IT Dean's Meeting

The Evolving Discipline(s) of IT (and their relation to computer science): A Framework for Discussion

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This article summarizes a report presented on February 9-10, 2002 in Washington DC, to a group of 30 deans of colleges and schools of information technology (IT), who have been meeting semiannually under the sponsorship of the Computing Research Association (CRA). The rapid increase in IT academic units and programs represents a positive response by universities to societal needs [1, 2]. Our objective was to identify the issues facing these academic programs, stimulate discussion among the Deans, and begin an ongoing dialogue within the community to clarify the intellectual agenda(s) of the IT field. The presentation was structured as a set of questions each followed by some remarks to stimulate discussion.

A significant portion of our thoughts on these issues have been informed by launching our own Information Science program in the fall of 1999, and spending the better part of the last 3 years developing the program within a context that is still dominantly mainstream computer science.

What are the forces that are driving the development of a new IT discipline?

Discussion:

The critical role that IT is coming to play in modern life is generating a new broader agenda for IT education and research. While computing was formerly of concern mainly to engineers and scientists, the military, and back-office business managers, now it is something that everyone experiences and whose misuse or failings can have profound effects on society. We have identified three gaps in the IT education landscape that are motivating innovations in academic curricula:

a. Students and employers have recently started to require new knowledge-and-skills profiles; not infrequently, students who are interested in computing careers find computer science too narrow, mathematical, and physical-science oriented, while MIS is insufficiently deep in technical content and too focused on traditional business topics and culture. This represents an ***intellectual gap*** in our educational frameworks. To the extent that the bodies of knowledge, which can fill the gap, are incomplete, this gap also signifies a need for research.

b. There is also a need for education leading to computer literacy/fluency for students who are not pursuing IT careers [3]; this represents a second educational gap – the ***IT literacy/fluency gap***. Just as universities now require that all students meet proficiency standards in mathematics and English composition, there should be a

proficiency requirement for IT knowledge and skill. IT educators should play a role in helping to define the IT knowledge and skill requirements for non-IT majors.

c. Some observers have identified another gap – a ***professional practices gap*** that centers on expertise in current technologies and how to apply them to solve problems [4]. According to this point of view, current IT programs are heavily weighted in favor of conceptual and theoretical material, and as a result students are not sufficiently prepared for the practical challenges they face as IT professionals.

Additional pressure for the IT field to make changes comes from frequent media reports of out-of-control or failed software projects, computer glitches, overly complex products with awkward and confusing user interfaces, and deficient information security. There is a general public perception that the IT field is not fulfilling its responsibilities to society as well as it should.

Finally, there is pressure from government to broaden the IT research agenda – for example, the PITAC report [5]. This 1998 report of the President's Information Technology Advisory Committee set out a broad agenda for IT research, including more attention to socio-economic and workforce impacts. Some of the government response has been construed as criticism of the computer science field for being too theoretical and too narrow.

Of the three gaps, our focus in this discussion is on the intellectual gap; it is in this gap that we can find the foundations of a new IT discipline with a new research agenda.

What bodies of knowledge comprise the new IT discipline?

Discussion:

A new academic discipline should address issues of ongoing concern that are not adequately addressed by existing disciplines. To characterize a new IT discipline that meets this criterion, we must first consider the broader IT intellectual universe – that is, a definition of the IT field that includes not only the technical aspects, but all aspects of IT development and use -- including the technical, cognitive, managerial, social, and economic aspects. The more IT becomes integrated with and essential to our lives, the more urgent is the need to consider IT from more than a purely technical perspective.

Figure 1 illustrates the bodies of knowledge contained within the broad IT intellectual universe. We envision this as a continuum from fundamental computing principles (far left), to the impact of technology on society (far right). In the center are the information design sub-disciplines, where cognitive/social constraints meet the technical constraints of computing. Although most topics, e.g., user interface design, can

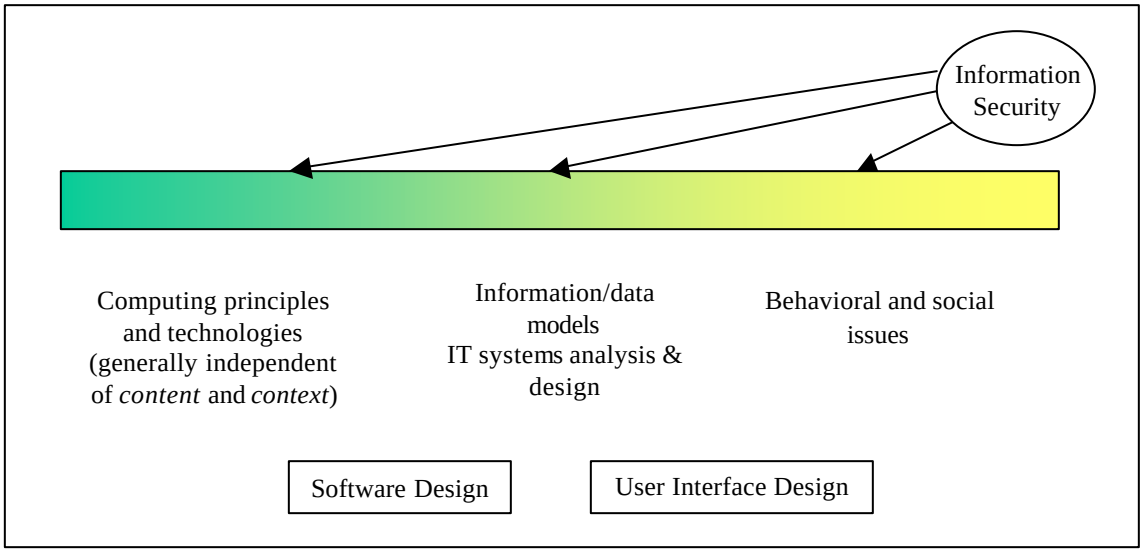

Figure 1. Subject matter continuum of the broad IT discipline

be represented as an interval on the continuum, some areas, such as security, are concerned with issues that span the continuum, from the performance of encryption algorithms to the laws that govern privacy rights.

Figure 2 illustrates the location of the IT intellectual gap in a 2-dimensional vision of the IT universe. The vertical axis represents subject matter (i.e., the continuum of Figure 1, rotated left). The horizontal axis represents another continuum – that of theoretical/conceptual study of a topic versus professional-practice-oriented education and research.

The two ellipses are a symbolic representation of the location and coverage of the computer science and MIS fields. As the figure shows, the field of computer science is focused on both the conceptual/scientific aspects of computing and, to a significant but lesser extent on professional practice (namely, mastery of the technical skills of programming and software development). However, little attention is paid to non-technical concerns of IT use and impact. (This is not a criticism; the need for highly skilled computer science graduates is not diminished by the existence of other categories of IT professionals, just as in medicine we need surgeons, pediatricians, and epidemiologists.) To complement the discipline of computer science, the field of management information systems (MIS) focuses on the use and impact of IT, within a particular context: business. Both research and education in MIS focus more on professional practices than conceptual underpinnings.

The diagram in Figure 2 reveals two gaps: at the lower right is the professional practice gap, where a number of the programs offered by new IT schools and focusing their attention. Denning [4] has written about this gap and the need for developing a foundation of best practices in the IT field. At the upper left is the intellectual gap we are concerned with here: the study of IT use and impact from a scientific perspective. To fill this intellectual gap, we propose that a new IT discipline is needed. Some areas within the

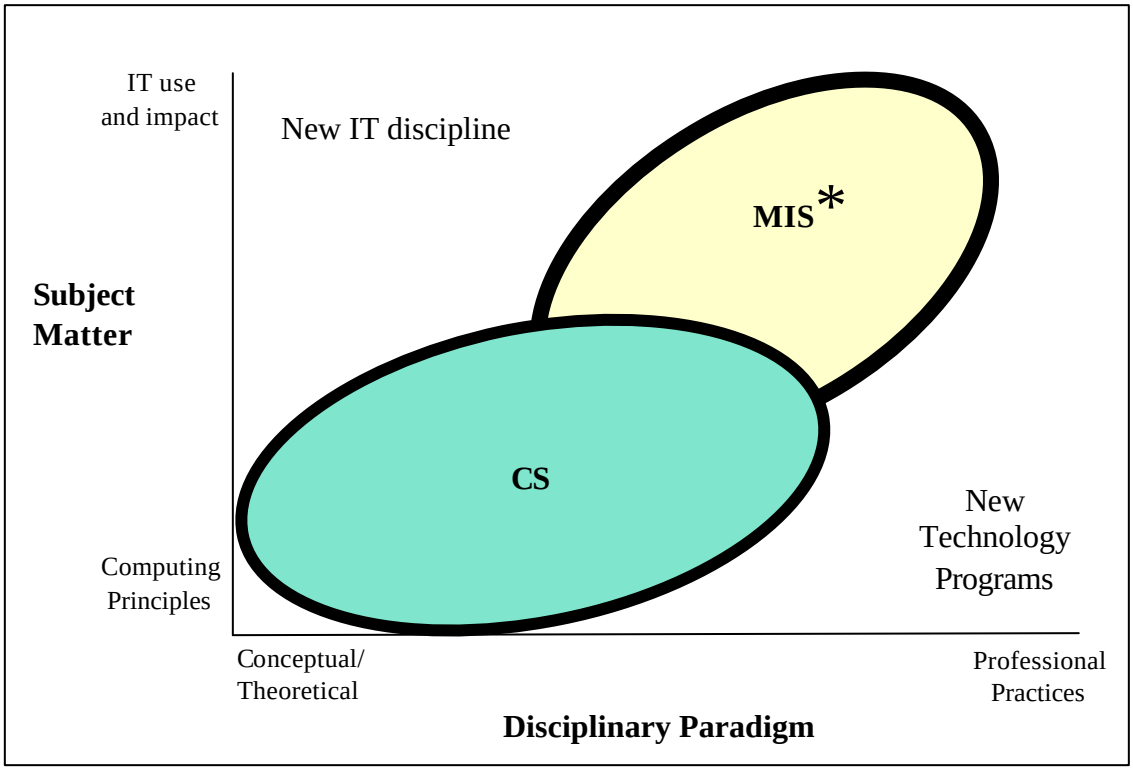

Figure 2.The gap(s) in IT academic disciplines

new discipline are already being pursued, for example: information security, knowledge management, data warehousing/data mining, information visualization, collaborative computing, and requirements engineering. However, these topics (and the researchers who study them) often do not live comfortably in departments of computer science.

Some broad areas of interest within the new IT discipline include:

- The study of information: how it is acquired, organized, communicated, managed and used by people and organizations, and how IT changes those processes, sometimes in fundamental ways.
- The study of IT applications per se, including application taxonomies based on technical requirements, functional characteristics, information models, and domain or context of use (e.g. business, government, education, health care, publishing, the military, law enforcement, media & entertainment, science & engineering).
- Techniques and tools for managing the design, development and deployment of large complex IT systems.
- The study of how IT affects human behavior and quality of life.
- The study of how IT affects social and political institutions, and how those institutions in turn affect the development and use of IT.

What knowledge and skills should educational programs provide in the new IT discipline?

Discussion:

We have argued that there is a need for a new science-oriented discipline focusing on the design, use and impact of information technology-based systems. In order to study the science of computers in use, we need to understand both the capabilities and behavior of computers, and the capabilities and behavior of the users (as individuals and as social groups).

Although it is premature to define specific courses and curricula in detail, it would be worthwhile to begin building a consensus about the material that should be covered in both undergraduate and graduate programs in the new IT discipline. Below are some suggested topics for an undergraduate major, based on the Information Science curriculum we developed and implemented at Northeastern [6].

- Structure and use of information
  - Information/data models
  - How people and organizations use information
- Computer science concepts and technologies
- Information systems
  - Analysis, design, management, evaluation
- Behavioral science foundations and methodologies
- Human-computer interaction
- Social and organizational informatics

What are the research goals of the new IT discipline?

Discussion:

A research agenda for the new IT discipline is suggested by the National Research Council report *Making IT Better* [7], which defines socio-technical research as that which:

> combines work in technical disciplines, such as computing and communications, with research in the social sciences to understand how people, organizations, and IT systems can be combined to most effectively perform a set of tasks.

The National Science Foundation, in its program solicitation for Information Technology Research [8], presents an even broader definition. The NSF defines research under the topic "Augmenting Individuals and Transforming Society" as research aimed at:

> understanding how people use information, how they can use it more easily, and how more and more people can use IT for more and more tasks. We seek to amplify human physical, mental and sensory abilities, to enhance the performance and experiences of human beings in a variety of activities, occupations and social contexts.

(Note: As responsible scientists, we should also include language such as "We also seek to understand the negative effects of IT on the quality of life of workers and citizens, and on our social institutions, and seek ways to prevent or minimize those effects.)

Both of the reports quoted above include more specific lists of basic science goals and IT application goals, such as: "theories for linking IT design to social and economic outcomes" and "technologies for assisting in teaching, learning, collaboration". [7].

Below we suggest some broad areas of investigation that will fall within the scope of the new IT discipline:

- To study how people and organizations acquire, store, communicate and use information, and how the use of IT changes these function.
- To develop improved models and techniques for integrating technical and contextual issues in developing IT system requirements and designs.
- To develop improved models and techniques for evaluating whether IT systems achieve their objectives.
- To advance the state of the art in user interface design and evaluation
- To study the impacts (positive or negative) of IT on quality of life, on interpersonal behavior, and on our social institutions.
- To develop new research methods and tools for conducting the research above.

How should research faculty in these new areas be evaluated ?

Discussion:

Unlike computer science, the new IT discipline focuses on understanding applications and what makes them succeed. Tools may be developed that do not embody any new technical concepts, but that combine and adapt known techniques for a new purpose or organizational context. Models of user performance may be developed that have nothing new to say about computer performance. Well-understood computational techniques may be studied, not for the efficiency of their algorithms but for their match (or mismatch) with the requirements of a particular task. Faculty in the new IT discipline are more likely to be consumers than generators of new ideas in computer science; this needs to be recognized, and the research evaluated in other ways.

Another fundamental difference between research in computer science and the new IT discipline is the scientific methodology needed. To study the relationship between technology and its users, empirical research methods typical of the behavioral, social and health sciences are required. Skill in empirical research may be more important than skill in the mathematical proof techniques used in computer science. This essential difference in research methodology must also be recognized and factored into the hiring and evaluation process.

What has the response been so far to these pressures and opportunities?

Discussion:

As demonstrated by the large attendance at the February IT Deans meeting, Universities are responding to the pressures for change in large numbers. Many universities and colleges have created new programs with a broader intellectual agenda, and many more are in the planning stages of such programs. The diversity of these programs, in their administrative loci, the names of their degrees, the subject matter covered, and their intellectual/ pedagogical objectives, is great:

- There are undergraduate and graduate programs in Information Science or informatics now offered by schools of computing or newly-formed schools of IT.
- There are degrees in Information Systems[1] that focus on the use of information technology in a business context.
- There are undergraduate programs in Information Technology focusing on professional practices and the mastery of current technologies and tools.
- There are masters and a few Ph.D. programs in Information Science and Technology offered as interdisciplinary degrees or through expanded schools of Library Science.

Government funding agencies, particularly the National Science Foundation with its new program in Information Technology Research (ITR) [8] have responded also.

Professional Societies have responded – in particular, a new model curriculum for degrees in Information Systems [9] has been developed and is influencing curricula in many schools of Business and Management.

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[1] Although we use the name Information Systems to signify programs with a business orientation and Information Technology to signify a technology orientation, in reality the names Information Systems and Information Technology are used for many similar programs.

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