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Developing a Faculty Information System at Carnegie Mellon University*

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Carnegie Mellon University (CMU) is known for its efforts in the area of academic computing. The development of a faculty information system to serve the campus community was the first step in a series of projects designed to upgrade administrative computing. Valuable lessons were learned from this development effort, which laid the groundwork for future cooperation between college and administrative units in the realization of common goals. The Institutional Research Division, in collaboration with CMU's Administrative Systems Department, was instrumental in the design and development of this system and was a major beneficiary of the resulting improved access to integrated information.

Historical Perspective

Investigation into the possibility of developing a system which would contain information about faculty began in early 1983. Discussions among personnel in several central administrative offices highlighted the need for a more flexible means of obtaining information about faculty for purposes of individual review and summary data analysis. In the same time period, one college was actively pursuing the development of a data base containing information on its own faculty to meet

the same kinds of needs. These projects coalesced in late 1983 with the initiation of the Faculty Information System (FIS) project under the auspices of the director of university planning. This system would be designed by a committee of university representatives to meet the common and specialized needs of central administrative, college, and department users.

The need for accessible, comprehensive information about faculty from a single source was well documented. Diverse offices on campus were individually compiling information about faculty, using paper files, standard reports, or locally developed data bases. This information was needed for a variety of similar projects—from individual salary review to tenure, flow and work-load analyses, and survey responses. Coming from a variety of sources, information used within the university and reported to external agencies was often inconsistent.

Most of this information about faculty was gathered and stored centrally in the payroll/personnel and student records systems on one of the university's main-frame computers. These systems were designed for use by the respective administrative offices to accomplish their specific functions. Constraints imposed by hardware, software, and data communications prohibited easy access to these systems by all campus community members who needed to make use of the data.

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Goals

The purpose of the FIS project was to provide authorized members of the campus community with flexible, easy access to centrally stored information about faculty. The specific goals, outlined at the initiation of the project were these:

1. To provide an integrated data base of faculty information from which queries, reports, and analyses could easily be generated
2. To provide access to both current and historical information.

The ultimate goal was to provide information which would support faculty-related decision-making processes, both centrally and in the colleges and departments. This system was not, however, designed as a true Decision Support System. It lacked a modeling component or specific tools which would directly assist a decision maker in planning and problem solving (Moore and Greenwood, 1984; Sheehan, 1982; Karon, 1986). Consistent with CMU strategy for computer use, the objective was to provide information and to encourage users to download this information into modeling software housed in a personal computer or on the local area network, a procedure that de-emphasizes the time-sharing mode of operation necessary for storage of such large sets of data.

System Design by Committee

The FIS was designed by a committee with members from the Planning Office, who were to serve in a coordinative role; members from Administrative Systems, who were to undertake the actual development; and representatives from each of the administrative and college offices, who would develop specifications for the system. The committee of approximately 18 members had the responsibility for defining the content of the system and designing the appearance of the on-line screens. The latter was the task to which the most time was devoted. This "design-by-committee" or user-controlled design approach is part of an overall philosophy of systems design that hinges on user participation. The practice of including the users in the design process allows them to set system criteria and have control over the design of the interface between themselves and the system (Lucas, 1982). The FIS project was the first large-scale administrative project at CMU to use this approach.

The central role of the Institutional Research Division in the development of this system flowed naturally from institutional research expertise in gathering, interpreting, and analyzing university data (Saupe, 1981). This was not a new role but, rather, one which evolved with the increasing reliance on computerized information systems. Institutional research professionals directed committee meetings and discussions, investigated data needs and problems, and worked to build a consensus where the perspectives and needs of users varied. The original design process lasted for two years, but the committee continues to meet occasionally to discuss ongoing issues and to plan future developments.

General System Design

Certain features of the general system design were established at the beginning of the project. The committee determined that the ideal system would include biographical, salary, teaching, research, and publications data and would eventually provide an on-line vita for all faculty members. Projects were to be tackled one at a time, beginning with a biographical screen. The following operating assumptions were defined at the outset of the project, and the expectations of the system were set.

1. The FIS would be developed in a relational data-base management system (DBMS), chosen to provide easy access to information about individuals through on-line screens and to summary data by means of a flexible retrieval capability.
2. The FIS would be a "retrieval" system, fed with information from the current payroll/personnel and student records systems. Central processing of payroll/personnel and student records data would continue in the originating systems. Any changes needed in FIS data would be made through these originating systems, following established procedures, and be passed back to the FIS.
3. The system would be used to accumulate historical information previously stored only on paper records or on computer tapes.
4. Data entry would be kept to a minimum but would be available for a few data items not stored on the central production systems. This information would be entered by users at the department level.
5. The system would eventually become an employee information system, storing data about all university employees.

Technical Implementation

The technical implementation was the responsibility of the Administrative Systems Department. One full-time programmer/analyst was assigned to the project and worked closely with the Planning Office and the FIS committee in designing the data base, transferring the data, and developing the user interfaces.

The decision regarding the hardware and software to be used in building the system was based upon available data-base technology and available CMU resources. In an effort to keep abreast of new developments and products in the data-base field, a state-of-the-art relational data-base management system, INGRES (Relational Technology, Inc., Alameda, CA), was chosen as the vehicle for development of the FIS. This meant that the system would be written in-house. Using the tools provided by INGRES, a customized relational data base and user interface were built to meet the needs of the campus community.

A "relational" system is designed to follow the set of principles that form the "relational model" (Date, 1982). This model provides a way of looking at and manipulating data that offers users great ease of use and powerful data-retrieval capabilities. The relational model's way of representing data as grouped in sets or tables (often called "relations") is easy for both users and data-base

programmers to understand. Data items and the relationships between these items are presented to the user in logical tabular form. "Views" (or logical representations) of the same data can be created for users who need regular access to different combinations of data elements.

Although relational and relational-like DBMS products were available for microcomputers, a mainframe DBMS was chosen for the FIS. Since the data would be shared by many users across campus and since some of the data would be highly confidential in nature, central control of the data was necessary. Further, the large quantity of data required a machine with sufficient storage capacity. The INGRES software runs on one of CMU's VAX 11/780 minicomputers, configured with 16 megabytes of memory and running the VMS operating system. This particular DBMS was already being used, with success, as the data-base management tool for other administrative applications. Investigations into the capabilities of the product suggested that it would offer a good development environment for the system. The user interfaces, such as the forms system and report-writing capabilities and the programmer tools of INGRES, offered the flexibility and ease of use important in a DBMS.

An additional advantage of INGRES, which was also very important to the FIS project, was its ability to carefully control access to the data. An elaborate system of "permissions" was developed for the FIS, granting users access to specified information (e.g., biographical only, biographical and salary) about faculty in their department or college. The VAX VMS operating system already provided an additional overall level of security, offering protection schemes at the user account, directory, and file levels.

Procedures were established to move data from the payroll/personnel system to the FIS on a regular basis. Data files are shipped once a week from the originating systems across a network to the VAX, where they are loaded into the data base. The FIS is composed of a series of screens which users access through a main menu. Information is displayed based upon values entered into any field on the screen. Users may also retrieve selected data elements by writing their own ad hoc queries. The FIS is supported by Administrative Systems in technical, user-training, and ongoing user-assistance capacities.

Detail System Design

The design process was accomplished through a series of monthly meetings, during which time committee members determined what categories of individuals would be included in the FIS and designed screens to meet user needs for information on individual faculty members. The committee discussed, in elaborate detail, the format and content of each screen. The goal was to ensure that the information would be inclusive and presented in a format that was useful to the campus community.

Five screens and the underlying INGRES data-base structure were designed and put into operation over the two-year period. The first screen, a Faculty Biographical Screen (Figure 1), was designed to display basic biographical and appointment information on individual

faculty members. The second, showing salary payments to faculty members, evolved into a series of three linked screens which list salary data in three levels of detail: five years of payments by year and time period (academic and summer payments; Figure 2); one year's payments by category (E&GO, Research, and Other; Figure 3); and one year's payments by center and account number within the above categories (Figure 4). The third effort was the design of a Faculty Teaching and Evaluation Screen (Figure 5) in which a record of courses taught and their teaching evaluation scores was to accumulate for five years.

FACULTY BIOGRAPHICAL DATA		AS OF:
SSN:		Street1:
Name:		Street2:
Title:		City:
Home Dept #:	Dept Name:	State:
Dept #:	Dept Name:	Zipcode:
Job Code:	Job Title:	Phone:
% Full Time:	Expired/current:	Univ Address:
Other Dept#:	Dept Name:	Univ Phone:
Job Code:	Job Title:	Marital Stat:
% Full Time:	Expired/current:	Sex:
Other Dept#:	Dept Name:	Birthdate:
Job Code:	Job Title:	Race:
% Full Time:	Expired/current:	Visa:
-----DECISION DATES-----		Employment Status:
Orig-Appnt:		Full/Part Time:
Re-Appnt:		Relation Code:
Promotion:		User ID:
Retirement:		Highest Degree:
Tenure Code:		Degree Date:
Eligibility:		Where Earned:
Tenure Date:		

Figure 1. Faculty Information System—Faculty Biographical Screen.

The first challenge faced by the committee was to coordinate college and administrative user perspectives on the data so that the final system would be equally valuable to all. This required that committee members develop a common set of data definitions. The committee began by defining the universe of individuals to be included in the FIS. After considerable discussion and investigation, it was agreed that the term "faculty," and therefore the data contained in the data base, would encompass full-time tenure-stream positions, full- and part-time non-tenure-stream teaching positions, and faculty-equivalent research/scientist positions. Persons in the latter category were considered faculty by the colleges but had been counted as researchers by administrative offices. Further discussion of screen format and contents revealed the necessity for minor university policy changes and a few alterations in the payroll/personnel system. Several new job class codes were added, as was the capability to maintain records on courtesy appointments that have no associated salary payments. Most important for this system, and for planning purposes, was the enhancement of the payroll/personnel system to capture information about faculty joint appointments and the percent of a faculty member's time associated with each. This information was maintained by the colleges but was not included in the central system. The cooperation and support of those responsible for the originating systems was critical to the success of this project.

Figure 2. Faculty Information System—Faculty Salary Screen 1.

Figure 5. Faculty Information System—Faculty Teaching and Evaluation Screen.

Figure 3. Faculty Information System—Faculty Salary Screen II.

Figure 4. Faculty Information System—Faculty Salary Screen III.

The most complicated task mandated by the committee was to combine data items from several production systems into a centralized inquiry system. The Faculty Teaching and Evaluation Screen required data from three systems: student records, payroll/personnel, and faculty course evaluation, and significant problems were encountered in the attempt to accurately match data items for each faculty member from the different systems. These difficulties derived from the attempt to use data from inflexible systems which were designed for other purposes. In some cases, data were incomplete (e.g., names of instructors teaching courses in the student records system were missing); in others, they were inconsistent between systems. An in-depth investigation by institutional research professionals revealed that the problems had two primary sources. First, departments did not always supply to the Registrar's Office complete information about changes after the semester had

begun. Members of the FIS committee were instrumental in emphasizing the importance of this task and encouraging improved departmental compliance. Other data problems lay within the technical structure and operations of the student records and faculty course evaluation systems. Finding solutions to these problems was beyond the scope of the FIS project, but efforts continue toward this end.

Finally, the FIS was transformed into an Employee Information System by the inclusion of information about all non-student employees in the university—one of the original long-term goals of the FIS. Its implementation was prompted by changes in personnel office procedures, which required an on-line Personnel Action Notice (PAN) Screen. This screen provided users with an on-line duplication of the paper form used to process employee information. This information now stored in the data base offers users the ability to obtain employee data easily, in the same way they can acquire faculty data, without relying on the originating payroll/personnel system. This process also resulted in improved communication between college and administrative offices.

System Use by Institutional Research

While the committee effort was directed toward the development of the screens, one of the most useful features of the chosen data-base management system was the capability of users to retrieve data in an ad hoc fashion. Using the INGRES query language called QUEL, users can quickly retrieve any combination of data elements and perform counts, sum, averages, or other simple arithmetic operations. It is also easy to save data and query results in a file and to download these to a personal computer for further analysis within spreadsheet or statistical packages. The capability to perform ad hoc queries has had a major impact on the ability of institutional research professionals to satisfy ongoing needs and to answer new questions relating to university employees, without the need of programming support.

The data base was immediately employed for the annual faculty count, which was expanded to include "special faculty" as defined by the FIS committee. In the second year of operation, standard reports listing and counting faculty members by various categories, such as rank, tenure and leave status, were written to further automate this annual process. Other traditional institutional research projects, such as tracking tenured faculty, including average ages and time in tenure by college/department, were greatly simplified; new projects, such as the annual production of a faculty profile, were implemented; and many smaller questions about faculty and staff were easily and quickly answered. All of these projects were accomplished using the ad hoc query capability, supplemented, where necessary, with the use of a spreadsheet, graphics, or statistical software on a personal computer. The query facility was also used when university preparation for potential budget cuts due to the Gramm-Rudman bill required the calculation of the percent of salary dollars charged to Federal research, by category of employee (Faculty, Research, and Other), tenure status, and college. This analysis could not have been accomplished prior to the development of the FIS without considerable program-

ming effort. Further, the fact that an analysis of this kind was never anticipated in the design of the system illustrates the flexibility of the relational data base as a tool for analysis. Additional projects, such as university-wide teaching-load analyses and analyses of faculty course evaluation results will be undertaken when data problems are resolved.

The roles and activities of professionals in the Institutional Research Division have also been affected by the implementation of this system. A primary function of institutional research is that of transforming data into information (Saupe, 1981). Since the FIS is not a true Decision Support System, the data require manipulation before they are useful as information. Institutional research professionals have become "expert users" of the data base, understanding its contents and continually learning more about its capabilities to meet increasingly complex requests for information. Dependence on administrative programmers has greatly decreased, while the accuracy of the data distributed from the Planning Office has improved. This is a result of improved access, of the ability to actively monitor the data, and of the new consensus regarding data definitions. This pioneering role played by the Planning Office in using the FIS served to demonstrate its potential and encourage use among the campus community. Finally, due to the institutional research role in developing and using the system and to staff shortages, an institutional research professional was actively involved in all aspects of user training: assisting in training classes, visiting user offices for personalized instruction and assistance, and answering questions when users encountered difficulties in using the system. This level of involvement was useful both in terms of providing support and encouragement to new users and in continuing the investigation of user needs and requirements.

Evaluation of System and Design Effort

An evaluation of the work done to date on the Faculty Information System must address two questions. First, has the system met the explicit goals established at the outset of the project? These were to provide an integrated data base of faculty information from which information could easily be obtained and which would include both current and historical data. Second, is the system being used by the campus community? In addition, an evaluation of the design-by-committee approach used in this project is important for future design efforts.

The system has met the established goals and objectives in some areas but has fallen short in others. Two primary requirements of the system, faculty biographical and salary data and screens, are fully functional, updated smoothly and regularly, and easily accessible. The third area addressed by the design effort, the faculty teaching and evaluation history data and screen, is still incomplete and requires further attention. Additional information requirements outlined in the initial discussion, such as faculty publications history, are yet to be addressed.

The issue of user acceptance of the system is multi-dimensional. The user community comprises 69 individuals, in positions ranging from secretarial to presidential. A survey of all users conducted in April of 1985 indicated that the majority are not making use of the system. Only fifteen users completed the survey; of

these, ten had used the screens and six had used the query capabilities. Only a few of those who responded used the system either regularly or intensively during certain periods. An analysis of computer charges to the data-base account over the two-year period shows slight but regular increases in usage by college users and large increases by administrative users, primarily the Planning Office.

These results raise the question of whether the system met the implicit goals of the committee. That is, is the FIS a useful tool for the projects for which it was intended? The committee effort was dedicated to the design of on-line screens which were to facilitate decision making about individual faculty members, both centrally and locally. The design and operation of the functional screens should have been successful in fulfilling this goal. The lack of use may have several explanations. First, all of the data in the completed segments of the system are still available on paper copy, as they were prior to system development. Second, delays and problems encountered during development, particularly with the reconfiguration of salary data, tempered initial enthusiasm and postponed usage of the screen segment. Further, salary information about some faculty members was not as useful as originally anticipated until the more recent changes in access permissions were implemented.

The ad hoc query capabilities of the system provide users with the ability to aggregate data according to their individual needs. Those who have committed the time to learning the query language and the structure of the data in the system find it very useful. However, the majority of users has not become comfortable with the query language. It appears that the varying levels of expertise in the use of the query capabilities of this system reflect the varying levels of computer expertise in the user community in general. In order to meet specific, complicated information needs, users requested assistance in the form of standardized queries and reports. These would facilitate rapid retrieval of information by users who are less knowledgeable about the data base and the query language and provide a common set of tools for all users. These requests have yet to be fulfilled, but their completion should encourage additional use of the system.

Finally, and perhaps most important, it appears that many users have not altered established work patterns in order to take advantage of the FIS. All users were offered training by Administrative Systems in the use of the system, and the majority attended these classes. Individual assistance is available through a phone call. However, the information contained in the system can still be obtained from paper copies, however cumbersome, and staff members are accustomed to using these sources. Clearly, the successful development and operation of a system designed to meet the needs of users does not automatically translate into alterations in work patterns and use of the system. There was at least one instance, however, in which development of skill in using the FIS was actively encouraged by a supervisor as a means of job enhancement for a new user.

An evaluation of the design effort itself is also necessary. This effort had both positive and negative aspects, and problems have been identified which should aid in future design projects. The design process can be described as largely successful. Attendance at committee meetings was excellent. Committee members often

arrived with comments, questions, or issues and provided considerable input. Members were cooperative and, after relatively brief discussions, were able to reach a consensus. Although use is not as heavy as might have been hoped, users are satisfied with the content and the appearance of all currently functional aspects of the system. Further, administrative and college users were successful in merging their varying perspectives to achieve a common goal. This may be one of the most important and enduring aspects of this design effort.

The primary disadvantage of this method was its costliness in terms of time. It required many meetings to design each screen, and delays were inevitable as administrative systems system designers were required to conduct investigations about whether a requested combination of data elements would be possible with available information. Expectations were raised and lowered as deadlines were missed; completed screens were sometimes sent back to the drawing board for the incorporation of a new suggestion or requirement. In evaluating this aspect, two changes are recommended. First, more up-front analysis of user needs and of the originating systems should be undertaken before convening the first committee meeting. Second, a means is needed to establish when a segment of the project (e.g. a screen) is complete according to specifications. This should be coupled with a standardized method for requesting changes or additions and an ongoing schedule for implementation.

This is not an evaluation of a completed project but, rather, of an ongoing effort. Some of the lessons learned in this project have been incorporated into the new administrative data-base design effort. Other questions, particularly those relating to use of the system, will not be answered finally until the system has been in operation for a longer period of time.

Future Directions

In an ideal world, all university information would be stored in one location and any combination of data elements would be easily, even immediately, accessible. This is consistent with Joplin's (1980) "guiding principles of data-base construction," namely, that the data base should contain information from all university components and be stored in one central location. CMU is moving in this direction by planning for the development of a University Information System (UIS). As a first step in this project, the FIS is being merged with student records data to form a single relational data-base system using INGRES on a mainframe computer. It is anticipated that the UIS will eventually encompass data on space, student accounts receivable, and financial aid.

This project will provide authorized campus users with retrieval-based access to student records, payroll/personnel, and other data without allowing access to the originating systems, much as was done with the FIS. The UIS is not intended to replace or change any of the current production systems, although these production systems are scheduled for replacement over the next few years. The new production systems will be fully compatible with INGRES and will continue to support the integrated functions of the UIS.

The incorporation of the FIS into the UIS involves a redesign of the underlying data-base structure which

will make the FIS fully compatible with the student records data. For example, basic biographical data common to both systems will be stored in a single biographical table. The new structure will make it easier for users to query the data base since data on all employees will be fully and consistently integrated. The permanent link with the student records data will also facilitate the resolution of data problems encountered in the original FIS design process. The screens already in operation in the FIS will be reproduced in the new system, with some variations resulting from the new underlying data-base structure. Requests for standard reports and queries will also be fulfilled in the new system. One of the specific project goals for this integrated system is to use it for the production of university teaching-load analyses.

The design-by-committee approach is also being used in this project and incorporates most of the changes suggested in our evaluation. Institutional research personnel have devoted considerable time to the analysis of user needs, based on individual interviews, and are preparing a user specifications document. Administrative systems personnel are undertaking a thorough analysis of data items in the originating systems. This groundwork is required to ensure completion of the project in a much shorter time period than required for the FIS.

The ability to extract data from the University Information System and move files across a network to personal work stations will be stressed during the training phase of the UIS project. Initially, users will be encouraged to obtain desired data sets by using standard programs or ad hoc queries and to download these to their personal computers for further analysis. With the release of INGRES's distributed data-base technology, the UIS can be transformed into a truly distributed system, with data sets residing on servers and work stations connected to the campus network. This new technology will offer faster access to shared sets of data and will move away from a single mainframe source.

This is an ambitious project but one which should serve to meet campus needs for university information in a manner which was not possible several years ago. It is expected that this new system will be of great benefit to the institutional research and planning process and will provide unique opportunities for members of the campus community to obtain and use university operating data.

Summary

The need for a single, easily accessible source of data about faculty prompted the development of Carnegie Mellon's Faculty Information System (FIS) and its expansion to include data about all employees.

The effort to design an FIS centered on the development of a series of screens addressing three areas of interest to users: biographical data, salary data, and data on teaching history. A committee of representatives from both academic and administrative offices was formed to design the system. The committee focused its attention on identifying and defining necessary data items, specifying screen layouts, and determining security rules. The primary benefits of the design-by-committee approach were user control of the end product and the improvement in communications between academic and administrative offices. The major problem with this approach, as it was implemented for this

project, was its high cost in terms of time. A revised approach, involving more analysis of user needs prior to committee meetings and fewer group meetings, is recommended and is being used for the University Information System (UIS) development.

The software chosen to build the FIS application was INGRES, a relational data-base management system. INGRES was chosen because of the flexibility and ease of use it offers both end users and programmers, as well as for its application development tools, report writer facility, and robust ad hoc query language. Further, relational data-base technology offers the ability to expand or change data tables without affecting existing applications.

While the system design effort focused on the development of the screens to display information about individuals, the ability of a user to query the data base at any time for specified sets of data, without the assistance of a programmer, is one of the more valuable aspects of the FIS. The ad hoc query language gives users immediate access to specific data elements chosen and ordered to meet their purposes. Users can aggregate this data using the query language, and/or can download the data to their personal computers for further analysis in spreadsheet or statistical software. This downloading has the additional advantage of lessening CPU and disk space usage on a mainframe, thus minimizing the potential for overloading the system. Ad hoc queries and file extraction have been used to great advantage by the Institutional Research Division, whose work serves both to demonstrate the potential of the system to other users and to provide faster, more accurate information in response to traditional and new requests. While some users have followed this example, many have not had either the time to learn the query language or the inclination to alter established work patterns.

The proven flexibility and ease of use of an INGRES data base, as demonstrated by the FIS, have encouraged the university to support further development. The UIS will integrate data on faculty, staff, students, and space. The use of INGRES for other university systems is currently being investigated, with the eventual goal of implementing the emerging distributed data-base technology and thereby providing a wide range of users with access to needed data across the campus network.

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