CO4212 Game Theory in Computer Science

Credits: *15* **Convenor:** *Dr FJ de Vries* **Semester:** *2nd*

Prerequisites:	*none*				
Lectures:	*24*	*hours*	**Problem Classes:**	*8*	*hours*
Surgeries:	*8*	*hours*	**Independent Study:**	*72.5*	*hours*
Assessment:	*Coursework: 40% + Two hour exam in May/June: 60%*				

Subject Knowledge

Aims This module teaches the fundamental concepts of game theory in the context of applications in computer science.

Learning Outcomes Students should be able to: describe different mathematical models of games; state and discuss basic concept from game theory, such as Nash equilibria; calculate Nash equilibria of game trees and strategic form games; list a number of application areas of computer science where game theoretical models are relevant; apply methods from algorithmic game theory to the modelling and analysis of real-world problems.

Methods Class sessions together with course notes, recommended textbooks, worksheets, and some additional hand-outs and web support.

Assessment Marked problem-based worksheets, class tests, traditional written examination.

Skills

Aims To teach students scientific writing, modelling and problem solving skills.

Learning Outcomes Students will be able to: write short, clear, note based, summaries of technical knowledge; solve abstract and concrete problems (both routine seen, and simple unseen).

Methods Class sessions together with worksheets.

Assessment Marked problem-based worksheets, class tests, traditional written examination.

Explanation of Prerequisites A basic understanding of discrete mathematics, calculus, linear algebra, and probability will be helpful.

Module Description Modern computer science has to deal with large, heterogeneous networks in which a large number of autonomous agents interact. Often, such systems are not centrally planned, but evolve in a distributed fashion as a result of the interaction of agents. They can be modelled using concepts from game theory. This module introduces the basic concepts from game theory and discusses their use in the solution and modelling of problems faced by computer scientists. Examples include the prediction of the equilibrium state reached via the interaction of selfish users in a communication network, and the comparison of that state with a globally optimised state. Other examples include the design of mechanisms ensuring that individual players will behave in a way that achieves a desirable global state of the system.

Syllabus The course will roughly cover the following topics:

- Part 1: An Introduction to Non-Cooperative Game Theory
  - Definition of game trees (extensive games with perfect information)
  - Backward induction
  - Strategies and strategy profiles
  - Games in strategic form

- Symmetric games
- Dominance and eliminaion of dominated strategies
- Nash equilibrium
- Reduced strategies
- Subgame perfect Nash equilibrium (SPNE)
- Commitment games.
- Bimatrix games
- Matrix notation of expected payoffs
- The best-response condition
- Existence of mixed equilibria
- Degenerate games
- Zero-sum games
- Extensive games with imperfect information
- Perfect recall

• Part 2: Some Topics at the Interface of Game Theory and Computer Science

- The price of anarchy (coordination ratio) and the price of stability
- Network routing games
  * Atomic and non-atomic routing games
  * Pigou's example
  * Braess's paradox
- Network design games
- Complexity of computing equilibria
- Vickrey auctions
- Applications of game theory in computer science

Reading List

[A] Bernhard von Stengel, *Notes on Game Theory Basics,* Available from the module webpage.

[A] Rahul Savani, *Notes on Routing Games,* Available from the module webpage.

[A] Noam Nisan, Tim Roughgarden, Eva Tardos, Vijay V. Vazirani (Eds.), *Algorithmic Game Theory,* Cambridge University Press, 2007. We are likely to cover parts of Chapters 1, 2, 17 and 18.
Online: http://www.cambridge.org/journals/nisan/downloads/nisan_non-printable.pdf.

[C] Martin J. Osbourne, *An Introduction to Game Theory,* Oxford University Press.

[C] Ken Binmore, *Playing for Real,* Oxford University Press.

Resources Web page, study guide, worksheets, handouts, copies of research articles, lecture rooms with OHP and data projector.

Module Evaluation Course questionnaires, course review.