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PROGRAM PLANNING AND DEVELOPMENT OF A NATIONAL UNIVERSITY TELECONFERENCE NETWORK USING SIMULATION

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Abstract

This study is an attempt to provide the management of the National University Teleconference Network (NUTN) with effective decision rules for its program planning and development. A simulation model based on SLAM is developed for accomplishing this task. Both qualitative and quantitative data are used in the development of this model. The decision rules are based on two priority rules such as the highest priority be given for executing an activity pertinent to a program on a First Come First Served (FCFS) basis with and without preemption. The results obtained from the simulation model have been found to be in close agreement with the actual operations. Interestingly enough, the fact that the product under consideration is information itself makes this study unique from other conventional project management studies commonly found in the literature.

1. Introduction

Teleconferencing is an emerging administrative and educational system. The teleconference, as a media, integrates and harnesses the telephone, radio, television, and computer to expedite transfer of knowledge and decision making. In terms of cost and time effectiveness, delivery through teleconferencing appears to be a promising means for universities to share information and talent, discuss common issues, and resolve mutual problems.

This thought inspired continuing educators and their colleagues in educational television to create a National University Teleconference Network (NUTN). In an experimental mode, initial operations have been undertaken to learn how best to develop a more permanent network - a network which can serve the long-term interests of higher education.

Membership in NUTN is composed primarily of graduate research universities actively engaged in high technology and research, and accredited 4-year public and private universities with capabilities in telecommunications. Currently there are 67 member universities in NUTN, representing 37 states throughout the United States. Many member universities are credited with long histories of research and development in teleconferencing. They also have the capability to originate and receive audio and video programs in suitable conference facilities, and to supply any additional services if required.

When a program is in preparation for delivery, three entities interact with each other within the network. These entities are the originating university, the receiving universities, and the coordinating office. More precisely, the receiving universities are either a subset or the entire set of member universities. It is very likely that a program delivered by the originating university is of no interest to a few member universities.

2. Purpose of the Study

The activities undertaken by each of the three entities are many and varied. However, the most critical and important of the three entities is the coordinating office. Oklahoma State University Extension serves as the coordinating office of NUTN. This office coordinates activities pertaining to several simultaneous programs between the originating universities and the member universities.

It is not surprising then to note that the available manpower in the coordinating office of NUTN is a critical resource that dictates to a great extent the timely accomplishments of the programs in the pipeline. All activities pertaining to a program undertaken by the coordinating office are informatory in nature and are executed by two distinct categories of staff attached to this office. They are the professional staff and the clerical staff. Presently there are 2.75 full-time equivalent (FTE) of professional staff and 0.875 FTE of clerical staff employed by the coordinating office. The fact that the product under consideration is information itself makes this study unique from other conventional project management studies commonly found in the literature.

With the present staffing, the number of programs that can be effectively executed by the coordinating office in a given year is valuable information to both the coordinating office and NUTN as a whole. This and many other questions posed by the executive committee of NUTN led the authors to develop, delineate and accomplish specific objectives in the best interests of the network.

3. Objectives

The focus of this paper is to document and report the development of a project management study undertaken over a considerable length of time to accomplish four very specific objectives. They are:

(a) To determine the appropriate activities undertaken by each of the entities, and their associated precedence relationships.

(b) To determine the appropriate activity time estimates, and to develop a PERT/CPM network diagram for each entity.

(c) To develop an overall PERT/CPM network diagram for the whole system based upon the results obtained in (a) and (b), and to determine the average program completion time.

(d) To determine the number of programs (both audio and video) and their activity schedules that can be effectively executed by the coordinating office in a given year subject to the availability of resources.

4. Data Collection and Analysis

During late 1982 and early 1983, NUTN accomplished the delivery of two programs, both an audio and a video teleconference. This enabled the members of NUTN, especially those attached to the coordinating office, to acquire first hand experiences helpful in meeting the objectives. The coordinating office staff, having acquired meaningful experiences on the above, was in a position to supply relevant data for the accomplishment of objectives (a), (b), and (c). A series of discussions were then held with the coordinating office staff to elicit their account of experiences. In particular, optimistic, pessimistic, and a most-likely time estimate in number of weeks for each activity were established in order that the triangular distribution could be used to describe the inherent variability in time estimates for all of the activities undertaken by the three entities.

Due to the contributions made by participative management, it was possible to achieve replanning by accomplishing some activities simultaneously that were originally perceived to have had certain dependencies. The result was a considerable reduction in expected completion time. Eventually, a total of ten, nine, and twelve distinct activities were identified as the responsibility of the originating university, receiving universities, and the coordinating office for each program from the time of origination until its completion.

An even more challenging task was to go about setting up the premise for accomplishing the final objective (d). Consequently, a need arose to recognize separately the contributions made by both professional and clerical staff attached to the coordinating office. Through further discussion with the coordinating office staff, it was possible to obtain a measure of the contributions made by these staff in performing each activity. It was recognized that five out of the twelve activities undertaken by the coordinating office staff did not require contributions by the clerical staff. Furthermore, the sequence of contributions made on the remaining seven was first by the professional staff followed by the clerical staff. The simulation model developed for accomplishing objective (d) is described in Section 6.

5. Activity Precedence Relationships and Simplifications

A description of the activities undertaken by the three entities are presented in Tables 1, 2, and 3.
The network diagrams for the individual entities are presented in Figures 1, 2, and 3 while that for the whole system is given in Figure 4. Note in Figure 4 that activity 7B immediately follows activity 5B, whereas activity 6B flows parallel to both 5B and 7B, even after 7B is completed.

Accomodating the execution of parallel activities by the same resource, either professional or clerical, in a simulation model would require altering a unit of resource to two. Again when there is only a single activity flow, the two units of resource have to be combined to one. Instituting such alterations in the simulation model, though not difficult, would make the model more complicated than desired for practical purposes. In order to simplify, it was decided to divide the time on activity 6B and distribute it among activities 5B and 7B. Thus creating another activity that would immediately follow activity 7B and have its ending node the same as the one for activity 6B. For convenience, activities 5B, 7B, and the one created with revised times were renumbered as 5B, 6B, and 7B respectively. The estimates of the revised times were based upon past experiences of the coordinating office staff.

TABLE 1: Description of Activities In Originating Institution A

Activity	Description
1A	Negotiate internally
2A	Develop proposal and set teleconference date
3A	Forward proposal to coordinating office
4A	Negotiate and develop program announcement with cooordinating office
5A	Prepare marketing packets
6A	Finalize transmission date
7A	Prepare to transmit program
8A	Mail marketing packets
9A	Participate in program facilitators conference call
10A	Transmit program

TABLE 2: Description of Activities In Coordinating Office B

Activity	Description
1B	Promote network
2B	Negotiate and develop program announcement with originating institution
3B	Distribute program announcement to receiving institutions
4B	Make "go-no go" decision
5B	Process program decisions
6B	Respond to questions, coordinate program facilitators conference call, and follow up on fixed fees
7B	Adapt and distribute evaluation instruments
8B	Coordinate activities when program is transmitted
9B	Collect fees and evaluations
10B	Summarize evaluations
11B	Distribute fees and evaluation summaries
12B	Prepare and distribute final report

TABLE 3: Description of Activities

In Receiving Institution C

Activity	Description
1C	Evaluate benefit/cost
2C	Determine marketing strategies from marketing packets
3C	Execute marketing strategy
4C	Collect enrollees
5C	Participate in program facilitators conference call
6C	Determine equipment needs
7C	Organize program
8C	Receive program
9C	Forward evaluations and number of enrollees to coordinating office

Moreover, the activities 9B and 10B and the activities 11B and 12B are both pairs of parallel activities. For the former, the activity 9B has a maximum duration of 2 weeks which is less than the minimum duration of 3 weeks for 10B. While for the latter, both activities 11B and 12B, respectively have a maximum and minimum duration of 1 week. Therefore the activities 9B and/or 11B will not be on a critical path at anytime. Thus, considering only the activities 10B and 12B as those required to be executed by a unit of resource, either professional or clerical, would suffice for the purposes of the simulation study.

6. Description of the Simulation Model

A conventional approach for analyzing a PERT-type network with the aid of a simulation language such as SLAM 1 faces severe limitations in this situation. The reason is that both resources are limited and are used unequally in executing six of the nine activities.[+] This required the development of a modified approach for accomplishing objective (d).

The solution was to treat each teleconference program as one requiring the services of a unit defined to be 2.75 FTE of professional resource and a unit defined to be 0.875 FTE of clerical resource. Activities not requiring any contribution from the clerical resource were assigned zero activity times. Consequently, two AWAIT nodes, one corresponding to the unit of professional resource and the other to the unit of clerical resource were introduced. Finally the result was to incorporate AWAIT, EVENT, and MATCH nodes in the conventional PERT-type network referenced previously. The EVENT node was introduced in order to determine the time when a program was first taken in to execute its first activity. The MATCH nodes were introduced to ensure correct matching of attribute values assigned to the programs routed within the network model. Thus, in order to accomplish the aforesaid objectives, a combined network-discrete event simulation model as described in Figure 5 was developed.

Two priority rules have been considered appropriate for examining the sensitivity of the simulation model. They are:

Rule 1

Highest priority be given for executing an activity pertinent to a program on a First Come First Served (FCFS) basis, without preemption.

Rule 2

Highest priority be given for executing an activity pertinent to a program on a First Come First Served basis, with preemption.

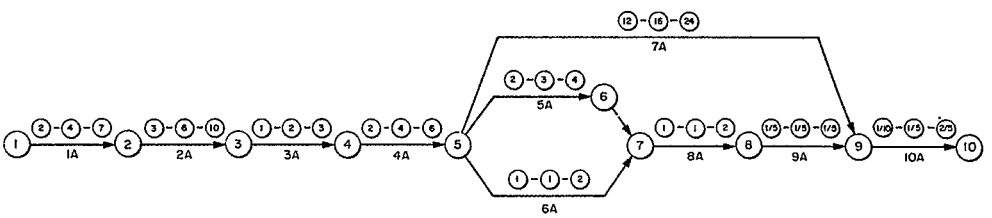

Figure 1: Network Flow Diagram for the Originating Institution A

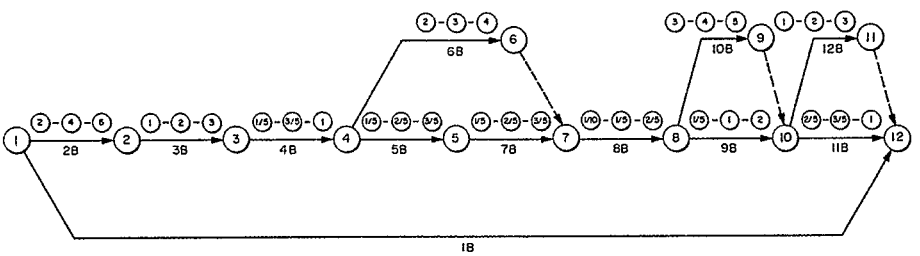

Figure 2: Network Flow Diagram for the Coordinating Office B

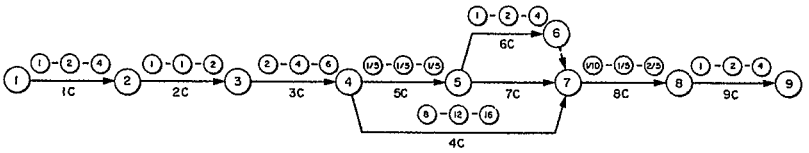

Figure 3: Network Flow Diagram for the Receiving Institution C

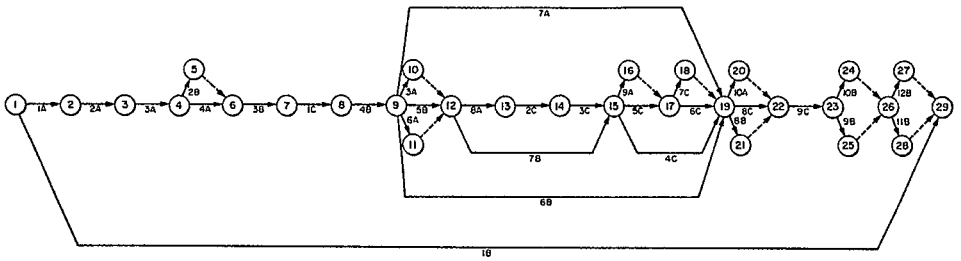

Figure 4: Network Flow Diagram for the Whole System

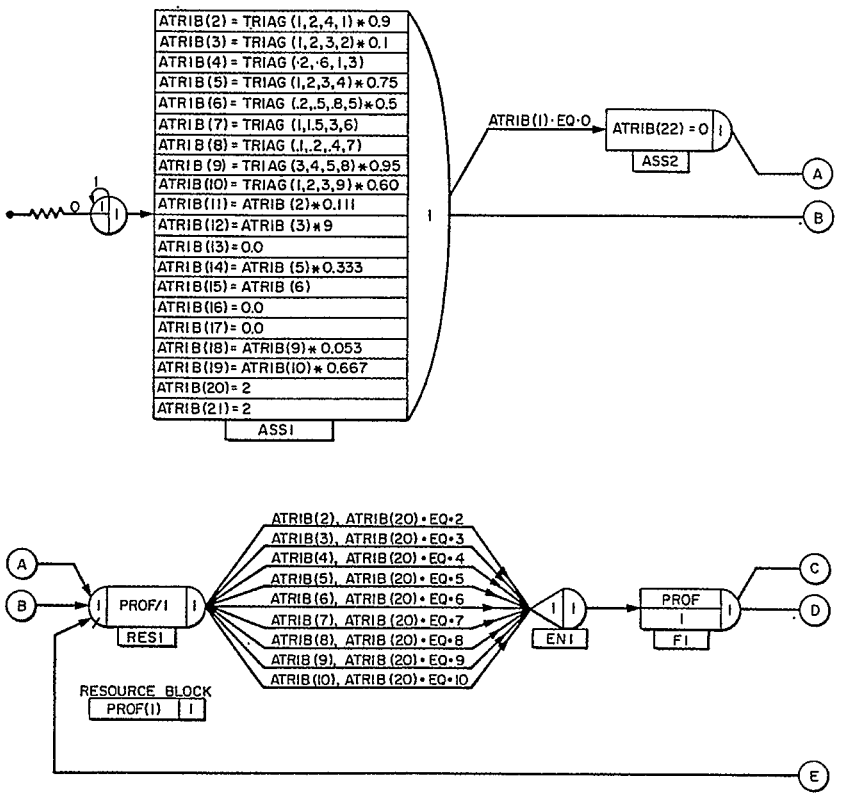

Figure 5: Network for Combined Network-Discrete Event Model of the Whole System

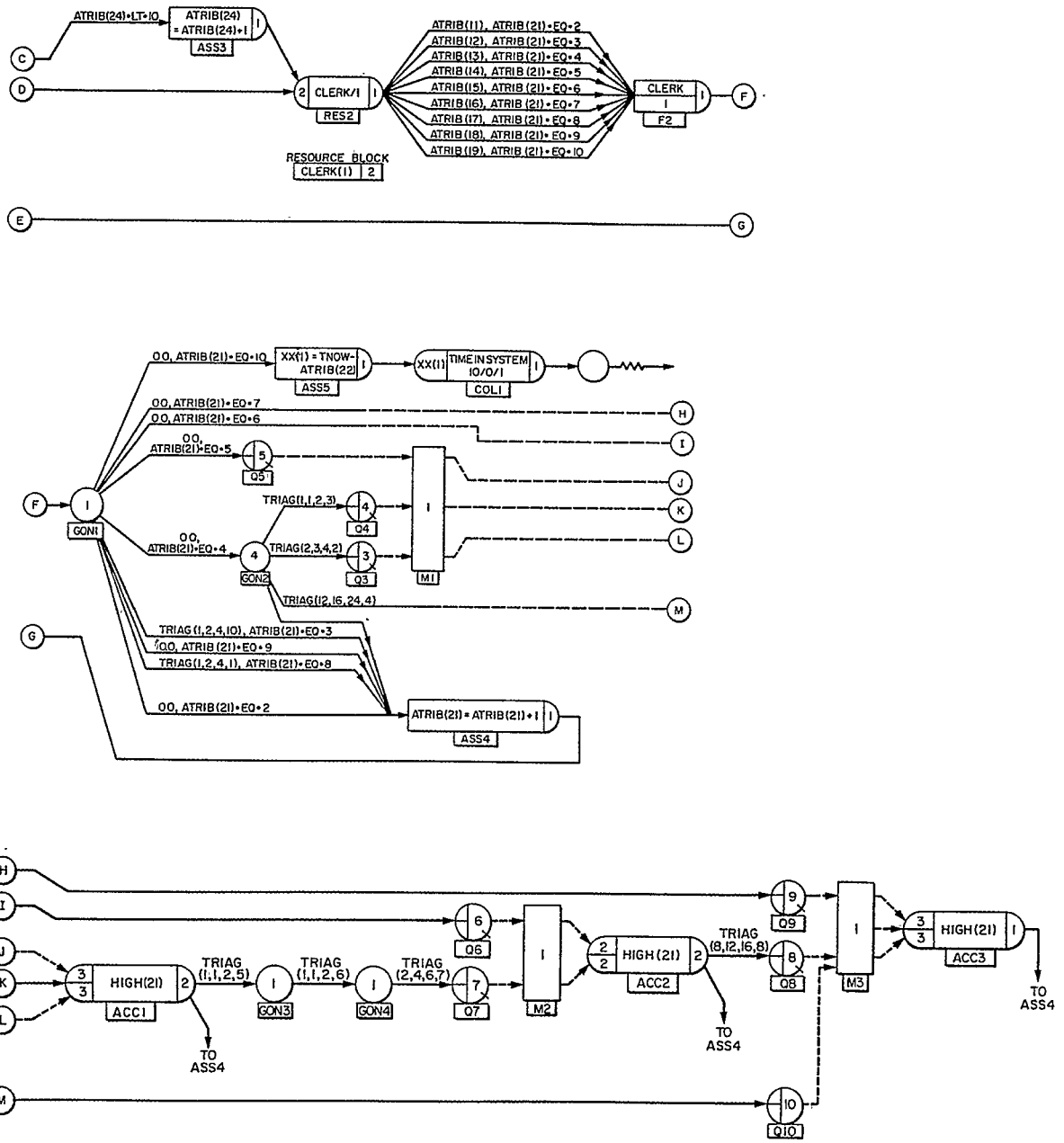

Figure 5 con't: Network for Combined Network-Discrete Event Model of the Whole System

7. Experimental Set-up

NUTN is presently going through the developmental phase. The focus during this phase is on executing a fixed number of selected programs, both audio and video. Upon successfully completing the developmental phase, NUTN will transfer its attention to a permanent phase where programs will be delivered continuously. During this period, there will be an adequate number of programs available in the pipeline to keep the coordinating staff fully occupied. However, due to the sequencing in the utilization of the resources to be observed in executing each activity and the varying activity times, the resources may not be utilized fully.

In order to adequately represent both developmental and the permanent phases of NUTN, the simulation study was carried out in two parts for both priority rules. First, a simulation run that would route a fixed number of entities through the network until all of them have their activities completed was accomplished.

The second part considered creating sufficient number of entities, that represents the availability of adequate number of programs in the pipeline. The purpose is to attain a high utilization of both resources by taking in as many programs as possible.

In both parts, the parameters of interest to NUTN are:

1. The average time required to complete one program
2. The average utilization of both resources, and
3. The time each program was first started.

Additionally, in the former the total time taken to complete all (N) programs, and in the latter, the number of programs that can be completed within a specified time are of interest to NUTN.

Preliminary simulation runs also showed that the professional is the most scarce (critical) resource of the two. This is to be expected since the percentage contribution made by the professional resource is much higher than that made by the clerical resource in most of the activities. Therefore, a simulation run that is representative of the permanent phase was also performed by maintaining two units of professional and one unit of clerical resources for priority rule 1. Since preemption is not possible with a resource capacity of any more than one, the same run can not be performed with priority rule 2.

It should be noted that the parameters obtained for a set of seed values are representative of one sample point in the whole population. Therefore two sets of simulation runs were performed. One with the default seed values and the other with user defined seed values. Although the parameters obtained from the two sets of simulation runs will not adequately represent the whole population of programs, they will however, enable NUTN be aware of the fact that varying activity durations can be encountered for the same activity in different programs.

8. Discussion of Results

Tables 4,6,8, and 10 represent the results obtained with default seed values while 5,7,9, and 11 represent those obtained with user defined seed values. It can be noted from tables 4 and 5, and 6 and 7 that during the developmental phase the total time taken for completing all (N) programs closely matches for both seed values except for a few exceptions. Moreover, a larger increase in total completion time results in stepping-up from 6 programs to 7 under priority rule 1. Under the priority rule 2, the above holds true in going from 5 to 6 programs. It can therefore be generalized that, during the experimental phase, the effective number of programs to work on simultaneously without incurring too high a delay in completing all programs is 6 and 5, respectively with priority rules 1 and 2. With these many programs, the utilization of professional resource is also considerably high in the neighborhood of 90 percent.

Table 4: Results of the Simulation Run for Priority Rule 1 and Fixed Number of Programs with Default Seed Values

NUMBER OF PROGRAMS N	AVERAGE WEEKS REQUIRED TO COMPLETE ONE PROGRAM	AVERAGE UTILIZATION (%)		TOTAL WEEKS TAKEN TO COMPLETE ALL N PROGRAMS	WEEK IN WHICH EACH PROGRAM WAS FIRST STARTED									
		PROFESSIONAL	CLERICAL											
	PROF = 1 UNIT; CLERK = 1 UNIT; SEED = DEFAULT VALUE				1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
1	40.71	28.76	9.94	40.71	0.0									
2	43.67	51.17	19.08	46.29	0.0	3.3								
3	44.71	68.31	23.35	52.03	0.0	3.3	5.7							
4	48.59	75.77	25.41	62.28	0.0	3.3	5.7	8.3						
5	49.29	89.01	29.92	65.92	0.0	3.3	5.7	8.3	10.0					
6	55.33	92.55	29.90	76.84	0.0	3.3	5.7	8.3	10.0	12.2				
7	59.59	84.46	26.74	97.87	0.0	3.3	5.7	8.3	10.0	12.2	22.5			
8	64.47	89.18	28.33	105.50	0.0	3.3	5.7	8.3	10.0	12.2	22.5	23.8		
9	66.31	91.29	28.89	116.00	0.0	3.3	5.7	8.3	10.0	12.2	22.5	23.8	27.2	
10	65.45	92.25	29.64	127.70	0.0	3.3	5.7	8.3	10.0	12.2	22.5	23.8	27.2	81.4

Table 5: Results of the Simulation Run for Priority Rule 1 and Fixed Number of Programs with User Defined Seed Values

NUMBER OF PROGRAMS N	AVERAGE WEEKS REQUIRED TO COMPLETE ONE PROGRAM	AVERAGE UTILIZATION (%)		TOTAL WEEKS TAKEN TO COMPLETE ALL N PROGRAMS	WEEK IN WHICH EACH PROGRAM WAS FIRST STARTED									
		PROFESSIONAL	CLERICAL											
	PROF = 1 UNIT; CLERK = 1 UNIT; SEED = USER DEFINED VALUE				1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
1	39.04	27.59	9.95	39.04	0.0									
2	42.36	50.92	15.29	44.06	0.0	1.8								
3	41.35	67.75	22.09	49.70	0.0	1.8	3.7							
4	46.42	78.09	26.90	56.16	0.0	1.8	3.7	6.4						
5	53.42	83.11	28.39	65.67	0.0	1.8	3.7	6.4	9.7					
6	54.89	88.17	29.88	76.57	0.0	1.8	3.7	6.4	9.7	16.7				
7	54.75	83.12	27.87	93.37	0.0	1.8	3.7	6.4	9.7	16.7	28.4			
8	58.04	82.28	27.01	109.00	0.0	1.8	3.7	6.4	9.7	16.7	29.9	31.0		
9	56.06	89.55	29.47	115.10	0.0	1.8	3.7	6.4	9.7	16.7	29.9	31.0	73.2	
10	59.07	83.40	27.78	138.10	0.0	1.8	3.7	6.4	9.7	16.7	29.8	31.1	69.0	72.1

Table 6: Results of the Simulation Run for Priority Rule 2 and Fixed Number of Programs with Default Seed Values

NUMBER OF PROGRAMS N	AVERAGE WEEKS REQUIRED TO COMPLETE ONE PROGRAM	AVERAGE UTILIZATION (%)		TOTAL WEEKS TAKEN TO COMPLETE ALL N PROGRAMS	WEEK IN WHICH EACH PROGRAM WAS FIRST STARTED									
		PROFESSIONAL	CLERICAL											
	PROF = 1 UNIT; CLERK = 1 UNIT; SEED = DEFAULT VALUE				1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
1	40.71	28.76	9.94	40.71	0.0									
2	41.44	50.06	18.66	47.32	0.0	3.3								
3	41.94	70.52	24.10	50.40	0.0	3.3	5.7							
4	46.02	80.55	27.01	58.58	0.0	3.3	5.7	8.1						
5	46.84	90.63	30.46	64.75	0.0	3.3	5.7	8.1	11.9					
6	50.37	83.73	27.05	84.94	0.0	3.3	5.7	8.1	11.9	19.5				
7	50.42	80.98	25.64	102.10	0.0	3.3	5.7	8.1	11.9	19.3	51.5			
8	56.96	84.17	26.73	111.80	0.0	3.3	5.7	8.1	11.9	19.5	32.5	36.4		
9	58.06	88.29	27.94	120.50	0.0	3.3	5.7	8.1	11.9	19.3	32.5	34.1	55.8	
10	53.96	90.72	29.15	129.90	0.0	3.3	5.7	8.1	11.9	19.3	32.5	54.5	65.9	76.2

Table 7: Results of the Simulation Run for Priority Rule 2 and Fixed Number of Programs with User Defined Seed Values

NUMBER OF PROGRAMS AVAILABLE	NUMBER OF PROGRAMS STARTED	NUMBER OF PROGRAMS COMPLETED	AVERAGE WEEKS REQUIRED TO COMPLETE ONE PROGRAM	AVERAGE UTILIZATION (%)		ENDING TIME IN WEEKS	WEEK IN WHICH EACH PROGRAM WAS FIRST STARTED														
				PROFESSIONAL	CLERICAL																
	PROF = 1 UNIT; CLERK = 1 UNIT; SEED = USER DEFINED VALUE						1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th	15th
10	8	2	44.90	100	41.03	52	0.0	1.8	3.7	6.4	9.7	16.7	29.8	31.1							
10	8	4	47.62	100	39.06	60	0.0	1.8	3.7	6.4	9.7	16.7	29.8	31.1							
20	12	7	57.04	100	34.95	104	0.0	1.8	3.7	6.4	9.7	16.7	28.4	29.8	32.3	68.8	74.2	81.7			
	PROF = 2 UNITS; CLERK = 1 UNIT; SEED = USER DEFINED VALUE						1st 16th	2nd 17th	3rd 18th	4th 19th	5th 20th	6th 21st	7th 22nd	8th 23rd	9th 24th	10th 25th	11th 26th	12th 27th	13th 28th	14th 29th	15th 30th
20	16	5	45.26	98.52	69.33	52	0.0 32.8	0.0	4.7	7.0	8.4	8.4	12.2	12.8	14.0	20.3	22.5	22.7	24.3	29.8	32.4
40	23	13	58.28	99.26	74.63	104	0.0 69.4	0.0 70.2	4.7 73.8	7.0 76.0	8.4 85.8	8.4 85.8	12.2 90.4	12.8 100.2	14.0	20.3	22.5	22.7	24.3	31.9	67.7

The results presented in tables 8 and 9, and 10 and 11 are representative of the permanent phase under both priority rules. The parameters obtained under the two different seed values match more closely than those obtained in the developmental phase. Under the priority rule 1, increasing the professional resource to two units enabled the NUTN coordinating staff to complete approximately twice as many programs as can be completed with one unit of resource within a specified time. In that event the average utilization of the clerical resource also doubled from 35 percent to 70 percent, approximately.

Table 8: Results of the Simulation Run for Priority Rule 1 and Fixed Simulation Time with Default Seed Values

NUMBER OF PROGRAMS AVAILABLE	NUMBER OF PROGRAMS STARTED	NUMBER OF PROGRAMS COMPLETED	AVERAGE WEEKS REQUIRED TO COMPLETE ONE PROGRAM	AVERAGE UTILIZATION(%)		ENDING TIME IN WEEKS	WEEK IN WHICH EACH PROGRAM WAS FIRST STARTED														
				PROFESSIONAL	CLERICAL																
	PROF = 1 UNIT; CLERK = 1 UNIT; SEED = DEFAULT VALUE						1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th	15th
10	9	NONE	—	100.00	41.68	52.0	0.0	3.3	5.7	8.3	10.0	12.2	22.5	23.8	37.2						
10	9	3	50.98	100.00	38.55	60.0	0.0	3.3	5.7	8.3	10.0	12.2	22.5	23.8	37.2						
20	12	7	58.32	100.00	34.46	104.0	0.0	3.3	5.7	8.3	10.0	12.2	22.5	25.3	65.6	68.7	100.0	103.1			
	PROF = 2 UNITS; CLERK = 1 UNIT; SEED = DEFAULT VALUE						1st 16th	2nd 17th	3rd 18th	4th 19th	5th 20th	6th 21st	7th 22nd	8th 23rd	9th 24th	10th 25th	11th 26th	12th 27th	13th 28th	14th 29th	15th 30th
20	19	4	46.28	99.04	71.21	52.0	0.0 22.3	0.0 32.8	3.2 34.4	3.3 34.5	5.5	5.5	7.3	8.1	8.6	9.3	10.9	11.6	18.5	19.5	21.8
40	27	12	58.30	99.52	69.30	104.0	0.0 22.3	0.0 29.4	3.2 70.9	3.3 71.1	5.5 73.3	5.5 86.4	7.3 88.6	8.1 88.9	8.6 92.7	9.3 93.0	10.9 102.8	11.6 103.9	18.5	19.5	21.8

Table 9: Results of the Simulation Run for Priority Rule 1 and Fixed Simulation Time with User Defined Seed Values

NUMBER OF PROGRAMS AVAILABLE	NUMBER OF PROGRAMS STARTED	NUMBER OF PROGRAMS COMPLETED	AVERAGE WEEKS REQUIRED TO COMPLETE ONE PROGRAM	AVERAGE UTILIZATION (%)		ENDING TIME IN WEEKS	WEEK IN WHICH EACH PROGRAM WAS FIRST STARTED													
				PROFESSIONAL	CLERICAL															
	PROF = 1 UNIT; CLERK = 1 UNIT; SEED = USER DEFINED VALUE						1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th	15th
10	8	2	44.90	100	41.03	52	0.0	1.8	3.7	6.4	9.7	16.7	29.8	31.1							
10	8	4	47.62	100	39.06	60	0.0	1.8	3.7	6.4	9.7	16.7	29.8	31.1							
20	12	7	57.04	100	34.95	104	0.0	1.8	3.7	6.4	9.7	16.7	28.4	29.8	32.3	68.8	74.2	81.7			
	PROF = 2 UNITS; CLERK = 1 UNIT; SEED = USER DEFINED VALUE						1st 16th	2nd 17th	3rd 18th	4th 19th	5th 20th	6th 21st	7th 22nd	8th 23rd	9th 24th	10th 25th	11th 26th	12th 27th	13th 28th	14th 29th	15th 30th
20	16	5	45.26	98.52	69.33	52	0.0 32.8	0.0	4.7	7.0	8.4	8.4	12.2	12.8	14.0	20.3	22.5	22.7	24.3	29.8	32.4
40	23	13	58.28	99.26	74.63	104	0.0 69.4	0.0 70.2	4.7 73.8	7.0 76.0	8.4 85.8	8.4 85.8	12.2 90.4	12.8 100.2	14.0	20.3	22.5	22.7	24.3	31.9	67.7

Table 10: Results of the Simulation Run for Priority Rule 2 and Fixed Simulation Time with Default Seed Values

NUMBER OF PROGRAMS AVAILABLE	NUMBER OF PROGRAMS STARTED	NUMBER OF PROGRAMS COMPLETED	AVERAGE WEEKS REQUIRED TO COMPLETE ONE PROGRAM	AVERAGE UTILIZATION (%)		ENDING TIME IN WEEKS	WEEK IN WHICH EACH PROGRAM WAS FIRST STARTED													
				PROFESSIONAL	CLERICAL															
	PROF = 1 UNIT; CLERK = 1 UNIT; SEED = DEFAULT VALUE						1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th	15th
10	7	3	44.23	100.0	37.3	52.0	0.0	3.3	5.7	8.1	11.9	19.3	32.5								
10	8	3	44.23	100.0	34.2	60.0	0.0	3.3	5.7	8.1	11.9	19.3	32.5	54.5							
20	12	7	53.46	100.0	33.4	104.0	0.0	3.3	5.7	8.1	11.9	19.3	32.7	64.3	65.9	68.3	80.9	103.2			

Table 11: Results of the Simulation Run for Priority Rule 2 and Fixed Simulation Time with User Defined Seed Values

NUMBER OF PROGRAMS AVAILABLE	NUMBER OF PROGRAMS STARTED	NUMBER OF PROGRAMS COMPLETED	AVERAGE WEEKS REQUIRED TO COMPLETE ONE PROGRAM	AVERAGE UTILIZATION (%)		ENDING TIME IN WEEKS	WEEK IN WHICH EACH PROGRAM WAS FIRST STARTED													
				PROFESSIONAL	CLERICAL															
	PROF = 1 UNIT; CLERK = 1 UNIT; SEED = USER DEFINED VALUE						1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th	15th
10	8	3	43.14	100	39.27	52	0.0	1.8	3.6	6.4	12.5	14.1	27.0	28.4							
10	8	4	44.72	100	36.96	60	0.0	1.8	3.6	6.4	12.5	14.1	27.0	28.4							
20	12	7	53.9	100	34.08	104	0.0	1.8	3.6	6.4	12.5	14.1	28.3	29.6	32.3	71.9	74.2	75.5			

During the permanent phase, with continued execution of programs over a longer period, it is reasonable to expect a steady state being attained for the average time for completing one program. Motivated by this fact, a simulation run was performed over a period of 8 years having 100 entities (programs) created in the pipeline. Beginning from 52 weeks, a summary report of this run was requested in the computer routine every 4 weeks until the end of 8 years.

The graphs shown on Figures 6 and 7 evidence the fact that the average time for completing one program levels off at 65 weeks with priority rule 1, while it is only 56 weeks with priority rule 2. Furthermore, the response to levelling began much earlier with priority rule 2 than with priority rule 1.

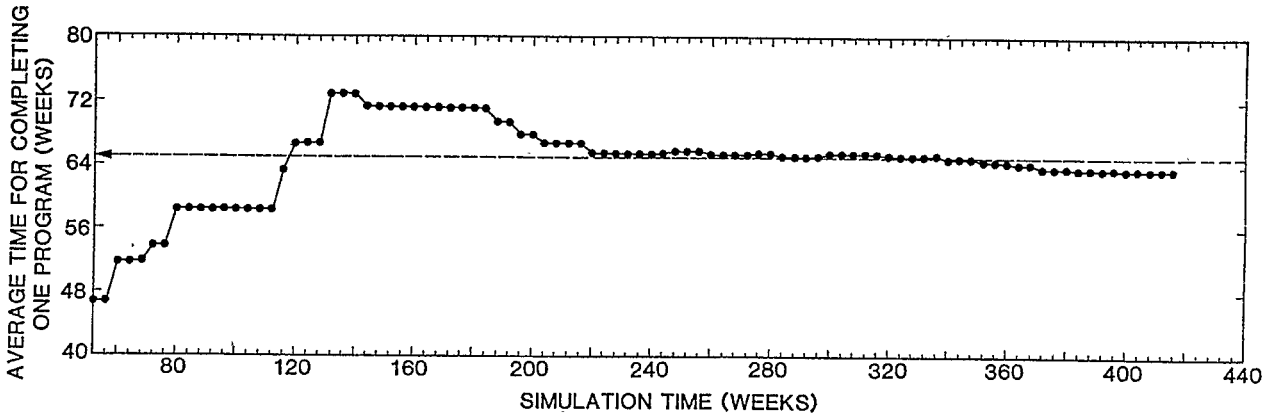

Figure 6: Variation of Average Time for Completing One Program vs. Simulation Time with Priority Rule 1

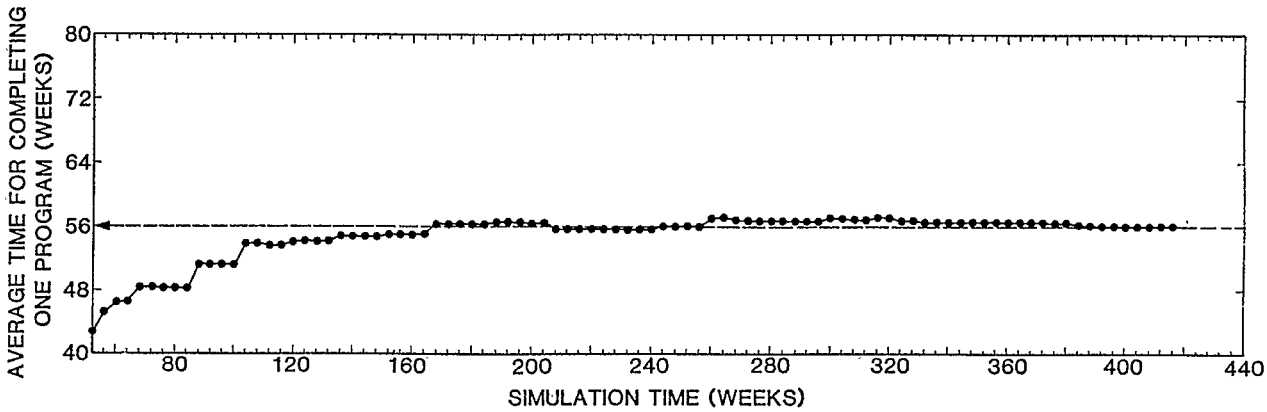

Figure 7: Variation of Average Time for Completing One Program vs.Simulation Time with Priority Rule 2

9. Conclusions

In order to make a good estimate on the variability of parameters determined above, a series of simulation runs should be performed with different sets of seed values. Such an analysis will provide the coordinating staff with the information on sufficient number of sample points representative of the many different programs that will be executed. With many sample points confidence limits could also be established on these parameters.

The simulation runs performed for a duration of 8 years show that the priority rule 2 with preemption is a better decision rule to be exercised by the NUTN coordinating staff. This results in about 9 weeks (65-56) lower duration on average completion time for one program as opposed to priority rule 1.

To conclude, the results obtained from the simulation model have been found to be in close agreement with the actual program completion times experienced by the NUTN members. As a consequence and due to its inherent flexibility, the simulation model has gained the acceptance of NUTN coordinating office.

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