6.004 Recitation 10
L10 – Sequential Circuits: Methods with Guarded Interfaces

Problem 1

Recall the following interface and the corresponding **mkFifo (Fifo#(1, t))** module implementation of a FIFO queue given in lecture:

```
interface Fifo#(numeric type size, type t);
  method Action enq(t x);
  method Action deq;
  method t first;
endinterface
```

Create an module implementation using the following interface, using **Bit#(8)** as type t, where `pop` both dequeues and returns the follow of the first element in the Fifo:

```
interface Fifo#(numeric type size, type t);
  method Action enq(t x);
  method ActionValue pop;
endinterface
```

```
module mkPopFifo8 (Fifo#(1,Bit#(8)));
  Reg#(Bit#(8)) d <- mkRegU;
  Reg#(Bool) v <- mkReg(False);

  method Action enq(Bit#(8) x) if (!v);
    v <= True;
    d <= x;
  endmethod

  method ActionValue#(Bit#(8)) pop if (v);
    v <= False;
    return d;
  endmethod
endmodule
```

`Explore:` Try changing some of the assignment operators ("< -", "< =", "=") into the other ones. What compiler errors do you receive?

"< -" to "<=" Will give "assignment forbidden" if occurs in general module context (where many initializations with Registers using "< -" occur, or may complain that you are assigning a Register before instantiation.

("< -" to "=") or ("=" to "< -") will give a type error, as the compiler expects to have the value instantiated but is instead being set equal to the return type of a module, or vice versa.

"<=" to ("=" or "< -") will complain about an improper assigning of the variable. These other operators try to assign the lhs to the rhs, so if we have a Reg#(t) being "assigned" a 't' the compiler may think that this variable is instead a different local variable with the same name of type t, that is being assigned without being declared

Problem 2

Create a "streaming" rule that uses your "pop" Fifo implementation. This rule should be contained in a module that creates 3 Fifos, an "input" Fifo, a "storage" Fifo which takes its enqueues from items dequeued from the input Fifo, and an "output" Fifo, which takes its enqueues from items dequeued from the storage Fifo. *(hint: You will need 2 rules to accomplish this)*

```
module streamFifo();
 Fifo#(1,Bit#(8)) inQ <- mkPopFifo8;
 Fifo#(1,Bit#(8)) midQ <- mkPopFifo8;
 Fifo#(1,Bit#(8)) outQ <- mkFifo8;

 rule toMid;
   let v <- inQ.pop;
   midQ.enq(v);
 endrule

 rule toOut;
   let v <- midQ.pop;
   outQ.enq(v);
 endrule
endmodule
```

Problem 3

Create a version of the FIFO queue that can hold 2 elements. Note: When this FIFO only has a single element in it, this element should be at the “front” of the queue, or in other words it should be the element about to be dequeued/the “first” element.

```
module mkPop2ItemFifo8 (PopFifo#(2,Bit#(8)));
  Reg#(Bit#(8)) a <- mkRegU;
  Reg#(Bit#(8)) b <- mkRegU;
  Reg#(Bool) full <- mkReg(False);
  Reg#(Bool) empty <- mkReg(True);

  method Action enq(Bit#(8) x) if (!full);
    Bool newFull = False;
    if (empty) begin
      a <= x;
    end
    else begin
      b <= x;
      newFull = True;
    end
    full <= newFull;
    empty <= False;
  endmethod

  method ActionValue#(Bit#(8)) pop if (!empty);
    Bool newEmpty = False;
    let retVal = a;
    if (full) begin // when removing a, move b to a
      a <= b;
    end
    else begin // otherwise, becomes empty
      newEmpty = True;
    end
    full <= False;
    empty <= newEmpty
    return retVal;
  endmethod
endmodule
```

Expressing Loops in Bluespec

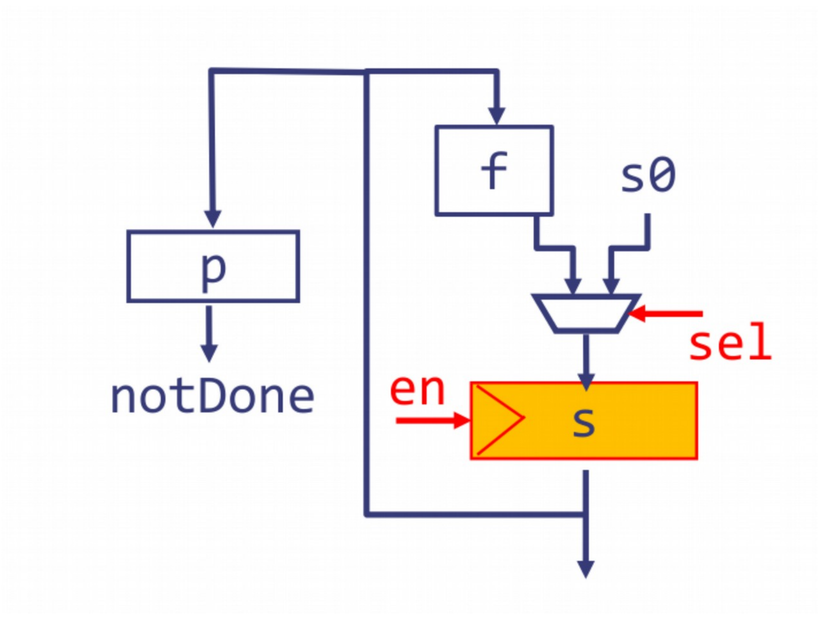
Consider the following while loop in Python:

```
s = s0
while (s > 5):
  s = s - 1
return s
```

The number of iterations that this loop will perform is dependent on the initial value s0. As a result, the loop cannot be described by unfolding. Instead, we can use a **register** to hold the value of *s* from one iteration to the next. Once we've done that, we can use a **rule** to update the value of *s* each cycle until the computation terminates.

The following diagram and Bluespec implementation describe this process:

```
Reg#(Bit#(8)) s <- mkReg(s0);
rule iteration if (s > 5);
  s <= s – 1;
endrule
```



For the described Python code, f(s) = s – 1, and p(s) = (s > 5). 'sel' only picks s0 for the initial value of s, and 'en' is dependent on 'notDone', or the output of p(s)