

## CLAIMS

1. A computer-implemented method for updating a sub-tree of a world-state Merkle Patricia Trie (MPT) within a blockchain network, the method comprising: creating, by a consensus client of the blockchain network, an update tree comprising a root node of the sub-tree of the world-state MPT and other nodes added to the update tree, wherein a current node of the sub-tree is initially set to be a next node of the sub-tree referenced by the root node of the sub-tree;

executing, by the consensus client, a traversal of at least a portion of the sub-tree in multiple iterations, and, in each iteration, for the current node of the sub-tree:

determining whether a current iteration is the first time the current node is visited by the traversal and,

(i) if so, finding a corresponding node in the world-state MPT and a search path, the current node having an address and the corresponding node being a node in the world-state MPT having a corresponding address, the search path being a depth traversal to the corresponding node in the world-state MPT, or

(ii) if not, moving the current node to be the parent node of the current node and then, if the current node is the root node of the sub-tree, returning the update tree as a result of the iterations and otherwise continuing with a next iteration;

determining whether the search path has one or more intermediate nodes and, if so, adding the one or more intermediate nodes to the update tree and tagging each added node to indicate that the added node is a node that the sub-tree does not include;

determining a type of the current node of the sub-tree and a value or values of the current node, the type being one of a leaf node, an extension node, or a branch node;

comparing the current node of the sub-tree to the corresponding node of the world-state MPT and executing one of:

(a) if the current node of the sub-tree and the corresponding node of the world-state MPT are leaf nodes, and the values are unequal, or if the current node of the sub-tree is a leaf node and the corresponding node of the world-state MPT is not a leaf node, adding the corresponding node of the world-state MPT to the update tree, and then moving the current node to be the parent node of the current node and then, if the current

node is the root node of the sub-tree, returning the update tree as a result of the iterations and otherwise continuing with a next iteration;

(b) if the current node of the sub-tree and the corresponding node of the world-state MPT are extension nodes, adding the current node of the world-state MPT to the update tree, and moving to a next iteration of the traversal setting the current node of the sub-tree to a node referenced by the extension node, wherein a node that is neither a leaf node nor an extension node is a branch node, wherein a branch node has a plurality of slots and two or more of the slots points to a respective child node of the branch node;

(c) if the current node of the sub-tree and the corresponding node of the world-state MPT are branch nodes and the current iteration is the first iteration in which the current node is visited, determining whether the values of the current node and the corresponding node are different, and

(i) if the values are different, adding the corresponding node of the world-state MPT to the update tree, moving the current node to be the parent node of the current node and then, if the current node is the root node of the sub-tree, returning the update tree as a result of the iterations and ending the iterations, and otherwise continuing with a next iteration, or

(ii) if the values are not different, moving to a next iteration of the traversal setting the current node of the sub-tree to a node in the sub-tree pointed to by a next slot of the current node of the sub-tree; or

(d) if the current node of the sub-tree and the corresponding node of the world-state MPT are branch nodes and the current iteration is not the first iteration in which the current node is visited, determining whether all slots between the current node and the corresponding node have been compared, and

(i) if all slots have been compared, setting the current node to be the parent node of the current node and then, if the current node is the root node of the sub-tree, returning the update tree as a result of the iterations and ending the iterations, and otherwise continuing with a next iteration, or

(ii) if all slots have not been compared, iteratively comparing

remaining slots of the current node that are not NULL with slots of the current node of world-state MPT until encountering a pointer in the remaining slots that is different from the corresponding slot in the corresponding node of the world-state MPT, moving the current node of the sub-tree and the corresponding node of world-state MPT to be the node pointed to by non-NULL slot, and then continuing with a next iteration; and  
5 transmitting, by the consensus client, after the traversal is completed, the update tree of the sub-tree to a non-consensus node of the blockchain network, the non-consensus client updating a locally stored sub-tree using the update tree to provide an updated sub-tree that provides a state of accounts associated with the non-consensus client.

10 2. The method of claim 1, further comprising, during at least one iteration, finding a corresponding node in the world-state MPT, and providing a search path, one or more nodes in the search path being marked as intermediate nodes, and marked as being absent from the sub-tree.

15 3. The method of claim 1, wherein comparing values of the current node of the sub-tree and a current node of the world-state MPT is performed in response to determining that the current node of the sub-tree and a current node of the world-state MPT are branch nodes, and that the current iteration is a first iteration, in which the current node of the sub-tree is considered.

20 4. The method of claim 1, wherein the traversal is ended in response to determining that the current node of the sub-tree is the root node.

5. The method of claim 1, wherein the locally stored sub-tree is updated by one or more of replacing a node of the sub-tree with a node of the update tree, and inserting a node of the update tree into the sub-tree.

25 6. The method of claim 1, wherein the update tree is created in response to a request received by the consensus client from the non-consensus client.

7. The method of claim 1, wherein the update tree is created in response to determining that a value of a root node of the sub-tree and a value of the root node of the world-state MPT are different.

8. A non-transitory computer-readable storage medium coupled to one or more computers and having instructions stored thereon, which are executable to update a sub-tree of a world-state Merkle Patricia Trie (MPT) within a blockchain network, the instructions being executable by the one or more computer to:

creating, by a consensus client of the blockchain network, an update tree comprising a root node of the sub-tree of the world-state MPT and other nodes added to the update tree by the following operations, wherein a current node of the sub-tree is initially set to be a next node of the sub-tree referenced by the root node of the sub-tree;

executing, by the consensus client, a traversal of at least a portion of the sub-tree in multiple iterations, and, in each iteration, for the current node of the sub-tree:

determining whether a current iteration is the first time the current node is visited by the traversal and,

(i) if so, finding a corresponding node in the world-state MPT and a search path, the current node having an address and the corresponding node being a node in the world-state MPT having a corresponding address, the search path being a depth traversal to the corresponding node in the world-state MPT, or

(ii) if not, moving the current node to be the parent node of the current node and then, if the current node is the root node of the sub-tree, returning the update tree as a result of the iterations and otherwise continuing with a next iteration;

determining whether the search path has one or more intermediate nodes and, if so, adding the one or more intermediate nodes to the update tree and tagging each added node to indicate that the added node is a node that the sub-tree does not include;

determining a type of the current node of the sub-tree and a value or values of the current node, the type being one of a leaf node, an extension node, or a branch node;

comparing the current node of the sub-tree to the corresponding node of the world-state MPT and executing one of:

(a) if the current node of the sub-tree and the corresponding node of

the world-state MPT are leaf nodes, and the values are unequal, or if the current node of the sub-tree is a leaf node and the corresponding node of the world-state MPT is not a leaf node, adding the corresponding node of the world-state MPT to the update tree, and then moving the current node to be the parent node of the current node and then, if the current node is the root node of the sub-tree, returning the update tree as a result of the iterations and otherwise continuing with a next iteration;

(b) if the current node of the sub-tree and the corresponding node of the world-state MPT are extension nodes, adding the current node of the world-state MPT to the update tree, and moving to a next iteration of the traversal setting the current node of the sub-tree to a node referenced by the extension node, wherein a node that is neither a leaf node nor an extension node is a branch node, wherein a branch node has a plurality of slots and two or more of the slots points to a respective child node of the branch node;

(c) if the current node of the sub-tree and the corresponding node of the world-state MPT are branch nodes and the current iteration is the first iteration in which the current node is visited, determining whether the values of the current node and the corresponding node are different, and

(i) if the values are different, adding the corresponding node of the world-state MPT to the update tree, moving the current node to be the parent node of the current node and then, if the current node is the root node of the sub-tree, returning the update tree as a result of the iterations and ending the iterations, and otherwise continuing with a next iteration, or

(ii) if the values are not different, moving to a next iteration of the traversal setting the current node of the sub-tree to a node in the sub-tree pointed to by a next slot of the current node of the sub-tree; or

(d) if the current node of the sub-tree and the corresponding node of the world-state MPT are branch nodes and the current iteration is not the first iteration in which the current node is visited, determining whether all slots between the current node and the corresponding node have been compared, and

(i) if all slots have been compared, setting the current node

to be the parent node of the current node and then, if the current node is the root node of the sub-tree, returning the update tree as a result of the iterations and ending the iterations, and otherwise continuing with a next iteration, or

(ii) if all slots have not been compared, iteratively comparing  
5 remaining slots of the current node that are not NULL with slots of the current node of world-state MPT until encountering a pointer in the remaining slots that is different from the corresponding slot in the corresponding node of the world-state MPT, moving the current node of the sub-tree and the corresponding node of world-state MPT to be the node pointed to by non-NULL slot, and then continuing with a next iteration; and  
10 transmitting, by the consensus client, after the traversal is completed, the update tree of the sub-tree to a non-consensus node of the blockchain network, the non-consensus client updating a locally stored sub-tree using the update tree to provide an updated sub-tree that provides a state of accounts associated with the non-consensus client.

15 9. The computer-readable storage medium of claim 8, configured with further instructions executable by the one or more computer to, during at least one iteration, find a corresponding node in the world-state MPT, and providing a search path, one or more nodes in the search path being marked as intermediate nodes, and marked as being absent from the sub-tree.

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10. The computer-readable storage medium of claim 8, wherein comparing values of the current node of the sub-tree and a current node of the world-state MPT is performed in response to determining that the current node of the sub-tree and a current node of the world-state MPT are branch nodes, and that a current iteration is a first iteration, in which  
25 the current node of the sub-tree is considered.

11. The computer-readable storage medium of claim 8, wherein the traversal is ended in response to determining that the current node of the sub-tree is the root node.

12. The computer-readable storage medium of claim 8, wherein the locally stored sub-tree is updated by one or more of replacing a node of the sub-tree with a node of the update tree, and inserting a node of the update tree into the sub-tree.

5 13. The computer-readable storage medium of claim 8, wherein the update tree is created in response to a request received by the consensus client from the non-consensus client.

14. The computer-readable storage medium of claim 8, wherein the update tree is  
10 created in response to determining that a value of a root node of the sub-tree and a value of the root node of the world-state MPT are different.

15. A system, comprising:

one or more computers; and

15 one or more computer-readable memories coupled to the one or more computers and having instructions stored thereon, which are executable to update a sub-tree of a world-state Merkle Patricia Trie (MPT) within a blockchain network, the instructions being executable by the one or more computers to:

create, by a consensus client of the blockchain network, an update  
20 tree comprising a root node of the sub-tree of the world-state MPT and other nodes added to the update tree by the following operations, wherein a current node of the sub-tree is initially set to be a next node of the sub-tree referenced by the root node of the sub-tree;

execute, by the consensus client, a traversal of at least a portion of the sub-  
25 tree in multiple iterations, and, in each iteration, for the current node of the sub-tree:

determine whether a current iteration is the first time the current  
node is visited by the traversal and,  
(i) if so, finding a corresponding node in the world-state  
MPT and a search path, the current node having an address and the corresponding  
30 node being a node in the world-state MPT having a corresponding address, the

search path being a depth traversal to the corresponding node in the world-state  
MPT, or

(ii) if not, moving the current node to be the parent node of  
the current node and then, if the current node is the root node of the sub-tree,  
5 returning the update tree as a result of the iterations and otherwise continuing with  
a next iteration;  
determining whether the search path has one or more intermediate  
nodes and, if so, adding the one or more intermediate nodes to the update tree and  
tagging each added node to indicate that the added node is a node that the sub-tree  
10 does not include;  
determining a type of the current node of the sub-tree and a value or  
values of the current node, the type being one of a leaf node, an extension node, or  
a branch node;  
comparing the current node of the sub-tree to the corresponding  
15 node of the world-state MPT and executing one of:  
(a) if the current node of the sub-tree and the corresponding  
node of the world-state MPT are leaf nodes, and the values are unequal, or if the  
current node of the sub-tree is a leaf node and the corresponding node of the  
world-state MPT is not a leaf node, adding the corresponding node of the world-  
20 state MPT to the update tree, and then moving the current node to be the parent  
node of the current node and then, if the current node is the root node of the sub-  
tree, returning the update tree as a result of the iterations and otherwise continuing  
with a next iteration;  
(b) if the current node of the sub-tree and the corresponding  
25 node of the world-state MPT are extension nodes, adding the current node of the  
world-state MPT to the update tree, and moving to a next iteration of the traversal  
setting the current node of the sub-tree to a node referenced by the extension node,  
wherein a node that is neither a leaf node nor an extension  
node is a branch node, wherein a branch node has a plurality of slots and two or  
30 more of the slots points to a respective child node of the branch node;

(c) if the current node of the sub-tree and the corresponding node of the world-state MPT are branch nodes and the current iteration is the first iteration in which the current node is visited, determine whether the values of the current node and the corresponding node are different, and

5 (i) if the values are different, adding the corresponding node of the world-state MPT to the update tree, moving the current node to be the parent node of the current node and then, if the current node is the root node of the sub-tree, returning the update tree as a result of the iterations and ending the iterations, and otherwise continuing with a next iteration, or

10 (ii) if the values are not different, moving to a next iteration of the traversal setting the current node of the sub-tree to a node in the sub-tree pointed to by a next slot of the current node of the sub-tree; or

(d) if the current node of the sub-tree and the corresponding node of the world-state MPT are branch nodes and the current iteration is not the

15 first iteration in which the current node is visited, determining whether all slots between the current node and the corresponding node have been compared, and

(i) if all slots have been compared, setting the current node to be the parent node of the current node and then, if the current node is the root node of the sub-tree, returning the update tree as a result of the iterations and

20 ending the iterations, and otherwise continuing with a next iteration, or

(ii) if all slots have not been compared, iteratively comparing remaining slots of the current node that are not NULL with slots of the current node of world-state MPT until encountering a pointer in the remaining slots that is different from the corresponding slot in the corresponding node of the world-

25 state MPT, moving the current node of the sub-tree and the corresponding node of world-state MPT to be the node pointed to by non-NULL slot, and then continuing with a next iteration; and

transmit, by the consensus client, after the traversal is completed, the update tree of the sub-tree to a non-consensus node of the blockchain network, the non-

30 consensus client updating a locally stored sub-tree using the update tree to provide

an updated sub-tree that provides a state of accounts associated with the non-consensus client.

16. The system of claim 15, wherein the one or more computer-readable memories are  
5 configured with further instructions executable by the one or more computer to, during at least one iteration, find a corresponding node in the world-state MPT, and providing a search path, one or more nodes in the search path being marked as intermediate nodes, and marked as being absent from the sub-tree.

10 17. The system of claim 15, wherein comparing values of the current node of the sub-tree and a current node of the world-state MPT is performed in response to determining that the current node of the sub-tree and a current node of the world-state MPT are branch nodes, and that a current iteration is a first iteration, in which the current node of the sub-tree is considered.

15 18. The system of claim 15, wherein the traversal is ended in response to determining that the current node of the sub-tree is the root node.

19. The system of claim 15, wherein the locally stored sub-tree is updated by one or  
20 more of replacing a node of the sub-tree with a node of the update tree, and inserting a node of the update tree into the sub-tree.

20. The system of claim 15, wherein the update tree is created in response to a request received by the consensus client from the non-consensus client.

25 21. The system of claim 15, wherein the update tree is created in response to determining that a value of a root node of the sub-tree and a value of the root node of the world-state MPT are different.