IS Management by Constraints: Coupling IS Effort to Changes in Business Bottlenecks

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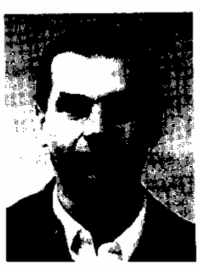
The Theory of Constraints (TOC) has recently proved successful in focusing industrial and service organizations. This paper applies TOC principles to the Management-of-Information-Systems (MIS) in the organization.

Deming's process of on-going improvement (POOGI) manages the update of IS goals to accommodate changes in the business environment. The process includes the definition of goals for IS; definition of performance metrics; process improvement objectives for the short, medium and long term; and the identification of constraints limiting the quality of the current process design.

We identify three modes of interaction between TOC and information systems: 1) subordination of MIS to elevate strategic business constraints; 2) focused treatment of constraints on the throughput of the IS unit; and, 3) the development of information systems to support the TOC methodology.

We draw a framework and a methodology showing how MIS can be more effective using the TOC way of management. In order to systematically explore the location of the organization's constraints we adapt the Value Chain and Value System models to the identification of organizational constraints.

Keywords: Theory of Constraints, MIS policy, MIS strategy, MIS lifecycle



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1. Information Systems, Industrial Engineering and the TOC

Management practices in industry as-a-whole undergo profound changes as the methodologies of Total Quality Management (TQM), Just In Time (JIT), and the Theory of Constraints (TOC) are being absorbed. This revolution currently addresses the less studied domains of services and research and development (R&D). The Information Systems (IS) industry, intensive in R&D and with the profile of a services industry, is one of the more problematic to manage. IS projects exceed their predetermined budgets and schedules more frequently than other industries and are more prone to malfunction.

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Data from TRW, IBM and GTE [16] demonstrate that if the cost of fixing an error detected in the preliminary product definition stage is one unit, it costs three units to fix the same error during general design, six units during detailed design, ten units if the error is detected in the programming lifecycle stage, sixty units if detected in acceptance tests and a hundred and ninety units if the error is detected while the system is operational. Though this data demonstrates the weaknesses of late error detection, a study by Daly [2] states that 70% of design errors and 75% of programming errors are detected by the customer during the product acceptance and operation lifecycle stages. Considering that maintenance accounts for between 40% and 70% of IS budgets [16], the slow adoption of software engineering [12], and quality assurance standards [11], these figures demonstrate that the IS department must rationalize to improve the quality of its production process.

The leading TQM thinkers differ in the scope set by their definitions of quality. Deming [3] defines quality as: 'Fit to requirements'. This definition implies that requirements adequately describe the product or service. In many software applications written requirements fail to transmit the 'feel' of the system as well as other nonfunctional features. Juran's [13] definition: 'Fit to usage and user' better reflects that the judge is the user and not the requirements. The distinction between satisfying the user and satisfying the requirements is a frequent stumbling block in supplier-customer relations. Taguchi's [18] definition requires: 'Correctness from the first time, uniformity, and user satisfaction'. This definition recognizes two entities: the supplier and the user. Correctness from the first time measures the volume of product rejects and rework required by the process. Uniformity of process output measures product related variables. User satisfaction measures the application of the product over time. Garvin's [6] definition provides a list of eight attributes: 'performance, features, reliability, conformance, durability, serviceability, aesthetics, perceived'. These attributes elaborate on the issue of user satisfaction. Garvin's definition is thus close to a marketing perspective of product quality from the customer's viewpoint, i.e., the value per dollar produced by the product.

While Statistical Quality Control literature has a narrow focus on the measurement of tightly defined quantitative product attributes, TQM literature takes a 'total' perspective starting with the commitment of senior management, through customer perceptions of quality, on to the production or service process, finally focusing on the measurement of specific attributes. TQM thus spans the range from 'philosophical' guidelines on one extreme to 'pragmatic' statistical techniques on the other.

We suggest that insufficient interaction between general operations management professionals and IS management is a major obstacle in the rationalization of the IS industry. In this study we present a framework for the application of Theory of Constraints (TOC) principles [5,8,9,17] to the Management of Information Systems (MIS). A partial application of TOC principles to MIS was done by Floyd and Ronen [4].

This study starts with the TOC's seven-step operations management methodology. A hierarchical model of IS activities is then presented, consistent with the TOC's top-down philosophy. We then use TOC methodologies to re-analyze MIS case studies, operationalize TOC principles for the MIS environment, and examine those areas of MIS where the application of the TOC is particularly lucrative. The paper ends up with a normative methodology of MIS implementation according to TOC principles.

2. A Hierarchical Model of the TOC

We describe the TOC's seven-step operations management focusing methodology, introduce the cost/utilization investment decision making technique, and conclude with the Drum/Buffer/Rope production scheduling methodology.

3. Seven Steps – TOC's Operations Management Methodology

The Theory of Constraints (TOC) is a global managerial methodology that helps the manager to concentrate on the most critical issues. The TOC business policy translates into a seven-step methodology for the identification of business-unit constraints and their confrontation [4,17]. The methodology is verbalized as follows:

1. Define the system's goal.
2. Determine proper, global and simple measures of performance.

3. Identify the system's constraints.
4. Decide how to exploit the constraints.
5. Subordinate everything else to the above decision.
6. Elevate the system constraints.
7. If, in the previous steps, the constraint was eliminated, go back to step three, but do not let inertia become the system's constraint.

This seven-step methodology is performed at the frequency of short-range planning – once or twice a year – by top and middle management. After the business mission is defined, the goal for each business unit is derived from it and defined explicitly. Measures of performance need to be proper – measure the actual throughput of the system. Measures should reflect the business unit's contribution to profits rather than some vague feature such as efficiency. Measures should take a global view of the business rather than a narrow sectarian perspective. Finally, performance measures should be simple enough to be applied by line workers in an intelligent mode. Simple measures provide the workers with information they can use, unlike sophisticated measures that produce accurate but useless data.

The first three steps – identification of the system goal, definition of measures, and identification of constraints – are the diagnostic part of the process. The next three steps – exploitation of the constraint resource, subordination of all other resources to it, and elevation of the constraint resource – provide the cure. The seventh step protects the business from the disastrous effects of inertia.

For example, Ford motor company's goal is to make more money by achieving sustainable competitive advantage in the international automotive arena. Measures of performance include throughput, sales, market share, and after – tax income. Ford's statement 'Quality is Job One' reflects the company's recognition that quality constrains the achievement of sustainable competitive advantage. This implies that while other goals such as expanding production capacity, developing marketing networks, or reducing production costs are important, their importance is secondary. Ford exploits the quality constraint by focusing its restricted quality improvement resources on Taurus – Ford's flag product – where marginal profits are maximized. Secondary goals such as the addition of new features to the Taurus are subordinated to the quality goal. They are undertaken only if they do not compete for resources with the quality goal and provided that their introduction will add to the product's quality. Ford's strategy is to focus its quality efforts on a different car every year. The quality constraint is elevated by training employees to focus on the quality issue, measure the quality of the tasks they perform, and improve the quality delivered by their system. TOC's techniques or the exploitation and elevation of the quality issue will, in the long term, remove quality from its status as the constraint to Ford and replace it by some other issue. Japanese manufacturers, for example, consider lack of consumer excitement to constrain the achievement of their long-term strategic goals. Improving product quality, while still important, is of secondary importance to them. At some time in the future, Ford may achieve excellent quality, at the parts-per-billion (PPB) defect level, leaving its competition behind at the parts-per-million (PPM) defect level. Seeking better production quality, at that stage, would indicate that inertia has become the system's constraint. The seventh step, testing against inertia, is TOC's operationalization of Deming's [3] process of on-going improvement (POOGI) principle.

Operations management decisions dictate facility layout design and prescribe capital budgeting for new equipment. Cost/utilization is a TOC technique for facility layout design and for the prioritization of property, plant and equipment investments.

4. TOC and MIS

TOC and MIS interact in three modes. First, IS-aiming, applies TOC techniques to the organization. Constraints obstructing the organization's ability to accomplish its global goals are the objectives for IS to confront. Constraints in the organization's ability to produce timely information for decision makers, to communicate information about orders, and to retrieve stored data are particularly appropriate for IS to tackle. For example, Merrill-Lynch is developing information systems to elevate the communication bottleneck occurring between 9AM and 11AM among thousands of its clients (corporate and individual) communicating with forty account executives. Client trade instructions are communicated to the dozen traders on the trading floor for execution. The goal here is to take over as much trading business as possible. Merrill-Lynch would get more business if the communication between its account executives, its clients and its traders were improved. Even physical constraints such as machine capacity can be exploited better through the use of MIS.

In the second type of interaction, IS-constraints, IS executives apply TOC principles to expose the constraints of the IS function. These constraints restrict the application of IS technology to the organization's constraints. The typical IS department maintains a backlog of applications waiting to be developed. This backlog reflects the existence of bottlenecks in the application development process.

The third type of interaction, computer-aided TOC (CAT), applies information technology to facilitate utilization of TOC techniques in the organization. CAT includes computer monitoring of resource utilization rates, computerized resource scheduling according to the DBR technique, prioritization of purchasing decisions according to TOC's cost/utilization technique, and computer simulators training employees in the application of TOC principles.

In this article we deal with IS-aiming – how to identify the organization's constraints, and how to make information technology instrumental in tackling them.

5. Constraints at the Organizational Level

Coman's [1] top-down methodology for the formation of an IS policy, is consistent with the TOC top-down approach. Modern managerial perspective views IS as a tool subordinated to the accomplishment of the organization's strategy. The model identifies three dimensions: the organizational dimension covering the span from a mission down to the individual IS project; the product lifecycle dimension beginning with the initiation of a project, through its development, all the way to maintenance and finally termination; and the professional IS dimension covering disciplines of hardware architecture, operating systems, knowledge and database management systems, telecommunications, user interface, etc.

Executives applying the TOC to IS should start by defining a goal for the IS department. Since IS is an instrument subordinated to the organization, it is prerequisite to analyze the organization first. We start by stating the organization's mission, continue by defining measures of performance, and then locate the system's constraints. The next step is to implement TOC's seven-step constraint identification and confrontation methodology. The role of information systems is to exploit the constraint, help subordinate non-constraint resources or elevate the constraint. The issue facing practitioners is how to scan the organization for constraints in a systematic method. We hereby present the value-chain and value-system models [15] focusing on primary and support business activities.

6. The Value Chain

The value-chain model [15] analyzes the firm's business activities. The value chain creates a matrix listing primary activities directly associated with the product line on the X-axis, and support activities providing corporate support on the Y-axis. Every cell describes the interaction between a primary and a support activity, as value added to the product being processed from left to right. In the example of a production firm (Fig. 1) the product flows from the development stage, through the manufacturing floor to the marketing distribution chain, concluding with the service stage. Support activities include corporate planning in charge of strategy, accounting and control monitoring the product's flow through the system, human resource management responsible for quality trained and motivated staff, and technology development seeking and absorbing new technologies for the long term. Primary activities usually account for internal constraints while support activities account for policy constraints.

The value-chain matrix identifies constraints and bottlenecks along the value-added axis. The value-system technique extends the axis to include supplier and customer value chains that are constructive in the identification of external constraints. Consideration of supplier and consumer value chains is consistent with Deming's [3] prerogative to mobilize suppliers and distributors as part of the total quality effort, blurring the firm's boundaries. While the value chain targets what the TOC terms 'internal constraints' the value system targets 'external constraints'.

PRIMARY ACTIVITIES

SUPPORT ACTIVITIES	Product Development	Manufacturing	Marketing Distribution	Service
Corporate Planning				
Accounting and Control				
Human Resource Management				
Technology Development				

Fig. 1. The value chain model. Primary activities.

General Motors' (GM) promotion of the Manufacturing-Automation-Protocol (MAP) [14] standard illustrates how IS helps to exploit a constrained activity. GM realized from its analysis of the Japanese automotive industry, that work in process (WIP) is a constraint on the way to better quality and reduced cost. When headquarters get the complete picture of inventory and WIP levels at all facilities it will become possible to exploit the WIP constraint. IS could elevate the communication bottleneck by networking facility computers together. The MAP was designed to bridge the current state of 'islands of automation'. The value chain marks the constraint on the intersection of the manufacturing primary activity and the corporate control support activity.

Lack of connectivity between the products of different vendors did not constrain the market for data processing equipment. Vendors were therefore not motivated to reach a universal standard. GM's solution was to organize a powerful users group committed to purchasing only MAP compatible equipment. The users group applies its power to transfer its own communications constraint up the value system to its suppliers. IS vendors facing a new value system, where non-standardization constrained their business, were induced to comply with the MAP standard.

Two important performance measures of primary activities are lead time – the time from the moment the activity was initiated until its completion, and 'right first time' – the proportion of tasks that were correct from the first time. Long lead times constrain the system's responsiveness to customer demand and to changes in the market-place, constituting a bottleneck on the firm's competitiveness and profitability. A high proportion of defects requires rework, limiting the system's capacity and introducing internal bottlenecks. Many defects generate consumer dissatisfaction, reduce demand, forming an external demand bottleneck. Digital Equipment Corporation (DEC) [10] illustrates how expert system technology can reduce lead-times and defect proportion. DEC sales personnel and order processing clerks register customer orders for a wide variety of VAX system configurations, applying a broad range of information located in several manuals. Manually, it took up to three days to configure orders, only 80% of which were correctly configured. The configuration problem constrained DEC's ability to expand into the upper end of the market where systems were even more complex to configure. It also constrained DEC's ability to introduce new technology due to the long training lead times. The constraint is thus located at the intersection of marketing distribution on the primary activity dimension, and technology development on the support technology dimension. DEC's introduction of the Expert-System-Configurator (Xcon) reduced order configuration time to between three and five minutes, reducing rework in half to 10% of orders. Likewise, the service and human resource bottleneck is better exploited as clerks liberated from routine orders concentrate on more complex tasks.

Intel Corporation is at the forefront of VLSI technology development. Incorrect management of its human resources would constrain its status as an industry leader. Human resource management is particularly complex at its research and development laboratories. Intel prescribes a set of managerial duties to support its corporate culture. These duties load R&D managers with daily, weekly, quarterly and annual tasks. The time bottleneck is identified at the intersection of product development – on the primary activity dimension, and human resource management – on the support activity dimension. Due to their time constraint managers either comply with their human resource management responsibilities, on account of their technical duties or reduce the quality of their managerial performance. Intel's Managerial Support Information System (MSIS) [7] helps managers to plan, monitor and aggregate human resource management tasks. As the time constraint is exploited, the quality of managerial tasks has risen.

While the value chain targets what the TOC terms 'internal constraints' the value system targets 'external constraints'.

The analogous treatment of internal and external processes is consistent with TQM philosophy viewing the organization as a chain of suppliers and customers and treating suppliers and customers as extensions of the organization.

7. Conclusions

The TOC offers a comprehensive methodology for the harnessing of MIS to the organization's goals. This article presented a complete top-down application of the TOC from business policy formation, down through the seven-step operations management focusing methodology, and cost/utilization investment decision making technique, to the Drum/Buffer/Rope production scheduling methodology.

The heart of the TOC methodology consisted of a seven-step effort focusing cycle.

We demonstrate how the value-chain and value-system models can be mobilized to produce a systematic search for constraint domains. These constraints are set as targets for the MIS activity.

These tools extend the TOC to examine potential future constraints in addition to current constraints, suggest exploitation of competitor constraints to establish barriers for entry into the market, and offer a hierarchy of constraints starting from the cash flow constraint at the corporate level down to the constraints restricting the contribution of MIS to the organizational mission.

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