Fixed-point Implementation of Dataflow Graphs

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Issues of Fixed-point Implementation

- Simulation vs. analysis
- Re-entry of schematic
- Rewriting nodes for fixed-point arithmetic
- Reliable scaling
- Wordlength determination
- Effective utilities
Translation into Fixed-point “Stars”

- Preserving structure by using inheritance
- Replacing data type
- Adding/initializing states for precision
- Modifying the description of the function, if needed.

Floating-point Star

```python
defstar {
   name {foo}
   domain {SDF}
   input {
      name{in}
      type{float}
   }
   output {
      name{out}
      type{float}
   }
} 
go {
   double t = Do(double(in[0]));
   out[0] << t;
}
```

Fixed-point Star

```python
defstar {
   name {foo}
   domain {SDF}
   input {
      name{in}
      type{Fix}
   }
   output {
      name{out}
      type{Fix}
   }
} 
defstate {
   name{10, in_Prec}
   type{string}
   default("3.13,tsr")
} 
go {
   Fix t = Do(Fix(in[0]));
   out[0] << t;
}
```

In the Future, Hopefully

- Interface is designed with the abstract data type
- Type specific implementations can be generated from interface
- Implementation can be selected for simulation
Generation of Simulation Models

- Select the right implementation

Generic System with Interface Stars

Simulation Model with Implementation Stars

foo.in:

defstar {
    name {foo}
    domain {SDF}
    input {
        name {in}
        type {Number}
    }
    output {
        name {out}
        type {Number}
    }
    go {
        Number t = Do(Number(in[0]));
        out[0] << t;
    }
}
Fixed-point Data Type

- **Miscellaneous modes**
  - Sign – Two’s complement or Unsigned
  - Overflow – Saturation, Wrapped, or Saturate to zero
  - Precision reduction – Rounding or Truncation

- **Determination of IWL?** *Distribution profiler*

- **Determination of TWL/FWL?** *Optimization manager*

**Utilities**

- Keeps track of a variable
- Estimates the range from statistical info, mean, variance, skewness, kurtosis

Unimodal & Symmetric: \( R = |\mu| + n \cdot \sigma \)

Multimodal or Nonsymm: \( R = R_{\text{max}} + g \)

<table>
<thead>
<tr>
<th>Mean</th>
<th>Variance</th>
<th>Skewness</th>
<th>Kurtosis</th>
<th>Possible Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.453</td>
<td>2.394</td>
<td>5.321</td>
<td>31.453</td>
<td>4.892</td>
</tr>
</tbody>
</table>

Integer Wordlength: 3
Utilities

- Performance Monitor
  - Calculates fixed-point performance on/offline
  - Shows MSE, # of overflows, SQNR

- Optimization Manager
  - Generates ptcl script to manage repetitive simulation
  - Finds minimum wordlengths
  - Searches the optimum wordlengths

Example script:

```plaintext
... while ($Result != SATISFIED) {
  set prec [getNewPrec $12_in_Prec]
  setstate $12_in_Prec prec
  ... run 10000
  set Result [getResult]
}
...```

Graph:
- Search Space
- Minimum wordlength
- No feasible solution!