Session 3547

Curriculum Development of an Advanced Communications Course by Sharing Properly Wireless and Wireline Systems in Electronics Engineering Technology Program.

Dr. Rafiqul Islam
DeVry Institute of Technology
2700-3rd Avenue S.E.
Calgary, Alberta, Canada T2A 7W4
Tel: 403-207-3123
Fax: 403-207-6225
Email: rislam@cal.devry.ca

Abstract

Wireless communications appears to be a technology that will shape our society in the 21st century. All indications are that this growth will continue at a rapid pace as wireless communications will convert the already shrinking world into a global village. The primary components and industry players that encompass the various wireless infrastructures including cellular, PCS (Personal Communications Services), paging, LMDS (Local Multipoint Distribution Services), wireless LANs and satellite services are expected to grow at double digit rates.

Fiber optics is one of the hottest fields in wireline communication systems as it has wide applications in telecommunications as well as in networking (LANs and WANs). Fiber optics therefore is favored in this paper over conventional transmission systems such as open-wire line, coaxial cable and waveguide.

The phenomenal growth in these new technologies, especially in wireless, has put new demands on the job duties of engineers and technologists. Industries are increasingly seeking graduates with appropriate background and training in these technologies. Wireless systems are only wireless in one sense; relying completely on wires for their function. It is my believe that the two will continue to compete for market share in the future. This paper describes a proposed advanced communications course in the form of lecture and laboratory studies. This course is designed for the study of both wireless and wireline communications systems in correct proportion as identified by the industry. Such studies provide specific skills that will be immediately usable in the industry. Knowledge of these crucial fields will broaden the undergraduate experience of technology and enhance their employment opportunities very greatly.

Introduction

People like the convenience of wireless (cordless) technology. The convenience and portability of wireless communications has put it in high demand[1]. The field of cellular radio and personal communications services (PCS) is expanding at a rate which is difficult to fathom. Modern communications techniques that involve digital signal processing, spread spectrum multiple access, advanced coding and modulation methods and sophisticated simulation and design techniques are adding to its real future growth[2]. According to the market projection there will be over half a billion wireless subscribers around the world by 2000[3]. MTA-EMCI believes that the field of wireless personal communications has the potential to grow strongly in the near future all over the world with the greatest in the Asia/Pacific region where more than half of the world's population lives[4].

Worldwide, Local Multipoint Communications Systems (LMCS), known in the U.S. as LMDS is a fixed wireless broadband access technology in which signals are transmitted in a point to multipoint method. It can provide two-way voice, data, internet and video services. The advantages of this broadband wireless access are being recognized around the world[5].

Wireless Local Area Networks (LANs) were one of the most prominent applications that were envisioned by the FCC members when releasing the ISM (industry, scientific and medical) bands. It will provide an impact on future applications such as military operations, emergency medical services, environmental responses, law enforcement, highway maintenance, office or campus support systems[6].

The new era of satellite telephony will bring true meaning to the term "global communications". Inclusion of data communications and messaging features will make the satellite phones even more valuable to subscribers[7]. Several prototypes of the satellite phones will be fully operating within the next three years. These systems could change the ways the people maintain contact with one another, especially those living in remote, sparsely populated areas poorly serviced by existing means of communications. Many of these remote areas will for the first time be given a chance to experience modern telecommunications[8].

The wide bandwidth, the further extension of transmission distance and the EMI immunity are the reasons for the preferred choice of fiber optic over all other wireline communication mediums. In case of cellular/PCS systems and LMDS/LMCS systems, the base station is the gateway between wireline and wireless network. The base station is then connected to the Public Switched Telephone Network/Integrated Services Digital Network (PSTN/ISDN). An OC-n (Optical Carrier) or DS-n line is used to make this connection. The design and development of communication systems is greatly focused on SONET/SDH (Synchronous Optical Network/Synchronous Digital Hierarchy) providing data transmission rates up to 10 Gbps. Wavelength Division Multiplexing (WDM) and Optical Networking (ON) offer far greater capacity than current electronic network can deliver. WDM technology is also being applied to international undersea fiber optic cable networks such as Africa Optical Network (Africa ONE). This project integrates several telecommunications technologies such as satellites, digital mobile radio and terrestrial fiber optic networks to connect all the African countries. The project will serve as a major part of the global undersea fiber optic infrastructure connecting the world when completed by the end of 1999[9]. Instead of using these technologies separately in their own application areas, we can combine them and achieve even greater benefits in terms of low prices and seamless operations for rapidly growing future multimedia communication services. So a full understanding of all parameters in both cellular radio and optical fiber environment is required for the marriage of both technologies for the third generation mobile communications[10].

Course sequence for electronic communications

An electronic communications course sequence is followed here at DeVry in the Electronics Engineering Technology (EET) program. There are two core courses and several elective courses (Figure 1). The foundation of this course sequence is EET-368 (Communications System), which deals with fundamental concepts and theories of electronic communications systems with emphasis on analog communication sub systems. At first the students study the basic concepts of operation of a typical communication system in terms of block diagrams (a transmitter, a channel and a receiver). During the progression of the course, electromagnetic signals, signal analysis, noise, analog and digital modulation and demodulation techniques, transmissions lines and antennas are studied in preparation for the next course in the sequence, EET-465 (Data Communications and Networking). The purpose of this course is to bridge the first and the third communication courses. This course covers the concepts of digital data communications and computer networks by exploring information theory, telephone system, modems, network layer protocols and software/hardware aspects of local area networks(LANs). The proposed advanced communications course will be offered as a modification of the existing advanced communications course (EET-470) in term of the content and the correct proportion of the wireless and wireline systems as identified by the industry. The remaining two elective courses are Telecommunication Technologies and Advanced Computer Networks. Telecommunication Technology addresses the public switched telephone networks whereas the Advanced Computer Networks focuses on the design and implementation of an actual network.

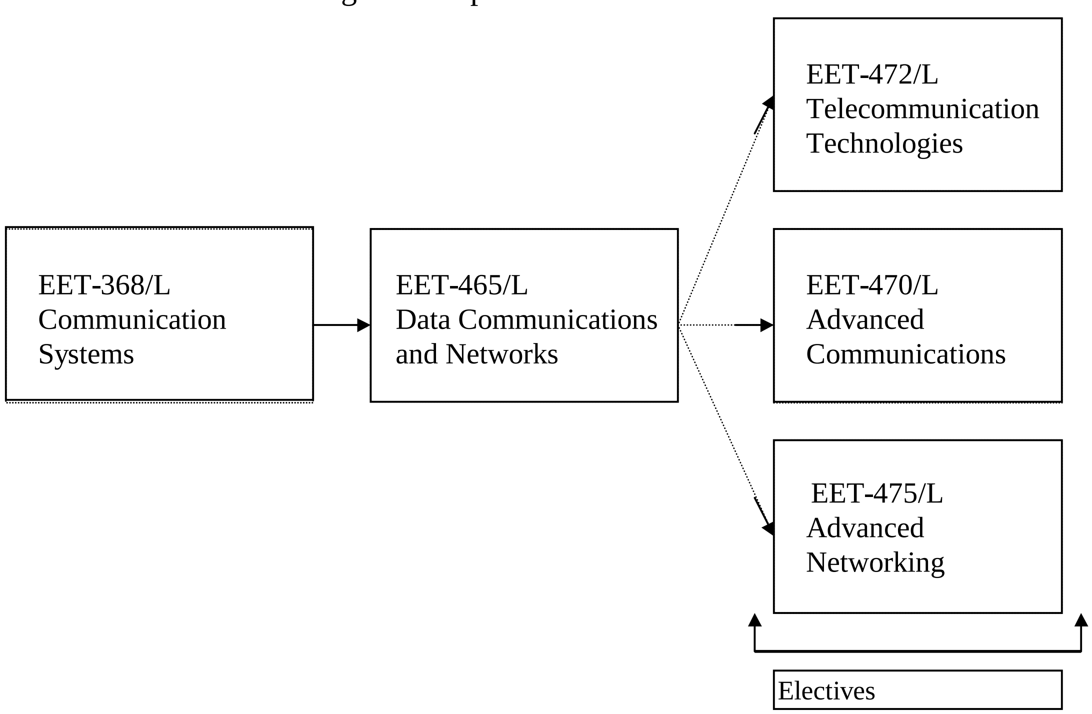

Figure 1 EET electronic communication course sequence

Industry trends

Signs of explosive growth in wireless industry are everywhere. Worldwide, new cellular networks are coming on line continuously and in great numbers. In addition, billions of dollars will be spent to expand and upgrade the existing systems. Cellular carriers in the U.S. alone will need nearly 15,000 new cell sites over the next ten years to complete their coverage, upgrade their systems, and meet the growing demand for cellular service. PCS service providers are also planning for 10,000 sites as they have yet to reach their full potential[4].

Canada's wireless industry is growing at the rate of 20% or more a year. More than C$3 billion will be invested in PCS infrastructure in Canada in the next 5 to 10 years. More than 10,000 Canadians are directly employed in the wireless industry and an estimated 10,000 more jobs will be created in the next ten years. Market penetration of wireless technologies is 7% in Canada today and is expected to reach 33% by 2000[11].

The International Mobile Telecommunications 2000 (IMT-2000) will be the first large-scale development of a wireless system for both voice and data. Its influence will be felt not only on telecommunication industry but also computer and consumer electronic industries. The cost of developing and launching satellites and spares, satellite control facilities, some of the ground communication network and developing the users' phones is formidable ranging from U.S. $2.5 billion to 5 billion, while regional systems are closer to $1 billion[8.]

Telephone and cable companies are testing and rolling out more and more fiber optic networks. Utility companies are stringing fiber optic cable in anticipation of offering new communication services. The cost to develop the major portions of Africa ONE project is estimated to be $2.6 billion. In the U. S. an establishment of fiber optic data network

technology on board the nation's newest aerospace platforms is achieved. The trend of the aerospace industry demands higher cost-performance products in designing avionics/aerospace optoelectronic modules than their first generation counterparts[12]. In Canada's telecommunications market of nearly 15 billion dollars a year, fiber optic is playing a vital role[13].

The rapid growth in the wireless and wireline industries has created a shortage of qualified engineers and technologists over the past several years[14]. The presenters from the leading wireless companies at the GWEC faculty workshop at the University of Texas in August 1998 expressed even more concern about the shortage. They wished to establish a fruitful cooperation between industry and the academic institutions to address this issue.

Teaching suggestions

As there are two dominant modules for this course such as wireline and wireless systems, it is difficult to find a text book that covers the both. It is therefore very important that you carefully select a text book based on the needs and supplement materials with handouts as necessary.

The students must be kept abreast of developments and trends in the instantly and continuously changing spectrum of wireless and wireline communications. Assignment of report writing (short) on topics such as wireless LANs, LMDS (LMCS in Canada), WDM or any other collaborative writing assignments of informal and formal reports will encourage students to gather information from recent publications, journals and Internet home pages. If time permits, the information and knowledge acquired by one group can be shared to the rest of the class through short presentation. Not only will such experience prepare the students for industry, it will also give them opportunities for positive human relations and goal oriented behavior.

Whenever possible use simulation packages. The advanced Electronics Smith chart may help save fragment of lecture times.

A field trip should be arranged to a local cellular/PCS service provider where the students can see the real life base stations and cellular switches and find out the associated problems and the ways to troubleshoot them. In addition to field trips, cell site internship projects will provide the students an opportunity to manage/engineer a cell site and to perform various tests and engineering measurements. In the case of satellite communications, a laboratory experiment may be supplemented with the use of videos covering such things as installation, analysis/measurements, troubleshooting that are difficult to duplicate in laboratories.

Course content outline

1. Fiber optic communications:

   * Advantages / disadvantages.
   * Review of basic optic and ray theory.
   * Properties and characteristics of different types of fiber.
   * Attenuation and dispersion limitations of the optical fiber system.
   * Properties and characteristics of light sources and optical detectors.
   * Design of a complete fiber optics system.
   * Fiber optic testing.
   * Advanced applications such as SONET/SDH and FDDI.

2. Transmission lines:

   * Wave propagation on mismatched lines: standing waves, characteristics of open and shorted lines.

* Introduction to the Smith chart and its applications for measuring input impedance as well as impedance matching.
* Properties of TDR as test equipment for transmission line measurements in the time domain.
* Properties and the characteristics of the metallic waveguides : modes of propagation, Phase and group velocities, characteristic impedance and the cut-off frequency for particularly the dominant mode.

3. Antennas:

* Properties of the basic types of antennas : radiation patterns.
* Properties and characteristics of single element antennas : helical and dish antennas in terms of power gain and beamwidth.
* Antenna arrays.

4. Cellular/PCS systems:

* Cellular system, cellular concept and cellular operation.
* Cell-splitting and frequency reuse strategies.
* Channel assignment and hand-off.
* Cellular standards : AMPS and TACS.
* Implementation of the base station and the cellular phone details.
* Performance criteria : voice reception quality and the service quality.
* Multiplexing and multiple access techniques : FDMA, TDMA, CDMA and FHMA.
* Digital cellular / PCS standards : IS-54, IS-136, GSM, DCS-1800, PACS PDC, IS-95 etc.

5. Satellites:

* Different components of satellite communications with emphasis on geostationary satellites (GEOS).
* Keplar's laws governing the satellites.
* Uplink and downlink C/N_0 expressions.
* Uplink and downlink loss budgets.
* Characteristics of certain advanced satellite systems: LEOS (IRRIDIUM, Teledesic), MEOS , GPS, DGPS etc.

6. Microwaves:

* Properties and characteristics of microwave vacuum tube devices.
* Properties and characteristics of microwave semiconductor devices.
* LMDS/LMCS.

7. Wireless LANs:

* Properties and characteristics of various types of wireless LANs.
* Comparison between wireless and wireline LANS in terms of cost , speed and reliability.
* Wireless LANs applications.

Distribution of allocated times for different topics in theory course is given in figure 2.

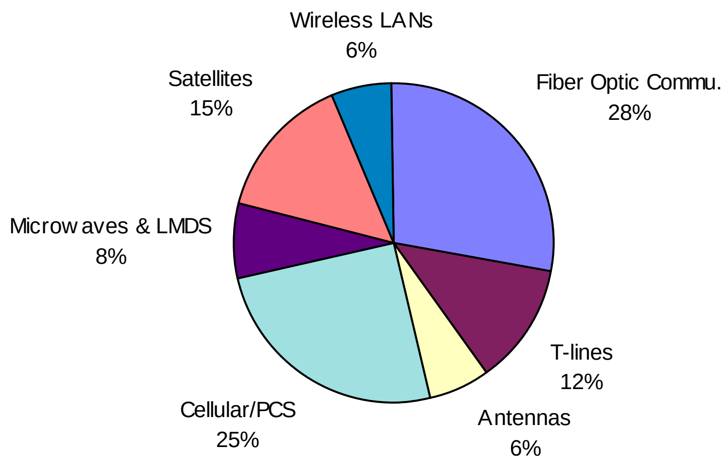

Figure 2 Distribution of time allocation by topics

Laboratory course

This laboratory course directly supports the Advanced Communication Systems course. Laboratory exercises provide students with experience in complete communication systems, including cellular/PCS, wireless LANs, wireline, optical and microwave systems and satellite communications. Performance measurements in terms of tests and the subsequent interpretation of results and troubleshooting are emphasized because they are considered as the most valuable skills to be developed by the engineering technologists.

Caution must be taken while performing microwave experiments. There should not be any interference of frequency with any other devices. Laser diodes should not be used as it might damage the retina of the eye.

Laboratory course outline

List of suggested lab experiments (hardware and software)

1. A TDR (Time Domain Reflectometer) or a combination of a pulse generator (5% duty cycle) and an oscilloscope.
2. Impedance matching using single stub.

3. T-line characteristics, R and G parameters and the determination of the characteristic impedance.
4. A fiber optic link (e.g., Hewlett Packard Model HFBR-0501 kit).
5. A fiber optic simulation package (e. g., Tektronix FMTAP fiber Trace Analysis Software).
6. Wireless LAN using Eithernet modems (e. g., The Hopper DS, from WiLAN Inc.).
7. A microwave Training Kit (e. g., Model 550-SS from LRL).
8. Software packages such as MATLAB, HPBasic, or Lab View for developing a mobile analog cellular testing method.

Suggested design projects

1. Design a basic commercial cell site using software tools.
2. Using a commercial frequency planning tool design a frequency reuse plan.
3. Use OPNET (OPtical Network Engineering Tools) to model and simulate a communication network.

Distribution of techniques/methods for implementing the related lab course is illustrated in figure 3.

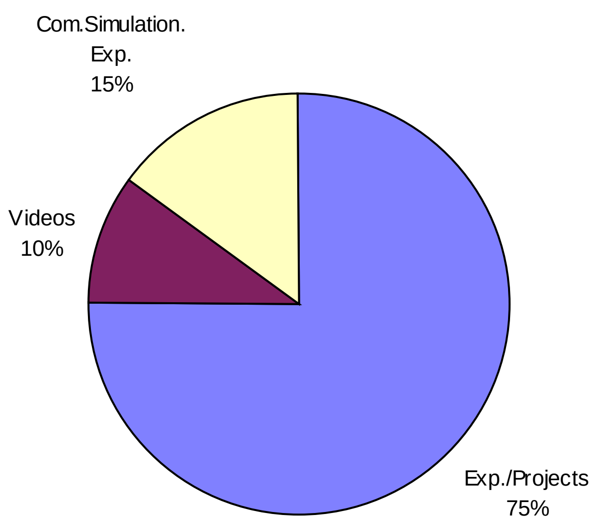

Figure 3 Distribution of allocated times by techniques/methods.

Conclusion

The explosive growth in wireless and wireline industries over the past several years has created a critical shortage of trained engineers and technologists. The proposed advanced communication course is designed to study both wireless and wireline communications systems in direct proportion to demand from the industry. More emphasis is placed upon the study of wireless systems because of the great demand for technologists in the implementation of such systems in the newer satellites. It remains to be seen, however, whether satellite based mobile communications systems will be viable in term of cost in low population density regions of the world. In that case the two technologies may continue to compete with each other in the fields of telecommunications and networking.

My study has also pointed out the increasing tendencies towards integration of the two technologies in a given project. If this trends continues as seems likely it will only serve to make the EET graduates more marketable. In any case a sound knowledge of both wireless and wireline technologies will equip the graduate to make an uniformed choice. Overall, this course will provide the theoretical foundation and also enable the EET graduates to acquire hands-on analytical and problem solving skills towards better preparation for the challenges and changes ahead of them in both industries.

Bibliography

1. Theodore S. Rappaport, ‘The wireless revolution’ IEEE Commu. Mag., Nov. 1991, pp 52-71.
2. Theodore S. Rappaport, ‘Introduction’ Cellular Radio & Personal Commu. Volume 2.
3. Peter Maclaren, Nortel ‘Third Generation Wireless’ GWEC Faculty Workshop, August 13-15, 1998.
4. Ron Schneiderman, ‘Future Talk’ IEEE Press, 1997, pp 4 & 17.
5. Rashid Skaf, ‘LMCS Comes Alive’, Wireles Telecom - The Magazine of CWTA, Vol. 16, No. 2, Second Quarter, 1998 pp 48-50.
6. K. Palhlavan, T. H. Robert and M. E. Chase, ‘Treands in Local Wireless Networks’ IEEE Commu. Mag., Vol. 33, No. 3, Mar. 1995.
7. Alex Binkley, ‘Anywhere and Everywhere - A satellite update’ Wireless Telecom, Vol. 15, No. 4, Fourth quarter, 1997.
8. Barry Miller, ‘Satellites Free the Mobile phones’ IEEE Spectrum, Mar. 1998, pp 26-35.
9. PatrickR. Trischilla and W. C. Marra, ‘Applying WDM Technologyto Undersea Cable Networks’, IEEE Commu. Mag. Feb. 1998.
10. H. S. Al-Raweshidy, Radio Over Fiber for the Third Generation Mobile Communications’ GLOBECOM 98 Tutorials & Workshops, Sydney Australia, Nov. 8-12, 1998.
11. ‘Wireless Communications- A Special Report’, The Finalcial Post, August 10, 1998, p W_2.
12. M. W. Beranek, E. Y. Chan, H. E. Hager, Q. N. Lee, ‘Status of Optoelectronics Module Packaging for Avionics/ Aerospace Applications’ LEOS 98 Advanced Program for annual Meeting, Dec. 1-4, 1998, p 65.
13. Business Report, ‘The Calgary Sun’, Aug. 25, 1998 P 39.
14. Electronic Engineering Times, Dec. 9, 1996, p 102.

Biography

Dr. Rafiqul Islam has been on the faculty of the DeVry Institute of Technology, Calgary, Alberta, Canada, for the last five years. He has eight years of working experience in the areas of communications and computer applications in power and control systems. He also taught for four years at the West Coast University, Los Angeles, California.

His areas of interest include cellular and PCS phones, satellite systems, fiber optics and wireline and wireless LANs.