PhD course “Game theory and Optimization for Economics: Modern Information and Telecommunication Networks”,

Norwegian University of Science and Technology, Trondheim

Lecturer: Dr. Bruno Tuffin, INRIA and University of Rennes, France

The course will take place on November 16 – November 20.

To register for the course, please send an email to Ingjerd Fugleberg Kildal: ingjerd.kildal@iot.ntnu.no

If you have any questions regarding the course, you can contact Ingjerd Fugleberg Kildal at NTNU.

1. Outline of the course

This course provides in-depth knowledge how the methods of game theory, continuous optimization and auction theory are applied for analysis of important problems in modern economics. Selected application field is modern information economics and in particular, Internet and Internet based services, communication networks.

The course is naturally divided into two submodules. Submodule 1 (2 days) deal with methodology: overview of basic notions of continuous optimization, game theory and auction theory, which are important for economic analysis. Submodule 2 (3 days) provides the students with practical knowledge how the concepts from Submodule 1 are used for analysis of different phenomena in information economics. In order to cement the student’s knowledge, the students will be asked to explore further relevant economic themes writing essays on approved topics, which will be graded.

In this way, the course will present a balance of theory and practice, giving comprehensive overview of relevant mathematical optimization and game theoretical models together with the key issues in telecommunication network economics. The mathematical foundations enable the reader to understand the economic issues arising at this pivotal time in network economics, from business, research and political perspectives. Some of the practical examples include app stores, volume-based pricing, auctions for advertisements, search engine business models, the network neutrality debate, the relationship between mobile operators and mobile virtual network operators, and the economics of security.

Structure of the course and final assessment:

The course will encompass five full days of tuition. The first day will only consist of lectures; each subsequent day will consist of lectures and case study/problem solving sessions. Total of six lectures is planned, each lecture is four academic hours with breaks in between.

The case studies and working on problems should be done in pairs. For case studies, the students will need an access to a computer with internet connection (for data search and download) and a suitable implementation software, such as Matlab. The case studies will end in writing short essays and small presentations by students. The course will end with a take-home written exam and the final assessment is done by combining the grade for the essays (50%) with the grade for the exam (50%).

2. Course contents:
Submodule 1. Methodology: optimization, game theory, auctions (1.5-2 days)
This submodule gives an overview of theoretical concepts, which will be further explained and illustrated with practical economic examples in Submodule 2.

Topics:

1. Optimization
- Continuous optimization methods
- Fixed-point results

2. Game theory
- Vocabulary and definitions
- Non-atomic games
- Bayesian games
- Congestion games
- Potential games
- Stackelberg games
- Repeated games

3. Auctions
- General principles and desirable properties
- The revelation principle
- First-price auctions
- Iterative open auctions
- Second-price auctions
- Revenue-equivalence results
- Vickrey–Clarke–Groves auctions
- Combinatorial auctions
- Double-sided auctions

Submodule 2. Application: Economics of modern telecommunication networks (3-3.5 days)
This submodule shows how to apply game theoretic and optimization methodology of Submodule 1 to analyze important economic problems from economics and planning of modern telecommunication networks and related information and service economics. Optimization and game theoretical issues are further developed and explained in parallel of analyzing economic situations. For those primarily interested in telecommunication economics this submodule gives an adequate introduction into the subject and supply the possibilities to deepen one’s knowledge.

Part of the topics listed below will be treated during the lectures, while others will serve as topics for case studies and essays for independent work and examination.

Topics:

1. Economics of access service providers
- History and evolution of access pricing models
- Expectations of users and ISPs, impact on other actors
- Flat-rate pricing
- Volume-based pricing
- Congestion and value-based pricing
- Pricing and connection acceptance control
- Multiclass pricing
- Auctions
- Interference-based pricing for wireless networks
- The Kelly mechanism
- Economics of bundling

2. Economics at the content and application level
- A bit of history
- Advertising
- Auctioning for advertising slots: basic principles
- Auctions between advertisers
- Extensions of the basic auction model
- Pay-per-click or pay-per-view?
- Learning
- Existing tools/companies
- Paid applications versus free applications with advertisements
- Economics of clouds/grids
- Economics of peer-to-peer systems
- Economics of content delivery networks

3. Interactions among network service providers
- Introduction
- Auctions for wireless spectrum
- Why use auctions?
- Auction rules and evolution
- Evolving from simultaneous ascending auctions to incentive auctions
- Competition between access providers
- Association models based on user utility
- Aggregated demand models
- Providers competing in multiple-time-scale decision games
- To license or not to license resources?
- Client but competitor: the (unsustainable?) situation of MVNOs
- Exploiting secondary markets
- Can MNO–MVNO associations survive? Observations from different countries
- Can MNO–MVNO associations survive? Theoretical approaches
- The economics of interconnection
- The problem of incentivizing intermediate entities
- Some proposals for ad-hoc networks or multi-hop cellular networks
- The economics of community networks

4. Interactions among content or application service providers
- Competition at the content level
- General models
- Online TV competition
- An illustrative model of competition among free CPs with advertising
- A specific case: competition between search engines
- The economics of network security
- Economic models for security analysis
- Competition among security providers
- Collaboration/competition issues
Background Reading:


Handouts:

Handouts will consist of: lecture slides, lecture notes written and copies of the key articles.

Problems:

Computational problems and exercises will be distributed among the participants during each lecture. These problems are meant to be solved during practical sessions and are similar to the exam questions.

Essays and case studies:

Students will choose the topics of essays from those not covered during the lectures in Submodule 2 and develop them using the modern research literature, presenting survey of relevant game theoretic and optimization models, where appropriate. Essays will be graded by commission composed from the lecturer and NTNU staff members.