Libraries

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Contents

Chapter 1

Libraries

1.1 Amiga® RKM Libraries: 23 Exec Lists and Queues

The Amiga system software operates in a dynamic environment of data
structures. An early design goal of Exec was to keep the system flexible and open-ended by eliminating artificial boundaries on the number of system structures used. Rather than using static system tables, Exec uses dynamically created structures that are added and removed as needed. These structures can be put in an unordered list, or in an ordered list known as a queue. A list can be empty, but never full. This concept is central to the design of Exec. Understanding lists and queues is important to understanding not only Exec itself, but also the mechanism behind the Amiga's message and port based interprocess communication.

Exec uses lists to maintain its internal database of system structures. Tasks, interrupts, libraries, devices, messages, I/O requests, and all other Exec data structures are supported and serviced through the consistent application of Exec's list mechanism. Lists have a common data structure, and a common set of functions is used for manipulating them. Because all of these structures are treated in a similar manner, only a small number of list handling functions need be supported by Exec.

1.2 23 Exec Lists and Queues / List Structure

A list is composed of a header and a doubly-linked chain of elements
called nodes. The header contains memory pointers to the first and last nodes of the linked chain. The address of the header is used as the handle to the entire list. To manipulate a list, you must provide the

address of its header.

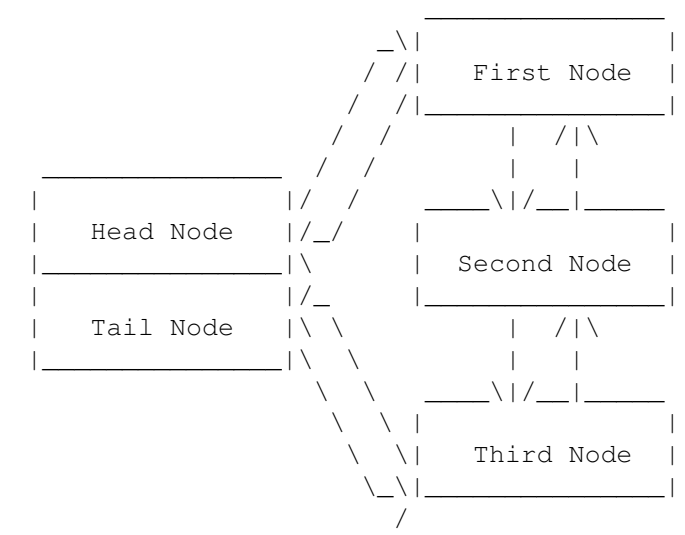


Figure 23-1: Simplified Overview of an Exec List

Nodes may be scattered anywhere in memory. Each node contains two pointers; a successor and a predecessor. As illustrated above, a list header contains two placeholder nodes that contain no data. In an empty list, the head and tail nodes point to each other.

Node Structure Definition

List Header Structure Definition

Node Initialization

Header Initialization

1.3 23 / List Structure / Node Structure Definition

A Node structure is divided into three parts: linkage, information ↩
, and
content. The linkage part contains memory pointers to the node's successor and predecessor nodes. The information part contains the node type, the priority, and a name pointer. The content part stores the actual data structure of interest. For nodes that require linkage only, a small MinNode structure is used.

```
struct MinNode
{
    struct MinNode *mln_Succ;
    struct MinNode *mln_Pred;
};
```

ln_Succ
points to the next node in the list (successor).

```
ln_Pred
    points to the previous node in the list (predecessor).

When a type, priority, or name is required, a full-featured Node structure
is used.

    struct Node
    {
        struct Node *ln_Succ;
        struct Node *ln_Pred;
        UBYTE        ln_Type;
        BYTE         ln_Pri;
        char        *ln_Name;
    };

ln_Type
    defines the type of the node (see <exec/nodes.h> for a list).

ln_Pri
    specifies the priority of the node  (+127 (highest) to -128
    (lowest)).

ln_Name
    points to a printable name for the node (a NULL-terminated
    string).

The Node and MinNode structures are often incorporated into larger
structures, so groups of the larger structures can easily be linked
together.   For example, the Exec Interrupt structure is defined as
follows:

    struct Interrupt
    {
        struct Node is_Node;
        APTR        is_Data;
        VOID        (*is_Code)();
    };

Here the is_Data and is_Code fields represent the useful content of the
node.  Because the Interrupt structure begins with a Node structure, it
may be passed to any of the Exec
                List
                 manipulation functions.
```

1.4 23 / List Structure / Node Initialization

```
                Before linking a node into a list, certain fields may need  ↩
                   initialization.
Initialization consists of setting the
                ln_Type
                ,
                ln_Pri
                , and
```

ln_Name
 fields
to their appropriate values (A MinNode structure does not have these fields). The successor and predecessor fields do not require initialization.

The
ln_Type
 field contains the data type of the node. This indicates to Exec (and other subsystems) the type, and hence the structure, of the content portion of the node (the extra data after the
Node
 structure).
The standard system types are defined in the <exec/nodes.h> include file. Some examples of standard system types are NT_TASK, NT_INTERRUPT, NT_DEVICE, and NT_MSGPORT.

The
ln_Pri
 field uses a signed numerical value ranging from +127 to -128 to indicate the priority of the node. Higher-priority nodes have greater values; for example, 127 is the highest priority, zero is nominal priority, and -128 is the lowest priority. Some Exec lists are kept sorted by priority order. In such lists, the highest-priority node is at the head of the list, and the lowest-priority node is at the tail of the list. Most Exec node types do not use a priority. In such cases, initialize the priority field to zero.

The
ln_Name
 field is a pointer to a NULL-terminated string of characters. Node names are used to find and identify list-bound objects (like public message ports and libraries), and to bind symbolic names to actual nodes. Names are also useful for debugging purposes, so it is a good idea to provide every node with a name. Take care to provide a valid name pointer; Exec does not copy name strings.

This fragment initializes a
Node
 called myInt, an instance of the

Interrupt
 data structure introduced above.

```
    struct Interrupt interrupt;

    interrupt.is_Node.ln_Type = NT_INTERRUPT;
    interrupt.is_Node.ln_Pri  = -10;
    interrupt.is_Node.ln_Name = "sample.interrupt";
```

1.5 23 / List Structure / List Header Structure Definition

As mentioned earlier, a list header maintains memory pointers to ↩
 the first

and last nodes of the linked chain of nodes. It also serves as a handle for referencing the entire list. The minimum list header ("mlh_") and the full-featured list header ("lh_") are generally interchangeable.

The structure MinList defines a minimum list header.

```
    struct MinList
    {
        struct MinNode *mlh_Head;
        struct MinNode *mlh_Tail;
        struct MinNode *mlh_TailPred;
    };
```

mlh_Head
    points to the first node in the list.

mlh_Tail
    is always NULL.

mlh_TailPred
    points to the last node in the list.

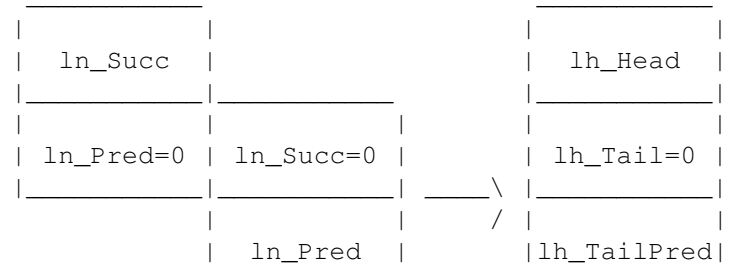
In a few limited cases a full-featured List structure will be required:

```
    struct List
    {
        struct Node *lh_Head;
        struct Node *lh_Tail;
        struct Node *lh_TailPred;
        UBYTE        lh_Type;
        UBYTE        lh_Pad;
    };
```

lh_Type
    defines the type of nodes within the list (see <exec/nodes.h>).

lh_pad
    is a structure alignment byte.

One subtlety here must be explained further. The list header is constructed in an efficient, but confusing manner. Think of the header as a structure containing the head and tail nodes for the list. The head and tail nodes are placeholders, and never carry data. The head and tail portions of the header actually overlap in memory. lh_Head and lh_Tail form the head node; lh_Tail and lh_TailPred form the tail node. This makes it easy to find the start or end of the list, and eliminates any special cases for insertion or removal.



```
                    |____________|       |____________|
```

Figure 23-2: List Header Overlap

The lh_Head and lh_Tail fields of the list header act like the ln_Succ and lh_Pred fields of a node. The lh_Tail field is set permanently to NULL, indicating that the head node is indeed the first on the list -- that is, it has no predecessors. See the figure above.

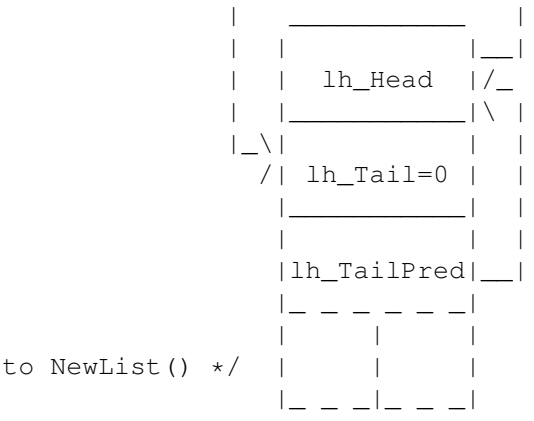
Likewise, the lh_Tail and lh_TailPred fields of the list header act like the ln_Succ and lh_Pred fields of a node. Here the NULL lh_Tail indicates that the tail node is indeed the last on the list -- that is, it has no successors. See the figure above.

1.6 23 / List Structure / Header Initialization

List headers must be properly initialized before use. It is not adequate to initialize the entire header to zero. The head and tail entries must have specific values. The header must be initialized as follows:

1. Set the lh_Head field to the address of lh_Tail.
2. Clear the lh_Tail field.
3. Set the lh_TailPred field to the address of lh_Head.
4. Set lh_Type to the same data type as the nodes to be kept the list. (Unless you are using a MinList).

Figure 23-3: Initializing a List Header Structure



```
    /* C example - equivalent to NewList() */
    struct List list;

    list.lh_Head          = (struct Node *) &list.lh_Tail;
    list.lh_Tail          = 0;
    list.lh_TailPred      = (struct Node*) &list.lh_Head;
    /* Now set lh_Type, if needed */

    ;Assembly example - equivalent to NEWLIST
          MOVE.L  A0,LH_HEAD(A0)  ;A0 points to the list header
          ADDQ.L  #4,LH_HEAD(A0)  ;Bump LH_HEAD(A0) to address of LH_TAIL
          CLR.L   LH_TAIL(A0)
          MOVE.L  A0,LH_TAILPRED(A0)
    ;Now set LH_TYPE, if needed.
```

The sequence of assembly instructions in the figure above is equivalent to the macro NEWLIST, contained in the include file <exec/lists.i>. Since the

MinList
structure is the same as the
List
structure except for the

type and pad fields, this sequence of assembly language code will work for both structures. The sequence performs its function without destroying the pointer to the list header in A0 (which is why ADDQ.L is used). This function may also be accessed from C as a call to NewList(header), where header is the address of a list header.

1.7 23 Exec Lists and Queues / List Functions

Exec provides a number of symmetric functions for handling lists. ↩ There

are functions for inserting and removing nodes, for adding and removing head and tail nodes, for inserting nodes in a priority order, and for searching for nodes by name. The prototypes for Exec list handling functions are as follows.

```
   Exec Functions
   --------------
   VOID AddHead( struct List *list, struct Node *node );
   VOID AddTail( struct List *list, struct Node *node );
   VOID Enqueue( struct List *list, struct Node *node );
```

```
   struct Node *FindName( struct List *list, UBYTE *name );
   VOID Insert( struct List *list, struct Node *node, struct Node *pred );
   VOID Remove( struct Node *node );
   struct Node *RemHead( struct List *list );
   struct Node *RemTail( struct List *list );

   Exec Support Functions in amiga.lib
   -----------------------------------
   VOID NewList( struct List *list );
```

In this discussion of the Exec list handling functions, header represents a pointer to
List
header, and node represents pointer to a
Node
.

1.8 23 / List Functions / Insertion and Removal

The Insert() function is used for inserting a new node into any position
in a list. It always inserts the node following a specified node that is already part of the list. For example, Insert(
header
,
node
,pred) inserts the node node after the node pred in the specified list. If the pred node points to the list header or is NULL, the new node will be inserted at the head of the list. Similarly, if the pred node points to the
lh_Tail

of
the list, the new node will be inserted at the tail of the list. However, both of these actions can be better accomplished with the functions mentioned in the "
Special Case Insertion
" section below.

The Remove() function is used to remove a specified node from a list. For example, Remove(
node
) will remove the specified node from whatever list it is in. To be removed, a node must actually be in a list. If you attempt to remove a node that is not in a list, you will cause serious system problems.

1.9 23 / List Functions / Special Case Insertion

Although the
Insert()
function allows new nodes to be inserted at the head and the tail of a list, the AddHead() and AddTail() functions will do so with higher efficiency. Adding to the head or tail of a list is common practice in first-in-first-out (
FIFO
) or last-in-first-out (
LIFO
or stack) operations. For example, AddHead(
header
,
node
) would insert the node at the head of the specified list.

1.10 23 / List Functions / Special Case Removal

The two functions RemHead() and RemTail() are used in combination ↩
with

AddHead()
and
AddTail()
to create special list ordering. When you combine AddTail() and RemHead(), you produce a first-in-first-out (FIFO) list. When you combine AddHead() and RemHead() a last-in-first-out (LIFO or stack) list is produced. RemTail() exists for symmetry. Other combinations of these functions can also be used productively.

Both RemHead() and RemTail() remove a
node

from the list, and return a
pointer to the removed node. If the list is empty, the function return a
NULL result.

1.11 23 / List Functions / MinList/MinNode Operations

All of the above functions and macros will work with long or short ↩
format
node structures. A
MinNode
structure contains only linkage information.
A full
Node
structure contains linkage information, as well as type,
priority and name fields. The smaller MinNode is used where space and
memory alignment issues are important. The larger Node is used for queues
or lists that require a name tag for each node.

1.12 23 / List Functions / Prioritized Insertion

The list functions discussed so far do not make use of the ↩
priority field
in a
Node
. The Enqueue() function is equivalent to
Insert()
, except it
inserts nodes into a list sorting them according to their priority. It
keeps the higher-priority nodes towards the head of the list. All nodes
passed to this function must have their priority and name assigned prior
to the call. Enqueue(
header
,mynode) inserts mynode behind the lowest
priority node with a priority greater than or equal to mynode's. For
Enqueue() to work properly, the list must already be sort according to
priority. Because the highest priority node is at the head of the list,
the
RemHead()
function will remove the highest-priority node. Likewise,

RemTail()
will remove the lowest-priority node.

FIFO Is Used For The Same Priority.

If you add a node that has the same priority as another node in the
queue, Enqueue() will use
FIFO
ordering. The new node is inserted
following the last node of equal priority.

1.13 23 / List Functions / Searching by Name

Because many lists contain nodes with symbolic names attached (via ↩ the

ln_Name
 field), it is possible to find a node by its name. This naming technique is used throughout Exec for such nodes as tasks, libraries, devices, and resources.

The FindName() function searches a list for the first node with a given name. For example, FindName(
header
, "Furrbol") returns a pointer to the first node named "Furrbol." If no such node exists, a NULL is returned. The case of the name characters is significant; "foo" is different from "Foo."

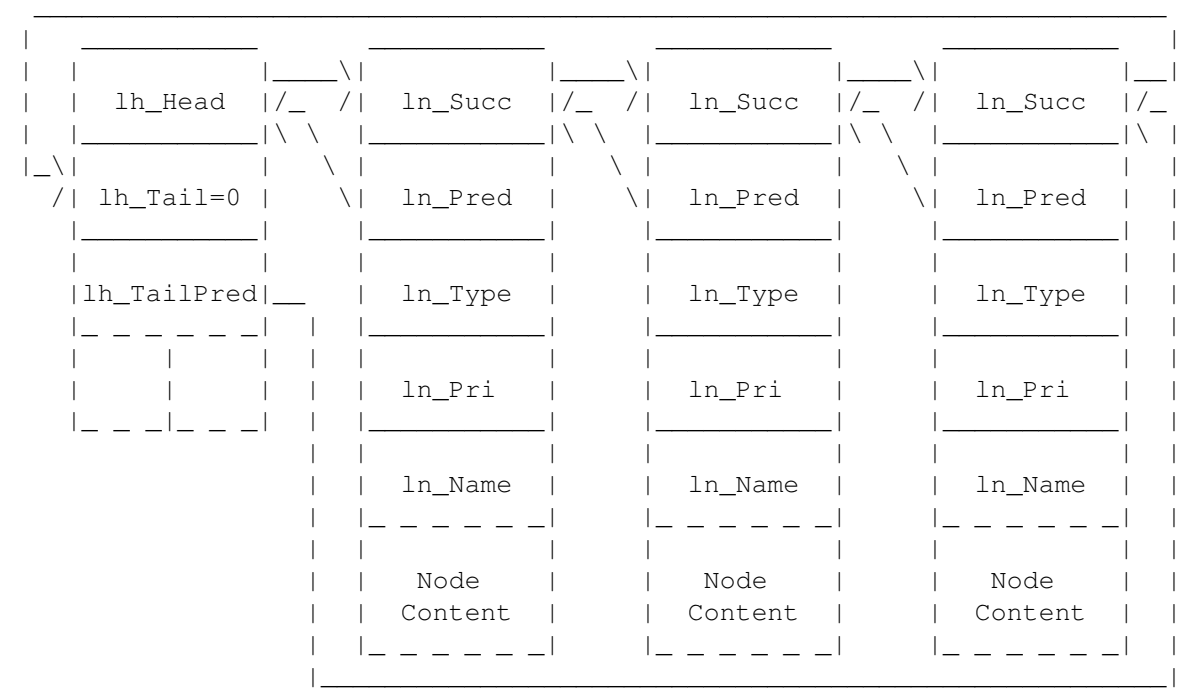


Figure 23-4: Complete Sample List Showing all Interconnections

1.14 23 / List Functions / More on the Use of Named Lists

To find multiple occurrences of nodes with identical names, the FindName()
function is called multiple times. For example, if you want to ↩ find all

the nodes with the name pointed to by name:

```
    VOID DisplayName(struct List *list,UBYTE *name)
    {
    struct Node *node;

        if (node = FindName(list,name))
            while (node)
            {
                printf("Found %s at location %lx\n",node->ln_Name,node);
                node = FindName((struct List *)node,name);
            }
        else printf("No node with name %s found.\n",name);
    }
```

Notice that the second search uses the node found by the first search. The

FindName()
function never compares the specified name with that of the starting node. It always begins the search with the successor of the starting point.

1.15 23 / List Functions / List Macros for Assembly Language Programmers

Assembly language programmers may want to optimize their code by using assembly code list macros. Because these macros actually embed the specified list operation into the code, they result in slightly faster operations. The file <exec/lists.i> contains the recommended set of macros. For example, the following instructions implement the REMOVE macro:

```
    MOVE.L  LN_SUCC(A1),A0       ; get successor
    MOVE.L  LN_PRED(A1),A1       ; get predecessor
    MOVE.L  A0,LN_SUCC(A1)       ; fix up predecessor's succ pointer
    MOVE.L  A1,LN_PRED(A0)       ; fix up successor's pred pointer
```

1.16 23 / List Functions / Empty Lists

It is often important to determine if a list is empty. This can be done in many ways, but only two are worth mentioning. If either the

lh_TailPred
field is pointing to the list header or the
ln_Succ
field of the
lh_Head
is NULL, then the list is empty.

In C, for example, these methods would be written as follows:

```
    /* You can use this method...   */
    if (list->lh_TailPred == (struct Node *)list)
        printf("list is empty\n");

    /* Or you can use this method   */
    if (NULL == list->lh_Head->ln_Succ)
        printf("list is empty\n");
```

In assembly code, if A0 points to the list header, these methods would be written as follows:

```
    ; Use this method...
    CMP.L   LH_TAILPRED(A0),A0
    BEQ     list_is_empty

    ; Or use this method
    MOVE.L  LH_HEAD(A0),A1
    TST.L   LN_SUCC(A1)
    BEQ     list_is_empty
```

Because LH_HEAD and LN_SUCC are both zero offsets, the second case may be simplified or optimized by your assembler.

1.17 23 / List Functions / Scanning a List

Occasionally a program may need to scan a list to locate a particular node, find a node that has a field with a particular value, or just print the list. Because lists are linked in both the forward and backward directions, the list can be scanned from either the head or tail.

Here is a code fragment that uses a for loop to print the names of all nodes in a list:

```
    struct List *list;
    struct Node *node;

    for (node = list->lh_Head ; node->ln_Succ ; node = node->ln_Succ)
        printf("%lx -> %s\n",node,node->ln_Name);
```

A common mistake is to process the head or tail nodes. Valid data nodes have non-NULL successor and predecessor pointers. The above loop exits when

node->ln_Succ is NULL. Another common mistake is to free a node from within a loop, then reference the free memory to obtain the next node pointer. An extra temporary pointer solves this second problem.

In assembly code, it is more efficient to use a look-ahead cache pointer when scanning a list. In this example the list is scanned until the first zero-priority node is reached:

```
            MOVE.L  (A1),D1         ; first node
    scan:   MOVE.L  D1,A1
```

```
            MOVE.L  (A1),D1         ; lookahead to next
            BEQ.S   not_found       ; end of list...
            TST.B   LN_PRI(A1)
            BNE.S   scan
            ...                     ; found one

    not_found:
```

Exec List Example

1.18 23 / List Functions / Important Note About Shared Lists

It is possible to run into contention problems with other tasks when manipulating a list that is shared by more than one task. None of the standard Exec list functions arbitrates for access to the list. For example, if some other task happens to be modifying a list while your task scans it, an inconsistent view of the list may be formed. This can result in a corrupted system.

Generally it is not permissible to read or write a shared list without first locking out access from other tasks. All users of a list must use the same arbitration method. Several arbitration techniques are used on the Amiga. Some lists are protected by a semaphore. The ObtainSemaphore() call grants ownership of the list (see the "Exec Semaphores" chapter for more information). Some lists require special arbitration. For example, you must use the Intuition LockIBase(0) call before accessing any Intuition lists. Other lists may be accessed only during Forbid() or Disable() (see the "Exec Tasks" chapter for more information).

The preferred method for arbitrating use of a shared list is through semaphores because a semaphores only holds off other tasks that are trying to access the shared list. Rather than suspending all multitasking. Failure to lock a shared list before use will result in unreliable operation.

Note that I/O functions including printf() generally call Wait() to wait for I/O completion, and this allows other tasks to run. Therefore, it is not safe to print or Wait() while traversing a list unless the list is fully controlled by your application, or if the list is otherwise guaranteed not to change during multitasking.

1.19 23 Exec Lists and Queues / Function Reference

The following charts give a brief description of the Exec list and queue functions and assembler macros. See the Amiga ROM Kernel Reference Manual: Includes and Autodocs for details about each call.

Table 23-1: Exec List and Queue Functions

Exec Function	Description
AddHead()	Insert a node at the head of a list.
AddTail()	Append a node to the tail of a list.
Enqueue()	Insert or append a node to a system queue.
FindName()	Find a node with a given name in a system list.
Insert()	Insert a node into a list.
IsListEmpty	Test if list is empty
NewList()	Initialize a list structure for use.
RemHead()	Remove the head node from a list.
Remove()	Remove a node from a list.
RemTail()	Remove the tail node from a list.

Table 23-2: Exec List and Queue Assembler Macros

Exec Function	Description
NEWLIST	Initialize a list header for use.
TSTLIST	Test if list is empty (list address in register). No arbitration needed.
TSTLST2	Test is list is empty (from effective address of list). Arbitration needed.
SUCC	Get next node in a list.
PRED	Get previous node in a list.
IFEMPTY	Branch if list is empty.
IFNOTEMPTY	Branch if list is not empty.
TSTNODE	Get next node, test if at end of list.
NEXTNODE	Get next node, go to exit label if at end.
ADDHEAD	Add node to head of list.
ADDTAIL	Add node to tail of list.
REMOVE	Remove node from a list.
REMHEAD	Remove node from head of list.
REMHEADQ	Remove node from head of list quickly.
REMTAIL	Remove node from tail of list.