Module Code:	**NME3502**
Module Title:	**Parallel Computer Architectures, Computer Clusters**
School(s) Involved in Delivery:	Computing and Engineering
Name of Course(s):	Embedded Systems Engineering Electronics and Computer-Based System Design
Module Leader:	Dr V. Holmes
Location:	Queensgate
Module Type:	Optional
Credit Rating:	15
Level:	Masters
Learning Methods:	Lecture 24 hours Practical 24 hours Unsupervised 102 hours
Pre-requisites:	-
Recommended Prior Study:	C/C++ programming language
Co-requisites:	-
Professional Body Requirements:	-
Graded or Non-Graded:	Graded
Barred Combinations:	-

Synopsis

Many existing and future computer-based applications impose exceptional demands on performance that traditional predominantly single-processor systems cannot offer. Large-scale computational simulations for scientific and engineering applications now routinely require highly parallel computers.

The availability of powerful computers and high-speed networks as low-cost commodity components are changing the way computers are used. This module will focus on large-scale distributed and parallel systems such as: "cluster computing" in local-area-networks; and "grid computing" in wide-area networks.

The aim of this module is to provide an in-depth introduction to Cluster technologies and applications. The hands-on laboratory exercises will provide the necessary practical experience with Cluster middleware software required to construct Cluster applications.

Outline Syllabus

Parallel systems
Parallel Computer Architectures: Flynn's Classification, Legacy Parallel Computers, and Current
Parallel Computers, Trends in Supercomputers.
Software Issues in Parallel Computing: parallel programming, parallel algorithms, programming models (MPMD, SPMD), message passing, MPI.

Computer Clusters
Cluster Architectures: Cluster- Definition and Distinctions, local and global clustering, cluster as a server, categories of cluster hardware and software, High-Performance, High-Availability, High-Throughput clusters.Cluster Middleware OSCAR, ROCKS, or similar. Running a simple MPI programs on OSCAR cluster.

Learning Outcomes

- **Knowledge and Understanding**

a) Understand the fundamental aspects of parallel and distributed processing.
b) Understand the need for and evolution of Computer Clusters in the context of processor- and data-intensive applications.
c) Discern the fundamental components of Cluster environments, such as Commodity Components for Clusters, Network Services/Communication software, Cluster Middleware, Resource management, and Programming Environments
d) Understand Scalability issues- Performance Metrics and Measures, and speed up in Parallel Processing Applications.

- **Abilities**

e) Setup a computer Cluster, deploy Cluster software and tools using OSCAR or similar middleware.
f) Evaluate a Cluster in the context of its application using an appropriate software tool and benchmarks.
g) Justify the applicability of Cluster for a specific application.

Assessment Strategy

- **Formative Assessment**

  Formative assessment will be provided through tutorial sessions and feedback during practical sessions.

- **Summative Assessment**

- Assessment Tasks	**Outcomes**	**Weight**
1. 2-hour examination.	a, b, c, d	60%
2. Cluster design project developed as the module progresses, encompassing analysis, planning, hardware and software design, practical implementation and evaluation report.	e, f, g	40%

- Assessment Criteria

Task 1

1.1 Explain the fundamental aspects of parallel and distributed processing
1.2 Explain the need for and evolution of Computer Clusters in the context of processor- and data-intensive applications.
1.3 Compare and contrast contemporary Commodity Components for Clusters, Network Services/Communication software, Cluster Middleware, Resource management, and Programming Environments
1.4 Assess Scalability - Performance Metrics and Measures, and speed up in Parallel Processing Applications.

Task 2

2.1 Choice and application of appropriate design methods to a practical Cluster system.
2.2 Ability to implement a Cluster design on a LAN.
2.3 Critical evaluation and reporting of results in the form of a formal report in the recommended format

Learning Strategy

The subject material will be presented in lecture form, supported by tutorials and laboratory based sessions. This will allow the development of understanding and the enhancement of practical skills, whilst providing a mechanism for ongoing formative assessment.

The assignment work is based on timetabled laboratory sessions, giving the opportunity for feedback as the work progresses.

Resources required

Lecture theatre with networked PC & projection system.
Cluster Laboratory facilities for 2 hours/week time-tabled and 8 hours/week unsupervised

Indicative References

William Gropp, Ewing Lusk, Jon Hall, and Thomas Sterling: "Beowulf Cluster Computing with Linux (Scientific and Engineering Computation)", (MIT Press, Cambridge Mass. 2nd Edition, 2003), ISBN 9780262692922

Mostafa Abd-El-Barr: " Advanced computer architecture and parallel processing", (Hoboken, N.J. ; [Great Britain] : Wiley-Interscience, c2005), ISBN 0471467405, An electronic book accessible through the library

K. H. Hoffmann: "Parallel algorithms and cluster computing: implementations, algorithms and applications", (Series: Lecture Notes in Computational Science and Engineering, Vol. 52 c2006)**,** ISBN 9783540335399

David H. M. Spector: "Building Linux Clusters"**,** (O'Reilly and Associates, July 2000), ISBN 1565926250

I. Foster and C. Kesselman: "The Grid 2: Blueprint for a New Computing Infrastructure", (Morgan Kaufmann, 2004), ISBN 1558609334

Daniel Minoli**: "**Networking Approach to Grid Computing", (John Wiley & Sons, Incorporated 2004) ISBN 0471687561

Journal of Cluster Computing, Springer Science+Business Media B.V., ISBN 1386-7857 (Paper) 1573-7543 (Online)