이더리움 확장성 이슈 및 샤딩

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Agenda

- Ethereum Scaling Challenges
- Ethereum Sharding
  - Block Proposer
  - Cross-shard Communication
  - Stateless Client
  - Fork Choice Rule of Shard Chain

Ethereum Scaling Challenges

Issues on Ethereum

CryptoKitties

Release

트랜잭션 정체현상 폭증

BAT

ICO

Gas Price: 580,000 GWei
=> $25000를 TX fee로 지불

Ethereum Scaling Challenges

Issues on Ethereum

실생활에 필요한 Dapp 지원 불가

거래가 지연될수록 **증가하는 거래비용**

탈중앙 지향 가상화폐의 **중앙화 현상** 심화

Ethereum Scaling Challenges

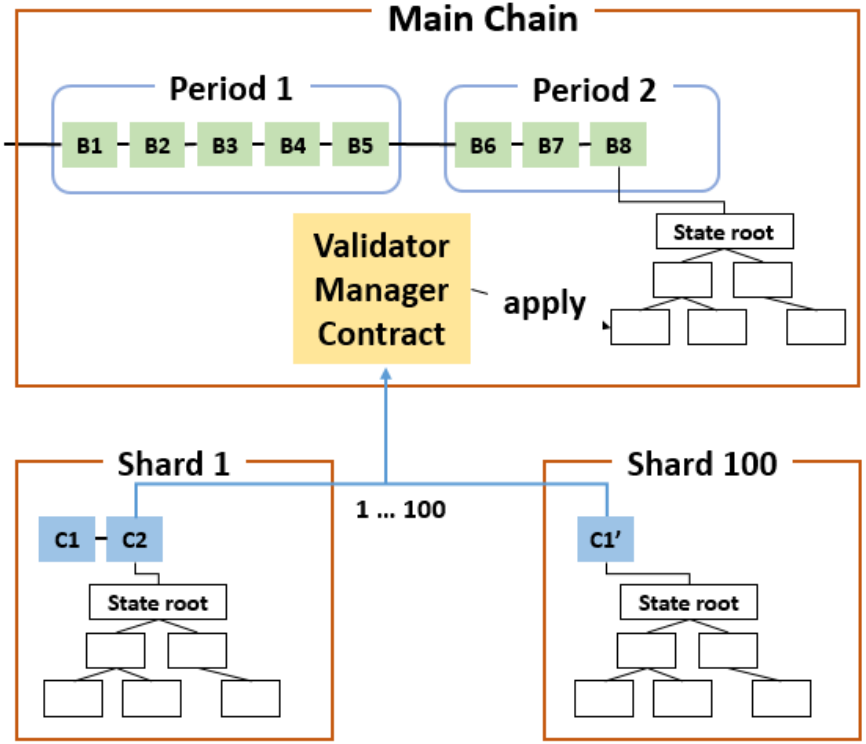
Current Attempts to Resolve

Name	Method	Description
Casper	**On**-chain	작업증명 방식에서 지분증명 방식으로 전환
Raiden Network	**Off**-chain, **Channel**-based	사용자간 처음과 마지막 거래만 기록하되, 중간 거래는 **Off**-chain의 채널에서 sign된 거래 교환으로 진행
Sharding	**On**-chain, **Chain**-based	검증자는 블록체인 state의 일부만 검증
Plasma	**Off**-chain, **Chain**-based	트리 구조의 다중 블록체인을 구축

Ethereum Sharding

Overview

출처: Ethereum Sharding: Overview and Finality

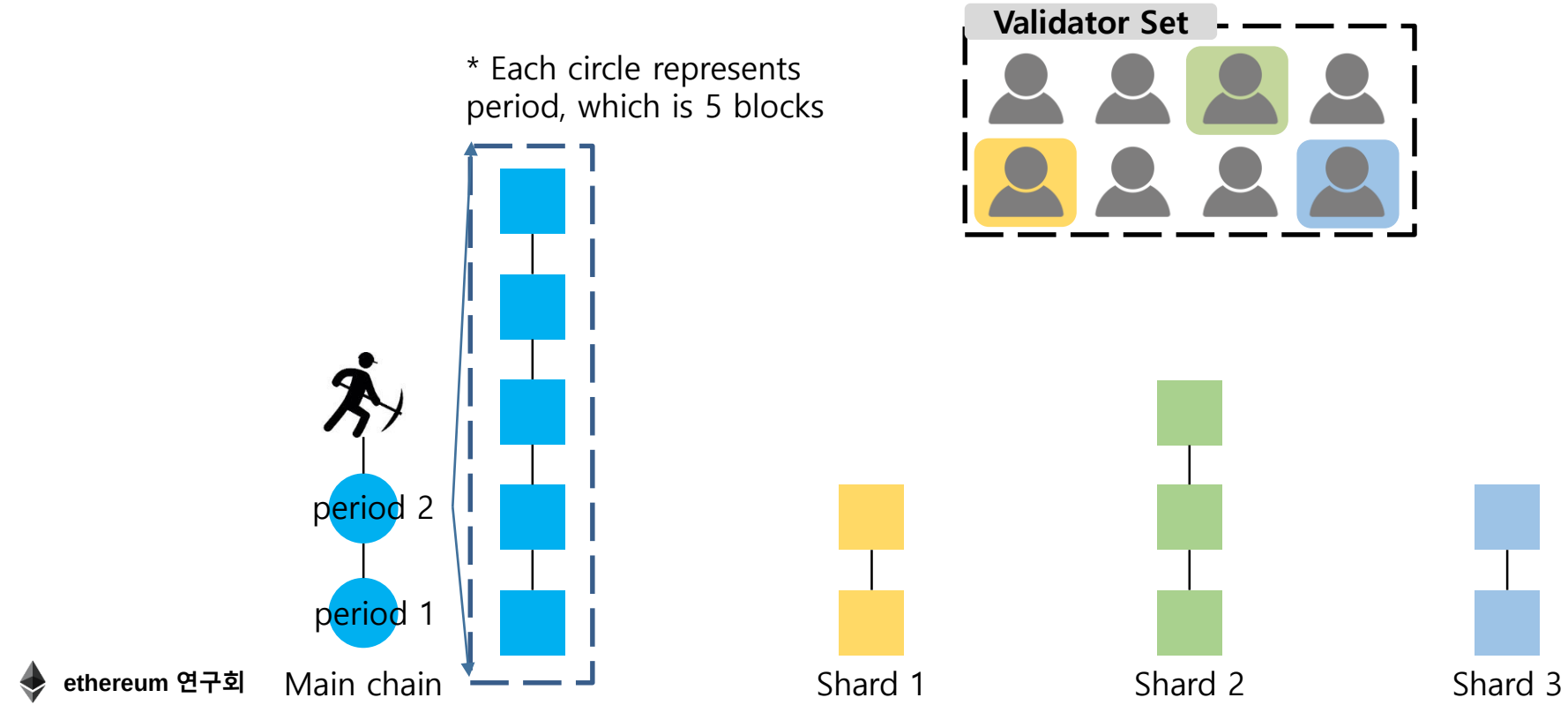


- No need to fork
- **Validator Manager Contract** 을 통해 mainnet에 바로 적용 가능
- Phase 1 will provide
  - A set of shard validators
  - 100 Ethereum shards
  - Each shard will have "stateless clients", "account abstraction"

Ethereum Sharding

Block Proposal

출처: Asia-Pacific Ethereum Meetup



Ethereum Sharding

Block Proposal

출처: Asia-Pacific Ethereum Meetup

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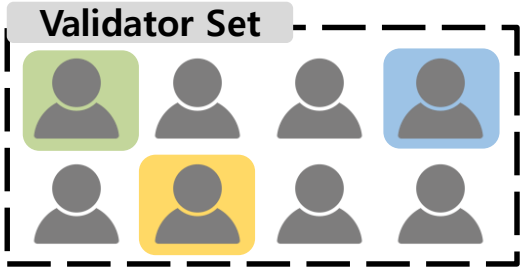
Ethereum Sharding

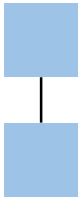
Block Proposal

출처: Asia-Pacific Ethereum Meetup

LOOKAHEAD_PERIODS = 4

* LOOKAHEAD는 Validator가 어느 시점에, 어느 샤드를 봐야 하는지 미리 알려주기 위함





Main chain

Shard 1

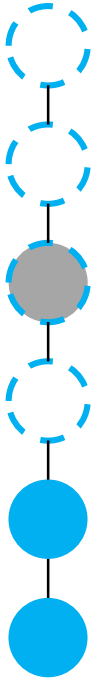
Shard 2

Shard 3

Ethereum Sharding

Block Proposal

출처: Asia-Pacific Ethereum Meetup



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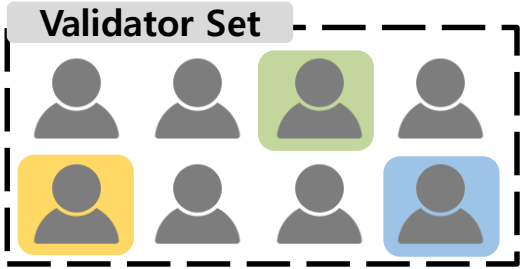

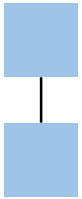

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Ethereum Sharding

Block Proposal

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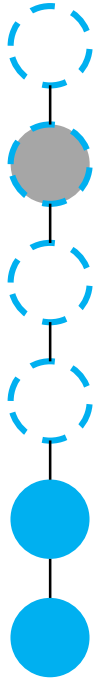

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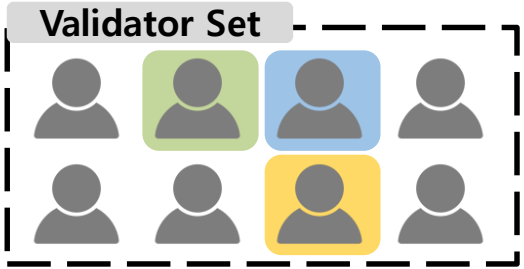

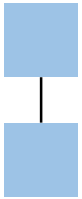

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Ethereum Sharding

Block Proposal

출처: Asia-Pacific Ethereum Meetup

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Ethereum Sharding

Block Proposal

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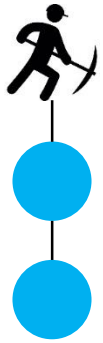
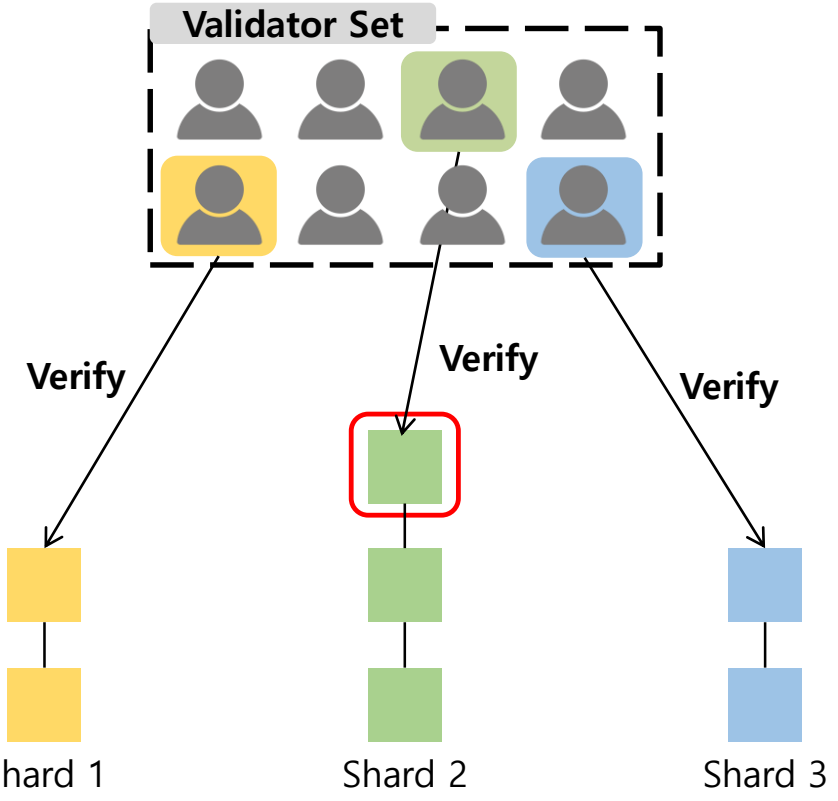


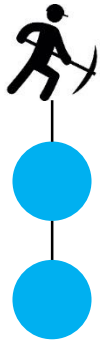
Main chain



Ethereum Sharding

Block Proposal

출처: Asia-Pacific Ethereum Meetup



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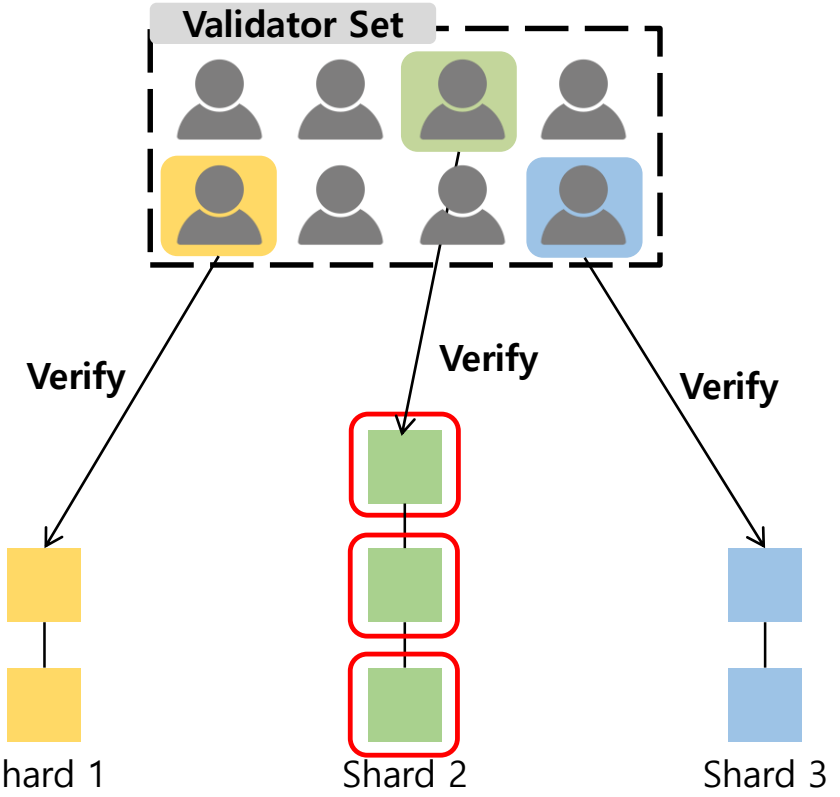
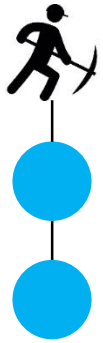


Ethereum Sharding

Block Proposal

출처: Asia-Pacific Ethereum Meetup



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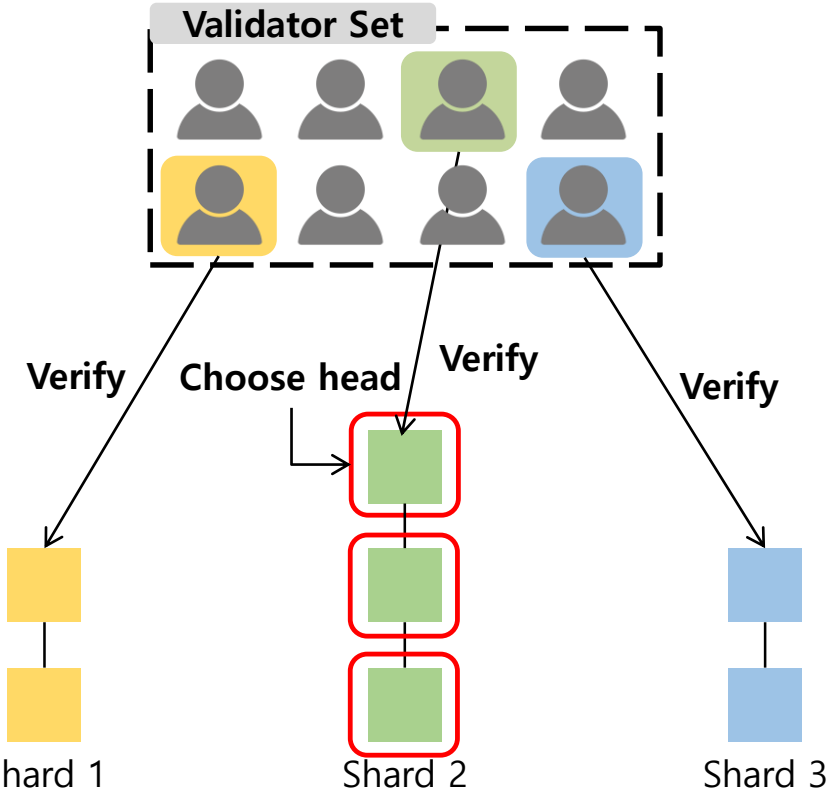

Ethereum Sharding

Block Proposal

출처: Asia-Pacific Ethereum Meetup

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4. **Client submits transaction with access list and witness => backup slides**
5. Validator pull relevant transactions from the mempool
6. Validators submit collation header to the root chain

Ethereum Sharding

Block Proposal

출처: Asia-Pacific Ethereum Meetup

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Ethereum Sharding

Block Proposal

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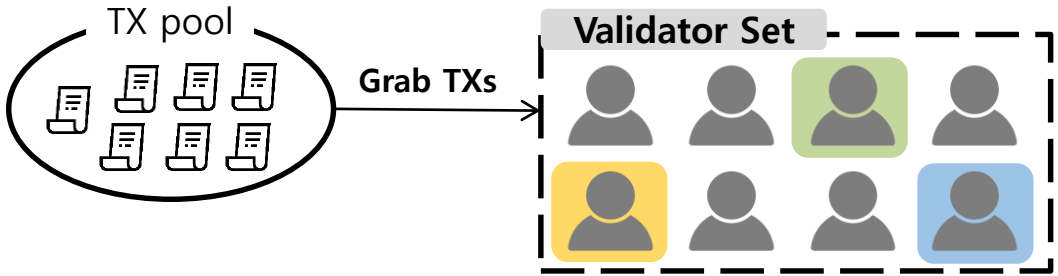
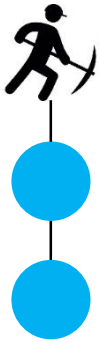
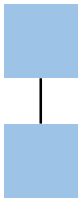




Main chain

Shard 1

Shard 2



Shard 3

Ethereum Sharding

Block Proposal

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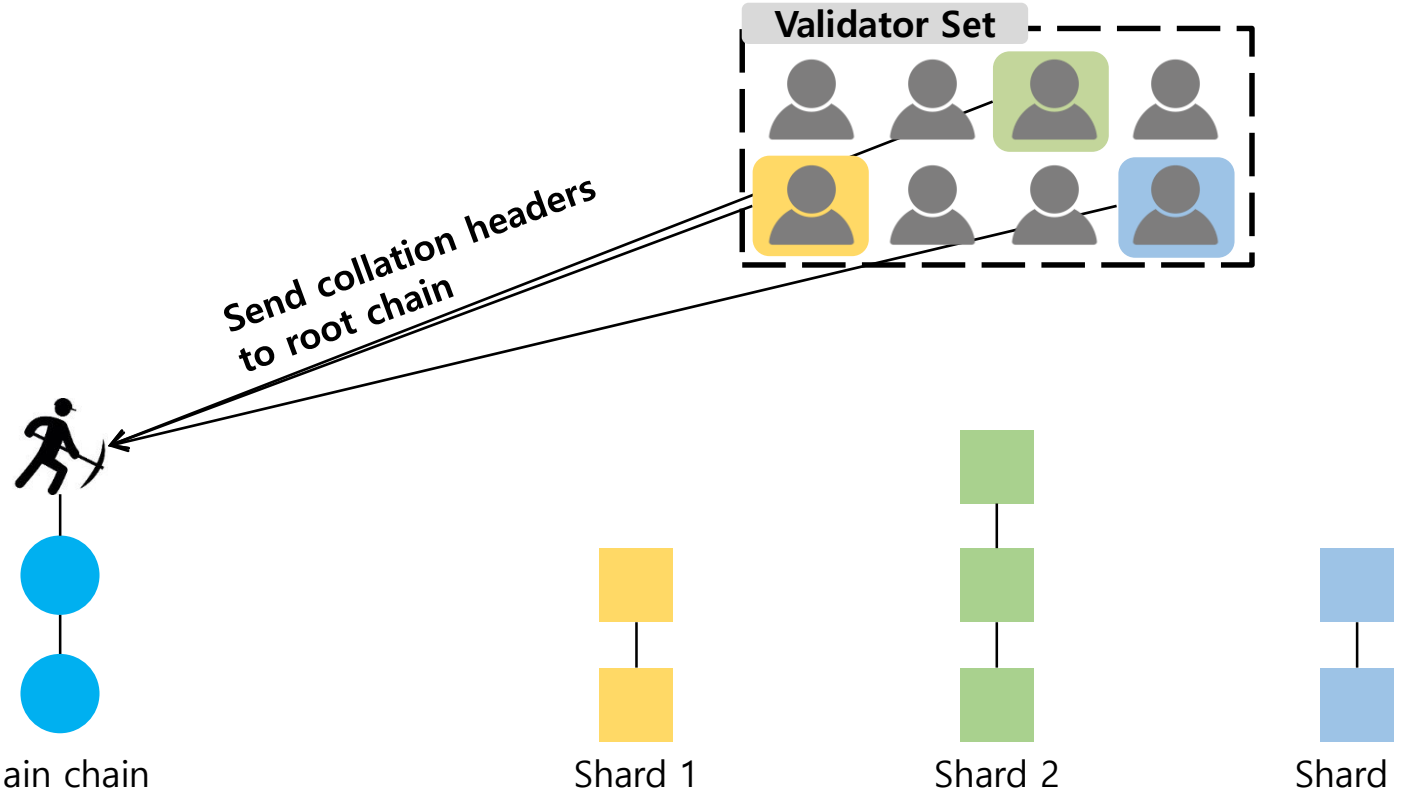
Ethereum Sharding

Block Proposal

출처: Asia-Pacific Ethereum Meetup



Ethereum Sharding

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How to handle the case that evil validator submits invalid block?

Ethereum Sharding

Block Proposal

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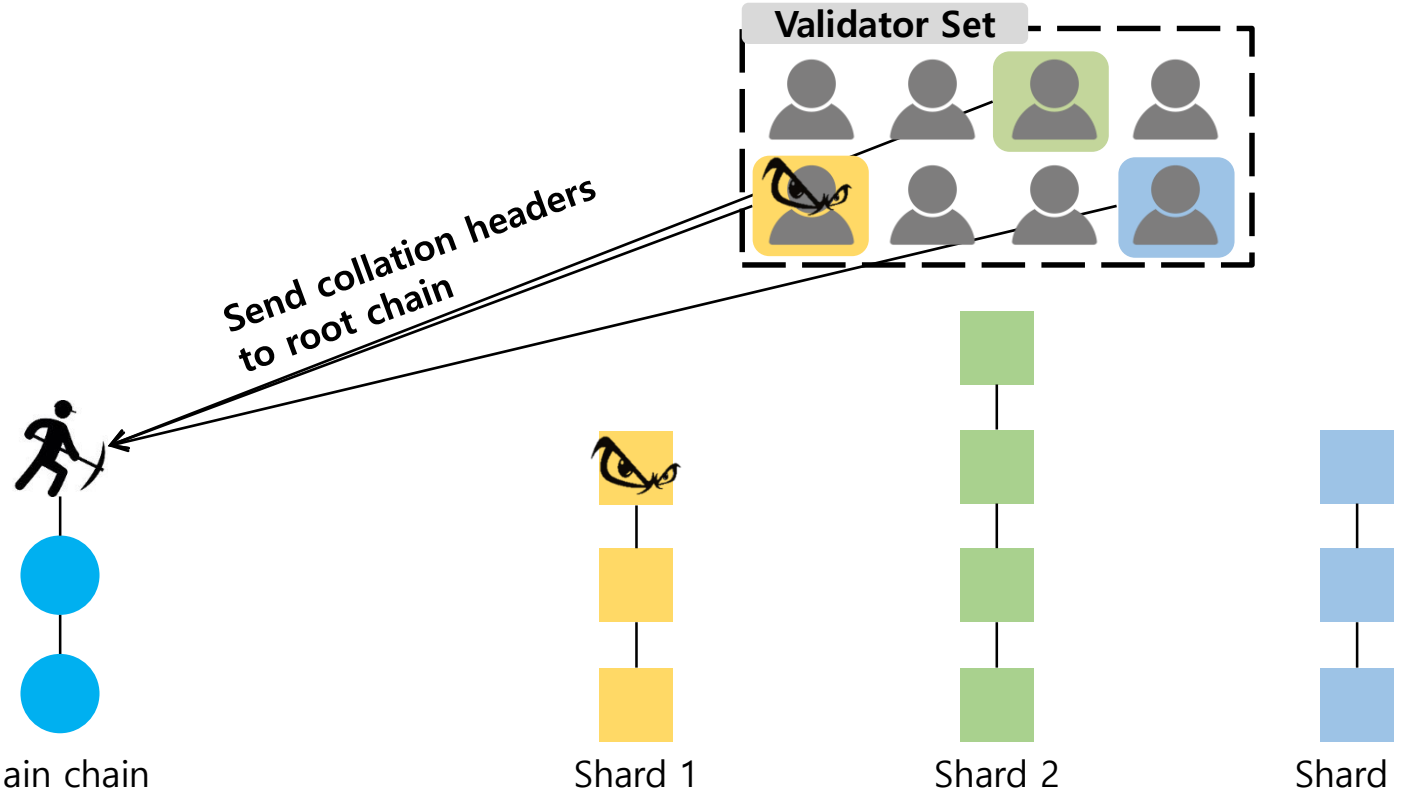


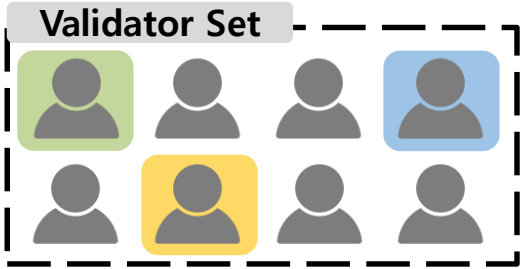
Ethereum Sharding

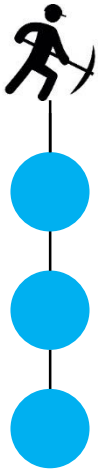
Block Proposal

출처: Asia-Pacific Ethereum Meetup

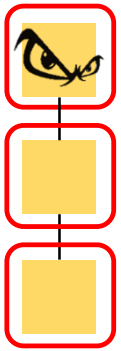
1) Validation 단계에서,
shard 1의 validator가
invalid collation을 notify

2) 새로운 분기 생성

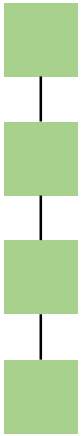




Main chain



Shard 1



Shard 2

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Ethereum Sharding

Block Proposal

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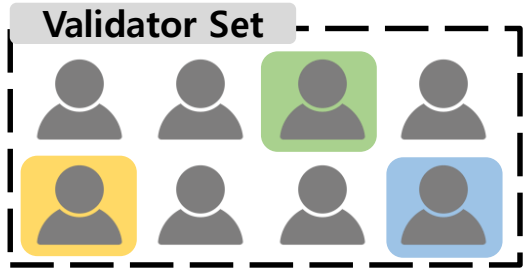

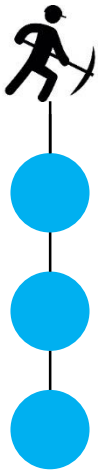

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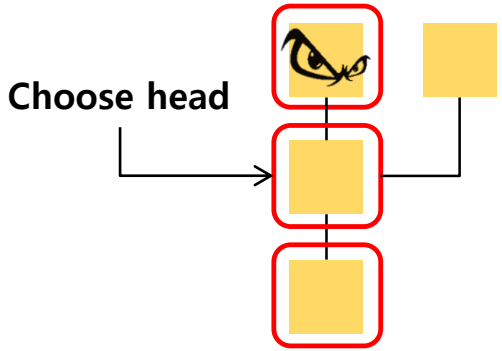

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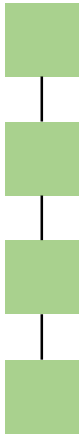

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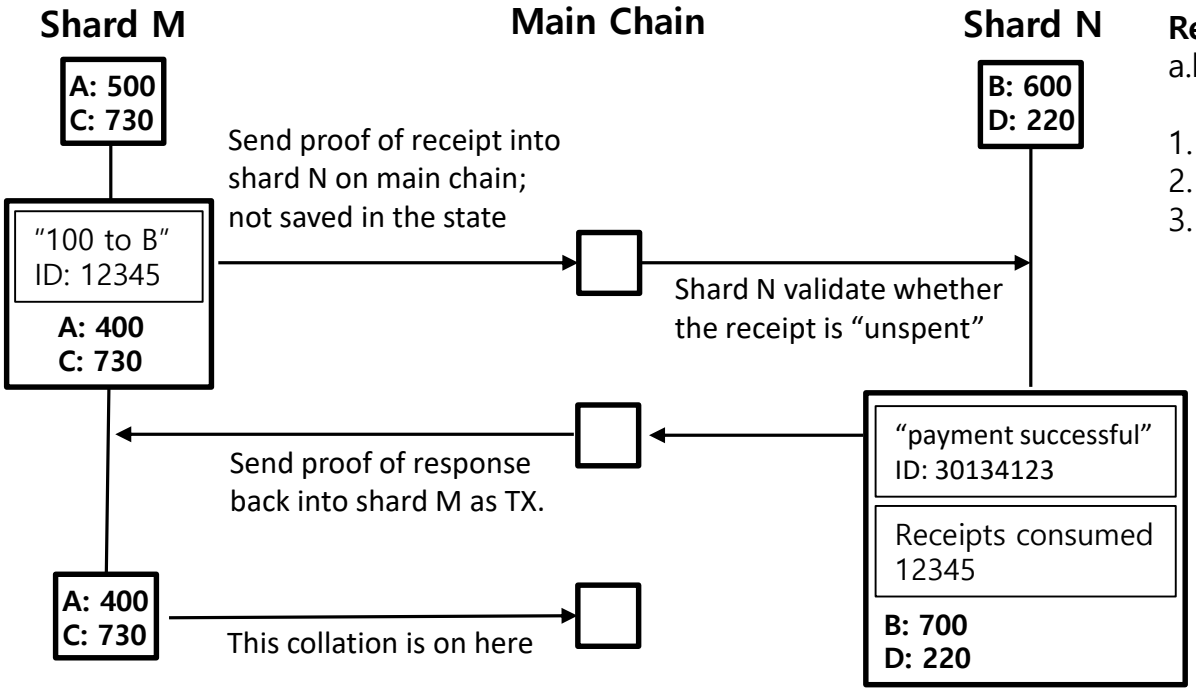
How to handle the case that evil validator submits invalid block? → **How Casper works on this!**

Ethereum Sharding

Cross-Shard Communication

출처: Sharding FAQ



Receipt-based communication
a.k.a "debit" or "credit" base.

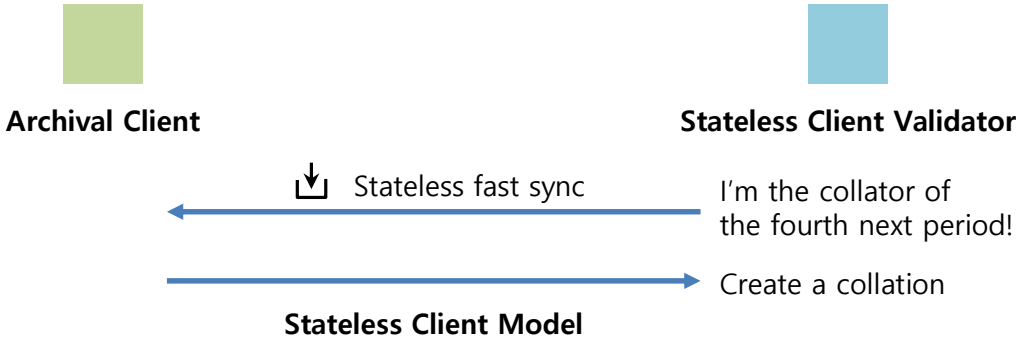
1. Send a TX on Shard M and create a receipt
2. Wait for the first TX to be included
3. Send a TX on shard N which includes the proof of the receipt. (validate the receipt & increase appropriate balance)

Ethereum Sharding

Stateless Client

출처: Ethereum Sharding: Overview and Finality

- **Basic Concept**
  - Stateless clients only store the state trie root
  - The archival clients store the full state trie and provide the merkle branches that the given collation needs
  - With these branches, the stateless clients are able to build partial state trie and verify
  - Validator only have to validate the recent collations to sync with the shard



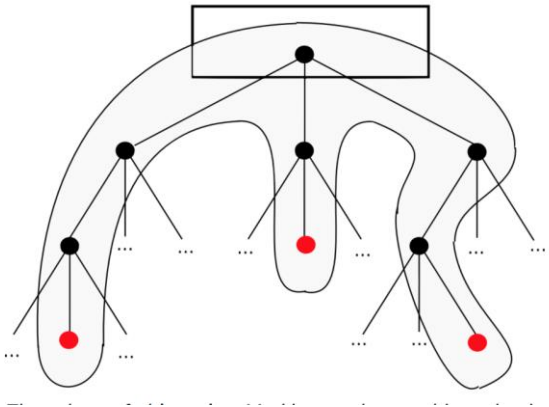
Ethereum Sharding

Stateless Client – Data Format

```
Transaction:
[
   [nonce, act, data, ...], # TX body
   [node1, node2, node3, ...]  # witness
]
```

```
Collation:
[
   [shard_id, ..., sig], # header
   [tx1, tx2, ...],  # TX list
   [node1, node2, ...]  # witness
]
```

- Transaction **must** specify an ***access list*** enumerating the parts of the state
- "**witness**", an RLP-encoded list of Merkle tree nodes that provides the portion of the state



"**Access list**" allows the collator to process the tx with only the state root

RLP(Access list)
=> witness

Ethereum Sharding

Stateless Client – State Transition Function

- **AS-IS:** STF(S, B) -> S' where S, S' are states, B is a block (or could be a transaction T)

- **TO-BE** (because, in a stateless client model, nodes do not store the state)
  S-> the state root of S
  B-> (B,W), where W is a "witness" – a set of merkle branches proving the values
  STF-> STF', which takes as input a state root and a block-plus-witness, and outputs the new state root

Ethereum Sharding

Stateless Client – Pros

- Miners and full nodes in general no longer need to store any state
- Blockchain economics can focus purely on pricing bandwidth and computation
- Disk I/O is no longer a problem for miners and full nodes; (Disk I/O has historically been the primary source of DoS attack)
- Security is increased by reshuffling clients between shards

Ethereum Sharding

Stateless Client – Who Store State?

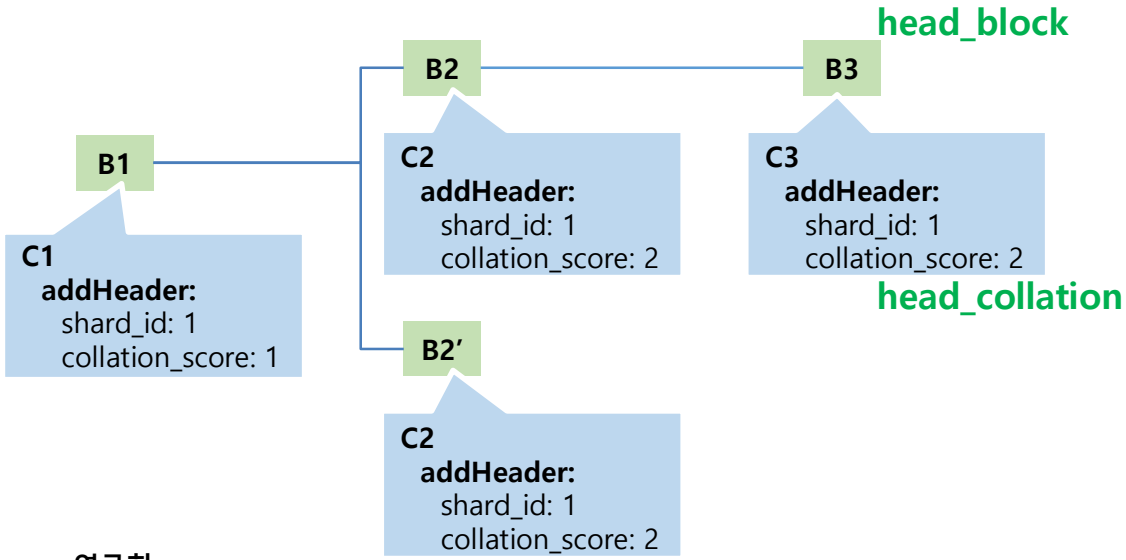
- Basically, “voluntary base”, “welfare storage”
- Any new state trie object by default stored by all full nodes for 3 months
- After 3 months, clients can forget randomly
  - After 12 months, still stored by 25% of nodes, 5% after 60 months
  - Clients can set up channels with paid archival nodes and make it last forever
- Dapp users randomly store some portion of storage keys

Ethereum Sharding

Fork Choice Rule of Shard Chain

출처: Ethereum Sharding: Overview and Finality

- The fork choice rule depends on the longest main chain.
- Not simply the head collation of "longest valid shard chain", but **"The longest valid shard chain within the longest valid main chain"**



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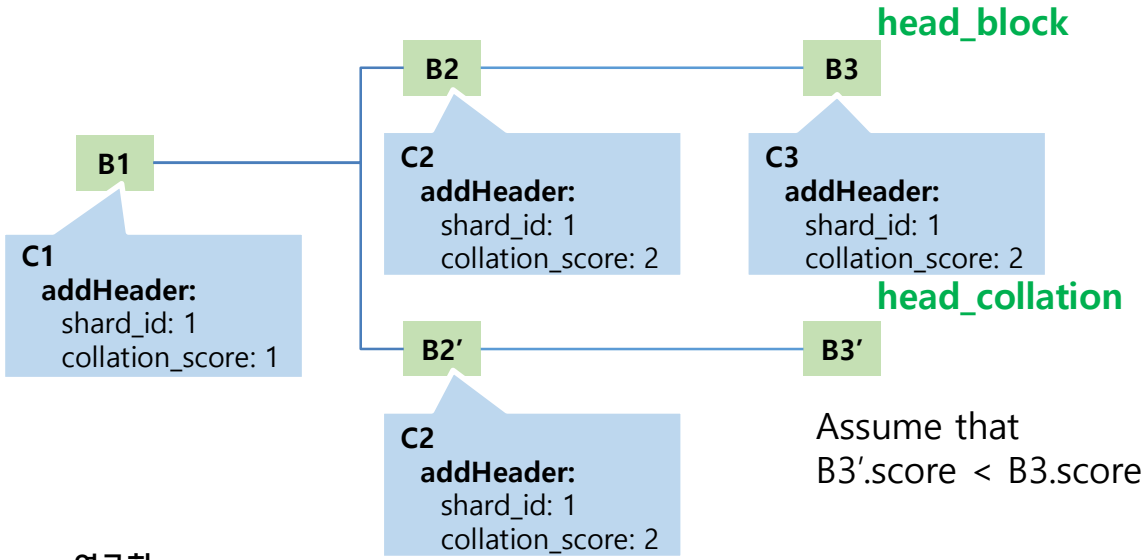

Ethereum Sharding

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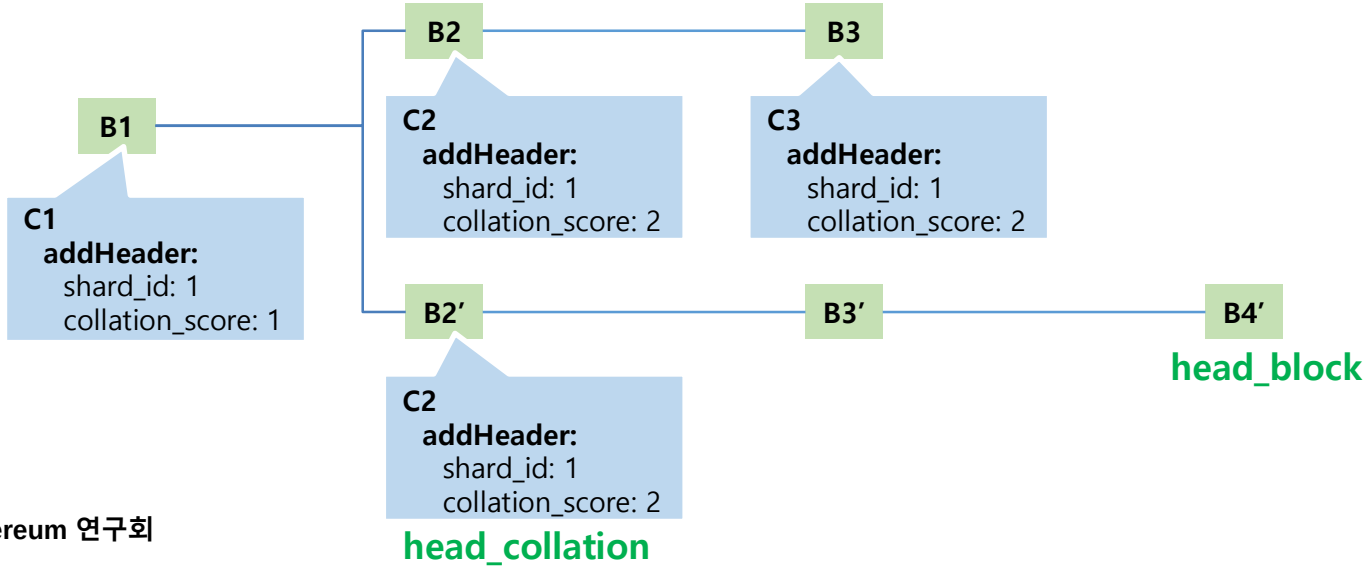

Ethereum Sharding

Issues on Sharding

출처: Ethresear.ch

Many on-going topics on Ethereum Sharding, please visit ethresear.ch

- Merge blocks and synchronous cross-shard state execution
- Proposal/confirmation separation: a bug and a fix
- Delayed state execution, finality and cross-chain operations
- Delayed state execution in practice
- Fork-free sharding
- Cross Shard Locking Scheme
- State-minimised executions

References

- **Ethresear.ch**
- https://medium.com/@icebearhww/ethereum-sharding-and-finality-65248951f649
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