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|#

EVENT: Start with the library "mlp" using the compiled version.

```
; counter.bm: a simple clock counter, x is the clock.
;   similar to acc when we take our output from the combinational elt.
;
; RESULTS:
; if we look at the combinational output (Ycomb)
;   with initial value of reg: 0 , OK can prove Ycomb = len . [log: counter]
;   with initial value of reg: 1 , fails (expectedly) in COUNT-CORRECT-AX
;     in case p x = e, [log: counter2]
; if we look at Yreg (i.e. register output) then:
;   with initial value of reg: 0 , fails (expectedly) in COUNT-CORRECT-AX
;     in case p x = e, [log: counter4]
```

```

; with initial value of reg: 1 , OK can prove Yreg = len . [log: counter3]
; ANALYSIS:
; The issue is a confusion of the intent of the SPEC: if we are counting the
; number of "pulses" then indeed we can look at the Reg-output, and initialize
; it with zero, because #pulse = len(clk) - 1 = len(any input string) - 1 .
; In other words, the issue is with NUMER-COUNT x =LEN x. If we want to count
; the number of pulses, then we should have number-count x = len x -1, and
; then initialize w/ 0 and look at Reg-out. Check: OK!
; CONCLUSION:
; The model (essentially Mealy) is fine even for looking at Reg-outs, but
; be careful of translating specs involving number of "clock ticks". My tics
; are really "periods", and the engineer's tick are "pulses" of which there are
; always one less when based on an operational semantics looking at things
; "at the end of clock periods".
;
; COMPARISON w/ PAILLET, and PAILLET inferred spec:

;;; DEFINITION OF CIRCUIT:
#|
(setq sysd '(sy-count (x)
(Ycomb S Inc Yreg)
(Yreg R 0 Ycomb)
))

(setq counter '( |#
; BM DEFINITIONS and A2 LEMMAS, generated by BMSYSD:
; comb_inc.bm: INCrement combinational element
; U7-DONE

DEFINITION:  $\text{inc}(u) = (1 + u)$ 

; Everything below generated by: (bmcomb 'inc '() '(x))

DEFINITION:
s-inc(x)
= if empty(x) then E
  else a(s-inc(p(x)), inc(l(x))) endif

;; A2-Begin-S-INC

THEOREM: a2-empty-s-inc
empty(s-inc(x)) = empty(x)

```

THEOREM: a2-e-s-inc
 $(s\text{-inc}(x) = E) = \text{empty}(x)$

THEOREM: a2-lp-s-inc
 $\text{len}(s\text{-inc}(x)) = \text{len}(x)$

THEOREM: a2-lpe-s-inc
 $\text{eqlen}(s\text{-inc}(x), x)$

THEOREM: a2-ic-s-inc
 $s\text{-inc}(i(c.x, x)) = i(\text{inc}(c.x), s\text{-inc}(x))$

THEOREM: a2-lc-s-inc
 $(\neg \text{empty}(x)) \rightarrow (l(s\text{-inc}(x)) = \text{inc}(l(x)))$

THEOREM: a2-pc-s-inc
 $p(s\text{-inc}(x)) = s\text{-inc}(p(x))$

THEOREM: a2-hc-s-inc
 $(\neg \text{empty}(x)) \rightarrow (h(s\text{-inc}(x)) = \text{inc}(h(x)))$

THEOREM: a2-bc-s-inc
 $b(s\text{-inc}(x)) = s\text{-inc}(b(x))$

THEOREM: a2-bnc-s-inc
 $\text{bn}(n, s\text{-inc}(x)) = s\text{-inc}(\text{bn}(n, x))$

;; A2-End-S-INC

; eof:comb_inc.bm

DEFINITION:
 $\text{topor-sy-count}(ln)$
= **if** $ln = \text{'ycomb}$ **then** 1
 elseif $ln = \text{'yreg}$ **then** 0
 else 0 **endif**

DEFINITION:
 $\text{sy-count}(ln, x)$
= **if** $ln = \text{'ycomb}$ **then** $s\text{-inc}(\text{sy-count}(\text{'yreg}, x))$
 elseif $ln = \text{'yreg}$
 then if $\text{empty}(x)$ **then** E
 else $i(0, \text{sy-count}(\text{'ycomb}, p(x)))$ **endif**
 else $\text{sfix}(x)$ **endif**

```

;; A2-Begin-SY-COUNT

THEOREM: a2-empty-sy-count
empty (sy-count (ln, x)) = empty (x)

THEOREM: a2-e-sy-count
(sy-count (ln, x) = E) = empty (x)

THEOREM: a2-lp-sy-count
len (sy-count (ln, x)) = len (x)

THEOREM: a2-lpe-sy-count
eqlen (sy-count (ln, x), x)

THEOREM: a2-pc-sy-count
p (sy-count (ln, x)) = sy-count (ln, p (x))

;; A2-End-SY-COUNT

;;; SPEC definition:
; FIRST (misunderstood) spec:
; note: written when looking at the combinational output..
;
;(defn numer-count (x)
;  (if (empty x)
;      0
;      (inc (numer-count (p x)) )))
;
; intent verification: should have numer-count = len; prove but don't use.
;(prove-lemma numer-count-len ()
;(equal (numer-count x) (len x))
;)

DEFINITION:
numer-count (x)
=  if empty (x) then 0
   else len (x) - 1 endif

;a cheap way: (len (p x))

; this is the standard extension from last-char-fun to MLP-string-fun,
; see theta.bm .

```

DEFINITION:

```
spec-count (x)
=  if empty (x) then E
   else a (spec-count (p (x)), numer-count (x)) endif
```

```
; Paillet's spec do not define an additional function, just a relation
; that must be verified by the circuit output. See below.
```

```
;;; Circuit CORRECTNESS:
; THIS is where it matters which line we take as output!
```

```
; Count-correct-ax is a "predicative correctness statement", i.e. what we would
; do if we didn't have functional equality as a specification method, but
; instead used a purely axiomatic approach.
```

THEOREM: count-correct-ax

$$(\neg \text{empty}(x)) \rightarrow (l(\text{sy-count}('yreg, x)) = \text{numer-count}(x))$$

```
; to go to a functional equality once we have the "last" (ax) statement is
; a trivial induction, if we start out with an P-L split which is unnatural
; for BM, so we force it w/ a USE hint of A-p-l-split
```

THEOREM: a-p-l-split

$$\begin{aligned} &(\neg \text{empty}(x)) \\ &\rightarrow (\text{sy-count}('yreg, x) \\ &\quad = a(\text{p}(\text{sy-count}('yreg, x)), l(\text{sy-count}('yreg, x)))) \end{aligned}$$

THEOREM: count-correct

$$\text{sy-count}('yreg, x) = \text{spec-count}(x)$$

```
; PAILLET CORRECTNESS:
```

```
EVENT: Disable count-correct.
```

```
EVENT: Disable count-correct-ax.
```

```
; count-paillet-correct obtained trivially (without recursion) as expected.
```

THEOREM: count-paillet-correct

$$\begin{aligned} &(\neg \text{empty}(x)) \\ &\rightarrow (\text{sy-count}('yreg, x) = i(0, \text{s-inc}(\text{p}(\text{sy-count}('yreg, x)))))) \end{aligned}$$

```
; my (more intuitive) version of "simple" (no recursion req'd) correctness:
```

THEOREM: count-correct-simple
((\neg empty (x) \wedge (\neg empty (p (x))))
 \rightarrow (l (sy-count ('yreg, x)) = inc (l (p (sy-count ('yreg, x))))))
; eof: counter.bm
;))

Index

a, 2, 5
a-p-l-split, 5
a2-bc-s-inc, 3
a2-bnc-s-inc, 3
a2-e-s-inc, 3
a2-e-sy-count, 4
a2-empty-s-inc, 2
a2-empty-sy-count, 4
a2-hc-s-inc, 3
a2-ic-s-inc, 3
a2-lc-s-inc, 3
a2-lp-s-inc, 3
a2-lp-sy-count, 4
a2-lpe-s-inc, 3
a2-lpe-sy-count, 4
a2-pc-s-inc, 3
a2-pc-sy-count, 4

b, 3
bn, 3

count-correct, 5
count-correct-ax, 5
count-correct-simple, 6
count-paillet-correct, 5

e, 2–5
empty, 2–6
eqlen, 3, 4

h, 3

i, 3, 5
inc, 2, 3, 6

l, 2, 3, 5, 6
len, 3, 4

numer-count, 4, 5

p, 2–6

s-inc, 2, 3, 5

sfix, 3
spec-count, 5
sy-count, 3–6

topor-sy-count, 3