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# The Organization of Software Development: A Cybernetic Perspective

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## Abstract

*This paper considers an organizational perspective upon software development. It proposes the use of a cybernetic approach is complementary to the more conventional software process improvement paradigm. The findings of three case studies are briefly presented.*

## Introduction

The rise of the Software Process Improvement (SPI) paradigm has been widely recounted. By focusing upon the processes undertaken in software development, researchers have sought to identify models of good practice which are conducive to high quality of output.

The concern of this paper is to introduce a complementary programme of work which focuses upon organizational issues i.e. the broader context within which processes take place. Through this organizational perspective we seek to consider how software quality is affected by the structures of the organization and their interaction with the business environment i.e. issues outwith the remit of conventional SPI practice.

Thus the question we address in this paper is: "How should software development be optimally organized?". We argue that a coherent, theoretical foundation is required on which to base the analysis and design of organizational processes. Such a foundation is obtained from the study of patterns of organization known as cybernetics (Wiener 1948, Ashby 1965). Cybernetics has been influential in the development of systems approaches to the study of human organizations (Checkland, 1981) and continues as a broad subject of enquiry today (Capra, 1996). The particular focus of this paper is upon the Viable System Model (VSM) and its use in the diagnosis of the effectiveness of software development teams. An important feature of the VSM is that it can be applied to organizational design at any level of "recursion" (e.g. the team, the department, the organisation as a whole).

## The Viable System Model (VSM)

In a series of idiosyncratic books, Beer has proposed a cybernetic theory of effective organization (Beer, 1972; Beer, 1979; Beer, 1985). In these, he sets out a model of what he terms a *viable system*, i.e. a system (an organization of some kind) which is capable of maintaining separate existence, of surviving on its own (1979, p.113). This is the central idea in Beer's philosophy. Organizations (at whatever level) are to be seen as systems (i.e. goal directed entities made up of interacting parts, operating in an environment of some kind). The issue is: what form of internal "architecture" is required if these systems are to be viable?

In this paper we will restrict ourselves to a scanty description of the five sub-systems of the VSM. Beer proposes that each of these must exist and be effective in order for an organization to be viable.

- System One is concerned with operations. It is made up of a collection of operational systems, each comprising an area of operational activity (operational unit) and the local management structure responsible for directly managing the operational unit (operational management).
- System Two is concerned with coordination. It provides a co-ordination service which 'dampens' the instability caused by conflict between parts of System One. For example, a process model might constitute a System Two where it provides a framework for co-operation between production teams.
- System Three is concerned with management. It steers the organization towards its current objectives. It interprets the policy decisions of higher management and maintains the operations of System One. To System Three, the internal operations of System One are opaque; perforce, it carries out its management on a resources-results basis.
- System Four is concerned with organizational intelligence. It enables the organization to learn and adapt. It searches the environment of the organization for opportunities and threats. It provides a model of the organization and the environment which serves as a basis upon which hypotheses are explored and changes proposed to the organization as a whole (e.g. "move into Java development").
- System Five is concerned with policy. The values and beliefs espoused through System Five should be shared with all other elements of the organization. An important part of this role is thus to arbitrate between System Three and System Four. Conflict can arise because of the different functional emphases on the status quo (System Three) and change (System Four).

The reader seeking to know more about VSM is referred to the original texts of Beer and to related academic writings (e.g. Flood & Jackson, 1991). Our presentation of case studies will be confined to reporting some of our findings. It is not necessary for the reader to have a full understanding of VSM in order to proceed with this paper.

## Case Studies

Carrying out a VSM study of an existing organization involves the development of a mapping between the components and the model and the individuals, teams and departments that the modeller identifies in the organization. This mapping allows the modeller to identify omissions (i.e. threats to viability) in the organization and to critique its capability to carry out the different functions effectively. In this way the use of the VSM can assist a diagnostic of organizational effectiveness.

In three case studies the VSM has been found to be a useful diagnostic aid. In each we were able to identify issues which threatened product quality and organizational viability. The three case studies concern Daffodil Systems, Violet Computing and Heather Manufacturing Systems (pseudonyms have been used in all cases).

### *Daffodil Systems*

Daffodil Systems (DS) was a small in-house software development department (sixteen programmers) of a company that operated chemical plants. The department was sub-divided into two further teams, one of which specialised in mainframe based software whilst the other developed PC applications. As much of the work undertaken by DS was safety-critical they had been required to gain certification from government agencies. This they had achieved and, in addition, had gained a reputation for high quality through the parent company's own internal quality audits.

At the time of the study the parent company was introducing some radical organizational changes that would affect DS. In particular, the monopoly that DS held for internal projects was to be ended. In future, project managers who required software development would be able to go to external software houses as well as DS.

In the face of this change, DS's strategy was to continue to operate as they had been doing and to rely upon their existing processes to continue to uphold their quality of output and by this to continue to win orders from project managers. Superficially, this strategy seemed to have merit. However, the VSM analysis exposed the unsafe assumptions upon which it was founded.

The analysis highlighted the System 2 functionality whereby the two teams within DS (i.e. mainframe and PC's) shared programmer resources. Coordination within DS relied upon an informal system which was operated by the two team leaders. When a new project was initiated, each team leader would schedule it so as to make sure that its completion date avoided completion dates held by the other team. By doing so they were able to share resources between the teams. For example, if the mainframe team were close to the completion of a project they could Ôborrow' an additional programmer from the PC team (e.g. to undertake additional testing duties). By sharing resource in this way they were able to operate to high quality standards even under the stress of an impending completion date.

As a result of the VSM analysis we were able to point out how this informal arrangement for sharing resource was unsuited to the new, competitive business environment that DS would operate in. The team leaders relied upon being able to schedule the completion of projects at their discretion. The project managers who needed the software products had very limited powers to contest the decision as they were unable to take their business elsewhere. As a result of the ending of DS's monopoly completion dates would become as negotiable as price and specification. This would mean that the team leaders would lose some discretion over these completion dates. As a result the two teams were likely to find that they had projects whose completion dates coincided. They would then be unable to Ôborrow' resource from the other. This would make it more difficult to complete projects successfully and could threaten quality (e.g. if tests or peer reviews were sacrificed because of resource shortage).

### *Violet Computing*

Violet Computing (VC) was a large, well-established operating systems development team. Over a number of years VC had undertaken several quality initiatives and as a result were recent winners of a prestigious quality award. As our study commenced a series of organizational changes were being introduced to VC. These were intended to encourage product stability whilst enhancing the responsiveness of the team to customer requirements and to encourage product stability. A principal means of achieving these goals was the initiation of a project structure for the various development teams within VC. This meant that enhancements to the product would be carried out if and only if customers requested them.

Our VSM analysis was extensive. Whilst we could see the rationale that underpinned the change to a project structure we became concerned by some of its likely effects. In particular we found that the recent organizational changes assumed that the business environment would be stable and that the enhancements requested by customers would be relatively minor in scale. The VSM analysis showed how meta-systemic (i.e. Systems 3, 4 & 5) management of technical issues would be ineffective in a number of other circumstances. VC would have difficulty in initiating technical enhancements for their own sake (e.g. in anticipation of customer requirements) and would be unable to manage enhancements that affected a large number of the development teams. In effect they had devolved too much power from Systems 3, 4 & 5 to System 1. Quality could then be endangered if the teams were required to undertake fundamental enhancements to the product without support from an effective organizational structure.

### *Heather Manufacturing Systems*

Our study of Heather Management Systems (HMS) concerned a groupware development project. This was being undertaken by and for the sales division of the company. Although their project had been well received by users, there was concern over a number of issues at the time of our VSM analysis. In particular, it was felt that the project was not addressing some pressing issues.

Our VSM analysis quickly established the reason why. The project was founded upon the assumption that the sales division had a high degree of autonomy. The VSM showed that this assumption was unsafe; in practice the sales division was engaged in a series of collaborative networks with other teams. Therefore, the groupware project, which was solely concerned with the sales division, could not address issues those important areas of functionality which were the shared province of the sales division and other divisions. As a result we proposed that the groupware development project be redefined so as to give it wider organizational authority. Our proposal has gained credence in the organization as already some divisions other than sales have now started to adopt the groupware technology.

## Conclusion

These studies are encouraging. In each case, using the VSM, we have been able to shed light on organizational issues which affected the efficacy of software development. Further to this it is interesting to note that two of our cases (DS and VC) concerned organizations that had achieved a reputation for high quality. Yet in these cases there were threats to quality which seemed to stem from beyond the software development process itself. The DS case is particularly clear. Faced with wide-ranging organizational changes they took the decision to trust in their technical competence and to keep operating as they always had done. This was in the defensible belief that by operating in the established manner they would maintain standards of quality and reap the reward in the marketplace. However, we were able to identify how the organizational changes would undermine some of their working practices with consequent threats to quality. As a result, DS were able to introduce process changes in anticipation of the difficulties that were likely to arise.

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