Liquid Democracy for Rating Systems

Hemanath Peddireddi

Department of Computer Science

University of Warwick

Supervised by Markus Brill

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Abstract

TODO: finish

This project explores how liquid democracy can be used to enhance rating systems by integrating it into vodle, an online polling platform where users rate options using sliders. Traditional liquid democracy models do not always reflect participants' true preferences, especially when some users abstain from voting or when some individuals gain too much influence. To address this, the project adds support for ranked delegation and weighted vote splitting.

Keywords:

Contents

Chapter 1

Introduction

1.1 Motivation - TODO (Finalise)

Liquid democracy has strong theoretical appeal as a flexible and participatory decision-making model, but practical implementations remain rare and underexplored. Most existing research assumes idealised conditions, while real-world systems must contend with asynchronous participation, limited user engagement, and the potential for structural issues like delegation cycles or vote loss.

Vodle, as a platform for collective decision-making, presents an opportunity to explore how liquid democracy can be adapted to work in practice. This project is motivated by the need to understand and resolve the challenges of integrating delegation-based voting into an existing system, while improving the platform's fairness, expressiveness, and overall user experience.

1.2 Vodle - will change or remove

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. When the poll ends, the ratings submitted by voters are then aggregated and a result is calculated.

INSERT IMAGE OF SLIDERS

1.3 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 who make decisions on their behalf for the duration of a fixed term. While this model is scalable and practical for large populations, it introduces several limitations. Elected representatives often make decisions based on party lines, personal convictions, or external influences such as lobbying groups, which may not accurately reflect the preferences of their constituents (Blum and Zuber, 2016). In addition, because elections are infrequent, this system tends to be unresponsive to shifts in public opinion. Citizens are unable to easily adjust or retract their delegation, which limits their ability to influence decisions once representatives are in office (Blum and Zuber, 2016). As a result, participation is both indirect and inflexible, which can lead to disengagement and dissatisfaction among voters.

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). In comparison to a direct democracy, the bar for participation is lowered as voters no longer need to stay informed and engaged to pass a vote because they can trust a delegate to do it on their behalf. These delegations can also be updated or revoked at any time, giving users more control over how their vote is used in comparison to a traditional representational democracy where your representative can only be changed at certain points in time.

1.4 Project Goal - TODO

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

Key features include ranked delegation and vote splitting ...

1.5 Project Outline - TODO

This report is structured as follows: *will add when report is written*

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 - casting voters.
- **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 "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

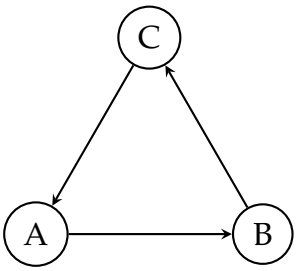

Figure 2.1: Delegation cycle: A delegates to B, B to C, and C back to A.

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.

Abstentions

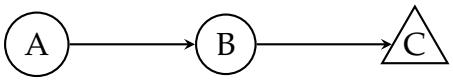

Figure 2.2: Delegation chain ending in abstention: A delegates to B, B to C. C abstains, causing the votes of A and B to be lost.

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

Ranked delegation improves liquid democracy by allowing voters to list several trusted delegates in order of preference. Instead of choosing just one delegate, a voter can specify a ranked list so that if their top choice is unavailable (due to abstention, involvement in a cycle, or other reasons) the system can use the next delegate specified. This method reduces the risk of losing votes while keeping voters actively involved in the decision making process (Brill et al., 2022).

Implementing ranked delegation requires a mechanism to decide among multiple possible delegation paths. This is done through a *delegation rule*, a function that, given a ranked delegation instance and a delegating voter, selects a unique path leading to a *casting voter* (Brill et al., 2022).

Several key properties help evaluate these delegation rules:

- **Guru Participation:** Ensures that a voter accepting delegated votes (a "guru") is never worse off by doing so. Receiving additional delegations should not decrease their influence over the final outcome (Kotsialou and Riley, 2020).
- **Confluence:** Guarantees that each delegating voter ends up with one clear and unambiguous delegation path. This property simplifies vote resolution and enhances transparency (Brill et al., 2022).
- **Copy Robustness:** Prevents strategic manipulation where a voter might mimic another's vote outside the system to gain extra influence. A copy-robust rule makes sure that duplicating a vote externally does not yield more combined power than a proper delegation (Brill et al., 2022; Behrens and Swierczek, 2015).

The literature considers several delegation rules, each with distinct trade-offs:

Depth-First Delegation (DFD): Selects the path beginning with the highest-ranked delegate, even if the resulting chain is long. Although it prioritizes individual trust preferences, DFD can violate guru participation (Kotsialou and Riley, 2020).

Breadth-First Delegation (BFD): Chooses the shortest available delegation path and uses rankings only to resolve ties. This approach usually produces direct, predictable chains and satisfies guru participation, although it might sometimes assign a vote to a lower-ranked delegate (Kotsialou and Riley, 2020; Brill et al., 2022).

MinSum: Balances path length and delegation quality by selecting the path with the lowest total sum of edge ranks. Being confluent, MinSum avoids both unnecessarily long chains and poorly ranked delegations (Brill et al., 2022).

Diffusion: Constructs delegation paths in stages by assigning votes layer by layer based on the lowest available rank at each step. This method tends to avoid poor delegations but can sometimes produce unintuitive outcomes due to its tie-breaking procedure (Brill et al., 2022).

Leximax: Compares paths based on their worst-ranked edge. This ensures that especially low-ranked delegations are avoided early in the path while maintaining confluence (Brill et al., 2022).

BordaBranching: Takes a global view of the delegation graph by selecting a branching that minimizes the total rank across all delegation edges. It satisfies both guru participation and copy robustness, though it is more computationally intensive (Brill et al., 2022).

In summary, ranked delegation enhances liquid democracy by reducing the risk of lost votes. The choice of delegation rule not only affects system efficiency but also influences fairness and robustness. 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 for practical deployment in platforms such as vodle.

For our implementation, MinSum will be chosen as ...

Vote Splitting

2.2 Existing Implementations of Liquid Democracy

To understand how liquid democracy can be practically integrated into vodle, it is important to examine how similar systems have been implemented in real-world contexts. This section explores two implementations, LiquidFeedback and Google Votes, that offer valuable insights into the technical, social, and usability challenges associated with applying liquid democracy at scale.

2.2.1 LiquidFeedback

LiquidFeedback is one of the earliest and most influential real-world implementations of liquid democracy. Developed as an open-source platform, it was notably adopted by the German Pirate Party in 2010 to facilitate internal policy-making through online participation (Behrens et al., 2014). The platform allowed members to submit proposals, debate them in structured phases, and vote either directly or via transitive delegation.

In LiquidFeedback, users could choose different delegates for different topics, allowing them to assign their vote to someone they trusted on a specific issue. These choices remained in place until the user changed them, which meant that certain individuals could gradually accumulate more influence if others did not update their delegations. When multiple proposals were put forward, the system used a ranking-based voting method (such as the Schulze method) to decide which one should win. This approach compares each proposal against the others and selects the one that would win the most head-to-head matchups. Importantly, the system only accepted a proposal if it clearly beat the alternative of doing nothing, helping to avoid unnecessary or unpopular changes.

In practice, the Pirate Party's use of LiquidFeedback revealed several key dynamics

relevant to this project. The platform was successful in enabling large-scale participation and crowdsourced policy formation, but it also demonstrated common risks of liquid democracy. Such as the existence of super-voters, as discussed previously.

Another practical issue was the complexity of the system. LiquidFeedback was difficult to understand for many users, especially those unfamiliar with concepts like transitive delegation or multi-stage voting which limited its accessibility and contributed to declining engagement over time (Kling et al., 2015).

For a platform like vodle, the experience of LiquidFeedback highlights several important design considerations. First, user interfaces must be intuitive enough to allow voters to participate without needing deep technical knowledge. Second, the user must be know the status of their delegation at a glance - improving the understanding of the platform. Finally, ensuring that votes lead to visible and actionable outcomes is critical for sustained engagement.

2.2.2 Google Votes

Google Votes was an internal experiment at Google designed to explore the practical application of liquid democracy within a corporate environment. Built on top of the company's internal Google+ social network, it operated between 2012 and 2015 and allowed employees to participate in decision-making by either voting directly or delegating their vote to a colleague (Hardt and Lopes, 2015).

Delegations in Google Votes were category-specific, meaning that users could choose different delegates for different areas of interest, such as food, events, or technical infrastructure. These delegations were persistent but could be overridden at any time, giving users flexibility to either rely on trusted experts or vote independently as needed. The system supported transitive delegation and allowed users to reclaim control by casting their own vote, even after delegating.

The platform placed strong emphasis on usability and transparency. Delegation features were rolled out incrementally, with additional tools such as voting power estim-

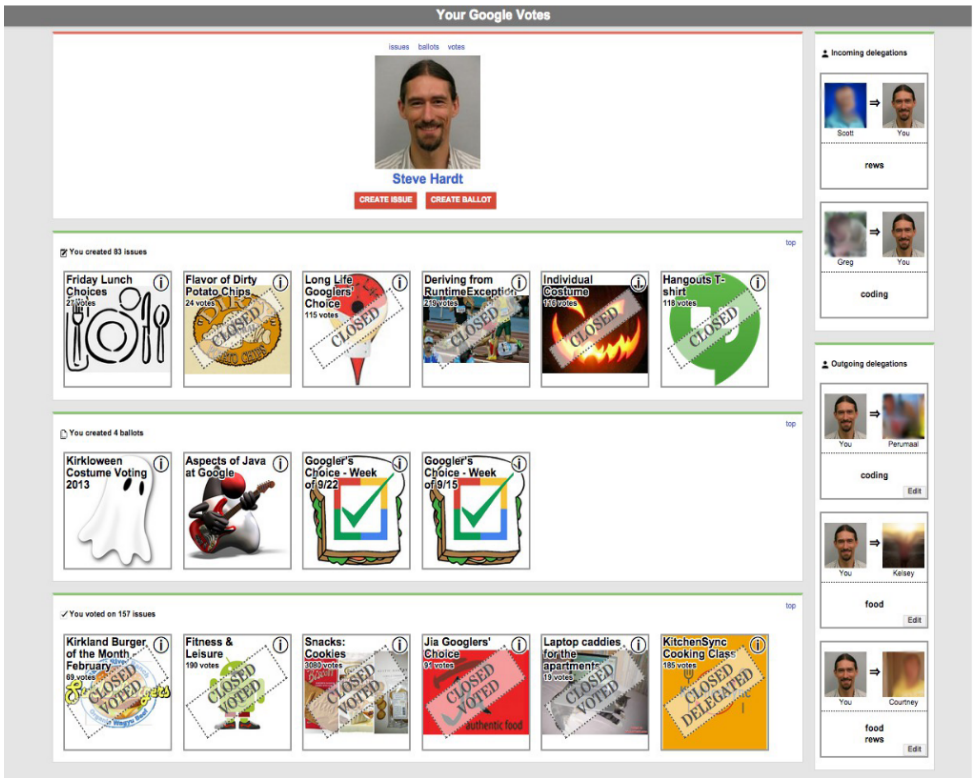

Figure 2.3: Screenshot taken from Hardt and Lopes (2015) showing the user interface of Google Votes.

ates and delegation advertisements helping users understand their influence. One key design principle was what the authors called the "Golden Rule of Liquid Democracy": if a user delegates their vote, they should be able to see how it is being used. To that end, users received notifications when their delegate voted, and all votes were visible to the relevant group. This encouraged accountability and gave voters confidence that their delegated votes were being used appropriately.

While Google Votes was never made publicly available, it served as a successful demonstration of liquid democracy in a structured, real-world setting. It showed that delegative voting could improve engagement and decision-making within large organisations, especially when designed with attention to user experience. For Vodle, the system provides a concrete example of how features like topic-specific delegation, transparency tools, and real-time voting feedback can make liquid democracy more practical and accessible.

2.3 Agent Based Modelling

2.4 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.

2.4.1 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". This can be visualised in the illustration below.

TODO: Make summary better

To summarise, any delegation or vote splitting mechanism must be designed so that it only adds to an option's overall rating and never reduces it. This ensures that

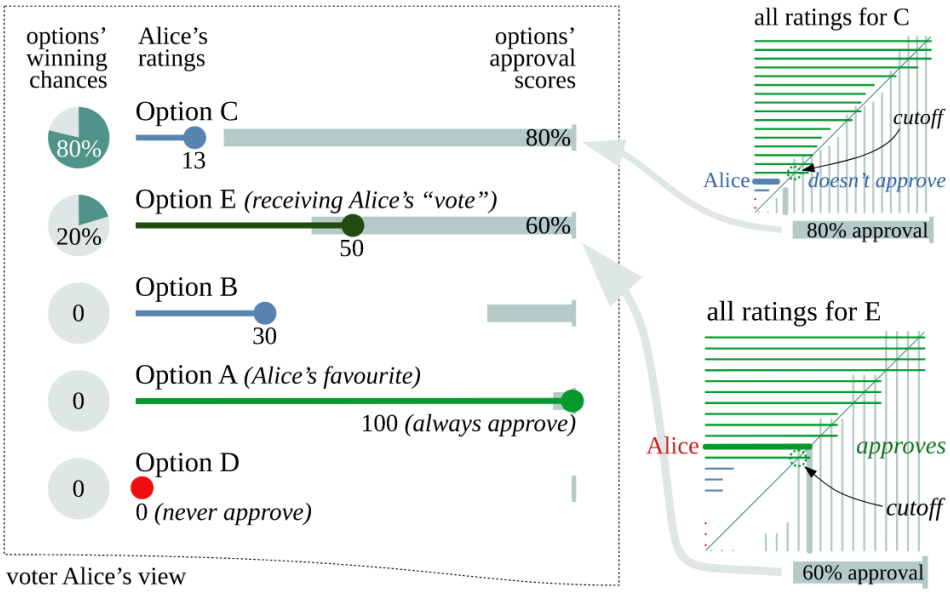

Figure 2.4: Graphic from Heitzig et al. (2024) representing MaxParC from the view of some voter Alice. Each rating value represents a conditional commitment by Alice to approve the respective option. Approval scores, number of voters that approve the option, are represented by light bars coming in from the right, options are sorted by descending approval score. Alice is counted as approving an option if her rating needle overlaps with the approval score bar.

delegated input remains consistent with MaxParC's conditional approval model and preserves the original intent of the voter.

2.4.2 Technologies Used

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

2.4.3 Existing Partial Implementation of Liquid Democracy

2.4.4 Design Philosophy

2.5 Summary

Chapter 3

System Specifications

The background research as well as the project's goal and motivation have laid out the objectives for the project. This section outlines the objectives.

3.1 Project Objectives - TODO: add references to the research etc.

Objectives are split into core and extended objectives. Core objectives are prioritised as they aligned more closely to the project's main goal.

Core Objectives:

1. **Implement a Core Delegation Model into vodle:** Build upon the existing, partially implemented delegation code within the vodle platform to create a fully functional system, including resolving key challenges such as cyclic delegations.
2. **Implement Ranked Delegation into vodle:** Add a backup delegation mechanism to vodle, allowing users to specify an ordered list of up to 3 delegates, and using the MinSum algorithm to determine the activated delegation paths.
3. **Implement a Vote Splitting Delegation Variation into vodle:** Add functionality to vodle to delegate fractions of their rating to different delegates. Use the

will come back to when research written up system to calculate final ratings.

4. **Implement Ability to Delegate Options to Different Users**: Allow users to delegate the ratings of specific options to different delegates.

Extension Objective:

1. **Simulate Delegation Mechanisms:** Perform agent-based modelling to analyse the effectiveness of various delegation systems, especially those planned to be implemented into vodle (Objectives 1-3).

3.2 Project Requirements

intro - talk about why we need to break down objectives further, define functional and non functional requirements.

break each objective down into F and NF.

Chapter 4

Design and Implementation (can split into separate chapters)

Chapter 5

Evaluation

Chapter 6

Project Management

Chapter 7

Conclusions

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