

Project Based Teaching Methodology for Embedded Engineering Education

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Abstract—An Embedded System is an integration and combination of customized hardware and optimized software designed for a specific function running continuously. In recent years, the usage of Embedded Systems all over the globe has increased drastically in different domains of engineering and its applications. There are more opportunities for a fresh engineer with embedded expertise skills. The manpower required with these skills is a hot cake in the Industry. Designing a curriculum for embedded system course in engineering education is certainly a challenging task and should meet the requirements of the Industry standards. Today exploring different ideas and innovation of new techniques are mandatory for a fresh engineering graduate. Hence Project based active learning teaching methodology is essential in the area of Embedded System Engineering Education (ESEE) at undergraduate level. This paper describes about the Embedded System Engineering and Micro Processors & Micro Controllers courses. A project based and active learning teaching methodology is developed and applied to these courses. This paper presents the procedure to implement a teaching methodology to develop embedded systems for different applications in the area of Engineering Education. This paper also discusses the results for the case study projects for the above mentioned courses. This teaching methodology is applied for ARM9 processor based embedded system development project used for telecom applications and the outcome of these courses are explained with the results. The outcome of this course is a research paper presented at National Conference is also discussed.

Keywords—Embedded System, Embedded Engineering Education, Micro Processor and Micro Controller, Active Learning Methodology, Course.

I. INTRODUCTION

Embedded Systems are characterized by the presence of, processors running application specific programs. Typical examples of Embedded Systems are printers, cellular phones and automotive engine controller units. In embedded systems, with the flexibility of software and increasing application specific logic solutions makes an Embedded System an attractive option. As system complexity grows and customization of processor board increases, the embedded system design approach for application specific systems is becoming more appealing. This makes many academicians and researchers to make efforts in the design and analysis of Embedded Systems [1][6]. In this paper teaching methodology for engineering education is discussed elaborately and case

study of project based teaching methodology is implemented for two different courses called Micro Processors & Micro Controllers and Embedded System. We also presents the course related projects with the results. This paper emphasis current work and literature review of embedded engineering education curriculum including Micro Processor and Micro Controller course. A Project based teaching methodology is developed to implement project based curriculum for both courses like Micro processors & Micro controllers and Embedded System in Electronics and Communication Engineering Education stream. Under this teaching methodology, teams of two to three students were able to merge effectively and successfully completed their final/major projects on the ARM920T based processor board and AT89S52 Microcontroller related projects.

II. RELATED WORK & LITREATURE REVIEW

Borrego Maura, Jesiek.B.K, and Beddoes.K described and represented about the engineering education research, this paper also specifies about the aspects that should be involved and what is to be required to strengthen the engineering education [1]. Kumar, Mercado, Manimaran and Rover presented similarities and differences between Linux and Vxworks in a real-time system course [2].Wald, M described the difficulties present in developing engineering education in Europe. This paper mainly focused on developments in colleges and higher engineering education to activate learning in engineering education [3]. May.D, Terkowsky.C discussed the areas of competence and accreditation boards for engineering education. This paper also described engineering education in laboratories [4]. Reed-Rhoads, T conducted a workshop which gives a list of new engineering education research and is offered as a project in Center for Advancement of Scholarship on Engineering Education. This workshop gave handbook which contains research and project management and teaching methodology in engineering education [5]. In this paper an effective way of project based teaching methodology is developed and effectively implemented for two courses at Department of ECE, Vidya Jyothi Institute of Technology, Hyderabad, India and a research paper is presented by our students in a National level Conference as an outcome of this project based teaching methodology.

III. DESIGN OF PROJECT BASED TEACHING METHODOLOGY

Before starting to teach any course in engineering education, Instructor should identify active learning topics, methods and areas those can be enhanced to in-house project level implementation in the same semester or year. Designing of active learning teaching methodology is a challenging task of any course in engineering education [7] [8]. These courses are aimed at more senior undergraduates to synthesize their knowledge acquired from multiple prerequisite courses, and to facilitate their ability to realize ambitious real-world projects in a short time [9],[13] [18]. The students will be able to create better impressions, awareness in the area of open source technology in subsequent job interviews. The following methodology is used to maximize the teaching potential of engineering education in Embedded System Engineering and Micro Processor based application development courses[10][11][12]. At end of the semester, students give presentations and demonstrations of their active learning experience and their projects [17]. The following are the main steps for implementing project based teaching methodology for any course in the engineering education.

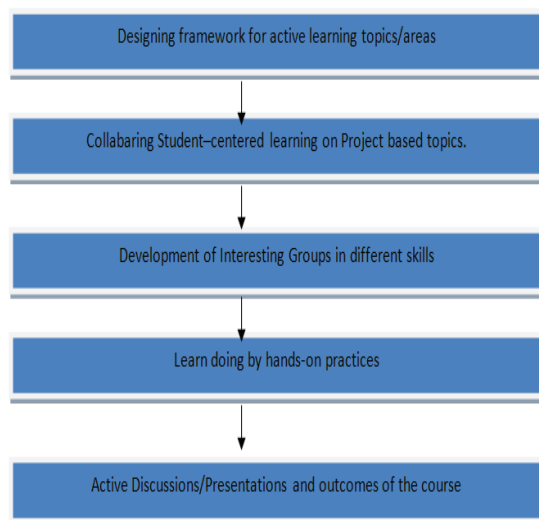


Fig. 1. Project Based Teaching Methodology

IV. RESULTS AND DISCUSSIONS

A. Project Based Teaching Methodology for Micro Processor & Microcontroller Course

Micro Processors & Micro Controller course is a 3rd year level course is very much suitable and has a huge scope for implementation of mini/major projects and active learning methods [15]. The class in this course is designed with student centered and interactive sessions with the live examples and demonstrations with simple applications like Traffic Lights Application, Automatic Vending Machine etc. In this curriculum Instructor will identify active learning topics like 8086 micro processor architecture and its instruction set, i/o

interfacing using 8555 for customized hardware circuit designed by the student. Instructor will also teach overview and architecture of 8051 Micro Controller for one week and next week Instructor presents an instruction set of 8051 Micro Controller and later see that student will actively involved in doing small programs using Simulator Softwares like Keil and Micro Vision as shown in the figure 2 and figure 3 [14]. Instructor should direct the students to learn architecture, instruction set and able to write a simple program with simulation and letting the student will to test that program on actual 8051 based hardware system. At this point of time student will get more ideas to implement with 8051 based hardware system. All these ideas are evaluated efficiently by the Instructor and discussed thoroughly with the various issues while implementation [19] [20]. For example if a student is able to write a program to read data from a port then Instructor should help student to develop algorithm/program to read data from an A/D converter which is interfaced to 8051 based hardware system.

With the knowledge and above hands on experience of above course, students are able to implement a project titled with Design Robot with Night Vision Capability Using RF for their mini project at Department of ECE, Vidya Jyothi Institute of Technology, Hyderabad, India. The main aim of this project is to design a system that behaves like a robot and control system using RF technology as shown in the figure 4. This project describes a economical solution of robot control embedded system as shown in the figure 4. This can be used for different sophisticated engineering robot applications. The control system comprises of an RF transmitter and receiver, a microcontroller that collects data from the RF receiver and controls the robot.

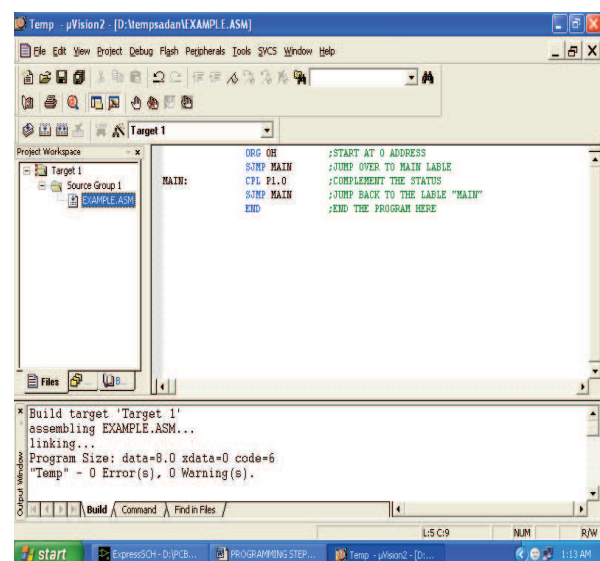


Fig. 2. Micro version Keil Simulator for Intel 8051 Micro controller

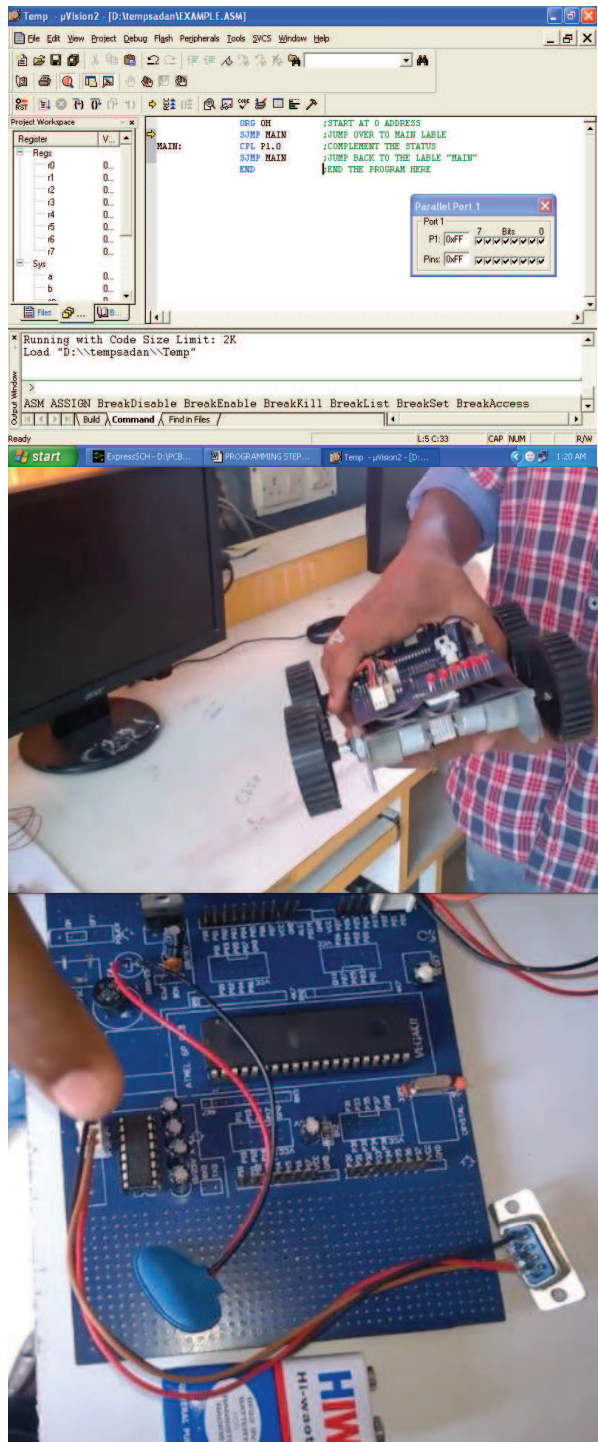


Fig. 3. Micro version Keil Simulator for Intel 8051 Micro controller



Fig. 4. Students Demonstrating Projects

The main activities while implementing project shown in figure3 and figure 4 are

- Assembling the components like microcontroller, Max232, DC motors, RF Encoder, RF Decoder STR 433 and STT 433.
- The Keil Software 8051 development tools are used to develop/compile of application source code written in embedded C language.

- An Assembler is used for linking source files to create HEX file which is transplanted to target board and it is tested successfully.

The outcomes of above activities, the student able to not only assemble and customize electronic devices also develop the code for a specific application.

B. Project Based Teaching Methodology for Embedded System Course

Project based Teaching Methodology is applied to another course for Electronics and Communication Engineering Education for final year students at Department of ECE, Vidya Jyothi Institute of Technology, Jawaharlal Nehru Technological University, Hyderabad, India [9]. The name of this course is Embedded Systems, it consists of series of lectures that covers the embedded system design concepts. In this course Instructor presents concepts and features of operating systems, role of operating system for customized embedded hardware systems. Instructor also explains the procedure to develop the embedded system for a particular application using any processor based board. In our class the Instructor discussed architecture of the ARM 9 processor board and features of operating system running on ARM 9 processor board as shown in the figure 5. Instructor also expressed many active learning methods like demonstrating linux operating system code from open source website kernel.org. As a result these discussions and clarifications with different issues, students are able to transplant latest kernel from kernel.org as their major project and they are able to analysis the ARM processor board for telecom application. Linux kernel source is analyzed as shown in the figure 5 [11] [16][21].

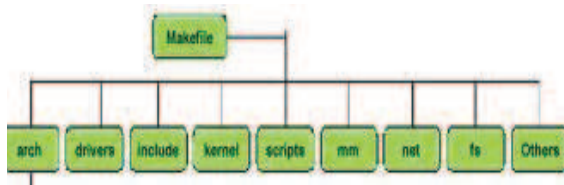


Fig. 5. Linux kernel source tree

Before starting the process of implementation of project based teaching methodology for Embedded System course students need to install a cross compiler tool for building the kernel image using arm-linux-gcc-4.4.3 arm as cross compiler.

A. Install Cross Compiler:

After downloading cross compiler arm-linux-gcc-4.4.3.tgz compressed file, untar it by executing the following command.

```
# sudo tar xfvz arm-linux-gcc-4.4.3.tgz
```

```
# cd opt/ARM/toolschain/4.4.3/bin
```

```
# export PATH=$PWD:$PATH
```

To test whether it is installed or not use the following command.

```
# arm-linux-gcc -v
```

This command will get the version of cross compiler and gives the status of its installation.. Then students downloaded linux kernel source code from Kernel.org. This board supports linux-2.6 version.

B. Configuring the kernel for ARM 9mini2440:

Students configured linux kernel for mini2440 using menuconfig as shown in the figure 6.

To set configuration for the target board and build the kernel image, use the following commands:

```
# cd linux-2.6.32.2
```

```
# cp config_mini2440_x35 .config
```

```
# make ARCH=arm CC=arm-linux- menuconfig
```

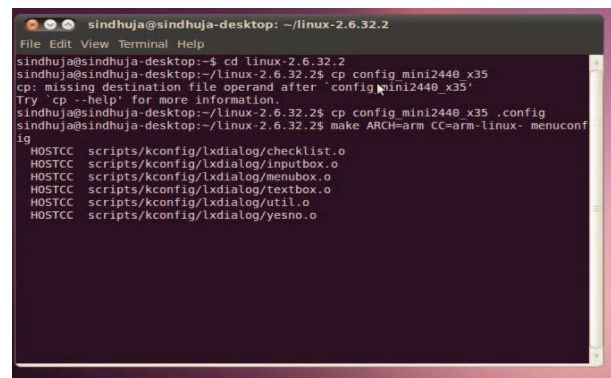


Fig. 6. Configuration of Kernel for ARM mini2440

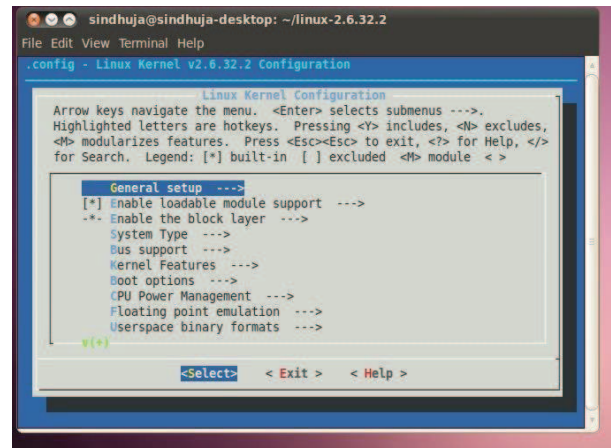


Fig. 7. Menuconfig for mini2440 kernel

After doing this, configuration technical specifications are written into .config file as shown in the figure 6 and figure 7.

C. Cross Compiling Kernel:

The Linux kernel supports many CPU architectures. In the linux source tree, each architecture has its own directory like arch/arm for ARM architecture [19], [22]. For building the kernel image and to build embedded system, use the following command

```
# make ARCH=arm CC=arm-linux-
```

After cross compiling the resulting kernel image is placed in arch/arm/boot directory and the last messages are depicted in the figure 8.

```
CHK include/linux/version.h
make[1]: `include/asm-arm/mach-types.h' is up to date.
CHK include/linux/utsrelease.h
SYMLINK include/asm -> include/asm-arm
CALL scripts/checksyscalls.sh
CHK include/linux/compile.h
Kernel: arch/arm/boot/Image is ready
Kernel: arch/arm/boot/zImage is ready
```

Fig. 8. Message showing zImage is ready

D. Flashing Kernel Image on to Processor Board

To flash this zImage into board using windows, students need a ARM USB Download Driver and DNW tool. Then PC is connected to the processor board using RS232 female to female cable and USB cable for transferring the image from the host system to target board. The processor board is configured in nor mode then power ON. The serial port configurations and its settings are shown in the DNW-titlebar when port is opened successfully (COM1, 115200bps). Open the DNW and the following messages can be viewed as shown in the figure 9.

```
DNW v0.50L - For WinCE [COM1][USB][ADDR:0x30000000]
Serial Port USB Port Configuration Help

***** FriendlyARM BIOS 2.0 for 2440 *****
[x] Format NAND FLASH for Linux
[v] Download vivi
[k] Download linux kernel
[y] Download root_gaffs image
[a] Absolute User Application
[n] Download Nboot for WinCE
[l] Download WinCE boot-logo
[w] Download WinCE HK.bin
[d] Download & Run
[z] Download zImage into RAM
[g] Boot linux from RAM
[F] Format the nand flash
[b] Boot the system
[s] Set the boot parameters
[u] Backup NAND Flash to HOST through USB(upload)
[r] Restore NAND Flash from HOST through USB
[q] Goto shell of vivi
Enter your selection:
```

Fig. 9. Nor mode of Friendly ARM mini2440

Press “k” to flash the kernel. Then students will get following messages.

“Enter your selection: k, USB host is connected.
Waiting a download.”

Select USB port-> Transmit and choose the file to send to the board.

Power off board and switch to nand mode then students will get boot messages on hyper terminal in windows. Reboot the processor board with the new kernel image. Booting of the kernel on ARM920T board is shown in the figure 10.

```
arm-HyperTerminal
File Edit View Call Transfer Help

=====
:=load Image of Linux..Uncompressing Linux.....
=====
..... done, booting the kernel.
Linux version 2.6.32.24JITLINUX (sindhujasindhuj-desktop) (gcc version 4.4.3 (
ctng-1.6.1) ) #1 PREEMPT Wed Apr 16 23:55:09 IST 2014
CPU: ARM920T (41129200) revision 0 (ARMv4T), cr=c0007177
CPU: VIVT data cache, VIVT instruction cache
Machine: FriendlyARM Mini2440 development board
ATAG_INITRD is deprecated; please update your bootloader.
Memory policy: ECC disabled, Data cache writeback
CPU S3C2440A (id 0x32440001)
S3C24XX Clocks, (c) 2004 Simtec Electronics
S3C244X: core 405.000 MHz, memory 101.250 MHz, peri
CLOCK: Slow mode (1.500 MHz), fast, MPLL on, UPLL ontime 5562 seconds)t
Built 1 zonelists in Zone order, mobility grouping on. Total pages: 16256rri Wi
Scr: negS3C2440
lib80211: comm line: nointrd root=/dev/mtdblock3 init=/linuxrc console=ttySAC0
tem halregistered for SPCP8x5
Try to bring e entries: 256 (order: -2, 1024 bytes)c2440-sdi: powered down.Parti
Dentry cache hash table entries: 8192 (order: 3, 32768 bytes)
System halted.cp8x5ectedrfac
SLUB: Genslabs=11, HwAlign=32, Order=0-3, MinObjects=0, CPUs=1, Nodes=1.....
Hierarchical RCU implementation.
NR_IRQS:85

Connected 0/01:15 ANS2W 115200 8-M-1 SCROLL CAPS NUM Capture Print echo
```

Fig. 10. Booting the Kernel on ARM920T Board

C. Outcome of Embedded System course

The outcome of the Embedded System course is a research paper presented in a National Conference on Communications Signal Processing and Systems- NCCSPS-2014 [22][23].

V. CONCLUSION

This paper describes an effective project-based teaching methodology developed at the Department of Electronics and Communication Engineering, Vidya Jyothi Institute of Technology, Hyderabad, India to teach a Embedded System course and Micro Processor and Micro Controller Courses. This methodology gives students to learn concepts and course contents actively. After this course with the project based learning methodology students are able to not only design a customized embedded system but also able to present their projects as a research paper at International/National Conferences or well reputed research journals globally.

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