Reporting the Experience of a Post-Graduate Program in Computer Network Operations, Internet Technology and Operating Systems' Support

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Abstract

This paper describes a post-graduate program in Computer Network Operations, Internet Technology and Operating Systems' Support, organized by the Federal University of Rio de Janeiro and which has had a considerable success. One of the main contributions of this paper is the discussion of an appropriate curriculum for computer network managers. The paper also focuses on the main objectives and issues of the program, which are a practical application-oriented curriculum and the need to provide a strong foundation on some inter-related computing and telecommunication sub-areas.

Index Terms - Innovative Degree Programs, Curriculum for Computer Network Managers, Computer Network Management

1. Introduction

Technology is changing so quickly, and particularly in computer networks, Internet technology, telecommunications and operating system areas, that those who do not keep in continuous education, will be left behind in the inexorable technology revolution. With the explosion of interest in the information superhighway, obtaining a strong foundation in computer networks and Internet technology has become more important than ever. Accordingly, there has been a need for providing the background technical professionals need to succeed in the twenty-first century and more specifically we have been witnessing an incredible demand for topics associated with Computer Network Operations, Network Management and Internet technology.

The use of computer networks for applications that were supposed to be feasible only after the beginning of the new millenium or which would not be technologically feasible before that time, are currently in full utilization and have already matured. To survive such a revolution, many organizations have had to go through an urgent adaptation to the new era, becoming more agile, more competitive and globalized. The professionals who are well prepared to dominate those technologies and in consequence able to develop new network applications and services at their companies, will influence the future of their companies, and will become essential professionals.

The need for specialized professional education in computer networks and Internet technology has already been recognized by several world-class universities [01,02,03], which have been offering

programs in this area. These programs differ from normal M.Sc. or Ph.D. programs in the subjects taught and in format. They have practical application-oriented curricula that stress how to convert theory into reality. These universities receive students from all over the world and usually issue a Diploma degree for those who successfully accomplish the program.

The MOT C.N. (Master Of Technology in Computer Networks) programme of the Federal University of Rio de Janeiro borrowed some ideas from these programmes and innovated in many aspects that will be discussed in this paper. These aspects involve mainly a balance of three main areas: Computer Networks/Telecommunications, Internet Technology and Operating System Support. One of the factors that motivated the conception of a totally new programme was the fact that there was no standard curriculum for this type of professional. Up to now, we have had well defined curricula for system analysts, computer science engineers, electronic and telecommunication engineers, such as described in [17], but none for computer network/operation managers or for Internet technology professionals. The professionals who have been performing the tasks of network managers or Internet technology developers come originally from other areas, such as the above mentioned, because of the lack of an appropriate curriculum.

2. Aims of the MOT C.N. Program

The MOT C.N program of the Computing Center (NCE) of the Federal University of Rio de Janeiro (UFRJ) aims at providing a strong foundation for graduated professionals and has a *hands-on* approach which differentiates it from ordinary short training courses. Actually, the MOT C.N. program was the first of its kind in Brazil, offering a one-year practical application-oriented curriculum, centered around three main areas: Networking Technology, Internet Technology and Operating Systems Support. These subject areas have many topics in common and are well integrated in the program.. Figure 1 illustrates the common ground of these three areas.

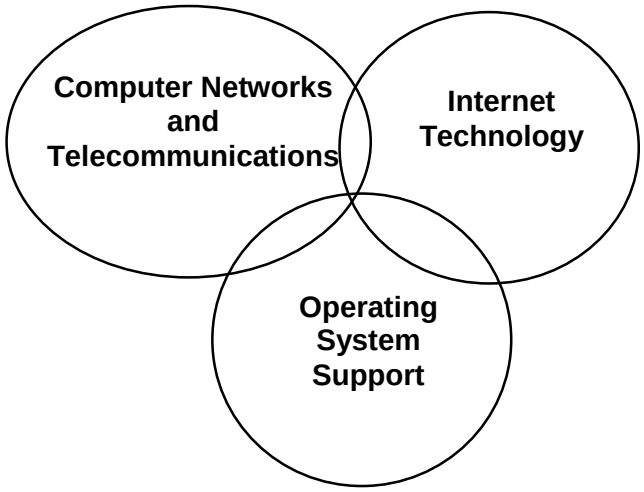

Figure 1. Interaction of the three main areas of the MOT C.N. program

3. Some Necessary Conditions for Offering a High-Quality Program

There are several necessary conditions (though not sufficient) that have to be fulfilled to achieve a high-quality program. Among these conditions are:

- Lecturers have to be highly qualified and must be selected for their professional experience, as well as their academic credentials and teaching skills. The professionals attending this program (the students) are paying a significant amount of money and are themselves very experienced. Consequently, they are very demanding customers and expect the best instructors. The MOT C.N. instructors have, at least, ten years of practical experience in their respective areas of expertise, and Ph.D., D.Sc. or M.Sc. academic degrees, issued by highly ranked international universities.

- Generally speaking, the disciplines have to meet the needs of the companies, giving students a wide and deep knowledge of several subjects, while preparing them for several tasks at the company, such as: coordinating teams; proposing new applications and services; having knowledge of network equipment; designing backbones; supporting different operating systems; providing network security; providing the configuration, expansion and installation of services and applications; supporting Internet and intranet technology at the company.

- Most companies need professionals with a new background and not only clever system analysts or electronic or telecommunication engineers with just technological education. Companies seek professionals with a good technical education and with an entrepreneurial attitude, capable of creating total solutions for the needs of their clients. Such solutions generally demand solid knowledge of computer networks, data base access via WWW, audio, video and naturally interactivity. These issues tend to be supported by fourth generation languages such as Java, Active X, and Script Languages for the Internet. All these concepts support intranet solutions.

- The institution that provides the program must have very good laboratories to give support to the several disciplines and technologies. These laboratories are usually PC-like workstations running Windows™9X, WindowsNT™, Netware™; workstations running UNIX-like operating systems, such as Sun OS™, Solaris© and AIX™. These labs must also have multimedia kits and video cameras attached to the workstations. This infrastructure is used in disciplines that show multimedia applications on the Web. Another type of laboratory is the networking laboratory, which is mandatory. It must include equipment such as Hubs, Switches, Routers, Modems, and also equipment for teaching the practical aspects of cabling.

- Some additional issues to provide high-quality training are comfortable classrooms, modern projection equipment and a library with very good collections of books, journals, reports, thesis, and conference proceedings.

- The students of this type of program are very busy people, who do not have time to make copies of the educational material. Accordingly, all the material of the program is prepared beforehand and handouts are given to the students, comprising copies of overhead projection

material, papers, etc. Additionally, all lecturers must prepare their material in PowerPoint© format, according to the program standards.

4. Program Subjects

This section presents the program disciplines, grouped according to the technology areas. The objective of showing this grouping is to emphasize the importance of each area addressed. Our experience at the NCE has shown that to reach our aims, these subjects have to be taught, otherwise the professional will lack a proper formation which will enable him to take decisions and solve problems. These disciplines are grouped in the Y diagram shown in figure 2, which constitutes the MOT C.N. program.

The MOT C.N. program starts with the Data Communications [04,05,06] and TCP/IP Architecture subjects [07]. These two subjects are basic for the rest of the Datacomm/Networks area. Datacomm serves as an introductory program, leveling students in this subject. It has a short duration and addresses the basic concepts of serial data transmission, modulation, error detection and correction, some communication protocols and data communication services.

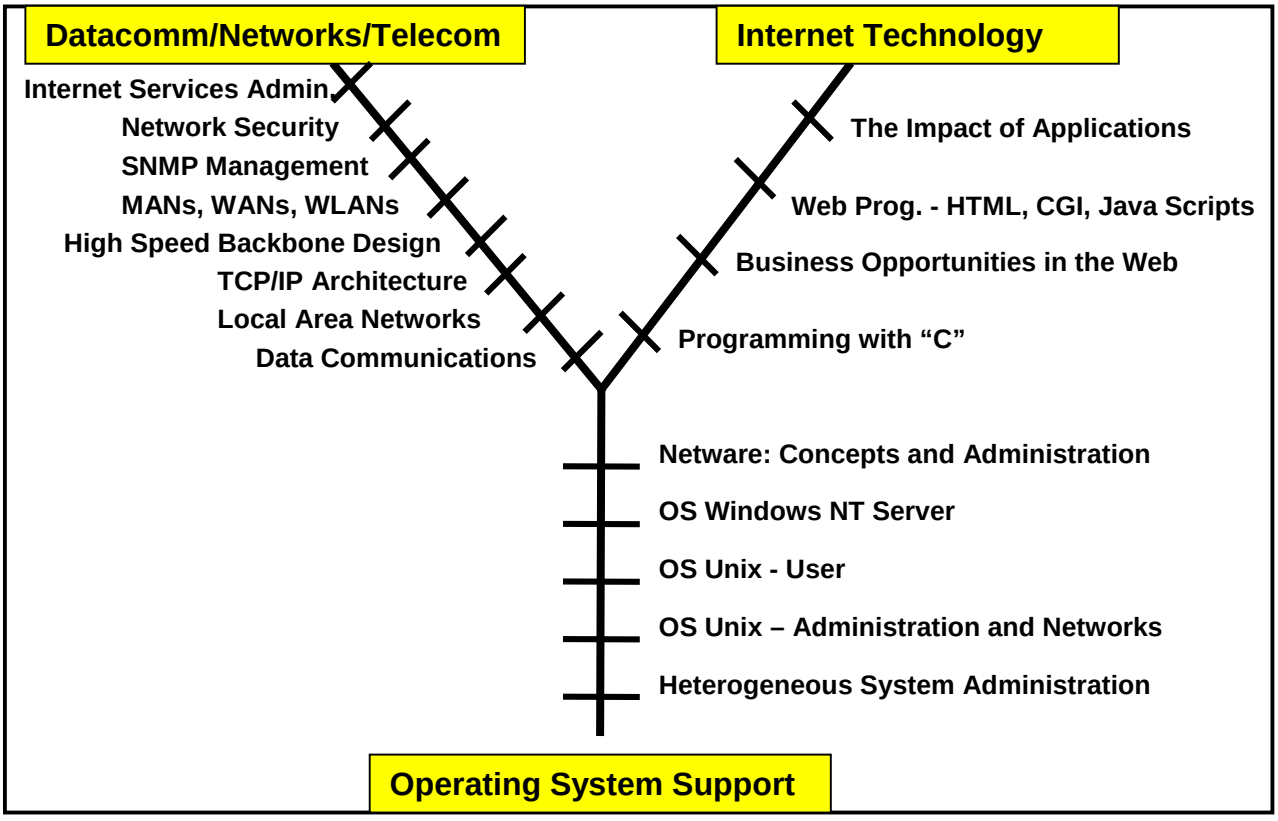

Figure 2 - Organization of the MOT C.N. Program Main Subjects

The “Local Area Networks” course [04,06] is a standard theoretical course. However, there are some practical activities in cabling and also LAN case studies. Students are also introduced to LAN equipment such as Hubs and Switches. On the other hand, the “Designing High-Speed Backbones ” course demands a highly experienced instructor, capable of describing previous personal experiences and proposing several case studies to be solved by the students. The main topics of this course are: Fast Ethernet, Gigabit Ethernet, FDDI and ATM.

The “Internet – managing services” course and the “SNMP management” [08] course are two lab-based *hands-on* courses. The first one teaches how to manage several Internet services on three different O.S. platforms: the Unix [10], the Windows NT [11] and the Netware[12]. Among the services are electronic mail, list servers, anonymous FTP, News, WWW, etc. The second course addresses the Internet management model, i.e., TCP/IP architecture, components, information structure and the management protocols SNMP V.2, RMON and RMON2. Additionally, it focuses on management platforms, such as Sunnet Manager, HP OpenView and IBM Netview. It also discusses some directions for network management using the Web.

Another fundamental subject for network managers and web developers is network security [09]. This course addresses the main topics by carrying out analysis and implementation approaches. Students are taught about historical security cases, classes of attacks, intruder types and common security failures on Internet services. The concepts, types and architectures of Firewalls are discussed, together with examples of usage. This course also discusses authentication mechanisms, such as one-time password, ciphering, secret key and public key, auditing, etc. The course is half theoretical and half *hands-on.* Students have to learn the use of several tools for network security and demonstrate their control of the system.

The last subject in the Netwoks area is the “MANs, WANs and WLANs (Wireless LANs)” subject [04]. It addresses the LAN-MAN-WAN interconnection problems and several WAN implementation options. Other issues are: interfaces, topologies, reliability, speed and equipment for MANs, WANs and WLANs.

Unlike most Computer Networks and Telecommunications Diploma programs [01,02,03], the MOT C.N. program of the UFRJ provides a comprehensive training in the most important operating systems currently in use. Our experience at the NCE/UFRJ has demonstrated that the *network manager* has to have very good knowledge of the management of several operating systems. This experience has to be in the use, installation and support of several computer network related tools. The NCE’s experience has been acquired by operating large networks such as the Federal University of Rio de Janeiro LAN network and the “Rede Rio” WAN network. “Rede Rio” is a WAN network that connects the main universities, research centers and many other government and non-profit institutions in the city of Rio de Janeiro.

All operating system (OS) courses are lab-based *hands-on* courses. Each course presents the general aspects of each different system and focuses on the tasks of installation, configuration, security and mainly the management of network services. The subjects taught have been highly appreciated by the students because they go through several O.S. environments giving them the opportunity to compare different systems. This will be extremely useful at their companies, when deciding which system is best for a certain application.

The Unix course [10] was split into two courses, i.e., the "Unix-user" and the "Unix-management" courses, as most students did not have previous knowledge of the Unix system. This division helped them to follow the course because there is an interval of one month between these two courses, which students use to do lab practice.

There is one course in the operating systems area, the “Managing Heterogeneous Operating Systems” [16], which is also very important. Many large companies (or large institutions) have different operating systems running on different hardware platforms. As a consequence, various issues in managing such heterogeneous environment arise. Some of the issues are: general directory service, file server integration, sharing printing services, creation and administration of accounts and groups, providing remote access and backup strategies, etc. This course addresses these issues.

The third area of the MOT C.N. program is the Internet Technology area. The network manager needs some general knowledge about some very important subjects, such as programming with the “C” Language, Web programming, the Impact of Some Applications in the network and also Strategies and Business Opportunities in the Web.

Some people may wonder why we offer a subject of “Programming with the “C” Language”. One of the main reasons is that many present *network managers* come from the mainframe support sector of large companies or do have a mainly electronic/telecommunications background. These professionals need a brush up on their programming skills because they are outdated in programming languages. Another reason is the "Web programming" course which also requires a minimum programming background. A last reason for teaching programming with the "C" language is that, regarding network operations and management, students have to be able to perform basic tasks that require some knowledge of the “C” language. The aim is not to give full training in programming, but provide them with the basic knowledge of programming with the “C” language, which is necessary to carry out basic tasks.

After the “Programming with the “C” Language” subject, students are introduced to Web programming [13,14], which addresses the construction of Web pages, forms and applications with some degree of interactivity, using Java Scripts.

In the Internet area there is also a subject about "Strategies and Business Opportunities in the Web" [15]. This course presents and discusses several successful web applications, in completely different areas of business. The discussion embraces different aspects of Web usage, such as transaction security, ethic, web marketing, intranets, etc.

Another fundamental course is the one which studies the impact of some applications in the network. In this course, several highly demanding applications are installed and employed, providing a basis for several network performance studies. These applications are: video conferencing with software packages such as Netmeeting, Mbone, CuSeeMe; video-on-demand with Netshow, Web animations with Shock Wave and Flash and general aspects of video and audio on the Web with Real Video and Real Audio.

5. General Information about the MOT C.N. Program

The MOT C.N. is a 400-hour program, lasting for one year. For each class hour students are supposed to spend 2.5 hours of study at home.

As already stated, the students of the MOT C.N. program are graduated professionals, working in several companies and either they pay for the program or they are sponsored by their companies. One problem that had to be faced quite early was the problem of providing day training and conciliate this with normal working hours at the students' companies. It is a widely held view that the performance of day training is much better than the noturnal one. After consulting several companies about the best time schedule, classes were organized to happen three times a week (two working mornings and Saturday mornings). Another alternative would be, for example, a whole working day, like what happens in many MBA programs. However, most companies in Rio de Janeiro provided information stating that this type of professional, who operates or manages network equipment, could not be absent from the company the whole day. Therefore, the alternative of a whole working day at the university was abandoned. There have been a few cases in which the only possibility for students would be to study in the evenings. For the time being this alternative has not been explored, but has not been discarded either.

Regarding students' performance evaluation, there are usually two assignments (theoretical and/or practical) for each subject (30% to 50% of the final grade), which students do alone or in groups and an individualized assessment (50% to 70% of the final grade). Evaluations follow the same criteria of M.Sc. programs, i.e.: A=Excellent, B=Good, C=Pass, D=Fail.

At the end of the program, students that achieve an overall rate (average) of "B", or superior, receive a certificate of "Specialist in Computer Network Management and Internet Technology".

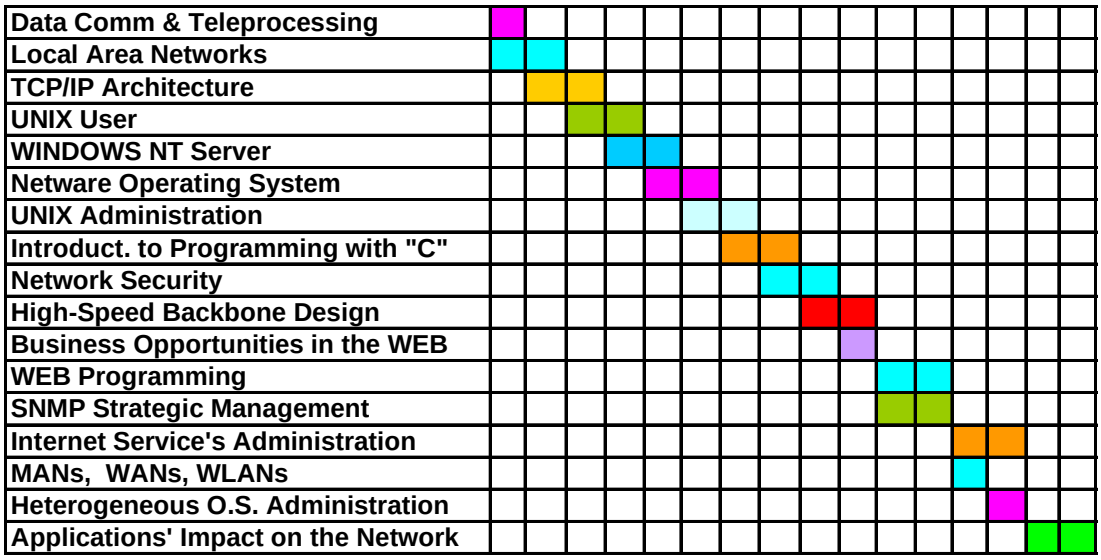

Figure 3 - MOT 's sequence of courses.

Figures 4, 5, and 6 show the percentage of each type of sponsorship in 1997, 1998 and 1999. It is worth mentioning that during the three initial years of the MOT program course, all 32 vacancies were occupied. Therefore, the sampling universe to collect the data were 32 students in each group.

From the graphs below and from what we know about the economic situation of Brazil between 1997 and 1999, it is possible to draw some conclusions. The pie graphs show that the percentage of students paying individually doubled from 1997 to 1999. This probably indicates that the students found the course very good and recommended it to other students (word of mouth is one of the most effective forms of marketing). It is also important to note that there was an increase in individual participation despite the economic crisis during these years. It also reflects the fact that students consider it very important to invest in their future.

The percentage of Federal Government and State Government sponsored students decreased from 1997 to 1999 as a result of government cuts on training in this period.

Another clear indication of the economic crisis is represented by the decrease in the participation of students sponsored by private and mixed economy companies. Due to the privitazation program, the Brazilian telecommunications and networking market expanded from 1997 to 1999. However, this was not reflected in an increase in the number of students sponsored by private companies. On the contrary, there was a decrease in the percentage of their participation.

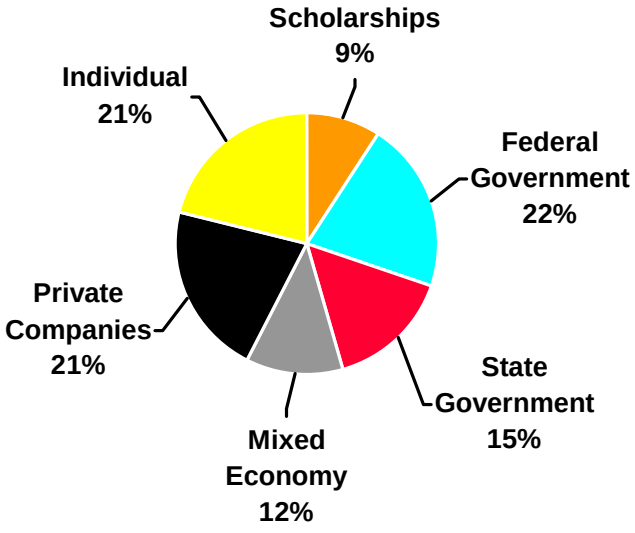

Figure 4 – Student Distribution in 1997

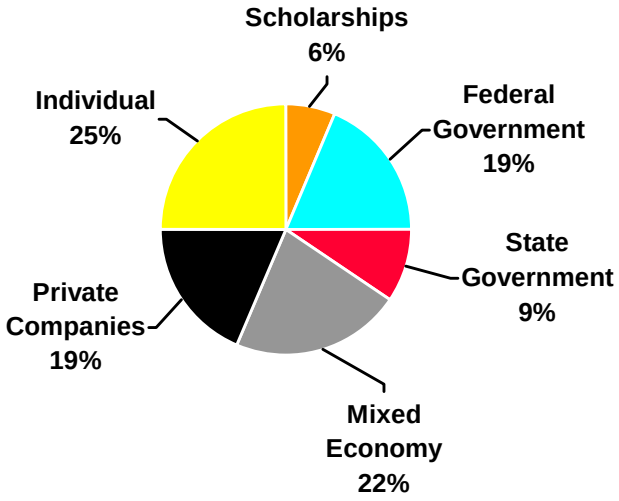

Figure 5 – Student Distribution in 1998

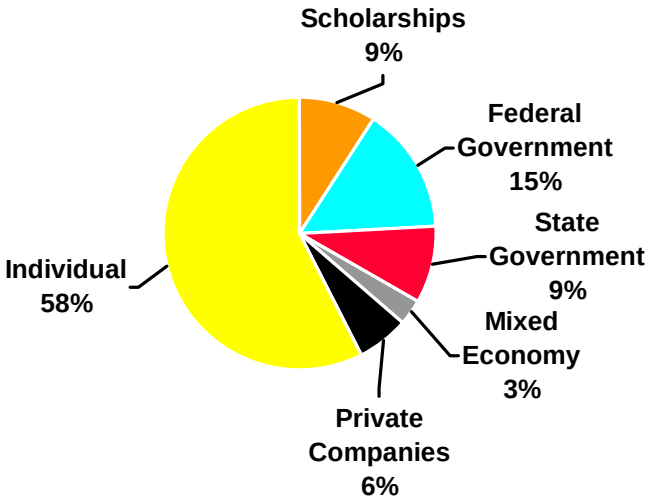

Figure 6 – Sudent Distribution in 1999

6. Conclusions

This paper described a post-graduate program in Computer Network Operations, Internet Technology and Operating Systems' Support, organized by the Federal University of Rio de Janeiro.

One of the main contributions of this paper was the discussion of an appropriate curriculum for *computer network managers*. The paper discussed the main issues of such a program by addressing the needs for a new curriculum for this type of professional. Many of these needs were identified by several companies, which contributed to delineate the program characteristics.

The paper also addressed the content of the MOT C.N. program, presenting the subjects taught and commenting on several relevant aspects. MOTs' program differs from the program of several universities [01,02,03] in several aspects. One of MOT's biggest difference from other programs is the importance of operating system support. This difference is probably due to the fact that they have distinct objectives.

It is our belief that the professionals who attend this program have fresh valuable insights into new applications that can be supported by computer networks and that can be distributed accross several systems. Such applications can be developed at the students' companies, making their expertise extremely valuable for their companies and for themselves.

7. References

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