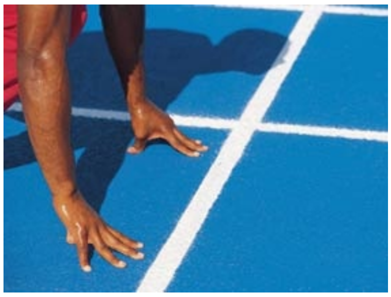
maXbox



maXbox Starter 41

Deal with Big Numbers

1.1 A Big Decimal or Big Int Interface

Today we step through numbers and infinity.

As you may know there's no simple solution to print, calculate or store big numbers or decimals, for example you want to compute 400000078669 / 2000123 your calculator shows (so does my Casio FX-880P):

199987.7401

So this is not the end of the line, a second test is

maxcalcF('400000078669 / 2000123')

and we get: 199987.740088485

And there are even more numbers that need to compute so we switch to http://www.wolframalpha.com to get the real precision thing or at least an approximation:

199987.7400884845581996707202507045816682274040146530988344
21683066491410778237138415987416773868407092963782727362267
220...

http://www.wolframalpha.com/input/?i=400000078669%2F2000123

again as you suppose the numbers go on.

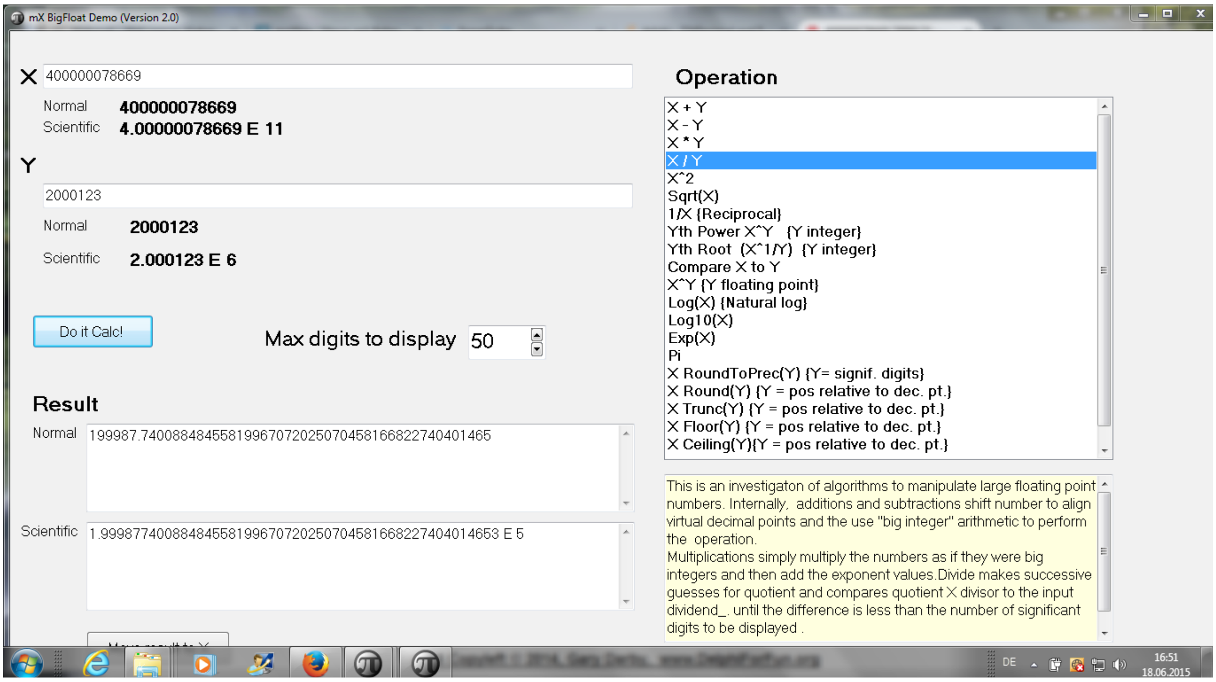
Use "Power Towers" to write them down. The decimal point is the most important part of a decimal number like above. Without it, we would be lost ... and not know what each position meant.
Dividing decimals is almost the same as dividing whole numbers, except you use the position of the decimal point in the dividend to determine the decimal places in the result. Our division is always an approximation.

Approximate means you're going to round the number. Because you're not actually giving the exact number, all those numbers after the decimal, the rounded number is called an approximation:

199987.7401 is roundToPrec4 of: 199987.740088485

Although, you probably wondered how they get those nice and fancy graphical user interfaces (GUI) for large numbers, here in maXbox we do also have one:

maXbox3 `568_U_BigFloatTestscript2.pas` Compiled done: 6/18/2015



The idea that you are approximating is that, as you are only taking the first 50 decimal places as you can see at the screen-shot.
The same like wolfram goes like this:

199987.7400884845581996707202507045816682274040146530988344
2168306649141077823713841598741677386840709296378272736226 7
2205

When we try to write this decimal number (or the well known PI or SQR(2)) in decimal notation, we get an endless stream of digits.
3.141592653589723.....and so on forever.
But suppose instead, we use fractional notation. Then we can write each part as a precise (irreducible)

$$\frac{400000078669}{2000123}$$

A fraction is an exact ratio of 2 numbers, and if those 2 numbers are integers, or at least rational numbers, then the fraction can more

appropriately be called a rational number. An irrational number can be represented as an approximation to a rational number to an extremely high degree of accuracy.
It's quite clear that there are fractions which can't be expressed in finite decimal form!
Now, here's the big problem. Not every number is rational! For example there is no fraction for sqrt(2). That is, no matter what whole numbers m and n you pick, m/n is not the square root of 2. Euclid wrote down a real AND beautiful proof of this fact around 2300 years ago.

Interesting point about those real numbers is also the possibility to divide the number to his prime factorization:

29×37×127^(-1)×179×15749^(-1)×2082607

```
maxcalcF('29*37*(127^-1)*179*(15749^-1)*2082607');
```

>> 199987.740088485

1.2 Real Big Integer

So what about big integers? For example you want to compute fact(70), your calculator shows:

fact(70) = 1.19785716699699e+100 or **maxcalcF**('70!')

1.19785716699699E100

or even more

1.19785716699698917960727837216890987364589381425464258 57... × 10^100

but the maximum range on Pascal, C or Delphi depends on your operating system types, means nowadays an int64 range is big.
Now that the "signed" words are finally up-to-par with the unsigned integer types, languages introduce a new 64-bits integer type, called Int64, with a whopping range of -2^63..2^63 - 1

Another way is to use a type extended, but the limitation is precision like

```
Writeln(FloatToStr(Fact(70)))
```

it only shows 1.2E+0100 or 1.19785716699698966E100

With a BigInt Library you'll see the full range of Fact(70):

1197857166996989179607278372198789275553662800958278984531968000000000000000

All examples can be found online:

maxbox3\examples\161_bigint_class_maxprove2.txt

http://www.softwareschule.ch/examples/161_bigint_class_maxprove2.txt

The call respectively the calculation goes like this:

```
function GetBigIntFact(aval: byte): string;
//call of unit mybigint
var mbRes: TMyBigInt;
   i: integer;
begin
  mbRes:= TMyBigInt.Create(1);
  try
    //multiplication of factor
    for i:= 1  to aval do
      mbRes.Multiply1(mbres, i);
    Result:= mbRes.ToString;
  finally
    //FreeAndNil(mbResult);
    mbRes.Free;
  end;
end;
```

Or you want the power of 100 like 2^100=
12676506002282299670376

```
function BigPow(aone, atwo: integer): string;
var tbig1, tbig2: TInteger;
begin
  tbig1:= TInteger.create(aone);
  //tbig2:= TInteger.create(10);
  try
    tbig1.pow(atwo);
  finally
    result:= tbig1.toString(false);
    tbig1.Free;
  end;
end;
```

At least one really big, it's 333^4096 (10332 decimal digits)!:

85424105895770887322966965917914584710138161386222147182917
67781049536057906627318361093758865620577697322240787369539
81504332246815140327668478948527046875787550310970504170251

82159123158149832522632506558096888465749900859669714028055
7172226167217308161576577272999913389932448720516828003070
67049948583875478861163177472370389199969581395362347697256
70960895462872160261732690973238984844130761428601643232816
96899530174488741933479651249141554621396684104620616204908
08738502674650541288448161671070156327238251274328179200400
93890996761080835353394335725524764503872061091991652109449
19392226034862115885018213075725104899320094825429972785833
08567702799428942416066175248810727171285940075837283674910
40238020148038165962562077292113243073436214316216978130335
33870396651279893801306533507055182475982690042018637954924
71837910714543445430478178723995293717173465603902499439767
52390512439014099231872228674262774255372493330431055176825
66636232366673489784851223121246465215815916502622714756503
41470134146173462494457636856525872971987877831270158832603
81720501132263714345569154398039964038547327865662026993558
29785045595252413682840639314284074867518100746598657655945
81378019251453464202570850546505546651918600042626257608188
49535769666297091453700207198739748884149693263644965541429
60625942272943281855130658659637414117763954618293009737119
20497440723531587803915956018581696810199146742826127160616
96675183761740650324877602818378317677730431971470829242037
19559841427945394611344759210789672710312151288626779198995
38701143923451064706611017647623102481237637914918894554224
08190814870673307938473049085663216256407994368677685271087
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89755570766416722785651840954388568904657279312763515446538
14727117240451212404891260149108022108352756826060916165752
75842968506140334676934667568824407601228835743948301133856
67291848920157649283141024291690280652494545083790886477617
43720126167236379124481127893994316258310107716760682781353
13052205927671502890929477717785458301559276426947626959261
74086054203450601228998156862816770206156286995619547713403
66063324712132695944068411905946566611734854030824623340469
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34205014438776231018691956945896654929451766257449857738007
27444065544750842262982606864122383198213933891466795134120
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57839740121048013161681915430491815656845135427468061756390
04934440540270331262335589548473966818981111982651233800107
48747405008943837472732619075280509937188130644867401433861
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78217708481814130975623645815400519531072329972316424125029
83311338676548007573475077494264378039776424697719572306930
88766695667158451604134516400656364381872715873008395723257
97940380735398040659721222058817651087721809880276579722510
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92937093469772528468011757947147166512152435404133191490416
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55359947722039227225423876928932200844350921818577101458295
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89935099549137644474027777583956137051269588783021487059246
17598489865075863183194186708153376785925896453521253497876
13552701597508011611524503843754837913945812148834125113809
99171425821993170789973409296543662081

I'm trying to move a part of SysTools to Win64. There is a class `TStDecimal` which is a fixed-point value with a total of 38 significant digits. The class itself uses a lot of ASM code.

```
function BigDecimal(aone: float; atwo: integer): string;
begin
 with TStDecimal.create do begin
  try
   //assignfromint(aone)
   assignfromfloat(aone) //2
   RaiseToPower(atwo)  //23
   result:= asstring
  finally
   free
  end;
 end;
end;
```

SysTools is hosted under Sourceforge:

http://www.sourceforge.net/projects/tpsystools

The class `TStDecimal` is defined in the unit `StDecMth`. It has the following description: `StDecMth` declares and implements `TStDecimal`. This is a fixed- point value with a total of 38 significant digits of which 16 are to the right of the decimal point.

1366556882568704.2292943165706246

☝ It is important to note that Infinity is not a real number, it is an idea. An idea of something without an end.

Infinity is not "getting larger", it is already fully formed. Sometimes students or people (including me) say it "goes on and on" which sounds like it is growing somehow. But infinity does not do anything, it just is.

```
Writeln('')
Writeln('Big Lotto Combination 1600 of 5000!')
Writeln('')
Writeln(BinominalCoefficient(5000, 1600));
Writeln('')
Writeln('Same Lotto Comb 6 of 45!')
Writeln(BinominalCoefficient(45, 6));     -->8145060
Writeln('Same Lotto Comb 39 of 45!')
Writeln(BinominalCoefficient(45, 39));  -->8145060
```

OK, 1/3 is a finite number (it is not infinite). But written as a decimal number the digit 3 repeats forever (we say "0.3 repeating"):

0.33333333333333333333... (etc.)

There's no reason why the 3s should ever stop: they repeat infinitely.
Okay, I hope you're not one of those people who denies 0.999... = 1, because it sounds like you're saying 0.333... doesn't exactly equal 1/3. If there are only a finite amount of 3s, I wouldn't argue a bit that they're not equal, but with an infinite amount, they are.

Test the script with **F9** / F2 or press Compile.

Conclusion And we can easily create much larger numbers than those! But none of these numbers are even close to infinity. Because they are finite, and infinity is ... not finite!

“Wise men speak because they have something to say; Fools, because they have to say something”. -Plato

Feedback @ max@kleiner.com

Literature: Kleiner et al., Patterns konkret, 2003, Software & Support

http://www.softwareschule.ch/download/codesign_2015.pdf

http://www.softwareschule.ch/download/XXL_BigInt_Tutorial.pdf

http://www.mathsisfun.com/numbers/infinity.html

https://github.com/maxkleiner/maXbox3/releases

1.3 Appendix Study with BigInt Direct

```
// TODO: Copy a file in a connected share path
//this is 333^4096:


function GetBigIntDirect: string;
 //Unit mybigint
var mbResult: TMyBigInt;
    i: integer;
begin
  mbResult:= TMyBigInt.Create(333);
  try
   // Faktoren im Zaehler aufmultiplizieren  ---> 2^12=4096
   for i:= 1  to 12 do begin
     mbResult.Multiply(mbresult, mbresult);
     //writeln(inttostr(i)+': '+mbresult.tostring);
     end;
   Result:= mbResult.ToString;
  finally
   //FreeAndNil(mbResult);
   mbResult.Free;
  end;
end;


 TMyBigInt = class
   private
    Len: Integer;
    Value: AnsiString;
    procedure Trim;
    procedure Shift(k: Integer);
    procedure MultiplyAtom(Multiplier1: TMyBigInt; Multiplier2: Integer);
   public
    constructor Create(iValue: Integer = 0);
    procedure Add(Addend1, Addend2: TMyBigInt);
    procedure Multiply(Multiplier1, Multiplier2: TMyBigInt); overload;
    procedure Multiply(Multiplier1: TMyBigInt; Multiplier2: Integer); overload;
    function ToString: string;
    procedure CopyFrom(mbCopy: TMyBigInt);
   end;
```