The Liquid Democracy Journal

on electronic participation, collective moderation, and voting systems

Issue 5

Berlin, 2017-05-11

The Liquid Democracy Journal is dedicated to the idea of Liquid Democracy, which is a democratic principle that uses transitive delegations to unite the best of direct and representative democracy.

But this journal is not just limited to Liquid Democracy; it also covers those topics coming up when implementing it: **electronic particatipation, collective moderation, and voting systems.**

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Editorial

by the Editors, Berlin, May 11, 2017

It has been a while since the last issue of The Liquid Democracy Journal was published. Since then, a lot has happened. Just days after the last issue, the Association for Interactive Democracy was invited by The Office of the High Commissioner for Peace to the Colombian government. It was an honor to join the "Conectados por la Paz" conference in Bogotá. We congratulate president Santos and the Colombian people for the successful peace process ending 50 years of an internal armed conflict.

Meanwhile in Europe, the Swiss water economy discussed challenges Switzerland's water economy will encounter. During the process LiquidFeedback was used and the final study "When water becomes the new oil. How Switzerland will handle the conflicts of the future." suggests "Liquid Decision Making" for the cooperation of stakeholders.

The Association for Interactive Democracy intensified the scientific cooperation with several universities. In the field of computational social choice, we delivered a keynote on "LiquidFeedback and a fair process of decision making" at the COST Action Industry Day in Toulouse, France. The LiquidFeedback team was also invited by the University of Bologna, Italy to present at a workshop on "The Future of Democracy".

After LiquidFeedback 3.1 paved the way for democratic software and product development as well as a more democratic collaborative knowledge management, the upcoming LiquidFeedback 4 will come with an authorization and integration module for the seamless interaction with engagement platforms and third party applications in general, introduce geo-tagging and geospatial indexing while keeping up its standards in regard to the task of ensuring fairness and equal treatment of all participants for democratic decision-making. The interface of LiquidFeedback will change to material design with a focus on accessibility.

This issue will reveal new details on the origins of Liquid Democracy and give an account of

some aspects of our current development and scientific work in the context of the European research and innovation action "WeGovNow – Towards #WeGovernment: Collective and participative approaches for addressing local policy challenges" and take a closer look at LiquidFeedback's new "Issue Limiter" approach and the challenge of fair distance calculation for location-based searches in geospatial systems.

The Editors

Corrigendum

In the articles "5 Jahre Liquid Democracy in Deutschland" (German) and "5 years of Liquid Democracy in Germany" (English translation), both being part of **Issue #1** of this journal, it has been claimed that the idea of Delegated Voting (transitive delegation) was first formulated by Lewis Carroll in his work "The Principles of Parliamentary Representation", published in 1884. Reading the *original* publication written by Lewis Carroll, [Carroll] we must conclude that Lewis Carroll did *not* propose a transitive delegation of votes with more than two steps in that publication. However, it is true that some of the ideas which we find in Liquid Democracy today have already been stated by him in the late 19th century. This will be elaborated on in the following article "The Origins of Liquid Democracy" [Origin].

In the editorial of **Issue #4**, we criticized that in Google's experiment on Liquid Democracy it was allowed to cast private ballots that "were hidden from the users". According to the last paragraph on page 4 of the referenced paper [GooglePaper], private votes are only described as one possible way for the proposed "general framework to define the space of all vote-transparency-compliant policies", while the same paragraph states that "making all votes publicly visible" was used in case of Google Votes, instead. However, page 12 of the paper states that users may "choose to cast a 'personal vote' which means they decline all incoming delegations and use only their own single vote". In either case, our critique in regard to allowing private votes in the proposed framework is still valid. Instead of *"as so in case of Google's experiments"* read *"as so in case of the paper [GooglePaper] describing Google's experiments"*. Instead of the paragraph beginning with *"As the experiment had to fulfill [...]"* read *"Hardt and Lopes propose in their paper that only those ballots that use delegated voting weight need to be public."* Instead of *"Therefore, the participants of the system did not have any way to check the results of the system; they had to blindly trust the results"* read *"Therefore, the participants of the system would not have any way to check the results of the system; they would have to blindly trust the results"*. These corrections have been included in revision 2 of the electronic version of Issue #4 of The Liquid Democracy Journal.

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The Origins of Liquid Democracy

by Jan Behrens, Berlin, May 11, 2017

In late 2009, we (Jan Behrens, Axel Kistner, Andreas Nitsche, and Björn Swierczek) started to develop LiquidFeedback, a software for proposition development and decision making. [PLF] One of our goals was to provide a feasible implementation of Liquid Democracy. Back then, "Liquid Democracy" was only a vague concept to us that we stumbled upon in the orbit of the Pirate party movement in Germany. [Huwald] This article shall show that most of the ideas had already been thought of many decades ago, even though crucial details were devised around the millenium change.

Lewis Carroll's Principles of Parliamentary Representation from 1884

More than 130 years ago, Lewis Carroll (Charles Lutwidge Dodgson) described in his book "The Principles of Parliamentary Representation" the concept of giving candidates in an election a choice

- to use received votes for themselves,
- to transfer those votes to other candidates,
- or to leave them unused. [Carroll, pp.41-42]

It should be noted that the proceedings described in his book were specifically meant for elections of people (i.e. for representative democracy where members of a house of representatives are elected) and not for empower-

Lewis Carroll (Charles Lutwdige Dodgson)
Photograph 1863 by Oscar Gustave Rejlander

ing the electorate to decide on certain issues themselves. Furthermore, the transfer of votes (according to his proposal) was carried out by *candidates* receiving those votes and not by voters.

His reasons to propose a transfer of votes by the candidates were to avoid a "waste of votes" in multi-winner elections where members of a house of representatives are being elected. Therefore, his proposal can be seen as alternative to "Single Transferrable Vote" (STV) systems, which had already been known at that time. Carroll justified his proposal by pointing out deficiencies found in the known methods to transfer votes using STV at that time, [Carroll, pp.30-32] and by claiming that preferential voting would be too complex for the "ignorant elector":

» *One great objection to this method is the confusion it would cause in the mind of an ignorant Elector, who, though quite able to name his favourite Candidate, would be utterly puzzled if told to arrange 5 or 6 names in order of merit.«*

LEWIS CARROLL, 1884
[CARROLL, PP.29-30]

Following the premise that neither excessive votes received by a candidate nor votes for those candidates who do not get elected should be lost, and arguing that it would not be feasible to let the voter decide who to transfer surplus and/or unused votes to, Carroll reasons that it must be "the candidate himself, for whom the votes have been given" who must have authority to dispose those votes. Guarding against skepticism, he explains that whoever trusts someone so far as to serve as a member of a house of representatives, he or she shouldn't have a problem to trust that person to transfer the vote in lieu thereof:

» *The Elector must understand that, in giving his vote to [a candidate] 'A', he gives it him as his absolute property, to use for himself, or to transfer to other Candidates, or to leave unused. If he cannot trust the man, for whom he votes, so far as to believe that he will use the vote for the best, how comes it that he can trust him so far as to wish to return him as Member?«*

LEWIS CARROLL, 1884
[CARROLL, P.34]

Obviously this argument could also serve in favor of transitive delegated voting, which was about to be invented more than 100 years later.* However, Carroll's proposal didn't explicitly mention any transitive element, i.e. more than one step of transferring votes further. [Carroll, pp.36-40, pp.44-45]

While Lewis Carroll was probably the first person to propose empowering candidates to transfer their received votes, his proposal didn't contain any element to empower people to participate on particular issues themselves (which is arguably one of the most important aspects of Liquid Democracy, as described in the following).

---

* *There are more reasons to facilitate transitivity of delegations, as explained in [PLF, chapter 2].*

Tullock's proposal in 1967

About 83 years later, Gordon Tullock proposed a hybrid of direct and representative democracy in form of a proportional representation scheme where each voter may decide to either represent him- or herself or to choose a representative. Each representative would be given a voting weight equal to the number of his or her voters but a voter could also elect him- or herself as their own representative (in which case they would receive a voting weight of at least 1). Tullock suggested to use the possibility of watching proceedings through broadcast and voting "by wire" (see also [Armytage14]) to allow an unlimited number of voters to represent themselves if they wish so. Tullock noted that only the existence of "computers" and "modern electronics" could make this possible:

» *Indeed, until the development of the computer, the system would have been impracticable, which is probably the reason it has not heretofore been proposed. [...] With modern electronics there is no necessity for all representatives to meet in the same hall, consequently there is no maximum on the number of representatives. Voting could easily be done by wire, and the proceedings could be broadcast. In the extreme case, there seems no reason why people who wish should not vote for themselves and then fill their days by casting their single vote for and against the various proposals.«*

Gordon Tullock, 1967
[Tullock, pp.145-146]

Tullock's proposal might have been the first step towards a democracy where each voter may decide him- or herself whether to engage in decisions directly or through representation. It is thus a hybrid of direct and representative democracy. However, his proposal still differs from Liquid Democracy in at least two important ways: neither delegation by topic (i.e. nominating different people for different subject areas or issues) [PLF, subsection 2.2.2] nor the possibility to instantly revoke transferred voting weight [PLF, subsection 2.2.4] is part of Tullock's proposal. Tullock, however, did not expect his ideas to be the "best possible suggestions" but rather saw them as a potential step for "a better and more scientific political structure" in the future:

» *New ideas always seem radical and bizarre. I would not claim that the new ideas I have advanced in these essays are the best possible suggestions. I hope, however, that they will play at least some role in the search for a better and more scientific political structure.«*

Gordon Tullock, 1967
[Tullock, p.157]

Two years later: Miller's Program for Direct and Proxy Voting

In 1969, James C. Miller foresaw in his publication "A program for direct and proxy voting in the legislative process" that within the next 20 or 30 years, every household would have a "console tied into a computer". According to his ideas, such a computer console could not only be used for children to do their homework, making out grocery lists, or paying bills, but also for making political decisions such that each voter could decide on every issue:

» *Some, in fact, have predicted that within 20 or 30 years every home will have a console tied into a computer upon which the children do their homework, the housewife will make out her grocery list, and the husband will pay the family's bills. Such a computer console also could be used to record political decisions, giving each voter an opportunity to cast his ballot on every issue and have it recorded through the machine.«*

James C. Miller, 1969
[Miller, pp.107-108]

Just like Tullock, Miller proposed that voters may use computer technology to vote on every single issue themselves or to delegate their vote to a representative if they wish to. But Miller further suggested that voters could determine themselves how long such a delegation shall be in effect:

» *[...] instead of electing representatives peridically for a tenure of two years or more, why not allow citizens to vote directly or delegate proxy to someone else for as long as they like (which is, of course, analogous to stockholder voting schemes in large corporations).«*

James C. Miller, 1969
[Miller, p.108]

While not foreseeing the difficulty regarding verifiability of such an electronic system, Miller did have some ideas about potential security measures, which were quite futuristic for that time:

» *Safeguards, of course, would have to be installed so that no one could record decisions on the machine except its owner. For instance, a special metal key, a coded combination, or even a thumbprint might be required to operate the machine.«*

James C. Miller, 1969
[Miller, p.108]

As of today, we know that measures such as "special metal keys", coded combinations, or even retina scans will not be able to solve the problem of verfiable secret elections using computers (see also section 3.4 on the "Wahlcomputerproblem" in [PLF]). Nonetheless, (and disregarding the antiquated gender roles) Miller's proposal in that time is to be considered "visionary" (see also [Armytage14]).

As already said, the aspect of verifiability of electronic ballots is ignored by Miller at that time. Furthermore, his proposal (as well as Tullock's proposal) still differs in another way from what we call "Liquid Democracy" today: delegates who receive votes as proxies are not explicitly enabled to delegate their vote further. Such an extension isn't conflicting with Miller's proposal (and might even be considered part of the "stockholder voting schemes" he referenced) but to our knowledge hasn't been explicitly mentioned by him.

Miller, however, already proposed the ability to revoke a previously given delegation at any time. Ironically, the ability to instantly disempower (or empower) a representative was seen by Miller as a positive influence on the representative's freedom to vote his conscience because the dynamic representation scheme would allow representatives to "reverse their stand":

» *Under the proposal, the representative would be subject to instant recall by each and every voter. If a representative did not maintain the approval of those whose proxy votes he held, he would have them withdrawn and would find himself no longer a representative (unless, of course, he picked up proxy votes somewhere else). Such recall would be on a day-to-day or even an hour-to-hour basis. In a way, such a scheme probably would allow greater freedom for a representative to practice statesmanship and vote his conscience. Under the present system a representative must conform his general actions to the wishes of his (regional) supporters in order to be elected. But under the proposal, if a representative's ideas on policy issues changed and he conscientiously decided to reverse his stand, he could remain a representative by gathering proxy support from others holding the same general position.«*

James C. Miller, 1969
[Miller, p.110-111]

Miller also considered the idea that voters might make their decision whether to vote directly or via proxy on a per-issue basis:

» *Most voters [...] would utilize some combination [...], voting on major issues personally and delegating proxy to someone else for the minor decisions. Thus, the third feature of the proposal is a provision for proxy as well as direct voting.«*

James C. Miller, 1969
[Miller, p.108]

The internet of the 90's: Rob Lanphier's Public Ballot Stewardship

The ideas from the 1960's reappeared on the internet around 1995.* Rob Lanphier proposed the "Public Ballot Stewardship": a model for electronic democracy. [Lanphier] [Armytage14] He distinguished two forms of elections: general elections (using a secret ballot) and public elections. Depending on the impact of what is voted on, either a "general election" would be held, or – for more "mundane" things – a public ballot would be held, where everyone knows which way everyone else voted:

» *General elections are what we now know as general elections. Private ballot, one person/one vote, you snooze you lose. Nothing fundemenatally different here from what we now call voting. These would be used on special issues like constitutional amendments, presidential elections, and other "big-ticket" items. Public elections are public ballot votes. Everyone knows which way everyone else voted, by name. They would be a matter of public record. These elections would be for the more "mundane" things, like budgets, minor bills, declaration of "National Boy Scouts Week", etc.«*

Rob Lanphier, 1995
[Lanphier]

In his proposal, the public elections provide a dynamic delegation system: Lanphier proposed that for each issue that is being decided in a public ballot, one may either decide to rep-

** We didn't find a proof for the exact date of publication. The article published at the URL http://robla.net/1996/steward/ (accessed 2016-04-19) written by Rob Lanphier has a copyright notice dated 1995 [Lanphier] and has been cached on archive.org since 2005. James-Green Armytage states 1995 as the year of Lanphier's publication. [Armytage14]*

resent him- or herself or to choose a "steward" to vote on one's behalf. He furthermore notes two important aspects: one should be able to change the steward at any time, and for particular decisions one should be able to override the steward's vote by temporarily ceding the vote from the steward and voting directly. [Lanphier] Lanphier even proposed to allow different delegations in different subject areas:

> *Maybe, instead of one "body", there could be several congresses, each with assigned powers of their own. One congress dedicated to the interior, one to defense, one to education. People could pick individual stewards for each, or choose one to handle all. Perhaps this would be done on an individual basis, where the steward has trusted advisors that actually choose the vote in their given specialty.«*
>
> **Rob Lanphier, 1995**
> [Lanphier]

Lanphier's proposal doesn't explicitly state that delegates may further delegate their votes (see [PLF, chapter 2] for transitive delegation). The cited "trusted advisors" could, however, be seen as a precursor to what would later be proposed in the 2000's by Bryan Ford and others.

There was one other important aspect which Lanphier addressed in his publication: the internet (as of 1995) didn't provide means to identify its users. Lanphier pointed out that it would be necessary to verify that one person gets exactly one vote (and not two, three, or more, by creating multiple accounts). He assumed, however, that this problem would be solved in the near future:

> *The main problem facing electronic voting on the Internet is verifying that one person gets one vote, and that all people are represented (even those without Internet access). Verification of identity is a problem that plagues many applications on the Internet (such as making purchases on the net, or filing taxes on the net), and so this one will likely be solved regardless of whether electronic voting makes it an issue.«*
>
> **Rob Lanphier, 1995**
> [Lanphier]

Similar considerations can also be found in our book "The Principles of LiquidFeedback", [PLF, subsection 6.1.1] even though we were not aware of his publication at the time of writing our book. It should be noted that Lanphier's optimistic views in regard to emerging means of identity verification on the internet would fail to come true, at least for another 20 years.

Bryan Ford's Delegative Democracy

In the early 2000's*, Bryan Ford proposed two ideas which he calls "Delegative Voting" [FordDV] and "Delegative Democracy" [FordDD] of which the former can be seen as further development of Lewis Carroll's ideas (a method to avoid wasted votes when electing individuals without preferential ballots) and the latter

** We didn't find a proof for the exact date of publication. The PDF published at http://www.brynosaurus.com/deleg/deleg.pdf carries a date of May 15, 2002 and has been cached on archive.org since 2005. A link to the document as well as Ford's pages on Delegative Voting have been cached on archive.org since 2004. See also [Armytage14], where Ford's ideas are dated 2002.*

contains elements akin to Lanphier's proposal. However, instead of following Lanphier's idea to facilitate two different forms of ballots (secret and public) for different kinds of decisions, Ford demanded "privacy of the individuals" and a transitive delegation system at the same time for the same decisions. He named the following 6 basic principles to describe his form of "Delegative Democracy":

- **"Choice of Role":**
  Each voter may select to be an "individual" with the right of privacy (see below) or to be a "delegate".

- **"Low Barrier to Participation":**
  It must be easy to become a "delegate" (e.g. not require campaigning).

- **"Delegated Authority":**
  Delegates may use voting weight that has been transferred to them.

- **"Privacy of Individuals":**
  Individuals' votes are "private" (i.e. hidden from other delegates or individuals).

- **"Accountability of Delegates":**
  Delegates' votes are made public.

- **"Specialization by Re-Delegation":**
  Delegates may re-delegate their voting weight to each other.

As for the last point, Ford added the important property of transitivity to the delegation model which wasn't mentioned in the previous proposals of Tullock, Miller, and Lanphier. However, in regard to the Wahlcomputerproblem (see [PLF, chapter 3]), he makes a big step backward (when compared to Lanphier) because his proposal may not be applied to electronic systems without losing another imporant property of democractic processes, namely verifiability.

Following Ford's step backward, the idea of privacy of the individual and accountability of the delegate would later be described by Hardt and Lopes [Hardt&Lopes] as a possible solution regarding their "Golden Rule of Liquid Democracy" (which, we think, is a dangerous euphemism). [Editorial4]

Even though we do not consider private electronic ballots to be part of the concept of Liquid Democracy or to meet democratic standards at all [Editorial4], Bryan Ford may have been the first person to add transitive delegations as the last missing piece to describe what is called "Liquid Democracy" today.*

Ford furthermore described three possible "extensions" to the delegation model: "backup choices", "split delegation", and "restricted and transitive delegation". Bryan Ford didn't provide any notes on implementation in his paper, neither for a system fulfilling those 6

** Later, other persons claimed to be the "inventors" of Liquid Democracy. However, we can not confirm their claims. [Deseriis] See also [QA010]. We would also like to note that most ideas were already formulated in 1967, 1969, and 1995 by Tullock, Miller, and Lanphier respectively.*

basic principles listed above nor for these three extensions. Section 4 of his paper just reads, "Implementing Delegative Democracy : Under Construction". [FordDD] As it could be shown later in [PLF, subsection 2.4.2] and [PD], two of his extensions would add certain unwanted properties to his system (negative voting weight and/or unequal treatment of the participants).

2004: Combining transitive delegations with preferential voting on issues

James Green-Armytage described in 2004* and 2005 another system that is incorporating transitive delegations for decision making. [Armytage05] He called his system "Direct Democracy by Delegable Proxy", which consists of the following two "fundamental elements":

- **"Direct democracy / delegable proxy system"** (transitive delegations), and
- **"Ranked Ballot, pairwise tally"** (preferential voting).

Opposed to the visionary views in 1967 and 1969, Armytage didn't see the internet as an application field yet:

> *Should the votes [should] take place over the internet, or only at controlled polling stations? The internet poses problems of security and problems of equal access, so I suggest that official polling stations are a preferable venue. The voter interface should be electronic (paper ballots would probably just be too clumsy for this system), and every effort should be made to assure that the votes are being counted accurately.«*
>
> **JAMES GREEN-ARMYTAGE, 2005**
> **[ARMYTAGE05]**

It should be noted that electronic voting machines do not solve the problems of verifiable electronic voting either. [PLF, section 3.4] [BVerfG] [CCC] However, combining transitive delegations [PLF, chapter 2] with a preferential voting system on proposals [PLF, section 4.12] are some of the key elements found in our software LiquidFeedback, even though we were not aware of Armytage's website at the time of creation of our software. Armytage also proposed that delegations shall be "issue-specific" in order to allow for a delegation to experts in each field, and he explained the importance of transitivity:

> *One reason this might be good is that it would allow voters to indicate as proxies people who are knowledgeable in the field that a specific issue relates to. For example, if the issue is relevant to ecology, then a voter might indicate an ecologist as their proxy for that issue, or a staff member at an NGO that deals with the environment. Or, rather than being a matter of a field of study, a voter may delegate his vote to someone whom he knows has educated themselves well about that issue in parti-*

* *An early draft of his ideas is available on archive.org. [Armytage04]*

cular. For example, if the issue is choosing between different versions of a trade bill and the voter knows someone who has read all of the different versions personally. Even if most voters would not know such a person, their proxies and their proxies' proxies might.«

James Green-Armytage, 2004
[Armytage04]

The publication of LiquidFeedback in 2009

In the year 2009, Jan Behrens, Axel Kistner, Andreas Nitsche, and Björn Swierczek presented "LiquidFeedback", which doesn't only incorporate the ideas regarding Liquid Democracy as described above*, but also includes other features such as proportional minority representation and preferential voting which go beyond the ideas of Liquid Democracy. A more detailed description of LiquidFeedback can be found in the book, "The Principles of LiquidFeedback". [PLF]

Summary

The origins of Liquid Democracy date back as far as 1884, [Carroll] though most core elements were not foreseen until 1969, when James C. Miller published "A program for direct and proxy voting in the legislative process". [Miller] In the year 1995, the idea of vote delegation was re-thought in the context of the emerging use of the internet. [Lanphier] The element of transitivity was brought up by several people after the millenium change.

The term "Liquid Democracy" became popular in Germany when the Pirate party movement proposed to overcome the limitations of direct and representative democracy. [Huwald] Even though the Pirate party arguably never succeeded in establishing a sustainable application of Liquid Democracy, they helped the idea to gain attention by public media.

LiquidFeedback was created independently of any particular party as a feasible software solution to help political parties or other organizations to implement Liquid Democracy within their organization. Beside the concepts of Liquid Democracy, a particular set of rules of procedure was combined with the ideas of Liquid Democracy to allow users to engage in a collective decision-making process where all participants are treated equally. [PLF] With the publication of LiquidFeedback, it is possible to apply Liquid Democracy to real-world scenarios.

** with the exception of secrecy as explained in chapter 3 of [PLF]*

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A Fair Distance Function

by Jan Behrens and Björn Swierczek, Berlin, May 11, 2017

When developing democratic proposition development and decision making software, the processing of user-generated geospatial data poses certain questions when it comes to the ordering of search results by location-based relevance. One aspect of location-based relevance is the *distance* of a geographical object from/to a given point (e.g. a search center). While we usually mean the euclidean or spheroidal surface distance* when we speak of "distances", other mathematical distance functions are thinkable and useful, as will be shown in this article. Beside proposing a particular distance function, we will also consider practical aspects of database indexing when using such a distance function.

Mathematic preliminaries

We will use the term "distance function" for a mathematical function f that maps two geographical objects G and S (each being a subset of Earth's surface E) to a non-negative real number $f(G, S) \in \mathbb{R}_0^+$. Within this article, however, we will only consider those functions where the second argument S is a singular point (which we will refer to as the "search center"), while the first argument G may be any other geographical shape (e.g. a point, path, or polygon). Therefore, the functions considered within this article are not "metrics" because a metric maps two objects of the same set to a non-negative real number. Furthermore, we will allow a distance function to return zero even if the two objects are not equal; e.g. the distance between a path and a point on that path may be zero even if the point and the path are two distinct (non-equal) objects.

A distance of zero will denote the highest possible relevance for an object G in regard to a certain search center S; higher numbers will denote less relevant matches.

** The spheroidal surface distance is the shortest possible distance on the reference spheroid used to model Earth.*

Note that even when we write $G \subseteq E$, we only consider those G which are finite unions of basic geographical objects, and not, for example, fractals or non-measurable sets.

Nearest-neighbor searches and distance functions

Distance functions are a necessity for database queries in the form of "Show me the object(s) which are closest to my location". While the distance function is the only mandatory prerequisite for such a nearest-neighbor search (and totally sufficient for a linear search), a fast indexing system requires further support functions to speed up nearest-neighbor searches. A working set of such support functions can be found at the GiST framework that is used by PostgreSQL. [GiST] At first sight, we will focus on the distance function though, keeping in mind that a final solution will require further considerations in order to implement fast indexing techniques which are necessary for scalable applications.

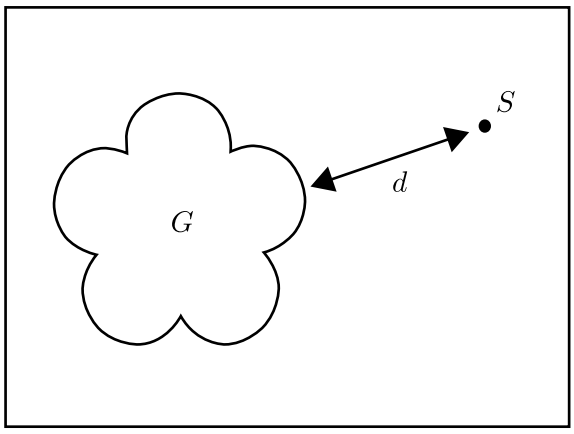

Figure 1: The shortest way (euclidean distance) from a geographical object G to a search center S

The trivial approach

The easiest function to be used for nearest-neighbor searches is to determine the shortest possible spheroidal surface distance d (or euclidean distance in case of flat maps) between a search center S and the geographical object G.

See Figure 1

Challenge I: Object size

While, at a first glance, the trivial approach of simply determining the shortest possible distance might seem to be straight forward and fair, a closer look reveals a serious problem: objects that cover large areas have a higher chance to return a shorter distance (or even zero if they cover the search center). If these objects are part of user-generated content (e.g. created by an initiator of a LiquidFeedback initiative), then users might be tempted to create intentionally oversized geometric objects in order to optimize search results for their content. Honest users aiming to select exactly those regions or locations that are really affected by their initiatives would be at disadvantage to users entering oversized and thus incorrect geometries. Even if it is still possible that some other users penalize such attempts by giving respective bad ratings to proposals with wrong or slightly wrong geospatial metadata, it would still be possible that the overall data quality is compromised due to tactical considerations of certain users. As shown in the section "Requirements for a fair distance function" below, we can compensate the advantage of big objects in a proper way.

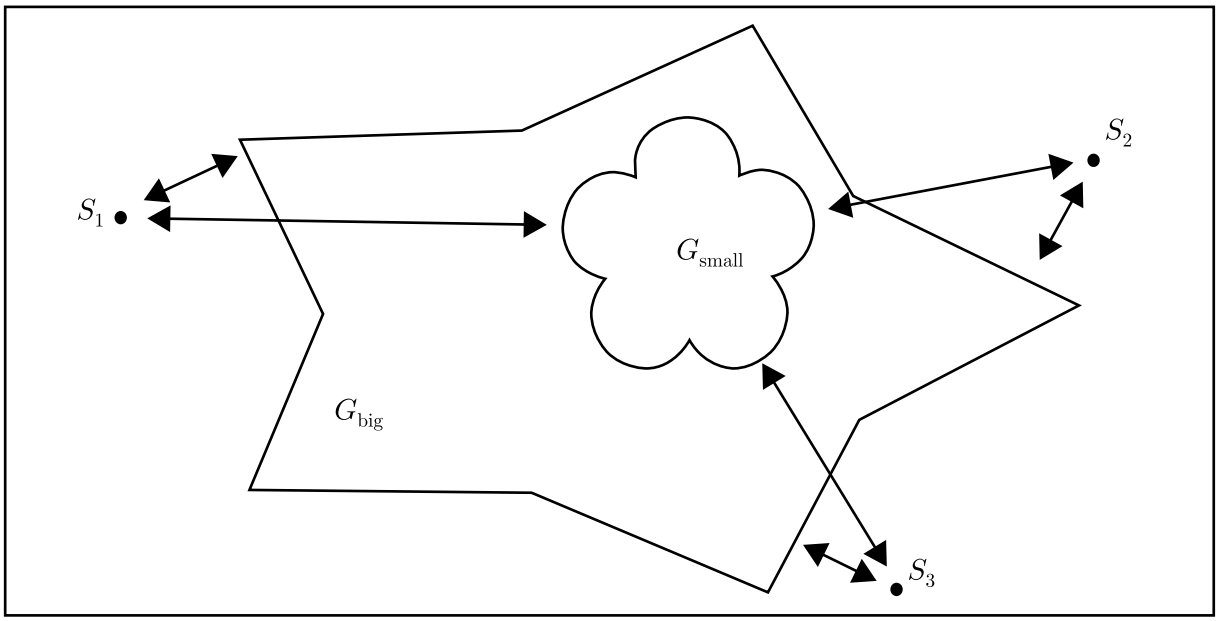

Figure 2: Big objects having advantages in comparison to small objects

Challenge II: Relevance

Following the demand of a democratically driven proposition development process that is moderated by the users (i.e. collectively moderated), location-based relevance will not only depend on geographical properties but also on the ratings of the users (i.e. voters). Depending on the kind of search, we would also need to take the voter or supporter situation (e.g. "likes") into account when sorting data by (location-based) relevance. One method to include user ratings for the location-based relevance of objects would be to simply divide the geographical distance by the number of votes such that an object that is 90 times as far away but has 100 times more votes than another object will appear first in the list of entries based on location-based relevance. While this may affect the efficiency of index lookups inside a database (and thus require further consideration, see section "Weighted nearest-neighbor searches" below), it is otherwise easy to convert any distance function to a function which will take the weight of an object into account (e.g. by including a simple division as explained before).

It should be noted that in many cases, the number of votes isn't suitable to be directly taken into consideration as weight. This is because clone-proofness is an important property of proposition development and decision making systems. [PLF, section 4.11] In case of competing proposals with geographical metadata, the "Harmonic Weighting" algorithm (compare [PLF, subsection 4.10.1]) might be a more suitable approach.

In the context of multi-winner elections, the counting scheme used by "Harmonic Weighting" has also been described by Thiele in 1895. [Janson] [Skowron] For the sake of weighting geographical objects, however, we require more than a selection of candidates (like in multi-winner voting systems) and even more than a ranking of all candidates (which is a natural by-product of sequentially working multi-winner voting systems): we require the system to return a weight (i.e. a real number) instead of just a rank for each candidate. See [PLF, Appendix B] for an example (column "Harmonic Weight" in table on [PLF, p.177]).

Requirements for a fair distance function

Our aim is that increasing the size of a geographical object doesn't give a general advantage to appear earlier in nearest-neighbor searches. It should be noted that the "size" in this context doesn't necessarily mean "area" or "length". For example, neither a huge polygon nor a set of thousand points or a long line (note that the latter two have an area of zero) should gain an advantage over a single point. When we speak of "general advantage", we must define this in mathematical terms since changing the size or location of an object can always optimize the distance in regard to a *particular* search center. With "general advantage" we rather mean that the distance $f(G,S)$ (with G being a geographical object and S being a search center point) can't be optimized in regard to *all* possible search centers, or by demanding that the average result of the distance function f (or the squared distance function, see Figure 3) over all possible search points is constant.

For all geographical objects $G \in \{x \subseteq E \mid x \neq \emptyset\}$:

$$\iint_{S \in E} f^2(G,S)\ \mathrm{dA} = \mathrm{const},$$

where E is the set of all points on Earth's surface and dA is the infinitesimal surface area.

Figure 3: Constancy of average of square of distance

The requirement in Figure 3, however, is not sufficient for a fair distance function because $f(G,S)$ is not bounded: raising $f(G,S)$ to a very high value for some search centers would allow lowering $f(G,S)$ for many other search centers.

A stricter requirement would be that the area for which the distance function yields values equal to or less than a limit L is independent of G and must only depend on L (e.g. the area must be equal to $\pi \cdot L^2$ as demanded by the formula given in Figure 4).

$$\iint_{\substack{S \in \{x \in E \mid \\ f(G,x) \leq L\}}} 1 \cdot \mathrm{dA} = \pi L^2$$

Figure 4: Strict requirement for the area where the distance function yields values smaller than a certain limit

This stricter requirement is automatically fulfilled for all $L \in \mathbb{R}_0^+$ if we only consider singular points as geographical objects on a flat map and if f is the euclidean distance function between the two points G and S, because the area around a point G where the distance to that point is less than a limit L is exactly $\pi \cdot L^2$. * If we are able to fulfill this requirement also for other geographical objects G which are not singular points (e.g. polygons of any size or multiple points), no general advantage could be gained by adding locations or areas to G, because the size of the area, where a search center S could be located to return an $f(G, S)$ lower than a certain value, would be independent of G.

Unfortunately the requirement in Figure 4 is generally infeasible for geographical objects that have an area greater than zero because it would conflict with treating all points inside the object's area equally. We can still demand the requirement depicted in Figure 4 to be true for all $L \in \mathbb{R}_0^+$ when the geographical object G has an area of zero (i.e. only consist of points and paths). For all other objects, we propose to violate this criterion. Notwithstanding, our proposal will still fulfill the requirement in the limiting case where small geographical objects (in terms of covered area) in relation to their distance from the search point are being considered.

See Figure 5

Let $|G|$ be the size of the area covered by G (e.g. $|G| = 0$ if G only consists of singular points), then there exists a factor $c_0 \in \mathbb{R}^+$ such that for all $G \subseteq E$ and all $L \in \mathbb{R}_0^+$ with $\pi L^2 \geq c_0 \cdot |G|$:

$$\iint\limits_{\substack{S \in \{x \in E \mid \\ f(G,x) \leq L\}}} 1 \cdot \mathrm{dA} = \pi L^2.$$

Figure 5: Fulfillment of formula from Figure 4 for all L being large enough

Proposal for a fair distance function

Considering what has been discussed above, we propose the algorithm described in Figure 6 to serve as a "fair distance function" which is parameterized with a search center point S and a geographical object G on the spheroid. An example of its application is shown in Figure 7.

See Figures 6 and 7

The choice of c_1 directly corresponds to a penalty for search center points S that are located inside or touch the geographical object G: the result of the fair distance function equals to $\sqrt{c_1 \cdot |G| \,/\, \pi}$ in this case (which is proportional to the radius of a circle with the same surface area than the geographical object G). In order to fulfill the demand stated in Figure 3, the second constant c_2 is chosen dependent on c_1 such that the penalties for search center points

* *The surface area of a circle with radius r is $\pi \cdot r^2$.*

Let c_1 and c_2 be two constants, where $\frac{1}{2} < c_1 < 1$ and $c_2 = \frac{c_1^2}{2c_1 - 1}$.

1. Calculate the surface area $|G|$ of the geographical object G (zero if G only consists of points and paths but not, for example, filled polygons).
2. Calculate the shortest spheroidal surface distance d between the geographical object G and the search center point S (zero if S is located inside or touching G).
3. Calculate the surface area $|G_{\text{extra}}|$ covered by all points on the spheroid which are not in G but whose shortest spheroidal surface distance to G is less than d.
4. Let $R = \min(c_1 \cdot |G| + c_2 \cdot |G_{\text{extra}}|\,,\ |G| + |G_{\text{extra}}|)$.
5. The result of the fair distance function is: $f(G, S) = \sqrt{\frac{R}{\pi}}$.

Figure 6: Proposed algorithm

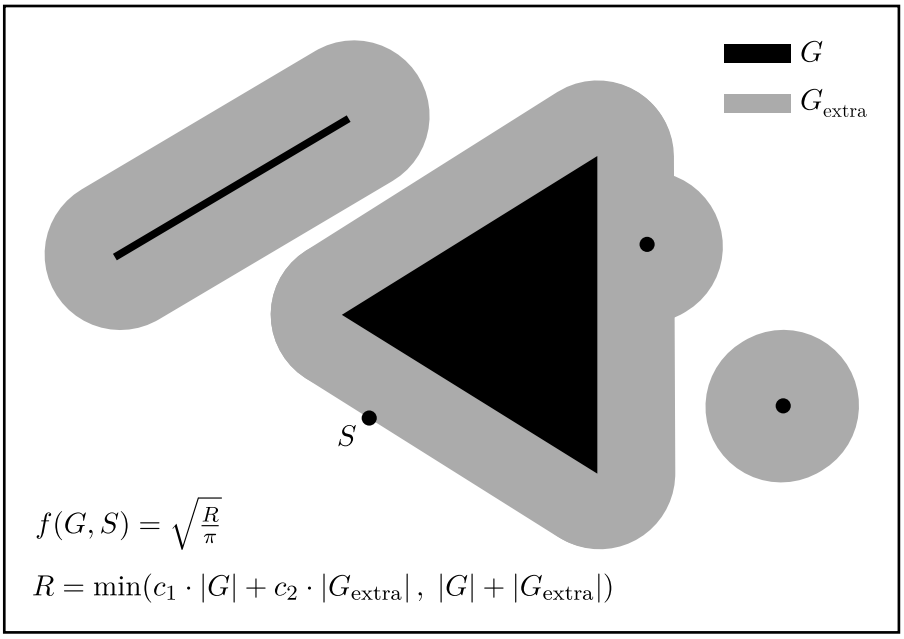

Figure 7: Example calculation where G is a union of 4 basic geographical objects (line, triangle, two points), and where $S \notin G$

S inside the geographical object G are compensated on the outside (see Figure 9). An optimal value for c_1 would be $1/2$ because in case of a geographical object which consists of a huge number of singular points randomly scattered over a certain surface area, the statistical average for $|G_{\text{extra}}|$ is half of that area.

See Figure 8

Therefore, no (statistical) advantage could be gained by replacing filled areas of a geographical object with a huge number of singular points covering that surface area.

Setting $c_1 = 1/2$, however, would cause a discontinuity because $\lim_{c_1 \to 1/2} c_2 = \infty$. A reasonable compromise seems to be $(c_1, c_2) = (2/3,\ 4/3)$. This way, search center points that are located inside the geographical object are slightly overpenalized, but the discontinuity is solved smoothly.

See Figure 9

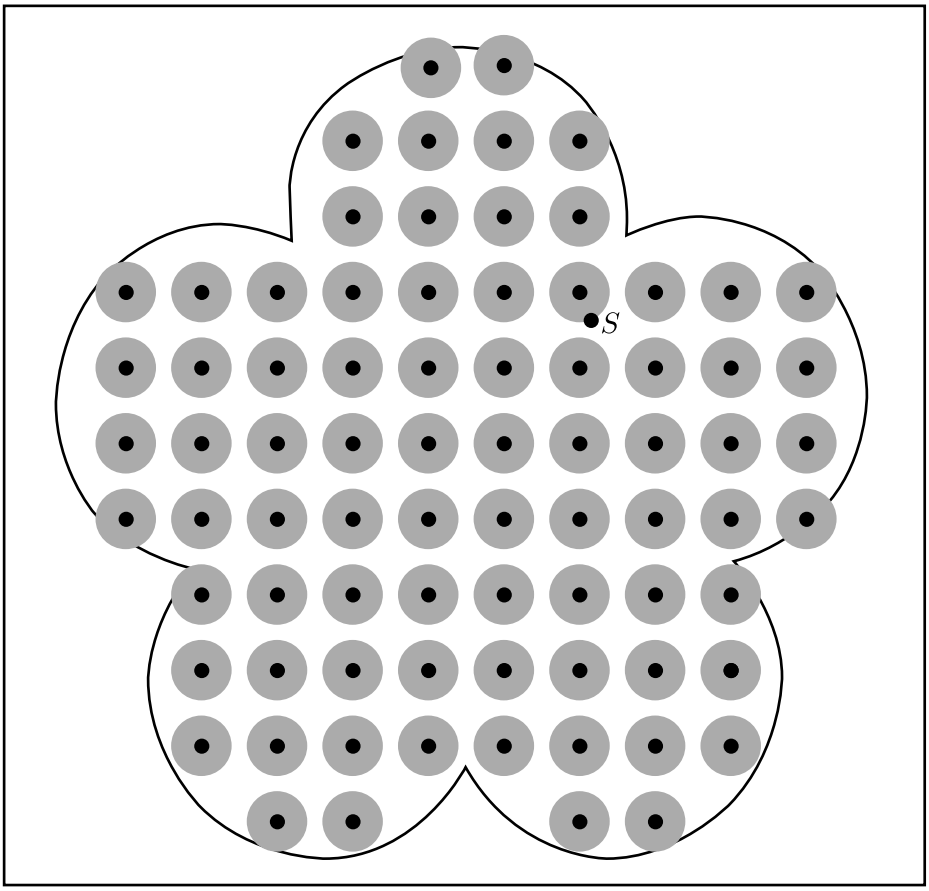

Figure 8: For an S randomly placed inside the outer shape, the grey area G_{extra} will cover half of the area within the outer shape in the average case

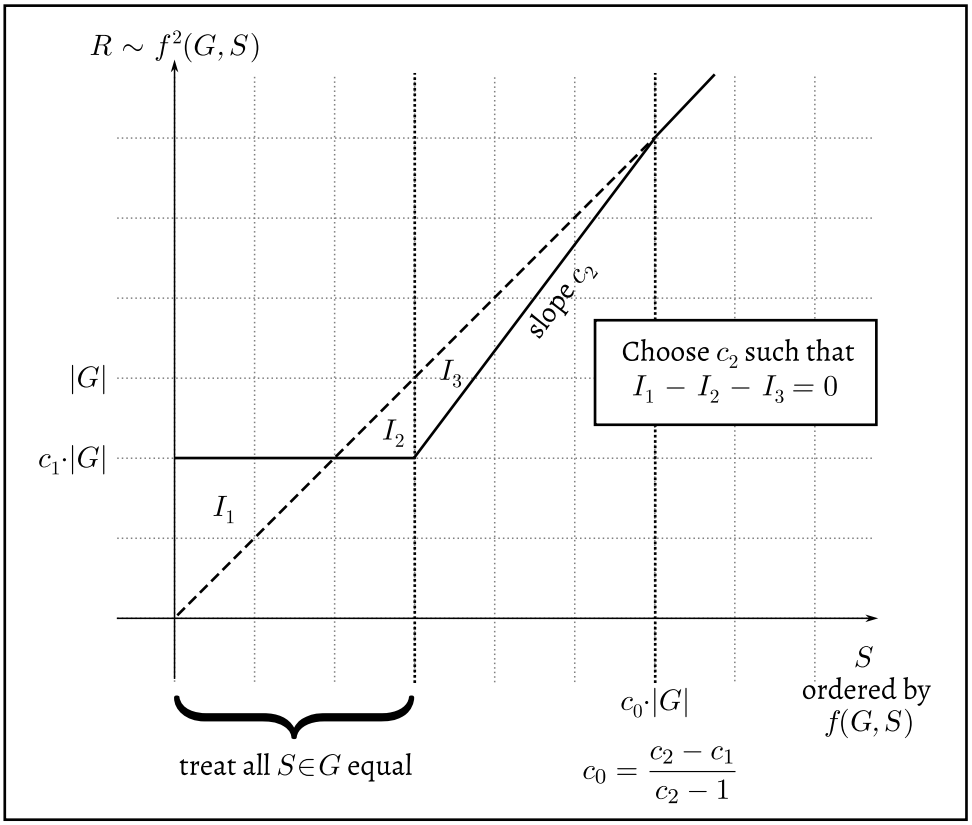

Figure 9: Picking c_2 such that the formula in Figure 3 is fulfilled

In the limiting case where small geographical objects in relation to their distance from the search point S are being considered, we know that $|G_{\text{extra}}| \gg |G|$ from which follows that $R = |G| + |G_{\text{extra}}|$. Then R is equal to the area of all points with spheroidal surface distance to the geographical object G equal to or smaller than d (see Figure 7). The area for which the distance function yields values below a limit L is therefore equal to $\pi \cdot L^2$ because from $f(G,S) \leq \sqrt{R \,/\, \pi} = L$ follows that $R \leq \pi \cdot L^2$. Therefore, the demand stated in Figure 4 is fulfilled in this limiting case (see Figure 5 for the precise condition; factor c_0 is given in Figure 9).

Implementation as part of the PostgreSQL extension "pgLatLon"

PostgreSQL is an open-source database management system. [PostgreSQL] The fair distance function has been implemented as part of a PostgreSQL extension named "pgLatLon", [pgLatLon] which was originally contributed as part of LiquidFeedback. The implementation uses numerical integration (similar to the Monte Carlo method) in order to determine the area $|G|$ and extended area $|G_{\text{extra}}|$ on the Earth spheroid. While the area of a polygon can also be calculated more easily and more

accurately, the calculation of the extended area $|G_{\text{extra}}|$ seems to be rather difficult if numerical calculation was to be avoided.

The sample points for numerical intergration on the spheroid (as calculated by the "pgl_sample_points" function) are generated by using a spiral with sample points occurring at the golden angle, similar to a pattern found in many plants, e.g. sunflowers.

See Figure 10 and 11

Completing the GiST interface with a distance estimator function

While the distance function is a mandatory prerequisite for a nearest-neighbor search, further support functions are needed to speed up nearest-neighbor searches when using database indices. PostgreSQL provides the GiST interface to enable fast nearest-neighbor searches for custom functions and operators. "pgLatLon" includes facilities to create indices on geographical objects, including support for nearest-neighbor search using (a) the spheroidal surface distance or (b) the "fair distance"

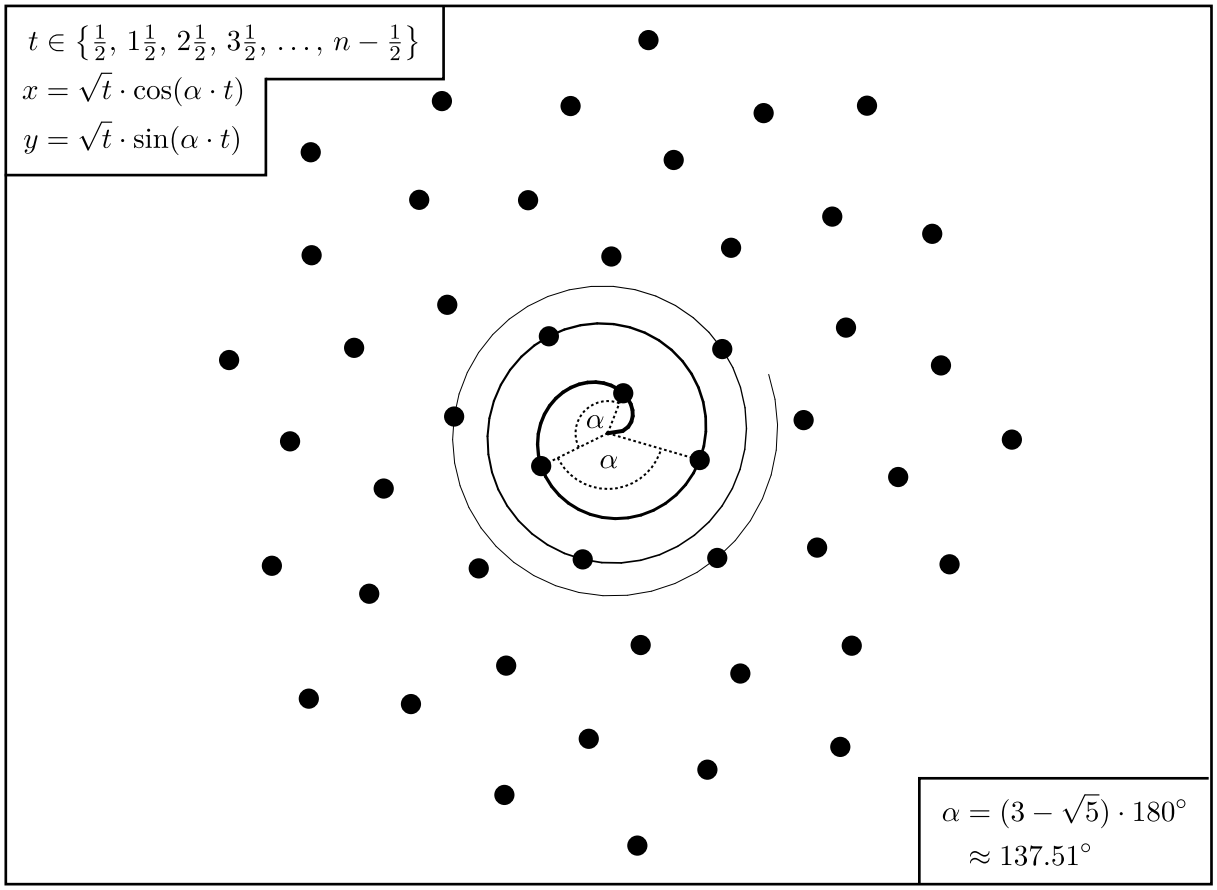

Figure 10: Using the golden angle to create sample points for numerical integration

```
/* half of (spherical) earth's surface area */
#define PGL_HALF_SURFACE (PGL_RADIUS * PGL_DIAMETER * M_PI)

/* golden angle in radians */
#define PGL_GOLDEN_ANGLE (M_PI * (sqrt(5) - 1.0))

/* create a list of sample points covering a bounding circle
    and return covered area */
static double pgl_sample_points(
  pgl_point *center,  /* center of bounding circle */
  double radius,      /* radius of bounding circle */
  int samples,        /* number of sample points (MUST be positive!) */
  pgl_point *result   /* pointer to result array */
) {
  double double_share = 2.0;  /* double of covered share of earth's surface */
  double double_share_div_samples;  /* double_share divided by sample count */
  int i;
  double t;  /* parameter of spiral laid on (spherical) earth's surface */
  double x, y, z;  /* normalized coordinates of point on non-rotated spiral */
  double sin_phi;  /* sine of sph. coordinate of point of non-rotated spiral */
  double lambda;   /* other sph. coordinate of point of non-rotated spiral */
  double rot = (0.5 - center->lat / 180.0) * M_PI;  /* needed rot. (in rad) */
  double cos_rot = cos(rot);  /* cosine of rotation by latitude */
  double sin_rot = sin(rot);  /* sine of rotation by latitude */
  double x_rot, z_rot;  /* normalized coordinates of point on rotated spiral */
  double center_lon = center->lon;  /* second rotation in degree */
  /* add safety margin to bounding circle because of spherical approximation */
  radius *= PGL_SPHEROID_A / PGL_RADIUS;
  /* if whole earth is covered, use initialized value, otherwise calculate
      share of covered area (multiplied by 2) */
  if (radius < PGL_MAXDIST) double_share = 1.0 - cos(radius / PGL_RADIUS);
  /* divide double_share by sample count for later calculations */
  double_share_div_samples = double_share / samples;
  /* generate sample points */
  for (i=0; i<samples; i++) {
    /* use an offset of 1/2 to avoid too dense clustering at spiral center */
    t = 0.5 + i;
    /* calculate normalized coordinates of point on non-rotated spiral */
    z = 1.0 - double_share_div_samples * t;
    sin_phi = sqrt(1.0 - z*z);
    lambda = t * PGL_GOLDEN_ANGLE;
    x = sin_phi * cos(lambda);
    y = sin_phi * sin(lambda);
    /* rotate spiral by latitude value of bounding circle */
    x_rot = cos_rot * x + sin_rot * z;
    z_rot = cos_rot * z - sin_rot * x;
    /* set resulting sample point in result array */
    /* (while performing second rotation by bounding circle longitude) */
    result[i].lat = 180.0 * (atan(z_rot / fabs(x_rot)) / M_PI);
    result[i].lon = center_lon + 180.0 * (atan2(y, x_rot) / M_PI);
  }
  /* return covered area */
  return PGL_HALF_SURFACE * double_share;
}
```

Figure 11: C implementation in "pgLatLon" (part 1 of 3)

```
/* fair distance between point and cluster (see README file for explanation) */
/* NOTE: sample count passed as third argument MUST be positive */
static double pgl_fair_distance(
  pgl_point *point, pgl_cluster *cluster, int samples
) {
  double distance;       /* shortest distance from point to cluster */
  pgl_point *points;     /* sample points for numerical integration */
  double area;           /* area covered by sample points */
  int i;
  int inner = 0;         /* number of sample points within cluster */
  int outer = 0;         /* number of sample points outside cluster but
                            within cluster enlarged by distance */
  double result;
  /* calculate shortest distance from point to cluster */
  distance = pgl_point_cluster_distance(point, cluster);
  /* if cluster consists of a single point or has no bounding circle with
      positive radius, simply return distance */
  if (
    (cluster->nentries==1 && cluster->entries[0].entrytype==PGL_ENTRY_POINT) ||
    !(cluster->bounding.radius > 0)
  ) return distance;
  /* if cluster consists of two points which are twice as far apart, return
      distance between point and cluster multiplied by square root of two */
  if (
    cluster->nentries == 2 &&
    cluster->entries[0].entrytype == PGL_ENTRY_POINT &&
    cluster->entries[1].entrytype == PGL_ENTRY_POINT &&
    pgl_distance(
      PGL_ENTRY_POINTS(cluster, 0)[0].lat,
      PGL_ENTRY_POINTS(cluster, 0)[0].lon,
      PGL_ENTRY_POINTS(cluster, 1)[0].lat,
      PGL_ENTRY_POINTS(cluster, 1)[0].lon
    ) >= 2.0 * distance
  ) {
    return distance * M_SQRT2;
  }
  /* otherwise create sample points for numerical integration and determine
      area covered by sample points */
  points = palloc(samples * sizeof(pgl_point));
  area = pgl_sample_points(
    &cluster->bounding.center,
    cluster->bounding.radius + distance,  /* pad bounding circle by distance */
    samples,
    points
  );
  /* perform numerical integration */
  if (distance > 0) {
    /* point (that was passed as argument) is outside cluster */
    for (i=0; i<samples; i++) {
      /* count sample points within cluster */
      if (pgl_point_in_cluster(points+i, cluster, true)) inner++;
      /* count sample points outside of cluster but within cluster enlarged by
          distance between point (that was passed as argument) and cluster */
```

Figure 11: C implementation in "pgLatLon" (part 2 of 3)

function as defined above. However, the corresponding GiST distance estimator function implemented by pgLatLon uses the spheroidal surface distance function in both cases. It is still possible to do nearest-neighbor searches for the "fair distance" function because the distance estimator function of the GiST framework is always allowed to return smaller values, though the performance may be less optimal.

Considering the voting weight

The second challenge mentioned above is to not only consider geographical properties but also the ratings of others users (i.e. voters) when performing a search. For a pair of a single search center point S and a geographical object G, this can be easily achieved by dividing the value R (as calculated in the algorithm explained above) by a number representing the strength of support by the voters. In the easiest case, this could be the total number of votes. However, in order to create a clone-proof process, vote counting mechanisms should be used where clone-proofness is ensured (e.g. restrict voters to vote only for one object or use a clone-proof counting scheme such as Harmonic Weighting).

```
      else if (
        pgl_point_cluster_distance(points+i, cluster) < distance
      ) outer++;
    }
  } else {
    /* if point is within cluster, just count sample points within cluster */
    for (i=0; i<samples; i++) {
      if (pgl_point_in_cluster(points+i, cluster, true)) inner++;
    }
  }
  /* release memory for sample points needed for numerical integration */
  pfree(points);
  /* if enlargement was less than doubling the area, then combine inner and
      outer sample point counts with different weighting */
  /* (ensures fairness in such a way that the integral of the squared result
      over all possible point parameters is independent of the cluster) */
  if (outer < inner) result = (2*inner + 4*outer) / 3.0;
  /* otherwise weigh inner and outer points the same */
  else result = inner + outer;
  /* convert area into distance (i.e. radius of a circle with the same area) */
  result = sqrt(area * (result / samples) / M_PI);
  /* return result only if it is greater than the distance between point and
      cluster to avoid unexpected results because of errors due to limited
      precision */
  if (result > distance) return result;
  /* otherwise return distance between point and cluster */
  else return distance;
}
```

Figure 11: C implementation in "pgLatLon" (part 3 of 3)

Weighted nearest-neighbor searches

As previously noted, the distance estimator function of the GiST framework is allowed to return distances shorter than the actual distances. While the penalty of the fair distance function only increases the returned distance (at least in case of a flat map or, by approximation, in case of short distances on the spheroid*), considering voting weight might decrease a returned distance. Therefore, it is no longer feasible to use the spheroidal surface distance as an estimation for distances that have been re-weighted according to the number of votes. Whenever an additional weight of an object is taken into account, the index should store such a weight in the index tree so that the corresponding GiST distance estimator can consider this weight by decreasing the returned estimation for the distance accordingly. In the same fashion, the estimated distance can be increased when a geographical object has an area $|G| > 0$. While the latter is not necessary (since it is always allowed to return distances shorter than the actual distance), it may speed up calculation. Both adjustments, however, will require to store additional data in the index tree.

Just storing this data in this index tree (and returning the worst case in case of a non-leaf node) doesn't allow for a fast index operation yet: the tree would also need to be organized in a way that considers the additional data. There are many possibilities to achieve this (R-trees, kd-trees, fractals, etc.), and the choice of index structure goes beyond the scope of this article. In either case, a performant implementation would not be trivial.

Nonetheless, it is possible to work around this issue in SQL by performing SELECTs with an (exponentially) increasing LIMIT clause within a custom function. This approach is less optimal than using a specialized index, but an example is given in pgLatLon's source code (version 0.10) in lines 27 through 85 of the file "create_test_db.schema.sql" .

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The development of "pgLatLon", including the fair distance function, was contributed to LiquidFeedback by FlexiGuided GmbH, Berlin and co-funded by the European Union's Horizon 2020 research and innovation programme under grant agreement n° 693514 ("WeGovNow").

"pgLatLon" is available as an open-source software under the terms of the MIT-License and may be downloaded at the project page of the Public Software Group e.V.:
http://www.public-software-group.org/pgLatLon

** The difference between a flat map and a spheroid used to model Earth tends towards zero for small distances. "pgLatLon" version 0.10 ensures that the fair distance function never returns values smaller than the actual spheroidal surface distance (see last if-else-clause in Figure 11, for example), which introduces a tiny error (that tends towards zero for small distances) but ensures that the GiST functions behave consistently which is required for proper index operation.*

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 693514.

[Evolution] Jan Behrens: The Evolution of Proportional Representation in LiquidFeedback. In "The Liquid Democracy Journal on electronic participation, collective moderation, and voting systems", Issue 1, March 20, 2014, pp. 32-41. ISSN 2198-9532. Published by Interaktive Demokratie e. V., available at http://www.liquid-democracy-journal.org/issue/1/The_Liquid_Democracy_Journal-Issue001-04-The_evolution_of_proportional_representation_in_LiquidFeedback.html

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[PLF] Behrens, Kistner, Nitsche, Swierczek: "The Principles of LiquidFeedback". ISBN 978-3-00-044795-2. Published January 2014 by Interaktive Demokratie e. V., available at http://principles.liquidfeedback.org/

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LiquidFeedback's Issue Limiter

by Jan Behrens, Andreas Nitsche, and Björn Swierczek, Berlin, May 11, 2017

LiquidFeedback is a software that doesn't just implement transitive proxy voting (Liquid Democracy) but also provides a process for proposition development and decision making that is collectively moderated by all participants. [PLF, section 4.3] The electorate isn't just voting on proposals but also fully in power to develop these proposals and to select which of them are available in the final voting procedure. While each individual participant may put up proposals for consideration, only those proposals that gain enough supporter votes are admitted to pass to a longer discussion phase or be eligible for final voting. [PLF, section 4.6] LiquidFeedback version 1.0 through 3.2 used a configurable supporter quorum (of, for example, 10%) relative to the number of participants who enlisted in a particular subject area (optional "membership" in a subject area) to determine the required count of supporter votes. [PLF, section 4.9]

There are two major drawbacks with this approach:

- The effects of enlisting in a subject area are difficult to explain to a user of the software. Often participants won't actively update the subject areas they are interested in or engaged in. Furthermore, the requirement to select subject areas is an obstacle when integrating LiquidFeedback with other software components.

- A minority exceeding the configured quorum in its size will be capable to flood the system with proposals. While LiquidFeedback provides a system that restricts participants to not post more than a configurable count of proposals within a given time, this approach doesn't scale as the number of participants grows. [Evolution] [Finite]

A previous idea to solve the second drawback has been published in [Finite] but was never implemented. In the remainder of this article, we'll present a new approach that is simpler but addresses both of the drawbacks listed above.

Using the "active" member count as reference population

Starting with LiquidFeedback version 4, whenever a relative quorum is configured, the reference (i.e. 100%) will be measured by the number of active participants in the system, which is the number of participants that have logged in within a configurable time frame (e.g. within the last year). So-called "membership" in subject areas will be completely removed. Instead it will be able to opt-out from receiving e-mail notificiations in particular subject areas, but this choice will not have any effect on the reference population. Only regular logins will be required for voters to be counted as part of the reference population.

Adaptively adjusting the admission quorum

LiquidFeedback 4 will also include a mechanism called "issue limiter", which adaptively adjusts the admission quorum for issues based on the number of currently open issues that have already been admitted in the respective subject area. This way, the number of admitted issues in a subject area does not grow unboundedly if a certain fraction of the eligible voters attempts to post and support as many issues as possible. In theory, this enables LiquidFeedback to be used for groups of any size. [Finite]

An adaptive admission quorum can be abused in such a way that by posting and supporting many different issues, the quorum will automatically rise and prohibit other minorities from having their issues pass the quorum. Nonetheless, the advantages of an adaptive admission quorum seem to outweigh the disadvantages when comparing it to a proportional representation scheme. See [Finite] for a detailed discussion of this issue, including an elaboration how LiquidFeedback still assures certain minorities' rights in case of a dynamically adjusted admission quorum.

The basic principle behind the "issue limiter" is that increasing the number of open and admitted issues by a given absolute count increases the required supporter count by a certain (constant) factor. In turn, issues that are closed (e.g. because of finally having been voted upon) reduce the required supporter count by the same factor. This results in an exponential (or logarithmic) correlation between the number of open issues and the currently required supporter count to let a new issue pass to discussion phase.

Using S to denote the required supporter count, B_0 to denote the desired supporter count when no issues are open, and n as the number of open issues, the relation can be described as follows:

$$S = B_0 \cdot {f_1}^n,$$

where $f_1 \in \mathbb{R}^+$ is a configurable factor.

In order to simplify configuration, the formula can also be expressed as:

$$S = B_N \cdot {f_N}^{\frac{n}{N}-1}$$

with an arbitrary $N \in \{1, 2, 3, 4, \ldots\}$,
$f_N = {f_1}^N$, and $B_N = B_0 \cdot f_N$.

In this case, S is the actual required supporter count, B_N is the required supporter count if N issues were open, and f_N is a factor (or divisor) by which the supporter count is modified if N more (or less, respectively) issues are open.

Considering different runtimes

The described approach doesn't yet take into account that different issues may have different runtimes. Counterintuitively, open issues that have a shorter runtime should be weighted more (i.e. increase the required supporter count more) because an equillibrium of N open issues that have a short runtime require more interactions of the participants than N open issues with a longer runtime. Taking different runtimes into account, the number S of required supporters calculates as follows:

$$S = B_N \cdot f_N^{\frac{n^*}{N}-1}$$

$$\text{with } n^* = \sum_{i=1}^{n} \left[\left(\frac{d_i}{D} \right)^{-a} \right]$$

where d_i is the total runtime of an issue i after admission for discussion phase (i.e. discussion time + verification time + voting time), D is a reference runtime (e.g. runtime of a default policy), and $a \in [0,1]$ is an exponent selecting how much the runtimes of different issues are taken into account.

Choice between relative or absolute supporter count

While the exponential relationship between open issues and the required supporter count doesn't require taking the total number of active participants into account, the implementation of the issue limiter still allows to use a relative base quorum (Q_N) instead of an absolute number of required supporters (B_N). In this case, $B_N = Q_N \cdot M$, where M is the total number of active participants (see section on "active" members above for a definition).

Choice between adaptive quorum, static quorum, or both

LiquidFeedback 4 will give organizations who are operating an installation of the software a choice to select whether an adaptive quorum (as explained above) or a static quorum (as implemented by LiquidFeedback version 1.0 through 3.2) will be used.

Also a combination of both mechanisms is possible if low activity shall not decrease the required supporter count boundlessly. However, when static quora are used, they will always be relative and refer to the number of currently active participants (e.g. the number of participants who logged into the system within the last year).

Acknowledgements

The development of LiquidFeedback's Issue Limiter was contributed to LiquidFeedback by FlexiGuided GmbH, Berlin and co-funded by the European Union's Horizon 2020 research and innovation programme under grant agreement n° 693514 ("WeGovNow").

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[Evolution] Jan Behrens: The Evolution of Proportional Representation in LiquidFeedback. In "The Liquid Democracy Journal on electronic participation, collective moderation, and voting systems", Issue 1, March 20, 2014, pp. 32-41. ISSN 2198-9532. Published by Interaktive Demokratie e. V., available at http://www.liquid-democracy-journal.org/issue/1/The_Liquid_Democracy_Journal-Issue001-04-The_evolution_of_proportional_representation_in_LiquidFeedback.html

[Finite] Jan Behrens, Andreas Nitsche, and Björn Swierczek: A Finite Discourse Space for an Infinite Number Of Participants. In "The Liquid Democracy Journal on electronic participation, collective moderation, and voting systems", Issue 4, July 28, 2015, pp. 42-52. ISSN 2198-9532. Published by Interaktive Demokratie e. V., available at http://www.liquid-democracy-journal.org/issue/4/The_Liquid_Democracy_Journal-Issue004-02-A_Finite_Discourse_Space_for_an_Infinite_Number_of_Participants.html

[PLF] Behrens, Kistner, Nitsche, Swierczek: "The Principles of LiquidFeedback". ISBN 978-3-00-044795-2. Published January 2014 by Interaktive Demokratie e. V., available at http://principles.liquidfeedback.org/

Readers of the Journal Asked – LiquidFeedback Developers Answer (#2)

by the developers of LiquidFeedback, Berlin, May 11, 2017

Q9: Did you ever consider a non-transitive preferential delegation model instead of the transitive delegations used by LiquidFeedback?

The proof on negative voting weight given in Issue #3 of "The Liquid Democracy Journal" [PD] seems to only cover hybrid models (i.e. transitive preferential delegations), as Figure 4.3 shows transitivity.

We never considered a preferential-only (i.e. non-transitive preferential) delegation model due to the considerations elaborated on in section 2.4.2 of our book, "The Principles of LiquidFeedback". [PLF] Nonetheless, our proof [PD] given in Issue #3 also covers the case of non-transitive delegation systems. Non-transitive delegation systems would violate property 6 ("Equality of direct and delegating voters"). Figure 4.3, where transitive propagation is visible, is justified by the previous case 3 as well as property 6. Note, however, that property 6 does *not* demand transitivity. Properties 1 and 6 both explicitly make no statement on delegation chains:

Property 1: "[...] when one of A's delegates is delegating further [...], no assumptions are made at this point."

Property 6: "[...] This rule only applies if the delegates whose votes are copied do not delegate futher. No assumptions are made otherwise (see also Property 1)"

Therefore, also preferential-only delegation systems (i.e. systems without transitive delegation) are covered by our proof and cannot fulfill the 7 properties demanded in [PD]. The consequences of our findings are summarized in [Circular].

Q10: Why do you implement delegations through a transfer of voting weight? Wouldn't it be better to let participants publish "vote recommendations" and require voters to copy each vote recommendation instead of giving a general power of attorney through delegation? This way, each participant would always have the same voting weight, which is more democratic than having people with different voting weight, isn't it?

Transferring voting weight has the same effect as automatically copying the ballot of your delegate. Refer to Figures 2.7 and 2.8 in [PLF]. Requiring participants to manually copy a vote recommendation instead of giving a power of attorney would disadvantage those people who have less time because their vote wouldn't be counted unless they copy a vote recommendation for each respective issue being debated in the system. Moreover, people with technical abilities could program bots and be counted nonetheless. Therefore, disabling automatic delegations would only affect those people who couldn't program or use bots. This would create an imbalance between the influence of technically skilled persons or well-organized groups and people who do not know how to program or how to use bots. These considerations were already elaborated on in our book, "The Principles of LiquidFeedback", section 2.4.2 ("Delegations and 'one man – one vote'"). [PLF]

Additionally, publishing preferential ballots before the respective poll is closed facilitates tactical maneuvers, which has been mathematically proven with the Gibbard-Satterthwaite Theorem in 1973/1975. [Gibbard] See also [GoD].

[Circular] Jan Behrens: Circular Delegations – Myth or Disaster? In "The Liquid Democracy Journal on electronic participation, collective moderation, and voting systems", Issue 3, January 23, 2015, pp. 35-36. ISSN 2198-9532. Published by Interaktive Demokratie e. V., available at http://www.liquid-democracy-journal.org/issue/3/The_Liquid_Democracy_Journal-Issue003-02-Circular_Delegations_-_Myth_or_Disaster.html

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[PLF] Behrens, Kistner, Nitsche, Swierczek: "The Principles of LiquidFeedback". ISBN 978-3-00-044795-2. Published January 2014 by Interaktive Demokratie e. V., available at http://principles.liquidfeedback.org/

Also published by Interaktive Demokratie e.V.:

The Principles of LiquidFeedback

This book gives an in-depth insight into the philosophical, political and technological aspects of decision making using the internet and the "secrets" of LiquidFeedback, a computer software designed to empower organizations to make democratic decisions independent of physical assemblies, giving every member of the organization an equal opportunity to participate in the democratic process.

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