Work in Progress - Adaptation of a Computer Networks Curriculum for Non-Technical Audience

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Abstract - **A variety of computer networks related courses are being offered as part of mainstream curricula at the undergraduate as well as graduate level in many engineering and computer science programs. The pervasiveness of computer networks in all aspects of industry and education make a basic understanding of networking as important to non-science majors as other scientific disciplines such as physics and chemistry. Understanding how the Internet works is a fundamental part of modern engineering education, but there are few opportunities for those in non-technical fields to learn about networking. As networking becomes increasingly important to business and K-12 education, those without engineering background will become more likely to be in positions that require them to make decisions about how networks will be deployed and used.**

This paper describes first steps in adapting a standard computer networking curriculum, as required by most science and engineering programs, to the needs of those outside of engineering disciplines. The paper is divided into two sections; the first addresses the parts of the curriculum that we are initially concerned with implementing. The second section discusses educational techniques that we are using to help students learn these unfamiliar concepts in ways that should enable them to use the knowledge when appropriate.

Index Terms – Computer networks curricula, adaptation of technical courses.

KEY NETWORKING TOPICS

We have not yet implemented an entire networking course for non-majors. Instead, we are integrating key components of the networking curriculum into a course entitled ``Administering Instructional Media Programs," a course originally designed for individuals who would be working in schools and managing film projectors, VCRs and other such equipment. The course has not been offered in several years and is now being re-cast as a course for people who are likely find themselves at school systems in technology-leadership roles (e.g. computer coordinator or principal). A significant part of the course will be focused on understanding computer networks, network applications and the Internet. Other parts, beyond the scope of this paper, will include training, funding and managing large numbers of networked computers.

The networking part of the curriculum will follow the now popular ``top-down" approach [1]. The majority of the time will initially be focused on application layer topics; many non-technical people, for example, are often surprised to learn that the only thing that separates a *workstation* from a *server* is the software that each runs. For those working in schools, this is especially important because ``guerrilla networking" is often the only way that a teacher can make basic services like file sharing available to themselves and their students. The transport layer will be covered only briefly, as the implications of this layer are of little concern to those who are not writing network applications at the socket level. The network layer, and related themes such as routing concepts, are of much greater concern to the layman, as routers and network address translation (NAT) are topics that have direct impact on how and whether one is connected to the Internet. Similarly, issues pertaining to the link layer and local area networks (LANs) are of concern, for instance, to someone making decisions on how to spend money on equipment and management of a building's network.

Understanding something about these networking topics is essential if one is to assess the competence and effectiveness of maintenance staff or a consultant. The link layer is the part of networking that is most likely to continue to change in significant ways, so understanding the issues in choosing between different media as they emerge is essential. For example, improvements in the capacity of twisted pair copper has implications for whether fiber is worth the additional expense; the deployment of 802.11b in many cases obviates the need for some copper.

PEDAGOGICAL TECHNIQUES

Many educators have long assumed that teaching students generalized principles would allow them to use the techniques in a wide variety of situations [2]. A preponderance of evidence, however, suggests that humans often do not transfer knowledge from one situation to another, and that the ability to apply knowledge to new situations is a better measure of learning than is recall of a specific fact or method [3]. This comes as little surprise to engineering professors who are often frustrated that students who have done well in calculus or discrete mathematics courses often fail to see the how to apply such mathematics in the context of an engineering course. One of the most successful techniques in computer science is the power of abstracting different parts of a process

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to simplify the design process. Expert engineers use abstraction facilely and, likely, do not appreciate how difficult it is to develop this adaptive expertise [4]. Research in mathematics education, for example, has shown that teachers (experts) often do not recognize which problems students will find most difficult [5]. Two techniques we use to counter these problems are the use of analogies and the concept of creating a ``time for telling'' [6].

The cognitive mechanisms involved in making use of analogy for transfer are a well-studied area in cognitive psychology [7]. Simply providing a single analogy is often not enough to induce a good enough understanding for transfer to a new situation. One study showed that two analogies and a principle explaining them are very helpful in forming a usable schema. In demonstrating how a TCP connection is initiated, for example, we show students how this type of initiation is the same for several protocols, like FTP and HTTP, as well as when people meet each other. In addition to analogies we also provide a script that describes how all of these protocols work similarly. These different examples together with the over arching principle of a handshake should help students to understand the concept of handshaking in other protocols at other networking layers as well [8].

Many people in education now recognize the value of a ``student-centered'' classroom [9]. Moreover, many educators embrace constructivism [10], which is an epistemology that posits that knowledge is constructed in the learner's head. Those with a more positivist view believe that knowledge is unchanging and that the goal of instruction is to metaphorically open students' heads and pour the knowledge in so that they will ``have'' it when they need it. Many believe that constructivism calls for ``hands-on'' learning and for students to have more control over what it is they learn. It is not the case, however, that constructivism means that a lecture cannot be an effective means for instruction. A series of studies indicated that with proper preparation, a lecture yields better learning than do two lectures (or the time-honored summarize the chapter and then hear a lecture).

A common intricacy in psychology, not unlike computer engineering, is that once a particular theory or solution is presented, it seems self-evident, but when one is asked to consider a similar situation the solution no longer seems self-evident. In related studies, the authors had students evaluate simplified data sets from classic studies in cognitive psychology. After evaluating these data sets, (which included, for example, sets of numbers that people were asked to memorize), while trying to explain the results, students received a lecture explaining the phenomenon demonstrated by the data. Having struggled with making sense of the data, the lecture became an ``aha!'' or ``teachable moment.'' The same technique has been shown to work in teaching statistics as well [6].

Our proposal is to similarly develop activities which will help prepare students for learning from lectures about networking subjects. For example, students might be asked to come up with ways to allow one computer to provide a variety of different services and follow that activity with a lecture about ports. As an additional example, we plan to develop similar activities to prepare students to learn about the distributed Domain Name Server system and NAT.

SUMMARY

This paper describes a plan to provide computer networking instruction to non-technical audience. We presented a brief description of the topics we consider most important followed by a description of some pedagogical techniques that we think will help make the course more accessible. These same techniques, proven in psychology and statistics instruction, may also be useful in similar adaptation of a wide range of science and engineering courses in the future.

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