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Research Article

A Novel Rescheduling Model for Agricultural Food Products Management in Cross-Border Electronic Commerce

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Abstract: This study aims to investigate the rescheduling model for agricultural food products management in cross-border electronic commerce using logistic chain theory. Agricultural products chain scheduling in cross-border electronic commerce manages and controls the project progress through critical chain identification and buffer insertion but suffers from left-extension problem. To solve this issue, a new rescheduling model for agricultural food products management in cross-border electronic commerce using logistic chain theory is proposed in this study. In the new rescheduling model, the critical logistic chain was adopted to reschedule the plan with left-extension. Then the influence factors in the chain were analyzed to evaluate their effects on the left-extension. By doings so, a reasonable rescheduling model was established for managing the agricultural products critical chain. Numerical validation has been carried out in this study to examine the performance of the proposed rescheduling model. The analysis results indicate that the proposed rescheduling model could solve the left-extension problem in the agricultural products critical chain and hence is useful for practical application in cross-border electronic commerce.

Keywords: Agricultural food, cross-border electronic commerce, logistic chain, rescheduling

INTRODUCTION

In recent years, Critical Chain Project Management (CCPM) attracts extensive attention in agricultural food products in cross-border electronic commerce. The fundamental principles of CCPM are to use critical chain instead of traditional Critical Path (CP) and insert project buffer at the end of project (Goldratt, 1997). Research of CCPM used to focus on the two aspects of critical chain identification and buffer size setting. The critical chain is defined as the longest chain of precedence and resource dependent activities that determines the overall duration of a project. Efficient algorithms are needed to find the critical chain in large-scale, complex precedence and high resource constrains projects. Mendes *et al*. (2009) designed a priority-based genetic algorithm for the identification of critical chain with the random number coding. Rabbani *et al*. (2007) set up a model to recognize the critical chain in project under uncertainty and the objective function is minimizing the expected project duration and variance. Tian and Cui (2009) determined the project critical chain with a dynamic programming heuristic algorithm. Cheng and Wu (2006) developed a kind of project scheduling model with an appointment time window constraints and designs a heuristic combined with branch and bound method to identify critical chain in this type of project model.

After the identification of critical chain, project buffer and feeding buffer are inserted into project network. Due to the complexity of the project network, insertion of feeding buffers often causes a variety of problems, such as precedence and resource re-confliction, which can be solved by rescheduling. However, after rescheduling some new problems arise. The non-critical chain may start earlier than critical chain (non-critical chain extension), or the critical chain may break down in some points. These problems lead to an unreasonable plan, in which due date is longer than critical chain.

So far, only a few literatures have been concerned about these problems. Herroelen and Leus (2001) indicated that after feeding buffer insertion, resources conflict may occur in some parts of the original baseline plan, resulting in the disable of buffers in warning and protection. Therefore, after feeding buffer insertion, the original baseline plan needs to be modified, but they haven' studied to show how to adjust. Peng and Wang (2010) regarded the feeding buffer as a new activity to reschedule project. Cui *et al*. (2010) used the branch and bound method for local and global rescheduling and result of experiment in the study shows the method is effective in solving re-confliction problem. However, little work has been done to address the non-critical chain extension and critical chain break problems after rescheduling the agricultural food products critical chain.

To solve the non-critical chain extension problem in agricultural food products critical chain project plan after feeding buffer insertion, a two stages heuristic algorithm is proposed in this study to obtain a reasonable critical chain plan. First, a simple project example is taken to illustrate the problems in feeding buffer insertion. Then the two-stage method is presented. In the first phase, three priority rules together with a dynamic programming are proposed for rescheduling to solve precedence and resource confliction. After rescheduling, projects with problems of non-critical chain extension and critical chain break are rescheduled again by a heuristic algorithm proposed in this second stage and the reasonable critical chain plan is obtained. Finally, the 110 Patterson projects are applied in an experiment to test the feasibility of the algorithm.

MATERIALS AND METHODS

Problem description: Feeding buffer insertion may lead to new conflictions, which is illustrated in Fig. 1 with a simple project. Boxes correspond with activities which share a same duration time illustrated by the width of boxes. Letters in the boxes represent resource types used by activity and numbers stand for the number of resources required. There are three chains in the project, including one critical chain and two non-critical chains. Assuming there are five units of resource C available, baseline schedule (a) in Fig. 1 is without precedence and resource confliction. While schedule (b) is formed by inserting feeding buffer with Cut and Paste Method (C&PM) (Goldratt, 1997), confliction of resource C appears among the activities in process in Δt.

To solve resource conflicts in Fig. 1 and 2 provides three rescheduling schemes to left shift activities with conflict of Resource C. Figure 2a shifts activity in critical chain left to eliminate conflict of resource C, but this approach causes gap between the activities in critical chain which means breaking of critical chain. Figure 2b shifts activity in non-critical chain 1 forward instead, yet a new problem arises: non-critical chain 1 starts earlier than critical chain, resulting in non-critical chain extension. Figure 2c shifts activity in non-critical chain 2 forward. This activity uses the least number of Resource C among the three conflicting activities and we can see that shift of the least resource using activity leads to less extension than Fig. 2b. In all, each of the three kinds of rescheduling can solve resource conflict, nevertheless new problems arise and more effort is needed to get appropriate critical chain schedule.

In summary, after feeding buffer insertion, resource conflict may be caused, which can be solved by rescheduling with new problems arising such as critical chain break or delay. Either of the two problems leads to longer project duration than critical chain, in counter to the basic theory that length of critical chain decides the project duration. Therefore, effective approach is needed for further solution of all the problems to obtain a reasonable critical chain plan.

Solution approaches: In this section, a two-stage approach is proposed to solve all the problems. In the first stage, three new priority rules for rescheduling are proposed with dynamic programming to solve confliction. In the second stage, a heuristic algorithm is designed to solve the consequent problem of critical chain break or delay after first stage's rescheduling.

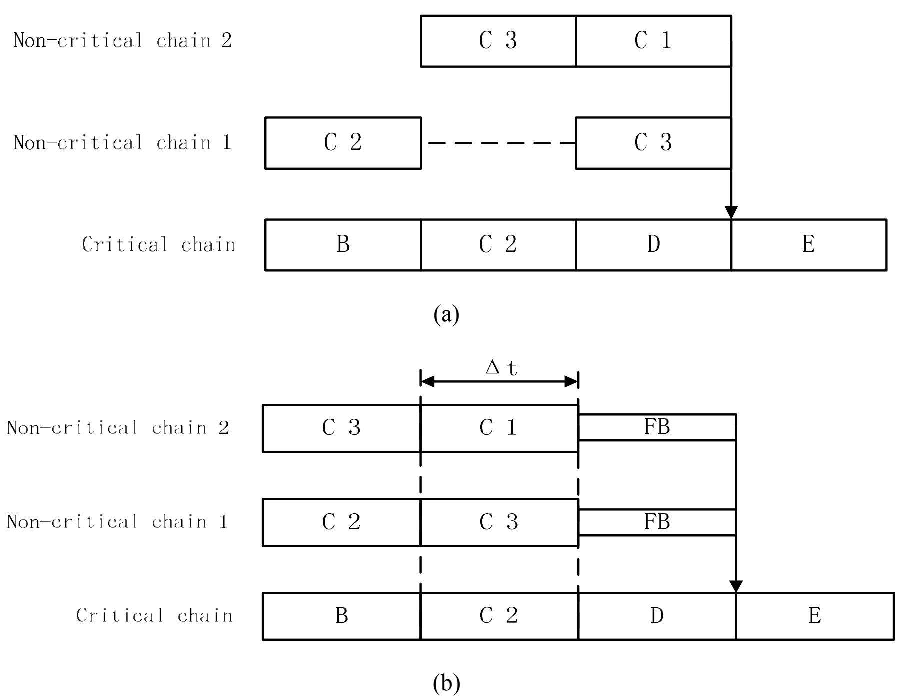

Fig. 1: (a) Baseline schedule, (b) Buffered schedule

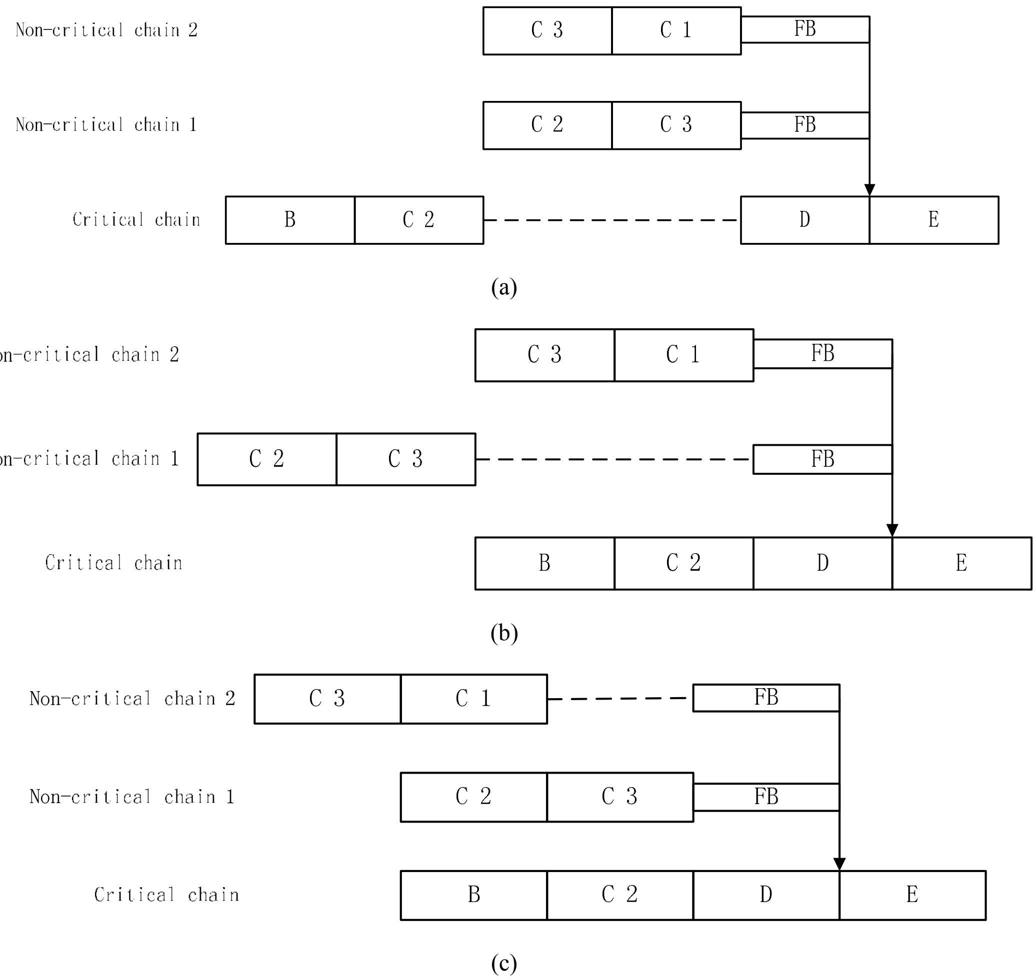

Fig. 2: (a) Left-shifting of critical chain activity, (b) Left-shifting of non-critical chain activity, (c) Left-shift of least resource using activity

The overall approaches are as shown in Fig. 3, where the whole process of the two-step rescheduling is as follows:

Step 1: Generate the baseline schedule by branch and bound, identify the critical chain and noncritical chain and insert buffers with C&PM.

Step 2: Rescheduling the buffered plan with the dynamic programming and priority rules introduced above, so the initial solution schedule S^0 is obtained.

Step 3: Check if there is any break or delay of critical chain in S^0. If yes, go to the next step, if no, heuristic ends.

Step 4: Generate neighborhood solutions from current solution S^0: for each non-zero feeding buffer, we decrease one time period and reschedule plan again. So at each iteration step, number of the neighborhood solutions obtained equals to number of non-zero feeding buffers.

Step 5: Sort neighborhood solutions by increasing of project duration. The first solution schedule serves as the input schedule for the next iteration step.

Step 6: Go to step 2.

RESULTS AND DISCUSSION

To verify the performance of the proposed method, simulation was carried out in the experimental test. The 90 projects of Patterson are applied to test if the heuristic algorithm can be common used. Their critical chain baseline plans are set up by branch and bound with the feeding buffer size. Each plan is rescheduled by dynamic programming and three priority rules into three plans separately in the first stage. Among the three, plan with the shortest duration and its corresponding priority rule are chosen. Data about critical chain break or delay about the selected plans is listed in Table 1. It can be seen that after first stage rescheduling, there are 81 projects showing break or

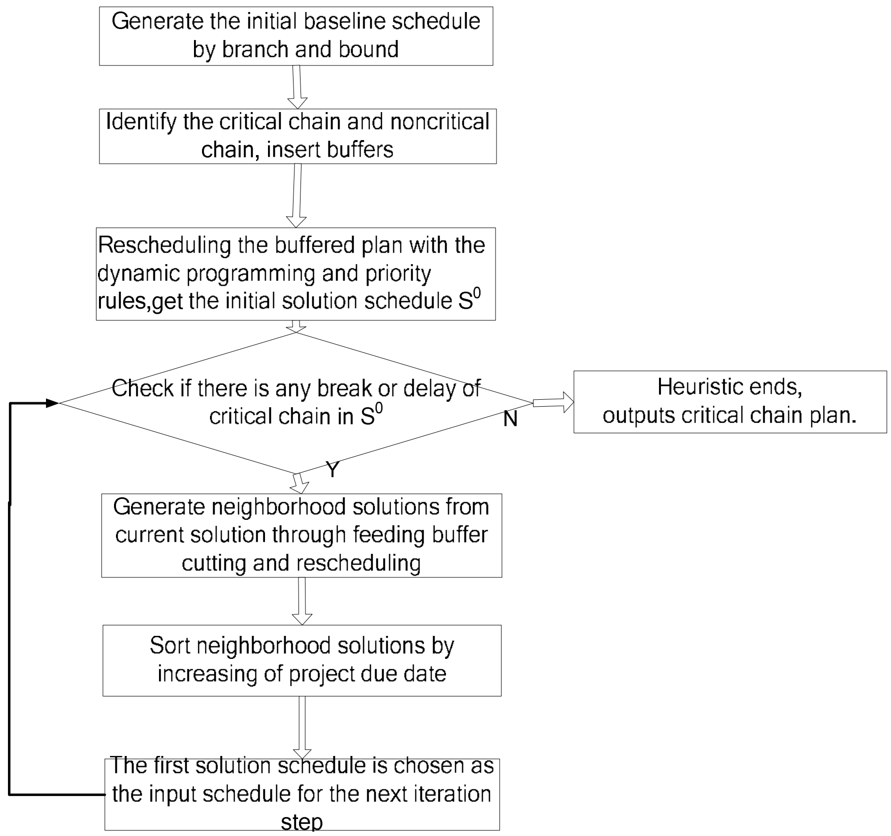

Fig. 3: The whole approach for rescheduling

Table 1: Use of three priority rules in 110 Patterson projects

Project extending	Rate of extension	Priority rule 1	Priority rule 2	Priority rule 3	Projects can be rescheduled again
81	22.5%	15	78	43	76

delay of critical chain, with the average project extension rate of 22.5%. The first priority rule is best adopted in 15 projects, the second priority rule is best adopted in 78 projects and the third one is best used in 43 projects. In addition, in some projects, more than one priority rules can be applied to get the same due date. Hence, the sum of three project numbers is larger than 90. Meanwhile, it can be seen in Table 1 that the rescheduling eliminates critical chain break and non-critical chain extension. As a result, the duration of project plan equals to length of critical chain. It can be expected reasonable and a completion performance in practical execution. By rescheduling using the proposed method, the number of projects could be extended to suitable value and the average rate could be increased in the project execution. Moreover, the average rate of reduced project completing time could be decreased.

Then, the 81 project plans with problems after first stage rescheduling are rescheduled again by second stage heuristic algorithm and 76 projects can be solved and transformed into more reasonable plans. As a result, it’s confirmed that the presented rescheduling algorithm can be available in most projects.

CONCLUSION

Traditional agricultural food products critical chain research focuses on critical chain identification and project buffer sizing and overlooks the problems of the non-critical chain and feeding buffer. Problems such as resource and precedence re-confliction, critical chain break or non-critical chain extension often emerges after feeding buffer insertion, which impact a lot on the feasibility of critical chain plan. In this study, a two-phase approach is proposed to solve these problems. The analysis results on two case studies have confirmed that the presented approach can solve rescheduling problems in most projects for agricultural food products management in cross-border electronic commerce. The findings of this study can provide theoretical support for practical usage for agricultural food products management in cross-border electronic commerce.

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