Integration of the Cisco Networking Academy at a Four-Year University

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Background

The Information Technology (IT) program at The University of Southern Mississippi began as a transfer option for community college students majoring in computer programming technology. When implemented this option satisfied resource constraints of space, funding, and faculty. For the first two years, the option worked in that the degree offered was interdisciplinary with major courses provided by computer science and business. The only expenditure was faculty advisor time for less than fifty majors. This degree option might have continued, but a program accreditation visit required curriculum changes and a separate degree program. An application for a new degree program was approved in 1997. The concept was to offer the degree as an interdisciplinary program with most of the required courses taken from different academic units within the university, e.g. computer science and business.

The interdisciplinary program would have been implemented; however, a proposal to establish an articulated degree program was approved by the National Science Foundation (NSF). Because of budget constraints and the difficulty of having a new degree program approved by the state governing board, university administration decided to utilize the approved interdisciplinary program to develop the new degree program. As a subcontract of NSF grant number DUE-9950085, the university received funds to develop a four-year articulated curriculum in computer networking. This funding provided the justification to acquire laboratory space, faculty, and equipment that would not have been available otherwise.

Program Development

To articulate the community college curriculum, a faculty committee compared published course outcomes to develop equivalent courses offered by the university. Table 1 shows the original list of courses identified as transferable into the four-year degree. Of the 15 courses identified, nine had academic equivalents already in place leaving six courses to be created. The content areas for these courses were system maintenance, data communications, network components, network planning & design, project management, and operating platforms. These courses were created along with 13 other courses to complete the four-year curriculum.

Collectively, the courses offered a two-course sequence in computer architecture & maintenance, a four-course sequence in local area networking, a four-course sequence in wide area networking, a five-course sequence in Windows client-server networking, a two-course sequence in open source client-server networking, and a two-course senior capstone sequence.
Table 1: Community College Transfer Courses

<table>
<thead>
<tr>
<th>Course Number</th>
<th>Hrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENG 1113</td>
<td>3</td>
</tr>
<tr>
<td>ENG 1123</td>
<td>3</td>
</tr>
<tr>
<td>MAT 1313</td>
<td>3</td>
</tr>
<tr>
<td>PSC 1113</td>
<td>3</td>
</tr>
<tr>
<td>SPT 1113</td>
<td>3</td>
</tr>
<tr>
<td>PHY 1213</td>
<td>3</td>
</tr>
<tr>
<td>CNT 1513</td>
<td>3</td>
</tr>
<tr>
<td>WNT 1513</td>
<td>3</td>
</tr>
<tr>
<td>WNT 2723</td>
<td>3</td>
</tr>
<tr>
<td>CNT 1614/2634</td>
<td>4</td>
</tr>
<tr>
<td>CNT 1624/2644</td>
<td>4</td>
</tr>
<tr>
<td>WNT 1214</td>
<td>4</td>
</tr>
<tr>
<td>CPT 1214</td>
<td>4</td>
</tr>
<tr>
<td>WNT 2524</td>
<td>4</td>
</tr>
<tr>
<td>CNT 1414</td>
<td>4</td>
</tr>
</tbody>
</table>

One area to be evaluated was the decision to offer a vendor neutral or vendor specific curriculum. A vendor neutral curriculum would not rely on a single vendor or vendors for curriculum content. An example would be to present a foundations course in data communication without referencing a specific vendor. Another example might be to discuss computer architecture without referencing a manufacturer such as INTEL. While this approach would allow students to develop their own decisions about the best operating environment, it would limit a program’s curriculum resources. The final decision regarding which approach would be best rests with input from the program’s local industrial advisory committee. Simply stated, if a program does not provide graduates that would be hired by these companies, students would be less likely to enroll in the program.

For the four-year program being discussed, the decision of a vendor specific curriculum was predetermined because the community college partner adopted the Cisco Networking Academy Program (CNAP) for coverage of the local area networking curriculum. A second focus of the two-year curriculum was coverage of a second industry operating system (Novell). These decisions were dictated by a state-wide community-college curriculum committee to make certain two-year graduates could be employed by Mississippi industries.

To meet articulation requirements, a four-course sequence was developed by the university to accommodate the CNAP program. The faculty committee decided to offer four additional courses modeled after the second level of Cisco industry certification, Cisco Certified Network Professional (CCNP). To expand on a vendor specific curriculum, a five-course sequence utilizing the Windows operating system was also implemented. These sequences provided students with three of the most popular industry certification tracks available if they wanted to pursue if they chose to do so. These decisions were not made without input from the four-year program’s Industry Advisory Committee (IAC). The IAC stated that the Windows operating system and CCNP content should be part of the curriculum for a four-year IT graduate.
A second area of consideration involved individuals that might enter the four-year program with Cisco Certified Network Associate (CCNA) certification. The faculty committee determined that anyone with a certification would be allowed to enter the CCNP curriculum, but each person would be counseled regarding this decision. To date, no one with CCNA certification has completed the CCNP course sequence without first completing the CCNA course sequence.

Laboratory Development

A major component of the four-year program was an integrated laboratory space. New space was not available from university administration to accommodate the articulated degree program; however, space was reallocated from another academic unit to house it. The reallocated space provided a 1000 sq ft area for design, development, and implementation of the program. Additional space would not be available from university administration if needed, so the laboratory had to be highly functional to support multiple courses with laboratories. In addition to the original 19 courses developed for the four-year program, a four-course sequence in information security was added. This resulted in a total of 23 courses that had to be scheduled in a single laboratory space. The faculty used a modified systems development life cycle as a guideline in formulating a workable solution – investigation, analysis, design, and implementation.

Since the laboratory would be used for more than one course, a compromise had to be made between network topology, hardware & software compatibility, space, and cost. The network topology for the laboratory had to be highly configurable to support multiple network configurations while different operating systems had to be accommodated for some courses.

The systems analysis showed that the laboratory network topology not only had to be highly configurable in the software sense, but also in the hardware sense. The network’s physical layout had to be interchangeable, meaning that the network design had to allow for actual changes to the physical topology. Each course utilized the laboratory computer workstations, and it was necessary to find a solution that would allow for different operating system installations on them. After much research, the solution was determined to be Removable Hard Drives (RHD) for the computer workstations.

The RHD solution allowed the laboratory to leverage the investment in workstation hardware while minimizing cost and space constraints. The workstations were provided with a single RHD containing all of the software applications used by faculty and students for general computing, and additional RHD sets were purchased to support specialized courses.

Two additional workstations with Microsoft Windows Server 2003 were used to maintain a stand-alone, Active Directory domain. The two systems provided centralized authentication, authorization, auditing, file and print services, network infrastructure services including DNS, DHCP, WINS, and MSDNAA software distribution services.

A flexible network infrastructure shown in Figure 1 was developed around the use of three networking devices: 1) a Cisco router was deployed to provide firewall protection, Network
Address Translation (NAT), and Virtual Local Area Network (VLAN) routing; 2) multiple distinct broadcast domains were provided by a managed layer-2 switch in conjunction with the Cisco router; 3) four low-cost unmanaged hubs were used for workstation connectivity with up to eight workstations connected to a hub with each hub connected to the layer-2 managed switch. Hubs were selected instead of switches to facilitate packet sniffing when using protocol or network analyzers.

![Figure 1: Laboratory Network Topology Diagram](image)

To permit internet access, the outside interface of the Cisco router was configured with a campus IP address which managed internal dynamic and static routing for the laboratory. Network security was implemented by using Access Control Lists (ACL) and Content Based Access Lists (CBAL) to block known hostile traffic (netbus, nimda, backoffice), to block access to certain sites (gaming or hacker), and to block student file downloads (MP3 and AVI). The Cisco router’s inside interface was configured using IEEE 802.1q trunking and was provisioned for as many sub-interfaces as deemed appropriate. Sub-interfaces were designed with private IP addresses in compliance with RFC 1918. The first class B address space was selected and subnetted to provide 14 subnets with each subnet managing 4000 host addresses. This provided a sufficient number of subnets to support a wide array of instructional topologies and an adequate number of host addresses to permit student implementation of variable length subnet masks. This addressing scheme provided a unique subnet for each row of computers depicted in Figure 2. Students were provided sufficient addresses to plan, coordinate, and deploy redundant DHCP services for their subnet. Additionally, students could implement DHCP relay agents and deploy centralized DHCP services for multiple subnets from a single server.
Figure 2: Physical Layout for 32 Workstation Laboratory

The primary set of RHDs was configured so that all workstations were on a single broadcast domain and permitted student group activities such as reviewing online curricula, online testing, or other individualized student activity to be monitored by faculty. The software configuration for the primary RHD set included Microsoft Windows XP Professional, Office 2003 Professional, Projects 2003 Professional, Visio 2003 Professional, Visual Studio.NET 2003, Symantec Antivirus, Fluke Network Analyzer & Protocol Analyzer, NetFormx, Netscape, and Adobe Reader 6.0.

As noted in a previous section, other RHD sets were purchased to support certain courses. Five RHD sets were needed to cover topics in NOS I, NOS II, Windows Networking, Linux I, and TCP/IP. Including the primary RHD set, 192 hard drives were required to populate six RHD sets for the laboratory. During a laboratory exercise, faculty would assign students individual RHDs onto which they would install an operating system. By changing uplink cables on the managed layer-2 switch, the laboratory was changed from a single broadcast domain to a segmented network with different VLANs. This change permitted students to enable services such as DHCP, IIS, DNS, and mail services without interfering with the campus network or other students in the laboratory. Upon completion of the laboratory exercise, the layer-2 switch would be reconfigured to the default single broadcast domain.

Considerations of a Vendor Specific Networking Curriculum

In the case of the Cisco CNAP program, faculty have access to a complete online curriculum, online testing, online course evaluations, and curriculum updates. This access reduced the time needed for course development and allowed faculty more time in the classroom and laboratory. To participate in the Cisco CNAP program, faculty must be certified in order to have access to these resources. CCNA certification indicates a foundation in and apprentice knowledge of networking. CCNP certification indicates advanced or journeyman knowledge of networks.
In addition to industry certification(s), faculty are also required to have additional instructor certification. Cisco Certified Academy Instructor (CCAI) status denotes a proficiency in delivering the instruction required to support the diverse needs of the CNAP program. To meet CCAI requirements, faculty must complete the Cisco Networking Academy Instructor Orientation Course, complete all curriculum course training (including final exams, skills tests, and demonstration of pedagogical skills), maintain the requirements for recognized industry certification, and teach each course in the curriculum. They must also participate in additional training when the online curriculum is updated. If these requirements are not successfully completed, the faculty member will lose access to the online resources.

In order to offer the CCNP curriculum at Southern Miss, two faculty participated in the certification process. The rationale was that one would serve in a backup capacity. Each faculty member required $36,000 in institutional support to complete CCNA, CCNP, and CCAI certifications. This cost reflected a two-week workshop registration fee for each course and travel cost to attend training. It did not include faculty salary or adjunct pay while faculty attended training. The cost for faculty training might appear high; however, one should consider that the approved training location for faculty was located in Texas. In addition to the initial training and certifications costs, faculty must maintain industry certification by retesting every 2-3 years.

Because of continuing education requirements for faculty, any institution considering this type of program must make allowances for faculty pursuing tenure. If the institution has a required research component as part of tenure criteria, most faculty will not be successful in obtaining tenure or promotion if allowances are not made for faculty teaching in the CNAP program. If tenure allowances are not feasible, an institution could use different criteria for annual faculty evaluation, have a dual-system (research track or teaching track) for faculty evaluation or classify faculty differently such as, instructor or lecturer.

Cost Considerations

A prime consideration in the development of the four-year program was the significant cost savings realized from a single multi-purpose laboratory compared to multiple single-purpose laboratories. Since space was fixed, it was even more important that the laboratory be able to satisfy all program course requirements. With ever increasing hardware requirements needed to support current operating systems, the laboratory has received three different workstation upgrades since 1998. From Table 3, it can be determined that computing performance increased with each upgrade; however, the acquisition cost remained about $700 per workstation. Display costs were similar with increased display quality while cost remained about $300 per unit. Each RHD required a mounting frame for the workstation. This was a one-time cost of $50 per workstation. Since the RHD frame was a one-time expense, the recurring cost for the laboratory averaged $1000 per workstation on a three-year replacement cycle. No cost savings were realized when compared to one single-purpose laboratory; however, significant cost savings were realized when the $32,000 upgrade cost for the laboratory was compared to the $192,000 cost required to upgrade six single-purpose 32 workstation laboratories. The 192 RHDs used in the laboratory added another $19,200 to the initial cost; however, once purchased the cost would not
recur unless hard drive replacement was required. With the primary RHD set not considered, it
could be stated that five additional single-purpose laboratories were obtained at no cost.

Table 3: Workstation Specifications

<table>
<thead>
<tr>
<th>Generation</th>
<th>CPU</th>
<th>RAM (MB)</th>
<th>Video</th>
<th>Display</th>
<th>Media 1</th>
<th>Media 2</th>
<th>Media 3</th>
<th>Media 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1998</td>
<td>P3-866</td>
<td>256</td>
<td>4</td>
<td>15-CRT</td>
<td>X</td>
<td>X</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>2001</td>
<td>P4-1.4</td>
<td>512</td>
<td>32</td>
<td>17-CRT</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>N/A</td>
</tr>
<tr>
<td>2004</td>
<td>P4-2.8</td>
<td>512</td>
<td>128</td>
<td>17-LCD</td>
<td>X</td>
<td>N/A</td>
<td>N/A</td>
<td>X</td>
</tr>
</tbody>
</table>

In addition to the workstation replacement cost, software cost had to be managed. Costs were
minimized by the use of educational software, Microsoft Developer Network Academic Alliance
(MSDNAA) licensing, and volume licensing. Use of the MSDNAA software in the laboratory
reduced the cost of the initial procurement of the workstations as well as the upgrade cost for
new operating system versions.

MSDNAA products allowed students access to the most current versions of a wide range of
developer tools for educational use. MSDNAA products most frequently downloaded by
students for use in their courses can be found in Table 4. Even with educational pricing, most
students would not be able to purchase the software; however, with the MSDNAA program the
only cost for students would be the $80 to obtain Microsoft Office 2003 Pro. The MSDNAA
program permitted legal operating system installations by the students for the networking
laboratory courses, and students were permitted to legally download a copy of all MSDNAA
products for their home use.

Table 4: Typical Student MSDNAA Software Downloads

<table>
<thead>
<tr>
<th>Application Title</th>
<th>Educational Price</th>
<th>Student Source</th>
<th>Student Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microsoft Windows XP Professional (Full Copy)</td>
<td>$300</td>
<td>MSDNAA</td>
<td>$0</td>
</tr>
<tr>
<td>Microsoft Office 2003 Pro</td>
<td>$240</td>
<td>Campus License</td>
<td>$80</td>
</tr>
<tr>
<td>Microsoft Projects 2003 Pro</td>
<td>$200</td>
<td>MSDNAA</td>
<td>$0</td>
</tr>
<tr>
<td>Microsoft Visio 2003 Pro</td>
<td>$160</td>
<td>MSDNAA</td>
<td>$0</td>
</tr>
<tr>
<td>Microsoft Visual Studio 2003 Pro</td>
<td>$90</td>
<td>MSDNAA</td>
<td>$0</td>
</tr>
<tr>
<td>Microsoft Windows Server 2003 (Full Copy)</td>
<td>$470</td>
<td>MSDNAA</td>
<td>$0</td>
</tr>
<tr>
<td>Symantec Antivirus</td>
<td>$33</td>
<td>Campus License</td>
<td>$0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$1493</strong></td>
<td></td>
<td><strong>$80</strong></td>
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</tbody>
</table>

Continuous Improvement

A part of any program evaluation or continuous improvement plan should be to model the
program after specific accreditation program criteria, if available, and satisfy all requirements to
seek program accreditation. Accreditation requirements serve as a minimum standard when
comparing academic or technical programs at different institutions. Accreditation requirements
allow arguments to be made to obtain additional resources from the university administration,
and these requirements address student concerns about lack of program accreditation. On more
than one occasion, the authors have explained why the IT program was “not accredited.”
Several different organizations were interested in establishing accreditation criteria for the IT discipline. It appears that the Computing Association Commission (CAC) of the Accreditation Board for Engineering and Technology (ABET) will be the approved accrediting body for information technology programs. CAC guidelines will be followed to develop the Southern Miss IT program objectives since IT program outcomes have been approved by the ABET executive board and pilot accreditation visits for IT programs will be conducted in 2004-05.

Program outcomes provide the foundation to compare similarly named programs. These outcomes are broadly stated to allow for individual program differences, but narrow enough in scope so that IT graduates share a common knowledge base. The program outcomes published in the ABET 2005-06 CAC program guide for undergraduate IT programs state that information technology graduates should have the ability to:

(a) Use and apply current technical concepts and practices in the core information technologies
(b) Analyze, identify, and define the requirements that must be satisfied to address problems or opportunities faced by organizations or individuals
(c) Design effective and usable IT-based solutions and integrate them into the user environment
(d) Assist in the creation of an effective project plan
(e) Identify and evaluate current and emerging technologies and assess their applicability to address the users’ needs
(f) Analyze the impact of information technology on individuals, organizations and society, including ethical, legal and policy issues
(g) Demonstrate an understanding of best practices and standards and their application
(h) Demonstrate independent critical thinking and problem solving skills
(i) Collaborate in teams to accomplish a common goal by integrating personal initiative and group cooperation
(j) Communicate effectively and efficiently with clients, users and peers both verbally and in writing, using appropriate terminology
(k) Recognize the need for continued learning throughout their career

Table 7 illustrates enrollment and graduation trends in the Information Technology program at Southern Miss since the program began. These trends to some degree follow enrollment trends at the community college feeder programs. When the articulation agreement was implemented, the job market was very good so many community college graduates entered the IT workforce. Beginning in 2000, a significant increase in majors in the Southern Miss IT program occurred, which coincided with an economic decline in the IT industry. Enrollment at the community college IT feeder programs also declined. Feedback from community college faculty indicated that the decline was due to poor job placement for two-year graduates. Enrollment has stabilized at the community colleges, and the community college faculty indicate that current majors plan to transfer to Southern Miss to complete a four-year degree. For future planning, Southern Miss IT faculty estimate an average enrollment of 200 majors and 50 graduates per year for the program.

Table 7: Southern Miss Information Technology Enrollment and Graduation Data
Summary

The growth in the Information Technology discipline and the constantly changing technology make it difficult to choose current topics and incorporate them into a static curriculum. The result is a constantly evolving curriculum that is driven by current technology and industry-best practices. Institutions that utilize vendor specific curriculum must be prepared to manage the costs associated with implementing and maintaining the program. If the Cisco CNAP program is considered, then faculty teaching in the program must be given special consideration for tenure and promotion to ensure their success.

Program accreditation, if available, is vital for any new discipline. It offers minimum standards when potential students consider an institution. Accreditation also provides a framework that faculty can utilize when requesting new or replacement resources for their program.

Southern Miss would not have been able to establish the current IT program without the external funds that were received. These funds purchased all equipment for the program and provided one of two faculty positions needed to establish the program. These funds also allowed the program to demonstrate to university administration that Information Technology was a “real” discipline and that sustained enrollment was possible after the funding period ended. Enrollment remains strong and the authors consider the program to be successful.

References

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