The Principles of LiquidFeedback

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"The best weapon of a dictatorship is secrecy,
but the best weapon of a democracy
should be the weapon of openness."

Niels Bohr

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Foreword

"The times they are a-changin' "—thus sang pop icon Bob Dylan in the 1960s. We know now that he was right, but his was a linear change at a relatively slow pace. Driven by modern technology, we find ourselves today in the midst of a transition that is taking place in a much faster, exponential fashion: The processing power of all the computing devices with which mankind is now blessed doubles every eighteen months. Although only two decades ago still quite unimaginable, this new, transitional technology is presently pervading all sectors of society in every nook and cranny of the globe, and it is profoundly changing nearly everything it encounters in ways that we are only beginning to understand.

At the same time we are witnessing what could be called the final demise of the nineteenth century, or, more precisely, of that century's systems, institutions and structures created to cater to the needs of a bygone age. Among these may not only be the nation-state, the workers' union, the church, the nuclear family, monogamy, matrimony, the newspaper, the book, print-literacy, the university and an international power equilibrium dominated by the West, but also the political party and even representative democracy. Certainly in Europe and the United States, but also in other parts of the world, representative democracy shows alarming signs of deterioration, of getting bogged down and becoming ossified. There is growing consensus that, as a system of government, it is weakening to the point of exhaustion. Representative democracy seems unable to live up to the expectations

we once had, it increasingly meets with scepticism from citizens who feel detached and disenfranchised—it is, in short, in a crisis of legitimacy and efficiency. Something similar, no doubt, could be said about the political party, which is among representative democracy's principal bodies, but which today is also among the world's most distrusted institutions, often lacking in vision and ideology and no longer able to aggregate the hopes and aspirations of the citizenry in an era of much less conformity than the one in which this classical, patriarchal and relatively closed institution was once conceived.

Nowadays, we are confronted with a whole range of negative and positive responses to this major development. Political populism, for example, is now discernible all across the Northern hemisphere, to some extent providing a valid diagnosis though without offering a feasible remedy. Technocratic "solutions" are rife as well—meant to enhance representative democracy's efficiency but at the same time invigorating its legitimacy problem. On the national level this is exemplified by the creation of so-called "quangos" (or quasi-autonomous NGOs), which implement legislation without being democratically accountable; the United Kingdom has now more than a thousand of them. On the supra-national level equally unaccountable and undemocratic bodies such as the European Commission have been called into being. Some see the answer to representative democracy's ailment—also called the "democratic fatigue syndrome"—in *sortition* or lot-drawing (rather than, or in combination with, elections): a means to select citizens for public office that was used, for instance, in classical Athens and in various Italian republics such as Venice during the Renaissance. Numerous initiatives are also being taken across the globe to involve citizens directly in politics and political decision-making, even in connection with constitutional drafting processes such as in Iceland, Ireland and, most recently, the United Kingdom.

To the casual observer all this trying, groping and exploring, all this trial and error, may be bewildering, but what seems certain is that we are on the brink of a new era and that democracy is on its way to becoming more direct, participatory and deliberative. The technology that today is changing

the world so profoundly and quickly is coming to democracy's aid in this respect, as more and more (free and open source) software is becoming available that facilitates what has been dubbed "strong democracy"—a democratic system in which citizens govern themselves to the greatest extent possible.

In this fascinating development, LiquidFeedback stands out as the most promising technological break-through to date. Based on a broad range of specific forms of knowledge and expertise ranging from mathematics to state-of-the-art voting theory, LiquidFeedback constitutes a coherent, sophisticated and visionary tool for solid participant-driven proposition development and decision-making processes. Small wonder that it has already acquired a certain international reputation and is now being used to facilitate democratic processes in various countries, in diverse contexts and in a variety of organisations, including political parties.

This book, written by the inventors of LiquidFeedback themselves, will guide even readers who are not very tech savvy through all its astonishing possibilities while providing a real understanding of all the practical and theoretical considerations that constitute the basis for its design and use. In *The Last Vote,* his recently published analysis of the trials and tribulations democracy is presently going through, senior journalist Philip Coggan states: "If there is one region of the developed world where democracy seems to be most threatened, it is Europe." The coming into being of LiquidFeedback and the publication of this book suggest that we need not despair, that help is under way and that there is hope for democracy, even in Europe.

The Hague
December 2013

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http://principles.liquidfeedback.org/

Contents

Chapter 1

Introduction

1.1 Preface

LiquidFeedback is a computer software that has been developed by the *"Public Software Group e. V."* to empower organizations to make democratic decisions independent of physical assemblies while also giving every member of the organization an equal opportunity to participate in the democratic process.

LiquidFeedback delivers reliable results about what the members want and can be used for information, suggestion, or directive depending on the organizational needs and the national legislation. It can be used for binding decisions in an organization or—following the idea of interactive democracy—as a new communication channel between the members and the board.

Originally designed for political parties and other organizations, LiquidFeedback is also being used in civic participation as an additional communication channel between citizens and their administration, in constituency participation for better connecting representatives to their electoral district and even in corporate participation projects.

Users don't need to install LiquidFeedback, instead they can just access it using an ordinary web browser. This also means using LiquidFeedback is platform independent. However, the

operating organization needs to run an internet server. There are several aspects an organization should take into consideration to smooth the way to success.

Within this book, we shall explain the principles and rules of procedure developed for LiquidFeedback, which allow organizations to push the boundaries of democratic self-organization.

This book shall be a reference for anybody attempting to set up a participation system using LiquidFeedback or any other software. It shall also help to understand the "secrets" of LiquidFeedback. While this book is certainly no "user guide" that needs to be fully understood to participate using LiquidFeedback, it may be enlightening to have an idea of the design considerations. Last but not least, this book is intended to help developers of future participation systems.

1.2 Democracy vs. Republic and a new approach

"It has been observed that a pure democracy, if it were practicable, would be the most perfect government."[1]

Alexander Hamilton

With this notion Alexander Hamilton unfavorably compared pure (or direct) democracy to the republic proposed by the Constitutional Convention in Philadelphia. James Madison defined republic as *"a government in which the scheme of representation takes place."*[2] This republic was to be what we call today a representative democracy.

A representative democracy is founded on the principle of elected individuals representing the people. Usually you elect a representative (individual or party) for a fixed term. If you change your mind during the term—you can't do much about it. Also representatives usually stand for a whole package of political objectives. If you don't find your own mix—you need to accept compromises.

"The two great points of difference between a democracy and a republic are: first, the delegation of the Government, in the latter, to a small number of citizens elected by the rest; secondly, the greater number of citizens, and greater sphere of country, over which the latter may be extended."[2]

James Madison

On the other hand, a pure (or direct) democracy, where most or all questions are decided by referendum, may be less efficient, is believed to be impracticable on a large scale, and warnings of a mob rule go back as far as Plato.[3]

Madison emphasized limitations: *"pure democracy, by which I mean a society consisting of a small number of citizens, who assemble and administer the government in person,* [...]*."*[2]

Hamilton believed the very character of *"ancient democracies, in which the people themselves deliberated,* [...] *was tyranny."*[1]

Representative democracy has always been more than an adequate response to technical limitations in its time—representation is division of labor in politics.

This being said, many people hold up the dream of a pure democracy. New technology such as the internet could place it within reach. Of course this is only the technical aspect. The remaining question is: Will everybody be able to deal with every question or will people stop participating? Will selfish and superficial decisions predominate? Will the outcome be "tyranny"?

This is where *Liquid Democracy* offers a promising solution. The basic idea: voters can delegate their vote to a trustee (technically a transitive proxy). The vote can be further delegated to the proxy's proxy thus building a network of trust. All delegations can be done, altered and revoked by topic; e. g. I myself vote in environmental questions, Anne represents me in foreign affairs, Mike represents me in all other areas—but I can change my mind at any time. A *dynamic scheme of representation* takes place.

Anyone can select their own way ranging from pure democracy on the one hand to representative democracy on the other. Basically one participates in what one is interested in but for all

other areas gives their vote to somebody acting in their interest. Obviously, one may make a bad choice once in a while, but they can change their mind at any time.

What about the practical value of this approach? First of all it provides an alternative organizational concept wherever defined groups, i. e. organizations, decide on issues. Sure enough and for good reasons, we will not see any republic being replaced in the foreseeable future and maybe never will. But apparently Liquid Democracy has the potential to revolutionize decision-making within political parties and thus changing the course of politics.

Chapter 2 of this book gives an in-depth insight into this fascinating organizational concept of *dynamic division of labor,* its implementation in LiquidFeedback, and it will also deal with common misconceptions.

1.3 Project LiquidFeedback

"[...] every man is a sharer [...] and feels that he is a participator in the government of affairs, not merely at an election one day in the year, but every day."[4]

THOMAS JEFFERSON

LiquidFeedback combines concepts of a collectively moderated, self-organized discussion process (quantified, constructive feedback) and Liquid Democracy (delegated or proxy voting).

LiquidFeedback covers the process from the introduction of the first draft of a proposal to the final decision. This way it allows all members to participate not only in voting but also in developing ideas. Discussing an issue before voting increases the awareness of pros and cons, chances and risks, and allows people to consider and suggest alternative trade-offs which can become part of the final voting procedure.

Extra effort has been made to ensure *minorities* can express their view and stay visible. On the other hand, the system can also handle the challenge of noisy minorities.

Although we want everybody to be able to participate in the development of ideas, we believe at the first instance many drafts

will be created by closed groups or even individuals. This is no problem, providing everybody can find out about the initiative, everybody can contribute by making suggestions, everybody can create an alternative initiative, and everybody can vote in the end.

In LiquidFeedback, every member may launch an initiative. During the discussion period the initiators advertise their proposals and get feedback about the degree of support within the organization. Furthermore, they obtain suggestions for developing their initiative. These suggestions are quantified by LiquidFeedback in terms of how much support may be gained or lost by implementing a suggestion. As we will later justify, only the initiators decide whether a suggestion will be implemented or not. The idea of what a proper implementation is like may differ vastly. Therefore, after a new draft has been published, members can mark whether the suggestion has been implemented in their sense.

At this point, we want everyone to work towards the same goal and only require *constructive feedback* within an initiative. We don't expect improvements of an initiative from people who think the basic idea is preposterous. If someone feels that there is something with which they fundamentally disagree, they should express their disagreement by launching or supporting an alternative initiative or simply vote 'No' when it comes to voting.

Since we neither want to force people into unwanted compromises nor to encourage them to vote based on majorities and chances rather than political objectives (i. e. nobody who wants to vote for A shall be encouraged to vote for B just because B has better chances to win and C is even worse), we allow voters to express preferences that are counted using a sophisticated system based on recent research in social choice theory.

Intentionally there is no request-commission with special privileges to consolidate proposals based on change requests. As a result there may be so-called "clones" i. e. very similar initiatives with seemingly minor differences (that may be important to some voters though). These "clones" should generally not harm a basic idea due to vote-splitting (and obviously also not support it). LiquidFeedback's voting system takes care of these

considerations as well.

Finally we build on traceability to ensure integrity. This is what we also call transparency (in the political meaning of the word).

In this book, chapter 3 deals with the verifiability of voting systems in general and discusses the consequences for LiquidFeedback; chapter 4 elaborates the proposition development process and is all about algorithms: self-organization, fairness, minorities, voting; and chapter 5 advocates Open Source for democracy software, explains the license policy of LiquidFeedback, and deals with the necessity to publish certain voting-relevant data to allow verifiability of the process for the participants.

1.4 Prospects and impact

"Because of this system, the concentrated power of boards of directors can be minimized and made more directly accountable to large memberships. This, in turn, makes for more substantive dialogue about what members want. It avoids the familiar pattern of leaders trying to temper members' demands for change and urging them to be 'politically realistic.'
LiquidFeedback would appear to invert this dynamic by empowering the members of a party or organization to make their 'leaders' more directly accountable to them. Instead of elected leaders and boards neutralizing dissent and co-opting power threats, members can collectively determine how they really feel about issue x or y, and demand that the organization publicly advocate those positions."[5]

David Bollier

LiquidFeedback is designed to enable political parties and organizations of any size to make binding decisions even if the topic is controversial. Collaboration of the participants is no precondition. Collective moderation allows a self-organized proposition development process.

In many cases, however, we expect LiquidFeedback decisions to be introduced as suggestions into the decision-making of rep-

resentatives. This can still have a large impact if the results are acknowledged as trustworthy and indisputable.

Even where the results are not binding and only meant as an indication for a representative (or the board members), there must be no doubt that they express the will of the participants. This way, board members learn what the majority really wants and can make right and responsible decisions based on the "popular vote."

If the results of a system are meant to express the opinion of a given group, there has to be an agreement within the group on how to use it and every member of the group (and only they) must have voting right in the system with exactly one account. Indisputable rules need to define which decisions are possible and when and how they are made.

Chapter 6 discusses the real world integration of LiquidFeedback, application fields and preconditions.

Chapter 2

Liquid Democracy

2.1 Democracy and division of labor

The division of labor—specialization and cooperation—is part of the success story of the human species. Over the centuries division of labor has become increasingly complex and no modern society can exist without.

Representative democracy constitutes division of labor in the field of politics. Yet representation is not without controversy:

"But the problem with representative democracy is that public opinion can only be expressed crudely. Citizens vote every few years—and then a single legislator is said to 'represent' you and tens of thousands of other citizens for a fixed term. But if circumstances change, if you change your mind or if you don't like all elements of a candidate's bundle of political views, you're out of luck. Your opinion can be safely ignored by those in power. Politicians come to mold and manipulate public opinion, with help from corporate money ('manufacturing consent', in Chomsky's terms), rather than public opinion having sovereignty over politicians."[5]

David Bollier

Time and again we hear calls for direct participation. But how can direct participation possibly compete with representation?

2.2 The principles of Liquid Democracy

A promising approach is Liquid Democracy. It makes division of labor available to the voters. But while representative democracy remains static, Liquid Democracy offers a dynamic solution.

The decision for or against division of labor is left to the individual (i. e. the voter), applies to his or her own vote, can be topic-specific, and can be altered at any time.

2.2.1 Delegated voting

The basic idea is a democratic system in which most issues are decided by referendum. Considering nobody has enough time and knowledge for every issue, votes can be delegated by topic, i. e. it is possible to give *different* people a power of attorney, depending on the topic. Furthermore, delegations are transitive and can be revoked at any time. Liquid Democracy is sometimes referred to as *Delegated* or *Proxy Voting*.

While one way to describe delegations is the transfer of voting weight to another person (see Figure 2.1), you can alternatively think of delegations as automated copying of the ballot of a trustee (see Figure 2.2).

While at assemblies with voting by a show of hands it is naturally possible to copy the vote of other people, in Liquid Democracy this becomes an intended principle.

As mentioned in section 1.2, anyone can select their own way ranging from pure democracy to representative democracy by participating in what one is interested in while giving their vote to somebody acting in their interest for all other areas.

2.2.2 Topic-based delegations

It is possible to do, alter and revoke delegations by topic, e. g. person A (e. g. Alice) votes herself in environmental questions, is represented by person B (e. g. Bob) in foreign affairs, and

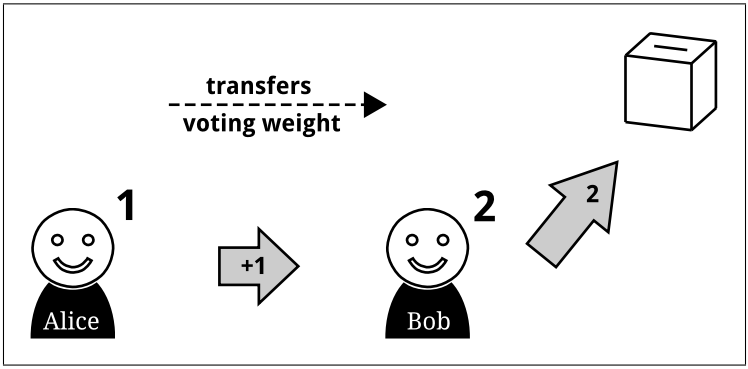

Figure 2.1: *Alice transfers her voting weight to Bob, who is using it together with his own voting weight to cast a ballot.*

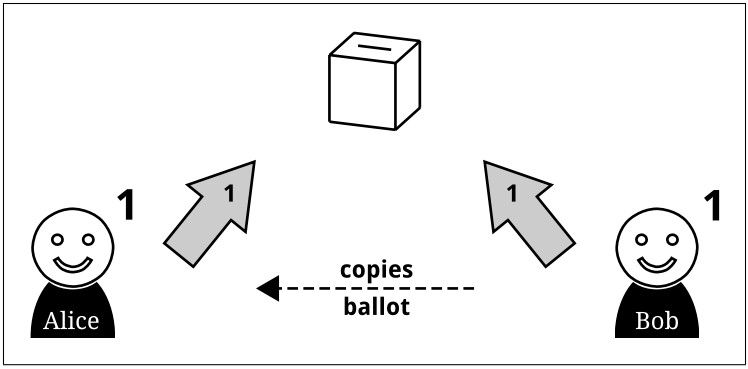

Figure 2.2: *If Alice copies the ballot of Bob and casts this copy along with Bob's original ballot, then this also gives Bob an effective voting weight of 2.*

by person C (e. g. Chris) in all other areas. In our example, Alice directly votes in environmental questions, delegates her vote for foreign affairs to Bob, and for all remaining areas to Chris. In other words: Alice decides herself in environmental questions and copies Bob's decision in foreign affairs and she copies Chris' decision in all areas but environmental questions or foreign affairs.

Why should somebody who apparently is not capable or willing to vote him- or herself delegate his or her vote to someone else? While one may not be inclined to deal with issues in a given area, e. g. fiscal politics, there may still be something at stake for the same individual. Topic-based delegations allow to assign the own vote to a trustee for a topic and thus strengthen one's own wing in a political party without the need to vote on issues of a certain subject area directly.

A traditional (static) representation scheme tends to marginalize distributed minorities. In contrast, Liquid Democracy allows everyone to seek appropriate representation regarding certain topics on the top level. E. g. in a static representation system the actual representation of a 10% minority largely depends on the local distribution and consequently on how much they can influence their respective delegates, but the dynamic representation in Liquid Democracy allows the minority to organize independently of local boundaries and ideally to express the idea with 10% voting power on the top level.

This does not only hold for defined minorities but also for any minority idea to be discussed. (We will return to the protection of minorities in section 4.10 on page 72.)

2.2.3 Transitive delegations without restrictions

In many cases, already the ability to select and evaluate an expert, which will represent your interests adequately, requires partial expert knowledge in a subject area. Therefore, in order to avoid delegations that would be purely based on populism, it is possible to delegate to a trustee who will further delegate the vote to someone else. E. g. person A does not know an expert for a

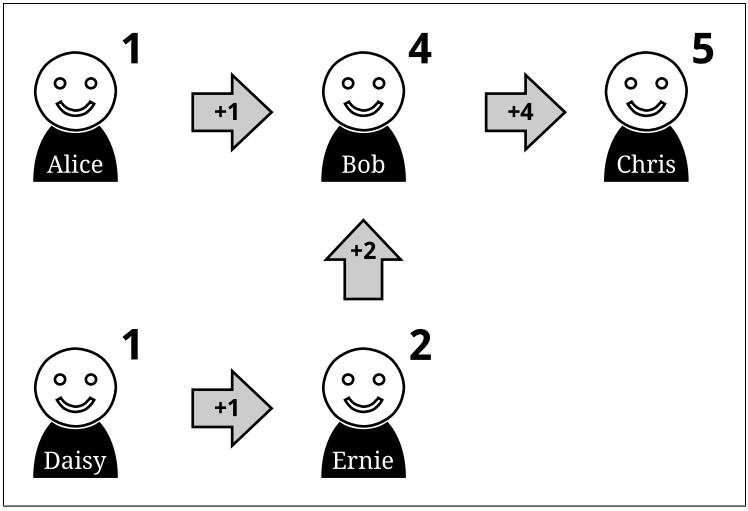

Figure 2.3: *Example of transitive delegation: Alice delegates to Bob, Daisy delegates to Ernie, Ernie delegates his and Daisys vote to Bob, who delegates all the votes from Alice, Daisy and Ernie together with his own vote to Chris, who gets a potential voting weight of 5.*

given issue, but person A trusts another person B in this regard. If person B doesn't feel confident to decide on that particular issue him- or herself, then person B can further delegate to the expert C, which causes the expert C to get the additional voting weight of both person A and person B).

As we will later reason in section 2.4, an important property of transitive delegations in Liquid Democracy is that the possibility to delegate is *unrestricted*. That means delegating an issue must not reduce your voting weight in any way.

2.2.4 Revocation of delegations at any time

While in a representative democracy you lose control over your elected representatives, Liquid Democracy allows to change or

revoke a delegation at any time, either for all issues, some issues or even one single issue.

As a consequence, this empowers eligible voters to intervene in any topic at any time by simply making a decision themselves. It obviously limits the power of well-known politicians, yet allowing them to do their job—as long as the voters are convinced by their actions.

2.3 Implementation in LiquidFeedback

The implementation of LiquidFeedback follows the principles outlined above. Here we only want to mention the implementation specific refinements and extensions.

As previously explained, Liquid Democracy allows topic-based delegations. But what does "topic-based" mean in practice? LiquidFeedback distinguishes between three levels of delegations:

- Delegation for all issues in all subject areas within an organizational unit (e. g. a chapter of a political party, or the whole (top level) organization),
- Delegation for all issues in a particular subject area (e. g. "traffic") of an organizational unit,
- Delegation for a single issue, which is a group of already existent competing proposals to be voted upon together.

Sometimes it is unclear which subject area covers a particular proposal. This question can't be solved by a computer algorithm but has to be answered by humans. As we will later see in chapter 4, LiquidFeedback follows a concept where there is no moderator or request commission with special privileges. Thus it is up to the participants in which subject area to make a particular proposal. Previously defined rules of procedure must regulate which subject areas within the system exist and what kind of resolutions they may enact. Whenever the participants in a particular subject area decide on something that is not to be

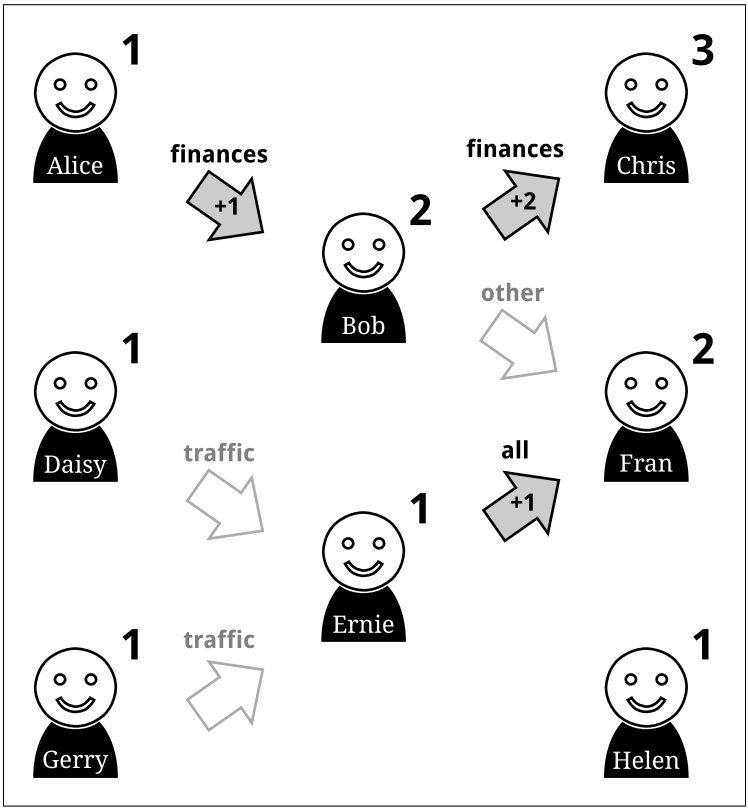

Figure 2.4: *An example of topic-based delegations: Alice delegates finances to Bob, Bob delegates finances to Chris and all other issues to Fran. Daisy and Gerry each delegate traffic to Ernie, who delegates all issues to Fran. Shown above is the potential voting weight for issues on finances.*

decided in that subject area, such a resolution must be void, just like when a committee is exceeding its authority. Defining and enforcing these rules and procedures is generally out of scope of LiquidFeedback, but decisions in this context may also be made within LiquidFeedback using a designated subject area.

Delegations are not only applied to the final vote on a given issue but also applied during its discussion, where it is possible to rate other people's proposals. Whenever a more fine-graded delegation exists (e. g. a delegation for a particular issue), a more general delegation (e. g. a delegation for the respective organizational unit) is overruled for the affected subject area or issues. The same holds when you make use of your own vote: If you enter a discussion by supporting or opposing proposals or make your own proposals, then you can't delegate your vote during discussion. If you participate in a final voting, you can't delegate in that final voting. Any form of direct participation will suspend existing delegations. (A proxy can not vote in the presence of the principal.)

It is possible to configure LiquidFeedback in such way, that delegations to other people must be confirmed regularly. This way it is possible to protect people from "forgetting" their outgoing delegations and to avoid empowering people with a greater voting weight than actually intended. The voting weight of people who don't use the system for a given period of time will automatically be suspended until those people return and acknowledge their own outgoing delegations.

2.4 Common misconceptions

2.4.1 The myth of circular delegations

The by far most discussed issue is the so-called circular delegation problem. What happens if the transitive delegations lead to a cycle, e. g. Alice delegates to Bob, Bob delegates to Chris, and Chris delegates to Alice? Would this lead to an infinite voting weight? Do we need to take special measures to prohibit such a situation?

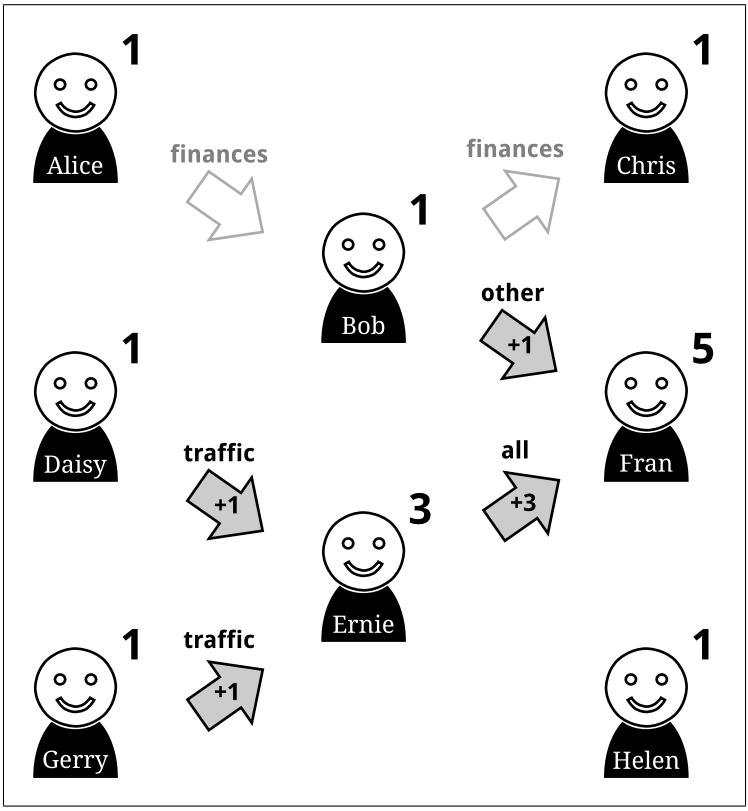

Figure 2.5: *The same situation as in Figure 2.4 but showing the potential voting weight for traffic issues instead.*

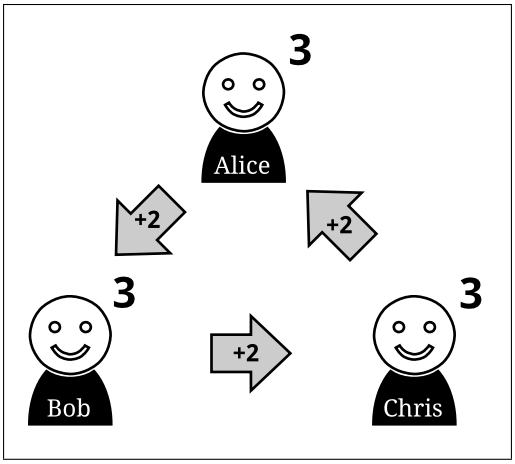

Figure 2.6: *Example of circular delegation: Alice delegates to Bob, who delegates to Chris, who delegates to Alice and everyone has a potential voting weight of 3.*

In fact, this is a nonexistent problem: A cycle only exists as long as there is no activity in the cycle in which case the cycle has no effect. As already explained in the previous section on page 28, as soon as somebody casts a vote, their (outgoing) delegation will be suspended. Therefore, the cycle naturally disappears before it is used.

In our example: If Alice and Chris decide to vote, then Alice will no longer delegate to Bob, and Chris will no longer delegate to Alice (see Figure 2.7). If only Alice decides to vote, then only Alice's delegation to Bob is suspended and Alice would use a voting weight of 3. In either case the cycle is automatically resolved and the total voting weight used is 3.

2.4.2 Delegations and "one man – one vote"

A second big issue is transitivity of delegations. Many people argue a multi-level buildup of delegation power (using the transitivity of delegations) creates power beyond control or violates

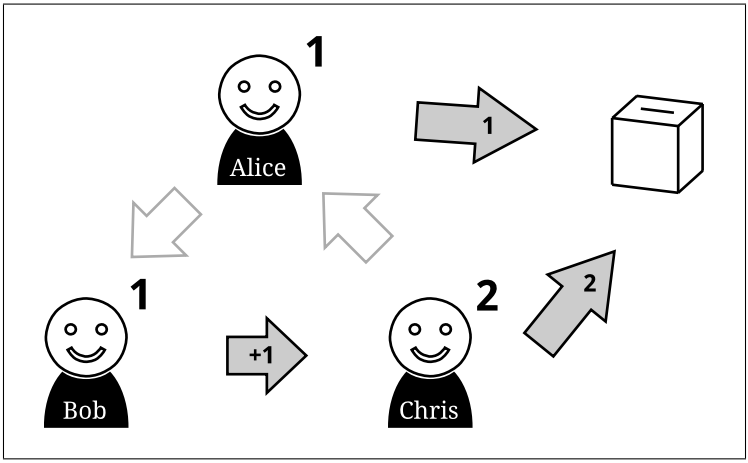

Figure 2.7: *Example of circular delegation: If Alice and Chris decide to vote, then Alice utilizes a voting weight of 1 and Chris utilizes a voting weight of 2.*

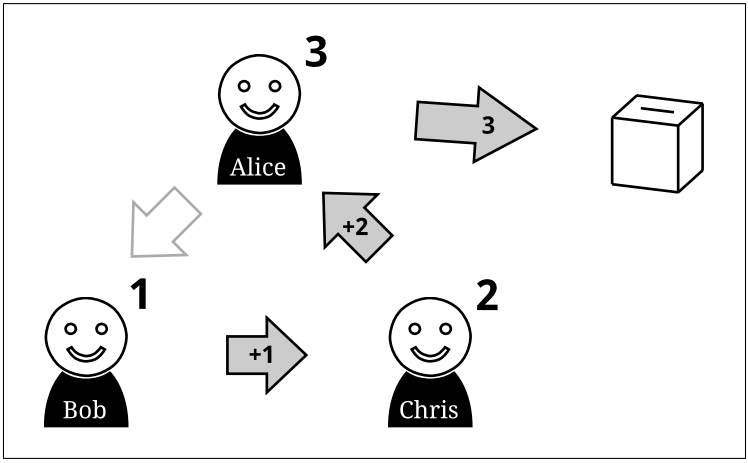

Figure 2.8: *Example of circular delegation: If only Alice decides to vote, then Alice utilizes a voting weight of 3.*

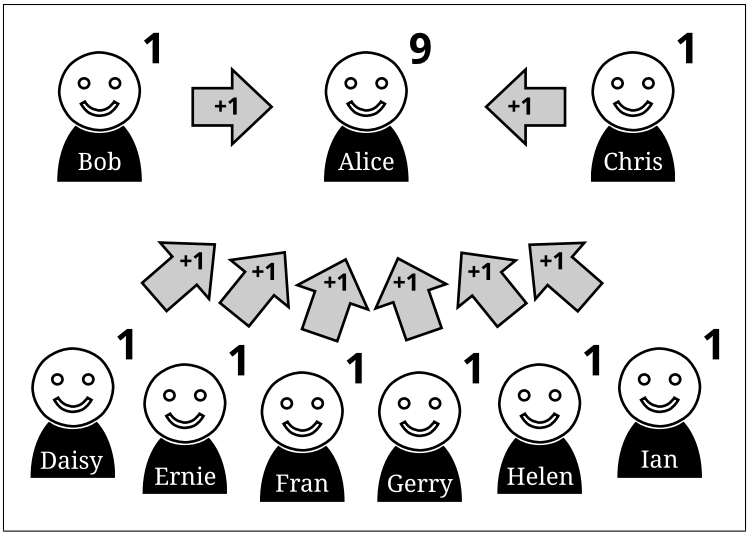

Figure 2.9: *A well-known politician receiving many direct delegations. In order to reduce the politician's voting weight to less than half, 5 people must revoke their delegation.*

the democratic principle of "one man – one vote."

Let's take a closer look at these arguments: If delegations were non-transitive, this means that if someone delegates an issue to you, delegating this issue to someone else would cause a loss of voting power for those people who delegated to you. This would push people to either decide on issues themselves or lend their power directly to well-known politicians.

Whenever someone (e. g. a well-known politician) receives many delegations directly, and not through intermediate proxies, then many people have to intervene to revoke the power granted to the trustee (see Figure 2.9). However, if someone receives delegations through intermediate proxies, then everyone in this proxy-chain is an additional chance for intervention and a single person might reduce the power of a well-known politician significantly (see Figure 2.10). Transitive delegations thus increase the possibility to control those who are given power.

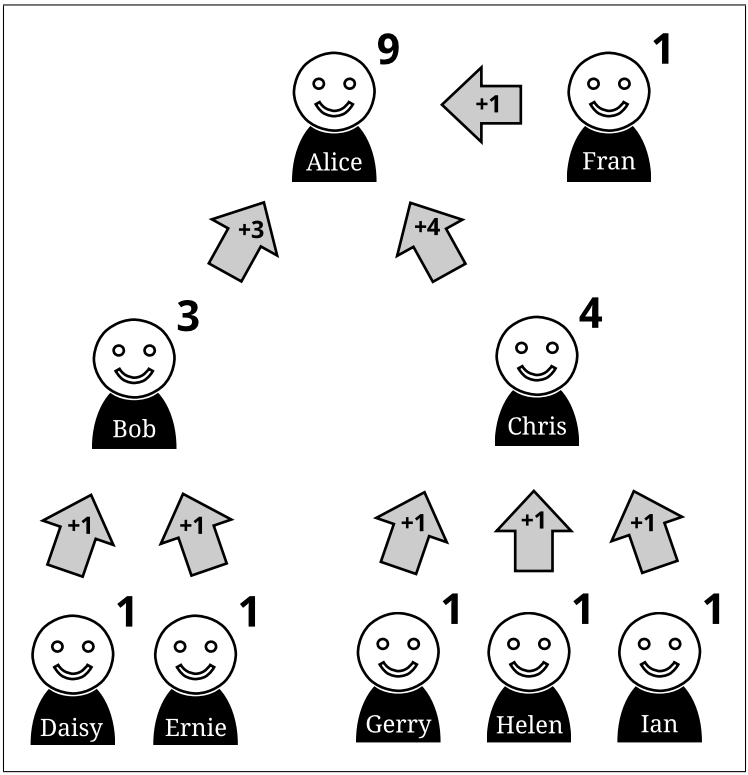

Figure 2.10: *In case of transitive delegations, Daisy and Ernie may delegate to Bob, even if they know that Bob won't decide on a particular issue himself but delegate his vote to Alice. The same holds for Gerry, Helen, and Ian with Chris and Alice. Bob and Chris serve as an intermediate link and may reduce Alice's voting weight instantly by 3 or 4 respectively. Thus two persons may be sufficient to reduce Alice's voting weight by 5: E. g. if Chris and Ernie would revoke their delegations and decide on an issue themselves, Alice would lose 5 votes, reducing her voting weight from 9 to 4, so that she could be overruled by Chris and Ernie.*

Some people still claim that delegations violate the principle of "one man – one vote." Do delegations cause people to gain more voting weight than others? At a first glance it appears like those people who receive delegations are treated differently during counting of the votes because they have a greater voting weight. But in fact every eligible voter has still exactly *one* vote: As previously mentioned on page 22, delegations can be seen as "copying the vote" of another voter. Any person who decides to delegate his or her own vote (hence copying the vote of another person) does this on a voluntary basis. The possibility to participate in the voting procedure by delegation enables people to use their own vote also in those cases where they do not have time to deal with an issue themselves. On the contrary, restricting the possibility to delegate would lead to situations where people could not make use of their own voting right unless they are able to decide on all issues themselves.

Even if the transitivity of delegations was only restricted on a case-by-case basis (e. g. people could decide whether their delegation can be passed on to another trustee), then in a technical system for decision-making the following situation might arise:

Assume we have two persons, Alice and Bob. Alice received 30 delegations, of which 20 are limited to those cases where Alice votes herself (either because these delegation reached a maximum delegation chain length, or because they had been restricted in another way). Lets further assume that Alice does not want to vote herself but to delegate the decision to Bob. Alice now has the following two options:

(a) Tell the system to delegate her vote to Bob. This way Alice can back up Bobs position with 10 votes plus her own vote.

(b) Ask Bob by e-mail or phone how he will decide on the issue and vote accordingly. This way Alice backs up Bob's position with 30 votes plus her own vote.

It is obvious that if Alice spends more effort to ask Bob directly, she may use more votes than if she'd just use the delegation system. But Liquid Democracy has been created to overcome exactly these effects: People should be treated equally and

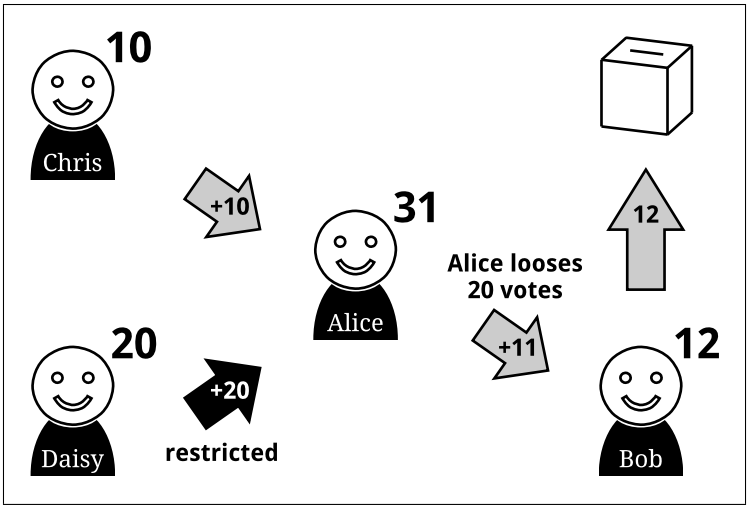

Figure 2.11: *If some delegations would be restricted, then delegating to Bob could cause Alice a huge loss of voting weight.*

independently of whether they have time to deal with an issue themselves or delegate it to another person. There are even more implications if one attempts to restrict the transitivity of delegations:

- Alice might be pushed to deal with the issue herself, even if she knows that Bob has better expertise.
- In case of general delegations, Alice might alternatively be tempted to give Bob her account data and password in order to avoid the loss of votes.
- Furthermore, delegation of votes is always possible for people with technical skills: They could program automatic internet agents which perform delegations amongst each other outside of the system (i. e. copying ballots) and connect to an online participation system to cast the votes. While one effect is that less skilled voters would be discrim-

inated, another bad side effect would be that such "hidden" delegations are no longer transparently visible.

The same holds, when attempting to "attenuate" delegated voting weight, e. g. by reducing the weight of delegated votes using a factor or any similar means.

Such measures, while often intended to equalize power, in fact would undermine the principle of "one man – one vote" and thus discriminate those who can't circumvent the system or who are not willing to decide on every issue themselves. This is why unrestricted transitive delegations (as introduced on page 24) are an integral part of Liquid Democracy. With unrestricted transitive delegations the problems described above do not arise, and all people will have their vote counted independently of their social integration or their technical abilities to implement delegations outside the system.

Delegations are always given voluntarily and they are revocable at any time. Unrestricted transitive delegations are treating delegating voters and direct voters equally, which is most democratic and empowers those who could not organize themselves otherwise.

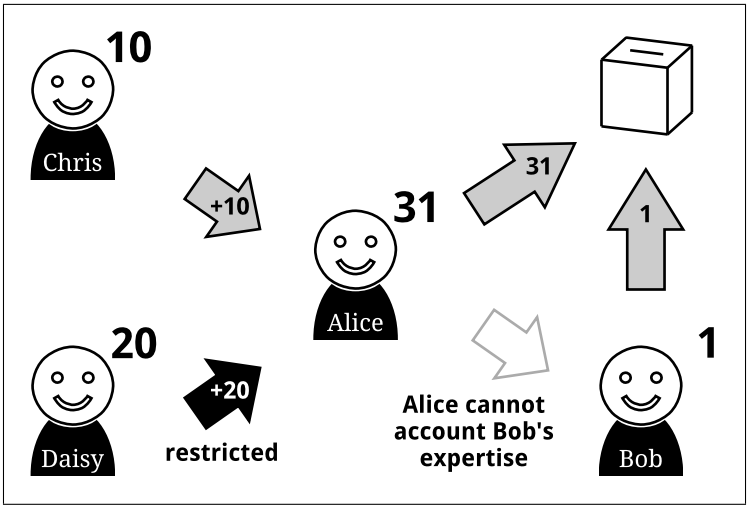

Figure 2.12: *Restricted delegations would push Alice to vote on a topic herself, even though she wants to consider Bob's expertise in this case. This is why Liquid Democracy utilizes transitive delegations that are* ***not*** *restricted or "attenuated."*

Chapter 3

Open ballot vs. secret ballot

3.1 Verifiability of voting systems

Democratic decision-making processes must be verifiable to be trustworthy. Enduring trust may only arise out of the possibility for the participants to verify the correct execution of all processes on their own. Verification that is only performed by an authority can't create continuous trust in a democratic system. Therefore, we will analyze particular voting systems regarding their ability to be verified by the participants based on a scenario of usage within a bigger organization, e. g. a political party. Finally, we discuss the consequences for LiquidFeedback.

3.2 Verifiability of non-electronic voting systems

3.2.1 Voting by show of hands

Our first subject of study will be to analyze the possibilities of verification of a "voting by a show of hands" by the members

of an organization in which this kind of voting is used.

Prior to the voting itself, there will be a check on who is eligible to vote. Usually this so-called *"accreditation"* (or *"voter registration"*) is done by checking an identification card of the alleged member and comparing it with the organization's database. The check is executed by appointees of the organization. The verification of this process by the other members of the organization is thus limited because the process may be only checked as much as members are allowed to access the data for accreditation. Members might not have access to all files of an organization and therefore can't check if a particular person is really a member and if this person is entitled to vote within the organization.

Nevertheless, it is possible for participants to notice errors or manipulations. As an example, we shall name the wrongful accreditation of an excluded ex-member or—in case of a political party—the wrongful accreditation of a "mole" of a competing party. In these cases a single participant is necessary to detect the wrongful accreditation and to cause public awareness of such an issue. A voter casting multiple votes instead of one vote can also be detected by the participants, as all participants of the vote have to raise their hands at the same time. The voting itself can be verified completely by the participants because while the hands are shown, everyone may check who is casting a vote and that each person is only casting one vote. It is also possible to verify the correct counting of the votes because the hand signs are visible for the participants.

Verifiability of "voting by show of hands":

Only eligible voters cast a vote:	*limited verifiability*
Only one vote cast by one voter:	*fully verifiable*
Votes are counted correctly:	*fully verifiable*

The previous example is the basis for almost all democratic decision-making processes. It is the most common voting method, and it has been used from Athenian democracy in ancient Greece through decisions in contemporary parliaments. All

other voting methods are—with one exception—just variations of voting by a show of hands.

3.2.2 Secret voting using a ballot box

The exception mentioned above is the secret ballot. In its most common form, a ballot box is used because of the unique property of its insertion slot to separate the cast ballot from each voter while maintaining verifiability due to its obvious (clear) design. The functionality of this mechanism is as easily verifiable that already children can understand and verify its correct implementation.

Let's have a look at the verifiability in detail using the example of an organization that uses voting with a ballot box for their decisions:

The accreditation itself (the identification who is eligible to vote) is the same as it was in the previous example of voting by a show of hands and thus can be verified by other members of the organization in a limited way. It is possible, if a single participant detects an error or fraud, to cause public awareness of the issue.

Moreover, it is—just like in the case of voting by a show of hands—possible to verify that each person is just casting one ballot, because the process of inserting the ballot into the ballot box is public. If necessary, one might require that the ballots may only be cast after they have been enclosed by an envelope, so it is possible to check that really only one ballot is cast per eligible voter when counting the ballots. All participants may verify that only people who passed the accreditation process cast a ballot and not for example representatives of the press who attend the meeting of the members.

If (a) the participants may see for themselves that the ballot box is empty before the voting starts, if (b) they can observe the closed ballot box during the cast of ballots (from closing the empty box to opening it again for counting), and if (c) the counting of the ballots is done publicly, then the participants can be sure that each person only cast one ballot and that the counting of the ballots is done correctly.

Verifiability of "secret voting with ballot box":

Only eligible voters cast a vote:	*limited verifiability*
Only one vote cast by one voter:	*fully verifiable*
Votes are counted correctly:	*fully verifiable*

3.2.3 Secret voting using distributed ballot boxes

As a special case, we shall have a look at the case of a secret ballot where multiple ballot boxes are used at the same time but at different locations. Assuming a manipulation of the accreditation process, it is possible for one person to try casting multiple ballots at different locations. Such fraud might not be conspicuous. However, because of the limited number of ballot boxes in total and because of their distance to each other and the limited time frame before the poll is closed, it is difficult for a single individual to manipulate the outcome in a noteworthy quantity. For a large scale manipulation there would be a lot of accessories needed, who may themselves cause a disclosure of such a fraud and who of course are liable themselves for participating in such a fraud. For distributed elections in some countries, semi-permanent markings (e. g. on a voter's hand) are used to further increase the difficulty to keep such fraud attempts undetectable.

Verifiability of "distributed ballot boxes":

Only eligible voters cast a vote:	*limited verifiability*
Only one vote cast by one voter:	*largely verifiable*
Votes are counted correctly:	*fully verifiable*

Of course—as already noted in the previous section—this only holds if the ballot boxes can be observed by the public at all time from closing the empty box to opening it again for counting.

3.2.4 Secret postal voting

As last method of non-electronic voting, we will examine postal voting (also known as "absentee ballot" in the U.S.). The accreditation is done by sending a ballot paper to the voter and is thus not verifiable by the participants. Neither obvious errors nor manipulations, like accrediting one person multiple times, can be detected by the voters.

The participants of the poll send the filled out ballot back to the voting office, which is collecting the ballots. This process is also not verifiable by the voters.

Only the last part, the actual counting of the votes, may be verifiable (if it is done publicly). As the voters need to trust the authority which is responsible for the preceding steps, being able to observe the counting of the votes doesn't have an impact on the overall verifiability of the whole process, because in case of a manipulation only the manipulated set of ballots would be counted "correctly." A public counting gives the proceeding a deceiving illusiveness of verifiability, which in fact—as explained above—is not existent at all. Due to this, even the counting of the ballots is sometimes not done publicly.

Verifiability of "secret postal voting":

Only eligible voters cast a vote:	***not** verifiable*
Only one vote cast by one voter:	***not** verifiable*
Votes are counted correctly:	*fully verifiable*

3.3 Verifiability of electronic voting systems

After examining the verifiability of non-electronic voting systems in the previous section, we'll now have a look at electronic voting systems.

Before we start considering particular methods of electronic voting, it has to be noted that these electronic voting systems

are an inherent part of any electronic participation system for democracy as long as there are quantified ratings including but not limited to final polls on ratifying a proposal. In case of LiquidFeedback, for example, any rating of a proposal is already comparable to participation in an electronic voting. This doesn't only apply to LiquidFeedback but also to any other system with quantified ratings by the participants. Electronic participation systems elevate electronic voting to an always present principle.

But now let's have a look at particular methods of electronic voting:

3.3.1 Open electronic ballot

Open electronic ballot means that both the accreditation and the casting of the ballots is done using an adequate identification token (e. g. a name) which is suitable to determine the person casting a ballot, given his or her identification token. The cast ballots are published along with that identification token.

The verification of the accreditation process itself may be limited because not all members might have access to the data used for determining who is eligible to vote (e. g. who has paid the membership fees). However—analogue to the voting by a show of hands—there are still ways to detect errors, as it is published who is casting which ballot.

Multiple ballots by the same person can also be easily detected. In such cases, the identification token would appear twice. Using an identification token which allows you to determine the person casting a ballot, it is also possible to check that only accredited persons have voted and not, for example, representatives of the press. Also the counting of the votes is verifiable, as all data is made publicly visible.

Verifiability of "open electronic ballot":

Only eligible voters cast a vote:	*limited verifiability*
Only one vote cast by one voter:	*fully verifiable*
Votes are counted correctly:	*fully verifiable*

Because an open ballot is not always desired, there are several approaches trying to achieve anonymity with electronic voting processes. Basically these approaches split into two different kinds: The first approach is to separate the electronic ballot from the person who is casting the ballot (which we will refer to as "voting computer type I"), and the second approach is to create an identity which is *decoupled* from the real person for casting the ballot (which we will refer to as "voting computer type II").

3.3.2 Voting computer type I

The first kind of approach to achieve anonymity in electronic voting processes tries to simulate the properties of a physical ballot box. Regardless of if an electronic voting machine is used or a voting software which runs on computers that are connected via the internet, none of these approaches are verifiable by the voters. Opposed to the little knowledge to understand the principles of a ballot box and to verify its correct application, there is always a huge amount of expert knowledge necessary to even understand the processes happening inside an electronic machine or a computer software. But even if there was the necessary knowledge, participants could still not check the used voting machine in practice, or—in case of internet voting—all voter's computers, which are connected to the internet.

Systems which utilize cryptography to separate the electronic ballot from the person casting the vote fall into this category as well. When judging these systems, it is important to not only consider the presumed mathematical properties but also the assumptions leading to these properties as well as the possibility to verify their correct application. Complexity of desktop computers or tablet PCs, including their hardware, firmware, and software, render verification by voters impossible, so that it is not possible to check if there has been some kind of fraud using trojans or other malware.

Regarding the "voting computer type I" we also refer to the work of the "Chaos Computer Club"[6] and the campaign "Wij vertrouwen stemcomputers niet"[7].

Verifiability of "voting computer type I":

Only eligible voters cast a vote:	***not** verifiable*
Only one vote cast by one voter:	***not** verifiable*
Votes are counted correctly:	***not** verifiable*

For the sake of completeness, it shall be noted that the lack of verifiability doesn't only apply to the correct counting of the votes but also to the anonymity of the voters. The voters can't make sure that they are truly anonymous when casting their ballot.

3.3.3 Voting computer type II

Another approach to achieve anonymity in electronic voting processes is to do an open electronic ballot with identities that are *decoupled* from the real person. By doing an open ballot with the decoupled identities, one may try to avoid the problems of the previously discussed voting computer type I and achieve the verifiability of the open electronic ballot. These decoupled identities which are used for the open electronic ballot, however, must be assigned in a way such that every identity has a real person behind it and that no person uses multiple identities. This may be achieved using a central authority, e. g. the executive board of an organization, which assigns a pseudonym to each eligible voter, or a government office which issues an electronic signature card allowing to electronically sign ballots. Whether there is a real person behind each identity can't be verified by the participants though.

Because such a pseudonymous identity is not suitable for the participants to gather who really cast a ballot, it is not possible to verify the accreditation process at all. The participants also cannot verify if each person cast only one vote, because it's not possible to exclude the possibility that one person got multiple identities. Instead, the voters must trust, for example, the government authority that issued the electronic signature card.

Eventually—analogue to the postal ballot—the only remaining

thing to verify is that ballots are counted, where the participants can't verify that each ballot is originating from a unique eligible voter. The open ballot thus gives the whole procedure a deceiving illusiveness of verifiability, which in fact is not existent at all.

Verifiability of "voting computer type II":

Only eligible voters cast a vote:	***not** verifiable*
Only one vote cast by one voter:	***not** verifiable*
Votes are counted correctly:	*fully verifiable*

Furthermore, the ballot is not even secret since the pseudonym has been assigned by an authority (e. g. by the government or by the executive board of an organization). Any person who obtains information about the assignment of pseudonyms, either with consent of the authority or by stealing that information, would gain complete knowledge of every voter's ballot.

One may try to enhance the "voting computer type II" in the following manner: For every poll, another identification token (e. g. the real name) is used to publish a list of all participating voters. Both the list of real names in this example and a list of ballots with pseudonymous identification tokens is then published. One might argue that given the list of participating voters it is possible to verify who cast a vote and that one voter only cast one ballot, as the count of real names and the count of ballots can be verified.

But lets take a closer look at this idea: Because the ballots are published in a pseudonymized fashion, each voter has to verify his or her own ballot. It is not possible to detect fraud by noticing large-scale unusual voting behavior of other people. However, it is still possible to detect fraud if

- you notice you're on the list of participating voters but haven't taken part in the poll yourself, or if
- you have taken part in the poll but don't find your

pseudonymous token with your correct ballot in the published result.

Does this grant voters verifiability of the proceedings while maintaining anonymity?

First of all, it has to be noted that verifying one's own ballot isn't as easy as it appears. If you use a computer to cast your vote, and if this computer has been manipulated by an attacker, then it is not sufficient to use your own computer to verify that your ballot has been published (and counted) correctly because an attacker could manipulate any information displayed. Instead of using only your own computer for verification, various channels should be used to publish the cast ballots. To verify that your own vote is counted correctly you'd need to ensure that the ballot data shown to you is the same as the ballot data shown to other voters, who verify their own votes. Assuming disciplined behavior of all participants, it is thus possible for each voter to verify that his or her vote has been counted correctly and that there were no malicious extra ballots inserted to the count.

While at a first glance, this appears like a solution for the problem of verifiable and anonymous electronic voting, there remain two unresolved problems, which are both due to the fact that anonymity is required:

At first a problem already discussed when talking about the "voting computer type I" is still unresolved, that is inherent to any form of secret electronic voting: The complexity of desktop computers, tablet PCs, or any other dedicated electronic voting machines does not only have an impact on the ability to verify the correct counting of votes but also an impact on the ability to verify that anonymity is ensured properly. Real world systems are too complex to ensure that the overall voting procedure does really guarantee anonymity.

But despite these general unresolvable problem of electronic voting, there is yet another problem with the described method of the improved "voting computer type II": If you notice that your own vote has been counted in a wrong way, there is no way to fix the situation but by disclosing the link between your true identity and the pseudonymous identity under which the ballot

was publicly posted. However, disclosure of the link between your true identity and the pseudonymous identity used for the ballot is not possible as long as you want to keep up anonymity. One still might argue that it would be sufficient if one voter is "brave" enough to reveal his or her identity to uncover a fraud. However, it is not possible to prove that your vote was manipulated—you can only *claim* that it showed up wrongly in the result. This isn't sufficient to verify whether the poll has been or has not been manipulated. It should be noted that this lack of provableness is also existent in the "open electronic ballot," but in case of the open ballot it is usually possible to correct those ballots that are claimed to have been recorded in a wrong way.

3.4 The "Wahlcomputerproblem"

In the previous sections it has been shown that secret electronic voting can't be implemented in a safe way such that the anonymity and the results of a poll can be verified by the participants. These observations and conclusions have also been part of a jury trial in the Federal Constitutional Court of Germany, where the usage of NEDAP* voting machines for general elections was finally forbidden by court order in 2009.[8] While the case was about specific voting machines, a general declaration has been made by the judges. To back up our statements of the previous sections, we shall have a look at the expert opinion[9] of the Chaos Computer Club, which was heard by the federal court:

Beneath an intense test of the specific NEDAP voting machine type, the authors of the expert opinion state some general considerations about the usage of computers for secret voting. Traditional pen-and-paper ballots are well known and by following a number of simple steps it is easy to prevent manipulations, which is important for the security especially under bad circumstances:

*Nedap N.V., a company based in the Netherlands

"Für Wahlen mit Papier und Stift sind mögliche Manipulationsverfahren seit mehr als hundert Jahren bekannt und werden mit sehr einfach zu befolgenden und logisch erschließbaren prozeduralen Methoden verhindert. Die einfache Überprüfbarkeit von Papier-und-Stift-Wahlen durch jeden Wähler bildet einen großen Sicherheitsfaktor, der in der Vergangenheit die Entdeckung von Wahlfälschungen auch unter widrigen Umständen erlaubte."[9]

The possible tampering methods for elections with paper and pen have been known for more than hundred years and are prevented by procedural methods which are very easy to follow and logical deducible. The simple verifiability of pen-and-paper-elections by the voter constitutes a huge security factor, which has made the discovery of election forgeries possible in the past—even under adverse circumstances.

The authors are describing that the development of manipulation methods is a highly dynamic process where new discoveries are made, which can make previous assumptions obsolete at any time. The practical verification can only be done by experts, not by the voter, and can only have limited success:

"Die Entwicklung von Angriffs- und Manipulationsverfahren in der Computertechnik ist ein hochdynamischer Prozeß, bei dem in sehr kurzen Abständen neue Erkenntnisse entstehen. Diese neuen Erkenntnisse machen häufig die vorherigen Annahmen über die notwendigen Sicherheitsmaßnahmen obsolet. Das kontinuierliche Verfolgen der letzten Entwicklungen, das Nachvollziehen der Angriffsmethoden und die Beurteilung der Risikoentwicklung für den spe-

The development of attack and manipulation methods in computer science is a very dynamic process in which new findings arise at very short intervals. Often these new findings make previous assumptions regarding necessary security measures obsolete. The continuous tracking of the latest developments, understanding the attack methods, and evaluation of the risk changes for the specific use case can only be done by experts. This requires significant efforts and

zifischen Anwendungsfall ist nur von Experten zu leisten. Dies erfordert erhebliche Aufwendungen und führt in der Praxis immer nur zu einem beschränkten Erfolg. Die Überprüfbarkeit etwaiger Schutzmaßnahmen durch den Wähler ist nicht zu realisieren. [...]"[9]

leads only to limited success in practice. Voter's ability to verify any deployed protective measures can't be achieved.

Furthermore, the authors are describing that the high dynamic of the development of manipulation methods also leads to the possibility of actual manipulations which could remain completely undetected. This problem can't be eliminated by a certification process, even if it is done very thoroughly:

"Die grundlegende Dynamik der Angriffsentwicklung ist einer der wesentlichen Risikofaktoren computergestützter Wahlverfahren. Im Gegensatz zum altbewährten Verfahren können jederzeit bislang unbekannte, nicht absehbare Angriffsmethoden entwickelt werden, die unerkannt bleiben und eine Wahlfälschung ermöglichen. Selbst ein sehr gründlicher Zertifizierungsprozeß ermöglicht es nicht, diesen Risikofaktor zu eliminieren, und ersetzt nicht die Überprüfbarkeit durch den Wähler. [...]"[9]

The basic dynamic of attack development is one of the significant risk factors of computer supported voting methods. In contrast to the well-tried system [of non-electronic voting], not yet known and not foreseeable attack methods can be developed that remain undiscovered and make election forgery possible. Not even a very thorough certification process is able to eliminate this risk factor, and it can not supersede verifiability by the voter.

The authors state that voting methods must also work under bad circumstances while staying verifiable:

"Ein Wahlverfahren muß [...] so beschaffen sein, daß es unter allen, also auch unter widrigen Umständen funktioniert und überprüfbar bleibt. [...]"[9]

A voting method must be such that it works and stays verifiable under any—including adverse—circumstances.

Also a practical example from the recent German past is given by the authors. In former East Germany it was possible for courageous citizens to make an (at least unofficial) proof of systematic election forgery by observing the ballot boxes, the counting of the votes, and comparing the summed results with the official results. With electronic voting machines this would not have been possible:

"Selbst unter den Bedingungen der DDR war der inoffizielle Nachweis der Wahlfälschung durch Beobachtung der Auszählung in den Wahllokalen, Zusammentragen der Ergebnisse aus den einzelnen Wahllokalen und Vergleich mit den offiziellen Zahlen möglich. Mutige Bürger haben so versucht, den systematischen Wahlbetrug in der DDR aufzudecken. Mit Wahlcomputern wäre dies nicht möglich gewesen, die Ergebnisse hätten bereits unsichtbar in den Computern manipuliert werden können."[9]

Even under the conditions of the GDR [German Democratic Republic; former East Germany] the (unofficial) proof of election forgery was possible by watching the counting of the votes, gathering the results from the different polling places and comparing them with the official results. Using voting computers, this would not have been possible for courageous citizens as the results could have been invisibly manipulated inside the computers.

Constanze Kurz
Frank Rieger
Rop Gonggrijp

Translation: Behrens, Kistner, Nitsche, Swierczek

We therefore conclude once more: In real world it is *not* possible to implement a secret electronic voting system whose functionality can be verified by the voters. The German term *"Wahlcomputerproblem"* is used to refer to this problem.* The three design goals

- verifiability by the participants,
- secrecy of the ballots, and
- using an electronic system for casting the ballot

are not achievable at the same time for a particular voting system. You may only cover two of these three design goals at once: It is possible to create secret electronic ballots, but they will not be verifiable by the voters. If you need verifiability, it is also possible to create a secret ballot with real ballot boxes instead of voting computers. But the only way to gain verifiable electronic voting is to do an open electronic ballot and to surrender anonymity.

Whenever citizens are entitled to vote on something, there is usually a secret ballot. It is a constitutional requirement for parliamentary elections in most democratic countries. Secret ballots shall ensure the anonymity of a voter casting a ballot and thus ensure freedom to vote for any option without anxiety for personal consequences. Assuming their correct implementation, nobody can be coerced to vote for someone or something which he or she is not really in favor of. Secret ballots are an integral part of democratic states. Any parliamentary election which doesn't make use of a secret ballot is usually not considered to meet democratic standards.

Does this foil all forms of electronic democratic participation? While for parliamentary elections the anonymity of voters is a necessity that shouldn't be questioned, there are other decision-making processes where an anonymity of the voters is not always desired. One example for open ballots are decisions *within* a parliament: It is often desired that the general public can gather information about the voting behavior of their elected representa-

*The German word *"Wahl"* means "choice" or "election".

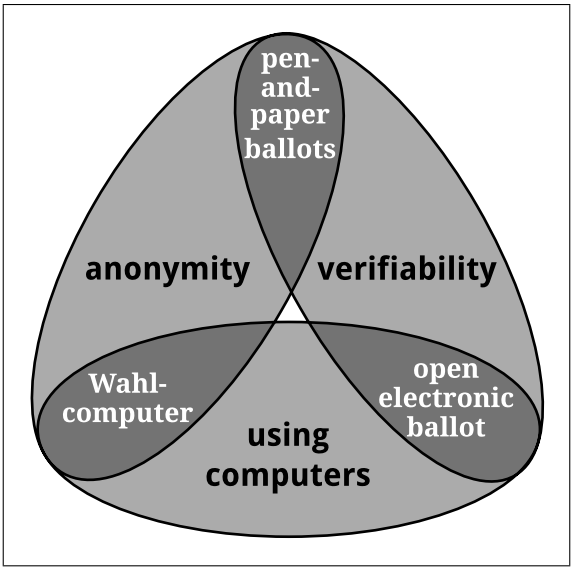

Figure 3.1: *Set diagram "Wahlcomputerproblem"*

tives on political issues, as otherwise those politicians would not be accountable for their actions and nobody would know which politicians were passing a particular law or provision. Thus some parliamentary decisions are even made by roll call, where every voter's decision is recorded ("recorded vote").

While Liquid Democracy doesn't aim to be used within a parliament itself, there are other areas of applications where democratic decisions by recorded vote are possible and can grant advantages: Political parties and other organizations might want to structure their decision-making processes in a transparent way so it is made possible for outsiders to take insight into the internal processes of the organization. Political parties can use such public disclosure to fight reproaches of nontransparent lobbying and nepotism. We will get back to the usage by political parties in chapter 6, starting on page 119.

3.5 Modern alchemy

Despite our previous reasoning, there are numerous attempts to solve the "Wahlcomputerproblem". A common argument is that IT security is all about risk management. While in most IT systems risk management is a reasonable practice, this must not be applied to the verifiability of secret ballots in democratic decision-making processes, as it is—like previously explained—in practice impossible to prove that one's vote has been counted incorrectly by the system and not been intentionally entered by the voter in a certain way. Exposing the verifiability of democracy to risk management undermines the trustworthiness of democracy itself—unfortunately ***not*** just in those cases where an actual fraud happens. In either case the damage cannot be repaired with financial transactions.

Nevertheless, there are certain advances in crypto-mathematics which aim to solve this problem. While these efforts are of academic interest, they cannot solve the general problem as we have already discussed in subsections 3.3.2, 3.3.3, and section 3.4.

Reputable research papers on secret voting algorithms always list assumptions, under which the mathematical proofs are

valid. While certain algorithms may have interesting (theoretical) properties, their real-world application can't address the inherent problems of secret electronic voting. In case of respectable papers, this may be deduced from the assumptions stated in those papers.

However, electronic voting systems are part of a potential multi-million dollar industry. Therefore, the "assumptions" mentioned above are sometimes hidden or played down in research papers on this topic. Often "major advances" are advertised, claiming that only a few more problems need to be addressed to create a verifiable electronic voting system.

We would like to advise our readers to be cautious when reading about promises made by the vendors of secret electronic voting solutions. We also want to repeat: When judging these systems, it is important to not only consider the presumed mathematical properties but also the assumptions leading to these properties as well as the voter's ability to verify their correct application.

3.6 Scope of LiquidFeedback

LiquidFeedback is not implementing secret voting but only aims for those use cases where a *recorded vote* is intended. In these cases, LiquidFeedback can be used to create a trustworthy, verifiable, and fair process for democratic decision-making. Thus LiquidFeedback solely relies on the "open electronic ballot" as method to decide on issues or to rate proposals.

The accreditation process, however, is not part of LiquidFeedback and must be implemented separately. So it is possible to operate LiquidFeedback as a "voting computer type II" by using pseudonyms as identification tokens. We strongly discourage the use of LiquidFeedback under such operating conditions for democratic purposes, though there are some non-politic use cases (i. e. use in companies) where verifiability might be dispensable. In political contexts verifiability must not be surrendered and LiquidFeedback should only be used in those cases where a recorded vote is desired or acceptable. Whenever a secret ballot is desired,

we strongly urge to refrain from using any electronic voting solution (including LiquidFeedback) and recommend to use real ballot boxes in those cases instead.

3.7 LiquidFeedback for the public

In the previous sections, we explained why online democracy should only be used in those cases where an open ballot is acceptable. Does this exclude the public from electronic decision-making?

LiquidFeedback can be used for civic and constituency participation as an *additional* communication channel between citizens and their administration, or voters and their representative, respectively. An open ballot can be used for petitions or suggestions to the actual lawmakers, while the final decision is done by elected representatives, who have been voted by secret ballot.

But LiquidFeedback is not limited to nonbinding petitions or suggestions by the public. Political organizations, and political parties in particular, may use LiquidFeedback for binding decisions, thus empowering their own members and becoming more attractive to citizens. This would be an invitation of a given political party to make politics—in Lincoln's words[10]—*of the people, by the people, for the people.* This party would still have to convince the general public in secret elections.

Chapter 4

LiquidFeedback and a fair process for decision-making

4.1 Structured discussion

Democracy and decision-making is not just about voting but also needs a discussion process to allow participants to form opinions. The ability to express opinions and to debate them is an integral part of democracy, as knowledge about arguments and counter-arguments is the basis of reasonable decision-making. But "reasonability" is subjective and depends on the will of the participants. In order to provide a fair process for decision-making that scales with several thousand or more participants, LiquidFeedback employs a *structured* discussion where it is *not* possible for every participant to reply to any contribution. Instead, LiquidFeedback employs a system for exchanging arguments which agitates people to make constructive proposals in order to gain other people's support.

4.1.1 Initiatives

An "initiative" is the main way to express a will for a specific issue and to substantiate this will by giving arguments and counter-arguments against other initiatives and their arguments. Every eligible voter inside the LiquidFeedback system is allowed to create a new initiative. An initiative basically consists of:

- a non-alterable title,
- a text body ("draft"), which may contain a resolution text and/or an explanatory statement (collection of arguments),
- a list of participants which are entitled to update the draft ("initiators"),
- a list of participants which are supporting the initiative with their voting weight ("supporters").

When creating a new initiative, a participant may decide him or herself whether to create that new initiative as an *alternative* initiative to an existent group of competing alternatives or to open a new group of alternative initiatives starting with one initiative on its own. While one initiative may be biased, participants which create alternative initiatives to an already existing initiative will display other views and opinions.

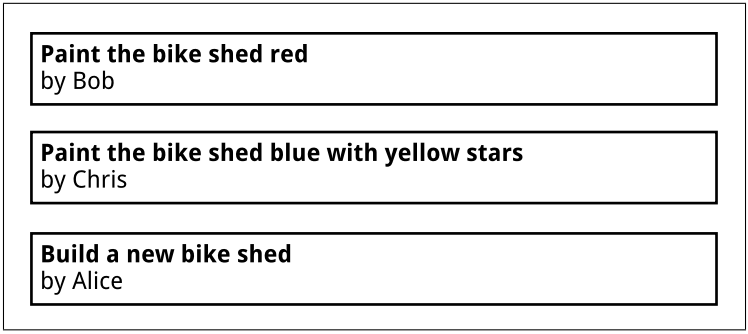

Figure 4.1: *A list of initiative titles with their initiators.*

During discussion of an issue, the initiators try to improve their draft in order to gain supporters. Each participant may support as many initiatives as he or she wishes, including alternative initiatives that are competing with each other.

By encouraging the initiators to prepare ordered overviews for an issue, newcomers to the discussion will have an instant overview on an issue instead of needing to examine long discussion threads, as it would be the case in classical web forums or mailing lists. The initiators do not need to be unbiased, which is a very important advantage when using the system to discuss and decide on controversial topics.

4.1.2 Suggestions

Whenever someone likes the general idea of an initiative but doesn't like the particular proposal for resolution, or if someone demands that a certain aspect should be taken into account, or if someone thinks that a certain question should be answered, then it's possible to write a suggestion for the initiators. The initiative as well as it's suggestions are visible to all other participants.

Suggestions may only be written by participants who generally support an initiative, though their support might be conditional (e. g. "I only support the proposal, if . . . "). Whenever someone supports an initiative only under certain conditions that are not met yet, we speak of *"potential supporters."* In all other cases we call them *"satisfied supporters."* Beside writing your own suggestions, it is also possible to rank other people's suggestions as long as you are a supporter or potential supporter of the corresponding initiative. You can rank both your own suggestions and other people's suggestions as:

- must be implemented
- should be implemented
- should not be implemented
- must not be implemented

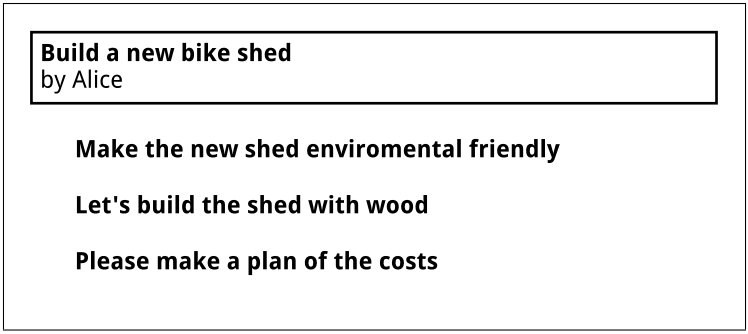

Figure 4.2: *Suggestions to an initiative.*

As it is a subjective matter to decide if an initiator has actually implemented a suggestion properly, the participants may also mark if according to their opinion the suggestion

- has been implemented by the initiators,
- has not been implemented by the initiators (yet).

All rankings/markings of each participant are visible to all other participants.

Marking at least one suggestion as "must be implemented" and "has not been implemented" automatically turns you into a *potential* supporter of the initiative this suggestion belongs to. The same holds when you mark a suggestion as "must not be implemented" but you consider it as "has been implemented." The initiators of an initiative (as well as other participants) can analyze the quantified ratings of the suggestions in order to improve their initiatives. However, initiators are not forced to change their draft, even if a majority of supporters demand it. (We will return to this issue later when discussing protection of minorities in section 4.10, subsection 4.10.6 on page 86.)

4.1.3 Free discussion

Requiring participants to channel their contributions into initiatives and suggestions is necessary for a large-scale discussion

but may be overkill when people simply want to do brainstorming. While LiquidFeedback itself does only provide *structured* means of discussion, it does not deter people from using other means of discussion such as: round tables, closed or open web forums, private discussions, etc.

As we will later see in section 4.5 ("Deadlines and full disclosure") and section 4.6 ("Issue states"), the results of such side-channel discussions are still required to be disclosed and structured eventually.

4.2 Fairness and scalability through Liquid Democracy

All principles of Liquid Democracy, as discussed in chapter 2, are also part of the LiquidFeedback decision-making process. This does not only apply to final decisions but also to supporting initiatives and rating suggestions during the structured discussion process.

Using the concept of Liquid Democracy within the software LiquidFeedback, it allows people to have their interests represented during discussion, regardless of their ability to spend time or effort for a particular issue. In return, people are not urged to decide on issues where they lack expertise.

4.3 Collective moderation

Democratic processes inside organizations are traditionally organized by a chairman, a "request commission," or similar institutions. As LiquidFeedback aims to allow every participant to gain equal rights and chances in the decision process, LiquidFeedback generally abstains from empowering one or multiple participants to have any special privileges for moderating a discussion or decision-making process. Instead, the moderation is done in a collective process where every person has equal rights. This collective moderation process consists of:

- unlabeled groups of alternative initiatives, where every participant may add an initiative on his or her own choice,
- a predefined timing framework determining when alternative initiatives can be posted, when initiatives can be updated, or when it is possible to finally vote on particular initiatives,
- the requirement for initiatives to reach a certain quota of supporters, and
- sorting all contributions (initiatives and suggestions) based on their supporters and individual rankings using special algorithms.

These mechanisms will be explained in more detail in the following sections.

4.4 Unlabeled groups of alternative initiatives

It is well-known in opinion research that a slightly different question can create a massively different outcome of a survey. LiquidFeedback is not a survey tool though and thus doesn't ask predefined questions. Instead, all participants post their notions directly as initiatives (see subsection 4.1.1 on page 60). Initiatives create groups of competing alternatives. These groups are called "issues." To avoid influence through a title of subject, issues carry no "name" or "description" within the system but just an abstract number (i. e. "issue #1234"). Each initiative, however, has a name that may be freely chosen upon creation of the initiative.

When listing several groups of competing alternatives, three initiative titles (or more when desired by a user) are used for each group of alternative initiatives to give a roundup on the discussed issue. This approach avoids the need for an unbiased "referee", that might be impossible to find—or at least impossible to select—in a political context. To create a representative

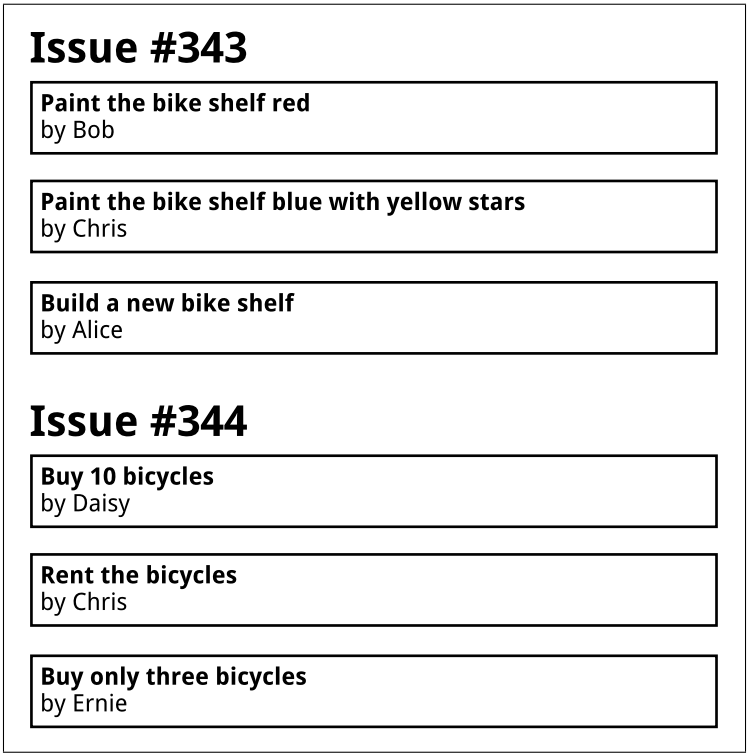

Figure 4.3: *Two numbered issues, which are each consisting of 3 competing initiatives.*

composition, the initiatives are sorted using a special algorithm, and then the first three initiative titles are used for an overview on the issue. The algorithm for sorting the initiatives will be explained later in subsection 4.10.1 on page 74 ("Harmonic Weighting").

4.5 Deadlines and full disclosure

When we talk about LiquidFeedback providing a fair process for decision-making, then we mean giving every participant a reasonable and fair chance to be heard and to influence the decision-making process. In order to influence decision-making, it is vital to have the necessary information about ongoing plans for resolutions. While it is neither possible nor desirable to prohibit people from making political plans within closed groups, eventually all participants must be able to gain knowledge about these plans and have enough time to react to them.

Using LiquidFeedback for making decisions ensures that all planned resolutions must be posted within the system in order to become a final decision. All initiatives and suggestions inside LiquidFeedback are instantaneously visible to all participants. A timing framework, which we will describe in the next section, further ensures that all participants have enough time to react to any proposal entered into the system.

4.6 Issue states

Every issue in LiquidFeedback (which may consist of one or more alternative initiatives) is required to pass certain stages (or states) during its lifetime:

- admission phase,
- discussion phase,
- verification phase,
- voting phase.

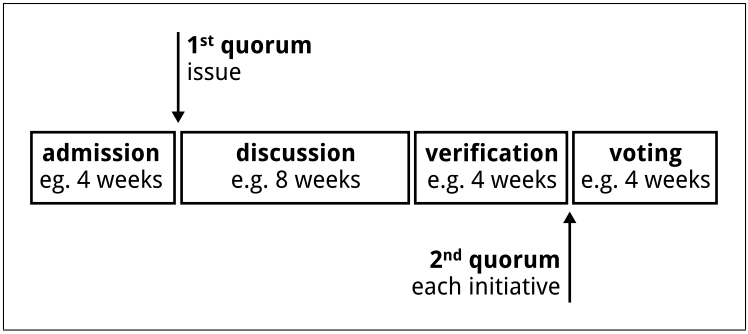

Figure 4.4: *The four phases of an issue in LiquidFeedback.*

A group of alternative initiatives (i. e. an issue) always enters these stages simultaneously. This means that all initiatives in competition with each other share the same state.

4.6.1 Admission phase

A group of alternative initiatives starts in the admission phase when its first initiative is created. During admission phase, the system determines if there is interest at all in discussing the issue. This is done by requiring a certain quorum of supporters (including *potential* supporters) for at least one of the alternative initiatives. When one initiative reaches this first quorum, then the admission phase ends instantaneously and the initiative (as well as all other alternative initiatives belonging to this issue) will proceed in discussion phase. If no initiative manages to pass the first quorum, then the issue will be closed after a preset time and not discussed or voted upon further.

4.6.2 Discussion phase

Whenever a group of alternative initiative enters discussion phase, then all participants can notice that there is a real interest to resolve or at least discuss an issue. During discussion phase (as well as admission phase) supporters of initiatives may

give suggestions, and initiators are able to update their drafts in order to improve their resolutions and arguments. Whenever an initiator updates their draft, all supporters are notified about the update. It is up to the supporters to revoke their support or to update the rating of suggestions whenever the initiators change their current proposal. If a supporter doesn't react to an initiator's update of an initiative, then his or her support is still counted by the system as elsewise initiators would be deterred from making improvements to their proposals. However, the system displays which supporter of an initiative has acknowledged the latest draft.

As initiators are able to update their drafts during discussion (and admission) phase, LiquidFeedback furthermore allows initiators to completely revoke their initiative, as such behavior can't be algorithmically avoided: Initiators could still update their draft to a text like "This initiative is void", even if it was not possible to revoke an initiative formally. As we will see in the following subsection, when explaining the verification phase, LiquidFeedback implements countermeasures against initiators who change their drafts (or revoke their initiatives).

The discussion phase takes a fixed amount of time. After this time has elapsed, all alternative initiatives enter verification phase as described below.

4.6.3 Verification phase

Because initiators can change their drafts during discussion phase, it might be possible to betray supporters of an initiative by making a certain proposal and then in the last minute change this proposal in a shocking way. The verification phase exists to give supporters time to revoke their support:

During verification it is not possible to update initiative texts anymore. However, it is possible to add new alternative initiatives, which will be competing against the existent ones. This enables participants to re-create an initiative which was changed or revoked by an initiator in the last moments of discussion phase. Supporting initiatives (as well as revoking your support for an initiative) is possible during admission phase, discussion phase,

and verification phase.

The verification phase, like the discussion phase, also takes a fixed amount of time. Each initiative needs to pass a second quorum of supporters at the end of verification phase. Opposed to the first quorum in admission phase, the second quorum needs to be passed by each alternative initiative independently and only considers *satisfied* supporters and not *potential* supporters. (For an explanation of "satisfied" and "potential" supporters refer to subsection 4.1.2 on page 61.) The second quorum reduces the work load for those participants who want to participate in the final voting as described below.

4.6.4 Voting phase

During voting phase all participants may vote in favor or against those alternative initiatives which have passed the second supporter quorum. In addition it is possible to express preferences amongst those initiatives you are in favor of or against. The voting phase takes just like discussion and verification phase a fixed amount of time.

Details of the voting rules are described in section 4.12, starting on page 91. During voting phase, any cast ballots are temporarily hidden until voting phase ends. This will be justified in section 4.14 starting on page 109.

4.7 Different policies for different kinds of decisions

LiquidFeedback may be used to make different kinds of decisions, for example:

- making decisions affecting the budget of the organization,
- changing or deciding upon a manifesto for an organization,
- changing statutes of an organization, or
- giving recommendations to parliamentary representatives.

Different timings and quorums might be suitable for different kinds of decisions. Moreover, in some contexts there might be supermajority requirements during final voting, as for example changing the statues of some organizations requires 2/3 of the votes to be in favor of the motion.

To allow different values for timings and supporter quorums, and to allow the possibility of supermajority requirements for certain decisions, LiquidFeedback allows its users to have so-called *"policies"* for different kinds of decisions.

As LiquidFeedback aims to give every participant equal rights, the classification of initiatives is not accomplished by a request commission or a similar institution. Instead, the policy for a group of alternative initiatives is chosen by the first initiator of the first initiative. As the first initiator shouldn't gain extra advantages by choosing a policy, it is vital to have rules of procedure that regulate which policy may be used for what kind of decisions. Thus, what applies to the "subject areas" as explained on page 26 also applies to "policies": Whenever the participants decide on something using the wrong policy, then such a resolution must be void, just like a committee exceeding its authority. When participants notice that a given initiative exceeds its policy's capacity, they should state their concerns in an alternative initiative and promote to discuss the issue in new initiatives with the correct policy.

In particular, a policy in LiquidFeedback contains the following:

- a name of the policy and a text describing for which decisions the policy may be used,
- the maximum time for one initiative to reach the first supporter quorum (maximum time of admission phase),
- a value for the necessary quorum of supporters during admission phase (first quorum),
- the duration of the discussion phase,
- the duration of the verification phase,

- a value for the necessary quorum of supporters at the end of verification phase (second quorum),
- the duration of the voting phase,
- optional (super)majority requirements during final voting.

4.8 Subject areas

LiquidFeedback allows delegating different subject areas to different people. Issues must thus be structured by assigning each issue to a subject area. To avoid the need for a moderator or request commission with special privileges, the initiator of the first initiative of an issue decides to which subject area his or her initiative belongs. As already explained on page 26, previously defined rules of procedure must regulate which subject areas within the system exist and what kind of resolutions they may enact.

4.9 Determining the necessary quorum

The "policies," as described in section 4.7, allow to set a certain fraction (e. g. 10%) of supporters to be required for a group of initiatives to be further discussed or for a particular initiative to enter the final voting process. Whenever we talk of a fraction of people, we need to define the reference population though.

As not everyone will be interested in every kind of decision, LiquidFeedback does not base the supporter quorum on all participants within the system. Instead, participants can become enlisted for a particular subject area, which causes them to get counted as part of the reference population when calculating a necessary quorum.

In addition it is possible to declare interest in a particular group of alternative initiatives (i. e. interest in an "issue"). This

happens automatically when becoming a direct* supporter of one or multiple initiatives of this issue. You need to either be enlisted in the subject area where an issue is discussed in, or have declared interest in that particular issue (e. g. by supporting one of the initiatives directly) to be taken into account for the reference population.

To consider the effect of delegations on supporter counts, the reference population is further increased by people that are delegating, i. e. by those people who would not be member of the reference population otherwise but who delegate the issue to someone that already counts for the reference population.

This calculated reference population is then used to determine the absolute supporter count that is necessary to surpass a supporter quorum. E. g. if the reference population is 500, and if the selected policy requires a 10% quorum, then a supporter count of 50 is needed.

4.10 Protection of minorities

Democracy means that decisions are made by majorities (see also section 4.13, "Majority Rule" on page 106). Consequentially, every decision without unanimous assent leads to an overruled minority. Nevertheless, minorities can—*and must be*—protected in certain ways:

First of all, most democracies grant their people unalienable rights which can't be abolished even by a majority of the parliament. These rights are one important form of minority protection, as a decision to discriminate a particular group of people might be unconstitutional and thus void when negotiated in court. This form of protection can't be ensured algorithmically and thus is—by principle—out of scope of LiquidFeedback or any other computer system. It needs to be implemented in a constitution, party statutes, etc. and carried out by humans who judge about every single case.

Another form of minority protection can be implemented algorithmically though: In a democracy, every group (including

* *direct* means "not via delegation" here

minorities) must have the chance to promote their positions. It is vital for a democracy that groups consisting of less than 50% may propose alternative proposals, which are then presented and discussed in an adequate way. In general meetings or party conventions the presentation of such minority viewpoints is classically done by assigning discussion time. But using an internet-based system like LiquidFeedback allows to have a huge amount of proposals at discussion in parallel. However, when a huge number of people wants to put a huge number of proposals to discussion, a limited resource is the *placement on the screen*. In an online system we thus do not allocate "discussion time" but "display positions," i. e. we determine a fair ordering when listing different

- issues within a subject area,
- initiatives for an issue, or
- suggestions for an initiative.

In the following two subsections 4.10.1 and 4.10.2, we will explain two algorithms in detail: one algorithm that is used to order the list of alternative initiatives for issues ("Harmonic Weighting"), and another algorithm that is used to order the list of suggestions for each initiative as well as the list of issues in admission phase within a subject area ("Proportional Runoff"). Subsection 4.10.3 will cover further details on sorting issues in LiquidFeedback. These algorithms are executed at regular intervals during admission, discussion, and verification phase, and once at the beginning of voting phase to create a fair ordering of any text contributions posted within the system.

If you are not interested in the particular details of these algorithms, you may skip the following three subsections and jump forward directly to subsection 4.10.4 on page 84, where we talk about the common problem of "noisy minorities" and give reasons for the defined proportional representation algorithms. In subsections 4.10.5 and 4.10.6, we will discuss further differences between LiquidFeedback and traditional decision-making systems which also have an impact on minority protection.

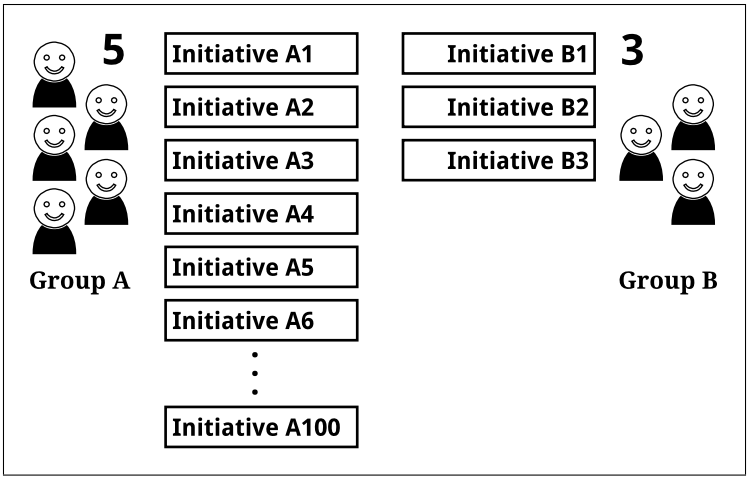

Figure 4.5: *Exemplary situation where a majority (62.5 %) supports a huge number of initiatives (100 initiatives), and there is a minority (37.5 %) which wants to present 3 other initiatives.*

4.10.1 Harmonic Weighting

The most straightforward approach to sort alternative initiatives within an issue would be to do it based on their supporter count. But as it is possible to support multiple alternative initiatives at the same time, sorting initiatives just based on their supporter count could compromise minorities' ability to display their viewpoints: any group which is larger than a minority and which creates and supports many alternative proposals would "bury" the proposals made by this minority.

On the other hand, limiting supporters to support only one initiative of a group of alternative initiatives would have other side-effects: whenever a minority is unsettled on details of a given proposal, multiple initiatives could lead to a vote-splitting that would harm the minority's ability to put up at least one of their proposals to a proper display position. (This problem also has to be taken into account for the final vote, see section 4.11 on page 87.)

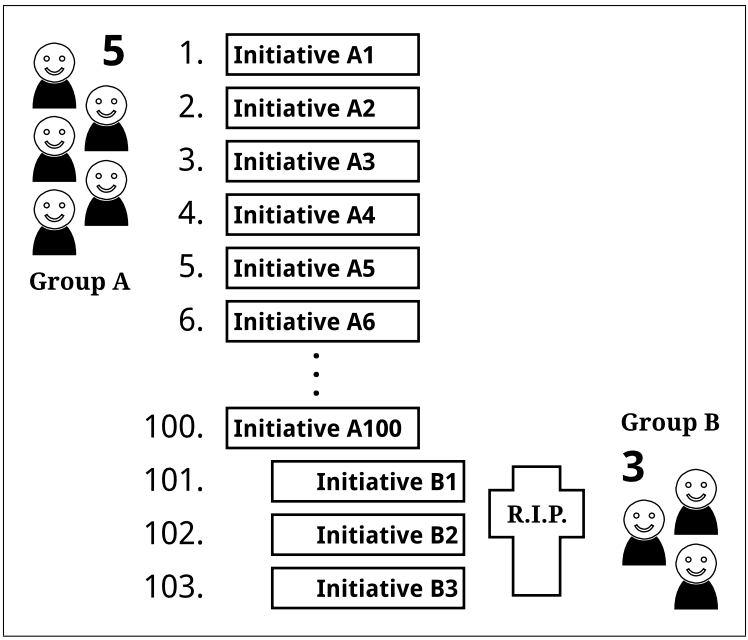

Figure 4.6: *Sorting initiatives based on their supporter count causes the initiatives supported by group B to be "buried" below 100 other initiatives.*

For sorting alternative initiatives for an issue, we need a system that allows participants to support *multiple* alternative initiatives simultaneously. It also needs to grant minorities fair display positions independent of the number of initiatives that are supported by larger groups of people *and* independent of the number of initiatives the minority supports itself. To achieve these goals, LiquidFeedback uses the following algorithm to assign display positions to alternative initiatives:

1. All initiatives are marked as unplaced (i. e. having no display position assigned yet).

2. Each supporter which supports at least one unplaced initiative gets assigned a weight of d/n, where d is the amount of own+delegated voting weight (e. g. 1 in case of no incoming delegations) and n is the number of *unplaced* initiatives which *this* person supports.

3. Each unplaced initiative gets assigned a weight equal to the sum of the weight of all its supporters.

4. That unplaced initiative with the lowest sum is placed, starting from the worst position.*†

5. Steps 2 through 4 are repeated until all initiatives are assigned a display position.

Since a supporter's n value is decremented by one whenever an initiative that this person supports has been assigned to a position, the total weight utilized by each supporter after this process is $d \times (1 + 1/2 + 1/3 + ... + 1/n)$. As the sum $1 + 1/2 + 1/3 + \ldots$ is also known as the harmonic series in mathematics, we call this method "Harmonic Weighting."

*If there are initiatives not admitted for voting (due to a lack of sufficient supporters) after voting has started, then, as long as there are non-admitted initiatives which have not been assigned to a display position yet, only these initiatives are eligible for assignment during this step; i. e. the initiative with the lowest sum amongst the non-admitted initiatives is chosen to be assigned to the position.

†In case of a tie, only the newest initiative with the least weight is chosen to be placed on the position in this round.

Minority	$M = 1$	$M = 2$	$M = 3$
40%	2	5	7
30%	3	6	10
25%	4	8	12
20%	5	10	15
15%	6	13	20
10%	10	20	30
5%	20	40	60
3%	33	66	100
1%	100	200	300
$p\%$	$\lfloor 100/p \rfloor$	$\lfloor 200/p \rfloor$	$\lfloor 300/p \rfloor$

Figure 4.7: *Exemplary minorities and their guaranteed worst-case display position for M initiatives, if each member of the minority supports the same set ($\mathfrak{S}$) of initiatives and that set ($\mathfrak{S}$) contains at least M initiatives ($|\mathfrak{S}| \geq M$).*

The described algorithm assures a proper minority representation for the discussion in the following manner: Let P be the total number of people who support any of the alternative initiatives of the issue (direct or via delegation), let $\mathfrak{S}$ be a subset of those alternative initiatives, and let M be a positive integer less than or equal to the number of initiatives in $\mathfrak{S}$ (i. e. $M \leq |\mathfrak{S}|$). If there is a minority of *more than* $P \cdot M/(1+N)$ persons (including delegating persons) of which each person supports all those (and only those) initiatives in $\mathfrak{S}$, then this will cause M initiatives of $\mathfrak{S}$ to be displayed amongst the first N positions. For example, if we consider the first five display positions ($N = 5$), then a minority exceeding the size of $16\frac{2}{3}\%$ (of P) will occupy at least 1 position amongst the first 5 positions, a minority exceeding the size of $33\frac{1}{3}\%$ will occupy at least 2 positions amongst the first 5 positions, and so on. If we increase the number of positions considered, then even smaller minorities are taken into account. For example: a minority of 4.8% will be able to place at least one initiative amongst the first 20 displayed initiatives. See Figure 4.7 for an overview of the resulting worst-case display positions that minorities of given sizes will attain.

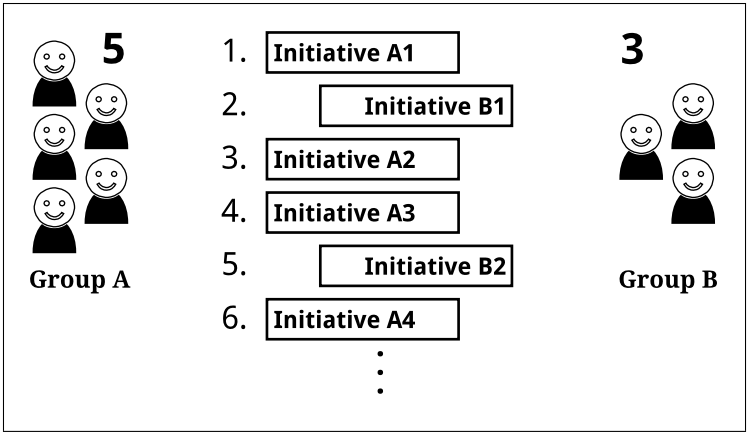

Figure 4.8: *Harmonic Weighting ensures that each group gains a fair share of attention.*

While the given property of minority protection always holds in those cases where all members of the minority support exactly the *same* set ($\mathfrak{S}$) of initiatives, it additionally holds also in those cases where parts of the minority support initiatives that are not supported by all members of the minority (i. e. initiatives that are not in $\mathfrak{S}$), as long as those other initiatives which are supported by parts of the minority do not gain a better display position than the best-ranked M initiatives of $\mathfrak{S}$.*

*Proof: When all but M initiatives of set $\mathfrak{S}$ (and—if existent—any other initiatives that are supported by parts of the minority) have been assigned to a display position, then each of the M remaining initiatives in $\mathfrak{S}$ receives more than $\frac{1}{M} \cdot P \cdot M/(1+N) = P/(1+N)$ voting weight. If $N+1$ (or more) positions are yet to be assigned, then, in order to outrank one of these initiatives from the first N positions, $N+1-M$ (or more) other initiatives would need to receive a voting weight of more than $P/(1+N)$. Since every supporter (including delegating supporters) has only a total weight of 1 in each round, we need more than $(N+1-M) \cdot P/(1+N) = P - P \cdot M/(1+N)$ people of which each person supports at least one unplaced initiative that is not in $\mathfrak{S}$. This would be a contradiction, since P is the total number of people available, and of these people there are already more than $P \cdot M/(1+N)$ persons who only support those unplaced initiatives that are in $\mathfrak{S}$.

In order to facilitate constructive feedback within the system, *potential* supporters (see page 62) are included in the count, except for those initiatives which have been admitted for voting when voting has started. As (potential) support is a requirement for ranking suggestions in an initiative, including potential supporters for the Harmonic Weighting discourages people to post or rank suggestions to initiatives which they oppose fundamentally. Instead, people are encouraged to focus on constructive feedback to those initiatives which they think are promising to end up as alternatives to be voted in favor of. In turn, it is in the interest of potential supporters that promising initiatives gain a proper display position. Even in verification phase (when the draft of an initiative cannot be updated anymore), initiatives that have many potential supporters are still of interest because they may be used as a boilerplate for a new initiative to be posted before voting starts.

An example calculation of the Harmonic Weighting is available in appendix B on page 169.

4.10.2 Proportional Runoff Algorithm

While the "Harmonic Weighting" method performs well for determining the display order of alternative initiatives, it is not suitable for sorting suggestions. One reason for being unsuitable is because the Harmonic Weighting only considers one kind of support while it is possible to rank suggestions in different ways ("must be implemented" vs. "should be implemented," see page 61). Another reason why Harmonic Weighting is unsuitable for ordering suggestions is due to the following difference between initiatives and suggestions: Suggestions usually complement each other, but initiatives often include a complete point of view on a certain issue. While it is a desired effect that supporting an initiative which already has a lot of supporters can significantly reduce your harmonic weight given to another *competing* initiative of the *same* issue, it would be less desired that ranking a suggestion which is commonly agreed on significantly affects your ability to push other suggestions for the same initiative to a better display position. In a similar fashion, multiple

issues in a subject area may complement each other. Therefore, the "Harmonic Weighting" is neither used to sort suggestions for an initiative nor to order issues within a subject area. Instead, we use a generalized* version of the so-called "Proportional Runoff Algorithm":

The Proportional Runoff Algorithm[11] is a an idea for a simple vote counting system producing proportional rankings, closely related to the "Single Transferable Vote"† but creating an ordered list of winners. We do not use this system to decide on any proposal, but we use it to sort the suggestions belonging to an initiative and to sort the issues in a subject area. For each participant, we need to create a *virtual* ballot, that is used as input to the algorithm:

In case of sorting suggestions belonging to an initiative, these virtual ballots contain 4 preference sections:

- 1^{st} preference:
  all suggestions ranked as "must be implemented" and marked as "has not been implemented," or "must not be implemented" and "has been implemented" by the participant,

- 2^{nd} preference:
  all suggestions ranked as "should be implemented" and marked as "has not been implemented," or "should not be implemented" and "has been implemented" by the participant,

- 3^{rd} preference:
  all suggestions ranked as "must be implemented" and marked as "has been implemented," or "must not be implemented" and "has not been implemented" by the participant,

*Since the algorithm described in [11] does not allow voters to give multiple candidates an equal rank, we modify the algorithm here in such way that fractional numbers are used instead of integers.

†see glossary

- 4^{th} preference:
  all suggestions ranked as "should be implemented" and marked as "has been implemented," or "should not be implemented" and "has not been implemented" by the participant.

In case of sorting issues within a subject area*, the virtual ballots contain only one preference section:

- 1^{st} (and only) preference:
  all issues that are yet in admission† state and where the participant supports at least one initiative of that issue as satisfied or potential supporter.

The virtual ballots are created automatically and just serve the purpose of being used for the calculation explained below. They must not be confused with ballots for actually voting on an issue. In the following description of the algorithm, we will refer to the suggestions or issues on that ballots as "candidates." In case of delegations, the ballots are accordingly duplicated to represent the increased voting weight by delegation. We proceed as follows:

1. All candidates which are mentioned on at least one ballot are marked as unplaced. (Candidates that are not mentioned on at least one ballot are excluded from this algorithm and sorted after all others.)

2. All unplaced candidates are marked as remaining.

*For cases when a user wants to display issues of a *set* of subject areas instead of a *single* subject area, LiquidFeedback additionally applies the algorithm to *all* subject areas of an organizational unit at once in an independent run. While it would create better results to apply the algorithm to each possible combination of subject areas, this could lead to performance issues, as a pre-calculation of those orderings is inefficient due to the exponential count of possible combinations of subject areas.

†When sorting issues, Proportional Runoff is only applied to those issues in the subject area that are in admission state. The treatment of issues in discussion, verification, and voting phase is discussed in the next subsection 4.10.3.

3. The score of all candidates is (re-)set to zero.

4. Store a temporary value for each candidate and (re-)set it to zero.

5. For each ballot: Determine the first preference section containing a remaining candidate. If there is such section, then for each remaining candidate in that section increase these candidate's temporary values by the following amount: voting weight divided by the number of remaining candidates in that section.

6. Determine a factor such that multiplying that factor with the temporary value calculated in steps 4 and 5 and adding this product to the candidate's scores causes at least one candidate to reach a score of 1.0 but no candidate to exceed a score of 1.0.

7. Perform the addition described in step 6 and remove those candidates which reach a score of 1.0 from the list of remaining candidates.

8. Repeat steps 4 through 7 as long as there is more than one remaining candidate.

9. If there is one remaining candidate, then this candidate is placed, starting from the worst position. If there is no remaining candidate, then tie-breaking* is needed between those candidates which have been removed during the last application of step 7.

10. Steps 2 through 9 are repeated until all candidates but one have been placed.

11. The last unplaced candidate gets the first position.

An example calculation of sorting suggestions using Proportional Runoff is available in appendix C on page 179.

*The newest candidate is assigned the worse position.

The main difference between the Harmonic Weighting and the Proportional Runoff Algorithm is that in every round the Harmonic Weighting divides one's voting weight equally amongst all supported non-placed initiatives *independently* of the other voter's choices, while in Proportional Runoff the distribution of voting weight in one round is *dependent* of the other voter's choices: If one suggestion or issue receives a lot of voting weight by other voters, then the Proportional Runoff Algorithm causes excessive voting weight to be transferred to other suggestions/issues (just like in "Single Transferable Vote" systems excessive voting weight is transferred to other candidates).

Both the Harmonic Weighting and the variant of the Proportional Runoff Algorithm as described above serve as a measure to guarantee minorities a proper representation within listings of alternative initiatives or suggestions to those initiatives. When sorting a list of issues though, the Proportional Runoff Algorithm is only applied to those issues that are in admission phase. The next subsection will explain how issues in other phases are being sorted.

4.10.3 Sorting issues in discussion, verification, and voting phase

In admission phase there might be plenty of issues which are *not* of general interest. When viewing the list of issues in a subject area that are in admission state, then this list of issues is sorted based on Proportional Runoff as explained in the previous subsection. Any issue that has reached discussion phase, however, *is* of general interest because those issues are expected to be voted upon later. Since supporting initiatives in the discussion and/or verification phase is crucial for passing the second supporter quorum (and may thus have an impact on the decision-making process that goes *beyond sorting* of proposals), supporting initiatives in those phases should not reduce one's ability to promote other issues, as otherwise people could refrain from giving their support due to tactical considerations.

When ordering issues within a subject area, the Proportional Runoff Algorithm is thus only considering those issues that are

in admission phase. Issues in discussion, verification, and voting phase are sorted by other criteria, e. g. the remaining time in the current phase (i. e. "urgent" issues first).*

Even though Proportional Runoff is not used to order certain issues within a subject area, minorities are still granted proportional representation *within* each issue, as the Harmonic Weight is used in *all* issue phases to create an order of the initiatives within each of these issues.

4.10.4 Noisy minorities

A phenomenon often observed is that proposals seem to be highly controversial when discussed on media like mailing lists and yet gain a huge majority for or against them when they are finally voted upon. One reason for this effect is the correlation between the sensed collective opinion and the motivation to engage in a debate. This correlation concurs with the fact that in discussion threads a lot of text may be posted without being rated by all participants. Such postings are yet taken into account when participants judge about the current state of discussion. This sometimes yields to a deceiving equilibrium of opinions, where it seems that there are approximately 50% of the participants in favor of and 50% of the participants against a proposal, independent of the real distribution of opinions.

In other words: Depending on the discussion media, noisy minorities may cause people to sense a widespread public opinion which in fact is just argued by a small minority.

Noisy minorities can—unless certain measures are taken—cause a big harm to democratic decision-making processes, as

*It might be desired to offer users a view of *all* issues within a subject area, regardless of their current state. Since issues in admission state are sorted differently than those issues which have passed the first supporter quorum, it is difficult to create a "merged" view that is useful and appears intuitive to the users. Issues in admission phase may be displayed in a different column than the other issues, or it is also possible to implement some kind of interspersing. The details of these mechanisms are dependent on the implementation of the user interface and generally go beyond the scope of this book. However, an example for a possible interspersing algorithm is given in appendix F on page 193.

people are misled regarding the public opinion or majority opinion within an organization. In addition to creating a biased impression on majority stakes, a noisy minority can drown the viewpoints of other minorities which are less noisy.

There have been various approaches to curb noisy minorities. Some of these systems allow people to vote other people's contributions down, causing them to gain a worse display position or even creating a bad scoring for the respective author, which has an impact on the future positioning of that author's contributions. Such systems, however, do not assign each minority a fair share of attention but instead allow majorities to suppress minorities. They are thus *not* suitable to protect minorities from other noisy minorities.

Instead, LiquidFeedback relies on the proportional representation algorithms as discussed in subsections 4.10.1 and 4.10.2. These algorithms do not empower majorities to silence minorities, but they assign each minority a *fair share* of attention independent of their agitation. Of course, these algorithms as well as the final voting procedure may only be fair, if it is ensured that one person may not get more than one account in the system (see also chapter 6, subsection 6.1.1 on page 120).

4.10.5 The importance of Liquid Democracy for the protection of minorities

Liquid Democracy (see chapter 2) plays also an important role regarding the protection of minorities:

Traditionally, minorities have to run through local chapters of an organization first, where they need to gain a majority for their viewpoint (i. e. convince more than 50% of the local people) in order to present their issues to a higher body (e. g. through a local representative in a higher board).

Even in cases where a proportional voting system like "Single Transferable Vote" (see glossary) is facilitated to create a proportional mix of representatives, such an approach creates a static group of representatives and does not allow spontaneous minorities to represent their ideas independently of those people who have been elected into a position of power.

LiquidFeedback, however, offers a *scalable* discussion process where a broad number of people can discuss issues beyond the limitations of geographical boundaries or previously elected persons. The flexible transitive delegations offered by Liquid Democracy are vital for this scalability. Liquid Democracy and the previously discussed algorithms allows people to overcome the constraints of classical procedures of decision-making, thus empowering any minority to present their viewpoint directly to a broad audience.

4.10.6 Rivaling alternatives vs. change requests

Traditional decision-making processes often facilitate means of "change requests," where there is a ballot deciding whether a particular proposal should be changed. LiquidFeedback utilizes competing initiatives instead,* where the text of each initiative may not be changed by anyone but the initiators. This is an important measure for the protection of minorities because it allows any group or any individual to present their own point of view on any issue and to campaign for support until the final voting starts.

However, when there are several rivaling alternatives, then classical voting systems often cause a division of support amongst similar candidates. Thus, certain measures must be taken as otherwise people would be deterred from posting their own alternatives, which in turn would grant existing initiators a disproportionate position of power. These measures are explained in the following section regarding the "Independence of Clones Criterion."

*Suggestions may still serve as a means of change requests, but they are nonbinding for the initiators.

4.11 The Independence of Clones Criterion

Whenever multiple competing candidates or proposals are nominated to be voted upon, a lot of voting systems cause harm to those candidates or proposals which have similar alternatives.

Example: In plurality voting we can have a situation where one candidate A gets 90 votes, while 140 voters are in favor of two other candidates B_1 and B_2 which are quite similar to one another. But plurality voting forces all voters to choose exactly one option. Vote splitting may arise for the similar candidates such that B_1 and B_2 each only get about 70 of the votes, causing candidate A to win with 90 votes. Candidate A still wins in those cases where more than 90 voters would prefer *both* candidate B_1 *and* candidate B_2 to candidate A.

A historic example of such vote-splitting happened in 1969 when the Canadian city which is now known as "Thunder Bay" was amalgamating: The citizens were entitled to decide on their new city's name. In opinion polls, more people preferred the name "The Lakehead" to the name "Thunder Bay". But finally, when the voting started, each voter could choose *one* of the following three options:

- Thunder Bay
- Lakehead
- The Lakehead

When the ballots were counted using plurality voting, "Thunder Bay" received 15,870 votes, "Lakehead" received 15,302 votes, and "The Lakehead" received 8,377 votes.[15, p.291] Thus, the city has been named Thunder Bay even though it's conjecturable that more people preferred either "Lakehead" or "The Lakehead" as name.

Obviously any voting system with this flaw pushes people to abstain from proposing alternatives—or even worse: encourages "false flag" operations such as promoting an alternative with the sole purpose to harm an existing similar candidate or proposal.

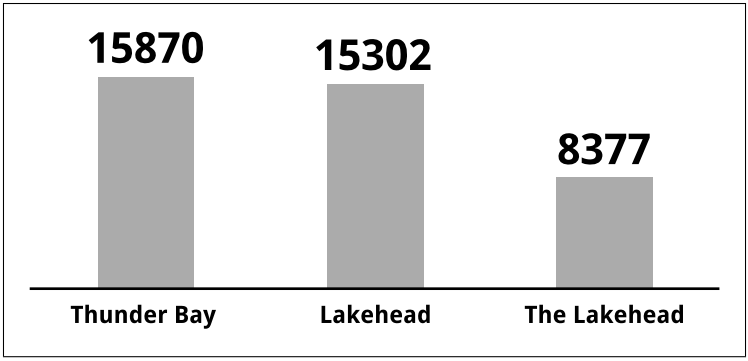

Figure 4.9: *The results of the poll in 1969 where the citizens were to decide upon their city's name. Each voter could vote for one of the three options. The name "Thunder Bay" won.*

Fortunately, there are voting systems which do not have this flaw. Nicolaus Tideman was the first person to formalize the problem and to create a criterion, the so-called "Independence of Clones Criterion," which can be used as a benchmark for voting systems. In the abstract of his paper, he writes:

"'Independence of clones' is a generalization of the condition of not being subject to the perverse consequences of vote-splitting that arise under plurality voting."[12]

Nicolaus Tideman

A precise definition of this criterion can be found in Tideman's original paper[12] as well as online in a publication by Markus Schulze[16].

A voting system fulfilling the Independence of Clones Criterion does not harm (or favor) those candidates or proposals which have similar alternatives ("clones") on the ballot. One attempt to achieve independence of clones is to use a voting method called "Approval Voting." In approval voting, voters may not vote for just one candidate but instead for as many candidates or proposals as the voter likes. In such case *perfect* clones would not harm each other: If B_1 and B_2 were identical candidates or

identical proposals, then everyone who would approve B_1 would also approve B_2 and vice versa. However, in cases where B_1 and B_2 are not *exactly* identical but only very similar, they might still harm each other, as people who prefer B_1 to B_2 might only give their approval to B_1 in order to let B_1 outrank B_2.

In Tideman's sense, a voting system fulfilling the "Independence of Clones Criterion" is not just resistant to *perfect* clones but also to a generalized variant of clones. Only considering perfect clones wouldn't make much sense anyway, as in the case of electing persons there is no such thing as a "perfect clone" of another human; and in the case of proposals, people might simply agree on always voting for that proposal which has been published first if there are two identical proposals. When evaluating voting systems regarding independence of clones, we should thus also include similar clones.

When we speak of similar clones, we need to provide an exact mathematical definition though. Tideman uses the following definition for "clones":

> *"A proper subset of two or more candidates, S, is a set of clones if no voter ranks any candidate outside of S as either tied with any element of S or between any two elements of S."*
>
> TIDEMAN [12, p.186]

In other words: Assuming that each voter ranks all candidates or proposals according to personal preference, then "clones" are those candidates or proposals which are ranked equally or at least in a consecutive manner by *every* voter (e. g. if B_1 and B_2 are clones and one voter prefers B_1 to A, then this voter must also prefer B_2 to A, but he or she might still prefer B_1 to B_2 or vice versa).

It should be noted that Tideman's criterion might be generalized further, as it only considers candidates that are ranked in a consecutive manner by *all* voters. A single voter may thus prohibit that two candidates are seen as clones according to Tideman's definition. We can construct a voting system which does

fulfill Tideman's definition of Independence of Clones and is yet subject to the "consequences of vote-splitting that arise under plurality voting," which Tideman states in the abstract of his paper. Let's consider a voting system where the winner is determined in the following way:

1. Each voter creates a preference ranking of all candidates.
2. Only if there exist clones according to Tideman's definition in [12, p.186], then for each set S of clones, keep one candidate of S but eliminate all other candidates of S from the ballots.*
3. That candidate which is most often listed as first remaining candidate on the ballots is declared winner.

The system described above would formally fulfill the Independence of Clones Criterion but still suffers the consequences of vote-splitting, as it is equivalent to plurality voting, except in corner cases when *all* voters rank clones in a consecutive manner. Nevertheless, the Independence of Clones Criterion can still be used as an indication for determining whether a voting system is susceptible to unfair treatment in case of similar candidates. In particular, if the Independence of Clones Criterion is not fulfilled, then it is proven that such unfair treatment happens. While it would be nice to have a stricter criterion at hand, we should still require a voting system to fulfill the Independence of Clones Criterion as formulated by Nicolaus Tideman. For the remainder of this book we will use Tideman's definition for Independence of Clones.

As Nicolaus Tideman's definition implies that voters create a personal ranking of the candidates, it is difficult to apply his definition to the previous example of approval voting, as approval voting only lets voters either approve or disapprove a candidate but not create a ranking.[12, p.189] However, if we interpret Tideman's definition in such way that candidates are clones if all voters *would* rank them in a consecutive manner if they *could* rank them, then approval voting is not independent of clones in Tideman's sense.

*The rule deciding which of the candidates to keep can be arbitrary.

Tideman himself states:

*"While approval voting can [...] be made independent of **perfect** clones, approval voting is not **generally** independent of clones."*[12, p.190]

This is one of the reasons why LiquidFeedback doesn't use approval voting but a preferential voting system, which is explained in the next section.

4.12 Preferential voting for the final decision

In this section, we will explain the process that allows all participants to agree on a final resolution after admission phase, discussion phase, and verification phase of an issue have passed. The voting mechanism described here is applied to all those initiatives which have passed the second supporter quorum (see section 4.6 starting on page 66). All voters may vote in favor or against each of these competing initiatives, and they may additionally express preferences amongst those initiatives:

Approval	1st preference	*A*
	2nd preference	*B C*
	3rd preference	*D*
Abstention		*E F*
Disapproval	preferred to those below	*G H I*
	ranked worst	*J K*

Figure 4.10: *Example for a preferential voting ballot in LiquidFeedback, where 11 initiatives (A through K) are ranked by the voter. The number of subsections in the approval and disapproval sections is dynamic and may increase or decrease as necessary, depending on each voter's requirements.*

As already mentioned in subsection 4.10.6 (page 86), using a system that would cause a division of support amongst similar proposals could deter people from posting their own alternatives,

which in turn would grant existing initiators a disproportionate position of power. Allowing voters to express their preferences is the first step to avoid such harmful division of support. As LiquidFeedback lets voters express preferences in the approval as well as the disapproval section of a ballot, LiquidFeedback aims not only to avoid a division of support amongst those proposals that are both favored to the status quo but also discourages voters to vote in favor of a proposal for the sole purpose to outrival another proposal.

Letting voters express their preferences, however, is not sufficient to address these issues. We also need to *count* those expressed preferences in a way such that the "Independence of Clones Criterion" is fulfilled (see section 4.11 on page 87).

There are several ways to count voters' preferences that fulfill the Independence of Clones Criterion, but they differ in many other properties. For LiquidFeedback, we selected the so-called "Schulze Method" as voting system for the final voting, as it fulfills certain other criteria amongst Independence of Clones and has also been successfully applied in practice.[13][14][15]

4.12.1 Schulze Method

The "Schulze Method" is a single-winner preferential voting system which fulfills a number of desired criteria, including:

- Independence of Clones[14, p.13] (see section 4.11 on page 87)
- Monotonicity[14, p.12] (see glossary)
- Reversal symmetry[14, p.14] (see glossary)
- Taking majorities into account by always selecting a member of the Schwartz set as winner[16, p.57] (see page 94)
- Independence of Smith-dominated alternatives (ISDA or Smith-IIA)[15, p.296][16, p.52] (see section 4.14 on page 109)

For an explanation of these listed criteria see the references in parenthesis.

The Schulze method as a *single-winner* system always selects one winner based on the voters preferences. As it is also a valid outcome that no initiative is resolved upon (i. e. status quo wins), we need to add the status quo as an implicit candidate to each ballot. LiquidFeedback internally converts the preferential ballots with approval and disapproval section of each voter in such way that the added status quo is ranked below those initiatives which the voter approves and above those initiatives which the voter disapproves:

Original ballot		
Approval	1st preference	*A*
	2nd preference	*B C*
	3rd preference	*D*
Abst.		*E F*
Disappr.	pref. to below	*G H I*
	ranked worst	*J K*

Converted	
1st	*A*
2nd	*B C*
3rd	*D*
4th	*E F* ***SQ***
5th	*G H I*
6th	*J K*

Figure 4.11: *Original ballot (with "Approval", "Abstention" and "Disapproval" section), and converted ballot with explicit status quo (**SQ**).*

At the end of the voting phase, these converted ballots are counted using the rules of the Schulze method to determine a winner of the final voting.

The Schulze method determines a winner by comparing every alternative with every other alternative (including the implicitly added status quo). The comparison of two alternatives X and Y is done in such way that for every voter it is counted whether this voter prefers X to Y, prefers Y to X, or is indifferent about them (i. e. ranking those alternatives equally). If more voters prefer X to Y than there are voters which prefer Y to X, then we say X defeats Y in pairwise comparison.

If there is exactly one alternative which defeats all other alternatives in pairwise comparison,* then this alternative is the

*Such a candidate is called "Condorcet winner."

winner. Unfortunately, there are cases when no alternative defeats all other alternatives (see Figure 4.12).

In these cases, it is still possible to determine the smallest non-empty set of alternatives which are not defeated by any other alternative outside this set in pairwise comparison. This set of alternatives is called the "Schwartz set," due to THOMAS SCHWARTZ, who discovered this set.[17, p.105] The winner selected by the Schulze method is always one that is contained in the Schwartz set. When there is more than one alternative in the Schwartz set, then the Schulze method determines a winner as follows: All candidates that are not in the Schwartz set are eliminated and won't be considered anymore. The weakest pairwise defeat between non-eliminated candidates is replaced by a pairwise tie. The Schwartz set is re-calculated, considering only the non-eliminated candidates. The whole process is repeated until the Schwartz set contains only one candidate, which is then declared winner.* Hence the Schulze method is sometimes also referred to as "Schwartz Sequential Dropping" (SSD). In order to determine the weakest pairwise defeat, it is necessary to define the strength of a defeat. There are different ways to do it, and LiquidFeedback follows MARKUS SCHULZE's recommendation[16, p.64] to primarily measure the strength by the winning votes and secondarily by the opposing votes. In other words: The weakest pairwise defeat is the defeat with the fewest votes for the winner of the pairwise defeat, or—if there is more than one pairwise defeat fulfilling this—that defeat with the fewest votes for the winner and the most votes for the loser of the pairwise defeat.

An illustration of Schwartz sequential dropping is given on pages 96 through 98. A numerical example is given in appendix D on page 185.

*For an exact description including the treatments of corner cases, refer to [14, p.18]. Also note that there are other implementations of this algorithm which yield to the same winner (see also [16, p.4]).

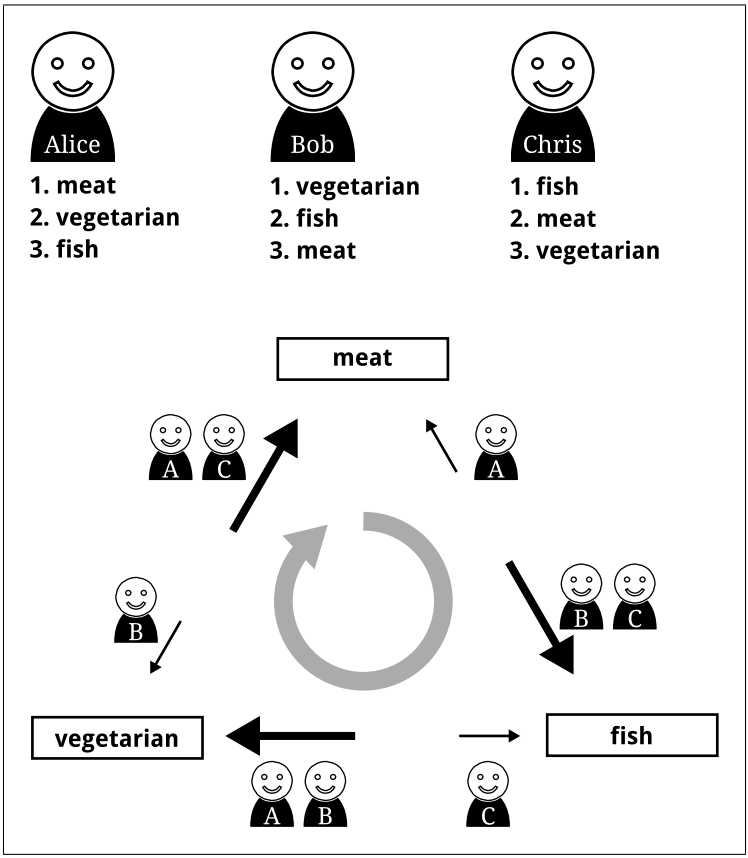

Figure 4.12: *A cyclic collective preference ("Condorcet's paradox"), where there is a majority that prefers vegetarian food to fish (Alice and Bob), and a majority that prefers meat to vegetarian food (Alice and Chris), and a majority that prefers fish to meat (Bob and Chris).*

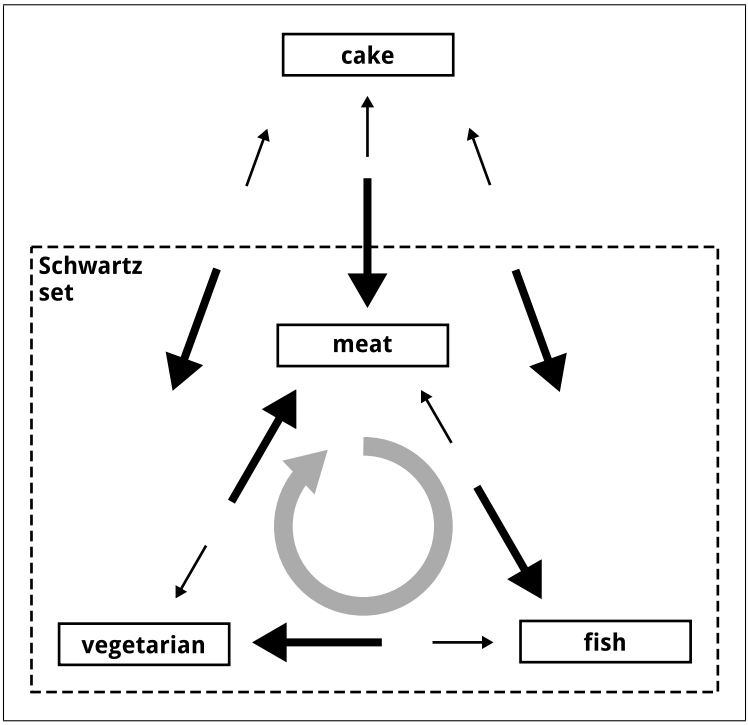

Figure 4.13: *The Schwartz set is the smallest non-empty set where each candidate inside the set is not defeated in a pairwise comparison with every other candidate outside the set. In this example, the Schwartz set contains the candidates "vegetarian", "meat", and "fish", because (a) none of these candidates is defeated by any candidate outside this set ("cake" in this example), and (b) there is no smaller subset fulfilling this property.*

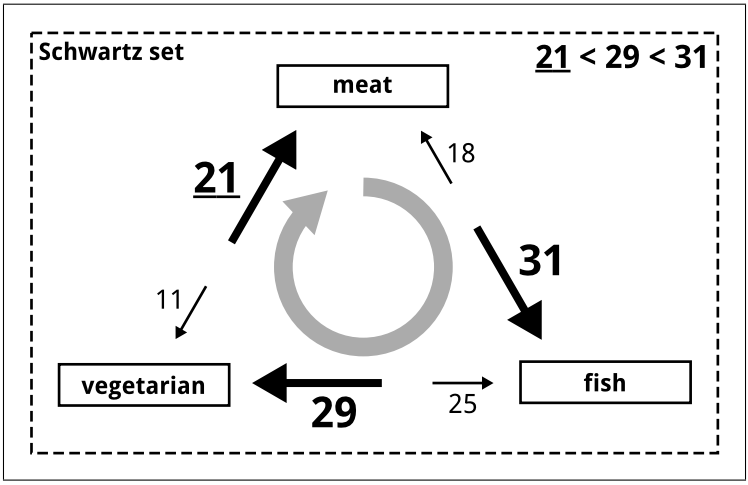

Figure 4.14: *Schwartz sequential dropping only considers those candidates that are inside the Schwartz set. If there is more than one candidate inside the Schwartz set, then the weakest defeat amongst these candidates is removed (strictly speaking: replaced by a tie). LiquidFeedback measures the strength of the defeats primarily by the absolute number of winning votes. In this example, "meat" defeating "vegetarian" is the weakest defeat as 21 is smaller than 31 or 29.*

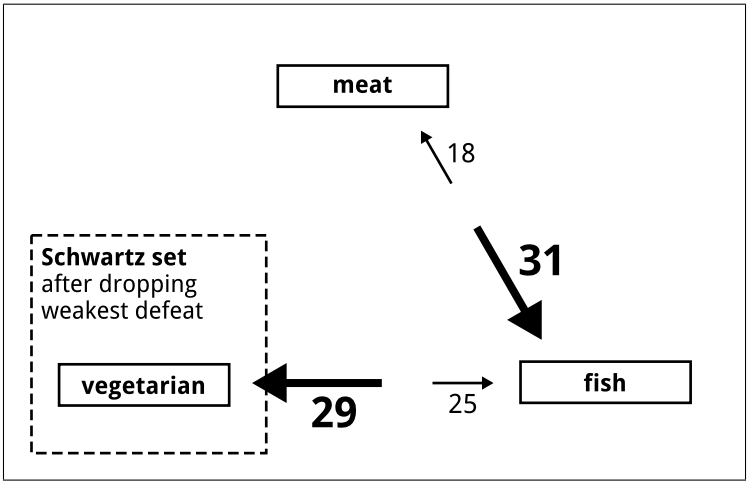

Figure 4.15: *After dropping the weakest defeat, the Schwartz set is re-calculated. If the re-calculated Schwartz set contains only one candidate, then this candidate is declared winner (here: vegetarian food). If the re-calculated Schwartz set would contain more than one candidate, all candidates outside the Schwartz set would be removed and the whole process would be repeated with the remaining candidates.*

In addition to determining a winner, the Schulze method can also be used to create a ranked order of all alternatives ("Schulze ranking") where the first alternative is the winner, the second alternative is the runner-up, etc.*

As Markus Schulze states,[16, p.64] there has been some debate about how to measure the strength of a pairwise defeat. Considering Figure 4.14 on page 97, that defeat with the smallest absolute number of winning votes (21 votes in the example depicted in Figure 4.14) is not necessarily the defeat with the worst ratio of winning to opposing votes (e. g. $29/25 < 21/11$) and not necessarily the defeat with the worst difference between winning and opposing votes (e. g. 29–25 < 21–11). In an earlier definition of the Schulze method, the strength of a pairwise defeat was generally recommended to be measured by the difference between winning and opposing votes instead of the absolute number of winning votes.[14, p.10, p.17] In a more recent publication, however, Markus Schulze recommends to primarily measure the strength by the absolute number of winning votes and secondarily by the opposing votes[16, p.64] (as already mentioned on page 94).

This approach is justified as follows: If there is a cyclic collective preference (Condorcet's paradox), then it is unavoidable that at least one majority is ignored. If there is a defeat with a huge number of voters who rank the compared alternatives equally, then these voters won't care whether one or the other alternative is chosen to be winner. Defeats where this is the case will have a low number of absolute winning votes. Ignoring people who do not care about a preference between two candidates is obviously less harmful than ignoring people who do care. Thus, the absolute number of winning votes is primarily used to determine the weakest defeat.†

*Refer to the calculation of the relation "$\mathcal{O}$" in the definition of the Schulze method in [15] or [16]. Note: In case of ties, some form of tie-breaking is needed in order to compute a Schulze ranking, as "$\mathcal{O}$" is a *partial* order (see [15, p.269] or [16, p.5]).

†Another reason to choose that defeat with the lowest absolute number of winning votes as the weakest defeat is that this approach ensures the fulfillment of Woodall's plurality criterion, see [16, p.64] and [18].

4.12.2 Tie-breaking

In almost every voting system there is a possibility of ties between candidates (in our case: between proposals). In a few rare cases you can avoid ties, e. g. when deciding on two alternatives and having an odd number of voters where abstention is not allowed. Of course this can't be generally assured. Nevertheless, for most voting systems the probability of ties fortunately tends to zero as the number of voters increases, which is also the case for the winner* of the Schulze Method (see section "Resolvability" in [15] or [16]). Ties are still possible though, and LiquidFeedback needs a way to deal with them.

While ties are usually resolved by a second ballot or by drawing lots, neither of these approaches is suitable for LiquidFeedback: A second ballot could cause a massive delay of the determination of the final winner, as the voting phase would need to be repeated, which might take days or weeks according to the policy that is in effect. Depending on external time constraints, this could practically result in no decision to be made in time, thus preferring the status quo in case of ties, which is not desired as there might be a huge majority for changing the status quo. The other option, drawing lots (i. e. randomness), is also not an option because LiquidFeedback aims to provide results that are *verifiable* by the participants. Using a random generator could not be verified by the participants unless its mechanism were to be sufficiently simple and used in a public meeting (e. g. coin toss at a meeting of the members).

Due to these practical obstacles, LiquidFeedback needs to resort to other means of tie-breaking. One possible approach is to give priority to the pair-wise comparison of all proposals with the status quo (i. e. letting those proposals win which perform bet-

*Unfortunately, while this holds for the winner, this does not generally hold for the candidates gaining the second, third, etc. Schulze ranks (see also end of section on "Resolvability" in [16, p.38] and example 3 in [16, p.17]). Since these candidates might be taken into consideration as final winner when applying additional criteria (see section 4.12.3 in this book), an additional deterministic method for tie-breaking beyond that explained in this subsection might be justified and thus implemented in future versions of LiquidFeedback.

ter when compared to the status quo). However, such a solution still can't solve all ties (e. g. those ties where two different proposals are simply ranked equally on all ballots) and furthermore could give voters an incentive for tactical voting, as approving or disapproving a proposal in comparison with the status quo would have an important effect in those cases where there is a tie between two proposals.

For the reasons explained above, LiquidFeedback falls back on a very simple mechanism for breaking ties: In case of a tie, the initiative which was entered first wins.* While this approach may appear arbitrary, there is a reasoning behind it: Assuming a system where there are ballots about change requests, a tie usually means that the change request is not approved and thus the previous proposal is kept. Both LiquidFeedback's approach and change requests yield to the same result, where that initiative wins that was created first. To not discourage initiators to update their drafts, it is always the creation time of the *first* draft that is taken into account for tie-breaking between initiatives.

4.12.3 Treatment of the status quo

As already explained on page 93, the status quo is added as implicit option prior to counting the ballots. While it is most "democratic" to treat all possible options equally†, it is often desired to treat the status quo in a special way. Usually so-called "supermajority requirements" favor the status quo under certain circumstances. A supermajority is a majority that is not just greater than 50% but greater than or equal to a higher value (e. g. 2/3). Markus Schulze lists two tasks of supermajority requirements:[16, p.65]

1. protecting the status quo from accidental majorities
2. preventing the status quo from cycling

Unfortunately, adding additional requirements for a candidate to be attainable as winner can cause paradox situations when using

*If an initiative is tied with the status quo, then the status quo wins.
†see also "Neutrality" in glossary

the Schulze method. This holds already for those cases where we require a 50%-majority in a pairwise comparison with the status quo. Consider the following example:

We have 3 options: A, B, and the status quo (SQ).

49% of the voters prefer B to A to SQ.
21% of the voters prefer SQ to B to A.
19% of the voters prefer SQ to A to B.
11% of the voters prefer A to SQ to B.

When compared to SQ, then A has a majority:
60% of the voters prefer A to SQ.

When compared to SQ, then B has *no* majority:
51% of the voters prefer SQ to B.

But there is also a majority which prefers B to A:
70% of the voters prefer B to A.

If we treat all options equally, then the Schulze method selects B as winner, as the defeat of SQ over B is weakest and thus eliminated. (The Schulze ranking is: $B > A > SQ$.) If we require an option to defeat the status quo in direct comparison to be winner of the ballot, then B must not win. We might select A as winner. But doing so results in the following situation: Option A wins, but actually 70% prefer B to A. The situation can thus be considered most unstable. One possibility to fix this situation is to neither allow A nor B to win in case of such paradox, thus resulting in SQ to win, which has the worst Schulze rank though.

Given the example above, every possible solution in this particular case (A, B or SQ wins) has a bad taste. LiquidFeedback thus offers a set of configuration options per policy (for policies see section 4.7 starting on page 69) which allow you to choose the behavior. Depending on the configuration per policy, certain extra criteria are then required for an initiative to be attainable as winner. As the Schulze method can not only be used to select a single winner but also to create a ranking, the winner is then that initiative with the best ranking that fulfills the configured extra criteria, as long as it is still better ranked than the status quo. If there is no such initiative, then all initiatives fail (i. e. the status quo wins). The configurable extra criteria are:

1. **direct (super)majority requirements:**
   One may select that an initiative must defeat the status quo directly in a pairwise comparison with a certain number of absolute or relative votes (e. g. 50% or 2/3 of the voters must have preferred an initiative to the status quo on their ballots).*

2. **beat-path supermajority requirements:**
   It is also possible to require an initiative X to beat the status quo indirectly through a beat-path (i. e. there exists a path such that X defeats Y_1, Y_1 defeats Y_2, ..., Y_{n-1} defeats Y_n, and Y_n defeats the status quo) where every defeat has a certain number of absolute or relative votes, e. g. a 2/3-majority.

3. **prohibit reverse beat-paths:**
   One may decide that a winning initiative must never be tied in a Condorcet's paradox (including any "weak" Condorcet paradoxes with ties) with the current status quo. In other words: If the Smith set (see glossary) contains the status quo, then the status quo always wins. In combination with direct supermajority requirements *or* beat-path supermajority requirements, this prohibts cycles of the status quo due to slight changes of voting behavior. A positive side effect of this option is to enforce that a winner always has a simple majority when compared directly to the status quo, and this winner will always have the best Schulze rank unless it is the status quo. Thus possible "unstable" results (see also option 4 below) are avoided naturally.†

4. **detect multistage majorities:**
   One may select whether an initiative should be disqualified as winner if letting it win could cause another initiative (which didn't have the required direct majority or supermajority in the first ballot) to win in a repetition of the

*This corresponds to Markus Schulze's recommendation in [16, p.66].

†Furthermore, using option 3 to enforce a simple majority for a winner does not cause an increased necessity for tie-breaking as explained in the footnote on page 100, because the winner will be either the status quo or an initiative that gained the first Schulze rank.

ballot.* Using this configuration option, we thus disallow results that are to be considered "unstable".† A prohibited unstable result in the sense of this rule is defined as follows:

An initiative A being better ranked than the status quo is an "unstable" result (and thus must not win), if and only if there exists another better ranked initiative B such that (1) more voters prefer B to A than vice versa, and (2) more voters prefer B to A than voters preferring B to the status quo or less voters prefer A to B than voters preferring the status quo to B.‡

Using these configuration options, it is possible to avoid unstable results, protect the status quo from oscillating due to accidental majorities, or to implement supermajority requirements according to given statues of an organization.§

Markus Schulze recommends in his paper [16, p.66] a procedure which is equivalent to requiring a direct (super)majority in a pairwise comparison with the status quo according to the above explained configuration option 1, while not using options 2, 3 and 4. It should be noted that this approach does not prohibit cycles of the status quo due to slight changes of voting behavior. Consider the example on the next page:

*Assuming all voters keep their preferences in the repeated ballot.

†If (a) there is no requirement for an initiative to directly beat the status quo, or (b) reverse beat-paths are prohibited (according to configuration option 3) and the requirement to directly beat the status quo is limited to a simple majority, then all results are stable automatically and this configuration option 4 has no effect on the winner of an issue.

‡Using this (invariable) definition for "unstable" results (instead of simply checking if the result would change in a repeated ballot), we avoid that *adding* a supermajority requirement (e. g. a direct 2/3-majority) causes an initiative to win, while with a smaller majority requirement (e. g. a direct 50%-majority) the status quo would have won (because a higher supermajority requirement could prevent a change of the result in a repeated ballot, while a smaller requirement does not prevent it). We thus fulfill the desirable property for supermajority requirements that if the status quo had won in the absence of those requirements, it must also win in the presence of those requirements (see [16, p.65]).

§Note that a cycle of the status quo is still possible due to tactical considerations of the voters. See also [19] and [20].

We have 3 options: A, B, and the status quo (SQ).

33% of the voters prefer B to A to SQ.
33% of the voters prefer SQ to B to A.
34% of the voters prefer A to SQ to B.

If we simply require a $^2/_3$-majority in a pairwise comparison with the current status quo, then A wins. Subsequent repetitions of the ballot (assuming honest voter behavior) would not change the situation. However, just 1% of the voters with volatile behavior could cause a cycle of the status quo in subsequent repetitions of the ballot.

We therefore conclude that supermajority requirements as a sole measure to stabilize the status quo are not sufficient. To avoid oscillations due to slightly changing majorities, LiquidFeedback offers prohibiting reverse beat-paths according to configuration option 3 as explained above, which can be combined with beat-path supermajority requirements according to configuration option 2.

Sometimes it might be unavoidable to require a direct supermajority according to configuration option 1 (e. g. due to organizations' statutes or applicable law). In these cases, prohibiting reverse beat-paths is not sufficient to ensure a voting result that would not change if the ballot was repeated and all voters cast the same preferences as in the first ballot. Consider the following third example:

We have 3 options: A, B, and the status quo (SQ).

60% of the voters prefer B to A to SQ.
30% of the voters prefer SQ to B to A.
10% of the voters prefer A to SQ to B.

When compared to SQ, then A has a majority *greater* than $^2/_3$:
70% of the voters prefer A to SQ.

When compared to SQ, then B has a majority *smaller* than $^2/_3$:
60% of the voters prefer B to SQ.

But there is also a huge majority which prefers B to A:
90% of the voters prefer B to A.

If a direct supermajority of 2/3 is required in this example, then B must not win, despite the fact that it defeats every other alternative in pairwise comparison. However, in this example A beats the status quo with a 70% majority, hence surpassing the required 2/3-supermajority. While in this situation slight changes of the majorities could not cause a *cyclic* change of the status quo, selecting A as winner can still be considered an unstable outcome, as B defeats all other options in pairwise comparison and there is a huge majority (90%) which prefers B to A. Thus repeating the ballot yields to a new winner B. Using the configuration option 4 ("detecting multistage majorities") it is possible to prohibit A to be winner in this example and instead select the status quo as winner, because A would be considered an "unstable" outcome. Nevertheless, we still can't consider this to be an optimal choice, as the status quo is a Condorcet-loser (i. e. it is defeated by every other alternative in pairwise comparison).

As seen in the last example, direct supermajority requirements cause paradox situations. When a protection of the status quo is desired, we thus recommend to use beat-path supermajority requirements according to option 2 instead, and to prohibit reverse beat-paths according to option 3.

4.13 Majority rule

In a democratic system decisions are made by majorities ("majority rule"). While this statement seems trivial, it requires further discussion due to certain misconceptions about the term "majority."

Let's consider the following situation: We have two proposals B_1 and B_2, where B_2 is equal to B_1 but contains certain additional elements, such that all people who are preferring B_2 to the status quo also prefer B_1 to the status quo but not vice versa. Let's further assume that 90% of the voters prefer B_1 to the status quo, and 51% prefer B_2 both to the status quo and to B_1. This situation is depicted in Figure 4.16.

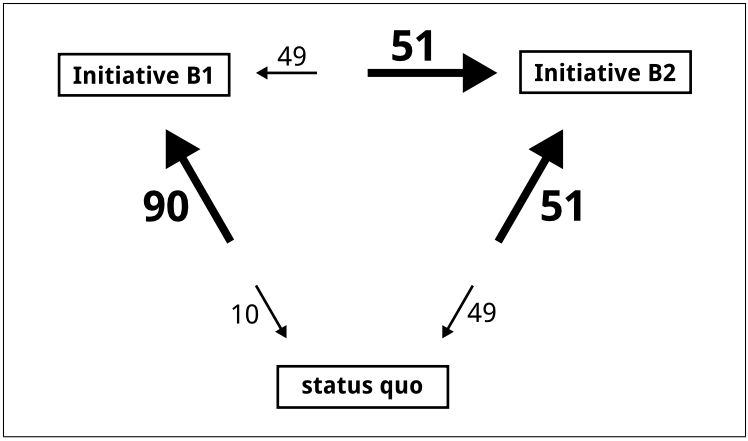

Figure 4.16: *While a huge majority prefers B_1 to the status quo, there is still a (smaller) majority that prefers B_2 to B_1, and B_2 to the status quo.*

While some people argue that B_1 should win because the "largest majority" prefers B_1 to the status quo, majority rule requires that B_2 wins, because there is a majority preferring it to both the status quo and to B_1: If there were two subsequent ballots, one about if the status quo should be replaced by B_1, and one about if B_1 should then be replaced by B_2, then both would be successful due to a majority each. Changing the order of those ballots yields to the same result: If there is a first ballot about replacing the status quo with B_2, then B_2 wins. A further ballot on replacing B_2 with B_1 would fail.

Choosing B_1 instead of B_2 as a final winner would mean that a 49%-minority outweighs a 51%-majority. Of course, this would be against the principles of democracy.*

*Another argument, why B_2 must be winner, is as follows: Let's assume both proposals are about changing the statutes of an organization. B_1 doesn't change anything but an (obvious) mistake regarding the placement of a comma in a sentence. B_2 fixes the comma as well, but additionally demands real changes to the membership rules of the organization. Since there is no reason to not fix the comma mistake, B_1 will gain a very high

When we speak about "majorities" it thus usually doesn't matter how large the majority is, as long as it is greater than 50%. There are only two exceptions:

- Cases where there is no option that is preferred to all other options (Condorcet's paradox, see Figure 4.12 on page 95), and
- Supermajority requirements, as discussed in subsection 4.12.3 starting on page 101.

In cases of a Condorcet's paradox, a violation of the majority rule is inevitable. However, by using the Schwartz set (see page 94) and by sequentially dropping those defeats with the smallest majority, the Schulze method reduces this violation of the majority rule to a minimum.*

Supermajority requirements, in contrast, are an *intended* violation of the majority rule. It is important to note that requiring a supermajority breaks the principles of democracy, because minorities in favor of the status quo gain a higher voting weight than other eligible voters in these cases. E. g. requiring a $^2/_3$-supermajority gives voters who are in favor of the status quo twice(!) the weight as other voters. This said, supermajority requirements should always be an *exception* and only be used in such cases where an additional stabilization of the status quo is really desired (e. g. regarding the statutes of an organization). Supermajority requirements must never be mistaken as a means of minority protection not just because violation of the majority rule breaks the principles of democracy, but also because supermajority requirements would only privilege those minorities

approval rate. This approval rate has no informative value about the voters' opinion on changing the membership rules according to B_2. If B_1's approval rate could outvote the majority for B_2 (effectively yielding to "approval voting" as explained in section 4.11 starting on page 87), then people in favor of B_2 would be enticed to vote tactically by disapproving B_1 (i. e. ranking it worse than the status quo) even if they want to fix the comma mistake. Even worse, people might get motivated to promote initiatives that slightly improve the status quo just to outrank other initiatives that are preferred by the voters.

*See also discussion about "defeat strength" on page 99.

which are in favor of the current status quo while discriminating other minorities.[21] Instead, other measures must be taken to protect minorities, as explained in section 4.10, starting on page 72.

4.14 Avoiding tactical voting

In order to discuss tactical voting, we have a look at the following three different kinds of voting methods:

(a) Voting methods where it is not possible to express all preferences (e. g. "Approval Voting"):

In this case, each voter is obviously forced to make a (possibly strategic) decision on which preferences to express. In other words: The voter must decide which information to *reduce* when expressing their preferences.

(b) Voting methods where each voter may express preferences and in addition indicate the strength of some or all of one's preferences (e. g. by giving scores as in "Score Voting" or qualified rankings as in "Majority Judgment"):

Also in this case, each voter is obviously forced to make a (possibly strategic) decision by *adding* information to their preferences: Voters must decide on a "strength" of preferences, although no unambiguous scale or reference for "preference strength" or "grades" is existent.

(c) Voting methods where each voter may express all their preferences but not give additional information on the "strength" of their preference (e. g. "Schulze Method"):

Even though each voter may express exactly their preference, tactical voting cannot be eliminated completely as stated by the Gibbard-Satterthwaite theorem.[22]

We therefore conclude that it is *impossible* to avoid the possibility of tactical voting in all cases. LiquidFeedback, however, takes the following measures to reduce the possibility of tactical voting:

- allowing voters to express all their preferences without forcing them to either reduce (a) or add (b) information,

- choosing a voting system that fulfills certain criteria (see Schulze Method in subsection 4.12.1 on page 92) which reduces the susceptibility to tactical voting, and

- temporarily hiding cast ballots during voting phase.

In particular, the Schulze method fulfills the so-called "Independence of Smith-Dominated Alternatives" (ISDA) criterion. This means that alternatives which are not member of the Smith set have no impact on the results of a voting procedure.[15, p.296] The Smith set is usually equivalent to the previously introduced Schwartz set but may be bigger in cases where there are ties.* Thus, when there is no Condorcet's paradox and the winner is not tied with another alternative, LiquidFeedback entirely prohibits advantages through tactical voting.† In all other cases, voters might still gain an advantage through tactical voting.‡ This problem is not specific to LiquidFeedback but a consequence of Arrow's impossibility theorem.[22, p.588]

*For a precise definition of the Smith set refer to the glossary.

†Of course, this cannot prohibit all attempts of tactical voting, but it can reduce incentive to vote in a tactical way. Note that tactical voting may still create Condorcet's paradoxes where there would have been no Condorcet's paradox in case of honest voter behavior.

‡Methods other than the Schulze method have been proposed to reduce the potential of tactical voting even more. In his book "Collective Decisions and Voting – The Potential for Public Choice," Nicolaus Tideman proposes two methods that he calls "Alternative Smith" and "Alternative Schwartz" rule, which he claims are less susceptible to tactical voting than Schulze's method.[13, p.237] Tideman, however, states that this improvement comes at a price, since these methods fail other criteria, in particular monotonicity[13, p.233] (refer to the glossary for a description of "monotonicity"). In either case, tactical voting cannot be completely eliminated. Nevertheless, future versions of LiquidFeedback might eventually support these voting systems as an optional alternative to the Schulze method in order to allow different trade-offs between the resistance against tactical voting and other desirable voting system criteria like monotonicity.

It is thus still necessary to temporarily hide cast ballots from the other voters during voting phase until the voting phase has finished.*

4.15 Summary

The LiquidFeedback process for decision-making contains much more than just Liquid Democracy: While Liquid Democracy is an integral part of LiquidFeedback, LiquidFeedback empowers its participants to engage in a scalable discussion process where every participant has *equal rights.*

LiquidFeedback can assure that every participant gains knowledge of ongoing plans for resolutions early enough to be able to intervene where desired.

While LiquidFeedback follows the democratic principle of the majority rule, its decision-making process implements multiple mechanisms to *protect minorities* in such way that noisy minorities do not harm other minorities.

Research in social choice theory, most notably the efforts of Kenneth Arrow, Thomas Schwartz, Nicolaus Tideman, Markus Schulze, and of course Condorcet†, influenced the design of LiquidFeedback, yielding to a decision-making process where voters may express their true preferences and the potential of tactical voting is drastically reduced.

*Just like delaying publication of opinion polls on election day until the polling places are closed, as practiced in many countries.

†see "Condorcet, marquis de" in glossary

Chapter 5

Open Source & Open Data

5.1 LiquidFeedback is an Open Source software

LiquidFeedback is a software that is licensed free of charge under the terms of an "Open Source" license to any individual or organization. However, it does not need to be installed by every individual of an organization: Once installed by an organization, it can be used by its members through a normal web browser from any computer or smart-phone with internet access. A software being "Open Source" basically means that:

- The software may be obtained free of charge and even (re)distributed. There is no royalty or other fee for distribution.
- The source code (the code which the authors use to create and maintain the program) is available to the users of the software.
- It is allowed to modify the software and distribute it (at least under the same conditions as the original software).

Strictly speaking, there are a few more requirements for a software to be called "Open Source." For a more detailed definition refer to *"The Open Source Definition"* as published by the Open Source Initiative.[23]

LiquidFeedback's license fulfills all the criteria of the Open Source Initiative and grants anyone the right to merge the software with other software. For this or other purposes, it is additionally possible for any individual or organization to sublicense the software where desired or necessary for merging it with other software under different licenses.[24] LiquidFeedback's license in detail is depicted in Figure 5.1.

The software is published by the association *Public Software Group e. V.* in Berlin, Germany, and may be obtained free of charge from their website:

`http://www.public-software-group.org/`

As previously explained, LiquidFeedback is not to be installed on every user's computer, but participants access an organization's installation of LiquidFeedback simply through their web browser. For installing the software for an entire organization, certain technical skills are required, and in addition to the software installation a bunch of organizational procedures need to be defined (see chapter 6, starting on page 119). For consulting and hosting, the inventors of LiquidFeedback and authors of this book offer commercial services, see:

`http://liquidfeedback.com/`

5.2 Advantages of Open Source for online decision-making

Using Open Source software for online decision-making systems has several advantages: First of all, licensing a decision-making software as Open Source empowers organizations to refine any implementation detail of the system for their needs while being independent of a particular vendor (the source code of the program is available and it can be modified by any skilled com-

Figure 5.1: *License and copyright notice of the software "LiquidFeedback" as published by Public Software Group e. V.*

puter programming specialist or company). Copies of the software that have been substantially modified shall carry a different work title than "LiquidFeedback" though, in order to allow distinctness between "LiquidFeedback" and any other (modified) software by other authors.

Secondly, software that is available as Open Source may help people with technical knowledge to use parts of the software to create third-party software components to verify results of complex vote counting processes.

Note: As voters can't verify which version of the software is actually installed (or distributed) by an organization, the concept of "Open Source" can *not* be a solution to the "Wahlcomputer-problem" as discussed in chapter 3.

5.3 Availability of data in LiquidFeedback

As also discussed in chapter 3, section 3.6 (page 56), LiquidFeedback only aims for decision-processes where a recorded vote is desired. LiquidFeedback publishes all voting-relevant data in both human readable and machine readable form. The "voting-relevant data" does not only consist of the ballot data in final voting but also of the used delegations as well as information on who supported which initiative, as these supporter counts decide which initiatives were made available to be voted upon during voting phase. For this purpose, LiquidFeedback creates so-called "snapshots" that record:

- which people at the end of the admission, discussion and verification phases
  - have been counted for the "reference population" (see section 4.9 starting on page 71), or
  - have supported a certain initiative (including information about whether they were a potential or satisfied supporter and if they had seen the recent draft at that time and *which* particular version of the draft it was),

- every voter's ballot at the end of voting phase, and
- all used delegations for these processes (i. e. who delegated to whom).

As it is not sufficient for verification to use your own computer to verify that your ballot has been published and counted correctly (see also section 3.3.3 starting on page 46), it is important that the data above is made available to all participants in such way that it can be spread on various channels and talked about or referenced such that it is not possible to cheat voters by showing different data to different voters.

5.4 Democracy and Open Data

Making decisions using a recorded vote may not just be a requirement for the sake of verifiability but can have several other advantages: A political party, for example, may use recorded votes to give the public (and thus their potential voters) a comprehensive insight into their decision-making process.

However, Open Data in the context of democracy is more than just publishing current proposals and recorded votes of decision-makers: In order to either make a sound decision yourself or to monitor your delegatee's decision (either in a representative or in a liquid democracy system) it is vital to have broad access to information regarding the subject that is debated on. For these purposes additional systems and mechanisms must be employed, as we will also discuss later in chapter 6, section 6.2 on page 130.

Chapter 6

Real world integration

6.1 The five questions of political participation

The previous chapters discussed many of the considerations during software design and how LiquidFeedback approaches various challenges. Now we would like to draw the attention to real world integration, which usually is an underestimated task.

We will discuss this along five simple questions. Some of which may sound trivial and the answers may seem just too obvious, but answering may turn out to be more complicated than it appears. Answering these questions carefully and in depth will pave the way towards success. We would like to encourage any organization planning to use LiquidFeedback to do the additional work of dealing with these questions, as any short cut may lead to improper use, disappointment, endless controversies within the organization, useless results, and jeopardize the whole purpose.

In this chapter, we will not only raise these basic questions but also give advice on how LiquidFeedback can be used by any organization in a positive and useful way and how common misconceptions can be avoided. The chapter also reflects the experience we have gained since the first release of LiquidFeedback was

published in 2009. However, all raised questions apply for every electronic participation and are not specific to LiquidFeedback.

6.1.1 *Who* may participate? (And how are these people identitifed?)

The first question that appears for an organization willing to use LiquidFeedback is who will be the entitled participants and therefore will get access to the system.

Even though at a first glance this question seems trivial, answering this question in detail might turn out more complicated than it seems. While granting limited read-access to the general public might be desirable in most cases, allowing everyone to participate is usually not reasonable: people that are member of one political party should obviously not decide the target course of a competing political party, since such a privilege might easily be abused to harm the other party. Ideally those people (and only those people) should be allowed to participate in a decision-making process that are affected by its outcome; e. g. the manifesto of an organization should be decided upon by the members of that organization, or the design of a playground should be decided upon by those children who will later use it.* Unfortunately, the group of people that is affected by a certain decision is sometimes not definite: How close do you need to live next to a park in order to be "affected" by its design? What about visitors from other cities or the necessary funding for that park?

Whatsoever these questions are answered, a clear criterion must be determined which decides who is entitled to participate. Also practical considerations need to be made regarding the identification of the people that may participate:

Organizations (e. g. political parties) usually have a member database that can be used for accreditation of the participants, while in other application areas (e. g. civic participation) other

*The final decision might still be subject to further bodies, e. g. the implementation of a decision might depend on previously decided budgets, or—as in our example—a decision of children on how to design their playground might be overruled by their parents due to safety considerations.

ways to obtain the accreditation data may become necessary. The accreditation process has to ensure that only entitled persons get access to the system with *exactly one account*. A reconciliation of the participants in LiquidFeedback with the organization's member database on a regular basis is essential to keep up with changes taking place within the organization (e. g. new members, terminated memberships, name changes, change of chapter affiliation). While defining the accreditation and reconciliation processes, an organization should think about both possible attempts to defraud and possible mistakes, keeping in mind the processes depend on the quality of the member database.

Sometimes several groups (e. g. local chapters of a political party) exist and need to discuss and decide issues within this group. They may also be entitled to vote on a higher level (e. g. the state unit of a given political party). Apart from the hierarchical structure there may be groups dealing with specific questions (e. g. organizing committees or thematic think tanks). I. e. in a real world situation there may be proper subsets and overlapping affiliations. Both can be handled easily using *organizational units* (see glossary) in LiquidFeedback as long as the necessary information on affiliations is available (e. g. in the member database).

LiquidFeedback was designed for voting by roll call ("recorded vote") only. It is not intended for anonymous use where participants can sign up without any control whether the participant belongs to an intended group of participants. It is also not intended for pseudonymous use where participants within the system are hidden behind nicknames and only a special group of administrators know (or can guess) who really signed up.

There are two main reasons for voting by roll call only:

- At first, as discussed throughout chapter 3, the verifiability of a voting and participation system like LiquidFeedback is essential. The outcome of the system may only be used if the verifiability is seriously taken into account. Any anonymous usage of LiquidFeedback (or any other electronic system) will not give reliable results because—in short—this is not possible.

Organizations using electronic systems anonymously often argue they do not use the system for binding decisions but just for opinion forming and thus nonbinding recommendations. This argument is misleading and dangerous: results will either influence decisions in some way in which case the organization is already trapped, or they will be entirely ignored in which case it is unclear why they were created in the first place. The impossibility of anonymous usage of an electronic platform can not be compensated by regarding the results as "nonbinding." Results are reliable or not—there is no third possibility. If they are not reliable they are worthless.

Sometimes the pseudonymous usage of LiquidFeedback is intended instead of anonymous usage with the argument of personal rights and data protection or privacy concerns, but also this is not possible. A voting system is only reliable if *the participants* of the system are able to review how the votes are counted and *who* was casting a vote.* With pseudonymous usage of LiquidFeedback only a group of administrators would have the knowledge about the real participants. This gives the administrators (or hackers) an inappropriate power of being able to manipulate the system. It even opens the door for blackmailing. If there is a need to vote secretly, the only way is to do exactly this (a secret vote) using a traditional ballot box. Any attempt to simulate secrecy with an electronic system is not a step towards protection but collects data that ought to be secret and is in fact an attack against secrecy.

- Secondly, every organization using LiquidFeedback needs to ensure that only the eligible participants can get access to the system with exactly one account. So called "sock puppets" must be avoided,† such that one user account matches exactly one person in the real world. As discussed before, in anonymous or pseudonymous systems there is

*This is also possible in secret elections using ballot boxes, as the act of casting the folded ballot paper into a box is done publicly.

†see also "sock puppet" in glossary

> not even a chance of identifying sock puppets. Nowadays the possibilities of social engineering and the abilities of hacking computer systems are very advanced. There is even software for organizing and managing an army of sock puppets in social networks and all appear to be living persons. Very often these sock puppets are sold as "followers" or "friends" in social networks by specialized agencies. Lobby groups work as spin doctors to manipulate the public opinion just like hidden sponsors rate products or services on sales platforms and online shops and make them appear more positive and popular than actual consumers would rate them. (This practice is also known as "astroturfing.")
>
> While a proper accreditation process might address the problem of "sock puppets," this process cannot be verifiable for the participants unless every participant is identifiable within the system (see also section 3.3 starting on page 43).

To solve these problems every single participant in the LiquidFeedback system has to be relatable to the correspondent real person. The system has to be installed as a transparent system to make it verifiable and thus reliable. Without transparency regarding the identity of the participants, it would be impossible for the participants to discover certain errors or manipulations (see also section 3.4 starting on page 49).

As LiquidFeedback is a web based platform, the participants usually need access to the internet. Even in countries with a high technological standard internet may not be available in all areas. Internet access depends on many aspects, and if LiquidFeedback is used e. g. as a civic participation system, even the social and cultural status needs to be considered. An interesting aspect for emerging economies, for example, is that private people do not use desktop computers so much but mobile devices and tablets. This provides a wide range of usage of LiquidFeedback also in these areas.

But even if not everybody has an own computer, mobile phone or tablet, some alternatives are thinkable: An organi-

zation could provide computers for members in its office and branches. Trustees could be found to help handicapped people who are not able to use computers. And last but not least, people who really cannot access the system could delegate their vote to another trustworthy participant. For this, an organization can create an offline delegation process, e. g. setting the delegations in the system for this member according to their request on a paper form.

6.1.2 *What* is the subject of participation?

LiquidFeedback is designed as a decision-making platform that does not need a moderation on issues discussed within the system but integrates a special kind of collective moderation as described throughout chapter 4. Thus LiquidFeedback is technically not restricted to single issues that may be discussed, but it allows discussion on any topic the participants like to discuss.

Subject areas can be predefined by the organization, but it is also possible to set up a minimal system and let the system grow over time by making the participants decide on the subject areas to be added (see section 2.3 starting on page 26, and section 4.8 on page 71). Subject areas should be chosen wisely, keeping in mind it should be as clear as possible to determine which subject area a new topic should be assigned to.

Even in cases where the subject areas are organized by the participants, or in case where there is a general subject area like "all other topics," not every topic that is discussed and decided upon within a participation system will have consequences though: e. g. a system installed to collect and decide upon new product ideas within a company might not allow for debating on pay rises, or a system for civic participation regarding local town planning is not provided to change tax laws.

In order to avoid wrong expectations and pointless efforts by the participants, the subject of participation needs to be defined (e. g. civic participation in a defined local area, participation of members of a political party on program issues, participation of members of an association on its statutes etc.) and should be actively communicated to the participants.

6.1.3 *Which* instruments are used?

Not every participation solution fits every purpose. If open democratic self-organization of a large group with real conflicts is intended, LiquidFeedback may be the first choice to provide means of a structured discussion and to provide a binding decision-making process. We leave it to the assessment of every organization whether the LiquidFeedback approach as outlined in the previous chapters fits their needs.

In some cases the vote has to be kept secret (e. g. in government elections). This is clearly no application field for any electronic system. As explained in section 3.4 and Figure 3.1 on page 54, anonymity and verifiability never go together in an electronic system. This is why LiquidFeedback or any other electronic system should never be used if secret voting is intended or required.

If instruments for participation are discussed, one has to go to the very beginning of communication: People want to interfere and want to exchange their opinions. This is usually done in personal discussions. We do this all day long within our families, with our colleagues, neighbors etc. without even thinking about it. Thus, personal discussion is maybe even not seen as an "instrument of participation," but it is the natural habit of human beings to let information flow and to let the people learn about the others and the world. This seems easy, because we are so very used to it, but it is also very limited. As long as discussions take place in small groups up to 10 people everything is fine. They can sit around a table and focus on their subject easily. But what about larger groups, 20, 50, 100, or even thousands of people? How can they participate in a discussion process and can be heard if they have to say something interesting? The answer is that an in-depth discussion with live meeting of a bigger crowd of people with personal interaction is simply not possible.

Polls may be used to find out about opinions in a group. But only some questions can be asked in a survey—usually with limited answer options—and there is no interaction with the participants to develop new ideas. Anyway, if only some questions appear and it is not necessary to go into detail or open up for

new ideas, this may be the perfect way to get quick results on a given issue. However, one should keep in mind that the question that is being asked may have a huge impact on the answer given.

In hearings usually there are more opportunities to talk with experts about a subject and to go into details. Usually it is limited to the person or group that is being asked, the number of participants is limited, and the number of questions is limited due to time constraints. But also this kind of participation may be interesting in some cases where a group wants to hear a special group of experts. So it may perfectly fit the needs.

In general assemblies, voting by show of hands will be the usual procedure of decision-making. A constructive and fair discussion process is only possible if the number of participants is small enough. Assemblies with a huge number of people do not scale. To overcome this problem, many organizations use delegates to vote in a meeting of delegates on behalf of the members. This comes with a price as direct participation is not possible anymore and still doesn't solve the problem entirely because meetings of delegates very often also exceed the size favorable for a discussion. There are pros and cons for delegates: division of labor, scalability, resources *vs.* static character of the division of labor, lack of representation of minority's ideas (see also chapter 4, subsection 4.10.5 on page 85).

Voting with ballot boxes was already discussed in chapter 3. The process of using ballot boxes may be complicated but is used for electing governments in democratic states worldwide. It is the only process we know so far that allows admission control combined with the possibility to cast a secret vote. If implemented correctly, nobody can find out which of the participants has given which vote. Using an electronic system to cast the ballot, this is not possible.

This is why LiquidFeedback should only be used as a participation instrument where every member may be identified by the other participants and voting can be done by recorded vote.

LiquidFeedback can be used by large groups with real conflicts and does *not* depend on bipartisan cooperation. The participants don't have to be at the same place, they can access the system worldwide using the internet, and they even don't

have to do this at the same time. LiquidFeedback allows asynchronous work and can handle real conflicts and noisy minorities. The possibility of self-organization by collective moderation and unmatched minority protection make LiquidFeedback a powerful and so far unrivaled proposition development and decision-making software.

As we will also discuss later in section 6.2 on page 130, it may be reasonable to facilitate multiple instruments of participation at once. Sometimes these instruments may complement each other, e. g. to allow a free discussion as supplementary means to a structured discussion (see also chapter 4, subsection 4.1.3 on page 62). However, it must be strictly avoided to create confusion about which instrument shall be used for a particular purpose. For example, it would be counter-productive if there are multiple participation systems to vote for a final decision on the same topic: some participants would not use both systems, such that either system cannot not provide useful results.

6.1.4 *How* are the instruments used?

Whichever participation instruments are chosen, before launching a participation system it must be defined *how* these instruments are being used.

In case of assemblies, regulations should be made on how to assign discussion time. To conduct a secret ballot using ballot boxes, it needs to be decided when the polling places are open. Will there be one or multiple ballot boxes? How are the votes being counted?

It is vital to answer these questions *in advance,* as elsewise the results are meaningless since participants might be deluded about the consequences of their decisions (e. g. prematurely closing a polling place would exclude voters who relied on previously announced opening hours).

Also in the case of LiquidFeedback many detail questions must be answered in advance. Some of these questions have been already mentioned in the previous subsections 6.1.1 and 6.1.2: Who may participate and how is access control realized? Which kind of subject areas are available? What kind of decisions can

be made and how do the policies for different kind of decisions look like? (For policies, see section 4.7 starting on page 69.)

Special considerations must be taken when LiquidFeedback or any other electronic participation system is used for binding decisions: Even if verifiability for the participants is guaranteed (see chapter 3), the risk of (detectable) manipulation can still not be ruled out completely. It is thus advisable to not put decisions into effect immediately but to allow for a "time for complaints" after publication of the voting results. During this time, voters should be able to find fault with the voting results. Detailed rules of procedure should be established to ensure that decisions are reliable and final after the time for complaints has elapsed.

6.1.5 *Why* to participate?

Why should someone make an effort and participate? What is the possible impact that makes participating a useful undertaking?

In many cases people participate in political decision processes because they want to improve their personal situation. Their personal interest influences how much they are willing to invest on a given subject. Motivation also depends on their personal assessment of their chances to influence the decision and the possible impact of a given participation i. e. the binding character of the decisions or the commitment of the actual decision makers (e. g. board members, law makers).

Intensity of participation will increase if participants feel a question is important. On the other hand, motivation will decrease if participants feel the solution of a given problem is already in good hands (e. g. trust in representatives, satisfaction with an administration).

Not all factors that decrease participation quota are to be seen as harmful: If everybody's satisfied with a certain topic or elected representatives, then there might be no need for broad political involvement. The participation quota *itself* doesn't qualify as a target function (e. g. it would be a bad idea to "motivate" action by infuriating people). Nevertheless, it is important to make participation systems as attractive as possible.

Factors influencing the participation quota:

commitment, binding results:	*increasing*
interest in issues:	*increasing*
personal assessment of importance:	*increasing*
discontent with the status quo:	*increasing*
access barriers:	*decreasing*
results being ignored:	*decreasing*
trust in representatives:	*decreasing*
satisfaction with administration:	*decreasing*

Figure 6.1: *Factors influencing participation quota.*

One approach to achieve attractiveness is simplicity—but this may cause serious drawbacks: If a system only allows you to vote "yes" or "no" to a predefined question, then voters may be influenced by whoever is preparing the question. Voters would not be able to express their real wishes but instead be forced to agree to one of two statements that are both dissatisfying or even harmful. As we have also shown in chapter 4, fairness and self-organization requires certain rules and agreements, which—of course—cause a certain amount of complexity as well as limitations for each individual (e. g. in LiquidFeedback it is not possible to update or revoke an initiative just before voting starts).

Up to a certain extent, people will have to learn about rules and regulations if the overall process shall be fair. A well-organized user support might help in this regard. While LiquidFeedback's processes might appear complicated at first, successfully promoting an initiative in LiquidFeedback can be much easier than going through a classical hierarchy.

The complexity of a discussed issue is usually a bigger challenge: Even if access barriers can be reduced to a minimum (e. g. by providing a skilled user support or other assistance), political work is still... work! While this statement sounds trivial, its implications should not be underestimated: there has to be

some incentive to motivate people to actually do the work, if people shall do more than simply taking part in a controversial "yes"/"no" question.

In case of LiquidFeedback the crucial question is: "Why to invest work and effort to write initiatives, read other people's proposals, and rate and vote upon them?" Installing a LiquidFeedback system whose outcome doesn't have any real world consequences is pointless. Ideally, the result of voting is binding; if that's not possible, then elected representatives should at least feel committed to implement the decisions made by the participants.

In either case it is wise to keep track of previously made decisions and their state of implementation. This may be done in an additional information system like explained in the following section 6.2.

6.2 Informed decision-making

While LiquidFeedback allows a structured, self-organized discussion process and a sophisticated system for voting, it is not intended as a general information platform. Valuable contributions to a discussion depend on knowledge. It is therefore recommended to set up additional systems in order to provide access to data related to the subject of participation, i. e. a system to access protocols of previous meetings, insight into the work of an executive board or, for example, a openly accessible land development plan in case of decisions regarding land-use planning, etc. This is usually the *first* step to take before even considering to install a particular participation system.

The gathering of such data is work intensive. Depending on available funding, these systems might be fed by employees of a political party or—in case of civic participation—by employees of the state. While those information systems are not a necessary precondition to collective decision-making, these additional information sources might help people to gain a better overview on debated issues either to decide on them themselves or to monitor their delegates within a Liquid Democracy system.

Of course, using centralized information systems may also bear the risk of biased information in order to drive people to a certain political decision. Therefore, whenever data is consolidated or interpreted, the original data (i. e. raw data) should be made available as well. It is best to provide both human- as well as machine-readable interfaces for accessing the data, as this reduces barriers to access the information and also allows further automated processing of the data.

Even with the previously mentioned considerations respected, information might still be biased. Any small group or individual, however, may still collect data from other sources and present them in an adequate way. LiquidFeedback's representation algorithms, as explained in chapter 4, section 4.10 starting on page 72, give those people a fair chance to be heard.

6.3 Application areas

In this section, we discuss the specifics of the different application areas and refer to the questions of political participation as outlined in section 6.1 starting on page 119.

6.3.1 LiquidFeedback in political parties

Along with associations, political parties are the original application area LiquidFeedback has been designed for. Political parties play a key role in forming the political will of a society, and they seek to influence or even control government decisions. They usually unite citizens interested in politics on a voluntary basis and have some liberty in organizing their decision-making.

In this context, LiquidFeedback can be used in a fairly binding way. Depending on the organizational needs and the national legislation, some restrictions may apply (e. g. some decisions may be reserved to a traditional party convention).

It is possible to limit the use to certain local chapters, certain fields, certain kinds of decisions, or reserve the right to veto. However, if such limitations are applied by a given party, it is essential to be clear on them and to avoid false expectations.

LiquidFeedback can deliver reliable results about what the participating members want. By empowering the ordinary members, main stream political parties become more connected and attractive to citizens which not only makes democracy stronger but arguably also helps party leaders to overcome the loneliness at the top.

Without changing the political system, parties can decide to introduce Liquid Democracy principles as they see fit and use the results for information, suggestion, directive, or as the actual decision. These and all other parties (or their candidates) will continue trying to canvass voters in secret elections.

Installing LiquidFeedback as a transparent system where all votes are recorded and each member's influence on the decision-making process is published can underline the reliability of a party and therefore convince voters to vote for such a party. As already explained in chapter 3, section 3.4, using LiquidFeedback for voting by roll call is not just a necessity to avoid the "Wahlcomputerproblem" but also a chance to give voters an insight into the internal processes of the party and thus fight reproaches of nontransparent lobbying and nepotism.

1. *Who may participate?* Most likely the answer will be: the members. Existing member databases will be the first choice as a reference. They should also provide information about chapter affiliations. Circumstances will decide if a centralized process or a local approach will be preferred.

   Regular reconciliation is a must to keep up with changes (e. g. new and terminated memberships, changes of chapter affiliation). Furthermore, the voting privileges may depend on the payment status of due membership fees.

   Some parties require an additional public* introduction of every user at a local assembly to be done every once in a while (e. g. every year). This measure shall avoid the buildup of sock puppets or identity theft (e. g. from members who passed away).

*at least accessible for members

2. *What is the subject of participation?* Typically a party has to decide on political, internal, and personnel issues. If secret voting is either required or intended for some issues, we strongly discourage the use of LiquidFeedback for the questions concerned, e. g. a secret election of persons must be done using a real ballot box (pen-and-paper voting). For all other questions, there should be a clear agreement on what can be dealt with and how binding the results are for the particular kind of decision (e. g. suggestions for representatives, directives for board members, binding decisions—maybe with a veto right for the treasurer). A clear definition of the subject of participation can avoid disappointment and controversies within the organization.

3. *Which instruments are used?* The focus of this section is the use of LiquidFeedback, but it won't be the only instrument in use. Refer to section 6.1, subsection 6.1.3 as well as section 6.2 for further information.

4. *How are the instruments used?* Political parties need to decide on a variety of decision types: bylaws, manifesto, programmatic, organizational, press releases, etc.

   The different kinds of decisions are easily determinable in most cases and sometimes require different policies in terms of timing and majority requirements. Refer to chapter 4, section 4.7 (starting on page 69) for an overview of the possible parameters and available options. We advise to consider our remarks in section 4.13 (starting on page 106) before using supermajority requirements for any kind of decision. If supermajorities are still desired, refer to section 4.12.3 (starting on page 101) for the necessary detail questions to be answered.

   Sometimes very quick decisions are demanded of political parties. LiquidFeedback may empower *all* members of a political party to contribute to these decisions, but since LiquidFeedback allows people to delegate, even in this case not everyone needs to be involved directly in every (short-term) decision. Nevertheless, agreements must be made

on how quick certain decisions can be made and which decisions can be decided on a fast-track at all.

Special care must be taken when deciding on the subject areas to provide within the system: Since choice of the subject area has an impact on which delegations are used by the system, there should be clear rules which subject area in the system can be used for what kind of decisions. In case of doubt, avoid a huge number of extra subject areas in favor of a clearer scheme.

5. *Why to participate?* The only long lasting motivation to keep spending effort in a party-wide LiquidFeedback system is to be able to influence the course of the party. It is thus suggested to use LiquidFeedback for binding decisions for the party. These decisions could create an official "party position" for any kind of issue, and elected representatives may use these positions as recommendations for their work in the parliament.

6.3.2 LiquidFeedback in associations

Associations of any kind can use LiquidFeedback for their internal organization purposes. For large organizations this provides an alternative to classic hierarchies.

1. *Who may participate?* Once again most likely the members. Existing member databases will be the first choice as a reference. Not all organizations are organized democratically though. Some kind of decisions might be reserved to a subset of the members. LiquidFeedback can implement such voting rights by grouping these members in an own organizational unit with designated subject areas.

   A process of personal introduction in a public meeting may be required in order to avoid sock puppets. This process might be repeated on a regular basis (e. g. once a year) to exclude members that are no longer active in the organization.

2. *What is the subject of participation?* Some associations, e. g. CSOs (civil society organizations), may want to decide both political issues and organizational questions. In such organizations the potential use of LiquidFeedback is very similar to political parties. In other organizations (e. g. sports clubs) the main focus will be organizational decisions.

3. *Which instruments are used?* The focus of this section is the use of LiquidFeedback, but it won't be the only instrument in use. Refer to section 6.1, subsection 6.1.3 as well as section 6.2 for further information.

4. *How are the instruments used?* The statements regarding political parties (see page 133) hold also for most other organizations. Consider that some kinds of decisions may not exist in all associations (e. g. not all organizations have a political manifesto).

5. *Why to participate?* The key-factors giving motivation to take part in an electronic participation system depend on the kind of organization using it. In many but not all cases it will be similar to political parties. Formally binding decisions might not be as important though, as long as decisions within the system have a real impact.

6.3.3 LiquidFeedback in grassroots movements

Grassroots movements develop spontaneous when people get mobilized by a political issue. They lack power structures, only have minimal organizational structures, and there is usually no definition of "membership."

This is why it seems impossible for any grassroots movement to set up an accreditation process, let alone to tell who will be bound to the decisions. We don't know of any grassroots movement which successfully managed to setup electronic participation.

However, parts of a grassroots movement can develop into a more elaborated structure which would allow electronic participation, but these organizations wouldn't be considered grassroots movements in the above sense.

6.3.4 LiquidFeedback for citizens

There is a lot of discussion about civic participation, usually because of an actual or assumed lack of representation. However, the demand for civic participation appears to be highly selective in terms of the subjects and the interest groups involved. Referenda seem to be a legitimate way, but they are not always possible and have their own shortcomings.

A binding participation system based on LiquidFeedback would require a general agreement within the population or a law for that matter. It would also impose high technical requirements and wouldn't allow secret voting which would have to be done outside this system, i. e. in a separate referendum.

As of now, one approach is establishing an *additional* communication channel between voters and their administration—very similar to the idea of petitions. The representatives are to make responsible decisions based on the popular vote. This is to build trust in the administration's work and to contribute to the perception of accountable politics. Consequently, existing implementations show a tendency of representatives to become more communicative by explaining politics both in the debate and following the decision. Such a system should be a permanent offer to the citizens and be regarded *infrastructure*—ready to use whenever the need arises. The sole existence of such a system can change attitude of both citizens and politicians.

But internet based participation systems like LiquidFeedback can also help to overcome the limitations of a referendum: LiquidFeedback can be used to *prepare a referendum* as it allows to consider pros and cons, to enhance propositions, and to suggest alternatives. If alternatives exist, its preferential voting can be used for the preselection of the question to be asked in the actual referendum.

1. *Who may participate?* Most often the people who are eligible voters in a region, state or country, or permanent residents shall be allowed to participate in the system. Depending on the existence and availability of a voter register or a similar database, an accreditation process has to be defined.

   Just like "normal citizens," elected representatives should use the system to promote their point of view prior final decision by the citizens. This makes sure the expertise of the representatives becomes part of the discourse in the system.

   In addition to citizens (including representatives) the political administration can take a special role in the system: Upcoming issues in a parliament or other administrative decisions can be entered into the system to "poll" the opinion of the citizens. (Refer to appendix E on page 189 for an explanation of LiquidFeedback's polling mode.)

2. *What is the subject of participation?* The kind of topics to be discussed depend on the political administration installing the system. It should be clearly communicated which issues can be discussed and what kind of resolutions will not be taken into consideration by the elected representatives. False expectations should be avoided.

   In addition to allowing citizens to bring up issues themselves, the political administration can automatically enter all issues discussed in the parliament into the LiquidFeedback system.

3. *Which instruments are used?* The focus of this section is the use of LiquidFeedback, but it won't be the only instrument in use. Refer to section 6.1, subsection 6.1.3 as well as section 6.2 for further information.

4. *How are the instruments used?* For civic participation we suggest to keep subject areas and policies as simple as possible. The suitable subject area for a given issue should be easily determinable. In many cases it will be sufficient to

only offer one policy for citizen-instigated initiatives. For administration-instigated initiatives, an additional policy using LiquidFeedback's polling mode (see appendix E) is most likely a good choice.

An important consideration is the run-time of issues: Media coverage plays an important role for the success of civic participation. While international and nationwide media can inform about the project, local media coverage is essential for the discourse within the participation system. LiquidFeedback intentionally leaves room for local media to take an active part in organizing the discourse in the state, county, or community. However, in order to allow a public discourse to develop, it is *vital* to allow for a discussion, verification, and voting time that is long enough. The demand for instant results and impatience of the participants may seduce an administration to provide short timings. While these shorter timings may be practical for many trivial issues being discussed in the system, they inhibit the possibility to handle topics with a greater complexity, thus destroying the participation infrastructure. In order to bring the participation system to success, it is necessary to enter administration-instigated initiatives early enough. If this is not possible, then the processes outside the system might need to be adjusted to allow citizens a thorough formation of opinion in due time.

5. *Why to participate?* In most cases it will not be possible to use LiquidFeedback for binding decisions by the citizens. Nevertheless, LiquidFeedback's output can be used by the parliament or the political administration as a suggestion. A higher commitment will usually be an encouragement for participation.

6.3.5 LiquidFeedback in a constituency

A *"constituency LiquidFeedback"* is a way for a representative (e. g. a house member) to share the power with the people in their electoral district.

1. *Who may participate?* A representative will want to offer participation to people in their constituency. Depending on the jurisdiction there may be a centralized voter register which can be used. In other cases (in particular countries without resident registration) an active accreditation process needs to be organized.

   Usually existing activities prior to the elections (e. g. the voter registration drive in the United States) are utilized to accredit the first participants. This helps to streamline the process and increases the awareness of the participation promise among the voters. Obviously, the accreditation process should be pursued when in office.

2. *What is the subject of participation?* As a constituency system will usually be based on a commitment (i. e. an election pledge), decisions can be as binding as the representative wants. They can be restricted to certain areas of politics or certain issues can be excluded.

   It is up to the representative to set the rules of their commitment at the time of running for office. The ideas reach from consulting the constituency in certain matters to just representing the popular vote. In the first case, a representative gets a balanced opinion (as opposed to e-mails or letters sent to the representative—sometimes originating from noisy minorities). The latter case means the representative will always follow the popular vote but may fight for their own position within the LiquidFeedback proposition development process and attempt to convince the people in their constituency.

   There may be positions a representative can not accept for ethical reasons or due to party loyalty. This should be considered before making a commitment: limitations should be disclosed along with the pledge.

3. *Which instruments are used?* The focus of this section is the use of LiquidFeedback, but it won't be the only instrument in use. Refer to section 6.1, subsection 6.1.3 as well as section 6.2 for further information.

4. *How are the instruments used?* Usually the same considerations as made in subsection 6.3.4 apply (see page 137).

5. *Why to participate?* The motivation to participate depends on the representative's commitment to honor the public vote.

6.3.6 LiquidFeedback in corporations

Visionary boards are interested in unleashing the creativity of their employees. This can be achieved with a *"corporate LiquidFeedback."*

1. *Who may participate?* The intended participants are all or certain employees of a given company. Due to the nature of a company-employee relationship, a corporation may want to offer incognito participation to encourage employees to give their real opinion. In this case, we are usually not talking about democratic decisions: the board will always have the last word, primarily act in the interest of the corporation and be fully responsible. Therefore, verifiability of results may be subject to a risk assessment by the board.

   There are use-cases where companies decided to allow pseudonymous access to their LiquidFeedback system. Even if the risk of undetected manipulation is acceptable for the executive board, anonymity still can't be guaranteed. Just to name one example: the deactivation of accounts of former employees might disclose their identity. But even if the anonymization process is executed very thoroughly, neither the verifiability of the results nor the verifiability of proper anonymization will be achieved for the participants in those cases (see chapter 3, starting on page 39).

2. *What is the subject of participation?* The possible subjects depend on the will of the board of the company and may range from product ratings to technical expert questions or from work organization to customer strategies.

3. *Which instruments are used?* The focus of this section is the use of LiquidFeedback, but it won't be the only instrument in use. Refer to section 6.1, subsection 6.1.3 as well as section 6.2 for further information.

4. *How are the instruments used?* The configuration of LiquidFeedback's policies and subject areas depend on the individual use case.

5. *Why to participate?* Depending on the use-case, participation can either be mandatory or meant as an offer, e. g. to channel suggestions for the improvement of work procedures.

6.3.7 LiquidFeedback in cooperatives

Cooperatives are "little democracies" in the economy. Cooperatives and other employee-owned businesses can use a *"cooperative LiquidFeedback"* for binding decisions.

1. *Who may participate?* This question is answered by the "articles of partnership" or a similar document and/or applicable law. Usually the participants will be the members of the cooperative or the shareholders of the employee-owned company.

   Sometimes people have different voting weight according to their share. Currently LiquidFeedback does not have support for voting weight depending on the interest share but may be extended in future or customized versions.

2. *What is the subject of participation?* To which extent decisions can be binding depends on the jurisdiction. Exceptions may be necessary (e. g. because of the personal liability of some or all board members). In most cases companies will have great room to maneuver. There needs to be a clear definition which decisions shall be made using LiquidFeedback.

3. *Which instruments are used?* The focus of this section is the use of LiquidFeedback, but it won't be the only instrument in use. Refer to section 6.1, subsection 6.1.3 as well as section 6.2 for further information.

4. *How are the instruments used?* The different kinds of decisions and their necessary LiquidFeedback-policies depend on the agreement between the members or shareholders and will most likely be written in the "articles of partnership" or a similar kind of contract. Refer to chapter 4, section 4.7 starting on page 69 for an overview of the possible parameters and available options in LiquidFeedback.

   Because of the nature of financial decisions (investments) a long-term stability of some decisions can be desired, which may be achieved by supermajority requirements. Refer to section 4.12.3 starting on page 101 for the necessary detail questions to be answered.

5. *Why to participate?* If decisions are binding, there is a direct financial interest.

6.4 Technical installation, maintenance, and user support

After answering all organizational questions, technical considerations have to be made as well.

Depending on the size of an organization or the number of participants, LiquidFeedback might need to be installed on a dedicated internet server system. Automation regarding the reconciliation of accounts in the LiquidFeedback system and an existing member database or registration office might be necessary as well. The necessary efforts for proper data management is often underestimated, creating serious problems like people with duplicate accounts (hence double voting weight) or people who do not get access to the system even if they are entitled to vote. These issues can seriously harm the reliability of the results, jeopardizing the whole undertaking.

Technical issues may also arise at the end-user side of the system, e. g. forgotten passwords or misconceptions in how to use the system. It is advisable to organize proper user support, such that participants experiencing technical problems can be assisted.

Furthermore, administrators shall look out for security updates of any deployed software components. This is a special challenge if parts of the software have been customized (see also chapter 5, section 5.2 starting on page 114).

With a thought-out plan, skilled staff and/or competent service providers, however, it is feasible to master these obstacles.

Chapter 7

Postface

Liquid Democracy is associated with a lot of ideas regarding the future of democracy. Some of these ideas, like using computers for secret ballots, are illusions. But at the same time, Liquid Democracy has great potential for breaking the iron law of oligarchy; the concept of Liquid Democracy as well as recent discoveries in voting theory (and of course the availability of computer technology) make it possible to create a new form of democratic decision-making. With LiquidFeedback we present specific rules of procedure for a democratic process, providing every participant with truly *equal rights* to the maximum possible extent while maintaining feasibility and effectiveness also in cases when the number of participants is huge.

While we should demand an equal treatment of all participants in every democratic system,* we must conclude that the equal treatment of all proposals and of all eligible voters is often not realized—not even in those cases where everyone is allowed to take part in a ballot.

We hope that the principles presented in this book create a higher awareness of the deficiencies commonly found in existing decision-making processes and that we will encourage politicians and political parties to stand up for new forms of democratic

*with the exception that sometimes elected representatives are needed

participation where these problems have been solved. We believe that the concepts of this book are suitable for political parties and other organizations to provide a truly democratic decision-making process, if desired. By publishing LiquidFeedback as an Open Source software, we do not just give a theoretical background for an improved system for decision-making but also provide a software that is fit for service in real scenarios.

However, the success of implementing LiquidFeedback—or any other electronic decision-making system—strongly depends on proper planning and preparations. We would like to advise our readers to not underestimate this task and consult chapter 6 in this matter. Following the variety of advice given in this book, a new form of democratic self-organization is feasible today, that can revolutionize democracy as we know it.

— *Berlin, 2014*

Starting on the next page you will find a *glossary* explaining common phrases regarding voting theory in general and LiquidFeedback's concepts in particular. Even if you have read all previous chapters, it may be informative to browse through the glossary, as it contains some extra information that didn't fit into the previous chapters.

Appendix A

Glossary

Absolute majority
: See "Majority"

Admission phase
: The first of the 4 "issue states", which a group of "alternative initiatives" may pass through. During admission phase at least one initiative of a group of alternative initiatives must pass a first "supporter quorum" in order to proceed to "discussion phase". See section 4.6 starting on page 66 for details.

Alternative initiative
: "Initiatives" in LiquidFeedback are grouped with other competing alternative initiatives. Groups of alternative initiatives are also referred to as "issue". It is decision of the creator (i. e. first initiator) of an initiative to decide whether an initiative gets grouped together with an existing group of alternative initiatives (an existing "issue"), or whether a new group of alternative initiatives (a new "issue") is created (which then consists of just one initiative at time of posting). After "voting phase" only one alternative per group of competing alternatives may win. Further information about initiatives and groups of alter-

native initiatives is found throughout chapter 4 starting on page 59.

Alternative vote

See "Instant-runoff voting"

Anonymity

In this book we refer to anonymity when no person can relate a voter's ballot to the person who was casting that ballot. (Note: In voting theory, the adjective "anonymity" is sometimes used to refer to voting systems which treat all voters equally, while the adjective "neutrality" is used to refer to voting systems which treat all candidates equally.[21] However, in this book we use the adjective "anonymity" in a colloquial manner to describe the inability to identify a person who cast a particular ballot.) Chapter 3, starting on page 39, deals with the difficulties of secret ballots in combination with electronic systems.

Approval voting

Approval voting is a voting system where each voter decides for each candidate whether he or she approves or disapproves that candidate (i. e. it is possible to vote for as many candidates as one wants to), but no further preferences may be expressed. That candidate with a "plurality" of votes, i. e. that candidate which has received most approvals, is the winner.[25] While approval voting was invented in the mid 1970s,[13, p.170] CONDORCET already described a system very similar* to approval voting in the 18^{th} century.[26] For more information regarding approval voting see also section 4.11 starting on page 87,

*In 1793 (during the French Revolution) CONDORCET suggested in his proposal for a constitution of France a form of approval voting where the number of approvals per voter is limited to the number of seats to be filled. CONDORCET's motivation was to find an approximation for his method of pairwise comparisons, which would not select the worthiest (i. e. best) candidate but at least a candidate that is believed by a majority to be competent, since his favored method of pairwise comparisons was difficult to calculate without the not-yet-invented computer technology of the 20^{th} century. See also: [26, p.XIII, p.47, p.181, p.200], [28, p.98], [29, p.431].

the footnote in section 4.13 on page 107, and section 4.14 on page 109.

Arrow's impossibility theorem
: A theorem proven by Nobel laureate Kenneth Arrow in his publication *A Difficulty in the Concept of Social Welfare*[30] from 1950, where he showed that preferential voting systems cannot fulfill certain reasonable criteria at once. An important interpretation of his work is the "Gibbard-Satterthwaite theorem".

Astroturfing
: The practice of organized (anonymous) rating of products or services on the internet using "sock puppets" in order to make those products or services appear more positive and popular than actual consumers would rate them. (See also subsection 6.1.1 starting on page 120.)

Autonym
: A name, distinct from a person's legal name, to identify a person. Opposed to a "pseudonym", an "autonym" is not suitable to hide a person's identity as it is well-known to which real person an autonym belongs.

Ballot
: The term "ballot" is used either (a) to refer to the whole voting procedure or (b) to refer to each voter's ballot paper (or electronic/virtual ballot) on which the voter chooses his or her favorite candidate(s) and/or preferences.

Beatpath method
: See "Schulze method"

Candidate
: While a candidate usually refers to a person running for office in an election, we also use the term "candidate" to refer to proposals/motions that are voted upon. In LiquidFeedback, all "initiatives" that have passed the second "supporter quorum" (as well as the "status quo" as an

implicit candidate) are candidates to the final voting utilizing the "Schulze method". Furthermore, "issues", "initiatives", and "suggestions" are candidates to the "Harmonic Weighting" and "Proportional Runoff" algorithms that are used to create a fair ordering when listing issues, initiatives, and suggestions.

Clone

In voting system theory, clones are a set of similar candidates (or proposals) to be voted upon. Voting systems which do not fulfill the "Independence of Clones criterion" may either harm or favor those candidates which have similar "clones" available to be voted upon.

Clone-independent voting system

See "Independence of clones"

Cloneproof Schwartz sequential dropping

See "Schwartz sequential dropping"

Collective cyclic preference

See "Condorcet's paradox"

Condorcet criterion

A criterion to benchmark voting systems. A voting system fulfilling the Condorcet criterion always selects—if existent—that candidate as winner which is defeating every other candidate in pairwise comparison. (See also "Condorcet winner" and "Pairwise defeat".) A pairwise comparison between two candidates is carried out by comparing the preferences of each voter regarding two candidates X and Y: If more voters prefer X to Y than there are voters which prefer Y to X, then we say X defeats Y in pairwise comparison. As a candidate which defeats every other candidate in a pairwise comparison does not always exist (see also "Condorcet's paradox"), this criterion has further been generalized to the "Smith criterion" and the "Schwartz criterion". A voting system which does not fulfill the Condorcet criterion obviously fails the democratic principle of the "Majority rule". The "Schulze method"

fulfills the Condorcet criterion as well as the "Smith criterion" and "Schwartz criterion".

Condorcet loser

A "Condorcet loser" is a candidate that is defeated by every other candidate in pairwise comparison (see "Pairwise defeat").

Condorcet, marquis de

Marie Jean Antoine Nicolas de Caritat, marquis de Condorcet, born in 1743, was philosopher, mathematician and political scientist in the spirit of the Age of Enlightenment and rationalism. His thinking was driven by the idea of an enlightened human who interprets his environment in a scientific manner. Condorcet's philosophical writings evaluate *insight* as the main propulsion for the progress of mankind. He advocated to abolish death penalty, to free all slaves immediately, equal rights for women and black people, and public education for everyone. Before and during the French Revolution, he published scientific books on voting methods. Condorcet was member of the jury which ruled on the deposed king and decided to guillotine him. But after that decision of the jury, Condorcet—as an opponent of death penalty itself—agitated against the execution of the king. From then on he was seen as a traitor of the revolution. He spent his last years on the run and died under unexplained circumstances in a jail of the revolutionaries.[26]

Condorcet's paradox

Condorcet's paradox (also named "voting cycle") is a paradox situation where there is a cyclic collective preference. An example for such a voting cycle is depicted in Figure 4.12 on page 95. This paradox was first described by Condorcet in 1785 and rediscovered a numerous times in the 20$^{\text{th}}$ century.[26][27][31, p.163] LiquidFeedback deals with these cycles by using the "Schulze method", which drops the weakest "pairwise defeats" where necessary (see subsection 4.12.1 starting on page 92).

Condorcet winner
: A "Condorcet winner" is a candidate that defeats every other candidate in pairwise comparison (see "Pairwise defeat"). A voting system fulfilling the "Condorcet criterion" always selects the Condorcet winner—if existent—as winner of the ballot. As shown by CONDORCET, there are cases when no such candidate exists ("Condorcet's paradox").

Constituency
: An electoral district.

Cyclic collective preference
: See "Condorcet's paradox"

Delegation
: In context of "Liquid Democracy", a delegation means to authorize another person to vote for you, i. e. giving a power of attorney. Delegations can either be described as transferring your own voting weight to another person (see Figure 2.1 on page 23) or as automated copying of the ballot of a trustee (see Figure 2.2 on page 23). LiquidFeedback allows three kinds of delegations: delegations for an "organizational unit", delegations for a "subject area" within that organizational unit, and delegations for a single "issue" (i. e. for a particular group of "alternative initiatives"). Delegations are thoroughly explained in chapter 2, starting on page 21.

Discussion phase
: The second of the 4 "issue states", which a group of "alternative initiatives" may pass through. In "admission phase" and "discussion phase" the initiators may update the "drafts" of their initiatives in order to increase their "supporter" count. See section 4.6 starting on page 66 for details.

Draft
: The text body of an "initiative" in LiquidFeedback. See subsection 4.1.1 on page 60.

First supporter quorum
See "Supporter quorum"

General (im)possibility theorem
See "Arrow's impossibility theorem"

Gibbard-Satterthwaite theorem
The Gibbard-Satterthwaite theorem states that there exists no "preferential voting system" which can entirely prohibit advantages through tactical voting.[22] It is the reason why in LiquidFeedback (in order to avoid tactical voting) the ballots of other voters are not visible during "voting phase". See section 4.14 starting on page 109 for more information.

GOCHA set
Another name for "Schwartz set". GOCHA is the abbreviation for: **G**eneralized **O**ptimal-**CH**oice **A**xiom.[13, p.154]

Harmonic Weighting
The Harmonic Weighting algorithm is used to create a fair ordering of "initiatives" within an "issue". See subsection 4.10.1 on page 74 for a detailed explanation of the algorithm and appendix B on page 169 for an example.

Independence of Clones criterion
A criterion to benchmark voting systems. A voting system which does not fulfill the "Independence of Clones criterion" is susceptible to cause another candidate to win if "clones" are added to the list of eligible candidates. This may result in a harming or favoring of candidates or proposals that are similar to other alternative candidates. See section 4.11 starting on page 87 for details.

Independence of Smith-dominated alternatives (ISDA)
A criterion to benchmark voting systems. Any voting system which is independent of Smith-dominated alternatives does not select a different winner if a candidate that has not been part of the "Smith set" is removed from the ballot.[15, p.296, (4.7.5)] In turn, adding a candidate to the ballot causing any kind of voter's preferences does not

change the outcome of the voting, as long as that added candidate will not be member of the "Smith set".

Initiative

The main concept to express a will for a specific issue in LiquidFeedback. Initiatives are introduced in subsection 4.1.1 on page 60 of this book.

Initiator(s)

Initiators are the responsible persons for an "initiative" in LiquidFeedback. An initiator may update the "draft" of an initiative during "admission phase" and "discussion phase".

Instant-runoff voting

Instant-runoff voting (also called "Alternative vote") is a voting system where each voter creates a list of candidates in order of personal preference. At the beginning of the count only the first candidate on each ballot is taken into consideration. If one candidate has a "majority" (not "plurality"*!*) of the votes (i. e. the candidate is listed first on more than 50% of the ballots), then that candidate is the winner. If no candidate has a majority of votes, then the candidate with least votes is eliminated from all ballots. The votes for that candidate are then transferred to the next non-eliminated candidate on each ballot. The procedure is repeated until one candidate has a majority. While Instant-runoff voting fulfills the "Independence of Clones criterion", it does neither fulfill "monotonicity" nor the "Condorcet criterion".

Interaktive Demokratie e. V.

The "Interaktive Demokratie e. V." is a non-profit association located in Berlin, Germany, founded in 2010. While it has been founded by the inventors of LiquidFeedback to facilitate the use of electronic media in democratic decision-making processes, it does *not* publish the software LiquidFeedback. This book has been published by the "Interaktive Demokratie e. V." though. See "Public Software Group e. V." for the or-

ganization that is publishing LiquidFeedback. The website of "Interaktive Demokratie e. V." is: `http://www.interaktive-demokratie.org/`

ISDA
Abbr. for "**I**ndependence of **S**mith-**D**ominated **A**lternatives".

Issue
A group of one or more alternative initiatives which are competing with each other. See "Alternative initiative" for more details.

Issue state
In LiquidFeedback, all groups of alternative initiatives may pass through 4 states (also called "phases"): "admission phase", "discussion phase", "verification phase", and "voting phase". See section 4.6 starting on page 66 for details.

Liquid Democracy
An approach to combine the positive aspects of representative and direct democracy. Liquid Democracy uses transitive delegations to allow a division of labor in a democratic process while not having to empower elected representatives for a fixed period of time. Liquid Democracy is explained in detail in chapter 2 of this book, starting on page 21.

LiquidFeedback
LiquidFeedback is a computer software that employs mechanisms of "Liquid Democracy" (see chapter 2, starting on page 21) as well as those concepts explained in chapter 4 (starting on page 59) of this book to allow online decision-making using the internet. The first version of LiquidFeedback Core (the backend of the software) was published on 2009–10–27 by the "Public Software Group e. V.". LiquidFeedback is updated and maintained by the "Public Software Group e. V.", which is also copyright holder of the project. More information on its licensing model is found in chapter 5, starting on page 113.

Majority

A majority is a fraction of a group of people that consists of more than 50% of that group. Sometimes the terms "simple majority" and "absolute majority" are used to denote the reference population for measuring 50%: In case of simple majorities, the group used to measure the 50% consists only of those persons who participate in a ballot and who do not abstain; e. g. more voters have to vote "yes" than voters who vote "no" in order to gain a simple majority. In case of absolute majorities, the group used to measure the 50% does not necessarily depend on the ballot but may consist, for example, of all members of an organization (independently of who takes part in a ballot), such that if the organization has X members, then more than $X/2$ people must agree on something to gain an absolute majority. In pairwise comparisons with the "Schulze method", LiquidFeedback honors simple majorities; i. e. voters who rank two candidates equal are ignored for deciding who wins in a pairwise comparison. (See also "Pairwise defeat".) The term "majority" should not be confused with "relative majorities" (see "Plurality") or "qualified majorities" (see "Supermajority requirement").

Majority judgment

A voting system where voters give a grade to candidates, and the median grade is calculated for each candidate. That candidate with the best median wins. "Majority judgment" should not be confused with the concept of "majority rule". Despite its name, "majority judgment" does not honor the "majority rule": Even if there is a "majority" which prefers a candidate X to another candidate Y and there are no "cyclic collective preferences", then Y might still be chosen as winner when using "majority judgment". Majority judgment does thus not fulfill the "Condorcet criterion". (See also section 4.14 on page 109.)

Majority rule

The democratic principle of majority rule states that a

"majority" (i. e. more than 50% of those participants involved in a decision) may decide and thus overrule a "minority". Violating this rule would allow minorities to overrule majorities (see "Supermajority requirement" for an example for the violation of "majority rule"). LiquidFeedback follows the principle of "majority rule", which is discussed in section 4.13 on page 106, as long as there are no "cyclic collective preferences" (see "Condorcet's paradox").

Marquis de Condorcet
See "Condorcet, marquis de"

Minority
While "majorities" consist of more than 50% of people, "minorities" consist of less than 50% of people. Since in a democratic system decisions are made by majorities ("majority rule"), any decision without unanimous assent leads to an overruled minority. Despite the concept of "majority rule", minorities can and must be protected in certain ways. Protection of minorities is further discussed in section 4.10 starting on page 72.

Monotonicity
A criterion to benchmark voting systems. A voting system fulfilling monotonicity does not harm a candidate if some voters rank this candidate higher while keeping the relative order of all other candidates on their ballot equal. The "Schulze method" fulfills monotonicity.[15, p.287] Monotonicity should not be confused with the "participation criterion" or the "no show paradox".

Neutrality
A voting system fulfilling neutrality treats all alternatives (e. g. candidates or proposals) equally. Voting systems which prefer the status quo violate neutrality.[21]

No show paradox
When a voting system suffers the "no show paradox", then participating in a ballot and stating a preference list where you prefer X to Y might select Y as winner, while

without your participation X would have won. The "no show paradox" is closely related to the problem that "tactical voting" cannot be avoided under all circumstances. While the described property of a voting system is obviously not desired, it has been proven that it cannot be avoided if the voting system shall also fulfill the "Condorcet criterion".[32] The no show paradox should not be confused with a lack of "monotonicity".

Open Source

See chapter 5 starting on page 113, as well as *The Open Source Definition*[23].

Organizational unit

LiquidFeedback allows a set-up where different organizational units of an organization have their own zone within the system. Voting rights for a person can be restricted to that set of organizational units where the person is member of. Each organizational unit can have one or more "subject areas" within the system. The organizational unit is the highest level for a "delegation" (see section 2.3 on page 26).

Pairwise defeat

In a "preferential voting system", a candidate X defeats another candidate Y in pairwise comparison when there are more voters who preferred X to Y than there are voters who preferred Y to X. The idea of considering pairwise defeats has already been mentioned by CONDORCET in the 18^{th} century.[14, p.17][26][27] When the "Schwartz set" contains more than one candidate, then the "Schulze method" uses the strengths of the pairwise defeats to determine a winner. (For details refer to subsection 4.12.1 starting on page 92.) There are different methods to measure the strength of a pairwise defeat, e. g. using the ratio of winning votes to losing votes, the difference between winning votes and losing votes, or the absolute number of

winning* votes. LiquidFeedback uses the last mentioned method for the reasons explained on page 99.

Participation criterion
: A criterion to benchmark voting systems. A voting system fulfilling the participation criterion does not suffer the "no show paradox". Unfortunately, it has been proven that any voting system that fulfills the "Condorcet criterion" can not fulfill the "participation criterion" and thus may suffer the "no show paradox" in certain cases.[32] Also the "Schulze method" violates the participation criterion.[14, p.16] However, as the "Schulze method" fulfills the "Independence of Smith-dominated alternatives" criterion, this problem is reduced.

Perfect clone
: In voting system theory, a perfect clone is a candidate (or proposal) that is completely identical to another candidate (or proposal). It is possible to generalize clones (see section 4.11 starting on page 87).

Phase
: See "Issue state"

Plurality
: When there are multiple groups of people, then the "plurality" is that group which is largest. The largest group is not always greater than 50% of all people; i. e. a "plurality" is not necessarily a "majority" (see also the example of *Thunder Bay* on page 87). If the groups may overlap, then a majority is not necessarily a plurality either (e. g. in "approval voting" there might exist multiple candidates that are approved by more than 50% of the voters, but there is usually only one candidate with the highest number of approvals).

Plurality voting
: Plurality voting is a voting system where each voter must

*in combination with the number of losing votes as a secondary criterion, if there is a tie with the absolute number of winning votes

decide for one "candidate". That candidate which receives most votes wins. Plurality voting is susceptible to the phenomenon of vote-splitting, i. e. two similar candidates (see "Clone") may harm each other (see section 4.11 on page 87). While it is still widely used, plurality voting has already been criticized by CONDORCET in the 18th century. He showed that a candidate that is preferred to every other candidate by a majority ("Condorcet winner") may receive least votes in plurality voting.[26, p.179][28, p.94]

Policy

LiquidFeedback allows to configure different sets of rules for different kinds of decisions. These rule sets are called "policies". They are described in section 4.7 starting on page 69.

Potential supporter

In LiquidFeedback a potential supporter of an "initiative" supports an initiative only under certain conditions that are not met yet. On page 62 it is explained, under which circumstances a supporter is a potential supporter. A supporter which is not a "potential supporter" is called a "satisfied supporter". See also "Supporter".

Power of attorney

See "Delegation"

Preferential voting system

A voting system where the voters may express their individual preferences by giving a personal ranking* of the candidates.

Proportional Runoff

The Proportional Runoff algorithm is used to create a fair ordering within a "subject area" of those "issues" that are in "admission phase", and it is used to create a fair ordering of all "suggestions" to an "initiative". In

*usually a *weak order,* where two or more candidates may be ranked equally by a voter

subsection 4.10.2 starting on page 79, a detailed explanation of the algorithm is given. An example is found in appendix C on page 179.

Pseudonym
: A name, distinct from a person's legal name, to hide a person's identity. Opposed to an "autonym", for a "pseudonym" it is not well-known to which real person a pseudonym belongs to. However, actions done using the same pseudonym can be linked with each other. A pseudonym may be disclosed either accidentally, intentionally, or with malicious intent.

Public Software Group e. V.
: The "Public Software Group e. V." is a non-profit association located in Berlin, Germany, founded in 2009. It is the copyright holder and original creator of the software LiquidFeedback, and it maintains and publishes new versions of this software. The association's website is: `http://www.public-software-group.org/`

Qualified majority
: See "Supermajority requirement"

Quorum
: See "Supporter quorum"

Range voting
: See "Score voting"

Relative majority
: See "Plurality"

Reversal symmetry
: A criterion to benchmark voting systems. In a voting system fulfilling reversal symmetry, the outcome of the voting procedure will be reversed if all voters cast a reversed ballot.[33, p.157] In particular: a voting system fulfilling reversal symmetry does never select the same unique winner (that is a winner without tie-breaking) if the preferences of all ballots are reversed. The "Schulze method" fulfills

this criterion[14, p.14][15, p.286], while "Instant-runoff voting", for example, does not.

Satisfied supporter

A "supporter" of an "initiative" which is not a "potential supporter" is called a "satisfied supporter".

Schulze method

The Schulze method is a preferential voting system (i. e. a method to count preferential ballots) that has been invented in 1997.[14, p.9] It is used in LiquidFeedback to count preferential ballots at the end of "voting phase". It analyzes "pairwise defeats" to determine a winner, and it fulfills a lot of desirable criteria, of which some are listed in subsection 4.12.1 on page 92. Other names for the Schulze method include "beatpath method" or "(clone-proof) Schwartz sequential dropping" (SSD or CSSD). Markus Schulze, the inventor of the Schulze method, prefers the name "Schulze method" though and notes that the other names refer to specific heuristics for implementing the Schulze method.[16, p.4] The Schwartz sequential dropping heuristic is used as a description of the Schulze method in this book (see subsection 4.12.1 starting on page 92), while LiquidFeedback internally uses beatpaths to determine the winner. Both algorithms yield to the same winner though.

Schulze ranking

In addition to the winner, the "Schulze method" also creates a *strict partial order* of all candidates.* If there are no ties, then this relation can be used to create a ranking† ("Schulze ranking") of all alternatives, where the winner gets the first rank, the runner-up the second rank, etc.

Schwartz criterion

A criterion to benchmark voting systems. A voting system fulfilling the Schwartz criterion always selects a winner from the "Schwartz set". The "Schwartz criterion"

*described as relation "$\mathcal{O}$" in either [15] or [16]

†a linear order

implies the "Smith criterion", which in turn implies the "Condorcet criterion". The "Schulze method" fulfills all three criteria.

Schwartz sequential dropping
See "Schulze method"

Schwartz set
The Schwartz set (also known as "GOCHA set") is a subset of the "Smith set". It is the smallest non-empty set of candidates, where no member of the set is defeated by any non-member of the set in pairwise comparison.[13, p.154][17, p.105] (See also "Pairwise defeat".)

Score voting
A voting method where each voter assigns a score to each candidate. The candidate with the best average score wins. Score voting is highly susceptible to tactical voting.[13, p.175] While no voter has an advantage by providing a reversed ranking of candidates (i. e. no voter would rank a candidate X higher than another candidate Y, if he or she prefers Y to X), there is a high incentive to hide the true preferences by giving scores that are only at the top or at the bottom of the permitted range, thus effectively yielding to "approval voting".

Second supporter quorum
See "Supporter quorum"

Secret ballot
A method of voting where it is not possible to identify a person who cast a particular ballot (see also "Anonymity"). In secret ballots there are often further requirements, such as the inability to prove a third person how one's own voting behavior has been.

Similar clone
See "Clone" and section 4.11 starting on page 87 for a discussion about similar clones.

Simple majority
See "Majority"

Single Transferable Vote (STV)
: A class of preferential voting systems that select a given number of winners (i. e. a group of candidates) that proportionally represent the voters. Votes are assigned to the most preferred candidate on each ballot. Each candidate needs to reach a certain quota (i. e. threshold) of votes to be elected as a winner. If a candidate has no chance to win, or if a candidate has excessive votes, then his or her (excessive) votes are transferred to the respective next preferred candidate on each ballot. Different STV systems differ in how they determine which votes are to be transferred.

Single-winner election method
: A voting method where a single-winner is chosen (e. g. a president in case of electing persons or a proposal in case of deciding on an issue). The "Schulze method" is a single-winner election method[14] but may additionally be used to create a ranked order of all candidates (see "Schulze ranking").

Smith criterion
: A criterion to benchmark voting systems. A voting system fulfilling the Smith criterion always selects a winner from the "Smith set". The "Schwartz criterion" implies the "Smith criterion", which in turn implies the "Condorcet criterion". The "Schulze method" fulfills all three criteria.

Smith-dominated alternatives
: See "Independence of Smith-dominated alternatives"

Smith set
: The Smith set is the smallest non-empty set of candidates where each member of the set defeats each non-member of the set in pairwise comparison[13, p.154] (see also "Pairwise defeat"). It is a superset of the "Schwartz set". The set is named after John H. Smith, who generalized the "Condorcet criterion",[34, p.1038] creating a new criterion that would later be known as "Smith criterion".

Sock puppet
: A pseudonymous online identity used for deceptive purposes. Using sock puppets, a single individual can manipulate the outcome of an online ballot by casting multiple votes with different identities. Sock puppets may also serve as a deceptive means to back your statements in an online discussion thread. See also chapter 3, starting on page 39, as well as subsection 4.10.4 on page 84, and subsection 6.1.1 on page 120.

Status quo
: The status quo refers to the current state or current situation. Regarding voting theory, the status quo is that condition that will continue to be, when any motion to change the current situation is rejected. LiquidFeedback treats the status quo as an implicit "candidate" in final voting (see Figure 4.11 on page 93). A voting system that fails to treat the status quo equally to all other options violates "neutrality".[21] For LiquidFeedback's treatment of the status quo, refer to subsection 4.12.3 starting on page 101.

Strategic voting
: See "Tactical voting"

STV
: See "Single Transferable Vote"

Subject area
: Each "organizational unit" may have several subject areas, in which issues are discussed. The subject area has an effect on the "delegations" that are in effect for a particular issue. See section 2.3 on page 26 as well as section 4.8 on page 71.

Suggestion
: Suggestions in LiquidFeedback are change requests for "initiatives". These change requests may be marked by the author or any other (potential) supporter of the initiative as optional or mandatory (see page 61). Suggestions may only be written by participants who generally

support an initiative (see also "Potential supporter") and they are always nonbinding for the respective initiator of the initiative which the suggestion has been made for.

Supermajority requirement

A supermajority requirement (or a requirement of a "qualified majority") means that a "majority" ($> 50\%$) is not sufficient for a "candidate" to win. Instead, the percentage of approvals must be greater than (or equal to) a higher value (usually $2/3$). Supermajority requirements are a violation of the "majority rule". They may serve as a measure to stabilize the "status quo", but they are *not* suitable to protect minorities.[21] LiquidFeedback's "policies" allow a configuration such that supermajorities can be required, if desired. (See subsection 4.12.3 starting on page 101.)

Supporter

Initiatives in LiquidFeedback must collect a certain number of supporters ("supporter quorum") in order to be further discussed or voted upon. Participants may support as many initiatives as they want, including competing alternatives. (See also "Initiative".) In order to encourage only constructive feedback, supporting an initiative (at least as a "potential supporter") is a precondition to be allowed to write and rank "suggestions" to an initiative. Participants who oppose an initiative shall post "alternative initiatives" instead.

Supporter quorum

In order to proceed from "admission phase" to "discussion phase", one "initiative" of a group of "alternative initiatives" needs to pass a first supporter quorum; i. e. enough supporters must support an initiative to avoid that the "issue" is canceled automatically by the system. For the first supporter quorum, "potential supporters" are taken into account as well as "satisfied supporters". In order to be admitted for voting, each initiative must furthermore pass a second supporter quorum at the end of "verification phase" to proceed to "voting phase". For the second

supporter quorum only "satisfied supporters" are taken into account. For more information refer to section 4.6 starting on page 66 and section 4.9 starting on page 71.

Tactical voting
Tactical voting means voters make strategic decisions when casting their ballot to increase the chance of an outcome they are satisfied with. LiquidFeedback takes certain measures to discourage participants from tactical voting. See section 4.14 on page 109 for details.

Tie-breaking
A procedure to select a distinct winner in those cases where a voting method is undecided about a group of potential winners is called "tie-breaking". Tie-breaking often involves randomness (e. g. when there is a draw between two options, then a coin is flipped to determine the winner). LiquidFeedback, however, does not use randomness for tie-breaking (see subsection 4.12.2 on page 100).

Unit
See "Organizational unit"

Verification phase
The third of the 4 "issue states", which a group of "alternative initiatives" may pass through. In this stage it is no longer possible to update a draft of an initiative. See section 4.6 starting on page 66 for details.

Voting cycle
See "Condorcet's paradox"

Voting phase
The fourth of the 4 "issue states", which a group of "alternative initiatives" may pass through. During voting phase the participants may cast a preferential ballot on those initiatives which passed a second "supporter quorum" after "verification phase". See section 4.6 starting on page 66 for details.

Weak Condorcet's paradox
: A generalization of "Condorcet's paradox" where ties in addition to "majorities" are taken into account.

Weakest pairwise defeat
: See "Pairwise defeat"

Appendix B

Example of Harmonic Weighting

Let's assume there are 8 persons (P_1 through P_8) and 8 initiatives (A_1, A_2, A_3, B_1, B_2, B_3, C, and D). There are no delegations, and the persons support the initiatives as follows:

Person	**Supported initiatives**
P_1	A_1, A_2, A_3
P_2	A_1, A_2, A_3
P_3	A_1, A_2, A_3
P_4	A_1, A_2, A_3
P_5	A_1, A_2, A_3
P_6	B_1, B_2, B_3, C, A_3
P_7	B_1, B_2, B_3, C, D, A_2
P_8	B_1, B_2, B_3, D

Let's further assume that A_1 was created before A_2, and A_2 was created before A_3. Let's also assume that B_1 was created before B_2, and B_2 was created before B_3.

In step 1 (see page 76), all initiatives are marked as unplaced. We then successively place initiatives, beginning with the worst display position #8.

Round 1

In the first round (i. e. first execution of step 2 and step 3), each persons weight calculates as follows:

Person	**Supported initiatives**	**Person's weight in round #1**
P_1	A_1, A_2, A_3	$1/3 \approx 0.33$
P_2	A_1, A_2, A_3	$1/3 \approx 0.33$
P_3	A_1, A_2, A_3	$1/3 \approx 0.33$
P_4	A_1, A_2, A_3	$1/3 \approx 0.33$
P_5	A_1, A_2, A_3	$1/3 \approx 0.33$
P_6	B_1, B_2, B_3, C, A_3	$1/5 = 0.2$
P_7	B_1, B_2, B_3, C, D, A_2	$1/6 \approx 0.17$
P_8	B_1, B_2, B_3, D	$1/4 = 0.25$

Yielding to the following weights of each initiative:

Initiative	**Supported by**	**Initiative's weight in round #1**
A_1	P_1, P_2, P_3, P_4, P_5	$5/3$ ≈ 1.67
A_2	P_1, P_2, P_3, P_4, P_5, P_7	$5/3 + 1/6$ $= 11/6 \approx 1.83$
A_3	P_1, P_2, P_3, P_4, P_5, P_6	$5/3 + 1/5$ $= 28/15 \approx 1.87$
B_1	P_6, P_7, P_8	$1/5 + 1/6 + 1/4$ $= 37/60 \approx 0.62$
B_2	P_6, P_7, P_8	$1/5 + 1/6 + 1/4$ $= 37/60 \approx 0.62$
B_3	P_6, P_7, P_8	$1/5 + 1/6 + 1/4$ $= 37/60 \approx 0.62$
C	P_6, P_7	$1/5 + 1/6$ $= 11/30 \approx$ **0.37**
D	P_7, P_8	$1/6 + 1/4$ $= 5/12 \approx 0.42$

Initiative C has the lowest weight and is thus assigned to display position #8. Since not all initiatives have been placed yet, we repeat these steps in the next round.

Round 2

When initiative C has been placed, the number of unplaced initiatives that are supported by P_6 and P_7 decreases by one, yielding to an increased weight for these persons:

Person	**Supported initiatives that are unplaced**	**Person's weight in round #2**
P_1	A_1, A_2, A_3	$1/3 \approx 0.33$
P_2	A_1, A_2, A_3	$1/3 \approx 0.33$
P_3	A_1, A_2, A_3	$1/3 \approx 0.33$
P_4	A_1, A_2, A_3	$1/3 \approx 0.33$
P_5	A_1, A_2, A_3	$1/3 \approx 0.33$
P_6	B_1, B_2, B_3, A_3	$1/4 = 0.25$
P_7	B_1, B_2, B_3, D, A_2	$1/5 = 0.2$
P_8	B_1, B_2, B_3, D	$1/4 = 0.25$

Using the new weights of each person, the weights of each initiative calculate as follows:

Initiative	**Supported by**	**Initiative's weight in round #2**
A_1	P_1, P_2, P_3, P_4, P_5	$5/3$ ≈ 1.67
A_2	P_1, P_2, P_3, P_4, P_5, P_7	$5/3 + 1/5$ $= 28/15 \approx 1.87$
A_3	P_1, P_2, P_3, P_4, P_5, P_6	$5/3 + 1/4$ $= 23/12 \approx 1.92$
B_1	P_6, P_7, P_8	$1/4 + 1/5 + 1/4$ $= 7/10 = 0.7$
B_2	P_6, P_7, P_8	$1/4 + 1/5 + 1/4$ $= 7/10 = 0.7$
B_3	P_6, P_7, P_8	$1/4 + 1/5 + 1/4$ $= 7/10 = 0.7$
D	P_7, P_8	$1/5 + 1/4$ $= 9/20 =$ **0.45**

Now initiative D has the lowest weight and is assigned to display position #7. Since not all initiatives have been placed yet, we continue with the next round.

Round 3

After initiatives C and D have been placed, each person's weight calculates as follows:

Person	**Supported initiatives that are unplaced**	**Person's weight in round #3**
P_1	A_1, A_2, A_3	$1/3 \approx 0.33$
P_2	A_1, A_2, A_3	$1/3 \approx 0.33$
P_3	A_1, A_2, A_3	$1/3 \approx 0.33$
P_4	A_1, A_2, A_3	$1/3 \approx 0.33$
P_5	A_1, A_2, A_3	$1/3 \approx 0.33$
P_6	B_1, B_2, B_3, A_3	$1/4 = 0.25$
P_7	B_1, B_2, B_3, A_2	$1/4 = 0.25$
P_8	B_1, B_2, B_3	$1/3 \approx 0.33$

Yielding to the following weights of each initiative:

Initiative	**Supported by**	**Initiative's weight in round #3**
A_1	P_1, P_2, P_3, P_4, P_5	$5/3$ ≈ 1.67
A_2	P_1, P_2, P_3, P_4, P_5, P_7	$5/3 + 1/4$ $= 23/12 \approx 1.92$
A_3	P_1, P_2, P_3, P_4, P_5, P_6	$5/3 + 1/4$ $= 23/12 \approx 1.92$
B_1	P_6, P_7, P_8	$1/4 + 1/4 + 1/3$ $= 5/6 \approx$ **0.83**
B_2	P_6, P_7, P_8	$1/4 + 1/4 + 1/3$ $= 5/6 \approx$ **0.83**
B_3	P_6, P_7, P_8	$1/4 + 1/4 + 1/3$ $= 5/6 \approx$ **0.83**

Thus, in the third round tie-breaking is needed between B_1, B_2, and B_3. As B_3 has been created last, B_3 is assigned to display position #6. Since not all initiatives have been placed yet, we continue with the next round.

Round 4

Person's weights:

Person	**Supported initiatives that are unplaced**	**Person's weight in round #4**
P_1	A_1, A_2, A_3	$1/3 \approx 0.33$
P_2	A_1, A_2, A_3	$1/3 \approx 0.33$
P_3	A_1, A_2, A_3	$1/3 \approx 0.33$
P_4	A_1, A_2, A_3	$1/3 \approx 0.33$
P_5	A_1, A_2, A_3	$1/3 \approx 0.33$
P_6	B_1, B_2, A_3	$1/3 \approx 0.33$
P_7	B_1, B_2, A_2	$1/3 \approx 0.33$
P_8	B_1, B_2	$1/2 = 0.5$

Initiative's weights:

Initiative	**Supported by**	**Initiative's weight in round #4**
A_1	P_1, P_2, P_3, P_4, P_5	$5/3$ ≈ 1.67
A_2	P_1, P_2, P_3, P_4, P_5, P_7	$5/3 + 1/3$ $= 2$
A_3	P_1, P_2, P_3, P_4, P_5, P_6	$5/3 + 1/3$ $= 2$
B_1	P_6, P_7, P_8	$1/3 + 1/3 + 1/2$ $= 7/6 \approx$ **1.17**
B_2	P_6, P_7, P_8	$1/3 + 1/3 + 1/2$ $= 7/6 \approx$ **1.17**

Again, tie-breaking is needed between B_1 and B_2. Since B_2 has been created last, B_2 is assigned to display position #5. Since not all initiatives have been placed yet, we continue with the next round.

Round 5

Person's weights:

Person	**Supported initiatives that are unplaced**	**Person's weight in round #5**
P_1	A_1, A_2, A_3	$1/3 \approx 0.33$
P_2	A_1, A_2, A_3	$1/3 \approx 0.33$
P_3	A_1, A_2, A_3	$1/3 \approx 0.33$
P_4	A_1, A_2, A_3	$1/3 \approx 0.33$
P_5	A_1, A_2, A_3	$1/3 \approx 0.33$
P_6	B_1, A_3	$1/2 = 0.5$
P_7	B_1, A_2	$1/2 = 0.5$
P_8	B_1,	1

Initiative's weights:

Initiative	**Supported by**	**Initiative's weight in round #5**
A_1	P_1, P_2, P_3, P_4, P_5	$5/3$ $\approx$ **1.67**
A_2	P_1, P_2, P_3, P_4, P_5, P_7	$5/3 + 1/2$ $= 13/6 \approx 2.17$
A_3	P_1, P_2, P_3, P_4, P_5, P_6	$5/3 + 1/2$ $= 13/6 \approx 2.17$
B_1	P_6, P_7, P_8	$1/2 + 1/2 + 1$ $= 2$

Even though initiative B_1 has less supporters than initiative A_1, initiative A_1 gains less Harmonic Weight due to the previous placement of B_2, B_3, C, and D. Thus A_1 is assigned to display position #4. Since not all initiatives have been placed yet, we continue with the next round.

Round 6

Person's weights:

Person	**Supported initiatives that are unplaced**	**Person's weight in round #6**
P_1	A_2, A_3	$1/2 = 0.5$
P_2	A_2, A_3	$1/2 = 0.5$
P_3	A_2, A_3	$1/2 = 0.5$
P_4	A_2, A_3	$1/2 = 0.5$
P_5	A_2, A_3	$1/2 = 0.5$
P_6	B_1, A_3	$1/2 = 0.5$
P_7	B_1, A_2	$1/2 = 0.5$
P_8	B_1	1

Initiative's weights:

Initiative	**Supported by**	**Initiative's weight in round #6**
A_2	P_1, P_2, P_3, P_4, P_5, P_7	$5/2 + 1/2$ $= 3$
A_3	P_1, P_2, P_3, P_4, P_5, P_6	$5/2 + 1/2$ $= 3$
B_1	P_6, P_7, P_8	$1/2 + 1/2 + 1$ $= \mathbf{2}$

Initiative B_1 has the lowest weight and is thus assigned to display position #3.

After placing initiative B_1, person P_8 does not support any initiative that is unplaced anymore. Thus, in the next round, we only calculate the weight of persons P_1 through P_7.

Round 7

Person	Supported initiatives that are unplaced	Person's weight in round #7
P_1	A_2, A_3	$1/2 = 0.5$
P_2	A_2, A_3	$1/2 = 0.5$
P_3	A_2, A_3	$1/2 = 0.5$
P_4	A_2, A_3	$1/2 = 0.5$
P_5	A_2, A_3	$1/2 = 0.5$
P_6	A_3	1
P_7	A_2	1
P_8	$\varnothing$	–

Initiative	Supported by	Initiative's weight in round #7
A_2	P_1, P_2, P_3, P_4, P_5, P_7	$5/2 + 1$ $= 7/2 =$ **3.5**
A_3	P_1, P_2, P_3, P_4, P_5, P_6	$5/2 + 1$ $= 7/2 =$ **3.5**

Since there is a tie, we assign initiative A_3 to display position #2, as that initiative was created last.

Round 8

Person	Supported initiatives that are unplaced	Person's weight in round #8
P_1	A_2	1
P_2	A_2	1
P_3	A_2	1
P_4	A_2	1
P_5	A_2	1
P_6	$\varnothing$	–
P_7	A_2	1
P_8	$\varnothing$	–

Initiative A_2 gets a final weight of 6 and is assigned to display position #1.

Final result

The final ordering is as follows:

Position	**Initiative**	**Supporter count**	**Harmonic Weight**
#1	A_2	6	$= 6$
#2	A_3	6	$= 3.5$
#3	B_1	3(!)	$= 2$
#4	A_1	5	≈ 1.67
#5	B_2	3	≈ 1.17
#6	B_3	3	≈ 0.83
#7	D	2	$= 0.45$
#8	C	2	≈ 0.37

Appendix C

Example of Proportional Runoff

Let's assume there are 7 persons (P_1 through P_7) and 3 suggestions (A, B, and C). There are no delegations, and the persons rank the suggestions as follows:

(table on next page)

Person	**Suggestion**	**Ranked as**
P_1	A	"must be implemented" "has not been implemented (yet)"
	B	"must be implemented" "has not been implemented (yet)"
	C	not ranked
P_2	A	"should be implemented" "has not been implemented (yet)"
	B	"should be implemented" "has not been implemented (yet)"
	C	not ranked
P_3	A	"must be implemented" "has not been implemented (yet)"
	B	"should be implemented" "has not been implemented (yet)"
	C	not ranked
P_4	A	"should be implemented" "has not been implemented (yet)"
	B	"must be implemented" "has not been implemented (yet)"
	C	not ranked
P_5	A	not ranked
	B	"should be implemented" "has not been implemented (yet)"
	C	"must be implemented" "has not been implemented (yet)"
P_6	A	not ranked
	B	"should be implemented" "has not been implemented (yet)"
	C	"must be implemented" "has not been implemented (yet)"
P_7	A	not ranked
	B	"should be implemented" "has not been implemented (yet)"
	C	"must be implemented" "has not been implemented (yet)"

This yields to the following virtual ballots (see page 80) of each person:

Person	**1st preference**	**2nd preference**
P_1	A, B	–
P_2	–	A, B
P_3	A	B
P_4	B	A
P_5	C	B
P_6	C	B
P_7	C	B

We start the algorithm by marking all candidates (i. e. all suggestions) as "unplaced." In the next step all "unplaced" candidates are marked as "remaining":

Unplaced candidates	A, B, C
Remaining candidates	A, B, C

The score of each candidate is set to zero, and an additional temporary value for each candidate is set to zero as well. Now for each ballot, the first preference section containing a remaining candidate is determined. If there is such section, then for each remaining candidate in that section, the temporary values are increased by the voting weight (i. e. "1", as there are no delegations in this example) divided by the number of remaining candidates in that section. This yields to the following scores and temporary values:

Candidate	**Score**	**Temporary value**
A	0	$1/2_{(P_1)} + 1/2_{(P_2)} + 1_{(P_3)} = 2$
B	0	$1/2_{(P_1)} + 1/2_{(P_2)} + 1_{(P_4)} = 2$
C	0	$1_{(P_5)} + 1_{(P_6)} + 1_{(P_7)} = 3$

We determine the factor such that multiplying that factor with each candidate's value and adding the result to the score of the candidate causes at least one candidate to reach a score of 1 but no candidate to exceed a score of 1. This factor is 1/3.

For each candidate, the score is increased by the product of their temporary value and the previously determined factor 1/3:

Candidate	**New score**
A	$0 + 2 \cdot 1/3 = 2/3$
B	$0 + 2 \cdot 1/3 = 2/3$
C	$0 + 3 \cdot 1/3 = 1$

Since suggestion C reached a score of 1, it is no longer remaining:

Unplaced candidates	A, B, C
Remaining candidates	A, B

As there is still more than one remaining candidate, a new temporary value for each candidate is calculated. Because suggestion C is no longer remaining, persons P_5, P_6, and P_7 now also contribute to the temporary value for suggestion B:

Candidate	**Score**	**Temporary value**
A	$2/3$	$1/2_{(P_1)} + 1/2_{(P_2)} + 1_{(P_3)} = 2$
B	$2/3$	$1/2_{(P_1)} + 1/2_{(P_2)} + 1_{(P_4)}$ $+1_{(P_5)} + 1_{(P_6)} + 1_{(P_7)} = 5$
C	1	0

We determine the factor such that multiplying that factor with each candidate's value and adding the result to the score of the candidate causes at least one candidate to reach a score of 1 but no candidate to exceed a score of 1. This factor is $1/15$.

For each candidate, the score is increased by the product of their temporary value and the previously determined factor $1/15$:

Candidate	**New score**
A	$2/3 + 2 \cdot 1/15 = 4/5$
B	$2/3 + 5 \cdot 1/15 = 1$
C	1

Since suggestion C reached a score of 1, it is no longer remaining:

Unplaced candidates	A, B, C
Remaining candidates	A

Because there is only one remaining candidate (suggestion A), that candidate is placed to display position #3. The two yet un-

placed candidates are B and C, which are marked as remaining again for the following process:

Unplaced candidates	B, C
Remaining candidates	B, C

The score of each candidate is reset to zero, and the additional temporary value for each candidate is reset to zero as well. Now for each ballot, the first preference section containing a remaining candidate is determined. If there is such section, then for each remaining candidate in that section, the temporary values are increased by the voting weight (i. e. "1", as there are no delegations in this example) divided by the number of remaining candidates in that section. This yields to the following scores and temporary values:

Candidate	**Score**	**Temporary value**
B	0	$1_{(P_1)} + 1_{(P_2)} + 1_{(P_3)} + 1_{(P_4)} = 4$
C	0	$1_{(P_5)} + 1_{(P_6)} + 1_{(P_7)} = 3$

We determine the factor such that multiplying that factor with each candidate's value and adding the result to the score of the candidate causes at least one candidate to reach a score of 1 but no candidate to exceed a score of 1. This factor is $1/4$.

For each candidate, the score is increased by the product of their temporary value and the previously determined factor $1/4$:

Candidate	**New score**
B	$0 + 4 \cdot 1/4 = 1$
C	$0 + 3 \cdot 1/4 = 3/4$

Since suggestion B reached a score of 1, it is no longer remaining:

Unplaced candidates	B, C
Remaining candidates	C

Because there is only one remaining candidate (suggestion C), that candidate is placed to display position #2. The only unplaced candidate left is suggestion B:

Unplaced candidate	B

That candidate (suggestion B) is assigned the best display position #1.

Final result

The final ordering is as follows:

Position	Suggestion
#1	B
#2	C
#3	A

Appendix D

Example of Schulze method
(using Schwartz sequential dropping)

Let's assume there are 5 persons (P_1 through P_5) and 3 initiatives (A, B, C). The three initiatives plus the status quo (SQ) result in a total count of 4 candidates to the Schulze method. P_2 delegates to P_1, and P_1, P_3, P_4 and P_5 cast a ballot as follows:

Ballot of voter P_1 (with double voting weight due to P_2):

Approval	A
Abstention	–
Disapproval	B C

Ballot of voter P_3:

Approval	1^{st} preference	B
	2^{nd} preference	A
	3^{rd} preference	C
Abstention	–	
Disapproval	–	

Ballot of voter P_4:

Approval	1st preference	C
	2nd preference	B
	3rd preference	A
Abstention	–	
Disapproval	–	

Ballot of voter P_5:

Approval	1st preference	C
	2nd preference	B
Abstention	A	
Disapproval	–	

These ballots with approval and disapproval section need to be converted to preferential ballots including the status quo (SQ) as a candidate. The status quo (SQ) is preferred to those initiatives which are in the disapproval section of the ballot, and all initiatives that are in the approval section of the ballot are preferred to the status quo:

Person	**Preferences**
P_1 ($+P_2$)	$A > SQ > B = C$
P_3	$B > A > C > SQ$
P_4	$C > B > A > SQ$
P_5	$C > B > A = SQ$

Comparing each candidate with each other candidate, we determine the voters preferring one candidate to another:

	prefers A	**prefers** B	**prefers** C	**prefers** SQ
to A	–	P_3, P_4, P_5	P_4, P_5	$\varnothing$
to B	P_1 ($+P_2$)	–	P_4, P_5	P_1 ($+P_2$)
to C	P_1 ($+P_2$), P_3	P_3	–	P_1 ($+P_2$)
to SQ	P_1 ($+P_2$), P_3, P_4	P_3, P_4, P_5	P_3, P_4, P_5	–

Counting the numbers (incl. delegations):

	prefers A	**prefers** B	**prefers** C	**prefers** SQ
to A	–	3 voters	2 voters	0 voters
to B	2 voters	–	2 voters	2 voters
to C	3 voters	1 voter	–	2 voters
to SQ	4 voters	3 voters	3 voters	–

The Schwartz set consists of candidates A, B, and C, since this is the smallest set where each candidate inside the set is pairwise unbeaten by any candidate outside the set:

SQ against A	0 voters against 4 voters
SQ against B	2 voters against 3 voters
SQ against C	2 voters against 3 voters

$\{A, B, C\}$ is the smallest set, because we can't reduce it to $\{A, B\}$ (C beats B in pairwise comparison), we can't reduce it to $\{A, C\}$ (B beats A in pairwise comparison), we can't reduce it to $\{B, C\}$ (A beats C in pairwise comparison), and we can't it reduce it to either $\{A\}$, $\{B\}$ or $\{C\}$ (each of them is beaten by one other candidate).

We discard all candidates that are outside the Schwartz set, which is SQ in our case. The remaining candidates A, B, and C have the following preference matrix:

	prefers A	**prefers** B	**prefers** C
to A	–	3 voters	2 voters
to B	2 voters	–	2 voters
to C	3 voters	1 voter	–

The weakest defeat is C against B:

A against C	3 voters against 2 voters
B against A	3 voters against 2 voters
C against B	2 voters against 1 voters

(2 is smaller than 3)

The defeat of C against B is considered weakest, because (as justified on page 99) we measure the strength of a defeat primarily by the absolute number of winning votes ($2 < 3$).

Replacing the defeat of C against B with a tie (e. g. 0 voters against 0 voters), we get the following new preferences:

	prefers A	**prefers** B	**prefers** C
to A	–	3 voters	2 voters
to B	2 voters	–	0 voters
to C	3 voters	0 voters	–

The re-calculated Schwartz set is containing only a single candidate B, since B is neither defeated by A nor by C in pairwise comparison:

A against B	2 voters against 3 voters
C against B	0 voters against 0 voters

Thus B is the winner.

Appendix E

LiquidFeedback's polling mode

E.1 Problem of negative voting weight

When integrating LiquidFeedback in existing democratic systems based on elected representatives, an organization or the elected representatives may want to use LiquidFeedback to poll people's opinions about propositions which are later voted upon in an assembly of delegates. In this appendix we shall show that using LiquidFeedback for polling opinions requires certain adjustments to the decision-making process that has been previously discussed in chapter 4.

LiquidFeedback normally requires initiatives to reach a certain quorum of supporters (see first and second quorum in section 4.6 starting on page 66). Issues (i. e. groups of alternative initiatives) where no initiative reaches the first quorum and initiatives which do not reach the second quorum will not be voted upon. This means supporting an initiative might lead to a vote on that initiative, while not supporting it could cause the issue to be canceled by the system. In the latter case, the representatives

will get no clear result from the system. This is effectively some kind of negative voting weight, as we can reason as follows:

Supporting an initiative may lead to voting, which in turn could lead to a clear statement of the people *against* a proposal. Not supporting an initiative may lead to cancellation of the issue, which in turn means there is *no* clear statement of the people.

Interpreting an initiative's failure to pass a quorum as a decision against a proposal is misleading, as an initiative might have no opponents (i. e. 100% approval) but can still fail a quorum if too few people are interested in the issue. On the other hand, not interpreting the failure to pass a supporter quorum as a decision against the idea could encourage people to support initiatives they oppose.

E.2 Adjustment of the LiquidFeedback process

If elected representatives need to poll people's opinion for a decision that is made outside the system (e. g. in a parliament or executive board meeting) and that decision is made in either case, even if the issue has failed the quorum inside LiquidFeedback, then LiquidFeedback's decision-making process must be adjusted. For this adjustment, LiquidFeedback supports the so-called "polling mode": The polling mode enables privileged members (e.g. board members) to create poll issues with one or more alternative initiatives which do not need to reach a supporter quorum to get into final voting. Because of this, poll issues do not have an admission phase but start directly in the discussion phase. Since these issues are not created by initiative of the participants but due to external factors (e. g. agenda of the parliament), poll issues have a freely configurable timing for discussion, verification and voting phase, that can be adjusted on a per-issue-basis.

While the term "polling mode" suggests that LiquidFeedback is used to allow voters to simply cast a poll, LiquidFeedback's polling mode allows much more: In an ordinary poll the answers

are given by the inquirer, but LiquidFeedback allows voters even in polling mode to create their own answers (i.e. alternative initiatives which have not been part of the original set of proposals). Opposed to the initiatives entered by the elected representatives, such alternative initiatives still need to reach a quorum to get into final voting.

It should be noted that the "polling mode" is inconsistent with the goal of a decision-making process where every participant is treated equally. Therefore, it is not part of the principles of LiquidFeedback as discussed in chapter 4. However, in cases where LiquidFeedback is integrated into an existing democratic system, it might be necessary to consider the polling mode to avoid negative voting weight.

E.3 Further considerations

When using the polling mode, further considerations must be kept in mind:

Simply creating a single initiative in polling mode is not always suitable for asking a "yes"/"no" question. This is because the status quo (i.e. no initiative winning) takes on a special position in the count of the votes. Under certain circumstances, the status quo has an advantage over other initiatives (see subsection 4.12.3 starting on page 101). Thus, if you want to ask a yes/no question with a single initiative, it needs to be phrased in a way that disapproving the initiative leads to the status quo. If neither answer leads to the status quo (e.g. if there is no status quo on a given question yet), then it is necessary to create two initiatives for a yes/no question, i.e. one initiative representing the "yes" answer to the question and another initiative representing the "no" answer to the question.

As explained above, if the voters are dissatisfied with giving "yes" or "no" as an answer to a question, they may always create their own answers. This overcomes a constraint present in classical polls.

Appendix F

A possible solution for interspersing open issues in all states

F.1 Motivation

As explained in chapter 4, subsection 4.10.3 on page 83, a list of issues in admission phase is sorted differently than a list of issues in discussion, verification, and voting phase. Issues in admission phase gain a *proportional* representation amongst the group of all issues in a subject area that are in admission state, while issues in discussion, verification and voting phases are usually sorted by the *remaining time* left in their current phase.

In the footnote on page 84, we mentioned that depending on the particular user interface, it might be desirable to create a *merged* view that utilizes some kind of interspersing to create a combined list of issues in admission, discussion, verification, and voting phase. In this appendix F, we want to present a short outline of a possible solution to create such an interspersed list, combining the two different sorting criteria in a useful way.

F.2 Design goals

A merged list that contains both issues in admission phase and issues in discussion, verification and voting phase should at least fulfill the following properties:

1. An issue $\mathfrak{I}_1$ in admission state should never get a display position better than another issue $\mathfrak{I}_2$ that is in discussion, verification or voting phase, if the issue $\mathfrak{I}_1$ has more time left in admission phase than the issue $\mathfrak{I}_2$ has left in its phase. That means: Urgent issues that have passed the first supporter quorum will never be pushed away by less urgent issues in admission phase, that have more time left in admission phase.

2. A huge number of issues in admission state should never worsen the display position of an issue in discussion, verification or voting phase by more than a constant factor f, i. e. an issue in discussion, verification or voting phase which would have reached position $p \in \mathbb{N} \setminus \{0\}$ when there were no issues in admission state should never get a worse position than $f \cdot p$, even in those cases where there is a huge amount of issues in admission phase.

F.3 Description of a possible algorithm

A possible algorithm fulfilling these criteria is given below:

1. For each issue $\mathfrak{I}$ in admission phase that gained position $A_{\mathfrak{I}}$ from Proportional Runoff (where the first position is denoted by 1, the second position is denoted by 2, etc.), another value $B_{\mathfrak{I}} = 2 \cdot A_{\mathfrak{I}} - 1$ is calculated.

2. All open issues in the subject area are marked as unplaced.

3. That issue is placed to the next display position p, starting from the best position $p = 1$, which has fewest time left in

its current state, while only those issues are considered that are either admitted (and thus in discussion, verification, or voting phase) or have a value $B_\mathfrak{I} \leq p$. If no issue fulfills these criteria, then the issue with the smallest $B_\mathfrak{I}$ is chosen.

4. Step 3 is repeated until all issues have been placed.

The factor f would be equal to 2 in this case. Further mathematical analysis of the properties of this algorithm could be subject of future studies.

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Index