To: WG5/J3

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Subject: Comments on draft TR on Module Enhancements J3/03-123

Date: Mar 2003

Subsequent to writing the previous version of this paper I have spent some time looking carefully at the issues related to the functionality needed for this enhancement. My conclusion is that the previous paper, J3/03-143, was broadly correct in its conclusions but not in its emphasis nor in its presentation.

Having decided that a submodule approach to supporting the separation of the design of user interface and facility implementation is the right one, the key issue is what is the relationship between a submodule and its parent module. In Fortran terms what is the nature of the association between entities in the parent and entities of the same name in a submodule. It should be noted that what we are defining as a submodule is an additional non-executable program unit similar to a module and which like a module constitutes a separate scoping unit.

A submodule is delimited by statements of the form

```
SUBMODULE (<parent-name>) <submodule-name>
…
ENDSUBMODULE <submodule-name>
```

The <parent-name> identifies the parent that will have declared a number of named entities and possibly accessed a number of others by use association or by a previous level of parent/child association. All of these entities will be visible in the submodule. The question is what are the association rules that apply to these entities within the submodule? Host association was suggested in 03-123. This I contend is very much an inappropriate choice.

Host association currently has two essential propertiies:

1. the host is a containing program unit at the source code level, and
2. if in the contained scope a name available from the host via host association is redeclared then the local name refers to a new local entity and access to the host entity is masked

Both of these are inappropriate for the submodule/parent relationship. By definition a submodule is not contained within its parent module. To have a submodule redeclaration of a parent entity create a new local entity that masks access to the parent entity is likely to cause an error. For example, with the 03-123 the following code structure would be legal.

```
MODULE POP
  INTEGER,PARAMETER::N=10
FORWARD INTERFACE
  FUNCTION FUN(a)
    REAL::a(N),FUN
  ENDFUNCTION FUN
ENDINTERFACE
ENDMODULE POP

SUBMODULE(POP)::SON
  INTEGER,PARAMETER::N=50  ! new local N masking the host associated N
  CONTAINS
  IMPLEMENTATION FUN
    FUNCTION FUN(a)
      REAL::a(N),FUN  ! because of the IMPLEMENTATION bracketing this N is the parent N
```

```
                    ! not the local one that normally would be accessed in this
context
      ! body of function
    ENDFUNCTION FUN
  ENDIMPLEMENTATION FUN
  FUNCTION SUBFUN(a)
    REAL::a(N),SUBFUN  ! no bracketing means this N is the local one accessed normally
    ! body of function
  ENDFUNCTION SUBFUN
ENDSUBMODULE SON
```

A further complication arises since it would appear to be legal under the proposed host association rule that SUBFUN could have been named FUN. In this case we have the confusion of which FUN would be invoked by a reference to FUN in other procedures within the submodule.

An interface body declared in the parent can only refer to a parent entity. If this interface is redeclared in the submodule but a local entity of a similar name is also declared that masks the parent entity the characteristics of the procedure could be different and hence in error. Even if language is added to say that in this case the parent entity is accessed and not the local submodule entity there is much scope for confusion. Fundamentally any reference within a submodule to a name inherited from the parent should be a reference to the parent entity.

Use association is closer to what is required but is not totally appropriate either. As currently defined use association applies from one named program unit to another identified by name, which is essentially what applies for a submodule/parent. However, use association at present applies only via a USE statement that must name a module. The entities that are made accessible from this module are controlled first by the accessibility attributes declared for them in the module and secondly by the controls that are applied locally on the USE statement. A submodule of necessity must have access to all accessible entities from its named parent. There is no local control in the parent/child inheritance and the accessibility attributes in the parent do not apply to this association. Finally use association deals with redeclaration by the simple expedient of banning it. Any redeclaration of a name made visible by use association is currently defined as an error.

I contend a new parent association is required. In this case,

1. all entities visible in the parent are accessible in the submodule,
2. redeclaration in part or in full of a parent entity is permitted but such declaration must confirm attributes and characteristics of the parent entity and are a reference to the parent entity, a new entity is not created, and
3. although redeclaration is permitted neither redefinition nor reinitialization is allowed (in other words a data entity can be given a value or a procedure defined once only in any chain of descendents.

It should be noted that with this form of association between submodule and parent, host association still applies between the contained scope of a procedure. In the case of the parent declared interface body it accesses the data environment of the parent by host association and for the implementation defined in the submodule it accesses the data environment of its containing submodule by host association. In this case this includes the data environment of the parent inherited into the submodule by the association rules defined above, plus any new data environment declared within the submodule. This latter by definition must be additional to and different from the parent data. I contend that this is precisely the desired behaviour.

The only remaining language that is needed is a keyword to indicate that a specific interface body declaration applies to a descendent procedure and not an external. This I contend for the reasons set out in the previous version of this paper should be a keyword that qualifies the interface body not a whole

interface block. In honour of the foresight of Maureen Hoffert who first raised some of these issues with her "F-word" proposals in 1987, I would propose we spell this `FORWARD` and it be used a prefix to the `FUNCTION` or `SUBROUTINE` header statement on a interface body.

With this definition of association no other language syntax is needed nor is any desirable. The TR will be relatively simple in both concept, description and implementation. It will also be straight forward to employ with very much less scope for opaque or erroneous code.

The following is an example of the sort of program structure that is possible with this proposal. The basic package is one providing facilities for variable precision arithmetic (drawn from my VPA module). The interface declarations are included in a parent module and the implementation definitions are given in two submodules, one defines the arithmetic operations the other the logical comparison procedures.

```
MODULE VARIABLE_PRECISION_ARITHMETIC

PRIVATE
INTEGER,PARAMETER :: radd=8
INTEGER,PARAMETER :: rad=100000000
TYPE NUMBER
  PRIVATE
  INTEGER         :: exp=rad+2     ! holds the base rad exponent
  INTEGER,POINTER :: sig(:)=>NULL()! holds the significand
ENDTYPE NUMBER
INTEGER :: ndig=14   ! controls the current accuracy
                     ! initially set to provide at least 104D

INTERFACE ASSIGNMENT(=)
  FORWARD ELEMENTAL SUBROUTINE num_ass_num(var,expr)
    type(NUMBER),INTENT(IN) :: expr
    type(NUMBER),INTENT(INOUT) :: var
  ENDSUBROUTINE num_ass_num
  FORWARD ELEMENTAL SUBROUTINE num_ass_int(var,expr)
    INTEGER,INTENT(IN) :: expr
    type(NUMBER),INTENT(INOUT) :: var
  ENDSUBROUTINE num_ass_int
ENDINTERFACE  ASSIGNMENT(=)

INTERFACE OPERATOR(+)
  FORWARD ELEMENTAL FUNCTION num_plus_num(l,r)
    type(NUMBER),INTENT(IN) :: l,r
    type(NUMBER) :: num_plus_num
  ENDFUNCTION num_plus_num
FORWARD ELEMENTAL FUNCTION num_plus_int(l,r)
    type(NUMBER),INTENT(IN) :: l
    INTEGER, INTENT(IN) :: r
    type(NUMBER) :: num_plus_int
  ENDFUNCTION num_plus_int
FORWARD ELEMENTAL FUNCTION int_plus_num(l,r)
    INTEGER, INTENT(IN) :: l
    type(NUMBER),INTENT(IN) :: r
    type(NUMBER) :: int_plus_num
  ENDFUNCTION num_plus_num
  FORWARD ELEMENTAL FUNCTION plus_num(r)
    type(NUMBER),INTENT(IN) :: r
    type(NUMBER) :: plus_num
  ENDFUNCTION plus_num
ENDINTERFACE  OPERATOR(+)

INTERFACE OPERATOR(<)
  FORWARD ELEMENTAL FUNCTION num_lt_num(l,r) ! OPERATOR(<)
    type(NUMBER),INTENT(IN) :: l,r
    LOGICAL :: num_lt_num
```

```
  ENDFUNCTION num_lt_num
ENDINTERFACE  OPERATOR(<)

PUBLIC :: NUMBER,PRECISION,ASSIGNMENT(=),OPERATOR(+),OPERATOR(<)

ENDMODULE VARIABLE_PRECISION_ARITHMETIC
```

The first submodule will define assignment and the arithmetic operators,

```
SUBMODULE(VARIABLE_PRECISION_ARITHMETRIC)::VPA_ARITH_PROCS
CONTAINS

  ELEMENTAL SUBROUTINE num_ass_num(var,expr)  ! redeclares and refers to interface from
    type(NUMBER),INTENT(IN) :: expr           ! parent
    type(NUMBER),INTENT(INOUT) :: var
    ! implements assignment between NUMBER values truncating to current precision if
    ! necessary
    ! body of procedure
  ENDSUBROUTINE num_ass_num

  ELEMENTAL SUBROUTINE num_ass_int(var,expr)  ! redeclares and refers to interface from
    INTEGER,INTENT(IN) :: expr                ! parent
    type(NUMBER),INTENT(INOUT) :: var
    ! implements assignment of an INTEGER to a NUMBER performing the required conversion
    ! body of procedure
  ENDSUBROUTINE num_ass_int

  ELEMENTAL FUNCTION num_plus_num(l,r)  ! redeclares and refers to interface from
    type(NUMBER),INTENT(IN) :: l,r      ! parent
    type(NUMBER) :: num_plus_num
    ! implements addition between a NUMBER and a NUMBER
    ! body of procedure
  ENDFUNCTION num_plus_num

  ELEMENTAL FUNCTION num_plus_int(l,r)  ! redeclares and refers to interface from
    type(NUMBER),INTENT(IN) :: l        ! parent
    INTEGER, INTENT(IN) :: r
    type(NUMBER) :: num_plus_int
    ! implements addition between a NUMBER and an INTEGER
    ! body of procedure
  ENDFUNCTION num_plus_int

  ELEMENTAL FUNCTION int_plus_num(l,r)  ! redeclares and refers to interface from
    INTEGER, INTENT(IN) :: l            ! parent
    type(NUMBER),INTENT(IN) :: r
    type(NUMBER) :: int_plus_num
    ! implements addition between an INTEGER and a NUMBER
    ! body of procedure
  ENDFUNCTION int_plus_num

  FORWARD ELEMENTAL FUNCTION plus_num(r)  ! redeclares and refers to interface from
    type(NUMBER),INTENT(IN) :: r          ! parent
    type(NUMBER) :: plus_num
    ! implements monadic addition for a NUMBER
    ! body of procedure
  ENDFUNCTION plus_num

END SUBMODULE VPA_ARITH_PROCS
```

Note the redeclarations in the submodule reconfirm the attributes and characteristics of entities accessed from the parent.

The following submodule would independently implement the logical comparison operators for VPA

```
SUBMODULE(VARIABLE_PRECISION_ARITHMETRIC)::VPA_COMP_PROCS
CONTAINS
  ELEMENTAL FUNCTION num_lt_num(l,r) ! OPERATOR(<) the interfaces here are simple so
                                     ! will not be fully redeclared
    ! implements the logical < comparison between NUMBER values
    ! body of procedure
  ENDFUNCTION num_lt_num
END SUBMODULE VPA_COMP_PROCS
```

This time the whole parent declarations are not repeated merely referenced from the parent declaration via the interface name `num_lt_num`.