Chapter 4

Cooperative Message Passing

This chapter describes the CMMD functions used for cooperative (that is, synchronous or blocking) point-to-point message passing.

The cooperative message-passing functions are

```
CMMD_send_block[_v]
CMMD_receive_block[_v]
CMMD_send_and_receive[_v]
CMMD_swap
```

These functions synchronize the sending and receiving nodes before sending the data. Once a node has called one of these functions, it "blocks," or waits for its share of the transmission to be complete, before it does anything else. More precisely, the sending node waits until it has injected the last byte of the message into the Data Network; the receiving node waits until it has received into memory the last byte from the Data Network.

These functions can be used in conjunction with each other, or with the asynchronous message-passing functions described in Chapter 6. For example, a message can be transmitted via an asynchronous send plus a cooperative receive.

Implementation Note. Blocking functions use the CMMD handshake protocol, as explained in Section 2.1.1 and in more detail in Appendix B, Section B.2. Invoking a blocking function places the node in a polling loop. The sending node, having sent a *request to send* (*RTS*), does nothing but check for incoming messages until the *acknowledgment* (*ACK*) from the destination node arrives; then it transmits data until the message transmission is complete. (See Figure 7.) The receiving node does nothing but check for incoming messages until the RTS arrives. Then it sends its ACK and resumes checking for messages until the transmission is complete. (See Figure 8.)

Copyright © 1995 Thinking Machines Corporation

4.1 Buffers and Arrays

The “messages” (or “buffers”) transmitted by message-passing functions are arrays of data. Transmission copies the data from some location in the sending node’s memory to some location in the receiving node’s memory.

Most of the cooperative message-passing functions handle three kinds of arrays: serial arrays, vector serial arrays, and parallel arrays. (Asynchronous functions do not accept vector serial arrays.)

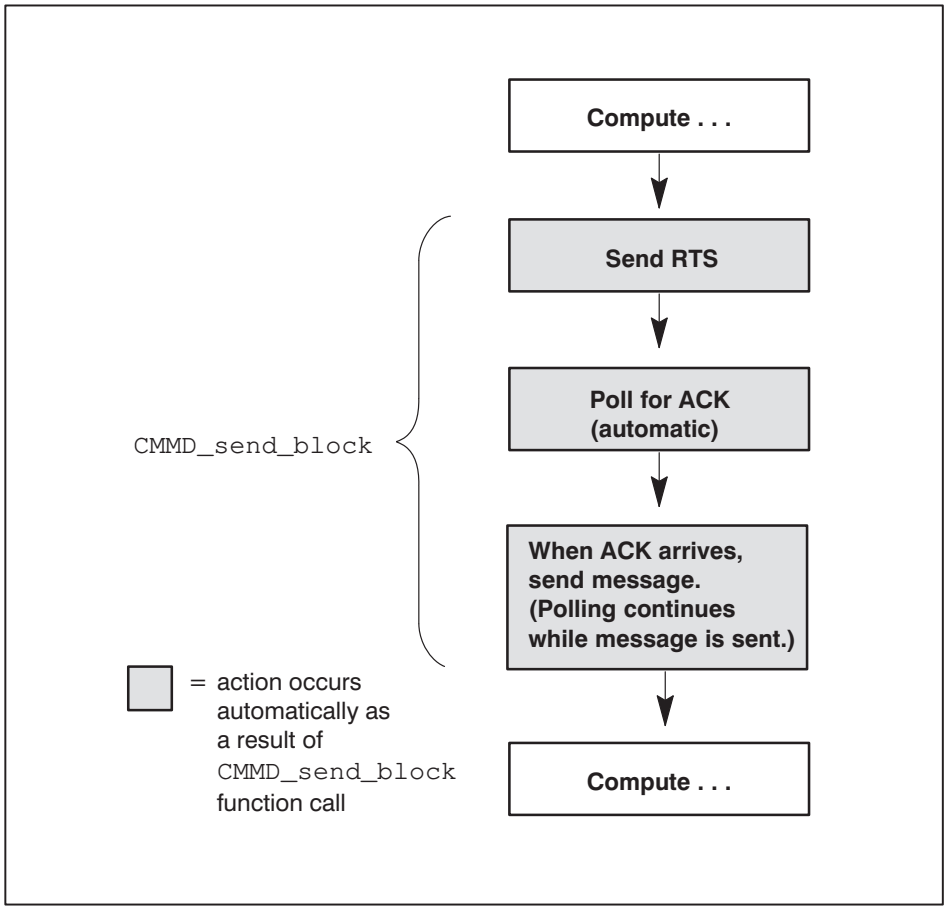


Figure 7. Blocking send.

Version 3.3, April 1995
Copyright © 1995 Thinking Machines Corporation

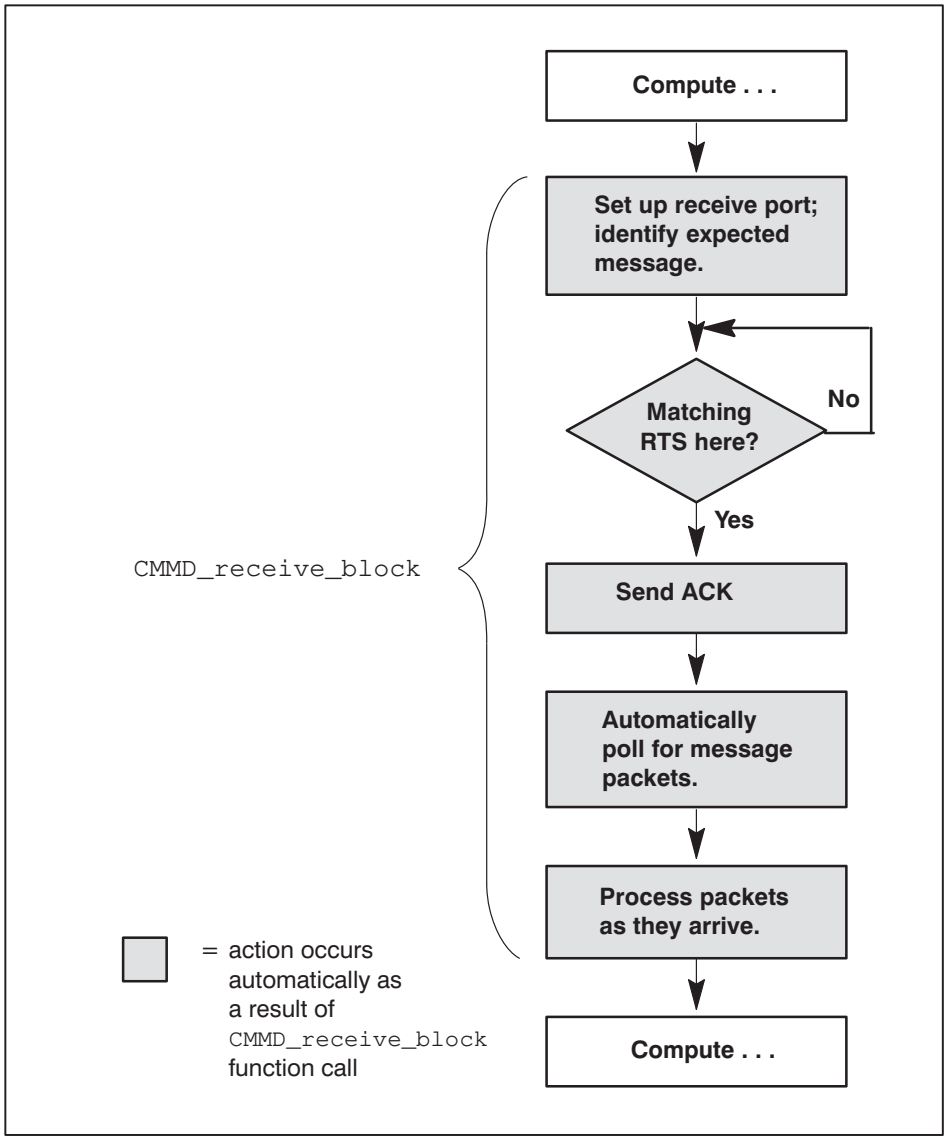


Figure 8. Blocking receive.

Copyright © 1995 Thinking Machines Corporation

4.1.1 Serial Arrays

As explained in Section 3.6, serial arrays reside in "microprocessor memory" on the node, or (for a host program) on the host.

Serial arrays may be standard C or Fortran variables, arrays, or structures, CM Fortran "FE arrays," or C* "scalar variables."

Serial arrays are described to CMMD functions by location (the *buffer* argument) and length (the *buffer_desc* argument). The length supplied to the function is arbitrary.

CMMD does not require the lengths of sending and receiving buffers to match; in particular, the receiving buffer may be longer than the sending buffer, to accommodate messages of various sizes.

Serial arrays may be sent to, or received from, other serial arrays, either block serial or vector serial. They may not be sent to, or received from, parallel arrays.

Implementation Notes: Currently, serial buffers must be less than 2^{25} bytes (32 Mbytes) in length. This limit is set by the symbolic limit CMMD_BYTE_LIMIT, and may change in future releases.

As a rule of thumb, communication operations that use doubleword-aligned memory are generally faster than those that use word-aligned memory; they, in turn, will be faster than those that use byte-aligned data. In some cases, alignment may significantly impact performance.

4.1.2 Parallel Arrays

Parallel arrays reside in VU memory on the nodes. They cannot exist on the host.

Parallel arrays *always* correspond to application-defined arrays, never to ordinary variables or structures. Cooperative message-passing functions must always transmit either a complete parallel array or a properly defined array section. Send and receive buffers must be identical. (Asynchronous functions cannot transmit array sections.)

Parallel arrays have *shape* as well as size. An 8 x 8 parallel array is not the same as a 16 x 4 parallel array: one cannot be the destination for the other. (On the other hand, a 512 x 512 array can be the destination for a 512 x 512

Version 3.3, April 1995
Copyright © 1995 Thinking Machines Corporation

section of a 1024 x 1024 array, and vice versa.) For CM Fortran arrays, the layout and alignment of the source and destination arrays must be identical.

The syntax for functions handling parallel arrays varies according to the language in which the arrays are created and used:

- In CM Fortran, a parallel array represents a CM array. (More precisely, it represents the CMRT descriptor that defines that array.) When you supply a CM array to a messaging function, you use the `CMMD_PARALLEL_ARRAY` keyword as the *`buffer_desc`* argument; CMMD then gets all information on array size, shape, type, and location from the CMRT descriptor.

- In C*, a parallel array represents a parallel variable. (More precisely, it represents a pointer to the pvar descriptor that defines that parallel variable.) When you supply a C* parallel variable to a messaging function, you supply the length (in bytes) of a single data element as the *`buffer_desc`* argument, and use the `void:void` data type for the *`buffer`* argument (as shown in the syntax statements for the various functions); CMMD then gets all information on array size, shape, type, and location from the pvar descriptor.

- In DPEAC, a parallel array represents a VU data or instruction space address in `ALL_DPS` space. In this case, the *`buffer_desc`* argument is simply the length in bytes of the data to be transmitted, just as if the buffer were a serial buffer. The system recognizes the address as being in VU memory, and acts accordingly.

  (See the *VU Programmer's Handbook* and the *CMMD User's Guide* for information on programming in DPEAC and for some hints on using DPEAC with CMMD.)

Implementation Note: In Version 3.0 and above, parallel buffers must be smaller than 2^{25} bytes for all VUs, or 2^{23} bytes (8 megabytes) for one VU. (Again, this may change in future releases.)

Programmers may also wish to note more details regarding "serial memory" and "parallel memory." Serial memory is cacheable; parallel memory typically is not. The VUs can access only parallel memory. The microprocessor can access all of memory; however, accesses into VU memory are typically slower than accesses into cacheable memory, since each access represents an uncached load.

Copyright © 1995 Thinking Machines Corporation

In addition, the microprocessor can access the memory of any single VU as if it were serial memory. Again, however, the access will be slower than an access to serial memory.

Moving Data between Serial and Parallel Memory

CMMD cannot transfer data between serial and parallel memory. If you need to move data between these two types of memory, you must first use language resources (such as CM Fortran Utility Library routines, for CM Fortran) to move the data from one type of memory to another on the source node, and then transmit the data to the destination node.

Array Sections. You can use parallel array sections as arguments to blocking send and receive functions. Let us take a CM Fortran array as an example. The normal CM Fortran calling rules apply. CM Fortran evaluates any array expression, including array sections, into a canonical temporary array; it then passes the temporary array to the calling function or subroutine.

What CMMD sees, therefore, is this temporary array. Suppose a program contains the line

```
CMMD_send_block(2, CMMD_DEFAULT_TAG,
     A(1:64,257:512), CMMD_PARALLEL_ARRAY)
```

An array of 64 x 256 elements is passed to `CMMD_send_block`. `CMMD_send_block` transfers that array in its entirety and requires a destination array dimensioned 64 x 256 for the receipt of this transfer.

Suppose the matching receive call were

```
CMMD_receive_block(1, CMMD_DEFAULT_TAG,
     B(1:64,1:256), CMMD_PARALLEL_ARRAY)
```

In this case, the message would be received into a temporary buffer created by CM Fortran to hold the array section. When the message arrives, CMMD marks the buffer as modified, causing CM Fortran to modify the original array accordingly.

The creation of these temporary arrays does, of course, consume some resources of time and space; the expense varies according to the geometry and layout involved.

Version 3.3, April 1995
Copyright © 1995 Thinking Machines Corporation

4.1.3 Vector Serial Arrays

A serial array, sent by `CMMD_send_block`, begins at the starting place identified by the *`buffer`* argument, and proceeds for *`buffer_desc`* sequential bytes. A vector message, sent by `CMMD_send_block_v`, takes a number of possibly noncontiguous (but evenly spaced) elements from the buffer, and sends those as a sequential message. (In other words, it performs an implicit gather.) It uses four arguments for information: *`buffer`*, *`elem_count`* (the number of elements in the vector), *`stride`*, and *`elem_len`*.

Usually, the stride specified for `CMMD_send_block_v` is larger than the element length. This difference creates the vector send: *`elem_len`* bytes are put into the message, then (*`stride`* minus *`elem_len`*) bytes are skipped over, then the next *`elem_len`* bytes are added to the message, and so on, until the specified number of elements has been placed in the message to be sent.

If the stride and element length are specified as being equal, the result is the same as a nonvector send: (*`elem_len`* * *`elem_count`*) bytes are sent.

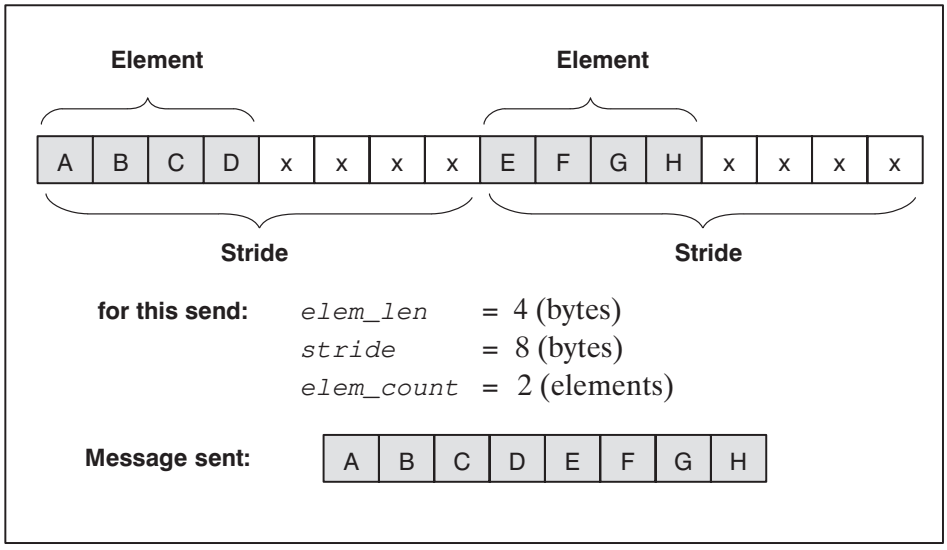


Figure 9. A vectored send.

If the stride is smaller than the element length, `CMMD_send_block_v` sends *`elem_len`* bytes starting at each stride. For example, a stride of 0 would result in the same element being sent *`elem_count`* times.

Copyright © 1995 Thinking Machines Corporation

Note that you do not specify the total length of the message in a vectored call. Rather, the "true" length is the result of multiplying the number of elements by the element length. Note that this implies that unless the element length is greater than or equal to the stride, the buffer itself must be longer than the message to be sent from it.

As an example of regular and vectored sends, let us consider the case of a 4 x 6 matrix A, filled with 32-bit integers from 0 to 23, laid out in memory as follows:

$$A = \begin{bmatrix} 0 & 1 & 2 & 3 & 4 & 5 \\ 6 & 7 & 8 & 9 & 10 & 11 \\ 12 & 13 & 14 & 15 & 16 & 17 \\ 18 & 19 & 20 & 21 & 22 & 23 \end{bmatrix}$$

To send the top row of the matrix as a message to node 5, you would use the call

```
CMMD_send_block(5, CMMD_DEFAULT_TAG, &A, 24)
```

To send the first column of the matrix to node 3, on the other hand, you would need a vector send, stating that you were sending four elements (*elem_count*), each four bytes long (*elem_len*), located 24 bytes apart (*stride*).

```
CMMD_send_block_v(3, CMMD_DEFAULT_TAG, &A, 4, 24, 4)
```

Usually, the receiving node would accept the first message with a standard receiving call (`CMMD_receive_block`) and the second with a vector receiving call (`CMMD_receive_block_v`), thus preserving the original geometry of the data. They are not, however, required to do so. Indeed, you could transpose this sample matrix by sending each row as a sequential message, but having each received as a six-element vector.

As shown in the example above, *elem_len* and *stride* usually reflect your data element sizes. Note, though, that CMMD does not constrain them to do so. If a function call requests the transfer of partial data elements, CMMD will oblige.

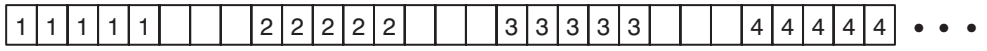
Note, too, that element lengths of sent and received vectors are not necessarily identical. Let us look at some examples of sending and receiving 32-bit integers. (In the diagrams below, a single box represents an integer, 4 bytes long.)

Version 3.3, April 1995
Copyright © 1995 Thinking Machines Corporation

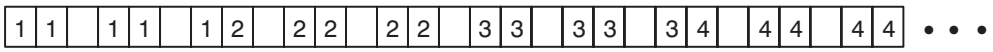
Example 1: *selem_len* > *delem_len*

```
selem_len = 20, sstride = 32,
delem_len = 8,  dstride = 12
```

The source buffer contains



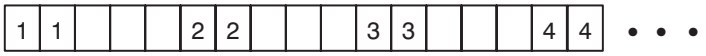
and the destination buffer (after the operation) contains



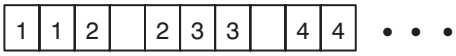
Example 2: *selem_len* < *delem_len*

```
selem_len = 8,  sstride = 20,
delem_len = 12, dstride = 16
```

The source buffer contains



and the destination buffer (after the operation) contains



The placement of the data in the destination buffer thus depends on the relationship between *stride* and *elem_len* in the receive call.

- If *stride* > *elem_len* (the usual case), the elements are placed in the specified buffer at intervals, each separated by (*stride* minus *elem_len*) bytes.
- If *stride* = *elem_len*, then the elements are placed contiguously in the buffer, as for a standard receive.
- If *stride* < *elem_len*, subsequent elements overwrite previous ones where they overlap.

Copyright © 1995 Thinking Machines Corporation

Gathers and Scatters. While `CMMD_send_block_v` and `CMMD_receive_block_v` are frequently paired, so that data is sent and received with a constant vector striding, it is possible for the source and destination vector striding to be different. For instance, sequential data may be broken into a vector (thus "scattering" the data), or a vector received as sequential (thus "gathering" it). Figure 10 shows the four possible patterns.

Performance and Implementation

Vector send and receive functions are convenience functions only; they do not perform as well as block serial operations. For Version 3.0 and higher, cooperative vectored transmissions are implemented with temporary arrays. This implementation may change at future releases. Users may prefer to create their own temporary arrays, gather data into those, and use the block serial send and receive routines (scattering data again on the receiving node if necessary). This is true particularly if the same temporaries will be used more than once.

For Version 3.0 and higher, the following limits exist: element length and stride must each be less than 2^{16} bytes in size; number of elements must be less than 2^{28} bytes long; and total buffer length must be less than 2^{25} bytes long. These limits are set by the symbolic limits `CMMD_ESIZE_LIMIT`, `CMMD_ESTRIDE_LIMIT`, `CMMD_ECOUNT_LIMIT`, and `CMMD_BYTE_LIMIT`. They may change in future versions of the library.

Copyright © 1995 Thinking Machines Corporation

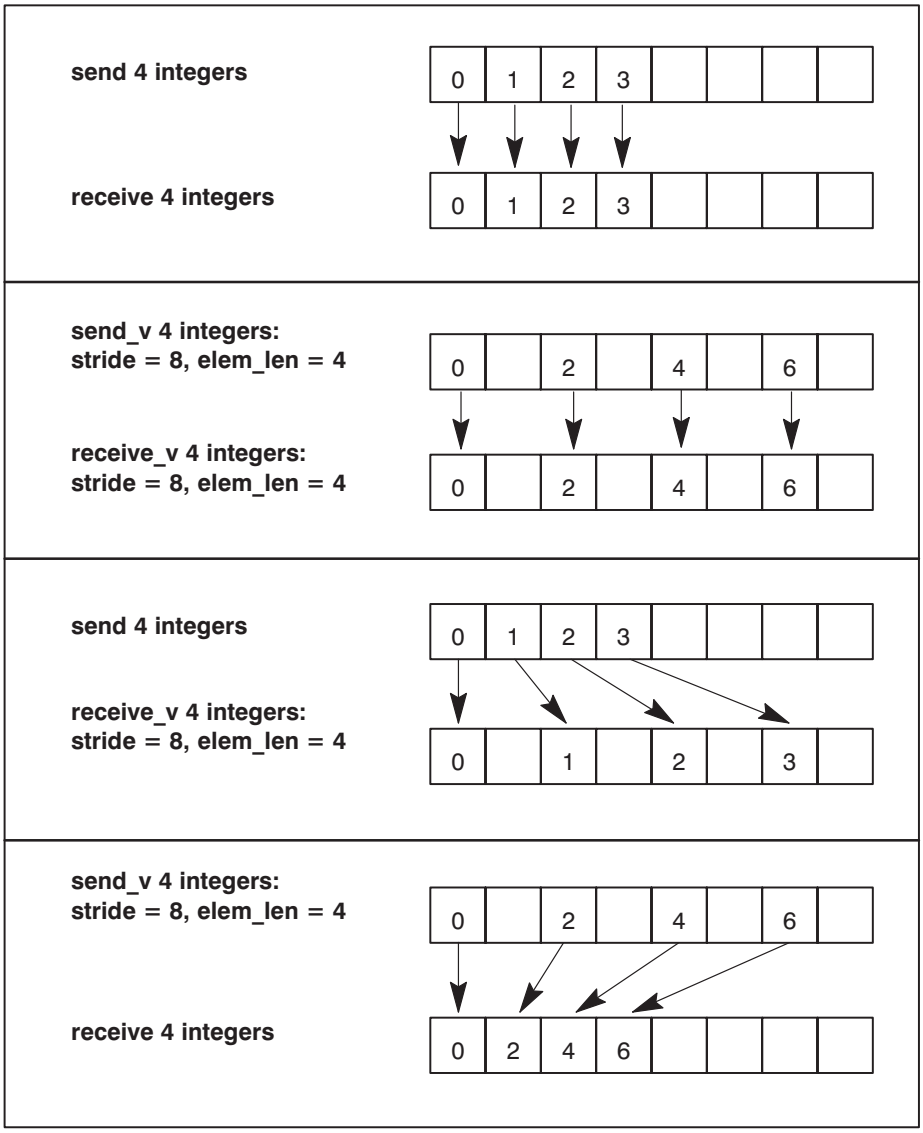


Figure 10. Sending and receiving data.

Copyright © 1995 Thinking Machines Corporation

4.2 Reference Pages

The remainder of this chapter contains reference pages for the following functions:

Sending a message:
`CMMD_send_block`
`CMMD_send_block_v`

Receiving a message:
`CMMD_receive_block`
`CMMD_receive_block_v`

Simultaneous sends and receives:
`CMMD_send_and_receive`
`CMMD_send_and_receive_v`

Two-node message swapping:
`CMMD_swap`
`CMMD_swap_v`

Version 3.3, April 1995
Copyright © 1995 Thinking Machines Corporation

CMMD_send_block
CMMD_send_block_v

These functions send the contents of a specified buffer to the given destination node.

SYNOPSIS

C Syntax

```
int CMMD_send_block(int dest_node, int tag,
        void *buffer, int buffer_desc)

int CMMD_send_block_v(int dest_node, int tag,
        void *buffer, int elem_len, int stride,
        int elem_count)
```

CM Fortran Syntax

```
INTEGER FUNCTION  CMMD_send_block(dest_node, tag,
        buffer, buffer_desc)

    INTEGER   dest_node, tag, buffer_desc
    <ARRAY>   buffer

INTEGER FUNCTION  CMMD_send_block_v(dest_node, tag,
        buffer, elem_len, stride, elem_count)

    INTEGER   dest_node, tag, elem_len, stride, elem_count
    <ARRAY>   buffer
```

C* Syntax, for Parallel Arrays Only

```
int CMMD_send_block (int dest_node, void:void *buffer,
        int array_element_length)
```

ARGUMENTS

dest_node	An integer identifying the node to which the message is to be sent.
tag	A positive integer that serves as a label for the message, or CMMD_DEFAULT_TAG.

Copyright © 1995 Thinking Machines Corporation

buffer The area in memory that contains the message to be sent.

buffer_desc (Nonvector sends only.) A buffer descriptor. For serial arrays, or parallel variables in DPEAC, a non-negative integer specifying the length of the buffer across all VUs, in bytes. For CM Fortran parallel arrays, the keyword `CMMD_PARALLEL_ARRAY`. For C* parallel arrays, the length in bytes of a single data element.

elem_len (Vector sends only.) An integer specifying the length of each element in the vector.

stride (Vector sends only.) An integer specifying the distance in bytes between the starting addresses of vector elements.

elem_count (Vector sends only.) An integer specifying the number of elements in the vector.

array_element_length
(C* only.) Length of a single element in the array.

RETURNS

These functions do not return until the message has been transmitted. Return values are as follows:

Return Value	Meaning
0	The transfer succeeded; the full message was sent.
1	Failure — not all array elements were sent.
`CMMD_ERRVAL`	An error occurred.

See Section 5.3 for a description of the accessor functions you can use to determine how many bytes of a message were actually sent.

DESCRIPTION

The `CMMD_send_block` functions send the contents of a specified buffer to the given destination node. (A buffer length of 0 sends a zero-length message; there must be a receiving peer node.) The destination node must be inside the partition, or it must be the host; otherwise, an error results. The message may be identified by a user-supplied tag; the symbol `CMMD_DEFAULT_TAG` is the standard default tag.

Version 3.3, April 1995
Copyright © 1995 Thinking Machines Corporation

The transfer does not take place until the receiving node has made a call to one of the CMMD receive functions, indicating that it is ready to receive the message. The function blocks until the transfer takes place.

Buffers. Serial arrays must be sent to serial buffers, parallel arrays to parallel buffers. If you need to transfer data between serial and parallel arrays, you must do the transformation and the transfer in two separate steps.

For parallel arrays, source and destination buffers must be identical in size and shape. For CM Fortran, they must either use canonical layout or be identical in layout and alignment.

Buffers should not overlap other buffers used in communication operations.

For more detailed information on buffers, see Section 4.1.

Vector Sends. A serial array, sent by `CMMD_send_block`, begins at the starting place identified by the *`buffer`* argument, and proceeds for *`buffer_desc`* sequential bytes. A vector message, sent by `CMMD_send_block_v`, takes a number of possibly non-contiguous elements from the buffer, and sends those as a sequential message. (In other words, it performs an implicit gather.)

Ordinarily, the stride specified for `CMMD_send_block_v` is larger than the element length. This difference creates the vector send: *`elem_len`* bytes are put into the message, then (*`stride`* minus *`elem_len`*) bytes are skipped over, then the next *`elem_len`* bytes are added to the message, and so on, until the specified number of elements has been placed in the message to be sent.

If the stride and element length are specified as being equal, the result is the same as a nonvector send: (*`elem_len`* * *`elem_count`*) bytes are sent.

If the stride is smaller than the element length, `CMMD_send_block_v` sends *`elem_len`* bytes starting at each stride. For example, a stride of 0 would result in the same element being sent *`elem_count`* times.

Note that you do not specify the total length of the buffer in a vectored call. Rather, the length is the result of multiplying the number of elements by the element length. Note that this implies that unless the element length is greater than or equal to the stride, the buffer itself must be longer than the message to be sent from it.

Copyright © 1995 Thinking Machines Corporation

Callback and Handler Functions. `CMMD_send_block` and `CMMD_send_block_v` cannot be called by handler functions or callback functions.

Version 3.3, April 1995
Copyright © 1995 Thinking Machines Corporation

CMMD_receive_block
CMMD_receive_block_v

These functions receive a serial or parallel array, or a vector serial array, from *source_node*; they block until the full message is received.

SYNOPSIS

C Syntax

```
int CMMD_receive_block(int source_node, int tag,
          void *buffer, int buffer_desc)

int CMMD_receive_block_v(int source_node, int tag,
          void *buffer, int elem_len,
          int stride, int elem_count)
```

Fortran Syntax

```
INTEGER FUNCTION CMMD_receive_block(source_node, tag,
          buffer, buffer_desc)

    INTEGER source_node, tag, buffer_desc
    <ARRAY> buffer

INTEGER FUNCTION CMMD_receive_block_v(source_node,
          tag, buffer, elem_len, stride,elem_count)

    INTEGER source_node, tag, elem_len, stride, elem_count
    <ARRAY> buffer
```

C* Syntax, for Parallel Arrays Only

```
int CMMD_receive_block (int source_node, int tag,
          void:void *buffer, int array_element_length)
```

ARGUMENTS

source_node — An integer identifying the node from which the message will be sent (`CMMD_ANY_NODE` allows any node to be the sender).

Copyright © 1995 Thinking Machines Corporation

tag A positive integer, or CMMD_DEFAULT_TAG, that serves as a label for the message. Alternatively, CMMD_ANY_TAG, which allows receipt of a message labeled with any tag.

buffer The area in memory that will contain the message to be received.

buffer_desc (Buffer descriptor, nonvector sends only.) A nonnegative integer defining the number of bytes in the receive buffer, or the keyword CMMD_PARALLEL_ARRAY, for a CM Fortran parallel array; or the length of a single data element, for a C* parallel array.

elem_len (Vector function only.) An integer specifying the length of each element in the vector, in bytes.

stride (Vector function only.) An integer specifying the distance in bytes between the starting addresses of the vector elements.

elem_count (Vector function only.) An integer specifying the number of elements in the vector.

array_element_length
(C* only.) Length of a single element in the array.

RETURNS

These functions return only after the message has been received and copied into the specified buffer. They return an integer value, as follows:

Return Value	Meaning
0	The transfer succeeded; full message was received.
1	Failure — not all array elements were received.
CMMD_ERRVAL	An error occurred.

If the return value is 1, your program can call CMMD_bytes_received (see Section 5.3) to get the number of bytes actually received. Note that if the number of bytes actually received is less than the number requested, the excess portion of the receive buffer is left in an undefined state.

Version 3.3, April 1995
Copyright © 1995 Thinking Machines Corporation

DESCRIPTION

The CMMD_receive_block functions post a receive buffer as being available to receive a message of a particular length or array type, with a specified tag; they then wait for a message with the specified tag to be sent from the specified source. These routines can take the special symbol CMMD_ANY_NODE as the source argument, indicating that any source node is acceptable, and the symbol CMMD_ANY_TAG as the tag argument, indicating that any tag will be accepted.

If CMMD_ANY_NODE is given, the program can call the function CMMD_msg_sender to get the node identifier of the actual sender; if CMMD_ANY_TAG is used, CMMD_msg_tag can be called to get the tag of the accepted message.

Upon transmission, data is received into the specified buffer.

As with the CMMD_send_block[_v] routines, the buffers must not overlap with other buffers being used in communications functions. Also, parallel arrays must be identical in size and shape on sending and receiving nodes.

Vector Messages. CMMD_receive_block_v may be used when incoming data is to be stored in noncontiguous memory locations. The call specifies that the information to be received be considered a vector of *elem_count* elements, each *elem_length* bytes long, each element to be placed in an area of the buffer that is *stride* bytes in length.

The placement of the data in the buffer thus depends on the relationship between *stride* and *elem_len*.

- If *stride* > *elem_len* (the usual case), the elements are placed in the specified buffer at intervals, each separated by (*stride* minus *elem_len*) bytes.
- If *stride* = *elem_len*, then the elements are placed contiguously in the buffer, as for a standard receive.

If *stride* < *elem_len*, subsequent elements overwrite previous ones where they overlap.

Callback and Handler Functions. CMMD_receive_block and CMMD_receive_block_v cannot be called by handler functions or callback functions.

Copyright © 1995 Thinking Machines Corporation

CMMD_send_and_receive
CMMD_send_and_receive_v

These two functions cause a node to send one message and receive one simultaneously. The node blocks until both messages have completed.

SYNOPSIS

C Syntax

```
int CMMD_send_and_receive(int source_node, int source_tag,
          void *inbuffer, int inbuf_desc, int dest_node,
          int dest_tag, void *outbuffer, int outbuf_desc)

int CMMD_send_and_receive_v(int source_node, int source_tag,
          void *inbuffer, int in_elem_len, int in_stride,
          int in_elem_count, int dest_node, int dest_tag,
          void *outbuffer, int out_elem_len, int out_stride,
          int out_elem_count)
```

Fortran Syntax

```
INTEGER FUNCTION CMMD_send_and_receive(source_node, source_tag,
          inbuffer, inbuf_desc, dest_node, dest_tag, outbuffer,
          outbuf_desc)

    INTEGER   source_node, source_tag, inbuf_desc,
    INTEGER   dest_node, dest_tag, outbuf_desc
    <ARRAY>   inbuffer, outbuffer

INTEGER FUNCTION CMMD_send_and_receive_v(source_node,
          source_tag, inbuffer, in_elem_len, in_stride,
          in_elem_count, dest_node, dest_tag, outbuffer,
          out_elem_len, out_stride, out_elem_count)

    INTEGER source_node, source_tag
    INTEGER in_elem_len, in_stride, in_elem_count
    INTEGER dest_node, dest_tag
    INTEGER out_elem_len, out_stride, out_elem_count
    <ARRAY> inbuffer, outbuffer
```

C* Syntax, for Parallel Arrays Only

```
int CMMD_send_and_receive(source_node, int source_tag,
                          void:void *inbuffer, int inbuf_desc,
```


Version 3.3, April 1995
Copyright © 1995 Thinking Machines Corporation

```
                    int dest_node, int dest_tag,
                    void:void *outbuffer, int outbuf_desc)
```

ARGUMENTS

source_node	An integer identifying the node from which the incoming message will be received.
source_tag	A positive integer, or CMMD_DEFAULT_TAG, labeling the message to be received. Alternatively, CMMD_ANY_TAG.
inbuffer	The area in memory that will contain the message to be received.
inbuf_desc	(Nonvector function only.) The length, in bytes, of the buffer that will hold the message received by this node. For CM Fortran parallel arrays, the keyword CMMD_PARALLEL_ARRAY. For C* parallel arrays, the length, in bytes, of a single data element.
in_elem_len	(Vector function only.) Length, in bytes, of each element in the vector to be received by this node.
in_stride	(Vector function only.) Number of bytes between starting addresses of elements in the vector that constitutes the message to be received by this node.
in_elem_count	(Vector function only.) Number of elements in the vector to be received by this node.
dest_node	An integer identifying the node to which this node will send a message.
dest_tag	A positive integer labeling the message that will be sent by this node.
outbuffer	The area in memory holding the message to be sent by this node.
outbuf_desc	(Nonvector function only.) The length, in bytes, of the buffer that will hold the message sent by this node. For CM Fortran parallel arrays, the keyword CMMD_PARALLEL_ARRAY. For C* arrays, the length, in bytes, of a single data element.

Copyright © 1995 Thinking Machines Corporation

out_elem_len (Vector function only.) Length, in bytes, of each element in the vector to be sent by this node. Should be a multiple of the appropriate data type size.

out_stride (Vector function only.) Number of bytes by which starting addresses of elements in the vector to be sent are separated. Should be a multiple of *out_elem_len*, or 0.

out_elem_count (Vector function only.) Number of elements in the vector to be sent by this node.

RETURNS

`CMMD_send_and_receive` and `CMMD_send_and_receive_v` do not return until the calling node has sent one message and received one. They return integer values, as follows:

Return Value	Meaning
0	The transfer succeeded; full message was sent.
1	Failure — not all bytes were sent or received.
`CMMD_ERRVAL`	An error occurred.

If the return value is 1, the application can call `CMMD_bytes_sent` (see Section 5.3) to get the number of bytes actually sent, and `CMMD_bytes_received` to get the number of bytes actually received. Note that if the number of bytes actually received is less than the number requested, the excess portion of the receive buffer is left in an undefined state.

DESCRIPTION

These two functions cause nodes to send and receive messages simultaneously. Any number of nodes can take part in one of these calls; the only requirement is that each node must both send a message and receive a message. (See `CMMD_swap` and `CMMD_swap_v` for a simpler way to send and receive simultaneously when two nodes are involved, each serving as both source and destination for the other.)

The functions cause the message in the calling node's outbuffer to be passed to the destination node at the same time that a message is read into the calling node's inbuffer from the source node. Buffers may not overlap with other buffers being used in communication functions.

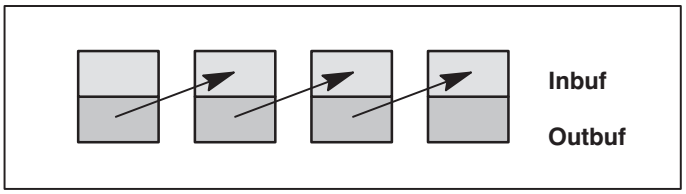
Version 3.3, April 1995
Copyright © 1995 Thinking Machines Corporation

NOTES

1. In vector operations, the strides for sent and received messages do not have to be equal.

2. Sends and receives may be mixed with `send_and_receive` functions. For example, you might mix these calls in order to create an end-off shift on four nodes:

   Node 0: `CMMD_send_block`: uses boundary value, sends to node 1
   Node 1: `CMMD_send_and_receive`: receives from 0, sends to 2
   Node 2: `CMMD_send_and_receive`: receives from 1, sends to 3
   Node 3: `CMMD_receive_block`: receives from 2



Callback and Handler Functions. These functions cannot be called by handler or callback functions.

Copyright © 1995 Thinking Machines Corporation

CMMD_swap
CMMD_swap_v

These functions send a serial or parallel array (or a vector serial array, for `swap_v`) to *partner*, and receive one from *partner*. They block until both transmissions are complete.

SYNOPSIS

C Syntax

```
int CMMD_swap(int partner, void *inbuffer, int inbuf_desc,
        void *outbuffer, int outbuf_desc)

int CMMD_swap_v(int partner, void *inbuffer, int in_elem_len,
        int in_stride, int in_elem_count, void *outbuffer,
        int out_elem_len, int out_stride, int out_elem_count)
```

Fortran Syntax

```
INTEGER FUNCTION CMMD_swap(partner, inbuffer, inbuf_desc,
        outbuffer, outbuf_desc)

    INTEGER   partner, inbuf_desc, outbuf_desc
    <ARRAY>   inbuffer, outbuffer

INTEGER FUNCTION CMMD_swap_v(partner, inbuffer,in_elem_len,
        in_stride, in_elem_count,outbuffer, out_elem_len,
        out_stride, out_elem_count)

    INTEGER   partner, in_elem_len, in_stride, in_elem_count
    INTEGER   out_elem_len, out_stride, out_elem_count
    <ARRAY>   inbuffer, outbuffer
```

C* SYNTAX, for Parallel Arrays Only

```
 int CMMD_swap(int partner, void:void *inbuffer,
        int inbuf_desc, void:void *outbuffer, int outbuf_desc)
```

ARGUMENTS

partner	An integer identifying the node with which a message is to be swapped.

Version 3.3, April 1995
Copyright © 1995 Thinking Machines Corporation

inbuffer The buffer that will hold the received message.

inbuf_desc (CMMD_swap only.) The length, in bytes, of the buffer that will hold the message received by this node. For CM Fortan parallel arrays, the keyword CMMD_PARALLEL_ARRAY. For C* parallel arrays, the length, in bytes, of a single data element.

in_elem_len (CMMD_swap_v only.) The length, in bytes, of each element in the vector to be received by this node.

in_stride (CMMD_swap_v only.) Number of bytes between starting addresses of elements in the vector to be received by this node.

in_elem_count (CMMD_swap_v only.) Number of elements that constitute the vector to be received by this node.

outbuffer The buffer holding the message to be sent by this node.

outbuf_desc (CMMD_swap only.) For serial arrays, the length, in bytes, of the buffer that will hold the message received by this node. For CM Fortran parallel arrays, the keyword CMMD_PARALLEL_ARRAY. For C* parallel arrays, the length, in bytes, of a single data element.

out_elem_len (CMMD_swap_v only.) Length, in bytes, of each element in the vector to be sent by this node.

out_stride (CMMD_swap_v only.) Number of bytes by which starting addresses of elements in the vector to be sent are separated.

out_elem_count (CMMD_swap_v only.) Number of elements in the vector to be sent by this node.

RETURNS

These functions return an integer value, as follows:

Return Value	Meaning
0	The transfer succeeded; full message was sent.
1	Failure — not all bytes were sent or received.
CMMD_ERRVAL	An error occurred.

Copyright © 1995 Thinking Machines Corporation

Callback and Handler Functions. These functions may neither call nor be called by handler or callback functions.

DESCRIPTION

`CMMD_swap` is identical to `CMMD_send_and_receive` (and `CMMD_swap_v` to `CMMD_send_and_receive_v`) where the source node equals the destination node. Note that users cannot specify tags for swaps. The swap functions automatically use `CMMD_DEFAULT_TAG`.

For an explanation of serial versus vector functions, see `CMMD_send_block`.

Version 3.3, April 1995
Copyright © 1995 Thinking Machines Corporation