A Comparative Analysis of Various Project Networking Techniques: A Review

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***Abstract*--In this paper,we investigate various networks programming methods adopted for project assessment as now a day's infrastructure sector is on boom. Therefore, there is a demandto take care of all related aspects of the project. This paper deals with various project evaluation techniques which have been proposed by various researchers. A combining algorithm has been frame out to get optimum results in comparison of existing methods. For this purpose, various techniques have been discussed such asCritical path method, Project evaluation review technique, Project crashing etc.Further, numerical illustrations have been provided by a suitable example.**

Keywords:Critical path method, Project evaluation review technique, Project Crashing, Survey.

Subject Classifications: 90-02, 90B10, 90B15.

I. INTRODUCTION

Execution of any project involves high risk of return to its shareholders. Thus it is responsibility of executer to utilize their resources in optimizing manner. Every investor expects high return on their investment. This return can only realize after the final product has been delivered and this is possible only when project can be completed on or before the date of expected date. Various project handling techniques presented in the literature to handle such problems. Some of These techniques are namely critical path method, project evaluation review techniques, gantt chart etc.

Critical path method (CPM) was discovered by Morgan R. Walker of EI Dupont de Nemours & co., and J E Kelli of Remington Rand Circa in1957. The computation was designed for the UNIVAC 1 computer. The first test was made in 1958. CPM was applied to the construction of a new chemical plant. In March 1959, the method was applied to a maintenance shut down at the Du-Pont works in lousiville Kentucky, unproductive time was reduced from 125 to 93 hrs. CPM generally regarded as the activity oriented network.

The Project Evaluation Review Technique (PERT) was devised in 1958 for the Polaris missile program by program evaluation branch of the special project office of US Navy, helped by the Lockheed missile systems division and the consultant firm of Booz-allen&Hemilton. The calculations have been so arranged so that they could be carried out on the IBM naval ordinance research computer (NORC) at Dahlgren.

II. LITERATURE REVIEW

The discussed techniques can be classified in the category such as:

2.1 Critical Path Method (CPM)

The Critical Path Method (CPM) has been useful for project planning yet its float calculation errors in cases of complex schedules hinders its ability to provide decision supports during project control, namely corrective actions and forensic analysis of schedules. To improve project control, Peter and Roy (2009) suggested CPM and Critical chain project management (CCPM) for organizations. The study focused that each organization using CCPM would have to identify its level of tolerance of risk and the possible decision making strategies that could use in case of the project slippage. They also discussed about various software packages which use different algorithms to analyse any project. T Hegazy (2012) in his study enhanced the critical path segments (CPS) scheduling technique and incorporates a rich visualization of all as-built events made by all parties, including work stops, accelerations, and rework. Its improved critical path calculation incorporates the decision variables used at the project control stage such as revised construction methods. It also uses a modified float calculation with forward-pass only to avoid float errors. A case study is used to demonstrate the proposed technique and its benefits for project control. This research has the potential to revolutionize scheduling computations to resolve CPM drawbacks and provide decision support capabilities to improve project planning and control. CPM, a technique for analyzing projects by determining the longest sequence of tasksor the sequence of task with the least slack to plan, schedule and control a project which involves a combination of interrelated activities.CPM has been applied by various Researchers. These activities are used to analyse the project.Goksu and Catovic(2012) conducted a research on effectiveness and efficiency of PERT and CPM method on a furniture company "Dallas". They find it very effective for furniture industry and its competitiveness. As these method help the industry to answer the project completion time and controlling the resources.

2.2 Project Evaluation Review Technique

The PERT technique accepts that scheduling is a stochastic problem and takes this variability in the duration of activities into account. Normally the upside potential for early completion is smaller than the downside potential for delay.Linda (1989) discusses CPM and PERT techniques useful for library management. Yakhchali (2008) proposed new method called PERT11.This method is a novel approach to project scheduling with stochastic activity durations. This method helps to reduces beta distribution problem arises in PERT, as suggested method use monte-carlo approach, and to minimise the drawback associate with it. This method use cumulative distribution function of /latest starting and finishing and floats of activities based on confidence interval.

Li and Liu (2011) in their paper come up with an improved PERT Method which is suitable for risk assessment the suggested improved method useful for engineering project activity time and variance by formula nearer to practical situation. This method provides the revision policy to evaluate optimized results in terms of improved probability and risk rate due to interrelated activities mode and easily applicable on spliced network for engineering projects.Yaghoubi and Noori (2013) presented a heuristic method for consumable resource allocation problem in multiclass dynamic project evaluation and Review Technique network,this method use Poisson processes with different arrival rates.

Styen(2003)conducted a research on a comparison between combination of various network analysis approached to accelerate engineering projects. Moreover he emphasised on lack of holism in PERT and CPM techniques. Thus to compete in critical and concurrent engineering environment, he provided integrated CPM approach.

2.3 Graphical Evaluation Review Technique (GERT)

The GERT approach addresses the majority of the limitations associated with PERT/CPM techniques.GERT allows loops between the tasks. Van Slyke (1963)was the first of many researchers to apply Monte Carlo simulation to study PERT moreoverPrinstker (1977) introduced human factors in these techniques, and one such technique is GERT.This method is used for complex systems. Another type of GERT is Q-GERT and it is useful for a queuing system.

2.4 Gantt chart (GC)

Gantt charting is a simple time charting tool developed by Henry L.Gantt in 1917; these charts are graphical representation of project and networking. In these chart each task in a project is represented by a horizontal bars. The length of each bar represents the time required to complete the task. Horsley and William (1991) discussed various software options present to analysis a Gantt chart for any project. These programs are such as: Microsoft project, Micro Planner X-Pert from Micro planning international, Milestones etc.Robert and Miksch(2000) worked upon a visualization of medical plans compared to Gantt and PERT charts;he presented and discussed the features and advantages. His study tried to cover these techniques in designing network.

2.5 Project Crashing (PC)

Crashing is the procedures by which project duration can be shorten up by expediting selective activities within the project. But it requires allocating more resources than usual to compress activity duration which in turns increases the budget of that activity. This method is useful when managers want to avoid incoming bad weather season.Haga et al(2001) created a computer simulation model to determine the order in which activities should be crashed. The optimal crashing strategy for a PERT network to minimize the expected value of the total(crash + overrun)cost has been given a specified penalty function for last completion of the project. Singh et al (2010) presented unit based crashing PERT network for optimization of software project cost. Moreover, they presented a technique called "Unit crashing" to reduce the total project cost. Here, unit crashing means to crash the project duration by one unit (day) instead of crashing it completely. They considered iterative method which continues until all activities along the critical path are crashed by desired amount. Recently Islam (2013) developed an algorithm for an optimum crashing method to minimize the required cost while attaining a specified completion time.

2.6 Fuzzy Project Evaluation Review Technique (FPERT)

In this method the activities time schedule considered in precise manner.Sharafi et al (2008) presented a model for project scheduling for fuzzy preceding activities. They presented a new method based on the fuzzy theory. In his study the duration of activities is triangular fuzzy numbers (TFN) where it is assumed that relationships between the activities are not crisp.Saeinia and Hashemin(2012) use the trapezoidal fuzzy number for time cost trade off in fuzzy projects with constrained consumable resource. Where in activity duration depend upon the amount of resource allocation. They proposed algorithm used to minimize the direct and indirect cost of the project.

2.7 Stochastic time and resource constraints (STARC)

Stochastic Time and Resource Constraints is used to illustrate the effectiveness of computer simulation for project planning. STARC, first developed in 1984, is a

PERT network simulation tool. Badiru (1991) presented simulation as a useful analytical tool for project network analysis.STATGRAPHICS software is used to illustrate some of the post-simulation statistical analyses that can be conducted; they also discussed the recent improvements made to the STARC simulation shareware. Elkarablieh et al. (2007) presented STARC as static analysis for efficient repair of complex Data. For optimizing any project through STARCdivided in to:

(1) The Recurrent Field i.e. fields that the predicate method uses to traverse the structure.

(2) The Local Field constraints i.e. how the activities are correlated or interdependent.

2.8 Others approaches

Elmabrouk(2011) presented a research on an alternative approach for project optimization; he provided a framework for crashing for crashing total maintenance project time at the least total cost by using Linear Programming technique in place of PERT. A prototype example of boiler is used to show how suggested technique is used for strategic decision making and assisting managers dealing with crashing maintenance projects activities. Kosztyan and Kiss(2011) proposed a new network technique that is known as Matrix Based Project Planning Methods. In this method,first those tasks are selected which have to be or can be realized during project. Then the dependencies of activities are determined taking the project constraints in to account.Panagiotopoulos and Apostolos (2012) also used linear programming method for project time series forecasting.Boushaahla(2013) show to easily convert a PERT/CPM network to a Petri Net (PN) Model. Research proposes a PN based modelling approach to provide a formal way to verify that all activities are well connected in the project network. This method not only considers resources but also focus on different types of variables/ constraints related to a project.

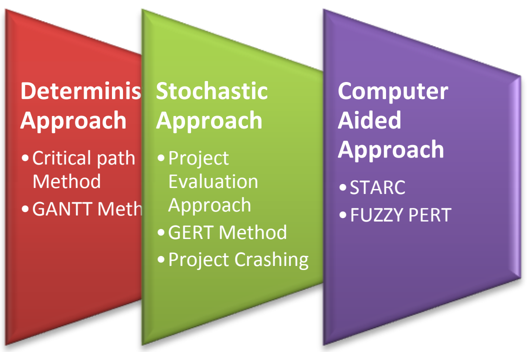

Fig. 1: Various approaches for Project scheduling.

III. ABBREVIATIONS

Following notions are used for modelling purpose:

ST: Slack time

ES: Earliest Start time

EF: Earliest Finish time

LS: Latest Start time

LF: Latest Finish time.

IV. METHODOLOGY

In this paper, we are trying to reflect the suitability of various project networking techniques. For this purpose,a comparative analysis has been done. Moreover we considered a numerical problem and solved that using Critical Path Method and PERT Method which involves activity specification and their sequencing. A work break down structure helps to provide information for activities and their sequencing. Sequencing of the task mainly focused on

- Which tasks should take place before this task happens?
- Which tasks should be completed at the same time as this task?
- Which tasks should happen immediately after this task?

Using this activity sequence and time duration for the activity a network diagram has to set up and assign the completion time for each activity. Then for the project different time such as, ES, EF, LF and LS is to be calculated.The float time for an activity is the time between the earliest (ES) and the latest (LS) start time or between the earliest (EF) and latest (LF) finish times.

A distinguishing feature of PERT from CPM is its ability to deal with uncertainty in activity completion time. For each activity, the model usually includes three time estimates: O*ptimistic time*, it isgenerally the shortest time in which the activity can be completed. It is common practice to specify optimistic time to be three standards deviations from the mean so that there is an approximately a 1% chance that the activity will be completed within the optimistic time. Then next is *most likely time*, the completion time having the highest probability. *Pessimistic time* isthe longest time that an activity might require. Three standard deviations from the mean are commonly used for the pessimistic time. PERT assumes a beta probability distribution for the time estimates. For a beta distribution, the expected time for each activity can be approximated as:

Expected time = (Optimistic + 4 x Most likely + Pessimistic) / 6

To calculate the variance for each activity completion time, if three standard deviation times were selected for the optimistic and pessimistic times, then there are six standard deviations between them, so the variance is given by: $[(\text{Pessimistic} - \text{Optimistic}) / 6]^2$

V. NUMERICAL ILLUSTRATIONS:

In this section, to verify the above methods, we illustrate a numerical examplenamely'*thesis completion project*'. Table1 represents below is a list of activities and sequencing requirements as indicated, which comprise necessary activities for the completion of a thesis. Literature Search, Topic Formulation, Committee Selection, Formal Proposal, Company Selection and Contact, Progress Report, Data Collection, Data Analysis, Conclusion, Rough Draft, Final Copy of thesis.

Table 1. Activity involve for Thesis completion

S no	Activity	Description	Most optimistic time	Most pessimistic time(weeks)	Most Likely Time
1	1-2	Literature Search (A)	1	5	1.5
2	2-3	Topic Formulation (B)	1	3	2
3	2-4	Committee Selection ©	1	5	3
4	3-5	Formal Proposal (D)	3	5	4
5	4-5	Company Selection and Contact (E)	2	4	3
6	4-6	Progress Report (F)	3	7	5
7	5-7	Formal Research (G)	4	6	5
8	6-7	Data Collection (H)	6	8	7
9	7-8	Data Analysis (I)	2	6	4
10	7-9	Conclusion (J)	5	8	6
11	8-10	Rough Draft (K)	1	3	2
12	9-10	Final Copy (L)	3	7	5

PERT and CPM Analysis of Project

Table 2. Calculation for Project EvaluationReview Method

	Start node	End node	Optimistic time	Most Likely time	Pessimistic time	Activity time	Standard Deviation	Variance
A	1	2	1	5	1.5	3.75	0.08	0.01
B	2	3	1	3	2	2.5	0.17	0.03
C	2	4	1	5	3	4	0.33	0.11
D	3	5	3	5	4	4.5	0.17	0.03
E	4	5	2	4	3	3.5	0.17	0.03
F	4	6	3	7	5	6	0.33	0.11
G	5	7	4	6	5	5.5	0.17	0.03
H	6	7	6	8	7	7.5	0.17	0.03
I	7	8	2	6	4	5	0.33	0.11
J	7	9	5	8	6	7.17	0.17	0.03
K	8	10	1	3	2	2.5	0.17	0.03
L	9	10	3	7	5	6	0.33	0.11
Project results								
Sum of critical activity variance								0.4
Square root of total							0.63	

Table3. Calculation for Critical Path Method

Activity	Start node	End node	Activity time	Early Start	Early Finish	Late Start	Late Finish	Slack	Standard Deviation
Project			34.42						0.63
A	1	2	3.75	0	3.75	0	3.75	0	0.08
B	2	3	2.5	3.75	6.25	8.75	11.25	5	0.17
C	2	4	4	3.75	7.75	3.75	7.75	0	0.33
D	3	5	4.5	6.25	10.75	11.25	15.75	5	0.17
E	4	5	3.5	7.75	11.25	12.25	15.75	4.5	0.17
F	4	6	6	7.75	13.75	7.75	13.75	0	0.33
G	5	7	5.5	11.25	16.75	15.75	21.25	4.5	0.17
H	6	7	7.5	13.75	21.25	13.75	21.25	0	0.17
I	7	8	5	21.25	26.25	26.92	31.92	5.67	0.33
J	7	9	7.17	21.25	28.42	21.25	28.42	0	0.17
K	8	10	2.5	26.25	28.75	31.92	34.42	5.67	0.17
L	9	10	6	28.42	34.42	28.42	34.42	0	0.33

On the basis of above CPM table a network diagram has been formed for the activities, as given below:

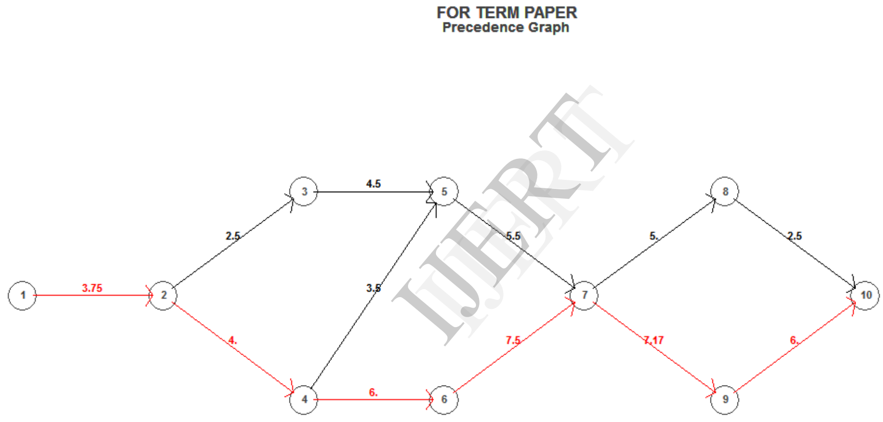

Fig. 2. Network Diagram of Activities

Gantt chart Analysis

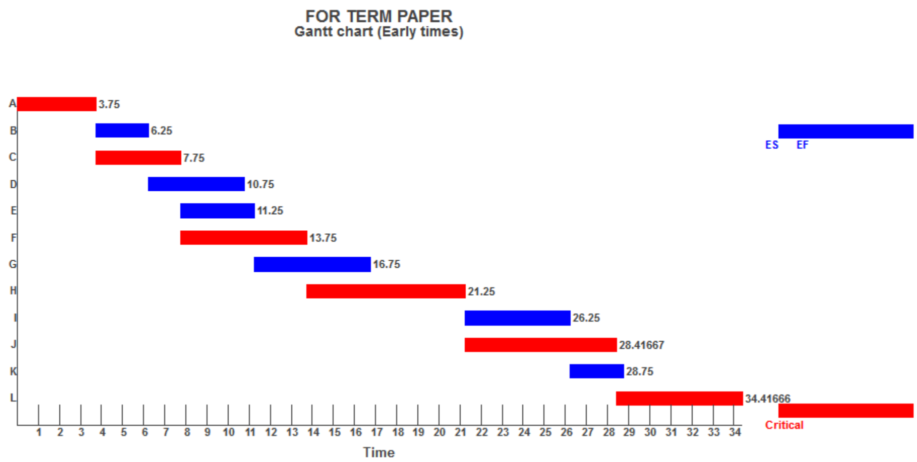

Fig. 3. Activities Early Time Calculation

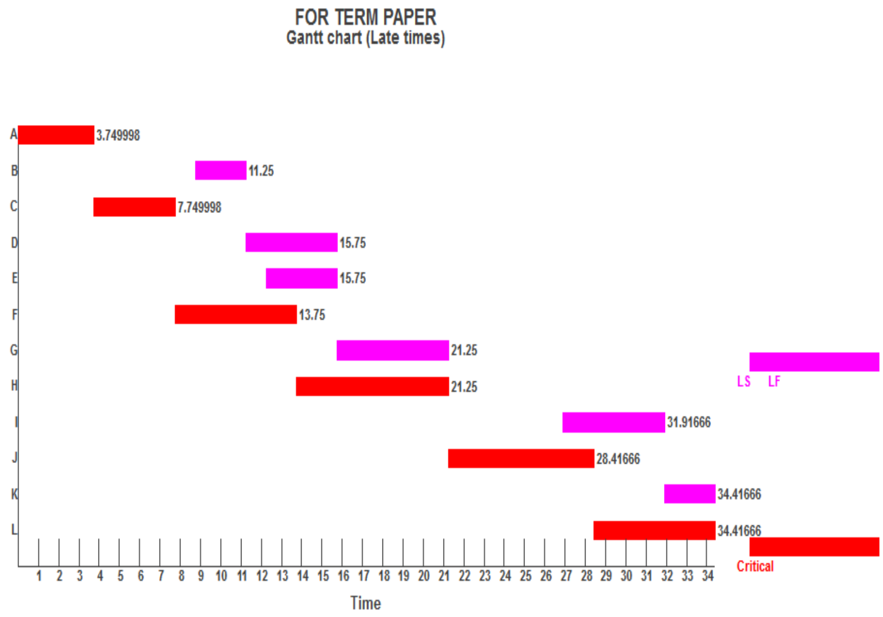

Fig. 4. Activities Late times

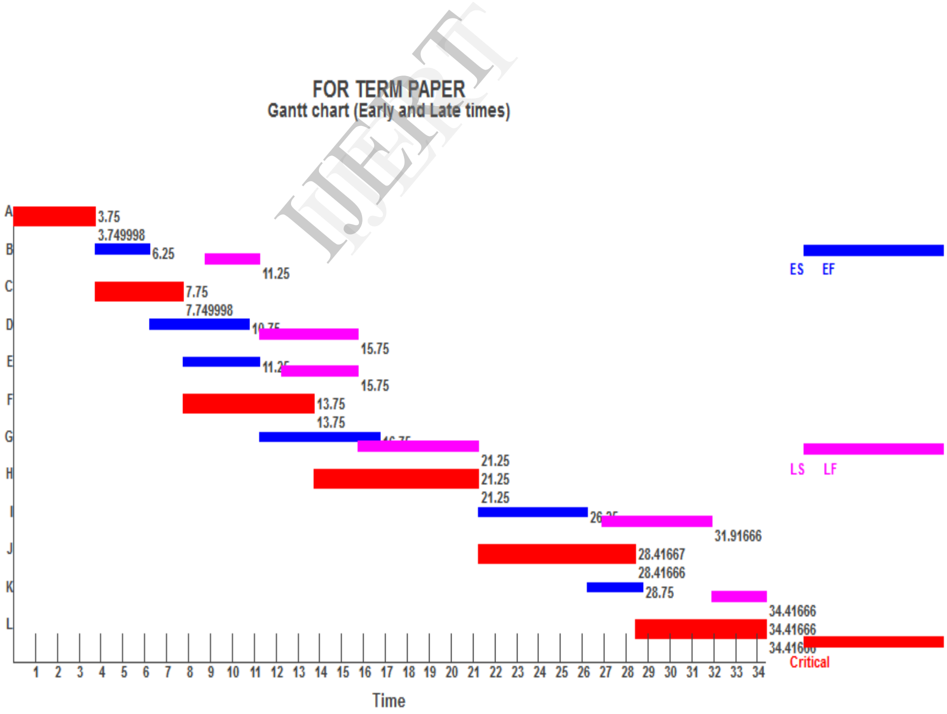

Fig. 5. Activities Early and Late times Calculation

VI. RESULTS ANALYSIS

Finding of the numerical illustration shows that for a stochastic project, PERT consider the average weighted mean of times, which further used to find Critical Path of Project. Total completion time of thesis calculated about 34.41 weeks.

VII. CONCLUSION

In this paper, we have concluded that there are various techniques proposed for analysing a network problem. To optimize the resources at any point of time it is necessary to use right method at right time. Thus after analysing the various methods we reached at conclusion that for any project involving high level certainty the critical path method provides a significant direction for such project. When a project becomes stochastic, and activities depend on internallythen study suggests using Project crashing method, where total project time can be minimizing considering minimum cost. Fuzzy PERT is more efficient technique then other computer added techniques, as this technique analyse the project very precisely and reached to the optimum point for the project.

VIII. REFERENCES

[1] Adedeji B. Badiru "A simulation approach to PERT network analysis",SIMULATIONOctober 1991 vol. 57 No. 4 245-255.

[2] Adedeji B. Badiru "STARC 2.0(stochastic time and resource constraints): An improved pert network simulation tool", Computers & Industrial Engineering 01/1991; DOI: 10.1016/0360-8352(91)90011-T.

[3] Ali Göksu, Selma Ćatović "Implementation of Critical Path Method and Project Evaluation and Review Technique", 3rd International Symposium on Sustainable Development May 31 - June 01 2012, Sarajevo.

[4] ApostolosPanagiotopoulos, MSc "Optimising Time Series Forecasts through Linear Programming",Thesis submitted to the University of Nottingham for the degree of Doctor of Philosophy, 2012, December.

[5] Horsley, F. William. "Means Scheduling Manual: On-Time, On Budget Construction, Up-to-Date Computerized Scheduling",3rd ed. Kingston, MA: R.S. Means Co., 1991.

[6] Linda Main, "CPM and PERT in Library Management", Special libraries winter, vol 80, 1989, No.1.

[7] Mohammad Sharafi, FariborzJolai, HosseinIranmanesh, and S.M. Hatefi, "A Model for Project Scheduling with Fuzzy Precedence Links",Australian Journal of Basic and Applied Sciences, 2(4): 1356-1361, 2008 ISSN 1991-8178.

[8] NafishSarwar Islam, "Complex Project Crashing Algorithm", IOSR Journal of Business and Management (IOSR-JBM) e-ISSN: 2278-487X, p-ISSN: 2319-7668. Volume 11, Issue 4 (Jul. - Aug. 2013), PP 10-17.

[9] Omar m. Elmabrouk, "A Linear Programming Technique for the Optimization of the Activities in Maintenance Projects", International Journal of Engineering & Technology IJET-IJENS Vol: 11 No: 01

[10] Peter Stelth, Professor Guy Le Roy, "Projects' Analysis through CPM (Critical Path Method)",School of Doctoral Studies (European Union) Journal,July, 2009 No. 1.

[11 Priti Singh, FlorentinSmarandache, Dipti Chauhan, "A Unit Based Crashing Pert Network for Optimization of Software Project Cost", August 2010,viXra: 1008.0032

[12] R.Kosaraand S.Miksch, "A Visualization of Medical Therapy Plans Compared to Gantt and PERT Charts", Proceedings of the 7th International Workshop on Temporal Representation and Reasoning (TIME-2000), pp. 173-181, 2000

[13] Saeed Yaghoubi, SiamakNoori, Mohammad MahdaviMazdeh. "A heuristic method for consumable resource allocation in multi-class dynamic PERT networks" Journal of Industrial Engineering International 2013, 9:17

[14] TarekHegazy, Wail Menesi, "Enhancing the critical path segments scheduling technique for project control", Canadian Journal of Civil Engineering, 2012, 39(9): 968-977, 10.1139/l2012-024

[15] Wayne A. Haga, Tim O'keefe, "Crashing Pert Networks: A Simulation Approach",4th International conference of the Academy of Business and Administrative, July 2001

[16] Y. Saeinia andS.S. Hashemin, "Time cost trade-off in fuzzy projects with constrained consumable resource,"Journal of Applied Sciences Research, 8(4): 2253-2259, 2012 ISSN 1819-544X.

[17] ZsoltTiborKosztyán andJuditKiss,"Matrix-Based Project Planning Methods" Problems of Management in the 21st Century Volume 1, 2011 67.