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Research on Software Project Schedule Based on Critical Chain

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Abstract. Based on the problems and causes of the system analysis software project schedule, the idea of introducing critical chain technology into the software project schedule is proposed. This paper expounds the basic concept of the critical chain schedule of the software project, describes its core idea in detail, and constructs the critical chain schedule model of the software project. Then the objectives and construction principles of the software project critical chain schedule model are analyzed, and the implementation process is explained. Finally, the feasibility of the software project critical chain schedule is verified by examples.

1. Introduction

Software projects as a capital-intensive, labor-intensive, knowledge-intensive system engineering, the content of its management is diversified and unique. Its schedule goal is one of the three basic objectives of the software project^[1]. And software project schedule management is a series of management processes to ensure that the project is completed on time^[2]. It is an important part of project schedule management, as well as the key and difficult point in software project management. Scientific and reasonable schedule can shorten the construction period and reduce the cost of the project, enable the project to be put into production early, and seize the opportunity to obtain good economic and social benefits. Because traditional project schedule technology CPM/PERT does not consider resource constraints, uncertain factors and human behavior, it often fails to play its due role in practice, prone to delays, overspending, etc. and its failure rate is high. Thus, there are major flaws in project uncertainty and risk management^[3]. Combining the new ideas of critical chain technology to study the software project schedule, this paper puts forward some improved ideas and methods.

2. Status of software project schedule plan

2.1 Problems with the software project schedule plan

Project schedule delay is a common problem in software project execution. Traditional schedule planning tools mainly include Gantt Chart Method, Critical Path Method and Program Evaluation and Review Techniques. These methods play an important role in the progress management of traditional engineering projects with resource consumption as the main feature. But there are some limitations in practice. The Gantt Chart Method does not express the logical relationship between processes, so it is impossible to establish a network between processes. CPM and PERT only identify critical paths from the perspective of time. And the role of resource constraints in software project



schedule management is ignored. According to relevant statistics, only one third of the software projects are completed within the planned time^[4]. Obviously, these methods are not ideal and will bring more resource consumption to the later software project testing and maintenance.

2.2 Analysis of the reasons for the delay of software project schedule

(1) Lack of implementation plan

Project plan is a document used to guide project execution and control. A successful software project should begin with the development of the right project plan. The main elements of the project plan include: clear project deliverables, define work packages, estimate construction periods, develop work package schedules, manage resource effectiveness, cost budgets, integrate schedules and budgets, define key performance indicators or milestones, and define key success factors. In terms of the current state of the software industry, most software project managers are transformed from programmers. In formulating the project plan, they rely too much on the previous work experience or intuition, so their decision is lack of data support. What's more, they usually use the non-phased method blindly, thus they can not effectively use the project management system to assist in the development of the project plan.

(2) Technical update issue

Software project is a kind of project based on information technology. In the era of knowledge and information economy, development of computer software and information technology is increasing exponentially. When making progress plans, it is easy to ignore the problem of technological progress, mainly manifested in the difficulty of estimating information technology, the lack of corresponding change schemes in the event of technological changes, etc.

(3) Resource constraint problem

The success of any project is inseparable from the support of rational allocation of multiple resources. In the process of software project, the main constraints are personnel constraints, budget constraints, time constraints and equipment, material constraints. Most projects have parallel operations, and only when all parallel operations are completed can they be transferred to the next operation. The time remaining to complete the operation in advance in a parallel operation is wasted, and the delayed process will bring the delay to the next process. In such cases, the conflict of any resource can affect the effective conduct of the project or even lead to failure.

(4) The impact of "student syndrome"

The so-called "student syndrome" is a popular description of the behavior and habits of learning work that people usually form. After considering uncertainties and risk factors, people are generally used to leaving room for their tasks. Manifesting in the software project, the project staff first strives for safe time. Due to inertia, the project personnel do not show their full enthusiasm when they know that they have enough time at the beginning of the project. When it is urgent, they will start to work hard. In this way, the original abundant time is wasted, which means the emergence of the phenomenon of pre-loosening happening. And in the event of accidents, it often results in delays in the construction period.

3. The basic concept and core idea of software project critical chain schedule

3.1 The basic concept of software project critical chain schedule

Critical Chain is a new project management method proposed by Israeli scientist Eli Goldratt in 1997. Critical chain schedule emphasizes analyzing the critical factors which affect the project construction period during project implementation to manage the project systematically. It sets project buffering mechanism transportation buffering mechanism and resource buffering mechanism to eliminate the impact of uncertainties on project plan execution. It requests project managers to think with system thought in project schedule and to arrange various resources of the project systematically. It emphasizes global thinking, advocate using project overall time mechanism, and then to shorten project construction period^[5,6].

Software project critical chain schedule is the longest path formed by resource balance. The software project critical chain schedule increases the resource constraints and uncertainties of the software project to the same level as the logical constraints between processes. It believes that the total construction period of a software project is determined by the resource supply and demand, construction period, and immediate relationship of each processes.

3.2 The core idea of software project critical chain schedule

(1) Consider the actual constraints in the software project critical chain schedule. In the schedule network, the delay of non-critical paths and their conflicts in resource usage can affect the progress of critical paths, and these are important aspects of the delay in the overall progress of the project. Software project critical chain schedule coordinate the overall situation with systematic thinking. It analyzes the whole project's process, finds the route that restricts the completion time of the whole process, and seeks the best utilization plan to constrain the resources.

(2) Buffer is set to deal with uncertainties. Set input buffers in the software project critical chain to ensure that the effects of delays in non-critical chains on critical chains are mitigated. Setting up a buffer on a critical chain is to ensure that resources are available when they are needed.

(3) The complexity of the software project schedule is reflected in the management of person. Software projects are intellectually intensive, labor-intensive projects that are heavily influenced by human resources. In the software project, the technical level, experience, communication skills and composition of the personnel largely determine the progress of the project^[7].

4. Construction of critical chain progress schedule of software project

4.1 The objectives of software project critical chain schedule

(1) Reduce the uncertainty of software project development. Software project contains more uncertain factors. The model effectively relieves the uncertain factors of the software project by setting the buffers, and it can ensure the completion of the software project progress target.

(2) Avoid resource conflicts in software projects. Traditional project management technologies only consider the time constraints and ignore resource conflicts between software projects. The model can effectively avoid resource conflicts between software projects by constructing critical chains rather than critical paths.

(3) Estimate construction period accurately. Whether the construction period estimate is effective or not is one of the important factors that determine whether the plan is feasible or not. An effective estimation period is an important goal of model hypothesis.

4.2 Construction principle of critical chain schedule model of software project

The basic principle framework of software project critical chain can be expressed as follows:

First, the constraints of the project schedule determine the project cycle. The cycle of the whole system depends on the progress of the project, and its cycle is the longest work route of the project, which is also one of the project schedule constraints.

Second, the construction period of the non-restriction link can not be determined by its own potentials but by the realization of the constraint period to its requirements. Over a period of time, human resources, material resources and financial resources are limited, and only by guaranteeing the potential of constraints, it can contribute to the progress of the whole system and is beneficial to the whole system. So the schedule of non-restrictive factors should be adjusted and arranged according to the progress needs of the constraints.

Third, it is of no practical significance to save a lot of construction period in the non-restriction link. The shortening of the construction period of non-constrained links is not always equal to the amount of construction period shortening of the project system. Save a lot of time in the non-constrained link, so that it ends early, but it is the constraint that determines the system cycle of the whole project. If the constraints on the non-constrained link point of the demand have not yet arrived, it only increases the

leisure time of non-constrained link which is useless for system.

Fourth, in order to ensure the project cycle, buffers must be set to protect constraints. Buffers can be divided into resource buffers, input buffers, and so on. These buffers protect the project system in advance or on time. Both the choice of buffer mechanism and the determination of buffer size play a considerable role in the project progress.

Fifth, the scheduling of each task should be based on optimism, with buffers control to ensure that all tasks are completed on time. If there was no pressure at first, they would be lazy, inefficient and wasted a great deal of time. At the same time, we should also face the reality, consider the impact of uncertainties on the progress of the project and set up a buffer.

Sixth, there is a resource conflict in the project, and if the resource capacity is not exceeded, it should be arranged at the same time. If they are exceeded, especially in the case of constraints or progress that have affected constraints, their schedule should be staggered to avoid concurrency.

Seventh, when determining the constraints of the master schedule, we should consider all the constraint links of the whole system. Restricting the master schedule plan is an overall schedule based on all constraints. The project lead period changes with the influence of uncertain factors, the size of the project task and the resource load situation, and it is obtained by the schedule after the determination of the progress plan.

4.3 The process of the software project critical chain schedule model

According to the characteristics of the software project and the construction goals of the critical chain schedule model, this paper established the software project critical chain schedule model. The progress is shown as follows:

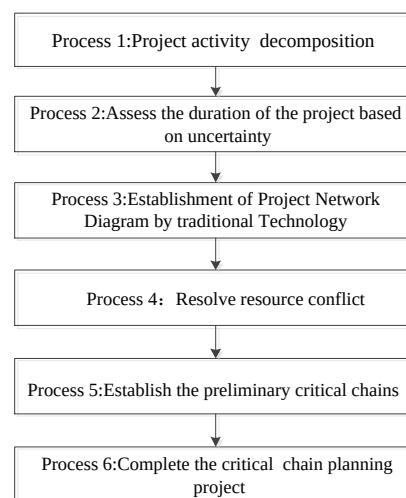


Figure1 The process of the software project critical chain schedule model

Process one: Use WBS to complete the decomposition of software project activities. When decomposing a software project, you should fully consider the characteristics of the software project.

Process two: Estimate the construction period based on uncertainty. Evaluate each task time according to PERT or by the project manager based on experience. Due to the rapid development of information technology, the development of most software projects is carried out in a relatively new environment and the estimation of the construction period is carried out in the absence of historical data, which will face more uncertain factors. Therefore, for software projects, the estimation of the time of each task in the project and the total construction period of the whole project should be established based on the uncertainty.

Process three: According to the traditional schedule technology, under the condition of no resource constraints, according to the activity with the smallest total time difference, find the critical path of the project and establish a preliminary plan network diagram.

Process four: Resolve resource conflicts and establish initial critical chains. The critical chain is the

longest total construction period that takes into account both the process logical relation and the resource constraint. Calculate the total construction period on each path from the start point to the endpoint on the network plan diagram after resolving the resource conflict; find the path with the longest total construction period, and output all the tasks on the chain. And if there are multiple chains with the same total time, take one of them.

Process five: Calculation and set up of buffers. In the calculation process of buffer, the uncertainty factors are more and the risk is greater. Quantifying the risks of the software project and calculating the size of buffer area can ensure the project is completed successfully. After calculating the size of buffers, set the project buffer at the end of the project to prevent delays in the whole critical chain and set the input buffer at the end of non-critical chain branches to avoid delays in operations on non-critical chains.

Process Six: Complete the progress schedule for the critical chain. Move the start time of all non-critical chain activities back as much as possible without affecting critical activities.

5. Instance application

5.1 Case background

Take a small website construction project as an example, the main constraint of the project is human resource constraints (Key personnel include project managers, project demand analysts, profile designers, interface designers, programmers). In addition to human resources, computer equipment is the most basic equipment in the construction process of the project, assuming that the equipment is fully provided. For most software projects, "human" is the most critical resource and a potential resource bottleneck through resource constraint analysis. However, other physical materials are consumed in small quantities during project development. In other words, the buffer does not require a lot of space. So this assumption is consistent with the actual situation of most website construction projects. Therefore, in this case, the technical staff of the project is mainly considered as the main resource constraint of the project. Resource conflict jobs are data processing, and the rest of the jobs are only represented by letters. The task decomposition and estimation time of the project are shown in the table.

Table1 Activity decomposition table

Process number	Process name	Estimated construction period
A	Module 1 design	18
B	Module 2 design	18
C	Module 3 design	18
D	Module 4 design	18
E	Module 1 coding and testing	16
F	Module 2 coding and testing	16
G	Module 3 coding and testing	16
H	Module 4 coding and testing	16
I	Code integration	12
J	Integration testing	14
K	Package release	20

5.2 Application of traditional technology

After the process time is estimated, the network planning technique is applied. The currently used network planning technologies are CPM (critical path method) and PERT (Program evaluation and review techniques). The critical path method is to search for the critical path of the project through

network technology, give priority to the resources on the critical path, and try to compress the time required. The program evaluation and review techniques focuses on the evaluation and review of each process and controls the offset. Establish a network map based on traditional technology .As shown in figure 2,obviously its critical path CP is $1 \rightarrow 4 \rightarrow 6 \rightarrow 7 \rightarrow 8 \rightarrow 9$ and the project cycle is 80 days.

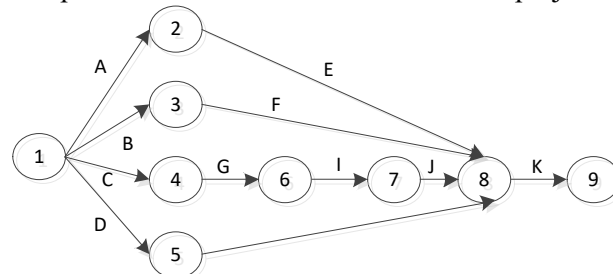


Figure 2 example network chart

5.3 Application of software project critical chain schedule model

In the case, the traditional plan ignores the impact of resource conflicts and allows the influence of uncertain factors. To this end, it must be improved with critical chain technology. Introduce transport buffer FB and project buffer PB. Based on the qualitative analysis of project schedule management and the discussion of the buffer quantification section, the size of FB and PB can be approximated as half of the sum of the transport time and the operating time of the critical chain. The network chart and diagram for eliminating resource buffering and introducing buffers are shown in Figure 3.

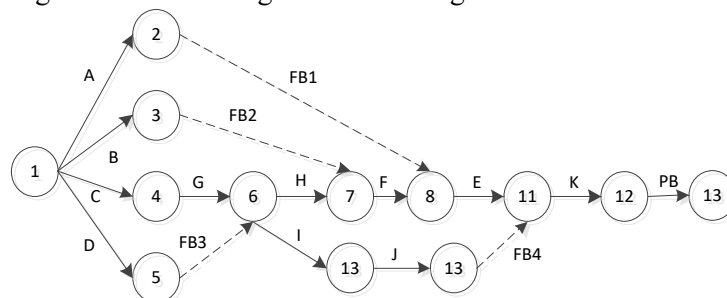


Figure3 critical chain network chart

The figure shows:: FB1=FB2=FB3=4.5(days), FB4=6.5(days)

The critical chain is: $1 \rightarrow 4 \rightarrow 6 \rightarrow 7 \rightarrow 8 \rightarrow 11 \rightarrow 12 \rightarrow 13$; the project cycle is $9+8+8+8+8+10+21.5=76.5$ (days)

In the actual operation of the project, if effective control is implemented, the actual project cycle will be less than 76.5 days. However the cycle planned by traditional technology is 80 days. According to this plan, the actual cycle will be much longer than 80 days. Because it ignores the impact of multi-task resources and indulges the negative effects of uncertainties.

6. Conclusion

(1) There are many problems with the software project schedule. The main reasons for the delay in IT schedules are the lack of implementation plans, the impact of ignoring technological advances, resource constraints, and the impact of student syndrome.

(2) In theory, this method can overcome the lack of flexibility, passive management, the inability to solve problems caused by the uncertainty of environmental changes to the project comprehensively and effectively in traditional methods, and it can effectively address the impact of resource conflicts, "student syndrome" and other factors to ensure that the project is completed as planned.

(3) As a new thought and method, there are some immature places in the software project critical chain schedule model, which requires further research. For instance, this method is only applicable to the case of a single resource constraint. For a variety of resource-constrained projects, there is still a lack of research on how to construct a critical chain. Second, the estimation of the buffer size is too

simplistic, and it is difficult to meet the needs of project management in a complex environment. Therefore, these require further research and exploration.

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