

A GENERAL UNIVERSITY SIMULATION

MODEL

H. K. Eldin Ph.D.

Oklahoma State University

Stillwater, Oklahoma

C. C. Daniel

NASA/MSFC

Huntsville, Alabama

Abstract

This paper presents the results of an attempt to develop a general simulation program for the study of the utilization and allocation of resources in the university environment. The problem area examined covers the use of both physical and human resources. The simulation program was written in GPSS 1100.

Introduction

The use of simulation as a technique for the examination of the interactive aspects of the operation of physical systems has increased greatly within the past few years. The vast majority of these simulations are designed to attack

a specific problem and as such are greatly limited in their application.

The lack of generality in simulation programs has tended to foster a large degree of duplication of effort. While many unique situations may exist in which specialized simulation programs are

appropriate, there also exist a large number of similiar systems which can benefit from the development of generalized simulation models. The university system is an environment in which the basic elements are relatively stable from institution to institution. The simulation model developed for a general university situation would, with certain modifications, be expected to hold for other universities. Based on this assumption, the authors have attempted to develop a general model for the study of the university resource utilization problem. The results of this effort are the context of this paper.

Description of the Physical System

The program presented in this paper simulates the physical university environment presented in Figure 1. This environment consist of the physical facilities, including the classrooms and the support facilities, and the human resources of the university staff. The basic problem is to examine the allocation and utilization of the available resources under various system conditions.

Each potential class in the basic university system must function within the available student and resource limits. Therefore, of all potential courses to be offered by the university, only those in

which there is sufficient student enrollment and for which there are available both the required physical and human resources, can be offered. The enrollment limit for each class level is established by the university on the basis of funds available and alternate demands on the resources. The work time for the university system is also a function of the type of students enrolled in the system. Additionally, this relationship influences both the time and amount of resource utilization.

Desirable Characteristics of the Program

The basis of any generalized simulation program is the ability of multiple users to utilize the program with only minor system changes. To accomplish the objective of program generalization, the following characteristics were included in the program:

1. A relatively simple and easy method of data input.
2. A choice of output options.
3. The ability to vary the discrete control distributions.
4. The ability to change system control limits within a simulation run.

These characteristics tend to provide a program with the flexibility required of a general model.

Model Description

In describing the simulation model, the following areas will be discussed: model assumptions, programming language and computer requirements, unique features, model inputs, model outputs, and model execution.

Model Assumptions

The following assumptions have been made in the development of the university simulation model:

1. Class length is one hour.
2. Any class which does not have a required number of students enrolled or which cannot find available space, will not be offered.
3. Classroom space and instructor personnel are allocated on a first come first serve basis. However, allocation on a priority basis is possible.
4. All control distributions are discrete in nature.
5. The utilization of support facilities, that is, administrative, laboratory, and computational facilities, is separate from the utilization of classrooms and instructors.
6. The daily operating time of the university is variable.

7. Course classroom allocation is made on the basis of the number of students in the course and the classroom range into which the course falls.

Programming Language and Computer Requirements

A general flow diagram of the simulation program is presented in Figure 2. The program is written in GPSS 1100 for the UNIVAC 1108 computer. The number of FUNCTIONS, and MATRIX SAVEVALUES required is dependent on the size of the system to be simulated.

The program is currently set up to run in the 48K partition on the 1108 computer. However, as the size of the system to be simulated is increased, the core required for the program will also increase.

Unique Features of the Program

In developing this simulation model, it became apparent that the greatest problem to be overcome was the requirement for the vast number of transactions generated in the university environment. The approach taken to overcome this problem was the use of a carrier transaction which served the same function as the normal flow transactions. As a result, the initial portion of the program took

the following form:

```
*
* DETERMINE THE NUMBER OF STUDENTS
* ENROLLED IN EACH SPECIALTY
ZZZ ADVANCE
SPECNU VARIABLE X$TOTNU*FN$SPEC.PROB
MSAVEX SPEC1(P$PAR1,1),V$SP-
ECNU
LOOP PAR1,ZZZ
```

A single transaction performs the calculations for all specialities in the system. The enrollment in each speciality is determined on the basis of a discrete probability function inputted at program initiation.

Another unique feature of the program is that all program inputs are provided by either the INITIAL or the FUNCTION statements. A description of the input procedure will be provided in a later section of this paper.

To provide for multiple simulations of a number of semesters, the program can be utilized with a RESET card as shown below:

```
*
START 1
RESET
START 1
```

A system printout will be provided for each START card. Any number of basic

simulations may be run in this manner.

Model Inputs

As stated previously all model inputs can be provided through the use of the INITIAL and FUNCTION cards.

It is assumed that sufficient data is available to provide for discrete distributions in the following areas:

1. Total number of students enrolled.
2. Percentage of students at each class level, i.e., junior, senior, etc.
3. Percentage of students in each speciality.
4. Percentage of each type of student, i. e., full time, part time, etc.
5. Distribution of class types and sizes.
6. Distribution of course size requirements.
7. Distribution of instructor requirements.
8. Distribution of support requirements.

The INITIAL card inputs involve such factors as:

1. Class size limit.
2. Work hour limits.
3. Classroom definitions.
4. Instructor definitions.
5. Speciality course definitions.

The program output requires a MSAVEX, matrix savevalue, definition for each classroom. The definition takes the following form:

```
*
* INSTRUCTOR DEFINITIONS
    MATRIX SMITH(8,5),JONES(8,5)
* CLASSROOM DEFINITIONS
    MATRIX EN315(8,5),EN215(8,5)
*
```

At the beginning of each simulation, the instructor and classroom schedule are reset to zero.

```
*
    INITIAL SMITH(1-8,1-5),0/
           JONES(1-8,1-5),0
*
    INITIAL EN315(1-8,1-5),0/
           EN215(1-8,1-5),0
*
```

The possible courses which may be offered are also supplied by INITIAL cards.

```
*
    INITIAL INDEN(1,1),4133/
           INDEN(2,1),4211
*
```

Classroom size limits are specified in range values as follows:

<u>Range</u>	<u>Size</u>	<u>Cummulative Freq.</u>
1	10	.05
2	10 20	.45
3	20 50	.65
4	50 100	.85
5	100 250	1.00

The discrete function is then inputted to the program in a FUNCTION statement as follows:

```
*
RANGE FUNCTION,D V$CALC,.05,1
        .45,2 .65,3 .85,4 1.0,5
*
```

The major portion of the simulation model consist of a schedule update sequence based on a series of indirect assignment blocks. The assignment of a classroom name takes the following form:

```
*
    ASSIGN PAR17,*CLASS.NAME
*
```

where CLASS.NAME is a name valued function containing the utilization distribution for the classrooms.

The hour at which the classroom is to be used is specified as follows:

```
*
    ASSIGN PAR16,FN$TIME
*
```

where TIME is a numeric valued function containing a discrete distribution relating to the hours of the day during which the classroom will be available.

Model Outputs

The outputs from the simulation program are composed of the following:

1. A master schedule for each speciality showing:
 - a) Course number.

- b) The instructor who is teaching the course.
 - c) The credit hours for the course.
 - d) The number of students enrolled in the course.
 - e) The classroom utilized.
 - f) The time of day at which the course is to be offered.
2. A schedule for each classroom.
 3. A schedule for each instructor.
 4. A listing of all nonscheduled courses.
 5. A listing of all request for support services.

This output may be restricted or expanded through the use of the PRINT option.

Model Execution

The program has been setup to simulate on a semester basis with the number of semesters to be simulated as a user option. The simulation takes the form of multiple schedule modifications as follows:

```

*
* UPDATE CLASSROOM SCHEDULES
      MSAVEX *PAR17(P$PAR16,1),P$-
          PAR7
      MSAVEX *PAR6(P$PAR5,6),P$PA-
          R16
      MSAVEX *PAR17(P$PAR16,5),P$-
          PAR7
*

```

The use of indirect referencing allows for the use of any number of classrooms without model modification. The instructor schedules are updated in a similar manner, however, the instructor selection process is based on a specialty selection process. An example of the specialty selection process is as follows:

<u>Type</u>	<u>Instructors</u>
1	Jones, Smith, Eldin
2	Jones, Brown, Daniel
3	Brown, Smith
4	Eldin, Brown

The selection sequence for the above inputs is as follows:

```

*
      ASSIGN PAR18,MX$*PAR6(P$PAR-
          R5,2)
      ASSIGN PAR19,*INST.FUNCT
      ASSIGN PAR30,FN$*PAR19
      ASSIGN PAR20,*INSTRUCT
*

```

The above sequence will select an instructor of the required type and will ready his schedule for update. All outputs are in the form of name valued attributes. This option provides for easy simulation analysis.

Analysis

The university simulation model was developed in order to study the interactive aspects of the university scheduling and resource allocation problems. The

model was designed in such a manner that system input data and model operating sequence could be altered without an alteration of the basic model itself. In the process of developing the model the following options were considered:

1. A calculation of the utilization of the university personnel and facilities.

This option was factored into the model, however, the feasibility of calculating a utilization rate for university personnel was found to be limited. This limitation developed due to the multiple aspects of the instructor's work load.

2. A projection analysis and forecasting system was examined for use in the area of instructor and classroom definitions.

3. Several methods were examined for use in the study of the support and service facilities of the university. The method which was finally factored into the model provides the following data:

- a) A listing of all request for support along with the type of support requested.
- b) A tabulation of the number of request for each support facility along with the durations

of the support activity.

The procedure for comparing two alternative systems is based on simulation runs utilizing the same random number base. The system outputs may be compared on either a direct utilization basis or on the basis of the system scheduling sequence.

Conclusions

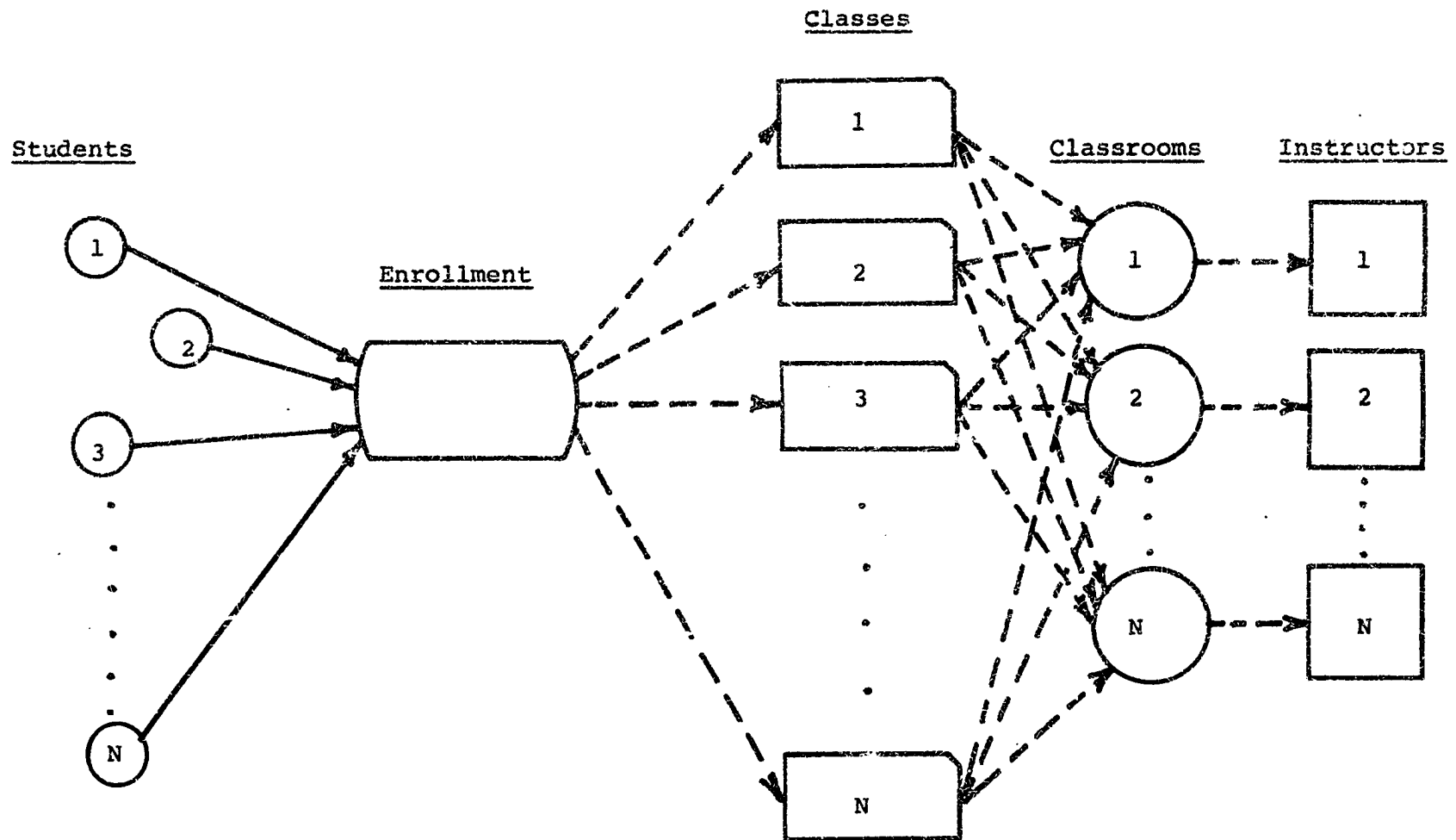
The university simulation model presented in this paper provides the basic structure for an effective method of analysis of the dynamic university system. The system outputs are provided in a form which can easily be analyzed.

The main limitation of the program is in the area of the required supporting discrete distributions. If sufficient data is available the basic model should be applicable to any university system.

When a large system is to be simulated it is recommended that the user utilize a data tape for inputs rather than standard punched cards.

The model presented in this paper is intended to illustrate that the technique of simulation can provide a valuable tool in the study of the university system. While for the factors considered the basic model does provide a general simulation basis, there are certain unique system characteristics which

may be required in each application. It is believed that the options provided in the simulation program will allow for the consideration of these unique features without major program changes.



The number of classes, classrooms, and instructors can vary from 1 to N. The flow pattern is a user option.

Figure 1. The University System Configuration

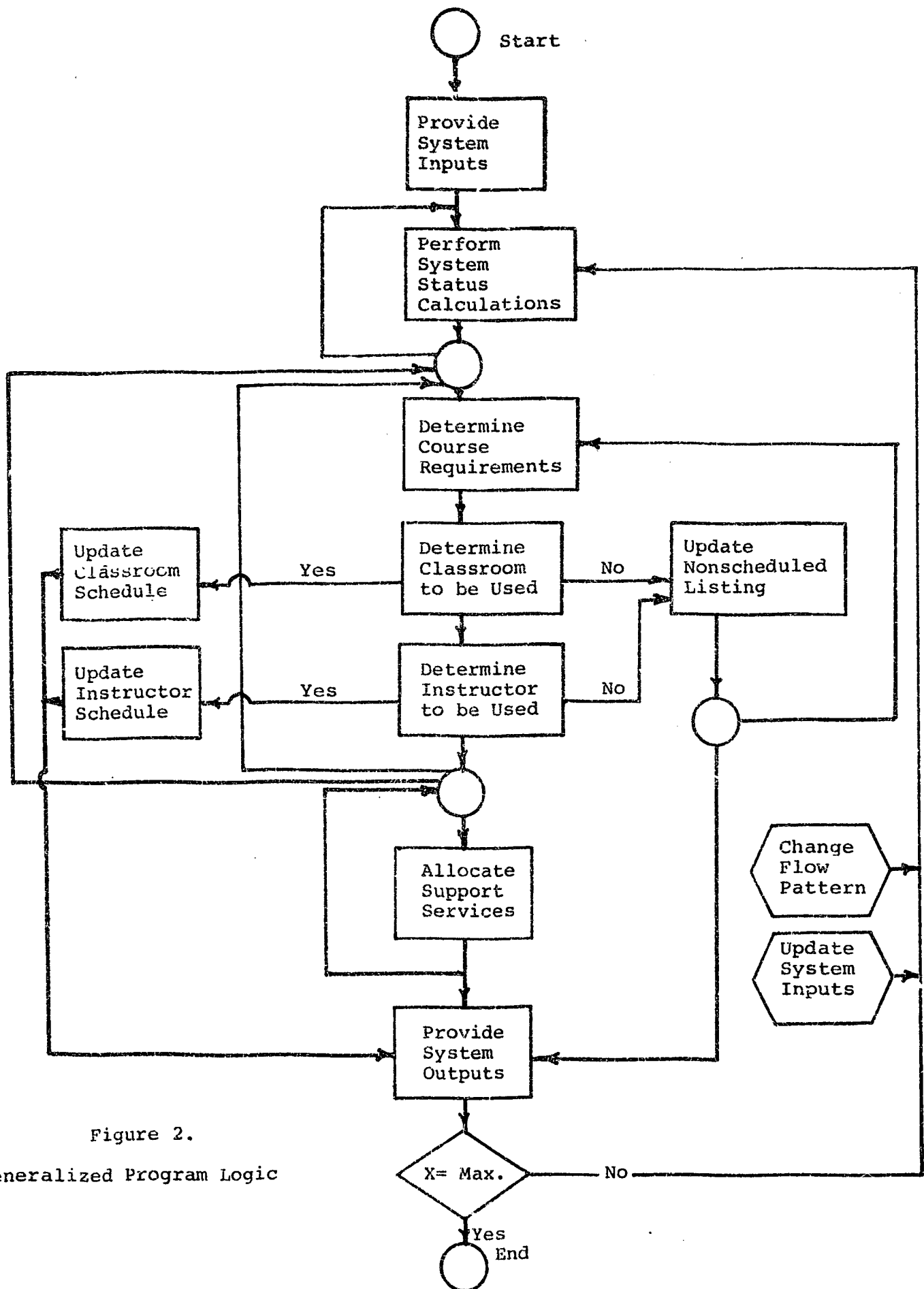


Figure 2.
Generalized Program Logic