11 ENABLING VIRTUAL ORGANIZATIONS IN A TECHNOLOGICAL DISTRICT

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A Technological District (TD) is a form of Collaborative Network in a limited geographical area, where a variety of economic entities (enterprises, research centres, public administrations) are involved in high-intensive research activities and distributed scientific-technological processes, including knowledge sharing and technological innovation.In this paper, we hypothesize a TD scenario where a Virtual Breeding Environment (VBE) defines main working and sharing principles in order to enable collaboration between its members. One important goal is that of increasing chances and preparedness of TD members in the constitution of Virtual Organizations (VOs). We introduce a VBE organisational framework for a TD and we propose an approach to identify configurations of a VO addressed to carry out an innovation project.

1 INTRODUCTION

The territorial dimension of scientific research and technological transfer activities is absolutely significant in a knowledge economy development on local basis. This is shown by several examples (e.g.: Silicon Valley and Bangalore) which exhibit some common characteristics:

- presence of Universities or Research Centres able to transfer knowledge to the local territory;
- an industrial structure able to absorb and utilize such knowledge;
- presence of dynamic local governments and category associations;
- a system of SMEs that, as "technological partner" becomes the contact point between research institutions and large enterprises
- consolidated fund rising activities.

This has led to the concept of Technological District (shortly, TD), i.e. a regional cluster of learning firms and institutions (universities, consultants, research centres, spin-offs), working in complementary technologies, in terms of the quality of all of the communication networks within which technological information is shared and transmitted from one firm to another, (Antonelli, 2000). The development of a plurality of dissimilar but complementary cooperative relationships in a collaborative network is the key source of innovation. Empirical evidences are given in (Patrucco, 2003; Quintana-García and Benavides-Velasco, 2005).

In a TD, value creation is strictly cooperative and collaborative while value capture is essentially competitive. This kind of strategic interdependence is known as "coopetitive system of value creation" (Nalebuff and Brandenburger, 1997)**.** The incentive to collaborate derives from the fact that the success of a firm doesn't necessarily mean the failure of the others and different forms of cooperation may be adopted in order to enhance, at the same time, individual and common interests.

An emerging experience of TD is represented by the Logistics and Production TD in the area around the Gioia Tauro (Calabria, Italy) seaport.

Economic activities in the area of Gioia Tauro can be classified along 3 levels:

1. commercial transit (core functions): essentially based on transhipment activities carried out by 2 main terminal operators ("Medcenter Container Terminal" and "BLG Automobile Logistcs Italia");
2. seaport services (support functions). They can be grouped in: transport and shipping services (e.g.: shipping companies and linear agents), cargo handling at the terminals (e.g.: cargo controlling or warehousing companies), services dedicated to the maritime customers of the seaport (e.g.: reparation, cleaning of ships) and port authority services (management of property assets, safety regulations, environmental protection, etc) ;
3. hinterland industries (secondary functions): these activities generate added value to the goods through transformation and semi-product manufacturing processes (the containerised goods are removed from the containers, transformed, packaged again, controlled, labelled, etc.). At the time being, these activities have very limited extension but the territory shows a good growth potential; as matter of fact, a plethora of SMEs of different manufacturing industries (especially woodworking, agrifood and packaging) as well as insurance and bank companies (focused on transportation and ship insurance, trade financing, etc.) are located in the Gioia Tauro area.

The depicted economic structure and the presence in Calabria of logistic and production research centres (labs at University of Calabria and at University of Reggio Calabria, CNR centres, …) concur to the establishment of favourable conditions for a TD. In 2005, the National and Local Governments established a "Framework Program Agreement", in order to foster a "Logistic and Production TD" in the area of Gioia Tauro. The objective is pursued through the promotion of innovation projects (shortly, IPs) in *advanced supply chain management, cross-docking and materials handling management, coordination of finishing and packaging activities (quality control, product assembly, finished goods packaging), demand chain and order fulfilment management (cost-effective pick up, delivery and reverse logistics), control of pallets and container pooling activities*.

In this paper, we present some results emerging from research activities developed in one of these projects, namely "LogNET-LOGICA". A framework, based on a Virtual Breeding Environment (briefly, VBE)[1] structure, is introduced in order to enable collaborative innovation processes in a TD; particular emphasis is addressed to the problems of:

- characterizing a TD network where Virtual Organisations (shortly, VOs) may emerge;
- identifying competencies in partners and organisational structures of a VO specifically addressed to carry out an IP.

[1] In (Camarinha-Matos and Afsarmenesh, 2005a) a VBE is defined as "an association or pool of organizations and their related supporting institutions that have both the potential and the interest to cooperate with each other, through the establishment of a "base" long term cooperation agreement. When a business is identified by one member, a subset of the VBE members can be rapidly selected to form a virtual organisation"

Similar problems have been already faced in previous action research projects, e.g. the "Virtual Factory" project (Schuh et al, 1998), and a process theory of competency rallying, grounded in a study of successful VOs, has been given in (Katzy and Crowston, 2001). Main contribution of our work consists in providing a mechanism to identify and marshal competencies in a TD, that is, to structurally determine what competencies and from which partner companies are required to carry out a specific IP.

2 REQUIREMENTS FOR A TD-VBE MODEL

In a TD, strong and long-lasting relationships among actors often leads to rigid specialization situations and the TD governance structure becomes very similar to a traditional hierarchy, losing flexibility and global competitiveness. Such a situation determines the need to establish "weak connections" among partners to facilitate the possibility of a TD actor to frequently be a member of different value chains.

In order to achieve the required level of organizational flexibility, the temporariness of collaboration assumes a strategic importance: a TD actor could choose time to time the most appealing cooperation with other actors and provide its expertise in many different temporary organizations. A TD-VBE, i.e. a VBE whose members are economic actors of a TD, can realize and improve coopetitive dynamics among TD actors in order to carry out IPs. In a TD-VBE, instead of the prevailing fixed and long-term partner relationship, short-term and dynamic coalition among TD actors becomes the main stream**.** A TD-VBE management model may be based on:

flexible "weak connections" networks. In a TD the division of labour is cognitive based. Each TD actor carries out well defined activities in a value chain and, at the same time, it continuously develops know how and products/process/organization innovation. In a TD-VBE, dynamic actor aggregations, based on flexible weak connections, may be created, time to time, to provide innovative solutions for business opportunities. Under this perspective, a TD-VBE can potentially be regarded as a permanent laboratory of research and innovation.

TD knowledge management. In a TD, the knowledge capital (know how, best practices, relations among TD actors consolidated by practice, etc.) constitutes an important source of competitive advantage in global markets. In a TD-VBE, through an effective knowledge management, each innovation, even if realized by a single actor, rapidly becomes property of the whole district and, thus, shared with other TD actors.

Strong competition among TD actors. Making a TD actor rapidly informed about real capabilities of any others, a TD-VBE determines positive competitive effects among actors that could be involved in a same value chain stage. In other words, the local B2B market turns out to be highly transparent: the best production supplier, the most effective services supplier, the cheapest and the most innovative logistic provider are known by everyone in the TD.

The introduction of a TD-VBE is a necessary context for effective creation of VOs as confirmed by recent surveys (Katzy and Sung, 2003). Such studies highlight that most projects assume the existence of a stable source network (a VBE) from which short-term cooperation in VOs emerges. Furthermore, most of the reported projects do not provide information on the VBE model even when the source network is considered the indispensable factor for the creation of VOs.

A TD-VBE may provide most of the advantages described in (Camarinha-Matos and Afsarmanesh, 2005b) but, of course, it needs to be properly managed during its entire life cycle (i.e.: creation, operation and metamorphosis). In next sections, we focalize our attention only on a base functionality in the TD-VBE operation stage: the VO management[2].

3 MANAGING A VO IN A TD-VBE

In what follows we describe main organizational variables for the management of collaborative innovation processes in a TD-VBE. In particular we consider market-driven innovation that could happen when a solution for a new business problem is requested by some TD actors and this request is needed to be converted into an IP. A suitable combination of technical expertises are needed to be found in the TD-VBE in order to match the problem with a technology. An IP is a project carried out by a VO specifically addressed to innovate a product, a method of production, a form of business organization or simply uses for existing products.

TD Actors/Relationship

One of the critical aspects for the success of a TD consists in the pre-existence on the TD territory of specialised actors involved in scientific and technological knowledge management processes. The presence and role of research centres in a TD represents the main difference between classical Industrial Districts (IDs), which rapidly spread in Italy and Japan since the seventies, and TDs. In the Italian experience, IDs did not developed around Universities and they do not present high tech vocation (in contrast with the Cambridge and Silicon Valley experiences). Of course, other fundamental TD actors, that can be connected through a number of different types of relationships (e.g. client-supplier, knowledge sharing, collaborative design, etc) are represented by enterprises in the TD. Strongly dependent on the local dimension of the TD, a set of factors can condition the TD development and TD the actors relationship (availability of specialized and cheap human resources; diffused entrepreneurial spirit; strong connections with the outlet markets; effective choices in regional and national policy).

TD-VBE Roles

In the TD-VBE four main roles are present:

TD-VBE member. A TD actor may become a TD-VBE member once showing its readiness to contribute in TD-VBE activities and its willingness to be involved in possible VOs. Each of them assumes a set of responsibilities in business relationships with other TD-VBE members and has a set of rights/authorizations needed to enjoy supporting tools and services provided by the TD-VBE service centre.

TD-VBE service centre (TD-SC). In a TD-VBE, multiple value activities are performed by different TD-VBE members that work together in a value network, i.e. a web of relations needed to generate economic value through complex value exchanges among involved actors. This value network requires a variety of supporting information services. Such services may be provided by a TD-VBE Service Centre (shortly, TD-SC) in order to promote cooperation among TD-VBE

[2] A detailed list of base functionalities required at any VBE life cycle stage is provided in (Camarinha-Matos et al. 2005a).

members, to fill skill/competency gaps in the TD-VBE, to make available value added services and organizational/technological standards, to define an "ethical code" and behavioural rules in collaboration processes, to improve coordination among TD-VBE members and to transfer knowledge patterns from research centres to enterprises. Furthermore, the TD-SC acts as an aggregator of TD-VBE members for the development of High-Tech programmes; in particular, it identifies the network of all possible configurations of a VO addressed to carry out an IP.

Collaboration catalyst. It is a TD-VBE member that markets TD competencies and assets, negotiates with (potential) customers and identifies new business opportunities. It launches through the TD-SC a request to collaborate in an IP. Successively, it evaluates and selects a configuration of potential collaborators among the ones proposed by the TD-VBE service centre.

Potential collaborator. It is a TD-VBE member that has declared its willingness to collaborate in an IP. In order to asses technical feasibility of innovative ideas it may launch through the TD-SC a new request to collaborate in an innovation subproject and may respond to some others. A potential collaborator participates to the negotiation phase aimed to form a VO only if it belongs to the collaboration configuration selected by the catalyst.

TD-VBE activities

Main TD-VBE activities and roles are represented in tab.1

Table 1 – Activities and roles in a TD-VBE

Activity	Responsible	Participants
Customer Relationship Management	Collaboration catalyst	TD-SC
Identifying a collaboration business opportunity	Collaboration catalyst	
Launching a request to collaborate in an IP	Collaboration catalyst.	TD-SC
Building a potential collaboration network	TD-SC	TD-VBE members, potential collaborators
Identifying the candidate VO-configurations sub-network	TD-SC	
Managing the development of feasibility studies for any IP	TD-SC	Potential collaborators
Evaluating potential collaboration configurations	Collaboration catalyst	TD-SC, potential collaborators
Selecting a collaboration configuration	Collaboration catalyst	
VO formation negotiation	Collaboration catalyst	Selected potential collaborators, TD-SC

VO activities and roles

The success of a VO depends on a balanced provision of management competencies, co-ordination roles and an effective innovation process management. A set of roles and activities should be taken into account for the VO management:

Roles:

the VO partner is a selected potential collaborator that operates in the VO according to a "cooperation agreement" stipulated in the negotiation phase. Each VO partner is responsible for a step in the VO value chain and develops a dedicated interface with the VO to interact with other VO partners. It offers technological know how, resources and expertise to the VO as well as it is exposed to ideas and demands that would have not been apparent operating outside the VO;

the VO broker has the responsibility to market the VO and to retail its competencies. Besides organizing the response to a customer request, the VO broker acts as a promoter to develop and multiply a market opportunity through interaction with involved stakeholders;

the VO coordinator is a TD-VBE member that has been selected by the VO partners in order to organize and coordinate decisional processes in the VO life cycle. It supervises the operations of the VO offering time, project management, and budget control. Additionally the VO coordinator could manage the knowledge engineering process, e.g. replacing partners who do not perform satisfactorily;

the VO service provider enables and supports VO life cycle processes by providing VO partners with technological and information tools and standards, best practices and successful communication models.

Activities

Main activities and roles in the VO life cycle phases are represented in tab.2.

Table 2 – VO life cycle activities and roles

Activity	Responsible	Participants
VO creation		
"Cooperation agreement" stipulation + VO coordinator selection	VO broker	VO partners
Resources analysis and sub-processes definition	VO coordinator	VO partners
Risk analysis	VO coordinator	VO broker
Mapping VO activities on VO members + Virtual Process Breakdown	VO coordinator	VO partners
Selection and integration of elementary critical processes	VO coordinator	VO service provider
Formal definition of process responsibility and authority	VO coordinator	VO partners
Information system design	VO coordinator	VO service provider
Legal aspects and quality standards definition	VO coordinator	VO broker + VO service provider
VO operation		
VO launching	VO coordinator	VO Broker
Virtual process coordination + Risk management + Business process management and monitoring + Quality control and logistic management	VO coordinator	VO service provider
VO dissolution		
Information storing and sharing among partners	VO broker	VO coordinator + VO service provider
Result evaluation	VO broker	VO coordinator + VO partners
Intellectual knowledge property management	VO coordinator	VO broker + VO service provider + VO partners

4 IDENTIFYING VO CONFIGURATIONS IN A TD-VBE

In a TD-VBE, the nature of collaborations is characterized by a high rate of innovation based on continuous knowledge sharing and research results dissemination. When an IP is required to be collaboratively decided on, the classical sequential approach to the identification of partners and configuration of a VO cannot always be applied, (Volpentesta and Muzzupappa, 2005). A more effective approach may be based on building a network of candidate VO configurations, on evaluating them and on selecting the most adapt for the development of the required

IP. The first part of this process is based on a top-down phase and a bottom-up phase3. The top-down phase consists of two sequential steps:

- building a "potential collaboration network". In such a network a weak relationship between two TD-VBE members is established whenever one of them expresses its interest in collaborating on an IP (or sub-project) proposed by the other one;
- identifying the sub-network of all candidate VO-configurations. A candidate VO-configuration is a structured minimal cluster (TD-VBE economic entities and their weak inter-relationships) capable, in principle, to collaboratively develop a feasibility study for the IP identified by the catalyst.

The second phase consists of the bottom-up development of feasibility studies for the IP carried out by potential collaborators in the candidate VO-configurations sub-network.

Building a potential collaboration network. This step starts as soon as the catalyst launches an initial request for collaboration on an IP p^* (shortly, RFC(p^*)) and it takes place in a lapse of time established by the TD-SC. At any moment a TD-VBE member could select an RFC(p), amongst the ones forwarded by the TD-VBE Service Centre, and decide to announce its intention to collaborate on p (in such a case, it may launch other requests for collaboration on some subprojects of p). More precisely, when a TD-VBE member decides to collaborate on p, it becomes a potential collaborator through sending to the TD-SC an expression of interest to respond to RFC(p), conditional on obtaining responses to RFC(p_i), where p_i is a subproject of p, $i=1,..,n$.

Multiple executions of this task, carried out by different TD-VBE members, induce a recursive formation of a potential collaboration network that is represented through a conceptual data model at the TD-SC side.

Identifying the candidate VO-configurations sub-network. In this step TD-SC analyses the potential collaboration network in order to select only those potential collaborators and expressions of interest that could be an integral part of a VO-configuration. In this task the TD-SC could be supported by a Decision Support System based on results presented in Volpentesta (2007) where the logical structure underneath a VO-configuration has been theoretically and algorithmically characterized. On one hand, the logical structure of a VO defines a top-down decomposition of the initial IP in gradually less complex subproject; on the other hand, it identifies potential collaborators and the requirements of their knowledge exchanges and collaborations in a VO-configuration.

Managing the development of feasibility studies. In this step the TD-SC is required to manage the process of recursive composition of feasibility study tasks carried out by potential collaborators along the candidate VO-configurations sub-network. A feasibility study task consists of an analytical and experimental investigation description about an innovative product or a business process in compliance with requirements set out in the RFC(p) which the potential collaborator is responding to. Of course, a potential collaborator could complete its assigned task

[3] Volpentesta and Muzzupappa (2006) have faced the case of collaborative projects for innovative product concept design. They have proposed a process formal model making use of logical structures based on concepts related to direct hypergraphs.

only if it has received all the required responses to RFC(p_i), where p_i is a subproject of p, $i=1,..,n$.

Once this three steps process has been carried out by the TD-SC and potential collaborators, a sub-network of candidate VO-configurations as well as their corresponding feasibility studies have been determined. Successively, the collaboration catalyst evaluates them and selects the most promising one for the formation of a VO.

5 CONCLUSIONS AND FUTURE WORKS

In this paper we have introduced a VBE organisational framework specifically addressed to enable collaborative innovation processes in a Technological District. Most of these processes relies on the identification of an effective configuration of a VO that can convert a market request, based on social needs and customer requirements, into an IP.

Besides, we have proposed an approach to identify a network of candidate VO-configurations and to manage feasibility studies for an IP along this network. An early and partial implementation of the approach has been carried out in the project "LogNET-LOGICA", through involving some research labs of the three universities in Calabria and few enterprises of the TD of Gioia Tauro. However, further research activities should be developed to fully implement and validate such an approach.

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