Liquid Democracy for Rating Systems

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Abstract

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A project to enhance rating systems with liquid democracy features, focusing on implementing and analyzing various delegation mechanisms within the Vodle decision making system.

Contents

Chapter 1

Introduction

1.1 Vodle

Vodle is an online platform where users participate in polls to vote on subjects through user created polls. Each poll contains a set of options, and users provide ratings for each option from 0 to 100, where a larger number means that they prefer the option more, using a slider (below). When the poll ends, the ratings submitted by voters are then aggregated and a result is calculated.

INSERT IMAGE OF SLIDERS

1.2 Liquid Democracy

Liquid democracy is a decision-making system that combines elements of both direct and representative democracy that offers a voter more flexibility than traditional voting models.

In direct democracy, every participant votes individually on each issue. This model offers the most individual input but can become impractical for large-scale decision-making due to the high level of participation required from each individual. As Ford (2002) states, direct democracy assumes that all individuals are both willing and

able to engage meaningfully with every decision, which is often not the case in large groups due to the variance in both the interest and knowledge of voters. The cognitive demand of staying informed on all matters, combined with the time commitment necessary for constant participation, makes direct democracy unmanageable at scale.

In a representative democracy, citizens elect officials to deliberate and decide on legislation and policies on their behalf. While this system is more scalable than direct democracy, it introduces certain limitations:

- vote based on party lines, personal convictions, or special interests rather than strictly reflecting constituent preferences
- time btwn elections - unresponsive to rapidly evolving public opinion

Liquid democracy addresses these limitations by allowing voters to either cast their votes directly or delegate them to someone that they trust or to abstain from voting entirely (Blum and Zuber, 2016). **Talk about lowering bar for participation**These delegations can be updated or revoked at any time, giving users control over how their vote is used. Delegations are also transitive, meaning a vote can be passed through multiple levels of trusted participants. For example, if Alice delegates to Bob who in turn delegates to Charlie, Charlie's vote would then represent three individuals (Alice, Bob and Charlie).

1.3 Motivation

need to add

1.4 Project Goal

The project's main goal is to integrate liquid democracy into the vodle platform.

Key features include ranked delegation and weighted voting ...

1.5 Project Outline

This report is structured to clearly illustrate the project's progression and outcomes:

Chapter 2 presents background research, including existing variations of liquid democracy, real-world implementations, and relevant aspects of vodle's design and system architecture.

Chapter 3 defines the system specifications and outlines the project's objectives in detail.

Chapter 4 discusses the methodology used, including the iterative approach, planning, and risk assessment strategies.

Chapter 5 describes the design and implementation process of integrating liquid democracy into vodle.

Chapter 6 evaluates the implemented system through unit testing, user feedback, and commentary from the project customer.

Chapter 7 covers project management aspects such as legal and ethical considerations, a reflection on risk management, and personal reflections on the development process.

Chapter 8 concludes the report and discusses potential directions for future work.

Chapter 2

Research

This chapter provides background context for the development of a liquid democracy system within Vodle. It builds on the concepts introduced earlier, focusing on more detailed research into known limitations of liquid democracy and potential solutions proposed in academic literature. Additionally, the technical foundations and design philosophy of Vodle as a platform are explored.

Throughout this chapter, several diagrams are used to illustrate how votes move through a liquid democracy system. To clarify the roles of different voters, the following symbols are used:

- **Circles** indicate voters who delegate their vote to someone else.
- **Squares** represent voters who cast their own vote and do not delegate.
- **Triangles** show voters who abstain - neither voting directly nor delegating to others.

2.1 Liquid Democracy

Liquid democracy, or delegative voting, allows voters to either cast a vote directly, delegate it to someone they trust, or abstain (Blum and Zuber, 2016). A key feature

is that delegations are transitive - a chain of users that all delegate to each other sequentially ends with a single final voter who casts their vote on behalf of all those in the chain.

Whilst the transitivity property enables concentration of voting power with trusted individuals, it can also lead to unintended consequences. Chains of delegations may result in cycles that prevent votes from being cast, or allow certain individuals to accumulate an excessive share of influence, creating so-called super-voters. These problems amongst others motivate the need for alternative delegation mechanisms, as discussed in the following subsections.

2.1.1 Issues with Liquid Democracy

Delegation cycles

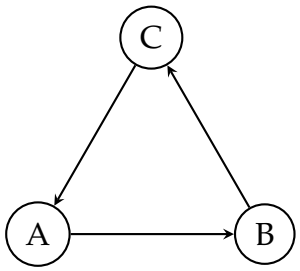

Figure 2.1: Delegation cycle: A delegates to B, B to C, and C back to A.

Delegation cycles occur when a vote is delegated in such a way that it ends up forming a loop (Brill et al., 2022), preventing the vote from reaching a final, resolvable destination. For example, if Alice delegates her vote to Bob, Bob delegates to Charlie, and Charlie delegates back to Alice, the votes become trapped in a cycle (seen above) and can be treated as a loss of representation (Christoff and Grossi, 2017).

This issue is particularly problematic because it can nullify votes without the affected users ever realising. In systems where cycles are not explicitly detected and handled, these votes are discarded silently, potentially changing the final outcome of the votes.

Delegation cycles are increasingly likely to emerge in dynamic voting systems, where delegations can be added, removed, or modified at any point in time. Delegations

that initially did not form part of a cycle may later contribute to one as other voters add a new delegation or alter an existing one.

Paragraph on how size of the system affects the possibility of cycles?

Abstentions

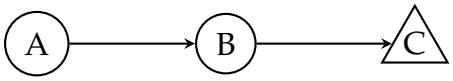

Figure 2.2: Delegation chain ending in abstention: A delegates to B, B to C. C abstains, causing the votes of A and B to be lost.

In liquid democracy, abstention is where a voter neither casts a vote nor delegates their vote to another user (Brill et al., 2022). This includes both deliberate abstention, where a voter knowingly chooses not to participate, and passive abstention, where a voter may be unaware of an ongoing poll or are unable to engage with it.

Abstentions are especially impactful when they occur at the end of a larger delegation chain, as all votes passed along the chain to that voter are effectively lost (Brill et al., 2022). The voters whose decisions were passed along the chain may also be unaware that their votes have been nullified, worsening the effect of the abstention.

Super-voters

In liquid democracy, a super-voter is an individual who receives a large number of delegated votes, therefore gaining disproportionate influence over decisions (Kling et al., 2015). While this behaviour may reflect voters' genuine preferences, it can lead to a concentration of power that goes against the intended egalitarianism and democratic ideals of liquid democracy.

Although liquid democracy allows users to alter their delegation at any time, in practice, many voters may not actively monitor or even know how their vote is being used. This can allow a small number of super-voters to dominate outcomes, especially in systems with large delegation chains.

Real-world examples of this phenomenon have been documented. In the German Pirate Party's use of LiquidFeedback, certain users received so many delegations that their votes were like "decrees" (Sven Becker, 2012; Kling et al., 2015) even though they were not elected officials. Kling et al. (2015) noted that the super-voters generally voted in line with the majority, therefore not drastically affecting the outcome of the votes and contributed to the stability of the system. However, the potential for individuals to single-handedly influence the results remained a concern.

This pattern is not limited to traditional online voting platforms. It can also be seen within decentralised autonomous organisations (DAOs) - blockchain-based entities where decisions are made collectively by token holders without central leadership. These organisations use token-based voting to decide on critical issues like protocol upgrades and funding allocations. Hall and Miyazaki (2024) studied 18 decentralised autonomous organisations (DAOs) and found that voting power was often concentrated in the hands of a few delegates. While most did not control a large share of all available tokens, low participation meant that their share of actual votes cast was disproportionately high. In several DAOs, the top five delegates accounted for over 50% of all votes cast, and in the DAO Gitcoin, this figure exceeded 90%.

2.1.2 Variations of Liquid Democracy

The challenges discussed in the previous section, such as delegation cycles, vote loss due to abstentions, and the emergence of super-voters, highlight inherent vulnerabilities in the standard liquid democracy model. To mitigate these issues, a range of enhancements have been proposed that modify how delegations are expressed, resolved, or overridden. These include techniques that allow voters to specify multiple delegates or distribute their vote to multiple casting voters. Each approach introduces different trade-offs and requires algorithmic support to ensure sound and interpretable outcomes.

The following subsections present several such variations, along with the algorithms

that support them.

Ranked Delegation

One way to improve the reliability of liquid democracy is through ranked delegation. Instead of selecting a single delegate, voters can provide an ordered list of trusted individuals. If a higher-ranked delegate cannot cast the vote, due to abstaining, becoming part of a cycle, or being otherwise unavailable, the system attempts to use the next delegate in the list. This structure increases the chance that votes are not lost while preserving the core interaction model for voters (Brill et al., 2022).

To implement ranked delegation, the system must determine which delegation path to follow when multiple options are available. This is achieved using a delegation rule - a function that takes as input a ranked delegation instance and a delegative voter and outputs a path from that voter to a casting voter (a voter that does not delegate or abstain, casting their own vote) (Brill et al., 2022).

Several rules have been proposed in the literature, each with distinct properties and trade-offs.

Before examining these rules, it is useful to outline several properties that are commonly used to evaluate them:

Guru participation ensures that a voter who accepts delegated votes (a guru) is never disadvantaged by doing so. That is, receiving additional delegations should not reduce their influence over the outcome (Kotsialou and Riley, 2020).

Confluence requires that each voter have a single, unambiguous delegation path. This property simplifies the resolution of delegations and enhances system transparency (Brill et al., 2022).

Copy robustness aims to prevent a specific form of strategic manipulation which occurs when a voter who would normally delegate decides to act as a casting voter and mimics the behaviour of their delegate outside the system (for example, by copying

their vote using external communication). In non-copy-robust systems, this behaviour can result in a greater combined influence for both the original delegate and the copier, effectively bypassing the system. A copy-robust rule avoids this problem by ensuring that the combined voting weight of the mimicked behaviour does not exceed what it would have been through proper delegation (Brill et al., 2022; Behrens and Swierczek, 2015), giving equal opportunities to all voters.

The main delegation rules that were considered for implementation are:

Depth-First Delegation (DFD) selects the path with the highest-ranked first delegate, even if it results in a long chain. While this rule prioritises individual trust rankings, it fails to satisfy the *guru participation* property, as show by Kotsialou and Riley (2020).

Breadth-First Delegation (BFD) prioritises the shortest available delegation path and uses rankings only to resolve ties. This approach generally results in more direct and predictable delegation chains and satisfies *guru participation* (Kotsialou and Riley, 2020; Brill et al., 2022), though it may assign votes to lower-ranked delegates.

MinSum strikes a balance between path length and preference by selecting the path with the lowest total sum of edge ranks. This rule is *confluent* and helps avoid both long chains and poorly ranked delegations, making it suitable for general use (Brill et al., 2022).

Diffusion builds delegation paths in stages, assigning votes layer by layer based on the lowest available rank at each step. This approach avoids poor delegations but can occasionally produce unintuitive results due to its tie-breaking method (Brill et al., 2022; **?**).

Leximax addresses this by comparing delegation paths based on their worst-ranked edge. It ensures that poorly ranked delegations are avoided, especially near the beginning of a path, and maintains the *confluence* property (Brill et al., 2022).

BordaBranching takes a global view of the delegation graph and selects a branching that minimises the total rank across all delegation edges. It satisfies both *guru participation* and *copy robustness*, making it well-suited for robust and equitable systems

(Brill et al., 2022). However, this rule can be computationally intensive to implement.

In summary, ranked delegation significantly improves the reliability of liquid democracy, as it results in a lower chance of a delegated vote being nullified. The choice of delegation rule influences not only system efficiency but also the fairness of outcomes. While simpler methods such as DFD and BFD are easier to implement, advanced rules like MinSum, Leximax, and BordaBranching offer stronger guarantees and are better suited to practical deployment in platforms such as vodle.

Weighted/ vote splitting

Voting power is distributed across multiple delegates to reduce reliance on any single individual (Gölz et al. (2021)).

2.2 Implementations of Liquid Democracy

2.2.1 LiquidFeedback

2.2.2 Google Votes

2.3 vodle

Vodle is a web-based platform for participatory group decision-making. Users participate in polls that allow them to rate a set of options using sliders. When the poll ends, these ratings are aggregated and the MaxParC rating system is used to determine the final result of the poll.

2.3.1 MaxParC

Understanding MaxParC is important for this project because it forms the core of how vodle interprets group preferences. Since this work involves modifying vodle's voting

behaviour through the integration of liquid democracy, it is essential to understand how MaxParC processes input ratings. In particular, understanding how changes in individual ratings influence the final outcome of a poll helps to frame the implications of delegating or reweighting votes.

Maximum Partial Consensus (MaxParC), the rating system used by vodle, was introduced by Heitzig et al. (2024). It is a decision-making method designed to address the limitations of traditional voting systems, in particular the potential for majority rule to suppress minority viewpoints. The primary objective of MaxParC is to achieve a balance between fairness, consensus, and efficiency in group decision-making.

Each voter rates an option from 0 to 100 (x), representing their willingness to approve that option if and only if $< x\%$ of users do not approve that option. Therefore, a rating of 0 means "do no approve no matter what" and a rating of 100 means "approve no matter what" or "always approve".

2.3.2 Architecture

Technologies Used

why info is relevant to the project - e.g. need to jsonify data. what makes angular different etc

2.3.3 Design Philosophy

2.4 Summary

Chapter 3

Objectives

Chapter 4

Design and Implementation (can split into separate chapters)

Chapter 5

Evaluation

Chapter 6

Conclusions

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