Embedded System Education in Taiwan: Past and Future

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Outline

- VLSI Circuit and Systems/SoC Education Program in Taiwan (2000-2010)
- Intelligent Electronics Education Program in Taiwan (2011-2016)
- Embedded System Education Program (2003-2010)
- 4C Electronics (4C) Education Program (2011-2016)
VLSI Circuit and Systems/SoC Education Program in Taiwan (2000-2010)
Ministry of Education
National Program for Promoting Education in Advanced SoC Design

2006/1/1 ~ 2000/12/31

total budget : 1,033,012,000 NT$
Program objectives

1. To cultivate college students with advanced skills in SoC fields
   ● plan and develop advanced courses, lab modules
   ● organize short-term training workshop, summer schools, and teaching forum
   ● held various students competition to encourage

2. To improve students’ competence in international activities
   ● Encourage participation in various international forum and workshop
   ● Reward students who can enter the final list of international competition
   ● Support professors to publish textbooks in English

3. To develop the core capability in system integration
   ● Working with heterogeneous system integration, particularly aims to develop core capability across multiple disciplines
National Program for Promoting Education in Advanced SoC Design

MOE Advisory Office

SoC Office

SOC PAC

EDA PAC

P&L PAC

EDA Office/Consortium

P&L Office/Consortium

MSD PAC

S&IP PAC

MSD Office/Consortium

S&IP Office/Consortium

ESW PAC

ESW Office

ESW Course & Curriculum

Intl. Corp. Programs

Ind. & Aca. Forum

Std. Act. & Promotion

Partner Universities

Partner Universities
Execution Strategies

Ministry of Education
Area consortiums

- plan course roadmap
- execute promotion plan
- execute the international involvement
- Plan inter-discipline
- Organize competitions
- Evaluate and

Universities, Colleges

- Build course materials
- Develop lab modules
- Build demo lab
- Participate activities
- Develop special modules
- Organize students to enroll competitions
- Execute the course program

Industry
A centralized site for course materials

- So far, we collect 106 course materials and 35 lab modules
- Currently 710 users registered and 4,793 downloads

![Bar chart showing registered and downloaded counts from 2005 to 2010.]
Course promotion and deployment

- 2007: 25,449
- 2008: 25,085
- 2009: 33,819
- 2010: 34,155

Dept
Students
1. Each area consortium performed on-site reviews and visited totally 127 departments in all of the universities.
   - Each review not only evaluated the program results in terms of teaching quality, student learning, and final projects,
   - but also collected many interesting and valuable user experiences for those course roadmap.

2. Develop a across-field course—”Advanced Patent Search and Application” to attract more attentions in patent search and acquirements. The course attract more than 1800 students each year.

3. Develop—”Embedded System Product Design” to train students hands-on experiences by learning:
   - Create innovative ideas,
   - Develop product and real implementation
   - Prepare business plan for the promotion
Organize domestic competitions

- CAD competition
- Embedded System (ESW)
- IC design contest
Computer Aided Design in integrated circuit

1. A competition combining software and hardware knowledge
2. Question sets are announced 6 months before the contest
3. Competition is based two categories: open topics and given-questions. Fixed questions are given by domestic major companies in electronics design automation.
4. The winners are subsided to participate international conferences and design contests.
5. Taiwan students won『Internatioanl ACM SIGDA CADathlon at ICCAD design contests』1st place: twice, 2nd place: twice, and the 4th place
Student competition - CAD

Number of teams enrolled in 2005~2009

- Non-specific problem
- Marathon
- Specific problem
1. Supported by CIC (NSC chip implementation center)

2. Students have to go through a complete design flow from RTL design, logic synthesis, layout, and place&route.

3. Design contest is organized in one day from 8:30am until 20:30pm.

4. The contest includes 5~7 categories: college layout design, analog circuit design, full-custom IC design, cell-based IC design, and FPGA.

Total 1464 students participation
IC design competition
1. A system design contest emphasizes on software and hardware integration:
   • Embedded system software
   • Open-source design
   • Innovative embedded system
   • HW/SW integration

2. The contest is open to public for the whole day. Students exchange their experience and learn from others.

3. Several board platforms are provided by domestic companies and system industry.

<table>
<thead>
<tr>
<th></th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
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<tbody>
<tr>
<td>teams</td>
<td>98</td>
<td>127</td>
<td>201</td>
<td>213</td>
<td>283</td>
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Embedded system competition
Embedded system competition
## Domestic Academic Activities

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<tr>
<th>Activities</th>
<th># of</th>
<th># of participants</th>
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<tbody>
<tr>
<td>Local workshop</td>
<td>48</td>
<td>9,231</td>
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<td>Seed teacher training</td>
<td>29</td>
<td>1,541</td>
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<tr>
<td>Technical forum</td>
<td>146</td>
<td>5,294</td>
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<tr>
<td>Student training</td>
<td>23</td>
<td>1,809</td>
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<tr>
<td>Industrial forum</td>
<td>47</td>
<td>2,361</td>
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<tr>
<td>Course announcement</td>
<td>22</td>
<td>2,133</td>
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<tr>
<td>Area Consortium meetings</td>
<td>13</td>
<td>2,236</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>328</strong></td>
<td><strong>24,605</strong></td>
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</table>
## Contributions to International Conferences

<table>
<thead>
<tr>
<th></th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
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<tbody>
<tr>
<td>ICCAD</td>
<td>10</td>
<td>15</td>
<td>11</td>
<td>17</td>
<td>18</td>
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<tr>
<td>DAC</td>
<td>8</td>
<td>12</td>
<td>12</td>
<td>15</td>
<td>15</td>
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<tr>
<td>ITC</td>
<td>5</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>2</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>23</strong></td>
<td><strong>29</strong></td>
<td><strong>26</strong></td>
<td><strong>35</strong></td>
<td><strong>35</strong></td>
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</table>
## PCB design and service

<table>
<thead>
<tr>
<th>Service promotion workshop</th>
<th>High speed PCB workshop</th>
<th>Training the trainer</th>
<th>workshop</th>
<th>proposal</th>
<th>PCB board</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>18</td>
<td>138</td>
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</table>
Summary

• National-wide teaching quality in IC and SoC design is significantly improved. More students are attracted to join this area.

• More advanced designs are carried out and more papers are accepted in prestigious conferences.

• More collaborations are enabled among academic universities, research institutes, and the industry.

• Attract many international visits to learn the successful story
Intelligent Electronics Education Program in Taiwan (2011-2016)

2011/4/1 ~ 2016/12/31

total budget : 1,000,000,000 NT$
National Program of Intelligent Electronics

High value-added Solutions for MG+4C

Medical  Green  Car  3C

Intelligent Electronics Education Program

MOE  MOEA  NSC  MOH

Advanced Industry technology
Intelligent Electronics Education Program

Cultivate advanced capability in system integration

Encourage multi-discipline (course, lab modules, intern etc)

Consolidate in-depth skills

Develop advanced courses

More international involvement

Increase international visibility

Student training

Innovative System design

Advanced courses (3D IC、…, )

Core courses

Basic courses

Teacher capability

International activities

VLSI/SoC projects/plan

K12 students and teacher
Program Organization

- MOE Advisory Office
- NIEP Education Program Office/ATP
- Advanced Education Platform Center
- 4C
- Medical
- Green
- Application Design
- Universities
- Application specific education labs
Embedded System Education Program
(2004-2010)
Previous SoC and Embedded System Education Promotion Program (2004-2010)

■ Embedded System Consortium

– The last (but not least) consortium founded by the MOE under the VLSI/SoC CSE Program

– Address the challenges of embedded software development for SoC systems

– Chairs of Embedded System Consortium
  • Prof. Youn-Long Steve Lin, 2004-2006
  • Prof. Chung-Ta King, 2006-2008
  • Prof. Jenq-Kuen Lee, 2008-2010
MOE/VLSI Program/ESW Consortium

- MOE Advisory Office
  - SoC Office
    - EDA Office/Consortium
      - EDA PAC
    - P&L Office/Consortium
      - P&L PAC
  - MSD Office/Consortium
    - MSD PAC
  - S&IP Office/Consortium
    - S&IP PAC

- SOE PAC
- ESW PAC

- ESW Office
  - ESW Course & Curriculum
  - Intl. Corp. Programs
  - ESW Forum
    - Ind. & Aca. Forum
    - Std. Act. & Promotion

- Partner Universities
ESW Consortium Activities

- Technical forum
  - 9 workshops/1328 attendees/2006-2010
- Training the trainer workshop
  - 18 workshops/1142 profs/TAs/2006-2010
- Summer camp
  - 100 undergraduates/2008, 2010
- International forum
  - 8 workshops/1158 attendees/2006-2010
- Industrial forum
  - 12 workshops/838 attendees/2006-2010
ESW Consortium Activities

- ESW Curriculum
- Develop reference ESW curricula for universities
  - Develop or enhance courseware including Labs for ESW courses
  - Promote ESW curricula for CS/EE depts
Curricula from ACM, IEEE-CS, other universities

Embedded software curricula

New course or course module

Seek for project leaders

Team up course development team

Course development

Course trial run

Development strategies
Deployment strategies

Development phase

Embedded software curricula CFP

Proposal and budget review

Project grant and curricula deployment

Progress review and On-site visit

Regular course promotion workshop

ESW office

Review boards and MOE

Deployment strategies
Embedded software curricula

- Universities
  - train students with research, design and development abilities

- Technical universities
  - offer trainings to students with technical skills and implementation abilities
Embedded Hardware/SoC
- Digital Logic Design
- Electronic and Electric Circuit
- Computer Architecture
- Microcontroller System Labs

Embedded Software
- System Software and Assembly Language
- Introduction to Programming
- Introduction to OS

Technical universities

Fundamental
- Computer Architecture
- Electronic and Electric Circuit
- Digital Logic Design
- System Software and Assembly Language

Intermediate
- Embedded System Labs
- Introduction to Embedded Systems
- Embedded Software Programming
- Interface Design

Advanced
- Device Drivers for Embedded Systems
- Implementation of USB Devices/Drivers
- Existing Courses
- Newly Developed

Existing Courses

Newly Developed
Results and experiences

■ 17 courses/8 modules/2684 students enrolled

■ Course development projects
  – about total USD 50,000-100,000 for the course development
  – total USD 15,000 per year for maintenance

■ 71 professors from more than 26 universities involve the course development
  – 40% professors are from EE and related departments
  – 60% professors are from the CS department
Results and experiences

■ Each course development project
  – 200-500 slides/notes
  – Some projects published textbooks
  – 4-15 hands-on labs/TA-notes

■ Number of courseware download
  – 2371 download (2007-2010)
Results and experiences (Cont.)

- Curricula promotion workshops every year
  - More than 800 attendees including professors, students, and engineers from industries

- Received >200 proposals and approved >140 proposals from 2005-2010
  - About USD 10,000 to 100,000 is funded for the first year
Results and experiences (Cont.)

- ESW education infrastructures have been established in more than 30 universities
  - > 2000 students enrolled these courses under the ESW curricula deployment program
Results and experiences (Cont.)

- Challenges and issues
  - the common education platform
    - to develop different sets of hands-on labs over various platforms
    - require all hands-on labs to be developed over one or two common hardware platforms
  - the development of hands-on labs
    - TA notes, reference source codes or reports, and knowledge and experiences learned from the labs are extremely important
Results and experiences (Cont.)

- Establish a database for hands-on labs
  - Lab road map
  - >100 labs
  - peer review
# Embedded System Design Contest

<table>
<thead>
<tr>
<th>Year</th>
<th>Students</th>
<th>Team</th>
<th>Awarded students</th>
<th>Awarded team</th>
</tr>
</thead>
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<tr>
<td>2006</td>
<td>159</td>
<td>53</td>
<td>45</td>
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<tr>
<td>2007</td>
<td>127</td>
<td>59</td>
<td>45</td>
<td>16</td>
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<tr>
<td>2008</td>
<td>527</td>
<td>143</td>
<td>67</td>
<td>25</td>
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<tr>
<td>2009</td>
<td>508</td>
<td>221</td>
<td>95</td>
<td>35</td>
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<tr>
<td>2010</td>
<td>562</td>
<td>216</td>
<td>90</td>
<td>33</td>
</tr>
<tr>
<td>Total</td>
<td>1883</td>
<td>692</td>
<td>342</td>
<td>124</td>
</tr>
</tbody>
</table>

Students: 159 + 127 + 527 + 508 + 562 = 1883

Team: 53 + 59 + 143 + 221 + 216 = 692

Awarded students: 45 + 45 + 67 + 95 + 90 = 342

Awarded team: 15 + 16 + 25 + 35 + 33 = 124
Microsoft Imagine Cup 2010, 2011 Embedded System Champions

Microsoft Reveals Imagine Cup 2011 Winners, Unveils $3 Million Grant Program

NEW YORK — July 13, 2011 — Microsoft Corp. today announced the winners of the ninth annual Microsoft Imagine Cup, the world’s premier student technology competition, honoring student innovations that address global problems such as improving road and fire safety, eradicating poverty, and creating a more sustainable environment. The company also unveiled plans to launch a three-year, $3 million competitive grant program to help recipients realize their vision of solving the world’s toughest problems.

“The innovators, entrepreneurs and humanitarians who compete in the Imagine Cup have developed an inspiring spectrum of projects, raising the bar higher and higher each year,” said S. Somasegar, senior vice president, Developer Division, Microsoft. “We are in awe of the students’ solutions for addressing social and real-world challenges, and want to help them take their projects to the next level with the financial, technical and business support they need to change the world.”

Imagine Cup 2011 Award Highlights

Image 4 of 8

NTHUCS

Taiwan’s Team NTHUCS sets up their display booth at the Imagine Cup 2011 Worldwide Finals. The team won the Embedded Development contest with project RIGHTIE This Way, which computes the safest fire escape routes in real time as detected by a wireless sensor network.

Web-Ready
Print-Ready
Key working items in new education program

- A common teaching platform
- Construct a complete Lab database
- Need top-down (system-view) curriculum design
4C Electronics (4C) Education Program (2011-2016)
Basics of 4C Electronics (4C) Education Consortium

- Sponsored by Ministry of Education
- Chair of 4C electronics
  - Prof. Tien-Fu Chen
- Project period from 2011 to 2016
  - 1st stage 2011 to 2014
- Budget
  - Curriculum/education key lab development: USD 500,000/year
  - Curriculum/education key lab promotion: > USD 1,000,000/year
- >15 universities/30 profs. involved
Objectives

- Promote 4C Electronics (4C) education in Taiwan
- Top-down: train EE/CS talents with system-level design views
- Bottom-up: identify key technologies/IPs in future 4C IC/IT products
Approaches

- Develop and promote curriculum and lab in 4C key areas
  - Interdisciplinary/System/applications/common education platform

Key areas

- Innovative Interdisciplinary System design
- Key technologies/IPs
- Hands-on projects/key labs
- Interdisciplinary course
- IC core courseware
- Key areas
Approaches

- Identify 5 important 4C key areas (application specific, top-down system view)
- Propose curriculum for each key area (based on what we have developed during past 10 years)
- Design an interdisciplinary course for each key area
- Design a common education platform for each key area (can be used in all courses in each key area)
- Design an application-specific hands-on course for each key area
- Help university to establish the education lab in key area
Curriculum and labs

Hands-on projects/key labs
- Lab for Telematics
- Lab for 3D multimedia
- Lab for cloud SoC
- Lab for IoT SoC
- Lab for cognitive radio

Interdisciplinary course
- Intro. to Telematics
- Introduction to Cyber Physical System

IC core courseware
- Embedded Toolchain, I/O device driver, Embedded system design, VLSI, HW/SW co-design, Introduction to SoC, SoC lab, Programmable HW design, Intro. digital signal processing, Embedded compiler, multimedia SoC, ...

Key areas
- Telematics
- 3D multimedia
- SoC/Electronics for cloud
- SoC/Electronics for IoT
- Cognitive Radio
Platform and hands-on lab

- Reproducible, maintainable, common education platform for each key area
- Develop hands-on labs for each key area and its database
  - Lab notes
  - Hardware/software packages
  - TA notes
  - References
  - Student reports
  - Discussion forum
Common platform for Telematics

- Panda board

**CPU**
- OMAP4430 application processor:
  - Dual-core ARM® Cortex™-A9 MPCore™ with Symmetric Multiprocessing (SMP) at 1 GHz each. Allows for 150% performance increase over previous ARM Cortex-A8 cores.
  - Full HD (1080p) multi-standard video encode/decode
  - Imagination Technologies’ POWERVR™ SGX540 graphics core supporting all major APIs including OpenGL® ES v2.0, OpenGL ES v1.1, OpenVG v1.1 and EGL v1.3, delivering 2x sustained performance compared to the previous SGX530 core

**Memory**
- 1 GB low power DDR2 RAM
- Full size SD/MMC card cage with support for High-Speed & High-Capacity SD cards

**Connectivity**
- Onboard 10/100 Ethernet

**Expansion**
- 1x USB 2.0 High-Speed On-the-go port
- 2x USB 2.0 High-Speed host ports
- General purpose expansion header (I2C, GPMC, USB, MMC, DSS, EFM)
- Camera expansion header

**Dimensions**
- Height: 4.5" (114.3 mm)
- Width: 4.0" (101.6 mm)
- Weight: 2.6 oz (74 grams)

**Display**
- HDMI v1.3 Connector (Type A) to drive HD displays
- DVI-D Connector (can drive a 2nd display, simultaneous display; requires HDMI to DVI-D adapter)
- LCD expansion header

**Audio**
- 3.5" Audio in/out
- HDMI Audio out

**Debug**
- JTAG
- UART/RS-232
- 2 status LEDs (configurable)
- 1 GPIO Button

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OMAP4430 Processor

- Highlights:
  - 1GHz Dual-Core ARM Cortex-A9 MPCore
  - 1080p Video
  - 3D Graphics Accelerator
  - Memory: 1GB Low Power DDR2 RAM

Status LEDs

SD/MMC Card Slot

Serial/RS-232

Camera Connector

USB 2.0 OTG

Audio in/out

Power Supply 5V

Power/Reset Buttons

10/100 Ethernet & 2x USB 2.0 Host ports

WLAN/Bluetooth

Expansion Connector

DVI Out

HDMI Out (Type A)

LCD Expansion

ITAG
Common platform and lab for Telematics

- **Hardware platform**
  - 多鏡頭視訊擷取裝置 (USB Camera)
  - 中控運算平台 (OMAP4430 on PandaBoard)
  - 儲存裝置 (SD Card)
  - 中控顯示裝置 (LCD Monitor)
Common platform and lab for Telematics
Common platform and lab for cognitive radio

Avnet TI OMAP/Spartan-6 FPGA
Common platform and lab for cognitive radio

RF front end (by local vendor):
Summary

- VLSI Circuit and Systems/SoC Education Program in Taiwan (2000-2010)
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Thanks for your attention