A Program Translator

Marvin J. Goldstein
Donald A. Aker
Computer and Information Services Department

Naval Underwater Systems Center
Newport, Rhode Island/New London, Connecticut
In this memorandum, we discuss a computer program that promotes FORTRAN program compilability between computers that have different FORTRAN compilers. The computer program translates VAX FORTRAN structured GO TO-less control elements that are not American National Standard FORTRAN 77 into structured simulated analogs that are compilable by any FORTRAN compiler. This program is intended to complement a recently developed program that promotes program readability.
NAVAL UNDERWATER SYSTEMS CENTER
NEW LONDON LABORATORY
NEW LONDON, CONNECTICUT  06320

Technical Memorandum

A PROGRAM TRANSLATOR

Date: 21 November 1983
Prepared by: Marvin J. Goldstein
Computer and Information Services Department

Donald A. Aker
Computer and Information Services Department

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ABSTRACT

In this memorandum, we discuss a computer program that promotes FORTRAN program compilability between computers that have different FORTRAN compilers. The computer program translates VAX FORTRAN structured GO TO-less control elements that are not American National Standard FORTRAN 77 into structured simulated analogs that are compilable by any FORTRAN compiler. This program is intended to complement a recently developed program that promotes program readability.

ADMINISTRATIVE INFORMATION

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INTRODUCTION

In an earlier memorandum [1], one of the authors discussed a computer program that aids in structuring code entirely in FORTRAN. The computer program is a labor saving tool whose use eliminates effectively the manual effort of formatting code according to programming style conventions [1, 2, 3] that promote FORTRAN program readability. In particular, the computer program eliminates the laborious effort of manually indenting GO TO-less syntactical control elements of structured coding, as well as their simulated transportable analogs, that appear in Figure 1. But the GO TO-less forms, unlike their simulated analogs, are not compilable in general by FORTRAN compilers that are implementations of American National Standard FORTRAN 77 [4], with the exception of the IF THEN ELSE which is part of the standard. For example, although the GO TO-less forms in Figure 1 are compilable by DEC's VAX FORTRAN compiler, they are not compilable by UNIVAC's ASCII FORTRAN compiler. Therefore, if one wishes to promote compilability of FORTRAN programs by different FORTRAN compilers, one should not use the GO TO-less forms.

However, since the GO TO-less forms are easier to code than their simulated analogs, they have been used extensively when supported by a vendor's FORTRAN compiler in spite of the transportability problem that their use presents. Therefore, in order to reduce the reprogramming effort required for FORTRAN programs that contain these forms and will eventually migrate to UNIVAC 1100 series computers, we have written a computer program in PASCAL that will translate the GO TO-less forms in Figure 1 into their simulated transportable forms.

CONTROL STRUCTURES TRANSLATED BY THE TRANSLATOR

If P is a Boolean expression, then the following control structures on the left are translated by the translator into their simulated transportable analogs on the right. New statement labels that are inserted in the simulated forms by the translator are greater than 20000; for example, the translator will generate values greater than 20000 for the statement labels n1 and n2 of the simulated analog of the Block DO WHILE, and for the statement label n1 of the simulated analog of the Block DO n2 WHILE. Note that a new statement label is inserted to implement a simulated form, only if one is not present in the GO TO-less form that can be used.
GO TO-less FORMS

Block DO WHILE

DO WHILE(P)
.
.
.
.
END DO

GO TO n2

CONTINUE

Block DO n2 WHILE

DO n2 WHILE(P)
.
.
.
.
...
.
.
.
.
END DO

GO TO n1

CONTINUE

DO J=1,N
.
.
.
.
.
.
.
.
.
END DO

n1 CONTINUE
AN EXAMPLE

Since the computerized translation of GO TO-less forms in a program may upset the order of the program's statement labels, or generate simulated forms that are not indented exactly as they are in Figure 1, resequencing of statement labels, or reindentation of control structures, if desired, can be done easily with the aid of the structured programming tool "CLEAN" described in [1].

For example, consider translating the GO TO-less structures in the program segment in Figure 2. The translator will transform this program segment into the one given in Figure 3, where the statement labels are out of sort and the simulated DO WHILE is not indented exactly as it is in Figure 1. Program CLEAN can be used now to transform the program segment in Figure 3 into the one in Figure 4, where the statement labels are now in order, and the DO WHILE is indented as it is in Figure 1. These transformations can be accomplished on both the VAX 11/780 and UNIVAC 1100/62.

The following sequence of VAX JCL commands will translate Figure 2 into Figure 3, when the translator TRANS in directory [MJG.CLEAN] on nodes 2, 3 and 7 is executed with Figure 2 assigned to the translator's input text file INFILE and Figure 3 to the translator's output text file OUTFILE:

\$ ASSIGN FIG2.FOR INFILE
\$ ASSIGN FIG3.FOR OUTFILE
\$ RUN [MJG.CLEAN]TRANS

Execution of program CLEAN in directory [MJG.CLEAN] with Figure 3 now assigned to CLEAN's input text file INFILE, and Figure 4 to CLEAN's output text file OUTFILE, resequences statement labels and reindents control structures, using a label increment of 50 and an indentation factor of 3:

\$ ASSIGN FIG3.FOR INFILE
\$ ASSIGN FIG4.FOR OUTFILE
\$ RUN [MJG.CLEAN]CLEAN
\$ Options:  C
\$ Label increment:  50
\$ Indentation factor:  3

The corresponding UNIVAC JCL commands to accomplish these transformations are given below.

Translation of Figure 2 into Figure 3:
@ASG,A USER*FILE.
@ASG,T INFILE.
@ASG,T OUTFILE.
@COPY,I USER*FILE.FIG2, INFILE.
@XQT,Y TRANS*PASCAL.TRANS
@COPY,I OUTFILE., USER*FILE.FIG3

Transformation of Figure 3 into Figure 4:
@COPY,I USER*FILE.FIG3, INFILE.
@XQT,Y CLEAN*PASCAL.UTIL
(User inputs to CLEAN)
@COPY,I OUTFILE., USER*FILE.FIG4

When copying FIG2 (or FIG3) into data file INFILE, the cycle number of FIG2 (or FIG3) must be zero.
**FIGURE 2**

C This program tests the accuracy of double precision pseudoinverse routines. It prints the minimum (mindgt), maximum (maxdgt) and expected number of significant digits (exsdgt) in the elements of the computed pseudoinverse of each matrix A. (The standard

```
50
1050 A1=N
9000 A1=ONE/A1
1500 PRINT 1050-A1
1800 DO J=1,4
2200 CONTINUE
2400 CONTINUE
END
```

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C***********************************************************************
C* AUTHOR: M. J. GOLDSTEIN
C* THIS PROGRAM TESTS THE ACCURACY OF DOUBLE PRECISION PSEUDOINVER-
C* SION ROUTINES. IT PRINTS THE MINIMUM (MINDGT),MAXIMUM (MADXGT) AND
C* EXPECTED NUMBER OF SIGNIFICANT DIGITS (EXSDGT) IN THE ELEMENTS
C* OF THE COMPUTED PSEUDOINVERSE OF EACH MATRIX A. (THE STANDARD
C***********************************************************************

DIMENSION A(6,4),AINVT(6,4),G(4,6)
DO WHILE (N.LE.LM)
IF (.NOT.(N.LE.LM))GO TO 50020
GENERATE THE N-TH MATRIX A AND ITS PSEUDO-
INVERSE TRANSPOSE AINV
A1=TW0**(2*N)
A1 INV=ONE/A1
PRINT 1,050,A1,N
DO 50000 I =1,6
GO TO(50,250,450,450,250,650).
1:IF((J.EQ.1).OR.(J.EQ.4))GO TO 100
GO TO 150
THEN
A(I,J)=A1+A4
AINVT(I,J)=(A1INV+A4INV)/EIGHT
GO TO 200
ELSE
A(I,J)=A1-A4
AINVT(I,J)=(A1INV-A4INV)/EIGHT
CONTINUE
GO TO 850
2.5:
IF((J.EQ.1).OR.(J.EQ.3))GO TO 300
GO TO 350
THEN
A(I,J)=A2
AINVT(I,J)=A2INV/EIGHT
GO TO 400
ELSE
A(I,J)=-A2
AINVT(I,J)=-A2INV/EIGHT
CONTINUE
GO TO 850
3,4:
IF((J.EQ.1).OR.(J.EQ.2))GO TO 500
GO TO 550
THEN
A(I,J)=A3
AINVT(I,J)=A3INV/EIGHT
GO TO 600
ELSE
A(I,J)=-A3
AINVT(I,J)=-A3INV/EIGHT
CONTINUE
GO TO 850
GO TO 950
C CONTINUE
GO TO 49900
END
AUTHOR: M. J. GOLDSTEIN

FIGURE 4

C THIS PROGRAM TESTS THE ACCURACY OF DOUBLE PRECISION PSEUDOINVERSE ROUTINES. IT PRINTS THE MINIMUM (MINTG) AND MAXIMUM (MAXDTG) AND EXPECTED NUMBER OF SIGNIFICANT DIGITS (EXSDT) IN THE ELEMENTS OF THE COMPUTED PSEUDOINVERSE OF EACH MATRIX A.

DIMENSION A(6,4),AINVT(6,4),G(4,6)

DO WHILE(N.LE.LM)
  A1=TW0**(2*N)
  A1INV=ONE/A1
  PRINT 1
  DO 100 I=1,6
    DO 950 J=1,4
      A(I,J)=A1+A4
      AINVT(I,J)=(A1INV+A4INV)/EIGHT
      CONTINUE
    CONTINUE
  CONTINUE
  N=N+1
  GO TO 50
100 CONTINUE
1050 STOP

FORMAT (1H ,19HVALUE OF A1 IS NOW ,D20.12,10H N IS NOW ,I2)

END

1: IF((J.EQ.1).0R.(J.EQ.4))GO TO 150
   GO TO 200
2,5: IF((J.EQ.1).0R.(J.EQ.3))GO TO 350
   GO TO 400
3,4: IF((J.EQ.1).0R.(J.EQ.2))GO TO 550
   GO TO 600
6: IF((J.EQ.1).0R.(J.EQ.4))GO TO 750
   GO TO 800
7: IF((J.EQ.1).0R.(J.EQ.2))GO TO 850
   GO TO 900
8: IF((J.EQ.1).0R.(J.EQ.4))GO TO 950
   GO TO 1000

CONTINUE
PROGRAM FEATURES

The following program features should be emphasized:

1. Each FORTRAN module processed by the program translator must terminate on the FORTRAN END statement.

2. The translator will process FORTRAN modules that use either upper or lower case characters.

3. The translator will process all program modules in a FORTRAN file so that a FORTRAN file containing more than one FORTRAN module may be assigned to the text file INFILE.

4. Only the GO TO-less structures in Figure 1 are modified by the translator. All other FORTRAN statements remain unchanged! Therefore, FORTRAN modules that do not use any of the GO TO-less structures in Figure 1 are left unchanged by the translator.

5. Modified statements occupy the same print positions as the statements that they replace; however, new statements that are added (conditional and explicit transfers of control) are not indented to conform with the indentation convention shown in Figure 1.

6. New statement labels generated by the translator have values greater than 20000, so that, in general, they will not interfere with existing statement labels.

7. To complement the program translator, program "CLEAN" can be used to resequence statement labels and reindent control structures!
OVERVIEW OF TRANSLATION ALGORITHM

The translation algorithm is based on the observation that the GO TO-less structures in Figure 1 can be translated into their simulated analogs by using push-down stacks. Essentially the line numbers of statements that introduce GO TO-less structures are placed on a push-down stack when they are encountered. When an END DO (structure terminator) is encountered, however, the stack is "popped" and the structure terminator is paired with the line number at which the structure is introduced.

For example, consider the following simple nest of GO TO-less structures:

```
  1  DO I = 1, N
  2         DO J = 1, N
            C(I,J) = 0.0
        END DO
     END DO
```

When a DO line is identified, its line number (line i) is placed on a push-down stack, so that immediately after the second DO has been processed, the push-down stack for our simple nest contains

```
line 2  --- top of stack
line 1
```

When an END DO is identified, it is converted to a labeled CONTINUE statement, the line number at the top of the stack is removed and placed on an auxiliary stack along with the label, n(3-i), of the CONTINUE statement. This properly pairs in the auxiliary stack the line number introducing a GO TO-less structure with the label assigned to the structure terminator. Processing the code from beginning to end in this manner, the translator generates the auxiliary stack:

```
Auxiliary stack:
  line 1, n2  --- top of stack
  line 2, n1
```

and the partially translated code:

```
  1  DO I = 1, N
  2         DO J = 1, N
            C(I,J) = 0.0
      n1    CONTINUE
    n2    CONTINUE
```

Now reading the partially translated code from beginning to end, when a line number is encountered that matches the line number on the top of the auxiliary stack, the translator inserts the stack label in the corresponding line of FORTRAN and then "pops" the stack. This procedure is repeated until the auxiliary stack is empty. The final translated code is

```
  DO n2 I = 1, N
    DO n1 J = 1, N
        C(I,J) = 0.0
      n1    CONTINUE
    n2    CONTINUE
```

SUMMARY

A computer program is available that translates VAX FORTRAN structured GO
to-less control elements that are not American National Standard FORTRAN 77
into structured simulated analogs that are compilable by any FORTRAN
compiler. This capability reduces the manual reprogramming effort required to
successfully recompile VAX FORTRAN programs on other computer systems with
FORTRAN compilers that will not compile these non-standard control elements.
This capability, like program "CLEAN" [1], is being provided to NUSC/NET users
as a software development aid in producing more maintainable FORTRAN programs.

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Marvin J. Goldstein, Computer and Information Services Dept.
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TM No. 831169
21 November 1983
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