Viable Systems Model: More Support Tools Needed

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Abstract. Stafford Beer proposed a Viable Systems Model, which was supposed to support successful management of enterprises. Since then numerous research works have referred to that model in management, information systems, and computer sciences. However, in the area of enterprise modeling there is a shortage of tools that would give an opportunity to create detailed enterprise models that would adhere to the VSM and would also be applicable for advanced model visualization and analysis. If available, appropriate modeling tools could help to utilize such features of VSM as fractality, distributed control, and variety handling mechanisms; and provide the possibility of overall adherence to those principles of cybernetics that become increasingly important in modeling enterprises in a socio-cyber-physical context.

Keywords: VSM, fractal systems, service systems, variety management, distributed control

1 Introduction

The Viable Systems Model (VSM) was introduced by Stafford Beer [1]. The model was intended for management of autonomous enterprises in changing circumstances. Many explanations in the original model descriptions refer to human nature and organizational systems of enterprises. The author of the model also points to challenges of the application of the model, e.g. difficulty in identifying the granularity of the purpose to be achieved by the autonomous system [2].

The VSM is rooted in ideas of cybernetics and comprises five mutually related systems [3]: System 1 is responsible for the production and delivery of enterprise goods or services to the pertinent environment; System 2 is intended to determine the set of organizational units which comprise System 1; the task of System 3 is to manage the set of operational units comprising System 1; System 4 is mainly responsible for decisions regarding the future role of the enterprise in the environment; System 5's function is to balance the present and future of the enterprise; it constitutes the highest level of authority in the enterprise. One of the essential features of VSM is its suitability for supporting self organization and variability handling, e.g. System 5 can absorb all variability which Systems 3 and 4 cannot absorb between themselves.

The VSM has been applied and supported methodologically and technologically by several followers of Beer's ideas in organizational sciences. The most comprehensive reports on these works are available in [3] and [4]. The model has also been applied to other types of systems. For instance, the VSM has been used in business process management [5, 6], information systems development [7, 8], and in service systems management [9, 10].

Despite many attempts to use the VSM there is still a shortage of tools dedicated to VSM based modeling. Therefore the purpose of this paper is to introduce a discussion on requirements for modeling tools that can help to utilize the strengths of the VSM in the contemporary enterprise modeling environments.

The paper is structured as follows. Section 2 considers benefits of the use of the VSM and also challenges that are related to VSM based modeling. Section 3 discusses VSM based modeling issues in a particular VSM application area. Namely, service provisioning systems are considered using the concept of Viable Enterprise Bus [10]. Section 4 concludes the paper with a short discussion and points to further research regarding VSM based modeling.

2 VSM Based Models: Benefits and Challenges

While enterprise modeling does not necessarily include detailed models of information systems, in this paper we do not neglect them. Therefore, firstly we will examine whether there can really be benefits resulting from the use of the VSM in information systems oriented enterprise modeling (Section 2.1). Afterwards we will discuss the challenges found in VSM based modeling (Section 2.3).

2.1 Benefits of Using VSM

Practically all sources that refer to the VSM, point to the following benefits of the model [3, 4]:

- *Conformance to principles of cybernetics*
- *Fractality*
- *Variability management*
- *Integration of centralization and decentralization (distribution) of control*

These benefits apply to any systems of the enterprise, be they social, information or physical systems.

With respect to information systems in particular, a comprehensive overview and analysis of applications of VSM are provided in [11]. The authors derived the following benefits achieved by using the VSM:

- *Viability* (ability to assess viability)
- *Transparency* (helps users who deal with local parts of the system grasp the system in its broader context)
- *Modeling* organizational structure, environment, and communication flows between subsystems, and also between subsystems and the environment for description, diagnosis, and design purposes

- *Modularization* that helps to decompose complex systems and perform different types of analysis and further decompositions
- *Combinability* (with different systems approaches, with organizational knowledge, for closing the gap between theoretical and practical aspects of agility)
- *Context independency* (the model can be applied to different types of systems)

Considering the above mentioned benefits, it can be concluded that the use of the VSM in enterprise modeling merits the support of enterprise modeling tools. In the next section we will discuss VSM related modeling problems that may have hindered its wider use in enterprise modeling.

2.2 Challenges of VSM based modeling

One of the main challenges is the fact that the *model itself is not very simple*. The VSM prescribes 5 (sub) systems which are connected with a number of information channels (also the information channels that connect subsystems to the environment should be considered; see the visualization of VSM in Fig. 1).

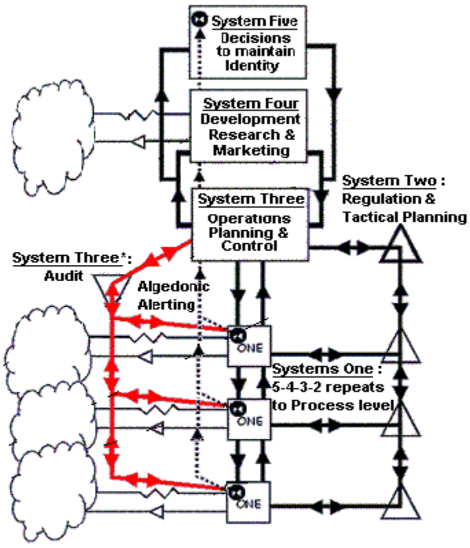

Fig. 1. Viable Systems Model (available at https://commons.wikimedia.org/wiki/File:Vsm.gif)

A two dimensional view of the model does not allow all relationships clearly to be seen. Neither does it allow fractal decomposition of the model to be seen. When considering decomposition, there is no possibility of distinguishing between different types of systems (e.g., software versus social systems). While one of the benefits of the VSM is its independence of context, in the modeling of enterprise architecture it is important to distinguish between different layers of the enterprise [12].

For better visualization of the model, its three dimensional representation with the ability to navigate the fractal levels and relationships has been developed [4] and is available at http://www.vsmod.org/. However, this model can be populated with just the text and it is tailored to organizational systems only. Thus it is hard to use it for modeling business processes or information systems service architectures. However, the implementation of multidimensional visualization of the model helps us to see that this type of representation assists in better populating and navigating the VSM.

Thus, for meeting the first challenge "the model is relatively complex", the following features of the tool could be helpful:

- Multidimensional visual representation of the model (with navigation ability)
- Possibility of populating VSM elements with diagrams

In the previous section, the possibility of combining VSM with other models has been mentioned as one of the benefits. However *there is no research to ascertain which combinations are useful*. Different authors use some of the possible combinations [11], but specifications that could be used in tool development are far from being well defined. It appears natural to combine VSM and ArchiMate [12] language, or VSM and BPMN [13], however, currently suggested combinations do not go beyond the level of hypothesis. Nevertheless we can derive the requirement, that:

- The modeling tools for the use of the VSM must offer an opportunity to directly relate the VSM to models developed by other modeling tools, such as enterprise architecture modeling tools, business process modeling tools, and possibly others.

The above-discussed issues also imply that the modeling tool has to support different types of decomposition. We can distinguish between *fractal decomposition*, where the elements of the representation do not change, but only the scale of representation changes. A well known example of fractal decomposition is a multi-level data flow diagram. In fractal decomposition of VSM, the VSM is decomposed into VSMs at different levels of scale. On the other hand the *decomposition into other types of models* should also be possible. In addition it might be necessary to switch between alternative decompositions. Thus the following requirements emerge:

- Support for VSM fractal decomposition
- Support for nesting of alternative models
- Maintaining several decompositions of one and the same node

Regarding the relationships to the environment (represented by clouds in Fig. 1), these relationships actually can be business intelligence systems that perform monitoring of the environment and analysis of monitoring results. Thus *the relationships (channels) in the original model can turn into the nodes* in the case of the use of business intelligence systems. Therefore one more requirement has to be considered, namely:

- The relationships in the model must have a dual nature: the nature of the link and the nature of the node.

The above discussed challenges show that most probably the use of the VSM on a regular basis in enterprise modeling could be possible only if dedicated modeling tools were available. To develop these, further research is necessary to identify detailed requirements for VSM based modeling tools. To achieve this, both: (1) theoretical analysis of the VSM and (2) analysis of its practical applications should be performed. In the next section we will discuss the concept of Viable Enterprise Bus, which is the application of the VSM to software service provisioning, in order to illustrate some of the practical modeling issues that have to be considered in the context of VSM based modeling.

3 Modeling Issues Regarding Viable Service Bus

In the previous section, while analyzing the challenges of VSM based modeling, a number of requirements for the tools supporting this type of modeling were derived.

In this section we will see how these requirements apply to modeling issues with respect to Viable Service Bus [10] that is suggested as a logical concept of service provisioning systems. It should be noted that Viable Service Bus should not be considered as an obsolete service management concept "enterprise service bus" to be compared with microservice systems [14], as it does not contradict principles behind the microservice architecture.

The author of Viable Service Bus concept [10] Jafarov, suggests accommodating, within the model, 15 design principles based on cybernetic concepts of Beer's VSM [1] - see also Fig. 1. Table 1 illustrates how each principle relates to the tool requirements discussed in the previous section. If the requirement is mandatory to satisfy the principle, "x" is used, and if the requirement could help to satisfy the principle, "v" is used; "!" is used if the implementation of the requirement may cause tool related challenges with respect to the principle. In the remainder of this section the citations of each principle from [10] will be provided. The relationships between the principles and the requirements are derived from explanations of principles in [10] which include detailed statements of the principles, service oriented architecture rationale, and enterprise service bus implications.

Variety principle basically refers to service interoperability. It states that "To obtain control, control must have the variety that is as great as the variety of the situations to be controlled".

Viability principle refers to standardized integration of services for the sake of interoperability. "Remaining viable is the ultimate goal of the system".

Value creation principle mainly refers to service reusability and standardization. "Resources of the system are directed and controlled to achieve viability through effective and efficient value creation".

Value preservation points to the interoperability between existing or newly uploaded or alternative services. "The ongoing survival of the system is dependent on risks management that is dedicated to preserving the proposed value".

Black box imposes service contracts that contain only essential information about the services. "The system must be supplied with interfaces that describe what goes into it, what goes out of it, and what the relations between inputs and outputs are; *encapsulating the logic* of any functions behind it".

Channels principle refers to the messaging system. "The system must provide transparency in capacity management and capability in data transduction, in a secure and reliable manner, in order to achieve viable balance in information channels".

Service recursion principle implies service *abstraction*, *reusability*, statelessness, *discoverability*, and *composability*:" The design of the system, that is derived from the design principles, is invariant, in order to provide cohesion in the system, so that the synergies across the operational units are exploited at all levels of recursion so as to ensure that the system as a whole delivers more than the sum of its parts".

Table 1. Tool requirements for supporting Viable Service Bus design principles

Requirement	Variety	Viability	Value creation	Value preservation	Black box	Channels*	Service recursion*	Service autonomy*	Service deviation	Service bargain	Service performance	Service audit	Service intelligence	Service policy	Service alert
Multidimensional visual representation of the model	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Possibility to populate VSM elements with diagrams	x	x	v	v	x	v	v		v	x	v				x
Relation to other modeling tools		x	x	x	v	v	v			x	v	v	v	v	v
Support for VSM fractal decomposition	x	x	x	x	x	v	x	x	x	x	x	x	x	x	v
Support for nesting of alternative models	x	x	v	v	v	v	v		v	v	v	v			v
Maintaining several decompositions of one and the same node	x	x	v	v	!				v	v	v	v		v	v
The relationships in the model shall have dual nature: the nature of the link and the nature of the node	v	x	x	x	x	x		x	x		x	v	x		x

Service autonomy principle refers to high level of control of services over their environment. "The system and its embedded subsystems must be designed as self-organizing entities, with a maximum degree of autonomy for actions that would only be constrained by the maintenance of cohesion towards the goal of implementing the system".

Service deviation principle refers to good coordination of operations in order to avoid deviations in subsystems. "The system must coordinate the operations to avoid possible deviations in its subsystems, by adjusting them to accepted levels of service provision and by reporting any possible deviations that would assist future improvement and evaluation".

Service bargain principle requires regulation of resource consumption. "The system must regulate its resource consumption, collect the feedback on the services it provides; as well as compare the services and converge them as necessary".

Service performance principle implies monitoring of service performance. "The system must manage the services it provides and monitor their performance against agreed objectives".

Service audit principle implies high variety and intra-operational checks on the services. "The system must undertake sporadic, wide in variety, intra-operational checks on the services it provides; to prevent and remove any impediments which may arise from incidents and problems during operation".

Intelligence principle implies that services are aware of their environment. "The system must have the awareness of the environment that surrounds it; by monitoring it for possible opportunities, which could contribute to overall viability of the system".

Service policy principle implies compliance with legislative and regulatory obligations. "The system as a whole must comply with legislative and regulatory obligations, and have a clear policy that would define consistent identity of the system, its goal and its purpose".

Service alert principle implies that the "system must be endowed with a mechanism that would alert it in situations that require immediate actions".

Table 1 shows that all requirements derived from VSM tool support challenges are relevant for Viable Enterprise Service Bus design principles. In the header of the table, some principles are marked with an asterisk. These are principles (namely, Channels, Service recursion, Service autonomy) that required features which were not derived from the analysis of tool support challenges in Section 2. To support these principles the following additional requirements for VSM based modeling support can be stated:

- The tool shall support bottom-up abstraction in each fractal level and among the levels
- The tool shall support searchable service (and possibly different architecture pattern) library
- Not only should the links of the VSM have dual nature (link and node), but the same applies also to nodes of the VSM.

4 Conclusions

This paper introduces discussion about modeling tools that would be appropriate to Viable Systems Model (VSM) based modeling. By analyzing challenges of VSM based modeling, seven requirements for tool support were derived. These requirements were analyzed against Viable Service Bus design principles as one of the application examples of VSM based modeling. The analysis revealed that all requirements are valid, but the set of these requirements has to be extended with the addition of three more requirements. Thus the paper reveals altogether 10 requirements that should be met in tools that can be used for VSM based modeling. These requirements are VSM specific and do not mention many "default" features that are common in contemporary modeling tools. The statements of requirements used in the paper are acknowledged to be rather shallow and have only an illustrative purpose. In future, in order to achieve more rigorous requirements, the direction should be towards deeper theoretical research and experiments. Nevertheless the paper provides a starting point for further activities in tool development for VSM based modeling.

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