The Quality of Service Paradigm as the Focus of Net-Centric Computing: a Postgraduate Course

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ABSTRACT

In the past three years a new postgraduate elective course on Net-centric computing was developed for a Master□s degree in Information Technology. The course evolved around the core subject topics included in the Computer Science body of knowledge as suggested by the IEEE Computer Society/ACM Task Force in the Computing Curricula 2001 report, with a strong emphasis on the relationship between networking technology and the applications delivered in a global networked environment.

Keywords

Net-centric computing, quality of service, postgraduate course, information technology.

1. INTRODUCTION AND BACKGROUND

Postgraduate degrees offered at Auckland University of Technology (AUT) typically have a strong emphasis on professional education and attempt to balance research and professional practice; the underpinning educational philosophy places a high value on providing a solid theoretical and research-based foundation from which best professional IT practice can be derived. As a professional postgraduate qualification, The Master of Information Technology (MInfoTech) addresses the educational needs of Information Technology (IT) professionals: these needs vary along the stages of their professional and personal growth.

1.1 The Student Body

Typically, the student body would include IT professionals who wish to extend and update their technical, management, and/or research skills and capabilities. These students are motivated to complete the degree and advance their career to a higher level in the corporate or organizational hierarchy. Another segment of the student population are the students who have recently completed their undergraduate studies and are using the Master□s degree as a vehicle to change career direction or gain a local (New Zealand based) IT qualification (Petrova et al, n. d.) The wide range of experience of the students and the diversity of disciplines and occupations that are under the umbrella of □Information Technology professional□ (Denning, 2001) is reflected in the broad nature of the Masters degree. While there is a clear structure and some easily identifiable □tracks□, there are no specialties as part of the degree□s design.

1.2 Content Areas

Examples of papers available or planned to be offered in the degree are listed below. The papers are focused either on technical IT issues or IT management issues, and students are encouraged to take a balance of papers from these two tracks through the choice of electives (Figure 1).

- Technical IT Track: Middleware, Net-centric computing, Data Mining and Knowledge Engineering, Collaborative Computing, Ubiquitous computing, Bioinformatics , Information Security.

- IT Management Track: IT Strategy and Policy, Integrating Information Technology and the Enterprise, eBusiness, Service Relationship Management, Strategic Information Technology, ICT Issues in the Small to Medium Enterprise sector, Contract Management.

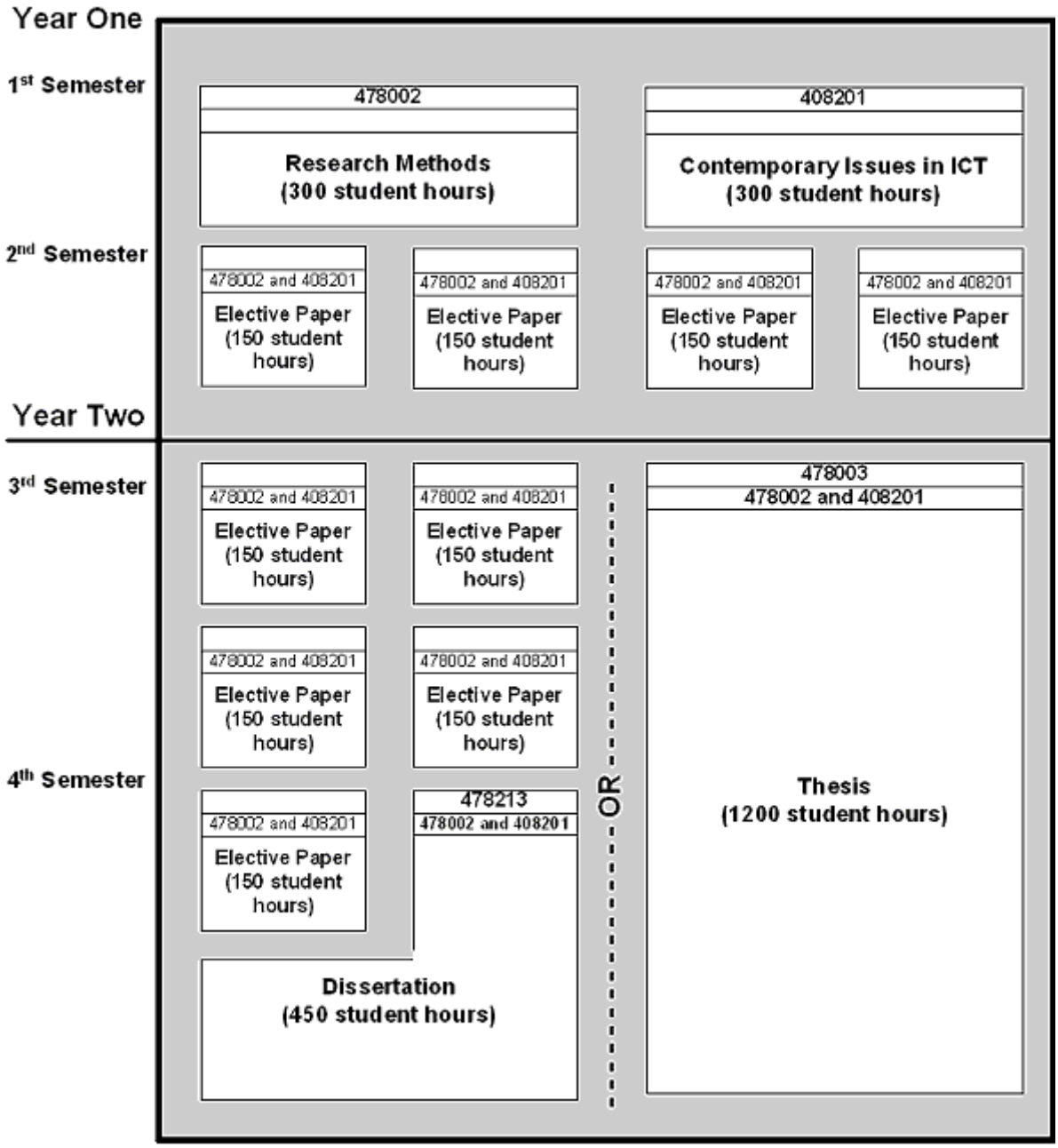

Figure 1. MInfoTech structure

Developing a balance of technical ability and business acumen is the approach taken towards meeting the expected graduate profile. This include the acquisition of advanced knowledge and capabilities in a specialist field of IT as well as the ability to apply them creatively and rigorously to new situations and problems. Other important aspects of the graduate profile are the development of excellent oral and written communication skills alongside the ability to work effectively as members of team and with people from various cultures and backgrounds. The graduate profile emphasises that an MInfoTech graduate will be able to:

- Carry out research in information technology and integrate research findings with practice.
- Evaluate and critique the literature in a specialist field, analyse with rigour and argue a position.
- Learn independently and understand the need to continue learning as a professional through research and scholarship.

2. NET-CENTRIC COMPUTING

The contemporary notion of net-centric computing is derived from the understanding of the Internet as a global public network used to support software superstructures such as the Web. In the following sections the characteristics of net-centric computing are discussed form sevaral perspectives.

2.1 The Academic Perspective

The global networked environment as a subject area of net-centric computing study is described by Cole (2001) who defines net-centric computing as □connected computing□. According to Cole, in the future computers will be used exclusively in the context of their ubiquitous connectivity. Cole goes on to make the point that net-centric computing is neither □communications□ nor □networking□ but is inclusive of both.

With the development of sophisticated distributed applications such as real-time multimedia the networking environment acquires new features. This is the view supported by y Tilley (2001) who defines the underlying principle of net-centric computing as that of an intelligent distributed environment where applications and data are available on demand. These two definitions are broad enough to allow for a significant scope in determining the breadth and depth of an academic study of net-centric computing and are widely used in defining net-centric courses curricula.

2.2 The Industry Perspective

Net-centric computing attracts significant interest from network and telecommunications practitioners as a vehicle for innovation. One innovation suggested by Smith and Tilley (2001) is to apply net-centric technologies to achieve enterprise-wide integration (for example, legacy systems or business-to-business applications). Three key drivers for the innovative use of net-centric computing are highlighted by Daniel (2001): the emergence of non-traditional computing devices and of mobile computing devices, the ever-increasing networking capabilities, and the need for more sophisticated network management and administration. The are related to the five growth areas identified earlier by Cross (1997) as net-centric computing motivators: the increase in desktop computing power, the expansion of the Internet, the trend towards switch-based local area networks, the development of Quality of Service (QoS) protocols, and the need for

strong network security.

2.3 Net-Centric Computing Paradigms

Comparing and analysing the academic and the industry perspectives, a number of interesting areas for advanced studies can be identified: network security, network performance, mobile infrastructures and communication protocols and standards. Added to them are the issues that arise at the point of contact between networks and applications - creating the user interface is just one example. Although the definitions outlined in 2.1 are broad enough to encompass this wide spread of topics, there is a need to reduce their range if they are to be used to form the basis of a postgraduate course in net-centric computing. A suggested framework is depicted in Figure 2. It shows the key drivers and growth areas collapsed into two paradigms. The first paradigm is shift towards applications □written once-run anywhere□(Hamilton, 1996.). The second paradigm refers to the provision of a QoS network capable of delivering these applications.

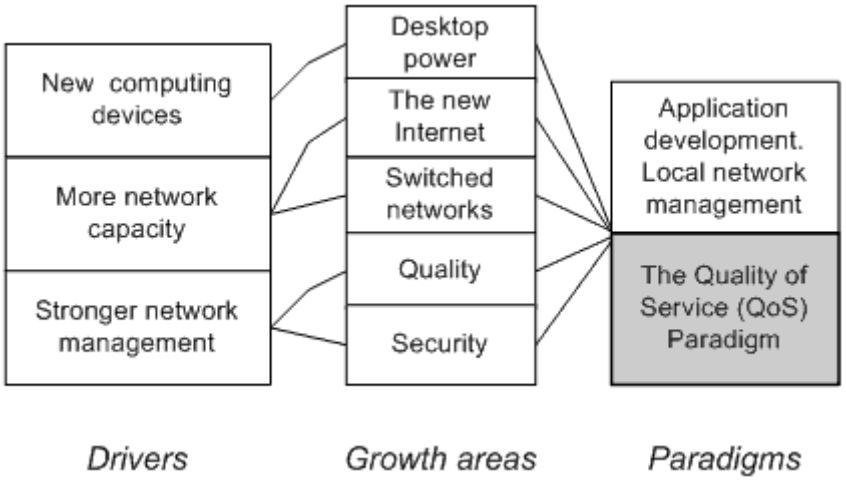

Figure 2. Drivers, growth areas and paradigms

The number of applications which need more network capacity (such as distributed multimedia systems and improved network management (operating systems) is increasing (Angin et al, 1997). The growth in the area of mobile and wireless computing and mobile communications has also been significant. Quality of service requirements such as guaranteed bandwidth, sufficiently high throughput, controlled end-to-end packet delay and low jitter, as well as requirements related to secure end-to-end delivery and economically viable network service models have driven the development of a number of protocols and frameworks and solutions capable of providing sustained quality of service to networks - including cellular and ad-hoc mobile networks, switched networks and IP networks. Research and industry efforts have been directed to issues related to QoS provision mostly at the network and at the transport layer. To satisfy the need for flexibility at the application layer and to relieve the user of the need to define low level specification, techniques and approaches such as QoS mapping, QoS adaptation, and reservation protocols have been suggested and discussed widely in the literature. The objective of a comprehensive QoS framework is to ensure the overall, end-to-end presentation of multimedia and real-time data. QoS is addressed in their own specific way by all components of the framework - including users, applications (and databases), system, and networks.

While traditional areas such as software development and local area network management are typically covered in similarly named academic courses, the issues related to providing QoS are often treated within a range of teaching subjects including

data communications, networking, operating systems, and database design. At the undergraduate level (computer engineering, computer science, information technology, and information systems) such a spread is justifiable, as learners need to acquire detailed knowledge and specific skills. However, two major challenges face educators at the postgraduate level. The first one relates to the need to develop students□ understanding of the global network as an enabler without relying on the sum of detailed knowledge pertinent to all undergraduate courses mentioned. The second challenge is the need to establish the foundations for a view of the global network as an environment for innovative and not always predictable developments (Waldo, 2001). Next, three distinctly net-centric curricula development approaches are described in the light of these challenges.

2.4 Net-Centric Computing Curricula

The net-centric computing oriented course at the University of Melbourne (elective 433-768, a component of several Master□s degrees, offered by the Faculty of Engineering) focuses entirely on two very specific areas: cluster computing and grid computing. The choice to develop two topics at a significant level of depth reflects the Computer Engineering (CE) discipline approach to teaching net-centric computing.

At the opposite end of the spectrum is the solution that has been implemented in the advanced networking course INFOSYS 730 at the Faculty of Commerce (University of Auckland). This Master of Commerce (Information Systems) course offers a broad overview of technologies and some of the emerging trends without a specific focus on any of them □ reflecting the Information Systems (IS) discipline understanding of the relationship between network technologies and information systems.

The postgraduate course 408203 "Net-Centric Computing" at AUT can be viewed almost as bridge between the CE view and the IS view. It has a strong emphasis on the services provided by information and communication technologies to distributed applications. Furthermore its intended audience are neither CE nor IS students but students enrolled in the MInfoTech programme offered by the School of Computing and Information Sciences. Based on the simplified framework in Figure 2 and guided by the general set of core subjects for net-centric computing suggested by the ACM Computing Curricula 2001, the course focuses on the impact of the QoS paradigm on global networks. Relevant topics from two areas are covered - advanced communication standards, and network computing architectures (Figure 3). Special emphasis is given to mobile and wireless networking.

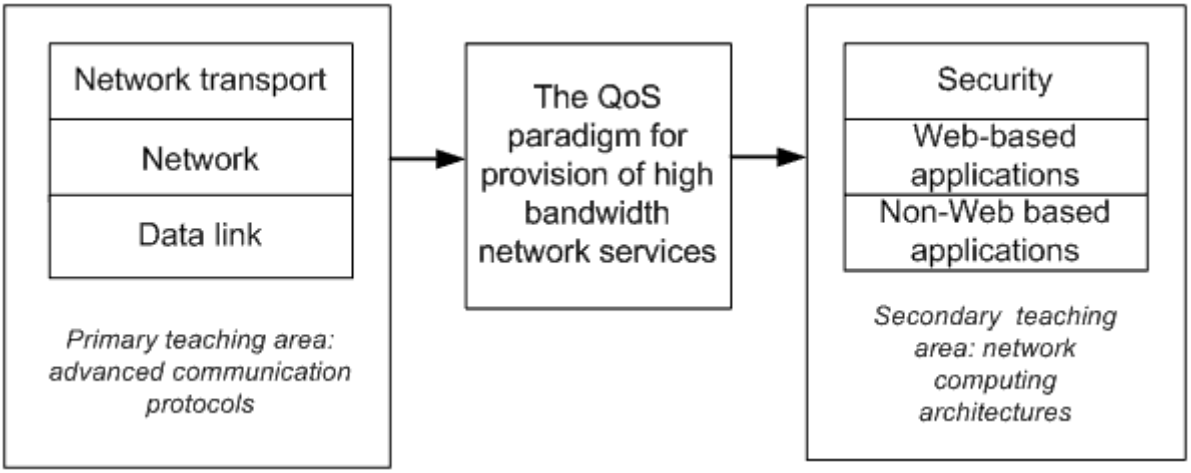

Figure 3. The teaching areas of net-centric computing

Our view is that performance is the key factor for any net-centric system, and that a postgraduate study should focus on the issues related to providing broadband network services of high quality. Accordingly the course framework parallels two separate knowledge hierarchies: the prescribed IS body of knowledge (where telecommunications is a sub-area of one of the three major subject areas) and the prescribed CE body of knowledge with networking as a core topic.

The course discussed here provides the CE view of networking as a discipline area with specific problems, issues and trends, and the IS view of networking as a support infrastructure. In the next section some of the practical aspects of course development and delivery will be discussed.

3. TEACHING AND LEARNING STRATEGIES

In line with the overall philosophy of the programme (Buchan et al, 2002) this course we emphasise project-based learning in which students are engaged and active and their learning experience is one of personal transformation. The idea is to develop a constructive learning environment that values the practical application of knowledge and promotes critically reflective researchers and professionals with strong technical capabilities in the computing discipline.

Students gain an in-depth knowledge in two key areas of computer networking and data technologies (Figure 3) by undertaking research assignments including small projects. This implies a requirement for students to be active learners who take responsibility for their own learning and professional development. The course aims and objectives are achieved by the following learning outcomes:

- Examine current trends in Web application development;
- Conduct an in-depth review of key network standards and technologies;
- Examine emerging trends in network and data technologies;
- Effectively research current issues in net-centric computing.

3.1 Activities

At the beginning of the course students are given a set of pre-readings (typically □ both academic journal and industry articles). Some lecture notes are available to help them brush up their existing knowledge of networking and to prepare for class presentations and discussions. The following teaching and learning activities are implemented:

- Personal reading and research assignments;
- Lecturer-led discussion and lecture-style presentation of information;
- Guest lectures and mini lectures by invited speakers;
- Student class presentations on pre-selected topics;
- Student online participatory activities;
- Self-directed learning;
- Live demonstrations using available hardware and software resources.

3.2 Teaching Resource Development

Currently, two lecturers are involved in teaching and developing course material. Based on their expertise and interests, the course development workload has been equally divided between them. Course resources include lecture notes and an annotated selection of readings. Assessment includes research assignments and participatory activities. Research assignments relate to topics in the teaching areas; some past and

current examples are listed below:

- Campus-wide wireless LANs: Is it a dream or a reality?
- Wireless network security: A survey of problems and possible solutions.
- Deployment of Wi-Fi technology in New Zealand.
- Tools for network performance management.
- Deployment of broadband technology in New Zealand.
- Deployment of CDMA 2000 technology in New Zealand.
- Developing a software tool for teaching and learning LAN design.
- A simulation study of a wireless MAC protocol.
- The Internet: technical challenges and solutions in the network layer.
- The Internet: technical challenges and solutions in the transport layer.
- Distributed computing and the changing nature and role of middleware.
- A comparative study of protocols providing QoS.
- The evolution of peer-to-peer networks.
- Mobile computing, its role in the business world its future.
- A comparative study of mobile commerce applications.
- Ad-hoc networks: Current developments and future trends.

Course material is regularly updated to incorporate new development and latest technologies in the areas of Net-centric computing. A number of additional sources of information such as the AUT Library and eLibrary are available, and recommended Web sites are used to support student capabilities development. An online learning platform hosts a significant part of the course and provides a discussion space which is used to enhance both student learning and course administration.

3.3 Course Assessment

The teaching team keeps a check on the assessment programme and the instruments used to ensure validity in the assessment process and consistency of standards achieved. This is especially important as we move away from examination as the major form of assessment. Assessment is interleaved with delivery (Carter & Boyle, 2002) and students are encouraged to work independently and develop transferable skills, but are given significant support and individual attention complemented by peer-to-peer interaction and feedback in class. Pre-moderation of assessment is compulsory and is peer-based, with a separation of the roles of the assessor and the moderator.

Three summative assessment instruments assess student performance ☐ the two research assignments and a participatory task based on the principles of hybrid learning (Petrova, 2001), using the adopted online platform. The assignments contribute jointly 80% towards the final grade; the remaining 20% are allocated through participation. The minimum pass in each assignment is 40% but an overall average mark of 50% is required to complete the course.

4. DISCUSSION AND CONCLUSION

We ran this course for the first time in semester 2, 2002 with a very small class. Students achieved consistent B+ on the average, and the overall pass rate was 100% (in line with other MInfoTech courses). Students evaluated their experiences as positive. Comments included statements such as ☐deeper knowledge was gained" and ☐problem solving skills were acquired". Students expressed appreciation of the strong support received throughout the course. Since then the course has run every semester with an average class size of six students and achievement results and student feedback similar to the ones quoted above. Starting from 2005, the course will run every second

semester.

We see the strengths of the course in its coherent structure and the opportunities it provides for student-centred learning. Future development work will continue with industry-sought input on curriculum updates, further deployment of innovative assessment instruments such as a □live□ course Web page, and even stronger focus on □on-the-edge□ net-centric computing content. Personal engagement of staff, potentially publishable student work and strong links with ongoing research are the key success factors for effective computer science education (Fincher et al, 2001, p. 37); we hope to make these factors the hallmark of the course.

5. ACKNOWLEDGEMENTS

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