Blockchain Basics Assignment

1. Blockchain Basics

A blockchain is a decentralized digital ledger that records transactions in a secure, transparent, and tamper-proof manner. Each record, known as a block, contains a list of transactions and is linked to the previous block using cryptographic hashes, forming a continuous chain. This structure ensures data integrity because once recorded, the information in a block cannot be easily altered without changing all subsequent blocks, which requires consensus across a network of participants (nodes). Blockchain operates on a peer-to-peer network, making it highly resistant to fraud and unauthorized changes. It is widely used in cryptocurrency systems like Bitcoin but also in other industries. Key features include transparency, immutability, decentralization, and security.

Real-Life Use Cases:

1. Supply Chain Management: Blockchain tracks goods from origin to delivery, ensuring authenticity and reducing fraud.
2. Digital Identity Verification: Provides secure, tamper-proof digital IDs useful in banking, voting, and government services.

2. Block Anatomy

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+-------------------------------------------------+
|                  Block Header                   |
+-------------------------------------------------+
| Previous Hash     | a3f5...9b2c                 |
| Timestamp         | 2025-06-09 00:20:30         |
| Nonce             | 103245                      |
| Merkle Root       | 92d3...af7e                 |
+-------------------------------------------------+
|                   Block Data                    |
+-------------------------------------------------+
| Transaction 1     | Alice -> Bob: 5 BTC          |
| Transaction 2     | Bob -> Charlie: 2 BTC        |
| Transaction 3     | Dave -> Eve: 1.5 BTC         |
| ...               | ...                         |
+-------------------------------------------------+
```

The Merkle root is a single hash representing all transactions in the block. It is generated by repeatedly hashing pairs of transaction hashes until one final hash remains. For example, if a block has 4 transactions, each transaction is hashed (H1 to H4), then pairs are hashed (H12 = H1+H2, H34 = H3+H4), and finally Merkle Root = hash(H12 + H34). If any transaction changes, the Merkle root changes, enabling fast and secure verification of data integrity.

3. Consensus Conceptualization

Proof of Work (PoW):

Proof of Work is a consensus mechanism where miners compete to solve complex mathematical puzzles to validate transactions and create new blocks. The first to solve it broadcasts the solution, and others verify it. This ensures network security but consumes a lot of computational power. The energy requirement comes from running powerful hardware continuously for solving puzzles, making attacks costly.

Proof of Stake (PoS):

Proof of Stake selects validators based on how many coins they lock (stake) in the network. It doesn't use computation like PoW but relies on economic commitment. The more coins you stake, the higher the chance to validate blocks. It's more energy-efficient and secures the network through rewards and penalties.

Delegated Proof of Stake (DPoS):

Delegated Proof of Stake allows token holders to vote for delegates (validators) who produce blocks. Voting power is proportional to token holdings. Elected validators take turns validating transactions and are rewarded for doing so honestly. Misbehaving validators can be voted out, ensuring network performance and trust.