STUDENT DASHBOARD FOR A MULTI-AGENT APPROACH FOR ACADEMIC ADVISING

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Abstract

The objective of this research is to demonstrate the performance of a new mechanism to improve the advising of students in a nontraditional college environment, specifically the University of Texas at El Paso (UTEP). Minority serving institutions, commuter campuses and institutions with a high percentage of student transfers are unable to keep a tightly controlled cohort of students progressing through the curriculum. Students usually have varied course loads and different priorities due to family, financial needs or other responsibilities. Therefore, there is a need for an individualized approach to advising. The school's administration faces challenges scheduling courses and allocating diminishing resources to satisfy student demand. In addition, faculty needs to assess the efficacy of their curriculum in a program, and collecting longitudinal student data is difficult.

A web application system (mobile compatible) using a multi-agent approach has been developed to allow the students (agents) to take more control over their individualized advising. In this context, the student tool becomes an agent, and the school provides the environment with a desirable behavior for the system. This research will identify the school's administrators as the academic control objective and will be referred to as the "Operator". This paper focuses on the agent system by building a dashboard tool that collects each individual student's information regarding their progress through the curriculum in a program, and then generates advising recommendations. The agent logic employs principles used in project management tools designed for resource of schedule optimization. The tool helps students optimize their resources to complete their degree sooner. It provides a visualization map of course sequences, customized for each student based on their history of courses completed and then making advising adjustments that will optimize the time to obtain the degree under a constrained set of resources. At the same time, the agent system provides real-time feedback to the department administration. The second tool is the department administration dashboard that consolidates the collected data from the students through several semesters (historical data) plus the predicted effects of the recommended plans. This enables a better resource allocation from the administration and deeper analysis of the curriculum effectiveness. Previous work has presented some limited insight into the multi-agent approach and the critical path methods. However, the proliferation of mobile devices and Cloud computing enables a larger scale application of the proposed methodology. The results acquired at this point show a very high acceptance of the system by the students. The complete dataset will be discussed extensively in the results section.

Introduction

Students' time to graduation in college is one of the most important metrics used to evaluate higher education institutions. This is a metric of performance used at a national level. Time to graduation is affected by many factors. Most of these factors are social, economic and planning in nature. There have been attempts to provide incentives to students to encourage them to graduate from college as quickly as possible in order to optimize the use of available resources [1]. When compared, some of these incentives have been more effective than others [2]. Some students take longer than expected to graduate with a 4-year undergraduate degree.

Specifically, at The University of Texas at El Paso (UTEP) students take longer than the national average [3] to graduate [4]. Some of the factors for this delay include: social setting (commuter campus), low-income student population, cohorts not as homogeneously defined as in a residential campus, under 15 credit enrollment, school/work overload, student's schedule planning, diminishing resources to universities and colleges, and the lack of available data to the students and the department administration. All of these characteristics make the advising process very time consuming and one that is not always tailored to the specific need of the student being advised, but a general one-fits-all process. In some cases the data is available but the amount of time needed to search for it makes it prohibitive to the department administration and/or student. Currently, there is a lack of a readily available and user-friendly system capable of implementing a systematic and repeatable process to analyze data in real time (to optimize resource allocation), and present it accordingly to students and the department administration. The current advising systems at UTEP are based on historical values only. The advising workflow that the department administration uses drives the advising process. Currently the advising process has the following characteristics: a top-down system, centralized, with one-way communication, manual monitoring, and a few customer choices. It is very similar to the early power grid before the smart grid [6]. Since the developed system is inspired by the smart grid the same terminology will be used in this paper. Specifically, in the smart grid the "operator" term is used to refer to the administration of the smart grid. In this study the term operator will refer to the department administrators. In the smart grid terminology, the term "agents" is used to refer to the independent user that uses the power grid. In this study it will refer to the students. Another characteristic of the current advising system is that it has partial information without real-time input from the agents as shown in Figure 1. Due to all of the previously mentioned characteristics, a large gap in communication leaves a lot of room for the optimization of this process.

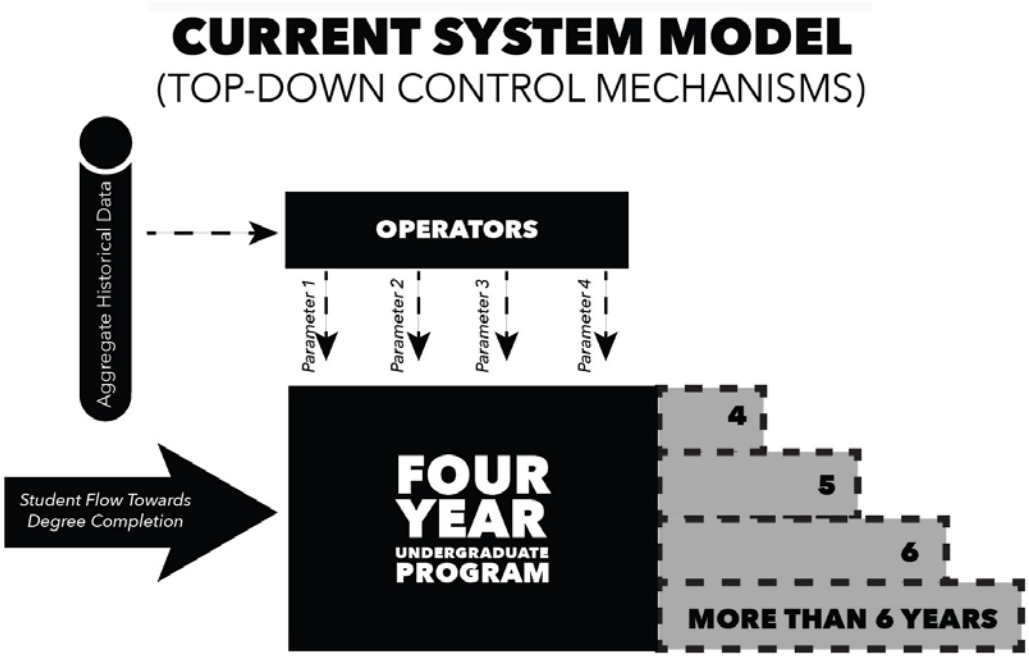

Figure 1. Current control system used for advising (Top-Down approach).

In order to optimize the advising process in the setting previously defined and keeping in mind a systems approach to this challenge, we are proposing the application of a multi-agent technique that will allow the students to take more control of their individualized advising. This proposed system is similar to the smart grid concept which was chosen due to the positive feedback from the implementation of such distributed control systems [5]. In this context, the student tool becomes an agent and the program administrators become operators that provide (with certain flexibility) the environment with a desirable behavior for the agents. The flexibility of the system allows the agents to choose a path to graduation optimizing the agents' resources. Similar to the Supervisory Control and Data Acquisition (SCADA) model, the operator would provide parameters to maximize the throughput of agents through the system (degree program). But it is up to the students to provide the proper parameters to the agent to finally choose the load (classes, work, and other activities) that they can handle to make an optimal resource allocation decision. The designed Multi-agent control system provides instant feedback to the agent detailing the most probable outcomes based on the agent selection of classes in combination with common workloads ranging from one hour to forty-hour workweeks.

The smart grid works based on incentives. Similarly, the operator can provide incentives based on the dashboard information coming from the aggregate data of the agents. This approach creates an elastic system, as opposed to a top-down deterministic system. Using the concept of distributed control in real time, the dashboard updates using the agent's feedback in real time. Having this information channel available, as shown in Figure 2, enables the operators to do near real-time resource assignment. For example, if the operator sees on the dashboard that 60 students are planning to take the Electric Circuits 1 class (Code name for the Electric Circuits 1 class is EE2350) and there is currently only one section scheduled of EE2350 with 30 available seats, then the operator can then make the decision to move another instructor to open another section of EE2350 where it will have a greater impact of moving more agents through the system to graduate faster. Another possible solution that the operator can provide is to move the EE2350 class to a larger classroom that will fit the 60 students. This creates an optimization of available resources taking into consideration the agents' available resources at that point in time (semester class schedule, time available, money, etc.). The proposed system will simulate a Multi-Agent Control System implemented on an educational setting and potentially this control system can change agent behavior and positively impact degree progression and subsequently graduation rates. A longitudinal analysis is starting at this point to analyze the degree progression of agents starting to use the system.

In this proposed model the operators and agents receive real-time data from the agents' choice of schedule and using that information plus historical data from previous semesters they can incentivize the system by accelerating the flow of agents through the system. Agents provide real-time data input to the systems and the operator sees this data. Using this system, the agents obtain access to general historical data in real-time to help plan the load for the short and long term. This historical data is presented to the agent in a user-friendly way. In the current environment agents usually do not look at this historical data to plan their graduation path.

Materials, Methods and Implementation

This research specifically focuses on the impact of the "Multi-Agent control system applied to a social setting". This pilot has been focusing on the Electrical Engineering department student body that represents university demographics, accordingly [7]. This research has measured students' perceived value of using this system and the results of the perceived value can be seen in Table 1 in the Results section. These results are discussed in

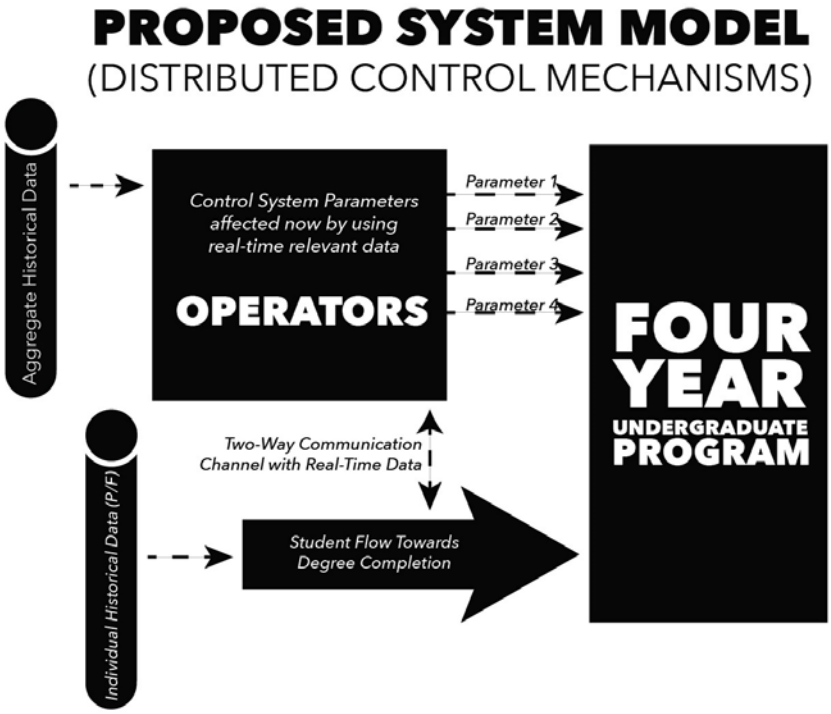

Figure 2. Proposed Distributed Control System.

the Discussion section. In the implementation phase, students were instructed to start using the system before meeting with their advisors. Given the demographics of the population, content, and subject matter involved, this type of study has not been previously done. This research provides important information for the engineering and engineering education fields due to the demographics projected by the US Census bureau [10]. Based on the effectiveness of this system, it could be added to the engineering institution toolbox to increase STEM success in higher education institutions and later be implemented to other colleges.

The methodology leading to the development of this system started with the analysis and mapping of the systems (degree plan and advising process) currently in place. Mapping the required flow of agents in the current degree plan provided a critical path to a degree plan. For this analysis the critical path was mapped for the classes required to graduate with a BSEE degree. The next step was to create the mathematical model to simulate the iterative nature of the system. The mathematical model is equivalent to a discrete Finite Impulse Response filter (FIR), as shown in Figure 3.

The BSEE degree plan is being used as a pilot to measure the effectiveness of the distributed Complex Discrete Data Control System. The BSEE degree plan is shown below in Figure 4. This research started in the summer of 2014 and we are continuing to build the infrastructure required for its support. In Phase 1 of the implementation, a modified shell for the school's Learning Management System (LMS) was acting as the agent and operator dashboard. This student view (agent) is shown in Figure 5 where the student gets access to the forms and other resources for advising before the advising appointment.

The students had to complete several forms only once. The most important form used to discover the students' progression towards their graduation was a degree checklist in MS-Excel (Figure 6). Students uploaded all documents into the LMS system. The MS-Excel file had several complex algorithms shown as a form within the file that validated the student's progress. This is shown in Figure 7. This excel form notified the students of their eligibility for future courses using a color-coded diagram. This color-coded system indicated prerequisites

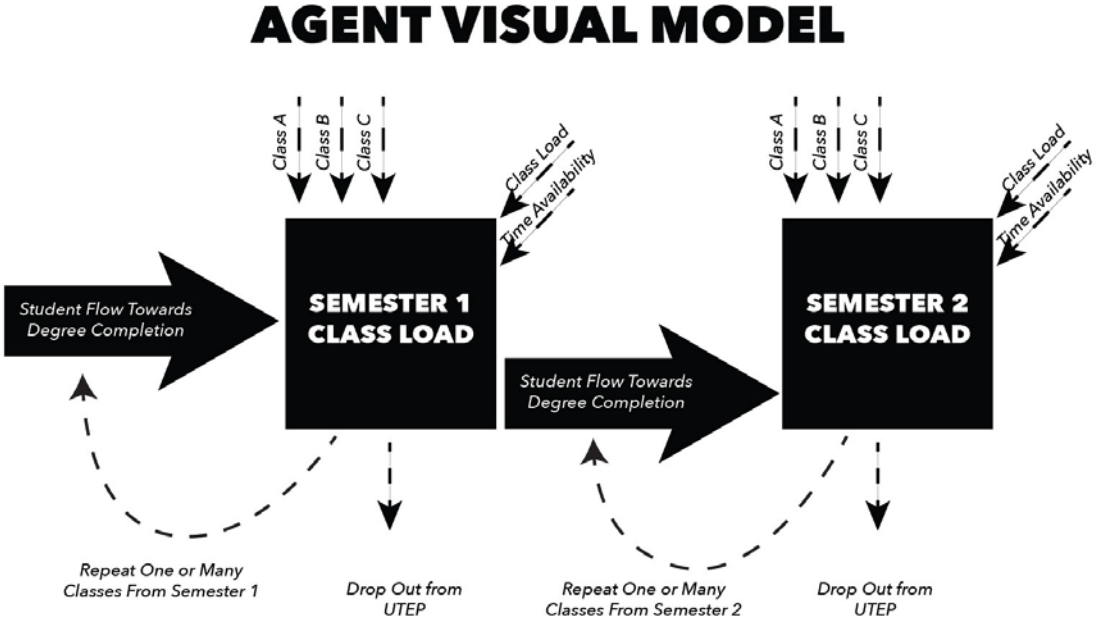

Figure 3. Agent Visual flow model (FIR model).

ELECTRICAL AND COMPUTER ENGINEERING

2013-2014

	Math Placement in Calculus:				English Placement in ENGL 1311:			Total credits per Semester
LOWER DIVISION	MATH1411* Calc 1	EE1305* Intro EE	EE1105* EE1305 lab		PHYS2420* Intro Mech	ENGL1311* Engl Cmp	Choose UNV	18
	MATH1312* Calc 2	EE2369* Dig. Sys 1	EE2169* EE2369 Lab		PHYS2421* Fld & Wave	ENGL1312* Crit Wrtg	HIST1301* US Hist 1	17
	MATH2326* Diff Eq.	EE2350* Circuit 1	EE2372* Soft Dsgn 1		CHEM1305* Chem 1	COMM1302* Bsn Comm		15
	MATH2313* Calc 3	EE2351* Circuit 2	EE2151* EE2351 Lab	EE2353* C.T. Signal		Choose ART	HIST1302* US Hist 2	16
UPPER DIVISION	MATH3323* Matrx Algb	EE3338* Electron 1	EE3138* EE3338 Lab	EE3353* D.T. Signal	EE3325* Ap Quantum	EE3321* EMF		16
	EE3384* Probablty	EE3340* Electron 2	EE3376* Micro 1	EE3176* EE3376 Lab	EE3195* J.P.O.	EE3329* Elec. Dev	Choose HMN	17
		EE4220* S. Proj 1	EE41xx Lab	EExxxx Elective	EExxxx Elective	CE2326* Econ Sci Engr	POLS2310* Int Pol	15
		EE4230 S. Proj 2	TECH Tech Elec	EExxxx Elective	EExxxx Elective		POLS2311* Am Gov	14
							TOTAL cr =	128

Figure 4. Electrical and Computer Engineering degree plan.

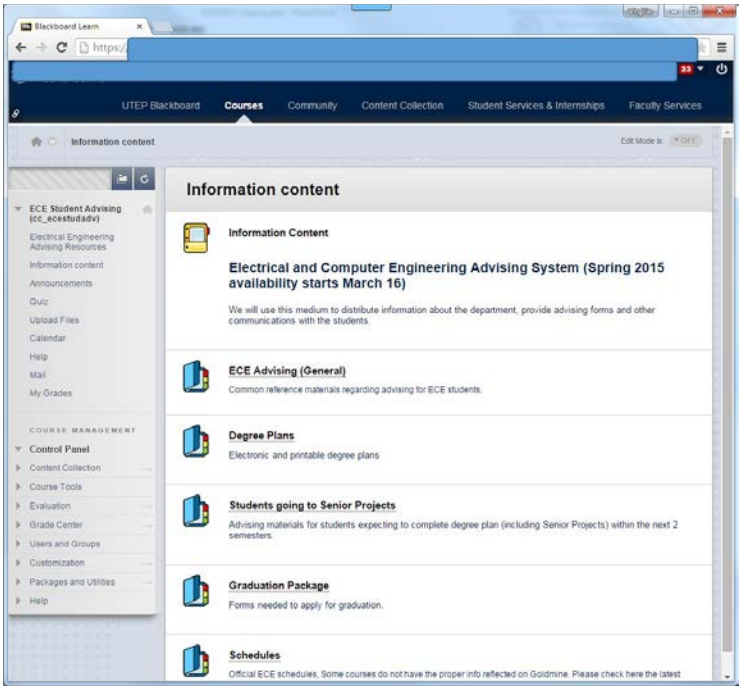

Figure 5. Student LMS used as prototype dashboard on Phase 1 of the pilot.

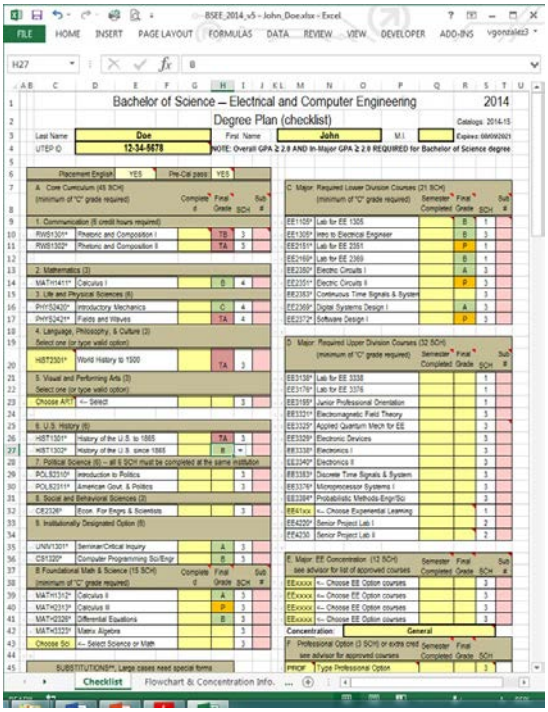

Figure 6. Student capture form.

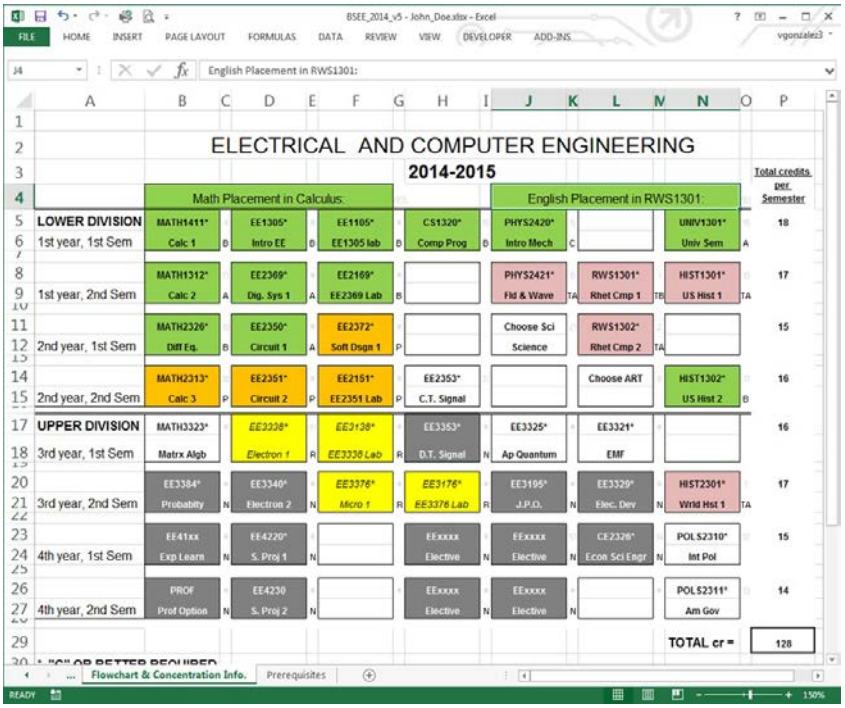

Figure 7. Eligible courses for student.

and co-requisites. It also had the option to provide more details to the students regarding reasons for ineligibility to enroll in other courses, such as co-requisites or pre-requisites. In the new phase of the pilot implementation the agents had access to the web-based platform iAdvise. This web platform could be opened from any mobile device making it an agnostic platform. The agents then filled the online forms using their mobile device or computer as shown in Figure 8. The complex algorithms from the excel file were applied and the functionality of

these algorithms was extended to allow for the processing of more data such as expected graduation date based on the number of credits passed and expected registrations remaining. Figure 9 shows the student's progress along with the classes in which he/she can enroll based on classes already taken. Another addition to the online platform was the load calculator in which the student was able to get feedback on historical data on passing rates to help the agent determine the load of classes to be taken the next semester.

During Phase 1 of the pilot, the operator or advisor view consisted of access to the same reports in the LMS system and the MS-Excel forms plus an existing data analytics tool, as shown in Figure 10. The risk assessment tool, currently being used by the school, only provides a "risk" level assessment based exclusively on historical data and does not make any recommendations. Using the iAdvise platform, the student was able to obtain the passing rate of students that have taken those classes during the last 5 years. Using this information, the student was able to plan a balanced number of classes to prevent an overload that could result in a low grade.

Being developed for this research is the infrastructure needed to integrate mobile and online environments (iAdvise). These environments (app/online) allow for the search of historical data and provide real-time feedback to the agent in a user-friendly manner. The design and implementation of a database with several tables is designed as the back end of the system. A critical part of the design is the algorithm needed to calculate the load of the agents. This critical path was analyzed using several total quality management (TQM) techniques [7]. Some of these techniques take into account organizational and cultural changes [8]. In this research we used the results from Microsoft Project. Several templates were created using this management tool. These templates represented the Electrical Engineering degree plan shown in Figure 11 [13]. Resources were then allocated representing the number of credits that a student can take and requirements for each class. An example of these templates is shown in Figure 12 where a load balancing function was used to level the workload to 12 credits for a student that already had committed 20 hours per week. This algorithm takes into account the following parameters: agents' class schedule, workload, and class difficulty based on historical data of pass/fail rates. Another important aspect of the algorithm is that it takes into account the "60 Hours Rule" developed by Dr. Mulinazzi [9]. This rule assumes that a person can be productive for 60 hours a week for the length of a semester. This parameter provides a great reference due to the nature of the demographics of this campus.

The operators are benefiting from this system by having access to real-time data. A dashboard has been developed for the operator that shows the number of agents planning to take each class of the curriculum. This will optimize the way the operator distributes the resources of the department to maximize the flow of agents through the system. With this data readily available to the operator, the system's bottlenecks are clearly shown and at the same time a prediction for future demand for the course is realized based on current system saturation levels. The operator is able to quickly see underutilized areas of the system without having to dig for hours looking for that important data. This is a system of systems with an iterative nature. As more iterations are available it will be able to statistically predict a long-term agent data flow with more accuracy.

In this first iteration of the system, data has been gathered, and results on the following fronts are shown in the results sections:

- Initial results on agent performance in iteration 1 (Quantitative Survey on the results of how fast the agents perceive to be moving through the system).
- Agent perception of the system (Qualitative Survey) and Operator perception of the system.

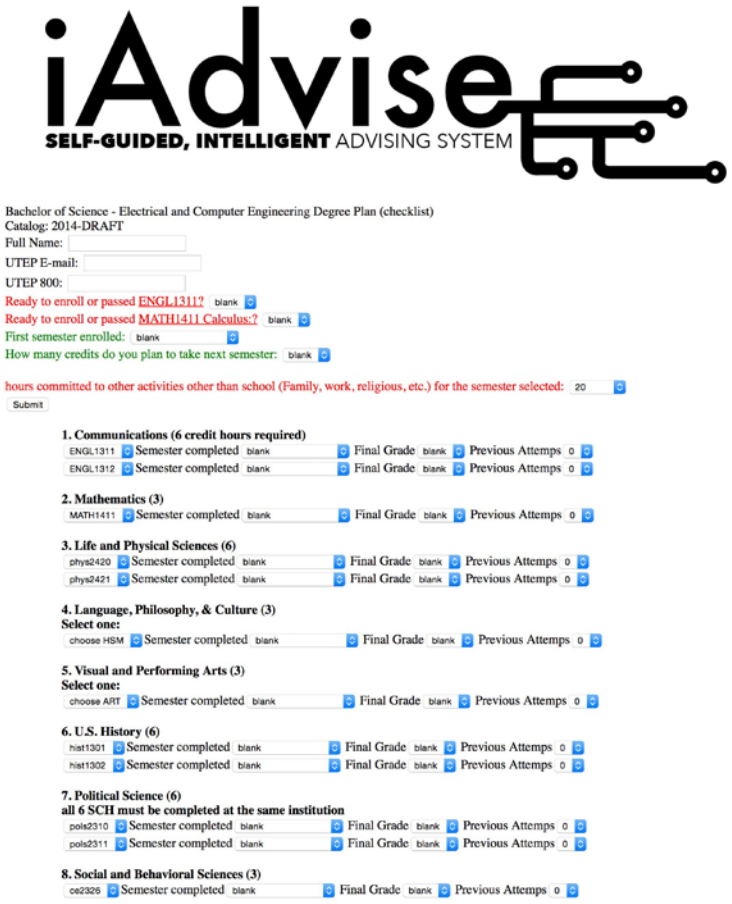

Figure 8. iAdvise system form for advising.

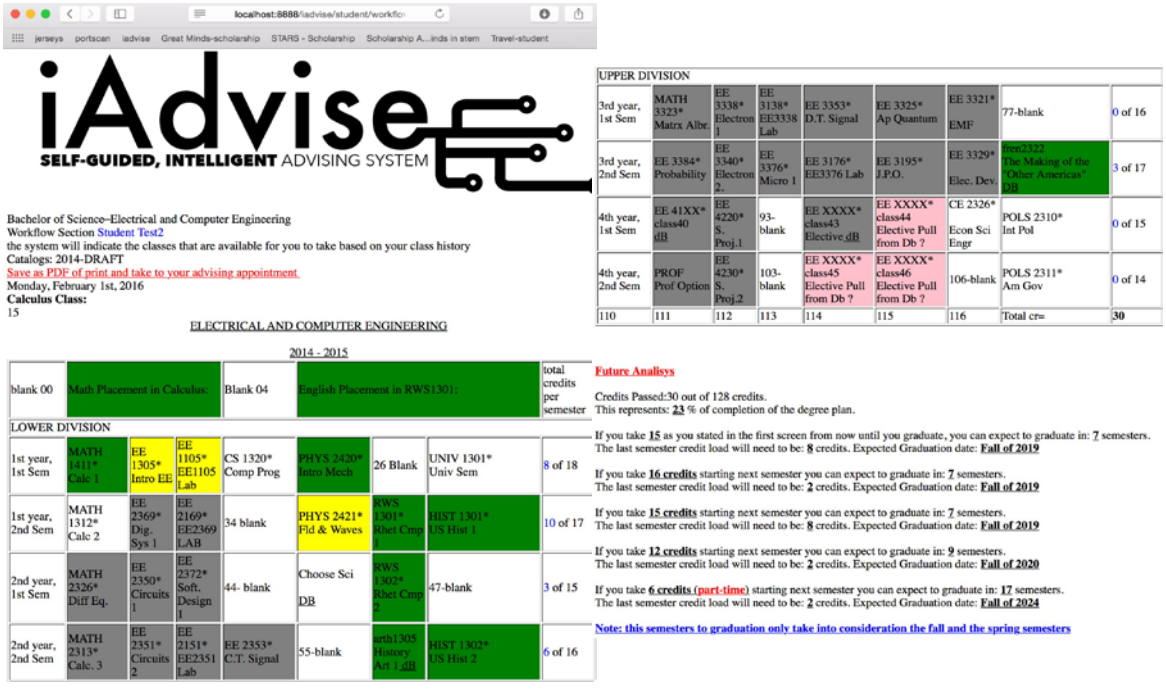

Figure 9. iAdvise system providing real-time feedback to the student on available to enroll classes and expected graduation date based on input to the system.

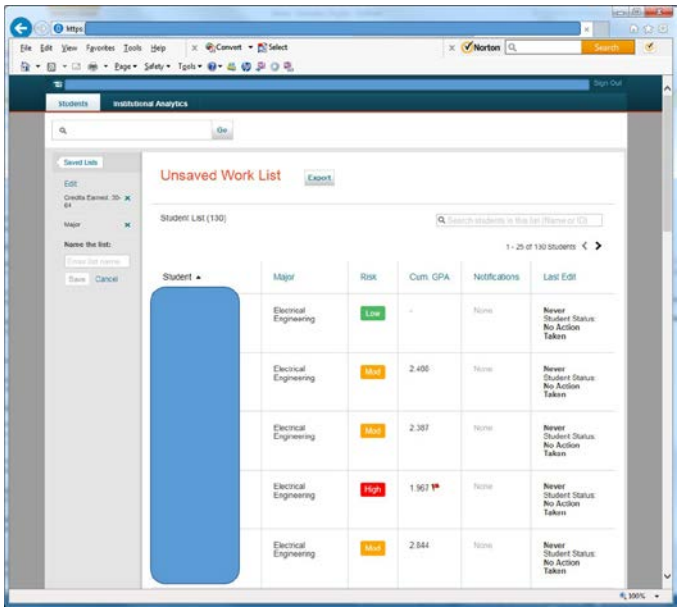

Figure 10. Advisor existing dashboard based on historical data used during Phase 1 of the pilot.

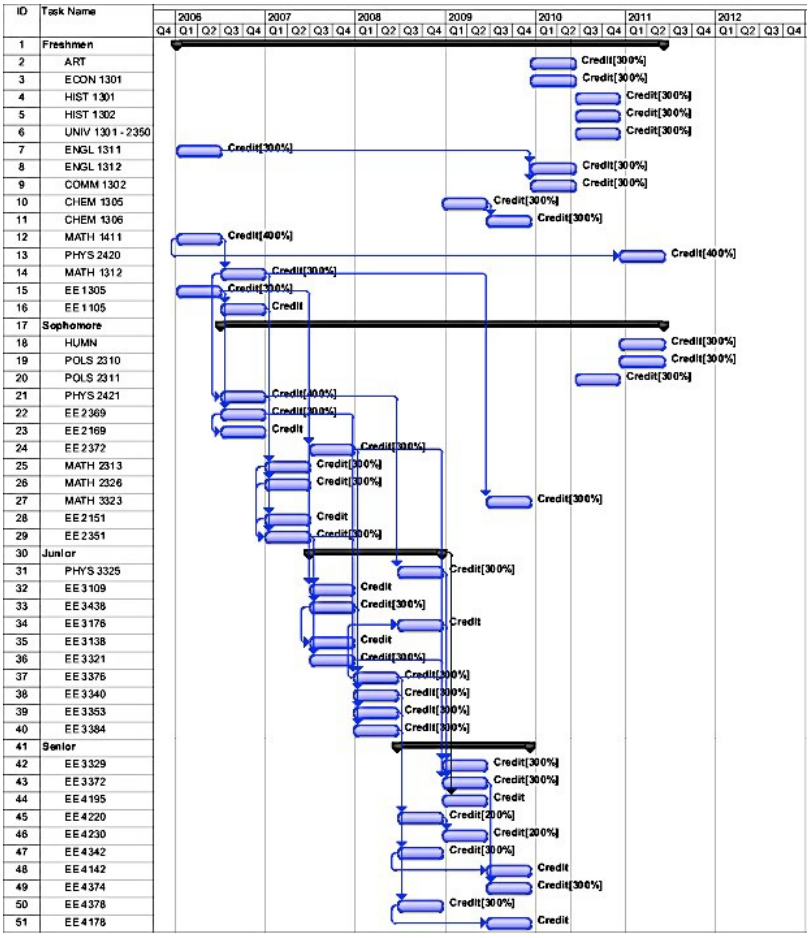

Figure 11. Screen view of Gantt chart of course sequence.

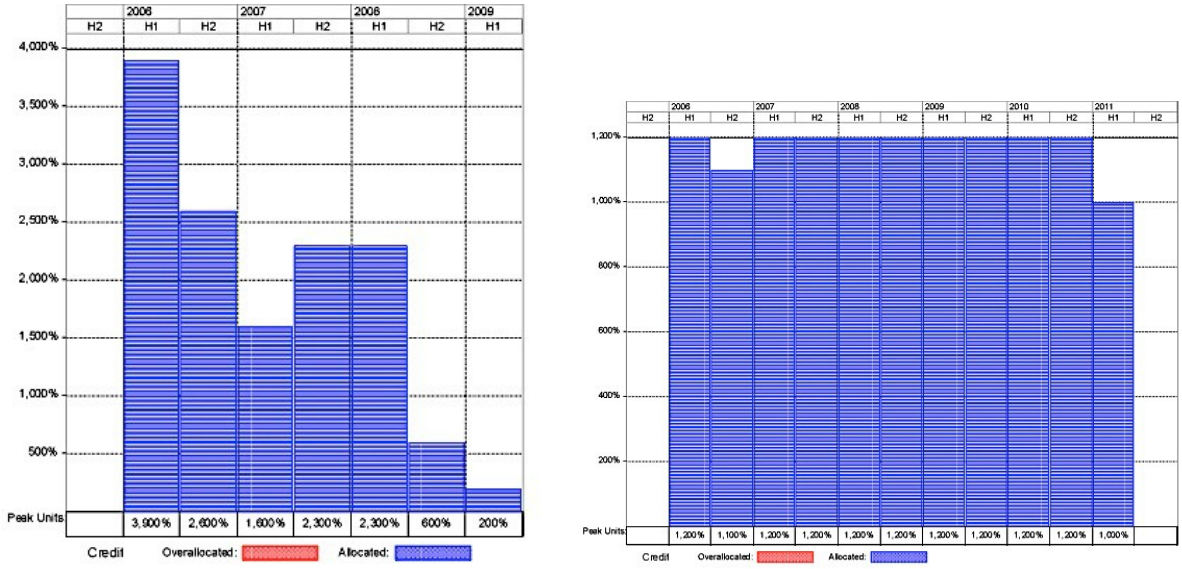

Figure 12. Credits unrestricted and credits leveled respectively.

Research focus on impact of iAdvise on agent's flow through the system

The main focus of this research is on the speed of progression towards a degree for the agents. Most of the benefits of the Multi-agent control system in the short term have already been listed. However, one very important benefit is how this system affects graduation rates. The speed at which an agent goes through the system is directly related to the graduation rate. As more and more agents go through the system's optimally available resources, the shorter the time needed to complete a degree. In order for this experiment to be done, a longitudinal analysis needs to be done. This longitudinal analysis began this Spring 2015 with the first iteration of students using the iAdvise platform. Results from this first semester usage is shown at the end of the results section.

Research focuses on student perceived value

Another focus of this research is the students' perceived value of a tool like this. Experiments were conducted to analyze student perceived value of the system. The first of these survey instruments was given to a group of 107 students. Furthermore, for this experiment, a post-attitudinal survey was given to all of the agents using the system after they have used it. This survey was conducted by an independent entity not related to the development team.

Results and Assessment

Results of this study are in an early stage. At this point the results of this system are in an early stage, after a semester of results. However, after the design of the model and using a first implementation on the LMS website and the automated forms, a positive response from agents and operators (students and department administrators) has been obtained. For example, there are fewer cases of students enrolling in courses where they lack the proper prerequisites due to errors.

During Phase I of the implementation, one important benefit surfaced. Using the LMS allowed the department to reallocate resources due to the load reduction on the advisors. The EE department used to have 3 full-time employees devoted to student advising. After the first part of the implementation concluded, only one advisor and two part-time student advisors (MS students acting as undergraduate advisors) were needed. The number of students advised per semester increased using this system. Previously 160 students were advised

per semester (Fall 2013). During Fall 2014 the number of advised students increased to 240. Using the current data from this first implementation plus historical data that is available, a benchmark was created before the distributed Complex Discrete Data Control System was implemented.

The results of the pre-attitudinal survey follow (N=107). This survey consisted of 6 questions, one was a Likert type, and two were a multiple choice, two were yes or no and a final open ended question. Table 1 shows the results of question 1.

Question 1: "Please number your ideal advising system from 1 to 4 (**1 being the most preferred** and 4 the least preferred).

A. _____ Face to face by appointment
B. _____ Online system that is mobile compatible
C. _____ An application that you install on a desktop computer
D. _____Other

System Type	Most Prefered	Prefered	not prefered	Least Prefered
Face to Face	78	16	8	5
Mobile	21	54	28	1
Desktop	10	29	48	16
Other	1	6	10	59

Table 1. Results from question 1.

Question 2: "What type of advising would you prefer?

a) I would like a manual system where I make an appointment and go to an advisor to get help with the pre-requisites and co-requisites of the classes that I plan to take.
b) I would like an electronic system that is running 24/7 and helps me with the pre-requisites and co-requisites of the classes that I am planning to take as well as provides additional information such as success rates of the classes I plan to take to help with the load balancing.
c) Other:_____ explain:_____ "

What type of advising would you prefer?				
	Face to face with advisor	Electronic system that is running 24/7	Other	Total
Students	61	46	0	107
Percentage	57%	43%	0%	100%

Table 2. Shows the results of the answers received for question 2.

After grouping the answers from questions 1 into two groups: "at least preferred" and "not preferred", resulting percentages are shown in Figure 13.

Question 3: "Would you like to have information about previous students' success rates for the classes that you plan to take the next semester to balance your load?

a) Yes
b) No

Would you like to have information about previous students success rates of the classes that you plan to take the next semester to balance your load?			
	Yes	No	Total
Students	103	4	107
Percentage	96.30%	3.70%	100.00%

Table 3. Shows the results of the answers received for question 3.

Question 4: "Would you like to know what is the recommended class load as you add classes to your schedule and combine that with a part time job?

a. Yes
b. No

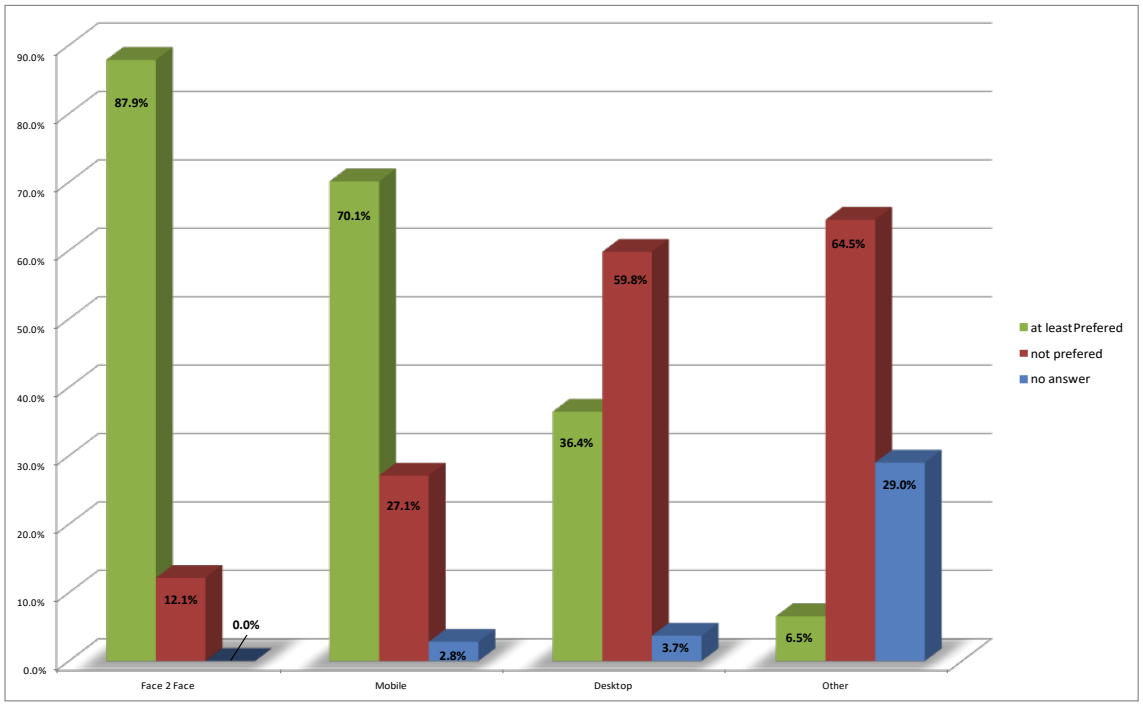

Figure 13. Percentage preference of different advising systems.

Would you like to know what is the recommended class load as you add classes to your schedule and combine that with a part time job?			
	Yes	No	Total
Students	105	2	107
Percentage	98%	2%	100%

Table 4. Shows the results of the answers received for question 4

Question 5: "What other commitments do you have every week (select all that apply)?

a) School Full-time _____ hrs/week
b) School Part-time
c) Work _____ hrs/week
d) Family commitments _____
e) Other commitments _____hrs/week

What other commitments do you have every week?					
	Student FT	Student PT	Work	Family	Other
Students	104	3	33	38	33
Percentage	97.20%	2.80%	30.80%	35.50%	30.80%

Table 5. Shows the results of answers for question 5

In addition to results shown in Table 5 reflecting what other commitments students have every week, an average of Work/Family/ Other commitments was calculated with results showing an average of 52.1 hours committed to activities per student. Table 6 displays the students' preference by grouping the answers from question one into two groups. These two groups being prefer and not prefer.

Advising System Type			
System Type	at least Preferred	not preferred	no answer
Face 2 Face	87.90%	12.10%	0.00%
Mobile	70.10%	27.10%	2.80%
Desktop	36.40%	59.80%	3.70%
Other	6.50%	64.50%	29.00%

Table 6. Students' preference grouped by preferred and not preferred from Table 1.

Post-iAdvise Usage Survey Results

Survey results from the students utilizing the system have been captured and are shown below. This last survey was designed to measure two aspects of the iAdvise system. The first aspect measured was if the system was reaching established goals and, if that was the case, how well it was performing at reaching those goals. In other words, was the system functional and what was the performance. The first question focuses on the agent choice of advising system. It is very important to consider the fact that agents have used both systems. This brings more relevance to the question because they are able to compare both systems. Table 7 shows the agents' responses to this question. As can be seen, use of iAdvise is overwhelmingly preferred over the current system. Statistics on the preference of usage of the iAdvise platform were collected during the Spring 2016 advising season and are shown below.

1. Which would you prefer to use to see classes that you would like to enroll in?		
The iAdvise System	49	92%
The Excel file form	4	8%

Table 7. Results from post development question 1 Spring 2016.

According to the literature review, one of the main causes of extended time to graduation is flawed schedules created by students. Not choosing the right course is one of the worst scenarios since it creates a non-optimal usage of time and money. Question 2 directly asks students about the ability of iAdvise to prevent them from enrolling in courses that do not count towards their degree. Table 8 clearly indicates that the vast majority of the agents agree on the positive impact that using iAdvise has in preventing them from making less than optimal course choices

2. Do you believe a system like iAdvise can prevent you from enrolling in classes that do not count towards your degree?		
Yes	49	92%
No	4	8%

Table 8. Results from post development question 2 Spring 2016.

Question 3 of the post iAdvise usage survey focuses on ease of access to information. Due to inaccessibility, information that could be gathered by the agent is seldom sought out. Even if the agents understand the notion of "the more credits that I enroll in and pass the faster I graduate", it is not often that agents actually take the time to calculate their time to graduation. According to Landis, an expert in the field of engineering education, the more time and effort a student devotes to planning their career (setting up time milestones), the more successful they will be. The iAdvise Multi-agent control system provides the agent with the tools to make that planning easy and readily available even by using their mobile phone. It can be seen from the results that 85% of the agents agree with the statement that the iAdvise control system provides them with expected graduation dates as shown in Table 9. This question provides a positive answer to the second research question "Does the Multi-Agent control system provide the agents with more control over their advising process?" Preventing the agents from enrolling in courses that are not needed empowers them by providing information when it is needed.

3. After using the iAdvise system do you have an idea of your expected graduation date?		
Yes	45	85%
No	8	15%

Table 9. Results from post development question 3 Spring 2016.

Knowledge of the expected graduation date is a powerful piece of information. In designing the survey instrument, it was decided that it was important to include question 4 as a follow-up to question 3. The purpose was to investigate if the agents would be motivated by discovering their expected graduation date according to their course enrollment and specific to their curriculum progression at the time of using the iAdvise system. As expected, agents reacted positively to the discovery of their expected graduation date. What was unexpected from the results was the positive bias that was discovered with an acceptance of 87% as displayed in table 10.

4. Does seeing your expected graduation date motivate you?		
Yes	46	87%
No	7	13%

Table 10. Results from post development question 4 Spring 2016.

The results from question 5 addresses the important relationship between courses enrolled in and graduation date. The iAdvise system provides information regarding different scenarios using past course history plus agent specified credits to be enrolled in. The system tries to make the agent aware of the different outcomes for graduation dates. From the response of the agents it is clear that the iAdvise Multi-agent control system is functional with a high performance in this category. The goal of informing the agents of this relationship was accomplished at 98%.

5. After using the iAdvise system do you see the actual impact of the relationship between credits enrolled per semester and your graduation		
Yes	52	98%
No	1	2%

Table 11. Results from post development question 5 Spring 2016.

Question 6 was designed to measure the ability of the iAdvise system to provide information to the agent in regards to load balancing. The iAdvise algorithm is based on the measurement of devoted time to three areas: academics, work and family. From the results shown in Table 12 it can be seen that according to the agents' responses to the survey, 87% of them can better plan their semester load in conjunction with their academic commitments. This question is of high importance since the results back up the positive answer to the second research question "Does the Multi-Agent control system provide the agents with more control over their advising process?"

6. After using the iAdvise system can you better plan your semester class load in conjunction with your outside school commitments (work and/or family) based on your available time?		
Yes	46	87%
No	7	13%

Table 12. Results from post development question 6 Spring 2016.

Question 7 focused on agents' recent experience and how that translates to long-term accomplishment based on the usage of the iAdvise system. This question measured the agents' trust in the system to provide support in accomplishing the agents' goal of on-time graduation. The results from the survey can be seen in Table 13. These results show that 92% of the agents agree with the positive effect of using the iAdvise Multi-agent control system.

This is an outstanding acceptance rate for this category.

7. If you keep using the iAdvise system semester after semester, do you think you can graduate on time (4.5 years)?		
Yes	49	92%
No	4	8%

Table 13. Results from post development question 7 Spring 2016.

Question eight focused on the ease of use of the iAdvise Multi-agent control system. The agents have previously used both systems and can compare them and provide their assessment of both systems using as criteria "ease of use". In table 14 the results show that agents find the iAdvise system an easier to use advising tool when compared to the generation 2, the Excel file method. This question directly relates to our research question "Can a Multi-agent control system be applied to an advising system?" After analyzing the results, the answer has to be yes due to the answer in question eight in which agents not only compare it to the present system, but agents actually prefer the iAdvise Multi-agent control system.

8. Which system would you say is easier to use?		
The iAdvise System	44	83%
The Excel file form	9	17%

Table 14. Results from post development question 8 Spring 2016.

Question nine focuses on the performance of the iAdvise Multi-agent control system in comparison to the current second generation advising system. One of the final results of the advising system is to be able to fill out the advising form and submit it for registration. The results of this analysis are shown in table 15. These results provide a great insight relating performance of the iAdvise system in comparison to the second generation system. While the second generation advising process does this manual process, the iAdvise system provides the form ready to be printed or saved as a PDF for the agent. The iAdvise system facilitates the process for the advisor by pointing out the classes that need to be validated in order for the advisor to sign the advising form. Agents agree 94% to 6% in this study that the iAdvise Multi- agent control system is faster than the current system.

9. Does the iAdvise system help you complete the "Academic Advising Form" faster and easier than the previously stablished process by your EE		
Yes	50	94%
No	3	6%

Table 15. Results from post development question 9 Spring 2016.

Another performance question is question ten. This question focuses on the comparison to the current second generation advising system and the iAdvise Multi-agent control system in the area of class interdependencies and how fast the agents can obtain the answers. The second generation system is semi-automatic and, as mentioned before, it requires a desktop computer with MS Excel installed in order for the macro functions to run. The iAdvise Multi-agent control system is an agnostic web-based, mobile-friendly system that does not require specialized software. The results in Table 16 show a clear 94% preference of the iAdvise Multi- agent system over the second generation advising process. Once more these results back up the positive answer to the research question "Does the Multi-Agent control system provide the agents with more control over their advising process?" By providing a faster way to perform a task the system is inviting the agent to take more control of their advising process.

10. Does the iAdvise system help you check class pre@requisites and co@ requisites faster than with previous methods? (the previous method was using the Excel File editing of "BSEE_2014_v5.xlsx" or the degree plan)?		
Yes	50	94%
No	3	6%

Table 16. Results from post development question 10 Spring 2016.

Q11. What do you think of the iAdvise system?

Most common adjectives of the system were: faster, good, better

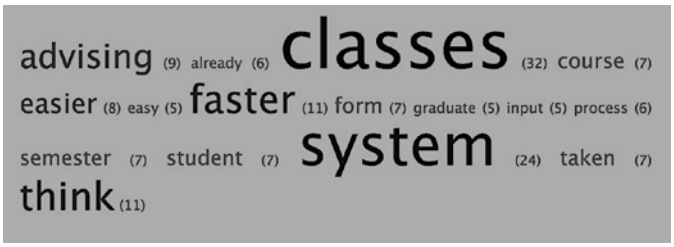

Figure 14. Shows a tag cloud with the most common words from question 11.

Question 12. What other features would you add to the iAdvise system?

Some of the comments suggested that the iAdvise Multi-agent control system could use more graphics to make it even more appealing to the agents. The automatic check of transcripts was another common suggestion. Finally, it was suggested to develop a link to the UTEP Banner database and the iAdvise database to be able to automatically provide Class Reference Numbers (CRN) numbers and specific class times.

Discussion

At this point the research of the Multi-Agent Control System with the application of social modeling has begun and every day more results are becoming available after the first iteration of the online system went live Spring 2015. After analyzing results of the attitudinal surveys for the past 5 years it can clearly be seen that the students' perception of technology and learning change in a positive direction after the proper usage of advanced technology by students [12]. This multi agent control system provides an option to traditional advising methods by providing a custom advising solution taking into consideration external factors affecting the students' life. Moreover the Multi Agent Control System is on a platform that is very popular (mobile app) among college students making it very appealing to them.

From the results of the survey questions shown above in the different tables, it can be seen that the student preference is to have a face-to-face system with an approval rate of 87% among the students. The second preference is to have a mobile application for advising with an approval rate of 70.1%. These results provide evidence for student approval of the iAdvise system. Another interesting result is the fact that, on average, the students surveyed have 52.1 hours per week committed to school and other activities. This makes an excellent case for the need for the iAdvise system that can be accessed 24/7 for advising without the need for the students to spend time scheduling a meeting for advising in addition to the length of the advising meeting itself. Even in the event that an appointment with an advisor is needed, the length of this appointment is potentially reduced.

Conclusion

At this point more and more student data is becoming available since the Multi-Agent Control System is acquiring information from the students. The first cycle of the data collection has begun this Spring 2016. Based on the data acquired from previous years on the partial automation of the advising process, it is clear that the next logical step is to combine the information from the different sources and display them in a more user friendly manner as the iAdvise system is doing it right now. The operators of the system have now a dashboard and they are using it. As for the agents, this

proposed Multi agent distributed control system is doing the streamlining of the advising process. At this point the question of "Can a Multi-agent distributed control system be used as an advising system?" can be answered with a clear yes based on the results from the surveys, agents, and operators. Furthermore, the answer to the first secondary question: "Can an advising system modeled after a Multi-agent distributed control system provide more control to the agents over their individualized advising?" The answer again based on the functional results and the qualitative results is YES. The Multi-agent distributed control system provides more information to the agent empowering them to use this new information to better manage their flow across the system. Lastly the answer to the second secondary question "Can an advising system modeled after a Multi-agent distributed control system improve the operator visibility over the advising system?" The answer based on the functional results is YES due to the fact that the Multi-agent control provides more visibility by showing the intended enrollment for the next semester, bottleneck information based on previous class attempts, and total level enrollment. The Multi agent control system, iAdvise provides an option to traditional advising methods by providing a customized advising solution tailored to each student and taking into consideration external factors affecting the students' life. Moreover, the Multi agent control system is on a platform that is very popular (mobile app) among college students making it very appealing to them. Most importantly, based on all of the post usage survey results, the iAdvise system proves that a Multi agent distributed control system provides a new way to optimize human and infrastructure resources. The optimization of these resources maximize the flow of agents across the educational system and minimize time losses in an educational setting.

Future Work

At this point in time, after examining student data in the system, we can see that the system could be expanded by adding modules to increase the accuracy of the system predictions. A couple of the features of this Multi-Agent Control System that can be added in the future to increase the accuracy of the system are the correlation of prerequisites to forecasting future course Pass/Fail and the analysis of learning outcomes in each course to provide an agent preparedness factor to the algorithm. A longitudinal analysis should also be done as the students' preference may change in the future, making the iAdvise system more popular than face to face or the opposite.

References

1. Jacobsen, D. M., "Adoption patterns of faculty who integrate computer technology for teaching and learning in higher education," 1998 World Conference on Educational Multimedia and Hypermedia & World Conference on Educational Tele-communications.

2. R. Schroeder, et al., "TQM in Education: Changing the Culture of Schools" 1997; nsf.gov. http://www.nsf.gov/awardsearch/ showAward.do?AwardNumber=9712991. (accessed: 4/1/2015).

3. U.S. Department of Education National Center for Education Statistics, http://nces.ed.gov /fastfacts/display.asp?id=40, . (accessed: 4/1/2015).

4. Reeve Hamilton, "At UTEP, Success Is Not All About Graduation Rates", March 2, 2012, http://www. nytimes .com/2012/03/02/us/utep-calls-for-success-criteria-other- than-graduation rates.html?pagewanted=all&_r=0

5. Steve Bossart, Senior Energy Analyst, DOE "Smart Grids & Microgrids for Government & Military Symposium" October 24-25, 2013, Arlington, VA.

6. X. Fang, S. Misra, G. Xue, D. Yang. Smart grid – the new and improved power grid: a survey. IEEE

Communications Surveys Tutorials (2011).

7. B. Flores, "CAMPUS DIVERSITY FACTS",http://research.utep.edu/Default.aspx? tabid =44271, 1995-2007, (accessed 4/1/2015).

8. J.V. Koch, "TQM: Why is its impact in higher education so small?," *TQM Magazine*, vol. 15, no. 5, 2003, pp. 325.

9. R. Schroeder, et al., "TQM in Education: Changing the Culture of Schools " 1997; nsf.gov. http://www.nsf.gov/awardsearch/showAward.do?AwardNumber=9712991. Accessed: 24 May 2010.

10. Landis, Ray, "Studying Engineering: A Road Map to a Rewarding Career", 2nd Edition, Discovery Press, 2000.

11. Colby, Sandra L. and Jennifer M. Ortman, *Projections of the Size and Composition of the U.S. Population: 2014 to 2060*, Current Population Reports, P25-1143, U.S. Census Bureau, Washington, DC, 2014.

12. Perez, O. A., Gonzalez, V., Pitcher, M. T. & Golding, P. (2011).Work in progress: analysis of mobile technology impact on STEM based courses; specifically introduction to engineering in the era of the iPad. Paper presented at the 118th ASEE Annual Conference and Exposition, Vancouver, BC, Canada, June 26-29, 2011

13. Gonzalez V. and Esparza D. 2010. "Work in progress - advising tool to improve the time for graduation and the transfer of students from a community college to engineering school," Proc. 40th ASEE/IEEE Frontiers in Education, Washington, DC, pp. T3H- 1– T3H-2.

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