Byte Ordering and Byte Manipulation Functions

Byte Ordering Functions

- Unfortunately, not all computers store the bytes that comprise a multibyte value in the same order.
- Consider a 16-bit integer that is made up of 2 bytes. There are two ways to store this value.
  - **Little Endian** − In this scheme, low-order byte is stored on the starting address (A) and high-order byte is stored on the next address (A + 1).
  - **Big Endian** − In this scheme, high-order byte is stored on the starting address (A) and low-order byte is stored on the next address (A + 1).

Byte Ordering Functions

- To allow machines with different byte order conventions communicate with each other, the Internet protocols specify a canonical byte order convention for data transmitted over the network. This is known as Network Byte Order.
- While establishing an Internet socket connection, you must make sure that the data in the sin_port and sin_addr members of the sockaddr_in structure are represented in Network Byte Order.

Byte Ordering Functions

- Functions for converting data between a host's internal representation and Network Byte Order are as follows −

- **unsigned short htons(unsigned short hostshort)** − This function converts 16-bit (2-byte) quantities from host byte order to network byte order.
- **unsigned long htonl(unsigned long hostlong)** − This function converts 32-bit (4-byte) quantities from host byte order to network byte order.
- **unsigned short ntohs(unsigned short netshort)** − This function converts 16-bit (2-byte) quantities from network byte order to host byte order.
- **unsigned long ntohl(unsigned long netlong)** − This function converts 32-bit quantities from network byte order to host byte order.

Byte Ordering Functions

- These functions are macros and result in the insertion of conversion source code into the calling program.
  - On little-endian machines, the code will change the values around to network byte order.
  - On big-endian machines, no code is inserted since none is needed; the functions are defined as null.

Program to Determine Host Byte Order

```
#include <stdio.h>
 int main(int argc, char **argv)
 {
 union {
short s;
char c[sizeof(short)];
 }un;

un.s = 0x0102;  //hexadecimal
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);
 }
```

- The elements of a union occupy a common "piece" of memory. So un.s and un.c[] refer to same memory

- s= 0x0102, therefore
- If c={0x02, 0x01}→ Little Endian
- If c={0x01, 0x02}→ Big Endian

Byte Manipulation Functions

- Unix provides various function calls to help you manipulate IP addresses.
- These functions convert Internet addresses between ASCII strings (what humans prefer to use) and network byte ordered binary values (values that are stored in socket address structures).
- The following three function calls are used for IPv4 addressing −
  - **int inet_aton(const char *strptr, struct in_addr *addrptr)**
  - **in_addr_t inet_addr(const char *strptr)**
  - **char *inet_ntoa(struct in_addr inaddr)**

Byte Manipulation Functions

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

- This function call converts the specified string in the Internet standard dot notation to a network address, and stores the address in the structure provided.
- The converted address will be in Network Byte Order (bytes ordered from left to right). It returns 1 if the string was valid and 0 on error.
- example –

```
#include <arpa/inet.h>
(...)
int retval;
struct in_addr addrptr;
memset(&addrptr, '\0', sizeof(addrptr));
retval = inet_aton("68.178.157.132", &addrptr);
(...)
```

Byte Manipulation Functions

in_addr_t inet_addr(const char *strptr)

- This function call converts the specified string in the Internet standard dot notation to an integer value suitable for use as an Internet address. The converted address will be in Network Byte Order (bytes ordered from left to right). It returns a 32-bit binary network byte ordered IPv4 address and INADDR_NONE on error.
- example –

```
#include <arpa/inet.h>
(...)
struct sockaddr_in dest;
memset(&dest, '\0', sizeof(dest));
dest.sin_addr.s_addr
            =inet_addr("69.172.156.131");
(...)
```

Byte Manipulation Functions

char *inet_ntoa(struct in_addr inaddr)

- This function call converts the specified Internet host address to a string in the Internet standard dot notation.
- Example

```
#include <arpa/inet.h>
(...)

char *ip;
ip = inet_ntoa(dest.sin_addr);
 printf("IP Address is: %s\n",ip);

(...)
```

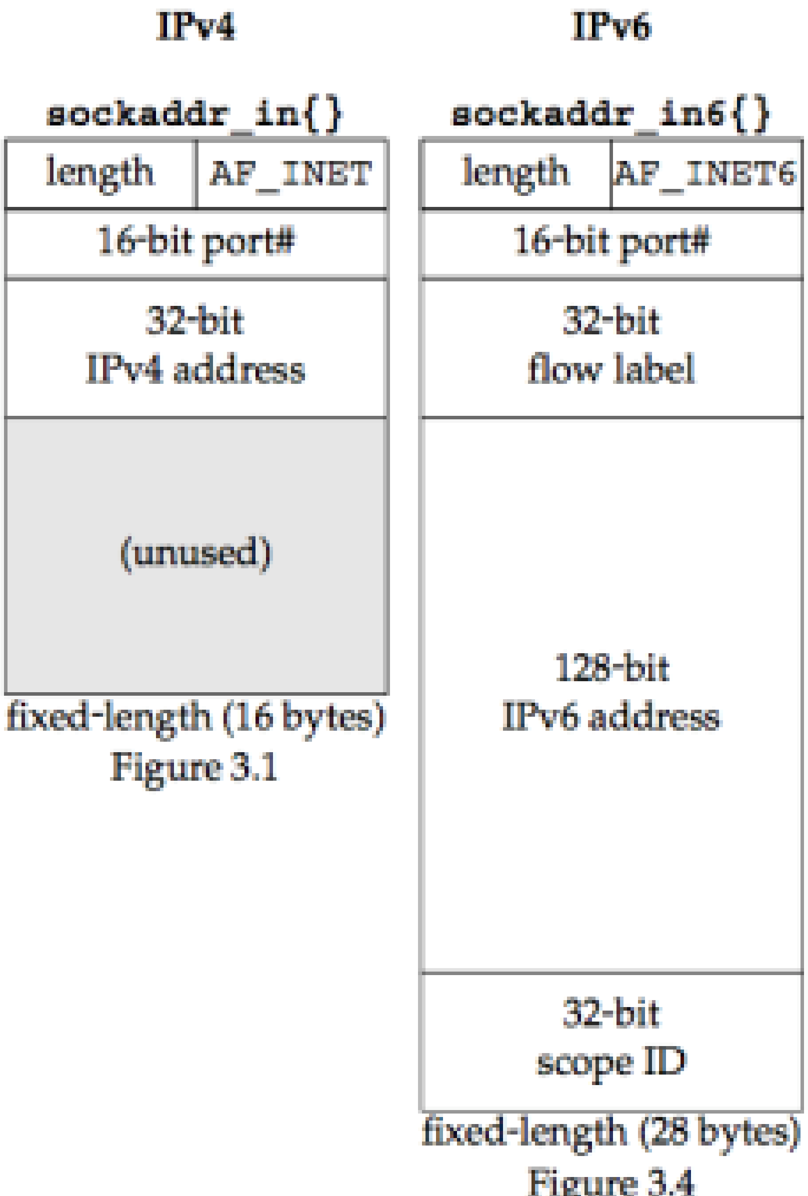
IPv6 Address Structure

```
struct in6_addr {
  uint8_t  s6_addr[16];              /* 128-bit IPv6 address */
                                     /* network byte ordered */
};

#define SIN6_LEN      /* required for compile-time tests */

struct sockaddr_in6 {
  uint8_t          sin6_len;         /* length of this struct (28) */
  sa_family_t      sin6_family;      /* AF_INET6 */
  in_port_t        sin6_port;        /* transport layer port# */
                                     /* network byte ordered */
  uint32_t         sin6_flowinfo;    /* flow information, undefined */
  struct in6_addr  sin6_addr;        /* IPv6 address */
                                     /* network byte ordered */
  uint32_t         sin6_scope_id;    /* set of interfaces for a scope */
};
```

IPv6 Address Structure

- The SIN6_LEN constant must be defined if the system supports the length member for socket address structures.
- The IPv6 family is AF_INET6, whereas the IPv4 family is AF_INET.
- The members in this structure are ordered so that if the sockaddr_in6 structure is 64-bit aligned, so is the 128-bit sin6_addr member. On some 64-bit processors, data accesses of 64-bit values are optimized if stored on a 64-bit boundary.
- The sin6_flowinfo member is divided into two fields:
  - The low-order 20 bits are the flow label
  - The high-order 12 bits are reserved
- The use of the flow label field is still a research topic.

IPv6 Address Structure



Compare IPv4 and IPv6 Address Structures

IPV6 Address Structure

Example:

```
int listen_sock_fd;
struct sockaddr_in6 server_addr;  // IPV6 address

/* Create socket for listening (client requests) */
        listen_sock_fd = socket(AF_INET6, SOCK_STREAM, IPPROTO_TCP);

/* Assign Values to  IPV6 address*/

        server_addr.sin6_family = AF_INET6;
        server_addr.sin6_addr = in6addr_any;  //#
        server_addr.sin6_port = htons(SERVER_PORT);

        /* Bind address and socket together */
bind(listen_sock_fd, (struct sockaddr*)&server_addr, sizeof(server_addr));

/*rest all code is same as of IPV4*/
```

instead following may be used to assign loopback address only

```
inet_pton(AF_INET6, "::1", &server_addr.sin6_addr);
```