NAG Library Routine Document

G05TCF

Note: before using this routine, please read the Users' Note for your implementation to check the interpretation of **bold italicised** terms and other implementation-dependent details.

1 Purpose

G05TCF generates a vector of pseudorandom integers from the discrete geometric distribution with probability p of success at a trial.

2 Specification

```
SUBROUTINE G05TCF (MODE, N, P, R, LR, STATE, X, IFAIL)

INTEGER          MODE, N, LR, STATE(*), X(N), IFAIL
REAL (KIND=nag_wp) P, R(LR)
```

3 Description

G05TCF generates n integers x_i from a discrete geometric distribution, where the probability of $x_i = I$ (a first success after $I + 1$ trials) is

$$P(x_i = I) = p \times (1 - p)^I, \qquad I = 0, 1, \ldots.$$

The variates can be generated with or without using a search table and index. If a search table is used then it is stored with the index in a reference vector and subsequent calls to G05TCF with the same parameter value can then use this reference vector to generate further variates. If the search table is not used (as recommended for small values of p) then a direct transformation of uniform variates is used.

One of the initialization routines G05KFF (for a repeatable sequence if computed sequentially) or G05KGF (for a non-repeatable sequence) must be called prior to the first call to G05TCF.

4 References

Knuth D E (1981) *The Art of Computer Programming (Volume 2)* (2nd Edition) Addison–Wesley

5 Parameters

1:     MODE – INTEGER   *Input*

On entry: a code for selecting the operation to be performed by the routine.

MODE = 0
    Set up reference vector only.

MODE = 1
    Generate variates using reference vector set up in a prior call to G05TCF.

MODE = 2
    Set up reference vector and generate variates.

MODE = 3
    Generate variates without using the reference vector.

Constraint: MODE = 0, 1, 2 or 3.

2:      N – INTEGER   *Input*

    On entry: n, the number of pseudorandom numbers to be generated.

    Constraint: N $\geq$ 0.

3:      P – REAL (KIND=nag_wp)   *Input*

    On entry: the parameter p of the geometric distribution representing the probability of success at a single trial.

    Constraint: **machine precision** $\leq$ P $\leq$ 1.0 (see X02AJF).

4:      R(LR) – REAL (KIND=nag_wp) array   *Communication Array*

    On entry: if MODE = 1, the reference vector from the previous call to G05TCF.

    If MODE = 3, R is not referenced by G05TCF.

    On exit: the reference vector.

5:      LR – INTEGER   *Input*

    On entry: the dimension of the array R as declared in the (sub)program from which G05TCF is called.

    Suggested value:

          if MODE $\neq$ 3, LR = 8 + 42/P approximately (see Section 8);
          otherwise LR = 1.

    Constraints:

          if MODE = 0 or 2, LR $\geq$ 30/P + 8;
          if MODE = 1, LR should remain unchanged from the previous call to G05TCF.

6:      STATE($*$) – INTEGER array   *Communication Array*

    Note: the actual argument supplied must be the array STATE supplied to the initialization routines G05KFF or G05KGF.

    On entry: contains information on the selected base generator and its current state.

    On exit: contains updated information on the state of the generator.

7:      X(N) – INTEGER array   *Output*

    On exit: the n pseudorandom numbers from the specified geometric distribution.

8:      IFAIL – INTEGER   *Input/Output*

    On entry: IFAIL must be set to 0, -1 or 1. If you are unfamiliar with this parameter you should refer to Section 3.3 in the Essential Introduction for details.

    For environments where it might be inappropriate to halt program execution when an error is detected, the value -1 or 1 is recommended. If the output of error messages is undesirable, then the value 1 is recommended. Otherwise, if you are not familiar with this parameter, the recommended value is 0. **When the value -1 or 1 is used it is essential to test the value of IFAIL on exit.**

    On exit: IFAIL = 0 unless the routine detects an error or a warning has been flagged (see Section 6).

6 Error Indicators and Warnings

If on entry IFAIL $= 0$ or -1, explanatory error messages are output on the current error message unit (as defined by X04AAF).

Errors or warnings detected by the routine:

IFAIL $= 1$

On entry, MODE $\neq 0$, 1, 2 or 3.

IFAIL $= 2$

On entry, N < 0.

IFAIL $= 3$

On entry, P < 0.0 or P > 1.0,
or MODE $= 0$ or 2 and P is so small that LR would have to be larger than the largest representable integer. Use MODE $= 3$ in this case.

IFAIL $= 4$

On entry, P is not the same as when R was set up in a previous call to G05TCF with MODE $= 0$ or 2.

On entry, the R vector was not initialized correctly or has been corrupted.

IFAIL $= 5$

On entry, LR is too small when MODE $= 0$ or 2.

IFAIL $= 6$

On entry, STATE vector was not initialized or has been corrupted.

7 Accuracy

Not applicable.

8 Further Comments

The time taken to set up the reference vector, if used, increases with the length of array R. However, if the reference vector is used, the time taken to generate numbers decreases as the space allotted to the index part of R increases. Nevertheless, there is a point, depending on the distribution, where this improvement becomes very small and the suggested value for the length of array R is designed to approximate this point.

If P is very small then the storage requirements for the reference vector and the time taken to set up the reference vector becomes prohibitive. In this case it is recommended that the reference vector is not used. This is achieved by selecting MODE $= 3$.

9 Example

This example prints 10 pseudorandom integers from a geometric distribution with parameter $p = 0.001$, generated by a single call to G05TCF, after initialization by G05KFF.

9.1   Program Text

```
     Program g05tcfe

!    G05TCF Example Program Text

!    Mark 24 Release. NAG Copyright 2012.

!      .. Use Statements ..
       Use nag_library, Only: g05kff, g05tcf, nag_wp, x02amf
!      .. Implicit None Statement ..
       Implicit None
!      .. Parameters ..
       Integer, Parameter               :: lseed = 1, maxlr = 5000, nin = 5,    &
                                           nout = 6
!      .. Local Scalars ..
       Real (Kind=nag_wp)               :: p
       Integer                          :: genid, ifail, lr, lstate, mode, n,   &
                                           subid
!      .. Local Arrays ..
       Real (Kind=nag_wp), Allocatable  :: r(:)
       Integer                          :: seed(lseed)
       Integer, Allocatable             :: state(:), x(:)
!      .. Intrinsic Procedures ..
       Intrinsic                        :: int
!      .. Executable Statements ..
       Write (nout,*) 'G05TCF Example Program Results'
       Write (nout,*)

!    Skip heading in data file
       Read (nin,*)

!    Read in the base generator information and seed
       Read (nin,*) genid, subid, seed(1)

!    Initial call to initialiser to get size of STATE array
       lstate = 0
       Allocate (state(lstate))
       ifail = 0
       Call g05kff(genid,subid,seed,lseed,state,lstate,ifail)

!    Reallocate STATE
       Deallocate (state)
       Allocate (state(lstate))

!    Initialize the generator to a repeatable sequence
       ifail = 0
       Call g05kff(genid,subid,seed,lseed,state,lstate,ifail)

!    Read in sample size
       Read (nin,*) n

!    Read in the distribution parameters
       Read (nin,*) p

!    Use suggested value for LR
       If (p<x02amf()) Then
!      P is too close to 0.0 to calculate LR, so
!      set to MAXLR, which means we will use MODE = 3
         lr = maxlr
       Else
         lr = int(8.0E0_nag_wp+4.2E1_nag_wp/p)
       End If

!    If R is a reasonable size use MODE = 2
!    else do not reference R and use MODE = 3
       If (lr<maxlr) Then
         mode = 2
       Else
         mode = 3
         lr = 0
```

```
      End If

      Allocate (x(n),r(lr))

!     Generate the variates
      ifail = 0
      Call g05tcf(mode,n,p,r,lr,state,x,ifail)

!     Display the variates
      Write (nout,99999) x(1:n)

99999 Format (1X,I12)
    End Program g05tcfe
```

9.2   Program Data

```
G05TCF Example Program Data
1  1  1762543     :: GENID,SUBID,SEED(1)
10                :: N
0.001             :: P
```

9.3   Program Results

```
 G05TCF Example Program Results

          451
         2238
          292
          225
         2256
          708
          955
          239
          696
          397
```

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