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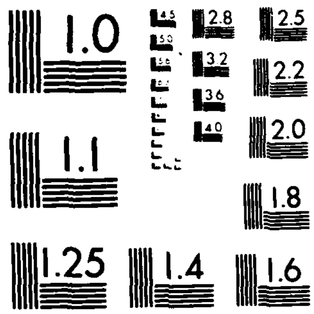

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VOLUME VIII

(2)

AD-A142 783

2nd AFSC STANDARDIZATION CONFERENCE

COMBINED PARTICIPATION BY:
DOD-ARMY-NAVY-AIR FORCE-NATO

30 NOVEMBER - 2 DECEMBER 1982
TUTORIALS: 29 NOVEMBER 1982

DAYTON CONVENTION CENTER
DAYTON, OHIO

SPONSORED BY
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TUTORIAL
MIL-STD-1815
ADA HIGH ORDER LANGUAGE

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This technical report has been reviewed and is approved for publication.

JEFFERY L. PESLER
Vice Chairman
2nd AFSC Standardization Conference

ERWIN C. GANGL
Chief, Avionics Systems Division
Directorate of Avionics Engineering

FOR THE COMMANDER

ROBERT P. LAVOIE, COL, USAF
Director of Avionics Engineering
Deputy for Engineering

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This is a collection of UNCLASSIFIED papers to be distributed to the attendees of the Second AFSC Avionics Standardization Conference at the Convention Center, Dayton, Ohio. The scope of the Conference includes the complete range of DoD approved embedded computer hardware/software and related interface standards as well as standard subsystems used within the Tri-Service community and NATO. The theme of the conference is "Rational Standardization". Lessons learned as well as the pros and cons of standardization are highlighted.

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This is Volume 8

Volume 1	Proceedings pp. 1-560
Volume 2	Proceedings pp. 561-1131
Volume 3	Governing Documents
Volume 4	MIL-STD-1553 Tutorial
Volume 5	MIL-STD-1589 Tutorial
Volume 6	MIL-STD-1679 Tutorial
Volume 7	MIL-STD-1750 Tutorial
Volume 8	MIL-STD-1815 Tutorial
Volume 9	Navy Case Study Tutorial

PROCEEDINGS OF THE

2nd AFSC STANDARDIZATION CONFERENCE

30 NOVEMBER - 2 DECEMBER 1982

DAYTON CONVENTION CENTER
DAYTON, OHIO

Sponsored by:

Air Force Systems Command

Hosted by:

Aeronautical Systems Division

FOREWORD

THE UNITED STATES AIR FORCE HAS COMMITTED ITSELF TO "STANDARDIZATION." THE THEME OF THIS YEAR'S CONFERENCE IS "RATIONAL STANDARDIZATION," AND WE HAVE EXPANDED THE SCOPE TO INCLUDE US ARMY, US NAVY AND NATO PERSPECTIVES ON ONGOING DOD INITIATIVES IN THIS IMPORTANT AREA.

WHY DOES THE AIR FORCE SYSTEMS COMMAND SPONSOR THESE CONFERENCES? BECAUSE WE BELIEVE THAT THE COMMUNICATIONS GENERATED BY THESE GET-TOGETHERS IMPROVE THE ACCEPTANCE OF OUR NEW STANDARDS AND FOSTERS EARLIER, SUCCESSFUL IMPLEMENTATION IN NUMEROUS APPLICATIONS. WE WANT ALL PARTIES AFFECTED BY THESE STANDARDS TO KNOW JUST WHAT IS AVAILABLE TO SUPPORT THEM: THE HARDWARE; THE COMPLIANCE TESTING; THE TOOLS NECESSARY TO FACILITATE DESIGN, ETC. WE ALSO BELIEVE THAT FEEDBACK FROM PEOPLE WHO HAVE USED THEM IS ESSENTIAL TO OUR CONTINUED EFFORTS TO IMPROVE OUR STANDARDIZATION PROCESS. WE HOPE TO LEARN FROM OUR SUCCESSES AND OUR FAILURES; BUT FIRST, WE MUST KNOW WHAT THESE ARE AND WE COUNT ON YOU TO TELL US.

AS WE DID IN 1980, WE ARE FOCUSING OUR PRESENTATIONS ON GOVERNMENT AND INDUSTRY EXECUTIVES, MANAGERS, AND ENGINEERS AND OUR GOAL IS TO EDUCATE RATHER THAN PRESENT DETAILED TECHNICAL MATERIAL. WE ARE STRIVING TO PRESENT, IN A SINGLE FORUM, THE TOTAL AFSC STANDARDIZATION PICTURE FROM POLICY TO IMPLEMENTATION. WE HOPE THIS INSIGHT WILL ENABLE ALL OF YOU TO BETTER UNDERSTAND THE "WHY'S AND WHEREFORE'S" OF OUR CURRENT EMPHASIS ON THIS SUBJECT.

MANY THANKS TO A DEDICATED TEAM FROM THE DIRECTORATE OF AVIONICS ENGINEERING FOR ORGANIZING THIS CONFERENCE; FROM THE OUTSTANDING TECHNICAL PROGRAM TO THE UNGLAMOROUS DETAILS NEEDED TO MAKE YOUR VISIT TO DAYTON, OHIO A PLEASANT ONE. THANKS ALSO TO ALL THE MODERATORS, SPEAKERS AND EXHIBITORS WHO RESPONDED IN SUCH A TIMELY MANNER TO ALL OF OUR PLEAS FOR ASSISTANCE.

ROBERT P. LAVOIE, COL, USAF
DIRECTOR OF AVIONICS ENGINEERING
DEPUTY FOR ENGINEERING

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AIR FORCE SYSTEMS COMMAND
ANDREWS AIR FORCE BASE DC 20334

29 AUG 1982

REPLY TO ATTN OF: CV

SUBJECT: Second AFSC Standardization Conference

TO: ASD/CC

1. Since the highly successful standardization conference hosted by ASD in 1980, significant technological advancements have occurred. Integration of the standards into weapon systems has become a reality. As a result, we have many "lessons learned" and cost/benefit analyses that should be shared within the tri-service community. Also, this would be a good opportunity to update current and potential "users." Therefore, I endorse the organization of the Second AFSC Standardization Conference.

2. This conference should cover the current accepted standards, results of recent congressional actions, and standards planned for the future. We should provide the latest information on policy, system applications, and lessons learned. The agenda should accommodate both government and industry inputs that criticize as well as support our efforts. Experts from the tri-service arena should be invited to present papers on the various topics. Our AFSC project officer, Maj David Hammond, HQ AFSC/ALR, AUTOVON 858-5731, is prepared to assist.

ROBERT M. BOND, Lt Gen, USAF
Vice Commander

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MIL-STD-1815
ADA HIGH ORDER LANGUAGE

Instructor: Maj. Richard E. Bolz
U.S. Air Force Academy

ABSTRACT

This tutorial will discuss the development history, design and implementation of Mil Std 1815 (the Ada programming language). The syntax and semantics of the language will be covered in overview fashion with emphasis on data typing and the use of Ada as an object-oriented design language.

BIOGRAPHY

Major Richard E. Bolz has earned the BS and MS in Computer Science from Penn State University and has been a member of the Computer Science Department at the U.S. Air Force Academy since 1973. He is the co-developer of 'Software Engineering with Ada', A 4-day course for managers, analysts, designers and programmers.

As long as there were no machines, programming was no problem at all; when we had a few weak computers, programming became a mild problem and now that we have gigantic computers, programming has become an equally gigantic problem. In this sense the electronic industry has not solved a single problem, it has only created them — it has created the problem of using its product.

E. W. Dijkstra

Turing Award Lecture, 1972

SYMPTOMS OF THE SOFTWARE CRISIS

> "...appear in the form of software that is non-responsive to user needs, unreliable, excessively expensive, untimely, inflexible, difficult to maintain, and not reusable."
>
> *David Fisher*

AS A REACTION TO THE SOFTWARE CRISIS, THE U.S. DEPARTMENT OF DEFENSE SPONSORED THE DEVELOPMENT OF THE ADA PROGRAMMING LANGUAGE AND ITS ENVIRONMENT

THE ADA CULTURE

* A PROGRAMMING LANGUAGE
* A PROGRAMMING ENVIRONMENT
* A WAY OF THINKING

ADA

* REPRESENTS A "major advance in programming technology, bringing together the best ideas on the subject in a coherent way designed to meet the real needs of practical programmers." *I. C. Pyle*

* IS A LANGUAGE THAT DIRECTLY EMBODIES AND ENFORCES MODERN SOFTWARE ENGINEERING PRINCIPLES

ABSTRACTION

* EXTRACT ESSENTIAL DETAILS

* OMIT INESSENTIAL DETAILS

* EACH LEVEL OF DECOMPOSITION REPRESENTS AN ABSTRACTION

* EACH LEVEL MUST BE COMPLETLY UNDERSTOOD AS A UNIT

* OUR VIEW OF THE WORLD FORMS LADDERS OF ABSTRACTION

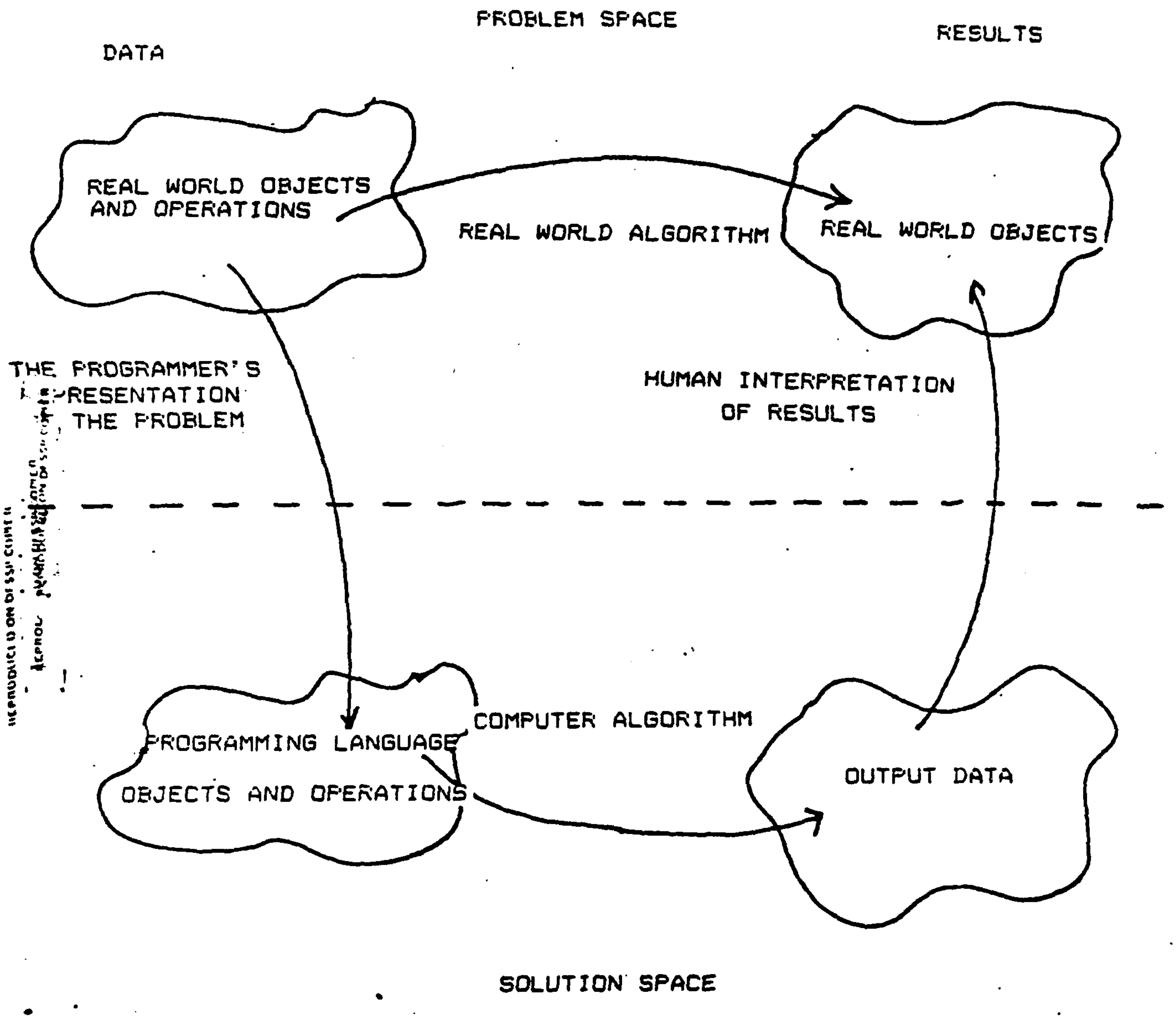
INFORMATION HIDING

* MAKE DETAILS OF AN IMPLE-MENTATION INACCESSIBLE

* ENFORCE DEFINED INTERFACES

* FOCUS ON THE ABSTRACTION OF AN OBJECT BY SUPRESSING THE DETAILS

* PREVENT HIGH LEVEL DECISIONS FROM BEING BASED ON LOW LEVEL CHARACTERISTICS



From the Programming Language Landscape by Henry Ledgard and Michael Marcotty (c) 1981 Science Research Associates, Inc. Reproduced by permission of the publisher

Figure 5-1: Model for a Typical Programming Task

ADA DESIGN GOALS

* RECOGNITION OF THE IMPORTANCE OF PROGRAM RELIABILITY AND MAINTAINABILITY

* CONCERN FOR PROGRAMMING AS A HUMAN ACTIVITY

* EFFICIENCY

LANGUAGE REQUIREMENTS (STEELMAN)

* STRUCTURED CONSTRUCTS
* STRONG TYPING
* RELATIVE AND ABSOLUTE PRECISION SPECIFICATION
* INFORMATION HIDING AND DATA ABSTRACTION
* CONCURRENT PROCESSING
* EXCEPTION HANDLING
* GENERIC DEFINITION
* MACHINE DEPENDENT FACILITIES

ADA FROM THE TOP DOWN

* ADA SYSTEMS ARE COMPOSED OF

  -- SUBPROGRAMS

  -- PACKAGES

  -- TASKS

* ALL PROGRAM UNITS HAVE A TWO PART STRUCTURE

  -- SPECIFICATION (VISIBLE PART)

  -- BODY (HIDDEN PART)

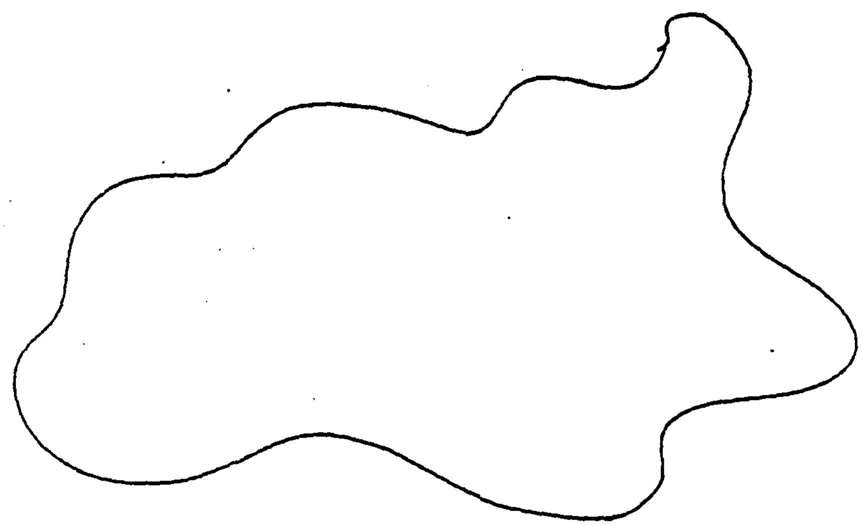


Figure 6-1: Symbol for an Undefined Entity

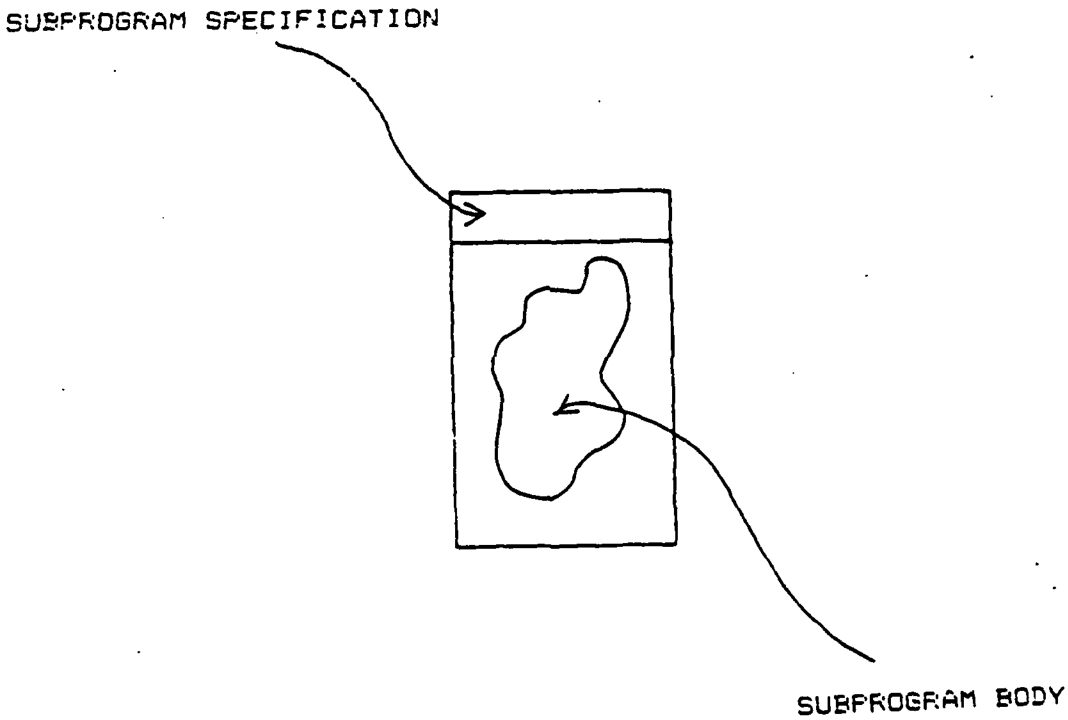


Figure 6-2: Symbol for an Ada Subprogram

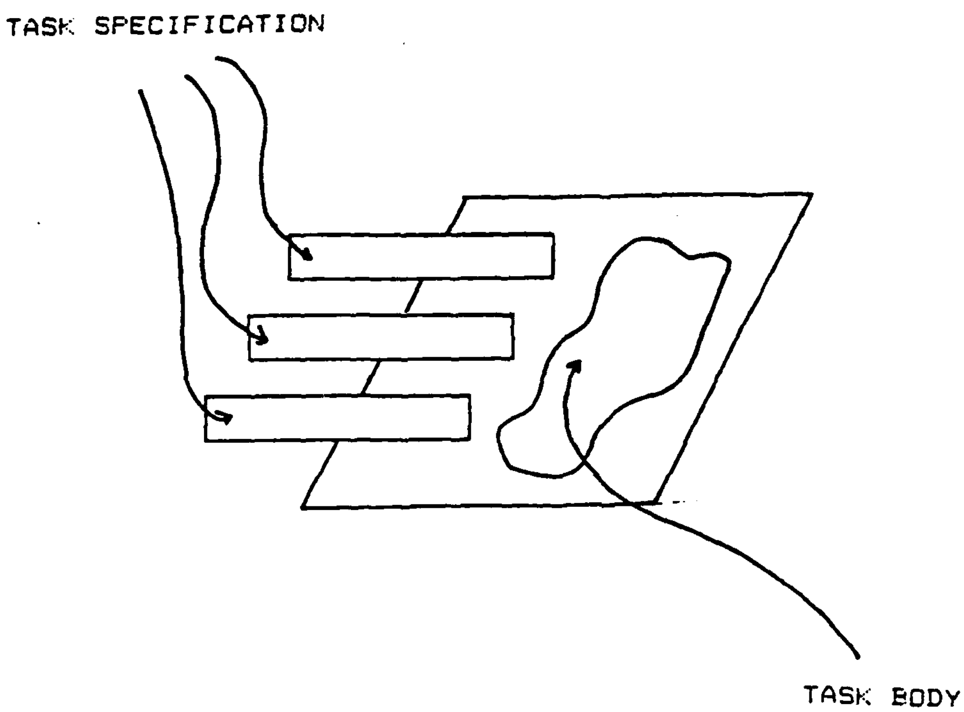


Figure 6-3: Symbol for an Ada Task

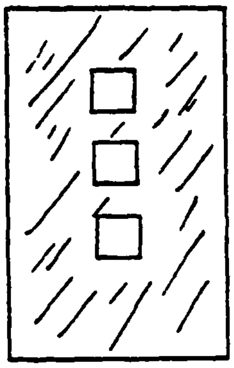


Figure 6-4: Package with Visible Parts

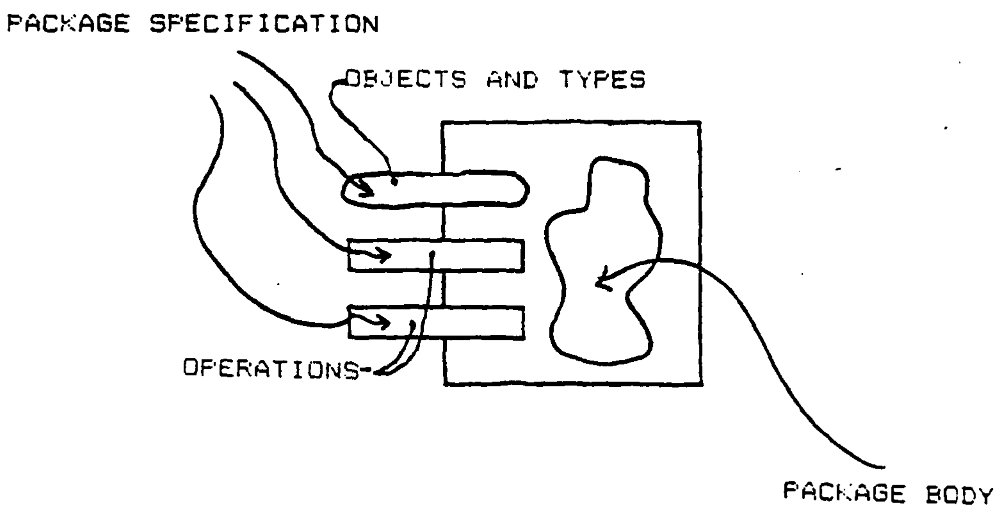


Figure 6-5: Symbol for an Ada Package

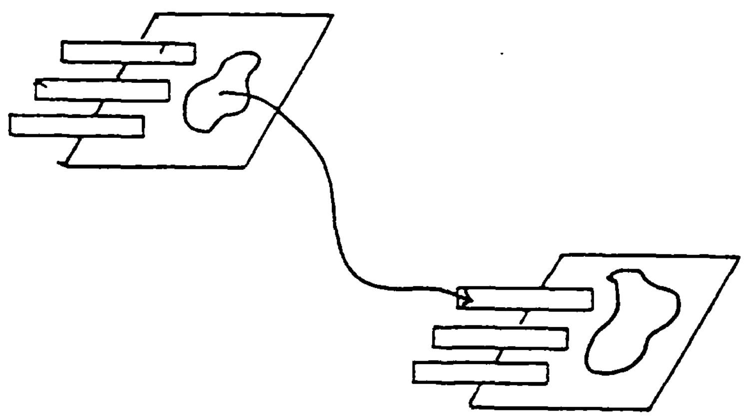


Figure 6-6: Communicating Ada Tasks

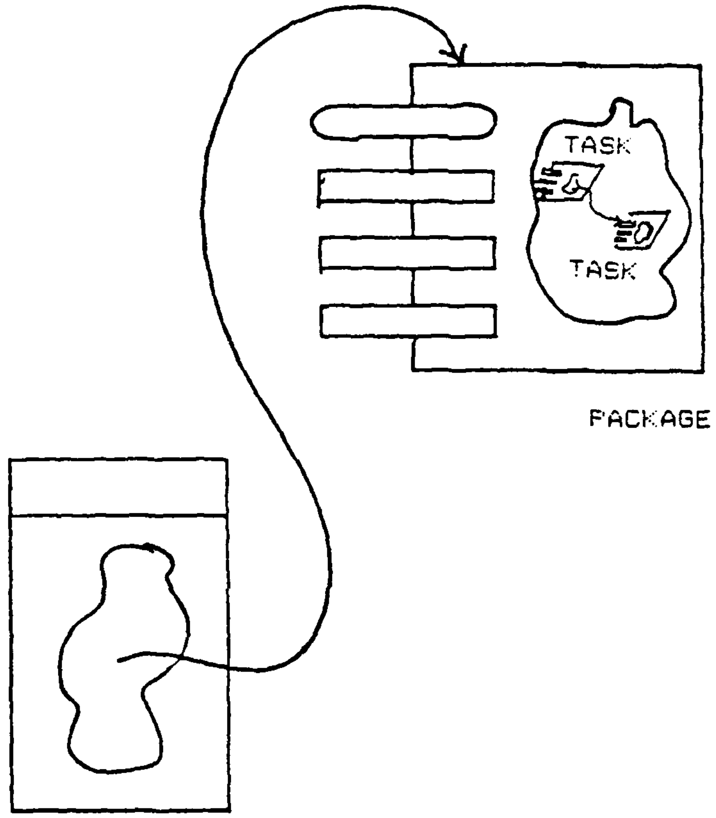


Figure 6-7: Nesting Ada Program Units

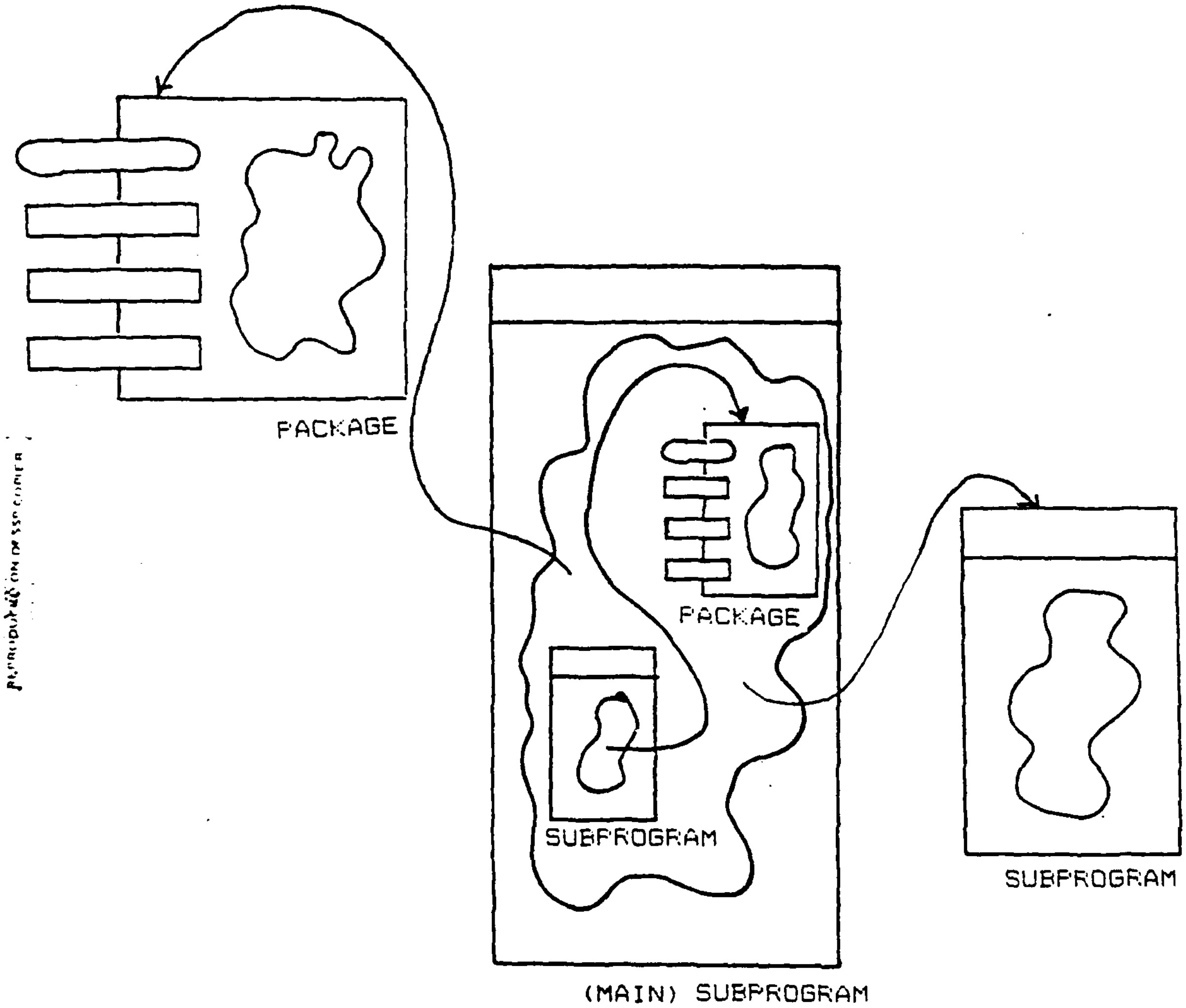


Figure 6-8: An Ada Program from the Top Down

ADA FROM THE BOTTOM UP

* ALL CONSTRUCTS ARE BUILT FROM A STANDARD OR EXTENDED CHARACTER SET (ASCII)

* LEXICAL UNITS INCLUDE

  -- IDENTIFIERS

  -- NUMERIC LITERALS

  -- CHARACTER LITERALS

  -- STRINGS

  -- DELIMITERS

  -- COMMENTS

ADA RESERVED WORDS

abort	declare	generic	of	select
abs	delay	goto	or	separate
accept	delta		others	subtype
access	digits	if	out	
all	do	in		task
and		is	package	terminate
array			pragma	then
at	else		private	type
	elsif	limited	procedure	
	end	loop		
begin	entry		raise	use
body	exception		range	
	exit	mod	record	when
			rem	while
		new	renames	with
case	for	not	return	
constant	function	null	reverse	xor

TYPE DEFINITIONS

* A TYPE CHARACTERIZES

  -- A SET OF VALUES

  -- A SET OF OPERATIONS APPLICABLE TO THOSE VALUES

* ADA CLASSES OF TYPES INCLUDE

  -- SCALAR

    - INTEGER

    - REAL

    - ENUMERATION

  -- COMPOSITE

    - ARRAY

    - RECORD

  -- ACCESS

  -- PRIVATE

  -- SUBTYPE AND DERIVED TYPE

DECLARATIONS

* CREATE OBJECTS OF A GIVEN TYPE

* ADA DECLARATIONS PERMIT

  -- VARIABLES

  -- CONSTANTS

  -- DYNAMIC CREATION

NAMES

* DENOTE DECLARED ENTITIES

* MAY BE OVERLOADED

* ARE STRONGLY TYPED

OPERATORS AND EXPRESSIONS

* PREDEFINED OPERATORS INCLUDE

-- EXPONENTIATING	**		
-- MULTIPLYING	*	/	
	mod	rem	
-- UNARY	+	-	
	not	abs	
-- ADDING	+	-	&
-- RELATIONAL	=	/=	<
	<=	>	>=
-- LOGICAL	and	or	xor
	and then	or else	
-- MEMBERSHIP	in	not in	

* OPERATOR SYMBOLS MAY BE OVERLOADED

STATEMENTS

* PROVIDE CONTROL AND ACTION

* ADA STATEMENTS INCLUDE

-- SEQUENTIAL

- ASSIGNMENT
- NULL
- SUBPROGRAM CALL
- RETURN
- BLOCK

-- CONDITIONAL

- IF
- CASE

-- ITERATIVE

- LOOP
- EXIT

-- OTHER STATEMENTS

- ENTRY CALL	- RAISE
- ACCEPT	- CODE
- ABORT	- GOTO
- DELAY	
- SELECT	

SUBPROGRAMS

* ARE THE BASIC EXECUTABLE UNIT

* ADA SUBPROGRAMS INCLUDE

  -- PROCEDURES

  -- FUNCTIONS

PACKAGES

* PERMIT THE COLLECTION OF GROUPS OF LOGICALLY RELATED ENTITIES

* DIRECTLY SUPPORT INFORMATION HIDING AND ABSTRACTION

* PERMIT AN INDUSTRY OF SOFTWARE MODULES

TASKS

* PERMIT COMMUNICATING SEQUENTIAL PROCESSES

* USE THE CONCEPT OF A RENDEZVOUS

* SPECIAL STATEMENTS ARE PROVIDED FOR TASK CONTROL

EXCEPTION HANDLING

* PERMITS ERRORS TO BE CAPTURED FOR GRACEFUL DEGRADATION
* IS BLOCK STRUCTURED
* EXCEPTIONS MAY BE PRE-DEFINED OR USER DEFINED

GENERIC PROGRAM UNITS

* DEFINE HIGH LEVEL TEMPLATES

* PERMIT PARAMETERIZATION OF SUBPROGRAMS AND PACKAGES

* ENCOURAGE GENERAL PURPOSE SOFTWARE LIBRARIES

REPRESENTATION SPECIFICATIONS

* PERMIT MAPPING THE LANGUAGE TO THE UNDERLYING MACHINE

* INCLUDE SPECIFICATION OF

  -- LENGTH

  -- ENUMERATION TYPE REPRESENTATION

  -- RECORD TYPE REPRESENTATION

  -- ADDRESS SPECIFICATION

* PERMIT ACCESS TO

  -- INTERRUPTS

  -- IMPLEMENTATION DEPENDENT FEATURES

INPUT/OUTPUT

* ACHIEVED THROUGH THE PACKAGE FACILITY

* PREDEFINED I/O PACKAGES

  -- HIGH-LEVEL IO

    - SEQUENTIAL_IO

    - DIRECT_IO

    - TEXT_IO

  -- LOW_LEVEL IO

SUMMARY OF LANGUAGE CHARACTERISTICS

* GENERAL PURPOSE

* EMPHASIS ON RELIABILITY AND MAINTAINABILITY

* DIRECTED TOWARD EFFICIENT USE FOR LARGE, FREQUENTLY MODIFIED SYSTEMS

* INCORPORATES THE BEST OF EXISTING SOFTWARE TECHNOLOGY

* ENCOURAGES AND ENFORCES SOFTWARE ENGINEERING PRINCIPLES

In the development of our understanding of complex phenomena, the most powerful tool available to the human intellect is abstraction. Abstraction arises from a recognition of similarities between certain objects, situations or processes in the real world, and the decision to concentrate on these similarities, and to ignore the differences.

C.A.R. Hoare

Notes on Data Structuring

DEFINE THE PROBLEM

* GIVEN A BINARY TREE,
  COUNT ITS LEAVES

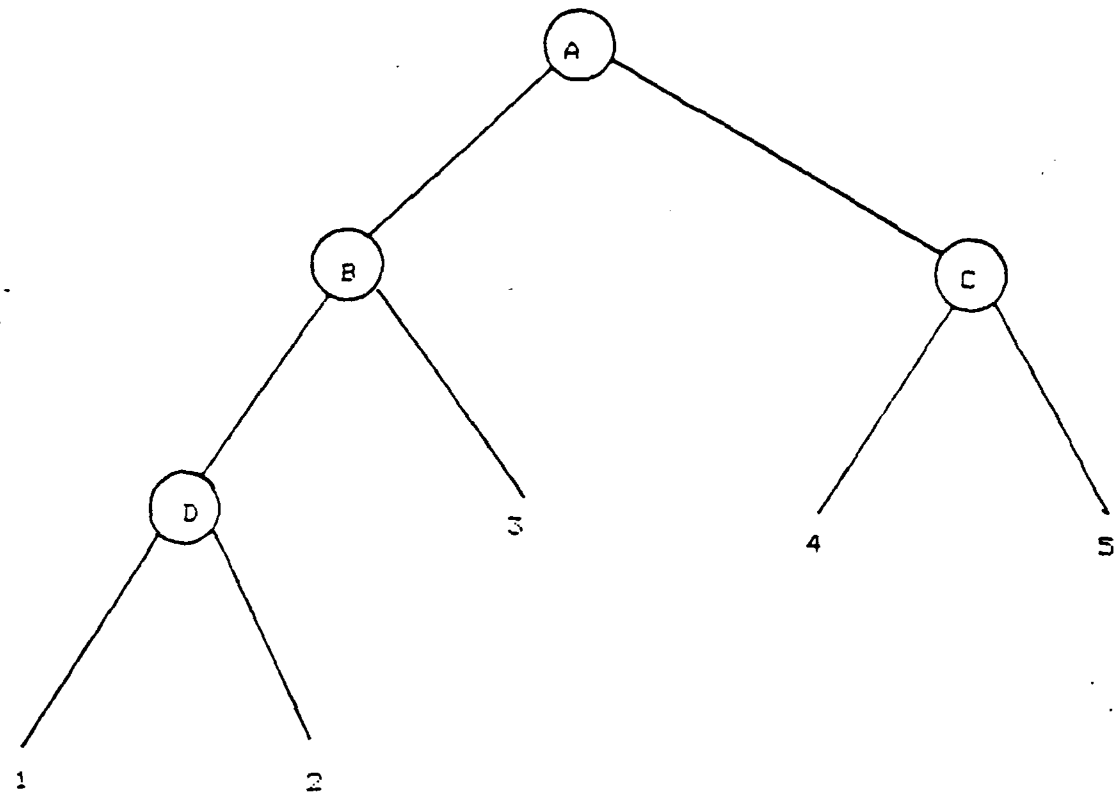


Figure 7-1: A Binary Tree

COUNTING LEAVES

* IF THE TREE IS A LEAF

  NUMBER_OF_LEAVES(TREE) = 1

* IF THE TREE CONSISTS OF TWO SUBTREES

  NUMBER_OF_LEAVES(TREE) =
    NUMBER_OF_LEAVES(RIGHT_SUBTREE) +
    NUMBER_OF_LEAVES(LEFT_SUBTREE)

ASSUMPTIONS ABOUT THE SOLUTION

* THE IMPLEMENTATION LANGUAGE CONTAINS BASIC CONTROL STRUCTURES

  -- SEQUENTIAL

  -- CONDITIONAL

  -- ITERATIVE

* THERE ARE NO PREDEFINED OBJECTS OR OPERATIONS

* THE IMPLEMENTATION LANGUAGE HAS FACILITIES FOR CREATING OBJECTS AND OPERATIONS

DEVELOP AN INFORMAL STRATEGY

KEEP A PILE OF THE PARTS OF THE TREE THAT HAVE NOT YET BEEN COUNTED. INITIALLY, GET A TREE AND PUT IT ON THE EMPTY PILE; THE COUNT OF THE LEAVES IS INITIALLY SET TO ZERO. AS LONG AS THE PILE IS NOT EMPTY, REPEATEDLY TAKE A TREE OFF THE PILE AND EXAMINE IT. IF THE TREE CONSISTS OF A SINGLE LEAF, THEN INCREMENT THE LEAF COUNTER AND THROW AWAY THAT TREE. IF THE TREE IS NOT A SINGLE LEAF BUT INSTEAD CONSISTS OF TWO SUBTREES, SPLIT THE TREE INTO ITS LEFT AND RIGHT SUBTREES AND PUT THEM BACK ON THE PILE. ONCE THE PILE IS EMPTY, DISPLAY THE COUNT OF THE LEAVES.

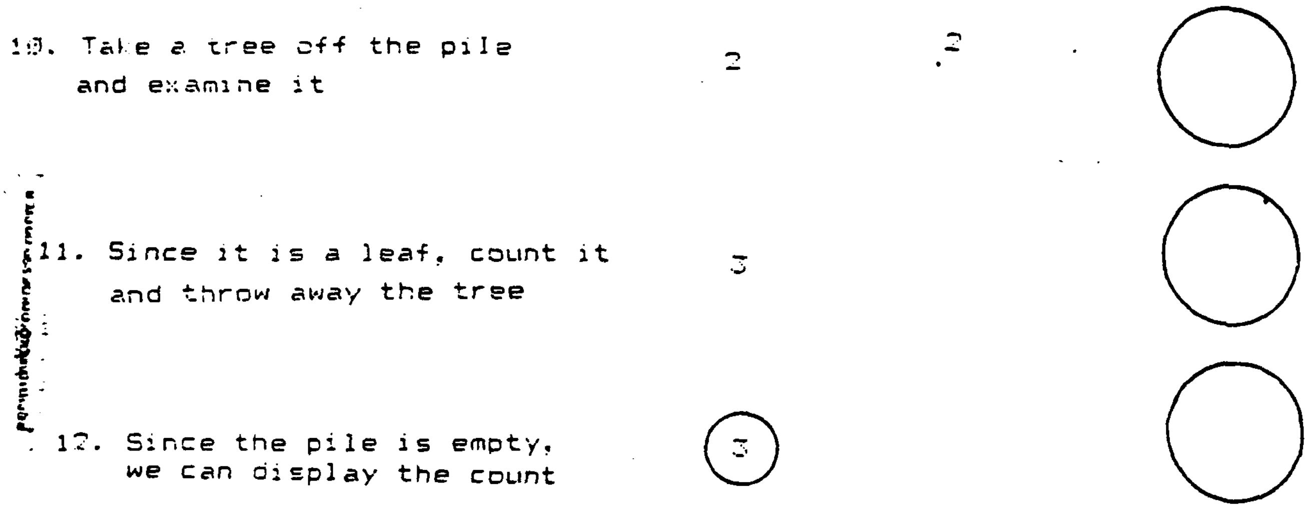
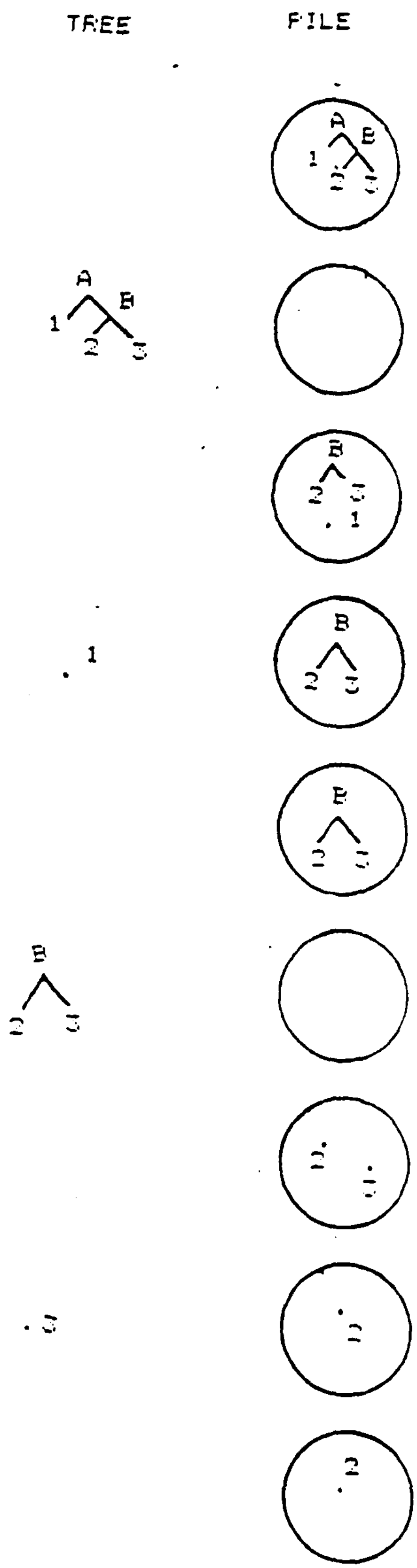


Figure 7-2: Example of Counting the Leaves

	LEAF_COUNT
1. Initially:	Ø
2. Take a tree off the pile and examine it	Ø
3. Since it is a tree, split it and return the subtrees	Ø
4. Take a tree off the pile and examine it	Ø
5. Since it is a leaf, count it and throw away the tree	1
6. Take a tree off the pile and examine it	1
7. Since it is a tree, split it and return the subtrees	1
8. Take a tree off the pile and examine it	1
9. Since it is a leaf, count it and throw away the tree	2



FORMALIZE THE STRATEGY

IDENTIFY OBJECTS AND THEIR ATTRIBUTES

KEEP A PILE OF THE PARTS OF THE TREE THAT HAVE NOT YET BEEN COUNTED. INITIALLY, GET A TREE AND PUT IT ON THE EMPTY PILE ; THE COUNT OF THE LEAVES IS INITIALLY SET TO ZERO. AS LONG AS THE PILE IS NOT EMPTY, REPEATEDLY TAKE A TREE OFF THE PILE AND EXAMINE IT. IF THE TREE CONSISTS OF A SINGLE LEAF , THEN INCREMENT THE LEAF COUNTER AND THROW AWAY THAT TREE. IF THE TREE IS NOT A SINGLE LEAF BUT INSTEAD CONSISTS OF TWO SUBTREES, SPLIT THE TREE INTO ITS LEFT AND RIGHT SUBTREES AND PUT THEM BACK ON THE PILE. ONCE THE PILE IS EMPTY, DISPLAY THE COUNT OF THE LEAVES.

THE OBJECTS OF INTEREST ARE

* LEAF_COUNT

* PILE

* LEFT_SUBTREE
  RIGHT_SUBTREE
  TREE

FORMALIZE THE STRATEGY

IDENTIFY OPERATIONS ON THE OBJECTS

KEEP A PILE OF THE PARTS OF THE TREE THAT HAVE NOT YET BEEN COUNTED. INITIALLY, GET A TREE AND PUT IT ON THE EMPTY PILE; THE COUNT OF THE LEAVES IS INITIALLY SET TO ZERO. AS LONG AS THE PILE IS NOT EMPTY, REPEATEDLY TAKE A TREE OFF THE PILE AND EXAMINE IT. IF THE TREE CONSISTS OF A SINGLE LFAF, THEN INCREMENT THE LEAF COUNTER AND THROW AWAY THAT TREE. IF THE TREE IS NOT A SINGLE LEAF BUT INSTEAD CONSISTS OF TWO SUBTREES, SPLIT THE TREE INTO ITS LEFT AND RIGHT SUBTREES AND PUT THEM BACK ON THE PILE. ONCE THE PILE IS EMPTY, DISPLAY THE COUNT OF THE LEAVES.

THE OPERATIONS OF INTEREST ARE

* LEAF_COUNT
  - -- DISPLAY
  - -- INCREMENT
  - -- ZERO
* PILE
  - -- IS_NOT_EMPTY
  - -- PUT
  - -- PUT_INITIAL
  - -- TAKE
* LEFT_SUBTREE
  RIGHT_SUBTREE
  TREE
  - -- GET_INITIAL
  - -- IS_SINGLE_LEAF
  - -- THROW_AWAY

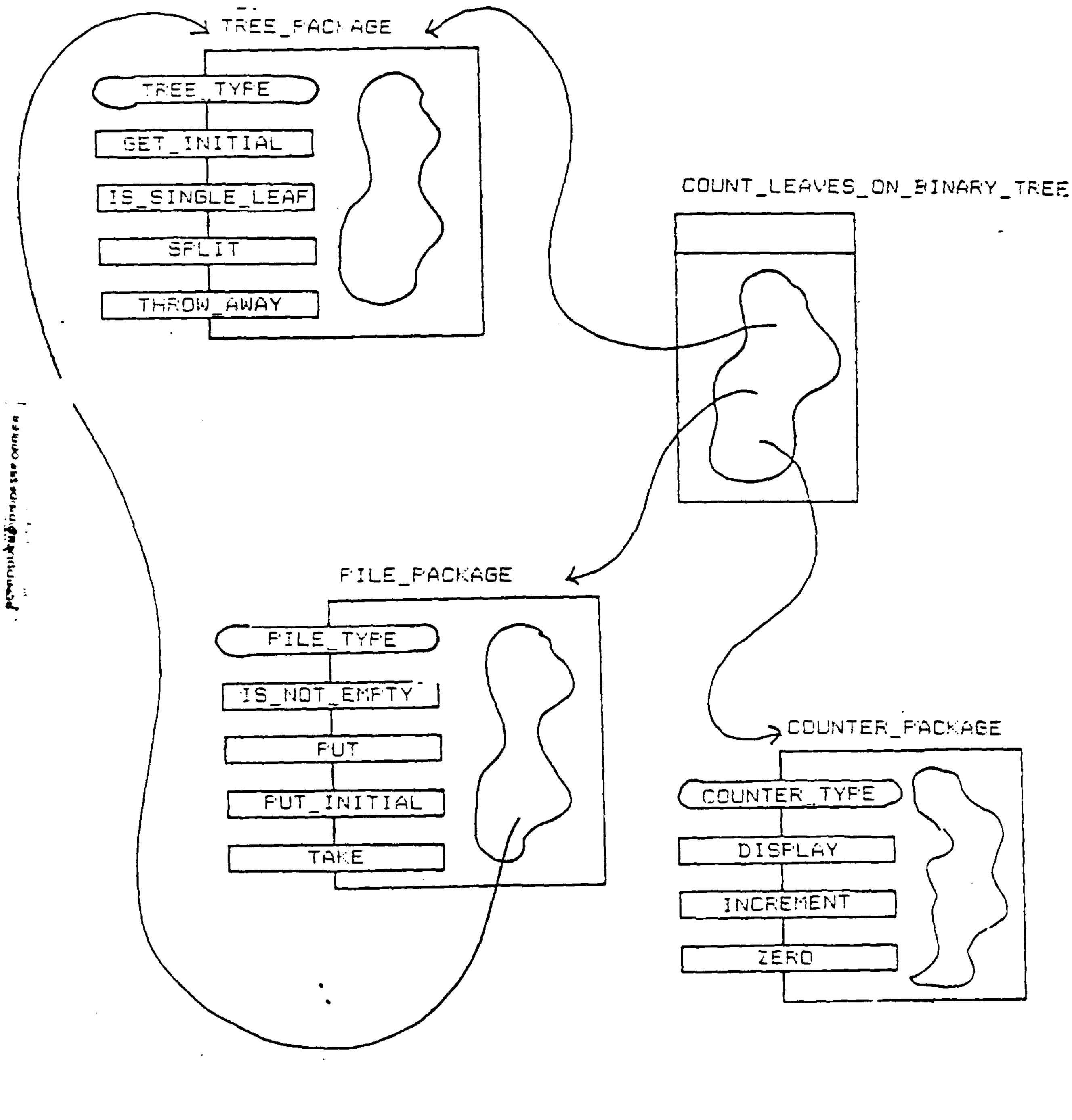


Figure 7-3: Design of COUNT_LEAVES_ON_BINARY_TREE

FORMALIZE THE STRATEGY

ESTABLISH THE INTERFACES

```
package COUNTER_PACKAGE is
  type COUNTER_TYPE is limited private;
  procedure DISPLAY   (COUNTER : in     COUNTER_TYPE);
  procedure INCREMENT(COUNTER : in out COUNTER_TYPE);
  procedure ZERO      (COUNTER : out    COUNTER_TYPE);
private
  ...
end COUNTER_PACKAGE;
```

FORMALIZE THE STRATEGY

ESTABLISH THE INTERFACES

```
with TREE_PACKAGE;
package PILE_PACKAGE is
  type PILE_TYPE is limited private;
  function  IS_NOT_EMPTY(PILE : in     PILE_TYPE) return BOOLEAN;
  procedure PUT          (TREE : in out TREE_PACKAGE.TREE_TYPE;
                          ON   : in out PILE_TYPE);
  procedure PUT_INITIAL  (TREE : in out TREE_PACKAGE.TREE_TYPE;
                          ON   : in out PILE_TYPE);
  procedure TAKE         (TREE : out    TREE_PACKAGE.TREE_TYPE;
                          OFF  : in out PILE_TYPE);
private
  ...
end PILE_PACKAGE;
```

FORMALIZE THE STRATEGY

ESTABLISH THE INTERFACES

```
package TREE_PACKAGE is
  type TREE_TYPE is limited private;
  procedure GET_INITIAL    (TREE       : out    TREE_TYPE);
  function  IS_SINGLE_LEAF (TREE       : in     TREE_TYPE)
                            return BOOLEAN;
  procedure SPLIT          (TREE       : in out TREE_TYPE;
                            LEFT_INTO  : out    TREE_TYPE;
                            RIGHT_INTO : out    TREE_TYPE);
  procedure THROW_AWAY     (TREE       : in out TREE_TYPE);
private
  ..
end TREE_PACKAGE;
```

FORMALIZE THE STRATEGY

IMPLEMENT THE OPERATIONS

```
with COUNTER_PACKAGE, PILE_PACKAGE, TREE_PACKAGE;
use  COUNTER_PACKAGE, PILE_PACKAGE, TREE_PACKAGE;
procedure COUNT_LEAVES_ON_BINARY_TREE is
  LEAF_COUNT     : COUNTER_TYPE;
  LEFT_SUBTREE   : TREE_TYPE;
  PILE           : PILE_TYPE;
  RIGHT_SUBTREE  : TREE_TYPE;
  TREE           : TREE_TYPE;
```

```
begin
  GET_INITIAL(TREE);
  PUT_INITIAL(TREE, ON => PILE);
  ZERO(LEAF_COUNT);
  while IS_NOT_EMPTY(PILE)
    loop
      TAKE(TREE, OFF => PILE);
      if IS_SINGLE_LEAF(TREE) then
        INCREMENT(LEAF_COUNT);
        THROW_AWAY(TREE);
      else
        SPLIT(TREE,
              LEFT_INTO  => LEFT_SUBTREE,
              RIGHT_INTO => RIGHT_SUBTREE);
        PUT(LEFT_SUBTREE, ON => PILE);
        PUT(RIGHT_SUBTREE, ON => PILE);
      end if;
    end loop;
  DISPLAY(LEAF_COUNT);
end COUNT_LEAVES_ON_BINARY_TREE;
```

DATA TYPES ADDRESS

* MAINTAINABILITY
    - -- THE NEED TO DESCRIBE OBJECTS WITH A FACTORIZATION OF PROPERTIES
* READABILITY
    - -- THE NEED TO SAY SOMETHING ABOUT THE PROPERTIES OF OBJECTS
* RELIABILITY
    - -- THE NEED TO GUARANTEE THAT PROPERTIES OF OBJECTS ARE NOT VIOLATED
* REDUCTION OF COMPLEXITY
    - -- THE NEED TO HIDE IMPLEMENTATION DETAILS

A TYPE CHARACTERIZES

* A SET OF VALUES

* A SET OF OPERATIONS
  APPLICABLE TO OBJECTS
  OF THE NAMED TYPE

ADA CLASSES OF TYPES INCLUDE

* SCALAR

  -- THE VALUES HAVE NO COMPONENTS

* COMPOSITE

  -- THE VALUES CONSIST OF COMPONENT OBJECTS

* ACCESS

  -- THE VALUES PROVIDE ACCESS TO OTHER OBJECTS

* PRIVATE

  -- THE VALUES ARE NOT KNOWN TO A USER

* SUBTYPE AND DERIVED TYPE

* TASK TYPE

INTEGER TYPES

* INTRODUCE A SET OF
  CONSECUTIVE EXACT INTEGERS

* USER-DEFINED TYPES

```
type LINE_COUNT     is range     0 .. 66;
type INDEX          is range    55 .. 77;
type FATHOM         is range -5000 ..  0;
type TOTAL_ELEMENTS is range 1 .. (ROWS*COLUMNS);
```

SUMMARY OF INTEGER DATA TYPES

* SET OF VALUES

-- A SET OF CONSECUTIVE INTEGERS

* STRUCTURE

-- range L .. U

WHERE L AND U ARE STATIC EXPRESSIONS

REPRESENTING LOWER AND UPPER BOUNDS

* SET OF OPERATIONS

-- ADDING	+	-		
-- ASSIGNMENT	:=			
-- EXPONENTIATING	**			
-- EXPLICIT CONVERSION				
-- MEMBERSHIP	in	not in		
-- MULTIPLYING	*	/	mod	rem
-- QUALIFICATION				
-- RELATIONAL	=	/=	<	<=
	>	>=		
-- UNARY	+	-	abs	

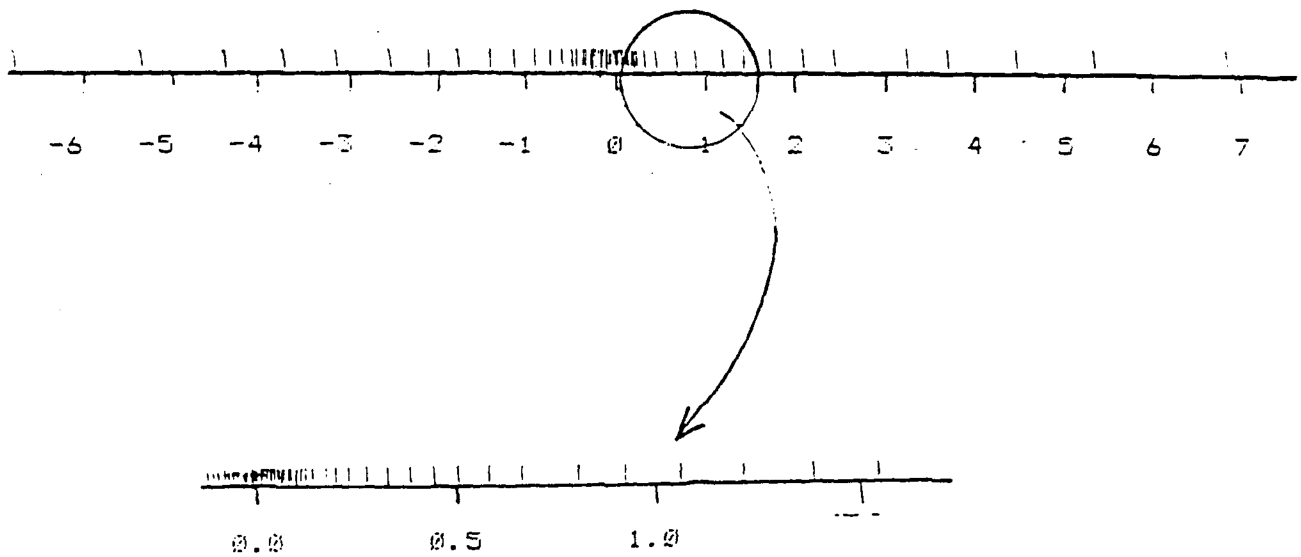


Figure 8-3: Floating Point Model Numbers

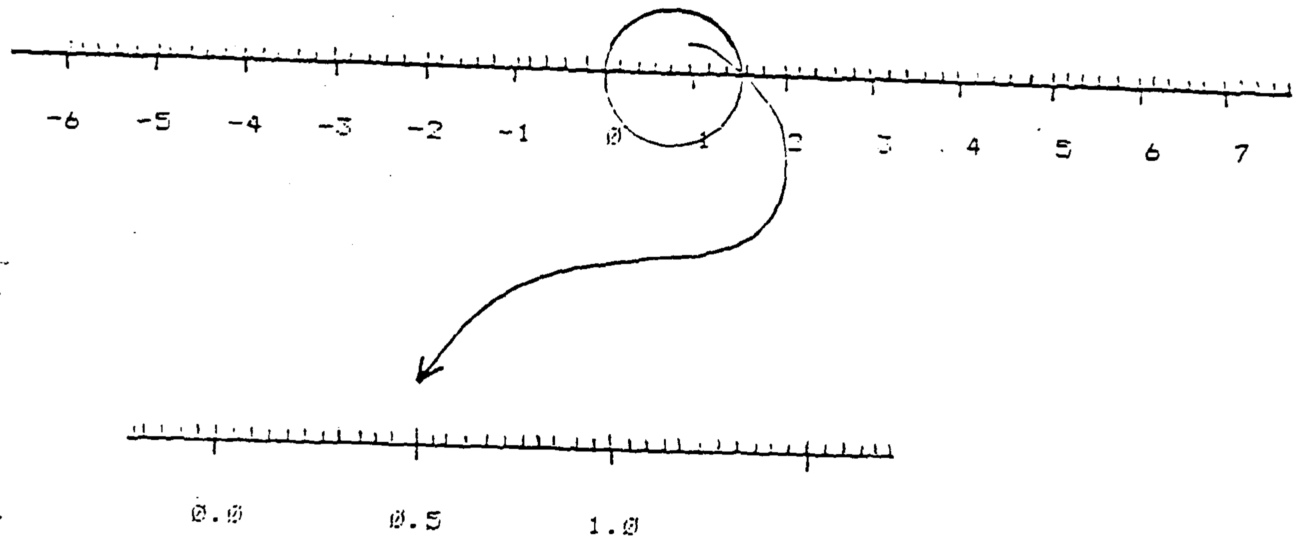


Figure 8-4: Fixed Point Model Numbers

SUMMARY OF REAL DATA TYPES

* SET OF VALUES

-- APPROXIMATIONS TO THE REAL NUMBERS

* STRUCTURE

-- *digits N range L .. U*

SPECIFIES RELATIVE ACCURACY

WHERE N IS A STATIC INTEGER REPRESENTING

THE NUMBER OF SIGNIFICANT DIGITS AND

WHERE L AND U ARE STATIC EXPRESSIONS

REPRESENTING LOWER AND UPPER BOUNDS

-- delta N range L .. U

SPECIFIES ABSOLUTE ACCURACY

WHERE N IS A STATIC REAL VALUE

REPRESENTING THE DELTA AND

WHERE L AND U ARE STATIC EXPRESSIONS

REPRESENTING LOWER AND UPPER BOUNDS

* SET OF OPERATIONS

-- ADDING	+	-		
-- ASSIGNMENT	:=			
-- EXPONENTIATING	**			
-- EXPLICIT CONVERSION				
-- MEMBERSHIP	in	not in		
-- MULTIPLYING	*	/	mod	rem
-- QUALIFICATION				
-- RELATIONAL	=	/=	<	<=
	>	>=		
-- UNARY	+	-	abs	

* ATTRIBUTES

-- FIXED POINT ATTRIBUTES

ADDRESS	SIZE
BASE	MACHINE_OVERFLOWS
FIRST	SAFE_SMALL
LAST	SAFE_LARGE

```
-- FLOATING POINT ATTRIBUTES
   ADDRESS        MACHINE_MANTISSA
   BASE           MACHINE_OVERFLOWS
   DIGITS         MACHINE_RADIX
   EMAX           MACHINE_ROUNDS
   EPSILON        MANTISSA
   FIRST          SAFE_EMAX
   LARGE          SAFE_LARGE
   LAST           SAFE_SMALL
   MACHINE_EMAX   SIZE
   MACHINE_EMIN   SMALL
```

* PREDEFINED TYPES

DURATION

FLOAT

LONG_FLOAT

SHORT_FLOAT

ENUMERATION TYPES

* INTRODUCE AN ORDERED SET OF DISTINCT VALUES

* USER-DEFINED TYPES

```
type CARD_SUIT     is (CLUBS,  DIAMONDS,
                        HEARTS, SPADES);
type GEAR_POSITION is (DOWN, UP);
type MOTOR_STATE   is (OFF, FORWARD, REVERSE);
type HEX_DIGIT     is ('A', 'B', 'C', 'D', 'E', 'F');
```

SUMMARY OF ENUMERATION TYPES

* SET OF VALUES

-- ORDERED SET OF DISTINCT VALUES

* STRUCTURE

-- (E_Ø, E_1, ... E_n)
WHERE E_i IS AN ORDERED ENUMERATION
LITERAL

* SET OF OPERATIONS

-- ASSIGNMENT	:=			
-- MEMBERSHIP	in	not in		
-- QUALIFICATION				
-- RELATIONAL	=	/=	<	<=
	>	>=		

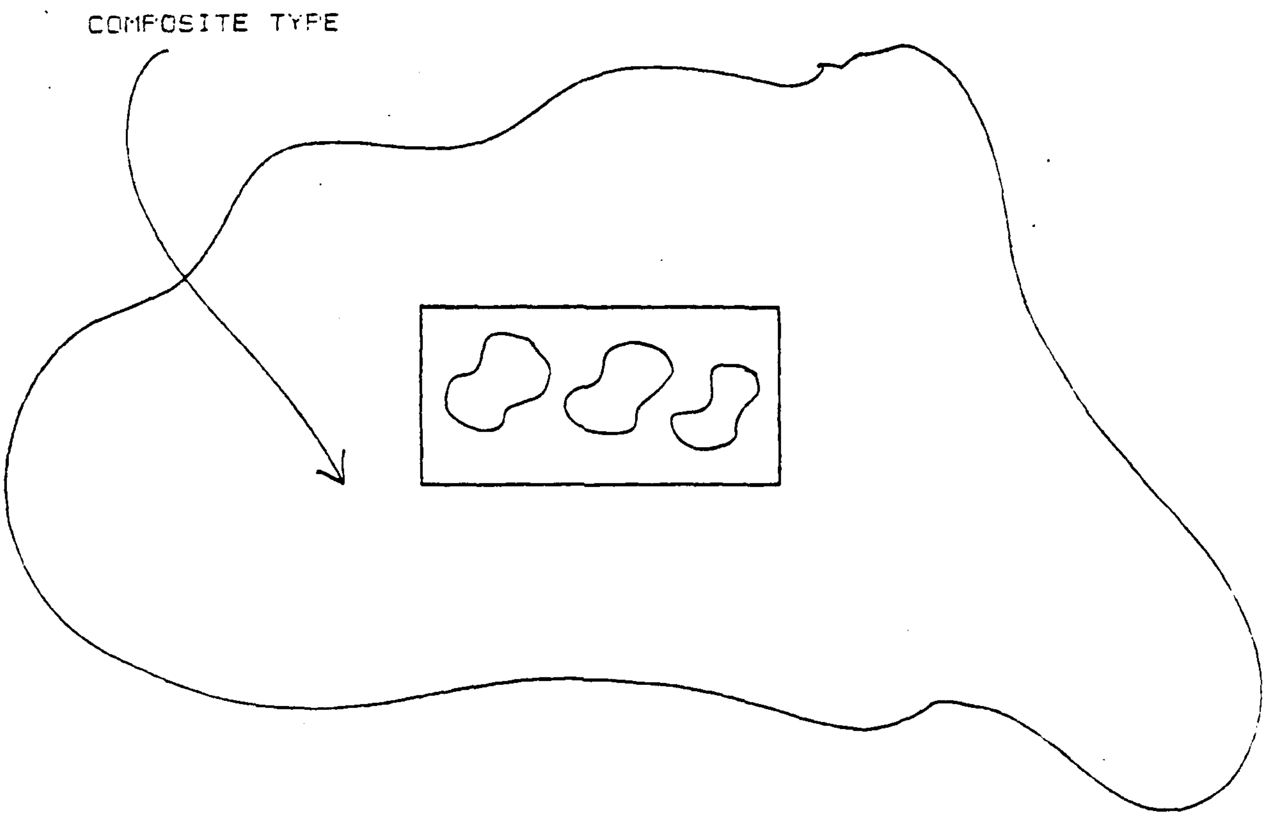
* ATTRIBUTES

ADDRESS	PRED
BASE	SIZE
FIRST	SUCC
IMAGE	VAL
LAST	VALUE
POS	WIDTH

* PREDEFINED TYPES

BOOLEAN

CHARACTER



-- VALUES HAVE COMPONENTS
-- INCLUDES
  -- ARRAY TYPES
  -- RECORD TYPES

Figure 8-5: Composite Data Types

ARRAY TYPES

* INTRODUCE AN INDEXED COLLECTION OF SIMILAR TYPES

* CONSTRAINED TYPES

```
type GAME_BOARD is array (1 .. 8, 1 .. 8) of CHESS_PIECES;
type LIST       is array (INTEGER range -100 .. 10) of FLOAT;
type VECTOR     is array (INTEGER range 1 .. MAXIMUM_INDEX)
                   of FLOAT;

type LONG_ARRAY  is array (EXTENDED_INDEX) of FLOAT;
type SHORT_ARRAY is array (EXTENDED_INDEX range 10 .. 49) of FLOAT;

type RECORD_OF_WORK is array(DAY range MONDAY .. FRIDAY)   of HOURS;
type OVERTIME       is array(DAY range SATURDAY .. SUNDAY) of HOURS;
type FULL_WEEK      is array(DAY)                          of HOURS;
```

* UNCONSTRAINED TYPES

```
type BIT_VECTOR is array(INDEX range <>) of BOOLEAN;
type MATRIX     is array(INDEX range <>, INDEX range <>) of FLOAT;
```

SUMMARY OF ARRAY TYPES

* SET OF VALUES

  -- INDEXED COLLECTION OF SIMILAR TYPES

* STRUCTURE

  -- array(INDEX...) of COMPONENT
  AN UNCONSTRAINED ARRAY TYPE
  WHERE INDEX... IS A LIST OF
  UNCONSTRAINED DISCRETE TYPES

  -- array INDEX_CONSTRAINT of COMPONENT
  A CONSTRAINED ARRAY TYPE
  WHERE INDEX_CONSTRAINT IS A LIST
  OF DISCRETE TYPES

* SET OF OPERATIONS

-- ADDING	&		
-- AGGREGATES			
-- ASSIGNMENT	:=		
-- EXPLICIT CONVERSION			
-- INDEXING			
-- LOGICAL	and	or	xor
-- MEMBERSHIP	in	not in	
-- QUALIFICATION			
-- RELATIONAL	=	/=	<
	<=	>	>=
-- UNARY	not		

* ATTRIBUTES

ADDRESS	LAST(J)
BASE	LENGTH
FIRST	LENGTH(J)
FIRST(J)	RANGE
LAST	SIZE

* PREDEFINED TYPES

STRING

RECORD TYPES

* INTRODUCE A COLLECTION OF (POTENTIALLY) DIFFERENT COMPONENT TYPES

* SIMPLE RECORD TYPES

```
type DAY_OF_YEAR is
  record
    DAY   : INTEGER range 1 .. 31;
    MONTH : MONTH_NAME;
    YEAR  : NATURAL;
  end record;

type CPU_FLAGS is
  record
    CARRY     : BOOLEAN;
    INTERRUPT : BOOLEAN;
    NEGATIVE  : BOOLEAN;
    ZERO      : BOOLEAN;
  end record;
```

```
type CPU_STATE is
  record
    PRIORITY : INTEGER range Ø .. 7;
    FLAG     : CPU_FLAGS;
  end record;
```

* DISCRIMINATED RECORDS

```
type SQUARE(SIDE : INTEGER := 4) is
  record
    MATRIX : SIMPLE_ARRAY(1 .. SIDE, 1 .. SIDE);
  end record;

type TWO_SQUARES(LENGTH : INTEGER) is
  record
    FIRST  : SQUARE(LENGTH);
    SECOND : SQUARE(LENGTH);
  end record;
```

* VARIANT RECORDS

```
type AIRCRAFT_RECORD(KIND : AIRCRAFT_ID := UNKNOWN) is
  record
    AIRSPEED    : SPEED;
    HEADING     : DIRECTION;
    LATITUDE    : COORDINATE;
    LONGITITUDE : COORDINATE;
    case KIND is
      when CIVILIAN      =>
        null;
      when MILITARY      =>
        CLASSIFICATION : MILITARY_TYPE;
        SOURCE         : COUNTRY;
      when FOE | UNKNOWN =>
        THREAT         : THREAT_LEVEL;
    end case;
  end record;
```

SUMMARY OF RECORD TYPES

* SET OF VALUES

-- COLLECTION OF (POTENTIALLY) DIFFERENT COMPONENTS

* STRUCTURE

```
-- record
     component_list
   end record
```

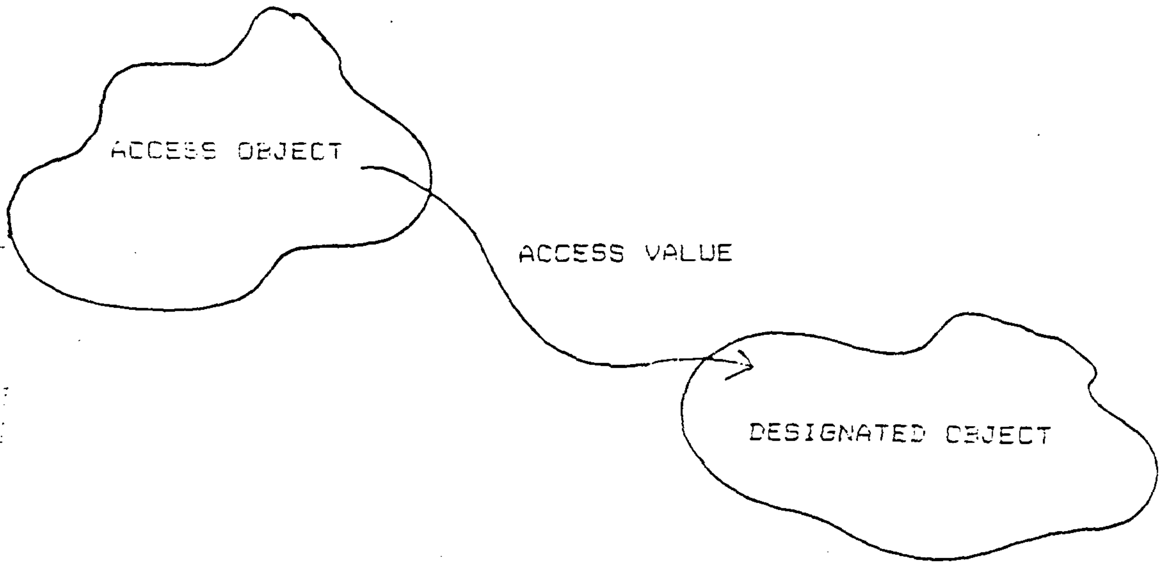
WHERE COMPONENT_LIST NAMES THE ELEMENTS OF THE RECORD

* SET OF OPERATIONS

-- AGGREGATES		
-- ASSIGNMENT	:=	
-- EXPLICIT CONVERSION		
-- MEMBERSHIP	in	not in
-- QUALIFICATION		
-- RELATIONAL	=	/=
-- SELECTION		

* ATTRIBUTES

ADDRESS	LAST_BIT
BASE	POSITION
CONSTRAINED	SIZE
FIRST_BIT	



-- VALUES PROVIDE ACCESS TO OTHER OBJECTS

Figure 9-6: Access Data Type

ACCESS TYPES

* PROVIDE DYNAMIC ACCESS TO OTHER OBJECTS

* SIMPLE TYPES

```
type BUFFER is
  record
    MESSAGE  : STRING(1 .. 10);
    PRIORITY : INTEGER range 1 .. 100;
  end record;
type BUFFER_POINTER is access BUFFER;
```

* INCOMPLETE TYPES

```
type NODE;
type LINK is access NODE;
type NODE is
  record
    LEFT  : LINK;
    VALUE : STRING(1 .. 5);
    RIGHT : LINK;
  end record;
```

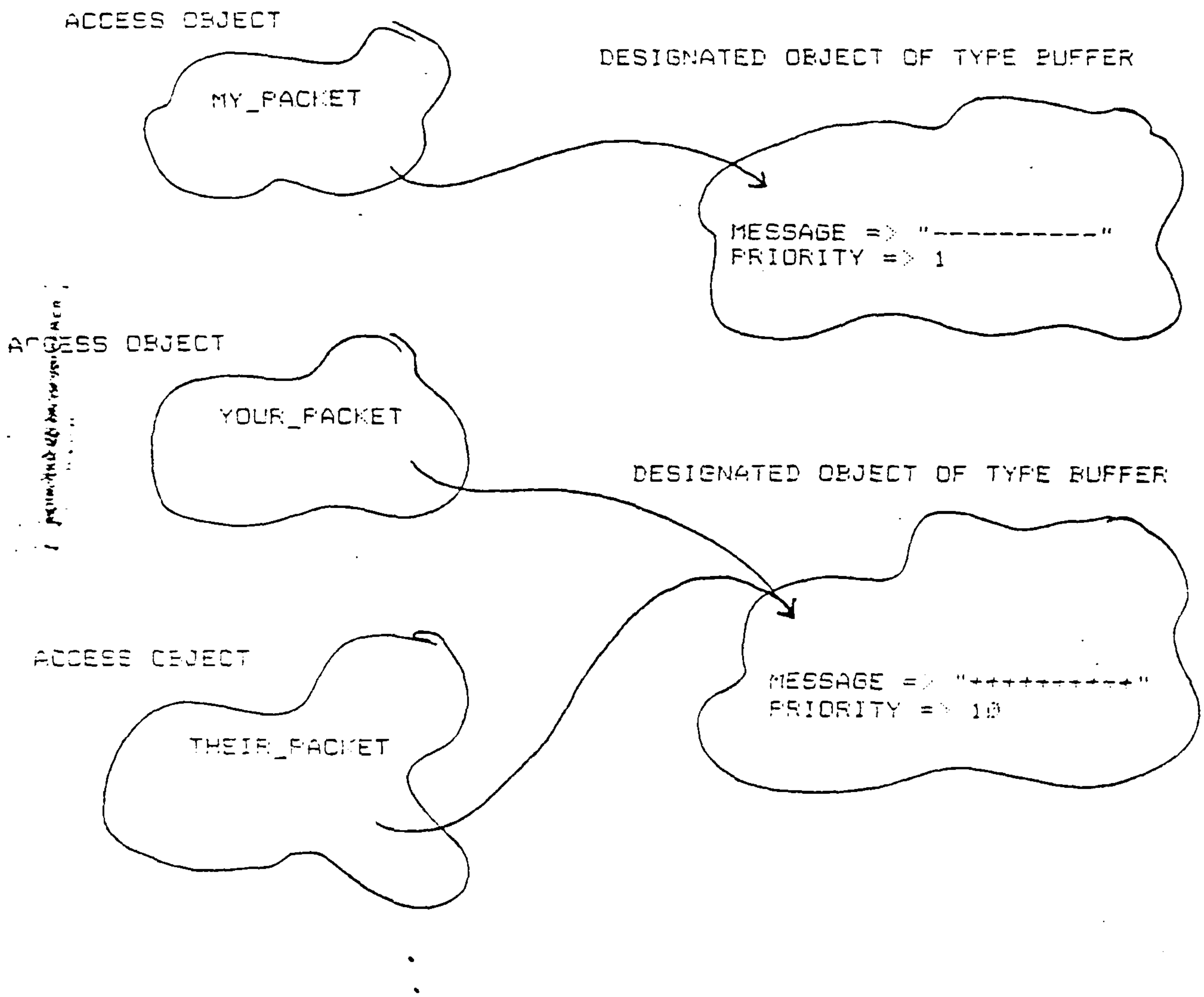


Figure 8-7: Relationship of Access Values and Objects

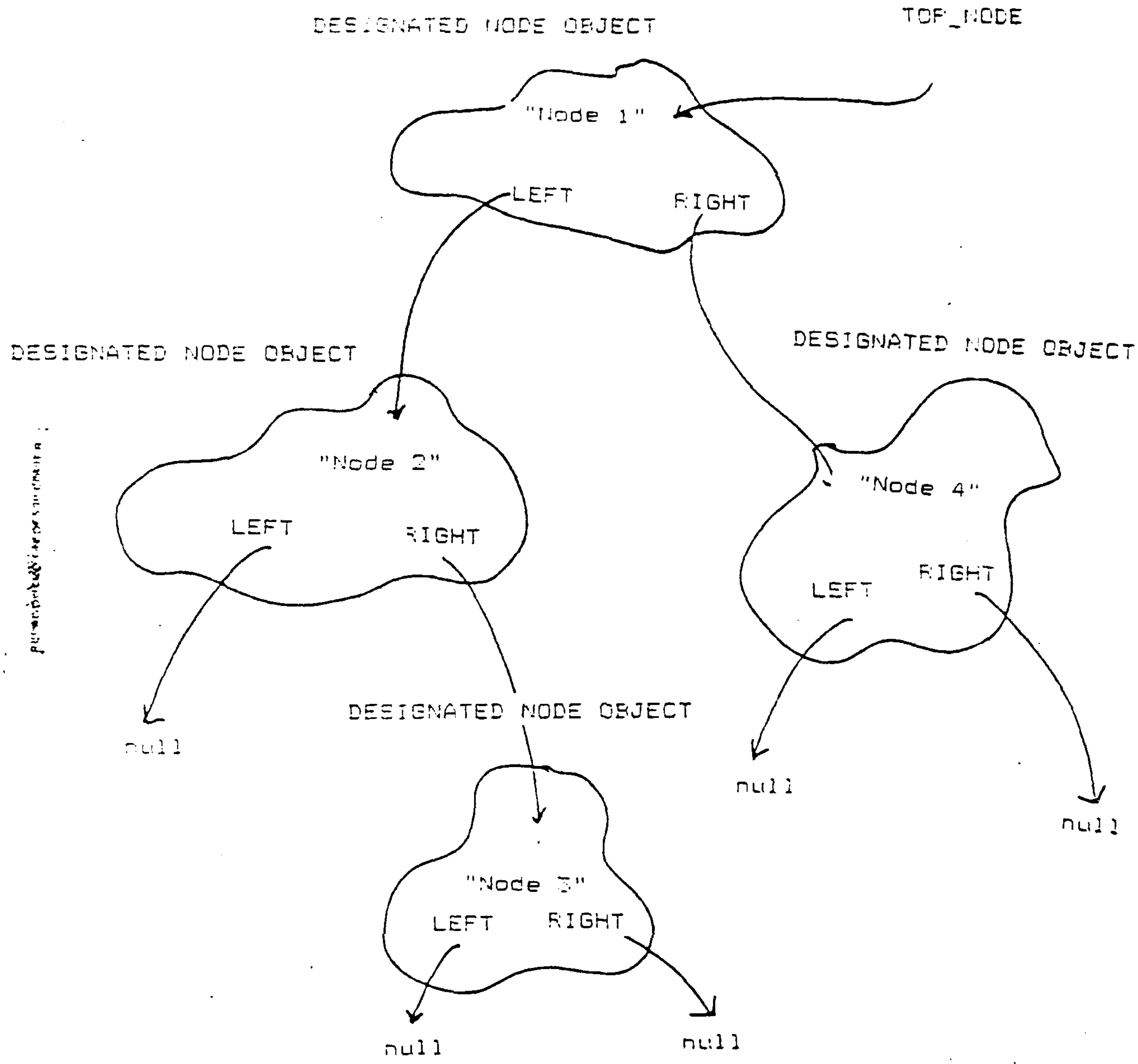


Figure 8-8: Designating the Relationship of Objects

SUMMARY OF ACCESS TYPES

* SET OF VALUES

  -- ACCESS VALUES TO DESIGNATED OBJECTS

* STRUCTURE

  -- access subtype_indication
  WHERE SUBTYPE_INDICATION IS THE TYPE OF
  THE DESIGNATED OBJECT

* SET OF OPERATIONS

-- ALLOCATION		
-- ASSIGNMENT	:=	
-- EXPLICIT CONVERSION		
-- INDEXING		
-- MEMBERSHIP	in	not in
-- QUALIFICATION		
-- RELATIONAL	=	/=
-- SELECTION		

* ATTRIBUTES

ADDRESS	SIZE
BASE	STORAGE_SIZE

PRIVATE DATA TYPES

* DEFINE ABSTRACT DATA TYPES WHOSE VALUES ARE HIDDEN FROM THE USER

* LIMITED PRIVATE TYPES

```
package PASSWORD is
  type VALUE is limited private;
  function  IS_VALID(CODE                  : in  VALUE)
                     return BOOLEAN;
  procedure SET     (CODE                  : out VALUE;
                     AUTHORIZATION_LEVEL : in NATURAL);
private
  type VALUE is new STRING(1 .. 40);
end PASSWORD;
```

* PRIVATE TYPES

```
package RANDOM is
  type NUMBER is private;
  procedure SET(SEED : in INTEGER; VALUE : in out NUMBER);
  function  UNIFORM_RANDOM return NUMBER;
private
  type NUMBER is
    record
      SEED_VALUE : INTEGER;
      VALUE      : FLOAT;
    end record;
end RANDOM;
```

SUMMARY OF PRIVATE DATA TYPES

* SET OF VALUES

  -- HIDDEN FROM THE USER

* STRUCTURE

  -- HIDDEN FROM THE USER

* SET OF OPERATIONS

  -- EXPLICIT CONVERSION

  -- MEMBERSHIP

  -- QUALIFICATION

  -- FOR LIMITED PRIVATE TYPES
  ONLY THOSE OPERATIONS DEFINED IN THE CORRESPONDING PACKAGE SPECIFICATION ARE AVAILABLE

  -- FOR PRIVATE TYPES
  OPERATIONS OF ASSIGNMENT AND TEST FOR EQUALITY OR INEQUALITY ARE AVAILABLE IN ADDITION TO THOSE DEFINED IN THE PACKAGE SPECIFICATION

* ATTRIBUTES

  ADDRESS   BASE   SIZE

SUBTYPES AND DERIVED TYPES

* PROVIDE FURTHER FACTORIZATION OF TYPE CHARACTERISTICS

* SUBTYPES

```
-- RANGE CONSTRAINT
   subtype INDEX       is NON_NEGATIVE range 0 .. 10;
-- ACCURACY CONSTRAINT
   subtype COARSE      is WEIGHT delta 10.0;
-- INDEX CONSTRAINT
   subtype VECTOR_3D   is VECTOR(1 .. 3);
-- DISCRIMINANT CONSTRAINT
   subtype HEAT_SENSOR is SENSOR(KIND => TEMPERATURE);
```

* DERIVED TYPES

```
type MASS   is new FLOAT;
type WEIGHT is new FLOAT;
type BUDGET is new FLOAT range 0.0 .. 12_000.0;
```

* TYPE CONSTRAINTS ARE STATIC; SUBTYPE CONSTRAINTS NEED NOT BE STATIC

DECLARATIONS

* SIMPLE DECLARATIONS

```
DISTANCE : FLOAT;
RESPONSE : CHARACTER;
NUMBER   : INTEGER;
GRADES   : array(1 .. 100) of FLOAT;
```

* DECLARATIONS WITH CONSTRAINTS

```
NAME   : STRING(1 .. 40);
BOTTOM : INTEGER range -10 .. -1;
```

* DECLARATIONS WITH INITIAL VALUES

```
RANGE : DISTANCE := 0.0;
```

* CONSTANT DECLARATIONS

```
FIRST_MONTH : constant MONTH_NAME := JANUARY;
PI          : constant            := 3.141_592_65;
DIAMETER    : constant            := 4;
```

VALUES

* SIMPLE VALUES ARE DENOTED BY LITERALS

```
-- INTEGER NUMERIC LITERAL 1_Ø24
-- REAL NUMERIC LITERAL    Ø.398_829_138
-- ENUMERATION LITERAL     BLOCKED
-- CHARACTER STRING        "WAREHOUSE"
-- NULL ACCESS VALUE       null
-- CHARACTER LITERAL       'b'
-- BASED NUMERIC LITERAL   16#1FFE#
```

* COMPOSITE VALUES ARE DENOTED BY AGGREGATES

EXPRESSIONS

* CREATE NEW VALUES FROM PRIMARIES AND OPERATORS

* PRIMARIES INCLUDE

-- STRING LITERAL	"prompt"
-- NUMERIC LITERAL	10.125
-- NAME	MATRIX_1
-- ALLOCATOR	new COUNT'(0,0,0,0)
-- FUNCTION CALL	COS(37.5)
-- TYPE CONVERSION	INTEGER(123.9)
-- QUALIFIED EXPRESSION	COEFFICIENT'(0.53)
-- PARENTHESIZED EXPRESSION	(3 ** 4)
-- NULL VALUE	null

* BASIC OPERATORS IN ORDER OF PRECEDENCE ARE

-- EXPONENTIATING	**		
-- MULTIPLYING	*	/	
	mod	rem	
-- UNARY	+	-	
	not	abs	
-- ADDING	+	-	&
-- RELATIONAL	=	/=	<
	<=	>	>=
-- LOGICAL	and	or	xor
	and then	or else	
-- MEMBERSHIP	in	not in	

SEQUENTIAL STATEMENTS

* ONE STATEMENT IS EXECUTED AFTER ANOTHER IN A LINEAR FASHION

* KINDS OF SEQUENTIAL INCLUDE

  -- ASSIGNMENT

  -- NULL

  -- PROCEDURE CALL

  -- RETURN

  -- BLOCK

* WE WILL ALSO CONSIDER THE GOTO IN THIS SECTION

ASSIGNMENT STATEMENTS

* REPLACE THE CURRENT VALUE OF A VARIABLE FROM AN EXPRESSION VALUE

* TYPE OF BOTH SIDES OF THE ASSIGNMENT MUST BE COMPATIBLE

* ASSIGNMENT STATEMENT EXAMPLES

```
VALVE_RECORD(1 .. 10)              := VALVE_RECORD(6 .. 15);
VOLTAGE_1                          := VOLTAGE_2 + 24.0;
MATRIX_1                           := MATRIX_2;
LOCAL_SCHEDULE.all                 := COUNT'(0,0,0,0);
SCHEDULER_TABLE(READY)             := SCHEDULER_TABLE(READY) + 1;
VALVE_RECORD(COUNT_1).OPEN)        := TRUE;
VALVE_RECORD(1 .. 10)              := VALVES'(1 .. 10 =>
                                        (NAME      => "SPARE     ",
                                        POSITION  => "WAREHOUSE ",
                                        OPEN      => FALSE,
                                        FLOW_RATE => 0.0));
```

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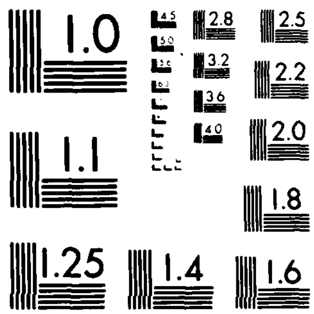

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

NULL STATEMENT

* EXPLICITLY STATES INACTION

* NULL EXAMPLE

```
null;
```

RETURN STATEMENT

* RETURN CONTROL FROM A SUBPROGRAM

    — PROCEDURE   return;

    — FUNCTION   return <expression>;

* A SUBPROGRAM MAY HAVE MULTIPLE RETURNS

* PROCEDURE EXAMPLE

```
procedure INSTALL(BUFFER : in     LINE;
                  LIST   : in out TABLE;
                  TOP    : in out POSITIVE) is
begin
  LIST(TOP + 1) := BUFFER;
  for INDEX in 1 .. TOP
    loop
      if LIST(INDEX) = BUFFER then
        return;
      end if;
    end loop;
  TOP := TOP + 1;
end INSTALL;
```

BLOCK

* TEXTUALLY ENCAPSULATES A SEQUENCE OF STATEMENTS

* MAY BE NAMED AND HAVE A LOCAL EXCEPTION HANDLER

* BLOCK EXAMPLES

```
begin
  A := B/C;
exception
  when NUMERIC_ERROR =>
    A := 0.0;
end;

SWAP:
  declare
    TEMP : FLOAT;
  begin
    TEMP := VOLTAGE_1;
    VOLTAGE_1 := VOLTAGE_2;
    VOLTAGE_2 := TEMP;
  end SWAP;
```

GOTO STATEMENT

* UNCONDITIONALLY (AND UNGRACEFULLY) TRANSFER CONTROL

* GOTO EXAMPLE

```
<<SHUT_DOWN>> START_POWER_DOWN_SEQUENCE;
 ...
goto SHUT_DOWN;
```

CONDITIONAL STATEMENTS

* SELECTION OF ONE OF A NUMBER OF ALTERNATIVE SEQUENCE OF STATEMENTS

* CONDITIONAL STATEMENTS INCLUDE

    -- IF

    -- CASE

IF STATEMENT

* SELECTS ONE OR NONE OF A SEQUENCE OF STATEMENTS DEPENDING ON THE TRUTH VALUE OF ONE OF SEVERAL EXPRESSIONS

* IF EXAMPLES

```
if COUNT_1 < 0 then
  COUNT_1 := 0;
end if;

if VALVE_RECORD(1).OPEN then
  VALVE_RECORD(2).OPEN := TRUE;
  VALVE_RECORD(3).OPEN := FALSE;
else
  VALVE_RECORD(2).OPEN := FALSE;
  VALVE_RECORD(3).OPEN := TRUE;
end if;
```

```
if VOLTAGE_1 > VOLTAGE_2 then
  VOLTAGE_1 := VOLTAGE 2;
elsif VOLTAGE_1 < VOLTAGE_2 then
  VOLTAGE_2 := VOLTAGE_1;
else
  null;
end if;
```

CASE STATEMENT

* SELECTS ONE SEQUENCE OF STATEMENTS BASED ON THE VALUE OF A DISCRETE EXPRESSION

* CASE EXAMPLES

```
case PROCESS_STATE is
  when RUNNING => SCHEDULER_TABLE(RUNNING) := 1;
                  IS_ACTIVE := TRUE;
  when READY   => SCHEDULER_TABLE(READY)   :=
                    SCHEDULER_TABLE(READY) + 1;
                  IS_ACTIVE := FALSE;
  when BLOCKED => SCHEDULER_TABLE(BLOCKED) :=
                    SCHEDULER_TABLE(BLOCKED) + 1;
                  IS_ACTIVE := FALSE;
  when DEAD    => SCHEDULER_TABLE(DEAD)    :=
                    SCHEDULER_TABLE(DEAD) + 1;
end case;
```

```
case COUNT_1 is
  when 1        => VALVE_RECORD(COUNT_1).OPEN := TRUE;
  when 2 | 3    => VALVE_RECORD(COUNT_1).OPEN := FALSE;
  when 5 .. 10  => VALVE_RECORD(COUNT_1).OPEN := FALSE;
  when others   => VALVE_RECORD(COUNT_1).OPEN := TRUE;
                   VALVE_RECORD(COUNT_1).FLOW_RATE := 1.0;
end case;
```

ITERATIVE STATEMENTS

* PERMITS A SEQUENCE OF STATEMENTS TO BE EXECUTED ZERO OR MORE TIMES

* FORMS OF ITERATION INCLUDE

  -- BASIC LOOP

  -- FOR LOOP

  -- WHILE LOOP

* ALSO ASSOCIATED WITH THE LOOP STATEMENT IS THE EXIT STATEMENT

LOOP EXAMPLES

```
loop
  GET_SAMPLE;
  PROCESS_SAMPLE;
end loop;

loop
  GET_SAMPLE;
  exit when TEMP > MAX_TEMP;
  PROCESS_SAMPLE;
end loop;

OUTER_LOOP:
  loop
    ...
    INNER_LOOP:
      loop
        ...
      end INNER_LOOP;
    ...
  end OUTER_LOOP;
```

```
for INDEX in RUNNING .. DEAD
  loop
    SCHEDULER_TABLE(INDEX) := 0;
  end loop;

for INDEX in reverse TOTAL_VALVES
  loop
    VALVE_RECORD(INDEX).OPEN := FALSE;
  end loop;

for INDEX in 1 .. COUNT_1
  loop
    ...
  end loop;

for I in VALVES'RANGE
  loop
    ...
  end loop;

while (SCHEDULER_TABLE(1).FLOW_RATE > 10.0) and (not IS_EMPTY)
  loop
    ...
  end loop;
```

SUBPROGRAMS

* ARE THE BASIC EXECUTABLE UNIT

* PROVIDE ALGORITHMIC ABSTRACTION

* ADA SUBPROGRAMS INCLUDE

  -- PROCEDURES

  -- FUNCTIONS

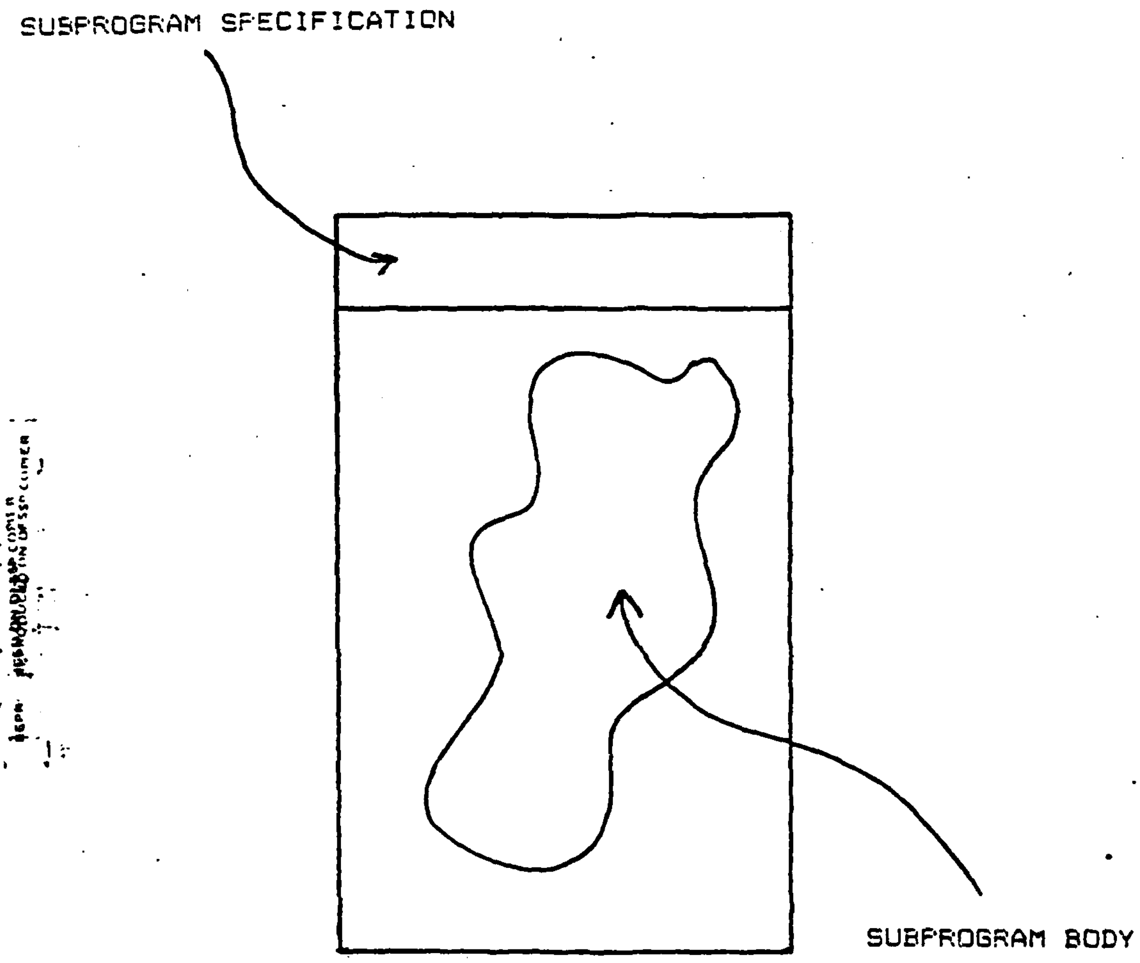

Figure 10-1: Symbol for an Ada Subprogram

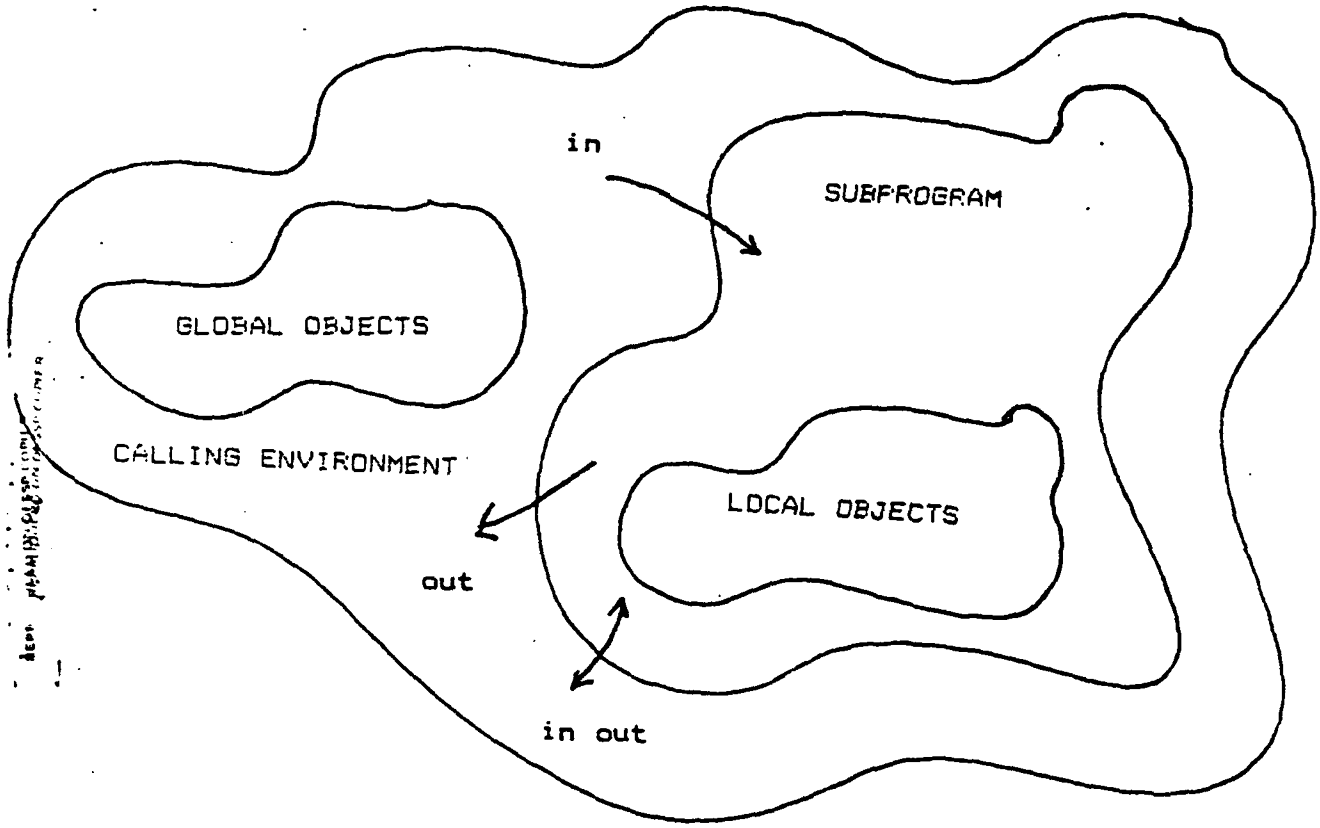

Figure 10-2: Model of an Ada Subprogram

PARAMETER MODES

* IN

  -- ONLY THE ACTUAL VALUE IS USED; THE SUBPROGRAM CANNOT MODIFY THE VALUE

* OUT

  -- THE SUBPROGRAM CREATES A VALUE BUT DOES NOT USE THE VALUE OF THE ACTUAL PARAMETER

* IN OUT

  -- THE SUBPROGRAM USES THE VALUE FROM THE ACTUAL PARAMETER AND MAY ASSIGN A NEW VALUE TO IT

NAMING SPECIFICATIONS

* SIMPLE SPECIFICATIONS

```
procedure COUNT_LEAVES_ON_BINARY_TREE;
procedure PUSH  (ELEMENT : in     INTEGER;
                 ON      : in out BUFFER);
procedure ROTATE(POINT   : in out COORDINATE;
                 ANGLE   : in     RADIANS);
function COS(ANGLE : RADIANS)   return FLOAT;
function "*"(X, Y  : in MATRIX) return MATRIX;
function RANDOM return FLOAT;
```

* SPECIFICATIONS WITH DEFAULTS

```
procedure PRINT(BANNER    : in STRING;
                CENTERED  : in BOOLEAN := TRUE;
                SKIP_PAGE : in BOOLEAN := TRUE);
```

* OVERLOADED SPECIFICATIONS

```
procedure SET(LISTING  : in BOOLEAN);
procedure SET(PIXEL    : in COLOR;
              FRAME    : in out BUFFER);
procedure SET(PRIORITY : in NATURAL);
procedure SET(ADDRESS  : in NATURAL);
```

SUBPROGRAM BODIES

* COMPLETE THE ALGORITHM INTRODUCED IN THE SPECIFICATION

* MAY BE SEPARATELY COMPILED

* TAKE THE FORM

```
specification
begin
  sequence_of_statements
  (exception part)
end;
```

SUBPROGRAM CALLS

* GIVEN THE FOLLOWING PROCEDURES

```
procedure SEARCH_FILE(KEY   : in     NAME;
                      INDEX : out    FILE_INDEX);
procedure SLEEP      (TIME  : in     DURATION := 10.0);
procedure SORT       (DATA  : in out NAMES;
                      ORDER : in     DIRECTION := ASCENDING);
procedure SORT       (DATA  : in out NUMBERS;
                      ORDER : in     DIRECTION := ASCENDING);
procedure TURN_ON    (LIGHT : in     LOCATION);
```


* POSITIONAL PARAMETER CALLS

```
SEARCH_FILE("SMITH, J", RECORD_ENTRY);
SLEEP(120.0);
SORT(PERSONNEL_NAMES, DESCENDING);
SORT(GRADES, ASCENDING);
TURN_ON(OFFICE_LIGHTS);
```

* NAMED PARAMETER ASSOCIATION

```
SEARCH_FILE(KEY   => "SMITH, J",
            INDEX => RECORD_ENTRY);
SLEEP(TIME => 120.0);
SORT(DATA  => PERSONNEL_DATA;
     ORDER => DESCENDING);
```

* CALLS WITH DEFAULTS

```
SORT(PERSONNEL_DATA);
SLEEP;
```

* GIVEN THE FOLLOWING FUNCTIONS

```
function COS (ANGLE  : in RADIANS)     return FLOAT;
function HEAT(SENSOR : in SENSOR_NAME) return FLOAT;
function "+" (X, Y   : in MATRIX)      return MATRIX;
```

* SIMILAR OPTIONS APPLY

```
DISTANCE := LENGTH * COS(30.0);
VALUE    := HEAT(SENSOR => WING_TIP);
SUM      := "+"(FIRST_MATRIX, SECOND_MATRIX);
SUM      := FIRST_MATRIX + SECOND_MATRIX;
```

PACKAGES

* PERMIT THE COLLECTION OF GROUPS OF LOGICALLY RELATED ENTITIES

* DIRECTLY SUPPORT INFORMATION HIDING AND ABSTRACTION

* PERMIT AN INDUSTRY OF SOFTWARE MODULES

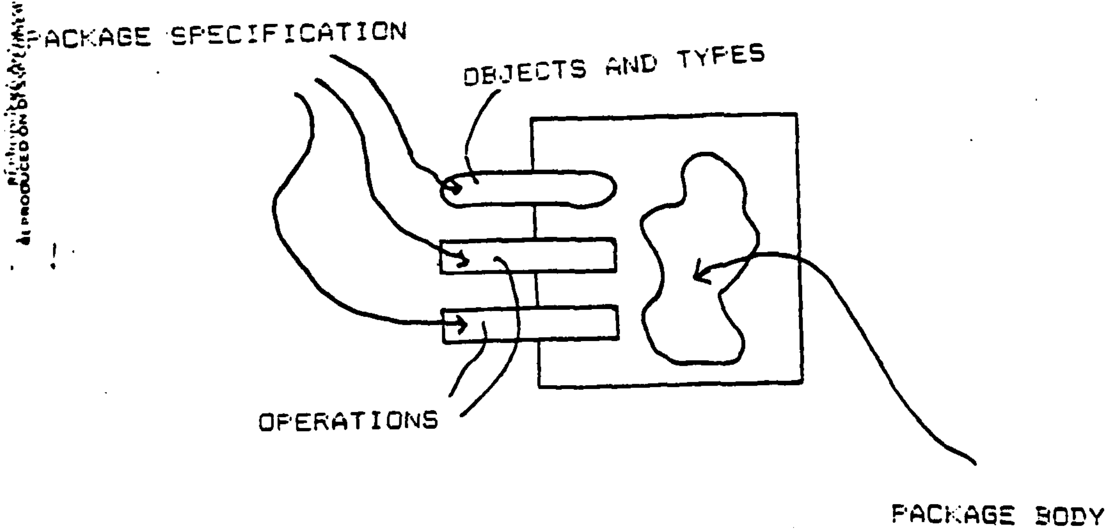

Figure 13-1: Symbol for an Ada Package

PACKAGE SPECIFICATIONS

* FORM A CONTRACT BETWEEN THE IMPLEMENTER OF THE PACKAGE AND THE USER

* MAY BE SEPARATELY COMPILED

* TAKE THE FORM

```
package SOME_NAME is
  ...
end SOME_NAME;
```

* MAY BE FURTHER DIVIDED

  -- VISIBLE PART

  -- PRIVATE PART

PACKAGE VISIBILITY

* GIVEN THE FOLLOWING

```
package COMPLEX is
  type NUMBER is record
                  REAL_PART      : FLOAT;
                  IMAGINARY_PART : FLOAT;
                end record;
  function "+"(A, B : in NUMBER) return NUMBER;
  function "-"(A, B : in NUMBER) return NUMBER;
  function "*"(A, B : in NUMBER) return NUMBER;
end COMPLEX;
```

* PACKAGES AS DECLARATIVE ITEMS

```
procedure MAIN_PROGRAM is
  procedure FIRST is ... end FIRST;
  package COMPLEX is ... end COMPLEX;
  package body COMPLEX is ... end COMPLEX;
  procedure SECOND is ...
    procedure THIRD is ... end THIRD;
    ...
  end SECOND;
begin
  -- sequence of statements
end MAIN_PROGRAM;
```


* PACKAGES AS LIBRARY UNITS

```
with COMPLEX;
package MAIN_PROGRAM is ...
```

NAMING VISIBLE COMPONENTS

* SIMPLE VISIBILITY

```
with COMPLEX;
procedure SOME_PROGRAM is
  NUMBER_1, NUMBER_2 : COMPLEX.NUMBER;
begin
  ...
  NUMBER_1.IMAGINARY_PART := 37.961;
  NUMBER_1 := COMPLEX."+"(NUMBER_1, NUMBER_2);
  ...
end SOME_PROGRAM;
```


* DIRECT VISIBILITY

```
with COMPLEX;
procedure ANOTHER_PROGRAM is
  use COMPLEX;
  NUMBER_3, NUMBER_4 : NUMBER;
begin
  NUMBER_3 := NUMBER_3 + NUMBER_4;
end ANOTHER_PROGRAM;
```

PACKAGE BODIES

* COMPLETE THE DECLARATION OF ENTITIES INTRODUCED IN THE SPECIFICATION

* MAY BE SEPARATELY COMPILED

* TAKE THE FORM

```
package body SOME_NAME is
  ...
end SOME_NAME;
```

PACKAGES AND PRIVATE TYPES

* DEFINE ABSTRACTIONS WHOSE STRUCTURAL DETAILS ARE HIDDEN

* TWO CLASSES OF TYPES

  -- PRIVATE

  -- LIMITED PRIVATE

* PRIVATE TYPE EXAMPLE

```
package MANAGER is
  type PASSWORD is private;
  NULL_PASSWORD : constant PASSWORD;
  function GET return PASSWORD;
  function IS_VALID(P : in PASSWORD) return BOOLEAN;
private
  type PASSWORD is range 0 .. 7_000;
  NULL_PASSWORD : constant PASSWORD := 0;
end MANAGER;
```

EXCEPTIONS

* NAME AN EVENT THAT CAUSES SUSPENSION OF NORMAL PROGRAM EXECUTION

* DRAWING ATTENTION TO THE EVENT IS CALLED RAISING THE EXCEPTION

* THE RESPONSE TO THE EVENT IS CALLED HANDLING THE EXCEPTION

* PERMIT GRACEFUL DEGRADATION

DECLARING AND RAISING EXCEPTIONS

* EXCEPTIONS MAY BE USER-DEFINED

```
ABOVE_LIMITS, BELOW_LIMITS : exception;
PARITY_ERROR               : exception;
FATAL_DISK_ERROR           : exception;
```

* SOME EXCEPTIONS ARE PRE-DEFINED

```
-- CONSTRAINT_ERROR
-- NUMERIC_ERROR
-- PROGRAM_ERROR
-- STORAGE_ERROR
-- TASKING_ERROR
```

* RAISING AN EXCEPTION MAY BE DONE EXPLICITLY

```
raise FATAL_DISK_ERROR;
raise ABOVE_LIMITS;
raise;
raise NUMERIC_ERROR;
```

RAISING PREDEFINED EXCEPTIONS

* CONSTRAINT_ERROR

  -- RAISED WHEN A RANGE, INDEX, OR DISCRIMINANT CONSTRAINT IS VIOLATED

* NUMERIC_ERROR

  -- RAISED WHEN A NUMERIC OPERATION YIELDS A RESULT THAT CANNOT BE REPRESENTED

* PROGRAM_ERROR

  -- RAISED WHEN ALL ALTERNATIVES OF A SELECT STATEMENT HAVING NO ELSE PART ARE ALL CLOSED, OR IF AN ERRONEOUS CONDITION IS DETECTED

* STORAGE_ERROR

  -- RAISED WHEN THE DYNAMIC STORAGE ASSOCIATED ALLOCATED TO AN ENTITY IS EXCEEDED

* TASKING_ERROR

  -- RAISED WHEN EXCEPTION ARISE DURING INTER-TASK COMMUNICATION

HANDLING EXCEPTIONS

* WHEN AN EXCEPTION IS RAISED, PROCESSING IS ABANDONED AND CONTROL PASSES TO AN EXCEPTION HANDLER

* A HANDLER MAY APPEAR AT THE END OF A BLOCK OR THE BODY OF A SUBPROGRAM, PACKAGE, OR TASK

* EXCEPTION HANDLERS TAKE THE FORM OF A CASE STATEMENT

A TASK

* IS AN ENTITY THAT OPERATES IN PARALLEL WITH OTHER PROGRAM UNITS

* PHYSICALLY MAY EXECUTE ON MULTICOMPUTER SYSTEMS, MULTIPROCESSOR SYSTEMS, OR WITH INTERLEAVED EXECUTION ON A SINGLE PROCESSOR

* REQUIRES A MEANS FOR INTER-TASK COMMUNICATION

TASKS

* PERMIT COMMUNICATING SEQUENTIAL PROCESSES

* USE THE CONCEPT OF A RENDEZVOUS

* SPECIAL STATEMENTS ARE PROVIDED FOR TASK CONTROL

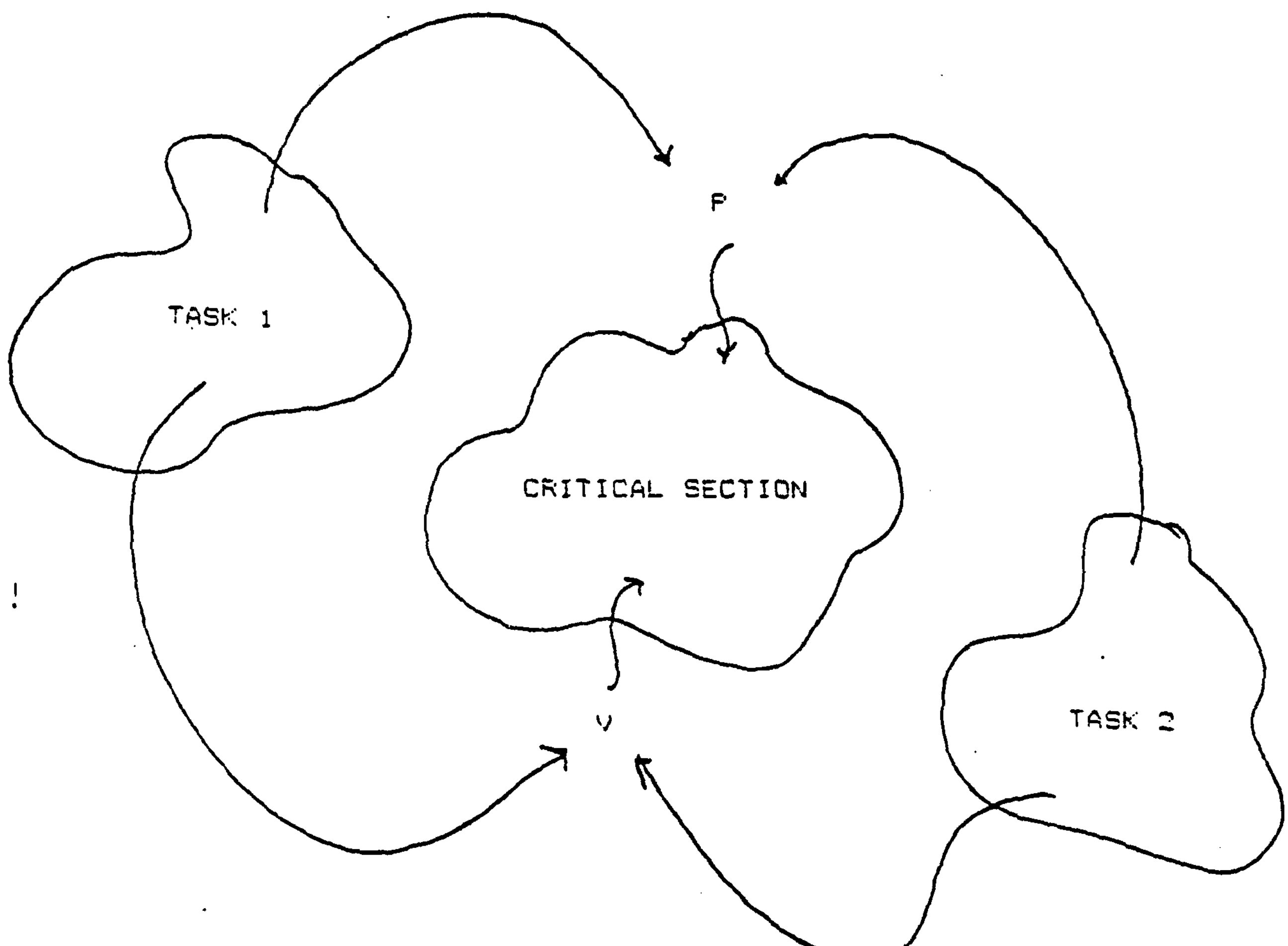

Figure 16-1: Task Communication with Semaphores

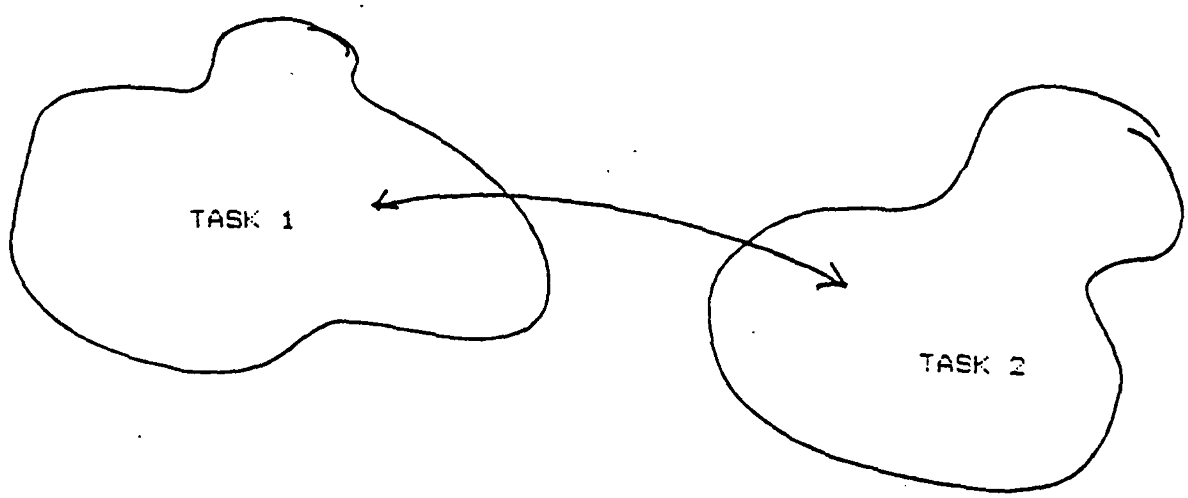

Figure 16-2: Tasks as Communicating Sequential Processes

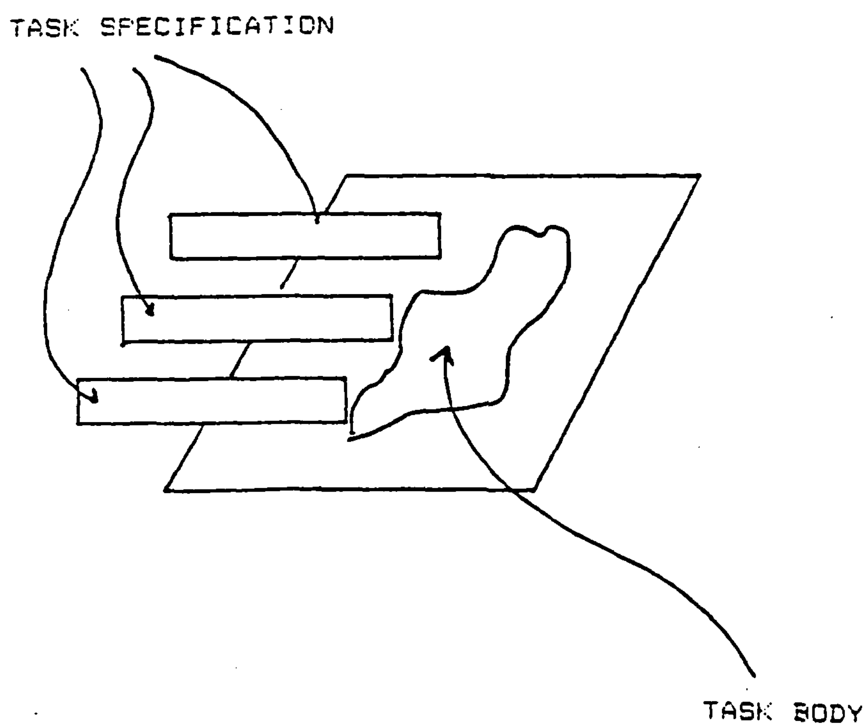

Figure 16-3: Symbol for an Ada Task

THE FORM OF ADA TASKS

* TASKS ARE ACTIVATED IMPLICITLY

* A PARENT TASK WILL NOT TERMINATE UNTIL ALL OTHER DEPENDENT TASKS HAVE TERMINATED

  -- A TASK DEPENDS ON AT LEAST ONE MASTER

  -- A MASTER IS A TASK, A CURRENTLY EXECUTING BLOCK OR SUBPROGRAM, OR A LIBRARY UNIT

  -- A TASK THAT IS A DESIGNATED ACCESS OBJECT OR COMPONENT THEREOF, DEPENDS ON THE MASTER THAT ELABORATED THE ACCESS TYPE

  -- ANY OTHER TASK DEPENDS ON THE MASTER WHOSE EXECUTION CREATED THE TASK OBJECT

TASK SPECIFICATIONS

* INTRODUCE THE NAME OF THE TASK OBJECT OR TASK TYPE, ALONG WITH VISIBLE ENTRIES

* MAY NOT BE SEPARATELY COMPILED

* TAKE THE FORM

```
task SOME_NAME is
  -- TASK ENTRIES
end SOME_NAME;
```

TASK ENTRIES

* DEFINE THE PATH OF COMMUN-ICATION WITH A GIVEN TASK

* HAVE A FORM SIMILAR TO SUBPROGRAM DECLARATIONS

* SEMANTICS ARE DIFFERENT THAN FOR SUBPROGRAM CALLS

NAMING VISIBLE COMPONENTS

* GIVEN THE FOLLOWING

```
task PROTECTED_STACK is
  pragma PRIORITY(7);
  entry POP (ELEMENT : out INTEGER);
  entry PUSH(ELEMENT : in  INTEGER);
end PROTECTED_STACK;
```

* NAMING AN ENTRY

```
PROTECTED_STACK.POP(MY_VALUE);
PROTECTED_STACK.PUSH(36);
```

* RENAMING AN ENTRY

```
procedure PROTECTED_POP(ELEMENT : out INTEGER)
  renames PROTECTED_STACK.POP;
```

ENTRY SEMANTICS

* EACH ENTRY DEFINES AN IMPLICIT QUEUE

* ONLY ONE TASK MAY RENDEZVOUS WITH AN ENTERED TASK AT A TIME; ALL OTHERS WAIT IN ORDER OF ARRIVAL IN THE QUEUE

* A TASK MAY BE IN ONE OF FOUR STATES

  -- RUNNING (CURRENTLY ASSIGNED TO A PROCESSOR)

  -- READY (UNBLOCKED AND WAITING FOR PROCESSING)

  -- BLOCKED (DELAYED OR WAITING FOR A RENDEZVOUS)

  -- TERMINATED (NEVER OR NO LONGER ACTIVE)

PRIORITY

* A STATIC VALUE ASSOCIATED WITH EVERY TASK (AND THE MAIN PROGRAM) THAT INDICATES A DEGREE OF URGENCY

* MAY BE EXPLICITLY SET WITH A PRAGMA

* DOES NOT AFFECT THE ORDER IN WHICH A QUEUED TASK WILL BE SERVED

* IF TWO OR MORE TASKS ARE IN THE READY STATE, THE ONE WITH THE HIGHEST PRIORITY WILL BE SELECTED TO RUN

ASYMMETRY OF TASKS

* THE CALLER MUST KNOW THE NAME OF THE SERVER

* THE SERVER DOES NOT KNOW THE NAME OF THE CALLER

* TASKS MAY STILL CALL ONE ANOTHER MUTUALLY

```
task FIRST_TASK is
  entry SERVICE;
end FIRST_TASK;

task SECOND_TASK is
  entry SERVICE;
end SECOND_TASK;

task body FIRST_TASK is ...
task body SECOND_TASK is ...
```

FAMILIES OF ENTRIES

* DEFINE A SET OF PEER ENTRIES INDEXED BY A DISCRETE VALUE

* GIVEN THE FOLLOWING

```
type IMPORTANCE is (LOW, MEDIUM, HIGH);
task MESSAGE is
  entry GET(IMPORTANCE)(M : out MESSAGE_TYPE);
  entry PUT(IMPORTANCE)(M : in  MESSAGE_TYPE);
end MESSAGE;
```

* NAMING A FAMILY MEMBER

```
MESSAGE.GET(HIGH)(YOUR_MESSAGE);
MESSAGE.PUT(IMPORTANCE => HIGH)(MY_MESSAGE);
```

TASK BODIES

* DEFINE THE ACTION OF A TASK

* MAY BE SEPARATELY COMPILED (ONLY AS A SUBUNIT)

* TAKE THE FORM

```
task body SOME_NAME is
  ...
end SOME_NAME;
```

SAMPLE TASK BODIES

* SIMPLE BODY

```
task WATER_MONITOR;

task body WATER_MONITOR is
begin
  loop
    if WATER_LEVEL > MAXIMUM_LEVEL then
      SOUND_ALARM;
    end if;
  end loop;
end WATER_MONITOR;
```

* BODY WITH AN ACCEPT CLAUSE

```
task CONSUMER is
  entry TRANSMIT_MESSAGE(M : in STRING);
end CONSUMER;

with LOW_LEVEL_IO;
use  LOW_LEVEL_IO;
task body CONSUMER is
begin
  loop
    accept TRANSMIT_MESSAGE(M : in STRING) do
      SEND_CONTROL(MODEM, M);
    end TRANSMIT_MESSAGE;
  end loop;
end CONSUMER;
```

STATEMENTS

* PROVIDE PRIMITIVE FLOW OF CONTROL

* CLASSES OF STATEMENTS

  -- SEQUENTIAL

  -- CONDITIONAL

  -- ITERATIVE

CONDITIONS FOR RENDEZVOUS

* AN ENTRY CALL FROM OUTSIDE THE TASK

* A CORRESPONDING ACCEPT IN THE TASK BODY

* FOR SIMPLE RENDEZVOUS, A TASK WILL PUT ITSELF TO SLEEP IF IT ARRIVES AT A SYNCHRONIZATION POINT BEFORE ANOTHER

* WHEN THE RENDEZVOUS IS COMPLETE, THE TWO TASKS ARE RELEASED TO CONTINUE IN PARALLEL

ACCEPT STATEMENTS

* CORRESPOND TO TASK ENTRIES

* MUST APPEAR DIRECTLY IN
  THE TASK BODY

* OPTIONALLY DEFINE A SET
  OF STATEMENTS FOR THE
  RENDEZVOUS ACTION

* A GIVEN ENTRY MAY HAVE ONE
  OR MORE CORRESPONDING
  ACCEPT CLAUSES

* SAMPLE ACCEPT STATEMENTS

```
task SEQUENCER is
  entry PHASE_1;
  entry PHASE_2;
  entry PHASE_3;
end SEQUENCER;

task body SEQUENCER is
begin
  accept PHASE_1;
  accept PHASE_2;
  accept PHASE_3 do
    INITIATE_LAUNCH;
  end PHASE_3;
end SEQUENCER;
```

TASK STATEMENTS

* DELAY STATEMENTS

* STATEMENTS FOR TASK SYNCHRONIZATION

DELAY STATEMENT

* SUSPENDS PROCESSING FOR AT LEAST THE GIVEN TIME INTERVAL (IN SECONDS)

* SIMPLE DELAY STATEMENTS

```
delay 10.0;
delay DURATION(NEXT_TIME - CALENDAR.CLOCK);
```

* ADDING NAMED NUMBERS FOR READABILITY

```
SECONDS : constant DURATION := 1.0;
MINUTES : constant DURATION := 60.0;
HOURS   : constant DURATION := 3600.0;

delay 2.0*HOURS + 7.0*MINUTES + 36.0*SECONDS;
```

CLASSIFICATION OF TASKS

* ACTOR TASKS

-- HAS NO VISIBLE COMMUNICATION PATHS

-- MAY CALL OTHER TASK ENTRIES

-- SAMPLE APPLICATION

```
task PRODUCER;
```

* TRANSDUCER TASKS

-- HAS VISIBLE ENTRIES

-- MAY CALL OTHER TASK ENTRIES

-- SAMPLE APPLICATION

```
task MESSAGE_PASSER is
  entry RECEIVE_MESSAGE(M : in MESSAGE);
end MESSAGE_PASSER;
```

* SERVER TASKS

-- HAS VISIBLE ENTRIES

-- DOES NOT CALL OTHER TASK ENTRIES

-- SAMPLE APPLICATION

```
task CONSUMER is
  entry TRANSMIT_MESSAGE(M : in STRING);
end CONSUMER;
```

CLASSES OF TASK COMMUNICATION

* SIMPLE COMMUNICATION

* SELECTIVE RENDEZVOUS BY THE SERVER

  -- SELECTIVE WAIT

  -- SELECTIVE WAIT WITH AN ELSE PART

  -- SELECT WITH GUARDS

  -- SELECT WITH A DELAY ALTERNATIVE

  -- SELECT WITH A TERMINATE ALTERNATIVE

* SELECTIVE RENDEZVOUS BY THE CALLER

  -- TIMED ENTRY CALL

  -- CONDITIONAL ENTRY CALL

SIMPLE COMMUNICATION

* AN ACTOR TASK

```
-- CUSTOMER TASK
MAKE_DEPOSIT(ID     => 1273,
             AMOUNT => 1.0);
```

* A SERVER TASK

```
-- TELLER TASK
accept MAKE_DEPOSIT(ID     : in INTEGER;
                    AMOUNT : in FLOAT) do
  BALANCE(ID) := BALANCE(ID) + AMOUNT;
end MAKE_DEPOSIT;
```

SELECTIVE WAIT

* SELECT ONE OF SEVERAL POSSIBLE ENTRIES

* THE SELECTION IS NON-DETERMINISTIC

* A SERVER TASK


```
-- TELLER TASK
loop
  select
    accept MAKE_DEPOSIT(ID : in INTEGER; AMOUNT : in FLOAT) do
      ...
    end MAKE_DEPOSIT;
  or
    accept MAKE_DRIVE_UP_DEPOSIT(ID : in INTEGER; AMOUNT : in FLOAT)
      do ...
    end MAKE_DRIVE_UP_DEPOSIT;
  end select;
end loop;
```

SELECTIVE WAIT WITH AN ELSE PART

* SELECT ONE OF SEVERAL POSSIBLE ENTRIES OR AN ELSE PART IF NO TASKS ARE WAITING FOR SERVICE

* A SERVER TASK

```
-- TELLER TASK
loop
  select
    accept MAKE_DEPOSIT(ID : in INTEGER; AMOUNT : in FLOAT) do
      ...
    end MAKE_DEPOSIT;
  or
    accept MAKE_DRIVE_UP_DEPOSIT(ID : in INTEGER; AMOUNT : in FLOAT)
      do ...
    end MAKE_DRIVE_UP_DEPOSIT;
  else
    DO_FILING;
  end select;
end loop;
```

SELECT WITH GUARDS

* SELECT ONE OF SEVERAL POSSIBLE ENTRIES THAT ARE OPEN BASED ON EVALUATION OF A GUARD CLAUSE

* A SERVER TASK

```
-- TELLER TASK
loop
  select
    when BANKING_HOURS =>
    accept MAKE_DEPOSIT(ID : in INTEGER; AMOUNT : in FLOAT) do
      ...
    end MAKE_DEPOSIT;
  or
    when DRIVE_UP_HOURS =>
    accept MAKE_DRIVE_UP_DEPOSIT(ID : in INTEGER; AMOUNT : in FLOAT)
      do ...
    end MAKE_DRIVE_UP_DEPOSIT;
  else
    DO_FILING;
  end select;
end loop;
```

SELECT WITH GUARDS

* SELECT ONE OF SEVERAL POSSIBLE ENTRIES THAT ARE OPEN BASED ON EVALUATION OF A GUARD CLAUSE
* A SERVER TASK

```
-- TELLER TASK
loop
  select
    when BANKING_HOURS =>
    accept MAKE_DEPOSIT(ID : in INTEGER; AMOUNT : in FLOAT) do
      ...
    end MAKE_DEPOSIT;
  or
    when DRIVE_UP_HOURS =>
    accept MAKE_DRIVE_UP_DEPOSIT(ID : in INTEGER; AMOUNT : in FLOAT)
      do ...
    end MAKE_DRIVE_UP_DEPOSIT;
  else
    DO_FILING;
  end select;
end loop;
```

SELECT WITH A DELAY ALTERNATIVE

* SELECT ONE OF SEVERAL POSSIBLE ENTRIES OR A DELAY PART IF NO TASKS ARE WAITING FOR SERVICE

* A SERVER TASK


```
-- TELLER TASK
loop
  select
    accept MAKE_DEPOSIT(ID : in INTEGER; AMOUNT : in FLOAT) do
      ...
    end MAKE_DEPOSIT;
  or
    delay 30*MINUTES;
    TAKE_A_BREAK;
  end select;
end loop;
```

SELECT WITH A TERMINATE ALTERNATIVE

* SELECT ONE OF SEVERAL POSSIBLE ENTRIES OR A TERMINATE PART

* CONDITION FOR TERMINATION

  -- TASK PARENT IS READY TO TERMINATE

  -- DEPENDENT TASKS ARE TERMINATED OR READY TO TERMINATE

  -- NO CALLING TASKS NEED SERVICE

* A SERVER TASK


```
-- TELLER TASK
loop
  select
    accept MAKE_DEPOSIT(ID : in INTEGER; AMOUNT : in FLOAT) do
      ...
    end MAKE_DEPOSIT;
  or
    terminate;
  end select;
end loop;
```

ALTERNATE FORMS OF TASK TERMINATION

* SIMPLE ABORT

```
abort TELLER;
```

* GIVING A TASK ITS LAST WISHES

```
SHUT_DOWN;
delay 30*SECONDS;
abort TELLER;
```

TIMED ENTRY CALL

* ATTEMPT RENDEZVOUS WITH A SERVER TASK FOR A STATED MINIMUM TIME

* A CALLING TASK

```
-- CUSTOMER TASK
select
  MAKE_DEPOSIT(ID => 1273, AMOUNT => 1_000.0);
or
  delay 10.0*MINUTES;
  TAKE_A_HIKE;
end select;
```

CONDITIONAL ENTRY CALL

* ATTEMPT IMMEDIATE RENDEZVOUS WITH A SERVER TASK

* A CALLING TASK

```
-- CUSTOMER TASK
select
  MAKE_DEPOSIT(ID => 1273, AMOUNT => 1_000.0);
else
  RUN_AWAY;
end select;
```

PROBLEMS WITH CURRENT PROGRAMMING ENVIRONMENTS

* LACK OF COMMON INTERFACES

* INCONSISTANCY AMONG TOOLS

* LACK OF MEANINGFUL TOOLS

* INABILITY TO PROCURE PROPER TOOLS

EXPECTATIONS OF STONEMAN

* REDUCED COMPILER DEVELOPMENT COSTS
* REDUCED TOOL DEVELOPMENT COSTS
* IMPROVED SOFTWARE PORTABILITY
* IMPROVED PROGRAMMER PORTABILITY

ARCHITECTURE OF THE ADA PROGRAMING SUPPORT ENVIRONMENT

* KAPSE

-- KERNAL ADA PROGRAMMING SUPPORT ENVIRONMENT

* MAPSE

-- MINIMAL ADA PROGRAMMING SUPPORT ENVIRONMENT

* APSE

-- ADA PROGRAMMING SUPPORT ENVIRONMENT

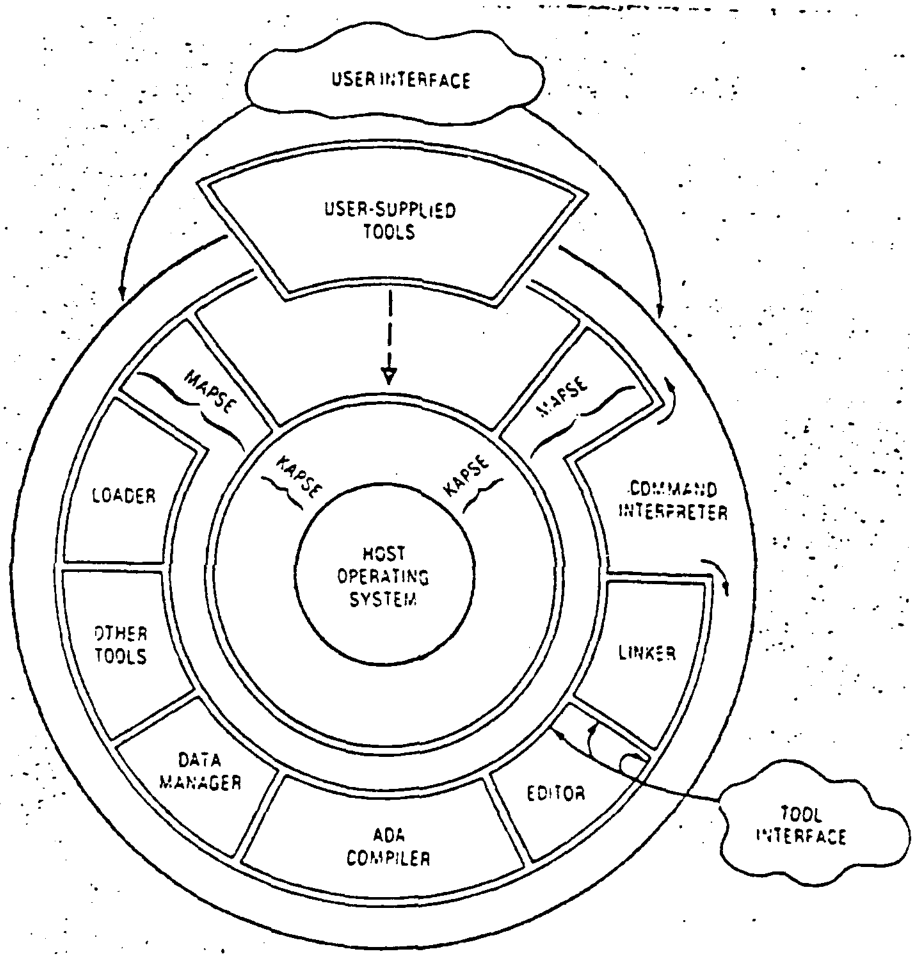

Figure 22-1: The Ada Programming Support Environment (APSE)

THE APSE DATA BASE

* PROVIDES A REPOSITORY FOR ALL PROJECT INFORMATION
* PROVIDES A CENTRAL POINT OF MANAGEMENT
* FACILITATES CONFIGURATION MANAGEMENT

KAPSE

* IS THE MOST PRIMITIVE LEVEL OF THE APSE
* PROVIDES THE LOGICAL TO PHYSICAL APSE INTERFACE
* PROVIDES PRIMITIVE ACCESS TO PROGRAM LIBRARIES

MAPSE

* PROVIDES A ROBUST TOOL SET

  -- TEXT EDITOR

  -- PRETTY PRINTER

  -- COMPILER

  -- LINKER

  -- SET-USE STATIC ANALYZER

  -- CONTROL-FLOW STATIC ANALYZER

  -- DYNAMIC ANALYSIS TOOLS

  -- TERMINAL INTERFACE ROUTINES

  -- FILE ADMINISTRATOR

  -- COMMAND INTERPRETER

  -- CONFIGURATION MANAGER

* DIANA CAN PROVIDE A COMMON INTERFACE AMONG TOOLS

  -- DESCRIPTIVE INTERMEDIATE ATTRIBUTED NOTATION FOR ADA

APSE

* PROVIDES TOOLS FOR

-- CREATION OF DATA BASE OBJECTS

-- MODIFICATION

-- ANALYSIS

-- TRANSFORMATION

-- DISPLAY

-- EXECUTION

-- MAINTENANCE

* TWO CLASSES OF TOOLS EXIST

-- GENERIC TOOLS THAT APPLY TO ALL PROGRAMMING TASKS WITHOUT REGARD FOR SPECIFIC DISCIPLINES

-- METHODOLOGY-SPECIFIC TOOLS THAT SUPPORT A PARTICULAR PROGRAMMING OR MANAGEMENT DISCIPLINE

THE SUCCESS OF ADA

```
SUCCESS :=                DESIGN
          + IMPLEMENTATION
          +                CLOUT
          +                 NEED
```

And the Lord said, Behold, the
people is one, and they have
all one language; and this they
begin to do; and now nothing
will be restrained from them,
which they have imagined to do.

Genesis 11:6

King James Version

F

8