Socket programming

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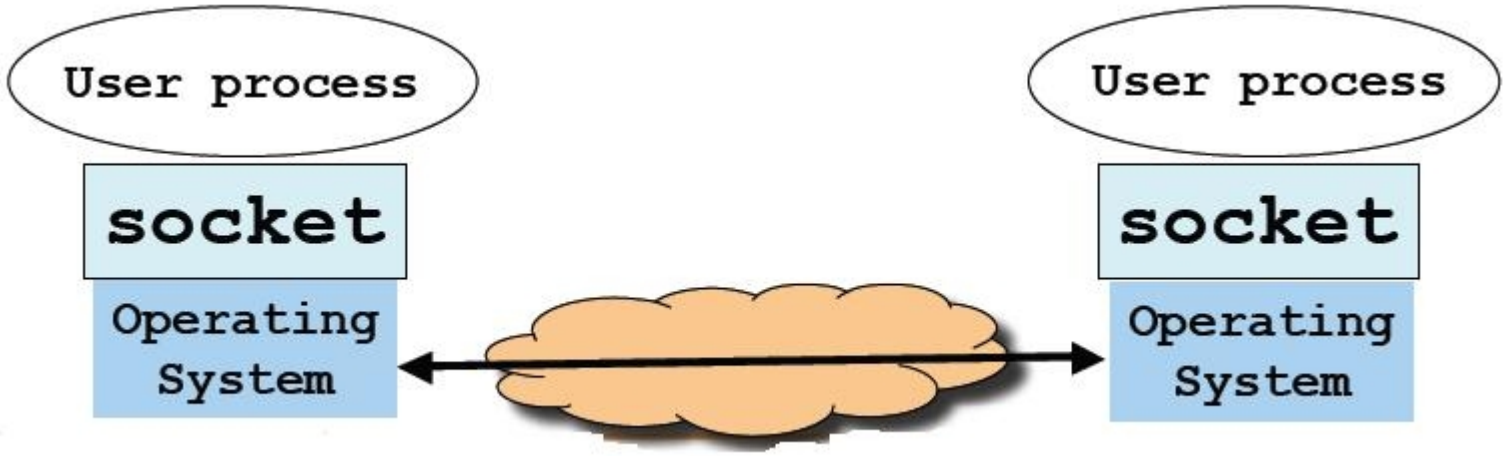
Socket: End Point of Communication

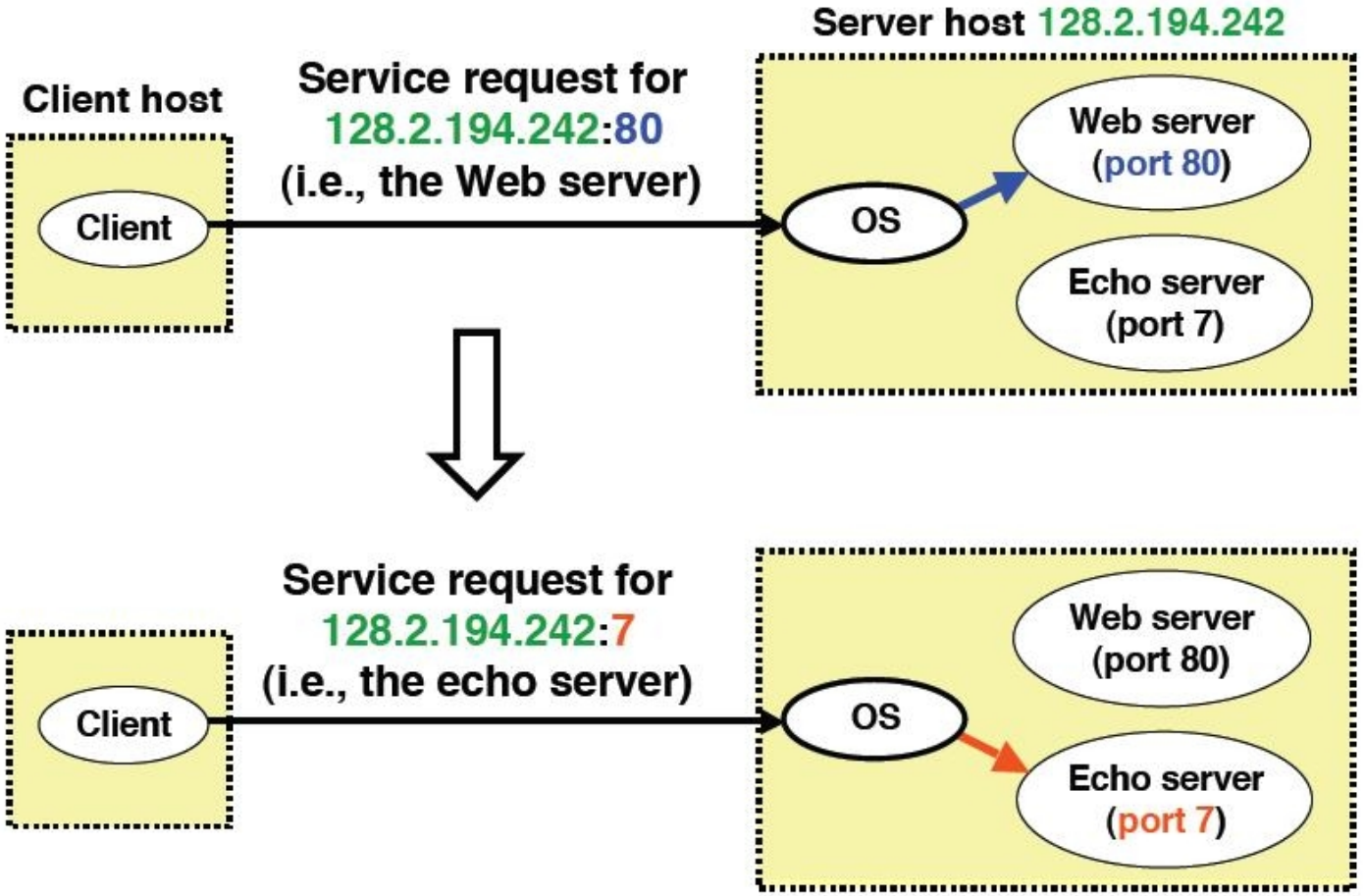
- Sending message from one process to another
  - Message must traverse the underlying network
- Process sends and receives through a socket
  - In essence, the doorway leading in/out of the house



Identifying the Receiving Process

- Sending process must identify the receiver
  - Address of the receiving end host
  - Identifier (port) that specifies the receiving process
- Receiving host
  - Destination IP address (32-bit) uniquely identifies the host
- Receiving process
  - Host may be running many different processes
  - Destination port (16-bit) uniquely identifies the socket (process)

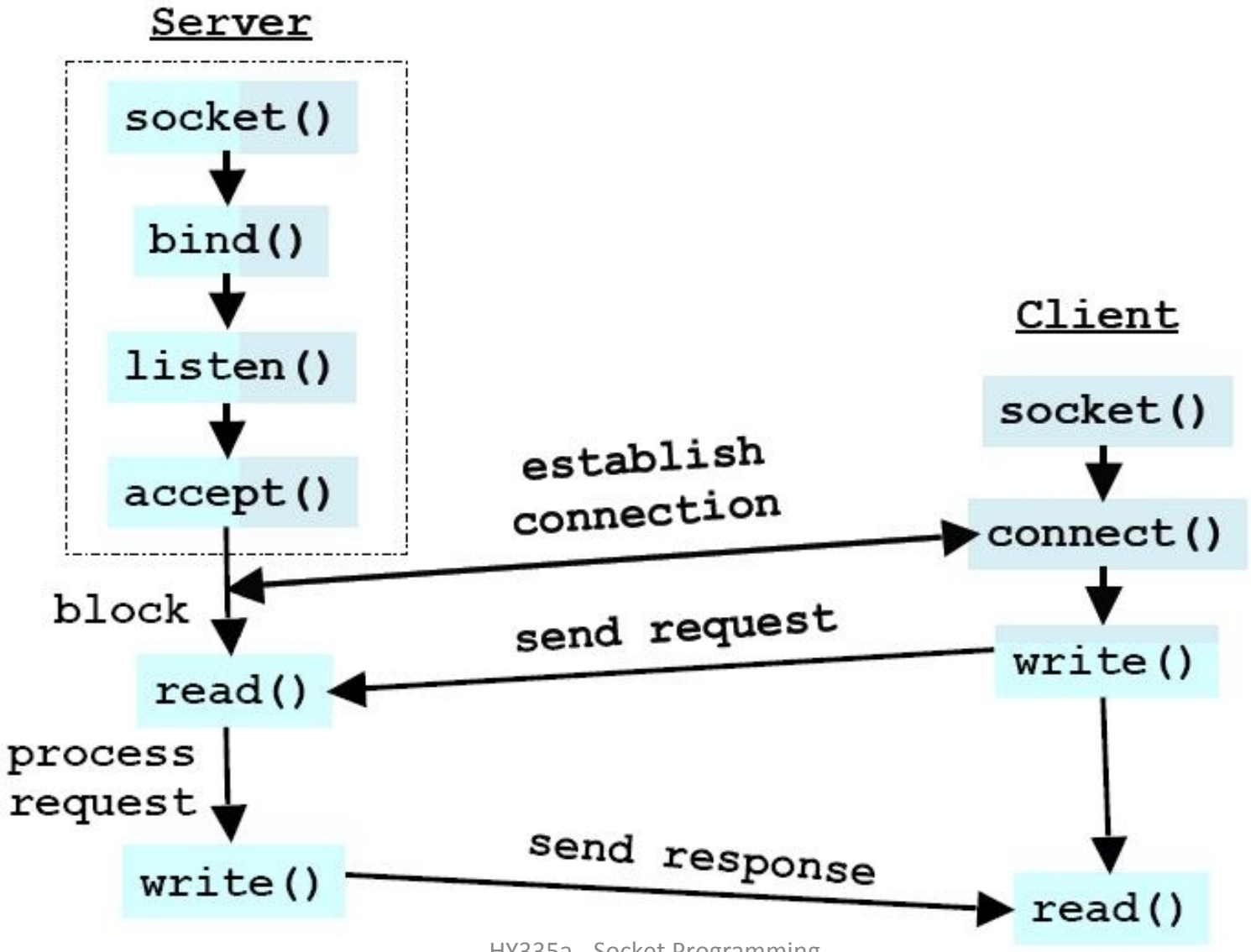
Using ports to identify Services



Using sockets in C

The UNIX Socket API

Overview


Server
socket()
bind()
listen()
accept()
Client
socket()
establish
connection
connect()
block
send request
write()
read()
process
request
write()
send response
read()

socket()

- int socket(int domain, int type, int protocol)
  - Creates a socket
- Domain specifies the protocol family
  - AF_UNIX, AF_LOCAL for local communication
  - AF_INET for IPv4 Internet protocols (use this)
- Type specifies the communication
  - SOCK_STREAM for TCP
  - SOCK_DGRAM for UDP
- Protocol specifies the protocol (set to 0 as domain and type imply the protocol)
- RETURN
  - On success returns socket descriptor, else -1

bind()

- int bind(int socket, struct sockaddr *address, int addrLen)
  - Assigns a specific address to the socket
- socket → the socket descriptor
- address → the host address
- addr_len → the size of the address struct

- RETURN
  - 0 on success, else -1

sockaddr & sockaddr_in

```
struct sockaddr_in  {
   short int sin_family; // Address family
   unsigned short int sin_port; //Port number
   struct in_addr sin_addr; //Internet address
   unsigned char sin_zero[8];
};

struct in_addr {
   unsigned long s_addr;
}

struct sockaddr_in addr;
struct sockaddr *address = (struct sockaddr *)&addr;
    //Type casting
```

listen()

- int listen(int sockfd, int backlog)
  - Listens (waits) for incoming connections
- sockfd → the socket descriptor
- backlog → max number of connections

- RETURN
- 0 on success, else -1

accept()

- int accept(int sockfd, struct sockaddr *addr, socklen_t *addrlen)
  - Accepts an incoming connection
- sockfd → the socket descriptor (after a call to listen())
- addr →pointer to a struct that is filled with the client's address (optional)
- addrlen → the size of the addr struct

- RETURN
  - 0 on success, else -1

send() / receive()

- ssize_t send(int sockfd, const void *buf, size_t len, int flags);
  - send data using the specified socket
- ssize_t recv(int sockfd, void *buf, size_t len, int flags);
  - Receive data from the specified socket and store it to buf

- sockfd → the socket descriptor
- buf → buffer to send or receiver
- len → the length of the buffer
- flags → (set to 0)

- RETURN
  - The total number of bytes sent/received, else -1

connect()

- int connect(int sockfd, const struct sockaddr *addr, socklen_t addrlen)
  - Connect to a socket

- sockfd →the unconnected socket descriptor
- addr →the server's address
- addrlen → the size of the addr struct

- RETURN
  - On success 0, else -1

close()

- int close(int fd)
  - Closes the socket
- fd → the socket descriptor
- RETURN
  - 0 on success, else -1

Example

TCP Server and TCP client in C

Socket creation

```
int sock;

if((sock = socket(AF_INET,SOCK_STREAM,IPROTO_TCP)) <
   0) {
        fprintf(stderr,"Failed to create TCP socket");
}

if(setsockopt(sock, SOL_SOCKET, SO_REUSEADDR,
   &optval, sizeof(optval)) < 0) {
        fprintf(stderr,"could not reuse address");
}
```

Reuse the same port number

Bind port to socket

```
struct sockaddr_in addr;

memset(&addr, 0 ,sizeof(addr)); //clear memory block for
                                //addr
addr.sin_family = AF_INET;
addr.sin_addr.s_addr = INADDR;
addr.sin_port = htons(server_port);

if(bind(sock, (struct sockaddr *)&addr, sizeof(addr)) < 0)
   {
        fprintf(stderr,"cannot bind socket to address");
   }
```

Wait for incoming connections

```
If(listen (sock, 5) < 0) {
      fprintf(stderr,”error listening”);
}
```

Specifies max number of incoming connections

Client establishes connection

```
struct sockaddr_in sin;

struct hostent *host = gethostbyname(argv[1]);

in_addr_t server_addr = *(in_addr_t) *host->h_addr_list[0];

memset(&sin,0,sizeof(sin));

sin.sin_family = AF_INET;
sin.sin_addr.s_addr = server_addr; // = inet_addr(server_IP) ;
sin.sin_port = htons(server_port);

if(connect(sock, (struct sockaddr *)&sin, sizeof(sin)) < 0) {
        fprintf(stderr, "cannot connect to server");
}
```

use raw IP address

Accept incoming connections

```
struct sockaddr_in addr;
int addr_len = sizeof(addr);
int c_sock;

c_sock = accept(sock,
      (struct sockaddr *)&addr, &addr,
  &addr_lin);

if(c_sock < 0) {
  fprintf(stderr,”error accepting connection”);
}
```

Send data

```
int send_packets(char *buffer, int buf_len) {
   sent_bytes = send(sock, buffer, buf_len, 0) ;

   if(send_bytes < 0) {
       fprintf(stderr, “send() failed”);
   }
   return 0;
}
```

Receive data

```
int receive_packets ( char *buffer, int buf_len) {
   int num_received = recv(sock, buffer, buf_len, 0);

   if(num_received < 0) {
       fprintf(stderr,”recv() failed”);
   } else if (num_received == 0) {
       //sender has closed connection
       return EOF;
   } else {
       return num_received;
   }
```

What happens when data exceed buffer size?

#include the appropriate libraries

```
#include <unistd.h> /* access to system calls */
#include <sys/types.h> /*widely used types */
#include <netdb.h> /* gethostbyname() etc.*/
#include <arpa/inet.h> /*htons etc. */
#include <sys/socket.h> /*socket structs */
#include <netinet/in.h> /*internet sockets,
                          sockaddr_in etc. */
```

Datagram Sockets (UDP)

- Similar to stream sockets but:
  - Use SOCK_DGRAM instead of SOCK_STREAM
  - No need to establish and terminate connection
  - Use recvfrom() and sendto() instead of recv() and send()

```
ssize_t recvfrom(int sockfd, void *buf,
  size_t len, int flags, struct sockaddr
  *src_addr, socklen_t *addrlen);

 ssize_t sendto(int sockfd, const void
  *buf, size_t len, int flags,const struct
  sockaddr *dest_addr, socklen_t addrlen);
```

Using sockets in Java

TCP Client

```
public static void main(String argv[]) throws Exception
{
   String sentence = "Hello";
   String modifiedSentence;
   //create the socket
   Socket clientSocket = new Socket("hostname", port);
   //get the input and output stream that are attached to the
   socket
   DataOutputStream outToServer = new
   DataOutputStream(clientSocket.getOutputStream());
   BufferedReader  inFromServer = new BufferedReader(new
   InputStreamReader(clientSocket.getInputStream()));

   outToServer.writeBytes(sentence + '\n'); //send
   modifiedSentence = inFromServer.readLine();       //receive
   System.out.println("From  server: " + modifiedSentence);
   clientSocket.close(); //close the socket
}
```

TCP Server

```
public static void main(String argv[]) throws Exception
{
   //create the server socket
   ServerSocket welcomeSocket = new ServerSocket(port);
   //accept the connection
   Socket connectionSocket = welcomeSocket.accept();
   //get the streams
   DataOutputStream outToClient = new
   DataOutputStream(connectionSocket.getOutputStream());
   BufferedReader  inFromClient = new BufferedReader(new
   InputStreamReader(connectionSocket.getInputStream()));
   //receive from client
   String clientSentence = inFromClient.readLine();
   //send to client
   outToClient.writeBytes(clientSentence.toUpperCase());
}
```

Datagram Sockets(UDP) in Java

- No initial handshaking and therefore no need for welcoming socket (server socket)
- No streams are attached to the sockets
- The receiving process must unravel the received packet to obtain the packet's information bytes
- The sending host creates "packets" by attaching the IP destination address and port number to each batch of bytes it sends

UDP Client

```
public static void main(String args[]) throws Exception   {
    BufferedReader inFromUser =  new BufferedReader(new
    InputStreamReader(System.in));
    DatagramSocket clientSocket = new DatagramSocket();  //UDP
                                                          //Socket
    InetAddress IPAddress = InetAddress.getByName("hostname");
    String sentence = inFromUser.readLine();

    byte[] sendData = new byte[1024];
    byte[] receiveData = new byte[1024];

    sendData = sentence.getBytes();
```

UDP Client

```
    DatagramPacket sendPacket =
            new DatagramPacket(sendData, sendData.length, IPAddress,
                    9876);
    clientSocket.send(sendPacket); //send a UDP packet

    DatagramPacket receivePacket  =  new
    DatagramPacket(receiveData, receiveData.length);
    clientSocket.receive(receivePacket); //receive a UDP packet
    String modifiedSentence = new String(receivePacket.getData());

    System.out.println("FROM SERVER:" + modifiedSentence);
    clientSocket.close();
}
```

UDP Server

```
public static void main(String args[]) throws Exception {
    DatagramSocket serverSocket = new DatagramSocket(9876);
    byte[] receiveData = new byte[1024];
    byte[] sendData = new byte[1024];

    DatagramPacket receivePacket =
            new DatagramPacket(receiveData, receiveData.length);
    serverSocket.receive(receivePacket);

    String sentence = new String(receivePacket.getData());
```

UDP Server

```
    InetAddress IPAddress = receivePacket.getAddress();


    int port = receivePacket.getPort();

    String capitalizedSentence = sentence.toUpperCase();
    sendData = capitalizedSentence.getBytes();

    DatagramPacket sendPacket =
          new DatagramPacket(sendData, sendData.length,
    IPAddress, port);

    serverSocket.send(sendPacket);
}
```

Classes

- ServerSocket
- Socket
- DatagramSocket
- DatagramPacket
- InetAddress

http://download-llnw.oracle.com/javase/1.5.0/docs/api/ (Java API)