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COMPARISON OF DIFFERENT SIMULATIONS METHODS IN CASE OF SERVICE-PROVIDING COMPANIES

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ABSTRACT

Optimal functioning of a market oriented company, in particular the service providing company, is an important example of optimisation of actions within the context of complex environment. In this article we discuss the prospective approach to represent reliably the quality dynamics of such a company, in order to contribute to possible future its quality management.

The agent-based modelling is extracted, among the set of modelling methods, to serve as a frame for representing the generic service providing company and to analyse its dynamics with emphasis on extracting the quality dynamics.

KEY WORDS

agent based modelling, service providing company, simulation modelling

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INTRODUCTION

Simulation modelling, and numerical simulations in particular, currently figure as a rather useful, in some disciplines unavoidable tool for predicting characteristic elements of a dynamic for the simulated system. That applies to service-providers, the companies which offer specific services on the market. Corresponding examples range from health-service providers, to informatics-communication service providers, to business, to leisure etc.

Their dynamics is highly non-trivial since they ought to operate, in general, within the competitive, market with a broad set of conditions to be fulfilled if they want to be attractive for potential users. Modern companies are often distributed, heterogeneous systems. Their function in providing a service is a result of cooperation among spatially separated elements which work based on different principles, with differences present at all levels, including the subtle ones related to satisfying the different end-user groups.

Among the variety of characteristics of such companies the quality is distinguished as an ultimate, scalar quantity unifying the company’s internal characteristics as well as its performance on the market, especially related to end-users experiences. In short, the quality depends on functioning of each and every element of the company. A natural question is how to govern the quality dynamics of a company? In other words, how to modify for a given amount, how to improve, or at least preserve the existing quality level of a company in a competitive, global, rather dynamical market? Typical questions related to quality are, e.g. the following: how to measure quality of the service? How to weigh functioning of company’s departments in their contribution to the overall quality? What tolerances should be imposed onto the departments’ functioning? What are the proper frequency and intensity in checking the departmental work? And, finally, how to perform regularly and reliably the topics implied in previous questions, so that checking the quality interferes minimally with the regular functioning of the company?

Previously, starting point was the fact that reliably collecting and interpreting the service users attitudes, toward the company and toward the services utilised, is a solid fundament for representing and possibly modifying the dynamics of the company, in particular the dynamics of its quality [1].

In this article we use the simulation modelling in order to reliably represent a given company, or a class of companies, end to enable further researchers or practitioners to utilise the model to check probable company’s dynamics depending on the used set of its characteristics.

In section two we list the basics of modelling and simulations, and in section three list and compare several well-known and developed simulation methods. In section four we discuss some implications of choosing the simulation method for service-providing company dynamics simulation.

GENERAL CHARACTERISTICS OF MODEL OF SERVICE-PROVIDER

Let us extract the characteristics of a generic service-providing company, which are encountered in analyses of diverse companies of such type, yet which can be modified in a variable amount depending on a particular case.

Underlying hypothesis is that quality of a service-providing company can be reliably determined (and short-term predicted) based on its accompanying, validated simulation model. Goal of the approach is to test the hypothesis which is conducted directly, i.e. by formulating the simulation model of a service-providing company in a relatively uncharacterised environment. Quality of different parts and the complete model is then evaluated based on the simulation results.

There are several specific goals related to the stated, general goal: (i) quantify the influence of internal information flow, i.e. that within the company, onto the end-user satisfaction and other end-user characteristics, (ii) determine the confidence level of evaluated quality level on the basis of statistical properties of surveyed end-users, (iii) analyse short-term and long-term dynamics of the modelled system, (iv) estimate the intensity of nonlinearity of influences that system's characteristics have onto the end-user satisfaction level, (v) rank micro-level characteristics of system's elements regarding their contribution to the overall end-user satisfaction level, (vi) formulate in details the procedures for service-providers, so that the procedures efficiently contribute to bringing about the predicted change of quality level. Regarding that, the intensity, and sequence of actions involved is to be emphasised. Finally; (vii) extract the characteristic combinations of characteristics of elements of the modelled system as a basis for its validation.

We treat the service-providing company as overall providing the two services and consisting of two departments. Choice of two services is an interpolation between the minimal number of one provided service, and some other number, generally larger than two. With two services one can expect more-complex yet still treatable and interpretable dynamics of service providing. Furthermore, one can expect the ranking of services to emerge as a result of both the users' attitudes and company's own optimisation of formulated goals. One may argue that larger number of services brings about more complicated description but without qualitatively new aspects of dynamics.

Two departments of the company are the department for providing services (DPS) and department for quality management (DQM), the later known also as department for quality control, quality assessment, etc. in various cases. These departments are the part of the same company, yet their functioning is co-opetitive, i.e. simultaneously cooperative and competitive. Being parts of the same firm introduces cooperativeness. However, specific functions put the departments in mutual competitiveness. DPS utilises available resources to perform services to users within the framework as set, at least partially, by the prescriptions from the DQM. On the other hand, DQM measures users satisfaction (to be described in more details further in the text) and formulates prescriptions for DPS in order to achieve optimisation of available resources and achieved user satisfaction. Thus input for DPS are resources from environment and prescriptions from the DQM, while its output are services. Similarly, input for DQM are user attitudes about the services, while its output are prescriptions to DPS. In that way one formulates feedback loop including the two departments and users. The competitiveness between DPS and DQM is seen in handling the prescriptions: one may reasonably expect that DPS solely would like to minimise efforts in providing services from available resources and consequently minimise the influence of prescriptions, especially is they ask for changes in operations of DPS. Conversely, DQM would like the prescriptions to be strict and completely followed, no matter what are the accompanied changes. Formally, one does not need to formulate strictly separated two departments. However, natural division of represented functions and their further implementation in the model is simpler, and easier to interpret is such division is made. The final note regarding the departments is that usually DQM is an existing, single department of a company, but DPS usually consists of several departments, possibly sub-contractors that can be spatially separated. We consider that co-opetiveness of the dynamics of the real departments within DPS is of smaller order of importance than co-opetiveness between DPS and DQM. Because of that we do not refer explicitly to complex structure of the DQM and instead treat it further as a single, monolithic unit.

Along with stated goals and assumed structure of the service-providing company, one cannot formulate the model without simultaneously representing the system's environment in the model. The environment consists of (i) population (with the service users being a part of it) and of (ii) other institutions.

Population, as part of the modelled environment is represented rather rudimentary, in the form of agents with characteristic dynamics. That dynamics includes internal part, and externally induced change of some of characteristics. One may argue that population's characteristics include age, level denoting the need for the service, as well as other characteristics which are probably of lesser importance for the service itself, but of greater importance for feedback about the provided service. It is assumed that in modern market regularly the feedbacks are collected and utilised in optimisation of services. Regarding feedback collecting, population characteristics include expressivity and satisfaction. For the presented modelling, it suffices to describe the expressivity as a combination of willingness to express ones attitudes, and of intensity of ones attitudes. Satisfaction is equivalent to individual service-user given grade of the service. Collecting and analysing feedbacks is a measurement of quality of services as expressed in part by the users' satisfaction, but screened with their expressivity which introduces a certain bias in the measurement. Since reliability of measurements influences service-providers' dynamics it is to be treated on equal footing as the very providing of services. Preliminary one can think about the following three different populations: younger population with assumed more intense reactions, older population with assumed calmer reactions, and general population serving as a nominal group.

The institutions to be represented in the model are furthermore divided into other companies and into rules which incorporate laws and customs of conducting services. Other companies are either competition, in the assumed competitive market, or collaborators such as contractors or subcontractors. All stated parties have their internal dynamics, as well as mutual interactions.

COMPARISON OF SIMULATION METHODS FOR MODELLING SERVICE-PROVIDERS

Possible simulation methods for stated modelling include system dynamics, neural networks and agent-based modelling. Stated methods are of proven, considerable importance in modelling. However, in the context of service-providing modelling some of their characteristics figure as advantages while other as disadvantages. In the next three sub-sections we describe the three listed modelling methods and their characteristics which are disadvantageous for modelling the service providing company.

Before proceeding, let us state that because of compactness we will not least characteristics that all three simulation methods share, or that are of lesser importance for final decision of their suitability for the present purpose.

SYSTEM DYNAMICS

System dynamics is a powerful method for modelling of diverse types of complex system. It unifies analytic and synthetic approach through representing the modelled system as a combination of elements with relations. The elements are not the non-separable units of matter, energy or information but functionally separated parts of the system, possibly being systems themselves on the next level of modelling.

System dynamics treat modelled system in small number of categories, which generally represent a whole class of entities. In that sense, within a system dynamics model, one would expect to encounter one category representing population, or possibly two or some other small number of categories partitioning the population. However, that may become insufficiently sensitive to characteristics of an individual user. Since nowadays one tends to use method with the maximal sensitivity to individual user preferences the collective character of categories encountered within the system dynamics is considered as its disadvantage.

NEURAL NETWORKS

Neural network is a method for forming the nonlinear interpolator, the structure of which is based on the initially existing data set relevant to modelled system.

The structure of the neural network, the number of layers, number of neurons in layers and their relations, however, are defined in details based on some statistical properties of interpolated sets as a whole. On the one hand that makes possible formulation of rather simple neural networks. However, on the other hand a drawback occurs in that the resulting structure can be rather independent of realistic structure of modelled system. Since one would like to model a service-provider with fluctuating, or in other way variable, characteristics such as variable number of components and relations, described structure of a neural network figures as its disadvantage for our modelling.

AGENT-BASED MODELLING

Agent-based modelling is simulation method in which functional units are treated as agents, abstract units with prescribed dynamics, e.g. rules of interaction.

That method includes agents, environment and rules. Agents are either individual or collective, regarding the number of humans included in a given agent. In our case, it is opportune that both individual agents (users of services) and collective agents (a company or its departments) are represented in the model.

Main disadvantage of the agent-based modelling is rather large complexity of its validation. However, other stated methods also include non-trivial validation. Therefore we do not treat complex validation of agent-based model as eliminatory property but as an existing disadvantage that must be taken proper care of. Cause of complex validation is related to non-trivial link between the (prescribed) micro-level and obtained macro-level.

NOTE ABOUT VALIDATION

Validation of agent-based models has been separately treated in literature. It is highly non-trivial topic without unique approach. First let us consider approaches to validation of agent-based model in general, and subsequently the validation of agent-based models for services.

VALIDATION OF AGENT-BASED MODELS

Regarding that matter, Liu compares statistical characteristics of data sets generated *in silico* with the data obtained experimentally and in various areas [2]. Validation on such data sets is considered simpler than validation on realistic data, yet its importance is also smaller. Overall, the use of data sets generated in simulations is useful yet not final step in validation of some model [2]. Moss formulated a spectrum of simulation models which can be put in the ordered list so that neighbouring two models differ slightly in relevant characteristics [3]. On the one end of such a list is the empirical model generated based on the realistic data. On the other end of the list is purely theoretical model, possibly modified by internally generated data. Moss assumed that it is possible to formulate a definite relation between the models which are neighbouring in the list, and eventually thereby link the models on the opposite ends of the list [3]. As a result, one could in principle link theory and experiment. Fonoberova et al.

started from the following fact about formulated models: there are certain variations in output quantities caused by variations in input quantities [4]. These variations are in their approach related to pairs of variations that occur in realistic cases. In that sense a dynamical causal relationship is established and utilised as a basis for validation [4].

VALIDATION OF AGENT-BASED MODELS FOR SERVICES

Having in mind the current status of development of validation procedure for agent-based models in general, it is somewhat expected that validation of agent-based models for services is of similar, rather undeveloped status. Contributions to development of that kind of validation include work of Baxter et al. who use agent-based modelling to formulate Customer Relationship Management approach. In that approach the customer population is sufficiently represented [5]. The authors demonstrate the higher quality of their approach in comparison with approaches utilising macroscopic modelling with averaged data about (potential) customers. The modelling they formulate includes customer population dynamics because of what the authors analyse spreading of information about the company among the customer population [5]. Kaihara analyses supply chain in case when the environment (presumably the customer population) is highly dynamic [6]. It is shown that, after taking into account the interactions between the agents on the market (i.e. the customers) one reaches the optimal distribution for allocating the product between the production and selling [6]. Finally, Terano and Naitoh formulate the agent-based model to extract the optimal market strategy in specific, modelled market [7]. The market is characterised with competition among companies. The companies are agents that optimise their behaviour based on the collected, time-dependent data. They validated their results for the markets of television programme and of audio-cassettes [7].

Following described works, we state the hypothesis that is is possible to formulate and validate agent-based model of dynamics of quality in case of innovative company, market service provider. In case the hypothesis is proved then one can use a large number of tools (i.e. the validated models) to simulate reliably and check regularly quality of company's depertment work, with minimal influence on their predicted functioning. Contrary to that, the rejection of the hypothesis implies either that the contribution of the validated simulation models is rather unimportant to service provider quality dynamics, or that it is not possible to validate formulated models at the present level of understanding. As a result, one would be forced to investigate for possible other approaches to modelling the quality dynamics of a service providing company.

CONCLUSION

To conclude the previous discussion, the problem of quality management is transformed into the following two lower-level problems: (i) how to formulate the simulation model of innovative company, in particular the market service provider, and (ii) how to validate thereby formulated model?

Overall, the stated approach may contribute to development of modelling methodology and simulation of quality management in innovative companies, in particular the service providers.

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