Abstract - This work reports on an ongoing NSF-funded effort to develop plans for a new Electrical and Computer Engineering curriculum with an embedded systems focus. The program specifically addresses the needs of the automotive and related industries. Project goals include the development of a comprehensive roadmap that comprises course offerings, topical content, the necessary technology and software acquisitions, and a time-bound plan for phasing in the new curriculum. An initial concept statement and framework for the curriculum, developed on the basis of an assessment of similar efforts at other universities as well as consultations with an advisory panel, will be presented at the conference.

Index Terms – Curriculum development, Embedded systems.

INTRODUCTION

The Department of Electrical and Computer Engineering at the University of Detroit Mercy is undertaking a review of the current ECE program in order to create comprehensive plans to reformulate, streamline, and develop a new curriculum. This work outlines our initial assessment of the needs that form the basis of this curriculum development effort, while also describing the planning process that is being used to provide form and substance to it through a consultative process within industry and academia. It is our expectation that at the end of the planning process we will have a comprehensive roadmap that includes course offerings and topical content, technology and software acquisitions, and a time-bound plan for phasing in the new curriculum.

The evolution of computer technology is marked by a major fork. One branch of the evolutionary tree is focused on raw computing power and represented by Sparc, MIPS, Pentium and Power-PC chips used in personal computers and advanced workstations. The other branch, which is 30 times larger in unit volume, is represented by embedded microcontroller systems [1]. The automotive industry is a good example of the increasing focus on the latter. Electronics use in automobiles has been increasing steadily to improve reliability and add more functionality. For example, the 2001 model year electronics accounted for 19% of the cost of mid-sized cars and is expected to reach 25% by year 2005 for mid-sized cars, and possibly 50% for luxury models [2]. Much of this increase is a consequence of the move to distributed microcontroller-based processing systems (engine, anti-lock brake, transmission, climate control, GPS, and telematics for example) communicating via standard protocols such as Control Area Network (CAN). The effective treatment of such distributed real-time embedded systems in a computer engineering curriculum requires an integrated approach which treats sensor/actuator interface circuit design, microcontroller architectures and peripherals, real-time operating systems, networking and distributed processing, and low and high level systems programming, in a holistic fashion.

PROGRAM FOCUS

As a result of our normal curricular assessment process, and regular but informal consultation with our alumni in managerial positions in the local industries, it has become clear that a program that concentrates on small-scale embedded and distributed digital systems would serve the emerging workforce and educational needs of US industry.

The automotive context of this embedded systems focus does not limit the applicability of the program developed. Increasing use of embedded controllers can be noted for the telecommunications, military, aerospace and consumer electronics industries among others. Furthermore, the automobile provides a severe environment for electronics as well as a test bed for many of the latest applications of embedded technology. Therefore, while the focus is specific, the implications of this work go far beyond our local context.

Some of the more specialized topics that we believe should be considered for inclusion in this new program include:

- interface circuit design -- sensor signal conditioning, drivers for stepper and servo DC motors, solenoids and actuators, etc.;
- mixed-signal programmable devices;
- embedded system design -- microcontrollers (HS12, PIC etc.), Digital Signal Processors, peripherals, device synchronization, multitasking, real-time systems;
- distributed processing for embedded systems -- the use of multiple small (PIC, HC05-HS12...) processors together to provide distributed control and improved reliability, distributed processing networking protocols, shared computation, redundancy and task sharing;
- digital communication and networking.

This topic selection is a result of preliminary consultation with our stakeholders and an evaluation of the present and
future trends in the automotive and related industries which predominate in southeast Michigan.

PLANNING PROCESS

A curriculum planning process is necessary to investigate the individual program topics, their relationships, and the pedagogy necessary to present them in an integrated fashion at an undergraduate level. We are utilizing three vectors of inquiry to meet these goals. The first vector of inquiry is based on a series of formal meetings (both group and individual) with our constituents - representatives drawn from our industrial partners, alumni base, and industrial advisory board. This varied group of people has been asked to consider their educational needs (relative to embedded and distributed systems) based on the large and clearly identified trends in their industries. The second vector attempts to interrogate programs and planning processes implemented by schools with a history of innovation and a commitment to undergraduate education. This involves careful review of programs nationwide, utilizing multiple national ratings, published program catalogs, web-based materials, and phone enquires. The third vector involves the exploration of the substantial educational literature available including such publications as the IEEE Transactions on Education and the Journal of Engineering Education. Moreover, numerous national conferences have sponsored special sessions, conference papers, and round table discussions focusing on curriculum development, and the design of technical curricula.

At the end of the planning period, we expect to generate the following outcomes:

- A compilation of the topical content for courses, particularly for topics that are new in the sense that they address emerging technologies and hence are non-traditional;
- A prioritization of the topics since covering everything may not be feasible;
- A list of courses and their appropriate hierarchy in the curriculum;
- An identification of the necessary technologies that would be needed to offer this new curriculum so that appropriate acquisition of laboratory equipment could be addressed and the attendant facilities set up; and
- A time-bound roadmap for phasing in the new curriculum.

OBSERVATIONS

One must begin an endeavor like this by understanding that there are many differing definitions of embedded systems. A review of over two hundred programs nationwide supports this observation. The programs in computer engineering vary widely, from substantially software based programs (closely allied with more traditional computer science), to programs dedicated to language-based hardware-software co-design of ASIC or FPGA based Systems-on-a-chip (SOCs), to curricula which emphasize custom digital integrated circuit design. A review of the literature presents a similar variety of approach.

There has been some excellent work done on developing curricula for embedded systems [3]-[6]. Additionally, a number of authors have considered the broad issues associated with current and future trends in computer engineering [7]-[8]. It is clear that there is no one correct curricula or approach to treating embedded systems. Rather, one must take into careful consideration the regional employment demands, as well as the preparation necessary for graduate study.

It is necessary to practice careful discernment regarding the rapid technological fluctuations that are prevalent today. Specifically, industry can be expected to make regular demands of undergraduate preparation to meet their perceived needs. Sometimes these expectations will provide valuable insights into changing career paths, and at other times the demands will be inappropriate, and best understood as related to the “tools and toys” of the trade. Engineering students must have a fundamental concept base which allows agility and flexibility, for if a program is too specialized, the range of opportunities available for graduates will be compromised.

In the course of investigating the content and structure of a new program to address the design and development of distributed small-scale embedded systems as appropriate for the automotive industry, it became clear that close ties to the fundamental disciplines associated with electrical engineering was critical. The wide variety of distributed sensors, their associated electronic interfaces, the large-scale control systems, and the extreme environments within which they operate require careful treatment of analog and digital electronic circuit design, communication and control theory, mathematics, and physics. These topics traditionally constitute the core of the electrical engineering discipline.

Keeping in mind the above factors, a viable theme for our new curriculum will be discussed at the conference.

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REFERENCES