PARANOIA . ADA :

SAMPLE OUTPUT REPORTS

Paranoia.Ada (R)

A Diagnostic Benchmark

- -

Paranoia.Ada is a program to diagnose floating-point arithmetic in the context of the Ada(*) programming language. The program evaluates the quality of a floating-point arithmetic implementation with respect to the proposed IEEE Standards P754 and P854.

Paranoia.Ada is derived from the original BASIC programming language version of Paranoia developed and copyrighted by Professor W.M. Kahan of the University of California, Berkeley.

The BASIC Paranoia program is described in "Paranoia: A Floating-Point Benchmark", by Richard Karpinsky, Byte Magazine, Vol. 10, No. 2, February 1985, pp. 223-235.

Paranoia.Ada replicates in Ada the test algorithms originally implemented in BASIC and adheres to the evaluation criteria established by Kahan.

Paranoia.Ada incorporates a major structural redesign and employs applicable Ada architectural and stylistic features.

* Ada is a registered trademark of the U.S.Government, AJPO (Ada Joint Program Office)

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Paranoia Report for type D_FLOAT                19:38:42  22-Apr-1986
DEC ACS 1.0-7 VAX/785 (VMS 4.2)

SYSTEM_NAME: VAX_VMS

Small Integral Values Test

Radix, Precision, and Closest Relative Separation Test

Normalized Subtraction Test

Guard Digit on Subtraction Test

Guard Digit on Multiplication Test

Guard Digit on Division Test

Rounding for Addition/Subtraction Test

Rounding for Multiplication Test

Rounding for Division Test

Rounding Sticky Bit Test

Commutative Multiplication Test

Underflow Test
    FLAW:
        Comparison says X /= Z, and yet X - Z = 0.0
        X = 4.040761830951613E-39
        Z = 2.938735877055718E-39
    SERIOUS DEFECT:
        Exception NUMERIC_ERROR was NOT raised to report
        underflow for Y := X - Z
        Confusion will be caused when innocent statements
        like:
            if (x=z)
            then ...
            else ... (f(x)-f(z))/(x-z) ...
        encounter division by zero although actually
        X / Z = 1.0 + 3.7500000000000000E-01
    SERIOUS DEFECT:
        Range is too narrow, U1 ** 4 underflows

Conversion Rounding Test

Overflow Test

Integer Power Test

Division by Zero Test
```

```
Paranoia Summary for type D_FLOAT              19:38:42  22-Apr-1986
DEC ACS 1.0-7 VAX/785 (VMS 4.2)


SERIOUS DEFECTS discovered                      2
FLAWS discovered                                1

Small Integral Values -1.0, 0.0, 0.5, 1.0, 2.0,
                       3.0, 4.0, 5.0, 8.0, 9.0,
                       24.0, 27.0, 32.0, and 240.0 are o.k.

Radix, Precision, and Closest Relative Separation

  Ada Implementation Attributes
    D_FLOAT'MACHINE_RADIX                        2
    D_FLOAT'MACHINE_MANTISSA                    56 bits
    D_FLOAT'MANTISSA                            31 bits
    D_FLOAT'DIGITS                               9 decimal digits
    D_FLOAT'EPSILON
         9.31322574615478S2E-10

  Calculated Values
    Radix                                        2
    Precision                                   56 digits of Radix
    U1 [1.0 - nextafter(1.0, 0.0)]
         1.38777878078144S7E-17
    U2 [nextafter(1.0, 2.0) - 1.0]
         2.77555756156289l4E-17

Subtraction is normalized

Guard Digits

    Subtraction:     has guard digit
    Multiplication:  has guard digit
    Division:        has guard digit

Rounding

  Ada Implementation Attributes
    D_FLOAT'MACHINE_ROUNDS                  TRUE

  Calculated Values
    Addition/Subtraction: appears to be correctly rounded
    Multiplication:       appears to be correctly rounded
    Division:             appears to be correctly rounded
    Sticky bit;           used incorrectly or not at all

Multiply commutes correctly for 20 pairs

Underflow

  Ada Implementation Attributes
    D_FLOAT'SMALL
```

```
Paranoia Summary for type D_FLOAT                19:38:42  22-Apr-1986
DEC ACS 1.0-7 VAX/785 (VMS 4.2)


          2.3509887016445750E-38
      D_FLOAT'SAFE_SMALL
          2.938735877055718BE-39

    Calculated Values
      EO - smallest positive number
          2.938735877055718BE-39
      UO - underflow threshold
          2.938735877055718BE-39

Conversion from +-x.5 to INTEGER rounds FROM_ZERO

Overflow

    Ada Implementation Attributes
      D_FLOAT'MACHINE_OVERFLOWS              TRUE
      D_FLOAT'LARGE
          2.1267647922655134E+37
      D_FLOAT'SAFE_LARGE
          1.701411833812410 7E+38
      D_FLOAT'LAST
          1.7014118346046923E+38

    Calculated Values
      VO - overflow saturation
          1.7014118346046923E+38
      V  - overflow threshold
          1.7014118346046923E+38

Integer Powers were calculated correctly

Division by 0.0 handled correctly


With respect to the proposed IEEE standards P754 and P854:
     The arithmetic diagnosed has unacceptable serious defects


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Paranoia calculations elapsed time       0.9300 seconds
Paranoia report elapsed time             0.6800 seconds
```

```
Paranoia Report for type G_FLOAT                20:05:18  22-Apr-1986
DEC ACS 1.0-7 VAX/785 (VMS 4.2)

SYSTEM_NAME: VAX_VMS

Small Integral Values Test

Radix, Precision, and Closest Relative Separation Test

Normalized Subtraction Test

Guard Digit on Subtraction Test

Guard Digit on Multiplication Test

Guard Digit on Division Test

Rounding for Addition/Subtraction Test

Rounding for Multiplication Test

Rounding for Division Test

Rounding Sticky Bit Test

Commutative Multiplication Test

Underflow Test
    FLAW:
        Comparison says X /= Z, and yet X - Z = 0.0
        X = 7.648691388618505E-309
        Z = 5.562684646268003E-309
    SERIOUS DEFECT:
        Exception NUMERIC_ERROR was NOT raised to report
        underflow for Y := X - Z
        Confusion will be caused when innocent statements
        like:
            if (x=z)
            then ...
            else ... (f(x)-f(z))/(x-z) ...
        encounter division by zero although actually
        X / Z = 1.0 + 3.750000000000000E-01

Conversion Rounding Test

Overflow Test

Integer Power Test

Division by Zero Test
```

```
Paranoia Summary for type G_FLOAT              20:05:18  22-Apr-1986
DEC ACS 1.0-7 VAX/785 (VMS 4.2)


SERIOUS DEFECTS discovered                      1
FLAWS discovered                                1

Small Integral Values -1.0, 0.0, 0.5, 1.0, 2.0,
                       3.0, 4.0, 5.0, 8.0, 9.0,
                       24.0, 27.0, 32.0, and 240.0 are o.k.

Radix, Precision, and Closest Relative Separation

  Ada Implementation Attributes
    G_FLOAT'MACHINE_RADIX                        2
    G_FLOAT'MACHINE_MANTISSA                    53 bits
    G_FLOAT'MANTISSA                            51 bits
    G_FLOAT'DIGITS                              15 decimal digits
    G_FLOAT'EPSILON
         8.881784197001252E-16

  Calculated Values
    Radix                                        2
    Precision                                   53 digits of Radix
    U1 [1.0 - nextafter(1.0, 0.0)]
         1.110223024625157E-16
    U2 [nextafter(1.0, 2.0) - 1.0]
         2.220446049250313E-16

Subtraction is normalized

Guard Digits

    Subtraction:     has guard digit
    Multiplication: has guard digit
    Division:        has guard digit

Rounding

  Ada Implementation Attributes
    G_FLOAT'MACHINE_ROUNDS                  TRUE

  Calculated Values
    Addition/Subtraction: appears to be correctly rounded
    Multiplication:       appears to be correctly rounded
    Division:             appears to be correctly rounded
    Sticky bit;           used incorrectly or not at all

Multiply commutes correctly for 20 pairs

Underflow

  Ada Implementation Attributes
    G_FLOAT'SMALL
```

```
          1.944692274331607E-62
      G_FLOAT'SAFE_SMALL
          5.562684646268003E-309

    Calculated Values
      E0 - smallest positive number
          5.562684646268003E-309
      U0 - underflow threshold
          5.562684646268003E-309

Conversion from +-x.5 to INTEGER rounds FROM_ZERO

Overflow

    Ada Implementation Attributes
      G_FLOAT'MACHINE_OVERFLOWS              TRUE
      G_FLOAT'LARGE
          2.571100870814383E+61
      G_FLOAT'SAFE_LARGE
          8.988465674311576E+307
      G_FLOAT'LAST
          8.988465674311579E+307

    Calculated Values
      V0 - overflow saturation
          8.988465674311579E+307
      V  - overflow threshold
          8.988465674311579E+307

Integer Powers were calculated correctly

Division by 0.0 handled correctly


With respect to the proposed IEEE standards P754 and P854:
    The arithmetic diagnosed has unacceptable serious defects


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Paranoia calculations elapsed time      1.2600 seconds
Paranoia report elapsed time            0.7100 seconds
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```
Paranoia Report for type H_FLOAT                20:47:00  22-Apr-1986
DEC ACS 1.0-7 VAX/785 (VMS 4.2)

SYSTEM_NAME: VAX_VMS

Small Integral Values Test

Radix, Precision, and Closest Relative Separation Test

Normalized Subtraction Test

Guard Digit on Subtraction Test

Guard Digit on Multiplication Test

Guard Digit on Division Test

Rounding for Addition/Subtraction Test

Rounding for Multiplication Test

Rounding for Division Test

Rounding Sticky Bit Test

Commutative Multiplication Test

Underflow Test
    FLAW:
        Comparison says X /= Z, and yet X - Z = 0.0
        X = 1.155722955444782142777795499704352E-4932
        Z = 8.405257857780233765656694543304382E-4933
    SERIOUS DEFECT:
        Exception NUMERIC_ERROR was NOT raised to report
        underflow for Y := X - Z
        Confusion will be caused when innocent statements
        like:
            if (x=z)
            then ...
            else ... (f(x)-f(z))/(x-z) ...
        encounter division by zero although actually
        X / Z = 1.0 + 3.750000000000000000000000000000000E-01

Conversion Rounding Test

Overflow Test

Integer Power Test

Division by Zero Test
```

```
Paranoia Summary for type H_FLOAT              20:47:00  22-Apr-1986
DEC ACS 1.0-7 VAX/785 (VMS 4.2)


SERIOUS DEFECTS discovered                      1
FLAWS discovered                                1

Small Integral Values -1.0, 0.0, 0.5, 1.0, 2.0,
                       3.0, 4.0, 5.0, 8.0, 9.0,
                       24.0, 27.0, 32.0, and 240.0 are o.k.

Radix, Precision, and Closest Relative Separation

  Ada Implementation Attributes
    H_FLOAT'MACHINE_RADIX                        2
    H_FLOAT'MACHINE_MANTISSA                   113 bits
    H_FLOAT'MANTISSA                           111 bits
    H_FLOAT'DIGITS                              33 decimal digits
    H_FLOAT'EPSILON
         7.703719777548943412223911770339709E-34

  Calculated Values
    Radix                                        2
    Precision                                  113 digits of Radix
    U1 [1.0 - nextafter(1.0, 0.0)]
         9.629649721936179265279889712924637E-35
    U2 [nextafter(1.0, 2.0) - 1.0]
         1.925929944387235853055977942584927E-34

Subtraction is normalized

Guard Digits

    Subtraction:     has guard digit
    Multiplication: has guard digit
    Division:        has guard digit

Rounding

  Ada Implementation Attributes
    H_FLOAT'MACHINE_ROUNDS                     TRUE

  Calculated Values
    Addition/Subtraction: appears to be correctly rounded
    Multiplication:       appears to be correctly rounded
    Division:             appears to be correctly rounded
    Sticky bit;           used incorrectly or not at all

Multiply commutes correctly for 20 pairs

Underflow

  Ada Implementation Attributes
    H_FLOAT'SMALL
```

```
Paranoia Summary for type H_FLOAT                20:47:00  22-Apr-1986
DEC ACS 1.0-7 VAX/785 (VMS 4.2)


          1.10065682146379182109343180209360 5E-134
      H_FLOAT'SAFE_SMALL
          8.40525785778023376565669454330438 2E-4933

    Calculated Values
      E0 - smallest positive number
          8.40525785778023376565669454330438 2E-4933
      U0 - underflow threshold
          8.40525785778023376565669454330438 2E-4933

Conversion from +-x.5 to INTEGER rounds FROM_ZERO

Overflow

    Ada Implementation Attributes
      H_FLOAT'MACHINE_OVERFLOWS                 TRUE
      H_FLOAT'LARGE
          4.54274202684754306593327379930002 7E+133
      H_FLOAT'SAFE_LARGE
          5.94865747678615882542879663314003 3E+4931
      H_FLOAT'LAST
          5.94865747678615882542879663314003 5E+4931

    Calculated Values
      V0 - overflow saturation
          5.94865747678615882542879663314003 5E+4931
      V  - overflow threshold
          5.94865747678615882542879663314003 5E+4931

Integer Powers were calculated correctly

Division by 0.0 handled correctly


With respect to the proposed IEEE standards P754 and P854:
     The arithmetic diagnosed has unacceptable serious defects



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Paranoia calculations elapsed time       3.7500 seconds
Paranoia report elapsed time             0.6900 seconds
```

```
Paranoia Report for type MAX_DIGITS                20:09:27  28-Apr-1986
DEC ACS 1.0-7 VAX/785 (VMS 4.2)

SYSTEM_NAME: VAX_VMS

Small Integral Values Test

Radix, Precision, and Closest Relative Separation Test

Normalized Subtraction Test

Guard Digit on Subtraction Test

Guard Digit on Multiplication Test

Guard Digit on Division Test

Rounding for Addition/Subtraction Test

Rounding for Multiplication Test

Rounding for Division Test

Rounding Sticky Bit Test

Commutative Multiplication Test

Underflow Test
    FLAW:
        Comparison says X /= Z, and yet X - Z = 0.0
        X = 1.155722955444782142777795499704352E-4932
        Z = 8.405257857780233765656694543304382E-4933
    SERIOUS DEFECT:
        Exception NUMERIC_ERROR was NOT raised to report
        underflow for Y := X - Z
        Confusion will be caused when innocent statements
        like:
            if (x=z)
            then ...
            else ... (f(x)-f(z))/(x-z) ...
        encounter division by zero although actually
        X / Z = 1.0 + 3.750000000000000000000000000000000E-01

Conversion Rounding Test

Overflow Test

Integer Power Test

Division by Zero Test
```

```
Paranoia Summary for type MAX_DIGITS          20:09:27  28-Apr-1986
DEC ACS 1.0-7 VAX/785 (VMS 4.2)


SERIOUS DEFECTS discovered                    1
FLAWS discovered                              1

Small Integral Values -1.0, 0.0, 0.5, 1.0, 2.0,
                       3.0, 4.0, 5.0, 8.0, 9.0,
                       24.0, 27.0, 32.0, and 240.0 are o.k.

Radix, Precision, and Closest Relative Separation

  Ada Implementation Attributes
    MAX_DIGITS'MACHINE_RADIX                   2
    MAX_DIGITS'MACHINE_MANTISSA              113 bits
    MAX_DIGITS'MANTISSA                      111 bits
    MAX_DIGITS'DIGITS                         33 decimal digits
    MAX_DIGITS'EPSILON
         7.703719777548943412223911770339709E-34

  Calculated Values
    Radix                                      2
    Precision                                113 digits of Radix
    U1 [1.0 - nextafter(1.0, 0.0)]
         9.629649721936179265279889712924637E-35
    U2 [nextafter(1.0, 2.0) - 1.0]
         1.925929944387235853055977942584927E-34

Subtraction is normalized

Guard Digits

    Subtraction:    has guard digit
    Multiplication: has guard digit
    Division:       has guard digit

Rounding

  Ada Implementation Attributes
    MAX_DIGITS'MACHINE_ROUNDS              TRUE

  Calculated Values
    Addition/Subtraction: appears to be correctly rounded
    Multiplication:       appears to be correctly rounded
    Division:             appears to be correctly rounded
    Sticky bit;           used incorrectly or not at all

Multiply commutes correctly for 20 pairs

Underflow

  Ada Implementation Attributes
    MAX_DIGITS'SMALL
```

```
Paranoia Summary for type MAX_DIGITS          20:09:27  28-Apr-1986
DEC ACS 1.0-7 VAX/785 (VMS 4.2)


          1.10065682146379182109343102093605E-134
      MAX_DIGITS'SAFE_SMALL
          8.40525785778023376565669454330438 2E-4933

    Calculated Values
      E0 - smallest positive number
          8.40525785778023376565669454330438 2E-4933
      U0 - underflow threshold
          8.40525785778023376565669454330438 2E-4933

Conversion from +-x.5 to INTEGER rounds FROM_ZERO

Overflow

    Ada Implementation Attributes
      MAX_DIGITS'MACHINE_OVERFLOWS          TRUE
      MAX_DIGITS'LARGE
          4.54274202684754306593327379930002 7E+133
      MAX_DIGITS'SAFE_LARGE
          5.94865747678615882542879663314003 3E+4931
      MAX_DIGITS'LAST
          5.94865747678615882542879663314003 5E+4931

    Calculated Values
      V0 - overflow saturation
          5.94865747678615882542879663314003 5E+4931
      V  - overflow threshold
          5.94865747678615882542879663314003 5E+4931

Integer Powers were calculated correctly

Division by 0.0 handled correctly


With respect to the proposed IEEE standards P754 and P854:
    The arithmetic diagnosed has unacceptable serious defects


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Paranoia calculations elapsed time      4.4200 seconds
Paranoia report elapsed time            0.7100 seconds
```