International Journal for Quality research
UDK- 005
Scientific Review Paper (1.02)

Simulation Of Quality Goals: A Missing Link Between Corporate Strategy And Business Process Management

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Abstract: *This paper describes design methodology for quality goals simulation model as a supporting tool for quality goal-directed decision-making at strategic management level.*
The paper presents such an integrated, system (MIS/DES) and draw attention to the essential role of simulation based strategic quality goal-directed decision-making within it. With proposed approach it is possible to converge, or focus, comprehensive but static MIS knowledge in dynamic simulation models and to fully utilize prediction power of simulation for effective and integrated quality goal-directed strategic decision making. Importance of modeling in field of control, equality of knowledge and models, dynamic nature and complexity of models and real systems from viewpoint of modern cybernetic science are also presented in the paper.
The final goal is a purposeful decision-making simulation system that guides in the right direction strategically focused management action promising implementation of strategic plans and achievement of related quality goals.
In its experimental section the paper describes a quality goals model designed for concrete environment. Overall model structure, components structure, components relations, mathematical models, and other elements of modeling approach are also given in this section. Finally, an example of successfully designed simulation solution is given. The approach presented in the paper gives verbal and mathematical problem description, builds ontology of quality goals problem domain, uses Extended Petri Nets as modeling tools in order to obtain faithful model which easily can be replicated in object oriented class and object hierarchy.
Keywords*: quality goals, simulation, corporate strategy, business process management*

1. INTRODUCTION

Area of quality goals is subject of numerous polemics, debates and misunderstandings additionally facilitated with ambiguity found in literature and practice. According to Juran definition quality goal is an aimed-at quality target. A goal is specific, it is usually quantified and is to be met within a specific period time [15, 16, 21, 22]. Having in mind industrial sector and business systems diversity Juran highlights quality goals related with:

1. Product performance,
2. Competitive performance,
3. Quality improvement,
4. Low quality costs and
5. Macro processes performance.

Works of many researchers are under the

influence of his authority and quality school [4, 5, 6, 7, 8]. At the same time, with development of this entity in the quality area very similar process in the field of management and economic science take place. In the field of economic science new disciplines as performance efficiency measurement, management control productivity etc, have been developed. Mentioned disciplines highlight financial perspective and performance indexes hierarchy related with specific business aspects [1, 2, 3].

In the field of management science new concepts as management by objectives (MBO), performance management, operations management etc, have been developed.

Lack of previous partial approaches in terms of linking financial and business processes aspect compensate concepts as Balanced Score Card (BSC) and Strategy Focused Organization developed by Kaplan and Norton [9, 10, 11].

In their model strategy map consists of four perspectives:

- Financial,
- Customer (including product quality),
- Process perspective and
- Learning and growth.

Within financial perspective two strategies can be distinguished:

- Productivity strategy with:
  - Cost structure improvement and
  - Asset utilization improvement,
- Growth strategy with:
  - New revenue sources
  - Increase of customer value.

At lower hierarchy level is Customer perspective with:

- Product/Service attributes (price, quality, availability),
- Customer value proposition (functionality, selection),
- Relationship (service, partnership),
- Image

At lower hierarchy level is Process perspective with:

- Operation management processes,
- Customer management processes,
- Innovation processes and
- Regulatory and social processes.

As the base for all previously mentioned is Learning and Growth perspective with:

- Organization capital (culture, leadership, alignment, teamwork),
- Information capital and
- Human capital.

In this way, using performance indicators system, an effect of performance indicators change at lower hierarchy levels on overall company goal is determined.

However, problems as relating indicators on the same hierarchy level, synergy effect of parallel changes of several performance indicators as well as dynamic aspect of change are still evident. Previously mentioned facts motivated authors of the papers for more than 15 years work in order to find solution of these problems.

Strategic management as the highest of all management levels gives direction to values, culture, goals, and missions to all functional units of the business system. Under wide corporate strategy established by strategic management there are business-level strategies as well as functional unit strategies. The greatest challenge for top management is to create an organization in which every employee, department and function is linked inextricably to the organization’s mission and vision.

The strategic management literature advocates the establishment of a system of strategically focused management controls to monitor progress and ensure the implementation of strategic plans and related goals. Strategic control system is software based process which allows strategic management to determine whether a business unit is performing adequately, and which provides feedback for subordinate management levels and directs its future actions. Thus, the primary purpose of management software control systems is to support strategy by providing information to all management levels for planning, control and decision making.

The basic management problems at this and other levels of management hierarchy are integration of strategic and tactical decision making, developing the capability for different plans and schedules reconfiguration and synchronization in a very short cycle as well as handling various kinds of exceptions. Data sources needed for information required for proper functioning of the management software control system are stored in management information system (MIS) databases.

MIS encompasses within itself all knowledge about business system necessary for system functioning and control in line with business and quality goals at all levels of management hierarchy. MIS integrates all data and processes of a business organization into a unified information system and it is basic model of structure and behavior of an organization.It is necessary to emphasize that MIS system is a static model of dynamic and complex structure and behavior of business system. On the other hand, MIS replicates real system on the level of abstraction that is not satisfactory for decision making on the operational and tactical level.

With MIS alone, anticipating future potential system states, evaluating various management strategies and accurate real-time, goal-directed decision-making - is not possible and this implies lack of knowledge. The reason why comprehensive, integrated knowledge stored in an MIS system is not fully utilized is nonexistence of dynamic control models across organization, or, as the paper propose, non existence of Discrete-Event Simulation (DES) models.One of fundamental postulates of modern cybernetic theory states that control of any real system is not possible without corresponding control model. Additionally, model must be, as much as possible, replication of the real system because effectiveness of control depends on similarity between modeled system and corresponding model. This is reason why effective modeling is one of the most important and difficult steps in the development of reliable software systems.

Models are not static reflections of the modeled environment, but dynamic constructions achieved through trial-and-error by the individual. What models represent is not only the structure of the environment but also its behavior, insofar as it has an influence on the system. Models function as recursive generators of predictions about the world and itself. As a consequence of complexity and multidimensional, hierarchical nature of real systems there is no "absolutely accurate" model of reality: there are many different models, any of which may be adequate for solving particular problems, but no model is capable to solve all problems.

Also, in modern cybernetic theory *knowledge* is understood as consisting of *models* that allow the survival, adaptation and growth of a cybernetic system in its environment, by *anticipation* of possible perturbations. A cybernetic (goal directed) system makes predictions by its knowledge i.e. models in order to achieve certain goal, ultimately – survival, adaptation and growth. So true knowledge is an instrument of survival, adaptation and growth and true knowledge consists of models – generators of predictions. There is no any criterion of true knowledge other than the *prediction* power it gives.

This is reason why simulation has enormous potential within the management efforts of today's organization. Correctly applied, simulation provides an instrument for continuous improvement of the entire organization. This paper claims that simulation not only describes the future state of a business process, but also indicates the best way to reach that state. The difference, and the power, of Discrete-Event Simulation (DES) is its ability to mimic dynamic manufacturing systems, consisting of complex structures and many heterogeneous interacting components.

This paper describes design methodology for quality goals simulation model as a supporting tool for quality goal-directed decision-making at strategic management level.The paper presents such an integrated, system (MIS/DES) and draw attention to the essential role of simulation based strategic quality goal-directed decision-making within it. With proposed approach it is possible to converge, or focus, comprehensive but static MIS knowledge in dynamic simulation models and to fully utilize prediction power of simulation for effective and integrated quality goal-directed strategic decision making. Importance of modeling in field of control, equality of knowledge and models, dynamic nature and complexity of models and real systems from viewpoint of modern cybernetic science are also presented in the paper.

The final goal is a purposeful decision-making simulation system that guides in the right direction strategically focused management action promising implementation of strategic plans and achievement of related quality goals. In its experimental section the paper describes a quality goals model designed for concrete environment. Overall model structure, components structure, components relations, mathematical models, and other elements of modeling approach are also given in this section. Finally, an example of successfully designed simulation solution is given. The approach presented in the paper gives verbal and mathematical problem description, builds ontology of quality goals problem domain, uses Extended Petri Nets as modeling tools in order to obtain faithful model which easily can be replicated in object oriented class and object hierarchy.

2. QUALITY GOALS MODELING

According to recent literature review quality goals field is considered from different viewpoints, issues (timeless, cost, conformity) and objects related to products, processes and resources. Figure 1. Presents quality goals three dimensional system space.

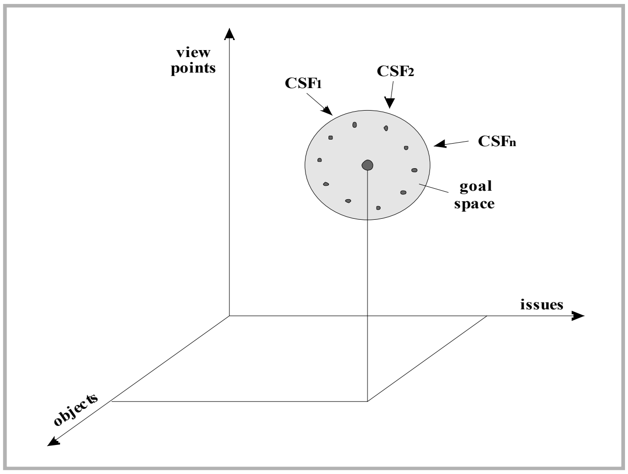

Figure 1. Quality goals system space

Goetsch and Davis [21] and other authors [16, 22] using Juran works as a base determine quality goals in accordance with strategic procedure (Figure2).

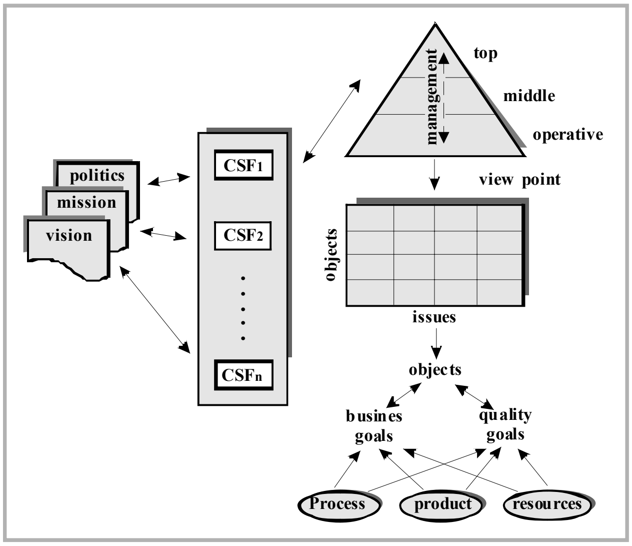

Figure 2. Defining quality goals

In order to accomplish quality goals simulation experiments it is necessary to complete its classification. Figure 3 presents a classification number structure and Figure 4 a process classification number.

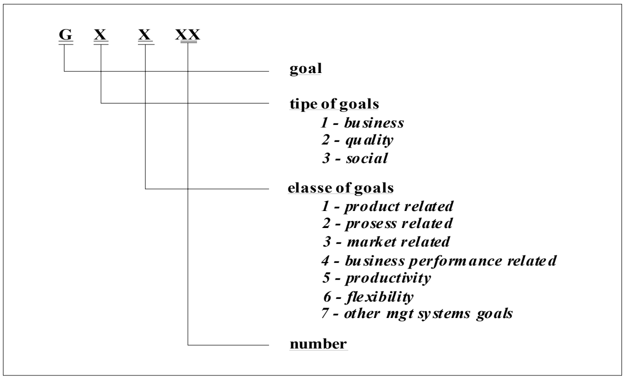

Figure 3. Classification number structure

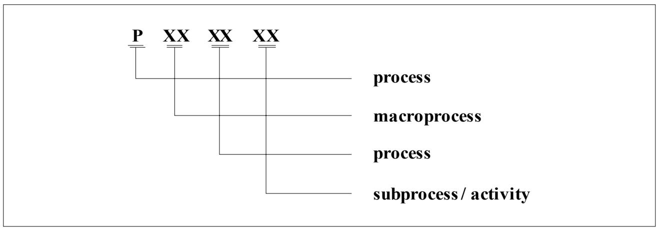

Figure 4. Process classification structure

Using general modeling concept as a base, models for exploring influence of various performance or business system change are developed. Definition of is important level of change, complete goal change dynamics, the most influential variable for quality goal change, optimal change scenario is important in this procedure. This is reason why conceptual model of quality goals must be converted in functional model. Figure 5 presents functional extended Petri net model of quality goals.

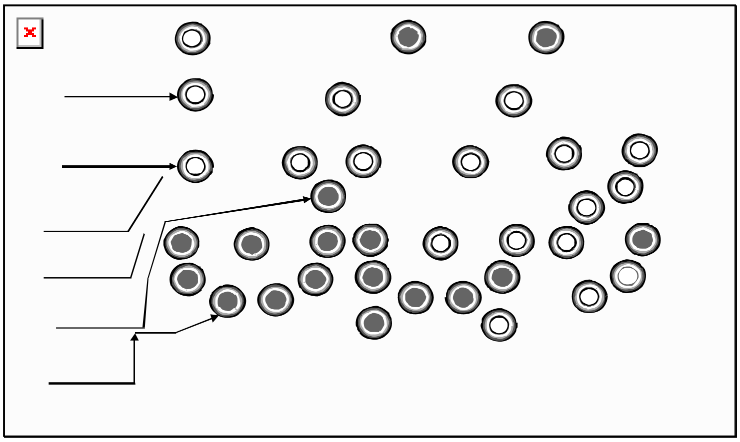

Figure 5. Functional extended Petri net model of quality goals

Quality goals system encompasses key quality aspects like product reliability, safety and conformity. Mentioned quality elements are sub goals in quality goals system hierarchy. In accordance with standard ISO 9001:2000 inseparable elements of quality goal system are quality costs and orientation towards customer. Quality costs are in relation with productivity which can be autonomous business system goal, or as a element of quality goals system. Orientation towards customer is in relation with flexibility which also can be autonomous business system goal, or as a part of quality goals system. Mentioned facts are foundation for quality goals system modeling and simulation in the next phase. The paper presents quality goals model designed by conceptual modeling technique and simulation software solution, based on mentioned model, for dynamic modeling of goal fulfillment in time scale.

3. QUALITY GOALS SIMULATION MODEL

Authors using conceptual modeling technique approach perform goals decomposition at strategic level and identify productivity and flexibility as main quality sub goals . By sub goals analysis, at lower goal hierachy level, goals classification is performed and sub goals are defined at different levels of goals hierarchy Figure xx presents structure of quality goals as well as relations of sub goals that make possible this integration. Proposed approach uses for this case extended Petri Nets in order to obtain faithful simulation model which easily can be replicated in object oriented class and object hierarchy of simulation software solution.

Presented model depicts structure of quality goals system hierarchy. Directionlessness of, for this purpose extended, Petri Nets enables two-way, bottom-up and top-down, data flow through the model from underlying data base up to corresponding quality level as well as from entering value of desired quality level in order to obtain initial values of corresponding initial values.

Quality goals simulation software solution

Main menu of quality goals simulation software solution contains links as follows:

1. Quality level assessment
2. Quality index assessment
3. Influential variables weight factors
4. Optimal combination of influential variables
5. Maximum quality level
6. Maximum quality index
7. Review, entry and correction of influential variables

Initial data for execution of underlying mathematical model are contained in 39 (thirty nine) programming structures. Mentioned programming structures model current, maximum and minimun values of 27 (twenty seven) basic elements as well as for 12 (twel) calculted elements. Model contains also a programming structure for weight factors values modeling.

Structure of quality goals system model presented in the paper is as follows:

Quality index, Quality level, Flexibility, Product conformity, Quality costs, Productivity. Preventive costs, Price, Quality realization, Internal shortage costs, External shortage costs, Delivery date, Product performance properties, Product safety, Product reliability, Customer orientation, Quality planning, Employees training, Service costs, Quality evidence, Equipment improvement, Other preventive costs, Laboratory research and testing, Energy costs, Inspection costs, Amortization, Process analysis and development, Measurement tools costs, Material costs, Other quality evidence costs, Scrap costs, Other internal shortage costs, Rework costs, After sale costs, Transport and travel costs, Other external shortage costs, Flexibility, Acceptable delivery date, Other productivity costs.

Quality level assessment

When this option in main menu is selected program calls corresponding function which, using basic data and mathematical equations, calculates twelve wanted values and then presents calculated quality level, influential variables and weight factors values. This function calculates quality level and other element values for current values of basic elements. It is possible to correct basic elements values in different scenarios of simulation solution experiments in corresponding intervals selecting option 7 (seven).

Quality index assessment

Selecting this option program calls corresponding function which, using basic data and mathematical equations, calculates twelve wanted values and then presents calculated quality level, influential variables and weight factor values.

This function calculates quality index and other influential variables values for current values of basic variables. It is possible to correct basic elements values in different scenarios of simulation solution experiments in corresponding intervals selecting option 7 (seven).

Influential variables weight factors assessment

Quality level value in this model is related with 27 (twenty seven) independent variables defined within specified intervals.Mathematical equations of the model are linear and this is reason why extreme values of quality level are obtained by extreme values of influential variables. Program uses mentioned fact and by means of corresponding function calculates minimum and maximum quality level value possible for current system state. Possible interval of quality level change is obtained by subtracting mentioned values (Qmax – Qmin).

In order to calculate weight factor of each influential variable program calculates value of quality level change in relation with every influential variable change inside its interval span from minimum up to maximum value. During calculation values of other variables are at current level.

$$ddQ(i) = Q(maxV(i) - Q(minV(i))$$

Weight factor of each influential variable is calculated by:

$$R(i) = (ddQ(i)/ dQ)x100$$

Program then sorts obtained array R(i) as descending and presents obtained result in corresponding tables. Weight factor R(i) values are not constants and changes during program execution in relation with values of influential variables change.

This may be considered as an advantage comparing with scenario of R(i) calculation with influential variables average values.

Search for optimal combination of influential variables

When this option in main menu is selected program performs the same calculations as in previous selections and delivers calculated array to the graphic function. This function translates the array in a graphic presentation or corresponding summarizing histogram.

Program presents to the user only influential variables with sum total influence of approximately 80 percents.

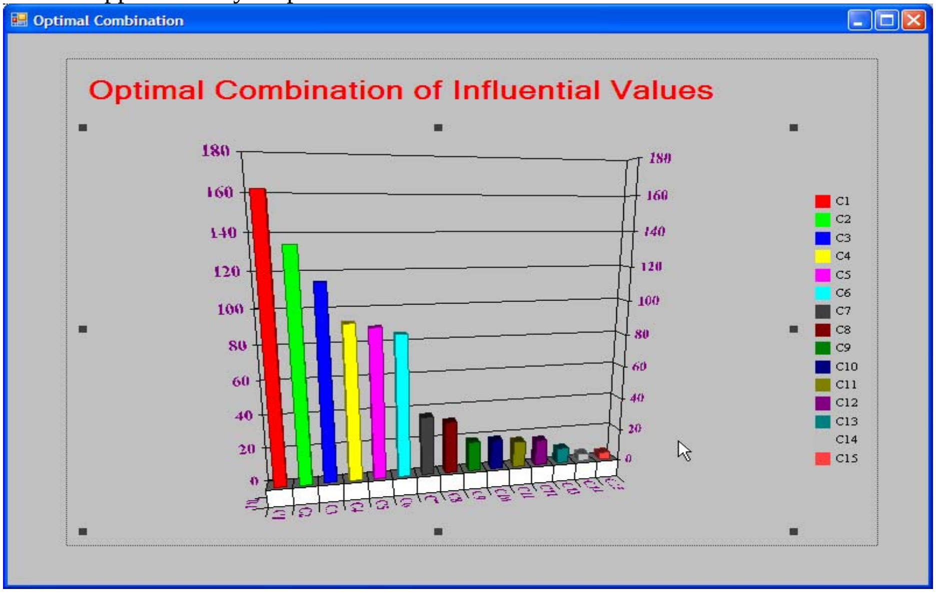

Figure 6. Optimal combination of influential value

Maximum quality level and maximum quality index

When this option in main menu is selected program calls corresponding function which, using basic data and mathematical equations, calculates twelve wanted values and then presents calculated maximum quality level or index, influential variables and weight factors values.

This function calculates maximum quality level or index and other element values for current values of basic elements. It is possible to correct basic elements values in different scenarios of simulation solution experiments in corresponding intervals selecting option 7 (seven).

Review, entry and correction of influential variables are facilitated by last option in the main menu.

4. CONCLUSIONS

The paper presents a quality goals model designed for concrete business environment and in short depicts overall model structure, components structure, components relations, mathematical models, and other elements of modeling approach. Finally, an example of successfully designed simulation solution is given.

Proposed simulation solution approach gives verbal and mathematical problem description, builds ontology of quality goals problem domain, uses Extended Petri Nets as modeling tools in order to obtain faithful model which easily can be replicated in object oriented class and object hierarchy.

It is possible to successfully model quality goals by means of conceptual modeling and specially extended Petri nets approach. Developed simulation software solution enables quality level and quality index assessment, influential variables weight factors, optimal combination of influential variables, maximum quality level and maximum quality index definition.

From previously depicted performances of simulation software solution it is clear that it can be used by quality managers in everyday practice for quality improvement efforts.

Obtained decision-making simulation system guides in the right direction strategically focused management action promising implementation of strategic plans and achievement of related quality goals.

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Received: 15.09.2009 Accepted: 15.11.2009 Open for discussion: 1 Year