HAWSIM SIMULATION OF SOCIAL SERVICES

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Abstract

This paper describes one aspect of a large developmental effort to convert and apply the full range of systems technology to community mental health programs. Community mental health is treated functionally as the delivery of health and welfare services which currently operates as a fragmented aggregate of unrelated means. In the attempt to design more efficient health and welfare systems, simulation models are built and subjected to perturbation analyses. HAWSIM, an acronym for Health And Welfare SIMulation was developed specifically as a problem oriented discrete event simulation language to build these models as a tool for management evaluation and program planning of public social services. The developmental history and application of HAWSIM are described including a brief overview of some of the problems in simulating social systems.

In the late fall 1966 a research project was established at the Adolf Meyer Zone Center, a multi-component psychiatric facility in Decatur, Illinois whose objectives were the conversion and application of operations research and systems analysis techniques to the problems of mental health and more generally to the issue of health and welfare service delivery. One of the intended tasks was to build and simulate models of the activities of the many agencies involved in the health and welfare system and to design alternative system configurations of agencies and services. These configurations would then be simulated through time to test the effectiveness of the designs.

After a period of defining broad basic goals, simulation was begun in the spring of 1967. The first exploratory simulation of the Juvenile Court system written in GPSS/III[1] for the 7094-II at the University of Illinois. This program, although it never completely successfully executed, was quite instructive. It pointed up the types of data necessary and it gave the first indication of what was to be our later path in terms of simulation languages. This GPSS program, although it represented only a small part of the criminal court system and did not contain much detail of social significance, was quite lengthy and demanded a number of specialized routines to assist in decision making. GPSS also forced the inclusion of a large number of details which seemed to be of little significance in terms of health and welfare systems.

In the fall of 1967 the matter of a specific simulation language was examined in detail. The choice was between using already existing simulation languages, the main contenders being GPSS[2] and SIMSCRIPT[3], and constructing a new language specifically for health and welfare simulation. The languages considered for this latter possibility were FORTRAN IV and PL/I. After considerable trade-off evaluations, the decision was made to write a simulation language using PL/I. This

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decision was made because it seemed desirable to develop a language which allowed users to think and write in terms meaningful to social systems and to improve communication between the programmer and workers actually engaged in managing social agencies and delivering services. PL/I was chosen over FORTRAN because of its greater flexibility and because of its character manipulation ability.

The logical design of the language, called HAWSIM for Health And Welfare SIMulation, was completed by November 1967, and programming was begun immediately. HAWSIM is a problem oriented discrete-event simulation language written entirely in PL/I. It is composed of three major completed segments, PRESIM, a pre-compiler which expands the HAWSIM statements into PL/I statements and builds a number of tables; PROSIM, a set of simulation routines, SIMOUT which reads the tables prepared by PRESIM and the data generated by the simulation program and prints the simulation report.

PRESIM is a two-pass pre-compiler. It reads the HAWSIM program (in card format) and produces a complete simulation program for input to the PL/I compiler. PRESIM expands the HAWSIM statements into PL/I statements and builds several tables for its own use and for later use by the simulation program and the output routine.

PRESIM has an additional feature which is rather unusual: it makes specific provision for the compilation of user PL/I coding in the middle of the generated PL/I statements. PRESIM is well documented and an experienced PL/I programmer can add options or additional HAWSIM statements with only a moderate time expenditure.

PROSIM contains the driver routine and the various simulation routines. Many of the routines are based on GPSS routines but as more experience is gained and new problems arise, routines specifically designed to solve the type of problems that arise in simulating health and welfare agencies have been included.

SIMOUT, originally very similar to the standard GPSS output, now has major differences in the areas of cost accounting and referrals. The main resources of most health and welfare agencies are their personnel. These resources have characteristics such as salaries, overhead, administrative responsibilities, hours of availability and vacations. An attempt has been made to cost out most of these characteristics and present the results in a form usable to health and welfare administrators. Referral patterns are generally considered to be an important feature of social agency systems. The number of referrals along with the referral source and referral destination to and from each agency is printed along with a cross referral matrix. A listing of the paths of individuals through agencies is given. These paths are in form of Agency A to Agency B, A to B to C, and A to B to C to D. A, B, C, and D represent any of the agencies. For each path the number of individuals traversing it is given. To date no need has been found to include more than four agencies in any path.

The key HAWSIM document, the syntax, is expressed in Backus-Naur-Form. As a computer language it looks very much like PL/I with several minor exceptions. The first set of cards are special HAWSIM title cards, there are severe restrictions on iterative DO loops, and the HAWSIM statements may appear any place within the program. The precompiler, PRESIM, expands the HAWSIM statements into PL/I statements, and skips over PL/I statements leaving them unchanged. Thus PL/I is a subset of HAWSIM giving HAWSIM the benefit of the powerful features of PL/I including input-output, program structure, character manipulation, decision making, etc. From the beginning a concerted attempt has been made to keep HAWSIM simple and straightforward and to make it moderately self-documenting and understandable to those primarily concerned with health and welfare agency operations.

Some of the more important and representative HAWSIM statements are the SPECIFY, REQUEST, DELAY UNTIL and WAIT FOR statements. Table I presents several examples of each of these statements.

The SPECIFY statement is used to define the resources, both personnel and physical (as beds, cars, pharmacy, etc.), of an agency. Number 1 is an example of a SPECIFY statement used for a regularly salaried employee. In this case three social workers are being declared. Each has a salary which may be expressed in yearly, monthly, weekly or hourly units and each has certain hours of availability. At present the key word "WORK_TIME" is simply translated to 2000 hours but a scheme for specifying specific hours of availability is under consideration. The social workers may devote a portion of their time to administrative duties. Each will devote a certain percentage of time providing direct and indirect services. They may also be responsible for some non-time dependent other or overhead expenditures. Number 2 defines an automobile which costs $2 an hour to operate, can carry four passengers, and accounts for an extra $500 per year in paper work and related overhead expenses. Number 3 is a half-time psychiatrist obtained on an hourly basis. He also costs an additional $2,000 per year in office space.

The REQUEST statement is used to obtain the services of an agency resource and to specify the direct interaction of a resource and a case. The REQUEST statement also controls all queing. If a resource is not available when the request is made, the person is placed in a queue until the resource becomes available. Presently all queing is based on a first in - first out principle. There has been no need for a "preempt" ability as exists in GPSS. Number 4 simply requests the use of a car. Number 5 specifies that two social workers are required and when their services are available they will both be utilized by the client for an hour and one-half. Resources are selected by (1) can the resource serve the case immediately ? and (2) which resource has the shortest queue ? Any specified delays are not acted upon until all requested resources are available. Number 6 illustrates a specific request with only social worker number three being acceptable. Number 7 requests a psychiatrist for a fifty-minute psychotherapy session with an additional $2.75 expenditure, perhaps for medication, above and beyond his usual salary.

The DELAY UNTIL statement allows the programmer to delay processing on a case until a particular time or time range. Number 8 specifies that the case will be delayed at this point until it is "WORK_TIME", i.e., 8-12 and 1-5 Monday-Friday with the exception of holidays. If the person executes the statement during regular working hours, no delay takes place and processing continues uninterrupted.

Number 9 specifies that people may pass through this point only between the hours of 8:15 a.m. and 1:45 p.m. on Tuesdays. People arriving at this statement at any other time will be delayed until 8:15 a.m. on the next Tuesday. Number 10 is rather straightforward except that people may pass through only at exactly 4:15 p.m. on the following day. Number 11 merely illustrates the delays may specify only one day a year. Number 11 is a rather poor statement, for if October 15 should happen to fall on a Saturday there would be a long wait.

The WAIT FOR statement stops processing for a client until the specified resource is completely free. Number 12 demonstrates a typical usage of the WAIT FOR statement. The car has a capacity of four; if one person is presently using the car then three more people may fit in. Unfortunately the car is probably half way between here and there traveling sixty miles per hour. It simply would not do to REQUEST the car until it is again available. The WAIT FOR statement will simply hold the person until the car is again available and a legal REQUEST can be made. Number 13 will delay a person until one of the social workers is free and Number 14 will delay until social worker Number 2 is available. Number 15 is similar to Number 14 except that the required social worker is specified by some variable, variables being allowed in most executable HAWSIM statements.

Some other HAWSIM statements allow a programmer to determine the history of a person in terms of agencies visited, to declare parameters of people and to assign values to these parameters, to change the value of an agency resource parameter initialized in a SPECIFY statement, to delay a person a specific amount of time, to refer a person from one agency to another, to inject and remove a person from simulation, to follow an individual person throughout the simulation and to trace the flow of people through a section of coding..

HAWSIM usage has included: programming simulation models of the agencies in the mental health subsystem, validating the simulation models, and performing exploratory perturbations. The original systems analysis and definition phase involved all publicly financed agencies concerned with health and welfare in a five county area. However, it became increasingly obvious, especially after programming had begun, that because of sheer magnitude this goal was unobtainable in the near future. Consequently, the immediate goal was redefined to concentrate on the mental health subsystem in Macon County. This mental health subsystem was defined to consist of those agencies receiving funds from the Illinois Department of Mental Health or which process cases that are diagnosed as "mental". These include the Macon Unit (28 bed inpatient/outpatient) at the Adolf Meyer Zone Center, two general hospitals with psychiatric wards, a state mental hospital, the county mental health clinic, the county legal system including sheriff, state's attorney and courts and the local offices of the Division of Vocational Rehabilitation, Department of Public Aid and Department of Children and Family Services.

Intensive data was collected on each agency to determine their processing characteristics. This included one or more in-depth interviews with agency heads and key service personnel, specific data collection by staff members, and data from the central files of the state offices. This information was then expressed in terms of detailed "agency flow-charts" which contained the input decision points, processing functions, and output for each agency just as any computer flowchart. Simulation programs were written describing each of the primary agencies (i.e., primary responsibility to mental health) in detail and each of the secondary agencies (i.e. primary responsibility in areas other than mental health) only for their mental health functions.

The attempt to validate these models clearly demonstrated the need for a more substantial data base and for a number of specific improvements to HAWSIM. The collection of a data base turned out to be a major problem. The local agencies typically carried little or no historical data and usually it was entirely in the form of unedited interview reports and the like. The central state offices carried fragmented information peculiar to department programs and it was difficult to obtain because of bureaucratic resistance, limited data processing resources, non-disclosure regulations, and laws limiting cross-departmental usage of data processing equipment. Data collected from these central offices was generally of limited value. Since names or other common identifier were seldom provided, recipients could not be followed from one agency to another. Data was generally restricted only to recipients and rejections or immediate referrals were not included. There was little available regarding agency operations or resource utilization. Data formats, codes and tape characteristics varied widely demanding extensive editing before use. By combining the variable data from all sources it was nonetheless possible to construct a moderate data base sufficiently adequate for the purpose of validating the simulation models. These will, of course, need revision as more complete data is collected.

A number of perturbations have been performed. These have been primarily tests of the capability of HAWSIM but several interesting results have been obtained. One representative perturbation involved a simple policy decision in the Macon Unit. The current policy restricts admission only to those who may gain maximum benefit from short-term, intermediate services (in contrast to acute, intensive cases managed in general hospitals' psychiatric units and long term chronic cases in state hospitals). The perturbation changed the policy to one of admitting all patients until the Unit was filled and maintained at maximum capacity. This resulted in an expected decrease in the number of patients admitted to the general hospital psychiatric wards and an increase in the utilization of the Macon Unit. There was a slight increase in state hospital admissions and decreases in usage of the other agencies due to differences in referral patterns following service at the general hospitals and the Macon Unit. The differences in overall system costs were quite striking. The perturbation indicated a saving of approximately $150,000 per year in overall system cost. Costs associated with the Macon Unit increased slightly mainly in connection with admission procedure (car transportation, psychiatric interviews, etc.) State hospital costs increased slightly due to increased utilization; and costs of other agencies decreased somewhat. The costs of private hospital psychiatric wards decreased greatly because of the significant decrease in usage and the high cost of hospital care. Costs increased negligibly at the Macon Unit due to some additional psychotropic medication.

A particularly salient observation was that even with the increased patient input to the Unit, no additional utilization of available staff time was required. Actually as measured by total staff hours available and utilized, the same level of service program could be maintained with the additional patient load and a 40% reduction in staff members.

Other perturbations to date have included:

(1) A forecasting run in which a 1.2% population increase per year was postulated to predict when the current facilities would need expansion.

(2) A series of changes in which the input to the state hospital was eliminated and the resident population was returned to the community. This series consisted of several alternatives which all utilized the facilities of the Macon Unit.

(3) A series in which all mental cases were treated in the community without the use of either the state hospital or the Macon Unit. This set of eight perturbations involved a number of methods of absorbing the input to the state hospital and the Macon Unit and returning the resident population to the community. The final perturbation of this series was a composit of most of the previous runs and was quite a dramatic change from the present system of handling mental cases.

Perturbation plans at present include modifications in the areas of:

(1) Planning and Forecasting, e.g. population growth trends over time, service demand patterns, and changes in the characteristics of the input population.

(2) Policy Formulation, e.g., costs associated with various programs, interrelationship between agency functions (referral paths), allocation of staff, redistribution of service load and function, and interagency boundary maintenance configurations.

(3) Administrative Control, e.g. delay times in delivery of services, numbers of cases passing through decision points, addition or subtraction of staff members, types of service delivered, intra-agency organization configurations, cost associated with different modes of service.

Our program plan is to study in detail and then perturb the mental health subsystem. As more knowledge and expertise is developed the goal is to slowly broaden out into the other service subsystems of the total health and welfare system. It will be impossible to simulate the entire system in detail at present because of compiler and machine size and speed limitations, but through the use of abbreviated "black box" coding in some parts of the system it should be possible to study and then perturb the health and welfare system with detailed reproduction of internal agency functioning only when necessary.

Further HAWSIM developments are planned in four general areas. The first, language modifications, concerns additions and corrections to the language and the support subroutines. Several new statements are to be added and the inevitable errors will have to be removed. The fundamental logic of HAWSIM is established and is fully operational but, as the entire project is developmental and as new problems arise, the means to solve them must be incorporated. The second development is an evaluation routine. At present perturbations are performed by putting together a number of pre-coded agency routines (each in the appropriate level of complexity), validating the specially constructed model, modifying the model to correspond with the perturbation request, and then comparing the result of the validation run with the results of the perturbation. This usually results in numerous routine clerical computations necessary to evaluate the perturbation. The planned evaluation routine will compare most of the generated statistics, flagging the significant differences, and also flagging results which are predicted to discriminate between the two runs. The third planned development, a management game, is highly dependent on the evaluation routine. It appears that, although a great deal of work will be necessary, little additional programming will be necessary. The problems can be run using the HAWSIM system and the results analyzed by the evaluate routine with the simple addition of scoring algorithm and a printout of the critical variables. A fourth development, unrelated to the previous three, is the completion of the HAWSIM manual. The manual, as well as describing the HAWSIM language, will discuss usage techniques, the interaction of HAWSIM and PL/I, its base language, the pre-compiler, execution subroutines and the output routine and some techniques for modifying them. The manual will be a part of a handbook describing the application of systems technology to health and welfare and particularly mental health services as we have attempted to do it in our work. The handbook, intended to be instructional to others in their efforts, is expected to be published in late spring, 1970.

As a result of our experience to date, I might allude to a number of major problems in attempting to simulate health and welfare systems. The first is that a system does not exist. The several agencies providing health and welfare services were all started as a result of some perceived need and the specific response to that need. The result is a large number of independent agencies with isolated programs. There are few attempts to provide any continuity of care and persons with more than one need usually must request services from several agencies, each with their own service requirements and processing delays. Agencies do refer cases from one to another, but this is usually only marginally effective and in any case the number of referrals is only a small percentage of the total service load. For these reasons it is difficult to achieve system effects of any magnitude. Also many perturbations involve changes or different interpretations of state and federal laws, thus raising issues of political and legislative action.

Another problem is that of simulating the decision making process. At present most decisions in the simulation models are based strictly on probabilities. This is adequate for describing the processes and for certain types of perturbations but it would result in gross errors if the characteristics of the input population were to change. The decisions of some agencies are spelled out in precise terms but in others there is wide latitude for judgment and individual opinion. These decisions must be made explicit at some time and the simulation program must take account of the subjective character of some judgments and the characteristics of the people served. A related problem is how to change the characteristics of people after service. This is straightforward for financial assistance and job training but very difficult to specify for prison or psychotherapy.

A final problem is one basic to system analysis---overall system cost-effectiveness. The total expenses of public agencies are usually known and open to public inspection. The problem is in determining suitable measures of effectiveness. The overall goal may be posited as a better life for all. But the intermediate subgoals are less easy to specify and there is considerable disagreement on many of them. There is also disagreement as to the proper way of measuring our degree of attainment of them. Even where a measurement goal can be specified our techniques are often questionable, especially in mental health, criminology, and social services.

Cost-effectiveness evaluations will be difficult. We expect to use effectiveness measures when they are available and when they are not to use the judgment of experts in the field and responsible officials.

It is probably important to provide some understanding of the climate in which this developmental effort has taken place. The Mental Health Zone Center concept in Illinois established 8 different zones throughout the state and each zone serves as a co-terminus region for the delivery of mental health services. In each zone substantial mental health facilities have been constructed to support a variety of inpatient and outpatient programmatic services. One basic rationale in this rationalization plan is that each zone center would function independently to develop methodologies and technologies relevant to its geographical catchment area and its specific programs. In time these developments could be exported to other zones throughout the state. The development of HAWSIM has reached the state where it is now available for export to all other zone centers and for that matter available also to mental health clinics or a variety of health and welfare social agencies. As indicated in my earlier remarks many improvements are yet to be made in increasing the effectiveness of HAWSIM but it does work now to a valuable degree. The introduction of this computer tool to the social service sector forecasts a significant sort of change in the administrative management and evaluation of public health and welfare programs.

TABLE I

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1.  %SPECIFY 3 SOCIAL_WORKERS, RATE = 8600 PER YEAR, 7350 PER YEAR, 5.00 PER HOUR,
    %          AVAILABLE=WORK_TIME, WORK_TIME, 2000 HOURS PER YEAR,ADMIN. = 10%, 0%, 50%,
    %          INDIRECT RATIO = 20%, 20%, 20%, OTHER COST = 2000, 1885, 3500;

2.  %SPECIFY CAR, CAPACITY = 4, RATE = 2 PER HOUR, OTHER COST = 500;

3.  %SPECIFY PSYCHIATRIST, RATE = 25 PER HOUR, AVAILABLE = HALF WORK_TIME, OTHER COST = 2000;

4.  %REQUEST CAR;

5.  %REQUEST 2 SOCIAL_WORKERS, DELAY = 1.5 HOUR;

6.  %REQUEST SOCIAL_WORKER, 3, DELAY = 15 MINUTES;

7.  %REQUEST PSYCHIATRIST, $ = 2.75, DELAY = 50 MINUTES;

8.  %DELAY UNTIL WORK_TIME;

9.  %DELAY UNTIL 8:15 AM - 1:45 PM, TUESDAY,

10. %DELAY UNTIL 4:15 PM TOMORROW;

11. %DELAY UNTIL WORK_TIME, OCT 15;

12. %WAIT FOR CAR;

13. %WAIT FOR SOCIAL_WORKER;

14. %WAIT FOR SOCIAL_WORKER, 2;

15. %WAIT FOR SOCIAL_WORKER, (SOCIAL_WORKER(ID));
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BIOGRAPHIES

Mr. Byran A. Bremner received his B.S. and M.S. in experimental psychology from Washington State University and has long been interested in the application of computer and systems science to psychological and social phenomena. Formerly with the Illinois Department of Mental Health and now as a research associate at the Heller School, he has served as principal programmer with the mental health systems research project presented here since its inception. He has been chiefly responsible for the development of HAWSIM which facilitates significantly the application of computer simulation models to the administrative management of human services.

Professor William F. Eicker, who took his doctorate in clinical psychology from UCLA is principal investigator of the research project "The Application of Systems Technology to Social and Mental Health". His early academic work was completed at Berea College and Ohio State University. After completing a clinical internship at the Veterans Administration, his professional interests evolved from classical dyadic psychotherapy through state-wide mental health planning and lately the conversion of the system engineer's paradigm to the social symbiosis of mental health. Dr. Eicker is currently involved with the developmental planning and design of a single delivery human services system.