Descriptor of environment machine: ENVIMA

Summary:

One presents in this document the functions allowing to recover the characteristic values whole or real dependent on the platform used. Were added some constant mathematics and certain parameters related to the core use and files.

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Contents

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1 General presentation and justification

The definition of the types real and double precision by the standard FORTRAN 77 does not allow to carry out portable scientific software, with unicity of source and of the comparable digital performances [bib1], [bib2]. FORTRAN 90 integrate the concept length at the time of the declaration of the various types but unfortunately this does not bring any insurance as for the real precision used, the latter depending on the implementation of the compiler.

Standard IEEE-P745 [3] defines the terminals of binary precision but is not applied by all:

type	significant figures	
	always	sometimes
single precision	6	7 or 8
double precision	15	16
simple extent	>9	-
double extent	>18	-

It is thus necessary to compensate for the imperfections of the standard FORTRAN 77, which does not fix rules of representation of the numbers, although there exist suitable algorithms making it possible to determine certain parameters dynamically.

This version ofENVIMA is resulting from a preceding realization going back to 1990 which appeared too plentiful, from many functions not having never been used in *Code_Aster*. Their realization in FORTRAN was replaced by a code written out of C allowing to gather them with the whole of the functions presenting of adherences to the machines and/or the operating systems. On this occasion, the functions of the type complexes of which the use was marginal, and who present a real difficulty of portability the existing complex type in FORTRAN but not out of C, were purely removed.

The software package ENVIMA gather several functions without arguments, of name – EM, which makes it possible to reach, starting from any routine FORTRAN, with the parameters necessary characterizing the machine on which the treatment is carried out.

The parameters are statically defined in each version of the software package for:
- entireties: length, values extreme;
- logics: length;
- the floating ones: base system of representation, length of the mantissa, relative precision, representable extreme values;
- constants: particular constants (π , Not.);
- files: limiting sizes (related to constraints of exploitation of the machines).

Four groups of functions are available:
- arithmetic parameters (definition of the numbers),
- parameters for the core use central,
- parameters for the core use auxiliary (files),
- values of constants.

Some definitions:
- **Unit of addressing** : Each manufacturer defines for a machine a mode of addressing of information in memory; the measuring unit of this address is the unit of addressing: the word was used formerly on certain platforms, it is now the byte on most workstations containing processors x86.

- **Length** : Chaque type of variable is characterized by a length of representation out of machine; this one can to be measured out of bits, bytes or units of addressing. The manager of memory JEVEUX

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used in *Code_Aster* this information at the time of the definition of the attribute of the type requires of objects created.

1.1 Arithmetic parameters

1.1.1 Representation of the integers

Four parameters are available for the variables of the whole type standard (`integer`):
- the length of an entirety measured out of bits, bytes, or units of addressing;
- the maximum number of significant figures to represent the number into decimal;
- the representable maximum value i.e. greatest positive entirety i such as all the entireties of the interval $[-i,+i]$ are represented by the whole type;
- range defined by the greatest entirety i such as:
  - $-i$ that is to say exact,
  - for formula $-i<i_a,i_b<+i$ the operation formulates $|i_a \oplus i_b|$ with formula $\oplus \in \{+,-,*\}$: that is to say exact and formula does not exceed i in absolute value.

1.1.2 Representation of the real numbers

The definition of the standard real type in the standard `FORTRAN 77` does not allow to carry out portable software with unicity of source and comparable digital performances. To achieve this goal, we chose to use in the whole of *Code_Aster* the type except standard `REAL*8`, admitted by very many compilers and which leads to the closest representations (`64 bits` on any punt forms).

One can give the following impression of the representation machine of the floating numbers:

$x=\sigma\, B^E \sum_{k=1}^{N} x(k)\, B^{-k}$ where x indicate a real number,

σ the sign,

B the base of representation (2 most of the time),

E the exhibitor ($E_{min} \le E < E_{max}$),

N the number of digits allocated with the mantissa.

This representation imposes obviously $0<x(1)<B$ and $0<x(i)<B$ for $1<i<N$. It is thus noted that two distinct realities x_1 and x_2 the representation above is written with the same exhibitor E can differ at least from B^N . When the exhibitor differs from a unit, the difference between two realities is at least of B^{1-N} .
Values B, N, E_{min} and E_{max} were introduced into the software and can be recovered by the adequate function.

It is then easy to define the following characteristic values: smallest positive reality: $B^{E_{min}-1}$, greatest positive reality: $B^{E_{max}}(1-B^N)$, the smallest relative increment: B^{-N} , the greatest relative increment: B^{1-N}

The parameters available are:
- the length out of bits, bytes or units of addressing;
- the maximum number of significant figures to represent the number into decimal;
- the base of representation B of the floating numbers;
- the length of the mantissa;
- the relative precision is such as any reality other than `1.0` is not represented by: formula $1.0-\varepsilon_1<1.0<1.0+\varepsilon_2$ with $\varepsilon_1=(1/b)\varepsilon_2$
- representable positive extreme values: maximum (overflow) and minimum (underflow);
- the range is defined by greatest reality such as if $\varepsilon_1, \varepsilon_2, \varepsilon_3$ are about the relative precision formulates ε_1 :

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- formula $-x$ that is to say correctly representable by formula $-x(1.\pm\varepsilon_1)$;
- for formula $1/x<|a|,|b|<x$ the operation formulates $a\oplus b$ with $\oplus\in\{+,-,*,/\}$ is such as formula $1/x<|a\oplus b|<x$ is correctly represented by formula $a(1\pm\varepsilon_2)\oplus b(1\pm\varepsilon_3)$.

1.1.3 Representation of logics

Only one parameter is necessary:
- the length in bytes.

1.2 Special values

The actual value `Not` (Not has Number) can be obtained on the machines supporting arithmetic `IEEE`. Historically on waiters CRAY the value used was `UNDEF`, it could apply to floating but too with the entireties. This value is used in certain cases (search for bug) to reset the zones memory associated with the objects managed by `JEVEUX`.
The assignment of variables by the value `Not` then allows to detect their use in floating operations because it immediately causes a stop of the code with emission of a signal (handler) which can be recovered.

1.3 Parameter related to the core use central

The length in bytes of the unit of addressing of the machine is the only accessible parameter.

1.4 Parameters of use of the files

Two parameters are available:
- maximum size in bytes of a file,
- maximum size in bytes of the whole of the open files.

They were introduced only because of the constraints related to the exploitation of shared resources (on the waiter centralized aster, limitation of the temporary space of files associated with a batch processing) and are used in the management of the files of binary direct access of the manager of memory.

1.5 Constant mathematics

A set of universal constants (optimal in the type requested) is provided to the user.
These constants are (currently):
- values of π and of 2π ,
- the value of the absolute zero for the temperature,
- parameters of conversion radian/degree and degree/radian.

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2 Provided functions and their use

2.1 General information

To help with the use of these functions, one endeavoured to codify the name of the functions starting from three components:

- nature GG size:
  - LB length out of bits,
  - LO length in bytes,
  - MY maximum positive value,
  - SEMI minimal positive value,
  - GA range of values.

- The type All size to which it applies:
  - IS INTEGER (entirety),
  - LS LOGICAL (logic),
  - R8 REAL*8 (reality),
  - C8 COMPLEX*8 (complex).

- The suffix EM (Environment Machine).

For the parameters length (l_) the functions are of whole type. The names of function are form: GGTTEM.

For the parameters whose value depends on the type, the type of the function will be that of the required value. In this case the names of function are form: TTGGEM.

Since these functions are not part of the intrinsic functions of the language, it is essential to declare their type in each unit of program user.

2.2 Logical type

- Standard logical type (LOGICAL)

Type of the function	Provided parameter	Function ENVIMA	Platform 64 bits	Platform 32 bits
INTEGER	Length in bytes	**LOLSEM**	8	4

2.3 Whole type

- Standard whole type (INTEGER)

Type of the function	Provided parameter	Function ENVIMA	Platform 64 bits	Platform 32 bits
INTEGER	Length in bytes	**LOISEM**	8	4
INTEGER	Maximum value	**ISMAEM**	formula $2^{63}-1$	formula $2^{31}-1$ 2147483647

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2.4 Real type

- Standard real type (REAL*8)

Type of the function	Provided parameter	Function ENVIMA	Platform 64 bits	Platform 32 bits
REAL*8	Relative precision	**R8PREM**	2.220D-16	2.220D-16
REAL*8	Maximum value	**R8MAEM**	1.798D+308	1.798D+308
REAL*8	Minimal value	**R8MIEM**	2.225D-308	2.225D-308
REAL*8	Range	**R8GAEM**	1.340D+154	1.340D+154

2.5 Parameters of use of the files

These parameters are used in reasons of constraints of exploitation on the waiters whose resources are shared. The bases (files glob.i and vola.i) are in general created on a limited shared space (/tmp).

Type of the function	Provided parameter	Function ENVIMA	Platform 64 bits	Platform 32 bits
INTEGER	Maximum length of a file in bytes	**LOFIEM**	12582912	2048000
INTEGER	Cumulated size of the files in bytes	**MOFIEM**	50331648	50331648

2.6 Assignment of binary constants

For the construction of masks on the numerical information, it is necessary to reach the weights of the bits quickly. Those are accessible by the whole function ISPBEM (number of the bit).

ISPBEM (4) = 00000000000000000000000000001000 = $2^{4-1} = 8$

2.7 Assignment of constant mathematics or physics

The particular constants are accessible starting from the type from the required variable:

Type of the function	Provided parameter	Function ENVIMA	Value
REAL*8	π	**R8PI**	3.141592653589793D+00
REAL*8	2π	**R8DEPI**	6.283185307179586D+00
REAL*8	Conversion radian/degree	**R8DGRD**	1.745329251994330D-02
REAL*8	Conversion degree/radian	**R8RDDG**	5.729577951308232D+01
REAL*8	Absolute zero (temperature)	**R8T0**	273.15

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2.8 Particular values

These values are available on all the machines having arithmetic IEEE.

Type of the function	Provided parameter	Function ENVIMA	Value
INTEGER	Value aggressive an error at the time of a floating operation	**ISNNEM**	9223372036854775807.
REAL*8	Value aggressive an error at the time of a floating operation	**R8NNEM**	Not
REAL*8	Value of initialization of the structures of data	**R8VIDE**	1.797693134862316+308

2.9 Utility

Subroutine FORTRAN IMPVEM allows to publish overall the various values characteristic of the processing machine on the file of logical number of unit IUL. An example is given in appendix.

CAL IMPVEM (IUL) : print all the characteristics of the standard types.

2.10 Precautions for use

Since these functions are not part of the intrinsic functions of the language, it is essential to declare their type in each unit of program user. In this case the names of function are TTGGEM with All type of the function and GG nature of the size (*cf.* example of use).

Note:

The values concerning the entireties are in the whole implicit type (functions starting with a letter L or N).

Functions ENVIMA are available in the library C utilitai of *Code_Aster*, and are pressed for the majority on the standard bookstores C : files of heading <limits.h> and <float.h> [bib4].

By definition any operation of bearing of a subset of Code_Aster on other materials requires the preliminary bearing ofENVIMA. The use of the standard headings notably limits a research deepened in the documentation of the manufacturer.

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4 Appendix: Portability and Effectiveness

If software written with ENVIMA are portable, ENVIMA is not portable: it requires a rewriting by using the directives of the pre processor C.

Rules of use of the functions ofENVIMA are the same ones as for any call of function which must be done out of internal loops.

The effectiveness is increased with regard to the homogenisation and the portability of the code which sees disappearing from all the routines of the instructions (or from DATED) specific to the machine.

The effectiveness is increased with regard to the digital resolution thanks to the values which as well as possible define the precision, the maximum and the minimum, the range of use.

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5 Appendix: Result of the subroutine impvem

The following impressions are the result of under program impvem, they can be easily obtained by using the command file *Code_Aster* according to:

```
BEGINNING (DEBUG=_F (ENVIMA=' TEST'));
END ();
```

See the file result case test ZZZZ103.

The file result produced on a platform Calibre6 (fort.8) contains the various characteristic values printed in a decimal and hexadecimal format.

```
-------------------------------------------------
---- ENVIMA VERSION 97 MULTI MACHINES    --------
-------------------------------------------------
----- LENGTH OUT OF BITS

 LBISEM  ENTIRETY   INTEGER               64

 ----- LENGTH IN BYTES

 LOLSEM  LOGIC  LOGICAL               8
 LOISEM  ENTIRETY   INTEGER               8
 LOR8EM  REALITY     REAL*8                8
 LOC8EM  COMPLEX COMPLEX*16           16

 ----- LENGTH AND SIZE OF FILE

 LOFIEM  IN BYTES                      12582912
 MOFIEM  IN BYTES                      50331648

 ----- STANDARD ENTIRETY

 ISMAEM  ENTIRETY   INTEGER              9223372036854775807  7FFFFFFFFFFFFFFF
 ISNNEM  ENTIRETY   INTEGER              9223372036854775807  7FFFFFFFFFFFFFFF

 ----- REAL*8


 FORMAT Of IMPRESSION OF FLOATING (1X, A, 1PD24.15, 2X, Z16)

 R8BAEM  BASE NUMERATION    REAL*8        2.000000000000000D+00  4000000000000000
 R8PREM  RELATIVE PRECISION REAL*8        2.220446049250313D-16  3CB0000000000000
 R8MAEM  MAXIMUM            REAL*8        1.797693134862316+308  7FEFFFFFFFFFFFFF
 R8MIEM  MINIMAL            REAL*8        2.225073858507201-308    10000000000000
 R8GAEM  RANGE              REAL*8        1.340780792994259+154  5FEFFFFFFFFFFFFE
   R8NNEM      NOT   WITH   NUMBER                     REAL*8                  Not
FFF7FFFFFFFF0000
  R8VIDE   VACUUM                        REAL*8             1.797693134862316+308
7FEFFFFFFFFFFFFF
  RMIREM   B  **  -  T                                     1.110223024625157D-16
3CA0000000000000
  RMAREM   B  **  (1-T)                                    2.220446049250313D-16
3CB0000000000000
  RMINEM   B  **  (EMIN-1)                                 2.225073858507201-308
10000000000000
  RMAXEM   B  **  EMAX  (1-B  **  (-  T))                  8.988465674311579+307
7FDFFFFFFFFFFFFF
```


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```
 ----- WEIGHT OF BITS 1 WITH LBIS
 ISPBEM  BITS NUMBER FROM RIGHT TO LEFT

   1                    1
   2                    2
   3                    4
   4                    8
   5                   16
   6                   32
   7                   64
   8                  128
   9                  256
  10                  512
  11                 1024
  12                 2048
  13                 4096
  14                 8192
  15                16384
  16                32768
  17                65536
  18               131072
  19               262144
  20               524288
  21              1048576
  22              2097152
  23              4194304
  24              8388608
  25             16777216
  26             33554432
  27             67108864
  28            134217728
  29            268435456
  30            536870912
  31           1073741824
  32           2147483648
  33           4294967296
  34           8589934592
  35          17179869184
  36          34359738368
  37          68719476736
  38         137438953472
  39         274877906944
  40         549755813888
  41        1099511627776
  42        2199023255552
  43        4398046511104
  44        8796093022208
  45       17592186044416
  46       35184372088832
  47       70368744177664
  48      140737488355328
  49      281474976710656
  50      562949953421312
  51     1125899906842624
  52     2251799813685248
  53     4503599627370496
  54     9007199254740992
  55    18014398509481984
  56    36028797018963968
```

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```
  57     72057594037927936
  58    144115188075855872
  59    288230376151711744
  60    576460752303423488
  61   1152921504606846976
  62   2305843009213693952
  63   4611686018427387904

 ----- PARTICULAR VALUES  PI, DEPI,…

  R8PI      REALITY   REAL*8                                3.141592653589793D+00
400921FB54442D18
  R8DEPI    REALITY   REAL*8                                6.283185307179586D+00
401921FB54442D18
  R8DGRD    REALITY   REAL*8                                1.745329251994330D-02
3F91DF46A2529D39
  R8RDDG    REALITY   REAL*8                                5.729577951308232D+01
404CA5DC1A63C1F8

-------------------------------------------------

---- FINE TEST ENVIMA MULTI MACHINES -------------

   OK

-------------------------------------------------
```

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