Performance Evaluation for Network Engineering

IK3506

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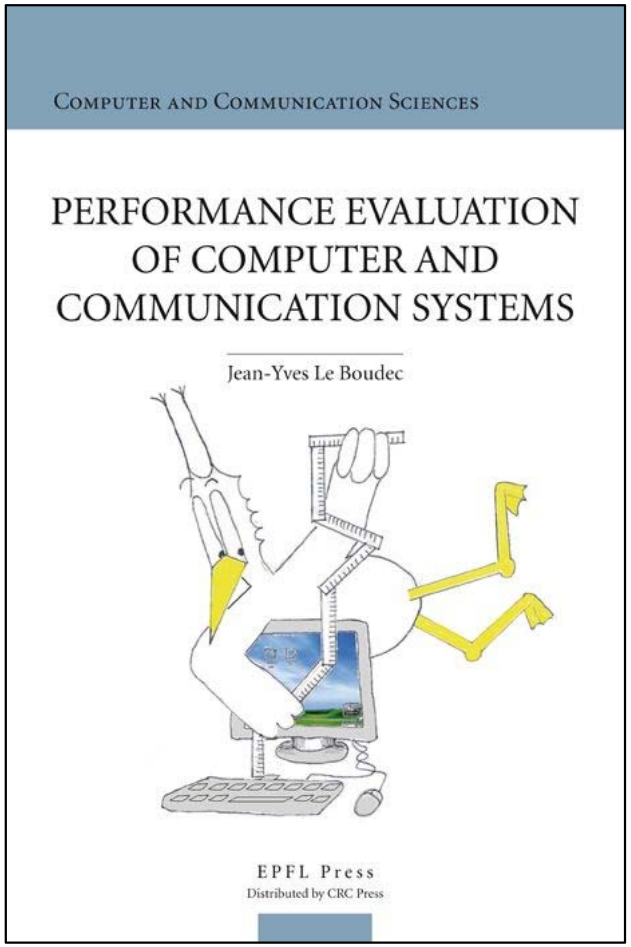
This course covers

General-Purpose Theoretical Subjects in Networking Field

- **Confidence Intervals** (Ch. 2)
- **Simulation** (Ch. 6)
- **Queuing Theory & Networks** (Ch. 8)
- **Palm Calculus** (Ch. 7)
  - Higher-level reinterpretation of queuing theory
- **Model Fitting** (Ch. 3)
- ~~**Tests** (Ch. 4)~~



Organization: *Combinatorial Assessment!*

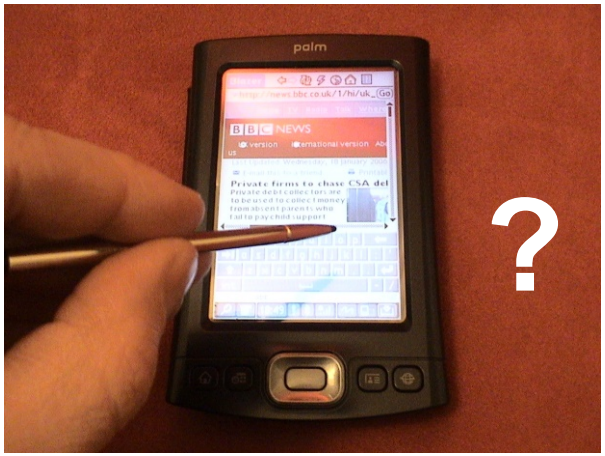
9 Lectures + 1 Question Session (10%)

4 Homeworks (40%), Mini-Project (50%)

~~**Final exam (30%) from textbook examples in case of IK2219**~~

More information: ***http://web.ict.kth.se/~jwcho/IK2219-Course-Plan.pdf***

Palm Calculus ???



Palm Calculus

- The pinnacle of this course, *Palm Calculus*, was named after
  - **Conrad "Conny" Palm** (1907-1951), Swedish statistician
    - studied at KTH
    - laid a foundation for **elegant** unification of queuing theory and point process

Why Theory? : Common Language

Fairness in general networks

Proportional Fairness

Max-Min Fairness

Unification under optimization theoretic framework in 2000 [MO00]

Max-Min Fairness

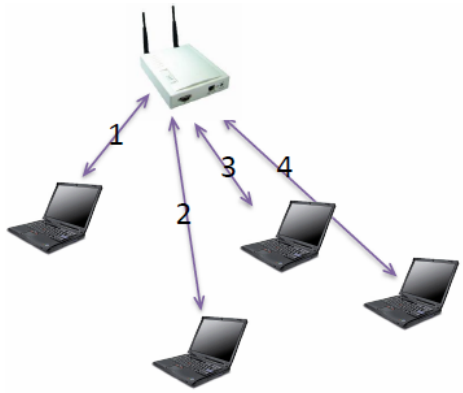
Proportional Fairness

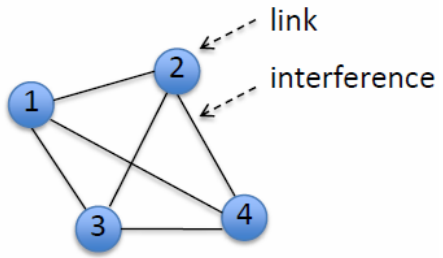
Other Fairness Concepts in Microeconomics

Re-Unification under axiomatic framework in 2013 [JOE13]

[MO00] J. Mo and J. Walrand, "Fair end-to-end window-based congestion control", **IEEE/ACM Transactions on Networking**, October 2000.
[JOE13] C. Joe-Wong, S. Sen, T. Lan, and M. Chiang, "Multi-resource allocation: Fairness-efficiency tradeoffs in a unifying framework", **IEEE/ACM Transactions on Networking**, December 2013.

Why Theory? : Profundity





Interference graph

A key formula in Wi-Fi networks:

Collision probability <-> Number of nodes

Bianchi [BIA00] proved the formula in 2000 under decoupling assumption.

This assumption has been validated only recently through a few theoretical results [BOR10] derived from mean field theory.

[BIA00] G. Bianchi. "Performance analysis of the IEEE 802.11 distributed coordination function", **IEEE Journal on Selected Areas in Communications**, March 2000. (Total citation counts: 6585)

[BOR10] C. Bordenave, D. McDonald, and A. Proutiere. "A particle system in interaction with a rapidly varying environment: Mean field limits and applications", **Networks and Heterogeneous Media**, March 2010.

Why Theory? : Simply Indispensable

Example:

Suppose you sample inter-arrival times of a bus for a very long time and found out that the average is m=10 minutes with standard deviation σ=5 minutes.

On the next day, you are waiting for the same bus at the same station.
How long are you expected to wait on average?

~~Wrong answer: 5 minutes~~

Correct answer: 6 minutes and 15 seconds

Feller's Paradox

Seemingly simplistic questions just can't be answered without theory.

Review Question Session (10%)

- **Objective:** icebreaking for communication among all participants!
- **How?**: Present how to solve 1-2 questions in “Review Questions”
  - All the review questions and solutions are available on Moodle
  - You will be assigned to one lecture, at the beginning of which you can use 5 minutes for presentation.

- **<u>Strongly Recommended Alternative</u>**
  - You can present your research problem which you are attempting to connect to methodologies in the course.

- Grading
  - **Is it presented within 5 minutes? (80%)**
  - Questions are solved correctly and understandably? (20%)

Homework Assignments (40%)

- **You will learn a considerable part of the course just by doing your homework!**

- **Performance Data Summarizations** (Chapter 1)
- **Random Waypoint Simulation** (Chapters 6, 7)
- **Queuing Theory form Palm Viewpoint** (Chapters 7, 8, 6)
- **Web Server Simulation** (Chapters 8, 6)

- **Obtain MATLAB license ASAP if you don't have one!**

- **Homeworks will be graded in a rather merciless way:**
  - You are unlikely to achieve any point if your answer is incorrect.
  - You'd better score 75% or more of all homeworks to pass the course.

Mini-Project (50%)

- **Guideline for Topics**
  - Most Desirable : A ***case study*** showing how methodologies in the course are applied to your real research problems.
  - Very Desirable: Bring up one of **papers in your research area**, which must be closely connected to the course.
  - Very Desirable : Choose one of **alternative topics** (papers) on Moodle
- **Grading**
  - Mini-Project Proposal : 5%
    - One page description of the project by the designated deadline
  - Mini-Project Presentation : 25%
    - Present the goal and methodology in a clear & understandable way
  - Mini-Project Report : 20%
    - Present the same in a prosaic way where you demonstrate your full understanding of the methodology.
- **Refer to the detailed description on Moodle!**

Revelation: **No All-Cure-Potion** for Research

- **Mere application of *well-known* theoretical results is unwelcome**
  - At least in top-tier journals and conferences
    - Why?: The **lack of theoretical novelty** of well-known results
  - Option 1: You need to make genuine theoretical contributions.
  - Option 2: You need to apply unknown (undiscovered) recent advances.

Mathematicians

Doable for engineers

- **Dizzyingly *vast* theoretical subjects**
  - **Even a dozen of courses can't cover its vastness.**
  - Among them, you must **find** the best-matching one, if any **exists**.
  - You must ensure that the **combination** of your given problem and the theory results in a **pragmatic** and **implementable** outcome.
  - Realistically speaking, you can **rarely** find such a **combination** in well-known theoretical results.

Grim Truth

- **To find such a rare combination for your research, you must be capable of digging out recent advances by yourself.**

- **<u>The overall objectives of this course</u>**
  - To expose students to the most **essential theoretical** results for data processing in the field of networking
  - To help develop mathematical ***muscles*** and ***immunity*** in **most-connected** theoretical results in the field of networking, which you **flex later** to bravely dive into new advances in various theoretical subjects.