Structures of data sd_nume_ddl, sd_nume_equa, sd_stockage and sd_prof_chno

Summary:

This document describes the structures of data NUME_DDL , NUME_EQUA , STORAGE and PROF_CHNO used to define the classification of the unknown factors of the linear systems and the storage of the assembled matrices and the vectors solution and second member.

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1 General information

One NUME_DDL is used to define the classification of the unknown factors (and equations) of a linear system. It is pointed out that the unknown factors of such a system are components carried by nodes of GRID (or of the late nodes of LIGREL).

The matrices which one wants to describe are square, hollow, symmetrical or not.

When a matrix is not-symmetrical, its hollow structure is symmetrical.

The classification of the unknown factors of a system is similar to that of the components of one CHAM_NO . Moreover the SD PROF_CHNO described in this document is that referred by the SD CHAM_NO [D4.06.05 - Structure of Data field].
The SD NUME_DDL also the description of the tables of storage of the values of the assembled matrices [D4.06.10 - Structure of Data contains sd_matr_asse]. One calls STORAGE this part of the structure of data.

The relations of dependence between these objects can be represented by:

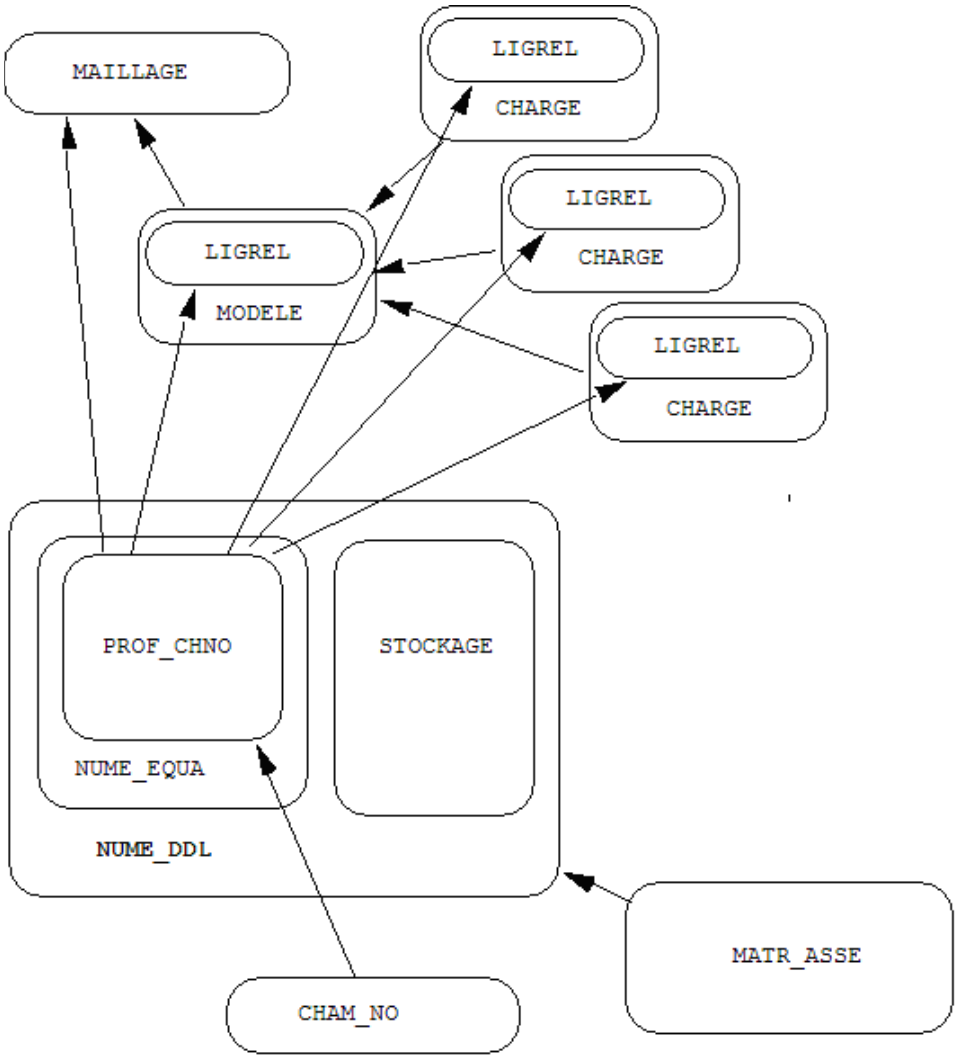

Figure 1-a: Links of the NUME_DDL, NUME_EQUA, STORAGE and PROF_CHNO with the other structures of data

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2 Tree structures

Here the tree structure of the various objects presented in this document.

```
NUME_DDL (K14):: =record
          ♦ .NUMÉRIQUE     NUME_EQUA
          ♦ .NUML       NUML_EQUA
          ♦ .NSLV       OJB S  V K24  dim=1

NUME_EQUA (K19):: =record
          ♦ .NEQU       OJB S  V I    dim=2
          ♦ .REFN       OJB S  V K24  dim=4
          ♦ .DELG       OJB S  V I

PROF_CHNO (K19):: =record
          ♦ .PRNO       OJB XC V I NUM
          ♦ .LILI       OJB S  NR K24
          ♦ .NUEQ       OJB S  V I
          ♦.DEEQ    OJB S  V I

NUML_EQUA (K19):: =record
          ♦ .JOIN       OJB S  V  I
          ♦ .PRNO       OJB XC V  I
          ♦ .NEQU       OJB S  V  I   dim=2
          ♦ .DELG       OJB S  V  I
          ♦ .NLGP       OJB S  V  I
          ♦ .NUEQ       OJB S  V  I
          ♦ .NULG       OJB S  V  I
          ♦ .NUGL       OJB S  V  I
          ♦ .PDDL       OJB S  V  I

STORAGE (K14):: =record
          ♦ .SMOS       STOC_MORSE  # to describe the initial hollow matrix
          ◊ % storage adapted to the solvor 'LDLT'
            .SLCS       STOC_LCIEL  # is used to describe the factorized matrix
          ◊ % after factorization by 'MULT_FRONT'
            .MLTF       MULT_FRONT  # to describe the factorized matrix

STOC_LCIEL (K19):: =record
          ♦ .SCBL       OJB   S  V  I
          ♦ .SCDI       OJB   S  V  I
          ♦ .SCDE       OJB   S  V  I
          ♦ .SCHC       OJB   S  V  I
          ♦ .SCIB       OJB   S  V  I
           ◊ % If storage is that adopted to factorize with LDLT:
             % line storage of sky uses classification 'RCMK'
             % storage "Morse" uses initial classification
             ♦ . M2LC     OJB   S  V  I
             ♦ .LC2M      OJB   S  V  I

STOC_MORSE (K19):: =record
          ♦ .SMDI       OJB   S  V  I
          ♦ .SMDE       OJB   S  V  I
          ♦ .SMHC       OJB   S  V  I

MULT_FRONT (K19):: =record
          ♦ .ADNT       OJB   S  V  I4
```

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♦ .GLOB OJB S V I4
♦ .LOCL OJB S V I4
♦ .PNTI OJB S V I4

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3 The object NUME_DDL

The object NUME_DDL is used to define the classification of the unknown factors (and equations) of a linear system.

```
NUME_DDL (K14):: =record
          ♦ .NUMÉRIQUE     NUME_EQUA
          ♦ .NUML       NUML_EQUA
          ♦ .NSLV       OJB S  V K24 dim=1
```

It thus contains three objects. First refers to the object NUME_EQUA (see §4):

```
NUME_DDL (1:14)/'.NUMÉRIQUE'=NUMÉRIQUE_EQUA
```

Second refers to the object NUML_EQUA (see §6):

```
NUME_DDL (1:14)/'.NUML'=NUML_EQUA
```

The last object .NSLV store the name of sd_solvor who will be used by default.

NSLV (1) : name of sd_solvor who will be used by default.

4 The object NUME_EQUA

The object NUME_EQUA refers to the classification of the equations. It contains three objects:

```
NUME_EQUA (K19):: =record
          ♦ .NEQU       OJB S  V I    dim=2
          ♦ .REFN       OJB S  V K24  dim=4
          ♦ .DELG       OJB S  V I
```

The object .REFN store some information:
- REFN (1) : name of the grid subjacent with NUME_DDL ;
- REFN (2) : name of the size simple partner (TEMP_R, DEPL_R, PRES_C,...) ;
- REFN (3) : linear solvor by default (MUMPS, MULT_FRONT);
- REFN (4) : I nutilized.

The object .NEQU store dimensions:
- NEQU (1) : full number of equations (length of .VALE nodal fields);
- NEQU (2) : full number of degrees of freedom (length of .NUEQ in PROF_CHNO).

The object .DELG described (a little) the equations of the type “Lagrange”:
- DELG (ieq) =-1 : SI the equation ieq corresponds to the component LAGR range by second node of a mesh SEG3 carrying an element of Lagrange (Lagrange 1) ;
- DELG (ieq) =-2 : if the equation ieq corresponds to the component LAGR range by the third node of a mesh SEG3 carrying an element of Lagrange (Lagrange 2);
- DELG (ieq) =0 : the equation is not of type “Lagrange”.

5 The object PROF_CHNO

The structure of data PROF_CHNO the profile of classification defines, i.e. the description of the unknown factors. In *Code_Aster*, the unknown factors are necessarily carried by nodes. Nodes of one PROF_CHNO are of two types:
- “Physical” nodes of the grid my (concerned with the model);

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- Late nodes[1] of one (or several) LIGREL who are based on the grid my.

Objects of PROF_CHNO are the following:

```
PROF_CHNO (K19):: =record
          ♦ .PRNO       OJB XC V I NUM
          ♦ .LILI       OJB S  NR K24
          ♦ .NUEQ       OJB S  V I
          ♦ .DEEQ       OJB S  V I
```

5.1 Object PRNO

The object .PRNO is a numbered contiguous collection of vector of entireties.

```
♦ .PRNO       OJB XC V I NUM
```

This collection describes which are the components carried by the nodes implied in PROF_CHNO by indicating the name of LIGREL of model and those of LIGREL with meshs and/or late nodes. If it is about one LIGREL with meshs and late nodes (DDL_IMPO , LIAISON_DDL ...), that makes it possible to identify the late nodes implied in PROF_CHNO . On the other hand, if it is about one LIGREL only with late meshs (FORCE_NODALE ...), it does not point towards any object of collection of .PRNO .
What wants to say that the object PRNO (1) inform about the degrees of freedom carried by the nodes of the grid (on which necessarily the model is based) subjacent with PROF_CHNO and that other objects of the collection .PRNO (when they exist) inform about the degrees of freedom carried by the nodes which do not belong to the grid (late nodes).

The late nodes are defined in LIGREL . With each LIGREL nomlig an object corresponds .PRNO (ili) of index ili. The number of LIGREL is that corresponding to nomlig in the pointer of name .LILI .
For example, the collection .PRNO will contain:

- .PRNO (1) : nodes of the grid my ;
- .PRNO (2) : late nodes of LIGREL whose name is in .LILI (2) ;
- .PRNO (3) : late nodes of LIGREL whose name is in .LILI (3) ;
- ...

If nec is the number of coded entireties of the size associated with PROF_CHNO :

- .PRNO (1) is length (nb_noeuds (my))* (2+nec) ;
- .PRNO (1ili) is length (nb_noeuds_tardifs (LIGREL (ili))* (2+nec).

Each node is described by two entireties and a vector of coded entireties length nec that one calls the descriptor-size [D4.06.05 - Structure of Data field].
Let us take the example of the nodes of the grid my :

- nb_cmp is the component count increased by the node ino grid;
- ieq is the address in the object .NUEQ first component carried by the node ino.

```
  v = PRNO (1)
  v  (ino-1) * (2+nec) +1) = ieq
  v  (ino-1) * (2+nec) +2) = nb_cmp
                              <.
  v  (ino-1) * (2+nec) +2+1)      |
  …                           |  Descriptor-size of the node ino
  v  (ino-1) * (2+nec) +2+nec     |
                              <
```

Note:

1 A late node in Code_Aster corresponds to a node added by a dualized limiting condition (DDL_IMPO, LIAISON_DDL,...). This node was added during the creation of the load and was stored in LIGREL corresponding to carry Lagrange. They do not appear in the structure of data grid and they have negative numbers.

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All the components carried by the same node are consecutive in .NUEQ. This is why one does not store that the address of first. The components are ordered in the order of the catalogue of the sizes. Unfortunately, size associated with .PRNO is not stored in PROF_CHNO .

5.2 Object LILI

The object .LILI is a pointer of names which gives access the elements of the collection PRNO .

♦ .LILI OJB S NR K24

By convention, one stores in LILI (1) the value &MAILLA, which wants to say that the object PRNO (1) inform about the degrees of freedom carried by the nodes of the grid subjacent with PROF_CHNO. Nevertheless the name of the grid is not stored.

Other objects of the collection .PRNO (when they exist) inform about the degrees of freedom carried by the nodes which do not belong to the grid (late nodes). These late nodes are defined in LIGREL. With each LIGREL nomlig an object corresponds .PRNO (ili). The number of LIGREL is that corresponding to nomlig in the pointer of name .LILI.

5.3 Object NUEQ

The object .NUEQ is a vector of entireties.

♦ .NUEQ OJB S V I

It is a vector of indirection between the object .PRNO and the object .VALE CHAM_NO who refer it PROF_CHNO. This vector of indirection makes it possible to be freed from the rule according to which the components of a node are followed in the order of the catalogue of the sizes but also that each component corresponds indeed to an unknown factor in NUME_DDL.
In practice, this vector is almost always the identity (NUEQ (I) =I). This case more the general mean two things:

1. There are as many unknown factors in components on the nodes corresponding to LIGREL model and on the late nodes of LIGREL late of the dualized loadings;
2. Classification is a tautology: the unknown factors are in the order of the components of the catalogue on each node.

On the following example, there are three nodes. The first node has as components DX , DY and DZ , the second node has as components DX and DY and the third node has as components DX and DZ . In this case, the object .NUEQ is such as NUEQ (I) =I :

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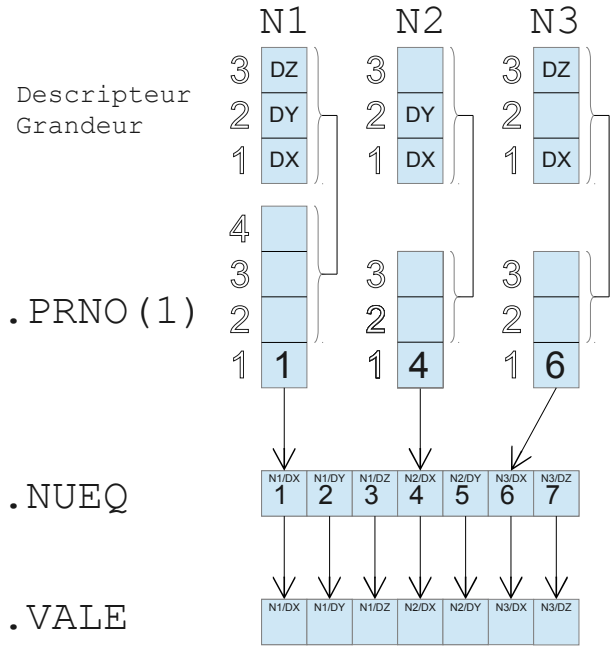

Nevertheless, this vector is not also any more commonplace in two precise cases:

- When one creates `macr_elem_stat` with an aim of separating the internal degrees of freedom from the external degrees of freedom of the macronutrient. One can then factorize the matrices partially (the part corresponding to the internal ddls);
- When one defines relations of identity between certain degrees of freedom. One uses this case in certain situations (XFEM and contact of the LAKE type).

For the first case, one always has `.NUEQ` and `.VALE` of the same length. On the other hand, the order is not inevitably the same one. For example, one takes again the preceding case by saying that node 1 must be in the last (it corresponds to a macronutrient which must be in last position to be able to profit from partial factorizations in the solvor `LDLT`). The diagram becomes the following:

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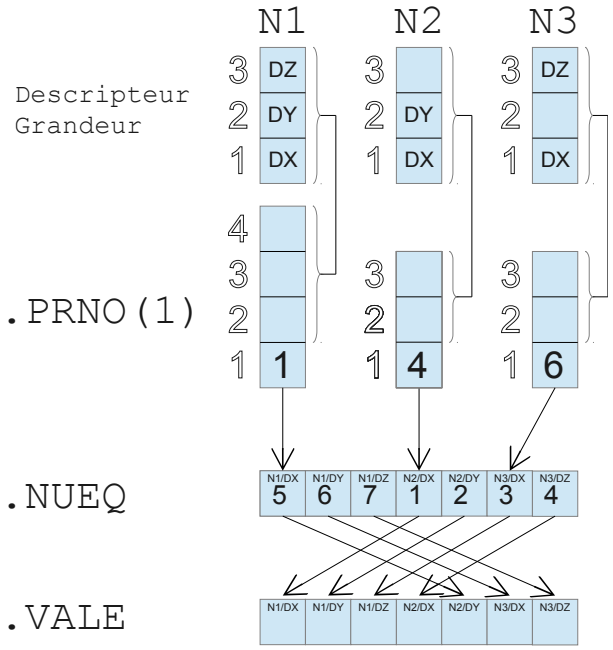
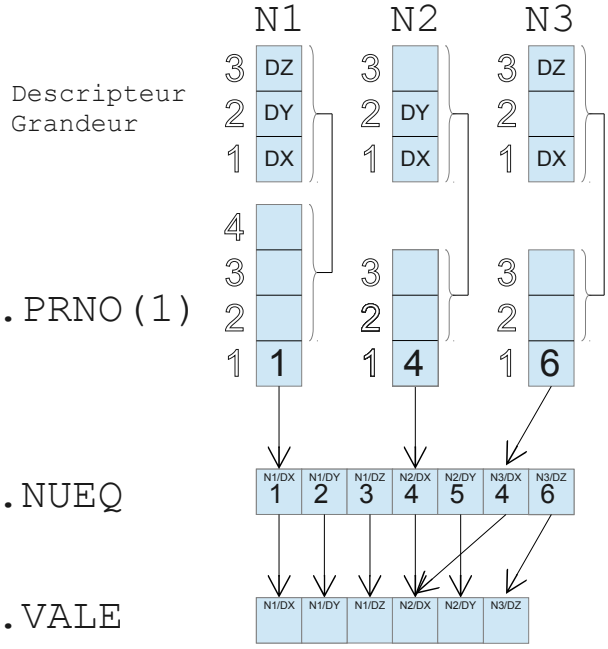


It is always a bijection enters .NUEQ and .VALE but it is not any more one tautology (NUEQ (I) ≠ I). Finally the last case is the taking into account of relation of identity between two degrees of freedom. For example, the same case is taken again, except that this time, it is written that displacement DX second node is equal to displacement DX third node.



This time, there is not any more a bijection: there is less of unknown factors than of degrees of freedom.

Note:

If the solvor is MULT_FRONT, it is checked that the vector corresponds to the identity. What means that one cannot use this solvor in the case of the static macronutrients or when there exist relations of identity between degrees of freedom. In these cases, solvor MUMPS should be used.

5.4 Object DEEQ

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The object .DEEQ is a vector of entireties length 2*neq. With neq is the number of equations of PROF_CHNO.

♦. DEEQ OJB S V I DIM=2*neq

It is a vector "reverses" .PRNO who describes (partially) the equations.
If nueq is a number of equation (i.e addresses in the object .VALE), then:
V ((nueq-1) *2+1): ino
V ((nueq-1) *2+2): ICMP
With following convention:

- If ino>0 and icmp>0 : nueq is the equation associated with ICMP^{ième} component range by the node ino grid.
- If ino>0 and icmp<0 : nueq is one of the two equations which dualisent the blocking of ICMP ^{ième} componentnode ino grid.
- If ino=0 and icmp=0 : nueq is an equation of dualisation of a linear relation between several components.

R*emarque:*
In the case of the taking into account of the relations of identity in classification, as several nodes/component correspond to the same equation, by convention, one indicates the first couple node/component.

6 The object NUML_EQUA

The object NUML_EQUA refers to the classification of the equations if the solvor used is MUMPS and that the user activated the option MATR_DISTRIBUE=' OUI'.

```
NUML_EQUA (K19):: =record
          ♦ .JOIN      OJB S  V  I
          ♦ .PRNO      OJB XC V  I
          ♦ .NEQU      OJB S  V  I   dim=2
          ♦ .DELG      OJB S  V  I
          ♦ .NLGP      OJB S  V  I
          ♦ .NUEQ      OJB S  V  I
          ♦ .NULG      OJB S  V  I
          ♦ .NUGL      OJB S  V  I
          ♦ .PDDL      OJB S  V  I
```

♦ .JOIN
This vector is dimensioned with the number of couplings of the graph of communication. For each coupling, one finds the processor in link with the current processor. If the value is -1 then the processor running does not take part in this coupling.

♦ .PRNO
This object is identical (in its architecture) to .PRNO of one PROF_CHNO The difference lies in the fact that the classification of the degrees of freedom is local for the processor considered.

♦ .NEQU
- NEQU (1) : local number of equations (length of .VALE nodal fields);
- NEQU (2) : local number of degrees of freedom (length of .NUEQ in PROF_CHNO).

♦ Local .DELG dim=neq
This object is similar to the object .DELG of one NUME_EQUA.

♦ .NLGP

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This vector provides the total number of the ddl for PETSc. This solvor needs contiguous blocks of lines. With this intention, one adapts classification for him.

♦ Local .NUEQ dim=neq
It is a vector of indirection between the object .PRNO and the object .VALE CHAM_NO. See .NUEQ of one NUME_EQUA.

♦ .NULG
It is a vector of indirection which makes it possible to pass from the local classification of the degrees of freedom (of .NUML) with the total classification (of .NUMÉRIQUE)

♦ .NUGL
It is a vector of indirection which makes it possible to pass from the total classification of the degrees of freedom (of .NUMÉRIQUE) with the local classification (of .NUML)

♦ .PDDL
It is a vector which makes it possible to know by which processor are had the local ddl.

7 The object STORAGE

The hollow matrices of Code_Aster have a whole a symmetrical structure: if has (I, J) exist, then has (J, I) also exist.

For a hollow symmetrical matrix, one stores only his “higher” part (has (I, J) for J≥I). The structure of data STORAGE described how the nonworthless terms of the upper part of matrix are stored.

For a nonsymmetrical matrix, one stores the upper part and the lower part. As these 2 parts have the same structure (except for a transposition), the storage of the upper part is enough.

Note:
Although theoretically, the nonworthless terms of a matrix can be had unspecified way, the filling of the matrices of Code_Aster is such as all DDLs carried by a node are connected to all DDLs carried by the other nodes being next to this node via a finite element. The matrix is thus formed small rectangles full corresponding to connectivity with the nodes of the model. In particular, there exist small blocks on all the diagonal of the matrix.

7.1 The object STOC_LIGN_CIEL

For the online storage of sky, the objects are the following:

```
STOC_LCIEL (K19):: =record
          ♦ .SCBL       OJB   S  V  I
          ♦ .SCDI       OJB   S  V  I
          ♦ .SCDE       OJB   S  V  I
          ♦ .SCHC       OJB   S  V  I
          ♦ .SCIB       OJB   S  V  I
          ◊ . M2LC      OJB   S  V  I
          ◊ .LC2M       OJB   S  V  I
```

.SCDE	S V I dim=4	
	(1) (2) (3) (4)	many equations neq size of the blocks of the matrix t_bloc number of blocks necessary to the storage of the values of the matrix n_bloc maximum height of the columns of the matrix
.SCHC	S V I dim=neq	

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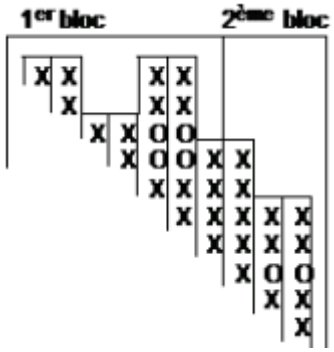
	(I)	height of I^{ème} column
.SCDI	S V I dim=neq	
	(I)	address of the diagonal term of I^{ème} column in its block
.SCBL	S V I dim=n_bloc+1	
	(1) (K+1)	0 number of the last column of the block K notice : a column can belong only to one block
.SCIB	S V I dim=neq	
	(I)	number of the block which contains I ^{ème} column of the matrix
. M2LC	S V I dim=neq	
	ieq_m	ieq_lc : give the correspondence between the classification of storage “Morse” (ieq_m) and the classification of storage “line of sky” (ieq_lc)
.LC2M	S V I dim=neq	
	ieq_lc	ieq_m : give the correspondence between the classification of storage “line of sky” (ieq_lc) and the classification of storage “Morse” (ieq_m)

Example:




```
SCDI (1)  =     1                SCDI (6)      =   17
SCDI (2)  =     3                SCDI (7)      =   22
SCDI (3)  =     4                SCDI (8)      =   6
SCDI (4)  =     6                SCDI (9)      =   11
SCDI (5)  =     11               SCDI (10)     =   17

SCHC (1)  =     1                SCHC (6)      =   6
SCHC (2)  =     2                SCHC (7)      =   5
SCHC (3)  =     1                SCHC (8)      =   6
SCHC (4)  =     2                SCHC (9)      =   5
SCHC (5)  =     5                SCHC (10)     =   6

SCBL (1)  =     0                SCIB (1 to 7)  =   1
SCBL (2)  =     7                SCIB (7 to 10) =   2
SCBL (3)  =     10
```

7.2 The object STOC_MORSE

For Morse storage, the objects are the following:

```
STOC_MORSE (K19):: =record
```

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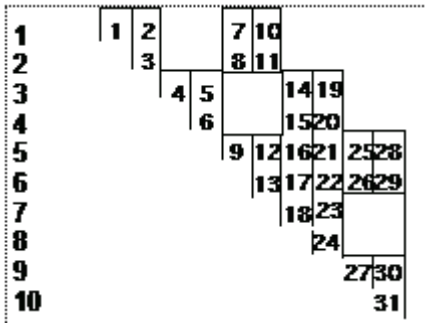
```
        ♦ .SMDI       OJB    S  V  I
        ♦ .SMDE       OJB    S  V  I
        ♦ .SMHC       OJB    S  V  I
```

.SMDE	S V I dim=3	
	(1) (2) (3)	many equations neq many terms stored in the half-matrix n_termes number of block 1
.SMHC	S V I dim=n_termes	
	(I)	number of line of I^{ème} stored term
.SMDI	S V I dim=neq	
	(I)	address of the diagonal term of I^{ème} column in the block It is necessary thus that all the diagonal terms are stored in the matrix

Example:




```
 SMDI (1)  =   1       SMDI (6)  =   13
 SMDI (2)  =   3       SMDI (7)  =   18
 SMDI (3)  =   4       SMDI (8)  =   24
 SMDI (4)  =   6       SMDI (9)  =   27
 SMDI (5)  =   9       SMDI (10) =   31

SMHC (1)  =   1
SMHC (2)  =   1
SMHC (3)  =   2
SMHC (4)  =   3
SMHC (5)  =   3
SMHC (6)  =   4
SMHC (7)  =   1
SMHC (8)  =   2
SMHC (9)  =   5
…
SMHC (28) =   5
SMHC (29) =   6
SMHC (30) =   9
SMHC (31) =  10
```

7.3 The object MULT_FRONT

For storage MULT_FRONT., the objects are the following:

```
MULT_FRONT (K19):: =record
          ♦ .ADNT       OJB    S  V  I4
          ♦ .GLOB       OJB    S  V  I4
```

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- .LOCL OJB S V I4
- .PNTI OJB S V I4

That is to say lgind , the sum amongst neighbors of the super-nodes.

- .GLOB OJB S V I4 dim=lgind
  This vector gives the whole of the neighbors of the super-nodes
- .LOCL OJB S V I4 dim=lgind
  This vector establishes for the numbers of lines of the super-nodes, the correspondence between the local classification of the son and the local classification of the father.
- .ADNT OJB S V I4 dim=matr_init
  Dimension matr_init is the size of the initial matrix (Morse). It is the vector of the addresses of the initial terms in the factorized matrix.
- .PNTI OJB S V I4 dim= 19*neq+10
  Office plurality in the same vector of a succession of work tables.

8 Examples

An example of NUME_DDL associated to the three linear solveurs ('LDLT', 'MULT_FRONT', 'GCPC') in the document [D4.06.10 - Structure of Data is given sd_matr_asse].

Warning : The translation process used on this website is a "Machine Translation". It may be imprecise and inaccurate in whole or in part and is provided as a convenience.
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