A COMPUTER PROGRAM FOR GENERATING AND MANAGING SCHEDULES FOR CONSTRUCTION PROJECTS

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ABSTRACT

A computer program, ATOP, for generating and managing construction schedules is presented. The program includes tools for interactive project breakdown into locations. The activities needed to accomplish each location are definied using an activity type library which also forms a knowledge source for initial schedule calculation. The initial schedule can be analyzed and improved with the aid of tools provided by the program.

1. Introduction

Nowadays computer-based scheduling is an important project planning tool. Typically, these tools include a networking technique as a basic data representation format in order to provide functions to calculate total project time and activity times. Usually the technique used is precedence diagramming technique (Willis 1986) or modifications thereof.

An important feature of these tools is that they are a useful aid to preparing project networks. As reported by a number of researchers, for example (Bennett and Ormerod 1984) and (Allam 1988), practitioners consider project networks an overly complex means of planning. This problem is partially solved by some recent computer programs. From the computer program user's point of view, these aids provide a practical interface to networks i.e. a high level abstraction behind which the complexity of actual project networks is hidden.

At the same time as clear improvements have occurred in the development of scheduling tools, some researchers have directed their work towards the automatic generation of schedules. The work has focused on planning procedures requiring considerable personal skill and expertise; examples of such procedures are the determination of work breakdown structures; determination of dependencies between site activities; resource selection and site activity duration estimation. Commercially available planning and scheduling tools provide little assistance for accomplishing these procedures. Furthermore, it seems that methods of defining how to plan represent an area of basic research need as only scant attention has been paid to analyzing processes according to how one plans or should plan. These views concur with the finding that the current planning tools, especially software packages require an existing plan as input rather than assist in a plan preparation process. Examples of computer programs to generate construction project plans and schedules are :

- CONSTRUCTION PLANEX (Zozaya-Gorostiza et al. 1989) and OARPLAN (Darwiche et al. 1989) which generate schedules from a description of building components.
- TIME (Gray 1987), MIRCI (Alshawi 1989) and ELSIE (Brandon et al. 1988) which generate schedules from a general description of a project.
- PLATFORM II which generate schedules based on both activity types selected from a library and further information added interactively to the plan by user (Levitt et al. 1987).

MIRCI and the recent re-implementation of CONSTRUCTION PLANEX provide facilities to transfer generated schedules to commercial scheduling software packages for final planning.

R&D efforts aimed at the automatic generation of project schedules have shown that it is possible to broaden computer programs to cover also planning procedures which draw on personal skill and expertise. This can improve the efficiency of the planning process and the quality of plans.

Most R&D efforts related to the automatic generation of project schedules have focused merely on the schedule generation process. Therefore only little attention has been paid on aids to analyzing and improving schedule proposals. The objective of this paper is to present an effort approaching a computer program which generates automatically an initial schedule and provides an aid to analyzing and to improving it. The development approach is presented by describing a prototype computer program.

2. ATOP - computer program

ATOP (Approach TO construction Project scheduling) is a computer program for generating and managing construction project schedules. ATOP starts by defining a breakdown of locations. After that, one identifies the activities needed to accomplish each defined location. The identification process is assisted by the activity type library from which one selects activity types and assigns corresponding activities to a particular location of a project. Next, the program generates an initial schedule on the basis of optional activity information obtained from the activity type library. Finally, one can analyze and improve the schedule by the use of special tools provided within the system.

It was felt that hierarchical object-oriented data models of project activities and activity dependencies provide a sound basis for a scheduling tool which can be easily embedded into a practical schedule preparation process. This can be achieved by defining hierarchical (or network form) data structures in which various levels, nodes and links correspond to the schedule preparation process. The emphasis on modelling activity dependencies (covering all constraints having an effect on activity start, finish or performance) was also important; for a more detailed presentation refer to Kähkönen and Atkin 1990. It was felt that object-oriented data models of activity dependencies could offer distinct possibilities:

1. the ability to document the type of activity dependency or its priority;
2. generating selective reports about activity dependencies of a particular project; and
3. investigating alternative sequences of activities.

ATOP runs on a Macintosh II microcomputer. The development environment consists of an expert system shell, NEXPERT and SuperCard, a tool for building the user interface. Another version is being implemented on a IBM-compatible microcomputer in parallel.

3. The project breakdown phase

3.1 Generally

In order to make the planning of a building project and the monitoring of its progress easier, it is advisable to break down the project into sufficiently small parts or: activities, and also to consider activity dependencies. In practice, the project is often broken down into production units.

Generally, project management literature uses the term breakdown in the sense of a hierarchical division where each part of the project belongs to one of the top level categories. The highest hierarchical level is the project and the lowest is usually called a work package. Some presentations further divide work packages into tasks. Depending on the nature and field of the project, different intermediate levels are used for grouping purposes.

Usually the locations of components are incorporated into the breakdown hierarchy. Thus, element partition walls on the first and second floors are two different parts of the project since they have different locations. Correspondingly, the hierarchy diagram represents them as separate building components.

The first stage is to make the breakdown consistent with the accuracy requirements of the overall plan. As the project proceeds, the breakdown is adjusted accordingly. A clear-cut, uniform breakdown is needed for revising data.

In larger building construction projects, building/block/floor/room levels should be used as the hierachical levels of locations. At the level of overall planning, however, room breakdown is not necessary. A block is used to refer to a vertical section of a building that constitutes a separately implemented or suitable structural section, e.g. a wing. A space bounded by a block and a floor is called an area.

3.2 The work breakdown phase in ATOP

The application under work starts with the idea that the hierarchical breakdown consists of five levels:

PROJECT	- commercial building XXX, site YYY
SUBPROJECT	- interior work
BUILDING COMPONENT	- surface structures
ACTIVITY TYPE	- flooring work
ACTIVITY	- flooring work, 3rd floor

The breakdown of locations to be used is determined separately for each subproject and is used to define the activities. In this respect the system adheres to the object-oriented approach (Figure 1).

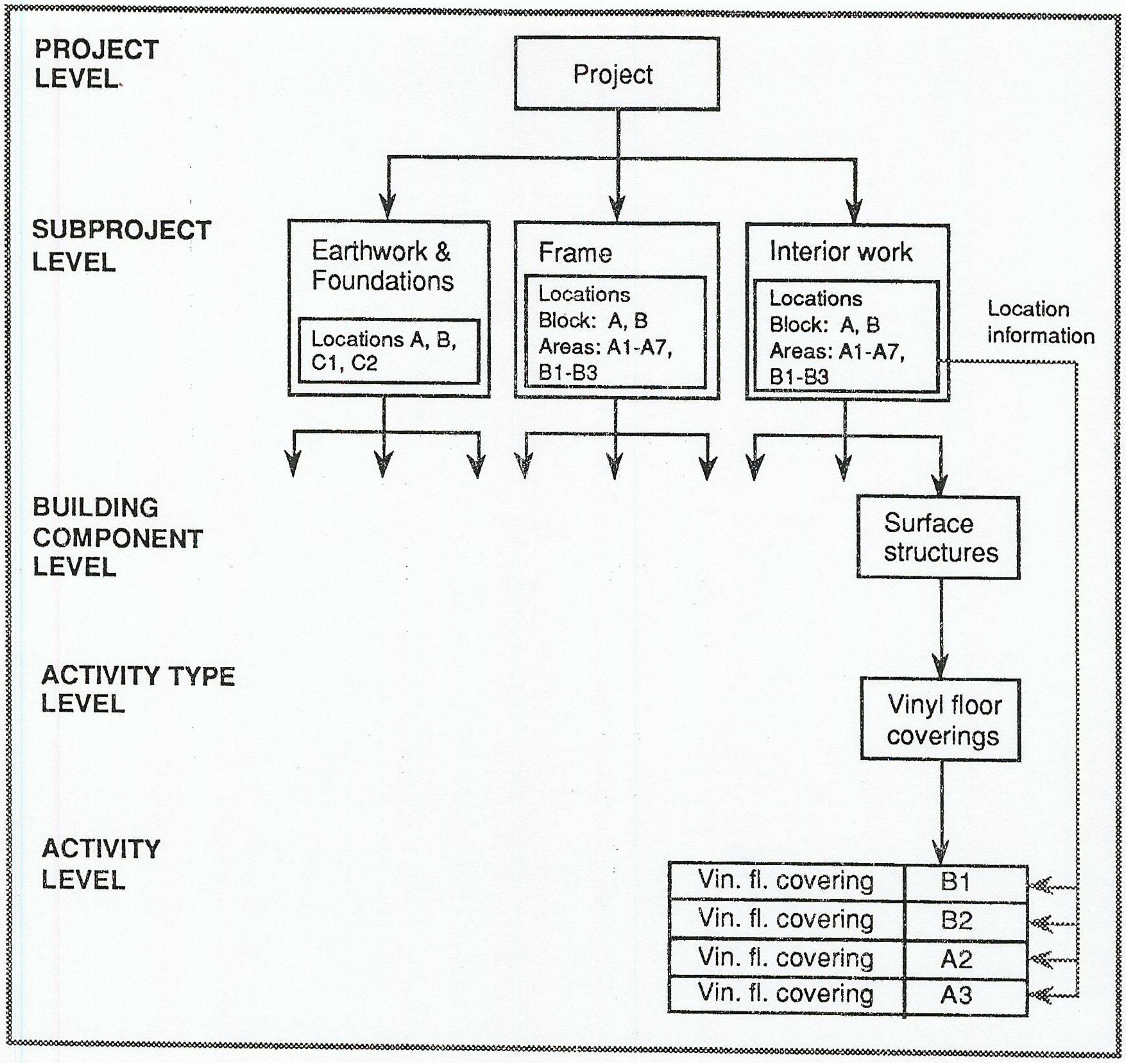

Figure 1 Various levels of the project breakdown model.

In practice, the breakdown of locations to be used is determined by the user who draws a graphic layout of the project on the computer display, i.e. a schematic representation, in which the target is divided into smaller units, blocks and areas (Figure 2).

The location diagram is one of the main means for accessing project plans; for instance, one can obtain activity lists for the desired areas and, in addition, one can define the sequence for accomplishing areas by pointing at them with the mouse driven cursor.

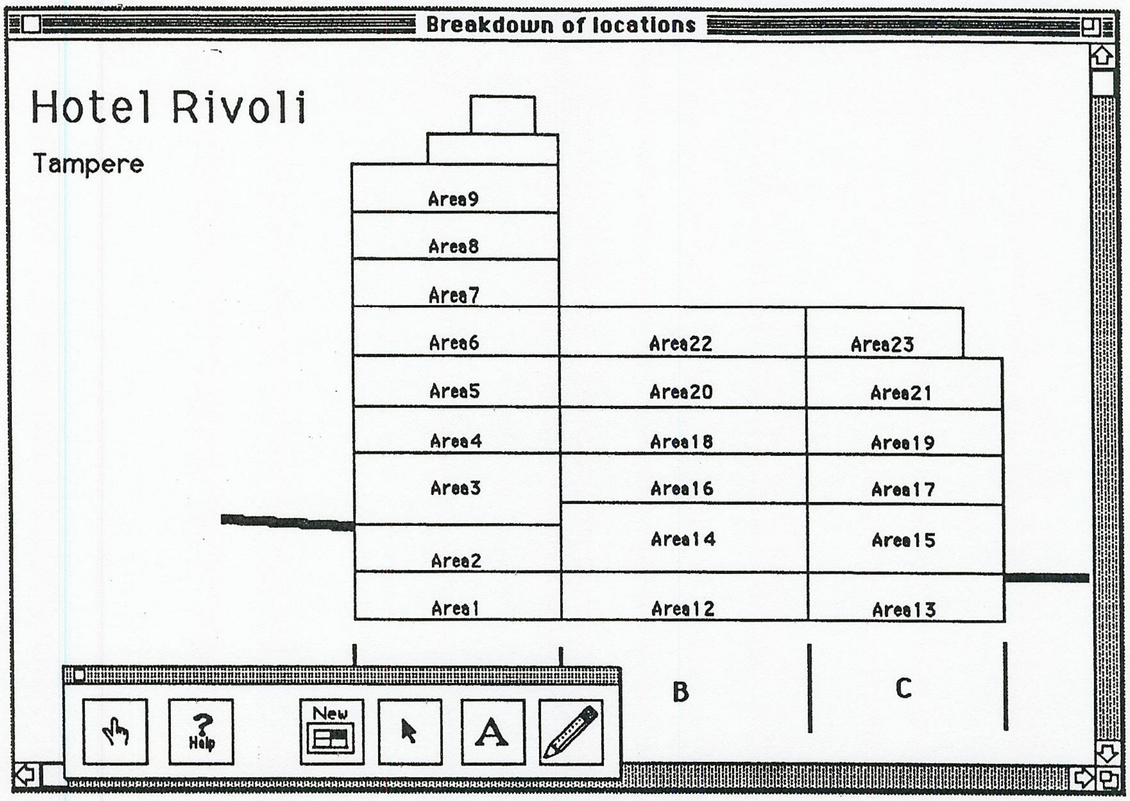

Figure 2 The breakdown of location is accomplished by preparing a graphic diagram which corresponds to a graphical layout of the project.

4. The activity assignment phase

4.1 Generally

In a pilot project designed to test the applicability of area-oriented planning, 22 areas were definied at the overall planning phase and the total number of activities to be planned was about 800. The pilot project made it clear that in order to be able to manage the large amount of information related to the activities, effective and user-friendly tools must be available.

4.2 The activity assignment phase in ATOP

As soon as the breakdown of locations used in the project have been input, the composition of activity lists can begin.

The basic material for composing activity lists consists of the activity type library from which the user can select the appropriate activity items for one area at a time. The activity type library has been arranged on the basis of building components, i.e. the activity types included are, in fact, building components. The library is hierarchical so as to facilitate browsing and access of various properties of activity types. When selecting activities from the library, only activities of the lower hierarchical levels can be chosen.

The activity type library is parameterised. The user specifies the activity type by setting the parameters on the basis of given alternatives such as:
Concrete wall cast on site
- shutterboard/shuttering/large form
- pump concreting/bucket concreting

When the activity type has been specified, the selected work crew, input of labour and activity dependencies can be displayed. Then the activity type can be copied to the project.

The activities are formed by defining the area where the activity type in question occurs. The actual planning deals with the activities - estimating their amount of work, sequence and activity dependencies. As noted earlier, the total number of activities becomes quite large. The activity information (work group, work accomplishment, etc.) is, however, defined for activity types - not for the activities at the lowest level of the breakdown (Figure 1). This reduces considerably the amount of data to be handled. The activities of different areas then inherit the data from the original activity types. This object-oriented data structure makes task management more effective and easier.

5. The generation, analysis and improvement phase

5.1 Generation of initial schedule

The ATOP computer program generates an initial schedule based on project descriptions defined by the user and further information is obtained from the activity type library. The definitions are

1. project name;
2. breakdown of locations;
3. activities assigned to each location;
4. activity type;
5. amount of work related to each task.

The definied activity type forms a link to the activity type library from which the system obtains the following optional information :

1. activity identification properties: code, name and measurement unit;
2. resources: materials, gang size and plant;
3. dependencies: typical dependencies to other activities; and
4. other activities needed; procurement, receipt of design information.

The information relevant to scheduling is organised in a project network model and therefore algorithms available for solving project networks can be used. The network model used in ATOP is the unified network model (Hendrickson and Zozaya-Gorostiza 1989).

5.2 Analysis and improvement of initial schedules

The hierarchical data structures of activities (Figure 1) and activity dependencies (Figure 3) form a basis for analysing schedules. The data structures establish a set of abstraction levels and properties related to activities and activity dependencies which enable one to cope with the complexity of the project network model.

Location versus time diagrams can be produced due to the use of breakdown of locations. These diagrams can be a useful tool in analysing progress of various gangs and possible interferencies between them.

The facilities of ATOP resulting from data structures representing activity dependencies are

- Separate decision making related to the sequence of activities and their overlap;
- Investigation of alternative sequencies of activities;
- Documentation of causes of activity dependencies;
- Selective reports from activity dependencies of a project network.

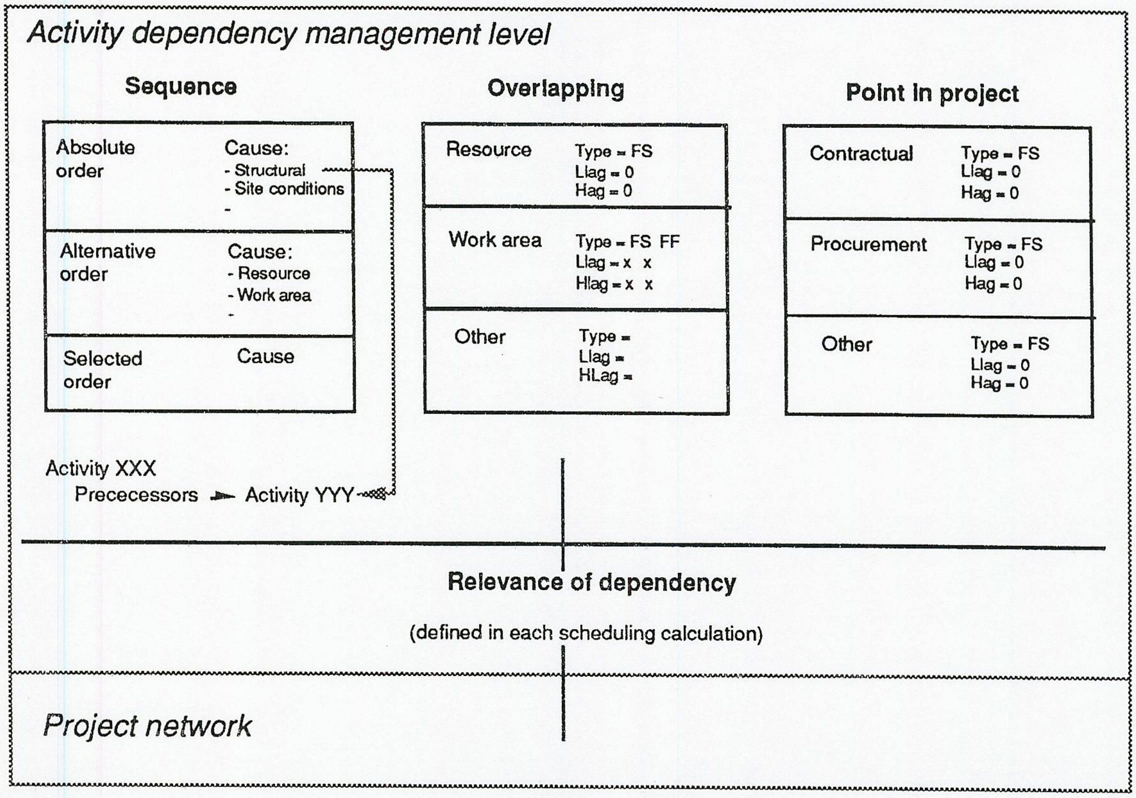

Figure 3 Data model for representing activity dependencies

6. Conclusions

The ATOP computer program generates an initial project schedule automatically on the basis of definitions input by the user and further optional information obtained from an activity type library. Object-oriented data models are used to represent project breakdown, causes and other properties of activity dependencies. In this way it is possible to establish different abstraction levels for complex project networks. These abstraction levels provide a useful interface to enable user to create, analyze and improve schedules based on project networks. When designing these data models and corresponding abstraction levels, emphasis should be put on the actual schedule preparation process in order to make data models reflect good practice.

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