Work-in-Progress: Student Dashboard for a Multi-agent Approach for Academic Advising

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Mr. Oscar Perez received his B.S. and Masters in Electrical Engineering from the University of Texas at El Paso with a special focus on data communications. Awarded the Woody Everett award from the American Society for engineering education August 2011 for the research on the impact of mobile devices in the classroom. He is currently pursuing a PhD in Electrical and Computer Engineering. Mr. Perez has been teaching the Basic Engineering (BE) – BE 1301 course for over 7 years. Lead the design for the development of the new Basic Engineering course (now UNIV 1301) for engineering at UTEP: Engineering, Science and University Colleges. Developed over 5 new courses, including UTEP technology & society core curriculum classes specifically for incoming freshman with a STEM background. Mr. Perez was awarded the 2014 ”University of Texas at El Paso award for Outstanding Teaching”. Mr. Perez has eight years of professional experience working as an Electrical and Computer Engineer providing technical support to faculty and students utilizing UGLC classrooms and auditoriums. Mr. Perez is committed to the highest level of service to provide an exceptional experience to all of the UGLC guests. Mr. Perez strongly believes that by providing exceptional customer service that UGLC patrons will return to make use of the various services the university offers. Mr. Perez enjoys working on the professional development of the students' employees at the UGLC. He shares with his student employees his practical experience in using electrical engineering concepts and computer technologies to help in everyday real-world applications. Mr. Perez has worked with the UTeach program at UTEP since its creation to streamline the transition process for engineering students from local area high schools to college by equipping their teachers with teaching strategies and technologies each summer. Oscar enjoys teamwork, believes in education as a process for achieving life-long learning rather than as a purely academic pursuit. He currently works on maintaining, upgrading and designing new computer classroom systems. Mr. Perez is inspired because he enjoys working with people and technology in the same environment.

WORK-IN-PROGRESS: STUDENT DASHBOARD FOR A MULTI-AGENT APPROACH FOR ACADEMIC ADVISING

ABSTRACT

The objective of this work is to demonstrate a mechanism to improve the advising of students in a nontraditional environment. 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, it is critical an individualized approach to advising.

The school administration faces more challenges scheduling courses and allocating diminishing resources to satisfy the student demand. In addition, the faculty needs to assess the efficacy of the curriculum in a program and collecting longitudinal student data is difficult.
We are proposing the application of a multi-agent approach to allow the students 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. We call the academic control objective the "Operator."

This paper focuses on the agent system by building a simple dashboard tool that will collect students' information about their progress through the curriculum in a program and will generate advising recommendations. The agent logic employs principles used in project management tools designed to help the students complete their degree plan sooner. For example, it would provide a visualization map of course sequences, customized for each student, 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 feedback to the Operator.

The second tool will be the Operator dashboard that will consolidate the collected data from the agents through several semesters (historical data) plus the predicted effects of the recommended plans. This should enable a better resource allocation and deeper analysis of the curriculum effectiveness. This tool is still under development. Previous work has presented some limited insight into the multi-agent approach however research and mapping of the critical path to graduation has been done. The proliferation of mobile devices and cloud computing enables a larger scale application of the proposed methodology to be developed for mobile devices.

INTRODUCTION

Throughout history there have been many attempts to provide an incentive to graduate from college as fast as possible in order to optimize the different resources available to students.[1] When compared, some of these incentives have been more effective than others.[2] Undergraduate 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 are: social setting (commuter campus), low-income student population, cohort is not as homogeneously defined as in a residential campus, and the lack of available data to the operator or the agents. In some cases the data is available but the time to search for it makes it prohibitive to the operator and/or agent to search for it. All of these characteristics make the advising process a very time consuming process that is not always tailored to the specific need of the student being advised. Currently, there is a lack of a readily available and user-friendly system capable to implement a systematic and repeatable process to analyze data in real time and present it accordingly to agents and operators to optimize resource allocation. The current advising systems are based on historical values only. The available data that the operator uses makes the advising process a top-down system, similar to the early power grid before the smart grid. Another characteristic of the 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 characteristics mentioned before a large gap on communication leaves a lot of room for the optimization of this process.

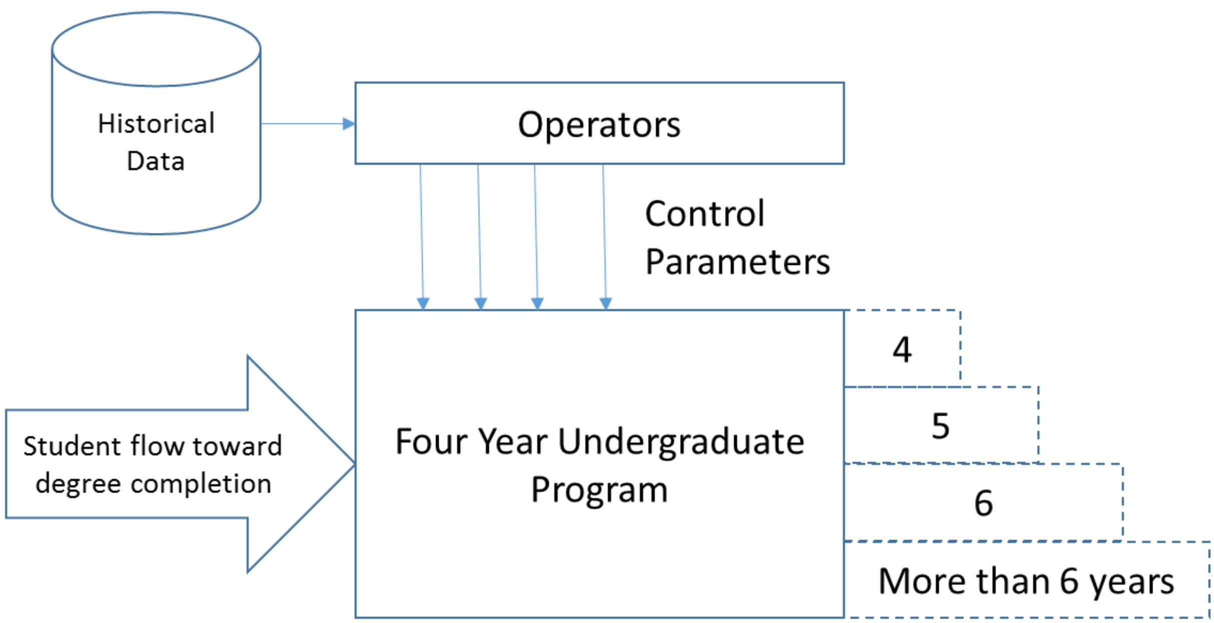


Figure 1. Current control system used for advising (Top-Down approach)

In order to optimize the advising process in the setting previously defined and having in mind a systems approach to this challenge we are proposing the application of a multi-agent technique to allow the students to take more control over 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 the environment with a desirable behavior for the agents with certain flexibility. 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 into 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 (part-time or full time).

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, not a top-down deterministic system. Using the concept of distributed control in real time, the dashboard updates using the agent's feedback also in real time. Having this information available 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 a specific class and there is currently only one section scheduled with 30 seats, the operator can then make the decision to move another instructor to open a section where it will have a greater impact of moving more agents' through the system to graduate them faster. 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 graduation rates.

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.

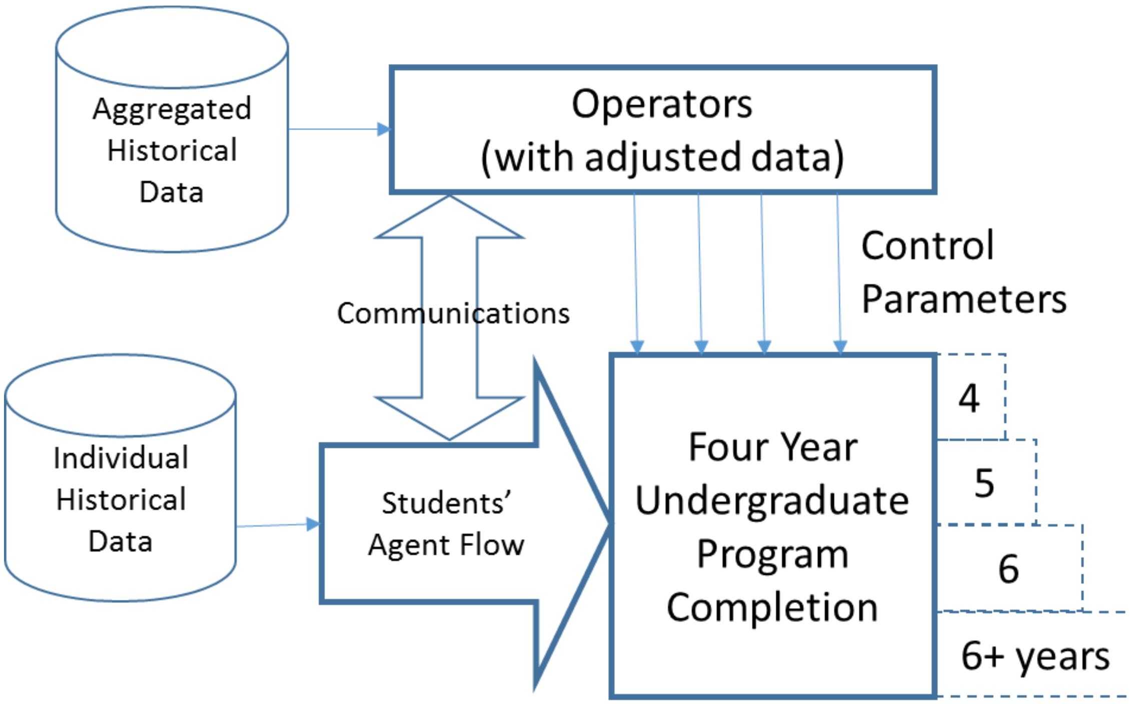


Figure 2. Proposed distributed control system

MATERIALS, METHODS AND IMPLEMENTATION

This research specifically focuses on the impact of the "Multi Agent control system applied to a social setting". This pilot will be focused on the Electrical Engineering department student body that represents the university demographics.[6] This research will measure students' perceived value of using this system. Before meeting with their advisor the agents will use the system. This type of study has not been previously done given the demographics, content, and subject matter involved. This research provides important information for the engineering and engineering education fields. Based on the effectiveness this system, it could be added to the engineering institution toolbox to increase STEM success in higher education institutions.

The current methodology to the development of this system starts with the analysis and mapping of the current systems (degree plan and advising process). Mapping the required flow of agents in the current degree plan provides 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 is 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.

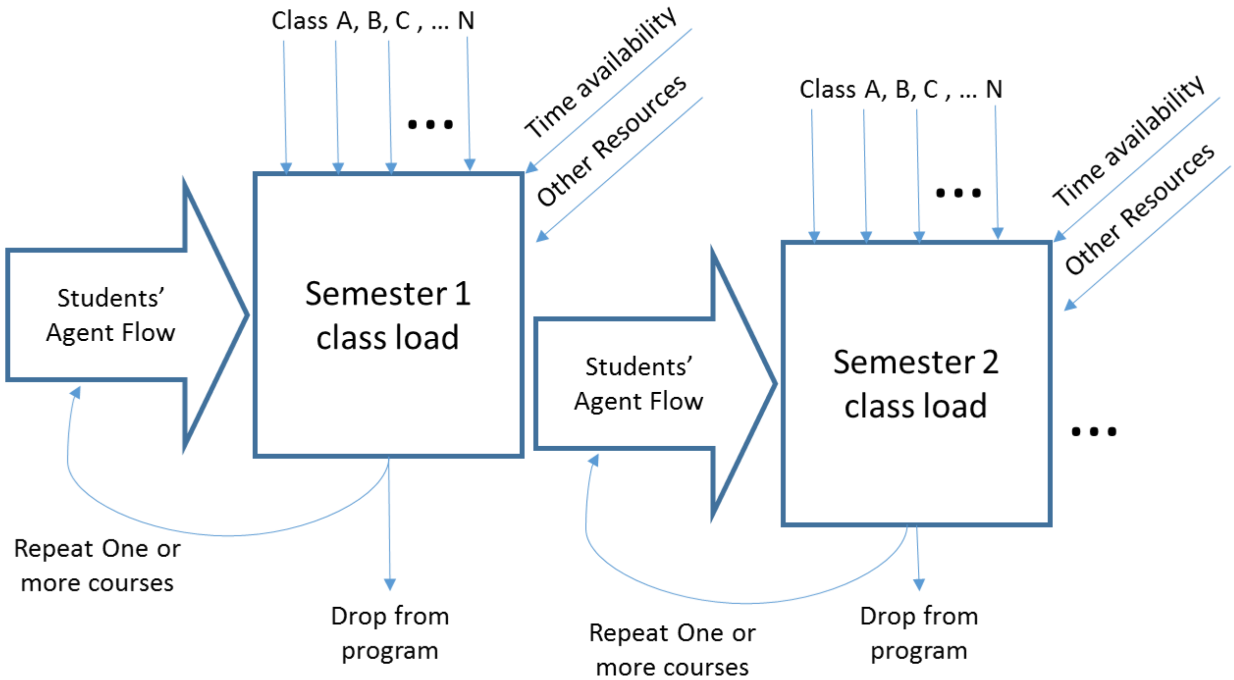


Figure 3. Agent Visual flow model (FIR model)

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.

ELECTRICAL AND COMPUTER ENGINEERING

2014-2015

	Math Placement in Calculus:				English Placement in RWS1301:			Total credits per Semester
LOWER DIVISION 1st year, 1st Sem	MATH1411* Calc 1	EE1305* Intro EE	EE1105* EE1305 lab	CS1320* Comp Prog	PHYS2420* Intro Mech		UNIV1301* Univ Sem	18
1st year, 2nd Sem	MATH1312* Calc 2	EE2369* Dig. Sys 1	EE2169* EE2369 Lab		PHYS2421* Fld & Wave	RWS1301* Rhet Cmp 1	HIST1301* US Hist 1	17
2nd year, 1st Sem	MATH2326* Diff Eq.	EE2350* Circuit 1	EE2372* Soft Dsgn 1		Choose Sci Science	RWS1302* Rhet Cmp 2		15
2nd year, 2nd Sem	MATH2313* Calc 3	EE2351* Circuit 2	EE2151* EE2351 Lab	EE2353* C.T. Signal		Choose ART	HIST1302* US Hist 2	16
UPPER DIVISION 3rd year, 1st Sem	MATH3323* Matrx Algb	EE3338* Electron 1	EE3138* EE3338 Lab	EE3353* D.T. Signal	EE3325* Ap Quantum	EE3321* EMF		16
3rd year, 2nd Sem	EE3384* Probablty	EE3340* Electron 2	EE3376* Micro 1	EE3176* EE3376 Lab	EE3195* J.P.O.	EE3329* Elec. Dev	Choose HMN	17
4th year, 1st Sem	EE41xx Exp Learn	EE4220* S. Proj 1		EExxxx Elective	EExxxx Elective	CE2326* Econ Sci Engr	POLS2310* Int Pol	15
4th year, 2nd Sem	PROF Prof Option	EE4230 S. Proj 2		EExxxx Elective	EExxxx Elective		POLS2311* Am Gov	14
							TOTAL cr =	128

* "C" OR BETTER REQUIRED

Figure 4. Electrical and Computer Engineering degree plan

This research started on summer of 2014 and we are continuing to build the infrastructure required for its support. Some of the preliminary process use a modified shell for the school Learning Management System (LMS) acting as the initial dashboard. This student view (agent) is shown in Figure 5 where the student gets access to some of the forms and other resources for advising.

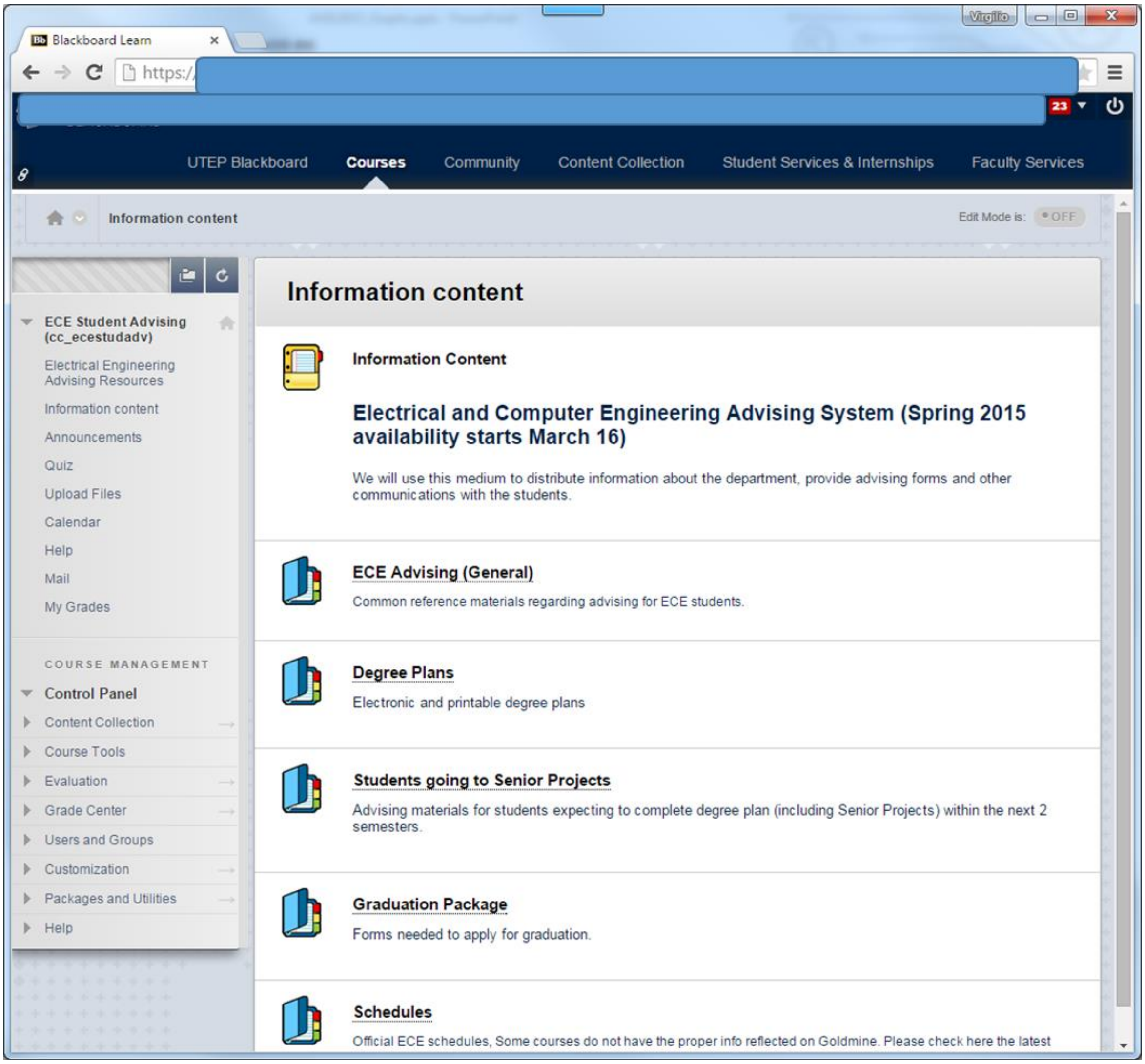
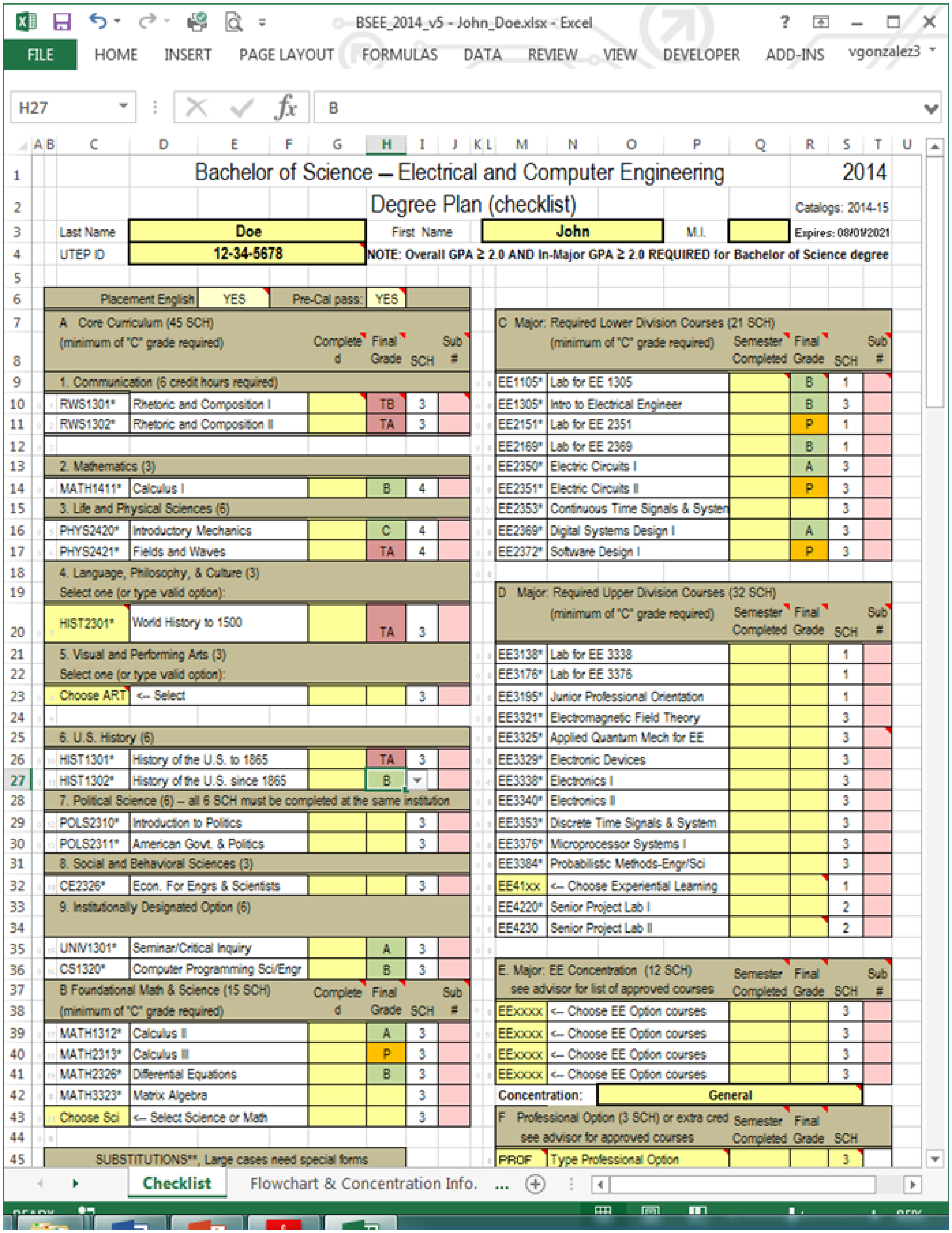


Figure 5, Student LMS used as prototype dashboard

The student fills several forms, including a degree checklist in MS-Excel (Figure 6) and uploads other documents into the system. The MS-Excel form validates the progress (Figure 7) and informs the student of the eligibility for future courses in a color coded diagram. It also provides optionally more details to the students regarding reasons for ineligibility to enroll in other courses, such as co-requisites or pre-requisites.



BSEE_2014_v5 - John_Doe.xlsx - Excel

Bachelor of Science – Electrical and Computer Engineering 2014

Degree Plan (checklist)

Catalogs: 2014-15

Last Name	Doe	First Name	John	M.I.	Expires: 08/01/2021
UTEP ID	12-34-5678	NOTE: Overall GPA ≥ 2.0 AND In-Major GPA ≥ 2.0 REQUIRED for Bachelor of Science degree			

Placement English: YES | Pre-Cal pass: YES

A Core Curriculum (45 SCH) (minimum of "C" grade required)		Completed	Final Grade	SCH	Sub #
1. Communication (6 credit hours required)					
RWS1301*	Rhetoric and Composition I		TB	3	
RWS1302*	Rhetoric and Composition II		TA	3	
2. Mathematics (3)					
MATH1411*	Calculus I		B	4	
3. Life and Physical Sciences (6)					
PHYS2420*	Introductory Mechanics		C	4	
PHYS2421*	Fields and Waves		TA	4	
4. Language, Philosophy, & Culture (3) Select one (or type valid option):					
HIST2301*	World History to 1500		TA	3	
5. Visual and Performing Arts (3) Select one (or type valid option):					
Choose ART	<-- Select			3	
6. U.S. History (6)					
HIST1301*	History of the U.S. to 1865		TA	3	
HIST1302*	History of the U.S. since 1865		B		
7. Political Science (6) -- all 6 SCH must be completed at the same institution					
POLS2310*	Introduction to Politics			3	
POLS2311*	American Govt. & Politics			3	
8. Social and Behavioral Sciences (3)					
CE2326*	Econ. For Engrs & Scientists			3	
9. Institutionally Designated Option (6)					
UNIV1301*	Seminar/Critical Inquiry		A	3	
CS1320*	Computer Programming Sci/Engr		B	3	

B Foundational Math & Science (15 SCH) (minimum of "C" grade required)		Completed	Final Grade	SCH	Sub #
MATH1312*	Calculus II		A	3	
MATH2313*	Calculus III		P	3	
MATH2326*	Differential Equations		B	3	
MATH3323*	Matrix Algebra			3	
Choose Sci	<-- Select Science or Math			3	

SUBSTITUTIONS**, Large cases need special forms

C Major: Required Lower Division Courses (21 SCH) (minimum of "C" grade required)		Semester Completed	Final Grade	SCH	Sub #
EE1105*	Lab for EE 1305		B	1	
EE1305*	Intro to Electrical Engineer		B	3	
EE2151*	Lab for EE 2351		P	1	
EE2169*	Lab for EE 2369		B	1	
EE2350*	Electric Circuits I		A	3	
EE2351*	Electric Circuits II		P	3	
EE2353*	Continuous Time Signals & Systen			3	
EE2369*	Digital Systems Design I		A	3	
EE2372*	Software Design I		P	3	

D Major: Required Upper Division Courses (32 SCH) (minimum of "C" grade required)		Semester Completed	Final Grade	SCH	Sub #
EE3138*	Lab for EE 3338			1	
EE3176*	Lab for EE 3376			1	
EE3195*	Junior Professional Orientation			1	
EE3321*	Electromagnetic Field Theory			3	
EE3325*	Applied Quantum Mech for EE			3	
EE3329*	Electronic Devices			3	
EE3338*	Electronics I			3	
EE3340*	Electronics II			3	
EE3353*	Discrete Time Signals & System			3	
EE3376*	Microprocessor Systems I			3	
EE3384*	Probabilistic Methods-Engr/Sci			3	
EE41xx	<-- Choose Experiential Learning			1	
EE4220*	Senior Project Lab I			2	
EE4230	Senior Project Lab II			2	

E. Major: EE Concentration (12 SCH) see advisor for list of approved courses		Semester Completed	Final Grade	SCH	Sub #
EExxxx	<-- Choose EE Option courses			3	
EExxxx	<-- Choose EE Option courses			3	
EExxxx	<-- Choose EE Option courses			3	
EExxxx	<-- Choose EE Option courses			3	

Concentration: General

F Professional Option (3 SCH) or extra cred see advisor for approved courses		Semester Completed	Final Grade	SCH
PROF	Type Professional Option			3

Checklist | Flowchart & Concentration Info.

Figure 6, Student capture form

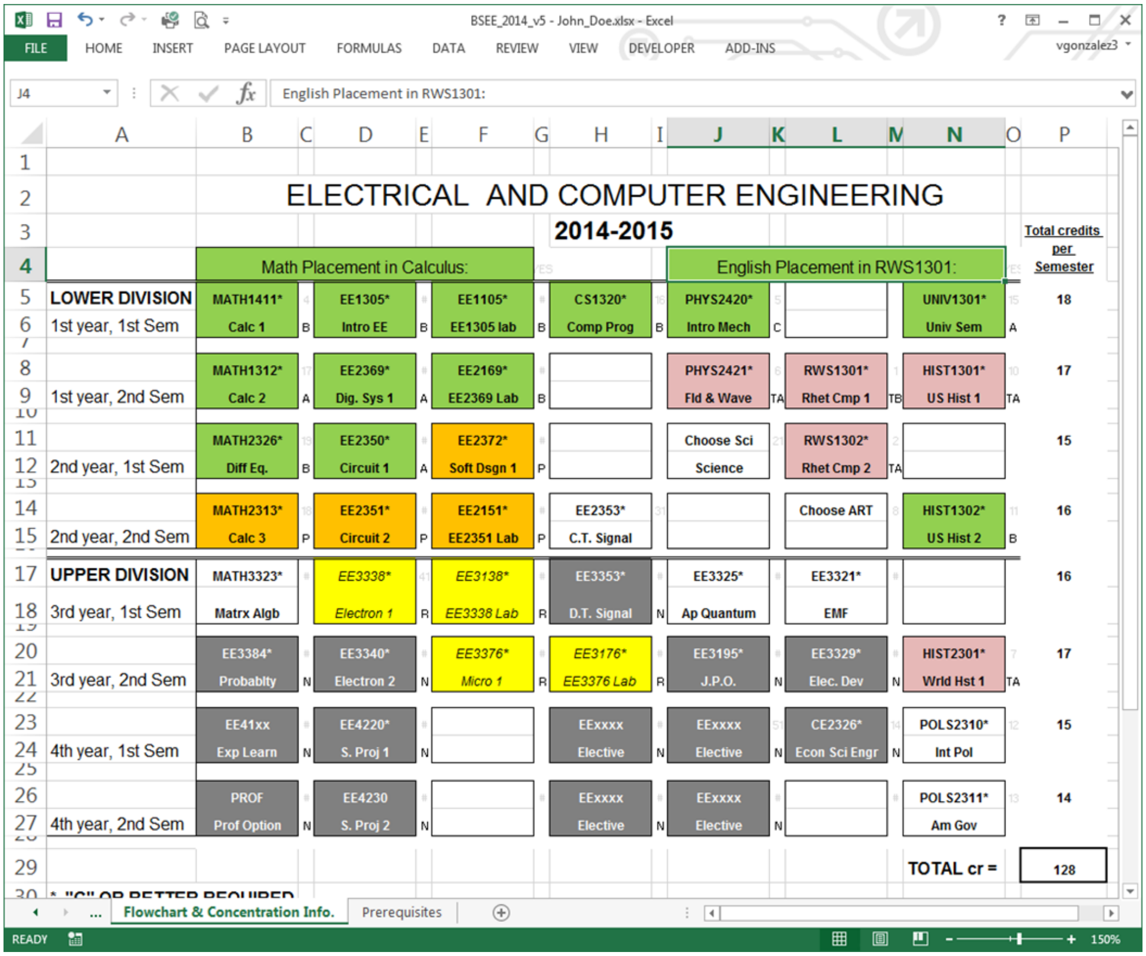


Figure 7, Eligible courses for student

The current operator or advisor view consist on access to the same reports in the LMS system, the MS-Excel forms plus a data analytics tool that already exists on the school, shown in Figure 8. The risk assessment tool currently being used by the school only provides a "risk" level assessment based exclusively in historical data and does not make any recommendation.

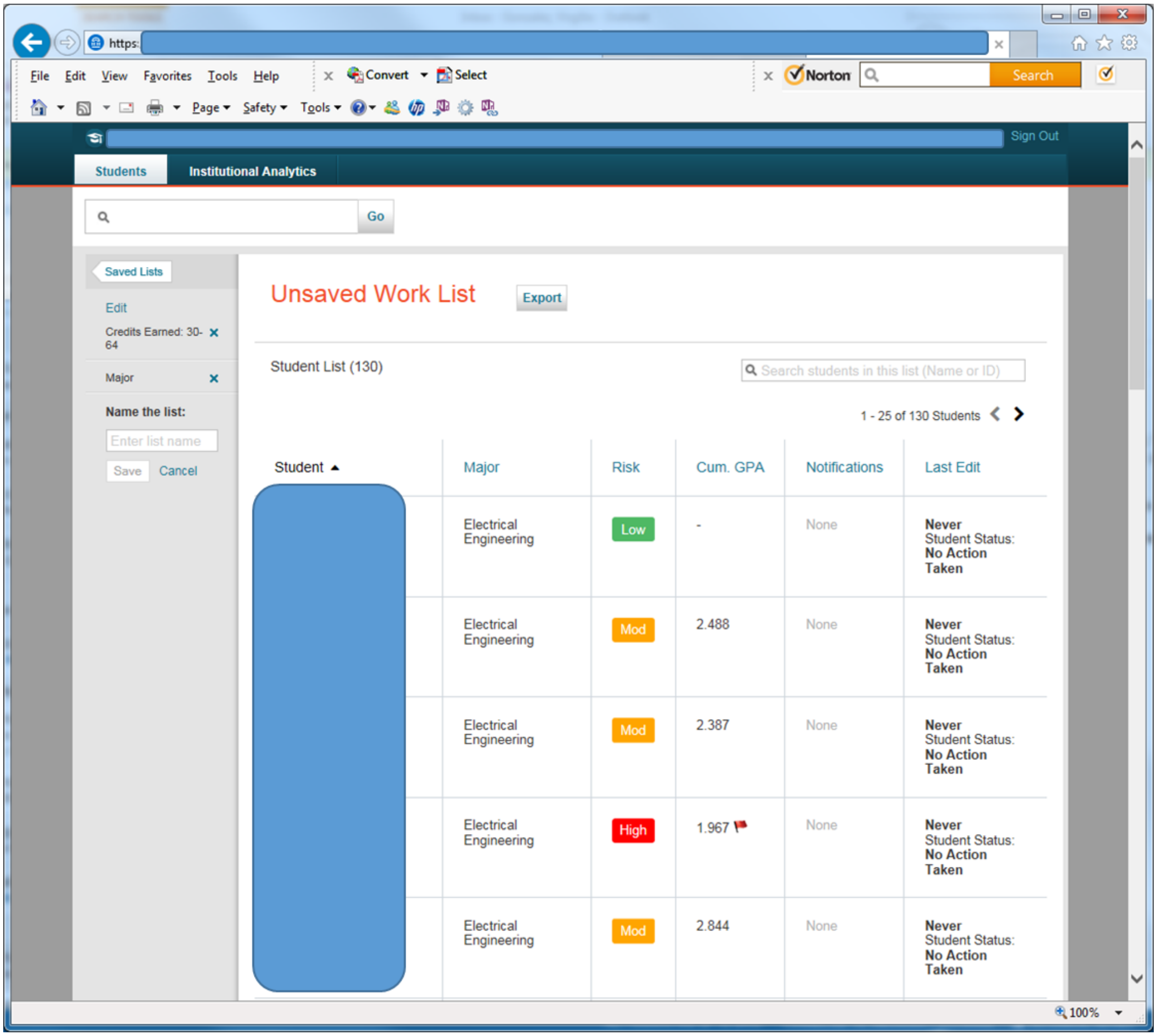


Figure 8. Advisor existing dashboard based on historical data.

The materials being developed for this research consist of the infrastructure needed to integrate mobile and online environments. These environments (app/online) will allow 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 was needed as the backend of the system. A critical part of the design is the algorithm 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 organization 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 Figure 9. Then we allocated resources representing the number of credits that a student can take and requirements for each class. An example of these templates is shown in Figure 10 where a load balancing function was used to level the workload to 12 credits for a student that is already 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 is 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.

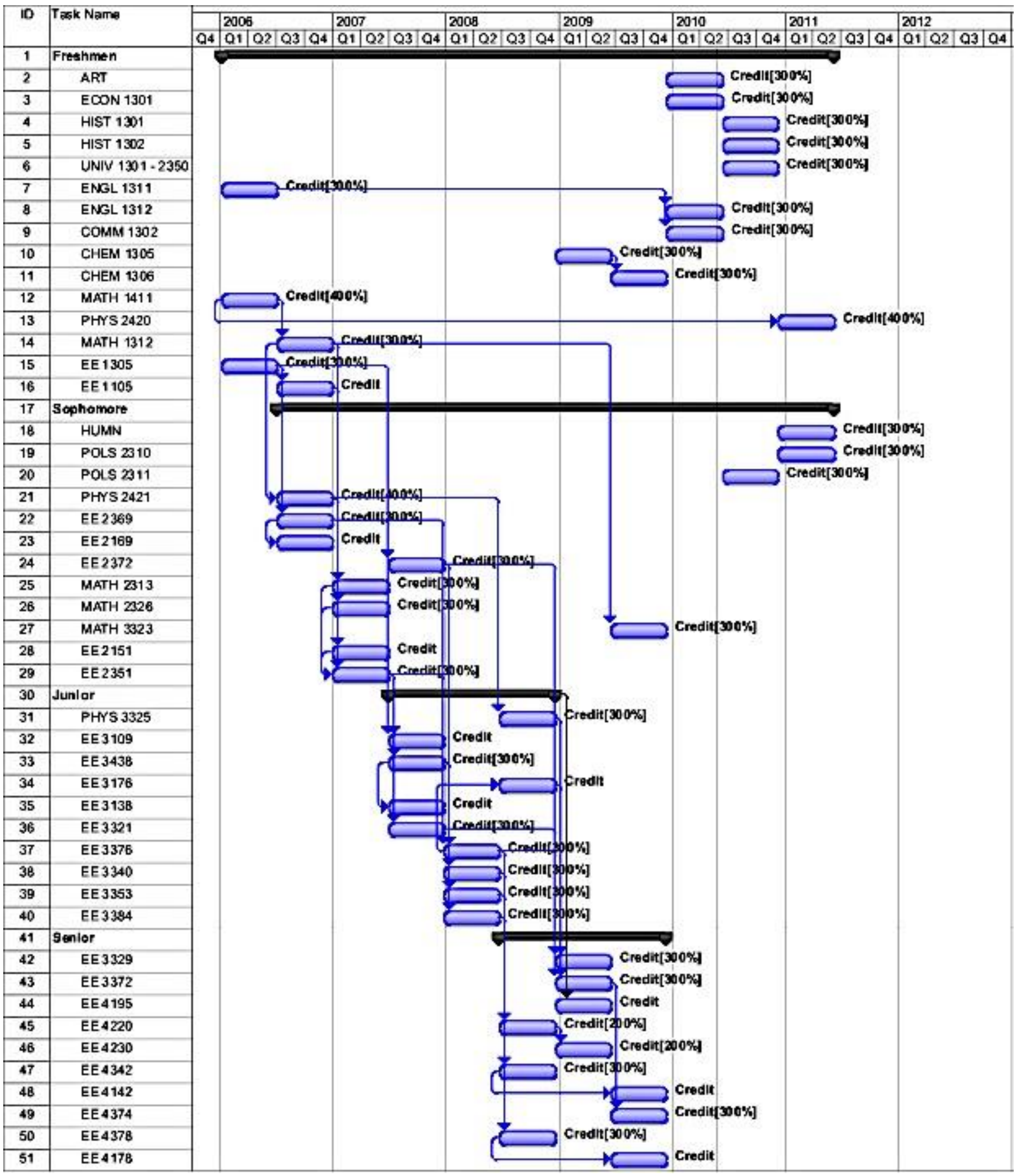


Figure 9. Screen view of Gantt chart of course sequence.

The operators will benefit from this system by having access to real-time data. A dashboard will be 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, it can then see the system's bottlenecks and predict future demand for the course based on current system saturation levels. The operator will be 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.

Other statistical data will also be gathered, such as:

- Overall agent performance as an aggregate in experiment 1 (Quantitative Survey of the results of how fast are the agents moving through the system).
- Agent perception of the system (Qualitative Survey) and Operator perception of the system, to name a few (Qualitative Survey) in experiment 2.

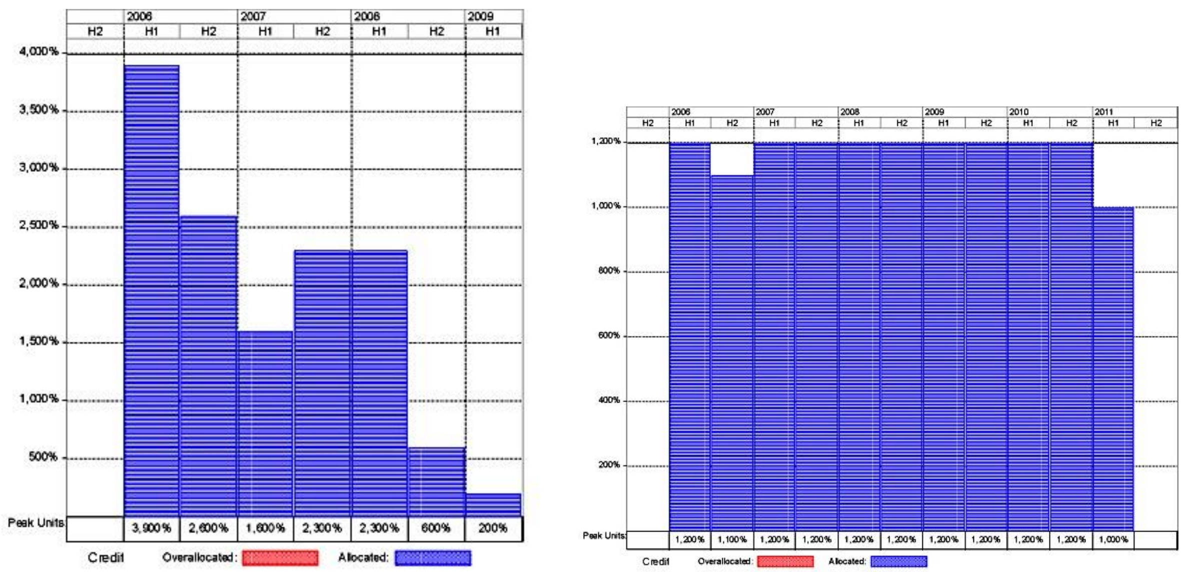


Figure 10. Credits unrestricted and credits leveled respectively.

Experiment 1 – Impact on agent's flow through the system

Most of the benefits of the Multi agent control system on the short term have already been listed, but 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 they will take to finish. In order for this experiment to be done, a longitudinal analysis needs to be done, which will begin this spring 2015.

Experiment 2 - Student perceived value

There will be experiments conducted to analyze student perceived value of the system by the agents and the operators. For this experiment, a post-attitudinal survey will be given to all of the agents using the system after they have used it. This survey will be conducted by an independent entity not related to the development team.

RESULTS AND ASSESMENT

The results of this system are in an early stage at this point, however after the design of the model and using a first implementation on the LMS website and the automated forms, we have obtained a positive response from agents and operators (students and advisors). For example there are fewer cases of cases of students enrolling in courses where they lack the proper prerequisites due to errors.

One important benefit allowed the department to reallocate resources due to the load reduction on the advisors. The EE department used to have 3 fulltime employees devoted to student advising; after the first part of the implementation has been concluded only one advisor is now necessary along with two part-time student advisors (MS students acting as undergraduate advisors). The number of student advised per semester has increased using this system. Previously 160 students were advised per semester (fall 2013); now 240 students were advised during the fall 2014. Using the current data from this first implementation plus more historical data that is available a benchmark will be created before the distributed Complex Discrete Data Control System is implemented.

Statistics on the process will be collected during the spring semester and be compared to previous years to be able to determine the impact of the current initial pilot.

DISCUSSION

At this point the research of the Multi Agent Control System with the application of social modeling has begun and more results will be available after the first iteration this spring 2015. After analyzing results of the attitudinal surveys for over 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. 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 will be on a platform that is very popular (mobile app) among college students which makes it very appealing to them.

CONCLUSION

At this point limited data is available since the Multi Agent Control System is at the beginning the of the implementation phase. Based on the data acquired up to now from the partial automation of the advising process it makes clear that the logical step is to combine the information from the different sources and display them in a user friendly manner to the operators of the system in a dashboard. As for the agents, this proposed Multi agent distributed control system will streamline the advising process. More data will be available by the end of spring 2015.

FUTURE WORK

Some 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 following: 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.

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