software AG

Natural for Mainframes

Natural Optimizer Compiler

Version 4.2.6 for Mainframes

October 2009

Natural

This document applies to Natural Version 4.2.6 for Mainframes and to all subsequent releases.

Specifications contained herein are subject to change and these changes will be reported in subsequent release notes or new editions.

Table of Contents

1 Natural Optimizer Compiler

This documentation for Natural Optimizer Compiler describes various aspects which should be taken into consideration when the Natural Optimizer Compiler is installed at your site.

In the remainder of the Natural Optimizer Compiler documentation the Natural Optimizer Compiler is also referred to as NOC, which is the product code.

For an explanation of the format abbreviations used in this documents, see the section *Possible Formats* in the Natural *Statements* documentation.

General Information	Various aspects of the Natural Optimizer Compiler and how to benefit most from the Natural Optimizer Compiler.
Installing the Optimizer Compiler	Installation of the Natural Optimizer Compiler.
Using the Optimizer Compiler	Statements and programs used for compilation. Statistical data on programs suitable for processing by the Natural Optimizer Compiler: `NOCSTAT` command. Examples of when to use the Optimizer Compiler.
Activating the Optimizer Compiler	How to switch on the Natural Optimizer Compiler.
Optimizer Options	Various options of the Natural Optimizer Compiler. How to apply `PGEN` to output generated code and internal Natural structures for examination. Influence by other Natural parameters.
Performance Considerations	How to achieve best performance considering data formats, arrays, alpha fields, `DECIDE ON` and numeric values.
Listing Zaps	How to receive an overview of the Zaps that have been applied to the Natural Optimizer Compiler.

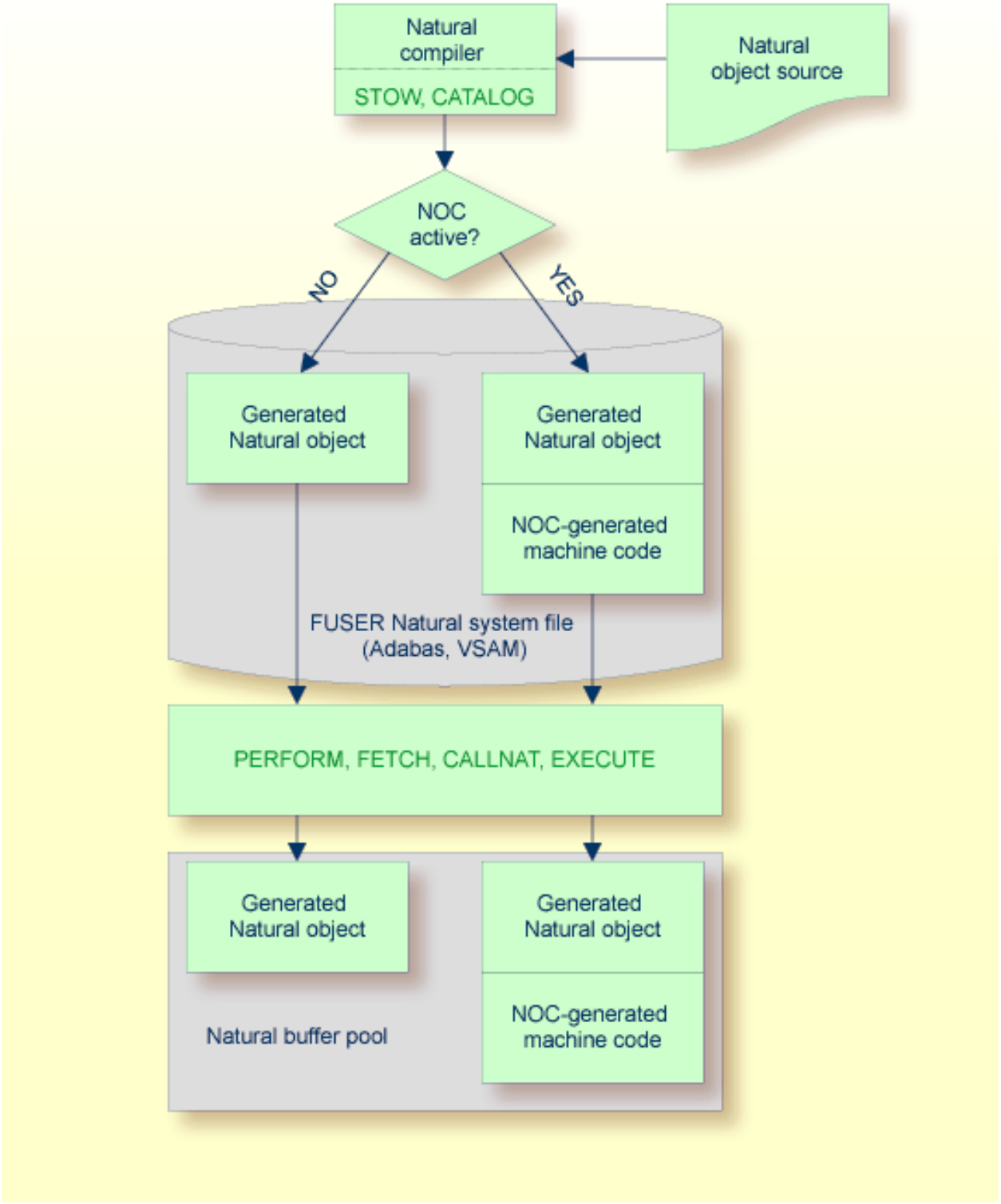
2 NOC - General Information

This section describes various aspects which should be taken into consideration when the Natural Optimizer Compiler is installed at your site. The information provided in this documentation helps you to make full use of the benefits offered by the Natural Optimizer Compiler.

Natural Nucleus Optimization

The Natural nucleus optimizes simple arithmetic, assignment, and comparison statements by translating parts of them into machine code. All programs are optimized automatically in this way.

The following graphic illustrates how the Natural Optimizer Compiler generates machine code when a Natural programming object is compiled or executed:


Natural compiler
STOW, CATALOG
Natural object source
NOC active?
NO
YES
Generated Natural object
Generated Natural object
NOC-generated machine code
FUSER Natural system file (Adabas, VSAM)
PERFORM, FETCH, CALLNAT, EXECUTE
Generated Natural object
Generated Natural object
NOC-generated machine code
Natural buffer pool

Natural Optimizer Compiler

The Natural Optimizer Compiler goes one step further than standard optimization. It compiles not only simple statements to machine code, but also complex statements and statement sequences.

The compiled code is further optimized as far as array range operations, field concatenation, and optimum base register assignment are concerned.

All statements (including arithmetic operations) optimized with NOC provide the same results as the same statements generated by standard Natural.

To activate the Natural Optimizer Compiler (see the relevant section), use the macro `NTOPT` in the Natural parameter module, the dynamic profile parameter `OPT`, the system command `NOCOPT`, or the `OPTIONS` statement.

All programs that are cataloged (`STOW` or `CATALOG` system command) with the Natural Optimizer Compiler activated are compiled to machine code. This will also result in the object code size of the programs being larger than usual, depending on how much of the program can be optimized.

A program executed with the `RUN` system command is compiled to machine code if the Natural Optimizer Compiler is activated with the system command `NOCOPT`, the macro `NTOPT` or the `OPTIONS` statement for all or part of the program.

To see if a program is suitable for compilation with the Natural Optimizer Compiler, use the `NOCSTAT` command as described in the relevant section.

Note: The dynamic recatalog feature (profile parameter `RECAT` set to `ON`) cannot be used with programs compiled to machine code.

To execute programs that have been compiled with the Natural Optimizer Compiler, it is not necessary that the Natural Optimizer Compiler is installed.

3 Installing the Natural Optimizer Compiler

This chapter describes how to install the Natural Optimizer Compiler (also referred to as NOC) in the various environments supported.

General Information

Installation Jobs

The installation of Software AG products is performed by installation jobs. These jobs are either created manually or generated by Software AG's System Maintenance Aid (SMA).

For each step of the installation procedure described below, the job number of a job performing the corresponding task is indicated. This job number refers to an installation job generated by SMA.

Using System Maintenance Aid

For information on using SMA for the installation process, refer to the System Maintenance Aid documentation.

Prerequisites

Products and versions are specified in the sections *Natural and Other Software AG Products* and *Operating/Teleprocessing Systems Required* in the current Natural Release Notes.

Installation Tape - z/OS

The installation tape contains the dataset listed in the table below.

Dataset Name	Contents
NOC*vrs*.LOAD	This dataset contains the Natural Optimizer Compiler load modules.

The notation *vrs* in dataset names represents the version, release and system maintenance level number of the product.

For a detailed description of the installation tape refer to the *Report of Tape Creation* which accompanies the tape.

Space Requirements

The space the dataset requires on disk is shown in the *Report of Tape Creation*.

Installation Tape - z/VSE

The installation tape contains the following dataset:

Dataset Name	Contents
NOC*vrs*.LIBR	LIBR backup file.

The notation *vrs* in dataset names represents the version, release and system maintenance level number of the product.

Installation Tape - BS2000/OSD

The installation tape contains the following dataset:

Dataset Name	Contents
NOC*vrs*.MOD	Optimizer Compiler module library.

The notation *vrs* in dataset names represents the version, release and system maintenance level number of the product.

For a detailed description of the installation tape refer to the *Report of Tape Creation* which accompanies the tape.

Space Requirements

The space the dataset requires on disk is shown in the *Report of Tape Creation*.

Installation Tape - VM/CMS

The installation tape contains the dataset listed in the table below.

Dataset Name	Contents
NOC*vrs*.TAPE	This dataset contains the Natural Optimizer Compiler load module.

The notation *vrs* in dataset names represents the version, release and system maintenance level number of the product.

For a detailed description of the installation tape refer to the *Report of Tape Creation* which accompanies the tape.

Space Requirements

The space the dataset requires on disk is shown in the *Report of Tape Creation*.

Copying the Tape Contents to Disk

To copy the tape contents to disk

1 Position the tape for the `TAPE LOAD` command by calculating the number of tape marks as follows:

If the sequence number of `NOC`*nnn*`.TAPE`, as shown by the *Report of Tape Creation*, is *n*, you must position over 3*n*- 2 tape marks (that is, `FSF 1` for the first dataset, `FSF 4` for the second, etc.)

2 Access the disk that is to contain the Natural installation files as Disk A.

3 Ask the system operator to attach a tape drive to your virtual machine at the address `X'181'` and mount the Natural Optimizer Compiler installation tape.

4 When the tape has been attached, enter the following CMS command:

```
TAPE REW
```

Position the tape by entering the CMS command:

```
TAPE FSF n
```

where *n* is the number of tape marks and is calculated as described above (3*n*- 2).

5 Load the Natural Optimizer Compiler/CMS installation material by entering the CMS command:

```
TAPE LOAD * * A
```

Keep the tape drive attached to your virtual machine, because the tape is needed later in the installation procedure.

Installation Procedure

Step 1 - Modify the Natural Parameter Module - Jobs I060, I080

Activate the Natural Optimizer Compiler by adding the following macro to your Natural parameter module (`NATPARM`):

```
NTOPT ON
```

Assemble and link the parameter module.

Step 2 - Relink all Natural Nuclei - Jobs I060, I080

Adapt the link steps for Natural.

- **z/OS**
  Add the following `INCLUDE` instruction to all links of the Natural nuclei (if you are using a shared nucleus, then include this statement in the link of the shared part):

```
INCLUDE NOCLIB(NOCNUC)
```

Add the corresponding DD statement:

```
//NOCLIB DD DSN=NOCvrs.LOAD,DISP=SHR
```

- **z/VSE**
  Add the following INCLUDE instruction and the corresponding sublibrary for the Natural Optimizer Compiler in the search chain for the linkage editor:

  ```
  INCLUDE NOCNUC
  ```

- **BS2000/OSD**
  Add the following INCLUDE instruction to the element LNATSHAR in NATvrs.JOBS:

  ```
  INCLUDE NOCNUC,NOCvrs.MOD
  ```

  Relink your Natural nucleus as described in *Link the Natural Nucleus* in Installing Natural under BS2000/OSD in the Natural *Installation* documentation.

- **VM/CMS**
  The list of text files to be included in the Natural module or DCSS is contained in REXX program NAT$LOAD EXEC (variable LOADLIST). To customize your Natural system, modify this EXEC with XEDIT by changing the LOADLIST as required.

  Add the following INCLUDE instruction to the program NAT$LOAD EXEC:

  ```
  LOADLIST = LOADLIST 'NOCNUC'
  ```

  Relink your Natural nucleus with the procedure NATBLDM.

Installation Verification

1. Recatalog an existing program or write a new program and then catalog it.
2. Check the directory information for the program you have just cataloged, by using the LIST system command:

   ```
   LIST DIR object-name
   ```

The directory information for the specified object will be displayed, showing the size of the machine code at the bottom of the screen.

4 Using the Optimizer Compiler - Overview

- What is Compiled and What is Not
- NOCSTAT Command
- Displaying the Size of the Machine Code
- Optimizer Usage Examples

5 What is Compiled and What is Not

The Natural Optimizer Compiler is particularly effective for programs that contain a considerable amount of data manipulation, such as computation, transfer, and logical condition processing.

The Natural Optimizer Compiler compiles the following statements to machine code:

- assignment statements (`ASSIGN` and `MOVE`)
- RESET
- arithmetic statements (`COMPUTE`, `ADD`, `SUBTRACT`, `MULTIPLY`, `DIVIDE`)
- conditional statements (`IF`, `DECIDE`)
- control statements (`FOR`, `REPEAT`)
- `ESCAPE`
- `COMPRESS`
- `EXAMINE`

  with the following clauses only:

  `GIVING NUMBER`, `GIVING POSITION` or `GIVING LENGTH` (see also the Natural *Statements* documentation).

`GIVING INDEX` is not optimized. Example:

```
EXAMINE #TEXT FOR #A GIVING NUMBER #NMB1
EXAMINE #TEXT FOR #A GIVING POSITION #POSEX5
EXAMINE #TEXT FOR #A GIVING LENGTH #LGHEX6
```

The Natural Optimizer Compiler *does not* compile the following statements:

- I/O statements (`DISPLAY`, `WRITE`, `READ/WRITE WORK FILE`).
- complex special statements such as `SEPARATE`.
- statements that pass control to another programming object such as `FETCH`, `PERFORM`, `CALLNAT`, `CALL`.
- statements that perform database access (`READ`, `FIND`, `HISTOGRAM`, `GET`, `UPDATE`, `DELETE`, `END TRANSACTION`, `BACKOUT TRANSACTION`)

Note: The options the Natural Optimizer Compiler provides cannot be used for specifying statements to be optimized as described in the **Optimizer Options**.

6 NOCSTAT Command

For programs optimized with the Natural Optimizer Compiler, certain statements can be directly converted into machine code when cataloged. As a result, when executing the optimized objects with Natural at runtime, the performance can be improved considerably.

The NOCSTAT command analyses cataloged programming objects and provides statistical information to help decide whether program statements benefit from optimization with the Natural Optimizer Compiler and, if so, to what extent they can be optimized.

If a program is cataloged (STOW, CATALL), the Natural compiler generates an internal (pseudo) object code based on the statements in the source program. In most cases, one source statement is transformed into one pseudo-code instruction. However, for complex statements, such as FOR and REPEAT, several pseudo-code instructions are generated. The NOCSTAT analyses are based on the generated pseudo-code instructions. Therefore, the number of statements indicated in the statistical reports may exceed the number of statements in the source program.

Invoking NOCSTAT

To invoke the NOCSTAT command

- Enter the direct command NOCSTAT.

  The main NOCSTAT screen is displayed:

```
14:02:01            ***** NATURAL NOCSTAT COMMAND *****            2000-09-04



Name ................. ________

Library ............... SAGTEST_



NOCable Objects only .. _

Output Report ......... X Statement Category
                        _ Statement Type
                        _ Code Profile
```

```
Output Destination .... X Screen

                        _ CSV to Work File 1

                        _ XML to Work File 1

                          with XSL ____________________________________


Progress Control ...... X




Command ===>

Enter-PF1---PF2---PF3---PF4---PF5---PF6---PF7---PF8---PF9---PF10--PF11--PF12---
      Help        Exit                                                  Canc
```

To obtain field-specific help information, either enter a question mark in the relevant field and press ENTER, or place the cursor in the field and press PF1. Press PF3 to exit NOCSTAT.

Generating Reports

You can generate statistical reports for a single program or a set of programs. If you analyze more than one program at a time, the reports are produced in series. When you have finished looking at one report, press ENTER to view the next report.

The main NOCSTAT menu provides the following options:

Field	Explanation	
Name	Enter a name or a range of names to specify the program(s) you want to examine:	
	value is any combination of one or more characters.	
	value	Single program.
	*	All programs.
	*value**	All programs whose names begin with *value*.
	value>	All programs whose names are greater/equal *value*.
	value<	All programs whose names are less/equal *value*.

Field	Explanation	
Library	Enter the name of a library or specify a range; the same applies as described for the Name field above. The current library is the default.	
NOCable Objects only	Mark this option to exclude programs already compiled with the Natural Optimizer Compiler. Otherwise, the NOCSTAT command selects all Natural programs specified in the Name and Library fields by default, including NOC-compiled programs.	
Output Report	Mark any of the options to select statements by category, type or code profile. See ***Statement Category***, ***Statement Type*** and ***Code Profile*** below.	
Output Destination	Mark any of the following options to determine the output format and destination:	
	Screen	Online display.
	CSV to Work File 1	Generates spreadsheets with comma-separated values. Use the file extension .csv to write the work file directly to your PC for further processing. You can only route reports to a PC if Entire Connection is installed.

	XML to Work File 1	Generates XML documents. Use the file extension ".xml" to write the work file directly to your PC for further processing.
		
		If a value is entered in the field "with XSL", a processing instruction is added at the top of the XML output document:
		
		`<?xml-stylesheet type="text/xsl" href="`
		`value "?>`
		
		The *value* entered should be the absolute or relative url of the style sheet, for example:
		
		`nocstat.xsl`
		
		or
		
		`http://natural.software-ag.de/nocstat.xsl`
		
		The processing instruction causes the document to be transformed according to the given style sheet when it is viewed by an XSLT-capable browser or transformed by a batch XSLT run. A typical use of this feature is to convert the output XML to an HTML page.

Field	Explanation	
		There are two XSLT style sheets delivered with Natural as text members NOCSTLS1 and NOCSTLS2 in the Natural library SYSEXUEX in the FNAT system file. NOCSTLS1 provides formatting instructions for report type ***Statement Category***, NOCSTLS2 for report type ***Statement Type*** as described below. Download the style sheets with file extension .xsl to the same directory in which the XML work files are stored. You can only route reports to a PC if Entire Connection is installed.
Progress Control	Only applies to Work File 1 output destinations. If this option is marked, a brief message appears online for each program listed in the report generated.	

Report Formats

You can choose between three output formats described below to display the statistics NOCSTAT provides for the statements analyzed. Different report layouts are produced for programs already optimized with the Natural Optimizer Compiler and for programs to be considered for optimization. The example reports below show the difference. Press PF3to interrupt report processing and return to the NOCSTAT menu.

- Statement Category
- Statement Type
- Code Profile

Statement Category

The statistical report generated with the option Statement Category lists various categories of statements with the corresponding number of occurrences and the total number of statements already optimized or suitable for optimization, depending on whether or not the program was optimized with the Natural Optimizer Compiler.

Example of NOC-Optimized Program:

```
14:07:17            ***** NATURAL NOCSTAT COMMAND *****            2000-09-04
               Library SAGTEST  Name NOCTEST1 Type Program

     MCG Options: (ON,OVFLW,INDX,MIX,IO)

      Database Loop:        0
    Database Simple:        0
    SORT / WORK I/O:       29
       FOR / REPEAT:        0
   Screen / Printer:       59
String Manipulation:        6
    Arith / Logical:        0
      Program Calls:        3
   Control Transfer:       49
        Block Start:       25
     Set Environment:        2
   System Functions:        0
      Miscellaneous:        0

   Total Statements:      949
      NOC optimized:      762  ( Ratio:  80 % )
     Longest NOC Run:      180  Statements
```

Example of Program without NOC Optimization:

```
14:13:01            ***** NATURAL NOCSTAT COMMAND *****            2000-09-04
               Library SAGTEST  Name NOCTEST2 Type Program

                     No NOC      NOCable
                    --------     --------
      Database Loop:        0            0
    Database Simple:        0            0
    SORT / WORK I/O:        0            0
       FOR / REPEAT:        0            5
   Screen / Printer:       57            0
String Manipulation:        4            8
    Arith / Logical:        0          491
      Program Calls:        3            0
   Control Transfer:       19           69
        Block Start:       15            0
     Set Environment:        0            0
   System Functions:        0            0
      Miscellaneous:        0            0

               Total Statements:      672
                NOC optimizable:      573  ( Ratio:  85 % )
                Longest NOC Run:      192  Statements
```

Report Columns and Fields:

Column	Explanation
No NOC	Statements not suitable for optimization.
NOCable	Statements suitable for optimization.
Field	
Database Loop	The number of database statements that generate a processing loop, such as FIND and READ.
Database Simple	Database statements that do not generate a processing loop, such as STORE, UPDATE, DELETE and GET.
SORT / WORK I/O	SORT and work file statements.
FOR / REPEAT	Statements generating loops.
Screen / Printer	Screen and printer I/O, such as WRITE, DISPLAY and INPUT.
String Manipulation	String statements, such as EXAMINE and COMPRESS.
Arith / Logical	Arithmetic and logical statements, such as MOVE, COMPUTE and IF.
Program Calls	Transfer of control to a subroutine or subprogram, such as PERFORM, CALLNAT and FETCH.
Control Transfer	Jumps within the program, such as ESCAPE BOTTOM, FOR and REPEAT loops.
Block Start	Non-executed statements that demarcate code blocks, such as DEFINE SUBROUTINE and AT END. These statements are never optimized because they are never executed.
Set Environment	Statements that set the environment, such as SET CONTROL, SET GLOBALS and SET KEY.
System Functions	Statements, such as TOTAL, SUM, COUNT, MAX, MIN and *COUNT.
Miscellaneous	Pseudo-code statements not relevant for optimization and, therefore, ignored by the NOC.
Totals	
Total Statements	The total number of statements found in the program. This number may not correspond to the actual source statements as described in the introduction to NOCSTAT command above.
NOC optimized	For an optimized program, these are the actual pseudo-code statements (as described in the introduction to NOCSTAT command above) that have been NOC-optimized to machine code.
NOC optimizable	For non-optimized programs, this is the possible number of statements that could be optimized. The figure may be slightly higher than the actual number, since certain factors are not considered in the NOCSTAT program. For example, a SUBSTRING statement that has more than four arrays will be indicated as "optimizable" though it will not be optimized.
Ratio	Relation between Total Statements and NOC-optimized statements or Total Statements and NOC-optimizable statements in percent.

Column	Explanation
Longest NOC Run	NOC-optimized program: The number of contiguous optimized statements - the fewer fragment sequences, the better the performance.
	Non-optimized program: The number of contiguous statements to be expected if the program were optimized.

Statement Type

The statistical report generated with the option “Statement Type” lists single statements with the corresponding number of occurrences and the NOC coding generated for optimized objects.

Example of NOC-Optimized Program:

```
09:21:45            ***** NATURAL NOCSTAT COMMAND *****            2000-09-06
                Library SAGTEST  Name NOCTEST1 Type Program

        Statement            Number
 ------------------------   --------
 DB AT CONDITION                 6
 READ/WRITE WORK FILE           29
 EXAMINE                         6
 WRITE                          51
 INPUT                           3
 NEWPAGE                         2
 REINPUT                         3
 FIND                            1
 READ                            2
 NOC CODE                      760
 BLOCK START                    18
 ON ERROR                        1
 END                             1
 STOP                            2
 RETURN                          3
 RETURN INLINE                  15
 ESCAPE ROUTINE                  3
 ESCAPE ROUTINE IMMEDIATE        1
 MORE
```

Example of Program without NOC Optimization:

```
09:23:15            ***** NATURAL NOCSTAT COMMAND *****            2000-09-06
                Library SAGTEST  Name NOCTEST2 Type Program

        Statement            No NOC   NOCable
 ----------------------   --------  --------
 DB AT CONDITION                 6         0
 MOVE/COMPUTE/ASSIGN             0       371
 EXAMINE                         4         0
 COMPRESS                        0         7
 WRITE                          47         0
 INPUT                           2         0
 NEWPAGE                         2         0
 REINPUT                         6         0
 FIND                            1         0
 READ                            1         0
 HISTOGRAM                       1         0
 ELSE/CLOSE LOOP                 0        55
 LOOPEND FOR/REPEAT              0         5
 BLOCK START                     8         0
 ON ERROR                        1         0
 END                             1         0
 STOP                            2         0
 RETURN                          2         0
 MORE
```

Code Profile

The statistical report generated with the option “Code Profile” displays contiguous sequences of statements grouped by categories in a source program suitable for optimization, or lists the NOC coding generated for an optimized program. Occurrences are highlighted.

Example of NOC-Optimized Program:

```
09:59:04            ***** NATURAL NOCSTAT COMMAND *****            2000-09-06
                Library SAGTEST  Name NOCTEST1 Type Program

 Line   Statement
 -----  -------------------------
 0000   ON ERROR
 0000   MCG OPTIONS
 0045   MCG OPTIONS
 0050   NOC CODE
 0050   NOC CODE
 0050   NOC CODE
 0050   NOC CODE
 1110   SET KEY
```

```
 1140   NOC CODE
 1140   NOC CODE
 1145   NOC CODE
 1145   NOC CODE
 1150   NOC CODE
 1150   NOC CODE
 1155   NOC CODE
 1155   NOC CODE
 1160   NOC CODE
 1160   NOC CODE
 MORE
```

Example of Program without NOC Optimization:

```
10:01:36            ***** NATURAL NOCSTAT COMMAND *****            2000-09-06
                Library SAGTEST  Name NOCTEST2 Type Program

 Line   Statement
 -----  ------------------------
 0000   ON ERROR
 0000   MCG OPTIONS
 0100   MOVE/COMPUTE/ASSIGN       <-- NOCable
 0100   MOVE/COMPUTE/ASSIGN       <-- NOCable
 0100   MOVE/COMPUTE/ASSIGN       <-- NOCable
 1920   MOVE/COMPUTE/ASSIGN       <-- NOCable
 1920   FOR                       <-- NOCable
 1920   MOVE/COMPUTE/ASSIGN       <-- NOCable
 1920   FOR/REPEAT IF             <-- NOCable
 1930   COMPRESS                  <-- NOCable
 1940   LOOPEND FOR/REPEAT        <-- NOCable
 1960   MOVE/COMPUTE/ASSIGN       <-- NOCable
 1960   MOVE/COMPUTE/ASSIGN       <-- NOCable
 1970   MOVE/COMPUTE/ASSIGN       <-- NOCable
 1970   MOVE/COMPUTE/ASSIGN       <-- NOCable
 1980   MOVE/COMPUTE/ASSIGN       <-- NOCable
 1980   MOVE/COMPUTE/ASSIGN       <-- NOCable
 1990   MOVE/COMPUTE/ASSIGN       <-- NOCable
 MORE
```

Batch Execution

Below are job examples for processing NOCSTAT reports in batch mode. After job execution, the work files generated can be transferred from host to PC for further processing with standard transfer tools.

Example Job z/OS:

```
//NOCBATCH JOB  (NOC,,,30),CLASS=K,MSGCLASS=X                          00000100
//NATEX EXEC PGM=NATBAT31,REGION=6200K,PARM=('IM=D')                   00000200
//STEPLIB  DD DISP=SHR,DSN=TESTNAT.LOAD                                00000300
//CMPRINT  DD SYSOUT=X                                                 00000400
//CMWKF01  DD DSN='NOC.NOCSTAT.OUT',DISP=(NEW,CATLG),                  00000500
            SPACE=(CYL,(1,1)),UNIT=SYSDA,VOL=SER=SAG001                00000600
//SYSOUT   DD SYSOUT=X                                                 00000700
//CMSYNIN  DD *                                                        00000800
NOCSTAT                                                              00000900
*,library,X,,,X                                                       00001000
.                                                                    00001100
FIN                                                                  00001200
/*                                                                   00001300
```

Example Job z/VSE:

```
* $$ JOB JNM=NOCTST,CLASS=5,DISP=D
* $$ LST CLASS=Q,DISP=D
// JOB NOCTST
// ASSGN SYS001,DISK,VOL=xxxxxx,SHR
// DLBL CMWKF01,'NOCSTAT.FILE.ONE',0
// EXTENT SYS001,xxxxxx,1,0,1,150
// EXEC NAT234BA,SIZE=NAT314BA,PARM='SYSRDR'
IM=D,OBJIN=R
/*
ADARUN DBID=185
/*
NOCSTAT
*;library;X; ; ; ;X;
.
FIN
/*
/&
```

Example Job BS2000/OSD:

```
/.BAT234 LOGON  NAT,1
/        SYSFILE SYSOUT=NAT314.OUT
/        SYSFILE SYSLST=NAT314.LST
/SKIP   .NOP000
================================================================================
      NAME   : E.NAT314          S T A R T  B A T C H   N A T U R A L
================================================================================
/.NOP000 REMARK
/        OPTION  DUMP=YES,MSG=FL
/        FILE    NOCSTAT.OUT,LINK=W01
```

```
/        FILE    ADAUSER  ,LINK=DDCARD
/        FILE    $SAG.ADA623.MOD       ,LINK=BLSLIBOO
/        SYSFILE TASKLIB=MOD234
/        SYSFILE SYSDTA=(SYSCMD)
/        FILE    NAT314.CMPRMIN,LINK=CMPRMIN
/        DCLJV   NATJV1,LINK=*NATB2JV
/        FILE    $NAT.ADALNK.PARMS,LINK=DDLNKPAR
/        REMARK  %%%%%%%%%%  BATCH-PHASE   %%%%%%%%%%%%%
/        EXEC    NAT314
NOCSTAT
*,ADE,X, , , ,X, , ,X
.
FIN
```

7 Displaying the Size of the Machine Code

With the Natural system command LIST, you can see whether a program has been compiled to machine code and also the size of the machine code.

To list compiled programs

- Enter the Natural system command

```
LIST DIR object-name
```

The directory information for the specified object will be displayed, showing at the bottom of the screen the size of the machine code, the OPT parameters used for the compilation and the NOC version under which the program was cataloged.

Details of the `LIST` command are provided in the Natural System Command Reference documentation.

8 Optimizer Usage Examples

The examples below illustrate when to use the Natural Optimizer Compiler to the best advantage and to give an indication of its power:

Example 1 - No Improvement

Nothing would be gained by using the Natural Optimizer Compiler for the following program:

```
DEFINE DATA LOCAL
  1 EMPLOYEES VIEW OF EMPLOYEES
    2 JOB-TITLE
    2 BIRTH
    2 NAME
  END-DEFINE
  FIND EMPLOYEES WITH JOB-TITLE = 'PROGRAMMER' OR = 'ANALYST'
                              OR = 'PROGRAMMER/ANALYST'
                              OR = 'SYSTEM ANALYST'
    DISPLAY JOB-TITLE BIRTH NAME
  END-FIND
  END
```

Example 2 - Considerable Improvement

If the following program is compiled with the Natural Optimizer Compiler, you will see a performance improvement of approximately 30 % (that is a 30 % reduction in CPU load). The program performs a statistical analysis of the age of IT-employees. Optimized statements are indicated in boldface.

In this example, NOC increases the object size by 20.5 %, due to 952 bytes of additional machine code:

Profile Parameter Setting	Size in Buffer Pool	Size of Machine Code Generated by NOC
OPT=NODBG	5768	952
OPT=OFF	4784	0

```
 DEFINE DATA
 LOCAL
 1 EMPLOY VIEW OF EMPLOYEES
   2 JOB-TITLE     (A25)
   2 BIRTH         (D)
 1 I               (I1)  INIT <1>
 1 CDATE           (D)
 1 NUMB            (N4)
 1 SUMM            (P7.2)
 1 SQUARE          (F8)
 1 DEVI            (F8)
 1 DEVIATION       (N3.4)
 1 MEAN            (P2.3)
 1 AGEDIS          (F8/1:70)
 1 AGEMAX          (F8)
 1 AGEH            (P3)
 1 AGE             (P3)
 1 AGEDAYS         (P15)
 1 LINE            (A71/1:20)
 1 REDEFINE LINE
   2 POINTS        (A1/1:20,0:70)
 END-DEFINE
 *
 MOVE *DATX TO CDATE
 *
 FIND EMPLOY WITH JOB-TITLE = 'PROGRAMMER' OR = 'ANALYST'
   OR = 'PROGRAMMER/ANALYST' OR = 'SYSTEM ANALYST'
AGEDAYS:= CDATE - BIRTH
   AGE:=AGEDAYS / 365
   ADD 1 TO AGEDIS(AGE)                  /* DISTRIBUTION
   ADD 1 TO NUMB
   ADD AGE TO SUMM
   COMPUTE SQUARE = SQUARE + AGE * AGE
 END-FIND
 *
 ***********************************************************************
 * COMPUTE ESTIMATES
 ***********************************************************************
 *
 COMPUTE DEVI = NUMB * SQUARE / (SUMM * SUMM) - 1
 COMPUTE DEVIATION = SQRT(DEVI)
 COMPUTE MEAN = SUMM / NUMB
 *
 ***********************************************************************
 * GRAPHIC DISPLAY
 ***********************************************************************
 *
 FOR I 1 70
   IF AGEDIS(I) > AGEMAX MOVE AGEDIS(I) TO AGEMAX
   END-IF
 END-FOR
```

```
FOR I 1 70
  COMPUTE AGEDIS(I) = AGEDIS(I) * 20 / AGEMAX
END-FOR
FOR I 1 70
  COMPUTE AGEH = 21 - AGEDIS(I)
  IF AGEH < 21 MOVE '*' TO POINTS(AGEH:20,I)
  END-IF
END-FOR
*
************************************************************************
* COMPLETE GRAPHIC DISPLAY
************************************************************************
*
MOVE '!' TO POINTS(*,0)
WRITE TITLE LEFT
 AGEMAX(EM=999)  20X  'DISTRIBUTION OF IT-EMPLOYEES BY AGE'
WRITE NOTITLE NOHDR
LINE(*) /
'0--------10--------20--------30--------40--------50--------60--------'
/  'MEAN='
```

Examples 3 and 4 - CPU Usage

The following program illustrates the difference in CPU usage, depending on the options you select when compiling the program. The table below lists the CPU usage in seconds and percent. The figures provided in the table were determined during a test run in an IBM z/OS environment. They can only serve as general orientation, since absolute values vary depending on the hardware applied.

```
DEFINE DATA LOCAL
1 #I1         (I4) INIT <1>
1 #I2         (I4) INIT <2>
1 #J1         (I4) INIT <3>
1 #J2         (I4) INIT <4>
1 #F          (I4)
1 #ARR1       (N7/10,5)
1 #ARR2       (N5/10,5)
END-DEFINE
*
FOR #F = 1 TO 1000000
  MOVE #ARR1(#I1,#I2) TO #ARR2(#J1,#J2)
END-FOR
*
END
```

Option	CPU seconds	CPU percentage
OFF	8.78	100
ON	0.63	7.18
INDX	0.85	9.68
OVFLW	1.71	19.48
INDX,OVFLW	2.00	22.78
INDX,OVFLW,NODBG	1.61	18.34
INDX,OVFLW,NODBG,NOSGNTR	1.61	18.34
NODBG	0.44	5.01
NOSGNTR	0.63	7.18
NODBG,NOSGNTR	0.44	5.01

```
DEFINE DATA LOCAL
1 #I1         (P7) INIT <1>
1 #I2         (P7) INIT <2>
1 #J1         (N7) INIT <3>
1 #J2         (N7) INIT <4>
1 #K1         (I4) INIT <5>
1 #K2         (I4) INIT <6>
1 #F          (I4)
1 #FIELD1     (P5)
1 #FIELD2     (N5)
1 #FIELD3     (I2)
END-DEFINE
*
FOR #F = 1 TO 500000
*
  #FIELD1:= #I1 - #I2 + (13 * 10 / 5)
  #FIELD2:= #J1 - #J2 + (13 * 10 / 5)
  #FIELD3:= #K1 - #K2 + (13 * 10 / 5)
*
END-FOR
*
END
```

Option	CPU seconds	CPU percentage
OFF	18.61	100.00
ON	4.95	26.60
INDX	4.95	26.60
OVFLW	5.38	28.91
INDX,OVFLW	5.38	28.91
INDX,OVFLW,NODBG	5.26	28.26
INDX,OVFLW,NODBG,NOSGNTR	5.09	27.35

Option	CPU seconds	CPU percentage
NODBG	4.79	25.74
NOSGNTR	4.81	25.85
NODBG,NOSGNTR	4.63	24.88
NODBG,NOSGNTR,ZD=OFF	4.51	24.23
NODBG,NOSGNTR,ZD=OFF,SIGNCHCK=OFF	4.41	23.70

9 Activating the Optimizer Compiler

To activate the Natural Optimizer Compiler, use one of the methods described in the following sctions, where first alternative is the most static one and the last alternative the most dynamic one.

All alternatives use the Optimizer options as described in the section ***Optimizer Options***. Using these options you can control how and when machine code is generated, what tracing options are to be used and what the target architecture will be. The Optimizer options are the only control mechanism for the Natural Optimizer Compiler.

Macro NTOPT

With the macro `NTOPT` in the Natural parameter module, you can activate the Natural Optimizer Compiler statically for a linked Natural nucleus. Every time this Natural nucleus is started, the same Optimizer options are used again.

Example 1:

```
NTOPT 'INDX,OVFLW,ZD=OFF'
```

Example 2:

```
NTOPT 'INDX,OVFLW,ZD=OFF,TRGPT',                                        -
      'TRSTMT,OPTLEV03'
```

Note the continuation character "-" in column 72.

See the section **Optimizer Options**for an explanation of the options setting used.

Dynamic Profile Parameter OPT

When starting a Natural session, you can dynamically activate the Optimizer Compiler by specifying the Natural profile parameter `OPT`. As a synonym for `OPT`, you can use `MCG`. The specification of the parameter module is overwritten. The options are only valid for the current session.

Example:

```
OPT=(INDX,OVFLW,ZD=OFF)
```

or

```
MCG=(INDX,OVFLW,ZD=OFF)
```

See the section *Optimizer Options* for an explanation of the option setting used.

System Command NOCOPT

When you have started a Natural session, you can invoke the Optimizer command screen with the Natural system command `NOCOPT`. The screen monitors the current setting of the Natural Optimizer Compiler options as they were specified during Natural startup. You can now modify the setting online.

The updated parameter setting is only valid for the current session.

Natural Statement OPTIONS

The MCG parameter of the Natural compiler statement `OPTIONS` provides the most flexible and powerful control over machine code generation, since different options can be set for individual statements in a program. So, within one Natural program, the NOC can be activated and deactivated several times to enclose ranges of statements with different options settings.

Example

```
OPTIONS MCG=(OVFLW,INDX,ZD=OFF)
```

or

```
OPTIONS MCG=OVFLW,INDX,ZD=OFF
```

The options string of the `MCG` parameter may start with a plus (+) or minus (-) sign, indicating that the values of options not mentioned should be left unaltered, and only the options present should be set (+) or reset (-), for example:

Example:

```
   OPTIONS MCG=+PGEN         /* turns tracing on

  (statements to be traced)

 OPTIONS MCG=-PGEN         /* turns tracing off
```

If the string starts with anything other than "+" or "-", all options are reset before the string is parsed.

Note: The Natural statement `OPTIONS` also provides other Natural compiler parameters than `MCG`.

See the section ***Optimizer Options***and for an explanation of the options setting used.

10 Optimizer Options

When the Natural Optimizer has been activated, you can specify checks by setting the options explained in this section.

The options cannot be used for specifying statements to be optimized.

List of Options

The following table lists and describes NOC options. Default values are underlined (this is the value that will be assumed if the option is not present).

A NOC option consists of a string surrounded by brackets or single quotation marks (except in the Natural `OPTIONS` statement), with options separated by commas. Some options have values, while the very existence of some options in the option string is sufficient to modify the environment.

The following rules apply:

- Optional clauses are surrounded by square brackets [ ].
- Choices are surrounded by curly braces { }.
- Each choice is separated by vertical lines "`|`".
- Only one of these choices can be specified;

  `ON` is equivalent to `Y` (Yes),

  `OFF` to `N` (No).
- Options specified without the optional clause `ON` or `OFF` (if applicable), or their equivalent values, are interpreted as set to `ON`. For example, `OVFLW` is identical to `OVFLW=ON`.
- Except for the option `OFF`, any specified option switches on optimizing (as if `ON` was specified) and the default values apply. For example, `INDEX` is identical to `ON,INDEX`.

Option	Explanation
`ABEND`	Forces the Natural Optimizer Compiler to generate code which causes Natural to be abnormally terminated immediately when the `ABEND` option is encountered by the Natural Optimizer Compiler during compilation. The option must appear by itself or it will be ignored. Other parameters are not changed or reset by this option. This option can be useful for debugging purposes.
`CACHE[={ON| OFF |Y|N}]`	Switches variable caching on or off. See also ***Variable Caching*** in the section Performance Considerations.
`CPU= /370`	Specifies the target architecture. The /370 option is valid for IBM and Siemens.
`DIGTCHCK[={ON| OFF |Y|N}]`	Specifies whether the digits of packed and unpacked numeric fields (formats P and N) are to be checked when moving to another variable of the same type and precision. For example, if `DIGTCHCK` is `ON` and an unpacked numeric variable (format N) contains an invalid digit, such as `X'FA'`, moving to another unpacked

Option	Explanation
	numeric variable with the same precision will generate a SOC7 (or NAT0954) error. If DIGTCHCK is OFF, no error is generated but the generated code is much faster.
ERRDUMP[={ON| OFF |Y|N}]	Specifies whether NOC should abend if an error condition is detected during the compile phase. This is useful for debugging the Natural Optimizer Compiler itself.
INDEX[={ON| OFF |Y|N}]	Specifies whether array indexes will be checked for out-of-bound values in the optimized code. See also the ***Warning*** below.
INDX[={ON| OFF |Y|N}]	Specifies whether array indexes will be checked for out-of-bound values in the optimized code. Additionally, RANGE will be set on. Therefore, this option is equivalent to INDEX=ON,RANGE=ON. See also the ***Warning*** below.
IO[={ON| OFF|Y|N}]	Reserved for future use.
LOOPS[={ON| OFF |Y|N}]	Provided for compatibility reasons only. No effect.
MIX[={ON| OFF |Y|N}]	Provided for compatibility reasons only. No effect.
NODBG[={ON| OFF|Y|N}]	If you have not set NODBG=OFF/N (default), the Natural Debugger can not be used to debug optimized code, because the Natural Debugger might not receive control for optimized statements. No additional code will be generated, the program will not run slower and will not consume more CPU time. If you have not set NODBG=ON/Y, additional code is generated to check whether TEST mode has been set on and the functionality of the Natural Debugger will not be limited. See also NODBG in the section *Performance Considerations*.
NOSGNTR[={ON| OFF |Y|N}]	Applies to packed numbers only. If NOSGNTR=OFF (default), signs of positive packed numbers which are the result of an arithmetic operation or the target of an assignment are set according to the COMPOPT parameter PSIGNF. If NOSGNTR=ON, the signs resulting from execution of the generated machine instruction are left unchanged. See also the section **Influence of other Natural Parameters**.
ON	Switches on optimizing. If no additional option is specified, the default value defined for each option is in effect. As indicated in the **Warning** below, this may cause unintended results, in particular regarding the options INDEX, INDX, OVFLW, and RANGE.
OFF	Switches off optimizing.

Option	Explanation
OPTLEV={ 2|3}	Specifies optimization level - roughly equivalent to the number of passes through the program. OPTLEV=3 is useful when PGEN is specified, since some branch targets cannot be determined during the first pass and PGEN output is made during the last pass. Thus, some values may be shown improperly.
OVFLW[={ON| OFF |Y|N}]	Specifies whether checks for overflow in arithmetic operations or assignments will be included in the optimized code. See also the *Warning* below.
PGEN[={ON| OFF |Y|N}]	Specifies whether a disassembly of the optimized code should be output. This option also enables all other tracing options. See also *PGEN Option* below.
RANGE[={ON| OFF |Y|N}]	Specifies whether range checks will be performed in operations with arrays. This ensures that array ranges will have an equal number of elements in corresponding dimensions of all operands. See also the *Warning* below.
SIGNCHCK[={ ON|OFF|Y|N}]	Specifies whether the result of a multiplication with a packed or unpacked numeric multiplier should be checked for a negative zero. If zero is multiplied by a negative number, the MP machine instruction generates a negative zero result. If SIGNCHCK is on, this negative zero is converted to a positive zero. The check for a negative zero is done for every multiplication with a packed or unpacked numeric multiplier.
TRENTRY	For internal use by Software AG only. Do not change the setting of this parameter.
ZD[={ ON|OFF|Y|N}]	Specifies whether divisors should be checked for zero. If this option is specified, then code is inserted, so that the program behaves according to the ZD profile parameter of Natural, that is, Natural error NAT1302 is issued or the result is zero. If this option is not specified, Natural error NAT0954 occurs if the divisor is zero. See also *ZD - Zero-Division Check* in the Natural *Parameter Reference* documentation.

Caution: For INDEX, INDX, OVFLW, and RANGE:

Apply values OFF and N with care. Suppressing overflow checking or array index checking may allow incorrect programs to lead to unpredictable results, storage corruption, or abnormal terminating.
See also the *Example of INDEX and OVFLW* below which demonstrates the impact of INDEX and OVFLW.

- Example of INDEX and OVFLW

- Optimum Code Generation

Example of INDEX and OVFLW

```
DEFINE DATA LOCAL
...
1 P1 (P1/9)
...
1 P3 (P3/9)
...
1 I (I4)
1 J (I4)
1 K (I4)
1 L (I4)
END-DEFINE
...
P1(I:J) := P3(K:L)
...
END
```

Explanation of Example

With `INDX=ON` or `INDEX=ON` set, code is generated to verify that `I`, `J`, `K` and `L` are within the ranges defined for `P1` and `P3` respectively.

With `INDX=ON` or `RANGE=ON` set, code is generated to verify that `I:J` and `K:L` denote ranges of the same length.

With `OVFLW=ON` set, code is generated to verify that the value of `P3` fits into the corresponding `P1` variable.

For example: Value `100` would cause an overflow here.

Example Error Situation:

If one of the occurrences of `P3` contains the value `100`, with `OVFLW=OFF` set, the value assigned to the corresponding `P1` occurrence will be zero. If the index variable `I` is zero or greater than `9`, with `INDX=OFF` set, storage areas that do not belong to Array `P1` will be corrupted. If these options (`OVFLW` and `INDX`) are set to `ON`, a Natural error occurs like it does in standard Natural runtime.

For the NOC option specified above, additional code is generated. However, this is well compensated for by the advantage of a check that, for example, protects against hard-to-debug errors. Undetected errors can, of course, lead to unpredictable results.

Optimum Code Generation

To assure that the least amount of code is generated and thus achieve optimum performance, use:

```
OPT='NODBG,NOSGNTR,SIGNCHCK=OFF,ZD=OFF'
```

However, only apply this setting to programming objects that have been thoroughly debugged; see also the *Warning*.

PGEN Option

The PGEN option causes the Natural Optimizer Compiler to output the generated code and internal Natural structures. Thus, code and structures can be examined, for example, for bug fixing, performance review and support issues.

An understanding of IBM's /370 assembler is required to interpret the results produced by the PGEN option.

We recommend that you use this option with the assistance of your local Software AG representative.

Setting PGEN

To use the PGEN facility, set the PGEN option when activating on the Optimizer Compiler.

Since the buffer is kept in memory, it is possible that the user thread will not be big enough to hold the trace information. In this case, try setting PGEN on only for the portion of the program which is to be traced, for example:

`OPTIONS MCG=(PGEN=ON,TRGPT=ON)`
or
`OPTIONS MCG=+PGEN,TRGPT`
	Turns tracing on, including tracing of the GPT entries

`OPTIONS MCG=(PGEN=OFF)`
or
`OPTIONS MCG=-PGEN`
	Turns tracing off

Various options affect the content of the output. The basic PGEN option causes a formatted listing of Natural source lines and a disassembly of the corresponding code to be generated and kept in

memory for extraction by the NOCSHOW utility as described below, under *Output of the PGEN Option*.

The TRSTMT, TRGPT, TRMPT and TRVDT options cause hex dumps of internal data structures associated with each line to be output.

The TRBASES and TRCACHE options cause information on base registers and cache variables to be printed out.

Sub-Options of the PGEN Option

The following table describes the options when PGEN=ON. For an explanation of the syntax used see the introduction to *List of Options* above.

Option	Explanation
LPP={5|..| 55 |..|255}	Lines-per-page for the trace output, only used when TREXT=ON.
NOsrcE[={ON| OFF |Y|N}]	If NOsrcE=OFF, the Natural source statement is included in the output.
TRACELEV={ 0 |..|255}	Specifies the trace level. Each bit in this one byte value specifies a buffer type to trace; these bits can be set on by using the TR*xxx* options as well.
TRBASES[={ON| OFF |Y|N}]	Specifies whether base register allocations are traced.
TRCACHE[={ON| OFF|Y|N}]	Specifies whether CACHE entries are traced.
TREXT[={ON| OFF |Y|N}]	If TREXT=ON, trace is directed to the user exit NOCPRINT as described below.
TRGPT[={ON| OFF |Y|N}]	Specifies whether GPT entries are traced.
TRMPT[=ON| OFF |Y|N}]	Specifies whether MPT entries are traced.
TRSTMT[={ON| OFF |Y|N}]	Specifies whether STMT entries are traced.
TRVDT[={ON| OFF |Y|N}]	Specifies whether VDT entries are traced.

See also the examples below.

Output of the PGEN Option

There are two places to where the Natural Optimizer Compiler can direct the output of PGEN:

- internal Buffer

- User Exit NOCPRINT

internal Buffer

The contents of this buffer is overwritten each time a CHECK, CAT, STOW or RUN command is executed. A system utility NOCSHOW is provided whereby the contents of this buffer can be viewed, searched or printed.

To invoke the NOCSHOW utility

- Enter the direct command NOCSHOW after a CHECK, STOW, CAT or RUN where the Natural Optimizer Compiler has been active.

The following PF keys are available on the screen:

Key	Function
PF2	Position to top of output
PF4	Position one line backward
PF5	Position one line forward
PF6	Print to Natural printer support No.1
PF7	Position one page backward
PF8	Position one page forward
PF10	Scan for text string
PF11	Repeat scan

User Exit NOCPRINT

If TREXT=ON is specified, the Natural Optimizer Compiler passes every output line to the user exit NOCPRINT instead of adding it to the trace buffer.

NOCPRINT is invoked following normal OS register conventions. Register 1 points to a full word containing the address of the 81 byte print line with ANSI carriage control characters in position 1. Register 13 points to an area of 18*4 bytes which may be used as a save area. Register 14 contains the return address and Register 15 contains the entry address of NOCPRINT.

The user exit NOCPRINT can be written in any language which supports the register conventions described above. It must be linked to the Natural nucleus together with the Natural Optimizer Compiler nucleus.

Working with the PGEN Output

This section provides hints and explanations on how to interpret the output created with the PGEN option.

- At the top of the PGEN output are some disassembled lines which do not appear to belong to any source line. These are the instructions which make up the prologue, which is executed whenever control passes from non-optimized to optimized code. Permanent base registers are loaded and control is passed to the correct point in the prologue. See *Example Section A* below.
- Sometimes a lot of source lines are printed without any code. This is because the Natural compiler puts a single line number in the object of statements which may span more than one line. See *Example Section B* below.
- If the NODBG=OFF (default) has been specified, a sequence of instructions is generated at the start of each Natural statement:

```
BALR R9,R11
DC X'....'
```

  This sequence sets the line number (in case of error) and checks whether the TEST mode is switched ON. Without this sequence, debugging of NOC-compiled statements by the Natural Debugger is not possible. See *Example Section C* below.
- Sometimes there is a line break between disassembled lines. This break indicates an internal statement separation. It happens because often a single Natural statement will generate multiple internal (pseudo-code) statements.

Example Section A:

```
000000 5880 D354          L     R8,RTADR+4
000004 5870 D370          L     R7,RTADR+32
000008 4810 6006          LH    R1,6(,R6)
00000C 1F60               SLR   R6,R0
00000E 47F1 A000          BC    15,0(R1,R10)
```

Example Section B:

```
0010 OPTIONS MCG=(PGEN=ON,TRGPT=ON)
0020 DEFINE DATA LOCAL
0030 1 I(I4)
0040 1 P(P7.2)
0050 1 T(P7.2)
0060 END-DEFINE
0070 *

0080 SETTIME
```

```
    0090 *

   000012 45E0 B040           BAL   R14,RETH
   000016 0036                DC    X'0036'

    0100 FOR I=1 TO 100000
```

Example Section C:

```
000018 059B                BALR  R9,R11
   00001A 003E                DC    X'003E'
   00001C D203 7000 833B      MVC   I,#VAR033B

   000022 059B                BALR  R9,R11
   000024 004C                DC    X'004C'
   000026 47F0 A040           BC    15,64(,R10)

   00002A 059B                BALR  R9,R11
   00002C 005A                DC    X'005A'
   00002E BFFF 8343           ICM   R15,15,#VAR0343
   000032 BF0F 7000           ICM   R0,15,I
   000036 1A0F                AR    R0,R15
   000038 BE0F 7000           STCM  R0,15,I

   00003C 059B                BALR  R9,R11
   00003E 006C                DC    X'006C'
   000040 BFFF 833F           ICM   R15,15,#VAR033F
   000044 BF0F 7000           ICM   R0,15,I
   000048 190F                CR    R0,R15
   00004A 4720 A066           BC    2,102(,R10)

    0110   ADD 1.00 TO P

   00004E 059B                BALR  R9,R11
   000050 0082                DC    X'0082'
   000052 FA41 7004 8347      AP    P,#VAR0347
   000058 DC00 7008 B488      TR    P+4(1),PSGNTR

    0120 END-FOR
    0130 *

   00005E 059B                BALR  R9,R11
   000060 0094                DC    X'0094'
   000062 47F0 A02A           BC    15,42(,R10)

    0140 T:=*TIMD(0080)

   000066 059B                BALR  R9,R11
   000068 009C                DC    X'009C'
   00006A 45E0 B0D8           BAL   R14,SYSFUNC
   00006E 0330 B881           DC    X'0330B881'
```

```
000072 F246 7009 8330      PACK  T,#VAR0330
000078 F040 7009 0002      SRP   T,2,0
00007E DC00 700D B488      TR    T+4(1),PSGNTR

 0150 T:=T / 10
 0160 *

000084 059B                BALR  R9,R11
000086 00AE                DC    X'00AE'
000088 F864 D100 7009      ZAP   OP1(7),T
00008E F811 D130 8349      ZAP   WORK2(2),#VAR0349
000094 45E0 B104           BAL   R14,ZDCHECK
000098 F240 7009 B355      PACK  T,ZEROZ
00009E 47F0 E01C           BC    15,28(,R14)
0000A2 FD61 D100 8349      DP    OP1(7),#VAR0349
0000A8 D204 7009 D100      MVC   T,OP1
0000AE DC00 700D B488      TR    T+4(1),PSGNTR

 0170 DISPLAY 'ELAPSED TIME (S)' T

0000B4 45E0 B040           BAL   R14,RETH
0000B8 00C0                DC    X'00C0'

 0180 END
```

Influence of other Natural Parameters

The global parameter ZD influences the behavior of the NOC compiler. See the description of the ZD option as described under ***List of Options*** above.

The COMPOPT parameter PSIGNF (see also the system command COMPOPT in the Natural *System Commands* documentation) influences the behavior by forcing the signs of positive packed decimal numbers to F if ON, and to C if OFF. The parameter is applied if NOSGNTR=OFF is specified.

See the chart below for packed data (Format P) ":"

NOSGNTR=OFF	and	PSIGNF=ON	All signs are normalized to F (default).
NOSGNTR=OFF	and	PSIGNF=OFF	All signs are normalized to C.
NOSGNTR=ON			All signs are left as they were generated by the last operation.

For numeric data (Format N) the signs are always normalized to F, regardless of the settings of NOSGNTR and PSIGNF.

11 Performance Considerations

Formats

Best performance is achieved when you use the data formats packed numeric (P) and integer (I4) in arithmetic operations.

Avoid converting data between the formats packed numeric (P), unpacked numeric (N), integer (I), and floating point (F), as this causes processing overhead even with optimized code.

As there is no interpretation overhead with optimized code, the differences between the various data formats become much more prominent: with optimized code the performance improvement gained by using format P instead of N, for example, is even higher than with normal code.

Example:

```
A = A + 1
```

In the above numeric calculation

- with non-optimized code, format P executes approximately 13 % faster than format N.
- with optimized code, however, format P executes approximately 56 % faster than format N.

The performance gain which would be achieved by applying the Natural Optimizer Compiler to this simple statement is

- with unpacked operands (N): 8 times faster
- with packed operands (P): 15 times faster

Arrays

Array range operations, such as

```
MOVE A(*) TO B(*)
```

are executed more efficiently than if the same function were programmed using a `FOR` statement processing loop. This is also true for optimized code.

When indexes are used, integer format I4 should be used to achieve optimum performance.

Alphanumeric Fields

We recommend that you adjust the length of the alphanumeric constant to the length of the variable, when moving an alphanumeric constant to an alphanumeric variable (format A), or when comparing an alphanumeric variable with an alphanumeric constant. This will significantly speed up operation, for example:

```
A(A5):='XYZAB'


...
IF A = 'ABC  ' THEN ...
```

is faster than

```
IF A = 'ABC' THEN ...
```

DECIDE ON

When using the `DECIDE ON` statement with a system variable, array or parameter *operand1*, it is more efficient to move the value to a scalar variable of the same type and length defined in the `LOCAL` storage section.

Numeric Values

When using numeric constants in assignments or arithmetic operations, try to force the constants to have the same type as the operation.

Rules of Thumb

- Any numeric constant with or without a decimal but without an exponent is compiled to a packed number having the minimum length and precision to represent the value, unless the constant is an array index or substring starting position or length, in which case it becomes a four-byte integer (I4). This rule applies irrespective of the variable types participating in the operation.
- Operations containing floating point will be executed in floating point. Add `E00` to numeric values to force them to be floating point, for example:

```
ADD 1E00 to F(F8)
```

- Operations not containing floating point, but containing packed numeric, unpacked numeric, date or time variables will be executed in packed decimal. For `ADD`, `SUBTRACT` and `IF`, force numeric constants to have the same number of decimal places as the variable with the highest precision by adding a decimal place and trailing zeros, for example:

```
ADD 1.00 TO P(P7.2)
```

This technique is unnecessary for `MULTIPLY` and `DIVIDE`.

Variable Positioning

To ease the optimization process, try to keep all scalar references at the front of the data section and all array references at the end of the data section.

Variable Caching

The Natural Optimizer Compiler contains an algorithm to enhance the performance even further. In terms of performance, a statement will differ depending on the types of operands. The statement will execute more slowly if one or more of the operands is a parameter, array or scalar field of Type N (numeric) or combinations of these operands. The NOC analyzes the program flow and determines which variables with one or more of these characteristics are read two or more times without being written to. It then moves the value of each variable to a temporary cache area where it can be accessed quickly under the following conditions:

- The variable is accessed often but seldom modified *and*
- The variable is an array of any type or a scalar field of Type N (numeric).

Most suitable for variable caching are programs with long sequences that repeatedly access the same variable, in particular if the variable is an array. Variable caching then avoids complex and recurring address computation.

Example of Variable Caching

The example program displayed below demonstrates the advantage of variable caching. Cataloged with NODBG (see below) and CACHE=ON, executing this program in a test environment took 47 % of the time required to execute the program with NODBG and CACHE=OFF. Cataloging the program with CACHE=ON, reduces the code generated by the NOC from 856 bytes to 376 bytes.

```
DEFINE DATA LOCAL
1 ARR(N2/10,10,10)
1 I(I4) INIT <5>
1 J(I4) INIT <6>
1 K(I4) INIT <7>
END-DEFINE
DECIDE ON EVERY ARR(I,J,K)
 VALUE 10 IGNORE
 VALUE 20 IGNORE
 VALUE 30 IGNORE
 VALUE 40 IGNORE
 VALUE 50 IGNORE
 VALUE 60 IGNORE
 VALUE 70 IGNORE
 VALUE 80 IGNORE
 VALUE 90 IGNORE
 NONE IGNORE
END-DECIDE
```

Caution: If the content of a cached variable is modified with the command MODIFY VARIABLE of the Natural Debugger, only the content of the original variable is modified. The cached value (which may still be used in subsequent statements) remains unchanged. Therefore, variable caching should be used with great care if the Natural Debugger is used. See also the *Natural Debugger* documentation.

NODBG

Once a program has been thoroughly tested and put into production, you should catalog the program with the **NODBG** option as described in the section Optimizer Options. Without debug code, the optimized statements will execute from 10% to 30% faster.

The code to facilitate debugging is removed when this option is specified, even with INDX or OVFLW options turned on.

12 Listing Zaps

If you want to have an overview of the Zaps that have been applied to the Natural Optimizer Compiler at your site, use the `DUMP` system command.

To obtain a Zap overview

- Enter the Natural system command

  ```
  DUMP ZAPS NOC
  ```

  A list of the Zaps that have been applied is displayed.

If no Zaps have been applied to the Natural Optimizer Compiler, you will receive the appropriate message.