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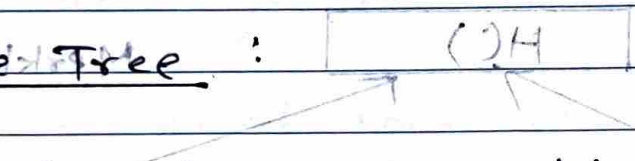
Experiment No : 1

Aim : Write a program to implement Merkle tree showing the cryptographic hash function in Blockchain.

Theory :

- A hash tree is also known as Merkle Tree. It is a tree in which each leaf node is labeled with hash value of data block and each non-leaf node is labeled with the hash value of its child node labels.

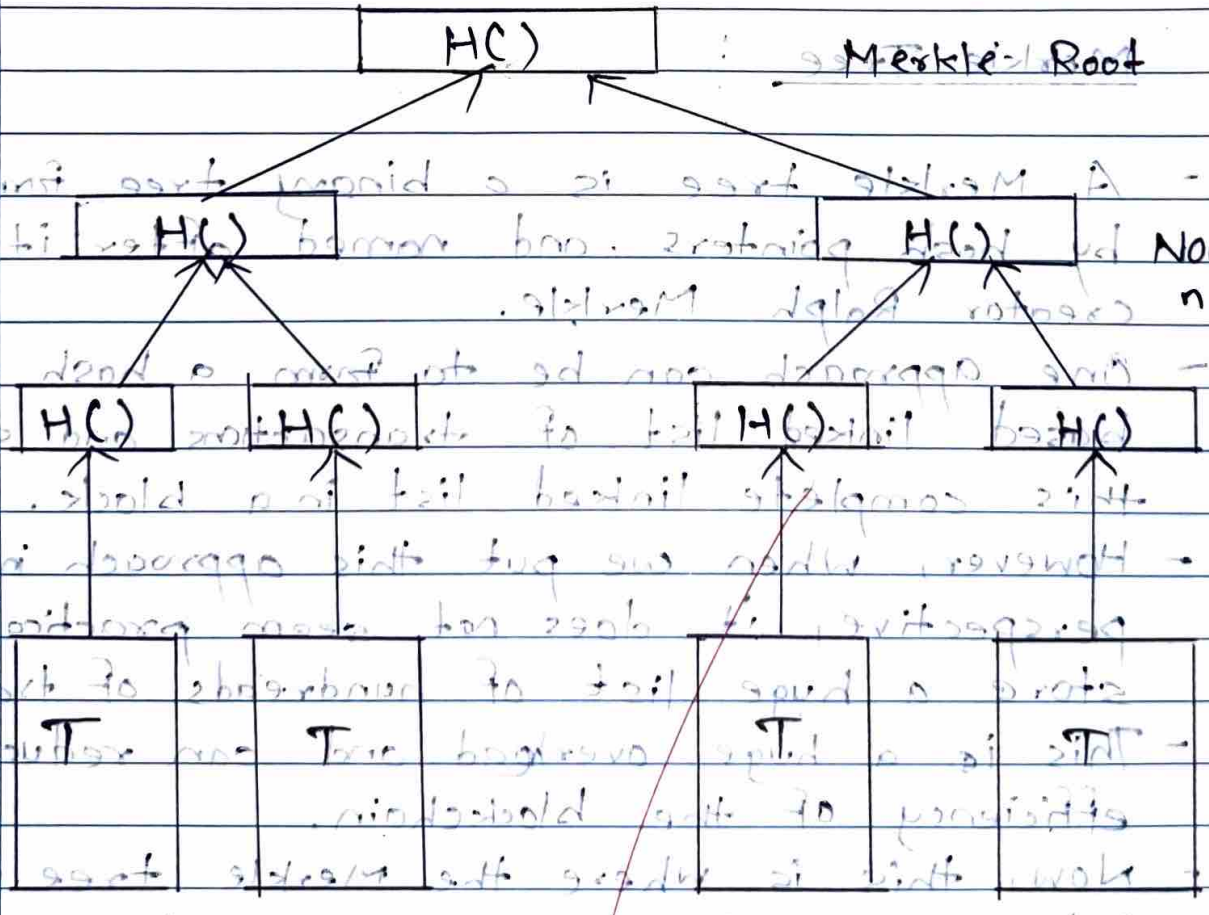
- **Merkle Tree** :



- A Merkle tree is a binary tree formed by hash pointers, and named after its creator Ralph Merkle.
- One approach can be to form a hash pointer-based linked list of transactions and store this complete linked list in a block.
- However, when we put this approach into perspective, it does not seem practical to store a huge list of hundreads of transactions
- This is a huge overhead and can reduce the efficiency of the blockchain.
- Now, this is where the Merkle tree comes into the picture. Merkle tree is a per-block tree of all the transactions that are included in the block.

- It allows us to hash of all transactions and proof of membership in a time-efficient manner.
- Hence, the blockchain is a hash-based linked list of blocks, where each block consists of a header and transactions.
- The transactions are arranged in a tree-like fashion, known as Merkle Tree.

Merkle Tree Structure



H() : Hash value
T : transaction

- A blockchain can potentially have thousands of blocks with thousands of transactions in each block. Therefore, memory space and computing power are two main challenges.
- It could be optimal to use as little data as possible for verifying transactions, which can reduce CPU processing and provide better security and this is exactly what Merkle tree offers.
- In a Merkle tree, transactions are grouped into pairs. The hash is computed for each pair and this is stored in the parent node.
- Now the parent nodes are grouped into pairs and their hash is stored in one level up in the tree. This continues till the root of the tree.
- The different types of nodes in Merkle tree is stored in root :-

1) Root node: The root of Merkle tree is known as the Merkle root and Merkle root is stored in the header of the block.

2) Leaf node: The leaf node contains the hash value of transaction data. Each transaction in the blocks has its data hashed and then this hash value is

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stored in leaf nodes.

3) Non-leaf Node : The non-leaf nodes contain the hash value of transaction data of their respective children.

- Bitcoin uses the SHA-256 hash function to hash the transaction data continuously till the Merkle root is obtained.
- Further, a Merkle tree is binary in nature.

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