

Best Practices and Trends in Computer Science and Engineering Education

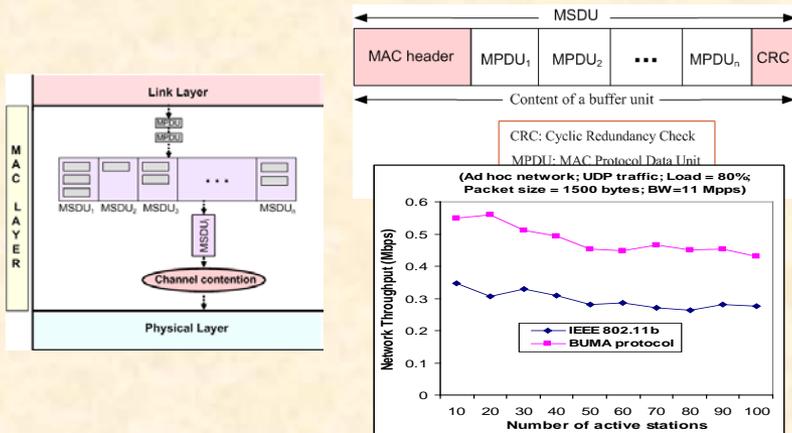
Dr Nurul Sarkar
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Auckland University of Technology, New Zealand
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My Research Interests

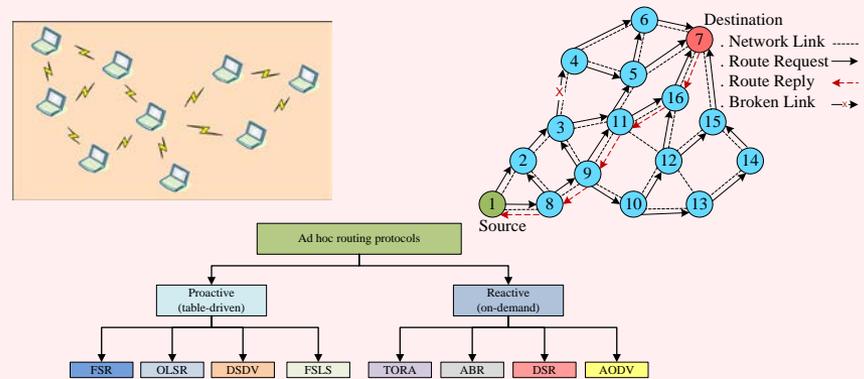
1. Computer Networking ...
2. Network Education
 - >> Developing tools to enhance methods for teaching and learning computer networking and hardware fundamentals.

Networking Research @AUT

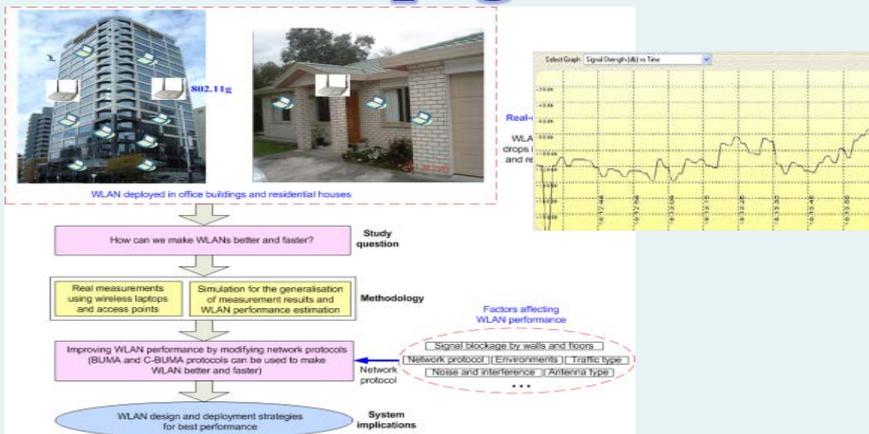
Network Protocols



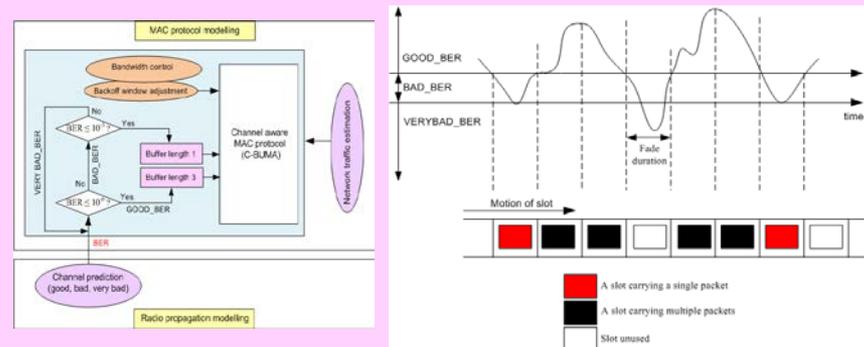
Routing and Transport Protocols



Radio Propagation



Cross-layer Optimization



Outline of Talk

CSE Education:

- Examples of the best teaching practices
 - Computer Networking
 - Hardware Fundamentals
- Trends
- Discussion Questions
- Summary and Conclusion

Motivation for CSE Education

1. “Professors are **fully committed** to **teaching**, research and public services”
(CSE BUET)
<http://www.buet.ac.bd/cse/faculty/index.php>
2. **A university teacher says**
“Teaching is our job, Research is our profession”
3. Best teaching practices
“**Research feed into Teaching**”

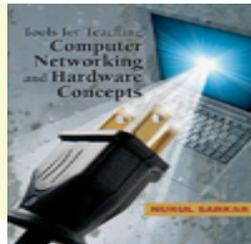
Teaching and Learning

Computer Networking and Hardware Fundamentals

CSE Education - Useful Resources

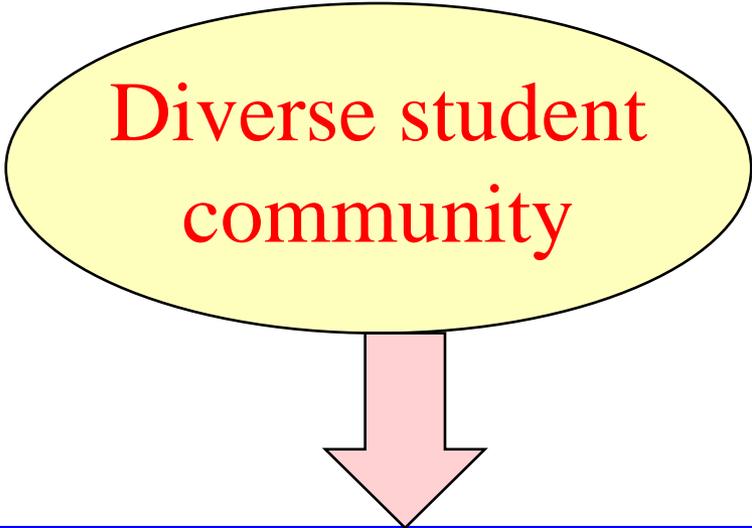
- IEEE Transactions on Education
- Australasian Association for Engineering Education
- The American Society for Engineering Education
- Int. Journal of Electrical Engineering Education
- Journal of Engineering Education
- Trends in Engineering Education - An International Perspective by Kulacki and Krueger
- Online Engineering Education: Learning Anywhere, Anytime by Bourne, et al. (J. of Eng. Education).

Sarkar, N. I. (2006) Tools for Teaching Computer Networking and Hardware Concepts. Info Science Pub.



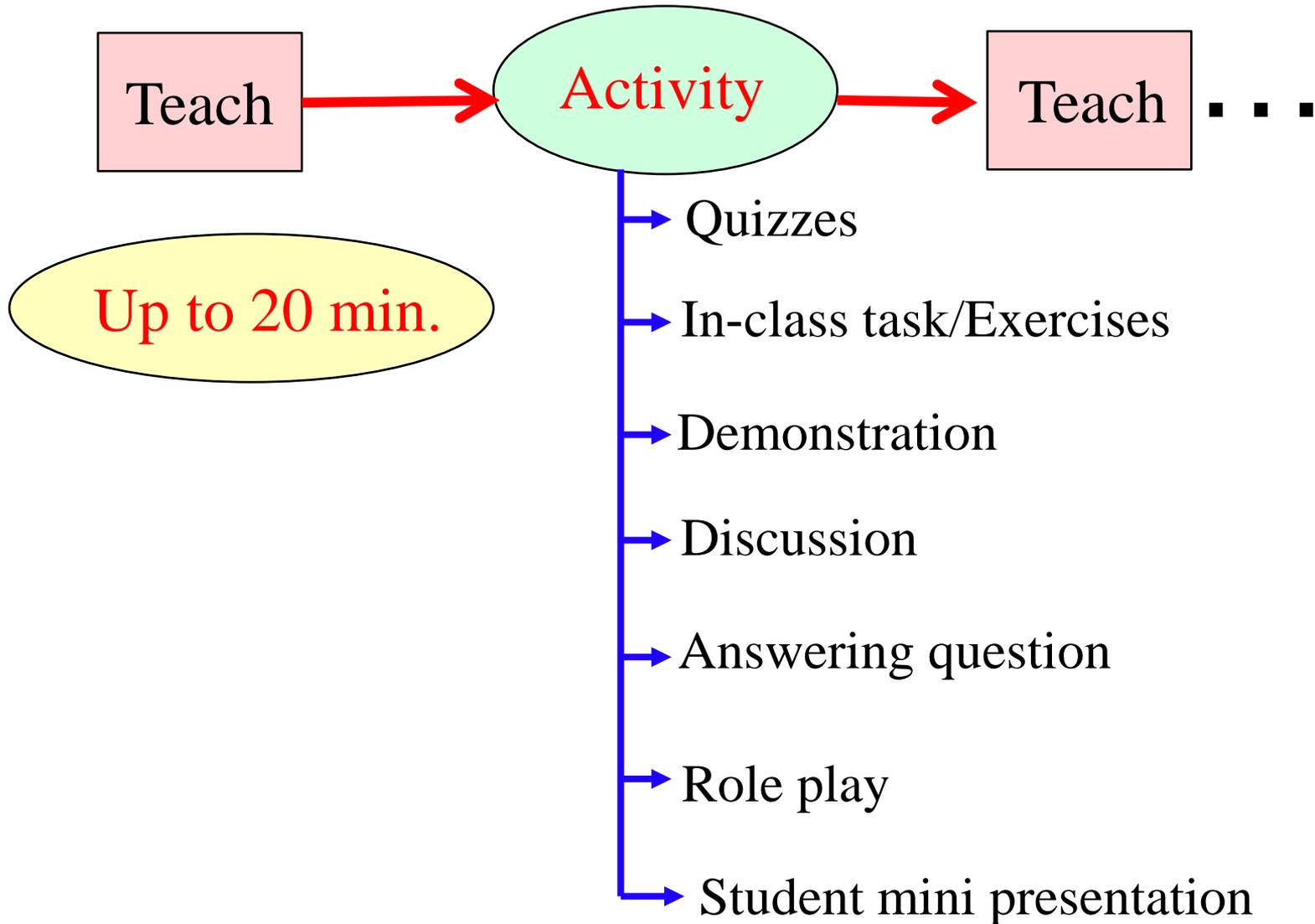
Our students ...

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?



...

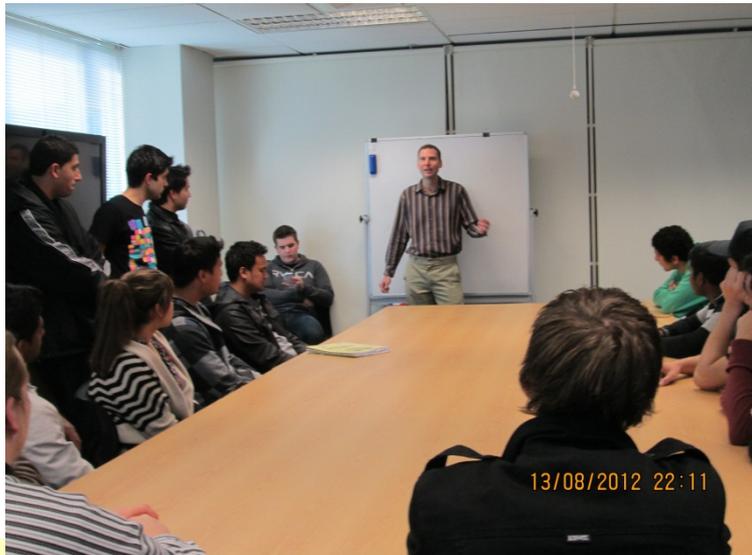
Teaching Advanced Network Technologies undergraduate course

- 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
 - **AUTOonline** (based on Blackboard)

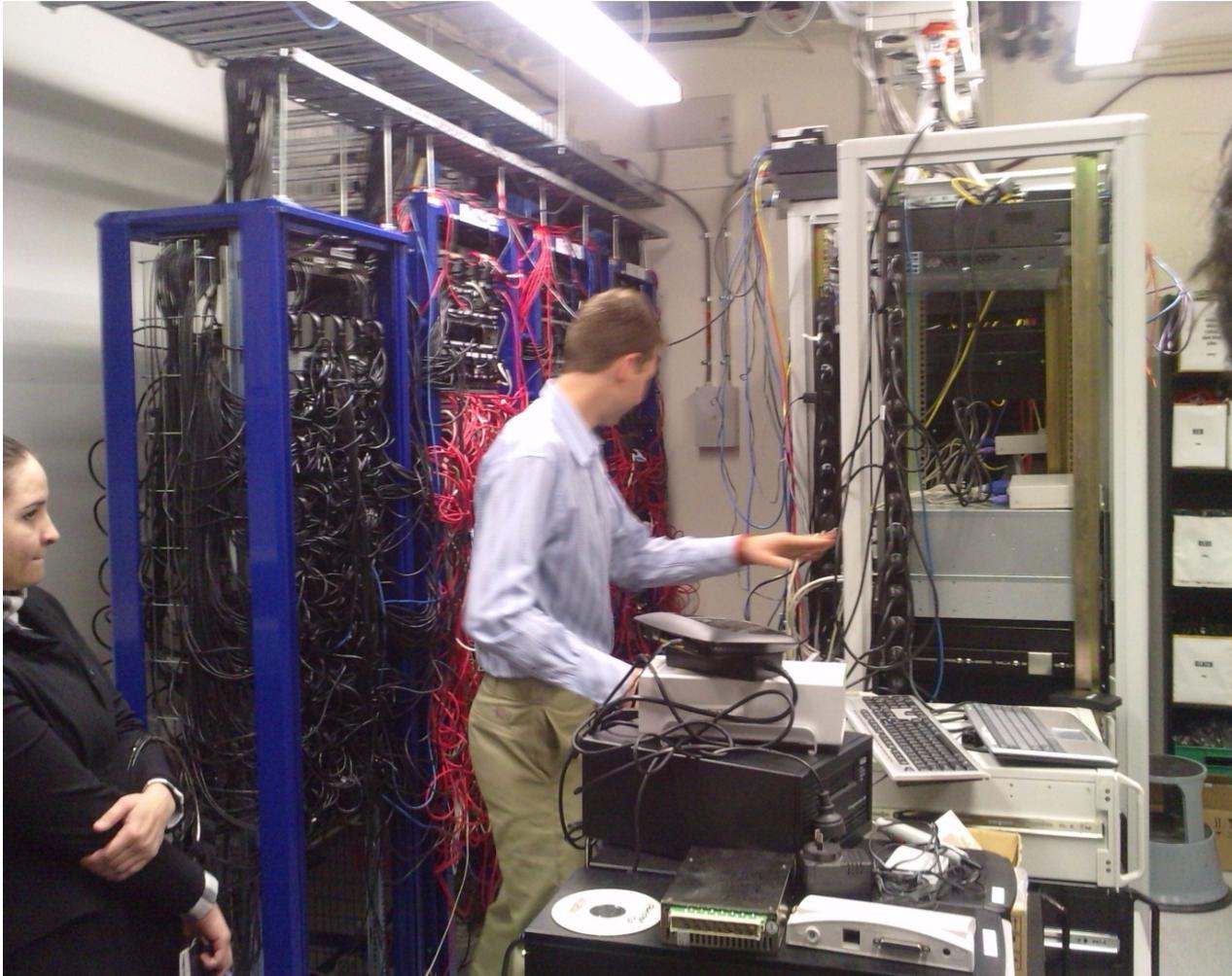
Recent Field Trip (1)



Tonkin & Taylor Ltd.



Recent Field Trip (2)



IT Manager and students in the Server room

Recent Field Trip (3)



IPStar
NZ Ltd.



Advanced networking students at the 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

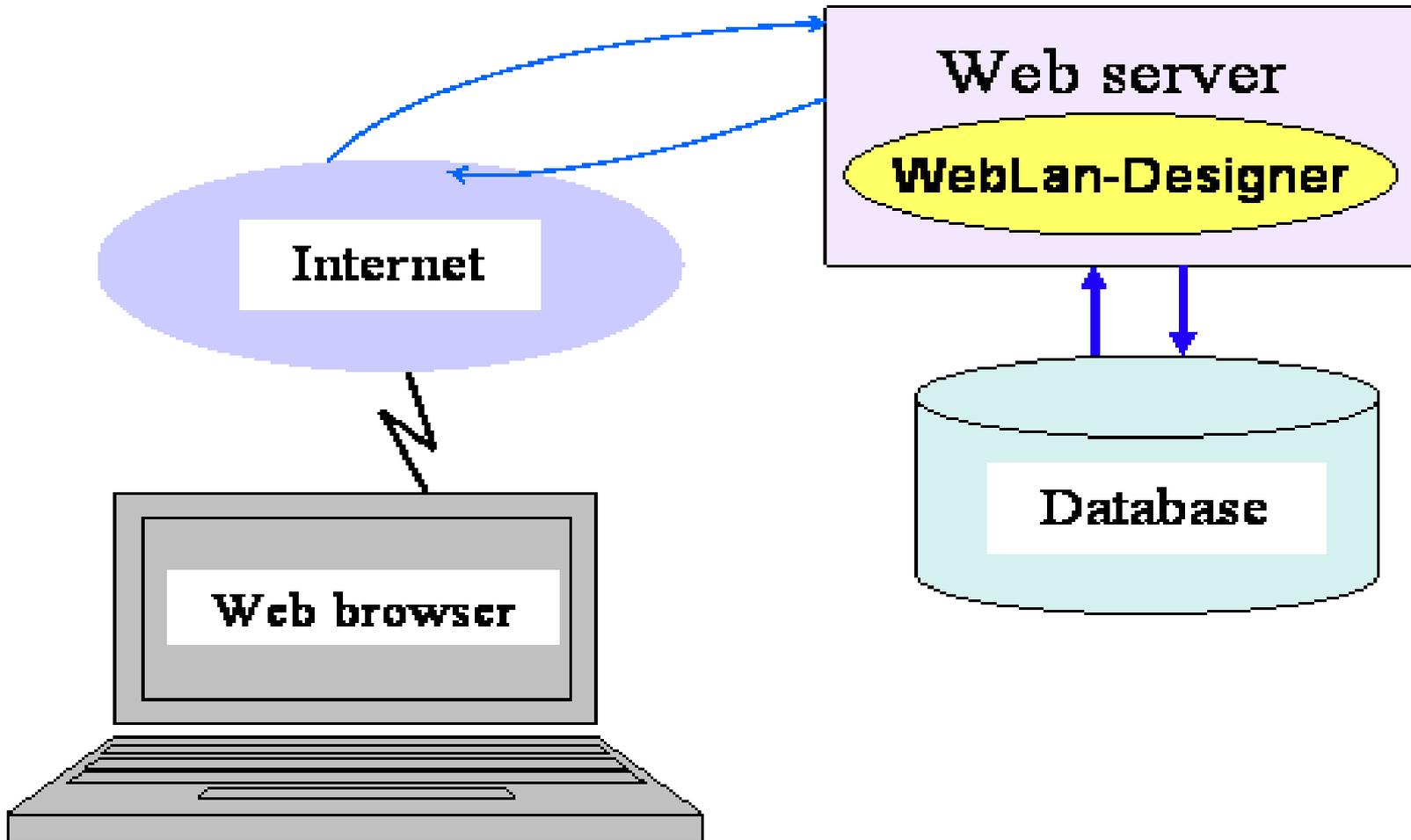
Example 1: Teaching Networking using WebLan-Designer

Why WebLan-Designer?

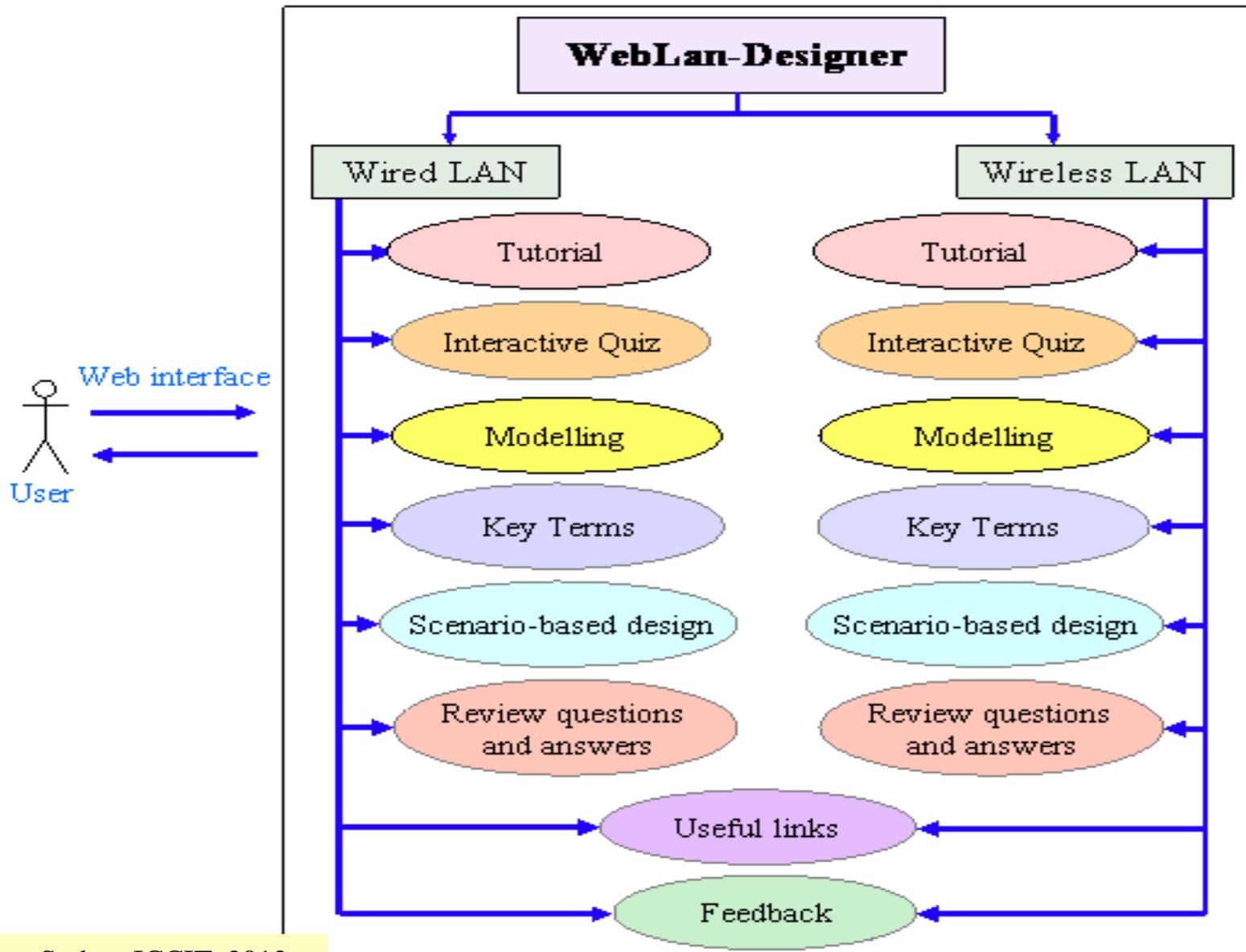
- Wanted to provide an interactive and flexible learning experience in computer networking at introductory level.

Sarkar, N.I. and K. Petrova (2011) 'Design and evaluation of a web-based tool for teaching network design to undergraduates'. TIJWLLT 6(4):39-59.

WebLan-Designer Architecture



WebLan-Designer - Components



Topology and access protocols

Topology

Access method

Wired
LAN

Physical bus logical bus
Physical star logical bus
Physical star logical star
Physical ring logical ring
Physical star logical ring

CSMA/CD

Token passing

Wireless
LAN

Ad Hoc Network
Infrastructure network

CSMA/CA

WebLan-Designer – Home page

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

The screenshot shows a Mozilla Firefox browser window displaying the WebLan-Designer Home page. The browser's address bar shows the URL <http://weblandesigner.elena.aut.ac.nz/>. The page features a blue header with the AUT logo on the left and the text "NETWORKING TUTORIALS WIRED & WIRELESS LAN DESIGN" on the right. A left-hand navigation menu lists various sections: Home, Wired LAN, Tutorial, Quiz, Modelling, Scenarios, Key Terms, Review Questions, Wireless LAN, Tutorial, Quiz, Modelling, Scenarios, Key Terms, Review Questions, and Useful Links. The main content area is titled "WebLan-Designer" and includes a circular logo with a network diagram. Below the title is a quote: "An Interactive system for Teaching and Learning both wired and wireless LAN design". The text describes the system as a tool for testing knowledge through interactive quizzes, learning about networking protocols and devices, and modeling LANs. It lists faculty members Nurul I. Sarkar (Project Leader) and Krassie Petrova, and developers Jeff Chiang, Geoff Lee, and Trung Ly. The page also mentions funding from the Auckland University of Technology and provides a link to the school's homepages. The date of the last update is September 20, 2011.

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 RELTS grant. The School of Computer and Information Sciences hosts the WebLan-Designer at <http://elena.aut.ac.nz/homepages/weblandesigner/>

Date of last update: September 20, 2011.

Interactive quiz

WebLan-Designer Wired LAN Quiz - Microsoft Internet Explorer

Address: http://elena.aut.ac.nz/homepages/weblandesigner/index.php?fuseaction=quiz.wired

AUT NETWORKING TUTORIALS
WIRED & WIRELESS LAN DESIGN

Home
Wired LAN
Tutorial
Quiz
Modelling
Scenarios
Key Terms
Review Questions
Wireless LAN
Tutorial
Quiz
Modelling
Scenarios
Key Terms
Review Questions
Useful Links
Feedback

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

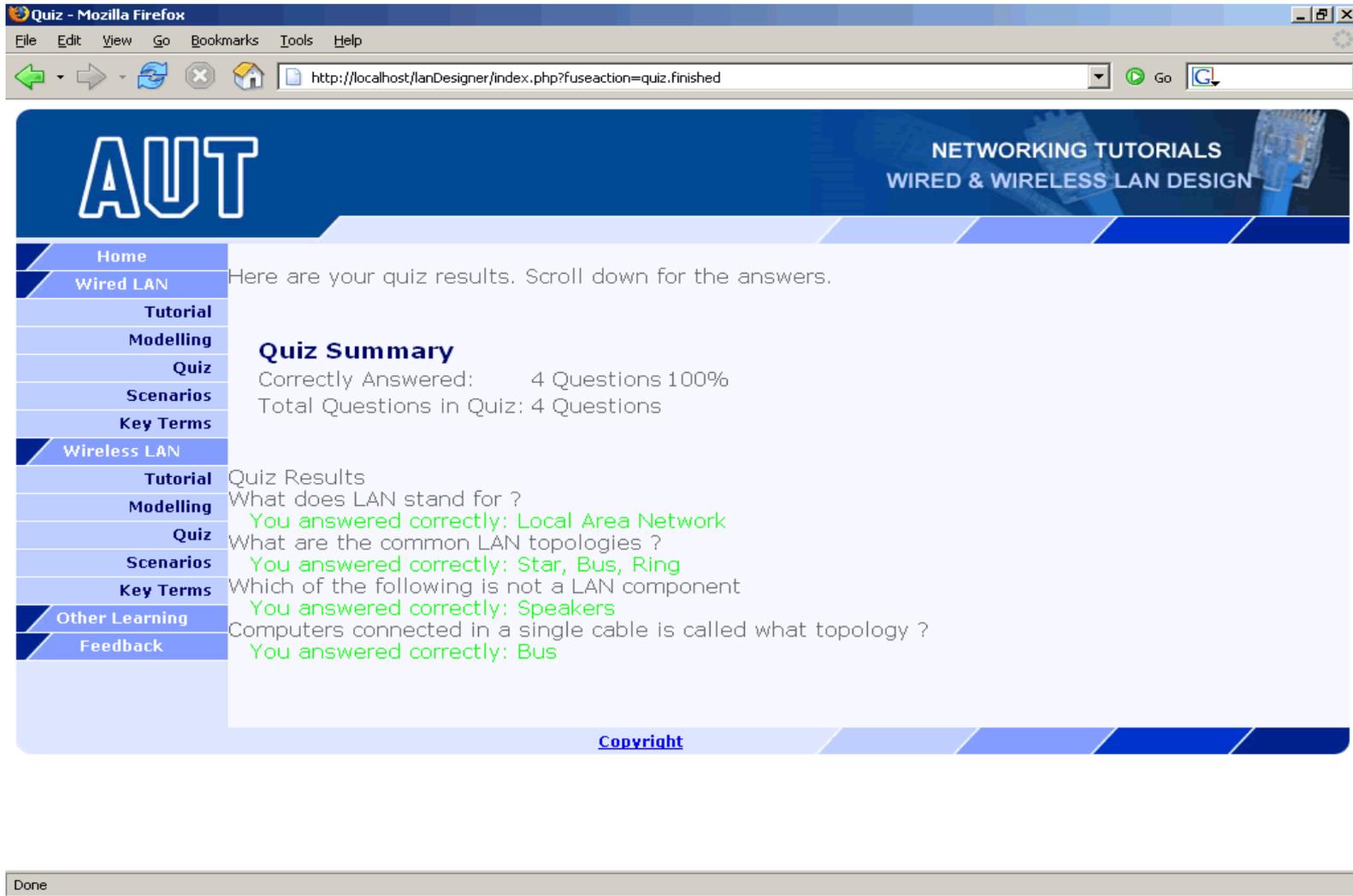
A network consists of the following basic components:

- 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



Quiz - Mozilla Firefox

File Edit View Go Bookmarks Tools Help

http://localhost/lanDesigner/index.php?fuseaction=quiz.finished

AUT

NETWORKING TUTORIALS
WIRED & WIRELESS LAN DESIGN

- Home
- Wired LAN
- Tutorial
- Modelling
- Quiz
- Scenarios
- Key Terms
- Wireless LAN
- Tutorial
- Modelling
- Quiz
- Scenarios
- Key Terms
- Other Learning
- Feedback

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

[Copyright](#)

Done

Network modelling

The screenshot shows a Microsoft Internet Explorer browser window titled "WebLan-Designer Wired LAN Modelling". The address bar contains the URL "http://elens.aut.ac.nz/homepages/weblandesigner/index.php?fuseaction=modeling.wired". The browser's toolbar includes buttons for Back, Forward, Stop, Home, Search, Favorites, Media, and Print. Below the browser window, the website header features the "AUT" logo on the left and the text "NETWORKING TUTORIALS WIRED & WIRELESS LAN DESIGN" on the right. A navigation menu on the left side lists various options: Home, Wired LAN (Tutorial, Quiz, Modelling, Scenarios, Key Terms, Review Questions), Wireless LAN (Tutorial, Quiz, Modelling, Scenarios, Key Terms, Review Questions), Useful Links, and Feedback. The main content area is titled "Wired LAN Modelling" and contains a form with the following fields: "Topology" (a dropdown menu showing "Physical Star, Logical Bus"), "Workstations" (a dropdown menu showing "20"), "Servers" (a dropdown menu showing "4"), and "Printers" (a dropdown menu showing "4"). Below these fields is a "Generate Model..." button. A note at the bottom of the form states: "The model will open in a new window, please enable JavaScript popup for this site."

Scenario-based wireless LAN

WebLan Designer Wireless LAN Scenarios - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Address: <http://elena.aot.ac.nz/homepages/weblandesigner/index.php?fuseaction=scenario.wireless>

Links: AUT Home Page | AUT Internet Login | My AUT | Auction | Air New Zealand Bookings & Offers Flight Bookings | Air NZ - Booking Itinerary

Wireless LAN Scenarios

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

[\[Scenario 1\]](#) [\[Scenario 2\]](#) [\[Scenario 3\]](#) [\[Scenario 4\]](#)
[\[Exercise 1\]](#) [\[Exercise 2\]](#)

Scenario 1

"Real Houses" is 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:

```
graph LR;
    CO[To CO] --- Tel[Telephone access to the house];
    Tel --- ADSL[ADSL Router];
    ADSL --- Server[Server];
    ADSL --- AP[Access point];
    Server --- LP[Local printer];
    AP --- Laptop[Laptop];
    subgraph Room1 [Room 1];
        Laptop;
    end;
```

Local intranet

Scenario-based wireless LAN

WebLan Designer Wireless LAN Scenarios - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Address: <http://elena.aot.ac.nz/homepages/weblandesigner/index.php?fuseaction=scenario.wireless>

Links: AUT Home Page | AUT Internet Login | My AUT | Auction | Air New Zealand Bookings & Offers Flight Bookings | Air NZ - Booking Itinerary

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Answer:

```
graph LR
    ToCO[To CO] --- Telephone[Telephone access to the house]
    Telephone --- ADSLRouter[ADSL Router]
    ADSLRouter --- Server[Server]
    ADSLRouter --- LocalPrinter[Local printer]
    ADSLRouter --- AccessPoint[Access point]
    AccessPoint --- Laptop[Laptop]
    subgraph Room1 [Room 1]
        Laptop
    end
```

Local intranet

Example 2: Teaching Server-based networking using customized net

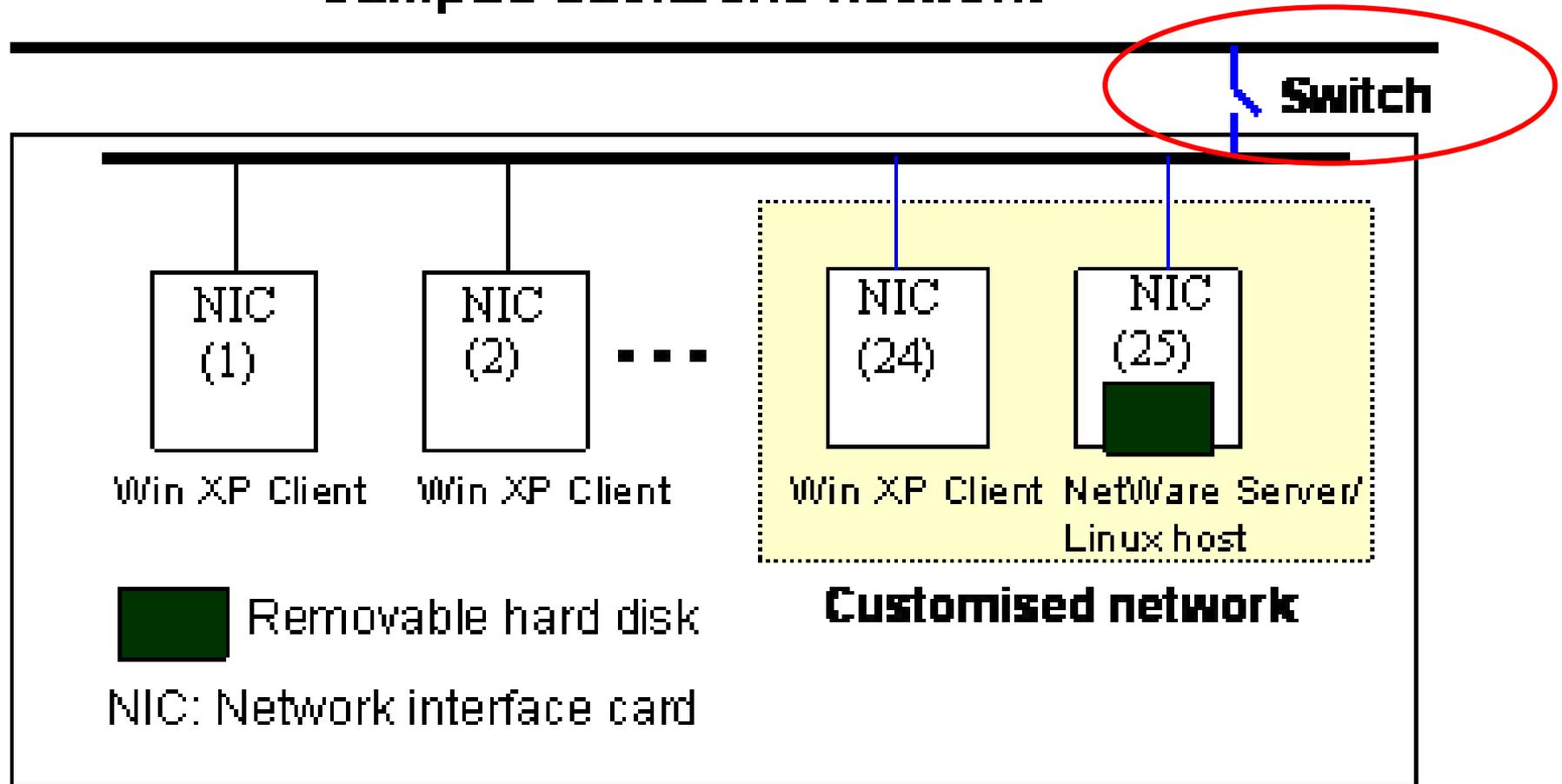
- Wanted to provide a hands-on learning activity in the computer laboratory.

Sarkar, N.I. (2006) 'Teaching computer networking fundamentals using practical laboratory exercises', IEEE Transactions on Education, 49(2) 285-291.

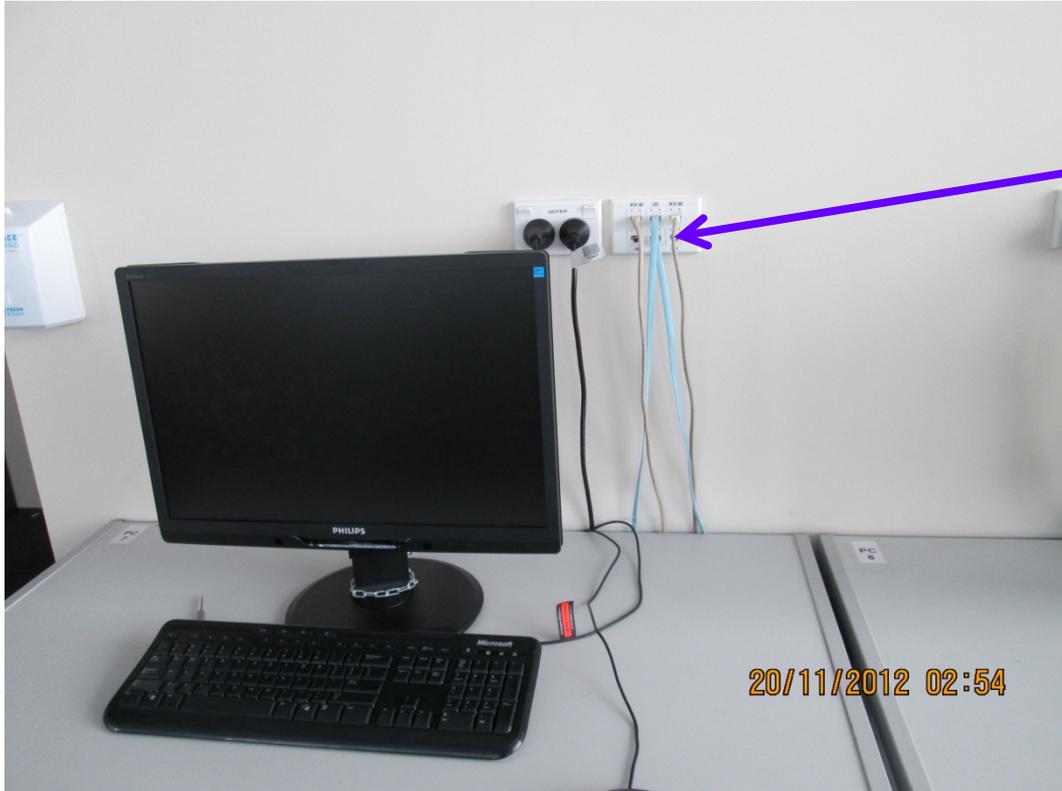
Sarkar, N.I. (2006) 'Teaching TCP/IP networking using practical laboratory exercises', Int. Journal of Information & Communication Technology Education.

AUT Networking Laboratory Environment (1)

Campus backbone network



AUT Networking Lab Env (2)



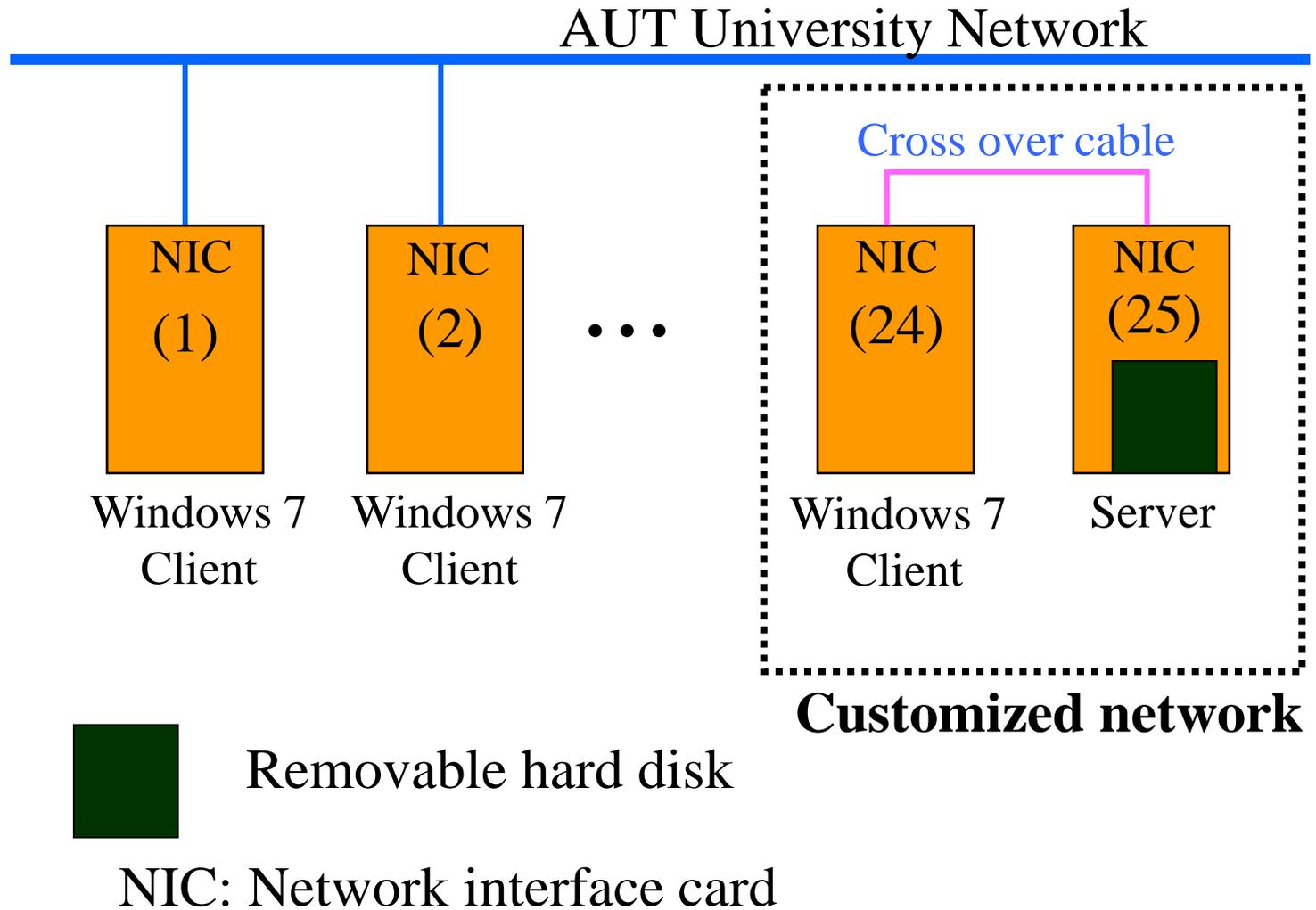
Disconnecting AUT
Network using cut-
through switch

- 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 Networking Lab Env (3)



AUT Networking Lab Env (4)



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**

Sarkar, N.I. and Craig, T.M (2006) “Teaching Wireless Communication and Networking Fundamentals Using Wi-Fi Projects” – IEEE Transactions on Education.

Wi-Fi Project Details (1)

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

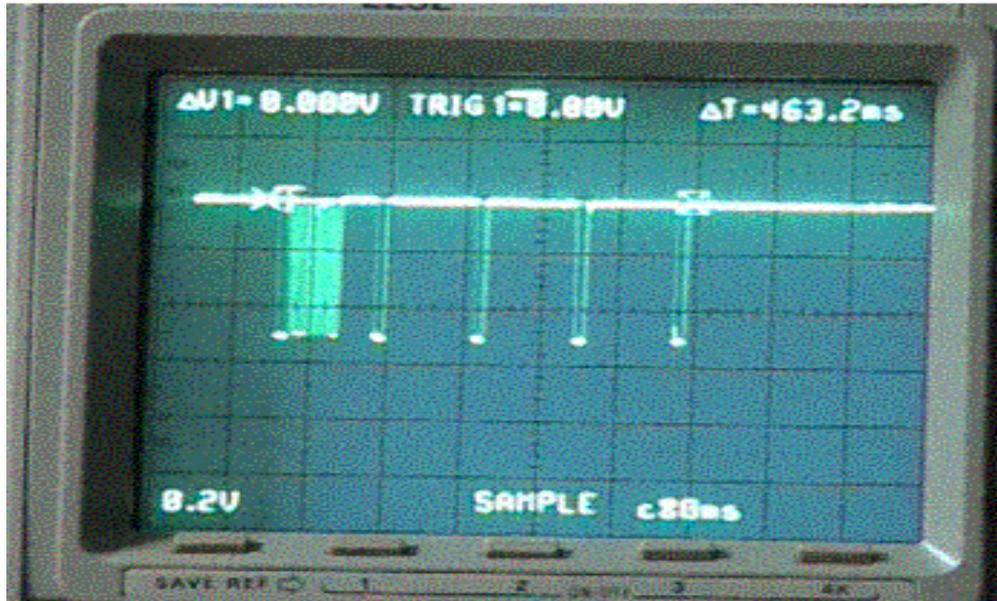
Wi-Fi Project Details (2)

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

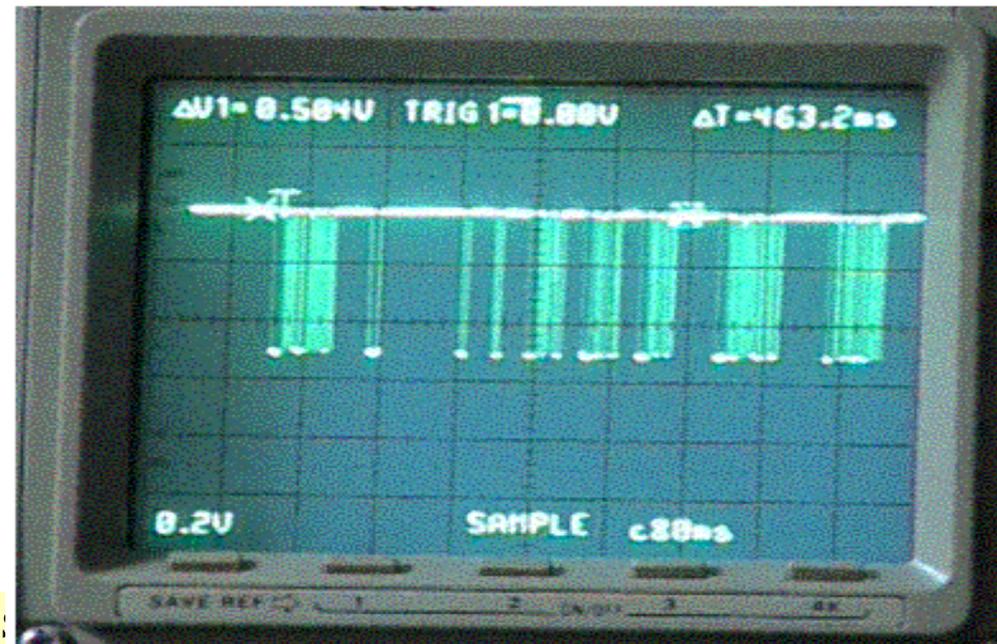
List of equipment (Gear)

- 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.

Wi-Fi Project Details (3)



The signal produced by a single remote control unit.

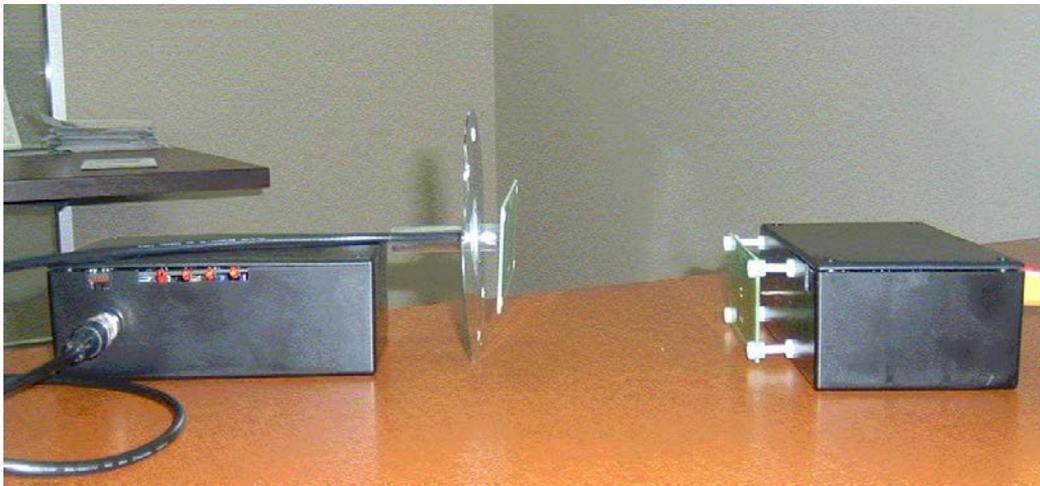


The signal trains from the two remote control units.

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

Sarkar, N.I. Craig, T. (2007) “A Low-Cost PIC Unit for Teaching Computer Hardware Fundamentals to Undergraduates” – ACM SIGCSE Bulletin.

Sarkar, N.I. and Craig, T.M. (2006) “Teaching Computer Hardware and Organization using PIC-based Projects” Int. Journal of Electrical Engineering Education.

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)

Projects

1. Data representation

2. Memory

3. LED matrix

4. LCD display

5. Speech generation

Hardware concepts

Binary sequence, bits and bytes.

Memory addressing, flash RAM, ROM, EEPROM.

Nibble, word, decoder, encoder, LED matrix, voltage and logic levels.

CPU, registers, I/O port, LCD display.

Processor, serial-to-parallel shift registers, amplifier.

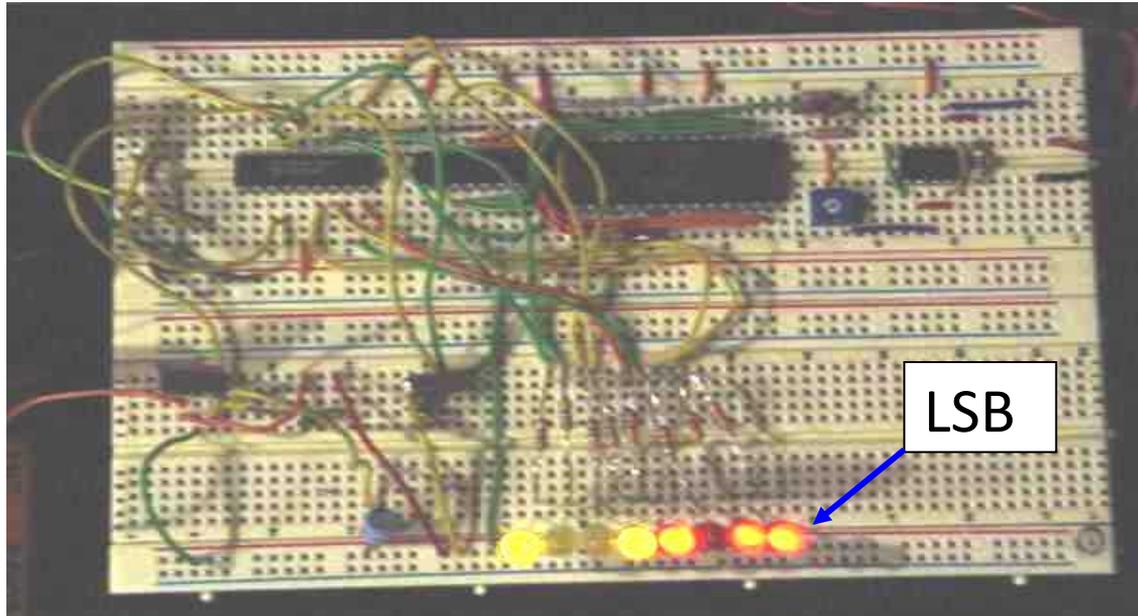
PIC Project Details (2)

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

List of components

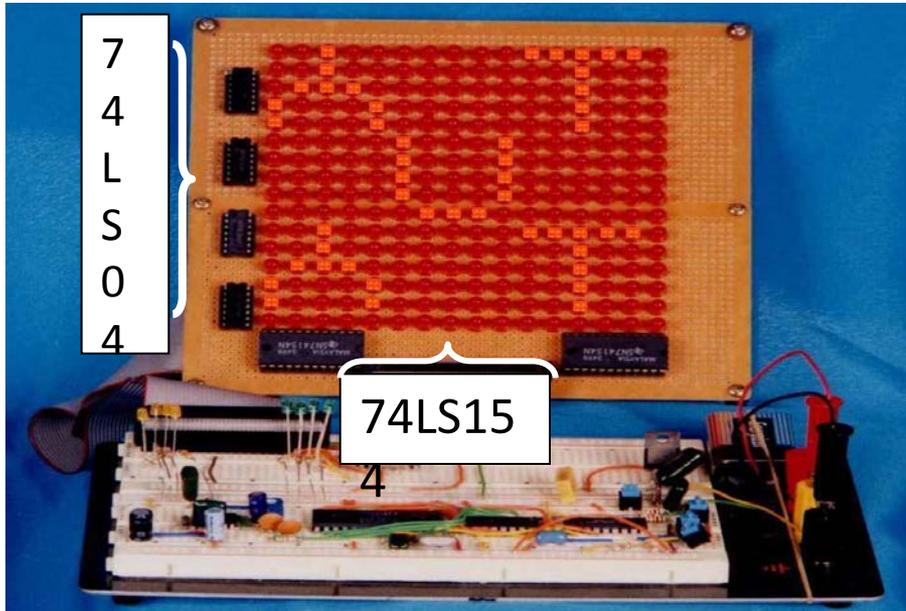
- PIC controllers
- Breadboard
- PIC Programmer kit
- LEDs
- LED Matrix display
- Speaker
- Resistors, capacitors and several chips

PIC Project Details (3)

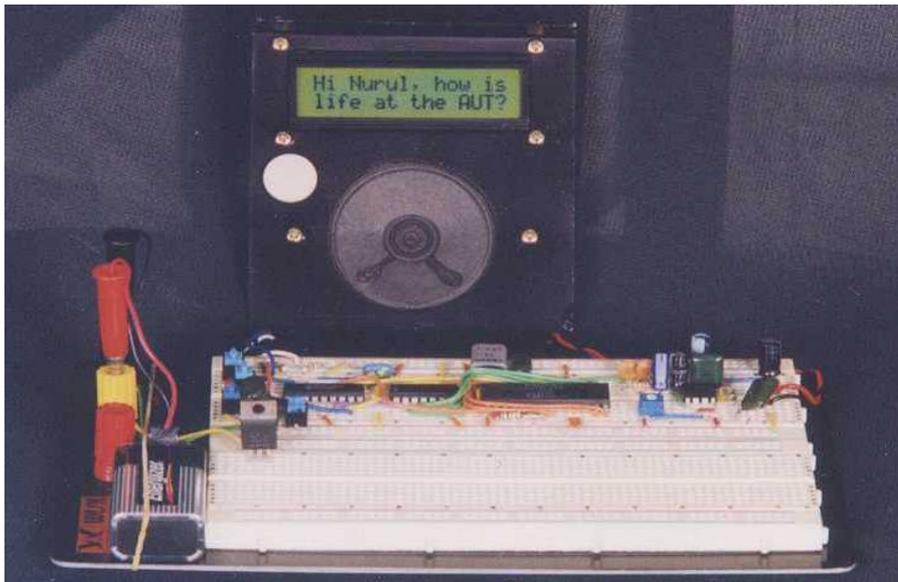


Project 1. The eight LED display represents the 1-byte word 10011011. The four yellow LEDs correspond to the most significant bits and the four red LEDs to the least significant bits.

PIC Project Details (4)

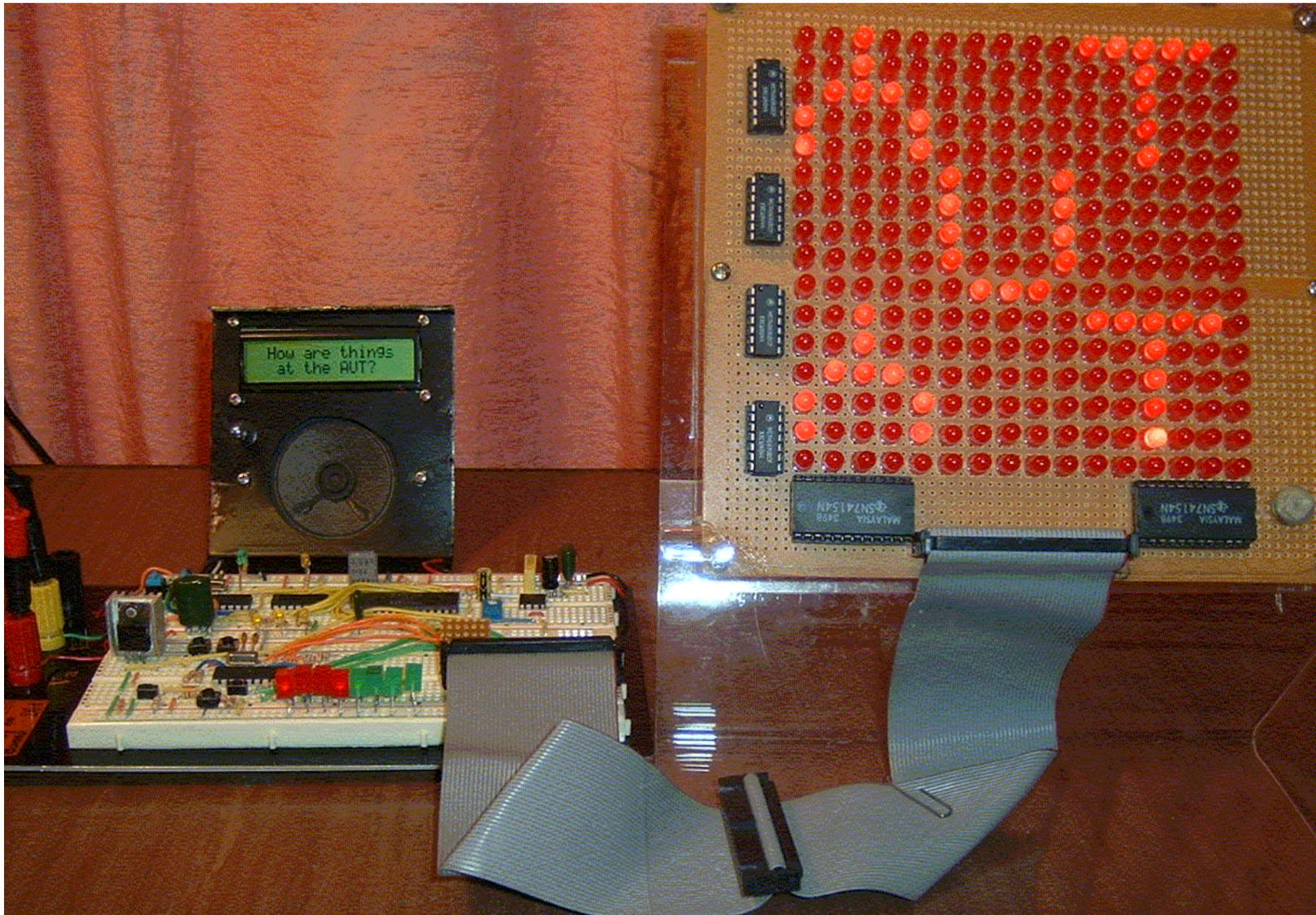


Project 3. LED
Matrix display



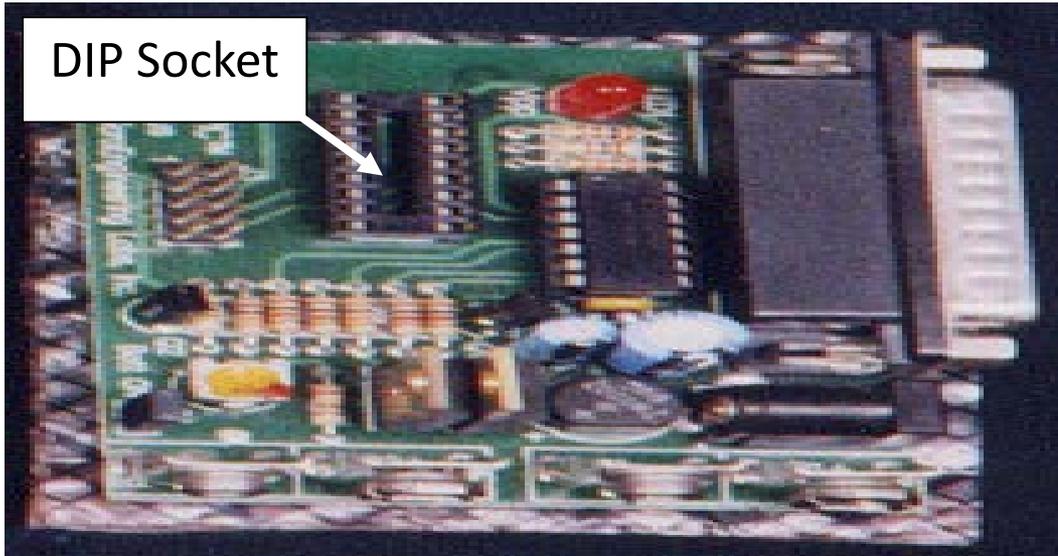
LCD display (Project 4)
combined with the speech
generator project (Project 5)

PIC Project Details (5)

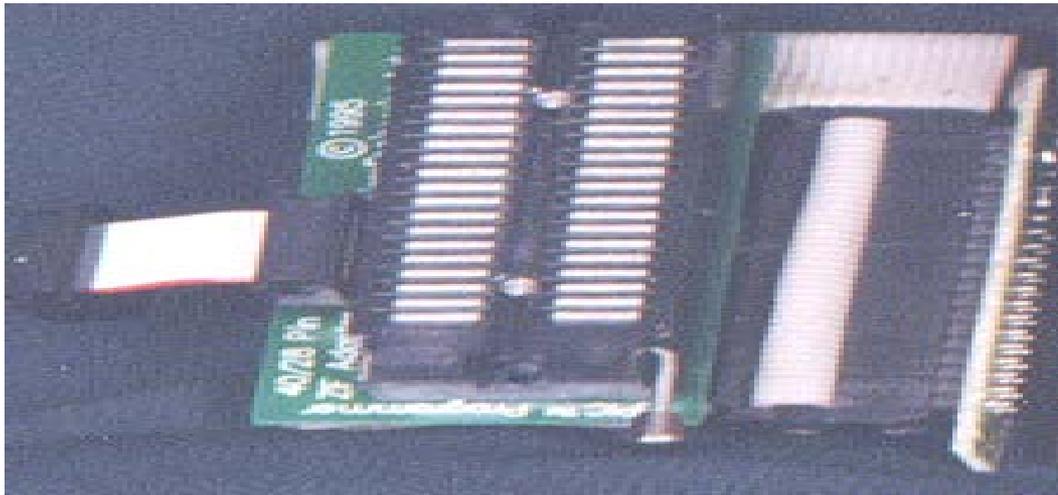


PIC project in a single unit

PIC Programming environment

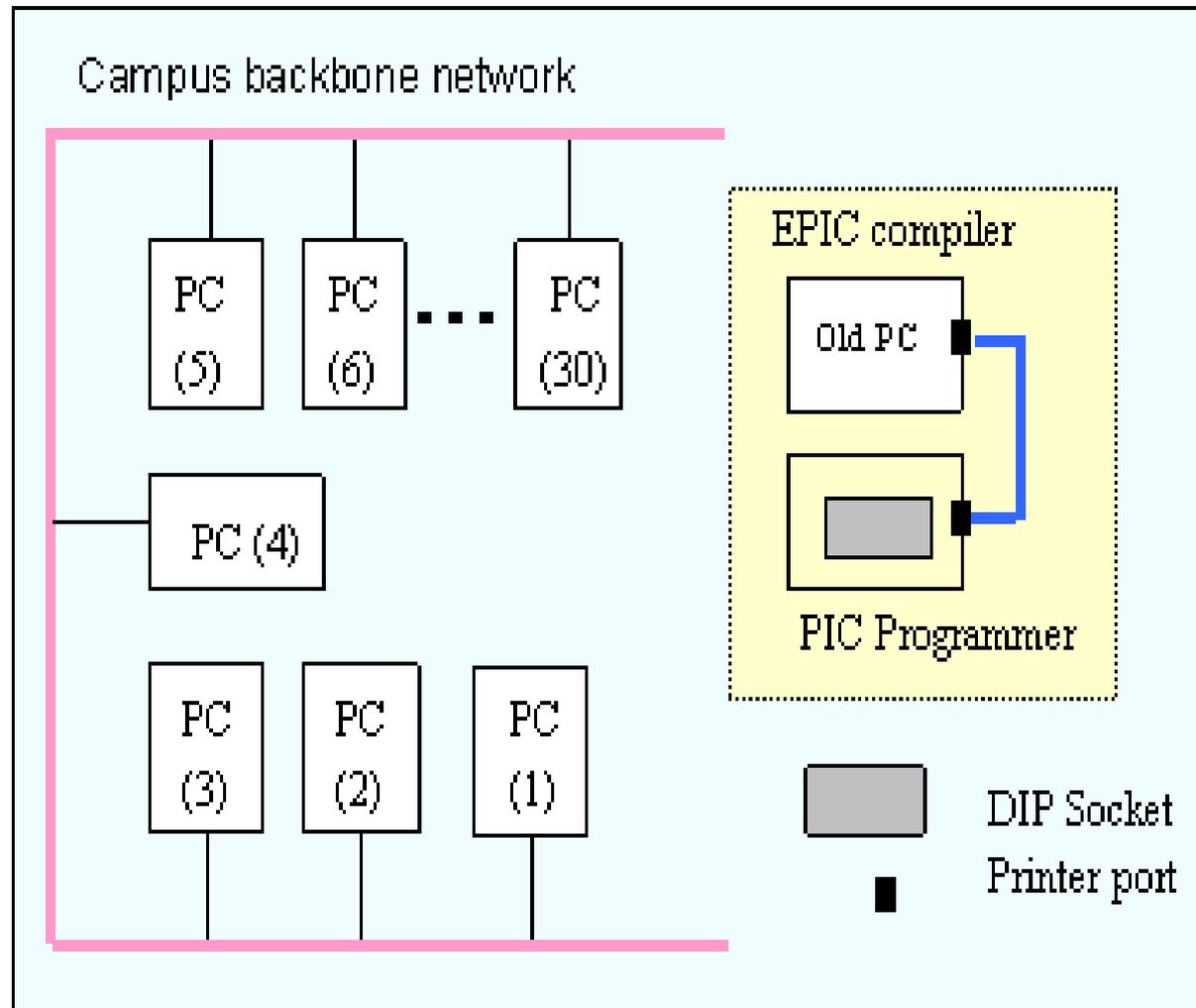


PIC programmer module



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
 - Computer Networking (Examples 1-3)
 - Hardware Fundamentals (Example 4)
- Trends
 - Discussion Questions
 - Summary and Conclusion

Trends in CSE Education

Trends in Eng Education: International Perspective by Kulachi & Krueger (2011)

An overview of contemporary international trends in engineering education is presented.

Flexible learning

Research feed into teaching

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

Online Engineering Education: Learning Anywhere, Anytime by Bourne et al. (2005)

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.

Model for On-Line Learning Networks in Engineering Education by Bourne et al. '97

- 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)

Summary of Literature Review

Kulacki & Krueger (2011)

Flexible learning,
Student centred,
Research feed into teaching

Bourne et al. (2005)

Making learning available
to **anyone, anywhere, anytime**

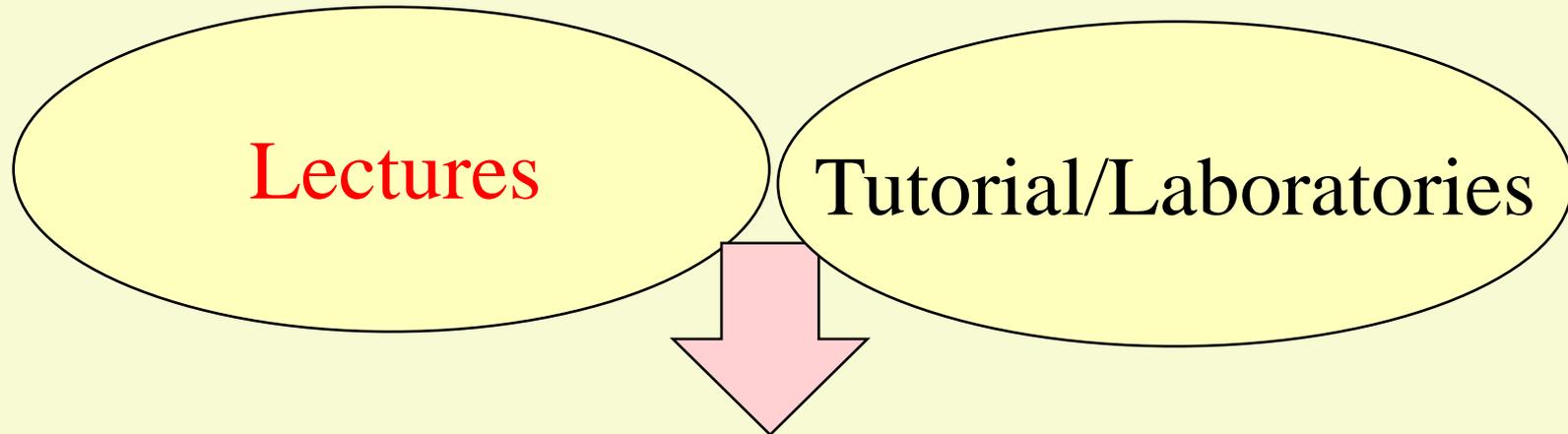
Bourne et al. (1997)

Flexible learning is a feature
of network-enabled learning

Tan et al. (1999)

Interactive multimedia
learning through **WWW**

CSE Education: Traditional Teaching/learning Methods



Efficient – already in place

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 =>

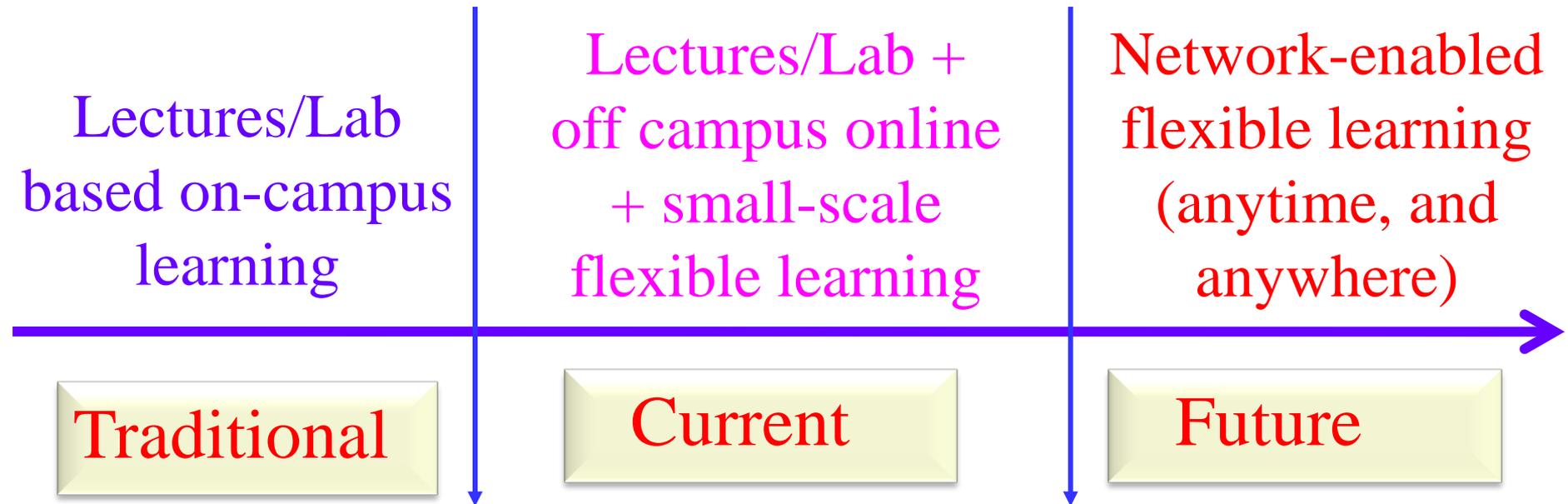
- >> Remote Laboratory (e.g. PlanetLab)
- >> Use simulated Laboratory

3. Map traditional teaching & learning methods into network-based teaching and learning.

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



Outline of Talk

CSE Education:

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