CLASS AND SUBCLASS DECLARATIONS

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1. INTRODUCTION

A central idea of some programming languages [28, 57, 58] is to provide protection for the user against (inadvertantly) making meaningless data references. The effects of such errors are implementation dependent and can not be determined by reasoning within the programming language itself. This makes debugging difficult and impractical.

Security in this sense is particularly important in a list processing environment, where data are dynamically allocated and de-allocated, and the user has explicit access to data addresses (pointers, reference values, element values). To provide security it is necessary to have an automatic de-allocation mechanism (reference count, garbage collection). It is convenient to restrict operations on pointers to storage and retrieval. New pointer values are generated by allocation of storage space, pointing to the allocated space. The problem remains of correct interpretation of data referenced relative to user specified pointers, or checking the validity of assumptions inherent in such referencing. E.g. to speak of "*A* of *X*" is meaningful, only if there is an *A* among the data pointed to by *X*.

The record concept proposed by Hoare and Wirth [58] provides full security combined with good runtime efficiency. Most of the necessary checking can be performed at compile time. There is, however, a considerable expense in flexibility. The values of reference variables and procedures must be restricted by declaration to range over records belonging to a stated class. This is highly impractical.

The connection mechanism of SIMULA combines full security with greater flexibility at a certain expense in convenience and run time efficiency. The user is forced, by the syntax of the connection statement, to determine at run time the class of a referenced data structure (process) before access to the data is possible.

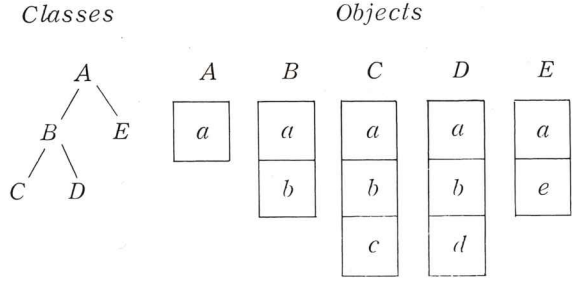
The subclass concept of Hoare [59] is an attempt to overcome

the difficulties mentioned above, and to facilitate the manipulation of data structures, which are partly similar, partly distinct. This paper presents another approach to subclasses, and some applications of this approach.

2. CLASSES

The class concept introduced is a remodelling of the record class concept proposed by Hoare. The notation is an extension of the ALGOL 60 syntax. A prefix notation is introduced to define subclasses organized in a hierarchical tree structure. The members of a class are called objects. Objects belonging to the same class have similar data structures. The members of a subclass are compound objects, which have a prefix part and a main part. The prefix part of a compound object has a structure similar to objects belonging to some higher level class. It can itself be a compound object.

The figure below indicates the structure of a class hierarchy and of the corresponding objects. A capital letter denotes a class. The corresponding lower case letter denotes the data comprising the main part of an object belonging to that class.



B, *C*, *D*, *E* are subclasses of *A*; *C* and *D* are sublasses of *B*.

2.1. *Syntax*

⟨class id.⟩ :: = ⟨identifier⟩
⟨prefix⟩:: = ⟨class id.⟩
⟨class body⟩:: = ⟨statement⟩
⟨main part⟩:: = class ⟨class id.⟩ ⟨formal parameter part⟩;
⟨specification part⟩ ⟨class body⟩
⟨class declaration⟩:: = ⟨main part⟩|⟨prefix⟩ ⟨main part⟩

2.2. *Semantics*

An object is an instance of a class declaration. Different instances of the same declaration are said to belong to class C, where C is the class identifier. If the class body does not take the form of an unlabelled block, it acts as if enclosed in an implicit block. The parameters and the quantities declared local to the outermost block of the class body are called the attributes of an object. The attributes can be referenced locally from within the class body, or nonlocally by a mechanism called remote acessing (5).

The parameters are transmitted by value. One possible use of the statements of the class body may be to initialize attribute values.

A prefixed class declaration represents the result of concatenating the declaration referenced by the prefix and the main part. The concatenation is recursively defined by the following rules.

1) The formal parameter lists of the former and the latter are concatenated to form one parameter list.

2) The specification parts are juxtaposed.

3) A combined class body is formed, which is a block, whose block head contains the attribute declarations of the prefix body and the main body. The block tail contains the statements of the prefix body followed by those of the main body.

The attributes of the main part are not accessible from within the prefix body, except by remote accessing. The attributes of the prefix are acessible as ordinary local quantities from within the body of the main part.

The object class represented by a prefixed class declaration is a subclass of the class denoted by the prefix. Subclasses can be nested to any depth by using prefixed class identifiers as prefixes to other class declarations.

Let A_0 be any class. If A_0 is prefixed, we will denote this prefix by A_1. The prefix of A_1 (if any) will be denoted by A_2 etc. The sequence

$$A_1, A_2, \ldots$$

will be called the "prefix sequence" of A_0. It follows from the syntax that if A_i and A_j both have A_k as prefix, they have identical prefix sequences.

It will be required that all prefix sequences are finite. (This excludes multiple occurrence of any class A_i in a prefix sequence.) Let

$$A_1, A_2 \ldots, A_n$$

be the prefix sequence of A_0. We shall say that the class A_i is "included in A_j" if $0 \leq i \leq j \leq n$.

3. OBJECT REFERENCES

Reference values in the sense of [59] are introduced, in a slightly modified form.

3.1. *Reference types*

3.1.1. *Syntax*

⟨type⟩ :: = ⟨ALGOL type⟩ | ref | ref ⟨qualification⟩
⟨qualification⟩ :: = (⟨class id.⟩)

3.1.2. *Semantics*

Associated with each object is a unique value of type ref, which is said to reference or point to the object. A reference value may, by qualifying a declaration or specification by a class identifier, be required to refer to objects belonging to either this class or any of its subclasses. In addition the value of any item of type reference is restricted to objects belonging to classes whose declarations are statically visible from the declaration or specification of the item.

The reference value none is a permissible value for any reference item, regardless of its qualification.

3.2. *Reference Expressions*

3.2.1. *Syntax*

⟨simple ref. expr.⟩ :: = none | ⟨variable⟩ | ⟨function designator⟩ | ⟨object designator⟩ | ⟨local reference⟩
⟨ref. expr.⟩ :: = ⟨simple ref. expr.⟩ | if ⟨Boolean expr.⟩ then ⟨simple ref. expr.⟩ else ⟨ref. expr.⟩
⟨object designator⟩ :: = ⟨class id.⟩ ⟨actual parameter part⟩
⟨local reference⟩ :: = this ⟨class id.⟩

3.2.2. *Semantics*

A reference expression is a rule for computing a reference value. Thereby reference is made to an object, except if the value is none, which is a reference to "no object".

i) *Qualification.* A variable or function designator is qualified according to its declaration or specification. An object designator or local reference is qualified by the stated class identifier. The expression none is not qualified.

No qualification will be regarded as qualification by a universal class, which includes all declared classes.

ii) *Object generation.* As the result of evaluating an object designator an object of the stated class is generated. The class body is executed. The value of the object designator is a reference to the generated object. The life span of the object is limited by that of its reference value.

iii) *Local reference.* A local reference "this *C*" is a meaningful expression within the class body of the class *C* or of any subclass of *C*. Its value is a reference to the current instance of the class declaration (object).

Within a connection block (5.2) connecting an object of class *C* or a subclass of *C* the expression "this *C*" is a reference to the connected object.

The general rule is that a local reference refers to the object, whose attributes are local to the smallest enclosing block, and which belongs to a class included in the one specified. If there is no such object, the expression is illegal.

4. REFERENCE OPERATIONS

4.1. *Assignment*

4.1.1. *Syntax*

⟨reference assignment⟩ :: = ⟨variable⟩: = ⟨reference expr.⟩ |
⟨variable⟩: = ⟨reference assignment⟩

4.1.2. *Semantics*

Let the left and right hand sides be qualified by *C*l and *C*r, respectively, and let the value of the right hand side be a reference to an object of class *C*v. The legality and effect of the statement depends on the relations that hold between these classes.

Case 1. *C*l includes *C*r: The statement is legal, and the assignment is carried out.

Case 2. *C*l is a subclass of *C*r: The statement is legal, and the assignment is carried out if *C*l includes *C*v, or if the value is none. If *C*l does not include *C*v, the effect of the statement is undefined (cf. 6.1).

Case 3. *C*l and *C*r satisfy neither of the above relations: The statement is illegal.

The following additional rule is considered: The statement is legal only if the declaration of the left hand item (variable, array or ⟨type⟩ procedure) is within the scope of the class identifier *C*r

and all its subclasses. (The scope is in this case defined after having effected all concatenations implied by prefixes.)

This rule would have the following consequences.

1) Accessible reference values are limited to pointers to objects, whose attributes are accessible by remote referencing (5).

2) Classes represented by declarations local to different instances of the same block are kept separate.

3) Certain security problems are simplified.

4.2. *Relations*

4.2.1. *Syntax*

⟨relation⟩ :: = ⟨ALGOL relation⟩ |
⟨reference expr.⟩ = ⟨reference expr.⟩ |
⟨reference expr.⟩ ≠ ⟨reference expr.⟩ |
⟨reference expr.⟩ is ⟨class id.⟩

4.2.2. *Semantics*

Two reference values are said to be equal if the point to the same object, or if both are none. A relation "*X* is *C*" is true if the object referenced by *X* belongs to the class *C* or to any of its subclasses.

4.3. *For statements*

4.3.1. *Syntax*

⟨for list element⟩ :: = ⟨ALGOL for list element⟩ | ⟨reference expr.⟩ |
⟨reference expr.⟩ while ⟨Boolean expr.⟩

4.3.2. *Semantics*

The extended for statement will facilitate the scanning of list structures.

5. ATTRIBUTE REFERENCING

An attribute of an object is identified completely by the following items of information:

1) the value of a ⟨reference expr.⟩ identifying an object,

2) a ⟨class id.⟩ specifying a class, which includes that of the object, and

3) the ⟨identifier⟩ of an attribute declared for objects of the stated class.

The class identification, item 2, is implicit at run time in a reference value, however, in order to obtain runtime efficiency

it is necessary that this information is available to the compiler.

For a local reference to an attribute, i.e. a reference from within the class body, items 1 and 2 are defined implicitly. Item 1 is a reference to the current instance (i.e. object), and item 2 is the class identifier of the class declaration.

Non-local (remote) referencing is either through remote identifiers or through connection. The former is an adaptation of the technique proposed in [57], the latter corresponds to the connection mechanism of SIMULA [28].

5.1. *Remote Identifiers*

5.1.1. *Syntax*

⟨remote identifier⟩ :: = ⟨reference expr.⟩ . ⟨identifier⟩
⟨identifier 1⟩ :: = ⟨identifier⟩ | ⟨remote identifier⟩

Replace the meta-variable ⟨identifier⟩ by ⟨identifier 1⟩ at appropriate places of the ALGOL syntax.

5.1.2. *Semantics*

A remote identifier identifies an attribute of an individual object. Item 2 above is defined by the qualification of the reference expression. If the latter has the value none, the meaning of the remote identifier is undefined (cf. 6.2).

5.2. *Connection*

5.2.1. *Syntax*

⟨connection block 1⟩ :: = ⟨statement⟩
⟨connection block 2⟩ :: = ⟨statement⟩
⟨connection clause⟩ :: = when ⟨class id.⟩ do ⟨connection block 1⟩
⟨otherwise clause⟩ :: = ⟨empty⟩ | otherwise ⟨connection block 2⟩
⟨connection part⟩ :: = ⟨connection clause⟩ |
⟨connection part⟩ ⟨connection clause⟩
⟨connection statement⟩ :: = inspect ⟨reference expr.⟩ do
⟨connection block 2⟩ |
inspect ⟨reference expr.⟩
⟨connection part⟩ ⟨otherwise clause⟩

5.2.2. *Semantics*

The connection mechanism serves a double purpose:

1) To define item 1 above implicitly for attribute references within connection blocks. The reference expression of a connection statement is evaluated once and its value is stored. Within a connection block this value is said to reference the connected object. It can itself be accessed through a ⟨local reference⟩ (see section 3.2.2).

2) To discriminate on class membership at run time, thereby defining item 2 implicitly for attribute references within alternative connection blocks. Within a ⟨connection block 1⟩ item 2 is defined by the class identifier of the connection clause. Within a ⟨connection block 2⟩ it is defined by the qualification of the reference expression of the connection statement.

Attributes of a connected object are thus immediately accessible through their respective identifiers, as declared in the class declaration corresponding to item 2. These identifiers act as if they were declared local to the connection block. The meaning of such an identifier is undefined, if the corresponding ⟨local reference⟩ has the value none. This can only happen within a ⟨connection block 2⟩.

6. UNDEFINED CASES

In defining the semantics of a programming language the term "undefined" is a convenient stratagem for postponing difficult decisions concerning special cases for which no obvious interpretation exists. The most difficult ones are concerned with cases, which can only be recognized by runtime checking.

One choice is to forbid offending special cases. The user must arrange his program in such a way that they do not occur, if necessary by explicit checking. For security the compiled program must contain implicit checks, which to some extent will duplicate the former. Failure of a check results in program termination and an error message. The implicit checking thus represents a useful debugging aid, and, subject to the implementor's foresight, it can be turned off for a "bugfree" program (if such a thing exists).

Another choice is to define ad hoc, but "reasonable" standard behaviours in difficult special cases. This can make the language much more easy to use. The programmer need not test explicitly for special cases, provided that the given ad hoc rule is appropriate in each situation. However, the language then has no implicit debugging aid for locating unforeseen special cases (for which the standard rules are not appropriate).

In the preceding sections the term undefined has been used three times in connection with two essentially different special cases.

6.1. *Conflicting reference assignment*

Section 4.1.2, case 2, *C*1 does not include *C*v: The suggested standard behaviour is to assign the value none.

6.2. *Non-existing attributes*

Sections 5.1.2 and 5.2.2: The evaluation of an attribute reference, whose item 1 is equal to none, should cause an error printout and program termination. Notice that this trap will ultimately catch most unforeseen instances of case 6.1.

7. EXAMPLES

The class and subclass concepts are intended to be general aids to data structuring and referencing. However, certain widely used classes might well be included as specialized features of the programming language.

As an example the classes defined below may serve to manipulate circular lists of objects by standard procedures. The objects of a list may have different data structures. The "element" and "set" concepts of SIMULA will be available as special cases in a slightly modified form.

```
class linkage; begin ref (linkage) suc, pred; end linkage;
linkage class link; begin
   procedure out; if suc ≠ none then
      begin pred. suc: = suc; suc. pred: = pred;
            suc: = pred: = none end out;
   procedure into (L); ref (list) L;
      begin if suc ≠ none then out;
            suc: = L; pred: = suc. pred;
            suc. pred: = pred. suc: = this linkage end into;
   end link;
linkage class list;
   begin suc: = pred: = this linkage end list;
```

Any object prefixed by "link" can go in and out of circular lists. If X is a reference expression qualified by link or a subclass of link, whose value is different from none, the statements

X. into (*L*) and *X*. out

are meaningful, where L is a reference to a list.

Examples of user defined subclasses are:

```
link class car (license number, weight);
   integer license number; real weight; . . . ;
car class truck (load); ref (list) load; . . . ;
car class bus (capacity); integer capacity;
   begin ref (person) array passenger [1 : capacity] . . . end;
list class bridge; begin real load; . . . end;
```


Multiple list memberships may be implemented by means of auxiliary objects.

```
link class element (X); ref X;;
```

A circular list of element objects is analogous to a "set" in SIMULA. The declaration "set S" of SIMULA is imitated by "ref (list) S" followed by the statement "S: = list".

The following are examples of procedures closely similar to the corresponding ones of SIMULA.

```
procedure include (X, S); value X; ref X; ref (list) S;
if X ≠ none then element (X). into (S);
ref (linkage) procedure suc (X); value X; ref (linkage) X;
   suc: = if X ≠ none then X. suc else none;
ref (link) procedure first (S); ref (list) S;
   first: = S. suc;
Boolean procedure empty (S); value S; ref (list) S;
   empty: = S. suc = S;
```

Notice that for an empty list S "suc (S)" is equal to S, whereas "first (S)" is equal to none. This is a result of rule 6.1 and the fact that the two functions have different qualifications.

8. EXTENSIONS

8.1. *Prefixed Blocks*

8.1.1. *Syntax*

⟨prefixed block⟩:: = ⟨block prefix⟩ ⟨main block⟩
⟨block prefix⟩:: = ⟨object designator⟩
⟨main block :: = ⟨unlabelled block⟩
⟨block⟩ :: = ⟨ALGOL block⟩ | ⟨prefixed block⟩
⟨label⟩:⟨prefixed block⟩

8.1.2. *Semantics*

A prefixed block is the result of concatenating (2.2) an instance of a class declaration and the main block. The formal parameters of the former are given initial values as specified by the actual parameters of the block prefix. The latter are evaluated at entry into the prefixed block.

8.2. *Concatenation*

The following extensions of the concepts of class body and concatenation give increased flexibility.

8.2.1. *Syntax*

⟨class body⟩ :: = ⟨statement⟩ | ⟨split body⟩
⟨split body⟩ :: = ⟨block head⟩;⟨part 1⟩ inner; ⟨part 2⟩
⟨part 1⟩ :: = ⟨empty⟩ | ⟨statement⟩;⟨part 1⟩
⟨part 2⟩ :: = ⟨compound tail⟩

8.2.2. *Semantics*

If the class body of a prefix is a split body, concatenation is defined as follows: the compound tail of the resulting class body consists of part 1 of the prefix body, followed by the statements of the main body, followed by part 2 of the prefix body. If the main body is a split body, the result of the concatenation is itself a split body.

For an object, whose class body is a split body, the symbol inner represents a dummy statement. A class body must not be a prefixed block.

8.3. *Virtual quantities*

The parameters to a class declaration are called by value. Call by name is difficult to implement with full security and good efficiency. The main difficulty is concerned with the definition of the dynamic scope of the actual parameter corresponding to the formal name parameter. It is felt that the cost of an unrestricted call by name mechanism would in general be out of proportion to its gain.

The virtual quantities described below represent another approach to call by name in class declarations. The mechanism provides access at one prefix level of the prefix sequence of an object to quantities declared local to the object at lower prefix levels.

8.3.1. *Syntax*

⟨class declaration⟩ :: = ⟨prefix⟩⟨class declarator⟩⟨class id.⟩
⟨formal parameter part⟩;
⟨specification part⟩⟨virtual part⟩
⟨class body⟩
⟨virtual part⟩ :: = ⟨empty⟩ | virtual: ⟨specification part⟩

8.3.2. *Semantics*

The identifiers of a ⟨virtual part⟩ should not otherwise occur in the heading or in the block head of the class body. Let $A_1, \ldots, A_n$ be the prefix sequence of A_0 and let X be an identifier occurring in the ⟨virtual part⟩ of A_i. If X identifies a parameter of A_j or a quantity declared local to the body of A_j, $j < i$, then for an object of class A_0 identity is established between the virtual quantity X and the quantity X local to A_j.

If there is no A_j, $j < i$, for which X is local, a reference to the

virtual quantity X of the object constitutes a run time error (in analogy with 6.2).

8.3.3. *Example*

```
class A; virtual: real X, Y, Z; . . . ;
A class B(X, Y); real X, Y; . . . ;
A class C(Y, Z); real Y, Z; . . . ;
A class D(Z, X); real Z, X; . . . ;
ref (A) Q;
```

The attribute reference $Q.X$ is meaningful if Q refers to an object of class B or D. Notice that all three subclasses contain objects with only two attributes.

8.4. *Example*

As an example on the use of the extended class concept we shall define some aspects of the SIMULA concepts "process", "main program", and "SIMULA block".

Quasi-parallel sequencing is defined in terms of three basic procedures, which operate on a system variable *SV*. *SV* is an implied and hidden attribute of every object, and may informally be characterized as a variable of "type label". Its value is either null or a program point [5]. *SV* of a class object initially contains the "exit" information which refers back to the object designator. *SV* of a prefixed block has the initial value null. The three basic procedures are:

1) detach. The value of *SV* is recorded, and a new value, called a reactivation point, is assigned referring to the next statement in sequence. Control proceeds to the point referenced by the old value of *SV*. The effect is undefined if the latter is null.

2) resume(*X*); ref *X*. A new value is assigned to *SV* referring to the next statement in sequence. Control proceeds to the point referenced by *SV* of the object *X*. The effect is undefined if *X.SV* is null or if *X* is none. null is assigned to *X.SV*.

3) goto(*X*); ref *X*. Control proceeds to the point referenced by *SV* of the object *X*. The effect is undefined if *X.SV* is null or if *X* is none. null is assigned to *X.SV*.

```
class SIMULA; begin
   ref(process)current;
   class process; begin ref(process)nextev; real evtime;
      detach; inner; current: =nextev; goto(nextev)end;
      procedure schedule(X, T); ref(process)X; real T;
            begin X.evtime: = T; ---------- end;
```

```
process class main program; begin
        L: resume(this SIMULA); go to L end;
schedule(main program, 0)end SIMULA;
```

The "sequencing set" of SIMULA is here represented by a simple chain of processes, starting at "current", and linked by the attribute "nextev". The "schedule" procedure will insert the referenced process at the correct position in the chain, according to the assigned time value. The details have been omitted here.

The "main program" object is used to represent the SIMULA object within its own sequencing set.

Most of the sequencing mechanisms of SIMULA can, except for the special syntax, be declared as procedures local to the SIMULA class body.

Examples:

```
procedure passivate; begin current: = current. nextev;
                                 resume(current)end;
procedure activate(X); ref X; inspect X when process do
    if nextev = none then
    begin nextev: = current; evtime: = current. evtime;
          current: = this process; resume(current)end;
procedure hold(T); real T; inspect current do
    begin current: = nextev; schedule(this process, evtime+T);
          resume(current)end;
```

Notice that the construction "process class" can be regarded as a definition of the symbol "activity" of SIMULA. This definition is not entirely satisfactory, because one would like to apply the prefix mechanism to the activity declarations themselves.

9. CONCLUSION

The authors have for some time been working on a new version of the SIMULA language, tentatively named SIMULA 67. A compiler for this language is now being programmed and others are planned. The first compiler should be working by the end of this year.

As a part of this work the class concept and the prefix mechanism have been developed and explored. The original purpose was to create classes and subclasses of data structures and processes. Another useful possibility is to use the class concept to protect whole families of data, procedures, and subordinate classes. Such families can be called in by prefixes. Thereby language "dialects" oriented towards special problem areas can be defined in a convenient way. The administrative problems in making user defined classes generally available are important and should not be overlooked.

Some areas of application of the class concept have been illustrated in the preceding sections, others have not yet been explored. An interesting area is input/output. In ALGOL the procedure is the only means for handling I/0. However, a procedure instance is generated by the call, and does not survive this call. Continued existence, and existence in parallel versions is wanted for buffers and data defining external layout, etc. System classes, which include the declarations of local I/0 procedures, may prove useful.

The SIMULA 67 will be frozen in June this year, and the current plan is to include the class and reference mechanisms described in sections 2-6. Class prefixes should be permitted for activity declarations. The "element" and "set" concepts of SIMULA will be replaced by appropriate system defined classes. Additional standard classes may be included.

SIMULA is a true extension of ALGOL 60. This property will very probably be preserved in SIMULA 67.

DISCUSSION

Garwick:

This language has been designed with a very specific line of thought just as GPL has been designed with a very specific line. Dahl's line is different from mine. His overriding consideration has been security. My effort has always been security but not to the same degree. I think that Dahl has gone too far in this respect and thereby lost quite a number of facilities, especially a thing like the "call by name". He can of course use a reference to a variable; this corresponds very closely to the FORTRAN type of "call by address", as opposed to the call by name in ALGOL and so for instance he can not use Jensens device. As you know in GPL, I use pointers. A pointer is not the same as a reference; it is a more general concept. So I think the loss of facilities here is a little too much to take for the sake of security.

The "virtuals" seem to be very closely corresponding to the "externals" in FORTRAN or assembly languages. But you see first of all you can only access things which belong to the same complex structure and secondly it seems to me that it is pretty hard to get type declarations for these procedures. You have to have declared the type of the value of the procedure and the type of parameters. In the example given the procedures seem to be parameterless and they do not deliver any value for the function. So I would like to know how Dahl would take care of that.

Dahl:

We think of SIMULA as an extension of ALGOL 60. We therefore

provide exactly the same kind of specification for a virtual quantity as you would do for a formal parameter. You can write procedure *P*; real procedure *Q*; array *A*; and so forth.

I would much have preferred to specify the formal parameters of *P* within the virtual specification of *P* itself. Then, of course, alternative actual declarations in subclasses could have been simplified by omitting much of the procedure heading. This would have made it possible to check at compile time the actual parameters of a call for a virtual procedure. But in order to be consistent with ALGOL 60, we decided not to do it in this way.

The virtual quantities are in many ways similar to ALGOL's name parameters, but not quite as powerful. It turns out that there is no analogy to Jensen's device. This, I feel, is a good thing, because I hate to implement Jensen's device. It is awful.

If you specify a virtual real *X*, then you have the option to provide an actual declaration real *X* in a subclass. But you cannot declare a real expression for *X*. So, if you specify a quantity which looks like a variable, you can only provide an actual quantity which is a variable. This concept seems more clean to me than the call by name of ALGOL.

To begin with, the whole concept of virtual variables seemed to be superfluous because there was nothing more to say about a virtual variable than what had already been said in the specification. But there is: you can say whether or not it actually exists. A virtual variable *X* takes no space in the data record of an object if there is no actual declaration of *X* at any subclass level of the object. Therefore you can use the device for saving space, or for increasing the flexibility in attribute referencing without wasting space. If you access any virtual quantity out of turn, the implementation can catch you and give a run time error message. It is a problem similar to the "null" problem.

Strachey:

Supposing you had classes *C* and *D*, could you then define procedures *P* in both and if so, if you defined one in *C* and one in *D*, both being called *P*, which one would win? Do the scopes go the reverse way from the ordinary scopes or do they go the same way?

Dahl:

Thank you for reminding me of the problem which exists here. The concatenation rule states that declarations given at different prefix levels are brought together into a single block head. Name conflicts in a concatenated block head are regarded as errors of the same kind as redeclarations in an ordinary ALGOL block head.

However, if there is a "name conflict" between a declared quantity and a virtual one, identity is established between the two, if the declaration and specification "match".

Strachey:

The other thing I was going to ask about is whether you have thought about the question of achieving security, not by making it impossible to refer to any thing which has gone away but by making it impossible to cause anything which is referred to, to go away. That is to say, by keeping an account of the number of pointers or references to each record, which is one of the methods of garbage collection and only letting it go away when this count reaches zero. The curious thing is this is generally faster than garbage collection.

Dahl:

We have made some experiments on that recently which suggest that it may not be faster.

Strachey:

Anyway, have you thought of this as an alternative method for providing security?

Dahl:

Evidently an actual parameter called by name is represented at run-time by a pointer of some kind, and you could achieve security by instructing the garbage collector to follow such pointers in addition to stored reference values. But then the price you pay for the call by name is much higher than for instance in ALGOL, where data referenced by any parameter has to be retained for other reasons. In my view, a call by name mechanism for classes would be a convenient device which would invite a programmer to entirely misuse the computer - by writing programs where no data can ever be de-allocated and without realizing it.

Petrone:

My first question was covered by Strachey but I now have another question which has arisen from his question. I am asking you whether the call by name mechanism was already present in the old SIMULA in the array case. And did you use it in garbage collection on arrays?

Dahl:

That is quite correct. There is a pointer from the object to the array, and the garbage collector will follow it. The reason why we did that is that an array is usually a big thing, which it is reasonable to regard as a separate object.

It is not reasonable to give a small thing like a real variable an independent existence, because that may cause very severe fragmentation of the store. Fragmentation is a disaster if you do not have a compacting scheme, and if you have one the fragmentation will tend to increase the time for each garbage collection and also the frequency of calling for it.

Petrone:

Your concatenation mechanism expresses the possibility of generating families of activity declarations - I am speaking now in terms of your old SIMULA - and the virtual mechanism seems to be a restricted call by name of quantities declared within such a family. Maybe it would be better to restrict the call by name to within an activity block, so that an activity block is equivalent to an ALGOL program with the full call by name mechanism available for procedures.

Dahl:

SIMULA in new and old versions has the complete call by name mechanism for parameters to procedures. You could also have name parameters to classes at no extra cost if you restricted any actual parameter called by name to be computable within the block enclosing the referenced class declaration. That is, it must only reference quantities which are local to that block or to outer blocks. But this is a rather unpleasant restriction considering that an actual parameter may be part of a generating expression occurring deep down in a block hierarchy.

SIMULATION PROGRAMMING LANGUAGES - NORTH HOLLAND (1968)

TWO PROPOSALS TOWARDS DISCRETE MODELLING

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1. INTRODUCTION

This work has two concerns, constructive and destructive. The destructive is to expunge the term "simulation language" from our vocabulary. The constructive is to present two independent facilities that may be of some value to the simulation builder.

The first is a language of commands to sequence in real or simulated time activities of interacting parallel processes. This may be added to whatever model-building language is used to express these activities.

The commands are of four kinds: those that suspend a process and express the conditions that must hold before its next activity may begin; those that may effect the status of other processes; those that mediate between processes which require shared resources; those that give a particular process control of the access to particular data. This last is required only when more than one process is in parallel execution in real time; i.e., when there is more than one processor or the single processor multiprograms that have access to this data controlled other than by means of these commands. Finally, since we are interested in simulation, there is a system-provided simulated-time-advancing process in terms of which some of these commands may take an application-oriented form.

The second and more important facility presented is a model-building language. I do not give the commands or predicates, the manipulation and enquiry capabilities, since these can be as extensive or parsimonious as in any other programming language and for much the same reasons of individual taste. What I give is the declaration syntax that allows to be determined whether or not expressions, built up by application of attributes or functions to objects, are well-formed. Effectively, I am proposing a type of data-object adequate to a persistent model of the real word. I then provide a data-structure in which these objects can be interpreted. The moti-