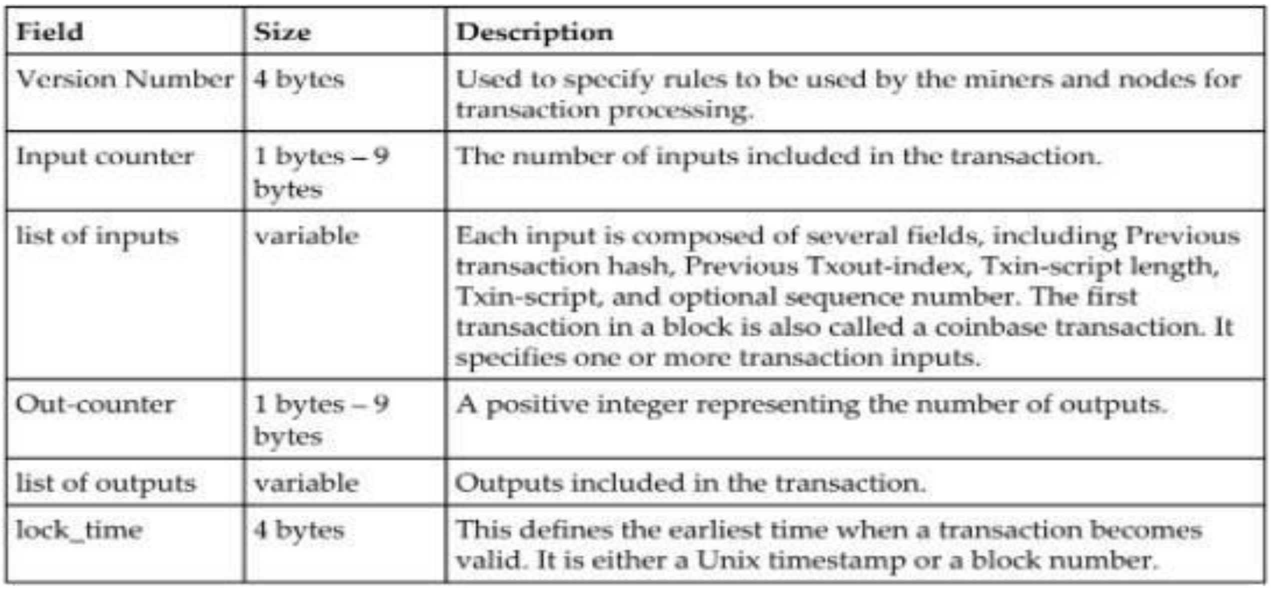
TRANSACTION STRUCTURE

A transaction at a high level contains metadata, inputs, and outputs. Transactions are combined to create a block. The transaction structure is shown in the following table:



Field	Size	Description
Version Number	4 bytes	Used to specify rules to be used by the miners and nodes for transaction processing.
Input counter	1 bytes – 9 bytes	The number of inputs included in the transaction.
list of inputs	variable	Each input is composed of several fields, including Previous transaction hash, Previous Txout-index, Txin-script length, Txin-script, and optional sequence number. The first transaction in a block is also called a coinbase transaction. It specifies one or more transaction inputs.
Out-counter	1 bytes – 9 bytes	A positive integer representing the number of outputs.
list of outputs	variable	Outputs included in the transaction.
lock_time	4 bytes	This defines the earliest time when a transaction becomes valid. It is either a Unix timestamp or a block number.

MetaData: This part of the transaction contains some values such as the size of the transaction, the number of inputs and outputs, the hash of the transaction, and a lock_time field. Every transaction has a prefix specifying the version number.

Inputs: Generally, each input spends a previous output. Each output is considered an Unspent Transaction Output (UTXO) until an input consumes it.

Outputs: Outputs have only two fields, and they contain instructions for the sending of bitcoins. The first field contains the amount of Satoshis, whereas the second field is a locking script that contains the conditions that need to be met in order for the output to be spent.

Verification: Verification is performed using bitcoin's scripting language.

Types of transaction:

There are various scripts available in bitcoin to handle the value transfer from the source to the destination. These scripts range from very simple to quite complex depending upon the requirements of the transaction. Standard transactions are evaluated using IsStandard() and IsStandardTx() tests and only standard transactions that pass the test are generally allowed to be mined or broadcasted on the bitcoin network. However, nonstandard transactions are valid and allowed on the network.

Pay to Public Key Hash (P2PKH):

P2PKH is the most commonly used transaction type and is used to send transactions to the bitcoin addresses. The format of the transaction is shown as folows:

ScriptPubKey: OP_DUP OP_HASH160 OP_EQUALVERIFY OP_CHECKSIG ScriptSig: The ScriptPubKey and ScriptSig parameters are concatenated together and executed.

Pay to Script Hash (P2SH):

P2SH is used in order to send transactions to a script hash (that is, the addresses starting with 3) and was standardized in BIP16. In addition to passing the script, the redeem script is also evaluated and must be valid. The template is shown as follows:

ScriptPubKey: OP_HASH160 OP_EQUAL

ScriptSig: [...]

MultiSig (Pay to MultiSig): M of n multisignature transaction script is a complex type of script where it is possible to construct a script that required multiple signatures to be valid in order to redeem a transaction. Various complex transactions such as escrow and deposits can be built using this script. The template is shown here:

ScriptPubKey: [. . .] OP_CHECKMULTISIG

ScriptSig: 0 [. . .] Raw multisig is obsolete, and multisig is usually part of the P2SH redeem script, mentioned in the previous bullet point.

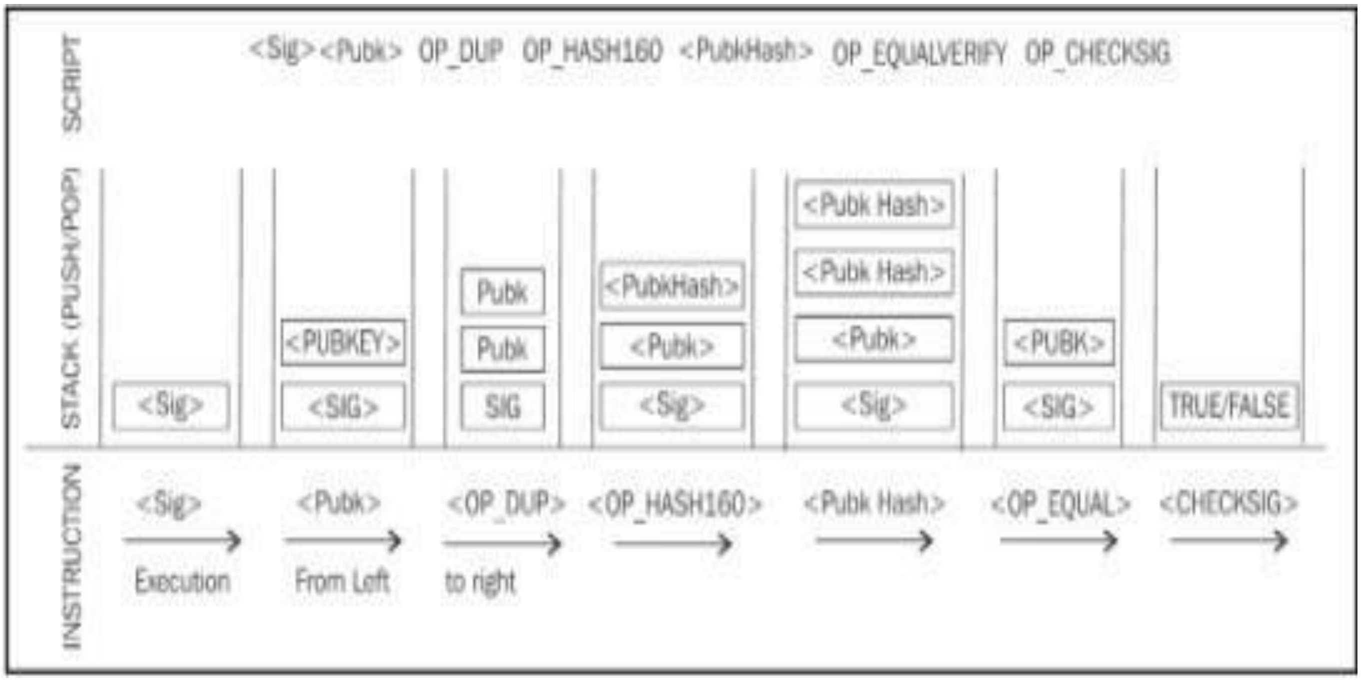
Pay to Pubkey: This script is a very simple script that is commonly used in coinbase transactions. It is now obsolete and was used in an old version of bitcoin. The public key is stored within the script in this case, and the unlocking script is required to sign the transaction with the private key. The template is shown as follows:

OP_CHECKSIG Null data/OP_RETURN: This script is used to store arbitrary data on the blockchain for a fee. The limit of the message is 40 bytes. The output of this script is unredeemable because OP_RETURN will fail the validation in any case. ScriptSig is not required in this case.

The template is very simple and is shown as follows:

OP_RETURN<data>

A P2PKH script execution is shown as follows:

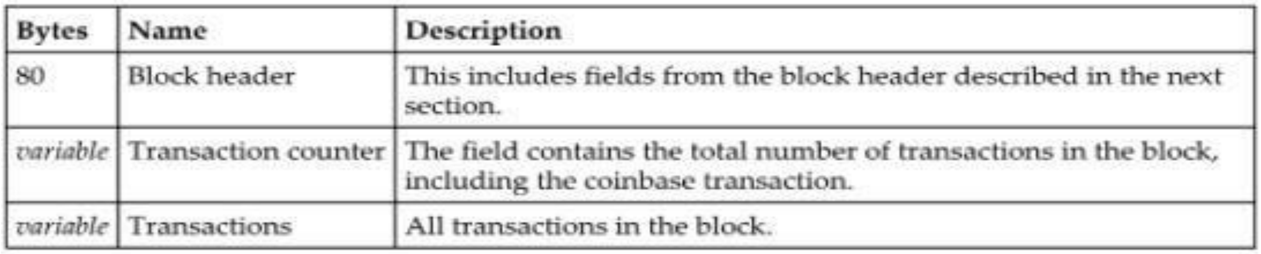


P2PKH script execution:

All transactions are eventually encoded into the hex before transmitting over the bitcoin network.

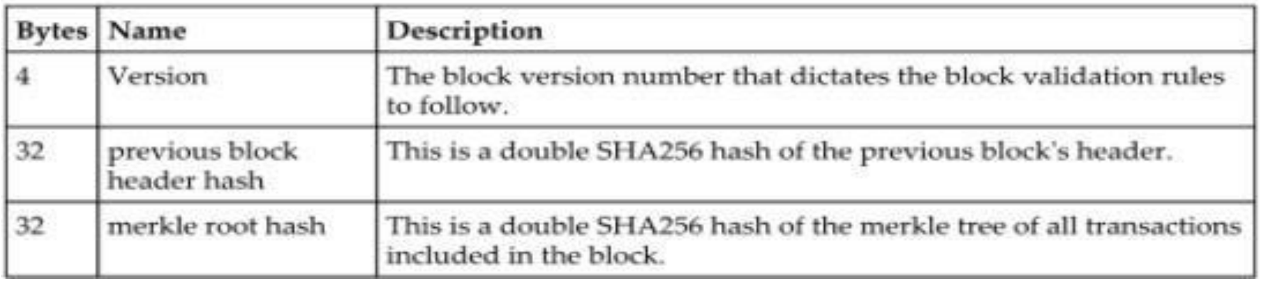
Blockchain is a public ledger of a timestamped, ordered, and immutable list of all transactions on the bitcoin network. Each block is identified by a hash in the chain and is linked to its previous block by referencing the previous block's hash. In the following structure of a block, a block header is described, followed by a detailed diagram that provides an insight into the blockchain structure.

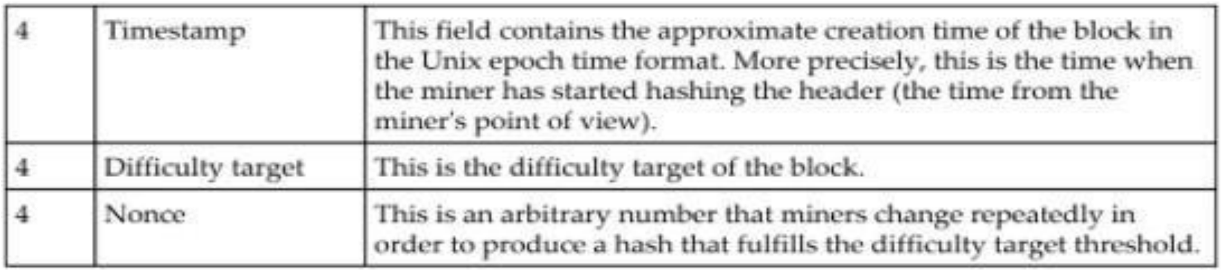
The structure of a block



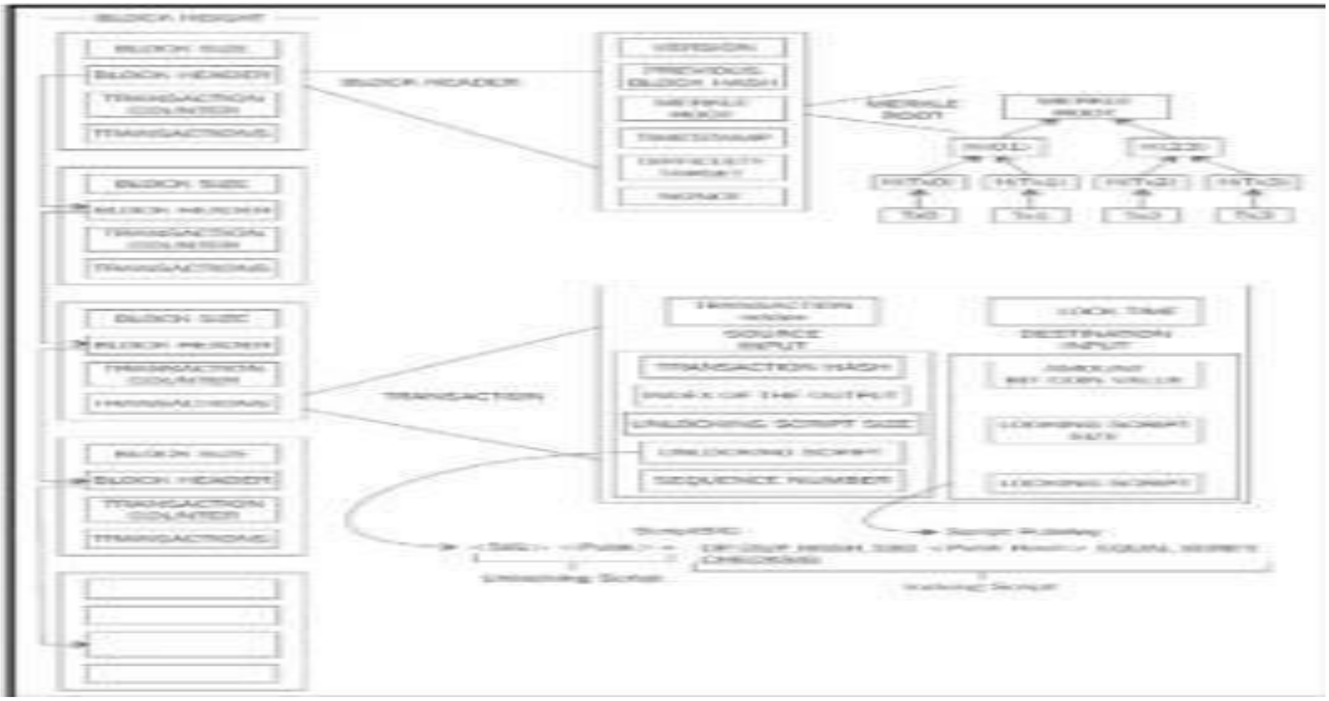
Bytes	Name	Description
80	Block header	This includes fields from the block header described in the next section.
variable	Transaction counter	The field contains the total number of transactions in the block, including the coinbase transaction.
variable	Transactions	All transactions in the block.

The structure of a block header





Bytes	Name	Description
4	Version	The block version number that dictates the block validation rules to follow.
32	previous block header hash	This is a double SHA256 hash of the previous block's header.
32	merkle root hash	This is a double SHA256 hash of the merkle tree of all transactions included in the block.
4	Timestamp	This field contains the approximate creation time of the block in the Unix epoch time format. More precisely, this is the time when the miner has started hashing the header (the time from the miner's point of view).
4	Difficulty target	This is the difficulty target of the block.
4	Nonce	This is an arbitrary number that miners change repeatedly in order to produce a hash that fulfills the difficulty target threshold.



A visualization of blockchain, block, block header, transaction and script.

As shown in the preceding diagram, blockchain is a chain of blocks where each block is linked to its previous block by referencing the previous block header's hash. This linking makes sure that no transaction can be modified unless the block that records it and all blocks that follow it are also modified. The first block is not linked to any previous block and is known as the genesis block.

The Genesis Block:

This is the first block in the bitcoin blockchain. The genesis block was hardcoded in the bitcoin core software.

Bitcoin provides protection against double spending by enforcing strict rules on transaction verification and via mining. Blocks are added in the blockchain only after strict rule checking and successful Proof of Work solution. Block height is the number of blocks before a particular block in the blockchain. The current height (at the time of writing this) of the blockchain is 434755 blocks. Proof of Work is used to secure the blockchain.

Each block contains one or more transactions, out of which the first transaction is a coinbase transaction. There is a special condition for coinbase transactions that prevent them to be spent until at least 100 blocks in order to avoid a situation where the block may be declared stale later on.

Stale blocks are created when a block is solved and every other miner who is still working to find a solution to the hash puzzle is working on that block. Mining and hash puzzles will be discussed later in the chapter in detail. As the block is no longer required to be worked on, this is considered a stale block.

Orphan Blocks : are also called detached blocks and were accepted at one point in time by the network as valid blocks but were rejected when a proven longer chain was created that did not include this initially accepted block. They are not part of the main chain and can occur at times when two miners manage to produce the blocksat the same time.