PREVIOUS NEXT

14.6 Ancillary Data

Ancillary data can be sent and received using the `msg_control` and `msg_controllen` members of the `msghdr` structure with the `sendmsg` and `recvmsg` functions. Another term for ancillary data is *control information*. In this section, we will describe the concept and show the structure and macros used to build and process ancillary data, but we will save the code examples for later chapters that describe the actual uses of ancillary data.

Figure 14.11 is a summary of the various uses of ancillary data we cover in this text.

Figure 14.11. Summary of uses for ancillary data.

Protocol	cmsg_level	cmsg_type	Description
IPv4	IPPROTO_IP	IP_RECVDSTADDR	Receive destination address with UDP datagram
		IP_RECVIF	Receive interface index with UDP datagram
IPv6	IPPROTO_IPV6	IPV6_DSTOPTS	Specify destination options
		IPV6_HOPLIMIT	Specify hop limit
		IPV6_HOPOPTS	Specify hop-by-hop options
		IPV6_NEXTHOP	Specify next-hop address
		IPV6_PKTINFO	Specify packet information
		IPV6_RTHDR	Specify routing header
		IPV6_TCLASS	Specify traffic class
Unix domain	SOL_SOCKET	SCM_RIGHTS	Send/receive descriptors
		SCM_CREDS	Send/receive user credentials

The OSI protocol suite also uses ancillary data for various purposes we do not discuss in this text.

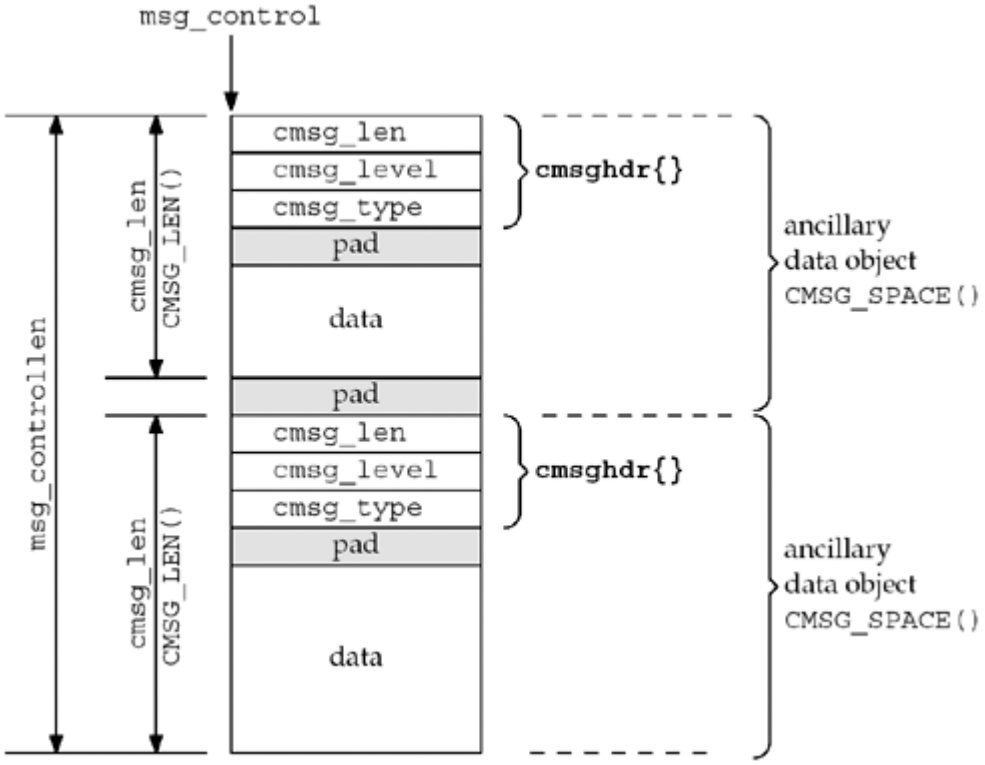
Ancillary data consists of one or more *ancillary data objects*, each one beginning with a `cmsghdr` structure, defined by including `<sys/socket.h>`.

```
struct cmsghdr {
  socklen_t  cmsg_len;   /* length in bytes, including this structure */
  int        cmsg_level; /* originating protocol */
  int        cmsg_type;  /* protocol-specific type */
      /* followed by unsigned char cmsg_data[] */
};
```

We have already seen this structure in Figure 14.9, when it was used with the `IP_RECVDSTADDR` socket option to return the destination IP address of a received UDP datagram. The ancillary data pointed to by `msg_control` must be suitably aligned for a `cmsghdr` structure. We will show one way to do this in Figure 15.11.

Figure 14.12 shows an example of two ancillary data objects in the control buffer. `msg_control` points to the first ancillary data object, and the total length of the ancillary data is specified by `msg_controllen`. Each object is preceded by a `cmsghdr` structure that describes the object. There can be padding between the `cmsg_type` member and the actual data, and there can also be padding at the end of the data, before the next ancillary data object. The five `CMSG_`*xxx* macros we describe shortly account for this possible padding.

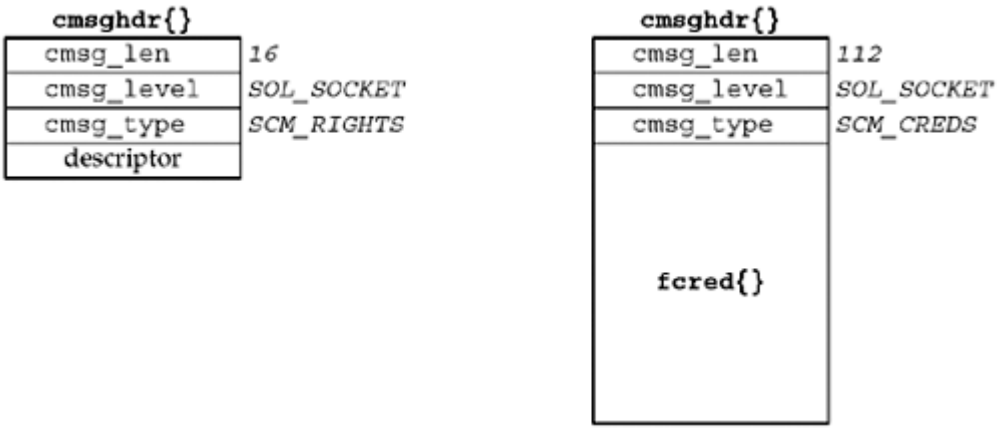
Figure 14.12. Ancillary data containing two ancillary data objects.



Not all implementations support multiple ancillary data objects in the control buffer.

Figure 14.13 shows the format of the `cmsghdr` structure when used with a Unix domain socket for descriptor passing (Section 15.7) or credential passing (Section 15.8).

Figure 14.13. `cmsghdr` structure when used with Unix domain sockets.



In this figure, we assume each of the three members of the `cmsghdr` structure occupies four bytes and there is no padding between the `cmsghdr` structure and the actual data. When descriptors are passed, the contents of the `cmsg_data` array are the actual descriptor values. In this figure, we show only one descriptor being passed, but in general, more than one can be passed (in which case, the `cmsg_len` value will be 12 plus 4 times the number of descriptors, assuming each descriptor occupies 4 bytes).

Since the ancillary data returned by `recvmsg` can contain any number of ancillary data objects, and to hide the possible padding from the application, the following five macros are defined by including the `<sys/socket.h>` header to simplify the processing of the ancillary data:

```
#include <sys/socket.h>

#include <sys/param.h> /* for ALIGN macro on many implementations */

struct cmsghdr *CMSG_FIRSTHDR(struct msghdr *mhdrptr);

                                        Returns: pointer to first cmsghdr structure or NULL if no ancillary data

struct cmsghdr *CMSG_NXTHDR(struct msghdr *mhdrptr, struct cmsghdr *cmsgptr);

                                        Returns: pointer to next cmsghdr structure or NULL if no more ancillary data objects

unsigned char *CMSG_DATA(struct cmsghdr *cmsgptr);

                                        Returns: pointer to first byte of data associated with cmsghdr structure

unsigned int CMSG_LEN(unsigned int length);

                                        Returns: value to store in cmsg_len given the amount of data

unsigned int CMSG_SPACE(unsigned int length);

                                        Returns: total size of an ancillary data object given the amount of data
```

POSIX defines the first three macros; RFC 3542 [Stevens et al. 2003] defines the last two.

These macros would be used in the following pseudocode:

```
struct msghdr     msg;
struct cmsghdr    *cmsgptr;

/* fill in msg structure */

/* call recvmsg() */

for (cmsgptr = CMSG_FIRSTHDR(&msg); cmsgptr != NULL;
     cmsgptr = CMSG_NXTHDR(&msg, cmsgptr)) {
    if (cmsgptr->cmsg_level == ... &&
        cmsgptr->cmsg_type == ... ) {
        u_char *ptr;

        ptr = CMSG_DATA(cmsgptr);
        /* process data pointed to by ptr */
    }
}
```

`CMSG_FIRSTHDR` returns a pointer to the first ancillary data object, or a null pointer if there is no ancillary data in the `msghdr` structure (either `msg_control` is a null pointer or `cmsg_len` is less than the size of a `cmsghdr` structure). `CMSG_NXTHDR`

returns a null pointer when there is not another ancillary data object in the control buffer.

> Many existing implementations of `CMSG_FIRSTHDR` never look at `msg_controllen` and just return the value of `cmsg_control`. In Figure 22.2, we will test the value of `msg_controllen` before calling this macro.

The difference between `CMSG_LEN` and `CMSG_SPACE` is that the former does not account for any padding following the data portion of the ancillary data object and is therefore the value to store in `cmsg_len`, while the latter accounts for the padding at the end and is therefore the value to use if dynamically allocating space for the ancillary data object.

PREVIOUS NEXT