Best Practices and Trends in Computer Science and Engineering Education

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Sarkar ICCIT 2012
My Research Interests

1. Computer Networking …

2. Network Education
   >> Developing tools to enhance methods for teaching and learning computer networking and hardware fundamentals.
Networking Research @AUT

Network Protocols

Routing and Transport Protocols

Radio Propagation

Cross-layer Optimization

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Outline of Talk

CSE Education:

➢ Examples of the best teaching practices
  o Computer Networking
  o Hardware Fundamentals

  o Trends

  o Discussion Questions

  o Summary and Conclusion
Motivation for CSE Education

1. “Professors are fully committed to teaching, research and public services” (CSE BUET)

2. A university teacher says
   “Teaching is our job, Research is our profession”

3. Best teaching practices
   “Research feed into Teaching”
Teaching and Learning
Computer Networking and Hardware Fundamentals
CSE Education - Useful Resources

- IEEE Transactions on Education
- Australasian Association for Engineering Education
- The American Society for Engineering Education
- Int. Journal of Electrical Engineering Education
- Journal of Engineering Education
- Trends in Engineering Education - An International Perspective by Kulacki and Krueger

Our students ...

Diverse student community

1. On-campus student (part-time/full time)
2. Off-campus student (distance education)
3. Home learners
4. Learners seeking continuing education
How do we teach CSE courses?

Teach → Activity → Teach

- Quizzes
- In-class task/Exercises
- Demonstration
- Discussion
- Answering question
- Role play
- Student mini presentation

Up to 20 min.
Teaching Advanced Network Technologies undergraduate course

- Third year (Level 7) paper
- **Topics:** Gigabit Ethernet, ATM, Frame Relay, MPLS, SONET, WDM networks, Cisco VoIP, QoS in IP networks, wireless QoS implementation.
- **Mode of delivery**
  - Lectures
  - Site visits
  - Tutorials/laboratories
  - Network modelling
  - AUTOnline (based on Blackboard)
Recent Field Trip (1)

Tonkin & Taylor Ltd.
Recent Field Trip (2)

IT Manager and students in the Server room
Recent Field Trip (3)

IPStar NZ Ltd.
Why Field Trips?

• Liking theory and practices
• “A link between theory and real-world practices is very important” – says IT Manager of IPStar NZ. Ltd.
• Students have indicated that they had learned a lot about Networking/Broadband technologies through the field trips.
• Student’s Reflection
  “Overall I feel I learned some new pieces of information regarding radio frequency and satellite which helped me to mentally piece together how exactly internet is provided nationwide. After hearing from IP-STAR’s technician I feel I better understand the pro’s and con’s of satellite internet”
Examples of Teaching Practices

• Example 1: Introductory networking using WebLan-Designer

• Example 2: Server-based networking using customized network

• Example 3: Wireless communications using Wi-Fi Projects

• Example 4: Hardware fundamentals using PIC-based projects
Example 1: Teaching Networking using WebLan-Designer

Why WebLan-Designer?

- Wanted to provide an interactive and flexible learning experience in computer networking at introductory level.

WebLan-Designer Architecture
WebLan-Designer - Components

WebLan-Designer

- Wired LAN
  - Tutorial
  - Interactive Quiz
  - Modelling
  - Key Terms
  - Scenario-based design
  - Review questions and answers
  - Useful links
  - Feedback

- Wireless LAN
  - Tutorial
  - Interactive Quiz
  - Modelling
  - Key Terms
  - Scenario-based design
  - Review questions and answers

User

Web interface
Topology and access protocols

- **Topology**
  - Wired LAN:
    - Physical bus logical bus
    - Physical star logical bus
    - Physical ring logical ring
    - Physical star logical ring
  - Wireless LAN:
    - Ad Hoc Network
    - Infrastructure network

- **Access method**
  - Wired LAN:
    - CSMA/CD
    - Token passing
  - Wireless LAN:
    - CSMA/CA
WebLan-Designer – Home page

http://weblandesigner.elena.aut.ac.nz/

WebLan-Designer

"An Interactive system for Teaching and Learning both wired and wireless LAN design"

Test your knowledge through interactive quizzes, learn about networking protocols and devices, model wired and wireless LAN, and have fun.

What does an Ethernet switch do? What is ring topology, and what is a backbone network? How to put together a network of 5 computers and a printer? The WebLan-Designer will assist you in finding the answers to these questions, and learn more about networking fundamentals.

Faculty members: Nurul I. Sarkar (Project Leader) and Krassie Petrova
Developers: Jeff Chiang, Geoff Lee and Trung Ly

The project was funded by the Auckland University of Technology through a contestable FEELTS grant. The School of Computer and Information Sciences hosts the WebLan-Designer at http://elena.aut.ac.nz/homespages/weblandesigner/

Date of last update: September 20, 2011.
Interactive quiz

Wired LAN Quiz

Which of the following statements about a LAN is TRUE?

- A. A computer network which covers a relatively small geographic area (eg. within a room or a building)
- B. A computer network which covers a relatively large geographic area
- C. A computer network which does not cover any geographic area
- D. None of the above

A network consists of the following basic components:

- A. Repeaters, hubs, cabling, modems, application software
- B. Fibre optic cabling, hubs, workstations, multistation access unit
- C. Network operating system, cabling, network cards, workstations
- D. All of the above

Which of the following statements about the bandwidth of a channel is TRUE?

- A. The greater the bandwidth, the higher the data rate
- B. The greater the bandwidth, the lower the data rate
- C. The lower the bandwidth, the higher the data rate
- D. All of the above
Quiz summary

Here are your quiz results. Scroll down for the answers.

**Quiz Summary**

Correctly Answered: 4 Questions 100%
Total Questions in Quiz: 4 Questions

Quiz Results

What does LAN stand for?
- You answered correctly: Local Area Network

What are the common LAN topologies?
- You answered correctly: Star, Bus, Ring

Which of the following is not a LAN component?
- You answered correctly: Speakers

Computers connected in a single cable is called what topology?
- You answered correctly: Bus
Network modelling

[Image of a network design tool interface with options for Wired LAN Modelling, including Topology (Physical Star, Logical Bus), Workstations, Servers, and Printers. The interface also includes a button to 'Generate Model' and a note saying the model will open in a new window, please enable JavaScript popup for this site.]

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Scenario-based wireless LAN

Wireless LAN Scenarios

Scenario-based questions and suggested answers, followed by scenario-based exercises.

Scenario 1

“Real Houses” is a real estate agency with a small office in Auckland. They have two computers (one on each of the two rooms of the office). The computers are connected to the Internet via an ADSL connection. One of the computers is a Windows 2003 server (WINS), and the other one is Windows XP workstation. A local printer is attached to the WINS server one of the workstations. The real estate agents use laptops in the field; when in the office they connect to the Internet using the ADSL modem and the wireless network cards fitted in each laptop.

Question: Draw a diagram detailing how the “Real Houses” office will be set up (Please note: the terms of the office lease do not allow drilling of holes for cables on the premises).

Answer:

![Diagram of Wireless LAN Scenario 1]
Scenario-based questions and suggested answers, followed by scenario-based exercises.

Scenario 1

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Question: Draw a diagram detailing how the "Real Houses" office will be set up (Please note: the terms of the office lease do not allow drilling of holes for cables on the premises).

Answer:

[Diagram of the network setup including ADSL Router, Server, Local printer, Access point, and Room 1.]
Example 2: Teaching Server-based networking using customized net

- Wanted to provide a hands-on learning activity in the computer laboratory.


AUT Networking Laboratory Environment (1)

Campus backbone network

Switch

NIC (1)  NIC (2)  ...  NIC (24)  NIC (25)

Win XP Client  Win XP Client  Win XP Client  NetWare Server/Linux host

Removable hard disk

NIC: Network interface card

Customised network
AUT Networking Lab Env (2)

Disconnecting AUT Network using cut-through switch

- AUT Lab Video
Customised Networks

• Is isolated from the university backbone network through a cut-through switch.

• **Why isolated?**
  - Campus network security
  - Allows students to modify various settings and configurations without interfering campus network.

• **Why removable HDs?**
  >> for installing different OSs, and modify various system settings without changing the standard classroom disk image for other users.
AUT University Network

NIC (1) - Windows 7 Client

NIC (2) - Windows 7 Client

NIC (24) - Windows 7 Client

NIC (25) - Server

Customized network

Cross over cable

Removable hard disk

NIC: Network interface card
Cisco gear for practical experience
Example 3: Teaching wireless communication using Wi-Fi Projects

“Wireless communication/networking often proves to be a quite challenging subject to teach in a meaningful way, ... students appear to find the subject rather dry and technical, and so quite boring”

Wanted to provide a hands-on learning experience

## Wi-Fi Project Details (1)

<table>
<thead>
<tr>
<th>Projects</th>
<th>Wireless networking concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Infrared (IR)</td>
<td>IR transmission link; signal interference; modulation and demodulation</td>
</tr>
<tr>
<td>2. 2.4 GHz</td>
<td>FM transmission; encoding and decoding; modulation and demodulation</td>
</tr>
<tr>
<td>wireless link</td>
<td></td>
</tr>
<tr>
<td>3. Wi-Fi</td>
<td>External Wi-Fi antenna; signal strength; response time and throughput</td>
</tr>
<tr>
<td>Antenna</td>
<td></td>
</tr>
<tr>
<td>4. Ad hoc Net</td>
<td>Peer-to-peer networking; file sharing; security</td>
</tr>
<tr>
<td>5. Infra Net</td>
<td>Infrastructure network; centralised network control; wireless access point</td>
</tr>
<tr>
<td>6. Net security</td>
<td>Access control; Firewalls; encryption; SSID</td>
</tr>
</tbody>
</table>
Wi-Fi Project Details (2)

• Wi-Fi projects are designed around low-cost Wi-Fi modules/cards available from local shops.

List of equipment (Gear)
• 1 PC and 2 laptops
• 1 Access Point
• 1 Transmitter module (2.4GHz)
• 1 Receiver module (2.4GHz)
• 2 ‘bow tie’ microwave antennas
• Metal-working tools (tin snips) and materials (tin cans, coax cable and connectors) for making microwave antennas of simple design, software for testing the efficiency of the Wi-Fi links.
The signal produced by a single remote control unit.

The signal trains from the two remote control units.
Wi-Fi Project Details (4)

Linking two computers via a wireless link.

Close-up view of the transmitter and receiver modules.
Benefits of Wi-Fi Projects

• **Hands-on:** Wi-Fi projects facilitate an interactive, hands-on learning experience.

• **Easy to use:** Wi-Fi projects are easy to use and set up for demonstrations.

• **Low cost:** Wi-Fi projects can be built with limited resources and budget.

• **Reusability:** Some hardware components of Wi-Fi projects can be reused in developing other projects.

• **Usefulness:** can be used either in the classroom or in the lab to provide hands-on learning experience.

• **Challenging:** Wi-Fi projects provide an opportunity for students to test their knowledge about wireless networking and communication.
Example 4: Teaching Hardware Concepts using PIC-based projects

- Wanted to provide a hands-on learning experience


What is a PIC microcontroller?

- Programmable Interface Controller (PIC) is an inexpensive single-chip computer.
- It contains a CPU, ROM, RAM, I/O lines, serial/parallel ports, timers, and other built-in peripherals such as A/D and D/A converters.
- There is a large variety of PIC microcontrollers on the market. We have chosen PIC 16F84 because of its availability, low cost and flash memory.
# PIC Project Details (1)

<table>
<thead>
<tr>
<th>Projects</th>
<th>Hardware concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Data representation</td>
<td>Binary sequence, bits and bytes.</td>
</tr>
<tr>
<td>2. Memory</td>
<td>Memory addressing, flash RAM, ROM, EEPROM.</td>
</tr>
<tr>
<td>3. LED matrix</td>
<td>Nibble, word, decoder, encoder, LED matrix, voltage and logic levels.</td>
</tr>
<tr>
<td>4. LCD display</td>
<td>CPU, registers, I/O port, LCD display.</td>
</tr>
</tbody>
</table>
PIC Project Details (2)

- PIC Projects are designed around the PIC16F84, a powerful 8-bit microcontroller chip that sells for less than $10.

List of components
- PIC controllers
- Breadboard
- PIC Programmer kit
- LEDs
- LED Matrix display
- Speaker
- Resistors, capacitors and several chips
Project 1. The eight LED display represents the 1-byte word 10011011. The four yellow LEDs correspond to the most significant bits and the four red LEDs to the least significant bits.
Project 3. LED Matrix display

LCD display (Project 4) combined with the speech generator project (Project 5)
PIC Programming environment

DIP Socket

PIC programmer module

ZIF (Zero Insertion Force) socket
PIC Programming in Practice

PIC programmer set up in a typical laboratory
Benefits of PIC Projects

- **Low cost:** Street price of a PIC16F84 is $7.5.
- **Easy to use:** PIC-based projects are easy to use and set up for demonstrations.
- **Hands-on:** facilitate an interactive, hands-on introduction to computer hardware concepts.
- **Reusability:** can be reused in developing a variety of projects on a breadboard.
- **Programmable:** can be reprogrammed many times over as students develop new programs for a variety of projects.
- **Usefulness:** can be used either in the classroom or in the lab to provide hands-on experience.
Outline of Talk

CSE Education:

✓ Examples of the best teaching practices
  o Computer Networking (Examples 1-3)
  o Hardware Fundamentals (Example 4)

➢ Trends
  o Discussion Questions
  o Summary and Conclusion
Trends in CSE Education
An overview of contemporary international trends in engineering education is presented.

1. Education:
Any depth, any time, and any place

2. Education:
Tailored and styled to the individual needs

3. Integration of
Tomorrow’s research into tomorrow’s instruction
Focused on quality, scale, and breadth in online learning, impact on continuing education of graduate engineers and degree-seeking students.

Quality of online education will improve as teaching and learning technologies improve.

Making learning available to anyone, anywhere, anytime.
A model for implementing on-line learning in engineering education is presented. Relationships between traditional learning strategies and network-enabled engineering education are discussed.

Learning anywhere and at anytime is a major feature of network-enabled learning model.

How do you provide laboratory facilities through web-based on-line learning?
Development of a Distance Lab using LabVIEW by Tan et al. (1999)

Developed a distant laboratory experiment for engineering students at National University of Singapore. Real-time modelling and control of a pilot-scale DC servo motor.

1. Lecture materials sent by postal mail (late 1880s)
2. Recorded media: Radios/TVs, tapes, telephones (Late 1960s and early ‘90s)
3. WWW
   Computers and Telecommunications (interactive multimedia learning)
<table>
<thead>
<tr>
<th>Summary of Literature Review</th>
<th>Flexible learning, Student centred, Research feed into teaching</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kulacki &amp; Krueger (2011)</td>
<td>Making learning available to anyone, anywhere, anytime</td>
</tr>
<tr>
<td>Bourne et al. (2005)</td>
<td>Flexible learning is a feature of network-enabled learning</td>
</tr>
<tr>
<td>Bourne et al. (1997)</td>
<td>Interactive multimedia learning through WWW</td>
</tr>
<tr>
<td>Tan et al. (1999)</td>
<td></td>
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</tbody>
</table>
CSE Education: Traditional Teaching/learning Methods

Limitations/Challenges:
1. Scalability (difficult to teach a large number of students, student dislike; no interactivity).
2. Laboratory learning -> small-group activity
Solutions: Network-enabled learning

1. Scalability =>
   - Internet/Web-based delivery
   - Bring high level of interactivity
   - Serve global student population

2. Alternative to traditional Lab learning =>
   >> Remote Laboratory (e.g. PlanetLab)
   >> Use simulated Laboratory

Benefits of Network-enabled CSE Education

- Flexible and m-learning
- Interactive and experiential learning (Constructivist approaches!)
- Increase the breadth and scale of CSE Education (i.e. education to global communities).
- Reducing the cost of replicating facilities (e.g. Labs) at multiple campuses/institutions.
- Driver for collaboration (teaching/learning)
Summary: Trends in CSE Education

Lectures/Lab based on-campus learning

Lectures/Lab + off campus online + small-scale flexible learning

Network-enabled flexible learning (anytime, and anywhere)
Outline of Talk

CSE Education:

✓ Examples of the best teaching practices
  o Computer Networking (Examples 1-3)
  o Hardware Fundamentals (Example 4)

✓ Trends

➢ Discussion Questions
  o Summary and Conclusion
Discussion Questions/Your turn

- Is flexible (anytime, anywhere) learning approach suitable for CSE education?
- Are virtual laboratories appropriate for CSE education?
- Is mobile learning (m-learning) model suitable for CSE education?

Talk to the person next to you and discuss/share your ideas (just a couple of minutes …)
Summary and Conclusion

- CSE education is moving towards an information rich, student-centred, research informed where learning can be conveniently extended beyond the University/School.
- **Network-enabled learning**
  - Making learning available to anyone, any where and anytime (i.e. flexible and m-learning).
- **WebLan-Designer** provides online support for off-campus students and enhances learning by providing a flexible mode for delivery of courses.
What next?

- Develop an efficient online learning management system to support interactive, flexible, and m-learning (i.e. smart network-enable learning).
- Develop hardware/software for remote laboratories.
- Improve the performance of broadband Internet for multimedia content delivery.
Thank you for your attention

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