DESIGN OF A COMPUTERIZED MEDICAL SCHOOL ADMISSIONS PROCESS

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ABSTRACT

A Computerized Admissions Process (CAP) was developed for the St. Louis University School of Medicine. This system is written in MUMPS and currently runs on a Tandem Computer System located at the Medical School. The system was designed to achieve several important goals. First, the system must be interactive, providing full integration of various clerical, word processing and administrative functions that comprise the admissions process. Second, there must be a capability for user-defined screening criteria. Third, data entry must be minimized. Fourth, the system must be designed to allow reconfiguration in order to reflect possible future changes in the overall admissions process. A discussion of the present admissions system as a single "state" of a more Generalized Action System (GAS) is presented.

INTRODUCTION

Every year the Office of Admissions at St. Louis University Medical School is confronted with the formidable task of selecting 155 candidates for its entering class from a total pool of approximately 6000 applicants. While this goal had been satisfactorily achieved for many years relying solely upon manual procedures, a decision to computerize a major portion of the admissions process was reached in the fall of 1981. Although the authors were aware of other computerized admissions systems serving medical schools (1-3), the particular requirements of St. Louis University were judged to be sufficiently unique to justify the development of an entirely new system.

HARDWARE AND SOFTWARE

The St. Louis University School of Medicine CAP currently runs in time-sharing mode on a triple-processor Tandem NonStop computer system located at the medical school. CAP software is comprised of approximately 40 routines written in the MUMPS language. We chose the MUMPS language for system implementation both for its advanced database processing capabilities and for programming efficiency (4). The functions of the various modules can be broadly grouped into the following areas: security, system configuration, file updating, screening, interview scheduling, word processing, report generation and statistics, workload monitoring and error detection.

OPERATION

All CAP operations, with the exception of tape handling and system backup procedures, occur interactively through video display terminals. System activities are divided into three areas: maintenance, administrative and clerical. Maintenance activities include the conversion of applicant information supplied by AMCAS tapes to MUMPS compatible format as well as periodic system backup. These actions are regularly performed by the programming staff. Administrative activities include preliminary applicant screening and final committee decision making concerning the acceptance status of applicants, and are assumed by a (faculty) member of the Committee on Admissions. Initial decisions concerning system configuration are determined by the Chairman of the Committee on Admissions, in consultation with a programmer. Clerical activities are performed by the Secretary to the Committee on Admissions. Some of these tasks include applicant file information updating, interview scheduling and generating correspondence concerning applicant decisions.

RELIABILITY, SECURITY AND ACCOUNTABILITY

Designers of any type of computerized information system must develop strategies for the achievement of reliability, security and accountability before the system is made available for general use. A reliable system is simply defined as one that is (almost) always available at the appropriate times, which also performs its designated functions in the expected fashion. A secure system is accessible to authorized users while remaining completely inaccessible to those without the proper authorization. A system demonstrating accountability not only performs correctly the tasks for which it has been designed, but also maintains information that will
enable the users to trace the exact sequence of actions that were initiated in order to achieve a given outcome. In practice, reliability, security and accountability often show a degree of overlap. System features that are designed to enhance reliability may have a positive effect upon accountability, and so on. Because of the extremely sensitive nature of the admissions process we have expended great effort toward the realization of a "fail-safe" system.

Of all of the potential problems that can occur while using a CAP, the most troublesome is undoubtedly the alteration or loss of applicant information. Although the Tandem NonStop computer system is designed to minimize this occurrence, further actions are necessary in order to provide complete reliability. On a regular basis a backup copy of the entire CAP is created and stored in a disaster-proof safe.

Although the computer system architecture and periodic backup procedures are effective in preventing large-scale losses of data, the elimination of data loss/alteration on a smaller scale requires different strategies. If we examine the causes of these occurrences we find they may result from errors in programming and/or user errors. While there exist no strategies guaranteeing the complete elimination of programming errors, the CAP maintains a transaction file that records sequentially decisions that change the status of applicants. This transaction file is checked daily against the main applicant activity file, and any discrepancies are promptly investigated. In the case of user error, the transaction file is consulted in order that the erroneous action may be quickly "undone." Before any successive actions are performed.

A reliable system is of little value unless measures are taken to ensure that only properly designated individuals are given access to the system. There are several ways in which adequate security is established for the CAP. First, each user of the system has his or her own password-protected logon name. This password is selected by the user and known only to the user, and can be changed at any time. Second, access to the admissions system can only be accomplished via a limited number of terminals. Any attempt to gain access to the system from an unauthorized terminal will not only meet with failure, but will immediately send an "alarm" message to the computer system manager describing the time and location of the attempted access. Finally, in the unlikely event that an unauthorized individual overcomes these safeguards and gains access to the system, his or her access can be discovered by consulting the user log file which will provide the logon time and the logoff time. By comparing the user log file with the transaction file, all of the unauthorized actions performed by this individual can subsequently be "undone.

CLERICAL AND ADMINISTRATIVE FUNCTIONS

As we have mentioned previously, the CAP must be capable of performing both administrative and clerical functions. In order to promote the most efficient utilization of an Admissions Committee member's time, his or her interaction with the system should be limited to administrative decision making. Other system activities requiring less expertise are reserved for the clerical staff. For example, should the administrative user indicate "acceptance" for a particular applicant, the appropriate files will be immediately updated to reflect this action. However, the task of printing the acceptance letter will be undertaken by the clerical user(s). This division of labor is strictly enforced by the functional organization of the software. Administrative users are prevented from performing clerical tasks and clerical users are likewise prevented from attempting to provide administrative decisions by built-in system safeguards.

USER-DEFINED APPLICANT SCREENING

The CAP gives the administrative user the capability of defining two types of screening rules that can be used to sort or rank applicants into various groups based upon pre-existing applicant data. A contingency rule can be used to generate a grouping of applicants that fulfill certain specified criteria. These individuals will usually be presented in alphabetical order. For example, one contingency rule might be constructed as follows:

SELECT <contingency criterion>

SELECT applicants from the states of Missouri or Illinois having total Medical College Admission Test (MCAT) scores greater than 60 (Rule 1).

Any rule that can be expressed in logical form, using AND, OR and NOT operators is acceptable. A ranking rule is similar to a contingency rule, with the additional specification of a score for each applicant that is set equal to an arithmetic expression comprising numeric data together with some combination of the four operators: +, -, *, / (addition, subtraction, multiplication and division). The following is an example of a ranking rule:

SELECT <contingency criterion> RANK <score=arithmetic expression>

SELECT applicants with completed files, RANK by score = .45 * Science GPA + total MCAT scores (Rule 2).
Applicants are selected and presented in rank order according to the score each has achieved. If more than one applicant is encountered with the same score, those applicants will be listed alphabetically. We may consider a contingency rule as a special case of a ranking rule, with the default ordering being alphabetical. We have combined similar rules with basic report formatting capabilities, resulting in the creation of a flexible and efficient report generator.

RESULTS
An evaluation of the effectiveness of a CAP must take into consideration the complementary issues of efficiency and effectiveness. Since the overall goal of any admissions process is the recruitment of the most suitable individuals for an incoming class, we must attempt to determine the effectiveness of the CAP in achieving this goal. Unfortunately we are unable at this time to compare the effectiveness of this admissions process with the earlier manual system because it has been in operation for a relatively short period. However, we have identified criteria which will enable a preliminary evaluation to be completed within the coming year.

After having had the opportunity to utilize the CAP for a total of 8 months, we find ourselves in an excellent position to evaluate the short-term efficiency of this system vis-a-vis the former manual system. The following improvements have been clearly demonstrated:

1. There has been a large improvement in "quality control" of application processing. Applications are rarely "temporarily misplagued" and Admissions Committee decisions are rendered more promptly and recorded permanently.

2. The production of hand-typed correspondence has been reduced by more than 90%, and the time required for applicant interview scheduling has been reduced by 75% from that of previous years. The chance of scheduling more than one applicant for a single interview slot has been entirely eliminated.

3. Computerized reports have completely replaced reports from previous years which were both compiled and typed by hand. The Committee on Admissions can now be certain of receiving immediate feedback regarding the cumulative credentials of the selected group and other relevant demographic data.

4. Admissions clerical personnel and committee members no longer need to consult the "paper" files to retrieve most types of applicant information.

Our best estimates demonstrate a reduction in time required of 35% for clerical personnel and 30% for administrative personnel for completion of the overall admissions process.

GENERALIZED ACTION SYSTEM (GAS)
When we began to examine the feasibility of developing a CAP, a classic systems analysis was initiated in order to design a system that would do little more than emulate the existing manual admissions process. After conducting a preliminary examination of other computerized systems our perspective changed. The fundamental question became: What kinds of features do CAPs have in common with one another, and how can we best exploit this knowledge to develop a "Generalized Action System" (GAS) capable of simulating a variety of possible CAPs? Although devising a solution to this problem is not without theoretical interest, other more practical concerns guided us in the direction of the GAS.

Consider the following scenario:
Several hundred man-hours are expended toward the completion of a CAP that is designed to replace the current manual admissions process. The system is installed and begins to function efficiently to the delight of everyone. One of the unwritten laws of system design (akin to the law of rising expectations) begins shortly to have its effect: "If a computerized system is performing a useful function, requests for 'enhancements' or 'new features' will quickly occur". Since most of these requested changes were not part of the original design specification, either of two outcomes are possible. Nothing at all may be done, in which case presently delighted users may gradually begin to resent the CAP for its inability to adapt itself to their changing needs. The other alternative requires the allocation of additional man-hours in order to redesign the present system to accommodate the revised specifications, potentially a very costly undertaking that will likely need to be repeated periodically. If the system designers had the foresight to implement a version of a GAS, the current system could have been reconfigured without extensive reprogramming in a short period of time. In the following discussion we will provide a brief conceptual description of a Generalized Action System.

The three fundamental concepts that enable us to understand the nature of a GAS are: networks, action states and transition rules. An action state can be defined as a grouping of individuals that have certain defined characteristics in common. A network is a grouping of action states into a well-defined topological pattern. Transition rules determine the requirements for individuals in one action state to move to
another action state within a given network. Let us illustrate these concepts with a concrete example of an extremely simple admissions process, which works as follows: In order to be considered for admission to School XYZ, all applicants must fill out a one-page form. Information on this form is reviewed by the admissions committee and the student is accepted or rejected depending upon the value of an evaluation score determined for each applicant by the admissions committee. We can identify four action states and three transition rules. The action states are: 1) application incomplete, 2) application complete, 3) accepted and 4) rejected. The transition rules are: 1) move from "application incomplete" to "completed" if form is filled out, 2) move from "completed" to "accept" if the evaluation score is greater than or equal to cutoff, and 3) move from "completed" to "reject" if the evaluation score is less than cutoff. As expected, we notice that no transition rule exists that will enable an individual to move directly from "application incomplete" to "accept" or "reject". The following matrix provides a mathematical representation of allowable transitions for the simple system we have described:

<table>
<thead>
<tr>
<th>TO STATE:</th>
<th>I</th>
<th>C</th>
<th>A</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>C</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>A</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>R</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

In this notation, the presence of a '1' indicates an allowable transition. As expected there are only three '1's which indicates three possible transitions. Although this configuration represents one of the simplest possible systems, any conceivable admissions system of arbitrary complexity can be represented in a similar fashion. The process required in order to transform a GAS into a version of a working CAP is summarized below.

**SUMMARY**

The approach we have chosen at St. Louis University School of Medicine for computerization of the admissions process led us to the design of a Generalized Action System (GAS) which was subsequently configured for particular institutional requirements. There exist five major determinants that must be specified in order to transform a GAS into a useable computerized admissions process:

1. All action states are defined, together with descriptions of the characteristics of each state.
2. Allowable transitions between action states are established.
3. Certain conditions must be fulfilled before allowable transitions may occur. Some of these conditions include authorization by a specific user or users, and the collection of certain kinds of information. Contingency rules, described earlier, may be included here.
4. The effects of transitions must be determined, such as the manner in which file updates are to occur and the types of correspondence generated.
5. A presentation mode for an allowable transition may be designated, in the form of a ranking rule described earlier. For example, in a transition to "application complete" we may choose to display applicants in this action state ranked according to MCAT scores.

If future circumstances mandate alterations to the existing admissions process, no additional programming is necessary. All that is needed are changes to the five determinants that define the structure of the CAP. This task can be easily accomplished using the GAS system generation program that has been specifically designed for this purpose. Because of the unequivocal success we have achieved at St. Louis University School of Medicine, we strongly recommend the GAS strategy as an excellent solution to the problems of application processing for other academic institutions.

**REFERENCES**