EY-CC155-WB-003

RSX-11M Operating System Internals

Student Workbook

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Student Workbook

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STUDENT GUIDE

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INTRODUCTION

This course is designed for the programmer of an RSX-11M system. A system programmer must troubleshoot system problems and write needed privileged code.

As a system programmer, your responsibilities will include the following:

- Determining features needed on system.
- Performing System Generations (SYSGENs).
- Maintaining the software by installing patches.
- Determining the cause(s) of system crashes.
- Providing needed privileged tasks.
- Writing new directive code.
- Assisting application programmers with system problems.

This course is designed to give you the knowledge and skills necessary to carry out these tasks.

COURSE GOALS

Upon completing this course, you should be able to:

1. Install and maintain RSX-11M software.
2. Use output from CDA to solve system problems.
3. Write privileged tasks which access the system data base.
4. Write privileged tasks which call system routines.
5. Write a new directive processing routine and add the directive to the system.
6. Determine system status by examining the system data base.
7. Use knowledge of the operating system to improve performance of applications software.

NON-GOALS

The following are not goals of this course:

1. The course does not teach you how to write a device driver.

2. The course does not teach you how to create a user-written Command Line Interpreter.

3. The course does not teach you how to make any modifications to system source code. Specifically, it will not teach you how to modify DCL in any way.

PREREQUISITES

You should have already taken RSX-11M Programming in FORTRAN/MACRO, or have equivalent experience using RSX-11M. You should also be able to read and understand MACRO-11 code.

COURSE ORGANIZATION

The student workbook handout is organized into modules which correspond to the major topics covered by the instructor during the course. Each module is designed to support the lecture by providing you with notes and exercises to guide your study.

A module is composed of five parts:

1. An Introduction which provides an overview of the module. It explains in general terms what the module covers and how the material within the module is related to your needs. Often, it introduces some of the important concepts detailed in the module.

2. Objectives which list the knowledge and skills you should obtain as a result of studying the module. Read these before the corresponding lecture, and review them after completion of the module and its exercises.

3. Resources which provide a list of reference materials for further information about the topics of the module and related topics. You should familiarize yourself with the reference materials because they are your primary source of information after you complete the course.

   Your instructor may suggest selected readings as preparation for a lecture, or for review and study after the lecture.

4. The module text which provides brief notes on topics covered in the lecture, with printed copies of lists, tables, diagrams, etc. your instructor may use in class. The texts provide you with notes to review after the lecture, and reduces somewhat the note-taking you must do during lecture.

   Note that the module text is a supplement to the lecture. It is not intended to be tutorial reading for learning the material on your own. Nor is it intended to replace the function of reference manuals which fully document the software. You are strongly encouraged to supplement these notes with notes of your own and with references to the system documentation.

5. Module Exercises which are designed to help you practice and test the knowledge acquired during lecture and study. If you can perform all of the written and/or lab exercises at the end of the module, you have mastered the objectives of that module.

   Your instructor may suggest particular lab exercises to concentrate on, if time or equipment limitations make it impossible to perform all of them. In addition, your instructor may provide additional suggestions for lab activities.

Modules

There are thirteen modules of this course. The following is a brief list of their major topics:

1. OVERVIEW OF RSX-11M describes the operating system and its goals.

2. THE SYSTEM DATA BASE describes the most important data structures and lists in the system data base.

3. EXECUTIVE MODULES describes the most important Executive modules.

4. FILE SYSTEM OVERVIEW describes the structure of a FILES-11 volume and the data structures needed to process it.

5. SYSTEM GENERATION describes the system generation process. (For reference only; this module is optional.)

6. PHYSICAL AND VIRTUAL MEMORY describes partitions, allocation of memory to tasks, checkpointing, function and use of memory management.

7. TASK MANAGEMENT describes the life cycle of a task.

8. SYSTEM SYNCHRONIZATION describes trap and interrupt processing, and access to the system data base.

9. WRITING PRIVILEGED TASKS describes writing, assembling, and building privileged tasks.

10. SYSTEM CRASHES uses CDA to troubleshoot system problems.

11. DIRECTIVE PROCESSING describes the directive dispatcher, the directive dispatch table, and directive processing routines.

12. I/O PROCESSING describes the components of the I/O system, ACPs, and QIO processing.

13. DEVICE DRIVER PROCESSING describes the driver data base and the structure of standard device drivers.

RESOURCES

1. RSX-11M Release Notes (AA-2573G-TC)

   Contains the most recent version information and should be read thoroughly before any system generation. Includes information on patching.

2. RSX-11M System Generation and Installation Guide

   Contains complete documentation on the installation and SYSGEN procedures.

3. RSX-11M/M-Plus I/O Operations Reference Manual

   Contains documentation on the FCS macros and subroutines.

4. RSX-11M/M-Plus Executive Reference Manual

   Contains descriptions of all system directives.

5. RSX-11M/M-Plus Crash Dump Analyzer

   Explains how to use the CDA facilities.

6. RSX-11M Guide to Writing an I/O Driver

   Contains a detailed description of the procedures involved in writing a new device driver.

1

OVERVIEW OF RSX-11M

INTRODUCTION

RSX-11M is designed to support many applications with particular emphasis on real-time applications. For this reason, a large number of services are provided to the programmer. This module presents a brief overview of these features, many of which will be examined in detail in later modules.

OBJECTIVES

1. List the major design goals of RSX-11M.
2. List the major features of RSX-11M.
3. List the major components of RSX-11M.

DESIGN GOALS

- Real-time system with

  8K word minimum Executive

  16K word minimal system (disk based, run time only)

  28K word system required for SYSGEN (version 4.0)

- Upward compatible with RSX-11D
- Support

  All PDP-11 processors

  Most processor options

  Full line of peripherals

- Provide system and task synchronization not relying on task priorities
- Provide extensive user facilities

  Complete file system

  Multiple language processors

  Debugging and maintainence tools

- Allow for any number of simultaneously executing user tasks
- Avoid using processor priority to synchronize access to system data base

CHARACTERISTICS OF RSX-11M

System Features

- Supports multiprogramming

  Several tasks can be memory-resident and active at same time

  Improves efficiency of system

  Allows quick response to events

- Provides some user control of some system functions

  Scheduling
  File access

- Completely 'Event-Driven'

  No 'monolithic monitor'

  Executive entered only as a result of trap or hardware interrupt

- Disk-Based

  Tasks stored on disk until loaded
  Allows quick task startup

- Provides multi-tasking facilities

  Dynamic task requests
  Passing data between tasks
  Sharing memory areas between tasks

Major Components of RSX-11M

- Executive - Contains code to perform system functions such as task scheduling, input/output operations, etc.
- File System - Provides efficient and convenient access to data and task files.
- Utilities - Provide services needed to program and support user applications.

THE EXECUTIVE

Components

- Trap and interrupt vectors - Used by hardware to provide trap and interrupt service.

  Vectors consist of 2 words:

  Word 1 - A value to go into the PC
  Word 2 - A value to go into the PS

  When a trap or interrupt occurs:

  Current values of PC and PS are pushed onto the stack

  Values in the vector are moved into the PC and PS

- System Stack - Maintained as temporary storage for system programs.
- System Common - Contains pointers to important areas of system data base.
- Executive Code - Performs system functions.
- Dynamic Storage Area - Contains most dynamically created system data structures.

Use of Physical Memory

- Executive contained in lowest area of memory
- Size depends on features chosen at SYSGEN; not greater than 20K words
- Executive has access to I/O page in top 4K words of address space
- Some device drivers may not be included within Executive
- Some directive service routines may not be included within the Executive

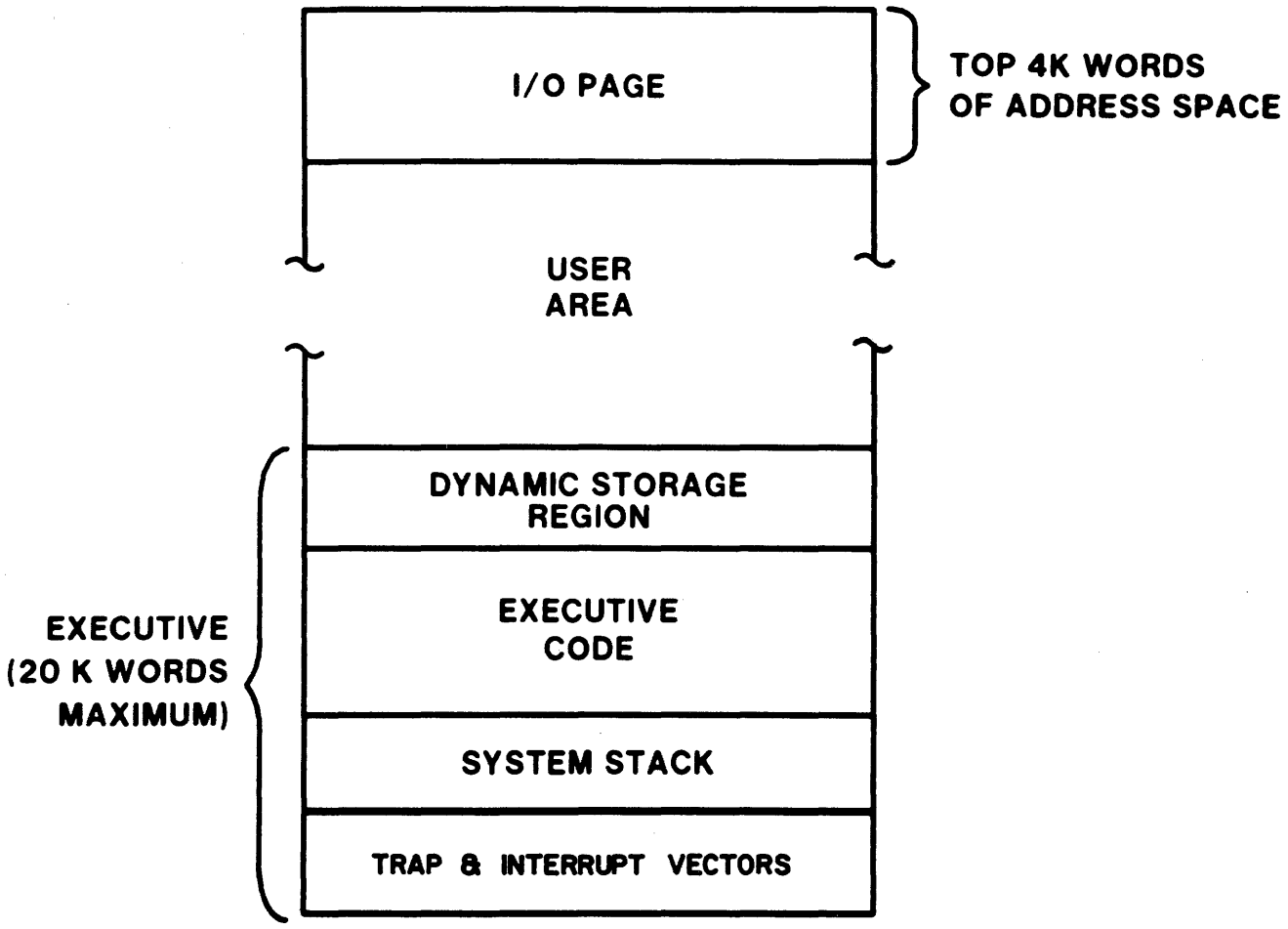


Figure 1-1 Typical Use of Physical Memory

THE FILE SYSTEM

Design Goals

- Allow programmer to organize data in a convenient manner
- Provide protection from unauthorized access
- Provide efficient use of disk space

Components

- Standard structures on disk and tape volumes
- Ancillary control processor (ACP) to provide programming interface to file structured volumes

    F11ACP - For disk volumes

    MTAACP - For magnetic tape volumes

- Application-oriented software

    FCS - File Control Services

    RMS - Record Management Services

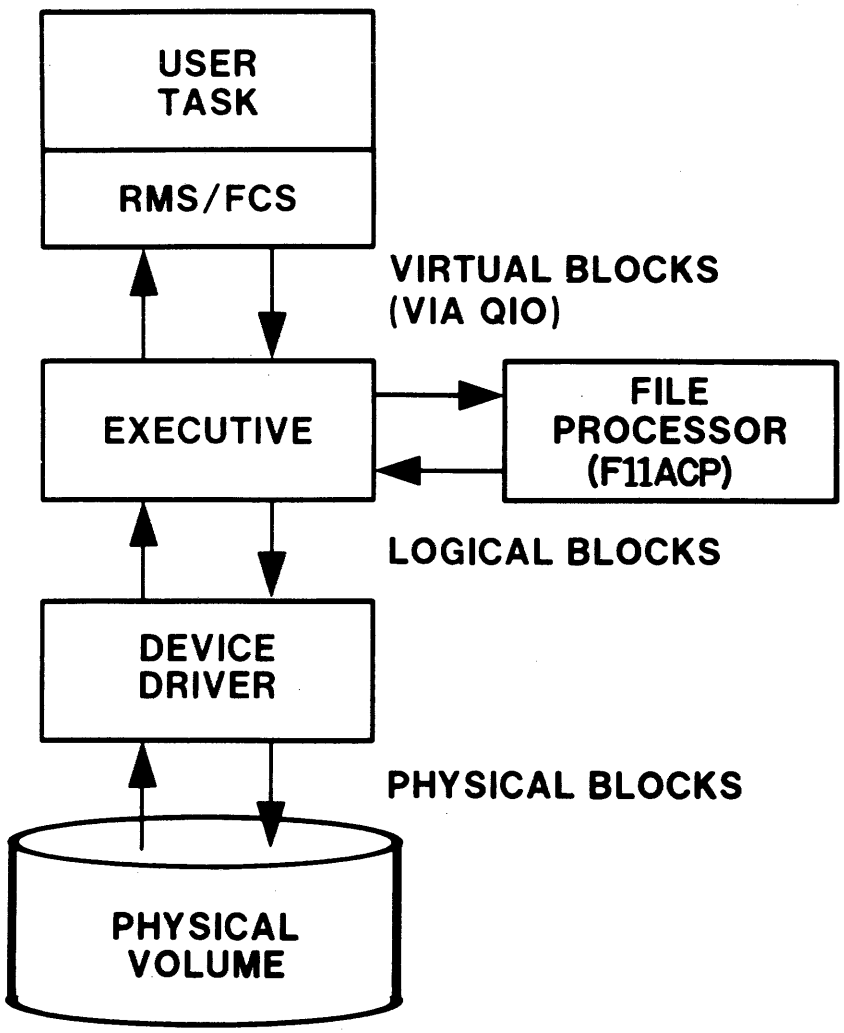


Figure 1-2 The File System

THE UTILITIES

- Tasks distributed with operating system

  Perform common maintenance and development functions

  Not included in memory-resident Executive

- Four general categories of utilities

  Language processors

  MACRO-11
  FORTRAN

  Program development utilities

  EDT
  EDI
  LBR

  System maintenance utilities

  BAD
  CMP
  VFY
  PAT

  File manipulation utilities

  PIP
  FLX
  DMP

THE SYSTEM DATA BASE

2

INTRODUCTION

The system data base includes the data structures which describe the current state of the system to the Executive. Every operation within the system has its effect on the system data base. Similarly, the state of the system data base at the time an operation is requested determines the success and effect of the operation.

Throughout this course, the system data base is used to explain the mechanics of various system operations. This module describes the most central system data structures, and how they are related. Future modules detail the data structures and their linkages.

OBJECTIVES

1. Describe the major system data structures associated with task management.
2. Describe the major system data structures associated with partition control.
3. Describe the major system data structures associated with I/O device control.
4. Describe how the Executive manages the Dynamic Storage Region.

STATIC AND DYNAMIC DATA STRUCTURES

- Static data structures

  Created when system is built

  Contained in Executive modules

  Example: Data structures for standard devices selected at SYSGEN are in the Executive module SYSTB.

- Dynamic data structures

  Created and eliminated as needed

  Contained in Dynamic Storage Region (DSR)

  Example: Data structures needed to define tasks to the system are in DSR.

The Dynamic Storage Region

- Contains dynamic data structures
- Space allocated and deallocated as needed
- Allocation of DSR:

  Performed by routines in module CORAL

  Length is multiple of 4 bytes

  Linked list of unallocated space is maintained by Executive

  No record of allocated space is kept

  First-fit algorithm is used

  List of preallocated I/O packets maintained if specified at SYSGEN

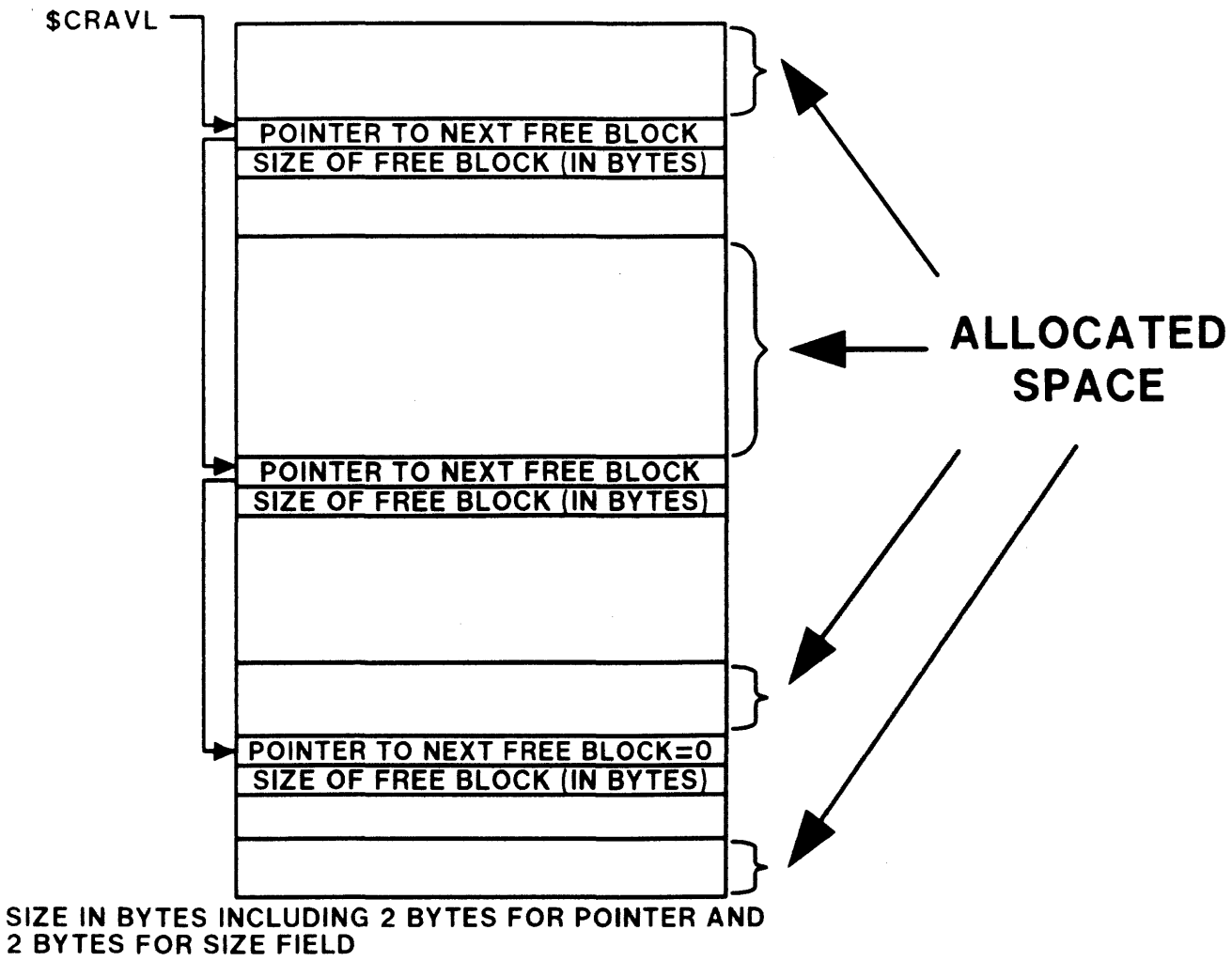


Figure 2-1 The List of Free Space in DSR

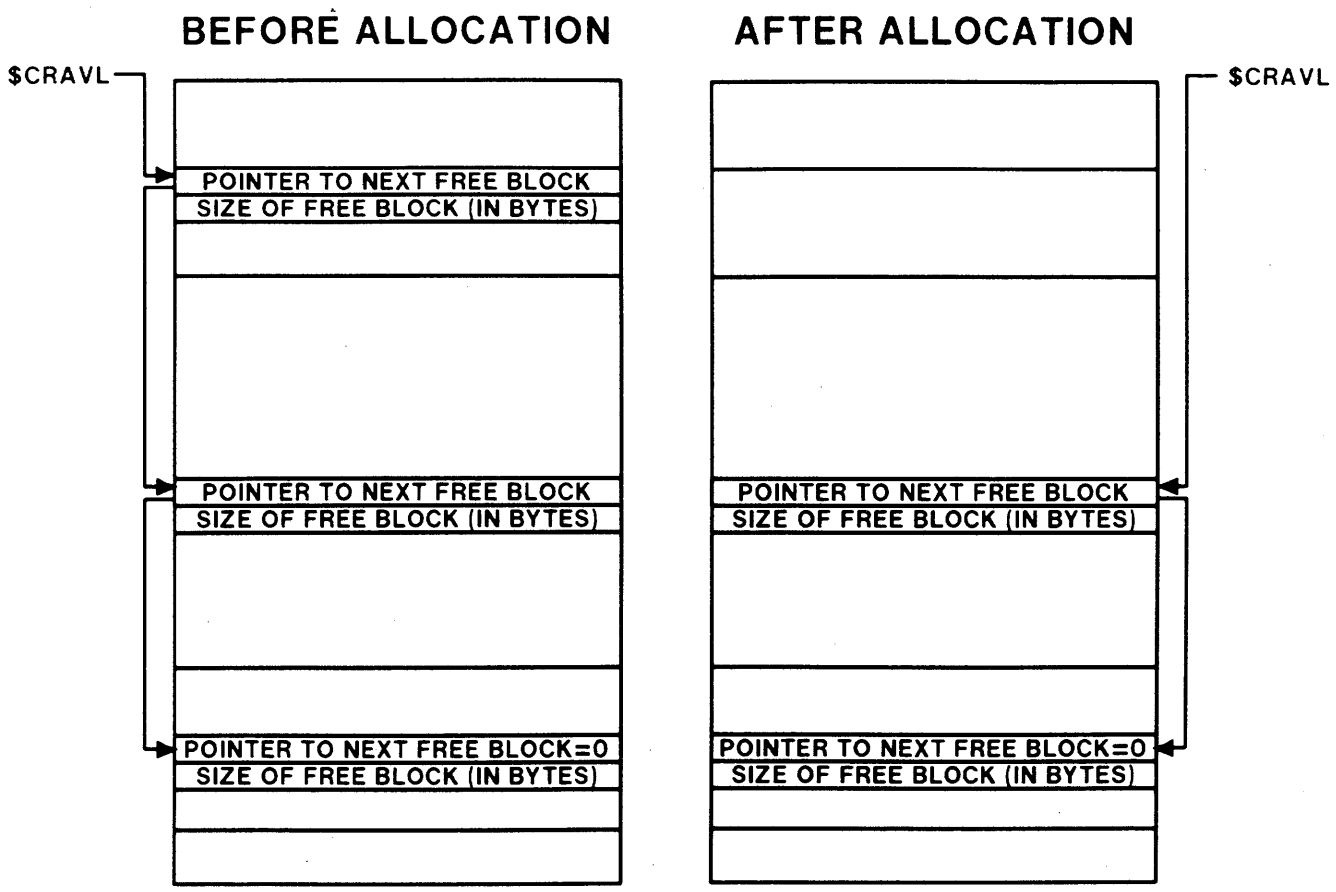


Figure 2-2 Allocating DSR

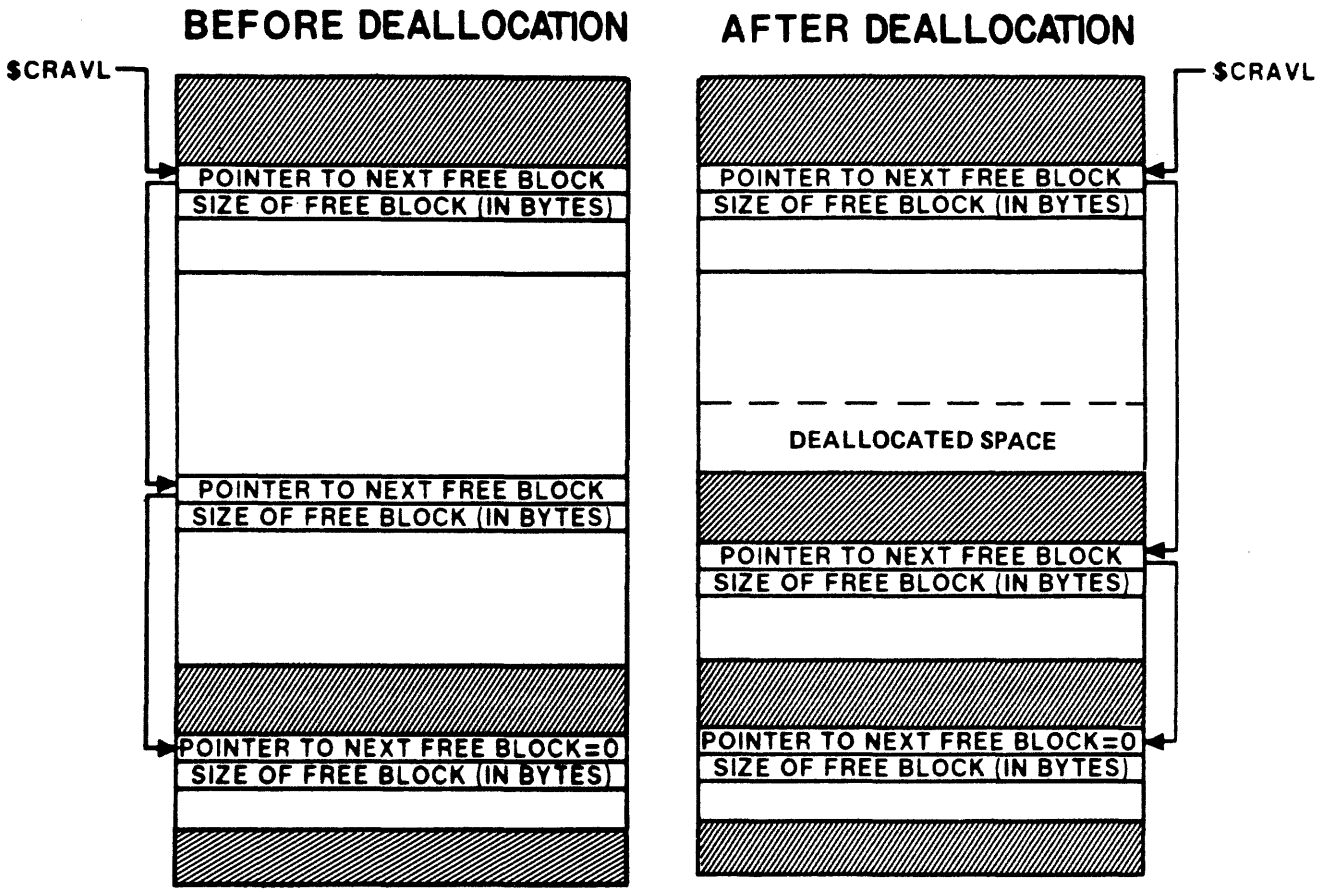


Figure 2-3 Deallocating DSR

TASK-RELATED DATA STRUCTURES AND LISTS

The Task Control Block (TCB)

- Defines task to system
- Contains information controlling task execution

  Task name

  Task priority

  Local event flags

  Task status words

- Contains pointers to other data structures including:

  T.RCVL - Receive queue listhead

  Points to linked list of data blocks queued by the 'SEND DATA' directive.

  T.ASTL - AST queue listhead

  Points to linked list of ASTs queued to task.

  T.UCB - Address of data structure (UCB) identifying TI:

  T.TCBL - Link word for System Task Directory

  T.PCB - Address of data structure (PCB) identifying partition in which task executes

  T.ACTL - Link word for Active Task List

- Allows task to load and begin execution quickly

  Contains pointer to task image on disk

  Identifies partition in which to load task

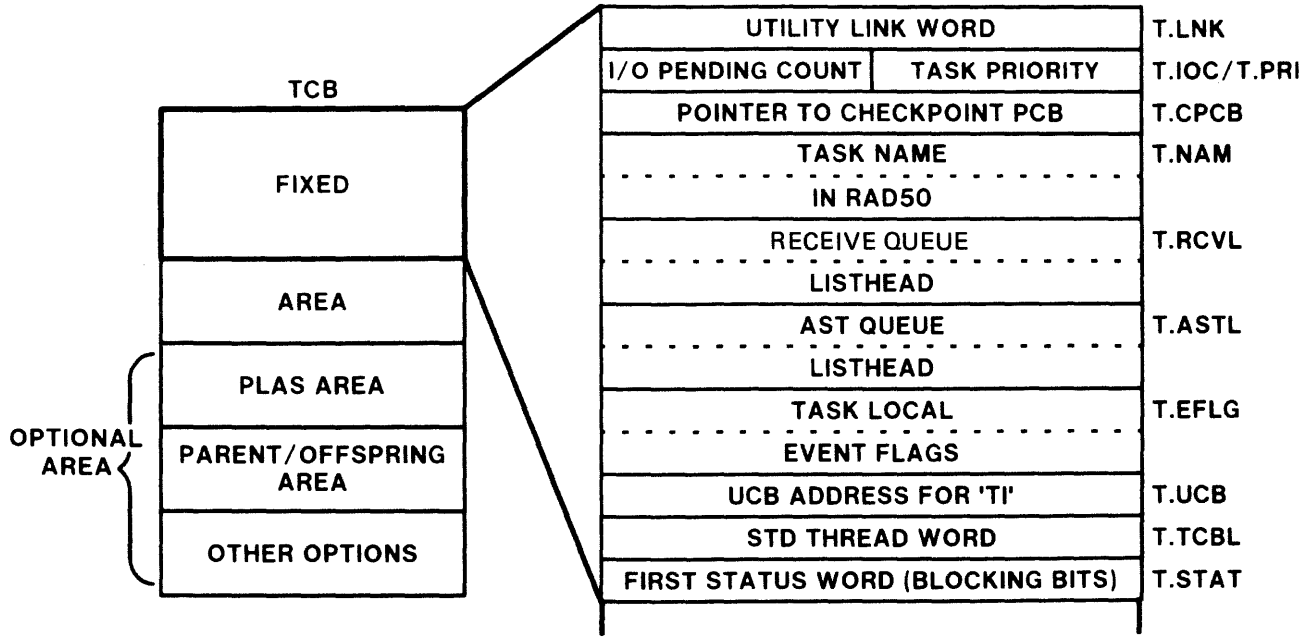


Figure 2-4 The Task Control Block
(First Part of Fixed Area)

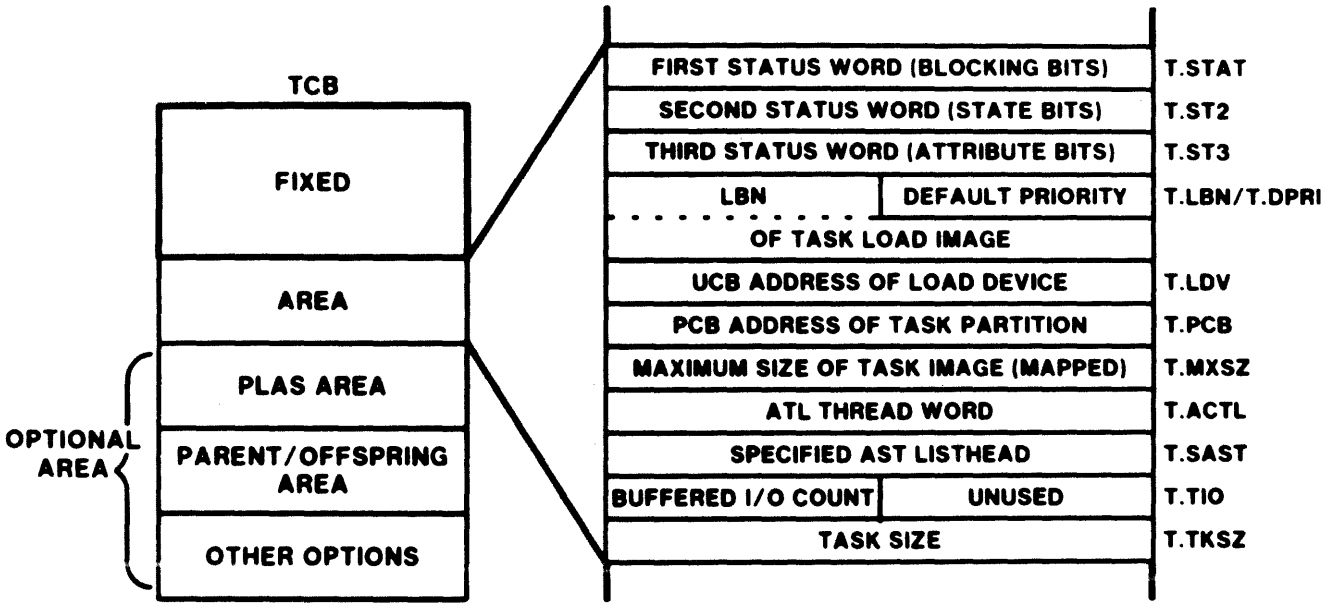


Figure 2-4 The Task Control Block
(Second Part of Fixed Area)

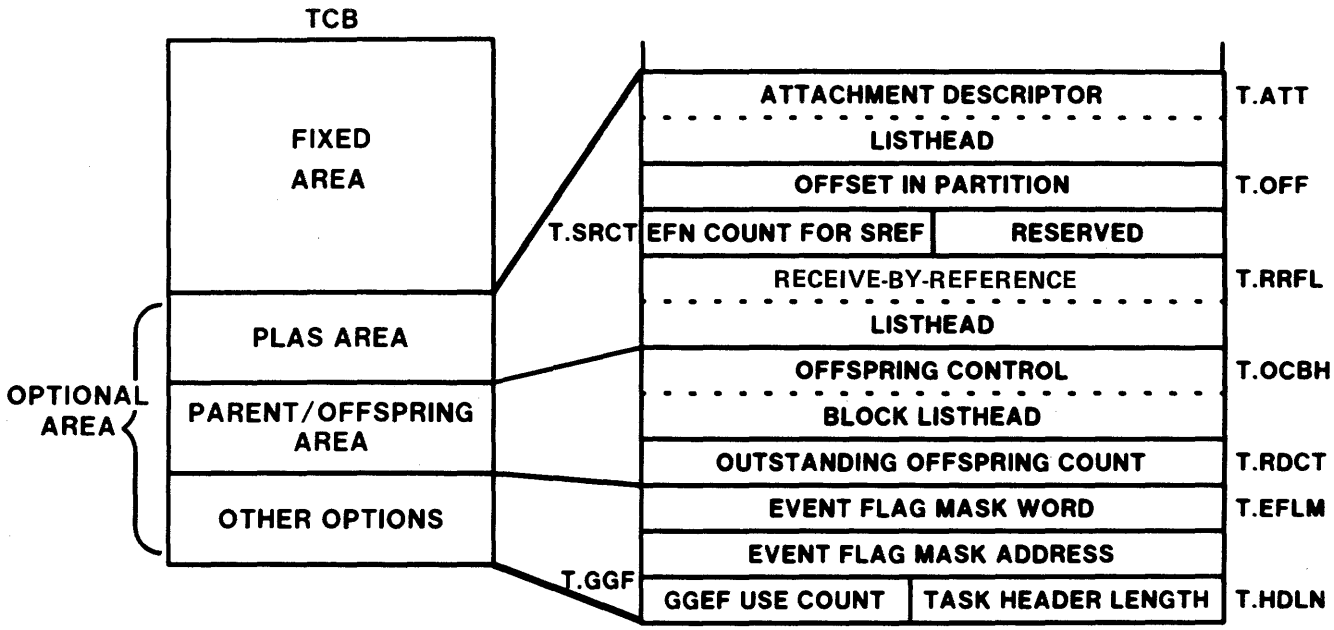


Figure 2-4 The Task Control Block
(Optional Area)

Table 2-1 Task Status Words

Offset	Bit	Symbol	Value	Meaning
T.STAT	15	TS.EXE	100000	Task not in execution
	14	TS.RDN	40000	I/O rundown in progress
	13	TS.MSG	20000	Abort message being output
	12	TS.NRP	10000	Task mapped to nonresident region
	8	TS.OUT	400	Task is out of memory
	7	TS.CKP	200	Task is being checkpointed
	6	TS.CKR	100	Task checkpointing requested

NOTE

The bits in T.STAT are called blocking bits. They must all be clear for the Executive to context switch to the task.

T.ST2	15	T2.AST	100000	AST in progress
	14	T2.DST	40000	AST recognition disabled
	13	T2.CHK	20000	Task not checkpointable
	12	T2.CKD	10000	Checkpointing disabled
	11	T2.SEF	4000	Task stopped for event flag
	10	T2.FXD	2000	Task fixed in memory
	9	T2.TIO	1000	Task engaged in terminal I/O
	8	T2.CAF	400	Dynamic checkpoint space allocation failure
	7	T2.HLT	200	Task is being halted
	6	T2.ABO	100	Task marked for abort
	5	T2.	40	Saved T2.STP on AST in progress
	4	T2.STP	20	Task stopped
	3	T2.	10	Saved T2.SPN on AST in progress
	2	T2.SPN	4	Task suspended
	1	T2.	2	Saved T2.WFR on AST in progress
	0	T2.WFR	1	Task in wait for state
T.ST3	15	T3.ACP	100000	Ancillary control processor
	14	T3.PMD	40000	Inhibit post mortem dump
	13	T3.REM	20000	Remove task on exit
	12	T3.PRV	10000	Task is privileged
	11	T3.MCR	4000	Task requested as external MCR function
	10	T3.SLV	2000	Task is slaved
	9	T3.CLI	1000	Task is a command line interpreter
	7	T3.NSD	200	Task does not allow send data
	6	T3.CAL	100	Checkpoint space allocated in task image
	5	T3.ROV	40	Task has resident overlays

The System Task Directory (STD)

- Linked list of TCBs
- Ordered by descending default priority
- Begins at listhead $TSKHD in System Common
- Linked through location T.TCBL in the TCB
- 'Null Task' TCB is last entry

  'Null Task' used to anchor system task lists

  When 'Null Task' is scheduled, the idle loop is performed until another task becomes ready to run

  'Null Task' TCB in System Common

  'Null Task' never executes

- TCB is inserted when task is installed
- New TCB inserted after others of same priority
- System maintains pointers (in SYSCM) to special tasks in STD

  $TKTCB - Current task TCB

  $TKNPT - Pointer to TCB of task termination task TKTN

  $MCRPT - Pointer to TCB of MCR task

  $LDRPT - Pointer to loader TCB

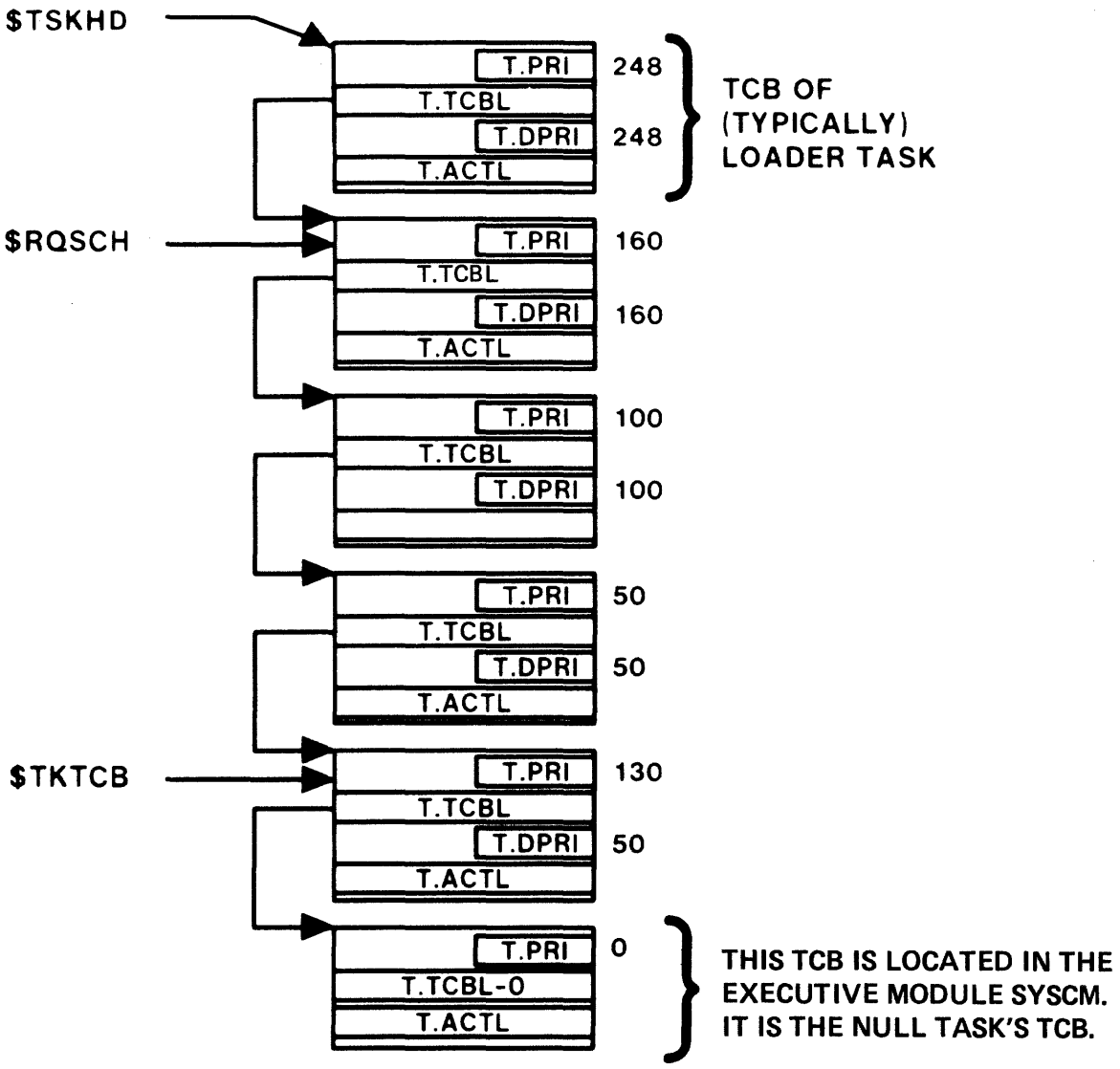


Figure 2-5 The System Task Directory

The Active Task List (ATL)

- Linked list of TCBs
- Ordered by descending priority
- Begins at $ACTHD in System Common
- Linked through T.ACTL in TCB
- 'Null Task' TCB is last entry
- TCB inserted when requested; Task becomes active
- New TCB inserted after others of same priority

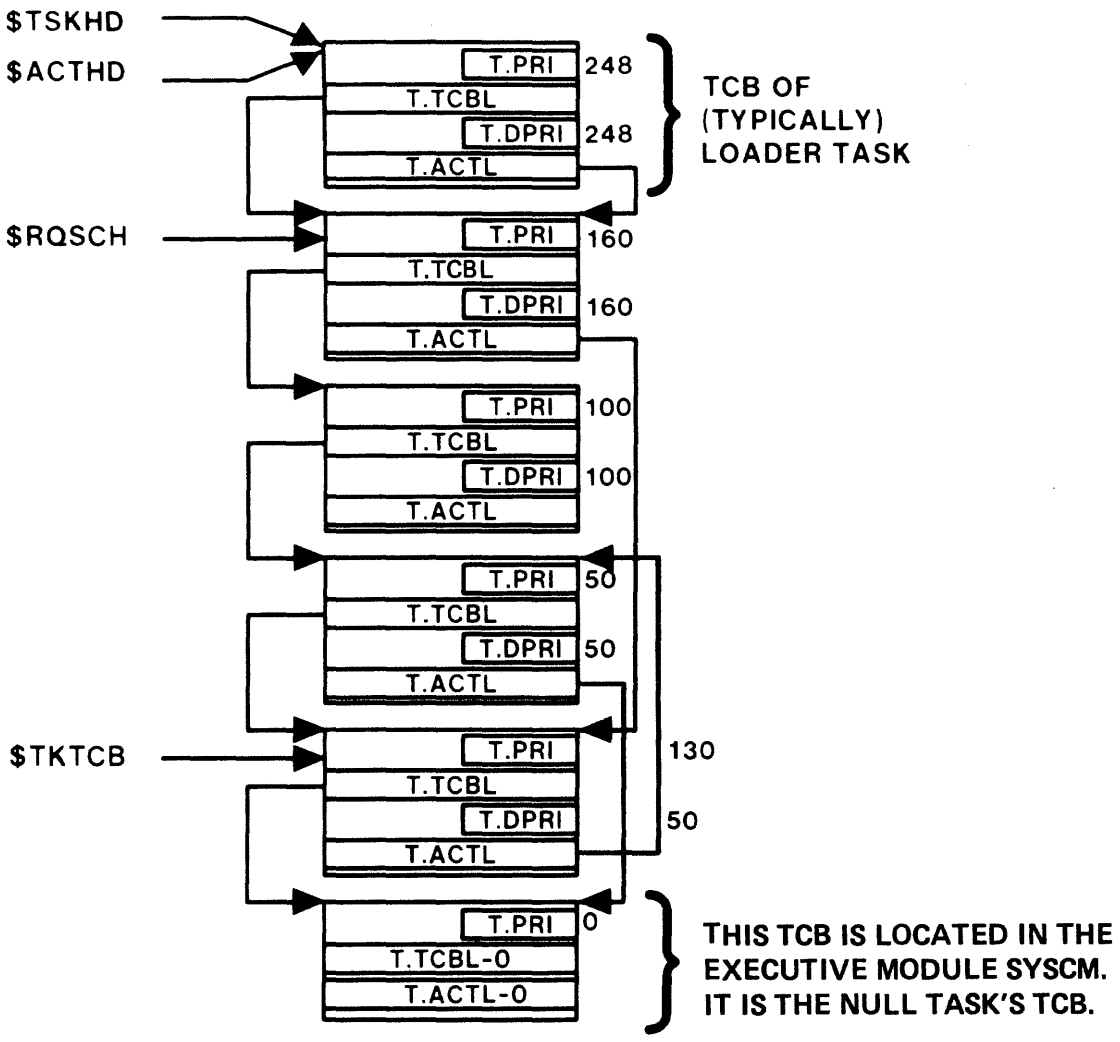


Figure 2-6 The Active Task List

PARTITION-RELATED DATA STRUCTURES AND LISTS

The Partition Control Block (PCB)

- Defines partition to system
- Contains information describing partition

  Partition name

  Physical starting address (32 word blocks number)

  Size of partition (in 32 word blocks)

  Partition busy word

  Partition status word

  Protection word

  Current UIC of owner task

- Pointers to other data structures

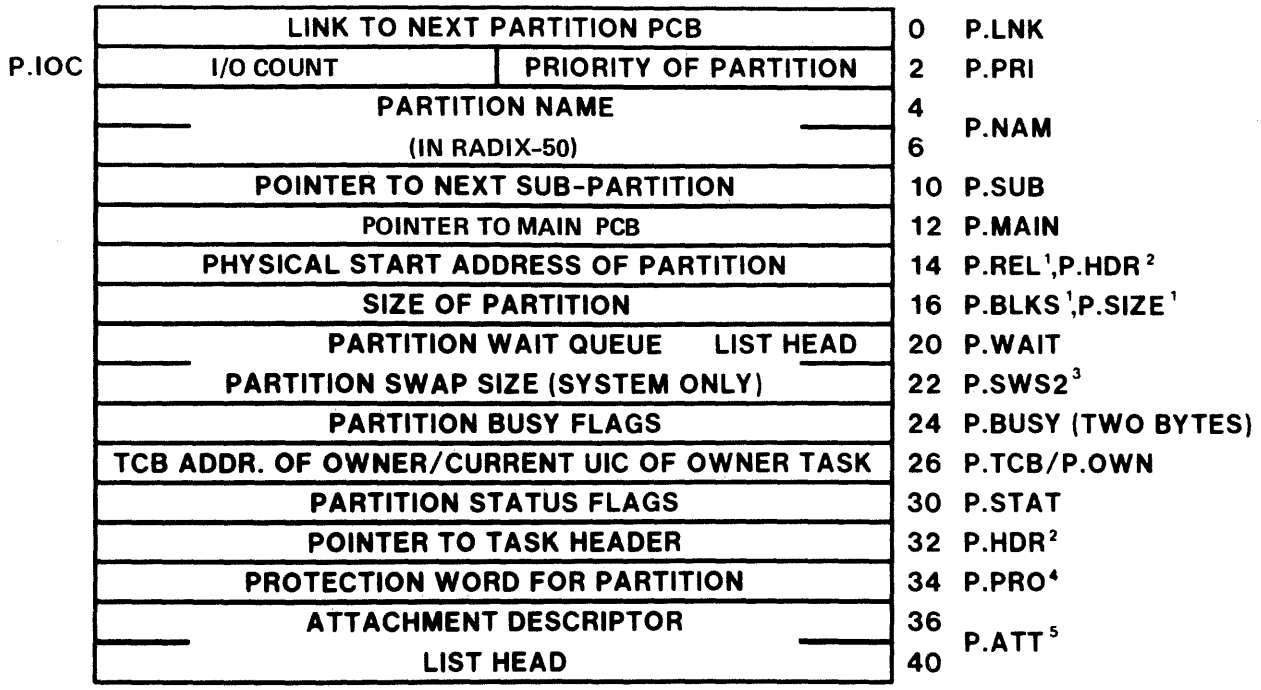
  If subpartition PCB, pointer to the main partition PCB

  Pointer to next subpartition PCB

  Pointer to queue of TCBs of tasks waiting for space in partition

  Pointer to attachment descriptor block for task

  Pointer to task header of resident task



1. 32 WORD BLOCKS FOR MAPPED SYSTEMS
   BYTES FOR UNMAPPED SYSTEMS
2. P.HDR=P.REL IN UNMAPPED SYSTEMS
3. FOR SUB-PARTITIONS OF SYSTEM CONTROLLED PARTITIONS
4. MAPPED SYSTEMS ONLY
5. MAPPED SYSTEM WITH PLAS ONLY

Figure 2-7 The Partition Control Block

Table 2-2 Partition Status Word

Bit	Symbol	Value	Meaning
15	PS.OUT	100000	Partition is out of memory
14	PS.CKP	40000	Partition checkpoint in progress
13	PS.CKR	20000	Partition checkpoint requested
12	PS.CHK	10000	Partition is not checkpointable
11	PS.FXD	4000	Partition is fixed
10	PS.PER	2000	Parity error in partition
9	PS.LIO	1000	Marked by shuffler for long I/O
8	PS.NSF	400	Partition is not shufflable
7	PS.COM	200	Library or common block
6	PS.PIC	100	Position independent library of common
5	PS.SYS	40	System controlled partition
4	PS.DRV	20	Driver is loaded in partition
3	PS.DEL	10	Partition should be deleted when not attached
2	PS.APR	4	Starting APR
1		2	Starting APR
0		1	Starting APR

The Partition List

- Linked list of PCBs
- Linked in order of increasing base address
- Begins at location $PARHD in System Common
- Linked through P.LNK in PCB
- PCB created and inserted in list by 'SET /MAIN' or 'SET /SUB' MCR or VMR command
- PCBs of subpartitions

    Task partitions

    Linked into list using P.LNK
    Linked to PCB of main partition using P.SUB

    System-controlled partitions

    Linked to main partition PCB using P.SUB
    Not linked through P.LNK

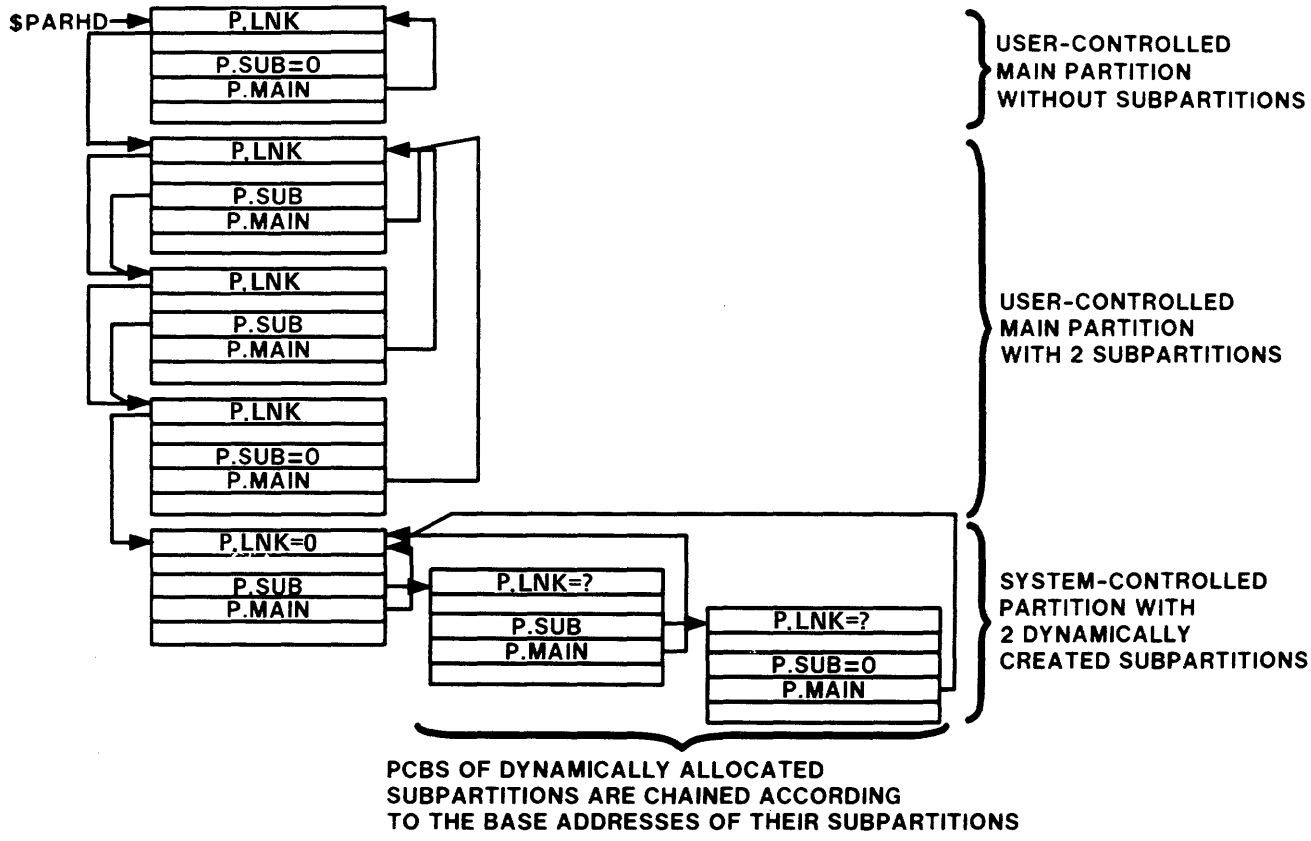


Figure 2-8 The Partition List

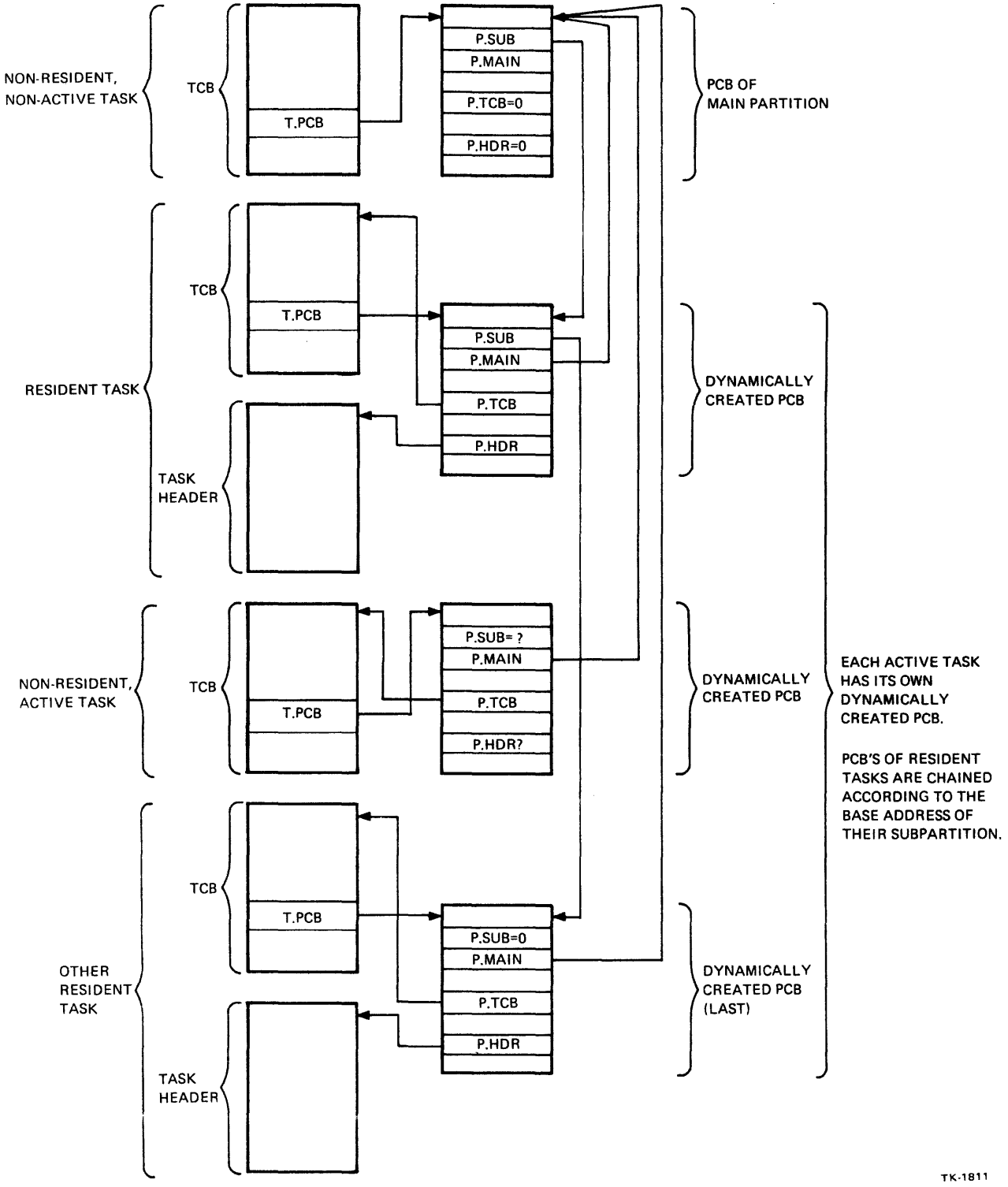


Figure 2-9 Relationship Between Task and Partition Structures

DEVICE-RELATED DATA STRUCTURES AND LISTS

The Device Control Block (DCB)

- Describes physical device type
- Contains information describing device

  Generic device name in ASCII (D.NAM)

  Physical units in system of this type (D.UNIT)

  Device functions supported (D.MSK)

- Pointer to data structures describing physical units (D.UCB)
- Pointer to entry points in device driver (D.DSP)

LINK TO NEXT DCB		0	D.LNK
POINTER TO FIRST UCB OF THIS DEVICE TYPE		2	D.UCB
GENERIC DEVICE NAME (IN ASCII)		4	D.NAM
HIGHEST UNIT NUMBER	LOWEST UNIT NUMBER	6	D.UNIT
LENGTH OF EACH UCB OF THIS DEVICE TYPE		10	D.UCBL
POINTER TO DRIVER DISPATCH TABLE		12	D.DSP
LEGAL FUNCTION MASK	CODES 0-15	14	D.MSK
CONTROL FUNCTION MASK	CODES 0-15	16	
NO-OP FUNCTION MASK	CODES 0-15	20	
ACP FUNCTION MASK	CODES 0-15	22	
LEGAL FUNCTION MASK	CODES 16-31	24	
CONTROL FUNCTION MASK	CODES 16-31	26	
NO-OP FUNCTION MASK	CODES 16-31	30	
ACP FUNCTION MASK	CODES 16-31	32	
PCB ADDRESS OF LOADABLE DRIVER		34	D.PCB

Figure 2-10 The Device Control Block

The Device List

- Linked list of DCBs
- Ordered by inclusion in SYSTB and by order of loading
- Begins at listhead $DEVHD in SYSCM
- Linked through location D.LNK in DCB

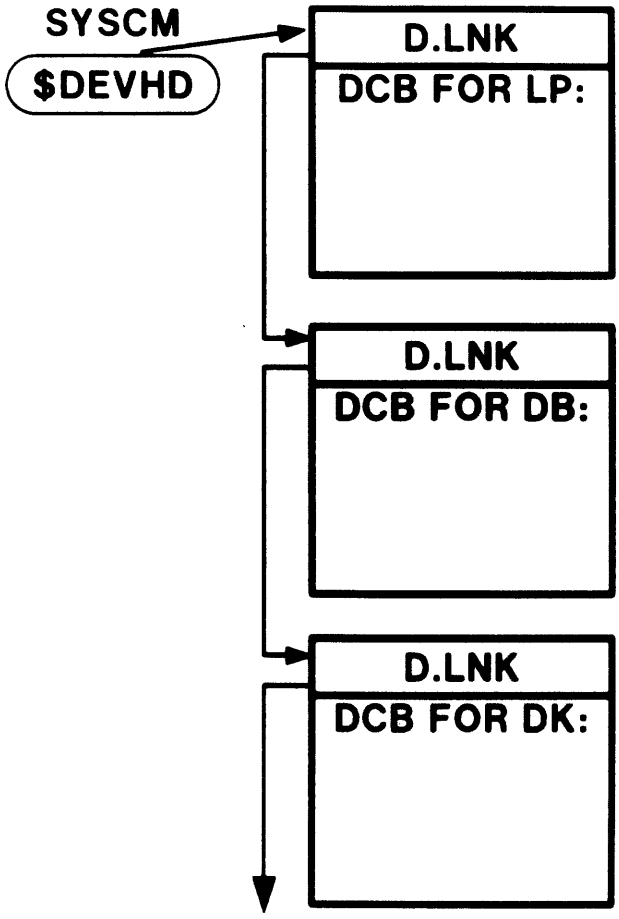


Figure 2-11 The Device List

Other Structures

- The Unit Control Block (UCB)

  One UCB per physical unit of type

  Size depends on device type

  Contains data used to describe physical unit

- The Status Control Block (SCB)

  One SCB per controller or per line if multiplexer

  Size depends on device type

  Contains data needed to control I/O operations

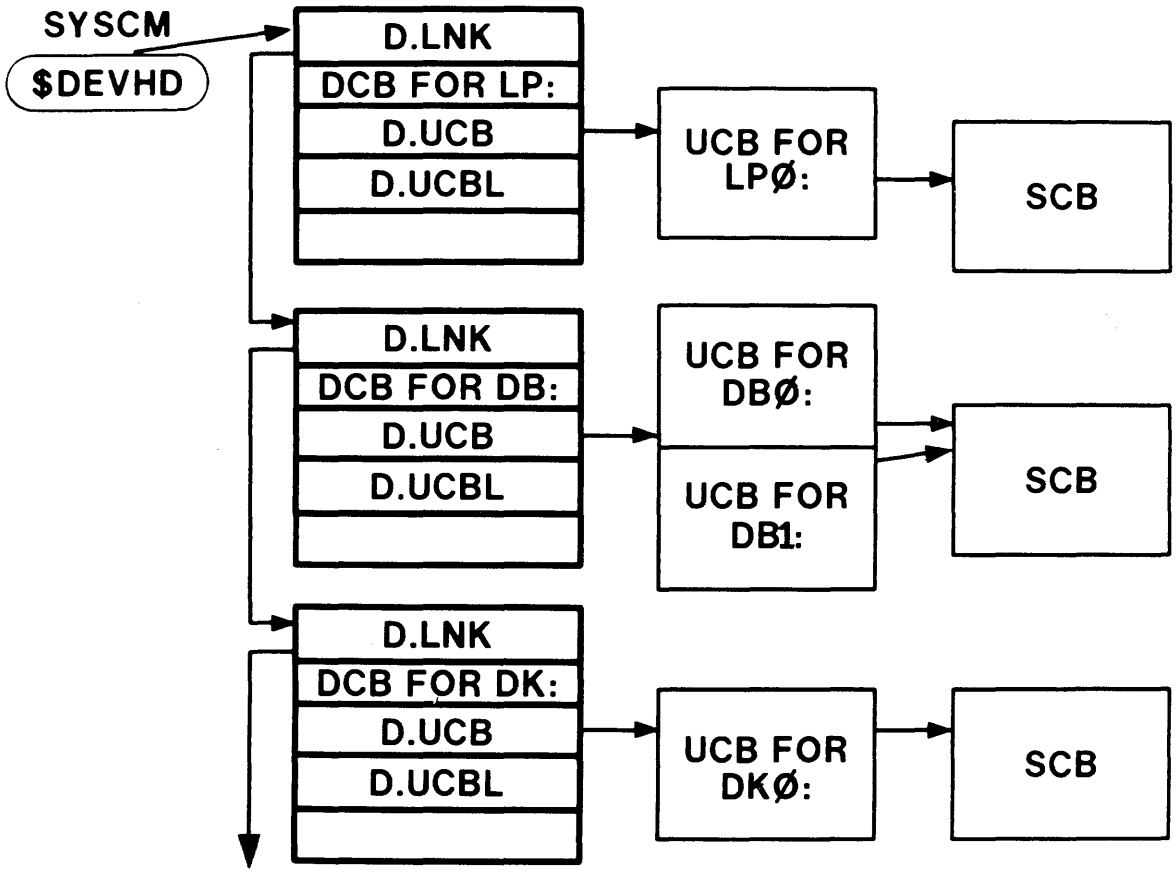


Figure 2-12 Other Data Structures

THE CLOCK QUEUE

The Clock Queue Control Block

- Describes time-dependent request
- Contains eight words; last three depends on type of request
- Five types of requests

  Mark Time

  Task request with periodic rescheduling

  Single shot task request

  Single shot internal subroutine (two types)

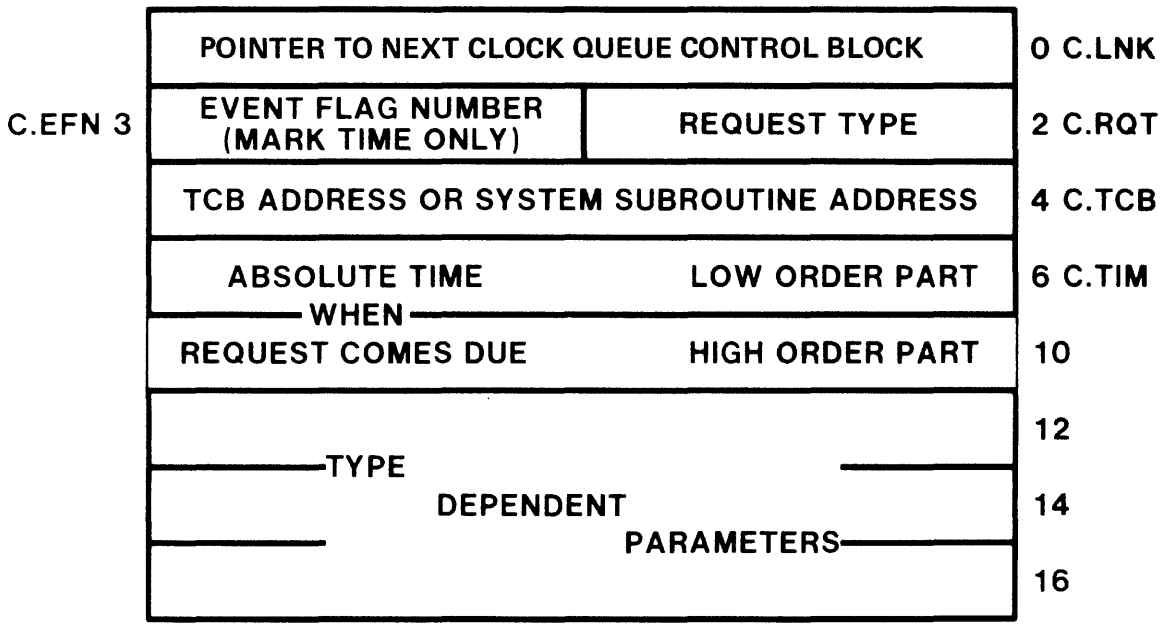


Figure 2-13 The Clock Queue Control Block

The Clock Queue

- Linked list of Clock Queue Control Blocks
- List ordered by increasing absolute time
- Scanned by code in TDSCH when clock interrupt occurs

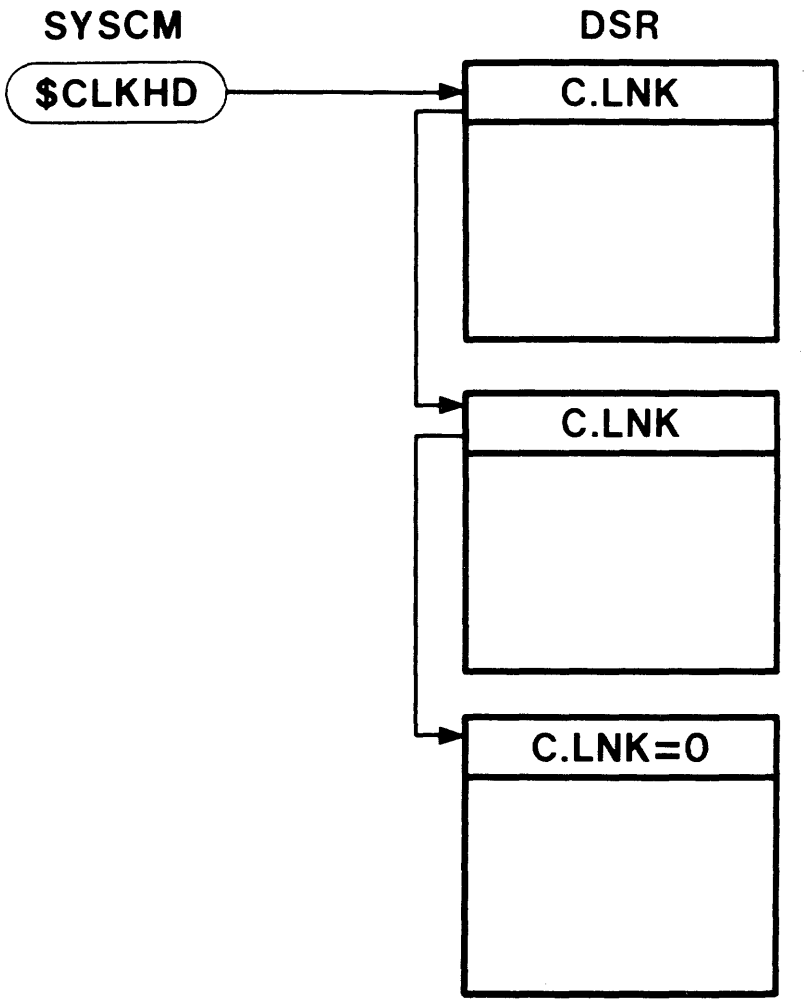


Figure 2-14 The Clock Queue

EXECUTIVE MODULES

3

INTRODUCTION

The Executive is composed of a number of modules. Each module contains code which performs a specific function or class of related functions. To effectively function as a systems programmer, you must be able to locate this code. This module provides a quick overview of the major modules in the Executive.

OBJECTIVES

1. Recognize the general function of a module (i.e., general, directive processing, or device driver).

2. Locate the code which performs a given Executive function.

OVERVIEW

- Over 9Ø possible modules in the Executive
- Modules conditionally assembled using symbols contained in [11,1Ø]RSXMC.MAC
- Three types of modules:

General Executive modules

Have names which relate to function

Example: SYSCM - System Common

Directive Processing modules

Have 5 character names

First two characters are 'DR'

Last three characters indicate function

Example: DRABO - Module for processing the abort directive

Device Driver modules

Have 5 character names

First two characters indicate device type

Last three characters are 'DRV'

Example: DKDRV - Device driver for RKØ5 disk drives

PRINCIPAL EXECUTIVE MODULES

System Common (SYSCM)

- Contains pointers to system lists

  $CRAVL - Pointer to first block of free pool space
  $TSKHD - Pointer to STD
  $ACTHD - Pointer to ATL
  $PARHD - Pointer to Partition List
  $DEVHD - Pointer to Device List
  $GGEF - Pointer to Group Global Event Flag List
  $CLKHD - Pointer to Clock Queue
  $FRKHD - Pointer to Fork Queue
  $CFLPT - Pointer to Checkpoint File PCB List
  $UMRWT - Pointer to UMR wait queue

- Contains pointers to specific data blocks

  $HEADR - Pointer to header of current task
  $TKNPT - Pointer to TCB of TKTN
  $SHFPT - Pointer to TCB of shuffler
  $TKTCB - Pointer to TCB of current task
  $RQSCH - Pointer to TCB of requested task
  $MCRPT - Pointer to TCB of MCR
  $LDRPT - Pointer to TCB of loader

- General system data

  $CMBEG - The TCB of the null task
  $UMRHD - First UMR mapping assignment block
  $CURPR - Current task priority
  $COMEF - Common event flags
  $PWRFL - Powerfail recovery request flag
  $ABTIM - Absolute time counter
  $STKDP - Stack depth indicator
  $INTCT - Clock interrupt ticks count
  $DYPMN - Days per month table
  $BTMSK - Bit mask table
  $IOABM - I/O active bitmap
  $TKPS - Ticks per second
  $CXDBL - Context switching disabled flag

System Entrance and Exit Routines (SYSXT)

- Contains routines used for entering and exiting the Executive

```
$DIRSV - Called when Executive entered by system trap
$FORK  - Used to create FORK process by driver
$FORK1 - Used to create FORK process by non-driver
$FORK2 - Used to create FORK process by CINT$ routine
$INTSV - Called when Exec entered by interrupt
$INTSE - Called when Exec entered by interrupt (Error
         Logging)
$INTSC - Called when Exec entered by interrupt (CINT$)
$INTXT - Called to exit the Exec after an interrupt
$DIRXT - Called to exit the Exec after a system trap
$SWSTK - Called to enter the Exec from a privileged task
```

- Contains code for the system 'idle loop'

DSR Allocation Routines (CORAL)

- Contains routines used to allocate space in DSR

```
$ALOCB - Allocates a block of specified size from DSR
$ALCLK - Allocates a clock queue control block from DSR
$DECLK - Deallocates a clock queue control block
$ALPKT - Allocates a 'send' or I/O request block
$DEPKT - Deallocates a 'send' or I/O request block
$DEACB - Deallocates a block
```

I/O Related Routines (IOSUB)

- Contains routines used in I/O-related processing

```
$GTPKT - Gets I/O packet from I/O queue
$GSPKT - Gets I/O packet
$IODON - Handles common I/O completion
```

PLAS Routines (PLSUB)

- Contains subroutines used to manipulate Program Logical Address Space (PLAS)

```
$SRNAM - Searches for specified partition
$CKACC - Checks if desired access to region is allowed
$CRATT - Creates Attachment Descriptor Block (ADB)
$SRATT - Searches for specified ADB
$SRWND - Searches for specified address window
$UNMAP - Unmaps address window
```

Queue Manipulation Routines (QUEUE)

- Contains subroutines used to manipulate queues

```
$CLINS - Inserts an entry into the clock queue
$CLRMV - Removes an entry from the clock queue
$QINSF - Inserts into FIFO queue
$QINSP - Inserts into priority queue
$QMCRL - Queues MCR command line
$QRMVF - Removes from front of queue
$QRMVT - Removes next entry with specified TCB address
```

Task Request Related Routines (REQSB)

- Contains subroutines used to handle task requests

```
$ABCTK - Aborts current task
$ABTSK - Aborts specified task
$BILDS - Sets up task stack and initialize task header
$ACTTK - Puts task in Active Task List (ATL)
$SETCR - Sets conditional scheduling request
$SETF  - Sets event flag
$DASTT - Declares a non-I/O related AST
$QASTT - Queues an AST to a specified task
$SRAST - Searches for specified type of AST
$SRSTD - Searches STD for specified task
$ACTRM - Removes task from ATL
$STPCT - Stops current task
$STPTK - Stops specified task
$RLPAR - Releases task partition
$RLPR1 - Releases specified partition
$NXTSK - Assigns next task to partition
$FNDSP - Finds space in system controlled partitions
$TSTCP - Tests if checkpoint should be initiated
$ICHKP - Initiates checkpoint of specified task
$CHKPT - Checkpoint task
$LOADT - Puts task in loader queue
$TSKRT - Requests task execution
$MAPTK - Maps task address window
```

SST Service Routines (SSTSR)

- Contains routines to service Synchronous System Traps (SST)

```
$EMSST - Non-RSX EMT instruction
$ILINS - Illegal or reserved instruction
$IOTRP - IOT instruction
$SGFLT - Memory protect violation
$TRACE - T-bit trap or BPT instruction
$TRPØ4 - Odd address, Non-existent memory, etc.
$SSTXT - Common SST exit routine
```

Time Dependent Scheduling (TDSCH)

- Contains routines to handle time dependent scheduling
- Entered from clock interrupt

  Updates system time and date
  Manages clock queue
  Checks for device timeouts
  Manages Round Robin scheduling
  Manages Executive level disk swapping

System Initialization (INITL)

- Executes only for system which has not been saved

  Contains the Executive transfer address location ($INITL)

- Performs system initialization functions

  Writes load device and image file information into SYSCM
  Initializes Processor Status Word
  Initializes Memory Management registers (Mapped system)
  Turns on memory management hardware (Mapped system)
  Initializes Unibus Mapping Registers (11/44, 11/70)
  Calculates size of physical memory
  Verifies the existence of the external directive commons
  Verifies the presence of the floating point processor
  Verifies the presence of EIS
  Verifies that all selected devices are online
  Verifies the presence of the watchdog timer
  Sets up system clock

- Deallocates its space to DSR
- Values initialized by INITL are written to system image by SAV task

Table 3-1 Executive Modules by Function

Function	Modules
Scheduling	
Task Scheduling	TDSCH - Time-Dependent Scheduling SYSXT - Normal Scheduling
Round Robin Scheduling	TDSCH
Disk-Swapping	TDSCH
Idle Loop	SYSXT
Interrupt Processing	
Clock Interrupts	TDSCH
I/O Interrupts	XXDRV - 'XX' Indicates Device
System Entrance	SYSXT
System Exit	SYSXT
Trap Processing	
Synchronous System Traps	SSTSR
'EMT' Traps	DRSUB DRDSP
'TRAP' Traps	DRSUB DRDSP
System Entrance	SYSXT
System Exit	SYSXT
Context Switching	SYSXT
Data Movement	BFCTL

Table 3-1 Executive Modules by Function (Cont)

Function	Modules
DSR Allocation	
For Clock Queue	CORAL
For FIFO Queues	CORAL
For Priority Queues	CORAL
For CLI Messages	CORAL
For Error Messages	ERROR
Error Logging	ERROR
I/O Processing	
I/O Parameter Block	IOSUB
UMR Allocation	IOSUB
I/O Completion	IOSUB

DIRECTIVE MODULES

Resident Directive Module (DRSUB)

- Contains entry points for routines entered by system traps

  $TRTRP - Handles TRAP instruction
  $EMTRP - Handles EMT instruction

- Contains commonly used routines

  $ELGEF - Eliminates Group Global Event Flag block
  $DEAGF - Deaccesses group global event flags
  $DRDSE - Declares significant event
  $DRWSE - Waits for significant event
  $MPXC1 - Maps the first directive common
  $MPXC2 - Maps the second directive common
  $DRQRQ - Queues an I/O request and calls driver
  $GTUCB - Gets UCB address for given device and unit
  $OTHR1 - Calls directive routine in second directive common

Directive Dispatcher (DRDSP)

- Contains code to process EMT traps
- Determines if EMT is

  Directive call

  Switch to Kernel mode

  Non-RSX EMT instruction

- Contains table defining directives in system

Table 3-2 Directive Processing Modules

	Entry	Module	Function
ABRT$	$DRABO	DRABO	Abort Task
ALTP$	$DRAP1	DRATP	Alter Priority
ALUN$	$DRASG	DRASG	Assign LUN
ASTX$S	$DRAXT	DRATX	AST Service Exit
ATRG$	$DRATR	DRREG	Attach Region
CINT$	$DRCIN	DRCIN	Connect to Interrupt Vector
CLEF$	$DRCEF	DRSED	Clear Event Flag
CMKT$	$DRCMS	DRCMT	Cancel Mark Time Requests
CNCT$	$DRCNC	DRSPW	Connect
CRAW$	$DRCRW	DRMAP	Create Address Window
CRGF$	$DRCRE	DRGEF	Create Group Global Event Flags
CRRG$	$DRCRR	DRREG	Create Region
CSRQ$	$DRCSR	DRCMT	Cancel Time Based Requests
DECL$S	$DRDSE	DRSUB	Declare Significant Event
DSAR$S	$DRDAR	DRDAR	Disable AST Recognition
DSCP$S	$DRDCP	DRDCP	Disable Checkpointing
DTRG$	$DRDTR	DRREG	Detach Region
ELAW$	$DRELW	DRMAP	Eliminate Address Window
ELGF$	$DRELE	DRGEF	Eliminate Group Global Event Flags
EMST$	$DREMS	DRSPW	Emit Status
ENAR$S	$DREAR	DRDAR	Enable AST Recognition
ENCP$S	$DRECP	DRDCP	Enable Checkpointing
EXIF$	$DREIF	DREIF	Exit If
EXIT$S	$DREXT	DREIF	Task Exit
EXST$	$DREXS	DRSPW	Exit With Status
EXTK$	$DREXP	DREXP	Extend Task
GCCI$	$DRGCL	DRGCL	Get command for command interpreter
GCII$	$DRCLI	DRCLI	Get command interpreter information
GLUN$	$DRGLI	DRGLI	Get LUN Information
GMCR$	$DRGCL	DRGCL	Get MCR Command Line
GMCX$	$DRGMX	DRMAP	Get Mapping Context
GPRT$	$DRGPP	DRGPP	Get Partition Parameters
GREG$	$DRGPP	DRGPP	Get Region Parameters
GSSW$S	$DRGSS	DRGSS	Get Sense Switches
GTIM$	$DRGTP	DRGTP	Get Time Parameters
GTSK$	$DRGTK	DRGTK	Get Task Parameters
MAP$	$DRMAP	DRMAP	Map Address Window
MRKT$	$DRMKT	DRMKT	Mark Time
QIO$	$DRQIO	DRQIO	Queue I/O Request
QIOW$	$DRQIO	DRQIO	Queue I/O Request and Wait
RCST$	$DRRCS	DRRAS	Receive Data or Stop
RCVD$	$DRREC	DRRAS	Receive Data
RCVX$	$DRREC	DRRAS	Receive Data or Exit
RDAF$	$DRRAF	DRRES	Read All Event Flags
RDXF$	$DRRAF	DRRES	Read Extended Event Flags

Table 3-2 Directive Processing Modules (Cont)

	Entry	Module	Function
RPOI$	$DRREQ	DRSPW	Request and pass offspring information
RQST$	$DRREQ	DRSPW	Request Task
RREF$	$DRRRF	DRMAP	Receive By Reference
RSUM$	$DRRES	DRRES	Resume Task
RUN$	$DRRUN	DRMKT	Run Task
SCAA$	$DRCLI	DRCLI	Specify command arrival AST
SCLI$	$DRCLI	DRCLI	Set command line interpreter
SDAT$	$DRSND	DRRAS	Send Data
SDRC$	$DRSRC	DRSPW	Send, Request, and Connect
SDRP$	$DRSRC	DRSPW	Send data request and pass offspring control block
SETF$	$DRSEF	DRSED	Set Event Flag
SFPA$	$DRFEX	DRPUT	Specify Floating Point AST
SMSG$	$DRSMG	DRSMG	Send message
SPND$S	$DRSPN	DRRES	Suspend
SPRA$	$DRPUT	DRPUT	Specify Power Recovery AST
SPWN$	$DRREQ	DRSPW	Spawn
SRDA$	$DRRCV	DRPUT	Specify Receive Data AST
SREA$	$DRREX	DRPUT	Specify Requested Exit AST
SREF$	$DRSRF	DRMAP	Send By Reference
SRRA$	$DRRRA	DRPUT	Specify Receive-By-Reference AST
STLO$	$DRSTL	DRSED	Stop for Logical OR of Event Flags
STOP$S	$DRSTP	DRRES	Stop
STSE$	$DRSTS	DRSED	Stop for Single Event Flag
SVDB$	$DRSDV	DRSST	Specify SST Vector Table for Debugging
SVTK$	$DRSTV	DRSST	Specify SST Vector Table for Task
ULGF$	$DRELE	DRCMT	Unlock group global event flags
UMAP$	$DRUNM	DRMAP	Unmap Address Window
USTP$	$DRUNS	DRRES	Unstop Task
WSIG$S	$DRWSE	DRSUB	Wait for Significant Event
WTLO$	$DRWFL	DRSED	Wait for Logical OR of Event Flags
WTSE$	$DRWFS	DRSED	Wait for Single Event Flag

DEVICE DRIVER MODULES

System Device Tables (SYSTB)

- Contains DCBs, UCBs and SCBs, for devices with resident data bases.
- Data bases for standard drivers are contained in SYSTB.
- User can include other device data bases in SYSTB at SYSGEN.

RK05 Driver (DKDRV)

- Device driver for RKØ5 disk drives.
- Contains code for performing I/O to device.
- Interrupts from RKØ5 drive cause entry into DKDRV at $DKINT

Table 3-3 Standard Device Drivers

Driver	Device
DKDRV	RKØ5 Disk Drives
DMDRV	RKØ6,RKØ7 Disk Drives
DBDRV	RPØ4,RPØ5,RPØ6 Disk Drives
DRDRV	RMØ2,RMØ3,RMØ5,RPØ7,RM8Ø Disk Drives
DLDRV	RLØ1,RLØ2 Disk Drives
LPDRV	Line Printer
TTDRV	Terminal
MMDRV	TU16,TE16,TU45,TU77 Magnetic Tape
MTDRV	TU1Ø,TE1Ø,TSØ3,TM11 Magnetic Tape
MSDRV	TSØ4 Magnetic Tape
DTDRV	TC11 DECtape
DXDRV	RXØ1 Floppy Disk Drive
DYDRV	RXØ2 Floppy Disk Drive
DDDRV	TU58 Disk Cartridge
DSDRV	RSØ3,RSØ4 Disk Drives
PPDRV	Paper Tape Punch
PRDRV	Paper Tape Reader
CTDRV	TA11 Cassette Tape
DFDRV	RSØ8 Fixed Head Disk Drive
DPDRV	RPØ2 Disk Drive
LKDRV	KMC-11 Line Printer, Controller

FILE SYSTEM OVERVIEW

4

INTRODUCTION

This module introduces the FILES-11 system. FILES-11 consists of an on-disk and in-memory data structure. The on-disk is the same for a number of related operating systems (i.e., IAS, RSX-11D, etc.). The in-memory structure is RSX-11M specific. This structure is a cache of information which improves the performance of the file system.

OBJECTIVES

1. Describe the on-disk and in-memory structures of the FILES-11 system.
2. Describe the directory structure used in FILES-11.
3. Describe how files are accessed on a FILES-11 volume.

RESOURCES

1. RSX-11M/M-Plus I/O Operations Reference Manual

CONCEPTS

FILES-11

- Method of organizing data on mass-storage media
- Common to: RSX-11M/M-PLUS, RSX-11D, IAS, TRAX, VMS

File system includes:

- File processing software such as FCS or RMS

  Provides easy interface between user program and file system

  Allows access data by means of user-defined records

- Executive code to handle queued I/O requests

  Result of QIO directive

  Provides synchronization of I/O operations

  Determines if I/O operation is file-oriented

- A device driver to handle primitive I/O operations

  Data transfers between the device and memory

- An ancillary control processor, ACP, which performs file-related I/O operations

  Possible conversion to driver operations

A FILES-11 volume may be:

- Any kind of disk (including floppy disks)
- DECtape

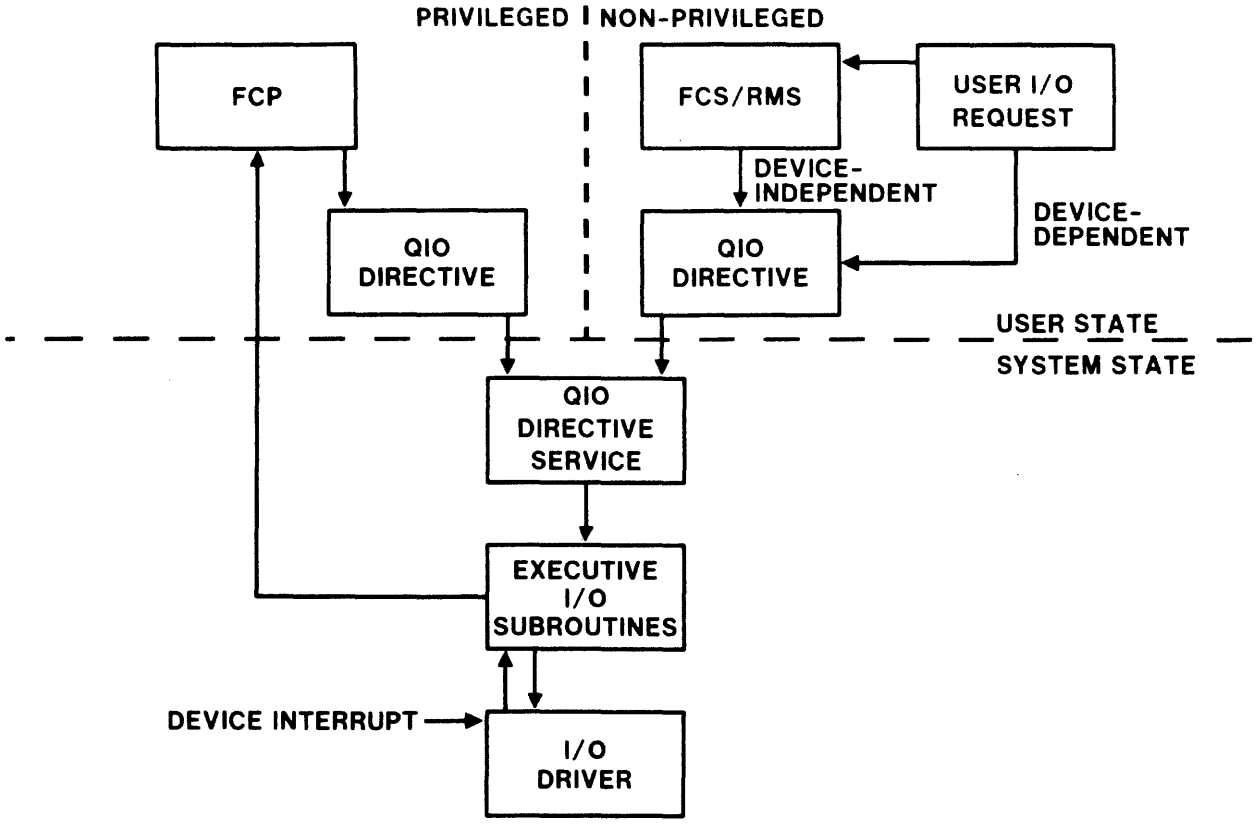


Figure 4-1 The File System

Files

Three units of measurement of space on media:

- Physical blocks

  Physically addressable unit

  Length dependent on type of media

  Usually 512 bytes
  RXØ1 - 128 bytes
  RXØ2 - 128 or 256 bytes

  Normally referenced by device driver

- Logical blocks

  Length equal to 512 bytes

  Block numbers unique for volume

  Begins at logical block Ø

  Highest logical block equals volume size minus one

  Normally referenced by the file processor (F11ACP)

- Virtual blocks

  Used by programmer to access data in files

  Length always equal to 512 bytes

  Virtual block numbers relative to file

  Begins at virtual block 1

  Highest virtual block equals file size

Files consist of two parts:

- The File Header
- The File Body

The File Header

- Contains description of file

  File name
  File owner
  File characteristics used by FCS and RMS
  Information for mapping virtual blocks to logical blocks

- Usually one block long (512. bytes); size depends on the file processor in use

The File Body

- Contains data stored by user and any control data appended by the file access method

- Consists of a number of contiguous groups of logical blocks (segments)

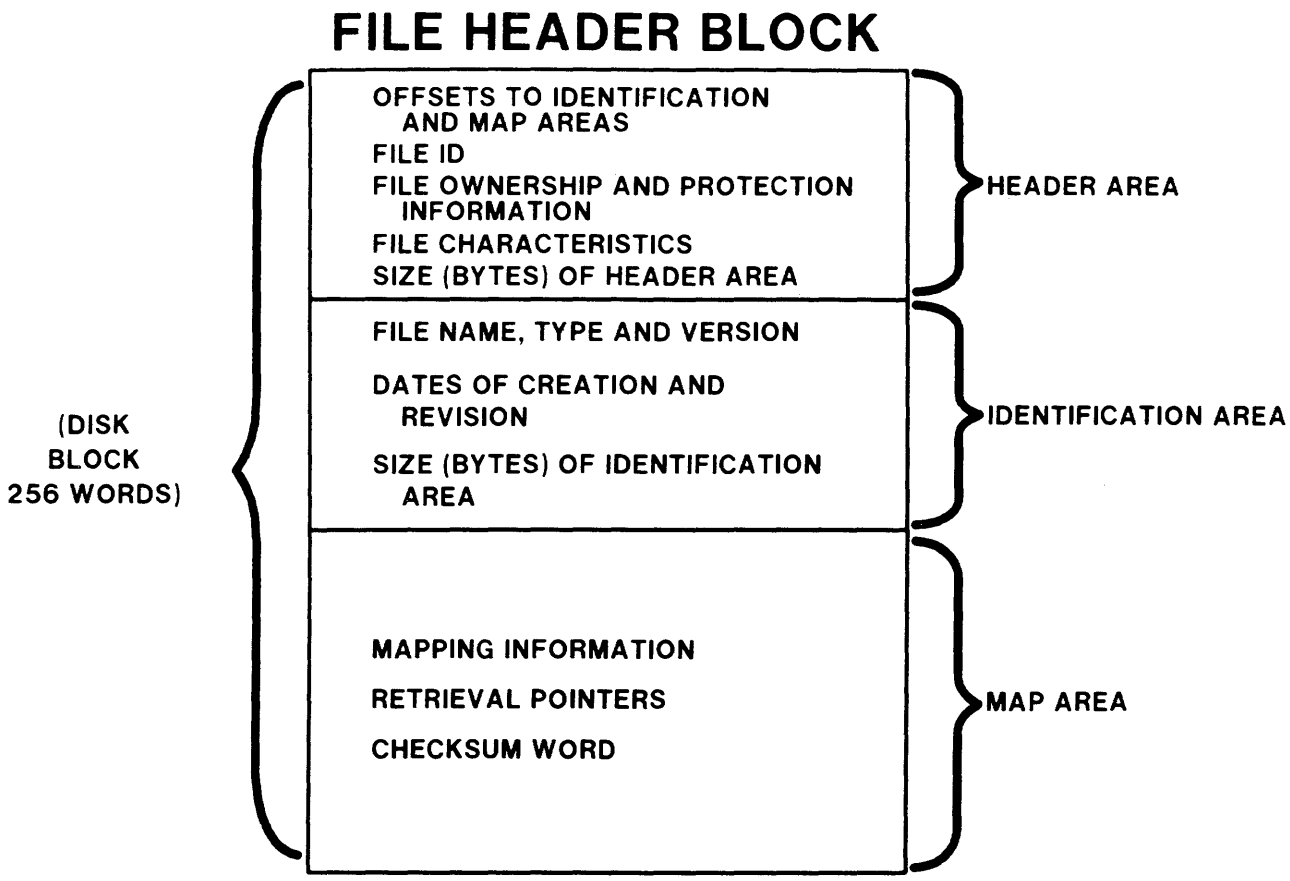


Figure 4-2 The File Header

```
Dump of DB2:[305,306]INTRO1.MOD;26 - File ID 7450,60,0
                                                File header

HEADER AREA
        H.IDOF          027
        H.MPOF          056
        H.FNUM,
        H.FSEQ          (7450,60)
        H.FLEV          401
        H.FOWN          [305,306]
        H.FPRO          [RWED,RWED,RWED,R]
        H.UCHA          000 =
        H.SCHA          000 =
        H.UFAT
                F.RTYP  002 = R.VAR
                F.RATT  002 =   FD.CR
                F.RSIZ  102 = 66.
                F.HIBK  H:0 L:000013 = 11.
                F.EFBK  H:0 L:000013 = 11.
                F.FFBY  310 = 200.
                (REST)
                000000 000000 000000 000000 000000 000000 000000 000000
                000000
IDENTIFICATION AREA
        I.FNAM,
        I.FTYP,
        I.FVER          INTRO1    .MOD;26
        I.RVNO          6
        I.RVDT          14-DEC-81
        I.RVTI          02:50:22
        I.CRDT          15-OCT-81
        I.CRTI          09:46:39
        I.EXDT          --
MAP AREA
        M.ESQN          000
        M.ERVN          000
        M.EFNU,
        M.EFSQ          (0,0)
        M.CTSZ          001
        M.LBSZ          003
        M.USE           002 = 2.
        M.MAX           314 = 204.
        M.RTRV
        SIZE    LBN
        11.     H:001 L:165751 = 125929.
CHECKSUM
        H.CKSM          123624
```

Example 4-1 The File Header for a Data File

```
Dump of DB2:[305,306]SPY.TSK;16 - File ID 16104,7,0
                                                File header

HEADER AREA
        H.IDOF          027
        H.MPOF          056
        H.FNUM,
        H.FSEQ          (16104,7)
        H.FLEV          401
        H.FOWN          [305,306]
        H.FPRO          [RWED,RWED,RWED,R]
        H.UCHA          200 =  UC.CON
        H.SCHA          000 =
        H.UFAT
                F.RTYP  001 = R.FIX
                F.RATT  000 =
                F.RSIZ  1000 = 512.
                F.HIBK  H:0 L:000050 = 40.
                F.EFBK  H:0 L:000051 = 41.
                F.FFBY  0 = 0.
                (REST)
                000000 000000 000000 000000 000000 000000 000000 000000
                000000
IDENTIFICATION AREA
        I.FNAM,
        I.FTYP,
        I.FVER          SPY       .TSK;16
        I.RVNO          22
        I.RVDT          14-DEC-81
        I.RVTI          02:50:28
        I.CRDT          05-JUN-81
        I.CRTI          14:14:33
        I.EXDT          --
MAP AREA
        M.ESQN          000
        M.ERVN          000
        M.EFNU,
        M.EFSQ          (0,0)
        M.CTSZ          001
        M.LBSZ          003
        M.USE           002 = 2.
        M.MAX           314 = 204.
        M.RTRV
        SIZE    LBN
        40.     H:001 L:172544 = 128356.
CHECKSUM
        H.CKSM          133671
```

Example 4-2 The File Header for a Task Image

Retrieval Pointers

- Defines the correspondence between logical and virtual blocks
- Contained in the file header:

  Maximum: 1Ø2 per header

  One fragment per retrieval pointer

  Maximum file length with 1 block per header: 26112 blocks

- Four bytes long

  One byte: number of virtual blocks in segment; maximum is 256 blocks.

  Three bytes: pointer to first logical block in segment.

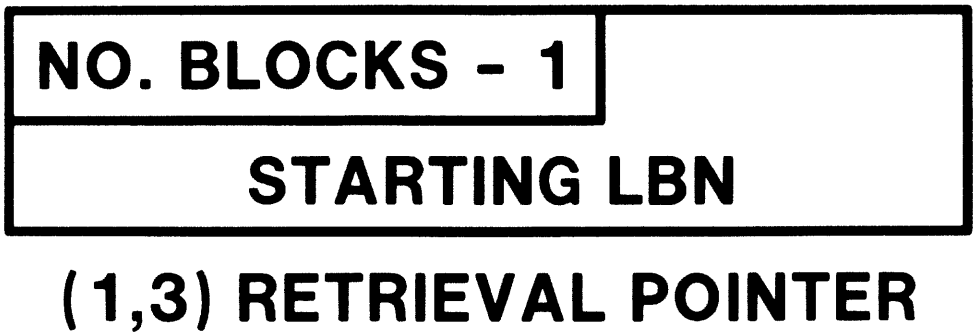


Figure 4-3 Retrieval Pointer

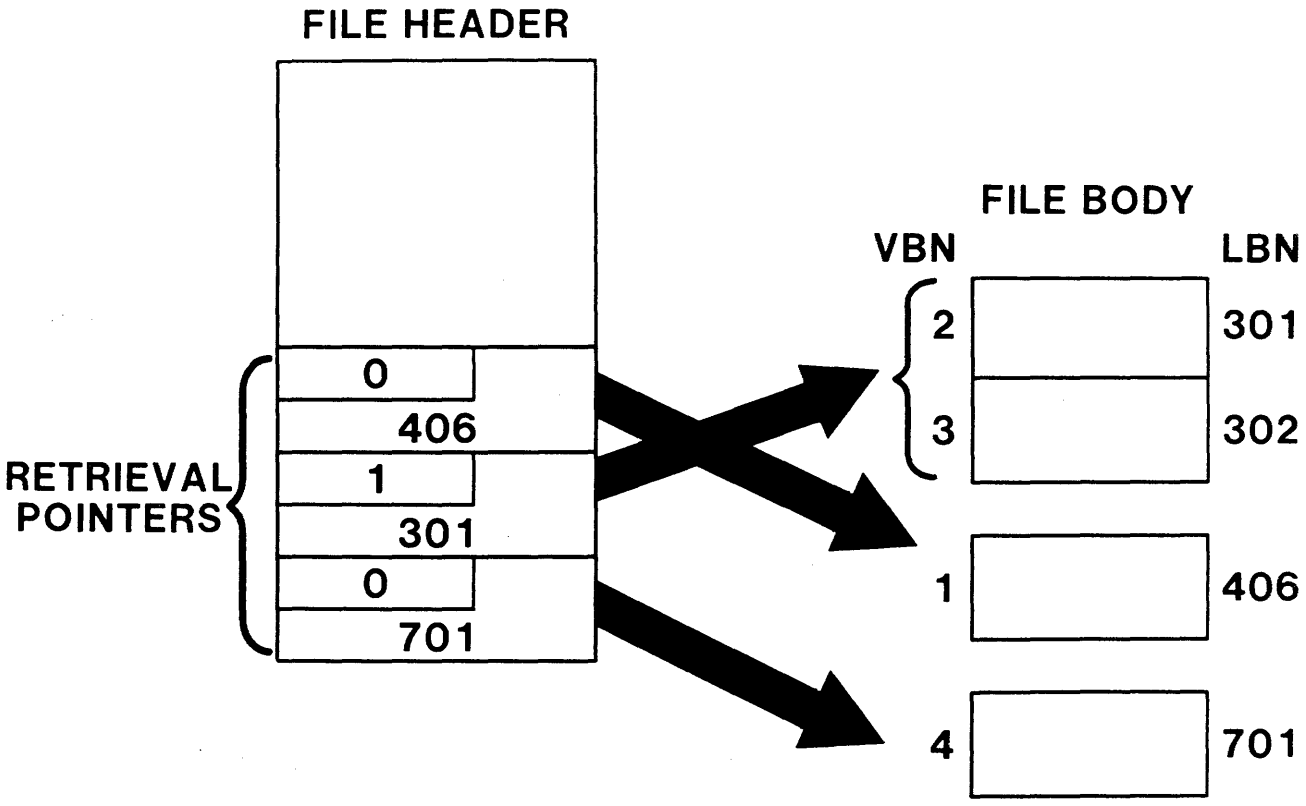


Figure 4-4 Mapping Virtual to Logical Blocks

File Directories

- Contains information needed to identify and locate files

  File name, type and version number

  File number (Relative number of file headers in index file)

  File sequence number (Number of times a file header is used)

- Two types of directories

  Master File Directory (MFD) -- One per volume

  User File Directory (UFD) -- As many as desired per volume

- Naming convention

  Name of directory: xxxyyy.DIR;1

  where

  xxx is a group number
  yyy is a member number

  Master File Directory: 000000.DIR;1

  User File Directory for UIC: [6,32]: 006032.DIR;1

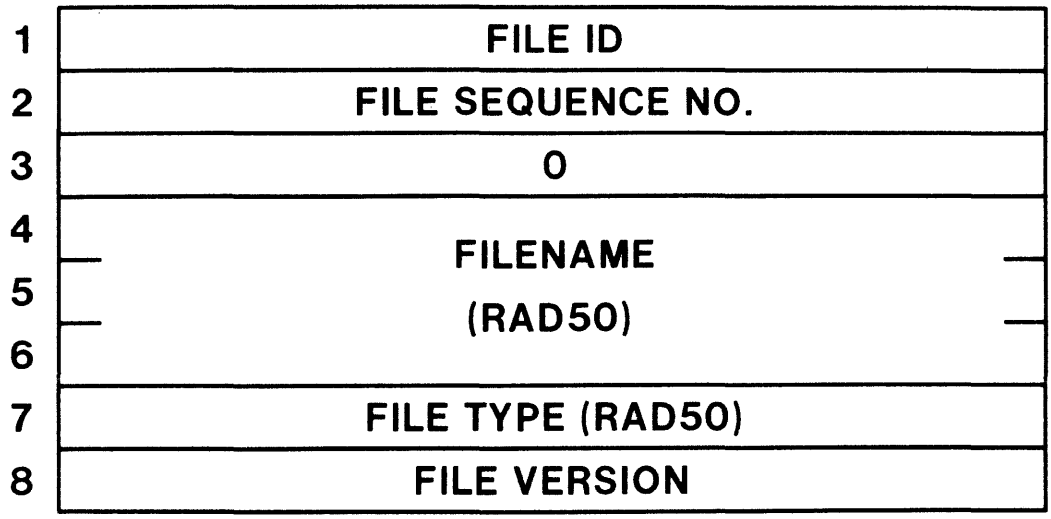


Figure 4-5 Directory Record

FILES-11 VOLUMES

The Standard Files

- The Index File: INDEXF.SYS
- The Bitmap File: BITMAP.SYS
- The Master File Directory: 000000.DIR
- The Bad Block File: BADBLK.SYS
- The System Checkpoint File: CORIMG.SYS

The Index File

- Contains basic structures needed by file system.

  Boot Block
  Home Block
  Index File Bitmap
  All File Headers

- Filespec: [0,0]INDEXF.SYS;1,
  File ID/SEQ: 1/1

- Boot Block

  Contains bootstrap code for hardware booting of device

  Always virtual block 1 of index file

  Always logical block 0 of volume

  Written by SAV command when the /WB switch is used

  If volume not bootable, contains code to print the message: THIS VOLUME DOES NOT CONTAIN A HARDWARE BOOTABLE SYSTEM

- Home Block

  Contains information needed by file system to access data on volume

  Volume label

  Pointer to index file bitmap

  Size of index file bitmap

  Checksum words to validate data in home block

  Always located in virtual block 2 of index file

  Located in first good block in sequence
  1, 400, 1000, 1400, ...

  Checksum used to identify homeblock

- Index File Bitmap

  Allows fast access to unused blocks in index file

  Always located beginning in virtual block 3 of index file

  One bit per possible file header in index file

  Bit is set to indicate if block is in use

  Bit clear if block is free

  Bit is set if block is in use

- File Headers

  Contained in virtual blocks starting at block 3+n, where n is the length of the bitmap

  First 16 headers are contiguous

  Virtual block of header = 2 + m + n

  where

  n = number of blocks in index file bitmap
  m = file number

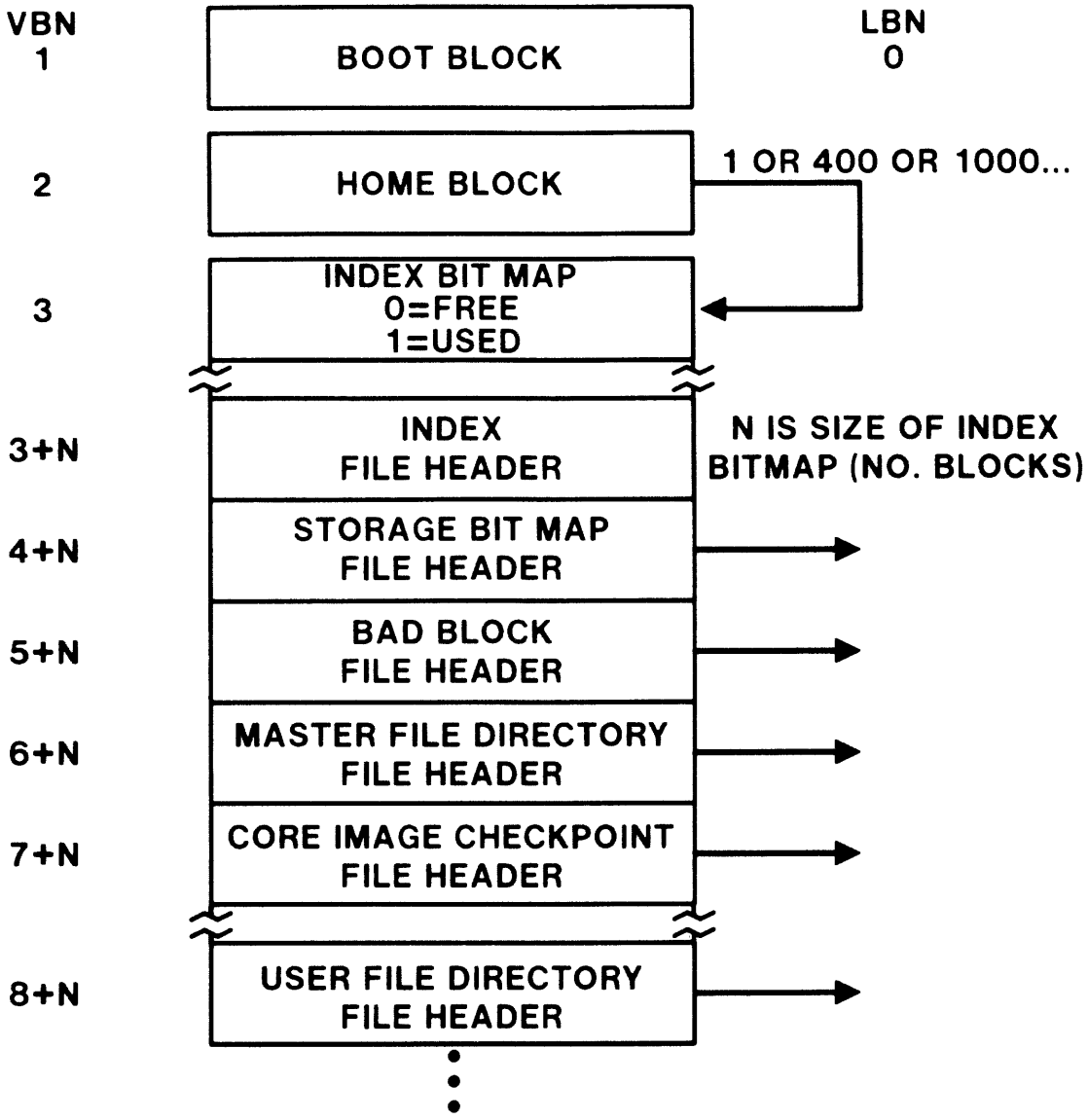


Figure 4-6 Structure of the Index File

The Bitmap File

- Virtual block number 1 contains allocation information used on RSX-11D
- Bitmap starts in virtual block number 2 of the bitmap file
- One bit per logical block on volume
- Value of each bit indicates status of corresponding block

  Bit set - block not allocated to file

  Bit clear - block allocated

- VFY compares clear bits with retrieval pointers
- Filespec: [0,0]BITMAP.SYS;1,
  File ID/SEQ: 2/2

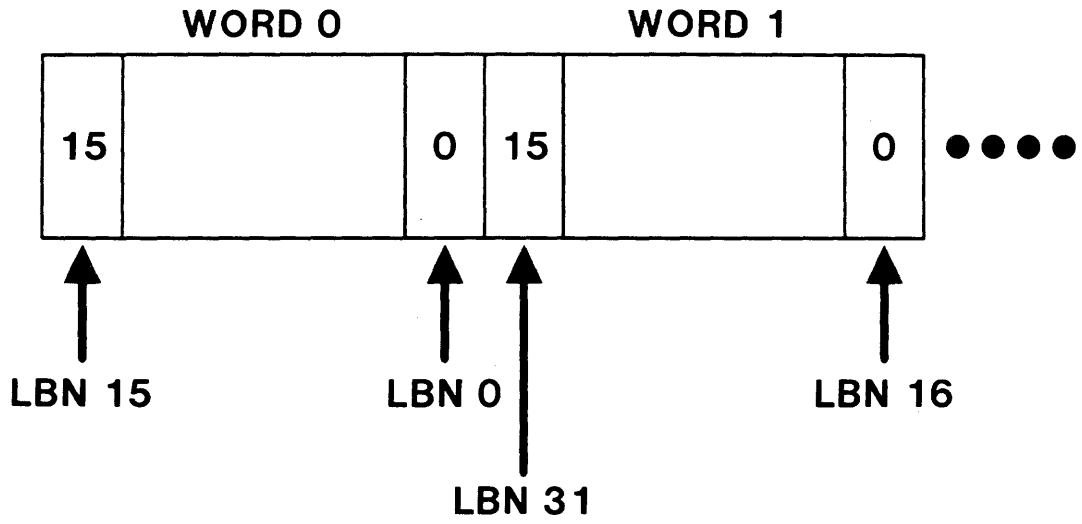


Figure 4-7 The Bitmap File

The Master File Directory

- Directory corresponding to UFD [0,0]
- Contains entries for the five standard files
- Contains entries for all UFDs on volume
- Contains entry for system account file RSX11.SYS
- Filespec: [0,0]000000.DIR;1,
  File ID/SEQ: 4/4

The Badblock File

- Used to keep bad blocks from being allocated to user files
- Bad block information created by BAD or entered by the user or manufacturer allocates blocks to file
- Filespec: [0,0]BADBLK.SYS;1, File ID/SEQ: 3/3
- No dynamic badblock handling

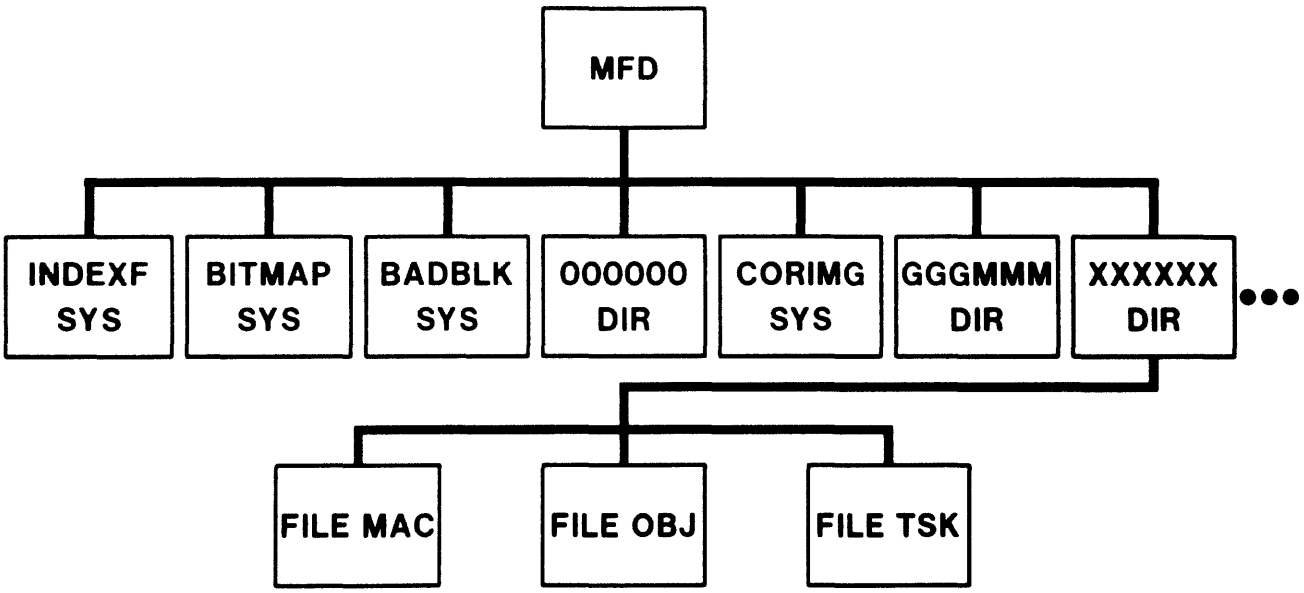


Figure 4-8 Two Level Directory Structure

The System Checkpoint File

- Used to checkpoint tasks
- No space allocated when volume initialized
- Space allocated by ACS command
- Always contiguous
- Filespec: [Ø,Ø]CORIMG.SYS;1,
  File ID/SEQ: 5/5

FUNCTIONS OF THE FILE SYSTEM

Creating a FILES-11 Volume

- FILES-11 volume created by INITIALIZE command
- Home block information can be modified by the HOME command
- Creates five standard files
- Volume characteristics determined:

    Volume label

    Number of blocks for default file extension

    Size of index file (number of blocks used for file headers)

    Number of files on volume

    Location of index file

    Default protection for files on volume

Creating a File

- Index file bitmap searched for first free block
- First free block used for file header
- Bitmap file searched for required number of free blocks to allocate initial file
- Entry for new file placed in UFD

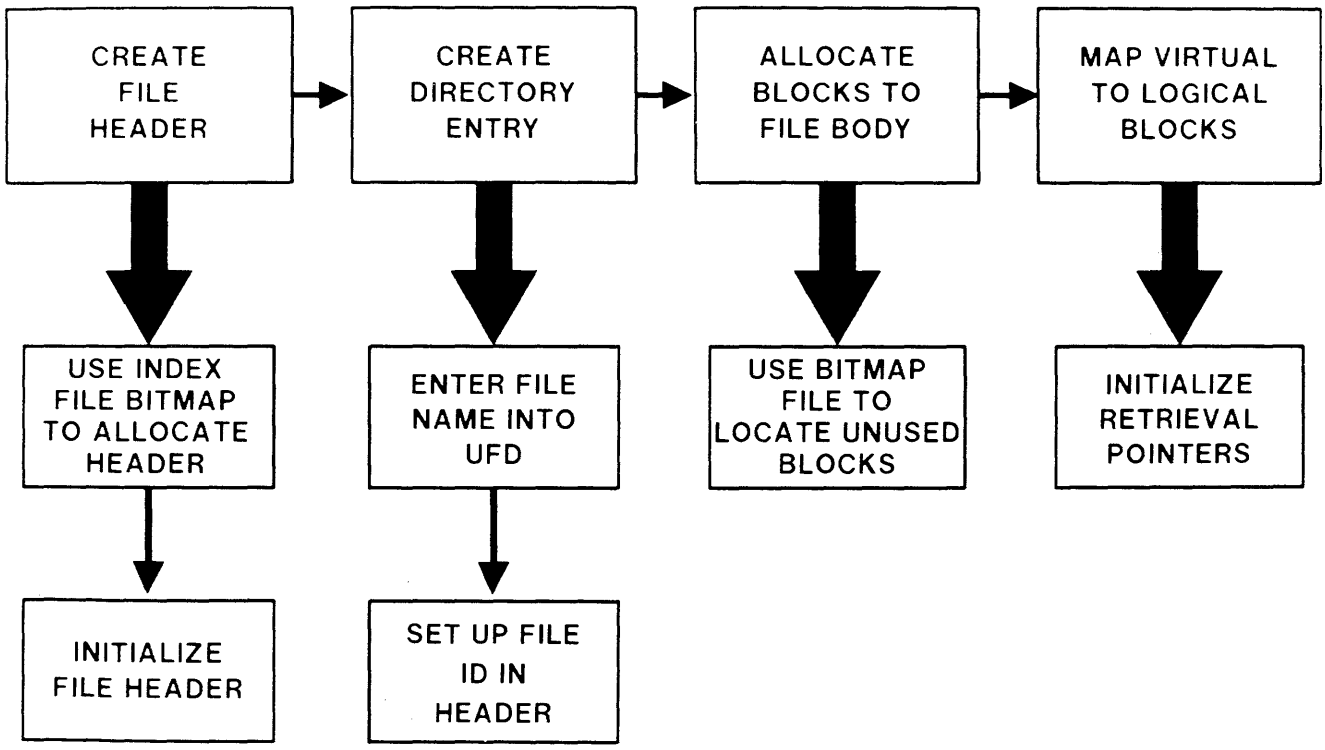


Figure 4-9 Creating a File

Accessing a File

- By file name - DB1:[1Ø1,1Ø1]DATA.DAT;1

  MFD from device mounted on DB1: is searched for 1Ø11Ø1.DIR

  File ID for 1Ø11Ø1.DIR is used to find the file header

  Retrieval pointers from header are used find UFD file

  UFD is searched for entry for DATA.DAT

  File ID for DATA.DAT is used to find the file header

  Retrieval pointers from header are used to find file

  File is accessed

- If file ID is known, file header can be accessed without using directories

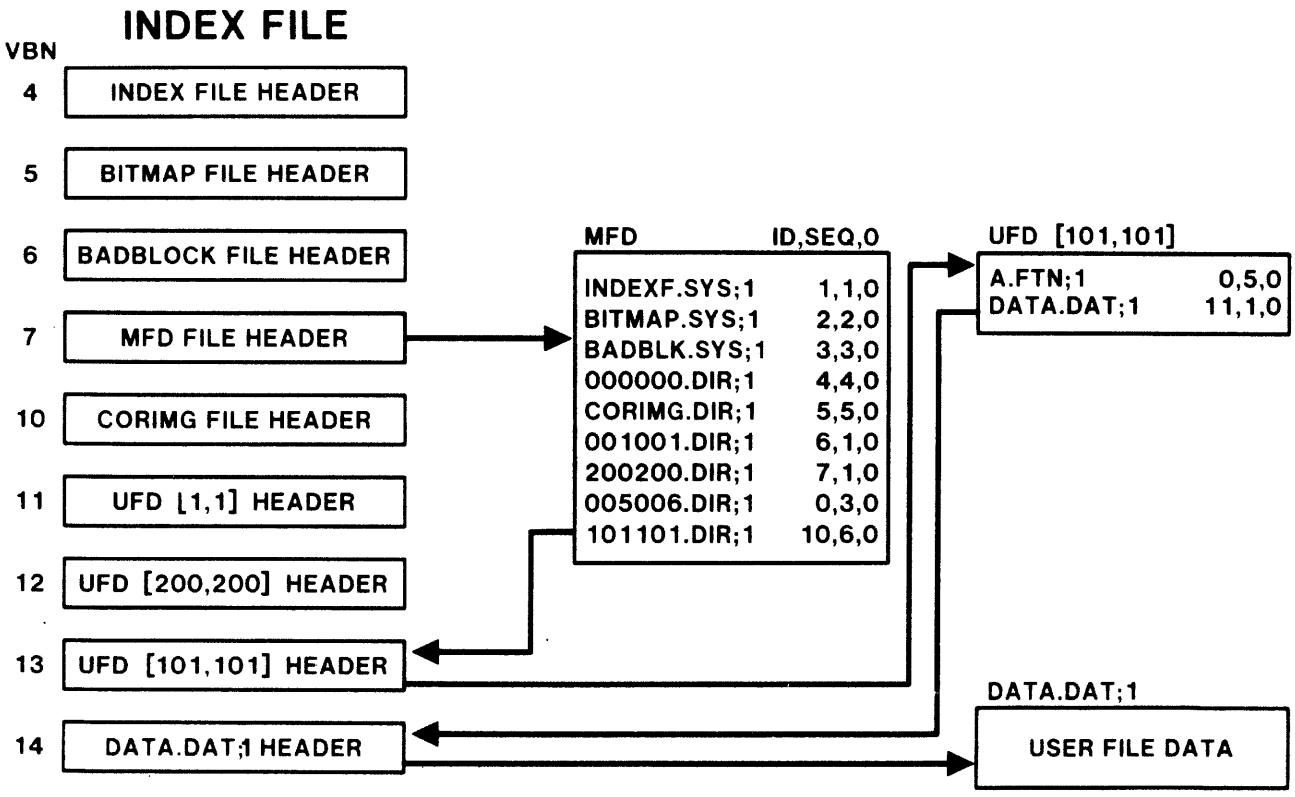


Figure 4-1Ø Accessing a File

THE FILE PROCESSOR

File Control Processors

- Privileged system task which handles file-specific I/O
- Processes QIO commands queued to its receive queue
- Several file processors supplied with system

    F11ACP - Used for FILES-11 disk volumes

    MTAACP - Used for magnetic tape volumes

    NETACP - Used by DECNET

- To speed up file operations, dedicate appropriate FCPxxn to volumes

```
>INS $FCPxxx/TASK=DB1FCP

>MOU DKØ:/ACP=DB1FCP
```

Logical Units

- Tasks specify I/O devices by using logical unit numbers.
- Each logical unit number refers to a unique I/O device.
- Pointer to an entry of the logical unit table for the task.
- The logical unit table is in the task header.
- Each entry is two words long:

  Word one is a pointer to the UCB for the device.

  Word two is a pointer to a FILES-11 window block if file is open; and Ø otherwise.

- FILES-11 window block is a data structure used to store retrieval pointers.
- Logical unit table constructed and units assigned at taskbuild.
- Logical unit assignments can be changed by:

  REASSIGN command

  ALUN$ directive

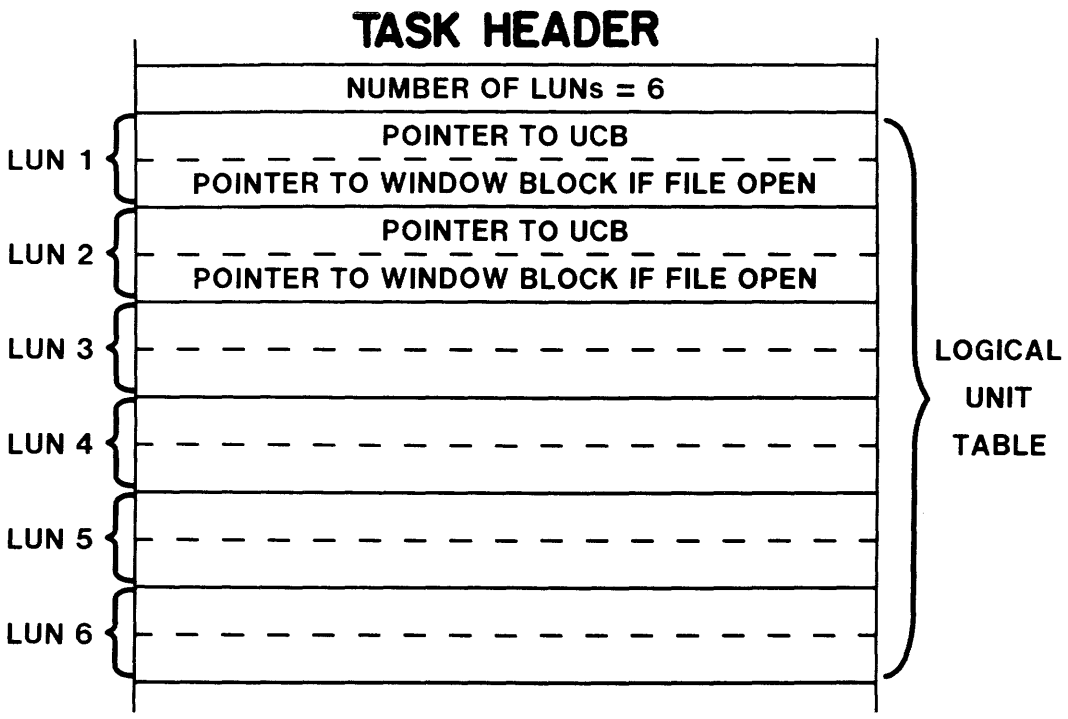


Figure 4-11 The Logical Unit Table

Data Structures

- The Volume Control Block (VCB)

  Created from information in home block

  One VCB per mounted volume

  Contains

  Transaction count for volume
  Logical block number of index file bitmap
  Logical block number of storage bitmap
  Pointers to other data structures, e.g. FCB

- The File Control Block (FCB)

  Created from file header

  One FCB per open file

  Contains

  Logical block number of file header
  File number and sequence numbers
  File owner and protection code

- FILES-11 Window Block

  One window block per accessor to file

  Contains

  Access privileges of accessor
  Retrieval pointers (seven by default)

NOTE

Retrieval pointers in the file header use one byte for the block count and three bytes for the disk address; those in the window block use two bytes for the count and four bytes for the disk address.

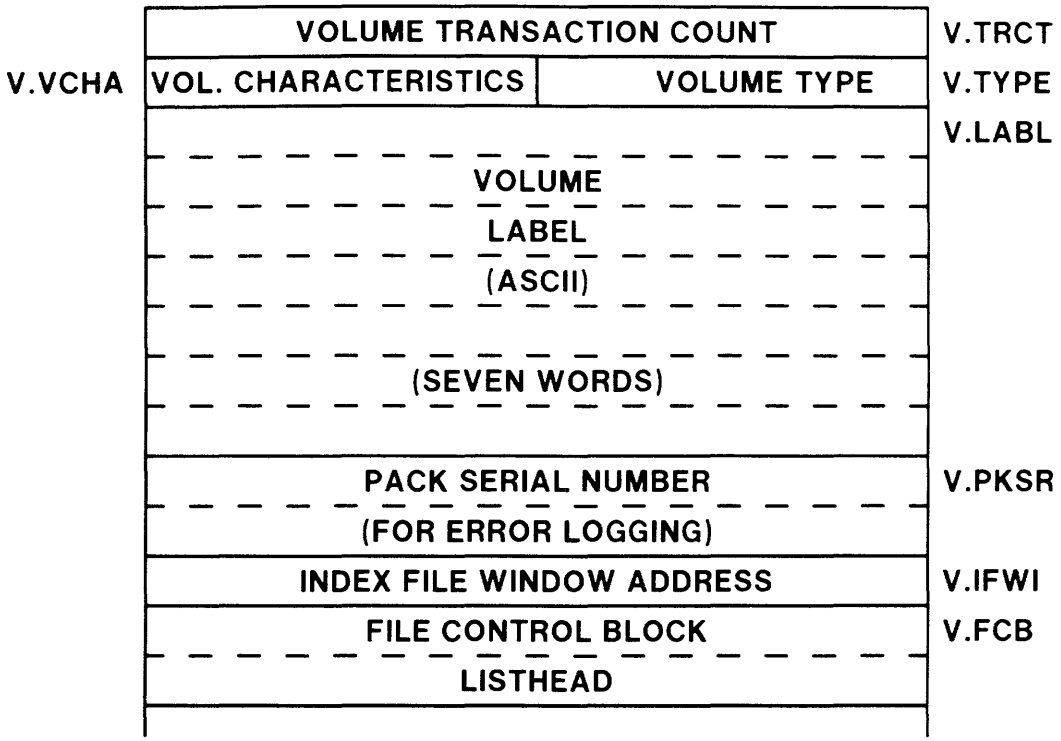


Figure 4-12 The Volume Control Block (Part One)

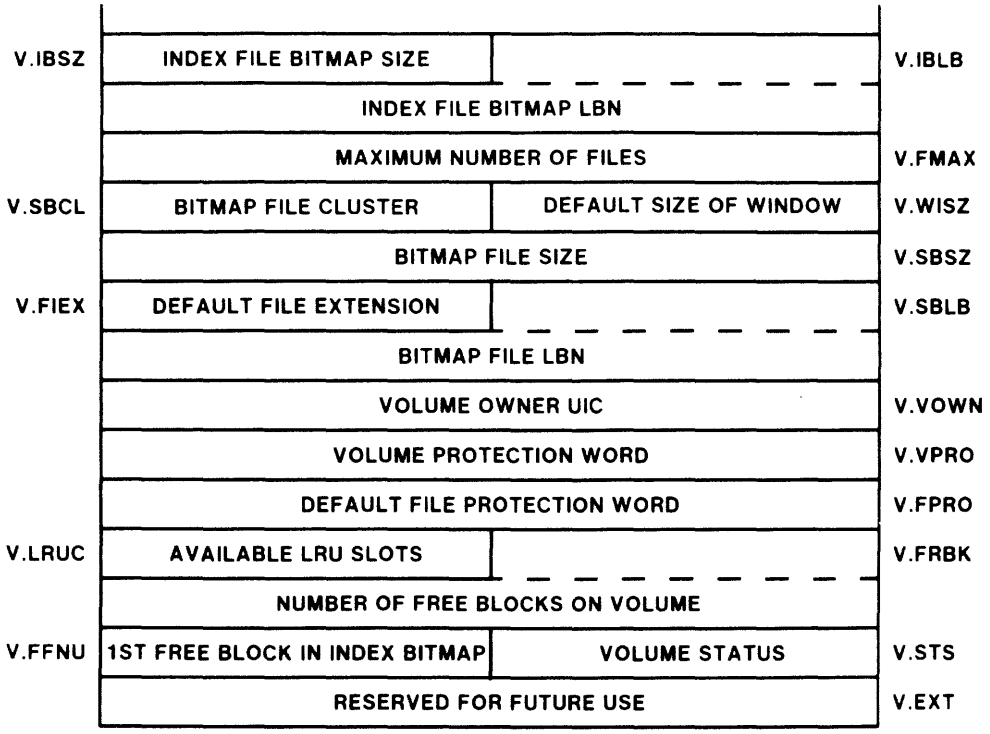


Figure 4-12 The Volume Control Block (Part Two)

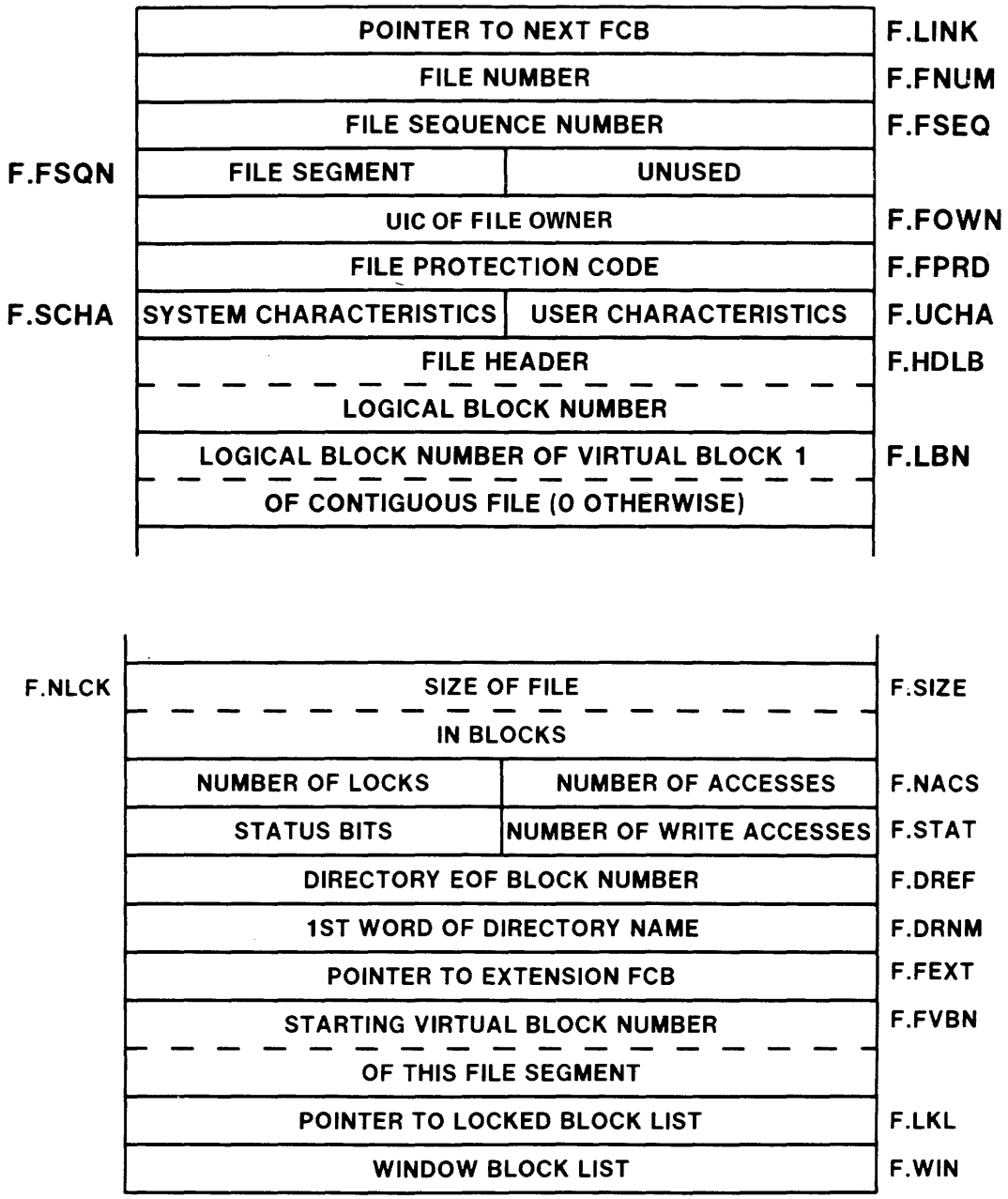


Figure 4-13 The File Control Block

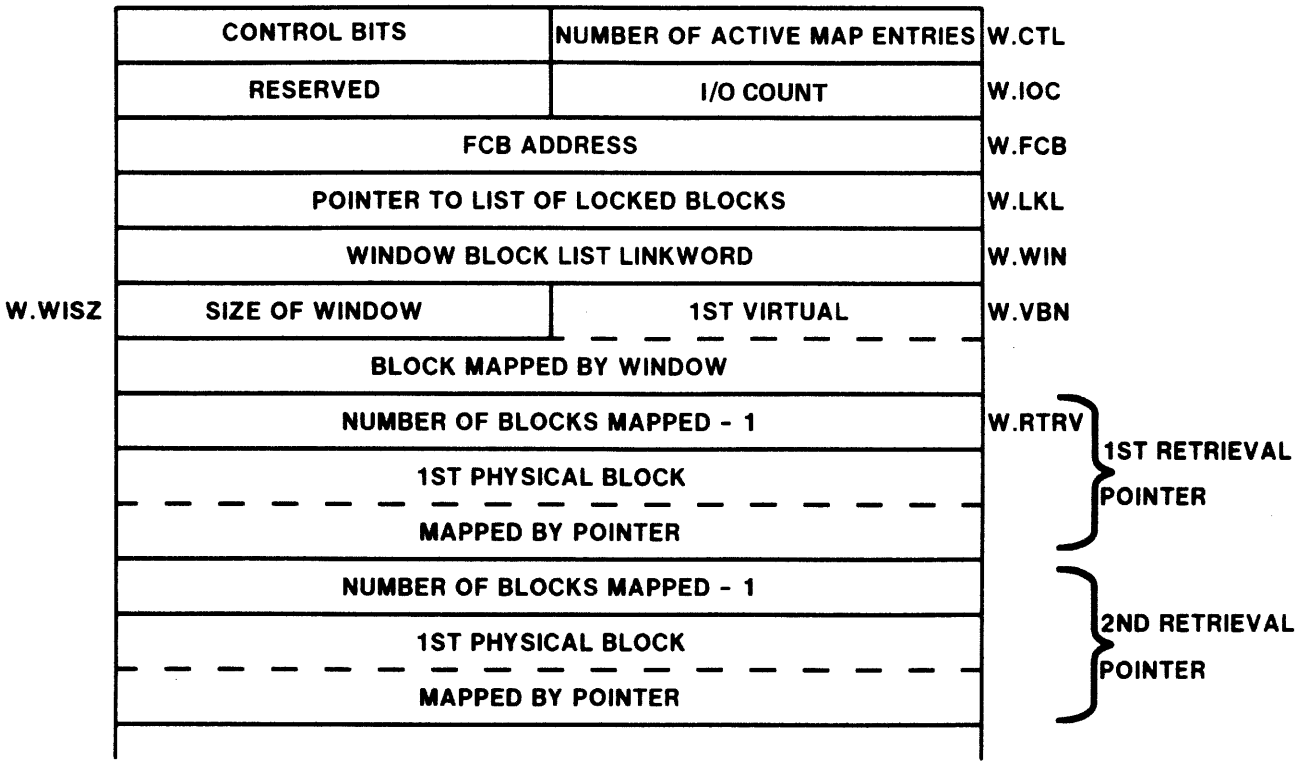


Figure 4-14 FILES-11 Window Block

Mounting a Volume

- Volume mounted by MOUNT command

  Compares the volume label with that specified in the MOUNT command

  Copies homeblock information into VCB

  Associates an ACP with the volume

- Steps in mounting a FILES-11 volume:

  Volume Control Block is created

  VCB is linked from the UCB using U.VCB

  Index file is opened

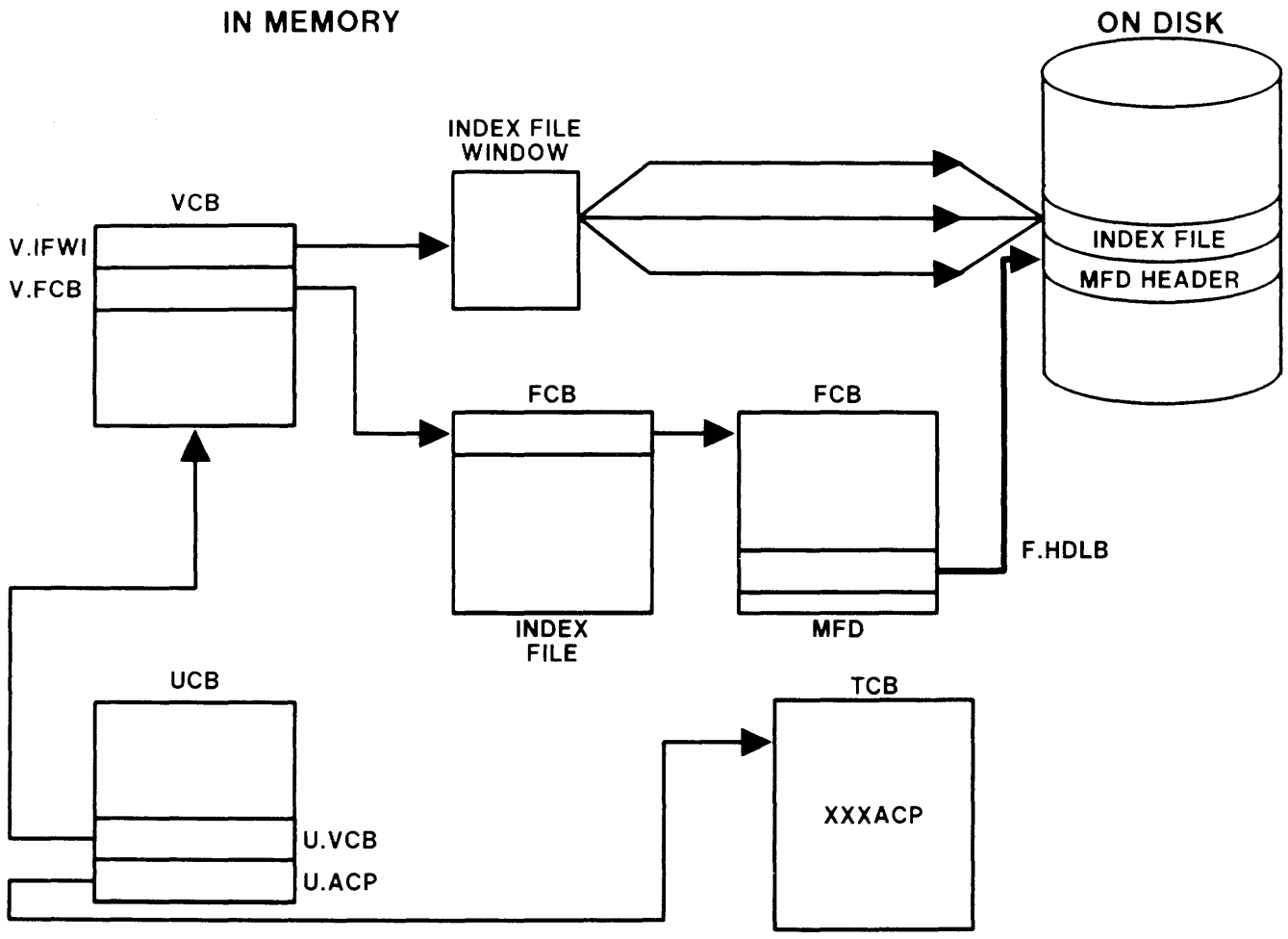


Figure 4-15 Mounting a Volume

Opening a File

- Steps in opening a file:

  File Control Block or FCB is created.

  FILES-11 window block is created for file.

  FCB is inserted in the FCB queue for volume.

  Pointer from logical unit table to window block is initialized.

- Shared files have only one FCB but separate window blocks.
- File system keeps, in memory, a list of FCBs of the more recently used directories.

  This list is called the LRU.

  Eliminates need to read directories from disk when file is accessed.

  Least recently used directory is flushed when new directory accessed if list is full.

  Size of LRU list is determined by LRU switch on INI or HOM command.

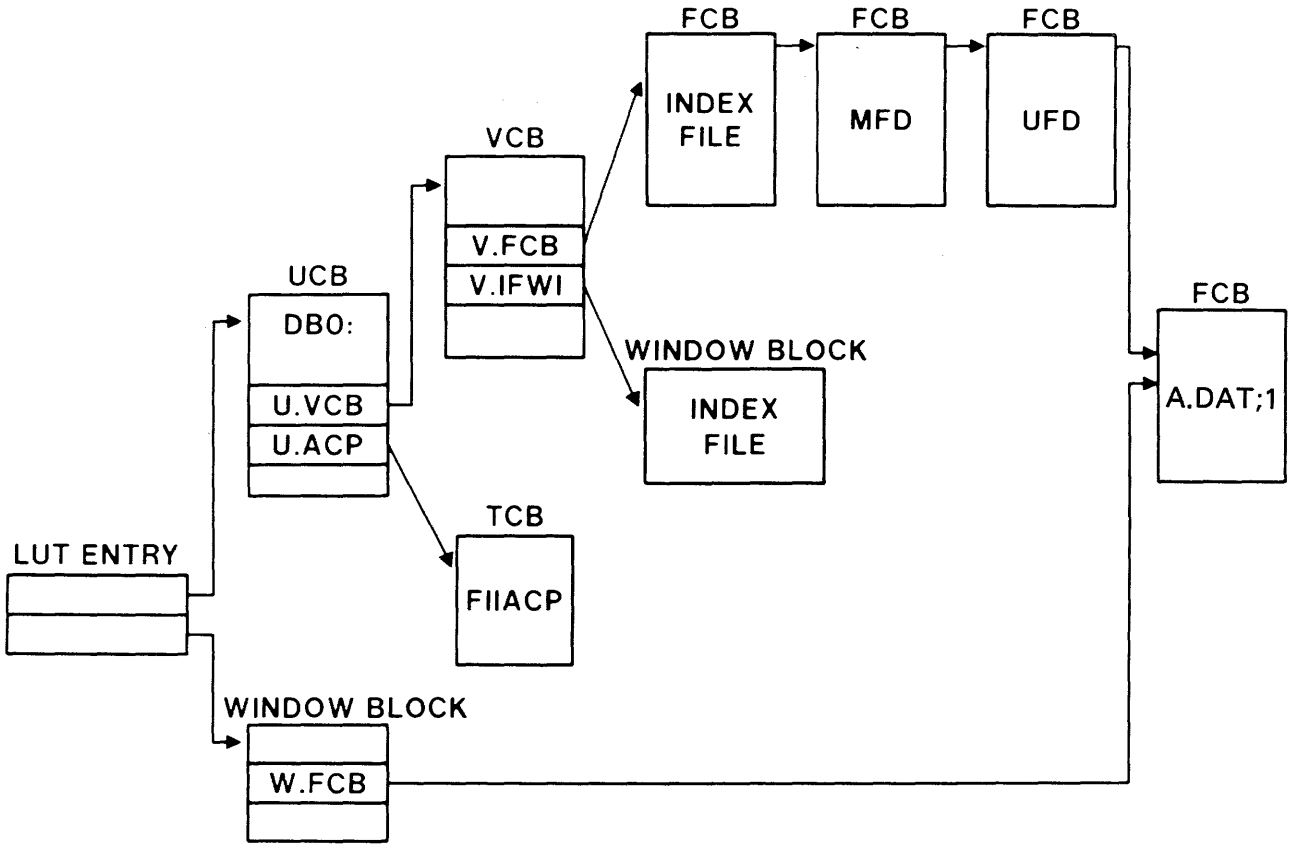


Figure 4-16 Opening a File

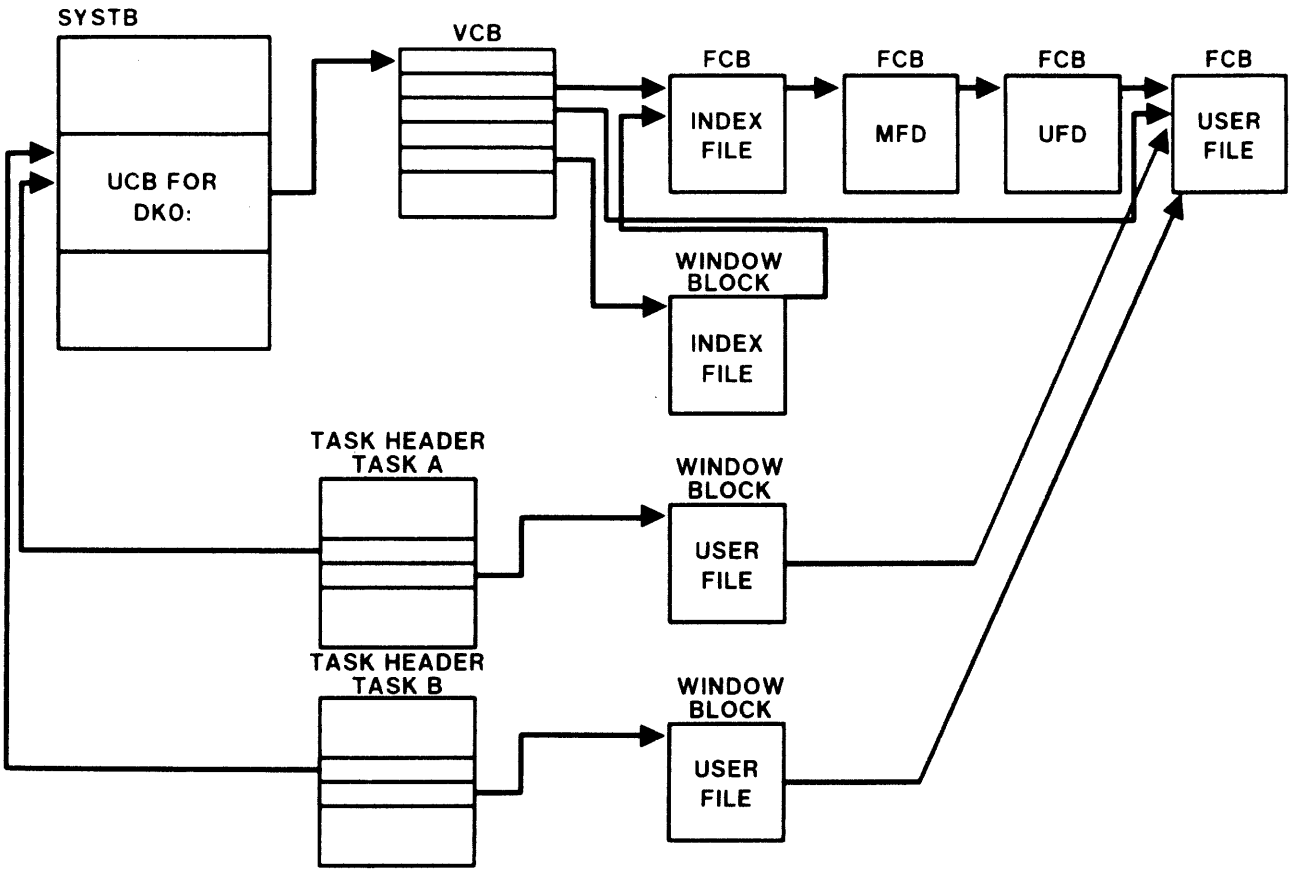


Figure 4-17 Shared Access

SYSTEM GENERATION

5

INTRODUCTION

The RSX-11M operating system is designed to support a large variety of application environments and possible hardware configurations available to the PDP-11 processor. The process used to adapt the system to these varied conditions is called System Generation or SYSGEN.

The RSX-11M SYSGEN procedure is designed to allow customizing of the operating system to be performed in an efficient and accurate manner. The procedure is run under the control of supplied indirect command files. Facilities such as VMR and SAV are provided to help the user set up his system quickly.

OBJECTIVES

1. Generate a functioning RSX-11M system.

2. Perform the ancillary functions, VMR and SAV, to produce a practical system.

RESOURCES

1. RSX-11M System Generation and Management Guide

OVERVIEW

SYSGEN Functions

- Provide support for existing hardware

  The processor model (e.g., PDP-11/44)

  Processor options (e.g., memory management, floating-point processor)

  Devices installed on system

  Number of controllers and physical units

  Vector and CSR addresses for all devices

- Provide needed software features

  Executive options (e.g., directives, 'round-robin')

  File system (version of F11ACP)

  Resident library support (e.g., FCPRES)

  Terminal support (e.g., full-duplex)

The SYSGEN Process

- SYSGEN procedure is contained in three indirect command files

  SYSGEN.CMD - First phase of SYSGEN

  Assembles Executive
  Assembles device drivers
  Creates command files to be used in phase two

  SYSGEN2.CMD - Second phase of SYSGEN

  Taskbuilds the Executive
  Taskbuilds the device drivers
  Creates needed libraries
  Taskbuilds the privileged system tasks

  SYSGEN3.CMD - Third phase of SYSGEN

  Allows system tasks to be rebuilt

- Between phase two and phase three, VMR should be applied to the new system

  Use VMR command file SYSVMR.CMD created by the SYSGEN procedure

  Can be edited to add desired partitions
  Must be edited if system is unmapped

  Configure the new system

  Set up partitions
  Load device drivers
  Install system tasks

- SYSGEN procedure creates saved answer file SYSSAVED.DAT

  Contains answers to SYSGEN questions in symbolic form
  File can be modified by user for use in later SYSGEN

Types of SYSGEN

- SYSGEN can be performed using the base-line system on the distribution kit

  Called a standalone SYSGEN

  System is dedicated to SYSGEN, no other users

- SYSGEN can be performed using an existing RSX-11M system

  Called an on-line SYSGEN

  Other users can use the system during most of the SYSGEN process

- MCR commands can be inhibited during the SYSGEN process

  Called a PREPGEN

  Saved answer file can be corrected/modified for use later in live SYSGEN

New Features for Version 4.0

- Autoconfigure option determines correct hardware configuration
  - Processor type
  - CSR and vector addresses
- Standard feature Executive option produces a mapped system
  - Most software options
  - Supports all layered products
- Improved saved answer file support
  - Saves responses to Phase II questions
  - Supports named input and output saved answer files
  - Can create a single saved answer file for Phase I and II
- A minimum of 28K words of memory is required for SYSGEN
- Directive commons increase POOL size
- Taskbuild .CMD and .ODL files are dynamically created
- A PLAS overlaid FCS resident library may be selected
- Either EDI or EDT may be selected for editing SYSGEN files
- Phase I can chain to Phase II without a break

PREPARING FOR SYSGEN

Distribution Kits

- There are several different kits available

  'Big Disk' distribution kit for RP04/05/06/07, RM02/03/05, RM80 and RA80

  RK06/07 distribution kit

  RL01/02 distribution kit

  RK05 distribution kit

- Distribution kit must be copied before SYSGEN using DSC

  Version 3.2 DSC cannot be used unless V 4.0 patch has been applied (see release notes)

  Copy of standalone DSC supplied with kit can be used

Autopatch

- A collection of patches to the released system

  Issued at regular intervals

  Also may include patches to layered products

- Must always be applied to released version without previous patches
- Uses an indirect command file to generate patched system

Individual Patches

- Patching source files

  Used for Executive, driver and MCR patches

  Use Source Language Input Program (SLP)

  Create SLP command file
  Invoke SLP with command file

  For MACRO-11 sources, output for SLP must be:

  Assembled
  Task-built
  Integrated into system (Method depends on component patched)

  Patching object files

  Used for patching utilities

  Use Object Module Patch Utility (PAT)

  Create MACRO-11 source file for correction
  Assemble correction file
  Apply correction to old object file using PAT

  Output from PAT must be:

  Task-built
  Reinstalled into the system

- Patching task image files

  Infrequently used for operating system patches

  Frequently used for patching layered products

  Use Task/File Patch Program (ZAP)

  Create ZAP command file
  Invoke ZAP to apply patches to task image file

- Patches supplied by DIGITAL are cumulative

  Apply a patch only if you have already applied all previous patches

  Unless the patch states otherwise, apply patch to most recent version of the component

DETAILS OF SYSGEN

Phase 1

There are seven sections in Phase 1

Setup - How SYSGEN is to be run

Target Configuration - The environment for which the SYSGEN is being performed

Host Configuration - The system on which SYSGEN is being run

Executive Options - What features are desired in the new system

Terminal Driver - Which type of terminal driver and which features are desired

System Options - Which file processor, CLI support, and POOL monitoring support is desired

Peripheral Options - Specification of devices, controllers and their vectors, and CSRs

After questions have been answered, the Executive and drivers are assembled

Phase 2

There are eight sections in Phase 2

Setup - How SYSGEN Phase 2 is to be run

Library Commons Creation - Modifies SYSLIB, creates other libraries used in taskbuilding system tasks

Executive Taskbuild - Creates system images RSX11M.TSK, EXCOM1.TSK and EXCOM2.TSK

System Image Creation - Creates RSX11M.SYS from RSX11M.TSK

Full-Duplex Terminal Driver Taskbuild - Creates the full-duplex driver if selected

Loadable Driver Taskbuild - Creates all drivers not built into the Executive

Privileged Task Taskbuild - Builds privileged system tasks

System VMR - Modifies RSX11M.SYS, creating partitions, installing tasks, etc.

Phase 3

- Optional - May be performed when and as often as desired
- Used to build optional tasks not included in distribution kit
- Used to rebuild supplied tasks to:

  Change defaults

  Incorporate support for ANSI magtape and/or FCS big-buffering

  Use a resident FCS library

- Used to rebuild tasks after patching
- VMR must be used to remove and install new versions of tasks installed in the system image

EXECUTIVE OPTIONS

Standard Feature Executive

- Allows the generation of a system supporting all standard features
- Requires a mapped system
- Provides the following:

```
DBMS-11 support
FILES-11 ACP support
RMS support
Nonresident task support
Loadable task loader
Directive commons
Memory management directives
All other Executive directives
Address checking support
I/O rundown support
Multiuser support
ANSI Magtape support
Loadable driver support
AST support
20K word Executive
Error logging
Powerfail recovery
User written driver support
System controlled partitions
Round-robin scheduler and disk swapping
Software write lock support
Queue manager
Shuffler
Crash dump support
Full-duplex terminal driver
DCL and two user written CLIs
POOL monitoring
PLAS resident FCS
'MIDDLE' F11ACP
```

The Terminal Driver

- Two possible terminal drivers:

  Half-duplex driver
  Full-duplex driver

- Half-duplex driver comes in three forms:

  Baseline
  Tailored
  Tailorable

- The baseline half-duplex driver

  Minimum terminal driver
  Not available with multiuser systems

- The tailored half-duplex driver features include:

  Automatic carriage/line feed
  Write with CTRL/O cancellation
  Breakthrough write
  CTRL/R rewrite
  Get multiple characteristics
  Get terminal driver options
  Read after prompt
  Read with no echo
  Read with special terminator
  CRT rubout support
  User terminal input buffering

- The tailorable driver allows selection of all possible terminal options

- The full-duplex driver includes:

  Task checkpoint during input
  Passes form feeds directly to the terminal
  Supports unsolicited input character AST (requires Executive AST support)
  Hold screen mode
  LA30P support
  Device independent cursor positioning
  Plus features included in the tailored half-duplex driver

- Full-duplex driver requires a mapped system with loadable driver support

Choosing a File Processor

- Several different versions of F11ACP available
- Versions differ in amount of overlaying and in number of internal buffers
- See discussion in module 'I/O Processing' for descriptions of available ACPS

USING VMR

Overview of VMR

- Can perform many of the same tasks as MCR

  Define partitions

  Load drivers

  Install tasks

- Commands operate on system image file
- Used to perform system initialization for needed features

  Set up partitions

  Load standard drivers

  Install system tasks and utilities

On a Mapped System

- SYSGEN generates a VMR command file which should be edited to produce the system desired
- All needed partitions are defined

  Driver partition

  Directive commons

  All leftover space goes in GEN

- Commands for partitions needed by application tasks must be added to the command file
- All DEC-supplied drivers are loaded
- All important system tasks are installed

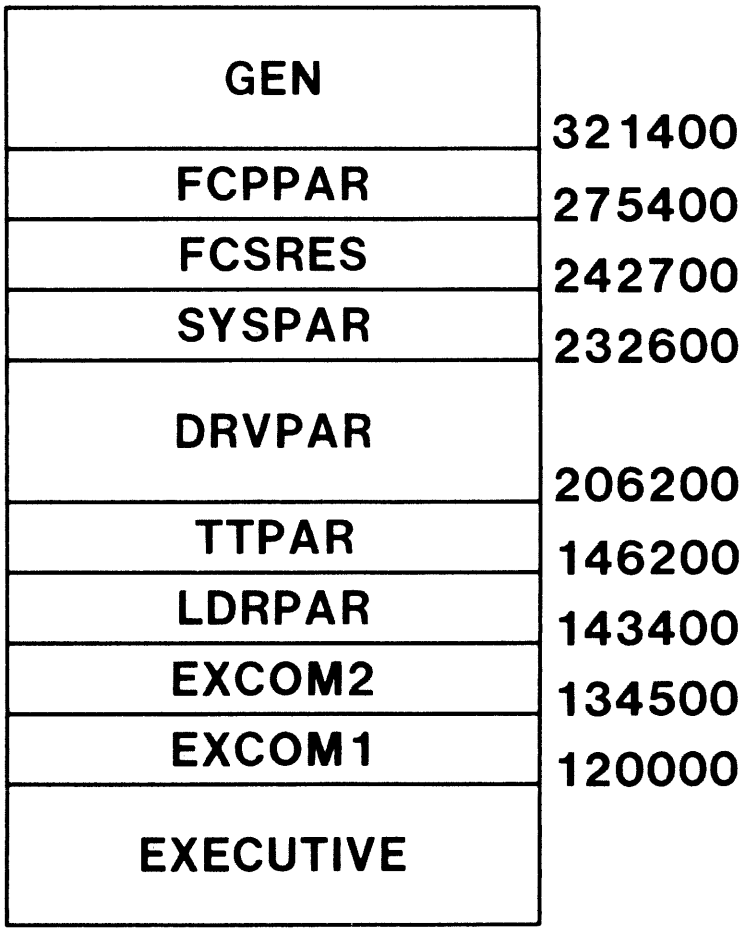


Figure 5-1 Partition Structure on Mapped Systems

On an Unmapped System

- Modification of SYSVMR.CMD recommended on unmapped system

  It is not possible for SYSVMR.CMD to create an optimal partition structure

- For unmapped 16K to 24K systems, VMR:

  Creates partition GEN and installs all tasks into it

  Length is always 40000 bytes

  Creates partition SYSPAR

  Length is 1000 bytes if FCPMIN chosen
  Length is 1200 bytes if FCPSML chosen

  Creates partition SPLPAR if PRT chosen

  Length is 10400 bytes

- For unmapped 24K to 28K systems, VMR:

  Creates partition GEN and installs all tasks into it

  Length is always 40000 bytes

  Creates partition SYSPAR

  Length is 1000 bytes if FCPMIN chosen
  Length is 1200 bytes if FCPSML chosen

  Creates partition PAR14K

  Length is 70000 bytes

  Creates partition SPLPAR if PRT selected

  Length is 10400 bytes

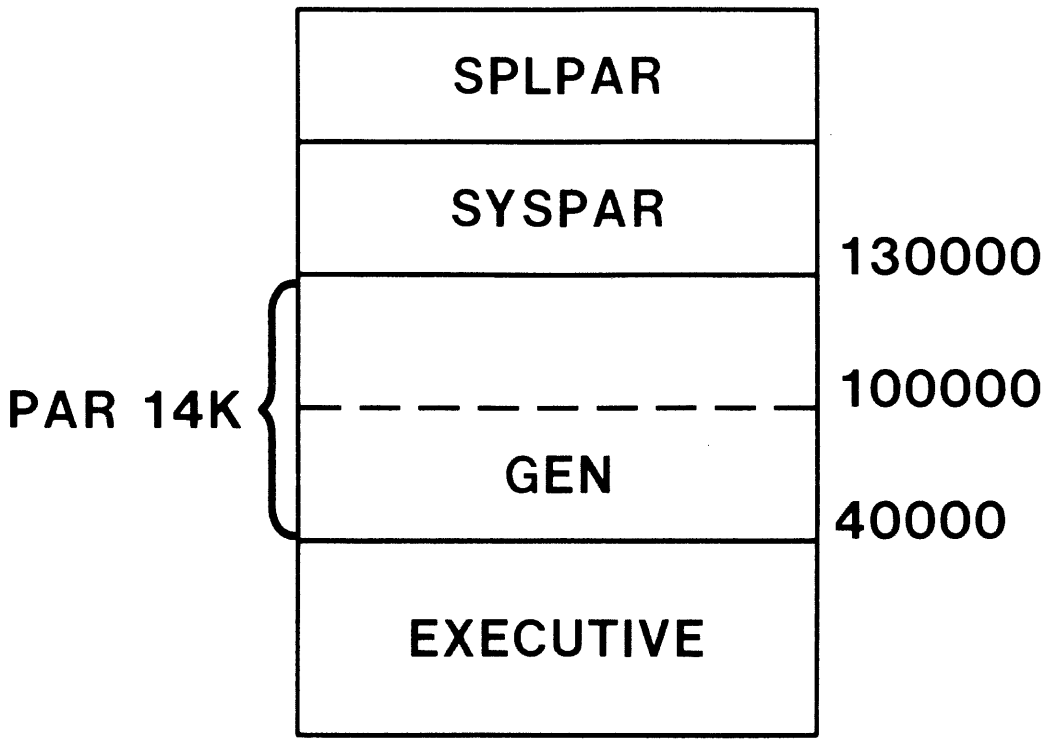


Figure 5-2 Partition Structure on Unmapped 24K to 28K Systems

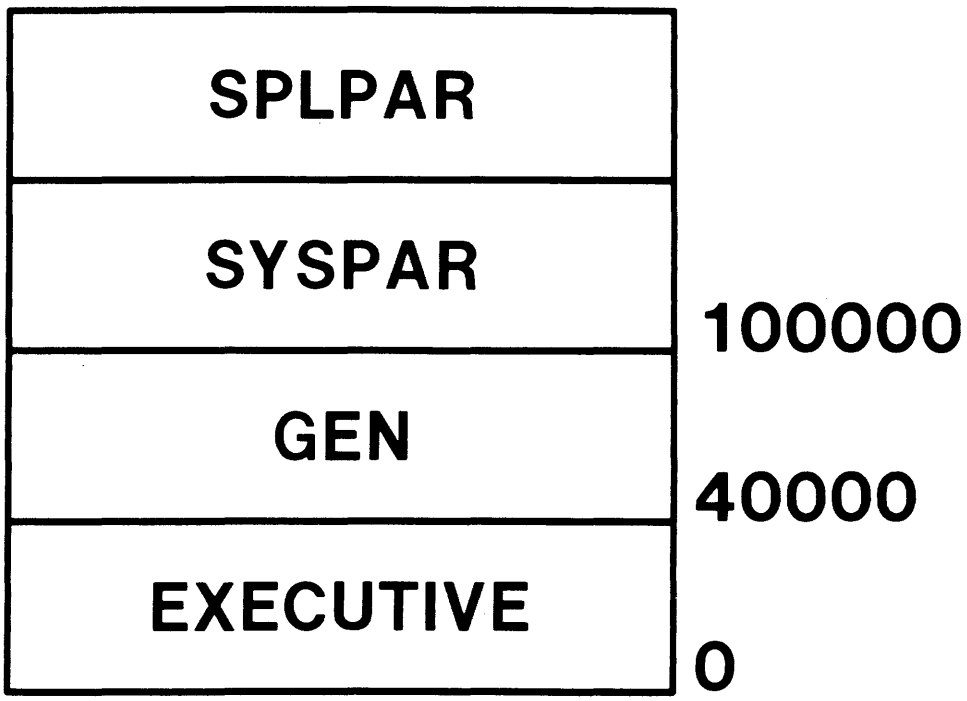


Figure 5-3 Partition Structure on Unmapped 16K to 24K Systems

SAVING THE NEW SYSTEM

- Copies the current system image into the system image file from which the system was booted
- Used to make a system hardware bootable
- System must be saved before compressed by DSC or BRU
- Requirements for saving a system

    SAV must run from CO:

    Error logging is not active

    All tasks are installed from LB:

    No checkpoint files are active

    No volumes are mounted except the load device

    The load device can be successfully dismounted

    No tasks have outstanding I/O

    No task is connected to interrupts

    All drivers, active tasks and fixed tasks reside within the saved area of memory

- Saving a system

    Lowest part of memory copied into buffer in SAV task

    Secondary bootstrap program loaded into low memory

    Special driver used to load system to and from disk

        Cannot use interrupts

        Same special drivers used by SAV and BOOT

Can create a bootstrap program within the volume bootblock

Reads in first block in system image file

Transfers control to secondary bootstrap in block just loaded into memory

Before writing system image to disk, converts logical block number in TCB into file ID

When system booted, file IDs in TCBs converted back into logical block number

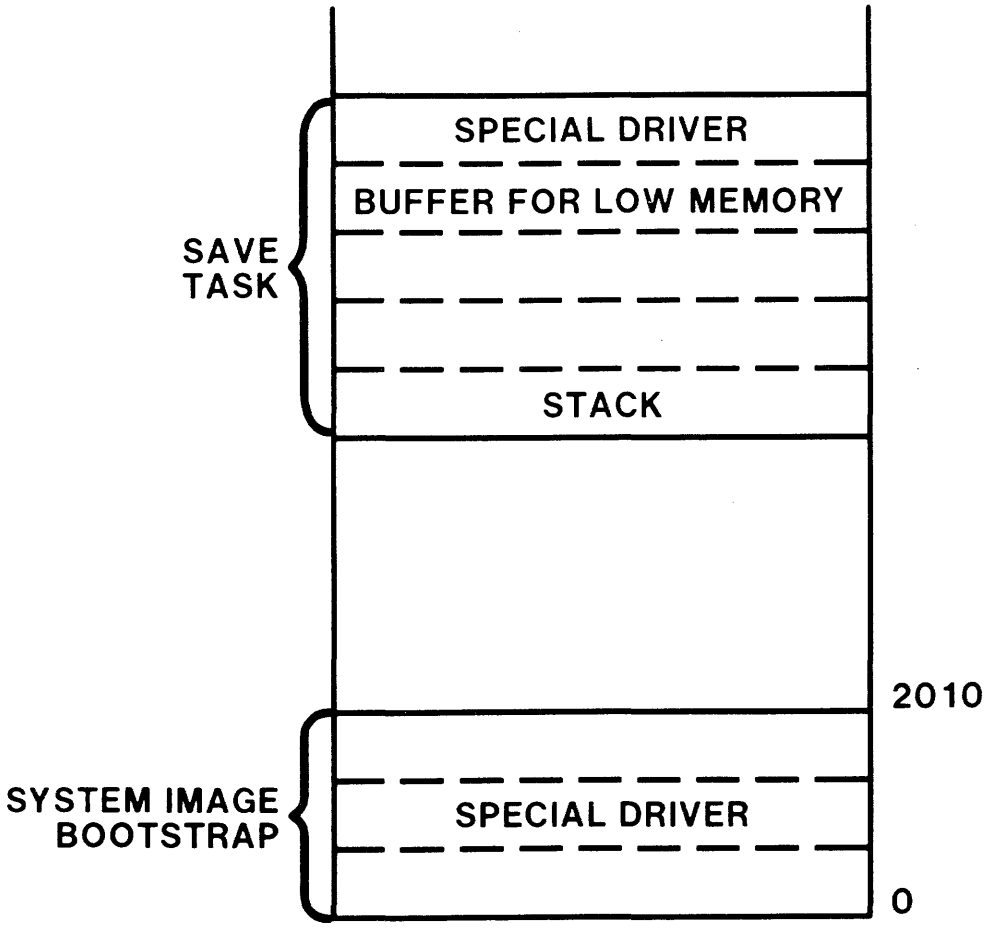


Figure 5-4 Saved System Image

PHYSICAL AND VIRTUAL MEMORY

INTRODUCTION

The most important resource managed by an operating system is physical memory. To manage memory, an operating system must define subdivisions of memory, allocate space to tasks, and optimize memory use. This module examines the data structures used to perform these tasks.

Since the PDP-11 uses 16-bit words, only 32K words of physical memory can be addressed unless some form of address relocation is provided. On the PDP-11, the KT-11 memory management hardware provides the mechanism for relocation. This module also explains the hardware and processing used.

OBJECTIVES

1. Diagram the data structures used by the Executive to control physical memory.

2. List the steps in checkpointing a task.

3. Describe the memory management hardware.

CONCEPTS

Physical Addresses

- A contiguous series of word addressable hardware locations
- Defines main memory and peripheral device registers

Virtual Addresses

- Set of addresses used within a task
- Program counter is a 16-bit register

  User task can reference addresses between Ø and 177777 octal

  Virtual addresses are local to a task

Unmapped Systems

- 32K words of addressing space
- Maximum physical memory is 28K words
- Programs built for specific memory location
- No memory protection

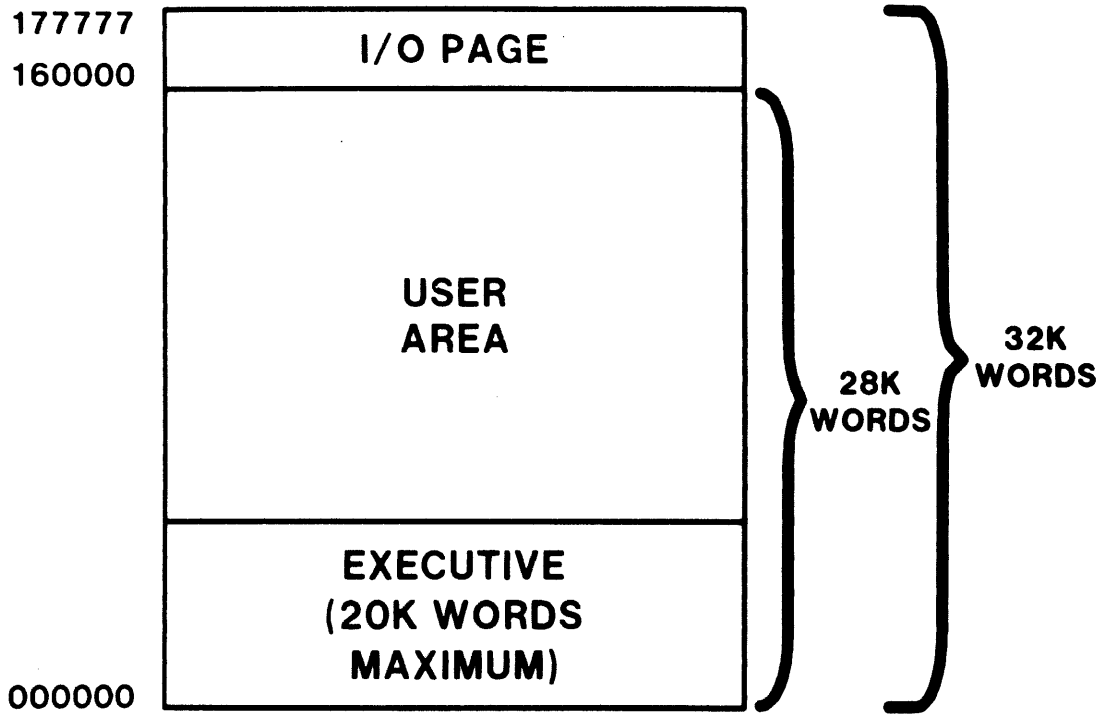


Figure 6-1 Typical Unmapped System

Mapped Systems

- KT-11 hardware is present
- Two types of mapped systems

  18-bit addresses
  128K words of addressing space
  124K words of physical memory

  22-bit addresses
  2Ø48K words of addressing space
  192ØK words of physical memory

- 16-bit virtual address converted to 18- or 22-bit physical addresses
- Virtual addresses range from Ø to 32767
- Relocation and memory protection provided

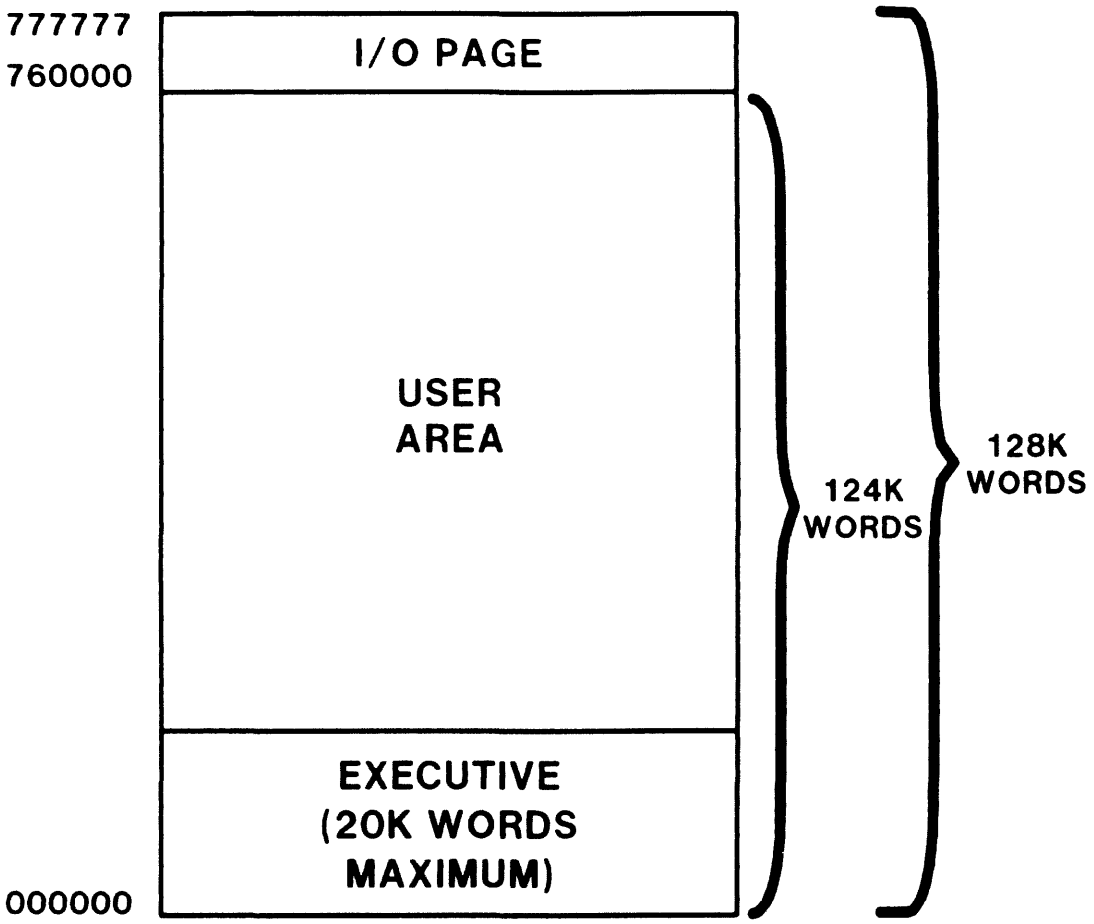


Figure 6-2 Typical Mapped System with 18-bit Addressing

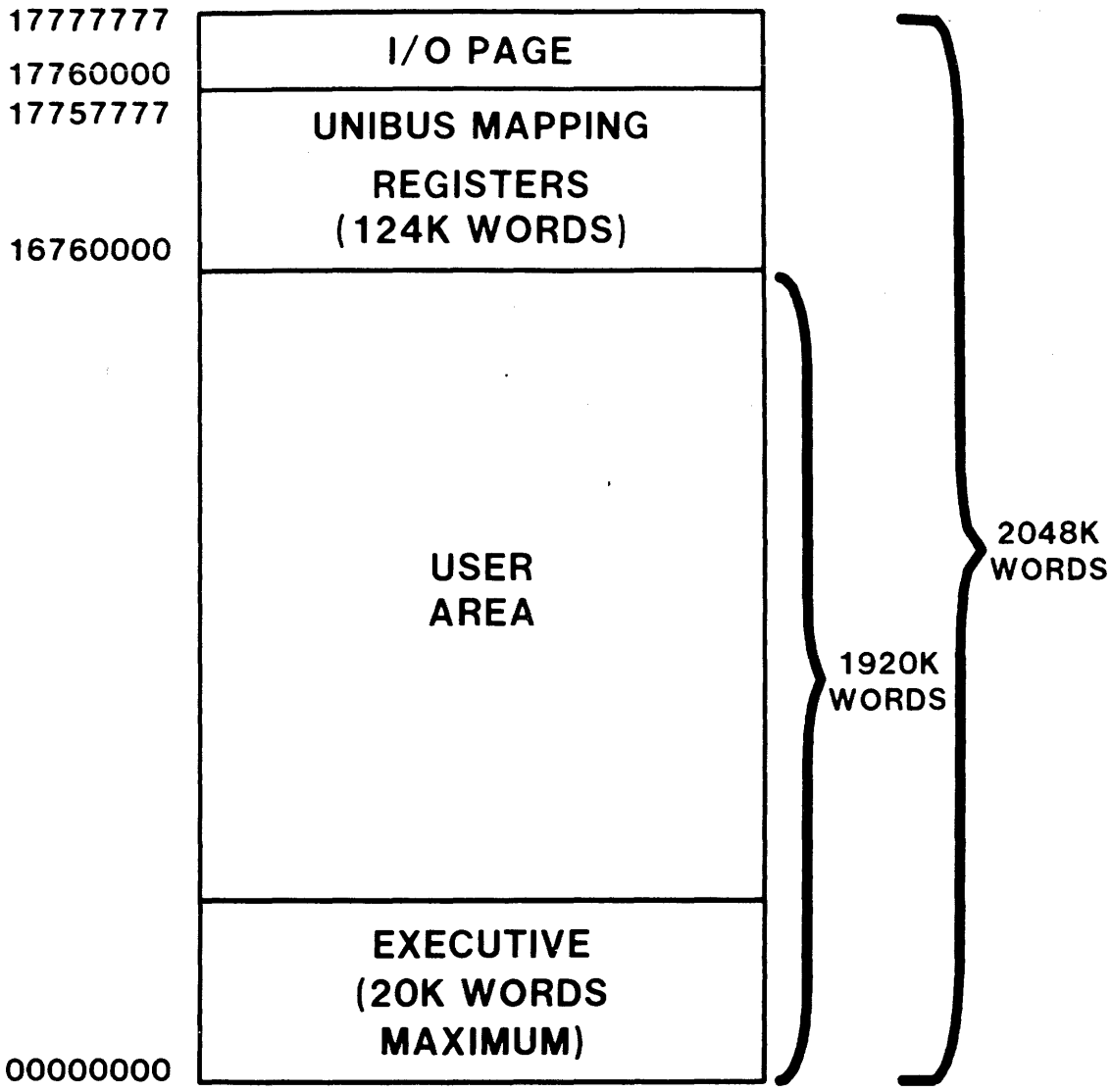


Figure 6-3 Typical Mapped System with 22-bit Addressing

MEMORY MANAGEMENT

Overview

- Basic functions

  Perform memory relocation/mapping

  Provide extended memory addressing capability

- Task is mapped in pages

  Page length is from 1 to 128 memory blocks

  Memory block is 32 words in length (100 octal bytes)

Memory Management Hardware

- Several sets of relocation registers: Active Page Registers (APRs)
- Each APR consists of two 16-bit words

  Page Address Register (PAR)
  Contains a physical memory address in units of 32 words memory blocks
  Used to relocate 4K words of virtual memory (one page)

  Page Descriptor Register (PDR)
  Contains the size of the virtual memory block to be relocated
  Provides control of access rights

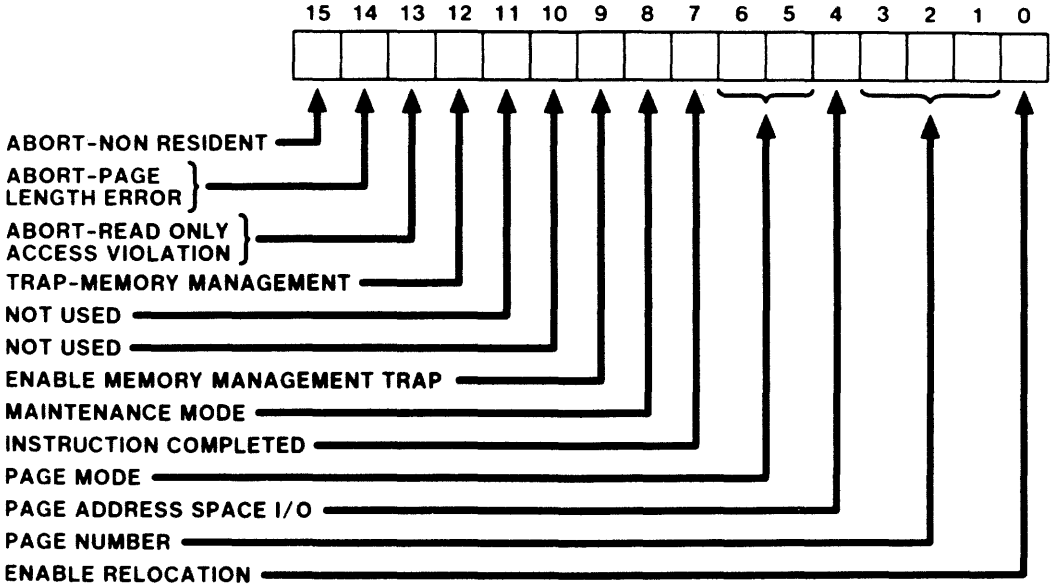
- Every mapped system contains at least two sets of eight APRs
  KERNEL Mode APRs
  USER Mode APRs
- Larger processors have more APRs
  APRs for KERNEL and USER mode Instruction and Data space
  Supervisor mode Instruction and Data space APRs
- The Processor Status Word (PS) determines the APRs in use
- Four memory management registers (MMRØ, MMR1, MMR2, and MMR3) control processor use of memory management

  MMRØ - Error flags
  Page number whose reference caused error
  Other status flags

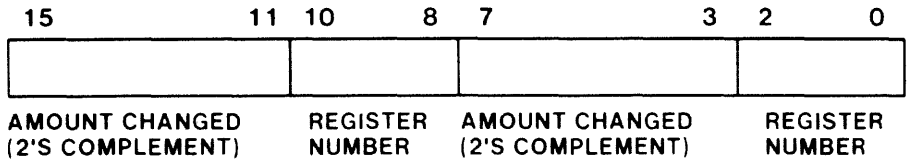
  MMR1 - Only on 11/44 and 11/7Ø
  Records any autoincrement/decrement of general purpose registers

  MMR2 - The Virtual Address Program Counter

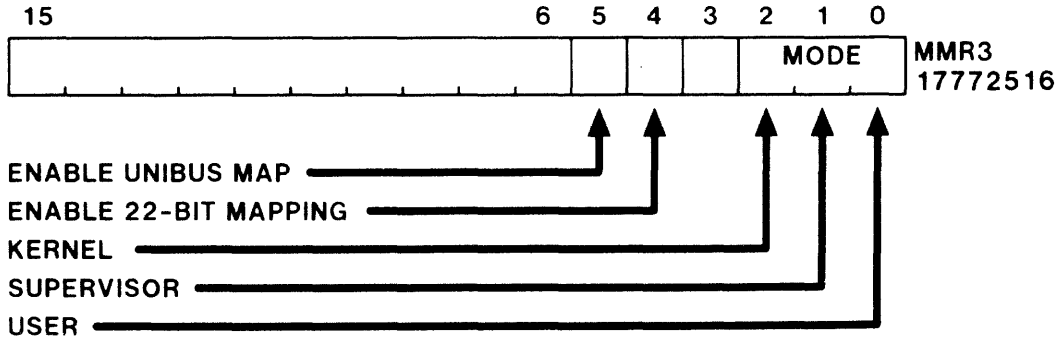
  MMR3 - Only on 11/44 and 11/7Ø
  Enables/disables
  Use of D space APRs
  22-bit mapping
  UNIBUS mapping



MEMORY MANAGEMENT REGISTER #0 (MMRO)



MEMORY MANAGEMENT REGISTER #1 (MMR1)



MEMORY MANAGEMENT REGISTER #3 (MMR3)

Figure 6-4 Registers Used by Memory Management

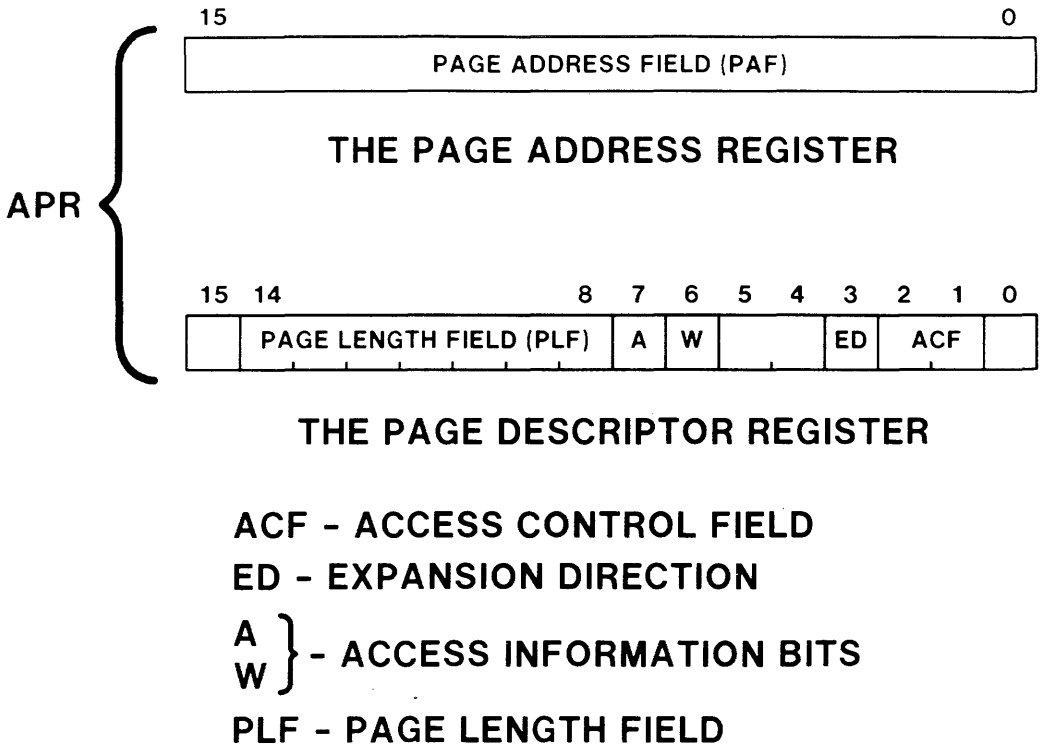


Figure 6-5 Active Page Registers

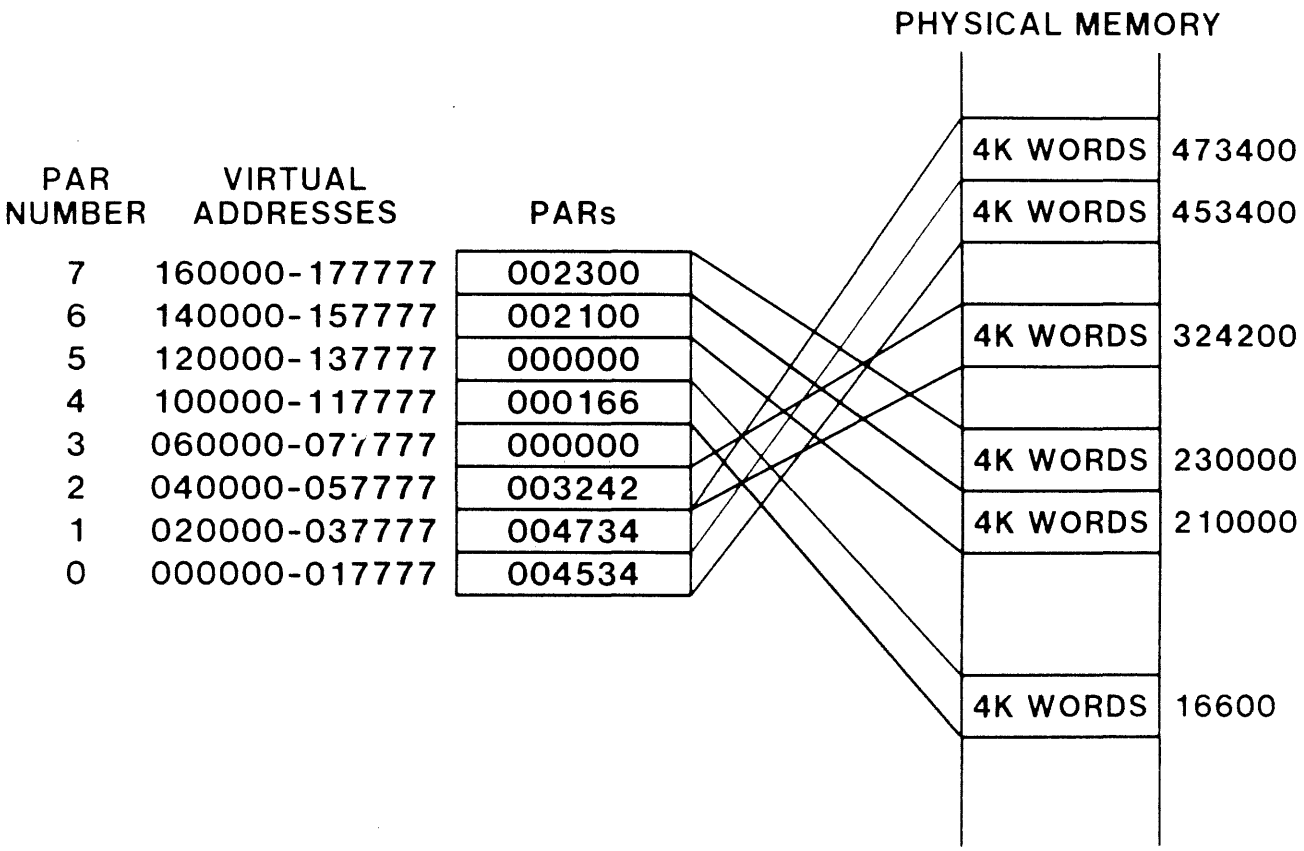


Figure 6-6 Page Address Registers

Software Use of Memory Management

- RSX-11M uses KERNEL and USER instruction space APRs
- KERNEL APRs are loaded so that

  APRs Ø through 3 or 4 point to Executive code and data

  4 APRs for 16K word Executives
  5 APRs for 2ØK word Executives

  APR 7 points to the I/O page

  Other APRs are dynamically mapped as needed

- User tasks are mapped using USER APRs

  If task does not map to the Executive

  APRs are used consecutively starting at APR Ø

  If task maps to the Executive

  APRs Ø through 3 or 4 are the same as the KERNEL

  APRs Ø through 3 or 4

  APR 7 points to the I/O page

  Other USER APRs are used to map the user task

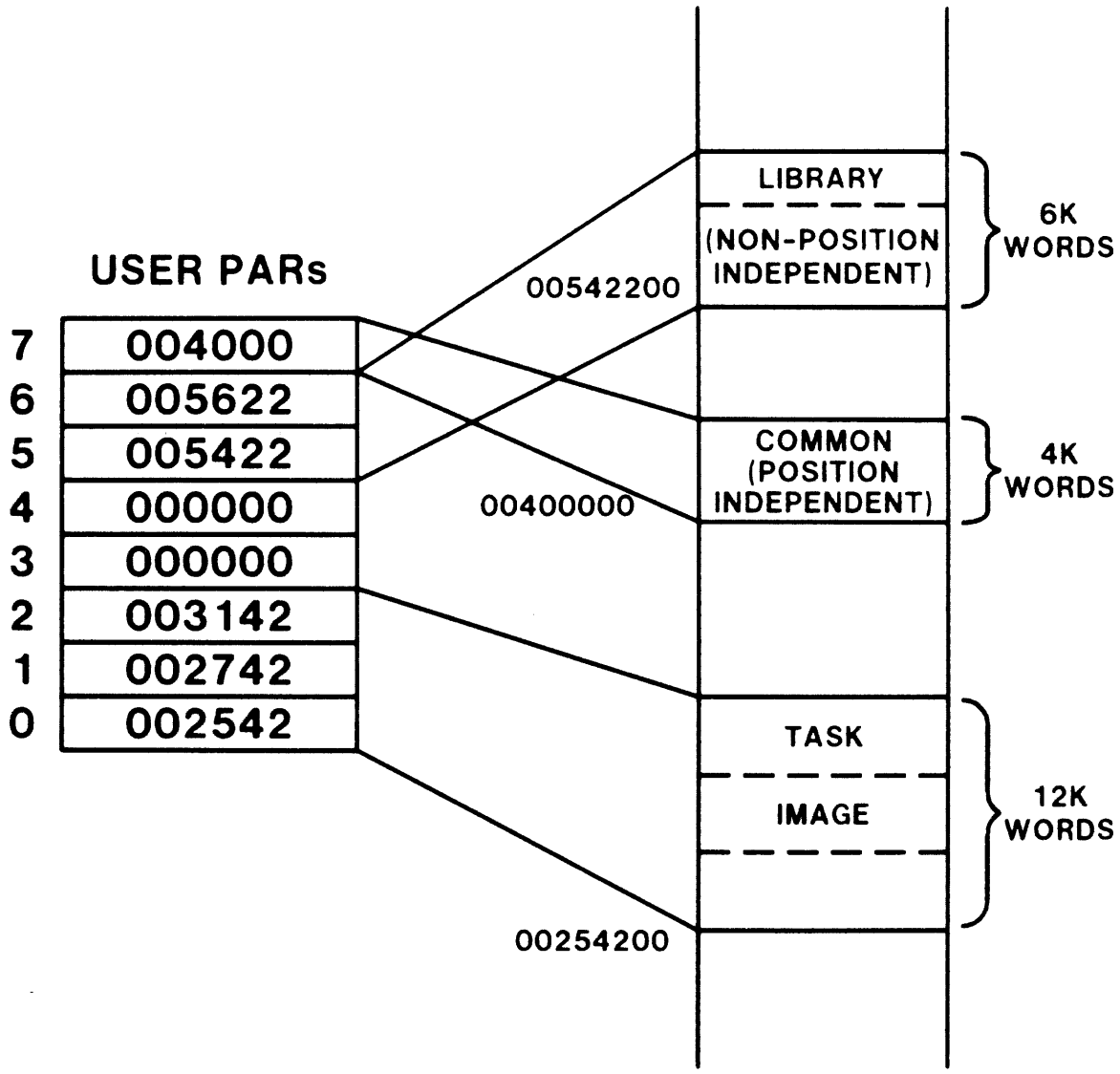


Figure 6-7 Use of Memory Management by a Nonprivileged Task

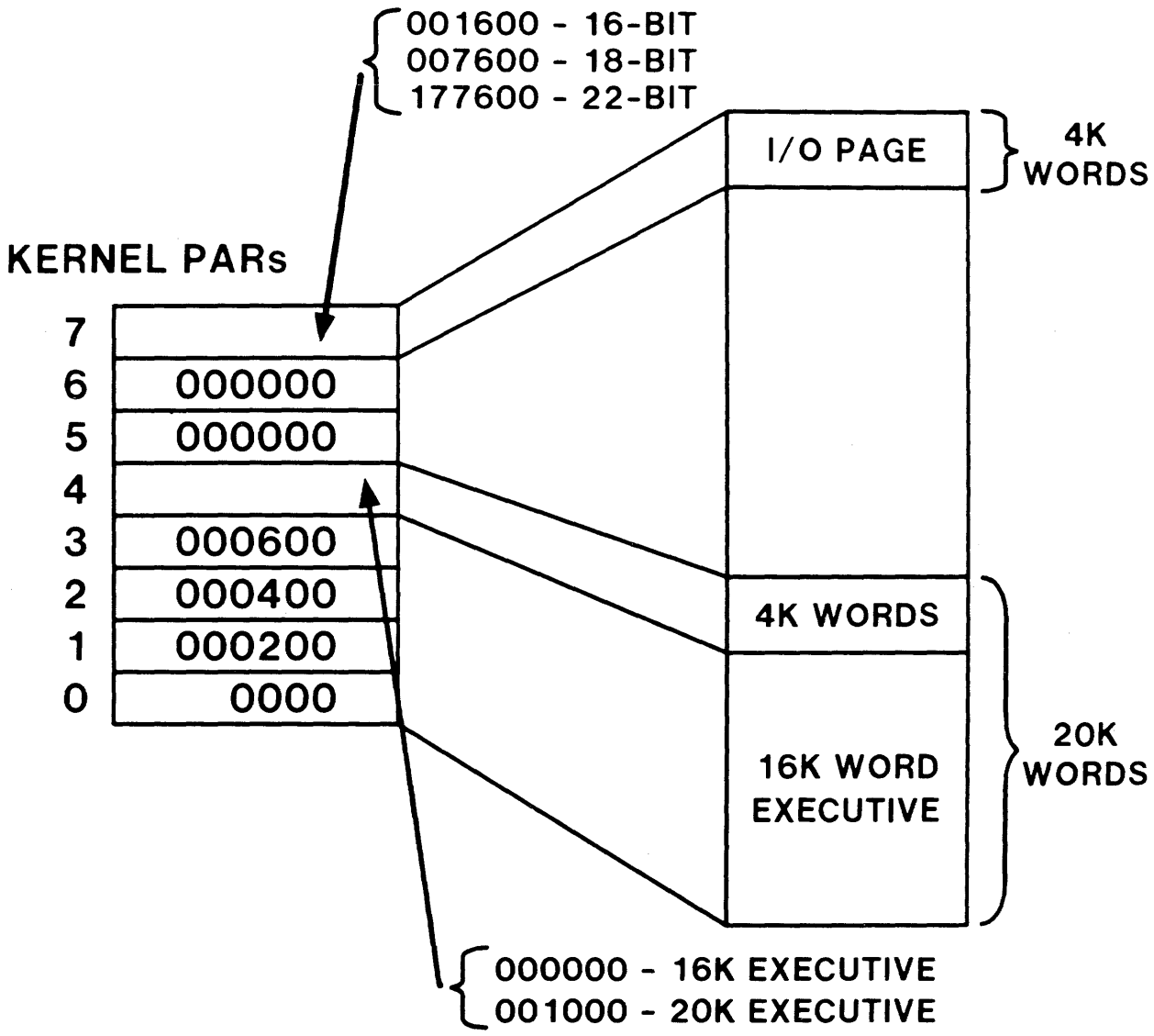


Figure 6-8 Use of Memory Management by the Executive

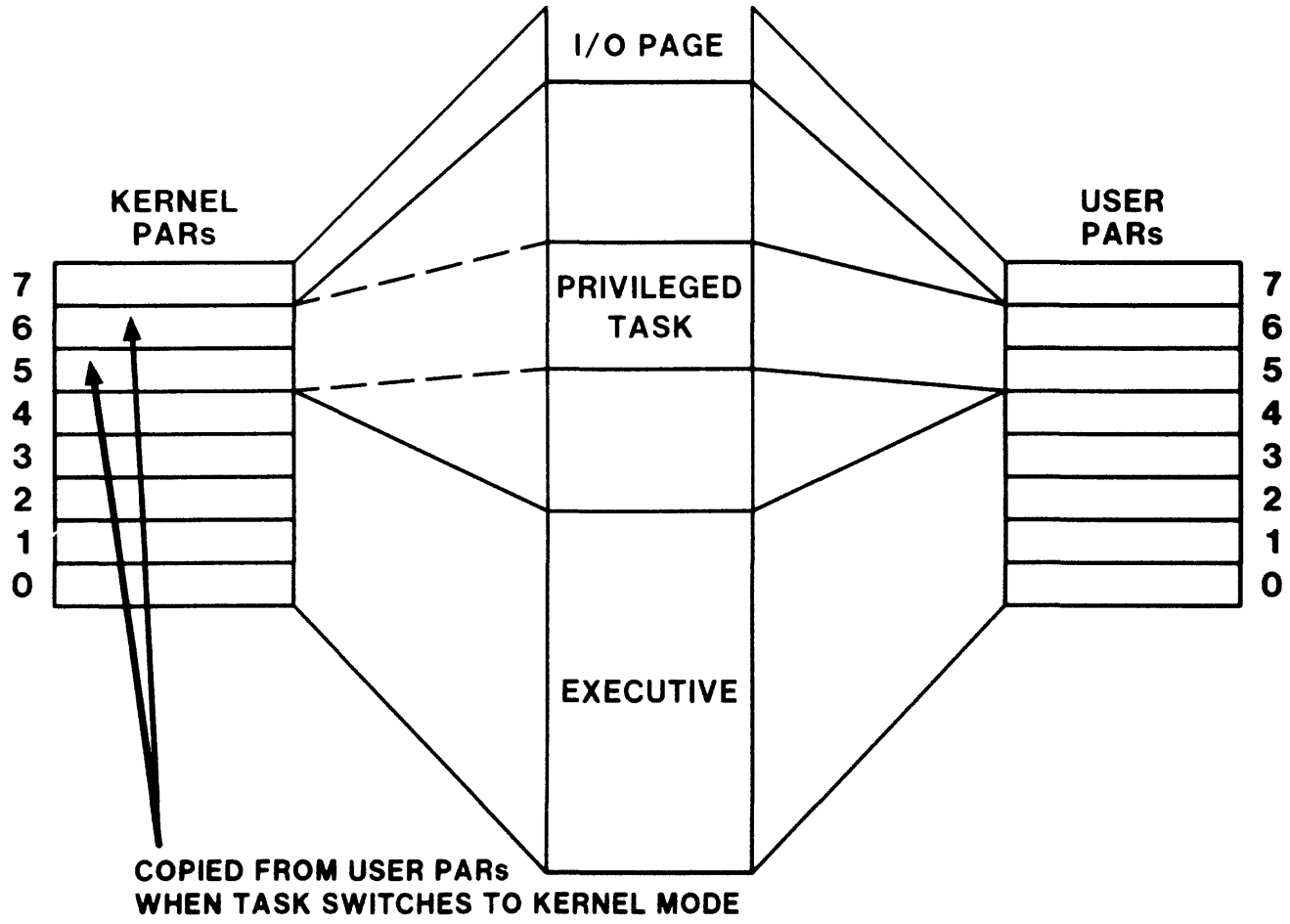


Figure 6-9 Use of Memory Management by a Privileged Task

ALLOCATING PHYSICAL MEMORY

Partitions

Task Partitions

- Controlled by user
- May be divided into subpartitions
- May be built to run in main partition or in one of the subpartitions
- Controlled by busy word P.BUSY in the PCB of the main partiton

Common Partitions

- Used for shared data or code
- Linked to task statically by taskbuilder or dynamically by using memory management directives

Device Partitions

- Pseudo-areas whose addresses overlay the I/O page
- Allow nonprivileged tasks to access the I/O page

System-Controlled Partitions

- Used to hold executable tasks, device drivers, and dynamic regions
- Space allocated as needed by the Executive
- Tasks loaded into dynamically created subpartitions

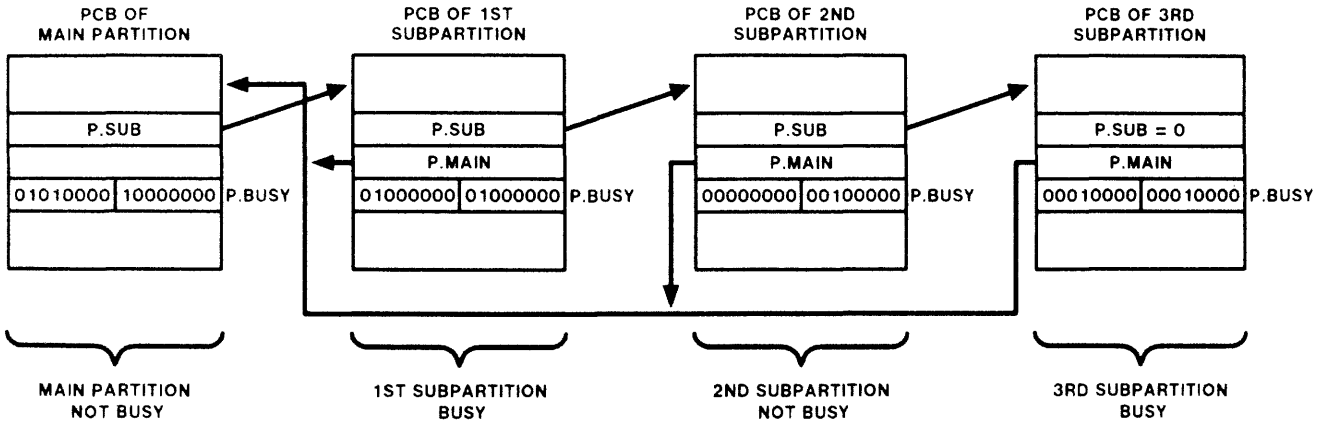


Figure 6-1Ø Subpartitions of a Task Partition

The Partition Wait Queue

- Linked list of TCBs of tasks waiting for space in partition
- Ordered by descending task priority
- When TCB is placed in wait queue of system controlled partition, subpartition PCB is created but not linked to partition list
- First task in queue is allocated space before others

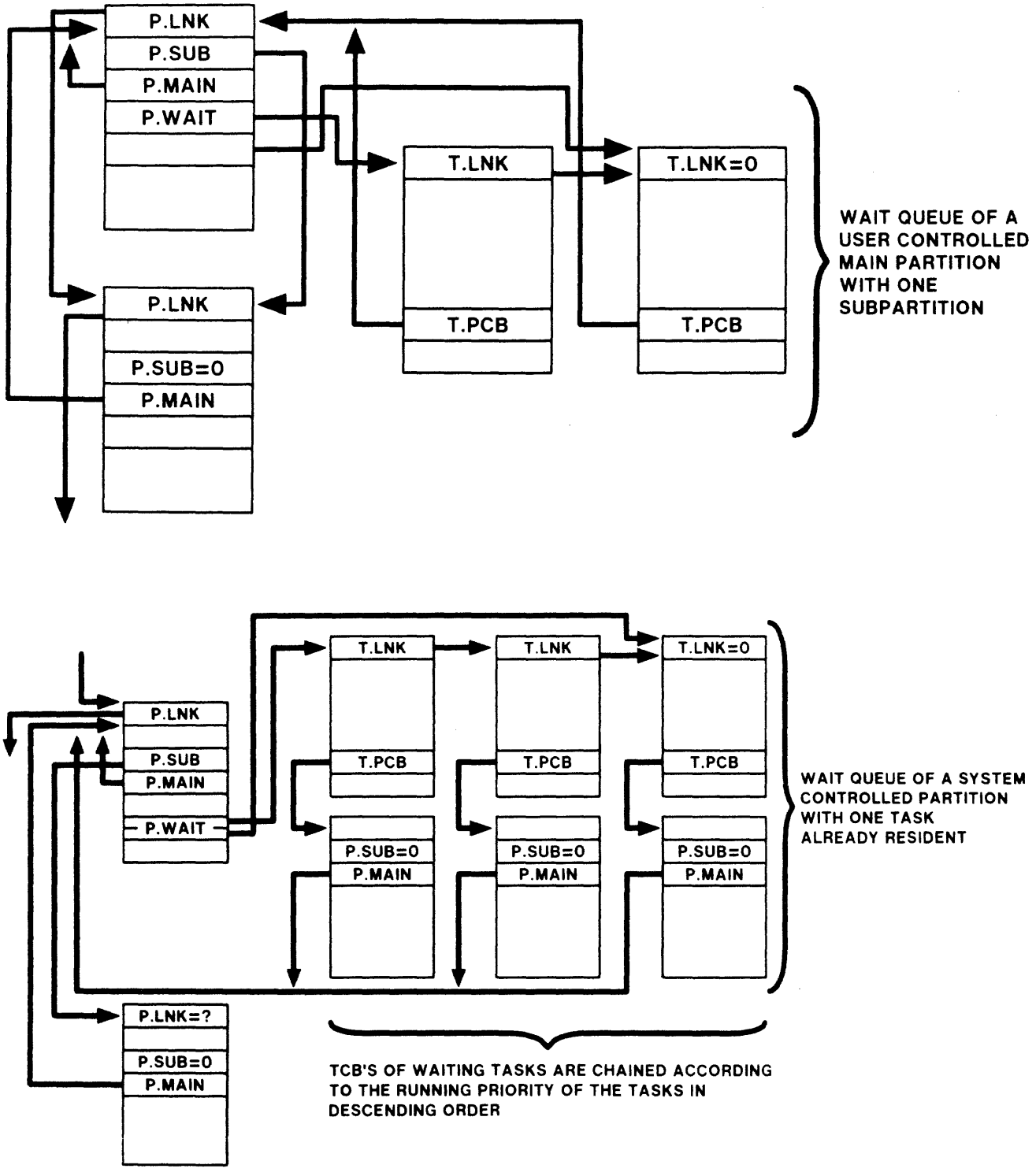


Figure 6-11 The Partition Wait Queue

USING PHYSICAL MEMORY

Loading Tasks

- Task TCB placed in loader queue after space allocated
- Loading performed by loader task, LOADR
- Loader task uses loader queue to decide which task to load next

  Utility link word, T.LNK, used to link TCBs in queue

  Location T.RCVL in the loader TCB is the queue listhead

- Steps in loading:

  Executive places TCB of task to be loaded in the loader queue (LOADRs receive queue)

  Executive unstops the loader

  Loader scans queue and loads task

  When queue is empty, loader calls $STPCT to stop itself

Checkpointing

- Task is copied from memory to space on a disk volume

  Allows a higher priority task to execute

  Copied either to a reserved area in task image file or to a system checkpoint file

  Reserved area only used if system checkpoint files are full

- Steps in checkpointing a task

  Test to see if task should be checkpointed

  Initiate the checkpoint operation

  Allocate checkpoint space and write the task to disk

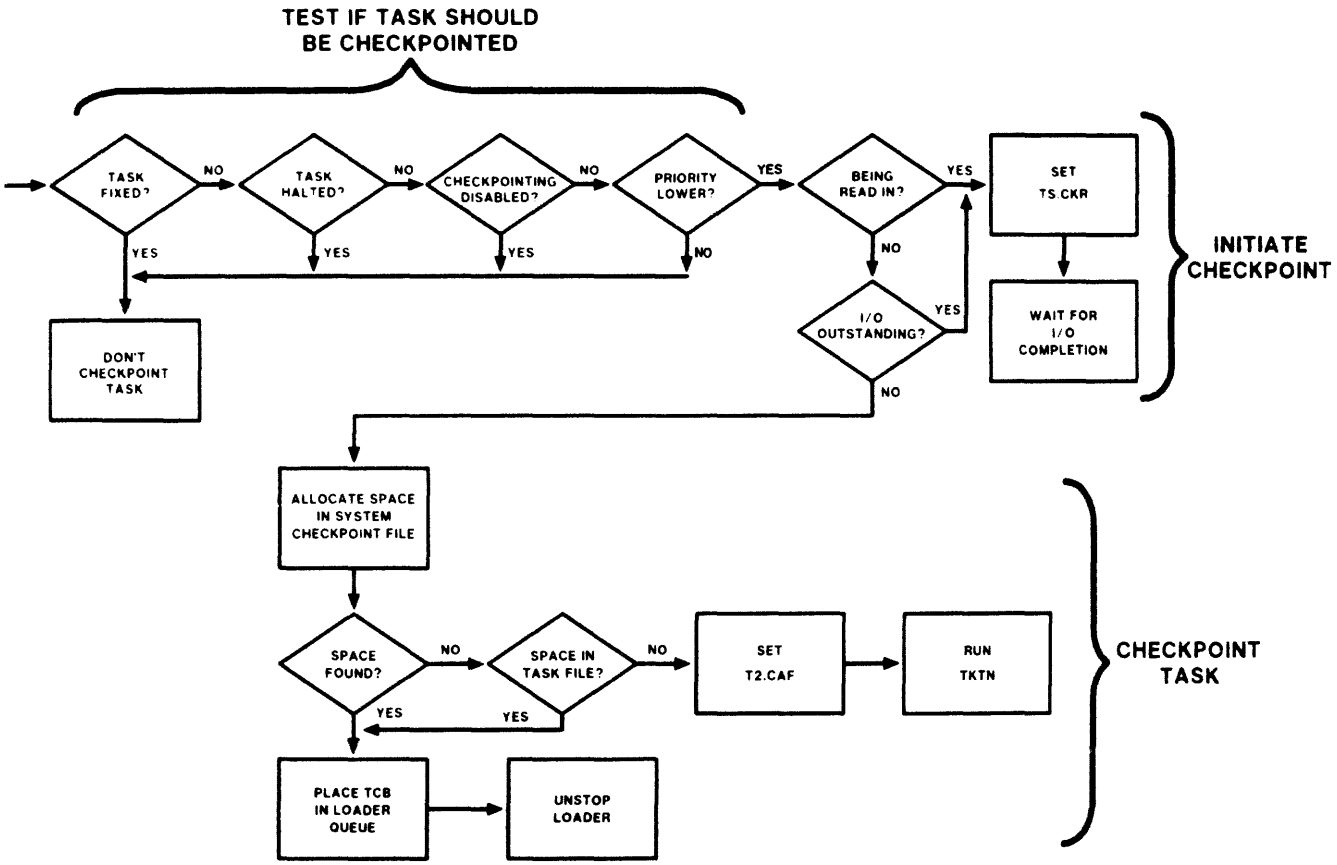


Figure 6-12 Steps in Checkpointing a Task

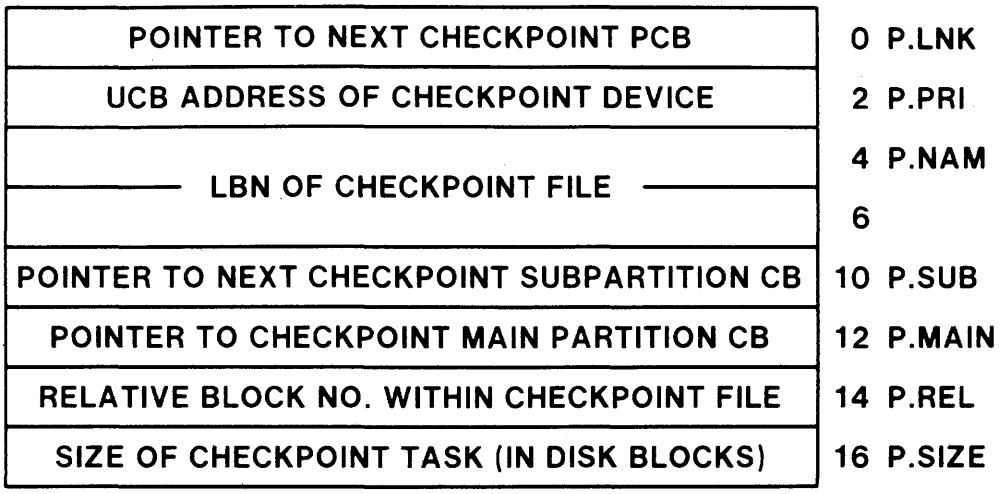


Figure 6-13 System Checkpoint Files: The Checkpoint PCB

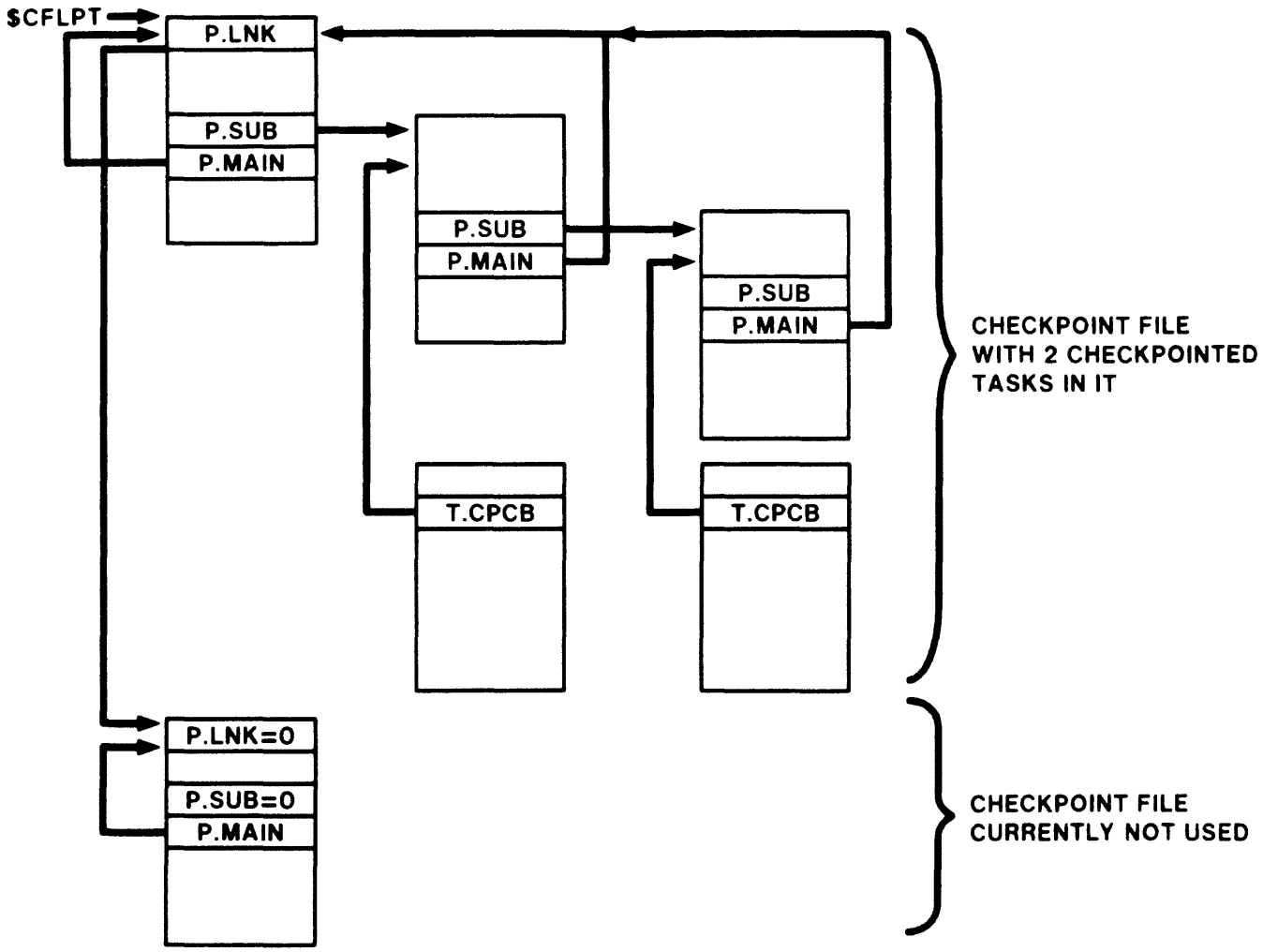


Figure 6-13 System Checkpoint Files: PCB Linkages

Shuffling

- Consolidates holes in a system-controlled partition
- Shuffling performed by shuffler task - SHUFL
- Performed in two passes over a system-controlled partition

Shuffler Pass One

- Partition list searched, from $PARHD, for system-controlled partition
- If task is in wait queue of system-controlled partition, shuffle operation is initiated
- Shuffle operation:

  Find next hole (first?)

  Find region following hole

  Determine if region is shufflable

  If shufflable, checkpointable and stopped, or blocked by MCR BLOCK command, task is checkpointed

  If shufflable, move region and contents to bottom of hole

  When all regions have been shuffled, invoke $NXTSK to reallocate space

- Nonshufflable regions

  Loaded device drivers

  Tasks connected to interrupt vectors

  Tasks fixed for parity errors

  Tasks with long outstanding I/O (did not complete in 1/2 second)

  Dynamic regions

  If nonshufflable region is found, next hole is found and process continues

- If pass one completes and the partition wait queue is not empty, pass two is invoked.

Shuffler Pass Two

- Attempts to gain space by finding a contiguous sequence of holes and lower priority checkpointable tasks
- Checkpoint operations initiated by calls to $ICHKP
- When checkpointing is complete, pass one is rerun

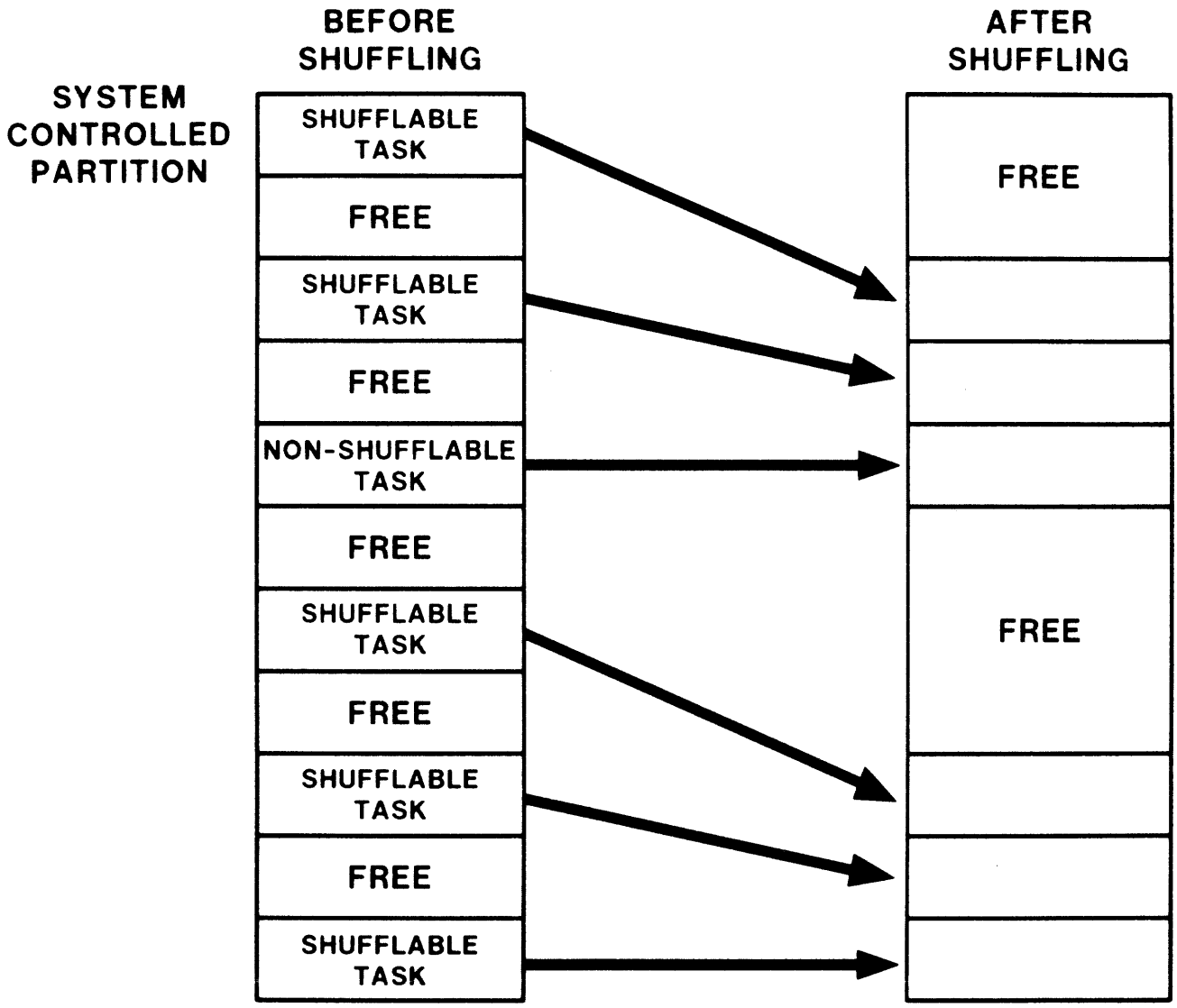


Figure 6-14 Shuffling Tasks

USING VIRTUAL MEMORY

Attaching

- Makes region available to attaching task
- Steps in attaching to a region:

  An Attachment Descriptor Block (ADB) is created

  ADB is linked to the PCB for the region using A.PCB in the ADB, and P.ATT in the PCB

  ADB is linked to the TCB for the task using A.TCB in the ADB, and T.ATT in the TCB

  ADB is linked into the ADB list for the partition using A.PCBL in the ADB

  ADB is linked into the ADB list for the task using A.TCBL in the ADB

	PCB ATTACHMENT QUEUE THREAD WORD		0	A.PCBL
A.IOC 1	I/O COUNT THROUGH THIS DESCRIPTOR	PRIORITY OF ATTACHED TASK	2	A.PRI
	TCB ADDRESS OF ATTACHED TASK		4	A.TCB
	TCB ATTACHMENT QUEUE THREAD WORD		6	A.TCBL
A.MPCT 7	MAPPING COUNT OF TASK THROUGH THIS DESCRIPTOR	STATUS BYTE	10	A.STAT
	PCB ADDRESS OF ATTACHED TASK		12	A.PCB

ATTACHMENT DESCRIPTOR BLOCK

BIT	MASK	
3	10	AS.DEL - TASK HAS DELETE ACCESS (1=YES)
2	4	AS.EXT - TASK HAS EXTEND ACCESS (1=YES)
1	2	AS.WRT - TASK HAS WRITE ACCESS (1=YES)
0	1	AS.RED - TASK HAS READ ACCESS (1=YES)

ATTACHMENT DESCRIPTOR STATUS BITS

Figure 6-15 The Attachment Descriptor Block

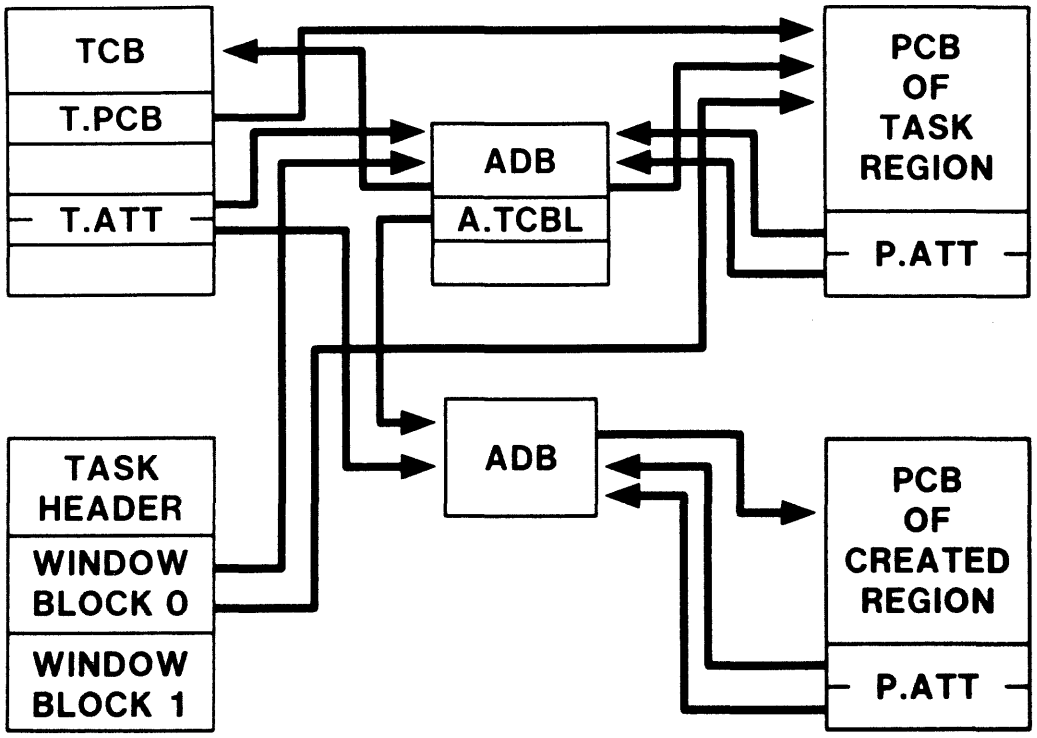


Figure 6-16 Attaching a Task to a Region

Mapping

- Task virtual address window block contains information needed to load APRs to allow access to physical region
- Task is mapped to a region if a window block contains the needed access information for the region

  Pointers to the PCB and ADB for the region

  High and low virtual address limits for the region

  Window size and offset in the physical region in 32 word blocks

  Number of APRs needed for the window and PDR information

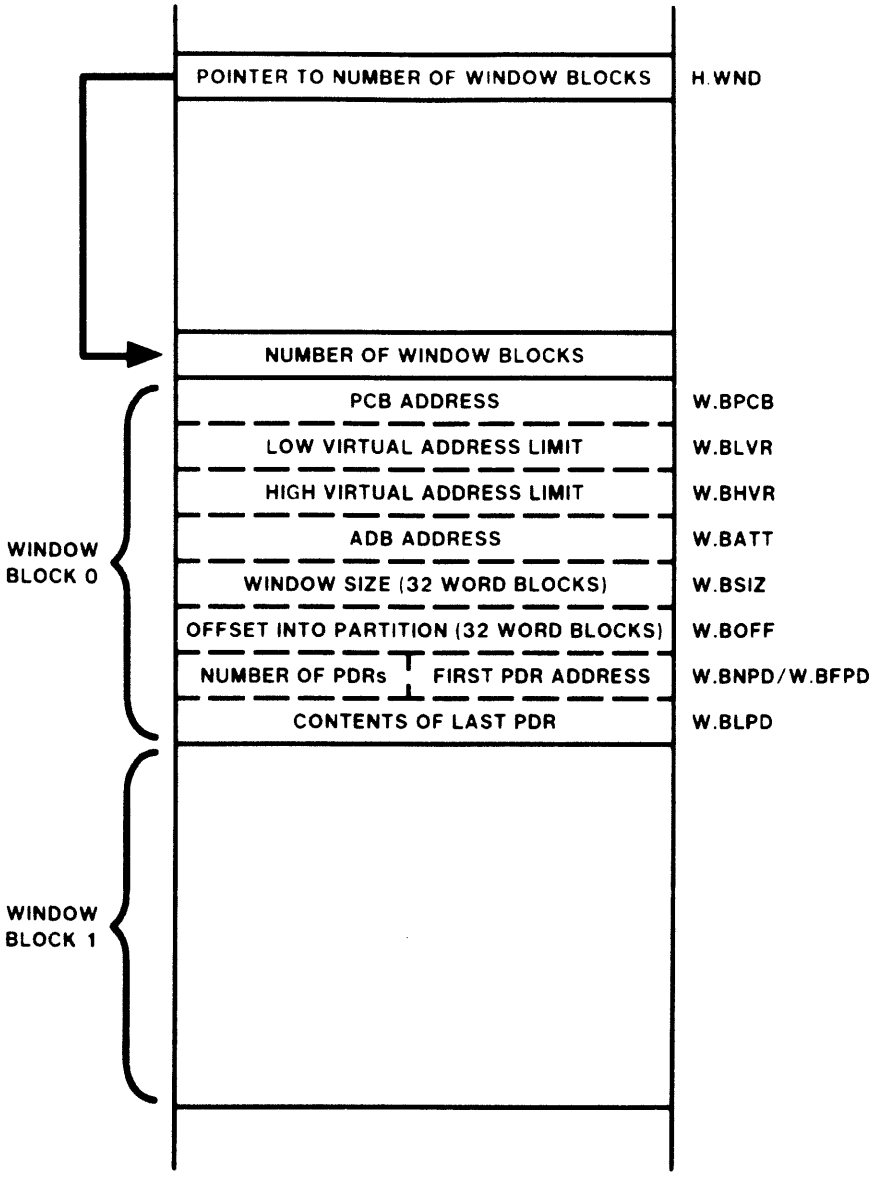


Figure 6-17 Task Virtual Address Window Blocks

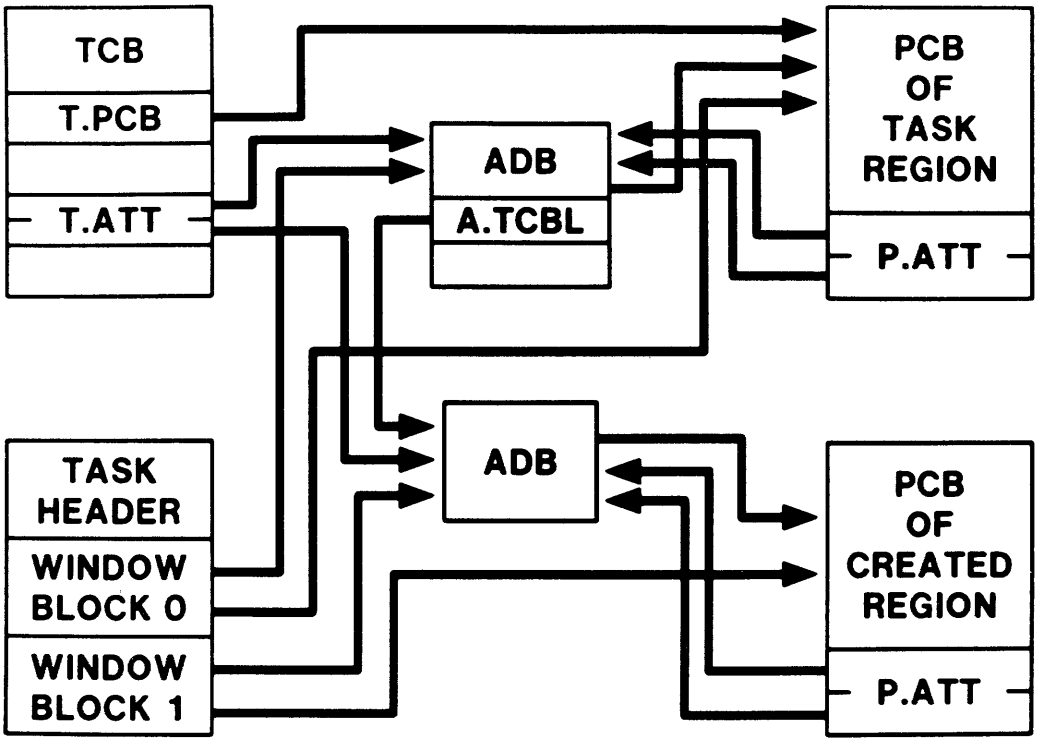


Figure 6-18 Mapping a Task Address Window to a Region

7

TASK MANAGEMENT

INTRODUCTION

The basic unit of executable code under RSX-11M is the task. Most tasks are user written, but some are system-supplied, such as the task-loader, MCR, etc. The Executive must manage the task scheduling and allocate needed resources to requesting tasks. This module describes the techniques used to manage tasks.

OBJECTIVES

1. Describe the content and functions of the task label blocks and task header.
2. Diagram the data structures used to manage task scheduling.
3. Describe the process of task termination.

RESOURCES

1. RSX-11M System List and Data Structures
2. RSX-11M/M-PLUS Executive Reference Manual

THE TASK IMAGE

The Task Image File

- Created by the taskbuilder
- Includes: label block group, checkpoint area (optional), task header, and task image

The Label Block Group

- Label block Ø

  Task and resident library data

  Used to set up TCB and task addressing windows in header

- Label block 1

  Table of LUN assignments for LUN 1 through LUN 128

  Used to create Logical Unit Table(LUT) in header

- Label block 2

  Continuation of Table of LUN assignments for LUN 129 through LUN 255 (if needed)

  Used to create LUT in header

- Label block 3

  Segment load list (optional)

  Resident libraries that contain memory resident overlays

The Checkpoint Area

- Used to provide checkpoint space when no space available in the system checkpoint files
- Size equal to size of header plus the task image

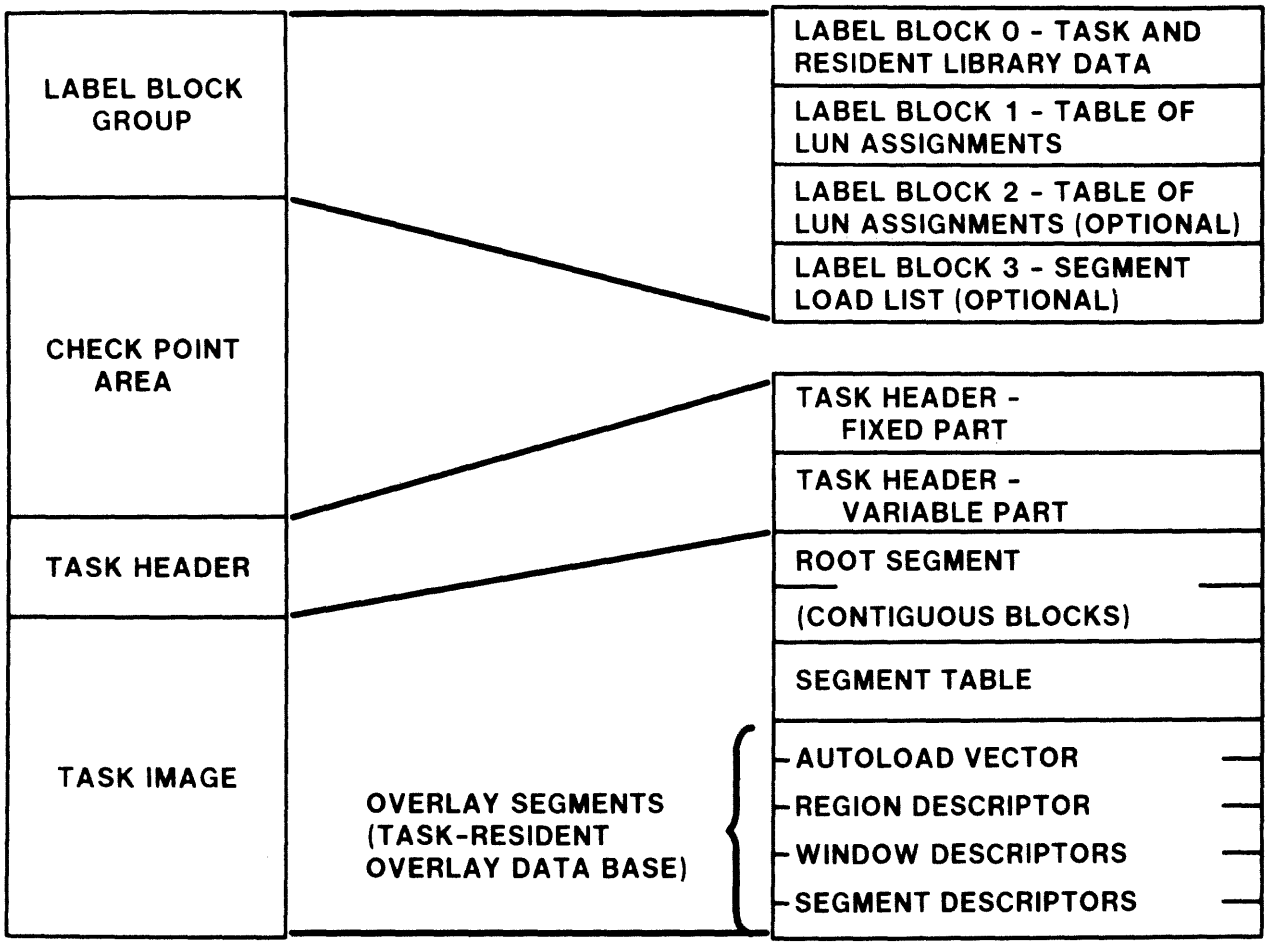


Figure 7-1 Task Image File

The Task Header

- Consists of two parts: fixed and variable
- Fixed part contains

  Event Flag mask word and address

  Initial values for PS, PC and SP

  Low-Core context: $DSW, and inpure storage area addresses for FCS, FORTRAN, etc.

  Pointers to specific areas within the variable part

- Variable part contains

  Window blocks

  Logical unit table

  Task context

- Window Block

  Describes task mapping

  Associates window with region

    Contains pointer to PCBs of regions used by task
    Pointers loaded at task installation

  Used to load APRs for task

  Initialized when task is installed

- Logical Unit Table

  Contains a two word entry for each logical unit used by the task

    Word one: address of the UCB of the device assigned to the logical unit (UCB address loaded at task installation)

    Word two: address of the FILES-11 window block of an open file

The Task Image

- Task code
- Overlay information

    Autoload vectors

    Region and window descriptors for memory-resident overlays

    Segment descriptors

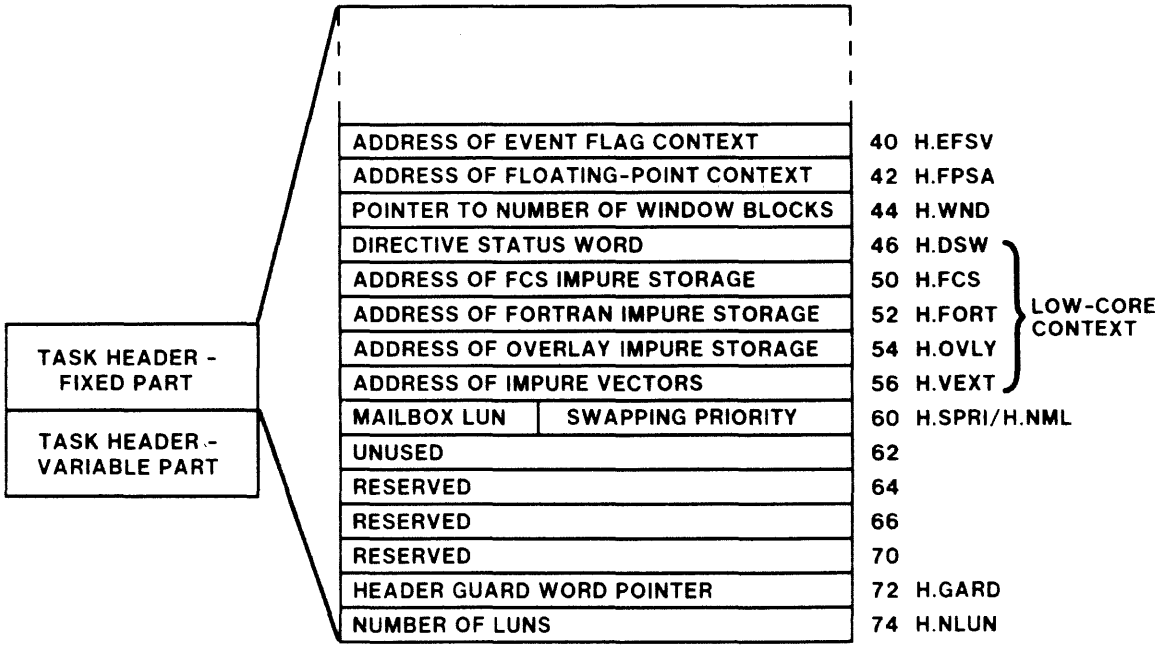


Figure 7-2 The Task Header: Fixed Part

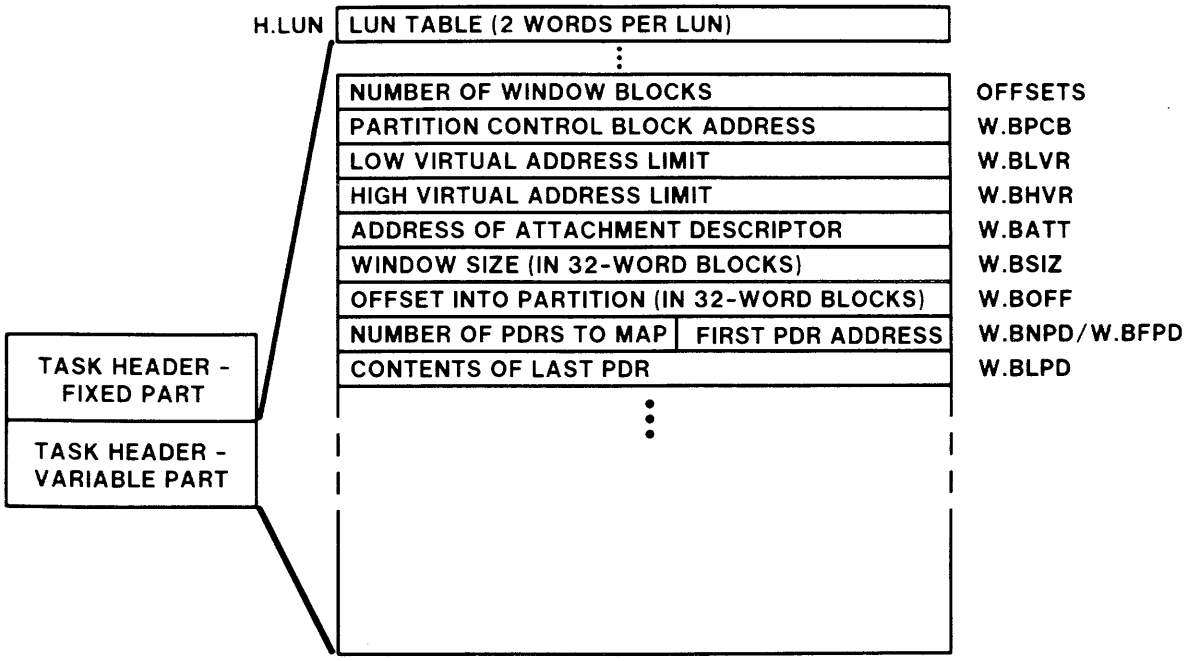


Figure 7-2 The Task Header: Beginning of Variable Part

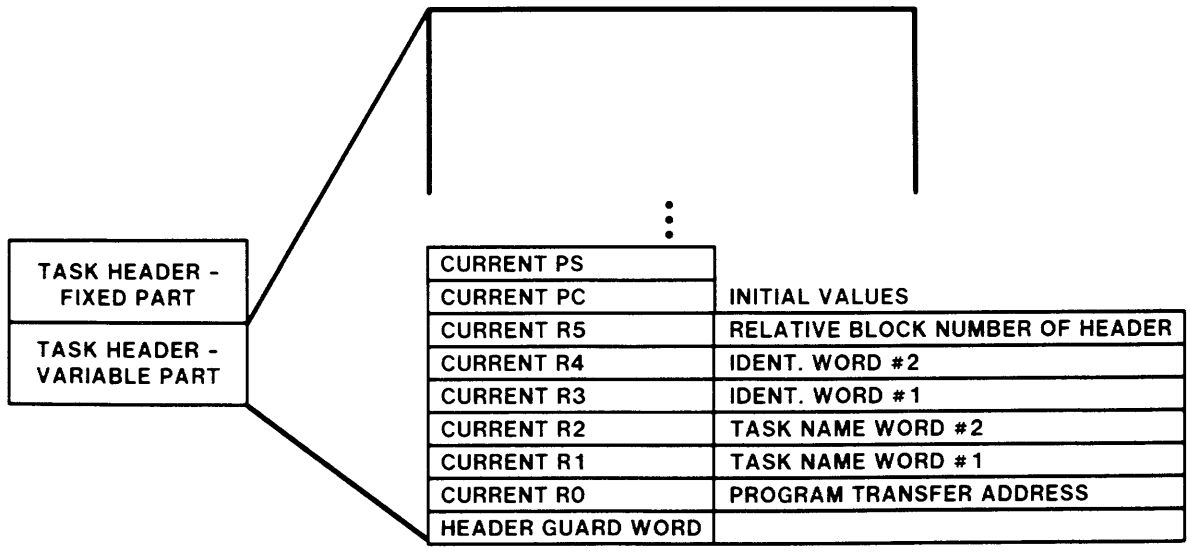


Figure 7-2 The Task Header: End of Variable Part

RUNNING A TASK

- Performed by MCR RUN command

  Directives

  RUN$
  RQST$
  SPWN$

- If task not installed, use MCR command

  Task is installed with name equal to terminal, TTnn

  Task is executed

  Task is removed on exit

- Two types of requests:

  Immediate request - is executed as soon as possible

  Time-dependent request

  Executed at a specified time

  Rescheduled to run periodically

- Steps in running a task

  Task is installed

  Task is activated

  Memory is allocated to task

  Task is loaded

  Task is scheduled

  Task is terminated

Installing

- Task is installed by MCR command

  Permanent installation by INS command

  Temporary installation by RUN command

- TCB is created and initialized
- Location T.PCB in TCB points to:

  The PCB of the partition or subpartition for which it was built (if partition is user-controlled)

  The PCB of the main partition (if partition is system-controlled)

- Locations T.LDV and T.LBN point to the load device and logical block number of the task image file
- Access rights to resident commons and libraries are checked
- Task TCB is inserted into the STD by routine $QINSP in module QUEUE
- Window blocks in header are initialized from the label blocks
- LUT is initialized from the label blocks and UCB addresses are loaded

Activating

- Task placed in the Active Task List (ATL)
- If task not installed and not privileged, it is temporarily installed

Allocating Memory

- Partition wait-queue used to schedule memory use

  Ordered by task priority

  Linked using T.LNK, the utility link word

  Starts at P.WAIT in PCB

- TCB placed in partition wait-queue

  When task is requested

  When task is checkpointed

Loading

- Task placed in loader queue

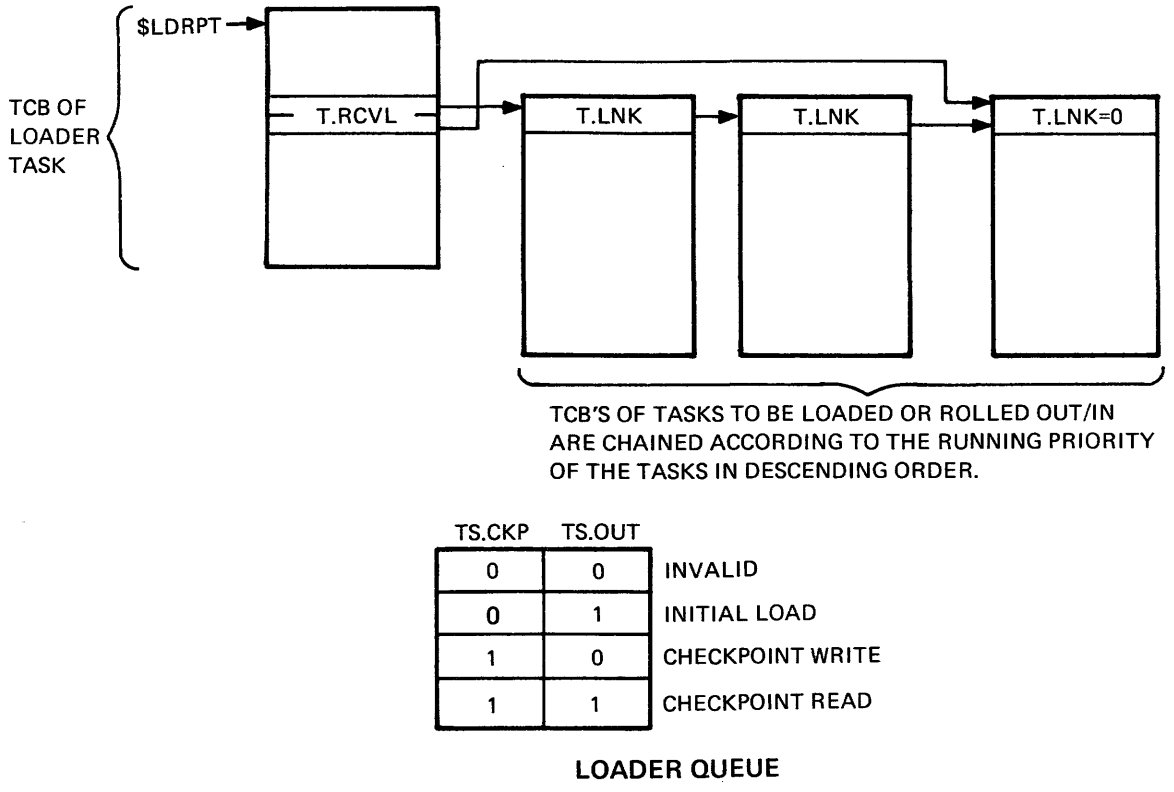
  Utility link word, T.LNK, links TCBs in queue

  Location P.WAIT in PCB is queue listhead

- In mapped system, task header copied into DSR

  Executive updates copy in DSR

  $DSW only data in task copy that is updated



TS.CKP	TS.OUT	
0	0	INVALID
0	1	INITIAL LOAD
1	0	CHECKPOINT WRITE
1	1	CHECKPOINT READ

LOADER QUEUE

TK-1813

Figure 7-3 The Loader Queue

Context Switching

- Current task's context stored in task header
- Task context includes:

  General registers (RØ - R5)

  Processor Status Word

  Stack pointer (R6)

  Program counter (R7)

  Floating-point registers

- Mapping context for current task is not saved
- New task's context is loaded from its header
- Mapping context for new task created using window blocks and PCBs

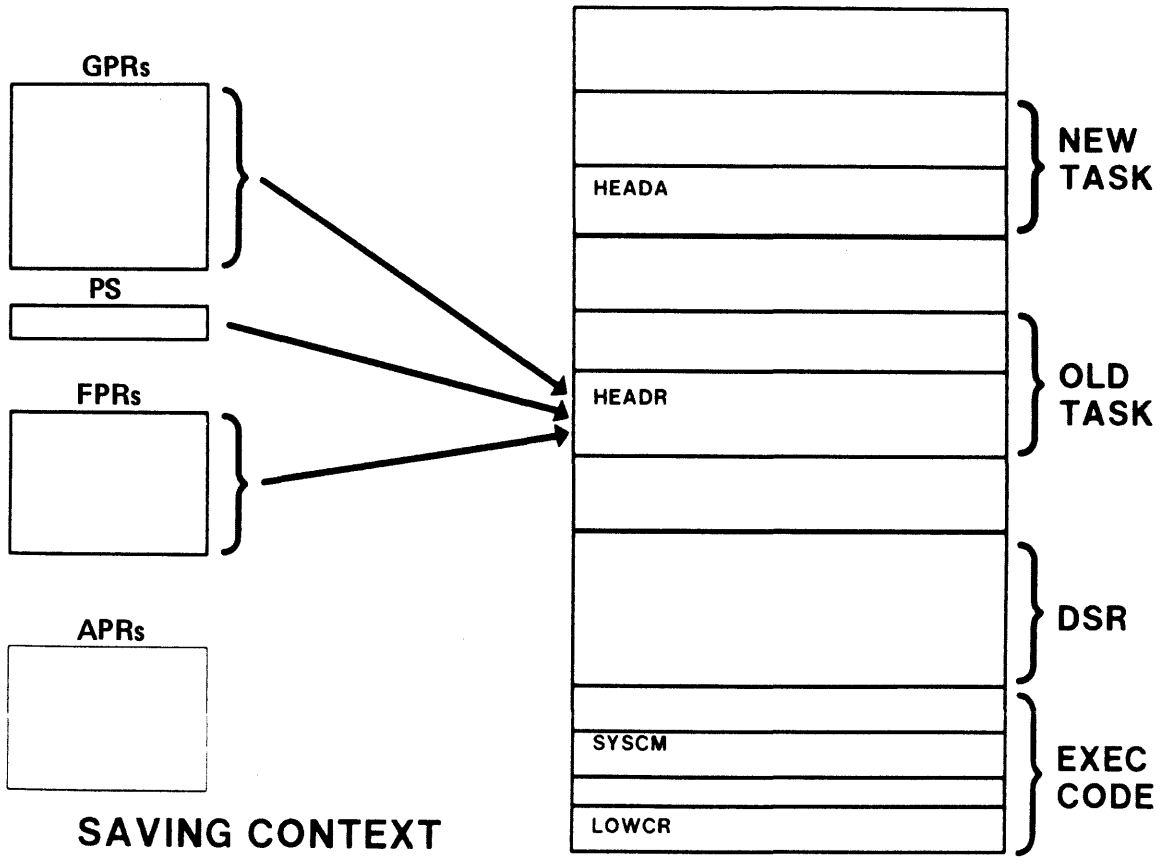


Figure 7-4 Context Switching: Saving Context

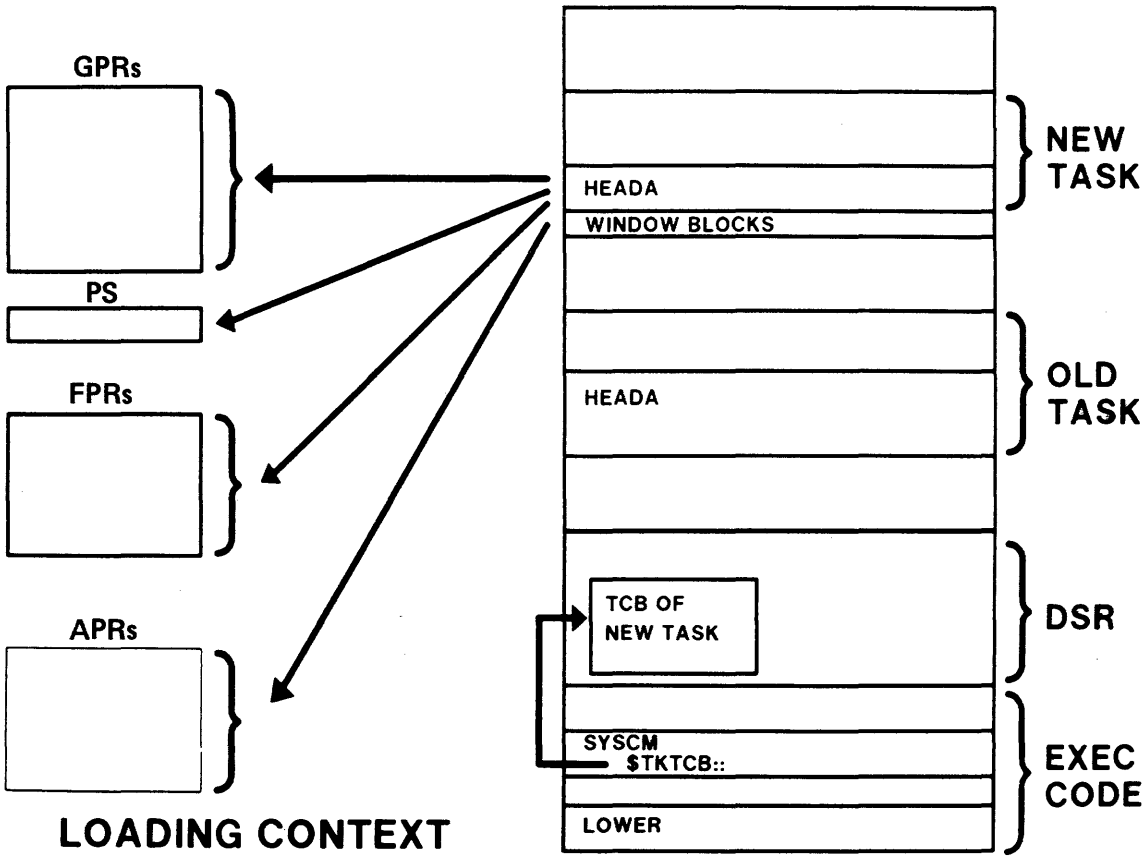


Figure 7-4 Context Switching: Loading Context

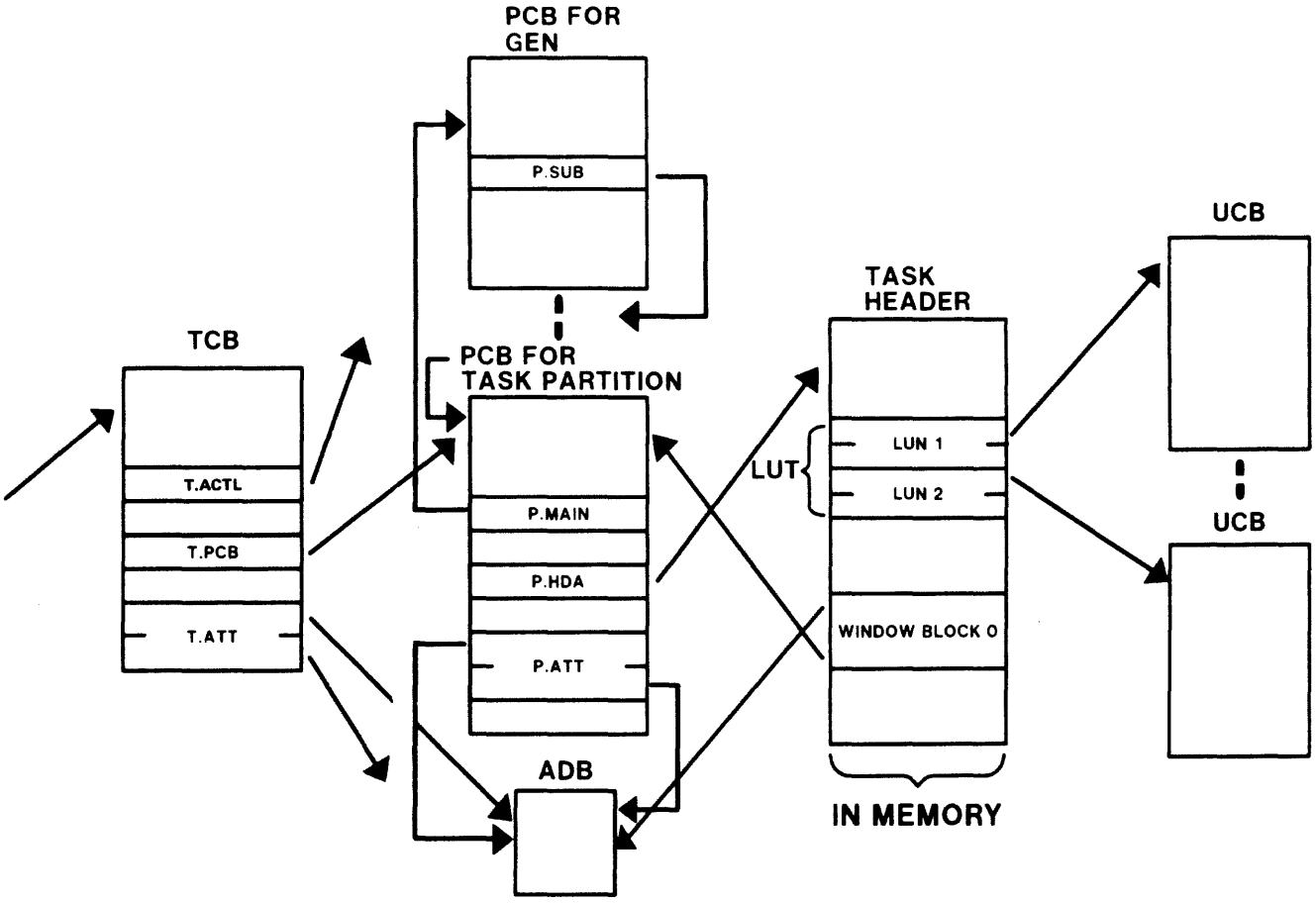


Figure 7-5 The Data Structures for an Active Task

SCHEDULING A TASK

Priority

- Scheduling request sets value in $RQSCH
- Value can be:

  The beginning of the ATL (e.g., after a significant event)

  Address of particular TCB (e.g., after a conditional scheduling request)

- Scheduling algorithm scans the ATL beginning at the TCB whose address is in $RQSCH
- System chooses:

  First resident unblocked task

  First task with a pending AST

Round Robin

- Tasks of the same priority share the CPU
- Is a SYSGEN option
- Parameters set at SYSGEN

  Round robin scheduling time interval

  Priority range for round robin

- For each priority in priority range

  Sublist of tasks of that priority is scanned

  TCBs of blocked, suspended or waiting tasks are skipped

  TCB of first eligible task is placed last in list of tasks with same priority

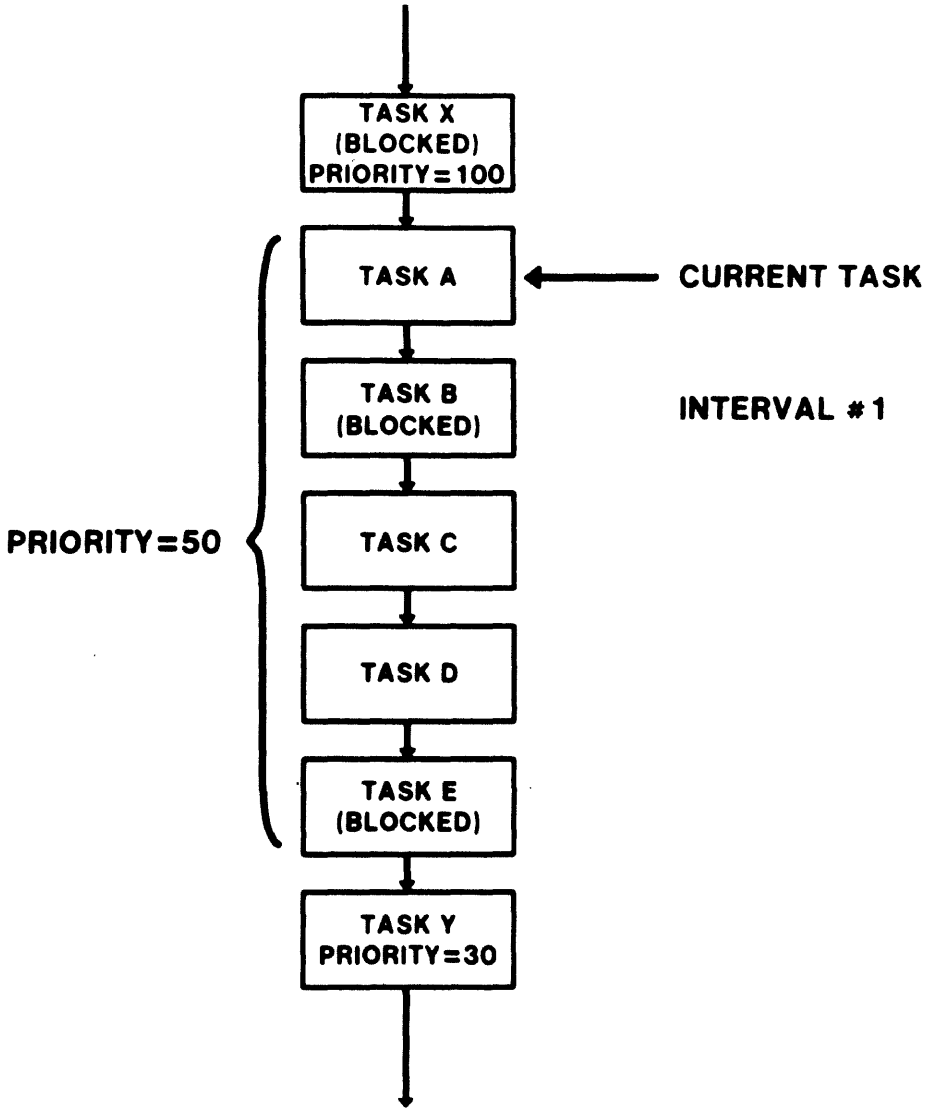


Figure 7-6 Round Robin Scheduling: Interval #1

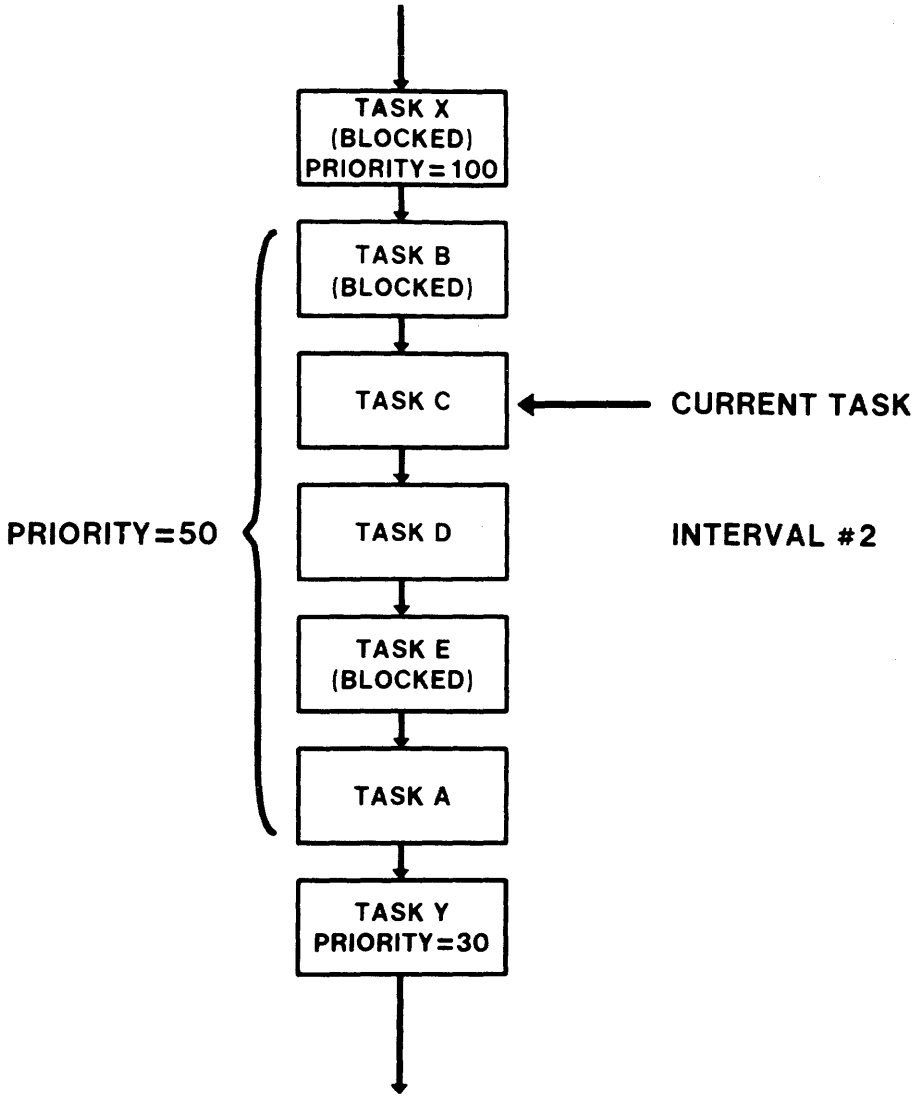


Figure 7-6 Round Robin Scheduling: Interval #2

Disk Swapping

- Allows tasks of similar priority to share memory
- Is a SYSGEN option
- Parameters set at SYSGEN

  Swapping priority

  Time interval for swapping

- Steps in disk swapping

  When task loaded, swapping priority is set at H.SPRI in the task header

  At the end of each swapping interval, H.SPRI is decremented

  H.SPRI is not decremented beyond the negative of the swapping priority

  For checkpointing, H.SPRI is added to the running priority

  When task is checkpointed, H.SPRI is set back to the swapping priority

Clock Scheduling

- Provides facility for tasks to run
  - At specific times
  - After specific time intervals
- When clock interrupt occurs, the clock queue is scanned
- Types of time dependent requests
  - Mark time request
  - Task request with periodic rescheduling
  - Single shot task request
  - Single shot internal subroutine

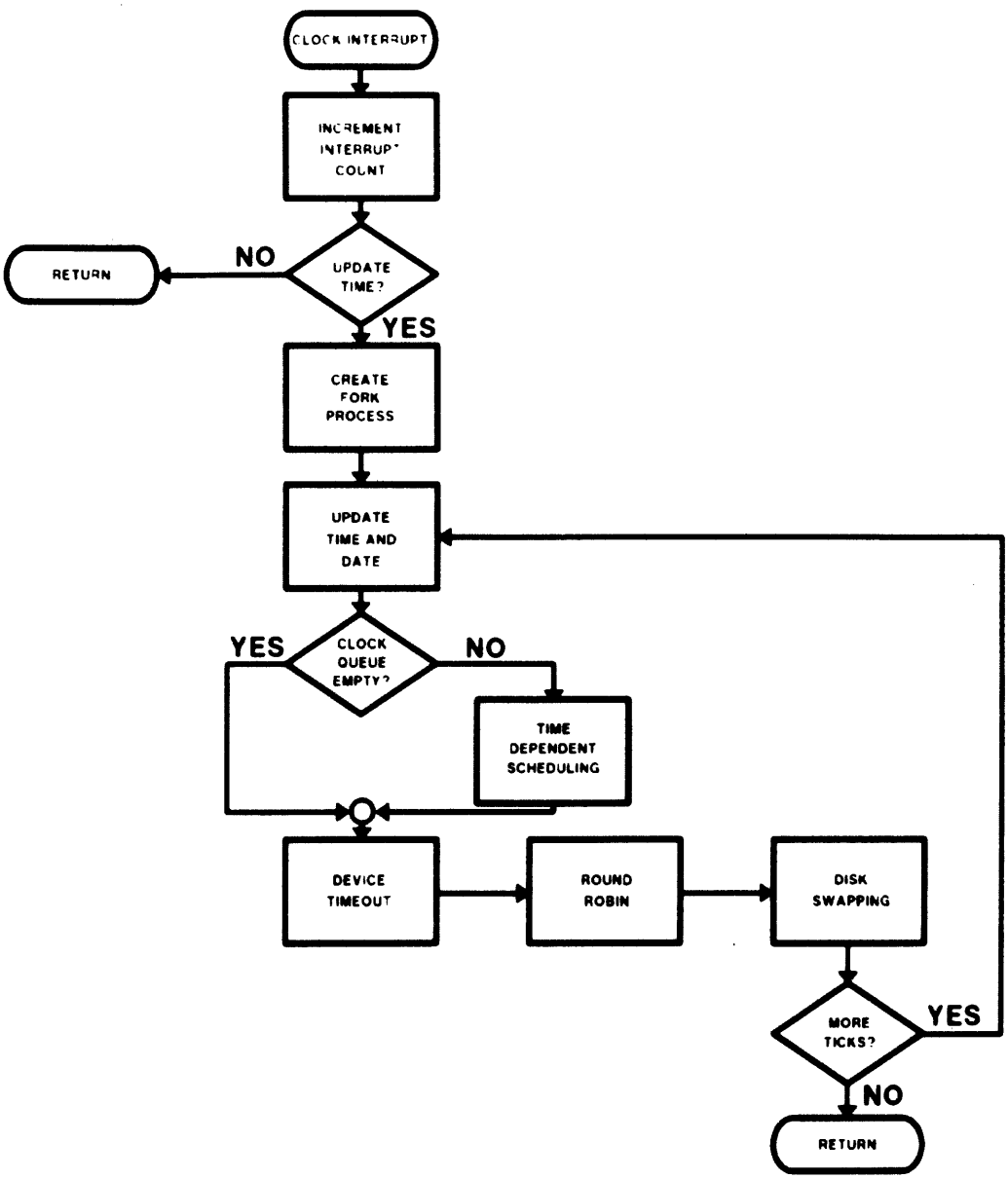


Figure 7-7 Time-Dependent Scheduling

AST Processing

- AST is used to notify a task when an asynchronous event has occurred
- Three phases in processing an AST

    Specifying the AST

        Allocate an AST control block

        Fill in the type of AST at A.CBL

        Link the block to the TCB at T.SAST

    Declaring the AST

        Queue the AST control block to the AST queue at T.ASTL

    Scheduling the AST

        Conditional schedule request is made

        After context switch to task, RESCH in SYSXT attempts to dequeue an AST

        Stopped task is activated to process the AST, then stopped again

- When an AST is scheduled

    Necessary data is pushed onto the task stack

    AST executes before return to task code

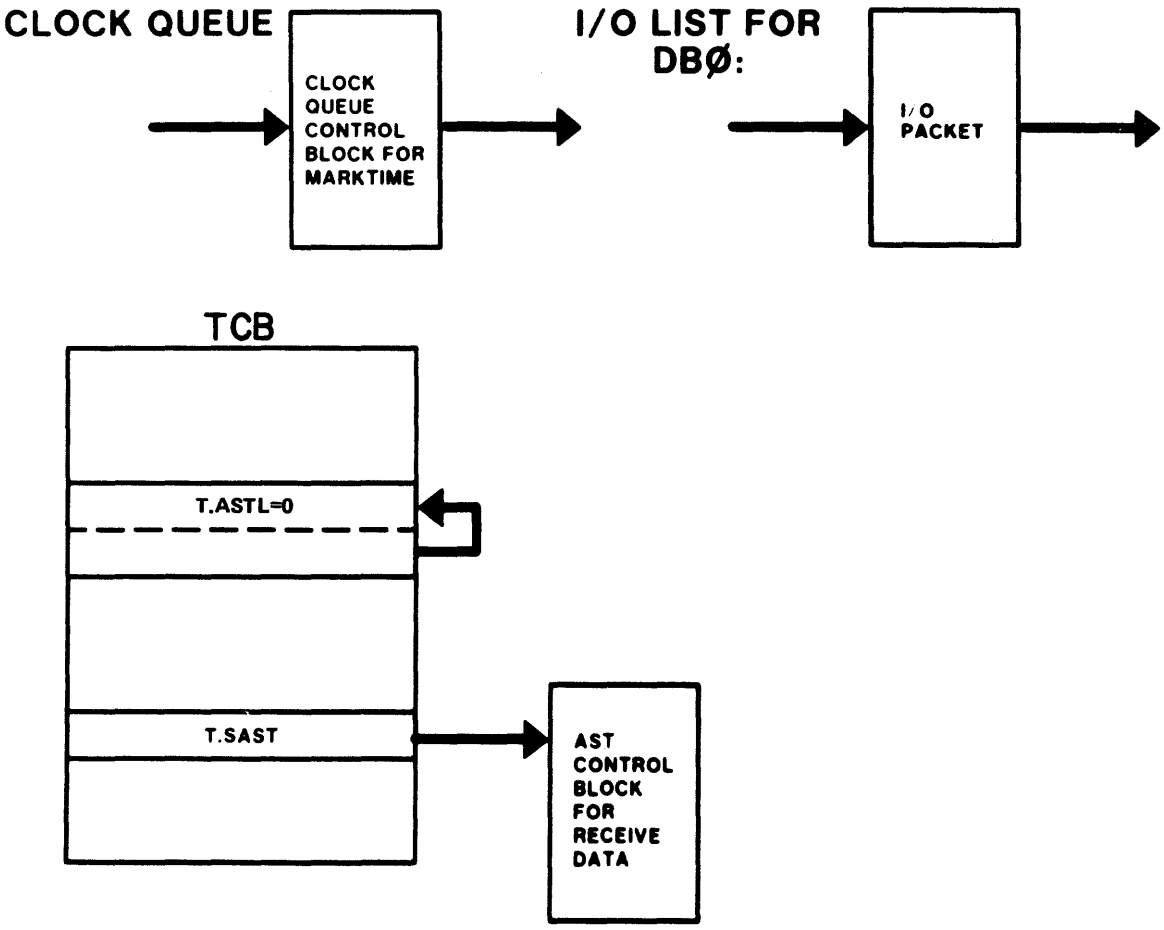


Figure 7-8 AST Processing: Sources of ASTs

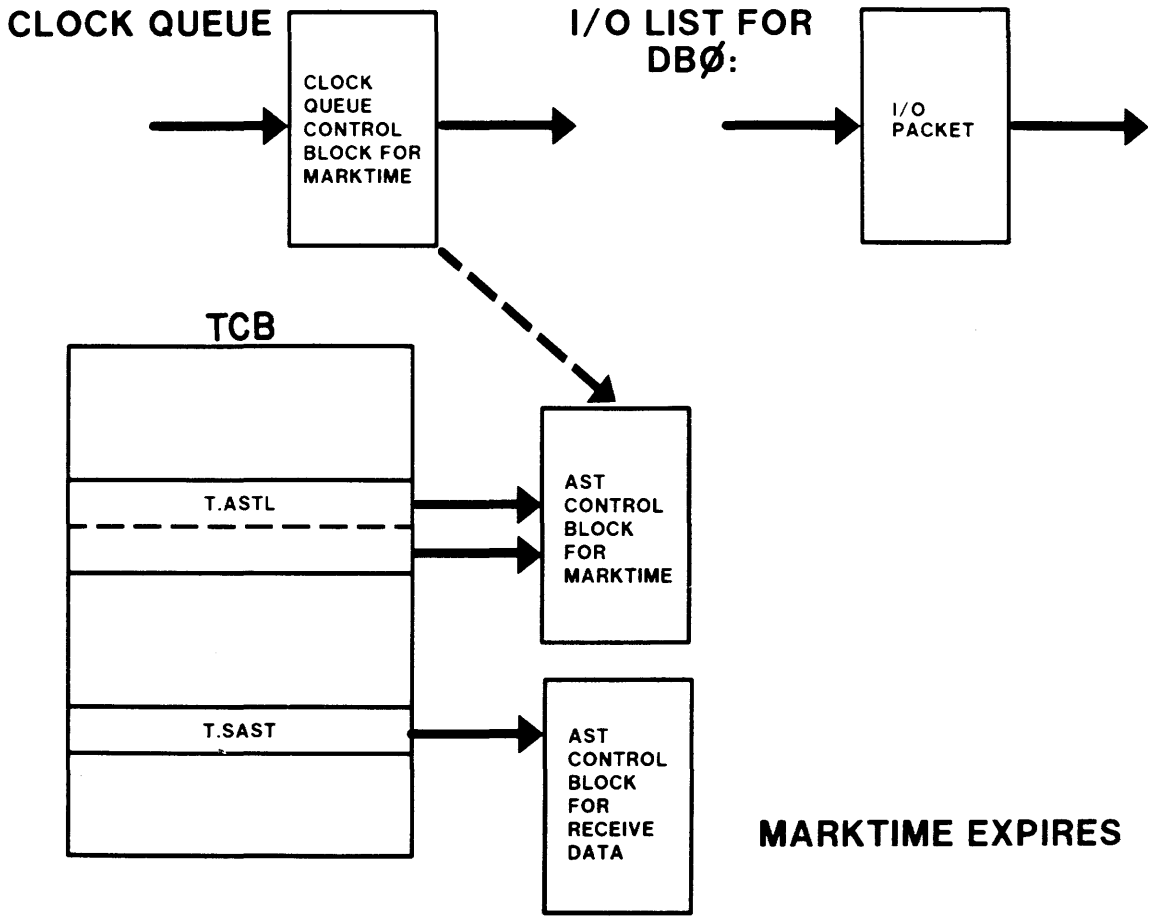


Figure 7-8 AST Processing: Marktime Expiration

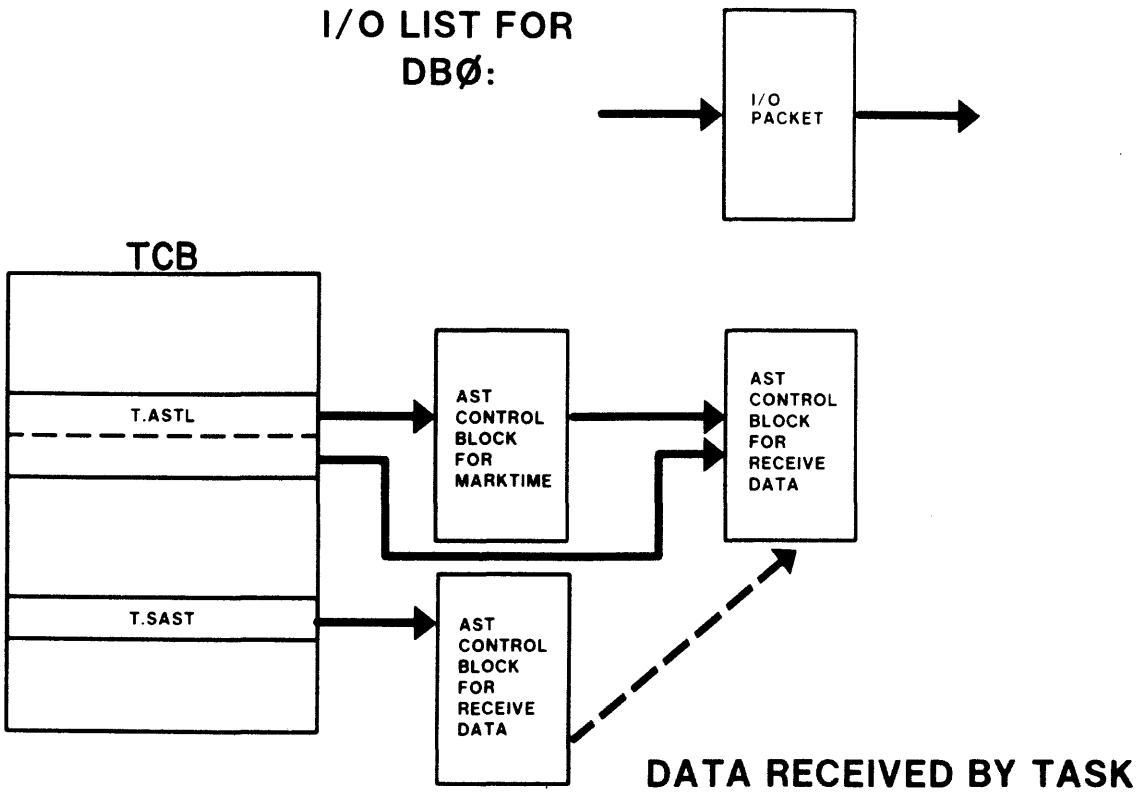


Figure 7-8 AST Processing: Completion of a Receive Data

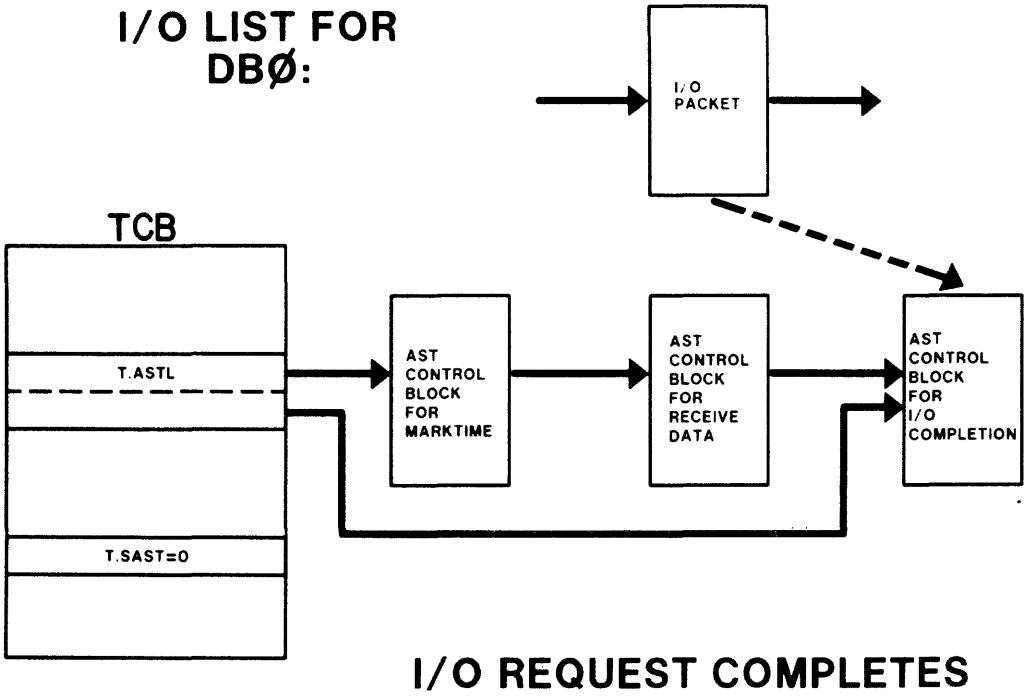


Figure 7-8 AST Processing: Completion of an I/O Operation

TASK TERMINATION

- Normal termination

  Task issues an exit directive

- Abnormal termination

  Another task issues an abort directive

  Task is aborted by an MCR abort command

  Task is aborted because of an SST

- Actions performed at task termination

  Halt task

  Cleanup system database

  Cancel mark time requests

  Break links to offspring tasks

  Disconnect interrupt vectors, if any

  If T3.REM = 1, deallocate TCB

  Deallocate header in pool if mapped system

  If abnormal exit, run TKTN

  Declare a significant event

- I/O Rundown

  Kill all I/O on each assigned LUN

  Detach all attached devices

  Close all files opened by task

Synchronous System Traps

- Trap vector for each type
- System response to SST

  Kernel mode: Crash system

  User mode: Abort task if no user SST vector

  Execute user-supplied routine if user SST vector

Table 7-1 Synchronous System Traps

Trap Vector	Trap Routine	Service Routine	Cause
4	$TRPØ4	$TRPØ4	Odd or nonexistent memory address error
25Ø	$SGFLT	$SGFLT	Memory protect violation
14	$TRACE	$TRACE	T-bit or BPT instruction
2Ø	$IOTRP	$IOTRP	IOT instruction
1Ø	$ILINS	$ILINS	Reserved instruction
3Ø	$EMTRP	$EMSST	Non-RSX EMT instruction
34	$TRTRP	$TRTRP	TRAP instruction
244	$FPPR8 (or $FPPR7)	$FPPR8	Synchronous floating-point exception

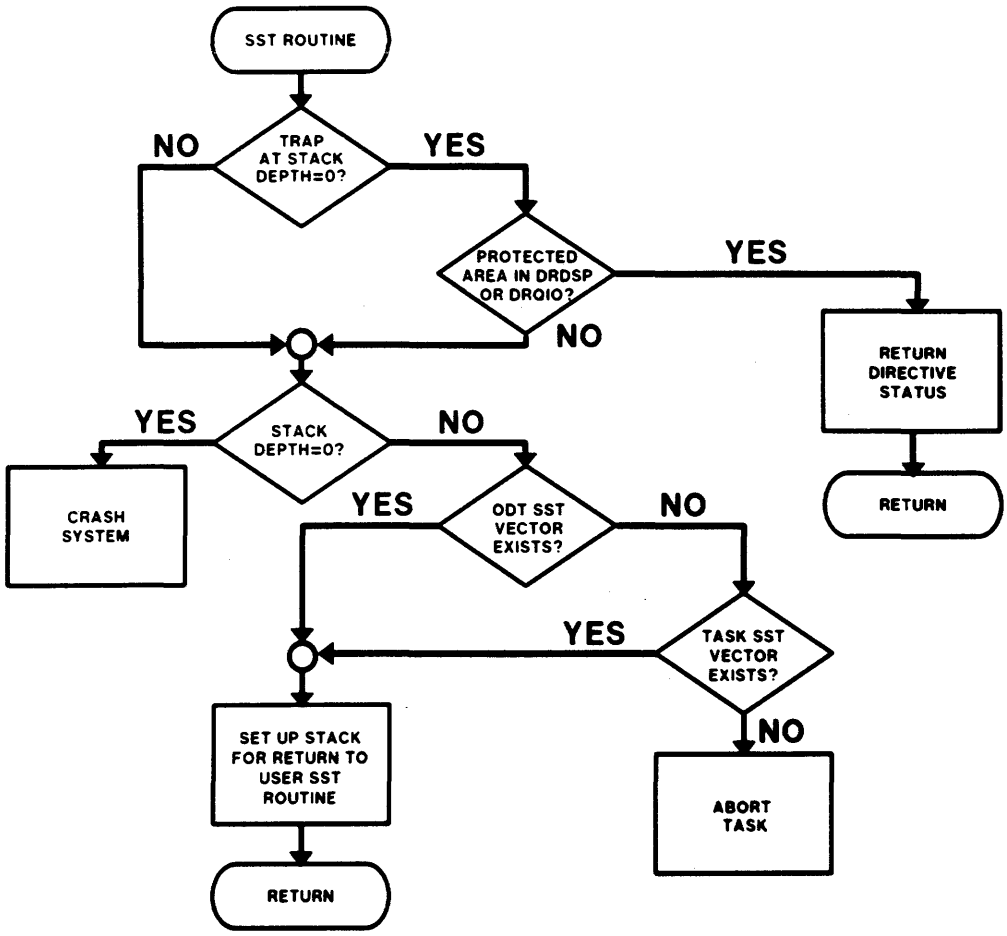


Figure 7-9 SST Processing

8

SYSTEM SYNCHRONIZATION

INTRODUCTION

A large number of activities are in progress at any given time while an RSX-11M system is in use. System synchronization is the term given to the system processing which keeps these activities from interfering with each other. One important activity which must be controlled is access to the system data base.

OBJECTIVES

1. Describe how a software trap is processed by the system.
2. Describe how a hardware interrupt is processed by the system.
3. Describe FORK processing.
4. Describe how a privileged task gets access to the system data base and code.

RESOURCE

1. RSX-11M System Lists and Data Structures

OVERVIEW

- Executive is driven by interrupts and traps

  Idle until interrupt or trap occurs

- System operation

  Executive booted into memory by ROM

  ROM starts Executive by initializing PS and PC

  Executive initializes the environment

    Enables memory management unit

    Turns on clock

    Drivers called at powerfail entry points

  Executive drops into idle loop and waits for interrupts

    Command typed in at a terminal

      Interrupt occurs

      Command passed to MCR or DCL

      MCR or DCL runs a task

      Task may issue traps

    Clock may interrupt functions

System Synchronization Functions

- Provides serial access to system database

  Process accessing system database 'owns' the database until finished

  'Race' conditions are avoided

- Provides orderly method of allocating CPU use between user and system

Software States

- User State

  User code executing

  Processor in USER mode

  Processor fully interruptable - Hardware priority is Ø

- System State

  Only state in which the shared system database should be accessed

  Processor in KERNEL mode

  Processor fully interruptable - Hardware priority is Ø

- Interrupt Service State

  Used to perform critical operations after an interrupt

  Processor in KERNEL mode

  Processor not fully interruptable - Hardware priority between 4 and 7

Software Processes

- Process - A stream of code in KERNEL mode performing a complete logical job

  Can be in the Executive or in a privileged task

- There are three types of processes contained in the Executive

  Trap process

  Services a software trap

  Performed in system state

  Interrupt Process

  Services a hardware interrupt

  Performed in interrupt service state

  FORK Process

  Allows process or task to get access to system database

  Performed in system state

The Stack Depth Indicator

- One word at location $STKDP in the Executive module SYSCM
- Indicates software state and number of interrupts which have occurred in KERNEL mode

  Value of +1 indicates processing in user state

  Value of Ø indicates processing in system or interrupt service state

    Trap or interrupt occurred from user state

  Negative value indicates processing in interrupt service state

    Trap occurred from system state

- Each time trap or interrupt occur, $STKDP is decreased by 1
- Each time a trap or interrupt process completes, $STKDP is increased by 1

Traps and Interrupts

- CPU hardware performs following steps

  New program counter and processor status are obtained from the vector

  Current program counter and processor status are pushed onto current stack

    Current stack is KERNEL stack if mapped system
    Current stack is USER stack if unmapped system

- New program counter contains address of trap service routine
- New processor status causes

  Processor to change to KERNEL mode
  Processor priority to change to level 7

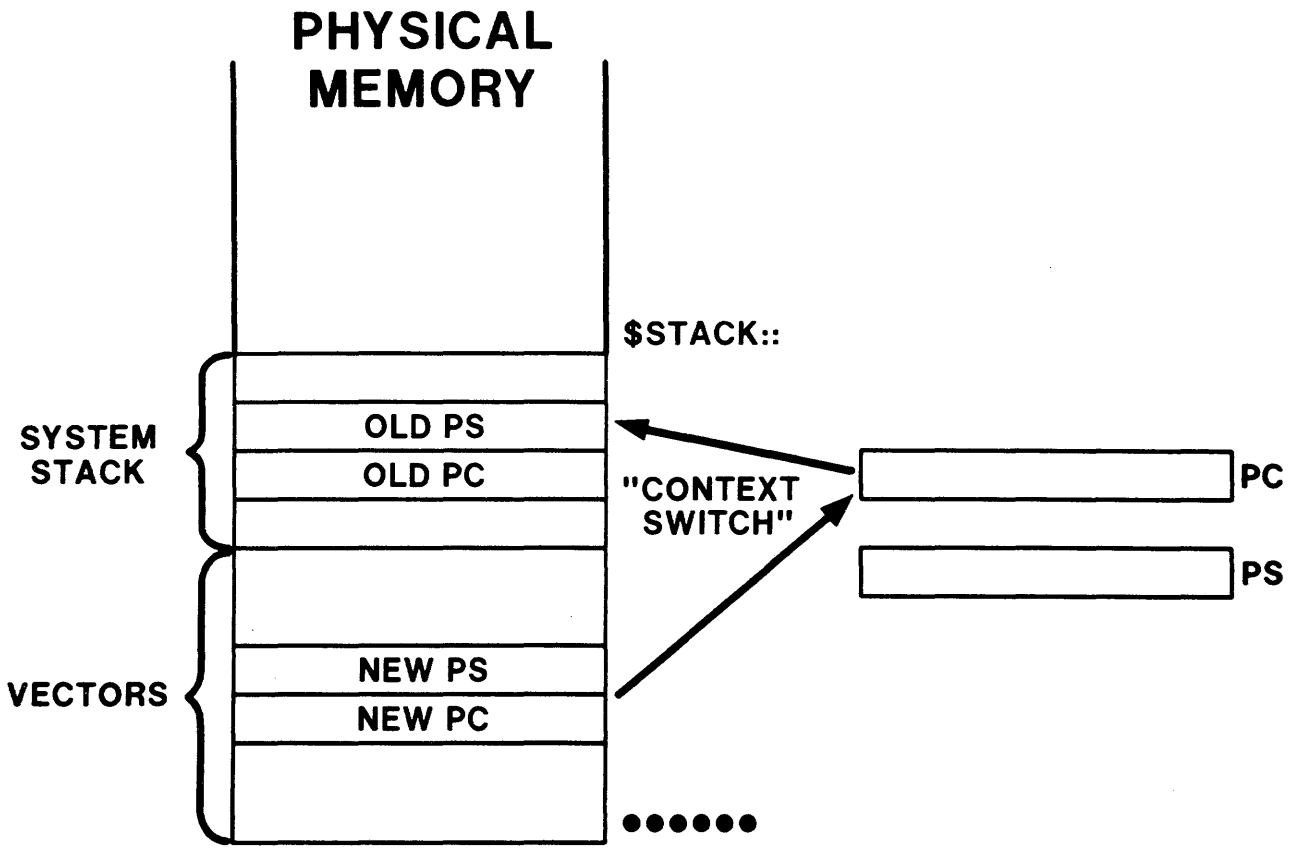


Figure 8-1 Handling Traps and Interrupts by the Hardware

TRAP PROCESSING

1. Trap caused by execution of a 'trap' instruction or synchronous system trap detected by the Executive

2. Each type of trap corresponds to a unique two word vector in low memory

3. Most common trap is 'EMT 377', the result of a directive call

4. EMT instructions

   Cause a transfer to location $EMTRP in module DRSUB

   Processing occurs in module $DRDSP, the Directive Dispatcher

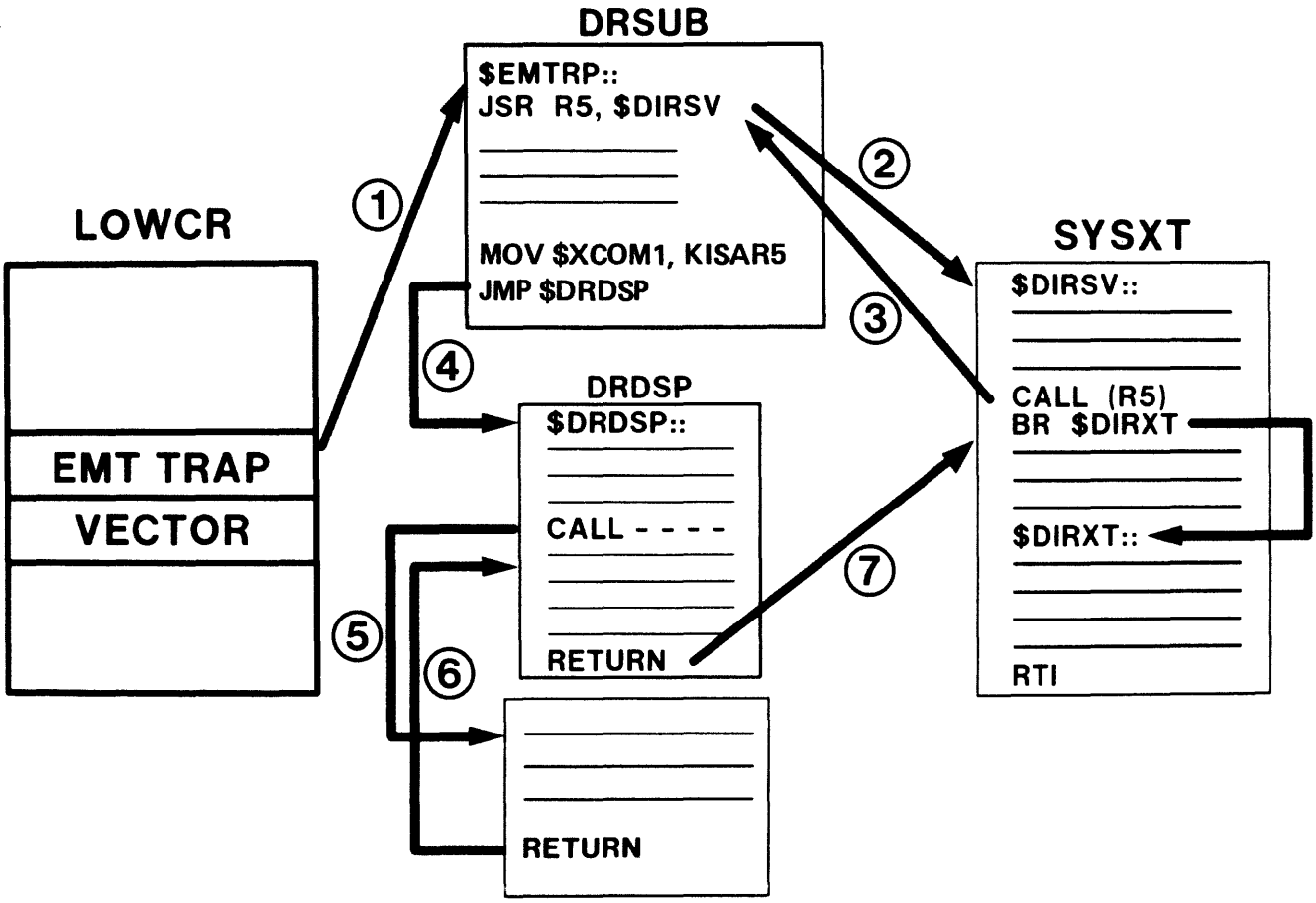


Figure 8-2 EMT Instruction Execution

The Directive Save Routine

- Code begins at label $DIRSV in module SYSXT
- Called by trap processing routine upon entry
- Processing in directive save routine

    Stack depth indicator is decremented to Ø

    R5 is saved on current stack by JSR instruction

    R4 is saved on current stack

    On unmapped system, loads R6 with pointer to system stack

    R3, R2, R1 and RØ are saved on system stack

    Performs coroutine call back to DRSUB

The Directive Exit Routine

- Code begins at label $DIRXT in module SYSXT
- Raises processor priority to 7 to lock out interrupts
- Checks for waiting FORK process

    If so: maps driver using KERNEL APR 5
    transfers control to next FORK process

- Increments $STKDP (Should now be +1)
- Restores general purpose registers
- Executes RTI instruction to return to USER mode

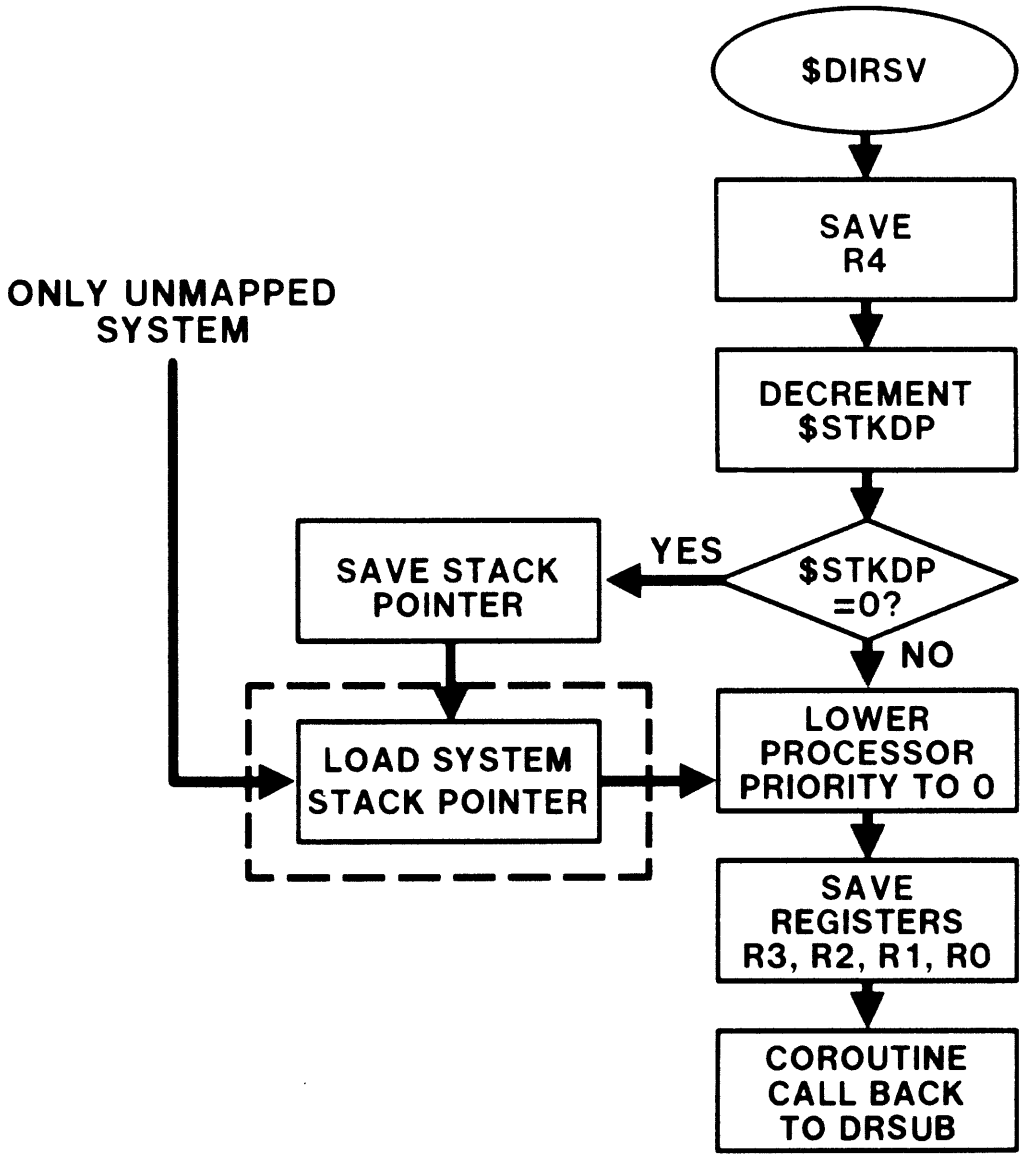


Figure 8-3 The Directive Save Routine

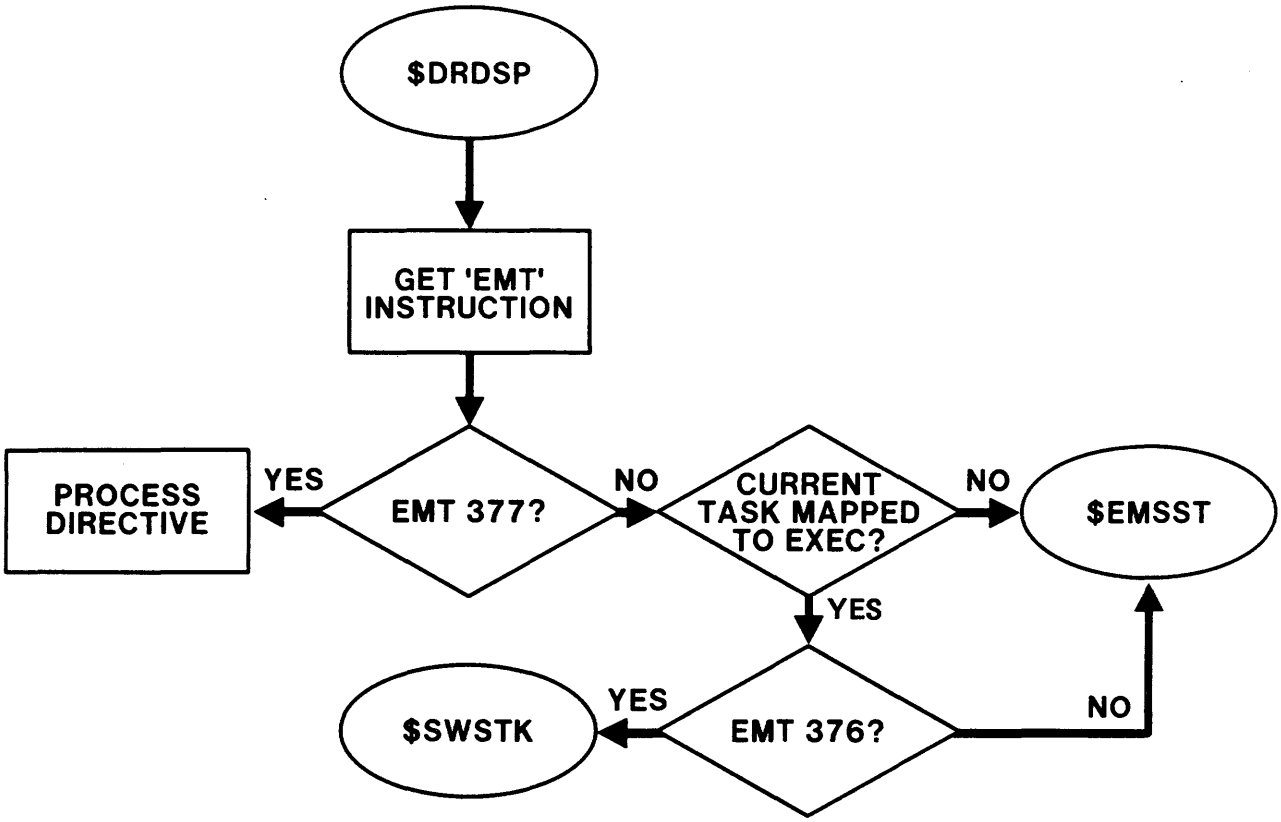


Figure 8-4 Common Processing in the Directive Dispatcher

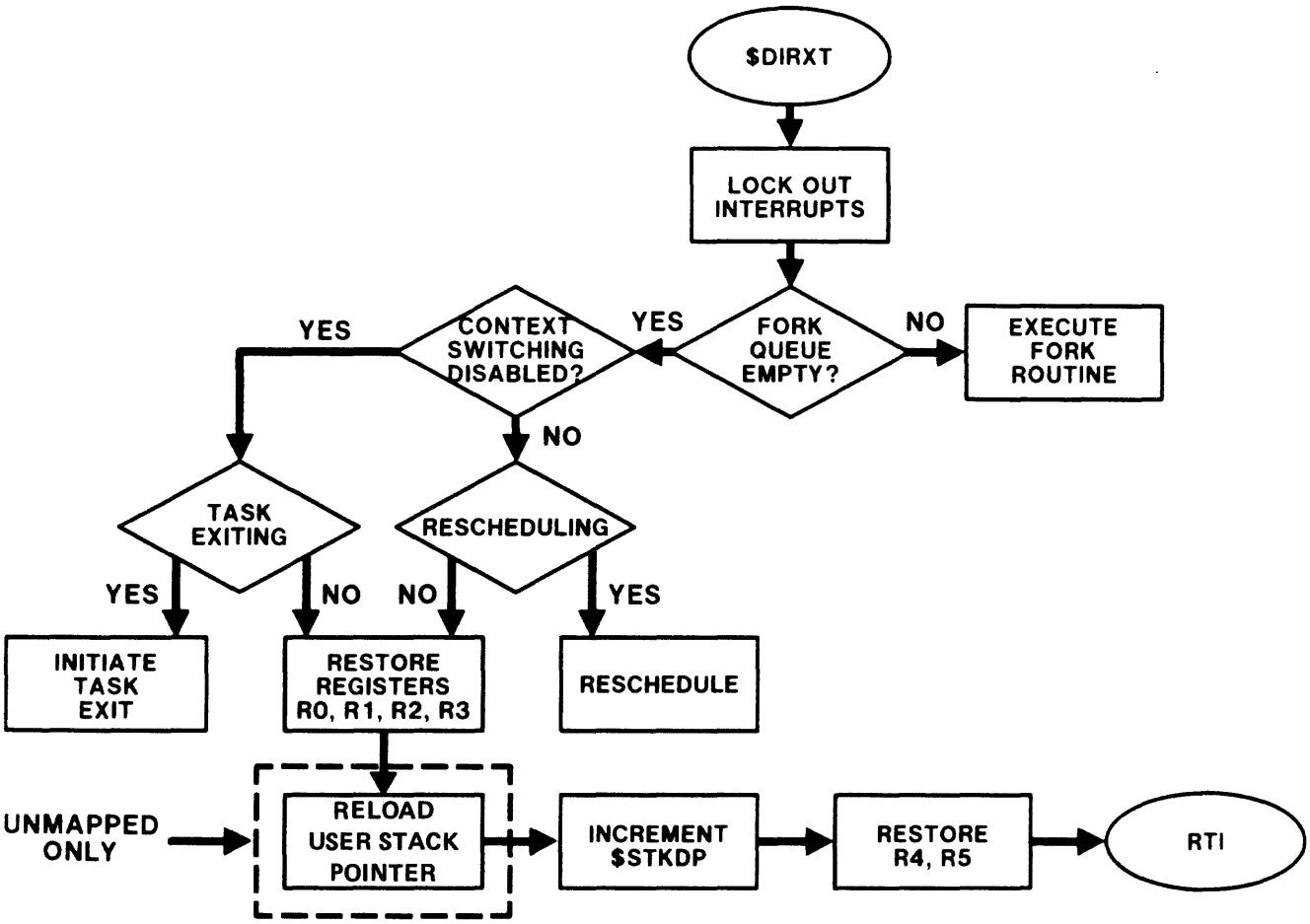


Figure 8-5 The Directive Exit Routine

INTERRUPT PROCESSING

- Interrupt caused by hardware event
- Device driver allows interrupt by setting 'interrupt-enable' bit device register
- Each device controller has its own 2-word interrupt vector in low memory

The Interrupt Save Routine

- Code begins at label $INTSV in module SYSXT
- Entry is with processor priority at level 7 to lock out other interrupts
- Called by interrupt service routine upon entry
- Processing in interrupt save routine

  Stack depth indicator is decremented by one

  R5 is saved on the current stack by JSR R5,$INTSV

  R4 is saved on the current stack

  On unmapped system, SP is loaded with the address of the system stack if entry is from user mode

  Processor priority is lowered to priority of the interrupting device

  Performs coroutine call back to the interrupt service routine

- Several versions of this routine are available in module SYSXT

  $INTSV - Used by devices without error logging

  $INTSE - Used by devices with error logging

  $INTSC - Used by connect-to-interrupt routines

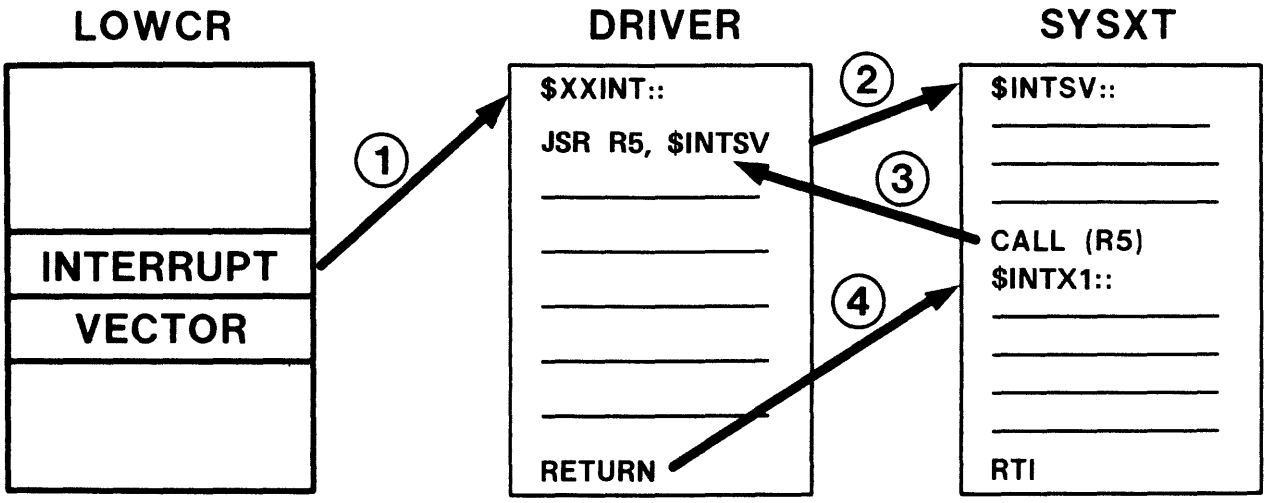


Figure 8-6 Interrupt Processing

Device Driver Processing

- Usually divided into three processing sections
- Processor Status Word in vector causes entry into interrupt service routine at priority 7

  All interrupts are blocked

  Usually $INTSV is called and lowers priority

- Critical processing is performed at the priority of the device

  For a terminal, the last input character is processed and the interrupt-enable bit is set for the next character

  If the system data base must be accessed, a FORK process is created

- A device driver can access the system data base only as a FORK process

  A FORK process executes at processor priority Ø

The Interrupt Exit Routine

- Code begins at label $INTX1 in the module SYSXT
- Raises processor priority to 7 to lock out interrupts
- Checks for waiting FORK process

  If one: lowers priority to Ø
  saves RØ - R3 on system stack
  executes the $DIRXT routine

- Increments $STKDP
- Restores general registers
- Executes RTI instruction to return to USER mode

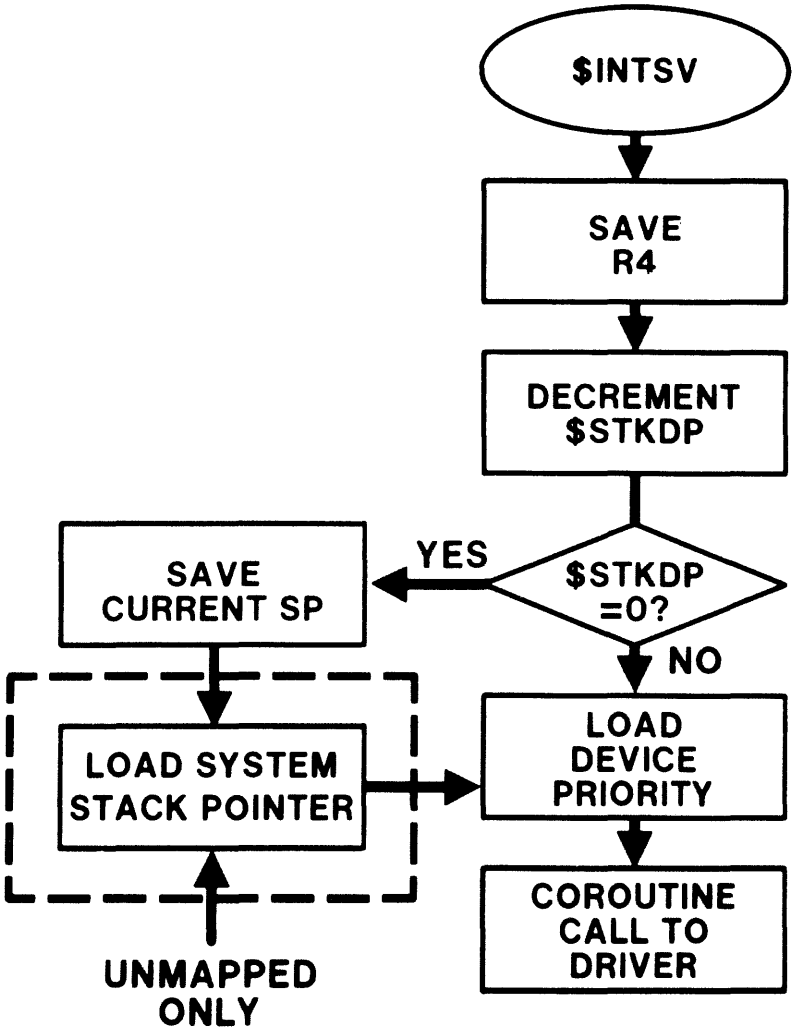


Figure 8-7 The Interrupt Save Routine

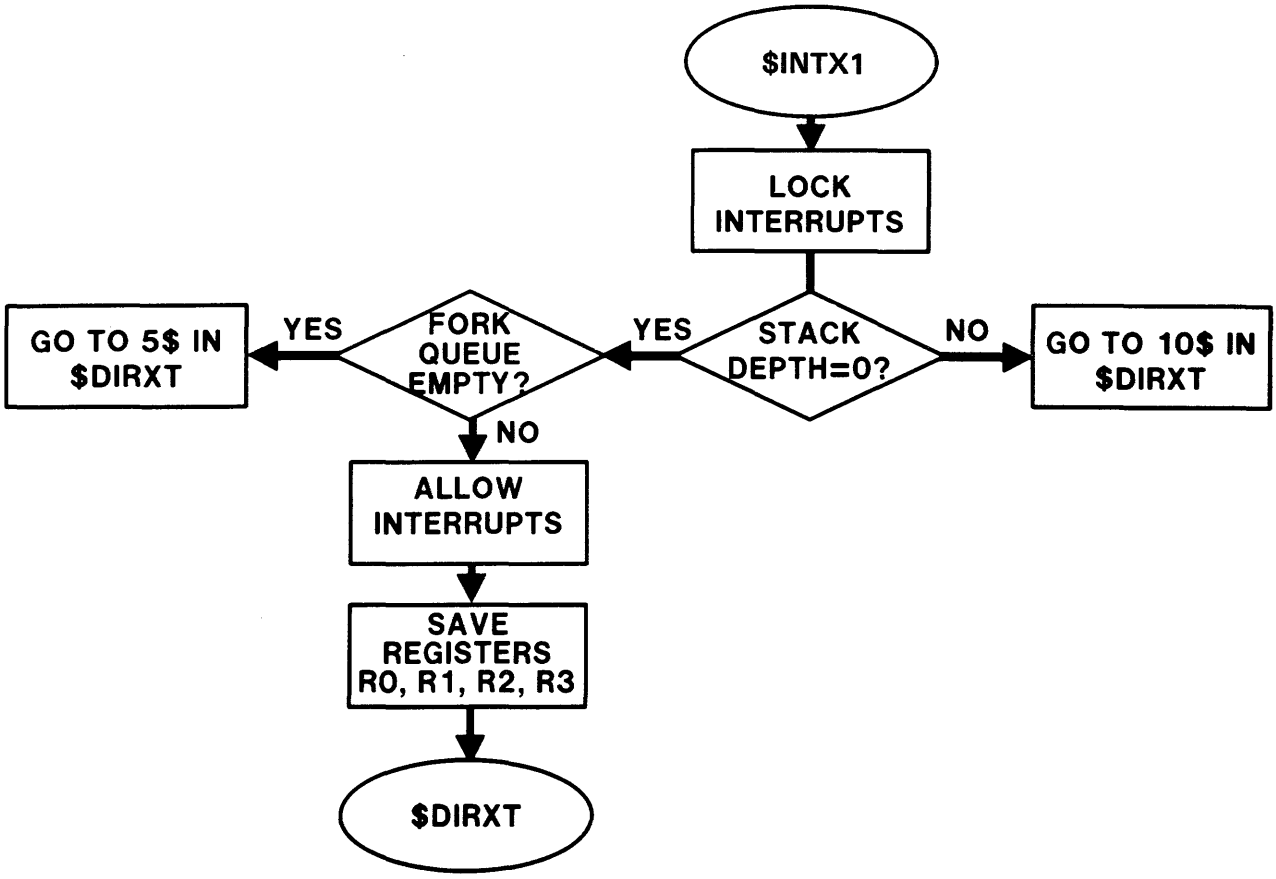


Figure 8-8 The Interrupt Exit Routine

FORK PROCESSING

- Provides serial access to the system data base

  Processes needing access are queued

  No process gains access until the current process is finished with the system data base

- Usually process is part of a device driver, but any privileged task can create a FORK process
- Created by routines in module SYSXT

  $FORK - Used by device drivers

  $FORKØ - Creates FORK process without saving R4 and R5

  $FORK1 - Creates FORK process saving R4 and R5

  $FORK2 - Used by connect-to-interrupt routines

The FORK Block

- Four word block containing

  Link word for FORK list

  Saved PC

  Saved R5

  Saved R4

- FORK block for device driver contained in the SCB

The FORK List

- FORK blocks are linked into FIFO queue called FORK list
- Begins at list head in SYSCM at location $FRKHD

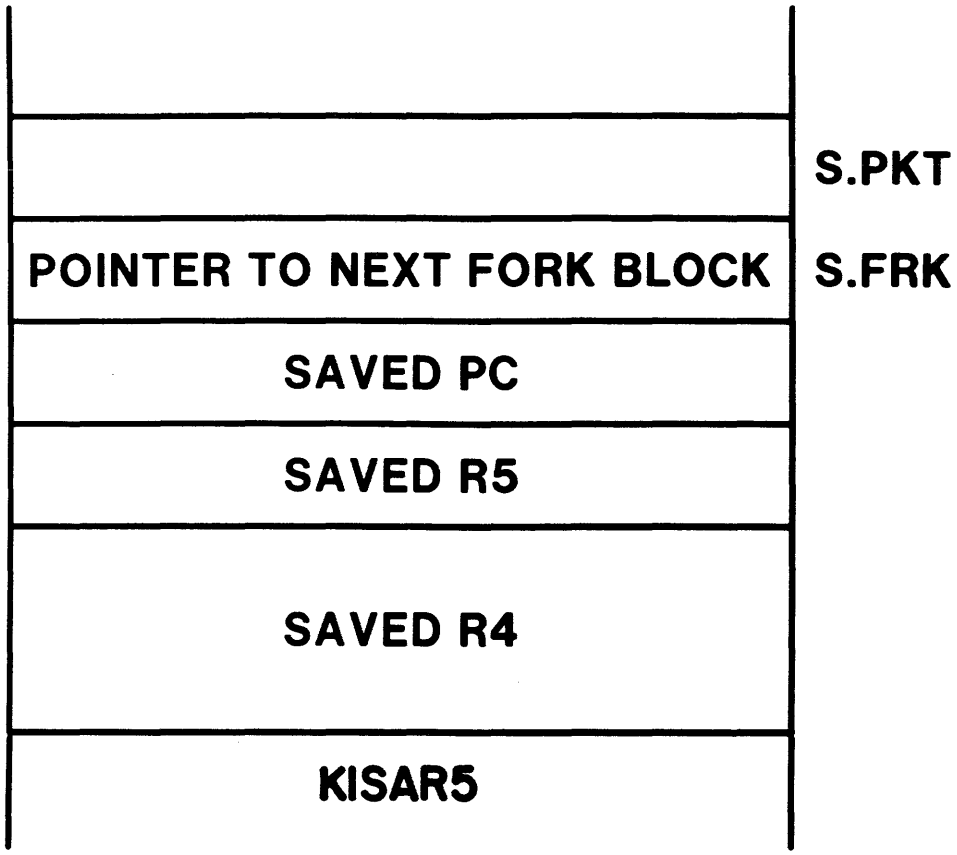


Figure 8-9 The FORK Block in the SCB

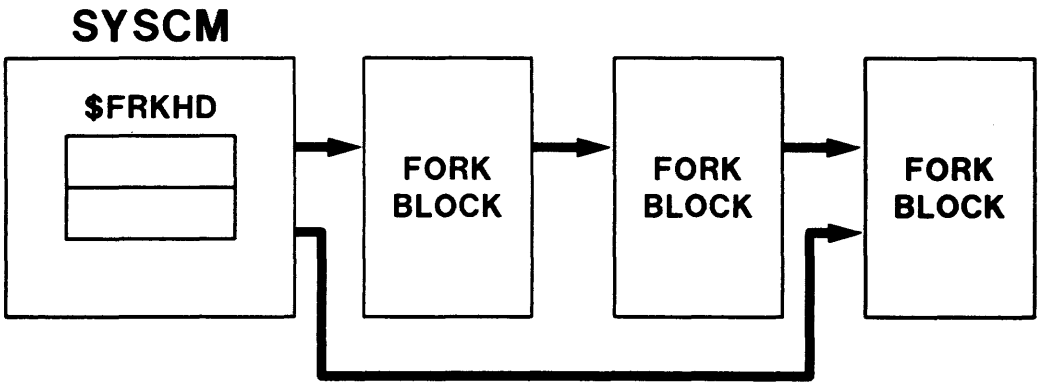


Figure 8-1Ø The FORK List

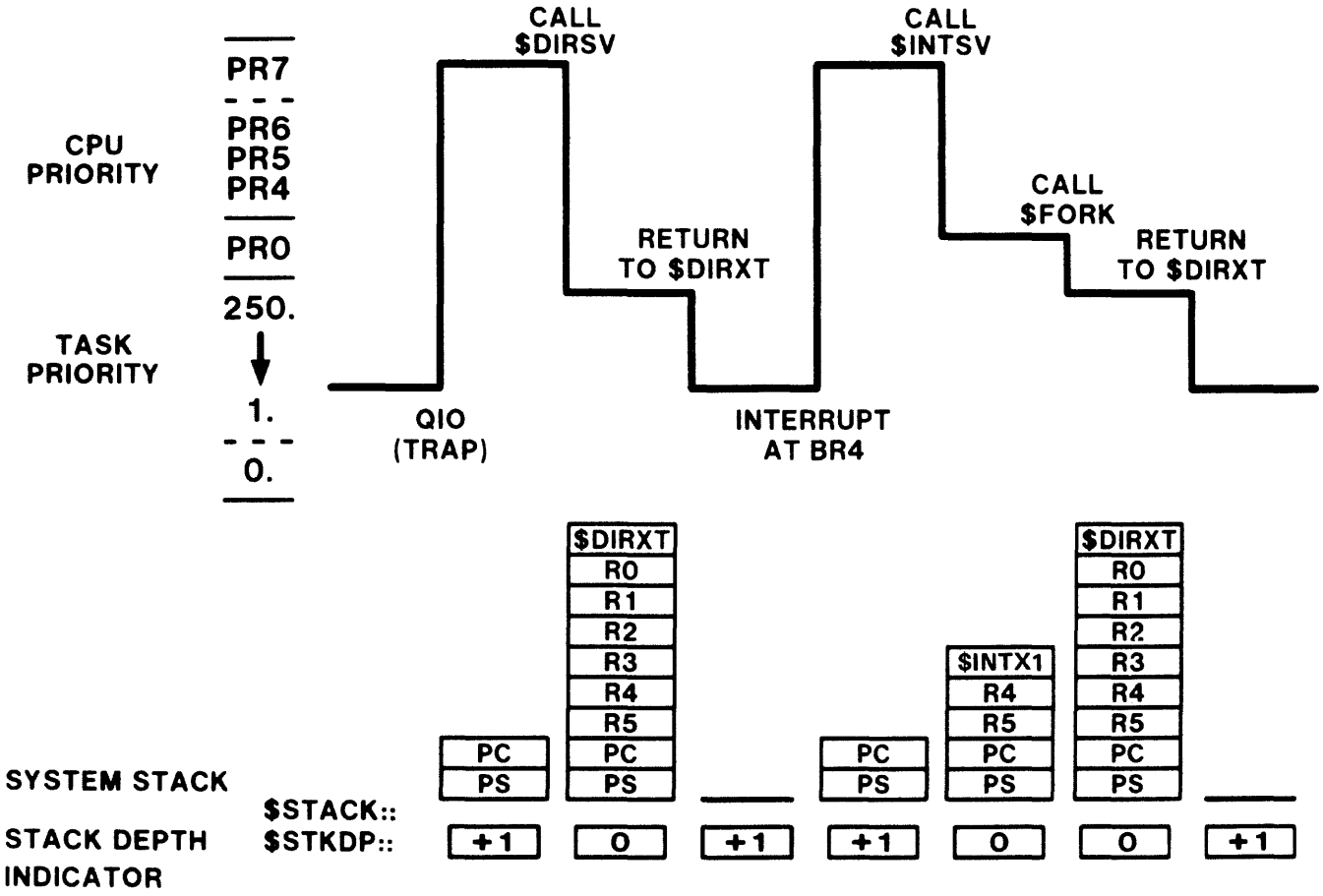


Figure 8-11 Interrupting a Task

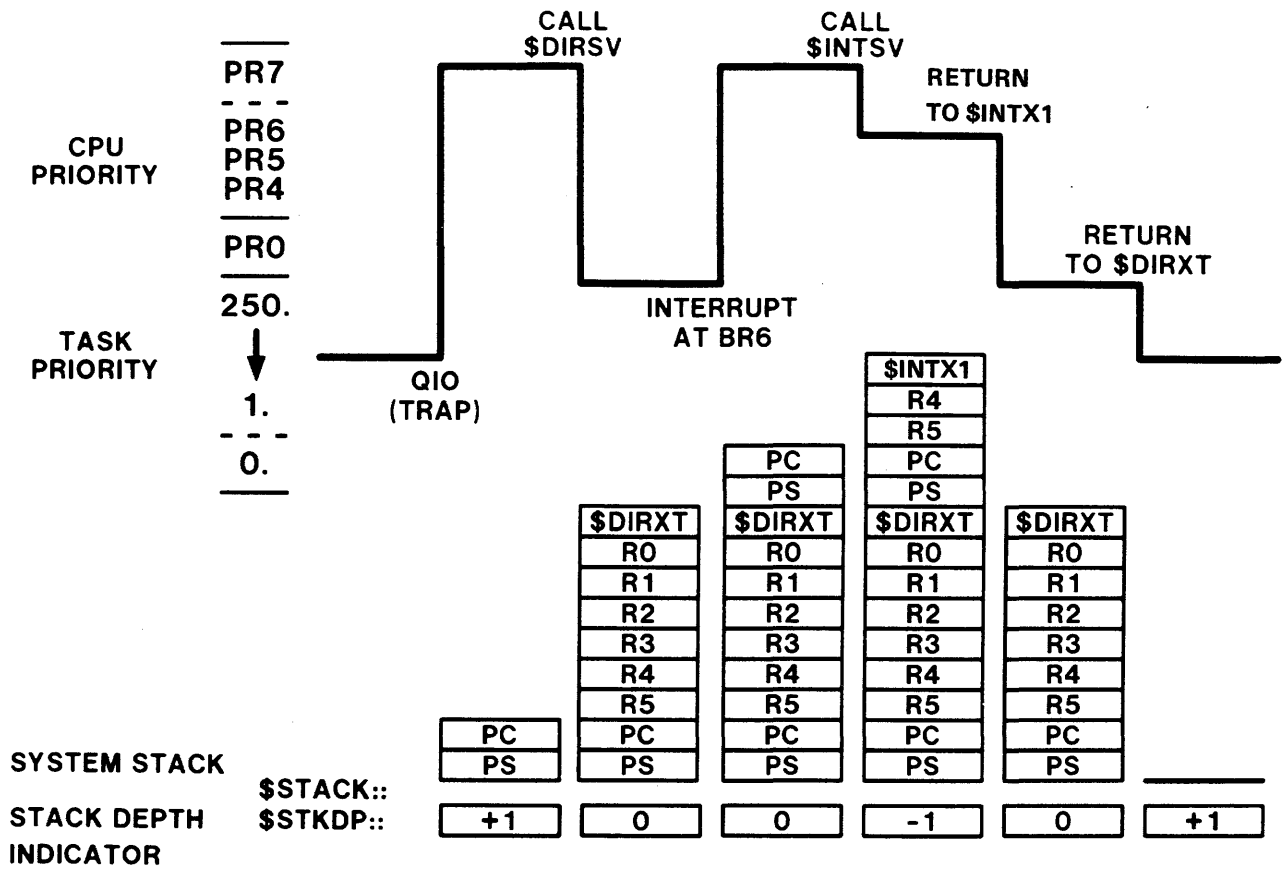


Figure 8-12 Interrupt Executive Processing a Directive

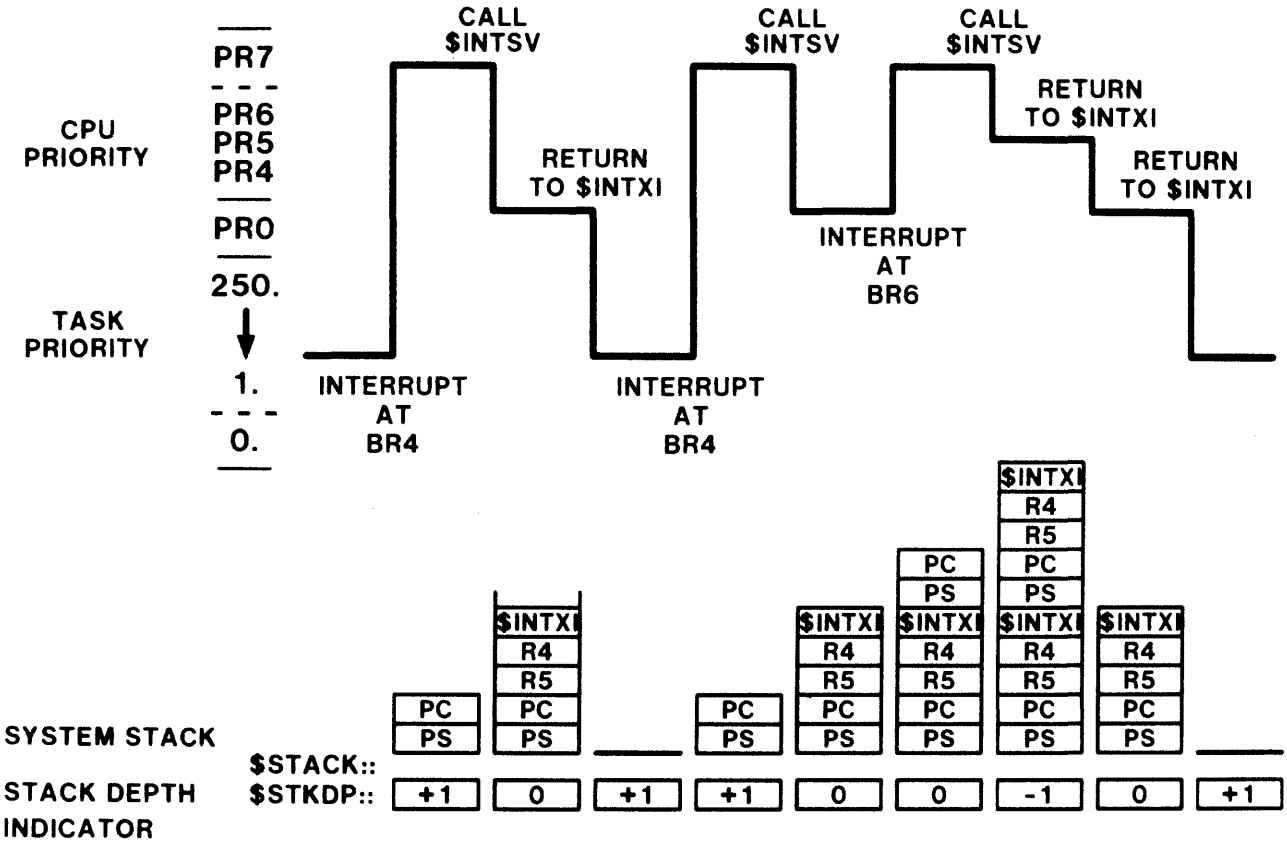


Figure 8-13 Interrupt Executive Processing an Interrupt

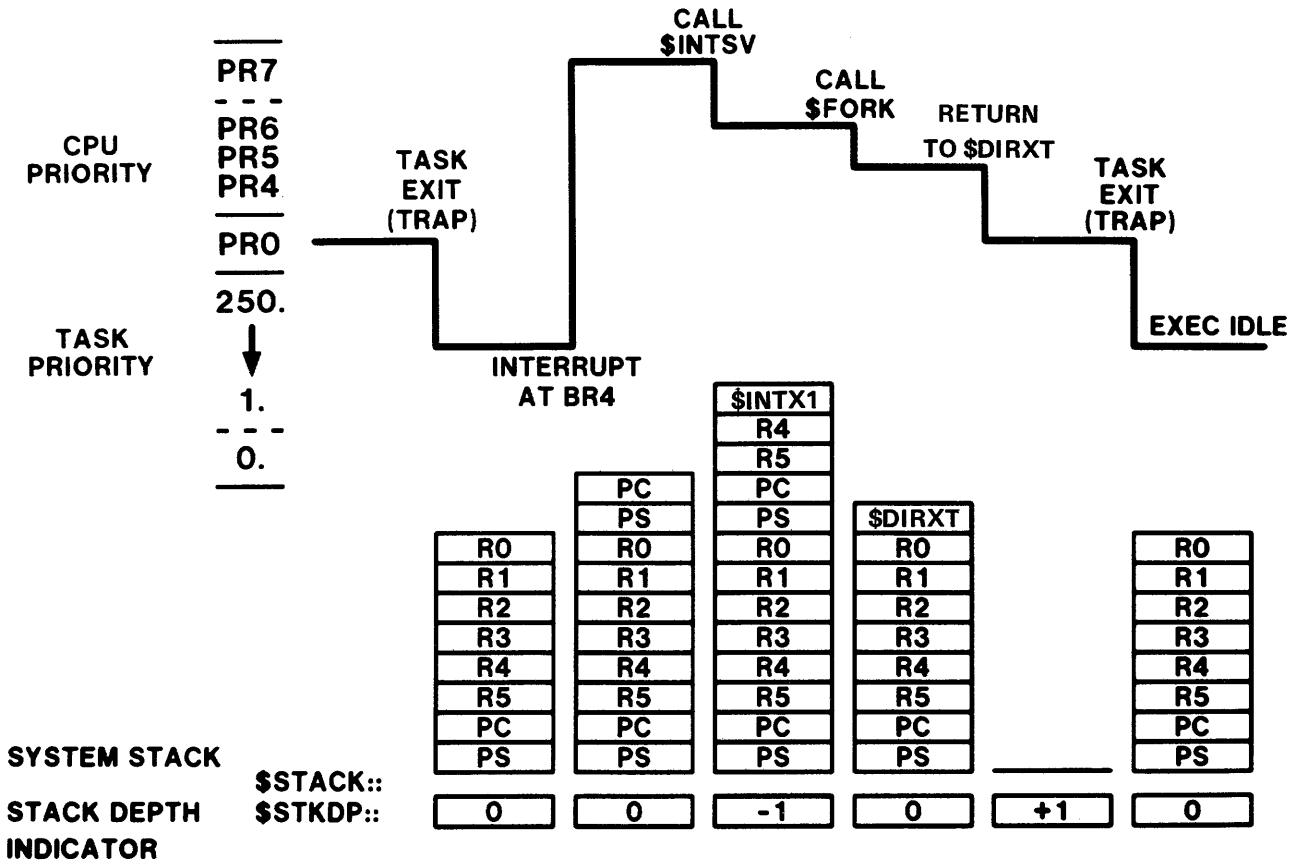


Figure 8-14 Interrupt Executive in an Idle Loop

PRIVILEGED TASKS

- Privilege bit is set in second status word in TCB

  Task can use privileged directives

  Task can perform privileged I/O functions

  Task can perform logical block transfers to/from mounted volumes

- Task is built privileged by using the /PR switch when taskbuilding

  /PR:Ø creates privileged task whose mapping is the same as that of a nonprivileged task

  /PR:n creates privileged task which maps to the Executive

  n = 4 if Executive is 16K words
  n = 5 if Executive is 2ØK words

Processing a Privileged Task

- Privileged task must switch to KERNEL mode to access system data base
- Switch to KERNEL mode is performed by CALL $SWSTK,LABEL instruction

  CALL macro translates this to EMT 376

  CALL macro is in SY:[11,10]RSXMC.MAC

  LABEL is a location in the privileged task to return when leaving KERNEL mode

- In module DRDSP, a jump to location $SWSTK in module SYSXT is executed
- The routine $SWSTK

  Moves the contents of USER mode APRs 5 and 6 to KERNEL mode APRs 5 and 6

  Moves the address of LABEL to location SP+16 on the stack

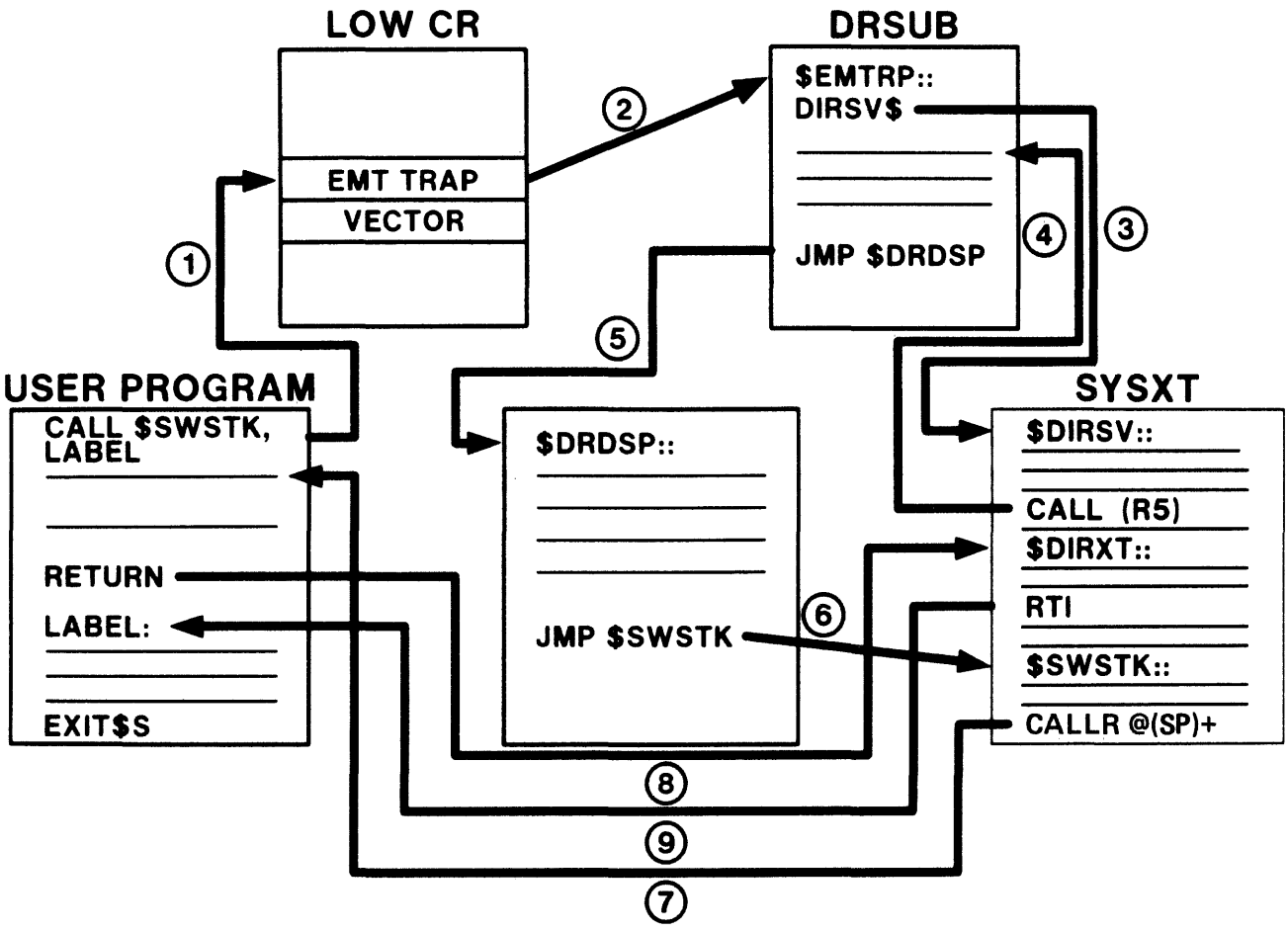


Figure 8-15 Privileged Task Processing

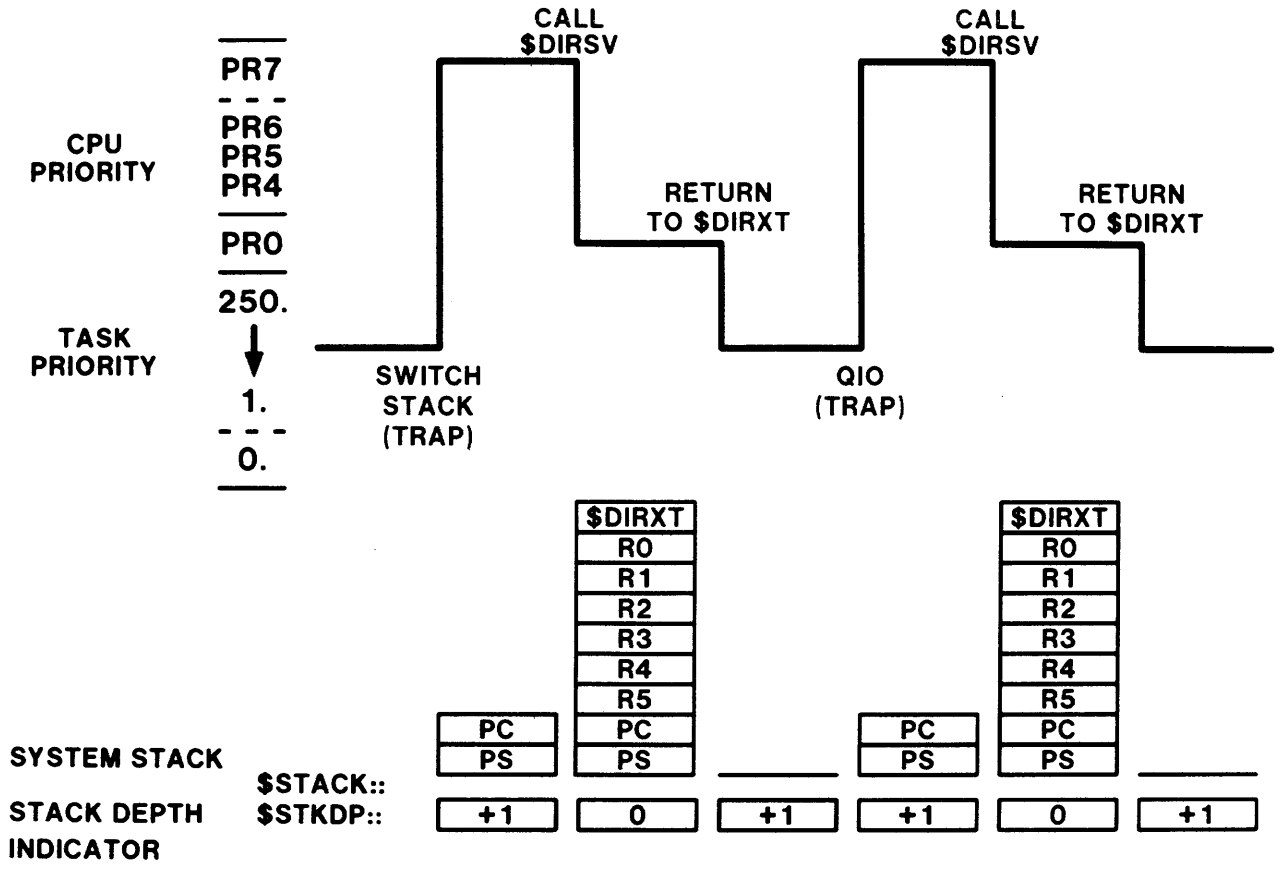


Figure 8-16 Privileged Task Switches Stack and Returns

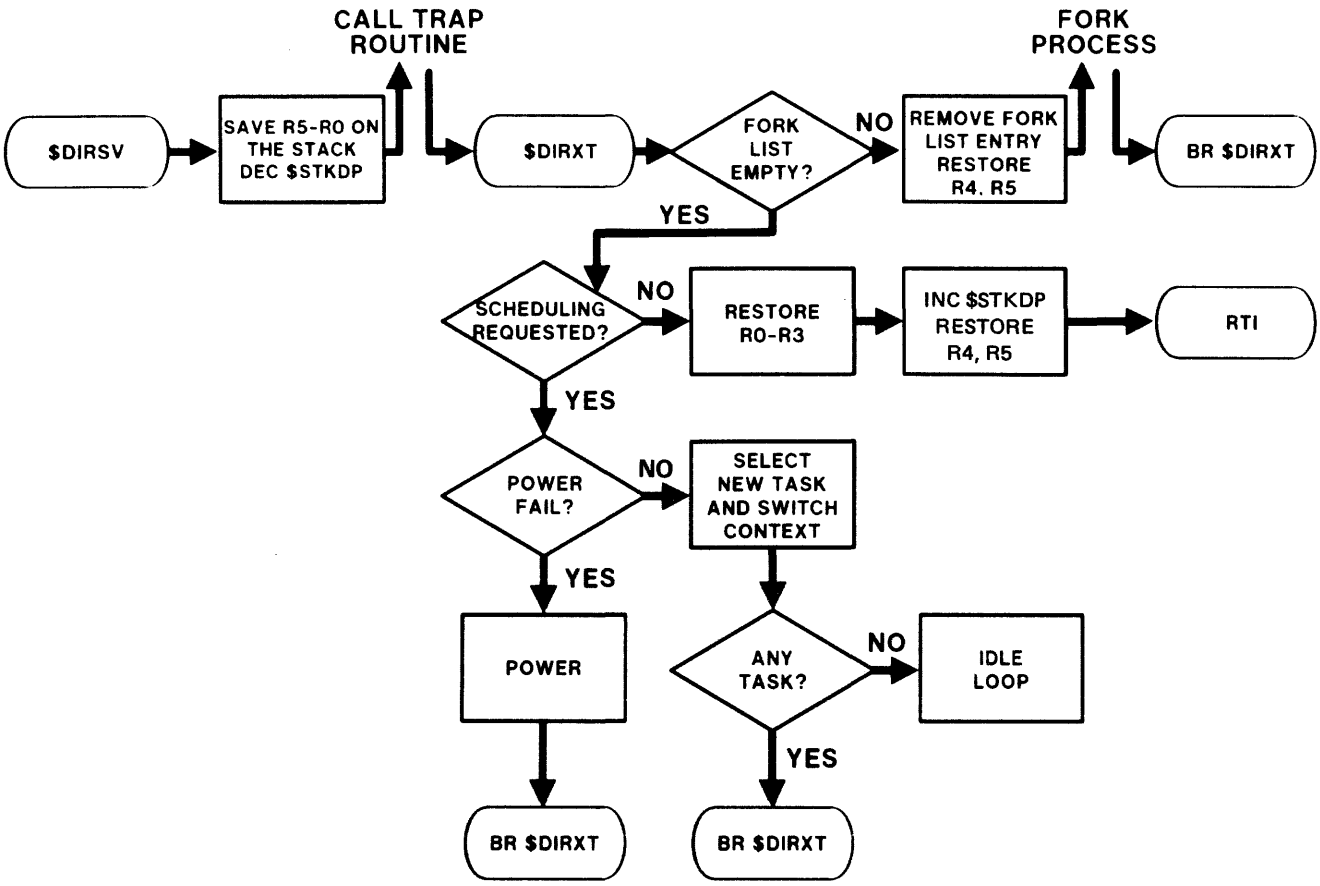


Figure 8-17 System Synchronization Logic: $DIRSV

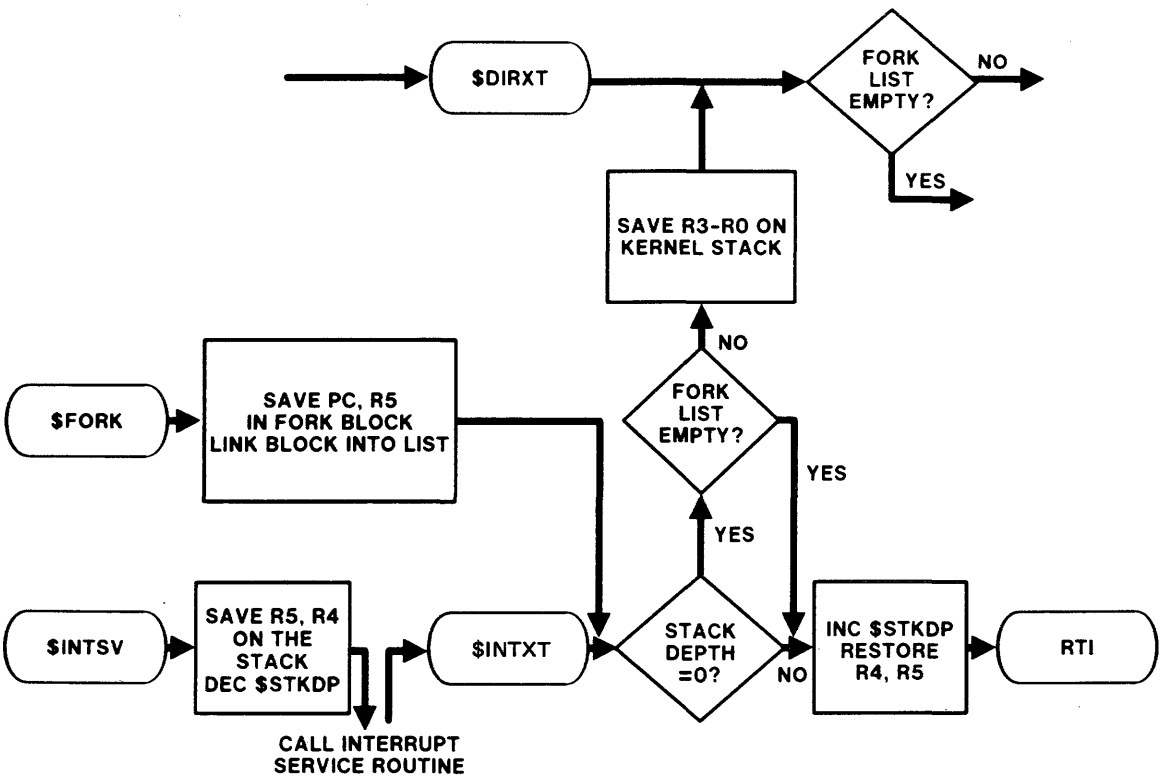


Figure 8-17 System Synchronization Logic: $DIRXT, $FORK, and $INTSV

WRITING PRIVILEGED TASKS

9

INTRODUCTION

In many practical environments, it is often necessary to write tasks which must interact with the Executive in ways not planned by the designers of the operating system. The tool used in these situations is the privileged task. (In this module, "privileged task" refers to a task which maps to the Executive.) A privileged task has access to both the system data base and Executive code and can therefore act as an extension of the operating system.

To write and use privileged tasks, the programmer must understand the operating system, the system data base and the methods that the Executive uses to synchronize access to the system data base. The previous modules, together with this module, provides that understanding.

OBJECTIVES

1. Assemble and taskbuild privileged tasks.
2. Use a privileged task to access the system data base.
3. Use Executive routines to perform tasks.

RESOURCES

1. RSX-11M System Lists and Data Structures

OVERVIEW

Why Write a Privileged Task

- To acquire the privileged attribute

  Allows task to issue privileged directives

  Allows access to any file without protection checks

  Allows task to issue logical block I/O to a mounted volume

- Tasks which map to the Executive have access to:

  Routines contained in the Executive

  Executive data base including

    System Common (SYSCM)

    System device tables (SYSTB)

    Dynamic Storage Region (POOL)

  The I/O Page

    Device registers

    Memory management registers

Privileged Task Structure

- Consists of at least three sections

  First section

  Executes in USER mode

  Contains the transfer point of the task

  Contains code for processing before transferring to system state

  Second section

  Executes in KERNEL mode

  Contains code which accesses Executive data

  Third section

  Executes in USER mode

  Contains return location from KERNEL mode

  Contains code for processing data obtained from the Executive in the second section

- USER Mode APRs

  For system with 16K word Executive

  APRs Ø - 3 are used to map the Executive

  APRs 4 - 6 are used to map the privileged task

  APR 7 is normally used to map the I/O page but can map an added 4K words of the task if needed

  Privileged task can be

  12K words if I/O page is needed in USER mode

  16K words if I/O page is not needed in USER mode

- For system with 20K word Executive

  APRs 0 - 4 are used to map the Executive

  APRs 5 and 6 are used to map the privileged task

  APR 7 is normally used to map the I/O page but can map an added 4K words of the task if needed

  Privileged task can be

    8K words if I/O page is needed in USER mode

    12K words if I/O page is not needed in USER mode

Restrictions on Privileged Tasks

- Parameter Passing

  User state to system state

  Values can be passed in registers RØ - R5

  Values can be passed in memory locations

  System state to user state

  Values can only be passed in memory locations since registers are restored

- Time spent in system state should be minimal

  Interrupt processing affected since the FORK queue is not serviced

  No other user task can execute

- No trap can occur in system state

  No directives can be executed

  Traps in system state cause a system crash

- Privileged instructions should be used with care

CREATING A PRIVILEGED TASK

Assembling a Privileged Task

- To assemble a privileged task to map to the Executive:

  >MAC File,File=[1,1]EXEMC/ML,[11,10]RSXMC/PA:1,[USER UIC]File

- EXEMC.MLB

  Contains

  Macros defining offsets

  Bit values for all system data structures

  Not needed if no reference is made to these structures

- RSXMC.MAC

  Contains

  Conditional assembly symbols defining the system

  Several commonly used macros such as CALL and CALLR

  Always needed to interpret CALL $SWSTK

Taskbuilding a Privileged Task

- The following command is needed to taskbuild a privileged task which maps to the Executive

```
>TKB File/PR:n=File,[1,1]EXELIB/LB,[1,54]RSX11M.STB
```

- EXELIB.

  Executive object library

  Contains global symbols for resolving offsets in data structures not resolved during assembly

- RSX11M.STB

  Executive symbol table file

  Allows resolution of Executive global symbols used in privileged task

SAMPLE PRIVILEGED TASKS

Tracing Through System Lists

- Function of privileged task

  Calculate and display size of free pool

- The pointer $CRAVL is used to access the list of free pool blocks
- $SWSTK is used to switch to system state
- Time spent in system state is minimal

  System data accessed in system state

- I/O performed in user

  No traps in system state

- Size of free pool is saved before return to user state

  Registers cannot be used to pass data from system to user state

Table 9-1 Pointers to System Lists

Pointer*	System List
$LOGHD	Logical device assignment list
$CRAVL	Free pool block listhead
$ACTHD	Active task list listhead
$CFLPT	Pointer to first checkpoint file PCB
$FRKHD	FORK queue listhead
$CLKHD	Clock queue listhead
$PARHD	Pointer to partition list
$TSKHD	Pointer to system task directory
$GGEF	Pointer to group global event flags list
$ERHEA	Error logging message queue listhead
$PKAVL	Pointer to list of preallocated I/O packets
$UMRHD	Mapping assignment block listhead
$UMRWT	UMR wait queue listhead
$MOULS	Mounted device listhead

*All pointers are located in SYSCM

Table 9-2 Pointers to Data Structures

Pointer*	Description
$HEADR	Pointer to current task header
$TKNPT	Pointer to TKTN TCB
$SHFPT	Pointer to shuffler TCB
$MCRPT	Pointer to MCR TCB
$TKTCB	Pointer to current task TCB
$LDRPT	Pointer to loader TCB

*All pointers are located in SYSCM

POOLA MACRO M1200 29-DEC-81 13:54 PAGE 3

```
 1                                          .TITLE  POOLA
 2                                  ;+
 3                                  ;** - POOLA - DISPLAY POOL SIZE
 4                                  ;
 5                                  ;       THIS TASK WILL CALCULATE AND DISPLAY THE TOTAL SYSTEM
 6                                  ;       DYNAMIC STORAGE REGION SIZE
 7                                  ;-
 8                                          .MCALL  QIOW$,EXIT$S,DIR$
 9                                          .NLIST  BEX
10 000000                          OUTQIO: QIOW$   IO.WVB,1,1,,,,<OUTBUF,0,40>
11 000030                          ARGLST: .BLKW   1                   ; ARG LIST FOR $EDMSG
12 000032    124     117     124   OUTMES: .ASCIZ  /TOTAL POOL = %D./
13           000045                BUFFL   =       .-OUTMES+20.
14 000053                          OUTBUF: .BLKB   BUFFL
15                                         .EVEN
16 000120                          START:
17 000120  005001                          CLR     R1                  ; FOR TOTAL FREE SPACE
18 000122  012700  000000G                 MOV     #$CRAVL,R0          ; POINT TO FIRST DSR PACKET
19 000126                                  CALL    $SWSTK,30$          ; SWITCH TO SYSTEM STATE
20 000132  066001  000002          10$:    ADD     2(R0),R1            ;; ADD IN SIZE OF THIS PACKET
21 000136  011000                          MOV     (R0),R0             ;; GET LINK TO NEXT PACKET
22 000140  001374                          BNE     10$                 ;; IF NE NOT END OF LIST
23 000142  006201                          ASR     R1                  ;; CONVERT TO WORDS
24 000144  010167  177660                  MOV     R1,ARGLST           ;; SAVE SIZE OF DSR
25 000150  000207                          RETURN                      ;; RETURN TO USER STATE
26                                  ;
27                                  ;       FORMAT AND PRINT OUTPUT
28                                  ;
29 000152  012700  000053'          30$:    MOV     #OUTBUF,R0          ; SET OUTPUT STRING
30 000156  012701  000032'                 MOV     #OUTMES,R1          ; AND INPUT STRING
31 000162  012702  000030'                 MOV     #ARGLST,R2          ; AND ARGUMENT LIST
32 000166                                  CALL    $EDMSG              ; FOR EDIT MESSAGE
33 000172  010167  177620                  MOV     R1,OUTQIO+Q.IOPL+2 ; UPDATE MESSAGE SIZE
34 000176                                  DIR$    #OUTQIO             ; WRITE OUT MESSAGE
35 000204                                  EXIT$S                      ; AND EXIT FROM PROGRAM
36           000120'                       .END    START
```

Example 9-1 Tracing Through System Lists
(Sheet 1 of 2)

```
POOLA   MACRO M1200  29-DEC-81 13:54  PAGE 3-1
SYMBOL TABLE

ARGLST  000030R          G$$TTK= 000000          L$$P11= 000002          Q.IOSB= 000010          T$$BTW= 000000
A$$CHK= 000000           H$$RTZ= 000074          L$$11R= 000000          R$$CON= 000000          T$$CCA= 000000
A$$CLI= 000020           IO.WVB= ****** GX       M$$CRB= 000124          R$$DER= 000000          T$$COM= 000000
A$$CNT= 000000           I$$CSZ= 000200          M$$CRX= 000000          R$$DSP= 000000          T$$CON= 000000
A$$CPS= 000000           I$$RAR= 000000          M$$EXT= 000000          R$$EIS= 000000          T$$CTR= 000000
A$$NSI= 000000           I$$RDN= 000000          M$$FCS= 000000          R$$EXV= 000000          T$$CUP= 000000
A$$PRI= 000000           K$$CNT= 177546          M$$MGE= 000000          R$$HDV= 000000          T$$C11= 000001
A$$TRP= 000000           K$$CSR= 177546          M$$MUP= 000000          R$$H11= 000004          T$$ESC= 000000
BUFFL = 000045           K$$DAS= 000000          M$$NET= 002627          R$$JP1= 000004          T$$GMC= 000000
C$$CDA= 000002           K$$IEN= 000115          M$$OVR= 000000          R$$JS1= 000004          T$$GTS= 000000
C$$CKP= 000000           K$$LDC= 000001          M$$XLN= 000400          R$$K11= 000001          T$$KMG= 000000
C$$INT= 000000           K$$TPS= 000074          N$$LDV= 000001          R$$LKL= 000001          T$$LWC= 000000
C$$ORE= 001000           LD$CO = 000000          N$$MOV= 000041          R$$L11= 000001          T$$MO3= 000002
C$$RSH= 177564           LD$DB = 000000          N$$UMR= 000030          R$$MPL= 000000          T$$RED= 000000
C$$RUN= 000000           LD$DD = 000000          OUTBUF  000053R         R$$M11= 000004          T$$RNE= 000000
D$$H11= 000003           LD$DK = 000000          OUTMES  000032R         R$$NDC= 000006          T$$RPR= 000000
D$$IAG= 000000           LD$DL = 000000          OUTQIO  000000R         R$$NDH= 000226          T$$RST= 000000
D$$ISK= 000000           LD$DM = 000000          P$$D70= 000000          R$$NDL= 000001          T$$RUB= 000000
D$$L11= 000001           LD$DR = 000000          P$$GMX= 000000          R$$SND= 000000          T$$SMC= 000000
D$$M11= 000003           LD$DS = 000000          P$$LAS= 000000          R$$X21= 000001          T$$UTO= 000036
D$$PAR= 000000           LD$DT = 000000          P$$MAX= 000400          R$$11M= 000000          T$$U58= 000001
D$$SHF= 000000           LD$DY = 000000          P$$OFF= 000000          R$$611= 000001          U$$DAS= 000000
D$$WCK= 000000           LD$LP = 000000          P$$OOL= 000000          START   000120R         U$$MHI= 000000
D$$YNC= 000000           LD$MM = 000000          P$$P45= 000000          S$$ECC= 000000          U$$MLO= 140000
D$$YNM= 000000           LD$NL = 000000          P$$RFL= 000000          S$$HDW= 000000          U$$MRN= 170230
D$$ZMD= 000000           LD$RD = 000000          P$$RTY= 000000          S$$LIB= 000000          V$$CTR= 000774
D$$Z11= 000001           LD$TT = 000000          P$$SRF= 000000          S$$NM1= 042513          V$$TLD= 000120
E$$DVC= 000000           LD$VT = 000000          P$$WND= 000000          S$$NM2= 046522          V$$TLM= 000205
E$$NSI= 000000           LK.SPN= 000002          Q$$OPT= 000005          S$$NM3= 052111          V$$TRM= 000000
E$$PER= 000000           LK.WAT= 000010          Q.IOAE= 000012          S$$OPT= 000000          X$$DBT= 000000
E$$XPR= 000000           L$$ASG= 000000          Q.IOEF= 000006          S$$UBD= 000000          X$$HDR= 000000
F$$LPP= 000000           L$$DBG= 000000          Q.IOFN= 000002          S$$WPC= 000036          $CRAVL= ****** GX
F$$LVL= 000001           L$$DRV= 000000          Q.IOLU= 000004          S$$WPR= 000005          $EDMSG= ****** GX
G$$TPP= 000000           L$$LDR= 000000          Q.IOPL= 000014          S$$WRG= 000000          $$$ARG= 000003
G$$TSS= 000000           L$$PTO= 000170          Q.IOPR= 000007          S$$YSZ= 044000          $$$OST= 000014

. ABS.  000000      000
        000212      001
ERRORS DETECTED:  0

VIRTUAL MEMORY USED:  11375 WORDS  ( 45 PAGES)
DYNAMIC MEMORY:  12692 WORDS  ( 48 PAGES)
ELAPSED TIME:  00:00:12
,POOLA=LB:[2,54]RSXMC/PA:1,[1,1]EXEMC/ML,DB2:[305,306]POOLA
```

Example 9-1 Tracing Through System Lists
(Sheet 2 of 2)

Calling Executive Routines

- Function of privileged task

  To simulate issuing an MCR command from a terminal

- Privileged task must construct MCR command block

  Terminal UCB is located by searching device list

  MCR command block (84 bytes) is allocated from pool by using routine $ALOCB

  Block is queued to MCR by using routine $QMCRL

  Block is deallocated on I/O error by calling $DEACB

- Time spent in system state is minimized by returning to user state to perform calculations, etc.

Table 9-3 Executive Pool Routines*

Entry Point	Description	Inputs	Outputs
$ALOCB	Allocates a variable length core buffer First fit Length in multiples of four bytes	R1 = Size of buffer	C-bit = Ø Block allocated C-bit = 1 Insufficient space RØ - Address of block R1 - Length of block
$DEACB	Deallocates a variable length core buffer	RØ = Address of block R1 = Block size	None

*All routines are in Executive module CORAL

Table 9-4 Executive Queueing Routines*

Entry Point	Description	Inputs	Outputs
$QINSF	Inserts entry at end of FIFO queue Saves RØ, R1	RØ = Address of listhead R1 = Address of new entry	None
$QINSP	Inserts entry in a priority ordered queue Saves RØ, R1	(Same as $QINSF)	None
$QINSB	Inserts entry at beginning of queue All registers are saved	(Same as $QINSF)	
$QRMVF	Removes entry from beginning of queue Saves RØ	RØ = Address of listhead	C-bit = Ø Entry removed C-bit = 1 Empty list R1 - Address of entry
$QRMVT	Removes entry with a specifed TCB address	RØ = Address of listhead R1 = TCB address	C-bit = Ø Entry removed C-bit = 1 Entry not found R1 - Address of entry
$QMCRL	Queues a command line to CLI of issuing terminal	R1 = Address of command line	None

*All routines are in Executive model QUEUE

Table 9-5 Other Executive Routines

Entry Point	Description	Inputs	Outputs
$SRSTD	Searches STD for specified task Module: REQSB	R3 = Address of RAD5Ø task name	C-bit = Ø Task found C-bit = 1 Task not found RØ = TCB address of task
$SRNAM	Search the partition list for a named partition Module: PLSUB	R3 = Address of RAD5Ø name	C-bit = Ø Partition found C-bit = 1 Not found R2 = PCB address
$CEFI	Converts an event flag number to an event flag address Module: EXESB	RØ = Event flag number R5 = TCB address of task	RØ = Mask word R1 = Event flag address

```
TERM    MACRO M1200  22-OCT-81 12:40  PAGE 3


                                        .TITLE  TERM
                                ;+
                                ;
                                ;       THIS TASK ASKS THE USER FOR A TERMINAL NUMBER AND A
                                ;       COMMAND LINE.  IT THEN PASSES THE COMMAND TO MCR
                                ;       AS IF HAD ORIGINATED AT THE SPECIFIED TERMINAL.  IT
                                ;       PERFORMS THIS TASK BY USING SYSTEM SUBROUTINES, $ALOCB
                                ;       AND $QMCRL, TO ALLOCATE A BLOCK FROM POOL AND PASS IT
                                ;       TO MCR.
                                ;
                                ;       THE TASK MUST BE BUILT PRIVILEGED AND MAP TO THE EXECUTIVE.
                                ;
                                ;       TO ASSEMBLE:
                                ;
                                ;       >MAC TERM=[1,1]EXEMC/ML,[11,10]RSXMC/PA:1,[(YOUR UIC)]TERM
                                ;
                                ;       TO BUILD:
                                ;
                                ;       >TKB TERM/PR:5=TERM,[1,54]RSX11M.STB/SS
                                ;
                                ;+
                                        .MCALL  EXIT$S,QIOW$S,DCBDF$
000000                                  DCBDF$
                                ;
                                ;       TERMINAL MESSAGES
                                ;
000000  012     015     105     PRMT:   .ASCII  <12><15>/ENTER A TERMINAL NUMBER: /     ;PROMPT
000003  116     124     105
000006  122     040     101
000011  040     124     105
000014  122     115     111
000017  116     101     114
000022  040     116     125
000025  115     102     105
000030  122     072     040
        000033                  PLEN    =       .-PRMT                  ;LENGTH OF PROMPT
000033  105     116     124     MES1:   .ASCII  /ENTER A COMMAND FOR MCR/
000036  105     122     040
000041  101     040     103
000044  117     115     115
000047  101     116     104
000052  040     106     117
000055  122     040     115
000060  103     122
        000027                  LENT1   =       .-MES1
000062  116     125     115     MESS1:  .ASCII  /NUMBER IS NOT OCTAL, TRY AGAIN!/
000065  102     105     122
000070  040     111     123
000073  040     116     117
000076  124     040     117
000101  103     124     101
000104  114     054     040
000107  124     122     131
000112  040     101     107
000115  101     111     116
000120  041
        000037                  LEN1    =       .-MESS1
```

Example 9-2 Calling Executive Routines
(Sheet 1 of 5)

```
TERM    MACRO M1200  22-OCT-81 12:40  PAGE 3-1

 33 000121     124     105     122  ERMES:  .ASCII  /TERMINAL NOT FOUND!/
    000124     115     111     116
    000127     101     114     040
    000132     116     117     124
    000135     040     106     117
    000140     125     116     104
    000143     041
 34          000023                  ERL     =       .-ERMES
 35 000144     116     117     040  POOL:   .ASCII  /NO POOL AVAILABLE!/
    000147     120     117     117
    000152     114     040     101
    000155     126     101     111
    000160     114     101     102
    000163     114     105     041
 36          000022                  PL      =       .-POOL
 37 000166     111     057     117  IOERR:  .ASCII  !I/O ERROR ON COMMAND INPUT!
    000171     040     105     122
    000174     122     117     122
    000177     040     117     116
    000202     040     103     117
    000205     115     115     101
    000210     116     104     040
    000213     111     116     120
    000216     125     124
 38          000032                  IOL     =       .-IOERR
 39                                          .EVEN                   ;MAKE SURE OF WORD BOUNDARY
 40                                  ;
 41                                  ;       PROGRAM DATA
 42                                  ;
 43 000220                          BUF:     .BLKB   4               ;BUFFER FOR TERMINAL NUMBER
 44 000224                          IOSB:    .BLKW   2               ;I/O STATUS BLOCK
 45 000230     124     124          NAM:     .ASCII  /TT/            ;TERMINAL NAME
 46 000232  177777                  ERRCNT:  .WORD   -1              ;ERROR INDICATOR
 47 000234  000000                  COMM:    .WORD   0               ;ADDRESS OF COMMAND LINE IN POOL
 48 000236  000000                  PLACE:   .WORD   0               ;ADDRESS OF POOL BLOCK
 49 000240  000000                  UCB:     .WORD   0               ;SAVED UCB ADDRESS
 50 000242  000000                  DCB:     .WORD   0               ;SAVED DCB ADDRESS
 51 000244  000000                  LOW:     .WORD   0               ;SAVED LOW UNIT NUMBER
 52 000246  000000                  HIGH:    .WORD   0               ;SAVED HIGH UNIT NUMBER
 53                                  ;
 54                                  ;       BEGINNING OF CODE
 55                                  ;
 56 000250                          TERM:    QIOW$S  #IO.WVB,#5,#1,,,,<#PRMT,#PLEN,#40>      ;PROMPT
 57 000322                                   QIOW$S  #IO.RVB,#5,#1,,#IOSB,,<#BUF,#4> ;GET 'TT' NUMBER
 58 000374  016703  177626                   MOV     IOSB+2,R3       ;SAVE CHARACTER COUNT
 59 000400  012700  000220'                  MOV     #BUF,R0         ;SET UP FOR CALL TO CONVERSION
 60 000404  005002                           CLR     R2              ; ROUTINE - FROM ASCII TO
 61 000406                                   CALL    $COTB           ;   BINARY(OCTAL)
 62                                                                  ; R1 WILL CONTAIN CONVERTED NUMBER
 63                                                                  ; R2 WILL CONTAIN TERMINATOR
 64 000412  005702                           TST     R2              ;TEST FOR ERROR
 65 000414  001402                           BEQ     CONT            ;IF NOT CONTINUE
 66 000416  000167  000436                   JMP     ERR1            ;GO TO ERROR ROUTINE
 67 000422                          CONT:    CALL    $SWSTK,BACK     ;;SWITCH TO SYSTEM STATE
 68 000426  012700  000000G                  MOV     #$DEVHD,R0      ;;PICK UP LISTHEAD FOR DCB LIST
 69 000432  011000                  L1:      MOV     (R0),R0         ;;GO TO NEXT DCB
 70 000434  001422                           BEQ     GO              ;;IF NONE FINISH UP
```

Example 9-2 Calling Executive Routines
(Sheet 2 of 5)

```
 71 000436  026760  177566  000004          CMP     NAM,D.NAM(R0)           ;;LOOK FOR 'TT' DCB
 72 000444  001372                          BNE     L1                      ;;IF NOT 'TT' GET NEXT DCB
 73 000446  116067  000006  177570          MOVB    D.UNIT(R0),LOW          ;;GET LOW UNIT NUMBER
 74 000454  116067  000007  177564          MOVB    D.UNIT+1(R0),HIGH       ;;GET HIGH UNIT NUMBER
 75 000462  020167  177560                  CMP     R1,HIGH                 ;;COMPARE INPUT WITH HIGH
 76 000466  003361                          BGT     L1                      ;;IF INPUT LARGER GET NEXT DCB
 77 000470  010067  177546                  MOV     R0,DCB                  ;;SAVE DCB ADDRESS
 78 000474  062767  000001  177530          ADD     #1,ERRCNT               ;;INDICATE NO ERROR HERE
 79 000502                          GO:     RETURN                          ;;RETURN TO USER STATE
 80 000504                          BACK:                                   ;NOW IN USER STATE
 81 000504  005767  177522                  TST     ERRCNT                  ;TEST FOR ERROR
 82 000510  001402                          BEQ     1$                      ;CONTINUE IF OK
 83 000512  000167  000430                  JMP     ERR2                    ;GO TO ERROR ROUTINE
 84 000516  016700  177520          1$:     MOV     DCB,R0                  ;GET DCB ADDRESS
 85 000522  016002  000002                  MOV     D.UCB(R0),R2            ;GET ADDRESS OF FIRST UCB
 86 000526  010104                          MOV     R1,R4                   ;MOVE FOR CALCULATIONS
 87 000530  166704  177510                  SUB     LOW,R4                  ;FIND THE NUMBER WITHIN UCBS
 88                                                                         ; FOR CURRENT DCB
 89 000534  016005  000010                  MOV     D.UCBL(R0),R5           ;GET UCB LENGTH
 90 000540  070504                          MUL     R4,R5                   ;CALCULATE OFFSET FOR UCB
 91 000542  060502                          ADD     R5,R2                   ;CALCULATE BEGINNING OF UCB
 92 000544  010267  177470                  MOV     R2,UCB                  ;SAVE UCB ADDRESS
 93 000550  012767  177777  177454          MOV     #-1,ERRCNT              ;RESET ERROR COUNT
 94 000556                                  CALL    $SWSTK,BACK2            ;;SWITCH TO SYSTEM STATE
 95 000562  012701  000124                  MOV     #84.,R1                 ;;SET BLOCK SIZE
 96 000566                                  CALL    $ALOCB                  ;;ALLOCATE BLOCK FROM POOL
 97 000572  103404                          BCS     NONE                    ;;NO ROOM IN POOL
 98 000574  005267  177432                  INC     ERRCNT                  ;;INDICATE NO ERROR HERE
 99 000600  010067  177432                  MOV     R0,PLACE                ;;SAVE ADDRESS OF POOL BLOCK
100 000604                          NONE:   RETURN                          ;;RETURN TO USER STATE
101 000606                          BACK2:                                  ;BACK IN USER STATE
102 000606  005767  177420                  TST     ERRCNT                  ;CHECK FOR ERROR
103 000612  001402                          BEQ     1$                      ;CONTINUE IF OK
104 000614  000167  000406                  JMP     ERR3                    ;GO TO ERROR ROUTINE
105 000620  012700  000124          1$:     MOV     #84.,R0                 ;SET LENGTH OF BLOCK
106 000624  016701  177406                  MOV     PLACE,R1                ;GET ADDRESS OF BLOCK
107 000630  112721  000040          2$:     MOVB    #40,(R1)+               ;PLACE BLANKS IN BLOCK
108 000634  077003                          SOB     R0,2$                   ;LOOP UNTIL THROUGH
109 000636  016767  177374  177370          MOV     PLACE,COMM              ;CALCULATE LOCATION OF COMMAND
110 000644  062767  000004  177362          ADD     #4,COMM                 ; LOCATION IN BLOCK
111 000652                                  QIOW$S  #IO.WVB,#5,#1,,,,<#MES1,#LENT1,#40>     ;PROMPT FOR COMMAND
112 000724  005067  177274                  CLR     IOSB
113 000730  005067  177272                  CLR     IOSB+2
114 000734                                  QIOW$S  #IO.RVB,#5,#1,,IOSB,,<COMM,#80.>        ;INPUT COMMAND
115 001006  103002                          BCC     3$                      ;CONTINUE IF OK
116 001010  000167  000272                  JMP     ERR4                    ;BRANCH IF QIO ERROR
117 001014  105767  177204          3$:     TSTB    IOSB                    ;CHECK FOR I/O ERROR
118 001020  002002                          BGE     4$                      ;CONTINUE IF OK
119 001022  000167  000260                  JMP     ERR4                    ;BRANCH IF ERROR
120 001026                          4$:     CALL    $SWSTK,BACK3            ;;SWITCH TO SYSTEM STATE
121 001032  016701  177200                  MOV     PLACE,R1                ;;GET ADDRESS OF BLOCK
122 001036  016761  177176  000002          MOV     UCB,2(R1)               ;;PLACE UCB ADDRESS IN BLOCK
123 001044                                  CALL    $QMCRL                  ;;QUEUE BLOCK TO MCR
124 001050                                  RETURN                          ;;LEAVE SYSTEM STATE
125 001052                          BACK3:                                  ;BACK IN USER STATE
126 001052                                  EXIT$S                          ;EXIT
127                                 ;
```

Example 9-2 Calling Executive Routines
(Sheet 3 of 5)

```
TERM    MACRO M1200  22-OCT-81 12:40  PAGE 3-3

                                        ;       ROUTINE TO HANDLE BAD TERMINAL NUMBER
                                        ;
001060                                  ERR1:   QIOW$S  #IO.WVB,#5,#1,,,,<#MESS1,#LEN1,#40>     ;PRINT MESSAGE
001132  012700  000220'                        MOV     #BUF,R0                 ;GET INPUT BUFFER ADDRESS
001136  005020                          CLEAR:  CLR     (R0)+                   ;CLEAR BUFFER
001140  077302                                  SOB     R3,CLEAR                ;R3 CONTAINS CHARACTER COUNT
001142  000167  177102                          JMP     TERM                    ;TRY AGAIN
                                        ;
                                        ;       ROUTINE TO HANDLE NON-EXISTENT TERMINAL
                                        ;
001146                                  ERR2:   QIOW$S  #IO.WVB,#5,#1,,,,<#ERMES,#ERL,#40>      ;PRINT MESSAGE
001220                                          EXIT$S                          ;EXIT
                                        ;
                                        ;       ROUTINE TO HANDLE POOL ALLOCATION FAILURE
                                        ;
001226                                  ERR3:   QIOW$S  #IO.WVB,#5,#1,,,,<#POOL,#PL,#40>        ;PRINT MESSAGE
001300                                          EXIT$S                          ;EXIT
                                        ;
                                        ;       ROUTINE TO HANDLE I/O ERRORS ON COMMAND INPUT
                                        ;       THE POOL BLOCK MUST BE DEALLOCATED!
                                        ;
001306                                  ERR4:   QIOW$S  #IO.WVB,#5,#1,,,,<#IOERR,#IOL,#40>      ;PRINT MESSAGE
001360                                          CALL    $SWSTK,FIN              ;;SWITCH TO SYSTEM STATE
001364  016700  176646                          MOV     PLACE,R0                ;;GET ADDRESS OF BLOCK
001370  012701  000124                          MOV     #84.,R1                 ;;SET BLOCK LENGTH
001374                                          CALL    $DEACB                  ;;DEALLOCATE BLOCK
001400                                          RETURN                          ;;LEAVE SYSTEM STATE
001402                                  FIN:                                    ;BACK IN USER STATE
001402                                          EXIT$S                          ;EXIT
        000250'                                 .END    TERM
```

Example 9-2 Calling Executive Routines
(Sheet 4 of 5)

```
TERM    MACRO M1200  22-OCT-81 12:40  PAGE 3-4
SYMBOL TABLE

A$$BIO= 000000          D.MSK   000014          K$$IEN= 000113          PRMT    000000R         T$$BTW= 000000
A$$BRT= 000000          D.NAM   000004          K$$LDC= 000144          P$$BPR= 000063          T$$BUF= 000000
A$$CHK= 000000          D.PCB   000034          K$$TPS= 000144          P$$CTL= 000000          T$$CCA= 000000
A$$CLI= 000004          D.UCB   000002          LD$CO = 000000          P$$FRS= 000310          T$$CCO= 000000
A$$CPS= 000000          D.UCBL  000010          LD$DD = 000000          P$$GMX= 000000          T$$CPW= 000000
A$$NSI= 000000          D.UNIT  000006          LD$DK = 000000          P$$HIL= 003100          T$$CTR= 000000
A$$PRI= 000000          D.VCAN= 000002          LD$DL = 000000          P$$LAS= 000000          T$$CUP= 000000
A$$TRP= 000000          D.VDEB= 177776          LD$DM = 000000          P$$LOL= 001130          T$$C11= 000001
BACK    000504R         D.VINI= 000000          LD$DR = 000000          P$$OFF= 000000          T$$ESC= 000000
BACK2   000606R         D.VOUT= 000004          LD$DS = 000000          P$$P45= 000000          T$$GMC= 000000
BACK3   001052R         D.VPWF= 000006          LD$DT = 000000          P$$RFL= 000000          T$$GTS= 000000
BUF     000220R         ERL   = 000023          LD$LP = 000000          P$$RTY= 000000          T$$HFF= 000000
B$$LV1= 030463          ERMES   000121R         LD$MM = 000000          P$$SRF= 000000          T$$HLD= 000000
B$$LV2= 020040          ERRCNT  000232R         LD$TT = 000000          Q$$OPT= 000005          T$$J16= 000001
CLEAR   001136R         ERR1    001060R         LENT1 = 000027          R$$DER= 000000          T$$KMG= 000000
COMM    000234R         ERR2    001146R         LEN1  = 000037          R$$EXV= 000000          T$$LWC= 000000
CONT    000422R         ERR3    001226R         LOW     000244R         R$$JS1= 000001          T$$RED= 000000
C$$CDA= 000002          ERR4    001306R         L$$ASG= 000000          R$$K11= 000001          T$$RNE= 000000
C$$CHE= 000000          E$$ACT= 000000          L$$DRV= 000000          R$$LKL= 000001          T$$RPR= 000000
C$$CKP= 000004          E$$DVC= 000000          L$$LDR= 000000          R$$L11= 000001          T$$RST= 000000
C$$CSR= 177404          E$$LOG= 000000          L$$PTO= 000036          R$$MOF= 000000          T$$RUB= 000000
C$$INT= 000000          E$$XPR= 000000          L$$P11= 000001          R$$M11= 000001          T$$SMC= 000000
C$$ONS= 000001          FIN     001402R         L1      000432R         R$$NDC= 000005          T$$SYN= 000000
C$$ORE= 002022          F$$LPP= 000000          MESS1   000062R         R$$NDH= 000226          T$$TRW= 000000
C$$OTM= 000000          F$$LVL= 000001          MES1    000033R         R$$NDL= 000001          T$$UTB= 000000
C$$RSH= 177564          GO      000502R         M$$CRB= 000124          R$$POI= 000000          T$$UTO= 000170
C$$RUN= 000000          G$$EFN= 000000          M$$CRX= 000000          R$$SND= 000000          T$$U58= 000001
C$$SMT= 000000          G$$TPP= 000000          M$$EIS= 000000          R$$11M= 000000          T$$VBF= 000000
C$$TTY= 177564          G$$TSS= 000000          M$$EXT= 000000          R$$60F= 000000          T$$30P= 000000
DCB     000242R         G$$TTK= 000000          M$$FCS= 000000          R$$611= 000001          UCB     000240R
D$$H11= 000001          HIGH    000246R         M$$MGE= 000000          S$$ECC= 000000          U$$MHI= 000000
D$$IAG= 000000          H$$RTZ= 000074          M$$MUP= 000000          S$$NM1= 051522          U$$MLO= 160000
D$$ISK= 000000          IOERR   000166R         M$$OVR= 000000          S$$NM2= 030530          U$$MRN= 170234
D$$L11= 000002          IOL   = 000032          NAM     000230R         S$$NM3= 046461          V$$CTR= 000400
D$$M11= 000001          IOSB    000224R         NONE    000604R         S$$TIM= 000000          V$$RSN= 000040
D$$PAR= 000000          IO.RVB= ****** GX       N$$LDV= 000001          S$$TOP= 000000          X$$DBT= 000000
D$$SHF= 000000          IO.WVB= ****** GX       N$$MOV= 000041          S$$WLK= 000000          $ALOCB= ****** GX
D$$WCK= 000000          I$$RAR= 000000          N$$UMR= 000034          S$$WPC= 000036          $COTB = ****** GX
D$$YNC= 000000          I$$RDN= 000000          PL    = 000022          S$$WPR= 000005          $DEACB= ****** GX
D$$YNM= 000000          K$$AST= 000000          PLACE   000236R         S$$YSZ= 022000          $DEVHD= ****** GX
D.DSP   000012          K$$CNT= 172542          PLEN  = 000033          TERM    000250R         $QMCRL= ****** GX
D.LNK   000000          K$$CSR= 172540          POOL    000144R         T$$ACR= 000000          $$$ARG= 000002

. ABS.  000036      000
        001410      001
ERRORS DETECTED:  0

VIRTUAL MEMORY USED:  10113 WORDS  ( 40 PAGES)
DYNAMIC MEMORY:  16120 WORDS  ( 62 PAGES)
ELAPSED TIME:  00:00:14
TERM,TERM/-SP=[1,1]EXEMC/ML,[11,10]RSXMC/PA:1,[7,1]TERM
```

Example 9-2 Calling Executive Routines
(Sheet 5 of 5)

SYSTEM CRASHES

10

INTRODUCTION

Only certain carefully defined SSTs are allowed in system state. System crashes occur when a software fault is recognized within system state. The processor trap mechanism signals the system crash. CDA is a SYSGEN option which aids the system programmer in tracing system faults. When a fault occurs, the Executive trap handling facility saves the register context in memory, then passes control to the crash routine, which dumps the memory to a disk or tape. The CDA utility may be used to format the dump information into a convenient report.

OBJECTIVES

1. To analyze a report generated by CDA to determine the cause of a system crash.

RESOURCES

1. RSX-11M/M-PLUS Crash Dump Analyzer
2. RSX-11M System Lists and Data Structures

CRASH PROCESSING

Causes of Crashes

- Processor traps in system state
  - Powerfail and parity error traps do not cause crash
  - Other processor traps cause system crash
  - System automatically crashes
- Processor HALTs or enters infinite loop
  - System must be manually crashed
- Manually crashing the system
  - Physical location 40 contains the instruction JMP $CRASH
    - Processor halted
    - Address 40 loaded
    - Processor restarted

Crash Sequences

- Three different crash sequences
  - Initiated by IOT
  - Initiated by EMT or TRAP
  - Initiated by other trap
    - Odd address
    - Illegal instruction
    - Memory management fault
    - Floating-point fault/PIRQ

Crash Sequences

- IOT

  Used when system detects an inconsistent system state

  Sequence:

  IOT trap vectors to the module SSTSR

  RØ - R5 are not saved

  Only PS and PC are pushed onto the stack

  Jump to $CRASH in module CRASH is executed

  Executive issues IOT only in modules DRDSP and SSTSR

- EMT or TRAP

  Results from EMT or TRAP attemp in system state

  Sequence:

  Directive save operation is performed

  Executive issues IOT

  Continue as with the IOT

- Other Traps

  Traps vector to module SSTSR

  Directive save operation is performed

  If Memory Management Fault, the status registers SRØ, SR1, and SR2 are pushed onto the stack

  One word fault code is pushed onto the stack

  Byte count of the information saved is pushed onto the stack

  Executive jumps to $CRASH

Obtaining a Crash Dump Analysis

- If XDT is present, respond with X to continue with crash
- Registers are printed on the console printer; the system halts
- Mount crash dump volume and press the continue switch
- After memory contents is saved, boot the system
- Run CDA to produce the analysis

  Inputs: The copy of memory created at the crash or by a previous execution of CDA

  The symbol definition file for the system

  Outputs: A listing file containing the analysis of the dump

  A binary file which is a copy of the contents of the crash dump volume

- Command Format:

```
>CDA <CR>
CDA>[listfile/sw],[binaryfile/sw]=symbolfile/STB,
crash-input[/sw]
```

- Two types of switches can be used

  Analysis switches - determine which CDA routines are applied to the input

  Function switches - provide control options

CRASH DUMP ANALYSIS

Finding the Cause of a System Crash

- Usually requires

  Output from the CDA utility

  Map of the operating system

  Listings and maps of relevant tasks

- Common steps in interpreting a crash dump

  Get KERNEL stack pointer

  Examine KERNEL stack and $STKDP for sequence of events (i.e., traps and interrupts)

  Find PC and PS when trap occurred (from KERNEL stack)

  Determine APRs in use and find which APR mapped the instruction at which the crash occurred

  Use the Memory Map to locate the proper partition or region

  Use the listing and map of the code occupying the region to locate the instruction

- System data base may have been corrupted long before crash occurred

  'Current Task' may not have caused crash

Table 10-1 CDA Switches

CDA Analysis Switches

/ACT Lists the TCBs for active tasks

/CLQ Lists the contents of the clock queue

/DEV Lists the information on all devices in the system

/HDR Lists the headers for all resident tasks

/PCB Lists the PCBs

/POOL Lists the contents of POOL

/STD Lists the contents of the STD

/ALL Lists the output of all analysis routines

/DUMP:a:b
Lists the contents of memory between the 18-bit addresses a and b

/TASK=name:a:b
Lists the virtual space of task 'name' between the 16-bit address a and b

Note: All analysis switches are used with the crash-input

CDA Function Switches

/LIMIT:n Limits output listing to n pages

Used on the list file

/MEMSIZ:n Saves nK words of memory in a binary file

Used on the binary file

/STB Identifies the symbol definition file

Used on the STB file for the system

Basic Information Provided in a CDA

The KERNEL Stack and $STKDP

- The KERNEL stack provides a record of the system entrances since system state was entered
- Each trap and interrupt causes task context to be saved on the KERNEL stack
- $STKDP indicates how many times context has been saved
- Contents of stack can be partitioned by locating the saved PSs

    Each PS indicates the start of context saved by a trap or an interrupt

    PS on stack located by position on stack

        First entry on stack is PS from first trap or interrupt

        Next PS will be nine words further on stack if trap or fork occurred

        Next PS will be five words further on stack if interrupt occurred

        Context pushed because SST contains 11 words plus extra trap specific words

    If an SST occurred, it is always the last context on stack

Contents of the APRs

- Determines mapping between virtual and physical addresses

    KERNEL APRs show mapping when crash occurred

    USER APRs show mapping of current user task

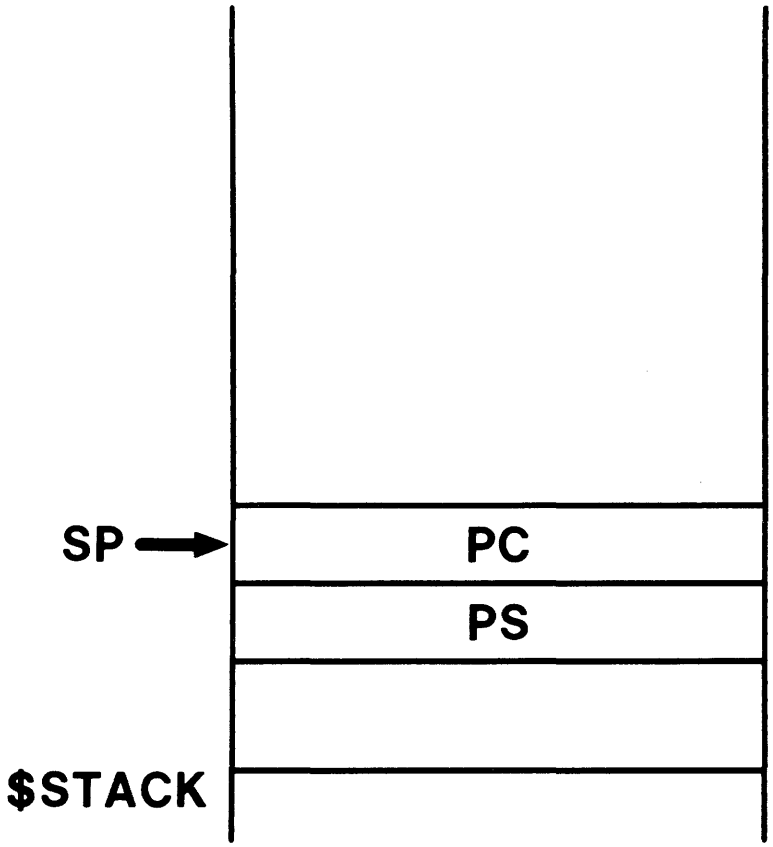


Figure 10-1 The Stack After a System Crash - IOT

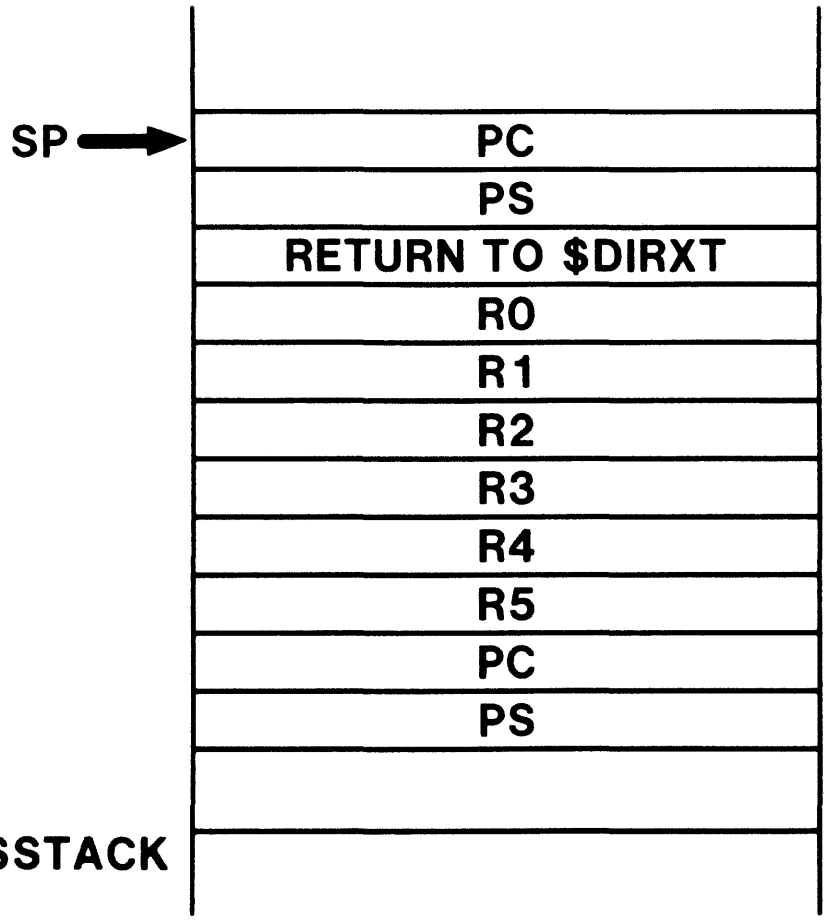


Figure 10-2 The Stack After a System Crash - EMT

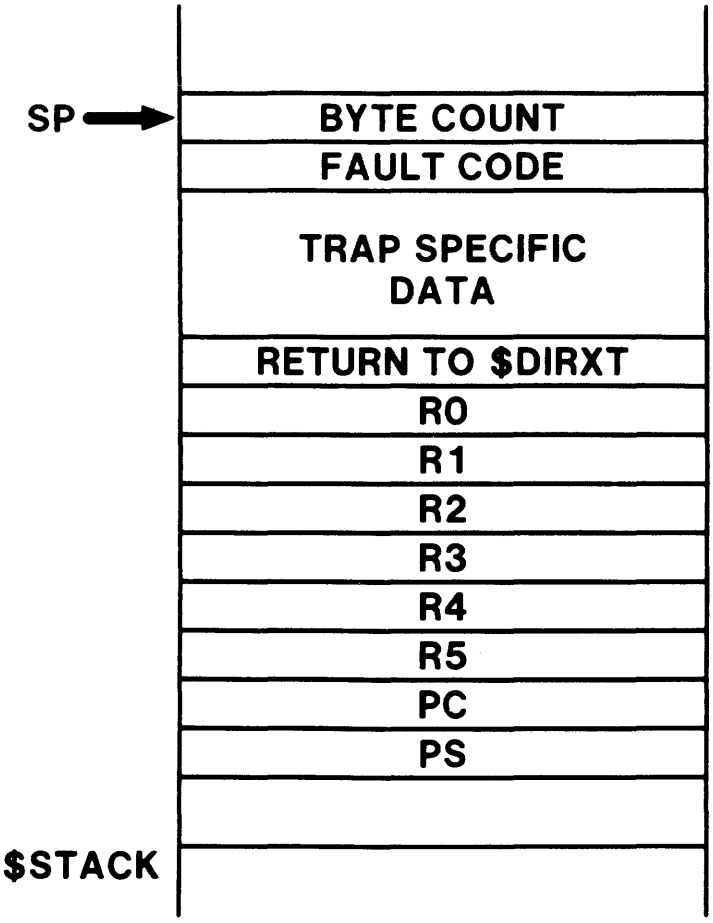


Figure 1Ø-3 The Stack After a System Crash - SST

Table 10-2 Fault Codes for SSTs

Code	Number of Bytes	SST Trap
0	4	Traps through vector 4 (Odd address, etc.)
2	10	Segment fault
4	4	Trace or break-point instruction
6	4	IOT instruction
10	4	Illegal or reserved instruction
11	6	Non-RSX EMT trap instruction
16	14	Floating-point exception (11/40)

KERNEL Stack Pointer = 000562

Location	Contents		
000556	024552	- PC at Crash	
000560	000010	- PS at Crash	SST Information
000562*	000004	- Number of bytes	
000564	000000	- SST Code	
000566	003120	- Addr of $DIRXT	
000570	000001	- R0	
000572	070514	- R1	
000574	074460	- R2	
000576	053204	- R3	Context at SST
000600	144000	- R4	
000602	000000	- R5	
000604	121204	- PC	
000606	030000	- PS	
000610	003126	- ADDR of $DIRXT	
000612	000000	- R0	
000614	070514	- R1	
000616	074460	- R2	Context at Trap
000620	053200	- R3	
000622	144000	- R4	
000624	000000	- R5	
000626	121206	- PC	
000630	170000	- PS	

Example 10-1 A Sample KERNEL Stack

AN EXAMPLE

Situation

- Privileged task TT2 is executing.

  Task prompts for terminal number.

  User enters terminal number.

  System crashes.

  CDA prints message:

  ```
  Pool link error at 000040 -- FWD ptr = 000167
  Size = 001736
  ```

Output from CDA

- Current task = RMDEMO

  Error indicates

  Error caused by another task
  Other task corrupted list of free pool blocks

- Contents of KERNEL stack indicate crash caused by IOT

  Consistent with pool pointer = 000167

  Note that 000167 is JMP instruction and 001736 is location of $CRASH

- Any recently or currently active privileged tasks may have caused crash

- Examination of listing of task TT2 shows that task allocates and uses a block of pool

  Address of pool stored at location PLACE in task

  Task map indicates address of PLACE is 121430

- Dump of task obtained from binary crash file

  Value of 054100 stored in PLACE

- Examination of pool dump indicates

  Value 000040 entered in 84 words starting at 054100

  Allocated block started at 054100 and contained 84 bytes

  Error at location 000630 in task: MOV should be MOVB

```
RSX-11M CRASH DUMP ANALYZER      V4.0        1-NOV-81    11:16        PAGE 1
VOLATILE REGISTERS

AFTER CRASH:  PS=000340    SP(K)=000660    SP(U)=121164

BEFORE CRASH:  PC=141362    PS=030000

R0=137034    R1=137034    R2=131120    R3=000000    R4=000167    R5=137014

MMR0=000001    MMR1=000000    MMR2=002326    MMR3=000060

                    U S E R                                  U N I B U S   M A P

  I   S P A C E          D   S P A C E                    1  00000000
  PDR       PAR          PDR       PAR                   2  00020000
077506    000000       000000    000000                   3  00040000
077406    000200       000000    000000                   4  00060000
077406    000400       000000    000000                   5  00100000
077406    000600       000000    000000                   6  00146200
077406    001000       000000    000000                   7  00166200
077506    004732       000000    000000                   8  17000000
033006    005132       000000    000000                   9  17000000
077406    177600       000000    000000                  10  17000000
                                                         11  17000000
                                                         12  17000000
              S U P E R V I S O R                        13  17000000
                                                         14  17000000
  I   S P A C E          D   S P A C E                   15  17000000
  PDR       PAR          PDR       PAR                   16  17000000
000000    000000       000000    000000                   17  17000000
000000    000000       000000    000000                   18  17000000
000000    000000       000000    000000                   19  17000000
000000    000000       000000    000000                   20  17000000
000000    000000       000000    000000                   21  17000000
000000    000000       000000    000000                   22  17000000
000000    000000       000000    000000                   23  17000000
000000    000000       000000    000000                   24  17000000
                                                         25  17000000
                                                         26  17000000
                    K E R N E L                          27  17000000
                                                         28  17000000
  I   S P A C E          D   S P A C E                   29  00045100
  PDR       PAR          PDR       PAR                   30  17760000
077506    000000       000000    000000                   31  00105100
077506    000200       000000    000000
077506    000400       000000    000000
077406    000600       000000    000000
077506    001000       000000    000000
077506    004732       000000    000000
077406    005132       000000    000000
077506    177600       000000    000000
```

Example 10-2 CDA - Volatile Registers

```
RSX-11M CRASH DUMP ANALYZER      V4.0      1-NOV-81   11:16      PAGE 2
KERNEL STACK

  KERNEL STACK:

    000400    000000  000000  000000  000000  000000  000000  000000  000000
    000420    000000  000000  000000  000000  000000  000000  000000  000000
    000440    000000  000000  000000  000000  000000  000000  000000  000000
    000460    000000  000000  000000  000000  000000  000000  000000  000000
    000500    000000  000000  000000  000000  000000  000000  000000  000000
    000520    000000  000000  000000  000000  000000  000000  000000  000000
    000540    000000  000000  000000  000000  000000  000000  000000  000000
    000560    000000  000000  131514  131534  133054  133036  123156  001662
    000600    006110  133304  044000  025312  132602  030000  026304  001000
    000620    026304  001000  131542  160020  133040  010024  011604  124670
    000640    000000  000002  000144  000000  036154  137014  141362  030000
    000660    003236  000000  136256  131120  000000  136320  134554  142576
    000700    170000
```

Example 10-3 CDA - KERNEL Stack

```
RSX-11M CRASH DUMP ANALYZER      V4.0       1-NOV-81   11:16       PAGE 3
SYSTEM COMMON

CRASH OCCURRED AT 11:12:27  1-NOV-81

CURRENT TASK = RMDEMO     TCB ADDRESS = 052110

$SYSID = 31      $EXSIZ = 120000     $SYSIZ = 9216./288K     $SYUIC = [1,54]

$STKDP = 000000      $COMEF:  <33-48> 000000  <49-64> 000000

SYSTEM NAME = RSX11M      $NTUIC = [1,54]

LOAD DEVICE = DR0      LBN = 00135325      FILE SIZE = 496.

SYSTEM FEATURE MASK (FIRST WORD) = 013377

      BIT SET              MEANING
      -------              -------
        EXT        22-BIT EXTENDED MEMORY SUPPORT
        MUP        MULTI-USER PROTECTION SUPPORT
        EXV        20K EXEC SUPPORTED
        DRV        LOADABLE DRIVER SUPPORT
        PLA        PLAS SUPPORT
        CAL        DYNAMIC CHECKPOINT SPACE ALLOCATION
        PKT        PREALLOCATION OF I/O PACKETS
        EXP        EXTEND TASK DIRECTIVE SUPPORTED
        OFF        PARENT/OFFSPRING TASKING SUPPORTED
        FDT        FULL DUPLEX TERMINAL DRIVER
        DYM        DYNAMIC MEMORY ALLOCATION SUPPORTED


SYSTEM FEATURE MASK (SECOND WORD) = 167400

      BIT SET              MEANING
      -------              -------
        DPR        DIRECTIVE PARTITION SUPPORT
        IRR        INSTALL, REQUEST, AND REMOVE TASK SUPPORT
        GGF        GROUP GLOBAL EVENT FLAG SUPPORT
        RAS        RECEIVE/SEND DATA PACKET SUPPORT
        RBN        ROUND ROBIN SCHEDULING SUPPORTED
        SWP        EXECUTIVE LEVEL DISK SWAPPING SUPPORTED
        STP        EVENT FLAG MASK IS IN THE TCB


SYSTEM FEATURE MASK (THIRD WORD) = 025214

      BIT SET              MEANING
      -------              -------
        CLI        MULTIPLE CLI SUPPORT
        EIS        SYSTEM REQUIRES THE EXTENDED INSTRUCTION SET
        STM        SYSTEM HAS SET SYSTEM TIME DIRECTIVE
        AST        SYSTEM HAS AST SUPPORT
```

Example 10-4 CDA - System Common
(Sheet 1 of 3)

```
RSX-11M CRASH DUMP ANALYZER      V4.0       1-NOV-81    11:16       PAGE 4
SYSTEM COMMON DUMP

 ADDR    LABEL   VALUE           ADDR    LABEL   VALUE           ADDR    LABEL   VALUE

007750           010316          010110 $PRIHL  003100          010250           000000
                 000207                 $PRILL  001130                           000000
         $HEADR  052654                 $PFRSZ  000310                           000000
                 160400                 $POLBP  000063                           000000
         $COMEF  000000                 $POLFL  000000                           000000
                 000000                 $PARPT  017320                           000000
         $SYSID  030463                 $CLKHD  045716                           000000
                 020040                 $COPT   043630                           000000

007770 $TKNPT   110610          010130 $PARHD  117734          010270           000000
       $SHFPT   111040                 $LDRPT  117510                           000000
       $CKCNT   172542                 $TSKHD  117510                           000000
       $CKCSR   172540                 $XCOM1  001200                           000000
       $CKLDC   000144                 $XCOM2  001345                           000000
       $SYUIC   000454                 $GGEF   000000                           000000
                000000                 $GFTCB  010150                           000000
       $EXSIZ   120000                 $GEFPT  010150                  $ERBAF   000000

010010 $PWRFL   000000          010150 $GEFDM  000254          010310           000000
       $SIGFL   000000                 $IDLCT  000001                           000000
       $LOGHD   000000                 $IDLPT  170017                           000000
       $MCRCB   000000                 $DYPMN  020035                           000000
       $LSTLK   000000                         020037                           000000
                000003                         020037                           000000
       $CRAVL   046464                         017440                           000000
                000000                         017440                           000000

010030 $ACTHD   117510          010170          020040          010330           000000
       $DICSV   001037                 $BTMSK  000001                           000000
       $TKTCB   052110                         000002                           000000
       $LBUIC   000454                         000004                           000000
       $ABTIM   041233                         000010                           000000
       $RQSCH   000000                         000020                           000000
       $STKDP   000000                         000040                           000000
       $DEVHD   040746                         000100                           000000

010050 $RNDCT   000005          010210          000200          010350           000000
       $SWPCT   000036                         000400                  $ERFID   000000
       $ERRPT   000000                         001000                           000000
       $CFLPT   050740                         002000                           000000
                000000                         004000                           000000
                026354                         010000                           000000
       $INTCT   177777                         020000                  $PRMOD   000106
       $FRKHD   000000                         040000                  $SYSIZ   022000

010070           010066          010230          100000          010370           000000
       $FMASK   013377                 $ERHEA  000000                           135325
                167400                         010232                           051104
                025214                 $ENTSQ  000000                           000760
       $HFMSK   000003                 $ERRSQ  000000                           177777
       $PTTCB   112314                 $ERFLA  000000                           000015
       $PRISZ   033364                         000000                  $DPM     000037
       $POLST   000401                         000000                           000030
```

Example 10-4 CDA - System Common
(Sheet 2 of 3)

```
RSX-11M CRASH DUMP ANALYZER      V4.0       1-NOV-81   11:16       PAGE 5
SYSTEM COMMON DUMP

 ADDR   LABEL  VALUE          ADDR   LABEL  VALUE          ADDR   LABEL  VALUE

010410         000074         010470 $PKAVL 054034         010550 $MCRPT 111750
               000074                $PKNUM 002403                       050712
       $TKPS   000144                $MXEXT 177777                       000000
               000121                $UMRHD 000000                       000040
               000013                $UMRPT 170200                       003404
               000001                       000034                       005015
               000013                $UMRWT 000000                       000076
               000014                       010504                       005015

010430         000033         010510 $TEMP0 111750         010570         041515
       $TTNS   000063                $TEMP1 052514                       037122
       $TLMTS  000200                $TEMP2 130562                       000000
               000000                $TEMP4 000000
               000014                $AVRHD 000000
               000001                $MOULS 047064
               000000                $CXDBL 000000
               000001                $SYSNM 051522

010450         000027         010530         030530
               000000                       046461
               000073                $CLICQ 000000
               000000                       010534
               000073                $CPTBL 010550
               000000                       052464
       $TIKLM  000143                       000000
               000000                       000000
```

Example 10-4 . CDA - System Common
(Sheet 3 of 3)

```
RSX-11M CRASH DUMP ANALYZER      V4.0       1-NOV-81   11:16       PAGE 6
SYSTEM COMMON ALPHABETIZED DUMP

$ABTIM 041233        $ERLOF    000        $MOULS 047064        $STKDP 000000
$ACTHD 117510        $ERRPT 000000        $MXEXT 177777        $SWPCT 000036
$AVRHD 000000        $ERRSQ 000000        $NTUIC 000454        $SYSIZ 022000
$CFLPT 050740        $EXSIZ 120000        $PARHD 117734        $SYSNM 051522
$CKCNT 172542        $FMASK 013377        $PARPT 017320        $SYUIC 000454
$CKCSR 172540        $FRKHD 000000        $PFRSZ 000310        $TEMP0 111750
$CKLDC 000144        $GEFDM 000254        $PKAVL 054034        $TEMP1 052514
$CLICQ 000000        $GEFPT 010150        $PKMAX    005        $TEMP2 130562
$CLKHD 045716        $GFTCB 010150        $PKNUM    003        $TEMP4 000000
$COPT  043630        $GGEF  000000        $POLBP 000063        $TKNPT 110610
$CPTBL 010550        $HEADR 052654        $POLFL 000000        $TKPS  000144
$CRAVL 046464        $HFMSK 000003        $POLST 000401        $TKTCB 052110
$CURPR    341        $IDLCT    001        $PRIHL 003100        $TSKHD 117510
$CXDBL    000        $IDLFL    000        $PRILL 001130        $TTNS  000063
$DEVHD 040746        $IDLPT 170017        $PRISZ 033364        $UMRHD 000000
$DICSV 001037        $INTCT 177777        $PRMOD 000106        $UMRPT 170200
$DPM   000037        $LBUIC 000454        $PTTCB 112314        $UMRWT 000000
$ENTSQ 000000        $LDRPT 117510        $PWRFL 000000        $WTCSR 017320
$ERBAF    000        $LOGHD 000000        $RNDCT 000005        $WTIDM 017320
$ERFID 000000        $LSTLK 000000        $RQSCH 000000        $XCOM1 001200
$ERFLA    000        $MCRCB 000000        $SHFPT 111040        $XCOM2 001345
$ERHEA 000000        $MCRPT 111750        $SIGFL 000000
```

Example 10-5 CDA - System Common Alphabetized Dump

```
RSX-11M CRASH DUMP ANALYZER      V4.0       1-NOV-81   11:16       PAGE 7
POOL STATISTICS


 > > > > >   Pool link error at 000040 -- FWD ptr = 000167   Size = 001736

POOL SIZE (BYTES) = 21376.

LARGEST FREE BLOCK (BYTES) = 36.

TOTAL FREE BYTES = 144.

NUMBER OF FRAGMENTS = 13.

MINIMUM BLOCK SIZE (BYTES) = 4.


POOL BITMAP (CONSTRUCTED FROM LINKED POOL, BLOCK FREE IF BIT SET):

      000000  000000  060000  002014  000000  000000  000200  001000
      000000  001400  000000  000000  000000  000000  000000  000000
      000000  000000  000000  000000  000000  000000  000001  000000
      000000  000000  000000  000000  000000  000000  000000  000000
      000000  000000  000000  007600  002000  000000  000000  000000
      000000  170000  000037  000000  003400  000000  000000  000000
      017740  000000  000000  000000  000000  000000  000000  000000
      000000  000000  000000  000000  000000  000000  000000  000000
      000000  000000  000000  000000  000000  000000  000000  000000
      000000  000000  000000  000000  000000  000000  000000  000000
      000000  000000  000000  000000  000000  000000  000000  000000
      000000  000000  000000  000000  000000  000000  000000  000000
      000000  000000  000000  000000  000000  000000  000000  000000
      000000  000000  000000  000000  000000  000000  000000  000000
      000000  000000  000000  000000  000000  000000  000000  000000
      000000  000000  000000  000000  000000  000000  000000  000000
      000000  000000  000000  000000  000000  000000  000000  000000
      000000  000000  000000  000000  000000  000000  000000  000000
      000000  000000  000000  000000  000000  000000  000000  000000
      000000  000000  000000  000000  000000  000000  000000  000000
      000000  000000  000000  000000  000000  000000  000000  000000
      000000  000000  000000  000000  000000  000000  000000  000000
      000000  000000  000000  000000  000000  000000  000000  000000
      000000  000000  000000  000000  000000  000000  000000  000000
      000000  000000  000000  000000  000000  000000  000000  000000
      000000  000000  000000  000000  000000  000000  000000  000000
      000000  000000  000000  000000  000000  000000  000000  000000
      000000  000000  000000  000000  000000  000000  000000  000000
      000000  000000  000000  000000  000000  000000  000000  000000
      000000  000000  000000  000000  000000  000000  000000  000000
      000000  000000  000000  000000  000000  000000  000000  000000
      000000  000000  000000  000000  000000  000000  000000  000000
      000000  000000  000000  000000  000000  000000  000000  000000
      000000  000000  000000  000000  000000  000000  000000  000000
      000000  000000  000000  000000  000000  000000  000000  000000
      000000  000000  000000  000000  000000  000000  000000  000000
      000000  000000  000000  000000  000000  000000  000000  000000
```

Example 1Ø-6 CDA - POOL Statistics
(Sheet 1 of 2)

```
RSX-11M CRASH DUMP ANALYZER      V4.0       1-NOV-81   11:16       PAGE 8
POOL STATISTICS

      000000  000000  000000  000000  000000  000000  000000  000000
      000000  000000  000000  000000  000000  000000  000000  000000
      000000  000000  000000  000000  000000  000000  000000  000000
      000000  000000  000000  000000  000000  000000  000000  000000
      000000  000000  000000  000000  000000  000000
```

Example 10-6 CDA - POOL Statistics
(Sheet 2 of 2)

```
RSX-11M CRASH DUMP ANALYZER      V4.0       1-NOV-81   11:16       PAGE 19
ACTIVE TASKS

TT2
------

  TCB ADDRESS = 054440     PAR = GEN        PCB ADDRESS = 055174

  LOAD ADDRESS = 00440400     LOAD DEVICE = SY0:     LBN = 00117403

  PRI = 50.     I/O COUNT = 1.     UIC = [7,377]     TI = TT2:

  MAX SIZE = 000031     EVENT FLAGS = <1-16> 000000  <17-32> 000000

  T.STAT:

  T.ST2:   -CHK  WFR

  T.ST3:   -PMD  REM  PRV  MCR

  T.TIO:   000000

  TCB DUMP:

    000000    000000  000462  000000  100100  000000  000000  054452  000000
    000020    054456  000000  000000  044256  007754  000000  020001  074000
    000040    000062  117403  046166  055174  000031  111404  000000  000000
    000060    000031  047102  047102  000000  000000  000000  054532  000000
    000100    054536  000000  000001  054462  000000
```

Example 10-7 CDA - Active Tasks: TT2

```
RSX-11M CRASH DUMP ANALYZER      V4.0       1-NOV-81   11:16       PAGE 30
TASK HEADERS

    000040    000000  000000  055102  000001  126202  000000  000000  000000
    000060    000376  000000  000000  000000  000000  055144  000007  046072
    000100    000000  042360  000000  043630  000000  046166  000000  046072
    000120    000000  046116  000000  046072  000000  000001  053654  120000
    000140    132277  046430  000123  000000  000612  051006  170000  124636
    000160    000000  177777  044000  000000  000056  120533  000000


TT2
------

  HEADER ADDRESS = 054554      TCB ADDRESS = 054440

  PS=170000     PC=122200

  R0=000000  R1=054350  R2=044336  R3=000001  R4=000001  R5=000060  SP=121172

  INITIAL PS = 170017   INITIAL PC = 121442   INITIAL SP = 121172

  HEADER SIZE = 122.    NO. OF WINDOWS = 1.   NO. OF LUNS = 6.

  CURRENT UIC = [7,377]      DEFAULT UIC = [7,377]

  H.WND = 054702    H.GARD = 054744    H.VEXT = 000000     H.SPRI = -5.

  DSW = 000001      H.FCS = 000000     H.FORT = 000000     H.OVLY = 000000


  LOGICAL UNIT TABLE:

  #  DEV  WINDOW   W.CTL   W.FCB   F.FNUM  F.FSEQ  F.STAT  NAC  NLCK
  -  ---  ------   -----   -----   ------  ------  ------  ---  ----
  1  SY0: 000000
  2  SY0: 000000
  3  SY0: 000000
  4  SY0: 000000
  5  TI0: 000000
  6  CL0: 000000


  WINDOW BLOCKS:

   PAR     VIRT LIMITS   ATT DESC  WND SIZE  OFFSET  1ST PDR  NO.  LAST PDR
   ---     -----------   --------  --------  ------  -------  ---  --------
  GEN     120000 123077   047074    000031   000000  177612    1    014006


  HEADER:

    000000    121172  000172  053254  135600  003777  003777  170017  121442
```

Example 1Ø-8 CDA - Tasks Headers: TT2
(Sheet 1 of 2)

```
RSX-11M CRASH DUMP ANALYZER      V4.0        1-NOV-81   11:16        PAGE 31
TASK HEADERS

    000020    121172  000000  000000  000000  000000  000000  000000  000000
    000040    000000  000000  054702  000001  000000  000000  000000  000000
    000060    000373  000000  000000  000000  000000  054744  000006  046166
    000100    000000  046166  000000  046166  000000  046166  000000  046072
    000120    000000  046116  000000  000001  055174  120000  123077  047074
    000140    000031  000000  000612  014006  170000  122200  000060  000001
    000160    000001  044336  054350  000000  000000
```

Example 10-8 CDA - Tasks Headers: TT2
(Sheet 2 of 2)

```
RSX-11M CRASH DUMP ANALYZER      V4.0       1-NOV-81   11:16       PAGE 82
POOL DUMP

053260   * 114250 * 053276 * 000001 * 115404  !XQ  M5F   A X2D!!( >V    !
053270   * 000000 * 000106 * 114250 * 000000  !     A0 XQ     !!  F (   !
053300   * 000401 * 115404 * 000000 * 001000  ! FQ X2D       L2!!        !
053310   * 000016 * 121350 * 000000 * 000000  !  N ZBX         !!  h"    !
053320   * 000401 * 000000 * 000000 * 000000  ! FQ             !!        !
053330   * 114730 * 121246 * 000000 * 000000  !XXX Z 8         !!X &"    !
053340   * 066117 * 131574 * 000000 * 000000  !QMG ...         !!01!3    !
053350   * 000033 * 000000 * 000000 * 000000  !  $            !!        !
053360     053640   000044   111404   041740  !N 2   6 WT6 J4P!! W$   `C!
053370     000000   000000   000001   111426  !           A WUN!!        !
053400     053640   000024   000000   000000  !N 2   T         !! W      !
053410     000403   000000   053640   000010  ! FS     N 2   H!!      W  !
053420     000000   000000 * 120412 * 000212  !         YOZ  CR!!      !  !
053430   * 143107 * 000000 * 000454 * 000454  !1.9       GT  GT!!GF  , , !
053440   * 170017 * 120750 * 120412 * 000000  !8PO Y6H YOZ     !! Ph! !   !
053450   * 000000 * 000000 * 000000 * 000000  !               !!         !
053460   * 000000 * 000000 * 000000 * 000000  !               !!         !
053470   * 053552 * 000002 * 143030 * 000000  !M9R   B 1$2     !!JW   F   !
053500   * 143142 * 000000 * 000373 * 000000  !1/Z       FK    !!bF  (    !
053510   * 000000 * 000000 * 000000 * 053634  !                N .!!      W!
053520   * 000006 * 046166 * 000000 * 043630  !  F LIN       KRH!!  vL   G!
053530   * 000000 * 041006 * 000000 * 046166  !    JVV       LIN!!   B  vL!
053540   * 000000 * 046072 * 000000 * 046116  !    LG4       LHN!!  :L  NL!
053550   * 000000 * 000002 * 046674 * 120000  !      B LQT YX !!     <M  !
053560   * 144277 * 052360 * 000243 * 000000  !2D1 MWX  DC     !!?HPT#    !
053570   * 001212 * 021006 * 115404 * 160000  ! PJ EQO X2D 53X!!    "    `!
053600   * 175577 * 053270 * 000156 * 000147  ! IW M5   BO  BW!! (8Vn s  !
053610   * 000616 * 066402 * 170000 * 121016  ! I8 QQZ 8P  Y7F!!   m P "!
053620   * 000000 * 000000 * 143107 * 000060  !          1.9  AH!!    GFO !
053630   * 000060 * 120431 * 000000 * 000000  ! AH Y1A         !!0  !     !
053640     054224   000014   000000   000000  !NF6   L         !! X       !
053650     000403   000000 * 054374 * 000062  ! FS      NIT  AJ!!     !X2 !
053660   * 026226 * 000000 * 055174 * 115274  !GEN      NSD XOL!! ,   !Z< !
053670   * 004076 * 000123 * 000000 * 000123  !ALO  BC       BC!!> S    S !
053700   * 000000 * 111404 * 000050 * 054750  !     WT6  A  NOP!!     ( hY!
053710   * 000000 * 046430 * 046430 * 000000  !     LMP LMP    !!    M M  !
053720   * 000000 * 000062 * 000000 * 131574  !      AJ       ...!!  2    !3!
053730   * 007537 * 000000 * 053732 * 000000  !BRO      NBJ     !!_    ZW  !
053740   * 053736 * 177776 * 000001 * 044000  !NBN  8N    A KT2!!^W"     H!
053750   * 054440 * 100400 * 020000 * 050000  !NJP TYX ED2 L2 !! Y       P!
053760   * 000062 * 142440 * 046142 * 115274  ! AJ 1UX LH4 XOL!!2  EbL< !
053770   * 000306 * 054440 * 000000 * 000000  ! D8 NJP         !!F  Y     !
054000   * 000306 * 000000 * 054002 * 000000  ! D8      NCJ    !!F    X   !
054010   * 000000 * 000000 * 054012 * 000000  !          NCR    !!     X   !
054020   * 054016 * 000000 * 000003 * 053742  !NCV        C NBR!! X     bW!
054030   * 000000 * 000000 + 055240 + 000044  !           NT    6!!      Z$ !
054040   + 000020 + 000000 + 044416 + 000400  !  P        K$V  FP!!      I  !
054050   + 135154 + 005103 + 140054 + 000000  !/3D AY$ 0/6     !!1:C ,@   !
054060   + 005077 + 140144 + 000070 + 000000  !AYW O1L  AP     !!? d@8    !
054070   + 000000 + 000000 + 000000 + 000000  !               !!         !
054100   * 000040 * 000040 * 000040 * 000040  !  2   2   2   2!!         !

                    [ABOVE LINE REPEATED 9. TIMES]

054220   * 000040 * 000040   000040   000040  !  2   2   2   2!!         !
054230     000040   000040   000040   000040  !  2   2   2   2!!         !
```

Example 10-9 CDA - POOL Dump
(Sheet 1 of 2)

```
RSX-11M CRASH DUMP ANALYZER      V4.0       1-NOV-81   11:16       PAGE 83
POOL DUMP

 054240     000040   000040   000040   000040  !  2    2    2    2!!          !
 054250     000040   000040   000040   000040  !  2    2    2    2!!          !
 054260     000040   000040 * 000040 * 000040  !  2    2    2    2!!          !
 054270   * 000040 * 000040 * 000040 * 000040  !  2    2    2    2!!          !
 054300   * 000040 * 000040 * 000040 * 000040  !  2    2    2    2!!          !
 054310   * 000040 * 000040 * 000040 * 000040  !  2    2    2    2!!          !
 054320   * 000040 * 000040 * 000040 * 000040  !  2    2    2    2!!          !
 054330   * 000040 * 000040 * 000040 * 000040  !  2    2    2    2!!          !
 054340   * 000040 * 000040 * 000040 * 000040  !  2    2    2    2!!          !
 054350   * 170000 * 125200 * 127542 * 000000  !8P  $KH .BR     !! ⁋ *b/     !
 054360   * 000004 * 130034 * 131100 * 000110  !  D .GD .T2   A2!!   0@2H   !
 054370   * 000000 * 000000 * 000000 * 000773  !               L$!!      ‹  !
 054400   * 111404 * 055050 * 044000 * 000540  !WT6 NQ  KT2   H2!!  (Z H`   !
 054410   * 121246 * 004110 * 140046 * 000000  !Z 8 AM  0/0     !!&"H &@    !
 054420   * 000005 * 140111 * 000056 * 000000  !  E 00Y  AF     !!  I@.     !
 054430   * 000000 * 100000 * 000000 * 053654  !     TSH      NAD!!       ,W!
 054440   * 000000 * 000462 * 000000 * 100100  !      GZ      TT2!!  2    @ !
 054450   * 000000 * 000000 * 054452 * 000000  !         NJZ     !!     *Y   !
 054460   * 054456 * 000000 * 000000 * 044256  !NJ0           KYF!!.Y      .H!
 054470   * 007754 * 000000 * 020001 * 074000  !BU6       ED3 SH !!1        ×!
 054500   * 000062 * 117403 * 046166 * 055174  ! AJ YQ$ LIN NSD!!2    vL!Z!
 054510   * 000031 * 111404 * 000000 * 000000  !  Y WT6          !!          !
 054520   * 000031 * 047102 * 047102 * 000000  !  Y LT4 LT4     !!   BNBN   !
 054530   * 000000 * 000000 * 054532 * 000000  !         NK4     !!     ZY   !
 054540   * 054536 * 000000 * 000001 * 054462  !NK8         A NJ4!!~Y      2Y!
 054550   * 000000 * 001000 * 121172 * 000172  !      L2 Y94  CB!!     z"z   !
 054560   * 053254 * 135600 * 003777 * 003777  !M4. 0    AKG AKG!!,V ;       !
 054570   * 170017 * 121442 * 121172 * 000000  !8PO ZDB Y94     !! ⁋"$z"    !
 054600   * 000000 * 000000 * 000000 * 000000  !                 !!          !
 054610   * 000000 * 000000 * 000000 * 000000  !                 !!          !
 054620   * 054702 * 000001 * 000000 * 000000  !NNR   A          !!BY        !
 054630   * 000000 * 000000 * 000373 * 000000  !           FK    !!     ‹    !
 054640   * 000000 * 000000 * 000000 * 054744  !                NOL!!       dY!
 054650   * 000006 * 046166 * 000000 * 046166  !  F LIN       LIN!!   vL   vL!
 054660   * 000000 * 046166 * 000000 * 046166  !    LIN       LIN!!   vL   vL!
 054670   * 000000 * 046072 * 000000 * 046116  !    LG4       LHN!!   :L   NL!
 054700   * 000000 * 000001 * 055174 * 120000  !      A NSD YX !!     !Z   !
 054710   * 123077 * 047074 * 000031 * 000000  !ZW9 LT.    Y     !!?&<N      !
 054720   * 000612 * 014006 * 170000 * 122200  ! I4 C30 8P   ZL2!!       ⁋ $!
 054730   * 000060 * 000001 * 000001 * 044336  ! AH   A    A KZN!!0       ^H!
 054740   * 054350 * 000000 * 000000 * 120424  !NI             Y06!!hX       !!
 054750   * 120502 * 000176 * 140354 * 135600  !Y2B  CF 04. 0   !!B!~ 1@ ;!
 054760   * 000454 * 000454 * 170017 * 121714  ! GT  GT 8PO ZHL!!, ,  ⁋L#!
 054770   * 120506 * 000000 * 000000 * 000000  !Y2F                !!F!        !
 055000   * 000000 * 000000 * 000000 * 000000  !                   !!          !
 055010   * 000000 * 000000 * 055102 * 000001  !         NQZ    A!!     BZ    !
 055020   * 126202 * 000000 * 000000 * 000000  !$XB                 !! ,        !
 055030   * 000376 * 000000 * 000000 * 000000  ! FN                 !!~         !
 055040   * 000000 * 055144 * 000007 * 046072  !    NRT    G LG4!!   dZ   :L!
 055050   * 000000 * 042360 * 000000 * 043630  !    KAH      KRH!!   ⁋D    G!
 055060   * 000000 * 046166 * 000000 * 046072  !    LIN      LG4!!   vL   :L!
 055070   * 000000 * 046116 * 000000 * 046072  !    LHN      LG4!!   NL   :L!
 055100   * 000000 * 000001 * 053654 * 120000  !      A NAD YX !!     ,W   !
 055110   * 132277 * 046430 * 000123 * 000000  !.61 LMP  BC      !!?4 MS     !
 055120   * 000612 * 051006 * 170000 * 124636  ! I4 MD8 8P   $EV!!    R ⁋ )!
 055130   * 000000 * 177777 * 044000 * 000000  !     80 KT2      !!      H   !
```

Example 10-9 CDA - POOL Dump
(Sheet 2 of 2)

```
DUMP    MACRO M1200  01-NOV-81 11:09  PAGE 3


                                                .TITLE  DUMP
                                        ;+
                                        ;
                                        ;       THIS TASK ASKS THE USER FOR A TERMINAL NUMBER AND A
                                        ;       COMMAND LINE.  IT THEN PASSES THE COMMAND TO MCR
                                        ;       AS IF HAD ORIGINATED AT THE SPECIFIED TERMINAL.  IT
                                        ;       PERFORMS THIS TASK BY USING SYSTEM SUBROUTINES, $ALOCB
                                        ;       AND $QMCRL, TO ALLOCATE A BLOCK FROM POOL AND PASS IT
                                        ;       TO MCR.
                                        ;
                                        ;       THE TASK MUST BE BUILT PRIVILEGED AND MAP TO THE EXECUTIVE.
                                        ;
                                        ;       TO ASSEMBLE:
                                        ;
                                        ;       >MAC TERM=[1,1]EXEMC/ML,[11,10]RSXMC/PA:1,[(YOUR UIC)]TERM
                                        ;
                                        ;       TO BUILD:
                                        ;
                                        ;       >TKB TERM/PR:5=TERM,[1,54]RSX11M.STB/SS
                                        ;
                                        ;+
                                                .MCALL  EXIT$S,QIOW$S,DCBDF$
000000                                          DCBDF$
                                        ;
                                        ;       TERMINAL MESSAGES
                                        ;
000000  012     015     105             PRMT:   .ASCII  <12><15>/ENTER A TERMINAL NUMBER: /     ;PROMPT
000003  116     124     105
000006  122     040     101
000011  040     124     105
000014  122     115     111
000017  116     101     114
000022  040     116     125
000025  115     102     105
000030  122     072     040
000033                  PLEN    =       .-PRMT                  ;LENGTH OF PROMPT
000033  105     116     124     MES1:   .ASCII  /ENTER A COMMAND FOR MCR/
000036  105     122     040
000041  101     040     103
000044  117     115     115
000047  101     116     104
000052  040     106     117
000055  122     040     115
000060  103     122
000027                  LENT1   =       .-MES1
000062  116     125     115     MESS1:  .ASCII  /NUMBER IS NOT OCTAL, TRY AGAIN!/
000065  102     105     122
000070  040     111     123
000073  040     116     117
000076  124     040     117
000101  103     124     101
000104  114     054     040
000107  124     122     131
000112  040     101     107
000115  101     111     116
000120  041
000037                  LEN1    =       .-MESS1
```

Example 10-10 Listing of Task TT2 (DUMP)
(Sheet 1 of 5)

```
DUMP    MACRO M1200  01-NOV-81 11:09  PAGE 3-1

 33 000121     124     105     122  ERMES:  .ASCII  /TERMINAL NOT FOUND!/
    000124     115     111     116
    000127     101     114     040
    000132     116     117     124
    000135     040     106     117
    000140     125     116     104
    000143     041
 34          000023                  ERL     =       .-ERMES
 35 000144     116     117     040  POOL:   .ASCII  /NO POOL AVAILABLE!/
    000147     120     117     117
    000152     114     040     101
    000155     126     101     111
    000160     114     101     102
    000163     114     105     041
 36          000022                  PL      =       .-POOL
 37 000166     111     057     117  IOERR:  .ASCII  !I/O ERROR ON COMMAND INPUT!
    000171     040     105     122
    000174     122     117     122
    000177     040     117     116
    000202     040     103     117
    000205     115     115     101
    000210     116     104     040
    000213     111     116     120
    000216     125     124
 38          000032                  IOL     =       .-IOERR
 39                                          .EVEN                           ;MAKE SURE OF WORD BOUNDARY
 40                                  ;
 41                                  ;       PROGRAM DATA
 42                                  ;
 43 000220                          BUF:     .BLKB   4                       ;BUFFER FOR TERMINAL NUMBER
 44 000224                          IOSB:    .BLKW   2                       ;I/O STATUS BLOCK
 45 000230     124     124          NAM:     .ASCII  /TT/                    ;TERMINAL NAME
 46 000232  177777                  ERRCNT:  .WORD   -1                      ;ERROR INDICATOR
 47 000234  000000                  COMM:    .WORD   0                       ;ADDRESS OF COMMAND LINE IN POOL
 48 000236  000000                  PLACE:   .WORD   0                       ;ADDRESS OF POOL BLOCK
 49 000240  000000                  UCB:     .WORD   0                       ;SAVED UCB ADDRESS
 50 000242  000000                  DCB:     .WORD   0                       ;SAVED DCB ADDRESS
 51 000244  000000                  LOW:     .WORD   0                       ;SAVED LOW UNIT NUMBER
 52 000246  000000                  HIGH:    .WORD   0                       ;SAVED HIGH UNIT NUMBER
 53                                  ;
 54                                  ;       BEGINNING OF CODE
 55                                  ;
 56 000250                          TERM:    QIOW$S  #IO.WVB,#5,#1,,,,<#PRMT,#PLEN,#40>      ;PROMPT
 57 000322                                   QIOW$S  #IO.RVB,#5,#1,,#IOSB,,<#BUF,#4> ;GET 'TT' NUMBER
 58 000374  016703  177626               MOV     IOSB+2,R3                   ;SAVE CHARACTER COUNT
 59 000400  012700  000220'              MOV     #BUF,R0                     ;SET UP FOR CALL TO CONVERSION
 60 000404  005002                       CLR     R2                          ; ROUTINE - FROM ASCII TO
 61 000406                               CALL    $COTB                       ;   BINARY(OCTAL)
 62                                                                          ; R1 WILL CONTAIN CONVERTED NUMBER
 63                                                                          ; R2 WILL CONTAIN TERMINATOR
 64 000412  005702                       TST     R2                          ;TEST FOR ERROR
 65 000414  001402                       BEQ     CONT                        ;IF NOT CONTINUE
 66 000416  000167  000436               JMP     ERR1                        ;GO TO ERROR ROUTINE
 67 000422                          CONT:    CALL    $SWSTK,BACK             ;;SWITCH TO SYSTEM STATE
 68 000426  012700  000000G              MOV     #$DEVHD,R0                  ;;PICK UP LISTHEAD FOR DCB LIST
 69 000432  011000                  L1:      MOV     (R0),R0                 ;;GO TO NEXT DCB
 70 000434  001422                       BEQ     GO                          ;;IF NONE FINISH UP
```

Example 10-10 Listing of Task TT2 (DUMP)
(Sheet 2 of 5)

```
DUMP    MACRO M1200  01-NOV-81 11:09  PAGE 3-2

 71 000436  026760  177566  000004          CMP     NAM,D.NAM(R0)           ;;LOOK FOR 'TT' DCB
 72 000444  001372                          BNE     L1                      ;;IF NOT 'TT' GET NEXT DCB
 73 000446  116067  000006  177570          MOVB    D.UNIT(R0),LOW          ;;GET LOW UNIT NUMBER
 74 000454  116067  000007  177564          MOVB    D.UNIT+1(R0),HIGH       ;;GET HIGH UNIT NUMBER
 75 000462  020167  177560                  CMP     R1,HIGH                 ;;COMPARE INPUT WITH HIGH
 76 000466  003361                          BGT     L1                      ;;IF INPUT LARGER GET NEXT DCB
 77 000470  010067  177546                  MOV     R0,DCB                  ;;SAVE DCB ADDRESS
 78 000474  062767  000001  177530          ADD     #1,ERRCNT               ;;INDICATE NO ERROR HERE
 79 000502                          GO:     RETURN                          ;;RETURN TO USER STATE
 80 000504                          BACK:                                   ;NOW IN USER STATE
 81 000504  005767  177522                  TST     ERRCNT                  ;TEST FOR ERROR
 82 000510  001402                          BEQ     1$                      ;CONTINUE IF OK
 83 000512  000167  000430                  JMP     ERR2                    ;GO TO ERROR ROUTINE
 84 000516  016700  177520          1$:     MOV     DCB,R0                  ;GET DCB ADDRESS
 85 000522  016002  000002                  MOV     D.UCB(R0),R2            ;GET ADDRESS OF FIRST UCB
 86 000526  010104                          MOV     R1,R4                   ;MOVE FOR CALCULATIONS
 87 000530  166704  177510                  SUB     LOW,R4                  ;FIND THE NUMBER WITHIN UCBS
 88                                                                         ; FOR CURRENT DCB
 89 000534  016005  000010                  MOV     D.UCBL(R0),R5           ;GET UCB LENGTH
 90 000540  070504                          MUL     R4,R5                   ;CALCULATE OFFSET FOR UCB
 91 000542  060502                          ADD     R5,R2                   ;CALCULATE BEGINNING OF UCB
 92 000544  010267  177470                  MOV     R2,UCB                  ;SAVE UCB ADDRESS
 93 000550  012767  177777  177454          MOV     #-1,ERRCNT              ;RESET ERROR COUNT
 94 000556                                  CALL    $SWSTK,BACK2            ;;SWITCH TO SYSTEM STATE
 95 000562  012701  000124                  MOV     #84.,R1                 ;;SET BLOCK SIZE
 96 000566                                  CALL    $ALOCB                  ;;ALLOCATE BLOCK FROM POOL
 97 000572  103404                          BCS     NONE                    ;;NO ROOM IN POOL
 98 000574  005267  177432                  INC     ERRCNT                  ;;INDICATE NO ERROR HERE
 99 000600  010067  177432                  MOV     R0,PLACE                ;;SAVE ADDRESS OF POOL BLOCK
100 000604                          NONE:   RETURN                          ;;RETURN TO USER STATE
101 000606                          BACK2:                                  ;BACK IN USER STATE
102 000606  005767  177420                  TST     ERRCNT                  ;CHECK FOR ERROR
103 000612  001402                          BEQ     1$                      ;CONTINUE IF OK
104 000614  000167  000406                  JMP     ERR3                    ;GO TO ERROR ROUTINE
105 000620  012700  000124          1$:     MOV     #84.,R0                 ;SET LENGTH OF BLOCK
106 000624  016701  177406                  MOV     PLACE,R1                ;GET ADDRESS OF BLOCK
107 000630  012721  000040          2$:     MOV     #40,(R1)+               ;PLACE BLANKS IN BLOCK
108 000634  077003                          SOB     R0,2$                   ;LOOP UNTIL THROUGH
109 000636  016767  177374  177370          MOV     PLACE,COMM              ;CALCULATE LOCATION OF COMMAND
110 000644  062767  000004  177362          ADD     #4,COMM                 ; LOCATION IN BLOCK
111 000652                                  QIOW$S  #IO,WVB,#5,#1,,,,<#MES1,#LENT1,#40>     ;PROMPT FOR COMMAND
112 000724  005067  177274                  CLR     IOSB                    ;CLEAR THE I/O STATUS - WORD 1
113 000730  005067  177272                  CLR     IOSB+2                  ;  "    "       "     - WORD 2
114 000734                                  QIOW$S  #IO.RVB,#5,#1,,IOSB,,<COMM,#80.>        ;INPUT COMMAND
115 001006  103002                          BCC     3$                      ;CONTINUE IF OK
116 001010  000167  000272                  JMP     ERR4                    ;BRANCH IF QIO ERROR
117 001014  105767  177204          3$:     TSTB    IOSB                    ;CHECK FOR I/O ERROR
118 001020  002002                          BGE     4$                      ;CONTINUE IF OK
119 001022  000167  000260                  JMP     ERR4                    ;BRANCH IF ERROR
120 001026                          4$:     CALL    $SWSTK,BACK3            ;;SWITCH TO SYSTEM STATE
121 001032  016701  177200                  MOV     PLACE,R1                ;;GET ADDRESS OF BLOCK
122 001036  016761  177176  000002          MOV     UCB,2(R1)               ;;PLACE UCB ADDRESS IN BLOCK
123 001044                                  CALL    $QMCRL                  ;;QUEUE BLOCK TO MCR
124 001050                                  RETURN                          ;;LEAVE SYSTEM STATE
125 001052                          BACK3:                                  ;BACK IN USER STATE
126 001052                                  EXIT$S                          ;EXIT
127                                 ;
```

Example 10-10 Listing of Task TT2 (DUMP)
(Sheet 3 of 5)

```
DUMP    MACRO M1200  01-NOV-81 11:09  PAGE 3-3

  128                                   ;       ROUTINE TO HANDLE BAD TERMINAL NUMBER
  129                                   ;
  130 001060                            ERR1:   QIOW$S  #IO.WVB,#5,#1,,,,<#MESS1,#LEN1,#40>     ;PRINT MESSAGE
  131 001132  012700  000220'                   MOV     #BUF,R0                 ;GET INPUT BUFFER ADDRESS
  132 001136  005020                    CLEAR:  CLR     (R0)+                   ;CLEAR BUFFER
  133 001140  077302                            SOB     R3,CLEAR                ;R3 CONTAINS CHARACTER COUNT
  134 001142  000167  177102                    JMP     TERM                    ;TRY AGAIN
  135                                   ;
  136                                   ;       ROUTINE TO HANDLE NON-EXISTENT TERMINAL
  137                                   ;
  138 001146                            ERR2:   QIOW$S  #IO.WVB,#5,#1,,,,<#ERMES,#ERL,#40>      ;PRINT MESSAGE
  139 001220                                    EXIT$S                          ;EXIT
  140                                   ;
  141                                   ;       ROUTINE TO HANDLE POOL ALLOCATION FAILURE
  142                                   ;
  143 001226                            ERR3:   QIOW$S  #IO.WVB,#5,#1,,,,<#POOL,#PL,#40>        ;PRINT MESSAGE
  144 001300                                    EXIT$S                          ;EXIT
  145                                   ;
  146                                   ;       ROUTINE TO HANDLE I/O ERRORS ON COMMAND INPUT
  147                                   ;       THE POOL BLOCK MUST BE DEALLOCATED!
  148                                   ;
  149 001306                            ERR4:   QIOW$S  #IO.WVB,#5,#1,,,,<#IOERR,#IOL,#40>      ;PRINT MESSAGE
  150 001360                                    CALL    $SWSTK,FIN              ;;SWITCH TO SYSTEM STATE
  151 001364  016700  176646                    MOV     PLACE,R0                ;;GET ADDRESS OF BLOCK
  152 001370  012701  000124                    MOV     #84.,R1                 ;;SET BLOCK LENGTH
  153 001374                                    CALL    $DEACB                  ;;DEALLOCATE BLOCK
  154 001400                                    RETURN                          ;;LEAVE SYSTEM STATE
  155 001402                            FIN:                                    ;BACK IN USER STATE
  156 001402                                    EXIT$S                          ;EXIT
  157         000250'                           .END    TERM
```

Example 10-10 Listing of Task TT2 (DUMP)
(Sheet 4 of 5)

```
DUMP    MACRO M1200  01-NOV-81 11:09  PAGE 3-4
SYMBOL TABLE

A$$BIO= 000000          D.MSK   000014          K$$IEN= 000113          PRMT    000000R         T$$RTW= 000000
A$$BRT= 000000          D.NAM   000004          K$$LDC= 000144          P$$BPR= 000063          T$$BUF= 000000
A$$CHK= 000000          D.PCB   000034          K$$TPS= 000144          P$$CTL= 000000          T$$CCA= 000000
A$$CLI= 000004          D.UCB   000002          LD$CO = 000000          P$$FRS= 000310          T$$CCO= 000000
A$$CPS= 000000          D.UCBL  000010          LD$DD = 000000          P$$GMX= 000000          T$$CPW= 000000
A$$NSI= 000000          D.UNIT  000006          LD$DK = 000000          P$$HIL= 003100          T$$CTR= 000000
A$$PRI= 000000          D.VCAN= 000002          LD$DL = 000000          P$$LAS= 000000          T$$CUP= 000000
A$$TRP= 000000          D.VDEB= 177776          LD$DM = 000000          P$$LOL= 001130          T$$C11= 000001
BACK    000504R         D.VINI= 000000          LD$DR = 000000          P$$OFF= 000000          T$$ESC= 000000
BACK2   000606R         D.VOUT= 000004          LD$DS = 000000          P$$P45= 000000          T$$GMC= 000000
BACK3   001052R         D.VPWF= 000006          LD$DT = 000000          P$$RFL= 000000          T$$GTS= 000000
BUF     000220R         ERL   = 000023          LD$LP = 000000          P$$RTY= 000000          T$$HFF= 000000
B$$LV1= 030463          ERMES   000121R         LD$MM = 000000          P$$SRF= 000000          T$$HLD= 000000
B$$LV2= 020040          ERRCNT  000232R         LD$TT = 000000          Q$$OPT= 000005          T$$J16= 000001
CLEAR   001136R         ERR1    001060R         LENT1 = 000027          R$$DER= 000000          T$$KMG= 000000
COMM    000234R         ERR2    001146R         LEN1  = 000037          R$$EXV= 000000          T$$LWC= 000000
CONT    000422R         ERR3    001226R         LOW     000244R         R$$JS1= 000001          T$$RED= 000000
C$$CDA= 000002          ERR4    001306R         L$$ASG= 000000          R$$K11= 000001          T$$RNE= 000000
C$$CHE= 000000          E$$ACT= 000000          L$$DRV= 000000          R$$LKL= 000001          T$$RPR= 000000
C$$CKP= 000004          E$$DVC= 000000          L$$LDR= 000000          R$$L11= 000001          T$$RST= 000000
C$$CSR= 177404          E$$LOG= 000000          L$$PTO= 000036          R$$MOF= 000000          T$$RUB= 000000
C$$INT= 000000          E$$XPR= 000000          L$$P11= 000001          R$$M11= 000001          T$$SMC= 000000
C$$ONS= 000001          FIN     001402R         L1      000432R         R$$NDC= 000005          T$$SYN= 000000
C$$ORE= 002022          F$$LPP= 000000          MESS1   000062R         R$$NDH= 000226          T$$TRW= 000000
C$$OTM= 000000          F$$LVL= 000001          MES1    000033R         R$$NDL= 000001          T$$UTB= 000000
C$$RSH= 177564          GO      000502R         M$$CRB= 000124          R$$POI= 000000          T$$UTO= 000170
C$$RUN= 000000          G$$EFN= 000000          M$$CRX= 000000          R$$SND= 000000          T$$U58= 000001
C$$SMT= 000000          G$$TPP= 000000          M$$EIS= 000000          R$$11M= 000000          T$$VBF= 000000
C$$TTY= 177564          G$$TSS= 000000          M$$EXT= 000000          R$$6OF= 000000          T$$3OP= 000000
DCB     000242R         G$$TTK= 000000          M$$FCS= 000000          R$$611= 000001          UCB     000240R
D$$H11= 000001          HIGH    000246R         M$$MGE= 000000          S$$ECC= 000000          U$$MHI= 000000
D$$IAG= 000000          H$$RTZ= 000074          M$$MUP= 000000          S$$NM1= 051522          U$$MLO= 160000
D$$ISK= 000000          IOERR   000166R         M$$OVR= 000000          S$$NM2= 030530          U$$MRN= 170234
D$$L11= 000002          IOL   = 000032          NAM     000230R         S$$NM3= 046461          V$$CTR= 000400
D$$M11= 000001          IOSB    000224R         NONE    000604R         S$$TIM= 000000          V$$RSN= 000040
D$$PAR= 000000          IO.RVB= ****** GX       N$$LDV= 000001          S$$TOP= 000000          X$$DBT= 000000
D$$SHF= 000000          IO.WVB= ****** GX       N$$MOV= 000041          S$$WLK= 000000          $ALOCB= ****** GX
D$$WCK= 000000          I$$RAR= 000000          N$$UMR= 000034          S$$WPC= 000036          $COTB = ****** GX
D$$YNC= 000000          I$$RDN= 000000          PL    = 000022          S$$WPR= 000005          $DEACB= ****** GX
D$$YNM= 000000          K$$AST= 000000          PLACE   000236R         S$$YSZ= 022000          $DEVHD= ****** GX
D.DSP   000012          K$$CNT= 172542          PLEN  = 000033          TERM    000250R         $QMCRL= ****** GX
D.LNK   000000          K$$CSR= 172540          POOL    000144R         T$$ACR= 000000          $$$ARG= 000002

. ABS.  000036      000
        001410      001
ERRORS DETECTED:  0

VIRTUAL MEMORY USED:  10113 WORDS  ( 40 PAGES)
DYNAMIC MEMORY:  16120 WORDS  ( 62 PAGES)
ELAPSED TIME:  00:00:13
DUMP,DUMP/-SP=[1,1]EXEMC/ML,[11,10]RSXMC/PA:1,[7,377]DUMP
```

Example 10-10 Listing of Task TT2 (DUMP)
(Sheet 5 of 5)

```
DUMP.TSK   Memory allocation map  TKB M39.7D      Page 1
                    1-NOV-81   11:09


Partition name : GEN
Identification : M4.0
Task  UIC      : [7,377]
Stack    limits: 120172 121171 001000 00512.
PRG xfr address: 121442
Task attributes: PR
Total address windows: 1.
Task  image  size  : 800. words
Task address limits: 120000 123007
R-W disk blk limits: 000002 000005 000004 00004.

*** Root sesment: DUMP


R/W mem  limits: 120000 123007 003010 01544.
Disk blk limits: 000002 000005 000004 00004.


Memory allocation synopsis:

Section                                          Title  Ident  File
--------                                         -----  -----  ----
. BLK.:(RW,I,LCL,REL,CON)     121172 001504 00836.
                              121172 001410 00776. DUMP   M4.0   DUMP.OBJ;2
$$RESL:(RO,I,LCL,REL,CON)     122676 000112 00074.


Global symbols:

IO.RVB 010400    IO.WVB 011000    $ALOCB 011346    $DEACB 011614    $DEVHD 010046    $QMCRL 021432



*** Task builder statistics:

    Total work file references: 850.
    Work  file  reads: 0.
    Work  file writes: 0.
    Size of core pool: 20506. words (80. pages)
    Size of work file: 768. words (3. pages)

    Elapsed time:00:00:04
```

Example 10-11 Map of Task TT2

```
RSX-11M CRASH DUMP ANALYZER      V4.0        1-NOV-81    11:39        PAGE 9
TASK DUMP


                              TASK DUMP OF TT2
                              ----------------


                TCB ADDRESS = 054440        HEADER ADDRESS = 054554


WINDOW BLOCKS:

 PAR      VIRT LIMITS    ATT DESC  WND SIZE  OFFSET  1ST PDR  NO.  LAST PDR
 ---      -----------    --------  --------  ------  -------  ---  --------
GEN     120000 123077    047074    000031    000000  177612    1    014006


WINDOW #1 -- TASK VIRTUAL LIMITS 120000-123077
----------------------------------------------

  PHYSICAL STARTING ADDRESS = 00440400
  ------------------------------------

  120000    000000  000172  053254  135600    !     CB M4. 0  !!  z ,V ;!
  120010    003777  003777  170017  121442    !AKG AKG 8PO ZDB!!     P"#!
  120020    121172  000000  000000  000000    !Y94             !!z"       !
  120030    000000  000000  000000  000000    !                !!         !
  120040    000000  000000  054702  000000    !         NNR    !!    BY   !
  120050    000000  000000  000000  000000    !                !!         !
  120060    000000  000000  000000  000000    !                !!         !
  120070    000000  054744  000006  046166    !    NOL    F LIN!!  dY   vL!
  120100    000000  046166  000000  046166    !    LIN      LIN!!  vL   vL!
  120110    000000  046166  000000  046072    !    LIN      LG4!!  vL   :L!
  120120    000000  046116  000000  000001    !    LHN        A!!  NL     !
  120130    115274  120000  123077  000000    !XOL YX  ZW9      !!<   ?&   !
  120140    000031  000000  000612  014006    !  Y       I4 C30!!         !
  120150    004070  000001  000000  135600    !ALX   A       0  !!8       ;!
  120160    053254  000000  100100  000000    !M4.       TT2     !!,V  @    !
  120170    000000  000000  000000  000000    !                !!         !

                  [ABOVE LINE REPEATED 60. TIMES]

  121140    000000  006003  010400  000005    !    A65 B.2   E!!         !
  121150    000001  000000  000000  054104    !  A           ND6!!       DX!
  121160    000120  000000  000000  000000    ! B              !!P        !
  121170    000000  006412  047105  042524    !    BCR LT7 KC.!!     ENTE!
  121200    020122  020101  042524  046522    !EF4 EFQ KC. LN4!!R A TERM!
  121210    047111  046101  047040  046525    !LUA LHA LT  LN7!!INAL NUM!
  121220    042502  035122  042440  052116    !KCJ IMJ KBP MSV!!BER: ENT!
  121230    051105  040440  041440  046517    !MFU JP2 J/X LN1!!ER A COM!
  121240    040515  042116  043040  051117    !JQ7 J7F KH2 MF1!!MAND FOR!
  121250    046440  051103  052516  041115    !LMX MFS MY8 JXM!! MCRNUMB!
```

Example 10-12 CDA of Task TT2
(Sheet 1 of 4)

```
RSX-11M CRASH DUMP ANALYZER      V4.0        1-NOV-81   11:39        PAGE 10
TASK DUMP

121260    051105  044440  020123  047516    !MFU K.  EF5 L$V!!ER IS NO!
121270    020124  041517  040524  026114    !EF6 J01 JRD GCT!!T OCTAL,!
121300    052040  054522  040440  040507    !MRF NKZ JF2 JQ1!! TRY AGA!
121310    047111  052041  051105  044515    !LUA MRQ MFU K/E!!IN!TERMI!
121320    040516  020114  047516  020124    !JQ8 EF. L$V EF6!!NAL NOT !
121330    047506  047125  020504  047516    !L$N LUM EL6 L$V!!FOUND!NO!
121340    050040  047517  020114  053101    !L22 L$W EF. M2A!! POOL AV!
121350    044501  040514  046102  020505    !K.3 JQ6 LHB EL7!!AILABLE!!
121360    027511  020117  051105  047522    !GVY EF1 MFU L$Z!!I/O ERRO!
121370    020122  047117  041440  046517    !EF4 LUG J/X LN1!!R ON COM!
121400    040515  042116  044440  050116    !JQ7 J7F K.  L38!!MAND INF!
121410    052125  000063  000000  000000    !MS/  AK        !!UT3      !
121420    000000  052124  000000  054104    !     MS.      ND6!!  TT  DX!
121430    054100  044336  044212  000002    !ND2 KZN KXJ   B!!@X^H H   !
121440    000021  005046  005046  005046    !  Q AX8 AX8 AX8!!   & & & !
121450    012746  000040  012746  000033    !CTF   2 CTF   $!!f   f    !
121460    012746  121172  005046  005046    !CTF Y94 AX8 AX8!!f z"& & !
121470    005046  112716  000001  012746    !AX8 W80   A CTF!!& N   f !
121500    000005  012746  011000  012746    !  E CTF B5H CTF!!  f   f !
121510    006003  104377  005046  005046    !A65 U61 AX8 AX8!!     & & !
121520    005046  005046  012746  000004    !AX8 AX8 CTF   D!!& & f   !
121530    012746  121412  005046  012746    !CTF ZCR AX8 CTF!!f  #& f !
121540    121416  005046  112716  000001    !ZCV AX8 W80   A!! #& N   !
121550    012746  000005  012746  010400    !CTF   E CTF B.2!!f   f   !
121560    012746  006003  104377  016703    !CTF A65 U61 DOS!!f     C !
121570    177626  012700  121412  005002    ! 50 CSH ZCR AXB!!  @  #  !
121600    004767  001004  005702  001402    !AW1  L6 A5J  SJ!!w   B   !
121610    000167  000436  104376  121676    ! B9  GF U60 ZG8!!w   ^ >#!
121620    012700  010046  011000  001422    !CSH BWN B5H  SZ!!@ &     !
121630    026760  177566  000004  001372    !GN   48   D  SB!!p-v   z !
121640    116067  000006  177570  116067    !X91   F  5  X91!!7   x 7 !
121650    000007  177564  020167  177560    !  G  46 EG1  42!!  t w p !
121660    003361  010067  177546  062767    !ADQ BW1  4V PLW!!q 7 f we!
121670    000001  177530  000207  005767    !  A  4H  CO A6W!!  X   w !
121700    177522  001402  000167  000430    ! 4B  SJ  B9  G !!R   w   !
121710    016700  177520  016002  000002    !DOP  4  DSJ   B!!@ P     !
121720    010104  166704  177510  016005    !BXD 8A.  32 DSM!!D DmH   !
121730    000010  070504  060502  010267    !  H RD6 OVR BZ9!!  DqBa7 !
121740    177470  012767  177777  177454    ! 3P CTW  80  3D!!8 w   , !
121750    104376  122000  012701  000124    !U60 ZIX CSI  BD!!^  $A T !
121760    004767  067362  103404  005267    !AW1 QOB UXD A.W!!w rn  7 !
121770    177432  010067  177432  000207    ! 2Z BW1  2Z  CO!!  7     !
122000    005767  177420  001402  000167    !A6W  2P  SJ  B9!!w     w !
122010    000406  012700  000124  016701    ! FV CSH  BD DOQ!!  @ T A !
122020    177406  012721  000040  077003    ! 2F CSY   2 TFS!!  Q    ^!
122030    016767  177374  177370  062767    !D11  16  12 PLW!!w !^x^we!
122040    000004  177362  005046  005046    !  D  1Z AX8 AX8!!  r^& & !
122050    005046  012746  000040  012746    !AX8 CTF   2 CTF!!& f   f !
122060    000027  012746  121225  005046    !  W CTF Z U AX8!!  f  "& !
122070    005046  005046  112716  000001    !AX8 AX8 W80   A!!& & N   !
122100    012746  000005  012746  011000    !CTF   E CTF B5H!!f   f   !
122110    012746  006003  104377  005067    !CTF A65 U61 AYO!!f     7 !
122120    177274  005067  177272  005046    ! OL AYO  OJ AX8!!<^7 :^& !
122130    005046  005046  005046  012746    !AX8 AX8 AX8 CTF!!& & & f !
122140    000120  016746  177260  005046    ! B  D1N  0  AX8!!P f O^& !
122150    016746  177242  005046  112716    !D1N  /Z AX8 W80!!f  "^& N !
```

Example 10-12 CDA of Task TT2
(Sheet 2 of 4)

```
RSX-11M CRASH DUMP ANALYZER      V4.0       1-NOV-81   11:39       PAGE 11
TASK DUMP

   122160    000001  012746  000005  012746    !  A CTF   E CTF!!  f   f !
   122170    010400  012746  006003  104377    !B.2 CTF A65 U61!!  f     !
   122200    103002  000167  000272  105767    !UQZ  B9  DZ VO1!!  w : w !
   122210    177204  002002  000167  000260    ! .6  YZ  B9  DP!! ~  w O !
   122220    104376  122244  016701  177200    !U60 ZM. DOQ  .2!!~ $$A  ~!
   122230    016761  177176  000002  004767    !D1Y  .O   B AW1!!@ ~~  w !
   122240    077170  000207  012746  000463    !TIP  CO CTF  G$!!x~  f 3 !
   122250    104377  005046  005046  005046    !U61 AX8 AX8 AX8!!  & & & !
   122260    012746  000040  012746  000037    !CTF   2 CTF   1!!f   f   !
   122270    012746  121254  005046  005046    !CTF ZAD AX8 AX8!!f ,"& & !
   122300    005046  112716  000001  012746    !AX8 W80   A CTF!!& N   f !
   122310    000005  012746  011000  012746    !  E CTF B5H CTF!!  f   f !
   122320    006003  104377  012700  121412    !A65 U61 CSH ZCR!!    @  #!
   122330    005020  077302  000167  177102    !AXP TKJ  B9  $J!!  B~w B~!
   122340    005046  005046  005046  012746    !AX8 AX8 AX8 CTF!!& & & f !
   122350    000040  012746  000023  012746    !  2 CTF   S CTF!!  f   f !
   122360    121313  005046  005046  005046    !ZA5 AX8 AX8 AX8!!K"& & & !
   122370    112716  000001  012746  000005    !W80   A CTF   E!!N   f   !
   122400    012746  011000  012746  006003    !CTF B5H CTF A65!!f   f   !
   122410    104377  012746  000463  104377    !U61 CTF  G$ U61!!  f 3   !
   122420    005046  005046  005046  012746    !AX8 AX8 AX8 CTF!!& & & f !
   122430    000040  012746  000022  012746    !  2 CTF   R CTF!!  f   f !
   122440    121336  005046  005046  005046    !ZBN AX8 AX8 AX8!!^"& & & !
   122450    112716  000001  012746  000005    !W80   A CTF   E!!N   f   !
   122460    012746  011000  012746  006003    !CTF B5H CTF A65!!f   f   !
   122470    104377  012746  000463  104377    !U61 CTF  G$ U61!!  f 3   !
   122500    005046  005046  005046  012746    !AX8 AX8 AX8 CTF!!& & & f !
   122510    000040  012746  000032  012746    !  2 CTF   Z CTF!!  f   f !
   122520    121360  005046  005046  005046    !ZB2 AX8 AX8 AX8!!P"& & & !
   122530    112716  000001  012746  000005    !W80   A CTF   E!!N   f   !
   122540    012746  011000  012746  006003    !CTF B5H CTF A65!!f   f   !
   122550    104377  104376  122574  016700    !U61 U60 ZSD DOP!!  ~ !%@ !
   122560    176646  012701  000124  004767    ! WN CSI  BD AW1!!&)A T w !
   122570    067022  000207  012746  000463    !QXR  CO CTF  G$!! n  f 3 !
   122600    104377  012702  000012  000402    !U61 CSJ   J FR!!  B     !
   122610    012702  000010  004567  000144    !CSJ   H ATW  BT!!B   w d !
   122620    005001  112005  122705  000040    !AXA W$M ZT7   2!!    E%  !
   122630    001774  122705  000011  001771    ! YT ZT7   I  YQ!!! E%  y !
   122640    162705  000060  120502  103010    !6OU  AH Y2B UQ2!!Ee0 B!   !
   122650    010004  010200  004767  000016    !BVT BYX AW1   N!!    w    !
   122660    010400  060501  112005  000764    !B.2 OVQ W$M  LT!!  Aa  t !
   122670    116002  177777  000207  010046    !X8R  8O  CO BWN!!      & !
   122700    012746  000021  005000  006000    !CTF   Q AX  A62!!f       !
   122710    006001  103002  066600  000002    !A63 UQZ QT2   B!!     m   !
   122720    005316  003371  000415  012746    !A/F ADY  F/ CTF!!N y   f !
   122730    000020  010146  005001  006300    !  P BX8 AXA BAX!!  f   @ !
   122740    006101  020116  103402  161601    !A8Q EF0 UXB 6PA!!A N     c!
   122750    005200  005366  000002  003367    !A$H A0F   B ADW!!  v   w !
   122760    022626  000207  010446  010346    !F V  CO B/0 B.F!! %  & f !
   122770    010546  016605  000006  004736    !B1N D.7   F AWF!!f      ^ !
   123000    012603  012604  012605  000207    !CQ$ CQ. CQ/  CO!!        !
   123010    000000  000000  000000  000000    !                !!       !
   123020    000000  000000  000000  000000    !                !!       !
   123030    000000  000000  000000  000000    !                !!       !
   123040    000000  000000  000000  000000    !                !!       !
   123050    000000  000000  000000  000000    !                !!       !
```

Example 1Ø-12 CDA of Task TT2
(Sheet 3 of 4)

```
RSX-11M CRASH DUMP ANALYZER      V4.0       1-NOV-81   11:39       PAGE 12
TASK DUMP

    123060    000000  000000  000000  000000    !              !!        !
    123070    000000  000000  000000  000000    !              !!        !
```

```
[END OF ANALYSIS OUTPUT]
```

Example 1Ø-12 CDA of Task TT2
(Sheet 4 of 4)

DIRECTIVE PROCESSING

11

INTRODUCTION

Many tasks require activities, such as I/O, which cannot be easily performed within a user task. To provide the facilities for these activities without requiring privileged tasks and extensive knowledge of the inner workings of the operating system, RSX-11M provides a set of system services called Executive directives.

Executive directives provide a simple interface to these services. This interface is through system macros for the MACRO-11 programmer and system subroutines for the FORTRAN programmer. The interface also provides a completion code for error checking.

OBJECTIVES

1. List the steps in processing an Executive directive.
2. Perform the steps necessary to add a user written directive to the system.

RESOURCES

1. RSX-11M System Lists and Data Structures
2. RSX-11M/M-PLUS Executive Reference Manual

THE USER TASK INTERFACE

- MACRO-11 task uses macros to invoke directives
- Three types of macros

  $-form
  $C-form
  $S-form

- FORTRAN tasks call subroutines
- Directive Parameter Block (DPB) used to pass data to system
- Result of directive execution indicated by

  Directive Status Word (DSW)

  Processor Status Word
  Set to indicate failure
  Clear to indicate success

Directive Parameter Block

- Data structure contained within the user task
- Contains parameters needed to execute the directive

  Directive identification code (DIC)
  Other parameters as needed
  Length depends on DIC, can be variable

- Location of DPB

  In task data area

  In user selected PSECT
  In PSECT $DPB$$

  On task stack

- Directive identification code always odd whole number

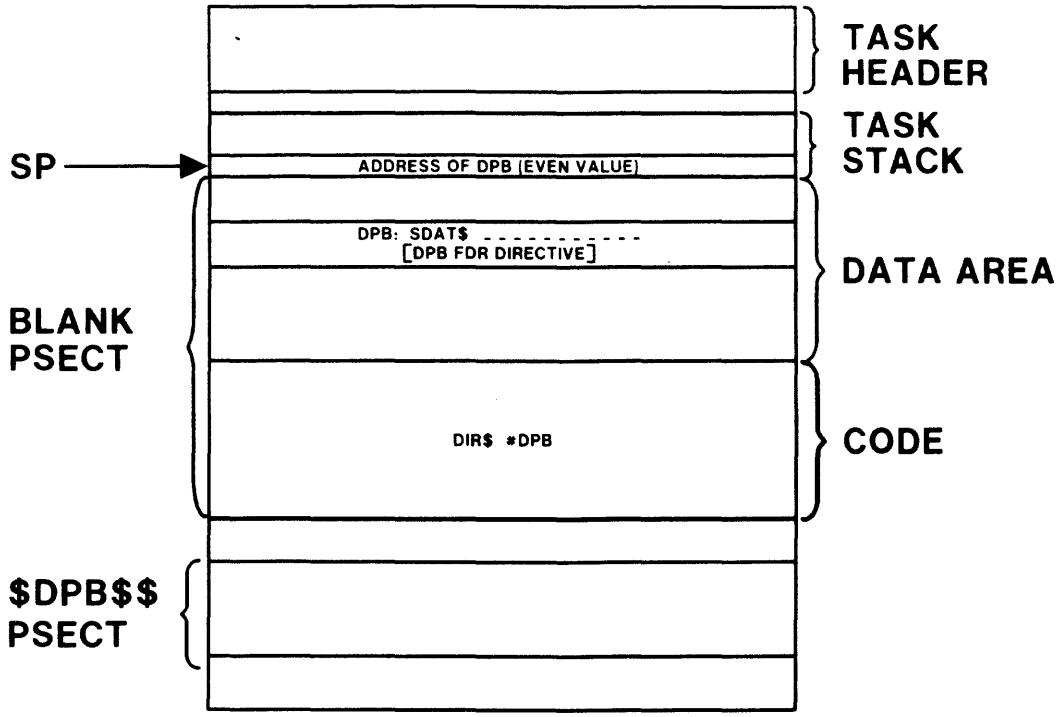


Figure 11-1 Directive Macros: '$' Form

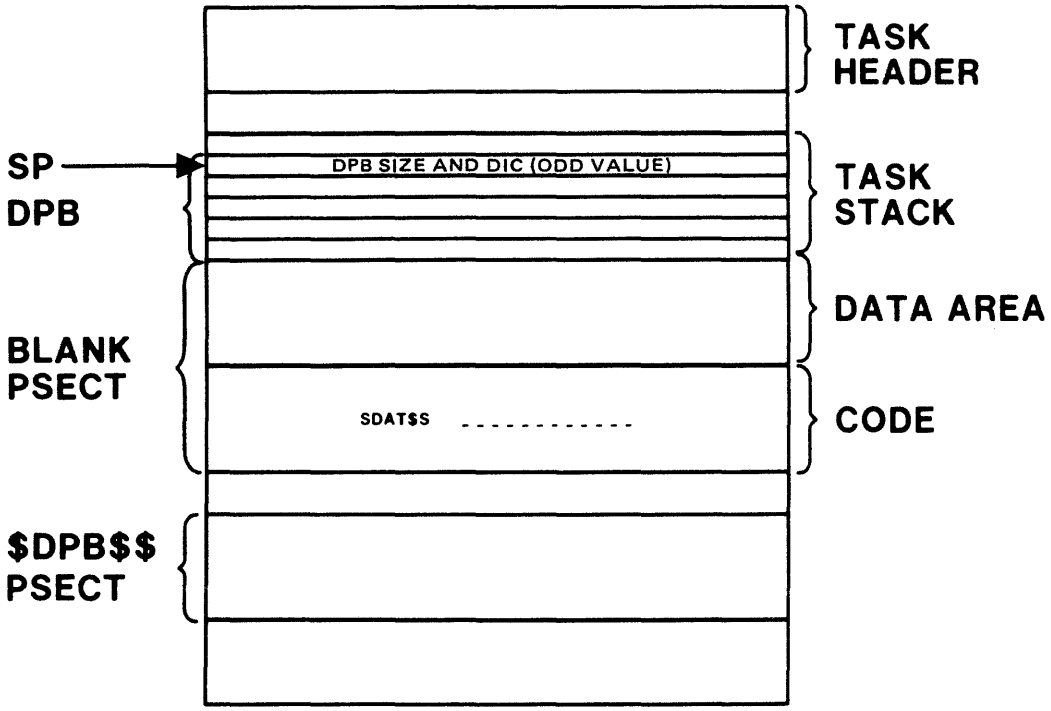


Figure 11-1 Directive Macros: '$S' Form

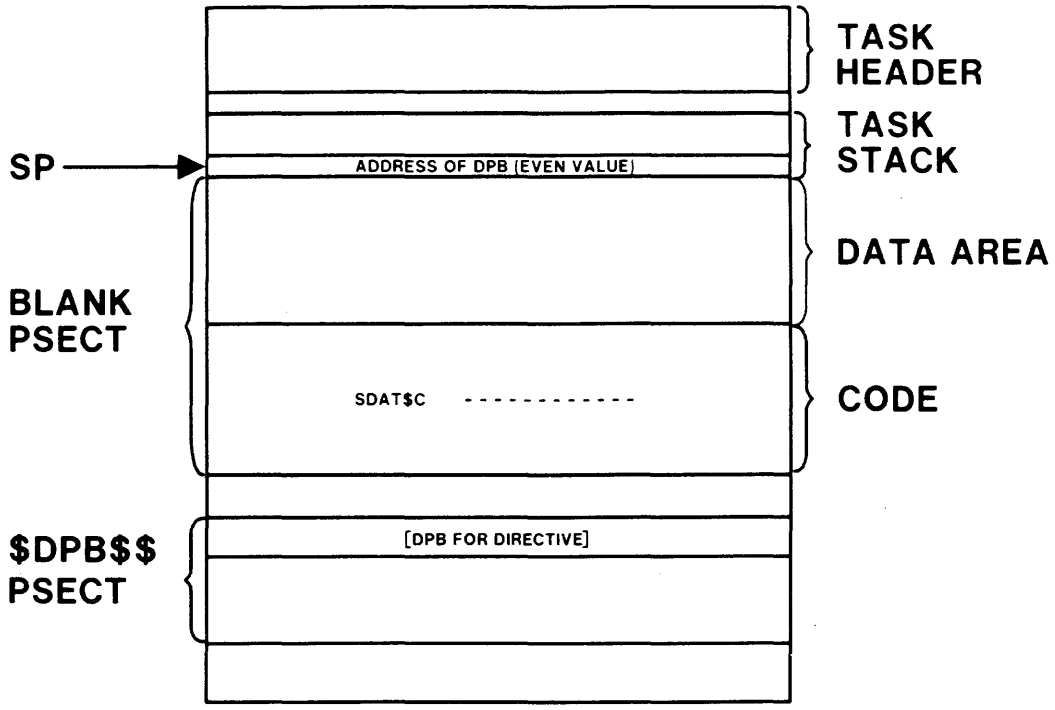


Figure 11-1 Directive Macros: '$C' Form

'$' FORM

```
SEND:   SDAT$   TASKB,BUF,5          SEND:       .BYTE   71.,5
                                                 .RAD50  /TASKB/
                                                 .WORD   BUF
                                                 .WORD   5
        DIR$    #SEND,ERR                        MOV     #SEND,-(SP)
                                                 EMT     377
                                                 BCC     .+6
                                                 JSR     PC,ERR
```

'$C' FORM

```
                                                 .PSECT  $DPB$$
                                     $$$         =       .
                                                 .BYTE   71.,5
                                                 .RAD50  /TASKB/
        SDAT$C  TASKB,BUF,5,PROG1,ERR            .WORD   BUF
                                                 .WORD   5
                                                 .PSECT  PROG1
                                                 MOV     #$$$,-(SP)
                                                 EMT     377
                                                 BCC     .+6
                                                 JSR     PC,ERR
```

'$S' FORM

```
TASKB:  .RAD50  /TASKB/              TASKB:      .RAD50  /TASKB/

                                                 MOV     #5,-(SP)
                                                 MOV     #BUF,-(SP)
                                                 MOV     TASKB+2,-(SP)
        SDAT$S  #TASKB,#BUF,#5,ERR               MOV     TASKB,-(SP)
                                                 MOV     (PC)+,-(SP)
                                                 .BYTE   71.,5
                                                 EMT     377
                                                 BCC     .+6
                                                 JSR     PC,ERR
```

Example 11-1 Macro Expansions for SEND DATA

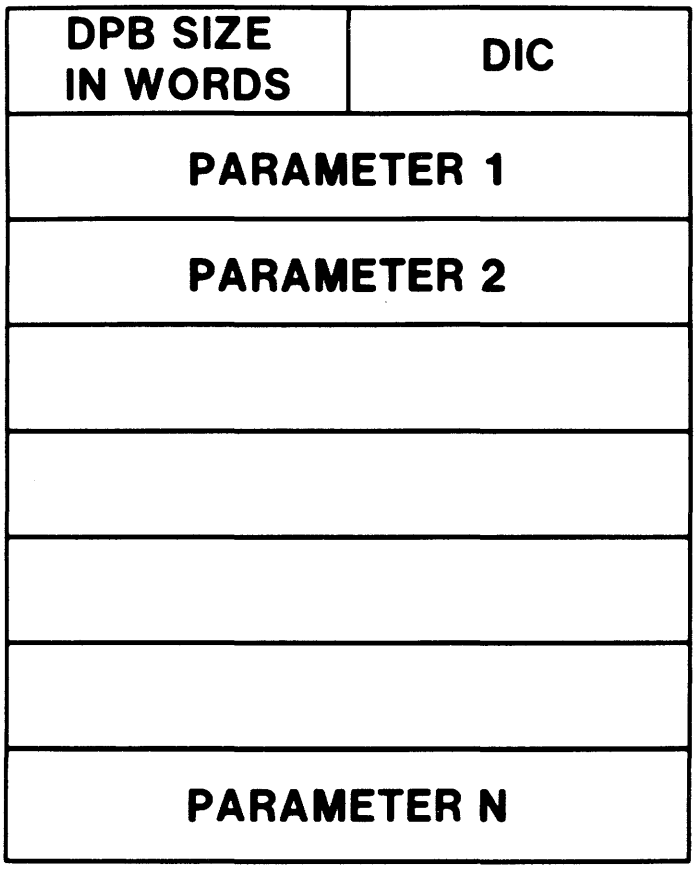


Figure 11-2 The Directive Parameter Block

Directive Status Word

- Executive returns a status code in the DSW
- In general, success is denoted by a status of +1
- The Set/Clear Event Flag directives use

    Ø to indicate success and flag clear

    2 to indicate success and flag set

- An error is indicated by a negative status
- Value stored at location $DSW in the task header (in task region)
- In FORTRAN, value returned in calling argument

THE DIRECTIVE DISPATCHER

- EMT trap causes entry to module DRSUB at $EMTRP
- Module DRDSP is mapped using KERNEL APR5 and control passes to module DRDSP at $DRDSP
- Routine $DRDSP distinguishs between directive calls, calls to $SWSTK and non-RSX EMT traps
- For directive calls

  KERNEL APR6 is used to map

  WDB or RDB if PLAS directive
  DPB otherwise

  Directive processing routine is called

- To process a request to switch to kernel mode, a jump to the Executive routine $SWSTK is executed
- For non-RSX EMT traps, a jump to $EMSST in SSTSR is executed

The Directive Dispatch Table

- Contains entry for each directive

  Address of service routine
  'Flags byte'
  Length in words (For variable length = Ø)

- Assembled in one of two possible forms

  Single table form

  Two words per possible directive

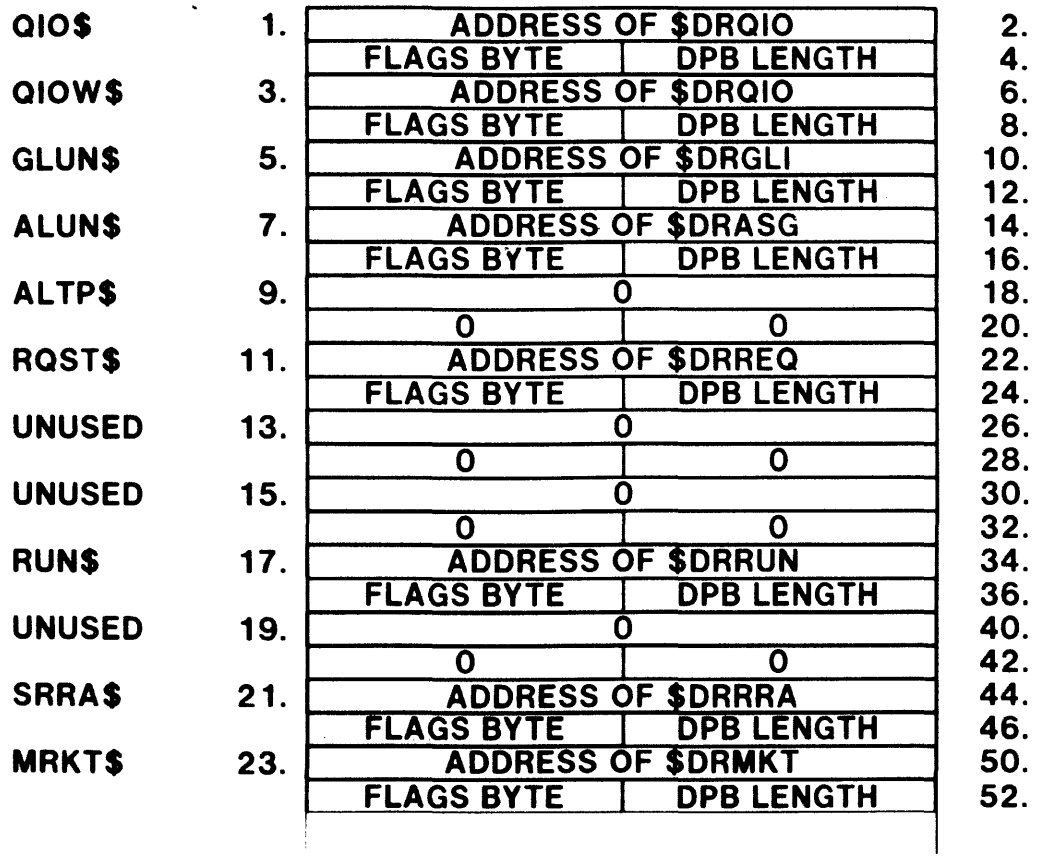
  Double table form

  One byte per possible directive
  Two words per existing directive

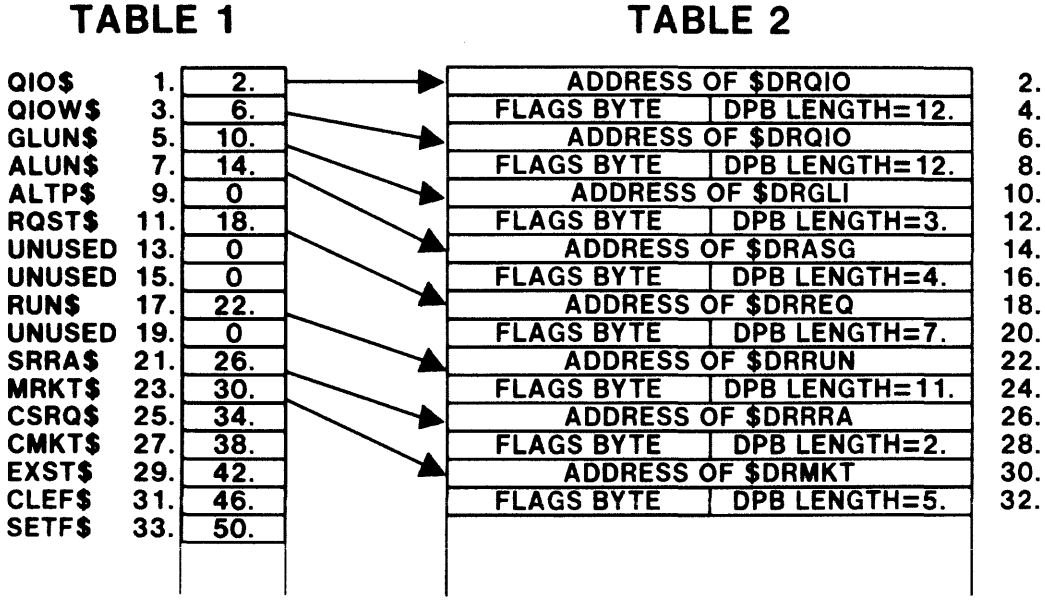
- The form which uses the least space is automatically chosen

  If less than 75 percent of directives exist, use the two table structure

  If 75 percent or more of the possible directives exist, use the one table structure



Single Table Form



Double Table Form

Figure 11-3 The Directive Dispatch Table

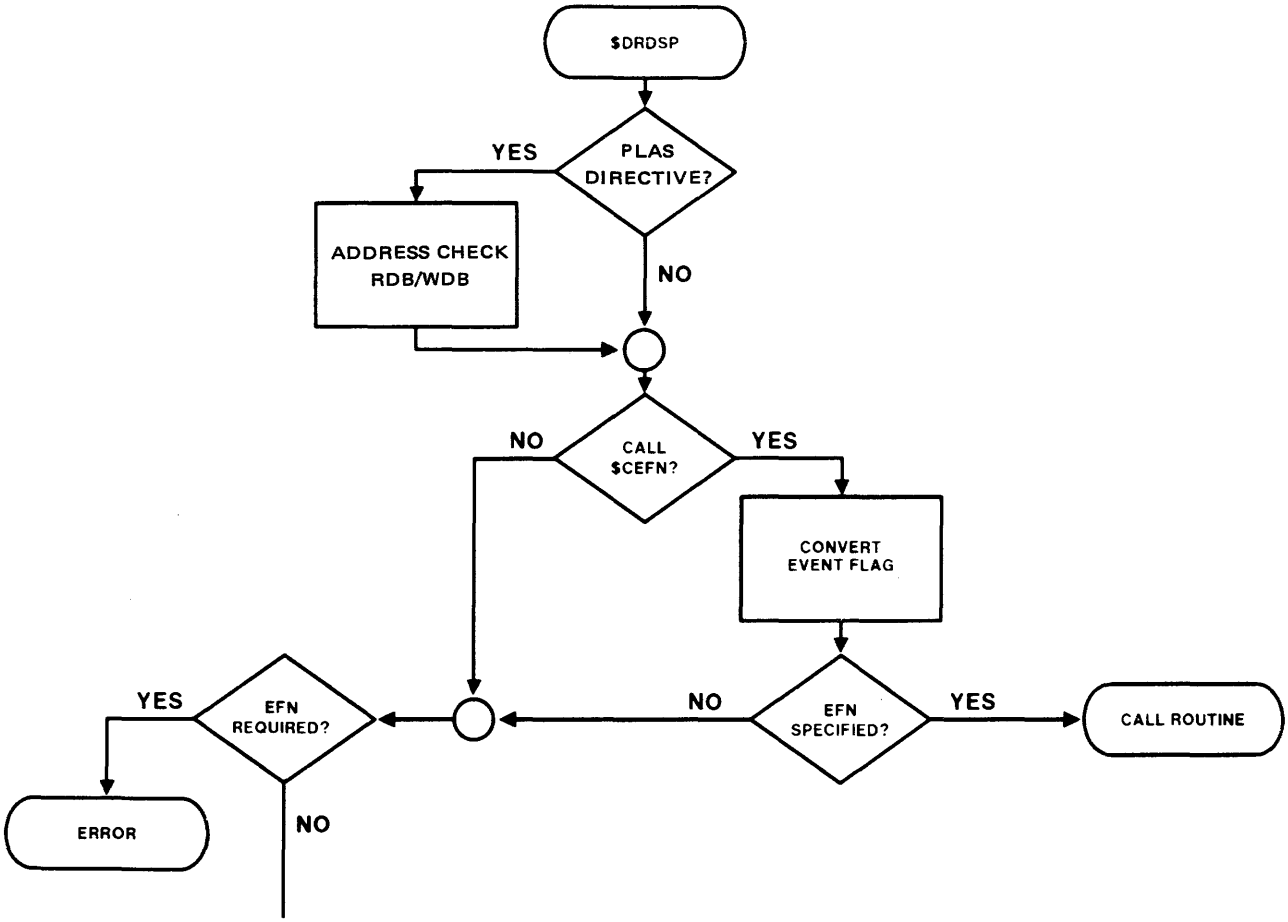


Figure 11-4 Processing in DRDSP
(Sheet 1 of 2)

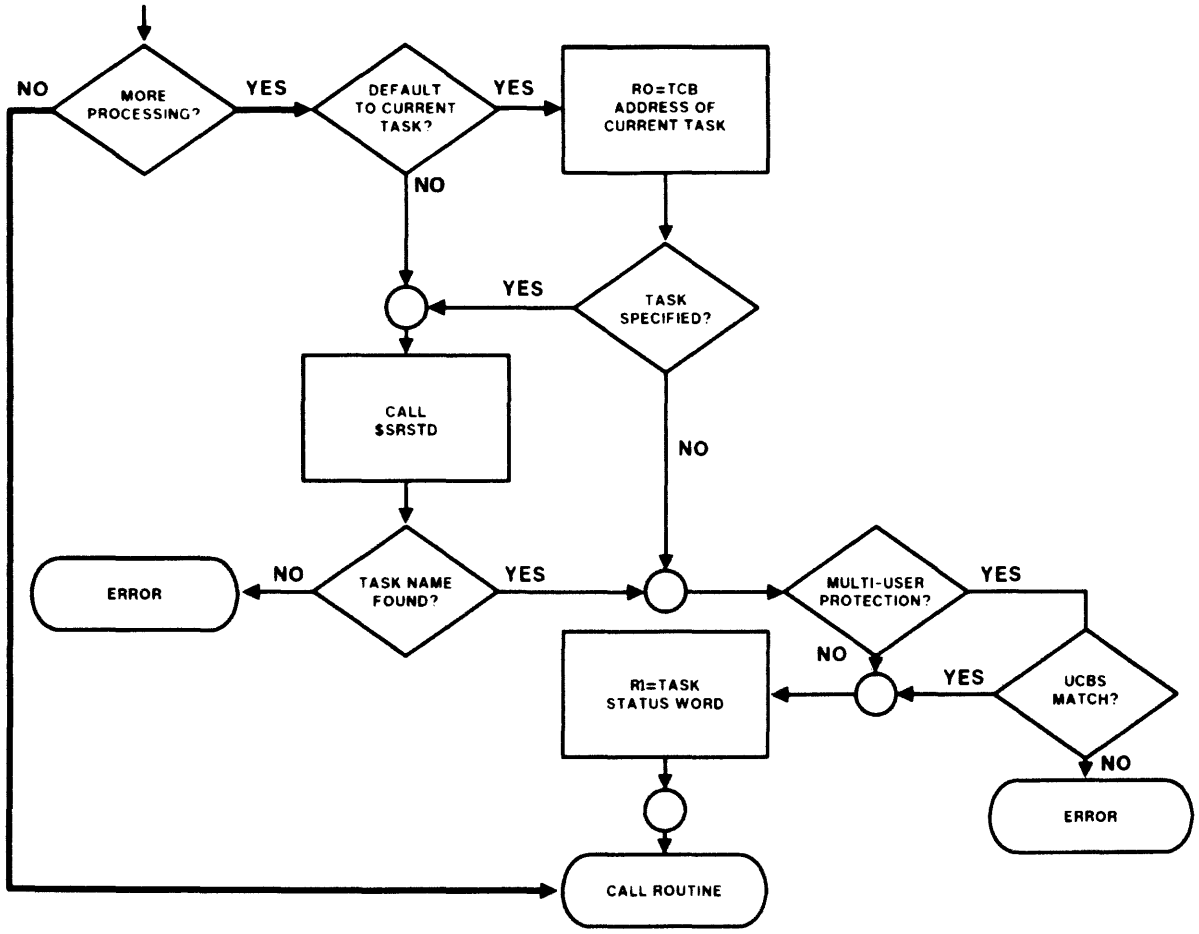


Figure 11-4 Processing in DRDSP
(Sheet 2 of 2)

DIRECTIVE PROCESSING ROUTINES

The Interface

- Directive processing routine is called with registers loaded as in Table 11-1
- Flag byte in directive dispatch table determines processing

  ACHKDB - Address PLAS definition block

  CEFNCL - Convert the event flag

  GEFUSE - Do not increment group global use count

  CEFNMT - Event flag must be specified

  DFCTSK - Task name defaults to current task

  MUPCHK - Perform multi-user protection check

  SRSTCL - Call $SRSTD to find TCB in STD

- Bits set in flag byte determine contents of RØ and R1

  If CEFNCL specified
  RØ - Event flag mask word
  R1 - Address of event flag

  If SRSTCL specified
  RØ - TCB address of specified task
  R1 - Address of status word in TCB

Table 11-1 Register Usage

Register	Contents
R5	Address of the TCB of the current task
R4	Address of the header of the current task
R3	Address of the next word in the DPB
R2	Address of the second task status word of the current task
R1	Depends on directive
R0	Depends on directive

The Directive Commons

- Most directive processing code removed from Executive

  Increases available DSR

- Two directive commons, EXCOM1 and EXCOM2

  Existence of commons determined at SYSGEN

  Kernel I-space APR 5 used to map directive commons

  Location of processing routine indicated by low order bit of address of routine in DDT

- Module DRSUB

  Is in the Executive

  Always mapped

  Contains the location $EMTRP

  Calls $DIRSV
  Maps to DRDSP which is in EXCOM1
  Contains coroutines $MPXC1 and $MPXC2 which are used to map EXCOM1 and EXCOM2

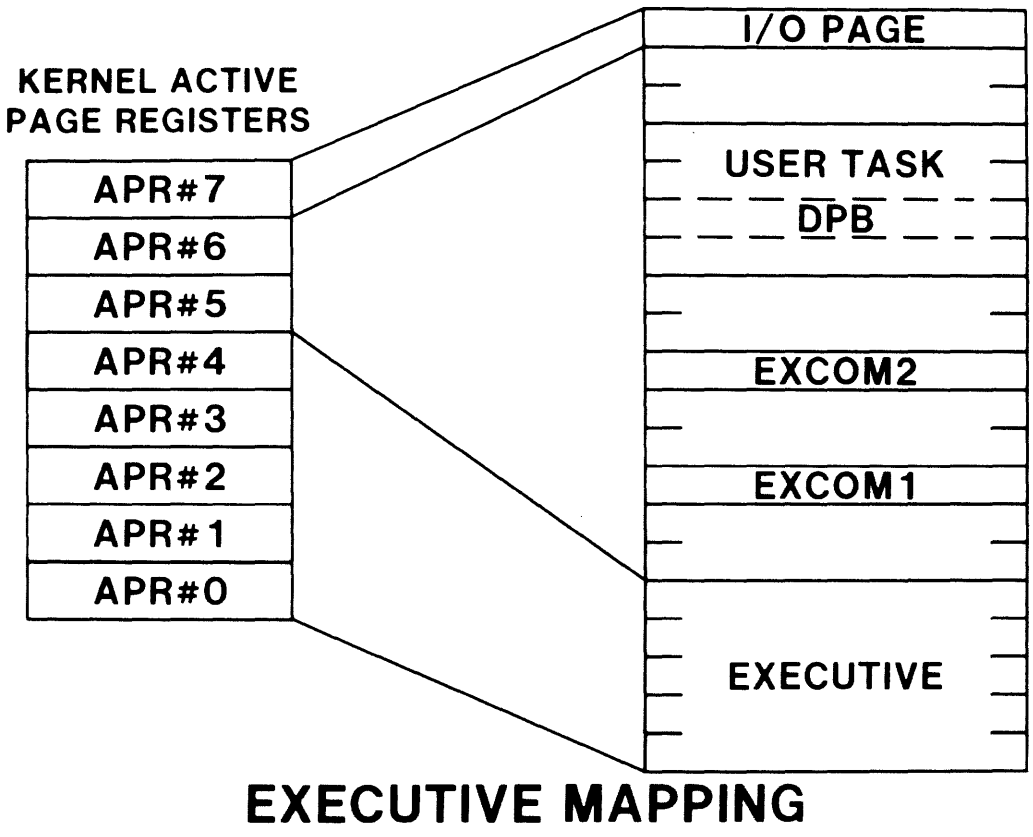


Figure 11-5 The Directive Commons: Standard Executive Mapping

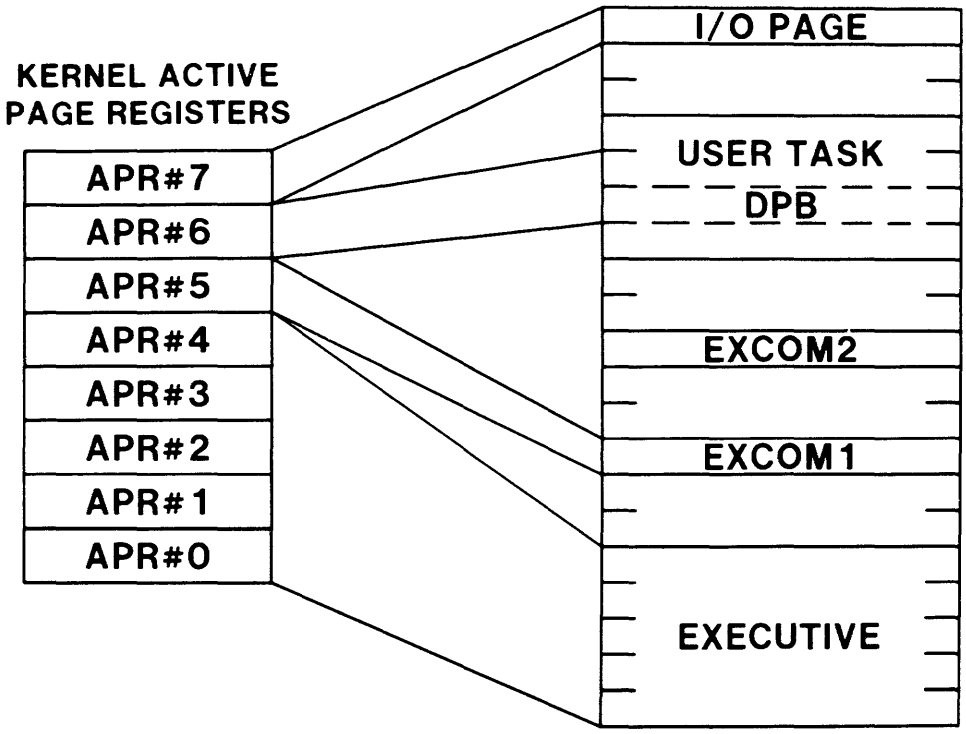


Figure 11-5 The Directive Commons: Mapping to Reference EXCOM1

Table 11-2 Directive Processing Modules

Module	Location	Routines
DRABO	EXCOM1	$DRABO
DRASG	EXCOM2	$DRATX
DRATP	EXCOM2	
DRATX	EXCOM1	
DRCIN	EXCOM2	$DRCIN, $DISIN
DRCLI	EXCOM1	$DRCLI, $STCLI, $STCL1
DRCMT	EXCOM1	
DRDAR	EXCOM1	$DRDAR, $DREAR
DRDCP	EXEC	$DRDCP, $DRECP
DRDSP	EXCOM1	$TRTRP, $DRTRP, $EMTRP, $DRDSP, $DRATP
DREIF	EXEC	$DREIF, $DREXT, $DREX1
DREXP	EXCOM2	$DREXP
DRGCL	EXCOM1	$GRGCL, $RLMCB, $RLCIB
DRGEF	EXCOM2	$DRCRE, $DRELE, $UNLCK, $GTGEF
DRGLI	EXCOM1	$DRGLI
DRGPP	EXCOM1	$DRGPP
DRGSS	EXCOM1	$DRGSS
DRGTK	EXCOM1	$DRGTK
DRGTP	EXCOM2	$DRGTP
DRMAP	EXCOM2	$DRCRW, $DRELW, $DRMAP, $DRUNM, $DRSRF, $DRRRF $DRGMX
DRMKT	EXCOM1	$DRMKT, $DRRUN
DRPUT	EXCOM1	$DRREX, $CAAST, $DRFEX, $DRPUT, $DRRRA, $DRRCV
DRQIO	EXCOM1	$DRQIO
DRRAS	EXCOM1	$DRRCS, $DRREC, $DRSND
DRREG	EXCOM2	
DRRES	EXCOM1	$DRUNS, $DRRES, $DRSTP, $DRSPN
DRSED	EXCOM1	$DRCEF, $DRRAF, $DRSEF, $DRSTS, $DRSTL, $DRWFL $DRWFS
DRSMG	EXCOM2	
DRSPW	EXCOM1	
DRSST	EXCOM1	$DRSDV, $DRSTV
DRSUB	EXEC	$ELGEF, $DEAGF, $SRGEF, $DRDSE, $TKWSE, $DRWSE $MPXC1, $MPXC2, $DETRG, $CITFR, $DRQRQ, $SRCCQ $GTUCB, $STCLI, $FNCLI, $TRTRP, $EMTRP, $OTHR1 $DRATP

Send/Receive Processing

- Used to transfer a 13-word data packet to a specified task
- Routine $DRSND in module DRRAS used to send data
- Routine $DRREC in module DRRAS used to receive data
- Steps in sending/receiving

An 18-word send/receive data block is allocated in DSR

Link word for receive queue
Sender name in RAD5Ø
13-word data area
UCB of TI: of sender
Current UIC of sender

A 13-word buffer in sender task is copied into DSR block

A 15-word buffer in user task receives sender name and data

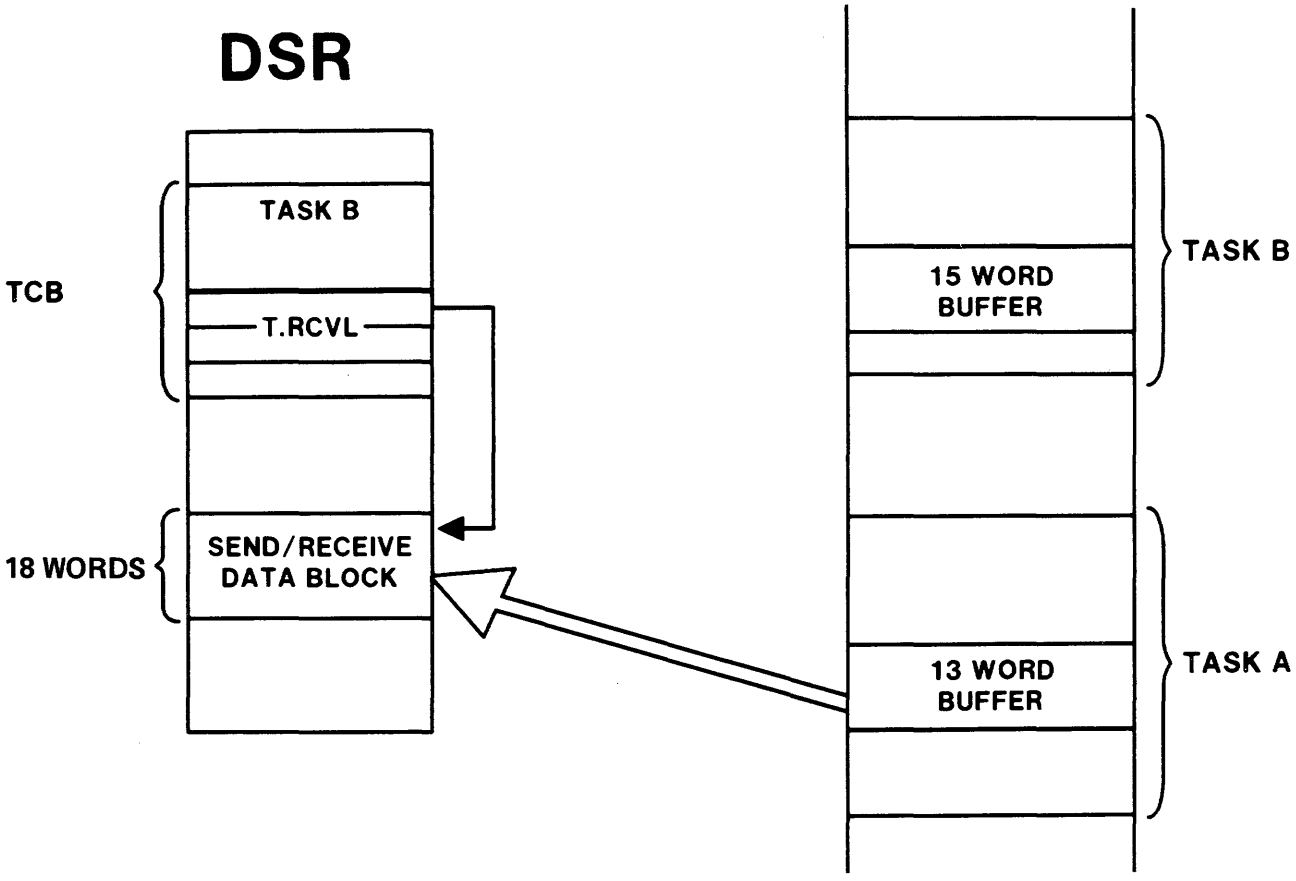


Figure 11-6 Send/Receive Processing: Send from TASK A

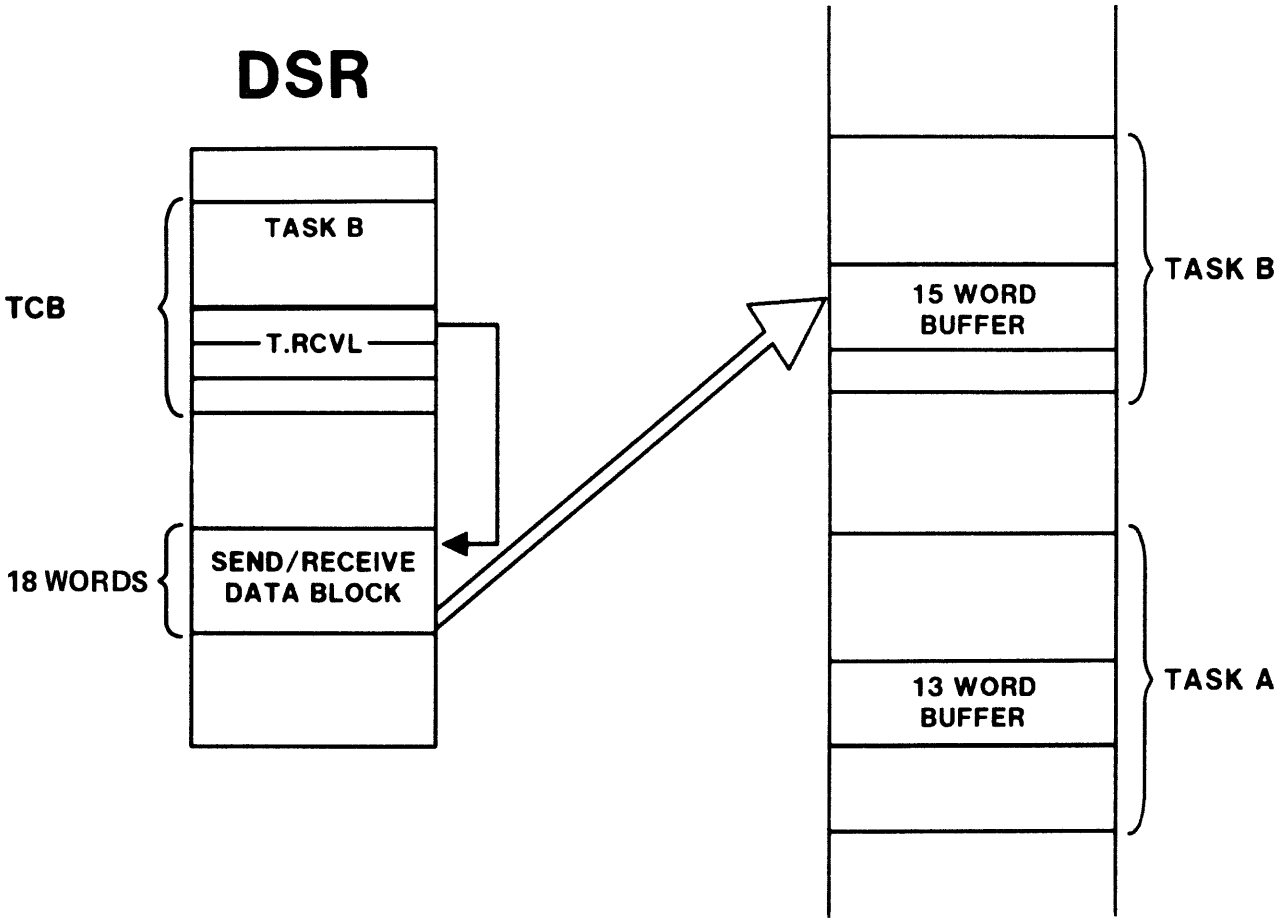


Figure 11-6 Send/Receive Processing: Receive by TASK B

Parent/Offspring Tasking

- Connecting TASKA to TASKB

  TASKB passes a one-word status back to TASKA when

  TASKB exits
  TASKB emits status

  TASKA is the parent task, TASKB is the offspring task

- TASKA spawns TASKB

  TASKA requests TASKB

  TASKA connects to TASKB

- Steps in connecting

  A 14-word offspring control block is allocated in DSR

  OCB is linked to the TCB of the offspring task at T.OCBH

  When offspring exits or emits status, status moved to OCB placed into first word in 8-word status area

  Status automatically moved into parent status buffer

  Parent task specifies event flag and/or AST for notification of the offspring's return of status

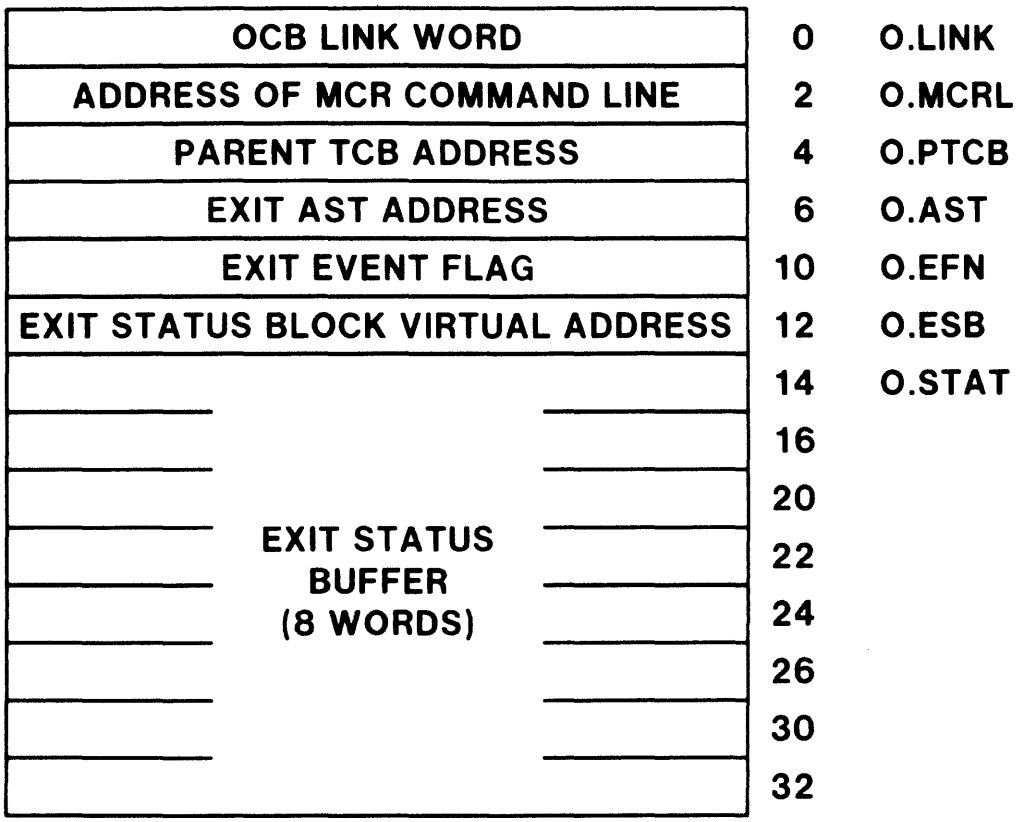


Figure 11-7 Parent/Offspring Tasking: Offspring Control Block

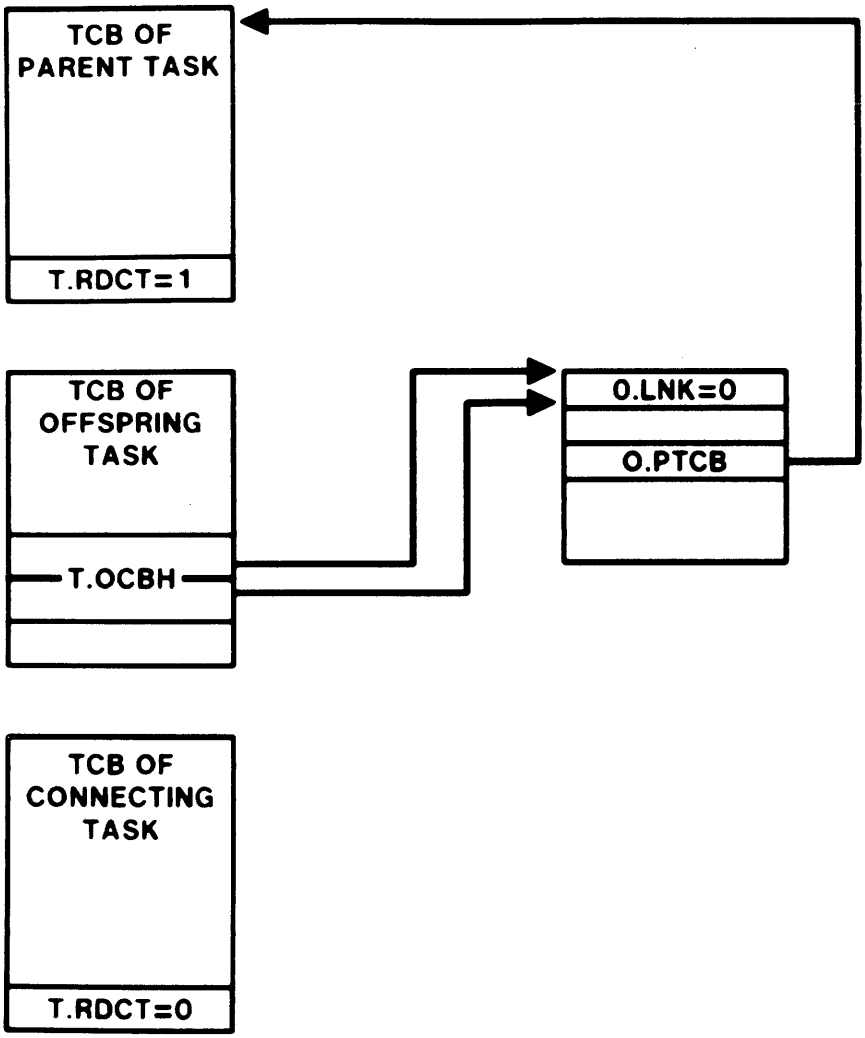


Figure 11-7 Parent/Offspring Tasking: Spawning a Task

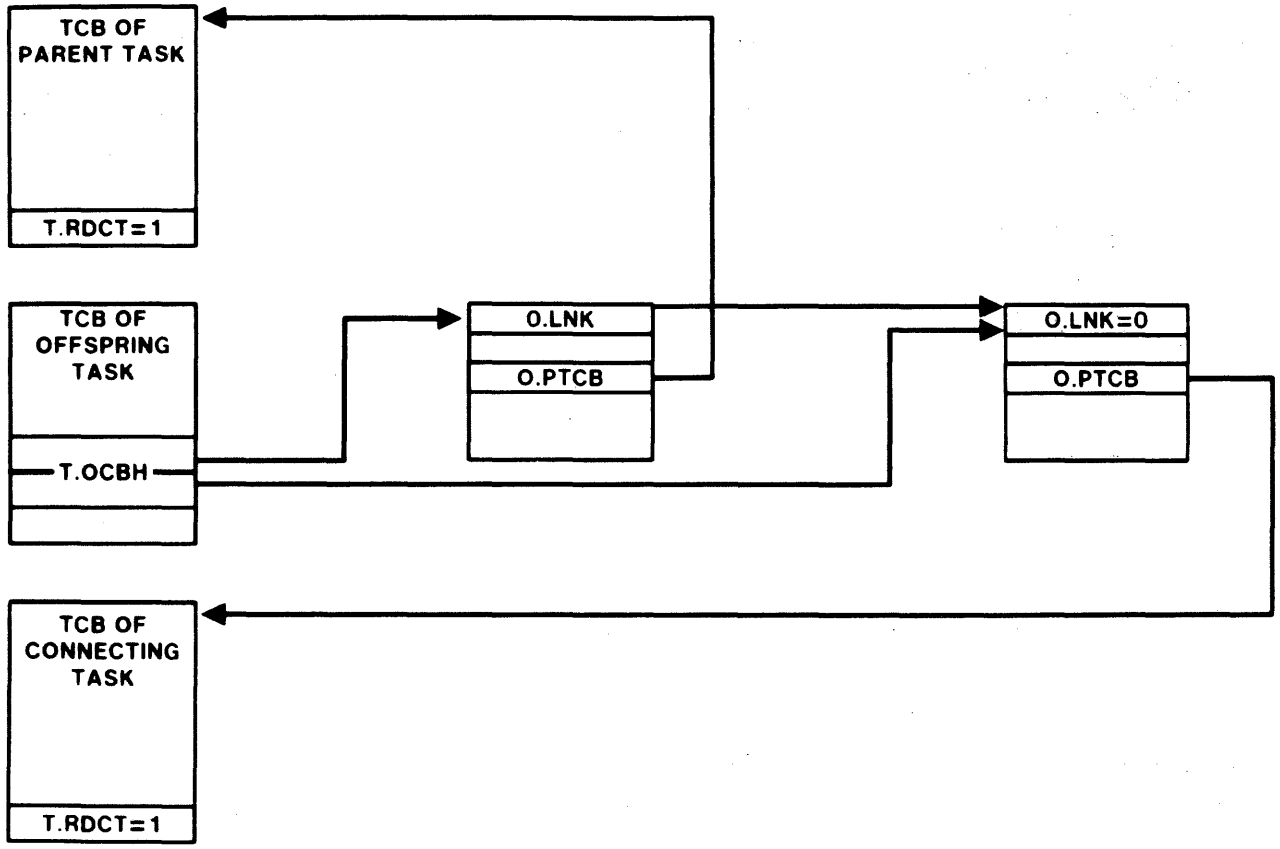
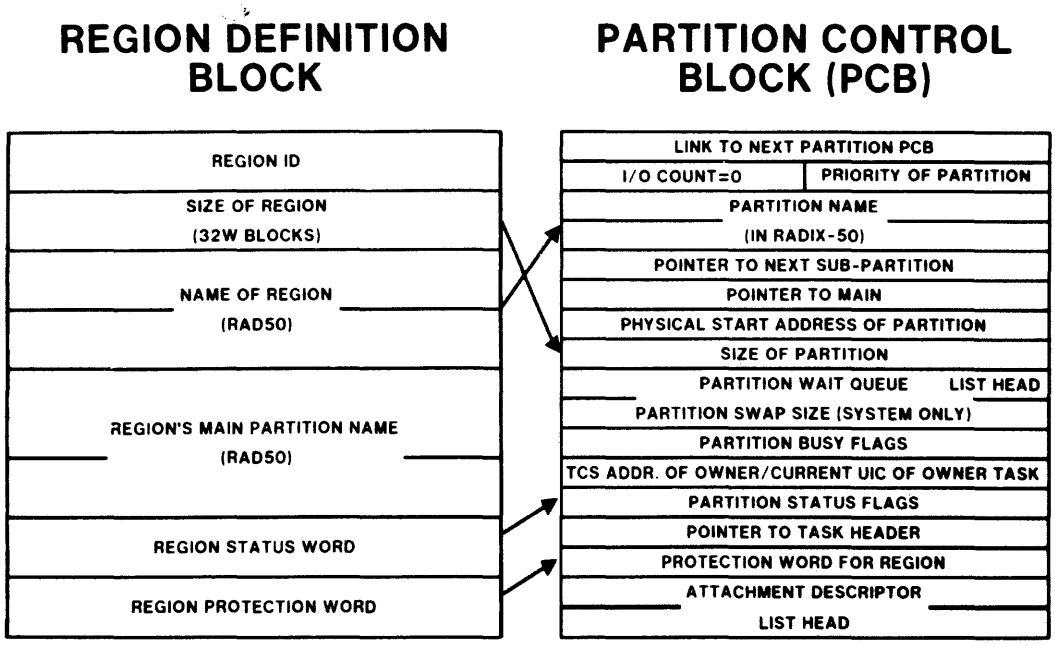


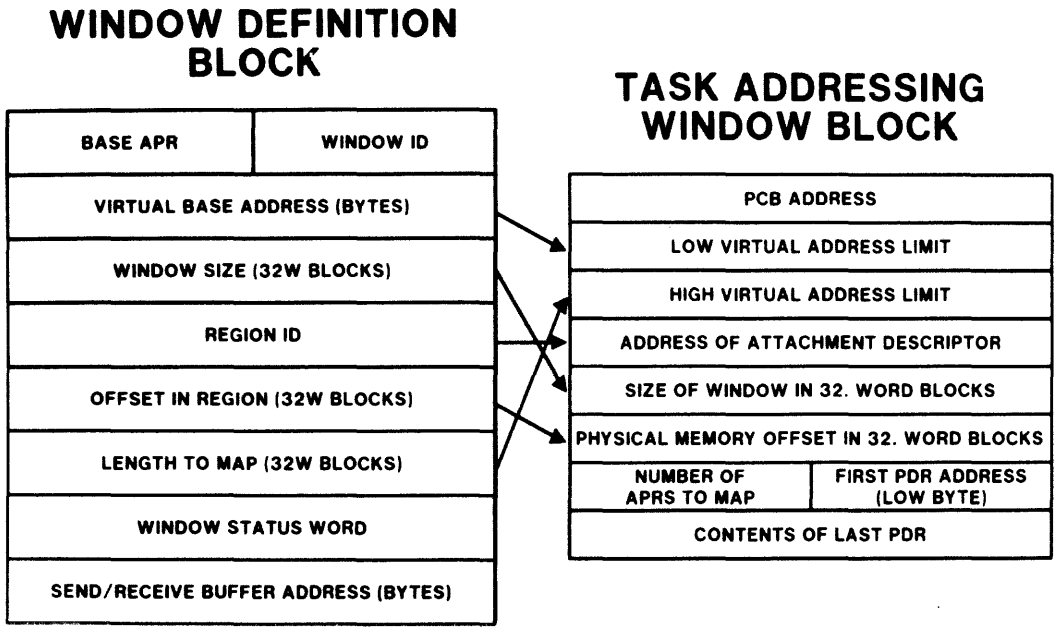
Figure 11-7 Parent/Offspring Tasking: Connecting to a Task

Memory Management Processing

- User task specifies information for creating/attaching to a region in a Region Definition Block (RDB)
- Information in RDB used to initialize PCB for subpartition in dynamic partition
- User task specifies information for creating/mapping an addressing window in a Window Definition Block (WDB)
- Information in WDB used to initialize window block in task header



CREATING A REGION



CREATING AND MAPPING A WINDOW

Figure 11-8 Memory Management Processing

ADDING A USER-WRITTEN DIRECTIVE

- Interface to the directive processing

  Structure of Directive Parameter Block must be determined

  Entry for new directive must be added to the DDT

  Directive processing routine must be written

  Macros to invoke directive must be written

  Directive processing routine must be built into the system

  Macros must be added to the system macro library

Structuring the Directive Parameter Block

- Information needed to execute directive
- Choose an unused DIC
- Choose order for necessary parameters

  If event flag is first parameter, specify CEFNCL and/or CEFNMT

  If task name is first parameter, specify DFCTSK and/or SRSTCL

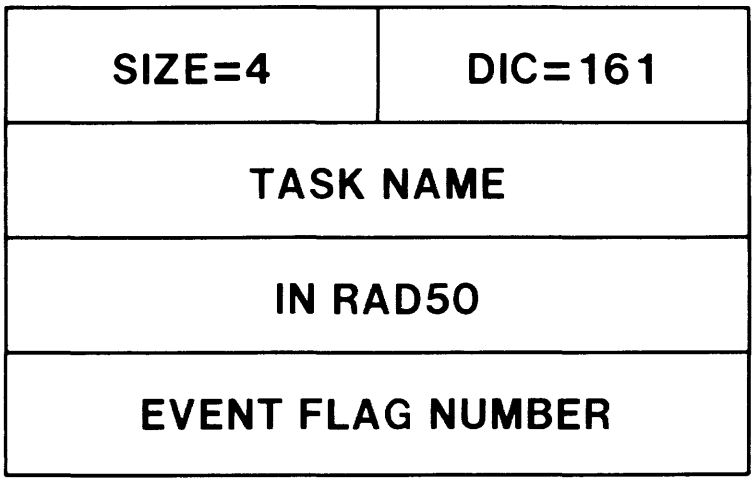


Figure 11-9 Directive Parameter Block for New Directive

Changes to the Directive Dispatcher

- DDT determines

  Which directive processing routine to call

  What processing to perform in DRDSP

  Size of DPB

  Where the module is to be located (directive commons)

- Each directive is represented by a line in the DIREC macro defined in the module DRDSP

- Format of line in DIREC macro is

```
MAC   DIC,DPBSIZ,DIRADR,MASK,COND,SECOND
```

Where

DIC	-	Directive Identification Code
DPBSIZ	-	Size of the DPB
DIRADR	-	Address of the Directive Processing Routine
MASK	-	Directive Processing Control Mask
COND	-	Conditional Assembly Parameters which must be defined if the directive is supported
SECOND	-	Conditional assembly parameters which if defined require that the directive have a variable length DPB

Example:

```
MAC   55.,2.,$DRCRR!PAG,<ACHKDB>,P$$LAS
```

This is the 'create region' directive.

PAG is set to 1 if directive common support is desired, Ø otherwise. The service routine will be placed in EXCOM2.

Place the following in the Directive Dispatch Table

```
        MAC   161.,4.,$DRFLG!PAG,<DFCTSK!SRSTCL>

DIC
Size of DPB
Processing Routine
Force to EXCOM2
Default to current task
Call $SRSTD to find TCB
```

Example 11-2 New Entry in the Directive Dispatch Table

The Directive Processing Routine and Macros

- Routine should be written to make use of the standard register usage in DRDSP
- Assembly with EXEMC and RSXMC
- Provide only macros needed by applications

```
        .TITLE  DRFLG
        .IDENT  /1.0/
;+
;  ** - $DRFLG - SET TASK'S LOCAL EVENT FLAG
;
;  THIS DIRECTIVE INSTRUCTS THE SYSTEM TO SET A SPECIFIED TASK'S LOCAL
;  EVENT FLAG.
;
;  DPB FORMAT:
;
;       WD. 00 -- DIC (161.), DPB SIZE (4.)
;       WD. 01 -- FIRST HALF OF TASK NAME (RAD50)
;       WD. 02 -- SECOND HALF OF TASK NAME (RAD50)
;       WD. 03 -- EVENT FLAG NUMBER (1-32.)
;
;  INPUTS:
;       R0 = TCB ADDR. OF TARGET TASK
;       R1 = ADDR. OF FIRST TASK STATUS WORD
;       R2 = ADDR. OF SECOND TASK STATUS WORD
;       R3 = ADDR. OF NEXT WORD IN DPB
;       R4 = ADDR. OF HEADER OF CURRENT TASK
;       R5 = ADDR. OF TCB OF CURRENT TASK
;
;  OUTPUTS:
;       C = 0 IF DIRECTIVE IS SUCCESSFULLY COMPLETED
;             DIRECTIVE STATUS D.RS22 IS RETURNED IF EVENT FLAG IS
;               ALREADY SET
;             DIRECTIVE STATUS D.RS00 IS RETURNED IF EVENT FLAG WAS
;               CLEARED
;       C = 1 IF DIRECTIVE IS REJECTED
;             DIRECTIVE STATUS D.RS97 IS RETURNED IF ILLEGAL EVENT
;               FLAG
;-
        .ENABL  LSB
$DRFLG::
        MOV     R0,R5   ;ADDR OF TARGET TASK TCB
        CALL    $CEFN   ;CONVERT TO EVENT FLAG MASK
        BCS     20$     ;ILLEGAL EVENT FLAG
        BIT     R0,(R1) ;EVENT FLAG ALREADY SET?
        BEQ     10$     ;NO, IF EQUAL
        DRSTS   D.RS22  ;RETURN STATUS
10$:    BIS     R0,(R1) ;SET THE EVENT FLAG
        DRSTS   D.RS00  ;RETURN STATUS
20$:    DRSTS   D.RS97  ;ILLEGAL EVENT FLAG STATUS
        .END
```

Example 11-3 Processing Routine for New Directive

```
;+
;       $ FORM OF MACRO FOR $DRFLG
;
        .MACRO  SLEF$ TN,EFN
        .BYTE   161.,4
        R50$    TN
        .WORD   EFN
        .ENDM   SLEF$
;+
;       $C FORM OF MACRO FOR $DRFLG
;-
        .MACRO  SLEF$C TN,EFN,ERR,PST
        .PSECT  $DPB$$
$$$     =       .
        .BYTE   161.,4
        R50$    TN
        .WORD   EFN
        .PSECT  PST
        MOV     #$$$,-(SP)
        EMT     ^O<377>
        .IF NB ERR
        BCC     .+6
        JSR     PC,ERR
        .ENDC
        .ENDM   SLEF$C
;+
;       $S FORM OF MACRO FOR $DRFLG
;-
        .MACRO  SLEF$S TN,EFN,ERR
        MOV$    EFN
        RFA$    TN
        MOV     (PC)+,-(SP)
        .BYTE   161.,4
        DIR$    ,ERR
        .ENDM   SLEF$S
```

Example 11-4 Macros for New Directive

Adding a Directive to the System

- Directive can be included in the Executive or in EXCOM2

  In the Executive if

  Directive commons not chosen at SYSGEN

  Not enough room in EXCOM2

  Otherwise in EXCOM2

- To include in the Executive

  Build with the Executive during SYSGEN

- To include in EXCOM2

  Build with EXCOM2 during SYSGEN

- Macros included in system macro library RSXMAC.SML

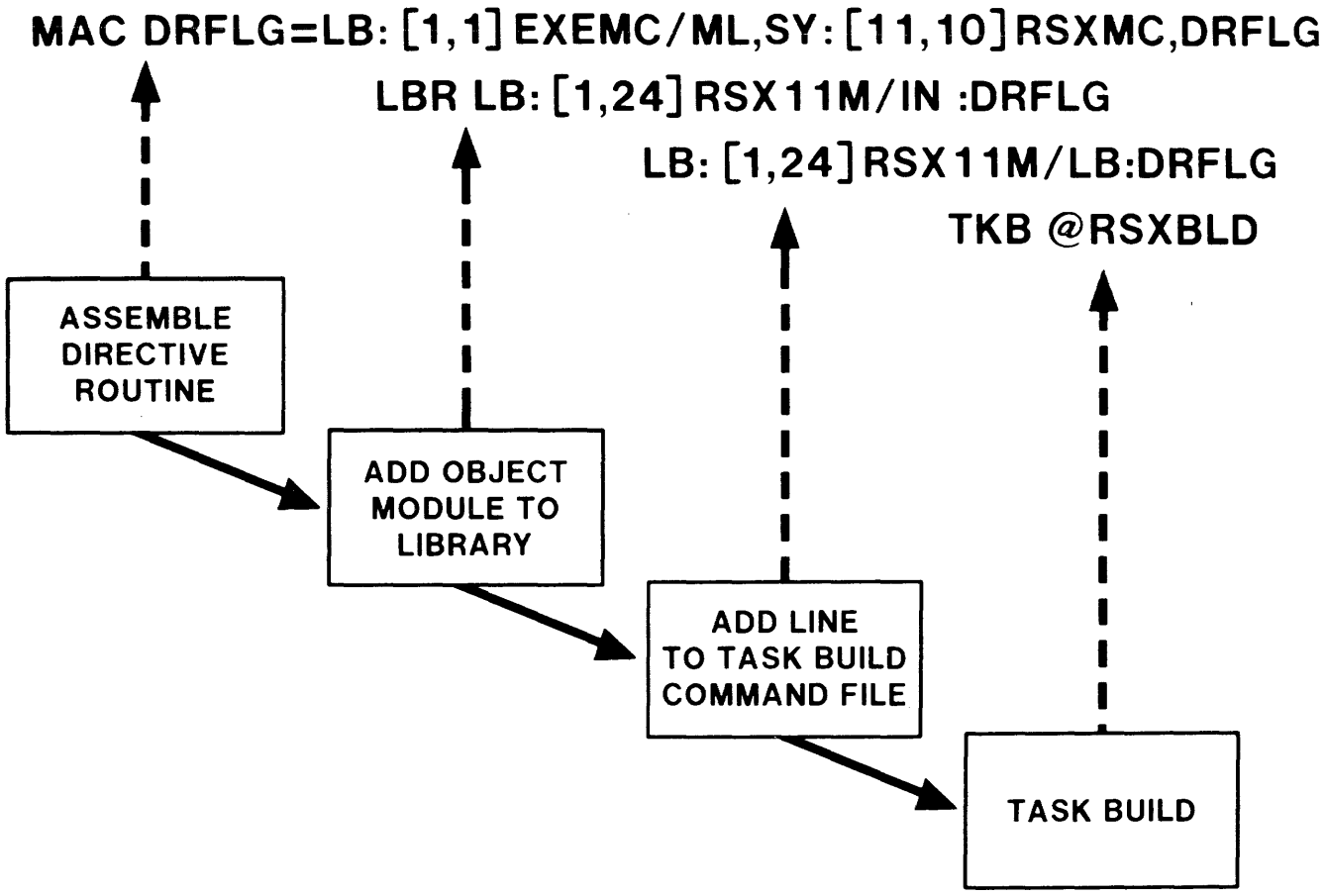


Figure 11-10 Assembling and Taskbuilding the Processing Routine

I/O PROCESSING

12

INTRODUCTION

Any modern operating system must provide a complete I/O system. Besides providing basic I/O device handling software, it must also provide a convenient file system.

Device drivers handle primitive I/O functions under RSX-11M. These drivers are tailored to individual devices and optimized to provide maximum performance. They are invoked by means of the QIO mechanism.

RSX-11M uses the FILES-11 file system. There are two levels of software support in the operating system for FILES-11. The more visible level includes the file access systems, FCS, and RMS. These systems provide all features needed in any application under RSX-11M. A more primitive level, in the form of ACPs (F11ACP), forms the interface between FCS/RMS and device drivers.

OBJECTIVES

1. Diagram the flow in the I/O system.
2. List the types of ACPs and their differences.
3. List the steps in processing an I/O request within DRQIO.

RESOURCES

1. RSX-11M System Lists and Data Structures
2. RSX-11M Guide to Writing an I/O Driver
3. RSX-11M/M-PLUS I/O Operations References Manual

OVERVIEW

Components of the I/O System

- The File System

  Used to structure data for convenient use in applications

  Provides software for easy manipulation of data

  Consists of:

    FILES-11 structures

    File Control Services (FCS)

    Record Management Services (RMS)

- QIO directive

  Used to request I/O service from the Executive

  Can be used directly in user task

  All file-system I/O requests converted into QIOs

- Device Drivers

  Used to control physical devices and perform actual I/O

  One required for each device type

  Carry I/O requests to transfer data

- Ancillary Control Processor (ACP)

  Performs functions subordinate to those of the driver

    Provides a file system for user tasks

    Handles protocols needed by a communications network

  Converts I/O requests into one or more request to a device driver

  Manipulates I/O parts of the system data base

  Three ACPs provided with RSX-11M

    F11ACP: Files-11

    MTAACP: Magtape I/O ACP

    NETACP: DECNET ACP

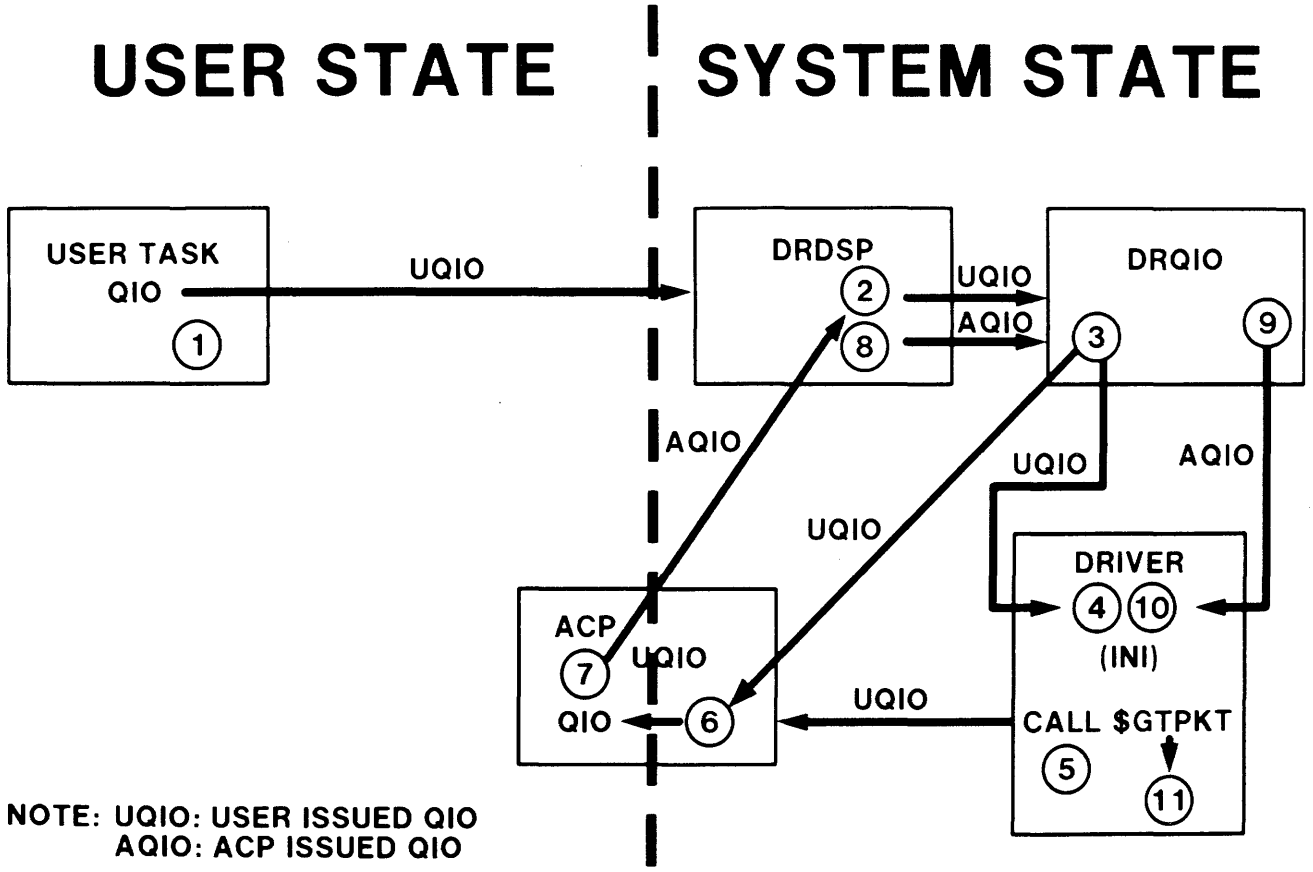


Figure 12-1 The I/O Process

Initiating I/O From a User Task

- Use QIO directives

  Harder to use than other methods

  Can be the most efficient method of I/O

  For file I/O, use virtual block transfers

  For non-file I/O, use logical block transfers

- Use high-level language I/O commands

  Easier to use than QIOs, but less efficient

  Language processor may convert to QIOs or convert to FCS/RMS commands

- Use FCS/RMS to perform file system I/O

  Allows data to be accessed in a form natural to the application

  File processor converts to QIOs

Processing I/O Request in DRQIO

- All I/O performed as a result of QIO directives
- QIO directive parameters are checked; directive status is returned
- Parameters used to create I/O packet
- I/O packet is queued to a device driver or to an ACP
- If ACP function, a number of checks are performed before queuing I/O packet

QIO PROCESSING

Logical Units

- Logical Unit Numbers (LUNs) identify the device to which I/O is to be performed
- LUN determines a unique entry in the task's Logical Unit Table (LUT) in the task header
- Each entry in the LUT is two words long
- When a task is installed, the first word of each LUT entry is initialized with the UCB address of the device
- When a file is opened on a volume, the second word of the corresponding LUN points to a FILES-11 window block

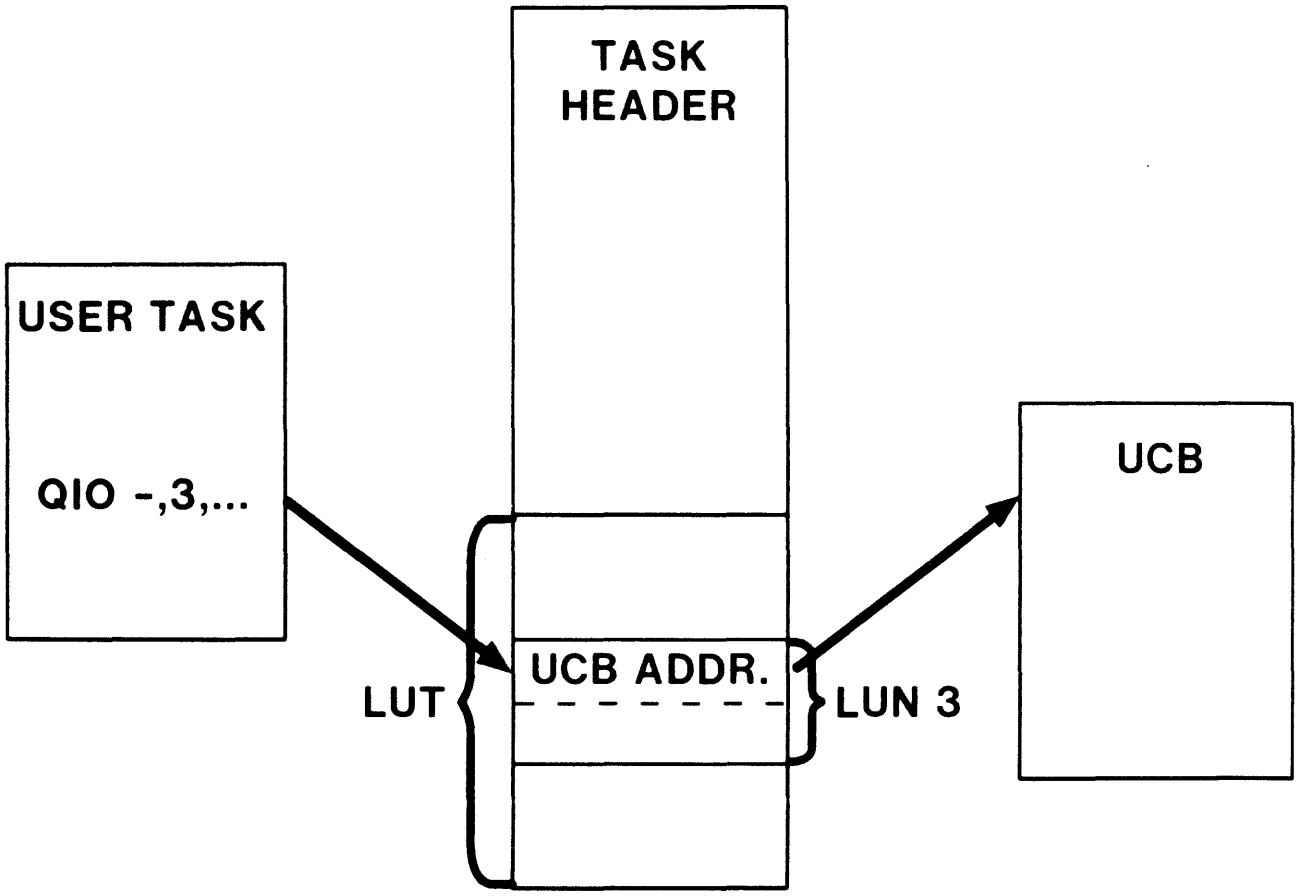


Figure 12-2 Logical Units

Processing Within DRQIO

- Locates the UCB for LUN

  Calls $MPLUN in module EXESB

- Checks to see if driver resident

  Location D.DSP in the DCB

- Clears specified event flag
- Clears I/O status block if specified
- QIO directive is now successful

  DSW shows success

  Any errors are reported as I/O errors in the IOSB

- Allocates space for I/O packet in POOL

  Calls $ALPKT in module CORAL

- Increments I/O request count in the TCB
- Copy data from DPB to I/O packet
- If function is IO.KIL, go the routine $IOKIL in module IOSUB
- Check if task has privileges to perform I/O
- Check function code against function masks in DCB
- If not legal function, return I/O error
- If control function, queue I/O packet to driver
- If 'no-op' function, return successful status
- If ACP function to mounted device, perform ACP function checks

The ACP Function Checks

- Implemented by a collection of primitive routines
- Each ACP requires a different group of these routines
- A two-level dispatch table, the Polish Interpreter Database, is used
- First level table, the Function Code Dispatch Vector, resides at FCDSP in DRQIO

  Each entry corresponds to a unique function code

  Each entry is a vector which points to a second level dispatch table

- Second level dispatch table contains primitive routines to be called

Table 12-1 Function Code Dispatch Vector

Function Code	Dispatch Table	Function
10	FCIFC	Illegal function
11	FCPKT	Find file name in directory
12	UNLCK	Unlock Block
13	FCPKT	Remove file name from directory
14	FCPKT	Enter file name in directory
15	FCACC	Access file for READ
16	FCACC	Access file for READ and WRITE
17	FCACC	Access file for READ, WRITE, and EXTEND
20	FCDAC	Deaccess file
21	FCRVB	Read Virtual Block
22	FCWVB	Write Virtual Block
23	FCEXT	Extend file
24	FCCRE	Create file
25	FCDEL	Mark file for DELETE/TRUNCATE file
26	FCPKT	Read file attributes
27	FCPKT	Write file attributes
30	FCPKT	User magtape control function
31	FCWVB	Transmit process message
32	FCRVB	Receive process message
33	FCCON	Connect to process
34	FCDIS	Disconnect from process
35	FCNCT	Network control process
36	FCIFC	Illegal function
37	FCIFC	Illegal function

Table 12-2 Polish Routines

Table	Routine	Function
FCIFC	IEIFC	Set illegal function status
FCACC	CKDMO	Check if volume marked for dismount
	CKALN	Check if file already accessed on LUN
	CKMOU	Check volume mounted this user
	CKACP	Set flag to queue to ACP
	BDPKT	Build an I/O packet
	CKRLK	Synchronize access and exit
FCDAC	CKNLN	Check if file accessed on LUN
	CKQMT	Queue to MTAACP if ANSI
	BDPKT	Build an I/O packet
	CKRLK	Synchronize and exit
FCRVB	CKNLN	Check if file accessed on LUN
	CKRAC	Check read access and exit
FCWVB	CKNLN	Check if file accessed on LUN
	CKWAC	Check write access and exit
FCCRE	CKDMO	Check if volume marked for dismount
	CKALN	Check if file accessed on LUN
	CKPKT	Join common ACP and check mount
FCDEL	CKTRN	Check if really truncate
	CKACP	Set flag to queue to ACP
	CKMOU	Check volume mounted by this user
	BDPKT	Build an I/O packet
	CKXIT	Exit
FCPKT	CKACP	Set flag to queue to ACP
	CKMOU	Check volume mounted by this user
	BDPKT	Build an I/O packet
	CKXIT	Exit
FCEXT	CKPND	Increment window pending count for extend
UNLCK	CKNLN	Check if file accessed on LUN
	UNLXT	Set registers and exit
FCCON	CKDMO	Check if volume marked for dismount
	CKALN	Check if process already connected on LUN
	CKCON	Address check connect buffer
	CKRLK	Interlock LUN usage and exit

Table 12-2 Polish Routines (Cont)

Table	Routine	Function
FCDIS	CKNLN	Check if process connected on LUN
	CKDIS	Check buffer and copy parameters
	CKRLK	Interlock LUN usage and exit
FCNCT	CKDMO	Check if volume marked for dismount
	CKCON	Address check buffer
	CKXIT	Exit

Queuing I/O Requests

- I/O request packets are queued by routine $DRQRQ in module DRSUB
- Processing in $DRQRQ

    Bit UC.QUE in U.CTL in the UCB is checked

    If set, packet queued to driver

    Contents of KERNEL APR 5 is saved on stack

    If driver loadable, base address of driver loaded into KERNEL APR 5

    The driver is called to initiate I/O

    When driver exits

        Control returns to $DRQRQ

        Original contents of KERNEL APR 5 are restored

ANCILLARY CONTROL PROCESSORS

Types of ACPs

- Standard ACPs

  Known to the Executive

  Executive includes special code for support

  Follow rules used by DEC in writing F11ACP and MTAACP

- User ACPs

  Not known to the Executive

  Known only to the driver which uses their services

  UC.QUE set in U.CTL to prevent ACP function checks in DRQIO

  Driver does preprocessing and queues requests to ACPs

  No change to the Executive code is necessary

- Foreign ACPs

  Between standard and user ACPs

  Known to the Executive

  No special services provided to support ACP

  Identified by foreign bit US.FOR in the UCB

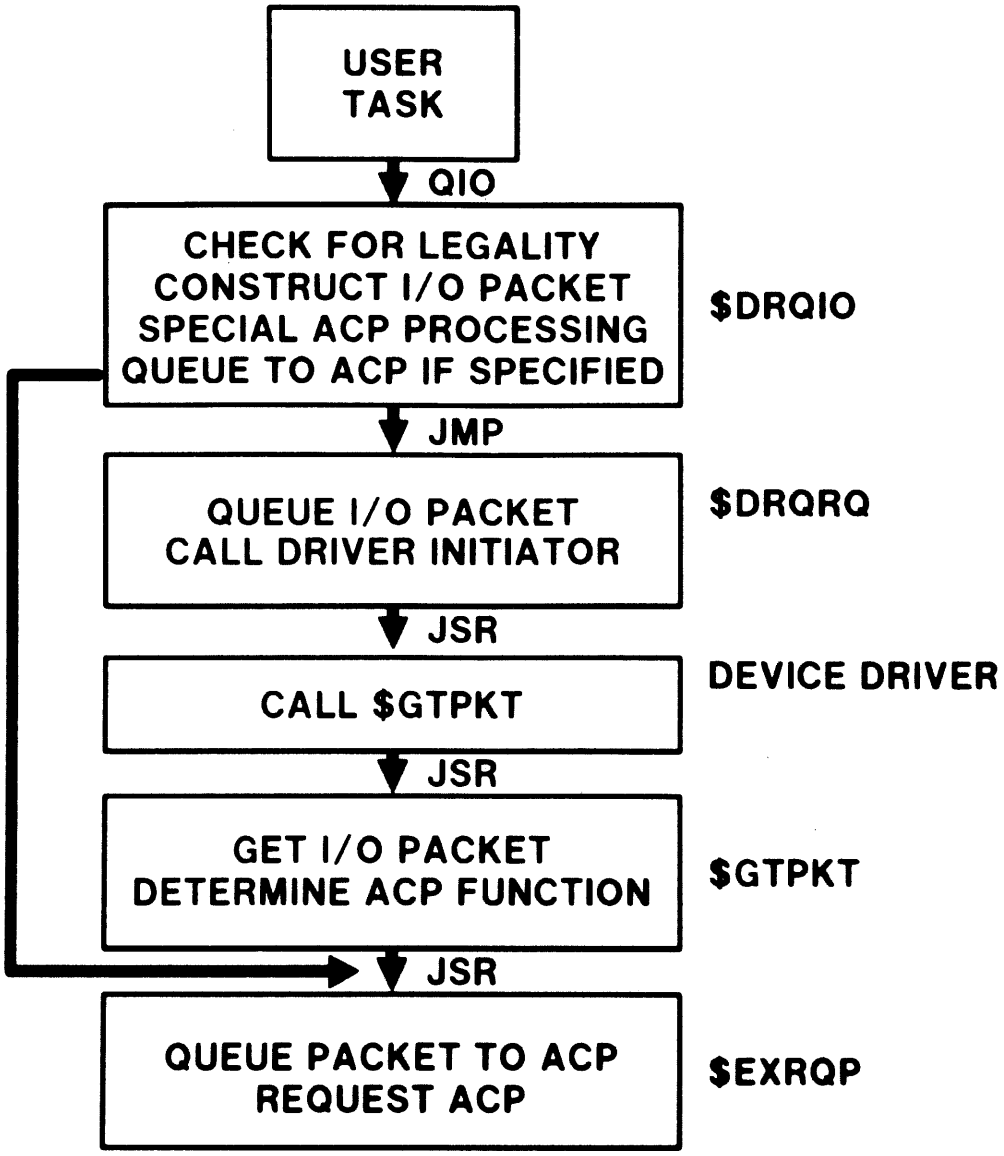


Figure 12-3 Standard ACP

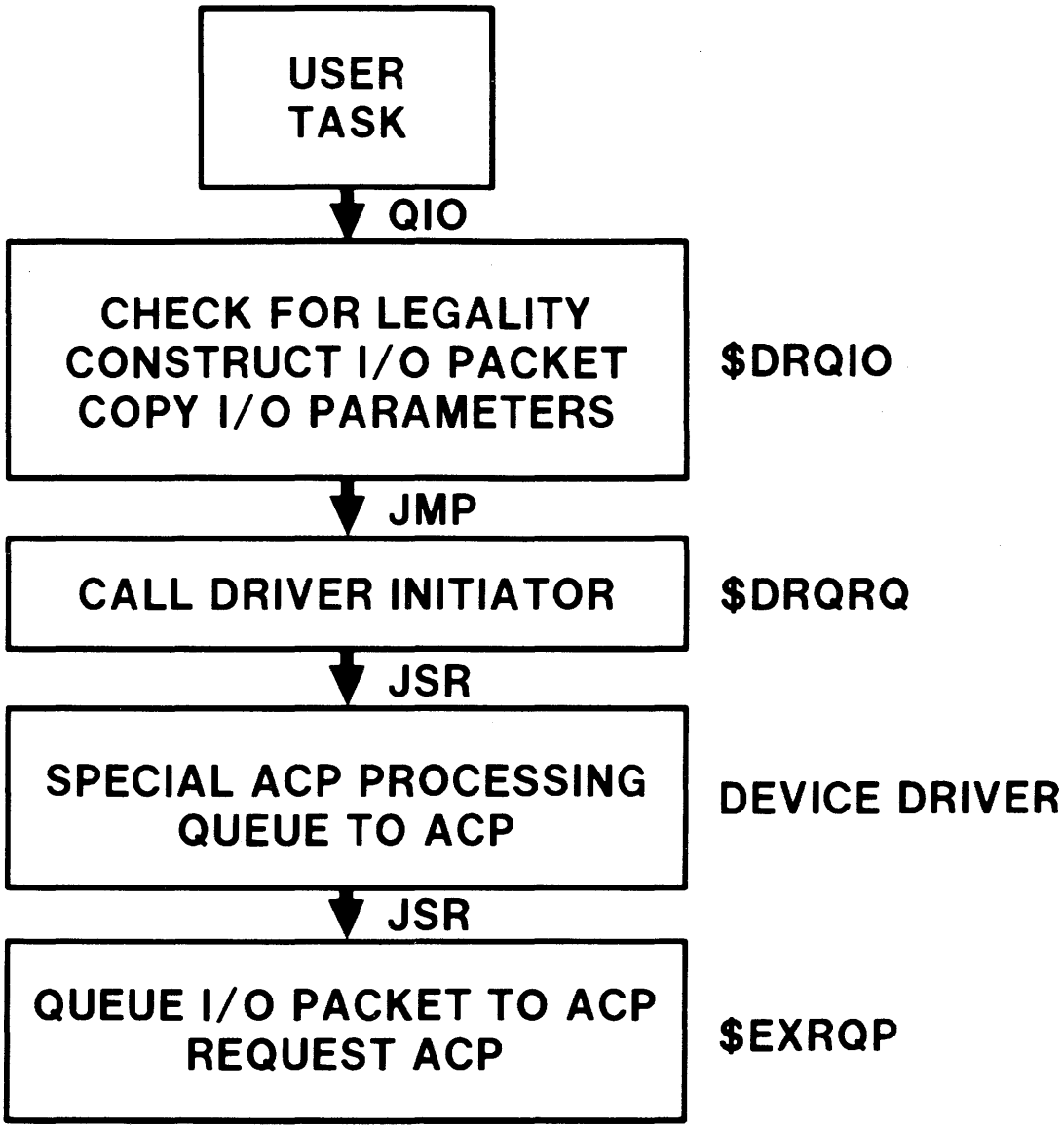


Figure 12-4 User ACP

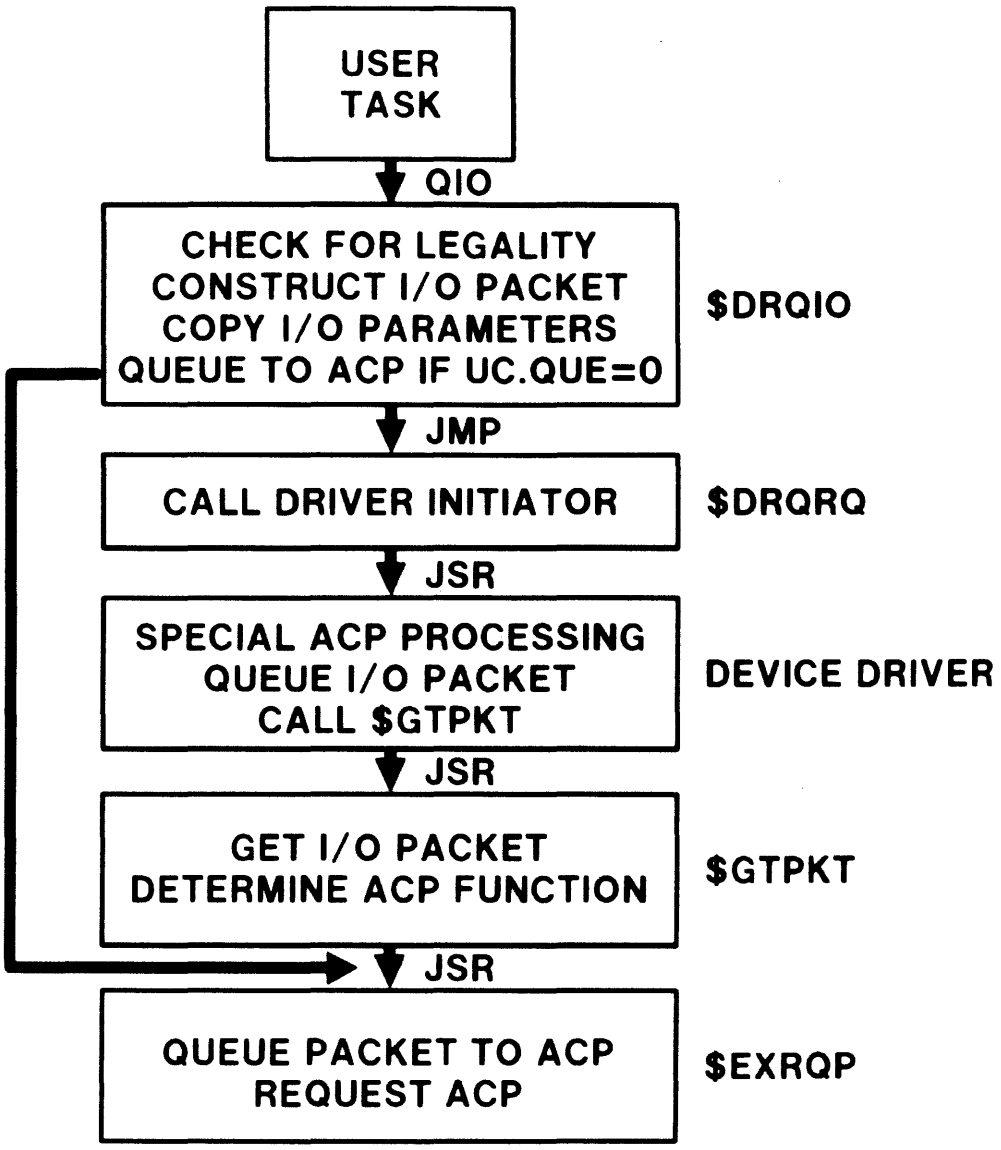


Figure 12-5 Foreign ACP

The FILES-11 (F11ACP)

- Implements the FILES-11 structure for disks
- Provides needed file primitives (open, close, etc.)
- Converts file primitives to driver primitives

    Open file requires several driver operations:

        Locating the file which may require several reads of directory records and headers

        Creating the FCB from the file header

        Creating the window block from the retrieval pointers

Versions available at SYSGEN

- MINIMUM Version

    Not recomended for general use

    Runs in 2K words of memory

    Heavily overlaid

    No internal buffers for storing data

    Mapped and unmapped systems

- SMALL Version

    Provides limited performance optimization

    Requires 10 to 100 times more I/O for directory lookups and file opens than larger ACPs

    Heavily overlaid

    Runs in 2.5K words of memory

    Mapped and unmapped systems

    Default version for unmapped systems

- MIDDLE Version

  Usually provides the best performance without using large amount of memory

  Provides buffers for storing directories and the index file bitmap

  Runs in 5K words of memory

  Mapped and unmapped systems

  Default version for mapped systems

- LARGE Version

  Provides the maximum performance for F11ACP

  Not overlaid

  Runs in 10K words of memory

  Provides larger buffers for storing directories

  Available only on mapped systems

DEVICE DRIVER PROCESSING

INTRODUCTION

Most tasks receive raw data from external sources and provide results to the user. It is usually necessary to keep large amounts of data available to the processor for instant use. To provide these services, an I/O system is needed. The basic component of this system is the software which handles the activities of the physical devices. Under RSX-11M, this software is called a device driver.

RSX-11M provides drivers for each supported peripheral device. The interface between a driver and the I/O system is simple and standard. The user can write drivers for non-standard devices by adhering to the requirements of this interface.

OBJECTIVES

1. Diagram the flow of control during device driver processing.
2. Determine the status of a device by examining its data structures.
3. Diagram the process of performing I/O with a DMA UNIBUS device on the PDP-11/44 or 70.

RESOURCES

1. RSX-11M System Lists and Data Structures
2. RSX-11M Guide to Writing a Device Driver

OVERVIEW

Methods of Performing I/O

- Device common

  Partition in I/O Page

  Built and used as any other common area

  Can only perform 'device-poll' device driving

- Direct access to I/O page

  Privileged task has access to I/O page

  Can only perform 'device-poll' device driving

- CINT$ Directive

  Task contains essential routines to drive device

  Very little knowledge of system interface required

  Easy to debug

  Interrupt driven

- Device Driver

  Integral part of the Executive

  Is written to use QIO mechanism

  Usually interrupt driven but can do 'device-poll'

Design Philosophy

- One device driver per device type

  Handles multiple controllers

- Common I/O processing done in Executive routines

  Queuing of I/O request in module DRQIO

  I/O completion handled by routine $IODON in module IOSUB

- Keep interrupt lockout to a minimum

  Run at priority 7, no more than 100 microseconds

  Run at priority of interrupting device, no more than 500 microseconds

- Use a FORK process to access the system data base

General Flow

- User task issues QIO directive

  Executive entered as result of EMT instruction

- Executive processes QIO

  Checks made on data in DPB

  Mapping adjusted to map to service routine and DPB

- Module DRQIO processes QIO

  Checks made on I/O request

  I/O packet created and queued to driver

- Driver called at initiate I/O entry point

  I/O packet retrieved

  Data in packet processed

  I/O device started

- Control returns to user task if asynchronous I/O, Executive otherwise
- When interrupt occurs, driver entered at interrupt entry point

DRIVER DATA BASE

- Location

  In module SYSTB for DEC-supplied drivers

  If user-written driver with

  Resident data base, in Executive
  Loadable data base, in DSR

Device Control Block (DCB)

- One per device type
- Describes static characteristics of device
- Linked to device list

  Headed by $DEVHD in Executive module SYSCM

  List linked by D.LNK in DCB

- Contains

  D.DSP - Address of Driver Dispatch Table

  D.MSK - Function masks for filtering QIO requests

  D.UCB - Link to first UCB

  D.UCBL - Length of UCB for device type

  D.NAM - Generic device name in ASCII

  D.UNIT - Highest and lowest unit number

- Used by QIO processing, not by driver

Unit Control Block (UCB)

- One per physical unit
- Contains mostly static data
- Most other data structures can be accessed from UCB
- UCB for unit Ø linked from D.UCB in the DCB for device type
- Other UCBs for device type contiguous with UCB for unit Ø
- Contains

    U.DCB - Pointer back to DCB for device type

    U.RED - Pointer to UCB of redirect device

    U.UNIT - Physical unit number

    U.SCB - Pointer to SCB of controller for this unit

- Used by both driver and Executive

Table 13-1 Important Entries in the UCB

Entry	Offset	Length	Contents
U.DCB	Ø	WORD	Address of DCB for device type
U.SCB	2Ø	WORD	Address of SCB for unit
U.UNIT	6	BYTE	Physical unit number
U.RED	2	WORD	Address of UCB for redirect
U.STS	5	BYTE	Unit status bits
U.ST2	7	BYTE	More unit status bits
U.CTL	4	BYTE	Unit control flags
U.CW1	1Ø	WORD	1st device characteristics word
U.CW2	12	WORD	2nd device characteristics word
U.CW3	14	WORD	3rd device characteristics word
U.CW4	16	WORD	4th device characteristics word
U.CLI	-6	WORD	Default CLI
U.LUIC	-4	WORD	Login UIC
U.OWN	-2	WORD	Owning terminal

Notes:
1. U.CLI and U.LUIC exist only for terminals
1. U.LUIC exists if system is multi-user

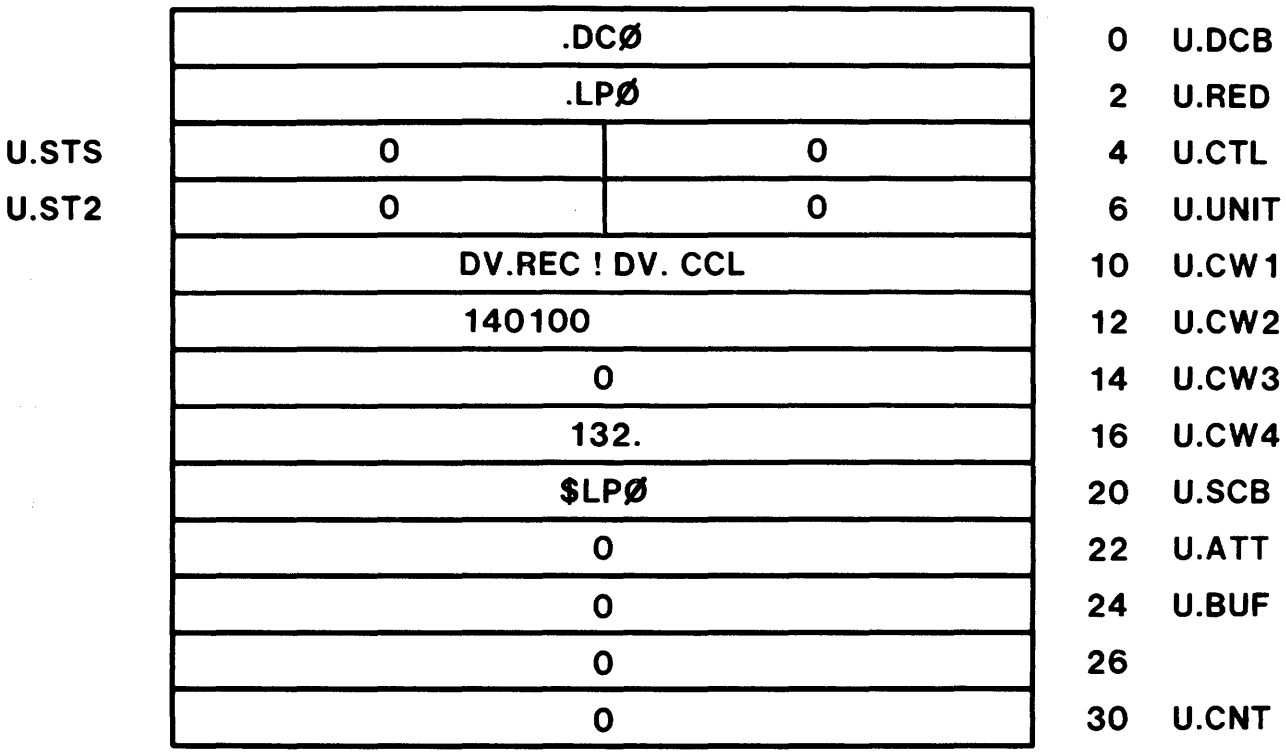


Figure 13-1 Unit Control Block for LP:

	0		-10	U.IOC
U.ERHL	8.	5	-6	U.ERSL
U.ERHC	0	0	-4	U.ERSC
	0		-2	U.OWN
	.DC0		0	U.DCB
	.DK0		2	U.RED
U.STS	UC.ALG!UC.NPR!UC.PWF	US.MNT	4	U.CTL
U.ST2	0	0	6	U.UNIT
	DV.DIR!DV.MNT!DV.F11!DV.MSD!DV.UMD		10	U.CW1
	0		12	U.CW2
	4800.		14	U.CW3
	512.		16	U.CW4
	$DK0		20	U.SCB
	0		22	U.ATT
	0		24	U.BUF
	0		26	
	0		30	U.CNT
	0		32	U.ACP
	0		34	U.VCB

Figure 13-2 Unit Control Block for DK:

Status Control Block (SCB)

- One SCB per controller
- Line multiplexers (DH-11, DJ-11, etc.) have one controller per line
- Most information is dynamic
- Linked from U.SCB in the UCB
- One SCB is linked from several UCBs if controller is common to several units
- Contains

    S.LHD - Device I/O queue listhead

    S.PKT - Address of current I/O packet

    S.PRI - Device priority

    S.CTM - Current time out count

    S.ITM - Initial time out count

    S.CSR - Address of Control Status Register

    S.FRK - The FORK block

- Used by driver and Executive

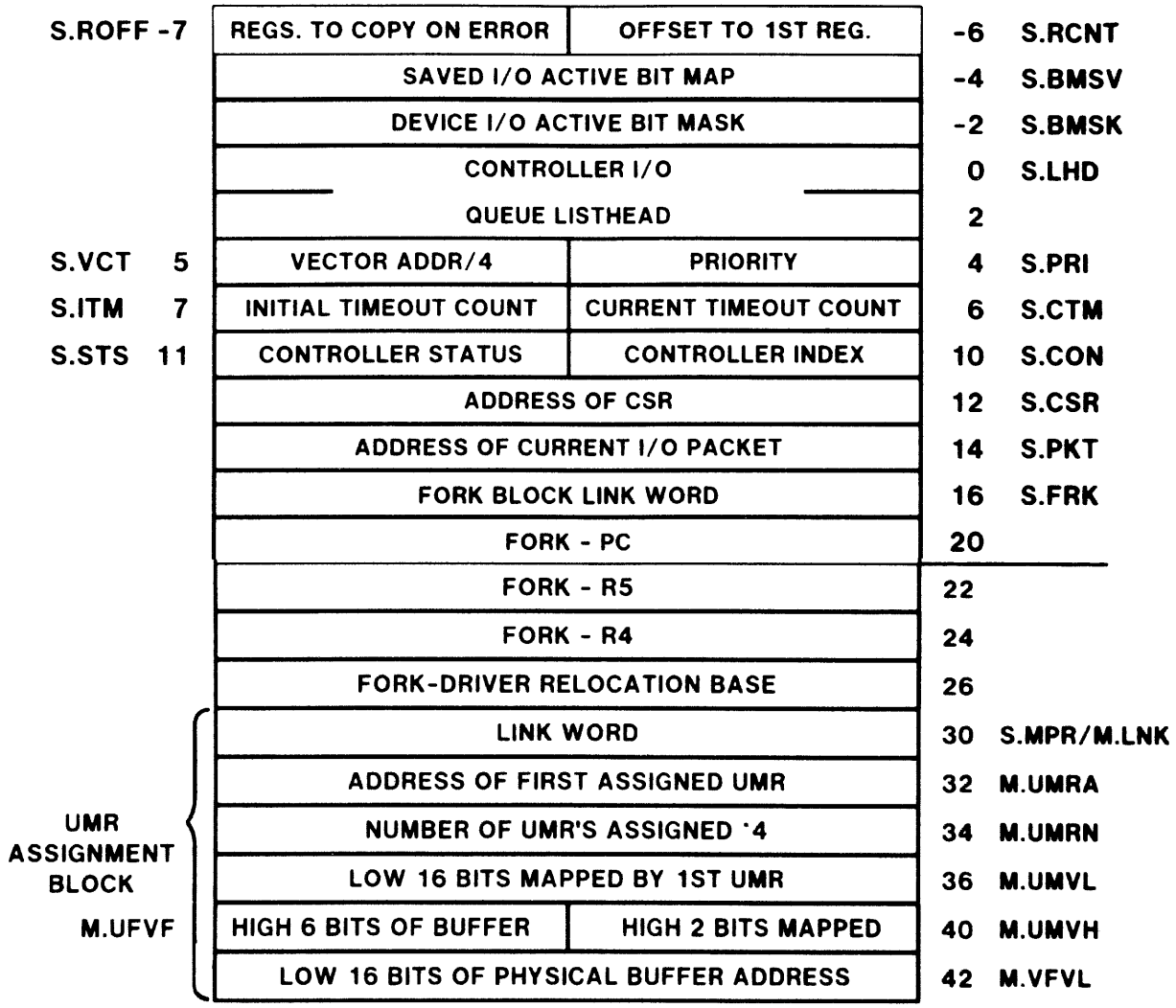


Figure 13-3 Status Control Block

I/O Packet

- Used to communicate between Executive and device driver
- Created by Executive in DSR
- One for each I/O request queued to driver
- Each SCB has an I/O queue consisting of pending I/O packets

  Linked from listhead S.LHD in the SCB

  Linked in order of decreasing task priority

  Packet is removed from queue when service begins

- Current I/O packet is linked from S.PKT in the SCB
- Contains

  I.PRI - Priority of request

  I.EFN - Event flag to use for synchronization

  I.TCB - Address of TCB of requesting task

  I.FCN - I/O function code

  I.IOSB - I/O status block address

  I.AST - Address of AST service routine

  I.PRM - I/O parameter list

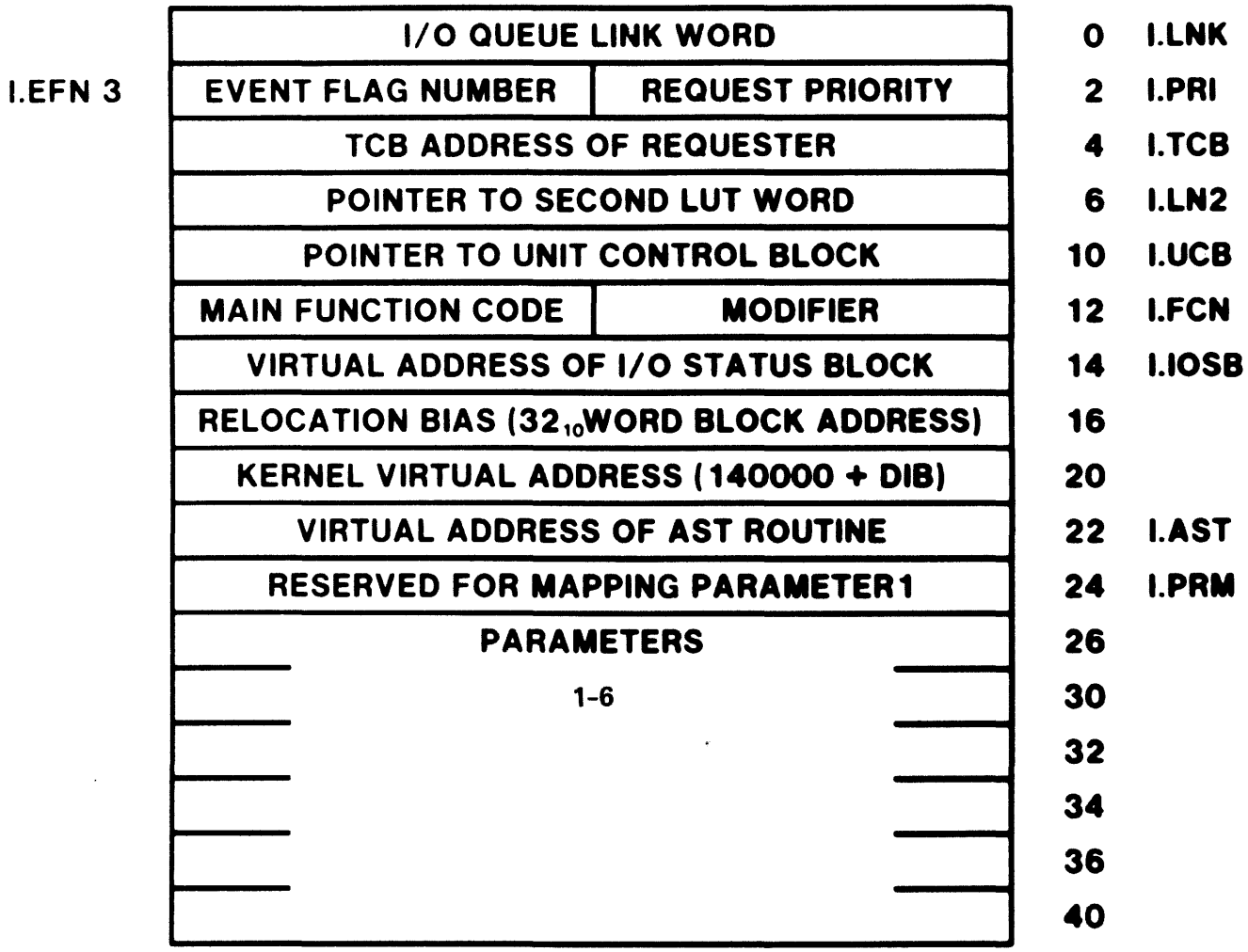


Figure 13-4 I/O Packet

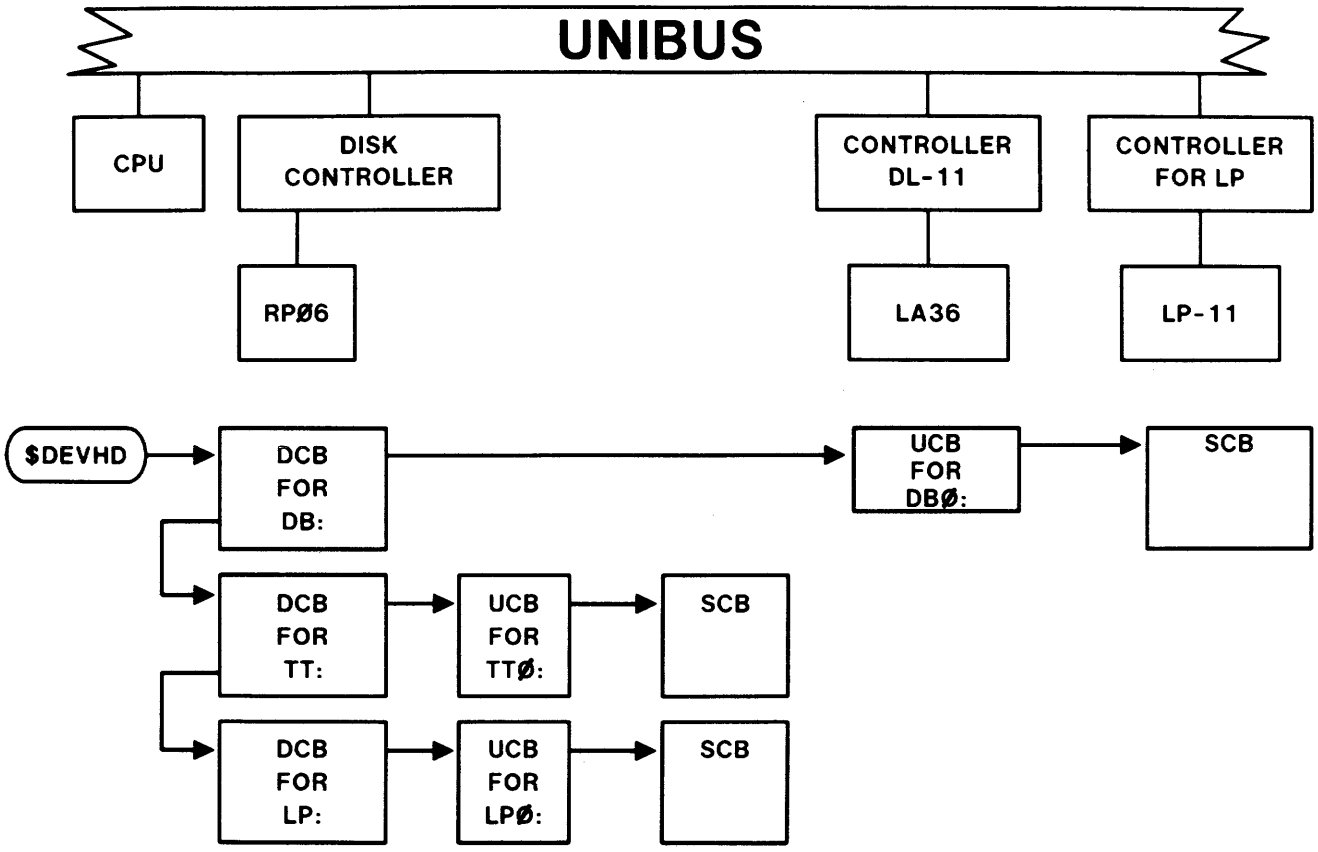


Figure 13-5 A Simple Configuration

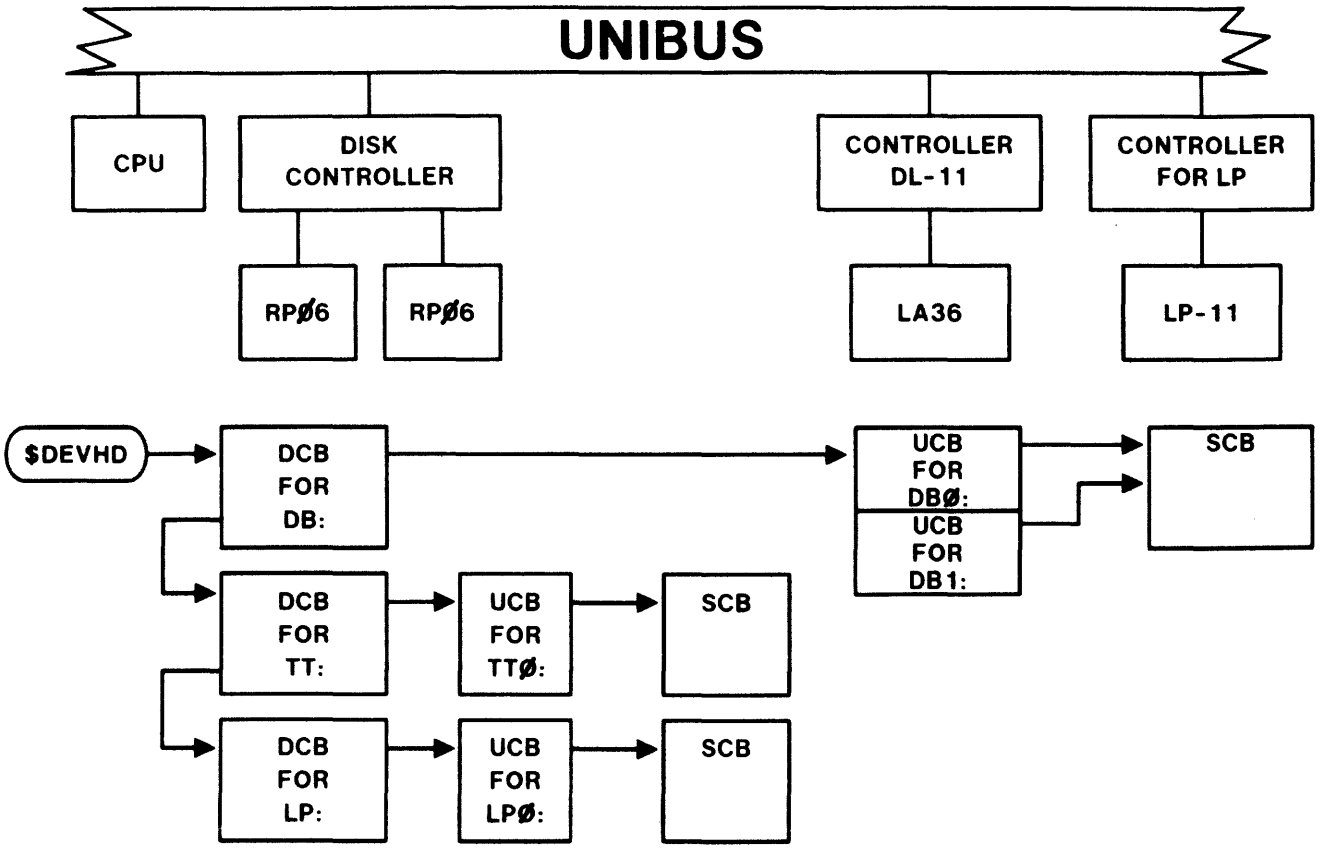


Figure 13-6 A Configuration with Multiple Units

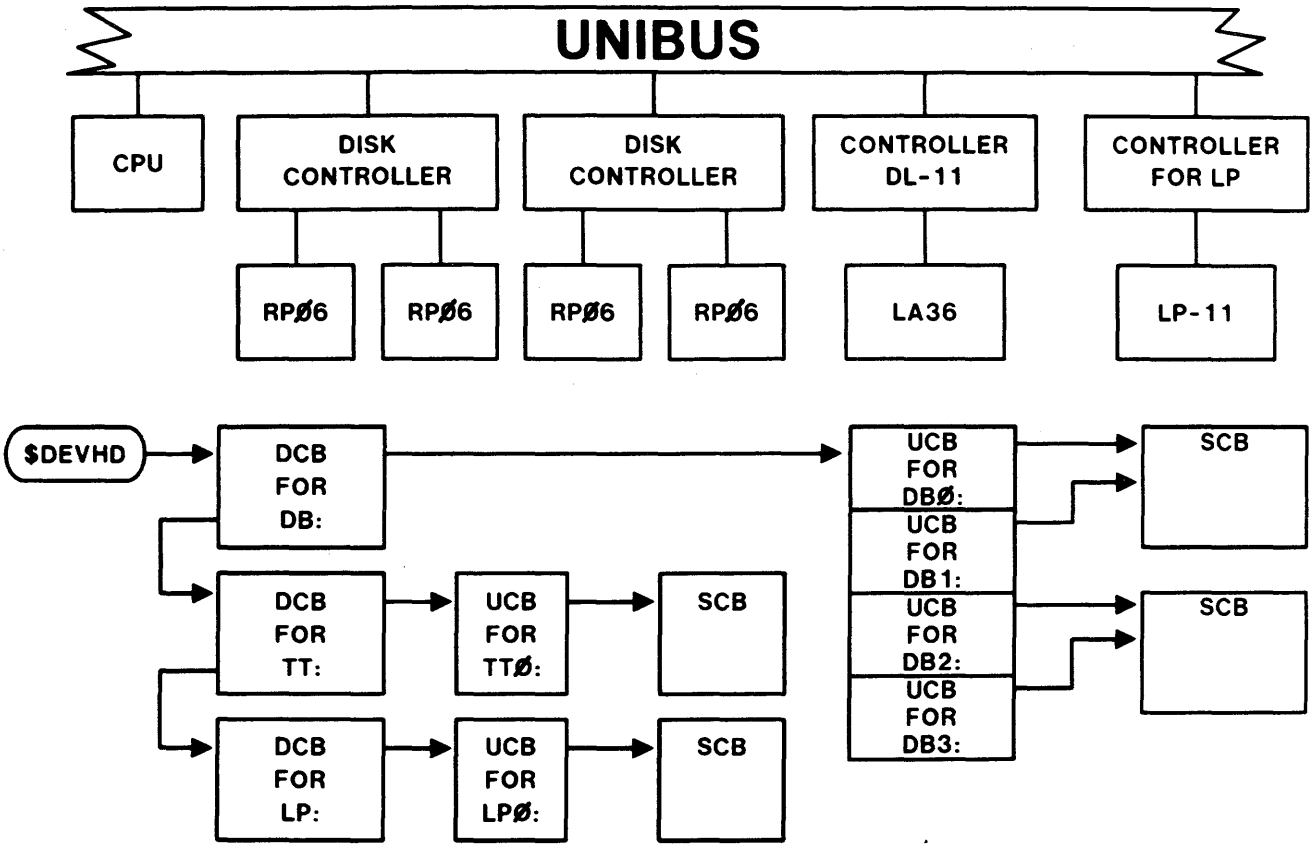


Figure 13-7 A Configuration with Multiple Controllers

DRIVER STRUCTURE

Driver Entry Points

- Initiate I/O Entry Point

  Used to initiate an I/O operation
  Called from routine $DRQIO
  Executes at processor priority Ø
  Name of entry point: XXINI

- Kill I/O Entry Point

  Cancels in-progress requests for non block-addressable devices

  Called from routines $DRQIO and $DREIF

  Executes at device priority

  Name of entry point: XXCAN

- Time-out Entry Point

  Used when driver does not interrupt within specified time interval after a request

  Called from module TDSCH

  Executes at device priority

  Action: Retry I/O operation

  After eight retries, I/O operation is aborted

  Name of entry point: XXTMO

- Powerfail Entry Point

  Called by module INITL and by SAVE to initialize device
  Reinitializes device after powerfail
  Called from routine POWER after power is restored
  Executes at processor priority Ø
  Name of entry point: XXPWF

- Interrupt Entry Point

  Services interrupts from device
  Address stored in interrupt vector
  Entered at processor priority 7
  Entry Point Names Critical

  XXINT - Single interrupt driver
  XXINP - Input, two interrupt drivers
  XXOUT - Output, two interrupt drivers

Driver Dispatch Table

- Table containing addresses of service routines for all entry points except the interrupt entry
- Table is in the device driver at location $XXTBL

```
$XXTBL::
            .WORD    XXINI    ;Initiate I/O
            .WORD    XXCAN    ;Cancel I/O
            .WORD    XXTMO    ;Device Timeout
            .WORD    XXPWF    ;Powerfail
```

- Pointed to by D.DSP in the DCB
- Entries are local symbols whose order is critical

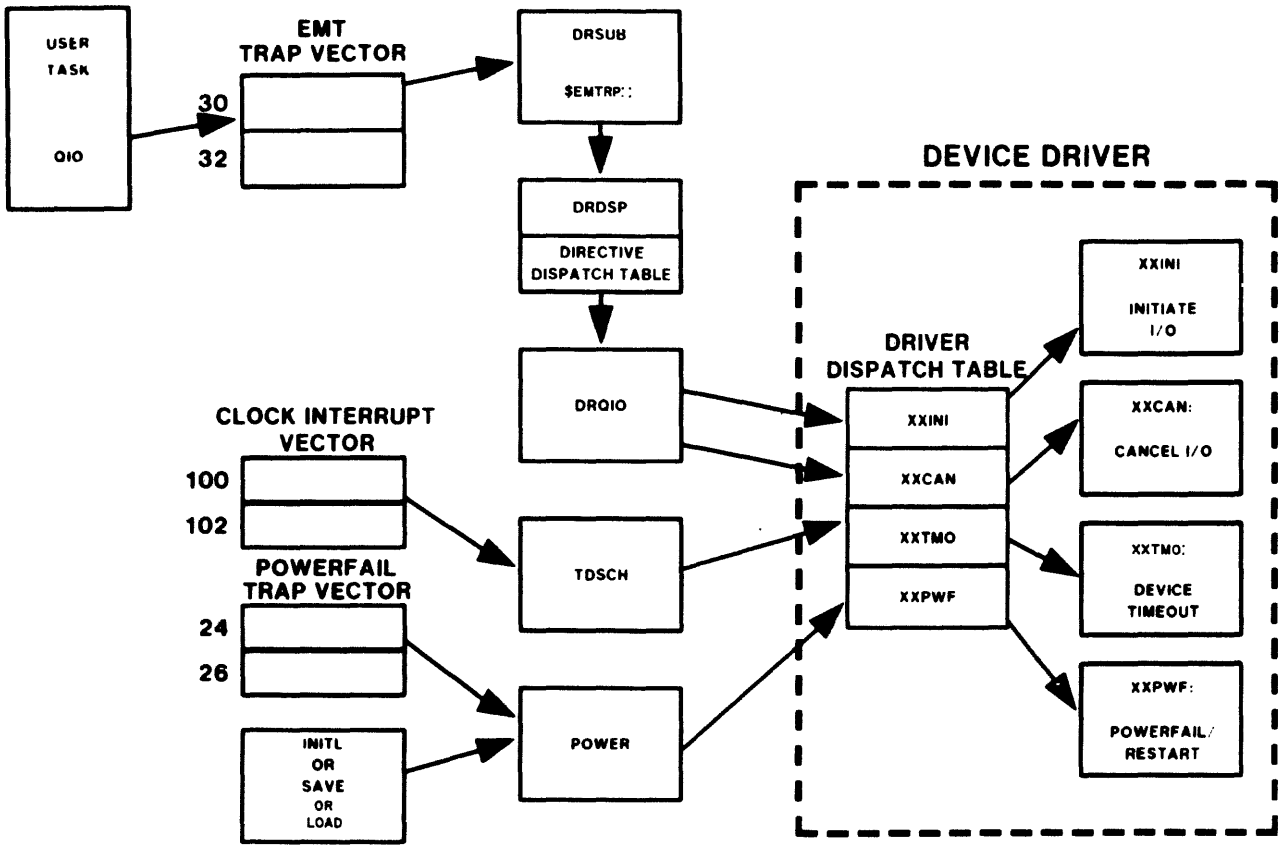


Figure 13-8 Driver Flow

```
          .TITLE  XXDRV
$XXTBL::
          .WORD   XXINI
          .WORD   XXCAN
          .WORD   XXTMO
          .WORD   XXPWF

XXINI:    CALL    $GTPKT
          BCC     .+4
          RETURN
          MOV     #IS.SUC&377,R0
          CLR     R1
          CALL    $IODON
XXCAN:
XXTMO:
XXPWF:
XXINT::   RETURN
          .END
```

Example 13-1 A Skeleton Driver

```
        .TITLE  XXTAB
        .MCALL  DCBDF$,UCBDF$
        DCBDF$
        UCBDF$
$XXDAT::
XXDCB:  .WORD   0
        .WORD   .XX0
        .ASCII  /XX/
        .BYTE   0,0
        .WORD   XXND-XXST
        .WORD   0
        .WORD   177777
        .WORD   30
        .WORD   0
        .WORD   177740
        .WORD   377
        .WORD   0
        .WORD   0
        .WORD   377
        .WORD   0

XXST=.
.XX0::  .WORD   XXDCB
        .WORD   .-2
        .BYTE   0,US.MNT,0,0
        .WORD   DV.MNT!DV.F11
        .WORD   0,0
        .WORD   80.
        .WORD   $XX0
        .WORD   0,0,0,0
        .WORD   0                       ;U.ACP
        .WORD   0                       ;U.VCB
XXND=.

$XX0::  .WORD   0
        .WORD   .-2
        .WORD   0,0,0,0,0,0,0,0,0,0

$XXEND::
        .END
```

Example 13-2 A Skeleton Driver Data Base

DRIVER PROCESSING

Initiate I/O

- Call $GTPKT to get an I/O packet

  Carry set on return from $GTPKT

  No packet

  ACP function

  Controller busy

- Registers on return from $GTPKT

  R1 - Address of I/O packet

  R2 - Physical unit number

  R3 - Controller index (into CNTBL)

  R4 - Address of SCB

  R5 - Address of UCB

- UCB address saved in CNTBL
- Perform initiation of I/O including

  Allocating UMRs if a DMA device on 11/44 or 11/70

  Setting up device timeout

  If error logging, call $BMSET

  Checking function code

  Performing operations on CSR(s)

  Mapping UMR(s) if required

  Enabling interrupts

Kill I/O

- Registers when entry point called

  R5 - Address of UCB

  R4 - Address of SCB

  R3 - Controller index

  R1 - TCB of current task

  RØ - Active I/O packet

- Processor is at device priority when called
- Cancel current I/O operation by

  Zeroing byte-count or flagging abort

  Canceling timeout by zeroing S.CTM in the SCB

- For DMA devices, current operation may not be canceled

Device Timeout

- Registers when entry point called

  R5 - Address of UCB

  R4 - Address of SCB

  R3 - Controller index

  R2 - Address of CSR

  RØ - I/O status code (IE.DNR)

- Processor at device priority when called
- Generate error message by calling $DVMSG with T.NDNR in RØ
- If error logging, call $DTOER
- Reset timeout count if required
- Retry I/O operation required number of times

Powerfail

- Registers when entry point is called

  R5 - Address of UCB

  R4 - Address of SCB

  R3 - Controller index

- Processor at processor priority Ø when called
- Uses timeout mechanism for device recovery

  Special timeout count is used for many devices

  Performs other initialization tasks (e.g., the KMC-11 for the lineprinter)

Interrupt Processing

- Registers R4 and R5 saved on entry, others cannot be used except in FORK process code
- Processor priority

  At call: 7

  After return from $INTSV: Device priority

  During FORK processing: Ø

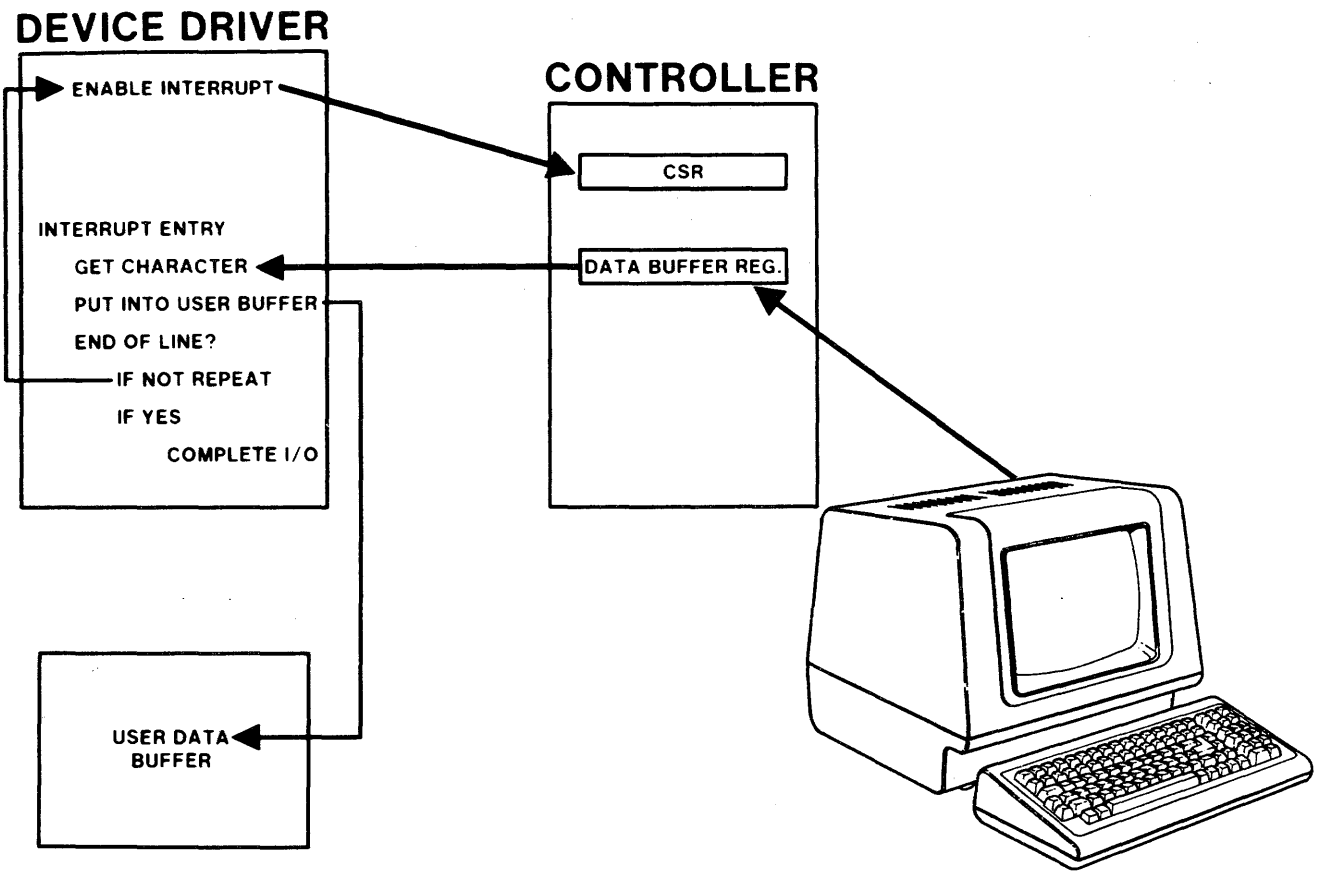


Figure 13-9 Interrupt Processing - Non DMA Device

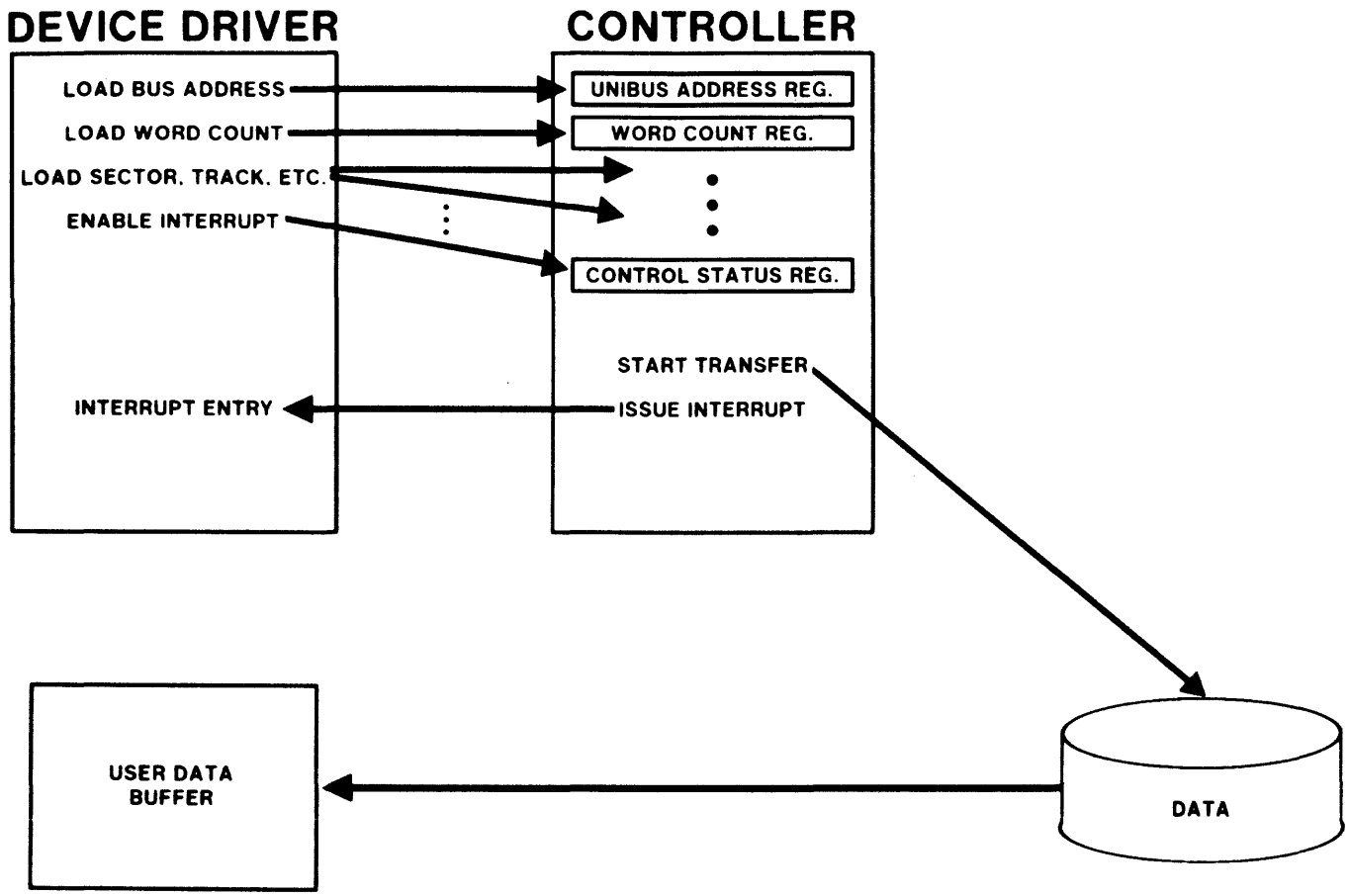


Figure 13-10 Interrupt Processing - DMA Device

ADVANCED DRIVER FEATURES

Loadable Drivers

- Not physically within the Executive, but in a user partition
- Frees part of KERNEL address space to be used to map added DSR
- LOAD command brings into memory
- UNLOAD command removes from memory
- Consists of three parts

    Interrupt Control Block in DSR

    Driver code loaded into driver partition

    Driver Data Base loaded in DSR

The Interrupt Control Block

- Created by LOAD command in DSR
- Contains

    Location to which control is transfered by interrupt

    Call to interrupt save routine, to save registers

    Code to map driver code using KERNEL APR 5

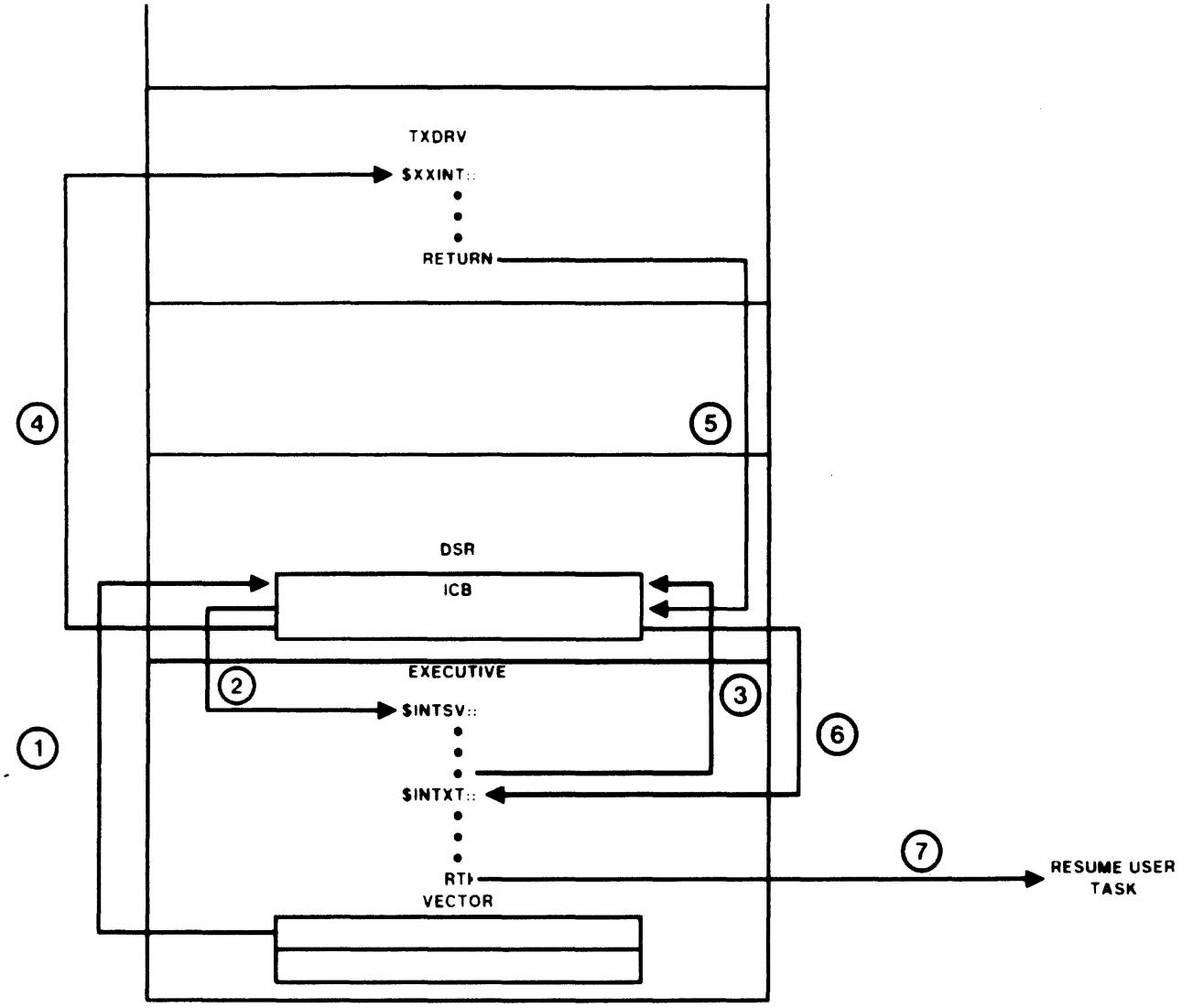


Figure 13-11 A Loadable Driver

113767 177776 50	MFPS TEMP
004537 ADDR OF $INTSV	JSR R5, @#$INTSV
177753(TYPICAL)	.WORD ↑C <PR1>
016704 000036	MOV TEMP,R4[1]
043704 177760	BIC↑C<17>,R4[1]
006304	ASL R4[1]
013746 172352	MOV @#KISAR5, -(SP)
012737 DRIVER RELOCATION BIAS 172352	MOV # RELBAS,@#KISAR5
004737 ADDRESS OF INTERRUPT SERVICE ROUTINE	JSR PC,@#INTSRV
012637 172352	MOV (SP)+,@#KISAR5
000207	RETURN
000000	TEMP:.BLKW 1[1]

1. MULTI-CONTROLLER DRIVERS

Figure 13-12 The Interrupt Control Block

Resident and Loadable Data Base

- Data base for loadable driver can be loadable or resident
- Resident data base created when system is built and included in the Executive
- Loadable data base can be created at any time

  Loaded in DSR by LOAD command if not already in memory

  Not unloaded by UNLOAD command

UNIBUS Mapping Registers

Problem:

- Direct Memory Access (DMA) devices

  Transfer data directly between the device and physical memory

  Require physical address to be passed to UNIBUS

- In some PDP-11s, physical addresses require 22 bits
- UNIBUS accepts only 18-bit addresses

Solution:

- 31 UNIBUS Mapping Registers (UMRs) are provided
- Each UMR maps 4K words of physical memory
- 124K words of address space just below the I/O page are relocated using UMRs

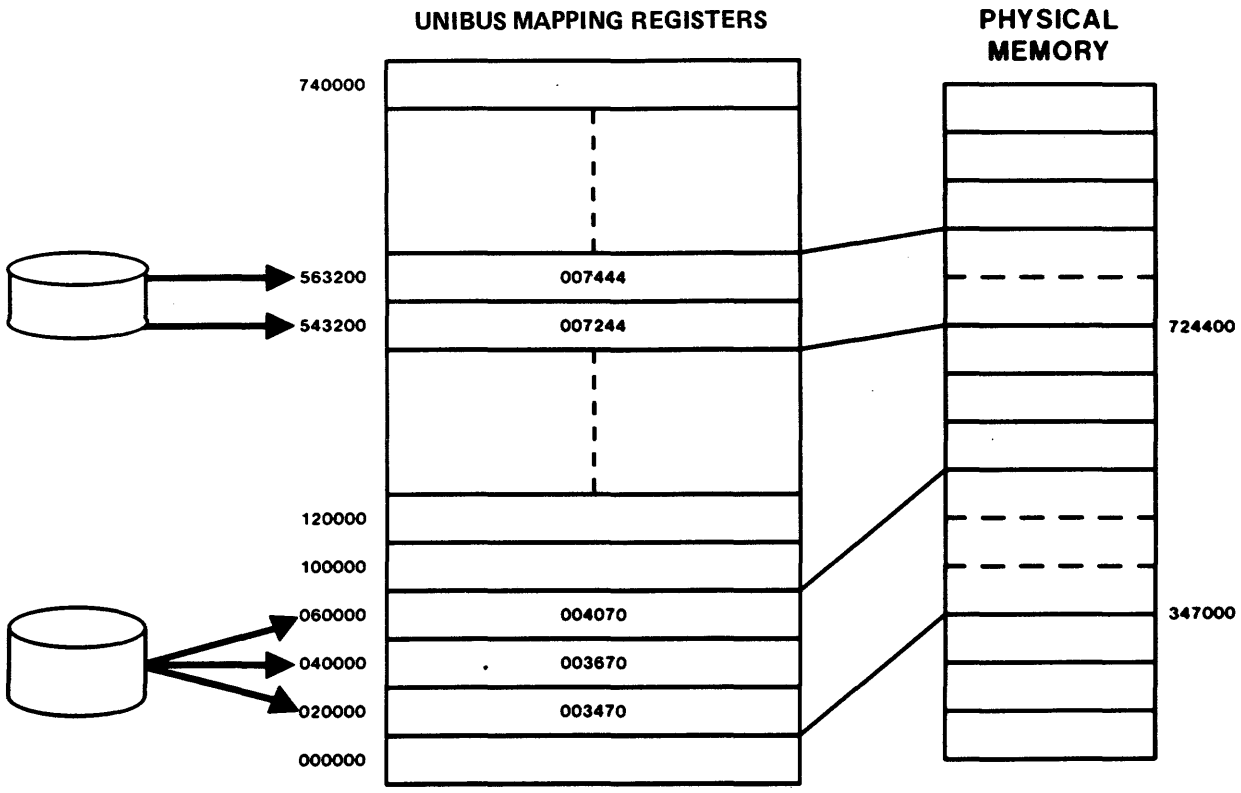


Figure 13-13 UNIBUS Mapping Registers

```
TRANSFER A BLOCK OF 8K WORDS
USER BUFFER ADDRESS = 1344200
UMR'S 3 AND 4 ARE TO BE USED
UMR STRUCTURE:
        BITS 13-17 = NUMBER OF UMR
        BITS 0 -12 = OFFSET TO BASE ADDRESS IN UMR
THEREFORE:
        UMR 3 = 13442
        UMR 4 = 13642
THE ADDRESS SUPPLIED TO THE UNIBUS IS 060000
```

Example 13-3 UMR Address Relocation

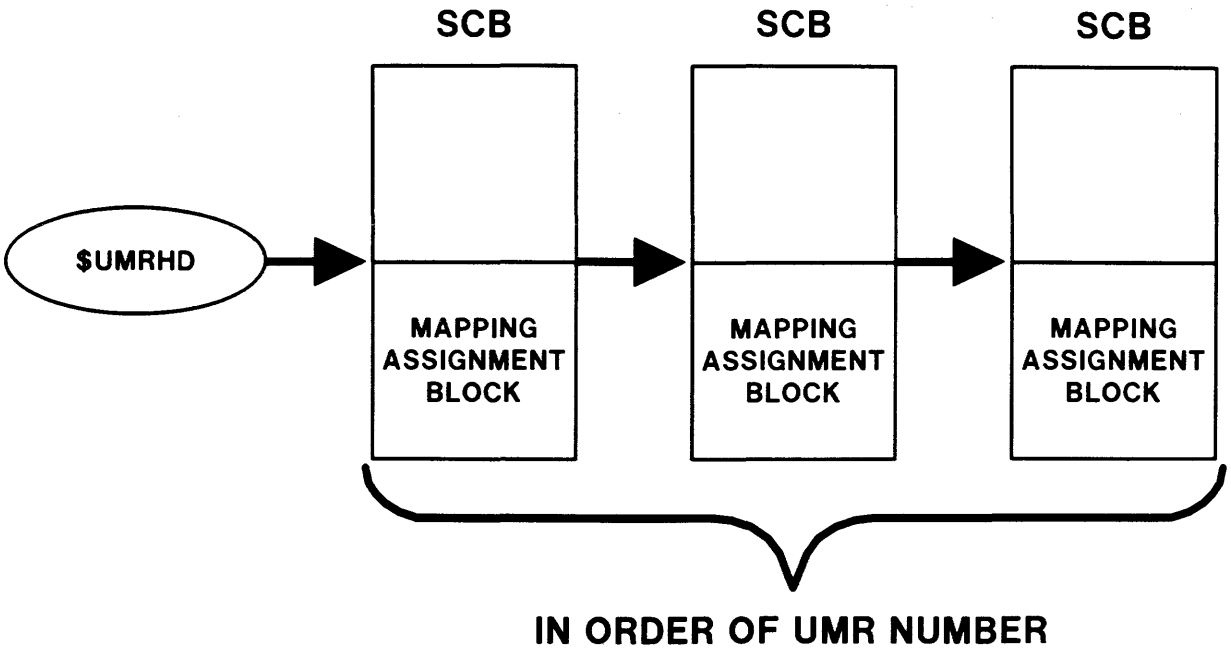


Figure 13-14 Mapping Assignment Block List

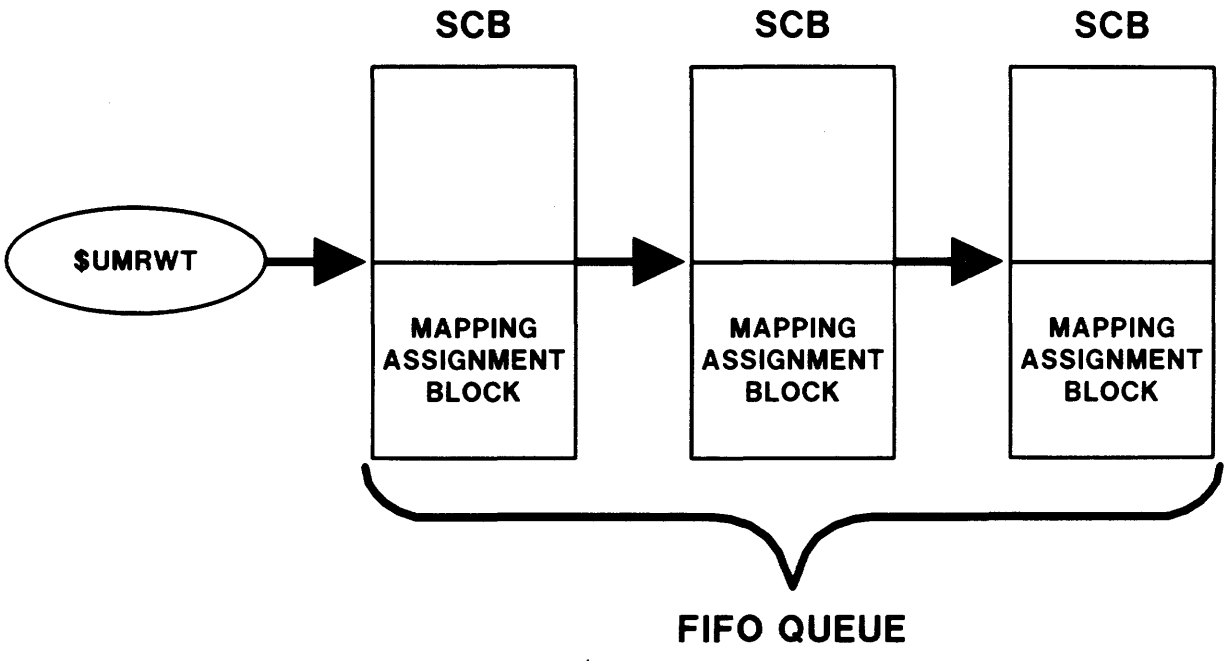


Figure 13-15 UMR Wait Queue

CONNECT-TO-INTERRUPT

- Privileged task which contains interrupt service routine, ISR

  Task may or may not be mapped to Executive

- Connect-to-interrupt directive (CINT$) used to set up interrupt service

  Interrupt Transfer Block (ITB) created in pool

  Address X.JSR in ITB loaded into PC of specified vector

  Vector must be greater than 60 and unused

  ITB contains code to map the ISR through KERNEL APR 5 and transfer control to it

  ITB also contains FORK block for ISR

  ITB linked to the ITB list of the task using T.CPCB in the TCB

  Task is made noncheckpointable and nonshufflable

- Connect-to-interrupt directive performs disconnect if issued with address of ISR equal to 0

  Task is made checkpointable and shufflable regardless of original status

- Interrupt service routine is limited to 4K words

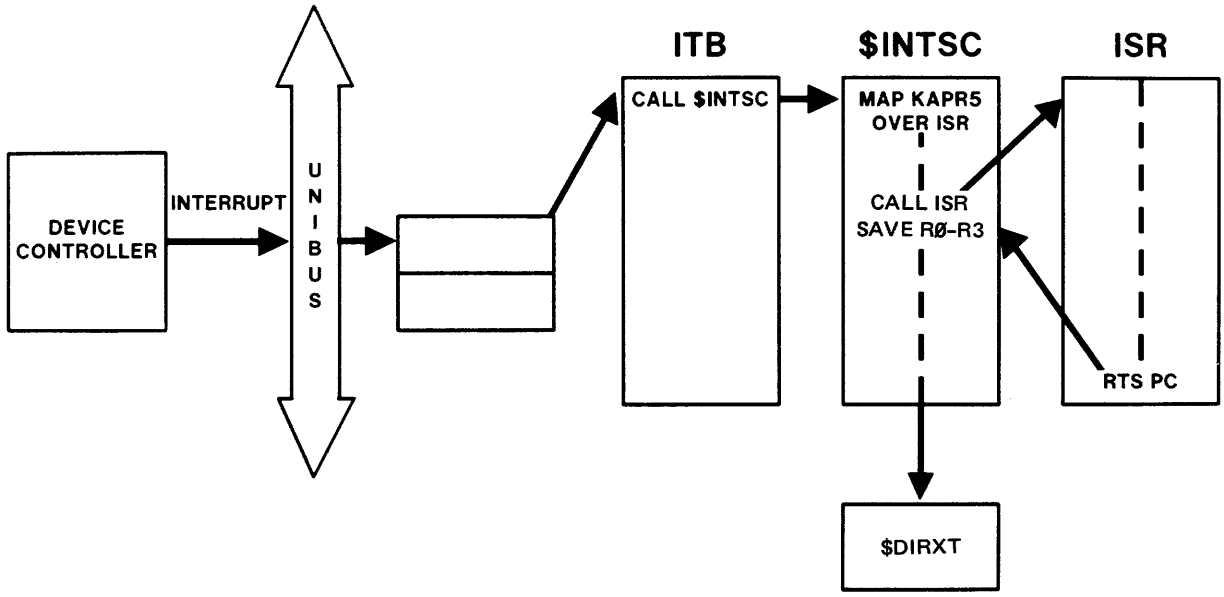
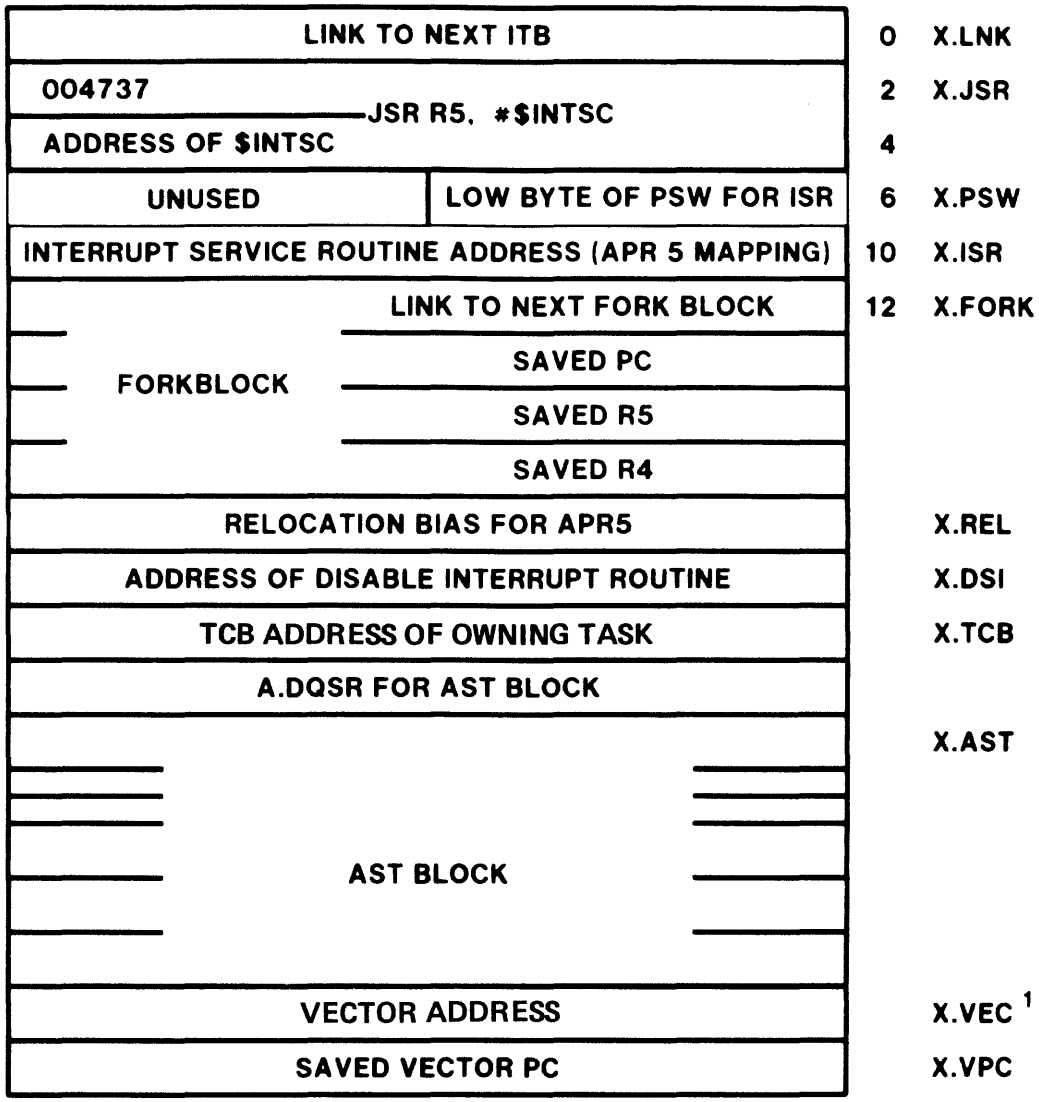


Figure 13-16 Connect-to-Interrupt Processing



1. IF AST SUPPORT THIS IS FIRST AND ONLY AST PARAMETER

Figure 13-17 The Interrupt Transfer Block

```
        .TITLE  CTI
        .IDENT  /1.0/
;+
; ** THIS TASK ILLUSTRATES THE CONNECT TO INTERRUPT VECTOR DIRECTIVE
;       THIS PRIVILEGED TASK CONNECTS TO A DR-11K.  THERE IS A
;       LOCAL OPERATOR CONSOLE (LOC BOX) ATTACHED TO THE DR-11K
;       WHICH HAS 3 PUSH BUTTONS.  THESE 3 SWITCHES WILL CAUSE
;       THE DR-11 TO INTERRUPT AND TO PERFORM THE FOLLOWING
;       OPERATIONS:
;
;               SWITCH 1 - THE INTERRUPT SERVICE ROUTINE
;                          WILL SAMPLE THE TIME, AND STORE
;                          THE NUMBER OF TICKS TO THE NEXT
;                          SECOND IN A BUFFER.
;
;               SWITCH 2 - THE ISR QUEUES AN AST TO THIS TASK
;                          WHICH WILL AVERAGE THE VALUES COLLECTED
;                          IN THE ISR AND PRINT IT ON 'TI'.
;
;               SWITCH 3 - THE ISR SETS A LOCAL EVENT FLAG WHICH
;                          CAUSES THIS TASK TO DISCONNECT FROM
;                          THE VECTOR AND EXIT.
;
;-
        .MCALL  CINT$,EXIT$S,QIOW$,ASTX$S,WTSE$,DIR$
        .NLIST  BEX
;       DEFINITIONS FOR THE DR-11K
DRVEC   =       230     ;VECTOR
DRCSR   =       167770  ;CONTROL AND STATUS REGISTER
DRBUF   =       167772  ;INPUT BUFFER REGISTER
SWTCH1  =       1       ;SWITCH 1
SWTCH2  =       2       ;SWITCH 2
SWTCH3  =       4       ;SWITCH 3
EF      =       2       ;EVENT FLAG FOR TASK
BUFSIZ  =       30.     ;NUMBER OF SAMPLES TO STORE
;
CINT:   CINT$   DRVEC,ISRBAS,DRINT,DREDIR,PR5,DRAST     ;CONNECT
DCINT:  CINT$   DRVEC   ;DISCONNECT
WAIT:   WTSE$   EF      ;WAIT FOR EF
PRINT:  QIOW$   IO.WVB,5,1,,,,<MES,0,40>        ;PRINT AVERAGE
FORMAT: .ASCIZ  /NUMBER OF SAMPLES TAKEN %D.  AVERAGE OF THE SAMPLES %O/
ERR:    .ASCIZ  /FAILED TO CONNECT TO VECTOR. DIRECTIVE STATUS = %D./
        .EVEN
MES:    .BLKB   100.    ;FORMATTED MESSAGE
        .ENABL  LSB
;
;       MAIN LINE CODE
;       CONNECT TO DR-11K INTERRUPT VECTOR AN PUT TASK TO SLEEP BY
;       WAITING ON LOCAL EVENT FLAG 2
;
START:
        CLR     COUNT           ;INITIALIZE NUMBER OF SAMPLES
        CLR     BUFFER          ;INITIALIZE SUM
        DIR$    #CINT           ;CONNECT TO INTERRUPT
        BCS     10$             ;FAILED TO CONNECT
        DIR$    #WAIT           ;PUT TASK TO SLEEP
        DIR$    #DCINT          ;DISCONNECT
        EXIT$S
;
;       CONNECT FAILED - PRINT ERROR MESSAGE
;
10$:    MOV     #MES,R0         ;OUTPUT BUFFER
        MOV     #ERR,R1         ;FORMAT SPECIFICATION
```

Example 13-4 Sample Connect-to-Interrupt Routine
(Sheet 1 of 3)

```
        MOV     #$DSW,R2        ;VALUE TO BE CONVERTED
        CALL    $EDMSG          ;FORMAT MESSAGE
        MOV     R1,PRINT+Q.IOPL+2 ;NUMBER OF BYTES IN MESSAGE
        DIR$    #PRINT          ;PRINT ERROR MESSAGE
        EXIT$S
;
;       AST WILL AVERAGE THE TIME SAMPLES AND PRINT ON TI
;
DRAST:
        MOV     COUNT,R0        ;NUMBER OF SAMPLES
        BEQ     35$             ;SKIP AVERAGING
        CLR     R1              ;ACCUMULATE SUM IN R1
        MOV     #BUFFER,R2      ;SAMPLES TO SUM
15$:    MOVB    (R2)+,R3        ;GET SAMPLE
        BIC     #177400,R3      ;DON'T SIGN EXTEND
        ADD     R3,R1           ;ADD INTO TOTAL
        SOB     R0,15$          ;GET NEXT VALUE
        DIV     COUNT,R0        ;GET AVERAGE
        MOV     R1,BUFFER       ;STORE QUOTIENT
35$:    MOV     #MES,R0         ;OUTPUT STRING
        MOV     #FORMAT         ;FORMAT SPECIFICATION
        MOV     #COUNT,R2       ;NUMBERS TO CONVERT
        CALL    $EDMSG          ;CONVERT MESSAGE
        MOV     R1,PRINT+Q.IOPL+2 ;NUMBER OF BYTES TO PRINT
        DIR$    #PRINT          ;WRITE SAMPLE AVERAGE
        TST     (SP)+           ;POP VECTOR ADDRESS
        CLR     BUFFER          ;RE-INITIALIZE SUM
        CLR     COUNT           ;AND COUNT OF SAMPLES
        ASTX$S                  ;EXIT AST
;
;       ISRBAS DEFINES THE BASE ADDRESS OF A 4K-WORD AREA THE
;       EXECUTIVE WILL MAP WITH KERNEL APR5.  THIS AREA MUST
;       CONTAIN THE INTERRUPT SERVICE ROUTINE, THE ENABLE/DISABLE
;       INTERRUPT ROUTINE, AND ANY DATA AREAS THAT THESE ROUTINES
;       WILL REFERENCE.
;
ISRBAS:
;       DATA BUFFERS NEEDED BY ISR
COUNT:  .WORD   0               ;NUMBER OF SAMPLES
BUFFER: .BLKB   BUFSIZ          ;BUFFER FOR INPUTS
        .EVEN
;
;       ENABLE/DISABLE INTERRUPTS ROUTINE
;       AUTOMATICALLY CALLED UNDER 3 CONDITIONS
;               1.  WHEN THE TASK CONNECTS TO AN INTERRUPT VECTOR
;                   TO ENABLE INTERRUPTS.
;               2.  WHEN THE TASK DISCONNECTS FROM THE INTERRUPT
;                   VECTOR TO DISABLE INTERRUPTS.
;               3.  WHEN THE TASK IS ABORTED TO DISABLE INTERRUPTS.
;
DREDIR: BCS     20$             ;IF CS DISABLE INTERRUPTS
        BIS     #100,@#DRCSR    ;ENABLE INTERRUPTS
        RETURN                  ;AND OUT
20$:    BIC     #100,@#DRCSR    ;DISABLE INTERRUPTS
        RETURN                  ;AND OUT
;
;       INTERRUPT SERVICE ROUTINE
;
;       THE ISR IS ENTERED AT PRIORITY 5 (SPECIFIED ON CINT$) WITH
;               R4 = SAVED AND FREE TO BE USED
;               R5 = ADDRESS OF FORK BLOCK IN THE ITB
;
DRINT:  BIT     #SWTCH1,@#DRBUF ;;;INPUT BUFFER REQUEST?
```

Example 13-4 Sample Connect-to-Interrupt Routine (Sheet 2 of 3)

```
        BEQ     30$             ;;;IF EQ, NO
        CMP     #BUFSIZ,COUNT   ;;;YES, BUFFER FULL?
        BEQ     50$             ;;;IF EQ, YES
        MOV     COUNT,R4        ;;;IF NE, NO
        ADD     PC,R4           ;;;CALCULATE BUFFER
        ADD     #BUFFER-.,R4    ;;;PIC ADDRESS TO STORE SAMPLE
        MOVB    @#$TTNS,(R4)    ;;;LOW BYTE OF TICKS TILL NEXT SECOND
        INC     COUNT           ;;;INCREMENT NUMBER OF SAMPLES
        BR      50$             ;;;EXIT FROM INTERRUPT
;
;       INTERRUPT WAS FROM SWITCH 2 OR 3
;
30$:    CALL    @#$FORK2        ;;;CREATE A SYSTEM PROCESS
        CLR     (R3)            ;DECLARE THE FORK BLOCK FREE
        BIT     #SWTCH3,@#DRBUF ;DISCONNECT FROM INTERRUPT?
        BNE     40$             ;IF NE, YES
;
;       SWITCH 2 => QUEUE AN AST TO THE TASK
;
        CALL    @#$QASTC        ;QUEUE AN AST
        BR      50$             ;EXIT FROM INTERRUPT
;
;       SWITCH 3 => DISCONNECT FROM INTERRUPTS.
;       SET LOCAL EVENT FLAG 2 TO WAKE UP TASK LEVEL CODE TO
;       ISSUE THE DISCONNECT
;
40$:    MOV     #EF,R0          ;EVENT FLAG 2 TO BE SET
        MOV     X.TCB-X.FORK(R5),R5 ;R5 POINTS TO THE TCB OF TASK
        CALL    @#$SETF         ;EXEC SUBROUTINE SETF
        RETURN                  ;EXIT INTERRUPT
;
;       EXIT FROM INTERRUPT.  TURN INTERRUPT BACK ON.
;
50$:    BIS     #100,@#DRCSR    ;TURN ON INTERRUPTS
        RETURN                  ;EXIT FROM INTERRUPT
;
;       ENSURE ISR + DATA + ENABLE/DISABLE SUBROUTINES FIT IN 4K
;
        .IIF    LT,<20000 - <. - ISRBAS>> .ERROR
        .END    START
```

Example 13-4 Sample Connect-to-Interrupt Routine
(Sheet 3 of 3)

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