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Identification

The Reload I/O Process
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Purpose

This section describes the organization and design of the reloading I/O process used by the hierarchy reconstruction process and the secondary storage reload process (BH.3).

Introduction

The reload I/O process handles the I/O for all reload processes. Communication between the I/O process and the reload processes is done through an I/O queue. The various reload processes approach the queue at different (random) times. The I/O process must merely keep up with work assigned to it by the reload processes. The backup scheme includes multiple reload processes to insure as fast a reload as possible given the several processors of a typical Multics installation.

The interaction between the I/O process and the reload processes is depicted in figure 1. The several reload processes make calls to the several entry points to the call handler routine when appropriate. The call handler then creates a new queue entry in the I/O queue, stores into this entry the process identification and reloader_id (passed as an argument in the call) and reconnects the various pointer chains which define the queue.

Associated with each reload process is a working directory for that process. In this working directory are several buffers and data bases through which any data transferred to the I/O process actually flow. The I/O queue entry merely specifies which reloader (and consequently which buffers) are responsible for the I/O request. There are two variables which are placed in each queue entry. These are:

1) The process identification of the reload process making the call. This is used to wakeup the reload process at a later time, and

2) The reloader identification. The "reloader_id" is a number used to identify the reload process to the I/O process. The numerical value of the "reloader_id" is used by the I/O process as an index into several of its tables.

The directory name, of course, allows unambiguous access to the correct buffers to be associated with the request. All reload processes are identical and hence corresponding buffer segments (directly inferior to the reload working directory) for different reload processes all have the same name. These latter names are known by the I/O process, and hence the only additional information needed in any one request is the directory name. (The directory path name is supplied at initialization time.)

On the other side of the queue, the I/O process goes blocked awaiting a wakeup signal from some reloader. When it finds a new request upon awakening it selects an input unit, copies the queue entry, deletes the entry in the queue, reads in the header from tape, stores the header information in the appropriate buffer, sets the status switches OFF, and starts I/O on the preamble and data segments. (This will be discussed in more detail later.)

When a reloader is initialized it calls the I/O process at the following initialize entry point:

```
call init_reloader (path_name, reloader_id);
```

where

```
dcl   path_name char(*),
      reloader_id bit (36);
```

applies.

path_name is the directory path name of the working directory for this reload process. The I/O process then makes the buffer segments of this reload process known to it and stores the segment numbers in a table which it keeps for its own reference. This table is indexed by the numerical value of "reloader_id". The PL/I declaration for this table is as follows:

```
dcl     1   table (max_proc),
        2   header_buffer ptr,
        2   preamble_buffer ptr,
        2   directory_buffer ptr;
```

If chfx is a routine which converts the directory name into its numerical value then a typical reference to the header buffer of reload process proc 1 would be

```
table(chfx(proc_1)).header_buffer -> ...
```

The PL/I declaration for the header buffer is as follows:

```
dcl  1  header ctl(hp),
       2  pre_status bit(1),
       2  dir_status bit(1),
       2  trap_sw bit(1),
       2  tmtype bit (17),
       2  uid bit (70),
       2  dtm bit (72),
       2  table_name char(12),
       2  table_index char(6),
       2  n fixed bin (17),
       2  slotno fixed bin (17),
       2  current_ln fixed bin(17),
       2  slot_name_ln fixed bin(17),
       2  slot_name char(hp ->header.slot_name_ln);
```

The next four sections describe respectively the reload I/O queue, the reload I/O call_handler, the reload I/O process, and the reload list (a list of reel labels used to define the reload sequence).

The Reload I/O Queue

The reload I/O queue is a doubly threaded list of entries. The entries are generated by the routine call handler common to all reload processes. With each call to getheader (an entry point withing the call handler routine) a new entry is created in the queue by allocating storage for it and setting the forward and backward pointer chains. After the entry is so established, the process identification and reloader_identification are stored in the queue and the I/O process is sent a wakeup signal.

Simultaneously, the I/O process is blocked awaiting a wakeup signal from a reload process. For each entry it

finds upon awakening it starts the I/O activity requested and deletes and frees the queue entry. The header buffer (directly inferior to the reloader's working directory) is then loaded with the header information. The status switches (explained later) are turned OFF and stored in the header buffer.

The PL/I declarations for the queue (header) and the queue entries are as follows:

```
dcl  1  ioq$header ext,
       2  lock bit (36),
       2  first_ptr bit (18),
       2  last_ptr bit (18),
       2  length fixed bin(17),
       2  var area (segment_size);
dcl  1  entry ctl(qp),
       2  forward_ptr bit (18),
       2  backward_ptr bit (18),
       2  reloader_id bit (36),
       2  process_id bit(36);
```

The Reload I/O Call Handler

The routine call handler is common to all reload processes and has the following entry points:

getheader

getpreamble

getdirectory

getsegment

When getheader is called the call handler creates a new entry in the queue. Into this entry it places the "reloader

identification" (found as an argument to the call) and the "processid". The I/O process is then awakened to insure that the newly created entry is processed and the reload process then goes blocked. Upon awakening, the entire header information will have been placed in the header buffer for this reload process. The header buffer contents are then merely copied into the argument list and the call handler returns.

When either getpreamble, getdirectory, or getsegment is called, the call handler assumes that a previous call to getheader has been made. The call to getheader instructs the I/O process to begin I/O on the preamble and, if present, the directory or data segment. When the I/O process finishes reading in the preamble (into the preamble segment for the appropriate reload process) it turns the preamble status switch (found in the header buffer for the process) ON to so indicate. A similar action is taken upon completion of the I/O for the optional directory or data segment.

When a call to getpreamble occurs, the call handler tests the preamble status switch and if it indicates that the preamble has been successfully read in, i.e. the switch is ON, it returns. If the switch is OFF the call handler calls block awaiting for a wakeup from the I/O process. (Whenever the I/O process sets any status switch a wakeup signal is sent to the appropriate reloader).

Calls to getdirectory and getsegment work exactly as do calls to getpreamble in relation to status switch operations.

If a call to getpreamble, etc. occurs not preceded by a call to getheader an error return is taken.

The call_handler is called in any of the following ways:

```
call getheader(reloader_id,srs,sfs,uid,dtm,incsw,dirsw,table_
name,table_index,n,slotno,slotname,errtn);

call getpreamble(reloader_no, errtn);

call getdirectory(reloader_no, errtn);

call getsegment(reloader_no, errtn);
```

Where the arguments are defined as follows:

reloader_id bit (36)	An identifier unique to each reload process. Each reloader_id has a different set of buffers (1 preamble, 1 header, 1 directory, etc.) associated with it.
srs bit(1)	segment-removed-switch (see BH.3)
sfs bit(1)	segment-follows-switch (see BH.3).
uid bit (70)	unique id of the terminal entry in the preamble
dtm bit (72)	date/time-file-last-modified of the terminal entry
incsw bit (1)	indicates whether the current record is considered to be incremental or checkpoint.
dirsw bit (1)	directory switch (ON if terminal entry is a directory branch)
table_name char(12)	the segment name of a table which contains the retrieval argument (reel label and record number) for the record currently being processed
table_index char(6)	An index into the above table.
n fixed bin(17)	number of entries in the preamble
slotno fixed bin(17)	slot number of the terminal entry
slotname char(*)	slotname of the terminal entry
errtn label	error return

Associated with each reloader_id (in addition to the buffers) is a "device scanning list" which gives the identification of the particular device wanted by the reloader. Ordinarily only the first entry in the list is non-random and is set to the device last used by the reloader associated with "reloader_id". When the I/O process then reaches for a device it tries to hook up to the device specified

by the first entry in the device scanning list. If the I/O process is successful in procuring this device then maximum use can be made of redundant preamble information. (Subsequent logical records on tape although completely independent often define similar positions in the file system hierarchy and therefore much of the preamble will be identical. To take advantage of this redundancy, it is best to put all such similar preambles and their data segment on the same tape at dump time. This will allow the reloader to take maximum advantage of the dumping scheme by using the same device for subsequent calls).

The Reload I/O Process

The reload I/O process must perform the following tasks:

1) Accept requests (from the I/O queue) for input of logical records from tape

2) Keep track of the logical record hierarchy (subrecords, etc.)

3) Handle end-of-tape error returns

4) Specify which tape reels should be used for a reload and in which order they should be used

5) Keep track of which buffers are associated with which reloader_id's and

6) Keep track of the device scanning list for each reloader.

The manner of accepting requests (by searching the I/O queue for new unprocessed entries upon response to a wakeup signal) is straight forward. Each time the I/O process completes its work for one reloader it searches the queue again and goes blocked if there are no new entries. The queue is loaded from the top and unloaded from the bottom with the assumption that the reloaders cannot get too far ahead of the I/O process. (The queue is set to a maximum size above which the reloaders cannot extend it.)

The logical record hierarchy used by backup is described in detail in BH.4.03 The general construction can be described by the following outline (the hierarchical character is then obvious):

1. Tape header

2. Tape records

a) Record no. 1

i. Header

ii. Preamble

(iii. Directory or data segment) - optional

b) Record no. 2

i. Header

ii. Preamble

(iii. Directory or data segment) - optional

.

.

.

c) Record no. n

i. Header

ii. Preamble

(iii. Directory or data segment) - optional

When a call to getheader is made the I/O process must find an available device, forward the tape to the beginning of the next logical reocrd, if not already there, and begin reading in the header data. Only after a complete record has been processed is the device made available for further calls to getheader.

End-of-tape returns are built in as a Multics I/O system facility. Upon detection of such a condition the I/O process must do the following:

1) Instruct the I/O System to unload this tape reel,

2) Search in the reload list (described later) for the next tape reel to be used, and

3) Instruct the I/O system to load this reel (on the same device presumably).

The manner in which the reload list is used is described in the next section.

The Backup I/O Reload List

As described in section BH.4.03 each tape created by the various backup processes includes a header (created by the Backup I/O process) which contains among other items a list of the tape reels to be used at reload time (hereafter called the reload list). Whenever a secondary storage reload is initiated, the last backup tape created is loaded to initialize the reload process. The header of this tape is then stored in a data base used by the I/O process (as the reload list). As the reloader finishes with a tape reel it instructs the I/O System to mount a new reel and specifies the appropriate reel via its reel label. Reels are reloaded in reverse chronological order - the last created is the first used.

While writing either type of checkpoint tape, the header will not include that particular checkpoint dump in the reload list. Checkpoint dumps do not exist until complete. Incremental tapes, however, do include their own label in the reload list. With this design the last tape created (possibly the tape being created) contains the correct reload list.

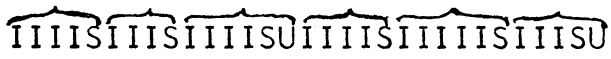
The I/O process determines which reel should be mounted by the information found in the reload list (information from reels already processed). Each header contains complete information specifying which reels should be used for the hierarchy reconstruction process. Each header specifies reels through n user checkpoint dumps (n being the user checkpoint retention period). Whenever a user checkpoint reel is encountered the reload list kept by the I/O process is reset to that in the header of the newly found user checkpoint reel. Then, if the reloading of the user checkpoint dump should not succeed completely, a further (older) user checkpoint dump will have been specified.

The hierarchy reconstruction process continues until a complete system checkpoint dump has been reloaded. When this occurs the second phase of the reloading process is entered (the secondary storage reload process, BH.3.02). This process continues to function until a complete user checkpoint dump has been reloaded.

If a system checkpoint reel cannot be found or does not exist the reloader skips this reel and notes that this system checkpoint dump cannot be reloaded completely. Those tapes that can be reloaded are, but the reloader does not enter the secondary reload phase until a complete system checkpoint dump has been reloaded. Once a complete system checkpoint dump has been reloaded all further such dumps are skipped. Note there are several system checkpoint dumps for each user checkpoint dump and if none of the former can produce a successful, complete reload by the time a user checkpoint dump is encountered, the user checkpoint must be skipped over. Each time the hierarchy reconstruction process skips over such a user checkpoint dump, the reload list is "updated" to include another (older) user checkpoint dump.

In that the reload list reflects which backup tapes have been created (in reverse order) the configuration is as follows: the first reels specified are incremental tape reels (each reel is a unit in itself). Then follows a system checkpoint dump which may consist of several reels. This entire sequence is then repeated several times before a user checkpoint dump (of possibly several reels) is encountered. This whole configuration is repeated once. The following might be the layout of a typical (reel header) reload list:

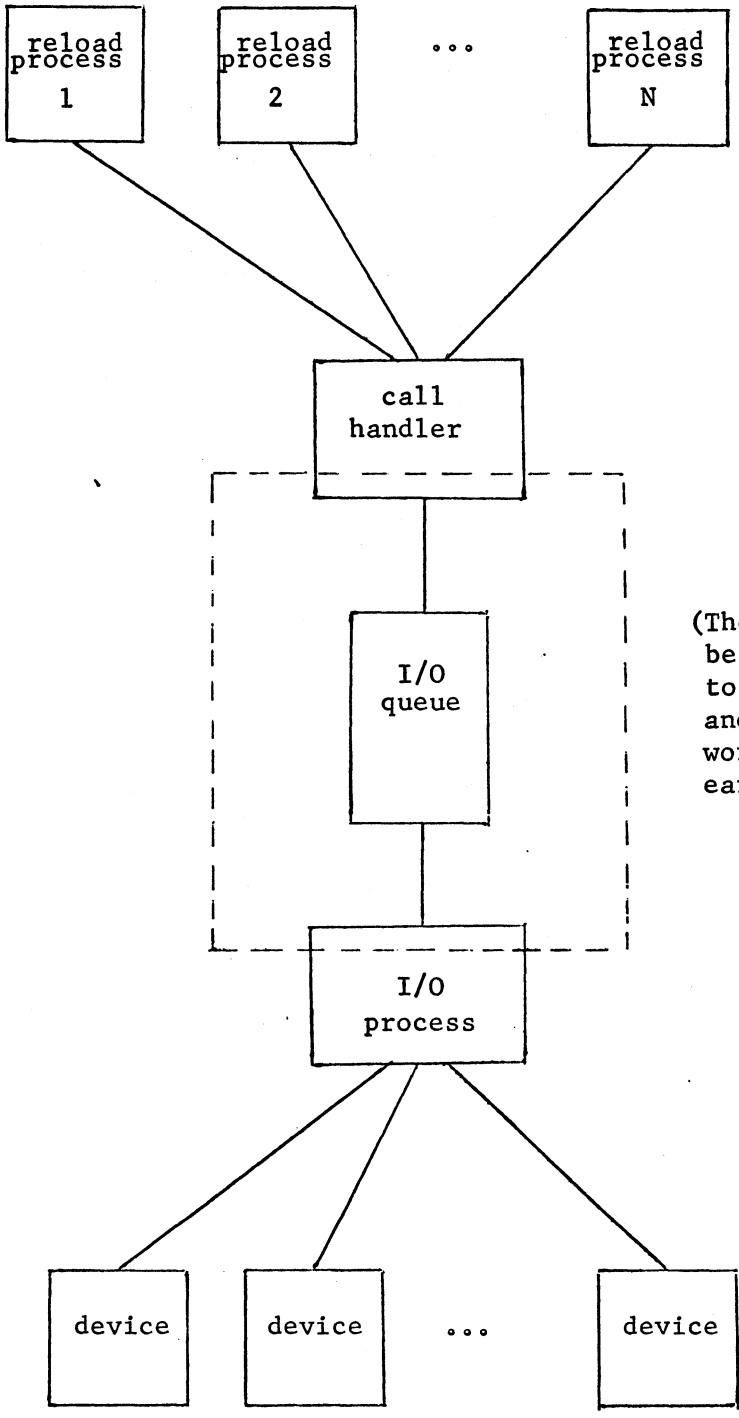
load first load last
(if necessary)



I represents 1 incremental tape

S represents 1 system checkpoint dump (possibly several tapes)

U represents 1 user checkpoint dump (possibly several tapes)



(The I/O queue can easily be removed, as indicated, to allow one dumping process and one device process to work synchronously on an early version of Multics.)

Figure 1