

# The Exploration and Practice of Embedded System Curriculum in Computer Science field

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## Abstract

*The particularity of talent needed for different research and development levels in embedded field is realized and the status of talent required for embedded industry is clarified through the deep and wide enterprise investigation and the process of embedded products development. Furthermore, talent in embedded field can be divided into four types, Hardware Design Talent, Drive Layer Design Talent, Secondary Development Talent and Application Software Development Talent. Based on Computer Specialty, appropriate curriculum system is established, which is more combined with Computer Specialty and fit for the cultivation of Embedded System talent needed for the society. This paper further elaborates teaching planning of related courses, curriculum and teaching programs of the relationship between courses. Finally, the practice results and recommendations about this curriculum are given.*

**Keywords:** Embedded system, curriculum system,

training mode, ARM.

## 1. Introduction

Embedded System is a new technical development trend after network technique. Embedded system teaching has been unfolded in foreign universities. Institute of Software and Microelectronics, Peking University has set up embedded system department and offered a series of professional courses, such as “Embedded Operating System”, “Embedded System Design” in 2002<sup>[1]</sup>; Computer College in Beijing University of Aeronautics and Astronautics set up the course of “Embedded System Design” in 2002; the statistics show that more than 200 colleges set up this course in china, including most of Department of Computer Science, Department of Electronic, Department of Automation and Software College in native universities from 2002<sup>[2]</sup>.

There are a lot of plans or competitions about Embedded System held by international organizations and companies, such as IEEE, Intel, Microsoft, Altera. Embedded System has been

recommended to be one of core curriculum in computer curriculum system which is made by IEEE Computer Society and ACM in 2004.

There are close relation among product development, technological progress and talent training in Embedded System field. The basis of above is teaching and practicing in Embedded System<sup>[3]</sup>.

## 2. Embedded System talent structure preliminary

Information Engineering College of Qingdao University set "Embedded System" course in Computer Science and Technology major for Undergraduate in 2003. Based on that, Embedded System major for Undergraduate was set up at 2005. Since then, class of "Embedded System" was voted among 2005 grade students. They will accept background education in Computer Science and Technology in 2 years and specialty education in Embedded System in the last 2 years.

In the demonstration of Embedded System major construction, we survey on the market's demanding for talents, training mode, training level, course system and teaching scheme from famous enterprise at home and abroad and IT company in local, such as Lucent, Huawei, Haier, Hisense. On survey, it clears off the talent demands on enterprise, refines different levels demanding for talent in process of product development in embedded and defines ideas of direction in the embedded System professional building. It is guaranteed a higher level of talent training, targeting more accurate, and more able to meet the needs of the community levels.

Business-to-embedded talent is urgently needed from embedded technology perspective. Embedded product development process can be aspects of products hardware design, drive layer design, the second development, application development and so on. Different aspects of research and develop-

ments need talent levels differently. So the talent in embedded field can be correspondingly divided into Hardware Design Talent, Drive Layer Design Talent, Secondary Development Talent and Application Software Development Talent.

## 3. Embedded System Course System

Embedded System is the perfect combination between software and hardware, which professionally involved in electronics, computer, communications and other knowledge. So, a complete curriculum system must be set up to teach the content of embedded System including many different courses. Embedded System is itself a computer system, which is a clipping, professional and micro computer system. Many basic and specialized courses which are set up by Computer Science and Technology Majors are also necessary for the design of Embedded System learners, including Digital Logic, C / C++ Programming, Operating System, Microcomputer Principle and so on. The curriculum only closely related to Embedded System and teaching organization is explored by this paper.

### 3.1. Guiding Ideology of Embedded System Curriculum Construction

(1) It is a scientific key of structuring Embedded System curriculum that according with the law of Social-to-embedded talent.

(2) Attention to its feasibility and practicality.

(3) Emphasize on Hard-Software system co-design. Embedded System is a soft-hardware system, so too much emphasis on hardware or software System will bring biased and be depart from the needs of society<sup>[4]</sup>.

(4) Enhance training of university students' comprehension professional quality. Based on that, the students' application ability and development

capability should be strengthened by training.

(5) Explore production-research talent training mode. Teaching case should be derived from the actual project and graduation design in terms of enterprises and their actual demands.

(6) Introduce the project-driven teaching model.

### 3.2. Embedded System Talent Training Goals

Through studying a series of courses, students take on a more solid expertise in embedded System, grasp the basic development technology and methods about soft-hardware embedded System and understand the SOC design and the technology of development. For example, students can design a kind of embedded System development board based on S3C44B0 micro-processor separately, complete

the design of Boot Loader independently, transplant  $\mu\text{C}/\text{OS-II}$  and develop the drive program of ethernet USB, LCD and so on.

### 3.3. Embedded System Courses Architecture

Based on the guiding ideology of embedded System course system construction and actual situation of Computer Science and Technology major in our college, orientation of cultivating Embedded System in the undergraduate major is located at Drive Layer Design and Secondary Development Talent. That level can greater integrate our education basis and be provided with adaptability and development. Embedded System Courses Architecture is adaptable for the level talents as following in figure 1:

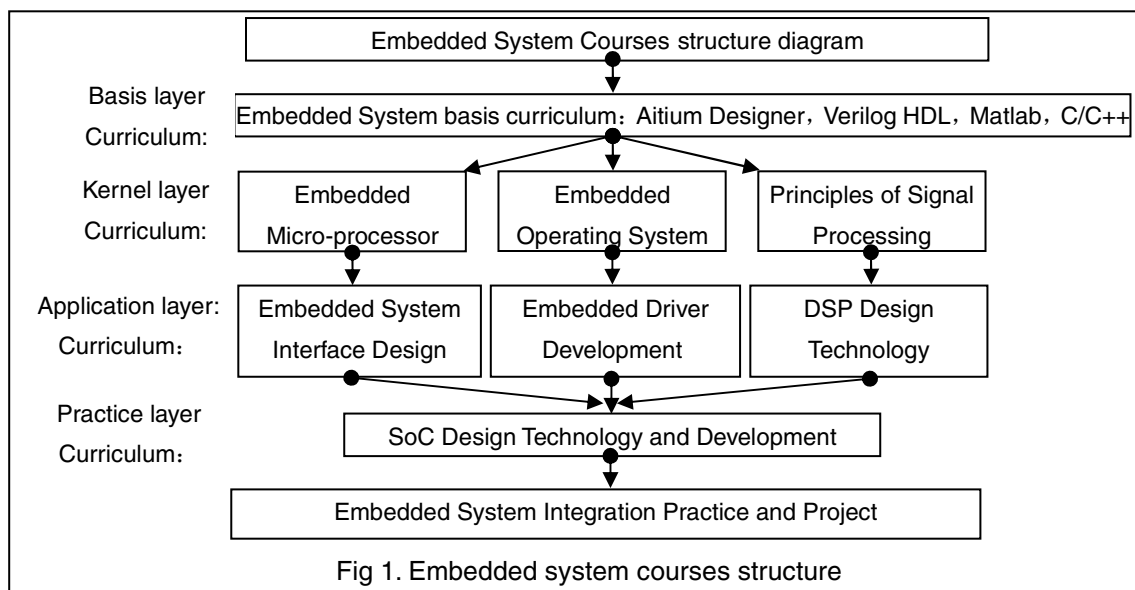


Fig 1. Embedded system courses structure

### 3.4. Embedded System Courses Teaching Plan

In Figure 1, there is curriculum closely related to Embedded System, mutual relations and the creation of order. Embedded System courses classified as basis layer curriculum, kernel layer

curriculum, application layer curriculum, practice layer curriculum. Among them, Embedded Micro-processor and Embedded Operating System are core curriculum in this direction. SoC design technology and development is comprehensively practice course which integrated using all the preorder courses. Based on the above Embedded System curriculum, the teaching plan is developed

as following in table 1.

Table 1. Embedded system courses teaching plan

Curriculum Name	Teaching weeks at class	Teaching weeks at practice	Opening weeks at practice	Semester
Altium Designer 6, Verilog HDL, Matlab	4	3	2	5
Embedded Micro-processor	4	2	2	6
Embedded Operating System	3	2	2	6
Principles of Signal Processing	3	2	2	6
Embedded System Interface Design	3	2	2	7
Embedded Driver Development	3	2	2	7
DSP Design Technology	3	2	2	7
SoC Design Technology and Development	3	2	2	8
Embedded System Practice and Project	16weeks			8

After the curriculum setting up, our college commissioned Computer Society in Qingdao to organize a seminar among universities, enterprises and institutions in Qingdao. There are more than 20 experts presenting at it. At the seminar, the experts made a lot of valuable advice, at the same time, experts made high price of the architecture. The curriculum is also in the form of the questionnaire to conduct a survey among students. The students are welcomed and appreciated this curriculum.

### 3.5. Embedded System Syllabus Analysis

(1)Embedded System Basis layer curriculum mainly teach several software tools, including PCB design software Altium Designer 6, hardware description language Verilog HDL, calculation language Matlab7, embedded programming language C/C++. They are basic tools and language of embedded System. Embedded System developers must get them.

(2)Embedded processor: Embedded Micro-processor is hardware core unit in Embedded System. Teaching three micro-processors ARM, DSP, FPGA related to embedded system together, the teaching school ratio of those is about 5:3:2. The main teaching contents of these three

categories of embedded microprocessors are system structure, command system and assembly language programming. These focus on teaching methods, not only can save hours but also easy to be understood and mastered by students.

Teaching in the ARM process, we take ARM7TDMI for example. The first processor in the latest ARM processor family Cortex is M3. The core is actually the concise version of ARM7, lower cost and simpler than that. Teaching in the DSP, the object is the most popular series of TI's TMS320C5000 chip and the main contents are architecture, the internal hardware resources and software resources. Teaching in the FPGA, the object is Cortex-M1 produced by ACTEL in order to integrate ARM, DSP and FPGA and lay a better foundation for SoC Design and Development.

(3)Embedded Operating System: Embedded Operating System is software core unit in Embedded System. The teaching object of this course is the open-source real-time operating system  $\mu$ C/OS-II. In the course ,we should concentrate on  $\mu$ C/OS-II , grasp the work of embedded System and understanding the transplant and cutting technologies.  $\mu$ C/OS-II is a compact, open-source, full-featured, real-time operating system. It is suitable for teaching and scientific

research that the theory will make clear in limiting school teaching. Once the students have mastered this OS, it is not difficult for them to study and use other OS.

(4)Principles of Signal Processing: This course mainly links Signal and System, DSP together. It is systemic to teach the basic concepts, principles and methods about a signal processing system and lay a good foundation for signal processing.

(5)Embedded System Interface Design: The course aims to grasp the external components technology and the expansion of methods for embedded System. On the basis of studying embedded processors, we focus on teaching the embedded system hardware interface design technology and methods. The course object is S3C44B0. Main contents are teaching S3C44B0 chip interface to expand the functionality, design methods and register setting, introducing common external reset circuit, the clock circuit, the expansion of memory (SDRAM / SRAM / FLASH), ethernet interface, USB interface, CF card interface, UART interface, LCD interface and detailing on the special function register configuration and programming to all types of interface.

(6)Embedded Driver Development: The course is aimed at the technical and methods of Embedded System development driven procedures. Based on S3C44B0 micro-processors and  $\mu$ C/OS-II real-time operating system, we teach the Boot Loader design, analysis the design feature of  $\mu$ C/OS-II device driver routine, design the drive of SDRAM, Ethernet, USB, CF card, UART, LCD interface.

(7)DSP Design Technology: The course aims to master the application of DSP to apply in digital signal processing technology and design methods. On the basic study of embedded micro-processor and signal processing principle, we take voice signal for example to practice all types of new treatment methods in signal processing courses based on TMS320C5509 micro-processors and

$\mu$ C/OS-II real-time operating system in order to deep students' understanding of DSP.

(8)SoC Design Technology and Development: The course is a comprehensive application and practice after many preorder-courses. Based on FPGA a series of Actel Cortex-M1 to teaching SoC design and technology, let the students independently developed a simple SoC. Cortex-M1 is an ARM processor specific designing for FPGA application, embedded in ACTEL FPGA. It is very convenience for SoC teaching. Students can facilitate use soft-core IP to expand all types of external interfaces in the FPGA. The students can use learned knowledge so as to integrated apply and comprehensive practice. In 2006, our college cooperates with ACTEL from the United States to establish a joint lab. ACTEL corporation has provided 40 sets of software and hardware development system based on Cortex-M1. This course demands students to complete products in group based on the development board independently, such as a converter between serial port and ethernet mouth, a CF card or hard disk controller, a U-disk controllers.

(9)Embedded System practice and project: Relying on IT companies and with the actual demands for the goals in Qingdao enterprises, students graduating design topics can be selected by practical applications from enterprises. Adopting the model as the core of students and school-based, supplemented by joint enterprise to complete, the outcome should be subjected to come from enterprises, completed in the schools, the results back to business.

## 4.Application Practice and Experience

Embedded System major for undergraduate was set up at 2005 in our college and we have some courses teaching in 2004 grade for practice. From that, we has achieved initial results, also received a

number of reform experience. A comprehensive teaching is in the promotion in 2005 grade. In the autumn semester of 2007, we completed the basic course of teaching about Embedded System in 2005 undergraduate. In the spring semester of 2008, we set three courses: Embedded Micro-processor, Embedded Operating System and Principles of Signal Processing. From these two semesters teaching effectiveness perspective, the curriculum system is successful. Students reflect the great harvest from the courses and practice. The architecture is new structure, specific content, the courses relationship clearly, the order reasonable and extent appropriate that get the recognition of some colleges and universities, enterprises and teachers and students. The architecture is high feasibility and good operational.

Embedded System curriculum requires the theory teaching in close connection with practice of teaching. So we use (3+2+2) structure in the design of teaching program. Take a course for example, if the school teaching arrange 3 academic period, the practice teaching is 2 academic period at least and 2 academic period needed for opening practice. Under arrangement, the expected demand I reached basically after completion of a course. In teaching process, we use the model of Group teaching. There is a high level teacher, a lecturer, practice teacher and guidance teacher in one group. The high level teacher help with other teachers define curricula, teaching program and assessment methods and other teaching documents and manage all aspects of teaching (including organizing external technical seminars or training at least 1 or 2 times in one course). Practice has proved the model more satisfactory.

Embedded System curriculum is characteristics with new content, broad knowledge, more practice. This requires teachers not only have higher theoretical level but also more abundant practical experience. Lecturers take part in guiding the

experiments so as to solve the issue of guidance teacher in insufficient level. Otherwise, we fix the relationship between the students and equipments and ensure that each student has his own equipment, manage it by oneself and open laboratory for students learning at any time. The above method is effective.

Anyway, Embedded System is a new technology and a new direction, new major as talent training. There are a lot of question to further explore and exchange. Please give us your valuable advice.

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