A SERVICE-ORIENTED PLATFORM FOR
COLLABORATIVE NETWORKED ORGANIZATIONS

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Abstract: The paper presents a distributed, service-oriented and open ICT infrastructure (ICT-I) being developed in a European research project which aims at helping members of Collaborative Networks in doing businesses together. ICT-I services are used on-demand, based on the ASP and pay-per-use models. The proposed ICT-I are so far being implemented to support members of virtual breeding environments, virtual organizations and professional virtual communities. Some information about its requirements, architecture, services, implementation and future work are also presented. Copyright © 2006 IFAC

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1. INTRODUCTION

Collaborative Networked Organizations (CNOs) has been considered the discipline in charge of studying all the manifestations of organizations when they work in an inter-linked and organized way (Camarinha-Matos et al., 04). Organizations of diverse types have increasingly sought for establishing strategic alliances in order to deal with the survival requirements arisen with the globalization. In this today’s reality agility becomes a must. Agility has several definitions and can embrace a number of perspectives. In fact agility represents a deep change of paradigm in the organizations’ values (Figure 1).

Survival => Excellence
Efficiency => Innovation
Cost reduction => Value creation
Quantity => Quality
Mass production & standardization => Customization & personalization
Stability => Flexibility & responsiveness
Co-operation => Collaboration
Centralized decision-making => Decentralized decision-making
Centralized, stationary and monolithic systems => Distributed/pervasive, mobile and service-oriented systems
Product-centered, static and fixed alliances => Goal-oriented, dynamic and temporary alliances

Fig. 1. Changes imposed by Agility (adapted from Jamali et al., 06).

From this agility angle Virtual Organizations (VO) can be considered a very important manifestation within CNO. A VO is a dynamic, temporary and logical aggregation of independent and heterogeneous organizations (enterprises, professionals, governmental, NGOs, etc.) that collaborate with each other as a strategic answer to attend a given (short-term or long-term) business opportunity or to cope with a specific need, and whose operationalization is achieved by a coordinated sharing of skills, resources and information, totally enabled by computer networks (Rabelo et al., 04). Actually VO aim at supporting organizations to achieve exactly those new values comprised by the agile concept.

The realization of the VO concept comprehends several dimensions. In fact it is not just a matter of wishing to act as a collaborative organization. Instead, organizations must have diverse levels of preparedness. One of them is related to the supporting ICT (Information and Communication Technology) infrastructure (or middleware). The implantation of any form of collaborative network depends on this, allowing CNO members to communicate with which other in such way collaborations and businesses through the network can be enlarged and reinforced.

However, the fast evolution of ICT technologies with reduced life cycles as well as the need to cope with technologies with different life cycles have represented a major difficulty for developing advanced collaborative tools. Work collaboratively brings enormous benefits to organizations (Camarinha-Matos et al., 06). In order to leverage
these potential benefits, more flexible and generic infrastructures need to be designed and enabling networked organizations to agilely define and set-up relations with other organizations.

This paper presents the ongoing work for developing an ICT infrastructure (ICT-I) that can cope with the requirements of agility. It is being developed within the ECOLEAD Project (www.ecolead.org), which aims to create strong foundations and mechanisms needed to establish the most advanced collaborative and network-based industry society in Europe.

The paper is organized as follows: Section 2 stresses the organizations’ problems to adopt collaborative platforms and the requirements of an ICT-I for CNOs. Section 3 introduces the proposed ICT-I rationale and reference architecture. Section 4 depicts the ICT-I services that are being derived for the CNO types covered in ECOLEAD as well as gives a brief overview about its first implementation. Section 5 presents some future work. Section 6 provides some conclusions.

2. CNO REQUIREMENTS

When dealing with collaborative infrastructures it is important to consider the different nature and size of the organizations. In Europe, for example, more than 98% of the companies are SMEs (Europe-EU, 05). As such, most of them have difficulties to have access to the main products of the market as they are complex, costly and requires high investment in supporting software, hardware and IT experts.

In general SMEs are aware about the importance to use ICTs to enhance the quality of their collaboration and hence to augment their competitiveness. Actually, organizations’ managers are constantly riddled with plenty of software advertisements which claim to be the collaborative solution for them and it is very difficult to judge only based on this. Despite the benefits of collaborative work, the major challenge is how to create an organization culture where collaboration can become part of the process and not only an option of work. Another critic barrier is how to develop a collaborative infrastructure that makes users indeed confident and enthusiastic to use it in the support of their networked businesses.

There is already available in the market software solutions and business frameworks that offer some support for collaboration. They support quite well traditional transaction-based business processes (purchasing, selling, manufacturing, shipping, etc.) among companies, most of them provided by ERP systems. In this type of processes, execution efficiency is the focus. However, CNOs require an additional type of process, which can be called collaborative-based processes. They use to be interactive/user-centric, asynchronous and not necessarily well structured. Here the focus is on flexibility and adaptability. Figure 2 lists just some and general CNO-related collaborative processes requested in the diverse phases of a VO life cycle. Therefore, an ICT-I should be designed also to deal with supporting functionalities for that.

![Fig. 2. CNO-related collaborative processes.](image)

In order to provide this support, there are several ICT-related issues that should be handled. In general, any organization would like to collaborate without noticing about the underlying ICT-I, i.e. using a totally transparent infrastructure. (SME) Managers want to make business, and not to waste time dealing with many issues they usually don’t know anything about it, like software deployment and low level configurations, setting up of security rights, ontology specifications, etc., etc. However, this is an ideal situation and current ICTs can’t support such level of abstraction at all. Despite this, an advanced ICT-I devoted to CNOs would had to support a long list of requirements. Some of them are listed in the figure 3. It can be said that they represent requirements for today’s CNOs.

![Fig. 3. ICT requirements of an ICT-I for CNO.](image)

Current collaborative platforms present several relevant restrictions for their fast and easy adoption by (CNOs of) professionals and SMEs. Most of them, at several and variable levels, are not open at all, requires huge infrastructures, are very expensive and complex to deploy and difficult to use, and they don’t support at all the requirements of CNO processes. That is the niche the proposed work / ICT-I is embarking. Actually, it doesn’t aim to compete with existing platforms. Instead, some of them will be used to support specific issues (e.g. fault tolerance, services persistence), some of them will be complemented and/or adapted for the CNO domain (e.g. CSCW and ontology tools) and there...
are issues for which specific CNO-related solutions are being developed. Therefore, the proposed ICT-I aims to act as a comprehensive, horizontal, integrated, distributed, evolving, open, seamless and transparent platform exclusively devoted to support CNOs, which makes it unique.

3. PROPOSED ICT-I

In order to cope with the mentioned requirements in the CNO domain, the concept of a plug & play (Miller et. al, 01) seems quite suitable. Applying this concept to the proposed ICT-I aims to provide CNO members and systems with means to be easily and quickly plugged into the ICT-I / CNO community and to further play, seamlessly. More concretely, an ICT-I that enables people to collaborate, systems to interoperate, knowledge to be shared and processes to be synchronized. One of the ICT-I rationale is the adoption of platform-independent specifications and ICT standards. An essential aspect related to the ICT-I design is related to one of the new agility values, which is based on the trend for developing systems under a service-oriented perspective, towards what has been called service oriented economy and sustainable business networks\(^1\). Roughly, it means to develop systems as small and composable units of utilities. They are paid-per-use according to business models, involving several and heterogeneous (CNO of) services providers, also meaning that a given service may have different implementations available over the network.

There is a number of conceptual approaches that can be applied to support these features. ICT-I applies the SOA (Service-Oriented Architecture) approach (Singh et al., 05). It can be seen as an application architecture in which all functions are seen as services. A service is a software unit that can both call for a service and be called by another service or, in other terms, a software system designed to support interoperable machine-to-machine interaction over a network (www.w3c.org). Every service has an interface which allows its access by a client from any device using any operating system in any language.

Web-services (WS) has been taken as the core technology to implement the SOA approach. In spite of some intrinsic problems, SOA / WS seem to be indeed a trend regarding their enormous advantages. All major B2B vendors are already applying WS-based solutions. Gartner institute has identified that 30% of SCM intranet applications and 20% of extranet use WS today. It is expected to reach 90% by the end of 2007. Applying the service-oriented paradigm to the proposed ICT-I means that the proposed collaborative platform is a “pulverized” open bus composed of many distributed services that are accessible on-demand. Therefore, it is not a package of software or self-contained modular platform. This is essential to support the desired ICT-I flexibility and scalability.

3.1 ICT-I Reference Architecture.

In order to provide an open and scalar model, ICT-I has a reference architecture (ICT-I-RA) from which instances-of it can be derived for different CNOs (Figure 4). In the ECOLEAD project three types of CNOs are being considered: VBE – Virtual Organizational Breeding Environment (AfSarmanesh et al., 05), VOM – Virtual Organization Management (Karvonen et al., 05) and PVC – Professional Virtual Communities (Bifulco et al., 05). In general, this means an ICT-I that allows well established groups of enterprises and of professionals to collaborate between each other and to manage this collaboration.

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technologies e.g. WSDL). This process is supported by UML methodology (Figure 5). Starting from the reference architecture, a particular architecture of specific services is derived. Each of them is completely specified independent of technology, then composing the reference framework. Once the involved implementation technologies are decided the framework is created and services can be coded.

Two other elements complement the reference architecture. Legacy systems services, which essentially provide information about activities inside a given company to satisfy vertical services needs. They use to be implemented in heterogeneous platforms and native front-ends. Portals correspond to and optional element. They are an integrator front-end with services or even with other portals as a way to invoke services directly by the end-user. Portals are not services.

3.2 Services Federation.

Based on the federation concept (Sun, 99), ICT-I considers all the involved services as members of a community, the Services Federation. This federation comprises the Basic, Horizontal, Vertical and Legacy systems services. The goal is that all existing services can coexist in a virtual logical repository of services which can be accessed transparently and seamlessly. The dynamic nature of the federation enables services to be added or withdrawn at any time according to pre-defined rules. From the ICT-I point view, once the business/collaborative processes are configured, the users and applications don’t need to know about which services are needed to support a collaborative transaction, where they are, how they should be executed, and which technologies were used in their implementations. Services are invoked, searched, discovered, composed and properly orchestrated / executed no matter where they are registered and deployed.

Considering the usual SME resources restrictions, their natural geographic distribution and mobility requirements, ASP (Application Service Provider) model (Dewire, 2002) seems the most adequate for the ICT-I in spite of some extra cares to be taken. This means that ICT-I services are accessed remotely, on demand, paid-per-use, based on a contractual software-based service for hosting, managing and providing access to the services federation, no matter where the repositories of services are. This makes possible to offer an affordable and “made to fit” ICT-I to companies.

3.3 ICT-I Scope and usage.

The use of the ICT-I is illustrated in Figure 6. Each CNO organization/actor tends to have its own portal. Each portal represents the access to services that have user interfaces. Depending on the configuration done, wider integrated collaborative portals can be created. The services themselves are stored in distributed services repositories (Services Federation). From a user-centric perspective, CNO actors can, under flexible but well defined security and on-demand usage policies, Communicate (C), access Data in information repositories (D), search and retrieve distributed bodies of Knowledge as well as ontologies (K), and monitor/control the execution of business Processes among CNOs (P).

Fig. 5. ICT-I derivation process.

From another side, networked organizations have their legacy systems. They perform their business transactions usually making use of ERP systems and generating information in corporate databases. In general, ICT-I assumes that this information can be accessed by enterprise’s services that somehow wrap existing legacy functions. Yet, that ICT-I services can also be invoked from enterprises’ B2B environments. This aims to extend the level of collaboration in a CNO as all (wrapped) enterprises’ services can be accessible by other enterprises, according to security configurations.

As it will be stressed in section 4, ICT-I is composed of Horizontal (C K P D) and Basic services. In practice, its services can be invoked in three basic situations: (a) Client-Server, (b) Intra-Server, and (c) Server-Server. Diverse ICT-I services can be invoked in each of these three situations. Client-Server case is used when a CNO actor (e.g. a VBE member) wants to access services provided by other CNOs through a centralized portal server. For example, a VO Planner who wants to know the competencies of VBE members or to open collaboration sessions with human peers in the CNOs. In this case, ICT-I needs to support the security and messaging, for instance. Intra-Server is used whenever a CNO portal is designed.
under SOA concepts, aggregating several vertical services. Depending on the business rules that have driven the services’ logic, ICT-I can support, for instance, the orchestration of the required services. Server-Server is used to support inter-CNO collaboration. For example, when a PVC portal needs to access a VBE for obtaining the list of companies that has some profile. In this situation semantic mediation service can be used for dealing with the different ontologies.

Interoperability is not the focus of the ECOLEAD ICT-I. It is seen as an enabler for collaboration. In this sense, attention has been put only on the essential aspects of interoperation required to support the planned collaborative services involved in cases (a), (b) and (c), also benefiting from outcomes of other projects and initiatives.

As far as security is concerned, a flexible model is being devised (Sowa et al., 2006). Security in CNO is fundamental as a way to reinforce trust building. The security framework that is being incorporated in the ICT-I supports authentication, authorization and accounting along the collaborative transactions that are carried out among CNO partners, regarding the different roles and privileges each one has in a CNO. This framework allows responsibilities (and eventually delegations) to be dynamically assigned to actors and required security mechanisms settled accordingly. In practice, it means that the access to the federation’s services and hence to information is filtered considering the users’ privileges.

Having presented all involved concepts applied in the ICT-I conception, ICT-I is defined as an open, distributed, scalable, transparent and security-embedded collaborative service-oriented infrastructure, tailored to support CNOs in modeling and execution of collaborative tasks, on-demand and paid-per-use.

4. ICT-I SERVICES AND IMPLEMENTATION

As mentioned in the previous section, ICT-I comprises a set of reference classes of supporting services that then should be derived for particular CNOs. In the ECOLEAD project, the ICT-I Reference Architecture is being derived to support the following services:

- **ICT-I Horizontal Services**
  - **CNO on-Demand Collaboration Services.** For supporting human collaboration: mailing, chat, task list, file storage, notification, calendar, wiki, forum, voice and syndication.
  - **CNO Knowledge Search Services.** For supporting knowledge sharing, in order to manage distributed/heterogeneous bodies of knowledge of CNOs. Ontologies are used for bridging semantic gaps among knowledge repositories allowing seamless information retrieval.
  - **Interactive, user-centered BP Management Services.** For supporting business process interconnection, providing support to task-oriented/interactive decisional activities.
  - **CNO Data Access Services.** For supporting systems interoperability, providing an easy-to-use environment for WS-based legacy systems RDBMS queries. This service provides tools for defining and configuring the database and the information that needs to be shared in a VO.

- **ICT-I Basic Services**
  - **ICT-I Security Services.** To support confidentiality, integrity, availability and authentication in the communications. This includes the log-in and user management service.
  - **ICT-I Billing Services.** To allow the implementation of different billing models to support the pay-per-use and on-demand services provision.
  - **ICT-I Services Composition.** To provide facilities to define and execute composed services according to BPEL standard for services composition.
  - **ICT-I Reporting Services.** For generation of reports to other services using pre-defined templates in well known formats (pdf, XML, HTML, etc.).
  - **ICT-I Services Registry and Discovery.** For supporting the services publishing in a repository as well as the search and browsing of services.

In terms of implementation technologies and basic environment, Web-Services/WSDL/HTTP/SOAP/UDDI have been used as the standard technologies in ICT-I. Axis/Jonas and JBoss are the containers used and services are coded in Java. Portlets were implemented in Liferay and Stringbeans. Services were deployed in distributed repositories, both on a Windows XP and Unix platforms.

Concerning deployment, it should be analyzed under two perspectives: client and server. From the client point of view, the ICT-I user needs just a browser. The ICT-I services themselves are stored outside the organizations, in services providers. Regarding some security requirements, a very small deployment of some elements is necessary, but this is automatically done. Evidently that some configurations are needed depending on the ICT-I services in use. For example, an organization should define its ontology mediation rules and security access, for instance. This is done off-line and it is up to systems administrators doing this. In the case some vertical service / application needs specific supporting software (but this is out of scope of ICT-I) then it will be necessary to deploy it locally. From the server point of view, services are built as components so they need component containers to deploy them. As servers usually have this kind of container, this is easily made. However, it is necessary to certify that servers should support QoS requirements as they will host the services.

5. ICT-I FOR FUTURE CNOs

CNO is an emergent area and new requirements can arise while it evolves. This section presents the
main guidelines being pursuit towards preparing ICT-I for future CNOs. From the technological perspective, it is believed that in the future CNOs will be immersed in an extremely volatile and pervasive computing environment where resources of several natures will be available for use. Yet, there will be several and heterogeneous communities of services providers (CNO of IT developers) that will publish their services following their particular rules and strategies. In this scenario, the evolution of the presented ICT-I should go in the direction of allowing it to take advantage of this in a smarter way in order to extend the level of collaboration among CNO members. One approach to support this is to introduce (some) autonomy in the ICT-I’s control mechanisms. Autonomy means to endow it with decision-making capabilities. For this, an ICT-I needs to be more “active” i.e. intelligent.

Under this vision, two basic guidelines have been considered in the future works within ECOLEAD: i) enlarging the collaboration borders to access all available resources, and ii) to drive intelligence regarding context awareness. The former means to develop mechanisms to gather all available CNO resources (information, knowledge, services, hardware and pervasive devices) and to make them accessible transparently and seamlessly. This can be achieved via grid platforms, pervasive networks, P2P mechanisms and intelligent information and knowledge retrieval systems. It is also necessary to manage the federation of IT providers (their life cycle and the services life cycles) and to harmonize policies for services publishing and advertisement.

The latter means to develop advanced searching and selection mechanisms over large-scale services repositories. This will consider semantics but also the “context” (process, idiom, physical device being used, trust level, etc.) a given service or user is. Interoperability problems can be mediated on the fly via autonomous services brokers. Web-based agents appear as a suitable technology for this.

6. CONCLUSIONS

This paper presented an ICT infrastructure (ICT-I) for supporting CNOs in doing businesses. It has been conceived based on the service oriented architecture paradigm, providing organizations with a transparent (mostly), platform-independent, easy deployable and configurable, secure-embedded, lean, distributed, scalar, on-demand and pay-per-use ICT-I. These features seem to make it somehow unique and useful for SMEs. ECOLEAD ICT-I is devoted to CNOs so it doesn’t compete or aims to replace existing B2B solutions. Instead, it complements them.

So far the ICT-I being derived covers a number of requirements of three types of CNOs / “ICT-I clients”: VBE, VOM and PVC.

The core implementation strategy applied was to use existing open-source software as much as possible and then to make the required adaptations for the ICT-I purposes. In general, all those mentioned ICT-I services use an open-source tool and have added value (CNO-related) on top of them. Other issues are not dealt by ICT-I and are totally incorporated with outcomes from other initiatives (e.g. fault tolerance, some aspects of security, legacy systems).

From the technological point of view, the chosen web-based technologies showed to be a good choice. The services integration (vertical, horizontal and basic) was carried out relatively smoothly. Once all services’ interfaces, parameters, UDDI, etc., were properly set up, all invocations – and hence the CNO processes – were executed without problems even having services physically deployed in several countries. Therefore, from the conceptual point of view, the ICT-I as a distributed WS-based infrastructure seemed to be a feasible approach.

ICT-I is still under development. Some services have been already implemented and some others will be ready in the next future. Next steps cover the development of other ICT-I services as well as its validation close to the project’s pilots.

REFERENCES