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INFORMATION TECHNOLOGY FOR INSTITUTIONAL MANAGEMENT IN HIGHER EDUCATION

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Abstract

A model for management administrative computing is presented. It is based on automation of administrative operations, which are carried out through a network of computer terminals, constituting a central information and control system. The investments in hardware are recovered in a short time by decrease of administrative staff, since the system eliminates duplication of data handling and substitutes the great majority of paper documents by electronically handled information. It was developed and implemented at University of São Paulo and is being adopted by other institution.

Introduction

Management in a university, as in any other institution, must be based on evaluation and planning. All planning and decision making needs information. Spurred by technological innovation and relentless cost reduction, new information technologies are growing at an explosive pace, being regarded by corporations as necessary for efficient management of enterprises. While these new technologies bring economic and other benefits, being used even in multinational corporate operations that require integrated systems with round the clock communications and global networks (e.g. banking, air traffic control, travel reservations), they pose new challenges for higher education institutional management.

In several countries, university institutional managers are aware that there is an urgent need to introduce university-wide integrated information technology systems, to support, for example, decisions about planning, resource allocation and financial management, allowing the institutions to get the most out of the resources available to them. Presently, in most universities, the existing departmental administrative computing systems may be adequate at the operational level but do not provide the needed information for institutional managers.

In this paper we describe an integrated information and control system developed by the authors for University of São Paulo (USP). It was developed using CASE – Computer Aided Software Engineering. Its definition, development and implementation strategies are discussed and the impact of such a system upon the university is assessed.

Evolution of administrative computing in universities

Development of administrative computing in universities started in the late sixties and early seventies. With the technology available at that time, batch systems were developed to help in the administration of the huge amounts of data that occur in higher education institutions, like students records, which have to be kept even after they leave the university. The typical systems developed in this phase were: personnel and position record system, used to process the pay roll, students record, stock administration, accounting, equipment, building and space administration.

Software was written manually by system analysts using, in most cases, high level languages (e.g. Cobol, PL/I). Some systems used data base managers. There was no integration between the different systems and their only common feature was that they usually run in the same central mainframe computer, frequently the same used for academic work,

although there was, afterwards, a tendency to have a central mainframe dedicated to administrative computing.

Since university activities (teaching, research, and consulting) occur in its academic departments, the big batch systems which were designed only for large data set administration, did not fulfill the needs for Departmental Administration. In the eighties, with the advent of departmental and personal computers, academic departments and institutes, independently, developed several small systems to support their administration. Although these systems can provide the needed support for departments, the Central Administration lacks the managerial support provided by an integrated information system.

Integration of departmental systems, using different languages and data base managers, tied up to the specificity of their hardware, is a difficult problem for software engineering. Problems with data consistency will be difficult to avoid, even for departments which are using the same software, because they may use different definitions for the same type of data. Furthermore, because the departmental systems are not integrated, there is some duplication of administrative work within the department (different clerks inputting the same data), besides duplication, in part, at the central administration.

Just to mention one example of the awareness towards this problem in higher education institutions, in England the Universities Funding Council is promoting cooperation, between universities, in software development for an integrated information system, through the Management Administrative Computing Initiative (MAC) allocating 6 million pounds for the period 89-92 (UFC, 1989).

Administrative computing at USP followed the trend observed in most universities. Batch systems were implemented in the early seventies to manage data like students' records, accounting, inventory and to process the pay roll. Up to 1986 the central administration still depended on these batch systems. Several departments had developed small systems, running on personal computers, to support their administrative needs, like accounting for research grants and contracts, publications of their academic staff, student records, stock control and inventory. This situation is inflationary in personnel because it causes the proliferation of partly parallel data, established for different users. In spite of the number of administrative clerks involved, the central administration received information as and when the operating unit considered it best and most of the time information was already outdated and established on the basis of incomplete or ill defined data.

University of São Paulo

Before describing the system implemented at USP it is convenient to present some general information about the University. It has 50.000 students, 15.000 of which are graduate students. It is a State University with an annual budget of US\$ 300 millions provided by the State and an extra US\$ 50 millions obtained from research grants and contracts. It is Brazil's largest research institution, with an average of two published papers per member of its academic staff per year. About 6.800 students a year are admitted in undergraduate courses, selected from 100.000 candidates through written entrance examinations.

USP has 33 units for teaching and research (Institutes and Faculties), 7 Interdisciplinary Institutes for Research and Extension Services (not involved with teaching at undergraduate level), 2 hospitals, 4 Museums, 2 large farms (one for crops and the other for livestock breeding, used for research and students training in agricultural sciences, veterinary and zootechny), a research ship for oceanography, a University Press with 17 bookshops and a FM radio station. Its units are distributed through 5 "campi", some of which are at a distance of 400 kilometers from the campus located at São Paulo city, where the central administration is situated. Its "campi" encompass a total land and area of 48 million square meters with a built area of 1.3 million square meters.

In organizational terms, USP's structure is similar to most European universities. The main administrative and academic executive responsibilities are concentrated on the Rector, who is nominated by the State Governor, for a four years period, from a list of three names elected by the University Senate and other central councils. Each teaching and research unit is headed by a Director, chosen by the Rector from a list of three names voted by the unit's council. Units are divided into departments and department heads are elected by department's councils. The Rector also appoints four vice-rectors, responsible for graduate studies, undergraduate studies, research and extension services, as well as the university general administrator.

Some of the units of research and teaching are quite large. As an example, the Polytechnical School has about 6.000 students and is subdivided into 14 Departments (e.g. Department of Chemical Engineering, Mechanical Engineering). The School of Economics and Business Administration has 3.600 students. Thus, some of USP's units have the size of some European universities.

Permanent appointments for professorship at USP are made through public and competitive exams; promotion is also based on merit. There are 5.200 faculty members, 80% of which with a rank equivalent to a doctoral degree or higher, and 70% hired in a full-time basis for teaching and research activities. There is a total of 15.000 non-faculty employees, subdivided into technical, administrative and operational staff. Each subdivision has its own career system with promotion based on evaluations performed every other year.

The system definition

In 1986, the Rector appointed as the University General Manager one of the authors (E. Wolyneć), an Associated Professor from the Institute of Physics, who at the time was the Head of the Nuclear Physics Linear Accelerator Laboratory. Because she was well acquainted with computing, it became immediately evident that administration of such a large and complex organization could not be efficiently carried out without the modern tools of information technology.

A proposal was made to automate administrative operations, which should be performed using a computer network, in such a way that all data would be registered only once and become accessible by administrators anywhere. Reducing the time needed by academic administrators in their day to day management of departmental, faculty, committee or university-wide affairs, the system should compensate the necessary hardware investments by a gain in productivity. Eliminating duplications in data handling and substituting the great majority of papers documents by electronically handled information, it should cut down the number of administrative clerks recovering the hardware investments by a decrease in salaries expenditure. Thus, it should be an integrated user-computer system, to support management, analysis and decision making functions, providing on line reports and performance indicators. Furthermore, it had to be developed and implemented in a period shorter than 4 years avoiding that changing Rector and institutional managers could interfere with the project.

Once these general principles were approved by the Rector, the next step was to choose the adequate hardware. Because the academic staff is acquainted with computers suitable for scientific processing and on line acquisition of experimental data, but usually not with mainframes designed for information systems, a survey was made of hardware used in corporate world like in banking, air traffic control, travel reservations and similar information systems that are based upon large networks. The network to support automation of USP

administration was estimated to need about 1500 terminals. At least for hardware available and prices in Brazil, Unisys A-series turned out to be the best solution. Its architecture was found particularly suitable for the application intended, meeting also the required access security.

One of the authors (H. L. Marin), a system engineer from the Computer Centre, was developing CASE (Computer Aided Software Engineering) tools, for Unisys A-series architecture to be used for developing information systems, as part of this PhD research program. He joined the project.

It was decided that the system should be defined from top to bottom, to avoid the danger that the relative power of administrative personnel might lead to a perpetuation of the way in which administrative tasks are fulfilled. It is known that end users tend to formulate requirements for automation such as not to change the flow of processes at all. The system was defined by E. Woly nec and H. L. Marin (Woly nec, 1988) and only institutional managers were consulted (e.g. the University Financial Director, the Vice-Rector for Undergraduate Studies)

Once the system was defined, a detailed project was written including costs, timing for development and implementation, training of personnel, network design and other relevant details. The whole project was presented in a meeting to all Directors of units of research and teaching and university institutional managers. Most of them became enthusiastic about it. The project written by E. Woly nec and H. L. Marin became part of the program submitted by USP to the Interamerican Bank for Development for a multi-year loan to support Institutional Development.

The CASE tools developed by H. L. Marin (Marin, 1988) allowed a fast development with a small team of initially 4 system engineers, increased up to 12 system engineers, during the implementation period. The whole system was developed and implemented in a period of 3 years.

Development tools and software structure

A brief description of the CASE tools developed to built the system is given, because it allows a better understanding of the software structure and some of its features, like access security.

LOGE is a tool which produces prototypes reproducing its own inner structure. It produces systems that process, in real time, transactions carried out through any terminal in the network. These transactions are processed by specific routines and stored in a data base managed by DMS-II. Reports are on line printed. The full data base can be accessed from any terminal in the network, however each authorized user is allowed to perform only a subset of the transactions and access a subset of the data base. A few institutional managers are authorized to perform any transaction and to access the complete data base.

The internal structure of the software is such that all requested transactions arrive at a main manager and are distributed to transaction managers (FROH). If the user is allowed to perform the transaction, the input data is transferred to a set of routines (WOTAN) whose function is to execute transactions, checking input data consistency and altering eventually the data base using DMS-II. The answer is sent by FROH to the requesting terminal.

FROH maintains also statistics about the system performance, like average response time, number of transactions executed by user or frequency of different transactions. Data about the network activities are maintained by the main manager, who controls the number of transactions managers (FROH), creating or eliminating them dynamically, in order to keep the response time close to a defined value. It is possible, using an utility (TETIS), to access the current status of the system: performance, number of active terminals and transaction managers.

The routine library (WOTAN) must be built in ALGOL, using well defined rules comprised in the development system. Several routines are already built in: password assignment, on line help, user cataloging, recording of all executed transactions with time, date, user and terminal.

There is another tool (WALTRAUTE) for editing screens, including those for on line help. Once edited, they are stored in the user data base through DMS-II, becoming immediately accessible. Another feature of WALTRAUTE is the production of user's manual.

The main manager, the transaction manager and the routines selection mechanism are all automatically provided by the development system, which also generates the necessary codes for part of the routine library. WALTRAUTE and TETIS are not specialized and can be used for all developed systems.

The system

The system developed for University of São Paulo is divided into subsystems according with end users, but from logical point of view it is a single system, constituting a single data bank. The main features of the subsystems are:

PROTEOS – Flow of documents control

This subsystem controls the flow of documents or processes within university units or through the university administration. It provides on line documents about the localization of documents processes (e.g. Finances Department, Faculty Director office) given the letter or process number or any set of words contained in the description of the documents. It also informs, on line, a summary of decisions taken, like: request authorized, consult Legal Department, submit to next Senate meeting. It provides lists of documents which are waiting decision for more than a week (or any given length of time). This subsystem performs, presently, an average of about 20,000 transactions per day, with an average response time of two seconds.

SIAF – Finances administration

Purchase orders are filled out on the screen of computer terminals and printed out in local printers. This subsystem processes and controls expenditures and provides, for all cost centers, their financial statement, showing their commitments and their free balance. It provides budget planning, the general accounting and controls the inventory. When a purchased item is received, the unit executes a transaction informing its arrival. If it is a consumable, it will be added to the stock inventory and for equipment the system attributes an inventory number to it and asks where it will be installed. SIAF processes payments, keeping records and produces checks or pay orders to the bank. It also controls income from research grants, contracts and extension services. Several reports are available, on line, for different managerial levels, showing as an example expenditures of a particular sub-account (e.g., chemicals for teaching laboratory, Xerox copies).

ALMOX – Control of the Central Store and local stock

The University processes a Central Store for consumables of general use, which are purchased in large quantities to lower costs. The system operates with on line requisitions from the units, which are printed out at the Central Store. It controls the stock inventory, charges cost centers, provides accounting information and also controls the local stock of departments. The same system is used within the units for requests from its departments or

laboratories. It provides several on line reports like statistical analysis of expenditure on consumables, e.g. laboratory supplies, stationery, etc.

ANIBAL – Suppliers Catalog

This subsystem provides, on line, records and information about suppliers to facilitate purchase for the Central Store or of items not available at the Central Store which are directly acquired by departments. Just as an example of the advantage of integration, when a purchase order is being filed and the supplier number is typed, the system will fill out all information about the supplier that is needed in the purchase order.

SIAP – Personnel Administration

This system keeps records of the academic and non academic staff, including their evolution in the career, their position in the organization structure, within a department, division, etc. It produces the pay roll. Several management reports are available. It is possible to obtain, as an example, the expenditure with salaries for a given sector of the organization (e.g. Library, electronic maintenance shop) or indicators like staff students ratio, salary expenditure per student.

QUIRON – Academic administration

This subsystem controls issues related to undergraduate and graduate students. Student's enrollment in disciplines is carried out on line. The system verifies if the student has completed requisites to enroll in a given discipline and also if there is conflict between schedules (enrolling in two disciplines which have lectures at the same time). As an example, the system can reject enrollment also if the student is in debt with the library. The system provides each lecturer with a special password which allows them to get, from any terminal in the network, lists to control presence in laboratory classes, or access to their students past performance in other disciplines. Students marks are input in the system by the lecturer and their final marks are calculated according with preset rules for each discipline. After final marks are validated by the lecturer, his password becomes invalid and only the central administration can change the mark of a student, backed up on official documents. The system keeps cumulative records of students and provides local transcripts of these records. A cumulative record for each member of the academic staff is also maintained, with information such as courses taught, teaching load, student's wastage rate in their courses, graduate students supervised or being supervised. Several evaluation reports are available, to lecturers on their student's performance, to heads of departments on the performance of its students and

lecturers, student's wastage ratio, staff teaching loads, graduate students per member of academic staff. Thesis completion average time, thesis completed per year per member of academic staff and, to institutional managers, more aggregate reports on the performance of Institutes and Faculties.

MOUSEION – Library Management

This subsystem comprises cataloguing, circulation and acquisitions. Students and members of the academic staff and other users of library can search the library data base from any terminal of the network or from REDEUSP, the university academic network, which connects all university computers dedicated to scientific processing (central mainframes and departmental computers) and is also connected to other networks (national and international). REDEUSP can be accessed from dedicated terminals or from PC's using a special software and telephone dial. Thus the library database can be accessed by faculty members from their offices, or from home. Access is also provided to other Brazilian universities connected to the network. The system also controls requests of xerox copies from journals to provide statistics on community interest in subscribed journals. Of course, library user's data are obtained from SIAP for employees and from QUIRON for students.

HERMES – University Press and Book administration

EDUSP, the University of São Paulo Press and book shops, edits and sells books in the university "campi". It also edits books in partnership with other publishers and sells books from other editors. HERMES provides book cataloging and control stock, acquisition, distribution and sales. Accounting is provided by SIAF and suppliers by ANIBAL. Employees can buy books and have the payment debited from their salaries, which are carried out automatically by SIAP and SIAF. Students can have special discounts or a parceled payment. HERMES verifies through QUIRON if the customer is a student.

THALES – Academic productivity control

This subsystem keeps a data base of published papers and patents of the academic staff and also their fields of expertise. The system provides curriculum vitae for members of the academic staff (only upon each member request). For the curriculum, personal data is obtained from SIAP, courses taught and theses supervised from QUIRON. Published papers and other relevant activities not controlled by the system are informed by members. Heads of departments and other institutional managers can access statistical data and performance indicators but not a person's curriculum. The system also provides lists of publications and

other data for departments' annual reports. It is possible to enquire who works in a particular field like polymers, superconducting materials, nuclear physics or a particular subject within nuclear physics.

ELETRONIC MAIL

While PROTEOS controls the flow of official documents, electronic mail within the University for exchange of messages, data files and other documents are provided by REDEUSP, which also allows electronic mail with other institutions through its connection with Brazilian networks and BITNET.

DONNER – Network management

This subsystem controls the network and maintains a data base on the location of all video terminals and printers and takes care of authorized users cataloging. Maintenance requests on the network or terminals are made by users through this subsystem. It also manages the printing of requested reports. Users can specify in which printer they want a report printed out. This avoids the need to have a printer for each video terminal. Users can also specify if they want the report printed at date or immediately. DONNER also informs, at the central computer, when one of the network lines is off and requires maintenance and keeps statistics on the network, such as number of terminals in use, number of printed reports. The number of reports and documents printed. Presently, is about 4,000 per day.

Each subsystem produces several management reports, but the most interesting reports are those which aggregate data from several of the subsystems allowing, as an example, to compare performance with costs.

At USP authorized users from any unit can access PROTEOS. All Faculty members can use electronic mail and access data, or reports, only on their personnel, their budget, their students or their academic productivity. Thus as far as Departments or Faculties are concerned the system behaves as a Departmental or Faculty system. At the Central Administration institutional managers can access data from any unit and reports with aggregate data from all units. Use of performance indicators provided by the system for evaluation and planning will be the subject of a forthcoming paper.

Staff training

The system built is friendly to end users and its transactional basis plus on line help made staff training very simple. For each of the subsystems, the staff which would operate the system received 8 hours training divided into two sections of four hours each. The training was provided for groups of twelve in each section. After most of the subsystems were implemented, institutional managers, at Faculty level and central administration, received a training of 5-6 days about the whole system and its use as a managerial tool.

Hardware investments

At the beginning of the project a decision was taken to rent the computer rather than buying it. Development started with an Unisys B-7900. After two years we moved to an A-10 and presently the system runs on an Unisys A-15F, working with a network of about 1,000 terminals, that is being enlarged to up 1,500 terminals (videos and printers). All terminals plus related network hardware were acquired for a total cost of US\$ 4,8 million. The 20% decrease in administrative personnel allowed by the implementation of the system reduces personnel expenditure (including social security and overhead) in US\$ 300,000 per month, allowing recovery of acquisition investments in about 16 months. After that there is a monthly saving of US\$200,000, discounting the expenditure with rental fares and maintenance of the mainframe system, that amounts to about US\$ 100,000.

The University had already a team of technicians for personal computers maintenance, which now also provides maintenance for terminals and the network. USP has presently 3,600 personal computers. The savings obtained by this in house maintenance, carried out by 50 technicians, comparing its costs with those that would be spent by contracting the maintenance from external companies, is equivalent to the salary expenditure of all the Computer Centre personnel. Administrative computing is only a small part of the Computer Centre activity, since the centre is also responsible for academic computing providing the infrastructure for research and teaching, including consultancy to members of the academic staff and software users courses.

Institutional development

Implementation of the system described was completed recently. A quantitative analysis of institutional changes caused by this management model is not yet possible. However, from managerial point of view, the most important achievement is the possibility of consulting, on line, managerial data to support decision making. All administrative operations have been speeded up and cost less labor, decreasing the administrative staff and also the time spent by the academic staff with management. Thus, from the administrative point of view the University became more efficient.

The system allowed a decentralization of the administration. As an example, prior to this system, every purchase order had to be sent to the Central Administration for approval. Now, this procedure is no longer necessary, since the system controls cost centers budgets.

Indicators generated by the system allowed the establishment of criteria for decisions taken by institutional managers. Thus decisions taken by the central administration are now more respected and accepted by the academic community. As an example, presently up to 20% of the budget allocated to Faculties is proportional to academic productivity (published papers, MSc and PhD thesis produced per member of the staff).

The detailed follow up of expenditures allowed the Central Administration to adopt policies that optimize the use of resources. The performance indicators generated by the system points out where actions may be needed for improvement. The follow up of these indicators with time will allow more efficient planning and an evaluation of adopted policies.

The University is now publishing an annual report containing all indicators generated by the system for each of the Institutes and Faculties, as well as, for the central administration and support units. This report is distributed to all members of the academic community, to Government and Research Funding agencies. These indicators allow a comparison between Institutes and Faculties and have had a positive effect upon the academic staff, which became more concerned about performance improvement.

The most important result can be quoted, as a consequence of efficient management, optimization of expenditures and resource allocation along with policies with reward academic performance, is that the academic productivity, measured by the number of published papers per member of the academic staff, has increased by 20% in each of the last two years.

System portability

The system was conceived as a model that could be adopted by other higher education institutions. Its complementation is nearly completed at Federal University of Parana. The CASE tools allowed a fast and efficient customization of the system, needed because Federal Universities are subjected to different regulations and have a different organizational structure. Several other federal universities decided already to adopt this system. Because a large portion of university organization and managerial problems are common to all institutions it is far more efficient to adopt an existing system, mainly when there are available tools which allow for customization, than having each institution developing its own system. Implementation of this system takes about one year because it requires reorganization of administrative operations.

Final remarks

In this paper we have shown that it is possible to develop an integrated information system for complex organizations such as higher education institutions. Such a system can be developed with a small team using available tools of information technology. Investments in hardware can be recovered by decrease of administrative staff, apart from institutional development that can be achieved by improved management and planning.

The system concept and software architecture can guide other institutions in planning and developing their own system. It is certainly more efficient and cheaper to build a new system, already integrated by conception and using up to date technology, than investing in hardware and personnel to integrate existing departmental systems, which in most cases do not encompass recent developments in information technology.

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