

22. FORMAL DESCRIPTION OF SIMULA COMMON BASE RUNTIME SYSTEM

```
begin ref (driver) CD;  
  ref (notice) nothead, POOL2TOP, POOL2BOTTOM;  
  ref (object) POOL1FIRST, POOL1LAST;  
  ref (driver) array DDISPLAY[1 : maxlevel];  
  ref (object) array DISPLAY [1 : maxlevel];  
  
  comment the integer maxlevel is assumed to be  
  defined when the RTS is written. The variables  
  and arrays above are "non-local" to the runtime  
  routines.  
  
  comment "driver" and "eventnotice" are sub-  
  classes of a class called "notice".  
  
  class notice (obj); ref (object) obj;  
    begin Boolean referenced; ref (notice) notc;  
    end notice;  
  
  notice class eventnotice (time); real time;  
    begin ref (eventnotice) BL, RL, LL;  
    end eventnotice;  
  
  notice class driver (drp, pex, drex, acs, md, level);  
    ref (program) pex; ref (driver) drex, drp;  
    ref (object) acs;  
    Boolean md; integer level;  
    begin Boolean con, rp, pb, dot, ob;  
      ref (eventnotice) evp;  
      ref (driver) cdrp, drch;  
    end driver;  
  
  comment all block instances are a subclass of  
  "object". This includes arrays and stored accumu-  
  lator stacks which have special values of PP.
```

```
class object (PP); ref (prototype) PP;  
    begin ref (driver) MDP; end object;
```

comment a prototype is a description of a family of block instances. One prototype is generated by the compiler for each procedure, class, subblock and prefixed block in the program;

```
class prototype (lg,nvirt,nrp,plev,nrl,level);  
    integer lg,nvirt,nrp,nrl,level,plev;  
    begin ref (program) statements,inretur,endblk,declare;  
        ref (prototype) array prefix[0:plev+1];  
        integer array relad,kind,type[nvirt+1 :  
                                nvirt+nrp+nrl];  
        Boolean array valu[nvirt+1 : nvirt+nrp];  
        ref array progaddr[1 : nvirt];  
        Boolean pb,ob,local classes;  
        integer vtype;  
    end prototype;
```

comment update display is used to update DISPLAY and DDISPLAY to reflect the textual situation defined by CD;

```
procedure update display;  
    begin integer i;  
        DDISPLAY [CD.level] :- CD;  
        for i := CD.level-1 step -1 until 1 do  
            DDISPLAY [i] :- DDISPLAY [i+1].drp;  
        for i := 1 step 1 until CD.level do  
            DISPLAY [i] :- DDISPLAY [i].obj;  
    end update display;
```

comment deletenotice is used to put a driver or event-notice in the list of available notices;

```
procedure deletenotice (x); ref (notice) x;  
    begin x.notc :- nothead; nothead :- x; end;
```

comment SUBBLOCKS

BB - begin subblock

EBL - end subblock;

procedure BB(p); ref (prototype) p;

begin

CD := new driver (new object (p), CD, none, CD, none, true,
p.level);

CD.obj.MDP := CD;

DISPLAY [p.level] := CD.obj;

DDISPLAY [p.level] := CD;

go to p.declare

end BB;

procedure EBL;

begin ref (driver) x;

x := CD.drp;

deletenotice (CD);

CD := x;

end EBL;

comment PROCEDURES;

comment procedure end;

universal procedure EPR (val);

begin ref (driver) x; ref (program) out;

x :- CD.drex;

out :- CD.pex;

restore (CD.acs);

if CD.dot then deletenotice (CD.drp);

deletenotice (CD);

CD :- x;

EPR := val;

update display;

go to out;

end EPR;

comment utility routine to enter declaration code
or in-line coding for parameter transmission;

procedure ENTPROC;

begin ref (driver) y;

CD.obj.MDP :- CD;

if CD.obj.PP.nrp = 0 then

begin update display;

go to CD.obj.PP.declare end;

y :- CD.drex;

CD :- new driver (y.obj,y.drp,none,CD,none,
false,y.level);

CD.con := y.con;

CD.cdrp :- y.cdrp;

DDISPLAY[y.level] :- CD;

go to CD.drex.pex;

end ENTPROC;

comment utility routine to enter declaration code of procedure or class after parameter transmission.

Note: It is assumed that prefix [0] of the prototype for a procedure points to the procedure itself;

```
procedure ENTER;  
  begin ref (driver) y;  
    y :- CD;  
    CD :- CD.drex;  
    CD.pex :- exit;  
    deletenotice (y);  
    update display;  
    go to CD.obj.PP.prefix [0].declare;  
  end ENTER;
```

comment NON-FORMAL, NON-VIRTUAL PROCEDURES;

comment call on normal procedure (local or non-local);

procedure CPR (p,acs);

ref (prototype) p; ref (object) acs;

begin

 CD := new driver (new object (p), DDISPLAY [p.level-1],
 exit,CD,acs,true,p.level);

 ENTPROC;

end CPR;

comment call on connected procedure (cfr. CONNECTION);

procedure CCP(p,c,acs);

ref (prototype) p; ref(object) acs;

ref (driver) c;

begin ref (driver) x;

 x := new driver (c.obj,c.cdrp,none,none,none,false,
 p.level-1);

 x.con := true;

 CD := new driver (new object(p),x,exit,CD,acs,
 true,p.level);

 CD.dot := true;

 ENTPROC

end CCP;

comment call on remote procedure;

procedure CDP (p,c,slc,acs);

ref (prototype) p; ref (object) c,acs;

ref (driver) slc;

begin ref (driver) x;

 x := new driver (c,slc,none,none,none,false,p.level-1);

 x.con := true;

 CD := new driver (new object(p),x,exit,CD,acs,true,
 p.level);

 CD.dot := true;

 ENTPROC;

end CDP;

comment VIRTUAL PROCEDURES;

comment ENTVIRT utility procedure for virtuals corresponding to ENTPROC. The routine must

1. check actual vs. formal number of parameters
2. check type/kind of parameters
3. perform calls by value;

procedure entvirt (p,dr,dot,acs);

ref (prototype) p; ref (driver) dr;

ref (object) acs; Boolean dot;

begin

CD :- new driver (new object(p),dr,exit,CD,acs,true,
p.level);

CD.dot := dot;

CD.obj.MDP :- CD;

store descriptors for name parameters;

store value parameters;

update display;

go to p.declare

end entvirt;

comment call on normal virtual procedure;

procedure CVP (cl,index,acs);

integer index;

ref (object) acs; ref (driver) cl;

begin ref (prototype) p,q;

p :- cl.obj.PP;

q :- p.progaddr(index) qua prototype;

if q == none then error ("cvp",1);

entvirt (q,cl,false,acs)

end CDVP;

comment call on connected virtual procedure;

```
procedure CCVP (c,index,acs);  
  integer index;  
  ref (object) acs; ref (driver) c;  
  begin ref (prototype) p,q;  
    p := c.obj.PP;  
    q := p.progaddr(index) qua prototype;  
    if q == none then error ("CCVP",1);  
    c := new driver (c.obj,c.cdrp,none,none,none,  
      false,p.level);  
    c.con := true;  
    entvirt (q,c,true,acs)  
  end CCVP;
```

```
procedure CDVP(c,index,slc,acs);  
  integer index;  
  ref (object) c,acs; ref (driver) slc;  
  begin ref (prototype) p;  
    p := c.PP.progaddr (index) qua prototype;  
    if p == none then error ("CDVP",1);  
    slc := new driver (c,slc,none,none,none,  
      false,p.level-1);  
    slc.con := true;  
    entvirt (p,slc,true,acs)  
  end CDVP;
```

comment CLASSES;

comment GENERATING REFERENCE;

comment begin class, enters declaration code if no parameters, otherwise continue with in-line parameter evaluation and return is later through ENTER.

procedure BC (x,slx,acs);

ref (prototype) x; ref (object) slx;

ref (object) acs;

begin ref (driver) y; ref (prototype) q;

 y := new driver (new object(x),slx.MDP,exit,CD,acs,
 true,x.level);

 y.ob := true; y.obj.MDP := y;

if x.nrp \neq 0 then

begin y := new driver (CD.obj,CD.drp,none,y,none,
 false,CD.level);

 y.con := CD.con;

 y.cdrp := CD.cdrp;

 CD := y;

 DDISPLAY[CD.level] := CD;

go to exit

end else CD := y;

 update display;

go to CD.obj.PP.prefix[0].declare

end BC;

comment begin class return, signifies the end of declaration code in a class.

procedure BCR(q); integer q;

begin ref (prototype) x,y;

 x := CD.obj.PP;

 y := x.prefix[q+1];

if y \neq none then go to y.declare;

go to x.prefix[0].statements

end BCR;

comment procedure corresponding to the statement inner;

```
procedure CINNER (lev); integer lev;  
  begin ref (prototype) p;  
    p :- CD.obj.PP.prefix[lev+1];  
    if p =/= none then go to p.statements  
  end CINNER;
```

comment end class body;

```
ref (object) procedure ECB(p); ref (prototype) p;  
  begin ref (program) out; ref (driver) x;  
    procedure delete;  
      begin x.rp := false;  
        if x.obj.PP.local classes then  
          begin  
            x.drex :- x.drp;  
            x.pex :- none;  
            x.acs :- none;  
          end  
          else begin x.obj.MDP :- none;  
            deletenotice(x)  
          end  
        end delete;  
      if p.plev ≠ 0 then go to p.prefix [p.plev-1]  
        .inretur;  
      x :- CD;  
      if CD.rp and not CD.pb then  
        begin CD :- CD.drp; delete; go to L2;  
      L1: CD :- CD.drp;  
      L2: while not CD.rp do CD :- CD.drex;  
        if not CD.pb then go to L1;  
        x :- CD.drp;  
        while not x.rp do x :- x.drex;  
        x.drex :- CD;  
      L3: if CD.pex =/= none then go to L4;  
        CD :- CD.drex;  
        go to L3;  
      L4: out :- CD.pex;  
    end else
```

```
begin
  if x.pb then
    begin CD :- x.drp;
      out :- x.obj.PP.endblk;
      deletenotice (x);
      go to ud
    end else
    begin out :- x.pex;
      CD :- CD.drex;
      ECB :- x.obj;
      restore (x.acs);
      delete
    end
  end;
  update display;
  ud : go to out
end ECB;
```

comment PREFIXED BLOCK;

comment begin prefixed block, enter declarations or
evaluate parameters. If latter case, return through EPBPAR;

procedure BPB (x); ref (prototype) x;

begin ref (driver) a,y,z;

 z :- new driver (new object(x),CD,none,none,none,true,
 x.level)

 z.rp := z.ob := z.pb := true;

 z.obj.MDP :- z;

 a :- CD;

while not a.rp do a :- a.drex;

 a.pex :- none;

 a.drex :- z;

if x.nrp \neq 0 then

begin

 y :- new driver (CD.obj,CD.drp,none,z,none,false,
 CD.level);

 y.con := CD.con;

 y.cdrp :- CD.cdrp;

 CD :- y;

go to exit;

end else CD :- z;

 DISPLAY [x.level] :- CD.obj;

 DDISPLAY [x.level] :- CD;

go to x.prefix[0].declare

end BPB;

comment end prefixed block parameters;

procedure EPBPAR;

begin ref (driver) y;

 y :- CD;

 CD :- CD.drex;

 deletenotice(y);

 DISPLAY [CD.level] :- CD.obj;

 DDISPLAY [CD.level] :- CD;

go to CD.obj.PP.prefix[0].declare

end EPBPAR;

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comment begin prefixed block return, end declaration
code in prefixed block;

procedure BPBR;

go to CD.obj.PP.prefix[0].statements;

comment end prefixed block;

procedure EPB;

go to CD.obj.PP.prefix[CD.obj.PP.plev-1].inretur;

comment QUASI-PARALLEL SEQUENCING;

comment resume;

procedure resume (x);

ref (object) x;

begin

ref (driver) y,z;

Boolean b;

if x ≠ none then

begin

z :- x.MDP;

if z == none then error ("resume",1);

if not z.rp then error ("resume",2);

y :- CD;

while not y.rp do y :- y.drex;

y.drex :- CD;

y.pex :- exit;

CD :- z;

while CD.pex == none do CD :- CD.drex;

exit :- CD.pex;

CD :- CD.drex;

y :- z;

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```
L:   b := y.pb;  
      y :- y.drp;  
      while not y.rp do y :- y.drex;  
      if not b then go to L;  
      y.drex :- z;  
      update display;  
      go to exit  
    end  
    else error ("resume",3);  
end resume;
```


comment detach;

ref (object) procedure detach;

begin ref (driver) x,y; ref (program) out;

x :- CD;

if x.rp then

begin while not x.pb do

begin x :- x.drp;

while not x.rp do x :- x.drex;

end;

CD.pex :- exit;

CD.drex :- CD;

y :- x;

x :- x.drp;

while not x.rp do x :- x.drex;

x.drex :- y;

x.pex :- none;

while y.pex == none do y :- y.drex;

out :- y.pex;

CD :- y.drex;

end else

begin

out :- CD.pex;

y :- CD.drex;

CD.pex :- exit;

CD.drex :- CD;

CD.rp := true;

detach :- CD.obj;

restore (CD.acs);

CD.acs :- none;

CD :- y;

end;

update display;

go to out

end detach;

comment call (not part of Common Base);

procedure call (x);

ref (object) x;

begin ref (driver) a,y,z; ref (program) next;

if x =/= none then

begin z :- x.MDP;

if z == none then error ("call",1);

if not z.rp then error ("call",2);

 y :- z;

while y.pex == none do y :- y.drex;

 next :- y.pex;

 z.pex :- exit;

 a :- y.drex;

 z.drex :- CD;

 z.rp := false;

 CD :- a;

 update display;

go to next

end else error ("call",3)

end call;

comment PARAMETER EVALUATION (THUNK);

comment call (enter) thunk;

procedure CTH(tha,thu,acs);

ref (program) tha;

ref (object) acs; ref (driver) thu;

begin

 CD := new driver (thu.obj,thu.drp,exit,CD,acs,false,
 thu.level);

 CD.con := thu.con;

 CD.cdrp := thu.cdrp;

 update display;

go to tha

end CTH;

comment end thunk;

ref procedure ETH(addr); ref addr;

 ETH := epr(addr);

comment CONNECTION;

procedure CONNECT (p,b1);

ref (object) p; integer b1;

begin

 CD :- new driver (p,CD,none,CD,none,false,CD.level+1);

 CD.con := true;

 CD.cdrp :- DISPLAY[b1].MDP;

 DDISPLAY [CD.level] :- CD;

 DISPLAY [CD.level] :- p

end CONNECT;

comment RELATIONS;

comment check in;

Boolean procedure CIN(x,c);

ref (object) x; ref (prototype) c;

if x != none then

begin if x.PP.plev > c.plev then

 CIN := x.PP.prefix[c.plev] == c

end;

comment INSTANTANEOUS QUALIFICATION (QUA);

ref procedure CIQ (x,c);

ref (object) x; ref (prototype) c;

begin ref (prototype) d;

 d :- x.PP;

if d.plev < c.plev then error ("CIQ",1);

if d.prefix [c.plev] /= c then error ("CIQ",2);

 CIQ :- x

end CIQ;

comment GO TO STATEMENTS;

comment utility procedure conddel;

procedure conddel (x); ref (driver) x;

begin

if x.md then

begin if not x.obj.PP.local classes then

begin if x.dot then deletenotice (x.drp);

deletenotice (x); x.obj.MDP :- none; end

else begin x.drex :- x.drp; x.pex :- none;

x.acs :- none end

end

else if x.dot then

begin deletenotice (x.drp);

deletenotice (x)

end else deletenotice (x);

end conddel;

comment go to normal label;

procedure GL (b,m); ref (object) b; ref (program) m;

begin ref (driver) d; Boolean legal;

while CD.obj /= b or not CD.md do

begin if CD.rp then

begin d :- CD.drp;

if d == none then error ("GL",1);

legal := CD.pb;

end else d :- CD.drex;

conddel (CD);

CD :- d;

end;

if not legal then error ("GL",2);

go to m;

end GL;

comment go to virtual label;

procedure GVL (bl,index); integer bl,index;

begin ref (program) k;

 k :- DISPLAY [bl].PP.progaddr (index) qua program;

if k = none then error ("GVL",1);

 GL (DISPLAY [bl],k);

end GVL;

procedure storecollapse(req); integer req;

begin

integer kin, typ, pnr;

Boolean pa, va;

ref (object) objch, x, y, na, mta, mfa, pobj;

ref (driver) drchn, drv;

ref (program) pexit;

ref (notice) d, lm;

ref z;

procedure chain (x); ref (object) x;

if x ≠ none then

begin

if (x.MDP==none or x.MDP is driver) then

begin x.MDP :- objch; objch :- x end

end chain; .


```
procedure chain2(y); ref (driver) y;  
  begin y.referenced := true;  
  y.drch :- drchn; drchn :- y end chain2;
```

```
procedure map (x); ref (driver) x;  
  if x ≠ none then  
    begin  
      L0: if not x.referenced then  
        begin  
          if x.drex == none then go to L6;  
          while not x.rp do x :- x.drex;  
          while x.pex == none do x :- x.drex;  
        L3: x :- x.drex;  
        L4: x.referenced := true;  
          if x.con then  
            begin  
              if x.cdrp ≠ none then begin chain2(x);  
              go to L5; end  
              end else if x.dot then chain2 (x.drp);  
              chain (x.acs);  
              chain (x.obj);  
            L5: if not x.rp then go to L3;  
              if x.pb then begin x :- x.drp;  
              go to L4 end;  
              x :- x.drp; go to L0;  
            L6: chain (x.obj);  
              x :- x.drp;  
              go to L0  
          end  
        end map;
```

```
procedure upd1(n); ref (notice) n;  
  begin procedure upd(z); name z; ref (object) z;  
    if z ≠ none then z :- z.mdp;  
    upd (n.obj);  
    inspect n when driver do upd (acs);  
  end upd1;
```

```
procedure upd2(n); name n; ref (notice) n;  
  if n != none then  
    begin  
      if n < POOL2TOP then n := n.notc  
    end upd2;
```

```
procedure maptree(e); ref (eventnotice) e;  
  begin if e == none then go to ret;
```

```
  L:  map(e.obj.MDP);  
      e.referenced := true;  
      if e.RL != none then  
        begin e := e.RL; go to L end;  
      if e.LL != none then  
        begin e := e.LL; go to L end;
```

```
  M:  e := e.BL;  
      if e != none then  
        begin if e.LL.referenced  
          then go to M  
          else begin e := e.LL; go to L end;  
        end;
```

```
  ret: end maptree;
```

```
ref (ref) procedure asgn(z,i); ref (prototype) z; integer i;  
  inspect z when prototype do  
    begin kin := kind[i]; typ := type[i];  
    pa := par[i]; va := valu[i];  
    asgn := pobj+relad[i]; i := i+1 end asgn;
```

```
ref (ref) procedure firstpointer(x,L); value L; ref (object) x;  
label L;
```

```
  begin ref (prototype) z;  
    z := x.PP;  
    if z.nrpointers = 0 then go to L;  
    pnr := 1; pobj := x; pexit := L;  
    firstpointer := asgn (z,pnr)  
  end firstpointer;
```

```
ref (ref) procedure nextpointer;  
  begin ref (prototype) z;  
    z := pobj.PP;  
    if pnr > z.nrpointers then go to pexit;  
    nextpointer := asgn (z,pnr)  
  end nextpointer;
```

```
procedure move (x,y,i); ref x,y; integer i;;
```

```
comment pass 1;
```

```
x := CD;  
while not x.rp do x := x.drex;  
x.pex := exit;  
x.drex := CD;  
POOL1LAST.val := none;  
map (CD);
```

L:

```
if objch /= none then  
  begin x := objch; objch := x.MDP; x.MDP := x;  
    z := firstpointer (x,L).val;  
    r: inspect z when object do  
      begin if MDP == none then chain (z)  
        else if MDP is driver then map(MDP)  
      end  
      when driver do map (this driver)  
      when eventnotice do maptree (this eventnotice);  
      z := nextpointer.val;  
      go to r  
    end;
```

rep2:

```
if drchn /= none then  
  begin drv := drchn; drchn := drv.drch;  
    inspect drv when driver do  
    inspect obj when object do  
    begin if MDP == none then chain (obj)  
    else if MDP is driver then map (MDP);  
  end;
```

```
    if cdrp =/= none then map (cdrp); drv.referenced := true  
end;  
    go to rep2  
end else if objch =/= none then go to L;
```

```
comment pass 2;
```

```
y := none;
```

```
na := x := POOL1FIRST;
```

```
nextblock:
```

```
    if x.MDP =/= x then
```

```
        begin if y == none then
```

```
            begin y := x; x.PP := none end
```

```
        end
```

```
    else begin x.MDP := na;
```

```
        na := na+x.PP.lg;
```

```
        if y =/= none then begin y.MDP := x; y := none end
```

```
    end;
```

```
x := x+x.PP.lg;
```

```
if x.PP =/= none then go to nextblock;
```

```
if y =/= none then y.MDP := none else x.MDP := none;
```

```
comment pass 3;
```

```
d := POOL2BOTTOM;
```

```
used:
```

```
    if d.referenced then
```

```
        begin upd1(d);
```

```
            d.referenced := false;
```

```
            if d == POOL2TOP then go to pass3end;
```

```
            d := d-drlg;
```

```
            go to used
```

```
    end;
```

unused:

```
if not POOL2TOP.referenced then  
  begin  
    POOL2TOP :- POOL2TOP+drlg;  
    if POOL2TOP == d then begin POOL2TOP :- POOL2TOP-drlg;  
    go to pass3end end else go to  
      unused  
    end;
```

```
move (POOL2TOP,d,drlg);  
POOL2TOP.notc :- d;  
d.referenced := false;  
updl(d);  
lm :- d;  
POOL2TOP :- POOL2TOP+drlg;  
d :- d-drlg;  
if d > POOL2TOP then go to used else  
  if not (d == POOL2TOP and d.referenced) then POOL2TOP :-  
    lm else  
      begin updl(d); d.referenced := false end;
```

pass3end:

comment pass 4;

x :- POOL1FIRST;

upnext:

y :- firstpointer (x,m);

update:

```
z :- y.val;  
inspect z when notice do  
  if z < POOL2TOP then y.val :- notc  
when object do y.val :- MDP;  
y :- nextpointer;  
go to update;
```

m:

```
x :- x+x.PP.lg;  
if x.PP /= none then go to upnext;  
x :- x.MDP;  
if x /= none then go to upnext;
```

comment pass 5;

mta :- x :- POOL1FIRST;

mfa :- x;

go to entpass5;

clear:

x.MDP :- none;

x :- x+x.PP.lg;

entpass5: if x.PP != none then go to clear;

if mfa != mta then move (mfa,mta,x-mfa);

mta :- mta+x-mfa;

x :- x.MDP;

mfa :- x;

if x != none then go to clear:

POOL1LAST :- mta;

comment pass 6;

d :- POOL2BOTTOM

nextnotice:

inspect d when eventnotice do

begin upd2(BL); upd2(LL); upd2(RL) end

when driver do

begin

upd2(drex); upd2(drp); upd2(erp);

upd2(cdrp);

if md then obj.MDP :- this driver

end;

if d != POOL2TOP then begin d :- d-drlg; go to nextnotice

end;

upd2(CD);

update display;

nothead :- none;

if req > POOL2TOP-POOL1LAST then

error ("storecollapse",1);

end storecollapse

end runtime system