MODULE *TimeUtils*

EXTENDS *Naturals*, *Sequences*, *TLC*

Use a fixed epoch for a consistent time base.

$FixedEpochYear \triangleq 2000$

$YearRange \triangleq FixedEpochYear \,..\, FixedEpochYear + 50$

$MinutesInDay \triangleq 24 * 60$

$IsLeapYear(year) \triangleq$
  LET
    $div4 \triangleq year\%4 = 0$
    $notDiv100 \triangleq year\%100 \neq 0$
    $div400 \triangleq year\%400 = 0$
  IN
    $div4 \land (notDiv100 \lor div400)$

$DaysInMonth \triangleq$
  $[i \in 1 \,..\, 12 \mapsto$
    CASE $i = 1 \to 31$
    $\Box i = 2 \to 28$
    $\Box i = 3 \to 31$
    $\Box i = 4 \to 30$
    $\Box i = 5 \to 31$
    $\Box i = 6 \to 30$
    $\Box i = 7 \to 31$
    $\Box i = 8 \to 31$
    $\Box i = 9 \to 30$
    $\Box i = 10 \to 31$
    $\Box i = 11 \to 30$
    $\Box i = 12 \to 31$
  ]

RECURSIVE $DaysUpToMonth(\_)$

$DaysUpToMonth(tp) \triangleq$
  IF $tp.month = 1$
   THEN 0
   ELSE $DaysUpToMonth([tp \text{ EXCEPT } !.month = tp.month - 1])$
        $+$ IF $tp.month = 2 \land IsLeapYear(tp.year)$
            THEN 29
            ELSE $DaysInMonth[tp.month - 1]$

$LeapDaysSinceEpoch(y) \triangleq$

$$
\begin{array}{l}
\quad \text{LET } d \triangleq y - FixedEpochYear \\
\quad \text{IN } \quad (d \div 4) - (d \div 100) + (d \div 400)
\end{array}
$$

$$
\begin{array}{l}
LinearTime(tp) \triangleq \\
\quad \text{LET} \\
\qquad yearOffset \triangleq (tp.year - FixedEpochYear) * 365 * MinutesInDay \\
\qquad leapYearOffset \triangleq LeapDaysSinceEpoch(tp.year) * MinutesInDay \\
\qquad monthOffset \triangleq DaysUpToMonth(tp) * MinutesInDay \\
\qquad dayOffset \triangleq (tp.day - 1) * MinutesInDay \\
\qquad hourOffset \triangleq tp.hour * 60 \\
\qquad minuteOffset \triangleq tp.minute \\
\quad \text{IN} \\
\qquad yearOffset + leapYearOffset + monthOffset + dayOffset + hourOffset + minuteOffset
\end{array}
$$

Predicates for time comparison and duration.

$$
\begin{array}{l}
Before(t1,\, t2) \triangleq LinearTime(t1) < LinearTime(t2) \\
After(t1,\, t2) \triangleq LinearTime(t1) > LinearTime(t2) \\
TimeBetween(t\_start,\, t\_end,\, t\_test) \quad \triangleq \ \wedge Before(t\_start,\, t\_test) \wedge Before(t\_test,\, t\_end) \\
\\
Within72Hours(start\_time,\, end\_time) \triangleq (LinearTime(end\_time) - LinearTime(start\_time)) \leq 72 * 60
\end{array}
$$

$$
\begin{array}{l}
MinTime(events) \triangleq \\
\quad \text{LET } times \triangleq \{e.time : e \in events\} \\
\quad \text{IN} \\
\qquad \text{CHOOSE } t \in times : \forall\, t\_other \in times : LinearTime(t) \leq LinearTime(t\_other)
\end{array}
$$

$$
\begin{array}{l}
MaxTime(events) \triangleq \\
\quad \text{LET } times \triangleq \{e.time : e \in events\} \\
\quad \text{IN} \\
\qquad \text{CHOOSE } t \in times : \forall\, t\_other \in times : LinearTime(t) \geq LinearTime(t\_other)
\end{array}
$$