Pascal Users Group

NUMBER 22 & 23

Pascal News

COMMUNICATIONS ABOUT THE PROGRAMMING LANGUAGE PASCAL BY PASCALERS

SEPTEMBER, 1981

Two for one ...

Or one for two?

* Pascal News is the official but informal publication of the User's Group.

* Pascal News contains all we (the editors) know about Pascal; we use it as the vehicle to answer all inquiries because our physical energy and resources for answering individual requests are finite. As PUG grows, we unfortunately succumb to the reality of:

  1. Having to insist that people who need to know "about Pascal" join PUG and read Pascal News - that is why we spend time to produce it!

  2. Refusing to return phone calls or answer letters full of questions - we will pass the questions on to the readership of Pascal News. Please understand what the collective effect of individual inquiries has at the "concentrators" (our phones and mailboxes). We are trying honestly to say: "We cannot promise more that we can do."

* Pascal News is produced 3 or 4 times during a year; usually in March, June, September, and December.

* ALL THE NEWS THAT'S FIT, WE PRINT. Please send material (brevity is a virtue) for Pascal News single-spaced and camera-ready (use dark ribbon and 18.5 cm lines!)

* Remember: ALL LETTERS TO US WILL BE PRINTED UNLESS THEY CONTAIN A REQUEST TO THE CONTRARY.

* Pascal News is divided into flexible sections:

  POLICY - explains the way we do things (ALL-PURPOSE COUPON, etc.)

  EDITOR'S CONTRIBUTION - passes along the opinion and point of view of the editor together with changes in the mechanics of PUG operation, etc.

  HERE AND THERE WITH PASCAL - presents news from people, conference announcements and reports, new books and articles (including reviews), notices of Pascal in the news, history, membership rosters, etc.

  APPLICATIONS - presents and documents source programs written in Pascal for various algorithms, and software tools for a Pascal environment; news of significant applications programs. Also critiques regarding program/algorithm certification, performance, standards conformance, style, output convenience, and general design.

  ARTICLES - contains formal, submitted contributions (such as Pascal philosophy, use of Pascal as a teaching tool, use of Pascal at different computer installations, how to promote Pascal, etc.).

  OPEN FORUM FOR MEMBERS - contains short, informal correspondence among members which is of interest to the readership of Pascal News.

  IMPLEMENTATION NOTES - reports news of Pascal implementations: contacts for maintainers, implementors, distributors, and documentors of various implementations as well as where to send bug reports. Qualitative and quantitative descriptions and comparisons of various implementations are publicized. Sections contain information about Portable Pascals, Pascal Variants, Feature-Implementation Notes, and Machine-Dependent Implementations.

- - - - - - ALL-PURPOSE COUPON - - - - - - (15-Dec-81)

Pascal Users Group
P.O. Box 4406
Allentown, Pa. 18104-4406 USA

Note

- We will not accept purchase orders.
- Make checks payable to: "Pascal Users Group", drawn on a U.S. bank in U.S. dollars.
- Note the discounts below, for multi-year subscription and renewal.
- The U. S. Postal Service does not forward Pascal News.

- -

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JOINING PASCAL USERS GROUP?

- Membership is open to anyone: Particularly the Pascal user, teacher, maintainer, implementor, distributor, or just plain fan.
- Please enclose the proper prepayment (check payable to "Pascal User's Group"); we will not bill you.
- Please do not send us purchase orders; we cannot endure the paper work!
- When you join PUG any time within a year: January 1 to December 31, you will receive all issues of Pascal News for that year.
- We produce Pascal News as a means toward the end of promoting Pascal and communicating news of events surrounding Pascal to persons interested in Pascal. We are simply interested in the news ourselves and prefer to share it through Pascal News. We desire to minimize paperwork, because we have other work to do.

- American Region (North and South America) Join through PUG(USA).

- European Region (Europe, North Africa, Western Asia): Join through PUG(EUR) Pascal Users Group, c/o Grado Computer Systems & Software, Weissenburgerstrasse 25, D-8000, Munchen 80, Germany.

- United Kingdom Region : join through PUG(UK) : Pascal Users Group, c/o Shetlandtel, Walls, Shetland, ZE2 9PF, United Kingdom.

- Australasian Region (Australia, East Asia - incl.India & Japan): PUG(AUS). Pascal Users Group, c/o Arthur Sale, Department of Information Science, University of Tasmania, Box 252C GPO, Hobart, Tasmania 7001, Australia. International telephone: 61-02-202374

RENEWING?

- Please renew early (before November) and please write us a line or two to tell us what you are doing with Pascal, and tell us what you think of PUG and Pascal News. Renewing for more than one year saves us time.

ORDERING BACK ISSUES OR EXTRA ISSUES?

- Our unusual policy of automatically sending all issues of Pascal News to anyone who joins within a year means that we eliminate many requests for backissues ahead of time, and we don't have to reprint important information in every issue--especially about Pascal implementations!

- Issues 1 .. 8 (January, 1974 - May 1977) are out of print.

- Issues 9 .. 12, 13 .. 16, & 17 .. 20 are available from PUG(USA) all for $15.00 a set, and from PUG(AUS) all for $A15.00 a set.

- Extra single copies of new issues (current academic year) are: $5.00 each - PUG(USA); and $A5.00 each - PUG(AUS).

SENDING MATERIAL FOR PUBLICATION?

- Your experiences with Pascal (teaching and otherwise), ideas, letters, opinions, notices, news, articles, conference announcements, reports, implementation information, applications, etc. are welcome. Please send material single-spaced and in camera-ready (use a dark ribbon and lines 18.5 cm. wide) form.
- All letters will be printed unless they contain a request to the contrary.

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APPLICATION FOR LICENSE TO USE VALIDATION SUITE FOR PASCAL

Name and address of reqestor: ______________________________

(Company name if requestor is a company): ______________________________

____

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Richard J. Cichelli
On behalf of A.H.J. Sale and R.A.Freak

Editor's Contribution

GOOFED AGAIN

Yes as all you loyal Pensylvanians have noticed in the last issue of PN we managed to mess up the zip code of Allentown PA, and of course the USPS has come down on us like a ton of bricks! Please note that the zip is 18014 not 18170. It has been corrected in the new APC.

THE NEW APC

Speaking of the new APC, we have simplified it some more, and added current prices for the UK and Europe, and have modified the reverse side of the coupon to reflect the new foreign editors, and their current addresses.

THE LATEST EUROPEAN SOLUTION

Speaking of the European editors, we have two new ones! One for the UK, and one for the Continent. Nick Hughes will be handling all business for Britain, and Hellmut Weber will be in charge of the European Region. Please see the APC for their addresses.

ON CALLING

Please restrict yourself to written correspondence when dealing with PUG. This is strictly a scholarly function. None of the editors (including myself) gets paid. All have a real job that pays their bills, and they owe their office hours to their employer. All PUG work is donated on their own time. So please write to the appropriate regional editor. It leaves a documentary trail that can be followed and handled as fast as we can. Honest!

COMBINED ISSUE

This is of course a combined issue. We are doing this to catch up and to beat the postal system and their high rates. If this upsets anyone we are sorry. We are doing our best.

ON BEING THE EDITOR

Anyone who is interested in being the new editor of PN should write to me at the main address (APC).

STANDARDS

Good news from the standard front! 7185.1 was approved by the international committee. More next issue from Jim Miner the Standards Editor.

THIS ISSUE

The highlight of ths issue is the long awaited (from last issue at least!) of Andrew Tanenbaum's EM1 compiler. I think it is really great. Tell us what you think! In the Here and There section Gregg Marshall has summarized the past few issues (15 .. 19) implementation notes. Thanx. In addition to the EM1 compiler, the Applications section includes an improved version of the subroutine "options", as well as a tree printing routine, and a set of routines to compress and expand text using Huffman codes. Good work! And finally the articles section has some fine contributions. Many people have asked (on the phone ... see above) about how the various CP/m compilers stack up. Now we have an answer. Also there is an article of the experiences of a novice teaching Pascal. From a geography teacher no less! And finally a probing article by Jonathan Yavner concerning problems with Pascal and some proposals for their solution.

Hope you like it.

Rick

Here and There With Pascal

Summary of Implementations

Implementation	Reference	Notes
ALL	#15:101	Pascal I (Derived from Pascal S)
BESM-6	#15:107	
Burroughs B5700	#15:107	
Burroughs B6700/B7700 (MCP)	#19:113	
CDC 6000	#19:115	
CDC 6000	#15:108	
Cyber 70 and 170	#15:108	
DEC PDP-11	#19:115	UCSD Pascal
DEC PDP-11	#15:111	
DEC PDP-11	#15:112	UCSD Pascal
DEC PDP-11	#15:124	
DEC PDP-11 (RSTS)	#15:100	Pascal S
DEC PDP-11 (RSX-11M/IAS)	#17:86	
DEC PDP-11 (RSX-11M/RT-11)	#15:101	Concurrent Pascal
DEC PDP-11 (Unix)	#15:111	
DEC PDP-11 (Unix)	#15:100	Pascal E
DEC PDP-11 (Unix)	#15:103	Modula
DEC PDP-15	#15:124	
DEC VAX	#17:89	
DEC VAX (Unix)	#19:115	
DG Eclipse	#17:106	
DG Eclipse (AOS	#15:110	RDOS,DOS)
DG Eclipse (AOS)	#15:109	
DG Eclipse (RDOS)	#15:108	
DG Nova (AOS	#15:110	RDOS,DOS)
Digico Micro 16E	#15:113	
Facom 230-45S	#15:112	
General Electric GEC4082	#15:113	
Golem B (GOBOS)	#17:104	
HP 1000	#19:116	
Honeywell 6000 (GCOS III)	#15:113	
Honeywell Level 6	#15:113	
IBM 3033	#19:120	
IBM 360/370	#15:114	
IBM 360/370	#15:115	
IBM 370	#17:104	
IBM 370	#19:117	
IBM 370	#15:124	
IBM 370	#17:102	
IBM 370/303x/43xx	#19:117	
IBM Series 1	#19:116	
IBM Series 1	#15:114	
ICL 1900	#15:116	
Intel 8080/8085	#15:119	
Intel 8080/8085	#15:118	
Intel 8080/8085	#15:119	
Intel 8080/8085	#17:102	
Intel 8080/8085	#15:117	
Intel 8080/8085 (CP/M)	#17:105	
Intel 8080/8085 (TRS-80)	#15:100	
Intel 8080/8085 (Northstar)	#15:100	
Intel 8086	#15:119	
Intel 8086	#15:103	
MOS Tech 6502 (Apple)	#15:107	
Modcomp II and IV	#15:120	
Motorola 6800	#15:120	
Motorola 6800	#19:120	
Motorola 6800	#19:121	
Motorola 6800	#17:102	
Motorola 6800 (Flex)	#15:123	
Motorola 68000	#19:121	
Motorola 6809	#15:103	
Motorola 6809 (MDOS09)	#17:102	
Nord 10 and 100 (Sintran III)	#15:121	
Perkin-Elmer 3220	#15:122	
Perkin-Elmer 7/16	#15:121	
RCA 1802	#17:103	
RCA 1802	#15:122	
Siemens 7.748	#15:124	
Sperry-Univac V77	#15:124	
Texas Instruments 990	#17:101	
Texas Intruments 9900	#15:124	
Zilog Z-80	#15:124	
Zilog Z-80	#19:123	
Zilog Z-80	#15:124	
Zilog Z-80	#17:88	
Zilog Z-80	#17:104	
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Zilog Z-80 (TRS-80)	#15:124	
Zilog Z-80 (TRS-80)	#19:124	
Zilog Z80	#15:118	
Zilog Z80	#15:119	
Zilog Z8000	#15:119	

Applications

EM1 COMPILER

```
1    #include "../h/local.h"
2    #include "../h/em1.h"

4    { (c) copyright 1980 by the Vrije Universiteit, Amsterdam, The Nether-
5      lands.  Explicit permission is hereby granted to universities to use
6      or duplicate this program for educational or research purposes.  All
7      other  use or duplication  by universities,  and all use or duplica-
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12          Dr. Andrew S. Tanenbaum
13          Wiskundig Seminarium
14          Vrije Universiteit
15          Postbox 7161
16          1007 MC Amsterdam
17          The Netherlands

19     Organizations wishing to modify part of this software for subsequent
20     sale  must   explicitly  apply  for   permission.  The exact arrange-
21     ments will be worked out on a case by case basis, but at  a  minimum
22     will require the organization to include the following notice in all
23     software and documentation based on our work:

25              This  product  is  based  on   the   Pascal    system
26          developed   by  Andrew   S.  Tanenbaum, Johan W. Stevenson
27          and Hans van Staveren of the Vrije  Universiteit,  Amster-
28          dam, The Netherlands.
29   }

31   {if next line is included the compiler is written in standard pascal}
32   {#define        STANDARD        1}

34   {if next line is included, then code is produced for segmented memory}
35   {#define        SEGMENTS        1}

37   {Author:        Johan Stevenson                   Version:        31}
38   {$l- : no source line numbers}
39   {$r- : no subrange checking}
40   {$a- : no assertion checking}
41   #ifdef STANDARD
42   {$s+ : test conformancy to standard}
43   #endif

45   program pem(input,em1,errors);
46   { This Pascal compiler produces EM1 code as described in
47      - A.S.Tanenbaum, J.W.Stevenson & H. van Staveren,
48          "Description of a experimental machine architecture for use of
49           block structured languages" Informatika rapport 54.
50     A description of Pascal is given in
51      - K.Jensen & N.Wirth,PASCAL user manual and report,Springer-Verlag.
52     Several options may be given in the normal pascal way. Moreover,
53     a positive number may be used instead of + and -. The options are:
54          a:      interpret assertions (+)
55          c:      C-type strings allowed (-)
56          d:      type long may be used (-)
57          f:      size of reals in words (2)
58          i:      controls the number of bits in integer sets (16)
59          l:      insert code to keep track of source lines (+)
60          o:      optimize (+)
61          p:      size of pointers in words (1)
62          r:      check subranges (+)
63          s:      accept only standard pascal programs (-)
64          t:      trace procedure entry and exit (-)
65          u:      treat '_' as letter (-)
66   }
67   {===============================================================}
68   #ifdef STANDARD
69   label 9999;
70   #endif

72   const

74   {powers of two}
75     t7            = 128;
76     t8m1          = 255;
77     t8            = 256;
78     t14           = 16384;
79     t15m1         = 32767;

81   {EM-1 sizes}
82     bytebits      = 8;
83     wordbits      = 16;
84     wbm1          = 15;           {wordbits-1}
85     minint        = -t15m1;
86     maxint        = t15m1;
87     maxintstring  = '0000032767';
88     maxlongstring = '2147483647';

90     bytesize      = 1;
91     wordsize      = 2;
92     addrsize      = wordsize;
93     pnumsize      = wordsize;
94     shortsize     = wordsize;
95     longsize      = 4;
96   #ifdef SFLOAT
97     floatsize     = 4;
98   #endif
99   #ifndef SFLOAT
100    floatsize     = 8;
101  #endif

103  {Pascal sizes. for ptrsize, realsize and fhsize see handleopts}
104   { EM-1 requires that objects greater than a single byte start at  a
105     word  boundary,  so their address is even.  Normally, a full word
106     is also allocated for objects of a single byte.  This extra  byte
107     is really allocated to the object, not only skipped by alignment,
108     i.e. if the value false is assigned to a  boolean  variable  then
109     both bytes are cleared.  For single byte objects in packed arrays
110     or packed records, however, only one byte is allocated,  even  if
111     the next byte is unused.  Strings are packed arrays.  The size of
112     pointers is 2 by default, but can be changed at  runtime  by  the
```

```
113        p-option.   Floating point numbers in EM-1 currently have size 4,
114        but this might change in the future to 8.   The  default  can  be
115        overwritten  by  the f-option. The routines involved with align-
116        ment are 'even', 'address' and 'arraysize'.
117      }
118      boolsize       = bytesize;
119      charsize       = bytesize;
120      intsize        = shortsize;
121      buffsize       = 512;
122      maxsetsize     = 4096;         {t15 div bytebits}

124    {maximal indices}
125      idmax          = 8;
126      fnmax          = 14;
127      smax           = 72;
128      rmax           = 72;
129      imax           = 10;

131    {opt values}
132      off            = 0;
133      on             = 1;

135    {for push and pop: }
136      global         = false;
137      local          = true;

139    {set bounds}
140      minsetint      = 0;
141      maxsetint      = 15;           {default}

143    {constants describing the compact EM1 code}
144      MAGICLOW       = 172;
145      MAGICHIGH      = 0;
146      meserror       = 0;
147      mesoptoff      = 1;
148      mesvirtual     = 2;
149      mesreg         = 3;
150      meslino        = 4;
151      mesfloats      = 5;

153    {ASCII characters}
154      tab            = 9;
155      newline        = 10;
156      hortab         = 11;
157      formfeed       = 12;
158      carret         = 13;

160    {miscellaneous}
161      maxsg          = 127;          {maximal segment number}
162      maxcharord     = 127;          {maximal ordinal number of chars}
163      maxargc        = 13;           {maximal index in argv}
164      rwlim          = 34;           {number of reserved words}
165      spaces         = '        ';
166      emptyfnam      = '              ';

168    {-------------------------------------------------------------------}
```

```
169  type
170  {scalar types}
171    symbol=      (comma,semicolon,colon1,colon2,notsy,lbrack,ident,
172                  intcst,charcst,realcst,longcst,stringcst,nilcst,minsy,
173                  plussy,lparent,arrow,arraysy,recordsy,setsy,filesy,
174                  packedsy,progsy,labelsy,constsy,typesy,varsy,procsy,
175                  funcsy,beginsy,gotosy,ifsy,whilesy,repeatsy,forsy,
176                  withsy,casesy,becomes,starsy,divsy,modsy,slashsy,
177                  andsy,orsy,eqsy,nesy,gtsy,gesy,ltsy,
178                  lesy,insy,endsy,elsesy,untilsy,ofsy,dosy,
179                  downtosy,tosy,thensy,rbrack,rparent,period
180                 );                      {the order is important}
181    chartype=    (lower,upper,digit,layout,tabch,
182                    quotech,dquotech,colonch,periodch,lessch,
183                    greaterch,lparentch,lbracech,
184                                                 {different entries}
185                  rparentch,lbrackch,rbrackch,commach,semich,arrowch,
186                    plusch,minch,slash,star,equal,
187                                                 {also symbols}
188                  others
189                 );
190    standpf=     (pread,preadln,pwrite,pwriteln,pput,pget,
191                  preset,prewrite,pnew,pdispose,ppack,punpack,
192                  pmark,prelease,ppage,phalt,
193                                                 {all procedures}
194                  feof,feoln,fabs,fsqr,ford,fchr,fpred,fsucc,fodd,
195                  ftrunc,fround,fsin,fcos,fexp,fsqrt,fln,farctan
196                                                 {all functions}
197                 );                      {the order is important}
198    libmnem=     (ELN ,EFL ,CLS ,WDW ,           {input and output}
199                  OPN ,GETX,RDI ,RDC ,RDR ,RDL ,RLN ,
200                                                 {on inputfiles}
201                  CRE ,PUTX,WRI ,WSI ,WRC ,WSC ,WRS ,WSS ,WRB ,
202                  WSB ,WRR ,WSR ,WRL, WSL, WRF ,WRZ ,WSZ ,WLN ,PAG ,
203                                      {on outputfiles, order important}
204                  ABR ,RND ,SIN ,COS ,EXPX,SQT ,LOG ,ATN ,
205                                                 {floating point}
206                  ABI ,ABL ,BCP ,BTS ,NEWX,SAV ,RST ,INI ,HLT ,
207                  ASS ,GTO ,PAC ,UNP, DIS, ASZ, MDI, MDL
208                                                 {miscellaneous}
209                 );
210    structform=  (scalar,subrange,pointer,power,files,arrays,carray,
211                  records,variant,tag);          {order important}
212    structflag=  (spack,withfile);
213    identflag=   (refer,used,assigned,noreg,samesect);
214    idclass=     (types,konst,vars,field,carrbnd,proc,func);
215    kindofpf=    (standard,formal,actual,extrn,forwrd);
216    where=       (blck,rec,wrec);
217    attrkind=    (cst,fixed,pfixed,loaded,ploaded,indexed);
218    twostruct=   (eq,subeq,ir,ri,il,li,lr,rl,es,se,noteq);
219                                                 {order important}

221  {subrange types}
222    sgrange=     0..maxsg;
223    idrange=     1..idmax;
224    fnrange=     1..fnmax;
```

```
225     rwrange=      0..rwlim;
226     byte=         0..t8m1;

228   {pointer types}
229     sp=   ^structure;
230     ip=   ^identifier;
231     lp=   ^labl;
232     bp=   ^blockinfo;
233     np=   ^nameinfo;

235   {set types}
236     sos=          set of symbol;
237     setofids=     set of idclass;
238     formset=      set of structform;
239     sflagset=     set of structflag;
240     iflagset=     set of identflag;

242   {array types}
243     alpha =packed array[idrange] of char;
244     fntype=packed array[fnrange] of char;

246   {record types}
247     errec=record
248       erno:integer;                {error number}
249       mess:alpha;                  {identifier parameter if required}
250       mesi:integer;                {numeric parameter if required}
251       chno:integer;                {column number}
252       lino:integer;                {line number}
253       linr:integer;                {relative to start of (included) file}
254       orig:integer;                {idem, but before preprocessing}
255       fnam:fntype;                 {source file name}
256     end;

258     position=record                {the addr info of certain variable}
259       ad:integer;                  {for locals it is the byte offset}
260       lv:integer;                  {the level of the beast}
261   #ifdef SEGMENTS
262       sg:sgrange                   {only relevant for globals (lv=0) }
263   #endif
264     end;

266   {records of type attr are used to remember qualities of
267     expression parts to delay the loading of them.
268     Reasons to delay the loading of one word constants:
269           - bound checking
270           - set building.
271     Reasons to delay the loading of direct accessible objects:
272           - efficient handling of read/write
273           - efficient handling of the with statement.
274   }
275     attr=record
276       asp:sp;                          {type of expression}
277       packbit:boolean;                 {true for packed elements}
278       ak:attrkind;                     {access method}
279       pos:position;                    {sg, lv and ad}
280       {If ak=cst then the value is stored in ad}
```

```
281     end;

283     nameinfo=record               {one for each separate name space}
284       nlink:np;                   {one deeper}
285       fname:ip;                   {first name: root of tree}
286       case occur:where of
287         blck:();
288         rec: ();
289         wrec:(wa:attr)            {name space opened by with statement}
290     end;

292     blockinfo=record        {all info of the current procedure}
293       nextbp:bp;            {pointer to blockinfo of surrounding proc}
294       lc:integer;           {data location counter (from begin of proc) }
295       ilbno:integer;        {number of last local label}
296       forwcount:integer;    {number of not yet specified forward procs}
297       lchain:lp;            {first label: header of chain}
298     end;

300     structure=record
301       size:integer;                       {size of structure in bytes}
302       sflag:sflagset;                     {flag bits}
303       case form:structform of
304         scalar   :(scalno:integer;        {number of range descriptor}
305                    fconst:ip              {names of constants}
306                   );
307         subrange:(min,max:integer;        {lower and upper bound}
308                    rangetype:sp;          {type of bounds}
309                    subrno:integer         {number of subr descriptor}
310                   );
311         pointer :(eltype:sp);             {type of pointed object}
312         power   :(elset:sp);              {type of set elements}
313         files   :(filtype:sp);            {type of file elements}
314         arrays,carray:
315                   (aeltype:sp;            {type of array elements}
316                    inxtype:sp;            {type of array index}
317                    arpos:position         {position of array descriptor}
318                   );
319         records :(fstfld:ip;              {points to first field}
320                    tagsp:sp               {points to tag if present}
321                   );
322         variant :(varval:integer;         {tag value for this variant}
323                    nxtvar:sp;             {next equilevel variant}
324                    subtsp:sp              {points to tag for sub-case}
325                   );
326         tag     :(fstvar:sp;              {first variant of case}
327                    tfldsp:sp              {type of tag}
328                   )
329     end;

331     identifier=record
332       idtype:sp;                          {type of identifier}
333       name:alpha;                         {name of identifier}
334       llink,rlink:ip;                     {see enterid,searchid}
335       next:ip;                            {used to make several chains}
336       iflag:iflagset;                     {several flag bits}
```

```
337       case klass:idclass of
338         types   :();
339         konst   :(value:integer);         {for integers the value is
340                     computed and stored in this field.
341                     For strings and reals an assembler constant is
342                     defined labeled '.1', '.2', ...
343                     This '.' number is then stored in value.
344                     For reals value may be negated to indicate that
345                     the opposite of the assembler constant is needed. }
346         vars    :(vpos:position);         {position of var}
347         field   :(foffset:integer);       {offset to begin of record}
348         carrbnd :();                      {idtype points to carray}
349         proc,func:
350           (case pfkind:kindofpf of
351              standard:(key:standpf);      {identification}
352              formal,actual,forwrd,extrn:
353                (pfpos:position;           {lv gives declaration level.
354                            sg gives instruction segment of this proc and
355                            ad is relevant for formal pf's and for
356                            functions (no conflict!!).
357                            for functions: ad is the result address.
358                            for formal pf's: ad is the address of the
359                            descriptor }
360                 pfno:integer;             {unique pf number}
361                 parhead:ip;               {head of parameter list}
362                 headlc:integer            {lc when heading scanned}
363                )
364           )
365     end;

367     labl=record
368       nextlp:lp;           {chain of labels}
369       seen:boolean;
370       labval:integer;      {label number given by the programmer}
371       labname:integer;     {label number given by the compiler}
372       labdlb:integer       {zero means only locally used,
373                              otherwise dlbno of label information}
374     end;

376   {--------------------------------------------------------------------}
377   var  {the most frequent used externals are declared first}
378     sy:symbol;              {last symbol}
379     a:attr;                 {type,access method,position,value of expr}
380   {returned by insym}
381     ch:char;                {last character}
382     chsy:chartype;          {type of ch, used by insym}
383     val:integer;            {if last symbol is an constant }
384     ix:integer;             {string length}
385     eol:boolean;            {true if current ch replaces a newline}
386     zerostring:boolean;     {true for strings in " "}
387     id:alpha;               {if last symbol is an identifier}
388   {some counters}
389     lino:integer;           {line number on code file (1..n) }
390     dlbno:integer;          {number of last global number}
391     lcmax:integer;          {keeps track of maximum of lc}
392     level:integer;          {current static level}
393     ptrsize:integer;
394     realsize:integer;
395     fhsize:integer;         {file header size}
396     argc:integer;           {index in argv}
397     lastpfno:integer;       {unique pf number counter}
398     copt:integer;           {C-type strings allowed if on}
399     dopt:integer;           {longs allowed if on}
400     iopt:integer;           {number of bits in sets with base integer}
401     sopt:integer;           {standard option}
402   {pointers pointing to standard types}
403     realptr,intptr,textptr,emptyset,boolptr:sp;
404     charptr,nilptr,stringptr,longptr:sp;
405   {flags}
406     giveline:boolean;       {give source line number at next statement}
407     including:boolean;      {no LIN's for included code}
408     eofexpected:boolean;    {quit without error if true (nextch) }
409     main:boolean;           {complete programme or a module}
410     intypedec:boolean;      {true if nested in typedefinition}
411     fltused:boolean;        {true if floating point instructions are used}
412     seconddot:boolean;      {indicates the second dot of '..'}
413   {pointers}
414     fwptr:ip;               {head of chain of forward reference pointers}
415     progp:ip;               {program identifier}
416     currproc:ip;            {current proc/func ip (see casestatement)}
417     top:np;                 {pointer to the most recent name space}
418     lastnp:np;              {pointer to nameinfo of last searched ident }
419   {records}
420     b:blockinfo;            {all info to be stacked at pfdeclaration}
421     e:errec;                {all info required for error messages}
422     fa:attr;                {attr for current file name}
423   {arrays}
424     source:fntype;          {name of pascal source file}
425     strbuf:array[1..smax] of char;
426     iop:array[boolean] of ip;
427                             {false:standard input, true:standard output}
428     rw:array[rwrange] of alpha;
429                             {reserved words}
430     frw:array[0..idmax] of integer;
431                             {indices in rw}
432     rsy:array[rwrange] of symbol;
433                             {symbol for reserved words}
434     cs:array[char] of chartype;
435                             {chartype of a character}
436     csy:array[rparentch..equal] of symbol;
437                             {symbol for single character symbols}
438     lmn:array[libmnem] of packed array[1..4] of char;
439                             {mnemonics of pascal library routines}
440     opt:array['a'..'z'] of integer;
441     forceopt:array['a'..'z'] of boolean;
442                             {26 different options}
443     undefip:array[idclass] of ip;
444                             {used in searchid}
445     argv:array[0..maxargc] of
446           record name:alpha; ad:integer end;
447                             {save here the external heading names}
448   {files}
```

```
449       em1:file of byte;       {the EM1 code}
450       errors:file of errec;
451                                {the compilation errors}
452     {==================================================================}

454     procedure gen2bytes(b:byte; i:integer);
455     var b1,b2:byte;
456     begin
457       if i<0 then
458         if i<minint then begin b1:=0; b2:=t7 end
459         else begin i:=-i-1; b1:=t8m1 - i mod t8; b2:=t8m1 - i div t8 end
460       else begin b1:=i mod t8; b2:=i div t8 end;
461       write(em1,b,b1,b2)
462     end;

464     procedure gencst(i:integer);
465     begin
466       if (i>=0) and (i<sp_ncst0) then write(em1,i+sp_fcst0)
467       else gen2bytes(sp_cst2,i)
468     end;

470     procedure genclb(i:integer);
471     begin if i<t8 then write(em1,sp_ilb1,i) else gen2bytes(sp_ilb2,i) end;

473     procedure genilb(i:integer);
474     begin lino:=lino+1;
475       if i<sp_nilb0 then write(em1,i+sp_filb0) else genclb(i);
476     end;

478     procedure gendlb(i:integer);
479     begin if i<t8 then write(em1,sp_dlb1,i) else gen2bytes(sp_dlb2,i) end;

481     procedure gen0(b:byte);
482     begin write(em1,b); lino:=lino+1 end;

484     procedure gen1(b:byte; i:integer);
485     begin gen0(b); gencst(i) end;

487     procedure gend(b:byte; d:integer);
488     begin gen0(b); gendlb(d) end;

490     procedure genident(nametype:byte; var a:alpha);
491     var i,j:integer;
492     begin i:=idmax;
493       while (a[i]=' ') and (i>1) do i:=i-1;
494       write(em1,nametype,i);
495       for j:=1 to i do write(em1,ord(a[j]))
496     end;

498     procedure gensp(m:libmnem);
499     var i:integer;
500     begin gen0(op_cal); write(em1,sp_pnam,4);
501       for i:=1 to 4 do write(em1,ord(lmn[m][i]))
502     end;

504     procedure genpnam(b:byte; fip:ip);
```

```
505     var n:alpha; i,j:integer;
506     begin
507       if fip^.pfpos.lv<=1 then n:=fip^.name else
508         begin n:='        '; j:=1; i:=fip^.pfno;
509           while i<>0 do
510             begin j:=j+1; n[j]:=chr(i mod 10 + ord('0')); i:=i div 10 end;
511         end;
512       gen0(b); genident(sp_pnam,n)
513     end;

515     procedure genend;
516     begin write(em1,sp_cend) end;

518     procedure genlin;
519     begin giveline:=false;
520       if opt['l']<>off then if main then gen1(op_lin,e.orig)
521     end;

523     procedure genreg(ad,sz,nr:integer);
524     begin
525       if sz<=wordsize then
526         begin gen1(ps_mes,mesreg); gencst(ad); gencst(nr); genend end
527     end;

529     {==================================================================}

531     procedure puterr(err:integer);
532     {as you will notice, all error numbers are preceded by '+' and '0' to
533       ease their renumbering in case of new errornumbers.
534     }
535     begin e.erno:=err; write(errors,e);
536       if err>0 then begin gen1(ps_mes,meserror); genend end
537     end;

539     procedure error(err:integer);
540     begin e.mess:=spaces; e.mesi:= -1; puterr(err) end;

542     procedure errid(err:integer; var id:alpha);
543     begin e.mess:=id; e.mesi:= -1; puterr(err) end;

545     procedure errint(err:integer; i:integer);
546     begin e.mesi:=i; e.mess:=spaces; puterr(err) end;

548     procedure asperr(err:integer);
549     begin if a.asp<>nil then begin error(err); a.asp:=nil end end;

551     procedure teststandard;
552     begin if sopt<>off then error(-(+01)) end;

554     procedure enterid(fip: ip);
555     {enter id pointed at by fip into the name-table,
556       which on each declaration level is organised as
557       an unbalanced binary tree}
558     var nam:alpha; lip,lip1:ip; lleft,again:boolean;
559     begin nam:=fip^.name; again:=false;
560       lip:=top^.fname;
```

```
561      if lip=nil then top^.fname:=fip else
562        begin
563          repeat lip1:=lip;
564            if lip^.name>nam then
565              begin lip:=lip^.llink; lleft:=true end
566            else
567              begin if lip^.name=nam then again:=true;  {name conflict}
568                lip:=lip^.rlink; lleft:=false;
569              end;
570          until lip=nil;
571          if lleft then lip1^.llink:=fip else lip1^.rlink:=fip
572        end;
573      fip^.llink:=nil; fip^.rlink:=nil;
574      if again then errid(+02,nam);
575    end;

577    procedure initpos(var p:position);
578    begin p.lv:=level; p.ad:=0;
579    #ifdef SEGMENTS
580      p.sg:=0
581    #endif
582    end;

584    procedure inita(fsp:sp; fad:integer);
585    begin with a do begin
586      asp:=fsp; packbit:=false; ak:=fixed; pos.ad:=fad; pos.lv:=level;
587    #ifdef SEGMENTS
588      pos.sg:=0;
589    #endif
590    end end;

592    function newip(kl:idclass; n:alpha; idt:sp; nxt:ip):ip;
593    var p:ip; f:iflagset;
594    begin f:=[];
595      case kl of
596        types,carrbnd:  {similar structure}
597          new(p,types);
598        konst:
599          begin new(p,konst); p^.value:=0 end;
600        vars:
601          begin new(p,vars); f:=[used,assigned]; initpos(p^.vpos) end;
602        field:
603          begin new(p,field); p^.foffset:=0 end;
604        proc,func:  {same structure}
605          begin new(p,proc,actual); p^.pfkind:=actual;
606            initpos(p^.pfpos); p^.pfno:=0; p^.parhead:=nil; p^.headlc:=0
607          end
608      end;
609      p^.name:=n; p^.klass:=kl; p^.idtype:=idt; p^.next:=nxt;
610      p^.llink:=nil; p^.rlink:=nil; p^.iflag:=f; newip:=p
611    end;

613    function newsp(sf:structform; sz:integer):sp;
614    var p:sp; sflag:sflagset;
615    begin sflag:=[];
616      case sf of
617        scalar:
618          begin new(p,scalar); p^.scalno:=0; p^.fconst:=nil end;
619        subrange:
620          new(p,subrange);
621        pointer:
622          begin new(p,pointer); p^.eltype:=nil end;
623        power:
624          new(p,power);
625        files:
626          begin new(p,files); sflag:=[withfile] end;
627        arrays,carray:  {same structure}
628          new(p,arrays);
629        records:
630          new(p,records);
631        variant:
632          new(p,variant);
633        tag:
634          new(p,tag);
635      end;
636      p^.form:=sf; p^.size:=sz; p^.sflag:=sflag; newsp:=p;
637    end;

639    procedure init1;
640    var c:char;
641    begin
642    {initialize the first name space}
643      new(top,blck); top^.occur:=blck; top^.nlink:=nil; top^.fname:=nil;
644      level:=0;
645    {reserved words}
646      rw[ 0]:='if      ';   rw[ 1]:='do      ';   rw[ 2]:='of      ';
647      rw[ 3]:='to      ';   rw[ 4]:='in      ';   rw[ 5]:='or      ';
648      rw[ 6]:='end     ';   rw[ 7]:='for     ';   rw[ 8]:='nil     ';
649      rw[ 9]:='var     ';   rw[10]:='div     ';   rw[11]:='mod     ';
650      rw[12]:='set     ';   rw[13]:='and     ';   rw[14]:='not     ';
651      rw[15]:='then    ';   rw[16]:='else    ';   rw[17]:='with    ';
652      rw[18]:='case    ';   rw[19]:='type    ';   rw[20]:='goto    ';
653      rw[21]:='file    ';   rw[22]:='begin   ';   rw[23]:='until   ';
654      rw[24]:='while   ';   rw[25]:='array   ';   rw[26]:='const   ';
655      rw[27]:='label   ';   rw[28]:='repeat  ';   rw[29]:='record  ';
656      rw[30]:='downto  ';   rw[[illegible]]:='packed  ';   rw[32]:='program ';
657      rw[33]:='function';   rw[[illegible]]:='procedur';
658    {corresponding symbols}
659      rsy[ 0]:=ifsy;        rsy[ 1]:=dosy;        rsy[ 2]:=ofsy;
660      rsy[ 3]:=tosy;        rsy[ 4]:=insy;        rsy[ 5]:=orsy;
661      rsy[ 6]:=endsy;       rsy[ 7]:=forsy;       rsy[ 8]:=nilcst;
662      rsy[ 9]:=varsy;       rsy[10]:=divsy;       rsy[11]:=modsy;
663      rsy[12]:=setsy;       rsy[13]:=andsy;       rsy[14]:=notsy;
664      rsy[15]:=thensy;      rsy[16]:=elsesy;      rsy[17]:=withsy;
665      rsy[18]:=casesy;      rsy[19]:=typesy;      rsy[20]:=gotosy;
666      rsy[21]:=filesy;      rsy[22]:=beginsy;     rsy[23]:=untilsy;
667      rsy[24]:=whilesy;     rsy[25]:=arraysy;     rsy[26]:=constsy;
668      rsy[27]:=labelsy;     rsy[28]:=repeatsy;    rsy[29]:=recordsy;
669      rsy[30]:=downtosy;    rsy[31]:=packedsy;    rsy[32]:=progsy;
670      rsy[33]:=funcsy;      rsy[34]:=procsy;
671    {indices into rw to find reserved words fast}
672      frw[0]:= 0; frw[1]:= 0; frw[2]:= 6; frw[3]:=15; frw[4]:=22;
```

```
673       frw[5]:=28; frw[6]:=32; frw[7]:=33; frw[8]:=35;
674     {char types}
675       for c:=chr(0) to chr(maxcharord) do cs[c]:=others;
676       for c:='0' to '9' do cs[c]:=digit;
677       for c:='A' to 'Z' do cs[c]:=upper;
678       for c:='a' to 'z' do cs[c]:=lower;
679       cs[chr(newline)]:=layout;
680       cs[chr(hortab)]:=layout;
681       cs[chr(formfeed)]:=layout;
682       cs[chr(carret)]:=layout;
683     {characters with corresponding chartype in ASCII order}
684       cs[chr(tab)]:=tabch;
685       cs[' ']:=layout;      cs['"']:=dquotech;      cs['''']:=quotech;
686       cs['(']:=lparentch;   cs[')']:=rparentch;     cs['*']:=star;
687       cs['+']:=plusch;      cs[',']:=commach;       cs['-']:=minch;
688       cs['.']:=periodch;    cs['/']:=slash;         cs[':']:=colonch;
689       cs[';']:=semich;      cs['<']:=lessch;        cs['=']:=equal;
690       cs['>']:=greaterch;   cs['[']:=lbrackch;      cs[']']:=rbrackch;
691       cs['^']:=arrowch;     cs['{']:=lbracech;
692     {single character symbols in chartype order}
693       csy[rparentch]:=rparent;      csy[lbrackch]:=lbrack;
694       csy[rbrackch]:=rbrack;        csy[commach]:=comma;
695       csy[semich]:=semicolon;       csy[arrowch]:=arrow;
696       csy[plusch]:=plussy;          csy[minch]:=minsy;
697       csy[slash]:=slashsy;          csy[star]:=starsy;
698       csy[equal]:=eqsy;
699     end;

701     procedure init2;
702     var p,q:ip; k:idclass;
703     begin
704     {undefined identifier pointers used by searchid}
705       for k:=types to func do
706         undefip[k]:=newip(k,spaces,nil,nil);
707     {standard type pointers. some size are filled in by handleopts}
708       intptr    :=newsp(scalar,intsize);
709       realptr   :=newsp(scalar,0);
710       longptr   :=newsp(scalar,longsize);
711       charptr   :=newsp(scalar,charsize);
712       boolptr   :=newsp(scalar,boolsize);
713       nilptr    :=newsp(pointer,0);
714       stringptr:=newsp(pointer,0);
715       emptyset  :=newsp(power,intsize); emptyset^.elset:=nil;
716       textptr   :=newsp(files,0); textptr^.filtype:=charptr;
717     {standard type names}
718       enterid(newip(types,'integer ',intptr,nil));
719       enterid(newip(types,'real    ',realptr,nil));
720       enterid(newip(types,'char    ',charptr,nil));
721       enterid(newip(types,'boolean ',boolptr,nil));
722       enterid(newip(types,'text    ',textptr,nil));
723     {standard constant names}
724       q:=nil; p:=newip(konst,'false   ',boolptr,q); enterid(p);
725       q:=p; p:=newip(konst,'true    ',boolptr,q); p^.value:=1; enterid(p);
726       boolptr^.fconst:=p;
727       p:=newip(konst,'maxint  ',intptr,nil); p^.value:=maxint; enterid(p);
728       p:=newip(konst,spaces,charptr,nil); p^.value:=maxcharord;
729       charptr^.fconst:=p;
730     end;

732     procedure init3;
733     var j:standpf; p:ip; q:np;
734         pfn:array[standpf] of alpha;
735         ftype:array[feof..farctan] of sp;
736     begin
737     {names of standard procedures/functions}
738       pfn[pread     ]:='read    ';  pfn[preadln     ]:='readln  ';
739       pfn[pwrite    ]:='write   ';  pfn[pwriteln    ]:='writeln ';
740       pfn[pput      ]:='put     ';  pfn[pget        ]:='get     ';
741       pfn[ppage     ]:='page    ';  pfn[preset      ]:='reset   ';
742       pfn[prewrite  ]:='rewrite ';  pfn[pnew        ]:='new     ';
743       pfn[pdispose  ]:='dispose ';  pfn[ppack       ]:='pack    ';
744       pfn[punpack   ]:='unpack  ';  pfn[pmark       ]:='mark    ';
745       pfn[prelease  ]:='release ';  pfn[phalt       ]:='halt    ';
746       pfn[feof      ]:='eof     ';  pfn[feoln       ]:='eoln    ';
747       pfn[fabs      ]:='abs     ';  pfn[fsqr        ]:='sqr     ';
748       pfn[ford      ]:='ord     ';  pfn[fchr        ]:='chr     ';
749       pfn[fpred     ]:='pred    ';  pfn[fsucc       ]:='succ    ';
750       pfn[fodd      ]:='odd     ';  pfn[ftrunc      ]:='trunc   ';
751       pfn[fround    ]:='round   ';  pfn[fsin        ]:='sin     ';
752       pfn[fcos      ]:='cos     ';  pfn[fexp        ]:='exp     ';
753       pfn[fsqrt     ]:='sqrt    ';  pfn[fln         ]:='ln      ';
754       pfn[farctan   ]:='arctan  ';
755     {parameter types of standard functions}
756       ftype[feof    ]:=nil;         ftype[feoln     ]:=nil;
757       ftype[fabs    ]:=nil;         ftype[fsqr      ]:=nil;
758       ftype[ford    ]:=nil;         ftype[fchr      ]:=intptr;
759       ftype[fpred   ]:=nil;         ftype[fsucc     ]:=nil;
760       ftype[fodd    ]:=intptr;      ftype[ftrunc    ]:=nil;
761       ftype[fround  ]:=nil;         ftype[fsin      ]:=realptr;
762       ftype[fcos    ]:=realptr;     ftype[fexp      ]:=realptr;
763       ftype[fsqrt   ]:=realptr;     ftype[fln       ]:=realptr;
764       ftype[farctan ]:=realptr;
765     {standard procedure/function identifiers}
766       for j:=pread to phalt do
767         begin new(p,proc,standard); p^.klass:=proc;
768           p^.name:=pfn[j]; p^.pfkind:=standard; p^.key:=j; enterid(p);
769         end;
770       for j:=feof to farctan do
771         begin new(p,func,standard); p^.klass:=func; p^.idtype:=ftype[j];
772           {idtype is used not for result type but for parameter type !! }
773           p^.name:=pfn[j]; p^.pfkind:=standard; p^.key:=j; enterid(p);
774         end;
775     {program identifier}
776       progp:=newip(proc,'_main   ',nil,nil);
777     {new name space for user externals}
778       new(q,blck); q^.occur:=blck; q^.nlink:=top; q^.fname:=nil; top:=q;
779     end;

781     procedure init4;
782     var c:char;
783     begin
784     {pascal library mnemonics}
```

```
785      lmn[ELN ]:='_eln';    lmn[EFL ]:='_efl';      lmn[CLS ]:='_cls';
786      lmn[WDW ]:='_wdw';
787      lmn[OPN ]:='_opn';    lmn[GETX]:='_get';      lmn[RDI ]:='_rdi';
788      lmn[RDC ]:='_rdc';    lmn[RDR ]:='_rdr';      lmn[RDL ]:='_rdl';
789      lmn[RLN ]:='_rln';
790      lmn[CRE ]:='_cre';    lmn[PUTX]:='_put';      lmn[WRI ]:='_wri';
791      lmn[WSI ]:='_wsi';    lmn[WRC ]:='_wrc';      lmn[WSC ]:='_wsc';
792      lmn[WRS ]:='_wrs';    lmn[WSS ]:='_wss';      lmn[WRB ]:='_wrb';
793      lmn[WSB ]:='_wsb';    lmn[WRR ]:='_wrr';      lmn[WSR ]:='_wsr';
794      lmn[WRL ]:='_wrl';    lmn[WSL ]:='_wsl';
795      lmn[WRF ]:='_wrf';    lmn[WRZ ]:='_wrz';      lmn[WSZ ]:='_wsz';
796      lmn[WLN ]:='_wln';    lmn[PAG ]:='_pag';
797      lmn[ABR ]:='_abr';    lmn[RND ]:='_rnd';      lmn[SIN ]:='_sin';
798      lmn[COS ]:='_cos';    lmn[EXPX]:='_exp';      lmn[SQT ]:='_sqt';
799      lmn[LOG ]:='_log';    lmn[ATN ]:='_atn';      lmn[ABI ]:='_abi';
800      lmn[ABL ]:='_abl';
801      lmn[BCP ]:='_bcp';    lmn[BTS ]:='_bts';      lmn[NEWX]:='_new';
802      lmn[SAV ]:='_sav';    lmn[RST ]:='_rst';      lmn[INI ]:='_ini';
803      lmn[HLT ]:='_hlt';    lmn[ASS ]:='_ass';      lmn[GTO ]:='_gto';
804      lmn[PAC ]:='_pac'     lmn[UNP ]:='_unp';      lmn[DIS ]:='_dis';
805      lmn[ASZ ]:='_asz';    lmn[MDI ]:='_mdi';      lmn[MDL ]:='_mdl';
806    {options}
807      for c:='a' to 'z' do begin opt[c]:=0; forceopt[c]:=false end;
808      opt['a']:=on;
809      opt['f']:=floatsize div wordsize;     {default real size in words}
810      opt['i']:=maxsetint+1;
811      opt['l']:=on;
812      opt['o']:=on;
813      opt['p']:=addrsize div wordsize;      {default pointer size in words}
814      opt['r']:=on;
815      sopt:=off;
816    {scalar variables}
817      b.nextbp:=nil;
818      b.lc:=0;
819      b.ilbno:=0;
820      b.forwcount:=0;
821      b.lchain:=nil;
822      e.chno:=0;
823      e.lino:=1;
824      e.linr:=1;
825      e.orig:=1;
826      e.fnam:=emptyfnam;
827      source:=emptyfnam;
828      lino:=0;
829      dlbno:=0;
830      argc:=1;
831      lastpfno:=0;
832      giveline:=true;
833      including:=false;
834      eofexpected:=false;
835      intypedec:=false;
836      fltused:=false;
837      seconddot:=false;
838      iop[false]:=nil;
839      iop[true]:=nil;
840      argv[0].ad:=-1;
841      argv[1].ad:=-1;
842    end;

844    procedure handleopts;
845    begin
846      copt:=opt['c'];
847      dopt:=opt['d'];
848      iopt:=opt['i'];
849      sopt:=opt['s'];
850      realsize:=opt['f'] * wordsize; realptr^.size:=realsize;
851      ptrsize:=opt['p'] * wordsize; nilptr^.size:=ptrsize;
852      fhsize:=6*intsize + 2*ptrsize;
853      textptr^.size:=fhsize+buffsize; stringptr^.size:=ptrsize;
854      if sopt<>off then begin copt:=off; dopt:=off end
855      else if opt['u']<>off then cs['_']:=lower;
856      if copt<>off then enterid(newip(types,'string  ',stringptr,nil));
857      if dopt<>off then enterid(newip(types,'long    ',longptr,nil));
858      if opt['o']=off then begin gen1(ps_mes,mesoptoff); genend end;
859      if ptrsize<>wordsize then begin gen1(ps_mes,mesvirtual); genend end;
860      if dopt<>off then fltused:=true;  {temporary kludge}
861    end;

863    {===============================================================}

865    procedure trace(tname:alpha; fip:ip; var namdlb:integer);
866    var i:integer;
867    begin
868      if opt['t']<>off then
869        begin
870          if namdlb=0 then
871            begin dlbno:=dlbno+1; namdlb:=dlbno; gendlb(dlbno);
872              gen0(ps_rom); write(em1,sp_scon,8);
873              for i:=1 to 8 do write(em1,ord(fip^.name[i])); genend;
874            end;
875          gen1(op_mrk,0); gend(op_lae,namdlb);
876          gen0(op_cal); genident(sp_pnam,tname);
877        end;
878    end;

880    function formof(fsp:sp; forms:formset):boolean;
881    begin if fsp=nil then formof:=false else formof:=fsp^.form in forms end;

883    function sizeof(fsp:sp):integer;
884    var s:integer;
885    begin s:=0;
886      if fsp<>nil then s:=fsp^.size;
887      if s<>1 then if odd(s) then s:=s+1;
888      sizeof:=s
889    end;

891    function even(i:integer):integer;
892    begin if odd(i) then i:=i+1; even:=i end;

894    procedure exchange(l1,l2:integer);
895    var d1,d2:integer;
896    begin d1:=l2-l1; d2:=lino-l2;
```

```
897      if (d1<>0) and (d2<>0) then
898        begin gen1(ps_exc,d1); gencst(d2) end
899    end;

901    procedure setop(m:byte);
902    begin gen1(m,even(sizeof(a.asp))) end;

904    procedure expandemptyset(fsp:sp);
905    var i:integer;
906    begin
907      for i:=2 to sizeof(fsp) div wordsize do gen1(op_loc,0); a.asp:=fsp
908    end;

910    procedure push(local:boolean; ad:integer; sz:integer);
911    begin assert not odd(sz);
912      if sz>wordsize then
913        begin if local then gen1(op_lal,ad) else gen1(op_lae,ad);
914          gen1(op_loi,sz)
915        end
916      else
917        if local then gen1(op_lol,ad) else gen1(op_loe,ad)
918    end;

920    procedure pop(local:boolean; ad:integer; sz:integer);
921    begin assert not odd(sz);
922      if sz>wordsize then
923        begin if local then gen1(op_lal,ad) else gen1(op_lae,ad);
924          gen1(op_sti,sz)
925        end
926      else
927        if local then gen1(op_stl,ad) else gen1(op_ste,ad)
928    end;

930    procedure lexical(m:byte; lv:integer; ad:integer; sz:integer);
931    begin gen1(op_lex,level-lv); gen1(op_adi,ad); gen1(m,sz) end;

933    procedure loadpos(var p:position; sz:integer);
934    begin with p do
935      if lv<=0 then
936    #ifdef SEGMENTS
937        if sg<>0 then
938          begin gen1(op_lsa,sg); gen1(op_adi,ad); gen1(op_loi,sz) end
939        else
940    #endif
941          push(global,ad,sz)
942      else
943        if lv=level then push(local,ad,sz) else
944          lexical(op_loi,lv,ad,sz);
945    end;

947    procedure descraddr(var p:position);
948    begin if p.lv=0 then gend(op_lae,p.ad) else loadpos(p,ptrsize) end;

950    procedure loadaddr;
951    begin with a do begin
952      case ak of
953        fixed:
954          with pos do
955            if lv<=0 then
956    #ifdef SEGMENTS
957              if sg<>0 then
958                begin gen1(op_lsa,sg); gen1(op_adi,ad) end
959              else
960    #endif
961                gen1(op_lae,ad)
962            else
963              if lv=level then gen1(op_lal,ad) else
964                begin gen1(op_lex,level-lv); gen1(op_adi,ad) end;
965        pfixed:
966          loadpos(pos,ptrsize);
967        ploaded:
968          ;
969        indexed:
970          gen0(op_aas);
971      end;  {case}
972      ak:=ploaded;
973    end end;

975    procedure load;
976    var sz:integer;
977    begin with a do begin
978      sz:=sizeof(asp); if not packbit then sz:=even(sz);
979      if asp<>nil then
980        case ak of
981          cst:
982            gen1(op_loc,pos.ad);  {only one-word scalars}
983          fixed:
984            loadpos(pos,sz);
985          pfixed:
986            begin loadpos(pos,ptrsize); gen1(op_loi,sz) end;
987          loaded:
988            ;
989          ploaded:
990            gen1(op_loi,sz);
991          indexed:
992            gen0(op_las);
993        end;  {case}
994      ak:=loaded;
995    end end;

997    procedure store;
998    var sz:integer;
999    begin with a do begin
1000     sz:=sizeof(asp); if not packbit then sz:=even(sz);
1001     if asp<>nil then
1002       case ak of
1003         fixed:
1004           with pos do
1005             if lv<=0 then
1006   #ifdef SEGMENTS
1007               if sg<>0 then
1008                 begin gen1(op_lsa,sg);
```

```
1009                  gen1(op_adi,ad); gen1(op_sti,sz)
1010                end
1011              else
1012  #endif
1013                pop(global,ad,sz)
1014            else
1015              if level=lv then pop(local,ad,sz) else
1016                lexical(op_sti,lv,ad,sz);
1017        pfixed:
1018          begin loadpos(pos,ptrsize); gen1(op_sti,sz) end;
1019        ploaded:
1020          gen1(op_sti,sz);
1021        indexed:
1022          gen0(op_sas);
1023      end;  {case}
1024  end end;

1026  procedure fieldaddr(off:integer);
1027  begin with a do
1028    if (ak=fixed) and not packbit then pos.ad:=pos.ad+off else
1029      begin loadaddr; gen1(op_adi,off) end
1030  end;

1032  procedure loadcheap;
1033  begin if formof(a.asp,[arrays..records]) then loadaddr else load end;

1035  {=================================================================}

1037  procedure nextch;
1038  begin
1039    eol:=eoln(input); read(input,ch); e.chno:=e.chno+1; chsy:=cs[ch];
1040  end;

1042  procedure nextln;
1043  begin
1044    if eof(input) then
1045      begin
1046        if not eofexpected then error(+03) else
1047          begin
1048            if fltused then begin gen1(ps_mes,mesfloats); genend end;
1049            gen0(ps_eof)
1050          end;
1051  #ifdef STANDARD
1052        goto 9999
1053  #endif
1054  #ifndef STANDARD
1055        halt
1056  #endif
1057      end;
1058    e.chno:=0; e.lino:=e.lino+1; e.linr:=e.linr+1;
1059    if not including then
1060      begin e.orig:=e.orig+1; giveline:=true end;
1061  end;

1063  procedure options(normal:boolean);
1064  var c,ci:char; i:integer;

1066  procedure getc;
1067  var b:byte;
1068  begin
1069    if normal then
1070      begin nextch; c:=ch end
1071    else
1072      begin read(em1,b); c:=chr(b) end
1073  end;

1075  begin
1076    repeat getc;
1077      if (c>='a') and (c<='z') then
1078        begin ci:=c; getc; i:=0;
1079          if c='+' then begin i:=1; getc end else
1080          if c='-' then getc else
1081          if cs[c]=digit then
1082            repeat i:=i*10 + ord(c) - ord('0'); getc;
1083            until cs[c]<>digit
1084          else i:=-1;
1085          if i>=0 then
1086            if not normal then
1087              begin forceopt[ci]:=true; opt[ci]:=i end
1088            else
1089              if not forceopt[ci] then opt[ci]:=i;
1090        end;
1091    until c<>',';
1092  end;

1094  procedure linedirective;
1095  var i,j:integer;
1096  begin i:=0; j:=0;
1097    repeat nextch until (ch<>' ') or eol;
1098    while chsy=digit do
1099      begin i:=i*10 + ord(ch) - ord('0'); nextch end;
1100    while (ch=' ') and not eol do nextch;
1101    if (ch<>'"') or (i=0) then error(+04) else
1102      begin nextch;
1103        while (ch<>'"') and not eol do
1104          begin
1105            if ch='/' then j:=0 else
1106              begin if j=0 then e.fnam:=emptyfnam;
1107                j:=j+1; if j<=fnmax then e.fnam[j]:=ch;
1108              end;
1109            nextch
1110          end;
1111        if source=emptyfnam then source:=e.fnam;
1112        including:=source<>e.fnam;
1113        i:=i-1; e.linr:=i;
1114        if not including then e.orig:=i
1115      end;
1116    while not eol do nextch;
1117  end;

1119  procedure putdig;
1120  begin ix:=ix+1; if ix<=rmax then strbuf[ix]:=ch; nextch end;
```

```
1122  procedure inident;
1123  label 1;
1124  var i,k:integer;
1125  begin k:=0; id:=spaces;
1126    repeat
1127      if chsy=upper then ch:=chr(ord(ch)-ord('A')+ord('a'));
1128      if k<idmax then begin k:=k+1; id[k]:=ch end;
1129      nextch
1130    until chsy>digit;
1131          {lower=0,upper=1,digit=2. ugly but fast}
1132    for i:=frw[k-1] to frw[k] - 1 do
1133      if rw[i]=id then
1134        begin sy:=rsy[i]; goto 1 end;
1135    sy:=ident;
1136  1:
1137  end;

1139  procedure innumber;
1140  label   1;
1141  const   imax = 10;
1142  var     i:integer;
1143          is:packed array[1..imax] of char;
1144  begin ix:=0; sy:=intcst; val:=0;
1145    repeat putdig until chsy<>digit;
1146    if (ch='.') or (ch='e') or (ch='E') then
1147      begin
1148        if ch='.' then
1149          begin putdig;
1150            if ch='.' then
1151              begin seconddot:=true; ix:=ix-1; goto 1 end;
1152            if chsy<>digit then error(+05) else
1153              repeat putdig until chsy<>digit;
1154          end;
1155        if (ch='e') or (ch='E') then
1156          begin putdig;
1157            if (ch='+') or (ch='-') then putdig;
1158            if chsy<>digit then error(+06) else
1159              repeat putdig until chsy<>digit;
1160          end;
1161        if ix>rmax then begin error(+07); ix:=rmax end;
1162        sy:=realcst; fltused:=true; dlbno:=dlbno+1; val:=dlbno;
1163        gendlb(dlbno); gen0(ps_rom); write(em1,sp_rcon,ix);
1164        for i:=1 to ix do write(em1,ord(strbuf[i])); genend;
1165      end;
1166  1:if (chsy=lower) or (chsy=upper) then teststandard;
1167    if sy=intcst then
1168      if ix>imax then error(+08) else
1169        begin is:='0000000000'; i:=imax+1;
1170          while ix>0 do
1171            begin i:=i-1; is[i]:=strbuf[ix]; ix:=ix-1 end;
1172          if is<=maxintstring then
1173            while i<=imax do
1174              begin val:=val*10 - ord('0') + ord(is[i]); i:=i+1 end
1175          else if (is<=maxlongstring) and (dopt<>off) then
1176            begin sy:=longcst; dlbno:=dlbno+1; val:=dlbno;
1177              gendlb(dlbno); gen0(ps_con); write(em1,sp_lcon,imax+1-i);
1178              while i<=imax do
1179                begin write(em1,ord(is[i])); i:=i+1 end;
1180              genend
1181            end
1182          else error(+09)
1183        end
1184  end;

1186  procedure instring(qc:char);
1187  var i:integer;
1188  begin ix:=0; zerostring:=qc='"';
1189    repeat
1190      repeat nextch; ix:=ix+1; if ix<=smax then strbuf[ix]:=ch;
1191      until (ch=qc) or eol;
1192      if ch=qc then nextch else error(+010);
1193    until ch<>qc;
1194    if not zerostring then
1195      begin ix:=ix-1; if ix=0 then error(+011) end
1196    else
1197      begin strbuf[ix]:=chr(0); if copt=off then error(+012) end;
1198    if (ix=1) and not zerostring then
1199      begin sy:=charcst; val:=ord(strbuf[1]) end
1200    else
1201      begin sy:=stringcst; dlbno:=dlbno+1; val:=dlbno;
1202        if ix>smax then begin error(+013); ix:=smax end;
1203        gendlb(dlbno); gen0(ps_rom); write(em1,sp_scon,ix);
1204        for i:=1 to ix do write(em1,ord(strbuf[i])); genend;
1205      end
1206  end;

1208  procedure incomment;
1209  var stopc:char;
1210  begin nextch; stopc:='}';
1211    if ch='$' then options(true);
1212    while (ch<>'}') and (ch<>stopc) do
1213      begin stopc:='}'; if ch='*' then stopc:=')';
1214        if ch=';' then error(-(+014));
1215        if eol then nextln; nextch
1216      end;
1217    if ch<>'}' then teststandard;
1218    nextch
1219  end;

1221  procedure insym;
1222    {read next basic symbol of source program and return its
1223    description in the global variables sy, op, id, val and ix}
1224  label 1;
1225  begin
1226  1:case chsy of
1227      tabch:
1228        begin e.chno:=e.chno - e.chno mod 8 + 8; nextch; goto 1 end;
1229      layout:
1230        begin if eol then nextln; nextch; goto 1 end;
1231      lower,upper: inident;
1232      digit: innumber;
```

```
1233         quotech,dquotech:
1234           instring(ch);
1235         colonch:
1236           begin nextch;
1237             if ch='=' then begin sy:=becomes; nextch end else sy:=colon1
1238           end;
1239         periodch:
1240           begin nextch;
1241             if seconddot then begin seconddot:=false; sy:=colon2 end else
1242             if ch='.' then begin sy:=colon2; nextch end else sy:=period
1243           end;
1244         lessch:
1245           begin nextch;
1246             if ch='=' then begin sy:=lesy; nextch end else
1247             if ch='>' then begin sy:=nesy; nextch end else sy:=ltsy
1248           end;
1249         greaterch:
1250           begin nextch;
1251             if ch='=' then begin sy:=gesy; nextch end else sy:=gtsy
1252           end;
1253         lparentch:
1254           begin nextch;
1255             if ch<>'*' then sy:=lparent else
1256               begin teststandard; incomment; goto 1 end;
1257           end;
1258         lbracech:
1259           begin incomment; goto 1 end;
1260         rparentch,lbrackch,rbrackch,commach,semich,arrowch,
1261         plusch,minch,slash,star,equal:
1262           begin sy:=csy[chsy]; nextch end;
1263         others:
1264           begin
1265             if (ch='#') and (e.chno=1) then linedirective else
1266               begin error(+015); nextch end;
1267             goto 1
1268           end;
1269       end {case}
1270     end;

1272     procedure nextif(fsy:symbol; err:integer);
1273     begin if sy=fsy then insym else error(-err) end;

1275     function find1(sys1,sys2:sos; err:integer):boolean;
1276     {symbol of sys1 expected. return true if sy in sys1}
1277     begin
1278       if not (sy in sys1) then
1279         begin error(err); while not (sy in sys1+sys2) do insym end;
1280       find1:=sy in sys1
1281     end;

1283     function find2(sys1,sys2:sos; err:integer):boolean;
1284     {symbol of sys1+sys2 expected. return true if sy in sys1}
1285     begin
1286       if not (sy in sys1+sys2) then
1287         begin error(err); repeat insym until sy in sys1+sys2 end;
1288       find2:=sy in sys1
1289     end;

1291     function find3(sy1:symbol; sys2:sos; err:integer):boolean;
1292     {symbol sy1 or one of sys2 expected. return true if sy1 found and skip}
1293     begin find3:=true;
1294       if not (sy in [sy1]+sys2) then
1295         begin error(err); repeat insym until sy in [sy1]+sys2 end;
1296       if sy=sy1 then insym else find3:=false
1297     end;

1299     function endofloop(sys1,sys2:sos; sy3:symbol; err:integer):boolean;
1300     begin endofloop:=false;
1301       if find2(sys2+[sy3],sys1,err) then nextif(sy3,err+1)
1302       else endofloop:=true;
1303     end;

1305     function lastsemicolon(sys1,sys2:sos; err:integer):boolean;
1306     begin lastsemicolon:=true;
1307       if not endofloop(sys1,sys2,semicolon,err) then
1308         if find2(sys2,sys1,err+2) then lastsemicolon:=false
1309     end;

1311     {===============================================================}

1313     function searchid(fidcls: setofids):ip;
1314     {search for current identifier symbol in the name table}
1315     label 1;
1316     var lip:ip; ic:idclass;
1317     begin lastnp:=top;
1318       while lastnp<>nil do
1319         begin lip:=lastnp^.fname;
1320           while lip<>nil do
1321             if lip^.name=id then
1322               if lip^.klass in fidcls then
1323                 begin
1324                   if lip^.klass=vars then if lip^.vpos.lv<>level then
1325                     lip^.iflag:=lip^.iflag+[noreg];
1326                   goto 1
1327                 end
1328               else lip:=lip^.rlink
1329             else
1330               if lip^.name< id then lip:=lip^.rlink else lip:=lip^.llink;
1331           lastnp:=lastnp^.nlink;
1332         end;
1333       errid(+016,id);
1334       if types in fidcls then ic:=types else
1335       if vars  in fidcls then ic:=vars else
1336       if konst in fidcls then ic:=konst else
1337       if proc  in fidcls then ic:=proc else
1338       if func  in fidcls then ic:=func else ic:=field;
1339       lip:=undefip[ic];
1340     1:
1341       searchid:=lip
1342     end;

1344     function searchsection(fip: ip):ip;
```

```
1345  {to find record fields and forward declared procedure id's
1346    -->procedure pfdeclaration
1347    -->procedure selector}
1348  label 1;
1349  begin
1350    while fip<>nil do
1351      if fip^.name=id then goto 1 else
1352        if fip^.name< id then fip:=fip^.rlink else fip:=fip^.llink;
1353  1:  searchsection:=fip
1354  end;

1356  function searchlab(flp:lp; val:integer):lp;
1357  label 1;
1358  begin
1359    while flp<>nil do
1360      if flp^.labval=val then goto 1 else flp:=flp^.nextlp;
1361  1:searchlab:=flp
1362  end;

1364  procedure opconvert(ts:twostruct);
1365  var op:integer;
1366  begin with a do begin
1367    case ts of
1368      ir: begin op:=op_cif; asp:=realptr; fltused:=true end;
1369      ri: begin op:=op_cfi; asp:=intptr; fltused:=true end;
1370      il: begin op:=op_cid; asp:=longptr end;
1371      li: begin op:=op_cdi; asp:=intptr end;
1372      lr: begin op:=op_cdf; asp:=realptr; fltused:=true end;
1373      rl: begin op:=op_cfd; asp:=longptr; fltused:=true end;
1374    end;
1375    gen0(op)
1376  end end;

1378  procedure negate(l1:integer);
1379  var l2:integer;
1380  begin
1381    if a.asp=intptr then gen0(op_neg) else
1382      begin l2:=lino; gen1(op_loc,0);
1383        if a.asp=longptr then
1384          begin opconvert(il); exchange(l1,l2); gen0(op_dsb) end
1385        else  {realptr}
1386          begin opconvert(ir); exchange(l1,l2); gen0(op_fsb) end
1387      end
1388  end;

1390  function desub(fsp:sp):sp;
1391  begin
1392    if formof(fsp,[subrange]) then fsp:=fsp^.rangetype; desub:=fsp
1393  end;

1395  function nicescalar(fsp:sp):boolean;
1396  begin
1397    if fsp=nil then nicescalar:=true else
1398      nicescalar:=(fsp^.form=scalar) and (fsp<>realptr) and (fsp<>longptr)
1399  end;

1401  function bounds(fsp:sp; var fmin,fmax:integer):boolean;
1402  {compute bounds if possible, else return false}
1403  begin bounds:=false; fmin:=0; fmax:=0;
1404    if fsp<>nil then
1405      if fsp^.form=subrange then
1406        begin fmin:=fsp^.min; fmax:=fsp^.max; bounds:=true end else
1407      if fsp^.form=scalar then
1408        if fsp^.fconst<>nil then
1409          begin fmin:=0; fmax:=fsp^.fconst^.value; bounds:=true end
1410  end;

1412  procedure genrck(fsp:sp);
1413  var min,max,sno:integer;
1414  begin
1415    if opt['r']<>off then if bounds(fsp,min,max) then
1416      begin
1417        if fsp^.form=scalar then sno:=fsp^.scalno else sno:=fsp^.subrno;
1418        if sno=0 then
1419          begin dlbno:=dlbno+1; sno:=dlbno;
1420            gendlb(dlbno); gen1(ps_rom,min); gencst(max); genend;
1421            if fsp^.form=scalar then fsp^.scalno:=sno else
1422              fsp^.subrno:=sno
1423          end;
1424        gend(op_rck,sno);
1425      end
1426  end;

1428  procedure checkbnds(fsp:sp);
1429  var min1,max1,min2,max2:integer; bool:boolean;
1430  begin
1431    if bounds(fsp,min1,max1) then
1432      begin bool:=bounds(a.asp,min2,max2);
1433        if (bool=false) or (min2<min1) or (max2>max1) then
1434          genrck(fsp);
1435      end;
1436    a.asp:=fsp;
1437  end;

1439  function eqstruct(p,q:sp):boolean;
1440  begin eqstruct:=(p=q) or (p=nil) or (q=nil) end;

1442  function string(fsp:sp):boolean;
1443  var lsp:sp;
1444  begin string:=false;
1445    if formof(fsp,[arrays]) then
1446      if eqstruct(fsp^.aeltype,charptr) then
1447        if spack in fsp^.sflag then
1448          begin lsp:=fsp^.inxtype;
1449            if lsp=nil then string:=true else
1450              if lsp^.form=subrange then
1451                if lsp^.rangetype=intptr then
1452                  if lsp^.min=1 then
1453                    string:=true
1454          end
1455  end;
```

```
1457  function compat(p,q:sp):twostruct;
1458  begin compat:=noteq;
1459    if eqstruct(p,q) then compat:=eq else
1460      begin p:=desub(p); q:=desub(q);
1461        if eqstruct(p,q) then compat:=subeq else
1462        if p^.form=q^.form then
1463          case p^.form of
1464            scalar:
1465              if (p=intptr) and (q=realptr) then compat:=ir else
1466              if (p=realptr) and (q=intptr) then compat:=ri else
1467              if (p=intptr) and (q=longptr) then compat:=il else
1468              if (p=longptr) and (q=intptr) then compat:=li else
1469              if (p=longptr) and (q=realptr) then compat:=lr else
1470              if (p=realptr) and (q=longptr) then compat:=rl else
1471                ;
1472            pointer:
1473              if (p=nilptr) or (q=nilptr) then compat:=eq;
1474            power:
1475              if p=emptyset then compat:=es else
1476              if q=emptyset then compat:=se else
1477              if compat(p^.elset,q^.elset) <= subeq then
1478                if p^.sflag=q^.sflag then compat:=eq;
1479            arrays:
1480              if string(p) and string(q) and (p^.size=q^.size) then
1481                compat:=eq;
1482            files,carray,records: ;
1483          end;
1484      end
1485  end;

1487  procedure checkasp(fsp:sp; err:integer);
1488  var ts:twostruct;
1489  begin
1490    ts:=compat(a.asp,fsp);
1491    case ts of
1492      eq:
1493        if fsp<>nil then if withfile in fsp^.sflag then asperr(err);
1494      subeq:
1495        checkbnds(fsp);
1496      li:
1497        begin opconvert(ts); checkasp(fsp,err) end;
1498      il,rl,lr,ir:
1499        opconvert(ts);
1500      es:
1501        expandemptyset(fsp);
1502      noteq,ri,se:
1503        asperr(err);
1504    end
1505  end;

1507  procedure force(fsp:sp; err:integer);
1508  begin load; checkasp(fsp,err) end;

1510  function newident(kl:idclass; idt:sp; nxt:ip; err:integer):ip;
1511  begin newident:=nil;
1512    if sy<>ident then error(err) else
1513      begin newident:=newip(kl,id,idt,nxt); insym end
1514  end;

1516  function stringstruct:sp;
1517  var lsp:sp;
1518  begin {only used when ix and zerostring are still valid}
1519    if zerostring then lsp:=stringptr else
1520      begin lsp:=newsp(arrays,ix*charsize); lsp^.sflag:=[spack];
1521        lsp^.aeltype:=charptr; lsp^.inxtype:=nil;
1522      end;
1523    stringstruct:=lsp;
1524  end;

1526  function address(var lc:integer; sz:integer; pack:boolean):integer;
1527  begin
1528    if lc >= maxint-sz then begin error(+017); lc:=0 end;
1529    if (not pack) or (sz>1) then if odd(lc) then lc:=lc+1;
1530    address:=lc;
1531    lc:=lc+sz
1532  end;

1534  function reserve(s:integer):integer;
1535  var r:integer;
1536  begin r:=address(b.lc,s,false); genreg(r,s,100); reserve:=r;
1537    if b.lc>lcmax then lcmax:=b.lc
1538  end;

1540  function arraysize(fsp:sp; pack:boolean):integer;
1541  var sz,min,max,tot,n:integer;
1542  begin sz:=sizeof(fsp^.aeltype);
1543    if not pack then sz:=even(sz);
1544    if bounds(fsp^.inxtype,min,max) then;  {we checked before}
1545    dlbno:=dlbno+1; fsp^.arpos.lv:=0; fsp^.arpos.ad:=dlbno;
1546    gendlb(dlbno); gen1(ps_rom,min); gencst(max-min);
1547    gencst(sz); genend;
1548    n:=max-min+1; tot:=sz*n;
1549    if sz<>0 then if tot div sz <> n then begin error(+018); tot:=0 end;
1550    arraysize:=tot
1551  end;

1553  procedure treewalk(fip:ip);
1554  var lsp:sp; i:integer;
1555  begin
1556    if fip<>nil then
1557      begin treewalk(fip^.llink); treewalk(fip^.rlink);
1558        if fip^.klass=vars then
1559          begin if not (used in fip^.iflag) then errid(-(+019),fip^.name);
1560            if not (assigned in fip^.iflag) then errid(-(+020),fip^.name);
1561            lsp:=fip^.idtype;
1562            if not (noreg in fip^.iflag) then
1563              genreg(fip^.vpos.ad,sizeof(lsp),ord(formof(lsp,[pointer])));
1564            if lsp<>nil then if withfile in lsp^.sflag then
1565              if lsp^.form=files then
1566                if level=1 then
1567                  begin
1568                    for i:=2 to argc do with argv[i] do
```

```
1569                      if name=fip^.name then ad:=fip^.vpos.ad
1570                    end
1571                  else
1572                    begin
1573                      if not (refer in fip^.iflag) then
1574                        begin gen1(op_mrk,0);
1575                          gen1(op_lal,fip^.vpos.ad); gensp(CLS)
1576                        end
1577                    end
1578                else
1579                  if level<>1 then errid(-(+021),fip^.name)
1580            end
1581        end
1582    end;

1584    procedure constant(fsys:sos; var fsp:sp; var fval:integer);
1585    var signed,min:boolean; lip:ip;
1586    begin signed:=(sy=plussy) or (sy=minsy);
1587      if signed then begin min:=sy=minsy; insym end else min:=false;
1588      if find1([ident..nilcst],fsys,+022) then
1589        begin fval:=val;
1590          case sy of
1591            stringcst: fsp:=stringstruct;
1592            charcst: fsp:=charptr;
1593            intcst: fsp:=intptr;
1594            realcst: fsp:=realptr;
1595            longcst: fsp:=longptr;
1596            nilcst: fsp:=nilptr;
1597            ident:
1598              begin lip:=searchid([konst]);
1599                fsp:=lip^.idtype; fval:=lip^.value;
1600              end
1601          end;  {case}
1602          if signed then
1603            if (fsp<>intptr) and (fsp<>realptr) and (fsp<>longptr) then
1604              error(+023)
1605            else if min then fval:= -fval;
1606                    {note: negating the v-number for reals and longs}
1607          insym;
1608        end
1609      else begin fsp:=nil; fval:=0 end;
1610    end;

1612    function cstinteger(fsys:sos; fsp:sp; err:integer):integer;
1613    var lsp:sp; lval,min,max:integer;
1614    begin constant(fsys,lsp,lval);
1615      if fsp<>lsp then
1616        if eqstruct(desub(fsp),lsp) then
1617          begin
1618            if bounds(fsp,min,max) then
1619              if (lval<min) or (lval>max) then error(+024)
1620          end
1621        else
1622          begin error(err); lval:=0 end;
1623      cstinteger:=lval
1624    end;

1626    {===================================================================}

1628    function typid(err:integer):sp;
1629    var lip:ip; lsp:sp;
1630    begin lsp:=nil;
1631      if sy<>ident then error(err) else
1632        begin lip:=searchid([types]); lsp:=lip^.idtype; insym end;
1633      typid:=lsp
1634    end;

1636    function simpletyp(fsys:sos):sp;
1637    var lsp,lsp1:sp; lip,hip:ip; min,max:integer; lnp:np;
1638        newsubrange:boolean;
1639    begin lsp:=nil;
1640      if find1([ident..lparent],fsys,+025) then
1641        if sy=lparent then
1642          begin insym; lnp:=top;   {decl. consts local to innermost block}
1643            while top^.occur<>blck do top:=top^.nlink;
1644            lsp:=newsp(scalar,wordsize); hip:=nil; max:=0;
1645            repeat lip:=newident(konst,lsp,hip,+026);
1646              if lip<>nil then
1647                begin enterid(lip);
1648                  hip:=lip; lip^.value:=max; max:=max+1
1649                end;
1650            until endofloop(fsys+[rparent],[ident],comma,+027);  {+028}
1651            if max<=t8 then lsp^.size:=bytesize;
1652            lsp^.fconst:=hip; top:=lnp; nextif(rparent,+029);
1653          end
1654        else
1655          begin newsubrange:=true;
1656            if sy=ident then
1657              begin lip:=searchid([types,konst]); insym;
1658                if lip^.klass=types then
1659                  begin lsp:=lip^.idtype; newsubrange:=false end
1660                else
1661                  begin lsp1:=lip^.idtype; min:=lip^.value end
1662              end
1663            else constant(fsys+[colon2,ident..plussy],lsp1,min);
1664            if newsubrange then
1665              begin lsp:=newsp(subrange,wordsize); lsp^.subrno:=0;
1666                if not nicescalar(lsp1) then
1667                  begin error(+030); lsp1:=nil; min:=0 end;
1668                lsp^.rangetype:=lsp1;
1669                nextif(colon2,+031); max:=cstinteger(fsys,lsp1,+032);
1670                if min>max then begin error(+033); max:=min end;
1671                if (min>=0) and (max<t8) then lsp^.size:=bytesize;
1672                lsp^.min:=min; lsp^.max:=max
1673              end
1674          end;
1675      simpletyp:=lsp
1676    end;

1678    function arraytyp(fsys:sos;
1679                      artyp:structform;
1680                      sflag:sflagset;
```

```
1681                    function element(fsys:sos):sp
1682                    ):sp;
1683  var lsp,lsp1,hsp:sp; min,max:integer; ok:boolean; sepsy:symbol; lip:ip;
1684      oksys:sos;
1685  begin insym; nextif(lbrack,+034); hsp:=nil;
1686    repeat lsp:=newsp(artyp,0); initpos(lsp^.arpos);
1687      lsp^.aeltype:=hsp; hsp:=lsp;  {link reversed}
1688      if artyp=carray then
1689        begin sepsy:=semicolon; oksys:=[ident];
1690          lip:=newident(carrbnd,lsp,nil,+035);
1691          if lip<>nil then enterid(lip);
1692          nextif(colon2,+036);
1693          lip:=newident(carrbnd,lsp,lip,+037);
1694          if lip<>nil then enterid(lip);
1695          nextif(colon1,+038); lsp1:=typid(+039);
1696          ok:=nicescalar(desub(lsp1));
1697        end
1698      else
1699        begin sepsy:=comma; oksys:=[ident..lparent];
1700          lsp1:=simpletyp(fsys+[comma,rbrack,ofsy,ident..packedsy]);
1701          ok:=bounds(lsp1,min,max)
1702        end;
1703      if not ok then begin error(+040); lsp1:=nil end;
1704      lsp^.inxtype:=lsp1
1705    until endofloop(fsys+[rbrack,ofsy,ident..packedsy],oksys,
1706                             sepsy,+041);  {+042}
1707    nextif(rbrack,+043); nextif(ofsy,+044);
1708    lsp:=element(fsys);
1709    if lsp<>nil then sflag:=sflag + lsp^.sflag * [withfile];
1710    repeat  {reverse links and compute size}
1711      lsp1:=hsp^.aeltype; hsp^.aeltype:=lsp; hsp^.sflag:=sflag;
1712      if artyp=arrays then hsp^.size:=arraysize(hsp,spack in sflag);
1713      lsp:=hsp; hsp:=lsp1
1714    until hsp=nil;  {lsp points to array with highest dimension}
1715    arraytyp:=lsp
1716  end;

1718  function typ(fsys:sos):sp;
1719  var lsp,lsp1:sp; oc,sz,min,max:integer;
1720      sflag:sflagset; lnp:np;

1722  function fldlist(fsys:sos):sp;
1723          {level 2: <<  typ}
1724  var fip,hip,lip:ip; lsp:sp;

1726  function varpart(fsys:sos):sp;
1727          {level 3: <<  fldlist <<  typ}
1728  var tip,lip:ip; lsp,headsp,hsp,vsp,tsp,tsp1,tfsp:sp;
1729      minoc,maxoc,int,nvar:integer; lid:alpha;
1730  begin insym; tip:=nil; lip:=nil;
1731    tsp:=newsp(tag,0);
1732    if sy<>ident then error(+045) else
1733      begin lid:=id; insym;
1734        if sy=colon1 then
1735          begin tip:=newip(field,lid,nil,nil); enterid(tip); insym;
1736            if sy<>ident then error(+046) else
1737              begin lid:=id; insym end;
1738          end;
1739        if sy=ofsy then  {otherwise you may destroy id}
1740          begin id:=lid; lip:=searchid([types]) end;
1741      end;
1742    if lip=nil then tfsp:=nil else tfsp:=lip^.idtype;
1743    if bounds(tfsp,int,nvar) then nvar:=nvar-int+1 else
1744      begin nvar:=0;
1745        if tfsp<>nil then begin error(+047); tfsp:=nil end
1746      end;
1747    tsp^.tfldsp:=tfsp;
1748    if tip<>nil then  {explicit tag}
1749      begin tip^.idtype:=tfsp;
1750        tip^.foffset:=address(oc,sizeof(tfsp),spack in sflag)
1751      end;
1752    nextif(ofsy,+048); minoc:=oc; maxoc:=minoc; headsp:=nil;
1753    repeat hsp:=nil;  {for each caselabel list}
1754      repeat nvar:=nvar-1;
1755        int:=cstinteger(fsys+[ident..plussy,comma,colon1,lparent,
1756                     semicolon,casesy,rparent],tfsp,+049);
1757        lsp:=headsp;  {each label may occur only once}
1758        while lsp<>nil do
1759          begin if lsp^.varval=int then error(+050);
1760            lsp:=lsp^.nxtvar
1761          end;
1762        vsp:=newsp(variant,0); vsp^.varval:=int;
1763        vsp^.nxtvar:=headsp; headsp:=vsp;  {chain of case labels}
1764        vsp^.subtsp:=hsp; hsp:=vsp;
1765              {use this field to link labels with same variant}
1766      until endofloop(fsys+[colon1,lparent,semicolon,casesy,rparent],
1767                        [ident..plussy],comma,+051);  {+052}
1768      nextif(colon1,+053); nextif(lparent,+054);
1769      tsp1:=fldlist(fsys+[rparent,semicolon,ident..plussy]);
1770      if oc>maxoc then maxoc:=oc;
1771      while vsp<>nil do
1772        begin vsp^.size:=oc; hsp:=vsp^.subtsp;
1773          vsp^.subtsp:=tsp1; vsp:=hsp
1774        end;
1775      nextif(rparent,+055);
1776      oc:=minoc;
1777    until lastsemicolon(fsys,[ident..plussy],+056);  {+057 +058}
1778    if nvar>0 then error(-(+059));
1779    tsp^.fstvar:=headsp; tsp^.size:=minoc; oc:=maxoc; varpart:=tsp;
1780  end;

1782  begin  {fldlist}
1783    if find2([ident],fsys+[casesy],+060) then
1784      repeat lip:=nil; hip:=nil;
1785        repeat fip:=newident(field,nil,nil,+061);
1786          if fip<>nil then
1787            begin enterid(fip);
1788              if lip=nil then hip:=fip else lip^.next:=fip; lip:=fip;
1789            end;
1790        until endofloop(fsys+[colon1,ident..packedsy,semicolon,casesy],
1791                                  [ident],comma,+062);  {+063}
1792        nextif(colon1,+064);
```

```
1793          lsp:=typ(fsys+[casesy,semicolon]);
1794          if lsp<>nil then if withfile in lsp^.sflag then
1795            sflag:=sflag+[withfile];
1796          while hip<>nil do
1797            begin hip^.idtype:=lsp;
1798              hip^.foffset:=address(oc,sizeof(lsp),spack in sflag);
1799              hip:=hip^.next
1800            end;
1801        until lastsemicolon(fsys+[casesy],[ident],+065);  {+066 +067}
1802      if sy=casesy then fldlist:=varpart(fsys) else fldlist:=nil;
1803    end;

1806    begin  {typ}
1807      sflag:=[]; lsp:=nil;
1808      if sy=packedsy then begin sflag:=[spack]; insym end;
1809      if find1([ident..filesy],fsys,+068) then
1810        if sy in [ident..arrow] then
1811          begin if spack in sflag then error(+069);
1812            if sy=arrow then
1813              begin lsp:=newsp(pointer,ptrsize); insym;
1814                if not intypedec then lsp^.eltype:=typid(+070) else
1815                  if sy<>ident then error(+071) else
1816                    begin fwptr:=newip(types,id,lsp,fwptr); insym end
1817              end
1818            else lsp:=simpletyp(fsys);
1819          end
1820        else
1821          case sy of
1822    {<<<<<<<<<<<<}
1823    arraysy:
1824      lsp:=arraytyp(fsys,arrays,sflag,typ);
1825    recordsy:
1826      begin insym;
1827        new(lnp,rec); lnp^.occur:=rec; lnp^.nlink:=top;
1828        lnp^.fname:=nil; top:=lnp;
1829        oc:=0; lsp1:=fldlist(fsys+[endsy]);  {fldlist updates oc}
1830        lsp:=newsp(records,oc); lsp^.tagsp:=lsp1;
1831        lsp^.fstfld:=top^.fname; lsp^.sflag:=sflag;
1832        top:=top^.nlink; nextif(endsy,+072)
1833      end;
1834    setsy:
1835      begin insym; nextif(ofsy,+073); lsp1:=simpletyp(fsys);
1836        if bounds(lsp1,min,max) then lsp1:=desub(lsp1) else
1837          if lsp1=intptr then
1838            begin error(-(+074)); max:=iopt-1 end
1839          else
1840            begin error(+075); lsp1:=nil end;
1841        if lsp1=intptr then sz:=iopt-1 else
1842          begin if bounds(lsp1,min,max) then {nothing}; sz:=max end;
1843        if (min<0) or (max>sz) or (sz div bytebits >= maxsetsize) then
1844          begin error(+076); lsp1:=nil; sz:=0 end;
1845        lsp:=newsp(power,sz div bytebits +1); lsp^.elset:=lsp1;
1846      end;
1847    filesy:
1848      begin insym; nextif(ofsy,+077); lsp1:=typ(fsys);
1849        if lsp1<>nil then if withfile in lsp1^.sflag then error(-(+078));
1850        sz:=sizeof(lsp1); if sz<buffsize then sz:=buffsize;
1851        lsp:=newsp(files,sz+fhsize); lsp^.filtype:=lsp1;
1852      end;
1853    {>>>>>>>>>>>>}
1854          end;  {case}
1855      typ:=lsp;
1856    end;

1858    function vpartyp(fsys:sos):sp;
1859    begin
1860      if find2([arraysy],fsys+[ident],+079) then
1861        vpartyp:=arraytyp(fsys,carray,[],vpartyp)
1862      else
1863        vpartyp:=typid(+080)
1864    end;

1866    {==============================================================}

1868    procedure block(fsys:sos; fip:ip); forward;
1869            {pfdeclaration calls block. With a more obscure lexical
1870              structure this forward declaration can be avoided}

1872    procedure labeldeclaration(fsys:sos);
1873    var llp:lp;
1874    begin with b do begin
1875      repeat
1876        if sy<>intcst then error(+081) else
1877          begin
1878            if searchlab(lchain,val)<>nil then errint(+082,val) else
1879              begin new(llp); llp^.labval:=val;
1880                if val>9999 then teststandard;
1881                ilbno:=ilbno+1; llp^.labname:=ilbno; llp^.labdlb:=0;
1882                llp^.seen:=false; llp^.nextlp:=lchain; lchain:=llp;
1883              end;
1884            insym
1885          end
1886      until endofloop(fsys+[semicolon],[intcst],comma,+083);  {+084}
1887      nextif(semicolon,+085)
1888     end end;

1890    procedure constdefinition(fsys:sos);
1891    var lip:ip;
1892    begin
1893      repeat lip:=newident(konst,nil,nil,+086);
1894        if lip<>nil then
1895          begin nextif(eqsy,+087);
1896            constant(fsys+[semicolon,ident],lip^.idtype,lip^.value);
1897            nextif(semicolon,+088); enterid(lip);
1898          end;
1899      until not find2([ident],fsys,+089);
1900    end;

1902    procedure typedefinition(fsys:sos);
1903    var lip:ip;
1904    begin fwptr:=nil; intypedec:=true;
```

```
1905      repeat lip:=newident(types,nil,nil,+090);
1906        if lip<>nil then
1907          begin nextif(eqsy,+091);
1908            lip^.idtype:=typ(fsys+[semicolon,ident]);
1909            nextif(semicolon,+092); enterid(lip);
1910          end;
1911      until not find2([ident],fsys,+093);
1912      while fwptr<>nil do
1913        begin assert sy<>ident;
1914          id:=fwptr^.name; lip:=searchid([types]);
1915          fwptr^.idtype^.eltype:=lip^.idtype; fwptr:=fwptr^.next
1916        end;
1917      intypedec:=false;
1918    end;

1920    procedure vardeclaration(fsys:sos);
1921    var lip,hip,vip:ip; lsp:sp;
1922    begin with b do begin
1923      repeat hip:=nil; lip:=nil;
1924        repeat vip:=newident(vars,nil,nil,+094);
1925          if vip<>nil then
1926            begin enterid(vip); vip^.iflag:=[];
1927              if lip=nil then hip:=vip else lip^.next:=vip; lip:=vip;
1928            end;
1929        until endofloop(fsys+[colon1,ident..packedsy],[ident],comma,+095);
1930                                                                      {+096}
1931        nextif(colon1,+097);
1932        lsp:=typ(fsys+[semicolon,ident]);
1933        while hip<>nil do
1934          begin hip^.idtype:=lsp;
1935            hip^.vpos.ad:=address(lc,sizeof(lsp),false); hip:=hip^.next
1936          end;
1937        nextif(semicolon,+098);
1938      until not find2([ident],fsys,+099);
1939    end end;

1941    procedure pfhead(fsys:sos;
1942                     var fip:ip;
1943                     var again:boolean;
1944                     param:boolean); forward;

1946    function parlist(fsys:sos; var hlc:integer):ip;
1947    var lastip,hip,lip,pip:ip; lsp,tsp:sp; iflag:iflagset; again:boolean;
1948        sz:integer;
1949    begin parlist:=nil; lastip:=nil;
1950      repeat  {once for each formal-parameter-section}
1951        if find1([ident,varsy,procsy,funcsy],fsys+[semicolon],+0100) then
1952          begin
1953            if (sy=procsy) or (sy=funcsy) then
1954              begin
1955                pfhead(fsys+[semicolon,ident,varsy,procsy,funcsy],
1956                       hip,again,true);
1957                hip^.pfpos.ad:=address(hlc,pnumsize+ptrsize,false);
1958                hip^.pfkind:=formal; lip:=hip;
1959                top:=top^.nlink; level:=level-1
1960              end
1961            else
1962              begin hip:=nil; lip:=nil; iflag:=[assigned,noreg];
1963                if sy=varsy then
1964                  begin iflag:=[refer,assigned,used,noreg]; insym end;
1965                repeat pip:=newident(vars,nil,nil,+0101);
1966                  if pip<>nil then
1967                    begin enterid(pip); pip^.iflag:=iflag;
1968                      if lip=nil then hip:=pip else lip^.next:=pip;
1969                      lip:=pip;
1970                    end;
1971                  iflag:=iflag+[samesect];
1972                until endofloop(fsys+[semicolon,colon1],
1973                                [ident],comma,+0102);  {+0103}
1974                nextif(colon1,+0104);
1975                if refer in iflag then
1976                  begin lsp:=vpartyp(fsys+[semicolon]);
1977                    sz:=ptrsize; tsp:=lsp;
1978                    while formof(tsp,[carray]) do
1979                      begin tsp^.arpos.ad:=address(hlc,ptrsize,false);
1980                        tsp:=tsp^.aeltype
1981                      end;
1982                  end
1983                else
1984                  begin lsp:=typid(+0105); sz:=sizeof(lsp) end;
1985                pip:=hip;
1986                while pip<>nil do
1987                  begin pip^.vpos.ad:=address(hlc,sz,false);
1988                    pip^.idtype:=lsp; pip:=pip^.next
1989                  end;
1990              end;
1991            if lastip=nil then parlist:=hip else lastip^.next:=hip;
1992            lastip:=lip;
1993          end;
1994      until endofloop(fsys,[ident,varsy,procsy,funcsy],
1995                      semicolon,+0106);  {+0107}
1996    end;

1998    procedure pfhead;  {forward declared}
1999    var lip:ip; lsp:sp; lnp:np; kl:idclass;
2000    begin lip:=nil; again:=false;
2001      if sy=procsy then kl:=proc else
2002        begin kl:=func; fsys:=fsys+[colon1,ident] end;
2003      insym;
2004      if sy<>ident then begin error(+0108); id:=spaces end;
2005      if not param then lip:=searchsection(top^.fname);
2006      if lip<>nil then
2007        if (lip^.klass<>kl) or (lip^.pfkind<>forwrd) then
2008          errid(+0109,id)
2009        else
2010          begin b.forwcount:=b.forwcount-1; again:=true end;
2011      if again then insym else
2012        begin lip:=newip(kl,id,nil,nil);
2013          if sy=ident then begin enterid(lip); insym end;
2014          lastpfno:=lastpfno+1; lip^.pfno:=lastpfno;
2015        end;
2016      level:=level+1;
```

```
2017      new(lnp,blck); lnp^.occur:=blck; lnp^.nlink:=top; top:=lnp;
2018      if again then lnp^.fname:=lip^.parhead else
2019        begin lnp^.fname:=nil;
2020          if find3(lparent,fsys,+0110) then
2021            begin lip^.parhead:=parlist(fsys+[rparent],lip^.headlc);
2022              nextif(rparent,+0111)
2023            end;
2024        end;
2025      if (kl=func) and not again then
2026        begin nextif(colon1,+0112); lsp:=typid(+0113);
2027          if formof(lsp,[power..tag]) then
2028            begin error(+0114); lsp:=nil end;
2029          lip^.idtype:=lsp;
2030        end;
2031      fip:=lip;
2032    end;

2034    procedure pfdeclaration(fsys:sos);
2035    var lip:ip; again:boolean; markp:^integer; lbp:bp;
2036    begin with b do begin
2037      pfhead(fsys+[ident,semicolon,labelsy..beginsy],lip,again,false);
2038      nextif(semicolon,+0115);
2039      if find1([ident,labelsy..beginsy],fsys+[semicolon],+0116) then
2040        if sy=ident then
2041          if id='forward ' then
2042            begin insym;
2043              if lip^.pfpos.lv>1 then genpnam(ps_fwp,lip);
2044              if again then errid(+0117,lip^.name) else
2045                begin lip^.pfkind:=forwrd; forwcount:=forwcount+1 end;
2046            end else
2047          if id='extern  ' then
2048            begin lip^.pfkind:=extrn;
2049              lip^.pfpos.lv:=1; insym; teststandard
2050            end
2051          else errid(+0118,id)
2052        else
2053          begin lip^.pfkind:=actual;
2054    #ifndef STANDARD
2055            mark(markp);
2056    #endif
2057            if not again then if lip^.pfpos.lv>1 then genpnam(ps_fwp,lip);
2058            new(lbp); lbp^:=b; nextbp:=lbp;
2059            lc:=address(lip^.headlc,0,false);  {align headlc}
2060            ilbno:=0; forwcount:=0; lchain:=nil;
2061            if lip^.idtype<>nil then
2062              lip^.pfpos.ad:=address(lc,sizeof(lip^.idtype),false);
2063            block(fsys+[semicolon],lip);
2064            b:=nextbp^;
2065    #ifndef STANDARD
2066            release(markp);
2067    #endif
2068          end;
2069      if not main then eofexpected:=forwcount=0;
2070      nextif(semicolon,+0119);
2071      level:=level-1; top:=top^.nlink;
2072    end end;
```

```
2074    {==============================================================}

2076    procedure expression(fsys:sos); forward;
2077            {this forward declaration cannot be avoided}

2079    procedure selectarrayelement(fsys:sos);
2080    var isp,lsp:sp;
2081    begin
2082      repeat loadaddr; isp:=nil;
2083        if formof(a.asp,[arrays,carray]) then isp:=a.asp^.inxtype else
2084          asperr(+0120);
2085        lsp:=a.asp;
2086        expression(fsys+[comma]); force(desub(isp),+0121);
2087                    {no range check}
2088        if lsp<>nil then
2089          begin a.packbit:=spack in lsp^.sflag;
2090            descraddr(lsp^.arpos); lsp:=lsp^.aeltype
2091          end;
2092        a.asp:=lsp; a.ak:=indexed;
2093      until endofloop(fsys,[notsy..lparent],comma,+0122);  {+0123}
2094    end;

2096    procedure selector(fsys: sos; fip:ip; iflag:iflagset);
2097    {selector computes the address of any kind of variable.
2098      Four possibilities:
2099      1.for direct accessable variables, 'a' contains offset and level,
2100      2.for indirect accessable variables, the address is on the stack.
2101      3.for array elements, the top of stack gives the index (one word).
2102        The address of the array is beneath it.
2103      4.for variables with address in direct accessible pointer variable,
2104        the offset and level of the pointer is stored in 'a'.
2105      If a.asp=nil then an error occurred else a.asp gives
2106      the type of the variable.
2107    }
2108    var lip:ip; l1,l2:integer;
2109    begin l1:=lino; inita(fip^.idtype,0);
2110      case fip^.klass of
2111        vars: with a do
2112          begin pos:=fip^.vpos; if refer in fip^.iflag then ak:=pfixed end;
2113        field:
2114          begin a:=lastnp^.wa;
2115            fieldaddr(fip^.foffset); a.asp:=fip^.idtype
2116          end;
2117        func: with a do
2118          if fip^.pfkind=standard then asperr(+0124) else
2119            begin pos:=fip^.pfpos; pos.lv:=pos.lv+1;
2120              if pos.lv>=level then if fip<>currproc then error(+0125);
2121              if fip^.pfkind<>actual then error(+0126);
2122              if sy=arrow then error(+0127);
2123            end
2124      end;  {case}
2125      while find2([lbrack,period,arrow],fsys,+0128) do with a do
2126        if sy=lbrack then
2127          begin insym;
2128            selectarrayelement(fsys+[rbrack,lbrack,period,arrow]);
```

```
2129            nextif(rbrack,+0129); iflag:=iflag+[noreg];
2130          end else
2131        if sy=period then
2132          begin insym; iflag:=iflag+[noreg];
2133            if sy<>ident then error(+0130) else
2134              begin
2135                if not formof(asp,[records]) then asperr(+0131) else
2136                  begin lip:=searchsection(asp^.fstfld);
2137                    if lip=nil then begin errid(+0132,id); asp:=nil end else
2138                      begin packbit:=spack in asp^.sflag;
2139                        fieldaddr(lip^.foffset); asp:=lip^.idtype
2140                      end
2141                  end;
2142                insym
2143              end
2144          end
2145        else
2146          begin insym; iflag:=[used];
2147            if asp<>nil then
2148              if asp=stringptr then asperr(+0133) else
2149              if asp^.form=pointer then
2150                begin
2151                  if ak=fixed then ak:=pfixed else
2152                    begin load; ak:=ploaded end;
2153                  asp:=asp^.eltype
2154                end else
2155              if asp^.form=files then
2156                begin l2:=lino; gen1(op_mrk,0); exchange(l1,l2); loadaddr;
2157                  gensp(WDW); asp:=asp^.filtype; ak:=ploaded; packbit:=true;
2158                end
2159              else asperr(+0134);
2160          end;
2161    fip^.iflag:=fip^.iflag+iflag;
2162  end;

2164  procedure variable(fsys:sos);
2165  var lip: ip;
2166  begin
2167    if sy=ident then
2168      begin lip:=searchid([vars,field]); insym;
2169        selector(fsys,lip,[used,assigned,noreg])
2170      end
2171    else begin error(+0135); inita(nil,0) end;
2172  end;

2174  {===================================================================}

2176  function plistequal(p1,p2:ip):boolean;
2177  var ok:boolean; q1,q2:sp;
2178  begin plistequal:=eqstruct(p1^.idtype,p2^.idtype);
2179    p1:=p1^.parhead; p2:=p2^.parhead;
2180    while (p1<>nil) and (p2<>nil) do
2181      begin ok:=false;
2182        if p1^.klass=p2^.klass then
2183          if p1^.klass<>vars then ok:=plistequal(p1,p2) else
2184            begin q1:=p1^.idtype; q2:=p2^.idtype; ok:=true;
2185              while ok and formof(q1,[carray]) and formof(q2,[carray]) do
2186                begin ok:=eqstruct(q1^.inxtype,q2^.inxtype);
2187                  q1:=q1^.aeltype; q2:=q2^.aeltype;
2188                end;
2189              if not (eqstruct(q1,q2) and
2190                  (p1^.iflag*[refer,samesect]=p2^.iflag*[refer,samesect]))
2191                then ok:=false;
2192            end;
2193        if not ok then plistequal:=false;
2194        p1:=p1^.next; p2:=p2^.next
2195      end;
2196    if (p1<>nil) or (p2<>nil) then plistequal:=false
2197  end;

2199  procedure callnonstandard(fsys:sos; moreargs:boolean; fip:ip);
2200  var nxt,lip:ip; lpos:position; l1,l2:integer;
2201      lsp,oldasp:sp;
2202  begin with a,lpos do begin
2203    nxt:=fip^.parhead; lpos:=fip^.pfpos;
2204    if fip^.pfkind<>formal then gen1(op_mrk,level-lv) else
2205      begin lexical(op_loi,lv,ad,ptrsize); gen0(op_mrs) end;
2206    while (nxt<>nil) and moreargs do
2207      begin lsp:=nxt^.idtype;
2208        if nxt^.klass=vars then
2209          if refer in nxt^.iflag then  {call by reference}
2210            begin l1:=lino; variable(fsys); loadaddr;
2211              if samesect in nxt^.iflag then lsp:=oldasp else
2212                begin oldasp:=asp; l2:=lino;
2213                  while formof(lsp,[carray]) and
2214                          formof(asp,[arrays,carray]) do
2215                    if (compat(lsp^.inxtype,asp^.inxtype) > subeq) or
2216                          (lsp^.sflag<>asp^.sflag) then asperr(+0136) else
2217                      begin descraddr(asp^.arpos);
2218                        asp:=asp^.aeltype; lsp:=lsp^.aeltype
2219                      end;
2220                  exchange(l1,l2);
2221                end;
2222              if not eqstruct(asp,lsp) then asperr(+0137);
2223              if packbit then asperr(+0138);
2224            end
2225          else  {call by value}
2226            begin expression(fsys); force(lsp,+0139) end
2227        else
2228          if sy<>ident then error(+0140) else
2229            begin lip:=searchid([nxt^.klass]); insym;
2230              if lip^.pfkind=standard then error(+0141) else
2231              if not plistequal(nxt,lip) then error(+0142) else
2232              if lip^.pfkind=formal then
2233                lexical(op_loi,lip^.pfpos.lv,
2234                        lip^.pfpos.ad,pnumsize+ptrsize)
2235              else
2236                begin gen1(op_lex,level-lip^.pfpos.lv);
2237                  genpnam(op_loc,lip)
2238                end
2239            end;
2240        nxt:=nxt^.next; moreargs:=find3(comma,fsys,+0143);
```

```
2241        end;
2242      while moreargs do
2243        begin error(+0144); expression(fsys); load;
2244          moreargs:=find3(comma,fsys,+0145)
2245        end;
2246      if nxt<>nil then error(+0146);
2247      if fip^.pfkind<>formal then genpnam(op_cal,fip) else
2248        begin lexical(op_loi,lv,ad+ptrsize,pnumsize); gen0(op_cas) end;
2249      asp:=fip^.idtype;
2250    end end;

2252    procedure fileaddr;
2253    var la:attr;
2254    begin la:=a; a:=fa; loadaddr; a:=la end;

2256    procedure callr(l1,l2:integer);
2257    var la:attr;
2258    begin with a do begin
2259      la:=a; asp:=desub(asp); gen1(op_mrk,0); fileaddr;
2260      if asp=intptr then gensp(RDI) else
2261      if asp=charptr then gensp(RDC) else
2262      if asp=realptr then gensp(RDR) else
2263      if asp=longptr then gensp(RDL) else asperr(+0147);
2264      if asp<>la.asp then checkbnds(la.asp);
2265      a:=la; exchange(l1,l2); store;
2266    end end;

2268    procedure callw(fsys:sos; l1,l2:integer);
2269    var m:libmnem;
2270    begin with a do begin gen1(op_mrk,0);
2271      fileaddr; exchange(l1,l2); loadcheap; asp:=desub(asp);
2272      if string(asp) then
2273        begin gen1(op_loc,asp^.size); m:=WRS end
2274      else
2275        begin m:=WRI;
2276          if asp<>intptr then
2277          if asp=charptr then m:=WRC else
2278          if asp=realptr then m:=WRR else
2279          if asp=boolptr then m:=WRB else
2280          if asp=stringptr then m:=WRZ else
2281          if asp=longptr then m:=WRL else asperr(+0148);
2282        end;
2283      if find3(colon1,fsys,+0149) then
2284        begin expression(fsys+[colon1]);
2285          force(intptr,+0150); m:=succ(m)
2286        end;
2287      if find3(colon1,fsys,+0151) then
2288        begin expression(fsys); force(intptr,+0152);
2289          if m<>WSR then error(+0153) else m:=WRF;
2290        end;
2291      gensp(m);
2292    end end;

2294    procedure callrw(fsys:sos; lpar,w,ln:boolean);
2295    var l1,l2,oldlc,errno:integer; ftype,lsp:sp;
2296    begin with b do begin oldlc:=lc; ftype:=textptr;
2297      inita(textptr,argv[ord(w)].ad); a.pos.lv:=0; fa:=a;
2298      if lpar then
2299        begin l1:=lino;
2300          if w then expression(fsys+[colon1]) else variable(fsys);
2301          l2:=lino;
2302          if formof(a.asp,[files]) then
2303            begin ftype:=a.asp;
2304              if (a.ak<>fixed) and (a.ak<>pfixed) then
2305                begin loadaddr; inita(nilptr,reserve(ptrsize));
2306                  store; a.ak:=pfixed
2307                end;
2308              fa:=a;  {store doesn't change a}
2309              if (sy<>comma) and not ln then error(+0154);
2310            end
2311          else
2312            begin if iop[w]=nil then error(+0155);
2313              if w then callw(fsys,l1,l2) else callr(l1,l2)
2314            end;
2315          while find3(comma,fsys,+0156) do with a do
2316            begin l1:=lino;
2317              if w then expression(fsys+[colon1]) else variable(fsys);
2318              l2:=lino;
2319              if ftype=textptr then
2320                if w then callw(fsys,l1,l2) else callr(l1,l2)
2321              else
2322                begin errno:=+0157;
2323                  if w then force(ftype^.filtype,errno) else
2324                    begin store; l2:=lino end;
2325                  gen1(op_mrk,0); fileaddr; gensp(WDW);
2326                  ak:=ploaded; packbit:=true;
2327                  if w then store else
2328                    begin lsp:=asp; asp:=ftype^.filtype; force(lsp,errno);
2329                      exchange(l1,l2)
2330                    end;
2331                  gen1(op_mrk,0); fileaddr;
2332                  if w then gensp(PUTX) else gensp(GETX)
2333                end
2334            end;
2335        end
2336      else
2337        if not ln then error(+0158) else
2338          if iop[w]=nil then error(+0159);
2339      if ln then
2340        begin if ftype<>textptr then error(+0160);
2341          gen1(op_mrk,0); fileaddr;
2342          if w then gensp(WLN) else gensp(RLN)
2343        end;
2344      lc:=oldlc
2345    end end;

2347    procedure callflp(fsys:sos; lpar:boolean; m:libmnem);
2348    begin with a do begin
2349      if lpar then
2350        begin variable(fsys); loadaddr;
2351          if not formof(asp,[files]) then asperr(+0161) else
2352            if (m<>EFL) and (asp<>textptr) then error(+0162);
```

```
2353        end
2354      else
2355        if iop[m=PAG]=nil then error(+0163) else
2356          gen1(op_lae,argv[ord(m=PAG)].ad);
2357      gensp(m); asp:=boolptr;  {not for PAG}
2358    end end;

2360    procedure callnd(fsys:sos; m:libmnem);
2361    label 1;
2362    var lsp:sp; sz,int:integer;
2363    begin with a do begin
2364      if not formof(asp,[pointer]) then asperr(+0164) else
2365        if asp=stringptr then asperr(+0165) else
2366          asp:=asp^.eltype;
2367      while find3(comma,fsys,+0166) do
2368        begin
2369          if asp<>nil then  {asp of form record or variant}
2370            if asp^.form=records then asp:=asp^.tagsp else
2371            if asp^.form=variant then asp:=asp^.subtsp else asperr(+0167);
2372          if asp=nil then constant(fsys,lsp,int) else
2373            begin assert asp^.form=tag;
2374              int:=cstinteger(fsys,asp^.tfldsp,+0168); lsp:=asp^.fstvar;
2375              while lsp<>nil do
2376                if lsp^.varval<>int then lsp:=lsp^.nxtvar else
2377                  begin asp:=lsp; goto 1 end;
2378            end;
2379    1:  end;
2380      sz:=sizeof(asp); int:=intsize+ptrsize;
2381      if sz>int then int:=(sz+int-1) div int * int;
2382      gen1(op_loc,int); gensp(m)
2383    end end;

2385    procedure callpg(m:libmnem);
2386    begin gensp(m); if not formof(a.asp,[files]) then asperr(+0169) end;

2388    procedure callrr(m:libmnem);
2389    begin
2390      if not formof(a.asp,[files]) then asperr(+0170) else
2391        if a.asp=textptr then gen1(op_loc,0) else
2392          gen1(op_loc,sizeof(a.asp^.filtype));
2393      gensp(m);
2394    end;

2396    procedure callmr(m:libmnem);
2397    begin teststandard; gensp(m);
2398      if not formof(a.asp,[pointer]) then asperr(+0171)
2399    end;

2401    procedure callpu(m:libmnem; zsp,asp,isp:sp);
2402    begin isp:=desub(isp);
2403      if formof(zsp,[arrays,carray]) and formof(asp,[arrays,carray]) then
2404        if (spack in (zsp^.sflag - asp^.sflag)) and
2405            eqstruct(zsp^.aeltype,asp^.aeltype) and
2406            eqstruct(desub(zsp^.inxtype),isp) and
2407            eqstruct(desub(asp^.inxtype),isp) then
2408          begin descraddr(zsp^.arpos); descraddr(asp^.arpos); gensp(m) end
2409        else error(+0172)
2410      else error(+0173)
2411    end;

2413    procedure call(fsys: sos; fip: ip);
2414    var lkey: standpf; lpar:boolean; lsp,lsp2:sp;
2415    begin with a do begin fsys:=fsys+[comma];
2416      lpar:=find3(lparent,fsys,+0174); if lpar then fsys:=fsys+[rparent];
2417      if fip^.pfkind<>standard then callnonstandard(fsys,lpar,fip) else
2418        begin lkey:=fip^.key;
2419          if lkey in [pput..phalt,feof..fabs,fround..farctan] then
2420            gen1(op_mrk,0);
2421          if lkey in [pput..prelease,fabs..farctan] then
2422            begin if not lpar then error(+0175);
2423              if lkey <= prelease then
2424                begin variable(fsys); loadaddr end
2425              else
2426                begin expression(fsys); force(fip^.idtype,+0176) end;
2427            end;
2428          case lkey of
2429            pread,preadln,pwrite,pwriteln:  {0,1,2,3 resp}
2430              callrw(fsys,lpar,lkey>=pwrite,odd(ord(lkey)));
2431            pput:
2432              callpg(PUTX);
2433            pget:
2434              callpg(GETX);
2435            ppage:
2436              callflp(fsys,lpar,PAG);
2437            preset:
2438              callrr(OPN);
2439            prewrite:
2440              callrr(CRE);
2441            pnew:
2442              callnd(fsys,NEWX);
2443            pdispose:
2444              callnd(fsys,DIS);
2445            ppack:
2446              begin lsp:=asp; nextif(comma,+0177); expression(fsys); load;
2447                lsp2:=asp; nextif(comma,+0178); variable(fsys); loadaddr;
2448                callpu(PAC,asp,lsp,lsp2)
2449              end;
2450            punpack:
2451              begin lsp:=asp; nextif(comma,+0179); variable(fsys); loadaddr;
2452                lsp2:=asp; nextif(comma,+0180); expression(fsys); load;
2453                callpu(UNP,lsp,lsp2,asp)
2454              end;
2455            pmark:
2456              callmr(SAV);
2457            prelease:
2458              callmr(RST);
2459            phalt:
2460              begin teststandard;
2461                if not lpar then gen1(op_loc,0) else
2462                  begin expression(fsys); force(intptr,+0181) end;
2463                gensp(HLT);
2464              end;
```

```
2465         feof:
2466           callflp(fsys,lpar,EFL);
2467         feoln:
2468           callflp(fsys,lpar,ELN);
2469         fabs:
2470           begin asp:=desub(asp);
2471             if asp=intptr then gensp(ABI) else
2472             if asp=realptr then gensp(ABR) else
2473             if asp=longptr then gensp(ABL) else asperr(+0182);
2474           end;
2475         fsqr:
2476           begin asp:=desub(asp);
2477             if asp=intptr then
2478               begin gen1(op_dup,intsize); gen0(op_mul) end else
2479             if asp=realptr then
2480               begin gen1(op_dup,realsize);
2481                 gen0(op_fmu); fltused:=true
2482               end
2483             else if asp=longptr then
2484               begin gen1(op_dup,longsize); gen0(op_dmu) end
2485             else asperr(+0183);
2486           end;
2487         ford:
2488           begin if not nicescalar(desub(asp)) then asperr(+0184);
2489             asp:=intptr
2490           end;
2491         fchr:
2492           checkbnds(charptr);
2493         fpred,fsucc:
2494           begin asp:=desub(asp); gen1(op_loc,1);
2495             if lkey=fpred then gen0(op_sub) else gen0(op_add);
2496             if nicescalar(asp) then genrck(asp) else asperr(+0185)
2497           end;
2498         fodd:
2499           begin gen1(op_loc,1); gen1(op_and,intsize); asp:=boolptr end;
2500         ftrunc:
2501           begin if asp<>realptr then asperr(+0186); opconvert(ri) end;
2502         fround:
2503           begin if asp<>realptr then asperr(+0187);
2504             gensp(RND); asp:=intptr
2505           end;
2506         fsin:
2507           gensp(SIN);
2508         fcos:
2509           gensp(COS);
2510         fexp:
2511           gensp(EXPX);
2512         fsqrt:
2513           gensp(SQT);
2514         fln:
2515           gensp(LOG);
2516         farctan:
2517           gensp(ATN);
2518       end;
2519     end;
2520   if lpar then nextif(rparent,+0188);
2521 end end;

2523 {==============================================================}

2525 procedure convert(fsp:sp; l1:integer);
2526 {Convert tries to make the operands of some operator of the same type.
2527   The operand types are given by fsp and a.asp. The resulting type
2528   is put in a.asp.
2529   l1 gives the lino of the first instruction of the right operand.
2530 }
2531 var l2:integer;
2532     ts:twostruct;
2533 begin with a do begin asp:=desub(asp);
2534   ts:=compat(fsp,asp);
2535   case ts of
2536     eq,subeq:
2537       ;
2538     rl,li,ri:
2539       opconvert(compat(asp,fsp));  { ri->ir etc.}
2540     lr,il,ir:
2541       begin l2:=lino; opconvert(ts); exchange(l1,l2) end;
2542     se:
2543       expandemptyset(fsp);
2544     es:
2545       begin l2:=lino; expandemptyset(asp); exchange(l1,l2) end;
2546     noteq:
2547       asperr(+0189);
2548   end;
2549   if asp=realptr then fltused:=true
2550 end end;

2552 procedure buildset(fsys:sos);
2553 {This is a bad construct in pascal. Two objections:
2554   - expr..expr very difficult to implement on most machines
2555   - this construct makes it hard to implement sets of different size
2556 }
2557 const   ncsw    = 16;   {tunable}
2558 type    wordset = set of 0..wbm1;
2559 var     i,j,val1,val2,ncst,l1,l2,sz:integer;
2560         cst1,cst2,cst12,varpart:boolean;
2561         cstpart:array[1..ncsw] of wordset;
2562         lsp:sp;

2564 procedure genwordset(s:wordset);
2565         {level 2: << buildset}
2566 var b,i,w:integer;
2567 begin
2568   if s=[] then w:=0 else
2569   if s=[wbm1] then w:=-t15m1-1 else
2570     begin w:=-1; b:=t14;
2571       for i:=wbm1-1 downto 0 do
2572         begin if i in s then w:=w+b; b:=b div 2 end;
2573       if wbm1 in s then w:=w-t15m1 else w:=w+1
2574     end;
2575   gen1(op_loc,w)
2576 end;
```

```
2578   procedure setexpr(fsys:sos; var c:boolean; var v:integer);
2579           {level 2: <<  buildset}
2580   {update lsp and sz variables of buildset and set c and v parameters}
2581   var min,max:integer; errno:integer;
2582   begin with a do begin c:=false; v:=0;
2583     expression(fsys); asp:=desub(asp);
2584     if asp<>nil then
2585       begin
2586         if lsp=nil then
2587           begin errno:=0;
2588             if not bounds(asp,min,max) then
2589               if asp=intptr then max:=iopt-1 else errno:=+0190;
2590             if max>(maxsetsize-1)*bytebits + (bytebits-1) then
2591               errno:=+0191;
2592             if errno<>0 then begin asperr(errno); max:=0 end;
2593             sz:=even(max div bytebits + 1); lsp:=asp;
2594           end
2595         else {asp<>nil and lsp<>nil}
2596           if asp<>lsp then asperr(+0192);
2597         if ak=cst then
2598           if pos.ad<ncsw*wordbits then
2599             begin c:=true; v:=pos.ad end;
2600       end;
2601     if not c then load
2602   end end;

2604   begin with a do begin  {buildset}
2605     varpart:=false; ncst:=0; sz:=maxsetsize; lsp:=nil;
2606     for i:=1 to ncsw do cstpart[i]:=[];
2607     if find2([notsy..lparent],fsys,+0193) then
2608       repeat l1:=lino;
2609         setexpr(fsys+[colon2,comma],cst1,val1); cst12:=cst1;
2610         if find3(colon2,fsys+[comma,notsy..lparent],+0194) then
2611           begin setexpr(fsys+[comma,notsy..lparent],cst2,val2);
2612             cst12:=cst12 and cst2;
2613             if cst2 and not cst1 then load;
2614             if cst1 and not cst2 then
2615               begin l2:=lino; gen1(op_loc,val1); exchange(l1,l2) end;
2616             if not cst12 then
2617               begin l2:=lino; gen1(op_mrk,0); exchange(l1,l2);
2618                 gen1(op_loc,sz); gensp(BTS)
2619               end;
2620           end
2621         else
2622           if cst12 then val2:=val1 else gen1(op_set,sz);
2623         if cst12 then
2624           if (val1<0) or (val2>=ncsw*wordbits) then error(+0195) else
2625             for i:=val1 to val2 do
2626               begin j:=i div wordbits + 1; ncst:=ncst+1;
2627                 cstpart[j]:=cstpart[j] + [i mod wordbits]
2628               end
2629         else
2630           if varpart then gen1(op_ior,sz) else varpart:=true;
2631       until endofloop(fsys,[notsy..lparent],comma,+0196);  {+0197}
2632     ak:=loaded;
2633     if (ncst=0) and not varpart then
2634       begin asp:=emptyset; gen1(op_loc,0) end
2635     else
2636       begin asp:=newsp(power,sz); asp^.elset:=lsp;
2637         if ncst>0 then
2638           for i:=1 to sz div wordsize do genwordset(cstpart[i]);
2639         if varpart and (ncst>0) then gen1(op_ior,sz);
2640       end
2641   end end;

2643   procedure factor(fsys: sos);
2644   var lip:ip; l1,i:integer; lsp:sp;
2645   begin with a do begin
2646     asp:=nil; packbit:=false; ak:=loaded;
2647     if find1([notsy..nilcst,lparent],fsys,+0198) then
2648       case sy of
2649         ident:
2650           begin lip:=searchid([konst,vars,field,func,carrbnd]); insym;
2651             case lip^.klass of
2652               func: {call moves result to top stack}
2653                 begin call(fsys,lip); ak:=loaded; packbit:=false end;
2654               konst:
2655                 begin asp:=lip^.idtype;
2656                   if nicescalar(asp) then  {including asp=nil}
2657                     begin ak:=cst; pos.ad:=lip^.value end
2658                   else
2659                     begin ak:=ploaded;
2660                       l1:=lino; gend(op_lae,abs(lip^.value));
2661                       if asp^.form=scalar then
2662                         begin load; if lip^.value<0 then negate(l1) end
2663                       else
2664                         if asp=stringptr then ak:=loaded
2665                     end
2666                 end;
2667               field,vars:
2668                 selector(fsys,lip,[used]);
2669               carrbnd:
2670                 begin lsp:=lip^.idtype; assert formof(lsp,[carray]);
2671                   descraddr(lsp^.arpos); lsp:=lsp^.inxtype;
2672                   asp:=desub(lsp);
2673                   if lip^.next=nil then ak:=ploaded {low bound} else
2674                     begin gen1(op_loi,2*intsize); gen0(op_add) end;
2675                   load; checkbnds(lsp);
2676                 end;
2677             end  {case}
2678           end;
2679         intcst:
2680           begin asp:=intptr; ak:=cst; pos.ad:=val; insym end;
2681         realcst:
2682           begin asp:=realptr; ak:=ploaded; gend(op_lae,val); insym end;
2683         longcst:
2684           begin asp:=longptr; ak:=ploaded; gend(op_lae,val); insym end;
2685         charcst:
2686           begin asp:=charptr; ak:=cst; pos.ad:=val; insym end;
2687         stringcst:
2688           begin asp:=stringstruct; gend(op_lae,val); insym;
```

```
2689             if asp<>stringptr then ak:=ploaded;
2690           end;
2691         nilcst:
2692           begin insym; asp:=nilptr;
2693             for i:=1 to ptrsize div wordsize do gen1(op_loc,0);
2694           end;
2695         lparent:
2696           begin insym;
2697             expression(fsys+[rparent]); nextif(rparent,+0199)
2698           end;
2699         notsy:
2700           begin insym; factor(fsys); load; gen0(op_teq);
2701             if asp<>boolptr then asperr(+0200)
2702           end;
2703         lbrack:
2704           begin insym; buildset(fsys+[rbrack]); nextif(rbrack,+0201) end;
2705       end
2706   end end;

2708   procedure term(fsys:sos);
2709   var lsy:symbol; lsp:sp; l0,l1,l2:integer; first:boolean;
2710   begin with a,b do begin first:=true; l1:=lino; l0:=l1;
2711     factor(fsys+[starsy..andsy]);
2712     while find2([starsy..andsy],fsys,+0202) do
2713       begin if first then begin load; first:=false end;
2714         lsy:=sy; insym; l1:=lino; lsp:=asp;
2715         factor(fsys+[starsy..andsy]); load; convert(lsp,l1);
2716         if asp<>nil then
2717           case lsy of
2718             starsy:
2719               if asp=intptr then gen0(op_mul) else
2720               if asp=realptr then gen0(op_fmu) else
2721               if asp=longptr then gen0(op_dmu) else
2722               if asp^.form=power then setop(op_and) else asperr(+0203);
2723             slashsy:
2724               if asp=realptr then gen0(op_fdv) else
2725               if (asp=intptr) or (asp=longptr) then
2726                 begin lsp:=asp;
2727                   convert(realptr,l1);  {make real of right operand}
2728                   convert(lsp,l1);  {make real of left operand}
2729                   gen0(op_fdv)
2730                 end
2731               else asperr(+0204);
2732             divsy:
2733               if asp=intptr then gen0(op_div) else
2734               if asp=longptr then gen0(op_ddv) else asperr(+0205);
2735             modsy:
2736               begin l2:=lino; gen1(op_mrk,0); exchange(l0,l2);
2737                 if asp=intptr then gensp(MDI) else
2738                 if asp=longptr then gensp(MDL) else asperr(+0206);
2739               end;
2740             andsy:
2741               if asp=boolptr then setop(op_and) else asperr(+0207);
2742           end {case}
2743       end {while}
2744   end end;
```

```
2746   procedure simpleexpression(fsys:sos);
2747   var lsy:symbol; lsp:sp; l1:integer; signed,min,first:boolean;
2748   begin with a do begin l1:=lino; first:=true;
2749     signed:=(sy=plussy) or (sy=minsy);
2750     if signed then begin min:=sy=minsy; insym end else min:=false;
2751     term(fsys + [minsy,plussy,orsy]); lsp:=desub(asp);
2752     if signed then
2753       if (lsp<>intptr) and (lsp<>realptr) and (lsp<>longptr) then
2754         asperr(+0208)
2755       else if min then
2756         begin load; first:=false; asp:=lsp; negate(l1) end;
2757     while find2([plussy,minsy,orsy],fsys,+0209) do
2758       begin if first then begin load; first:=false end;
2759         lsy:=sy; insym; l1:=lino; lsp:=asp;
2760         term(fsys+[minsy,plussy,orsy]); load; convert(lsp,l1);
2761         if asp<>nil then
2762           case lsy of
2763             plussy:
2764               if asp=intptr then gen0(op_add) else
2765               if asp=realptr then gen0(op_fad) else
2766               if asp=longptr then gen0(op_dad) else
2767               if asp^.form=power then setop(op_ior) else asperr(+0210);
2768             minsy:
2769               if asp=intptr then gen0(op_sub) else
2770               if asp=realptr then gen0(op_fsb) else
2771               if asp=longptr then gen0(op_dsb) else
2772               if asp^.form=power then
2773                 begin setop(op_com); setop(op_and) end
2774               else asperr(+0211);
2775             orsy:
2776               if asp=boolptr then setop(op_ior) else asperr(+0212);
2777           end {case}
2778       end {while}
2779   end end;

2781   procedure expression; { fsys:sos }
2782   var lsy:symbol; lsp:sp; l1,l2,l3,sz:integer;
2783   begin with a do begin l1:=lino;
2784     simpleexpression(fsys+[eqsy..insy]);
2785     if find2([eqsy..insy],fsys,+0213) then
2786       begin lsy:=sy; insym; lsp:=asp; loadcheap; l2:=lino;
2787         simpleexpression(fsys); loadcheap;
2788         if lsy=insy then
2789           begin
2790             if not formof(asp,[power]) then asperr(+0214) else
2791               if asp=emptyset then setop(op_and) else
2792                     {this effectively replaces the word on top of the
2793                      stack by the result of the 'in' operator: false }
2794               if not (compat(lsp,asp^.elset) <= subeq) then
2795                 asperr(+0215)
2796               else
2797                 begin exchange(l1,l2); setop(op_inn) end
2798           end
2799         else
2800           begin convert(lsp,l2);
```

```
2801          if asp<>nil then
2802            case asp^.form of
2803              scalar:
2804                if asp=realptr then gen0(op_cmf) else
2805                if asp=longptr then gen0(op_cmd) else gen0(op_cmi);
2806              pointer:
2807                if (lsy=eqsy) or (lsy=nesy) then gen0(op_cmp) else
2808                  asperr(+0216);
2809              power:
2810                case lsy of
2811                  eqsy,nesy: setop(op_cmu);
2812                  ltsy,gtsy: asperr(+0217);
2813                  lesy:  {'a<=b' equivalent to 'a-b=[]'}
2814                    begin setop(op_com); setop(op_and);
2815                      gen1(op_loc,0); expandemptyset(asp);
2816                      setop(op_cmu); lsy:=eqsy
2817                    end;
2818                  gesy:  {'a>=b' equivalent to 'a=b+a'}
2819                    begin sz:=even(sizeof(asp)); gen1(op_dup,2*sz);
2820                      gen1(op_beg,-sz); setop(op_ior);
2821                      setop(op_cmu); lsy:=eqsy
2822                    end
2823                end;  {case}
2824              arrays:
2825                if string(asp) then
2826                  begin l3:=lino; gen1(op_mrk,0); exchange(l1,l3);
2827                    gen1(op_loc,asp^.size); gensp(BCP)
2828                  end
2829                else asperr(+0218);
2830              records: asperr(+0219);
2831              files: asperr(+0220)
2832            end;  { case }
2833          case lsy of
2834            ltsy: gen0(op_tlt);
2835            lesy: gen0(op_tle);
2836            gtsy: gen0(op_tgt);
2837            gesy: gen0(op_tge);
2838            nesy: gen0(op_tne);
2839            eqsy: gen0(op_teq)
2840          end
2841        end;
2842      asp:=boolptr; ak:=loaded
2843    end;
2844  end end;

2846  {=================================================================}

2848  procedure statement(fsys:sos); forward;
2849                {this forward declaration can be avoided}

2851  procedure assignment(fsys:sos; fip:ip);
2852  var la:attr; l1,l2:integer;
2853  begin
2854    l1:=lino; selector(fsys+[becomes],fip,[assigned]); l2:=lino;
2855    la:=a; nextif(becomes,+0221);
2856    expression(fsys); loadcheap; checkasp(la.asp,+0222);
2857    exchange(l1,l2); a:=la;
2858    if not formof(la.asp,[arrays..records]) then store else
2859      begin loadaddr;
2860        if la.asp^.form<>carray then
2861          gen1(op_blm,even(sizeof(la.asp)))
2862        else
2863          begin gen1(op_mrk,0); descraddr(la.asp^.arpos); gensp(ASZ);
2864            gen0(op_bls)
2865          end;
2866      end;
2867  end;

2869  procedure gotostatement;
2870  {jumps into structured statements can give strange results. }
2871  label 1;
2872  var llp:lp; lbp:bp; diff:integer;
2873  begin
2874    if sy<>intcst then error(+0223) else
2875      begin llp:=searchlab(b.lchain,val);
2876        if llp<>nil then
2877          if llp^.seen then gen1(op_brb,llp^.labname)
2878          else gen1(op_brf,llp^.labname)
2879        else
2880          begin lbp:=b.nextbp; diff:=1;
2881            while lbp<>nil do
2882              begin llp:=searchlab(lbp^.lchain,val);
2883                if llp<>nil then goto 1;
2884                lbp:=lbp^.nextbp; diff:=diff+1;
2885              end;
2886  1:          if llp=nil then errint(+0224,val) else
2887              begin
2888                if llp^.labdlb=0 then
2889                  begin dlbno:=dlbno+1; llp^.labdlb:=dlbno;
2890                    gend(ps_fwa,dlbno);  {forward data reference}
2891                  end;
2892                gen1(op_mrk,diff); gend(op_lae,llp^.labdlb); gensp(GTO);
2893              end;
2894          end;
2895        insym;
2896      end
2897  end;

2899  procedure compoundstatement(fsys:sos; err:integer);
2900  begin
2901    repeat statement(fsys+[semicolon])
2902    until endofloop(fsys,[beginsy..casesy],semicolon,err)
2903  end;

2905  procedure ifstatement(fsys:sos);
2906  var lb1,lb2:integer;
2907  begin with b do begin
2908    expression(fsys+[thensy,elsesy]);
2909    force(boolptr,+0225); ilbno:=ilbno+1; lb1:=ilbno; gen1(op_zeq,lb1);
2910    nextif(thensy,+0226); statement(fsys+[elsesy]);
2911    if find3(elsesy,fsys,+0227) then
2912      begin ilbno:=ilbno+1; lb2:=ilbno; gen1(op_brf,lb2);
```

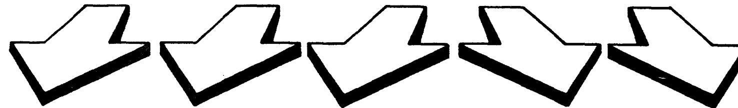
```
2913        genilb(lb1); statement(fsys); genilb(lb2)
2914      end
2915    else genilb(lb1);
2916  end end;

2918  procedure casestatement(fsys:sos);
2919  label 1;
2920  type cip=^caseinfo;
2921       caseinfo=record
2922          next: cip;
2923          csstart: integer;
2924          cslab: integer
2925       end;
2926  var lsp:sp; head,p,q,r:cip;
2927      l0,l1,l2,i,n,m,min,max:integer;
2928  begin with b do begin
2929    expression(fsys+[ofsy,semicolon,ident..plussy]); lsp:=a.asp; load;
2930    if not nicescalar(desub(lsp)) then begin error(+0228); lsp:=nil end;
2931    ilbno:=ilbno+1; l0:=ilbno; gen1(op_brf,l0);  {jump to CSA/B}
2932    ilbno:=ilbno+1; l1:=ilbno;
2933    nextif(ofsy,+0229); head:=nil; max:=minint; min:=maxint; n:=0;
2934    repeat ilbno:=ilbno+1; l2:=ilbno;   {label of current case}
2935      repeat i:=cstinteger(fsys+[comma,colon1,semicolon],lsp,+0230);
2936        if i>max then max:=i; if i<min then min:=i; n:=n+1;
2937        q:=head; r:=nil; new(p);
2938        while q<>nil do
2939          begin  {chain all cases in ascending order}
2940            if q^.cslab>=i then
2941              begin if q^.cslab=i then error(+0231); goto 1 end;
2942            r:=q; q:=q^.next
2943          end;
2944  1:    p^.next:=q; p^.cslab:=i; p^.csstart:=l2;
2945        if r=nil then head:=p else r^.next:=p;
2946      until endofloop(fsys+[colon1,semicolon],
2947                      [ident..plussy],comma,+0232);  {+0233}
2948      nextif(colon1,+0234); genilb(l2); statement(fsys+[semicolon]);
2949      gen1(op_brf,l1);
2950    until lastsemicolon(fsys,[ident..plussy],+0235);  {+0236 +0237}
2951    assert n<>0;
2952    dlbno:=dlbno+1; gendlb(dlbno); genpnam(ps_rom,currproc); gencst(-1);
2953    if (max div 3) - (min div 3) < n then
2954      begin gencst(min); gencst(max-min);
2955        m:=op_csa;
2956        while head<>nil do
2957          begin
2958            while head^.cslab>min do
2959              begin gencst(-1); min:=min+1 end;
2960            genclb(head^.csstart); min:=min+1; head:=head^.next
2961          end;
2962      end
2963    else
2964      begin gencst(n); m:=op_csb;
2965        while head<>nil do
2966          begin gencst(head^.cslab);
2967            genclb(head^.csstart); head:=head^.next
2968          end;
2969      end;
2970    genend; genilb(l0); gend(op_lae,dlbno); gen0(m); genilb(l1)
2971  end end;

2973  procedure repeatstatement(fsys:sos);
2974  var lb1: integer;
2975  begin with b do begin
2976    ilbno:=ilbno+1; lb1:=ilbno; genilb(lb1);
2977    compoundstatement(fsys+[untilsy],+0238);  {+0239}
2978    nextif(untilsy,+0240); genlin;
2979    expression(fsys); force(boolptr,+0241);
2980    ilbno:=ilbno+1; gen0(op_teq); gen1(op_zeq,ilbno);
2981    gen1(op_brb,lb1); genilb(ilbno)
2982  end end;

2984  procedure whilestatement(fsys:sos);
2985  var lb1,lb2: integer;
2986  begin with b do begin
2987    ilbno:=ilbno+2; lb1:=ilbno-1; genilb(lb1); lb2:=ilbno;
2988    genlin; expression(fsys+[dosy]);
2989    force(boolptr,+0242); gen1(op_zeq,lb2);
2990    nextif(dosy,+0243); statement(fsys);
2991    gen1(op_brb,lb1); genilb(lb2)
2992  end end;

2994  procedure forstatement(fsys:sos);
2995  {the upper bound is evaluated once and stored in a temporary local}
2996  var lip:ip; dsp,lsp:sp; tosym,cst1,cst2,local:boolean;
2997      val1,val2,endlab,looplab,oldlc,llc,lad:integer;
2998  begin with a,b do begin
2999    lsp:=nil; lad:=0; tosym:=true; local:=level<>1; oldlc:=lc;
3000    ilbno:=ilbno+1; looplab:=ilbno; ilbno:=ilbno+1; endlab:=ilbno;
3001    if sy<>ident then error(+0244) else
3002      begin lip:=searchid([vars]); insym;
3003        lsp:=lip^.idtype; lad:=lip^.vpos.ad;
3004        if local and
3005            ((lad<currproc^.headlc) or (lip^.vpos.lv<>level)) then
3006          error(+0245)
3007        else lip^.iflag:=lip^.iflag+[used,assigned];
3008      end;
3009    if not nicescalar(desub(lsp)) then begin error(+0246); lsp:=nil end;
3010    nextif(becomes,+0247); dsp:=desub(lsp); assert sizeof(dsp)=wordsize;
3011    expression(fsys+[tosy,downtosy,notsy..lparent,dosy]);
3012    cst1:=ak=cst; if cst1 then val1:=pos.ad; force(dsp,+0248);
3013    if not cst1 then gen1(op_dup,intsize);
3014    if find1([tosy,downtosy],fsys+[notsy..lparent,dosy],+0249) then
3015      begin tosym:=sy=tosy; insym end;
3016    expression(fsys+[dosy]);
3017    cst2:=ak=cst; if cst2 then val2:=pos.ad; force(dsp,+0250);
3018    if not cst2 then
3019      begin llc:=reserve(intsize);
3020        gen1(op_dup,intsize); gen1(op_stl,llc);
3021      end;
3022    if cst1 then
3023      begin
3024        if tosym then gen1(op_bgt,endlab) else gen1(op_blt,endlab);
```

```
3025          gen1(op_loc,val1)
3026        end
3027      else
3028        begin ilbno:=ilbno+1;
3029          if tosym then gen1(op_ble,ilbno) else gen1(op_bge,ilbno);
3030          gen1(op_beg,-intsize); gen1(op_brf,endlab); genilb(ilbno)
3031        end;
3032      assert eqstruct(a.asp,dsp);
3033      checkbnds(lsp); pop(local,lad,intsize); genilb(looplab);
3034      nextif(dosy,+0251); statement(fsys);
3035      push(local,lad,intsize);
3036      if cst2 then gen1(op_loc,val2) else gen1(op_lol,llc);
3037      gen1(op_beq,endlab); push(local,lad,intsize); gen1(op_loc,1);
3038      if tosym then gen0(op_add) else gen0(op_sub);
3039      a.asp:=dsp; checkbnds(lsp); pop(local,lad,intsize);
3040      gen1(op_brb,looplab); genilb(endlab);
3041      lc:=oldlc
3042    end end;

3044    procedure withstatement(fsys:sos);
3045    var lnp,oldtop:np; oldlc:integer; pbit:boolean;
3046    begin with b do begin
3047      oldlc:=lc; oldtop:=top;
3048      repeat variable(fsys+[comma,dosy]);
3049        if not formof(a.asp,[records]) then asperr(+0252) else
3050          begin pbit:=spack in a.asp^.sflag;
3051            new(lnp,wrec); lnp^.occur:=wrec; lnp^.fname:=a.asp^.fstfld;
3052            if a.ak<>fixed then
3053              begin loadaddr; inita(nilptr,reserve(ptrsize)); store;
3054                a.ak:=pfixed;
3055              end;
3056            a.packbit:=pbit; lnp^.wa:=a; lnp^.nlink:=top; top:=lnp;
3057          end;
3058      until endofloop(fsys+[dosy],[ident],comma,+0253);  {+0254}
3059      nextif(dosy,+0255); statement(fsys);
3060      top:=oldtop; lc:=oldlc;
3061    end end;

3063    procedure assertion(fsys:sos);
3064    begin teststandard;
3065      if opt['a']=off then
3066        while not (sy in fsys) do insym
3067      else
3068        begin gen1(op_mrk,0); expression(fsys); force(boolptr,+0256);
3069          gen1(op_loc,e.orig); gensp(ASS);
3070        end
3071    end;

3073    procedure statement; {fsys: sos}
3074    var lip:ip; llp:lp; lsy:symbol;
3075    begin
3076      assert [labelsy..casesy,endsy] <= fsys;
3077      assert [ident,intcst] * fsys = [];
3078      if find2([intcst],fsys+[ident],+0257) then
3079        begin llp:=searchlab(b.lchain,val);
3080          if llp=nil then errint(+0258,val) else
3081          begin if llp^.seen then errint(+0259,val) else llp^.seen:=true;
3082            genilb(llp^.labname)
3083          end;
3084        insym; nextif(colon1,+0260);
3085      end;
3086    if find2([ident,beginsy..casesy],fsys,+0261) then
3087      begin if giveline then if sy<>whilesy then genlin;
3088        if sy=ident then
3089          if id='assert  ' then
3090            begin insym; assertion(fsys) end
3091          else
3092            begin lip:=searchid([vars,field,func,proc]); insym;
3093              if lip^.klass=proc then call(fsys,lip)
3094              else assignment(fsys,lip)
3095            end
3096        else
3097          begin lsy:=sy; insym;
3098            case lsy of
3099              beginsy:
3100                begin compoundstatement(fsys,+0262);  {+0263}
3101                  nextif(endsy,+0264)
3102                end;
3103              gotosy:
3104                gotostatement;
3105              ifsy:
3106                ifstatement(fsys);
3107              casesy:
3108                begin casestatement(fsys); nextif(endsy,+0265) end;
3109              whilesy:
3110                whilestatement(fsys);
3111              repeatsy:
3112                repeatstatement(fsys);
3113              forsy:
3114                forstatement(fsys);
3115              withsy:
3116                withstatement(fsys);
3117            end
3118          end;
3119      end
3120    end;

3122    {==============================================================}

3124    procedure body(fsys:sos; fip:ip);
3125    var i,sz,letdlb,namdlb,inidlb:integer; llp:lp;
3126    begin with b do begin namdlb:=0;
3127    {produce PRO}
3128      genpnam(ps_pro,fip); gencst(fip^.headlc);
3129      gencst(ord(fip^.pfpos.lv<=1));
3130    {initialize files}
3131      if level=1 then  {body for main}
3132        begin dlbno:=dlbno+1; inidlb:=dlbno; gend(ps_fwa,inidlb);
3133          gen1(op_mrk,0); gend(op_lae,dlbno); gen1(op_lae,0); gensp(INI);
3134        end;
3135      trace('procentr',fip,namdlb);
3136      dlbno:=dlbno+1; letdlb:=dlbno;
```

```
3137    gend(ps_fwc,letdlb); gend(op_beg,letdlb);
3138  {the body itself}
3139    lcmax:=lc; currproc:=fip;
3140    compoundstatement(fsys,+0266);  {+0267}
3141    lcmax:=address(lcmax,0,false);  {align lcmax}
3142    trace('procexit',fip,namdlb);
3143  {undefined or global labels}
3144    llp:=lchain;
3145    while llp<>nil do
3146      begin if not llp^.seen then errint(+0268,llp^.labval);
3147        if llp^.labdlb<>0 then
3148          begin gendlb(llp^.labdlb); genpnam(ps_rom,fip);
3149            genclb(llp^.labname); gencst(lcmax); genend;
3150            {this doesn't work if local generators are around}
3151          end;
3152        llp:=llp^.nextlp
3153      end;
3154  {define BUG size}
3155    gend(ps_let,letdlb); gencst(lcmax-fip^.headlc);
3156  {finish and close files}
3157    treewalk(top^.fname);
3158    if level=1 then
3159      begin gendlb(inidlb); gen1(ps_con,argc+1);
3160        for i:=0 to argc do with argv[i] do
3161          begin gencst(ad);
3162            if (ad=-1) and (i>1) then errid(+0269,name)
3163          end;
3164        genend; gen1(op_mrk,0); gen1(op_loc,0); gensp(HLT)
3165      end
3166    else
3167      begin
3168        if fip^.klass<>func then sz:=0 else
3169          begin
3170            if not (assigned in fip^.iflag) then
3171              errid(-(+0270),fip^.name);
3172            sz:=even(sizeof(fip^.idtype)); push(local,fip^.pfpos.ad,sz);
3173          end;
3174        gen1(op_ret,sz); gen0(ps_end);
3175      end
3176  end end;

3178  {==================================================================}

3180  procedure block;  {forward declared}
3181  var ad:integer;
3182  begin with b do begin
3183    assert [labelsy..withsy] <= fsys;
3184    assert [ident,intcst,casesy,endsy,period] * fsys = [];
3185    if find3(labelsy,fsys,+0271) then labeldeclaration(fsys);
3186    if find3(constsy,fsys,+0272) then constdefinition(fsys);
3187    if find3(typesy,fsys,+0273) then typedefinition(fsys);
3188    if find3(varsy,fsys,+0274) then vardeclaration(fsys);
3189    if fip=progp then
3190      begin
3191        if iop[true]<>nil then
3192          begin ad:=address(lc,fhsize+buffsize,false);
3193            argv[1].ad:=ad; iop[true]^.vpos.ad:=ad
3194          end;
3195        if iop[false]<>nil then
3196          begin ad:=address(lc,fhsize+buffsize,false);
3197            argv[0].ad:=ad; iop[false]^.vpos.ad:=ad
3198          end;
3199        if address(lc,0,false)<>0 then gen1(ps_hol,lc);  {align lc}
3200        lc:=progp^.headlc; level:=1
3201      end;  {externals are also extern for the main body}
3202    while find2([procsy,funcsy],fsys,+0275) do pfdeclaration(fsys);
3203    if forwcount<>0 then error(+0276);  {forw proc not specified}
3204    nextif(beginsy,+0277);
3205    body(fsys+[casesy,endsy],fip);
3206    nextif(endsy,+0278);
3207  end end;

3209  {==================================================================}

3211  procedure programme(fsys:sos);
3212  var stdin,stdout:boolean; p:ip;
3213  begin
3214    nextif(progsy,+0279); nextif(ident,+0280);
3215    if find3(lparent,fsys+[semicolon],+0281) then
3216      begin
3217        repeat
3218          if sy<>ident then error(+0282) else
3219            begin stdin:=id='input   '; stdout:=id='output  ';
3220              if stdin or stdout then
3221                begin p:=newip(vars,id,textptr,nil);
3222                  enterid(p); iop[stdout]:=p;
3223                end
3224              else
3225                if argc<maxargc then
3226                  begin argc:=argc+1;
3227                    argv[argc].name:=id; argv[argc].ad:=-1
3228                  end;
3229              insym
3230            end
3231        until endofloop(fsys+[rparent,semicolon],
3232                    [ident],comma,+0283);  {+0284}
3233        if argc>maxargc then
3234          begin error(+0285); argc:=maxargc end;
3235        nextif(rparent,+0286);
3236      end;
3237    nextif(semicolon,+0287);
3238    block(fsys,progp);
3239    if opt['l']<>off then
3240      begin gen1(ps_mes,meslino); gencst(e.orig); genend end;
3241    eofexpected:=true; nextif(period,+0288);
3242  end;

3244  procedure compile;
3245  var lsys:sos;
3246  begin lsys:=[progsy,labelsy..withsy];
3247    repeat eofexpected:=false;
3248      main:=find2([progsy,labelsy,beginsy..withsy],lsys,+0289);
```

```
3249        if main then programme(lsys) else with b do
3250          begin
3251            if find3(constsy,lsys,+0290) then constdefinition(lsys);
3252            if find3(typesy,lsys,+0291) then typedefinition(lsys);
3253            if find3(varsy,lsys,+0292) then vardeclaration(lsys);
3254            gen1(ps_hol,address(lc,0,false)); lc:=0; level:=1;
3255            while find2([procsy,funcsy],lsys,+0293) do pfdeclaration(lsys);
3256          end;
3257        error(+0294);
3258      until false;  { the only way out is the halt in nextln on eof }
3259    end;

3261    {===============================================================}

3263    begin  {main body of pcompiler}
3264      rewrite(errors);
3265      init1; init2; init3; init4;
3266            {all this initializing must be independent of opts}
3267      reset(em1); if not eof(em1) then options(false);
3268      rewrite(em1); write(em1,MAGICLOW,MAGICHIGH);
3269    #ifdef GETREQUIRED
3270      get(input);
3271    #endif
3272      if eof(input) then gen0(ps_eof) else
3273        begin nextch; insym;
3274          handleopts; {initialize all opt dependent stuff}
3275          compile
3276        end;
3277    #ifdef STANDARD
3278    9999: ;
3279    #endif
3280    end.  {pcompiler}
```

```
1     /* collection of options, selected by including or excluding 'defines' */

3     /* select only one of the following: */
4     #       define  V7              1       /* Unix version 7 */
5     /* #    define  V6              1       /* Unix version 6 */
6     /* #    define  VPLUS           1       /* Unix version 6 plus diff listing */

8     /* select only one of the following: */
9     #       define  C7              1       /* version 7 C-compiler */
10    /* #    define  C6              1       /* version 6 C-compiler */
11    /* #    define  NC6             1       /* something between C6 and C7 */

13    #ifdef BOOT
14    #       define  INT_ONLY        1
15    #endif

17    #ifndef BOOT
18    #       define  HARDWARE_FP     1       /* if you've hardware floating point */
19    /* #    define  INT_ONLY        1       /* for interpreted programs only */
20    #       define  SFLOAT          1       /* for single precision floats */
21    #endif

23    /* Version number of the EM1 object code */
24    #       define  VERSION         2       /* 16 bits number */
```

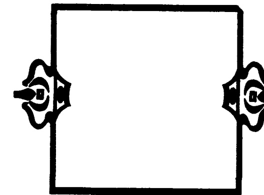


```
1    #define sp_fmnem 1
2    #define sp_nmnem 149
3    #define sp_fpseu 150
4    #define sp_npseu 30
5    #define sp_filb0 180
6    #define sp_nilb0 60
7    #define sp_fcst0 0
8    #define sp_ncst0 240
9    #define sp_ilb1 240
10   #define sp_ilb2 241
11   #define sp_dlb1 242
12   #define sp_dlb2 243
13   #define sp_dnam 244
14   #define sp_pnam 245
15   #define sp_scon 246
16   #define sp_rcon 247
17   #define sp_cst1 248
18   #define sp_cstm 249
19   #define sp_cst2 250
20   #define sp_lcon 251
21   #define sp_cend 255

23   #define ps_bss 150
24   #define ps_con 151
25   #define ps_end 152
26   #define ps_eof 153
27   #define ps_exc 154
28   #define ps_exd 155
29   #define ps_fwa 156
30   #define ps_fwc 157
31   #define ps_fwp 158
32   #define ps_hol 159
33   #define ps_ima 160
34   #define ps_imc 161
35   #define ps_let 162
36   #define ps_mes 163
37   #define ps_pro 164
38   #define ps_rom 165
39   #define sp_lpseu 165

41   #define op_aar 1
42   #define op_aas 2
43   #define op_add 3
44   #define op_adi 4
45   #define op_and 5
46   #define op_ans 6
47   #define op_beg 7
48   #define op_beq 8
49   #define op_bes 9
50   #define op_bge 10
51   #define op_bgt 11
52   #define op_ble 12
53   #define op_blm 13
54   #define op_bls 14
55   #define op_blt 15
56   #define op_bne 16
57   #define op_brb 17
58   #define op_brf 18
59   #define op_cal 19
60   #define op_cas 20
61   #define op_cdi 21
62   #define op_cdf 22
63   #define op_cfd 23
64   #define op_cfi 24
65   #define op_cid 25
66   #define op_cif 26
67   #define op_cmd 27
68   #define op_cmf 28
69   #define op_cmi 29
70   #define op_cmp 30
71   #define op_cms 31
72   #define op_cmu 32
73   #define op_com 33
74   #define op_cos 34
75   #define op_csa 35
76   #define op_csb 36
77   #define op_dad 37
78   #define op_ddv 38
79   #define op_dec 39
80   #define op_dee 40
81   #define op_del 41
82   #define op_div 42
83   #define op_dmd 43
84   #define op_dmu 44
85   #define op_dsb 45
86   #define op_dup 46
87   #define op_dus 47
88   #define op_exg 48
89   #define op_fad 49
90   #define op_fdv 50
91   #define op_fef 51
92   #define op_fif 52
93   #define op_fmu 53
94   #define op_fsb 54
95   #define op_hlt 55
96   #define op_inc 56
97   #define op_ine 57
98   #define op_inl 58
99   #define op_inn 59
100  #define op_ins 60
101  #define op_ior 61
102  #define op_ios 62
103  #define op_lab 63
104  #define op_lae 64
105  #define op_lai 65
106  #define op_lal 66
107  #define op_lar 67
108  #define op_las 68
109  #define op_lde 69
110  #define op_ldf 70
111  #define op_ldl 71
112  #define op_lex 72
113  #define op_lin 73
114  #define op_lnc 74
115  #define op_lni 75
116  #define op_loc 76
117  #define op_loe 77
118  #define op_lof 78
119  #define op_loi 79
120  #define op_lol 80
121  #define op_lop 81
122  #define op_lor 82
123  #define op_los 83
124  #define op_lsa 84
125  #define op_mod 85
126  #define op_mon 86
127  #define op_mrk 87
128  #define op_mrs 88
129  #define op_mrx 89
130  #define op_mul 90
131  #define op_mxs 91
132  #define op_neg 92
133  #define op_nop 93
134  #define op_nul 94
135  #define op_pad 95
136  #define op_psb 96
137  #define op_rck 97
138  #define op_rcs 98
139  #define op_res 99
140  #define op_ret 100
141  #define op_rol 101
142  #define op_ror 102
143  #define op_rtt 103
144  #define op_sai 104
145  #define op_sar 105
146  #define op_sas 106
147  #define op_sde 107
148  #define op_sdf 108
149  #define op_sdl 109
150  #define op_ses 110
151  #define op_set 111
152  #define op_shl 112
153  #define op_shr 113
154  #define op_sig 114
155  #define op_ste 115
156  #define op_stf 116
157  #define op_sti 117
158  #define op_stl 118
159  #define op_stp 119
160  #define op_str 120
161  #define op_sts 121
162  #define op_sub 122
163  #define op_teq 123
164  #define op_tge 124
165  #define op_tgt 125
166  #define op_tle 126
167  #define op_tlt 127
168  #define op_tne 128
169  #define op_trp 129
170  #define op_xor 130
171  #define op_xos 131
172  #define op_zeq 132
173  #define op_zge 133
174  #define op_zgt 134
175  #define op_zle 135
176  #define op_zlt 136
177  #define op_zne 137
178  #define op_zre 138
179  #define op_zrl 139
180  #define sp_lmnem 139
```

```
1    non-standard feature used
2    identifier '%s' declared twice
3    end of file encountered
4    bad line directive
5    unsigned real: digit of fraction expected
6    unsigned real: digit of exponent expected
7    unsigned real: too many digits (>72)
8    unsigned integer: too many digits (>72)
9    unsigned integer: overflow (>32767)
10   string constant: must not exceed one line
11   string constant: at least one character expected
12   string constant: double quotes not allowed (see c option)
13   string constant: too long (>72 chars)
14   comment: ';' seen (statements skipped?)
15   bad character
16   identifier '%s' not declared
17   location counter overflow: arrays too big
18   arraysize too big
19   variable '%s' never used
20   variable '%s' never assigned
21   the files contained in '%s' are not closed automatically
22   constant expected
23   constant: only integers and reals may be signed
24   constant: out of bounds
25   simple type expected
26   enumerated type: element identifier expected
27   enumerated type: ',' or ')' expected
28   enumerated type: ',' expected
29   enumerated type: ')' expected
30   subrange type: type must be scalar, but not real
31   subrange type: '..' expected
32   subrange type: type of lower and upper bound incompatible
33   subrange type: lower bound exceeds upper bound
34   array type: '[' expected
35   conformant array: low bound identifier expected
36   conformant array: '..' expected
37   conformant array: high bound identifier expected
38   conformant array: ':' expected
39   conformant array: index type identifier expected
40   array type: index type not bounded
41   array type: index separator or ']' expected
42   array type: index separator expected
43   array type: ']' expected
44   array type: 'of' expected
45   record variant part: tag type identifier expected
46   record variant part: tag type identifier expected
47   record variant part: type must be bounded
48   record variant part: 'of' expected
49   record variant: type of case label and tag incompatible
50   record variant: multiple defined case label
51   record variant: ',' or ':' expected
52   record variant: ',' expected
53   record variant: ':' expected
54   record variant: '(' expected
55   record variant: ')' expected
56   record variant part: ';' or end of variant list expected
57   record variant part: ';' expected
58   record variant part: end of variant list expected
59   record variant part: there must be a variant for each tag value
60   field list: record section expected
61   record section: field identifier expected
62   record section: ',' or ':' expected
63   record section: ',' expected
64   record section: ':' expected
65   field list: ';' or end of record section list expected
66   field list: ';' expected
67   field list: end of record section list expected
68   type expected
69   type: simple and pointer type may not be packed
70   pointer type: type identifier expected
71   pointer type: type identifier expected
72   record type: 'end' expected
73   set type: 'of' expected
74   set of integer: the i option dictates the number of bits (default 16)
75   set type: base type not bounded
76   set type: too many elements in set (see i option)
77   file type: 'of' expected
78   file type: files within files not allowed
79   var parameter: type identifier or conformant array expected
80   var parameter: type identifier expected
81   label declaration: unsigned integer expected
82   label declaration: label '%i' multiple declared
83   label declaration: ',' or ';' expected
84   label declaration: ',' expected
85   label declaration: ';' expected
86   const declaration: constant identifier expected
87   const declaration: '=' expected
88   const declaration: ';' expected
89   const declaration: constant identifier or 'type', 'var', 'procedure', 'function' or
90   type declaration: type identifier expected
91   type declaration: '=' expected
92   type declaration: ';' expected
93   type declaration: type identifier or 'var', 'procedure', 'function' or 'begin' expect
94   var declaration: var identifier expected
95   var declaration: ',' or ':' expected
96   var declaration: ',' expected
97   var declaration: ':' expected
98   var declaration: ';' expected
99   var declaration: var identifier or 'procedure', 'function' or 'begin' expected
100  parameter list: 'var','procedure','function' or identifier expected
101  parameter list: parameter identifier expected
102  parameter list: ',' or ':' expected
103  parameter list: ',' expected
104  parameter list: ':' expected
105  parameter list: type identifier expected
106  parameter list: ';' or ')' expected
107  parameter list: ';' expected
108  proc/func declaration: proc/func identifier expected
109  proc/func declaration: previous declaration of '%s' was not forward
110  proc/func declaration: parameter list expected
111  parameterlist: ')' expected
112  func declaration: ':' expected
```

```
113 func declaration: result type identifier expected
114 func declaration: result type must be scalar, subrange or pointer
115 proc/func declaration: ';' expected
116 proc/func declaration: block or directive expected
117 proc/func declaration: '%s' again forward declared
118 proc/func declaration: '%s' unknown directive
119 proc/func declaration: ';' expected
120 indexed variable: '[' only allowed following array variables
121 indexed variable: index type not compatible with declaration
122 indexed variable: ',' or ']' expected
123 indexed variable: ',' expected
124 assignment: standard function not allowed as destination
125 assignment: cannot store the function result
126 assignment: formal parameter function not allowed as destination
127 assignment: function identifier may not be de-referenced
128 variable: '[', '.', '^' or end of variable expected
129 indexed variable: ']' expected
130 field designator: field identifier expected
131 field designator: '.' only allowed following record variables
132 field designator: no field '%s' in this record
133 referenced variable: '^' not allowed following zero-terminated strings
134 referenced variable: '^' only allowed following pointer or file variables
135 variable: var or field identifier expected
136 call: array parameter not conformable
137 call: type of actual and formal variable parameter not similar
138 call: packed elements not allowed as variable parameter
139 call: type of actual and formal value parameter not compatible
140 call: proc/func identifier expected
141 call: standard proc/func may not be used as parameter
142 call: parameter lists of actual and formal proc/func incompatible
143 call: ',' or ')' expected
144 call: too many actual parameters supplied
145 call: ')' expected
146 call: too few actual parameters supplied
147 read(ln): type must be integer, char or real
148 write(ln): type must be integer, char, real, string or boolean
149 write(ln): ':', ',' or ')' expected
150 write(ln): field width must be integer
151 write(ln): ':', ',' or ')' expected
152 write(ln): precision must be integer
153 write(ln): precision may only be specified for reals
154 read/write: too few actual parameters supplied
155 read/write: standard input/output not mentioned in program heading
156 read/write: ',' or ')' expected
157 read/write: type of parameter not the same as that of the file elements
158 read/write: parameter list expected
159 readln/writeln: standard input/output not mentioned in program heading
160 readln/writeln: only allowed on text files
161 eof/eoln/page: file variable expected
162 eoln/page: text file variable expected
163 eof/eoln/page: standard input/output not mentioned in program heading
164 new/dispose: pointer variable expected
165 new/dispose: C-type strings not allowed here
166 new/dispose: ',' or ')' expected
167 new/dispose: too many actual parameters supplied
168 new/dispose: type of tagfield value is incompatible with declaration
169 put/get: file variable expected
170 reset/rewrite: file variable expected
171 mark/release: pointer variable expected
172 pack/unpack: array types are incompatible
173 pack/unpack: only for arrays
174 call: '(' or end of call expected
175 standard proc/func: parameter list expected
176 standard proc/func: parameter type incompatible with specification
177 pack: ',' expected
178 pack: ',' expected
179 unpack: ',' expected
180 unpack: ',' expected
181 halt: integer expected
182 abs: integer or real expected
183 sqr: integer or real expected
184 ord: type must be scalar or subrange, but not real
185 pred/succ: type must be scalar or subrange, but not real
186 trunc: real argument required
187 round: real argument required
188 call: ')' expected
189 expression: left and right operand are incompatible
190 set: base type must be bounded or of type integer
191 set: base type upper bound exceeds maximum set element number (255)
192 set: incompatible elements
193 set: ']' or element list expected
194 set: '..', ',' or ']' expected
195 set: elements do not fit (see i option)
196 set: ',' or ']' expected
197 set: ',' expected
198 factor expected
199 factor: ')' expected
200 factor: type of factor must be boolean
201 set: ']' expected
202 term: multiplying operator or end of term expected
203 term: '*' only defined for integers, reals and sets
204 term: '/' only defined for integers and reals
205 term: 'div' only defined for integers
206 term: 'mod' only defined for integers
207 term: 'and' only defined for booleans
208 simple expression: only integers and reals may be signed
209 simple expression: adding operator or end of simple expression expected
210 simple expression: '+' only defined for integers, reals and sets
211 simple expression: '-' only defined for integers, reals and sets
212 simple expression: 'or' only defined for booleans
213 expression: relational operator or end of expression expected
214 expression: set expected
215 expression: left operand of 'in' not compatible with base type of right operand
216 expression: only '=' and '<>' allowed on pointers
217 expression: '<' and '>' not allowed on sets
218 expression: comparison of arrays only allowed for strings
219 expression: comparison of records not allowed
220 expression: comparison of files not allowed
221 assignment: ':=' expected
222 assignment: left and right hand side incompatible
223 goto statement: unsigned integer expected
224 goto statement: label '%i' not declared
```

225 if statement: type of expression must be boolean
226 if statement: 'then' expected
227 if statement: 'else' or end of if statement expected
228 case statement: type must be scalar or subrange, but not real
229 case statement: 'of' expected
230 case statement: incompatible case label
231 case statement: multiple defined case label
232 case statement: ',' or ':' expected
233 case statement: ',' expected
234 case statement: ':' expected
235 case statement: ';' or 'end' expected
236 case statement: ';' expected
237 case statement: 'end' expected
238 repeat statement: ';' or 'until' expected
239 repeat statement: ';' expected
240 repeat statement: 'until' expected
241 repeat statement: type of expression must be boolean
242 while statement: type of expression must be boolean
243 while statement: 'do' expected
244 for statement: control variable expected
245 for statement: control variable must be local
246 for statement: type must be scalar or subrange, but not real
247 for statement: ':=' expected
248 for statement: type of initial value and control variable incompatible
249 for statement: 'to' or 'downto' expected
250 for statement: type of final value and control variable incompatible
251 for statement: 'do' expected
252 with statement: record variable expected
253 with statement: ',' or 'do' expected
254 with statement: ',' expected
255 with statement: 'do' expected
256 assertion: type of expression must be boolean
257 statement expected
258 label '%i' not declared
259 label '%i' multiple defined
260 statement: ':' expected
261 unlabeled statement expected
262 compound statement: ';' or 'end' expected
263 compound statement: ';' expected
264 compound statement: 'end' expected
265 case statement: 'end' expected
266 body: ';' or 'end' expected
267 body: ';' expected
268 body: label '%i' declared, but never defined
269 program parameter '%s' not declared
270 function '%s' never assigned
271 block: declaration or body expected
272 block: 'const', 'type', 'var', 'procedure', 'function' or 'begin' expected
273 block: 'type', 'var', 'procedure', 'function' or 'begin' expected
274 block: 'var', 'procedure', 'function' or 'begin' expected
275 block: 'procedure', 'function' or 'begin' expected
276 block: unsatisfied forward proc/func declaration(s)
277 block: 'begin' expected
278 block: 'end' expected
279 program heading: 'program' expected
280 program heading: program identifier expected
281 program heading: file identifier list expected
282 program heading: file identifier expected
283 program heading: ',' or ')' expected
284 program heading: ',' expected
285 program heading: maximum number of file arguments exceeded (12)
286 program heading: ')' expected
287 program heading: ';' expected
288 program: '.' expected
289 'program' expected
290 module: 'const', 'type', 'var', 'procedure' or 'function' expected
291 module: 'type', 'var', 'procedure' or 'function' expected
292 module: 'var', 'procedure' or 'function' expected
293 module: 'procedure' or 'function' expected
294 garbage at end of program



```
  1 (**       OPTIONS - RETURN CONTROL STATEMENT OPTION SETTING.
  2 *         COPYRIGHT (C) UNIVERSITY OF MINNESOTA  - 1978.
  3 *         A. B. MICKEL.       77/06/02.
  4 *
  5 *         THE ORIGINAL ROUTINE -OPTION- ACCEPTED A  ONE-CHARACTER
  6 *         OPTION  NAME AND RETURNED AN OPTION SETTING OF +, -, =,
  7 *         OR A POSITIVE INTEGER.
  8 *
  9 *         THIS VERSION, CALLED  -OPTIONS-,  ACCEPTS   ANY  STRING
 10 *         OF  1  TO  10 ALPHANUMERIC CHARACTERS (STARTING WITH AN
 11 *         ALPHA) AS THE  OPTION  NAME  AND  RETURNS A STRING   OF
 12 *         1  TO 10 CHARACTERS OR A POSITIVE INTEGER AS THE OPTION
 13 *         SETTING.  AN  EQUALS  SIGN  MAY  BE  USED  BETWEEN   AN
 14 *         OPTION   NAME  AND ITS OPTION SETTING.  IF THERE IS NO
 15 *         OPTION SETTING  AFTER  THE  EQUALS   SIGN,   THEN   THE
 16 *         EQUALS  SIGN ITSELF IS USED AS THE OPTION SETTING.   IF
 17 *         THE OPTION NAME IS FOLLOWED  BY  A  COMMA,  PERIOD,  OR
 18 *         RIGHT  PARENTHESIS, THE OPTION SETTING IS RETURNED AS A
 19 *         STRING OF 10 BLANK CHARACTERS.
 20 *
 21 *         THE INPUT VARIABLE -NAME- IS NOW TYPE ALFA, AND IN  THE
 22 *         RECORD  TYPE  -SETTING-,  THE FIELD -ONOFF- IS NOW TYPE
 23 *         ALFA.
 24 *
 25 *         SEE THE PASCLIB WRITEUP FOR EXTERNAL DOCUMENTATION.
 26 *         NOTE THAT THE NAME OF THIS VERSION IS -OPTIONS-.
 27 *
 28 *         SPIKE LEONARD - SANDIA NATIONAL LABORATORIES, LIVERMORE
 29 *         24 FEB 1981
 30 *
 31 *)
 32
 33 FUNCTION OPTIONS(NAME: ALFA; VAR S: SETTING): BOOLEAN;
 34
 35 CONST
 36    CSADDRESS = 70B (*CONTROL STATEMENT ADDRESS*);
 37
 38 TYPE
 39    CSIMAGEP = RECORD CASE BOOLEAN OF
 40                FALSE: (A: INTEGER);
 41                TRUE: (P: ¬LOWCORE)
 42               END;
 43    LOWCORE = PACKED ARRAY[1..80] OF CHAR;
 44
 45 VAR
 46    CSIMAGE: CSIMAGEP;
 47    OPNAME: ALFA;
 48    I: INTEGER                 (* INDEX IN CSIMAGE *);
 49    J: INTEGER                 (* INDEX FOR OPNAME *);
 50    K: INTEGER                 (* INDEX FOR S.ONOFF *);
 51    FOUND: BOOLEAN;
 52
 53 BEGIN (*OPTIONS*)
 54    FOUND := FALSE;
 55    S.SWITCH := FALSE;   S.SIZE := 0;
 56    CSIMAGE.A := CSADDRESS;
 57    I := 1 (*SKIP PROGRAM NAME AND PARAMETERS.*);
 58       WHILE CSIMAGE.P¬[I] IN [↑A↑..↑Z↑, ↑0↑..↑9↑, ↑ ↑] DO
 59          I := I + 1;
 60       IF NOT (CSIMAGE.P¬[I] IN [↑)↑, ↑.↑]) THEN
 61          I := I + 1 (*SKIP SLASH IF FIRST DELIMITER.*);
 62       WHILE NOT (CSIMAGE.P¬[I] IN [↑/↑, ↑)↑, ↑.↑]) DO
 63          I := I + 1;
 64
 65    IF CSIMAGE.P¬[I] = ↑/↑ THEN (*CRACK OPTIONS.*)
 66      REPEAT
 67        I := I + 1;
 68        J := 1;
 69        OPNAME := ↑          ↑;
 70        IF CSIMAGE.P¬[I] IN [↑A↑..↑Z↑] THEN BEGIN
 71          WHILE (CSIMAGE.P¬[I] IN [↑A↑..↑Z↑,↑0↑..↑9↑]) AND NOT FOUND
 72            DO BEGIN
 73            OPNAME[J] := CSIMAGE.P¬[I];
 74            J := J + 1;
 75            I := I + 1;
 76            IF (NAME = OPNAME) AND NOT (CSIMAGE.P¬[I] IN [↑A↑..↑Z↑])
 77              THEN BEGIN
 78              FOUND := TRUE;
 79              IF (CSIMAGE.P¬[I] = ↑=↑) AND
 80                NOT (CSIMAGE.P¬[I+1] IN [↑,↑,↑.↑,↑)↑]) THEN
 81                  I := I + 1;
 82              S.SWITCH := NOT (CSIMAGE.P¬[I] IN [↑0↑..↑9↑]);
 83              IF S.SWITCH THEN BEGIN
 84                S.ONOFF := ↑          ↑;
 85                K := 1;
 86                WHILE NOT (CSIMAGE.P¬[I] IN [↑,↑,↑.↑,↑)↑]) DO BEGIN
 87                  S.ONOFF[K] := CSIMAGE.P¬[I];
 88                  K := K + 1;
 89                  I := I + 1;
 90                  END;
 91                END
 92              ELSE
 93                WHILE CSIMAGE.P¬[I] IN [↑0↑..↑9↑] DO BEGIN
 94                  S.SIZE := S.SIZE*10
 95                     + (ORD(CSIMAGE.P¬[I]) - ORD(↑0↑));
 96                  I := I + 1;
 97                  END;
 98              END;
 99            END;
100          END;
101        IF NOT FOUND THEN
102          WHILE NOT (CSIMAGE.P¬[I] IN [↑,↑,↑.↑,↑)↑]) DO I := I + 1;
103      UNTIL (CSIMAGE.P¬[I] IN [↑.↑,↑)↑])  OR  FOUND;
104    OPTIONS := FOUND;
105 END (*OPTIONS*);
```

TREEPRINT - A Package to Print Trees on any Character Printer

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One of the problems facing a programmer who deals with complex linked data structures in Pascal is the inability to display such a structure in a graphical form. Usually it is too much to ask a system debugging tool to even understand records and pointers, let alone display a structure using them in the way it would appear in a good textbook. Likewise very few operating systems have a package of routines to display structures automatically. Pascal has a tremendous advantage over many languages in its ability to support definable types and structures. If the environment is incapable of dealing with these features, they become far less useful.

This lack became apparent to us in the process of writing an algebraic expression parser which produced internal N-ary trees. There was no way at the time under our operating system debugger (VAX/VMS) to get at the data structure we were generating. When the routines produced an incorrect tree we had no way of finding the specific error.

Our frustration led to the development of TREEPRINT. Starting with the algorithm of Jean Vaucher [1], we designed a general-purpose tool capable of displaying any N-ary tree on any character output device. The trees are displayed in a pleasant visual form and in the manner in which they would appear if drawn by hand. We feel that TREEPRINT is of general use -- hence its presentation here.

The structure of TREEPRINT is that of an independent collection of subroutines that any program can call. Unfortunately standard Pascal does not support this form, while our Pascal environment does. However, building TREEPRINT directly into a program should present no difficulty.

TREEPRINT requires no knowledge of the format of the data structure it is printing. It has even been used to print a tabular linked structure within a FORTRAN program! In order to allow this, two procedures are passed in the call to TREEPRINT. One is used to "walk" the tree, the other to print identifying labels for a given node. Other parameters are values such as the size of the nodes, the width of the page, etc. One of the advantages of this calling mechanism is that a single version of TREEPRINT can be used to display wildly different structures, even when they are within the same program.

One of the major features of TREEPRINT is its ability to span pages. A tree that is too wide to fit on one page is printed out in "stripes" which are taped together edge-to-edge after printing. In addition trees may optionally be printed either upside-down or reversed from left-to-right.

The method used by TREEPRINT is detailed in Vaucher's work [1]. In its current implementation additional support for N-ary structures has been added, as well as full connecting-arc printing and the reversal features. Basically, TREEPRINT walks the input tree and constructs an analogous structure of its own which indicates the positions of every node. The new structure is linked along the left edge and across the page from left-to-right. Once this structure is completed, TREEPRINT walks the new structures and prints it out in order. Once printout is finished, the generated structure is DISPOSE'd of.

There are only two minor problems in TREEPRINT currently. The first is that a structure which contains circular loops will hang the routine. This could be detected in the POSITION phase of TREEPRINT by checking each new node against all of its ancestors. However, if used in a non-Pascal application, this might fail due to problems in comparing pointers. If this check is necessary we suggest it be implemented in the LOWERNODE procedure passed to TREEPRINT. This procedure at least understands the type of pointer it is dealing with.

The second problem is a feature of the POSITION routine which centers a node above its sons. This tends to make the trees generated wider than necessary. This is largely a matter of taste -- some minor changes would remove this.

The listing of TREEPRINT which follows should serve to document the method of calling the routine. The functions of the user-supplied procedures are also detailed.

References

[1] Vaucher, Jean, "Pretty-Printing of Trees." Software- Practice and Experience, Vol. 10, pp. 553-561 (1980).

[2] Myers, Brad, Displaying Data Structures for Interactive Debugging, Palo Alto: Xerox PARC CSL-80-7 (1980).

[3] Sweet, Richard, Empirical Estimates of Program Entropy, Appendix B - "Implementation description", Palo Alto: Xerox PARC CSL-78-3 (1978).

```
  1 module TREEPRINT (input,output);
  2
  3 (*
  4     TREEPRINT - A routine to print N-ary trees on any character
  5       printer. This routine takes as input an arbitrary N-ary tree,
  6       some interface routines, and assorted printer parameters and
  7       writes a pictorial representation of that tree to a file. The
  8       tree is nicely formatted and is divided into vertical stripes
  9       that can be taped together after printing. Options exist to
 10       print the tree backwards or upside down if desired.
 11
 12       The algorithm for TREEPRINT originally appeared in "Pretty-
 13       Printing of Trees", by Jean G. Vaucher, Software-Practice and
 14       Experience, Vol. 10, 553-561 (1980). The algorithm used here
 15       has been modified to support N-ary tree structures and to have
 16       more sophisticated printer format control. Aside from a common
 17       method of constructing an ancillary data structure and some
 18       variable names, they are now very dissimiliar.
 19
 20       TREEPRINT was written by Ned Freed and Kevin Carosso,
 21       5-Feb-81. It may be freely distributed, copied and modified
 22       provided that this note and the above reference are included.
 23       TREEPRINT may not be distributed for any fee other than cost
 24       of duplication.
 25
 26     INPUT - The call to TREEPRINT is:
 27         TREEPRINT (TREE,TREEFILE,PAGESIZE,VERTKEYLENGTH,
 28                    HORIKEYLENGTH,PRINTKEY,LOWERNODE)
 29
 30         where the parameters are:
 31
 32           TREE - The root of the tree to be printed. The nodes of
 33                    the tree are of arbitrary type, as TREEPRINT
 34                    does not read them itself but calls procedure
 35                    LOWERNODE to do so. In a modular enviroment
 36                    this should present no problems. If TREEPRINT
 37                    is to be installed directly in a program TREE
 38                    will have to be changed to agree in type with
 39                    the actual tree's nodes.
 40           TREEFILE - A file variable of type text. The tree is
 41                    written into this file.
 42           PAGESIZE - The size of the page on output represented
 43                    as an integer count of the number of available
 44                    columns. The maximum page size is 512. Any size
 45                    greater than 512 will be changed to 512.
 46           LOWERNODE - A user procedure TREEPRINT calls to walk
 47                    the user's tree. The format for the call is
 48                    described below along with the functions
 49                    LOWERNODE must perform.
 50           PRINTKEY - A user procedure TREEPRINT calls to print
 51                    out a single line of a keyword description of
 52                    some node in the user's tree. The description
 53                    may be multi-line and of any width. The call
 54                    format is described below.
 55           VERTKEYLENGTH - The number of lines of a description
 56                    printed by PRINTKEY. This must be a constant
 57                    over all nodes. If VERTKEYLENGTH is negative,
 58                    its absolute value is used as the key length and
 59                    the whole tree is inverted on the vertical axis.
 60           HORIKEYLENGTH - The number of characters in a single
 61                    line of a description printed by PRINTKEY. This
 62                    must be a constant. If negative the absolute
 63                    value of HORIKEYLENGTH is used and the whole
 64                    tree is inverted from left to right.
 65
 66     CALLS TO USER PROCEDURES - The calls to user-supplied procedures
 67       have the following format and function:
 68
 69         PRINTKEY (LINENUMBER,LINELENGTH,NODE)
 70           LINENUMBER - The line of the node description to print.
 71             This varies from 1 to VERTKEYLENGTH. Since TREEPRINT
 72             operates on a line-at-a-time basis, PRINTKEY must be
 73             able to break up the output in a similiar fashion.
 74           LINELENGTH - The length of the line. PRINTKEY must
 75             output this many characters to TREEFILE - no more, no
 76             less.
 77           NODE - The node of the user's tree to derive information
 78             from.
 79
 80         LOWERNODE (NODE,SONNUMBER)
 81           SONNUMBER - The sub-node to return. A general N-ary tree
 82             will have N of them.
 83           NODE - The node of the user's tree to derive the
 84             information from.
 85           LOWERNODE, on return should equal NIL if that node does
 86             not exist, NODE if the SONNUMBER is illegal, and
 87             otherwise a valid sub-node. Note that circular
 88             structures will hang treeprint thoroughly. The condition
 89             that LOWERNODE returns NODE when N is exceeded must be
 90             strictly adhered to, as TREEPRINT uses this to know
 91             where to stop. LOWERNODE is used to hide the interface
 92             between TREEPRINT and the user's tree so that no format
 93             details of the tree need be resident in TREEPRINT.
 94
 95     OUTPUT - All output is directed to TREEFILE. There are no error
 96       conditions or messages.
 97 *)
 98
 99 (* The declaration of the user's node type. If type checking is a
100    problem this should be changed to match the type for the actual
101    nodes in a tree. *)
102
103 type
104     nodeptr = ^integer;
105
106 procedure treeprint (tree : nodeptr; var treefile : text;
107                      pagesize, vertkeylength, horikeylength :
108                      integer; procedure printkey; function
109                      lowernode : nodeptr);
110
111 type
112
113     reflink = ^link;
114     link = record
115                 next : reflink;
116                 pnode : nodeptr;
117                 pos : integer;
118                 lstem : boolean;
119                 ustem : boolean;
```

```
120          end;
121
122     refhead = ^head;
123     head = record
124                next : refhead;
125                first : reflink;
126          end;
127
128 var
129     maxposition, minposition, width, w, charp : integer;
130     startposition, beginposition, endposition : integer;
131     pagewidth, p, i, j, stemlength, vertnodelength : integer;
132     endloop : boolean;
133     line : packed array [1..512] of char;
134     L, oldL : reflink;
135     lines, slines, H, D : refhead;
136
137     procedure cout (c : char);
138
139         (* Cout places a character in the line buffer at the
140            current character position. The pointer charp is
141            incremented by this action to reflect the change. *)
142
143     begin  (* Cout *)
144         charp := charp + 1;
145         line[charp] := c;
146     end;  (* Cout *)
147
148     procedure cdump;
149
150         (* Cdump dumps all characters that have accumulated in
151            the line buffer. No characters are omitted and no
152            cr-lf is appended. *)
153
154     begin  (* Cdump *)
155         if charp > 0 then for charp := 1 to charp do
156             write (treefile,line[charp]);
157         charp := 0;
158     end;  (* Cdump *)
159
160     procedure ctrim;
161
162         (* Ctrim dumps all characters that have accumulated in
163            the line buffer with trailing spaces removed. A
164            WRITELN is used to end the line. *)
165
166     begin  (* Ctrim *)
167         while (charp > 0) and (line[charp] = ' ') do
168             charp := charp - 1;
169         if charp > 0 then for charp := 1 to charp do
170             write (treefile,line[charp]);
171         charp := 0;
172         writeln (treefile);
173     end;  (* Ctrim *)
174
175     function position (N : nodeptr; var H : refhead; pos : integer)
176                         : reflink;
177
178         (* Position is a recursive function that positions all the
179            nodes of the tree on the print page. In doing so, it
180            constructs an auxiliary data structure that is connected
181            by  line number along the edge and position from left to
182            right. In addition, it stores some of the original tree
183            connections for arc printing. *)
184
185     var
186         over, lastover, nodecount : integer;
187         Nlower : nodeptr;
188         L, left, right : reflink;
189         needright : boolean;
190
191     begin  (* Position *)
192         if N = nil then  (* Be defensive about illegal nodes. *)
193         position := nil
194         else
195         begin  (* Create a new node in our tree. *)
196             new (L);
197             position := L;
198             L^.pnode := N;
199             L^.ustem := false;
200             if H = nil then
201             begin  (* A new line has been reached. *)
202                 new (H);
203                 H^.next := nil;
204                 L^.next := nil;
205             end
206             else
207             begin  (* Shift position if conflicting. *)
208                 L^.next := H^.first;
209                 if H^.first^.pos < pos + 2 then
210                     pos := H^.first^.pos - 2;
211             end;
212             H^.first := L;
213             nodecount := 0;
214             over := 1;
215             repeat  (* Count the number of lower nodes. *)
216                 Nlower := lowernode (N,over);
217                 if ((Nlower <> N) and (Nlower <> nil)) then
218                     nodecount := nodecount + 1;
219                 over := over + 1;
220             until Nlower = N;
221             if nodecount > 0 then
222             begin  (* There are lower nodes, loop to position. *)
223                 L^.lstem := true;
224                 lastover := nodecount - 1;
225                 nodecount := over;
226                 over := - lastover;
227                 needright := true;
228                 repeat  (* Recursively evaluate lower positions. *)
229                     repeat  (* Find one that is non-nil. *)
230                         if nodecount > 0 then
231                             Nlower := lowernode (N,nodecount)
232                         else
233                             Nlower := N;
234                         nodecount := nodecount - 1;
235                     until Nlower <> nil;
236                     if Nlower <> N then
237                     begin
238                         left :=
239                             position (Nlower, H^.next, pos + over);
```

```
240                         if needright then
241                         begin
242                             right := left;
243                             needright := false;
244                         end
245                         else left^.ustem := true;
246                         over := over + 2;
247                     end;
248                 until (over > lastover) or (nodecount <= 0);
249                 pos := (left^.pos + right^.pos) div 2;
250             end
251             else
252                 L^.lstem := false;
253             if pos > maxposition then maxposition := pos
254             else
255                 if pos < minposition then minposition := pos;
256             L^.pos := pos;
257         end;  (* if N = nil *)
258     end;  (* Position *)
259
260 begin  (* Treeprint *)
261
262     (* Initialize various variables. *)
263
264     lines := nil;
265     minposition := 0;
266     maxposition := 0;
267     charp := 0;
268
269     (* Do various width and length calculations. *)
270
271     if pagesize > 512 then pagesize := 512;
272     width := abs (horikeylength) + 4;
273     stemlength := abs (vertkeylength) + 1;
274     vertnodelength := 3 * abs (vertkeylength) + 4;
275     if (width mod 2) = 0 then width := width + 1;
276     pagewidth := pagesize div width;
277
278     (* Construct our data structure and compute positions. *)
279
280     oldL := position (tree,lines,0);
281
282     (* If the horizontal reverse option is selected, reverse
283        every node on every line of the data structure. It is
284        also necessary to switch around the states of the USTEM
285        flags that tell who connects above a given node. *)
286
287     if horikeylength < 0 then
288     begin
289         H := lines;
290         while H <> nil do
291         begin
292             H^.first^.pos := maxposition -
293                              H^.first^.pos + minposition;
294             if H^.first^.ustem then
295             begin
296                 H^.first^.ustem := false;
297                 endloop := true;
298             end
299             else
300                 endloop := false;
301         L := nil;
302         while H^.first^.next <> nil do
303         begin
304             H^.first^.next^.pos := maxposition -
305                 H^.first^.next^.pos + minposition;
306             if H^.first^.next^.ustem then
307             begin
308                 if not endloop then
309                 begin
310                     H^.first^.next^.ustem := false;
311                     endloop := true;
312                 end;
313             end
314             else
315                 if endloop then
316                 begin
317                     H^.first^.next^.ustem := true;
318                     endloop := false;
319                 end;
320             oldL := H^.first^.next;
321             H^.first^.next := L;
322             L := H^.first;
323             H^.first := oldL;
324         end;
325         H^.first^.next := L;
326         H := H^.next;
327     end;
328 end;
329
330 (* If the vertical reverse option is selected, reverse the
331    entire tree on the vertical axis by flipping all the
332    head nodes along the edge. Arc reversal is handled in
333    the actual arc generation routines. They will scan the
334    previous line of info instead of the current one. *)
335
336 slines := lines;
337 if vertkeylength < 0 then
338 begin
339     H := nil;
340     while lines^.next <> nil do
341     begin
342         D := lines^.next;
343         lines^.next := H;
344         H := lines;
345         lines := D;
346     end;
347     lines^.next := H;
348 end;
349
350 (* Break up entire width into pages and loop over each. *)
351
352 startposition := minposition;
353 while startposition <= maxposition do
354 begin
355     page (treefile);
356     H := lines;
357     while H <> nil do
358     begin  (* Loop over all lines possible. *)
359         oldL := H^.first;
```

```
360     repeat  (* Find a node on current strip. *)
361         endloop := true;
362         if oldL <> nil then
363             if oldL^.pos < startposition then
364                 begin  (* Reject this node. *)
365                     oldL := oldL^.next;
366                     endloop := false;
367                 end;
368     until endloop;
369     for i := 1 to vertnodelength do
370     begin  (* Loop for each print line in a node. *)
371         L := oldL;
372         p := startposition;
373         while (p < startposition + pagewidth) and
374             (L <> nil) do
375         begin  (* Scan for nodes we need to draw. *)
376             if L^.pos = p then
377             begin  (* Found node at current position. *)
378                 if (i <= stemlength) then
379                 begin  (* Draw upper stem part of node. *)
380                     for w := 1 to (width div 2) do
381                         cout (' ');
382                     if ((vertkeylength < 0) and L^.lstem)
383                         or ((vertkeylength >= 0) and
384                         (H <> slines)) then cout ('*')
385                     else cout (' ');
386                     for w := 1 to (width div 2) do
387                         cout (' ');
388                 end
389                 else
390                 if (vertnodelength - i) < stemlength then
391                 begin  (* Draw lower stem part of node. *)
392                     for w := 1 to (width div 2) do
393                         cout (' ');
394                     if ((vertkeylength >= 0) and L^.lstem)
395                         or ((vertkeylength < 0) and
396                         (H <> slines)) then cout ('*')
397                     else cout (' ');
398                     for w := 1 to (width div 2) do
399                         cout (' ');
400                 end
401                 else
402                 if (i >= stemlength + 2)
403                    and (i <= stemlength * 2) then
404                     begin  (* Print node identifier. *)
405                         cout ('*');
406                         cout (' ');
407                         cdump;
408                         printkey (i - stemlength - 1,
409                            abs (horikeylength), L^.pnode);
410                         cout (' ');
411                         cout ('*');
412                     end
413                 else
414                     for w := 1 to width do cout ('*');
415                 L := L^.next;
416             end
417             else
418                 for w := 1 to width do cout (' ');
419             p := p + 1;
420         end;
421         ctrim;
422     end; (* for *)
423
424     (* Select the proper line to obtain arc info from. *)
425
426     if vertkeylength >= 0 then
427     begin
428         if H^.next <> nil
429         then L := H^.next^.first
430         else L := nil;
431     end
432     else L := H^.first;
433
434     p := startposition;
435     while (p < startposition + pagewidth) and (L <> nil) do
436     begin
437         endposition := L^.pos;
438         beginposition := L^.pos;
439         if L^.ustem then
440             while (L^.next <> nil) and L^.ustem do
441             begin
442                 L := L^.next;
443                 endposition := L^.pos;
444             end;
445         L := L^.next;
446         if (beginposition < startposition + pagewidth)
447            and (endposition >= startposition) then
448         begin  (* Found an arc we should draw. *)
449             while p < beginposition do
450             begin  (* Space over to proper position. *)
451                 for w := 1 to width do cout (' ');
452                 p := p + 1;
453             end;
454             if beginposition = endposition then
455             begin  (* Case of one node directly below. *)
456                 for w := 1 to (width div 2) do cout (' ');
457                 if H <> slines then cout('*')
458                 else cout(' ');
459                 for w := 1 to (width div 2) do cout (' ');
460                 p := p + 1;
461             end
462             else
463             begin  (* Normal multi-segment arc, then. *)
464                 if p = beginposition then
465                 begin  (* Begin with a half segment. *)
466                     for w := 1 to (width div 2) do
467                         cout (' ');
468                     for w := (width div 2) to width-1 do
469                         cout ('*');
470                     p := p + 1;
471                 end;
472                 while (p < endposition) and
473                       (p < startposition + pagewidth) do
474                 begin  (* Connect to the end segment. *)
475                     for w := 1 to width do cout ('*');
476                     p := p + 1;
477                 end;
478                 if p < startposition + pagewidth then
479                 begin  (* Draw end segment of the arc. *)
```

```
480                     for w := (width div 2) to width-1 do
481                        cout ('*');
482                     for w := 1 to (width div 2) do
483                        cout (' ');
484                     p := p + 1;
485                  end;
486               end;
487            end;
488         end;
489         ctrim;
490
491         (* We have now finished an entire line of tree. *)
492
493         H := H^.next;
494      end;  (* while H<>nil *)
495
496      (* Start up on a new page of material. *)
497
498      startposition := startposition + pagewidth;
499   end;  (* while startposition <= maxposition *)
500
501   (* All output is finished. It is now time to close out our extra
502      data structure. *)
503
504   while lines <> nil do
505   begin  (* Collect a line of stuff and dispose. *)
506      H := lines^.next;
507      while lines^.first <> nil do
508      begin  (* Kill a node. *)
509         L := lines^.first^.next;
510         dispose (lines^.first);
511         lines^.first := L;
512      end;
513      dispose (lines);
514      lines := H;
515   end;
516
517 end;  (* Treeprint *)
518
519 end.  (* Of module TREEPRINT *)
520
```

****

```
1
2  {
3      Written by:      Tom Slone
4                       Nov 15, 1980
5                       at Lehigh University,
6                       Bethlehem, PA 18015
7                       on a DEC System 20
8
9      (c) Copyright 1980
10
11 The author grants permission to copy for non-profit use, providing
12 this comment remains.
13
14 }
15  PROGRAM compress(in_file, out_file);
16  {
17      This program takes a text file and creates a compressed
18 version using Huffman codes.  Savings average 30-40%.  The compressed
19 file can be restored to normal using the sister program called
20 "RECALL".
21 }
22
23  LABEL
24     13;
25
26  CONST
27     minchar = 1 {This is the ordinal of the smallest character not to
28    be ignored, i.e. in this case only nulls are ignored.};
29     maxdepth = 64 {This should be 2**n, where n is the number of bits
30                 per character in the character set.};
31     maxlength = maxdepth;
32     maxint = 34359738367;
33     bit_size = 36 {Number of bits per machine word};
34
35  TYPE
36     bit = 0.. 1;
37     out_word = PACKED ARRAY [1.. bit_size] OF bit;
38     alphabet = minchar .. 127;
39     newchar = RECORD
40                  length: 0.. maxdepth;
41                  nchar: PACKED ARRAY [1.. maxdepth] OF bit
42               END;
43     treept = ^ tree;
44     tree = RECORD
45               sum: integer;
46               left, right: treept
47            END;
48
49  VAR
50     num_in_chars, num_out_words: integer;
51     pos: integer;
52     wd: out_word;
53     in_file: text;
54     out_file: FILE OF out_word;
55     tally: ARRAY [alphabet] OF RECORD
56                                   marked: boolean;
57                                   num_of: integer
58                                END;
59     trees: RECORD
60               t_num: 0.. maxlength;
```

```
61              trs: ARRAY [1.. maxlength] OF treept
62           END;
63     newcharset: ARRAY [alphabet] OF newchar;
64     stack: newchar;
65
66
67  PROCEDURE get_char;
68
69     BEGIN
70        REPEAT  num_in_chars := num_in_chars + 1;   get(in_file)
71        UNTIL eof(in_file) OR (ord(in_file^) <> 0)
72     END {GET_CHAR};
73
74
75  PROCEDURE fill_tally;
76 {Scan the file the first time and get a character count on
77 which to make the new Huffman character set.}
78
79     VAR
80        count: integer;
81
82     BEGIN
83        reset(in_file);
84        FOR count := minchar TO 127 DO
85           WITH tally[count] DO
86              BEGIN  marked := false;   num_of := 0  END;
87        IF NOT eof(in_file)
88        THEN
89           BEGIN
90              get_char;
91              WHILE NOT eof(in_file) DO
92                 BEGIN
93                    IF ord(in_file^) < minchar  THEN
94                       BEGIN
95                          writeln(tty, 'Bad character in input!^G', ord(
96                             in_file^));
97                          GOTO 13
98                       END;
99                    tally[ord(in_file^)]. num_of := tally[ord(in_file^)
100                      ]. num_of + 1;
101                   get_char;
102                END
103          END
104    END {FILL_TALLY};
105
106
107  PROCEDURE exchange(VAR x, y: integer);
108
109     VAR
110        temp: integer;
111
112     BEGIN  temp := x;   x := y;   y := temp  END {EXCHANGE};
113
114
115  PROCEDURE make_new_chars;
116 {Make the Huffman characters based on the character frequencies
117 of the file.}
118
119     VAR
120        temp: treept;
121        pos1, pos2, count: integer;
122        done, tr1, tr2: boolean;
123
124
125     PROCEDURE ground(t: treept; val: integer);
126 {Ground the character tree with NIL's}
127
128        BEGIN
129           WITH t^ DO
130              BEGIN  left := NIL;   right := NIL;   sum := val  END
131        END {GROUND};
132
133
134     PROCEDURE get_2_mins(VAR pos1, pos2: integer; VAR tr1, tr2:
135        boolean);
136 {Find the two characters or character trees with the smallest
137 frequencies.}
138
139        VAR
140           count, min1, min2: integer;
141
142        BEGIN {GET_2_MINS}
143           min1 := maxint;   min2 := maxint;
144           FOR count := minchar TO 127 DO
145              WITH tally[count] DO
146                 IF NOT marked
147                 THEN
148                    IF num_of < min2
149                    THEN
150                       IF num_of < min1
151                       THEN
152                          BEGIN
153                             min2 := min1;   tr2 := tr1;
154                             pos2 := pos1;   pos1 := count;
155                             tr1 := false;   min1 := num_of
156                          END
157                       ELSE
158                          BEGIN
159                             pos2 := count;   tr2 := false;
160                             min2 := num_of
161                          END;
162           FOR count := 1 TO trees. t_num DO
163              WITH trees. trs[count] ^ DO
164                 IF sum < min2
165                 THEN
166                    IF sum < min1
167                    THEN
168                       BEGIN
169                          min2 := min1;   tr2 := tr1;   pos2 := pos1;
170                          pos1 := count;   tr1 := true;   min1 := sum
171                       END
172                    ELSE
173                       BEGIN
174                          min2 := sum;   tr2 := true;   pos2 := count
175                       END;
176           IF NOT tr1   THEN  tally[pos1]. marked := true;
177           IF NOT tr2   THEN  tally[pos2]. marked := true
178        END {GET_2_MINS};
179
180
```

```
181     BEGIN {MAKE_NEW_CHARS}
182        trees. t_num := 0;
183        REPEAT
184           get_2_mins(pos1, pos2, tr1, tr2);
185           IF tr1 AND tr2
186           THEN
187              WITH trees DO
188                 BEGIN
189                    IF pos2 < pos1   THEN  exchange(pos1, pos2);
190                    new(temp);
191                    temp^. sum := trs[pos1] ^. sum + trs[pos2] ^. sum;
192                    temp^. left := trs[pos1];
193                    temp^. right := trs[pos2];   trs[pos1] := temp;
194                    t_num := t_num - 1;
195                    FOR count := pos2 TO t_num DO
196                       trs[count] := trs[count + 1]
197                 END
198           ELSE
199              IF NOT tr1 AND NOT tr2
200              THEN
201                 WITH trees DO
202                    BEGIN
203                       t_num := t_num + 1;   new(trs[t_num]);
204                       WITH trs[t_num] ^ DO
205                          BEGIN
206                             sum := tally[pos1]. num_of + tally[pos2].
207                               num_of;
208                             new(left);   new(right);
209                             ground(left, pos1);   ground(right, pos2)
210                          END
211                    END
212              ELSE
213                 WITH trees DO
214                    BEGIN
215                       IF tr2   THEN  exchange(pos1, pos2);
216                       new(temp);
217                       temp^. sum := trs[pos1] ^. sum + tally[pos2].
218                         num_of;
219                       temp^. left := trs[pos1];   new(temp^. right);
220                       ground(temp^. right, pos2);   trs[pos1] := temp
221                    END;
222           done := true;
223           FOR count := minchar TO 127 DO
224              done := done AND tally[count]. marked
225        UNTIL done AND (trees. t_num = 1)
226     END {MAKE_NEW_CHARS};
227
228
229  PROCEDURE get_new_char_set;
230 {Take the Huffman character set out of tree form and into array
231 form, so as to make accessing easier.}
232
233
234     PROCEDURE next_char(tpt: treept);
235
236        BEGIN
237           IF tpt^. right <> NIL
238           THEN
239              WITH stack DO
240                 BEGIN
241                    length := length + 1;   nchar[length] := 0;
242                    next_char(tpt^. right);   nchar[length] := 1;
243                    next_char(tpt^. left);   length := length - 1
244                 END
245           ELSE  newcharset[tpt^. sum] := stack
246        END {NEXT_CHAR};
247
248
249     BEGIN {get_new_char_set}
250        stack. length := 0;   next_char(trees. trs[1])
251     END {get_new_char_set};
252
253
254  PROCEDURE put_word(i: bit);
255 {Add a bit to the output buffer word and print when full.}
256
257     BEGIN
258        pos := pos + 1;   wd[pos] := i;
259        IF pos = bit_size  THEN
260           BEGIN
261              num_out_words := num_out_words + 1;   pos := 0;
262              out_file^ := wd;   put(out_file)
263           END
264     END {PUT_WORD};
265
266
267  PROCEDURE flush;
268 {Print out the final word, preceded by its length.}
269
270
271     PROCEDURE convert(i: integer; VAR w: out_word);
272
273        VAR
274           con: RECORD
275                 CASE boolean OF
276                    true: (j: integer) {Note: it is assumed that
277                    an integer takes up exactly one word.};
278                    false: (wd: out_word)
279                 END;
280
281        BEGIN  con. j := i;   w := con. wd  END {CONVERT};
282
283
284     BEGIN {FLUSH}
285        IF pos <> 0
286        THEN
287           BEGIN
288              num_out_words := num_out_words + 1;   out_file^ := wd;
289              put(out_file)
290           END
291        ELSE  pos := bit_size;
292        num_out_words := num_out_words + 1;   convert(pos, wd);
293        out_file^ := wd;   put(out_file)
294     END {FLUSH};
295
296
297  PROCEDURE write_integer(i: integer);
298 {Print an integer bit by bit.}
299
300     VAR
```

```
301       pow_2: integer;
302
303     BEGIN
304       pow_2 := maxdepth;
305       REPEAT
306         put_word(i DIV pow_2);   i := i - (i DIV pow_2) * pow_2;
307         pow_2 := pow_2 DIV 2
308       UNTIL pow_2 = 0
309     END {WRITE_INTEGER};
310
311
312  PROCEDURE put_new_char(VAR ch: newchar);
313 {Print a Huffman character.}
314
315     VAR
316       count: integer;
317
318     BEGIN
319       WITH ch DO
320         FOR count := 1 TO length DO
321           BEGIN  put_word(nchar[count])  END
322     END {PUT_NEW_CHAR};
323
324
325  PROCEDURE init_out;
326 {Print the generated Huffman character set into the beginning of
327 the file. so that "RECALL" can restore the file.}
328
329     VAR
330       i, j: integer;
331
332     BEGIN
333       rewrite(out_file);
334       FOR i := minchar TO 127 DO
335         BEGIN
336           write_integer(newcharset[i]. length);
337           put_new_char(newcharset[i])
338         END
339     END {INIT_OUT};
340
341
342  PROCEDURE translate;
343 {Scan the file a second time, only change from the standard
344 character set to the new one.}
345
346     BEGIN
347       init_out;   reset(in_file);
348       IF NOT eof(in_file)
349       THEN
350         BEGIN
351           IF ord(in_file^) = 0   THEN  get_char;
352           WHILE NOT eof(in_file) DO
353             BEGIN
354               put_new_char(newcharset[ord(in_file^)]);
355               get_char;
356             END;
357           flush
358         END
359     END {TRANSLATE};
360
361
362  PROCEDURE print_stats;
363 {Print the number percentage of pages saved.  Note:  The DEC-20
364 stores files by units of pages which are 512 words each.}
365
366
367     FUNCTION pages(i: integer): integer;
368
369       BEGIN
370         IF i MOD 512 = 0   THEN  pages := i DIV 512
371         ELSE  pages := i DIV 512 + 1
372       END {PAGES};
373
374
375     BEGIN {PRINT_STATS}
376       num_in_chars := num_in_chars DIV 2;
377       IF num_in_chars MOD 5 = 0
378       THEN  num_in_chars := num_in_chars DIV 5
379       ELSE  num_in_chars := num_in_chars DIV 5 + 1;
380       writeln(tty, 'There has been a ', ((pages(num_in_chars) - pages
381         (num_out_words)) / pages(num_in_chars)) * 100: 2: 1,
382         '% saving on your file.')
383     END {PRINT_STATS};
384
385
386  BEGIN {MAIN}
387     writeln(tty,
388       'Version 2.02 of Compress');
389     pos := 0;   num_in_chars := 0;   num_out_words := 0;
390     writeln(tty, 'Scanning.');   fill_tally;
391     writeln(tty, 'Calculating.');   make_new_chars;
392     get_new_char_set;   writeln(tty, 'Compressing.');   translate;
393     print_stats;   13:
394  END {MAIN}.
```

```
1
2  {
3       Written by:     Tom Slone
4                       Nov 15, 1980
5                       at Lehigh University,
6                       Bethlehem, PA 18015
7                       on a DEC System 20
8
9       (c) Copyright 1980
10
11 The author grants permission to copy for non-profit use, providing
12 this comment remains.
13
14 }
15  PROGRAM recall(in_file, out_file);
16  {
17      This program reads the Huffman codes printed in the
18 beginning of a file produced by the sister program, "COMPRESS"
19 and restores the rest of the file to its original form.
20 }
21
22  LABEL
23     13;
24
25  CONST
26     minchar = 1 {This is the minimum recognizable character
27                  (nulls are ignored)};
28     maxdepth = 64 {This number should correspond to the one for
29                    maxdepth in "COMPRESS"};
30     maxlength = maxdepth;
31     maxint = 34359738367;
32     bit_size = 36 {This number should correspond to the one for
33                    bit_size in "COMPRESS"};
34
35  TYPE
36     bit = 0.. 1;
37     in_word = PACKED ARRAY [1.. bit_size] OF bit;
38     alphabet = minchar .. 127;
39     old_char = RECORD
40                    length: 0.. maxdepth;
41                    nchar: PACKED ARRAY [1.. maxdepth] OF bit
42                 END;
43     treept = ^ tree;
44     tree = RECORD
45               CASE fruit: boolean OF
46                  true: (ch: alphabet);
47                  false: (left, right: treept)
48            END;
49
50  VAR
51     in_file: FILE OF in_word;
52     out_file: text;
53     branch: treept;
54     inp1, inp2: in_word;
55     num_left, pos: 0.. bit_size;
56     hay_dos, done: boolean;
57     depth: integer;
58
59
60  PROCEDURE init;
61
62     BEGIN
63        new(branch);   branch^. fruit := false;   branch^. left := NIL;
64        branch^. right := NIL;   reset(in_file);   inp1 := in_file^;
65        get(in_file);   inp2 := in_file^;   get(in_file);   pos := 1;
66        hay_dos := true;   done := false
67     END {INIT};
68
69
70  FUNCTION get_bit: bit;
71
72     VAR
73        con: RECORD
74                 CASE boolean OF
75                    true: (int: integer);
76                    false: (w: in_word)
77              END;
78
79     BEGIN
80        IF NOT eof(in_file)
81        THEN
82           IF pos < bit_size
83           THEN  BEGIN  get_bit := inp1[pos];   pos := pos + 1  END
84           ELSE
85              BEGIN
86                 get_bit := inp1[bit_size];   pos := 1;   inp1 := inp2;
87                 inp2 := in_file^;   get(in_file)
88              END
89        ELSE
90           BEGIN
91              IF hay_dos  THEN
92                 BEGIN
93                    con. w := inp2;   num_left := con. int + pos - 1;
94                    hay_dos := false
95                 END;
96              get_bit := inp1[pos];
97              IF pos = num_left   THEN  done := true
98              ELSE  pos := pos + 1
99           END
100     END {GET_BIT};
101
102
103  PROCEDURE fill_tree;
104
105     VAR
106        i: integer;
107        save_tree: treept;
108
109
110     FUNCTION get_integer: integer;
111
112        VAR
113           pow_2, ans, count: integer;
114
115        BEGIN
116           pow_2 := maxdepth;   ans := 0;
117           FOR count := 1 TO 7 DO
118              BEGIN
119                 ans := ans + pow_2 * get_bit;   pow_2 := pow_2 DIV 2
120              END;
```

```
121          get_integer := ans
122       END {GET_INTEGER};
123
124
125    PROCEDURE add_one(num_left: integer; VAR kh: alphabet; VAR tr:
126      treept);
127
128
129       PROCEDURE start(VAR t: treept);
130
131          BEGIN
132             IF t = NIL  THEN
133                BEGIN
134                   new(t);   t^. fruit := false;   t^. left := NIL;
135                   t^. right := NIL
136                END
137          END {START};
138
139
140       BEGIN {ADD_ONE}
141          depth := depth + 1;
142          IF depth > maxdepth  THEN
143             BEGIN
144                writeln(tty,
145                  'Your file is not compatible with this program!^G');
146                GOTO 13
147             END;
148          IF num_left = 0
149          THEN  BEGIN  tr^. fruit := true;   tr^. ch := kh  END
150          ELSE
151             IF get_bit = 0
152             THEN
153                BEGIN
154                   start(tr^. left);
155                   add_one(num_left - 1, kh, tr^. left)
156                END
157             ELSE
158                BEGIN
159                   start(tr^. right);
160                   add_one(num_left - 1, kh, tr^. right)
161                END;
162          depth := depth - 1
163       END {ADD_ONE};
164
165
166    BEGIN {FILL_TREE}
167       save_tree := branch;
168       FOR i := minchar TO 127 DO  add_one(get_integer, i, branch);
169       branch := save_tree
170    END {FILL_TREE};
171
172
173 PROCEDURE translate;
174
175
176    PROCEDURE convert(t: treept);
177
178       BEGIN
179          IF t^. fruit   THEN  write(out_file, chr(t^. ch))
180          ELSE
181             IF done
182             THEN  writeln(tty, 'Warning!  Character mismatch!^G')
183             ELSE
184                IF get_bit = 0   THEN  convert(t^. left)
185                ELSE  convert(t^. right)
186       END {CONVERT};
187
188
189    BEGIN {TRANSLATE}
190       rewrite(out_file);   WHILE NOT done DO  convert(branch)
191    END {TRANSLATE};
192
193
194 BEGIN {RECALL}
195    writeln(tty,
196      'Version 2 of Recall (Not compatable with version 1)!');
197    writeln(tty, 'Initializing.');   init;   depth := 0;   fill_tree;
198    writeln(tty, 'Recalling.');   translate;   13:
199 END {RECALL}.
```

Articles

The Performance of Three CP/M-Based Pascal Translators

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1981 October

Abstract

The translation-time and run-time performance of three CP/M-based Pascal translators — Sorcim's Pascal/M, MT MicroSYSTEMS' Pascal/MT+, and Ithaca InterSystems' Pascal/Z — are compared. Using a benchmark of eight programs on a 4MHz Z80-based microprocessor, we find that Pascal/M excels in translation time and that Pascal/Z excels in run time. Pascal/MT+'s translation time approaches that of Pascal/M for long programs. Several translator limitations are also illustrated by the benchmark.

Introduction

We recently had the opportunity to use and evaluate four micropro essor-based Pascal translators. We are reporting here the results of one aspe.t of this evaluation (namely, performance) for three of them.

The *performance* of a piece of software, such as a programming language translator, is measured in terms of the amount of resources required by the software to produce some useful result. The primary resource we are interested in is time. We measured both the time required to translate a source program into a machine-executable form and the time required to execute the translated program. The former is termed *translation time* and the latter *run time* (or execution time).

The three Pascal translators we evaluated are Sorcim's Pascal/M, MT MicroSYSTEMS' Pascal/MT+, and Ithaca InterSystems' Pascal/Z. All three run under Digital Research's CP/M operating system. We also evaluated a fourth translator, the UCSD Pascal system, which runs under its own operating system. We have excluded UCSD Pascal from our report because we do not feel a fair comparison of translator performance can be made across operating systems. Separating the performance attributable to the operating system from that attributable to the translator is a difficult task. Other translators beside these three run under CP/M, however. We limited the study to translators that accept essentially the full Pascal programming language and that are widely accessible to the general microcomputing public.

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Thus we eliminate from consideration several "tiny" Pascal translators, among others.

Translators

To better understand the behavior of the three Pascal translators and to better appreciate the performance results, we begin with a brief introduction to translator construction. We use *translator* in the generic sense — any software system that accepts as input a program in one language (the *source language*) and that produces as output a functionally equivalent program written in another language (the *object language*). If the source language is a high-level language such as Pascal and the object language is a low-level language such as assembly language or machine language, then the translator is called a *compiler*. If both the source and the object languages are low-level, then the translator is called an *assembler*. If the object language is not the machine language of some real machine, it becomes necessary to execute the object code with an *interpreter*, which simulates the object language on a real computer.

Compilers that translate source programs directly into object programs are called *one-pass* compilers. Sometimes compilers are written to perform one or more intermediate transformations between source and object; these are called *multi-pass* compilers. Multi-pass compilers generally take longer than one-pass compilers, but they often require less main memory, compile longer source programs, provide more complete diagnostics, and generate better object code. To conserve main memory (and again to increase the size of source programs that can be translated), multi-pass compilers often write out their intermediate transformations to temporary disk files.

We used version 3.19 of the Pascal/M translator. It is patterned after the UCSD Pascal system, comprising two components: a compiler that translates a Pascal source program into P-code — object code for a fictitious, Pascal-like P-machine — and an interpreter for the P-machine. It is a one-pass compiler written in Pascal. For short and moderately-sized programs the compiler uses no memory overlays, but long programs require swapping from the disk of segments of the compiler. It runs in 56K of main memory and requires no temporary files. The output from the compiler is a file containing P-code instructions, which is input to the P-machine interpreter. For compactness and efficiency, the interpreter is written in the assembly language of the host computer (a Zilog Z80, in our case).

We used version 5.2 of the Pascal/MT+ translator. It is a true compiler that generates object code for any of several microprocessors, including the Z80. It is a three-pass compiler written in Pascal: the first pass converts a source program into a sequence of logically related characters called *tokens*, the second pass builds a symbol table, and the third pass generates object code and places it in a Microsoft-format, relocatable object file. The compiler runs in 56K of main memory, using five memory overlays, and it uses one temporary file for the tokens.

We used version 3.2 of the Pascal/Z translator. It is also a compiler, but it generates an assembly-language program as its output. This assembly language requires a special assembler that is supplied with the translator, which can only generate Z80 object code. Pascal/Z is a one-pass compiler written in Pascal. It requires 56K of main memory (although 64K is recommended), using one memory overlay, and it requires no temporary files.

Benchmark

To adequately compare performance, we needed a *benchmark* — a point of reference for our measurements. A benchmark for a translator is a collection of source programs, written in the language the translator understands, that exercises various aspects of the translator's capabilities. Such benchmarks generally include short programs, long programs, and programs that stretch the limits of the translator, such as programs with deeply nested control structures or large data storage requirements. The idea is to include a mix of programs that are representative of the programs that the translator will encounter in normal, everyday use.

Rather than develop our own benchmark from scratch, we relied heavily on the work of others. In particular, seven of the eight programs in our benchmark were adapted from a performance study of the CDC 6400 Pascal translator running under the SCOPE 3.4 operating system, made several years ago by Niklaus Wirth, the designer of Pascal. We restricted our adaptations exclusively to the removal of implementation-dependent features, such as the presence of a hardware clock on the CDC 6400 and the maximum size of integers and reals. It is important to note that we made no other modifications to these programs. Several of them would not compile under one of the translators. We probably could have modified these programs to make them compilable. We opted instead to let our evaluation rest on a translator-independent benchmark.

The first benchmark is a 47-line program to compute the first 90 positive and negative powers of 2. The algorithm uses integer arithmetic exclusively, including multiplication and division. No standard Pascal functions (such as SQRT) are used, and arbitrary precision is simulated by storing each digit of the result separately in the elements of an array. "Powers of Two" is a useful benchmark since it heavily exercises integer arithmetic.

The second benchmark is a 43-line program to sort a 10,000-element array of arbitrary integers into ascending order. The sorting algorithm is called Quicksort, which relies extensively on a recursive procedure. The maximum depth of recursion is *ln*(10,000)=10. "Quicksort" is useful since it exercises recursion and array manipulation.

The third benchmark is a 32-line program to write and to read a file containing 1000 real numbers. First the numbers are written out, one per record, to a file. Then the file is reset and the numbers are read back in. The numbers are stored in internal format (that is, not in human readable form); no input/output conversions are performed. "Real IO" is useful since it exercises "naked" file handling.

The fourth benchmark is a 51-line program to solve the "eight queens" problem. The problem is to find the 92 configurations of eight queens on a chessboard such that no queen attacks another queen. The algorithm uses backtracking and recursion to exhaustively try all plausible chessboard positions. "Eight Queens" is useful since it heavily exercises iterative constructs such as for-loops and if-then-else statements, together with simple but repetitive array manipulation.

The fifth benchmark is a 47-line program to compute the first 1000 prime numbers. "Primes" uses essentially the same language features as Powers of Two, but involves more computations.

The sixth benchmark is a 29-line program to compute the ancestors of a group of individuals, given their parents. It uses a 100x100-element Boolean matrix to represent the individuals and the parent/offspring relationships among them. "Ancestor 1" is useful since it contains deeply nested control constructs and two-dimensional arrays, and thus exercises these aspects of a translator's capacity.

The seventh benchmark is a reimplementation of the previous one, using a 100-element Pascal set in place of a Boolean matrix. "Ancestor 2" is useful for comparing the performance of the implementation of sets.

The last benchmark is a 280-line program we wrote to compute the position of the moon at a given time and date. The program uses nine real arrays indexed by enumerated types, two record types, ten internal functions, and five internal procedures. Most of the functions are one-line long, and do such things as calculate the trigonometric functions in degrees and convert to and from radians and degrees. "Moon Position" is a useful benchmark since it heavily exercises real arithmetic and the compiler's capacity to handle moderately long programs.

Hardware

All of our benchmark programs were run on NorthStar Horizons, containing 4MHz Z80 microprocessors, 56K of main memory, and two double-density, single-sided 5-1/4-inch Shugart SA400 floppy disk drives. Although some of the manufacturers claim their translators will operate on smaller systems, we believe our system is the minimum configuration required for reasonable response and minimal frustration. All three translators were run under CP/M 2.2, using the NorthStar version distributed by Lifeboat Associates.

Methods

For each translator we first verified that each of the benchmark programs produced the correct results. We then removed all statements that wrote to the terminal screen, except for a WRITELN at the beginning of each program that wrote "GO" and a WRITELN at the end of each that wrote "STOP". We did not use these output messages for our measurements; they were merely to give us feedback that something was happening. To guarantee comparable run-time statistics, we compiled each program with all error checking, such as range checking and IO failure detection, disabled.

Because NorthStar Horizons are not equipped with hardware clocks, all timing measurements were made using a stopwatch. We timed each separate step (compile, assemble, link, and run) by typing the appropriate CP/M command line, waiting for the disk drives to stop spinning, and then simultaneously hitting the RETURN key and the start button on the stopwatch. We stopped the watch when the next CP/M command prompt ("A>") appeared. Thus all of our measurements include the time required by CP/M to process the command line, to locate and load the appropriate software into memory, and to prompt for the next command. This method does not measure the "bare bones" performance of the three Pascal translators and the object code that they produce. Nevertheless, we believe that it reflects the typical user's interactions, and thus the method accurately measures the performance that such users can expect for themselves.

Several of the measurements were taken twice to check for timing variance. In no case did the times differ by more than 0.3 seconds, which we attributed to variations in controlling the stopwatch. Thus the variance appeared insignificant.

Results

Tables 1 thru 3 show the results of translating and executing the benchmark programs with each of the three translators. Each column in the tables represents one CP/M command. Tables 4 and 5 summarize the results of the first three tables. In Table 4 translation time is computed as the sum of all the steps necessary to make the object programs executable.

Table 1 shows that Real IO would not compile under Pascal/M. Pascal/M does not support the READ and WRITE procedures on the type FILE OF REAL. As expected with an interpreter-based system, Pascal/M compiles quickly, but interpretation of the P-code is slow. Compile time remained approximately 80 lines of source code per minute, even with long programs such as Moon Position.

Pascal/MT+ successfully compiled all the benchmark programs (Table 2). Compilations are typically up to three times longer than with Pascal/M; total translation time is up to four times longer. Nevertheless, run time ranges from about 30% to 200% faster. Compile time was approximately 30 lines of code per minute for the short programs, but rose to 70 lines per minute for the long program. Total translation time was about 25 lines per minute for the short programs and 56 lines per minute for Moon Position.

Two of the programs would not compile under Pascal/Z (Table 3). Both had control structures too deeply nested (about eight levels) for the compiler to handle. Pascal/Z's compile time is only about one-third longer than Pascal/M's and about twice as fast as Pascal/MT+'s for short programs (approximately 65 lines per minute). But the extra assembly step required takes up to twice as long as the compile time. Table 4 shows that the overall translation time of Pascal/Z is three to four times slower than Pascal/M and ranges from about 25% to 200% slower than Pascal/MT+. Translation time for long programs decreased slightly (25 lines per minute as opposed to 20 lines per minute). Nevertheless, Pascal/Z consistently produced faster code than did Pascal/MT+, ranging from about 10% to 150% faster.

Conclusions

For applications that require frequent compilation but infrequent execution, or where run-time speed is unimportant, Pascal/M is a good choice.

Pascal/Z is the best alternative when run-time performance is paramount and your code only needs to run on Z80s. But be prepared for excruciatingly slow translation time, especially on long programs. Also be prepared to restructure your programs to get them to compile, especially if your system has less than 64K of main memory.

Pascal/MT+ lies somewhere between these extremes. Translation time is slow, but the relative speed (that is, lines of code per minute) improves significantly as program size increases. Similarly, run time is much better than Pascal/M, but not as good as Pascal/Z for most programs. Run-time performance for the two recursive benchmarks, Quicksort and Eight Queens, was relatively poorer than for the nonrecursive benchmarks.

We conclude with a strong admonition. We have reported here only one aspect of comparison between the three translators, namely time performance. There are many other aspects that must be considered when deciding on a translator to suit your own needs, such as robustness, documentation, support, language extensions, error handling, size of object code, and ease of use. For example, in applications where reentrant code is important, Pascal/Z is the only alternative of the three. We decided on Pascal/MT+ for our own applications, primarily because of the language extensions it provides (it is the most complete systems implementation language of the three) and its robustness (we seldom have to massage our code to get it to compile).

Acknowledgements

We extend our thanks to Dionex Corporation, Hewlett-Packard Laboratories, and Pluto Research Group for access to their computers and other resources during this study.

Program	Compile Time	Run Time
Powers of Two	34.6	29.5
Quicksort	32.3	5:23.0
Real IO	unsuccessful	N/A
Eight Queens	36.1	5:02.8
Primes	33.9	1:13.8
Ancestor 1	32.3	1:51.3
Ancestor 2	31.5	43.4
Moon Position	3:30.3	17.4

Table 1: Pascal/M Timing Results (in minutes and seconds).

Program	Compile Time	Link Time	Run Time
Powers of Two	1:31.3	30.4	9.6
Quicksort	1:30.7	39.0	2:47.6
Real IO	1:26.0	38.7	37.0
Eight Queens	1:32.8	30.9	2:30.5
Primes	1:31.6	30.3	11.6
Ancestor 1	1:30.5	33.6	24.9
Ancestor 2	1:28.3	31.5	23.8
Moon Position	3:59.5	53.2	12.8

Table 2: Pascal/MT+ Timing Results (in minutes and seconds).

Program	Compile Time	Assembly Time	Link Time	Run Time
Powers of Two	44.8	58.0	46.8	8.9
Quicksort	43.3	59.3	48.6	1:05.5
Real IO	38.3	58.9	56.1	20.9
Eight Queens	48.0	1:04.0	49.7	53.4
Primes	unsuccessful	N/A	N/A	N/A
Ancestor 1	unsuccessful	N/A	N/A	N/A
Ancestor 2	41.8	1:03.2	46.3	19.0
Moon Position	3:34.6	6:06.5	1:42.1	10.5

Table 3: Pascal/Z Timing Results (in minutes and seconds).

Program	Lines	Pascal/M	Pascal/MT+	Pascal/Z
Powers of Two	47	34.6	2:01.7	2:29.6
Quicksort	43	32.3	2:09.7	2:31.2
Real IO	32	N/A	2:04.7	2:33.3
Eight Queens	51	36.1	2:03.7	2:41.7
Primes	47	33.9	2:01.9	N/A
Ancestor 1	29	32.3	2:04.1	N/A
Ancestor 2	29	31.5	1:59.8	2:31.3
Moon Position	280	3:30.3	4:52.7	1:23.2

Table 4: Summary of Translation-Time Results (in minutes and seconds).

Program	Pascal/M	Pascal/MT+	Pascal/Z
Powers of Two	29.5	9.6	8.9
Quicksort	5:23.0	2:47.6	1:05.5
Real IO	N/A	37.0	20.9
Eight Queens	5:02.8	2:30.5	53.4
Primes	1:13.8	11.6	N/A
Ancestor 1	1:51.3	24.9	N/A
Ancestor 2	43.4	23.8	19.0
Moon Position	17.4	12.8	10.5

Table 5: Summary of Run-Time Results (in minutes and seconds).

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October 7, 1981

Mr. Rick Shaw
Pascal Users Group
P. O. Box 888524
Atlanta, Georgia 30338

Dear Mr. Shaw:

The enclosed article reports my reactions and those of my students to the first Pascal programming course that I taught. I am fairly new to the field of computer science and this particular teaching experience was exciting to say the least.

I hope this short piece will prove to be of interest to you and your readers.

Sincerely,

Gerald R. Pitzl
Associate Professor

GRP:ba

Encl.

MACALESTER COLLEGE

A Geographer Teaches Pascal -- Reflections on the Experience

Jerry Pitzl
Macalester College
St. Paul, Minnesota

Macalester College, a small (1700 students), liberal arts institution located in St. Paul, Minnesota, recently initiated a new major in Computer Studies. Several courses in programming have been offered over the years but increased student demand for a wider range of offerings and faculty recognition that a full and complete program would be necessary in order for us to keep pace with the rapidly growing field of computer science necessitated this significant change.

As a further enhancement to the computer program, Macalester College, in 1979, became the recipient of a National Science Foundation grant to be used to expand the use of computers within science laboratory settings. Initial purchases of hardware included three DEC MINC-11 computers especially configured for laboratory applications. In addition, the departments of geography, of which I am a member, and geology received a Magnavox S-4 Orion stand-alone graphics system, a 22" x 22" Talos S622 digitizer, and a 300 LPM Printronix Printer/Plotter. The graphics system is used primarily within the geography department in a computer mapping course.

During the academic year 1979-80 I was on a sabbatical leave and spent virtually all my time at the University of Minnesota auditing courses in a variety of computer and mathematics related areas. I had no prior knowledge of computer languages, but I knew that I would have to become familiarized as quickly as possible because I was slated to do the computer mapping course. Needless to say, the transition to the "kind of thinking" required for success in the computer field did not come that easily for me at first; my long-term background, primarily in the humanistic realms of geography, had produced a "mind set" that was placed in a mild form of intellectual shock at first exposure to computer operations, and this condition persisted for at least the first few weeks.

Fortunately, however, my introduction to computer programming was through the Pascal language. I found the language to be logically constructed and relatively easy to use. The form of program development using algorithm formulation and structure provided an ideal transition to the eventual writing of actual Pascal code. I soon became unequivocally "hooked" on Pascal. So much so that in the following year I set out to develop a course in programming with Pascal which was introduced during our January "interim" session of 1981. Interim is a one-month period in which courses not available in the regular semesters are given. It is a good time to introduce and test a topic or theme which may later become a regular curricular offering. In our case, Pascal was not a new topic on campus; it is being taught along with other languages in a one-semester course. However, I felt that the language should receive a great deal more emphasis and perhaps eventually be the sole subject of a full semester. It is, as most agree, the most appropriate language for teaching the concepts of structured programming.

The interim course contained 20 students, half of whom had varying degrees of experience with computer science and the rest with no experience whatever. The four-week time frame with two-hour sessions five days a week left little free time for either the students or the instructor. We covered all aspects of the language including a brief introduction to the use of records, external files and the pointer.

The students produced eight programs of varying difficulty and took four quizzes. The assigned readings came from Schneider, Weingart, and Perlman, Introduction to Programming and Problem Solving with Pascal, a widely used and thorough introduction to the language. As an added feature, G. Michael Schneider, one of the authors of the text, visited the class and gave us a most stimulating presentation.

As a final exercise in the course, the students were asked to complete a critique of the experience. Some of the questions asked and a sampling of the responses are presented here:

Item No. 1--Did you know a programming language before this course?

a. If yes, how would you compare Pascal to the language(s) you already know? Responses: requires new ways of thinking...about flow of control; most flexible language I know; much prettier...easy to use and efficient once the bad habits of needing the "go to" statement are broken; easier to understand than COBOL or FORTRAN; more high-powered than BASIC and more structured; more can be done with Pascal; more ways to approach a problem; compared to BASIC, Pascal is much more fun; more closely related to the English language.

b. If no, did you find that Pascal provided a meaningful introduction to programming? If yes, why? If no, why not? Responses: Yes, I think the structure is important; yes, it provides the basis for a new way of thinking; yes, good intro to the computer and how it works; yes, judging from the experiences of those in the terminal room using other languages, it seems that Pascal is the best language for understanding programming; yes, it is easy to work with; yes, Pascal has provided me with a meaningful introduction to programming; yes, it is easy to read a program...and the language is interesting; yes, Pascal was a good introduction in that I learned that programming is mostly paperwork before hand.

Item No. 7--Do you think that Pascal should be offered as a full, regular semester course? If yes, please state why; if no, please state why not.

Responses: Yes-- interesting, powerful; important for computer studies majors; good for structured programming; it is a relatively new language and computer studies majors should know it; it is the direction that computer languages will go; best for general purpose computing; becoming more widely accepted and used; valuable course for learning many aspects of computer science; better for beginners -- neat, beautiful language; more time needed than is available during interim; versatility and uses of the language are great; better to learn as a "first" language; a "fun" language; a "logical" language; very powerful.

--- There were no "no's" ---

Item No. 9--Do you think that you will choose to use Pascal in the future if you write computer programs?

--- All yes's ---

How would you rate our guest lecturer, Professor Schneider?

Responses: good, excellent; interesting; informative; amusing; a good prospect for a Mac prof; excellent; very knowledgeable; knows his stuff; great future; very good; great -- too bad we can't be assured of having him here; great teacher; 8 on a scale of 10; excellent; he really knows his stuff; excellent; 10 of 10; great; great guy; really knows what he's doing; liked him; slick and intelligent guy; fantastic; sparked my interest in computer science; the high point of the class; he is like the pointer -- dynamic.

Final Item--General comments.

Responses: best interim course ever taken; more challenging than BASIC; impressive language; I now have an understanding and a respect for computers; revived my ability to concentrate for extended periods of time; computers -- "it's rather amazing, isn't it?"

As the responses clearly suggest, the entire class was more than satisfied with the course and unanimous in their assessment of Pascal as a sound and usable programming language. It would be sheer understatement on my part to say that I was pleased with the outcome. I was ecstatic! The course is scheduled for the interim term of 1982 and the Pascal language offering during the regular semester will be expanded within the existing course framework.

I conclude with a plea to all who are in an academic setting to encourage the expanded offering of Pascal as the most appropriate language to use for introducing programming. I believe this to be true not only for students, but for others (faculty and staff) who are being tasked to climb aboard the expanding computer applications wave that apparently is nowhere near cresting.

****

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An Extension that Solves Four Problems
by Jonathan A. Yavner

1. The Dynamic Array.

The specification of dynamic arrays is currently a point of heated discussion among Pascal theorists. Pascal News #19 (labeled "17") contains eleven double-density pages of debate on the merits of the proposal contained in the DP 7185.1 standard. The most telling argument against the Sale syntax is the assertion that it is not intuitively obvious and therefore does not belong in a language whose users consider it the guardian of rational programming. The point is substantiated by the sheer prolixity of the bombast on the subject that has been published in PN, shouted across standards-committee conference tables, or otherwise made public. If the dynamic array really belongs in Pascal--and is not present because certain vociferous fanatics chanting "Stamp out the FORTRAN dinosaur!" want to make Pascal able to do everything FORTRAN can and don't care if Pascal becomes FORTRAN in the process--there has to be a better way.

2. Memory-resident Format Conversion.

I wonder about those fanatics, though. My company produces financial database-management systems, for which one would think Pascal an ideal language, given its data-security emphasis. However, such programming requires certain features commonly available in FORTRAN and BASIC which are difficult to simulate in Pascal. Such a feature is memory-resident format conversion. In most high-level languages, format conversion is performed as an integral part of I/O. Sometimes it is necessary to perform such conversion in memory, perhaps to add commas before output or to delete them after input. For these occasions FORTRAN provides its ENCODE and DECODE statements. BASIC implementations tend to have two or more string functions (with different names and formats for each implementation) to perform these conversions. I hear no fanatic-talk about adding these features to Pascal, yet the only way to force Pascal to perform non-I/O conversion is to declare an external procedure and then attach it to the appropriate routine in the run-time-library using some sort of aliasing mechanism--an extremely implementation-dependent method. If the implementation doesn't support external procedures or doesn't list the names of its library routines or doesn't allow them to be called by the user, the program must contain a source-code duplicate of the conversion routine--an extremely inefficient method.

This conversion problem is actually a special case of a more basic difficulty which has received occasional mention in this journal (though I can't find the references). Programming generality can be promoted by avoiding an either/or choice for main versus peripheral memory storage of files. In one of the references which I can't find, IBM's 48-bit unified addressing scheme is given as an example of where the capability to code storage-location-independent routines is provided to the assembly programmer.

3. The String.

Anyone who uses a version of BASIC (among others) that has a garbage collector becomes addicted to strings and finds Pascal and FORTRAN irritatingly restrictive. Like its close relative the dynamic array, there seems to be no obvious method of specifying string definition and manipulation.

4. Random-access I/O.

Pascal can be implemented on any computer with at least a processor and two magtapes. Such a computer is incapable of random-access I/O. For this reason no mention of such I/O appears in the standard. For this reason each of the vast majority of implementations which can supply random access has implemented incompatible extensions to provide this capability. The standard would be superior if there were some way to specify the format of such operations without either requiring them of all implementations or layering the standard. Use of a layered standard to define a language which includes intuitive obviousness among its design goals is a paradox.

5. The Solution.

The solution to the problems delineated above lies in the realization that dynamic arrays, strings, and files are but different facets of **the same data structure.** Simply extending slightly the definition of the file structure would allow files to perform the duties of strings and dynamic arrays. To avoid actually implementing garbage collection, files could be allocated in segments on the heap, each segment containing x sequences of the file and a pointer to the next segment, where x is determined from the equation
x=((nice segment size)-(pointer size)) DIV (sequence size).

Deletions from the standard: All references to conformant arrays, conformant array schemata, and compliance levels.

Changes to the standard, 6.4.3.5 (file types): The file element f.M has the enumerated values (Generation, Inspection, Direct). There exists an element f.Len whose value is the number of sequences in the file. The notation f[n] denotes the nth sequence of the file; the values for n are 0..(f.Len-1). There exists an element f.Pos,

whose value is such that f.R.first=f[f.Pos]. F.Pos shall be equal to f.Len if f.R=S(). Rule (b), describing the structure of a file of type text in Generation mode, shall apply also for Direct mode.

<u>Changes to the standard, 6.6.5.2 (file-handling procedures):</u>

```
get(f): If f0.M=Direct,
  pre-assertions:
    f0.L is defined
    f0.R<>S()
  post-assertions:
    f.M=f0.M
    f.Len=f0.Len
    f.Pos=f0.Pos+1
    f.L=f0.L~f0.R.first
    f.R=f0.R.rest
    If f.R<>S()
      f↑=f.R.first
    otherwise
      f↑ is undefined

put(f): If f0.M=Direct,
  pre-assertion:
    f0.R, f0.L, and f0↑ are defined
  post-assertions:
    f.M=f0.M
    f.Pos=f0.Pos+1
    f.L=f0.L~S(f0↑)
    f.R=f0.R.rest
    If f0.R=S(),
      f.Len=f0.Len+1
    otherwise
      f.Len=f0.Len
    If f.R<>S()
      f↑=f.R.first
    otherwise
      f↑ is undefined
```

<u>Additions to the standard, 6.6.5.2:</u>

```
init(f)
  pre-assertion:
    true
  post-assertions:
    f.M=Direct
    f.L=f.R=S()
    f↑ is undefined
    f.Len=f.Pos=0

seek(f,p)
  pre-assertions:
    f0.L and f0.R are defined
    f0.M IN [Direct]+seekmodes
    p IN [0..f0.Len]
```



```
  post-assertions:
    f.M=f0.M
    f.Len=f0.Len
    f.Pos=p
    f.L=f[0]~f[1]~f[2]~...~f[p-1]     (f.L=S() if p=0)
    f.R=f[p]~f[p+1]~...~f[f.Len-1]    (f.R=S() if p=f.Len)
    if f.R<>S()
      f↑=f.R.first
    otherwise
      f↑ is undefined
```

The implementation-defined set **seekmodes** shall be equivalent to the set of values for f.M other than Direct for which seek shall be valid.

The procedures d<fctn>(f,p,v1,v2,...,vn), where <fctn> shall be replacable by any of (read, write, readln, writeln), shall be equivalent to
begin seek(f,p); <fctn>(f,v1,v2,...,vn) end.

<u>Additions to the standard, 6.6.5.4 (ordinal functions):</u>

length(f) The function shall return the value of the element f.Len of file f; the set of values for f.M other than Direct for which f.Len is defined shall be implementation-defined.

pos(f) The function shall return the value of the element f.Pos of file f; the set of values for f.M other than Direct for which f.Pos is defined shall be implementation-defined.

6. <u>Example Program.</u>

This program fragment uses many facets of the extension outlined above. It has not been parsed, since currently there is no processor which accepts the extension. It is asserted that one of Pascal's greatest strengths lies in its ability to make this kind of general-purpose program reasonably portable. Comments would be appreciated, as it is conceivable that I may inflict upon the world a Pascal processor with this extension unless either I am drowned in a sea of hate mail or the proposal ceases to be an extension.

```
                program MoneyMarketIII(input,output);
const
  ScreenHeight = 24;
  ScreenWidth  = 79;
  MaxField     = 32;
  MaxScale     = 9;
type
  Whole       = 0..MaxInt;
  Short       = -32768..32767;
```

```
  Byte       = 0..255;
  SHIndex    = 1..ScreenHeight;
  SWIndex    = 1..ScreenWidth;
  ScaleIndex = -MaxScale..MaxScale;
  FieldTypes = ( A,B1,B2,B4,D,X );
  TableTypes = ( Control,FieldDesc );
  Date       = packed record
    year     : 1901..2100;
    month    : 1..12;
    day      : 1..31;
    end;
  TypeCross  = packed record { All implementation-dependent trickery
    goes through this type, thus isolating the programming changes
    necessary to move to a new processor. }
    case FieldTypes of
    A  :( aval  : Real );
    B1 :( b1val : Byte );
    B2 :( b2val : Short );
    B4 :( b4val : Integer );
    D  :( dval  : Date );
    X  :( xval  : packed array[1..MaxField] of Byte );
    end;
  TableRec   = packed record
    case rectype:TableTypes of
    Control   :( { Control record for each data file }
      name : packed array[1..8] of Char;
      fd   : Whole { Pointer to first field descriptor };
      nent : Short { Number of field descriptor entries };
      );
    FieldDesc :( { Descriptor for each field in data record }
      fx    : Short { Field number };
      ft    : FieldTypes;
      af    : Short { Auxillary field-type datum };
      loc   : Short { Location of field };
      leng  : Byte {  Length   of field };
      p     : Byte {  Screen page of fields };
      vx,vy : Byte {  Co-ordinates of value field };
      nx,ny : Byte {  Co-ordinates of name  field };
      name  : packed array[1..12] of Char;
      );
    end;
  Datafile   = packed file of Byte;
  TableFile  = file of TableRec;
var
  filcon : TableRec { File control record };
  table  : TableFile;
  data   : DataFile;
  filnum : Byte { Data-file number };
  page   : Byte;
  ln10   : Real;

procedure Format( { ENCODE example; also shows string usage }
  var output : Text;
  input      : Real;
```

8-Sep-81 Yet Another Extension

```
  scale      : ScaleIndex;
  leng       : Byte { This semicolon is illegal! -> };
  );

var
  temp       : Text;
  nonfrac,x  : Whole;
  abscale    : 0..MaxScale;
  comma      : 0..2;
begin
  abscale:=abs(scale) { Number of implied fractional digits };
  init(output);
  write(output,exp(ln(abs(input))-abscale*ln10):1:abscale);
  nonfrac:=length(output)-abscale-1 { Non-fractional digits };
  comma:=(nonfrac-1) MOD 3;
  init(temp);
  seek(output,0);
  for x:=1 to nonfrac do begin
    write(temp,output↑);
    get(output);
    if comma>0 then comma:=comma-1 else begin
      if x<>nonfrac then write(temp,',');
      comma:=2;
      end;
    end;
  if scale<0 then begin { Truncate decimal }
    x:=length(output);
    repeat
      x:=x-1;
      seek(output,x);
      until output↑<>'0';
    if output↑<>'.' then begin
      seek(output,nonfrac);
      for x:=nonfrac to x do begin
        write(temp,output↑);
        get(output);
        end;
      end;
    end
  else if scale>0 then while NOT eof(output) do begin
    write(temp,output↑);
    get(output);
    end;
  init(output) { Space should be recovered here };
  x:=leng-length(temp)-ord(input<0);
  if x>0 then write(output,' ':x);
  if input<0 then write(output,'-');
  while NOT eof(temp) do begin
    write(output,temp↑);
    get(temp);
    end;
  if length(output)>leng then begin
    init(output);
    for x:=1 to leng do write(output,'/');
```

```
      end;
  { System must dispose of local files here. }
    end;

procedure FormatDate(var output:Text; input:Date);
  begin
    init(output);
    with input do write(output,day:2,'/',month:2,'/',year:4);
    seek(output,3);
    if output↑=' ' then write(output,'0');
    end;

procedure Dump(var output,input:Text);
  { Generalized procedure to trim trailing blanks.  This routine is
    completely device-independent.  Output is assumed to be open. }
  label 1;
  var
    temp : Text;
    x    : Whole;
  begin
    reset(input) { Reset must perform a writeln if necessary };
    page(output) { Must also writeln };
    while NOT eof(input) do begin
      init(temp);
      while NOT eoln(input) do begin { Note the use of the end-of-line
        character as a flag.  Similar use of the end-of-page character
        is impossible because of the lack of the eop() function. }
        write(temp,input↑);
        get(input);
        end;
      readln(input);
      if length(temp)=0 then goto 1;
      repeat seek(temp,pos(temp)-1) until temp↑<>' ' OR pos(temp)=0;
      if temp↑=' ' then goto 1; x:= pos(temp); seek(temp);
      for x:=1 to x do begin
        write(output,temp↑);
        get(temp);
        end;

1:
      writeln(output);
      end;
    end;

procedure FillScreen( { Format and print a record }
  var output    : Text;
  var table     : TableFile { Possibly peripheral; so what? };
  var data      : DataFile { Almost certainly peripheral; requires
    that seek() be allowed on files which are associated with an
    external storage device and are in Inspection mode. }
  var tablentry : TableRec;
  page          : Byte;
  );
```

8-Sep-81 Yet Another Extension

```
  var
    screen,field : Text;
    i,j,base     : Whole;
    convert      : TypeCross;

procedure Posit(var output,input:Text; x:SWIndex; y:SHIndex);
  { Dynamic array example.  Input's maximum size depends on whether
    it is a value or a name.  Note that, in contrast to the con-
    formant array, a file argument can be packed (Text = packed
    file of char), but it cannot be passed by value, since allowing
    files to be assignment-compatible would create an ambiguity
    either of whose resolutions contains a paradox.   Oh well, such
    are the breaks . . . }
  begin
    seek(output,y*80+x) { Note that an end-of-line, in conformance
      to the standard, is assumed to occupy one sequence in the
      file.  Some ASCII computers use the old-fashioned chr(13)~
      chr(10) terminator instead of the ANSI-standard chr(10).
      Some computers have weird character sets that require escapes
      to enable certain subsets.  Many EBCDIC computers derive eoln
      from (file-position MOD record-length).  Such difficulties
      may force some implementations to prohibit the use of seek()
      on externally-associated textfiles and to use special-case
      Direct-mode-only code in all the file-handling procedures
      to produce extra-wide characters with special bits to indicate
      prefixes.  Ugh.  As I have suggested, my extension simplifies
      the programmer's job at the expense of creating double the work-
      load for the run-time library.  But anyone afraid of a little
      inefficiency should use an assembler--or a better computer!};
    reset(input);
    while NOT eof(input) do begin
      write(output,input↑);
      get(input);
      end;
    end;

  begin { FillScreen }
    init(screen);
    for i:=1 to ScreenHeight do writeln(screen,' ':ScreenWidth);
    base:=pos(data) { Assume data file already positioned };
    with tablentry, convert do begin
      seek(table,fd);
      for i:=1 to nent do begin
        with table↑ do if p=page then begin
          seek(data,base+loc);
          for j:=1 to leng do read(data,xval[j]);
          for j:=leng+1 to MaxField do xval[j]:='*';
          case ft of
            A  : Format(field,aval,af,vl);
            B1 : Format(field,b1val,0,vl);
            B2 : Format(field,b2val,0,vl);
            B4 : Format(field,b4val,0,vl);
            D  : FormatDate(field,dval);
```

```
            X   : write(field,xval:vl);
            end;
          Posit(screen,field,vx,vy);
          init(field);
          write(field,name:nl,' (',fx:1,')');
          Posit(screen,field,nx,ny);
          end;
        get(table);
        end;
      end;
    Dump(output,screen);
    end;

begin { MoneyMarketIII }
  ln10:=ln(10.0);
  { Determine filnum }
  dread(table,filnum,filcon);
  connect(data,filcon.name) { external is standard, why not connect? };
  reset(data) { Requires random-I/O ability in run-time environment };
  { Position datafile and determine page }
  FillScreen(output,table,data,filnum,page,ScreenHeight,ScreenWidth);
  { Other processing }
  end.
```

7. Optional String Functions.

The main point of this essay (whenever it pretended to have one) has been that Pascal has always had string-handling ability and that the addition of a few functions could provide enough improvement to obviate any need for a heavyweight boxing match to decide which dynamic array description method should be used. However, the example program is in many ways redundant, since the same kinds of code sequences appear repeatedly. For this reason the following suggested list of string functions is proposed. Implementing them in assembly would remove the restriction that the files must be of a specific type. The "type" File, as used below, reflects this generic capability, available only to intrinsic procedures.

```
procedure Append(var output,input:File);
  begin
    reset(input);
    while NOT eof(input) do begin
      write(output,input↑);
      get(input);
      end;
    end;

procedure Copy(var output,input:File);
  begin
    init(output);
    Append(output,input);
    end;
```



```
procedure Posit(var output,input:File; sequence:Integer);
  begin
    seek(output,sequence);
    Append(output,input);
    end;

procedure Switch(var output,input:File);
  begin
    Copy(output,input);
    init(input) { Actually, since the internal pointers are being
      switched, the input file would be left undefined (closed). }
    end;

procedure Extract(var input,output:File; loc,leng:Integer);
  var x:Integer;
  begin
    seek(input,loc);
    init(output);
    for x:=1 to leng do begin
      write(output,input↑);
      get(input);
      end;
    end;

procedure Insert(var output,input:File; sequence:Integer);
  var
    temp : File;
    x    : Integer;
  begin
    Extract(output,temp,0,sequence);
    Append(temp,input);
    while NOT eof(output) do begin
      write(temp,output↑);
      get(output);
      end;
    Copy(output,temp);
    end;

function Compare(var left,right:File):1..3;
  label 1;
  begin
    reset(left);
    reset(right);
1:
    if eof(left) then Compare:=3-ord(eof(right))
    else if eof(right) then Compare:=1+ord(eof(left))
    else if left↑<>right↑ then Compare:=1+2*ord(left↑<right↑)
    else begin
      get(left);
      get(right);
      goto 1;
      end;
    end;
```

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```
Function Locate(var parent,search:File):Integer;
  { Pre-assertions:  parent.M=Direct; parent.Pos is starting point. }
  { Post-assertions: parent.Pos=Locate+length(search) }
  { Locate is assigned the parent sequence number of the first element
    of search (starting the search from the input value of
    parent.Pos).  If the search file cannot be found in parent, Locate
    is returned as length(parent).  This definition avoids special-
    case handling both within Locate and in the calling code.  Compare
    this simplicity to the definition and use of DEC's BASIC instr/pos
    function! }
  label 1,2;
  var localroot:Integer;
  begin
    localroot:=pos(parent);
    while localroot<length(parent) do begin
      reset(search);
1:
      if eof(search) then goto 2;
      if eof(parent) then begin
        localroot:=length(parent);
        goto 2;
        end;
      if parent↑=search↑ then begin
        get(parent);
        get(search);
        goto 1;
        end;
      localroot:=localroot+1;
      seek(parent,localroot);
      end;
2:
    Locate:=localroot;
      end;
```

One final question: Should the first file argument of these string procedures be optional, as it is for the other intrinsic file procedures? Personally, I believe that the original file-omission option was a mistake, so I never use it. Allowing first-argument omission for the string-handling procedures would be difficult, since the second argument is often also a file. For these reasons, I vote "no."

J Miner 8 Sept 81

Open Forum For Members

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

970 BURRARD STREET
VANCOUVER, B.C.
V6Z 1Y3
TELEX 04-54395

1981 July 21

Dear PUG

subject: PRETTYPRINT

Prettyprint programs should reformat multiline comments into single line comments. This will help detect unmatched comment delimiters. It will also make it clear when bits of Pascal code are actually comments on how to **modify** the program.

OLD:

```
(* TO SUM THE INTEGERS
   for i:= 1 to 10 do *)
   a:= a+w[i];
```

NEW:

```
(* TO SUM THE INTEGERS *)
(* for i:= 1 to 10 do *)
   a:= a+w[i];
```

"A Comment on Comments"

W. Cox
GenRad/Futuredata
17361 Armstrong Ave.
Irvine, CA 92714

Introduction

While working on our Pascal compiler for the Intel 8086 (written in UCSD Pascal), I have studied closely several of the User's Group software tools with an eye toward converting them to that dialect. I have the following observations to make regarding the handling of comments by those tools and upon the definition of a comment in the Draft Standard proposal [1].

ISO Standard Comment Forms

This table enumerates the four forms of comment permitted by the Draft Standard.

Forms	Starting Delimiter	Ending Delimiter
1	"{"	"}"
2	"(*"	"*)"
3	"{"	"*)"
4	"(*"	"}"

Note: Forms 3 & 4 are prohibited by our UCSD compiler.

UCSD Pascal Comment Handling

The UCSD Pascal compiler that we use (a much-modified version 1.5) permits Forms 1 & 2 of comments, with a most useful twist: a comment begun by a curly bracket can _only_ be terminated by a curley bracket, and one begun by the "(*" digraph can _only_ be terminated by the "*)" digraph. Users whose systems don't permit both forms are unaffected, but those of us who have curley bracket characters are lucky. By using only form 1 for normal comments, we are able to "comment out" our temporarily delete bodies of text (using form 2) in a natural and error-free manner.

Draft Standard Suggestion

Since the above manner of comment handling is most useful to some of us, relatively cheap to implement for all of us, and invisible to those whose character sets don't permit it, I suggest that the Draft Standard, section 6.1.8 paragraphy 1, sentence 1 be rewritten as follows:

The constructs "{"..."}" and "(*"..."*)" shall be comments if the "{" or "(*" does not occur within a character-string. The constructs "{"..."*)" and "(*"..."}" are expressly forbidden.

The note in section 6.11 should be deleted.

Software Tools Commentary

It is interesting that the software tools published in Pascal News are not uniform in their handling of comments. XREF [4], written by Pascal's inventor, and ID21D [2] follow the UCSD convention while PRETTYPRINT [6] and REFERENCER [3] follow the Draft Standard. FORMATTER [7] doesn't recognize curley brackets at all!

References:

1. A.Addyman, et al. ISO DP/7185 -- A Draft Proposed Standard for the Programming Language Pascal.
   Pascal News # 18 (May, 1980)

2. Andy Mickel. Recoding a Pascal Program using 1D21D.
   Pascal News # 15 (September, 1979)

3. Sale, A.H.J. User Manual - Referencer.
   Pascal News # 17 (March, 1980)

4. Wirth, N., et al. Cross Referencer Generator for Pascal Programs.
   Pascal News # 17 (March, 1980)

5. Shillington & Ackland (ed). UCSD (Mini-Micro Computer).
   Pascal Version 1.5 (January, 1980)
   Note: This reference does not discuss the UCSD comment handling; it is included for completeness only.

6. Heuras & Ledgard. Pascal Prettyprinting Program.
   Pascal News # 13 (December, 1978)

7. Condict, Marcus & Mickel. Pascal Program Formatter.
   Pascal News # 13 (December, 1978)

255 huron street, room 350
toronto, ontario M5S 1A1

QUOTE REFERENCE NUMBER

(416) 978-4462

Hemenway Associates,
101 Tremont Street,
Boston MA 02108
U.S.A.

As a longtime user of the language Pascal I was interested to see a description of your language HA-PASCAL/I. As I read the description, however, I became concerned, and finally skeptical. While you have produced what will clearly be a good product and a very useful tool for the intended applications, I am concerned that you are selling a product as a Pascal language that is really not Pascal. (Pascal is not an acronym but a person's name, so it is usually written in normal case, like Ford Motors, Washington or San Diego.)

It seems to me - after reading just your advertising flyer - that your product HA-PASCAL/I is more accurately described as PL/I with some of the syntax of Pascal. Your memory references MEM and MEMW in particular use the concept of a "pseudo-variable" which is normal to PL/I but completely alien to Pascal. All Pascals that I know of use (built-in or library) FUNCTIONs and PROCEDUREs for this purpose - a FUNCTION to return a value; a PROCEDURE to send one. This is the spirit of Pascal; "pseudo-variables" are not. Also, your CALL statement for external routines is PL/I, not Pascal. All Pascals that I have used or seen declare external routines as a FUNCTION or PROCEDURE, as appropriate, with the subprogram body replaced by the keyword EXTERNAL (or EXTERN in a few cases).

Perhaps more importantly, your advertising makes no reference to the existence of the RECORD construct. The RECORD concept is one of the key concepts of Pascal; one of the things that makes Pascal Pascal. A Pascal without RECORDs is like a computer without a CPU, like a car without wheels.

Finally, your statement that the inaccessability to machine language in some Pascals (most provide it either inline or via EXTERNAL routines) prevents "the Pascal user from effectively programming his microprocessor" leads me to believe that you are equating machine programming with effective programming. I think if you consider the programmer's time in coding and debugging, you will find Pascal - even a p-code implementation - to be the more "effective".

I am bringing these problems to your attention to help prevent a situation in which people using your product think they are using Pascal, and try to move programs to a Pascal compiler and blame Pascal for not being your language. To be honest with your customers current and potential, you might choose to refer to HA-PASCAL/I as "a Pascal derivative for microcomputer systems programming" - which it is - rather than "a version of Pascal" - which I don't think it is.

Thank you.

Sincerely,

Ian F. Darwin
University of Toronto Computing Services
10 King's College Road
Toronto, Ontario M5S 1A1

/maklet/tik

CC:
T. Wood
Pascal User Group Newsletter

MELVIN E. CONWAY

July 9, 1981

Mr. Rick Shaw
Pascal Users Group
P.O. Box 88524
Atlanta, GA 30338

Dear Mr. Shaw:

I am interested in joining the Pascal Users Group. Please send information and the necessary materials.

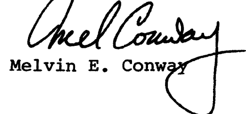
I am an independent contractor who has recently completed a Pascal-in-ROM for the Rockwell AIM 65; I expect Rockwell to release the ROMs this month. The noteworthy thing about this software is that it relates to the user like BASIC: there is no compilation phase requiring external file storage; it talks to the user entirely at the source-language level, including a source-level trace, source-level single-step, and immediate statement execution; and execution is possible right after a source-level change.

The AIM 65 version of the Instant Pascal (my trademark) design implements a substantial subset of the language, including character, string (an extension), real, enumerated, subrange, array, and record data types, as well as all statement forms.

Now that the product is real I am ready to start talking with people who see other uses for this technology, particularly those who are in a position to support its development. Fuller versions of this software for other microcomputers come to mind, as well as more specific tools, such as microprocessor software development systems. Your assistance in getting the word out will be appreciated.

Thanks for your help.

Very truly yours,



Melvin E. Conway

8 BROOK HEAD AVE., BEVERLY, MASS. 01915 U.S.A. PHONE (617) 922-5042

1 DEC 1981

RICK SHAW
PASCAL USER'S GROUP
DIGITAL EQUIPMENT CORPORATION
5775 PEACHTREE DUNWOODY RD.
ATLANTA, GEORGIA 30342

Dear Rick,

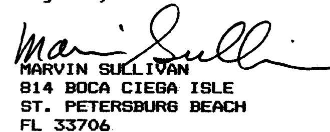
I found your address in the back of " Introduction to Pascal for Scientists" by James W. Cooper and so am writing to join the PUG.

I have for the last month owned an APPLE II w/48K, a PASCAL language card, an 80 column card, two disk drives, an Epson MX-80 printer,and a D.C. Hayes Micromodem. The purpose of all this equipment is to allow use of the PASCAL text editor as a word processor and to communicate my texts with a group of coworkers scattered all across the USA. It has worked well and I now fancy myself as a demon editor, however as a PASCAL programmer, a novice only. A program to select printer options- menu sort of things has been the extent of my programs.

The need for more information is clearly apparent as I have no other programming background to draw from so I am inclosing a few extra dollars(I hope, as I don't know exactly what the fee for joining is) for back issues of PASCAL NEWS- particularly those issues which have information about programs for ..storage and retrieval of files..storage and retrieval of addresses and print out of same..fast Fourier transforms..and most important when writing a letter how do I get the GD printer to page?

Thanks for whatever time you can spare to help me out.

Regards,



MARVIN SULLIVAN
814 BOCA CIEGA ISLE
ST. PETERSBURG BEACH
FL 33706

TRW

September 24, 1981

Pascal User Group
P. O. Box 888524
Atlanta, GA 30338

Attn: Rick Shaw

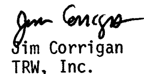
Dear Rick,

It was good talking with you last night. I would appreciate you placing the following text in your newsletter:

> We would appreciate contact from anyone utilizing Pascal under a VAX/VMS. We are specifically interested in the run-time efficiency of executable code. Any other comments would be appreciated. Please Contact:
>
> Jim Corrigan
> TRW, Inc.
> 5205 Leesburg Pk. (Suite 1106)
> Falls Church, VA 22041
>
> (703) 931-2017

Thanks again, Rick.

Yours truly,



Jim Corrigan
TRW, Inc.

JSC/dm

DEFENSE AND SPACE SYSTEMS GROUP OF TRW INC.
SKYLINE OFFICE *• 5205 LEESBURG PIKE, SUITE 1106, FALLS CHURCH, VIRGINIA 22041 • (703) 931-2010, 931-2017*

Three Rivers
Computer Corporation
195 Farmington Avenue
Farmington, Connecticut 06032
203/674-8367

October 28, 1981

Pascal User's Group
P.O. Box 4406
Allentown, PA 18170

RE: <u>Rush Request for Software Package Information</u>

Dear Sir or Madame:

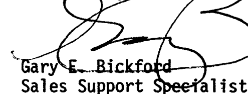
I have the responsibility of identifying "all" of the available software products and packages written in PASCAL. As you are aware, this is a very large task, and I have a very short time to acquire as much information as possible--about <u>two</u> weeks.

I need your help, and the help of as many people as you can contact. There is a benefit to at least some respondents. As you may know, our company produces a high-speed unshared computer (PERQ) which is a Pascal-based machine. We are looking for purchase, contract, OEM, third party and contributed or public domain applications and any other Pascal software. We will be negotiating distribution and license agreements immediately with qualified software sources.

Can you please assist me by: 1) forwarding any present compilations or catalogues you have of available software, to me immediately; 2) passing on this request to any other appropriate parties, by phone, if possible.

I greatly appreciate any information you can provide. Please feel free to contact me anytime at (203) 674-8367. Thank you. I shall look forward to hearing from you.

Kindest regards,



Gary E. Bickford
Sales Support Specialist

GEB/cao

CET Council for Educational Technology

* Devonshire Street, London W1N 2BA *Telephone:* 01-636 4186 *Chairman:* Professor J C West, CBE *Director:* G Hubbard

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Wellfield Road
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3rd December 1981

Dear Nick

CET TELESOFTWARE PROJECT

Thank you for your letter of 19th November. I am sorry I have not replied earlier.

Although all our current programs are in BASIC, our format was intended to be independent of language. We would like to distribute programs in other languages, including PASCAL, but on looking into the question, there appear to be a few problems which need to be sorted out first.

Firstly, there are a few characters used in PASCAL not covered by our format recommendations. I hope you have now received your copy of the recommendations and we would, of course, be interested in any comments from members of PUG.

Secondly, as you know, our telesoftware system at present is only available for use with the 380Z. Although PASCAL can be obtained for the 380Z, it will only work on 56K full disc machines with 80 character display.

Thirdly, it appears that very few Computer Assisted Learning programs have so far been written in PASCAL.

In view of these problems, it is likely that in the immediate future only a few people would be able to obtain PASCAL by telesoftware and find it useful. I therefore do not think PASCAL can be one of our first priorities, and we would not consider including programs in our library for a few months until our telesoftware service is fully established.

Thank you for your interest.

Yours sincerely

Chris Knowles

Chris Knowles
Telesoftware Project Manager

to Nick Hughes, PUG (UK), C/O Shetlandtel, Walls, Shetland, ZE2 9PF. UK.

RESPONSE PLEASE TO: NICK HUGHES, PUG (UK), C/O SHETLANDTEL, WALLS, SHETLAND. ZE2 9PF. U.K.
OR PUG (UK) ON PRESTEL MAILBOX No. 059571350

Coulter Electronics, Inc.

GENERAL OFFICE • 590 WEST 20th STREET • HIALEAH, FL 33010 • PHONE: 305-885-0131

PASCAL USERS GROUP
C/O RICK SHAW
BOX 88524
ATLANTA, GA. 30338

DEAR RICK,

I have spoken with the sales people at Microsoft in an attempt to purchase a copy of their new release of Pascal to run on CP/M. They told me that they were not selling to end users at this, time only to OEM. They also would not reveal the names of any of their OEM users but that if I could locate one maybe one would sell to me. Would you, Mr.Shaw, be able to refer me to any manufacturers who are using Microsoft Pascal and who hopefully would consider selling to an end user.

The main reason I want Microsoft Pascal is the compatibility of their object file format to Digital Research's for link and locate with RMAC assembled files. If you know any other suppliers whose Pascal is compatible to Digital Research's format please let me know.

I also would like to receive some information on the Pascal Users Group.

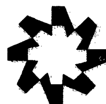
Thank you for your time. Any help will be appreciated.

Sincerely,

Ted Britton

Ted Britton

1



Nova Robotics 262 Prestige Park Road, East Hartford, CT 06108 (203) 528-7133

September 24, 1981

Rick Shaw
Pascal Users Group
PO Box 888524
Atlanta, GA 30338

Dear Rick:

Nova Robotics is a new user of the Oregon Software OMSI Pascal-2, and we are interested in what the Pascal Users Group has to offer. We have the OMSI Pascal on a PDP 11/34 running RSX-11M V3.2. Enclosed is our check for a one-year subscription.

We are also interested in knowing if any member of the Users Group is developing a Pascal compiler or cross-compiler for Intel's 8086/87. We have talked to Oregon Software. They currently have no plans and suggested we contact the Users Group. Any information you could supply would be appreciated.

Sincerely,

NOVA ROBOTICS LIMITED PARTNERSHIP

Linda J. Phillips

Linda J. Phillips
Manager of Software Engineering

LJP/rsh
Enclosures

To the editor:

Members of the Pascal Users Group may obtain a free copy of our new publication, Pascal Market News, by writing to me at the address below. Our publication is commercially slanted towards buyers and makers of Pascal hardware and software. Anyone requesting a free issue should be sure to indicate that he or she is a P. U. G. member.

Ray Jordan
Southwater Corp.
P O Box 5314
Mt. Carmel CT 06518

Rick,

A couple of items:

1. Pascal News continues to be outstanding! You took over a big task from Andy, and have done a super job. Please renew my subscription for three years. (Any possibility of PUG offering a lifetime membership for an appropriate fee?)

2. We are about to begin a large software development project and have choosen Pascal as the implementation language. We are developing a local networking capability for Control Data, IBM, and Honeywell mainframes. Users will be able to transfer data files, submit jobs, and route output files among the dissimilar mainframes. The system also includes a global mailbox facility for sending and receiving messages to/from other users.

We chose Pascal because of transportability, structure, and ease of code maintenance. Except for operating system interfaces and machine-dependent routines, the total system will be written in Pascal. It will be developed and maintained as one system, configurable for any of the mainframes.

I would be interested in hearing from any PUG members who have worked on similar large projects in Pascal.

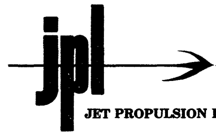
Sincerely,
Mike

Mike Bursher
928 Wright Avenue #903
Mt. View, CA 94043

(day) 408-744-5673

EOI ENCOUNTERED.

Implementation Notes



JET PROPULSION LABORATORY *California Institute of Technology • 4800 Oak Grove Drive, Pasadena, California 91103*

TO: Distribution

FROM: E. N. Miya

SUBJECT: Suite Report for University of Wisconsin Pascal on Univac 1100

Attached you will find the Validation Suite Report for the UW Pascal compiler on the Univac 1100. Sorry we could not get it to you sooner, it spent some time in our documentation section getting approval.

Please keep us informed about the progress of version 3.0 of the Suite.

Distribution:

R. J. Cichelli
B. Dietrich
A. H. J. Sale
R. Shaw ✓

Telephone (213) 354-4321 *Twx 910-588-3269* *Twx 910-588-3294*

PASCAL VALIDIATION SUITE REPORT

Authored by:
I.E. Johnson, E.N. Miya, S.K. Skedzieleweski

Pascal Processor Identification

Computer: Univac 1100/81

Processor: University of Wisconsin Pascal version 3.0 release A

Test Conditions

Testers: I.E. Johnson, E.N. Miya.

Date: April 1980

Validation Suite Version: 2.2

General Introduction to the UW Implementation

The UW Pascal compiler has been developed by Prof. Charles N. Fischer. The first work was done using the P4 compiler from Trondheim, then the NOSC Pascal compiler written by Mike Ball was used, and now all development is done using the UW Pascal compiler.

There are two UW Pascal compilers; one produces relocatable code and has external compilation features, while the other is a "load-and-go" compiler, which is cheaper for small programs. Most tests were run on the "load-and-go" version. Both compilers are 1-pass and do local, but not global optimization. The UW compiler is tenacious and will try to execute a program containing compile-time errors. This causes problems when running the Validation Suite, since programs that are designed to fail at compile time will appear to have executed.

Conformance Tests

Number of Tests Passed: 123

Number of Tests Failed: 16

Details of Failed Tests

Test 6.4.3.5-1 failed on the declaration of an external file of pointers (only internal files of pointers are permitted).

Tests 6.4.3.5-2, 6.4.3.5-3 and 6.9.1-1 failed due to an operating system "feature" which returns extra blanks at the end of a line. This problem affects EOLN detection.

Test 6.5.1-1 failed because the implementation prohibits

The research described in this paper was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under NASA Contract NAS7-100.

files that contain files.

Tests 6.6.3.1-5 and 6.6.3.4-2 failed because the current version of this implementation prohibits passing standard functions and procedures as parameters.

Test 6.6.5.3-1 failed to assign an already locked tag field in a variant record, but the standard disallows such an assignment! (Error in test?)

Test 6.6.5.4-1 failed to pack because of a subscript out of range. MACC notified.

Test 6.6.6.2-3 failed a nine-digit exp comparison. Univac uses 8 digit floating point.

Test 6.6.6.5-2 failed test of ODD function (error with negative numbers).

Test 6.8.2.4-1 failed because non-local GOTO statements are not allowed by this implementation.

Test 6.8.3.4-1 failed to compile the "dangling else" statement, giving an erroneous syntax error.

Tests 6.9.4-1 and 6.9.4-4 failed do unrecoverable I/O error. Problem referred to MACC.

Test 6.9.4-7 failed to write boolean correctly. UW right-justifies each boolean in its field; the proposed ISO standard requires left-justification.

Extensions

Number of Tests Run: 1

Details of Tests

Test 6.8.3.5-14 shows that an OTHERWISE clause has been implemented in the case stetement.

Deviance Tests

Number of Deviations Correctly Handled: 77

Number of Deviations Incorrectly Handled: 14

Number of Tests Showing True Extensions: 2

Details of Extensions

Test 6.1.5-6 shows that a lower case e may be used in real numbers.

Test 6.1.7-11 shows that a null string is accepted by this implementation.

Details of Incorrect Deviations

Tests 6.2.2-4, 6.3-6, 6.4.1-3 show errors in name scope. Global values of constants are used even though a local definition follows; this should cause a compile-time error.

Tests 6.4.5-3, 6.4.5-5 and 6.4.5-13 show that the implementation considers types that resolve to the same type to be "equivalent" and can be passed interchangeably to a procedure.

Test 6.6.2-5 shows a function declaration without an assignment to the function identifier.

Test 6.8.3.9-4 the for-loop control variable can be modified by a procedure called within the loop. No error found by implementation.

Tests 6.8.3.9-9, 6.8.3.9-13 and 6.8.3.9-14 show that a non-local variable can be used as a for-loop control variable.

Test 6.9.4-9 shows that a negative field width parameter in a write statement is accepted. It is mapped to zero.

Test 6.10-1 shows that the implementation substitutes the default file OUTPUT in the program header. No error message.

Test 6.10-4 shows that the implementation substitutes the existence of the program statement. We know that the compiler searched first but found source text (error correction).

Tests 6.1.8-5 and 6.6.3.1-4 appear to execute; this occured after the error corrector made the obvious changes.

Error Handling

Number of Errors Correctly Detected: 29

Number of Error Not Detected: 17

Details of Errors Not Detected

Tests 6.2.1-7, 6.4.3.3-6, 6.4.3.3-7, 6.4.3.3-8 and 6.4.3.3-12 show that the use of an uninitialized variable is not detected. Variant record fields are not invalidated when the tag changes. 6.4.3.3-12 incorrectly printed "PASS" when it should have printed "ERROR NOT DETECTED".

Test 6.6.2-6 shows the implementation does not detect that a function identifier has not been assigned a value within the function. The function should be undefined. The quality of the test could be improved by writing the value of CIRCLERADIUS.

Test 6.6.5.2-2 again runs into the EOLN problem.

Test 6.6.5.2-6 shows that the implementation fails to detect the change in value of a buffer variable when used as a global variable while its dereferenced value is passed as a value parameter. This sould not cause an error, and none was flagged. However, when the char was changed to a var parameter no error was detected, either.

Test 6.6.5.2-7 shows that the implementation fails to detect the change in a file pointer while the file pointer is in use in a with statement. This is noted in the implementation notes.

Test 6.6.5.3-5 shows the implementation failed to detect a dispose error; but again, the parameter was passed by value, not by reference! (Error in test)

Tests 6.6.5.3-7 and 6.6.5.3-9 show that the implementation failed to detect an error in the use of a pointer variable that was allocated with explicit tag values.

Tests 6.6.6.3-2 and 6.6.6.3-3 show that trunc or round of some real values. 2**36 does not cause a run time error or warning. In those cases, the value returned was negative. Error reported to MACC.

Tests 6.7.2.2-6 and 6.7.2.2-7 show that the implementation failed to detect integer overflow.

Tests 6.8.3.9-5 and 6.8.3.9-6 show that the implementation does not invalidate the value of a for-loop control variable after the execution of the for-loop. Value of the variable is equal to the last value in the loop. These tests could be improved by writing the value of m.

Implementation Defined

Number of Tests Run: 15

Number of Tests Incorrectly Handled: 0

Details of Implementation Definitions

Test 6.4.2.2-7 shows maxint equals 34359738367 (2**35-1).

Test 6.4.3.4-2 shows that a set of char is allowed.

Test 6.4.3.4-4 shows that 144 elements are allowed in a set, and that all ordinals must be >= 0 and <= 143.

Test 6.6.6.1-1 shows that neither declared nor standard functions and procedures (nor Assembler routines) be passed as parameters.

Test 6.6.6.2-11 details a number of machine characteristics such as

XMIN = Smallest Positive Floating Pt # = 1.4693679E-39

XMAX = Largest Positive Floating Pt # = 1.7014118E+38

Tests 6.7.2.3-2 and 6.7.2.3-3 show that boolean expressions are fully evaluated.

Tests 6.8.2.2-1 and 6.8.2.2-2 show that expressions are evaluated before variable selection in assignment statements.

Test 6.9.4-5 shows that the output format for the exponent part of real number is 2 digits. Test 6.9.4-11 shows that the implementation defined default values are:

integers : 12 characters
boolean : 12 characters
reals : 12 characters

Test 6.10-2 shows that a rewrite to the standard file output is not permitted.

Tests 6.11-1, 6.11-2, and 6.11-3 show that the alternative comment delimiter symbols have been implemented; all other alternative symbols and notations have not been implemented. In addition, it is interesting that the compiler's error correction correctly substituted "[" for "(." and ":=" for "%=" as well as a number of faulty substitutions.

Quality Measurement

Number of Tests Runs: 23

Number of Tests Incorrectly Handled: 2

Results of Tests

Test 5.2.2-1 shows that the implementation was unable to distinguish very long identifiers (27 characters). Test 6.1.3-3 shows that the implementation uses up to 20 characters in distinguishing identifiers.

Test 6.1.8-4 shows that the implementation can detect the presence of possible unclosed comments (with a warning). Statements enclosed by such comments are not compiled.

Tests 6.2.1-8, 6.2.1-9 , and 6.5.1-2 show that large lists of declarations may be made in a block (Types, labels, and var).

Test 6.4.3.2-4 attempts to declare an array index range of "integer". The declaration seems to be accepted, but when the array is accessed (All[maxint]), an internal error occurs.

Test 6.4.3.3-9 shows that the variant fields of a record occupy the same space, using the declared order.

Test 6.4.3.4-5 (Warshall's algorithm) took 0.1356 seconds CPU time and 730 unpacked (36-bit) words on a Univac 1100/81.

Test 6.6.1-7 shows that procedures may not be nested to a depth greater than 7 due to implementation restriction. An anomolous error message occurred when the fifteenth procedure declaration was encountered; the message "Logical end of program reached before physical end" was issued at that time, but a message at the end of the program said "parse stack overflow".

Tests 6.6.6.2-6, 6.6.6.2-7, 6.6.6.2-8, 6.6.6.2-9, and 6.6.6.2-10 tested the sqrt, atan, exp, sin/cos, and ln functions. All tests ran, however, typical implmentation answers (which use the Univac standard assembler routines) were slightly smaller than Suite computed. Error typically occurred around the 8th digit (Univac floating-point precision limit).

Test 6.7.2.2-4 The inscrutable message "inconsistent division into negative operands" appears. We think it means that I MOD 2 is NOT equal to I - I div 2 * 2. Problem reported to MACC.

Test 6.8.3.5-2 shows that case constants must be in the same range as the case-index.

Test 6.8.3.5-8 shows that a very large case statement is not permissible (>=256 selections). A semantic stack overflow occurred after 109 labels.

Test 6.8.3.5-18 shows the undefined state is the previous state at the end of the for-loop. The range is checked.

Test 6.8.3.9-20 shows for-loops may be nested to a depth of 6.

Test 6.8.3.10-7 shows with-loops may be nested to a depth of 7.

Test 6.9.4-10 shows that the output buffer is flushed at the end of a program.

Test 6.9.4-14 shows that recursive I/O is permitted using the same file.

Concluding Comments

The general breakdown of errors is as follows:

I/O

These problems are intimately tied to the EXEC 1100 operating system and its penchant to pad blanks on the end of a line. There is no plan to try to correct this problem. Does an external file of pointers make sense!

Changes in the standard

Jensen and Wirth (second edition) was used as the standard for development of this compiler. Since there are discrepencies between it and the ISO proposed standard, several deviations occured. The compiler will be brought into conformance on most of these errors when some standard is adopted.

Restrictions

Some restrictions will be kept, even after a standard is adopted. GOTO's out of procedures will probably never be implemented, but STOP and ABORT statements have been added to the language to alleviate the problem.

Bugs

Several previously unknown bugs were found by running the validation suite. Professor Fischer has been notified, and corrections should be included in the next release of the compilers.

One area that should be emphasized is the clarity of the diagnostics produced by the compiler. All diagnostics are self-explanatory, even to the extent of saying "NOT YOUR FAULT" when an internal compiler error is detected. A complete scalar walk-back is produced whenever a fatal error occurs. The compiler attempts error correction and generally does a very good job of getting the program into execution.

The relocatable compiler has extensive external compilation features. A program compiled using these facilities receives the same compile-time diagnostics as if it were compiled in one piece.

IMPLEMENTATION DESCRIPTION.

DEC-10, DEC-20 (LOTS) **PASCAL/PASSGO at LOTS**

---

1. DISTRIBUTOR/IMPLEMENTOR/MAINTAINER:

Distributor/Maintainer:
J. Q. Johnson
LOTS Computer Facility
Stanford University
Stanford, CA 94305 (415)497-3214
Arpanet:
Admin.JQJ@SU-SCORE

Implementor/Maintainer:
Armando R. Rodriguez
Computer Science Department
Stanford University
Stanford, CA 94305

2. MACHINE: Digital Equipment Corp. DEC-10 and DEC-20.

3. SYSTEM CONFIGURATION: DEC TOPS-10, TOPS-20; TENEX and WAITS monitors, using Concise Command Language (CCL). Uses KA-10 instruction set. Modifications for KI-10 improved inst. set, under development.

4. DISTRIBUTION:
   + Nondisclosure agreement required. See accompanying form.
     (*We require this with two purposes:
       a) To know how many copies are around, and who has them.
       b) To prevent the use of our improvements by profit-oriented organizations in products that would later be sold.*)
   + You should provide the transport medium. Methods used until now:
       - Through the Arpanet.
       - You send us a 9 track tape (no less than 1200 feet, please). Specify density and format desired. (default: 1600 bpi, DUMPER/BACKUP INTERCHANGE format).
       - You come by and get it on your tape.
   + Distributed on an "as is" basis. Bug reports are encouraged and we will try to fix them and notify you as soon as possible.
   + The compiler is going through a continual, although slow, improvement process. Users, and PUG, will be notified of major new releases and critical bugs.

5. DOCUMENTATION:
   + A modified version of the machine-retrievable manual from the original Hamburg package, as a complement to Jensen & Wirth.
   + A "help" file for online access to the most relevant topics.
   + A NOTES file with comments and hints from local users.
   + An implementation checklist.
   + A description of interesting parts of the internal policies (Packing mechanism, linkage conventions, the symbol table, a complete list of error messages, and a checklist to add predefined procedures).
   + All the documentation machine-retrievable.

6. MAINTENANCE POLICY:
   + We are our own main user: maintenance benefits us first.
   + No guaranteed reply-time.
   + One to four releases a year, for the next two years, at least.
   + Future Plans:
       - Support full Standard Pascal
       - Optional flagging of use of non-standard features.
       - Sets of any size (probably 144-element sets first)
       - CHAR going from space to '}'.
       - Make the heap a real heap.
       - 20-native version.
       - A more friendly user interface: Improvements in the debugger, more and better utility programs, more measurement tools; better error messages.

7. STANDARD:
   + It supports the standard as defined in Jensen & Wirth, except:
     - Records, Arrays and Files of Files are not supported.
     - Read and Write to non-text Files are not supported.
     - Set expressions that contain a range delimited by variables or expressions are not supported.
     - The heap works as a stack. Procedure DISPOSE 'pops' the given item and everything else that was created afterwards.
   + Set size is 72 elements, set origin is zero.
   + Type CHAR includes only from space to underbar. No lower case.
   + EXTENSIONS: Type ASCII; functions FIRST, LAST, UPPERBOUND, LOWERBOUND for scalars and arrays, respectively; MIN and MAX; separately compiled procedures; a string manipulation package; LOOP-EXIT construct; OTHERWISE in CASE statements; initialization procedures; DATE, TIME, REALTIME.

8. MEASUREMENTS:
   12000+ lines of PASCAL code, 590,000+ chars including comments.
   COMPILATION SPEED: around 13,000 chars/sec of CPU time on a 2050.
   EXECUTION SPEED: as good as that of the non-optimized FORTRAN compiler.
   COMPILATION SPACE: the compiler takes 50k of upper segment, and can work with 16k lower segment.
   You receive two compilers (hence the name). They support exactly the same language and features, but one of them (PASSGO) produces the code incore, which saves 25% CPU time and a lot of I/O in the compile-load-and-go sequence. This is ideal for development, and particularly helpful in a student environment.

9. RELIABLILITY: Very good. It is very heavily used at LOTS (the program that runs the most, after the editor). Implemented at 30+ sites.

10. DEVELOPMENT METHOD: We started with the Hamburg-76 compiler, distributed by DECUS, which is a very good compiler itself. We have been cleaning bugs, adding missing parts of the standard, and adding features in the last 18 months.

11. LIBRARY SUPPORT AND OTHER FEATURES:
   + Only the essential runtime routines are written in MACRO: most of the library is written in PASCAL.
   + Access to the FORTRAN library support.
   + Access to external FORTRAN and MACRO routines.
   + Separate compilation.
   + Symbolic Post-mortem dump.
   + Interactive runtime source-level debugging package.
   + PCREF, a cross-referencer derived from Hamburg's CROSS.
   + PFORM, a prettyprinter.
   + Statement counts.

Rational Data Systems

Pascal Users Group
c/o Rick Shaw
Digital Equipment Corporation
5775 Peachtreee Dunwoody Road
Atlanta, Georgia 30342

Dear Rick,

Enclosed is a copy of the report of the Validation Suite (2.2) for our Pascal implementations on Data General machines.

Please let me know if you need any further information for publication of this report in Pascal News.

Sincerely,

Douglas R. Kaye
President

DRK/nec

enclosure

245 West 55 Street New York City 10019   212-757-0011   TWX 710-581-6016

Rational Data Systems

PASCAL VALIDATION SUITE REPORT

Processor Identification

Computer: Data General Eclipse
AOS operating system

Processor: Rational Data Systems Pascal
AOS version, release 2.10

(Implementations for Nova and microNova under RDOS, DOS and MP/OS operating systems are functionally equivalent but were not tested.)

Test Conditions

Tester: Rational Data Systems

Validation Suite Version: 2.2

General Notes

Several tests contained statements of the form "read (f, a[i])", where "f" is a textfile and "a" is a "packed array [1..<n>] of char". In RDS Pascal, the rule that

> components of variables of any type designated packed shall not be used as actual variable parameters ([illegible].3)

is applied to "read" and "readln" as well as to user-written procedures and functions. Statements rejected by the compiler were changed to the form "read (f, xx); a[i] := xx", where "xx" is of type "char".

Some tests were not valid because they used 'structural' type compatibility. These were revised accordingly for 'name' type compatibility before running.

CONFORMANCE

Tests passed	**120**	
Tests failed	**12**	(7 causes)

Details of failed tests:

6.1.2-3: The significance limit is eight characters for both identifiers and reserved words.
6.2.2-3: Type declaration "p = ^node" is incorrectly handled when types named "node" are present both later in same scope and earlier in outer scope.
6.4.3.3-1, 6.4.3.3-3, 6.8.2.1-1: Empty records and empty field lists within record variants are rejected.
6.4.3.3-4: Tagfield "case which: boolean" is rejected when "which" is a known type identifier.
6.5.1-1: A file may not be an element of a record or of an array.
6.6.3.1-5, 6.6.3.4-1, 6.6.3.4-2, 6.6.3.5-1: Procedural and functional parameters are not supported.
6.6.5.3-2: Standard procedure "dispose" is not supported. (Implementation planned for release 2.20).

Details of erroneous tests:

6.1.8-3: Latest draft standard defines "(*" as exactly equivalent to "{", "*)" exactly equivalent to "}".
6.6.5.2-3: Some operating systems distinguish "empty" files (length = 0) from "nonexistent" files (name not known), while others do not.
6.9.4-4: Draft standard requires "write (f, 0.0:6)" to produce floating-point form ("0.0e+00" or similar); suite is testing for fixed-point form ("0.0").
6.9.4-7: Latest draft standard explicitly permits "True" and "False" as well as "TRUE" and "FALSE" when Booleans are written to textfiles.

DEVIANCE

Tests in which deviations were correctly detected	64	
Tests showing true extensions	3	
Tests in which erroneous deviations were not detected	26	(13 causes)

Details of tests showing true extensions:

6.1.7-11, 6.4.3.2-5, 6.4.5-11: Type compatibility rules for constant strings weakened to accommodate string-handling extensions.

Details of failed tests:

6.1.2-1: Redeclaration of "nil" permitted.
6.2.1-5: No error message when label is declared but not utilized.
6.2.2-4, 6.3-6, 6.4.1-3: If an identifier is declared in two nested scopes, and there is an erroneous usage of the identifier in the inner scope preceding the definition in the inner scope, the compiler does not detect the error. (Compare conformance test 6.2.2-3.)
6.2.2-7: Nested functions with same name cause erroneous compiletime error message.
6.4.3.3-11: Empty record rejected at compile time.
6.4.5-2: Subranges of same base type treated as identical in parameter/argument case.
6.6.2-5: Function may lack assignment statement.
6.6.3.5-2, 6.6.3.6-2, 6.6.3.6-3, 6.6.3.6-4, 6.6.3.6-5: Procedural and functional parameters not supported.
6.6.6.3-4: Integer arguments to "trunc" and "round" accepted.
6.8.2.4-2, 6.8.2.4-3, 6.8.2.4-4: Tolerates illegal jumps (to nonactivated statement, within structured statement).
6.8.3.9-2, 6.8.3.9-3, 6.8.3.9-4, 6.8.3.9-16: Assignment to control variable of "for" statement allowed.
6.8.3.9-9, 6.8.3.9-14, 6.8.3.9-19: Nonlocal control variable in "for" statement allowed.
6.9.4-9: Nonpositive field width in "write" to textfile allowed.

Details of erroneous tests:

6.1.5-6: Latest draft standard permits both "E" and "e" in real constants.

ERROR HANDLING

Tests in which errors were correctly detected	19	
Tests showing true extensions	1	
Tests in which errors were not detected	26	(10 causes)

Details of test showing true extension:

6.6.5.2-1: After a file has been opened with "reset", both "get" and "put" operations are allowed. (In fact, both operations are permitted at all times, regardless of how the file was opened.) This extension is provided to permit convenient random processing. RDS Pascal provides the ability to reposition files with the predeclared procedure "seek (<filename>, <integer expression>)". (Not permitted for files of type "text".)

Details of failed tests:

6.2.1-7, 6.4.3.3-6, 6.4.3.3-8, 6.5.4-1, 6.5.4-2, 6.8.3.9-5, 6.8.3.9-6:
No check is done at runtime for variables with "undefined" (uninitialized, etc.) values.
6.4.3.3-5, 6.4.3.3-7: Storage redefinition is permitted.
6.4.3.3-12: Empty record rejected at compile time.
6.4.6-7, 6.4.6-8, 6.7.2.4-1: No runtime check for illegal set assignments.
6.6.2-6: No runtime check for function that fails to execute assignment statement.
6.6.5.2-6, 6.6.5.2-7: File may be repositioned while buffer is "var" parameter or is record variable of "with" statement.
6.6.5.3-3, 6.6.5.3-4, 6.6.5.3-5, 6.6.5.3-6: Standard procedure "dispose" not supported.
6.6.5.3-7, 6.6.5.3-8, 6.6.5.3-9: Misuse of variable created by variant form of "new" is tolerated.
6.8.3.5-5, 6.8.3.5-6: No runtime error when case-index expression matches none of the case-constants.
6.8.3.9-17: Nested "for" statements may have the same control variable.

IMPLEMENTATION DEFINED

Number of tests run 15

Details of erroneous tests:

6.11-1: Alternate comment delimiters no longer belong to category "implementation-defined"; explicitly required by latest draft standard.
6.11-2: Equivalent symbol for uparrow no longer belongs to category "implementation-defined"; explicitly required by latest draft standard. Equivalent symbols for colon, semicolon, assignment symbol, and square brackets no longer defined; deleted from latest draft standard.
6.11-3: Equivalent symbols for comparison symbols not listed in draft standard.

Details of other tests:

6.4.2.2-7: The value of "maxint" is 32767. (But the value -32768 can be created by writing "-maxint-1" and is not rejected as erroneous.)
6.4.3.4-2: Declaration "set of char" is permitted.
6.4.3.4-4: Implementation permits sets to contain as many as 4080 elements. No set may contain negative elements; e.g. "set of 0..4079" is acceptable, "set of -1..4078" is not. This test brought to light a compiler error; the unacceptable declaration "set of -1..+1" was accepted by the compiler. However, an attempt to insert a negative element into a set (any set) will cause a runtime error. (Fixed in release 2.11).
6.6.6.1-1: Procedural and functional parameters not supported.

6.6.6.2-11: Reals are implemented using Data General's standard single-precision floatingpoint format:

sign: one bit
exponent: 7 bits, excess-64 notation
fraction: 24 bits (6 hexadecimal digits)

All results are normalized (i.e. leftmost hexadecimal digit of fraction is always > 0). However, the range of values that can be read from or written onto textfiles is smaller than the range of values that can be represented internally: conversion to/from ASCII is supported only for values in the range 1.0e-75..1.0e+75. Because this test relies on non-detection of underflow at runtime, it could not be executed without extensive modification. Ultimate results were:

beta	16
t	6
rnd	0
ngrd	1
machep	-5
negep	-6
iexp	7
minexp	-64
maxexp	63
eps	9.53674e-7
epsneg	5.96046e-8
xmin	5.39760e-79
xmax	7.23700e+75

6.7.2.3-2: Boolean expression "a and b" is fully evaluated.
6.7.2.3-3: Boolean expression "a or b" is fully evaluated.
6.8.2.2-1: Selection then evaluation for "a[i] := expr".
6.8.2.2-2: Selection then evaluation for "p^ := expr".
6.9.4-5: Two digits written in an exponent.
6.9.4-11: Default field widths for "write" to textfiles:

integers	variable
Booleans	variable
reals	8 characters

QUALITY
=======

Number of tests run 23

Details of erroneous tests:

6.7.2.2-4: Test of "mod" operator not in conformance with latest draft standard. Caused runtime error message "Non-positive Divisor in MOD Operation".
6.9.4-14: Recursive IO using same file allowed. This test contains a superfluous program parameter which caused the error message "program parameter not declared as file in outermost block". After correction of the error, it ran successfully.

Details of other tests:

5.2.2-1, 6.1.3-3: Significance limit for identifiers is eight characters.
6.1.8-4: No warning message generated when comment extends across several source lines.
6.2.1-8: Accepted 50 type declarations.
6.2.1-9: Accepted declaration and siting of 50 labels.
6.4.3.2-4: Declaration "array [integer] of integer" produced error message "array index may not be of type INTEGER".
6.4.3.3-9: Reverse correlation of fields in record.
6.4.3.4-5: This test was revised to use the RDS "time" extension, which is accurate only to the second. Procedure "Warshallsalgorithm" required 184 bytes of object code, and approximately 5 seconds of elapsed execution time (on a multi-user system).
6.5.1-2: Long declarations allowed.
6.6.1-7: Procedure/function nesting limit is eight.
6.6.6.2-6 (sqrt), 6.6.6.2-7 (arctan), 6.6.6.2-8 (exp), 6.6.6.2-9 (sin & cos), 6.6.6.2-10 (ln): RDS personnel not trained in numerical analysis, unable to interpret results of these tests.
6.8.3.5-2: No warning message when a "case" statement contains an unreachable path.
6.8.3.5-8: Accepted large "case" statement.
6.8.3.9-18: After normal termination (i.e. no "goto") of a "for" loop, the control variable has the value of the limit expression. (After execution of "for i := red to pink do ;", the value of "i" is "pink".)
6.8.3.9-20: Accepted "for" statements nested 15 deep.
6.8.3.10-7: Nesting limit of "with" statements is 12.
6.9.4-10: Textfile output is flushed at end of job when linemarker is omitted. (Note that no linemarker is inserted, however.)

EXTENSIONS
==========

Number of tests run 1

Details:

6.8.3.5-14: The "otherwise" clause in a "case" statement is not supported. (Refer to errorhandling tests 6.8.3.5-5 and 6.8.3.5-6.)

To: Pascal News, c/o Rick Shaw

From: David Intersimone - De Marco-Shatz Corp.

Re: Validation of AlphaPASCAL compiler

Here is a copy of a validation of the AlphaPASCAL compiler. I have given a few comments on the compiler and the validation suite in the validation report.

I have sent a copy of the report to Prof. Sale.

David Intersimone
David Intersimone 3/23/83
De Marco-Shatz Corp.
312 Maple Ave.
Torrance, Ca. 90503
(213) 533-5080

ALPHA MICROSYSTEMS AM-100/T

Pascal Validation Suite Report

Pascal Processor Identification

Computer: Alpha Microsystems AM-100/T

Processor: AlphaPASCAL V2.0

Installation: De Marco Shatz Corporation, Torrance, Ca., USA.

Test Conditions

Tested By: David Intersimone

Date: February / March 1981

Validation Suite Version: 2.2

Report Sent To:

Alpha Microsystems, Software Department, Irvine, Ca., USA.

Pascal News, c/o Rick Shaw, Atlanta, Ga., USA.

Prof. Arthur Sale, Department of Information Science,
University of Tasmania, Hobart, Tasmania, Australia.

Note:

'AlphaPASCAL' and 'AM-100/T' are trademarks of
Alpha Microsystems, Irvine, Ca., USA.

Conformance Tests:

Total Number of Conformance Tests: 139
Number of Tests Passed: 105
Number of Tests Failed: 34 (19 reasons)

Details of Failed Conformance Tests:

Tests 6.1.2-3, 6.3-1 8-character significance for identifiers.

Tests 6.1.6-1, 6.1.6-2, 6.2.1-1, 6.2.1-2, 6.2.2-5, 6.8.2.4-1, 6.8.3.7-3, 6.8.3.9-8 GOTO statements are not permitted without the ($G+) compiler option.

Test 6.2.2-3 The global type for the variable 'node' was used causing a mismatched type in the assignment of ptr^:=true;

Tests 6.4.3.3-1, 6.4.3.3-3 Empty records are not allowed.

Test 6.4.3.5-1 Only type or constant identifiers are allowed for file types.

Tests 6.4.3.5-2, 6.9.1-1 EOLN and EOF are not correctly implemented.

Test 6.5.1-1 The type of record fields and arrays cannot be a FILE type.

Tests 6.6.3.1-5, 6.6.3.4-1, 6.6.3.4-2 6.6.3.5-1 procedures and functions passed as parameters are not allowed.

Test 6.6.5.2-3 failed at runtime with 'invalid filename in RESET'.

Test 6.6.5.2-5 A REWRITE of the file sets EOF false.

Test 6.6.5.3-2 DISPOSE is not implemented. AlphaPASCAL uses MARK and RELEASE to recover memory allocated by NEW.

Test 6.6.5.4-1 PACK and UNPACK are not implememted. AlphaPASCAL automatically unpacks packed data structures.

Test 6.7.1-1 Operator precedence was changed for compatability with other Alpha Micro language processors.

Test 6.8.3.5-4 Crashed the compiler.

Test 6.8.3.9-1 Both expressions in a 'FOR' statement are not evaluated before assignment is done.

Test 6.8.3.9-7 ended up in an infinite loop showing that the test at the last increment caused wraparound(overflow) of the FOR variable.

Test 6.9.3-1 The READLN function is not correctly implemented.

Tests 6.9.4-3, 6.9.4-4, 6.9.5-1 It is illegal to READ into a packed character field.

Test 6.9.4-7 WRITE and WRITELN do not accept a Boolean variable as an argument. Also, as with tests 6.9.4-3 et al, it is illegal to read into a packed character field.

Deviance Tests:

Total Number of Deviance Tests: 94
Number of Deviations Correctly Detected: 55
Number of Tests Not Detecting Erroneous Deviations: 25 (16 reasons)
Number of Tests Showing True Extensions: 2 (2 reasons)
Number of Tests Incorrectly Handled: 12 (6 reasons)

Details of Tests Not Detecting Erroneous Deviations:

Test 6.1.2-1 nil can be used with types other than pointers.

Test 6.1.7-6 Strings can have bounds other that (1..n).

Test 6.1.7-9 Cases 1-4 were accepted. Cases 5-7 rejected.

Tests 6.2.2-4, 6.3-6, 6.4.1-3 Some scope errors are not detected.

Test 6.3-5 Signed constants are allowed in places other than constant declarations.

Test 6.4.3.2-5 Strings can a subrange of other than integers as an index type.

Test 6.4.5-2, 6.4.5-3, 6.4.5-4, 6.4.5-13 Type compatibility is used for variables.

Test 6.4.5-11 Operations on strings with different numbers of components are allowed.

Test 6.6.2-5 Function declarations with no assignment for the function identifier are allowed.

Test 6.6.6.3-4 TRUNC and ROUND will accept integer parameters.

Test 6.7.2.2-9 The unary operator plus(+) can be applied to non-numeric operands.

Tests 6.8.3.9-2, 6.8.3.9-3, 6.8.3.9-4 Assignment can be made to the FOR control variable.

Tests 6.8.3.9-9, 6.8.3.9-14, 6.8.3.9-19 Non-local variables can be used as FOR control variables.

Test 6.8.3.9-16 causes endless loop. FOR control variables can be READ.

Test 6.9.4-9 Field width parameters can be zero and negative. Field widths zero and -1 printed the same as field width 1.

Test 6.10-3 Shows that the standard file OUTPUT can be redefined. Compiled and caused a runtime error.

Details of Tests Showing True Extensions:

Test 6.1.7-11 null strings are allowed.

Test 6.10-1 Default file declarations in the program heading are ignored.

Details of Tests Incorrectly Handled:

Test 6.2.1-4 caused a bad poiner reference error in the compiler.

Test 6.4.3.3-11 Empty records are not allowed.

Test 6.4.5-5 Eight(8) character identifier significance.

Test 6.6.1-6 The procedure call one(c) did not have a semicolon (;) at the end of statement. An error message for the undefined forward procedure was not printed.

Tests 6.6.3.5-2, 6.6.3.6-2, 6.6.3.6-3, 6.6.3.6-4, 6.6.3.6-5 Procedures and functions passed as parameters are not allowed.

Tests 6.8.2.4-2, 6.8.2.4-3, 6.8.2.4-4 GOTO statements are not permitted without the ($G+) compiler option.

Error Handling Tests:

Total Number of Error Handling Tests: 46
Number of Errors Correctly Detected: 14
Number of Errors not Detected: 27 (16 reasons)
Number of Tests Incorrectly Handled: 5 (2 reasons)

Details of Errors not Detected:

Test 6.2.1-7 Local variables have values even though they were never assigned.

Tests 6.4.3.3-5, 6.4.3.3-6, 6.4.3.3-7, 6.4.3.3-8 No checking is done on the tag field of variant records.

Tests 6.4.6-7, 6.4.6-8 Bounds checking is not done on set types.

Test 6.6.2-6 Execution of a function without assignment of a value to the function variable is allowed.

Test 6.6.5.2-2 GET when the file is at eof does not cause a runtime error.

Tests 6.6.5.2-6, 6.6.5.2-7 did not cause a runtime error when the file position was changed while the file variable was in use.

Tests 6.6.5.3-7, 6.6.5.3-8, 6.6.5.3-9 No checks are made on pointers when they are assigned using the variant form of NEW.

Test 6.6.6.4-4 SUCC on the last value of an ordinal type does not cause a runtime error.

Test 6.6.6.4-5 PRED on the first value of an ordinal type does not cause a runtime error.

Test 6.6.6.4-7 CHR on a value past the limits of CHAR type does not cause a runtime error.

Test 6.7.2.2-6, 6.7.2.2-7 An error does not occur when the result of a binary integer operation is not -maxint <= 0 <= +maxint.

Test 6.7.2.4-1 Overlapping sets do not cause runtime errors.

Tests 6.8.3.5-5, 6.8.3.5-6 A runtime error does not occur when a CASE statement doesn't contain a constant for the value of the case expression.

Tests 6.8.3.9-5, 6.8.3.9-6 A FOR control variable can be used without an intervening assignment.

Test 6.8.3.9-17 Two nested FOR statements can use the same control variable.

Tests 6.9.2-4, 6.9.2-5 No error occurs when reading characters that don't form a valid integer or real.

Details of Tests Incorrectly Handled:

Test 6.4.3.3-12 Empty records are not allowed.

Tests 6.6.5.3-3, 6.6.5.3-4, 6.6.5.3-5, 6.6.5.3-6 DISPOSE is not implemented.

Implementation Defined Tests:

Total Number of Implementation Defined Tests: 15
Number of Tests Incorrectly Handled: 4 (4 reasons)

Details of Implementation Defined Tests:

Test 6.4.2.2-7 MAXINT is defined as 32767.

Test 6.4.3.4-2 Sets of characters are allowed.

Test 6.4.3.4-4 Set bounds are 0..4095

Tests 6.7.2.3-2, 6.7.2.3-3 Boolean expressions are fully evaluated.

Tests 6.8.2.2-1, 6.8.2.2-2 Variables are selected then evaluated.

Test 6.10-2 A REWRITE on the standard output file is allowed.

Test 6.11-1 Alternate comment delimiters are implemented.

Tests 6.11-2, 6.11-3 Equivalent symbols are not implemented.

Details of Tests Incorrectly Handled:

Test 6.6.6.1-1 Functions are not allowed to be passed as parameters.

Test 6.6.6.2-11 resulted in a floating point runtime error.

Test 6.9.4-5 executed in an endless loop. Output file from the WRITELN statement contained 1ABC.

Test 6.9.4-11 WRITELN does not allow Boolean variables.

Quality Tests:

Total Number of Quality Tests: 23
Number of Tests Incorrectly Handled: 7 (3 reasons)

Details of Quality Tests:

Tests 5.2.2-1, 6.1.3-3 Eight(8) character identifier significance.

Test 6.1.8-4 Unclosed comments are not detected.

Test 6.2.1-8 Fifty(50) Types were accepted.

Test 6.2.1-9 Fifty(50) LABELS were accepted.

Test 6.4.3.2-4 Gave the compile-time message: 'Array is too large'.

Test 6.4.3.3-9 Exact correlation between variant record fields.

Test 6.5.1-2 Long declaration lists are allowed.

Test 6.6.1-7 Seven(7) procedure/function declarations could be nested. Note: the compiler manual states that the max nesting level is 12.

Test 6.7.2.2-4 DIV by negative operands is implemented and consistent. DIV into negative operands is inconsistent. Quotient=TRUNC(A/B) for negative operands. MOD(A,B) lies in (0,B-1).

Test 6.8.3.5-2 Impossible CASE paths are not detected.

Test 6.8.3.9-18 Range checking is done on a CASE statement after a FOR loop.

Test 6.8.3.9-20 FOR statements can be nested to > fifteen(15) Levels.

Test 6.8.3.10-7 Eleven(11) WITH statements can be nested. The compiler manual states that the maximum nexting of procedures, with-do, and record type descriptions is twelve(12).

Test 6.9.4-10 Output is flushed at end-of-job.

Test 6.9.4-14 Recursive I/O is allowed.

Details of Tests Incorrectly Handled:

Test 6.4.3.4-5 'processtime' is not implemented.

Tests 6.6.6.2-6, 6.6.6.2-7, 6.6.6.2-8, 6.6.6.2-9, 6.6.6.2-10
Failed to compile because integer constants must be in the range +-32767, 'e' is not accepted as a substitute for 'E' in real constants, the program blocks where too large for the compiler to handle, and the compiler thought it had hit the end of the program when it hadn't.
Note: the compiler manual states that the object code for any procedure or function cannot be larger than 2000 bytes.

Test 6.8.3.5-8 failed to compile after 121 case statement parts because the program block was too large.

Extension Tests:

Total # of Extension Tests: 1

Details of Extension Tests:

Test 6.8.3.5-14 The extension 'OTHERWISE' is not implemented. 'ELSE' is accepted to handle the same function.

Notes about the AlphaPASCAL compiler:

Previous versions of AlphaPASCAL used the UCSD Pascal programming system. The new AlphaPASCAL system consists of a compiler, linker, external library and a run-time package. Text editors are used to create source programs. The compiler generates intermediate files for use by the linker. The linker takes the intermediate files and an external library to create a runnable P-code file.

External procedures and functions can be separately compiled and placed in an external library for future linking with programs. Machine language subroutines can also be written and linked into programs.

AlphaPASCAL run-time uses a virtual memory paging system so there is no size limit on P-code files. The run-time package provides for operator interrupts of program execution allowing program termination, program resumption and a backtrace of all procedures and functions currently active.

Comments on the Validation Suite:

1) Some tests are too large (oriented towards mainframes?). SQRT, ARCTAN, LN, etc. tests (6.6.6.2-6,7,8,9,10) should be broken up. These cause problems with a compiler on smaller machines. Correctness of function should use tests acceptable to large and small computers.

2) How about a new validation section called "performance"? Would showing the performance of compilation and execution (could be part of the QUALITY tests). Could check to see what(if any) optimization is done.

3) What good is the EXTENSION test and extension tests as part of DEVIANCE? Most deviations are extensions. Isn't the object of the suite to test language standards? All production compilers are going to have extensions. Some extensions will be "standard" in the industry while others will be strictly custom.

IMPLEMENTATION NOTES ONE PURPOSE COUPON

0. **DATE**

1. **IMPLEMENTOR/MAINTAINER/DISTRIBUTOR** *(* Give a person, address and phone number. *)*

2. **MACHINE/SYSTEM CONFIGURATION** *(* Any known limits on the configuration or support software required, e.g. operating system. *)*

3. **DISTRIBUTION** *(* Who to ask, how it comes, in what options, and at what price. *)*

4. **DOCUMENTATION** *(* What is available and where. *)*

5. **MAINTENANCE** *(* Is it unmaintained, fully maintained, etc? *)*

6. **STANDARD** *(* How does it measure up to standard Pascal? Is it a subset? Extended? How. *)*

7. **MEASUREMENTS** *(* Of its speed or space. *)*

8. **RELIABILITY** *(* Any information about field use or sites installed. *)*

9. **DEVELOPMENT METHOD** *(* How was it developed and what was it written in? *)*

10. **LIBRARY SUPPORT** *(* Any other support for compiler in the form of linkages to other languages, source libraries, etc. *)*

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PLACE
POSTAGE
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(FOLD HERE)

NOTE: Pascal News publishes all the checklists it gets. Implementors should send us their checklists for their products so the thousands of committed Pascalers can judge them for their merit. Otherwise we must rely on rumors.

Please feel free to use additional sheets of paper.

IMPLEMENTATION NOTES ONE PURPOSE COUPON