The theory and practice of bipartisan constitutional computer-aided redistricting

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THE THEORY

The theory behind bipartisan constitutional computer-aided redistricting essentially consists of three normative criteria which any systematic legislative redistricting scheme probably ought to seek to achieve. First, the redistricting system ought to be feasible such that it keeps computer time and other costs down to a minimum. Second, the system ought to provide legislative districts that will be approximately equal in population per representative so as to satisfy the Supreme Court's equality criterion, and the districts should be so shaped as to satisfy other legal requirements that relate to contiguity. Third, the system should consider the impact of the resulting districting on incumbents and on party balance so as to minimize the unhappiness which redistricting might otherwise produce for political leaders and for diverse political viewpoints.

These three criteria are summarized in the title of this paper. The adjective "computer-aided" refers to computer feasibility. It also emphasizes that the computer aids in redistricting like an elaborate desk calculator and does not do the redistricting itself. The adjective "constitutional" refers to the federal and state legal requirements with regard to equality and contiguity. The adjective "bipartisan" refers to promoting mutual party interests rather than ignoring the partisan impact that all redistricting inevitably has.¹

Computers can usefully supplement traditional hand methods of redistricting. This is so because the computer when adequately instructed has great (1) accuracy, (2) speed, (3) versatility to satisfy many criteria simultaneously including legal and political criteria, (4) ability to break deadlocks by facilitating political compromises, (5) ability to minimize disruption to incumbents, (6) inexpensiveness relative to the quality of the results, and (7) flexibility to allow for local variations and special considerations. The key questions in this paper relate to what criteria should the computer instructions seek to satisfy and to what extent have various redistricting programs addressed themselves to those criteria.

Satisfying computer feasibility

A logical approach to computer-aided redistricting if one had unlimited computer time and funds available might be to (1) establish an overall criterion of goodness; (2) have the computer generate every possible combination of precincts or census tracts into a given number of districts in the area to be redistricted; and then (3) apply the optimizing criterion to each of the districting patterns in order to determine which districting pattern maximizes the criterion.

Assuming agreement could be obtained among lawyers and politicians on a composite optimizing criterion, such an approach would lack computer feasibility. With any realistic number of precincts or census tracts larger than 40, the number of different districting patterns into which they could be made quickly becomes astronomical and infeasible to handle.²

A simple alternative to trying all possible combinations is to (1) start with the prevailing districting pattern; (2) move each precinct or census tract from the district that it is in into every other district; (3) each time a move is made check to see if the districting has been improved in light of the optimizing criterion; and (4) each time an improvement is made use that districting pattern as the one to be improved upon until no further improvements can be made.³

This method can avoid making a high percentage of moves that would be made in the all-combinations method by inserting into the computer program certain

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¹ On leave from University of Illinois

² From the collection of the Computer History Museum (www.computerhistory.org)
prerequisites that must be met before a move can even be checked against the optimizing criterion. For example, no move of a precinct from its present district to another district will be made if the move will cause either the district to which the precinct is moved or the district from which the precinct is moved to become non-contiguous, such that one could not go from any point in the district to any other point in the district without leaving the district. Likewise, no precinct will be moved from its present district if it is the only precinct or unit within the present district thereby destroying the district and decreasing the number of districts. In addition, the district from which a precinct is moved must be different from the district to which the precinct is moved.

The above system of moving each precinct from its present district to every other district in order to obtain successive improvements can also be supplemented by simultaneously trading a precinct from one district for a precinct from another district. Every pair of precincts gets an opportunity to be involved in such a trade provided the above-mentioned prerequisites with regard to contiguity, multiple-precinct districts, and diverse districts are met. When a trade is attempted, the resulting redistricting combination is checked against the legal and political optimizing criterion to see if an improvement has been made just as in the single precinct moving approach.

Alternatives to the moving-and-trading approach other than the all-combinations approach include such techniques as the pie-slices approach of Myron Hale,4 the diminishing-halves approach of Edward Forrest,5 and the transportation algorithm of Weaver and Hess.6 A comparative analysis by Michael Strumwasser emphasizing the computer feasibility aspects of these alternative approaches concluded: “The generalized swapping algorithms (moving-and-trading), following closely the human approach to such a problem, offer a better solution than either geometric allocation (the pie-slices and diminishing-halves approach) or mathematical programming (the transportation algorithm). While the latter two approaches are aesthetically satisfying, the simplifying assumptions are violated in practice.”7

One additional aspect of computer feasibility relates to the use of optical input and output. Edward Forrest has advocated the use of optical scanners to read maps as input into the computer,8 but this clearly seems to be less economically feasible than relying on the Census Bureau tapes which provide (for each census tract or enumeration district) information on population, longitude, latitude, and other miscellaneous information. Additional clerical work, however, is needed (1) to show what precincts touch each other precinct and if desired (2) to convert census tract boundaries and information into political precincts. Forrest also recommends maps as output, but the cost would be far higher than an output which says District 1 consists of Precincts A, B, and C, and District 2 consists of Precincts D and E, and so on. From that verbal information, one can easily draw district lines on a precinct map showing what precincts are joined together in the same district.9

Satisfying the legal requirements

The legal requirements which any computer-aided redistricting scheme should satisfy consist of equal population per district and generally contiguity within each of the districts.

Equality of population can be measured in a variety of ways. The crudest way, although sometimes quite dramatic, is to present the ratio between the most populous single-member district and the least populous single-member district in the area being redistricted. This simple approach obviously ignores all the information available about the population of the non-extreme districts. At the most complex end of a continuum of equality measures would be such esoteric figures as the squared geometric mean10 or the inverse coefficient of variation.11 These complex measures have no legal standing in that they have never been cited as appropriate for measuring equality in a published court decision or a statute.12

The most favorably cited measure of equality in the literature is to (1) divide the total population of the state or area to be districted by the number of districts or seats in the legislature in order to determine the ideal population per district or per representative;13 and (2) determine by what percentage the population of each actual district deviates from this ideal population.

If the percentage deviation from ideal for any district is more than a few percentage points, then the districting probably represents a violation of the equal protection clause of the Constitution and the democratic notion of one man, one vote. Thus in the most recent Supreme Court case dealing with the equality standard, Missouri’s congressional districting was declared unconstitutional even though no district deviated from the ideal by more than 3.13 percent. Justice Brennan delivering the opinion of the Court stated that the “standard requires that the State make a good-faith effort to achieve precise mathematical equality.”14

It should be noted that no matter how low the average deviation is if there is even one district that has a substantial percentage deviation from the ideal,
the whole districting will probably be held unconsti-
tutional. This must be recognized in writing the opti-
mizing criterion even though mathematicians find it
more aesthetic to minimize or maximize averages.16

Contiguity of districts is the second legal require-
ment. It is usually stated as a requirement in state
constitutions or state statutes, or prevails as a matter of
custom with minor exceptions, although it is not a
U.S. Supreme Court requirement. A district is con-
tiguous if one can go from any point in the district to
any other point without leaving the district.18 Con-
tiguity is sought for many purposes including the pur-
purpose of (1) simplifying redistricting by eliminat-
ing many alternative combinations of precincts, (2) en-
abling legislators to have easier access to their con-
stituents, (3) decreasing partisan gerrymandering, (4)
couraging people of similar interests to be together
in the same district, and (5) making districting patterns
more understandable and more aesthetically appealing.

A district can be contiguous and not compact, and
likewise it can be compact and not contiguous. Com­
pactness can either mean being geographically like a
circle or a square,17 or it can mean having its people
clustered close together regardless of the shape of the
perimeter of the district.19 Compactness is not a legal
requirement. In fact the Supreme Court recently said
"A State's preference for pleasingly shaped districts
can hardly justify population variances."19 Likewise the
Court disparaged the value of population compactness
as well as geographical compactness by saying "to
accept population variances, large or small, in order to
create districts with specific interest orientations is
antithetical to the basic premise of the constitutional
command to provide equal representation for equal
numbers of people."20

In spite of the importance the Supreme Court has
given to equality and the non-importance it has given
to compactness and in spite of the importance the
states have given to contiguity, a number of redis-
stricting programs heavily emphasize compactness at
the expense of equality and do not at all guarantee
contiguity.21

Satisfying the political requirements

It can be demonstrated that if the precincts, census
tracts, or other building blocks out of which districts
are made are small enough, then virtually perfect
equality can be provided and still allow room for taking
political interests into consideration. Given this leeway,
it seems reasonable to expect the politicians to want
computer-aided redistricting to (1) minimize disruption
to incumbents, and to (2) facilitate political compro-
mises.

Disruption to incumbents can be legally minimized
by the following techniques: (1) the prevailing district-
ing plan can be used as a starting point rather than
starting from an undistricted map of the state; (2) dis-
tricts that already come sufficiently close to the ideal
population can be removed from the redistricting;
(3) one can select building blocks from which districts
are built with the knowledge that these units will not
be broken into smaller pieces; (4) no move will be
consummated if the new districting is merely equal in
value to the previous one rather than an improvement
as measured by the optimizing criterion; (5) redistrict-
ing can be done to satisfy the equality requirement and
then district lines can be drawn so as to make the
number of districts dominated by the Democrats or
Republicans as equal as possible to the number before
the redistricting.

Political compromises can be facilitated in various
ways if the computer redistricting scheme inputs infor-
mation on the number of Democrats and Republicans
in each precinct or building block. For example, the
computer can quickly show the Democrats and Re-
publicans what is the maximum number of districts
which they could each dominate given the Court's
equality requirements and the partisan information.
From these outermost positions, both sides can work in
toward a compromise. Once the equality requirement
has been met, the computer simply shifts from an
equality optimizing criterion to a Democratic or a
Republican optimizing criterion in order to reveal those
outermost positions.22

Some compromises might require that districts in
certain sections of the state be drawn to favor the
Republicans up to a specified point and that districts
in other sections be drawn to favor the Democrats up
to a point while providing court-required equality. The
computer can aid in this kind of politically-oriented
redistricting, but only if it has been programmed to
provide for such a political option.

An option can also be exercised within the computer
program to make the percent of districts dominated by
the Democrats (or Republicans) as close as possible to
the percent of Democrats (or Republicans) in the state.
Doing so provides a kind of proportional representation
without the complicated voting procedures which are
usually associated with proportional representation.23

Finally, the computer also facilitates political com-
promises by quickly providing information on the
partisan composition of the districts in various tentative
redistricting plans.24a

In the most recent relevant Supreme Court decision
with regard to political considerations, the Court said,
“Problems created by partisan politics cannot justify an apportionment which does not otherwise pass constitutional muster.” The implication is that if the reapportionment otherwise passes constitutional muster, then problems created by partisan politics and legislative interplay can be legitimately considered.

In some states or areas, an additional political requirement for redistricting might relate to minimizing the negative reaction of minority ethnic groups like blacks or Spanish-speaking Americans. Just as the computer can attempt to provide proportional representation to the Democrats and Republicans, it can also attempt to provide proportional representation to minority ethnic groups by seeking to have the percentage of districts which they dominate equal to their percentage of the population within the state.

William Below and Michael Strumwasser have prepared computer programs that do seek to minimize disruption to incumbents and facilitate political compromises. Other programs, however, have lacked any attempt to consider their partisan effects although some have been labeled non-partisan. Labeling a redistricting program non-partisan does not make it non-partisan if the results change the partisan balance of power as they are likely to do. The non-partisan label has merely meant that the computer program so labeled ignores the partisan effects of its work, and thus cannot facilitate political compromises or minimize political disruption.

Robert Dixon in his comparative analysis of alternative computer approaches particularly emphasizes the importance of political sophistication and understanding the political impact of computer-aided redistricting.

THE PRACTICE

A computer program that was written in 1964 to satisfy the requirements of computer feasibility, constitutionality, and bipartisanship has thus far had some limited applications which might be worth reporting. Further applications are anticipated after the 1971 state legislatures convene and decide on the general procedures they intend to follow in redistricting the 50 states for congressional and state legislative purposes.

The first application of the bipartisan constitutional program consisted of experimental runs made to convert 90 downstate Illinois counties from 21 districts down to 18 districts. Using counties rather than precincts or census tracts as the building blocks out of which to make districts greatly limited the flexibility to maneuver. Under current constitutional standards units smaller than counties would be a court-ordered requirement. Nevertheless the redistricting was able to convert the original 21 districts, in which 8 violated the Illinois constitutional requirement of no more than 20 percent deviation, into 18 contiguous districts in which none violated the Illinois constitutional requirement. This conversion took only 81 seconds of computer running time.

After meeting the Illinois constitutional requirement, the program generated various politically-oriented districting patterns. They ranged from a pattern in which the Democrats obtained a majority in only 22 percent of the 18 districts, up to a pattern in which the Democrats obtained a majority in 39 percent of the districts. This ability to provide alternative political patterns could have facilitated the Republicans making some concessions in the downstate area in return for related concessions by the Democrats in the Chicago area. Instead both parties moved so slowly trying to develop political compromises that the constitutional deadline passed and an at-large election had to be held to choose the state legislature.

The next application of the bipartisan constitutional program was by William Below working for the California Assembly Committee on Elections and Apportionment in 1965. According to his report, “The program was applied to Assembly districts in Los Angeles, Orange, San Francisco, and Santa Clara counties. In San Francisco, the use of the program served only to verify that a particular set of goals was not obtainable. In each of the other counties, plans were produced which the committee staff considered good enough to submit to committee members and the affected incumbents. Three out of the thirty-one districts in Los Angeles (those which underwent the greatest change), were included in the assembly bill almost exactly as the program produced them. The plans for Orange and Santa Clara Counties were slightly changed on the advice of the incumbents.”

Below also reports that “Members of the committee staff with no data processing experience became proficient at specifying the initial plans, weights, and desired proportions necessary to use the program.” Below’s version of the program added increased flexibility by (1) allowing different political goals for each district rather than just having an overall political goal for the area to be redistricted, (2) interspersing moving and trading rather than doing all the trading after completing all the moving, (3) developing techniques for translating census areas into political areas, (4) simplifying the information inputed to preserve contiguity, and by (5) translating the program into the Fortran programming language.

The third application of the bipartisan constitutional program was by C-E-I-R, Inc., for the Illinois Republican Party in 1965. Norman Larsen, who handled
the application for C-E-I-R, reported that the politicians were more interested in being quickly and accurately provided with useful information on the characteristics of the districts in a variety of tentative redistricting plans than they were in having the computer produce an optimum output. The Republican Party was the minority party in the Illinois legislature at that time, and its districting patterns were less influential on the final result than the Democratic districting patterns. Nevertheless the Republican Party leaders did buy $31,000 of computer redistricting consulting services, and they appeared to be satisfied with what they obtained.

Like Below in California, Larsen in Illinois made various changes in the program to take into consideration the fact that thousands of townships and other units were used to create the districts rather than a mere 90 counties as in the original example. The contiguity checks in particular were streamlined. Continuous intermediate output was generated to allow a monitoring of convergence toward an optimum. Time saving conditions were also introduced to eliminate various kinds of moves that were not likely to lead to an improvement.

The experience received in applying the program in California for a bipartisan state legislative committee and the experience in Illinois for the minority political party showed that the bipartisan constitutional computer-aided redistricting approach is feasible from the three viewpoints of computer technology, law, and political realism. The approach would clearly be less meaningful if it failed to satisfy fully these three essential criteria. It is anticipated that other versions of this basic program and approach will be developed and applied to the 1971 redistricting which is about to get under way across the country.

REFERENCES

1. A computer program that seeks to achieve all three of these criteria and their sub-criteria simultaneously is described in:
   NAGEL
   Simplified bipartisan computer redistricting
   17 Stanford Law Review 563 1965

2. This was the finding of Garfinkel and Nemhauser as described in the masters thesis of:
   M STRUMWASSER
   A quantitative analysis of political redistricting
   UCLA School of Business Administration 1970

3. The essence of this precinct moving system was first developed by:
   H KAISER
   An objective method for establishing legislative districts
   10 Midwest Journal of Political Science 200 1966

4. M HALE
   Representation and reapportionment

5. E FORREST
   Apportionment by computer
   4 American Behavioral Scientist 23 1964

6. J B WEAVER S W HESS
   A procedure for nonpartisan districting: Development of computer techniques
   73 Yale Law Journal 288 1963

7. M STRUMWASSER
   Op cit Ref 3 at p 19

8. E FORREST
   Electronic reapportionment mapping
   Data Processing Magazine July 1965

9. Providing a map as output does not seem worth the extra cost over providing words as output. Along related lines, however, providing a system whereby one can move population units through a computerized typewriter and receive immediate feedback may be quite useful to politicians who want to do their own districting, but who want the computer to provide information on the alternatives they suggest rather than have the computer suggest alternatives. See:
   C STEVENS
   On the screen: Computer aided districting
   Conflicts Among Possible Criteria for Rational Districting 40-49 National Municipal League 1969

10. H F KAISER
    A measure of the population quality of legislative apportionment
    62 American Political Science Review p 208 1968

11. G SCHUBERT C PRESS
    Measuring malapportionment
    58 American Political Science Review p 302 1964

12. G BAKER
    Implementing one man, one vote: Population equality and other evolving standards in lower courts

13. Where there are multi-member districts involving different numbers of representatives in a state, the courts talk in terms of population per representative rather than population per district. Someday, however, the courts may recognize that one voter who is a member of the majority interest group in a district with two representatives and 2000 people has more political power than one voter in a dis-
strict with one representative and 1000 people, since the first voter can determine who two representatives will be. J BANZHAF III
Multi-member electoral districts—Do they violate the “One man, One vote” principle
75 Yale Law Journal p 1309 1966
14 KIRKPATRICK v PREISLER
394 U S 526 530 1969
Although Kirkpatrick dealt with congressional districting, its standards would probably equally apply to state legislative districting. In fact the equal protection clause which applies to state districts, more specifically requires equality than Article I of the Constitution which applies to congressional districts.
15 The programs developed by Bill Below and Henry Kaiser only optimize averages rather than force outliers under a maximum cut-off.
W BELOW
The computer as an aid to legislative reapportionment
An ALI-ABA course of Study on Computers in Redistricting
American Law Institute 1965
H KAISER
Op Cit Ref 3
16 For two intra-district units to touch or be contiguous they must share part of a common line no matter how small, not merely a common point. Legal boundaries of land areas adjacent to bodies of water normally extend over a portion of the water at least for the purpose of court and police jurisdiction if not for the purpose of ownership, and these extended boundaries should be used in determining contiguity not the shoreline.
E C REOCK
Measuring compactness as a requirement of legislative apportionment
5 Midwest Journal of Political Science 70 1961
18 WEAVER HESS
Op Cit Ref 6
19 KIRKPATRICK v PREISLER
394 U S 526 536 1969
20 Ibid p 533
21 WEAVER HESS
Op Cit Ref 6
FORREST
Op Cit Ref 5
The Kaiser program also lacks a guarantee of contiguity: KAISER
Op Cit Ref 3
22 For a discussion of the computer programming that is involved in both the equality optimizing criterion and the various political optimizing criteria, see:
F. H. NAGEL
Op Cit Ref 1
23 James Weaver impliedly defines “non-partisan” as providing proportional representation by stating, “A procedure blind to politics should provide a random opportunity for changes in the party in power, hopefully approximating the partisan ratio in the area.”
J WEAVER.
Fair and Equal districts: A how-to-do-it manual on computer use
p 3 National Municipal League 1970

The Weaver-Hess program, however, makes no attempt to provide proportional representation (i.e., to approximate the partisan ratio) other than by blind hope.
23a An additional option can easily be added to the program whereby the computer seeks to maximize the number of districts in which neither the Democrats nor the Republicans have more than 53 percent of the two-party vote. This would please political scientists who feel competitive districts make for more responsible representatives, but might displease politicians who prefer greater margins of safety.
24 KIRKPATRICK v PREISLER
394 US 526 533 1969
25 Thus far, the Supreme Court has refused to declare political line drawing unconstitutional where equality was provided, WMCA v Lomenzo, 382 U.S. 4 (1965). Someday, however, the Supreme Court might say that the equal protection clause is prima facie violated if the districting plan gives the minority party a substantially lower percentage of the districts than the percentage of minority party members in the state. This would be the case, for example, if the minority party constitutes 40 percent of the people in the state, but the lines are drawn so that the minority party dominates only 15 percent of the districts.
26 W BELOW
Op Cit Ref 1
M STRUMWASSER
Op Cit Ref 2
Both of these programs are based on the Nagel program, Op Cit Ref 1
27 This is true of the programs of Weaver-Hess, Op Cit Ref 6; Forrest, Op Cit Ref 5; Hale, Op Cit Ref 4; and Kaiser, Op Cit Ref 3. It is also true of the more obscure programs of C HARRIS
A scientific method of districting
9 Behavioral Science p 219 1964
J THORESON J LITTTSCHWAGER
Computers in behavioral science: Legislative districting by computer simulation
12 Behavioral Science p 237 1967
28 R DIXON
Democratic representation: Reapportionment in law and politics
pp 327-35 Oxford University Press 1968
29 NAGEL
Op Cit Ref 1
30 KIRKPATRICK v PREISLER
The court said “we do not find legally acceptable the argument that variances are justified if they necessarily result from a State’s attempt to avoid fragmenting political subdivisions by drawing congressional district lines along existing county, municipal, or other political subdivision boundaries.” 394 U.S. 526,533, 1969.
31 BELOW
Op Cit Ref 1
Information on the California application also comes from 1965 correspondence between William Below and this writer
32 Ibid p 7
33 Ibid
34 In a report from Norman Larsen to Jack Moshman of C-E-I-R, Inc. dated Nov 1 1965