Supporting Collaborative Networks for Complex Service-Enhanced Products

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Abstract. Several collaborative networks need to be involved in supporting the the life cycle of complex service-enhanced products. When addressing highly customized products, these networks need to consider the involvement of the customer and local stakeholders close to the customer. In this context, a set of integrated subsystems supporting both long-term strategic networks and goal-oriented virtual organizations is proposed. Experimental results are presented in the context of service-enhanced products in the solar energy sector.

Keywords: Collaborative Networks, Service-Enhanced Product, Consortia Formation, Collective Emotions.

1 Introduction

The development of complex and highly customized products such as a solar power plant, an intelligent building, or a special purpose complex machine, typically require contributions from several stakeholders from diverse knowledge sectors. Greater levels of efficiency could be achieved when these contributors are organized under the form of a collaborative network in order to better integrate their parts. In fact, most companies in these sectors are small and medium enterprises (SMEs), which can only cope with the complexity of the projects and reach markets in different geographical regions if collaborating with others.

Seeking business opportunities in different geographical regions in these domains often requires the involvement of the customer (co-creation) and collaboration with local suppliers in those target markets [1, 2]. This need motivated the emergence of the term *glocal enterprise*, to reflect the idea of thinking and acting globally, while being aware and responding adequately to the local preferences and constraints.

Furthermore, a growing number of business services are needed in association with the various phases of the product life-cycle, which led to the notion of service-enhanced product. For instance, in the case of solar energy, such business services can include: services for operation monitoring (energy monitoring, monitoring reports, system performance testing, site security, data analytics), preventive maintenance (panel cleaning, vegetation management, wildlife prevention, water drainage, retro-commissioning, upkeep of systems), corrective / reactive maintenance (on-site monitoring / mitigation, critical reactive repair, warranty enforcement), condition-

based monitoring, other support (training, audit), etc. [3, 4]. These services add value to the physical product, representing a great differentiation factor and creating space for new business opportunities.

With the exception of a few large companies, the market offer is rather fragmented while, from the customer side, there is a clear demand for the provision of integrated services (Fig. 1). The provision of integrated services also calls for collaboration among multiple stakeholders.

Fig. 1 – The need for integrated business services

In this context, there is a need to deal with different collaborative networks, operating at different stages of the life-cycle of the product and associated business services, which motivates the following research question:

What is a suitable platform and associated tools to support collaborative enterprise networks involved in the life-cycle of complex service-enhanced products?

This work was performed in the framework of the European research project GloNet which addressed the development of an agile virtual enterprise environment for networks of SMEs involved in highly customized and service-enhanced products [5].

The project developed a cloud-based system, which comprises a cloud-based platform offering multiple collaboration spaces [6], and a collaborative networking framework including functionalities for specification of products and business services, and management of collaborative networks (Fig. 2). This paper is mainly focused on the implemented subsystems for management of the various networks.

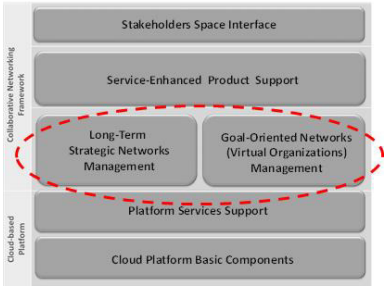

Fig. 2 – GloNet system architecture

2 Collaborative Networks Management

A number of sub-systems are provided in GloNet to support both long-term strategic networks and goal-oriented networks.

Long-term strategic networks management. The main purpose of this sub-system is to promote preparedness of its members for collaboration [7]. In the context of this network a growing number of service-enhanced products are created, leading to a product portfolio of the network.

Although this network is a typical virtual organizations breeding environment (VBE), the aim of supporting the *glocal* enterprise concept led to the involvement of the customer and other local stakeholders in the target market. In other words, for each target market the core VBE is extended with the inclusion of local members. In fact, the selection of partners for each goal-oriented virtual organization (VO) considers the extended recruitment space, as illustrated in Fig. 3.

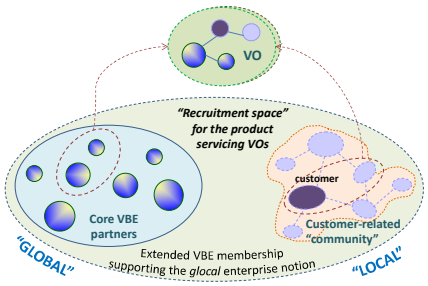

Fig. 3 – Extended VBE

The functionalities developed for this component support the main steps illustrated in Fig. 4:

- *members' recruitment*, including basic management services of admission and withdrawal of members;
- *members' profiling*, with members and network profile and competencies definition, network performance management, among other functionalities; and
- *VBE analysis*, through services that enhance the VBE life-cycle, including functionalities for trust management among VBE members and assessment of the alignment of their value systems. Additional analysis tools could be plugged here through a web services interface.

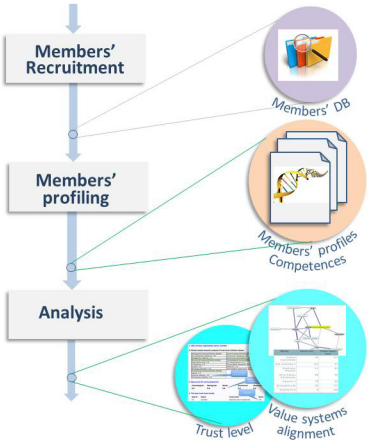

Fig. 4 – Business ecosystem management

Virtual organizations creation and negotiation subsystem. As mentioned above, for the creation of VOs, members are first selected from the core VBE, but additional members can be added, namely local entities from the geographical region of the

customer [8]. When an order for a new product or new integrated business service is received (the business opportunity that triggers the VO formation), the VO Planner initiates the creation process. This includes, among other steps, the detailed specification of the product or service order, the selection of the partners according to the necessary skills and competences, and the elaboration of the agreements and contracts that will regulate the operation of the VO. Fig. 5 summarizes the main steps of the consortium creation process:

- *Consortia generation*. This step aims at choosing a suitable set of partners to form the consortium for the VO [8]. It considers the requirements for the new VO, which depend on the specification of the new product or service, namely the necessary competences the potential VO Partners need to have. This is done performing a match with the existing competences in the VBE to identify the members that are suitable candidates to be part of the VO [7]. Then, a list of all possible VO combinations is generated automatically out of the members that can satisfy each goal. Furthermore, there is the possibility to manually impose "mandatory" or "preferred" partners in all possible consortia.
- *Filtering and selection*. In order to select the most appropriate consortium out of the list of previously generated consortia, the VO Planner can identify and assess, to certain extent, the risk level of each potential consortium [9]. In the current implementation, the system can infer the alignment level of the value systems of potential partners, as well as their level of trustworthiness [10]. Depending on the application domain, additional criteria could be added here. For instance, in the case of logistics-related goals, it could make sense to consider the geographical location of the potential partner. Nevertheless, the system provides a ranking of the potential consortia according to the selected criteria, being the final selection done by the human planner.

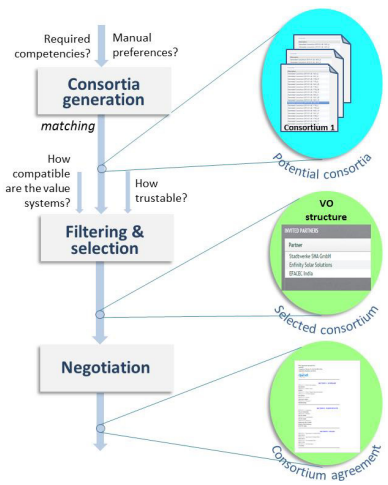

Fig. 5 – Partners' selection and negotiation

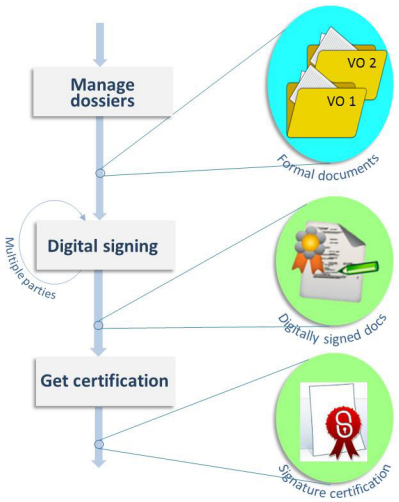

Fig. 6 – e-Notary services

- *Negotiation*. After having selected suitable partners to form the consortium, it is also important to have a negotiation mechanism that supports the process of

achieving agreements among them during the VO formation. These agreements will then be the basis for the governance principles of the VO during its operation phase. The implemented negotiation support functionalities facilitate the participation of multiple stakeholders in the negotiation of different subjects via a set of mechanisms that ensure the privacy and confidentiality ("virtual negotiation spaces (VNSs)") [8]. For each topic / clause that needs to be negotiated, the VO Planner can invite a subset of (potential) partners into a specific VNS. The agreement can be built following either a default or customized template. Templates contain general information agreed by all involved partners, but also specific clauses agreed by a set of partners. The agreement is represented in the form of a readable document.

After the VO agreement is reached, the VO Planner can create a dossier comprising all relevant documentation related to the specific consortium agreement. This package of documents is stored in an electronic notary system to which all VO partners need to access in order to digitally sign the agreement. The existence of an e-notary system at the level of a VBE is particularly relevant in a *glocal* (multi-cultural) context in order to avoid future misunderstandings during the operation of the VO. The developed Electronic Notary and Conservatory Sub-system provides mechanisms for signing documents and the possibility of exchanging agreements-related documentation with warranty of authenticity and validity. Furthermore, it provides a safe archive for such documentation. In this sub-system, the following main concepts are used:

- Dossier: a collection or folder that comprises several documents. Only a limited number of users will have access to a dossier, and the access is managed by the owner of the dossier, i.e., the user who created it (typically a VO Planner). In other words, the dossier represents a set of documentation for a specific consortium agreement, that is, a package of documents that support the consortium agreement;
- Signature: referring to a digital signature of a document. A consortium agreement, in order to be valid, will be signed by all involved partners; and
- File Certification: confirming the validity of a document. An authorized VBE Member may verify if a certain file has maintained its integrity or if it has been deceived.

Depending on the corresponding access rights, a user of the e-notary system is able to properly manage dossiers, sign and verify document signatures, etc. The sequence of use of these functionalities is illustrated in Fig. 6. For digital signatures and certification an asymmetric keys mechanism is used.

Supporting co-creation networks. In order to facilitate co-creation / co-design processes, a collaborative environment for multi-stakeholder based design of new business services, the Services Co-Design Negotiation (CoDeN) sub-system, was developed [11]. The involved participants (including the customer) in this process are initially selected by the initiator of the co-creation process. Similar to the Negotiation support sub-system for VO creation (mentioned above), this sub-system is also intended to generate an agreement that represents all consensus reached on the characteristics of a new business service. However, in this case, the process of reaching consensus is based on the *service design methodology* [12] that serves as a guide for the negotiation.

As illustrated in Fig. 7, a number of templates are used: *stakeholders mapping*, to identify the relevant stakeholders that have to be considered for direct and indirect contact with the new business service; *service blueprint diagrams*, considering: *User*, highlighting what the customer of the new business service does; *Touchpoints*, to identify the moments and places when the customer gets into direct contact with the new business service; *Service direct contact* and *Service back office*, to detect what should be the behaviour of the new business service staff; and *Means and processes*, to identify what else can be involved with the new business service.

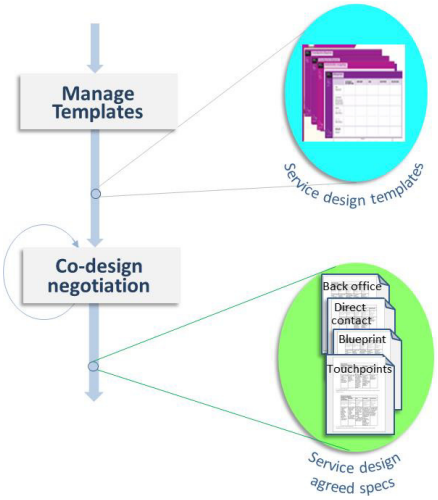

Fig. 7 – Service co-design support

The co-design involves thus a specialized iterative negotiation process, guided by the mentioned templates.

Supporting the emotional equilibrium of the network. The emotional equilibrium of a network contributes to supporting a healthy and sustainable collaboration among all the involved parties and in this way leverage the success rate of the collaborative network. Emotions play an important role in promoting the effective management of communications and interactions among participants, namely in what concerns dealing with *soft* issues such as inter- and inter-organizational abilities, problems in keeping team cohesion, leadership, decision-making, involvement of customers, potential conflicts resolution, etc. [13, 14]. Furthermore, it is assumed that emotions also contribute to the sustainability of the network, so the more positive the emotion is, the healthier the collaboration becomes and on the other hand, negative emotions constitute a risk factor [15].

In this context, an emotions-based supervision sub-system was also developed. This sub-system uses a collection of non-intrusive mechanisms to estimate the level of emotion of each member individually and of the collaborative network as a whole (collective emotion). Fig. 8 illustrates the adopted approach which comprises:

- a non-intrusive *evidence gathering* module that aims to collect the emotions' related data comprising both the member's and collaborative network's emotional information;
- an *emotional reasoning* module that uses the collected information and estimates (through a rule-based system): a) the members' emotional state, and b) the collective emotional state;
- the *members' emotional state* module shows all the corresponding evidences information and emotional state of the member;
- the *collective emotional state* module on its turn presents the evidences regarding the network as a whole and the collective emotional state;

- a *recommendations' processing* module that aims to give support to the network administrator by suggesting a plan of actions to enhance the collective emotional state of the network. These actions are merely suggestions and it is up to the administrator to put them in practice.

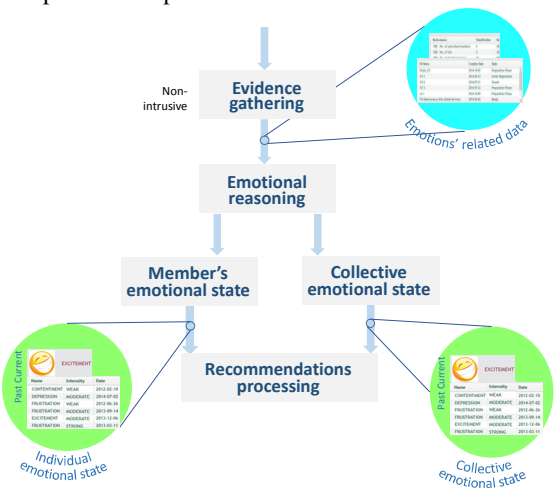

Fig. 8 – Emotions support system approach

All these sub-systems are part of the GloNet system, which provides a cloud-based collaborative environment and includes other functionalities developed by the other partners of the GloNet consortium, such as a product specification subsystem, a business services specification sub-system, sub-product / service recommendation sub-system, complex product portfolio repository, collaboration spaces, and workflow subsystem.

3 Validation

The developed functionalities and methodological guidelines were evaluated through the implementation of a realistic demonstrator in the solar energy sector. For this purpose, GloNet selected as case study the Charanka solar park in Gujarat, India, a contemporary project in which the iPLON partner participated in the Operations and Maintenance system. The Charanka project started during the early phases of GloNet, when relevant research results were not available yet, and thus it was mostly implemented through traditional methods in this sector. At that stage, only a small influence of GloNet could be noticed in terms of the use of the CNs concepts to help iPLON structure the various partnerships under the notions of VBE and VO. But the involved processes were essentially manual at that stage.

Nevertheless, the available data, acquired experience, and lessons learned, that are recent and thus easily recalled, constituted an important basis to help assessing the potential impacts of adopting GloNet results in similar future projects. As such, the

strategy was to use Charanka solar park as a reference case and to replicate, through the use of GloNet results, some relevant business scenarios selected from this case and to compare them with the traditional approaches (Fig. 9).

This case, where a European SME expanded its business to another continent in collaboration with local stakeholders, also provided insights on the implementation of the *glocal* enterprise concept.

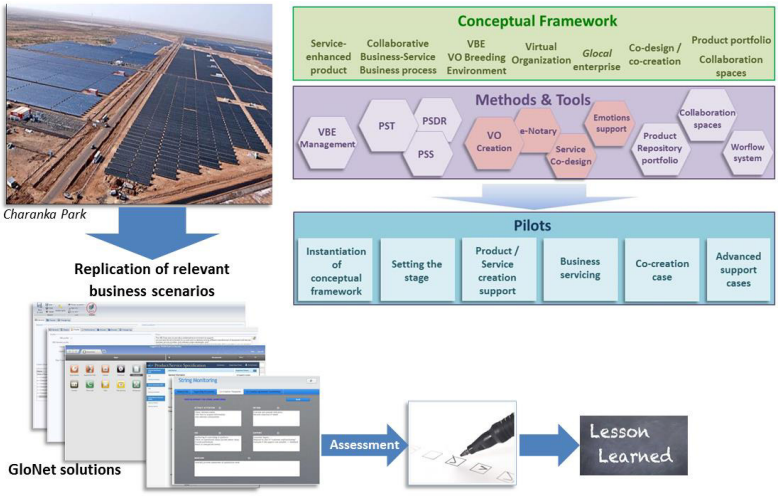

Fig. 9 – Demonstration and validation pilot

According to the assessment made by the end-users, the platform and collaboration support tools fit well the needs of the use case, although some improvements in the user interface style could be considered when evolving to a commercial product. Although the needed organizational changes are significant, the expected potential benefits are also very high, at least as it can be estimated at this stage. Furthermore, the conceptual framework for collaborative networks and service-enhanced products proposed by GloNet:

- Offers SMEs the opportunity to implement new business models based on collaboration;
- Certainly requires a change in the mind-set of companies operating in the solar energy and intelligent buildings sectors, which are more used to sub-contracting relationships; this also requires an extensive training plan;
- Offers SMEs the possibility of jointly having a more agile response in dynamic market contexts; and
- Provides an effective way of implementing the *glocal* enterprise concept, allowing SMEs to expand into new markets in other regions.

As part of the validation process, a group of external enterprises, i.e. members of the solar energy VBE (including about 40 enterprises), were invited to get a closer understanding of GloNet vision and solutions. This process involved a couple of training actions and an extensive workshop with demonstration of the implemented system. These external users were then invited to assess the various functionalities of the GloNet system. A partial example of their assessment is shown in Fig. 10.

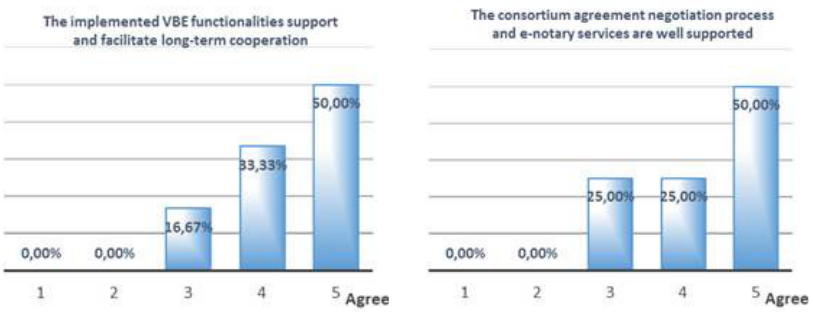

Fig. 10 – Example of validation results

The collected opinions regarding the CN management subsystem show a good level of agreement with the proposed functionalities. The combination of VBE and VO concepts in the system was particularly appreciated by the users. Regarding the emotional support subsystem, the assessment was also globally positive although with some natural dispersion of opinions. The inclusion of "members' expectations" as inputs for the tool was particularly appreciated by participants.

4 Conclusions and Further Work

GloNet developed an integrated environment to support complex and highly customized products. Particularly in the case of solar power plants, the collaborative enterprises networking, the notion of *glocal* enterprise, and the focus on supporting multi-stakeholder integrated business services, appear as very promising for future developments in this sector. The solutions developed in GloNet and demonstrated in the implemented pilot confirmed this expectation, and proved a very good fit with the identified needs. Furthermore, the developed functionalities contributed to point out new directions for achieving higher levels of effectiveness in the core business processes. Of particular relevance to the end-users is the set of mechanisms, environment, and tools to support multi-stakeholder co-creation / co-innovation in collaboration with the customer and local entities close to the customer.

As future work, this use case also showed the need to further address the needs of multi-cultural business ecosystems involving members from different geographical regions.

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