

F11XBFP

NAG Parallel Library Routine Document

Note: Before using this routine, please read the Users' Note for your implementation to check for implementation-dependent details. You are advised to enclose any calls to NAG Parallel Library routines between calls to Z01AAFP and Z01ABFP.

1 Description

Note: you should read the F11 Chapter Introduction before using this routine.

F11XBFP computes either the matrix-vector product $y = Ax$, or the transposed matrix-vector product $y = A^T x$, where A is an n by n real sparse matrix represented in coordinate storage format, distributed on a logical grid of processors in cyclic row block form. The routines F11ZAFP and F11XAFP must be called prior to F11XBFP to set up auxiliary information in the array IAINFO.

2 Specification

```

SUBROUTINE F11XBFP(ICNTXT, TRANS, N, NNZ, A, IROW, ICOL, CHECK, X,
1                Y, IAINFO, WORK, IFAIL)
  INTEGER          ICNTXT, N, NNZ, IROW(*), ICOL(*), IAINFO(*),
1                IFAIL
  DOUBLE PRECISION A(*), X(*), Y(*), WORK(*)
  CHARACTER*1      TRANS, CHECK

```

3 Data Distribution

3.1 Definitions

The following definitions are used in describing the data distribution within this document:

- M_b – the blocking factor for the distribution of the rows of the matrix.
- m_l – the number of rows of the matrix assigned to the calling processor (= IAINFO(3), see IAINFO).
- n_{int}^i – the number of internal interface indices (see Section 2.6 of the F11 Chapter Introduction) for the calling processor (= IAINFO(6), see IAINFO).
- n_{int}^e – the number of external interface indices (see Section 2.6 of the F11 Chapter Introduction) for the calling processor (= IAINFO(7), see IAINFO).

3.2 Global and Local Arguments

The input arguments TRANS, N, CHECK and IFAIL are global and so must have the same value on entry to the routine on each processor. The output argument IFAIL is global and so will have the same value on exit from the routine on each processor. The remaining arguments are local.

3.3 Distribution Strategy

Blocks of M_b contiguous rows of the matrix A are stored in coordinate storage format on a logical grid of processors cyclically row by row (i.e., in the row major ordering of the grid) starting from the $\{0, 0\}$ logical processor.

The vectors x and y are distributed conformally to the matrix A , i.e., x and y are distributed across the logical processor grid in the same way as each of the columns of the matrix A is distributed.

These data distributions are described in more detail in Section 2.5 of the F11 Chapter Introduction.

This routine assumes that the data has already been correctly distributed, and if this is not the case will fail to produce correct results. However, the Library provides utility routines, F01YAFP and F01YAFP, which assist you in distributing the data correctly. Descriptions of these routines can be found in Chapter F01 of the NAG Parallel Library.

4 Arguments

- 1:** ICNTXT — INTEGER *Local Input*
On entry: the BLACS context used by the communication mechanism, usually returned by a call to Z01AAFP.
- 2:** TRANS — CHARACTER*1 *Global Input*
On entry: specifies whether or not the matrix A is transposed:
 if TRANS = 'N', then $y = Ax$ is computed;
 if TRANS = 'T', then $y = A^T x$ is computed.
Constraint: TRANS = 'N' or 'T'.
- 3:** N — INTEGER *Global Input*
On entry: the order of the matrix A , n . It must contain the same value as the parameter N used in a prior call of F11ZAFP in which the array IAINFO was initialised.
Constraint: $N \geq 1$.
- 4:** NNZ — INTEGER *Local Input*
On entry: the number of non-zero elements in the matrix A stored on the calling processor. It must contain the same value as the parameter NNZ returned from a prior call of F11ZAFP in which the array IAINFO was initialised.
Constraint: $NNZ \geq 0$.
- 5:** A(*) — DOUBLE PRECISION array *Local Input*
Note: the dimension of the array A must be at least $\max(1, NNZ)$.
On entry: the non-zero elements in the blocks of the matrix A assigned to the calling processor. The local non-zero elements must have been reordered by a prior call of F11ZAFP.
- 6:** IROW(*) — INTEGER array *Local Input*
7: ICOL(*) — INTEGER array *Local Input*
Note: the dimension of the arrays IROW and ICOL must be at least $\max(1, NNZ)$.
On entry: the local row and column indices of the non-zero elements supplied in the array A. The contents of the arrays IROW and ICOL **must not** be changed between successive calls to library routines involving the matrix A .
- 8:** CHECK — CHARACTER*1 *Global Input*
On entry: specifies whether or not the validity of the arguments passed to F11XBFP should be checked:
 if CHECK = 'C', checks are carried on all arguments of F11XBFP;
 if CHECK = 'N', none of these checks are carried out.
 See also Section 6.3.
Constraint: CHECK = 'C' or 'N'.
- 9:** X(*) — DOUBLE PRECISION array *Local Input*
Note: the dimension of the array X must be at least $\max(1, m_l)$.
On entry: the local part of the vector x .
- 10:** Y(*) — DOUBLE PRECISION array *Local Output*
Note: the dimension of the array Y must be at least $\max(1, m_l)$.
On exit: the local part of the vector y .

11: IAINFO(*) — INTEGER array*Local Input*

Note: the dimension of the array IAINFO must be at least $\max(2, \text{IAINFO}(2))$.

On entry: the first IAINFO(2) elements of IAINFO contain auxiliary information about the matrix A . The array IAINFO must be initialised by a prior call of F11ZAFP, and additional information must be stored in IAINFO by a prior call of F11XAFP. The first IAINFO(2) elements of IAINFO must not be changed between successive calls to library routines involving the matrix A . See Section 3.2 of the F11 Chapter Introduction.

Note: On exit from F11ZAFP, the element IAINFO(3) contains m_l , the number of rows of the matrix assigned to the calling processor, and the elements IAINFO(6) and IAINFO(7) contain n_{int}^i and n_{int}^e , the number of internal and external interface indices (see Section 2.6 of the F11 Chapter Introduction) for the calling processor, respectively.

12: WORK(*) — DOUBLE PRECISION array*Workspace*

Note: the dimension of the array WORK must be at least $\max(1, n_{int}^i, n_{int}^e)$.

13: IFAIL — INTEGER*Global Input/Global Output*

On entry: IFAIL must be set to 0, -1 or 1. For users not familiar with this parameter (described in the Essential Introduction) the recommended values are:

IFAIL = 0, if multigriding is **not** employed;
IFAIL = -1 , if multigriding is employed.

On exit: IFAIL = 0 unless the routine detects an error (see Section 5).

5 Errors and Warnings

If on entry IFAIL = 0 or -1 , explanatory error messages are output from the root processor (or processor {0,0} when the root processor is not available) on the current error message unit (as defined by X04AAF).

Errors detected by the routine:

IFAIL = -2000

The routine has been called with an invalid value of ICNTXT on one or more processors.

IFAIL = -1000

The logical processor grid and library mechanism (Library Grid) have not been correctly defined, see Z01AAFP.

IFAIL = $-i$

On entry, the i th argument had an invalid value. For global arguments, this may also be caused by an argument not having the same value on all logical processors. An explanatory message distinguishes between these two cases.

IFAIL = 1

IAINFO was not set up by prior calls of F11ZAFP and F11XAFP.

IFAIL = 2

On entry, the data stored in the arguments N, NNZ, IROW, ICOL and IAINFO is inconsistent. This indicates that, after the array IAINFO was set up by calls of F11ZAFP and F11XAFP, at least one of these arguments was changed between successive calls to library routines.

6 Further Comments

6.1 Algorithmic Detail

Algorithmic details are considered in Section 2.8 of the F11 Chapter Introduction.

6.2 Computational costs

The number of arithmetic operations performed by F11XBFP on each logical processor is approximately $2 \cdot \text{NNZ}$. The number of communication operations depends on the sparsity pattern of the matrix A and the particular row block distribution used.

6.3 Use of CHECK

It is expected that a common use of F11XBFP will be to compute the matrix-vector product required in the application of F11BBFP to sparse linear systems. In this situation F11XBFP is likely to be called many times with the same matrix A . In the interests of both reliability and efficiency you are recommended to set CHECK to 'C' for the first of such calls, and to 'N' for all subsequent calls.

7 References

- [1] Saad Y (1996) *Iterative Methods for Sparse Linear Systems* PWS Publishing Company, Boston, MA

8 Example

See the Example Program for F11BAFP.
