Identity Based Consensus for Self-Governing Systems

Defence and Security Doctoral Symposium 2020

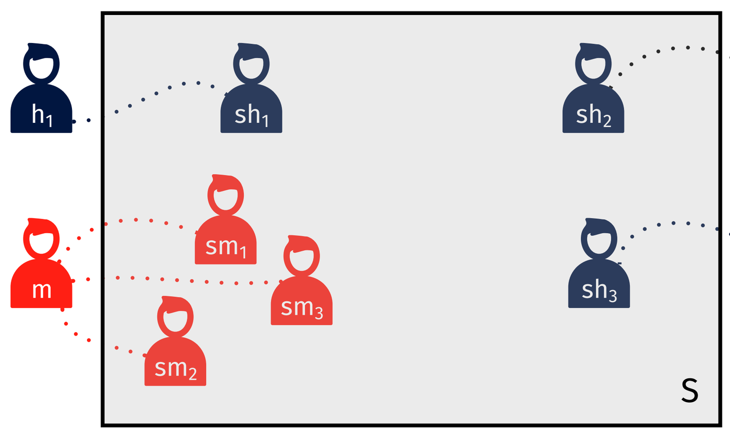
Data on a Blockchain is grouped in *blocks*, each of which contains multiple *transactions*. Blocks have to be resistant to replication over a 'byzantine' network. On those networks, writers can act maliciously in different ways:

- ☐ Attempt to store incorrect/invalid transactions on the Blockchain
- ☐ Use one input multiple times ('double spend')
- ☐ Censor the Blockchain by systematically withholding particular transactions

The selection of members responsible for data replication is a challenge in decentralised record-keeping systems.

'Byzantine' and 'Sybil' Actors

Lamport *et al.* (1982) show how a decentralised system (*S*) behaves when actors (*h, m*) spread incorrect or conflicting information, or withhold information. They describe how a system tolerates a limited fraction of these actors, often referred to as 'byzantine' actors. Douceur (2002) describes how a 'single faulty entity' (*m*), often referred to as a 'sybil' actor, can gain control of a redundant network by 'presenting multiple identities' ($sm_{1..3}$).

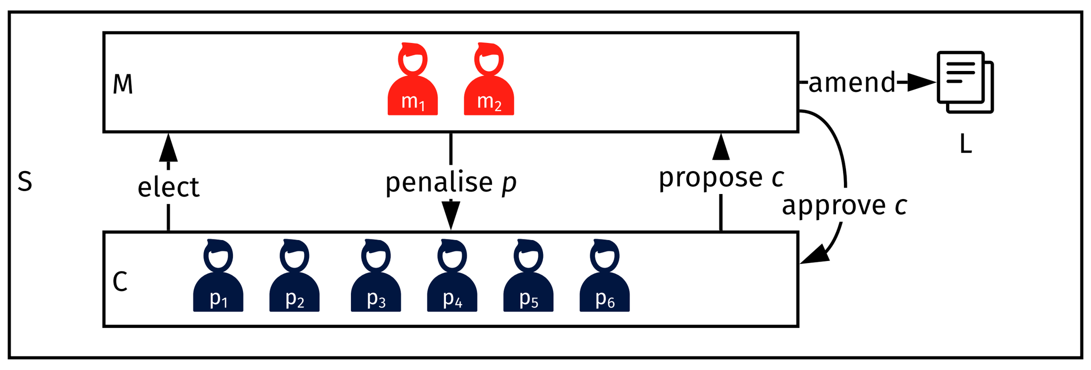


Membership Selection Strategies

- ☐ Proof-of-Work (Bitcoin; Nakamoto, 2008): Select a 'miner' to validate transactional data and to act as an ordering authority of transactions. Participants qualify as miners by expending computing resources.
- ☐ Proof-of-Stake (Conceptual Bitcoin forum post, later formalised by King et al., 2012): Being able to prove ownership of currency determines the difficulty of creating a new block, thus making participants who have held larger quantities of currency for longer more influential.
- ☐ Delegated Proof-of-Stake (Larimer, 2014): A variation to proof-of-stake, introducing a delegation scheme, in which 'shareholders may delegate their voting power to a representative'.
- ☐ Proof-of-Authority: Membership seclection 'by policy', i.e. through a pre-defined list of privileged actors (i.e. Schwartz et al., 2014, Hearn and Brown, 2019, Libra Association, 2020).

Membership Selection and Political Representation

A decentralised system *S*, comprised of regular participants ($p_{1..n}$) and participants with additional duties ('miners' $m_{1..n}$) who are appointed or elected to fulfil these duties. Participants propose candidate records, *c*, to be included in the entirety of public records. Miners decide, based on a legislative framework, *L*, whether a candidate record is permissible.



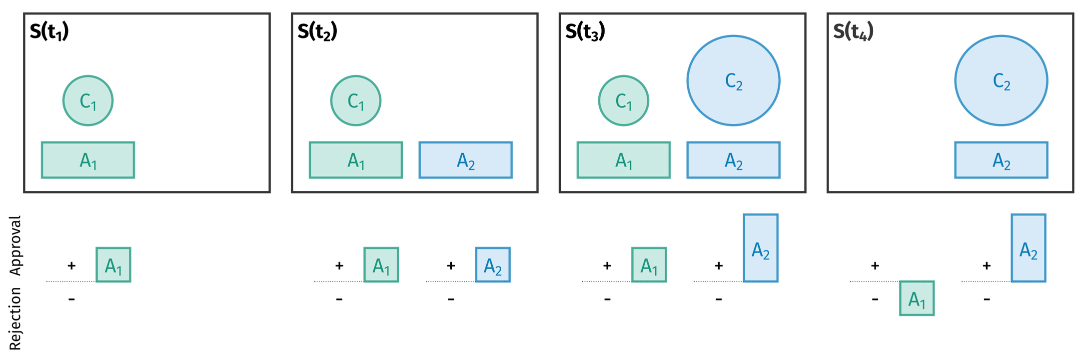
'One Person/One Vote' in Delegated Proof-of-Stake

Given that delegated 'Proof-of-Stake' effectively already implements a 'One Share/One Vote' paradigm, it can be easily restructured to support a 'One Person/One Vote' paradigm by introducing additional constraints to limit the number of shares and how they can circulate:

- ☐ Delegated proof-of-stake is performed using personhood tokens as stake.
- ☐ Every person with voting rights on the network receives a fixed number of personhood tokens once they enter the network.
- ☐ There is no other source of personhood tokens.
- ☐ Personhood tokens cannot be traded and are not given out as a reward.

Constituencies Evolve Over Time

Through messages of approval and rejection, authorities ($A_{1..2}$) are voted onto the system and removed from it. Authorities issue personhood tokens to their constituents ($C_{1..2}$).



Arithmetic Properties of Personhood Tokens

Members can endorse or discourage gatekeeping authorities via a broadcast message. These actions directly impact the reputation of the authority and thus the personhood score the authority can grant. Per authority $A_{1..n}$ a vector of endorsement scores $\vec{e}_{A_{1..n}}$ and a vector of discouragement scores $\vec{d}_{A_{1..n}}$ are kept publicly. Participants add to either of the vectors via a message they broadcast. This means that the influence a participant can exert on the reputation of another authority is proportional to their reputation.

Counteracting Sybil Attacks

A single malevolent authority can flood the network with sybil actors, who can disrupt any record-keeping and record-evolving activity on the network, permanently. We therefore need to implement countermeasures:

- ☐ *Temporal normalisation* can mitigate sybil attacks that go along with a sudden influx of bogus identities.
- ☐ An overall *constituency size ceiling* that limits the total number of identities, created by one authority, is introduced.
- ☐ A *quantitative safeguard enforcing diversity* is introduced. This gives reputational signals from diverse sources more weight.
- ☐ A *lower bound for personhood scores* is introduced.

Future Work

The protocol proposed lacks formalisation, intuition suggests that the concept of evolving constituencies, backed by identity authorities, that can be added to and removed from a network dynamically, has merit.

Future work must focus on formalising the protocol to evaluate its robustness.
A formal approach will ultimately prove or disprove its advantages over existing membership selection protocols, in the context of attacks.

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