EVALUATING THE COMPLETENESS OF PROJECT PLANS - AN AUTOMATED APPROACH

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ABSTRACT

This paper describes work which is taking place into the use of artificial intelligence techniques to evaluate construction project schedules. Following an introduction to the topic in which the need for evaluation is explained and possible types of evaluation are examined, two methods of checking completeness are presented: one in outline and one in detail with illustrations. The relationship between the two methods and the possibilities of future developments are covered.

INTRODUCTION

Planning is one of the most important tasks of the project manager. It is essential in order to ensure that all the work in a project is completed, at the correct time, in the correct order, as efficiently as possible and to the correct quality. With all these objectives, it is natural that several planning techniques have been developed and that several methods for the presentation of plans exist. Amongst the more commonly used are barcharts, precedence networks, arrow diagrams, line-of-balance and time-chainage charts.

Computers using traditional techniques are recognised as a practical aid for planning and in management research there is a growing movement towards automated systems that are capable of producing programmes of work. Some of the most notable of these are described in the work of Echeverry[1], Hendrickson[2], Levitt[3] and Mawdesley[4]. Such systems do not work algorithmically like the 'traditional' ones but draw heavily on the rapidly expanding field of knowledge based expert systems. They are intended to function either independently or as intelligent planning assistants.

Regardless of the methods used to produce the plans, the need to evaluate them is increasing. When they are produced by traditional methods, the growth in the size, complexity and demands of modern construction projects means that the possibility of mistakes is greater; when they are produced using automated planning systems, the use of some method of evaluation might be considered to be essential if the methods are to be true expert systems, gaining from their previous experience.

Some work has previously been done in using artificial intelligence techniques to evaluate project plans, most notably by Ibbs et al [5], and a paper on a different aspect of the same subject area was presented by the authors at the 6th ISARC [6].

This paper describes work being done as part of a research project which is partly supported by Tarmac Construction Major Projects Division. The aim of this project is to investigate the possibility of using artificial intelligence techniques to help in the evaluation of project programmes.

A project plan may be assessed against a number of criteria. There may be evaluation of, amongst other things:

- the logic connections present within a programme of work
- the time requirements and constraints set within a project contract
- the usage of labour, materials and plant
- the financial implications of a project
- the completeness of the plans within a project
- the risk involved in a project
- the safety implications of a plan.

The particular area discussed here, the evaluation of the completeness of programmes of work, forms a self-contained part of the whole project which is designed to interface with existing computer packages used for planning and financial control.

THE EVALUATION OF COMPLETENESS

It was considered important to ensure that any system which was developed should be able to operate with most formats of construction project plans, including specifically barcharts, networks, time-chainage charts and simple lists of the work involved in a project. These are all currently used by Tarmac Construction in their normal work. In order to meet this criterion, the system has been designed to accept as basic information the most fundamental of the techniques: a list of elements which together describe the work of the project. Two such lists are regularly produced for British construction projects:

- a list of the activity names
- a list of items from a bill of quantities.

These lists are usually produced independently for different purposes and should both contain all the work to be carried out in the project. They are however in different forms and the comparison of the elements is not a straightforward task. It is therefore difficult to identify whether they contain all the elements of work necessary for the completion of the project.

Two approaches to the evaluation of completeness have been considered and are described below.

A Generalised Construction Process Knowledge Base

The first approach requires one representation of the project, as described above. The individual elements are parsed and analysed and the resulting ‘standard descriptions’ processed using a Generalised Construction Process Knowledge Base to determine completeness and duplication.

The process of parsing involves breaking down an element from the work list, which might be an activity name, into its constituent parts. An example of this from a typical condensed description in a project plan is the activity name 'Br East abut found conc'. This could be written more fully as ‘East Bridge: Place Concrete to Abutment Foundations’, but is usually presented in some abbreviated format similar to that shown. It would be broken into the following elements:

- Br
- East
- abut
- found
- conc

These elements are analysed by attempting to recognise them as meaningful objects. This process means that an element such as 'Br' would be recognised as meaning BRIDGE. Several other words, such as 'Brd' and 'Brdg', are also understood as BRIDGE. Any unrecognisable element is assigned a meaning by the user and this information is added to the knowledge base of terms. The analysis of these elements identifies the major structures of the project. The user would be asked to classify these structures as one of the types of structure existing in the Generalised Construction Process Knowledge Base. This knowledge base, which is developed as new types of structure are classified, consists of an information structure or tree representing each different type of structure. The information stored within this tree contains all the relevant work necessary to complete this type of structure using normal construction methods and processes. An example of a portion of a tree is shown in Figure 1.

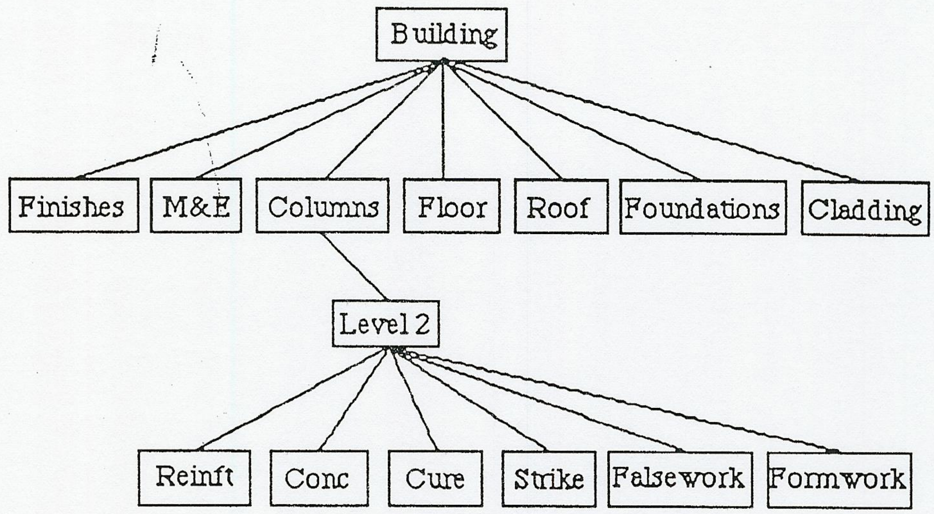


Figure 1: Section of a Generalised Construction Process Knowledge Base

The analysis of the project under consideration compares the work contained in it with the representation in the knowledge base associated with the major structures of the project. This analysis identifies any omissions or differences within the representation from normal construction practice. Furthermore, the level of detail of the plan for the various structures within the project can be assessed.

The major difficulties in implementing this approach lie in the creation and upkeep of the knowledge bases. For this approach to be successful the tree structures need to contain all the required work and be accurate. Furthermore, as a different tree is required for each different configuration of structure, whether or not they occur in the project under consideration, the storage requirements could be limiting. If the system could be made to learn from the various types of project which had been input to it rather than being fed with the knowledge bases initially, the approach might be not only viable but attractive.

Work on this approach has been halted in favour of the second method which promises to deliver results of higher quality with a much lower initial knowledge input requirement and which can produce the knowledge base described above.

Comparison Of Two Representations Of A Project

The second approach requires two independently produced representations of the project. One of these representations is processed to form an information tree similar to those mentioned in the previous section. The second representation is then processed in a similar manner and its information overlaid on the first information tree. From this procedure it is possible to identify differences in the project representations. These differences are either:

- Omissions
- Duplications
- Different levels of detail

This approach therefore permits the evaluation of completeness without the need for the initial development of a generalised construction knowledge base. This gives a saving in storage space and removes the effort of creating and updating the information stored within it. If both representations of a project suffer from the same omissions the system will fail to recognise this, a situation which should be unlikely if the representations are independently produced.

This method has been implemented and tested. The theory and initial experimental results are described below.

The process adopted by this system is similar to that described above for the generalised construction knowledge base approach. An element of work from the list, an activity name for instance, is parsed and the constituent elements are recognised. To reduce the number of user interactions needed to develop an information tree these elements are classified into categories of the user's choosing. The categories permit the system, provided no ambiguities exist, to identify automatically the order in which elements of the activity should be placed within the tree structure.

The categories can have any significance that the user requires. They allow the elements to be separated into an hierarchy of types of element. The system has default categories from which the user can start, and it is envisaged that little change to these will be needed. These are:

- Major structures - such as buildings and bridges.
- Minor structures - such as structural elements within the major structures.
- Work types - such as placing concrete, constructing formwork or bricklaying.
- Elements that may be discarded - such as 'and' or 'the'.
- Elements that are identifiers to other elements - such as '2' in 'floor 2'.

Development Of The Tree Structure

Once categorised the elements may be placed into the tree structure. If a new tree structure representation of the project is being developed the user is required to specify the order in which the tree should be built. For instance, it is possible, with the default categories, to create a tree where the highest nodes are major structures and the next levels down are minor structures followed by work types and so on. This is a structure orientated tree, showing primarily the number and type of structures contained within the project (see Figure 2).

At mid-tree level the sub-structures and structural elements contained within each structure are displayed and at the lowest levels the types of work involved in each structural element, and subsequently each structure within the project, are displayed.

If this ordering of the tree were to be reversed, that is the work types gaining a high priority position followed by minor structures and finally major structures, a work orientated tree would be created. This orientation lends itself to the analysis of what work types and hence which resources are necessary in the various areas and structures of a project (see Figure 3).

Obviously, it is possible to organise this information in many ways. The tree structure was used for simplicity but it has the drawback of only being able to represent one information structure at a time. Other methods of representation such as neural networks overcome this but were considered both difficult and rather slow to develop in this particular research environment.

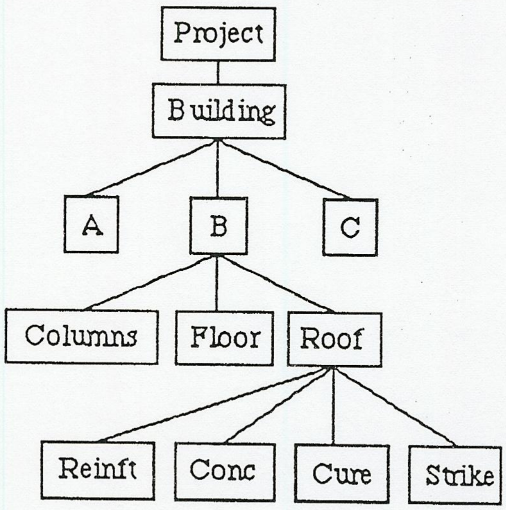


Figure 2: Structure Orientated Tree

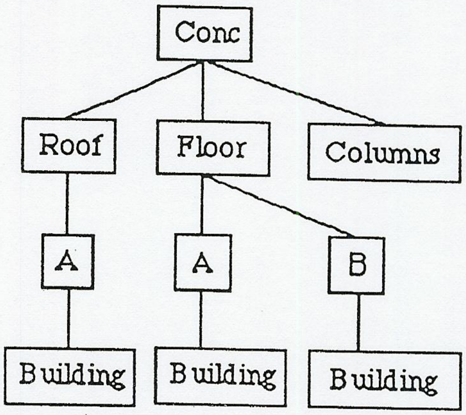


Figure 3: Work Orientated Tree

Placement Within The Tree

Each activity name or equivalent unit is placed within the tree by the following procedure.

The highest priority element from a name is selected and the system attempts to identify a similar element currently existing at the highest level of the tree. If a match can be found the searching process descends the tree. If at any stage a match cannot be found the system creates a new branch in the tree and orders the unplaced elements of the activity name accordingly.

During the creation of a new tree, if an activity does not create a new branch it is duplicating an activity previously placed. This identifies it as an activity for which the work will be carried out more than once.

The automated placing system fails only when an activity has an element that has not been categorised or has at least two elements within the same category. A knowledge base for recording such events exists in the system and this permits automatic processing of recurring situations.

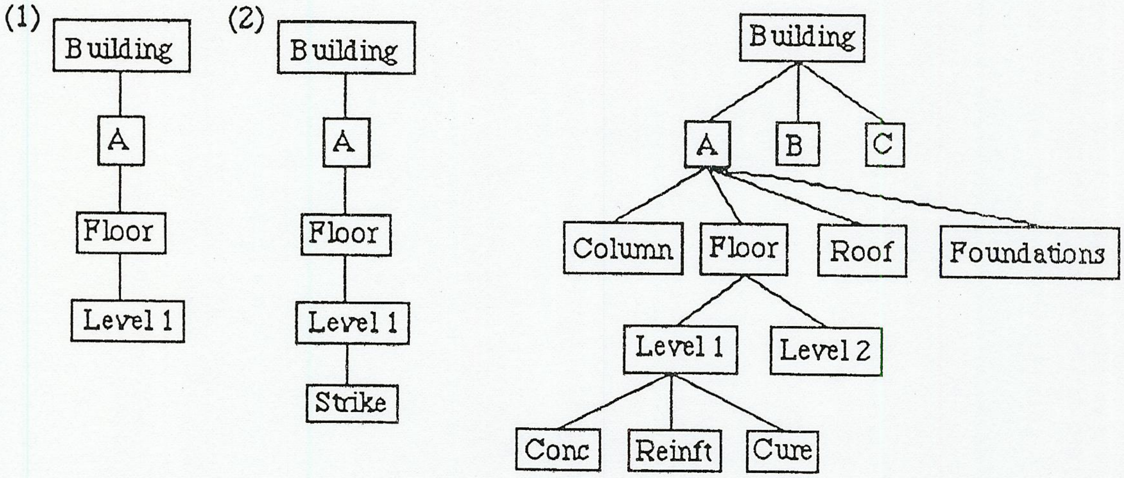
An example of the tree building procedure can be seen in Figure 4. The first instance shows an activity name that can be placed in the tree without creating a new branch. This is a duplication of an activity previously placed within the tree. The second instance shows an activity name that, on placing, creates a new branch at the lowest level.

Different Types Of Comparison

Once the first representation of a project has been processed and stored in the form of a project tree the second representation can be treated in a similar manner. When the information from the second representation is overlaid onto the existing project tree a comparison may be made.

The information that may be gained from this comparison differs depending on the nature of the two representations. For instance, for the project shown in Figure 5, if the tender plan were to be compared with the as-constructed plan the following information could be gained:

- Any alterations to the work content of the project would be illustrated.
- The level of detail within each of the plans might differ. If this were so the information from the more detailed plan would permit the work content of elements of the less detailed plan to be displayed.



An information tree into which activity names are being placed.

Figure 4: Examples of placement into a tree

If the two representations compared were a plan of work and a bill of quantities for the project, the comparative process should allow activities from the plan and items from the bill of quantities to be associated. The allocation of particular items from a bill to activities or vice versa is the process of 'Bill Splitting' [7] which permits the financial and associated resource information from the Bill to be passed into a plan of work for the project.

An example of this process can be seen in Figure 5. This shows partial information trees for a plan of work and a bill of quantities. The detail contained within the bill of quantities extends to one more level than that of the plan. It is possible therefore to associate the three bill items that are subsets of the 'Level 2 Reinforcement' with the single activity that contains the element 'Steel'.

DISCUSSION AND CONCLUSIONS

The method outlined above has been implemented in an experimental form on an IBM compatible 80386 computer running MSDOS. The package was written using Turbo-Pascal. The experience gained in the implementation has indicated that the method will prove successful on larger projects and enable a check for completeness to be performed.

In addition, and perhaps more valuably, it has been found that the automatic mapping of one project model on to another provides the basic information for checking not just completeness in terms of omissions and duplications but also other aspects, both of completeness and other evaluation criteria, for example:

- resource realism in terms of labour, plant and materials
- the financial implications
- the financial risk.

It is felt that with these benefits possible, it is worth pursuing the development and testing the method on real projects.

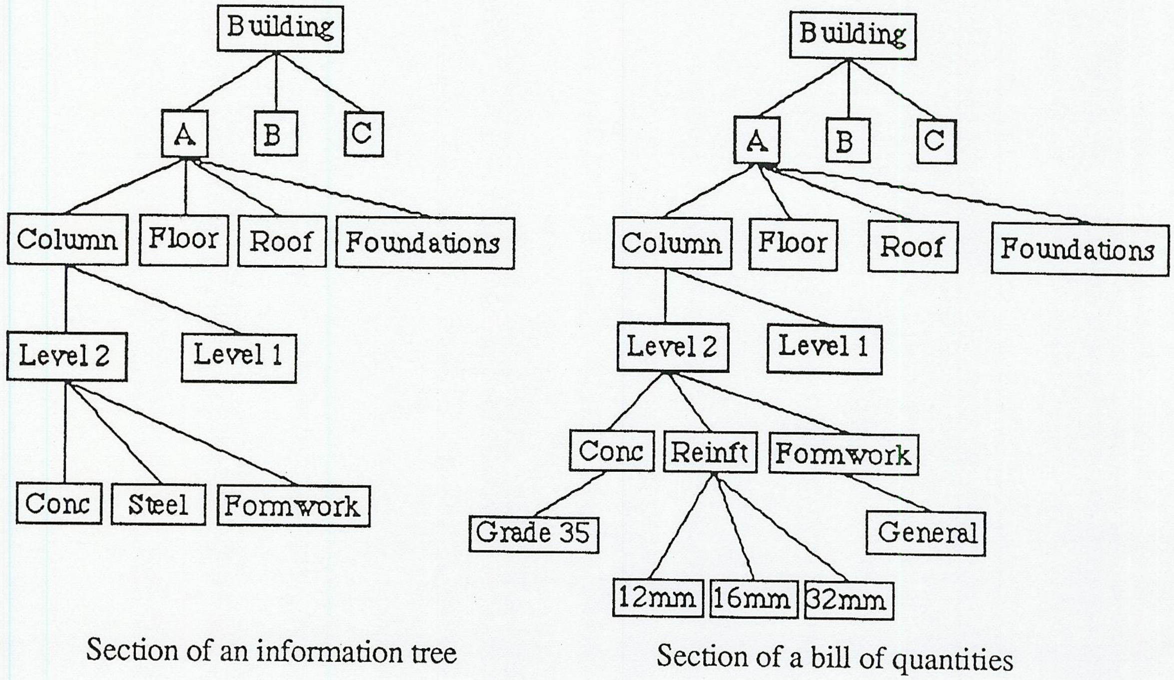


Figure 5: Bill Splitting

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