ERCIM "Alain Bensoussan" Fellowship Scientific Report

Fellow:	Orestis Telelis
Visited Location :	Center for Mathematics and Computer Science (CWI) Amsterdam
Duration of Visit:	5 October 2009 – 4 July 2010

I - Scientific activity

(1 page at maximum)

The fellow's research focused on the game-theoretic study of congestion effects and the design and evaluation of coordination mechanisms. These themes are motivated by efficient resource utilization in large-scale distributed environments. Modern computer communications networks are built upon a bulk of interconnected resources – storage, processors, network links etc. The infrastructure and the distributed software operating on it are arenas of strategic interaction among autonomous agents with individual ob jectives, i.e. end-users, communities, enterprises. Agents autonomously acquire resources over networking platforms to serve their individual needs. Their self-interested activity may well lead to inefficient overall resource utilization. Due to the large number of resources and agents, a central authority should specify local – per resource – utilization rules, to manipulate congestion effects towards system-wide cost efficiency. These sets of rules constitute Coordination Mechanisms.

Agents interact in the formal context of a strategic game, where each makes a strategic choice to optimize his individual objective. The most prominent stability (solution) concept for strategic games is the Nash equilibrium, where no agent may modify his strategy and improve his own objective. Another relevant stability concept is the strong equilibrium - introduced by Aumann in 1960 - which is resilient to coalitional deviations. The efficiency of stable configurations is quantified by the aggregate utility or cost incurred over all agents, often termed as social cost. The most established measure for quantifying efficiency of equilibria is the Price of Anarchy (PoA) introduced by Koutsoupias & Papadimitriou in 1999, as the worst-case ratio of the social cost of the least efficient equilibrium relative to the optimum achievable social cost. The design and analysis of Coordination Mechanisms have been largely exemplified in the context of multiprocessor scheduling, where each agent assigns a task he owns to one out of m parallel machines. A coordination mechanism is then the set of local scheduling policies deployed on the machines; these induce a strategic game, by indirectly deciding the cost (completion time) experienced by each agent on each machine. Cost efficiency of equilibrium assignments is measured by their makespan, i.e. completion time of the most delayed agent. The aim is to design a mechanism inducing pure Nash equilibria that are efficiently computable and have small Price of Anarchy. During his assignment at CWI, the fellow surveyed the existing literature on scheduling games and coordination mechanisms and worked on two generalizations of the scheduling context. The first is the context of *Scheduling with Setup Times* while the second is *Bottleneck Congestion Games*, that greatly generalize load balancing games, from the simple case of parallel machines to complexes of resources that can be e.g. network paths. Three scientific articles were produced during the author's stay at CWI, the contents of which are summarized in the following section. The fellow attended one workshop to present one of these works, which appears in the workshop's proceedings. The other two are submitted for review.

II- Publication(s) during your fellowship

Please insert the title(s), author(s) and abstract(s) of the published paper(s). You may also mention the paper(s) which were prepared during your fellowship period and are under reviewing.

1. Strategic Scheduling Games: Equilibria and Efficiency.
Laurent Gourves, Jerome Monnot, Orestis Telelis.
Chapter Under Review in "Just-In-Time Systems" (eds: Y. A. Rios-Solis, R. Z. Rios-Mercado) Springer Series on Optimization and its Applications (eds: P. M. Pardalos, D.-Z. Du), 2010.

Description. We survey extensively the recent literature on strategic scheduling games and coordination mechanisms. These have emerged by the need for understanding and manipulating congestion effects in systems of distributed resources that are operated by self-interested autonomous entities.

2. Selfish Scheduling with Setup Times.
Laurent Gourves, Jerome Monnot, Orestis Telelis.
Proceedings of the 5th International Workshop on Internet & Network Economics (WINE), Lecture Notes on Computer Science, vol. 5929, Springer, pages 202–303, 2009.

Abstract. We study multiprocessor scheduling games with setup times on identical machines. Given a set of scheduling policies (coordination mechanism) on the machines, each out of n players chooses a machine to assign his owned job to, so as to minimize his individual completion time. Each job has a processing length and is of a certain type. Same-type jobs incur a setup overhead to the machine they are assigned to. We study the Price of Anarchy with respect to the makespan of stable assignments, that are pure Nash or strong equilibria for the underlying strategic game. We study in detail the performance of a well established preemptive scheduling mechanism. In an effort to improve over its performance, we introduce a class of mechanisms with certain properties, for which we examine existence of pure Nash and strong equilibria. We identify their performance limitations, and analyze an optimum mechanism out of this class. Finally, we point out several interesting open problems.

3. On the Social Inefficiency of Equilibria in Linear Bottleneck Congestion Games.
Bart de Keijzer, Guido Schaefer, Orestis Telelis.
Submitted to the 3rd International Symposium on Algorithmic Game Theory (SAGT), 2010.

Abstract. We study the inefficiency of equilibrium outcomes in bottleneck congestion games. These games model situations in which strategic players compete for a limited number of facilities. Each player allocates his weight to a (feasible) subset of the facilities with the goal to minimize the maximum (weight-dependent) latency that he experiences on any of these facilities. We derive upper and (asymptotically) matching lower bounds on the (strong) price of anarchy of linear bottleneck congestion games for a natural load balancing social cost objective (i.e., minimize the maximum latency of a facility). We restrict our studies to linear latency functions. Linear bottleneck congestion games still constitute a rich class of games and generalize, for example, load balancing games with identical or uniformly related machines with or without restricted assignments.

III -Attended Seminars, Workshops, and Conferences

Please identify the name(s), date(s) and place(s) of the events in which you participated during your fellowship period.

5th International Workshop on Internet & Network Economics,
Rome, Italy, December 14-18, 2009.
Purpose: Presentation of the paper entitled "*Selfish Scheduling with Setup Times*",
co-authored with L. Gourves and J. Monnot.