Lesson 0

Concurrent Programming
Rinnakkaisohjelmointi (RIO)
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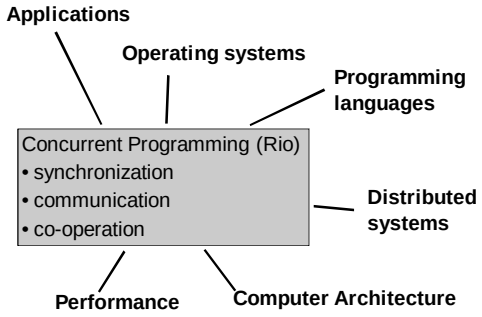
http://blueballfixed.ytmnd.com/

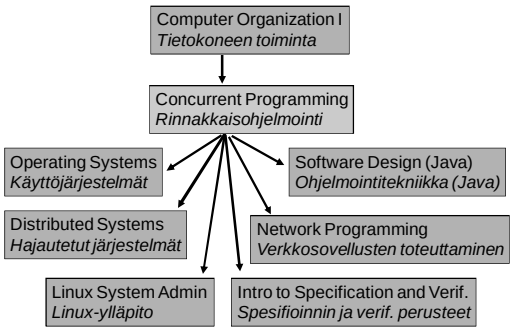
Concurrent Programming Spring 2011

- Administration — Lecture 0
  - Course area and learning goals
  - Learning methods
- Introduction to Concurrency — Lecture 1
- Slides in English, lectures in Finnish
  - Non-Finnish speakers can read the slides even if they do not understand the lectures

Connections



Course Connections



Motivation

- To know and understand …
  - Why concurrency is important
  - What are the concurrency problems in your systems
  - How concurrency problems are usually solved
  - What are the usual tools for solving concurrency problems
  - How concurrency problems may be solved at different system levels
    - HW, OS, progr. language library, application

Learning Goals

http://www.cs.helsinki.fi/group/rodes/kurssilmo/kurssikuvaukset/2008_09_01oppimistavoitteet.pdf
http://www.cs.helsinki.fi/group/rodes/kurssilmo/kurssikuvaukset/2008_09_01oppimistavoitteetE.pdf

- Concurrency and problems caused by concurrency
  - Basics, fundamental ideas, background
- Fundamental concepts and models in concurrency
  - Main emphasis is here!
  - E.g., “can explain special features of semaphores and monitors and use them properly in applications”, or “can explain how deadlocks can be prevented”.
- Concurrent programming in multicore and distributed systems
  - Get taste of it, more in later courses
- Concurrent programming in practice
  - Discussed in lectures
  - Practice with BACI (1 core) and in project (multicore)

What Good is Concurrent Programming for?

- All computer systems are inherently concurrent – one must understand concurrency to understand computer system operation
- Concurrency allows huge speedups for properly designed systems
- Concurrency causes complex problems that are not easy to solve without good understanding of concurrency
  - Should I use threads in my Java application or not?
  - **Would it be better to use locks, semaphores, monitors or transactional memory to solve synchr. and communication problems in my application?**
  - Why doesn't it do what I thought it would do?
  - How can I show my boss that it really works?

What is Not Covered?

- How to write efficient code for multicore systems?
- What types of applications are suitable for multicore systems?
- What programming paradigms exist to write efficient code for multicore systems?
- How to write multicore code so that it would run in many multicore systems?
- How to best utilize multicore GPU in your application?
  - CUDA - Compute Unified Device Architecture
  - How to partition your solution to multicore CPU & GPU?
- Programming distributed applications

Learning Methods

Mordechai Ben-Ari
http://stwww.weizmann.ac.il/g-cs/benari/

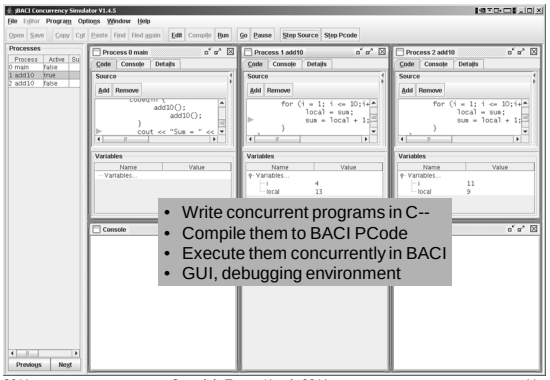
- Text book: Ben-Ari 2006 (& Stallings 2008)
- Lecture notes
  - Not perfect for self study – use with text book
- Summary lectures & discussions
- BACI – Ben-Ari Concurrency Interpreter
- Practice problems (kertaustehtävät)
- Homeworks (kotitehtävät)
- Project (laskuharjoitukset)
- Group meetings (practice sessions) (study circle teamwork, opintopiirit)
- Learning diary (elective)
- Course exam

William Stallings
http://www.acm.org/crossroads/xrds10-4/stallings.html

Lectures

- Summary lectures
  - Assumed: students have read the text book in advance
    - Basic knowledge of today's topic
- Discussion items
  - Goal: deeper understanding of today's topic
  - Students discuss given topics in small groups (2-3 students sitting next to each other)
    - Given topics
    - Students suggestions/question

BACI – Ben-Ari Concurrency Interpreter



- Write concurrent programs in C--
- Compile them to BACI PCode
- Execute them concurrently in BACI
- GUI, debugging environment

Java

- How to use Java for Concurrent Programming?
  - Threads
  - Messages (viestit)
  - Semaphores (semafori)
  - Monitors (monitori)
- Lectures
- Project

säikeet

Study Circles

opintopiirit

- Group work, team work
  - It is better to study in a team than alone
  - Peer student support
  - Study circles formed in the first group meeting
- Student centered learning
  - The student has responsibility on learning
  - Instructor facilitated learning
  - Instructors give good environment for learning
- Team work
  - Solving homework problems independently and then discussing them in study circles and in group meetings
  - Project
  - Any other co-operative work for this course

Creation of Study Circles

- Possibly the largest problem in study circle courses
  - "Ville promised, but did not do and he was not accessible. And then Maija did most of it. This is not right! Boohoo! ☹"
- Study circles are formed in the 1st group meeting
  - Goals should be similar
    - Easy in real life: "you will finish it or …"
  - Think about your goals before the 1st group meeting
    - Do I want to learn a lot, or just pass the course?
    - Will I help others, or just concentrate on my own work?
  - Discuss and agree on common goals before agreeing on forming a study circle
    - Finally, sign the "Study Circle Contract"

http://www.cs.helsinki.fi/u/kerola/rio/opintopiiri_sopimus.html

- Keep up with your agreement
  - Inform the study circle immediately, if you will not continue
  - Get quickly rid of peer students who do not work as agreed on

Practice Problems

- Practice problems

kertaustehtävät

  - Self evaluation
    - Do them only after you think you know the material
    - Do I understand it now?
    - They check only some part of the material, no guarantees!
  - Use does not directly affect your grade
    - No bookkeeping on material use
    - No credit toward course grade

https://www.cs.helsinki.fi/i/kerola/rio/kertaus/pract.html

Homework Problems

- Normal homework problems
- Learning happens when you *solve* the problems and *discuss* them
  - Study topic area first before trying out the problems
  - Work on the problems independently before discussing them
  - Reading a complete solution or giving one to peer student is wasting a good problem!
- Homework problems are discussed at
  - Study circle own meetings before group meetings
  - Group meetings with peer students at the table
- Affects your grade
  - You get homework points (hwp, lhp) for completed problems
  - Only for those present in group meeting

http://www.cs.helsinki.fi/group/nodes/kurssit/rio/2011k/laskuharj/lh1.html

Group Meetings

Laskuharjoitus

- Mark down the problems you have completed
- Assistant will organize you in tables
  - Each table should have a student solution for each problem
  - One or more tables may be in English in English speaking practice session
- Discuss all problems in your own table
  - You should have at least tried to solve all problems beforehand
  - You should understand all solutions at end
  - Other students in your table should understand all solutions at end
  - Correct solutions are available, consult assistant if needed
  - Usually no presentations in front of class
- Discuss additional topics given in solutions paper
  - Open ended discussions, no "correct" answers given
- Common discussion of selected problems/solutions
- Advice students in other tables, if needed

Project

- Team work with Study Circle, or alone
- Deeper understanding on practical concurrent programming
  - Other course components needed as background knowledge
- Affects your grade (20/60 points)

Studying for This Course

- Study weekly topics — read
  - Read the text book the same topics, with different approach
    - Use lecture slides if you find them useful — hear, discuss
  - Attend summary lectures and actively participate discussions — think
- Check your learning with self evaluation
  - Do practice problems and homework — do, evaluate
- Participate in study circle
  - Discuss homework — discuss
  - Weekly group meeting — discuss
  - Continue projects — do
  - Study circle meet face-to-face or in the web — discuss
- Finish project in time — read
- Study for exam — evaluate
- Course exam — do

think, do, reflect

Evaluation

- Self evaluation
  - Do practice problems after each topic
    - Does not affect your grade
  - Do homeworks each week
    - Do I understand or not?
    - What is there still to learn and how do I do it??
    - Affects your grade
- Course exam
  - Gives a fixed deadline for learning
  - Covers all topics
    - Topics learned in independent study as well as in study circles using various learning methods
  - Evaluates learning
    - Most of the grade based on this
    - Must reach certain level (50%) to pass the course

Grading

- Good work is awarded
- Diligence and knowledge is awarded
- Course component maximum grade points

Homeworks (min 1 p)	10 p
Project (min 1 p)	20 p
Course exam (min 15 p)	30 p
Total (min 30)	60 p

Course contents

- Lecture 0: Admin
- Lecture 1: Concurrency
- Lecture 2: Concurrency at Progr. Lang. Level — Concurrency and problems caused by concurrency
- Lecture 3: Critical Section Problem
- Lecture 4: Verifying Concurrent Programs
- Lecture 5: Deadlocks
- Lecture 6: OS Support for Conc: Semaphores
- Lecture 7: More on semaphores
- Lecture 8: Progr. Lang. Support for Conc: Monitors — Fundamental concepts and models in concurrency, Concurrent programming in practice
- Lecture 9: Concurrency Control in Distr. Environment
- Lecture 10: Crit. Sections in Distributed Environment — Conc. progr. in distr. systems
- Lecture 11: Practical Examples on Concurrency Control
- Lecture 12: Current Research, Course Summary
- Project: Java programming — Conc. progr. in practice

Motto

- "It is not good exercise, if you do not sweat"
- This is not a marathon!
- Study-week approach (3 study week course)
  - Total some 120 h / 3 sw course (= 3 work weeks)
- Top-down approach

5 yrs / 300 cu = 1 yr / 60 cu = 1600 h / 60 cu
= 26.67 h / 1 cu = 160 h / 6 cu

  - Total some 160 h / 6 cu (107 h / 4 cu) course

Summary

- Course administration
- Course components and learning methods
- BACI simulator
- Lecture format
- Project