CS492 Building Web3 & Blockchain Applications

Lecture 13: Centralized Decentralization
Simple Economics of DPoS Governance

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Outline

1. DPoS (Delegated Proof-of-Stake)
2. Centralized Decentralization
   - Tron Foundation's Steemit acquisition
   - Theoretical foundation for DPoS voting
   - DPoS Governance Attack Game
   - Does VPA (votes per account) matter?

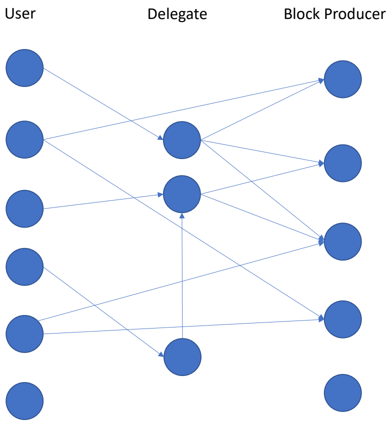
DPoS (Delegated Proof-of-Stake)

DPoS (Delegated Proof-of-Stake)

Disclaimer: This talk is not about which consensus mechanism is better.

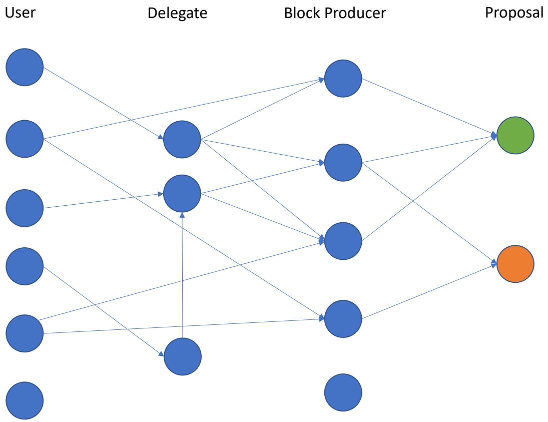
- Invented by Daniel Larimer (2017), and first applied to BitShares.
- Adopted by EOS, Steem/Hive, Tron, Lisk, Ark, etc.
- Block producers (BPs, also called witnesses) verify the transactions, produce a new block, and then get a reward.
- BPs are elected through votes by users (accounts), which is weighted by their stakes of the token.
- Users can directly vote, or indirectly vote via delegates (proxy).

DPoS: BP election



- A user is an account.
- Essentially, delegates and BPs are also users.
- A delegate is a user who receives delegation.
- A BP is a user who receives enough number of votes to be a BP.

DPoS: fork election



- For each proposal (e.g., fork), each BP approves or disapproves it.
- The proposal is approved if supermajority of BPs approves it.

Examples of DPoS blockchains

Table: **DPoS blockchains**

	BP (n)	BP for fork (k)	VPA (v)
Steem	20	17	30
Tron	27	19	1
EOS	21	15	30
Lisk	101	68	101

- BP (n): number of BPs
- BP for fork (k): number of BPs needed for a fork (or any on-chain decision)
- VPA (v): number of votes allowed per account

- Based on stake-weighted votes, n topmost users are elected as BPs.
- Any on-chain proposal (e.g., fork) is approved if at least k out of n BPs agree.
- Previously, VPA had been chosen without any theoretical foundation.

Advantages of DPoS

- energy efficient
  - BPs are trusted, so no additional work is needed, as opposed to the *Proof-of-Work* (PoW) consensus.
- faster and more scalable
- more democratic?
  - similarity between the blockchain election and the real-world election.

Disadvantages of DPoS

- centralization
  - Some poeple say “DPoS is largely considered to be the most decentralized approach to consensus mechanism.” But in reality?
  - One reason: VPA had been chosen without any theoretical foundation.
    - e.g., in a Lisk proposal,

Forum member “Consensus” suggested lowering this number to 20. This would limit the ability to share votes in a coalition and would improve decentralization of the network. On the other hand, “cc001” would prefer to increase it to 131.

- vote buying
- less secure (in the sense that the number of BPs are normally small)

Centralized Decentralization

Decentralization

- *Decentralization* is often claimed as one of the virtues of blockchain.
- One important aspect of decentralization is *governance*.
- That is, a blockchain should not be controlled by a centralized entity.
- Thus, not using founders' stake for voting is normally expected.

Tron Foundation's Steemit acquisition

Disclaimer: This talk is not about who's right and who's wrong.

- The Steem blockchain that has the main DApp, Steemit (`https://steemit.com`), a social media platform.
- In February 2020, the Tron Foundation acquired Steemit Inc that mainly developed and maintained the Steem blockchain.
- Previously, Steemit Inc promised not to use their stake for voting.
- However, the Tron Foundation did not mention such an agreement during the acquisition.
- Most top incumbent BPs covertly implemented and executed a reversible fork (ver 0.22.2) that prohibits a pile of tokens (previously owned by Steemit Inc) from voting and transferring, expecting that they could get a similar agreement from the Tron Foundation.

Tit-for-Tat Governance Attacks

- After fork 0.22.2, the Tron founder promised (on a blog post) not to use his vote, but after a few days, he created 20 ($n = 20$ for Steem) new accounts and voted for them using his stake and changed all of the top 20 BPs by his single account.
- To help the Tron Foundation, some cryptocurrency exchanges also participated in the vote via delegation even using *custodial tokens* (i.e., customers' tokens), but they retracted their votes later and apologized.
- The new top 20 BPs executed a tit-for-tat fork that seized the tokens of some previous top BPs.

There's no better way to put this: One man's "hack" is another's "legitimate exercise of power by a blockchain's duly elected leaders."[1]

[1] See `https://www.coindesk.com/steem-community-mobilizes-popular-vote-in-battle-with-justin-sun`, link to "Steem Community Mobilizes Popular Vote in Battle With Justin Sun."

DPoS as an indirect election

In terms of voting theory, DPoS is an *indirect* election.

- (BP election) first election uses a multiwinner voting rule based on approval preferences with a cap on ballot size
- (fork election) second election uses a supermajority voting rule.

An election based on weighted approval preferences is $E = (N, M, A, \overline{b}, w)$

- $N = \{1, 2, ..., \overline{n}\}$ is the set of *voters*
- $M = \{c_1, c_2, ..., c_{\overline{m}}\}$ is the set of *candidates*
- A is an *approval-based voting profile* with a *cap of ballot size* $\overline{b}$, i.e., a function $A : M \to 2^M$ such that $|A(i)| \leq \overline{b}$
- w is a *weight profile*, i.e., a function $w : N \to \mathbb{R}_+ \equiv \{x \in \mathbb{R} : x \geq 0\}$.

That is, $A(i)$ is the set of candidates that voter i finds acceptable, and $w(i)$ is the weight of voter i.

A multiwinner election rule based on weighted approval preferences is a function R such that

- $R(E, m) \in S_m(M) \equiv \{S \subseteq M : |S| = m\}$ is a size-m subset of candidates that receives the highest sum of the scores from voters
- the score that a candidate c gets from a voter i is $\mathbb{1}(c \in A(i)) \cdot w(i)$.

DPoS elections: BP election and fork election

- n: number of BPs
- k: number of BPs for fork
- v: VPA (votes allowed per account)

- Accounts vote for up to v *block producers* (BP) among accounts themselves.
- A vote is weighted by the amount of tokens that each account holds.
- There is no discount on voting for multiple candidates.
- n elected (i.e., n topmost in terms of weighted votes) BPs vote for a *fork* decision (i.e., a change of the rule of the blockchain) by a supermajority voting rule such that the decision is approved if at least k out of n BPs agree.

DPoS Governance Attack Game

We consider the DPoS Governance Attack Game, or simply the Governance Game.

1. In the first stage, Defender (with fixed δ tokens) votes for BPs.
2. In the second stage, Attacker acquires α tokens at a unit cost p and votes for BPs, where $p\alpha < 1$.

- Based on the rankings of the total weighted vote count, n BPs are elected (with a tie-breaking in favor of Attacker for simplicity).
- The payoffs of Attacker and Defender, denoted by π_A and π_D, are defined as follows:

$$\pi_A = \mathbb{1}(|BP_A| \geq k) - p\alpha$$
$$\pi_D = \mathbb{1}(|BP_A| < k) + p\alpha$$

Even distribution

Proposition (Even distribution)

In the governance game,

1. Attacker's voting for k candidates with equal shares, and
2. Defender's voting for $n-k+1$ candidates with equal shares and Attacker's voting for k candidates with equal shares is an equilibrium path of play in a subgame-perfect Nash equilibrium, which is unique when $v \leq \min\{k, n-k+1\}$.

Does VPA matter?

Whether VPA affects the minimum stake that Attacker should acquire for takeover (i.e., whether α^* is independent of v), may not still be clear.
It may be nontrivial because

- intuitively, decreasing v may decrease the "power" of one account
- but this applies to all accounts

Does VPA matter?

Example

Suppose $n = 3$ and $k = 2$, i.e., if at least 2 out of 3 BPs agree, they can take over the blockchain, and Defender has $\delta = 100$ tokens. We consider three values of VPA v to find $\alpha^*(n, k, v, \delta)$.
(i) $v = 3$: Defender should vote for all three (or at least 2) candidates with equal shares of 100. Since Attacker can vote for up to 3 candidates, in order to have 2 BPs elected, Attacker only needs 100 tokens, i.e., $\alpha^*(3, 2, 3, 100) = 100$.
(ii) $v = 2$: Defender should vote for 2 candidates with equal shares of 100. Since Attacker can vote for up to 2 candidates, in order to have 2 BPs elected, Attacker still only needs 100 tokens for the takeover, i.e., $\alpha^*(3, 2, 2, 100) = 100$.
(iii) $v = 1$: Defender should vote for 2 candidates with equal shares of 50, i.e., by dividing 100 tokens into 2 accounts. Since Attacker can also vote for only one candidate per account, in order to have 2 BPs elected, $\alpha^*(3, 2, 1, 100) = 2 \times 50 = 100$.
Moreover, one can easily check that $\alpha^*(3, 2, v, \delta) = \delta$ for all $v \geq 1$.

Does VPA matter?

- $\alpha^*(n, k, v, \delta)$ is independent of v, in general?
- Not really.
- Interestingly, α^* can be either increasing or decreasing in v, depending on the combination of n and k.
- If the majority of BPs is needed for a fork, a smaller VPA requires a larger stake for takeover, but only up to a certain point.
  - That is, a so-called "one vote per account" rule may not be needed.

TRC (takeover resistance coefficient)

The takeover resistance coefficient (TRC), denoted by $\tau(n,k,v)$, is the minimum ratio of Attacker's stake to Defender's stake for takeover.

Theorem (TRC)

In the governance game, the minimum stake required for Attacker to take over the governance is,

$$\alpha^*(n,k,v,\delta) = \tau(n,k,v)\cdot\delta, \tag{1}$$

where

$$\tau(n,k,v) = \frac{\max\{k,v\}}{\max\{n-k+1,v\}}. \tag{2}$$

Monotonicity of TRC

Corollary

The takeover resistance coefficient $\tau(n,k,v)$ is monotone in v, and the monotonicity depends on the combination of n and k as follows:

1. *If $k > \frac{n+1}{2}$, then $\tau(n,k,v)$ is decreasing in v, and*

$$\tau(n,k,v) = \begin{cases} \frac{k}{n-k+1} & v \le n-k+1, \\ \frac{k}{v} & n-k+1 \le v \le k, \\ 1 & v \ge k. \end{cases}$$

2. *If $k = \frac{n+1}{2}$, then $\tau(n,k,v) = 1$.*
3. *If $k < \frac{n+1}{2}$, then $\tau(n,k,v)$ is increasing in v, and*

$$\tau(n,k,v) = \begin{cases} \frac{k}{n-k+1} & v \le k, \\ \frac{v}{n-k+1} & k \le v \le n-k+1, \\ 1 & v \ge n-k+1. \end{cases}$$

TRC of DPoS blockchains

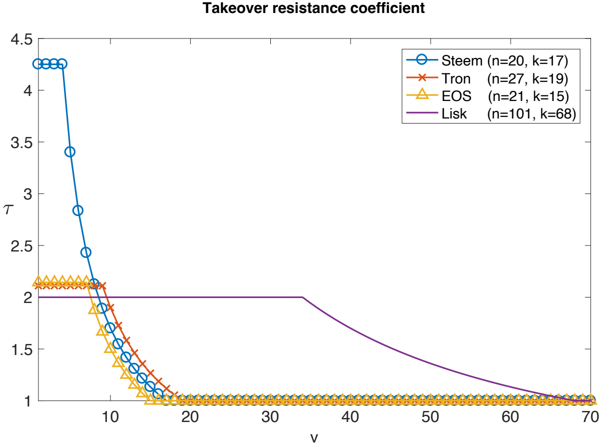


Figure: The takeover resistance coefficient (TRC), denoted by $\tau(n, k, v)$, is the minimum ratio of Attacker's stake to Defender's stake for takeover. The figure shows the TRCs with their actual parameters of n (number of BPs) and k (number of BPs for fork), varying VPA v.

Policy Implication

Table: **DPoS blockchains**

	BP (n)	BP for fork (k)	VPA (v)	**optimal VPA** (v^*)
Steem	20	17	30	4
Tron	27	19	1	9
EOS	21	15	30	7
Lisk	101	68	101	34

- BP (n): number of BPs
- BP for fork (k): number of BPs needed for a fork (or any on-chain decision)
- VPA (v): number of votes allowed per account
- optimal VPA (v^*): the maximum VPA that has the maximum TRC

- v^* minimizes the takeover risk, while maximizing voting flexiblity.
- "one vote per account" is not needed (unnecessary account creations may occur.)

Maximum TRC depending on k

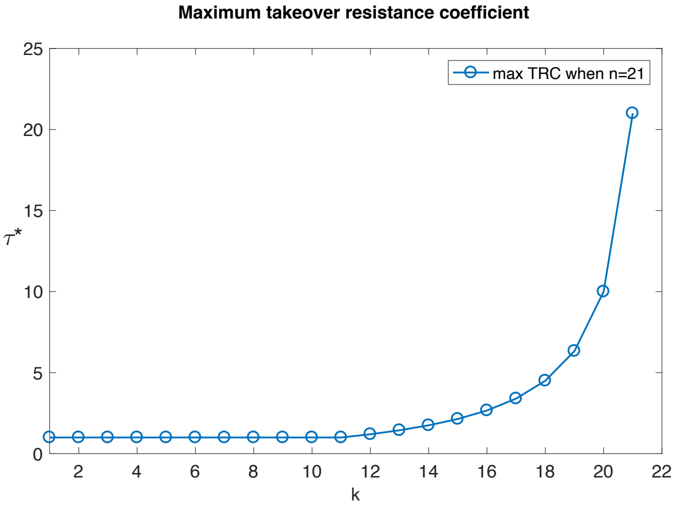


Figure: **Maximum takeover resistance coefficient.** The figure shows the maximum takeover resistance coefficient $\tau^* = \tau^*(n, k) = k/(n-k+1)$. For a fixed n (number of BPs, $n = 21$ in this figure), the marginal increase of TRC τ^* increases as k (number of BPs for fork) increases.

Conclusion

- DPoS blockchains are prone to centralization.
- The "optimal" VPA can be chosen with a microeconomic foundation.
  - minimizes the takeover risk, while maximizing voting flexiblity.
- "One vote per account" is not needed.
  - less flexible, so unnecessary account creations may occur.
- Which (n, k) (or even v) should be used may ultimately depend on many factors including technical limitations and philosophies of the blockchain.