A Model for Selecting CSCW Technologies for Distributed Software Maintenance Teams in Virtual Organisations

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Abstract

Software maintenance, just like any other software engineering activity, is being conducted in an increasingly distributed manner by teams which are often virtual. This paper critically reviews existing models for Virtual Organisations, investigates issues affecting Distributed Software Maintenance Teams (DSMT) and proposes a model for selecting the appropriate Computer Supported Cooperative Work (CSCW) and Groupware tools and technologies in order to facilitate communication and resource allocation for DSMT. This model builds on current theories, classifications and major concepts in the area of CSCW and advances the way DSMT are perceived. This theoretical model is yet to be empirically evaluated and enriched so that it includes Workflow management systems.

1. Introduction

Modern organisations face a dynamic environment that requires flexible and fast responses to changing business needs. Many of them have responded by adopting decentralised, team-based, distributed structures, described in the literature as virtual, network, or cluster organisations [8], [12].

A *virtual organisation* (VO) is defined as a geographically distributed organisation whose members are bound by a long-term common interest or goal, and who communicate and coordinate their work through information technology [1]. A key feature of VOs is the high degree of internal communication which they exhibit. Email has traditionally been used to share information and coordinate work, calling on expertise whenever needed regardless of where it resides. Recent technological advances now permit more formal and powerful means of communication, allowing groups to create and sustain a stronger identity without a shared physical setting and enabling it to exist without having visible participants [10], [14].

IT organisations quickly embraced distributed and virtual structures for their software engineering teams. One area where this has been successfully applied is in the area of software maintenance, a team-based activity which requires co-operation, formalised communication and relevant technological support, including CSCW and Groupware [19]. Maintenance tasks, starting from a request for change, all the way down to analysis, design, implementation, testing and delivery require communication in order to explore the alternatives, and documentation of past experience so as to aid the decision making process. It is known that more than 60% of the maintainers time is spent on looking for information that often have already been discovered during past maintenance activities [5].

The remaining of the paper is organised as follows: Section 2 critiques existing VO models and identifies related issues of concern. Section 3 investigates issues affecting DSMT in VOs. Section 4 proposes a model for selecting CSCW tools for supporting such maintenance teams. Finally, section 5 concludes the paper.

2. Virtual organisation models critique

A key factor in organisational survival is the ability to become faster, leaner, more competitive, customer-oriented and conscious of cost than ever before. As a result organisations have developed virtual structures in order to have greater leverage for flexibility than static organisations. VOs exist in cyberspace and are naturally build upon technology. However, the attributes that underpin their functionality rely primarily upon intangible elements such as trust and relationships.

An impressive array of different models, methodologies, theories and techniques exist for identifying and classifying concepts, dimensions and variables that characterise VOs and facilitate understanding of their structure and operations. This section briefly discusses and critiques eight VO models and attempts to underline any significant differences and detect common ground amongst various perspectives. These models can be grouped into four main categories according to their main focus on VO structure, communication, processes and lifespan.

- Burn et al. define six different forms of VO known as "*models of virtuality*" [4]. These depict the diversity of forms that a business operating in the VO may

undergo. The six forms are: (i) virtual faces, (ii) co-alliance models, (iii) star-alliance models, (iv) value-alliance models, (v) market alliance models and (vi) virtual brokers. The culture of a VO depends on the structural alliance, strategic positioning, knowledge management, and information communication technology surrounding that organisation [11]. The model of virtuality is very useful in specifying the various 'virtual' structures that an organisation may have. However it does not provide any kind of information regarding communication and networking issues. Moreover this approach is rather business oriented and lacks any significant technical detail.

- According to Ahuja, degree of hierarchy, centralisation and hierarchical levels are three distinct dimensions of structure [1]. *Degree of hierarchy* is reflected by the degree to which relationships in a network are directly reciprocal. *Centralisation* reflects the extent to which a network or group is organised around its focal point. *Hierarchical levels* reflect the number of levels one must go through in order to obtain information. This approach incorporates structure, networking and communication in both team and individual level. Still this model is not detailed enough and its dimensions are very generic.
- Van Wijk et al. propose a *VO life cycle model* that defines seven steps in the formation and dissolution of a VO, namely: (i) modification of strategy, (ii) co-operation strategy, (iii) weigh co-operation alternatives, (iv) selection of partners, (v) design and integration, (vi) management and (vii) dissolution and evaluation [20]. The model is quite accurate in considering the temporal nature of virtual organisations and has resulted from impressive literature survey on VOs lifecycle.
- The *dynamic decision style* model developed by Driver uses two dimensions of information processing [9]. *Information use* refers to the amount of information a person typically uses in decision-making. The *focus dimension* is concerned with whether the final outcome is focused on one single best solution or on many alternatives. These dimensions are used to construct a grid of five basic styles: (i) decisive, (ii) flexible, (iii) hierarchic, (iv) integrative and (v) systematic. This model regards the cognitive aspects of participants in virtual organisations as very important in helping towards organisation success. This perspective has certain merits but it overemphasises on human issues and more specifically individual characteristics as compared to structure and communication technology issues of VOs. It could be argued that decision making in virtual organisations is usually dictated from strict formal procedures.
- Palmer and Speier conducted a survey on fifty five organisations employing the virtual models [17]. Respondents identified several criteria, such as the scope of the work, the projected time spent on virtual work, types of projects, the range of involvement and the number of personnel involved, which suggest four *distinct VO types*: (i) permanent VOs, (ii) virtual teams, (iii) virtual projects and (iv) temporary VOs. The sample of this survey is relatively small and the resulted classification largely ignored in the recent VO literature.
- Campbell provides another *typology for VOs* according to structure, number of collaborating parties and communication patterns [6]. The four proposed types of VO are: (i) internal VO, (ii) stable VO, (iii) dynamic VO and (iv) web-company. This model focuses on the lifespan of relationships between collaborating parties. The 'stable VO' is challenged as a virtual organisation type.
- Mowshowitz considers advances in transportation, communication, and computing as necessary but not sufficient conditions for the emergence of the new VO paradigm. Standardisation of interaction, commoditisation of information and abstractification of property are the three distinctive sociotechnological patterns supporting VO [15]. Mowshowitz's approach is regarded as setting the foundation on the theory for the virtual organisation. However, there is an ongoing debate that Mowshowitz tends to a 'virtually organising' than a 'virtual organisation' perspective.
- Shao et al. discuss another VO model containing four variables: (i) connectivity, (ii) purpose, (iii) technology and (iv) boundary. Although they do not claim these variables to be the only ones defining VOs, they provide a useful *classification framework* for recognising VOs and for predicting part of their behaviour [18]. The clarity and ease of use of this model justify its popularity among VO managers and practitioners.

Table 1: Virtual organisation issues

	Ahuja	Burn	Campbell	Driver	Mowshowitz	Palmer	Shao	Van Wijk
Structure/Hierarchy	√	√	√				√	√
Communication/Interaction			√		√		√	√
Operations/Processes/Information	√	√		√	√		√	√
Lifespan			√			√		

Each of these models focuses on different aspects of VO. Some important concepts that are met more than once include structure (Burn), hierarchy (Ahuja), lifespan (Palmer), operations (Driver), communication (Campbell), information use (Driver), and interaction (Mowshowitz). There are also models that focus on the technological side of VO (Shao), some regard the underlying business model as most important (Van Wijk), while others are concerned with human related issues (Palmer). These models contribute into identifying the major issues of concern regarding VO and understanding how these issues might affect the structure, communications, operations and lifespan in DSMT. Table 1 presents all eight different VO models and whether they deal with such issues or not.

3. Investigation

Organisations and teams with virtual existence have special requirements relating to their particular characteristics such as distributed nature, time differences and cultural conflicts [7]. A number of issues arise, that affect teams in VOs as shown in the previous section, these are: *hierarchy*, *interaction*, *operations* and *lifespan*. This section discusses how these issues affect software maintenance teams and transform their requirements.

Previous work has revealed certain differences in the way maintenance teams operate [5], [19]. Firstly, *communication* among team members needs to be adequate in terms of both quality and quantity. A formalised method to document knowledge and expertise of experienced maintainers would formulate a *knowledge repository* which can be used across geographical and temporal frontiers. In a similar manner, DSMT need to establish a *pool of skills* which relate not only to programming languages, platforms and the like but also to specific applications and software versions/variants. Finally it is essential that team members *role attributes* are statically or more usually dynamically established in an effort to better utilise the full potential of the human factor across the VO.

4. Proposed model

CSCW research grew out of what was perceived to be some of the critical limitations of the office automation research program with its emphasis on automating office processes and procedures. The thrust of much of this research has been on developing an in-depth understanding of the practical contingencies of work practices. In contrast, the Workflow Management Systems (WFMS) research has its origins in the *business process reengineering* school with its focus on developing models of business processes and the associated workflows in order to design the systems needed to effectively manage these processes [2], [13]. The processes may be intra- or inter-organisational (e.g. business process modelling, team-based problem solving, and cross-tool working) and typically cut across multiple functions such as purchasing, inventory control, manufacturing, sales, and accounting. The specific set of tasks, resources, and information elements involved in the fulfilment of a business process such as order fulfilment or new product introduction constitutes a formal definition of a workflow [3].

According to the *n*-dim group in Carnegie Mellon University, "it is not surprising that the above two rather divergent perspectives on modelling work and designing computer systems to support work processes have contributed to an as yet unresolved debate". Given the nature of the collaborative work in DSMT that we attempt to support, a CSCW approach appears more appropriate. Current work is based on Nunamaker's work in classifying Groupware applications and tools, where WFMS are regarded as a single 'Workflow' applications category [16]. Future plans include expanding this model to cover WFMS in detail.

Hence, we propose a model for selecting suitable CSCW technologies, applications and tools for supporting DSMT that work as part of a VO. There is a variety of CSCW technologies that support either the communication or the resource and task structure of teams [16]. Certain technologies that are useful for generic collocated teams could prove obsolete for "virtual" ones.

Therefore, two filters are used to facilitate the identification of the most suitable CSCW technology. The first filter utilises the main DSTM requirements such as adequate communication, a skill pool, a knowledge repository and the role attributes. The second filter takes into account the principal VO issues of hierarchy, operations, interactions and lifespan. As shown on Table 2, email, Electronic Meeting Systems (EMS) and Video Conferencing (VC) may be used to satisfy communication requirements in DSMTs. Each one of these technologies has a different suitability level according to the communication needs of the team. Furthermore, their suitability must be also checked against VO issues such as the lifespan of the project/team and the cost of investment.

Table 2: Selecting CSCW technologies

CSCW tools	DSMT Requirement			VO Issues		
	Ad. Communication			Lifespan		
	High	Medium	Low	High	Medium	Low
Email	√	√		√	√	√
EMS		√	√	√		
VC	√	√		√	√	

This model is presented in Figure 1 and is supported by the following formula (1):

DSMT Maturity = DSMT Requirements + VO Issues + CSCW (1)

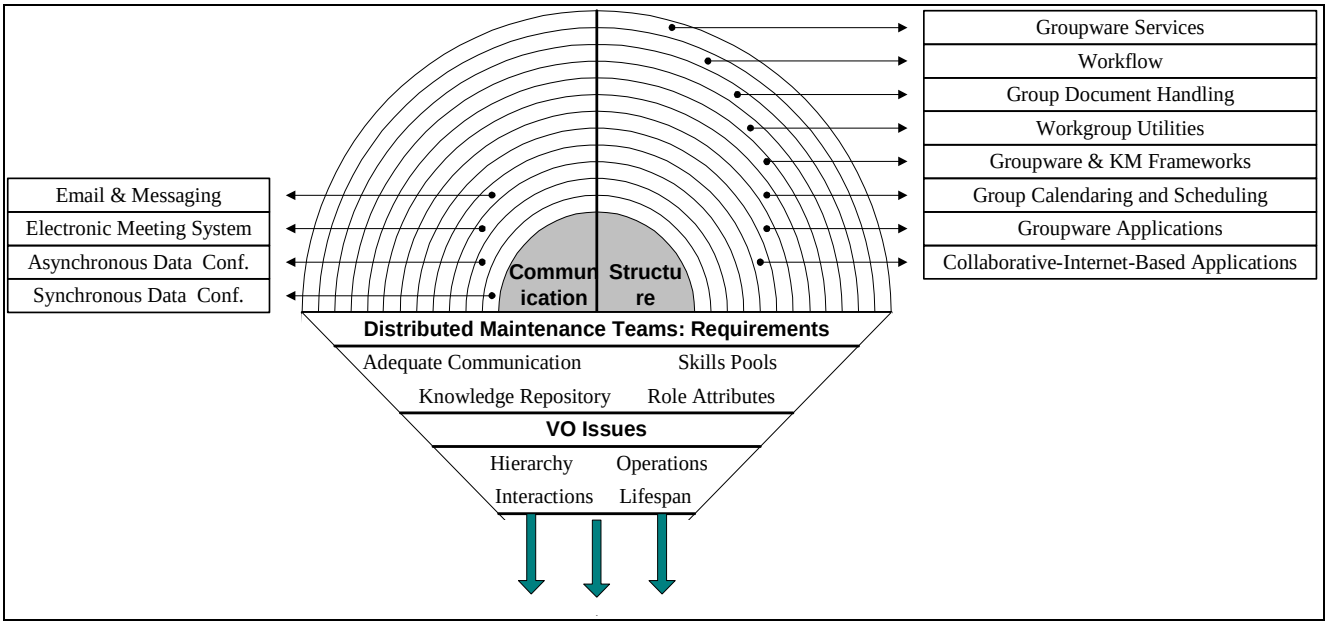

Figure 1: A selection model for CSCW technologies

The formula could be used to estimate success in achieving maturity in DSMT with respect to three key factors:

- Meeting DSMT requirements.
- Addressing Virtual Organisation issues.
- Using efficiently any supporting CSCW technology.

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