Towards a Standard Architecture for Digital Voting Systems - Defining a Generalized Ballot Schema

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Abstract—Many electoral jurisdictions have their own distinctive voting schemes. There is no clear consensus about the ideal voting scheme for fair elections. Various systems for electronic and online voting have been either proposed or developed, but these systems tend to be aimed at particular vote counting schemes e.g. plurality. This paper proposes a way to decouple the ballot casting process from the vote counting scheme, using a generalized ballot schema.

Index Terms— Voting Scheme, Component Based Architecture

I. Introduction

Social choice theorems such as those of Arrow [1] indicate that there are trade-offs in the design of voting schemes. There is no single ideal voting scheme that fulfills all the desirable criteria for fair elections, under all circumstances. Accordingly, many electoral jurisdictions have developed their own distinctive voting schemes. Digital voting systems (either electronic or online) are not always easily transferrable from one voting scheme to another. This makes digital voting systems either more expensive, less useful or less reliable than they could be, since each jurisdiction must do its own development, testing and verification. In other words, digital voting systems have tended to be developed as once-off bespoke software rather than using standard re-usable software components.

Various systems have been proposed for secure digital voting, including for example Helios [2], Prêt à Voter [3], Scantegrity [4], and VoteBox [5]. Each of these implicitly presupposes a specific voting scheme or else a set of related schemes e.g. plurality. They are not necessarily designed to be easily adapted to work with a different voting scheme.

This is potentially wasteful, particularly when an election authority chooses to invest in technology to improve the election process. It risks having sunk costs due to abandonment of the existing investment, if there were ever to be a radical innovation in its voting scheme, for example a move from preferential voting to an open list, or vice versa.

The next section will describe some of the main voting schemes in use throughout the world today. The following section will describe a generic representation of ballots, and the section after that will describe how the generic ballots can be used with the various voting schemes.

II. Voting Schemes

A voting scheme is an algorithm for counting of ballot papers. The main families of voting schemes are Plurality, Ranked Choice, Approval or Score Voting, Open List, Closed List and Hybrid schemes.

Many proposed solutions for electronic voting depend on assumptions about how the ballots might be counted i.e. which voting scheme is in place. This is often reflected in the design of the ballots. However it is desirable that ballot counting algorithms are designed according to the needs of the election, rather than according to the constraints of the current technology.

A common abstract data model for ballots, that will support (almost) all possible methods for counting of ballots, is needed in order to develop a common security framework for voting. Different voting methods could then be plugged in to the common framework.

A. Plurality

Plurality is the simplest possible form of voting scheme. Which ever candidate gets the most votes is the winner. Some variants of plurality have a second round in which voters must choose between the highest two candidates from the first round. Another variant is block voting, where there are multiple positions to fill and each voter has multiple votes, e.g. if there are 3 positions to fill, each voter chooses up to 3 candidates, and the 3 candidates with most votes are elected.

B. Ranked Choice Voting

Also known as Preferential Voting or Single Transferable Vote, Ranked Choice Voting is normally used in multi-winner districts so as to achieve proportional representation. Each voter ranks the candidates in strict order of preference, e.g. first, second, third and so on.

Proportional representation is achieved using ranked choice voting in multi-member districts. A quota is calculated so that number of candidates with a quota of votes cannot exceed the number of vacancies to be filled. If a candidate receives more votes than the quota, the surplus votes may be redistributed. There are many different methods for redistribution of surplus votes, for example Meek [6].

Ranked choice voting can be viewed as a generalization of single-winner plurality voting, and it would reduce to plurality voting if all voters used only their first preferences.

C. Approval and Score Voting

Approval Voting allows to express approval or disapproval of each candidate. A more general form of Approval Voting, known as Score Voting or Range Voting, allows the voters to indicate the intensity of approval or disapproval for each candidate.

D. Open List and Closed List Voting

List systems achieve proportional representation by allowing voters to choose one list of candidates. If we allow voters to also vote for a specific candidate within their party, then it is an open list system.

III. Ballot Schema Definition

The section describes a ballot schema which can be interpreted according to any of the voting schemes described in this paper. The generic ballot schema contains four levels:

- Approval or disapproval of lists of candidates
- Priority of approved lists
- Approval or disapproval of individual candidates
- Priority of approved candidates

A. Approval or Dissapproval of each List

The voter gives approval or disapproval to each list of candidates. The default option is non-approval. Disapproval of a list implies disapproval of all candidates on that list.

B. Priority for each approved list.

For each list to which approval was given the voter enters a positive whole number e.g. 1,2,3,..; the lowest number indicates highest preference. The scores do not need to be contiguous or unique. Priority can be interpreted either as a relative preference or an absolute score, depending on the counting scheme. Two or more lists can be given first preference; depending on the voting scheme that could be interpreted as a range vote, a spoilt vote or fractional first preferences. All approved lists must be given a numeric value to indicate degree of approval; a blank value implies disapproval.

If the voter disapproves more strongly of one list than another, then this can be indicated by giving a weak approval to one and a disapproval to the one other.

C. Approval or Disapproval of each Candidate

The voter indicates approval or disapproval of each candidate within an approved list. The default option is disapproval, so that a voter can choose to vote in plurality style by approving only one candidate.

D. Preference or Score for each Candidate

- The voter gives a score or preference for each candidate approved, where the best score is 1, the next best is 2 and so on. The scores need not be contiguous. The voter may rank two or more candidates at the same score. This allows the voter to use ranked choice style if required.

IV. Worked Examples

This section describes how various voting schemes can use the generic ballot schema.

A. List-Approval Voting Scheme

This first example is a fictional voting scheme, chosen purely to illustrate the flexible application of generic ballots.

Voters choose one list and indicate approval or disapproval of each candidate on that list. There can be a second preference list in case the the first list is below threshold or does not have enough candidates.

This scheme uses the top three levels of information in the ballot and ignores the information about relative priority of approved candidates.

B. Single-Winner Range Voting

In range voting, the sum of priorities is calculated for all candidates, except that non-approval of list is counted as the minimum allowed priority for all candidates on that list e.g. 99 or 999. The priority of a list is counted as the default priority for all candidates on that list, except where a specific priority is given to an individual candidate. The candidate with the lowest overall sum of priorities is the winner.

C. Multi Winner Plurality

In multi winner plurality, the voter has one vote for each vacant position. Suppose, for example that there are 3 positions to be filled, then the top 3 preferences of each ballot are counted at equal value. The candidates with most, 2nd most and 3rd most votes are elected.

D. PR-STV with fractional counting

The first preference candidate on the first preference list is counted as the overall first preference, followed by the next preference candidate on the first list, until all approved candidates from the first list are ranked, then the approve candidates from the next list are counted as the next preferences. Two or more lists with the same priority are treated as the same list when determining the order of the candidates.

E. Open List

The first priority approved list from the ballot is counted as the party vote. The first priority approved candidate on that list is counted as the personal vote.

V. Conclusion

This paper has shown a generic ballot schema that be used with potentially any vote counting algorithm, thus decoupling the ballot casting stage from the vote counting stage of an election. This will allow voting systems to be designed developed in a modular way, so that different voting algorithms can be plugged in to a common framework that supports different mechanisms for ballot counting.

VI. References

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