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DESIGN AND IMPLEMENTATION OF S-COMPILER INTERPASS

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CONTENTS

Chapter 1

INTRODUCTION

In 1983 Spring, an implementation project was held under the direct of Dr. Rodney M. Bates. The goal of the project was to implement a portable SIMULA system(S-Port) on Perkin Elmer interdata machines.

This report describes a design of Interpass which is a main part of the compiler to be used in the future[1] Perkin Elmer portable SIMULA system, and is organized as follows.

Chapter 1 is an overall introduction to the subject matter of this report.

Chapter 2 provides a brief history and some characteristics of SIMULA language.

Chapter 3 introduces S-Port, that is, what this system consists of and what is the main function of each part of the system.

Chapter 4 discusses the overall design of the Perkin Elmer portable SIMULA system.

Chapter 5 illustrates the Syntax/Semantics language(S/SL) which is used to construct the Interpass.

Chapter 6 discusses the design of Interpass by providing with the major data structures and the semantic operations.

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[1] This system is not available yet.

Chapter 7 shows some intresting problems which we met during the process of interpass design and implementation.

Chapter 8 concludes with a summary of the present status of the Interpass, i.e., what is done up until now, what can be done to make this Interpass design more perfect, and what we contribute to the future work.

Finally there is a reference section and an appendix of S/SL program listing which we implemented.

Chapter 2

SIMULA LANGUAGE

This chapter describes SIMULA language. It is organized in two parts. The first part introduces the historical development of SIMULA[2] and the second part discusses the principal features of SIMULA.

2.1 Development of SIMULA

SIMULA (SIMUlation LAnguage) is a general purpose programming language developed by Ole-Johan Dahl (OJD) and Kristen Nygaard (KN) of the NCC in 1967 under a contract with the Univac Division of Sperry Rand Corporation. The language is a true extension of ALGOL 60, i.e., it contains ALGOL 60 as a subset. However, SIMULA is historically an extended version of the SIMULA I which was also developed by OJD and KN at the NCC during the years of 1961-1964.

The initiating ideas for SIMULA I originated at the Norwegian Defense Research Establishment (NDRE) in the late fifties. At that time, the NDRE started work in the design of a language which could serve the dual purpose of system description and simulation programming. But the major development of this language was carried out at the NCC from the spring of 1961.

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[2] In this report, SIMULA indicates SIMULA 67. Because SIMULA 67 is the most prevalent version of the language today, and it is commonly called SIMULA.

SIMULA I was initially designed to provide a systems analyst with unified concepts which facilitate the concise description of discrete event systems. In other words, the initial ideas of this language were based upon a mathematically formulated "discrete event network" concept, as evidened by the title of the IFIP 1962 Munich paper, "SIMULA---an extension of ALGOL to the description of discrete event networks".

But as the language developed, the network concept was found to have shortcomings. The language designers of SIMULA I envisaged the important examples of systems which could not naturally be regarded as networks. The result of this was the abandonment of the "network" concept and the introduction of the "process" concept as the basic, unifying concept. That was in February 1964. Language designers no longer regarded a sytem as described by a "general mathematic structure" and instead understood it as a variable collection of interacting processes--each process being present in the program execution, the simulation, as an ALGOL stack. Graphical representaions of simplified(but structurally identical) versions of the program executions were used as models of the systems described by the language.

During 1965 and the beginning of 1966, OJD and KN spent most of the time using and introducing SIMULA I. But they became more and more interested in the possibilities of

SIMULA I as an existing[3] general purpose programming language. That was the starting point of SIMULA idea.

Language designers explored SIMULA I's list structuring and coroutine capabilities, the use of procedure attributes etc. Very soon they realized that important shortcomings existed in the language.

1. The inspect mechanism for remote attribute accessing turned out to be very cumbersome in some situations.

2. When writing simulation programs, processes often shared a number of common properties, both in data attributes and actions, but were structurally different in other respects so that they had to be described by seperate declarations.

In order to solve these problems, Hoare's record class construct was introduced along with the idea of "prefixing". Each of the processes would be a block instance consisting of two layers: a prefix layer containing a successor and predecessor pointer, and other properties associated with two-way list membership, and a main part containing the attributes.

With the gradual development that we described above, SIMULA was born in 1967.

2.2 Principal Features of SIMULA

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[3] "existing" in the sense that it was available on most of the major computer systems, being used over a long period of time by a substancial number of people throughout the world and having a significant impact upon the development of future programming languages

SIMULA is an extension of ALGOL 60. With some exceptions, the rules of ALGOL 60 have been preserved in SIMULA. The definitions of certain syntactic units, however, have been extended to account for the new concepts of SIMULA.

For example, as in ALGOL, the head of a SIMULA block contains declarations. However, in SIMULA these can be the declarations of classes as indicated by the redefinition of the syntactic unit declaration.

The principal features which convert ALGOL 60 to SIMULA provide the ability to

1. Declare a class,
2. Generate objects of a declared class,
3. Reference variables,
4. Form a hierarchical structure of class declarations.

2.2.1 Class Declaration

The notion of class in SIMULA can be traced back to the notions of block and block instance in ALGOL 60. An ALGOl block is a description of a composite data structure and associated algorithms. When a block is executed, a dynamic instance of that block is generated. The block instance is the composite data structure described by the block and contains the local variables of the block as well as information needed for the dynamic linkage to other blocks. It is possible to have interaction between instances of different blocks and even instances of the same block in the case of recursive procedure call.

The form of a class declaration in SIMULA parallels the form of a procedure declaration in ALGOL 60. A class declaration can have the following form.

```
class A (PA); SA;
begin DA;
    IA
    ; inner ;
    FA
end
```

The identifier A is the name of the class; PA is the formal parameter list of the class A and it contains only parameter names; SA is the list of specifications of the parameters in PA.

The class body begins with a list of declarations DA. The symbols IA and FA represents lists of instructions respectively called initial operations and final operations of the class A. The symbcl "inner" represents a dummy instruction acting as a separator between the initial and final operations.

The quantities passed as parameters in PA or declared in DA are called the attributes cf the class A and hence also attributes of any object of that class.

2.2.2 Object Generation

A central new concept in SIMULA is the "object". An object is a self contained program, having its own local data and actions defined by a class declaration.

The notion of object in SIMULA originated from the notions of record class and record introduced by Hoare and Wirth.

The expression

new A (...)

where A is a class, is an object generator. When encountered, it creates an object which is an instance of class A and starts execution of the initial operations of A. The execution continues until the end of the class body is encountered, at which time the execution terminated.

2.2.3 Reference Variables and Remote Identifiers

Each element of a simulation has attributes whose values determine the state of the element. Since elements are specified in SIMULA by the class declaration, their attributes are naturally represented by the variable which appears in the declaration.

When an object is executed, some of the actions performed involve attributes of the object itself. This is called local access of attributes and the usual rules of ALGOL apply.

The term remote access is used for the accessing of attributes of other objects. In this case a given attribute is not uniquely specified by merely mentioning its attribute identifier. It is also necessary to specify the object to which the considered attribute belongs. A remote access is thus performed in two steps.

1. The selection of a particular object,

2. The determination of the attribute of the selected object.

A new type of variable, the reference variable, is used for referring to objects. A reference to a newly created object is obtained during the execution of an object generator. This reference is analogous to a pointer. The language permits the calculation and assignment of references by introducing special operators

:- reference assignment

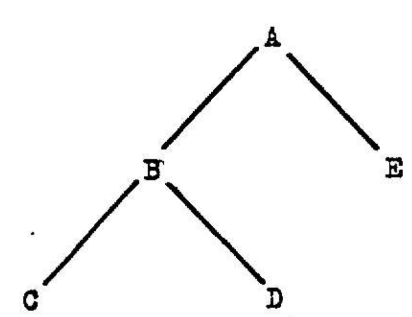
== reference equality

=/= reference inequality

to work with reference variables.

2.2.4 Hierarchical Declarations

A class declaration may be preceded by a prefix which is the name of another class. The prefixed class is now called a subclass of the



Hierarchy of classes and subclasses

prefix. The following is a declaration for the subclass B of the previously declared class A.

```
A class B(PB); SB;
 begin DB;
    IB
    ; inner ;
    FB
end
```

More generally a hierarchy of classes can be introduced by a succession of declarations of subclasses as follows.

```
class A...;
A class B...;
B class C...;
B class D...;
A class E...;
```

A graph corresponding to this hierarchy is an oriented tree. The root of the tree is the class that has no prefix. The prefix sequence of a given class is the sequence of classes encountered on the unique path going from the given class to the root. In the above example the prefix sequence of class C consists of C, B, and A.

A subclass is said to be inner to its prefixes. Thus C is inner to B and A. Conversely B and A are said to be outer to C.

Chapter 3

PORTABLE SIMULA SYSTEM

This chapter provides the information about the portable SIMULA system(S-Port) and discusses the major parts of that system.

3.1 Components of S-Port

S-Port is a portable implementation of the SIMULA language. It is initiated by the Norwegian Computing Center(Oslo) and the Program Library Unit(Edinburgh) in 1979. The system consists of three parts:

1. a portable front-end compiler,
2. a portable run-time support system, and
3. a machine dependent code generator.

The portable front-end compiler translates a source program written in SIMULA into the intermediate language S-code. The compiler itself is written in SIMULA.

The portable run-time support system is used to support the storage allocation, creation and management of objects and activation records, and garbage collection.

Both the front-end compiler and the run-time system will be distributed in the intermediate language S-code. This language is used to transmit an analysed SIMULA program from the front-end compiler to the code generator.

The code generator is a unique machine dependent part of the system and this will produce code for the target machine corresponding to the S-program. This code generator is often called a back-end compiler by contrast with the front-end compiler.

In order to be a complete SIMULA system, S-port is to be supported by this back-end compiler, i.e., code generator. The task of the back-end compiler is to translate the programs in S-code into the machine language of the given machine. So, from now on, we shall call that compiler S-compiler. This compiler must insert necessary links to the operating system of the object machine.

As we described, the Portable SIMULA system consists of three main parts, two language dependent parts and a target dependent part. But, in many cases, the system needs services that can only be provided through the operating system environment, e.g., file handling and interrupt monitoring.

The run-time system requires information about the options selected by the user, the current mode of operation and the environmental conditions applicable to the particular implementation.

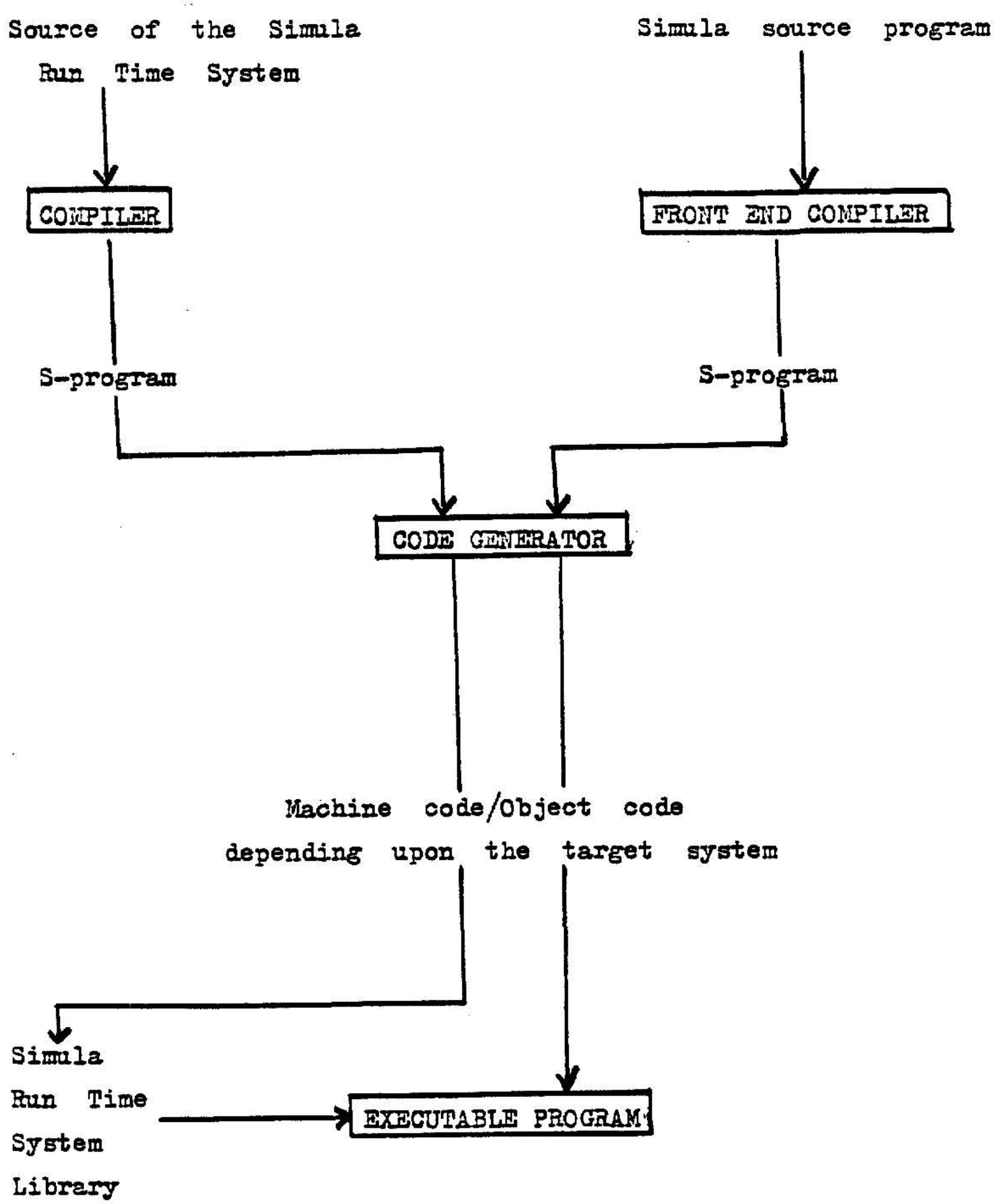
The front-end compiler also requires information about the compile time options selected by the user, and some information which is only known in each implemented system, such as default file names.

The environment interface support package provides system dependent services to the S-Port through Environment Interface. The Environment Interface itself is system independent and is organized according to the S-Code standards.

THIS BOOK CONTAINS NUMEROUS PAGES WITH DIAGRAMS THAT ARE CROOKED COMPARED TO THE REST OF THE INFORMATION ON THE PAGE.

THIS IS AS RECEIVED FROM CUSTOMER.

General Overview of S-Port



Chapter 4

PERKIN ELMER SIMULA SYSTEM

This chapter describes the overall design of the Perkin Elmer portable SIMULA system. This system is going to be implemented as a complete portable SIMULA system on Perkin Elmer interdata machines. It is to be run under the Unix operating system.

4.1 General Idea

S-Port, which was brought from Norway, provides a portable front-end compiler and a portable run-time support system. However, in order to be a complete portable SIMULA system, it is necessary to develop a machine dependent code generator, i.e., S-Compiler. Also, it is necessary to provide an environment interface support package compatible with the operating system of these machines.

We are going to write S-Compiler which translates the intermediate language S-Code to the 8/32 interdata code. Also we shall provide the Environment Interface which contains utility routines and interfaces to operating system.

Any SIMULA program can be translated into S-Code by the front-end compiler. Then the translated version of S-Code can be compiled by the S-Compiler, linked with the machine code version of the run time system and Environment Interface. This produces the final object code of the original SIMULA program.

4.2 S-Compiler Design

The S-Compiler written for Perkin Elmer machines consists of two parts:

1. a brand new pass Interpass, and
2. a set of modified passes of the Pascal/32 compiler.

4.2.1 Interpass

Interpass is an independent pass, and it translates the token stream* of S-code into the intermediate language of a modified version of Pass 6 of the PASCAL/32 compiler.

Interpass recognizes the operations indicated by the S-code and releases the appropriate tokens for the input stream of modified Pass 6. Unlike the original passes of Pascal/32 compiler, this pass, in certain cases, does not release the tokens at the end of the output stream. Instead through the use of pointers, the tokens are inserted into the middle of the output stream.

Interpass also allocates data space for the constants and for the global or local variables within the respective areas.

This pass uses S/SL as the main controlling language and this S/SL program calls a set of semantic operations coded in Sequential Pascal. S/SL interpreter for the Interpass is also written in Pascal.

4.2.1 Modified passes of Pascal/32 Compiler

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* Actually, it is a file of integers in binary byte form.

We use passes 6, 7, 8, and 9 of the Pascal/32 compiler which are written in Pascal, and modify especially Pass 6 and Pass 7. This section describes the major functions performed by the passes 1 through 9 and gives an account of modification of Pass 6, Pass 7 and Pass 8.

I. Pascal/32 Compiler

Pascal/32 compiler is an extensive modifications of Hartmann compiler for the concurrent and sequential Pascal languages. It is composed of 9 passes.

Pass 1 of the Pascal/32 compiler is the lexical scanner. It converts the character input to the compiler into the tokens recognized by the parser in Pass 2.

Pass 2 is for syntax analysis. This pass verifies the syntax of the intermediate code generated by Pass 1. The output of this pass is in the form of a polish postfix notation, the operands followed by the operator.

The main function of Pass 3 of the Pascal/32 compiler is name anlysis. This pass applies the language scope rules to convert references to an identifier into the references to the appropriate unique objects in each part of the program.

Pass 4 is for declaration analysis. This pass performs storage allocation and outputs data addressing information along with data type information in the intermediate code.

The main function of Pass 5 is operand analysis. This pass performs operand type checking on all of the operators in the program. This pass applies the operand compatibility rules of the language. It produces output which is effectively the assembler language for a stack machine.

Pass 6 of the Pascal/32 compiler is for program logic. It is designed primarily to perform constant folding, i.e., performing operations on constants at compile time rather than at run time. However, since this is the first pass to build entire procedures as in-memory data structures, it performs several other functions which either perform various other optimizations or rearrange intermediate code to simplify the operation of the later passes.

The main function of Pass 7 of the Pascal/32 compiler is Interdata 8/32 code generation. The input is essentially the instructions of the virtual stack machine output by Pass 5. The actual output from pass 7 is a set of 8/32 instructions in unformatted form.

Pass 8 performs machine dependent code optimization using the peephole technique. This pass makes instruction choices depending upon the length of the instruction. It maps the code labels to the actual machine addresses by generating a table.

Pass 9 is for code optimization. This pass converts the machine code into the format accepted by the linkage loader. It uses the table supplied by Pass 8 to replace the labels with the addresses.

II. Modification of Code Generator Passes

Modification of Pass 6

The data structure used in Pass 6 is a stack of lists of trees. And there's some optimization back to token stream. Each result operand is used only once, so this structure is suitable. The "dup" token of S-Code requires the duplication of its operand. It is not possible to represent this operation by a tree. Hence, Pass 6 is modified to generate graphs rather than trees.

Also, new tokens[5] must be included in the input token stream of thie pass for the language features which are present in S-Code but not in Pascal.

Finally, there's a modification about Pass 6 has to be able to read a mapfile and do random access to the main file containing tokens.

Modification of Pass 7

This pass is designed to hold the descriptors of the runtime operand on the compile time stack as long as they are not computed. The register containing the operand is freed after the computation of the result is complete. In order to process the tokens like "save" and "restore" in S-code, Pass 7 has to be modified to be able to save and restore with the temporary values.

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[5] For the list of these new tokens, look at S/SL program listing under "pass 6 New Input Tokens".

Also, this pass is for code generation, so it has to generate code for the new tokens introduced by S-Code.

Modification of Pass 8

Right now, Pass 8 eliminates duplicate constants. If same constant value appears twice, then it replaces them with a single copy of that constant. S-Code has initialized variables which behave like constants. For example, S-Code has initial constant values for the variables of the arithmetic type, data address type and instruction type. Pass 8 is therefore modified to include a way of distinguishing constant values and initializing variables, so that the latter do not have duplicates removed.

4.3 Environment Interface

The Environment Interface is used to do things depend on the unix operating system. It is written in language C, since this is the base language of the unix operating system.

This Environment Interface provides the system dependent services for the environment in which Perkin Elmer SIMULA system is to be implemented. It contains routines for the necessary environment switch between the Pascal environment and the C environment, since the run time environment of the Pascal code generator is different from that of unix and SIMULA environment is same as Pascal. This includes saving of stack pointers for both C stack and Pascal stack, and copying of parameters, because the parameter passing mechanisms are also different.

In addition to these, The Environment Interface introduces new functions for the Unix supplied editing services.

Chapter 5

SYNTAX/SEMANTIC LANGUAGE

This chapter serves as an introduction to Syntax/Semantic Language (S/SL) which we use to construct the Interpass. It is organized as follows. We first give general ideas about S/SL, and then the important features of S/SL are given. Also there is a brief explanation about how S/SL is implemented. Finally syntax diagrams[6] are given to illustrate the syntax of S/SL.

5.1 General Concepts

S/SL is a programming language developed at the University of Toronto as a tool for constructing compilers. It is a very modest language, incorporating only the following features: sequences, repetitions and selection of actions(statements); input, matching and output of tokens; output of error signals; subprograms(called rules); and invocation of semantic operations implemented in another language such as Pascal.

S/SL is a language without data or assignment; it is a pure control language. Data can be manipulated only via semantic operations.

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[6] We use syntax diagrams rather than BNF, because the structure of a program written in S/SL resembles a textual notation for syntax diagrams with statements relating to the output actions and calls to the semantic routines inserted.

An S/SL program behaves like a recursive descent parser with output actions and semantic routine calls included in it.

The semantic routines called by S/SL program can be parameterized or nonparameterized. The parameters passed to the parameterized routines can be only constants since S/SL does not contain any variables. The entire data handling process is carried out through the execution of these routines.

S/SL adheres to a strict data abstraction by seperating the algorithm from the data. The algorithm invokes the semantic routines where the data is manipulated.

5.2 Features of S/SL

Each S/SL program consists of a list of declarations followed by a list of executable rules. Each rule consists of a name, an optional return type and a sequence of actions(statements). Each rule has one of these two forms:

```
name: actions;
name >> type: actions;
```

A rule with the first form is called a procedure rule; a rule with the second form is called a choice rule. These two forms are analogous to procedures and functions in Pascal. In our dialect, the choice rule does not exist.

5.2.1 Declarations in S/SL

We need to make declarations that are used by S/SL rules. In particular we need to specify the set of input tokens, the set of output tokens, the set of error signals, the set of values returned by each choice rule and the set of values to be used as parameters to parameterized semantic ops . Each of these sets is declared by enumerating the names of their members; this is similar to defining enumerated types in Pascal. For example:

```
input: % Input Tokens[7]
  integer
  plus
  ...etc...;
output: % Output Tokens
  Int
  Add
  ...etc...;
error: % Error Signals
  missingSemicolon
  ...etc...;
```

5.2.2 Summary of S/SL Actions

There are eight different actions(statements) in S/SL.

1. The call action: This action is used to invoke a procedure rule. The appearance of @ followed by the name of a procedure rule signifies that the rule is to be called.

---

[7] Here we have shown the convention for comments in S/SL programs, namely, anything to the right of a % on a line is ignored.

2. The return action: The symbol >> in a rule signifies return before reaching the end of the rule. In choice rules, the >> must be followed by a value in the rule's specified retun range, and implicit return via the final semicolon is not allowed. In procedure rules, the return >> is not followed by a value. Usually >> is not used in procedures because return is implicit at the end of the rule.

3. The input(or match) action: The equal sign(=) followed by the appearance of an input token in a rule signifies that the next input should be read and must match the token.

4. The emit token: The appearance of a dot(a period) followed by an output token signifies that the token is to be emitted to the output stream.

5. The error action: The appearance of # followed by an error signal signifies that the error signal is to be emitted to a special error stream. Presumably this stream is used to print appropriate error messages.

6. The cycle action: This action is analogous to the loop structure in the high level languages like Pascal. Each cycle is of the form:

```
        {
          actions
                  }
```

The enclosed actions are repeated until a return(>>) or one of the cycle's exits(>) is encountered.

7. The exit action: The appearance of > signifies exit from the most tightly enclosing cycle.

8. The choice action: The effect of this action is analogous to a case statement in Pascal. The choice action is of the form:

```
[ selector
      | labels:
          actions
      | labels:
          actions
      | *:
          actions
  ]
```

A choice action can be a rule choice, a semantic choice or an input choice. If the selector is the name of an S/SL choice rule then the choice action is a rule choice. In a rule choice, the specified rule is called and then the choice tries to match the returned value to one of the labels. If the selector is the name of a semantic routine then the choice action is considered to be a semantic choice. In a semantic choice, semantic action is called and value it returns is used. If the selector is "=", we have an input choice, which tries to match the current input token to one of the labels. The actions associated with the matched labels are executed; if no label is matched, the final alternative, labelled by the star(*), is executed. This is analogous to the otherwise clause in a Pascal case statement. It is optional. If omitted, the selector must match one of the choice's labels. Otherwise, there is an error.

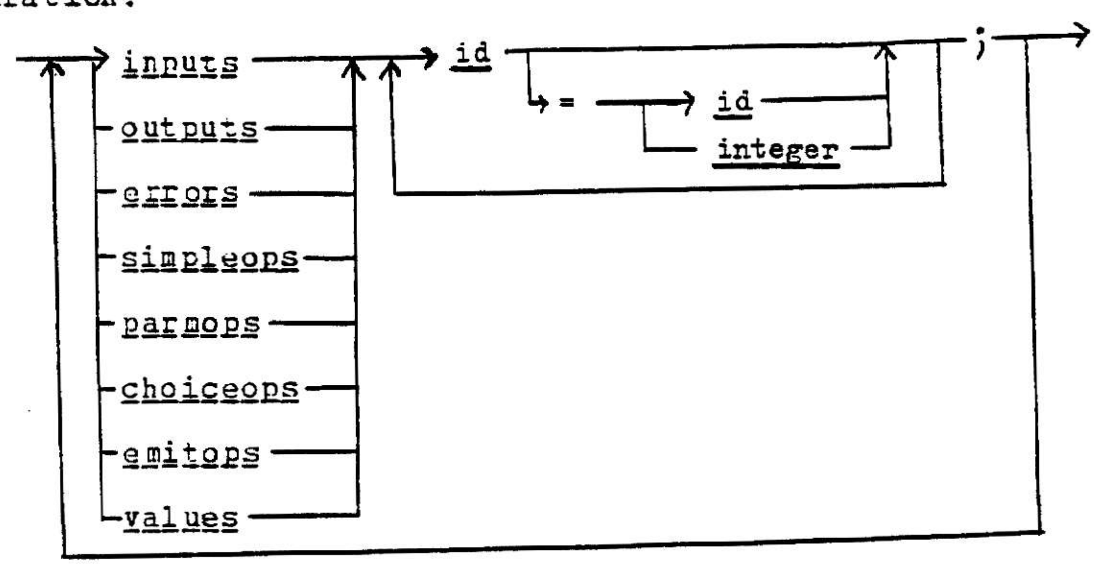
The choice action controls the decision process. The input token (in case of input choice) or the value returned (in case of a rule or a semantic choice) is only used as a determiner for the selection of a particular set of actions. It does not modify or manipulate any data. Our dialect has no rule choices.

5.3 Implementation of S/SL

S/SL is implemented by a translator which translates S/SL to an intermediate language. That language can be called SL-code. This is a machine-language-like instruction set encoded into a sequence of numbers. The result is a Pascal array of integers. The translated S/SL program is then interpreted by SL-code interpreter. That interpreter scans through the array by using a large case statement. Each instruction and semantic operation of SL-code has a counter part label in the case statement.

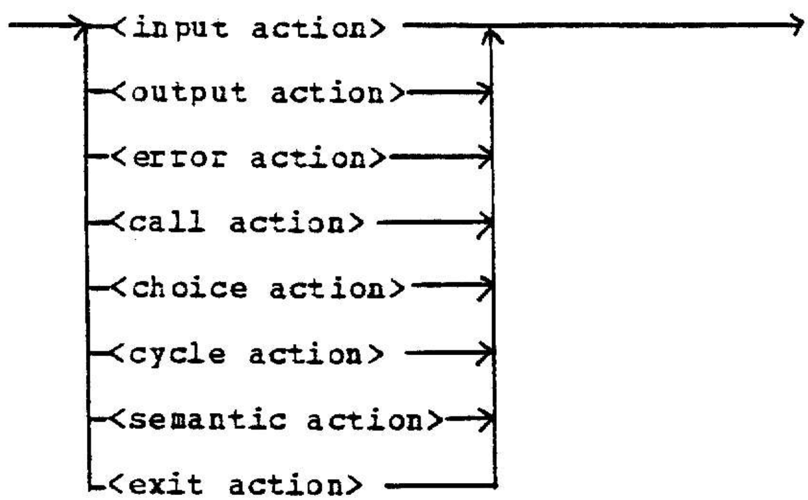
5.4 S/SL Syntax

declaration:



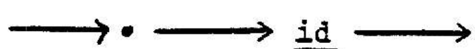
rule:

action:

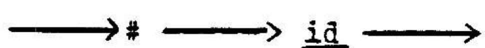


input action:

output action:

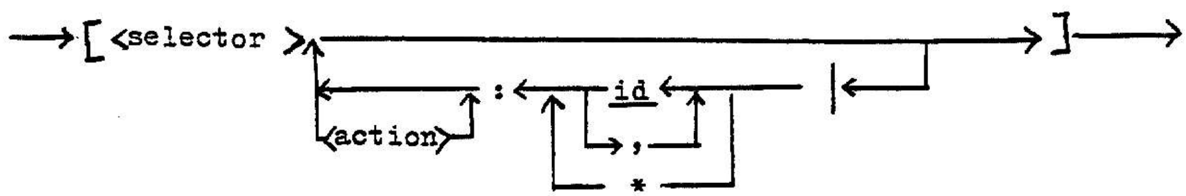


error action:

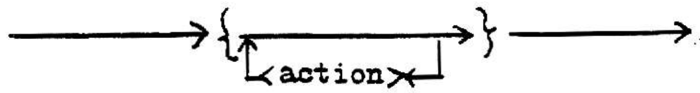


call action:

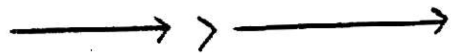
choice action:



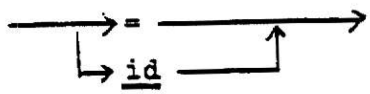
cycle action:



exit action:



selector:



Chapter 6

DESIGN OF INTERPASS

Interpass is a new pass and at the same time a major pass of the S-Compiler. Interpass includes a main controlling program coded in S/SL and a set of semantic routines coded in Pascal. This chapter discusses the design of Interpass. First, we give the detailed description of data structures and semantic operations used in Interpass. Then the general summary of how we built the S/SL program is given.

6.1 Data Structures and Semantic Operations of Interpass

6.1.1 S-stack and Associated Semantic Operations

This is a global stack which corresponds to the compile time stack defined in the S-code. It is a stack of pointers pointing to the descriptors.[a] This stack is implemented as a Pascal array of pointers.

As the compilation process in interpass progresses, the descriptors are continuously created and destroyed on the S-stack. Therefore push and pop operations are needed for this creation and destruction.

---

[a] The actions which the S-compiler should take upon recognition of a specific program element, are defined in terms of descriptors. These descriptors contain information about the objects which exist during the compilation process.

The stack semantics for assignment and addressing in the S-program requires that certain conditions on the descriptores held in the stack are valid. For example, the correct interpretation of the "assign" instruction and valid code generation is possible only if the second topmost descriptor on the stack is of ref mode.[9] At runtime the value held in the topmost descriptor is to be transferred to the location designated by the second topmost descriptor. The addressing instructions modify or replace the top descriptor on the stack. This means a new result descriptor must occupy the top of the stack at the end of translation. It is also necessary to set the mode, type or output pointer fields of the descriptor. Push and set operations are used to accomplish this. The emission of the right tokens in the output stream is possible only by examining the information. Verification operations and choice operations on the S-stack descriptors are needed for this.

Here is a list of some operations associated with S-stack.

--push descriptors

--pop the S-stack

--Set the mode field of the top of S-stack

--Set the output pointer field of the top of S-stack

--Return S-code type field of top of S-stack

---

[9] The mode or "access rule" in S-code is grouped in two modes, namely VAL and REF. VAL access rules describe values. REF access rules describe references to areas which have an associated address of some sort.

--Verify if top of S-stack is ref mode and so on.

6.1.2 Tag Stack, Tag Table and Associated Semantic Operations

The tag stack is a stack of tag values associated with the descriptors. Tags are S-code equivalent of identifiers. It is implemented as an array of integers within a predefined subrange. This stack is used to push something onto S-stack.

The tag table is an array of records subscripted by tag values. A tag record stores two kinds of information about a tag. One field of the record stores the tag state. A tag may be undefined, referenced or defined. The other field points to the descriptor associated with the given tag. This table is used to locate the descriptor when the tag naming it appears in the input. The table entries are modified at compile time when the tags are declared or undeclared.

Whenver a tag is read from the input stream, it is held temporarily in the tag stack. Since tags may be specified prior to their definition, it is necessary to verify the state of the tag whenever the tag is referred to. The tag value stored in the tag stack is used to create a new descriptor relating to that tag. The pointer to that descriptor will be stored in the tag table at the tag value.

As the arguments to a token are scanned further, the appropriate fields of the descriptor referring to the tag are set up. The setting operations may use the constant values being held in the count stack temporarily.

While interpreting the type conversion instructions it is necessary to examine the tag held in the tag stack in order to determine whether the conversion will be valid or not. Return or choice operations are needed to accomplish this.

Here is a list of some semantic oprations associated with the tag stack and with the tag table:

--read a tag from input, and push it onto the tag stack

--set the state of the tag

--select the descriptor

--verify if top of the tag stack is a record type, and so on.

6.1.3 <u>Count Stack and Associated Semantic Operations</u>

Count stack is a stack of integers. During the compilation of an S-progam, the count stack is used to temporarily hold the constant values which may appear in various program elements. In particular, the count stack can store:

--Size of an S-code type

--Number of a repetition value

--Number of a fixed repetition value

--Number of an indefinite repetition value

--Displacement

--Lower and upper bound of a range

--Byte, number and converted string values, and so on.

These values are placed on the count stack through push operations. It is sometimes necessary to increment or decrement the constant value on the count stack. Compile time addition and multiplication of the top two constants on the count stack is also needed in some translations. Therefore, simple semantic routines for these operations are introduced.

The count stack always holds the values temporarily. Once the constant has been used, it is discarded through a pop operation.

Here is a list of semantic operations for the count stack.

--push byte, number, etc.

--pop

--add top and second top of count stack and replace it by their sum

--add one(increment) to top of count stack

--subtract one(decrement) from top of count stack

--return the value of top of count stack and so on.

6.1.4 <u>Index Table Stack and Associated Semantic Operations</u>

This is a stack of tables of S-code jump indexes. Each entry contains a state(undefined, referenced, defined) and a Pass 6 label. Ordinarily, only the top table of the stack is visible. A maximum stack depth of two tables is sufficient.

The backward and forward jump instructions access the jump labels through indexing. When a jump instruction is translated, an index entry relating to the destination of the jump is changed. In particular, the state of the index will be changed depending on the kind of jump. The index will be undefined if the jump is forward jump. A set of Pass 6 labels is associated with the destination indices. It is necessary to allocate a new pass 6 label every time the destination is defined or referenced. Further, once a jump has occurred the corresponding index should be made available for reuse. But the Pass 6 labels can never be reused. A new index table is pushed when the compile time control enters a new scope level.

The following semantic operations operate on the index table stack:

--push a new index table on the index table stack with all entries undefined

--allocate a new pass 6 label and store it in the pass 6 label field of the table entry

--pop the index table stack

--set the state of the index, and so on.

6.1.5 Reachable Stack and Associated Semantic Operations

This is a stack of boolean values. It is used to indicate whether the current point in S-code is reachable, i.e., whether the runtime control can reach the current point. Initially it has only top entry with a value false. The top of the stack is turned true by the tokens associated with the backward destinations, forward destinations, switch destinations and the labels endif and else. The top is turned false by the tokens associated with backward jumps, forward jumps, unconditional gotos and switches. The stack is pushed when statically nested procedures are entered and popped when they are exited.

The following semantic operations are required to push, pop, set or return a boolean value to indicate the reachability of the S-code:

--push true or false onto the reachable stack

--pop the reachable stack

--set the top of reachable stack to true or false

--return the value of the top of reachable stack.

6.2 General Coding Methodology

Here is an example of how S/SL program is constructed. "add" is a simple arithmetic instruction which, at runtime, adds the top descriptor and the second topmost descriptor. The operations involved are:

1. If the top descriptor is of ref mode then change the top of the S-stack to hold the contents of the area referred to by this descriptor. And emit code "tpushind".

2. If the second topmost descriptor is of ref mode then change the second top of the S-stack is to hold the contents of the area referred to by this descriptor. And emit code "tpush2ndind".

3. Verify that the top and the second topmost descriptor type tags are equal.

4. Emit a pass 6 "tadd" token in the output token stream.

5. Push the S-code type field of the S-stack top descriptor onto the tag stack.

6. Pop the top and the second top descriptors from the S-stack.

7. Depending on the data type, emit the value, i.e., a Pass 6 type argument to "add".

S/SL invokes the following semantic routines for interpreting the "add" instruction.

```
@ForceTOSValue
@ForceSOSValue
oVerifySTosSosMDataDotTypesMatch
oEmitToken(tadd)
oPushTagWithSMDataDotType
oPopS
oPopS
[ oChooseTag
      | INT:
          oEmitValue(P6word)
      | REAL:
          oEmitValue(P6shortreal)
      | LREAL:
          oEmitValue(P6real)
      | *:
        oAbort(eArithmeticType)
]
```

@PushResultDescriptor

The S/SL rules @ForceTOSValue, @ForceSOSValue and @PushResultDescriptor invoke in turn the following semantic routines:

```
ForceTOSValue:
        [ oChooseSMDataDotMode
              | REFMode:
                   [ oChooseSMDataDotType
                         | INT, BOOL, CHAR, REAL, LREAL,
                           SIZE, OADDR, AADDR, GADDR,
                           PADDR, RADDR:
                             oSetSMDataDotMode(VALMode)
                             oEmitToken(tpushind)
                             oPushTagWithSMDataDotType
                             oEmitTagMTypeDotP6Type
                             oPopTag
                         | *:
                            oSetSMDataDotMode(VALADDRMode)
                   ]
              | *:
        ]

ForceSOSValue:
        [ oChooseSSosMDataDotMode
              | REFMode:
                  [ oChooseSSosMDataDotType
                        | INT, BOOL, CHAR, REAL, LREAL,
```

```
                              SIZE, OADDR, AADDR, GADDR, PADDR,
                              RADDR:
                                oSetSSosMDataMode(VALMode)
                                oEmitTokenAfterSSos(tpush2ndind)
                                oPushTagWithSSosMDataDotType
                                oEmitTagMTypeDotP6TypeBefore
                                 SMDataDotOutputpointer
                                oPopTag
                            | *:
                               oSetSSosMDataDotMode(VALADDRMode)
                        ]
                  | *:
              [

PushResultDescriptor:
              oPushSNewResultDescriptor
              oSetSMDataDotTypeToTag
              oPopTag
              oSetSMDataDotOutputPointer
              oTurnonSMDataDotHasP6Counterpart
```

Chapter 7

INTERESTING PROBLEMS

This chapter discusses some of the interesting issues which we met during the design of Interpass. The solutions adopted in each case are also described.

7.1 Unnesting of Procedure Bodies

7.1.1 Introducing the Problem

The **segment** instruction in S-code allows the existence of out of sequence code in the S-program.

segment-instruction

::= **bseg** <program-element>*[10] **eseg**

The intention of this instruction is that the enclosed elements must be located elsewhere and cannot be generally scanned in strict sequential order. In other words, the following piece of S-code:

sequence-1 **bseg** sequence-2 **eseg** sequence-3

will generate target code for sequence-1 and sequence-3 in direct control sequence while sequence-2 will be located somewhere else.

Besides the "bseg" and "eseg" tokens may be nested thus allowing for nested procedures. Pass 6 of the Pascal/32 compiler has no provision for handling such nested procedures. A direct handling of the non-sequential code can result in a waste of memory space.

---

[10] The asterisk(*) has the following meaning: "program-element" may occur zero or more times at this point.

7.1.2 Solution

The solution adopted was to use files for the treatment of code in the non sequential order. This was implemented as follows.

1. A main file or an output file is written physically in the order the tokens are produced. The main file is divided into fragments. It is assumed that within a fragment the physical and the logical ordering of the tokens is the same. But on the whole, the main file contains tokens which are not in order at all, because the fragments of this file have no inherent ordering, i.e.. they can be scattered within the main file.

2. There is another file called map file which allows Pass 6 to read the fragments of the output file in the correct logical order. The map file contains a list of pointers to the fragments. The physical ordering of the pointers is kept the same as the logical ordering of fragments to which they point. Pass 6 will read the map file sequentailly.

3. A fragment stack is defined. Each entry of this stack is the root of a list of pointers pointing to the fragments. The list itself is a double linked list of fragment pointer nodes. Each node stores a pair of main file pointers. The pair of main file pointers are a begin-fragment pointer and an end-fragment pointer. The begin-fragment pointer points to the first token of the fragment and the end-fragment pointer points to the last of the fragment.

7.2 Value Forcing

7.2.1 Introducing the Problem

The descriptors on the S-stack can be of ref mode. A value forcing operation on such a descriptor requires the insertion of a pass 6 "pushind" token at a place in the token stream just after the instruction token which generated this descriptor. The instruction token may be residing at a position other than the end of the token stream and the value forcing operation can be performed on a descriptor which is below the top of the S-stack. This requires inserting the "pushind" token at a spot other than at the end of the output token stream.

7.2.2 The Solution

The solution adopted is to insert the token in the middle of the stream by splitting a fragment. The insertion mechanism is implemented as follows:

1. The descriptor on the S-stack contains a field called output pointer which stores the pointer to the spot in the output stream.
2. The fragment containing this token is split into two fragments. This is done by searching for that fragment through a scan of the fragment pointers in the list attached to the top entry of the fragment.
3. The found fragment is split into two and a new fragment is linked between the two pieces. The inserted fragment contains the pointers to the tokens to be inserted. The token itself is written physically at the end of the main file.

In this way, the logical ordering of the tokens is arraged without disturbing the physical ordering of the emitted tokens in the output stream.

Chapter 8

CONCLUSION

As a participant of the Perkin Elmer Simula System project, we had an wonderful opportunity to know the characteristics of a group project. Besides, as a result of working for Interpass design, we got an opportunity to study the components of S-Port, the low level intermediate language S-code, and the fascinating language S/SL.

We also observed that the selection of Syntax/Semantic Language as the main control language was made well because the structure of S/SL suits perfectly the control structure of S-code.

Concerning the present status of the project, we can say that the work of Interpass which includes the coding of S/SL and the coding of semantic routines in Pascal is about 70 % complete. However no testing has done on the code developed so far except running through S/SL assembler.

The design of Interpass so far does not include the treatment of initializing attributes of a record type in S-code. Future work can be done so that Interpass design will include some additions to the related data structure and semantic operations, particularly in the record descriptors. Interpass design will also be modified to include the code for the utility library routines. The routines will involve the reading of S-code tokens from Interpass input stream, writing the tokens to Interpass output stream, allocating and freeing the descriptors during the compilation process and converting the text strings and input literals from S-code into internal form. One more thing what we can suggest is that for the efficiency and the convenience, making a S/SL pretty printer can be done as a part of the project.

Finally we can say that we have contributed to introducing a running SIMULA program in K.S.U. We can't run it yet, and it is just a commencement, but as the oriental saying indicates, "the commencement means it's already done the rest."

Appendix I

REFERENCES

REFERENCES

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Appendix II

S/SL PROGRAM LISTING

```
***** Tue Mar 13 16:56:45 1984
***** KANSAS STATE UNIVERSITY  *****
***** COMPUTER SCIENCE  DEPT   *****
***** MINI-COMPUTER LABORATORY *****

       *
** *   *       *   **
* * *  *          *  *
* * *  *       *  *  *
*   *  * *     *  *  *
*   *   *      *   ****
            *  *
             **
```

ILLEGIBLE DOCUMENT

THE FOLLOWING DOCUMENT(S) IS OF POOR LEGIBILITY IN THE ORIGINAL

THIS IS THE BEST COPY AVAILABLE

P-474

```
% Interpass Input Tokens

Inputs:

access
accessv
add
alt
and
anone
asscall
assign
asspar
assrep
attr
bdest
bjump
bjumpif
body
bseq
eseq
call
call_tos
c_aaddr
c_char
c_dot
c_gaddr
c_int
c_ireal
c_oaddr
c_paddr
c_raddr
c_real
c_record
c_size
compare
const
constspec
convert
deco
delete
deref
dinitarea
dist
div
dsize
dup
else
empty
endif
endmacro
endmodule
endprofile
endprogram
endrecord
```

```
 56 endroutine                          *
 57 endskip                             *
 58 eqv                                 *
 59 eval                                *
 60 existing                            *
 61 exit                                *
 62 export                              *
 63 external                            *
 64 false                               *
 65 fetch                               *
 66 fdest                               *
 67 fixrep                              *
 68 fjump                               *
 69 fjumpif                             *
 70 getobj                              *
 71 global                              *
 72 gnone                               *
 73 goto                                *
 74 if                                  *
 75 imp                                 *
 76 inco                                *
 77 index                               *
 78 indexv                              *
 79 info                                *
 80 initarea                            *
 81 insert                              *
 82 interface                           *
 83 internal                            *
 84 import                              *
 85 known                               *
 86 label                               *
 87 labelspec                           *
 88 line                                *
 89 local                               *
 90 locate                              *
 91 macro                               *
 92 main                                *
 93 mark                                *
 94 mcall                               *
 95 module                              *
 96 mpar                                *
 97 mult                                *
 98 neg                                 *
 99 nobody                              *
100 nosize                              *
101 not                                 *
102 nowhere                             *
103 onone                               *
104 or                                  *
105 pop                                 *
106 popall                              *
107 precall                             *
108 prefix                              *
109 profile                             *
110 program                             *
111 push                                *
```

```
pushc
pushlen
pushv
Qlt
Qle
Qeq
Qge
Qgt
Qne
range
record
refer
rem
remote
remotev
rep
repcall
restore
routine
routinespec
rupdate
save
sdest
select
selectv
setobj
setswitch
skipif
sub
switch
system
tag
text
t_geto
t_inito
t_seto
true
update
xor
zeroarea
visible         % These are not used in S-code
endvisible      % but are stored in visible
taglist         % and taglist files for
endtaglist      % identification.
;

% Simple Semantic Operations

SimpleOps:

oAddcount
oAddTagListEntryFromTagAndCount
oAdjustMinimumTagToTag
oAppendTagSosMProfileDotImportListWithTagMAttribute
oBeginSegment
oCheckTagMRecordInitialization
```

```
168 oCloseInputFileAndPop
169 oCloseOutputCopyFile
170 oComputeRangeSizeAndAlignmentUnCount
171 oCreateBodyDescriptorAtTag
172 oCreateLabelDescriptorAtTag
173 oCreateProfileDescriptorAtTag
174 oCreateSwitchDescriptorAtTagWithCountLabels
175 oDecrementCountByOne
176 oEmitStringToOutputCopyFile
177 oEndSegment
178 oFixThis
179 oIncrementCountByOne
180 oMakeTaglistTableEmpty
181 oMarkAndCopySSection
182 oMarkSSection
183 oMergeSSections
184 oMultiplyCount
185 oOpenOutputCopyFileWithStringVisible
186 oOpenOutputCopyFileWithStringTaglist
187 oPopCount
188 oPopIndexes
189 oPopMarkedSSectionMEmpty
190 oPopP6Label
191 oPopReachable
192 oPopS
193 oPopString
194 oPopTag
195 oPopUpdateAndRestoreTag
196 oPushAndOpenInputFileWithStringVisible
197 oPushAndOpenInputFileWithStringTaglist
198 oPushCountWithDuplicate
199 oPushCountWithInputByte
200 oPushCountWithInputIntegerLiteral
201 oPushCountWithInputNumber
202 oPushCountWithSMDataDotDisplacement
203 oPushCountWithSMDataDotFixrep
204 oPushCountWithSSosMDataDotFixrep
205 oPushCountWithTagMDataDotDisplacement
206 oPushCountWithTagMSwitchDotFirstP6Label
207 oPushCountWithTagMSwitchDotLastP6Label
208 oPushCountWithTagMTypeDotHasRepField
209 oPushCountWithTagMTypeDotIndefAlternateLength
210 oPushCountWithTagMTypeDotLength
211 oPushDownIndexes
212 oPushP6LabelWithNewLabel
213 oPushReachableWithFalse
214 oPushReachableWithTrue
215 oPushSNewResultDescriptor
216 oPushStringWithInputString
217 oPushSWithDuplicate
218 oPushSWithTagMDataDescriptor
219 oPushTagAndStringWithInput
220 oPushTagWithInputTag
221 oPushTagWithSMDataDotType
222 oPushTagWithSSosMDataDotType
223 oPushTagWithTagMTypeDotIndefRepTag
```

```
oPushUpdateWithTagAndUndefine                                                     *
oSetIndexSubCountDotP6LabelToNewLabel                                             *
oSetReachableToFalse                                                              *
oSetReachableToTrue                                                               *
oSetSDotHasP6CounterPart                                                          *
oSetSMDataDotMode                                                                 *
oSetSMDataDotOutputPointer                                                        *
oSetSMDataDotTypeToTag                                                            *
oSetTagMBodyDotP6plabToNewP6plab                                                  *
oSetTagMDataDotDisplacementToCount                                                *
oSetTagMProfileDotIdToInputString                                                 *
oSetTagMProfileDotNatureToInputString                                             *
oSetTagSosMDataDotFixrepToCount                                                   *
oSetTagSosMDataDotLowerBoundToCount                                               *
oSetTagSosMDataDotUpperBoundToCount                                               *
oSetTagSosMDataDotRepToCount                                                      *
oSetTagSosMProfileDotBodyTagToTag                                                 *
oSkipInputString                                                                  *
oStoreValuePackedAddressConstantTag                                               *
oStoreValueWithInputLongRealLiteralAtCount                                        *
oStoreValueWithInputLongStringAndPushCountLength                                  *
oStoreValueWithInputRealLiteralAtCount                                            *
oSwapMarkedSSections                                                              *
oSwapP6Labels                                                                     *
oSwapString                                                                       *
oTranslateTagUsingTagListTable                                                    *
oTurnOnSMDataDotHasP6Counterpart                                                  *
oTurnOnOutputCopying                                                              *
oTurnOffOutputCopying                                                             *
oTurnOnTagSosMDataDotHasRange                                                     *
oTurnOnTagSosMDataDotHasFixrep                                                    *
oVerifyAllIndexesUndefined                                                        *
oVerifySTosSosMDataDotTypesMatch                                                  *
oVerifyTagDotKindIsType                                                           *
;


% Semantic Operations with Parameters

ParmOps:

oAbort                                  % (errorCode)                             *
oAlignAreaToCount                       % (AreaName)                              *
oCreateDataDescriptorAtTag              % (DataDescrKind)                         *
oEmitToken                              % (P6Token)                               *
oEmitTokenAfterSSos                     % (P6Token)                               *
oEmitTokenAfterS3os                     % (P6Token)                               *
oEmitTokenToOutputCopyFile              % (TokenValue)                            *
oEmitValue                              % (Integer)                               *
oEmitValueAfterSSos                     % (Integer)                               *
oEmitValueAfterS3os                     % (Integer)                               *
oIncrAreaDisplacementByCount            % (AreaName)                              *
oPushCount                              % (Value)                                 *
oPushTagWithType                        % (ScodeType)                             *
oSetIndexSubCountDotState               % (IndexState)                            *
oSetSMDataDotMode                       % (DescriptorMode)                        *
```

```
oSetSMDataDotType                  % (ScodeType)
oSetSSosMDataDotMode               % (DescriptorMode)
oSetTagDotState                    % (TagState)
oSetTagMProfileDotProfileKind      % (ProfileKind)
oSetTagMProfileDotNature           % (ProfileNature)
oVerifyIndexSubCountDotState       % (IndexState)
oVerifySDotDescriptorKind          % (DataDescrKind)
oVerifySMDataDotMode               % (DescriptorMode)
oVerifySMDataDotType               % (ScodeType)
oVerifySSosMDataDotMode            % (DescriptorMode)
oVerifySSosMDataDotType            % (ScodeType)
oVerifyStringEqualsInputString     % (ErrorCode)
oVerifyTagDotState                 % (TagState)
;


% Choice Operations

ChoiceOps:

oChooseCountComparison
oChooseCountSosValue
oChooseCountValue
oChooseReachable
oChooseSDotDescriptorKind
oChooseSMDataDotHasP6CounterPart
oChooseSMDataDotMode
oChooseSMDataDotType
oChooseSMDataDotHasFixrep
oChooseSMDataDotHasRange
oChooseSSosMDataDotMode
oChooseSSosMDataDotType
oChooseSEmpty
oChooseTagDotState
oChooseTagMTypeDotHasRepField
oChooseTagMTypeStructured
;


% Emit Semantic Operations

EmitOps:

oEmitCount
oEmitIndexSubCountDotP6Label
oEmitP6Label
oEmitSMDataDotP6Level
oEmitSMDataDotP6Mode
oEmitSMDataDotDisplacement
oEmitSSosMDataDotP6Mode
oEmitStringToOutputCopy
oEmitTagMBodyDotP6Plab
oEmitTagMDataDotDisplacement
oEmitTagMLabelDotP6Stlab
oEmitTagMProfileDotId8Chars
oEmitTagMTypeDotLength
```

```
oEmitTagMTypeDotP6Type                                                     •
oEmitTagMTypeDotP6TypeBeforeSMDataDotOutputPointer                         •
oEmitValueAreaCountBytes                                                   •
;


% VALUES OF S/SL

Values:

% Scode Type:

BOOL                                                                       •
CHAR                                                                       •
INT                                                                        •
REAL                                                                       •
LREAL                                                                      •
SIZE                                                                       •
UADDR                                                                      •
AADDR                                                                      •
GADDR                                                                      •
PADDR                                                                      •
RADDR                                                                      •
SINT          % special -- not a type, but a kind of range                 •

% AreaName:

GlobalArea                                                                 •
ConstantArea                                                               •
LocalArea                                                                  •


% DescriptorMode:

REFMode                                                                    •
VALMode                                                                    •
VALADDRMode                                                                •

% IndexState:

UndefinedIndexState                                                        •
DefinedIndexState                                                          •
ReferencedIndexState                                                       •


% TagState:

UndefinedTagState                                                          •
SpecifiedTagState                                                          •
DefinedTagState                                                            •

% DataDescrKind:

GlobalDescrKind                                                            •
LocalDescrKind                                                             •
ConstantDescrKind                                                          •
```

```
AttributeDescrKind                                                          *
BodyDescrKind                                                               *
DeclaredTypeDescrKind                                                       *
BuiltinTypeDescrKind                                                        *
SwitchDescrKind                                                             *
LabelDescrKind                                                              *
ImportDescrKind                                                             *
ExportDescrKind                                                             *
ExitDescrKind                                                               *
ResultDescrKind                                                             *
ProfileDescrKind                                                            *

% ProfileKind: Tells what kind of routine a profile defines

knownProfileKind                                                            *
systemProfileKind                                                           *
externalProfileKind                                                         *
interfaceProfileKind                                                        *
ordinaryProfileKind                                                         *

% ProfileNature:

SIMULANature                                                                *
CNature                                                                     *
Pas32Nature                                                                 *

% TokenValue: These are redefined as values so ParmOps
%              can emit them to special places.

otVisible      = visible                                                    *   152
otEndVisible   = endvisible                                                 *   153
otTaglist      = taglist                                                    *   154
otEndTaglist   = endtaglist                                                 *   155
otModule       = module                                                     *    95

% BooleanValue:

P6True = 1          % constant values emitted to Pass 6                     *
P6False = 0                                                                 *

InterpassTrue = 1   % returned by interpass boolean valued ChoiceOps        *
InterpassFalse = 0                                                          *

yes = 1             % also used for boolean valued ChoiceOps                *
no = 0                                                                      *

% P6Relation: Relational operators

P6equal                                                                     *
P6greaterthan                                                               *
P6greaterthanequal                                                          *
P6lessthan                                                                  *
P6lessthanequal                                                             *
P6notequal                                                                  *

% P6Mode: P6plab and P6stlab are passed as actuals to ParmOps
```

```
%          to tell which kind of P6  label is wanted.

P6globalMode
P6constMode
P6localMode
P6plabMode
P6stlabMode

% P6Type:

P6word
P6shortreal
P6real
P6wordpair

% Pass 6 conversion kinds:

stdconv       % int to shortreal
stdlongconv   % int to (long)real
stdlengthen   % short real to (long)real
stdround      % some kind of real to int

% Misc.

P6ReturnAddressDisplacement = 4
P6FirstFormalDisplacement = 8

% Result values for oChooseCountComparison

CompGreater
CompEqual
CompLess



% ErrorCode: These are declared as values so they can
%            be emitted by ParmOps oAbort.  At the
%            moment all errors are fatal.

eArithmeticType
eConvertType
eIllegalRelation
eProfileDescriptor
eStackNotEmpty
eType
eUndefinedTag
eTagKind
eFixrepsDiffer
eDuplicateDefinition
eDeferredMacros

% The following are non-fatal errors

erModuleNamesMismatch
erCheckCodeMismatch
```

```
% P6Token: These are the output tokens produced by Interpass
%          as Pass 6 Input Tokens.



tpushconst
tpushind
tpushaddr
tpushlabel
textid
tfield
trange
tassign
tcopy
tnot
tand
tor
tneg
tadd
tsub
tmul
tdiv
tmod
tcompare
tcompstruct
tdeflabel
tjump
tfalsejump
tcaseexpr
tcasejump
tpop
tlconst
tconvrt
tpushlabel
tlongjump
tdefstlab


% Pass 6 New Input Tokens

taccess
tdup
tupdate
tupdatecopy
trupdate
trupdatecopy
tpop2nd
tpush2ndind
tsetobj
tgetobj
tsimpleindex
;

_!_

% PROGRAMS
```

```
SProgram:                                                        *

    =program                                                   110
    oPushStringWithInputString                                 216
    @ProgramBody                                                 *
    =endprogram                                                 54
    oPopString                                                 193
;


ProgramBody:                                                     *

[ =
    | main:                                                     92
        @ProgramElements                                         *
    | macro:                                                    91
        oAbort(eDeferredMacros)                                265     497
        =module                                                 95
        oSkipInputString                                       241
        oSkipInputString                                       241
        @MacroDefinitions                                        *
        =endmodule                                              52
    | global:                                                   71
        @GlobalModule                                            *
        =endmodule                                              52
    | *:
        { [ =
            | module:                                           95
                @ModuleHeader                                    *
                =body                                           19
                @ProgramElements                                 *
                =endmodule                                      52
            | *: >
          ]
        }
    ]
;

ModuleHeader:                                                    *

    oPushStringWithInputString   % Module id                   216
    oPushStringWithInputString   % Check code                  216
    [ =
        | existing:                                             60
            oSwapString                                        248
            oPushAndOpenInputFileWithStringVisible             196
            =visible                                           152
            oVerifyStringEqualsInputString(eModuleNamesMismatch) 291   501
            oSwapString                                        248
            oVerifyStringEqualsInputString(eCheckCodeMismatch) 291     502
            @TranslateVisibleDeclarations                        *
            =endvisible                                        153
            oCloseInputFileAndPop                              168
        | *:
            oSwapString                                        248
```

```
                oOpenOutputCopyFileWithStringVisible                     185
                oTurnOnOutputCopying                                     251
                oEmitTokenToOutputCopyFile(otModule)                     271   425
                oEmitStringToOutputCopyFile                              176
                oSwapString                                              248
                oEmitStringToOutputCopyFile                              176
                @TranslateVisibleDeclarations                              *
                oEmitTokenToOutputCopyFile(otEndVisible)                 271   422
                oCloseOutputCopyFile                                     169
                oSwapString                                              248
                oOpenOutputCopyFileWithStringTaglist                     186
                oEmitTokenToOutputCopyFile(otTaglist)                    271   423
                oEmitStringToOutputCopyFile                              176
                oSwapString                                              248
                oEmitStringToOutputCopyFile                              176
                { [ =
                    | tag:                                               143
                        oPushTagAndStringWithInput                       219
                        oPopTag                                          194
                        oPushCountWithInputNumber                        201
                        oPopCount                                        187
                    | *: >
                ] }
                oEmitTokenToOutputCopyFile(otEndTaglist)                 271   424
                oCloseOuputCopyFile                                        *
        ]
    ;

    TranslateVisibleDeclarations:                                          *

    [ =
        | constspec:        @TranslateConstSpec                           38     *
        | record:           @TranslateRecordDescriptor                   122     *
        | labelspec:        @TranslateLabelSpec                           87     *
        | profile:          @TranslateProfile                            109     *
        | info:             @TranslateInfo                                79     *
        | setswitch:        @TranslateSetSwitch                          138     *
        | insert:                                                         81
            oTurnOffOutputCopying                                        252
            @TranslateInsert                                               *
            oTurnOnOutputCopying                                         251
        ]
    ;


    TranslateInsert:                                                       *

        oPushStringWithInputString                                       216
        oPushStringWithInputString                                       216
        oPushTagAndStringWithInput                                       219
        oPushTagAndStringWithInput                                       219
        oSwapString                                                      248
        oPushAndOpenInputFileWithStringTaglist                           197
        =taglist                                                         154
        oVerifyStringEqualsInputString(erModuleNamesMismatch)            291   501
        oSwapString                                                      248
```

```
oVerifyStringEqualsInputString(erCheckCodeMismatch)            291    502
oMakeTaglistTableEmpty                                         180
{ [ =
    | tag:                                                     143
        oPushTagAndStringWithInput                             219
        oPushCountWithInputNumber                              201
        oAddTaglistEntryFromTagAndCount                          *
        oPopCount                                              187
        oPopTag                                                194
        oPopString                                             193
    | *: >
] }
=endtaglist                                                    155
oSwapString                                                    248
oCloseInputFileAndPop                                          168
oPushAndOpenInputFileWithStringVisible                         196
=visible                                                       152
oVerifyStringEqualsInputString(erModuleNamesMismatch)          291    501
oSwapString                                                    248
oVerifyStringEqualsInputString(erCheckCodeMismatch)            291    502
[ =
   | constspec:                                                 38
       oPushTagAndStringWithInput                              219
       oTranslateTagUsingTaglistTable                            *
       @TranslateConstSpec                                       *
       oPopString                                              193
   | record:                                                   122
       oPushTagAndStringWithInput                              219
       oTranslateTagUsingTaglistTable                            *
       @TranslateRecordDescriptor                                *
   | labelspec:                                                 87
       oPushTagAndStringWithInput                              219
       oTranslateTagUsingTaglistTable                            *
       @TranslateLabelSpec                                       *
       oPopString                                              193
   | profile:                                                  109
       oPushTagAndStringWithInput                              219
       oTranslateTagUsingTaglistTable                            *
       @TranslateProfile                                         *
       oPopString                                              193
   | routinespec:                                              131
       oPushTagAndStringWithInput                              219
       oTranslateTagUsingTaglistTable                            *
       @TranslateRoutineSpec                                     *
       oPopString                                              193
   | info:                                                      79
       @TranslateInfo                                            *
   | line:                                                      88
       @TranslateLine                                            *
   | setswitch:                                                138
       @TranslateSetSwitch                                       *
   | insert:                                                    81
       oPushStringWithInputString                              216
       oPopString                                              193
       oPushStringWithInputString                              216
       oPopString                                              193
```

```
    ]
    =endvisible                                               153
    oCloseInputFileAndPop                                     168
    oMakeTaglistTableEmpty                                    180
    oPopString                                                193
    oPopString                                                193
    oPopTag                                                   194
    oPopTag                                                   194
;


ProgramElements:                                                *
{ [ =
      | constspec:                                             38
           oPushTagWithInputTag                               220
           @TranslateConstSpec                                  *
      | const:                                                 37
           @TranslateConstantDefinition                         *
      | record:                                               122
           oPushTagWithInputTag                               220
           @TranslateRecordDescriptor                           *
      | push:                                                 111
           @TranslatePush                                       *
      | pushv:                                                114
           @TranslatePush                                       *
           @FoceTOSValue                                        *
      | pushc:                                                112
           @TranslateNonRecordConstValue                        *
      | dup:                                                   47
           oPushSWithDuplicate                                217
           @ForceTOSValue                                       *
           oEmitToken(tdup)                                   268   545
      | pop:                                                  105
           [ oChooseSDotDescriptorKind                        304
                 | profileDescrKind                             *
                      oAbort(eProfileDescriptor)              265   490
                 | *:
                      oPopS                                   192
           ]
      | popall:                                               106
           oPushCountWithInputByte                            199
           { [ oChooseCountValue                              302
                  | 0:
                      [ oChooseSEmpty                         312
                            | yes:                            435
                                 oPopCount                    187
                                 >
                            | *:
                                 oAbort(eStackNotEmpty)       265   491
                                 >
                      ]
                  | *:
                      oPopS                                   192
                      oDecrementCountByOne                    175
           ] }
      | assign:                                                12
```

```
            @ForceTOSValue                                                  *
            oVerifySSosMDataDotMode(REFMode)                               289   370
            oVerifySTosSosMDataDotTypesMatch                               256
            oPushTagWithSMDataDotType                                      221
            [ oChooseSMDataDotMode                                         306
                | VALMode:                                                 371
                    oEmitToken(tassign)                                    268   516
                    oEmitTagMTypeDotP6Type                                 336
                | VALADDRMode:                                             372
                    oEmitToken(tcopy)                                      268   517
                    oEmitTagMTypeDotLength                                 335
            ]
            oPopTag                                                        194
            oPopS                                                          192
            oPopS                                                          192
        | update:                                                          149
            @ForceTOSValue                                                  *
            oVerifySTosSosMDataDotTypesMatch                               256
            oVerifySSosMDataDotMode(REFMode)                               289   370
            oPushTagWithSMDataDotType                                       *
            oEmitTokenAfterSSos(tdup)                                      269   545
            [ oChooseSMDataDotMode                                         306
                | VALMode:                                                 371
                    oEmitToken(tupdate)                                    268   546
                    oEmitTagMTypeDotP6Type                                 336
                | VALADDRMode:                                              *
                    oEmitToken(tupdatecopy)                                268   547
                    oEmitTagMTypeDotLength                                 335
            ]
            oPopTag                                                        194
            oPopS                                                          192
            @ForceTOSValue                                                  *
        | rupdate:                                                         132
            @ForceTOSValue                                                  *
            oVerifySTosSosMDataDotTypesMatch                               256
            oVerifySMDataDotMode(REFMode)                                  287   370
            oPushTagWithSSosMDataDotType                                   222
            oEmitTokenAfterSSos(tdup)                                      269   545
            [ oChooseSSosMDataDotMode                                      310
                | VALMode:                                                 371
                    oEmitToken(trupdate)                                   268   548
                    oEmitTagMTypeDotP6Type                                 336
                | VALADDRMode:                                             372
                    oEmitToken(trupdatecopy)                               268   549
                    oEmitTagMTypeDotLength                                 335
            ]
            oPopTag                                                        194
            oPopS                                                          192
        | fetch:                                                            65
            @ForceTOSValue                                                  *
        | refer:                                                           123
            oVerifySMDataDotType(GADDR)                                    288   356
            @ForceTOSValue                                                  *
            oEmitToken(tadd)                                               268   522
            oEmitTagMTypeDotP6Type                                         336
            oPopS                                                          192
```

```
            oPushSNewResultDescriptor                        215
            oSetSMDataDotMode(REFMode)                       279    370
            oPushTagWithInputTag                             220
            oSetSMDataDotTypeToTag                           231
            oPopTag                                          194
            oTurnOnSMDataDotHasP6Counterpart                 250
            oSetSMDataDotOutputPointer                       230
        | deref:                                             42
            oVerifySMDataDotMode(REFMode)                    287    370
            oEmitToken(tpushconst)                           268    509
            oEmitValue(0)                                    272
            oPopS                                            192
            oPushTagWithType(GADDR)                          277    356
            @PushResultDescriptor                            *
        | select:                                            135
            @TranslateSelect                                 *
        | selectv:                                           136
            @TranslateSelect                                 *
            @ForceTOSValue                                   *
        | remote:                                            125
            @TranslateRemote                                 *
        | remotev:                                           126
            @TranslateRemote                                 *
            @ForceTOSValue                                   *
        | index:                                             77
            @TranslateIndex                                  *
        | indexv:                                            78
            @TranslateIndex                                  *
            @ForceTOSValue                                   *
        | inco:                                              76
            oVerifySMDataDotType(SIZE)                       288    353
            @ForceTOSValue                                   *
            oVerifySSosMDataDotType(DADDR)                   290    354
            @ForceSOSValue                                   *
            oEmitToken(tadd)                                 268    522
            oEmitValue(P6word)                               272    458
            oPopS                                            192
            oPopS                                            192
            oPushTagWithType(DADDR)                          277    354
            @PushResultDescriptor                            *
        | deco:                                              40
            oVerifySMDataDotType(SIZE)                       288    353
            @ForceTOSValue                                   *
            oVerifySSosMDataDotType(DADDR)                   290    354
            @ForceSOSValue                                   *
            oEmitToken(tsub)                                 268    523
            oPopS                                            192
            oPopS                                            192
            oPushTagWithType(DADDR)                          277    354
            @PushResultDescriptor                            *
        | dist:                                              44
            oVerifySMDataDotType(DADDR)                      288    354
            @ForceTOSValue                                   *
            oVerifySSosMDataDotType(DADDR)                   290    354
            @ForceSOSValue                                   *
            oEmitToken(tsub)                                 268    523
```

```
                oPopS                                                   192
                oPopS                                                   192
                oPushTagWithType(SIZE)                                  277    353
                @PushResultDescriptor                                     #
        | dsize:                                                         46
                oVerifySMDataDotType(INT)                               288    350
                @ForceSOSValue                                            #
                oEmitToken(tpushconst)                                  268    509
                oPushCountWithTagMTypeDotHasRepField                    208
                oEmitTagMTypeDotLength                                  335
                oEmitToken(tmul)                                        268    524
                oEmitValue(P6word)                                      272    458
                oEmitTagMTypeDotP6Type                                  336
                oEmitToken(tpushconst)                                  268    509
                oPushCountWithTag                                         #
                oEmitToken(tadd)                                        268    522
                oEmitValue(P6word)                                      272    458
                oPopS                                                   192
                oPushTagWithType(SIZE)                                  277    353
                @PushResultDesCriptor                                     #
        | locate:                                                        90
                oVerifySMDAtaDotTYpe(AADDR)                               #    355
                @ForceTOSValue                                            #
                @ForceSOSValue                                            #
                [ oChooseSSosMDataDotType                               311
                        | DADDR:                                        354

                        | GADDR:                                        356
                                oEmitToken(tadd)                        268    522
                                oEmitValue(P6word)                      272    458
                        | *:
                                oAbort(eType)                           265    492
                ]
                oPopS                                                   192
                oPopS                                                   192
                oPushTagWithType(GADDR)                                 277    356
                @PushResultDescriptor                                     #
        | setobj:                                                       137
                oVerifySMDataDotType(INT)                               288    350
                @ForceTOSValue                                            #
                oVerifySSosMDataDotType(DADDR)                          290    354
                @ForceSOSValue                                            #
                oEmitToken(tsetobj)                                     268    552
                oPopS                                                   192
                oPopS                                                   192
        | getobj:                                                        70
                oVerifySMDataDotType(INT)                               288    350
                @ForceTOSValue                                            #
                oEmitToken(tgetobj)                                     268    553
                oPopS                                                   192
                oPushTagWithType(DADDR)                                 277    354
                @PushResultDescriptor                                     #
        | access:                                                         5
                @TranslateAccess                                          #
        | accessv:                                                        6
                @TranslateAccess                                          #
```

```
                @ForceTOSVaue                                           *
        | add:                                                          7
                @ForceTOSValue                                          *
                @ForceSOSValue                                          *
                oVerifySTosSosMDataDotTypesMatch                      256
                oEmitToken(tadd)                                      268     522
                oPushTagWithSMDataDotType                             221
                oPopS                                                 192
                oPopS                                                 192
                [ oChooseTag                                            *
                        | INT:                                        350
                                oEmitValue(P6word)                    272     458
                        | REAL:                                       351
                                oEmitValue(P6shortreal)               272     459
                        | LREAL:                                      352
                                oEmitValue(P6real)                    272     460
                        | *:
                                oAbort(eArithmeticType)               265     487
                ]
                @PushResultDescriptor                                   *
        | sub:                                                        140
                @ForceTOSValue                                          *
                @ForceSOSValue                                          *
                oVerifySTosSosMDataDotTypesMatch                      256
                oEmitToken(tsub)                                      268     523
                oPushTagWithSMDataDotType                             221
                oPopS                                                 192
                oPopS                                                 192
                [ oChooseTag                                            *
                        | INT:                                        350
                                oEmitValue(P6word)                    272     458
                        | REAL:                                       351
                                oEmitValue(P6shortreal)               272     459
                        | LREAL:                                      352
                                oEmitValue(P6real)                    272     460
                        | *:
                                oAbort(eArithmeticType)               265     487
                ]
                @PushResultDescriptor                                   *

        | mult:                                                        97
                @ForceTOSValue                                          *
                @ForceSOSValue                                          *
                oVerifySTosSosMDataDotTypesMatch                      256
                oEmitToken(tmul)                                      268     524
                oPushTagWithSMDataDotType                             221
                oPopS                                                 192
                oPopS                                                 192
                [ oChooseTag                                            *
                        | INT:                                        350
                                oEmitValue(P6word)                    272     458
                        | REAL:                                       351
                                oEmitValue(P6shortreal)               272     459
                        | LREAL:                                      352
                                oEmitValue(P6real)                    272     460
                        | *:
```

```
                        oAbort(eArithmeticType)               265    487
                ]
                @PushResultDesriptor                            *
        | div:                                                 45
                @ForceTOSValue                                  *
                @ForceSOSValue                                  *
                oVerifySTosSosMDataDotTypesMatch              256
                oEmitToken(tdiv)                              268    525
                oPushTagWithSMDataDotType                     221
                oPopS                                         192
                oPopS                                         192
                [ oChooseTag                                    *
                        | INT:                                350
                            oEmitValue(P6word)                272    458
                        | REAL:                               351
                            oEmitValue(P6shortreal)           272    459
                        | LREAL:                              352
                            oEmitValue(P6real)                272    460
                        | *:
                            oAbort(eArithmeticType)           265    487
                ]
                @PushResultDescriptor                           *
        | rem:                                                124
                oVerifySMDataDotType(INT)                     288    350
                @ForceTOSValue                                  *
                oVerifySSosMDataDotType(INT)                  290    350
                @ForceSOSValue                                  *
                oEmitToken(tmod)                              268    526
                oPopS                                         192
                oPopS                                         192
                oPushTagWithType(BOOL)                        277    348
                @PushResultDescriptor                           *
        | neg:                                                 98
                @ForceTOSValue                                  *
                oEmitToken(tneg)                              268    521
                oPushTagWithSMDataDotType                     221
                oPopS                                         192
                [ oChooseTag                                    *
                        | INT:                                350
                            oEmitValue(P6word)                272    458
                        | REAL:                               351
                            oEmitValue(P6shortreal)           272    459
                        | LREAL:                              352
                            oEmitValue(P6real)                272    460
                        | *:
                            oAbort(eArithmeticType)           265    487
                ]
                @PushResultDescriptor                           *
        | and:                                                  9
                oVerifySMDataDotType(BOOL)                    288    348
                @ForceTOSValue                                  *
                oVerifySSosMDataDotType(BOOL)                 290    348
                @ForceSOSValue                                  *
                oEmitToken(tand)                              268    519
                oPopS                                         192
                oPopS                                         192
```

```
                oPushTagWithType(BOOL)                                      277    348
                @PushResultDescriptor                                         *
        | or:                                                               104
                oVerifySMDataDotType(BOOL)                                  288    348
                @ForceTOSValue                                                *
                @ForceSOSValue                                                *
                oVerifySTosSosMDataDotTypesMatch                            256
                oEmitToken(tor)                                             268    520
                oPopS                                                       192
                oPopS                                                       192
                oPushTagWithType(BOOL)                                      277    348
                @PushResultDescriptor                                         *
        | xor:                                                              150
                oVerifySMDataDotType(BOOL)                                  288    348
                @ForceTOSValue                                                *
                @ForceSOSValue                                                *
                oVerifySTosSosMDataDotTypesMatch                            256
                oEmitToken(tcompare)                                        268    527
                oEmitValue(P6notequal)                                      272    445
                oPopS                                                       192
                oPopS                                                       192
                oPushTagWithType(BOOL)                                      277    348
                @PushResultDescriptor                                         *
        | imp:                                                               75
                oVerifySMDataDotType(BOOL)                                  288    348
                @ForceTOSValue                                                *
                @ForceSOSValue                                                *
                oVerifySTosSosMDataDotTypesMatch                            256
                oEmitToken(tnot)                                            268    518
                oEmitToken(tand)                                            268    519
                oEmitToken(tnot)                                            268    518
        | eqv:                                                               58
                oVerifySMDataDotType(BOOL)                                  288    348
                @ForceTOSVaue                                                 *
                @ForceSOSValue                                                *
                oVerifySTosSosMDataDotTypesMatch                            256
                oEmitToken(tcompare)                                        268    527
                oEmitValue(P6equal)                                         272    440
                oPopS                                                       192
                oPopS                                                       192
                oPushSNewResultDescriptor                                   215
                oSetSMDataDotType(BOOL)                                     280    348
                oSetSMDataDotOutputPointer                                  230
        | not:                                                              101
                oVerifySMDataDotType(BOOL)                                  288    348
                @ForceTOSValue                                                *
                oEmitToken(tnot)                                            268    518
                oPushTagWithType(BOOL)                                      277    348
                @PushResultDescriptor                                         *
        | compare:                                                           36
                @ForceTOSValue                                                *
                @ForceSOSValue                                                *
                @CheckRelation                                                *
                oPushTagWithSMDataDotType                                   221
                [ oChooseTagMTypeStructured                                 315
                        | yes:                                              435
```

```
                        oEmitToken(tcompstruct)                                        268   528
                        oEmitCount                                                     323
                        oEmitTagMTypeDotLength                                         335
                    | *:
                        oEmitToken(tcompare)                                           268   527
                        oEmitCount                                                     323
                        oEmitTagMTypeDotP6Type                                         336
                ]
                oPopS                                                                  192
                oPopS                                                                  192
                oPushTagWithType(BOOL)                                                 277   348
                oPushResultDescriptor                                                  *
            | convert:                                                                 39
                oPushTagWithInputTag                                                   220
                [ oChooseSMDataDotType                                                 307
                    | CHAR:                                                            349
                        [ oChooseTag                                                   *
                            | CHAR, INT:                                               349   350

                            | *:
                                oAbort(eConvertType)                                   265   488
                        ]
                    | BOOL:                                                            348
                        [ oChooseTag                                                   *
                            | BOOL:                                                    348

                            | *:
                                oAbort(eConvertType)                                   265   488
                        ]
                    | INT:                                                             350
                        [ oChooseTag                                                   *
                            | INT:                                                     350

                            | CHAR:                                                    349
                                oEmitToken(trange)                                     268   515
                                oEmitValue(0)                                          272
                                oEmitValue(255)                                        272
                            | REAL:                                                    351
                                oEmitToken(tconvrt)                                    268   536
                                oEmitValue(stdconv)                                    272   465
                                oEmitValue(P6shortreal)                                272   459
                                oEmitValue(4)                                          272
                                oEmitValue(4)                                          272
                            | LREAL:                                                   352
                                oEmitToken(tconvrt)                                    268   536
                                oEmitValue(stdlongconv)                                272   466
                                oEmitValue(8)                                          272
                                oEmitValue(8)                                          272
                            | *:
                                oAbort(eConvertType)                                   265   488
                        ]
                    | REAL:                                                            351
                        [ oChooseTag                                                   *
                            | REAL:                                                    351

                            | INT:                                                     350
```

```
                        oEmitToken(tconvrt)                 268   536
                        oEmitValue(stdround)                272   468
                        oEmitValue(4)                       272
                        oEmitValue(4)                       272
                    | LREAL:                                352
                        oEmitToken(tconvrt)                 268   536
                        oEmitValue(stdlengthen)             272   467
                        oEmitValue(8)                       272
                        oEmitValue(8)                       272
                    | *:
                        oAbort(eConvertType)                265   488
                ]
        | LREAL:                                            352
            [ oChooseTag                                      *
                    | LREAL:                                352

                    | INT:                                  350
                        oEmitToken(tconvrt)                 268   536
                        oEmitValue(stdround)                272   468
                        oEmitValue(P6word)                  272   458
                        oEmitValue(4)                       272
                        oEmitValue(4)                       272
                    | REAL:                                 351
                        oEmitToken(tconvrt)                 268   536
                        oEmitValue(stdshorten)              272     *
                        oEmitValue(P6shortreal)             272   459
                        oEmitValue(4)                       272
                        oEmitValue(4)                       272
                    | *:
                        oAbort(eConvertType)                265   488
                ]
        | SIZE:                                             353
            [ oChooseTag                                      *
                    | SIZE:                                 353

                    | *:
                        oAbort(eConvertType)                265   488
                ]
        | AADDR:                                            355
            [ oChooseTag                                      *
                    | AADDR:                                355

                    | *:
                        oAbort(eConvertType)                265   488
                ]
        | DADDR:                                            354
            [ oChooseTag                                      *
                    | DADDR:                                354

                    | GADDR:                                356
                        [ oChooseSMDataDotMode              306
                                | REFMode:                  370
                                    oEmitToken(tpushind)    268   510
                                    oEmitValue(P6word)      272   458
                                | *:
                        ]
```

```
                                oEmitToken(tpushconst)              268   509
                                oEmitValue(0)                       272
                            | *:
                                oAbort(eConvertType)                265   488
                        ]
                | GADDR:                                            356
                    [ oChooseTag                                      *
                        | GADDR:                                    356

                        | AADDR:                                    355
                            [ oChooseSMDataDotMode                  306
                                | REFMode:                          370
                                    oEmitToken(tpushind)            268   510
                                    oEmitValue(P6word)              272   458
                                | *:
                            ]
                            oEmitToken(tpop2nd)                     268   550
                        | DADDR:                                    354
                            [ oChooseSMDataDotMode                  306
                                | REFMode:                          370
                                    oEmitToken(tpushind)            268   510
                                    oEmitValue(P6wordpair)          272   461
                                | *:
                            ]
                            oEmitToken(tpop)                        268   534
                        | *:
                            oAbort(eConvertType)                    265   488
                    ]
                | PADDR:                                            357
                    [ oChooseTag                                      *
                        | PADDR:                                    357


                        | *:
                            oAbort(eConvertType)                    265   488
                    ]
                | RADDR:                                            358
                    [ oChooseTag                                      *
                        | RADDR:                                    358

                        | *:
                            oAbort(eConvertType)                    265   488
                    ]
                | *:
            ]
            oPopS                                                   192
            @PushResultDescriptor                                     *
        | labelspec:                                                 87
            oPushTagWithInputTag                                    220
            @TranslateLabelSpec                                       *
        | label:                                                     86
            [ oChooseSEmpty                                         312
                | yes:                                              435

                | *:
                    oAbort(eStackNotEmpty)                          265   491
```

```
            ]
            oPushTagWithInputTag                                          220
            [ oChooseTagDotState                                          313
                | UndefinedTagState:                                      383
                    oCreateLabelDescriptorAtTag                           172
                    oSetTagDotState(SpecifiedTagState)                    282   384
                | SpecifiedTagState:                                      384

                | *:
                    oAbort(eDuplicateDefinition)                          265   496
            ]
            oEmitToken(tdefstlab)                                         268   539
            oEmitTagMLabelDotP6Stlab                                      333
            oSetTagDotState(DefinedTagState)                              282   385
        | goto:                                                           73
            oVerifySMDataDotType(PADDR)                                   288   357
            @ForceTOSValue                                                *
            oPopS                                                         192
            [ oChooseSEmpty                                               312
                | yes:                                                    435
                    oEmitToken(tlongJump)                                 268   538
                    oEmitTagMlabelDotP6Stlab                              *
                    oEmitSMDataDotP6Level                                 326
                | *:
                    oAbort(eStackNotEmpty)                                265   491
            ]
        | switch:                                                         141
            [ oChooseSEmpty                                               312
                | yes:                                                    435

                | *:
                    oAbort(eStackNotEmpty)                                265   491
            ]
            oPushTagWithInputTag                                          220
            oVerifyTagDotState(UndefinedTagState)                         292   383
            oPushCountWithInputNumber                                     201
            oVerifySMDataDotType(INT)                                     288   350
            @ForceTOSValue                                                *
            oEmitToken(tcaseexpr)                                         268   532
            oPopS                                                         192
            oCreateSwitchDescriptorAtTagWithCountLabels                   174
            oEmitToken(tcasejump)                                         268   533
            oEmitValue(0)                                                 272
            oDecrementCountByOne                                          175
            oEmitCount                                                    323
            oEmitValue(0)                                                 272
            oEmitValue(0)                                                 272
            oPushCountWithTagMSwitchDotFirstP6Label                       206
            { oPushCountWithTagMSwitchDotlastP6Label                      *
              [ oChooseCountComparison                                    300
                  | CompGreater: >                                        477
                  | *:
              ]
              oPopCount                                                   187
              oEmitCount                                                  323
              oIncrementCountByOne                                        179
```

```
                }
                oPopCount                                                   187
                oPopCount                                                   187
                oSetTagDotState(DefinedTagState)                            282    385
        | sdest:                                                            134
                oPushTagWithInputTag                                        220
                oVerifyTagDotState(DefinedTagState)                         292    385
                oPushCountWithInputNumber                                   201
                oPushCountWithTagMSwitchDotFirstP6Label                     206
                [ oChooseSEmpty                                             312
                        | yes:                                              435

                        | *:
                                oAbort(eStackNotEmpty)                      265    491
                ]
                oEmitToken(tdeflabel)                                       268    529
                oAddCount                                                     *
                oEmitCount                                                  323
                oPopCount                                                   187
        | fJumpIf:                                                           69
                oPushDownIndexes                                            211
                @ForceTOSValue                                                *
                @ForceSOSValue                                                *
                @CheckRelation                                                *
                oPushCountWithInputByte                                     199
                oSetIndexSubCountDotState(ReferencedIndexState)             278    378
                oSetIndexSubCountDotP6LabelToNewLabel                       225
                oPushTagWithSMDataDotType                                   221
                [ oChooseTagMTypeStructured                                 315
                        | yes:                                              435
                                oEmitToken(tcompstruct)                     268    528
                                oEmitCount                                  323
                                oEmitTagMTypeDotLength                      335
                        | *:
                                oEmitToken(tcompare)                        268    527
                                oEmitCount                                  323
                                oEmitTagMTypeDotP6Type                      336
                ]
                oPopCount                                                   187
                oPopS                                                       192
                oPopS                                                       192
                oPopTag                                                     194
                oEmitToken(tnot)                                            268    518
                oEmitToken(tfalsejump)                                      268    531
                oEmitIndexSubCountDotP6Label                                324
                oSetIndexSubCountDotState(ReferencedIndexState)             278    378
                oPopCount                                                   187
        | fJump:                                                             68
                oPushDownIndexes                                            211
                [ oChooseSEmpty                                             312
                        | yes:                                              435

                        | *:
                                oAbort(eStackNotEmpty)                      265    491
                ]
                oPushCountWithInputByte                                     199
```

```
                oVerifyIndexSubCountDotState(UndefinedIndexState)          285   376
                oSetIndexSubCountDotP6LabelToNewLabel                      225
                oEmitToken(tjump)                                          268   530
                oEmitIndexSubCountDotP6Label                               324
                oSetIndexSubCountDotState(ReferencedIndexState)            278   378
                oPopCount                                                  187
        | ldest:                                                            66
                oPushDownIndexes                                           211
                [ oChooseSEmpty                                            312
                        | yes:                                             435

                        | *:
                            oAbort(eStackNotEmpty)                         265   491
                ]
                oPushCountWithInputByte                                    199
                oVerifyIndexSubCountDotState(ReferencedIndexState)         285   378
                oEmitToken(tdeflabel)                                      268   529
                oEmitIndexSubCountDotP6Label                               324
                oSetIndexSubCountDotState(UndefinedIndexState)             278   376
                oVerifyAllIndexesUndefined                                 255
                oPopCount                                                  187
        | bjumpif:                                                          18
                oPushDownIndexes                                           211
                @ForceTUSValue                                               *
                @ForceSUSValue                                               *
                @CheckRelation                                               *
                oPushCountWithInputByte                                    199
                oVerifyIndexSubCountDotState(DefinedIndexState)            285   377
                oPushTagWithSMDataDotType                                  221
                oSwapCount                                                   *
                [ oChooseTagMTypeStructured                                315
                        | yes:                                             435
                            oEmitToken(tcompstruct)                        268   528
                            oEmitCount                                     323
                            oEmitTagMTypeDotLength                         335
                        | *:
                            oEmitToken(tcompare)                           268   527
                            oEmitCount                                     323
                            oEmitTagMTypeDotP6Type                         336
                ]
                oPopCount                                                  187
                oPopS                                                      192
                oPopS                                                      192
                oPopTag                                                    194
                oEmitToken(tnot)                                           268   518
                oEmitToken(tfalsejump)                                     268   531
                oEmitIndexSubCountDotP6Label                               324
                oPopCount                                                  187
                oSetIndexSubCountDotState(UndefinedIndexState)             278   376
        | bjump:                                                            17
                oPushDownIndexes                                           211
                oVerifyIndexSubCountDotState(DefinedIndexState)            285   377
                oSetIndexSubCountDotState(UndefinedIndexState)             278   376
                oVerifyAllIndexesUndefined                                 255
                oEmitToken(tjump)                                          268   530
                oEmitIndexSubCountDotP6Label                               324
```

```
    | bdest:                                                        16
        oPushDownIndexes                                            211
        [ oChooseSEmpty                                             312
            | yes:                                                  435

            | *:
                oAbort(eStackNotEmpty)                              265    491
        ]
        oPushCountWithInputByte                                     197
        oVerifyIndexSubCountDotState(UndefinedIndexState)           285    376
        oSetIndexSubCountDotP6LabelToNewLabel                       225
        oEmitToken(tdeflabel)                                       268    529
        oEmitIndexSubCountDotP6Label                                324
        oPopCount                                                   187
        oSetIndexSubCountDotState(DefinedIndexState)                278    377
    | skipif:                                                       139
        @ForceTOSValue                                              *
        @ForceSOSValue                                              *
        @CheckRelation                                              *
        oPushTagWithSMDataDotType                                   221
        oPopS                                                       192
        oPopS                                                       192
        [ oChooseTagMTypeStructured                                 315
            | yes:                                                  435
                oEmitToken(tcompstruct)                             268    528
                oEmitCount                                          323
                oEmitTagMTypeDotLength                              335
            | *:
                oEmitToken(tcompare)                                268    527
                oEmitCount                                          323
                oEmitTagMTypeDotP6Type                              336
        ]
        oPushP6LabelWithNewLabel                                    212
        oEmitToken(tnot)                                            268    518
        oEmitToken(tfalsejump)                                      268    531
        oEmitP6Label                                                325
        oMarkAndCopySSection                                        181
        @ProgramElements                                            739
        =endskip                                                     57
        [ oChooseReachable                                          303
            | InterpassTrue:                                        432

            | *:
                oSetReachableToTrue                                 227
        ]
        [ oChooseSEmpty                                             312
            | yes:                                                  435

            | *:
                oAbort(eStackNotEmpty)                              265    491
        ]
        oEmitToken(tdeflabel)                                       268    529
        oEmitP6Label                                                325
        oPopP6Label                                                 190
        oPopMarkedSSectionMEmpty                                    189
    | if:                                                            74
```

```
            @ForceTOSValue                                          *
            @ForceSOSValue                                          *
            @CheckRelation                                          *
            oPushTagWithSMDataDotType                             221
            [ oChooseTagMTypeStructured                           315
                | yes:                                            435
                    oEmitToken(tcompstruct)                       268   528
                    oEmitCount                                    323
                    oEmitTagMTypeDotLength                        335
                | *:
                    oEmitToken(tcompare)                          268   527
                    oEmitCount                                    323
                    oEmitTagMTypeDotP6Type                        336
            ]
            oPopCount                                             187
            oPopS                                                 192
            oPopS                                                 192
            oPushP6LabelWithNewLabel                              212
            oEmitToken(tfalsejump)                                268   531
            oEmitP6Label                                          325
            oMarkAndCopySSection                                  181
            @ProgramElements                                      739
            [ =
              | else:                                              48
                  @ForceTOSValue                                    *
                  oPushP6LablewithNewLabel                          *
                  oEmitToken(tjump)                               268   530
                  oEmitP6Label                                    325
                  oSwapMarkedSSections                            246
                  oSwapP6Labels                                   247
                  oEmitToken(tdeflabel)                           268   529
                  oPopP6Label                                     190
                  @ProgramElements                                739
              | *:

            ]
            =endif                                                 50
            @ForceTOSValue                                          *
            oMergeSSections                                       183
            oEmitToken(tdeflabel)                                 268   529
            oEmitP6Label                                          325
            oPopP6Label                                           190
        | bseg:                                                    20
            oMarkSSection                                         182
            oBeginSegment                                         166
            oPushReachableWithTrue                                214
            @ProgramElements                                      739
            =eseg                                                  21
            oPopReachablee                                          *
            oEndSegment                                           177
            oPopMarkedSSectionMEmpty                              189
        | profile:                                                109
            oPushTagWithInputTag                                  220
            @TranslateProfile                                       *
        | *: >
      ] ]
```

```
;



TranslateProfile:                                                          *

    oCreateProfileDescriptorAtTag                                          173
    oSetTagDotState(DefinedTagState)                                       282     385
    [ =
        | known:                                                           85
            oSetTagMProfileDotProfileKind(knownProfileKind)                283     406
            oPushTagWithInputTag                                           220
            oCreateBodyDescriptorAtTag                                     171
            oSetTagDotState(SpecifiedTagState)                             282     384
            oSetTagMBodyDotP6ptabToNewP6ptab                               *
            oSetTagSosMProfileDotBodyTagToTag                              240
            oPopTag                                                        194
            oSetTagMProfileDotIdToInputString                              234
            oSetTagMProfileDotNature(SIMULANature)                         284     414
            oPopTag                                                        194
        | system:                                                          142
            oSetTagMProfileDotProfileKind(systemProfileKind)               283     407
            oPushTagWithInputTag                                           220
            oCreateBodyDescriptorAtTag                                     171
            oSetTagDotState(DefinedTagState)                               282     385
            oSetTagSosMProfileDotBodyTagToTag                              240
            oEmitToken(textId)                                             268     513
            oSetTagMBodyDotP6ptabToNewP6ptab                               232
            oEmitTagMBodyDotP6ptab                                         *
            oPopTag                                                        194
            oSetTagMProfileDotIdToInputString                              234
            oEmitTagMProfileDotId8Chars                                    334
            oSetTagMProfileDotNature(CNature)                              284     415
            oSetTagMProfileDotIdToInputString                              234
        | external:                                                        63
            oSetTagMProfileDotProfileKind(externalProfileKind)             283     408
            oPushTagWithInputTag                                           220
            oCreateBodyDescriptorAtTag                                     171
            oSetTagDotState(DefinedTagState)                               282     385
            oSetTagSosMProfileDotBodyTagToTag                              240
            oEmitToken(textId)                                             268     513
            oSetTagMBodyDotP6ptabToNewP6ptab                               232
            oEmitTagMBodyDotP6ptab                                         *
            oPopTag                                                        194
            oSetTagMProfileDotIdToInputString                              234
            oSetTagMProfileDotNatureToInputString                          235
            oEmitTagMProfileDotId8Chars                                    334
            oPopTag                                                        194
        | interface:                                                       82
            oSetTagMProfileDotProfileKind(interfaceProfileKind)            283     409
            oSetTagMProfileDotIdToInputString                              234
        | *:
            oSetTagMProfileDotProfileKkind(ordinaryProfileKind)            *       410
            oSetTagMProfileDotNature(SIMULANature)                         284     414
    ]
    oPushCount(P6FirstFormalDisplacement)                                  276     473
```

```
    oSetAreaToCount(LocalArea)                                          *     365
    [ [ =
          | import:                                                    84
              oPushTagWithInputTag                                     220
              oPushUpdateWithTagAndUndefine                            224
              oVerifyTagDotState(UndefinedTagState)                    292   383
              oCreateDataDescriptorAtTag(ImportDescrKind)              267   398
              oAppendTagSosMProfileDotImportListWithTagMAttribute      165
              @QuantityDescriptor                                       *
              @AllocateLocal                                            *
              oPopUpdateAndRestoreTag                                  195
              oPopTag                                                  194
          | *: >
    ] ]
    [ =
          | export:                                                    62
              oPushTagWithInputTag                                     220
              oPushUpdateWithTagAndUndefine                            224
              oVerifyTagDotState(UndefinedTagState)                    292   383
              oCreateDataDescriptorAtTag(ExportDescrKind)              267   399
              oSetTagSosMProfileDotExportToTag                          *
              @QuantityDescriptor                                       *
              oPopUpdateAndRestoreTag                                  195
              oPopTag                                                  194
          | exit:                                                      61
              oPushTagWithInputTag                                     220
              oPushUpdateWWithTagAndUndefine                            *
              oCreateDataDescriptorAtTag(ExitDescrKind)                267   400
              oSetTagMDataDotTagToTag                                   *
              oSetTagSosMProfileDotExitToTag                            *
              oPushCount(P6ReturnAddressDisplacement)                  276   472
              oPopCount                                                187
              oPopUpdateAndRestoreTag                                  195
              oPopTag                                                  194
          | *:
    ]
    *endprofile                                                         53
;


AllocateLocal:                                                          *

    oAlignAreaToCount(LocalArea)                                       266   365
    oPopCount                                                          187
    oSetTagMDataDotDisplacementToCount                                 233
    oIncrAreaDisplacementByCount(LocalArea)                            275   365
    oPopCount                                                          187
;

TranslateConstSpec:                                                     *

    oVerifyTagDotState(UndefinedTagState)                              292   383
    oCreateDataDescriptorAtTag(ConstantDescrKind)                      267   391
    oSetTagDotState(SpecifiedTagState)                                 282   384
    @QuantityDescriptor                                                 *
    @AllocateConstant                                                   *
```

```
    oPopTag                                                   194
;

AllocateConstant:                                              *

    oAlignAreaToCount(ConstantArea)                           266    364
    oPopCount                                                 187
    oSetTagMDataDotDisplacementToCount                        233
    oIncrAreaDisplacementByCount(ConstantArea)                275    364
    oPopCount                                                 187
;

QuantityDescriptor:                                            *

% pre: a data descriptor on top of S-stack
% post: alignment and size on count Tos and Sos respectively

    oPushTagWithInputTag                                      220
    [ oChooseTag                                               *
         | CHAR:                                              349
              oPushCount(1)                                   276
              oPushCountWithDuplicate                         198
         | BOOL, SINT:                                        348    359
              oPushCount(2)                                   276
              oPushCountWithDuplicate                         198
         | REAL, UADDR, AADDR, SIZE, PADDR, RADDR:            351    354    35
              oPushCount(4)                                   276
              oPushCountWithDuplicate                         198
         | GADDR:                                             356
              oPushCount(8)                                   276
              oPushCount(4)                                   276
         | LREAL:                                             352
              oPushCount(8)                                   276
              oPushCountWithDuplicate                         198
         | INT:                                               350
              [ *
                  | range:                                    121
                      oTurnOnTagSosMDataDotHasRange           253
                      oPushCountWithInputNumber               201
                      oSetTagSosMDataDotLowerBoundToCount     237
                      oPushCountWithInputNumber               201
                      oSetTagSosMDataDotUpperBoundToCount     238
                      oComputeRangeSizeAndAlignmentOnCount    170
                  | *:
                      oPushCount(4)                           275
                      oPushCountWithDuplicate                 198
              ]
         | *:
              oVerifyTagDotKindIsType                         257
              [ oChooseTagMTypeDotHasIndefRepField             *
                   | InterpassTrue:                           432
                        =fixrep                               67
                        oPushCountWithInputNumber             201
                        oTurnOnTagSosMDataDotHasFixrep        254
                        oSetTagSosMDataDotFixrepToCount       236
                        oPushTagWithTagMTypeDotIndefRepTag    223
```

```
                                oPushCountWithTagMTypeDotLength                        210
                                oPopTag                                                194
                                oMultiplyCount                                           *
                                oPushCountWithTagMTypeDotIndefAlternateLength          209
                                oAddCount                                                *
                            | *:
                                oPushContWithTagMTypeDotLength                           *
                        ]
        ]
        oPushCountWithTagMTypeDotAlignment                                               *
        [ =
            | rep:                                                                     127
                oSwapCount                                                               *
                oPushCountWithInputNumber                                              201
                oSetTagSosMDataDotRepToCount                                           239
                oMultiplyCount                                                         184
                oSwapCount                                                               *
            | *:
                oPushCount(1)                                                          276
                oSetTagSosMDataDotRepToCount                                           239
                oPopCount                                                              187
        ]
        oSetTagSosMDataDotTypeToTag                                                      *
        oSwapCount                                                                       *
        oSetTagSosMDataDotLengthToCount                                                  *
        oSwapCount                                                                       *
        oPopTag                                                                        194
    ;


    PushResultDescriptor:                                                                *

        oPushSNewResultDescriptor                                                      215
        oSetSMDataDotTypeToTag                                                         231
        oPopTag                                                                        194
        oSetSMDataDotOutputPointer                                                     230
        oTurnOnSMDataDotHasP6Counterpart                                               250
    ;

    TranslatePush:                                                                       *

        oPushTagWithInputTag                                                           220
        [ oChooseTagDotState                                                           313
            | UndefinedTagState:                                                       383
                    oAbort(eUndefinedTag)                                              265    493
            | *:
        ]
        oPushSWithTagMDataDescriptor                                                   218
        oEmitToken(tpushaddr)                                                          268    511
        oEmitSMDataDotP6Mode                                                           327
        oEmitTagMDataDotDisplacement                                                   332
        oEmitSMDataDotP6Level                                                          326
        oSetSMDataDotMode(REFMode)                                                     279    370
        oSetSMDataDotOutputPointer                                                     230
        oPopTag                                                                        194
    ;
```

```

TranslateSelect:                                                        *

    oPushTagWithInputTag                                              220
    oVerifySDotMode(REFMode)                                            *     370
    oPops                                                               *
    oPushSNewResultDescriptor                                         215
    oPushSWithTagMDataDescriptor                                      218
    oPushTagWithSMDataDotType                                         221
    oPopS                                                             192
    oPopTag                                                           194
    oSetSMDataDotTypeToTag                                            231
    oPopTag                                                           194
    oEmitToken(tfield)                                                268     514
    oEmitTagMDataDotDisplacement                                      332
;

TranslateRemote:                                                        *

    oPushTagWithInputTag                                              220
    oVerifySMDataDotType(UADDR)                                       288     354
    @ForceTOSValue                                                      *
    oPopS                                                             192
    oPushSWithTagMDataDescriptor                                      218
    oEmitToken(tfield)                                                268     514
    oEmitTagMDataDotDsplacement                                         *
    oSetSMDataDotMode(REFMode)                                        279     370
    oSetSDotHasP6Counterpart                                            *
    oPopTag                                                           194
;

TranslateIndex:                                                         *

    oVerifySMDataDotType(INT)                                           *     350
    @ForceTOSValue                                                      *
    oVerifySSosDotMode(REFMode)                                         *     370
    oPushTagWithSSosMDataDotType                                      222
    oPopS                                                             192
    oPushCountWithTagMTypeDotLength                                     *
    oEmitToken(tsimpleindex)                                          268     554
    oEmitCount                                                        323
    oPopCount                                                         187
    oPopTag                                                           194
;


TranslateAccess:                                                        *

    oPushCountWithInputByte                                           199
    oPushTagWithInputTag                                              220
    oPushSWithTagMDataDescriptor                                      218
    oVerifySDotDescriptorKind(AttributeDescrKind)                     286     392
    oEmitToken(taccess)                                               268     544
    oEmitCount                                                        323
    oEmitTagMDataDotDisplcement                                         *
    oPopCount                                                         187
```

```
    @PushResultDescriptor                                              1766
    oSetSMDataDotMode(REFMode)                                         279   370
;


TranslateLabelSpec:                                                      *

    oVerifyTagDotState(UndefinedTagState)                              292   383
    oCreateLabelDescriptorAtTag                                        172
    oSetTagDotState(SpecifiedTagState)                                 282   384
;

ForceTOSValue:                                                           *

    [ oChooseSMDataDotMode                                             306
          | REFMode:                                                   370
              [ oChooseSMDataDotType                                   307
                    | INT, BOOL, CHAR, REAL, LREAL, SIZE, DADDR, AADDR,   350   348   349   351   352   35
                      GADDR, PADDR, RADDR:                             356   357   358
                          oSetSMDataDotMode(VALMode)                   279   371
                          oEmitToken(tpushInd)                         268   510
                          oPushTagWithSMDataDotType                    221
                          oEmitTagMTypeDotP6Type                       336
                          oPopTag                                      194
                    | *:
                          oSetSMDataDotMode(VALADDRMode)               279   372
              ]
          | *:
    ]
;

ForceSOSValue:                                                           *

    [ oChooseSSosMDataDotMode                                          310
          | REFMode:                                                   370
              [ oChooseSSosMDataDotType                                311
                    | INT, BOOL, CHAR, REAL, LREAL, SIZE, DADDR, AADDR,   350   348   349   351   352   35
                      GADDR, PADDR, RADDR:                             356   357   358
                          oSetSSosMDataDotMode(VALMode)                281   371
                          oEmitTokenAfterSSos(tpush2ndInd)             269   551
                          oPushTagWithSSosMDataDotType                 222
                          oEmitTagMTypeDotP6TypeBeforeSMDataDotOutputPointer   337
                          oPopTag                                      194
                    | *:
                          oSetSSosMDataDotMode(VALADDRMode)            281   372
              ]
          | *:
    ]
;


TranslateNonRecordConstValue:                                            *

    [ =
        | true:                                                        148
            oEmitToken(tpushconst)                                     268   509
```

```
            oEmitValue(True)                                          272     *
            oPushTagWithType(BOOL)                                    277   348
        | false:                                                       64
            oEmitToken(tpushconst)                                    268   509
            oEmitValue(False)                                         272     *
            oPushTagWithType(BOOL)                                    277   348
        | c_char:                                                      25
            oPushCountWithInputByte                                   199
            oEmitToken(tpushconst)                                    268   509
            oEmitCount                                                323
            oPopCount                                                 187
            oPushTagWithType(CHAR)                                    277   349
        | c_int:                                                       28
            oPushCountWithInputIntegerLiteral                         200
            oEmitToken(tpushconst)                                    268   509
            oEmitCount                                                323
            oPushTagWithType(INT)                                     277   350
        | c_real:                                                      33
            oStoreValueWithInputRealLiteralAtCount                    245
            oFixThis                                                  178
            oPushTagWithType(REAL)                                    277   351
        | c_lreal:                                                     29
            oStoreValueWithInputLongRealLiteralAtCount                243
            oFixThis                                                  178
            oPushTagWithType(LREAL)                                   277   352
        | text:                                                       144
            oStoreValueWithInputLongStringAndPushCountLength          244
            oPushTagWithType(CHAR)                                    277   349
        | c_size:                                                      35
            oPushTagWithInputTag                                      220
            oPushCountWithTagMTypeDotLength                           210
            oEmitToken(tpushconst)                                    268   509
            oEmitCount                                                323
            oPopCount                                                 187
            oPopTag                                                   194
            oPushTagWithType(SIZE)                                    277   353
        | nosize:                                                     100
            oEmitToken(tpushconst)                                    268   509
            oEmitValue(0)                                             272
            oPushTagWithType(SIZE)                                    277   353
        | anone:                                                       10
            oEmitToken(tpushconst)                                    268   509
            oEmitValue(0)                                             272
            oPushTagWithType(AADDR)                                   277   355
        | c_oaddr:                                                     30
            oPushTagWithInputTag                                      220
            oPushSWithTagMDataDescriptor                              218
            [ oChooseSDotDescriptorKind                               304
                | GlobalDescrKind, ConstantDescrKind:                 389   391

                | *:
                    oAbortIeTagKind)                                  265   494
            ]
            oEmitToken(tpushaddr)                                     268   511
            oEmitSMDataDotPbMode                                      327
            oEmitSMDataDotDisplacement                                328
```

```
            oEmitSMDataDotP6Level                                        326
            oPop$                                                        192
            oPopTag                                                      194
            oPushTagWithType(OADDR)                                      277    354
        | onone:                                                         103
            oEmitToken(tpushconst)                                       268    509
            oEmitValue(0)                                                272
            oPushTagWithType(OADDR)                                      277    354
        | gnone:                                                          72
            oEmitToken(tpushconst)                                       268    509
            oEmitValue(0)                                                272
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            oEmitToken(tpushlabel)                                       268    537
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                    >
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            ] }
            [ =
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             ]
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             [ oChooseSMDataDotType                                       307
                   | CHAR, INT, REAL, LREAL, SIZE, DADDR:                 349    350    351    352    353    354
                       oPushCountWithRelationValue(P6lessthanequal)       *      444
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             ]
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```

```
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```

DESIGN AND IMPLEMENTATION OF S-COMPILER INTERPASS

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AN ABSTRACT OF A MASTER'S REPORT

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ABSTRACT

The purposes of the report were: 1) to introduce and analyse the Perkin Elmer SIMULA system; 2) to describe the design of Interpass which is a main part of the compiler to be used in the Perkin Elmer SIMULA system.

The Perkin Elmer SIMULA system is a complete SIMULA system on 8/32 Perkin Elmer machines. It is to be run under the Unix operating system. It consists of a portable front-end compiler, a portable run-time support system and an S-Compiler. The portable front-end compiler and the portable run-time support system are provided by S-Port which was brought from Norway. Also there is an Environment Interface to facilitate the access to the Unix operating system.

The interpass is a brand new pass, and it plays the major role for the S-Compiler along with the modified passes of the Pascal/32 compiler. The Pascal/32 compiler is an extensive version of Hartmann compiler and it is available here at K.S.U. The Interpass is written in Syntax/Semantic Language(S/SL) and this primitive language S/SL calls semantic routines coded in Pascal.

The design of Interpass and the coding of S/SL which we intensively worked for are almost 70 % completed. The future work can be done about the design of Interpass by adding more data structures and semantic operations which we didn't do, especially for record descriptors and utility routines.