

# Inheritance

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# Agenda

## Inheritance

- Variables as Objects
  - Type bound procedures
- Type Extension and Inheritance
  - Extends attribute
  - Abstract Types
  - Abstract Interfaces



# Type-bound Procedures

Or "Procedures Bound to a Type by Name"

- Allows a Fortran subroutine or procedure to be treated as a method on an object of the given type.

`call object%method(...)`

`x = object%func(...)`

which is equivalent to

`call method(object, ...)`

`x = func(object, ...)`

- This syntax encourages an object-oriented style of programming that can improve clarity in some contexts.
- Procedures can also be bound by type to operators: [=, +, etc. ]



## Type-bound Syntax

The following example defines a derived type with 2 type bound procedures compute() and retrieve()

```
1  type my_type
2      real :: value
3  contains
4      procedure :: compute
5      procedure :: retrieve
6  end type my_type
```

- Type-bound procedures must be module procedures or external procedures with explicit interfaces.
- By default type-bound names are public, but each entity in a type (including components) can have a PUBLIC/PRIVATE attribute.



# Example

```
1  module myType_mod
2      private ! information hiding
3      public :: my_type ! except
4      type my_type
5          real :: my_value(4) = 0.0
6      contains
7          procedure :: write
8          procedure :: reset
9      end type my_type
10 contains
11     subroutine write (this, unit)
12     class(my_type) :: this
13         integer, optional :: unit
14         if(present(unit)) then
15             write (unit, *) this %
16                 my_value
17         else
18             print *, this%my_value
19         endif
20     end subroutine write
21 ...
```

```
1  ...
2      subroutine reset(variable)
3          class(my_type) :: variable
4          variable%my_value = 0.0 end subroutine
5          reset
6      end module myType_mod
```

Usage:

```
use myType_mod
type(myType) :: var
...
call var%write(unit=6)
call var%reset()
```

# Passed-object dummy arg

By default, type-bound procedures pass the object as the first argument.

- Can override behavior with **NOPASS** attribute.  
    procedure, **NOPASS** :: method  
    ...  
    call thing % method(...) ← No object is passed
- Can also specify which argument is to be associated with the passed-object with the **PASS** attribute:  
    procedure, **PASS**(obj) :: method  
    ...  
    subroutine method(x,obj,y)  
    ...  
    call thing % method(x,y) ← Thing is 2nd obj
- The default can be explicitly confirmed by  
    procedure, **PASS** :: method

**Strongly** recommend that you always use the default.



## Renaming and Generic

- Type-bound procedures can specify an alternative public name using a mechanism analogous to that for the module ONLY clause:

```
procedure :: write => writeInternal
```

```
...
```

```
call thing % method(...) ← No object is passed
```

- Similarly, an external name can be **overloaded** for multiple interfaces with the GENERIC statement:

```
type myType
```

```
contains
```

```
procedure :: addInteger
```

```
procedure :: addReal
```

```
generic :: add => addReal, addInteger
```

```
end type
```



# Inheritance

Fortran 2003 introduces OOP inheritance via the EXTENDS attribute for user defined types.

- Implementation is restricted to single inheritance.
  - Inheritance always forms hierarchical trees.
- Implementation is designed to be efficient such that offsets for components and type-bound procedures can be computed at compile time. ("single lookup")

With *type extension*, a developer may add new components and type-bound procedures to an existing derived type even *without* access to the source code for that type.





# Inheritance Terminology

- An extensible type without the EXTENDS attribute is considered to be a 'base type'.
  - Base types need not have any components.
  - Extension need not add any components.
- A type with the EXTENDS attribute is said to be an extended type.
  - 'Parent type' is used for the type from which the extension is made.
  - All the components, and bound procedures of the parent type are inherited by the extended type and they are known by the same names.



## Syntax for Extends

```
1  type Location2D
2      real :: latitude, longitude
3  end type Location2D
4
5  type, EXTENDS (Location2D) :: Location3D
6      real :: pressureHeight
7  end type Location3D
8      ...
9  type (Location3D) :: location
10     lat = location % latitude
11     lon = location % longitude
12     height = location % pressureHeight
```



# The Parent Component

- Every extended type has an *implicit component* associated with the parent type
  - The component name is the type name of the parent.
  - Provides *multiple* mechanisms to access components in parent type

From the previous example we could do:

```
1  type (Location2D) :: latLon
2  latLon = location % Location2D
3  lat = location % Location2D % latitude
```



## Extends and Type-bound

- Type-bound procedures in the parent may be invoked within extended types.
- Extended types may add additional type-bound procedures in the natural fashion.
- An extended type can *override* a type-bound procedure in the parent - specifying new behavior in the extended type.
  - The keyword **NON\_OVERRIDABLE** can be used to prohibit extended classes from overriding behavior:  
*procedure, **NON\_OVERRIDABLE** :: foo*



# Overriding Example

```
1  type square
2      real :: length
3  contains
4      procedure :: area => square_area
5  end type square
6
7  type, extends(square) :: rectangle ! inherits area
8      real :: width
9  contains
10     procedure :: area => rectangle_area ! overriding area
11 end type rectangle
12
13 real function square_area(this)
14     square_area = (this % length) ** 2
15
16 real function rectangle_area(this)
17     rectangle_area = (this % length) * (this % width)
```



# Abstract Types

- It is often useful to have a base type that declares methods (type-bound procedures) that are not implemented except in extended classes.
- Fortran 2003 uses the **ABSTRACT** attribute to denote such a type.
  - The **DEFERRED** attribute is used for those methods which are not to be implemented.
  - No variables can be declared to be of an abstract type.



# Abstract Example

```
1  type, ABSTRACT :: abstract_shape
2  contains
3      procedure (area_interface), DEFERRED :: area
4  end type abstract_shape
5  ...
6  ABSTRACT interface
7      subroutine area_interface(obj)
8          import abstract_shape
9          class (abstract_shape) :: obj
10     end subroutine area_interface
11 end interface
12 ...
13 type, EXTENDS(abstract_shape) :: square
14     real :: length
15 contains
16     procedure :: area => square_area ! Provide concrete
17 end type square
```



## Shape Class Exercise

Let's look at the shape class files. Then

- Create a new file `triangle_mod.F90` that contains
  - a constructor that creates a triangle object.
  - a function that calculates the area of a triangle.
- edit `test_shapes.F90` and add code to print the result

Then build the executable and run the code using `Makefile_exercise`.

