———————————————— MODULE RGA ————————————————

EXTENDS $Integers$, $Sequences$, $Naturals$, TLC, $InsertTree$

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CONSTANTS $Replica$

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VARIABLES $rtree$, $rtomb$, $rinsbuf$, $rtombbuf$, $rins\_incoming$, $rtomb\_incoming$, $chins$, $tcurrent$
$vars \triangleq \langle rtree, rtomb, rinsbuf, rtombbuf, rins\_incoming, rtomb\_incoming, chins, tcurrent \rangle$

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$List \triangleq Seq(Char)$

$Inscomm \triangleq$ INSTANCE $P2PComm$ WITH $incoming \leftarrow rins\_incoming$, $outbuf \leftarrow rinsbuf$

$Tombcomm \triangleq$ INSTANCE $P2PComm$ WITH $incoming \leftarrow rtomb\_incoming$, $outbuf \leftarrow rtombbuf$

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$TypeOK \triangleq \;\land tcurrent \in 1 .. Charnum + 1$
$\qquad\qquad\quad \land rtomb \in [Replica \rightarrow \text{SUBSET } Char]$
$\qquad\qquad\quad \land rtombbuf \in [Replica \rightarrow \text{SUBSET } Char]$
$\qquad\qquad\quad \land rtomb\_incoming \in [Replica \rightarrow \text{SUBSET } Char]$
$\qquad\qquad\quad \land chins \in \text{SUBSET } Char$
$\qquad\qquad\quad \land rtree \in [Replica \rightarrow \text{SUBSET } node]$
$\qquad\qquad\quad \land rinsbuf \in [Replica \rightarrow \text{SUBSET } node]$
$\qquad\qquad\quad \land rins\_incoming \in [Replica \rightarrow \text{SUBSET } node]$

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$Init \triangleq$
$\quad \land Inscomm!Init$
$\quad \land Tombcomm!Init$
$\quad \land rtree = [r \in Replica \mapsto \{\}]$
$\quad \land rtomb = [r \in Replica \mapsto \{\}]$
$\quad \land chins = Char$
$\quad \land tcurrent = 1$

$DoIns(r) \triangleq$
$\quad \exists ins \in node :$
$\qquad \land ins.father \in Readtree2set(rtree[r]) \cup \{\text{"o"}\}$
$\qquad \land ins.time = tcurrent$
$\qquad \land tcurrent' = tcurrent + 1$
$\qquad \land ins.ch \in chins$
$\qquad \land chins' = chins \setminus \{ins.ch\}$
$\qquad \land rtree' = [rtree \text{ EXCEPT } ![r] = @ \cup \{ins\}]$
$\qquad \land rinsbuf' = [rinsbuf \text{ EXCEPT } ![r] = @ \cup \{ins\}]$
$\qquad \land \text{UNCHANGED } \langle rtomb, rtombbuf, rins\_incoming, rtomb\_incoming \rangle$

$DoDel(r) \triangleq$
$\quad \exists del \in Char :$

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$$\land del \in Readtree2set(rtree[r])$$
$$\land \neg del \in rtomb[r]$$
$$\land rtomb' = [rtomb \text{ EXCEPT } ![r] = @ \cup \{del\}]$$
$$\land rtombbuf' = [rtombbuf \text{ EXCEPT } ![r] = @ \cup \{del\}]$$
$$\land \text{UNCHANGED } \langle chins, tcurrent, rtree, rinsbuf, rins\_incoming, rtomb\_incoming \rangle$$

do transitions

$Do(r) \triangleq$
   $\lor DoIns(r)$
   $\lor DoDel(r)$

send transitions

$Send(r) \triangleq$
   $\lor \land Inscomm!Send(r)$
    $\land \text{UNCHANGED } \langle chins, tcurrent, rtree, rtomb, rtombbuf, rtomb\_incoming \rangle$
   $\lor \land Tombcomm!Send(r)$
    $\land \text{UNCHANGED } \langle chins, tcurrent, rtree, rtomb, rinsbuf, rins\_incoming \rangle$

receive transitions

$Receive(r) \triangleq$
   $\land \quad \lor \land Inscomm!Receive(r)$
     $\land \text{UNCHANGED } \langle rtomb\_incoming, rtombbuf \rangle$
    $\lor \land Tombcomm!Receive(r)$
     $\land \text{UNCHANGED } \langle rins\_incoming, rinsbuf \rangle$
   $\land \quad rtree' = [rtree \text{ EXCEPT } ![r] = @ \cup rins\_incoming[r]]$
   $\land \quad rtomb' = [rtomb \text{ EXCEPT } ![r] = @ \cup rtomb\_incoming[r]]$
   $\land \quad \text{UNCHANGED } \langle chins, tcurrent \rangle$

$Next \triangleq$
  $\exists r \in Replica : Do(r) \lor Send(r) \lor Receive(r)$

$Spec \triangleq Init \land \Box[Next]_{vars}$

eventual consistency

$EC \triangleq Inscomm!EmptyChannel \land Tombcomm!EmptyChannel \Rightarrow$
    $\forall r1, r2 \in Replica :$
     $Readtree2list(rtree[r1], \text{``o''}, rtomb[r1], \{\}) = Readtree2list(rtree[r2], \text{``o''}, rtomb[r2], \{\})$

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