2006-558: IMPLEMENTATION OF INFORMATION ASSURANCE AND SECURITY IN EXISTING IT CURRICULA

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Session xxx

Implementation of Information Assurance and Security In Existing IT Curricula

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Abstract

The IT2005 model curriculum describes Information Assurance and Security as a pervasive theme that must be integrated throughout the IT curriculum. The associated knowledge area provides a minimum set of outcomes associated with this important subject. Implementing a knowledge area that is required across the entire curriculum is a significant challenge, since security has historically been given weak coverage in computing courses. In this paper we introduce the approaches used in two IT programs for implementing the IT2005 requirement for IAS as a "pervasive theme". We also include a brief introduction to IT2005 and to the Information Assurance Education community. It is our belief that any program that is preparing students to deploy computing technology in the current world environment should include security concerns in the curriculum. We hope that our experience can help others achieve this important goal.

Introduction

The Information Assurance and Security knowledge area in IT2005[1] was created through the interaction of the Information Technology and Information Assurance education communities.[2] Information Assurance and Security is one of 8 (Figure 1) pervasive themes introduced IT2005. The committee states "that these topics are best addressed multiple times in multiple classes, beginning in the IT fundamentals class and woven like threads throughout the tapestry of the IT curriculum"[3]. These themes are referenced in various knowledge areas, however, Information Assurance and Security is also a KA of it's own.

The IT community that has become SIGITE, the ACM Information Technology Education SIG, began the formal organizational process in Dec. 2001 with a meeting near Provo, Utah. By the spring of 2005 SIGITE had held 5 academically oriented conferences and produced numerous conference papers to explain the process,[4 5 6 7 8 9 10 11 12] and its committees had produced drafts of the IT accreditation criteria with ABET [13]participated in the creation of the Computing Curriculum Overview Document (CC2005)[14] and the IT2005[15] model curriculum. Three IT programs received accreditation through CAC of ABET in 2005. The IT community received international attention with presentations at conferences in South America, Europe, and China. And many IT programs are well on their way to implementing the IT model curriculum.

Pervasive Themes in IT2005

1. user advocacy
2. information assurance and security
3. ethics and professional responsibility
4. the ability to manage complexity through: abstraction & modeling, best practices, patterns, standards, and the use of appropriate tools
5. a deep understanding of information and communication technologies and their associated tools
6. adaptability
7. life-long learning and professional development
8. interpersonal skills

Figure 1

Information assurance has been defined as "a set of measures intended to protect and defend information and information systems by ensuring their availability, integrity, authentication, confidentiality, and non-repudiation." (National Security Agency, http://www.nsa.gov/ia/iaFAQ.cfm?MenuID=10#1).[16] Information assurance education, then, includes all efforts to prepare a workforce with the needed knowledge, skills, and abilities to assure our information systems, especially critical national security systems. Information assurance education has been growing in importance and activity for the past two decades. In 1998 there were seven universities recognized as Centers for Academic Excellence in Information Assurance Education (CAEIAE); in 2005 there were more than 60 recognized CAEIAE institutions and the number is likely to grow to almost 70 in 2006. The institutions and their respective programs are diverse and include: research and teaching institutions with programs in computer science, management information systems, and information technology. The work being done by SIGITE is important to the further expansion of information assurance education as information assurance expands beyond the development of information systems to include the entire system life cycle including deployment, operation, maintenance, a retirement of such systems.

Information Assurance and Security in the IT2005 Model Curriculum

If a knowledge area (KA) is to be “threaded” through a curriculum, the framework must be introduced early and then elaborated throughout the educational process. Fortunately, IT2005 uses a model that can:

1. be understood by freshman IT students
2. provide a framework to integrate IAS concepts that are integrated into nearly all of the other KAs

3. be rich enough to support a senior level course that ties everything together.

Figure 2 is a list of the IAS KA and its areas. The basic structure and vocabulary is derived directly from work done in the IA community, specifically Maconachy, et. al[17]. The number in parenthesis is the number of lecture hours the committee thought would be required to give an IT student minimum exposure to the unit. It should be noted that the ordering of units in all of the KAs, is first "Fundamentals", if there is one, and then the units are sorted in order of the number of core hours. This ordering should not be considered as any indication of the order the units would be covered pedagogically in an implemented curriculum.

The model is a cube (see Figure 2) that provides a simple visual representation that a freshman can understand, yet the 3 dimensional structure facilitates the detailed analysis required for use in technology specific contexts, and is comprehensive enough to encompass a capstone learning experience.

IAS. Information Assurance and Security (23 core hours)
- **IAS1. Fundamental Aspects (3)**
- **IAS2. Security Mechanisms (countermeasures) (5)**
- **IAS3. Operational Issues (3)**
- **IAS4. Policy (3)**
- **IAS5. Attacks (2)**
- **IAS6. Security Domains (2)**
- **IAS7. Forensics (1)**
- **IAS8. Information States (1)**
- **IAS9. Security Services (1)**
- **IAS10. Threat Analysis Model (1)**
- **IAS11. Vulnerabilities (1)**

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Figure 2

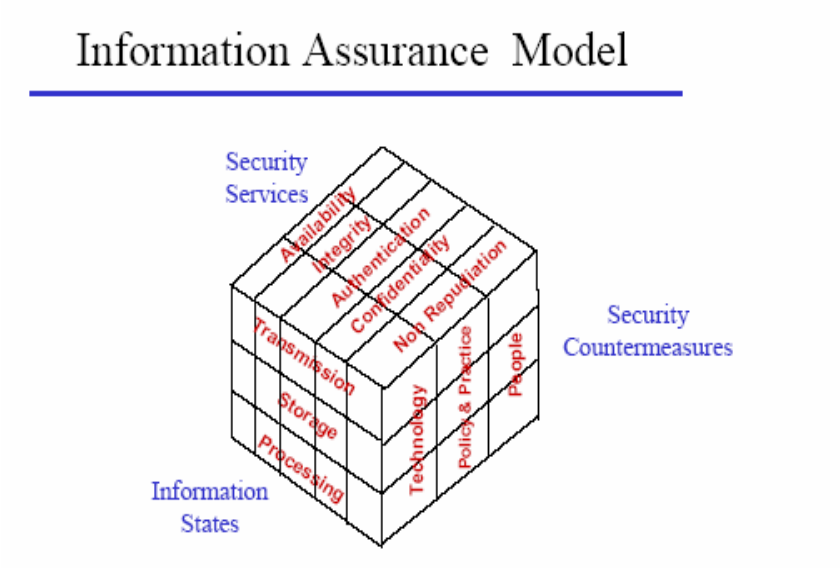

Figure 3

Integrating IAS into the BYU Curriculum

The BYU curriculum has evolved into what IT2005 calls a "core/integration first" approach[18]. Significant portions of the introductory material in operating systems, databases, web systems, networking had been moved to lower division courses by early 2004. Much of the shift occurred when the introduction to web systems was moved from the junior to the sophomore year and introductory material sufficient to understand web systems was included for networking, databases, operating system administration and OS process models. The improvements in flow and reduced redundancy have been noticeable in the upper division core courses. In late 2004 and early 2005 we began implementing the "pervasive theme" of IAS in earnest..

A senior level IAS class had been introduced into the curriculum in early 2004 and was made a requirement in 2005. However, we recognized that simply adding a required course at the end of a student's college experience would not be adequate. SIGITE discussions had placed security in the pervasive theme category at the very beginning, though the name of the KA wasn't chosen until 2004. We were faced with the challenge of integrating the IAS fundamentals into the introductory courses, morphing the security modules in the existing classes to use the MSRW[19] framework and bringing all of the students in the program up to speed on the new framework simultaneously.

Our approach has been to prepare one hour modules on the MSRW framework that can be used in an existing course to bring students up to speed or taught in seminars as needed. We are in the process of integrating the IAS Fundamentals into our introductory courses. We successfully integrated the IAS modules into the sophomore introduction to web-based systems course, which was already introducing all of the major IT areas. The course was modified to replace a 3 week team project experience with a 2 week team oriented lab and then using the time for IAS topics. Much remains to be done, but the initial experience is positive. The faculty seems unified in their desire to implement IAS as a pervasive theme. For example, 2 lecture and 3 lab hours are now included in the computer communications course. 3 lecture hours and 3 lab hours were added to the web

systems course. The IAS component of the database course was rearranged and strengthened with 1 lecture hour added. Similar adjustments have been made throughout the curriculum.

Integrating IAS into the Existing Purdue Curriculum

Two senior level IAS classes have been introduced into the curriculum at Purdue University. The first is entitled Network Security and the second is Introduction to Cyberforensics. There is also a Biometrics course offered in another department that CIT students at Purdue can take. In addition, we are currently developing an Applied Cryptography class for undergraduates. The combination of these four courses addresses most of the topics outlined in the Information Assurance and Security knowledge area of IT 2005. However, some of the fundamental aspects (IAS1) and operational issues (IAS3) are covered as topics in introductory and intermediate courses, which helps fulfill the prescription that IAS also be a pervasive theme.

In addition, the IAS courses serve the purpose of helping students achieve program outcomes. At Purdue we have found that our IAS courses map to the following IT program outcomes.

General student outcomes:

1. ability to apply knowledge of computing and mathematics appropriate to the discipline;
2. ability to function effectively on teams to accomplish a common goal;
3. understanding of professional, ethical and social responsibilities;
4. ability to analyze the impact of computing on individuals, organizations and society, including ethical, legal, security and global policy issues;
5. recognition of the need for, and an ability to engage in continuing professional development;
6. ability to use current techniques, skills, and tools necessary for computing practice.

Specific student outcomes:

1. ability to use and apply current technical concepts and practices in core information technologies;
2. understanding of best practices and standards and their application;
3. ability to assist in the creation of an effective project.

Summary of Implementation Approaches

In this section we categorize the techniques that we have used to integrate the IAS knowledge area from IT2005 into our programs.

1. Slip-streaming: This approach requires the opportunistic insertion of current events into discussions in the existing curriculum. For example, during a discussion of C I/O one could take 5 minutes and discuss how one of the SMTP buffer-overflow problems allowed a root kit to insert its code into a buffer and execute it because the code assumed that no one would ever enter more than 2000 characters without an end of line. It would also be wise to point out that one

should probably never use unbounded routines like “gets” and “puts” in production code because you are creating potential buffer overflow conditions every time they are used.

2. Mini-topics: This approach requires the preparation of 5-10 minute topic presentations covering IAS issues such as buffer-overflow and the dissemination of the curriculum materials to the faculty so that it requires minimal preparation to insert IAS content into existing lectures.
3. Complete lectures: This approach is useful when remedial instruction must be inserted into an existing course for students that attended a course before a topic was integrated into the current perquisite. The creation of 1 hour stand-alone lectures on various topics also allows one to easily create seminar sessions to help lab and teaching assistants understand the changes to content of courses as they evolve.
4. Modules of instruction: We have found that some topic areas simply don’t fit into a 1 hour format. For example, if one wanted to include digital forensics and media analysis in an operating systems class, one could insert a module on evidence gathering and chain of custody along with the technical aspects of media analysis. It is interesting that some students commented that they never understood file systems until they dissected them using forensic tools, thus providing a secondary benefit of the integration.
5. Companion courses: This approach takes an existing 3 credit hour technical course (such as Operating Systems) and adds a 1 credit hour companion course that focuses on IAS issues as they relate to the topic of the 3 credit hour course.
6. Complete courses: This is the most common approach to adding content to a curriculum. We have found that great efficiency in presentation can be gained by looking at course outcomes of the curriculum as a whole and then refactoring topic coverage to incorporate fundamental concepts early. In one case we found that certain topics were being covered 3 times at an introductory level in upper division courses because they didn’t share a common prerequisite and could be taken in different sequences. Putting introductions to operating systems concepts, databases, information assurance, networking, and system administration into a sophomore course freed 2-4 weeks of contact hours in each of our junior core courses. The additional time was used to include coverage of more advanced concepts.

Conclusion

Information Technology is maturing rapidly as an academic discipline. A public draft of the IT volume described in the Computing Curriculum 2005 Overview is ready for review. The SIGITE Curriculum Committee is soliciting feedback on the document. This paper presents a brief history of SIGITE, the ACM SIG for Information Technology Education, and a brief introduction to the Information Assurance Education community. We have discussed the integration of Information Assurance and Security concepts into IT2005 as a “pervasive theme” and have given examples of how existing IT programs have integrated IAS concepts into their curriculum.

In conclusion, we believe that a weakness in many computing programs is the inadequate treatment of security topics throughout the curriculum. The IT2005 model curriculum has benefited significantly through collaboration between the Information Assurance Education and IT Education communities. It is an axiom of system development that security is built in more effectively that it is added on. The IT2005 curriculum document requires that IAS be treated throughout the curriculum and we have given examples of how this can be accomplished

We have demonstrated that it is possible to integrate Information Assurance and Security concepts as a pervasive theme into an existing IT curriculum as is recommended by IT2005. We believe that the approaches we have used can be applied in other computing disciplines.

SIGITE and the CC 2005 Joint Task Force solicit feedback on the documents at http://www.acm.org/education/ .

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[1] SIGITE Curriculum Committee (2005), Computing Curriculum 2005, IT Volume (IT2005), http://www.acm.org/education/curric_vols/IT_October_2005.pdf

[2] Dark, M. Ekstrom, J. Lunt, B. *Integration of Information Assurance and Security into the IT2005 Model Curriculum,* SIGITE 2004, Newark, NJ

[3] IT2005, def of pervasive themes

[4] "What Is the New Discipline of Information Technology? Where Does It Fit?", by Barry Lunt, Han Reichgelt, Tina Ashford, Andy Phelps, Erick Slazinski, Cheryl Willis; Conference for Industry and Education Collaboration (CIEC) 2003, Jan 28-31, 2003, Tucson, AZ; proceedings on CD-ROM (no page numbers).

[5] "An Empirical Comparison of Baccalaureate Programs in Computing", by Barry Lunt, Han Reichgelt, Tina Ashford, Andy Phelps, Erick Slazinski, Cheryl Willis; Proceedings of the 2003 International Conference on Engineering and Computer Education (ICECE) Mar 17-20, 2003, Santos, SP, Brazil; proceedings on CD-ROM (no page numbers).

[6] "An Empirical Comparison of Baccalaureate Programs in Computing", by Tina Ashford, Barry Lunt, Han Reichgelt, Andy Phelps, Erick Slazinski, Cheryl Willis; Proceedings of the 2003 Interdisciplinary Conference for Teachers of Undergraduates, Wenham, MA, March 2003; proceedings on CD-ROM (no page numbers).

[7] "Education at the Seams: Preparing Students to Stitch Systems Together; Curriculum and Issues for 4-Year IT Programs", by Joseph J. Ekstrom, Barry Lunt; Proceedings of CITC-4 2003, October 16-18, West Lafayette, IN; p. 196-200.

[8] "A Comparison of Baccalaureate Programs in Information Technology with Baccalaureate Programs in Computer Science and Information Systems", by Han Reichgelt, Barry Lunt, Tina Ashford, Andy Phelps, Erick Slazinski, Cheryl Willis; Journal of Information Technology Education, vol 3, 2004, pp 19-34.

[9] "Education at the Seams: Preliminary Evaluation of Teaching Integration as a Key to Education in Information Technology", by Joseph Ekstrom, Barry Lunt, C. Richard Helps; 2004 ASEE Annual Conference and Exposition, June 20-23, 2004, Salt Lake City, UT; proceedings on CDROM (no page numbers); session 1450.

[10] "Defining the IT Curriculum: The Results of the Past 2½ Years", by Barry Lunt, Joseph Ekstrom, Sandra Gorka, Reza Kamali, Eydie Lawson, Jacob Miller, Han Reichgelt; 2004 ASEE Annual Conference and Exposition, June 20-23, 2004, Salt Lake City, UT; proceedings on CDROM (no page numbers); session 2558.

[11] "Defining the IT Curriculum: The Results of the Past 3 Years"; Informing Science and Information Technology Education (InSITE) 2005, Flagstaff, AZ, USA, June 16-19. Barry Lunt, Joseph Ekstron, Edith Lawson, Reza Kamali, Jacob Miller, Sandra Gorka, Han Reichgelt. Vol 2, pages 259-270.

[12] "Defining the IT Curriculum: The Results of the Past 2½ Years"; Proceedings of the International Conference on Engineering Education and Research (iCEER), June 27-30, 2004, Olomouc, Czech Republic. 2004; BARRY M. LUNT, Joseph J. Ekstrom, Edith A. Lawson, Reza Kamali, Jacob Miller, Sandra Gorka, Han Reichgelt; Proceedings on CD-ROM (no page numbers)
[13] ABET draft IT criteria
[14] Joint Task Force for Computing Curricula (2005), Computing Curricula 2005: Overview Document (CC2005), http://www.acm.org/education/curric_vols/CC2005_Final_Report2.pdf retrieved Jan, 16, 2006
[15] IT2005 (ibid)
[16] National Security Agency , Information Assurance: Frequently asked questions http://www.nsa.gov/ia/iaFAQ.cfm?MenuID=10#1 retrieved Jan. 16, 2006
[17] Machonachy, W. Victor; Schou, Corey D.; Ragsdale, Daniel; Welch , Don; "A model for Information Assurance: An Integrated Approach", Proceedings of the 2001 IEEE Workshop on Information Assurance and Security, United States Military Academy, West Point , NY, 5-6 June 2001.
[18] IT2005 Section 6.3
[19] ibid ref 17