Course Management in Capstone Courses

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Example Couse: DSP Design Laboratory

- DSP LAB is intended to provide a major design experience in digital signal processing involving the use and application of the current state-of-the-art DSP processors
- Capstone course in EECS, UMich.
- One of the two design oriented courses in EECS, UMich
- Weekly lecture (3hrs) plus structured labs
- No textbooks, only lecture slides + 94 documents from TI
- 4 students working together in design project using TI DSP
- Course ported to NTUEE in 2005
- Course plan reformed to enhance student project performance in 2006

What is DSP Design Lab about?

- Lectures: Introduces DSP processors: architecture and software
  - Assumes MATLAB and C background
  - Introduces DSP topics:
    - DSP processor architecture
    - Digital waveform generation
    - FIR and IIR filter implementation
    - Real-time computing
    - Continuous time processing using the DFT
    - Oversampling
    - Delta/sigma A/D and D/A converters
  - Introduce project planning and management
- Labs: Illustrate DSP concepts developed in lecture
  - Give practice with the hardware and software
  - Establish a starting point for projects
  - Lab code frequently serves as starting point for projects
- Projects: Student selected and implemented

Class Schedule

- Tentative class schedule (subject to change):

第1週	9/15	Lecture 01: Introduction.
第2週	9/22	中秋慶團圓
第3週	9/29	Lecture 02: Resource from TI, brief introduction to CPU, TI C6000 architecture, lab exercise 1 (Intro).
第4週	10/6	Lecture 03: Brief DSP overview, lab exercise 2 (LED).
第5週	10/13	Lecture 04: FFT, direct digital synthesis, lab exercise 3 (DDS).
第6週	10/20	Lecture 05: Dithering, McBSP & AIC23 codec, lab exercise 4 (AIC23).
第7週	10/27	Lecture 06: DM6437 intro., DSP fundamentals, filter basics, filter design (FIR), FIR implementation/circular buffer, lab exercise 5 (Multimedia processing).
第8週	11/3	Lecture 07: Continue on DSP fundamentals and FIR filtering, form project team, lab exercise 6 (FIR).
第9週	11/10	Lecture 08: Project planning/management.
第10週	11/17	Lecture 09: Introduction to DSP/BIOS,lab exercise 7 (DSPBIOS).
第11週	11/24	Lecture 10: Fixed point computing.
第12週	12/1	Lecture 11: IIR filtering part 1.
第13週	12/8	Lecture 12: IIR filtering part 2, lab exercise 8 (IIR).
第14週	12/15	Lecture 13: Oversampling, sigma-delta ADC.
第15週	12/22	Midterm exam.
第16週	12/29	Lecture 14: Intermediate project presentations.
第17週	1/5	Switched to Jan. 19 for project presentation/demo
第18週	1/12	期末考停課
第19週	1/19	Final project presentation & demo (project report due on Jan. 23)

Design Projects

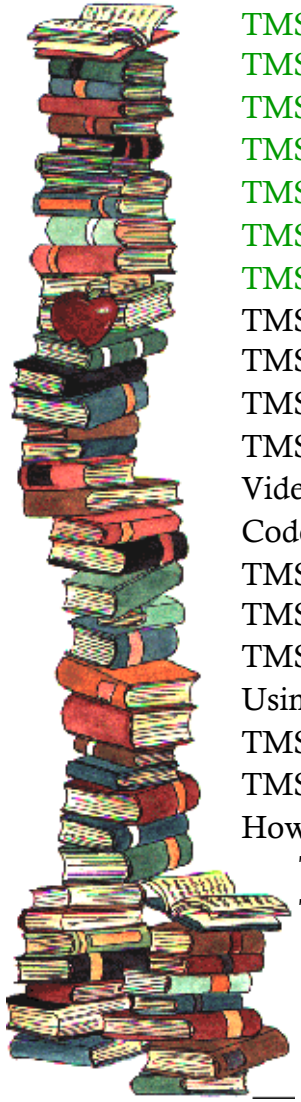
- Student defined and executed.
- Targeted to eventually become a commercial product.
- Projects are often a “proof-of-concept” or an “enabling” technology.
- Project management skills are taught to ensure good project outcome

Previous Students' Projects

- EMG-Based Boxing Game
- Pitch Corrector
- Music-to-note converter
- Voice Activated Dog Gate
- Voice Tracking System
- Software FM Radio Receiver
- EMG-Based Guitar
- EMG-Based Car
- Noise Cancellation
- Voice Controlled Hospital Bed
- OFDM Modem
- Acoustic QAM Modem.
- Midi Guitar.
- Music tuner.
- Heart Monitor.
- CCD Camera Based Motion Detector
- Virtual mouse.
- …

Design Platform: TMS320C6416T DSK

TI's Core C6xxx/C6416T Documentations



TMS320C6416TDSK Technical Reference (56 pages)
TMS320C64x Technical Overview (57 pages)
TMS320C6414T/TMS320C6415T/TMS320C6416T Fixed-Point Digital Signal Processors Datasheet (142 pages)
TMS320C64x/C64x+ DSP CPU and Instruction Set Reference Guide (835 pages)
TMS320C6000 Programmer's Guide (440 pages)
TMS320C6000 Optimizing C Compiler Tutorial (71 pages)
TMS320C6000 Assembly Language Tools User's Guide (416 pages)
TMS320C64x DSP Library Programmer's Reference (150 pages)
TMS320C6x Peripheral Support Library Programmer's Reference (223 pages)
TMS320C6000 Chip Support Library API Reference Guide (1108 pages)
TMS320C64x+ Image/Video Processing Library Programmer's Reference (136 pages)
Video Encoding Optimization on TMS320DM64x/C64x (15 pages)
Code Composer Studio Tutorials and Help Files
TMS320C6000 DSP Peripherals Overview Reference Guide (11 pages)
TMS320C6000 DSP Multichannel Buffered Serial Port (McBSP) Reference Guide (104 pages)
TMS320C6000 DSP Enhanced Direct Memory Access (EDMA) Controller Reference Guide (269 pages)
Using TMS320C6416 Coprocessors (Viterbi Coprocessor (VCP) (25 pages)
TMS320C64x DSP Turbo-Decoder Coprocessor (TCP) Reference Guide (85 pages)
TMS320C64x DSP Viterbi-Decoder Coprocessor (VCP) Reference Guide (57 pages)
How to Get Started With the DSP/BIOS Kernel (21 pages)
TMS320 DSP/BIOS User's Guide (292 pages)
TMS320C6000 DSP/BIOS 5.30 Application Programming Interface (API) Ref Guide (583 pages)

Obviously neither you nor the instructor nor the TAs are going to be able read and assimilate all this material in the time available. We will have to pick our battles, learn what is needed for the battle at hand and leave the rest for some other time.

What is the Point of Taking the Course?

Imagine…

When students graduated with
his/her MS degree…

Sky looks so bright…
Cloud seems so white…
Even your advisor looks so nice…

Think of all the stock you will get…
All the money you can make…

Life looks so beautiful…
What more can you ask for…
You feel like King/Queen of the world…

Our Purpose

- After graduation, there is no advisor around. Do students really have the confidence to face the challenge of unknown?
- How can we help them build the confidence? Try to get similar experience before leaving school
- The point of this course is to emulate the real challenges they will be facing after entering the real world
- Through this course, we want students to build the ability of learning and solving problems on their own
- The large scale design project (4 people) also give them a chance to learn how to work with the others, how to communicate with the others, and how to manage the project

Student feedbacks

- 雖然作業很多，但是我真的是有學到東西，讓我有充實的感覺，是我上過數一數二的課程，大觀念及小細節都會有提到，值得推薦的好課。
- 學期中作業份量似乎以研究生而言有點重，但是收穫良多，實驗部分可以動手操作，可以得到實際上的實務經驗。很棒的一堂課，但是也許期末專題嚇跑不少有興趣的學生選修...
- 內容豐富，學到很多數學基礎...
- 這門課是一門充實且有用的課程，希望老師之後可以繼續開授這類課程。整體來說，覺得收穫良多...
- 一整個學期下來修這門課，我能深深體會老師的貼心和巧思，總是有辦法讓我在上課時保持良好的狀況。循序漸進的課程和作業頁編排都很人性化，不會難到寫不出來可是卻要花一些時間聚思考。重點是時間花下去你真的會學到很多東西。這門課我給五顆星！水啦～
- 雖然是大學部的學生去修這門課，我仍覺得這是一個很好的訓練機會。雖然常常面臨作業交不出來的窘境，但堅持下來之後，才發覺收穫匪淺。我知道，以後的研究必將是像這種只有一堆 material 但卻無任何明顯的 link 可以發現，雖是為此吃了不少苦頭；但相對的，無形中增強了我面對這種境界的信心，也把我的心臟越磨越大顆...。十分感謝教授和助教學長的提策，同時也鼓勵像我這樣是大學部的學弟妹們，越早接受這種訓練絕對是有利而無害，但也請你們審慎評估修課的 loading...

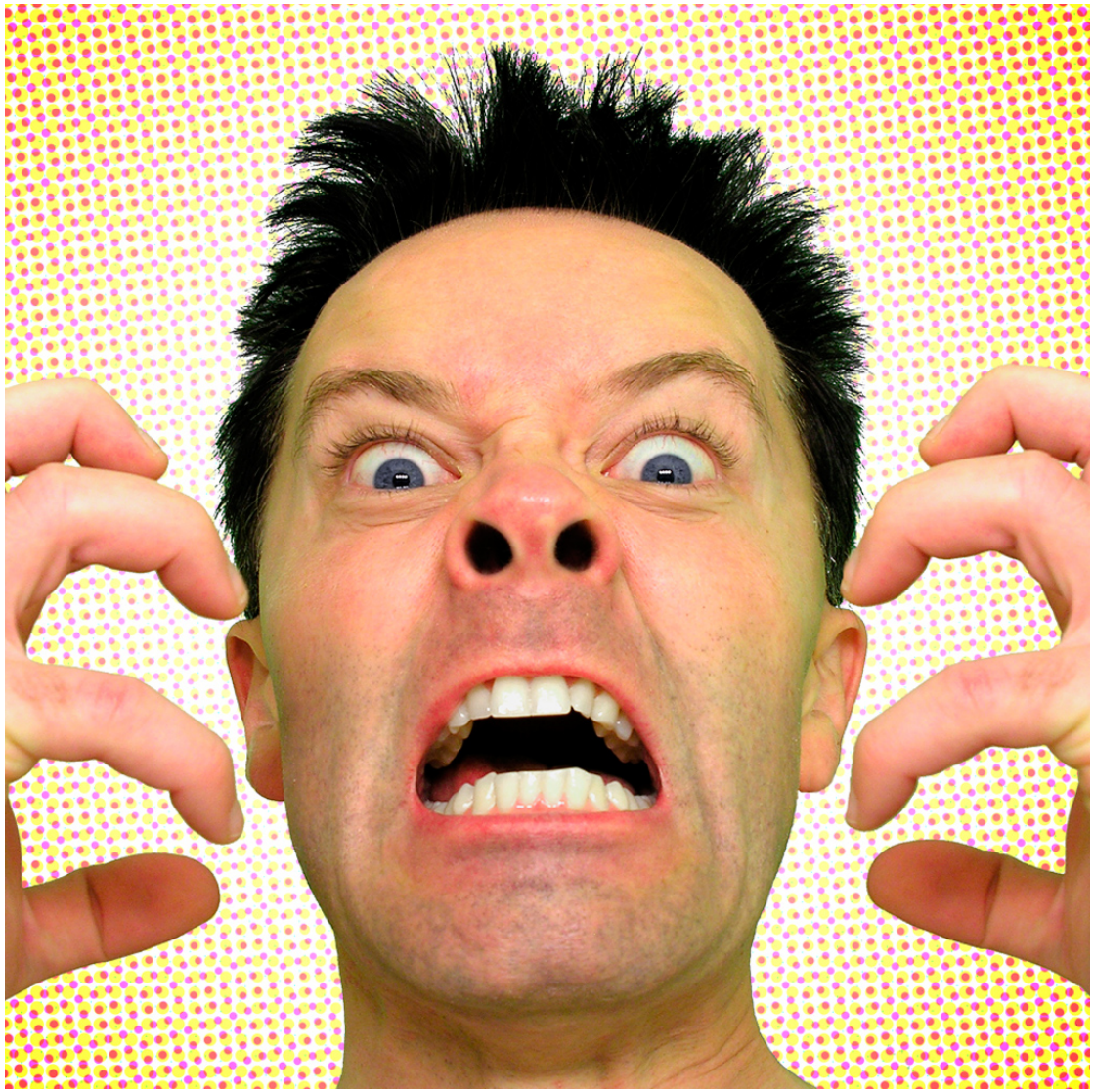
About the Design Projects

Project-based Course Design

- Why is it getting more popular?
- What are the benefits?
- Does it really work that well?
- What are the typical issues for the student projects?

Typical Project Issues

Typical Project Issues



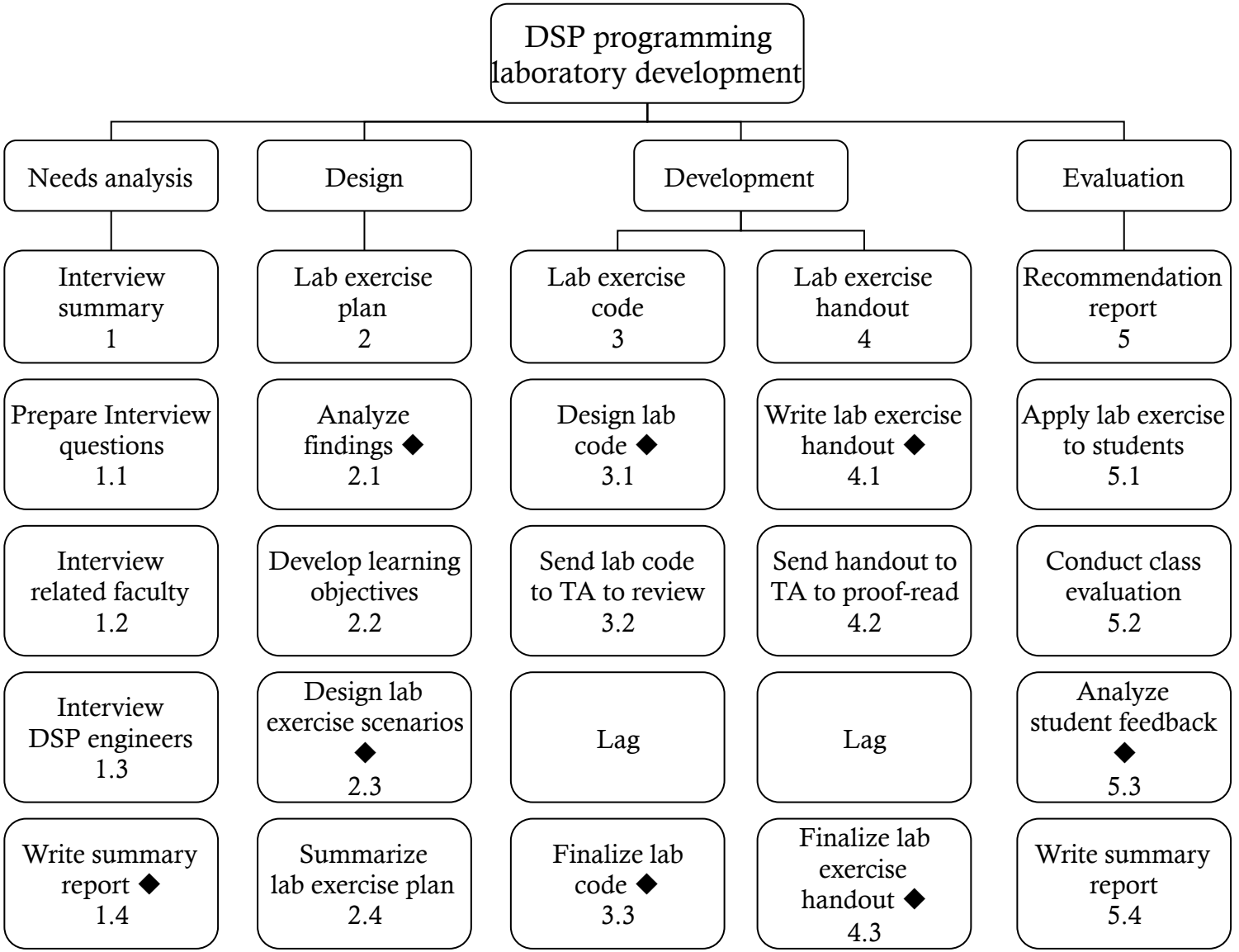
How to make student project work better?

- How do students usually form their teams?
- How should we help students form project teams?
- How are the project schedules actually handled in companies?
- Work Breakdown Structure (WBS)

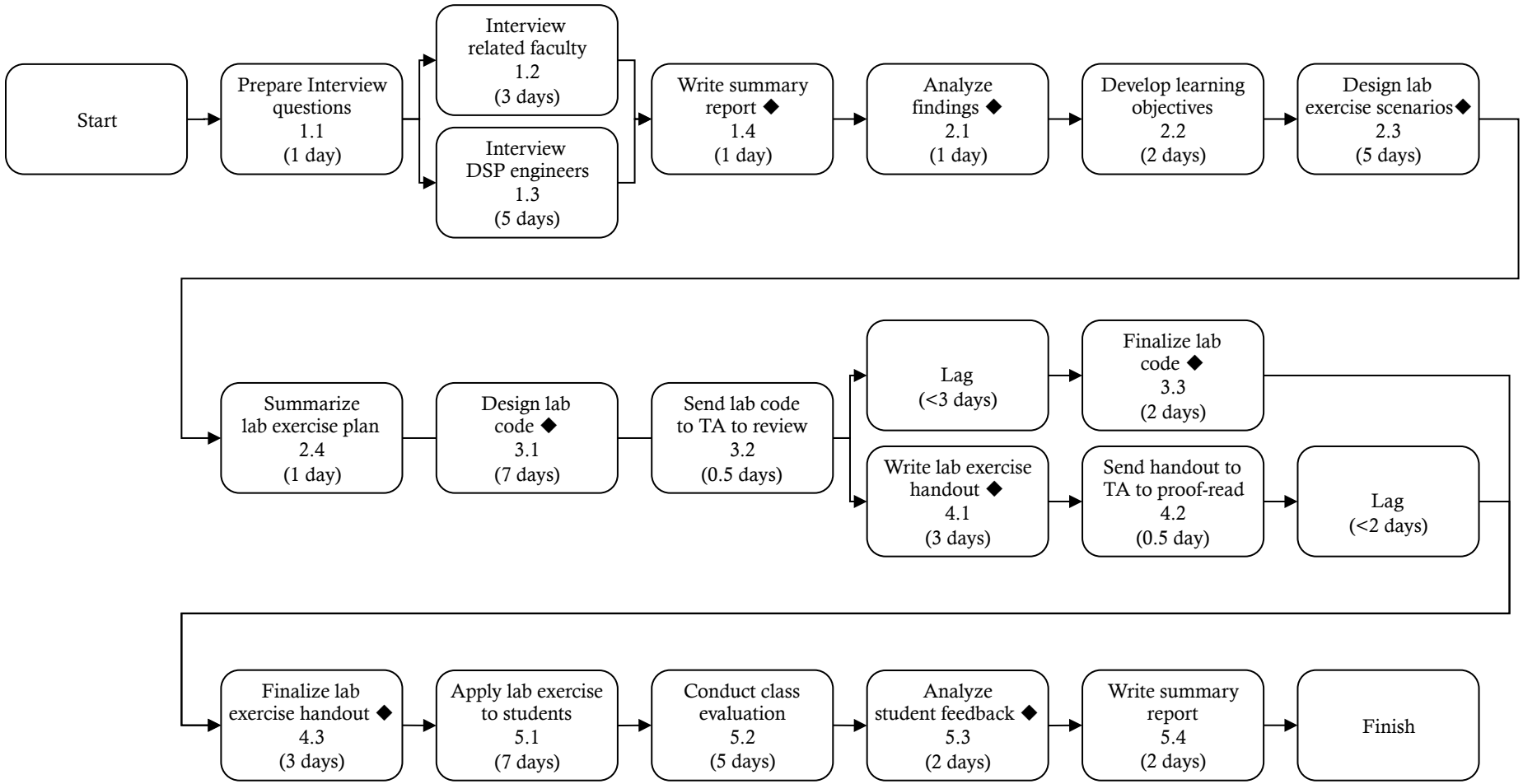
Learn to Manage the Projects

- Students tend to work on the project at the last 2 weeks of the semester. The result is usually unsatisfactory.
- We want students to manage project in a professional manner.
- We will introduce the project management method used by the professionals in IT/Business nowadays.
- Students will learn to use WBS (work breakdown structure) to form a detailed project plan by breaking it down to phases, deliverables, and tasks.
- Students will learn to use project management software to organize and track the status of your project.

WBS Example: Develop a DSP Lab. Course



From WBS to Task Network



Estimated time < 1+max{3, 5}+1+1+2+5+1+7+0.5+max{3+2, 3+0.5+2}+3+7+5+2+2 = 48 days

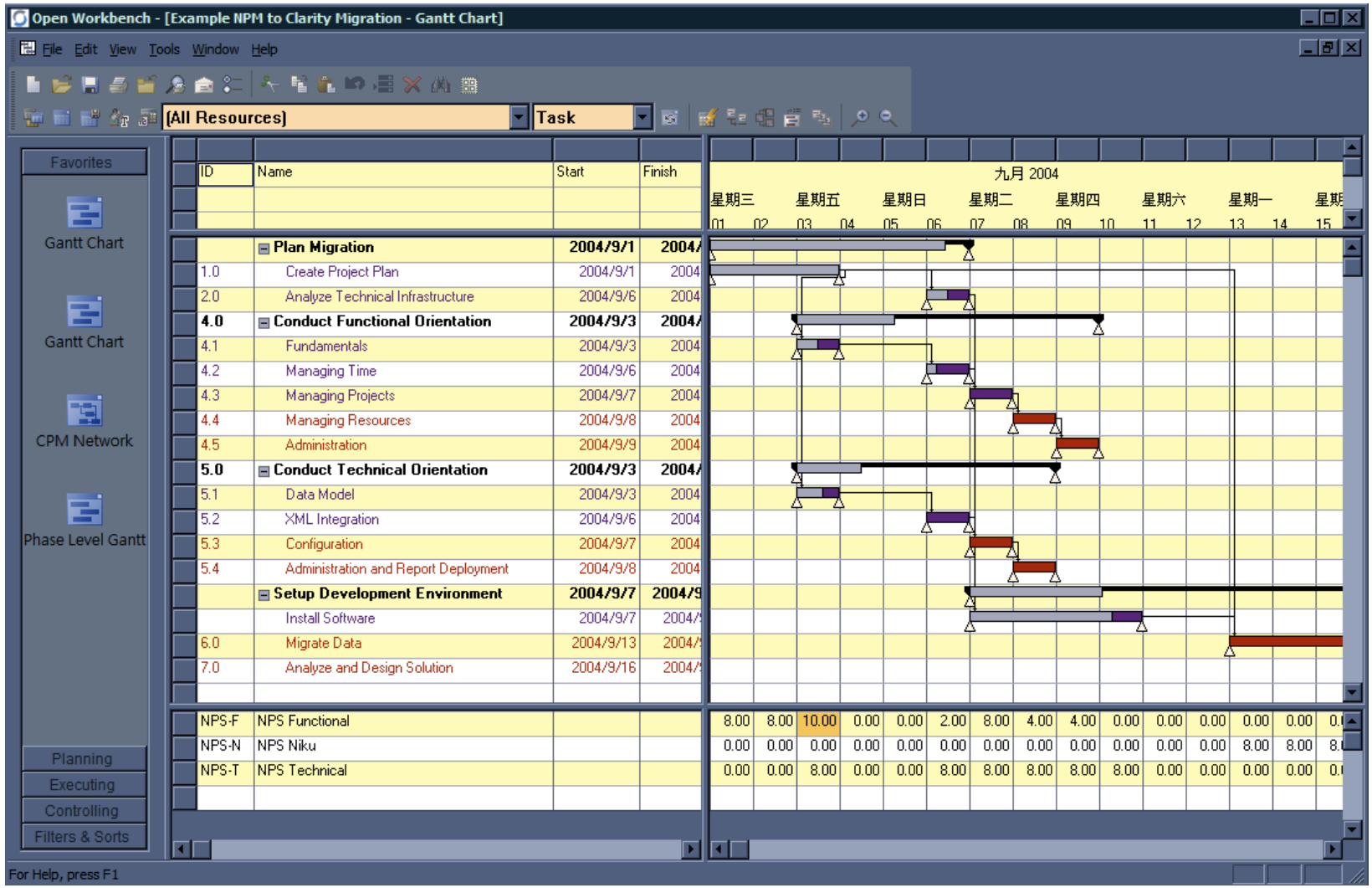
What do we usually do in our course?

- We have modified the WBS to fit the students' behaviors
- We ask each student to submit his/her project ideas
- We send the all ideas to all students for review
- We host an in-class meeting to form project teams out of common goals instead of friendship
- We give an 1.5-hour lecture about WBS and project management
- We then use 1 hour for the students to actually practice WBS technique
- We ask students to use project management software throughout the term
- We ask students to set their holidays in advance and try to reach agreement if there are significant differences among team members.
- We ask them to update their project status each week and show it to the whole class at the beginning of each lecture
- We make sure students revise their project plan to make it on schedule at all time

Software for Project Planning/Management

- Microsoft project --> free for two months.
- Open Workbench --> free at http://www.openworkbench.org/
- The time unit used in Open Workbench is in hours. To change it to days, make change in the resource property to set the availability of each resource to 1.0 (1 hr per day). (Note: resource = labor)
- In the resource property, change the weekends to workdays. Also mark the study days needed for midterm exam, final exam and the days needed for your research, GF birthday(s) in the calendar as holidays. (IMPORTANT!)
- Every project should keep track of the project status each week and present the updated Gantt chart in the class at the beginning of each lecture starting from next week.

Open Workbench Project Examples



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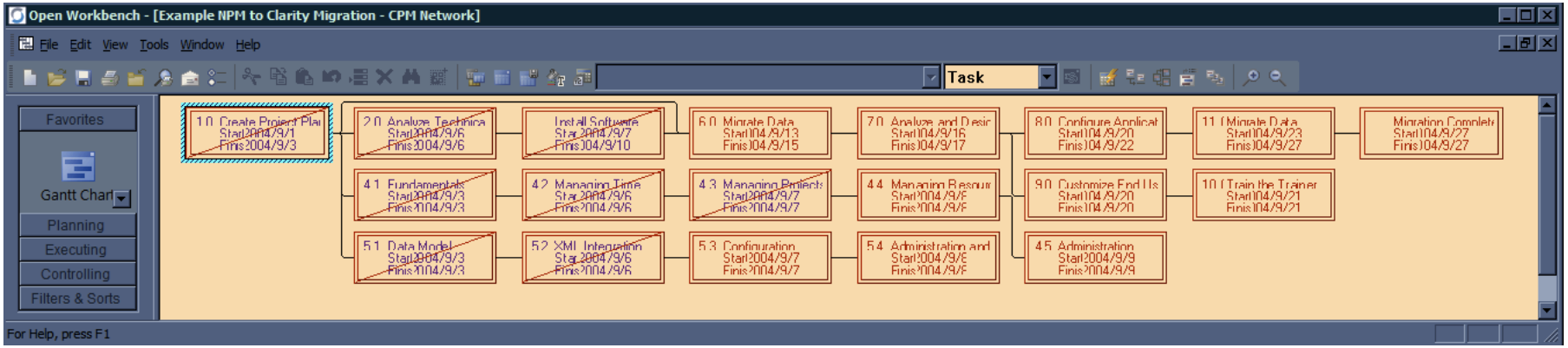

What are the benefits?

- Students tend to start planning their projects soon
- Student projects tend to reach much higher level of completion
- Student tend to have much more fun in doing their projects

Conclusions

- It is our pioneer work to combine project planning/management with project-based courses
- We are currently poring our approach to other NTUEE Lab. courses
- Our approach makes term project an enjoyable experience for most students
- Students get to learn how to plan/manage their projects, and how to work well with the team members that they do not know well
- Our effort is acknowledged by experts in system engineering as well as industry. A journal paper is currently in preparation for submission to IEEE Transaction in Education