Beyond Blockchains

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informal SYSTEMS

Distributed Algorithms // **EPFL Fall'20**

My Team

- Vienna
- Lausanne (Innovation Park)
- Berlin
- Toronto
- Belgrade
- Paris
- Zug



















informal SYSTEMS

Verifiable distributed **systems** *and* **organizations.**

We envision an open-source ecosystem of cooperatively owned and governed distributed organizations running on reliable distributed systems.

what we **do**

Systems (of Machines)

Informal designs, implements, and formally verifies distributed systems and protocols, including blockchain systems like Tendermint and Cosmos.

Organizations (of Humans)

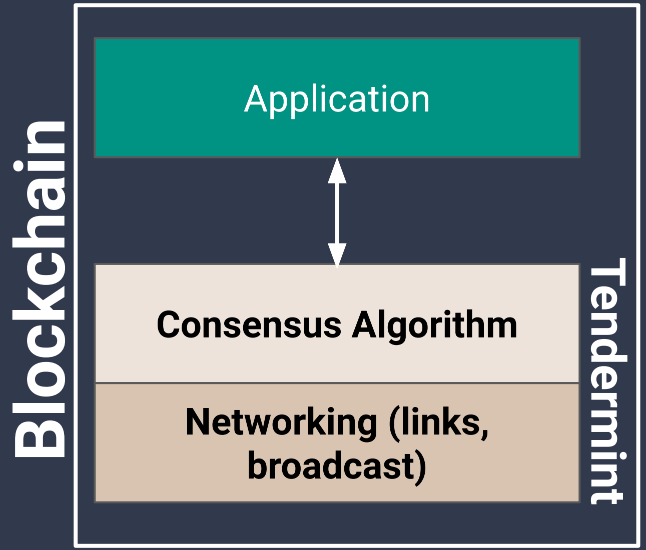
Informal develops tools to simplify the operation of organizations by leveraging open-source development, plaintext data, and distributed version control systems.

Roadmap

1. **Blockchains & BFT Consensus**
   Tendermint Core

2. **Beyond Blockchains**
   Inter-Blockchain Communication (IBC)

Consensus vs. Blockchain



(*aka* **Replicated State Machine**)

Consensus: *"processes propose values and have to agree on one among these values"*

Models:

- *Benign: crash-stop* processes (P, <>P algorithms)
- **Today: *Byzantine* processes**
  - e.g., buggy, malicious & adversarial, rational
  - Authenticated links (dig. sigs. assumption)

Blockchain

- Can mean different things
- Often, the whole stack is the "blockchain"
- Builds on a consensus core -> total order
  - Multiple instances of consensus
- Also known as: **Replicated State Machine**

Basic Tendermint BFT Consensus

Properties

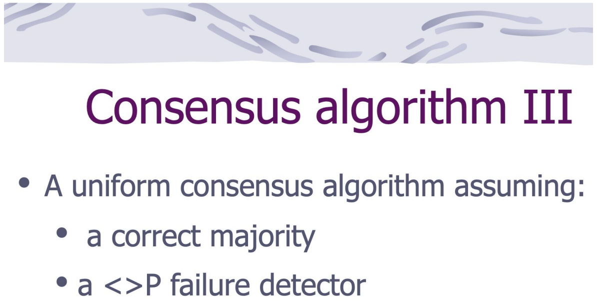
Validity Predicate-based Byzantine Consensus (Crain et al, 2017)

1. **Validity**: A decided value is *valid*, i.e., it satisfies a predicate *valid()*.
2. **Agreement**: No two correct processes decide differently.
3. **Termination**: All correct processes eventually decide on a value.
4. **Integrity:** No correct process decides more than once (w.r.t. a consensus instance).

http://arxiv.org/abs/1807.04938

Tendermint Algorithm Overview

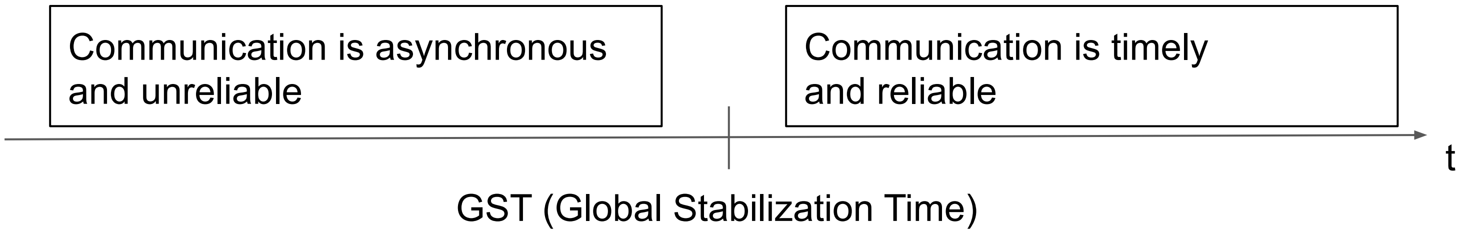
- Similar in spirit to Consensus algorithm III
- We assume a correct "majority":
  - $> \frac{2}{3}$ processes are correct (quorums)
  - $< \frac{1}{3}$ processes may be Byzantine
  - $N = 3f + 1$
- Processes take turns in the role of **proposer**
  - **Round-based model**
  - Each round has a predefined proposer
  - **Goal:** proposer locks everyone on a value



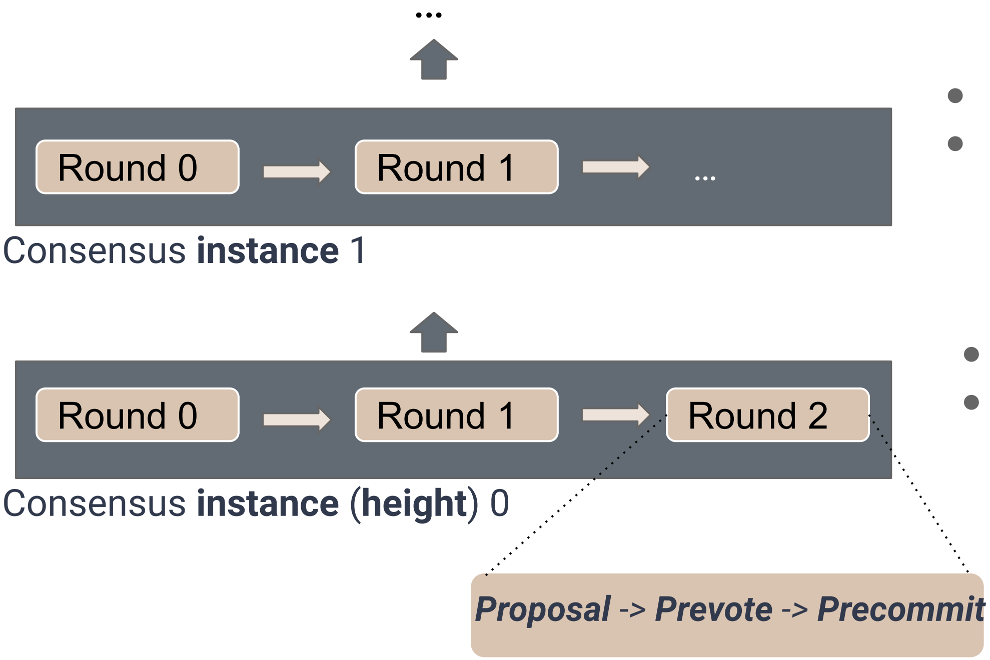
- $> \frac{1}{2}$ processes are correct
- $N = 2f + 1$
- Benign (non-Byzantine case)

System model

- Partially synchronous system model (DLS88)
  - Communication between correct processes is reliable and timely (bounded with Delta) after GST
- At most f processes can be faulty (Byzantine faults)
- Gossip communication:
  - If a correct process receives a message m at time t, all correct processes will receive m before max(t, GST) + Delta



Rounds



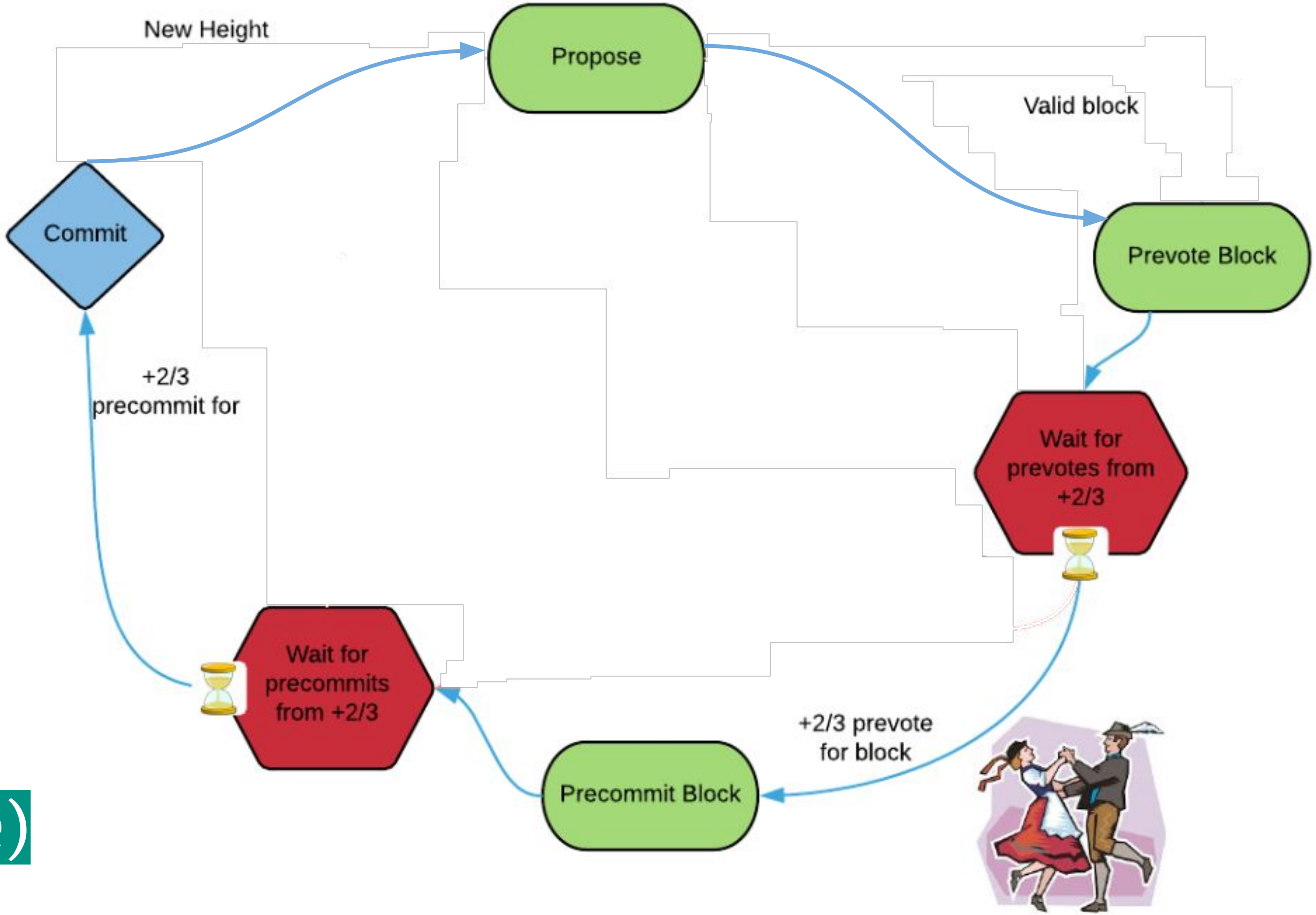
Round

- ***Proposal**, **Prevote**, **Precommit** -> decision*
- Has a predefined **proposer** process

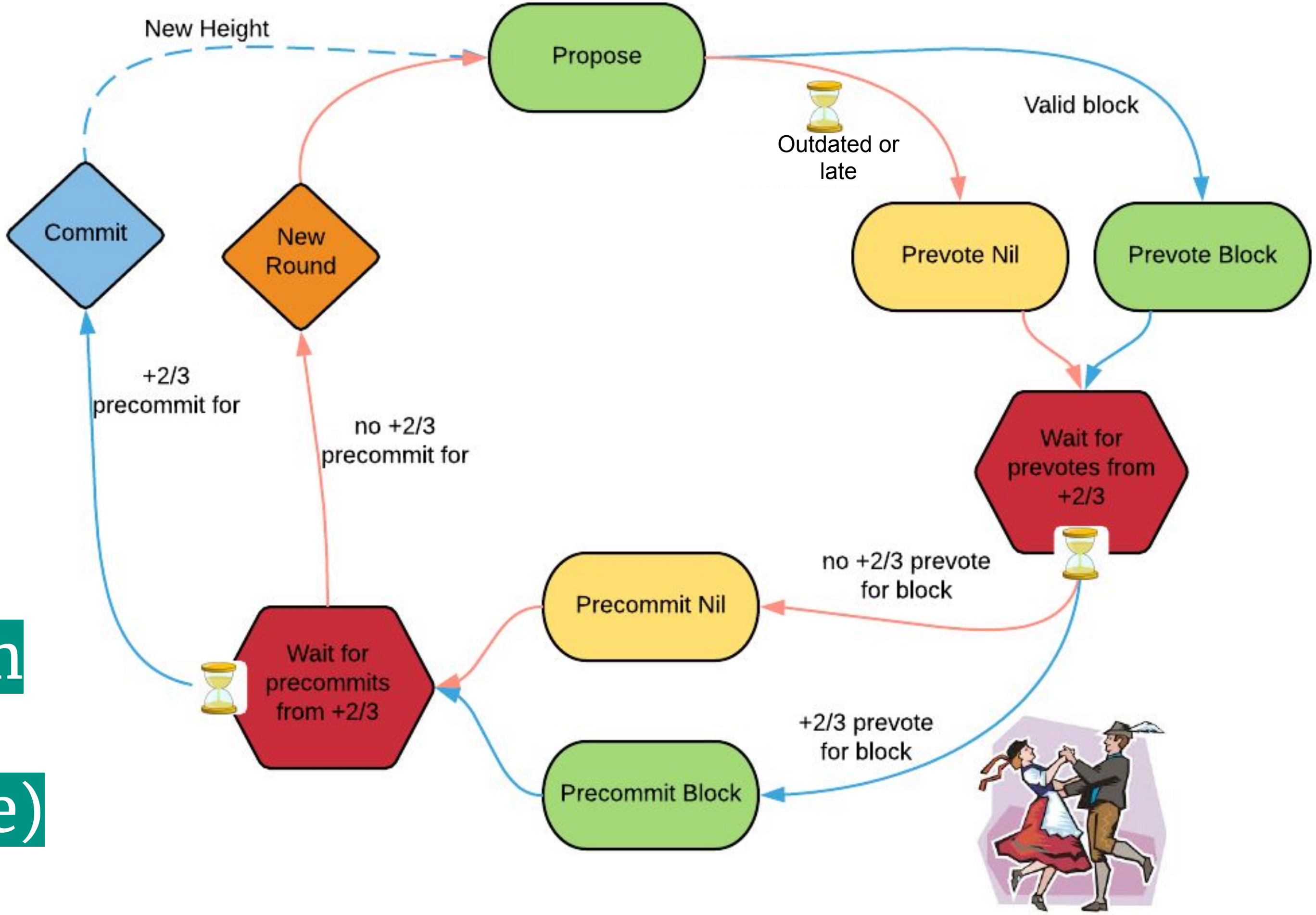
Locking

- **Locked values means PRECOMMIT was sent**
- Two variables keep track of the last locked value:
  - *lockedValue*
    - Retains the value itself; initially nil
  - *lockedRound,*
    - Initially -1

Algorithm Overview (good case)



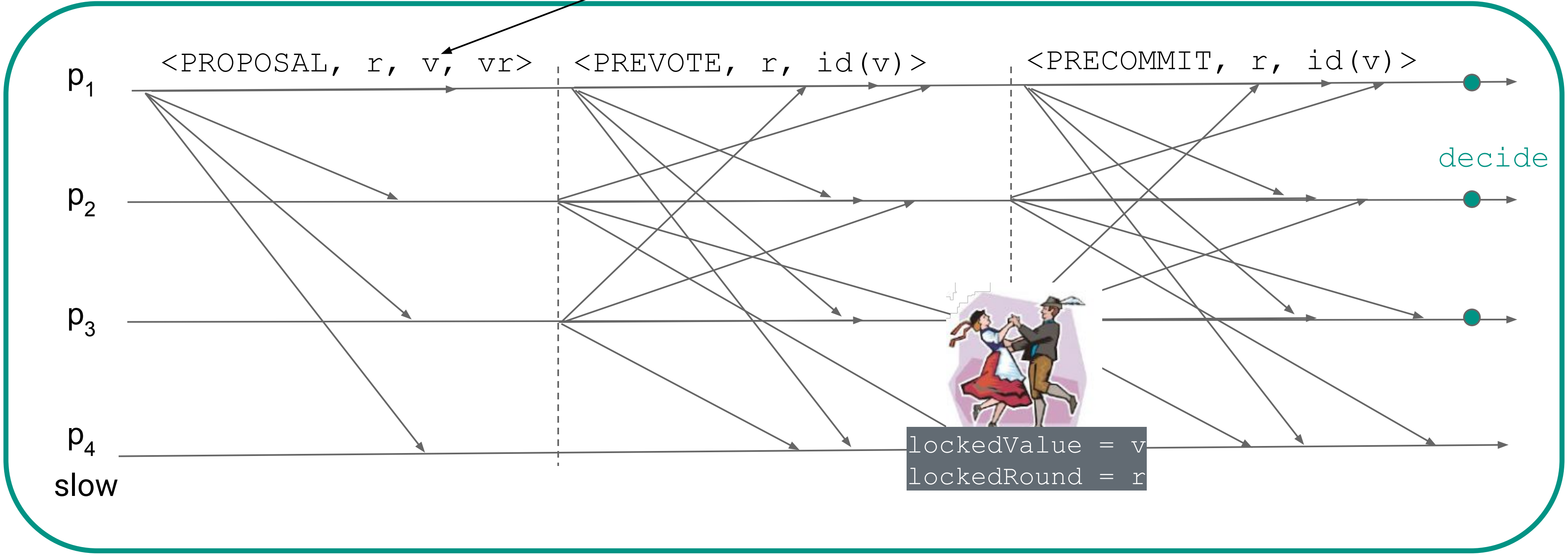
Algorithm Overview (complete)



Tendermint consensus algorithm

```
lockedValue = nil
lockedRound = -1
validValue = nil
validRound = -1
step = Propose
```

P1's round



Novelties

1. **Gossip layer** (instead of all-to-all links)
2. **Light client** (e.g., a mobile phone)
3. **Robustness** (Jepsen tests)
4. **ABCI** – interface b/t consensus and application layer

Open Challenges

1. **Rust** implementation
   (Focus on correctness: Model-based testing, Mocking)
2. **Formal verification**
   (TLA+, Stainless, Prusti, Isabelle)
3. **Inter-blockchain Communication – IBC**

Roadmap

1. **Blockchains & BFT Consensus**
   Tendermint Core

2. **Beyond Blockchains**
   Inter-Blockchain Communication (IBC)
   Quick Overview

IBC: Problem statement

?

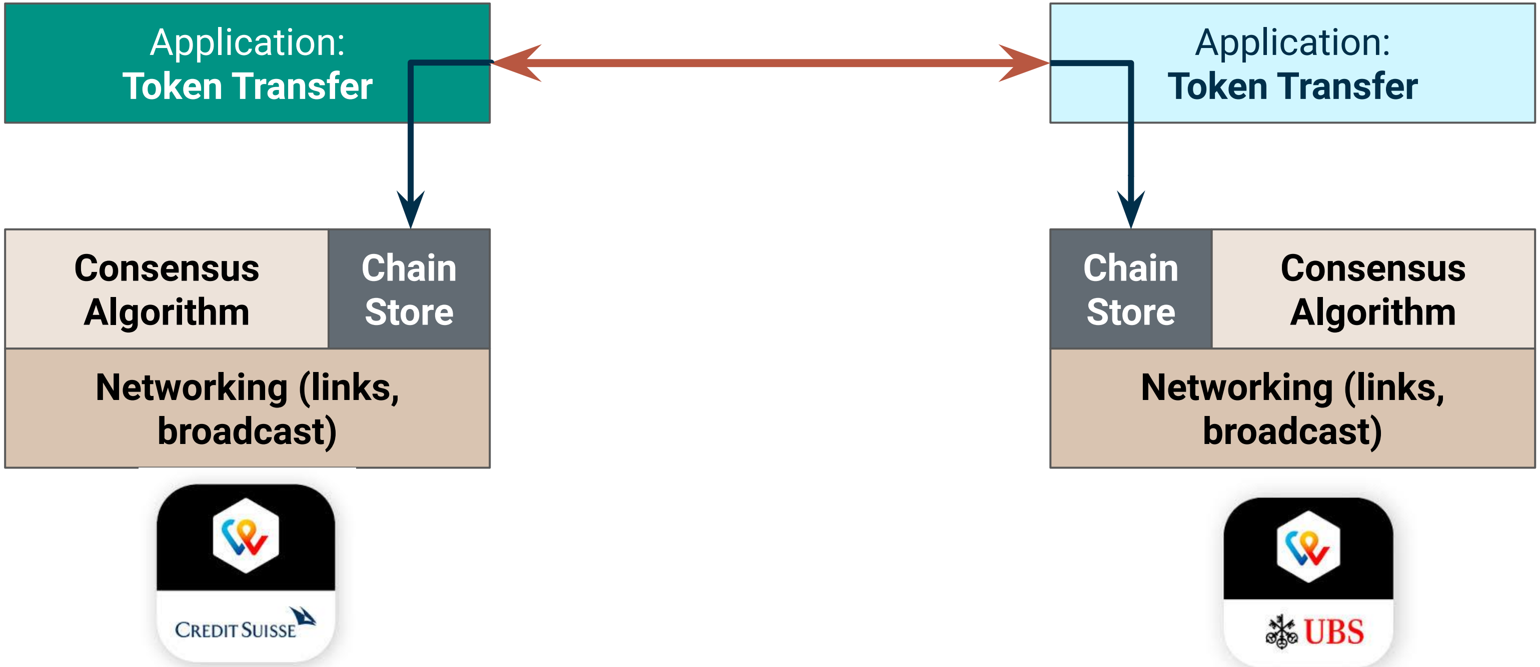
1. ***WHAT*** is communicated?
2. ***WHO*** communicates?
3. ***HOW*** to perform the communication?

CREDIT SUISSE	UBS
Application: **Token Transfer**	Application: **Token Transfer**
Consensus Algorithm	**Consensus Algorithm**
Networking (links, broadcast)	**Networking (links, broadcast)**

1. What is communicated?

(Australian Open Ledger)

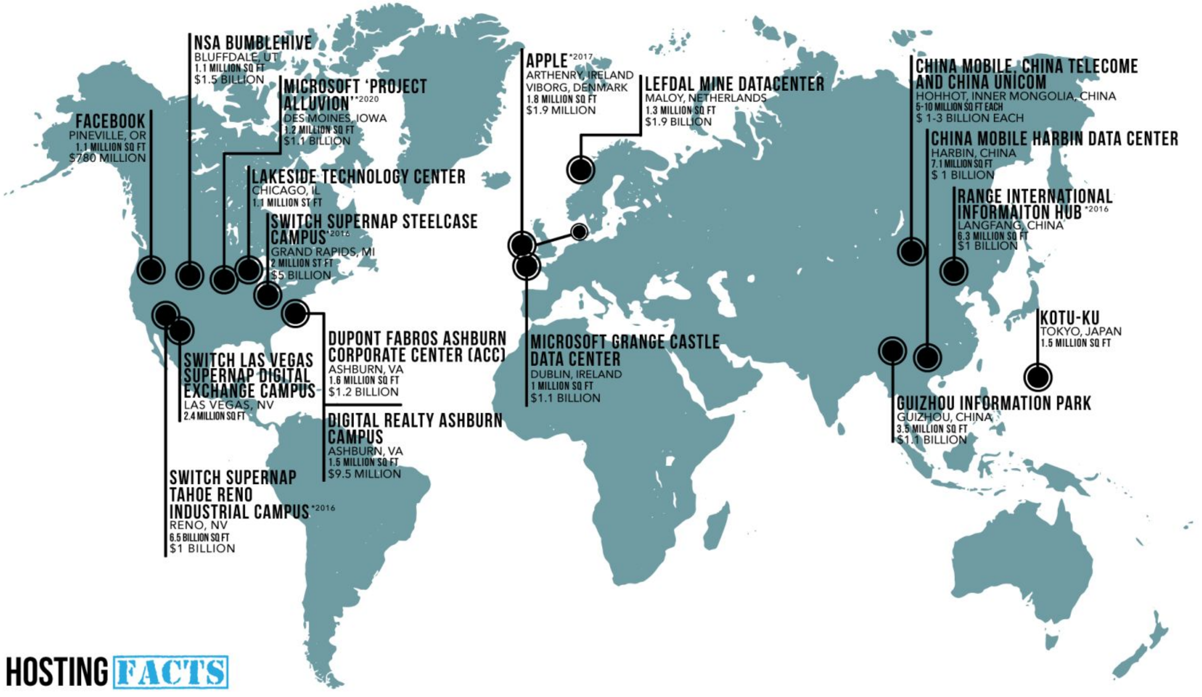
What is communicated?



2. Who communicates?

Application:
Token Transfer

Consensus Algorithm	**Chain Store**
Networking (links, broadcast)	



Recall that this is a replicated state machine

https://hostingfacts.com/where-website-live/

2. Who communicates?

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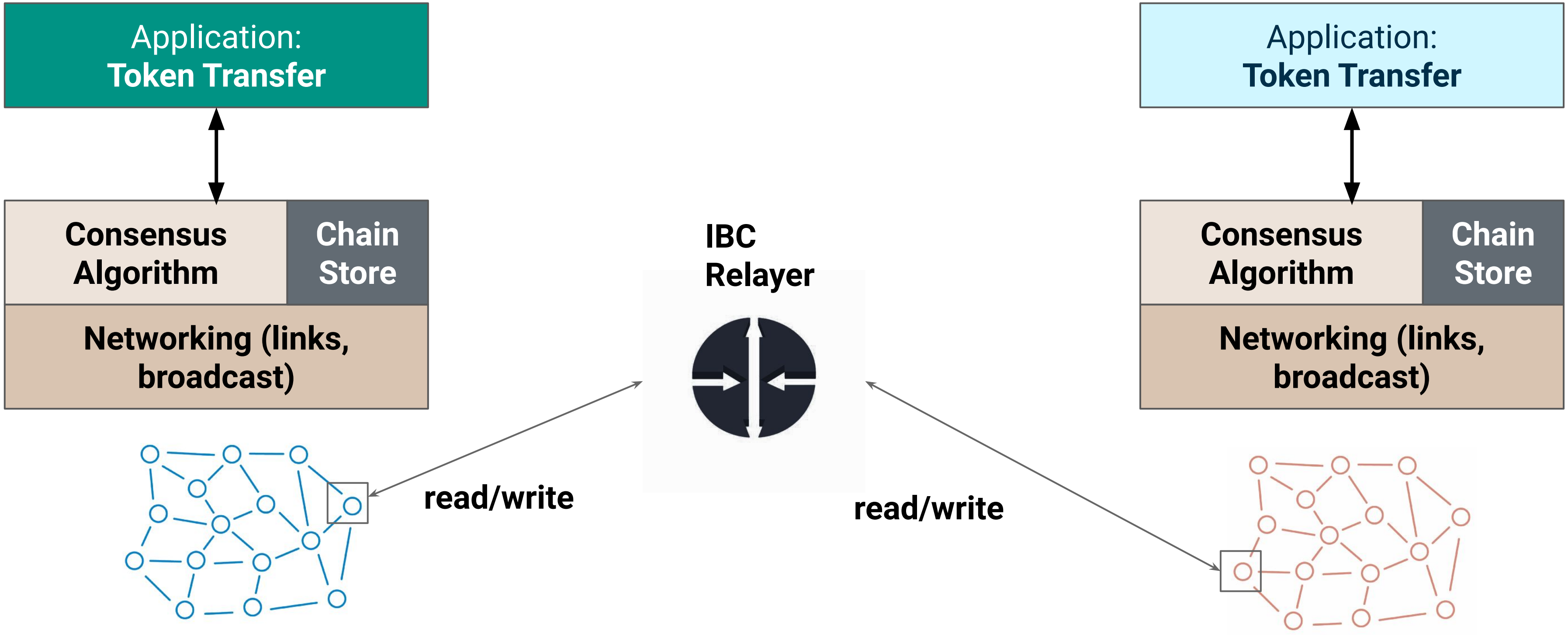
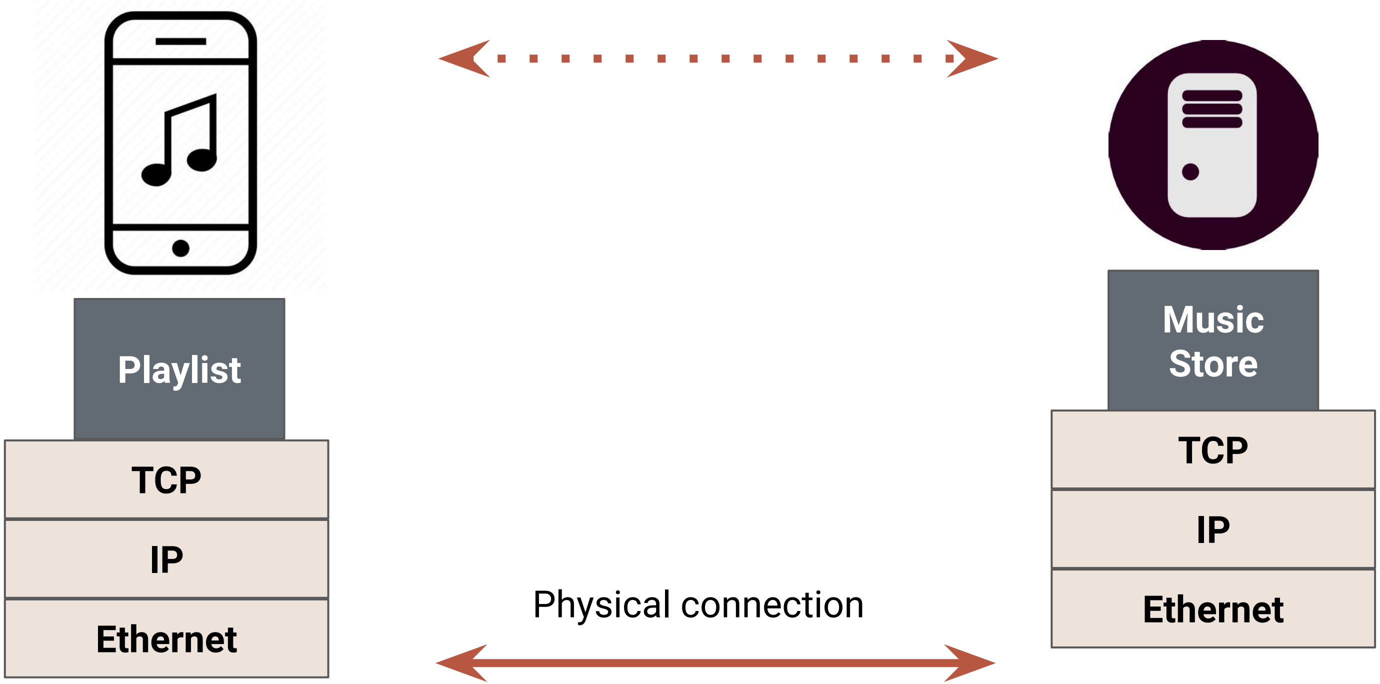
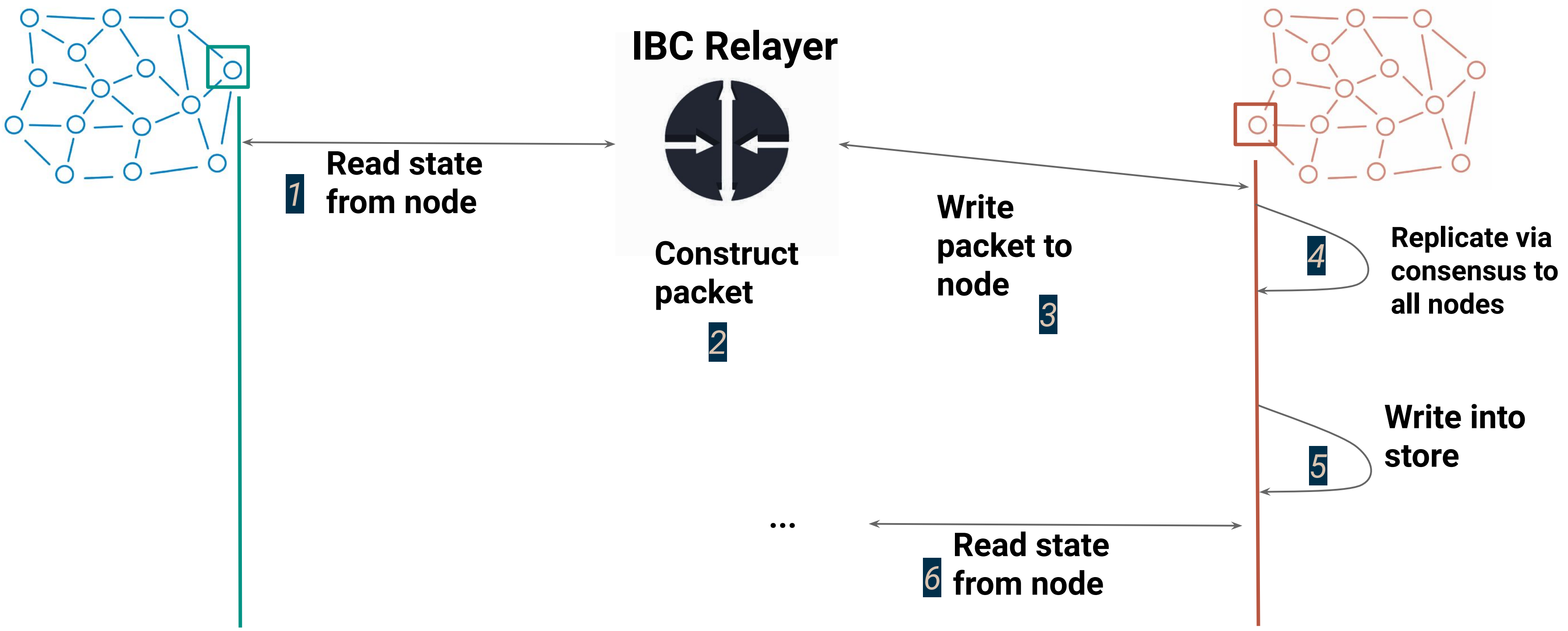


3. How?
Analogy with TCP/IP



3. How? Assuming no Byzantine faults



Student Projects

- **AT2** ~ implementation of consensus-less payments
- **IBC** ~ a “TCP/IP” for interconnecting ledgers
- **Rust** ~ Implementation of Tendermint modules (consensus, mempool, fast sync) using Prusti and Rust.
- **Stainless** ~ Implementation of Tendermint modules (consensus, mempool) using Stainless and Scala.
- **Facebook Libra** ~ comparative analysis of consensus algorithms.
- Mempool (performance analysis); adversarial engineering.

Complete list:
https://dcl.epfl.ch/site/education#collaborative_projects

Thank you!

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