THE PEER-TO-PEER NETWORK

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THE PEER-TO-PEER NETWORK

- Introduction
- Types of nodes
- Message format
- Control messages
- Transaction propagation
- Block propagation

THE PEER TO PEER NETWORK

WHAT IS THE PEER-TO-PEER NETWORK?

- How transactions and blocks are propagated to Bitcoin nodes
- Open, flat peer-to-peer network - no authentication, no special nodes
- Must be resistant to attacks:
  - Denial-Of-Service attacks
  - Sybil attacks

NETWORK COMMANDS

- VERSION
- VERACK
- ADDR
- GETADDR
- INV
- GETDATA
- GETBLOCKS
- GETHEADERS
- TX
- BLOCK
- HEADERS
- PING
- PONG

CONNECTING TO THE PEER-TO-PEER NETWORK

- Nodes initially connect to one or more seed nodes
- Addresses of other nodes on the network are gossiped using *ADDR* messages
- A Bitcoin Core node will connect to up to eight outbound peers
- Nodes may or may not accept inbound peers

DISCONNECTING AND BANNING (1)

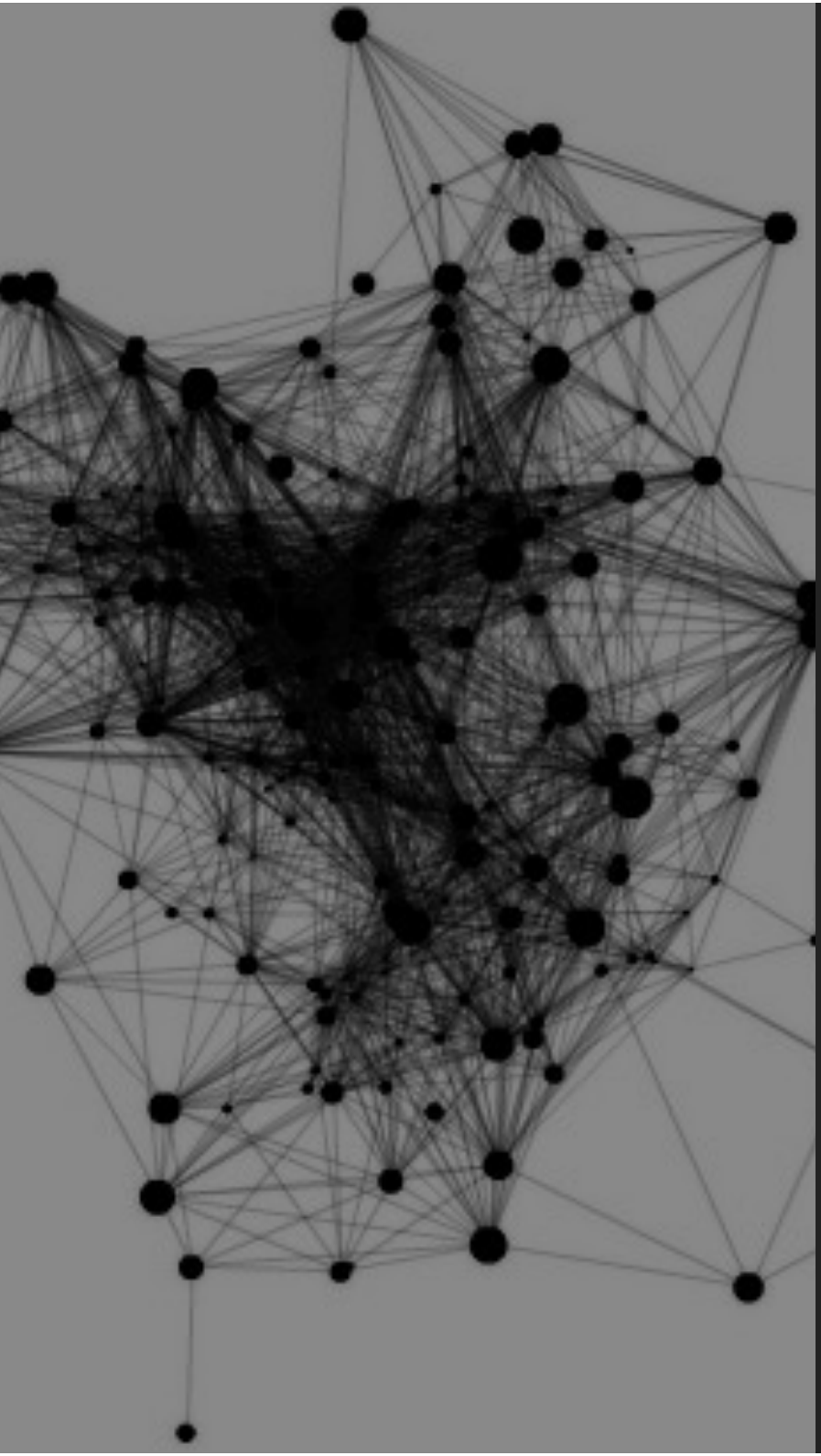
- Nodes which misbehave need to be removed:
  - They waste system resources
  - They take up slots that could be used for honest peers

DISCONNECTING AND BANNING (2)

- ‘bad behavior’ may include:
  - Invalid transactions or blocks
  - Unconnected blocks
  - Stalling
  - *Non-standard* transactions
  - Malformed messages

DISCONNECTING AND BANNING (3)

- Depending on the misbehavior, Bitcoin Core may:
  - Ignore the problem and continue
  - Disconnect the peer immediately
  - *Ban* the peer (disconnect and don't allow connections from the same IP address for 24 hours)
  - Apply DoS points. When the DoS score reaches 100, ban the peer



TYPES OF NODES

FULL NODE

- Also called a *fully validating* node
- Receives blocks as they are mined and propagated around the network
- Verifies the validity of all blocks and all transactions included in those blocks
- Enforces the *consensus rules* of the Bitcoin network
- Maintains a collection of all the unspent outputs
- The most secure and private way to use Bitcoin

PRUNED NODE

- A type of full node
- Discards old block data to save disk space
- Retains at least 2 days of blocks and undo data to allow for re-orgs
- Propagates new blocks but cannot serve old blocks
- As secure as a non-pruned full node

‘ARCHIVAL’ NODE

- Unlike a pruned node, retains all old block and undo data
- Can serve old blocks to peers on the network
- Signaled using **NODE_NETWORK** in the version handshake

SIMPLE PAYMENT VERIFICATION (SPV) NODE (1)

- Only downloads:
  - the block headers
  - information about specific transactions
- Can validate proof-of-work
- Can’t validate other network rules:
  - Can’t detect invalid or double-spend transactions
  - Can’t verify money supply

SIMPLE PAYMENT VERIFICATION (SPV) NODE (2)

- Can verify that a transaction is included in a block (by asking for Merkle proofs)
- Can’t verify that a transaction hasn’t appeared in the blockchain
- Can use Bloom filters to preserve (some) privacy

OTHER NODE OPTIONS

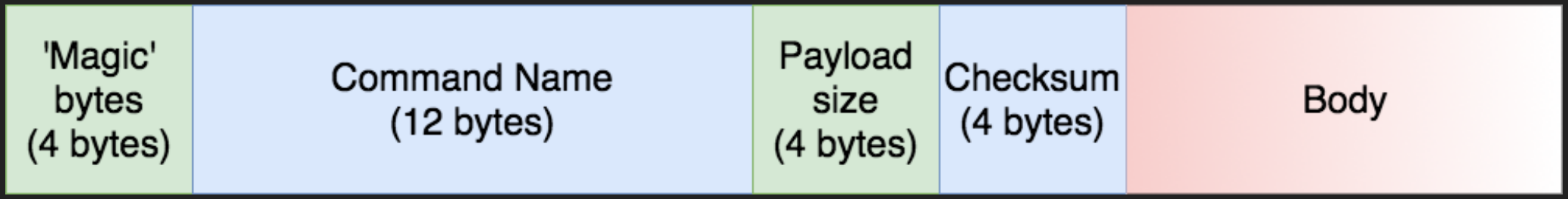
- **-blocksonly** - full node which doesn't propagate transactions
- **-nolisten** - node which makes outbound connections but doesn't accept inbound connections
- **-onion** - connect to peers using Tor
- **-proxy** - connect to peers via a proxy
- **-whitelist=<IP address or subnet>** -

MESSAGE FORMAT

MESSAGE FORMAT

- Bitcoin P2P messages contain a header and a payload
- Header is 24 bytes:
  - Magic (4 bytes): indicates the network (0xf9beb4d9 for Bitcoin
  - Command name (12 bytes): eg ADDR, INV, BLOCK, etc
  - Payload size (4 bytes): how large the payload is in bytes
  - Checksum (4 bytes): Double SHA256 of payload
- Payload: up to 32MB. Each command has its own defined format

MESSAGE FORMAT



EXAMPLE HEADER

- **f9beb4d976657261636b000000000000000000005df6e0e2**
- **f9beb4d9** : network magic for Bitcoin main net
- **76657261636b000000000000** : VERACK with zero padding
- **00000000** : payload size is zero
- **5df6e0e2** : checksum SHA256(SHA256(“”))

CONTROL MESSAGES

VERSION HANDSHAKE

- P2P connection starts with a version handshake
- Used by nodes to exchange information about themselves
- A node responds to a VERSION message with VERACK

VERSION MESSAGE (1)

- Version (4 bytes)
  - *highest version the transmitting node can connect to*
- Services (8 bytes)
  - *bitfield of services supported by the transmitting node*
- Timestamp (8 bytes)
  - *Unix timestamp of transmitting node*

VERSION MESSAGE (2)

- addr_recv services (8 bytes)
  - *services supported by the receiving node*
- addr_recv IP address and port (16 + 2 bytes)
  - *IPv6 address and port of receiving node*
- addr_trans services (8 bytes)
  - *services supported by the transmitting node (should be same as Services field)*
- addr_trans IP address and port (16 + 2 bytes)
  - *IPv6 address and port of transmitting node*

VERSION MESSAGE (3)

- nonce (8 bytes)
  - *random number used to detect if a node is connecting to itself*
- user_agent (compactSize + len)
  - *string indicating the software the node is using*
- start_height (4 bytes)
  - *height of the transmitting node's best blockchain*
- relay (bool - optional)
  - *indicates whether **INV** or **TX** messages should be sent to the transmitting node*

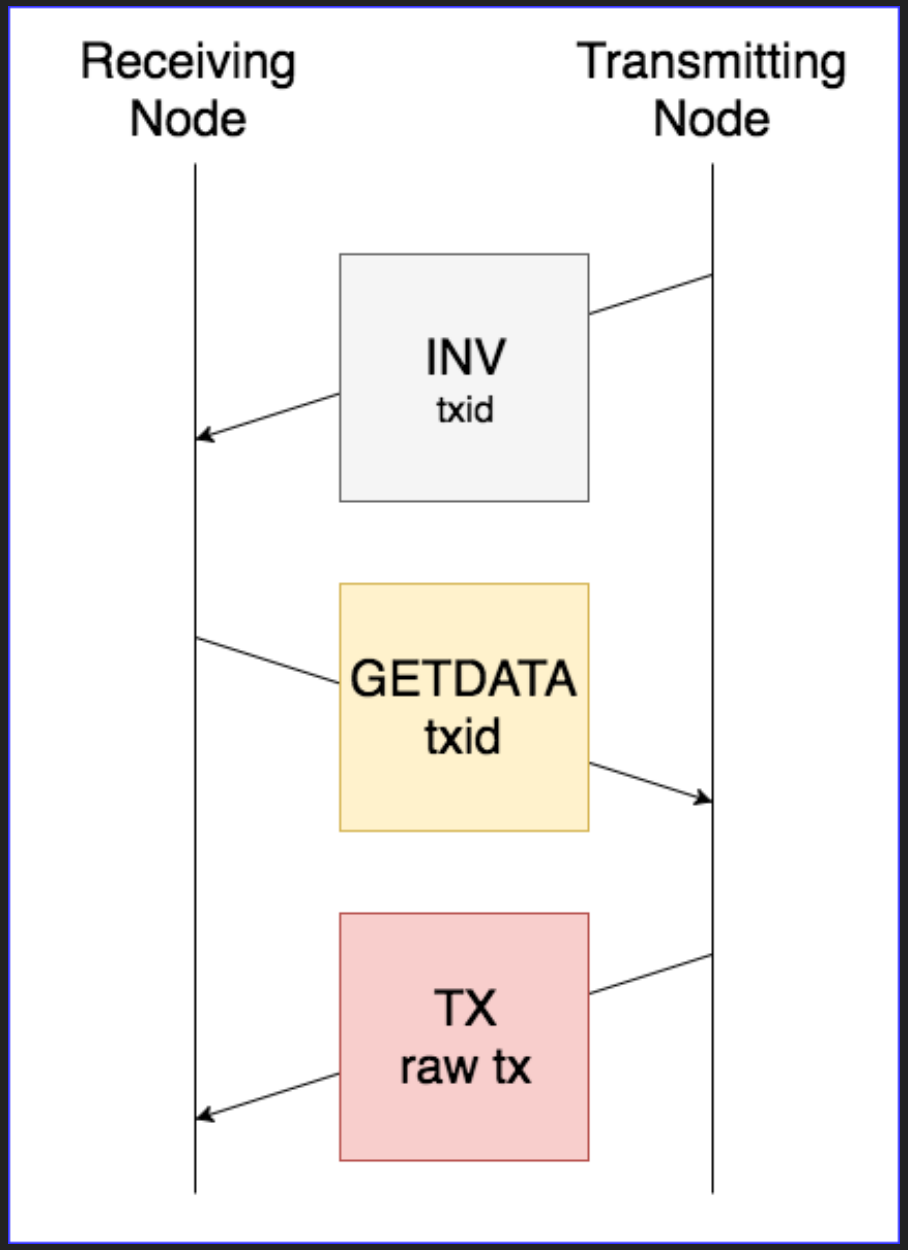
OTHER CONTROL MESSAGES

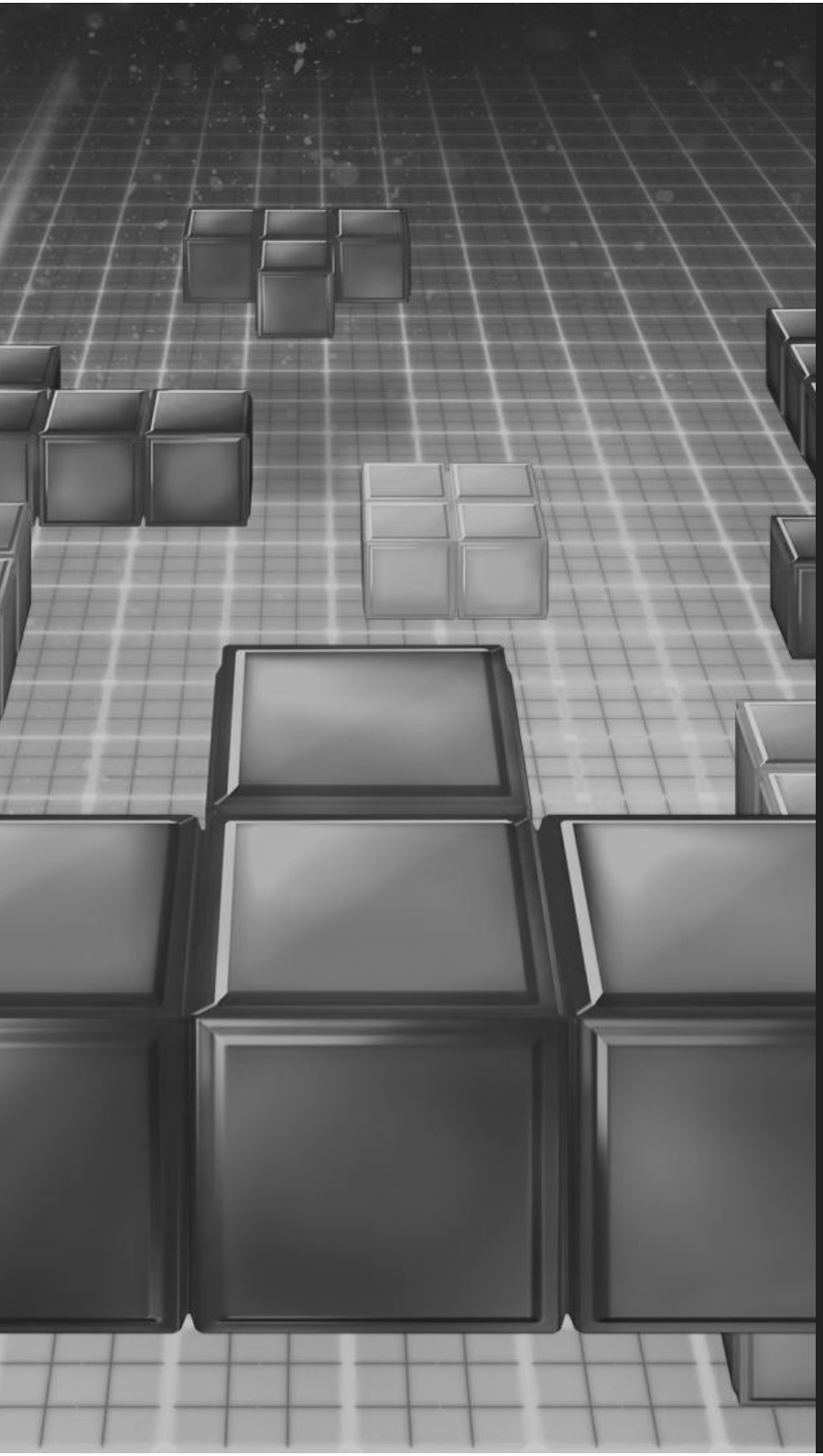
- VERACK - sent in response to a VERSION message
- ADDR - gossips connection information about other nodes
- GETADDR - requests information about other nodes
- PING/PONG - confirms connectivity
- FILTERLOAD / FILTERADD / FILTERCLEAR - sets and unsets bloom filters for SPV transaction propagation

TRANSACTION PROPAGATION

INVENTORY ANNOUNCEMENT

- New transactions are announced in an INV message
- INV messages contain the txid
  - (Can also contain block hashes)
- If the receiving node wants the announced inventory, it responds with a GETDATA message
- The announcing node then sends a TX messages


Receiving Node
Transmitting Node
INV
txid
GETDATA
txid
TX
raw tx



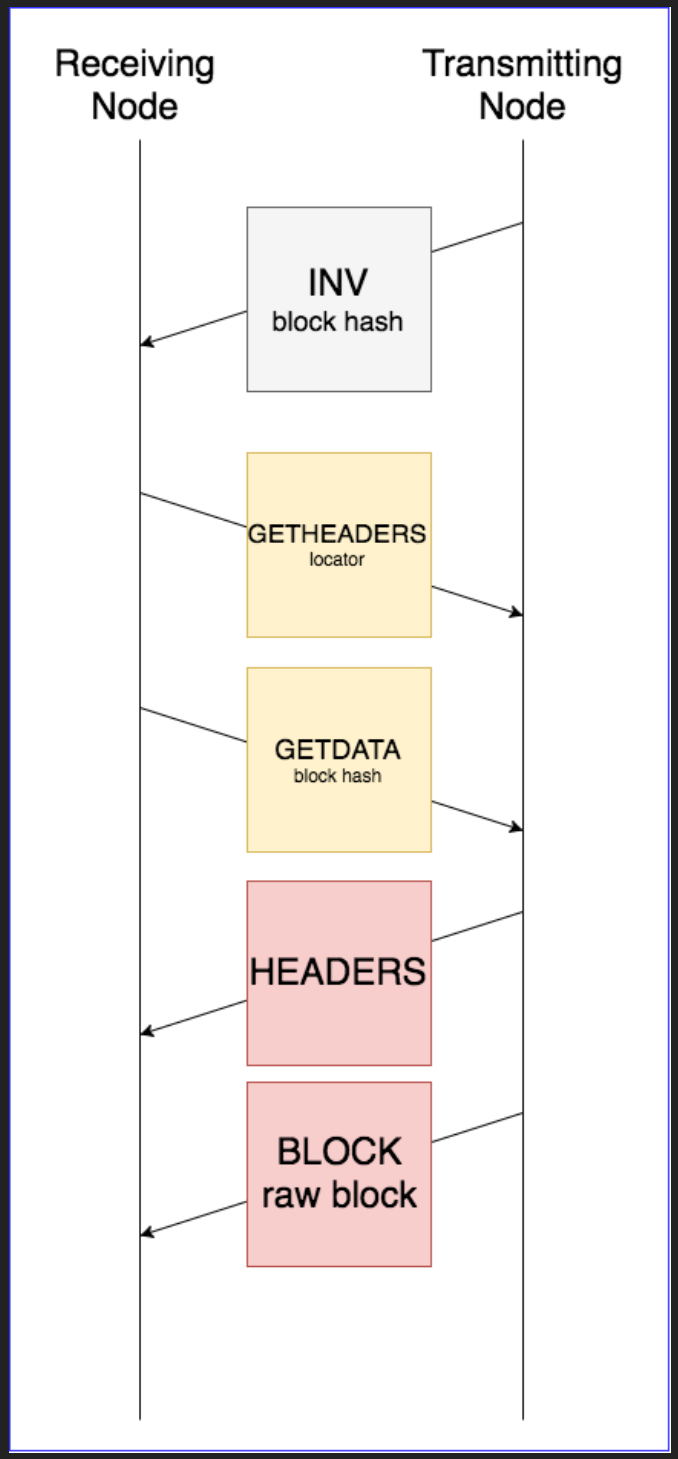
BLOCK PROPAGATION

BLOCK PROPAGATION

- Originally, blocks were propagated using INV-GETDATA-BLOCK
- v0.10.0 introduced ‘headers first’ syncing
- v0.12.0 introduced the SENDHEADERS message
- v0.13.0 introduced compact blocks
- v0.14.0 introduced High Bandwidth compact blocks

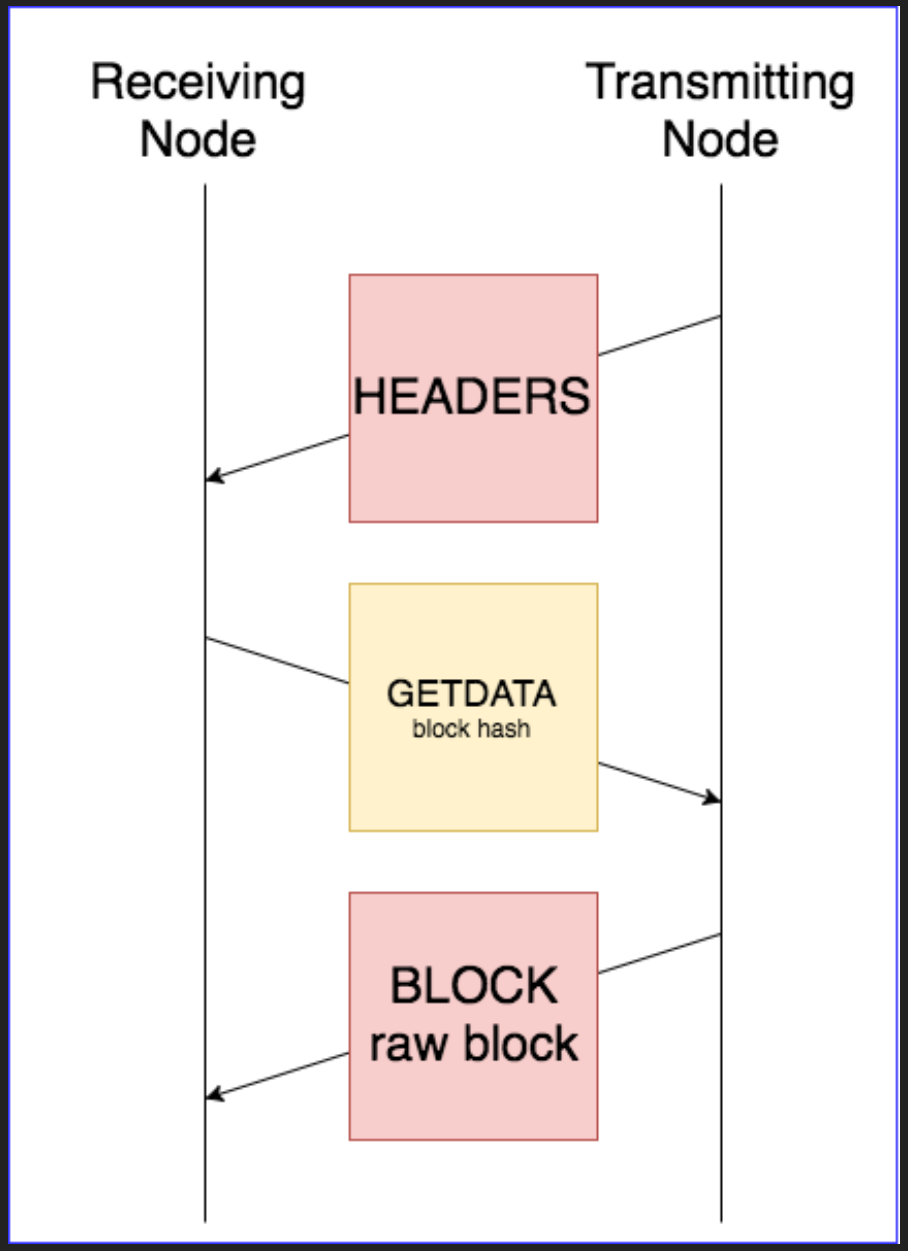
HEADERS-FIRST SYNCING

- Transmitting node sends INV with block hash as normal
- Receiving node responds with:
  - GETHEADERS (for block headers up to the tip)
  - GETDATA (for the tip block)
- Transmitting node sends:
  - HEADERS (connecting tip to the receiving node's best block)
  - BLOCK (containing the tip block)


Receiving Node
Transmitting Node
INV
block hash
GETHEADERS
locator
GETDATA
block hash
HEADERS
BLOCK
raw block

SENDHEADERS

- SENDHEADERS is a new control message in protocol version 70012
- Sent immediately after VERSION handshake
- Indicates that the transmitting node would prefer to receive HEADERs messages instead of INVs
- Saves a INV-GETHEADERS round trip
- Defined in BIP 130

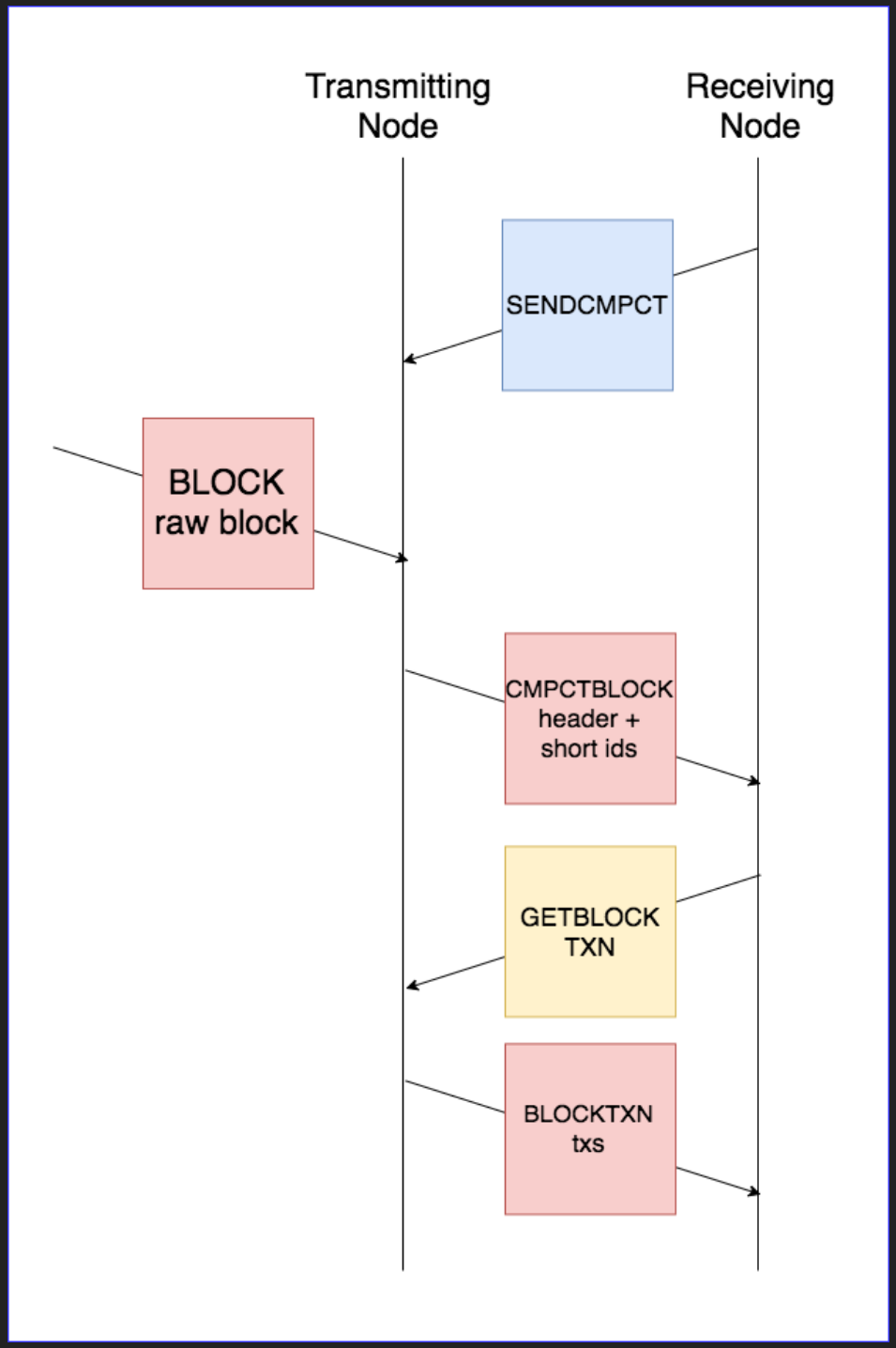

Receiving Node
Transmitting Node
HEADERS
GETDATA
block hash
BLOCK
raw block

COMPACT BLOCKS (1)

- Reduces time and bandwidth for propagating blocks
- Relies on fact that peer has already seen most transactions in a new block
- Enabled by node sending a SENDCMPCT message (similar to SENDHEADERS)
- Defined in BIP 152

COMPACT BLOCKS (2)

- Two modes:
  - low bandwidth - same number of messages as headers first block syncing, but saves on number of transactions sent
  - high bandwidth - sends cmpctblock message before the block has even been validated


Transmitting Node
Receiving Node
SENDCMPCT
BLOCK raw block
CMPCTBLOCK header + short ids
GETBLOCK TXN
BLOCKTXN txs