Agile professional virtual community inheritance via the adaptation of social protocols

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Abstract: Support for human-to-human interactions over a network is still insufficient, particularly for Professional Virtual Communities (PVCs). Among other limitations, adaptation and the learning-by-experience capability of humans are not taken into account in the existing models for collaboration processes in PVCs. This paper presents a model for adaptive human collaboration. A key element of this model is the use of negotiation for the adaptation of social protocols' modelling processes. A second contribution is the proposition of various adaptation propagation strategies as a means to continuously manage the PVC inheritance.

Keywords: adaptation; social protocols; professional virtual communities; PVCs; inheritance.

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1 Introduction

Enterprises constantly increase their efforts to improve their business processes. A main reason for this may be the fact that enterprises are exposed to a highly competitive global market. Among the most visible actions associated with this effort towards better support for better business processes, one may distinguish the current research work concerning web services and associated standards; high-level languages such as Web Services Business Process Execution Language (WS-BPEL) (Alves *et al.*, 2007) or Web Services Coordination (WS-Coordination) (Feingold and Jeyaraman, 2007) take the service concept one step further by providing a method to define and support workflows and business processes.

However, it should be noticed that most of these actions are directed towards interoperable machine-to-machine interactions over a network. Support for *human-to-human* interactions over a network is still insufficient and more research has to be done to provide both theoretical and practical knowledge to this field.

Among the various reasons for the weak support for human-to-human interactions, one may distinguish the following three reasons: first, many *social elements* are involved in the interactions among humans. An example of such a social element may be the role played by humans during their interactions. Social elements are usually difficult to model, *e.g.*, integrating nonverbal communication to collaboration models. Therefore, their integration to a model of interaction between humans is not easy. A second reason concerns the *adaptation capabilities* of humans, which are not only far more advanced than the adaptation capabilities of software entities, but are also not taken into account in the existing models for collaboration processes. A third reason is the *learning-by-experience* capability of humans, *i.e.*, the capability to extract know-how and knowledge from previous experiences and reuse it in similar situations.

Human-to-human interactions between people sharing a common practice have been studied for many years. Wenger (1998) coined the term ‘Community of Practice’ (CoP) to refer to “a set of interacting people engaged in a common practice. Practice refers to the work people do, but also to the ideas behind it – the shared understandings and the activities”. More recently, Wenger *et al.* (2002) refined the CoP concept by proposing the following definition: “a set of people who share a concerns, a set of problems, or a passion about the topic, who deepen their knowledge and expertise in this area by interacting on an ongoing basis”. Further refinements may be found in Coakes and Clarke (2006).

The concept of *Professional Virtual Communities* (PVCs) was proposed by the ECOLEAD project (2004–2008) and formalised by Bifulco and Santoro (2005) as a generalisation of CoPs. While the studies on CoPs focus mainly on interactions and, more specifically, the ‘common practice’, the interactions in PVCs may be classified into three areas: social, business and knowledge. While the core component of CoPs is the exchange of knowledge and experience via a common practice, social, business and knowledge elements are necessary for sustainable, motivated and durable PVCs (Crave and Vorobey, 2008).

The insufficient support for human-to-human interactions over a network is a strong limitation of a wide adoption of PVCs. As mentioned in Camarinha-Matos *et al.* (2005), a “professional virtual community represents the combination of concepts of virtual community and professional community. Virtual communities are defined as social systems of networks of individuals, who use computer technologies to mediate their relationships. Professional communities provide environments for professionals to share the body of knowledge of their professions […].” According to Chituc and Azevedo (2005), little attention has been paid to the social perspective on Collaborative Networks’ (CNs) business environment, including PVCs, in which social aspects are of high importance.

This paper is an attempt to provide a model for the human-to-human interactions within PVCs. The proposed model addresses, at least to some extent, the three characteristics of the interactions between humans. However, it should be kept in mind that the results presented here are a work in progress and, therefore, they are not claimed to be neither sufficient nor exhaustive.

The rest of this paper is organised as follows. In Section 2, the concept of *social protocol*, used to model collaboration processes, is presented. Section 3 then expands on the *adaptation* of social protocols. Next, *agile PVC inheritance* based on adaptation propagation strategies is discussed. Finally, Section 5 concludes this paper.

2 Structuring collaboration in PVCs

Appropriate support for structured collaborations in PVCs implies an analysis of PVCs as a sociosystem. Based on the characteristics of PVCs identified by such an analysis, an appropriate model of group interactions can be designed.

2.1 PVCs as heterogeneous and dynamic environments

As defined by Ekholm and Fridqvist (1996), "a human *sociosystem* has a composition of human individuals, its structure is the social behaviour repertoire, *i.e.*, interaction among human individuals". The sociosystem of PVCs is highly *heterogeneous* and *dynamic*.

The heterogeneity of PVCs exists at various levels of granularity. At a high level, a PVC usually consists of many different Virtual Teams (VTs). Each VT is different from the others co-existing in the same PVC in terms of goals, intentions, knowledge, processes, members, *etc*. At a lower level, one may notice that the structure of a VT is usually complex and heterogeneous. The roles played by the VT members, their skills and competences usually present a high level of diversity. A formal definition of VTs may be found in Santoro and Bifulco (2008).

Similar to the heterogeneity of PVCs, the dynamics of PVC exists at various levels of granularity. At a high level, the set of VTs that the PVC consists of evolves over time: new VTs are created to answer new needs and opportunities, unnecessary VTs are dissolved, the existing VTs change as new members enter and leave the community, *etc*. The dynamics of PVCs may hardly (not to say cannot) be foreseen at design time, as changes in a given PVC are naturally related to changes in its business environment (which is usually not a deterministic system). At a lower level, the structure of a VT evolves over time: some members may have job promotions and the skills of the members usually evolve (improve) in time. Additionally, the members of a given VT may face new situations implying the development of new solutions, new ways to collaborate, *etc*.

The solutions proposed in our former work to support the heterogeneity and dynamics of PVCs are summarised in Table 1. The heterogeneity of both PVCs and VTs is addressed by the concept of *social protocols*. The dynamics of PVCs are addressed by *group actions*, while the dynamics of VTs are addressed by the *adaptation of social protocols*. These three concepts will be presented in the next sections.

Table 1 Support for the heterogeneity and dynamics of PVCs

Levels of granularity	*Heterogeneity*	*Dynamics*
PVCs	Social protocols	Group actions
VTs	Social protocols	Adaptation

2.2 Modelling group interactions with social protocols

Support for human-to-human collaboration in PVCs should take into account the characteristics of PVCs as sociosystems that were presented in the previous subsection, *i.e.*, heterogeneity and dynamics.

2.2.1 Overview of social protocols

A first model for group interactions within a PVC was presented in Picard (2005). The proposed model is based on the concept of *social protocol*. Social protocols model collaboration at a group level. The interactions of the collaborators are captured by social protocols. Interactions are strongly related to social aspects such as the role played by collaborators. The proposed model integrates some of these social aspects, which may explain the choice of the term 'social protocols'. The heterogeneity of PVCs at the VT level is then at least partially addressed by the social protocol approach.

A social protocol aims to model a set of collaboration processes in the same way a class models a set of objects in object-oriented programming. In other words, a social protocol may be seen as a model whose instances are collaboration processes. Within a given PVC, various social protocols may be used to control the interactions within different subcommunities, addressing at least partially the high-level heterogeneity of PVCs.

Formally, a *social protocol p* is a finite-state machine consisting of $\{ S_p, S_p^{start}, S_p^{end}, T_p \}$, where S_p is the set of states, $S_p^{start} \subset S$ is the set of starting states, $S_p^{end} \subset S$ is the set of ending states and $S_p^{start} \cap S_p^{end} = \emptyset$, T_p is the set of transitions from state to state.

In a social protocol, collaborators – as a group – move from state to state via transitions. A transition may be triggered only by a collaborator labelled with the appropriate role. A transition is associated with the execution of an action. The execution of an action means the execution of remote code. Simple Object Access Protocol (SOAP) or Common Object Requesting Broker Architecture (CORBA) are examples of technologies that may be used for such remote code executions. A formal definition of the proposed model was already presented in Picard (2006a), while an algorithm for the structural validation of social protocols was presented in Picard (2007a).

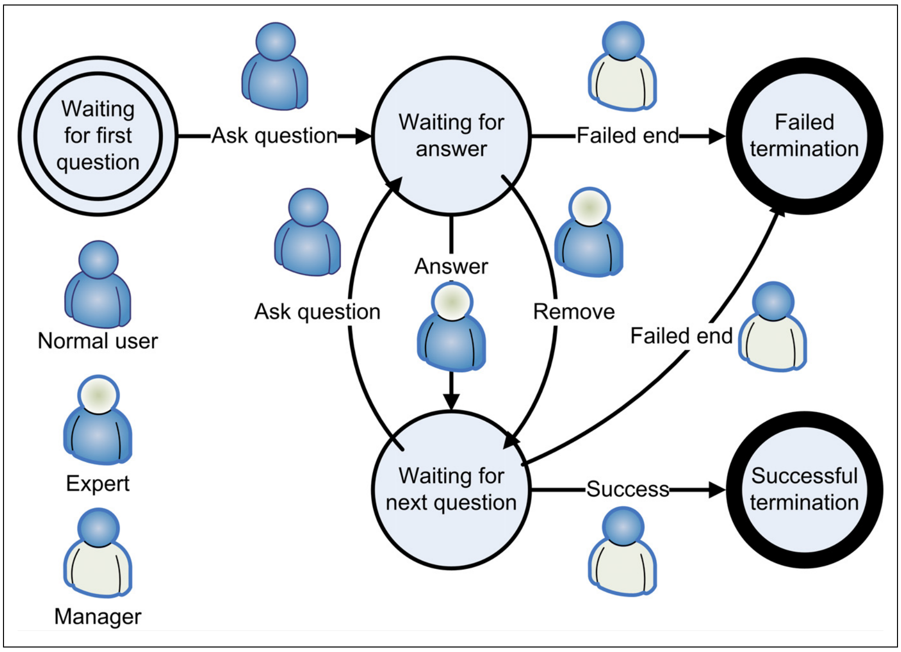
2.2.2 Social protocol example

A social protocol example, which is presented in this section, is oversimplified for readability reasons. Social protocols modelling real-world collaboration processes are usually much more complex.

The chosen collaboration process to be modelled as a social protocol may be described as follows: a set of users are collaborating on the establishment of Frequently Asked Questions (FAQ). Some users only ask questions, while others, referred to as 'experts' may answer the questions. Other users, referred to as 'managers', may interrupt the work on the FAQ document. The work on the document may be terminated either by a success (the document is written and the manager estimates that its quality is good enough to be published) or by a failure (the users do not find any way to collaborate and the manager estimates that the work on the FAQ should be interrupted).

A possible model of this collaboration process as a social protocol is presented in Figure 1. Five states are represented as circles. 'Waiting for first question' is a starting state; 'Failed termination' and 'Successful termination' are ending states. The transitions are represented as arrows, with an icon representing the associated role and text for the associated action.

Figure 1 A social protocol example (see online version for colours)



2.2.3 Group actions

A set of *group actions* have been identified to support *group dynamics*, *i.e.*, the dynamics of PVCs at a high level. A group action is a special action that may be executed to modify the set of VTs that the PVC consists of. A group action may, for instance, allows a collaborator to split a group into two or more groups or merge two or more groups into a single group. Group dynamics may be modelled by a set of group actions. More details may be found in Picard (2005).

2.2.4 Abstract, (semi-)implemented social protocols and social processes

The social protocol concept is refined by introducing three types of social protocols: abstract, semi-implemented and implemented.

An *abstract social protocol* is a definition of the potential interactions among various abstract collaborators in an abstract environment. An abstract collaborator is a hypothetical human being who possesses given skills and plays a given social role.

An example of an abstract collaborator may be a 'logistics expert'. The abstract environment refers to a set of potentially available services without any related implementation. For instance, an abstract environment may possess message delivery means, whatever the implementation of this service may be (e-mail, fax or a message-oriented middleware). Therefore, an abstract social protocol defines collaboration in abstract means and requires additional specification of the implementation of both collaborators and actions.

An *implemented social protocol* is a definition of the potential interactions among various identified collaborators, with a specification of all the potential actions as services provided by the environment. In an implemented social protocol, all social roles are assigned to existing human beings and potential actions may be executed by identified software entities. Therefore, an implemented social protocol may be instantiated as a *social process*.

A *social process* is an instantiation of an implemented social protocol. The state of the collaboration process (*i.e.*, the current state) is stored in a social process ruled according to a given implemented social protocol. Using the comparison above, an abstract social protocol may be seen as an interface or abstract class and an implemented social protocol may be seen as an implemented class, while a social process may be seen as an object in the object-oriented programming paradigm.

Finally, *semi-implemented social protocols* are social protocols whose implementation is partially specified: some collaborators may already be identified, while some other collaborators still have to be identified. Similarly, the implementation of some actions may be known, while the implementation of other actions still have to be specified. The concept of semi-implemented social protocols is particularly important in the PVC context. Indeed, some recurrent services may be offered by the PVC. Therefore, some abstract social protocols may be semi-implemented with the help of the services provided by the PVC, while other actions, depending on future VTs, may not be specified *ex ante*.

The relations between abstract, semi-implemented, implemented social protocols and social processes are summarised in Table 2.

Table 2 Abstract, (semi-)implemented social protocols and social processes

Types of social protocols	*Collaborators*	*Actions*	*Current state*	*Object-oriented paradigm*
Abstract social protocol	Abstract	Abstract	N/A	Interface
Semi-implemented social protocol	Partially specified	Partially specified	N/A	Abstract class
Implemented social protocol	Fully specified	Fully specified	N/A	Class
Social process	Fully specified	Fully specified	Known	Object

3 Adaptive social protocols

Social protocols address the heterogeneity of PVCs at both high and low levels and dynamics, at a high level (with the help of group actions). However, the need to support the dynamics of PVCs is still only partially addressed at the VT level.

3.1 Runtime versus design-time adaptation

In the workflow management literature, the information required to model and control a collaboration process has been classified according to various perspectives. In van der Aalst *et al.* (2003), five perspectives have been presented:

1. the *functional perspective* focuses on the activities to be performed
2. the *process perspective* focuses on the execution conditions for activities
3. the *organisation perspective* focuses on the organisational structure of the population that may potentially execute activities
4. the *information perspective* focuses on the data flow among tasks
5. the *operation perspective* focuses on the elementary operations performed by applications and resources.

A sixth perspective has been added in Daoudi and Nurcan (2007): the *intentional perspective* focuses on the goals and strategies related to a given process. One may easily notice that all six perspectives focus on elements that evolve over time.

In typical workflow management systems, two parts may be distinguished: a *design-time* part allows the definition of workflow schemas, while the *runtime* part is responsible for the execution of workflow instances. A main limitation of typical workflow management systems is the fact that once a workflow schema is instantiated, the execution of the workflow instance must stick to the workflow schema until it ends. This limitation is not an issue if the lifespan of the workflow instances is short compared to the time interval between two requests for changes in the workflow schema. When the lifespan of the workflow instances is long compared to the time interval between two requests for changes in the workflow schema, a high number of workflow instances has to be executed with an 'incorrect' workflow schema (*i.e.*, one that does not take the required changes into account) or cancelled. As a consequence, typical workflow management systems are not flexible enough to support collaborative processes in two cases: highly dynamic, competitive markets/environments and long-lasting collaboration processes.

In the case of highly dynamic, competitive markets/environments or long-lasting collaboration processes, there is a strong need for the possibility to modify a workflow instance at runtime. Such modifications are usually needed to deal with situations that have not been foreseen nor modelled in the associated workflow schema. *Social protocol adaptation* refers to the possibility to *modify a running social protocol instance* to new situations that have not been foreseen and modelled in the associated social protocol.

3.2 Negotiation-based adaptation

3.2.1 Rationale for negotiation-base adaptation

While social protocols support (at least to some extent) the integration of some social elements (such as roles) to models of interactions among humans, the adaptation capabilities of humans are not taken into account in social protocols. However, there is the need to provide adaptation mechanisms to social protocols. Indeed, interactions among humans are often a context-aware activity. In this paper, context awareness refers to the capabilities of applications to provide relevant services to their users by sensing and exploring the users' context (Dey *et al.*, 2001; Dockhorn Costa *et al.*, 2005). Context is defined as a "collection of interrelated conditions in which something exists or occurs" (Dockhorn Costa *et al.*, 2005). The users' context often consists of a collection of conditions, such as, *e.g.*, the users' location, environmental aspects (temperature, light intensity, *etc.*) and activities (Chen *et al.*, 2003). The users' context may change dynamically and, therefore, a basic requirement for a context-aware system is its ability to sense contexts and react to context changes.

In Picard (2006b), negotiations have been proposed as a method to adapt social protocols. The idea of negotiation of social protocols was presented as "an attempt to weaken constraints usually limiting the interaction between collaborators, so that the adaptation capabilities of humans may be integrate in the life of a social protocol". The idea of using negotiations as an adaptation means for social protocols comes from the fact that social protocols rule the interactions of all the collaborators in a given group. Therefore, each modification of the social protocol may influence all collaborators. As a consequence, the decision to modify a social protocol should be reviewed and approved by many collaborators. Negotiations are a classical way to make collaborative decisions and reach an agreement in situations where the expectations and goals of collaborators may be in conflict.

3.2.2 Layered adaptation

The adaptation of social protocols addresses changes in social processes and implemented and abstract social protocols. Indeed, when collaborators need to modify the potential interactions in a given state of the social process, the result of the negotiation is a change in the implemented social protocol ruling the social process. As an implemented social protocol may be a particular 'version' of an abstract social protocol, the modification of the implemented social protocol may lead to a modification of the associated abstract social protocol.

To illustrate the layered adaptation process, let us assume that a given group collaborates according to the abstract protocol presented in Section 2.2.2. The abstract protocol needs to be implemented so that a social process may be instantiated. The following implementation is summarised in Tables 3 and 4.

During the collaboration process, after some questions have been asked and answered, Bill Bogard identifies that one answer formerly sent by Jennifer Scott should be discussed. Currently, the social protocol does not allow collaborators to interact in such a way. Then, Bill Bogard starts the process of adaptation of the social protocol, starting a negotiation process about the need to comment on given answers. The chosen negotiation process concerns a relatively simple modification of the social protocol, *i.e.*, the addition of a new transition from the 'Waiting for next question' state to the same state associated with the 'Expert' role and implemented by the web service 'http://www.example.org/ws/commentAnswer' provided by the environment of the group. During the negotiation process, Amy Tony suggests that normal users should also have the right to comment on an answer, which is accepted by all the members of the group. As a consequence, the adaptation process leads to a new implemented social protocol, with two additional transitions (the first for the 'Expert' role and the second for 'Normal User') from the state 'Waiting for next question' associated with the previously mentioned web service.

Table 3 The implementation of roles for the example social protocol

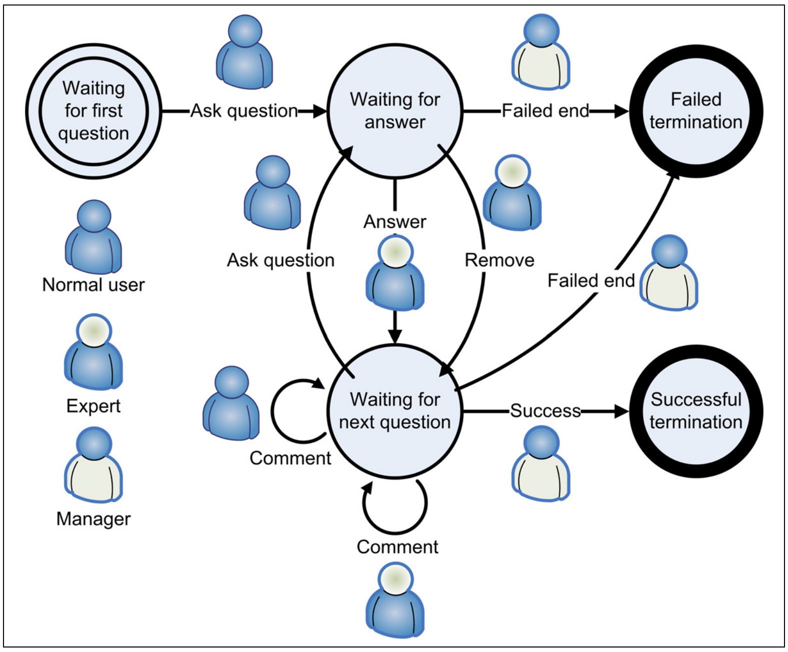
Roles	*Implementation*
Normal user	John Smith
	Amy Tony
Expert	Bill Bogard
	Jennifer Scott
Manager	Scott Tiger
	Anna Gates

Table 4 The implementation of actions for the example social protocol

Actions	*Implementation (web services)*
Ask question	http://www.example.org/ws/askQuestion
Remove	http://www.example.org/ws/removeQuestion
Answer	http://www.example.org/ws/answerQuestion
Failed end	http://www.example.org/ws/suppressFAQ
Success	http://www.example.org/ws/publishFAQ

An abstract social protocol may be extracted from the adapted implemented social protocol, as presented in Figure 2. In this adapted abstract social protocol, the two newly proposed transitions have been added, but no implementation is proposed for the abstract action 'comment'.

Figure 2 The adapted abstract social protocol (see online version for colours)



4 Adaptation of social protocols in PVCs

In the PVC context, adaptation leads to support for the dynamics of collaboration processes at the group level. Additionally, the decisions taken during the adaptation of social protocols may be reused by other groups facing similar problems.

4.1 Adaptation propagation strategies

The adaptation of a social protocol in a given group leads to the creation of a new version of the social protocol ruling collaboration within this group. Let us assume that the adaptation of a given social protocol P_1 in a given group *G* leads to the creation of a new social protocol P_1'. In the PVC context, various strategies may be used to manage the change caused by the adaptation of a social protocol:

- *Local adaptation strategy* – The other groups ruled by social protocol *P* are not affected by the adaptation and are still ruled by *P*. Social protocol *P'* is only used by group *G* and is not available for future groups.
- *Global propagation strategy* – The other groups ruled by social protocol *P* are not affected by the adaptation and are still ruled by *P*. Social protocol *P'* is used by group *G* and is available for future groups.
- *Instant propagation strategy* – The other groups ruled by social protocol *P* are affected by the adaptation, as they are now ruled by *P'*. Social protocol *P'* replaces *P* in the whole PVC.

It should be noticed that the instant propagation strategy may not always be used, as the changes provided by the adaptation of the social protocol may be in conflict with the current state of some collaboration processes.

Additionally, adaptation propagation is not always possible because of differences in terms of the available services in various environments. If two groups work in two different environments in which the sets of available services are different, the modifications provided by the collaborators of one group may not always be propagated to the second group. For instance, let us assume that two groups G_1 and G_2 collaborate according to the implemented protocol presented in Section 3.2.2. If group G_1 adapts the social protocol presented in Section 3.2.2, *i.e.*, adds two transitions so that experts and normal users may comment on answers, then the abstract social protocol is modified. However, group G_2 may take advantage of this adaptation if the action 'comment' may be implemented, *i.e.*, an implementation of this action in the environment of G_2 exists.

While layered adaptation may be seen as a limitation, it is a major improvement in the proposed adaptation mechanism. Indeed, in the case where the action implementation used by group G_1 is not available to G_2, the second group still has the possibility to choose another implementation of the 'comment' action. Therefore, adaptation propagation may be now done at the abstract level, allowing various groups to take advantage of the changes proposed by the other groups sharing the same abstract social protocol, but with an additional degree of freedom to implement actions.

4.2 Adaptation propagation in a VO-Inheritance management perspective

The concept of *Virtual Organisation Inheritance* (VO-I) has been defined in Loss *et al.* (2006a) as "the set of information and knowledge accumulated from past and current VOs along their entire life cycle. *Virtual organization inheritance management* (VO-I-M) corresponds to the VO activity that manages what has been inherited about given VOs, usually supported by computer systems."

In a VO-I-M perspective, the adaptation of social protocols may be seen as part of the VO-I, as presented in Figure 3. In the PVC presented in Figure 3(a), two protocols are available – P_1 and P_2 – and two VTs – *A* and *B* – are ruled by P_1. A new VT *C* may be created with either protocol P_1 or protocol P_2. It is then assumed that VT *A* has adapted protocol P_1, which leads to protocol P'_1. Figures 3(b), 3(c) and 3(d) illustrate the states of the PVC after adaptation in the case of local, global and instant adaptation strategies, respectively. In Figure 3(b), the newly created protocol P'_1 rules VT *A*, but is not available to VTs *B* and *C*. In Figure 3(c), the newly created protocol is available to the new VT *C*, but VT *B* is still ruled by P_1. In Figure 3(d), P'_1 is available to the new VT *C* and VT *B* is now ruled by P'_1.

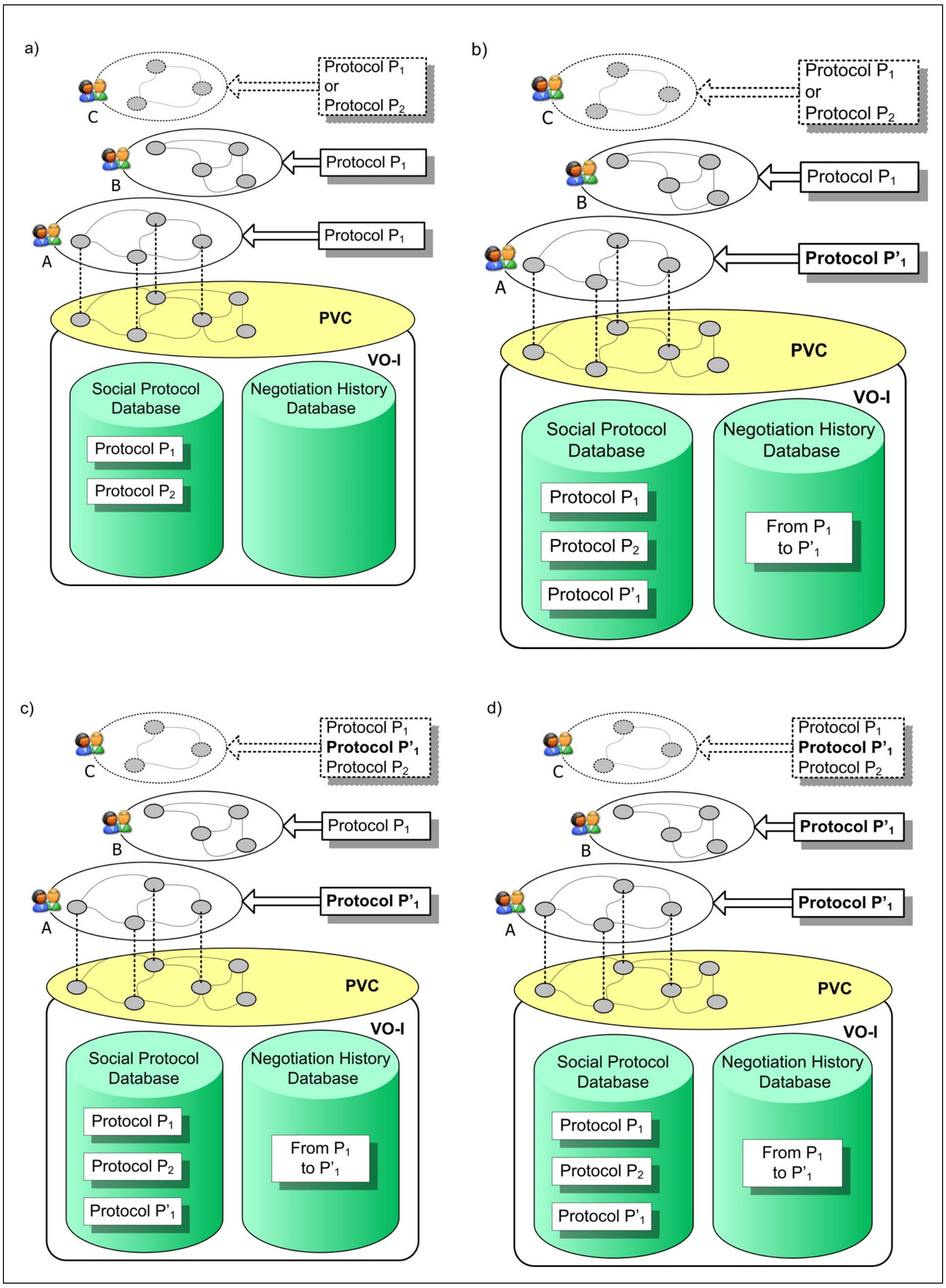
The newly created social protocol P'_1 embeds knowledge about an alternative way to collaborate. Social protocol P'_1 models the additional knowledge and expertise that have been required to react to unforeseen and unmodelled situations in social protocol P_1. Information about the negotiation process that leads from P_1 to P'_1 is available from the negotiation history database, as presented in Figure 3. One should notice that these knowledge and expertise should not necessarily be directly reused, but could be used for consultations about what happened in similar cases and the discovered solutions. Additionally, privacy should be taken into account. Collaborators who negotiated social protocol P_1 should explicitly agree to publish negotiation-related information before such information is available to other VTs.

The global propagation strategy would allow the collaborators of VTs to consult and eventually reuse the VO-I of VTs in which a social protocol has been adapted. The instant propagation strategy would enforce the reuse of newly created knowledge by other VTs in a normative way: the adapted social protocol 'overwrites' the original social protocol.

Finally, the proposed adaptation propagation strategies provide means for *continuous VO-I-M*, which leads to agile PVCs. A classical issue in VO-I-M is the frequency of VO-I capture. A briefing-debriefing technique was presented by Loss *et al.* (2006b), proposing the capture of VO-I by comparing the results of two interview meetings: the first interview meeting usually takes place before the VO is created, while the second one (the debriefing) takes place after VO dissolution or metamorphosis. The briefing-debriefing technique may be used "to double-check the plans, fine tune the assignments of tasks, rehearsal the actions and also to exchange lessons learned, evaluate the actions against the plans and to register explicitly the knowledge acquired, respectively". Therefore, the briefing-debriefing technique may capture more elements of the VO-I than just those related to social protocols. On the other hand, information about the adaptation of a social protocol would be captured by the briefing-debriefing technique during the debriefing session, while adaptation propagation strategies make information about the adaptation of a social protocol accessible to other VOs just after adaptation.

Therefore, propagation strategies may enable the continuous VO-I-M of social protocols, while the briefing-debriefing technique is less agile, but may capture more elements of the VO-I.

Figure 3 VO-I (a) before adaptation, (b) with a local adaptation strategy, (c) with a global propagation strategy and (d) with an instant propagation strategy (see online version for colours)



5 Conclusions

The introduction of adaptation of social protocols and adaptation propagation strategies provides computer support for the management of PVC inheritance related to collaboration processes. To our best knowledge, it is the first attempt to support the continuous management of VO inheritance, even if the proposed solution is limited to the PVC inheritance elements related to collaboration processes.

The main contributions presented in this paper are:

- a layered approach to the concept of social protocols allowing the separation of the collaboration structure from implementation
- the rationale for the adaptation of social protocols in PVCs as heterogeneous and dynamic sociosystems
- three strategies for adaptation propagation
- the proposition of the adaptation of social protocols and adaptation propagation as means for the continuous management of PVC inheritance.

The layered approach to social protocols and adaptation propagation are complementary, enabling a sound foundation for agile PVCs. PVCs supporting abstract social protocols and adaptation propagation would support VTs by, on the one hand, providing support for structured interactions among the collaborators and, on the other hand, allowing collaborators to modify the social protocols ruling their interactions and sharing their experience with the other VTs collaborating in a similar way (*i.e.*, sharing the same social protocol).

In a broader perspective, the adaptation of social protocols and its potential propagation may lead to similar changes in the area of workflow support systems, as we have witnessed in the area of content management systems with the rise of Web 2.0. Indeed, the adaptation of social protocols would blur the classical distinction between protocol 'producers' (or process designers) and protocol 'customers' (or process actors), as Web 2.0 blurs the distinction between content producers and content consumers.

Among future works, a formal model of the propagation strategies presented in this paper should be established and validated by experiments. A prototype is currently under implementation and will be tailored to the needs of a pilot for the construction sector. In the planned pilot for the construction sector, the solution presented in this paper has to be refined to support Virtual Breeding Environments (VBEs) and not only PVCs. The main challenge for the application of the presented solution to VBEs is the fact that the members of VOs are nonmonolithic, *i.e.*, each member of a VO consists of many individuals with various skills, cultures, goals, social networks, *etc*. Therefore, the concepts and models presented in this paper have to be adapted to support the duality of human-to-human interactions in VBEs: the interactions in VBEs occur among humans as individuals, as well as among humans as members of an organisation participating in VOs.

References

Alves, A., Arkin, A., Askary, S., Barreto, C., Bloch, B., Curbera, F., Ford, M., *et al.* (Eds.) (2007) 'Web services business process execution language version 2.0', WS-BPEL TC OASIS, April, http://docs.oasis-open.org/wsbpel/2.0/OS/wsbpel-v2.0-OS.pdf.

Bifulco, A. and Santoro, R. (2005) 'A conceptual framework for "Professional Virtual Communities"', in *Collaborative Networks and Their Breeding Environments*, Proc. of the 6th IFIP Working Conf. on Virtual Enterprises (PRO-VE 2005), Valencia, Spain: Springer, 26–28 September, pp.417–424.

Camarinha-Matos, L.M., Afsarmanesh, H. and Ollus, M. (2005) 'ECOLEAD: a holistic approach to creation and management of dynamic virtual organizations', in *Collaborative Networks and Their Breeding Environments*, Proc. of the 6th IFIP Working Conf. on Virtual Enterprises (PRO-VE 2005), Valencia, Spain: Springer, 26–28 September, pp.3–16.

Chen, H., Finin, T. and Joshi, A. (2003) 'An ontology for context-aware pervasive computing environments', Special issue on Ontologies for Distributed Systems, *Knowledge Engineering Review*, Cambridge University Press, Vol. 18, No. 3, pp.197–207.

Chituc, C.M. and Azevedo, A.L. (2005) 'Multi-perspective challenges on collaborative networks business environments', in *Collaborative Networks and Their Breeding Environments*, Proceedings of the 6th IFIP Working Conf. on Virtual Enterprises (PRO-VE 2005), Valencia, Spain: Springer, 26–28 September, pp.25–32.

Coakes, E. and Clarke, S. (2006) 'The concept of communities of practice', in *Encyclopedia of Communities of Practice in Information and Knowledge Management*, Idea Group Inc.

Crave, S. and Vorobey, V. (2008) 'Business models for PVC: challenges and perspectives', in L.M. Camarinha-Matos, H. Afsarmanesh and M. Ollus (Eds.) *Methods and Tools for Collaborative Networked Organizations*, Springer, pp.295–306.

Daoudi, F. and Nurcan, S. (2007) 'A benchmarking framework for methods to design flexible business processes', Special issue on Design for Flexibility, *Software Process: Improvement and Practice Journal*, Vol. 12, No. 1, pp.51–63.

Dey, A.K., Salber, D. and Abowd, G.D. (2001) 'A conceptual framework and a toolkit for supporting the rapid prototyping of context-aware applications', *Human-Computer Interaction*, Vol. 16, Nos. 2–4, pp.97–166.

Dockhorn Costa, P., Ferreira Pires, L. and van Sinderen, M. (2005) 'Designing a configurable services platform for mobile context-aware applications', *Int. J. of Pervasive Computing and Communications (JPCC)*, Vol. 1, No. 1, pp.27–37.

ECOLEAD project (2004–2008) 'European collaborative networked organizations leadership initiative', FP6-IST-506958, http://ecolead.vtt.fi/.

Ekholm, A. and Fridqvist, S. (1996) 'Modelling of user organisations, buildings and spaces for the design process', in *Construction on the Information Highway*, Proceedings from the CIB W78 Workshop, Bled, Slovenia, 10–12 June.

Feingold, M. and Jeyaraman, R. (2007) 'Web services coordination (WS-Coordination) version 1.1', OASIS Web Services Transaction WS-TX TC, 12 July, http://docs.oasis-open.org/ws-tx/wstx-wscoor-1.1-spec.pdf.

Loss, L., Pereira-Klen, A.A. and Rabelo, R.J. (2006a) 'Knowledge management based approach for virtual organization inheritance', in *Network-centric Collaboration and Supporting Frameworks*, Proc. of the 7th IFIP Working Conf. on Virtual Enterprises (PRO-VE 2006), Helsinki, Finland: Springer, September, pp.285–294.

Loss, L., Rabelo, R.J. and Pereira-Klen, A.A. (2006b) 'Virtual organization management: an approach based on inheritance information', in *Global Conference on Sustainable Product Development and Life Cycle Engineering*, São Carlos, SP, Brazil: Editora Suprema.

Picard, W. (2005) 'Modeling structured non-monolithic collaboration processes', in *Collaborative Networks and Their Breeding Environments*, Proc. of the 6th IFIP Working Conf. on Virtual Enterprises (PRO-VE 2005), Valencia, Spain: Springer, 26–28 September, pp.379–386.

Picard, W. (2006a) 'Adaptive collaboration in professional virtual communities via negotiations of social protocols', in *Network-centric Collaboration and Supporting Frameworks*, Proc. of the 7th IFIP Working Conf. on Virtual Enterprises (PRO-VE 2006), Helsinki, Finland: Springer, September, pp.353–360.

Picard, W. (2006b) 'Adaptive human-to-human collaboration via negotiations of social protocols', in *Technologies for Business Information Systems*, Proc. of the 9th Int. Conf. on Business Information Systems, Klagenfurt, Austria: Springer Verlag, 31 May–2 June, pp.193–203.

Picard, W. (2007a) 'An algebraic algorithm for structural validation of social protocols', *Lecture Notes in Computer Science* (LNCS 4439), Springer, pp.570–583.

Picard, W. (2007b) 'Continuous management of professional virtual community inheritance based on the adaptation of social protocols', in *Establishing the Foundation of Collaborative Networks*, Proc. of the 8th IFIP Working Conference on Virtual Enterprises (PRO-VE 2007), Guimaraes, Portugal, September, pp.381–388.

Santoro, R. and Bifulco, A. (2008) 'Professional virtual communities reference framework', in L.M. Camarinha-Matos, H. Afsarmanesh and M. Ollus (Eds.) *Methods and Tools for Collaborative Networked Organizations*, Springer, pp.277–294.

Van der Aalst, W.M.P., Weske, M. and Wirtz, G. (2003) 'Advanced topics in workflow management: issues, requirements, and solutions', *J. of Integrated Design and Process Science*, Vol. 7, No. 3, pp.49–77.

Wenger, E. (1998) *Communities of Practice: Learning, Meaning and Identity*, Cambridge, UK: Cambridge University Press.

Wenger, E., McDermott, R. and Snyder, W.M. (2002) *Cultivating Communities of Practice: A Guide to Managing Knowledge*, Boston: Harvard Business School Press.