

**NAME**

**mbuf** - memory management in the kernel IPC subsystem

**SYNOPSIS**

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

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

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

**Mbuf allocation macros**

```
MGET(struct mbuf *mbuf, int how, short type);
```

```
MGETHDR(struct mbuf *mbuf, int how, short type);
```

*int*

```
MCLGET(struct mbuf *mbuf, int how);
```

```
MEXTADD(struct mbuf *mbuf, char *buf, u_int size, void (*free)(struct mbuf *), void *opt_arg1,  
void *opt_arg2, int flags, int type);
```

**Mbuf utility macros**

```
mtod(struct mbuf *mbuf, type);
```

```
M_ALIGN(struct mbuf *mbuf, u_int len);
```

```
MH_ALIGN(struct mbuf *mbuf, u_int len);
```

*int*

```
M_LEADINGSPACE(struct mbuf *mbuf);
```

*int*

```
M_TRAILINGSPACE(struct mbuf *mbuf);
```

```
M_MOVE_PKTHDR(struct mbuf *to, struct mbuf *from);
```

```
M_PREPEND(struct mbuf *mbuf, int len, int how);
```

```
MCTYPE(struct mbuf *mbuf, short type);
```

*int*

```
M_WRITABLE(struct mbuf *mbuf);
```

**Mbuf allocation functions***struct mbuf \****m\_get**(*int how, short type*);*struct mbuf \****m\_get2**(*int size, int how, short type, int flags*);*struct mbuf \****m\_get3**(*int size, int how, short type, int flags*);*struct mbuf \****m\_getm**(*struct mbuf \*orig, int len, int how, short type*);*struct mbuf \****m\_getjcl**(*int how, short type, int flags, int size*);*struct mbuf \****m\_getcl**(*int how, short type, int flags*);*struct mbuf \****m\_gethdr**(*int how, short type*);*struct mbuf \****m\_free**(*struct mbuf \*mbuf*);*void***m\_freem**(*struct mbuf \*mbuf*);**Mbuf utility functions***void***m\_adj**(*struct mbuf \*mbuf, int len*);*void***m\_align**(*struct mbuf \*mbuf, int len*);*int***m\_append**(*struct mbuf \*mbuf, int len, c\_caddr\_t cp*);*struct mbuf \****m\_prepend**(*struct mbuf \*mbuf, int len, int how*);

*struct mbuf \**

**m\_copyup**(*struct mbuf \*mbuf, int len, int dstoff*);

*struct mbuf \**

**m\_pullup**(*struct mbuf \*mbuf, int len*);

*struct mbuf \**

**m\_pulldown**(*struct mbuf \*mbuf, int offset, int len, int \*offsetp*);

*struct mbuf \**

**m\_copym**(*struct mbuf \*mbuf, int offset, int len, int how*);

*struct mbuf \**

**m\_copypacket**(*struct mbuf \*mbuf, int how*);

*struct mbuf \**

**m\_dup**(*const struct mbuf \*mbuf, int how*);

*void*

**m\_copydata**(*const struct mbuf \*mbuf, int offset, int len, caddr\_t buf*);

*void*

**m\_copyback**(*struct mbuf \*mbuf, int offset, int len, caddr\_t buf*);

*struct mbuf \**

**m\_devget**(*char \*buf, int len, int offset, struct ifnet \*ifp, void (\*copy)(char \*from, caddr\_t to, u\_int len)*);

*void*

**m\_cat**(*struct mbuf \*m, struct mbuf \*n*);

*void*

**m\_catpkt**(*struct mbuf \*m, struct mbuf \*n*);

*u\_int*

**m\_fixhdr**(*struct mbuf \*mbuf*);

*int*

**m\_dup\_pkthdr**(*struct mbuf \*to, const struct mbuf \*from, int how*);

*void*

```
m_move_pkthdr(struct mbuf *to, struct mbuf *from);
```

```
u_int
```

```
m_length(struct mbuf *mbuf, struct mbuf **last);
```

```
struct mbuf *
```

```
m_split(struct mbuf *mbuf, int len, int how);
```

```
int
```

```
m_apply(struct mbuf *mbuf, int off, int len, int (*f)(void *arg, void *data, u_int len), void *arg);
```

```
struct mbuf *
```

```
m_getptr(struct mbuf *mbuf, int loc, int *off);
```

```
struct mbuf *
```

```
m_defrag(struct mbuf *m0, int how);
```

```
struct mbuf *
```

```
m_collapse(struct mbuf *m0, int how, int maxfrags);
```

```
struct mbuf *
```

```
m_unshare(struct mbuf *m0, int how);
```

## DESCRIPTION

An *mbuf* is a basic unit of memory management in the kernel IPC subsystem. Network packets and socket buffers are stored in *mbufs*. A network packet may span multiple *mbufs* arranged into a *mbuf chain* (linked list), which allows adding or trimming network headers with little overhead.

While a developer should not bother with *mbuf* internals without serious reason in order to avoid incompatibilities with future changes, it is useful to understand the general structure of an *mbuf*.

An *mbuf* consists of a variable-sized header and a small internal buffer for data. The total size of an *mbuf*, `MSIZE`, is a constant defined in `<sys/param.h>`. The *mbuf* header includes:

*m\_next*     (*struct mbuf \**) A pointer to the next *mbuf* in the *mbuf chain*.

*m\_nextpkt* (*struct mbuf \**) A pointer to the next *mbuf chain* in the queue.

*m\_data*     (*caddr\_t*) A pointer to data attached to this *mbuf*.

*m\_len* (int) The length of the data.

*m\_type* (short) The type of the data.

*m\_flags* (int) The *mbuf* flags.

The *mbuf* flag bits are defined as follows:

```
#define M_EXT          0x00000001 /* has associated external storage */
#define M_PKTHDR      0x00000002 /* start of record */
#define M_EOR         0x00000004 /* end of record */
#define M_RDONLY     0x00000008 /* associated data marked read-only */
#define M_BCAST       0x00000010 /* send/received as link-level broadcast */
#define M_MCAST       0x00000020 /* send/received as link-level multicast */
#define M_PROMISC     0x00000040 /* packet was not for us */
#define M_VLANTAG     0x00000080 /* ether_vtag is valid */
#define M_EXTPG       0x00000100 /* has array of unmapped pages and TLS */
#define M_NOFREE      0x00000200 /* do not free mbuf, embedded in cluster */
#define M_TSTMP       0x00000400 /* rcv_tstamp field is valid */
#define M_TSTMP_HPREC 0x00000800 /* rcv_tstamp is high-prec, typically
                                hw-stamped on port (useful for IEEE 1588
                                and 802.1AS) */

#define M_PROTO1      0x00001000 /* protocol-specific */
#define M_PROTO2      0x00002000 /* protocol-specific */
#define M_PROTO3      0x00004000 /* protocol-specific */
#define M_PROTO4      0x00008000 /* protocol-specific */
#define M_PROTO5      0x00010000 /* protocol-specific */
#define M_PROTO6      0x00020000 /* protocol-specific */
#define M_PROTO7      0x00040000 /* protocol-specific */
#define M_PROTO8      0x00080000 /* protocol-specific */
#define M_PROTO9      0x00100000 /* protocol-specific */
#define M_PROTO10     0x00200000 /* protocol-specific */
#define M_PROTO11     0x00400000 /* protocol-specific */
#define M_PROTO12     0x00800000 /* protocol-specific */
```

The available *mbuf* types are defined as follows:

```
#define MT_DATA        1          /* dynamic (data) allocation */
#define MT_HEADER      MT_DATA    /* packet header */
```

```

#define MT_VENDOR1  4      /* for vendor-internal use */
#define MT_VENDOR2  5      /* for vendor-internal use */
#define MT_VENDOR3  6      /* for vendor-internal use */
#define MT_VENDOR4  7      /* for vendor-internal use */

#define MT_SONAME    8      /* socket name */

#define MT_EXP1      9      /* for experimental use */
#define MT_EXP2     10     /* for experimental use */
#define MT_EXP3     11     /* for experimental use */
#define MT_EXP4     12     /* for experimental use */

#define MT_CONTROL  14     /* extra-data protocol message */
#define MT_EXTCONTROL 15    /* control message with externalized contents */
#define MT_OOBDATA  16     /* expedited data */

```

The available external buffer types are defined as follows:

```

#define EXT_CLUSTER  1      /* mbuf cluster */
#define EXT_SFBUF    2      /* sendfile(2)'s sf_bufs */
#define EXT_JUMBOP   3      /* jumbo cluster 4096 bytes */
#define EXT_JUMBO9   4      /* jumbo cluster 9216 bytes */
#define EXT_JUMBO16  5      /* jumbo cluster 16184 bytes */
#define EXT_PACKET   6      /* mbuf+cluster from packet zone */
#define EXT_MBUF     7      /* external mbuf reference */
#define EXT_RXRING   8      /* data in NIC receive ring */
#define EXT_PGS      9      /* array of unmapped pages */

#define EXT_VENDOR1  224    /* for vendor-internal use */
#define EXT_VENDOR2  225    /* for vendor-internal use */
#define EXT_VENDOR3  226    /* for vendor-internal use */
#define EXT_VENDOR4  227    /* for vendor-internal use */

#define EXT_EXP1     244    /* for experimental use */
#define EXT_EXP2     245    /* for experimental use */
#define EXT_EXP3     246    /* for experimental use */
#define EXT_EXP4     247    /* for experimental use */

#define EXT_NET_DRV  252    /* custom ext_buf provided by net driver(s) */
#define EXT_MOD_TYPE 253    /* custom module's ext_buf type */

```

```
#define EXT_DISPOSABLE    254    /* can throw this buffer away w/page flipping */
#define EXT_EXTREF       255    /* has externally maintained ref_cnt ptr */
```

If the `M_PKTHDR` flag is set, a *struct pkthdr m\_pkthdr* is added to the *mbuf* header. It contains a pointer to the interface the packet has been received from (*struct ifnet \*rcvif*), and the total packet length (*int len*). Optionally, it may also contain an attached list of packet tags (*struct m\_tag*). See `mbuf_tags(9)` for details. Fields used in offloading checksum calculation to the hardware are kept in *m\_pkthdr* as well. See *HARDWARE-ASSISTED CHECKSUM CALCULATION* for details.

If small enough, data is stored in the internal data buffer of an *mbuf*. If the data is sufficiently large, another *mbuf* may be added to the *mbuf chain*, or external storage may be associated with the *mbuf*. `MHLEN` bytes of data can fit into an *mbuf* with the `M_PKTHDR` flag set, `MLEN` bytes can otherwise.

If external storage is being associated with an *mbuf*, the *m\_ext* header is added at the cost of losing the internal data buffer. It includes a pointer to external storage, the size of the storage, a pointer to a function used for freeing the storage, a pointer to an optional argument that can be passed to the function, and a pointer to a reference counter. An *mbuf* using external storage has the `M_EXT` flag set.

The system supplies a macro for allocating the desired external storage buffer, `MEXTADD`.

The allocation and management of the reference counter is handled by the subsystem.

The system also supplies a default type of external storage buffer called an *mbuf cluster*. *Mbuf clusters* can be allocated and configured with the use of the `MCLGET` macro. Each *mbuf cluster* is `MCLBYTES` in size, where `MCLBYTES` is a machine-dependent constant. The system defines an advisory macro `MINCLSIZE`, which is the smallest amount of data to put into an *mbuf cluster*. It is equal to `MHLEN` plus one. It is typically preferable to store data into the data region of an *mbuf*, if size permits, as opposed to allocating a separate *mbuf cluster* to hold the same data.

## Macros and Functions

There are numerous predefined macros and functions that provide the developer with common utilities.

### **mtod**(*mbuf*, *type*)

Convert an *mbuf* pointer to a data pointer. The macro expands to the data pointer cast to the specified *type*. **Note:** It is advisable to ensure that there is enough contiguous data in *mbuf*. See `m_pullup()` for details.

### **MGET**(*mbuf*, *how*, *type*)

Allocate an *mbuf* and initialize it to contain internal data. *mbuf* will point to the allocated *mbuf* on success, or be set to `NULL` on failure. The *how* argument is to be set to `M_WAITOK` or

**M\_NOWAIT**. It specifies whether the caller is willing to block if necessary. A number of other functions and macros related to *mbufs* have the same argument because they may at some point need to allocate new *mbufs*.

**MGETHDR**(*mbuf, how, type*)

Allocate an *mbuf* and initialize it to contain a packet header and internal data. See **MGET**() for details.

**MEXTADD**(*mbuf, buf, size, free, opt\_arg1, opt\_arg2, flags, type*)

Associate externally managed data with *mbuf*. Any internal data contained in the *mbuf* will be discarded, and the **M\_EXT** flag will be set. The *buf* and *size* arguments are the address and length, respectively, of the data. The *free* argument points to a function which will be called to free the data when the *mbuf* is freed; it is only used if *type* is **EXT\_EXTREF**. The *opt\_arg1* and *opt\_arg2* arguments will be saved in *ext\_arg1* and *ext\_arg2* fields of the *struct m\_ext* of the *mbuf*. The *flags* argument specifies additional *mbuf* flags; it is not necessary to specify **M\_EXT**. Finally, the *type* argument specifies the type of external data, which controls how it will be disposed of when the *mbuf* is freed. In most cases, the correct value is **EXT\_EXTREF**.

**MCLGET**(*mbuf, how*)

Allocate and attach an *mbuf cluster* to *mbuf*. On success, a non-zero value returned; otherwise, 0. Historically, consumers would check for success by testing the **M\_EXT** flag on the *mbuf*, but this is now discouraged to avoid unnecessary awareness of the implementation of external storage in protocol stacks and device drivers.

**M\_ALIGN**(*mbuf, len*)

Set the pointer *mbuf->m\_data* to place an object of the size *len* at the end of the internal data area of *mbuf*, long word aligned. Applicable only if *mbuf* is newly allocated with **MGET**() or **m\_get**().

**MH\_ALIGN**(*mbuf, len*)

Serves the same purpose as **M\_ALIGN**() does, but only for *mbuf* newly allocated with **MGETHDR**() or **m\_gethdr**(), or initialized by **m\_dup\_pkthdr**() or **m\_move\_pkthdr**().

**m\_align**(*mbuf, len*)

Serves the same purpose as **M\_ALIGN**() but handles any type of *mbuf*.

**M\_LEADINGSPACE**(*mbuf*)

Returns the number of bytes available before the beginning of data in *mbuf*.

**M\_TRAILINGSPACE**(*mbuf*)

Returns the number of bytes available after the end of data in *mbuf*.

**M\_PREPEND**(*mbuf, len, how*)

This macro operates on an *mbuf chain*. It is an optimized wrapper for **m\_prepend**() that can make use of possible empty space before data (e.g. left after trimming of a link-layer header). The new *mbuf chain* pointer or NULL is in *mbuf* after the call.

**M\_MOVE\_PKTHDR**(*to, from*)

Using this macro is equivalent to calling **m\_move\_pkthdr**(*to, from*).

**M\_WRITABLE**(*mbuf*)

This macro will evaluate true if *mbuf* is not marked M\_RDONLY and if either *mbuf* does not contain external storage or, if it does, then if the reference count of the storage is not greater than 1. The M\_RDONLY flag can be set in *mbuf->m\_flags*. This can be achieved during setup of the external storage, by passing the M\_RDONLY bit as a *flags* argument to the **MEXTADD**() macro, or can be directly set in individual *mbufs*.

**MCHTYPE**(*mbuf, type*)

Change the type of *mbuf* to *type*. This is a relatively expensive operation and should be avoided.

The functions are:

**m\_get**(*how, type*)

A function version of **MGET**() for non-critical paths.

**m\_get2**(*size, how, type, flags*)

Allocate an *mbuf* with enough space to hold specified amount of data. If the size is larger than MJUMPAGESIZE, NULL will be returned.

**m\_get3**(*size, how, type, flags*)

Allocate an *mbuf* with enough space to hold specified amount of data. If the size is larger than MJUM16BYTES, NULL will be returned.

**m\_getm**(*orig, len, how, type*)

Allocate *len* bytes worth of *mbufs* and *mbuf clusters* if necessary and append the resulting allocated *mbuf chain* to the *mbuf chain orig*, if it is non-NULL. If the allocation fails at any point, free whatever was allocated and return NULL. If *orig* is non-NULL, it will not be freed. It is possible to use **m\_getm**() to either append *len* bytes to an existing *mbuf* or *mbuf chain* (for example, one which may be sitting in a pre-allocated ring) or to simply perform an all-or-nothing *mbuf* and *mbuf cluster* allocation.

**m\_gethdr**(*how, type*)

A function version of **MGETHDR()** for non-critical paths.

**m\_getcl**(*how, type, flags*)

Fetch an *mbuf* with a *mbuf cluster* attached to it. If one of the allocations fails, the entire allocation fails. This routine is the preferred way of fetching both the *mbuf* and *mbuf cluster* together, as it avoids having to unlock/relock between allocations. Returns NULL on failure.

**m\_getjcl**(*how, type, flags, size*)

This is like **m\_getcl()** but the specified *size* of the cluster to be allocated must be one of MCLBYTES, MJUMPAGESIZE, MJUM9BYTES, or MJUM16BYTES.

**m\_free**(*mbuf*)

Frees *mbuf*. Returns *m\_next* of the freed *mbuf*.

The functions below operate on *mbuf chains*.

**m\_freem**(*mbuf*)

Free an entire *mbuf chain*, including any external storage.

**m\_adj**(*mbuf, len*)

Trim *len* bytes from the head of an *mbuf chain* if *len* is positive, from the tail otherwise.

**m\_append**(*mbuf, len, cp*)

Append *len* bytes of data *cp* to the *mbuf chain*. Extend the *mbuf chain* if the new data does not fit in existing space.

**m\_prepend**(*mbuf, len, how*)

Allocate a new *mbuf* and prepend it to the *mbuf chain*, handle M\_PKTHDR properly. **Note:** It does not allocate any *mbuf clusters*, so *len* must be less than MLEN or MHLEN, depending on the M\_PKTHDR flag setting.

**m\_copyup**(*mbuf, len, dstoff*)

Similar to **m\_pullup()** but copies *len* bytes of data into a new *mbuf* at *dstoff* bytes into the *mbuf*. The *dstoff* argument aligns the data and leaves room for a link layer header. Returns the new *mbuf chain* on success, and frees the *mbuf chain* and returns NULL on failure. **Note:** The function does not allocate *mbuf clusters*, so *len* + *dstoff* must be less than MHLEN.

**m\_pullup**(*mbuf, len*)

Arrange that the first *len* bytes of an *mbuf chain* are contiguous and lay in the data area of *mbuf*, so they are accessible with **mtod**(*mbuf, type*). It is important to remember that this may involve

reallocating some mbufs and moving data so all pointers referencing data within the old mbuf chain must be recalculated or made invalid. Return the new *mbuf chain* on success, NULL on failure (the *mbuf chain* is freed in this case). **Note:** It does not allocate any *mbuf clusters*, so *len* must be less than or equal to MHLEN.

**m\_pulldown**(*mbuf, offset, len, offsetp*)

Arrange that *len* bytes between *offset* and *offset + len* in the *mbuf chain* are contiguous and lay in the data area of *mbuf*, so they are accessible with **mtod**(*mbuf, type*). *len* must be smaller than, or equal to, the size of an *mbuf cluster*. Return a pointer to an intermediate *mbuf* in the chain containing the requested region; the offset in the data region of the *mbuf chain* to the data contained in the returned mbuf is stored in *\*offsetp*. If *offsetp* is NULL, the region may be accessed using **mtod**(*mbuf, type*). If *offsetp* is non-NULL, the region may be accessed using **mtod**(*mbuf, uint8\_t*) + *\*offsetp*. The region of the mbuf chain between its beginning and *offset* is not modified, therefore it is safe to hold pointers to data within this region before calling **m\_pulldown**().

**m\_copym**(*mbuf, offset, len, how*)

Make a copy of an *mbuf chain* starting *offset* bytes from the beginning, continuing for *len* bytes. If *len* is M\_COPYALL, copy to the end of the *mbuf chain*. **Note:** The copy is read-only, because the *mbuf clusters* are not copied, only their reference counts are incremented.

**m\_coppacket**(*mbuf, how*)

Copy an entire packet including header, which must be present. This is an optimized version of the common case **m\_copym**(*mbuf, 0, M\_COPYALL, how*). **Note:** the copy is read-only, because the *mbuf clusters* are not copied, only their reference counts are incremented.

**m\_dup**(*mbuf, how*)

Copy a packet header *mbuf chain* into a completely new *mbuf chain*, including copying any *mbuf clusters*. Use this instead of **m\_coppacket**() when you need a writable copy of an *mbuf chain*.

**m\_copydata**(*mbuf, offset, len, buf*)

Copy data from an *mbuf chain* starting *off* bytes from the beginning, continuing for *len* bytes, into the indicated buffer *buf*.

**m\_copyback**(*mbuf, offset, len, buf*)

Copy *len* bytes from the buffer *buf* back into the indicated *mbuf chain*, starting at *offset* bytes from the beginning of the *mbuf chain*, extending the *mbuf chain* if necessary. **Note:** It does not allocate any *mbuf clusters*, just adds *mbufs* to the *mbuf chain*. It is safe to set *offset* beyond the current *mbuf chain* end: zeroed *mbufs* will be allocated to fill the space.

**m\_length**(*mbuf, last*)

Return the length of the *mbuf chain*, and optionally a pointer to the last *mbuf*.

**m\_dup\_pkthdr**(*to, from, how*)

Upon the function's completion, the *mbuf to* will contain an identical copy of *from->m\_pkthdr* and the per-packet attributes found in the *mbuf chain from*. The *mbuf from* must have the flag `M_PKTHDR` initially set, and *to* must be empty on entry.

**m\_move\_pkthdr**(*to, from*)

Move *m\_pkthdr* and the per-packet attributes from the *mbuf chain from* to the *mbuf to*. The *mbuf from* must have the flag `M_PKTHDR` initially set, and *to* must be empty on entry. Upon the function's completion, *from* will have the flag `M_PKTHDR` and the per-packet attributes cleared.

**m\_fixhdr**(*mbuf*)

Set the packet-header length to the length of the *mbuf chain*.

**m\_devget**(*buf, len, offset, ifp, copy*)

Copy data from a device local memory pointed to by *buf* to an *mbuf chain*. The copy is done using a specified copy routine *copy*, or `bcopy()` if *copy* is NULL.

**m\_cat**(*m, n*)

Concatenate *n* to *m*. Both *mbuf chains* must be of the same type. *n* is not guaranteed to be valid after `m_cat()` returns. `m_cat()` does not update any packet header fields or free mbuf tags.

**m\_catpkt**(*m, n*)

A variant of `m_cat()` that operates on packets. Both *m* and *n* must contain packet headers. *n* is not guaranteed to be valid after `m_catpkt()` returns.

**m\_split**(*mbuf, len, how*)

Partition an *mbuf chain* in two pieces, returning the tail: all but the first *len* bytes. In case of failure, it returns NULL and attempts to restore the *mbuf chain* to its original state.

**m\_apply**(*mbuf, off, len, f, arg*)

Apply a function to an *mbuf chain*, at offset *off*, for length *len* bytes. Typically used to avoid calls to `m_pullup()` which would otherwise be unnecessary or undesirable. *arg* is a convenience argument which is passed to the callback function *f*.

Each time `f()` is called, it will be passed *arg*, a pointer to the *data* in the current mbuf, and the length *len* of the data in this mbuf to which the function should be applied.

The function should return zero to indicate success; otherwise, if an error is indicated, then **m\_apply()** will return the error and stop iterating through the *mbuf chain*.

**m\_getptr**(*mbuf, loc, off*)

Return a pointer to the mbuf containing the data located at *loc* bytes from the beginning of the *mbuf chain*. The corresponding offset into the mbuf will be stored in *\*off*.

**m\_defrag**(*m0, how*)

Defragment an mbuf chain, returning the shortest possible chain of mbufs and clusters. If allocation fails and this can not be completed, NULL will be returned and the original chain will be unchanged. Upon success, the original chain will be freed and the new chain will be returned. *how* should be either M\_WAITOK or M\_NOWAIT, depending on the caller's preference.

This function is especially useful in network drivers, where certain long mbuf chains must be shortened before being added to TX descriptor lists.

**m\_collapse**(*m0, how, maxfrags*)

Defragment an mbuf chain, returning a chain of at most *maxfrags* mbufs and clusters. If allocation fails or the chain cannot be collapsed as requested, NULL will be returned, with the original chain possibly modified. As with **m\_defrag()**, *how* should be one of M\_WAITOK or M\_NOWAIT.

**m\_unshare**(*m0, how*)

Create a version of the specified mbuf chain whose contents can be safely modified without affecting other users. If allocation fails and this operation can not be completed, NULL will be returned. The original mbuf chain is always reclaimed and the reference count of any shared mbuf clusters is decremented. *how* should be either M\_WAITOK or M\_NOWAIT, depending on the caller's preference. As a side-effect of this process the returned mbuf chain may be compacted.

This function is especially useful in the transmit path of network code, when data must be encrypted or otherwise altered prior to transmission.

## HARDWARE-ASSISTED CHECKSUM CALCULATION

This section currently applies to TCP/IP only. In order to save the host CPU resources, computing checksums is offloaded to the network interface hardware if possible. The *m\_pkthdr* member of the leading *mbuf* of a packet contains two fields used for that purpose, *int csum\_flags* and *int csum\_data*. The meaning of those fields depends on the direction a packet flows in, and on whether the packet is fragmented. Henceforth, *csum\_flags* or *csum\_data* of a packet will denote the corresponding field of the *m\_pkthdr* member of the leading *mbuf* in the *mbuf chain* containing the packet.

On output, checksum offloading is attempted after the outgoing interface has been determined for a packet. The interface-specific field *ifnet.if\_data.if\_hwassist* (see *ifnet(9)*) is consulted for the capabilities of the interface to assist in computing checksums. The *csum\_flags* field of the packet header is set to indicate which actions the interface is supposed to perform on it. The actions unsupported by the network interface are done in the software prior to passing the packet down to the interface driver; such actions will never be requested through *csum\_flags*.

The flags demanding a particular action from an interface are as follows:

**CSUM\_IP** The IP header checksum is to be computed and stored in the corresponding field of the packet. The hardware is expected to know the format of an IP header to determine the offset of the IP checksum field.

**CSUM\_TCP** The TCP checksum is to be computed. (See below.)

**CSUM\_UDP**

The UDP checksum is to be computed. (See below.)

Should a TCP or UDP checksum be offloaded to the hardware, the field *csum\_data* will contain the byte offset of the checksum field relative to the end of the IP header. In this case, the checksum field will be initially set by the TCP/IP module to the checksum of the pseudo header defined by the TCP and UDP specifications.

On input, an interface indicates the actions it has performed on a packet by setting one or more of the following flags in *csum\_flags* associated with the packet:

**CSUM\_IP\_CHECKED** The IP header checksum has been computed.

**CSUM\_IP\_VALID** The IP header has a valid checksum. This flag can appear only in combination with **CSUM\_IP\_CHECKED**.

**CSUM\_DATA\_VALID**

The checksum of the data portion of the IP packet has been computed and stored in the field *csum\_data* in network byte order.

**CSUM\_PSEUDO\_HDR**

Can be set only along with **CSUM\_DATA\_VALID** to indicate that the IP data checksum found in *csum\_data* allows for the pseudo header defined by the TCP and UDP specifications. Otherwise the checksum of the pseudo header must be calculated by the host CPU and added to

*csum\_data* to obtain the final checksum to be used for TCP or UDP validation purposes.

If a particular network interface just indicates success or failure of TCP or UDP checksum validation without returning the exact value of the checksum to the host CPU, its driver can mark CSUM\_DATA\_VALID and CSUM\_PSEUDO\_HDR in *csum\_flags*, and set *csum\_data* to 0xFFFF hexadecimal to indicate a valid checksum. It is a peculiarity of the algorithm used that the Internet checksum calculated over any valid packet will be 0xFFFF as long as the original checksum field is included.

## STRESS TESTING

When running a kernel compiled with the option MBUF\_STRESS\_TEST, the following sysctl(8)-controlled options may be used to create various failure/extreme cases for testing of network drivers and other parts of the kernel that rely on *mbufs*.

*net.inet.ip.mbuf\_frag\_size*

Causes **ip\_output()** to fragment outgoing *mbuf chains* into fragments of the specified size. Setting this variable to 1 is an excellent way to test the long *mbuf chain* handling ability of network drivers.

*kern.ipc.m\_defragrandomfailures*

Causes the function **m\_defrag()** to randomly fail, returning NULL. Any piece of code which uses **m\_defrag()** should be tested with this feature.

## RETURN VALUES

See above.

## SEE ALSO

ifnet(9), mbuf\_tags(9)

S. J. Leffler, W. N. Joy, R. S. Fabry, and M. J. Karels, "Networking Implementation Notes", *4.4BSD System Manager's Manual (SMM)*.

## HISTORY

*Mbufs* appeared in an early version of BSD. Besides being used for network packets, they were used to store various dynamic structures, such as routing table entries, interface addresses, protocol control blocks, etc. In more recent FreeBSD use of *mbufs* is almost entirely limited to packet storage, with *uma(9)* zones being used directly to store other network-related memory.

Historically, the *mbuf* allocator has been a special-purpose memory allocator able to run in interrupt

contexts and allocating from a special kernel address space map. As of FreeBSD 5.3, the *mbuf* allocator is a wrapper around *uma(9)*, allowing caching of *mbufs*, clusters, and *mbuf* + cluster pairs in per-CPU caches, as well as bringing other benefits of slab allocation.

## AUTHORS

The original **mbuf** manual page was written by Yar Tikhyy. The *uma(9)* *mbuf* allocator was written by Bosko Milekic.