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|#

;; Matt Kaufmann

;; From a session with Shaun Cooper, 12/9/91. Based on CLI Internal Note 210 by Bill Young.

EVENT: Start with the initial \texttt{nqthm} theory.

**Definition:**

\[
\text{length} \ (x) = \begin{cases} 
1 + \text{length} \ (\text{cdr} \ (x)) & \text{if } \text{listp} \ (x) \\
0 & \text{else} \end{cases}
\]

**Definition:**

\[
\text{plistp} \ (x) = \begin{cases} 
\text{plistp} \ (\text{cdr} \ (x)) & \text{if } \text{listp} \ (x) \\
x & \text{else} \end{cases}
\]

**Definition:**

\[
\text{exp-p} \ (\text{exp})
\]
if $\exp \in \mathbb{N}$ then $t$
elseif $\neg \text{plistp} (\exp)$ then $f$
elseif $\text{length} (\exp) = 3$
then if $\text{car} (\exp) = '\text{plus}$
then $\text{exp-p} (\text{cadr} (\exp)) \land \text{exp-p} (\text{caddr} (\exp))$
elseif $\text{car} (\exp) = '\text{times}$
then $\text{exp-p} (\text{cadr} (\exp)) \land \text{exp-p} (\text{caddr} (\exp))$
elseif $\text{car} (\exp) = '\text{subtract}$
then $\text{exp-p} (\text{cadr} (\exp)) \land \text{exp-p} (\text{caddr} (\exp))$
else $f$
endif
endif
else $f$
endif

THEOREM: \text{exp-p-opener}
$(\exp \notin \mathbb{N}) 
\rightarrow (\text{exp-p} (\exp) = \begin{cases} 
\text{if } \neg \text{plistp} (\exp) \text{ then } f 
\text{elseif } \text{length} (\exp) = 3 
\text{then if } \text{car} (\exp) = '\text{plus} 
\text{then } \text{exp-p} (\text{cadr} (\exp)) \land \text{exp-p} (\text{caddr} (\exp)) 
\text{elseif } \text{car} (\exp) = '\text{times} 
\text{then } \text{exp-p} (\text{cadr} (\exp)) \land \text{exp-p} (\text{caddr} (\exp)) 
\text{elseif } \text{car} (\exp) = '\text{subtract} 
\text{then } \text{exp-p} (\text{cadr} (\exp)) \land \text{exp-p} (\text{caddr} (\exp)) 
\text{else } f 
\end{cases} 
\text{endif} 
\text{else } f \text{endif})$

DEFINITION:
\text{eval-s} (\exp) = \begin{cases} 
\text{if } \neg \text{exp-p} (\exp) \text{ then } 0 
\text{elseif } \exp \in \mathbb{N} \text{ then } \exp 
\text{elseif } \text{car} (\exp) = '\text{plus} 
\text{then } \text{eval-s} (\text{cadr} (\exp)) + \text{eval-s} (\text{caddr} (\exp)) 
\text{elseif } \text{car} (\exp) = '\text{times} 
\text{then } \text{eval-s} (\text{cadr} (\exp)) \ast \text{eval-s} (\text{caddr} (\exp)) 
\text{elseif } \text{car} (\exp) = '\text{subtract} 
\text{then } \text{eval-s} (\text{cadr} (\exp)) - \text{eval-s} (\text{caddr} (\exp)) 
\text{else } 0 \text{ endif} 
\end{cases}$

EVENT: Disable \text{exp-p-opener}.

DEFINITION:
\text{target-inst-p} (\exp) = \begin{cases} 
\text{if } \exp \simeq \text{nil} \text{ then } \exp \in '\text{add \ mult \ sub} 
\text{else } \text{plistp} (\exp) 
\end{cases}$
∧ (length (exp) = 2)
∧ (car (exp) = 'pushc)
∧ (cadr (exp) ∈ N) endif

**Definition:**
target-inst-list-p (exp)
= if listp (exp)
    then target-inst-p (car (exp)) ∧ target-inst-list-p (cdr (exp))
    else exp = nil endif

**Definition:**
single-step (inst, s)
= case on inst:
  case = add
    then cons (cadr (s) + car (s), cddr (s))
  case = mult
    then cons (cadr (s) * car (s), cddr (s))
  case = sub
    then cons (cadr (s) − car (s), cddr (s))
  otherwise cons (cadr (inst), s) endcase

**Definition:**
interpreter-target (inst-list, s)
= if listp (inst-list)
    then interpreter-target (cdr (inst-list), single-step (car (inst-list), s))
    else s endif

**Event:** Enable exp-p-opener.

**Definition:**
compile (exp)
= if ¬ exp-p (exp) then nil
  elseif exp ∈ N then list (list ('pushc, exp))
  elseif car (exp) = 'plus
    then append (compile (cadr (exp)),
            append (compile (caddr (exp)), list ('add)))
  elseif car (exp) = 'times
    then append (compile (cadr (exp)),
            append (compile (caddr (exp)), list ('mul'))) 
  elseif car (exp) = 'subtract
    then append (compile (cadr (exp)),
            append (compile (caddr (exp)), list ('sub)))
  else nil endif

**Event:** Disable exp-p-opener.
Theorem: compile-preserves-legality
\[ \text{exp-p (exp) } \rightarrow \text{target-inst-list-p (compile (exp))} \]

Theorem: interpreter-target-append
\[
\text{interpreter-target (append (inst-list1, inst-list2), s)} = \text{interpreter-target (inst-list2, interpreter-target (inst-list1, s))}
\]

first version: provides too weak of an inductive hypothesis
(prove-lemma compiler-correctness (rewrite)
  (implies (exp-p exp)
    (equal (eval-s exp)
      (car (interpreter-target (compile exp) s)))))
)

Definition:
compiler-correctness-induct (exp, s)
\[
= \begin{cases} 
\text{if length (exp) = 3} & \text{then compiler-correctness-induct (cadr (exp), s)} \\
\text{else t endif} 
\end{cases}
\]

Theorem: compiler-correctness-plus
\[ \text{exp-p (exp)} \rightarrow (\text{interpreter-target (compile (exp), s)} = \text{cons (eval-s (exp), s)}) \]

Theorem: compiler-correctness
\[ \text{exp-p (exp)} \rightarrow (\text{eval-s (exp)} = \text{car (interpreter-target (compile (exp), s))}) \]
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