

Fortran - Subprograms

Functions, Subroutines, Interfaces

Spring 2017

Victor Eijkhout and Charlie Dey

Subprograms

Subroutines and Functions

Our programs need to be organized and modular.

We achieve this through the use of Subroutines and Functions.

Subprograms

Subroutines and Functions

```
program without_fct

integer, parameter :: m = 100
integer            :: n, n2, i, j
real, dimension(m) :: a, a2
real              :: sum, aver, ...

! Read data (n,a) from a file

! Calculate Average
sum = 0.
do i=1, n; sum = sum + a(i); enddo
aver = sum / real(n)

! Read more data (n2, a2)
open ...; read ...; close ...

! Calculate Average again
s2 = 0
do j=1, n2
    s2 = s2 + a2(j)
enddo
aver2 = s2 / real(n2)
end program
```

Without using functions/subroutines, a lot of tedious coding.

Subprograms

Function Example

```
real function average(n, x)
integer      :: n, i
real, dimension(n) :: x
real        :: sum
sum = 0.
do i=1, n
    sum = sum + x(i)
enddo
average = sum / real(n)
end function average

program with_fct
! Declaration of variables
! Read data (n,a)

! Calculate Average
aver = average(n, a)    ! Function
                        ! call

! Read more data (n2, a2)
open ...; read ...; close ...

! Calculate Average again
aver2 = average(n2, a2)
end program
```

Instead, let's invoke a function `average()`
we now have less code and more reuse.

Subprograms

Subroutines and Functions

Advantages are:

- Reusable code
 - Function can be called multiple times and with different arguments
- Insulation from unintended side effects
 - only variables in the argument list are communicated
 - Local variables (i, sum) do not interfere
- Independent testing of subtasks
 - function compiled and tested separately

NOTE:

- The names in the parameter lists in the function definition and the function call do need not to have the same name but have to be the same type
- All arguments are "passed by reference"
 - if their value of the parameter changes in the function, the corresponding variable within the main program also changes.

Subprograms

Subroutines

```
subroutine average(aver, n, x)
integer      :: n, i
real, dimension(n) :: x
real        :: aver, sum
sum = 0.
do i=1, n
    sum = sum + x(i)
enddo
aver = sum / real(n)
end subroutine average

program with_sub
! Declaration of variables
! Read data (n1,a1)

! Calculate Average
call (aver1, n1, a1)      ! Subroutine
call
! Read more data (n2, a2)
open ...; read ...; close ...

! Calculate Average again
call average(aver2, n2, a2)
end program
```

Since everything is pass by reference, we can rewrite our earlier example using a subroutine instead.

Subprograms

Structure: Main Program

```
program name  
  specifications  
  execution statements  
  [ contains  
    internal routines ]  
end program [ Name ]
```

Specifications

- include use of modules
- implicit or strong typing
- namelist declaration
- type definitions
- variable declarations

Internal routines are subroutines and/or functions defined inside encapsulating program unit

Subprograms

Structure: Subroutines and Functions

```
subroutine name[ (argument list) ]  
  specification statements  
  execution statements  
  [ contains  
    internal routines ]  
end subroutine [ name ]  
  
return-type function name[ (argument list) ]  
  specification statements  
  execution statements  
  [ contains  
    internal routines ]  
end function [ name ]
```

Argument list - a way of passing data in/out of a subroutine or function

Specifications

- include use of modules
- implicit or strong typing
- namelist declaration
- type definitions
- variable declarations

Subroutines/Functions may also have internal routines of other subroutines and/or functions defined inside encapsulating subroutine/function unit

Subprograms

Arguments: Subroutines and Functions

```
real function average(n, x)
integer      :: n, i
real, dimension(n) :: x
real        :: sum
sum = 0.
do i=1, n
    sum = sum + x(i)
enddo
average = sum / real(n)
end function average
```

program with_fct

```
! Declaration of variables
! Read data (n1,a1)

! Calculate Average
aver = average(n1, a1) ! Function
                        ! call
! Read more data (n2, a2)
open ...; read ...; close ...

! Calculate Average again
aver2 = average(n2, a2)
end program
```

- Arguments passed to routines are called actual arguments, e.g. `n1`, `a2`, `n2` and `a2` in the main program
- Arguments in routines are called dummy arguments, e.g. `n` and `x` in the function
- Actual and dummy arguments must have number and type conformity.

Subprograms

Subroutines and Functions

- Subroutines
 - enables modular programming
 - structured like main program, but with argument list
 - may be internal, i.e. resides in the main program
 - or external, i.e. resides in "modules"
 - does **not** return a value
- Functions
 - enables modular programming
 - similar to subroutines (argument list, structure)
 - may be internal or external
 - returns a value

Subprograms

Summary: Subroutines vs Functions

```
subroutine average(aver, n, x)
integer          :: n, i
real, dimension(n) :: x
real            :: sum
sum = 0.
do i=1, n
    sum = sum + x(i)
enddo
aver = sum / real(n)
end subroutine average
```

```
real function average(n, x)
integer          :: n, i
real, dimension(n) :: x
real            :: sum
sum = 0.
do i=1, n
    sum = sum + x(i)
enddo
average = sum / real(n)
end function average
```

What's different vs. C/C++?

- no return statement
- all parameters are passed by reference
- function name is the return argument in a function

Subprograms - Exercise 1

Subroutines and Functions

Since all arguments are passed by reference,
write a subroutine swap of two parameters that exchanges the input values:

```
integer :: i=2,j=3  
swap(i,j)
```

Subprograms

Subroutines and Functions - Safeguarding your arguments

INTENT allows us to declare the intended behaviour of an argument.

- INTENT(IN) - the argument is for input only
- INTENT(OUT) - the argument is for output only
- INTENT(INOUT) - the argument is for input and/or output

Subprograms

Subroutines

```
subroutine average(aver, n, x)
integer, intent(in):: n
integer           :: i
real, dimension(n), intent(in) :: x
real, intent(out)  :: aver
real              :: sum
sum = 0.
do i=1, n
    sum = sum + x(i)
enddo
aver = sum / real(n)
end subroutine average

program with_sub
! Declaration of variables
! Read data (n1,a1)
! Calculate Average
call (aver1, n1, a1)      ! Subroutine
call
! Read more data (n2, a2)
open ...; read ...; close ...

! Calculate Average again
call average(aver2, n2, a2)
end program
```

Since everything is pass by reference, we can rewrite our earlier example using a subroutine instead.

Subprograms - Project Exercise 2

Subroutines and Functions

Write a function that takes an integer input and returns a logical corresponding to whether the input was prime.

```
logical :: isprime  
isprime = prime_test_function(13)
```

Read the number in, and print the value of the logical.

Subprograms - Project Exercise 3

Subroutines and Functions

Take the prime number testing program, and modify it to read in how many prime numbers you want to print.

Print that many successive primes.

Keep a variable `number_of_primes_found` that is increased whenever a new prime is found.

Subprograms

Polymorphism i.e. overloading functions

Polymorphism refers to a programming language's ability to process objects differently depending on their data type or class.

Fortran doesn't really do *Polymorphism*, but it gives us something called an Interface

Subprograms

Silly example: Interface

```
program Demo
implicit none
integer :: i, j
real :: x, y
i = 1
j = 2
x = 1.5
y = 2.5

call printvalues_real(x, y)
call printvalues_integers(i, j)

contains

  subroutine printvalues_integers(a, b)
    integer :: a, b
    print *, a, b
  end subroutine printvalues_integers

  subroutine printvalues_real(a, b)
    real :: a, b
    print *, a, b
  end subroutine printvalues_real

end program Demo
```

We have a program and 2 subroutines
One subroutine prints integers.
One subroutine prints reals.

Subprograms

Silly example: Interface

```
program Demo
implicit none

interface printValues
  subroutine printValues_integer(a, b)
    integer :: a, b
  end subroutine printValues_integer

  subroutine printValues_real(a, b)
    real :: a, b
  end subroutine printValues_real
end interface printValues

integer :: i = 1, j = 2
real :: x = 1.5, y = 2.5

call printValues(x, y)
call printValues(i, j)
```

```
contains
  subroutine printvalues_integers(a, b)
    integer :: a, b
    print *, a, b
  end subroutine printvalues_integers

  subroutine printvalues_real(a, b)
    real :: a, b
    print *, a, b
  end subroutine printvalues_real
end program Demo
```

Now we have one Interface that contains multiple subroutine. The interface is called with any parameter type and the proper subroutine is invoked.

Subprograms - Exercise 4

Interface

Write a interface, `calculate_circumference()` that calculates the circumference of an assumed shape depending on the number of arguments passed.

3 arguments, `calculate_circumference()` assumes it's a triangle

2 arguments, `calculate_circumference()` assumes it's a rectangle

1 arguments, `calculate_circumference()` assumes it's a circle