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In this issue:

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**Keywords:** graduate curriculum in Information Technology, MS program in Information Technology, graduate curriculum in Information Systems, graduate program in Computer Information Systems, curriculum design

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# Crafting an Architect-focused MS Program in Information Technology

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## Abstract

This paper presents the design of an MS program in Information Technology (MSIT), whose first entering class arrived in Fall 2001 and graduated in Spring 2003. The purpose of the paper is to share how we crafted an architect-focused program. Specifically, it highlights the need for an Information Systems program whose goal is to prepare systems integrators, discusses the design and content of a curriculum that has an architect focus, and outlines how the MSIS 2000 program model curriculum was molded to meet local needs.

**Keywords:** Graduate Curriculum in Information Technology, MS Program in Information Technology, Graduate Curriculum in Information Systems, Graduate Program in Computer Information Systems, Curriculum Design

## 1. INTRODUCTION

At our institution, every five years the graduate programs undergo an in-depth assessment in terms of their mission, target audience, currency, success of the graduates, and the competition. In 2000, the Computer Information Systems (CIS) department reviewed its MS program in Computer Information Systems (MSCIS) in light of the revised mission of the College, the other recently implemented Information Technology (IT) intensive MS programs in the Graduate School of Business, and the MSIS 2000 Model Curriculum (Gorgone and Gray, 1999) that was just unveiled. This review led to the decision to replace its highly successful twenty years old MSCIS program with a new MS program in information technology (MSIT). The major factors influencing this decision were:

- In 1998 and 1999 the College introduced five new specialized masters degree programs, Information Age MBA, MS in Global Financial Analysis, MS in Information Age Marketing (IAM), MS in Accounting Information Systems (AIS), and MS in Human Factors in Information Design (HFID), to serve the perceived new professional positions in the evolving information-age business arena. Three of these programs (AIS, HFID and IAM) targeted many of the career-changers that were previously served by our MSCIS program.

- The knowledge requirements of the Information Systems (IS) work force were changing and were not being met by our MSCIS program, especially, the knowledge of Web technologies and Electronic Commerce (e-Commerce) and their impact on business practices.
- The CIS Department saw an opportunity for a new program that focused on enhancing the careers of people who already have significant IS/IT experience.

Thus the guiding vision for the new program was the preparation of IS professionals with at least 2 years of IT work experience for IT/IS leadership careers in consulting firms and large businesses. More specifically, we felt that we can take information systems and software professionals with at least two years of systems development experience and in one year of full-time study prepare them for careers as project managers, system architects, information architects, process architects, and/or technology architects in the Internet-enabled business world.

This paper describes how we crafted our MSIT program. The rest of the paper is organized as follows. In the next section we present the positioning of the MSIT program and the need for an architect-focused IS program. This is followed with details of how the MSIT Program Core, Foundation and Electives layers were structured,

designed and specified. The MSIS 2000 model curriculum is used as a frame of reference. The last section summarizes our learning and conclusions.

## 2. MSIT PROGRAM POSITIONING, FOCUS AND KNOWLEDGE REQUIREMENT

Since the MSIS 2000 model curriculum was the best thinking of the IS academic community, we started the MSCIS program assessment with the view of restructuring the program requirements based on the recommendations of MSIS 2000 model curriculum. The proposal of career-track electives in the MSIS 2000 recommendations led us to look deeply into how IS careers were being impacted by e-Commerce and evolving Web technologies. We noted that Internet-enabled business practices were changing both the issues involved in building enterprise-wide business systems and the intellectual discipline that supports that activity. For example, the primary design drivers in traditional systems development are correctness, reliability and modifiability. However, in the building of enterprise-wide business systems, besides reliability and modifiability the other significant design drivers are robustness, scalability, security interface with the Web, and interoperability. Furthermore, whereas the intellectual discipline of traditional systems development is rooted in the architecture of the Von Neumann machine, structured analysis and design, relational databases, and information engineering, the intellectual discipline of enterprise-wide web-centric business systems is rooted in Java, object, and distributed systems technologies. We concluded that to be effective, tomorrow's systems professionals need to understand the new business paradigms and develop deep expertise in Java-based object-oriented and distributed systems technologies. In addition, to be successful this technical expertise needs to be complemented with understanding and skills in project management, process management, quality management, change management, team building and business re-engineering as they relate to software and information systems work.

This analysis and viewpoint led us to define the preparation of systems integrators who are called upon to architect IT solutions for Internet-enabled business processes as the gyroscope for the new MSIT program. By systems integrators we mean IS professionals who can play the roles of project managers, system architects, information architects, process architects, and/or technology architects in the Internet-enabled business world. The responsibilities and work activities of these roles are summarized below.

Systems architects work with business professionals and systems analysts to arrive at technical requirements for business scenarios. They handle issues of integrating multiple sources of information across heterogeneous platforms and they understand the architectures of legacy software to assemble integrated solutions.

Information architects are the guardians of corporate information models. They understand cross-functional flow of information and assume responsibility for managing the logical details for implementing the conceptual enterprise data and object models. They have authority to influence design level changes in projects to comply with enterprise information model and modeling standards.

Process architects facilitate the defining of work processes and standards and they monitor the effectiveness of the defined processes. They are also responsible for improving and architecting the development processes.

Technology architects ensure that technology resources are aligned with business requirements. They handle the issues of selecting and implementing new technologies.

In summary, the selection enterprise and inter-enterprise integrators as the gyroscope for the MSIT program we committed to produce graduate who could architect IT solutions that integrate business processes, Web applications and legacy systems, using a variety of network, voice and mobile computing technologies. Since architecting solutions is different from giving shape to user needs, which is the key focus of a systems analyst, it became clear to us that we need to re-direct the focus our curriculum and courses from the traditional analyst focus to an architect focus (Boster, Liu & Thomas, 2000; Garlan, 2000; Mills, 1985).

Our faculty concluded that the preparation of future systems integrators requires instilling in our graduates a thorough and deep understanding of the underlying theories, best practices and hands-on exposure to up-to-date software tools in the following areas:

- Emerging business models such as B2B, B2C, Many2 Many and m-Commerce
- Internet-based software tools for building e-business solutions
- Systems analysis and design methodologies for analyzing and designing enterprise-wide distributed e-business applications
- Computing infrastructure planning and methods for assessing the impact of e-business application on computer system performance
- Network components and network products that are driving the evolution of e-business applications
- Telecommunication networks modeling and methods for assessing bottlenecks and performance
- Methods, models and technologies for implementing appropriate levels of security
- Data mining, data warehousing and database design
- Project management processes for effectively executing IS projects
- Methods, models and technologies for integrating enterprise-wide applications and data sources

In the next four sections we discuss the crafting of the MSIT curriculum in terms of the MSIT architecture, the design of the MSIT program core, MSIT foundation and MSIT electives that together fulfill the MSIT program goal of systems integrators preparation.

### 3. MSIT ARCHITECTURE

We borrowed the architecture of the MSIS 2000 model curriculum and structured the MSIT curriculum in terms of the Foundation Layer, the Core Layer and the Electives Layers as shown in Figure 1.

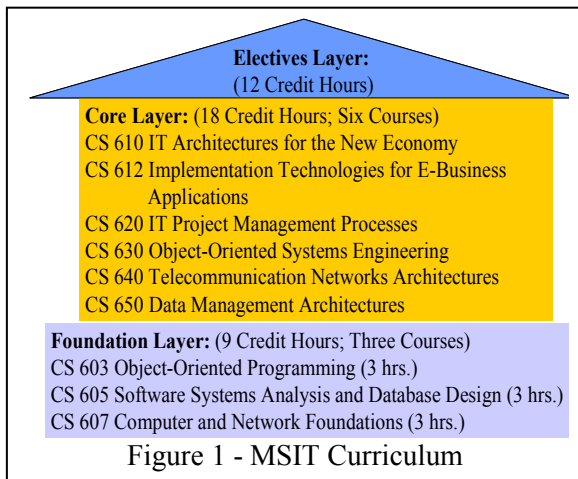


Figure 1 - MSIT Curriculum

Although the architecture of the MSIT program parallels the architecture of the MSIS 2000 model curriculum, the content of each layer is markedly different. We will discuss the design of each layer next.

### 4. MSIT PROGRAM CORE

The program architecture shows the relationships among the foundation layer, the core layer and the electives layer, but it does not reveal the order in which these layers are crafted. In practice, once the program goal is specified, the core layer is specified next. Table 1 summarizes the core layers of the MSIS 2000 model curriculum and the MSIT program. Although both curricula list six courses, two among these are quite different. For example, first the MSIS 2000 curriculum recommends to integrate the knowledge of the IS functional areas of IT project management, systems analysis and design, telecommunications, data management and IT policy with an explicit integration courses. In contrast, the MSIT program opens with a holistic course, CS 610 that serves as a “window” to the courses in the rest of the curriculum. Second, the IT policy and strategy course is in the core layer of the MSIS 2000 model curriculum but it is in the electives layer of the MSIT curriculum. The details of core layer courses are summarized next.

MSIS 2000 Recommendation	MSIT Program
	CS 610: IT Architectures for the New E-economy
	CS 612: Implementation Technologies for E-Business Applications
Project and Change Management	CS 620: IT Project Management Processes
Analysis, Modeling, and Design	CS 630: Object-Oriented Systems Engineering
Data Communications and Networking	CS 640: Telecommunication Network Architectures
Data Management	CS 650: Data Management Architectures
IS Policy & Strategy	
Integration	

Table 1 – The Core Layer Courses

**CS 610: IT Architectures for the New E-economy:** The objective of CS 610 is to introduce students to IT management issues in the context of a variety of emerging e-business *models* (B2B, B2C, many2many, m-commerce) and *participants* (small merchants, hyper-growth firms, mature firms).

As a “window” to the rest of the curriculum CS 610 uses the Harvard Business School case method to provide the students an understanding of the challenges of how companies build, acquire, and modify new systems and components, integrate e-business systems with legacy systems, ensure 24X7 reliability and security, identify and assimilate appropriate emerging information technologies, and utilize scarce IT talent and coordinate the work of geographically.

**CS 612: Implementation Technologies for E-Business Applications:** This course provides a close look at how e-Business systems are implemented using Java Server Pages (part of the J2EE standard). Technologies covered include Java Server Pages, Servlets, Java Beans and JDBC. It is taught as a hands-on course with extensive lab sessions and students build an e-Business system that implements a fictitious eCommerce store with web based inventory management.

**CS 620: IT Project Management Processes:** This objective of this course is to provide the technical knowledge and skills for successfully planning and executing IT projects. Using the tools and methods introduced in this course, project teams develop a comprehensive project plan for an e-business application. In addition, student teams’ research, identify and demo software engineering tools that support key software development and project management processes.

**CS 630: Object-Oriented Software Engineering:** This course prepares the student for systems development in the object-oriented paradigm. Students learn to perform requirements analysis, systems analysis and domain analysis, and how to document them in standard object-oriented specification tools. The hands-on modeling assignments illustrate the role of patterns, class libraries and object-oriented project management. Students learn how to architect systems that are suitable for extensive reuse.

**CS 640: Telecommunications Network Architectures:** The main objective of this course is to provide the students with the conceptual knowledge they need to design, procure, and manage network infrastructures for advanced e-business solutions. Students use a hands-on lab to learn how network components are integrated into working solutions. The focus of the lab assignments is on protocols and network technologies that are essential for architecting corporate infrastructures seamlessly integrated with the Internet.

**CS 650: Data Management Architectures:** This course examines the architectures of current database systems with particular importance on object oriented database systems and Web-connected database systems. The course uses Oracle 9i database systems for developing, designing, and managing large corporate database systems.

A distinguishing feature of these courses is the hands-on use of tools and an architect focus. The tools used in the core layer courses are:

- CS 612: Java Server Pages, Java Beans
- CS 620: Microsoft Project, and demo of requirements management, size estimation, testing, software configuration management, and team communication tools
- CS 630: Borland Together (a UML-base CASE tool for object-oriented modeling/development)
- CS 640: Students build, monitor, and maintain local and wide area networks using switches, routers, servers and other advanced equipment from leading manufacturers
- CS 650 Oracle 9i

Although the MSIT program is not in the business of providing technology training, our faculty believes that hands-on work with appropriate tools is an effective method to help students understand and learn to apply complex concepts. And, companies that recruit our students seem to value this perspective.

A second distinguishing feature of the MSIT core is the teaching of these courses with an architect focus. It was left for each faculty to implement the architect focus. In our three-year mini review of the MSIT program we found many manifestations of the architect focus (Mills, 1985; Gore, 2000. They are: Emphasis on industry and professional architectural standards in all courses; De-

veloping applications in Microsoft Windows environment and adapting them to run correctly in a shared Lenox server in CS 612; Coupling and cohesion analysis to assess the goodness of the program architecture in all programming courses; Emphasizing reuse in object-oriented system models; Shifting the focus of the analysis and design models from now and this system to future and other systems. The architect-focus is even emphasized in the IT project management course where assignments are designed to emphasize the architect focus in project management tasks listed in Table 2.

Project Manager Task	In Architect-focus
Manage the plan	Manage the deliverables
Control the scope	Define the boundary interfaces
Monitor time and cost	Get best value from time and cost
Manage human resources	Define right resources for the right job and monitor their effectiveness
Manage time and budget	Manage customer expectations

Table 2 – Architect focus

### 5. MSIT PROGRAM FOUNDATION

The purpose of the Foundation is to ensure that entering MSIT students possess the base knowledge and skills needed to successfully pursue courses in the Core. As summarized in Table 3, the MSIS 2000 model curriculum recommends six pre-program courses, three in the IS area and three in the business area. The MSIT program foundation layer consists of three courses that package the IS core material usually taught in six undergraduate courses in a typical BSCIS program. For example, our BSCIS students in the Five-Year MSIT program can waive the pre-program requirements if they successfully complete the pair of undergraduate courses listed in Table 4.

The pre-program requirements of the MSIT program differ from the MSIS 2000 recommendations in two ways. First, since the MSIT program is designed for IS professionals with at least 2 years of IS/IT experience, we chose to substitute the business foundation pre-program requirements of MSIS 2000 model curriculum with business experience. Second, the MSIT foundation requirements are both deeper and broader than the pre-program IS requirements of the MSIS 2000 recommendation. They cover basic procedural programming, object-oriented programming, software systems analysis, database design, and computer systems and telecommunications fundamentals.

MSIS 2000 Recommendation		MSIT Program
IS Foundations	Business Foundations	Pre-Program Requirements
Fundamentals of IS	Financial Accounting	Object-Oriented Programming
IT Hardware & Software	Marketing (Customer Focus)	Computer and Network Foundations
Program, Data & Object Structures	Organization Behavior	Software Systems Analysis and Database Design

Table 3– Foundation Layer

Pre-Program Requirements	Undergraduate Courses
CS 603: Object-Oriented Programming	CS 180: Programming Fundamentals CS 280: Object-Oriented Application Development
CS 605: Software Systems Analysis and Database Design	CS 350: Database Management Systems CS 360: Business Systems Analysis and Modeling
CS 607: Computer and Network Foundations	CS 240: Business Processing & Communications Infrastructure CS 480: Advanced Net-Centric Computing

Table 4–Undergraduate Equivalence

Our three years experience suggests that students who took our foundation courses performed better in the core courses than those who waived the foundation courses. In addition, students who took CS 603, 605 and 607 indicated high satisfaction with the learning they acquired in these courses. This is despite the fact that each semester some students struggled to master the required skills in CS 603, and few students had to repeat it.

### 6. MSIT PROGRAM ELECTIVES

The courses in the Electives layer enable the students to better align their career objectives. Students must take four elective courses; two must be CS and two are unrestricted. Although students are free to select electives, their choice need the approval of the MSIT program director. Except for CS 660 and CS 670, all CS electives are 700-level courses. We discuss how electives relate to IT careers.

**CS 660 (Object-Oriented Application Development) and CS 670 (Distributed Systems Architecture):** During the design of the MSIT program in 2000, we observed that integration, visibility and management across hardware platforms, operating systems, programming

languages, data structures, applications and business entities was becoming a priority for IT organizations. Since enterprise integration is not just a solution but a journey, we recognized that companies will need to continually evolve and optimize their solution architecture and infrastructure to provide an optimized portfolio of services under changing conditions. CS 660 and CS 670 were designed for students interested in positions associated with the task of enterprise integration.

Whereas CS660 is implementation focused, CS 670 targets designers, architects and integrators. Although CS 670 is taught without a heavy programming component, students probe into the various framework technologies like RMI, EJB, XML, CORBA and JMS to grasp the general principles and structure of distributed systems. A broad coverage of the various technologies and capabilities gives the students a good understanding of what facilities are available within the J2EE framework and when to use them.

These two courses were designed to be part of the Core layer. However, the decision to limit on the core to six courses, which is in-line with the MSIS 2000 model curriculum recommendation, led us to move these courses to the Electives layer.

**CS 723, Computer Security, Controls and Ethics:** This course on computer security supports all four career tracks of systems integrator, systems consultant, and network analyst and data warehouse architect. CS723 covers key information security risks facing businesses today and helps students understand how to protect data, networks and application software. It helps students think critically about the local, national and global information security issues in our highly networked society.

**CS 732, Advanced Topics in Systems Analysis and Design:** Students interested in starting their careers as systems analyst, team leaders or engagement managers take this course, which looks at the characteristics, strengths and weaknesses of various development methodologies, ranging from highly systematic or “disciplined” to ad hoc or “agile.” These include approaches such as Rational Unified Process, extreme programming, Web applications development, offshore development, open source collaboration, Soft Systems Methodology, Multiview, Participatory Design, and Contextual Design.

**CS 743, Advanced Topics in Computer Networks:** Students interested in careers as network consultants or network managers take CS 743 to deepen their understanding of the organizational communication technologies. Currently, the course has a strong focus on wireless technologies and their role in the corporate IT infrastructure; in addition, the course provides in-depth coverage of selected technical security, network design, and network management issues.

**CS 753, Data Warehousing and Data Mining:** Students pursuing careers in data administration, database management, and advanced data analysis take this course, which addresses key concepts and skills in data management, with a focus on the data warehousing function and the methods and tools for data mining.

**CS 801, IT Policy and Management:** Our capstone elective is designed for experienced IT students who aspire to senior level career positions, such as VP for IS, CIO, or CTO. It addresses challenges in managing the IS function in complex organizations, from the point of view of the CIO. Note that this topic is denoted as a required course in the Model Curriculum, but we chose to position it as an elective.

**CS 795, Special Topics Seminar:** This slot is available for offering experimental, special-topics or directed-study courses. Several students have used it to learn how to pursue IS research in faculty-led directed studies – in some cases, to discover whether to pursue an academic career (we know of two MSCIS graduates who joined doctoral programs at MIT and UCLA, and several of our MSIT students have applied or intend to apply to Ph.D. programs). Recently several students have also used this course as an opportunity to pursue a directed study on Microsoft's .Net platform.

**CS 881, CIS Internship:** This course enables students to pursue IT internships and acquire valuable experience with regional companies. For our international students, it opens up opportunities to work in the US.

**Unrestricted electives:** The MSIT structure allows a student to take two courses outside the CS area. Although many MSIT students take CS courses as their unrestricted electives, those who take electives outside CS usually have good reasons, such as:

- To improve entrepreneurial and negotiation skills, many students take ES 600, Entrepreneurship and/or MG 635, Negotiation.
- To make them attractive to accounting/consulting companies students take the auditing courses AC 747/748 and AC 761/762.
- To broaden their knowledge in the area of human factors students take HF 730, Visualizing Information, and HF 770, Prototyping Theory and Practice.
- Although the choices of unrestricted electives choices are extensive and address students' unique career requirements, the Department offered an experimental courses in .NET technology and a study-abroad course, Offshoring of IT-Enabled Services, in winter 2004.

## 7. SUMMARY AND CONCLUSION

Our experience suggests that in crafting an IS curriculum, it is important to first carefully define the program goal in terms of the program inputs and outputs. For

example, for our MSIT program the input is professionals with at least two years of IT/IS work experience and the output is the preparation of systems integrators who architect IT solutions. Once the program goal is specified, the next step is the design of the core curriculum. Although the MSIS 2000 model curriculum is a good starting point, we found that the MSIS 2000 core lacked the integration of e-Business models and technologies that were central to our curriculum. Therefore, CS 610 and CS 612 do not have parallel courses in the MSIS 2000 core. We were faced with a situation where the addition of CS 610 and CS 612 to the six course MSIS 2000 core would have expanded the core to eight courses. Thus, the selection of the core requires careful pruning and structuring and this resulted in pulling the IT Policy and Strategy course out of the core into the Elective layer.

We also discovered that course description and design cannot be directly extracted from the model curriculum recommendations. As discussed above the architect focus of our curriculum impacted the design and teaching of all the courses in our curriculum.

Once the core layer is specified, the foundation layer can be designed easily because its purpose is to instill and ensure that the entering student has the capability to handle the material covered in the core courses. The challenge of designing the foundation layer is how to package the foundation knowledge needed in a fixed set of courses.

The Electives layer is designed last and this is the place where the MSIS model curriculum is very useful in selecting the topics and/or courses that are relevant to the goals of the curriculum.

Our three-year review of the MSIT program showed that the systems integration preparation and the architect focus of the courses that guided the design of the program in 2000 is still valid. It could be argued that integrating platforms, systems, applications and technologies is even more crucial as organization become more global.

The Foundation layer is well designed and effective. Since some students struggle in CS 603, we need to determine whether extra support in the form of tutorial service, closed labs, remedial help, etc. is needed.

Courses in the Core layer of the MSIT curriculum are well conceived, designed, and delivered – largely due to extraordinary efforts by CIS faculty who invested their time to acquire, learn and implement new technologies. Use of state-of-the-art technologies in these courses is a distinguishing feature of our program, yet this creates a substantial burden on our faculty.

Our Elective courses provide students an opportunity to develop a distinguishing capability. The structural as-



pects of the Elective layer (4 electives, of which 2 must be CS and 2 are unrestricted) are sound, but further faculty review of the topical coverage of our electives is warranted.

In conclusion, the major challenge for our MSIT program today is attracting sufficient numbers of high-quality candidates at a time when enrollments in IT program nationwide have been declining. We are finding that our coherent and compelling message of architectural orientation of the MSIT program is ringing well with potential applicants.

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