Multimedia Animations to Enhance Learning Complex Concepts in Data Communications

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Abstract

This paper first identifies the problems associated with the teaching of data communications and describes a composite learning system to facilitate instruction. This courseware for data communications consists of three major components - a series of printed lecture notes, a computer-managed learning system and a series of animated multimedia demonstrations. From our experience, the multimedia component is particularly useful for students to learn physical processes and abstract concepts that are best presented as simulated animations. Examples of the multimedia components are illustrated in this paper to show the effectiveness of this animated visual imagery over traditional illustrations.

Keywords

multimedia, animations, data communications

1. Introduction

While the personal computer has revolutionised our workplace since its advent in the 1980s, communication technologies are going to play an increasingly vital role in delivering a wide range of services and facilities that will affect our daily lives over the next decade. Indeed, the utility of the computing machine is quite often bounded by the information sources available via the networks it is connected to, rather than its own computational capability.

Data communications is therefore an essential ingredient in the computer science / information technology curriculum and it is important that graduates from these disciplines have a thorough understanding of the subject matter. Data communications is renowned for its overuse of acronyms, the wide range of fundamental and highly technical concepts students have to grapple with, many of which need to be learned by rote. Coupled with these, there are a wide range of complex and abstract concepts that need to be understood.

Pilgrim and Leung (1993) cited the problems facing computing educators where the rapid changes in this technology have created many resource-related and curriculum planning problems that are common in computer science departments. They further suggested the use of simulation software and case studies in the delivery of data communication course materials to achieve operational efficiency.

Constrained by scarce resources, at Swinburne, we are experimenting with a new approach that attempts to improve efficiency and effectiveness in delivering the course contents. This approach consists of three components—the printed lecture notes, a computer-managed

learning system and a series of animated multimedia demonstrations used in conjunction with conventional lectures. The aggregation of these elements provides the students with a much richer learning environment for data communications.

This paper first describes the approach taken and then concentrates on the multimedia demonstrations and highlights how many of the complex and abstract concepts may be presented to the students using these animated sequences. Examples of the multimedia components are illustrated to show the effectiveness of these animations.

2. The Course Approach

As mentioned above, the course approach consists of three major components—printed lecture notes, a computer-managed learning system and a set of multimedia animations used during lectures to illustrate complex concepts.

2.1 Notes

The lecture notes, entitled 'Understanding Data Communications' (Leung, 1994), consist of eight modules. They cover the entire data communication unit and have been developed over the past six years. They were prepared as a series of Microsoft PowerPoint slides and printed in a bound volume. Each module contains the material to be covered in one or two lectures. The objectives of each module are clearly spelled out at the beginning of each module. Because of the fast changing nature of the subject materials, regular updates of the lecture notes are necessary. The fourth edition of the notes was published last year. These lecture notes have been converted to the latest version of Powerpoint to allow the slides to be projected using a portable LCD projector. The use of colour and slide builds has increased the motivational appeal of the presentations.

2.2 Computer-managed learning

The computer-managed learning (CML) system consists of a question bank covering four main modules. The Swinburne CML software runs over a network and provides full security and control of the testing schedule. The system provides the test result at the end of a test along with a list of areas where the student did not perform well. This immediate feedback enables the student to find out if he or she has adequately grasped the material studied and allows the student to seek appropriate help. The CML tests have proven popular with students who are unsure of their level of understanding of the concepts introduced during lectures.

2.3 Animated multimedia demonstrations

During 1995, a series of multimedia animations were created to assist in explaining complex concepts. These animations were created using a range of tools including Authorware Professional and Multimedia Toolbook. Each component typically consists of a short sequence of animated graphics, including appropriate use of scanned colour images, to illustrate a concept. These animation files are linked to an appropriate slide of the current Powerpoint presentation using the Object Linking technique. The animation appears as an icon on the slide and may be selected during the lecture to display the animation.

3. The Power of Animations

'A picture tells a thousand words' is a well known phrase that appropriately describes our experience with the use of the multimedia animations. Graphical animations are found to be particularly effective to explain complex concepts in a way that transcends the English language, such as processes involving interactions of a number of entities and those that are abstract in nature. At Swinburne, where a significant proportion of students are from non-English speaking backgrounds, this visual approach to explanation is proving to be very successful.

Prior to the use of multimedia animations, the lecturer would attempt to explain concepts using a two-dimensional, black and white diagram from the printed lecture notes. Although the diagram is generally supplemented by a page of textual information, students often find it difficult to grasp process-oriented concepts.

To illustrate this point, Figure 1 shows an example of a diagram as presented in the lecture notes that describes the Continuous RQ Error Control Scheme. This scheme is a commonly used communications protocol to facilitate the transmission of data between the primary and secondary computers. The diagram shows how the data packets are exchanged when no transmission error takes place. Whilst the figure contains the essential information about the protocol, because of the complexity of the protocol, even with the support of textual explanation, the fundamental concept is not easy for the student to grasp.

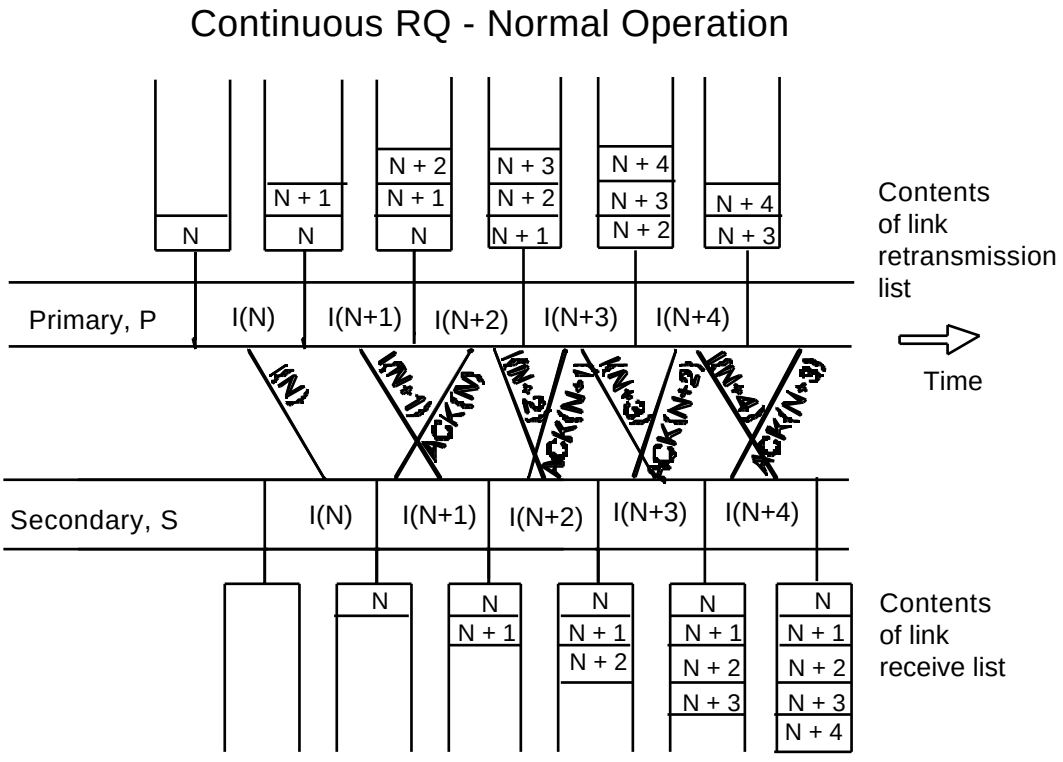

Figure 1. Continuous RQ Error Control Scheme.

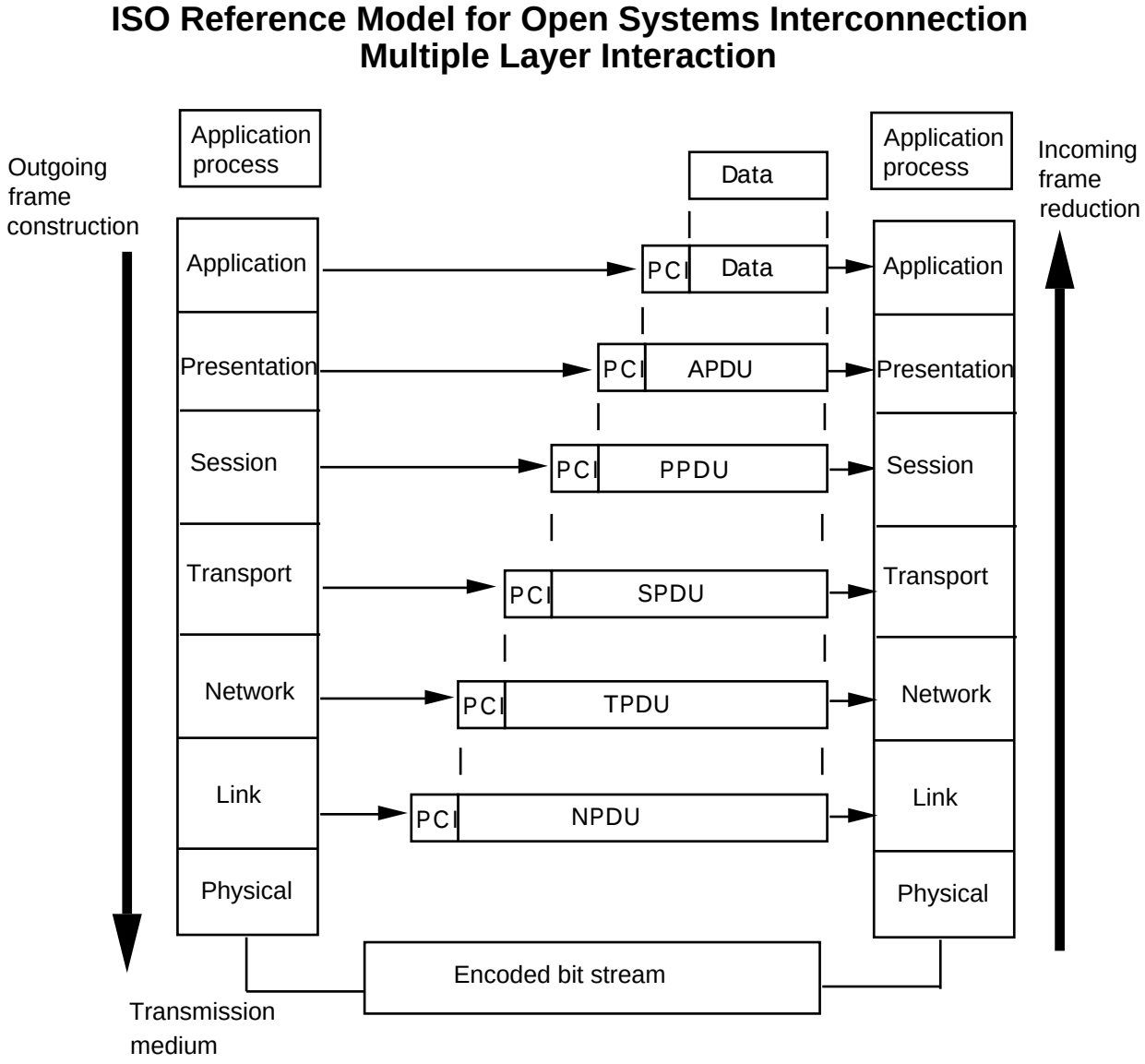

Figure 2. An excerpt of the existing lecture notes to illustrate the ISO Reference Model for Open Systems Interconnection.

In data communications, there are other abstract concepts that students find difficult to learn. For example the ISO Reference Model for Open System Interconnection is a typical case. This reference model, which consists of several deep conceptual ideas, provides the fundamental framework to enable two heterogenous computers to communicate with each other. Figure 2 shows a diagram used in the lecture notes to explain the different layers of the ISO model and the process in which data frames are manipulated before transmission via the physical medium. At the receiving end, the reverse process takes place and the computer retrieves the original data and the appropriate information to convert it in a format that can be interpreted and processed.

This static image does not provide an experience to allow the concept to be readily understood and usually requires a long explanation to describe the movement of the data frames and the operation of the protocol in detail. Books and lecture notes do have limitations and do not always assist student understanding. (Tyerman, 1993). The use of a variety of techniques, physical props and aids to help illustrate these types of concepts

relating to data communications, especially those dealing with data movement through a system, has been explored but are difficult to manage and use in a lecture situation.

Research suggests that visual analogies are a powerful mechanism for explaining complex systems by focusing attention and clarifying the context of verbal presentations (Pilon, Raymond and Raymond, 1995). Graphics can also simplify complex illustrations by removing unnecessary detail and presenting abstract ideas more concretely through the analogical use of space, lines and arrows. (Milton, 1992)

It is commonly accepted that the mind uses symbols to represent, store and manipulate information (Batten and Vander Velde, 1992). 'We have the ability to scan images recalled from memory, zoom into them acquiring more detail and transform them in multiple ways' (Lennon, 1995, p. 28). Visual models are a powerful tool used to present information as they stimulate recognition and transfer of information to people. Hoogeveen (1995) maintains that when visual models are added to text, people pick up and understand a story faster than if they are confronted with a text-only story. He relates this theory to the experience of reading stories to young children who form connections with the displayed pictures more than the words.

A static graphic image, as shown in figure 1, will provide a sufficient explanation of many simple concepts. There are many concepts that are so complex and abstract that a student cannot immediately relate them to their own world experience. Winn (1989) suggests complex abstract concepts such as 'predation' and 'transfer of energy in a food chain' can be depicted in a much more concrete manner as dynamic diagrams. The use of dynamic animations can have profound effect on what is learned and how learning occurs. Animations can excite, explain clearly with stunning examples and allow learners to play, ponder and develop an understanding of complex concepts. Figure 3 shows a snapshot of the multimedia animation that is used to describe the concepts conveyed in Figure 1.

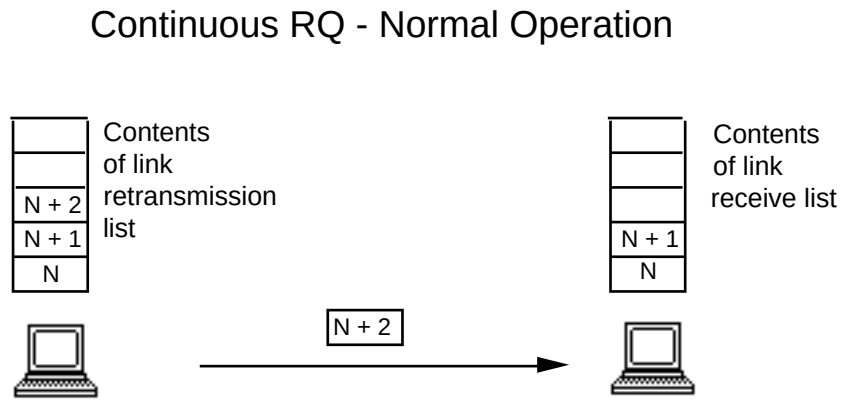

Figure 3. A snap-shot of the animation for the Continuous RQ error control scheme.

This animation sequence clearly shows the movement of packets of data between the systems and the full operation of the protocol in question. This visual animation allows this complex concept to be seen therefore making the facts and relationships easier to memorise (Kienegger-Domik, 1995). Also, these multimedia animations can inspire activity and motivate learning, leading to more effective instruction (Woolf and Hall, 1995; Nosal, 1995). The use of high quality animations in this way is supported by a number of empirical studies have proved that visualisation of concepts result in more effective learning relative to static graphics (Baek and Layne, 1988; Szabo, Dwyer and De Melo, 1981).

We also find that the use of multimedia animations has other advantages over the conventional paper medium. First, the voice-overs help the user focus on the parts of the display that are relevant to the concepts currently being explained. Timely application of voice in conjunction with graphical animations also greatly enhance learning. In the case of the print media, all the relevant graphics and labels, associated with the entire concept needs to be presented at the same time. This is in additional to the accompanying textual materials that need to be printed in a different area of the lecture notes.

4. Conclusion

The learning system described in this paper provides a very rich learning environment for the students. Such an environment is effective in data communications where there is a wide range of materials to be covered and understood by students The use of computer animations is an important ingredient to assist the student to grasp the underlying complex and abstract concepts quickly. This technique can be applied just as effectively to other disciplines.

The use of animations on the computers also helps the lecturer in the classroom in that they are conveniently embedded in the powerpoint presentation. Whilst there are so called self-paced learning material on selected topics in data communications available on video tape in the market place, the sequential access to the information also poses a severe limitation to their effectiveness.

Further enhancement of the current system is planned. We hope to migrate the entire learning system to CD-ROM and to make it available as a self-paced learning resource.

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6. References

Baek, Y. and Layne, B. (1988). Color, graphics and animation in a computer-assisted learning tutorial lesson, *Journal of Computer Based Instruction*, No. 15.

Batten, C. and Vander Velde, R. (1992). Using a multimedia approach to enhance learning through case studies, *Proceedings of ITTE 92*, Brisbane.

Hoogeveen, M. (1995). Towards a new multimedia paradigm: Is multimedia-assisted instruction really effective? *Proceedings of EDMEDIA 95*, Austria.

Kienegger-Domik, G. (1995). Intelligent visualization systems in educational environments, *Proceedings of EDMEDIA 95*, Graz, Austria.

Lennon, J. (1995). Mental imagery and visualisation. From the mind's machine to the computer screen, *Proceedings of EDMEDIA 95*, Graz, Austria.

Leung, Y. K. (1994). *Understanding Data Communications*, 4th Edition, Swinburne Press.

Pilgrim, C. J. and Leung, Y. K. (1993). Teaching data communications: A cross-Tasman experience, *Proceedings of the 13th New Zealand Computer Society Conference*, August 1993, Auckland, New Zealand.

Milton, J. (1992). Using the computer to teach for understanding, *Proceedings of ITTE 92*, Brisbane.

Nosal, M. (1995). Computer-assisted learning and multimedia in Mathematics and Statistics, *Proceedings of EDMEDIA 95*, Graz, Austria.

Pilon, D., Raymond, J. and Raymond, P. (1995). Software tools for improving classroom interaction, *Proceedings of EDMEDIA 95*, Graz, Austria.

Rieber (1990). Animation in computer-based instruction, *Educational Technology Research and Development,* Vol. 38.

Szabo, M., Dwyer, F. and DeMelo, H. (1981). Visual testing - Visual literacy's second dimension, *Educational Communication and Technology Journal*, No 29.

Tyerman, S. (1993). Using computer-aided instruction in an introductory programming course for first year engineering students, *Proceedings of ASCILITE 93*, Lismore.

Winn, W. (1989). The design and use of instructional graphics. In Mandl and Levin (Eds.), *Knowledge acquisition from text and pictures*, Amsterdam.

Woolf, B. and Hall, W. (1995). Multimedia pedagogues - Interactive systems for teaching and learning, *IEEE Multimedia*, May.