# A Novel Method for Determining Electoral Tendencies

**Guillermo De Ita Luna**

**Faculty of Computer Sciences, BUAP, México**

**deita @cs.buap.mx, http://www.cs.buap.mx/~deita**

**Abstract**

We show how certain methods derived from operational research area, in this case, the application of congested networks and non-cooperative games, are useful when modeling the dynamics of political preferences of a population.

Each candidate of a political contest is represented as an independent player with his own strategies. Each agent competes against each other in order to win a political contest, i.e., the political election is a competition among all the players. The winning candidate could vary in accordance to the changes of strategies that the candidates perform during their campaign forming so, a non-cooperative game with different political scenarios.

In a congested network, several players simultaneously aim at allocating sets of resources. In this case, a resource is a profile characterizing the necessities and preferences of the voters. The cost of a resource is given by a function of the congestion, i.e. the number of candidates using the same resource for trying to influence on the voters.

A state of the game is determined by the strategies that each of the players have selected. Each player is assumed to act selfishly, trying to minimize his individual cost. So, each candidate $A_i \in A$ chooses a strategy $s_i$ forming a scenario $e = (s_1,\ldots, s_n)$ and the cost function is computed for all limited resource and according to the scenario $e$.

Our method has been used for determining expected outcomes in two electoral contest. The first one was modeling the election of the principal of a Faculty of Computer Sciences in the State University of Puebla, México; and the second one analyzed the expected outcomes from students who are using the internet as a medium to express their political preferences, during the election for Mexico's President in 2012.

It was proven that in the specific case of modeling political elections carried out by sectors, like in the case of the election of the principal, where the voters are organized in a finite number of sectors and each sector emits a single vote, our method have obtained results very close to the real ones, even much more precise than those obtained by opinion surveys.

## 1) Introduction

As more and more commercial transactions are performed on networks, there is a growing interest in designing smart methods performing specific actions. One of the possible applications of the techniques from Operational Research could be for simulating specific human tasks. And in this context, an important human task has been the selection of a representative from a population.

The selection of a representative is both an important and common issue in practical situations, for instance; selecting the candidate of a political party, the head of a department, a local city mayor, a supervisor, and so on. This process refers to the need of choosing a representative within a group of people, according to different parameters, for example, people's preferences expressed by votes.

We analyze methods used in the operational research area that are applied in the modeling of distribution of a set of limited resources among a set of consumers, and where the distribution states that each consumer receives a quantity proportional to the requirement list given by the consumers.

In turn, the consumers can request more than a product only if they subtract a similar quantity of another product demanded by them. Each consumer defines an initial strategy that is a list containing the quantity demanded for each product.

The distribution of each product is modeled as a zero–sum game among non-cooperative agents; where a consumer can obtain more than a product only if another consumer obtains less than the same product. In order to satisfy the demands of the involved consumers, the list of all the consumers' requirements builds a congested network. The congested network allow us to determine the proportions of each product that will correspond to each consumer.

Our proposal has been used to analyze political tendencies in a population of voters. We propose to apply methods coming from operational research area. For instance, the use of congested networks and non-cooperative games for modeling the dynamics of political preferences of a population. In this case, the candidates represent the consumers while the requirement list of a candidate represents its political program to be applied to the voters (producers) in order to gain their political preferences.

Different mathematical formalisms have been developed to describe electoral systems and outcomes by modeling both voting rules and human behavior (see e.g. [Banks,Gill, Quin,Strom]). Nowadays, demoscopic studies (opinion polls) are accomplished in order to determine electoral preferences. Those surveys, as snapshots of a moment, allow us to make predictions for a very short term.

An opinion poll, in its traditional elaboration form, usually reflects outlying questions about the candidates, and about the political competition, such as; popularity indexes, perceptions on the nature of the candidates or their images, the impact of their campaigns, mottos, etc. Often the factors that are measured through those surveys point more to the interest of the candidates or their parties, than to the interest or perception of the voters.

Due to this panorama that lacks the necessary mathematical tools for determining electoral tendencies, we propose to apply methods coming from operational research area, in this case, the use of congested networks and non-cooperative games for modeling the dynamics of political preferences of a population.

## 2) Congested networks

Our method assumes that there exists a population of voters distributed in $k$ sectors, let $Pot = \{Z_1, Z_2, \ldots, Z_k\}$ be the $k$ voters' sectors. Let $WZ_i = |Z_i|$ be the number of voters from the sector $Z_i$. We assume that the cardinalities $WZ_i$, $i$=1,…,$k$ are known values. Let $A = \{A_1,\ldots,A_n\}$ be a set of $n$ intelligent agents. Each $A_i \in A$ represents one of the candidates competing in an electoral contest. A sector $Z_i$, $i$=1,…,$k$ is favorable to the candidate who obtains the majority of the votes in that sector.

Let $Ps = \{P_1, \ldots,P_m\}$ be the set of $m$ political profiles used by characterizing the voters. Such profiles are the key objects used to characterize how the voters base their vote decisions. The members of each sector are characterized and identified by specific values on the set of profiles, which represents the main political characteristics of the members in that sector. Usually, analysts can approximate those profiles and their relative positions after analyzing previous elections and carrying out a deep study on the political behavior of the voters.

A key element for modeling the political preferences of a population is to recognize the political profiles characterizing the voters, given that the agents use such profiles in order to influence on the voters. The promises and actions of the candidates are reflected via a set of weights assigned to the profiles. Thus, the set $Ps$ is also used to form the political plans of the candidates.

What the agent believes to have on a profile is represented by another weight. An agent (and sometimes his campaign team) organizes the profiles and their corresponding weights forming different hierarchies that creates different political programs to be applied, in accordance with the population's answer to those programs. We call each political plan, a strategy of the candidate.

A strategy $s_i$ of an agent $A_i$ is represented as: $s_i = \{(P_1,w_{i1}),(P_2,w_{i2}),\ldots(P_m,w_{im})\}$, where each weight $w_{ij}$, $j$=1, …, $m$ reflects the importance on the profile $P_j$ that the agent $A_i$ assigns in its political program ($s_i$). An agent applies one of its strategies to compete with other agents in order to gain a maximum number of sectors of the population. Let $S(A_i) = \{s_{i1}, s_{i2}, s_{i3}, \ldots, s_{in_i}\}$ be the set of different strategies that the candidate $A_i$ would apply during its participation in the political contest. A state $e = (s_1, \ldots, s_n)$ is reached when each player $A_i$ selects its strategy $s_i$. Let $S = \{e_1,\ldots,e_o\}$ be the set of different states formed by the multi-agent system.

In fact, each agent (or his advisers) has to determine which profiles (and their corresponding weights) the agent should promote, and how to arrange those profiles in a political program. According to the different scenarios or to the results obtained through the opinion polls, the agent forms his strategies.

While more and more agents utilize the same limited profile, such profile tends to saturate, and its influence on the voters will also become smaller and smaller. Thus, a congested game is an ideal formalism for modeling this kind of resource sharing. We model the competition for winning votes via a congested network [Feld,Quant].

A congested network is a triple (*A*,*Ps*, *k*), where *A* is the set of *n* players, *Ps* is the set of limited resources, and *k* is the increasing cost function which depends on the number of players using the same resource. Several players simultaneously aim at allocating sets of resources. The cost of a resource is given by a function of the congestion, i.e. the number of agents using the same resource. So, each agent $A_i \in A$ chooses a strategy forming a state $e = (s_1,\ldots, s_n)$ and the cost function is computed for all limited resource and according to the state *e*.

Then, a state $e_j \in S$ is one of the possible configurations into the multi-agent system, and according to the strategies applied by the different agents, each agent obtains a certain number of votes in such state. As the agents change their strategies during the political campaign in order to obtain more votes, they interactively form new states.

In our model, we consider how to distribute the votes among the agents for a specific state. Thus, we develop a process to estimate the number of votes obtained by each agent, according to the strategy that each one applies. When the political election is by sectors, the candidate who obtains the maximum number of votes in that sector is the candidate who wins the total sector.

Notice that given a state *e*, there is an agent who wins the maximum number of sectors, we call to such agent the *candidate* in the state *e*. Our model is performed each time that some changes in the strategies of the candidates are done and in order to find the competitor who obtains the maximum number of sectors for each current state.

Although to change an agent strategy (even if the candidate in the state *e* does not change his strategy) represents a change in the state from *e* to $e_0$, and the candidate who wins a maximum number of sectors could change too. Given a state *e*, a move of improvement for an agent $A_i$ through local values is done by the search of a neighbor $e_0$ where $A_i$ wins a higher number of sectors than in the state *e*. In our model, we look for the better strategies of a particular candidate, which allow him to win a higher number of sectors.

## 3) Study Cases

We have applied our method to model the election of the Director of the Faculty of Computer Sciences (FCC) in the State University of Puebla (BUAP), México, in March, 2011. During this election, the voters were organized in 11 sectors; 5 belonging to faculty members (professors), 5 to students and 1 to administrative workers.

In the FCC, there are two undergraduate programs: Computer Sciences and Computing Engineering. For each program, there are two sectors: Basic and Advanced. Then, there are four sectors at undergrad level; Basic Eng, Advanced Eng, Basic Cs, Advanced Cs, and additionally, one sector at graduate level (M. Sc.): Graduate.

There are about 1900 students at the undergraduate level and 46 students at graduate level. There are 117 faculty members and 15 administrative workers. In this election, 1448 of undergrad students and 40 graduate students cast their vote [DeIta]. The political preferences of professors and administrative personnel during the elections in the FCC were captured via classical opinion polls, this due to the size of those sectors.

On the other hand, the size of the student population and their vague answers for determining only one preferable candidate, give us the adequate scenario to validate our model. Thus, we simulate the tendencies of the vote just for the students' sectors.

In our system, the political campaign is developed on a certain time, in such a way that when a candidate recognizes a new way to improve his strategy, that new strategy is applied and then, the number of votes have to be re-computed for all the involved candidates. This continues until no further impact can be produced on the number of votes or when the election campaign is over.

Comparing the estimated results at the end of the campaign versus the real percentages obtained, the absolute errors on the percentages of the votes obtained for our model versus the real values, were: 2.5, 11.5, 2.5, 3.6, 7.2, which correspond to the sectors: Basic Eng, Advance Eng, Basic Cs, Advance Cs and Graduate sectors, respectively.

We have applied also our method for analyzing the expected outcomes from students who are using the internet as a medium to express their political preferences, during the election of Mexico's President in 2012. This process began with a survey on a web site advertised through the social network Facebook, obtaining so an array of responses. We have applied two learning algorithms on the matrix to recognize the significant profiles for characterizing to the voters, and also to build decision trees in order to determine the main political profiles for characterizing our population.

## 4) Conclusions

We have designed a model for simulating the process of selecting a representative in a democratic contest. Our system can be used to study the tendencies of the vote and for this, it is necessary to determine the relevant profiles characterizing the political behavior of voters. Those profiles model how the voters, in a specific election, make their vote decision.

In our proposal, we assume that each candidate determines a finite set of strategies (political programs). Each one of these strategies is formulated as a set of weights on the profiles characterizing the voters. The profiles used for characterizing the voters, and for expressing the strategies of the agents, have a limited nature. Consequently, a congested network is built. We have developed a method to perform the distribution of votes among the set of candidates, allowing so, to determine who will be the winner in a specific political scenario.

We have applied our model to simulate the elections of a director in a university setting, obtaining estimations very close to the real outcomes. We also have applied our method for analyzing the expected outcomes from students who are using the internet as a medium to express their political preferences, during the election of Mexico's President

in 2012. Future works includes the extension of the model to consider other election scenarios, as well as for analyzing the preferences of users for specific products.

**References**

[Banks] Banks, J. and J. Duggan, A dynamic model of democratic elections in multidimensional policy spaces, Quarterly Journal of Political Science, Vol.3, (2008), pp. 269-299.

[DeIta] De Ita G., Moyao Y. and Contreras M., Modeling Democratic Elections via Congestion Networks, First Int. Conf. on Social Eco-Informatics, Vol. 1, (2011), pp. 85-90.

[Feld] Fëldman, A., Röglin H. and Vöcking B., Computing Approximate Nash Equilibria in Network Congestion Games, Structural Information and Communication Complexity, LNCS, Vol. 5058, (2008), pp. 209-220.

[Gill] Gill, J. and Gainous J., Why does voting get so complicated? A review of theories for analyzing democratic participation, Statistical Science, Vol. 17, (2002), pp.1-22.

[Quant] Quant, M., Borm P., and Reijnierse H., Congestion network problems and related games, European Jour. of Operational Research, Vol. 172, (2006), pp. 919-930.

[Quin] Quinn, K.M. and Martin D., An Integrated Computational Model of Multiparty Electoral Competition, Statistical Science, Vol. 17:4, (2002), pp. 405-419.

[Strom] Strom, K., A Behavioral Theory of Competitive Parties, American Journal of Political Science, Vol. 34, (1990), pp. 565-598.

[Fab] Fabrikant A., Papadimitriou Ch. S., Talwar K., The Complexity of Pure Nash Equilibria, Procs. STOC04, June 2004, Chicago, Illinois, USA.(2004), pp.604-612.