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Conversion of NGP-0 Coordinates to Device Specific Coordinates

Conversion of NGP-0 coordinates to floating point PDP-10 coordinates was discussed in RFC #387. In general, however, it is undesirable to convert NGP coordinates to floating point coordinates because real devices require integer addressing. To this end, a means is described to convert NGP coordi- nates to integer coordinates in the range zero to M, where M is the maximum address of the device screen on a machine using 2's complement arithmetic. It would not, however, be difficult to modify this algorithm to operate on machines using one's complement or sign-magnitude arithmetic.

First consider the NGP coordinate format:

```
+--+-----------+
|  |   n       |
+--+-----------+
 s ^  FRACTION
 i
 g
 n
```

Where the sign occupies the most significant bit of the coordinate followed by bits of numerical information (initial implementation of NGP requires N=15). Negative numbers are represented by 2's complement. Conversion to device coordinates is accomplished by:

$$D = S * f + S$$

Where D =>integer device coordinate
      S =>scaling factor (typically M/2)
      f =>NGP fractional coordinate

Let us rewrite this as:

$$D = S*(2^n *f)/2^n +S$$

Now factor S into two terms:

$$S = Q * 2^{I}$$

Where Q is an odd integer and I is an integer.

When:

$$D = Q * 2^{I} *(2^{n} *f)/2^{n} +S$$

$$= Q * 2^{I-n} *(2^{n} *f) +S$$

The factor $(2^{n} *f)$ is represented in 2's complement form simply by extending the sign bit of f into the upper portion of the computer word, If Q = 1 (as it would be with many devices), it can be ignored. If Q >< 1, we may console ourselves that an integer multiply is faster on most machines than a floating point multiply. In fact, on a PDP-10, this multiply can usually be performed with no access to memory since Q is usually small.

We are now left with the 2^{I-n} factor. This can be accomplished with an arithmetic shift left by (I-n) or an arithmetic shift right by (n-I) as is appropriate. The offset factor, S, may now be added using an integer add.

The procedure for converting NGP coordinates to integer device coordinates is then:

1. move coordinate to a register and extend sign
2. integer multiply by Q (if necessary)
3. arithmetic shift left by (I-n)
4. integer add S

This procedure would generally be much faster than:

1. move coordinate to register and extend sign
2. float fractional coordinate
3. floating point multiply
4. floating point add
5. conversion to fixed point

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