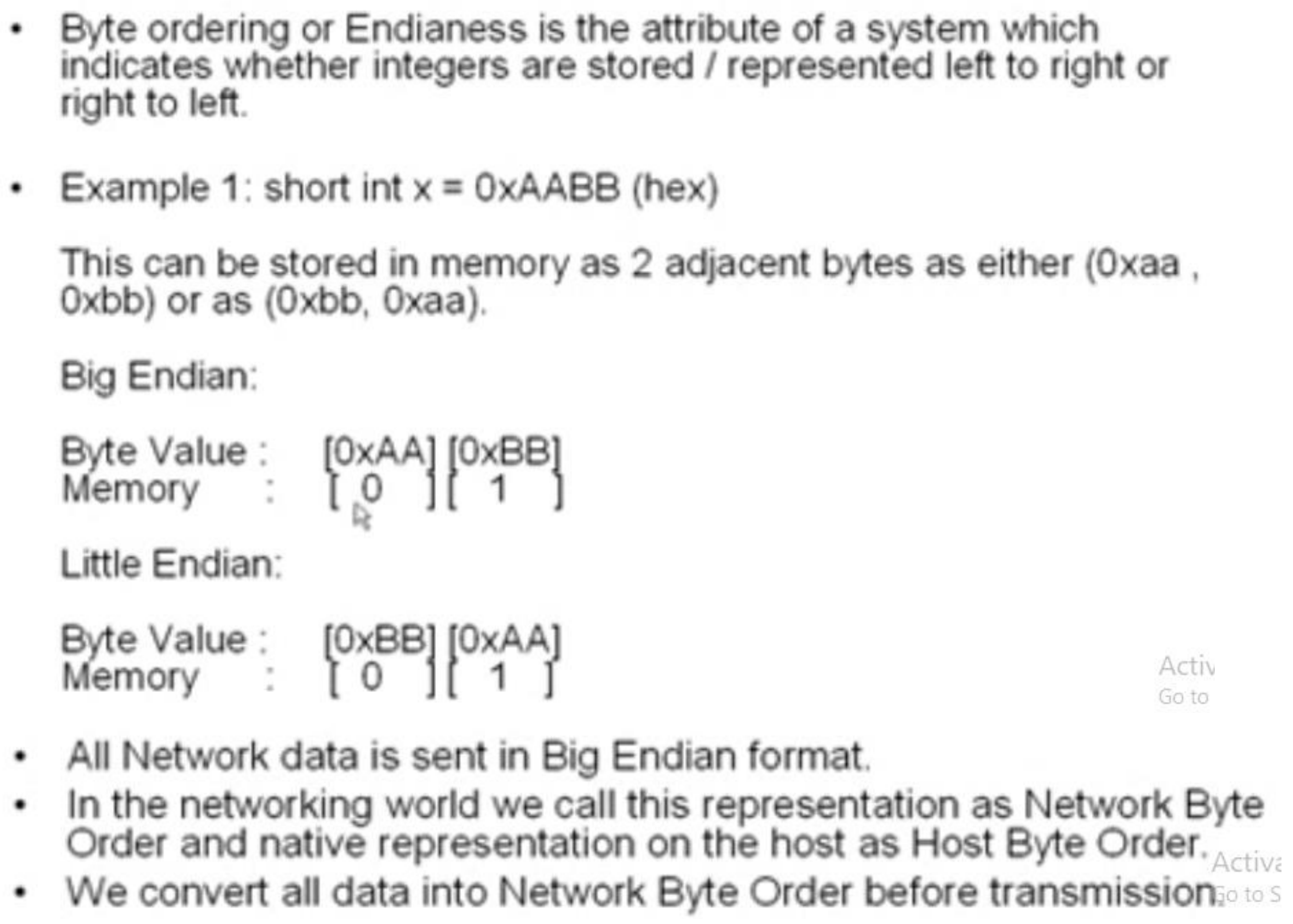
```
// IPv4 AF_INET sockets:

struct sockaddr_in
{
short sin_family;
// e.g. AF_INET, AF_INET6
unsigned short sin_port;
// e.g. htons(3490)
struct in_addr sin_addr;
// see struct in_addr, below
char sin_zero[8];
// zero this if you want to
            };
```

```
struct in_addr
{
unsigned long s_addr;
// load with inet_pton()
};
```

Choice of Port number

- Choose a port number that is registered for general use, from 1024 to 49151
  - Do not use ports 1 to 1023. These ports are reserved for use by the Internet Assigned Numbers Authority (IANA)
  - Avoid using ports 49152 through 65535. These are dynamic ports that operating systems use randomly. If you choose one of these ports, you risk a potential port conflict

Byte ordering



- Byte ordering or Endianess is the attribute of a system which indicates whether integers are stored / represented left to right or right to left.

- Example 1: short int x = 0xAABB (hex)

  This can be stored in memory as 2 adjacent bytes as either (0xaa , 0xbb) or as (0xbb, 0xaa).

  Big Endian:

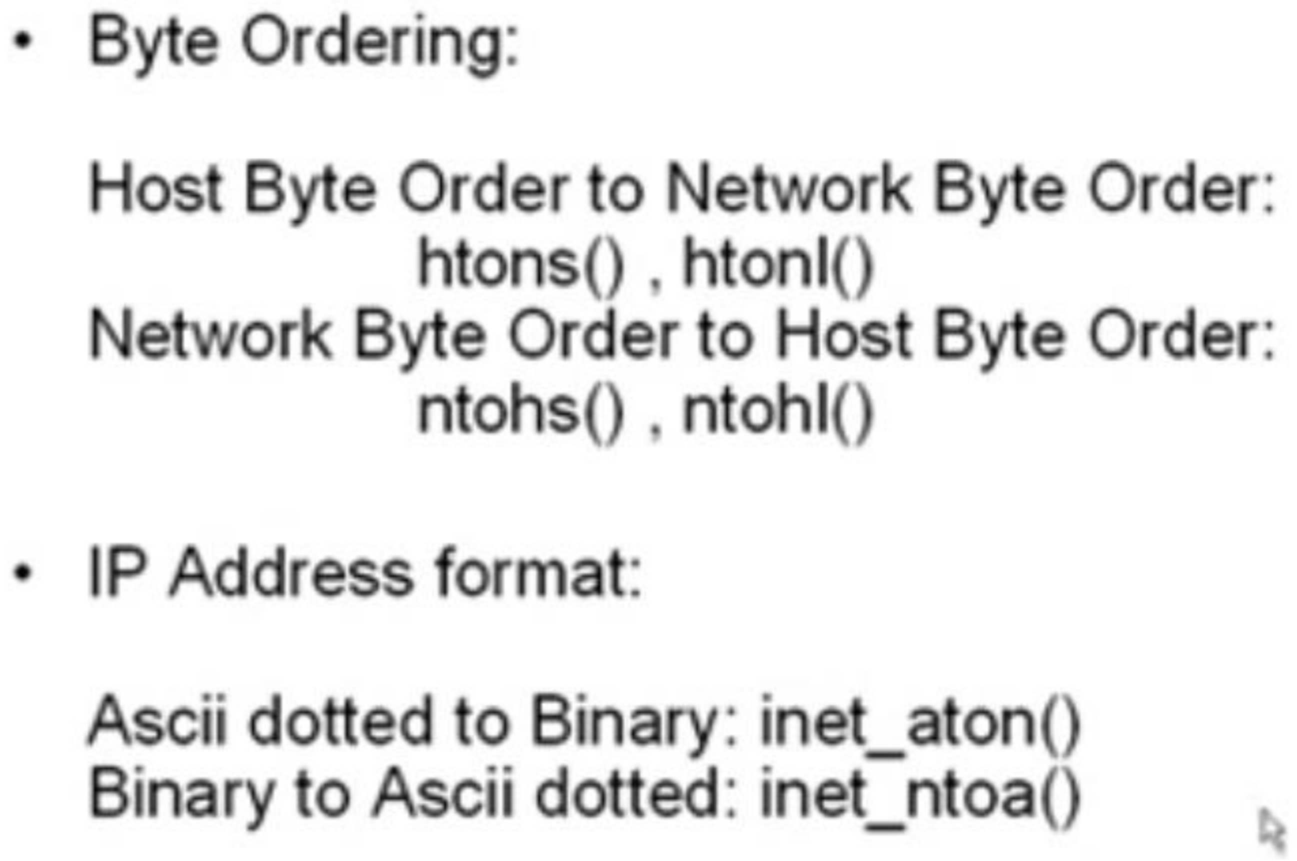
  ```
  Byte Value :   [0xAA] [0xBB]
  Memory     :   [  0  ][  1  ]
  ```

  Little Endian:

  ```
  Byte Value :   [0xBB] [0xAA]
  Memory     :   [  0  ][  1  ]
  ```

- All Network data is sent in Big Endian format.
- In the networking world we call this representation as Network Byte Order and native representation on the host as Host Byte Order.
- We convert all data into Network Byte Order before transmission.

Other functions



- Byte Ordering:

  Host Byte Order to Network Byte Order:
  htons() , htonl()
  Network Byte Order to Host Byte Order:
  ntohs() , ntohl()

- IP Address format:

  Ascii dotted to Binary: inet_aton()
  Binary to Ascii dotted: inet_ntoa()

Socket()

- int s = socket(domain, type, protocol);

where
  - s: socket descriptor, an integer (like a file-handle)
  - domain: integer, communication domain
    - e.g., AF_INET (IPv4 protocol)
    - **Note. We'll use AF_INET**
  - type: communication type
    - SOCK_STREAM: reliable, 2-way, connection-based service
    - SOCK_DGRAM: unreliable, connectionless
    - **Note. We'll use SOCK_STREAM**
  - protocol: **We'll set to 0**

Bind()

- The bind function assigns a local protocol address to a socket.
- The protocol address is the combination of either a 32-bit IPV4 address or a 128-bit IPV6 address, along with a 16-bit port number

```
#include <sys/socket.h>
int bind(int sockfd, struct sockaddr *address, int addr_len)
```

- sockfd: a socket descriptor returned by the socket()
- *address: a pointer to a protocol-specific address.
- addrlen: the size of the socket address structure

- Returns on success: 0, on error: -1

Listen()

- The listen function is called only by a TCP server to converts an unconnected socket into a passive socket.

```
#include <sys/socket.h>
int listen (int sockfd, int backlog);
```

- sockfd: a socket descriptor
- backlog: maximum number of connections that the kernel should queue for this socket

- Returns on success: 0, on error: -1

Accept()

- The accept function is called by the TCP server to return the next completed connection

```
#include<sys/socket.h>
int accept (int sockfd, struct sockaddr *cliaddr, int *addrlen);
```

- sockfd: socket descriptor
- *cliaddr: used to return the protocol address of the connected peer process
- *addrlen: length of the address

- Returns on success: a new (connected)socket descriptor, on error:-1

Connect()

- The connect function is used by a TCP client to establish a connection with a TCP server

```
#include<sys/socket.h>
int connect(int sockfd, struct sockaddr *servaddr, int addrlen);
```

- sockfd: a socket descriptor
- *servaddr: a pointer to a socket address structure
- addrlen: the size of the socket address structure

- Returns on success: 0, on error: -1

Read()

- The read function is used to receive data from the specified socket

```
#include <unistd.h>
int read(int sockfd, const void * buf, int nbytes);
```

- sockfd: a socket descriptor
- buf: buffer to store the data.
- nbytes: size of the buffer

- Returns: number of bytes read if OK,0 on EOF, -1 on error

Write()

- The write function is used to send the data through the specified socket

```
#include <unistd.h>
int write(int sockfd, const void * buf, int nbytes);
```

- sockfd: a socket descriptor
- buf: buffer to store the data.
- nbytes: size of the buffer

- Returns: number of bytes written if OK,0 on EOF, -1 on error

Close()

- The close function is used to close a socket and terminate a connection

```
#include <unistd.h>
int close (int sockfd);
```

- sockfd: This socket descriptor is no longer useable
- Returns on success: 0, on error: -1