Optimizing Electoral Boundaries

(Technical Report)

From Neutrality to Locality

(STS Research Paper)

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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1 INTRODUCTION

Every ten years, electoral boundaries are redrawn in the United States to account for population changes in what is known as redistricting. Redistricting is a critical part of the democratic process as it determines the representation of citizens in government. Historically, redistricting has been carried out by state legislatures in a highly partisan manner, where the controlling party both commissions and approves the new district maps. Thus with legislators in control of the process, it has been said that, “in an election, the voters choose their representatives; but in redistricting, the representatives choose their voters” (Indiana Chamber of Commerce, 1989, p. 19).

In recent years, many states have established *redistricting commissions* with the goal of removing the power of process from the legislative body (Green, 2017). After a series of high-profile legal challenges to its district maps from the 2011 redistricting cycle, Virginians voted to amend the state constitution in 2020, establishing the Virginia Redistricting Commission (VRC) to draw the state’s legislative districts. But the Commission failed to produce any maps in its inaugural attempt due to partisan disputes, resulting in the new districts being drawn by the Supreme Court of Virginia. One of the primary reasons for the Commission’s failure was that it did not have a single, neutral entity to draw the maps, with one Commissioner arguing that such an entity does not exist. The VRC thus opted to hire two sets of partisan mapmakers with the goal of melding their work (Keena, 2022).

In this thesis, I will explore the concept of *neutrality* in redistricting in two ways. First, I will explore *procedural neutrality* in redistricting through a computational approach. Second, I will explore neutrality more *abstractly*, by focusing on the technical and human elements of redistricting through the lens of the VRC.

2 OPTIMIZING ELECTORAL BOUNDARIES

In my technical report, I consider procedural neutrality through computational redistricting. I am interested in redistricting as an extension of the *capacitated p-median* problem which is a type of *clustering* (Laporte et al., 2019). There are three primary reasons for this. First, a centroid-based approach to clustering can naturally uncover the underlying political geography of a region, as centroids can be interpreted as the centers of mass of a district, and these will naturally gravitate towards areas of high population density (Weaver & Hess, 1963). Second, it has been shown that a minority group must be sufficiently clustered to have a chance at representation. For example, in Massachusetts, Republican voters make up an average of 36% of the voting population, thus in an ideal world, they would have representation in 36% of the districts. However, Massachusetts Republicans are dispersed throughout the state, and as a result, it is mathematically impossible to draw a district constituting a Republican majority. As a result, a Republican has not won a Congressional district in Massachusetts since 1994 (Duchin & Walch, 2022). Third, if computational models are to be used in redistricting, then they must be able to be understood by those who are not experts in computer science. Clustering is a well-understood concept with the key characteristic of *explainability*.

One of the first computational approaches to redistricting was published by Weaver and Hess (1963), which recognizes redistricting to be analogous to the *warehouse location-allocation* problem found in operations research. In the location-allocation problem, the objective is to identify the number, location, and size of the warehouses that will most efficiently serve a set of customers with goods (Cooper, 1963). Weaver and Hess formulate the problem such that districts are the warehouses and population units are the customers. In order to minimize the assignment cost, a compactness measure is proposed based on the physics principle of *moment of inertia*, which is the sum of squared distances from each unit to its axis of rotation, as this measure is smallest when the units are concentrated at the center (Weaver & Hess, 1963).

Due to the intractability of the problem, Weaver and Hess (1963) uses Cooper's iterative location-allocation heuristic (1963) where for each iteration, the new district centers are first located after which each population unit is allocated to a district. This procedure continues until there is no change in the location of the district centers. The allocation of each unit to a district is done using a subroutine that uses linear programming to solve what is known as the *transportation problem*, which seeks to minimize the distribution cost of transporting M goods to N locations (Bradley et al., 1977), where the cost is defined to be the *moment of inertia* (Weaver & Hess, 1963).

The approach taken in Weaver and Hess (1963) is similar to the well-known *K-means* algorithm introduced by MacQueen et al. (1967), in which the sum of squared distances from each point to its centroid is minimized. In previous work, I have approached the problem of redistricting using extensions of the *K-means* algorithm, such as *Weighted K-means*, which adds a weight to each cluster that allows for the penalization of clusters that are too large and the promotion of clusters that are too small (Bottman et al., 2007; Guest et al., 2019). I have also explored more generalized *Capacitated Clustering* approaches, which put limits on cluster sizes and assign units to clusters based on *priority* metrics (Liao & Guo, 2008; Mulvey & Beck, 1984). However, these previous efforts have been insufficient in achieving my goals. For the *Weighted K-means* approaches, I was unable to achieve a sufficiently low population deviation for Congressional districts. Further, the population deviation and district contiguity were inversely proportional in these approaches. For my *Capacitated Clustering* approaches, I was able to achieve near perfect population deviations, but at the cost of district contiguity.

In this research, I will explore more advanced approaches to the *capacitated p-median* problem with the goal of achieving contiguous districts with low population deviations. In particular, I am interested in using *minimum-cost flow* networks to model the problem as in George et al. (1997).

3 FROM NEUTRALITY TO LOCALITY

At the forefront of redistricting reform is the redistricting commission. In 2019, in response to reform advocates, the General Assembly approved a reading of an amendment that would create a type of bipartisan redistricting commission. The Virginia Redistricting

Commission (VRC) would consist of sixteen members, half of whom would be state legislators, equally divided between the two major political parties, while other half would be citizens recommended by legislative leaders and selected by retired judges. However, the commission would not have full autonomy, requiring approval of districting plans by the General Assembly—language which was opposed by various anti-gerrymandering groups. In the event of deadlock, the redistricting process would be assumed by the Supreme Court of Virginia (SCOVA) (Keena, 2022). The role of SCOVA in the process led to opposition from Black legislators, in part due to the fact that justices on the court were appointed by a Republican-controlled General Assembly. There were also arguments that the commission itself was designed to fail, due to the ease of deadlock made possible by the high supermajority threshold required for approval (Moomaw, 2020). But despite these oppositions, the amendment was sent to voters who approved it with a nearly two-to-one ratio (“Live Election Results; Constitutional Amendment #1”, 2020).

The success of a redistricting commission is often directly tied to its structure. While California’s *independent* Citizens Redistricting Commission produced maps in both the 2011 and 2021 redistricting cycles, New York’s commission failed its task despite having an independent structure. Other states, such as Utah and Maryland, which operate in *advisory* roles, produced maps only for their state legislatures to reject them (Imamura, 2022). But Virginia’s structure is unique, as it is the only *hybrid* redistricting commission in the nation—one with both citizens and legislators as members. While the hybrid structure was meant to promote bipartisanship, the VRC ultimately ultimately deadlocked due to partisan disputes (Keena, 2022). Thus if the VRC is to have success in the future, it must strive to overcome some of the obstacles that plagued it in the 2021 redistricting cycle.

Redistricting is a multifaceted problem that spans many domains, and one which poses complex legal challenges due to the various constitutional and statutory requirements of redistricting, as well as the frequent litigation of the resulting maps. Thus before drawing any maps, the Commission first needed to hire legal counsel. Despite calls to seek nonpartisan counsel from some citizen members and public comment, legislator members argued that there was no such thing as a neutral entity in the small legal field of redistricting. In what would become a trend, the Commission instead hired two sets of partisan attorneys (Commission, 2021b).

One of the first tasks the attorneys were given was to identify a neutral mapmaker to provide the required technical assistance to the Commission. While the VRC had a nonpartisan technical advisor from the Department of Legislative Services who was capable of creating maps, due to time constraints and the significant work load, the legal counsels advised the Commission to seek additional assistance. The VRC wanted the map maker to be familiar with the political geography of Virginia, and not simply be a redistricting expert, thus there was a recommendation that the map maker be from the state. However, only one nonpartisan mapmaker was ever presented, and not by consensus agreement amongst the legal counsels (Commission, 2021a).

The counsel representing the partisan interests of the Democratic party recommended that the University of Richmond's Spatial Analysis Lab (SAL) be the neutral party that does the map drawing. While the lab had no direct experience with redistricting, their research requires expertise in the Geographic Information System (GIS) tools used in the map drawing process, and the lab had recently done significant analysis and mapping of census demographics. However, the Republican counsel argued that time constraints were an issue, and that the lab's lack of experience in redistricting would be a problem. While the Republican counsel did not believe that SAL had a partisan lean, they expressed concerns that the public would, and argued in favor of two sets of partisan mapmakers (Commission, 2021a).

Many in the Commission felt that having multiple partisan mapmakers was setting them up for failure, and that if they kept "splitting the baby" on issues such as legal counsel and mapmakers, they might as well just accelerate the process being assumed by the Supreme Court of Virginia. There were also appeals that legislator members were pushing towards the old ways of redistricting, despite Virginians overwhelmingly voting in favor of a new process. The Commission only had a small window to produce the maps, and it was argued that it would be more timely to attempt to reconcile the maps of two competing parties than those of a single entity. Yet the Commission again split on party lines and voted to hire two sets of partisan mapmakers (Commission, 2021a).

The maps being drawn by SCOVA is not the result that Virginian's expected from the newly formed VRC. Thus in my STS research, I will ask the question of whether neutrality can exist in redistricting by exploring the technical and human elements of the process, and will focus on the Virginia Redistricting Commission and the challenges it faced in the 2021 redistricting cycle. My goal is to identify a solution to the *neutral mapmaker problem* in hopes of providing recommendations for future iterations of the VRC.

4 CONCLUSION

Redistricting is a complex and nuanced problem with both technical and human elements, and the process must balance the various competing goals of representation, such as competitiveness and fairness. Computational redistricting has been proposed as a way to achieve procedural neutrality in redistricting by removing politics from the process, but it is not without its challenges. In this thesis, I hope to detail both the promises and the challenges of computational redistricting while also highlighting some of the issues with the current redistricting process in Virginia. As the maps drawn in each redistricting cycle have a profound impact on the political landscape of the state, it is critical that the process be as fair and transparent as possible.

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