Breaking Problems Down

This section of notes shows you how to break down a large programming problem into smaller modules that are easier to manage.

James Tam

Designing A Program: Top-Down Approach

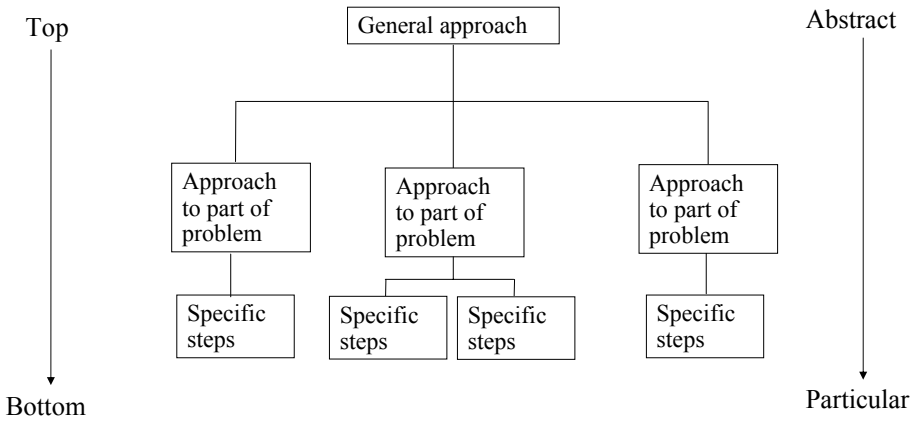

Figure extracted from Computer Science Illuminated by Dale N. and Lewis J.

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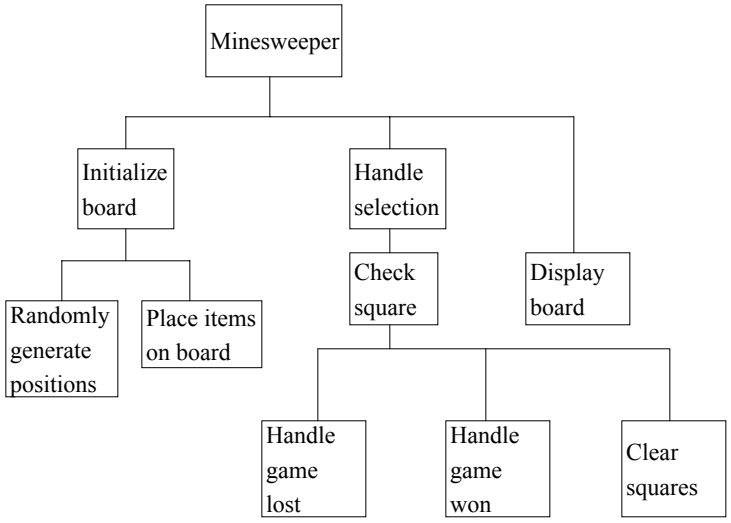
Top Down Approach: Programming



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Decomposing Problems Via The Top Down Approach

Characteristics

- Breaking problem into smaller, well defined modules
- Making modules as independent as possible (loose coupling)

Benefit

- Solution is easier to visualize
- Easier to maintain (if modules are independent)

Drawback

- Complexity – understanding and setting up inter module communication may appear daunting at first

Pascal implementation of program modules

- Procedures
- Functions

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Using Functions And Procedures In Pascal

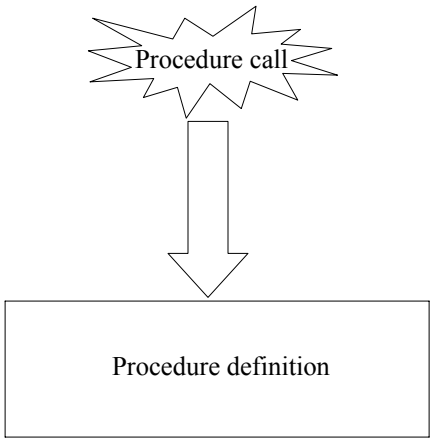
Definition

- Indicating what the function or procedure will do

Call

- Executing the code in the function or procedure

Procedures (Basic Case – No Parameters)



Defining Procedures (Basic Case – No Parameters)

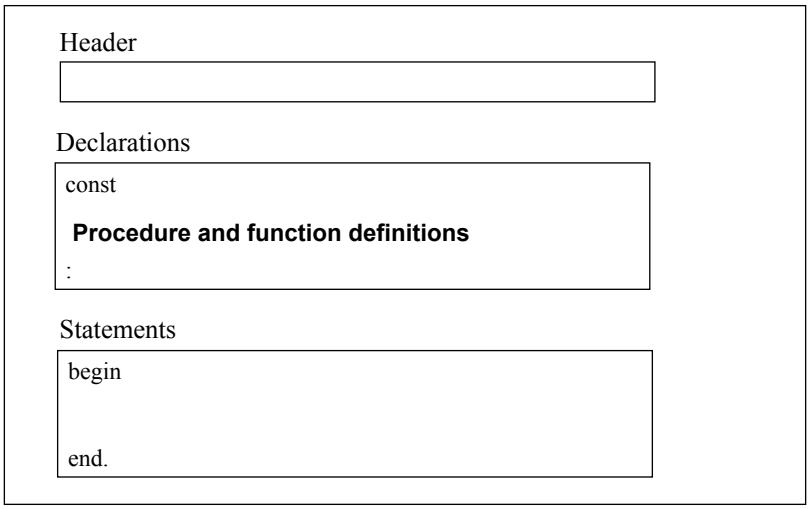
Format:

```
procedure name;
begin
        (* Statements of the function go here *)
end;  (* End of procedure name *)
```

Example:

```
procedure displayInstructions;
begin
        writeln ('These statements will typically give a high level');
        writeln('overview of what the program as a whole does');
end;  (* End of procedure displayInstructions *)
```


Where To Define Modules (Procedures)



Defining Local Variables

Exist only for the life the module

Format:

```
procedure name;
var
  (* Local variable declarations go here *)
begin
  :
end;
```

Example:

```
procedure proc;
var
  num  : integer;
  ch   : char;
begin
    :
end; (* Procedure celciusToFahrenheit *)
```


Calling A Procedure (Basic Case – No Parameters)

Format:

name;

Example:

```
displayInstructions;
```

Where To Call Modules (Procedures)

Most anywhere in the program

Header

Declarations

```
const
Procedure and function definitions
:
```

Statements

```
begin
    Call module: This example
end.
```


Procedures: Putting Together The Basic Case

A compilable version of this example can be found in Unix under
/home/231/examples/modules/firstExampleProcedure.p

```
program firstExampleProcedure (output);

procedure displayInstructions;
begin
  writeln ('These statements will typically give a high level');
  writeln('overview of what the program as a whole does');
end; (*Procedure displayInstructions *)

begin
    displayInstructions;
    writeln('Thank you, come again!');
end. (* Program *)
```

Procedures: Putting Together The Basic Case

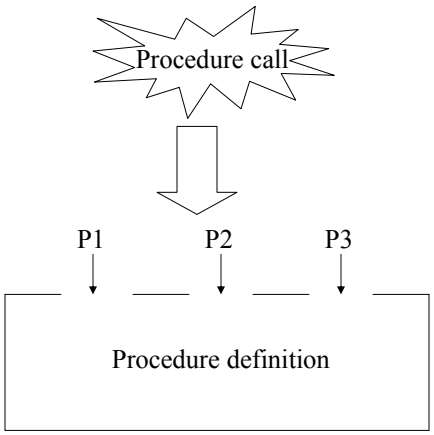
A compilable version of this example can be found in Unix under
/home/231/examples/modules/firstExampleProcedure.p

```
program firstExampleProcedure (output);

procedure displayInstructions;
begin
  writeln ('These statements will typically give a high level');
  writeln('overview of what the program as a whole does');
end; (*Procedure displayInstructions *)

begin
   displayInstructions;
   writeln('Thank you, come again!');
end. (* Program *)
```

Procedure definition

Procedure call

Procedures With Parameters



Defining Modules (Procedures) With Parameters

Format:

```
procedure name (Name of parameter 1 : type of parameter 1;
                Name of parameter 2 : type of parameter 2;
                        :                   :
                Name of parameter n : type of parameter n);
  begin
     (* Statements of the procedure go here *)
  end;
```

Example:

```
procedure celciusToFahrenheit (celciusValue :  real);
var
  fahrenheitValue : real;
begin
   fahrenheitValue := 9 / 5 * celciusValue + 32;
   writeln('temperature in Celsius: ', celciusValue:0:2);
   writeln('temperature in Fahrenheit: ', fahrenheitValue:0:2);
end; (* Procedure celciusToFahrenheit *)
```


Calling Modules (Procedures) With Parameters

Format:

name (*Name of parameter 1*, *Name of parameter 2*…*Name of parameter n*);

Example:

```
celciusToFahrenheit (celciusValue);
```

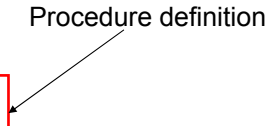
Procedures: Putting Together The Case Of Procedures With Parameters

A compilable version of this example can be found in Unix under
/home/231/examples/modules/temperatureConverter.p

```
program temperatureConverter (input, output);

procedure celciusToFahrenheit (celciusValue :  real);
var
  fahrenheitValue : real;
begin
  fahrenheitValue := 9 / 5 * celciusValue + 32;
  writeln('Temperature in Celsius: ', celciusValue:0:2);
  writeln('Temperature in Fahrenheit: ', fahrenheitValue:0:2);
end; (* Procedure celciusToFahrenheit *)
```


Procedures: Putting Together The Case Of Procedures With Parameters

A compilable version of this example can be found in Unix under
/home/231/examples/modules/temperatureConverter.p



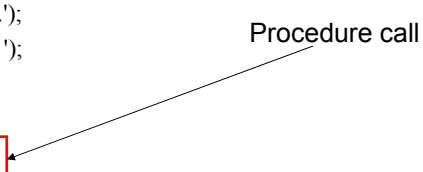

```
program temperatureConverter (input, output);

procedure celciusToFahrenheit (celciusValue :  real);
var
  fahrenheitValue : real;
begin
  fahrenheitValue := 9 / 5 * celciusValue + 32;
  writeln('Temperature in Celsius: ', celciusValue:0:2);
  writeln('Temperature in Fahrenheit: ', fahrenheitValue:0:2);
end; (* Procedure celciusToFahrenheit *)
```

Procedures: Putting Together The Case Of Procedures With Parameters (2)

```
begin
  var celciusValue :  real;
  writeln;
  writeln('This program will convert a given temperature from a Celsius');
  writeln('value to a Fahrenheit value.');
  write(‘Enter a  temperature in Celsius: ');
  readln(celciusValue);
  writeln;
  celciusToFahrenheit(celciusValue);
  writeln('Thank you and come again.');
end. (* Program *)
```


Procedures: Putting Together The Case Of Procedures With Parameters (2)

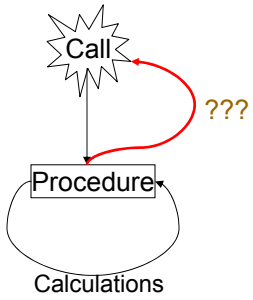
```
begin
  writeln;
  writeln('This program will convert a given temperature from a Celsius');
  writeln('value to a Fahrenheit value.');
  write('Input temperature in Celsius: ');
  readln(celciusValue);
  writeln;
  celciusToFahrenheit(celciusValue);
  writeln('Thank you and come again.');
end. (* Program *)
```



Retaining Information From A Module (Function Or Procedure) After The Module Has Ended

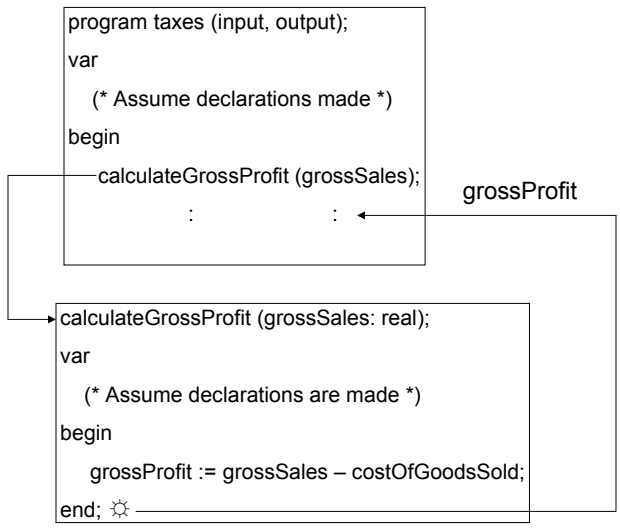
Information needs to be returned from the module

i.e.,



Retaining Information From A Module (Function Or Procedure) After The Module Has Ended (2)

e.g., producing an income statement

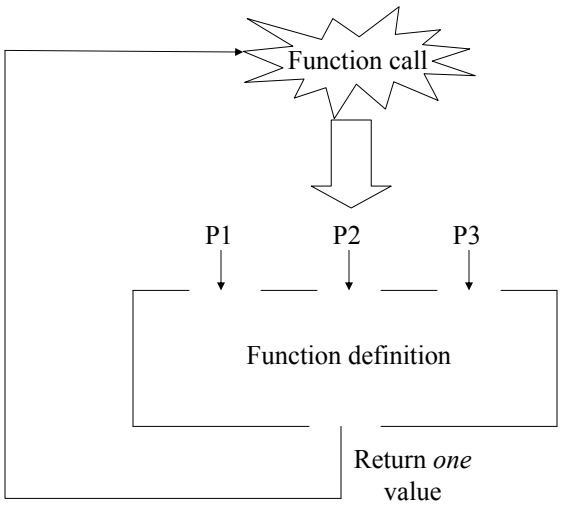


Retaining Information From A Module (Function Or Procedure) After The Module Has Ended (3)

Methods:

- **Return a value with a function**
- Pass parameters into the procedure as variable parameters (rather than as value parameters)

Functions



Defining Functions

Format:

```
function name (Name of parameter 1 : type of parameter 1;
               Name of parameter 2 : type of parameter 2;
                        :                   :
               Name of parameter n : type of parameter n):
                 return type;
 begin
     (* Statements of the function go here *)
             :                :
     name := expression; (* Return value *)
 end;
```

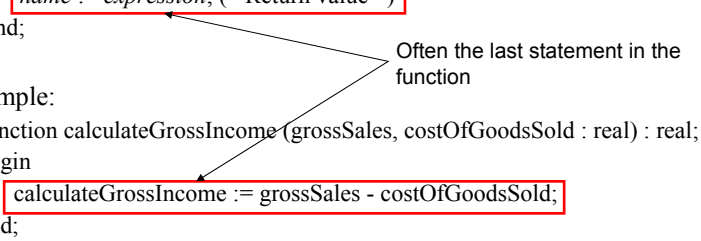
Example:

```
function calculateGrossIncome (grossSales, costOfGoodsSold : real) : real;
begin
    calculateGrossIncome := grossSales - costOfGoodsSold;
end;
```


Defining Functions

Format:

```
function name (Name of parameter 1 : type of parameter 1;
               Name of parameter 2 : type of parameter 2;
                        :                   :
               Name of parameter n : type of parameter n):
                 return type;
 begin
     (* Statements of the function go here *)
             :                :
     name := expression; (* Return value *)
 end;
```



Example:

```
function calculateGrossIncome (grossSales, costOfGoodsSold : real) : real;
begin
    calculateGrossIncome := grossSales - costOfGoodsSold;
end;
```

Calling Functions

Format:

name;

name (*name of parameter 1*, *name of parameter 2…name of parameter n*);

Example:

```
grossIncome := calculateGrossIncome (grossSales, costOfGoodsSold);
```


Functions: Putting It All Together

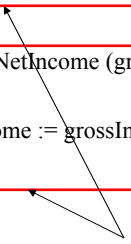
A compilable version of this example can be found in Unix under
/home/231/examples/modules/financialStatements.p

```
program financialStatments (input, output);

function calculateGrossIncome (grossSales, costOfGoodsSold : real) : real;
begin
  calculateGrossIncome := grossSales - costOfGoodsSold
end;

function calculateNetIncome (grossIncome, expenses : real) : real;
begin
  calculateNetIncome := grossIncome - expenses;
end;
```

Functions: Putting It All Together

A compilable version of this example can be found in Unix under
/home/231/examples/modules/financialStatements.p

```
program financialStatments (input, output);

function calculateGrossIncome (grossSales, costOfGoodsSold : real) : real;
begin
  calculateGrossIncome := grossSales - costOfGoodsSold
end;

function calculateNetIncome (grossIncome, expenses : real) : real;
begin
  calculateNetIncome := grossIncome - expenses;
end;
```



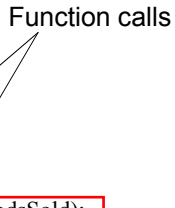
Function definitions

Functions: Putting It All Together (2)

```
procedure produceIncomeStatement;
var
  grossSales          : real;
  costOfGoodsSold : real;
  grossIncome        : real;
  expenses             : real;
  netIncome          : real;
begin
  write('Enter gross sales $');
  readln(grossSales);
  write('Enter cost of the goods that were sold $');
  readln(costOfGoodsSold);
  write('Enter corporate expenses $');
  readln(expenses);

  grossIncome := calculateGrossIncome (grossSales, costOfGoodsSold);

  netIncome := calculateNetIncome (grossIncome, expenses);
```

Functions: Putting It All Together (2)

```
procedure produceIncomeStatement;
var
  grossSales          : real;
  costOfGoodsSold : real;
  grossIncome        : real;
  expenses             : real;
  netIncome          : real;
begin
  write('Enter gross sales $');
  readln(grossSales);
  write('Enter cost of the goods that were sold $');
  readln(costOfGoodsSold);
  write('Enter corporate expenses $');
  readln(expenses);

  grossIncome := calculateGrossIncome (grossSales, costOfGoodsSold);

  netIncome := calculateNetIncome (grossIncome, expenses);
```



Functions: Putting It All Together (3)

```
(* Procedure produceIncomeStatement continued *)
  writeln;
  writeln('Gross sales $':26, grossSales:0:2);
  writeln('Less: cost of goods sold $':26, costOfGoodsSold:0:2);
  writeln('Gross income $':26, grossIncome:0:2);
  writeln('Less: expenses $':26, expenses:0:2);
  writeln('Net income $':26, netIncome:0:2);
  writeln;
end; (* End of procedure produceIncomeStatement *)
```

Functions: Putting It All Together (4)

```
(* Start of main program *)
begin
  writeln;
  writeln('This program will produce an income statement based upon your');
  writeln('gross sales figures, the cost of the goods that you sold and
  writeln('your expenses.');
  writeln;
  produceIncomeStatement;
  writeln('Thank you, come again!');
end.  (* End of entire program. *)
```


Retaining Information From A Module (Function Or Procedure) After The Module Has Ended

Methods:

- Return a value with a function
- **Pass parameters into the procedure as variable parameters (rather than as value parameters)**

Passing Parameters As Value Parameters

Previous examples

```
procedureName (p1, p2);
```

```
procedureName (p1, p2: parameter type);
begin
end;
```


Passing Parameters As Value Parameters

Previous examples

```
procedureName (p1, p2);
```

Pass a copy

```
procedureName (p1, p2: parameter type);
begin
end;
```

Passing Parameters As Value Parameters

Previous examples

```
procedureName (p1, p2);
```

Pass a copy

```
procedureName (p1, p2: parameter type);
begin
end;
```


Passing Parameters As Variable Parameters

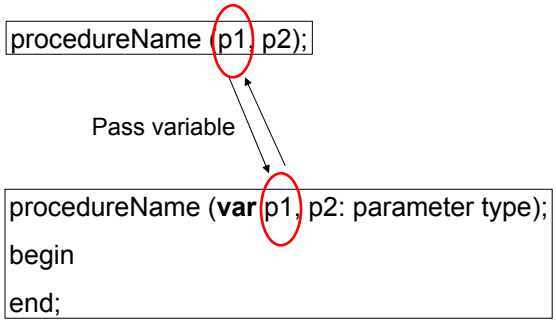
Example coming up

```
procedureName (p1, p2);
```

```
procedureName (var p1, p2: parameter type);
begin
end;
```

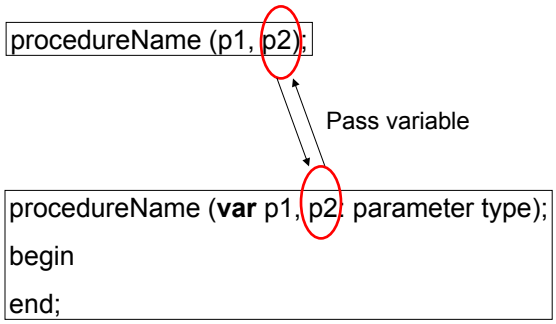
Passing Parameters As Variable Parameters

Example coming up



Passing Parameters As Variable Parameters

Example coming up



Procedure Definitions When Passing Parameters As Variable Parameters

Format:

```
procedure name (var Name of parameter 1 : type of parameter 1;
                var Name of parameter 2 : type of parameter 2;
                    :                       :
                var Name of parameter n : type of parameter n);
  begin
     (* Statements of the function go here *)
  end;
```

Example:

```
procedure tabulateIncome (     grossSales          : real;
                               costOfGoodsSold : real;
                           var grossIncome         : real;
                               expenses            : real;
                           var netIncome           : real);
  begin
    grossIncome := grossSales - costOfGoodsSold;
    netIncome := grossIncome - expenses;
  end;
```


Calling Procedures With Variable Parameters

Same as calling procedures with value parameters!

Format:

name (*name of parameter 1*, *name of parameter 2…name of parameter n*);

Example:

```
tabulateIncome(grossSales,costOfGoodsSold,grossIncome,expenses,
netIncome);
```

Passing Variable Parameters: Putting It All Together

A compilable version of this example can be found in Unix under
/home/231/examples/modules/financialStatements2.p

```
program financialStatments (input, output);

procedure getIncomeInformation (var grossSales          : real;
                                var costOfGoodsSold : real;
                                var expenses            : real);
begin
  write('Enter gross sales $');
  readln(grossSales);
  write('Enter the cost of the goods that were sold $');
  readln(costOfGoodsSold);
  write('Enter business expenses $');
  readln(expenses);
end;   (* End of procedure getIncomeInformation *)
```


Passing Variable Parameters: Putting It All Together (2)

```
procedure tabulateIncome (     grossSales          : real;
                               costOfGoodsSold : real;
                           var grossIncome         : real;
                               expenses            : real;
                           var netIncome           : real);
begin
  grossIncome := grossSales - costOfGoodsSold;
  netIncome := grossIncome - expenses;
end;   (* End of procedure tabulateIncome *)
```

Passing Variable Parameters: Putting It All Together (3)

```
procedure displayIncomeStatement (grossSales       : real;
                                  costOfGoodsSold  : real;
                                  grossIncome      : real;
                                  expenses         : real;
                                  netIncome        : real);
begin
  writeln;
  writeln('INCOME STATEMENT':40);
  writeln('Gross sales $':40, grossSales:0:2);
  writeln('Less: Cost of the goods that were sold $':40, costOfGoodsSold:0:2);
  writeln('Equals: Gross Income $':40, grossIncome:0:2);
  writeln('Less: Business Operating Expenses $':40, expenses:0:2);
  writeln('Equals: Net income $':40, netIncome:0:2);
  writeln;
end;   (*  End of displayIncomeStatement *)
```


Passing Variable Parameters: Putting It All Together (4)

```
procedure produceIncomeStatement;
var
  grossSales, grossIncome, costOfGoodsSold, expenses, netIncome :real;
begin
  getIncomeInformation(grossSales, costOfGoodsSold, expenses);
  tabulateIncome(grossSales,costOfGoodsSold,grossIncome,expenses,netIncome);
  displayIncomeStatement
    (grossSales,costOfGoodsSold,grossIncome,expenses,netIncome);
end;   (* End of procedure produceIncomeStatement *)
```

Passing Variable Parameters: Putting It All Together (5)

```
(* Begin main program *)
begin
  writeln;
  writeln('This program will produce an income statement based upon your');
  writeln('gross sales figures, the cost of the goods that you sold and');
  writeln('your expenses.');
  writeln;
  produceIncomeStatement;
  writeln('Thank you, come again!');
end.   (* End of main program *)
```


Scope

It determines when a part of a program (Constant, variable, function, procedure) is available for use in that program.

e.g., variables or constants must first be declared before they can be referred to or used.

```
begin
    var num: integer;
     num := 10;
      :          :
end.
```

Scope

It determines when a part of a program (Constant, variable, function, procedure) is available for use in that program.

e.g., variables or constants must first be declared before they can be referred to or used.

```
begin
  var num: integer;
  num := 10;
    :       :
end.
```

Declaration

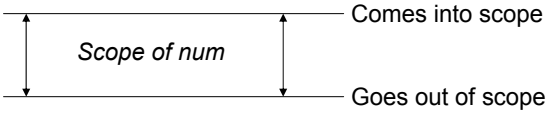
Usage

Scope

It determines when a part of a program (Constant, variable, function, procedure) is available for use in that program.

e.g., variables or constants must first be declared before they can be referred to or used.

```
begin
   var num: integer;
    num := 10;
     :       :
end.
```



James Tam

Scope (2)

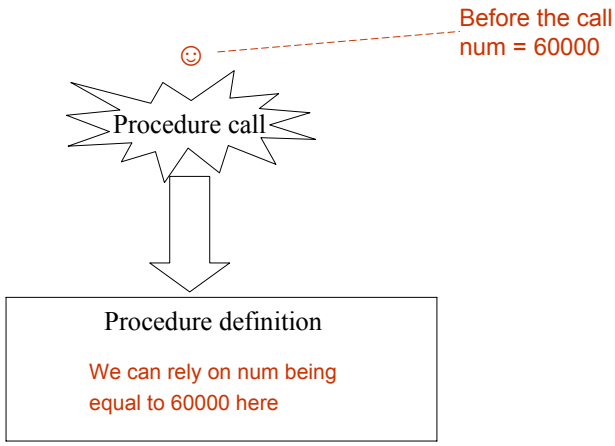
A complete version of this program can be found in Unix under:
/home/231/examples/modules/scope1.p

```
program scope1 (output);
const
  SIZE =  10;
var
  num  : integer;
  ch   : char;
procedure proc1;
var
  x, y :  real;
begin
  writeln('In proc1');
end;
begin

end.
```


Preconditions

Describe what should be true before a statement is executed

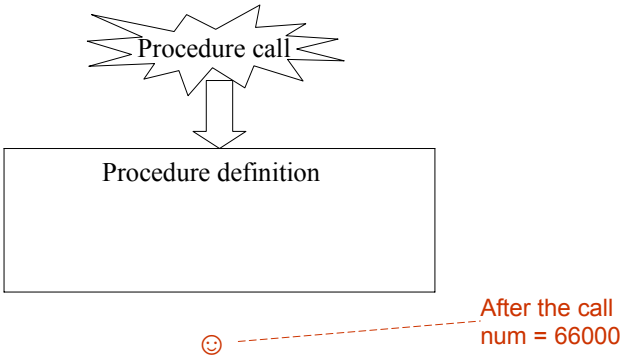
e.g., What will be the value of a variable before a procedure call.



Postconditions

Describe what should be true after a statement is executed

e.g., What will be the value of a variable after a procedure call.

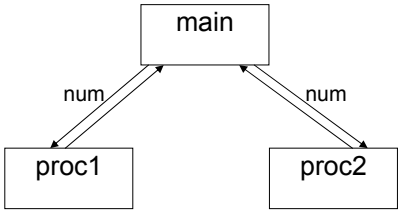


Preconditions And PostConditions

Relative: One procedure's postcondition can be another procedure's precondition

e.g.,

```
begin
  var num: integer;
  proc1(num);
  proc2(num);
end.
```



Preconditions And PostConditions

Assertions: Both make assumptions about what the state of (a part of) the program at a certain point.


```
procedure proc1 (num2: integer);
begin
  writeln('At start of proc1: num2=', num2);
  writeln('At end of proc1: num2=', num2);
end;

procedure proc2 (var num2: integer);
begin
  writeln('At start of proc2: num2=', num2);
  num2 := 20;
  writeln('At end of proc2: num2=', num2);
end;
```


Preconditions And Postconditions: An Example

A complete version of this program can be found in Unix under:
/home/231/examples/modules/conditions.p

```
program conditions (output);
var
  num1 : integer;

procedure proc1 (num2: integer);
begin
  writeln('At start of proc1: num2=', num2);
  writeln('At end of proc1: num2=', num2);
end;   (* Proc 1 *)

procedure proc2 (var num2: integer);
begin
  writeln('At start of proc2: num2=', num2);
  num2 := 20;
  writeln('At end of proc2: num2=', num2);
end;   (* Proc 2 *)
```

Preconditions And Postconditions: An Example (2)

```
procedure proc3;
begin
  writeln('At start of proc3: num1=', num1);
  num1 := 10;
  writeln('At end of proc3: num1=', num1);
end;   (* Proc 3 *)

begin
  var num2 : integer;
  num1 := 1;
  num2 := 2;
  proc1(num2);
  writeln;
  proc2(num2);
  writeln;
  proc3;
  writeln;
end.   (* Main Program * )
```


You Should Now Know

How to break a programming problem down into modules

What is the difference between a procedure and a function

What is the difference between a value parameter and variable parameter

How to define and call program modules (procedures and functions)

Variables and scope

- What is a local variable
- What is a global variable
- What is the scope of a procedure or function

What are preconditions and postconditions