2006-2628: THE ROLE OF APPLICATION DOMAIN TRACKS IN SOFTWARE ENGINEERING PROGRAMS

Donald Bagert, Rose-Hulman Institute of Technology

DONALD J. BAGERT Dr. Bagert is the Director of Software Engineering and a Professor of Computer Science and Software Engineering at the Rose-Hulman Institute of Technology in Terre Haute, Indiana. His research interests include software process improvement, software tools for student advising, and software methodologies. Dr. Bagert is a registered Professional Engineer in software engineering in the state of Texas. Contact him at Don.Bagert@rose-hulman.edu.

© American Society for Engineering Education, 2006

The Role of Application Domain Tracks in Software Engineering Programs

Abstract

Although it is generally acknowledged that understanding domain-specific information is essential for the proper development of software in that application area, requiring the inclusion of a particular application domain as part of a software engineering curriculum is a relatively recent occurrence. In particular, ABET software engineering program criteria (in use since 2002) and the joint IEEE-CS/ACM software engineering curriculum model released in 2004 both specify the ability to work in at least application domain as a requirement of graduates of baccalaureate software engineering degree programs. This paper will examine how the ABET-accredited software engineering degree programs have implemented these application domain tracks.

1. Introduction

Every software product is intrinsically tied to a particular application area. Over the years, as both the quantity and processing power of computers increased while their relative cost has decreased, the number of domain areas for which software is developed has continuously grown. The advent of undergraduate software engineering (SE) degree programs in the United States – all but one of them having started since 1999[5] - has caused the stakeholders in the SE education community to consider how to ensure that graduates are able to apply their knowledge to development of software in a particular domain area. Many such programs have created a "domain track" in one or more application areas and include the completion of such a track as a degree requirement.

This paper will discuss the implementation of such application domain tracks in U.S. software engineering undergraduate degree programs. Section 2 provides some background, while Section 3 describes how some accredited software engineering programs are implementing domain tracks, including the results of a survey of those programs. Finally, Section 4 looks at possible future directions for both the implementation of these domains, and the measuring of their effectiveness.

2. Background

Courses in various application domain areas have been prevalent in computing curricula for several decades in areas such as real-time and information systems. However, traditionally such courses have been recommended as individual electives rather than as a set of courses. However, there are instances of domain-oriented computing curricula, the most frequently-appearing example being management information systems (MIS) programs, which focuses on business applications.

The first software engineering degree programs in the United States were at the Master's level. Once again, application domain courses were often included as individual electives. The Software Engineering Institute (SEI) graduate curriculum model published in 1989[2] included

five categories of electives, one of them being "application domain topics"; one particular course discussed in more detail was in embedded real-time systems. A 2005 survey of Master's degree programs in software engineering[6] found that virtually all such programs included application domain electives, with more frequently listed domains being real-time embedded systems, networks, safety and wireless communication. That survey also noted one graduate program focused on a particular area: the Master of Science in Engineering with a concentration on Embedded Software Engineering at Gannon University.

In 1990, Gary Ford of the SEI suggested a model curriculum[8] that would be compatible with the general requirements for the ABET Engineering Accreditation Commission. Once again, application domain electives were suggested.

In 1997-99, the Working Group on Software Engineering Education and Training (WGSEET) developed the *Guidelines for Software Engineering Education*[3], which subsequently became the *de facto* source for undergraduate software engineering curriculum models for the next several years. This was perhaps the first curriculum model to state that there should be a required "Application Domain Component" in a software engineering curriculum. By 2002, a survey of U.S. software engineering degree programs stated that "Many of the degree plans also required the student to take three or more courses in a particular application domain are…Some of the institutions require a particular application domain (e.g. Mississippi State requires one in computer security), while others (such as the Milwaukee School of Engineering) allow the student to choose among one of several possible domain areas."[4]

The *Guidelines for Software Engineering Education* have recently been supplanted by *Computing Curricula-Software Engineering (CCSE) 2004*, a more comprehensive joint project of the IEEE Computer Society and ACM, the primary computing professional societies in the United States, which states that "As part of an undergraduate software engineering education, students should specialize in one or more [application] areas" [9].

Meanwhile, work was progressing on criteria that would be used by ABET to accredit software engineering programs. In 1999, an IEEE-CS/ACM joint task force had recommended that accreditation criteria for software engineering "should include work in one or more significant application domains"[7]. ABET included almost identical wording, requiring that "the ability to work in or more significant application domains" in its software engineering criteria since it first started accrediting SE programs in 2002[1].

3. Application Domains of Accredited Undergraduate Software Engineering Programs

3.1 Survey Responses

As of 1 October 2005, there were ten software engineering programs accredited by the Engineering Accreditation Commission of ABET[10]. The author sent a short survey concerning application domain tracks to the coordinators of those programs (see Appendix A); five were filled out and returned. The responding schools and their application domains are listed in Table 1.

Institution	Application Domains
Auburn University	Senior Project domain area, including • Artificial Intelligence • Compiler Front-ends • Database Systems • Software Engineering Tools • Wireless Engineering
Embry-Riddle Aeronautical University (Florida)	Aviation and Aerospace
Monmouth University	Embedded and Real-Time Software
University of Michigan-Dearborn	Game Design Information Systems Web/Database Engineering
University of Texas at Arlington	Senior Project domain area

Table 1. Application Domain Areas of Survey Respondents.

3.1.1 Domain Track Criteria

The survey respondents were asked to specify what criteria they use to determine their application domain areas and courses. Michigan-Dearborn's "rule of thumb" is "6 to 8 hours of course work in one of [their] 3 tracks…"

Monmouth lists only a single application domain. Monmouth's reasoning for embedded and real-time software is that it is "Very practical - we do not have enough students for multiple domains. [Embedded and real-time software] seems to be the area in most demand among our local employers."

Embry-Riddle's Aviation and Aerospace application domain is intrinsic with the mission of their university, and is therefore covered in several different area of SE major study, including "air traffic management, business, human factors, mathematics and meteorology", according to the survey response.

Two schools, Auburn and The University of Texas at Arlington, use senior projects to satisfy their application domain requirement, with no additional courses specifically required. Auburn lists "wireless, artificial intelligence, database systems, compiler front-ends, and software engineering tools" among their project domain areas.

3.1.2 Impact on Graduates

All of the survey respondents agree that their application domain area(s) helps prepare the students for the workplace (one reports that it helps their graduates meet program outcomes). Another school reported higher salaries in its application domain area, and another reports a number of graduates having gained employment in their domain area. Still, to date there is insufficient data to make a definitive conclusion about whether requiring an application domain

track is having an impact in the preparedness or marketability of software engineering graduates in the workplace.

3.2 Other ABET-Accredited Programs

Table 2 lists application domain track information for the ABET-accredited software engineering schools who did not respond to the survey. This information was obtained from the website for each of these institutions.

Institution	**Application Domains**
Clarkson University	Electrical and Computer Engineering
Florida Institute of Technology	Unknown
Milwaukee School of Engineering	Applied Optics and Photonics Commercial Applications Computer Gaming Computer Networks Data Communication Digital Signal Processing Electrical Engineering Industrial Engineering: Automation Industrial Engineering: Manufacturing Industrial Engineering: Simulation Mechanical Engineering
Mississippi State University	Computer Security
Rochester Institute of Technology	Artificial Intelligence Commercial and Management Applications Computer Engineering Computer Games Computer Graphics Communications and Networks Embedded Systems Imaging and Publishing Technology Industrial and Systems Engineering Mechanical Engineering Microelectronic Engineering Scientific and Engineering Computing

Table 2. Application Domain Areas of Other ABET-accredited schools.

3.2.1 Domain Track Criteria

The Clarkson University curriculum at http://www.clarkson.edu/ece/handbook/software.html does not list a specific application domain; however, each major is required to take several electrical and computer engineering courses, enough to count as a domain area.

Florida Tech's SE program at http://www.fit.edu/catalog/documents/2006_2007catalog.pdf does not list a specific application domain track. It therefore appears that the two-term senior project is involved in determining the domain area, or there is a domain embedded within several courses (as at Embry-Riddle).

The Milwaukee School of Engineering application domains are found on the MSOE website by going to http://www.msoe.edu/eecs/cese/courses/curriculum.php?progcode=SE and clicking on "Application Domain Elective". The webpage also states that "the application domain elective sequence requires a minimum of 9 hours [3 courses]".

The Mississippi State computer security application domain track is embedded within several courses in the SE curriculum (http://www.cse.msstate.edu/UNDERGRADUATE/BSSE.php), in a similar manner to Embry-Riddle. Also, several of the SE majors work at their Center for Computer Security Research (http://www.security.cse.msstate.edu/scholarships.shtml) through funding from the Department of Defense's *Information Assurance Scholarship Program* and a similar National Science Foundation program.

The Rochester Institute of Technology application domain tracks are listed on their website at http://www.se.rit.edu/appdomain.php. Each of their domain tracks are three courses long. The site also notes that "On occasion a student might identify an application domain not listed in our website. We have a process in place which students can use to propose an application domain different from the ones we have identified. We reserve the right to accept or reject the proposed domain." (Rose-Hulman – the author's place of employment – has also adopted this policy.)

3.3 Program Comparisons

To summarize the results by implementation type:

- Five ABET-accredited programs have their application domain track implemented as a sequence of courses (mostly three in number),
- Two programs implement the domain tracks using senior projects,
- Two programs have their application domain embedded within several required courses, and
- One program's domain(s) are unknown, but from the curriculum structure is in one of the latter two categories.

At least 5 of the 10 programs allow their students to take more than one application domain area. Certain domains are allowed at either two or three different schools (sometimes under slightly different names):

- Artificial Intelligence – 2 institutions
- Commercial Applications – 3
- Communications and Networks – 3
- Computer Gaming – 3
- Database Systems – 2

- Electrical and/or Computer Engineering – 3
- Embedded Systems – 2
- Industrial Engineering – 2
- Mechanical Engineering – 2

At the same time, this means that all domain areas appear in less than half of the accredited schools.

4. Future Directions

Those surveyed were asked about how they saw application domains evolving at their school over the next several years. Three of the schools responding to the survey that use multiple domain tracks said that at least one more domain would likely be added in the near future. One of the two schools survey using senior projects foresaw focusing on a particular domain, while the other was unsure of what would happen.

It is unclear how effective is to have a senior project in an application domain without the prerequisite knowledge from a set of prerequisite application domain courses, or vice versa. So, one possibility to investigate would be a multi-course domain track as well as a senior project in that area. However, for a school having more one than one track, it might be difficult to match students with the right senior project clients on a year-to-year basis.

As stated in Section 3.2.1, there is to date insufficient data to make a definitive conclusion about whether requiring an application domain track is having an impact in the preparedness or marketability of software engineering graduates in the workplace. So, a potential research project would be determine whether or not the inclusion of application domains are having an impact on the workplace, and if so, whether a certain type of domain or certain type of implementation (e.g. through senior projects) is having more of a positive impact.

Acknowledgments

The authors which to thank the following software engineering education colleagues in the software engineering education community which provided information for this paper:

- James Cross, Auburn University
- David Kung, University of Texas at Arlington
- Bruce Maxim, University of Michigan-Dearborn
- Jim McDonald, Monmouth University
- Massood Towhid Nejad, Embry-Riddle Aeronautical University (Florida)

References

1. ABET Engineering Accreditation Commission. *Criteria for Accrediting Engineering Programs,* ABET, Inc., Baltimore, Maryland, USA, 17 November 2004.

2. Ardis, Mark A. and Ford, Gary A., *1989 SEI Report on Graduate Software Engineering Education*, Carnegie Mellon TR CMU/SEI-89-TR-21, June 1989.

3. Bagert, Donald J.; Hilburn, Thomas B.; Hislop, Greg; Lutz, Michael; McCracken, Michael and Mengel, Susan., *Guidelines for Software Engineering Education Version 1.0*, Technical Report CMU/SEI-99-TR-032, Software Engineering Institute, Carnegie Mellon University, Pittsburgh PA, October 1999.

4. Bagert, Donald J. and Ardis, Mark A, "Software Engineering Baccalaureate Programs in The United States: An Overview", *Proceedings of the Frontiers in Education Conference*, Boulder, Colorado, USA, 5-8 November 2003, pp. S3C-1 to S3C-6.

5. Bagert, Donald J. and Chenoweth, Stephen V., "Future Growth of Software Engineering Baccalaureate Programs in the United States. *Proceedings of the ASEE Annual Conference,* Portland, Oregon, USA, 12-15 June 2005, CD-ROM, 8 pp.

6. Bagert, Donald J. and Mu, Xiaoyan, "Current State of Software Engineering Master's Degree Programs in the United States", *Proceedings of the Frontiers in Education Conference,* Indianapolis, Indiana, USA, 19-22 October 2005, CD-ROM, 8 pp.

7. Engel, Gerald L. "Program Criteria For Software Engineering Accreditation Programs," *IEEE Software,* Vol. 16, No. 6 (November/December 1999), pp. 31-34.

8. Ford, Gary A., *1990 SEl Report on Undergraduate Software Engineering Education,* CMU/SEI-90-TR-3, Carnegie Mellon University, Pittsburgh, Pennsylvania, USA, 1990.

9. Joint Task Force on Software Engineering Curricula, *Software Engineering 2004: Curriculum Guidelines for Undergraduate Degree Programs in Software Engineering*, ACM Press and IEEE Computer Society Press, 23 August 2004.

10. Website - http://www.abet.org/accrediteac.asp.

Appendix A
Survey Sent to U.S. Undergraduate Software Engineering Programs

1. Name of school:

2. What application domain(s) do you use to satisfy ABET software engineering criteria? (Just the names of each domain are sufficient, but if you have a more detailed description, please feel free to attach or send a link to it.)

3. Please answer part (a) if you have allow only one application domain, and part (b) if you have more than one.

   (a) What is your rationale for having a single application domain area?

   (b) What are your "rules of thumb" which all of your application domains follow? (e.g. at least 12 hours of coursework, senior project must be in that area)

4. What impact do you feel that your application domain(s) have had on graduates once they reach the workplace?

5. How do you see the role of application domains at your school evolving (if at all) over the next few years?