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|#

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

; ppltcpu.bm is our 1st pipelined CPU (on our way to SRC CPU):
;
; it's totally trivial and unrealistic: no jumps, and current values in
; (visible) register(s) can't be USED in instructions! (i.e. NO LOOPS).
;
;;;; (Sugared) Circuits:
#|
(setq sy-A '(SY-A (x)
(Ypc R 0 Ypcn)
(Ypcn S inc Ypc)
(setq sy-B '(SY-B (x))
       (Ypc R 0 Ypcn)
       (Ypcn S inc Ypc)
       (Ypr S Up Ypc)
       (Ypr2 R 0 Ypr)
       (Yi S Ui Ypr2)
       (Yi2 R 0 Yi)
       (Ye S Ue Yi2)
       (Yout R 0 Ye)
))

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

DEFINITION:  inc(u) = (1 + u)

; Everything below generated by: (bmcmb '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-inc(x) = E) = empty(x)
Theorem: a2-lp-s-inc
\[ \text{len}(\text{s-inc}(x)) = \text{len}(x) \]

Theorem: a2-lpe-s-inc
eq\text{len}(\text{s-inc}(x), x)

Theorem: a2-ic-s-inc
\[ \text{s-inc}(i(c, x, x)) = i(\text{inc}(c, x), \text{s-inc}(x)) \]

Theorem: a2-lc-s-inc
\[ (\neg\text{empty}(x)) \rightarrow (\text{l}(\text{s-inc}(x)) = \text{inc}(\text{l}(x))) \]

Theorem: a2-pc-s-inc
\[ p(\text{s-inc}(x)) = \text{s-inc}(p(x)) \]

Theorem: a2-hc-s-inc
\[ (\neg\text{empty}(x)) \rightarrow (\text{h}(\text{s-inc}(x)) = \text{inc}(\text{h}(x))) \]

Theorem: a2-bc-s-inc
\[ \text{b}(\text{s-inc}(x)) = \text{s-inc}(\text{b}(x)) \]

Theorem: a2-bnc-s-inc
\[ \text{bn}(n, \text{s-inc}(x)) = \text{s-inc}(\text{bn}(n, x)) \]

;;; A2-End-S-INC

; eof:comb_inc.bm

; comb_up.bm: Up combinational element (= fun1)
; \text{U7-DONE}

; arbitrary Char-Fun of arity 1:

Event: Introduce the function symbol \text{up} of one argument.

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

Definition:
s-up(x) = \text{if empty}(x) \text{ then E else a}(\text{s-up}(p(x)), \text{up}(l(x))) \text{ endif}

;;; A2-Begin-S-UP

3
THEOREM: a2-empty-s-up
\( \text{empty}(s\text{-up}(x)) = \text{empty}(x) \)

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

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

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

THEOREM: a2-ic-s-up
\( s\text{-up}(l(c_x, x)) = i(up(c_x), s\text{-up}(x)) \)

THEOREM: a2-ic-s-up
\( (\neg \text{empty}(x)) \rightarrow (l(s\text{-up}(x)) = up(l(x))) \)

THEOREM: a2-ic-s-up
\( s\text{-up}(l(c_x, x)) = i(up(c_x), s\text{-up}(x)) \)

THEOREM: a2-ic-s-up
\( (\neg \text{empty}(x)) \rightarrow (h(s\text{-up}(x)) = up(h(x))) \)

THEOREM: a2-ic-s-up
\( b(s\text{-up}(x)) = s\text{-up}(b(x)) \)

THEOREM: a2-ic-s-up
\( b(n, s\text{-up}(x)) = s\text{-up}(bn(n, x)) \)

;; A2-End-S-UP

; eof:comb_up.bm

; comb_ui.bm: Ui combinational element (= fun1)
; U7-DONE

; arbitrary Char-Fun of arity 1:
EVENT: Introduce the function symbol ui of one argument.

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

DEFINITION:
s-ui(x)
= if empty(x) then E
  else a(s-ui(p(x)), ui(l(x))) endif
Theorem: a2-empty-s-ui  
empty (s-ui (x)) = empty (x)

Theorem: a2-e-s-ui  
(s-ui (x) = e) = empty (x)

Theorem: a2-lp-s-ui  
len (s-ui (x)) = len (x)

Theorem: a2-lpe-s-ui  
eqlen (s-ui (x), x)

Theorem: a2-ic-s-ui  
s-ui (i (c_x, x)) = i (ui (c_x), s-ui (x))

Theorem: a2-lc-s-ui  
(¬ empty (x)) → (l (s-ui (x)) = ui (l(x)))

Theorem: a2-pc-s-ui  
p (s-ui (x)) = s-ui (p (x))

Theorem: a2-hc-s-ui  
(¬ empty (x)) → (h (s-ui (x)) = ui (h (x)))

Theorem: a2-bc-s-ui  
b (s-ui (x)) = s-ui (b (x))

Theorem: a2-bnc-s-ui  
b (n, s-ui (x)) = s-ui (b (n, x))

; A2-End-S-UI

; eof:comb_ui.bm

; comb_ue.bm: Ue combinational element (= fun1)
; U7-DONE

; arbitrary Char-Fun of arity 1:

EVENT: Introduce the function symbol ue of one argument.

; Everything below generated by: (bmcomb 'Ue '() '())
Definition:
\[ s-ue(x) = \begin{cases} 
  \text{if empty}(x) & \text{then } E \\
  \text{else } a(s-ue(p(x)), u(l(x))) & \text{endif} 
\end{cases} \]

;; A2-Begin-S-UE

Theorem: a2-empty-s-ue
\[ \text{empty}(s-ue(x)) = \text{empty}(x) \]

Theorem: a2-e-s-ue
\[ (s-ue(x) = E) = \text{empty}(x) \]

Theorem: a2-lp-s-ue
\[ \text{len}(s-ue(x)) = \text{len}(x) \]

Theorem: a2-lpe-s-ue
\[ \text{eqlen}(s-ue(x), x) \]

Theorem: a2-ic-s-ue
\[ s-ue(i(c_x, x)) = i(ue(c_x), s-ue(x)) \]

Theorem: a2-lc-s-ue
\[ \neg \text{empty}(x) \rightarrow (l(s-ue(x)) = \text{ue}(l(x))) \]

Theorem: a2-pc-s-ue
\[ p(s-ue(x)) = s-ue(p(x)) \]

Theorem: a2-hc-s-ue
\[ \neg \text{empty}(x) \rightarrow (h(s-ue(x)) = \text{ue}(h(x))) \]

Theorem: a2-bc-s-ue
\[ b(s-ue(x)) = s-ue(b(x)) \]

Theorem: a2-bnc-s-ue
\[ \text{bn}(n, s-ue(x)) = s-ue(\text{bn}(n, x)) \]

;; A2-End-S-UE

; eof:comb_ue.bm
**Definition:**

topor-sy-a (ln) = if ln = 'ypc then 0
  elseif ln = 'ypcn then 1
  elseif ln = 'ypr then 1
  elseif ln = 'yi then 2
  elseif ln = 'ye then 3
  elseif ln = 'yout then 0
  elseif ln = 'yec1 then 0
  else 0 endif

**Definition:**
sy-a (ln, x) = if ln = 'ypc then if empty (x) then E else i (0, sy-a ('ypcn, p (x))) endif
  elseif ln = 'ypcn then s-inc (sy-a ('ypc, x))
  elseif ln = 'ypr then s-up (sy-a ('ypc, x))
  elseif ln = 'yi then s-ui (sy-a ('ypr, x))
  elseif ln = 'ye then s-ue (sy-a ('yi, x))
  elseif ln = 'yout then if empty (x) then E else i (0, sy-a ('ye, p (x))) endif
  elseif ln = 'yec1 then if empty (x) then E else i (ue (ui (0)), sy-a ('ye, p (x))) endif
  elseif ln = 'yec then if empty (x) then E else i (ue (0), sy-a ('yec1, p (x))) endif
  else sfix (x) endif

;; A2-Begin-SY-A

**Theorem:** a2-empty-sy-a
empty (sy-a (ln, x)) = empty (x)

**Theorem:** a2-e-sy-a
(sy-a (ln, x) = E) = empty (x)

**Theorem:** a2-lp-sy-a
len (sy-a (ln, x)) = len (x)

**Theorem:** a2-lpe-sy-a
eqlen (sy-a (ln, x), x)
Theorem: \( \text{a2-pc-sy-a} \)
\[ p(\text{sy-a}(ln, x)) = \text{sy-a}(ln, p(x)) \]

\%; A2-End-SY-A

Definition:
\[ \text{topor-sy-b}(ln) = \]
\[ \text{if } ln = 'ypc \text{ then } 0 \] 
\[ \text{elseif } ln = 'ypcn \text{ then } 1 \] 
\[ \text{elseif } ln = 'ypr \text{ then } 1 \] 
\[ \text{elseif } ln = 'ypr2 \text{ then } 0 \] 
\[ \text{elseif } ln = 'yi \text{ then } 1 \] 
\[ \text{elseif } ln = 'yi2 \text{ then } 0 \] 
\[ \text{elseif } ln = 'ye \text{ then } 1 \] 
\[ \text{elseif } ln = 'yout \text{ then } 0 \] 
\[ \text{else } 0 \]  
endif

Definition:
\[ \text{sy-b}(ln, x) = \]
\[ \text{if } ln = 'ypc \text{ then if empty } (x) \text{ then } \text{E} \] 
\[ \text{else i}(0, \text{sy-b}('ypcn, p(x))) \] endif
\[ \text{elseif } ln = 'ypcn \text{ then s-inc } (\text{sy-b}('ypc, x)) \] 
\[ \text{elseif } ln = 'ypr \text{ then s-up } (\text{sy-b}('ypc, x)) \] 
\[ \text{elseif } ln = 'ypr2 \text{ then if empty } (x) \text{ then } \text{E} \] 
\[ \text{else i}(0, \text{sy-b}('ypr, p(x))) \] endif
\[ \text{elseif } ln = 'yi \text{ then s-ui } (\text{sy-b}('ypr2, x)) \] 
\[ \text{elseif } ln = 'yi2 \text{ then if empty } (x) \text{ then } \text{E} \] 
\[ \text{else i}(0, \text{sy-b}('yi, p(x))) \] endif
\[ \text{elseif } ln = 'ye \text{ then s-ue } (\text{sy-b}('yi2, x)) \] 
\[ \text{elseif } ln = 'yout \text{ then if empty } (x) \text{ then } \text{E} \] 
\[ \text{else i}(0, \text{sy-b}('ye, p(x))) \] endif
\[ \text{else sfix } (x) \] endif

\%; A2-Begin-SY-B

Theorem: \( \text{a2-empty-sy-b} \)
\[ \text{empty } (\text{sy-b}(ln, x)) = \text{empty } (x) \]

Theorem: \( \text{a2-e-sy-b} \)
\[ (\text{sy-b}(ln, x) = \text{E}) = \text{empty } (x) \]
Theorem: a2-lp-sy-b
\[ \text{len}(\text{sy-b}(ln, x)) = \text{len}(x) \]

Theorem: a2-lpe-sy-b
\[ \text{eqlen}(\text{sy-b}(ln, x), x) \]

Theorem: a2-pc-sy-b
\[ p(\text{sy-b}(ln, x)) = \text{sy-b}(ln, p(x)) \]

;; A2-End-SY-B

; SOME ANIMATION:
; (setq x5T (A (A (A (A (e) T) T) T) T))
;*(sy-A 'Yout x5t)
; (A (A (A (A (A (E) 0)
; ' (UE (UI (UP 0)))))
; ' (UE (UI (UP 1))))
; ' (UE (UI (UP 2))))
; ' (UE (UI (UP 3))))
;*(sy-A 'Ye x5t)
; (A (A (A (A (A (E) '(UE (UI (UP 0))))
; ' (UE (UI (UP 1))))
; '(UE (UI (UP 2))))
; ' (UE (UI (UP 3))))
; ' (UE (UI (UP 4))))
;*(sy-B 'Yout x5t)
; (A (A (A (A (A (E) 0)
; ' (UE (UI 0)))
; ' (UE (UI (UP 0))))
; ' (UE (UI (UP 1))))
;*(sy-B 'Ye x5t)
; (A (A (A (A (A (E) 0))
; ' (UE (UI 0)))
; ' (UE (UI (UP 0))))
; ' (UE (UI (UP 1))))
; *
; THIS SHOWS that Yout is not PPL but YE is. Proof of PPL YE w/ cork:
; (UE (UI (UP 0)))
; NOTE: I should really find a way to prove such a thing without going
; back to the circuit and altering def... (w/ DECORK & CORK?)

; This takes care of the PC loop:
THEOREM: eq-pc
\[ \text{sy-b}('ypc, x) = \text{sy-a}('ypc, x) \]

THEOREM: eq-a-b
\[ \text{sy-b}('ye, x) = \text{sy-a}('yec, x) \]

; EQ-A-B2: this phrasing REMOVES the need for fiddling with the circuit:
; i.e. has the cork explicitely in thm.

THEOREM: eq-a-b2
\[
\text{sy-b}('ye, x) =
\begin{array}{l}
\text{if empty}(x) \text{ then } E \\
\text{else } i(\text{ue}(0),\\
\quad \text{if empty}(p(x)) \text{ then } E \\
\quad \text{else } i(\text{ue}(\text{ui}(0)), \text{sy-a}('ye, p(p(x)))) \text{ endif}) \text{ endif}
\end{array}
\]

; EQ-A-B3: this is a weaker but more legible version of the explicitely
; corked thm.

THEOREM: eq-a-b3
\[
(\neg \text{empty}(p(x))) \rightarrow (\text{sy-b}('ye, x) = i(\text{ue}(0), i(\text{ue}(\text{ui}(0)), \text{sy-a}('ye, p(p(x))))))
\]

; Leaving the circuit alone AND WITHOUT EXPLICITING the cork, we get:

THEOREM: eq-a-b4
\[
(\neg \text{empty}(p(x))) \rightarrow (b(b(\text{sy-b}('ye, x))) = \text{sy-a}('ye, p(p(x))))
\]

; eof: ppltcpu.bm
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