A Curriculum for Future Information Technology

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Abstract: Computer science, information systems, information technology and other related programs have been evolving over the years to prepare students for the ever changing work force or to become research scientists. These program structures and curriculum gets updated rapidly even before a student had a chance to complete a four year cycle. When a student graduates, there may be a daunting challenge to find a right fit for a right job in today's global market. This paper proposes a curriculum paradigm that is based on sound engineering principles and need for applied education. The curriculum proposed here is based on student needs and industry outlook. It reduces educational cost for students, administrative cost for teaching institutions and training cost for industry. It also provides a first cut of curriculum that integrates a variety of disciplines under the information technology umbrella. The curriculum taxonomies are shown to illustrate the proposed concept. An initial road map and time schedules are shown to demonstrate the feasibility of this concept. The roles of students, faculty and industry supervisors are discussed. The approach proposed here will have a broader positive impact in information technology when adopted. Further research is needed to fully exploit the proposed concept.

1 MOTIVATION

Current education and curriculum in the global world is changing rapidly in many dimensions. There is a big debate on online versus on-campus education and there is no clear consensus on this issue. The cost of education for students and their parents is becoming increasingly unaffordable. The competition from the world markets is forcing students to quickly adapt to new technology, tools and emerging applications. Countries like India and China are producing information technology (IT) professionals in masses and in fast pace to quickly get them into job market. Some of these professionals may not have traditional IT degree, but they do perform well at work and cope with the changing environment. The international workforce is quickly replacing the domestic elites in current IT industry.

There is tremendous commonality and repetition in many of the fields such as computer science, information systems, information technology and related areas in most countries. All these disciplines can be simply classified under a large umbrella referred to as a unified information technology (UIT).

Current curriculum in UIT is based on a "silos" approach. It is categorized on subjects and the ability of students to learn in a chronological order. The international UIT work force today demonstrates that rigorous training in a given area also provides sufficient background in performing most of today's UIT jobs. Other disciplines provide some insight into new curriculum ideas, which are worth considering. In medical field, the four year curriculum is divided into two parts, where students study for two years in the classroom and work for two years on rotations (hands-on) to select a specific field. Similarly, in some engineering disciplines, the curriculum uses a common curriculum for two years and 2-3 years to specialize in a given field. These models provide motivation to develop a curriculum for UIT education.

2 INTRODUCTION

The UIT discipline referenced in this paper is

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presumed to be an umbrella for many computer related fields as mentioned before. A typical "**silos**" map for curriculum for computer science (CS), information systems (IS) and information technology (IT) is shown in Figure 1. Each column in the figure is a "silo" based on its categorization and ability of a student to learn in a chronological manner. However, there are some inter-dependencies in these "silos" as some topics are common among them. For example, some programming concepts learned in CS1 and CS2 are used in an OS class. This approach requires a four year period to complete a given specialization. However, this structure does not train students the way industry expects, as a consequence many organizations hire highly trained person versus highly educated person.

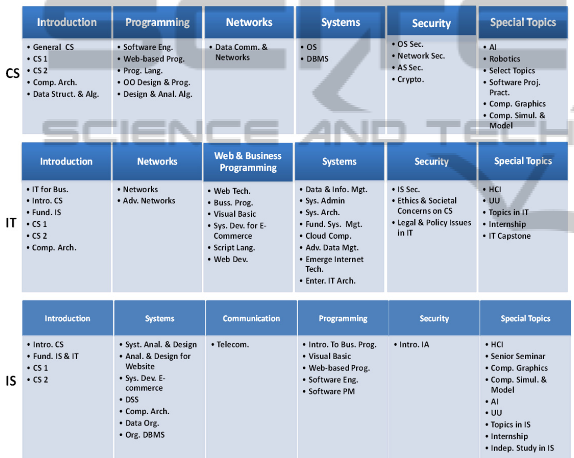

Figure 1: "Silos" map for CS, IS, IT.

This curriculum paradigm has many dimensions that address the fast changing technology and global market trends. However, it does not focus on future needs and anticipated technology. A curriculum should prepare students in the shortest amount of time with required educational background, certifications and skills that can be retained for a long period of time. It should provide a clear path to pursue careers in a particular area of expertise. It should focus on major domain applications instead of ever changing computer environments. These requirements for curriculum development need an approach than making cosmetic, pedagogical and incremental changes to existing programs. Engineering and Medicine fields have some unique characteristics that can be borrowed to develop new curriculum that will address many issues faced in current IT educational system.

3 CURRICULUM FOR UIT

The novel curriculum proposed would utilize the commonalities among many areas in IT; require practical skills for students, emerging industry needs, cost-cutting for student education and optimizing academic institution's resources. Each of these objectives will be met by the proposed curriculum. The main attributes of this proposed curriculum is described in the following sections.

3.1 Duration

Due to rapid changes in technological and industrial needs, the 4 year college should be reduced to 3 years. This will reduce the education cost and help students and parents in many ways. The three year period proposed is a continuous period including summers. This includes six semesters and three summers. It does not imply that four years without summers is close to three years with summers. Some of the time is used for internships, practical learning and certifications.

3.2 Topics

The current course structure will be divided into topics, which can be mixed and matched to suit a particular career track. For example, a database course is divided into many topics such as relational data model, data modeling, transactions, concurrency control, database programming and database administration. There is no course concept in this new model. In addition, certifications (research experience), applied experience and theoretical topics (foundations) are added to the curriculum to prepare students for industry and research careers. These items are modeled as a four layer architecture model as shown in Figure 2.

3.3 Teachers

The teaching approach that will be adapted in this curriculum would use different teachers drawn from academia, research labs and industry. It would consist of academicians, industry supervisors or domain experts and researchers. Each of them will play their own role in the curriculum. A single teacher teaches his/her expert topic instead of an entire course. As the topics change rapidly, domain experts from industry are brought in to cover emerging topics as needed. An academician at an institution may teach theoretical topics that he/she is considered as an expert or knowledgeable in the subject. An industry supervisor/domain expert will cover applied experience and certifications that are needed in the program. Similarly, a researcher from a research lab or another academic institution will provide research experience components relevant to the learned theoretical topics by students. The medium of teaching can be in the class-room, on-line, industrial site, or a lab depending on the type of topic and experience. All of the above faculty categories must be compensated by the host academic institution and be evaluated by students.

3.4 Career Tracks

In this model, the curriculum prepares a student for a given career track based on his/her interests and performance. Industry needs and their required skills and expertise will play a major role in the curriculum process. The career tracks depend on current industrial needs, which may change often. Advisors will assist students to choose an appropriate track that is suitable to their primary interest. There can be many types of career tracks in UIT. These tracks may depend on a specific area or a combination of one or more areas. A network security engineer track may require multiple topics and experiences along with some sort of certifications. The four layer model shown in Figure 2 illustrates this curriculum hierarchy.

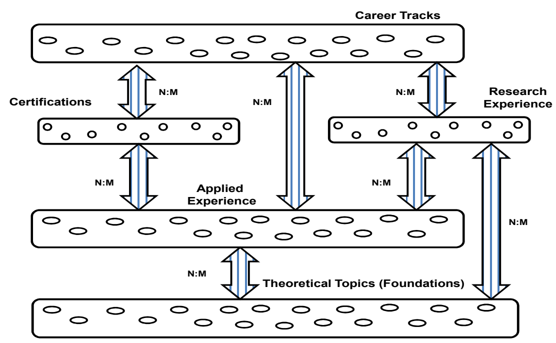

Figure 2: New Curriculum Architecture.

Students may need to take many topics and have many applied experiences to get into a particular career track. Some career tracks may require research experience and applied experience to complete a particular career. The proposed four layer model follows a many to many mapping from one layer to the next. This is a more general view of the model, however some layers may only have many to one mapping between them. That is, there are cases where many theoretical topics map to one applied experience. For example, one needs to learn data structures, TCP/IP and process management to write a Web server application. This is a many to one mapping. In another example, Web server and Process Management applications require knowledge of process or thread creation. This is a many to one mapping. Overall, many-to-many mapping cover all cases in this layered approach.

The disadvantage of training students for single track is that they may not find a suitable position in that track after graduation. In this case, a student can always switch to another career track and pursue that track to find a job. This is similar to medical schools, where they do a second residency. Students must choose the right career track to start with so that there will be no need for later switch. Advisors must point students to the right track based on market conditions. This approach is different from a current paradigm, where a student obtains a generic degree, sometimes special tracks (such as security, Web, E-commerce, networking) and could apply for many available jobs. As the industry is very much focused on hiring students with a specialized skill, the proposed solution should work better. One can do two career tracks, which may require more time to complete the program. The career track switch can also be done after working for a while, by upgrading your skills.

4 IMPLEMENTATION

The proposed curriculum has many facets in its implementation. The nature of this approach brings many unconventional avenues and innovations. The following sections provide detailed descriptions for implementing this model.

4.1 Homogenize IT Areas

As shown in Figure 1, UIT areas share many topics in common. Consider a data communication network course in each area. The fundamentals in data communication networks are the same for all areas, however their scope of leaning is different. For example, CS students learn to implement protocols, IS students focus on operation of protocols, and IT students train for network administration and configurations. All of them need foundations for data communication networks. Similarly, some other common areas such as Web Applications, Web Security and Software Engineering can be homogenized. There may be some areas that are very unique in a particular field, where there is no need to homogenize the area.

4.2 Development of Theoretical Topics

Developing unique topics in UIT requires more research and understanding of the proposed curriculum. To demonstrate the feasibility of the proposed concept, some database and network topics as well as required topics are identified and used for illustration. This is by no means a comprehensive study for the identified areas. The process of identifying a topic should be similar to identifying entities in a database model. A topic should have some theoretical or empirical grounds and unique in its domain. A topic can also be viewed as a nugget that has some foundation for future extension. For example, relational data model is a topic which has sound theoretical basis. Similarly, inter-process communication is a topic, which proliferates throughout Web technology. These topics are very unique and they have broader impact in their domain applications. We need to identify all such topics in UIT so that we can build a solid foundation for achieving the proposed curriculum. The ACM and IEEE Computer Society curriculums (ACM, 1968); (Computer Science Curricula, 2013); (Computing Curricula, 2013) over the years have used a different type of approach which is based on courses and fields that have emerged over the years and has no stability in its mission. The proposed curriculum divides existing curriculum into topics (more granularity) thus making them more stable. That is, there is a need for engineering and science principles in UIT education instead of training students for immediate needs of industry and technology evolution and making them obsolete after few years.

4.3 Development of Applied Experience

Applied experience involves hands-on training for UIT students. After learning theoretical topics, they need to get hands-on experience with current tools and techniques in industry. Academic institutions may or may not have resources such as Database tools at their home institution. Students also need experience in developing real world systems which can be provided by industry and through their experts. A typical applied topic may involve configuring a large network for operation and maintenance or a programming experience where students work with a large software project and building a module. We need to identify applied experience projects that are related to theoretical topics, which require further research in this area.

4.4 Development of Research Experience

Research experience involves understanding current research areas and problems. After learning theoretical topics and may be some applied experience, students can be exposed to some research experience. This experience can be provided to students through collaborations and internships with research organizations and other research institutions. We need to identify some topic areas to develop such research experience projects. A typical topic may consist of applying multi-core architecture knowledge to partition a computer intensive application to achieve higher performance. Such projects should be undertaken by students who are interested in research careers.

4.5 Identify Certifications

In today's industrial careers, certifications are vital components. Certifications such as A+, Network+, CCNA, CCNA, CISSP, and Security+ (Hein, 2012) are required for some jobs. These certifications cover wide array of topics and sometimes span across many areas. The theoretical topics and applied experience provided to students should cover some areas of certifications. A student pursuing a particular career track which requires certain certification should get complete knowledge and experience to pass that certification. There should not be a need for the student to get outside help to pass a certification. Identifying needs for certification requires further research to develop a comprehensive curriculum.

4.6 Development of Career Tracks

Today's career tracks are driven by current trends in technology. The current trends in technology are driven by industry without any scientific basis; otherwise they would have been stable for a long period of time. Sound principles must be extracted from the emerging technology and incorporated into topics in the curriculum. This requires more research and understanding of the proposed curriculum to cope with the current trend in career tracks. To illustrate the proposed concept, we have identified some career tracks in database and networks from Web sources (Career Tracks, 2013) and shown them in Figure 3.

4.7 Mapping Topics to Career Tracks

Mapping theoretical topics to career tracks follow the four layer architecture presented in Figure 2. This process requires further research to layout the exact mappings. In order to show some sample mappings, we have studied database and network areas and developed some mappings as shown in Figures 4 and 5. We need to get industry, research and academic organizations to develop all possible mappings from topics to career tracks.

4.8 Identify Industrial Supervisors

The proposed curriculum requires a strong collaboration between industry and teaching institutions. When topics are clearly identified in UIT, experts from industry need to be identified who can provide applied experience for students. Students may get this experience in their labs at their home institution or they may get this at a chosen industrial site. The supervisors who train students should be compensated by the host institution.

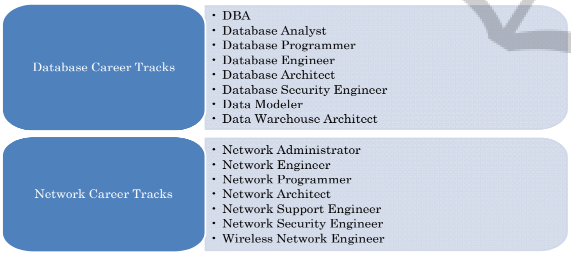

Figure 3: Career Tracks.

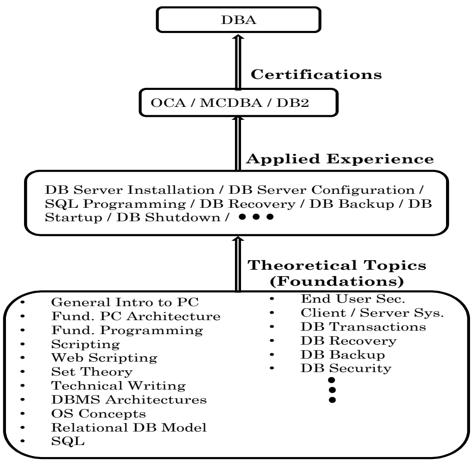

Figure 4: Database Topics / Career Tracks Mappings.

4.9 Identify Researchers

The proposed curriculum also requires a strong collaboration between research institutions and laboratories. Some students may pursue research careers after graduation and they need to be exposed to research trends to appreciate the type of environment and problems to be addressed in an area. The researchers who provide training to students should be compensated by the host institution.

4.10 Medium of Teaching

Media of teaching has many dimensions in this model. Theoretical topics can be taught in classroom or online. Applied experience can be obtained in a laboratory at host institution or at an industrial site working with a supervisor. Research experience can be obtained at a host institution, research organization or a research laboratory. Knowledge and practical experience for professional Certifications can be gained at a host institution or online provided by an expert professional in a given area. The teaching environment and medium is different from a traditional setting as done today.

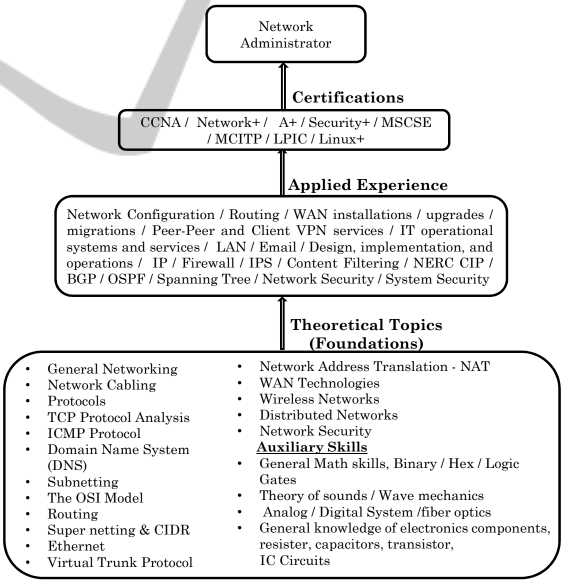

Figure 5: Network Topics / Career Tracks Mappings.

4.11 Development of Grading Policy

The grading policy needs more research and evaluation. However, the following grading policy is suggested for the proposed curriculum. For a given career track, a cumulative grade is given for each semester including summers. Over a three year period there are a total of 9 semesters including summers. A final cumulative grade is given for the entire program based on the average of 9 semester grades. For each topic, applied experience, research experience, and certification there will be an independent grade in each semester. After a particular topic, experience or certification is complete a letter grade will be given by an instructor or a supervisor. All these grades are used in each semester to compute a cumulative grade point for a particular semester. A letter grade of A, A-, B, B+, B- and C are used in the curriculum. Any cumulative grade less than C in any semester will be a fail grade and that student will have to repeat the whole semester. More studies are needed to refine this grading system.

4.12 Student Academic Plan

Figure 6 shows a typical academic plan for a particular career track for the 3 year period. In the plan, students are required to spend the first four semesters taking theoretical topics. These topics are intended to provide some foundation in the field of UIT and also prepare them for the applied experience topics. They will then spend the next 3 semesters doing rotational applied experience areas, where they will be assigned to industry and get training under a supervisor. One semester will be optional for those who want to have a research experience to conduct research under a researcher. If a student decides against the research experience then they have to continue with the applied experience. Students also have one semester option to prepare and take certifications in their chosen career tracks. Similarly student can opt against taking the certification and can continue with the applied experience. More studies are however needed to refine this academic plan.

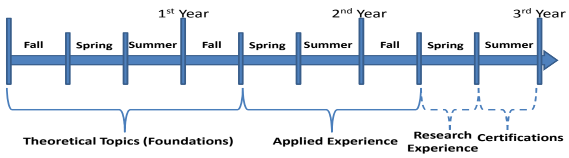

Figure 6: Academic Plan of proposed Curriculum.

4.13 Development of Tuition Plans

Tuition and fees is an institutional issue. We don't have any particular suggestions for this issue. However, a simplest way to charge tuition is based on a semester.

4.14 Payment Plans for Teachers

As the curriculum is divided into topics, applied experience, research experience and certifications, one can setup a payment plan based on the same categories and number of students. This issue is also related to an institution and we don't have any particular plan for this item.

5 PROS AND CONS

The proposed curriculum is novel and is not evolutionary in nature as such it will face resistance in its implementation. It needs a strong collaboration between academia and industry. However this collaboration will be hard to achieve as industry is not in the business of educating students. The UIT curriculum offers many benefits in spite of the above drawbacks. Students get full education and training from a bottom up approach along with hands-on experience and needed certificates. When a student graduates, he/she is ready for a real world job. Industry benefits immensely as they can hire students who don't need much training. The academic institutions can reduce their permanent faculty and overhead as supervisors and researchers take some of the teaching load in applied experience, research experience and certifications. Students will get better jobs in industry, possibly with the companies they were already associated with during their education. Fundamentals or theoretical knowledge acquired by students will remain with students for long. The UIT requires further research and pilot sites to understand and study the implementation issues.

6 CONCLUSIONS

This paper proposed a UIT curriculum that has a broader impact in education. The UIT curriculum approach is described in detail. A four layer architecture model is presented to capture its concept. Some sample examples of career tracks are illustrated to describe the new curriculum. A timeline required to complete a career track will be three years. The implementation issues and pros and cons of this concept are outlined. The curriculum proposed here requires further research and demonstration through some pilot sites to demonstrate its feasibility.

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