Scalability II

50.037 Blockchain Technology

Paweł Szałachowski

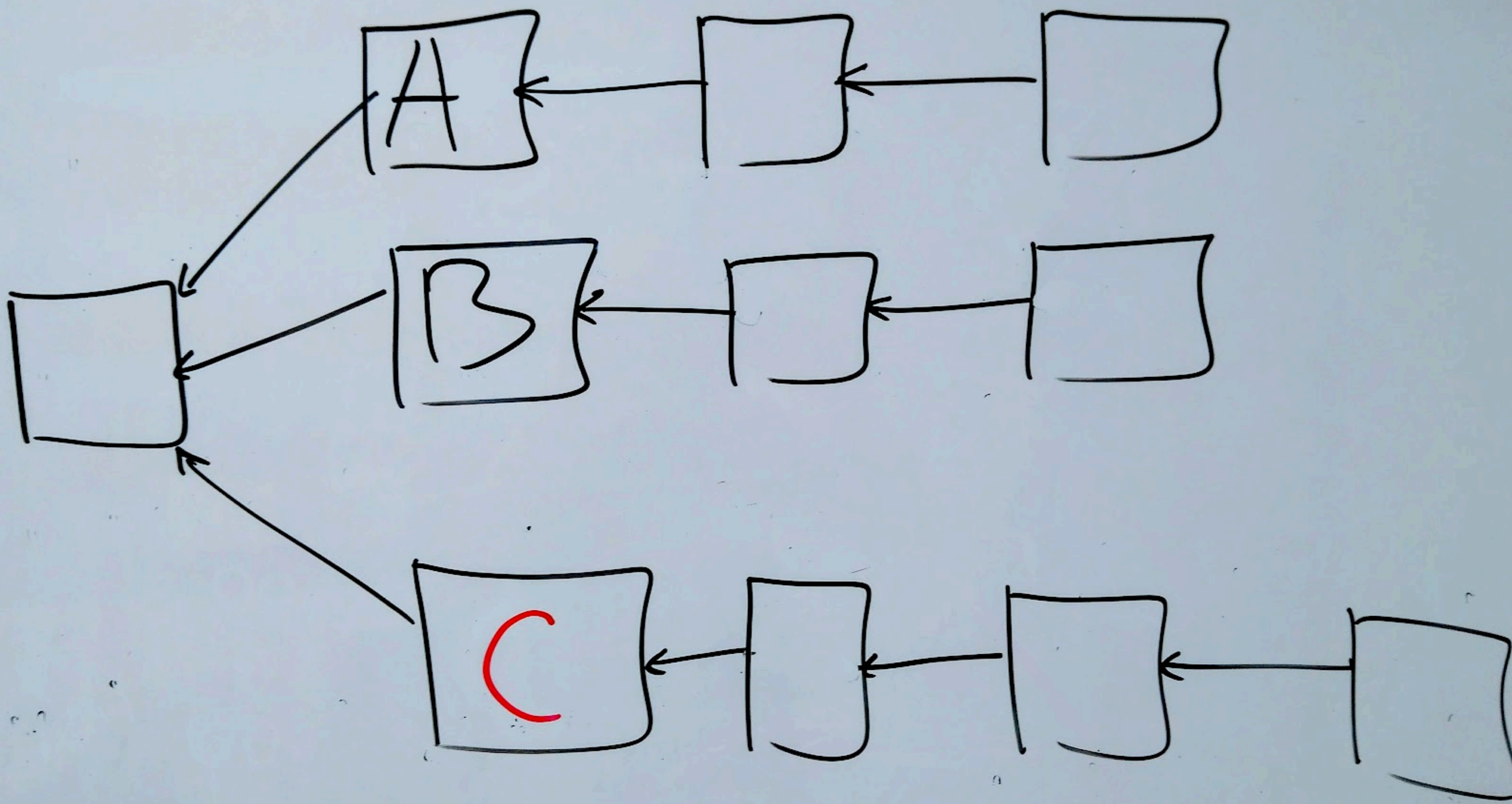
Directed Acyclic Graph (DAG)

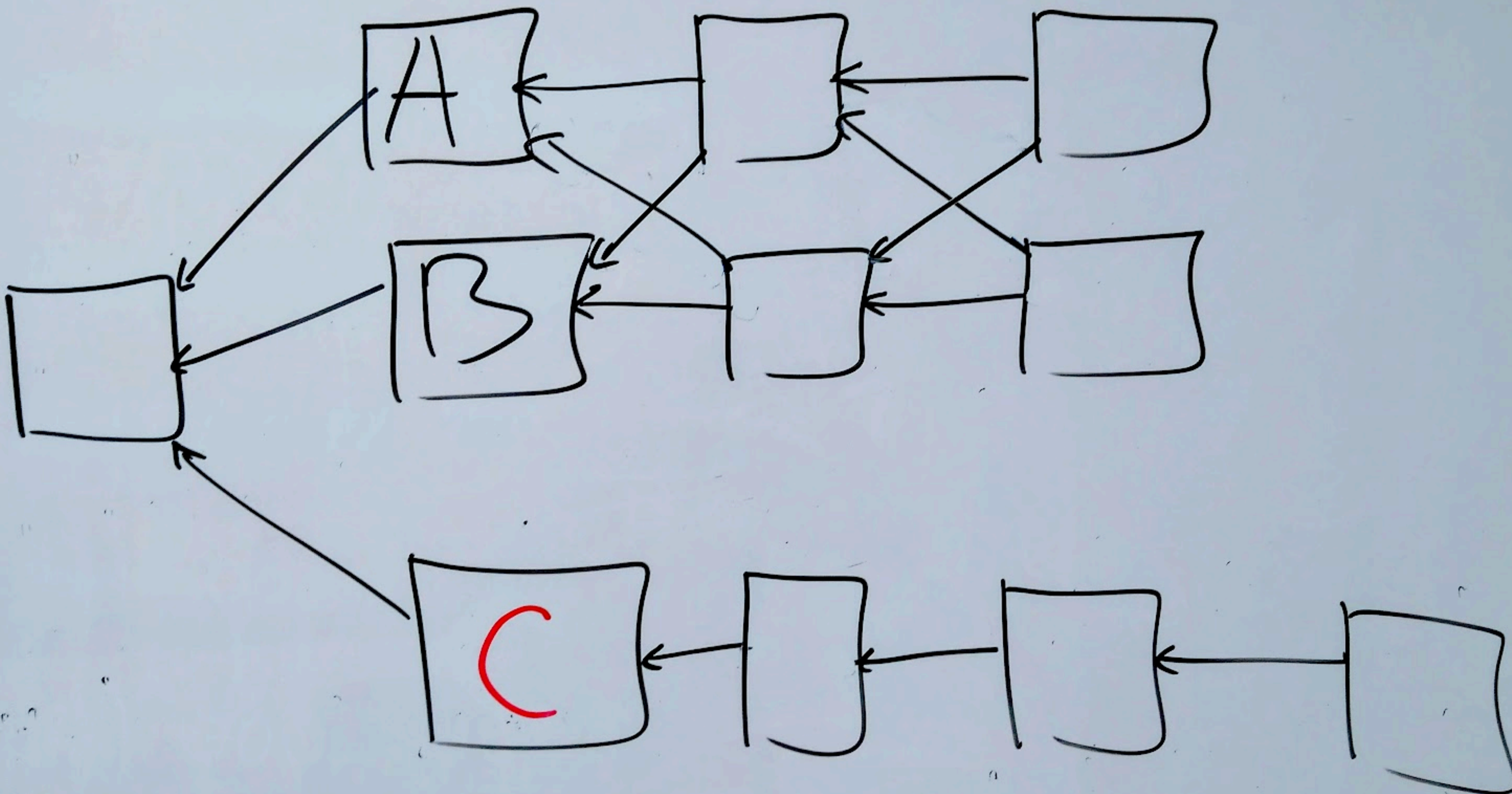
DAG

- Nakamoto-like consensus is very easy
- The chain structure is simple but has some limitations
  - Can we introduce a more efficient data structure?
- Graphs
  - More powerful, as blocks can encode their *worldviews*
  - Why acyclic?

SPECTRE

- https://eprint.iacr.org/2016/1159.pdf (payment oriented)
- Intuitions and insights:
  - Bitcoin is related to voting
    - Every block votes for its chain
    - Cloning in Bitcoin
  - Vote amplification (miners strengthen the majority decision)
  - DAG can be used to encode the longest-chain rule


A
B
C


A
B
C

SPECTRE

- Miners create PoW-protected blocks with Txs
  - Blocks point to all know *tips* of the DAG
  - Claiming they were created after them
- Blocks can have conflicting Txs
- Nodes maintain local copies of DAG and accept/reject Tx
  - RobustReject, Pending, RobustAccepted

SPECTRE

- Vote over blocks (pairwise)
  - How many think $A<B$ vs how many think $B<A$
    - This is just interpretation, does not have to be “*true*”
- Use results to accept/reject Txs
  - Tx of block B if:
    - All inputs are accepted
    - For every conflicting Tx’ in B’, $B < B'$

SPECTRE

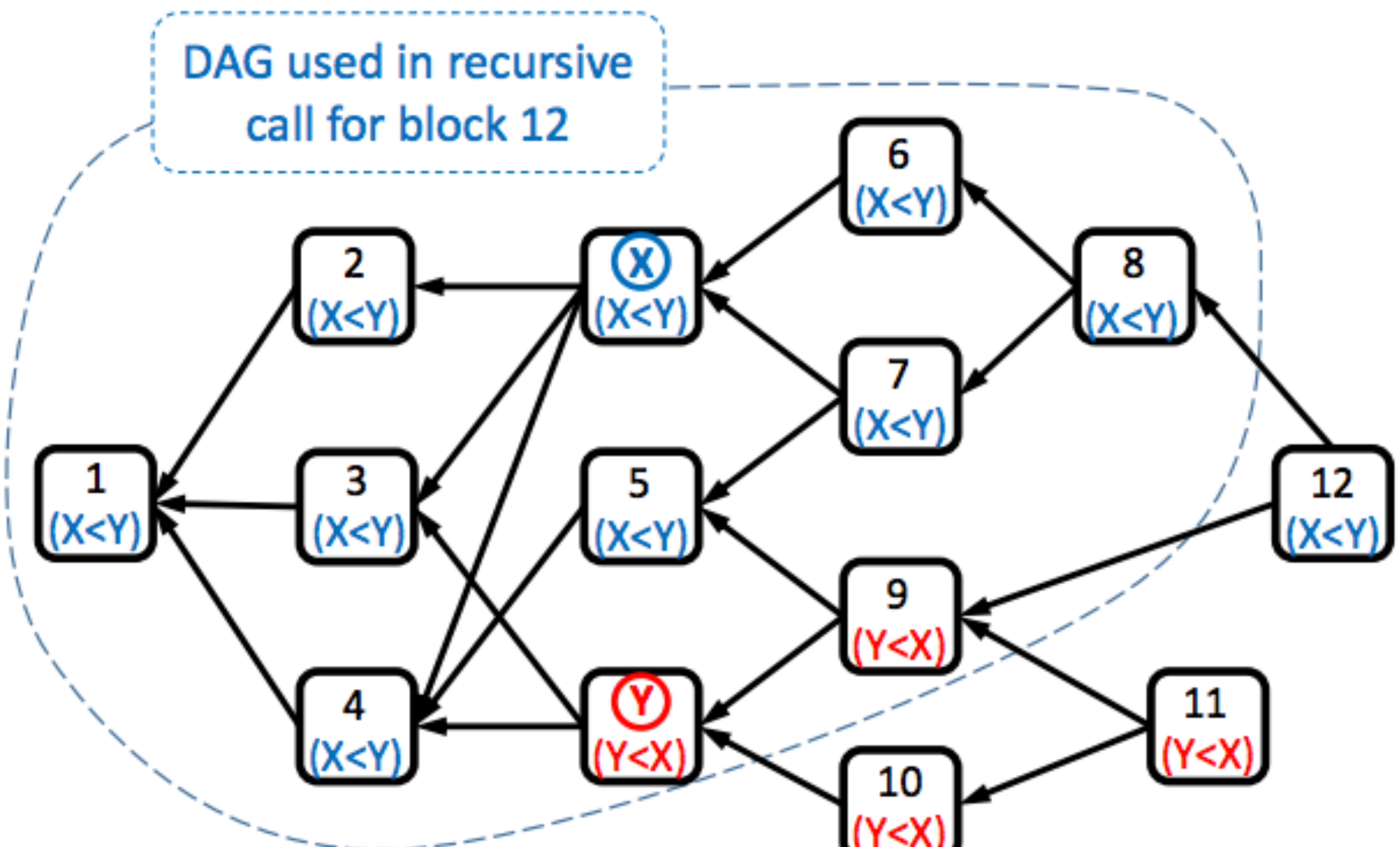


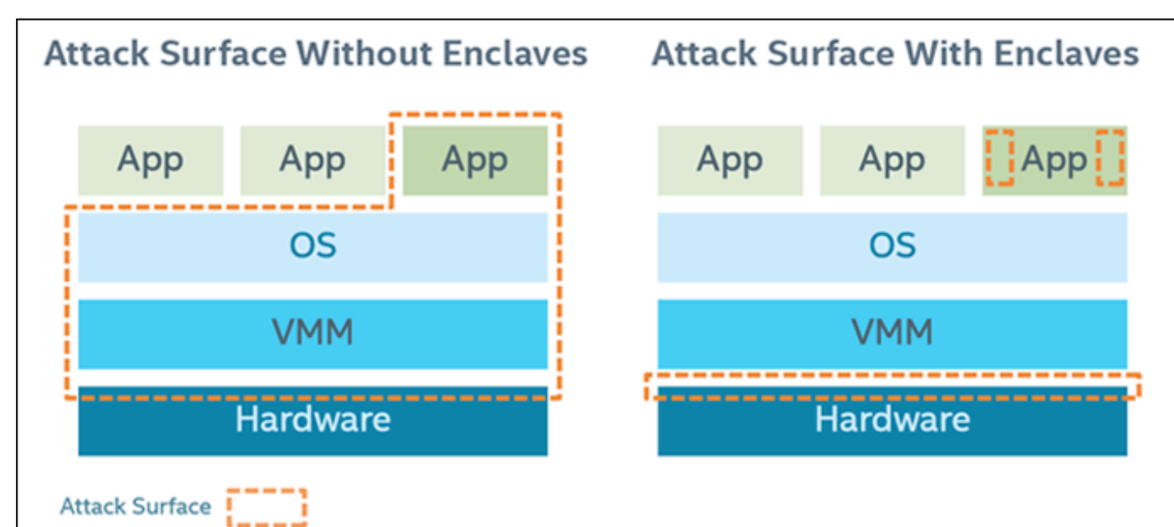
Fig. 1: An example of the voting procedure on a simple DAG. Block x and blocks 6-8 vote $x \prec y$ as they only see x in their past, and not y. Similarly, block y and blocks 9-11 vote $y \prec x$. Block 12 votes according to a recursive call on the DAG that does not contain blocks 10,11,12. Any block from 1-5 votes $x \prec y$, because it sees more $x \prec y$ voters in its future than $y \prec x$ voters.

- Quick confirmations, and clone-proof and amplified decisions
- Limitations?

Intel’s Proof of Elapsed Time (PoET)

Intel Software Guard Extensions (SGX)

- Set of new CPU instructions (Trusted Execution Environment — TEE)
- User code can allocate private regions of memory (**enclaves**), protected from other processes (even those running at higher privilege levels)
    - Running code and its memory is isolated from the rest of system
- Minimize trusted base
    - only CPU is trusted (even DRAM is untrusted, encryption needed)
- Attestation
    - Prove to remote system what code enclave is running



PoET

- Observation: PoW is introduced to mitigate Sybil attacks
  - … but with TEE that could be easier
- Idea: simulate PoW by sleep(…);
  - PoW-like guarantees
  - No energy waste
    - More energy vs more Intel SGX CPUs
  - Intel & SGX are trusted, not fully open, + see the recent attacks

PoET

1. A newcomer node downloads the trusted code and sends a *join* message with the signed attestation

2. Nodes verify and accept/reject

3. In each round, every nodes gets a trusted random R and calls

   sleep(R);

4. The first awake node sends a signed msg that she is a leader

5. The statement is validated and the blocks can be produced

Permissioned Blockchains

Permissioned Blockchains

- We discuss open/permissionless blockchains so far
  - Great for some use cases, not so great for other
    - Good: Append-only, decentralized, available, robust, transparent…
    - Bad: Slow, expensive storage&computation, volatility, immature technology, publicly available data, difficult to manage/update…
      - Mainly caused by the permissionless setting
  - Why not reuse some of those ideas and run a classic BFT consensus?
  - Efficiency could be one of the major benefits

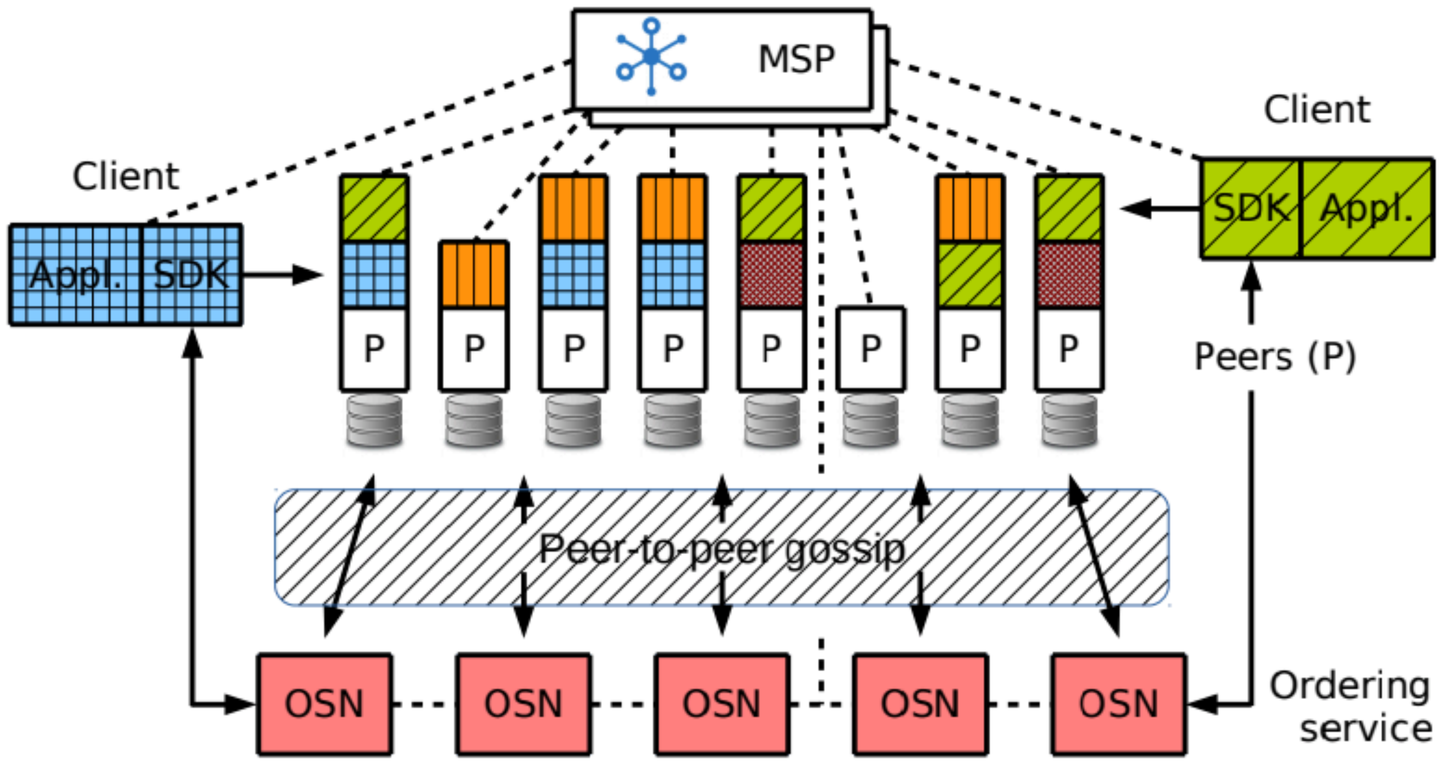
HYPERLEDGER

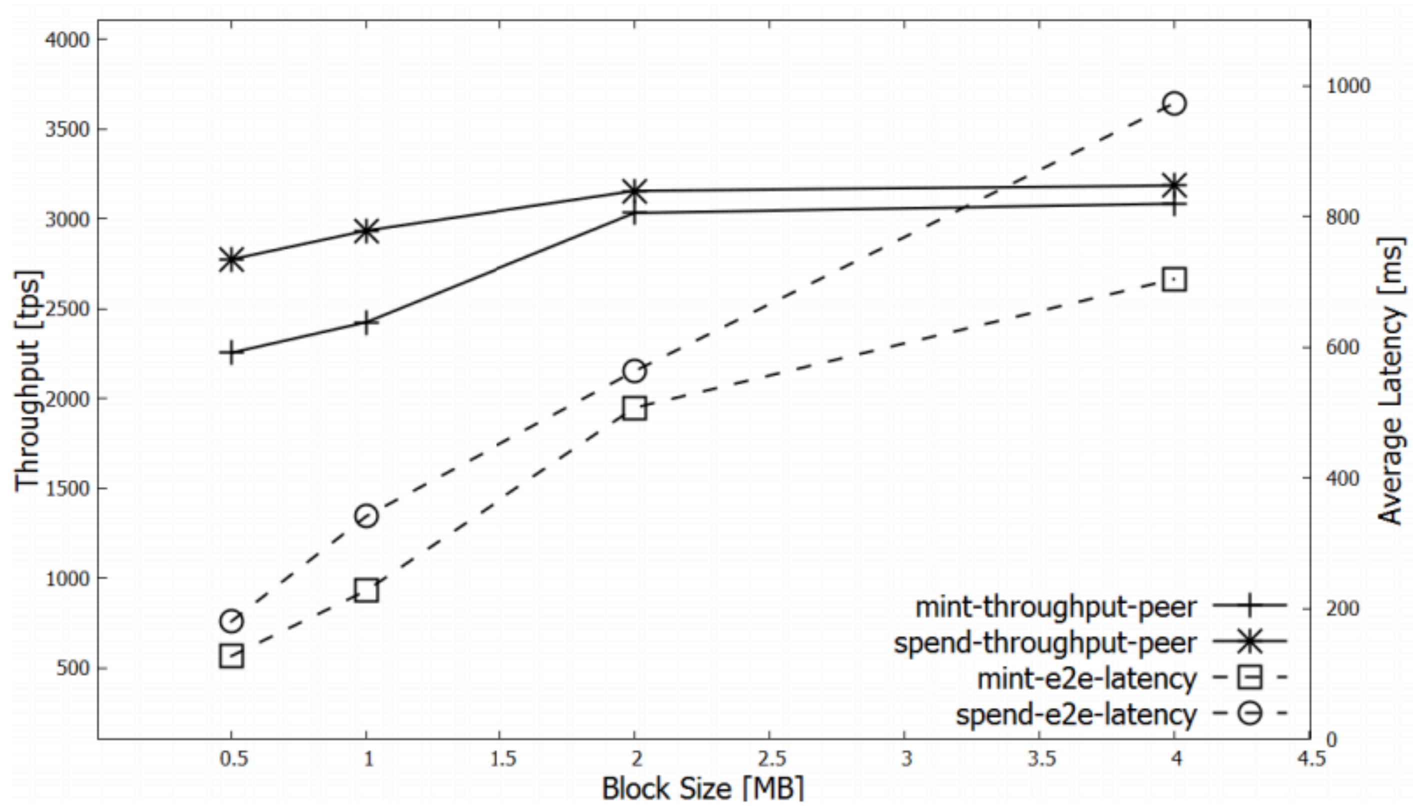
- Consortium
- Hyperledger Fabric (framework)
    - https://arxiv.org/abs/1801.10228
    - Business-oriented
    - Different consensus protocols supported
    - No built-in cryptocurrency
    - Powerful smart contracts

Hyperledger Farbic

- Membership service provider (MSP) provides identities to participants
- Clients submit transaction proposals for execution
- Peers execute transaction proposals and validate transactions
  - Only endorsing peers execute transactions (specified by a policy)
  - All peers maintain the blockchain ledger
- Ordering Service Nodes (OSN) establish the total order of all transactions

Hyperledger Fabric





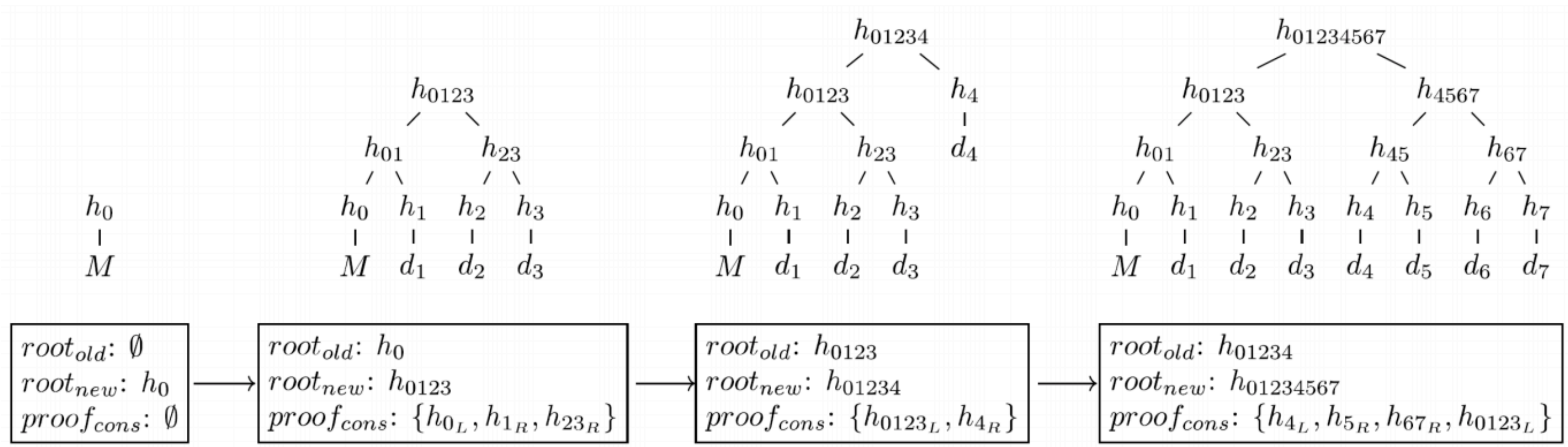
Centralized Ledgers

Certificate Transparency

- Maybe for some applications we could just use a centralized ledger?
- Problem: Certificate Authorities (CAs) can misbehave/get compromised unnoticed
  - How to detect attacks?
    - Let's make all CA actions publicly visible
- Centralized verifiable log server(s)
  - Desired properties similar as in blockchain
    - a public, verifiable, append-only log

Log Server

- History Tree with extension proofs



1. Client sends an object to be logged
2. Server responds with a *promise* and enqueues the object
3. Client needs to check that the promise is met (presence proof of the object)
4. Client needs to keep ensuring that the log is a) appending only, and b) non-equivocating

Certificate Transparency

- Intended for certificates but can be generalized to logging arbitrary artifacts
- Implemented, standardized https://tools.ietf.org/html/rfc6962, in production
- Pros: simpler, easier to manage, deploy, high-throughput, energy-friendly, …
- Cons: availability, censorship, trusted (in some scope), easier to misbehave, …

Reading

- Textbook 8.5
- inline references