Fixed-point Implementation of Dataflow Graphs

Seehyun Kim and Edward A. Lee

University of California at Berkeley

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.

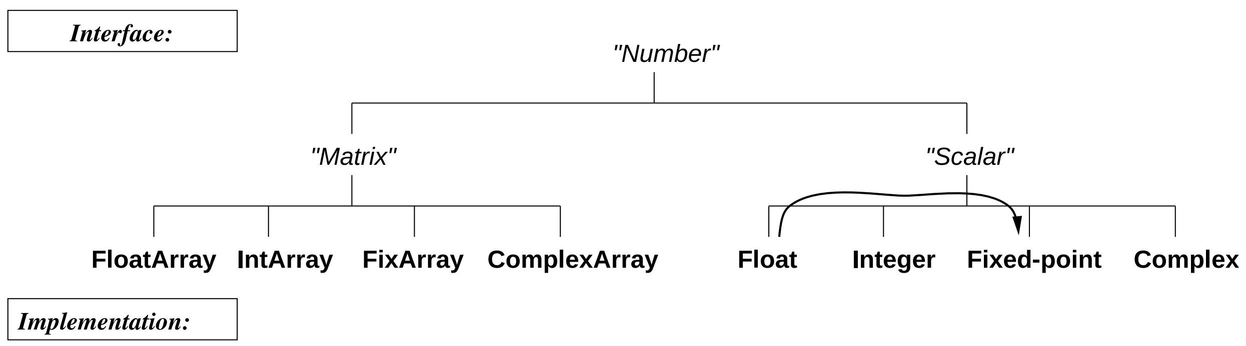
Floating-point Star

```
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

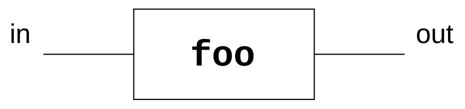
```
defstar {
  name {foo}
  domain {SDF}
  input {
    name{in}
    type{Fix}
  }
  output {
    name{out}
    type{Fix}
  }
  defstate {
    name{IO_in_Prec}
    type{string}
    default{"3.13,tsr"}
  }
  go {
    Fix t = Do(Fix(in%0));
    out%0 << t;
  }
}
```


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

Interface Design Example: `foo`



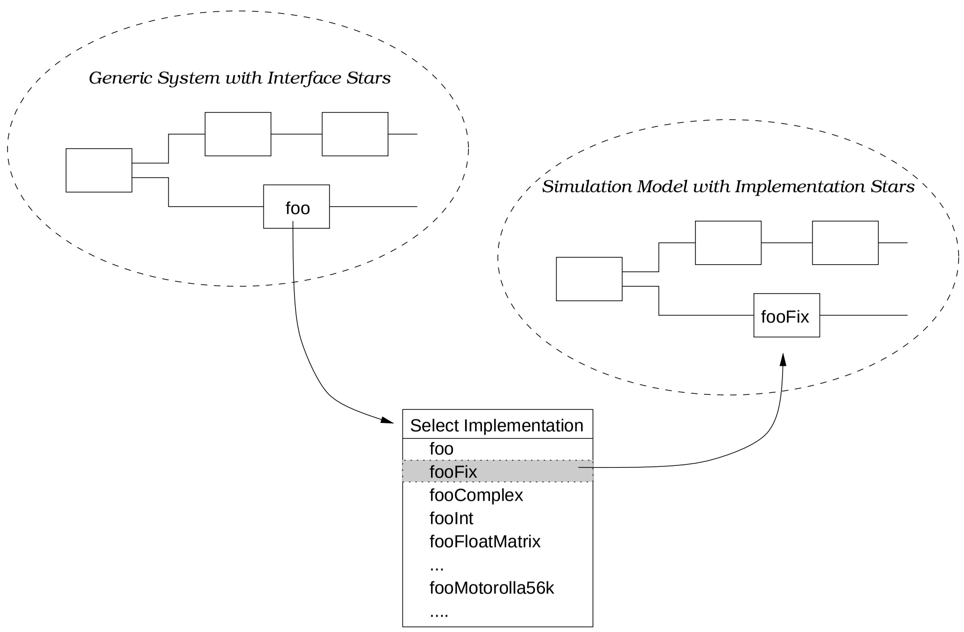
foo.in:

```
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;
  }
}
```

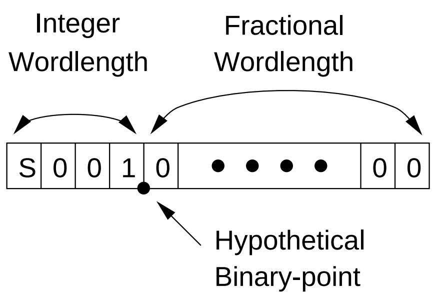
$\leadsto$ `Foo.pl, FooFix.pl, FooComplex.pl, FooMotorolla56k.pl ...`

Generation of Simulation Models

- Select the right implementation



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*

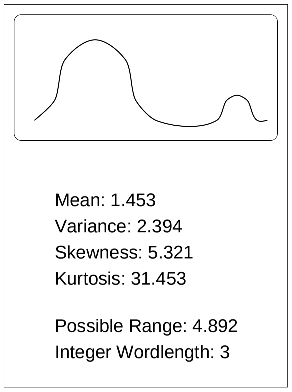
Utilities

☐ Distribution Profiler

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

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

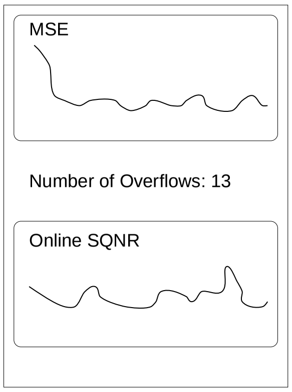
  Multimodal or Nonsymm: $R = R_{max} + g$



Utilities

☐ Performance Monitor

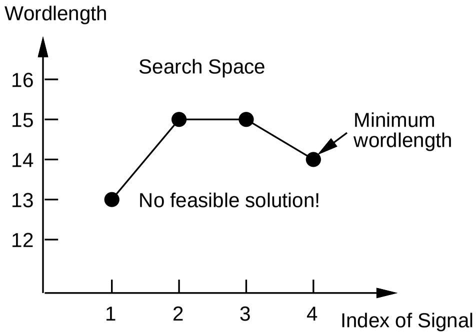
- Calculates fixed-point performance on/offline
- Shows MSE, # of overflows, SQNR



Utilities

☐ Optimization Manager

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



Example script:

```
...
while {$Result != SATISFIED} {
  set prec [getNewPrec $IO_in_Prec]
  setstate IO_in_Prec prec
  ...
  run 10000
  set Result [getResult]
}
...
```