Courseware Design Experience

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Abstract **- This paper is a short report of a University, government and industry collaboration. Australian Communications and Media Authority (ACMA) expressed interest in 2004 for a courseware design and delivery for their staff across the country. ACMA in collaboration with Royal Melbourne Institute of Technology (RMIT) defined the topics to be covered. The course has 42 contact hours. The initial concept of the course was aimed at further advancing the skills of ACMA staff. It has been extended to educate a wider population, thus to include the general public and industry.**
The development team of seven writers had support of university academic development group.
The full utilization of RMIT University's technological resources was used to the advantage of team members, such as Online tools (Blackboard) to communicate draft material. ACMA and RMIT management monitored course progress and organized peer review.

Index Terms - Digital wireless communication, Engineering and Technology Education, Staff professional development in the new technologies, University – government - industry collaboration

INTRODUCTION

The history of RMIT University begins with the Working Men's College in Melbourne in 1887. It is now one of the leading Australian educational institutions offering various programs in engineering, science, business, education and many other areas. The legacy of an institution that offers education for the working men and women still exists. RMIT offers many educational pathways and strongly supports life long learning. It has first-class links with industry in all aspects of education and research. RMIT is present worldwide in many engineering areas, such as sport, creating special bike designs, Digital Signal Processing in tennis racquet design, but also in aerospace, with a space suit design for astronauts.

School of Infrastructure, Electrotechnology and Building Services (SIEBS) is the largest technology school in RMIT offering a wide range of different programs on campus. The programs are further supported by industry placements, online and flexible delivery. SIEBS is one of the three RMIT schools that are operating the CISCO Academy program as an additional field of activity. The school also used to run an Intel training centre in the past. Now, CISCO and Microsoft curriculums are incorporated into programs offered by the Electrotechnology department of the school. All programs are offered to local and international students. As recognition of excellence in engineering education and appreciation for awareness to industry needs, SIEBS was approached by a government institution, Australian Communications and Media Authority (ACMA), with the request for a new courseware design tailored to their needs. The official title of the new course is defined as *Contemporary Digital Radio Technologies (CDRT).* ACMA's proposal was to offer professional development and skills upgrade to their staff working in the area of digital radio communications [1].The digital and wireless systems are changing at an ever-increasing rate. Mobile phones, wireless computer networks, digital video and audio broadcasting, Bluetooth and Global Positioning System are part of our life. Along with the escalation of new technology, various problems and issues do arise. These issues do not exclude wireless technology.
Thanks to ACMA, the course developed by RMIT is made available to the wider public. It is offered to anyone interested in engineering achievements in radio technology and is also accessible to RMIT students as a part of various programs, or as an elective subject.

PROJECT REQUIREMENTS

The initial steps were aimed at establishing project requirements and expenditure. An RMIT development team was established, and in cooperation with ACMA experts, a list of topics of interest was defined as following:

- Introduction
- Emission
- Signals and Noise
- Spectrum Use
- Digital Coding Methods and Multiplexing
- Global System for Mobile (GSM)
- Code Division Multiple Access (CDMA)
- Trans European Trunked Radio (TETRA)
- Motorola APCO
- Bluetooth
- Wireless Local Area Networks (WLANs)
- Wireless Metropolitan Area Networks (WMANs)
- Global Positioning System (GPS)
- Voice over IP (VoIP)
- Third Generation (3G) Networks and Beyond
- Wireless Application Protocol (WAP)
- Digital Television and Radio Broadcasting.

As both RMIT and ACMA are government institutions, functioning under their own scope of registrations and strict

regulations, clear relationship arrangements had to be established. It is specified via the contract arrangement signed by both parties. Agreements specify licensing and conditions of final product use, as well as payments, project tracking and the maintenance of the courseware relevance for the next 5 years.

Project outcomes delivered to ACMA were: a textbook of roughly 600 pages, instructor notes of 800 pages, CD containing the textbook and Power point presentations for students, and Instructor CD. Material is available online from RMIT University website. All chapters include review questions and exercises. Assessment is on-going, competency based. Course fits into the framework of ICT02 Telecommunications Training Package, defined by Australian communication industry. The course refers to the ICTTC096C Competency, which is *Conduct field tests of radio/wireless networks*. Successful course graduates can request transfer of credit for a number of courses in the communications engineering programs, offered at Australian universities. After all requirements were clearly established, planning was the next stage of the project. MS Project was used for the project management, as well as other tools for the course material development: Visio, Excel, LabView, and Matlab.

PROJECT PLANNING

Project planning was commenced from the first day of the negotiation with a potential customer. Since the course was to be designed for the teaching of already skilled people that were working with the new technology area, SIEBS had to ascertain if there was enough expertise to cover required material at the appropriate level. A project development team was created consisting of seven experts in particular disciplines. The experts were employed from RMIT University and external specialists. The areas of knowledge expanded from the scientific and research level, lecturing and teaching, CISCO and Microsoft certifications, and communication standards design.

Project expenditure is calculated for the entire project, consequently the unit price is established for the development material. In order to specify the expense, life-long experience in tertiary and industry teaching was used, along with CISCO and Intel examples. After the project outcomes were clearly defined and specified by the RMIT & ACMA agreement, separate contracts were signed with each development team member about individual roles and responsibilities. The team was induced by RMIT instructional designers and copyright coordinators, on the skills needed to produce quality teaching and learning material. RMIT professionals are a part of the extended project team, responsible for monitoring progress and any arising issues.

Finally, all tasks, resources, the progress meeting dates and milestones were established and circulated to the stakeholders. All initial activities took an extended length of time, and were performed concurrently with the preparation of the Agreement by legal teams of both parties. After signing the contract, the execution phase was started in June 2005. Figure 1 below illustrates part of the Gantt chart of the project. Forms of internal communication between team members, and externally with stakeholders were established. Online space at Online@RMIT site was allocated for project data storage. It was also used for peer review, copyright issues tracking and progress tracking. The University library, through the activity of liaison librarians, supports the development of new courses and delivery, by set of links related to the subject area. RMIT University is using Blackboard for online course development, delivery support, or complete online delivery. The project development site was later converted to the CDRT course delivery support site.

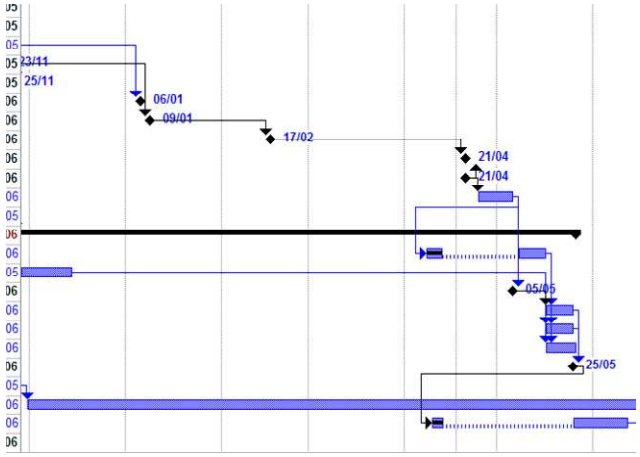

FIGURE 1
PART OF THE PROJECT GANTT CHART.

RISK ASSESSMENT

The major risk present, even before the beginning of the project, was the problem to establish the ground level of requirements and project outcomes, in the terms of licensing and copyright of the courseware material. This was a pilot project for SIEBS, and with recognition to the efforts of two legal teams, the project was ready to begin. One of the problems encountered was that a key development team member was overseas. An alternative solution to employ a new member was found, but the project management decision was to start the project with the incomplete team. It proved to be the risky, but justified decision at the end. During the project execution phase, another team member has spent significant amount of time overseas as well. The project was conducted uninterrupted, but some rescheduling of topic allocation has to be done. A few new communication standards were just endorsed during the project execution phase and the material had to be rewritten.

In many cases when the copyright permit could not be obtained, or the process was taking an extensive amount of time, a decision was made to abandon that bit of information and use other sources, or altering methods of conveying the message.

Business component of the project, such as cost predictions, could always be performed better, but one can never predict everything. Despite that, the project is

financially achieving positive outcomes. Writing teaching and learning material is rarely an activity that can bring a large financial reward, but there are other satisfactions and management always counts on that. In addition to that, we must say that there were no obstructions from the management side of both parties, RMIT and ACMA, and the support was inspiring and always consistent.

EXECUTION PHASE

Many activities and consultations have already been completed in the project planning phase. But only after the formal project agreement was signed, RMIT team commenced the development, attempting to follow timeliness as defined in that document. Four milestone dates were set for the whole project, three of which were for the development activities and one for the book, CD and Web publishing. The publishing team could only begin their tasks when material is written, peer reviewed and copyright issues cleared.

Student material consists of a textbook and CD with PowerPoint slides from the lectures. There are review questions in the textbook and on the slides as a part of each chapter. There is also a list of key terms and list of references. Answers to the review questions are in the second book called *CDRT Instructor Notes*, and also in the notes pages of the PowerPoint slides for the lectures. Instructor material consists of the same course book, *CDRT Instructor Notes*, and instructor CD with PowerPoint slides including notes pages.

All writers were using MS Office package for the material design. In addition to the standard software, such as Word and PowerPoint, development team members were using Visio to produce pictures. Every member was regularly drawing pictures, taking photos and writing equations. During the induction, before the execution phase, the project team had sessions with RMIT instructional designers and copyright coordinators about quality and copyright free material design. If there was a real need for unique copyrighted material to be used an, RMIT Coordinator from Copyright Management Service was responsible in providing the approval from the original copyright owner. There is a considerable log file and documentation with instructions and conditions under which material can be used, handed over to ACMA.

Development team had regular progress meetings, especially before the milestone dates and meetings with ACMA. Every member had to submit updated material, so that the current state of the project is established and any corrective actions were taken following ACMA instruction. Concurrently with the course development, program structure of the two telecommunication programs offered by the school, was upgraded to incorporate CDRT course as an elective subject.

Although the development team was selected based on the expertise in topic areas, writers have to continuously upgrade their knowledge during the course development. There were some essential changes in the technology and new standards endorsements during the project execution in all areas, particularly in the wireless networking and telephony. Consequently, in addition to the writing courseware material, team was working on the professional development. Two team members have upgraded their CISCO instructor certifications and three of them have attended Radio Frequencies Identification (RFID) training to become RFID instructors. The whole team has also attended a conference, supported by the World Health Organization (WHO), about health effects of radiation. Furthermore, they regularly attend building industry consultant (BICSI) seminars held in Melbourne and use BICSI material [2]. BICSI is a large international and industry association in the Communications industry.

CDRT COURSE CONTENT INTRODUCTION

Wireless communication is commonly associated with mobile phones, handheld devices and portable computers. It enables access to various types of information from different locations without being physically connected. However, wireless technology is not a new concept; it dates back centuries to when the first grounds of this field were being laid out. We could imagine that the preliminary wireless communication was discrete, digital optical communication in the earliest history, where zeros and ones were represented by *smoke* and *no smoke*.

In modern communication history, telegraphy was the first communication system used. Looking at the principles of operation, it was a digital communications system dating back to 1866.

Morse code uses a discrete alphabet of dots and dashes. For example, the well known ask for help message "***SOS***" is transmitted as "**…---…**". Interestingly, analog communication systems appeared later and took over the development: telephone in 1876 and phonograph in 1877. Elements of the Australian communications history as displayed in the Bendigo Post Museum are shown in Figure 2. Bendigo is a historic town in the Victoria's Goldfields region. Visitors of the museum in the former historic post office building still have a chance to send their own Morse code messages. A team member visited the museum and had the privilege to experience the gold rushe history of the 1850s and 1860s, the history of federation and the communications history.

Many great scientists have given their contribution to the wireless communications and are mentioned in the course material. Special attention was given to Nikola Tesla whose 150 anniversary, since he was born, is in this year, 2006.

The first broadcast systems, radio in 1920, and television later, used analog modulation, where an electromagnetic wave channel was used to carry information. Throughout the course, we have considered wireless and digital-communication history, wireless system components, types of wireless systems, digital radio technologies integration, and digital signal energy budget.

In the first few chapters, we introduced: source coding, sampling and quantisation, compression, encryption, channel coding, error detection and correction, line coding and multiplexing. We have used mathematical tools, at the appropriate level, when it was necessary, to better explain certain topics, or principles. We have referred to the

Information Theory which is a mathematical theory of information. Communication Theory is a branch of

FIGURE 2
BENDIGO (VICTORIA) POST OFFICE MUSEUM DISPLAY.

Information Theory. Digital Communication Theory is a part of Communication Theory. Claude Elwood Shannon (1916-2001), American scientist and mathematician, founded Information Theory and has greatly contributed to digital revolution. Every book on digital communication should mention Shannon. According to him, the measure of information can mathematically be expressed as a negative logarithm of information probability, as given in (1):

$$I = - \log p \qquad (1)$$

where ***p*** is the probability of an event to happen. Events produced by an information source could be expressed using different alphabets, but the most convenient alphabet is the binary, in one of the forms as given in (2):

*B = { H, L }, or B = { **N**orth, **S**outh }, or B = { **L**ight, **D**ark }, or just*

$$B = \{ 0, 1 \} \qquad (2)$$

where *H* and *L* stand for High and Low voltage level in an electrical, or electronics circuit; North and South refer to the poles of the magnetic domain on the hard disk, and Light and Dark refer to the signals on the fibre optic channel, or free air laser signals for the transmission of information.

The occurrence of one of two events, from the alphabet, carries certain amount of information according to (3):

$$I=-\log_2 p=-\log_2(0.5)=-\log_2 2^{-1}=-(-1)\log_2 2=1[bit] \qquad (3)$$

If an information source generates information in an analog form, it can be converted in a discrete form. After that, a digital alphabet as given in (2) can be used to express information. Consequently, since information from any source can be presented in digital form, the same digital information processing and transmission systems can be used for any type of data. In addition to that, in digital communication systems, information from low rate and high rate data sources can be mixed and sent through the same channel. Information theory is a complex mathematical theory, so detailed study is not part of this paper and was not a part of the CDRT course. For the comprehensive mathematical, digital communication theory background, please refer to the literature [3], [4] and similar references. For more information about wireless communication please refer to [5]-[11].

MULTIMEDIA APPROACH

Words, pictures and sound are used to convey the message in this course whenever it was possible. Emission, signal and noise, and spectrum are analyzed first. As known in radio technology, an electromagnetic wave is the information carrier. Wave structure and 3D, i.e. space propagation is explained. Obstructions to the perfect propagation are discussed next, and explained how to control them. In this area digital technology shows to be more reliable and powerful than former analog technology.

Electromagnetic waves can have a huge range of frequencies and this is where the spectrum allocation is explained. The spectrum spreads from extremely low frequencies (ELF) to extremely high frequencies (EHF). ELF starts from 30 Hz, while EHF goes up to 300 GHz. We could say that the spectrum is a public asset, or resource, and the spectrum management is a national and international welfare.

In radio communications, a channel signal is a modulated electromagnetic wave. Wave is a harmonic signal given as

$$x(t)=A\cos(2\pi ft+\Phi) \qquad (4)$$

The carrier, as presented, can be modulated by changing *A, amplitude, or/and f, frequency, or/and phase.*
This brings us to the topic of modulation. Modulation can be done using analog or digital techniques. Transmitter is the device responsible for the modulation, which is changing, high frequency carrier signal so that information is imbedded and carried to the other side.

In an analog communication system, carrier is modulated by analog message signal and such modulation techniques are known as Amplitude, Frequency, or Phase modulations, AM, FM and PM respectively. For example, high frequency radio systems are based on AM modulation, which is an analog modulation technique used for many years.

In a digital communications system, the carrier signal is discretely, or digitally modulated and such techniques are known as Amplitude, Frequency, or Phase Shift Keying. Combinations of them are often used for the design of most advanced techniques.

Many modulation techniques are explained in the CDRT course material using multimedia, sound and picture. Since the messages are broadcasted, security plays a crucial role in wireless communication. One of the most important

techniques applied here is spread spectrum. The following is a good example of how multimedia is used to discover and present the principles.

Hollywood actress Hedy Lamarr (born Hedwig Eva Maria Kiesler) and composer George Antheil patented frequency-hopped spread spectrum for the Secret Communication System in 1950s. Hedy Lamarr developed the concept in the 1940s, based on piano music playing. The US military did not use the invention until 1962. Today, the spread spectrum is extensively used in modern communications, from cordless, mobile phones to WLAN and internet.

Instead of playing the piano, we presented spread spectrum by playing a guitar. The most popular Australian song, an Australian icon, is selected and spread spectrum demonstrated in sound. The melody is played in its original frequency range. Figure 3 shows the original spectrum. The melody is played again with a frequency shift. Shifted spectrum can be seen in Figure 4. From the spectrogram we can see the distribution of signal power across frequencies in time scale as shown.

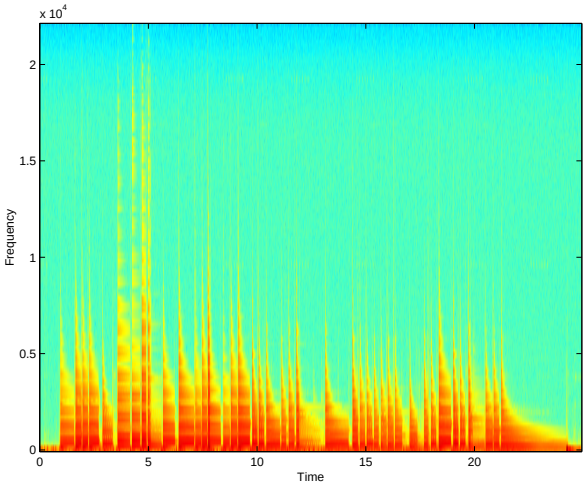

FIGURE 3
ORIGINAL SOUND SIGNAL SPECTRUM

The sound of the original and spread signals can be heard from the instructor, or student CDs. The circled part of the spectrogram in the Figure 4 shows students where the spectrum shift is. There are no differences in the principles of spreading a sound signal, and an electromagnetic wave. Using the sound and picture, students better understandthe phenomenon.

Similarly, other principles were explained using sound and images. Amplitude, Frequency and the Phase modulations can be seen and heard, as examples of analog systems. Following them Amplitude, Frequency and the Phase Shift Keying are given using multimedia approach.

The consideration of basic principles of operation finishes with chapter 5 and the following chapters are dealing with wireless digital communication applications.

APPLICATIONS COVERED BY THE CDRT COURSE

There is a wide range of applications but only the most developed and frequently used ones are covered in the course.

Digital cellular radio systems are presented firstly through the Global System for Mobile Communications (GSM). They basically belong to the second generation of mobile communication systems (2G/2.5G). Network structure, components and functioning is presented.

Code Division Multiple Access (CDMA) is another digital mobile phone system based on a cellular architecture. There is big difference in the radio interface and spectrum of those two systems.

Trans European Trucked Radio (TETRA) system is standardized by the CCITT (Comité Consultatif International Téléphonique et Télégraphique) as MPT 1327 (Ministry of Post and Telegraph). There are four main groups of trunking systems offered today. TETRA and APCO-25 are in group 4 of those digital standards. APCO is the Association of Public-Safety Communications Officials International and Project 25 is explained in the course.

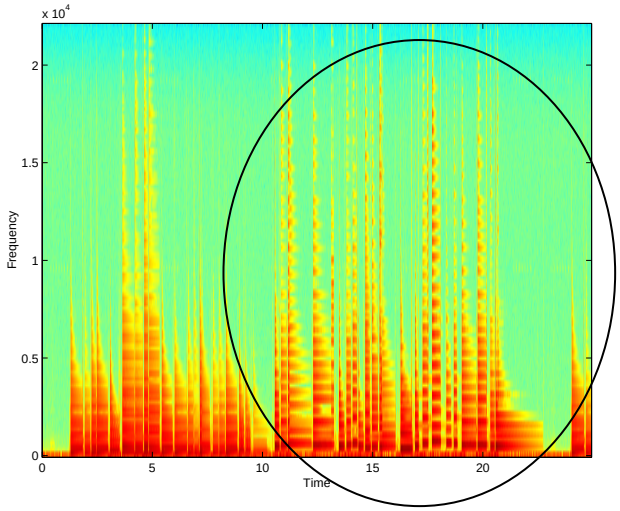

FIGURE 4
SPECTRUM OF THE SHIFTED SIGNAL

It is basically a set of industry standards for the public safety use of digital radio communications.

Bluetooth is a wireless, digital, short range communication system designed to replace wires in the office or home.

The next two chapters cover wireless local area networks and metropolitan area networks. Instructions on how to set up the network are given, along with a review of emerging standards. Wired LAN and MAN are now being replaced with wireless systems.

The Global Positioning System (GPS) is another interesting area covered in the next chapter. The list of GPS applications is substantial.

The list of amazing digital applications continues with Voice over IP (VOIP) or IP telephony. Following that is the story about 3G networks and the future trends.

Last but not least, is a great story of digital television which attracts lots of attention from the general population.

Review questions follow all chapters, while some of the topics have lab sessions defined so that course attendees can get some hands on experience. For the experienced ACMA staff, or the staff from the communications industry 42 hours of the delivery is just enough. For students at the university a minimum of 60 hours should be allocated with another 60 of self paced study. During the course students have to get familiar with the content, answer review questions and perform case studies and lab activities as specified in the instructors' documents.

CDRT Course and the Role of WHO

Finally, the role of World Health Organization (WHO) has to be mentioned and explained in any serious material referring to radio technologies. One of the WHO roles is to take care of Electro Magnetic Fields (EMF) effects, from

- Power lines, Electrical wiring, Machinery,
- Medical Equipment, Other Appliances,
- Communications Devices, Computers…

WHO established EMF project in 1996. WHO EMF activities are mostly studies and research of biological and health effects of Radio Frequency (RF) radiation. Temperature changes in the body exposed to radiation is a biological effect. Other, non-thermal effects are being investigated in many areas. WHO's main task is to keep the public informed and aware of any effects of Radio Technologies. The booklet 'Dialogue on risk to electromagnetic fields' produced by WHO, written in many languages, can be downloaded from the www.who.int/emf site.

CDRT course, offered to the public, has the function of educating people, and raising awareness of radio technologies benefits, applications and possible risks and dangers. CDRT development team attended WHO Seminar in Melbourne 2005 and discussion was conducted about the combined activities.

Maintenance Phase Instead of Closing Phase

According to the agreement, courseware material has to be regularly updated in order to always reflect the latest development in the digital radio technology. This means that some financial planning had to be put in place to ensure continuation of the project in the future. Budget for the maintenance should come from the project delivery, which is another follow up project .

The effectiveness of the project will be determined via an on-line survey, designed to be used after any course delivery. In addition to that, book readers, students and instructors, are encouraged to send their comments. This will allow the improvement for the new version of the material. Links are given in the textbook and Instructor Notes book. ACMA staff already had opportunities to give their comments after reading the first and second draft of the whole material. Their valuable suggestions were imbedded into the first edition of the books.

CDRT Course Delivery

The delivery starts from July 2006, and will be conducted at different sites across Australian capital cities. ACMA staff, and anyone else interested in the new technology development can attend. Thanks to ACMA's generosity, the course primarily designed for them is offered to the public. Since the whole course is present online, through Online@RMIT, powered by Blackbboard, it can easily be delivered to remote customers, such as in rural Australia. It can also be delivered internationally to any group of students, or industry, all over the world.

Acknowledgment

The project team would like to acknowledge ACMA's support and initiative for the development of this courseware material. It was a great educational and project management experience for all of the staff involved. We would also like to acknowledge support from the RMIT teaching and learning development groups. We also acknowledge great job performed by RMIT publishing and RMIT SET (Science Engineering and Technology) Portfolio management, as well and legal services.

Last, but not the least, special thanks is extended to all our families for their support. Hard work was being conducted in our "free" time, separating, isolating and protecting us from everyday life.

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