Cooperation and Coordination in Virtual Enterprises: the role of E-collaboration Tools

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Abstract: Virtual Enterprises are an emerging model for the organization of innovative enterprises. They are characterized by brief relationships and geographical dispersion of members. E-collaboration tools play a critical role in the integration of such organizational systems. In particular these tools support both cooperation and coordination. Cooperation has been defined as the problem of aligning goals among the members of an organization. Coordination, instead, includes those processes through which actors which share a common goal align their actions. Traditional organizations typically face these problems through slow and complex processes based on face to face interactions. Virtual enterprises, instead, have to develop techniques to rapidly integrate members which interact mainly through electronic channels. This paper discusses how e-collaboration tools can support cooperation and coordination in a virtual enterprise. The evolution of their role during a virtual enterprise life is described. Special attention is paid to the interaction between technological and organizational factors.

1. Virtual Enterprises: definitions and criticalities

A widespread, stereotyped image identifies a traditional organization with a physical place, where people work close to each other. In this ideal organization working time is standard, relationships have a long term orientation, decision rights belong to the owners and are delegated along a univocal and well defined hierarchy. Even culture is considered as largely shared among members.

As globalization, technological innovation and market turbulence challenge traditional business logic, firms are experimenting with new organizational models: the network organization [MS86] [NE92], the flexible firm [Vo96], the shamrock organization [Ha95].

Among these new models, the "virtual enterprise" or "virtual organization" [DM92] [Mo94] is one of the most popular. Galbraith [Ga95] defines a virtual corporation as "the exact opposite of the vertically integrated corporation. Instead of covering all the activities a business comprises – from raw materials to the ultimate consumer – the virtual corporation contracts out for all activities except those in which it is superior. As a result, a network of independent companies – each doing what it does best – acts together as if it were virtually a single corporation. Hence the name". Kasper-Fuehrer and [KA01] stress the transitory nature of the virtual enterprise, defining it as "a temporary network of independent organizations, companies, institutions, or specialized individuals that come together swiftly to exploit an apparent market opportunity". All these authors point out the key role that ICT play for Virtual Enterprises [Mo94] [VH98]. ICT allows the global reach needed in response to the expansion of the marketplace and of the businesses which serve it. Besides, it provides rich communication channels,

The image that Mowshovitz proposes to describe the functioning of virtual enterprises is "the switching principle". Connections among members are switched on and off according to the need, with the support of adequate technological systems.

The term virtual organization has been applied to movie production, networks of subcontractors in the automotive and electronic devices industries, consortia [Kr99], online sellers like Amazon.com [We99], remote insurance and banking services providers [Al97], personal computers manufacturers [Ma98], electronics [Ka99], and mechanics [KA01].

According to this view the main feature of virtual enterprises is connectivity: given a new business opportunity, firms quickly identify the competences needed to exploit it; they select from the population of potential partners those which excel in each of the needed competences; in the end, they integrate these partners in a productive system called virtual enterprise, which is based mainly on mutual adjustment processes [Mi83] supported by ICT. If the business opportunity proves ephemeral, virtual enterprises disband; otherwise they evolve toward a more stable organizational form as networks or vertically integrated firms.

Together with opportunities, however, virtual enterprises involve risks, as several researchers point out: increased conflict [HB03], lack of trust [Ha95], difficulties in systemic innovation [CT96], complex communication processes [DM99], unexpected disruptions that reverberate through the system [Sc99].

Compared with vertically integrated firms, virtual enterprises substitute hierarchy with incentives, formal and procedural coordination with complex communication systems. The problem is that, while vertically integrated firms are robust, but slow, virtual enterprises are fast, but fragile.

Virtual enterprises go often through a process of progressive inclusion of participants. Actors are asked for strong reputation to participate in the new activity. When this reputation is not considered sufficient, new actors face a period of "initiation" during which they demonstrate their commitment to the joint enterprise and acquire knowledge about their partners. During this phase, the aim of the interactions among the partners evolves. In the beginning the priority is to set shared goals. The problem to define shared goals is called "cooperation problem". Once shared goals have been defined, members must define rules, interaction procedures and routines to align their actions. This last set of activities is called the "coordination problem". In the following sections the role of e-collaboration tools in virtual enterprises will be discussed. In particular, the way these tools contribute to solve both the cooperation and the coordination problem will be considered.

2. The dimensions of Virtuality

DeSanctis, Staudenmayer and Wong [De99] explicitly consider the following four dimensions as important for virtual enterprises:

Space: individuals, teams and offices in virtual enterprises are often geographically distributed. This provides several advantages: the improvement of reactivity to local opportunities (or threats); the possibility to exploit differential costs; the reduction of transportation costs; the exploitation of time zones, which permits the productive process to occur twenty four hours a day (as often happens in the software development industry).

Time: virtual enterprises are modular systems. When a change is needed it can be obtained adding, subtracting or substituting a part. For example if extra capacity is needed in a plant, an external supplier can be involved in production; if a component can be produced with better results by a new supplier, the old one can be replaced. Participants, then, conceive the time of their relations to be brief.

Culture: "Culture" can be defined as the set of shared values and meanings that members of the same organization agree upon [Sh92]. In traditional organizations, stable relations contribute to the creation of a shared culture among members. In a virtual enterprise, each new configuration of linkages implies a new negotiation of values and meanings. This favors creativity and "contaminations", but increases conflict and misunderstandings.

Boundaries: in a virtual enterprise processes cross organizational boundaries. Production is controlled by different actors in different phases. These actors have their own priorities, their own methods and their own technologies. While an integrated firm has several mechanisms to control its employees behavior (authority, above all), virtual enterprises rely on complex processes of negotiation and mutual adjustment.

It is possible to think about virtuality as a vector whose variables are space, time, culture and boundaries. The level of virtuality increases when the time spent by the members in the same place decreases, when the duration of the relationship is short, when members share just a limited cultural background, when processes are controlled by several independent actors [MC05].

ICT allows organizational actors to communicate and share information across distance, time (when communication is asynchronous) and boundaries. The new relations enabled by ICT, however, are substantially different from the ones existing among co-located partners [MF96]. Since electronic channels are not as rich as face to face interactions [DL86], in virtual enterprises it is important to find solutions and tools to support reciprocal commitment and mutual understanding.

3. Cooperation and Coordination in traditional and Virtual Enterprises

Productive activities are characterized by the division of labor and its integration through different organizational forms. Market can be thought of as the simplest form: two actors work autonomously and coordinate through price. When two or more actors perform interdependent activities, two problems have to be solved in order to obtain an overall satisfying result [Si76] [Gr96]:

1. Cooperation;
2. Coordination.

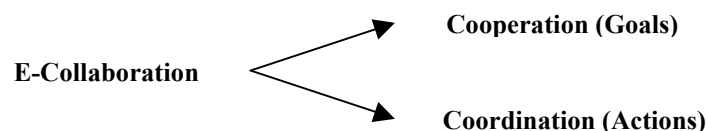E-collaboration tools support the solution of both the cooperation and the coordination problem (figure 1).

Figure 1: E-collaboration organizational problems.

Cooperation: each participant in an economic activity has its own structure of interests. For example, if we consider an economic exchange, the seller's interest is to maximize the price while the buyer's interest is to minimize it.

Cooperation can be defined as the problem of aligning goals. In order for a task to be successfully completed (when it is performed by several interdependent actors) participants must be willing to pursue a common goal. Organizational forms use different mechanisms to align goals when interests are divergent. In ideal market exchanges, cooperation occurs if the price offered by one party satisfies the other one. In hierarchies, instead, one party gives up a part of its decision rights for a fixed remuneration. Clans are communities in which social mechanisms influence the structure of interests of members.

The opportunism-based approaches to the theory of the firm have concentrated on cooperation as the most important organizational problem. The need to avoid that selfish behaviors may damage the overall performance (that is, the need to guarantee cooperation) is considered the reason for the emergence of hierarchies.

Coordination, instead, can be defined as the problem of aligning actions. Even if interests are convergent, participants in an economic activity incur in costs and failures due to poor communication, misunderstanding or different interpretations of events. Repeated interactions, identification, common experiences, allow members of an organization to develop tacit rules and shared cognitive structures that make coordination and mutual understanding easier. On the other hand these *routines* tend to be transported unchanged in new settings, leading to suboptimal behaviors [KZ96].

According to Boisot [Bo95], knowledge can be specific or diffuse, tacit or explicit. Knowledge is specific when only the members of a defined (organizational) community posses it. Organizational procedures, idiosyncratic languages, organizational values are examples of specific knowledge; concepts in physics, economics or informatics, instead, are diffuse knowledge (that is, there are many individuals who possess these concepts and their meaning is the same to everyone).

The knowledge-based approaches to the theory of the firm attribute to knowledge specificity great influence on the effectiveness of coordination. In fact, each organizational actor interprets the information he possesses according to his own knowledge basis.

Misunderstandings become likely when information is exchanged between two actors which interpret it according to different knowledge basis. Instead, when knowledge is diffuse, exchanged information are interpreted by different actors in a consistent way. If knowledge is explicit, it can be quickly transferred to partners while tacit knowledge requires frequent interaction and stable relationships to be learned. Coordination is easier, then, among partners which share the knowledge relevant for mutual understanding, above all when this knowledge is tacit.

In traditional, hierarchical organizations the main integration mechanism is authority. One of the involved actors sells a part of its decision rights to the other, who buys the right to impose decisions under a system of rules. Authority is used both for cooperation and for coordination purposes. Through hierarchy, in fact, a firm can impose cooperation to its members reducing opportunism-related risks. At the same time, since remuneration is not proportional to individual performance, under a hierarchical organization incentives are reduced.

Authority is exerted through explicit rules and directives. In hierarchies coordination is achieved through a centralized decision system. Coordination is based on a knowledge substitution effect: while in a market parties act and take decisions just according to their own knowledge, in hierarchies one party acts according to the others' judgment [CP96]. Since parties act on the basis of the same knowledge, coherent behaviors should be warranted. Through repeated interactions, besides, traditional organizations develop a shared knowledge base among participants. Actors have, partially, a common understanding of their business. This socially developed knowledge base reduces the risk of inconsistent behaviors.

As the level of virtuality grows, the mechanisms available to manage cooperation and coordination show different characteristics (table 1).

In virtual enterprises actors are independent and relationships are brief. Neither authority nor social mechanisms can be effectively applied to interactions. The only mechanism left to manage cooperation issues is negotiation. Negotiation, however, is an expensive mechanism in uncertain and complex interactions unless asset specificity is low [Wi85].

With regard to coordination, in virtual enterprises an explicit evaluation of available information is preferred to social or authority-based coordination. When information is exchanged that must be interpreted according to local and tacit knowledge, misunderstanding become likely unless a common understanding of the activity to be performed has been earlier established. The existence of official standards, as technological or quality standards has a critical role in improving coordination in virtual enterprises. Just as important is the role of universities, schools and professional associations or, inside organizations, training, which diffuse knowledge among individuals.

	Traditional Organization	*Virtual Enterprise*
Cooperation	*Imposed* (through authority)	*Negotiated*
Coordination	*Authority-based* or *routine based*	*Information-based*

Table 1: A comparison between traditional organizations and virtual enterprises.

4. Organizational relations in virtual enterprises

An interesting perspective to evaluate the implications of virtualization in innovative organizations is the relational perspective. The organization can be considered as a set of nodes (the actors), linked by relations which have a multidimensional nature: they involve technical, economic, social, psychological elements and so on. When the level of virtuality grows, the relations among members of an organization change profoundly. To describe this transformation four elements which characterize an organizational relation can be considered [MF96] [MC05]: the *goal* for which the relation was created, the *tools* (technological, but also contractual or organizational) which support the relation, the *rules* according to which actors interact and, in the end, the *cultural background* of the participants. The coherence among these four dimensions allows participants to integrate effectively their actions and decisions with each other and with the overall organizations.

In an organization with a high level of virtuality it is much less likely that goals and cultural background are homogeneous than in a traditional organization (where members work together for a long period an belong to a common hierarchy). A way to limit this problem is to choose participants with a strong professional reputation, or belonging to a network of selected partners. When this is not possible, the managers have to act on the two remaining dimensions of an organizational relation: the rules and the tools. Through a sophisticated system of rules, in fact, it is possible to discourage opportunistic behaviors and to coordinate actions. Rules, however, can make the organizational system rigid. Investments in the last dimension, tools, allow mutual adjustment among members. They improve flexibility and reactivity. Nonetheless, an indiscriminate use of technological tools risks to make the organization chaotic and ungovernable.

5. E-Collaboration and its relations with cooperation and coordination in Virtual Enterprises

E-collaboration technologies group a set of internet-based communication tools, which support both cooperation and coordination among distant workers. Among these tools, the most common are [BM02]:

– bulletin board: a message board, where a conversation can be carried on over time;
– forums: the subject is set and the discussion is carried on, either with all participants online, or over time;
– e-mail: the most common and widespread communication tool. Its main use is for text messages, normally relatively brief, often accompanied by attachments;
– chat: real-time text talk, where messages appear on both users screens;
– whiteboard: whiteboards allow two or more people to view and draw on a shared drawing surface;
– audio/video conferencing: use of audio or video to enhance human presence in meetings;
– screen sharing: both people have the same view of the screen and possibly the remote user can take control of the other user's system;
– meeting scheduling tools: creating meeting agendas and lists of issues or using calendars for organizing meetings;
– presentation capability: users can conduct presentations, i.e. show and annotate PowerPoint slides;
– project management: projects and project milestones, meetings, memos and project interactions are tracked. Project management with the traditional meaning of the term, i.e. creating Gantt or Pert charts and calculating the project budget is not considered;
– file and document sharing: documents and files are made available to a group of people;
– document management: document management includes sharing of documents. Documents are stored in a central server and users can work on them, either using their local applications, or the tool's functionality;
– synchronous work on files/documents: files/documents can be edited simultaneously by a number of users, either on each other's screen, or on a whiteboard.

E-collaboration tools have often been studied according to their capability to support more or less complex communications. Media richness theory [DL86] is the mainstream approach to this kind of research. Summarizing, according to this theory different communication tools can transmit different volumes of data per unit of time (media richness). Face to face is considered the richest medium, while email is considered a poor medium. The more the data transmitted, the less ambiguous the massage will result. As a consequence, the theory prescribes the adoption of rich media when ambiguous tasks are carried on, lean media when the performed task is not ambiguous. The empirical results obtained by studies based on media richness theory, however, are contradictory. While some studies have found a strong relationship between task ambiguity and media richness, other studies have found no relations at all or even inverse relations.

The mentioned studies usually do not distinguish if the considered media are used to support cooperation (i.e. to align goals) or to support coordination (i.e. to align actions). Clearly, the proper way to use each medium is different when the medium itself is used for cooperation or coordination purposes.

It is important to understand how e-collaboration tools have to be used:

1. in order to achieve cooperation;

2. in order to achieve coordination.

E-collaboration tools for Cooperation: cooperation is made easier by the existence of relationships 1) based on trust, 2) characterized by identification (of the individual with the organization) and 3) which support conflict resolution. The emergence of such relationships in computer mediated contexts follows different patterns with respect to non mediated situations.

Studying virtual settings, Jarvenpaa and Leidner [JL99] have found that the prevalent kind of trust which emerges is the so called "swift trust", that is, trust based on contextual information (e.g. a consultant is trusted because he has worked with important clients). This happens because members in Virtual Enterprises have a limited history of working together and little prospect of working together again in the future. In this situation they can not develop expectations about others based on personal knowledge. The communication medium, then, has a critical role: it facilitates cooperation if it is able to communicate contextual information.

Identification facilitates several processes which are related with the cooperation problem: the control of employees' behavior, group functioning, extra-role helping behavior, retention of valuable employees. Raghuram et al. [Ra01] hold that the communication medium itself can be a source of identification: that is, employees who use the same medium (face to face, email, instant messaging, telephone) tend to identify with each other and to cooperate more easily. This suggests that it is important to invest in technology and training in order to have a shared view of the communication media, from a practical, but also from a symbolic point of view.

Hinds and Bailey [HB03], with respect to the conflict resolution problem, have found that there is not much difference in the ways conflict arises in computer mediated and in non mediated contexts. Nonetheless in non mediated contexts conflicts are overcome much more easily. As a consequence, conflict resolution in mediated contexts is facilitated by rich media and by the possibility of repeated interactions.

E-collaboration tools for Coordination: e-collaboration tools are a valid support also for coordination activities. Through these technologies, in fact, information can be distributed among remote workers and mutual knowledge can be developed. While bulletin boards, forums, web sites are suitable tools for information sharing, interactive tools as videoconferencing, chats, screen sharing are useful for knowledge building. A relevant problem in virtual settings is that tacit knowledge is difficult to communicat through electronic channels. Storytelling, organizational narrations and knowledge maps are useful electronic supports for tacit knowledge transfer. In this case, however, e-collaboration tools can be effectively complemented by more traditional organizational mechanisms as face to face meetings, periods of training, periodical visits at the headquarter. To understand why e-collaboration tools show different performances in different settings, in fact, it is necessary to consider how they interact with the traditional management mechanisms. The effectiveness of email, for example, can be improved in teams with an experience of working together. Brief training periods, at the beginning and during the collaboration, enrich the communicative capabilities of the medium. Electronic tools do not substitute traditional organizational practices. Organizational and technological tools are interrelated, that is, if correctly designed they reinforce each other [Ro03].

Summarizing, while in stable settings e-collaboration tools are primarily used to make operative interactions easier (exploiting the possibility of collaborative work among geographically distributed members) in virtual enterprises their role grows dramatically. Since members, in virtual settings, work together only to exploit a specific and temporary business opportunity, it is likely that they do not know each other. Therefore, not only operative interactions, but also community building and knowledge building processes take place through electronic channels and e-collaboration tools in particular.

As we discussed earlier, during the first stages of a Virtual Enterprise existence, the aim of interactions evolves from a focus on cooperation towards a focus on coordination (Figure 2).

MAIN PROBLEMS

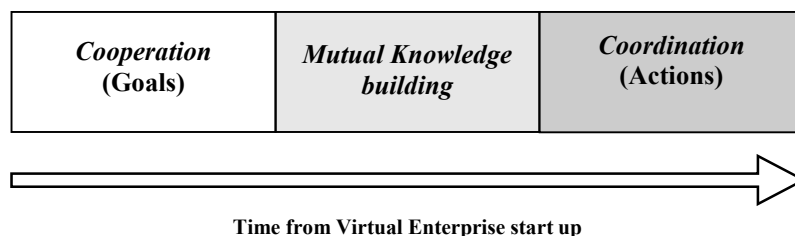| *Cooperation* (Goals)	*Mutual Knowledge building*	*Coordination* (Actions)

Time from Virtual Enterprise start up

Figure 2: Relation between Virtual Enterprise life cycle, Cooperation and Coordination.

As the virtual enterprise proceeds in its life cycle, the role of e-collaboration technologies shifts from improving cooperation towards improving coordination. In a second phase, when cooperation has been achieved, e-collaboration tools are used to create a base of shared knowledge. In the last stages they are used to efficiently coordinate actions.

We expect, then, that when a virtual enterprise is constituted, rich, synchronous media will be used to negotiate goals, exchange opinions, and compare visions of the world. As the virtual enterprise enters an operative phase, the need of rich communications decreases because the interactions are mainly due to operative coordination problems. Asynchronous, lean technologies as email are, in this case, sufficient to support the interdependencies among individuals.

The possibility to use e-collaboration tools separately from other organizational mechanisms increases when the duration of the relationships grows. In the first stages of a virtual enterprise existence a period of training is necessary, face to face meetings have to be frequent and formal descriptions of processes and organizational structures are a necessary support. Successively, when members know each other, electronic communication is sufficient to support interaction, since members have developed reliable knowledge about their partners' interests and competences.

Summarizing, in the early phases of existence of a virtual enterprise, when the need to build cooperation is stronger, we expect that richer e-collaboration media, as audio and videoconferencing, will be used. The use of these tools will be just partially structured and it will be complemented by a strong use of face to face. As the process of integration of the participants proceeds, coordination issues will become relatively more important. Un-structured and structured e-collaboration tools as presentations, screen sharing, shared whiteboards, forums, bulletin boards, will be used to build shared knowledge. In the end, when a good level of mutual knowledge has been reached, the use of document management systems for operative coordination will prevail on other e-collaboration tools.

6. CONCLUSIONS

Virtual enterprises are extremely complex systems where organizational and technological aspects play, more than ever, a critical role.

Virtualization can be understood as a process driven by advances in ICT, but also by changes in the competitive environment. These changes can be summarized as an overall increase in market turbulence. Organizations need to become more flexible and rapid in reacting to threats and opportunities. The main feature of virtual organizations, then, is the use of technological and organizational tools to relax some traditional constraints to their activities: mainly constraints of physical proximity and stability of relationships.

The ephemeral and dynamic nature of virtual enterprises makes traditional tacit mechanisms for cooperation and coordination less reliable. These mechanisms, in fact, rely mainly on a cultural background which is (to a certain degree) homogeneous. Developing this background requires long term relationships. On the other hand, in virtual enterprises there is an increased need for cooperation and coordination, due to the existence of divergent interests and to the innovative nature of the enterprise.

In traditional organizations knowledge and cooperation building activities are mainly conducted through face to face interactions. In this case electronic communication is exploited to share information among individuals with a good knowledge of each other's competencies and goals.

In virtual enterprises, instead, the geographical distribution of members and the short term orientation of the relationships makes face to face interaction costly and unpractical. Face to face is used only for very relevant activities. Cooperation building and knowledge building activities must be performed through electronic channels, e-collaboration tools in particular. E-collaboration tools, however, present different weaknesses when used for cooperation or for coordination purposes.

In the early phases of a virtual enterprise existence, cooperation is the main problem. Richer e-collaboration tools are needed. Besides, they must be complemented by face to face interactions, explicit training and liaison roles which support the definition of shared goals. Successively the building of a shared background gains importance. The support of traditional organizational mechanisms becomes less critical. Computer supported communication, in fact, has proved to effectively support this kind of interactions. In the end, when shared goals and a common knowledge base have been established, e-collaboration tools will mainly support information distribution and sharing.

In conclusion, the diffusion of e-collaboration tools in virtual enterprises could give the impression that, in this kind of innovative organizational systems, technological factors substitute for organizational mechanisms. The complex nature of virtual enterprises, instead, requires the intertwining of innovative and traditional integration mechanisms. The relation between these two categories of factors (organizational and technological) is dynamic and evolves during a virtual enterprise life cycle. Describing this evolution in terms of cooperation and coordination helps to understand how to design organizational and technological mechanisms in a synergistic way.

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