New Baccalaureate Degree with a Concentration in Industrial and Enterprise Networking

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Abstract
The curriculum and details concerning specific courses and course content are described for this innovative program which was developed by faculty from the Electrical and Computer Engineering Technology and Computer Science departments. The concentration in industrial and enterprise networking requires courses in programming languages, application programming, local and wide area networking, networking security, and wireless networking. Also required are hands-on laboratories that can be used by students for programming, development, and configuration of networks using different operating systems and hardware configurations. Similar programs, in Indiana and nationwide, are compared and contrasted. Also discussed are national, regional, and state demand and employment factors that provided justification for the new degree.

Background

Indiana-Purdue University, Fort Wayne[1] (IPFW) offers over 175 degree programs, is located in the 2nd largest city, and is the 5th largest university in Indiana. The new Bachelor of Science in Computer Engineering Technology (CPET) degree, which was approved by the Indiana Commission for Higher Education in October 2003, has an initial concentration in industrial and enterprise networking. The program is designed to be accreditable by the Technology Accreditation Commission (TAC) of the Accreditation Board for Engineering and Technology[2] (ABET) and to attract students who desire to pursue a career in the computer networking, automation, telecommunications, or other computer-electronics fields. The degree is a collaborative effort between the Electrical and Computer Engineering Technology (ECET) and Computer Science (CS) departments. The program is designed to provide training in modern, industry based areas that are experiencing growth in the northeast Indiana region, which has experienced considerable job loss in the manufacturing sector. The term, industrial, is used to mean business-related services. Some specific objectives considered while designing the curriculum were to:

1. Provide the industrial/manufacturing community with the technically trained manpower base to support manufacturing and commerce in the region;
2. Provide an educational center for retraining of workers with needed skills;
3. Provide graduates with desired skills in electronics and networking;
4. Fill a need for trained professionals in the computer networking, manufacturing, information technology, and telecommunication industries.

The B.S. in CPET program is focused on applications and application packages in technology work areas. This can be contrasted with Computer Engineering programs where the focus is on the theory and design of processors, computers, and computer-based systems. The initial degree focus on computer networking can be converted to other computer based application areas in reaction to market trends and employment opportunities. The adoption and integration of evolving technologies to meet changing needs is a priority in the program.

A graduate of this program will have the training and skills encompassed by a combination of CPET, ECET, CS, and supporting science, mathematics, general education, and other technical courses. CPET courses generally focus on software strongly related to hardware, while ECET courses focus on hardware and related software, and CS courses focus on computer program design topics such as programming languages and structure, Internet languages, and database structures and systems. A strong feature of this program is the adaptability of the curriculum to concentrate on technical applications similar to those being developed and implemented for use in industry such as: industrial networking, web-based control, electronic devices, web services, and other aspects of enterprise networking.

Curriculum

Core courses in the curriculum provide basic instruction in analog and digital circuit analysis with hands-on laboratory work. The fundamentals of computer systems, programming, and applications using word processors, spreadsheets, and high and low level computer languages are also introduced. The area of specialization provides in-depth knowledge about networking and the requisite hardware and software. Other required courses provide mathematical and communication skills, and sufficient knowledge of the industrial environment to perform effectively in the workplace. Current A.S. and B.S. programs in EET, also in the ECET department, are accredited by TAC/ABET and are scheduled for a TAC/ABET visit during Fall 04. The B.S. in CS program recently underwent an initial accreditation visit by the Computer Accreditation Commission (CAC) of ABET. Students in the CPET program have the option of obtaining a minor in Computer Science if they choose the requisite electives. Accreditation of the B.S. CPET will be sought after there are program graduates. Preparation for TC2K accreditation includes extension of the current departmental assessment and continuous improvement plan and use of course and curriculum outcomes that focus on development and implementation of computer systems as specified in the IEEE program criteria. A sample curriculum is shown in Appendix A and a semester hour breakdown, by area, is provided in Table 1.

Basic Science and Mathematics	24 hours
Technical Specialty	52 hours
Computer Programming and Technical Electives	20 hours
*General Education Areas III, IV, and V	15 hours
English and Communications	12 hours
Free Elective	3 hours
Total	**126 Semester hours**

Table 1: B.S. CPET Semester Hour Breakdown (Industrial and Enterprise Networking)

*General Education is a University requirement, meeting the TAC/ABET Communications, Humanities, and Social Science requirements. Pertinent General Education areas are defined as:

Area III: The Individual, Culture, and Society
Area IV: Humanistic Thought
Area V: Creative and Artistic Expression

The Computer Programming and Technical Electives in the B.S. in CPET program undergo constant updating and revision as the ECET and CS departments strive to keep up with rapid changes in the electronics and computer fields. These electives can be used to gain additional in-depth knowledge of networking, Web-based systems, or other selected topics in computer-electronics. Examples of some of the specialized technical courses available as electives are:

CPET 472 Automatic Control Systems
CPET 493 Wireless Networking
ECET 346 Advanced Digital Circuits
ECET 357 Real-Time Digital Signal Processing
ECET 365 Electrical Measurement
ECET 382 C++ Object Oriented Programming for Industrial Applications
ECET 466 Windows Programming for Industrial Applications
CS 260 Data Structures
CS 364 Introduction to Database Systems
CS 384 Numerical Analysis

A graduate will generally learn and use the following software: VB.NET, Assembly Language, Multisim, PSpice, Windows Server 2003, Linux Server, Java, MATLAB®, VHDL, LabVIEW®, ORACLE, and C++.

Comparison with Similar Curricula

Of particular interest may be how this new B.S. in CPET program compares to other, similar, well-established, TAC/ABET accredited B.S. programs. Five programs were selected to provide a nationwide cross-section of similar, already successful, accredited programs. Curriculum emphasis and specific coursework are compared and contrasted with the IPFW program. These five degree programs are shown below with data showing date of initial accreditation[3] and whether a semester or quarter system is used at the university.

1. Eastern Washington University (EWU), B.S. in Computer Engineering Technology (1991), quarter system[4]

2. University of Houston, B.S. in Computer Engineering Technology (1987), semester system[5]
3. Rochester Institute of Technology (RIT), B.S. in Computer Engineering Technology (1987), quarter system[6]
4. Southern Polytechnic State University (SPSU), B.S. in Computer Engineering Technology (1991), semester system[7]
5. University of Toledo, B.S. in Computer Science Engineering Technology (2001), semester system[8]
6. Indiana University Purdue University at Fort Wayne (IPFW), B.S. in Computer Engineering Technology (new), semester system.[1]

Excerpts from university program descriptions from the websites, are shown below and indicate goals/objectives of the programs:

EWU: (B.S. in Computer Engineering Technology) This major combines studies in selected areas of technology, computer science, physics, and mathematics to offer relatively equal emphasis on computer hardware and software.

Univ. of Houston: (B.S. in Computer Engineering Technology) The goal is to provide students with a high quality applications-oriented undergraduate education based on state-of-the-art technology as a preparation for productive employment. Computer Engineering Technology majors study the application of state-of-the-art components and software in contemporary computer systems. Students are given a solid foundation in mathematics, basic sciences, and electronics. A thorough study is made of digital circuits and systems, and microcomputer circuits and systems. Hardware, software, and firmware aspects of microcomputers are covered in detail.

RIT: (B.S. in Computer Engineering Technology) There is an increasing requirement in industry for graduates with an in-depth knowledge of both hardware and software design and development. The program bridges the gap between hardware and software by providing a solid foundation in both and tying the disciplines together with a curriculum that has intensive classroom and laboratory components. From a software perspective, students are provided with a strong background in leading edge development using programming languages that are fully entrenched in industry. Students learn industry standard approaches to application software development as well as state-of-the-art problem solving techniques. The hardware focus is on digital systems design and development. The curriculum includes in-depth design and analysis of combinational logic; sequential logic; and state machines, micro-controller systems, microprocessor systems and state-of-the-art computer technology.

SPSU: (B.S. in Computer Engineering Technology) The program utilizes a core of mathematics, physics, and electronics courses. These courses provide the scientific and technical background for an in-depth study of the hardware and software aspects of computers and related systems. The emphasis of the program is on microcomputers and their application to the solution of industrial problems relating to robotics, control, instrumentation, monitoring, data communications, networks, and automated testing. Suggested areas of special interest are Embedded Systems and Networks.

Univ. of Toledo: (B.S. in Computer Science Engineering Technology) The program includes hardware and software aspects of both computer design and computer applications. Computer design emphasizes the structure of computers and requires expertise in computational applications, digital design, microcomputer systems and computer architectures. Computer applications emphasize the use of computer software and require both low-level and high-level programming techniques, the use of mathematical algorithms, and a general knowledge of computer operating systems. Students learn how to assist in the planning, construction, troubleshooting, and management of both the hardware and software elements of sophisticated data networks. This unique curriculum is designed with an emphasis on computer data communications using current telecommunications technology. The networking courses focus on subjects such as digital communications, local and wide area networks, regional and global networks, and network planning and management.

To compare program emphasis areas, selected course areas from each of the universities are shown in Table 2. Data was extracted from the referenced web-sites.

	EWU[4]	Univ. of Houston[5]	RIT[6]	SPSU[7]	Univ. of Toledo[8]	IPFW[1]
Programming	Java (2), C++, OOP, Data Structures	"C"	uP "C", C++ (2)	Intro to "C", C++	VB.Net, C++, PERL/Java, Applied Pgmg Languages	VB.Net, Java (2), uP "C", C++
Networking	Intro	Microcomputer Networks	LAN's	Data Comm, LAN's (2)	LAN's (2), WAN's	Oper. Sys., LAN's, Data Comm, Network Security, WAN's,
Other Computer Courses	Assembly, Adv. uP, uP Arch.	Assembly, uP Arch., uP Interfacing	Assembly, Interfacing,	Assembly	Assembly, uP Arch.	Assembly,
Selected Technical Electives	CAD, Adv. Web Design, Rapid Prototyping	Oper Systems, Data Comm, Telecom, Java, Adv. "C", Adv Networks	Prof. Conc. in: LAN's (2), WAN's (2), Comm Elec (2)	Embedded Systems (3), Networking (3)	(2 courses) Can be Business, EET, other ET, or CSET electives	Wireless Net, LabView, Data Structures, Control Sys.
Electronics	DC, AC, Devices, CAD, Digital, PLD/FPGA, Control Sys., Commun. Elec.	DC, AC, Devices, CAD, Digital, PLD/FPGA, Commun. Elec, Laplace/ Fourier Anal.	DC, AC, Devices, Digital, PLD/FPGA, Laplace/ Fourier Anal.	DC, AC, Devices, Digital, PLD/FPGA, Instrument., Commun. Elec, Control Sys	DC, AC, Devices, Digital, PLD/FPGA, VLSI	DC, AC, Devices, Digital, PLD/FPGA, DSP
Math	Calc (2), Discrete Math	Calc (2), Numerical Methods	Calc (2), Differential. Eqs.	Calc (2), Numerical Methods, Differential. Eqs.	Calc (2), Numerical Methods, Statistics	Calc (2), Discrete Math
Science	Physics (2), Chemistry	Physics (2), Chemistry	Physics (2)	Physics (2)	Physics (2)	Physics (2)
Other			Co-op required			
Total Hours	(124)	124	(128)	130	128	126

Table 2: Course area comparison

Legend
uP = microprocessor
uC = microcontroller

If more than 1 course, the # of semester equivalent courses are in parentheses.
Equivalent semester hours are shown in parentheses for EWU & RIT, which are on the quarter system.

Commonality

All six programs provide

1. A fundamental base in mathematics, including two semesters of calculus and, with the exception of RIT, a numerical methods or discrete mathematics course. RIT and SPSU also require differential equations.
2. Two semesters of Physics. EWU and Houston also require a chemistry course.
3. Initial education in DC and AC circuits, devices (primarily integrated circuits), and in basic digital circuits and more advanced Programmable Logic Devices (PLD's) and Field Programmable Gate Arrays (FPGA's), with introduction to VHDL (Very High Speed Integrated Circuit (VHSIC) Hardware Description Language).

Other requirements: EWU, SPSU, and Houston require a Communications-Electronics course. EWU and SPSU also require a Control Systems course while Houston and RIT require a Laplace/Fourier analysis course. All of these courses are generally associated with classical EET programs.

Programming

1. Houston, RIT, and SPSU teach assembly, C and/or C++ and appear to concentrate on application programming in these languages. More advanced programming courses or other languages are electives.
2. EWU, Toledo, and IPFW also teach C and/or C++, but also require Java and other programming languages and/or courses.

Networking

1. All programs require an introductory networking course.
2. EWU, Houston, and RIT appear to generally focus on microprocessor interfacing with students selecting technical electives or a concentration to emphasize more advanced Networking concepts and applications.

Apparent overall focus

4. **EWU**: The program has advanced application programming and microcomputer-microprocessor emphasis with strong, classical EET requirements and electives in advanced subjects such as Web design and rapid prototyping.
5. **Houston**: The program has microcomputer-microprocessor interfacing and architecture emphasis with strong, classical EET requirements and electives in advanced languages and networking subjects.
6. **RIT**: The program has application languages (C and C++) and interfacing emphasis with strong, classical EET requirements and a two course sequence in a professional concentration area of LAN's, WAN's, or Comm-Electronics.
7. **SPSU**: The program has application languages (C and C++) and interfacing emphasis with strong, classical EET requirements and 3 required courses on

Data Comm/LAN's. Students can also choose additional advanced electives in embedded systems or networking.

8. **Toledo**: The program has advanced application programming emphasis and a 3-course sequence in networking.
9. **IPFW**: The program has an advanced application programming emphasis and a 5-course sequence in networking.

Closest resemblance to IPFW program: It appears that the IPFW program most closely resembles the University of Toledo program. This may be attributable to computer science influence on both programs. The EWU program also shows CS influence and similarity in the programming courses, but less apparent emphasis than the IPFW program on advanced networking courses.

Employment Possibilities

The employment outlook appears favorable for graduates possessing the knowledge and core skills necessary to implement and maintain computer networks and computer based electronic systems in industrial and enterprise applications. Increasing demand for more sophisticated electrical and electronic products, as well as the expansion of these products into all areas of industry will contribute to stronger employment growth in this specialty area. An indication of program need is that in the past 2 years approximately 250 students enrolled in non-credit courses, taught by ECET faculty, that were closely related to the proposed program.

A more general indication of demand is the result of focus groups, sponsored by the university and consisting of business leaders, that considered the Training and Development needs of the Northeast Indiana region. Some results of these Focus groups were that the top four additional education and training program needs were: basic computer training, MCSE certification, development in information technology and programming, and E-tools and web development. Graduates of the proposed program will be well versed in all four of these areas.

Nationally, the U.S Bureau of Labor Statistics (BLS) projects Industries with the fastest wage and salary employment growth for the period 2000-2010 and the number one growth industry is projected to be Computer and Data Processing Services with an average annual growth of 6.4%[9]. The BLS also maintains a table of fastest growing occupations. Data from this table[10] is shown in Table 3 and indicates that occupations for which graduates of this program may compete occupy many of the top ten positions.

Occupation	Employment		Change	
	2000	2010	Number	Percent
1. Computer software engineers, applications	380	760	380	100
2. Computer support specialists	506	996	490	97
3. Computer software engineers, systems software	317	601	284	90
4. Network and computer systems administrators	229	416	187	82
5. Network systems and data comm. analysts	119	211	92	77
6. Desktop publishers	38	63	25	67
7. Database administrators	106	176	70	66
9. Computer systems analysts	431	689	258	60

Table 3: Fastest growing occupations, 2000-10[10]

Bureau of Labor Statistics, Numbers in thousands of jobs]

Comments concerning Table 3:

Graduates of the proposed program would qualify as Computer Support Specialists, which is defined as a person who provides technical assistance, troubleshoots equipment and instrumentation, and advises customers and users through help desk operations. Graduates would also qualify for many of the network occupations. Graduates who choose to obtain a minor in Computer Science and pursue an M.S. in Applied Computer Science may enter the engineer, systems analyst, and database administrator occupations. Computer Engineering Technology graduates may be employed by advanced manufacturing companies, industrial automation organizations, and as technology consultants requiring workers with knowledge of embedded controller based systems.

The projections for the northeast Indiana region, compiled by the Indiana Department of Workforce Development office[11], are shown in Table 4:

Job Title	1998 Employment	2008 Employment	Annual Avg. Total Openings
Computer Engineers*	580	1020	50
Computer Support Specialists	700	1,160	50
Systems Analysts	1048	1860	90
Computer Programmers**	870	1,020	40
Computer Programmer Aides	100	120	10
Elect & Electronic Techns/Tehnls	790	800	10
Engineering Techns/Technls, NEC	670	760	20
Electronics Rprs, Comm/Ind Eq	160	180	10

* Includes Software Engineers (applications and systems software)

** Includes Embedded Systems

Table 4: North East Indiana Job Projections[11]

Base Period: 1998, Projected Period: 2008
WIA (Workforce Investment Act) Planning Region 3

Comments concerning Table 4:
Job titles in the Indiana database are not the same as the national database. Similar job titles were selected to correspond to positions for which CPET graduates may qualify.

Conclusion

The B.S. in CPET at IPFW was developed to meet the needs of the northeast Indiana region. Analysis of objectives/goals and curriculum for four B.S. programs in CPET and the closely related B.S. in CSET at TAC/ABET accredited institutions nationwide shows considerable commonality in fundamental courses during the first few years and in mathematics, science, and related courses. The emphasis areas appear to provide various levels of depth in programming and in networking. The CSET program at the University of Toledo, which is also physically near, approximately 110 miles, to IPFW, appears to bear the closest resemblance to the new IPFW program. The official government job projections, nationwide and regional, look good for graduates in this area; however, this data may lag the current national trend to move information technology support to other areas of the world. The bottom line is that all ET programs must continuously upgrade their curricula to meet the latest challenges of business and industry.

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3. A list of TAC/ABET Accredited Computer Engineering Technology Programs is at http://www.abet.org/accredited_programs/engineeringtechnology/TACWebsite.asp
4. Department of Engineering Technology & Multimedia Design, Eastern Washington University, Cheney, WA at http://www.technology.ewu.edu/
5. Department of Engineering Technology, University of Houston, Houston, TX at http://www.tech.uh.edu/et/
6. Department of Electrical, Computer, and Telecommunications Technology, Rochester Institute of Technology, Rochester, NY at http://www.rit.edu/~706www/new/index.php3
7. Department of Electrical and Computer Engineering Technology, Southern Polytechnic and State University, Marietta, GA at http://ecet.spsu.edu/
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Hal received his PE license in Indiana and his PhD in Engineering (EE). His research area is servo systems and he consulted for ITT Industries on weather satellite servos for 10 years. He is currently Associate Dean of the school of Engineering, Technology, and Computer Science, a senior member of IEEE and ISA, and an IEEE program evaluator with fourteen TAC/ABET accreditation visits completed.

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Appendix

B.S. Computer Engineering Technology – 126 semester credit hours

		Semester 1
4cr	CPET 101	Electrical Circuits
4cr	ECET 111	Digital Circuits
3cr	ECET 114	Intro to Microcomputer
		or CS 114 Intro to Visual Basic
3cr	MA 153	Algebra and Trigonometry I (GenEd Area I)
3cr	ENGW 131	Elementary Composition (GenEd Area I)
17 cr		
		Semester 2
3cr	CPET 181	Computer Operating Systems Basics
4cr	ECET 152	Electrical Circuits II
3cr	ECET 146	Digital Circuits II
3cr	MA 154	Algebra and Trigonometry II
3cr	COM 114	Fundamentals of Speech (GenEd Area I)
16 cr		
		Semester 3
4cr	ECET 204	Analog Electronics II
4cr	ECET 205	Introduction to Microprocessors
4cr	CS 160	Introduction to Computer Science I
4cr	MA 227	Calculus for Technology I
16 cr		
		Semester 4
2cr	ECET 296	Electronic System Fabrication
4cr	CS 161	Introduction to Computer Science II
3cr	MA 175	Introductory Discrete Mathematics
3cr	CPET 281	Local Area Networks and Management
3cr	Gen Ed Elective Area IV	
15 cr		
		Semester 5
4cr	PHYS 218	General Physics I (GenEd Area II)
4cr	CPET 355	Data Communication and Networking
		or CS 274 Data Communications plus 1 hour lab
4cr	ECET 305	Advanced Microprocessors
3cr	MA 228	Calculus for Technology II
15 cr		
		Semester 6
4cr	PHYS 219	General Physics II (GenEd Area II)
3cr	CPET 364	Networking Security
3cr	CPET 384	Wide Area Network and Design
		or CS 374 Computer Networks
3cr	ENGW 234	Technical Report Writing
3cr	IET 105	Industrial Management (Gen Ed Area III)
16 cr		

Semester 7

3cr	CPET 493	Wireless Networking
3cr	Approved CPET/ECET/CS Elective	
3cr	Approved Non CPET/ECET Tech. Elective	
1cr	CPET 490	Senior Design Project Phase I
3cr	Gen Ed Elective Area IV	
3cr	Gen Ed Elective Area III	
16 cr		

Semester 8

3cr	Approved CPET/ECET/CS Elective	
3cr	CPET 491	Senior Design Project Phase II (GenEd Area VI)
3cr	ENGW 421	Technical Writing Projects (GenEd Area VI)
3cr	Free Elective	
3cr	Gen Ed Elective Area V	
15 cr		