AC 2011-149: AN ONLINE MASTER OF SCIENCE PROGRAM IN ENGINEERING TECHNOLOGY

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Warren Rosen, Drexel University (Eng.Technology)

Dr. Warren A. Rosen received his Ph.D. in physics from Temple University in 1978. Between 1978 and 1985 Dr. Rosen served as assistant professor of physics at Colby and Vassar Colleges where he carried out research in optical physics, solar physics, and medical physics. From 1985 to 1996 he worked at the Naval Air Warfare Center, Aircraft Division in Warminster, PA where he established an optical communications laboratory for development and characterization of optical components, systems, and protocols for high-performance avionics data networks. Dr. Rosen is currently an assistant clinical professor at Drexel University, where he is responsible for developing and teaching courses in microprocessors, microcontrollers, and FPGAs. Dr. Rosen has carried out research sponsored by the National Security Agency, National Science Foundation, the National Oceanic and Atmospheric Administration, DARPA, the Office of Naval Research, and the Missile Defense Agency.

Dr. Rosen is the author or coauthor of over 50 publications and conference proceedings and the holder of five U.S. patents in computer networking and signal processing.

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Mr. Eric Carr is currently the Laboratory Technician for Drexel University's Engineering Technology program. Eric assists faculty members with the development and implementation of various Engineering Technology courses. A graduate of Old Dominion University's Computer Engineering Technology program, Eric enjoys finding innovative ways to use microcontrollers and other technologies to enhance Drexel's Engineering Technology course offerings. Eric is currently pursuing a MS in Computer Engineering at Drexel, and is an author of three technical papers in the field of Engineering Technology Education.

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Gerry Marekova, Drexel University (Eng.)

Gerry Marekova, M.S. is the Program Manager for the Engineering Technology (ET) program in the Goodwin College of Professional Studies at Drexel University. She has a Bachelor of Science Degree in Business Administration with major in Marketing (2003) and a Master of Science Degree in Higher Education Administration (2008), both from Drexel University. Ms. Marekova came to Drexel University in September of 1999 in the Bioscience and Biotechnology Department. In 2005 she joined the Goodwin College team as an Academic Advisor for part time students in Engineering and Sciences. In 2006 she became the Program Manager for the Engineering Technology Program at Goodwin College of Professional Studies. She is responsible for the academic progress and mentoring of the full and part time, and prospective students in the undergraduate and graduate programs. In addition, her current responsibilities include scheduling classes for Burlington County College and Drexel's main campus, maintaining partnership programs with community colleges and high schools. Some of the Marketing initiatives include; collaboration with the Drexel's admissions office towards increasing enrollment for all campuses by visits to local high schools, attendance to open houses, and organizing race car competitions. Ms. Marekova is responsible for full time faculty load and assisting full time faculty and Adjuncts with classes and student issues. Ms. Marekova serves as a member of the Curriculum Committee for the College and the Faculty Hiring Committee for the ET program. Ms. Marekova is also teaching the two parts of the UNIV 101 class, designed for freshmen students to help them adapt to college life. She has a strong interest in curriculum and program development. .

An Online Master of Science Program in Engineering Technology

Abstract

This paper describes a new Master of Science in Engineering Technology program at Drexel University. The goal of the program is to develop advanced level practitioners in industry who are interested in developing marketable skills to meet evolving workforce demands, seeking professional development, expanding opportunities for professional advancement, or pursuing a managerial position. To support this goal, the emphasis is on the applied aspects of the technological spectrum, such as product improvement, industrial practices, and engineering technology operation. The curriculum is multidisciplinary, and includes core courses in such areas as modern materials, rapid prototyping, programmable devices and systems, modern energy conversion technologies, sensors, measurements and microfabrication. In addition to these core courses, electives are offered in areas such as reliability engineering, lean manufacturing principles, green manufacturing, and project management. The program is designed to be extremely flexible; it permits the student to select a combination of courses relevant to individual career goals in technology or to provide the foundation for further advanced study. Both a thesis and a non-thesis (applied project) option are available. The program is currently available entirely online and several of the courses employ web-based laboratory exercises. Future plans include providing face-to-face, hybrid, and real-time videoconferencing delivery modes.

Introduction

The primary goal of the Master of Science in Engineering Technology (MSET) is to develop advanced level practitioners in industry who are interested in:

- developing marketable skills to meet evolving workforce demands
- seeking professional development
- expanding opportunities for professional advancement
- pursuing a managerial position

The MSET program provides a graduate level educational opportunity on a full- or part-time basis to those who have earned a bachelor's degree in engineering technology or in a related discipline from any college or university of recognized standing. The flexible program permits the student to select a combination of courses relevant to individual career goals in technology or to provide the foundation for further advanced study. In the future, courses will be delivered in several modes, including face-to-face, on-line, hybrid and real-time videoconferencing. Both thesis and non-thesis (applied project) options are available. The graduate students' advisory committee is under development and will include a graduate faculty representative from each related area. A final oral exam is required for both the thesis and non-thesis options.

Rationale for the Program

The MSET degree is intended to be a terminal professional technology degree. This graduate program uses a professional, multi-disciplinary, team-oriented, and project-oriented approach to graduate education. It focuses primarily on the applied aspects of the technological spectrum closest to product improvement, industrial practices, and engineering technology operation functions. It meets the need of graduate students who want to expand their knowledge in advanced engineering technology courses. It also provides the flexibility for graduate students to expand their knowledge in a specific technical specialty.

The MSET program meets the needs of the state-of-the-art industrial environments and it is distinct from most graduate Engineering Management and Engineering programs. Specifically, the MSET program offers courses focused on the technologies used in today's modern emerging industries. The MSET program is designed to:

- Provide specialized engineering technology education to those who currently hold an accredited baccalaureate degree in engineering technology. It is worth mentioning that many graduate engineering programs do not accept graduates from undergraduate engineering technology programs.
- Supply individuals with additional opportunities for advancement in their chosen careers.
- Offer additional engineering technology education to those desiring careers as instructors at the secondary or post secondary level.
- Allow practicing professionals the opportunity to update knowledge and skills based on the latest technological developments in the industrial environment.

The MSET program fulfills the University's strategic plan by enhancing flexibility of courses' delivery and by supporting non-traditional students. Specifically, this degree brings to fruition one of the strategic initiatives, which is to enhance continuing and professional development programs of study for career-oriented skill enhancement and personal growth. The MSET program continues the Drexel's long tradition of providing flexible, customized programs for working professionals, drawing on the strengths of the faculty and core curricular interests. Currently, the program is supported by seven full-time faculty with strong academic and industrial experience. All faculty hold Ph. D. degrees in various engineering areas and are actively involved in applied and educational research.

Program Objectives

Upon successful completion, the MSET graduate is expected to:

- Apply scientific and technological concepts to solving technological problems.
- Apply concepts and skills developed in a variety of technical and professional disciplines including computer applications and networking, materials properties and production processes, and quality control to improve production processes and techniques.
- Plan, facilitate, and integrate technology and problem solving techniques in the leadership functions of the industrial enterprise system.
- Engage in applied technical research in order to add to the knowledge of the discipline and to solve problems in an industrial environment.

- Apply theories, concepts, and principles of related disciplines to develop the communication skills required for technical-managers.

Admission requirements

In addition to the general Drexel graduate admission requirements applicants must provide a preliminary proposal of their intended plan of study, which should include a general set of objectives, an outline of the courses to be taken, and identification of a master's project topic to be pursued.

To be admitted to the graduate program in Engineering Technology, the following courses must be completed at the undergraduate level with a minimum grade of C:

1. Calculus 1
2. Calculus 2
3. Physics 1 (algebra-based)
4. Physics 2 (algebra-based)
5. DC/AC Circuit Analysis
6. Digital Electronics
7. Industrial Materials
8. Statistics

Candidates for the MSET degree must complete a minimum of 45 quarter credits. A minimum grade of B is required in all core courses and no more than two C grades in electives. Of the 45 quarter credits required for the degree, 30 must be earned at Drexel University, including 24 credits of Engineering Technology (ET) courses. A maximum of 15 transfer credits may be allowed for graduate courses taken at other institutions, if they are appropriate to the student's plan of study.

Program Curriculum (*45 post-baccalaureate credits*)

The program is based on Drexel's eleven-week quarter system. Core courses are developed for the MSET program specifically. Several elective courses are adapted from other graduate programs in the School of Technology and Professional Studies. The current program's curriculum is presented below.

Core Foundation Courses		**27.0**
ET 605	**Modern Materials**	**3.0**
ET 610	**Networks for Industrial Environment**	**3.0**
ET 615	**Rapid Prototyping**	**3.0**
ET 619	**Programmable Devices and Systems**	**3.0**
ET 620	**Microsystems and Microfabrication**	**3.0**
ET 725	**Sensors and Measurements**	**3.0**
ET 732	**Modern Energy Conversion Technologies**	**3.0**
PRST 503	**Ethics for Professionals**	**3.0**
PRST 504	**Research Methods & Statistics**	**3.0**

Electives (select three courses from the following)		9.0
ET 635	Engineering Quality Methods	3.0
ET 675	Reliability Engineering	3.0
ET 730	Lean Manufacturing Principles`	3.0
ET 755	Sustainable and Green Manufacturing	3.0
PROJ 501	Introduction to Project Management	3.0
PRST 512	Computing for Professionals	3.0

Capstone Courses		9.0
ET 775	Master's Project/Thesis in ET	3.0

Will be repeated for credits 3 times

Tentative Course Sequence

Fall		Credits
ET 605	Modern Materials	3.0
ET 610	Networks for Industrial Environment	3.0
	Total	6.0

Winter		Credits
ET 619	Programmable Devices and Systems	3.0
ET 620	Microsystems and Microfabrication	3.0
	Total	6.0

Spring		Credits
ET 615	Rapid Prototyping	3.0
PRST 504	Research Methods & Statistics	3.0
	Total	6.0

Summer		Credits
ET 732	Modern Energy Conversion Technologies	3.0
PRST 503	Ethics for Professionals	3.0
	Total	6.0

Fall		Credits
ET 725	Sensors and Measurements	3.0
ET 775	Master's Project/Thesis in ET I	3.0
	Total	6.0

Winter		Credits
	Elective	3.0
ET 775	Master's Project/Thesis in ET II	3.0
	Total	6.0

Spring		Credits
	Elective	**3.0**
	Elective	**3.0**
ET 775	**Master's Project/Thesis in ET III**	**3.0**
	Total	**9.0**

The program started in the fall quarter of the 2010-2011 academic year (AY). Most of the core and elective courses are developed. The remaining courses, which are under development, will be completed by the end of the spring term of the current AY. Below are examples of the courses that were developed.

ET 675 - Reliability Engineering

A graduate-level course in Reliability Engineering was developed as part of the MS degree program in Engineering Technology. The course is designed for on-line, web-based delivery in a 10-week term. The course materials can also be readily adapted to a more traditional classroom lecture format, including as a technical elective for advanced undergraduate engineering technology majors, or as an independent study course.

Course Motivation

Reliability emerged as an engineering subject in the 1950s in response to the widespread problems encountered by armed forces in the Second World War with equipment that was often inoperable, in need of frequent repair, and burdened with excessive maintenance requirements. The application of scientific principles to the testing, analysis, modeling, and prediction of failures in materials, parts, components, and systems -- and their mitigation and prevention -- created an engineering discipline with broad applications in aerospace, electronics, automotive, power generation, chemical processing, and communications. The success of the NASA Apollo Program, the realization of complex computers and global communications networks, the impressive safety record of today's commercial aviation, the advent of automobiles with ten-year, 100,000-mile warranties, and the pervasiveness of trouble-free consumer electronics products, to name but a few examples, stem from the progress and widespread application of Reliability Engineering. Bhote and Bhote present a persuasive case that the achievement of high reliability will separate the winners from losers in tomorrow's global manufacturing and services economy.[1]

Course Content

At many schools, Reliability Engineering is offered as a Senior/Graduate level course. Several universities have MS and Ph.D. programs in Reliability Engineering. Reliability Engineering topics may also be included in courses on Quality Assurance, Design Methodology, and Operations Research. There are several challenges in presenting a Reliability course to our target audience. First, Reliability Engineering tends to be a mathematical subject, often employing relatively sophisticated methods in probability and statistics. An intensive mathematics-based course may have limited appeal to many prospective students in Engineering Technology, especially for older, returning students and for those who have migrated to management and operations positions since their first technical degree. Nevertheless, this is one type of student we would like to reach with such a graduate course. The Reliability course should appeal to both technologists and engineering managers in diverse industries. Second, as noted above, many students have had little or else no previous exposure to reliability engineering, and therefore need to be introduced to its basic ideas and terminology before more specialized and advanced methods are treated at a level representative of industry applications. Third, students will have specific interests and motivations focused on their particular employment and interest, and need to see the relevance of Reliability to their industries and technologies. Finally, much current activity in reliability engineering is related to accelerated testing: HASS (High Accelerated Stress), HALT (High Accelerated Lifetime Testing), and MEOST (Multi-Environmental Over Stress Tests). These concerns are addressed in several ways using a Modular approach. The Modules allow students to adapt the course to their needs and elect specific modules covering industrial applications of Reliability. After several "foundation" modules introducing terminology, basic concepts, and perspective, we allow the students to select a combination of modules that will allow them to tailor the course to their specific interests. The modules and their topical content are listed below. All students take Modules 1 through 6, and then select four of the remaining modules (A through H) as electives. More modules are under development and include "Reliability for Medical Devices", "Reliability for Services", "Reliability for Robotics", "Reliability for Renewable Energy Systems", and "Reliability for Micro and Nano Systems".

Required modules:

- Module 1: Basics of Reliability (Part I)[2, 3, 4]
- Module 2: Basics of Reliability (Part II)[3, 4]
- Module 3: Probability Plotting, Data Analysis, and Simulation[5]
- Module 4: Reliability Modeling[3, 4]
- Module 5: Reliability Testing[1, 6, 7]
- Module 6: Reliability in Design and Product Development (Part 1)[8]

Elective modules:

- Module A: Software and Systems Reliability[9, 10]
- Module B: Reliability and Maintenance[11]
- Module C: Reliability for Electrical Power Generation and Distribution[12, 13]
- Module D: Reliability in Design and Product Development (Part II)[6, 14]
- Module E: Reliability in the Electronics Industry[15]
- Module F: Reliability in the Automotive and Aerospace Industry[16]
- Module G: Reliability in the Chemical and Process Industries[17, 18]
- Module H: The Business and Economics of Reliability[1, 19]

ET 725 - Sensors and Measurements

The major goal of the course is to develop an appreciation of principles and concepts of instrumentation technology for the measurement and/or control of process plant. A problem solving approach is used to facilitate learning of proper procedures for the collection and analysis of experimental data of the physical quantities as well as for building skills in critical thinking.

The ever-increasing complexity and multi-disciplinary nature of the design process creates the need for better understanding of application and performance monitoring of measurement instruments. To provide the required knowledge, the course covers general theories regarding instrumentation, measurements (I&M) and sensors. In addition, specific information on experimental procedures and homework assignments are given during lectures. Instrumentation and measurements courses are the foundations for quality in product design and manufacturing[20-27] involving many disciplines as prerequisites.

Course Motivation

To maintain higher productivity and to improve *safety standards* in the process industries, a properly trained workforce with expert skills in sensors, measurement techniques, process instrumentation and control techniques is essential. The use of I&M can be classified to three application schemes: 1) monitoring of processes and operations; 2) control of processes and operations; and 3) experimental engineering analysis. ET 725 sensors and measurements course provides a foundation and an avenue for physical system modeling and a system approach to the engineering problem.[22-28]

Course Content

The logical sequence of the course follows the flow of data from sensing element, transduction, signal conditioning and digital conversion (Figure 1). The course focuses on the following topics: specifications and characteristics of measuring instruments, statistical data analysis and processing, errors and uncertainties, sensor operation principles and characteristics, physical measurable quantities (pressure, flow rate, temperature, force, power, stress, liquid level, velocity, acceleration, etc.), miscellaneous measurements (pH, salinity, viscosity, chromatography analysis, humidity, displacement, etc.), amplifiers and actuators, signal conditioning circuits, data acquisition, and environmental measurements. The following book: R. S. Figliola, and D. E. Beasley. *Theory and Design for Mechanical Measurements*[29] was chosen as the required textbook for the course. Additional references are included in each of the 10 units of the course.

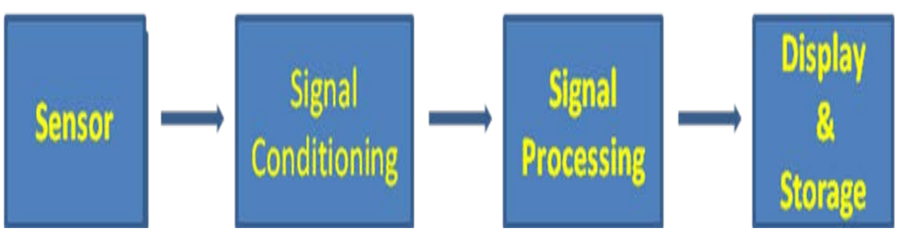

Figure 1. Typical block diagram of a measurement system.

Learning outcomes are linked to the course objectives and include the following: the concepts of experimental planning and design, data collection and analysis, use of modern data acquisition tools for collecting experimental data, the comparison of experimental and theoretical results, the assessment of the uncertainty and error sources in measurement systems, and the technical reports. After completing this course, the students will have an understanding of measurement principles, principles of operation, characteristics and performances of various transducers and sensors, and their applications in industry and research laboratories. The students will gain knowledge of data and error analysis, measurement data processing and interpretation, visualization techniques, signal conditioning and data acquisition.

Course Management

The course management website is straightforward, easy to access and handle (Figure 2). All course related materials, such as: lecture notes, power point presentations, assignments, homeworks, exams, solutions, links, etc. are presented in the course management system.

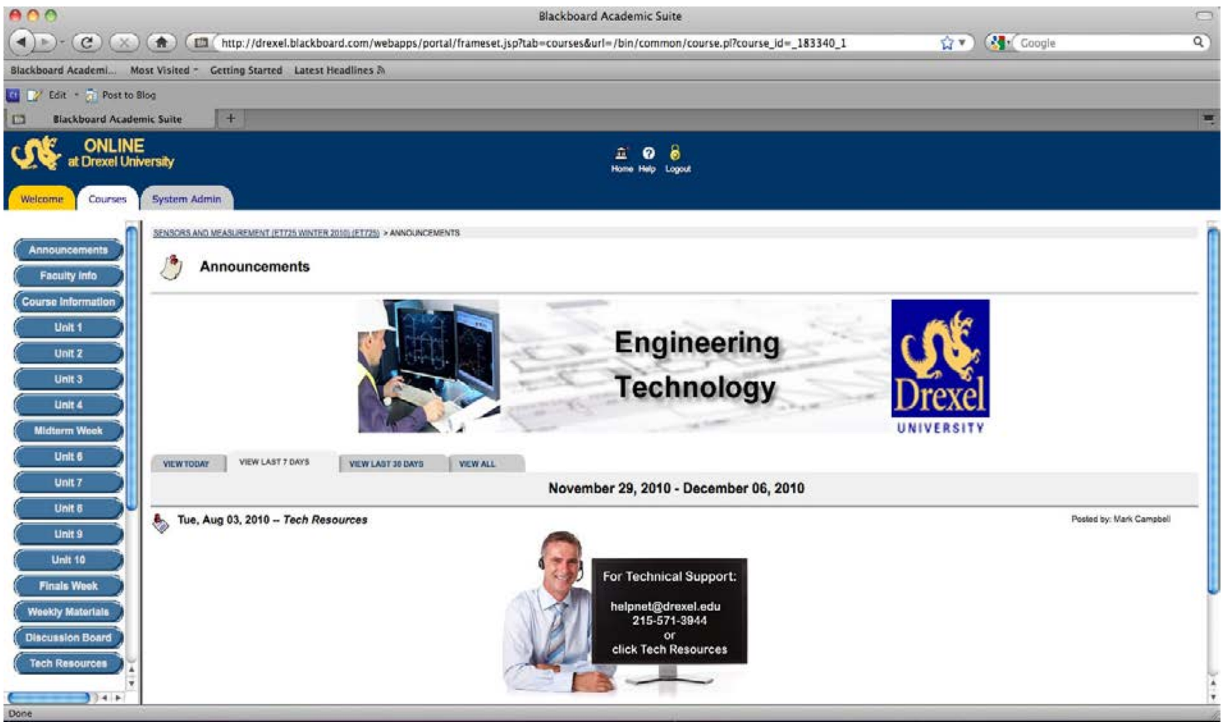

Figure 2. Main course webpage.

Students' performance and progress are evaluated through a combination of in-course and end-of-course assessments. A broad range of assessment methods (tools) are used in order to give a fair and balanced match to the range of knowledge, skills, and abilities that students develop, and to ensure that the program outcomes are achieved. Methods of assessment include homeworks, assignments, exams, and projects.

ET 610 - Advanced Networks for Industrial Environments

This course is intended to provide an in-depth overview of high-performance wired and wireless networks for industrial control, communications, and computing. The emphasis is on understanding current and newly emerging network architectures, protocols, and technologies in terms of performance, network services, ease of implementation, maintenance, reliability, risk, and cost.

Couse Motivation

High-performance data networks are one of the key enabling technologies in state-of-the-art industrial settings. It is essential that anyone interested in areas such as product improvement, industrial practices, engineering technology operation, etc. have a fundamental understanding of network protocols and hardware that may be needed in this environment.

After completing the course students will be familiar with topics such as the OSI and TCP/IP protocol stacks and common network protocols such as Ethernet,[30] IEEE 802.11,[31] Bluetooth,[32] Zigbee,[33] DPN3,[34] and CAN.[35] The goal is to enable students to make sensible decisions when selecting and implementing a network protocol for a particular industrial application.

Course Content

Topics covered in the 10-week course are shown below.

Week	Topic
1	Introduction to network protocols and technologies, the OSI and TCP/IP protocol stacks, circuit and packet switching, physical media
2	Application and Transport layers
3	Network (Internet) and Link layers
4	Physical layer
5	Ethernet
6	Introduction to Wireshark
7	Some typical industry-specific networks (CAN, DPN3, etc.)
8	Wireless network protocols
9	Network performance
10	Network security

The course begins with an introduction to what network protocols are using the example of collision sense in ordinary conversation and its application in first generation Ethernet. Next, the importance of layered protocols is discussed and the OSI and TCP/IP models are described. Circuit and packet switching are then described. Finally, physical media used in networking are discussed from the point of view of view of bandwidth vs. cost and ease of use, and reliability.

The next three weeks are devoted to a detailed description of each of the layers of the TCP/IP protocol stack. A top-down approach is used, starting with the Application and Transport layers and ending with the Physical layer. The text for the course is *Computer Networking: A Top-Down Approach*[36] by J.F. Kurose and K.W. Ross, early advocates of the top-down approach.

Next, Ethernet is introduced as an example of a real network protocol. Ethernet is not only ubiquitous in communications systems but it's also widely used in industrial control, for example to interconnect programmable logic controllers.

Wireshark[37] is used to give the student hands-on experience with their own local area network. Wireshark is a GUI-based open-source packet analyzer used for network troubleshooting and analysis. The software may be freely downloaded by the students under the terms of the GNU

General Public License, and versions are available for both PCs and Apple computers. Figure 3 presents a Wireshark screenshot showing the capture of packets corresponding to the request of a web page using the http protocol. The image shows the "Get" command, requesting the root document. The hostname is www.paleotechnologist.net. It took about 300 ms for the request to go out (via a VPN connection), reach the webserver, and be processed and returned. Because Wireshark can capture a large amount of information quickly it is essential for the students to learn how to start it up, capture the needed data, and then shut it down quickly before some other process makes an Internet request.

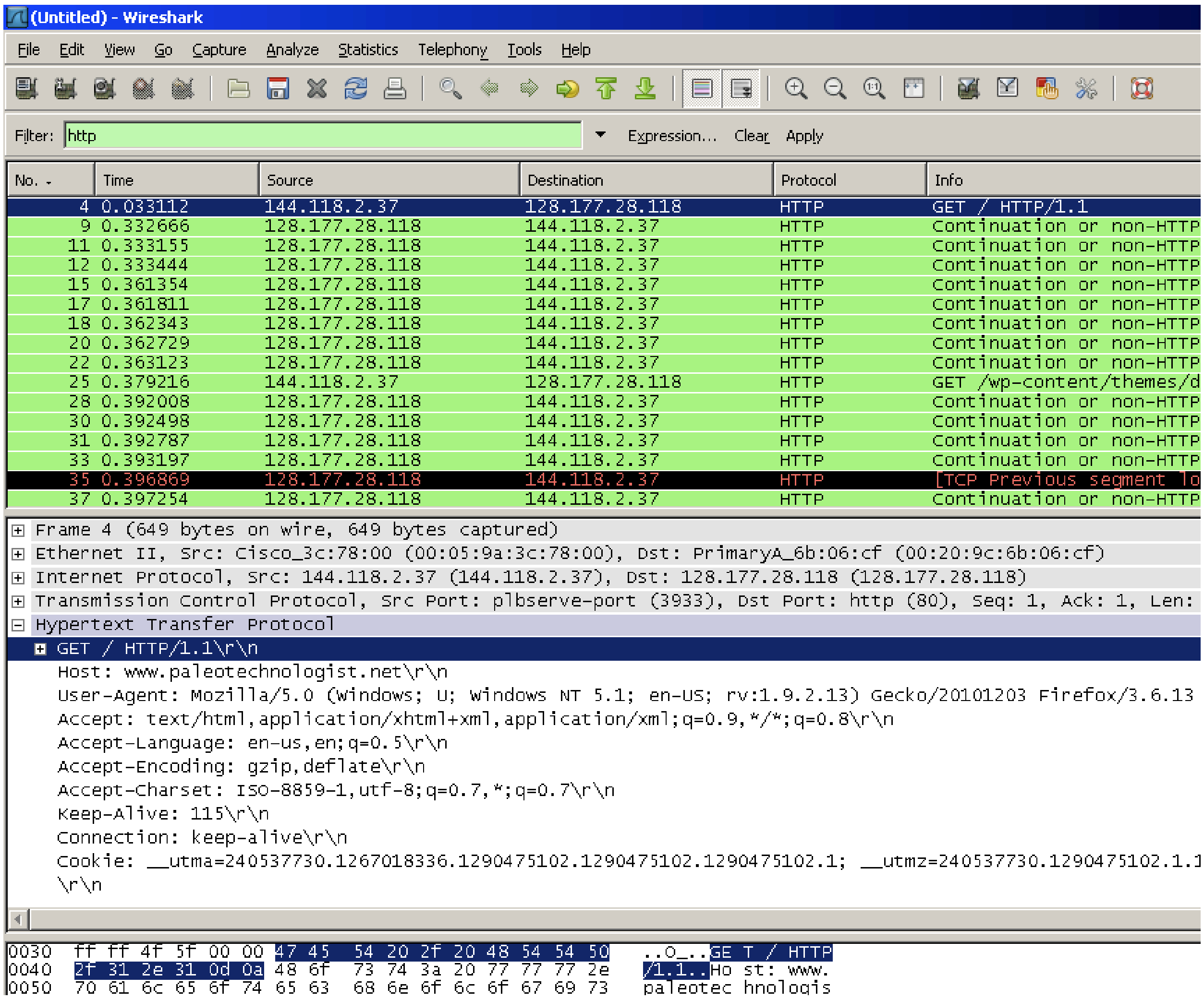

Figure 3. Wireshark screenshot.

Following the discussion of Wireshark, several industry-specific network protocols are discussed, including CAN and DPN3. CAN (Controller Area Network) is a multi-master serial bus protocol originally designed to transmit short messages between microcontrollers in an automotive environment. Since its inception in 1986, its range of applications has expanded into such areas as industrial automation and medical equipment. DPN3 (Distributed Network Protocol) is an open standard intended to provide interoperability between computers and intelligent devices in the electric utility industry. The standard provides for an IP-based serial point-to-point link.

Wireless network protocols are then discussed in some detail, including 802.11, Bluetooth, and Zigbee. Bluetooth is becoming increasing useful in industrial applications as cable replacement, in wireless sensor networks, and as an interface to IP-based networks. Zigbee is a suite of protocols designed for low-power, low data rate RF mesh networks used to control consumer electronics, heating/cooling systems, lights, etc. It is finding increasing use in distributed control and monitoring in industrial settings.

The two remaining topics are network performance and network security. Performance is considered in terms of throughput, latency, and network services. Security is an important consideration in the industrial environment. Particular emphasis is places on securing email, Virtual Private Networks, and security in wireless networks. The networks previously described are compared in terms of performance and security features.

Summary

A new Master of Science in Engineering Technology program at Drexel University has been developed and classes initiated during the 2010–11 academic year. The MSET degree is intended to be a terminal professional technology degree focused primarily on the applied aspects of the technological spectrum closest to product improvement, industrial practices, and engineering technology operation functions. It is designed to meet the needs of graduate students who want to expand their knowledge in advanced engineering technology courses. It also provides the flexibility for graduate students to expand their knowledge in a specific technical specialty. The program uses a professional, multi-disciplinary, team-oriented, and project-oriented approach to graduate education. Both a thesis and non-thesis (applied project) option are available.

Currently, the program is entirely online. In the future, courses will be delivered in several modes, including face-to-face, on-line, hybrid, and real-time videoconferencing. Examples of several of the courses offered are presented in this paper.

References

1. K. R. Bhote and A.K. Bhote (2004). *World Class Reliability: Using Multiple Environmental Overstress Tests to Make it Happen*, American Management Assoc., New York.
2. D.H. Besterfield (2008). *Quality Control*, 8th ed., Chapter 11, Prentice Hall, New York.
3. P.O'Connor (2002). *Practical Reliability Engineering*, Wiley, Hoboken, New Jersey.
4. R.D. Leitch (1995). *Reliability Analysis for Engineers: An Introduction,* Oxford University Press.
5. L. Wolstenholme (1999). *Reliability Modeling: A Statistical Approach,* Chapman & Hall, Boca Raton, FL).
6. M.A. Levin and T.T. Kalal (2003). *Improving Product Reliability: Strategies and Implementation,* Wiley, New York.
7. H.W. McLean (2009). *HALT, HASS, and HASA: Accelerated Reliability Techniques,* ASQ Press, Milwaukee.
8. B.S. Dhillon (1999). *Design Reliability: Fundamentals and Applications,* CRC Press, Boca

Raton, FL.
9. E. Bauer, X. Zhang, and D.A. Kimber (2009). *Practical System Reliability*, IEEE Press, Hoboken, New Jersey.
10. D.J. Smith (2001). *Reliability, Maintainability, and Risk*, Butterworth-Heinemann, Oxford, UK.
11. R. Smith and R.K. Mobley (2007). *Rules of Thumb for Maintenance and Reliability Engineers*, Butterworth-Heinemann.
12. A.A. Chowdhury and D.O. Koval (2009). *Power Distribution System Reliability: Practical Methods and Applications,* Wiley, New Jersey.
13. R.E. Brown (2009). *Electric Power Distribution Reliability,* 2nd ed., CRC Press, Boca Raton, FL.
14. D.N.P. Murthy, M. Rausand, and T. Osteras (2008). *Product Reliability: Specification and Performance,* Springer, Berlin.
15. T.I. Băjenescu and M.I. Bâzu (1999). *Reliability of Electronic Components: A Practical Guide to Electronic Systems Manufacturing,* Springer, Berlin.
16. B. Bertsche (2008). *Reliability in Automotive and Mechanical Engineering,* Springer-Verlag, New York.
17. M. Tweeddale (2003). *Managing Risk and Reliability for Process Plants*, Elsevier, Amsterdam.
18. J.P. Bentley (1993). *An Introduction to Reliability & Quality Engineering*, Longman, Essex, UK.
19. D. Nyman (2009). *The 15 Most Common Obstacles to World-Class Reliability: A Roadmap for Managers,* Industrial Press, New York.
20. K. Watanabe. *Instrumentation education in Japan: Despair and expectation.* IEEE Instrumentation & Measurement, Vol. 2, pp. 14-19, March 1999.
1. Beckwith et al. (1993). *Fundamentals of Mechanical Measurement*, Addison Wesley.
22. L. Cristaldi, A. Ferrero and V. Piuri. *Programmable Instruments, Virtual Instruments, and Distributed Measurement Systems*. IEEE Instrumentation & Measurement, Vol. 2, pp. 20-27, Sept.1999.
23. E. Doebelin (2004). *Measurement Systems; Applications and Design,* 5th ed., McGraw Hill, New York.
24. A. Eadie. *The Undergraduate Teaching of Measurement and Instrumentation.* Engineering Science and Education, pp. 109-113, June 1997.
25. A. S. Eadie. E.A. Knight, and I.J. Kemp. *Work-based Learning in Instrumentation.* Measurement and Control, Vol. 31, pp. 137-140, 1998.
26. C.D. Johnson (2003). *Process Control Instrumentation Technology*, Prentice Hall, New York.
27. G. Karady and K. A. Nigim. *Improve Learning Efficiency by Using General Purpose Mathematics Software in Power Engineering.* IEEE Trans. on Power Systems, Vol. 18, no. 3, pp 979-985, 2003.
28. T. Laopoulos. *Teaching Instrumentation and Measurement in the Complex-Systems Era*. IEEE Instrumentation & Measurement, Vol. 2, pp. 14-19, March 1999.
29. R. S. Figliola, and D. E. Beasley (2010). *Theory and Design for Mechanical Measurements*, 5th ed., John Wiley & Sons, New York.
30. IEEE 802.3 Ethernet Working Group, http://www.ieee802.org/3/. Accessed January 2, 2011.
31. http://www.ieee802.org/11/. Accessed January 2, 2011.
32. http://www.bluetooth.com/English/Pages/default.aspx. Accessed January 5 2011.
33. http://www.zigbee.org/. Accessed January 2, 2011.
34. http://www.dnp.org/. Accessed January 2, 2011.
35. R. Bosch, CAN Specification Version 2.0, http://esd.cs.ucr.edu/webres/can20.pdf. Accessed January 2, 2011.
36. J.F. Kurose and K.W. Ross (2010). *Computer Networking: A Top-Down Approach (5th Edition)*, Addison-Wesley, New York.
37. http://www.wireshark.org/. Accessed January 2, 2011.