
MODULE *StorageEngine*

EXTENDS *TLC, Integers, Sequences, Naturals*

CONSTANTS

MaxKeys, Order

You might want to define *MaxKeys* to use it in variables
or we can assume *Maxkeys* is a set of all real Numbers
MaxKeys is a set of all Real numbers

ASSUME $\wedge \text{MaxKeys} \in \text{Nat} \setminus \{0\}$

These Variables are just Arrays for holding a set of different data types

VARIABLE *object, controlState, subControlState, key, Ver, Edges, Path*

$\text{TypeOK} \triangleq \wedge \text{controlState} \in \{\text{"Start"}, \text{"middle"}, \text{"done"}\}$
 $\wedge \text{subControlState} \in \{\text{"Lf"}, \text{"Pt"}, \text{"Co"}\}$
 $\wedge \text{key} \in [\text{Nodes} \rightarrow \text{Nodes}]$
 $\wedge \text{Ver} \in [\text{Nodes} \rightarrow \text{Nat}]$

ASSUME $\wedge \text{Root} \in \text{Nodes}$
 $\wedge \text{MaxCardinality} \in \text{Nat}$
 $\wedge \text{MaxCardinality} \geq \text{Cardinality}(\text{Nodes})$

VARIABLES *values, versions, deleted, keys*

$\text{TypeOK} \triangleq \wedge \text{values} \in [0 \dots \text{MaxKeys} - 1]$
 $\wedge \text{versions} \in [0 \dots \text{MaxKeys} - 1]$
 $\wedge \text{deleted} \in [0 \dots \text{MaxKeys} - 1]$
 $\wedge \text{keys} \in [0 \dots \text{MaxKeys} - 1]$

$\text{root} \triangleq \text{INSTANCE } BPlusTree \text{ With } \text{root} \leftarrow \text{root}, \text{Order} \leftarrow \text{Order}, \text{keys} \leftarrow \text{KeyType}$

$\text{TypeInvariant} \triangleq$

$\wedge \text{root} \in BPlusTree$
 $\wedge \text{keys}[i] \neq \text{keys}[j] \text{ for all } i, j$
 $\wedge \text{values}[i] \neq \text{values}[j] \text{ for all } i, j$
 $\wedge \text{keys}[i] \neq \text{"deleted"} \text{ for all } i$

$\text{Init} \triangleq$

$\wedge \text{root} = \text{emptyTree}$
 $\wedge \text{keys} = [[\text{"deleted"}] \mapsto (\text{MaxKeys} - 1)]$
 $\wedge \text{values} = [[\text{"deleted"}] \mapsto (\text{MaxKeys} - 1)]$
 $\wedge \text{versions} = [0 \mapsto (\text{MaxKeys} - 1)]$
 $\wedge \text{deleted} = [\text{FALSE} \mapsto (\text{MaxKeys} - 1)]$

$\text{Create}(\text{key}, \text{value}) \triangleq$

$$\begin{aligned}
& \wedge \text{key} \neq \text{"deleted"} \\
& \wedge \text{keys}' = [\text{keys} \text{ EXCEPT } ![i] = \text{key}] \\
& \wedge \text{values}' = [\text{values} \text{ EXCEPT } ![i] = \text{value}] \\
& \wedge \text{versions}' = [\text{versions} \text{ EXCEPT } ![i] = 1] \\
& \wedge \text{deleted}' = [\text{deleted} \text{ EXCEPT } ![i] = \text{FALSE}] \\
& \wedge i' = (i + 1) \% \text{MaxKeys} \\
& \wedge \text{root}' = \text{Insert}(\text{root}, \text{key}, i) \\
& \wedge \text{Next} = \text{Create}(\text{key}, \text{value}) \\
\\
& \text{Read}(\text{key}) \triangleq \\
& \wedge \text{key} \neq \text{"deleted"} \\
& \wedge \text{EXISTS } i \in 0 \dots \text{MaxKeys} - 1 : \text{key} = \text{keys}[i] \\
& \wedge \text{value} = \text{values}[i] \\
& \wedge \text{version} = \text{versions}[i] \\
& \wedge \text{Next} = \text{Read}(\text{key}) \\
\\
& \text{Update}(\text{key}, \text{value}, \text{version}) \triangleq \\
& \wedge \text{key} \neq \text{"deleted"} \\
& \wedge \text{EXISTS } i \in 0 \dots \text{MaxKeys} - 1 : \text{key} = \text{keys}[i] \\
& \wedge \text{version} < \text{versions}[i] \\
& \wedge \text{deleted}[i] = \text{FALSE} \\
& \wedge \text{keys}' = \text{keys} \\
& \wedge \text{values}' = [\text{values} \text{ EXCEPT } ![i] = \text{value}] \\
& \wedge \text{versions}' = [\text{versions} \text{ EXCEPT } ![i] = \text{version} + 1] \\
& \wedge \text{deleted}' = \text{deleted} \\
& \wedge \text{root}' = \text{Update}(\text{root}, \text{key}, i) \\
& \wedge \text{Next} = \text{Update}(\text{key}, \text{value}, \text{version}) \\
\\
& \text{Delete}(\text{key}, \text{version}) \triangleq \\
& \wedge \text{key} \neq \text{"deleted"} \\
& \wedge \text{EXISTS } i \in 0 \dots \text{MaxKeys} - 1 : \text{key} = \text{keys}[i] \\
& \wedge \text{version} < \text{versions}[i] \\
& \wedge \text{deleted}[i] = \text{FALSE} \\
& \wedge \text{keys}' = \text{keys} \\
& \wedge \text{values}' = \text{values} \\
& \wedge \text{versions}' = [\text{versions} \text{ EXCEPT } ![i] = \text{version} + 1] \\
& \wedge \text{deleted}' = [\text{deleted} \text{ EXCEPT } ![i] = \text{TRUE}] \\
& \wedge \text{root}' = \text{root} \\
& \wedge \text{Next} = \text{Delete}(\text{key}, \text{version}) \\
\\
& \text{Spec} \triangleq \\
& \wedge \text{Init} \\
& \wedge \square [\text{Next}]_{\langle \text{keys}, \text{values}, \text{versions}, \text{deleted}, \text{root} \rangle}
\end{aligned}$$

\ * Modification History
\ * Last modified Mon Jan 23 05:55:43 CAST 2023 by goodwill

* Created Sat *Jan* 14 19:11:17 CAST 2023 by goodwill