CO4211 Discrete Event Systems

Credits: *15* **Convenor:** *Dr M Hoffmann* **Semester:** *2nd*

Prerequisites:	*Desirable: There are no specific pre-requisites for this module. A basic knowledge of discrete mathematics is assumed and some experience with probability theory would be useful. Familiarity with programming would help put some of the aspects of the module into context.*				
Lectures:	*22*	*hours*	**Problem Classes:**	*4*	*hours*
Surgeries:	*8*	*hours*	**Independent Study:**	*78.5*	*hours*
Assessment:	*Two hour exam in May/June: 100%*				

Subject Knowledge

Aims To teach the theory and practice of Discrete Event Systems.

Learning Outcomes At the end of this module, students should be able to

- employ some basic formalisms of behavioural modelling (such as automata and Petri nets) to model real-world examples;

Methods Lectures, surgeries, problem classes, worksheets, course notes, and textbook.

Assessment Traditional written examination.

Skills

Aims The ability to apply mathematical formalisms to model and analyse event driven systems.

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), including the formal modelling of discrete systems.

Methods Lectures, surgeries, problem classes, worksheets, course notes and textbook.

Assessment Traditional written examination.

Explanation of Prerequisites

There are no specific pre-requisites for this module. A basic knowledge of discrete mathematics is assumed and some experience with probability theory would be useful. Familiarity with programming would help put some of the aspects of the module into context.

Module Description

A discrete event system is a mathematical model of a system (such as computational device) that communicates with its environment by atomic actions (called events). For example, a user of the system pressing a button could send a signal to a controller. These events are assumed to be discrete in the sense that they occur instantaneously (as opposed to over a period of time).

The module will present an overview of various modelling and analysis techniques for discrete event systems. We start by looking at sequential systems (where no two events can occur simultaneously). Systems of this kind will be modelled by *finite automata*. This class is then extended to allow for events occurring simultaneously; these are modelled by *Petri nets*. Subsequently, we will study techniques that allow us to extract quantitative information about the behaviour of systems. This gives rise to the class of *probabilistic systems* (where we assume that a certain event occurs with a given probability) and we can then estimate the likelihood of situations such as system failure. Included in this section is an introduction to queuing theory.

Syllabus

The module will be divided into three parts.

Automata and Languages. We study automata as models of sequential discrete event systems. Topics covered are:

- Modelling of Discrete Event Systems by Automata.
- Automata and Languages.
- Nondeterministic Automata.
- Operations on Automata and Modelling of Systems.
- Optimizing Automata.
- Limitations of Automata.

Petri Nets. Petri nets allow us to extend the class of systems to those where events can happen concurrently. Topics covered are:

- The Petri Net Model of Discrete Event Systems.
- Petri Nets and Languages.
- Safety in Petri Nets.
- Comparison of the Petri Net Model and the Automata Model.

Markov Chains and Probabilistic Models. This class of models allows to analyse systems that embody uncertainty in the sense that events are only known to happen with a certain probability. Topics covered are:

- Review of Basic Probability Theory.
- Markov Chains as Discrete Event Systems.
- Analysis of Markov Chains: Convergence and Transition Probabilities.
- Introduction to Queueing Theory.
- $M/M/1$, $M/M/1/N$ and $M/M/m$ queues.

Reading List

[B] C. Cassandras and S. Lafortune, *Introduction to Discrete Event Systems,* Springer, 2008.

Resources Study guide, worksheets, handouts, lecture rooms with whiteboards and a data projector.

Module Evaluation Module questionnaires, course review.