

Data Structure.

In computer science a Merkle tree (hash tree) is a tree in which every leaf node is labelled with the hash of a data block and every non-leaf node is labelled with the cryptographic hash of the labels of its child nodes. To check whether a leaf node is part of a binary hash tree require computing a number of hashes. These trees can be used to verify any kind of data stored, and transferred in and between computers, i.e., that it arrives undamaged and unaltered. This data structure is used in cryptocurrencies like Bitcoin and Ethereum.

In a hash tree, when the top of the tree is available, the hash tree can be received from any non-trusted source. Furthermore, each branch of the tree can be checked immediately, even though the whole tree is not available yet.

Another data structure based on tree is the one called radix tree, that represents a space-optimized tree in which each node that is the only child is merged with its parent. In a radix tree, edges can be labeled with sequences of elements as well single elements. Radix trees can be used to construct associative arrays with keys that can be expressed as strings as well as for IP routing. In addition, these trees support insertion, deletion and searching operation on its nodes, as well as the lookup operation in which it can be determined whether a string exists in a tree. An extension of radix trees is a two colors tree, black and white. In this kind of tree, if the final node of the search string is white, the search has succeeded and if it is black, the search has failed.

Finally, a block in Ethereum consists of a header, a list of transactions and a list of uncle blocks. Ethereum transactions must be assembled into a data structure called trie (radix tree) to compute the root hash. The Ethereum implementation introduces different improvements: (i) each node is referenced by its hash to make the tree cryptographically secure, (ii) a number of node types are introduced to improve efficiency, and (iii) there are branch nodes with length 17, in which the first 16 correspond to the 16 possible hex characters in a key, and the final value element holds a value in which a key ends at the branch node. Furthermore, an important feature is a special hex-prefix (HP) used for keys, in which HP encodes whether the key is of odd or even length.