

Innovative Master's Program in Distributed Computing @ Melbourne

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This article presents a new Master's program offered at the University of Melbourne in the area of distributed computing.

1. Introduction

Distributed computing systems and applications are not only changing the face of computing discipline, but have also been constantly changing the way we live, conduct business, and interact as a society. From a layman's perspective, it all began with the emergence of the World-Wide Web, which put the world at her fingertips. But it should be noted that the history of distributed computing is as old as computer networks and the primary motivation for building such systems is to support the sharing of computing resources that are geographically distributed. The Web, as a distributed system and a killer application of the Internet, has transformed computing and society. It is used by millions of people everyday for various purposes including exchanging messages, reading news, downloading music, shopping online or simply accessing information about anything. It is used by organisations to market their services, reach customers, conduct business transactions, and deliver their services to customers at a low cost. These services are accessible through various types of devices including desktop computers, handheld devices such as PDAs (personal digital assistants) and smart-phones.

The demand for educational courses in advanced computing and networking has rapidly expanded in recent years as business and society are being transformed by the emergence of the Internet and the Web as ubiquitous media for enabling a knowledge-based global economy. This in turn has created a huge demand for Internet-based distributed computing technologies—such as Web- and Grid-services—and their applications that virtualise geographically-distributed resources to enable the creation of virtual enterprises, marketplaces, and service-oriented computing industries. However, skill-set required to meet these demands have not been addressed by the current academic programs in undergraduate or even in postgraduate programs. To address this skill gap, we have proposed a new Master of Engineering in Distributed Computing (MEDC) program at the University of Melbourne.

2. Introducing a New Masters Program

The new Masters degree in distributed computing, delivered by the Department of Computer Science and Software Engineering at the University of Melbourne, is primarily intended for graduates in Computer Science, Computer Engineering, combined Electrical/Electronic and Computer Engineering seeking technical and professional specialisation in Internet-based distributed computing, and also for professionals with a background in related disciplines, working in the ICT industry as software developers.

Our Masters program builds on the technical background gained by the students in their undergraduate studies and addresses the demand of the emerging information and communication technology (ICT) market with an emphasis on the use of industry standard and Internet-based distributed computing technologies in the development of networked enterprise systems and their applications.

The key objectives of our Masters program are that on completion, a graduate of the program will:

- have acquired substantial expertise in key areas of Internet programming and distributed computing,
- be able to apply the acquired techniques and knowledge to contribute to the development and implementation of enterprise software systems in organisations,
- be able to analyse and design ICT projects to meet current and future ICT needs, and
- be able to apply Internet-based distributed computing systems and algorithms to e-Science and e-Business applications.

To achieve the above objectives our Masters program has the following unique attributes:

- It has been designed to provide expertise for developing service-oriented, enterprise computing systems and applications that need to operate in wired/wireless network environments. These enterprise systems can scale from a single organisation to multiple organisations,
- It promotes the utilisation of industry standard distributed computing technologies such as J2EE and .NET,
- About half of the program focuses on highly specialised Distributed Computing topics such as Distributed Systems, Cluster and Grid computing, Distributed Algorithms, Mobile Systems Programming, Sensor Networks, and Web Services,
- A compulsory team-based project that emphasises the design and development of distributed computing technologies and their application in e-Science or e-Business areas.

3. Duration and Broader Entry Scope

The MEDC program admits three- or four-year degree graduates in Computer Science or Engineering including Physical Sciences and produces technically sophisticated graduates in Distributed Computing after 200 points (Level 1: two years program), 150 points (Level 2: one and half years program) or 100 points (Level 3: one year program) of full-time study. At Melbourne, we award 12.5 points for each subject and a full-time

student is normally expected to take a maximum load of 50 points in a given semester. The duration of the program depends on the student's previous academic background and work experience in computing area. Students holding a four-year degree in computer science or related discipline would normally complete in 1.5 years of full-time studies.

We draw the reader's attention to the fact that the entry pathways are designed to attract two categories of students with an undergraduate degree in the Physical Sciences or Engineering. The first category students would have an agreed level of Mathematics and Computer programming education and experience; and the second category students would have a major in Computer Science, Information Technology, or Software Engineering. Students in the first category are expected to complete 200 points of study, whereas those in the second category are expected to complete 100 to 150 points, depending on their academic standing and expertise. With these entry requirements, we are able to substantially increase the pool of potential students who could meet the University's expectations for a Masters program. The first 50 points of the Masters program are designed to ensure that students are adequately prepared to take the advanced 150 points at Masters level subjects. Details on entry requirements can be found at the program website [<http://www.cs.mu.oz.au/courses/mbc/medc.html>].

4. Program Structure

Our Department already offers several subjects as part of the two existing Masters Programs: Master of Information Technology and Master of Software Systems Engineering. We have taken the advantage of these programs and packaged some of the subjects along with five new subjects in the Distributed Computing area, especially developed for our new Masters program. The new subjects we introduced are: Distributed Systems: Principles and Paradigms, Distributed Algorithms, Mobile Computing Systems Programming, Sensor Networks and Applications, and Distributed Computing Project. We expect all MEDC students to complete them successfully along with other subjects as discussed below.

The subjects taught in MEDC are grouped into three different categories. The number of subjects from different groups (A, B, and C) to be studied by students entered at different levels (1, 2, and 3) is given in the table below:

Entry point	No. of Subjects to be Studied			Total Points
	Group A	Group B	Group C	
Level 1	4	10	1	200
Level 2	0	10	1	150
Level 3	0	6	1	100

The first subject group (Group A), foundation studies, consists of subjects that bring students up-to-date with advanced Computer Science concepts, techniques and tools.

The second subject group (Group B) offers advanced study in Distributed Computing technologies and its applications. MEDC students undertake at least four core recommended subjects (Subgroup B2) in addition to the core compulsory subject (Distributed Systems: Principles and Paradigms from Subgroup B1).

The third subject group (Group C) offers an opportunity for students to carry out a solid practical or research-oriented project in Distributed Computing. This project can be carried out by an individual or a team of students depending on the type of project and its scope.

Most of the subjects in Group A and C are offered twice a year; whereas, the Group B subjects are offered once a year. However, the “Distributed Systems” subject is offered twice as it is a foundation subject for MEDC students.

The complete list of subjects taught in different groups is given below.

Group A Subjects (12.5 points each) - Basic

- Programming & Software Development
- Algorithms & Complexity
- Internet Technologies
- Database Systems
- Operating Systems
- Data on the Web

Group B Subjects (12.5 points each)

Subgroup B1 - Core & Compulsory

- Distributed Systems: Principles and Paradigms

Subgroup B2 - Core & Recommended

- Cluster and Grid Computing
- Engineering for Internet Applications
- Distributed Algorithms
- Mobile Computing Systems Programming
- Networks and Parallel Processing
- Sensor Networks and Applications

Subgroup B3 - Electives

- Software System Security
- High-Performance Database Systems
- Web Technologies, Protocols & Architectures
- Systems Requirements Engineering
- IT Project Management
- Evolutionary & Neural Computation
- Machine Learning
- Agent Programming Languages
- Intelligent Software Agents

Group C Subject (25 points) - Core & Compulsory

- 433-659 Distributed Computing Project

For details on the above subjects and their contents, please visit the program website:
<http://www.cs.mu.oz.au/courses/mbc/medc.html>

5. Laboratory Infrastructure

The Department has excellent distributed computing facilities which are accessible to all postgraduate students. The existing facility is primarily based on Unix-class or Macintosh operating system environments. To further enhance our computing facility, during the formulation of our Masters program, we have interacted with leading IT companies and shared our plan for setting up specialised laboratories. We have received positive responses from several IT companies and they have shown great interest in supporting the program in various ways. In particular, we have received a notable support from Microsoft. They have offered funds for the establishment of a .NET lab for Distributed Computing and also provided a technical resource kit for all students joining our program.

In the last two years, we have received grants, totalling US\$40,000 in cash, from Microsoft to setup educational and research infrastructure for distributed computing driven by .NET technologies. We have established the 'Microsoft.NET Lab' containing desktop PCs and servers – all loaded with various software technologies including the .NET framework. The Lab resources are well utilised by our students of MEDC and our researchers working on the development of .NET-based Grid computing technologies.

6. Program Operation

The MEDC program is designed to admit students twice in a year - in February/March and July/August semesters. We have formally launched the program during May 2005. Our initial enrolments were 10 students and we started the program in August 2005 (Semester 2). We have attracted both national and international students - some of them who were working in software industry. We currently have approximately 40 students undertaking the MDEC program.

Among the five new subjects proposed to start along with our new Masters program, we first offered the "Distributed Systems" foundation subject from Semester 2, 2005. We have encouraged students from honours, 4th year software engineering, and other postgraduate programs to join our foundation subject. This subject had become popular and was able to enrol 44 students in Semester 2, 2005. The QoT (Quality of Teaching) survey revealed that the students had received the subject positively and had enjoyed it in addition to equipping themselves with new skills. This can be attributed to the innovative assignments that were given to the students as part of this subject. All students were highly enthusiastic and carried out team-based projects. They developed a distributed platform (middleware) supporting network games and illustrated its potential by implementing a multi-player car racing application. Microsoft presented the awards for three highest performing students from this subject as part of their support for our new Masters degree.

All the other new subjects we proposed have been offered in 2006 and they have been well received by students. We will continue to offer these in future semesters. The follow-up articles in DS Online will share our experience in offering those courses.

7. Microsoft Award for Top Students

On April 7, 2006 Microsoft representative Nigel Watson (Architect Advisor, Microsoft Australia) presented awards to top performing students studying subjects from the Master of Engineering in Distributed Computing for the academic year 2005. The top 3 graded students in the “Distributed Systems” subject received trophies (with their name inscribed). The Microsoft award included a smart-phone for first place, a creative Zen portable music player for second place and Office 2003, a wireless keyboard and mouse for third place. Students who received Microsoft award is shown below along with Director of master program (on the left) and Microsoft’s Architect Advisor (on the right).



Dr. Rajkumar Buyya (left) and Mr. Nigel Watson (right) with students who won Microsoft awards for their outstanding performance in distributed systems subject.

8. Summary and Conclusion

We have been able to identify the skill-gap that exists between undergraduate educational programs and industrial enterprise computing requirements and propose a new postgraduate program in Distributed Computing to fill that gap. The program is able to balance theoretical foundations with practical skills required for our graduates to excel in careers in both research and industry. The program has been in operation since 2005 and within a short span, it has established itself as an attractive Masters program and imparting students with skills that are essential for keeping industries, governments, and institutions in business for a long haul.

The program has a positive impact not only on those who enrolled in MEDC program, but also on other students at honours level (senior undergraduate students) and other postgraduate students as they can choose new MEDC subjects as electives. Based on skills gained in MEDC subjects, our students are able to easily gain employment in large multinational companies such as IBM or small-and-medium enterprises (SMEs) such as Intrepid Geophysics based in Melbourne.

Our Masters program has started making a long lasting impact on our research activities in Distributed Computing areas including Sensor Networks, Grid, Peer-to-Peer, and Mobile Computing. For example, some of our students were able to carry out innovative projects in distributed computing systems and applications, and publish regularly articles in research conferences based on the outcomes of their projects.

The teaching materials developed in our courses have been adopted by colleagues teaching in universities in the USA and Europe. In addition, we understand, from Microsoft's University relationship coordinators, that some universities in other countries have been exploring the possibility of initiating similar programs in their schools modelled after our MEDC program. This positive contribution to the community has definitely helped the University of Melbourne to position itself as a world leader in formulating and delivering innovative computing education.

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