

An Estimating Method for IT Project Expected Duration Oriented to GERT

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Abstract. Reworking in developing software exists widely in IT project management. But the current estimating methods on project duration cannot deal well with this problem. In this paper, some key concepts, such as adjusted activity, adjusted GERT network, expected project duration, expected critical path, are firstly defined. Then authors study estimating method on project duration for different rework modes, including serial, paratactic, and combined structure by encapsulating of activities. Finally, a general estimating method on IT project duration oriented to GERT is presented, and detailed steps are illustrated with an example project on IT software development.

Keywords: *Project Management, Project Schedule Estimation, Expected Duration*

I. INTRODUCTION

In project management, project schedule often faces with the problem how to know project duration under the restriction of resource. PERT (Program Evaluation and Review Technique) and CPM (Critical Path Method) are the most important project management techniques [1], which have been created out in the need of Western industrial and military establishments to plan, schedule and control complex projects [2].

GERT (Graphical Evaluation and Review Technique) is another important analysis technique, being widely using in engineering management and enterprise producing for strong ability to describe reworking in project management [1].

Reworking exists in IT project management widely, and GERT can describe it well. But current method to estimate project duration only can deal with determinate project network without reworking. So, the problem how to estimate project duration with reworking became key technique for the using of GERT. Currently, few such researches are made in the world. Very few research is made on estimating project duration oriented to GERT by simulating method [3]. But it is difficult to compute accurately project duration, especially when times of simulating is few, the error is more obvious. The paper tries to resolve the problem by encapsulating of activities.

In next section, key concepts, such as expected duration and expected critical path etc, are presented. In section 3, author research on estimating method on IT project duration under all kinds of reworking cases, including serial, paratactic, and combined

structure. General resolving method is given in section 4. In section 5, estimating method is used in a project example about the development of information system project.

2. EXPECTED CRITICAL PATH AND EXPECTED PROJECT DURATION

Under the condition with reworking, critical path can not be determined because the number of reworking for certain activity is not determinate. So there may be a lot of critical paths which have same activities in a project network diagram with reworking. Since the number of activities consisting of a critical path is determinate and each activity has determinate duration, project network diagram is determinate. Project duration could be infinite when reworking of certain activity always happened. If no reworking happened, GERT network became determinate network and project duration is determinate. Project duration can be computed by CPM and PERT methods. But both of the methods are not adapt to GERT network with reworking.

Although critical path and duration of the project based on GERT are not determinate, expect duration of each activity could be computed according to the probability distribution of the reworking. Then, according to expected duration of each activity, critical path of project can be computed by using CPM/PERT methods. Because this kind of critical path is based on expected duration of each activity, we call it as expected critical path of project, and corresponding duration as expected project duration. They are very useful in project schedule management when reworking could happen.

3. ESTIMATING OF EXPECTED PROJECT DURATION FOE DIFFERENT REWORKING MODES

3.1 Including One Reworking Activity

Here, being supposing that a project only includes one reworking activity A, and its duration is a , the probability of reworking is p . As shown in Fig.1. Now, how to compute project duration?

Noting the expected project duration as D , so

$$D = a + (p * D) \quad (1)$$

And

$$D = \frac{a}{1 - p} \quad (2)$$

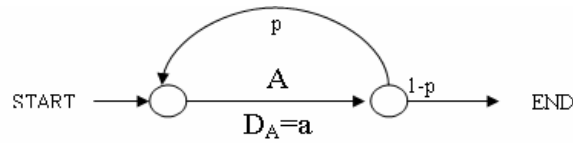


Figure 1. Project Including One Reworking Activity

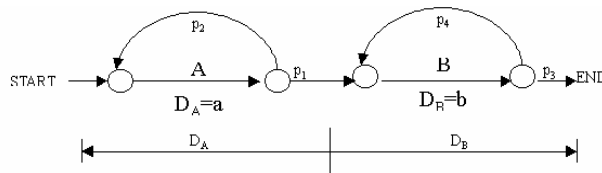


Figure 2. Serial Reworking

In the following, two extremities be analyzed,

(1) $p=0$

In this case, it means that no reworking exists, and expected project duration can be computed as following,

$$D = \frac{a}{1-p} \Big|_{p=0} = a \tag{3}$$

(2) $p=1$

In this case, it means that reworking always exists. As be showed in Equation (4), expected project duration is $+\infty$,

$$D = \frac{a}{1-p} \Big|_{p=1} = +\infty \tag{4}$$

Generally, bigger p shows higher reworking probability, so expected project duration is longer and $D=D(p)$ increased with increasing of reworking probability p .

Sometimes, it is usual that project allows top times of reworking. That is to say, after top number of reworking, the activity must be finished. The mode exists widely in project management practice. In this mode, computing expected project duration has practical meaning. Let's noting D_n as project duration while allowing n times of reworking for an activity, then the number list $\{D_n\}$ ($n=1,2,\dots$) has following equations,

$$D_0 = a \quad D_1 = a+pa$$

$$D_2 = a+pa+p^2a \quad \dots$$

$$D_n = a+pa+\dots+p^na$$

So,

$$D_n = \frac{a(1-p^{n+1})}{1-p}$$

Especially, while $n \rightarrow +\infty$, it means there is no limit for times of reworking. So

$$D = \lim_{n \rightarrow +\infty} D_n = \lim_{n \rightarrow +\infty} \frac{a(1-p^{n+1})}{1-p} = \frac{a}{1-p} \quad (5)$$

This conclusion is consistent with above the result.

3.2 Including Lots of Reworking Activities

3.2.1 Serial Reworking

As shown in Fig.2, a project includes two serial reworking activities A and B. Then

$$D = D_A + D_B$$

And D_A and D_B can be computed as Equation (1) and Equation (2) ,

$$D_A = a + (p_2 * D_A) \Rightarrow D_A = \frac{a}{1-p_2}$$

$$D_B = b + (p_4 * D_B) \Rightarrow D_B = \frac{b}{1-p_4}$$

So

$$D = D_A + D_B = \frac{a}{1-p_2} + \frac{b}{1-p_4} \quad (6)$$

3.2.2 Paratactic Reworking

As shown in Fig.3, a project includes two paratactic reworking activities A and B. Then

$$D = \max\{D_A, D_B\}$$

And D_A and D_B can be computed as Equation (1) and Equation (2) , so

$$D_A = a + (p_2 * D_A) \Rightarrow D_A = \frac{a}{1-p_2}$$

$$D_B = b + (p_4 * D_B) \Rightarrow D_B = \frac{b}{1-p_4}$$

Then

$$D = \max\{D_A, D_B\} = \max\left\{\frac{a}{1-p_2}, \frac{b}{1-p_4}\right\} \quad (7)$$

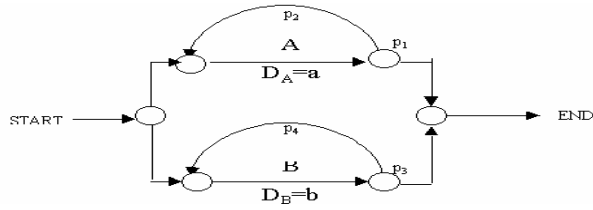


Figure 3. Paratactic Reworking

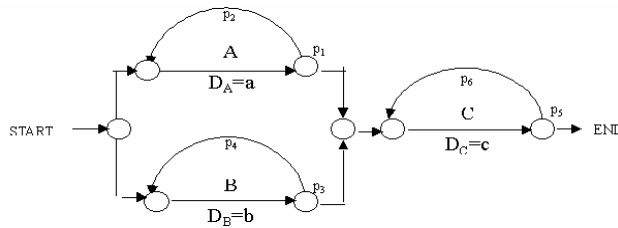


Figure 4. Combined Reworking

3.2.3 Combined Reworking

As shown in Fig.4, project includes serial reworking and paratactic reworking. Among of them, activities A and B are paratactic, being serial with activity C. Then, expected project duration is

$$D = \max \{D_A, D_B\} + D_C$$

According to Equation (6) and Equation (7), D be computed as following

$$D = \max \{D_A, D_B\} + D_C = \max \left\{ \frac{a}{1-p_2}, \frac{b}{1-p_4} \right\} + \frac{c}{1-p_6} \tag{8}$$

3.3 Reworking on Lots of Activities

As shown in Fig.5, if activity B needs reworking, activity A also must rework. Reworking relates to two activities.

According to Equation (1), then

$$D = (a + b) + (p_2 * D)$$

So

$$D = \frac{a + b}{1 - p_2} \tag{9}$$

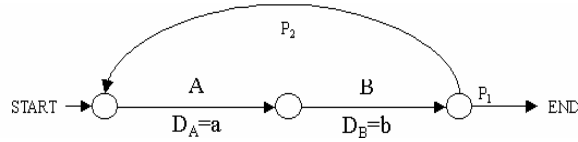


Figure 5. Reworking on Lots of Activities

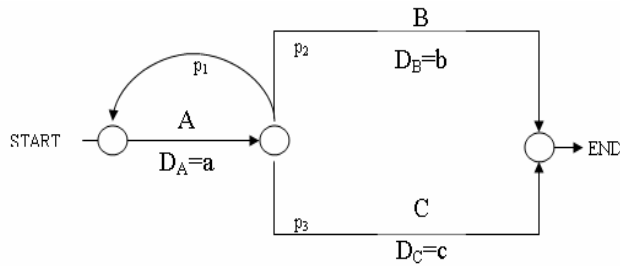


Figure 6. Multi-choices of Reworking

3.4 Multi-choices of Reworking

In IT project management, there are often lots of path choices for one activity. As shown in Fig.6, after activity A is finished, reworking could be happened at once or activity B or C could be executed. That is to say, after activity A be finished, there are three path choices. In this case how to compute project duration?

In fact, this case can be transformed to two reworking choices mode. Activity B and C can be encapsulated to one virtual activity D, as be shown in Fig.7.

After encapsulating activity B and C, according to the probability theory, the duration of virtual activity D can be computed as following

$$D_D = \frac{p_2 * b + p_3 * c}{p_2 + p_3} \tag{10}$$

So, project duration is

$$D = D_A + D_D = \frac{a}{1-p_1} + \frac{p_2 * b + p_3 * c}{p_2 + p_3} = \frac{a + p_2 * b + p_3 * c}{p_2 + p_3} \tag{11}$$

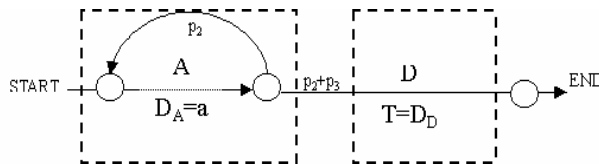


Figure 7. After Encapsulating Activity B and C

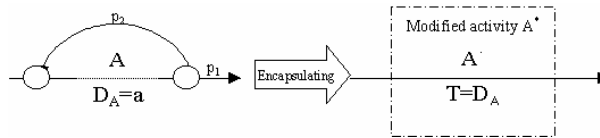


Figure 8. Encapsulating Activity

4. ESTIMATING STEPS OF EXPECTED PROJECT DURATION ORIENTED GERT

After discussing the computing method on expected project duration under different modes, we provide the general estimating steps of expected project duration oriented to GERT in the following.

4.1 Encapsulating Reworking Activities

The key step in estimating of expected project duration oriented to GERT is to transform GERT network with reworking activities to traditional determinate network without reworking activities. So the first step is to modify GERT network by encapsulating reworking activities, as shown in Figure 8. Activity A with reworking is transformed to modified activity A* without reworking by encapsulating. We call activity A* as adjusted activity of the activity A.

4.2 Computing of Duration of Adjusted Activity--- D_A^*

According to Equation (2), duration of adjusted activity A* is

$$D_A^* = \frac{a}{1 - p_2} \tag{12}$$

We call it as adjusted duration of activity A.

4.3 Generating Adjusted GERT Network

Doing as above two steps for all activities with reworking, we can generate new GERT network without reworking. We call the network as adjusted network diagram.

4.4 Computing of Expected Critical Path and Expected Duration

After eliminating reworking activity by encapsulating and generating adjusted GERT network, expected critical path and expected project duration can be computed by traditional CPM/PERT methods.

5. EXAMPLE

For better explaining the above method, here we give a IT development project consisting of system design, buying hardware, software analysis, buying software, hardware examining, hardware setup, etc, as shown in Fig.9. Among these activities, two activities, hardware examining and system examining, could exist reworking. If there exists questions in hardware examining activity, hardware modifying activity happened. System examining happens according to trouble degree. All activities duration and reworking probability are shown in Fig.9. Now, we try to compute expected critical path and project duration.

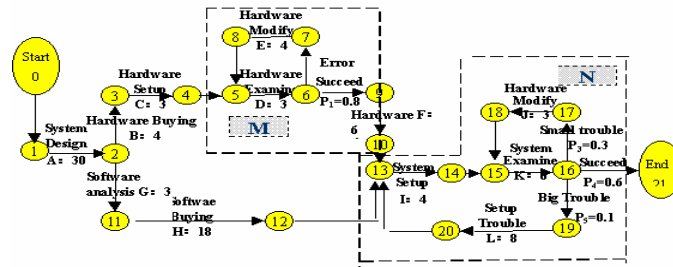


Figure 9. GERT Network of IT Project

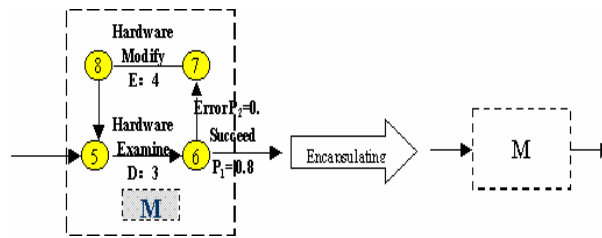


Figure 10. Modified Activity M after Encapsulating

5.1 Encapsulating Reworking Activities

In this example, there exist reworking in two activities. They can be encapsulated to two adjusted activities M and N, as shown in Fig.10 and Fig.11.

5.2 Computing of Expected Duration of Modified Activity

(1) Expected Duration of Adjusted Activity M

According to Equation (2), expected duration of adjusted activity M can be computed as following,

$$D=30+4+3+8.75+6+21.25=73 \text{ (days)}$$

6. CONCLUSIONS

Reworking exists widely in IT project management. The authors studied estimating method on project duration in different modes based on GERT network diagram, and got the general steps of computing project duration. The method not only adapts to GERT network with reworking, also adapts to traditional determinate project network without reworking. Maturity of the method needs to be more verified in the future.

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