AC 2011-269: A COLLEGE-INDUSTRY RESEARCH PARTNERSHIP ON SOFTWARE DEVELOPMENT FOR UNDERGRADUATE STUDENTS

Ana Elisa P. Goulart, Texas A&M University

Ana Goulart is currently an assistant professor at the Electronics and Telecommunications Engineering Technology Program at Texas A&M. She received her Ph.D. in Electrical and Computer Engineering from Georgia Tech, and a M.Sc. in Computer Engineering from North Carolina State University. Her research interests include protocols for real-time communications, IP telephony, wireless networks, and engineering education.

Chris Corti, Ph. D., Cisco Systems, Inc.
Matthew Robert Hawkes, Cisco

Manager, Software Engineering at Cisco

A College-Industry Research Partnership on Software Development for Undergraduate Students

Abstract

Collaboration means working together for a special purpose. When industry and academia collaborate, their purposes may be very different, e.g., academia focuses on education and theoretical research, and industry in general focuses on products and process efficiency. Therefore, it is not easy for faculty members in engineering programs to find collaboration projects that represent a win-win situation for both industry and academia. Such projects can represent a major contribution to the education of our engineering students.

In this paper, we present the case of an on-going college-industry research partnership on software development and testing. The students involved in this partnership are undergraduate students from the electronics and telecommunications engineering technology program at Texas A&M. The industry sponsoring this partnership is the IP Communications Business Unit at Cisco Systems, which develops the software for voice over internet protocol (VoIP) systems, such as IP Private Branch Exchange (IP-PBX) systems or call managers.

Introduction

Video-conferencing and Voice over Internet Protocol (VoIP) phones are popular among young and old. At home or work, Internet protocol (IP)- based communications has become a cost-efficient way of making phone calls. Is VoIP a telephone service, or a data application? The answer: both. In other words, IP-based communications combine requirements of traditional telephony and data applications. Therefore, they encompass all aspects of communication and software systems, such as protocols for setting up calls, routing, real-time services, and call processing software. This combination offers a great opportunity to advance the knowledge and understanding of our undergraduate students on data communication protocols and software systems.

On the labor market, IP-based communications has had great penetration in the telecommunication markets. There is a need in the industry for students. For instance, according to the US Bureau of Labor Statistics, there will be an incredible growth in the need for engineers and Information Technology professionals who have knowledge on the convergence of voice, video, and data communications, and their underlying protocols. Table I shows the statistics for two IT professions, both for 2-year and 4-year college degree. Note the expected growth is on the order of 50%.

Table 1 - Expected growth in IT professions [1]

Occupation	Employment		Percent Change
	2006	2016	
Network systems and data communications analysts (2-year degree)	262,000	402,420	53%
Computer software engineers, applications software (4-year degree)	507,000	733,430	45%

In spite of this huge potential, there has been little integration of software applications such as VoIP into undergraduate engineering curricula. As part of an effort to promote innovation in the education of IP-based communications and software applications, this paper describes a case study of industry-college partnership between Texas A&M and Cisco Systems. The work here described is the result of the internship of three undergraduate students and a faculty fellowship in the Summer of 2010.

The Academic Partner

On the academic side the major player is the Electronics and Telecommunications Engineering Technology (EET/TET) program at Texas A&M. This four-year engineering program offers several courses on electronics, instrumentation, embedded systems, and telecommunication networks. Most of the fundamental courses on electronics, programming, and communication protocols are taken by both electronics and telecommunication students. In general, students take specific classes either on the electronics track or telecommunications track only in their senior year. Moreover, the capstone senior design project teams always have a combination of both electronics and telecommunication students, and their design must include hardware, software and communication aspects. Therefore, we have noticed that electronics and telecommunication students have a good foundation on both electronics and telecommunication fields and may be hired by both industries.

The faculty who is actively involved in this project is an assistant professor in the EET/TET program. Although her background is mainly on telecommunications systems, she has been teaching classes to both electronics and telecommunication majors on Local Area Networks, Computer Networks Simulation and Modeling, and Wireless Transmission Systems. The topic of Voice over IP (VoIP) is often addressed in her lectures and given as project topics to the students. For instance, the projects address the signaling protocols, bandwidth requirements and performance of different audio encoders/decoders (codecs).

Since December 2007, this faculty has been working to build a VoIP telephone system in the telecommunication laboratories – a new "VoIP initiative" [2]. The idea is to use simple strategies to adapt undergraduate laboratories on computer networks to the teaching of VoIP protocols. New laboratory experiments were created to introduce our junior-level undergraduate students to

VoIP protocols, such as the session initiation protocol (SIP) and the real-time transport protocol (RTP).

However, industry support is essential to the success of this VoIP initiative and the creation of new laboratories, in terms of industry

- donating equipment,
- funding student workers and graduate assistants,
- updating faculty members on the new tools that industry uses in their daily operations,
- giving feedback on the knowledge and skills that industry expect from students.

The program and laboratories needed industry support, but how could academia contribute to industry? This is a question that has always been asked by the faculty, and probably the industry side had this same question in mind. The academic side was looking not only for simple donations of equipment but for research projects. In such projects faculty and students could provide their expertise to industry and at the same time bring new resources to their lectures and laboratories.

Since Cisco is a major developer of VoIP systems for small and large corporations, a partnership with Cisco has been one of the faculty's main goals. After several meetings with different business units at Cisco, and thanks to the support of a former student who is currently an executive at Cisco, the faculty was introduced to the engineers and managers of the IP Communications Business Unit (IPCBU) at Cisco and that is how this college-industry partnership began.

The Industry Partner

The IP Communications Business Unit develops a VoIP system, or IP Private Branch Exchange (IP-PBX) system also known as a call manager. This product delivers several services such as voice, video and mobility services, by connecting a large number of IP phones (on the order of thousands), multimedia applications, gateways to traditional telephony systems, and mobile devices.

One of the teams in the IP Communications Business Unit is a software development team managed by Matt Hawkes, whose group is based in Richardson, Texas. (We will address Matt's team as the "team".) The team consists of engineers being about half recent graduates, with the other half more seasoned engineers. The team's core initiative is to create a team of versatile members. They do this by encouraging cross-training, both within the team itself and between other teams in the business unit. One way they accomplish this is to often volunteer either some engineers or the entire team to help other teams that are over-tasked.

Another initiative in the group is innovation – thinking outside the box to invent improved solutions to existing problems. One example of this is sanity testing of phone loads during continuous integration. The team which was handling sanity testing was also the team developing the phone applications, and they used a mostly manual process. The team developed an automated process to log into the phones to execute and verify critical functionality. Of course

this relieved the development team of testing work, allowing them to concentrate on development and bug fixes, and it shortened the load release cycle as well. This work also exposed the team to phone applications, since they wrote the test automation, which was an area they had not previously worked in.

When the Texas A&M students began working with this Cisco team, the engineers emphasized the importance of versatility and innovation. The students were given projects where they could practice these values. In many cases, the projects were exploratory – one case being to design and develop new automation techniques. Although such new development does not immediately become released product, it eventually becomes integral to improving our development process, and by contributing in this way, the students are given the opportunity to value and internalize the team's core initiatives.

Technical Projects

The technical aspects of the collaboration can be better described by a brief description of the projects that students and faculty worked during the summer. Note that we had one student working directly with the development team, the automation (or test) team, and build team.

- *Automation Tool for Smart Regression (iAutomate)*
  As part of a broader "continuous integration" project[3], two Texas A&M summer interns were assigned to a project on Smart Regression, while a third intern was fully dedicated to the Test team. This project was well planned by the Cisco team even before students arrived.

  As part of the automation and testing, a large suite of testcases are included in each regression. Thus, when there are changes in the new software code for the call manager, all these testcases must be run. However, due to the large number of testcases, this regression takes several hours. The students were responsible for creating a system that would indicate only the testcases that were needed to be run depending on which parts of the code that had been changed in the new software build. As part of this effort, they were responsible to run all testcases in a regression suite, collect information about code coverage (i.e., which parts of the code and how many lines of code were tested by each testcase), and save this information in a database.

  To accomplish the above tests, the students learned several skills: writing scripts to run the testcases and collect data using Groovy/Java[7], working with a MySQL database, creating a web-based Grails[7] application (Figure 1) so that all team members could access. In conclusion, this project gave the students an excellent experience on software testing and data collection.

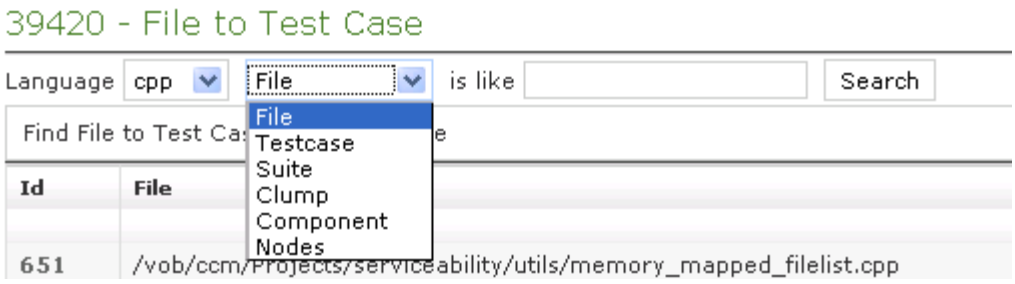

Figure 1 - File to testcase tool developed by the interns

- *Usability Study*

We started the partnership with an initial, short-term project in which three undergraduate students conducted a usability study of a new user interface (UI) developed for the call managers. It started in April and continued in the summer months. It definitely helped the Texas A&M team to get familiar with the Cisco product and prepare the students for their internship.

The method of evaluation was simple, based on a heuristic parameters[4] that are well defined for determining the usability of web pages or user interfaces. In addition, students helped organized a survey. Nine evaluators (students from non-engineering majors, such as animal science and general studies) performed the small task of adding a user and a phone in the call manager UI, and answered a survey. This study was useful to Cisco as an early field trial (EFT) of their new UI. Figure 2 shows the equipment setup using the IP phones and call managers that Cisco provided to the Texas A&M laboratory.

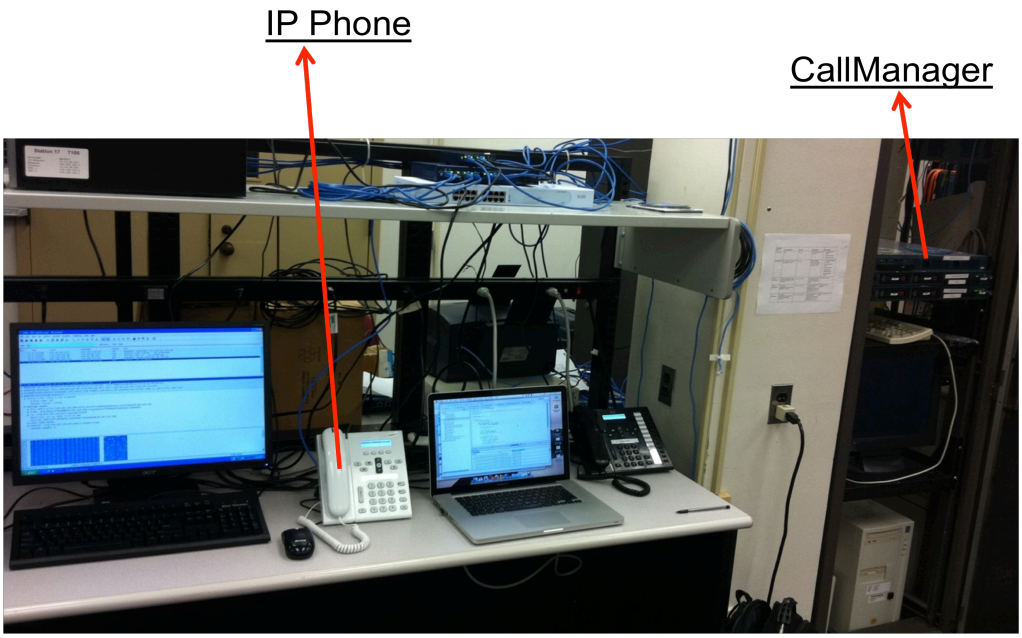

Figure 2 - Test equipment setup for the usability study

- *Finite State Machine Drawing Tool (iFSM)*
  Finally, the iFSM project illustrates how the faculty fellow contributed to the Cisco's team. There was a need to document the finite state machine code, which represents a core part of the call manager's operation. This code is written in C++ and contains keywords that define a Specification and Description Language (SDL) state machine. Then, one of Cisco principal engineers proposed the creation of a tool that would automatically parse the C++ code looking for state machine keywords and create an SDL diagram of the finite state machine. The Texas A&M faculty dedicated her time to create this tool (Figure 3). The drawing tool used was Graphviz, which is a graphical tool developed by AT&T. It is an open source tool, with which the faculty became familiar and later introduced it to the students in her classroom.

Figure 3 - Finite state machine drawing tool developed by the faculty fellow

Project Management using the Agile Process

The technical projects that students and faculty worked on were planned and implemented using a project management method called "Agile"[5]. Traditional project management (both for software and hardware products) uses a phased approach, such as the Waterfall approach used in software development. In the Waterfall approach we have the following phases: Requirements, Specification, Code, Testing, and Release. However, using the Agile approach, the projects are very iterative and incremental. The requirements are defined as "User Stories", and at each iteration, a User Story is expanded, coded and tested. The iterations that we worked on were three-weeks long. In this way, the students' tasks were defined incrementally, and after each three-week iteration, they had to demonstrate that something was accomplished. Figure 4 illustrates the progress of one of the Texas A&M iterations.

This idea of Agile was new to all members of the Texas A&M team. Students and faculty were exposed to this new concept in project management, learned the process, and appreciated the way their work was planned and managed. This was one of the keys of achieving success in the three projects previously described.

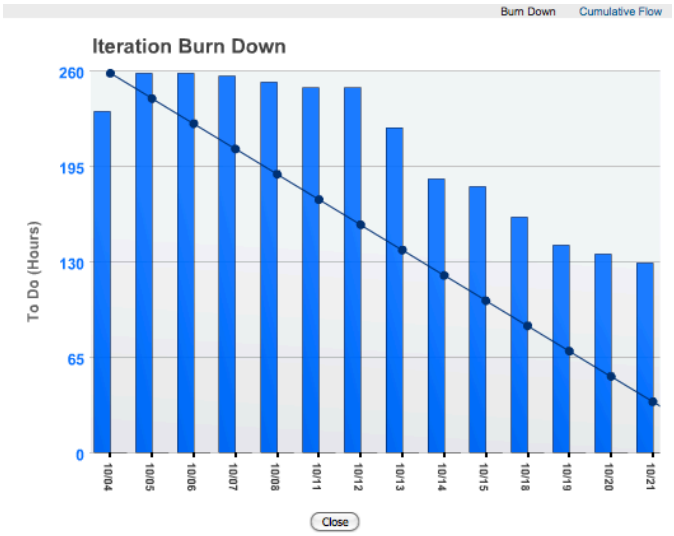

Figure 4 - Monitoring the progress of one Agile iteration

Lessons Learned

Here are some of the main lessons learned during this collaboration:

- Students can contribute immediately to projects, given adequate specifications and mentoring. They learned our development processes quickly after some introductory presentations, and, with occasional mentoring, began work on their user stories.
- Taking time to mentor the students is critical to their success. At first, we used some extreme programming techniques, helping them to get started designing/coding, to boost their confidence. Once they began to feel more comfortable, they began to ask more questions, and make good suggestions toward improving our software.

- Give adequate explanation of the work you are requesting. We used User Stories (in an Agile scrum team setting) to describe the work being requested, and worked with the students to fill in the tasks necessary to fulfill the acceptance criteria. Having the team, students and team developers, collaborate to fully describe tasks necessary to complete a user story benefitted students giving them a clear explanation of what is needed and empowered them as colleagues to raise questions.
- Ensure that each assignment is tractable and can be completed within a three-week iteration. In this way, students' confidence improves with their successes and can give feedback about their work within a short timeframe.

Conclusions

This paper described an industry-academia partnership that has been a win-win collaboration for both partners. The Texas A&M team has contributed to Cisco in projects that helped improve their operations, and the Cisco support to students and faculty has been outstanding. Both industry and academia have a common long-term vision, and that is a key point of this on-going collaboration.

The funding from Cisco came in different ways. The three interns were funded directly by Cisco, while the faculty fellowship was funded as a research project, which included the faculty's salary for the summer months and travel expenses. However, the Texas A&M and Cisco negotiations were a lengthy process, and a new funding model has finally been setup. After the summer work at Cisco, there was a new research project, which occurred in the Texas A&M campus. During this follow-up project we had new contract guidelines and non-disclosure agreement (NDA) defined between Texas A&M research agency and the Cisco research department.

The outcomes from this collaboration are benefitting the students directly. As we mentioned, a new project was funded during the Fall 2010 semester and we are just starting a new Spring 2011 project. The students are gaining a lot of experience on software development, on IP telephony systems, and on Agile project management. As engineering becomes a cross-discipline approach[6], such skills will benefit the students in whichever career path they choose.

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