
MODULE *TimeUtils*

EXTENDS *Naturals, Sequences, TLC*

Use a fixed epoch for a consistent time base.

$FixedEpochYear \triangleq 2000$

$YearRange \triangleq FixedEpochYear \dots FixedEpochYear + 50$

$MinutesInDay \triangleq 24 * 60$

$IsLeapYear(year) \triangleq$

LET

$div4 \triangleq year \% 4 = 0$

$notDiv100 \triangleq year \% 100 \neq 0$

$div400 \triangleq year \% 400 = 0$

IN

$div4 \wedge (notDiv100 \vee div400)$

$DaysInMonth \triangleq$

$[i \in 1 \dots 12 \mapsto$

CASE $i = 1 \rightarrow 31$

$\square i = 2 \rightarrow 28$

$\square i = 3 \rightarrow 31$

$\square i = 4 \rightarrow 30$

$\square i = 5 \rightarrow 31$

$\square i = 6 \rightarrow 30$

$\square i = 7 \rightarrow 31$

$\square i = 8 \rightarrow 31$

$\square i = 9 \rightarrow 30$

$\square i = 10 \rightarrow 31$

$\square i = 11 \rightarrow 30$

$\square i = 12 \rightarrow 31$

$]$

RECURSIVE $DaysUpToMonth(-)$

$DaysUpToMonth(tp) \triangleq$

IF $tp.month = 1$

THEN 0

ELSE $DaysUpToMonth([tp \text{ EXCEPT } !.month = tp.month - 1])$

+ IF $tp.month = 2 \wedge IsLeapYear(tp.year)$

THEN 29

ELSE $DaysInMonth[tp.month - 1]$

$LeapDaysSinceEpoch(y) \triangleq$
 LET $d \triangleq y - FixedEpochYear$
 IN $(d \div 4) - (d \div 100) + (d \div 400)$

$LinearTime(tp) \triangleq$
 LET
 $yearOffset \triangleq (tp.year - FixedEpochYear) * 365 * MinutesInDay$
 $leapYearOffset \triangleq LeapDaysSinceEpoch(tp.year) * MinutesInDay$
 $monthOffset \triangleq DaysUpToMonth(tp) * MinutesInDay$
 $dayOffset \triangleq (tp.day - 1) * MinutesInDay$
 $hourOffset \triangleq tp.hour * 60$
 $minuteOffset \triangleq tp.minute$
 IN
 $yearOffset + leapYearOffset + monthOffset + dayOffset + hourOffset + minuteOffset$

Predicates for time comparison and duration.

$Before(t1, t2) \triangleq LinearTime(t1) < LinearTime(t2)$
 $After(t1, t2) \triangleq LinearTime(t1) > LinearTime(t2)$
 $TimeBetween(t_start, t_end, t_test) \triangleq \wedge Before(t_start, t_test) \wedge Before(t_test, t_end)$

Help function for calculation if a time point occur within 72 hours.

$Within72Hours(start_time, end_time) \triangleq (LinearTime(end_time) - LinearTime(start_time)) \leq 72 * 60$

The earliest time point within a set of events

$MinTime(events) \triangleq$
 LET $times \triangleq \{e.time : e \in events\}$
 IN
 CHOOSE $t \in times : \forall t_other \in times : LinearTime(t) \leq LinearTime(t_other)$

The latest time point within a set of events

$MaxTime(events) \triangleq$
 LET $times \triangleq \{e.time : e \in events\}$
 IN
 CHOOSE $t \in times : \forall t_other \in times : LinearTime(t) \geq LinearTime(t_other)$