Modeling Democratic Elections via Congestion Networks

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***Abstract*—We address the problem for selecting a representative via a democratic election simulated by a multi-agent system. Due to lack of analytic tools for simulating electoral tendencies, we propose here, a model based on a set of non-cooperative agents which are competing for obtaining a maximum number of votes from a population. A key element in this model is to recognize the 'profiles' that characterize in a specific election how the voters make their political decisions. In order to influence the voters, the agents apply different strategies. In our model, an agent's strategy is represented via a vector of weights which indicate the amount on each profile the agent utilize to persuade the voters. We have programmed a simulation system of the voting tendencies by sectors, in agreement with the changes of strategies that the candidates perform throughout their political campaign. As the profiles used for characterizing the voters, and forming the strategies of the agents have a limited nature, then a congestion network is built. The use of a congestion network allows us to search the singular points of the competition system, enabling us to predict the possible winner of that competition according to the strategies used by the agents.**

Keywords-Multi-Agent System; Congestion Games; Electoral Simulation; Voting Tendencies

I. INTRODUCTION

The Artificial Intelligence (AI) has motivated the exploration of new reasoning issues and methods, as well as combined disparate reasoning modalities, into an unified framework which allows to deal with incomplete, imprecise, contradictory, and changing information.

In the AI, the application of intelligent agents has brought a great commercial interest, and it has been useful for decision making. One of the possible applications of the intelligent agents is to simulate specific human tasks. For example, 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 problem. For instance; selecting the candidate of a political party, the head of a department, a supervisor, etc. This means, when it is necessary to select the best representative within a group of people. Different methods have been intended to carry out this task.

We consider each one of the candidates as an independent player with his own strategies. Each agent competes against each other in order to win a political election. In [2], [3], [7], [8], [15], several models of voting are established assuming democratic systems. Particularly, the absolute majority system, where the player who obtains a relative majority becomes the winner, is studied.

In such systems, a candidate must obtain over 50% of the popular ballots to become the winner of the election. If none of the players overcome this threshold in the first round, then there is a runoff between the two top candidates to decide who is the winner.

Different mathematical formalisms have been developed to describe electoral systems and outcomes by modeling both voting rules and human behavior [3], [7], [15], [16]. We remit the reader to [3], [7], for a survey on the fundamental characteristics in voting and election theories. And in [6], [11], [15], [16], we can find practical examples of particular vote schemes occurring around the world.

In [9], [16], an analysis on the winning coalition structure of an election system is done as a simple legislative game, considering the importance of relative ideological positions in a legislative decision game, that is, as a non-cooperative game.

While in [3], [6], [13], the dynamics of their model is based on applying the search for equilibrium points, which must resolve the expectations of voters and the optimum policy choices of representatives assuming stationary environments.

Nowadays, demoscopic studies (opinion polls) are accomplished in order to determine some electoral preferences. Those surveys, as describers 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. Many times the factors that are measured through those surveys answer more to the interest of the political parties than to the perception of the voters.

Due to this panorama that lacks the necessary analytic tools for studying electoral tendencies, we propose a simulation system of the political behavior for certain voters segments in accordance to the changes of strategies that the candidates perform in the course of their campaign.

A key element for determining the winner of the contest, is to recognize the profiles characterizing the voters, given that all agents form their set of strategies based on promises and actions which try to influence the voters. Those promise and actions are reflected via a set of weights assigned to the profiles characterizing the voters.

Our logical model is an application of a congestion game [5], [10], [12]. Building a congestion game, allows us to realize a search for the singular points in the competition system,

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enabling us to predict the possible winner of an specific electoral contest. Once the singular points have been achieved, we can determine the winning strategy and the agent that will obtain the largest number of votes, that is, we can determine who will be the winner as well as its winning strategy.

In Section 1, we describe the problem to consider. In Section 2, we present the definition of the concepts and the mathematical objects to be used in our model. In Section 3, we describe how to model the political preferences of the voters. As well as the method used for determining a relative hierarchy among those preferences. In Section 4, we show the method used for computing the number of votes according to the hierarchy previously established. In Section 5, we describe a case study made during the principal' election in the Faculty of Computer Sciences- BUAP, México. In that election, we apply our model in order to predict the expected voting results by the student's sectors. In Section 6, we present the conclusion and future works.

II. Building the Multi-Agent Scenario

Let $\mathcal{A} = \{A_1, A_2, \ldots, A_n\}$ be a set of n intelligent agents. $A_i \in \mathcal{A}$ represents one of the competitors contending for a position or, in political terms, a candidate competing in a political election.

In the selection of a representative among a group of intelligent agents, it is common that beyond the beliefs, such selection also depends on the actions and the set of resources that each agent holds in order to persuade the population to vote for him.

We represent the resources used by the agents via a discrete set $\mathcal{P}\int = \{P_1, \ldots, P_m\}$. The elements of $\mathcal{P}\int$ are called "profiles". Such profiles are the key objects to characterize as the voters as the strategies of the candidates.

Each agent has to make sure to possess (or to offer to the voters) a certain quantity of each profile. The quantity of a profile that an agent believes to have is represented by a weight. An agent (and sometimes, his campaign's team) organizes the profiles and their corresponding weights in different ways, creating so different political programs to be used in accordance with the answer of the population.

We call to each one of the agent's programs a *strategy*. An agent apply one of its strategies to compete with other agents in order to obtain a maximum number of votes. A strategy s_i of A_i is a set of pairs: $s_i = \{(P_1, w_{i1}), (P_2, w_{i2}), \ldots, (P_m, w_{im})\}$, where each weight $w_{ij}, j = 1, \ldots, m$ is the amount of the profile P_j that the agent A_i applies in one of his political programs (s_i).

In fact, each agent (or his advisers) has to determine which profiles (and their corresponding weights) an agent should promote, and he also has to plan how to arrange those profiles in his political program. According to the different scenarios or to the results obtained through the opinion polls, as well as to the agent's knowledge about the preferences of the voters, the agent selects one of his strategies. However, the agents are autonomous and consequently, their strategies are private.

Let $S(A_i) = \{s_{i1}, s_{i2}, \ldots, s_{in_i}\}$ be the set of different strategies that the agent $A_i \in \mathcal{A}$ can apply for attracting voters.

TABLE I
EXAMPLE OF A STRATEGIES-MATRIX FOR A SET OF n AGENTS

	P_1	P_2	P_3	...	P_m
s_{11}	20	25	0	...	10
s_{12}	0	20	10	...	15
...				...	
s_{1n_1}	5	0	10	...	10
s_{21}	5	15	0	...	10
s_{22}	0	10	10	...	15
...				...	
s_{2n_2}	20	0	10	...	10
...				...	
s_{n1}	5	5	30	...	0
s_{n2}	10	10	15	...	5
...				...	
s_{nn_n}	10	10	0	...	17

We can order the set of strategies of the agents via a matrix called the strategies-matrix (see Table I). Once all agents have chosen one of their strategies $s_i \in S(A_i)$, $i = 1, \ldots, n$, a state (an action in the multi-agent system) is formed $e = (s_1, \ldots, s_n) \in S(A_1)X \ldots XS(A_n)$. Let $\mathcal{S} = \{e_1, \ldots, e_o\}$ be the set of different states formed by the multi-agent system.

Then, a state $e_j, j = 1, \ldots, o$ is one of the possible configurations of the multi-agent system, and according to the strategies applied by the agents, they obtain a certain number of votes in each state. As the agents change their strategies in order to obtain more votes, they interactively form new states into this multi-agent system.

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 congestion network is an ideal gadget for modeling this kind of share resources.

A congestion network game is a triple $(\mathcal{A}, \mathcal{P}\int, k)$, where $\mathcal{A}$ is a set of n players, $\mathcal{P}\int$ is a set of m limited resources, and k is an increasing cost function, which depends on the number of agents using the same resource [6], [13]. Every player has to choose a strategy which allows him to decrease his cost function value. A state $e = (s_1, \ldots, s_n)$ occurs when each player selects a strategy s_i. For each resource $P_i \in \mathcal{P}\int$, let P_i's congestion n_i be the number of players whose chosen strategy contains the profile P_i. The gain for player $A_t \in \mathcal{A}$ is $\sum_{P_j \in s_i} k_{P_j}(n_t)$ and the goal of each player is to maximize his earnings.

The cost of a resource (one edge on this network) is given by the function of the congestion, i.e., the number of agents allocating the same resource. This class of congestion networks has been extensively used in game theory [2], [5], [10]. In many applications, players incur some costs when they change their strategy. Hence, it is reasonable to assume that a player is only interested in changing his strategy if it significantly increase his earnings.

Seeking for the optimal interactive strategy of an agent is a hard problem, because its effectiveness depends mostly on the strategies of the agents involved [4]. Thus, we are modeling the selection of a representative as a non-cooperative

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game, where there is a limited quantity of each profile which represents a limited resource in a congestion network.

Another relevant element of our model consists in the way to characterize the voters' population. We use the same profiles applied in the codification of the strategies of the agents for characterizing the sector's of voters.

III. Characterizing the Sectors of Voters

Let $Pot = \{Z_1, Z_2, \ldots, Z_k\}$ be a population of voters distributed in k sectors. Let $WZ_i = |Z_i|$ be the number of voters of the sector Z_i. We assume that the cardinalities $WZ_i, i = 1, \ldots, k$ are known values. The members of each sector are characterized and identified by a set of 'profiles' which represents the main political characteristics of the members in that sector.

An important problem is to determine the main profiles used for characterizing each sector, as well as to determine its relative political importance among them. Usually, political experts can approximate those values after analyzing previous elections and carry out a profound study on the political behavior of the voters' population.

In our model, a significant sample of each sector of voters is selected to apply opinion polls. The responses obtained allow us to configure the set of profiles $\mathcal{P}\int$ as well as to determine the relative order of importance of each profile in each sector.

For designing the opinion polls, we considered the historical political behavior of the voters, the identification of their political and economical necessities, and the current electoral interests. In fact, the questions included in the opinion pulls are directed to recognize the real neccesities of the voters and not just to quantify the popularity of the candidates.

Given a sector $Z_i \in Pot$, a weight wz_{ij} for each profile $P_j \in \mathcal{P}\int$ is computed based on the responses obtained in the opinion polls. If a profile P_j is not relevant, then $wz_{ij} = 0$, and if a profile P_j is too important for characterizing Z_i, then wz_{ij} has to be a greater value than the other profiles' weights.

In some cases, the values wz_{ij} are obtained as the average of the values assigned to that profile by the selected sample of each sector. Therefore, if the weight of each profile is computed through opinion polls, it is adequate to calculate the average of responses, and to apply minimum squares to fit each poll with the average values of the sector in order to eliminate 'false positives'.

The false positives cases are represented as responses of voters who do not want to cooperate with the opinion polls, either when they try to be tricky or when a voter had sluggish responses. A formula which could be applied to eliminate false positives consists in, for example, eliminate the response of the voters whose total sum over the difference with the averages of the sector is greater than the 50% of the sum of the averages in that sector.

We consider as a relevant profile $Pc \in \mathcal{P}\int$ the impact that the political campaign has on the voters, in such a way that we are able to evaluate some changes of preferences of the voters before and during the political campaign. Furthermore, we have found that as a reflection of the heterogeneous character of the sectors, the profiles can have a positive or a negative influence on the voters when they make their political decision.

TABLE II
Relative weights for profiles characterizing each sector

$Sectors$	P_1	P_2	...	P_m
Z_1	AvP_1Z_1	AvP_2Z_1	...	AvP_mZ_1
Z_2	AvP_1Z_2	AvP_2Z_2	...	AvP_mZ_2
...				
Z_k	AvP_1Z_k	AvP_2Z_k	...	AvP_mZ_k

An order of relevance is given over the profiles of each sector $Z_i \in Pot$. Let AvP_jZ_i be the relative value given to the profile P_j with related to the other profile's values of the sector Z_i. For example, AvP_jZ_i could be the percentage of members from Z_i in which the profile P_j is their main profile.

The values $AvP_jZ_i, j = 1, \ldots, m$ could be percentages that determine a relative order over the set of profiles characterizing Z_i and then, usually $\sum_{j=1}^{m} AvP_jZ_i = 100\%$. Then, the values AvP_jZ_i build a hierarchy among the profiles of a same sector.

A simple way to determine the percentages values AvP_jZ_i of a sector Z_i, is to assign the same importance to all profiles and then, each percentage AvP_jZ_i is equal to 100% divided by the number of relevant profiles in Z_i.

Other way to compute $AvP_jZ_i, j = 1, \ldots, m$ is by adding up the average weights wz_{ij} obtained for all profiles and then, divide the corresponding weight of each profile by such sum, that is, for each fixed sector $Z_i, i = 1, \ldots, k$ $AvP_jZ_i = w_{ij} / \sum_{Pj \in \mathcal{P}\int} w_{ij}$.

Many times the sum of averages for the positive profiles is greater than the sum of averages of the negative ones, because the positive profiles have a greater influence than the negative ones to decide the vote in a proportion according to the political scenario which is being modeled.

We order the relative percentages AvP_jZ_i in a vector VZ_i, that is, $VZ_i[j] = AvP_jZ_i, j = 1, \ldots, m, i = 1, ..., k$. Each vector $VZ_i, i = 1, \ldots, k$ operates like a 'sieve' that selects the adequate proportion of the profiles to characterize a sector Z_i. The vectors VZ_i are stored as rows of a matrix $MPot$ (see Table II).

In the following section, we present a way to distribute the total number of votes among the agents. Such distribution depends on their strategies and the relevance of the profiles characterizing each sector.

IV. Computing the number of votes

Given a state $e = (s_1, \ldots, s_n)$, let w_{ij} be the weight for the profile $P_j \in \mathcal{P}\int$ that the agent $A_i \in \mathcal{A}$ applies in his strategy s_i. For each relevant profile P_j of a given sector Z_i, a sum of the weights of that profile is done among the agents determining the value $Top_j = \sum_{A_l \in \mathcal{A}} w_{lj}$. Top_j represents the total quantity of P_j to be shared among all agents.

Then, the value $PA_lP_j = (w_{ij} * AvP_jZ_i)/Top_j$ represents the proportional part that each $A_l \in \mathcal{A}$ has contributed to Top_j. Notice that $AvP_jZ_i = \sum_{A_l \in \mathcal{A}} PA_lP_j$.

Given a state $e \in \mathcal{S}$ and a sector Z_i, for each agent $A_l \in \mathcal{A}$, let $S(e, A_l, Z_i) = \sum_{j=1}^{m} PA_lP_j$ be the proportion of voters from the sector Z_i which are potential voters for the agent $A_l, l = 1, \ldots, m$. The cardinality of the sector WZ_i is divided among all agents in a proportional way due to the sum $S(e, A_l, Z_i)$.

We denote the number of voters of a sector Z_i for an agent $A_l \in \mathcal{A}$ as #Vote(A_l, Z_i) and that values is computed as:

$$\#Vote(A_l, Z_i) = WZ_i * (\frac{S(e, A_l, Z_i}{100}) \quad (1)$$

The value #Vote(A_l, Z_i) represents the proportional part of the members in the sector Z_i which are potential voters for $A_l, l = 1, \ldots, n$. Then, #Vote(A_l, Z_i) is computed for all sector $Z_i \in Pot$ in order to count the total voters from the population corresponding to an agent. Let $\#Votes(A_l, e)$ be the total voters for A_l and considering all the population, then

$$\#Votes(A_l, e) = \sum_{i=1}^{k} \#Vote(A_l, Z_i) \quad (2)$$

Given a state $e = (s_1, \ldots, s_n) \in S$, an *improvement step* for an agent A_i is a change of his strategy from s_i to s'_i changing to a new state e' and where his number of votes $\#Votes(A_i, e')$ increases with respect to the previous value $\#Votes(A_i, e)$.

Thus, we can see the neighborhood of a state e consisting of those states that derive from e only in one agent's strategy. The improvement over the number of votes of an agent A_i is precisely $\#Votes(A_i, e') - \#Votes(A_i, e)$. Consequently, the potential function for our system is $Total\_\#Votes(e) = \sum_{A_l \in \mathcal{A}} \#Votes(A_l, e)$.

Given a state e, a move of improvement through local optimal values is made by the search of a neighbor e' where $\sum_{A_i \in \mathcal{A}} \#Votes(A_i, e') > \sum_{A_i \in \mathcal{A}} \#Votes(A_i, e)$.

Notice that given a state e, there is an agent who obtains the maximum number of votes, we call such an agent *the candidate in the state e*, and it is denoted as $Candidate(A, e)$, which is computed as:

$$Candidate(A_l, e) = max\{\#Votes(A_l, e), l = 1, \ldots, n\} \quad (3)$$

Although to change an agent's strategy (even if the $Candidate$ does not change his strategy) represents a change in the state from e to e', and the agent who obtains the candidacy could change too.

In our system, we can analyze the fluctuations of the votes' tendencies in order to organize the strategies of a specific agent, either as 'bad' or 'good' strategies, according to the number of votes that the agent obtains. Furthermore, we can find which are the better strategies for a particular agent, according to a specific electoral scenario.

Assuming that all the people really vote, we have a fixed total number of votes and, if we look for an optimal point the search could be cyclic. Meaning that if an agent reduces his number of votes, then any other agent will increase his own number of votes. So, some agents could always improve their number of votes from one neighbor to another.

An adequate variable to avoid cyclic searches, is to consider the percentage of abstention in each sector. Although the abstention is a real fact in democratic systems, to determine the percentage of that abstention require a profound analysis of the traits and behavior of the population in previous elections.

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 political campaign is finished.

Of course, there are factors and events in an election that could not be directly modeled via a congestion game, since there are some hiding and misleading events that can occur throughout democratic elections. For example, in the presidential elections in México in 1988, during the counting of votes, the computational system 'fell down' for a certain number of hours, and when the system was finally restored, the voting tendencies had changed. Such tendencies did not change again during the remaining time of the computing process, giving so the victory to the candidate belonging to the government's political party [1], [14].

Thus, modeling electoral competitions, even though they call themselves democratic, holds a high grade of extra-legal manipulations that cause that the results of any computational system differ from what really happens. Specially, in corrupted processes, when the rules are manipulated, or when the rules are not clear established during the competition.

V. A Case Study

We have modeled the elections of the principal in the Faculty of Computer Sciences (FCC) in Puebla, México, where the vote casts are organized in 11 sectors; 5 belonging to professors, 5 to students and 1 to administrative workers.

In the FCC, there are two bachelor programs: Computer Sciences and Engineering in Computing. For each bachelor program, there are two sectors; Basic and Formal sectors. Then, there are four sectors at bachelor level; Basic_Eng, Advance_Eng, Basic_Cs, Advance_Cs and one sector at post-graduate level: Postgrade.

There are about 1900 students at the bachelor level and 46 students at post grade level. There are 117 Professors and 15 administrative workers. In this election, 1448 of bachelor students and 40 posgrate students voted. While 100% of administrative workers voted and 111 professors voted.

The political preference for professors and administratives can be captured via classical opinion polls due to the size of those sectors. In fact the biggest size of any of those sectors was 32 professors. Then, we can collect, for all professors and administratives, their political preference. On the other hand, the size of population of students and their vague answers for determining just one preferable candidate, generate the adequate scenario to prove our model. Thus, we simulate the tendencies of the vote just for the five students' sectors.

Then, we applied an opinion poll in order to recognize the profiles that distinguish the main features that students deem important to decide their vote. We found that the following

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TABLE III
MAIN PROFILES FOR CHARACTERIZING THE STUDENTS

Profile	*Description*
P1	Opinion of the classmates
P2	Opinion of the academic advisers
P3	Opinion of the professors
P4	Opinion of the political student groups
P5	Opinion of the official administration
P6	Commitment shown by the candidate
P7	Academic background of the candidate
P8	Political group that supports to the candidate
P9	Political work during the campaign
P10	Possible contact with the candidate
P11	Image and confidence shown by the candidate
P12	Whether they support reelection or desire a new administration

12-profiles were the most important for deciding their vote, (see Table III).

Afterward, another opinion poll was applied to the students in order to assign a relative order of the profiles according to what they consider from more to less important for making their political decision. We processed such opinion polls and computed the average of the responses. Adjustment by minimum squares was applied to the sample in order to eliminate the 'false positives'.

The formula applied to eliminate false positives consists of eliminating the students' cases where the sum of the difference with the averages of the sector is greater than the 50% of the sum of the same averages of that sector.

We found that some profiles have positive influences (called positive profiles) and others have negative influence (called negative profiles) on the students when they are deciding their vote. We also assign a relative percentage to each profile, according to the relative importance assigned by the students to those profiles. It is important to note that the FCC is an institution belonging to the area of engineerings and by tradition, the students give a great importance to the academic and professional aspects of the professors, sometimes they give much more relevance to those aspects than the image and the way that the professors interact with them.

The sum of the percentages over the positive profiles was 100%, while the sum of the percentages over the negative profiles generally gave values from 40% to 50%. According to the atmosphere that exists in the FCC, we detected that positive profiles had more impact than negative ones.

TABLE IV
RELATIVE WEIGHTS FOR PROFILES CHARACTERIZING SECTORS

Profile	Basic_Eng	Adv_Eng	Basic_Cs	Adv_Cs	Posgrade
P1	-1.1062	-2.789	-2.957	-0.9381	-3.06
P2	-0.9878	-0.194	9.58	-0.187	9.51
P3	10.896	10.361	10.46	9.41	8
P4	-1.3414	-1476	-1.7	-2.44	-1.66
P5	-1.15	-2.0354	-1.73	-4.41	-1.22
P6	19.565	19.458	16.64	17.47	17.956
P7	16.197	17.651	15.96	15.46	17.07
P8	11.677	12.168	10.91	12.5	11.11
P9	39.13	38.916	33.278	34.95	53.867
P10	14.92	14.94	13.563	15.6	12.889
P11	13.958	13.615	11.364	13.844	12.62
P12	-38.646	-39.124	-35.463	-39.5	-35.31

In Table IV, we present the results obtained after processing the opinion instruments showing the relative percentage of importance for each profile in each one of the 5 students' sector. Negative values are indicative of profiles with a negative impact on the students.

Of course, the agents do not know precisely neither what the most important profiles nor their importance is. Although, they intuitively recognize the importance of some profiles and they try to impact the voters through their political programs (strategies).

The strategies of each agent can be considered as a vector of 12-values, each value represents the intention of the candidate to influence the voters trough that corresponding profile. The weights constituting the strategies of the candidates were computed based on; the curriculum vitae, the proposals, the political group supporting the candidates, and in this particular case, in the knowledge and perception that the authors have about the candidates.

For any other electoral contest, opinion polls could be designed to calculate the corresponding weights in order to form the agents' strategies. Each agent applies one of his strategies creating a state e of the multi-agent system. The agents change their strategies at the moment and in accordance to the opinion polls that they know.

In Table V and VI we present some of the strategies used by the agents. At the beginning, we considered three agents competing for the position (see Table V). Later on, only two agents were considered, and we also recognize that the strategies applied to the bachelor sectors were different to those used for the postgraduate sector.

We analyze the percentages of the votes assigned to each candidate in accordance to the main changes in their strategies. The formulas (1) and (2) allow us to compute the number of votes for each agent, and in fact, is a way to simulate the outcomes obtained by the agents.

In Figure 1, we show three moments of the change of strategies just for one of the competing agents; at the beginning, in the middle and the final period of the political campaign. We also show the real percentages obtained for the selected agent in order to compare it with the estimations previously made.

TABLE V
INITIAL STRATEGIES' AGENTS

Profile	Director	Opponent_1	Opponent_2
P1	8	6	4
P2	6	5	4
P3	8	6	3
P4	5	5	2
P5	7	5	2
P6	10	5	5
P7	8	4	8
P8	8	8	3
P9	0	0	0
P10	8	5	5
P11	8	5	5
P12	10	-3	-5

The curve labeled as 'Initial_Vote_Estimate' represents the estimation of the percentage of votes obtained for A_1 con-

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sidering three competing agents. While the other two curves represent the estimation of the percentages of votes obtained for A_1 considering just two competing agents, which was the real number of competing candidates in this election.

TABLE VI
FINAL STRATEGIES' AGENTS

Profile	Dir_Bachelor	Dir_Post	Opp_Bachelor	Opp_Post
P1	9.5	5	5	8
P2	8	9.5	5	4
P3	7	9	8	5
P4	8.5	8.5	5	5
P5	6	6	3	3
P6	7	7	4	4
P7	8	8	5	5
P8	8	8	6.8	6.8
P9	6	9	8.5	5.5
P10	7	7	7	7
P11	8	8	6	6
P12	10	10	1	1

Comparing the estimated results at the end of the campaign versus the real percentages of votes, the absolute errors on the percentages of the votes obtained for the candidate labeled as *Opposite*, 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 Postgrade sectors, respectively.

If we want to model elections at the scale of, for example, governor of a city, the key point in our proposal is the partition of the voters into sectors with common and recognized necessities (profiles). That implies that we do not only have to know the sizes of the sectors, but we also have to analyze the political and economical historical behavior of those sectors. The demoscopic studies can be helpful for recognizing the profiles and their relative importance among them. Of course, this imply a bigger effort than just to apply the common opinion polls for analyzing political preferences. However, predictions more precise request deeper studies. And our model is a guide for how can be done those studies.

VI. CONCLUSION AND FUTURE WORK

We have designed a multi-agent system that simulates the process of selecting a representative in a democratic system organized by sectors. In our proposal, we assume that each prospectus determines a finite set of strategies (political programs). Each one of these strategies is constituted by a set of weights on the profiles characterizing the voters.

Our system can be used to study the tendencies of the vote and for this, it's necessary to determine the relevant profiles that characterize the political behavior of the voters. Those profiles model how the voters, in a specific election organized by sectors, make their political decision.

The profiles used for characterizing the voters, and for forming the strategies of the agents, have a limited nature. Consequently, a congestion network is built. Working with congestion networks allows us to apply a search for the singular points in the competition system, enabling us to predict which agent is expected to win the electoral contest and also, what was his winning strategy.

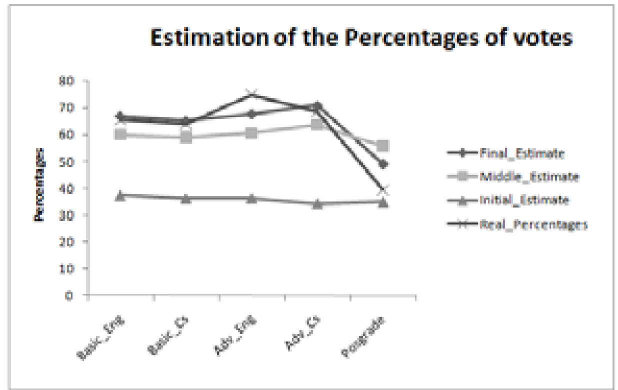

Fig. 1. Percentages of votes estimated and obtained for one of the candidates

We have applied our model to simulate the elections of the principal in the FCC - BUAP University, obtaining estimations very close to the real outcomes. Future works could come from the application of our model in other electoral contests, and specially, to scale our method at the level of cities' and countries' elections.

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