

Innovative Student Recruiting Approaches for Smaller and Liberal Art Institutions¹

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A Motivation

Lately, most American higher education institutions have witnessed a decline in student interest in the field of information technology (IT). According to the Taulbee Survey [2] by Computer Research Association, the number of newly declared computer-science (CS) majors declined 33% from fall 2002 to fall 2004. Minority students continue to be underrepresented, e.g., only 3.1% of CS Bachelor degree recipients are African-American students [2]. The continuous decrease in enrollment and the unbalanced ethnic demographics of computer disciplined programs will definitely jeopardize the competitiveness of the IT industry of this nation. Hence, *the question of how to attract and retain IT students has been a serious issue for many institutions, especially for smaller and liberal art institutions. In addition, the cost effectiveness of student recruitment is vital, since there are usually not enough resources available for the institutions to provide a more individual (personal) approach to marketing programs and recruiting students.*

It is widely agreed that the unrealistic expectation of career future and the lack of articulation of the field of study by many students contribute much to the high drop-out rate of computer disciplined programs. In the late 1990's many high school graduates selected computer disciplined majors before careful academic and career planning. For example, many of them could not even tell the difference between electrical engineering, computer engineering and computer science. Similar problems exist for other STEM (Science, Technology, Engineering and Mathematics) majors, resulting from the lack of a complete academic and career counseling service for high school students. Given the complex knowledge body of modern technology, even an experienced counselor may not know enough about all STEM programs offered at a university. Hence a *computer assisted academic counseling system may provide a sophisticated knowledge base to remedy the deficiencies of human counselors, thus helping to increase the readiness of high school graduates for college education.*

Since the dot-com bubble burst, the worldwide downturn in the IT industry has meant a greater difficulty in landing an entry level position for most IT graduates, due to the more intense competition in the job market. The trend of out-sourcing low level programming jobs by the industry aggravates this situation. However, in contrast to the lack of entry-level positions, plenty of positions are available for experienced IT professionals. There is even a shortage for professionals in many areas, such as experienced security advisors, software architects, and network administrators, which cannot be outsourced to other countries due to their importance to American businesses. As suggested by Mr. Rashid, a senior vice president of Microsoft Research [3], "It's² a major concern for us because we're a company that runs on people. Our hiring has continued to go up, but unfortunately what we're seeing right now is a decline in the potential supply." Without doubt, the content of CS curriculum should be reflective of both the latest market trends and time-tested principles. Hence, undergraduate

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² "It" refers to the students declining interest in computer disciplined programs.

IT education should allow each of its graduates to obtain a minimal theoretical knowledge base and a life-long motivation for learning, while simultaneously helping students to build a set of practical skills for their survival upon entrance into the job market. One possible solution is to create internship opportunities for students and expose them to real-world projects. However, one or two internship courses do not really make an IT student an experienced professional, due to the limited time and depth that a student can get involved. Therefore, *a supplementary but systematic multi-year practical training program may be a necessity for better preparing IT graduates for the international challenge.*

This paper proposes the work at Georgia Southwestern State University to solve the aforementioned problems:

- Designing, implementing, and installing a Computer aided Academic Counseling and studentT recrUitment System (CACTUS) to better attract and retain students, especially minority students. *Initially, the project will emphasize the attraction of African-American students for the undergraduate Computer Science program at Georgia Southwestern State University (GSW).* Equipped with a 3-D game interface, CACTUS guides students through the computer science curriculum and examines students’ readiness for the field of study. By utilizing existing mature technologies such as Web Blogs, CACTUS provides a comprehensive environment for potential students to learn about future careers from the alumni.
- Accompanying the implementation of CACTUS, *at no extra cost,* developing a piloting 3-year supplemental practical training program for the undergraduate CS program at GSW. Undergraduate students are involved in the whole product development cycle of CACTUS.

B Cactus Overview

Computer assisted Academic Counseling and studentT recruitment System (CACTUS) is essentially a multimedia Kiosk application that provides counseling service to high school students and helps them select fields of study and arrange future study and career plans based on their personal interests, academic backgrounds, and personality.³ Figure 1 presents the general structure of CACTUS and the workflow through which a high school graduate goes to obtain interactive counseling service from CACTUS.

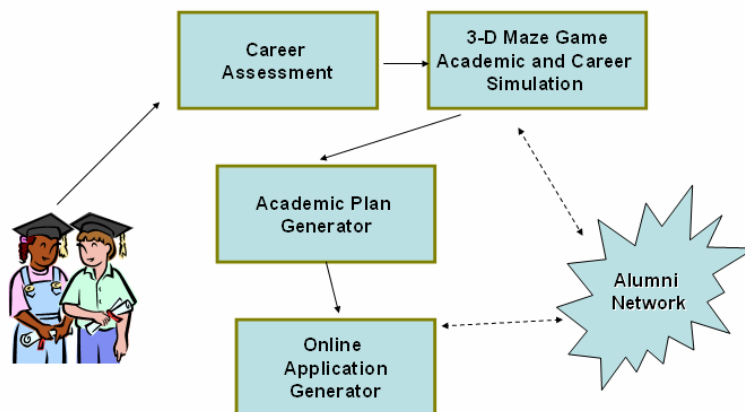


Figure 1. Service Flow of CACTUS

³ Notice that, initially, the CACTUS provides counseling service to computer science program only. However, it can be extended for other STEM majors.

CACTUS consists of five components: Career Assessment Module, Game Oriented Curriculum Introduction and Career Simulation, Academic Plan Generator, GSW Online Application Generator, and the Alumni Network. We now briefly describe the functionality of the five modules.

The **Career Assessment Module** provides a comprehensive computer based evaluation process which examines a student's career interests, personality, and basic skills. Based on the personality and aptitude of a student, a proper general categorization of careers (e.g., systems careers, analytical careers, and creative careers) is located. Then based on the general career categorization, a list of candidate fields of study is provided to the student.⁴ In addition, existing web based career assessment services (e.g., MAPP [8]) can be integrated into the system with the use of Web Service technology.⁵ GSW does not have to design its own personality assessment suite.

The **Game Oriented Curriculum Introduction and Career Simulation Module** is a 3-D maze game which attracts potential students and helps them to learn about the curriculum of the field of study via entertaining methods. Before entering the maze, a student must select one of the possible professions which he or she would like to pursue. Based upon his/her selection a particular game and description of the profession will be generated.⁵ The student has to find his way in the 3D maze from admissions through graduation to a job. The student will have two types of resources, time and money. Three levels, Introductory, Intermediate, and Advanced, determine how much time and money the student has available. Along the way the student will find many closed doors. Some doors will be more relevant to the selected profession than others. After clicking on a door, a multimedia introduction of a course will be presented to students. Selection of the right doors will increase the student's chance to successfully reach the exit of the maze. Near each door, the student will meet a gate-keeper who will challenge him with questions. The student will have options to either answer questions, which will take some time from his/her resources, or pay the gate-keeper for the answer. The goal is to reach the end of the maze before the resources are consumed. The student has enough money to pay all gate-keepers from entrance to exit of the maze at the introductory level, but not at the intermediate and advanced levels. The use of Alumni Network allows students to obtain assistance and guidance from alumni when playing the game. When the student advances to the next level of the game, a new set of questions will be generated. The student can save the current state of the game to take a break and continue the game later. As a result of playing this game, the student will learn more about the selected profession and understand all pros and cons of their selection.

Once a student has a clear understanding of the field of study, the **Academic Plan Generator** helps him/her to create a tentative study plan of his/her whole college education. Based on the degree requirements, multi-year course offering schedule, and the student's personal preference (e.g., graduation time, interested courses, and soft constraints, such as no more than 3 mathematics classes per semester), a personalized study plan is generated for the student. The student can modify the draft study plan via the graphic user interface. This process, without doubt, helps students to further understand their future academic and career path. More importantly, it allows educators to schedule and optimize the educational resources with the academic plans of all students [9].

Finally, the **Online GSW Application Generator** acquires the remaining of information required by the GSW application package and forwards the information to GSW educators, upon the approval of

⁴ Notice that the prototype of CACTUS will concentrate on computer science major only.

⁵ Technical issues in utilizing existing career assessment services will be discussed in C.1.

the student. This module utilizes the shared information of previous counseling steps and saves students efforts in preparing college applications.

During the previous academic and career counseling steps, the **Alumni/Mentor Network** provides a comprehensive environment for students to learn about their future career. The Alumni Network is a communication platform which integrates web mail, web Blog, and other various existing online communication approaches. The platform allows potential students to learn about the job market trend, rating of courses, and survival tricks from the current students and alumni.

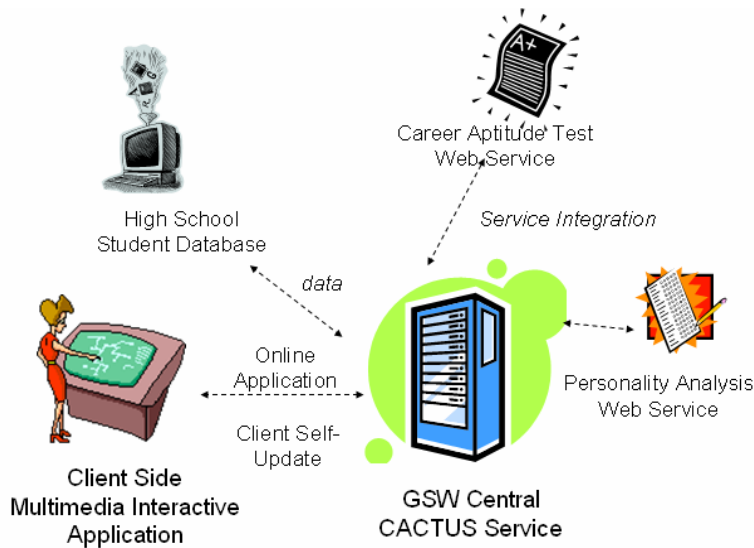


Figure 2. System Model of CACTUS

C System Model

We now briefly discuss the system model of CACTUS. As shown in Figure 2, CACTUS are deployed as two separate subsystems: (1) Client side Multi-media Interactive Application (also called CMIA), and (2) GSW Central CACTUS Service (also called “CACTUS Central Service” for short).

The CMIA is a Kiosk application which requires the Windows operating systems, e.g., Windows XP or Windows 2003. Since touch screen events of Kiosks are modeled as Mouse Events in Windows applications, developing Kiosk applications are essentially like developing a Windows application running on a conventional Personal Computer. In fact, CMIA can be downloaded and installed on any Windows PC; interested high school students can directly download CMIA and finish career counseling at home. However, we believe that due to the user friendly interface provided by Kiosk, the installation of a Kiosk at high schools may help attract more students.

The responsibility of CMIA is to render the counseling service directly to high school students. The CMIA must possess a strong multi-media rendering capability while maintaining an attractive appearance in order to deliver multi-media contents, such as the video welcome message from the department head of each major program, or live online interaction with alumni. Also, CMIA is responsible for delivering career assessment tests to students and collecting and sending results to a central service for further analysis. As program information and Alumni Network information may

change frequently, CMIA needs the ability to update itself once any change takes place. CMIA will periodically download the current version from a central service at GSW.

The CACTUS central service at GSW is a composite Web Service, which is a web application that communicates with other web services via standardized communications, like XML and SOAP protocols. CACTUS is a service *oriented* software which integrates many basic services and forms a new value added *composite* service. For example, there is no need to implement a Career Aptitude and Assessment Test at GSW. By adopting the Web Service technology, many existing web based Career Assessment Tests can be used. The job of the CACTUS central service is to deliver the web based test in a format favorable to high school students, send the completed test to the invoked Career Assessment Service, and then retrieve, customize, and deliver the results back to students. Although there are many different technical solutions for developing web services, we decided to use Microsoft Visual Studio .Net 2003, which is the standard development tool for most CS/CIS courses at GSW.

C.1 Technique Details

Only mature techniques are required to implement CACTUS. We now briefly discuss the technical challenges and solutions for the five components of CACTUS.

Career Assessment Module: The CAM is a typical application example of Web Service technology. Since the design of the career assessment test is the job of psychologists, the GSW CACTUS Central Service simply administers those online tests and retrieves the analysis results. However, one technical challenge here is that the analysis report returned by the invoked online personality test may not provide 100% of the information sought; the central service may have to parse the report and generate a customized report for students. For example, instead of telling students: “You are better at clerical and mathematics skills, however, your test on leadership scores lower. Thus engineering career fits you better”, the central service can select the available engineering curriculums and present them to the students. To parse the analysis report, techniques such as regular expressions and context free grammars are useful; natural language processing in artificial intelligence is also helpful. These techniques are covered in courses such as concepts of programming language, compiler construction, and artificial intelligence courses.

Game Oriented Curriculum Introduction and Career Simulation: This module needs to support rendering of multi-media data and 3-D graphics. Implementation can be started with a standard graphics package such as OpenGL [10] or DirectX [11]. However, a customized 3-D gaming package can be purchased at reasonable price and would save time in building the game.

Academic Plan Generator: Academic plan generation is essentially a constraint programming problem. Based on the degree requirements, student’s personal interests (e.g., to take music class or social science class to satisfy the breadth requirement), and soft constraints (e.g., no more than 3 mathematics classes in one semester), a personalized study plan is generated. The generation of such a study plan is essentially a topological sorting of all courses (as their partial order relation is defined by the pre-requisites of each course), while at the same time satisfying the soft constraints. This is a typical problem covered in the data structures and algorithms course.

GSW Online-Application: Mature techniques such as Active Server Page (ASP) or HTML with Backend scripts (e.g. Perl) are available for online-application. The job of this module is to collect

student information and store data into the GSW central database server. The application will be forwarded to the admissions office for processing.

Alumni Network: The Alumni Network is a combination of web mails and Blogs. Existing techniques are mature and freely available under the Unix system; however designers may have to resolve some operating system issues.

D Integration with Teaching

One nice feature of the implementation plan is that it is integrated into the teaching at GSW. The system is broken down into components. Each component is implemented as a course project and eventually assembled by graduate assistants. Graduate students are responsible for defining the specifications of each component and documenting them in the form of a sub-project contract. Undergraduate students in the corresponding classes will compete for the sub-contract. Winners of sub-contracts are granted one semester's assistantship.⁶ Notice that the implementation plan naturally leads to a 3-year practical training program, which enhances the existing CS/CIS curriculum at no extra cost.

In the following table, we summarize the technical problems faced by each component of CACTUS. We also display the information about the CS/CIS courses which cover the solutions to the technical challenges. Later, a detailed explanation of implementation will involve all the courses listed in the table.

Component Name	Technical Problems	Covered by Courses
Career Assessment Module	1. Web Service Invocation 2. Text Processing	Web Programming, Concepts of Programming, Compiler Construction, Artificial Intelligence
3-D Game (Career Simulation)	1. Multimedia Data Rendering 2. Game Programming	Operating Systems (system calls) Intro. to programming Computer Graphics
Academic Plan Generator	1. Representation of Course Pre-requisite Requirements 2. Constraint Programming	Data Structures and Algorithms Intro. to programming
GSW Online Application	1. Web form design (ASP) 2. Database application	Web Programming Internet Technology Intro. to Database Systems
Alumni Network	1. Server Management 2. OS Management	Micro-network Management Operating System

D.1 Examples of sub-contracts

We now disassemble CACTUS and discuss how to implement each of its components (specified as a *sub-contract*). As discussed earlier, graduate assistants, under the guidance of faculty members, will document and specify each sub-contract. Undergraduate students in the corresponding hosting course will compete for each sub-contract. For the convenience of reading, all sub-contracts are grouped by

⁶ In case no undergraduate students are able to solve technical challenges of some difficult sub-contracts, experienced programmers in GSW Web-i-Tech Center will assist in the implementation.

the hosting CS/CIS courses, preceded by a short course introduction, and followed by brief comments on the integration of teaching and research. Notice that the organization of this subsection also reflects the structure of the 3-year practical training program, which is the by-product of the CACTUS project implementation, at no extra cost. In the following, we list some examples of sub-contracts.

CSCI 3500: Data Structures & Algorithms - This course covers the basic data structures including stacks, queues, linked lists, heaps, and various search trees, by utilizing the abstract data type approach. Sorting and searching algorithms are analyzed for space and time complexities. Two sub-contracts, both of which are exploratory projects for the Academic Plan Generator module of CACTUS, are incorporated into the course as discussed below.

[Subcontract 1: Course Dependency Graph Rendering] – Students are required to design and implement a Windows application that renders an acyclic graph of all courses based on its pre-requisites. This project is a good experiment to enhance the understanding of acyclic graph and tree structures.

[Subcontract 2: Personalized Study Plan Generator] – Once given the course dependency graph, students are required to design and implement a topological sorting of courses. The generated study plan must satisfy the soft constraints proposed by students. The project is a challenging opportunity to practice sorting algorithms.

CIS 3200 Microcomputer Network Management -- This course is an introduction to network management and administration. It presents a managerial perspective of the architecture, operations, and management of distributed network systems.

[Subcontract 5: GSW Alumni Network] The objective is to set up and integrate HTTP, web mail, and web Blog servers to implement the GSW Alumni Network. Experiments with both Windows 2003 Server and Linux systems are required.

CSCI 4810: Computer Graphics - The course is seen as a broad introduction to the scope of computer graphics and will cover the basic principles of graphic display, algorithms and modeling. Topics include discussion on simple graphics primitives (lines, polygons, etc.), polygon filling, 2D and 3D transformations

[Subcontract 8: 3-D Maze Game] The students are asked to implement the experimental project on a 3-D maze game that will be used to organize the knowledge structure of the computer science curriculum. A player must browse through the CS curriculum to walk out of the maze.

CSCI 4830: Artificial Intelligence - This course provides an introduction to the problems and techniques of Artificial Intelligence. It surveys the major sub-disciplines of AI discussing topics such as problem spaces, search strategies, knowledge representation, natural language processing, expert systems and machine learning.

[Subcontract 9: Analysis of Career Assessment Test Result] Students are required to implement a natural language processing package which analyzes the career assessment test result, and propose a list of candidate fields of study for clients. The graduate assistants will determine which online career assessment to use.

E Related Work and Conclusion

There have been a number of existing student recruiting systems, e.g., M-Pathway Student Admin. System [16] and AdmissionsLegend [17]. Most American higher education institutions have web sites

to attract potential students; however, the novelty of the CACTUS project distinguishes itself from related systems.

The essential idea of the CACTUS project is to recruit and retain minority students via innovative and cost effective approaches. The introduction of the game oriented curriculum was inspired by the observations of K-12 and college educators [12, 13, 14] that minority students spend more time on video games and are more attracted to learning via fun methods than the majority. There are on-going projects (e.g., NSF # 0443101 [15]) which use computer gaming to help students maximize the understanding of engineering concepts. However, our idea of using games in recruiting students is novel.

Cost effectiveness in recruiting students has been a major concern for college educators, especially those serve at small and liberal art institutions with limited budgets. The design and implementation of CACTUS strives to achieve the maximum cost effectiveness. For example, with the use of Web Service technology, existing web based career assessment services can be utilized such that the career assessment cost that is borne by universities can be greatly lowered. Also, the whole project is organized into tangible components, each of which is implemented as a course project. Such practices not only reduce costs in implementation, but also thoroughly prepare students for the job market.

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