Network IPC: Sockets

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Abstract

1. Socket Address Structure
2. Byte Ordering Function
3. Address lookup Function
4. Address conversion Function
5. TCP Socket
6. Examples in textbook

1. Socket Address Structure

- Socket address = IP address + TCP or UDP port number
- Used in a socket function as a argument (as pointer).
- Each protocol define its own Socket Address Structure(IPv4, IPv6....)
- Begin with sockaddr_

  example: ipv4 - sockaddr_in

  ipv6 - sockaddr_in6

Generic Socket address structure

- Socket address structure are always passed by reference when passed as an argument to any of the socket function.
  - int bind(int , struct sockaddr * , socklen_t);

- <sys/socket.h> : Generic Socket address structure

```
struct sockaddr {
    sa_family_t   sa_family;
      /*address family: AF_xxx   value*/
    char   sa_data[14];   /*protocol specific address*/
}
```

Generic Socket address structure

- int bind(int , struct sockaddr * , socklen_t);
- Example:

```
struct sockaddr_in  serv;  /*IPv4 socket address structure*/
 /*  fill in serv{} */
bind(sockfd, (struct sockaddr *) &serv, sizeof(serv));
```

- Any calls to socket function must cast the pointer to the protocol-specific socket address structure to be a pointer to a generic socket address structure

IPv4 Socket Address Structure: sockaddr_in

/usr/include/netinet/in.h in: internet

```
struct sockaddr_in
{
  __SOCKADDR_COMMON (sin_);
  in_port_t sin_port;            /* Port number.  */
  struct in_addr sin_addr;       /* Internet address.  */

  /* Pad to size of `struct sockaddr'.  */
  unsigned char sin_zero[sizeof (struct sockaddr) -
              __SOCKADDR_COMMON_SIZE -
              sizeof (in_port_t) -
              sizeof (struct in_addr)];
};
```

```
#define __SOCKADDR_COMMON(sa_prefix) \
sa_family_t sa_prefix##family
```

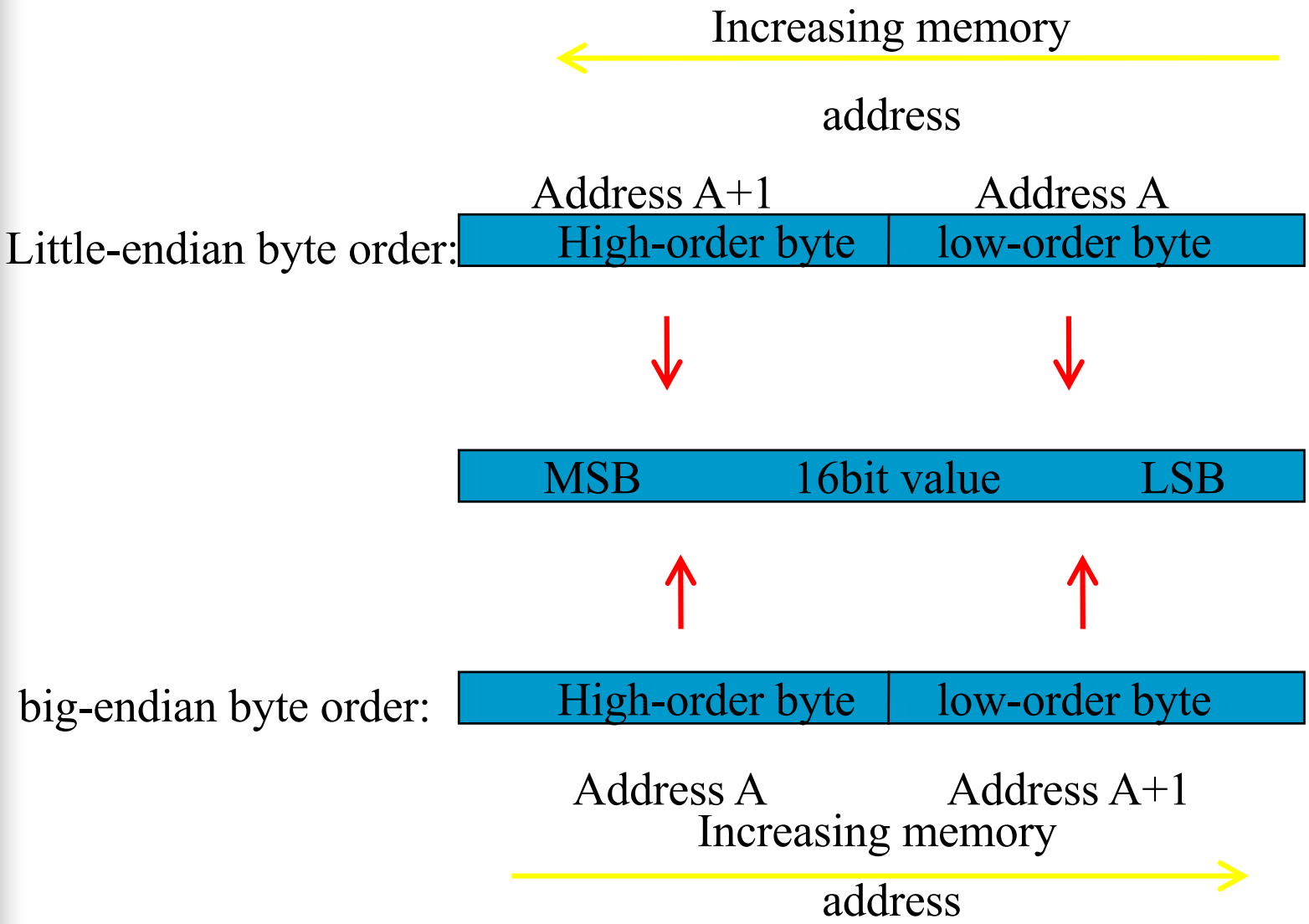
```
#define __SOCKADDR_COMMON_SIZE  (sizeof (unsigned short int))
```

sockaddr_in is expanded to:

```
struct sockaddr_in
{
  sa_family_t sin_family;
  in_port_t sin_port;            /* Port number.  */
  struct in_addr sin_addr;       /* Internet address.  */

  /* Pad to size of `struct sockaddr'.  */
  unsigned char sin_zero[sizeof (struct sockaddr) -
              (sizeof (unsigned short int) -
              sizeof (in_port_t) -
              sizeof (struct in_addr)];
};
```

- struct in_addr
  { in_addr_t s_addr; };

2. Byte Ordering Function



determine host byte order

```
#include "unp.h"
int  main(int argc, char **argv)
{
    union {  short  s;
             char   c[sizeof(short)];
    } un;
    un.s = 0x0102;
    printf("%s: ", CPU_VENDOR_OS);
    if (sizeof(short) == 2) {
        if (un.c[0] == 1 && un.c[1] == 2)       printf("big-endian\n");
          else if (un.c[0] == 2 && un.c[1] == 1)   printf("little-endian\n");
         else  printf("unknown\n");
    } else
        printf("sizeof(short) = %d\n", sizeof(short));
    exit(0);
}
```

Byte Conversion Function

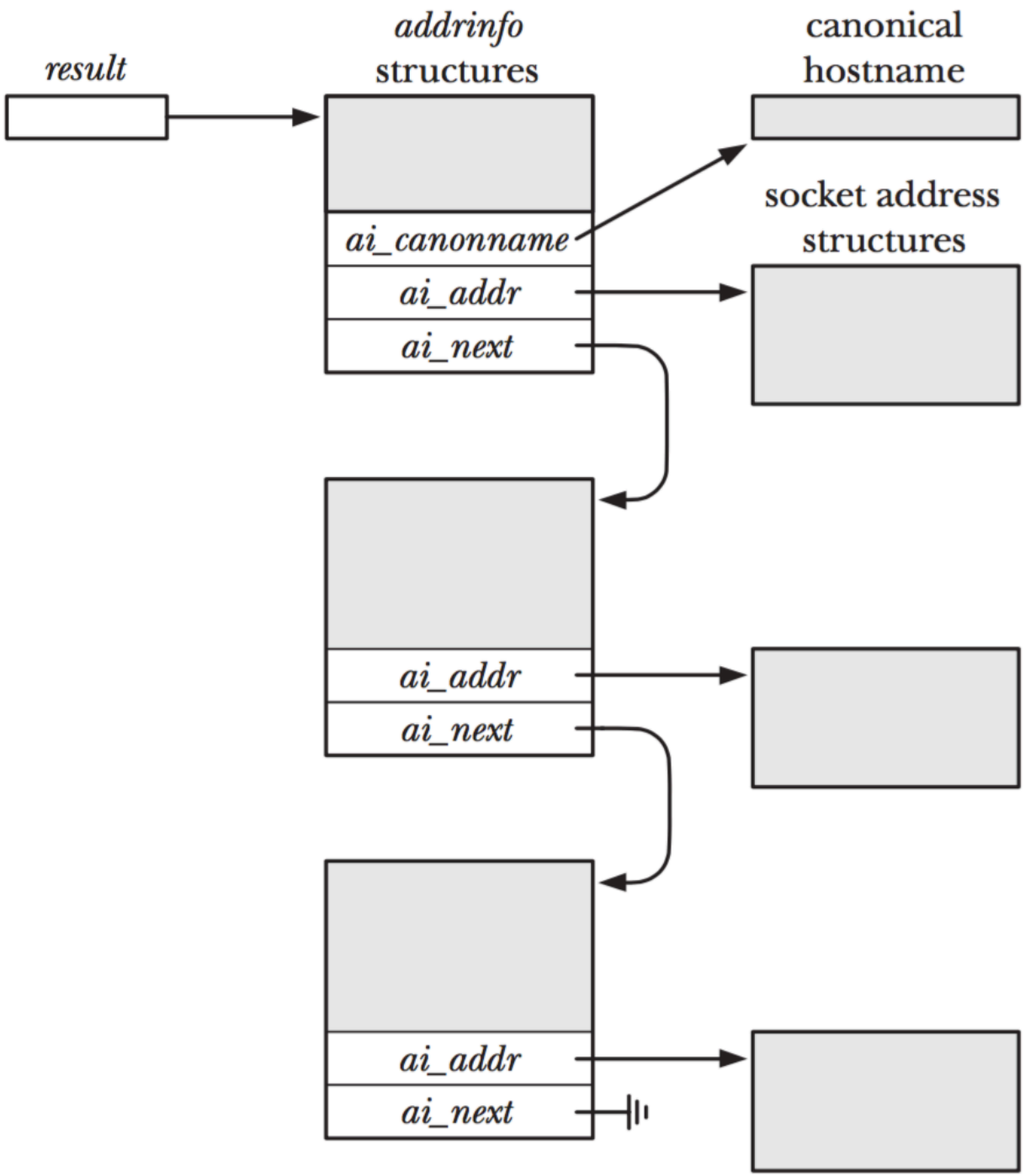
```
#include<netinet/in.h>
uint16_t    htons  (uint16_t    host16bitvalue);
uint32_t    htonl  (uint32_t    host32bitvalue);

uint16_t    ntohs  (uint16_t    net16bitvalue);
uint32_t    ntohl  (uint32_t    net32bitvalue);
```

- h: host
- n: network
- s: short(16bit)
- l: long(32bit)

3. Address Lookup

- #include <sys/socket.h>
- #include <netdb.h>
- int getaddrinfo(const char *restrict *host*,
  const char *restrict *service*,
  const struct addrinfo *restrict *hint*,
  struct addrinfo **restrict *res*);
- Returns: 0 if OK, nonzero error code on error

- void freeaddrinfo(struct addrinfo **ai*);


result
addrinfo structures
canonical hostname
socket address structures
ai_canonname
ai_addr
ai_next
ai_addr
ai_next
ai_addr
ai_next

4. Address conversion function

- Convert internet address between ASCII string and network byte ordered binary values(big endian)
- For example:

  Socket address structure

  <==>”203.255.74.129”

IPV4 Address conversion function

- #include<arpa/inet.h>

  int inet_aton(const char *strptr, struct in_addr *addrptr);

  /* return : 1 if string was valid,0 on error */

  Deprecated

  in_addr_t inet_addr(const char *strptr);

  /* return : 32bit binary network byte ordered IPv4 address;

  INADDR_NONE if error */

  char *inet_ntoa(struct in_addr inaddr); /*return pointer to dotted-decimal string*/

IPV4/IPV6 Address conversion function

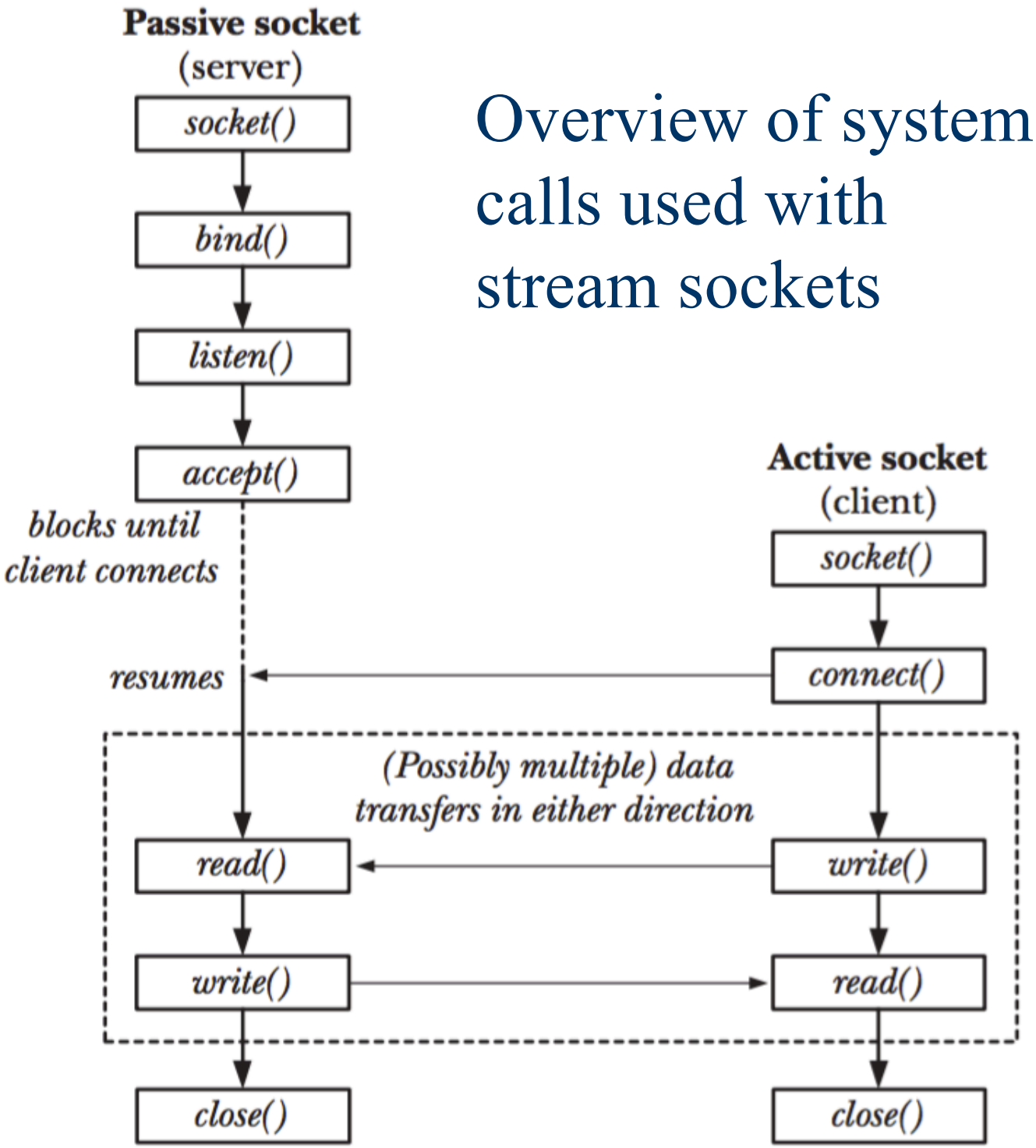
- p : presentation(string)
- n : numeric(binary)

```
#include<arpa/inet.h>
 int inet_pton(int family, const char *strptr, void *addrptr);
/* return: 1 if OK, 0 if input not a valid presentation format, -1 onerror
 */
/* string  TO  binary */

 const char *inet_ntop(int family, const void *addrptr, char *strpt,
 size_t len);
/* return : pointer to result if OK, NULL onerror */
/* len : size of the destination */
/* binary TO string */
```

5. Elementary TCP Socket

- socket function
- connect function
- bind function
- listen function
- accept function
- close function

Overview of system calls used with stream sockets



create Socket

```
#include <sys/socket.h>
int socket(int domain, int type, int protocol);
```

returns:nonnegative descriptor if OK, -1 on error

Normaly the protocol argument to the socket function is set to 0 except for raw socket.

int socket(int domain, int type, int protocol);

Domain	Description
AF_INET	IPv4 Internet domain
AF_INET6	IPv6 Internet domain (optional in POSIX.1)
AF_UNIX	UNIX domain
AF_UNSPEC	unspecified

Figure 16.1 Socket communication domains

Type	Description
SOCK_DGRAM	fixed-length, connectionless, unreliable messages
SOCK_RAW	datagram interface to IP (optional in POSIX.1)
SOCK_SEQPACKET	fixed-length, sequenced, reliable, connection-oriented messages
SOCK_STREAM	sequenced, reliable, bidirectional, connection-oriented byte streams

Figure 16.2 Socket types

Protocol	Description
IPPROTO_IP	IPv4 Internet Protocol
IPPROTO_IPV6	IPv6 Internet Protocol (optional in POSIX.1)
IPPROTO_ICMP	Internet Control Message Protocol
IPPROTO_RAW	Raw IP packets protocol (optional in POSIX.1)
IPPROTO_TCP	Transmission Control Protocol
IPPROTO_UDP	User Datagram Protocol

Figure 16.3 Protocols defined for Internet domain sockets

connect function

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

- Returns:0 if OK, -1 on error

bind function

```
#include <sys/socket.h>
int bind (int sockfd, const struct sockaddr *myaddr,
                socklen_t addrlen);
```

Returns: 0 if OK, -1 on error

==>this function assigns a local protocol address to a socket.

Process specifies		Result
IP address	port	
wildcard	0	kernel chooses IP address and port
wildcard	nonzero	kernel chooses IP address, process specifies port
local IP address	0	process specifies IP address, kernel chooses port
local IP address	nonzero	process specifies IP address and port

Figure 4.5 Result when specifying IP address and/or port number to `bind`.

listen function

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

Returns:0 if OK, -1 on error

- backlog =>specify the maximum number of connections that the kernel should queue for this socket.
- If the queues are full when client SYN arrives, TCP server ignore the SYN.

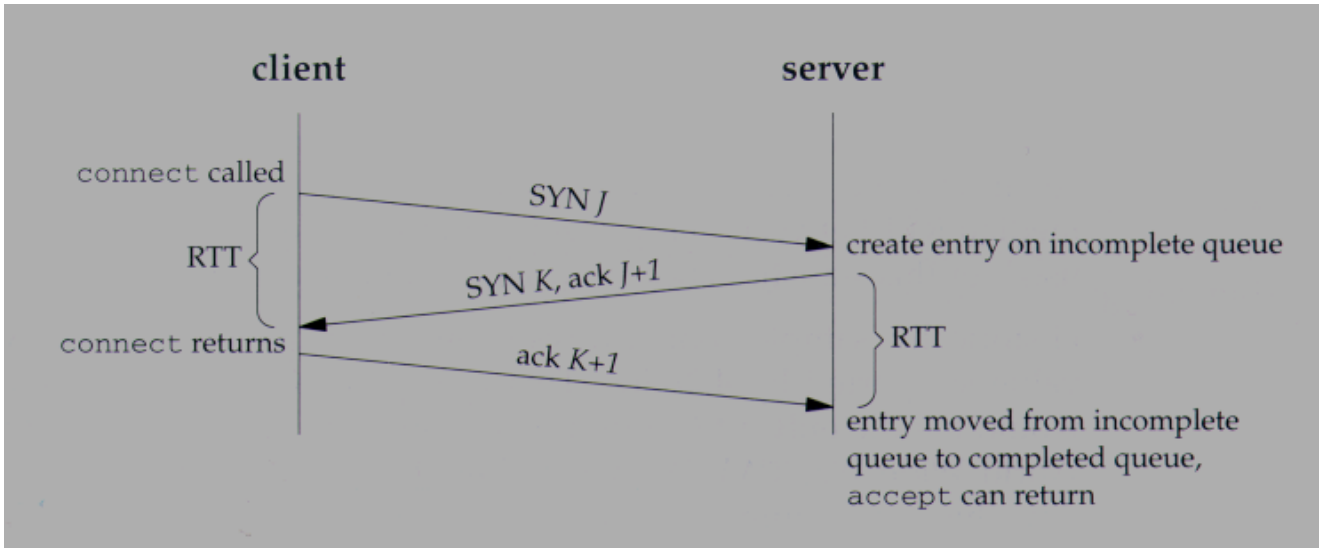


Figure 4.7 TCP three-way handshake and the two queues for a listening socket.

accept function

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

Returns:nonnegative descriptor if OK, -1 on error

⇒return the next completed connection from the front of the completed connection queue.

If queue is empty, the process is put to sleep.

close function

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

returns:0 if OK, -1 on error

6. Examples in textbook

- **Connection-Oriented Client**

  Fig 16.16
- **Connection-Oriented Server**

  Fig 16.17
- **Alternative Connection-Oriented Server**

  Fig 16.18
- **Connectionless Client**

  Fig 16.19
- **Connectionless Server**

  Fig 16.20