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Evaluation of CAPM systems by process modelling of GRAI Grids

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Abstract

This paper presents an approach to dynamic modelling of GRAI grids of production planning and control systems so that the performance of the CAPM systems can be evaluated. The approach implements some of the desirable extensions to GRAI grids to enable them to be dynamically modelled, described in earlier papers. It utilises one of the new flow charting modelling software packages. The approach has been applied to a case study project and experience gained is briefly described. As a preliminary result of the study, the paper concludes that the proposed methodology shows considerable promise. Planned further work leading to refinement and extension of the methodology are described.

Keywords

GRAI method, GRAI Grids, Process modelling, Simulation, CAPM systems

1 INTRODUCTION

In a paper to the IFIP WG5.7 Working Conference on Re-engineering the Enterprise in Galway in April 1995, MacIntosh and Carrie (1995) presented a paper on the use of the GRAI Method in Re-engineering. In that paper MacIntosh and Carrie (1995) gave a critique of the use of GRAI Grids within a methodology for improved manufacturing integration, including a discussion of its advantages, its limitations and several desirable extensions. Carrie and MacIntosh (1995) gave some additional detail. This paper reports on the developments achieved in connection with these desirable extensions, which were

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concerned with dynamically modelling production management systems described by GRAI grids, so that changes to the system can be evaluated quickly and easily.

The methodology described was the Strathclyde Integration Method, SIM, developed during a UK funded research project on manufacturing integration (Carrie, 1992, Carrie and MacIntosh, 1993a and 1993b, Carrie and MacIntosh, 1994). SIM uses a combination of Data Flow Diagrams and GRAI Grids to study manufacturing information systems in relation to the manufacturing systems which they support. The method has been described in a Workbook (Carrie et al, 1993). DFDs are used to provide a detailed model of the processes concerned, showing the relationships between individual processes and identifying the flows of material and information from one process to another. From these detailed DFDs, an overview DFD is synthesised which groups the detailed processes into a limited number of 'core' processes which form the basis for a GRAI Grid.

2 THE GRAI APPROACH AND THE GRAI GRID

Although GRAI Grids, and the GRAI approach in general, have been described frequently within the CAPM research literature, it may be worthwhile summarising the basic structure of the Grid.

The GRAI approach originates from work based at the University of Bordeaux 1 (Doumeingts, 1989). The two original components of the approach were the GRAI Net and the GRAI Grid. The Net provides a micro-view, in graphical network form, of decisions and activities in terms of their inputs, supporting resources, results, etc. They show a considerable amount of detail. The GRAI Grid provides a macro-view, or overview, of decisions and information flow within a manufacturing system in terms of the main functions concerned and the time frames of decisions taken. Since this early work, the GRAI approach has broadened to encompass tools for most of the analysis and design tasks involved in designing manufacturing systems. Many of these tools are also used by other methodologies. Some methodologies use different, but equivalent, tools. The GRAI Grid however is unique to the GRAI approach, and no other methodology seems to possess any equivalent tool.

GRAI Grids provide a diagrammatic overview of the decision making procedures and information flows within a production control system. They show the functions of the business and the time scales on which decisions are taken. Decisions are classified by their function (not necessarily a function defined in terms of the organisational structure) and by their timescales. Timescales are described according to the planning horizon (H) utilised in making the decision and the review period (P) after which they are reviewed or revised. The major information flows used in decision making processes and the inter-dependency of various decisions are also illustrated. Figure 1 shows a simplified GRAI Grid from a recent project. Double arrows show the flow of decisions while single arrows represent information flows, such as feedback. Decision centres occur at the intersections of rows and columns.

3 REQUIREMENTS FOR DYNAMIC MODELLING OF GRAI GRIDS

Carrie and MacIntosh, 1994, reported that the GRAI Grid was a very effective tool in summarising a CAPM system on a single sheet of paper so facilitating round table discussion of the system, while MacIntosh and Carrie (1995) expanded this comment

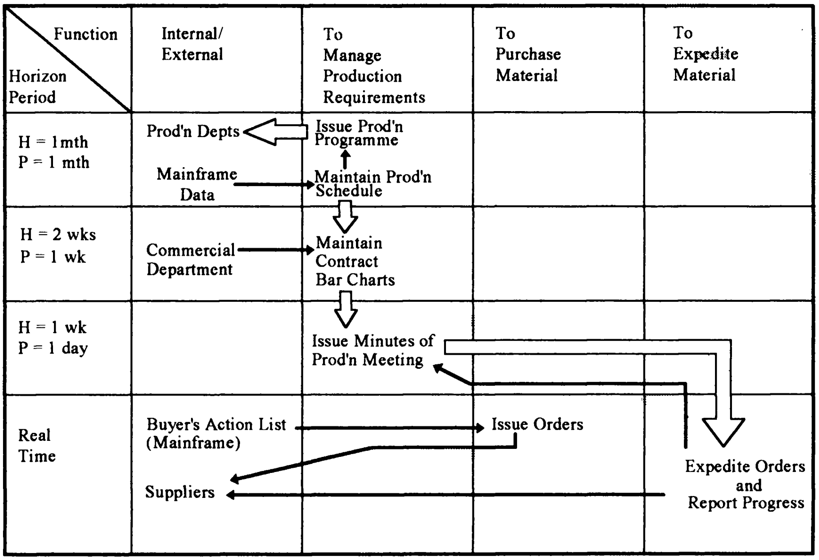

Figure 1 Simple example of a GRAI Grid from a recent project.

giving several advantages and limitations of the GRAI Grid technique. During the development of SIM some exploratory research was conducted into the dynamic modelling of information systems as represented in GRAI Grids. This suggested that several additional constructs would be necessary to enable the grid to be used as a dynamic modelling tool. These were described by Carrie and MacIntosh (1995) as follows:

> '1 <u>Time required to make a decision</u>
> It would be necessary to specify a time delay within a decision centre representing the time taken to make a decision. There is a dichotomy herein, in that given the speed of modern computers decisions should be more or less instantaneous, but in practice delays do occur while people get around to the task.

2 Delays in communicating between decision centres
The transmission of information or instructions between one decision centre and another involves a delay in practice, although in theory communications over a computer network should be virtually instantaneous.

3 Synchronisation of information flows
Before any decision can be taken all the relevant information should be available, thus it is necessary to wait until the last data is available before making the decision.

4 Time phasing of decisions
Although the grid identifies how often decisions are made, according to their period, there is nothing the indicate the phase relationship between decisions. For example two decisions may be made at three month intervals, but one may be made every January, April, July and October, whereas the other may be made in March, June, September and December.

5 Stability
The stability or otherwise of control systems is a well known problem if feedback loops are not properly designed to take delays into account. As a result of the four points mentioned the system may not behave as expected and may progressively degenerate over time. A further risk is that the quality of decisions gradually degenerates if one or more decision centres does not perform properly due to failing to operate on time or due to obsolescence of data.'

4 APPROACHES TO DYNAMIC MODELLING OF GRAI GRIDS

Various approaches to modelling GRAI grids have been evaluated, including discrete event simulation and business process re-engineering (BPR) tools. In this section these approaches will be reviewed briefly and a successful approach described.

Business process re-engineering focusses on the flow of information and the activities involved in executing a complete business process, such as the customer order fulfillment process, from customer order through all the stages of manufacture, inspection, test, packing and delivery. Recently several BPR software tools have been developed, but are frequently too IT-oriented to be very useful in the more general system modelling task. Bradley et. al (1995) gave an overview of some BPR software tools and highlighted their advantages and limitations.

The PROSIM (KBSI, 1993) package combines the PROCAP process description capture facility based upon the $IDEF_3$ methodology, generating a model consisting of process flow diagrams and object state transition networks, together with an interface to the WITNESS (AT&T ISTEL, 1994) discrete event simulation package. This combination seems very powerful at first sight, but in practice was found that the package could not handle processes with many branching and combining flows with feedback loops and created machines in WITNESS for each branch greatly complicating the resulting WITNESS model.

Experiments were carried out using the WITNESS package on its own. WITNESS has a high level user interface and is one of the most widely used discrete event simulation packages. Problems were encountered when activities in the process generated more than one type of output (e.g. such as documents with different names than in the input document). To implement this it was necessary to add physical elements (e.g. dummy machines) giving new names to the outputs. If there are many changes in the output generated then the total of dummy machines increased accordingly and the model become more complicated. While a method of modelling GRAI Grids was developed it was extremely cumbersome, and not a practical solution.

With both PROSIM and WITNESS it was difficult to add features in the models so that the model has a similar appearance to the GRAI grid.

Attention was then turned towards the recently developed flow charting tools, some of which combine the ability to depict systems graphically in flow chart form with capabilities to deal with resource management and dynamic simulation. Process Charter is one such tool. An overview of this package and a description of its use in modelling CAPM systems described in the form of GRAI grids will now be given.

5 PROCESS CHARTER

Process Charter, developed by Scitor Corporation (Scitor, 1995), not only has a flow charting capability but also it has other capabilities to deal with resource management and dynamic simulation. A brief overview of the steps in using the package will be given.

Drawing the flow chart

Creating the chart, selecting, positioning, and connecting the shapes necessary for describing a process is straightforward, as is entering text in them. It is easy to get all shapes positioned anywhere in the drawing area on first try, and adjusting them to get an ideal arrangement is a simple drag-and-drop activity.

Defining resources and calendars

The step starts by defining resources, including resource type (labor or material), standard and overtime, and length of work day. Next, various calendars are created to simulate real-world situations, such as five-day or six-day work schedules. Then resources and calendars are assigned to appropriate activities. Process Charter provides numerous options for controlling processes. For example, users can have a process that would flow down a certain path with specified probability, fixed cost, and time. The Paralleled Path Routing option enables an activity that sends output to several other activities simultaneously to be described easily.

Simulation

Process Charter accommodates variables such as flow rates, resource and time consumption, and other information for each step in a process. The program's interactive capabilities allow users to run live, animated simulations to identify key bottlenecks and constraints in a process. With Process Charter's analysis tools users can assign resources and maximize their utilization, add variables, such as time and costs, to flowchart elements, and quickly identify bottlenecks by viewing the overall process throughput. Colour animation brings simulation to life and identifies the stages in a process that require attention.

Result

Every time a simulation of a process is run, Process Charter automatically creates a series of graphs that depicts how much time and money is being spent on the simulated process. Process Charter helps users check validity of any change they are considering to a system with "what-if" analysis capabilities. With this powerful modelling capability, experiments can be done to see if any changes would actually make the system more efficient or would merely add cost without providing any real benefit.

During a simulation run, a wealth of important data is generated in the background. For example, the resource spreadsheet is updated to show total cost for people and material employed in the processes. Also the flow object spreadsheet shows average completion and waiting times for various parts of the process. The graphs that Process Charter produces during simulation greatly help the users to understand activity statistics.

6 MODELLING GRIDS BY PROCESS CHARTER

In this section of the paper the approach to modelling GRAI grids using Process Charter will be presented and illustrated by a case study. This case study concerns the customer orders fulfilment in a company producing inks for duplicating machines. The customer orders fulfilment is a core business process, and to improve response to its customers the company intended to modify the procedures used in production planning and control systems.

Construction of GRAI grids

Having completed the data collection, the next step is the construction of GRAI Grid. The construction of GRAI Grid and subsequent work follows the method described in the Workbook (Carrie et al, 1993). Once the structure of the GRAI grid has been defined it can be drawn using Process Charter. This has the advantage of requiring only one package to draw and simulate the Grid, but the package of course lacks facilities for checking whether a system obeys the rules of production management which a GRAI Method software tool might possess. One of the resulting GRAI grids of the system in the case study company is depicted in Figure 2. In that grid, information-flow is represented using a line with a single arrowhead and material flow is represented using a thick line with a large dot indicating the direction. Flow of decision frames are represented using lines with double arrowheads.

Briefly, the current practice in the company is as follows: Customer orders arrive in the sales department on a daily basis, a salesperson adds the orders to the list of orders already received and stores them in the system database. The consolidated forecast then is updated on a daily basis,and assumed to apply for the time horizon of one month. However re-building of a forecast for scheduling is done every month and this forecast is brought to a production meeting to make a master production schedule of all the orders. The meeting is conducted every week and the decisions made in the meeting have one month time horizon. Material purchase orders are derived from master production schedule then sent to the supplier every week. The master production schedule data is used in a build job master activity for making a detailed production plan which is sent to the production department for implementation.

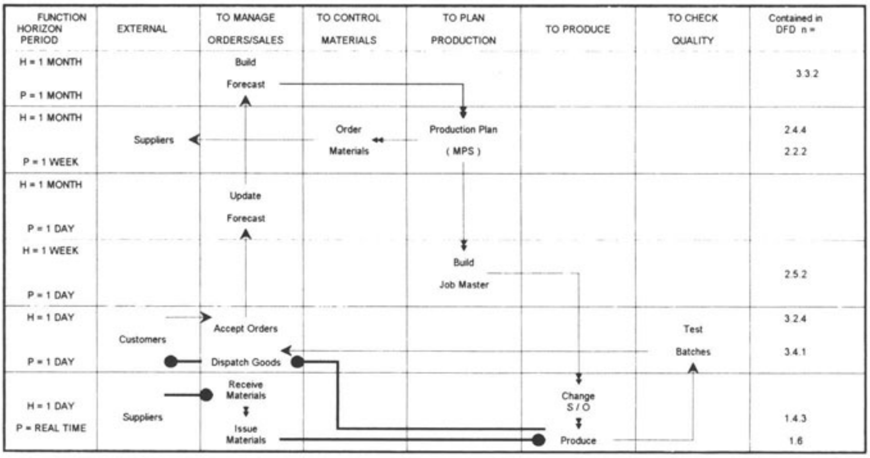

Figure 2 GRAI Grid from a case study.

Modelling the grids by Process Charter

The process of modelling GRAI grids using Process Charter requires several steps. First, the business process is mapped out using Process Charter's flow charting tool. Each decision centre is represented by a box in the flow diagram. The diagram of the model of the current situation is shown in Figure 3.

Dynamic modelling grids using Process Charter.

Once the flow chart has been defined, dynamic modelling of the GRAI grid can be undertaken. The necessary resources for the process are identified in the resources spreadsheet and various calendars created to give a true time dimension to the simulation of the process. After resources have been defined and calendars have been created, the resources and calendars are associated with each activity within the process. Finally, the process simulation is executed and the results are presented in the form of graphs and statistics. By analysing the results of the simulation run, management can assess the possibility of improvement to this process which is critical to the success of organisation.

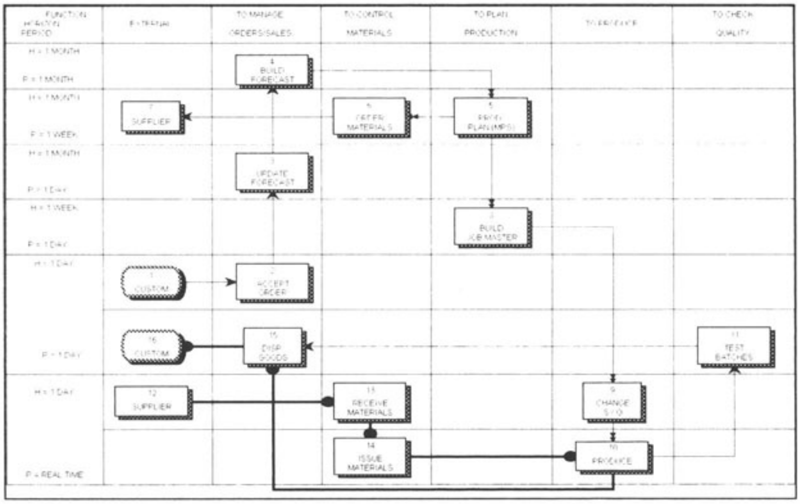

Figure 3 Grid in Process Charter

Analysis

During the course of the development of the project, a number of issues were identified which were to be addressed in connection with the development of an improved process. One of these issues concerns the two decision centres which relate to updating and building forecasts of customer orders, namely decision centres Updating Forecast and Build Forecast. In the current situation delays in Build Forecast were too long compared with the Production Planning meeting which was held every week. Thus some of the time forecast information which was needed at the time of the meeting was not available. It was desirable that those two decision centres were combined into one and the horizon and period adjusted accordingly. The new decision centre would have a time horizon of one month and time period of one week and its decision frame would be sent directly to Production Planning meeting every week.

With this change a new proposed grid was constructed. A new dynamic model of that grid was developed and is depicted at Figure 4. The next step was to experiment with the model. The results of the proposed model were then compared with the original situation. The preliminary comparison showed that the proposed model had an improvement of approximately 20%. It indicated that by combining those decision centres the system revealed a better performance.

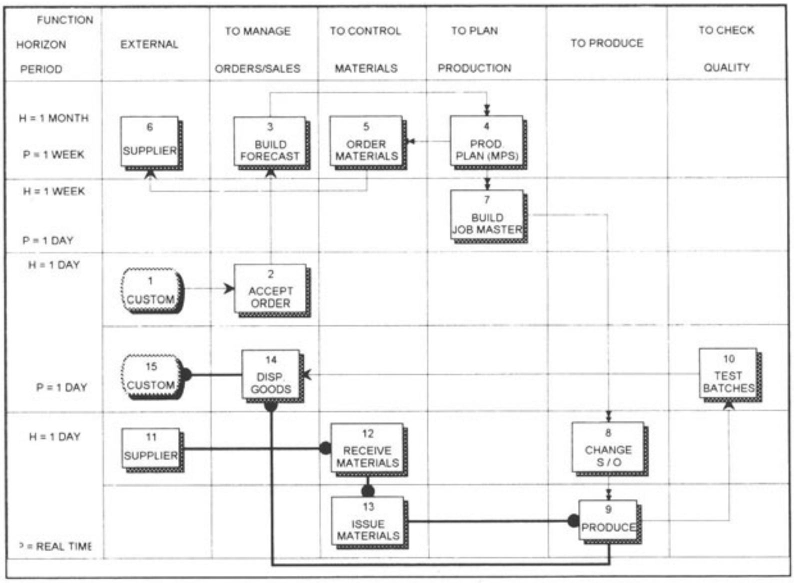

Figure 4 Grid in Process Charter after changes.

7 CONCLUSIONS

An approach to dynamic modelling of CAPM of GRAI grid has been presented. The result gained from applying the approach to a case study example shows that the developed model was a good representation of the system. The experimentation with the simulation model indicated that the approach can capture well the dynamic behavior of the system under study. It means that performance of the CAPM systems can be evaluated using this approach.

As a supporting tool for modelling and simulating the systems under study, Process Charter showed substantial value, especially its facilities for defining calendars and resources.

In relation to the five desirable extensions mentioned earlier, the new method addresses four out of the five. The time required to make a decision can be specified in the process properties; delays in communicating between decision centres can be defined in the calendar for each activity; synchronisation of information flows is handled in each process's input logic; the time phasing of decisions is specified in the calendars. As yet the method is not capable of analysing questions of stability.

Further work continues to investigate the effectiveness of the approach in a wider range of organisations, and in presenting the results in a more complete manner. Planned further work will be described including an approach which combines using process charting to model calendar-driven parts of a CAPM system with discrete event simulation to model the event-driven parts.

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9 BIOGRAPHY

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