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Number Representations and Precision in Vector Graphics

Implementation of an Arbitrary Precision SVG Viewer

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Summary

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- Vector graphics allow scaling but not arbitrary scaling
- We implemented a vector graphics viewer that does allow arbitrary scaling
- ... but it will take an arbitrary amount of time

Graphics Formats

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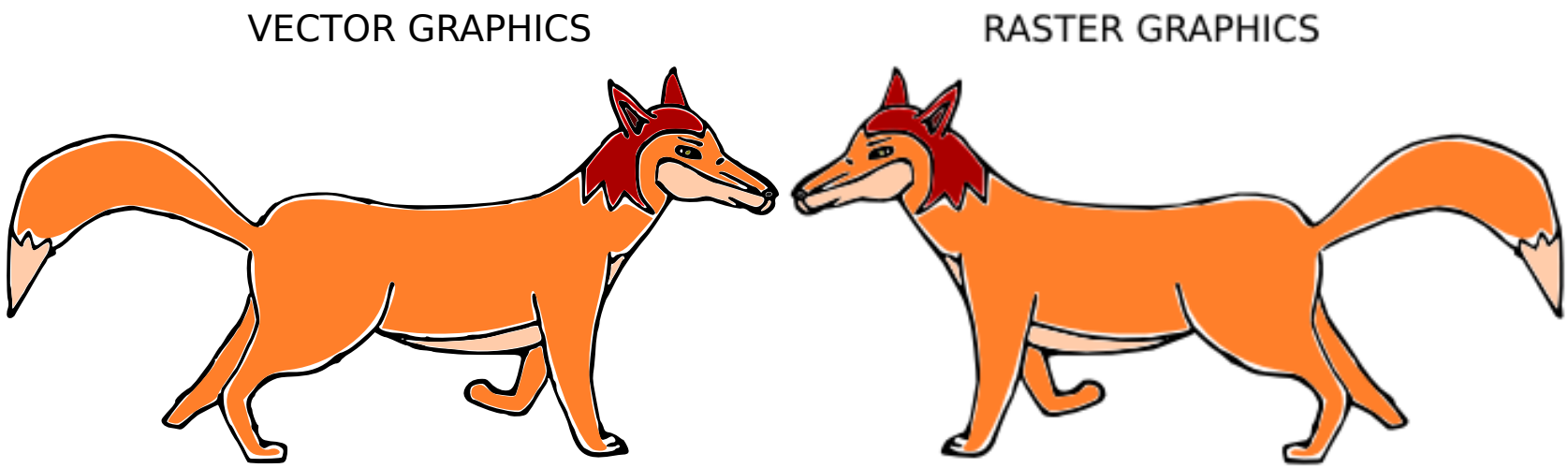
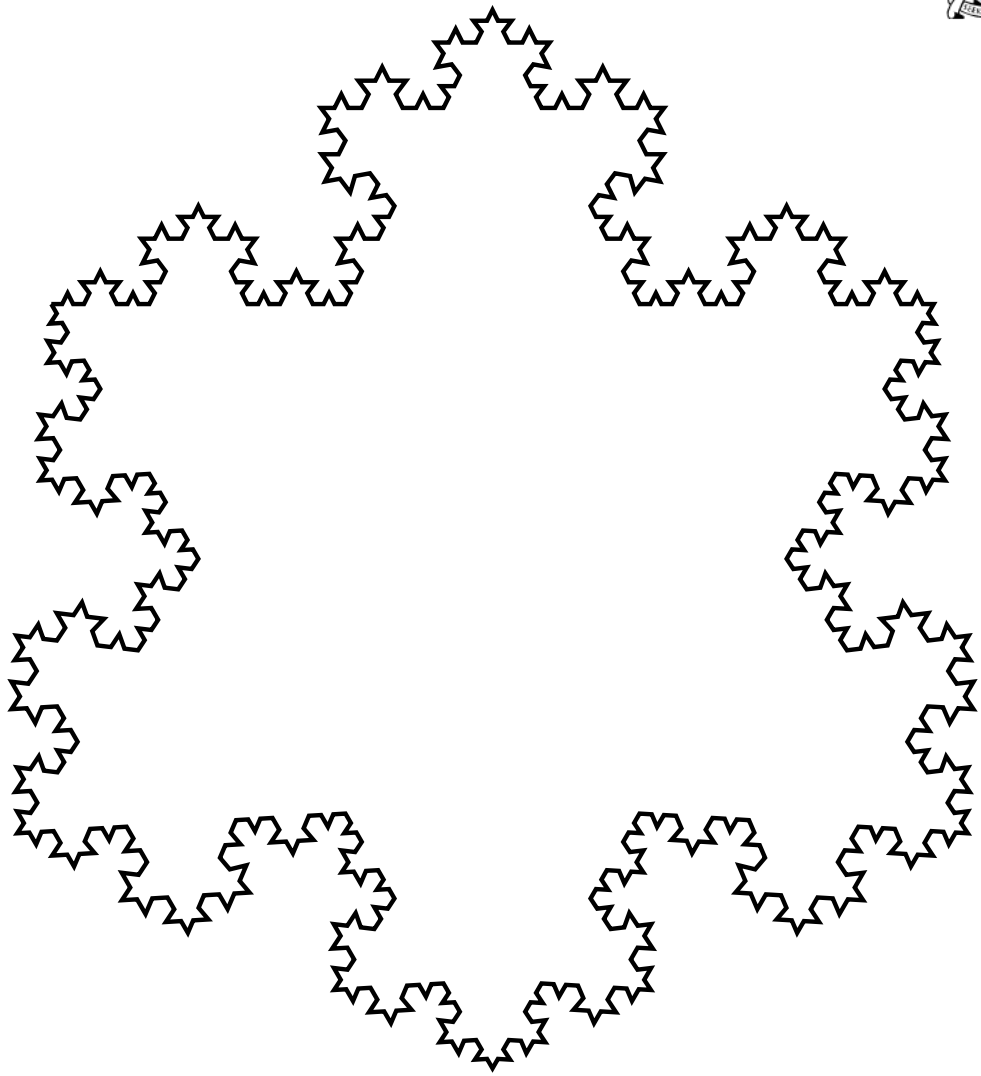
- Document formats (eg: PDF and SVG) are formats for vector graphics
- Vector graphics scale better than raster graphics



Why is there a zoom limit?



Why is there a zoom limit?

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- SVG, PostScript, PDF specify IEEE-754 *single* floating point number representations
- Range of values: $\approx 3 \times 10^{-38} \rightarrow 3 \times 10^{+38}$
- Rough Floating Point Definition[1]:

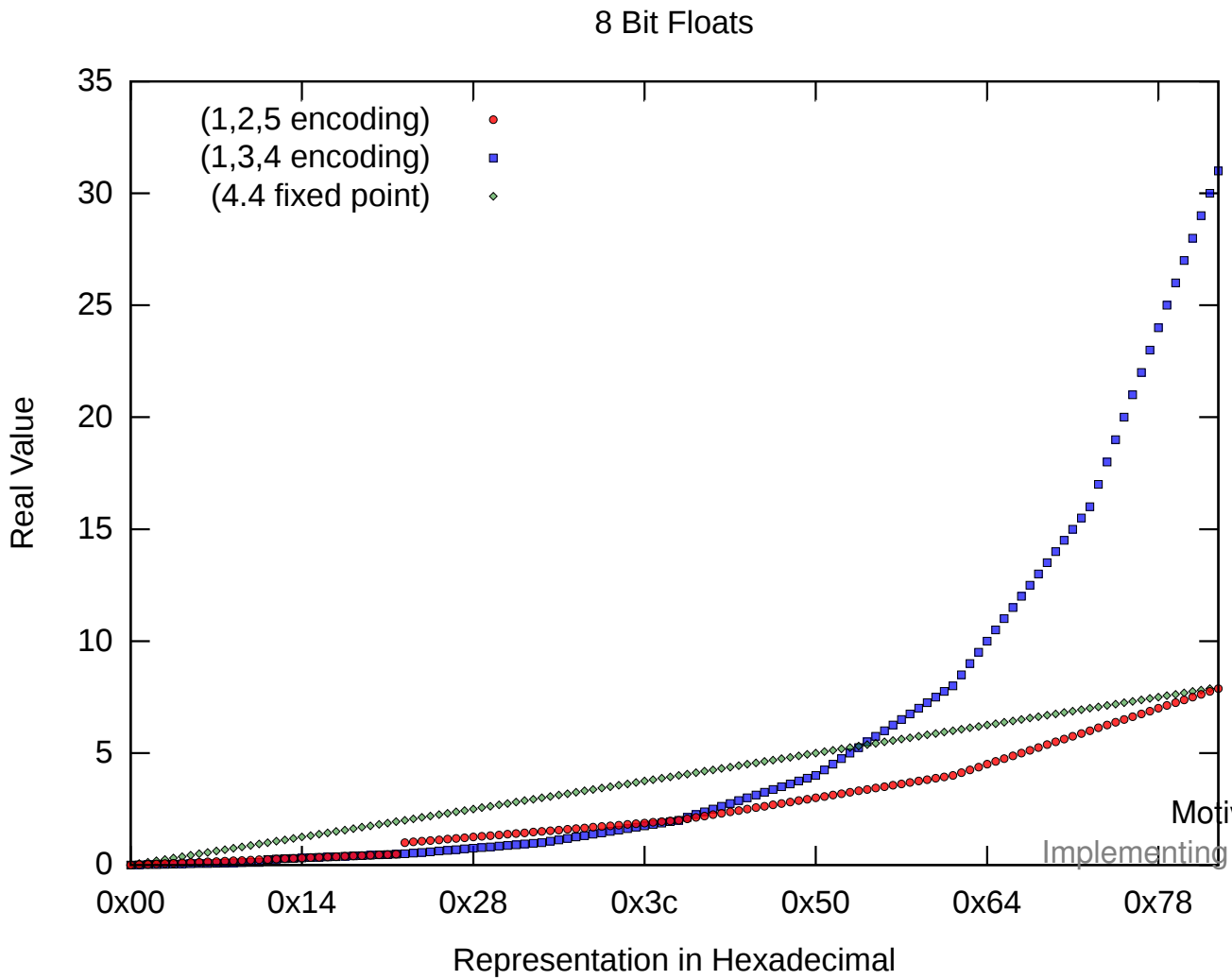
$$X = m \times 2^E \tag{1}$$

- m and E are encoded in a *fixed length* string of bits
- Floating Point $\approx$ Scientific Notation for computers

[1] IEEE-754 is more complicated

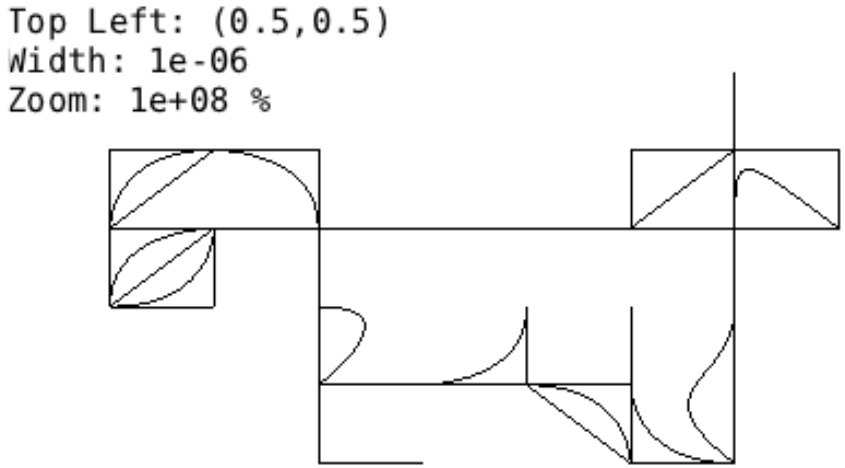
Visualisation of Floats

- With total length of *m* and *E* limited to 7 bits (1 sign bit)
- Showing positive numbers only



Floating point calculations go wrong

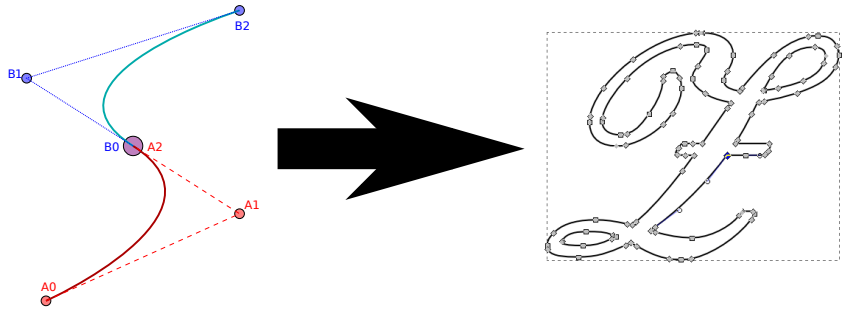
- At scale of only 1×10^{-6}, the fox is very sick



- Plank Length: 1.61×10^{-35} metres $> 3 \times 10^{-38}$
- Size of Universe: 4.3×10^{26} metres $<< 3 \times 10^{38}$
- Why isn't this good enough for 1×10^{-6}

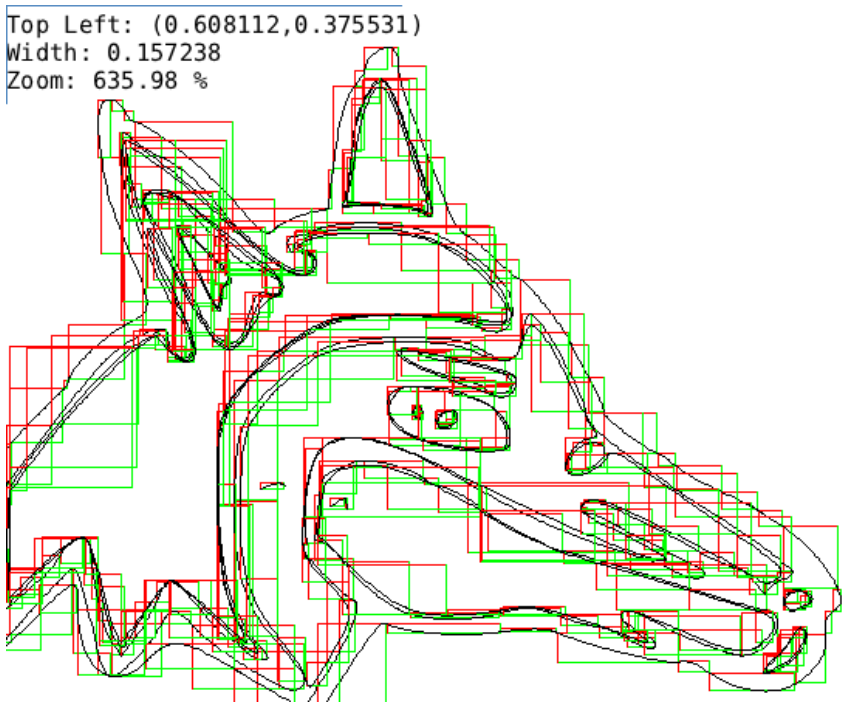
Structure of Vector Graphics

- Bézier Curve (Quadratic or Cubic Parametric Polynomial)
- Path of Bézier Curves $\rightarrow$ Shapes (with fill)
- Shapes include font glyphs, like this $\mathscr{Z}$



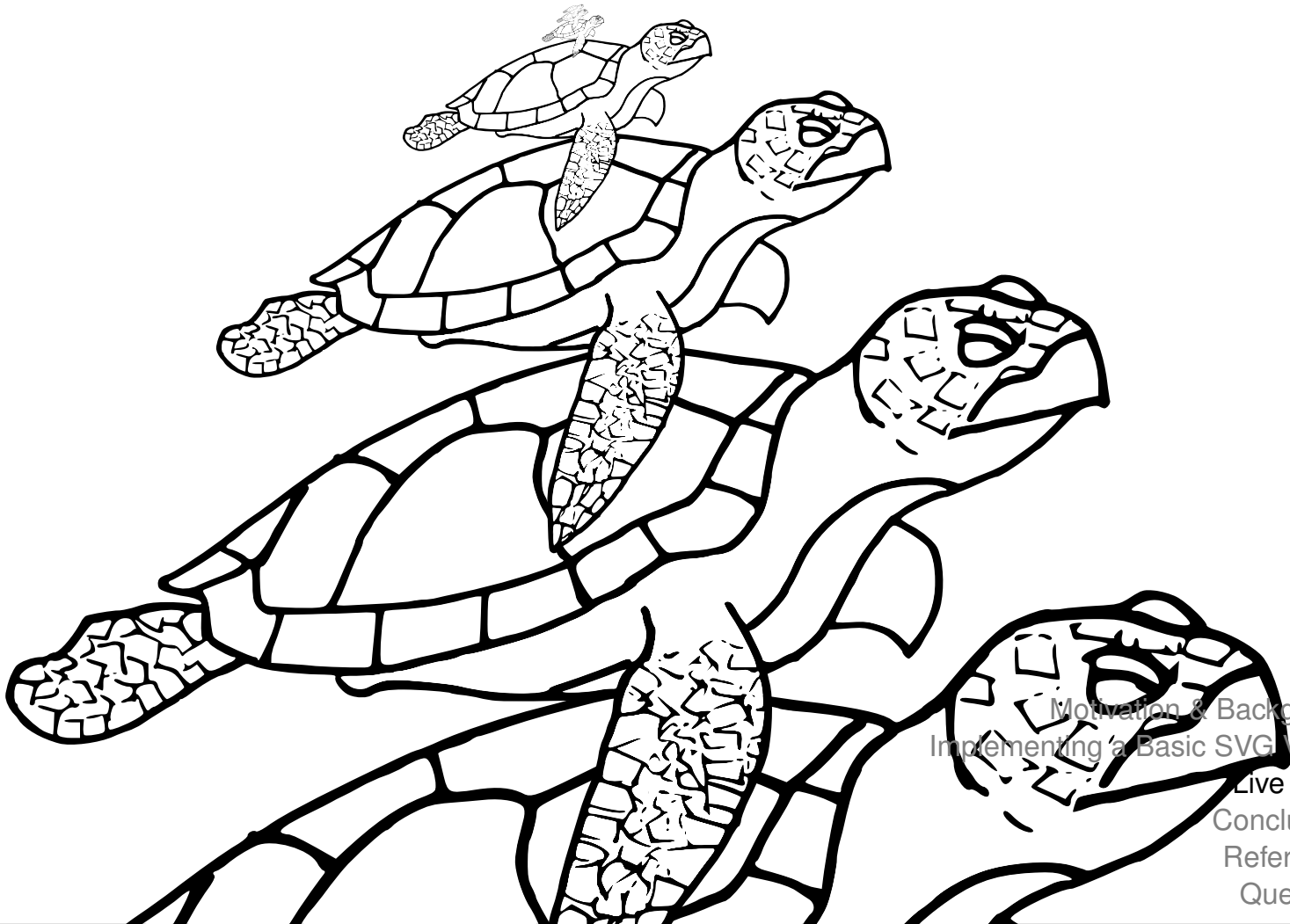
Structure of Vector Graphics III

- Rectangles show individual Béziers forming outline of the Fox



Live Demo

- We can import standard SVGs wherever we want
- If we are willing to wait long enough
- "... But, asks the scientist, what does that turtle stand on? To which the lady triumphantly answers: 'You're very clever, young man, but it's no use – it's turtles all the way down!'."



Conclusions

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- What we have done?
  - Implemented a basic SVG viewer
  - Demonstrated how precision affects rendering vector graphics
  - Using GMP rationals, demonstrated the ability to render SVGs scaled to an arbitrary position in a document
- Possible future work
  - Implement more of the SVG standard
  - Trial alternative number representations
  - Allow for saving and loading SVGs with arbitrary precision

Q: Why don't you have colour?

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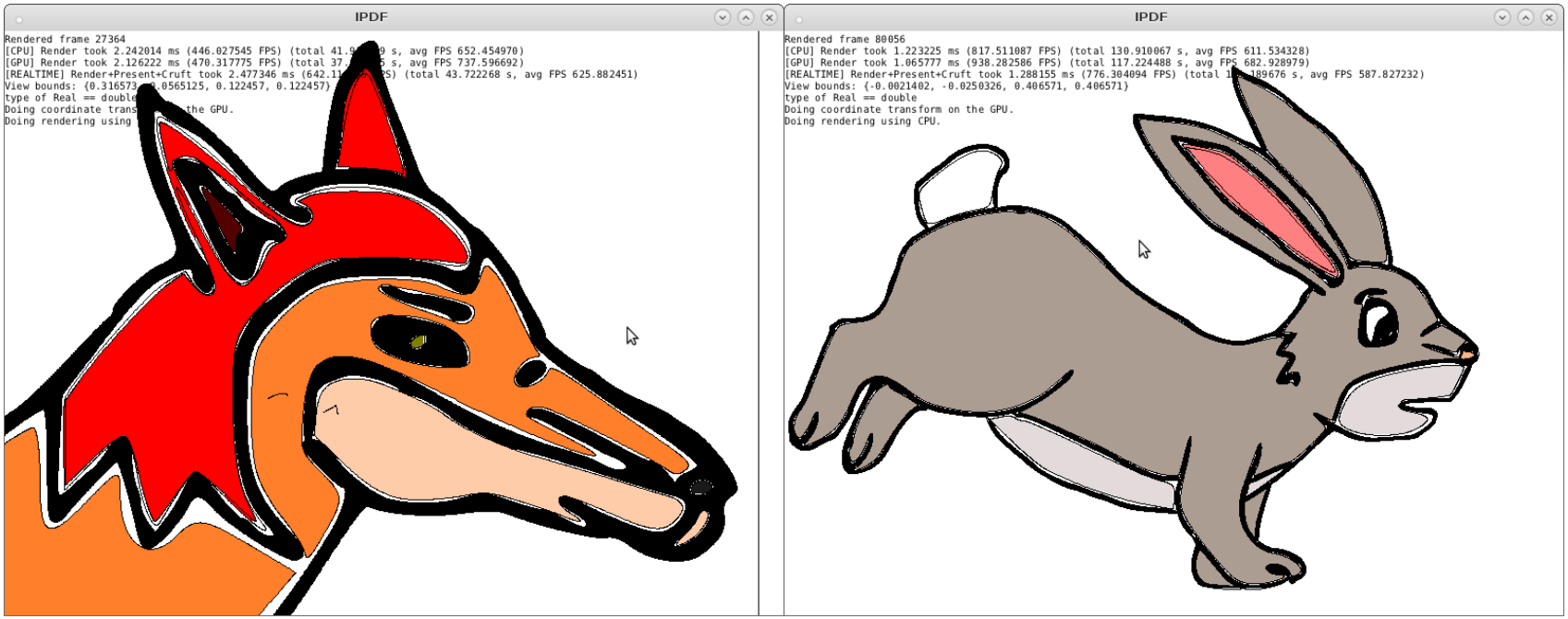
- We do![2]
- A complete implementation of SVG is "future work"



[2] If you are willing to wait long enough

Q: Why not just use doubles?

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- Any fixed precision format will still give inexact results
- But the inexact results will appear slower

Q: Arbitrary precision floats?

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- We support them as well!
- Rationals are more convenient:
  - Need to manually set precision
  - Some operations require infinite precision:

$$\frac{1}{3} = 0.33333333333333333333\ldots \times 10^{0} \qquad (2)$$

  - How do you choose when to increase precision?
- Could be future work