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

EVENT: For efficiency, compile those definitions not yet compiled.

THEOREM: zplus-comm1  
 $\text{zplus}(x, y) = \text{zplus}(y, x)$

THEOREM: zplus-comm2  
 $\text{zplus}(x, \text{zplus}(y, z)) = \text{zplus}(y, \text{zplus}(x, z))$

THEOREM: zplus-assoc  
 $\text{zplus}(\text{zplus}(x, y), z) = \text{zplus}(x, \text{zplus}(y, z))$

EVENT: Disable zplus.

EVENT: Add the shell *vehicle-state*, with recognizer function symbol *vehicle-statep* and 3 accessors: *w*, with type restriction (none-of) and default value zero; *y*, with type restriction (none-of) and default value zero; *v*, with type restriction (none-of) and default value zero.

DEFINITION:  $\text{hd}(x) = \text{car}(x)$

DEFINITION:  $\text{tl}(x) = \text{cdr}(x)$

DEFINITION:  $\text{empty}(x) = (\neg \text{listp}(x))$

THEOREM: tl-rewrite  
 $\text{tl}(x) = \text{cdr}(x)$

EVENT: Disable tl.

THEOREM: down-on-tl  
 $(\neg \text{empty}(x)) \rightarrow (\text{count}(\text{tl}(x)) < \text{count}(x))$

DEFINITION:  
 $\text{random-delta-ws}(lst)$   
 $=$  **if**  $\text{empty}(lst)$  **then** **t**  
     **else**  $(\text{hd}(lst) = -1)$   
          $\vee (\text{hd}(lst) = 0)$   
          $\vee (\text{hd}(lst) = 1)$   
      $\wedge \text{random-delta-ws}(\text{tl}(lst))$  **endif**

DEFINITION:  
 $\text{controller}(sgn-y, sgn-old-y)$   
 $= \text{zplus}(\text{ztimes}(-3, sgn-y), \text{ztimes}(2, sgn-old-y))$

EVENT: Disable controller.

DEFINITION:  
 $\text{sgn}(x)$   
 $=$  **if**  $\text{negativep}(x)$   
     **then if**  $\text{negative-guts}(x) = 0$  **then** 0  
         **else** -1 **endif**  
     **elseif**  $x \simeq 0$  **then** 0  
     **else** 1 **endif**

EVENT: Disable sgn.

DEFINITION:

```

next-state(delta-w, state)
=   vehicle-state(zplus(w(state), delta-w),
                  zplus(y(state), zplus(v(state), zplus(w(state), delta-w))),
                  zplus(v(state),
                        controller(sgn(zplus(y(state),
                                              zplus(v(state),
                                                    zplus(w(state), delta-w))))),
                        sgn(y(state))))))

```

DEFINITION:

```

final-state-of-vehicle(delta-ws, state)
=   if empty(delta-ws) then state
    else final-state-of-vehicle(tl(delta-ws),
                                next-state(hd(delta-ws), state)) endif

```

DEFINITION:

```

good-statep(state)
=   if y(state) = 0
    then (zplus(v(state), w(state)) = -1)
         ∨ (zplus(v(state), w(state)) = 0)
         ∨ (zplus(v(state), w(state)) = 1)
    elseif y(state) = 1
    then (zplus(v(state), w(state)) = -2)
         ∨ (zplus(v(state), w(state)) = -3)
    elseif y(state) = 2
    then (zplus(v(state), w(state)) = -1)
         ∨ (zplus(v(state), w(state)) = -2)
    elseif y(state) = 3 then zplus(v(state), w(state)) = -1
    elseif y(state) = -3 then zplus(v(state), w(state)) = 1
    elseif y(state) = -2
    then (zplus(v(state), w(state)) = 1)
         ∨ (zplus(v(state), w(state)) = 2)
    elseif y(state) = -1
    then (zplus(v(state), w(state)) = 2)
         ∨ (zplus(v(state), w(state)) = 3)
    else f endif

```

THEOREM: next-good-state

```

(good-statep(state) ∧ ((r = -1) ∨ (r = 0) ∨ (r = 1)))
→ good-statep(next-state(r, state))

```

DEFINITION:

```

zero-delta-ws(lst)
=   if empty(lst) then t
    else (hd(lst) = 0) ∧ zero-delta-ws(tl(lst)) endif

```

DEFINITION:

$\text{concat}(x, y)$   
= **if**  $\text{empty}(x)$  **then**  $y$   
  **else**  $\text{cons}(\text{hd}(x), \text{concat}(\text{tl}(x), y))$  **endif**

DEFINITION:

$\text{length}(x)$   
= **if**  $\text{empty}(x)$  **then**  $0$   
  **else**  $1 + \text{length}(\text{tl}(x))$  **endif**

THEOREM: length-0

$(\text{length}(x) = 0) = \text{empty}(x)$

THEOREM: decompose-list-of-length-4

$\text{zero-delta-ws}(lst)$   
 $\rightarrow ((\text{length}(lst) < 4) = (lst \neq \text{concat}(' (0\ 0\ 0\ 0), \text{cddddr}(lst))))$

THEOREM: drift-to-0-in-4

$\text{good-statep}(state)$   
 $\rightarrow (y(\text{final-state-of-vehicle}(' (0\ 0\ 0\ 0), state)) = 0)$

THEOREM: cancel-wind-in-4

$\text{good-statep}(state)$   
 $\rightarrow (\text{zplus}(\text{v}(\text{final-state-of-vehicle}(' (0\ 0\ 0\ 0), state)),$   
   $\text{w}(\text{final-state-of-vehicle}(' (0\ 0\ 0\ 0), state)))$   
   $= 0)$

THEOREM: once-0-always-0

$(\text{zero-delta-ws}(lst)$   
   $\wedge (y(state) = 0)$   
   $\wedge (\text{zplus}(\text{w}(state), \text{v}(state)) = 0))$   
 $\rightarrow ((y(\text{final-state-of-vehicle}(lst, state)) = 0)$   
   $\wedge (\text{zplus}(\text{v}(\text{final-state-of-vehicle}(lst, state)),$   
     $\text{w}(\text{final-state-of-vehicle}(lst, state)))$   
   $= 0))$

THEOREM: final-state-of-vehicle-concat

$\text{final-state-of-vehicle}(\text{concat}(a, b), state)$   
=  $\text{final-state-of-vehicle}(b, \text{final-state-of-vehicle}(a, state))$

THEOREM: zero-delta-ws-concat

$\text{zero-delta-ws}(\text{concat}(' (0\ 0\ 0\ 0), v)) = \text{zero-delta-ws}(v)$

EVENT: Disable concat.

EVENT: Disable next-state.



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