Multi-project sequencing in the retail sector

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Abstract. In the age of digitalization, the importance of automating internal business processes is increasing. A parallel event is the increase number of projects and their complexity.
Mathematical methods from the field of operation research can be used to determine the optimal sequencing in order to minimize the loss of benefit. And consequently, the optimal sequencing of the projects is sought, which maximizes the overall contribution margin.
The sequencing of the projects determines the total contribution to margin after the project is complete. Therefore, sequencing is of great importance for the company. Sequencing is currently performed manually but due to the number and complexity of the projects optimal solutions can no longer be guaranteed using manual sequencing. As a result, the company suffers a loss of benefit. The loss of added value is the difference between the maximum achievable total contribution margin and the actual total contribution margin achieved.

Keywords: Multi-project, Sequencing, Optimization.

1 The planning and problems of sequencing multi-projects A Subsection Sample

1.1. Sequencing requirements

A prerequisite for successful business management is planning. Complex relation-ships are systematically worked through and summarized. This summary contains in-formation about the consequences and effects of a decision. It is important to design this planning holistically. Underlying this should be thought processes and coordination. An important aspect in planning is the database. Good planning requires important information. The quality of the information has an influence on the deviation of the target from the actual state [1]. Only when the data has been collected post project can it be determined whether the problem was solved in the planned manner. The required data may be insufficient.
The planning of projects can be summarized in the form of a business case. The business case is the profitability analysis for the execution of the project [2]. This contains target information, action alternatives and economic consequence [3].
First, the foundations for a project are in detail. These include a project description with an economic goal. The benefit and the expected total costs should be easily calculable. By comparing the key figures, the company can make a decision. In addition to decision-making, a business case is used for investment planning. In a business case, not only financial aspects are considered. The risks and in particular the strategic economic basis of the enterprise is an important factor for decision-making [4].
In multi-project planning, it is decided which projects will be implemented in the specified time. The business cases support the decision making process. Projects are assigned priorities. On this basis, the company processes the projects. Through the implementation of the projects, the company expects a contribution margin as a benefit.
In order to minimize the loss of benefit and to determine the optimal sequencing, mathematical methods from the field of operation research can be used as a basis. Consequently, the optimal sequencing of the projects is sought, which maximizes the overall contribution to margin.

1.2. Definition of a Job

A project is a realization of a goal-oriented and time-limited undertaking. Project teams implement projects. Projects consist of several partial work steps, which can be carried out by several departments. As the result of a realized project, the company expects both economic and other benefits.

There may be projects that cost more money than they bring in. These projects could be triggered externally. An example would be the enactment of new laws by of the state. These projects are unavoidable for the company and must be implemented within the specified period. In addition to external influences, projects can be triggered internally, e.g. by changing system processes or software [5].

1.3. Controlling and adopting the characteristics of projects for sequencing

Planning itself is not enough. In order to ensure that the actual values correspond to the forecast values, activities must be monitored and controlled [6].
In project control, projects are evaluated using their parameters. The evaluation checks whether the project goals can be achieved. Typical evaluations are plan/actual comparisons. The evaluations must be monitored and evaluated at regular intervals. In order to detect deviations at an early stage and to initiate countermeasures, the observation times must be as small as possible. On the other hand, this leads to a greater control effort [7]. The observation times can take the form of milestones and strategic monitoring. Thus, standardization procedures can be implemented within the company [8].
The early detection of these risks enables control measures to be taken. The purpose of the control system is to minimize or eliminate the deviation from the planned project. If the deviation is too large, the countermeasure results in a new planning of the project. A new planning can also have other reasons. For example, it may be due to limited resources. Early recording and analysis of plan deviations shows the deviating development [9].
On this basis, the countermeasures are specified in concrete terms. Deviations cannot be avoided. The plan and the target comparison lead to new experiences. The experience can be used for future planning in the form of better forecasts. It becomes apparent that the business case is often based on very favorable assumptions and estimates. Only the control leads to the objectification of the imaginary profiles. The control goals are determined by the monitoring and review of the results.
Control activities must not be limited to the duration of the project. Checks must also be carried out after the project has been completed for a specific period. Under this prerequisite, the company can recognize concretely how the planned benefit will be achieved.
A plan/actual comparison can be carried out using a report. The variances can be recorded, analyzed and justified. The planned/actual comparison compares the planned values (target) with the actual values (actual). If variances exists, the causes of the variance are investigated. Only by providing information about the cause of the variance can you take corrective action [10].
Deviations are recorded by three variables:

- Planned size: The planned value estimated in the profitability analysis. It is the planning basis for project approval.
- Target size: Calculated by adjusting the planned value based on current facts.
- Actual size: The actual value [11].

Elementary decisions are made in order to achieve the project goals. The decisions are made based on the deviation analysis. If there are deviations in the negative area, the reasons must be clarified. Once the cause has been localized, countermeasures can be taken. This can take the form of countermeasures. If the control recognizes that the project goals are not reached, then the countermeasure can be undertaken for the reaching of the project goals [12].
In summary, controlling can contribute to achieving the project goals and thus also the benefits of the project. For the application of mathematical optimization methods for sequencing, however, it must be assumed that the project goals and thus the calculated contribution margins are achieved.

1.4. The state of the art in research for sequence problems

Multi-project planning also includes determining the optimal sequence in which the projects are to be implemented. In today's literature there are two problems in the field of operation research that deal with sequence problems. All two problems show a certain similarity to the multi-project sequence planning problem. These are the flow shop problem and the job shop problem.
The Flow Shop problem deals with the problem of the sequence of machine utilization. The machine sequence is defined from the beginning. The jobs to be processed are divided into partial processing steps TBi with i = (1, 2, …). Each TB is processed by a specified machine. In the problem definition there can be up to m machines and j jobs [13].

Fig. 1. Simple Flow Shop Problem with m machines [14]

Generally speaking, the flow shop problem is more complicated than illustrated in Figure 1. The jobs can have less than m operations. Thus the jobs do not run through all machines. At the start time t = 0, there are n independent jobs with m operations each. The sequence of the jobs is known and has no preparation times for processing or is included in the processing time of the job. All machines are available at any time and no processes are aborted [15].

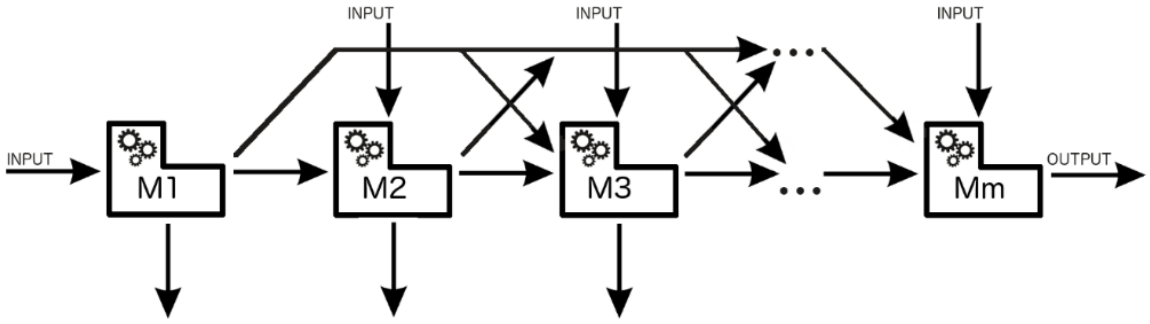

Fig. 2. General Flow Shop Problem with m machines [16]

A job shop problem exists where all work steps for each machine are not necessarily identical. Time-limited resources are allocated to process schedules. Sequences are defined for the individual order instances. This means when and on which production machine a work step takes place. [17].

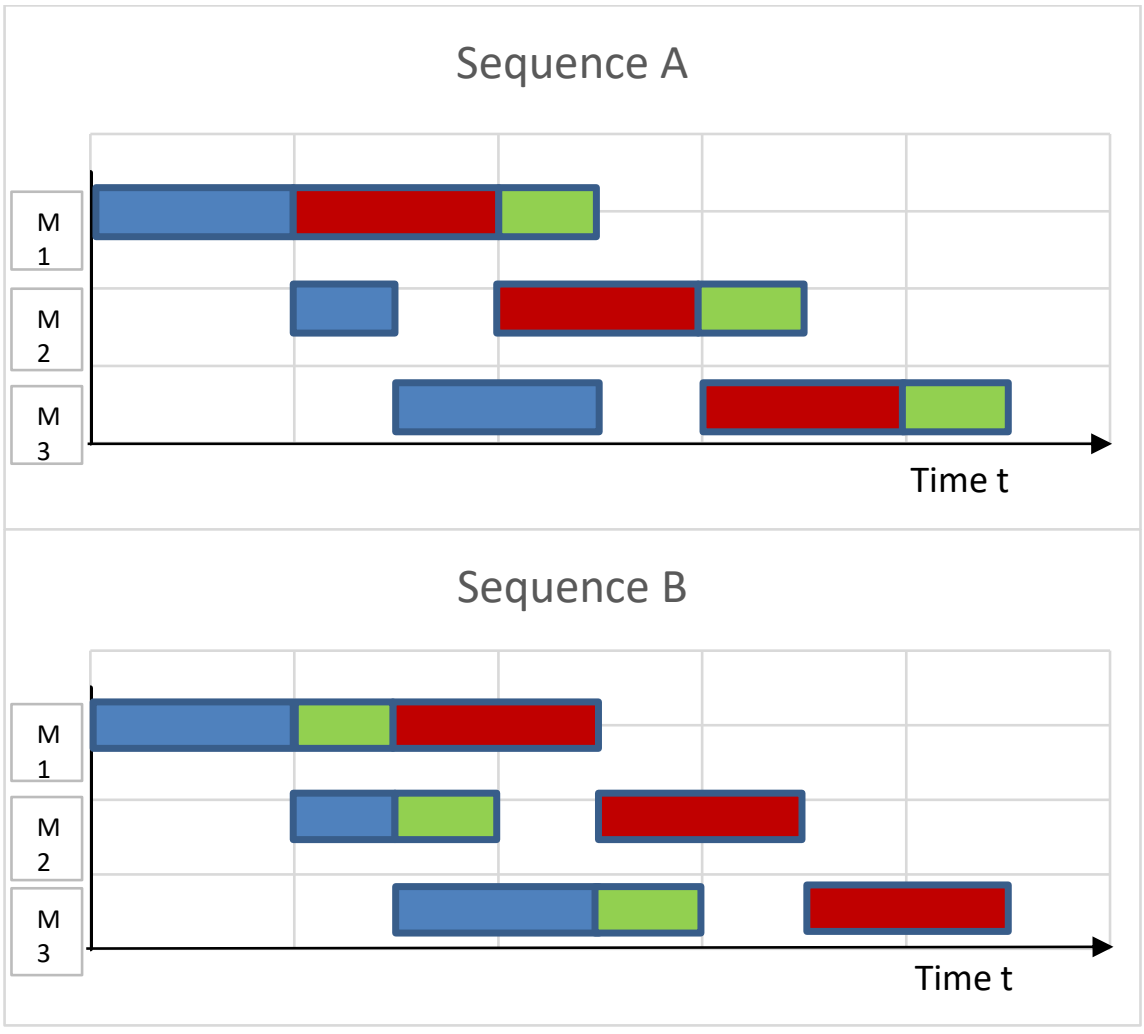

Fig. 3. Example for Sequencing of three projects and three machines

2 Further Research

The multi-project sequencing problem, on the other hand, differs in several respects from the problems presented. A major difference is the question whether existing projects should be implemented. This condition results in a nonlinear constraint. Thus, the multi-project sequence planning problem is a non-linear optimization problem (NLP for short). The constraints are linearized by the use of auxiliary variables. Thus the NLP becomes a linear problem (short LP). There are p projects in the problem definition. Only n projects can be implemented in the given time T, $(n \leq p)$. Thus a prioritization of the projects takes place. The difference of the multi-project sequence planning problem leads to the fact that no research in this direction can be found. The problem is initially defined and solved as an LP problem. Algebraic modeling languages (software like GAMS) are used for the solution. Furthermore, the solvers SIMPLEX and GUROBI have to be compared. Further contents will be clarified during the research. The research leads to the first solution for the existing problem.

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