

Module Code	EEU45C07
Module Name	Self Organising Systems
ECTS Weighting¹	5 ECTS
Semester taught	Semester 1
Module Coordinator/s	Prof. Nicola Marchetti
Module Learning Outcomes with reference to the Graduate Attributes and how they are developed in discipline	<p>On completion of this module the student will be able to:</p> <ol style="list-style-type: none"> 1. Understand the limitations and applicability of self-organising systems, in particular with respect to communication networks. 2. Model wireless communications and networking systems using information theory, network science, dynamical systems theory, and game theory. 3. Identify and describe the performance of communication systems and components by using agent-based modelling techniques. 4. Use software tools to solve relevant self-organising network engineering problems. 5. Design and conduct software-based experiments working in a project team, demonstrating understanding of group dynamics and related leadership aspects. 6. Present the relevant technical aspects in a written form, in a way that is both concise and precise. <p>Graduate Attributes: levels of attainment</p> <p>To act responsibly - Enhanced</p> <p>To think independently - Enhanced</p> <p>To develop continuously - Enhanced</p> <p>To communicate effectively - Enhanced</p>
Module Content	<p>Modern communications research is tending towards a dynamical description of networks; examples include 5G networks, Internet of Things (IoT), drone-based systems and Industry 4.0. These dynamics, which include movement, growth, competition and adaptation, add complexity to the networks. All of this drives the requirement for self-organising functionality within the network transmitters and receivers as central planning becomes increasingly infeasible.</p> <p>This module discusses the emergent properties of these kinds of self-organising and highly dynamic networks, offering new insights that can be used in their design and deployment. The module introduces the students to the emerging scientific field of self-organisation. The module will focus on different aspects of relevance to self-organising systems, including: local</p>

¹ [TEP Glossary](#)

behaviour – global properties paradigm, implicit system coordination, self-synchronisation in nature and engineering systems, and adaptivity to changes.

Information theoretical aspects of complex systems will be considered, in terms of specific quantities that characterize to what degree and in what sense a system can be defined as complex, and the relation to other aspects such as regularity and randomness in network abstractions. The module will also cover computing aspects, such as cellular automata, agent-based modelling and bio-inspired algorithms, using such approaches and related software tools to model and study modern communication networks such as 5G networks, Internet of Things, unmanned vehicle-based systems, Industry 4.0 and social networks.

The module will then introduce students to network science aspects such as the classification of networks into random, small world, scale free, and regular, and how this relates to the analysis and design of modern communication networks. The time evolution of complex networks, encompassing dynamical systems, chaos theory and fractal geometry aspects, will then be studied. The module will finally discuss how game theory can be applied to model self-organisation in a communication network. Fundamental concepts in cooperative and non-cooperative game theory will be introduced, illustrating how they can be applied to model radio resource management in current and future networks.

Module syllabus:

1. Introduction to self-organising systems; local behaviour – global properties paradigm, implicit system coordination, self-synchronisation in nature and engineering systems, adaptivity to changes.
2. Information theoretical aspects; measures of entropy and complexity, and application to self-organizing cellular and IoT networks.
3. Computing aspects; cellular automata and agent-based modelling for 5G - and beyond - moving networks (including drone-based networks) and IoT (e.g. traffic lights control, industry 4.0).
4. Application of bio-inspired algorithms to communication networks (e.g., genetic algorithms, simulated annealing).
5. Network science aspects; small world and scale free networks and application to 5G and beyond networks, IoT and social networks.
6. Dynamical systems, chaos theory and fractal geometry aspects; application to telecom traffic modelling, circuit and antenna design.
7. Modelling of wireless communications and networking problems using game theory.

Teaching and Learning Methods

The module is taught using a combination of lectures and tutorials. Every week one lecture is allocated to tutorials.

Four software-based lab sessions will demonstrate some of the concepts covered in class. Students will be required to complete a software-based project focusing on the application of self-organising systems analysis and design to emerging topics in wireless networks, such as 5G and beyond networks, IoT systems, moving networks (including drone-based networks), industry 4.0 and social networks.

Assessment Details²

Please include the following:

- **Assessment Component**
- **Assessment description**
- **Learning Outcome(s) addressed**
- **% of total**
- **Assessment due date**

Assessment Component	Assessment Description	LO Addressed	% of total	Week due
Examination	2 hour written examination	LO1, LO2, LO3, LO6	50%	n/a
In class quiz	50 minute written examination	LO1, LO2, LO3, LO6	20%	5
In class quiz	50 minute written examination	LO1, LO2, LO6	20%	11
Lab project	Written report based on four 2 hour lab sessions	LO3, LO4, LO5, LO6	10%	5-6-9-10

Reassessment Requirements

Examination (2 hours, 100%)

Contact Hours and Indicative Student Workload²

Contact hours: 52
Independent Study (preparation for course and review of materials): 61
Independent Study (preparation for assessment, incl. completion of assessment): 12

² [TEP Guidelines on Workload and Assessment](#)

Recommended Reading List	<ul style="list-style-type: none"> • <i>Self-organising Software - From Natural to Artificial Adaptation</i>, G. Di Marzo Serugendo, M.P. Gleizes, A. Karageorgos, Anthony, Springer, 2011. • <i>Elements of Information Theory, 2nd edition</i>, T.M. Cover & J.A. Thomas, Wiley, 2006. • <i>An Introduction to Agent-Based Modeling</i>, U. Wilenski & W. Rand, MIT Press, 2015. • <i>Networks – An Introduction</i>, M.E.J. Newman, Oxford University Press, 2010. • <i>Lectures on Fractal Geometry and Dynamical Systems</i>, Y. Pesin & V. Climenhaga, American Mathematical Society, 2009. • <i>Game Theory for Wireless Engineers</i>, A. MacKenzie, L. DaSilva, Morgan & Claypool Publishers, 2006.
Module Pre-requisite	Mathematics (JS), Physics, Signal Processing (preferably JS), Basic knowledge of Linear Algebra and Probability and Statistics.
Module Co-requisite	n/a
Module Website	Material available on BlackBoard
Are other Schools/Departments involved in the delivery of this module? If yes, please provide details.	No
Module Approval Date	
Approved by	
Academic Start Year	
Academic Year of Date	