

# Advanced enterprise resource management systems for the batch industry. The TicTacToe algorithm

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## Abstract

Since 1997 the authors have prototyped an enterprise resource management (ERM) system recommending essential improvements to the available software packages, which today claim automatic real time performance and an efficient transaction-oriented approach. The ERM system proposed is a decision-making tool for the manufacturing industry, which makes integrated financial/production trade-off planning and optimisation in the supply chain management. The application supports management cycles because during its use are available degrees of freedom to make the system work as a decision-making tool. The enterprises must be aware of its internal problems to be dynamically approachable instead of prematurely evolving to networked enterprises by links in the electronic commerce. ERM systems are capable of managing dynamically realistic and optimal delivery dates with price-time trade-off during the marketing activities. Cost objective functions integrated with system performance measures are developed, including a cost model to evaluate the due date policy economics in real time. The order management system proposed is based on the TicTacToe algorithm, which follows an exact non-combinatorial deterministic approach to time and optimise production sequences in multiproduct plants in very short time using asymmetric travelling salesman problem formulations for the scheduling task. The resulting tool is appropriate to fulfil the requirements of autonomous order entry systems in integrated real time systems. © 2001 Elsevier Science Ltd. All rights reserved.

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## 1. Introduction

Good management practices in the industry during the exploitation phase are necessary to preserve the firm during his whole life cycle. In the process industries, the driving force is not the same as years ago: lowering costs or filling manufacturing capacities. Low costs are the effect of other decisive facts, which are shorter lead-time, design of new products and processes, quality, service and reliability. The technical and business management in the process industry is linked to the workflow within Intranets and Internet, passing through the electronic mail for commerce and business

promotion. The companies must be turned in make-to-order operation linking the actual/forecasted orders instantly to the plant floor. Besides this, the manufacturing process innovation and the competence of the company have to be assessed in time to ensure a high technology status. Simulation and optimisation techniques are used simultaneously to operatively manage the firm's plans. Efficient evaluation and updating of plant's logistics inventory control, maintenance, production, quality, investment/retrofitting, accounting, finances and sales functions are now more necessary. Interactive on line schedulers tracking the production events and the financial resources in enterprise resource management (ERM) systems can assure the solvency with the overall enterprise management optimisation during the now a days short life cycle of products and processes. In this paper are compared the mean features and limitations of the actual commercial software with the proposed management system architecture.

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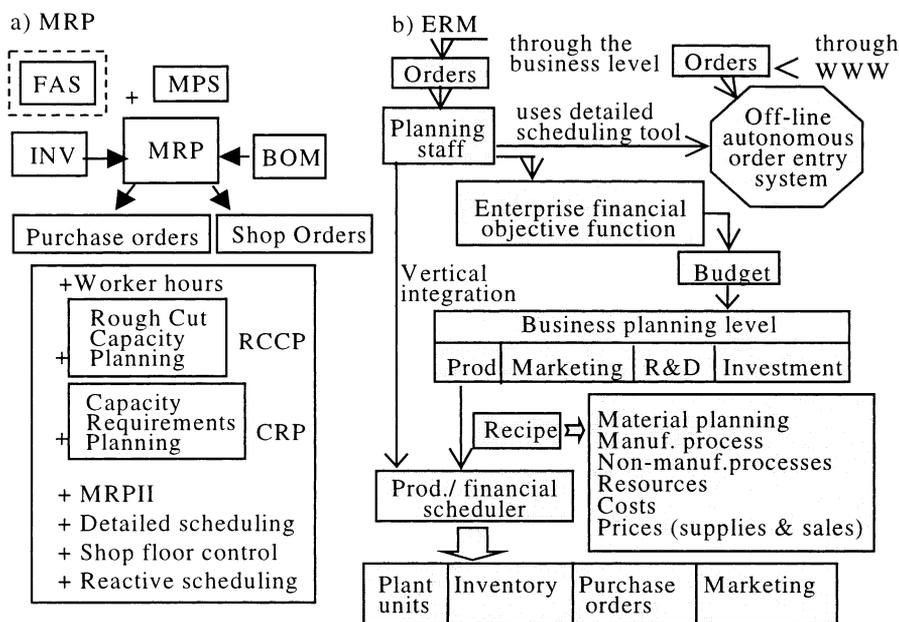


Fig. 1. Evolution of MRP Systems and the ERM system proposed.

## 2. The evolution of enterprise information and management systems

The success of enterprises depends on the systematic interchange between financial, technical and management expertise and this dynamic has to be supported with adequate tools. The ERM system proposed is a decision-making tool for the manufacturing industry. It is particularly different to the predecessors: material requirements planning systems (MRP), manufacturing resource planning extensions (MRP II), MRP II + DCS (distributed control systems), manufacturing executive systems (MES), or ERP systems. In Fig. 1 are represented besides the ERM proposed, the initial MRP modules master production schedule (MPS), final assembly schedule (FAS), inventory (INV), bill of materials (BOM) and its extensions to capacity requirements planning (CRP) (Baker, 1993).

One of the most important features of ERM is that not only production is scheduled and optimised. Cash inflows/outflows, business purchase/sales operations, commercial credits, bank loans, inflows/outflows of cash during R&D and many other activities as maintenance preventive plans, payroll or overhead costs can be taken into account during the trade-off overall planning optimisation and can be represented graphically in interactive Gantt charts. The ERM system pretends to be a system (because works as a whole) with cybernetic quality (because possesses auto-regulation possibilities) and that is why is defined as an enterprise 'management system'.

The application supports management cycles because during its use are available degrees of freedom to make

the system work as a decision-making tool. Actual systems do not fulfil this role because they stay at the integration of information; they do not develop multifunctional integration as ERM does. The planning approach of many enterprises is based on the hierarchical production planning, which frequently provokes great discrepancies requiring trial and error replanning activities because frequently the top plan proposed is *blind* to the real production situations. On the other hand, during the production practice, the plan ignores the financial objectives since are a result of the firstly decided production delivery dates: "*production*" decides and "*finance*" obeys. Although up-to-date economic information is a pre-requisite of optimal management, the high-level staff lacks time to frequently prepare or update short-term cash plans. The financial decisions regarding the supply chain are not backed up with a precise knowledge of the economic resources available and the effects that could provoke. The lack of an appropriate computer-aided tool/system in the market is the first reason of these limitations. If the financial forecasts are not tied with the production and marketing decisions, its operative value is uncertain. The difficulty lies in the fact that improving cash planning affects production scheduling by altering payments for final products and billing for raw materials. Without integrated financial/production plans, a company in the batch industry is managed like a black box, not assuring all its strong possibilities to preserve stability when unexpected events occur. If in the ERM interactive system interrelated constraints are placed between its two main functions – finances and production – new computer-aided loops can connect and regulate in real

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