PCAT Semantic Errors

Harry Porter
Dept. of Computer Science
Portland State University

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**Identifier is already defined**

An identifier may name a

- variable
- parameter to a procedure
- procedure
- type
- field within a record

All variable, parameter, procedure, and type names defined in a given scope must be different. Each procedure constitutes a new scope and the main body constitutes the outermost scope. Each identifier may only be defined once in each scope, but may be defined in one scope and then again in an inner scope.

Field names are handled a bit differently from variable, parameter, procedure, and type names. Each record type introduces a new namespace for its fields. The same ID may be used to name fields in several different records (even nested records), but every field in any one record type must have a different name. Also, an ID used as a field name may also name a variable, parameter, procedure, or type; record namespaces are disjoint from scopes.

**Identifier is not defined**

Whenever an identifier is encountered in the following places, there must be a corresponding definition within this scope or within an enclosing scope.

- As a type name, for example in the position of `foo` in any of the following:
  ```
  var x: foo := ...;
  type t is foo;
  type t is array of foo;
  type t is record ... f: foo; ... end;
  procedure ... (...) : foo is ...;
  procedure ... (...) : foo is ...
  ...
  ...;
  ```
- As an l-value, for example in the position of `foo` in:
  ```
  read (... foo, ...);
  foo := 23;
  a := foo + 1;
  ```
- In a procedure invocation (either as a statement or within an expression):
  ```
  foo (1,2,3);
  a := foo (4.5);
  ```
- As a FOR index, for example:
  ```
  for foo := 1 to 10 DO ... ;
  ```
- In a record constructor, for example in the position of `foo` in:
  ```
  a := foo { f1:=100; f2:=200 };
  ```
- In an array constructor, for example in the position of `foo` in:
  ```
  a := foo [{< 1, 2, 100 of 3, 4, 5 >}];
  ```
- As a field name. In the following two examples, there must be a field named `foo` in the record type of `r`:
  ```
  a := r.foo;
  a := r { ... foo:=100; ... };
  ```
Expecting a local or formal name
Expecting a type name
Expecting a procedure name

The name in question is defined but that name is not the right kind of thing. For example:

```plaintext
type foo is ...;
x := 4 * foo;
```

Another example of the error is:

```plaintext
var bar: integer := 0;
x := bar (1,2,3);
```

This field is already defined in this RECORD

In a record type declaration, each field must have a different name. Fields in nested records may share names, as in the following legal example:

```plaintext
type t is record
  f1: integer;
  f2: record
    f1: real;
    f2: boolean;
  end;
end;
```

Every field in RECORD must be assigned to exactly once

This error occurs when a RECORD constructor fails to assign to a field. In this example, an assignment to `f2` is missing:

```plaintext
type MyRec is record
  f1: integer;
  f2: real;
end;
x := MyRec { f1:=100 };    
```

Multiple assignment to field in RECORD constructor

The following is in error since `f1` is repeated.

```plaintext
x := MyRec { f1:=100; f2:=200; f1:=100 };  
```

Record constructor ID must name a RECORD type

Here is an example of the error:

```plaintext
type foo is array of ...;
x := foo { ... };    
```
**Type of expr is not compatible with this field's type**

In a record constructor, each field is given an initial value. The type of the initializing expression must be “assignment compatible” with the field's type. (See the error concerning type compatibility for assignment statements for the definition of “assignment compatible.”) An INTEGER to REAL coercion will be inserted if necessary.

In the following example, the assignment to \( f_1 \) is okay (a coercion will be inserted), but the assignment to \( f_2 \) is in error.

```plaintext
type MyRec is record
    f1: real;
    f2: real;
end;
x := MyRec { f1 := 13; f2 := true };
```

**Array constructor ID must name an ARRAY type**

Here is an example of the error:

```plaintext
type foo is record ... end;
r := foo [< 1, 2, 3 >];
```

**Type of expr is not compatible with ARRAY definition**

In an ARRAY constructor, the initial values are given by a series of expressions. The type of these expressions must be “assignment compatible” with the ARRAY type definition. Here is an example of the error:

```plaintext
type MyArr is array of boolean;
r := MyArr [< 1, 2, 3 >];
```

**Array count must be an INTEGER expression**

Here is an example of the error:

```plaintext
type MyArr is array of real;
r := MyArr [< 500.01 of 0.0 >];
```

**Type needed when initializer is NIL**

If the initializing expression for a VAR declaration is NIL, the type must be supplied. For all other expressions, the type can be deduced. However, “nil” is compatible with all RECORD and ARRAY types. The following is legal:

```plaintext
var x := 1.5;
var y: MyRec := nil;
```

**In assignment, type of LHS is not compatible with type of RHS**

The type of the expression on the right-hand side of the := must be “assignment compatible” with the type of the l-value on the left-hand side. By this we mean: the type on the right-hand side must match the type on the left-hand side exactly, with two exceptions. First, “nil” matches all RECORD and ARRAY types. Second, the type on the right-hand side may be INTEGER when the type on the left-hand side is REAL. (In this second case, an INTEGER to REAL coercion will be inserted.)

Here is an example of the error:

```plaintext
var x: boolean := false;
x := 3.14159;
```
**Type of initializing expr does not match the given type**

In a VAR declaration, if a type is specified, the type of the initializing expression must be “assignment compatible” with the type supplied in the declaration.

Here is an example of the error:
```
var x: integer := 3.14159;
```

**INTEGER, REAL, BOOLEAN, TRUE, FALSE, and NIL may not be redefined**

These identifiers—they are not keywords—have predefined meanings. Any attempt to use them in variable declarations, type definitions, procedure definitions, as parameter names, or as field names is in error.

**Array subcripting attempted on non-array value**

Here is an example of the error:
```
var a: integer := 0;
a[4] := 1;
```

**Array subscript must have type INTEGER**

Here is an example of the error:
```
var i: real := 3.5;
a[i] := 1;
```

**Field accessing attempted on non-record value**

Here is an example of the error:
```
var r: integer := 0;
x := r.myField;
```

**This field is not in this RECORD**

Here is an example of the error:
```
var r: record
  f1: integer;
  f2: real;
end;
x := r.f5;
```

**Incorrect number of arqs in procedure invocation**

If procedure `foo` is defined with 4 formal parameters, then any use of `foo` must provide exactly 4 arguments. Here is an example of the error:
```
procedure foo (i,j,k,l: integer) : integer is begin ... end;
x := foo (7,8,9);
```
Type of argument does not match parameter type

The type of the actual argument must be “assignment compatible” with the type of the formal parameter. A coercion from INTEGER to REAL will be inserted if the actual argument is of type INTEGER and the formal parameter is of type REAL.

Here is an example of the error:

```plaintext
procedure foo (a: integer) : integer is begin ... end;
x := foo (true);
```

Void procedure expected

Here is an example of the error. `foo` should be used in expressions, not as a statement.

```plaintext
procedure foo (x: integer) : boolean is begin ... end;
... foo (3);
```

Non-void procedure expected

Here is an example of the error. `foo` should be called at the statement level, not used in expressions.

```plaintext
procedure foo (x: integer) is begin ... end;
... a := foo (3);
```

Conditional expr after IF, ELSEIF, or WHILE is not BOOLEAN

The following code contains this error in both conditional expressions:

```plaintext
if 4+5 then
... elsif 3.1415 then
... else
... end;
```

Here is another example of the error:

```plaintext
while (1) do ... end;
```

Index of FOR must be previously declared as INTEGER

Here is an example of the error:

```plaintext
var i: real := 0.0;
... for i := 1 to 10 do ... end;
```

If the declaration of `i` had been completely forgotten, we would have gotten an “Identifier is not defined” error message.

All expressions in FOR statement must have type INTEGER

There will be two or three expressions in each FOR loop (the BY clause is optional). Here are examples of errors in all three places:

```plaintext
for i := 1.2 to (i<100) by MyRec{f1:=100;...} do ... end;
```
EXIT statement is not within a FOR, WHILE, or LOOP

Each EXIT is associated with the closest surrounding FOR, WHILE, or LOOP statement. Here is an example of the error:

```
procedure foo (...) is
begin
  for ... do
  ... end;
  exit;
end;
```

RETURN not allowed in the main program body

Execution automatically halts (i.e., returns to the operating system) after the last statement in a program body. Here is an example of the error:

```
program is
begin
  ...
  write ("bye-bye");
  return;
end;
```

RETURN from a non-void procedure expects a result value

Here is an example of the error:

```
procedure foo (...) : integer is
begin
  ...
  return;
  ...
end;
```

RETURN from a void procedure does not allow a result value

Here is an example of the error:

```
procedure foo (...) is
begin
  ...
  return 56;
  ...
end;
```
Type of RETURN value not compatible with PROCEDURE definition

The type of the expression appearing in a RETURN statement must be “assignment compatible” with the type specified in the header of the procedure. Here is an example of the error:

```
procedure foo (...) : boolean is
  begin
    ...
    return 56;
    ...
  end;
```

A coercion from INTEGER to REAL will be inserted in the RETURN statement in the following example:

```
procedure bar (...) : real is
  begin
    ...
    return 56;
    ...
  end;
```

Last executable stmt in this PROCEDURE is not a RETURN

Execution in a PROCEDURE must not “fall out the bottom.” Regardless of whether a PROCEDURE returns a result or not, it should end with a RETURN. Here is an example of the error:

```
procedure foo (...) : integer is
  begin
    ...
    i := 10;
  end;
```

Note that the following is legal since execution can never fall out the bottom of a LOOP statement without any EXIT statements:

```
procedure bar (...) : integer is
  begin
    loop
      i := i*i;
      write (i);
      end;
    end;
```

Dead code - execution can never reach this statement

Here is an example of the error:

```
procedure foo (...) is
  begin
    ...
    return;
    write ("Hello");
    ...
  end;
```
Dead code - execution can never reach the bottom of this loop

Here is an example of the error. No matter which branch of the IF is taken, the body of the WHILE loop can be executed at most once. Execution can never take the branch back to the top of the loop; something is wrong with this program's logic.

```plaintext
procedure foo (...) is
begin
  ...
  while ... do
    ...
    if ... then
      exit;
    else
      return;
    end;
  end;
end;
```

An operand of this operator has the wrong type

The following operators require their operand(s) to be either INTEGER or REAL:

```plaintext
unary+  unary-  +  -  *  /  <  <=  >  >=
```

For the operators listed here, one operand may be INTEGER and the other may be REAL. When mixed, the compiler will quietly insert a conversion from INTEGER to REAL for the INTEGER operand. Also, the compiler will always insert a conversion for each INTEGER operand to the division operator (/), even when both operands are INTEGER.

The following operators require their operand(s) to be BOOLEAN:

```plaintext
NOT      AND      OR
```

The following operators require both their operands to be INTEGER:

```plaintext
DIV      MOD
```

The following operators can handle any types, but both operands must be the same type:

```plaintext
=      <>
```

If one operand is INTEGER and the other is REAL, a conversion will be inserted silently to coerce the INTEGER to a REAL. Also, "nil" can be compared to any RECORD or ARRAY type.

READ stmt requires INTEGER or REAL args only

A READ statement can be used to read in INTEGER and REAL values only. As such, the l-values listed must have types of INTEGER and REAL. In the following code, the variable b causes this error:

```plaintext
var i: integer := 0;
f: real := 0.0;
b: boolean := false;
read (i, f, b);
```
WRITE requires INTEGER, REAL, BOOLEAN, or STRING args

This code is okay:

```pascal
var i: integer := ...;
f: real    := ...;
b: boolean := ...;
a: array of integer := ...;
write ("i=", i, "f=", f, "b=", b, "expr=", a[i+5]*7);
```

The WRITE statement cannot be used to print ARRAY or RECORD values (or “nil”). Here is an example of the error:

```pascal
write ("a=", a);
```