# EE517: Network Analysis & Dimensioning

## Module Details

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| **Title:** | Network Analysis & Dimensioning DRAFT |
| **Long Title:** | Network Analysis & Dimensioning |
| **Language of Instruction:** | English |
| **Module Code:** | EE517 |
| **Credits:** | 7.5 |
| **NFQ Level:** | 9 |
| **Field of Study:** | Electronic Engineering |
| **Valid From:** | 2017/18 (Sep 2017) |
| **Module Delivered In** | no programmes |
| **Administrator:** | Noel Murphy |
| **Module Coordinator:** | Conor McArdle |
| **Module Department:** | 20 - ELECTRONIC ENGINEERING |
| **Module Description:** | The aim of this module is to introduce the theory and practice of mathematical network analysis and optimisation methods as they apply to the problems of performance analysis of communications protocols, network dimensioning and capacity planning, network architecture design and traffic analysis in modern large-scale data networks, such as optically switched metro and access networks, datacenter and high performance computing interconnects, and femto-macro cell wireless network architectures. Network analysis is essential to understanding and evaluating the fundamental performance properties (e.g. latency, jitter, throughput, packet-drop rate) of complex network architectures and communications protocols. Network dimensioning methods are essential to planning and deploying large-scale networks under given capacity and cost constraints. This module will cover fundamental theory in probability, stochastic processes, queuing theory, graph theory and optimisation methods and apply them to solving various data network design and performance management problems. |

| **Learning Outcomes** | |
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| *On successful completion of this module the learner will be able to:* | |
| LO1 | Derive key results in queuing and teletraffic theory, as apply to the study of communication network performance analysis. |
| LO2 | Apply methods from probability and queuing theory to modelling of performance-related behaviour of a range of packet-switched and circuit-switched systems and networks. |
| LO3 | Apply queuing theory equations to calculate system performance measures (e.g. latency, throughput, packet loss) and to perform basic dimensioning of network resources to meet required performance targets. |
| LO4 | Develop a number of different probabilistic traffic models and determine their applicability to representing different network traffic types. |
| LO5 | Formulate a range of different network flow and resource dimensioning problems as mathematical optimisation problems. |
| LO6 | Apply optimisation theory to solving network flow, routing and resource allocation problems. |

| **Pre-requisite learning** |
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| ***Module Recommendations***<br>*This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.* |
| No recommendations listed |
| ***Co-requisite Modules*** |
| No Co-requisite modules listed |
| ***Pre-Requisite***<br>*This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.* |
| Knowledge of basic probability and queuing theory. Basic knowledge of data networks and protocols. |

# EE517: Network Analysis & Dimensioning

## Module Content & Assessment

| Indicative Content and Learning Activities |
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| **Course Introduction**<br>The what and why of network analysis and dimensioning. Typical questions answered by network analysis methods. Typical network design problems solved using dimensioning methods. Overview of the methods and the required mathematical background and tools. |
| **Review of Probability, Stochastic Processes and Markovian Queuing Systems**<br>Probability spaces, random variables, distribution functions, moment generation functions and transform methods, renewal processes, the Poisson process, continuous-time Markov Chains and Markovian queuing systems. |
| **Loss Systems and Applications to Blocking Network Analysis and Design**<br>The Erlang-B and Engset systems. Blocking in non-Markovian queues, Equivalent Random Theory (ERT), networks with blocking and the reduced load approximation. Applications to performance analysis of wavelength division multiplexed (WDM) optically-switched networks and hierarchical cellular networks. |
| **Quasi-Markovian/Non-Markovian Queuing Models**<br>Semi-Markov processes, mean delay and the delay distribution in the M/G/1 queue. Mean delay in G/M/1 and GI/GI/1 queues. Application to analysis of polling networks and Passive Optical Network (PON) performance. |
| **Network Traffic Modelling**<br>Interrupted Poisson Process (IPP), Markov Modulated Poisson Process (MMPP). Traffic autocorrelation, self-similar traffic, heavy tails and the Pareto distribution. Application to modelling of Internet, circuit-switched and transport traffic. |
| **Network Optimisation Theory**<br>Linear Programming (LP), Integer Linear Programming (ILP). LP and ILP solution methods and software tools. Problems on graphs, network flow problems, link-path and node-link formulations. |
| **Network Design and Dimensioning Problems**<br>Network dimensioning metrics, constraints and objectives. Uncapacitated and capacitated flow problems, optical network routing and wavelength assignment problem (RWA), network fairness problems, network topology design. |

**Continuous Assessment**

| *Assessment Type* | *Assessment Description* | *Outcome Addressed* | *% of total* | *Assessment Date* |
|---|---|---|---|---|
| Assignment | Network performance analysis assignment | 2,3 | 12.50 | Week 6 |
| Assignment | Network dimensioning/optimisation assignment | 5,6 | 12.50 | Week 10 |

**End of Module Formal Examination**

| *Assessment Type* | *Assessment Description* | *Outcome Addressed* | *% of total* | *Assessment Date* |
|---|---|---|---|---|
| Formal Examination | n/a | 1,2,3,4,5,6 | 75.00 | End-of-Semester |

| Reassessment Pre-Requisite |
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| **Repeat examination**<br>*Reassessment of this module will consist of a repeat examination. It is possible that there will also be a requirement to be reassessed in a coursework element.* |
| **Reassessment Description**<br>A continuous assessment resit is provided for this module. |

**DCU reserves the right to alter the nature and timings of assessment**

# EE517: Network Analysis & Dimensioning

## Module Workload

| Full Time hours per semester | | |
|---|---|---|
| *WorkLoad Type* | *WorkLoad Description* | *Hours* |
| Lecture | Theory and worked application examples. | 36 |
| Assignment Completion | Assignment 1 : Application of queueing network modelling methods to performance analysis of a communication system. | 24 |
| Assignment Completion | Assignment 2 : Application of optimisation solution methods to a network design/dimensioning problem. | 24 |
| Independent Study | Revision of lecture materials and prescribed reading. | 104 |
| | Total Hours | 188.00 |

**This module has no Part Time workload.**

## Module Resources

*Essential Book Resources*

**Donald Gross, John F. Shortle, James M. Thompson, Carl M. Harris 2008, *Fundamentals of Queueing Theory*, 4 Ed., Wiley [ISBN: 9780471791270]**

**Michał Pióro and Deepankar Medhi 2004, *Routing, Flow, and Capacity Design in Communication and Computer Networks*, 1 Ed., Elsevier [ISBN: 9780125571890]**

*Supplementary / Recommended Book Resources*

**Fayez Gebali 2008, *Analysis of Computer and Communication Networks*, 1 Ed., Springer [ISBN: 978038774437]**

**Biswanath Mukherjee 2006, *Optical WDM Networks*, 1 Ed., Springer [ISBN: 9780387291888]**

**Maciej Stasiak, Mariusz Głabowski, Arkadiusz Wiśniewski, Piotr Zwierzykowski 2010, *Modeling and Dimensioning of Mobile Networks: From GSM to LTE, From GSM to LTE*, 1 Ed., Wiley [ISBN: 9780470976036]**

*This module does not have any article/paper resources*

*This module does not have any other resources*

## Module Managers & Teachers

| Module Managers | | |
|---|---|---|
| *Semester* | *Staff Member* | *Staff Number* |
| Semester 1 | Conor McArdle | 80016642 |
| Semester 2 | Conor McArdle | 80016642 |
| Autumn | Conor McArdle | 80016642 |

| Module Teachers | |
|---|---|
| *Staff Member* | *Staff Email* |
| No Teacher Staff Assigned | |