SOM 825 – Advanced Mathematical Programming: Dynamic Network Systems

Spring 2012

Class Time: Tuesdays: 1:00-4:00PM
Classroom: ISOM Room 128

Instructor: Dr. Anna Nagurney
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Course Description:

This course is an advanced mathematical programming course and builds on the material in SOM 822. As such, it is assumed that the students are familiar with network equilibrium models and the fundamentals of variational inequality theory although a review of the latter will be given.

The course emphasizes the construction of dynamic network models, qualitative analysis, and algorithms for wide-ranging applications. It focuses on projected dynamical systems theory and its relationships to variational inequality theory. Projected dynamical systems theory has evolved as a powerful methodology for capturing the dynamics underlying complex network systems and the associated disequilibrium behavior since one of the notable features of a projected dynamical system is that its set of stationary points coincides with the set of solutions to a finite-dimensional variational inequality problem.

Specific applications that will be covered in the course include: dynamic games and oligopoly problems, dynamic spatial price equilibrium problems, dynamic transportation problems (both fixed and elastic demand ones), financial network problems, migration problems, and complex supply chains.

Stability analysis of such models will be discussed as well as algorithms with convergence results. Special features of the problems which enable the implementation of algorithms on massively parallel architectures will also be revealed.

In addition to finite-dimensional models, evolutionary variational inequality theory will also be introduced and relevant other methodologies for the modeling and solution of dynamic network problems highlighted.

There will be three books utilized as supplements for the course which will be made available to students in ISOM G28. These books are:

***Network Economics: A Variational Inequality Approach*, second and revised edition, 1999, Anna Nagurney, Kluwer Academic Publishers, Boston, Massachusetts.**

***Projected Dynamical Systems and Variational Inequalities with Applications*, 1996, Anna Nagurney and Ding Zhang, Kluwer Academic Publishers, Boston, Massachusetts.**

***Dynamic Networks and Evolutionary Variational Inequalities*, 2006, Patrizia Daniele, Edward Elgar Publishing, Cheltenham, England.**

The course will make heavy use of primary source materials, especially journal articles. The required reading list follows the Outline of Course Topics.

Outline of Course Topics

Introduction to Projected Dynamical System Theory

Qualitative Properties

Stability Analysis

The General Iterative Scheme

Dynamic Games and Oligopolistic Market Models (Classical and Spatial)

Dynamic Spatial Price Models and Algorithms
**** Quantity Formulation**
**** Price Formulation**

Dynamic Financial Network Models

Dynamic Traffic Network Models and Algorithms
**** Elastic Demand Models (Known Demand Functions and Known Travel Disutility**

Functions)
** Fixed Demand Models

Dynamic Supply Chains
** Multilevel
** Integrated with Social Networks
** With Environmental Decision-Making and Corporate Social Responsibility
** Electric Power Networks

The Internet and Evolutionary Variational Inequalities
** The Time-Dependent Braess Paradox

Requirements

The Required Reading List

P. Dupuis and A. Nagurney, Dynamical systems and variational inequalities (1993), *Annals of Operations Research*, 44, 9-42.

D. Zhang and A. Nagurney, On the stability of projected dynamical systems (1995), *Journal of Optimization Theory and its Applications*, 85, 97-124.

A. Nagurney, Parallel computation of variational inequalities and projected dynamical systems with applications (1997), in *Parallel Computing in Optimization,* A. Migdalas, P. M. Pardalos, and S. Storoy, editors, Kluwer Academic Publishers, Dordrecht, The Netherlands, pp. 343-411.

A. Nagurney, P. Dupuis, and D. Zhang, A dynamical systems approach for network oligopolies and variational inequalities (1994), *Annals of Regional Science*, 28, 263-283.

D. Zhang and A. Nagurney, Stability analysis of an adjustment process for oligopolistic market equilibrium modeled as a projected dynamical system (1996), *Optimization*, 36, 263-285.

J. Pan and A. Nagurney, Using Markov chains to model human migration in a network equilibrium framework (1994), *Mathematical and Computer Modeling*, 19, 31-39.

A. Nagurney, T. Takayama, and D. Zhang, Projected dynamical systems modeling and computation of spatial network equilibria (1995), *Networks*, 26, 69-85.

A. Nagurney and D. Zhang, On the stability of an adjustment process for spatial price equilibrium modeled as a projected dynamical system (1996), *Journal of Economic Dynamics and Control,* 20, 43-62.

J. Dong, D. Zhang, and A. Nagurney, A projected dynamical systems model of general financial equilibrium with stability analysis (1996), *Mathematical and Computer Modelling*, 24, 35-44.

D. Zhang and A. Nagurney, Formulation, stability, and computation of traffic network equilibria as projected dynamical systems (1997), *Journal of Optimization Theory and its Applications*, 93, 417-444.

A. Nagurney and D. Zhang, Projected dynamical systems in the formulation, stability analysis and computation of fixed demand traffic network equilibria (1997), *Transportation Science*, 31, 147-158.

D. Zhang, A. Nagurney, and J. Wu (2001), On the equivalence between stationary link flow patterns and traffic network equilibria (2001), *Transportation Research B*, 35, 731-748.

F. Yang and D. Zhang, Day-to-day stationary link flow pattern (2009), *Transportation Research B* 43, 119-126.

A. Nagurney, K. Ke, J. Cruz, K. Hancock, and F. Southworth, Dynamics of supply chains: A multilevel (logistical/informational/ financial) network perspective, *Environment & Planning B,* 29, 795-818.

T. Wakolbinger and A. Nagurney, Dynamic supernetworks for the integration of social networks and supply chains with electronic commerce: Modeling and analysis of buyer-seller relationships with computations (2004), *Netnomics,* 6, 153-185.

J. M. Cruz, Dynamics of supply chain networks with corporate social responsibility through integrated environmental decision-making (2008), *European Journal of Operational Research* 184, 456-472.

A. Nagurney, D. Parkes, and P. Daniele, The Internet, evolutionary variational inequalities, and the time-dependent Braess paradox (2007), *Computational Management Science* 4, 355-375.

A. Nagurney, Z. Liu, M.-G. Cojpcaru, and P. Daniele, Dynamic electric power supply chains and transportation networks: An evolutionary variational inequality formulation (2007), *Transportation Research E* 43, 624-646.

There will be regular written homework assignments given out in class that will be graded and returned. In addition, there will be two individual short projects, consisting only of class presentations, and a research paper project, consisting of a paper and class presentation, to be discussed further in class. The students are required to attend the classes. If a student cannot attend class, please notify Professor Nagurney via email or by phone prior to the class absence. This course will be run as a seminar.

Grading

Class participation:	**20%**
Homework:	**20%**
Individual class presentations:	**25%**
Research project and presentation:	**35%**