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ESTABLISHING A RETAIL CHAIN STORE BRANCH: A PERT APPLICATION

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BACKGROUND

This paper is the product of research done by the author during the late fall of 1971. The write up was postponed until the final results were obtained so that the predictions could be evaluated and the implementation observed. This is a true case; therefore, on request of the management of the chain store, names, exact times, and network details are omitted.

ABSTRACT

This paper illustrates how a quantitative scheduling approach, PERT, was successfully used in the evaluation of the establishment of a retail store branch prior to its construction. Important questions such as job sequencing, critical jobs, and approximate starting time for construction were successfully answered by means of the PERT model.

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Introduction

The establishment of a retail store is not a routine procedure. It is a very time-consuming and challenging responsibility for marketing experts. The degree of difficulty of this challenge depends on a host of factors, the most important of which is past experience. The specialists who are involved with the evaluation of the potential establishment of a new branch for a chain store encounter economic and time factors which are very complex and difficult to describe.

This paper illustrates how a quantitative scheduling approach, PERT, was successfully used in the evaluation of the establishment of a retail store branch prior to its construction. Important questions such as job sequencing, critical jobs, approximate starting time for construction, and others were successfully answered by means of the model. This is a true case; therefore, on request of the management of the chain store, names, exact times, and network details are omitted.

Setting Up the PERT Network

The PERT method is a management-oriented technique for the scheduling of a series of nonrepetitive jobs so that the entire project can be completed in the shortest amount of time. The PERT method, as it relates to the establishment of a chain store branch, serves to consider a series of interrelated activities in order to determine their optimum planning and scheduling for the attainment of the desired goals.

The preliminary step before executing the PERT algorithm is to develop the network model, which represents the interrelationships between activities and the general flow of these activities. (See Table 1 and Figures 1 and 2.) This development is accomplished by the following four-step procedure:

Step 1: Development of the logical sequence in which the activities must be performed to complete the project. An activity is the performance of a specific task and involves the effort of manpower.

Step 2: Drawing the arrow-diagram network, using activities and events. An event is represented by a node, which is the occurrence of a checkpoint in time. The node represents the accomplishment of a task rather than the performance of a task or activity. The event represents the start of activity(s) or the completion of activity(s).

Step 3: Assignment of activity times. Qualified people who had dealt in the past with the establishment of retail stores supplied three typical activity times: optimistic time (OT), most probable time (MPT), and most pessimistic time (PT).

Step 4: Numbering of nodes so that (1) each job has a unique set of nodes, (2) all activities entering a node have identical followers, (3) all activities leaving a node have identical predecessors, (4) a node represents the complete relationship between all entering and exiting jobs, and (5) the nodes are in ordered

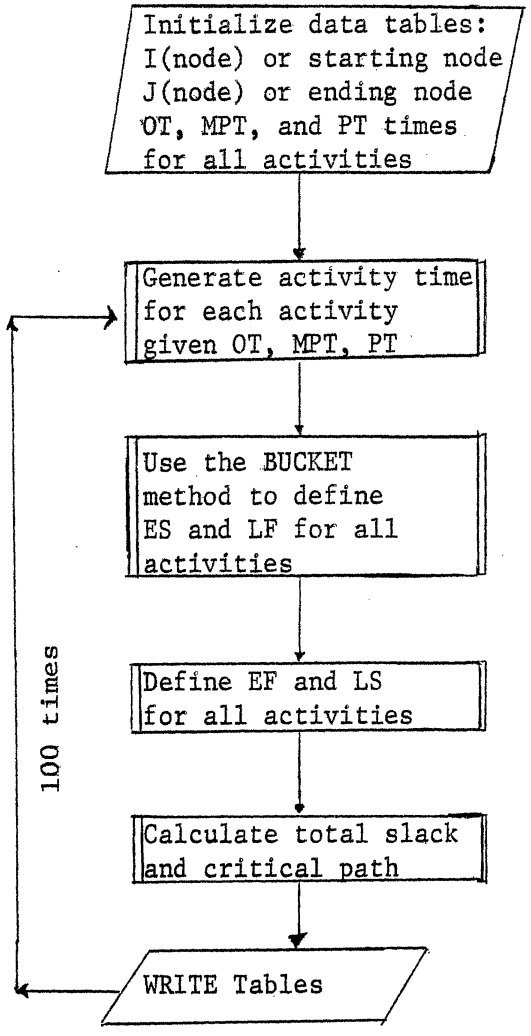
sequence with the beginning node smaller than the ending node.

Figures 1 and 2 represent the simplified version of the final network that was developed for the chain store. But some analysis of relations between activities is necessary. Originally, the activity from node 9 to 37 (analysis of general labor conditions) was a predecessor to the activities from node 17 to node 26 (architectural analysis of space and design requirements for the entire outlet) and from node 22 to node 31 (preparation of advertising budget and strategy). After a lengthy discussion, however, it was agreed that these three activities were unrelated for the principal reason that prevailing pay scales were not part of the activity of the "analysis of general labor conditions". It was also agreed that the departmental estimation of gross margins (activity from node 9 to node 14) did not depend on the analysis of number, policies, and location of wholesalers (activity from node 12 to node 14) since the demand for most of the products under consideration was fairly high and since it was known that wholesalers did not charge high prices. The company already possessed a record of the wholesalers and their policies in that location. It also seemed logical to assign selling areas to departments (activity from node 15 to node 17) only after the products to be sold were selected (activity from node 14 to node 15) because different products require both different areas and different locations in the store. For example, jewelry, candy, paperback books, and the kinds of goods conducive to impulse buying are often located near doors so that people passing in and out can be exposed to them. Because few people will buy furniture or appliances on an

impulse basis, these types of goods can be buried in the heart of the department store, several floors up. A nondetailed listing (including the necessary dummy activities for Step 4) of all activities is given in Table 1.

BUCKET Algorithm for Generating the Critical Path

A simple algorithm, called a "BUCKET" algorithm was devised and programmed in FORTRAN to define the critical path and the early and late starting times for the activities.[1] A detailed write up and listing of the program is summarized as follows:



[1] N.L. Wu, Business Programming in FORTRAN IV (Dubuque, Iowa: Wm. C. Brown Company, 1973).

Initially, the classical Beta distribution was considered for activity times, and the expected times were used for scheduling and for developing the critical path. (Results are shown in Figure 1.) However, a statistical analysis of past data collected by the firm made it clear that this approach might lead to an underestimate of the due date. A Chi-Square test indicated that a triangular distribution better fit the activity times; therefore, 100 triangular variates were generated for each activity, given the OT, MPT, and PT times of each activity, and consequently 100 due dates and critical paths were generated. These results are summarized in Table 2.

The early start (ES) and early finish (EF) times are obtained through the BUCKET method as follows. The early start time is that time at which an event can be started if all events preceding it have been started and completed as early as possible. The Forward Scan Rule as outlined here is the simplest way of calculating the ES for all activities.

Give each node a BUCKET value: BUCKET (I)

Initialize these BUCKET(I)s to zero

Now for each activity K proceed as follows:

BUCKET(JNODE)' $\leftarrow$ BUCKET(INODE)+TIME(INODE, JNODE)

if and only if BUCKET(JNODE)' $\rangle$ BUCKET(JNODE)

ES(K)=BUCKET(INODE)'

The latest finish (LF) time is that at which an event must be accomplished in order to avoid slippage in the project-completion date. For our retail store the project-completion date was

determined by the early finish time of the last activity. The Reverse Scan Rule as outlined here is the simplest way of calculating the LF for all activities:

Give each node a BUCKET value: BUCKET(I)

Initialize the BUCKET(I)s to the project completion date

Now for each activity K, starting with the last activity, proceed as follows:

BUCKET(INODE)' ← BUCKET(JNODE)-TIME(INODE, JNODE)

if and only if BUCKET (INODE)' < BUCKET(INODE)

LF(K)=BUCKET(JNODE)'

After all early start and late finish times are calculated for each activity (K), the early finish (EF) and late start (LS) for these activities can be obtained as follows:

EF(K)=ES(K)+TIME(K)

LS(K)=LF(K)-TIME(K)

The total slack time (TOTSL) for each activity (K) is the difference between the early start and the late start of the activity; TOTSL indicates how long an activity may be postponed without affecting the due date.

TOTSL(K)=LS(K)-ES(K)

The critical activities are those activities which cannot be delayed in order to finish the job as soon as possible. Therefore, if the total slack of an activity is zero, that activity is a critical activity.

A sample output of the PERT analysis for the retail store is given in Table 3. The observed critical activities for the case are listed in Table 4. The output of this analysis was used by management in determining where slack time would be available and where potential problems might develop. The activities on the critical path were carefully scheduled, and, in order to minimize delays, manpower was assigned accordingly.

TABLE 1

PERT Activities for Establishing a Chain Store (All Dummies are Included)

Nodes I	Nodes J	Activity	Optimistic Time (OT)	Most Probable Time (MPT)	Pessimistic Time (PT)
1	2	Dummy	0	0	0
1	4	Dummy	0	0	0
1	5	Dummy	0	0	0
1	6	Dummy	0	0	0
1	7	Dummy	0	0	0
1	8	Dummy	0	0	0
1	9	Analysis of retail trade potential	48	64	96
1	29	Research on availability of credit investigation	8	8	8
2	29	Research on number, kinds, and practices of financial institutions of the area	8	16	32
4	9	Analysis of potential customer drawing area	48	64	96
5	9	Area population analysis	16	24	32
6	9	Analysis of area-purchasing power	24	32	48
7	9	Analysis of competitive situation	16	24	32
8	9	Analysis of area's growth trends	16	24	32
9	11	Detailed demand analysis by department or product groups	16	48	96
9	14	Estimation of gross margins by department	32	48	64
9	37	Analysis of general labor conditions	32	48	96
11	12	Detailed demand forecast by department or product groups	16	48	96
12	14	Analysis of number, policies, and locations of wholesalers	0	0	0
14	15	Selection of product groups to be carried	0	0	0
15	16	Dummy	0	0	0
15	17	Assignment of selling areas to departments	64	96	192
16	17	Assignment of nonselling space for administrative functions	16	32	64
17	19	Dummy	0	0	0
17	20	Dummy	0	0	0
17	22	Dummy	0	0	0

TABLE 1 (Continued)

PERT Activities for Establishing a Chain Store (All Dummies are Included)

Nodes I	Nodes J	Activity	Optimistic Time (OT)	Most Probable Time (MPT)	Pessimistic Time (PT)
17	23	Dummy	0	0	0
17	24	Dummy	0	0	0
17	26	Architectural analysis of space and design requirements for the entire outlet	416	480	576
17	30	Preparation of merchandise budget planning	200	256	400
17	31	Obtain estimates of wages and salaries expenses	1	2	3
17	36	Setting up the organization structure	16	24	48
19	31	Estimation of delivery costs and policies	8	16	24
20	31	Setting pricing policies	0	0	0
22	31	Preparation of advertising budget and strategy	16	24	32
23	31	Design layouts for departments	128	192	256
24	31	Setting of operating-hours policy	1	2	3
26	27	Dummy	0	0	0
26	28	Dummy	0	0	0
26	29	Site-location analysis	48	64	96
27	29	Estimation of construction costs	8	16	24
28	29	Estimation of equipment costs	8	16	24
29	31	Preparation of a capital-budgeting program	24	32	96
30	31	Establishment of inventory-control system	3	5	16
31	33	Estimate operating costs	24	32	96
31	37	Obtaining bids for the physical plant	8	16	24
33	35	Dummy	0	0	0
33	37	Preparation of proforma income statements for next five years	24	32	96
35	37	Preparation of first-year cash flow	24	32	96
36	37	Manpower planning	64	128	160

TABLE 2

Summary of Results Using the Triangular Distribution in Generating Activity Times

Distribution and Statistics for 100 Runs

Classes	Midclass Value	Frequency	Probability
875-905⁻	890	1	.01
905-935⁻	920	3	.03
935-965⁻	950	11	.11
965-995⁻	980	15	.15
995-1025⁻	1010	21	.21
1025-1055⁻	1040	20	.20
1055-1085⁻	1070	16	.16
1085-1115⁻	1100	11	.11
1115-1145⁻	1130	1	.01
1145-1175⁻	1160	1	.01

Smallest simulated duration: 881 time units.

Largest simulated duration: 1147 time units.

Mean simulated duration: 1023.2.

Standard deviation of the simulated duration: 52.1.

Suggested (95% confidence) due date: 1095 time units.

Actual due date was 1084 time units.

TABLE 3

Sample Output of the PERT Analysis

ACTIVITY I	ACTIVITY J	GENERATED* TIME	ES	EF	LS	LF	TOTAL SLACK	CRIT PATH
1	2	0	0	0	829	829	829	
1	4	0	0	0	0	0	0	*
1	5	0	0	0	59	59	59	
1	6	0	0	0	47	47	47	
1	7	0	0	0	61	61	61	
1	8	0	0	0	67	67	67	
1	9	53	0	53	31	84	31	
1	29	8	0	8	835	843	835	
2	29	14	0	14	829	843	829	
4	9	84	0	84	0	84	0	*
5	9	25	0	25	59	84	59	
6	9	37	0	37	47	84	47	
7	9	23	0	23	61	84	61	
8	9	17	0	17	67	84	67	
9	11	38	84	122	84	122	0	*
9	14	37	84	121	148	185	64	
9	37	59	84	143	971	1030	887	
11	12	63	122	185	122	185	0	*
12	14	0	185	185	185	185	0	*
14	15	0	185	185	185	185	0	*
15	16	0	185	185	249	249	64	
15	17	103	185	288	185	288	0	*
16	17	39	185	224	249	288	64	
17	19	0	288	288	891	891	603	
17	20	0	288	288	907	907	619	
17	22	0	288	288	880	880	592	

TABLE 3 (Continued)

Sample Output of the PERT Analysis

ACTIVITY I	ACTIVITY J	GENERATED* TIME	ES	EF	LS	LF	TOTAL SLACK	CRIT PATH
17	23	0	288	288	703	703	415	
17	24	0	288	288	906	906	618	
17	26	482	288	770	288	770	0	*
17	30	378	288	666	523	901	235	
17	31	1	288	289	906	907	618	
17	36	29	288	317	913	942	625	
19	31	16	288	304	891	907	603	
20	31	0	288	288	907	907	619	
22	31	27	288	315	880	907	592	
23	31	204	288	492	703	907	415	
24	31	1	288	289	906	907	618	
26	27	0	770	770	829	829	59	
26	28	0	770	770	829	829	59	
26	29	73	770	843	770	843	0	*
27	29	14	770	784	829	843	59	
28	29	14	770	784	829	843	59	
29	31	64	843	907	843	907	0	*
30	31	6	666	672	901	907	235	
31	33	45	907	952	907	952	0	*
31	37	22	907	929	1008	1030	101	
33	35	0	952	952	968	968	16	
33	37	78	952	1030	952	1030	0	*
35	37	62	952	1014	968	1030	16	
36	37	88	317	405	942	1030	625	

*Activity times are generated using the triangular distribution

TABLE 4

Observed Critical Activities for the Establishment of the Retail Store
(Dummy Activities are not Included)

Activity Nodes		
I	J	Activity Description
4	9	Analysis of potential customer drawing area
9	11	Detailed demand analysis by department or product groups
11	12	Detailed demand forecast by department or product groups
12	14	Analysis of number, policies, and locations of wholesalers
14	15	Selection of product groups to be carried
15	17	Assignment of selling areas to departments
17	26	Architectural analysis of space and design requirements for the entire outlet
26	29	Site-location analysis
29	31	Preparation of a capital-budgeting program
31	33	Estimate of operating costs
33	37	Preparation of proforma income statements for next five years
Alternate Critical Path:		
35	37	Preparation of first-year cash flow

be Beta distributed, and their expected times are used to establish the critical path.

$t_e = \frac{O+4M+P}{6}$

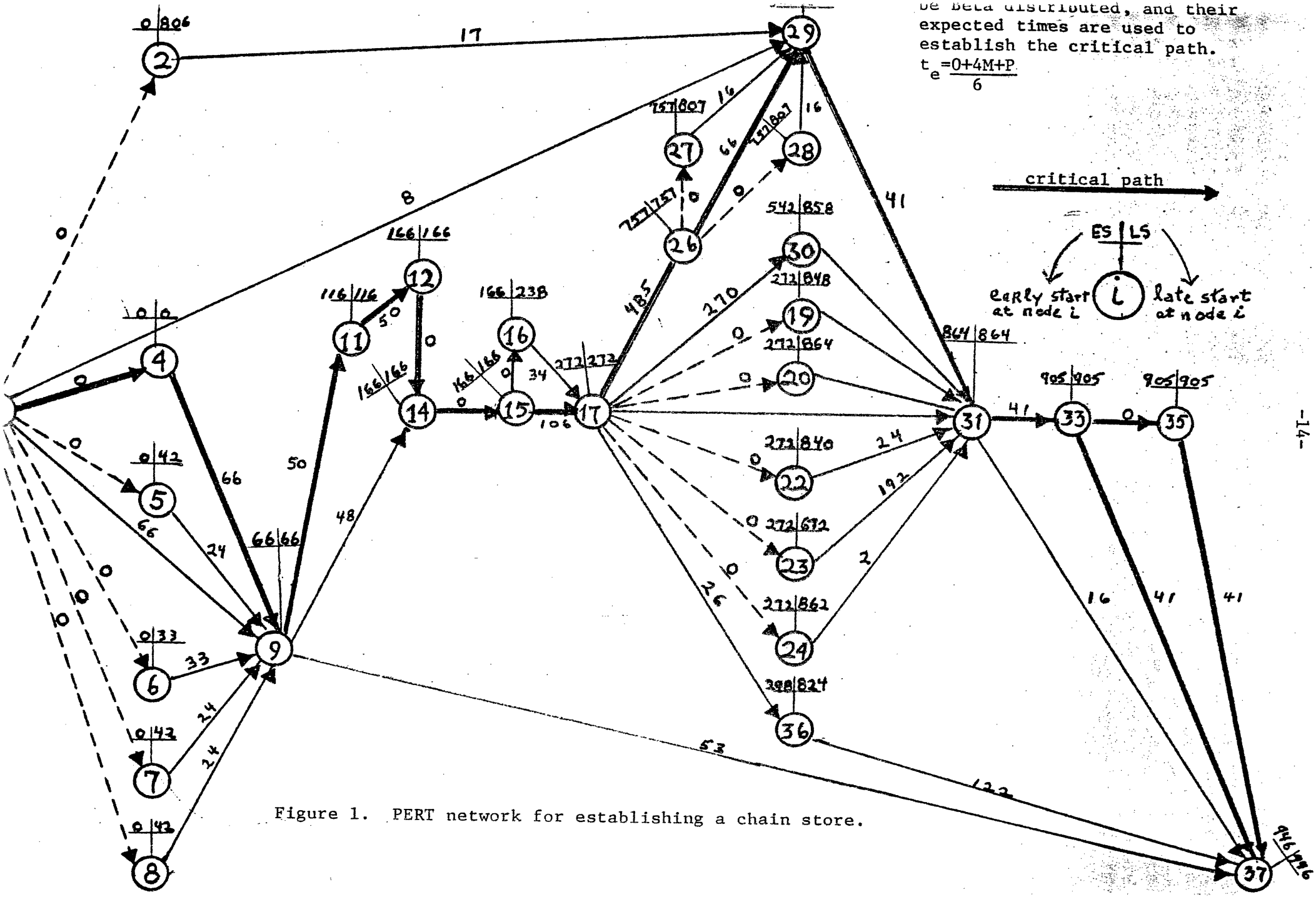


Figure 1. PERT network for establishing a chain store.

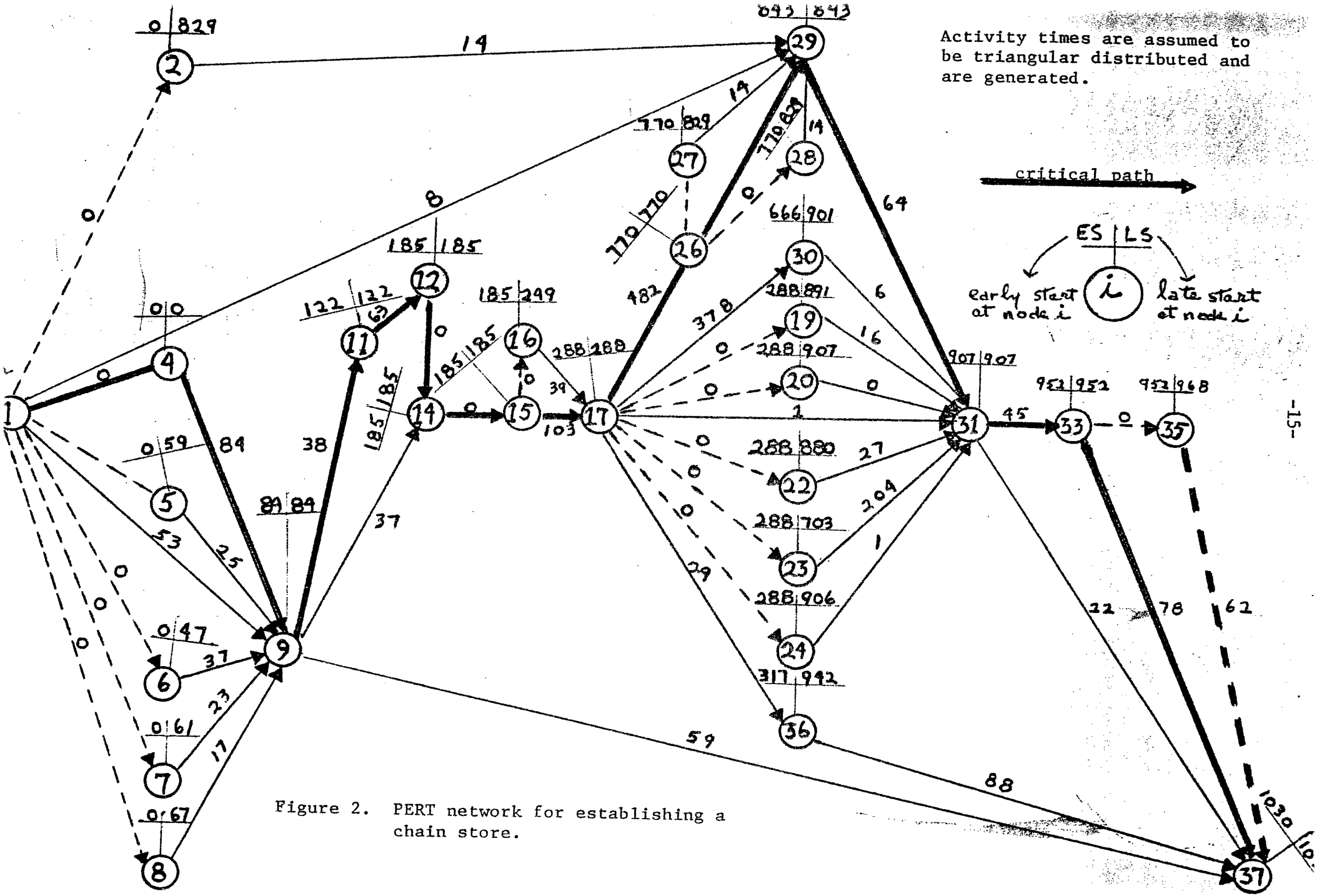


Figure 2. PERT network for establishing a chain store.