Post-Merge Client Architecture

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About Me
Everything you ever need to know about Ethereum clients...
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In 25 minutes...
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Hmm...
Ethereum Clients

Three Key Things To Know
Commonalities

**Networking**
- Peer discovery & management
- Sybil resistance
- DoS prevention
- Peer scoring
- Gossiping new data

**Blockchain**
- Tracking the block tree
- Re-org handling
- Operation/transaction mempools
- Sync
- State + transition function

Differences

Pretty much all the specific technologies
- LibP2P vs DevP2P
- Discv5 vs Discv4/DNS
- SSZ vs RLP
- Sha256 vs keccak
- BLS vs ECDSA
Slot Timing

+0s
Block

New slot begins every 12s.
Selected producer should create and publish their block as quickly as possible.

+4s
Attestations

Validators scheduled for this slot produce an attestation.
Attests to validator's view of the current chain head.
Produced earlier if block already imported.

+8s
Aggregates

Aggregators gather individual attestations into aggregates.
Can only aggregate matching attestations.
Key Differences - Large Execution State

● Storing world state efficiently is a huge challenge for execution clients

● Multiple different strategies for
  ○ Syncing
  ○ Pruning
  ○ Indexing

● Major performance challenges
The Post-Merge World
Deployment Model

Consensus Client

Engine API

Execution Client

LibP2P

Blocks, Attestations, Slashings, Exits

Transactions, Sync Data

DevP2P
Solution: Light Consensus Client

Build a light consensus client into execution clients.

Pros:
- Simple for users to run a basic node
- Reduced system requirements

Cons:
- Will always trail one slot behind head
- Not suitable for validator nodes
- Reduced security guarantees
Solution: Combine Clients

Combine the consensus and execution clients into a single executable.

Pros:
- Simple for users to start a new node

Cons:
- Bad for client diversity
- Dependency conflicts
- Increases coupling and cognitive load for core devs
- Encourages client scope creep
Problem: Real Deployment Complexity

- External Signer
- Validator Client
- Beacon Node
- Execution Client
- Prometheus
- Grafana
- Slashing Protection Database
- mev-boost
- Wallet
Solution: EthOS†

Move coordination up a layer by using/improving/building tools to manage configuration and integration of different clients and components.

Pros:
- Maintains decoupling of consensus and execution clients
- Decouples development model from deployment model
- Can include a full suite of functionality, monitoring etc
- Already exists in eth-docker, eth-wizard, DAppNode, Stereum and others

Cons:
- Hides complexity rather than removing it
- Extra layer means yet more software to build and maintain

† Not actually an OS
More Problems & Opportunities
Problem: Data Duplication

Consensus clients and execution clients both store the execution payload data.

All those transactions add up to a lot of disk space.

Both clients need to access the data to send to peers and handle API requests.
Solution: New engine API Methods

engine_getPayloadBodies - [https://github.com/ethereum/execution-apis/pull/146](https://github.com/ethereum/execution-apis/pull/146)

Efficiently request execution payload bodies from the execution client.

Pros:
- De-duplicates transaction data
- Batch requests for data make it reasonably efficient

Cons:
- More requests for the execution client database to handle
- Increases coupling between clients
Solution: Prune Historic Blocks

Store duplicate transactions but prune blocks aggressively.

Consensus specs only require storing ~5 months worth of blocks.

Pros:
- Simpler than deduplicating transactions
- Consensus disk space requirements become almost static

Cons:
- Doesn’t help archive nodes
- Older blocks become harder to find / potentially unavailable.
**Problem: Non-canonical Blocks and Re-orgs**

EL can return ACCEPTED and not execute non-canonical blocks
- Risks putting the consensus client into optimistic sync mode
- Might cause validator duties to be missed
- May make switching to that fork slower

**Take-away:**
- Short re-orgs need to be highly optimised to avoid missing validator duties
- Long re-orgs should be very rare and may not need to be so optimised
Learn from “the other side”

Embrace multi-component

Clean up some loose ends
Thank you!

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