From Lustre to Graphical Models and SCCharts

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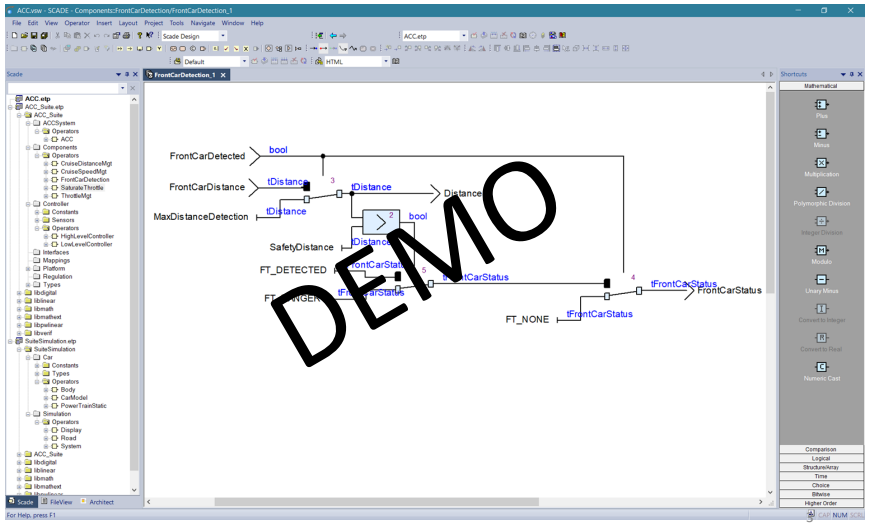
SCADE

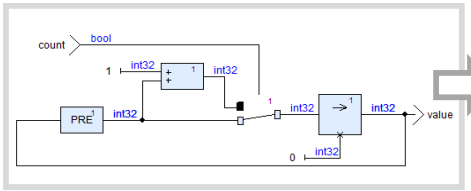


Motivation

Graphical Model

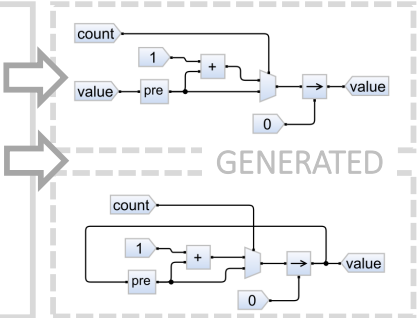
Validation with SCCharts

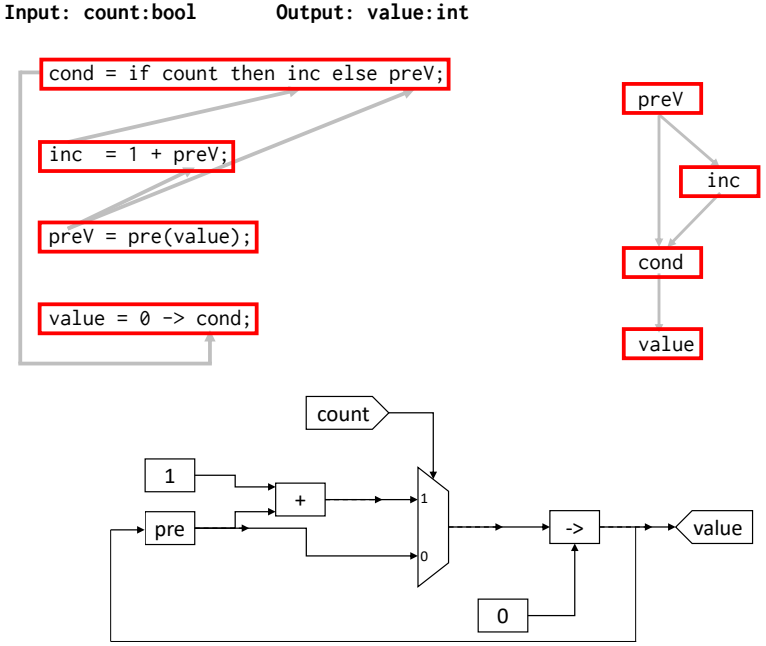
Sequential Constructiveness




```
L1 = count;
value = L7;
L2 = 1;
L3 = pre L7;
L4 = L2 + L3;
L5 = if L1 then (L4) else (L3);
L6 = 0;
L7 = (L6) -> (L5);
```

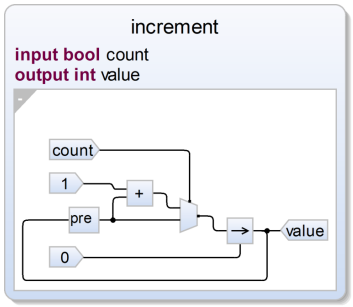
```
node Counter (count:bool)
  returns (value:int)
var L1:bool;
L2, L3, L4, L5, L6, L7:int;
let
  L1 = count;
  value = L7;
  L2 = 1;
  L3 = pre L7;
  L4 = L2 + L3;
  L5 = if L1 then (L4) else (L3);
  L6 = 0;
  L7 = (L6) -> (L5);
tel
```





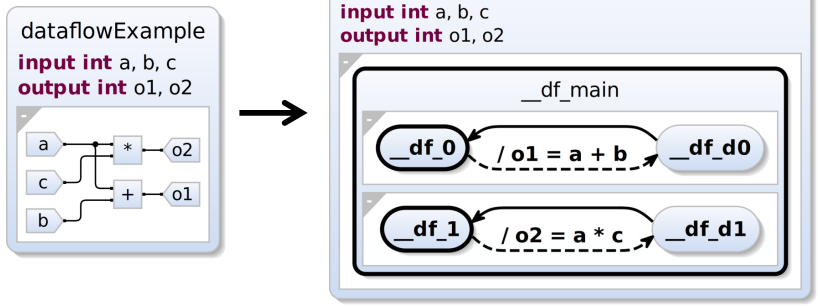

```
node increment (count:bool) returns (value:int)
var cond:int;
    inc:int;
    preV:int;

let
  cond = if count then inc else preV;
  inc  = 1 + preV;
  preV = pre(value);
  value = 0 -> cond;
tel
```

```
scchart increment {
  input bool count
  output int value

  dataflow {
    int cond, inc, preV

    cond = count ? inc : preV
    inc = 1 + preV
    preV = pre(value)
    value = 0 -> cond
  }
}
```

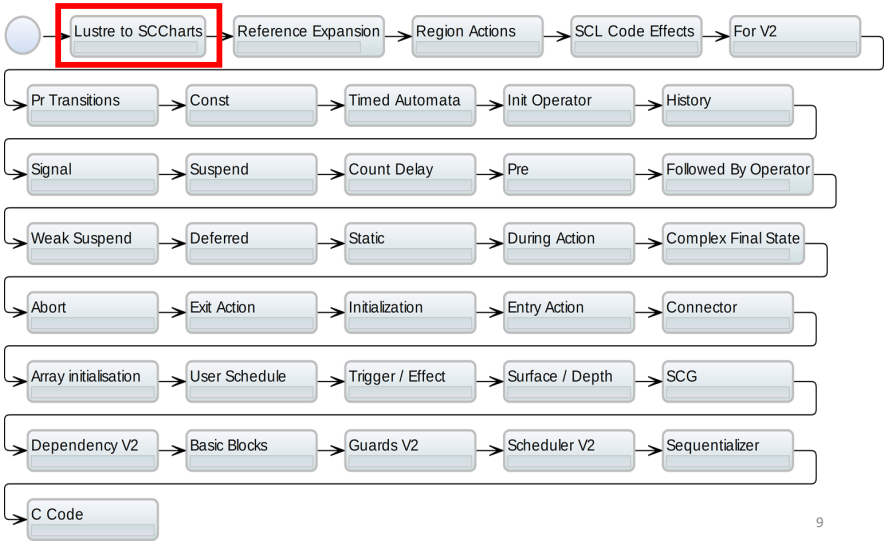


KIELER Demo

SCCharts Dataflow Semantics

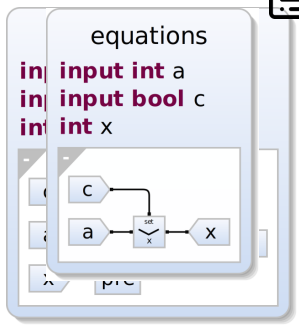


KIELER Compilation Chain



When Operator

```
node equations(a:int; c:bool)
  returns ();

var x:int when c;
let
  x = a when c;
tel.
```




```
scchart equations {
  input int a
  input bool c
  int x
  dataflow {
    x = c ? a : pre(x)
  }
}
```


Lustre Clock Calculus

Lustre

x	1	2	3	4	5	6	7	8	9
clk	true	false	true	false	false	true	false	true	true
x when clk	1		3			6		8	9

when, current?

SCCharts

x	1	2	3	4	5	6	7	8	9
clk	true	false	true	false	false	true	false	true	true
clk? x	1	1	3	3	3	6	6	8	9

Lustre When Operator

clk	true	false	true	false	true	true	false	false	true
x	true	false	false	true	true	false	false	false	true
y	true	false	false	true	false	false	true	true	false
xClk = x when clk	true		false		true	false			true
y when xClk	true				false				false

When Operator with Variables I

clk	true	false	true	false	true	true	false	false	true
x	true	false	false	true	true	false	false	false	true
y	true	false	false	true	false	false	true	true	false

xClk = clk? x	true	true	false	false	true	false	false	false	true
xClk? y	true	**false**	false	false	false	false	false	false	false

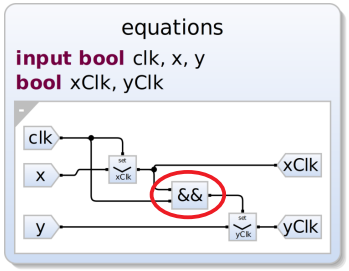
When Operator with Variables II

clk	true	false	true	false	true	true	false	false	true
x	true	false	false	true	true	false	false	false	true
y	true	false	false	true	false	false	true	true	false

xClk = clk? x	true	true	false	false	true	false	false	false	true
(clk&&xClk)? y	true	true	false	false	false	false	false	false	false

Hierarchical When

```
node equations(clk,x,y:bool)
  returns ();

var xClk:bool when clk;
    yClk:bool when xClk;
let
  xClk = x when clk;
  yClk = y when xClk;
tel.
```




```
scchart equations {
  input bool clk, x, y
  bool xClk, yClk

  dataflow {
    xClk = clk ? x
    yClk = (xClk && clk) ? y
  }
}
```

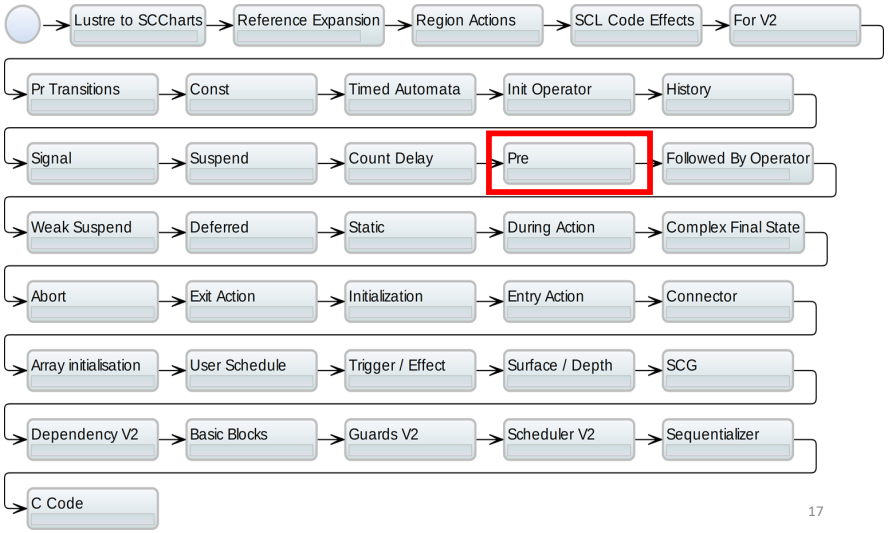

Current?

clk	true	false	true	false	true	true	false	false	true
x	true	false	false	true	true	false	false	false	true
y	true	false	false	true	false	false	true	true	false

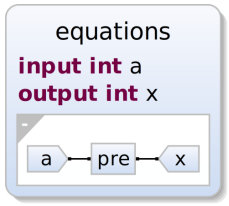
xClk = clk? x	true	true	false	false	true	false	false	false	true
(clk&&xClk)? y	true	true	false	false	false	false	false	false	false

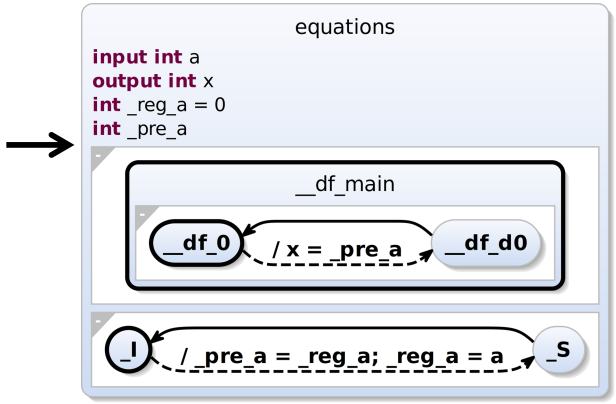
Always implicit *current* through variables

KIELER Compilation Chain



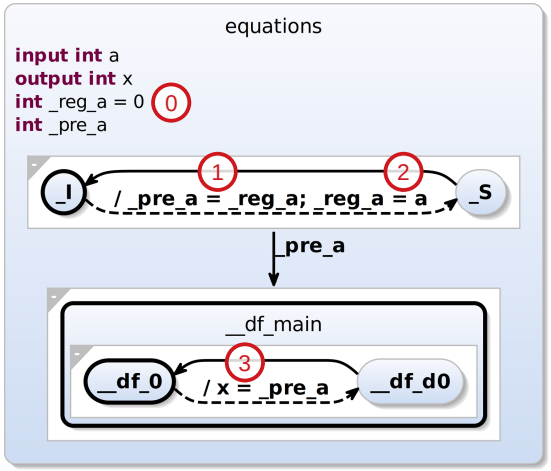
Pre Operator in SCCharts






```
scchart equations {
    input int a
    output int x

    dataflow {
        x = pre(a)
    }
}
```


Pre Operator in SCCharts Induced Dataflow View



Lustre Pre Operator and Clocks

clk	true	false	false	true	true	false	true	false	true
x	1	2	3	4	5	6	7	8	9
xClk = x when clk	1			4	5		7		9
pxClk = pre(xClk)	nil			1	4		5		7
pre(pxClk)	nil			nil	1		4		5

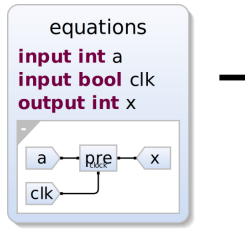
Pre Operator and Clocks with Variables

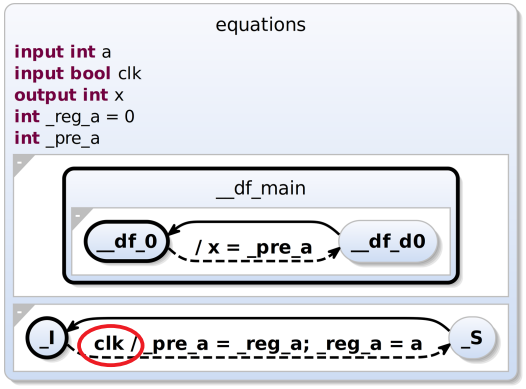
clk	true	false	false	true	true	false	true	false	true
x	1	2	3	4	5	6	7	8	9
xClk = clk? x	1	1	1	4	5	5	7	7	9
pxClk = pre(xClk)	nil	1	1	1	4	5	5	7	7
pre(pxClk)	nil	nil	1	1 nil	1	4	5 4	5	7 5

Clocked Pre Operator with Variables

clk	true	false	false	true	true	false	true	false	true
x	1	2	3	4	5	6	7	8	9
xClk = clk? x	1	1	1	4	5	5	7	7	9
pxClk = pre(xClk)	nil	1	1	1	4	5	5	7	7
pre(pxClk)	nil	nil	1	nil	1	4	5	5	7

Clocked Pre Operation in SCCharts

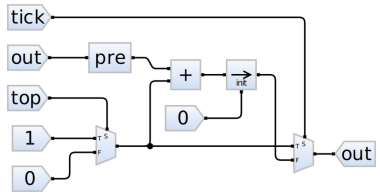




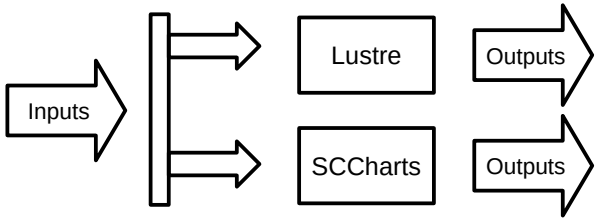

```
scchart equations {
    input int a
    input bool clk
    output int x

    dataflow {
        x = pre(a, clk)
    }
}
```


Model Recovery

```
node counting(tick:bool;top:bool)
   returns (out:int);
var v:int;
let
  v = if top then 1 else 0;
  out = if tick
      then v
      else (0 -> pre out + v);
tel.
```



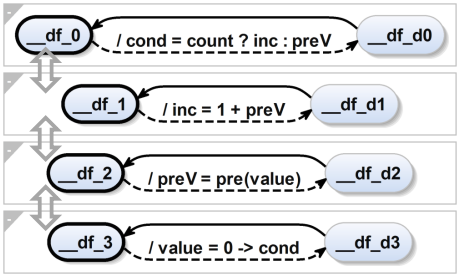
Behavior Preservation



Sequential Constructiveness Concurrency

```
node increment (count:bool)
       returns (value:int)
var cond:int;
    inc:int;
    preV:int;

let
  cond = if count then inc else preV;
  inc  = 1 + preV;
  preV = pre(value);
  value = 0 -> cond;
tel
```

Initialize-Update-Read

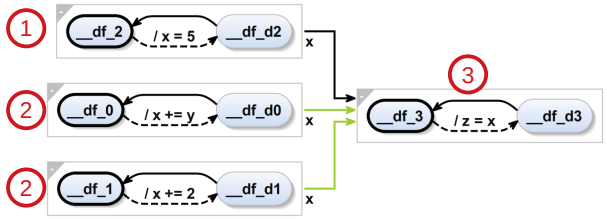


Sequential Constructiveness Sequentiality

```
node simpleInc ()
       returns (value:int)
let
  value = 0 -> value + 1;
tel
```

No Register Variable needed

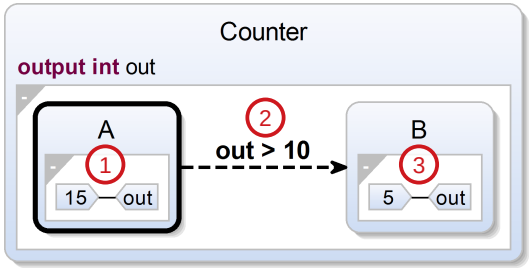

```
…
   x += y;
   x += 2;
   x =  5;
   z =  x;
…
```



Conditioned Updates:

```
…
   x =  5;
   x += b? y;
   x += c? 3;
…
```


Sequential Constructiveness Sequentiality with Automata



> Execute behavior of two states within one tick

Thank you!