3 Memory organization

All short pointers access memory locations within an MDS. They access all local and some global frames (§3.2.2.2)

3.2.2.2 Local and global frames

Global Frames

Programming Note: Except for the restriction that frames are contained entirely within a 64K bank, the maximum size of a frame is not specified by the architecture.

GlobalFrameHandle: TYPE = LONG POINTER TO GlobalVariables;

![Global frame diagram](image)

Figure 3.4 Global frame

The overhead words contain the flag bits trapxfers and codelinks used during control transfers (§9.3)

GlobalFrameBase: TYPE = LONG POINTER TO GlobalOverhead;

GlobalWord: TYPE = MACHINE DEPENDENT RECORD [
  available (0: 0..13): [0..37777B],
  trapxfers (0: 14..14): BOOLEAN,
  codelinks (0: 15..15): BOOLEAN];

GlobalOverhead: TYPE = MACHINE DEPENDENT RECORD [
  available (0): UNSPECIFIED,
  word (1): GlobalWord,
  global (2): GlobalVariables];
Local Frames

The globallink points to the procedure's global frame index. It is used to gain access to the procedure's global variables.

Notice that a local frame is sufficient to determine all of the other registers: given a local frame pointer, the program counter is obtained from its pc field, the global frame index from its globallink field, and the global frame handle and code segment address from the global frame table.

The global frame index of the current context is contained in the sixteen bit register GFI. Its value is obtained using LocalBase[LF].globallink.

GFI: GFTHandle;

The address of the global frame of the current context is contained in the 32 bit register GF. Its value is obtained using GFT[GF].globalFrame.

GF: GlobalFrameHandle;

The address of the code segment of the current context is contained in the register CB (the code base, a long pointer). Its value is obtained using GFT[GFI].codebase.

LocalOverhead: TYPE = MACHINE DEPENDENT RECORD [
  word (0): LocalWord,
  returnlink (1): ShortControlLink,
  globallink (2): GFTHandle,
  pc (3): CARDINAL,
  local (4): LocalVariables];
7 Assignment instructions

7.2.2 Global frame access

LGAn Long Global Address n

LGAn: PROCEDURE [n: [0..1]] =
BEGIN
PushLong[GF + n];
END;

LGAB Long Global Address Byte

LGAB: PROCEDURE =
BEGIN
alpha: BYTE = GetCodeByte[];
PushLong[GF + alpha];
END;

LGAW Long Global Address Word

LGAW: PROCEDURE =
BEGIN
word: UNSPECIFIED = GetCodeWord[];
PushLong[GF + word];
END;

7.2.2.1 Load global

LGn Load Global n

LGn: PROCEDURE [n: [0..2]] =
BEGIN
Push[Fetch[GF + n] i];
END;

LGB Load Global Byte

LGB: PROCEDURE =
BEGIN
alpha: BYTE = GetCodeByte[];
Push[Fetch[GF + alpha] t];
END;

LGDb Load Global Double Byte

LGDb: PROCEDURE =
BEGIN

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MESA 14.0 CHANGE SUMMARY
alpha: BYTE = GetCodeByte[];
Push[Fetch[GF + alpha] ↑];
Push[Fetch[GF + alpha + 1] ↑];
END;

7.2.2.2 Store global

SGB Store Global Byte

SGB: PROCEDURE =
BEGIN
alpha: BYTE = GetCodeByte[];
Store[GF + alpha] ↑ ← Pop[];
END;

SGDB Store Global Double Byte

SGDB: PROCEDURE =
BEGIN
alpha: BYTE = GetCodeByte[];
Store[GF + alpha + 1] ↑ ← Pop[];
Store[GF + alpha] ↑ ← Pop[];
END;

7.3.2.1 Read indirect

RGIP Read Global Indirect Pair

RGIP: PROCEDURE =
BEGIN
pair: NibblePair = GetCodeByte[];
ptr: POINTER = Fetch[GF + pair.left] ↑;
Push[FetchMds[ptr + pair.right] ↑];
END;

RGILP Read Global Indirect Long Pair

RGILP: PROCEDURE =
BEGIN
pair: NibblePair = GetCodeByte[];
ptr: LONG POINTER = ReadDbl[GF + pair.left];
Push[Fetch[ptr + LONG[pair.right]] ↑];
END;

9 Data types

9.1 Control links

LinkType: TYPE = {
    frame, oldProcedure, indirect, newProcedure};
**9.1.4 New procedure descriptors**

A *procedure descriptor* is used to create a new context. It contains the information necessary to obtain the global frame index GFI, the global frame pointer GF, the code segment pointer CB, the local frame pointer LF, and the starting PC value for the procedure. It consists of two fields:

```pascal
NewProcDesc: TYPE = MACHINE DEPENDENT RECORD [
  taggedGFI(0): UNSPECIFIED,
  pc (1): CARDINAL];
```

```pascal
MakeNewProcDesc: PROCEDURE [link: ControlLink] 
RETURNS [NewProcDesc] = 
BEGIN 
  IF ControlLinkType[link] # newProcedure THEN ERROR; 
  RETURN[LOOPHOLE[link]]; 
END;
```

The taggedGFI is the global frame index or'ed with 3. The new value of GFI is computed from taggedGFI. The global frame and the code base are then obtained from the global frame table using GFI.

The following is a sketch of this process (ignoring traps and other types of control transfers). §9.3 contains a complete description.

```pascal
proc: ProcDesc;
...
GFI ← And[proc.taggedGF, 1777748];
GF ← ReadDbl[@GFT(GFI).globalFrame];
CB ← ReadDbl[@GFT(GFI).codebase];
...
```

**9.1.4.1 Global frame table**

The Global Frame Table (GFT) contains the global frame handle and codebase of each module instance. It is at a fixed location GFT. The table is organized as an array; elements can be accessed by index GFTindex, or by relative pointer GFTHandle.

```pascal
GFT: LONG POINTER TO GlobalFrameTable = LOOPHOLE[mGFT];
GlobalFrameTable: TYPE = LONG BASE POINTER TO
```
9.1.4.2 Descriptor instruction

The descriptor instruction creates a procedure descriptor using GFI and a pc.

```
DESC Descriptor

DESC: PROCEDURE =
BEGIN
  word: UNSPECIFIED = GetCodeWord[];
  Push[Or[GF, 3]];
  Push[word];
END;
```

9.3 Control transfer primitive

```
SELECT ControlLinkType[nDst] FROM
  newProcedure = =>
BEGIN
  word: BytePair;
  proc: NewProcDesc = MakeNewProcDesc[nDst];
  GF ← And[proc.taggedGF, 177748];
  IF GF = LOOPHOLE THEN UnboundTrap[dst];
  GF ← ReadDbl[@GFT(GFI).globalFrame];
  CB ← ReadDbl[@GFT(GFI).codebase];
  IF Odd[LowHalf(CB)] THEN CodeTrap[GFI];
  npC ← proc.pc;
  IF npC = 0 THEN UnboundTrap[dst];
  word ← ReadCode[npC/2];
  nLF ← Alloc(IF npC MOD 2 = 0 THEN word.left ELSE word.right);
  npC ← npC + 1;
  StoreMds[@LocalBase[nLF].globallink] ← GF;
  StoreMds[@LocalBase[nLF].returnlink] ← src;
END;

frame = =>
BEGIN
```
9.4.1 Local function calls

```
LFC: PROCEDURE =
...
LFC: PROCEDURE =
...
```

9.4.2 External function calls

```
FetchLink: PROCEDURE [offset: BYTE] RETURNS [ControlLink] =
BEGIN
word: GlobalWord = Fetch[@GlobalBase[GF].word] ↑;
RETURN[
  IF word.codelinks THEN ReadDbl[@GFT[GF].codebase]
  ELSE ReadDbl[@GFT[GF].globalFrame];
END;
```

Design Note: If the links are stored in the code segment, they must be contained in the same 64K bank as the code base. This ensures that the calculation of the address of the link will not underflow in the low-order word or cause a borrow from the high-order word. Since frames are always completely contained in a 64K bank, this calculation is also accurate if the links are stored in the global frame.

9.5.1 Trap routines

```
CodeTrap: PROCEDURE [gfi: GFTHandle] = {
  TrapOne[@SD[sCodeTrap], gfi]);
```
Appendix A  Values of constants

Appendix A.2  Constant memory locations

mGFT  Global Frame Table

mGFT: LONG CARDINAL = 4000008;

Appendix B  Opcodes

LGAn  Long Global Address n (n = 0..1)
Push 32-bit value G + n.

LGAB  Long Global Address Byte
Push 32-bit value G + alpha.

LGAW  Long Global Address Word
Push 32-bit value G + alphabeta.

DESC  Descriptor
Push 32-bit procedure descriptor with pc alphabeta.