AN AUTOMATED MODEL FOR GENERATING A SHORT-INTERVAL SCHEDULE

Generating a short-interval schedule

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Abstract

Many problems occur on the construction site during the execution of the project. Some of these problems are due to a lack of detailed planning and scheduling. Although Short-Interval Scheduling (SIS) has proven to be a useful technique in managing the day-to-day work at the construction site, this technique is not extensively used. One of the reasons for this is the time consumed in the development of these schedules. This paper discusses the benefits of Short-Interval Schedules. Current manual SIS formats are presented. The paper introduces an automated model that will allow for the generation of Short-Interval Schedules.

Keywords: Construction, project, developing, schedule, goals, format

1 Introduction

Construction Scheduling is a major tool for the management of projects. Over the past decades, it has served as a fundamental basis for monitoring and controlling project activities. Although the use of this tool has enhanced the performance of the construction team and has helped them in executing projects more efficiently, studies have proven that a considerable amount of the eight-hour day is non-productive time, especially due to “waiting” time [Adrian]. This “waiting” time is characterized by events such as a laborer waiting for materials or equipment, a worker waiting for the help of another worker, a subcontractor waiting for the general contractor or vice-versa, and so on. The majority, if not all, of the non-productive time related to “waiting” can be traced to a lack of detailed planning and scheduling [Adrian].

During the implementation of the project, personnel involved in the actual execution of the work need a breakdown of the scheduled activities into more detailed tasks or work items with information on daily quantities and resources required. This allows for planning and managing the day-to-day work at the construction site more effectively. It also helps the project team to eliminate, or at least reduce, the non-productive time related to waiting, and to remain on schedule.

Normally, the main construction schedule does not contain sufficient detail to represent tasks on a daily basis. Due to the nature and long time periods needed for implementing construction projects, the scheduler has a limitation of details when developing the project network in order to keep the schedule practical to use. The scheduler then implements the main schedule with a certain level of detail depending on the complexity of the project and the intended user of the schedule. The average duration of any activity presented in the main schedule usually varies from 5 to 15 days, and sometimes double these figures. Including more activities at a higher level of detail and shorter duration may result in a more complicated schedule that is impractical to maintain. In addition, the construction project environment is inherently dynamic. It is impractical, if not impossible, to predict all aspects of the project prior to starting construction, and inevitably things do not always go as planned. With a large number of activities and subactivities implemented in the main construction schedule, it becomes tedious and time consuming to update the schedule whenever changes occur.

Developing SIS from the main schedule is advantageous to planning and managing the day-to-day work more effectively. Abstract information represented in the main schedule needs to be extracted. This information can then be expanded and used to reschedule, in detail, the daily/weekly tasks in order to meet the project team's short-term goals and objectives. The SIS won't substitute for the main schedule, but rather, it will be its compliment. The SIS has several advantages. It helps to increase the productivity by eliminating, or at least reducing, the non-productive time related to "waiting". Having the resources and materials ready on site, whenever needed, is one of the main benefits of SIS. It also instills in both workers and superintendents an immediate sense of urgency to get the job done. The effect is psychological and occurs because SIS establishes obtainable goals on a short-range basis. The short-range aspect is what makes the goal attractive and challenging.

The concept of SIS is not new. It was developed in the 1930s as a management technique to control the output of workers in manufacturing. It was known as a method for assigning a planned quantity of work to be completed by a specific time, and as a means to determining whether the quantity of work has been completed within the specified time limit [Kerzner, 1989]. Then it was introduced to the construction industry. It is explicitly recognized by several scheduling methodologies that have been available for many years and have been called by a number of names, such as: Short-Interval scheduling [Behan, 1966; Smith, 1968]; Short-term goal setting [Hadavi and Krizek, 1993], Shielding Production [Ballard and Howell, 1997].

Several experiments and research efforts have proven the necessity and impact of applying SIS on construction projects. They have concluded that short-term goals resulted in higher productivity than long-term goals [Hadavi and Krizek, 1993], and that, for construction crews, the largest categories of reasons for failure are missing materials and failure to complete prerequisite work [Ballard and Howell, 1997]. In addition, several case studies have also reflected the benefits of using SIS [AGC, 1994].

However, Short-Interval schedules have usually been implemented for only a limited part of the project. This is due to the time consumed in the development of these schedules, as well as the difficulty of updating them whenever changes occur. In addition, manual goals set by the foreman could sometimes be too easy to achieve, because he does not want to commit himself to difficult goals [Hadavi and Krizek, 93]. Thus, an automated model that uses information predetermined by the management can assure the quality of assignments given to the crew.

The next section presents an overview of current manual formats used in the management of construction projects. The following section presents an automated model that allow for the generation of SIS to assist the project team in managing and controlling day-to-day work. The model utilizes construction assemblies/components database to intelligently develop the Short-Interval Schedules.

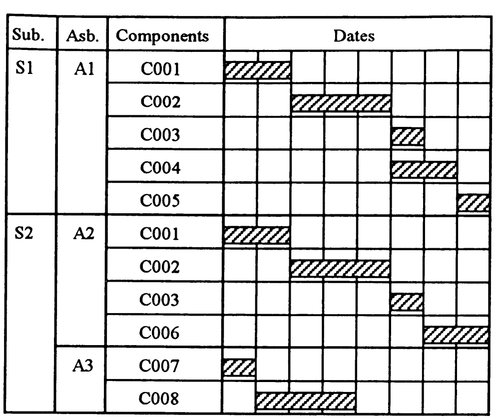
2 Current SIS formats

Depending on the quantity of work included in the activity, the process of developing a detailed schedule begins with breaking down the activities from the main schedule into subactivities that have smaller quantities, and/or assemblies. Then each assembly is divided into more finite details with components or work tasks.

- *Subactivities*: Depending on the quantity of the work contained in the activity in the main schedule, activities could be divided into several sections according to geographic location in the project. In this case, a portion of an activity called a subactivity represents each section. For example, a 10,000 ft^2 concrete slab could be divided into four sections of 2,500 ft^2 each.
- *Assemblies:* An assembly is the functional element of the building. It is a grouping of several building components. Each assembly has its own specifications. Activities and subactivities constitute one or more assembly. For example, a "construct footings" activity, or a "construct footings – Area A" subactivity, could be divided into two assemblies: "spread footings" and "strip
- *Components or work tasks*: A component is the fundamental unit of work in a project. It has a concise description of the work to be performed. For example, a "Cast-in-place beam and slab, two-way" assembly includes the following components: "forms in place, flat plate", "forms in place, exterior spandrel", "forms in place, interior beam", "reinforcing in place", "place and vibrate concrete", "finish floor", and "cure".

Their exist several formats to present detailed scheduling. Each format has its advantages and disadvantages. The different formats are:

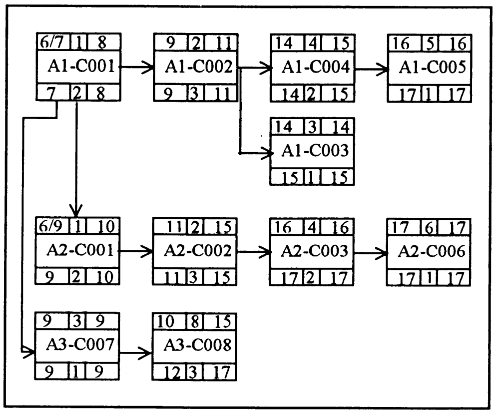
- *Bar Chart schedule* (Figure 1a) is developed in exactly the same way a main project Bar Chart is developed, thus has the same advantages and disadvantages. It is easy to implement, but does not represent the relation between the components.
- *Date List* (Figure 1b) is a list of start and finish dates given to each component. It presents exactly the same information as the Bar Chart, although not as clearly,
- *Network schedule* (Figure 1c) is developed in exactly the same way a main project network is developed. It is a very complicated and time-consuming tool to be used in detailed scheduling, especially with the great number of components activities can be broken down to. If an activity has 6 components that have to be done in four places. The result will be a network of 24 components just to breakdown one activity.
- *Matrix schedule* (Figure 1d) is a table where columns represent dates, rows represent subactivities, and cells represent different components. Each table usually displays one activity. This format is most effective when the activity being scheduled need to be broken down into subactivities, then into components. However, it is difficult to understand the logic behind this format if you are not its developer.
- *Graphic schedule* (Figure 1e) a graph that represents subactivities in their real geographical location in the project. Each subactivity contains its components. The logic between the subactivities is presented by arrows. The graph contains the same information as that contained in the Bar Chart and the Date List.
- *Short-Interval Scheduling form* (Figure 1f) is a table that represents the components to be performed for a specific duration, as well as the quantity and the resource needed for each component. The advantage of this form is that it contains more information than any other format. Although, it does not contain the logic between the components.



(a) Bar chart schedule

Sub.	Asb.	Components	Duration	Start	Finish
S1	A1	C001	2	6/7/99	6/8/99
		C002	3	6/9/99	6/11/99
		C003	1	6/14/99	6/14/99
		C004	2	6/14/99	6/15/99
		C005	1	6/16/99	6/16/99
S2	A2	C001	2	6/9/99	6/10/99
		C002	3	6/11/99	6/15/99
		C003	1	6/16/99	6/16/99
		C006	2	6/17/99	6/18/99
	A3	C007	1	6/9/99	6/9/99
		C008	3	6/10/99	6/15/99

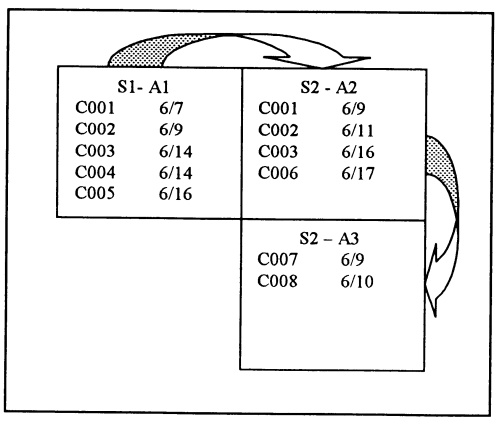
(b) Date list



(c) Network schedule

Sub		Dates										
S1	A1		C1	C1	C2	C2	C2	C4	C4	C5		
								C3				
S2	A2		C1	C1	C2	C2	C2	C3	C6	C6		
	A3		C7	C8	C8	C8						

(d) Matrix schedule



(e) Graphic schedule

S/A	Comp	Date	Quantity	Manpower	Equipment	Material
S1/A1	C001	6/7	2.56 c.f.	****	****	****
S1/A1	C002	6/9	5.11 c.f.	****	****	****
S1/A1	C003	6/14	1.5 s.f.	****	****	****
S1/A1	C004	6/14	6.74 c.f.	****	****	****
S1/A1	C005	6/16	7.21 c.f.	****	****	****
S2/A2	C001	6/9	2.56 c.f.	****	****	****
S2/A2	C002	6/11	5.11 c.f.	****	****	****
S2/A2	C003	6/16	1.5 s.f.	****	****	****
S2/A2	C006	6/17	9.82 c.f.	****	****	****
S2/A3	C007	6/9	2.61 c.f.	****	****	****
S2/A3	C008	6/10	4.43 c.f.	****	****	****

(f) Short-Interval scheduling form

Fig. 1: SIS formats

3 The proposed model

The proposed model will allow for the generation of a Short-Interval Schedule to help in more effectively planning and managing the day-to-day work at the construction site. Its main objective is to facilitate the development and the updating of these schedules. A proposed model for generating SIS from main schedules is depicted in Figure 2.

Based on project specific information, activities in the main schedule are broken down into subactivities and/or assemblies. This process may be accomplished manually through user input or automatically through intelligent interpretation of construction knowledge about activities, assemblies, and work items (components).

An assembly database for the model will be defined and will constitute various generic construction assemblies and needed construction information. A component database will also be defined and will contain information on construction work items. Information such as crew description and daily output will be stored in the components database.

Each activity/subactivity will be associated with one or more assembly. Each assembly will comprise of one or more component. A component code allows identifying the different components that constitute each assembly and their corresponding production information. Durations and percentage contribution of each component toward execution of each assembly will be calculated, and a mini-schedule of the assembly is generated.

The model output should include a set of mini-schedules for assemblies considered as shown in Figure 2.

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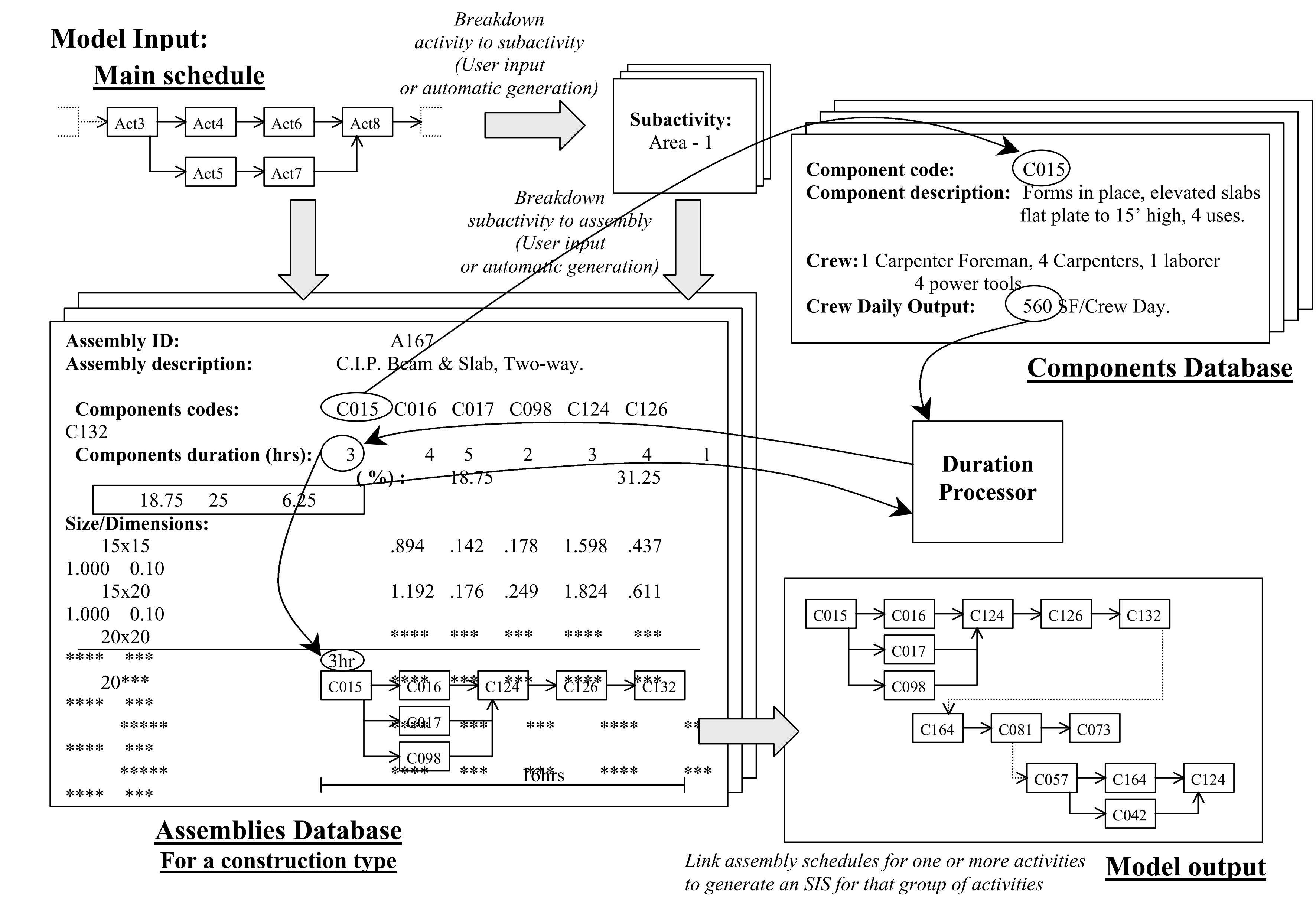

Fig. 2: The proposed model's diagram