Inter-organizational Collaboration: Product, Knowledge and Risk

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ABSTRACT

Inter-organizational collaboration is no longer entirely a free choice, but is close to a necessity imposed by economic, technical, and knowledge-related concerns. A deep understanding of collaboration will assist in making intelligent decisions on entering, operating, and evaluating collaborative ventures. The nature of the partners—industrial corporations, consultants, academic institutions and others—and the collaborative structure are important, but so too is the nature of the product. We consider its effects in the collaborative domain on knowledge, intellectual property, and catastrophic risk.

Keywords: Collaboration, knowledge management, ICSD, risk management,

1. INTRODUCTION

Inter-organizational collaboration entails multiple organizations working together to provide a product (perhaps in a very general sense), with value for the partners, and perhaps for a wider community, in the success of the product. Such collaboration is no longer entirely a free choice, but is close to a necessity imposed by economic, technical, and knowledge-related concerns. A deep understanding of collaboration will assist in making intelligent decisions on entering, operating, and evaluating collaborative ventures. Important factors include the structure of the collaboration [6,23], the nature and experience of the partners [20,24], collaboration-aware handling of policies and risk [10,14,21,22,27], knowledge [3,7,9,12,18], mental models [4], and information flow [13,14,16,17], and the goal of the collaboration, which we consider in this paper.

In [23], we reviewed four modes for multi-organizational collaboration, three of them collaborative, largely in the context of software development:

- Contractual development using subcontractors and vendors.
- Supply-chain structures.
- *Ad hoc*, short-lived virtual organizations.
- Long-term collaborations.

While we explicitly excluded development of open software in that earlier paper, we should here add federation as a fifth mode, whether a federation of individuals and organizations developing open software, a collection of libraries centralizing cataloging, or a group of franchisees who need to maintain the reputation and consistency of services provided.

In [23], we argued that software development in particular tends to encourage long-term collaborations, resulting either from long or iterated development cycles for novel applications, maintenance of a long-lived system, or the desire to preserve technical and knowledge-intensive relationships in a setting of increased trust and cultural familiarity [1,19,28].

As we considered risk and collaboration further, it became apparent that the nature of the product was also significant. As an initial classification, we consider (1) sharing of resources, (2) provision of services, (3) development or manufacture of material artifacts, and (4) creation or modification of intellectual property.

- Resources: In such ventures, partners tend either to be collocated, sharing support services, or more-or-less peers in the same field, sharing production resources. We consider two simple examples—a consortium of Brazilian tool-and-die manufacturers sharing excess plant capacity and staff [29], and a group of small companies or organizations centralizing coordinated business support services.
- Services: We consider three classes of examples: first, franchised or coordinated professional services, such as large tax accounting firms or independent insurance agents and adjusters; second, services meeting daily needs, such as fast-food franchises; and third, a virtual organization—an ad hoc or permanent confederation of concerns—bidding

(for example) to host social events or conferences, each providing a different aspect of support.

- Material artifacts: Most collaborative supply-chain operations fit here. We consider the manufacture of automobiles and of electronic devices. (While there is a contractual side here, the relationship often becomes obligate on both sides—there are at most a few suppliers of a specified part, and at most a few large customers for that part. Thus planning for future production inevitably takes on a significant collaborative dimension.)
- Intellectual property: Notable examples include collaborative software development [2,14,30], multi-author development of on-line courses, collaborative works of art or knowledge (although these often involve individuals and not organizations), and collaborative knowledge bases. One further example of interest is collaborative design and engineering of a novel structure [15]—while the building or other structure itself is clearly a material artifact, the difficulties often emerge in or from the design, which is clearly an intellectual product.

Individual collaborative ventures may of course comprise a mix of these characteristics, in both dimensions. A fast-food franchise operation, for example, comprises both a supply-chain operation to provide materials, and a federation to provide service, and its product is both a service and a material good, if not exactly a novel one. Likewise, structure building can be seen throughout as a mix of intellectual property and material artifact.

(While some consider most instances of resource or service sharing as coordination or cooperation rather than full collaboration, it is clear that there is a spectrum, based in part on the degree to which the partners share goals and a joint business plan, or contribute to a common venture, and in part on the complexity of collaborative arrangements and shared policies. In this paper, we will not further explore such distinctions.)

It is tempting to think that there can be central control over knowledge and risk in a collaborative project. But this is unlikely to be true even in the contractual mode, and of limited validity even for large, complex, long-lived single-organization projects.

Extended discussion of several papers at CENT 2011 (where an earlier version of this paper was presented) suggested that the overall project manager should have this knowledge. But the lifetime of a collaborative venture begins prior to the appointment of a project manager, in evaluating the proposed venture and forming the collaboration, and often outlasts him/her. Moreover, the project manager will rarely know the internals of business plans, processes, or components of other collaborators, and may not be privy to corporate management issues even at his/her own institution, and will typically not have the expertise to understand the issues of knowledge integration or collaborative risk in all relevant disciplines and domains.

These arguments apply, *mutatis mutandis*, for senior corporate executives or heads of requirements or risk management teams, as well. Nor would some sort of central clearinghouse or arbitrator be suitable, since a general principle (related to information hiding) would be to expose as little information as needed to such a party, both for protection and to avoid overcomplicating its role. This is an interesting question for further exploration.

In the balance of the paper, we consider the relationship between the nature of the product and the collaborative structure, product implications for the role of knowledge and the nature of knowledge objects, and implications for risk—in particular, motivated by current news, legal issues on the one hand, and the consequences of catastrophic failure for one partner on the other.

2. PRODUCT AND KNOWLEDGE

The different classes of product require different types of knowledge object [9,11,12].

Resources: A consortium of Brazilian tool-and-die manufacturers [29] organized in the last decade to share idle capacity, and possibly also portable tools and manpower. Since the partners work in a common domain, and processes were for the most part well-established, the role of knowledge is minimal—at most the specifications of parts made for a largely-shared client base. Likewise, establishing a common venture to share bookkeeping services such as payroll would expose some personnel and perhaps corporate information, but largely information already known to a good approximation by the other partners. Knowledge objects thus comprise primarily specifications and data sets, with minimal surprise, minimal required integration, and minimal interpretation.

Material artifacts: Two good examples are parts for automobile manufacture or electronic devices. Such ventures tend to fit into supply-chain collaboration. The relationship, even if legally contractual, is often collaborative in practice, obligate if not exclusive. Collaborators typically undertake differing parts or process steps. Relevant knowledge typically involves the physical interfaces (e.g., mechanical) and interactions (e.g., chemical) between components, and process and internal product knowledge must be revealed only insofar as necessary to satisfy specification. While constraints on factors such as safety and precision must be exposed, much of this is again largely shared if approximate knowledge. Knowledge objects are part/component specifications and descriptions plus external constraints. There will tend to be some surprise, a moderate amount of integration and collaborative knowledge [18], and varying but perhaps high amounts of encoding and interpretation needed. The most important dimension of knowledge sharing and integration lies in planning, requiring coordinated analysis, design, and implementation of changes.

Services: While knowledge for resource-sharing and production of material artifacts is largely product knowledge (plus common domain knowledge), service-oriented ventures inherently also and perhaps primarily need to share the knowledge needed to promote consistency and non-interference. While marketing and product knowledge are important for the fast-food example, sharing of process knowledge is important in the other two cases. For the independent agents, processes are common and shared, and consistency of process is typically what characterizes successful collaborative and franchise professional service ventures. With the catering service venture, on the other hand, processes are heterogeneous, and interactions are more frequent and less predictable, requiring that awareness of other partners' internal processes sufficient to minimize interference. For many such organizations, sharing will also include customer and/or supplier information and management guidelines. We would expect varying levels of surprise, a level of integration depending on the level and form of partner interactions, and moderate-to-high levels of encoding and interpretation.

Intellectual property: There is a spectrum here between loosely coupled components—as in the chapters of a book taking different points of view, or in software components that have little interaction except to share a user- and file-interface—and a single tightly-woven seamless product—such as a building design or a complex computer application. At the high end of the spectrum, the complications are significant—as we have discussed in our other papers. In the software example, partners have to have access to some knowledge of the internal technical and perhaps business processes at other partners, a view (not necessarily complete) of their domain knowledge bases, and some understanding of aspects of the internal structure of their components. The set of knowledge objects is diverse, and needs to encompass business and technical process knowledge, domain knowledge [5], and development knowledge. Knowledge is both a critical input and a critical output of the development process. Some knowledge (both input and output) may emerge from the collaboration, and be joint rather than individual property [18]. The levels of integration and of encoding/interpretation will tend to be very high, and the level of surprise likewise, especially since some knowledge objects will not initially exist, but come into existence only by integrating partner knowledge, or in the process of development and use of the product, and others will be dynamic, changing over the lifetime of the project.

Thus, resource-sharing collaborations tend to have minimal knowledge requirements; service and material artifact ventures have varying demands, generally with high needs for interpretation and encoding; and intellectual property efforts are characterized by diverse, dynamic and heterogeneous knowledge objects, with high levels of integration and dynamism, and a very high need for interpretation.

There are of course ventures that mix modes. In the building design example—with two or more architectural and/or engineering partners, the knowledge-sharing requirements are defined by a combination of those for intellectual property, material artifacts, and perhaps shared resources.

3. MORE ON KNOWLEDGE OBJECTS

We can distinguish three categories of knowledge objects entailed in the collaborative development of a product:

- Hard-coded: The physical structure of the product and its concomitant artifacts, its input data sets, and its output (if different from the product itself), and specifications and testing support for interfaces and component interactions.

- Soft-coded: Knowledge of processes, practices, and team/partner interactions.

- Meta-coded [11]: Views and understandings, related to cultural co-variances and to intellectual property protections.

When we consider the collaborative knowledge base itself, these become, respectively, the data in the knowledge base; its inference rules, forms, queries and reports, and its patterns of use; and the views available to each partner and collectively, and the informal guidelines for interpretation of that information.

In general, a product – whether of resource, service, material artifact, or intellectual property – bears a blend of hard-coded, soft-coded, and meta-coded knowledge in varying shares. Figure 1 provides an initial picture. Collaborative efforts require the sharing of product knowledge between partners, either by making common use of a set of knowledge objects, or by employing interfaces which act as links between knowledge objects [11,12]. At the same time, there is the tension at each collaborating partner between the benefits of sharing one's own knowledge with others and the risk of giving away competitive advantage and market share, and compromising intellectual property or reputation.

Balancing this tension is critical to the success of a collaboration. The balance must be envisaged prior to the start of a collaboration, maintained while collaborating, and reflected at the end of a collaborative venture–all of this making it, for each partner, subject to knowledge management: the assessment of and the decision on which knowledge objects to share, and whether to share in whole or in part.

In [9,12] we have suggested the knowledge objects approach for knowledge management in the context of collaborative software development. The broader horizon of collaborative engineering, or collaboration in general, leads to an extended definition of knowledge objects, with the distinction of hard-coded, soft-coded, and meta-coded knowledge. It results in different ways of knowledge sharing or protection depending on the category of a knowledge object. And it may even make the case for designing new knowledge objects that are specific for, or adapted to, a given collaborative setting.

Figure 1. Sharing of knowledge in collaboration

Nature of product	**Hard-coded**	**Soft-coded**	**Meta-coded**
Resource Sharing	Moderate	Moderate	Minimal
Service (homogeneous)	Moderate	Substantial	Minimal
Service (heterogeneous)	Moderate	Substantial	Moderate
Material Artifact	Substantial	Moderate	Moderate
Intellectual Property	Substantial	Substantial	Substantial

In addition, the management of knowledge objects in a collaborative context will have to be hierarchical [10,13,17]. Sharing will require agreed-on but flexible boundaries, hiding information via abstractions, filters, views and translations, and will need to handle "collaborative knowledge"—knowledge that results from integration of partner (and common) knowledge, and knowledge acquired through use of the product. Credit assignment will be a difficult problem where substantial collaborative knowledge is generated and used.

This hierarchical approach will have to extend not only to the knowledge base itself, but to risk management (RMMM) activities and configuration management as well [21].

4. PRODUCT AND LEGAL RISKS

Every venture of course may encounter a wide spectrum of risk. The discussion here treats only risks that arise because of collaboration, not those to which a single organization providing the same product would be subject to a comparable degree.

Resources: The individual data sets are of course proprietary, and in a case such as the tool-and-die example, there needs to be protection against theft of clients or jobs. But such risks are usually well-understood at the time a venture is begun, and standard safeguards exist. In the presence of goodwill, property issues can often be resolved with minimal trouble.

Services: In cases where the partners are peers supplying a common service, the main goals are consistency and reputation/reliability. Problems are well-understood, and structures exist to try to prevent them or recover from them. There are three refinements. First, if business information from the individual partners needs to be shared, difficulties are introduced as in the previous case. Second, in the heterogeneous case, there are two complications. To the extent that the partners are providing different services, as in the catering example, there is a risk that one partner will use the process or business information provided by the other to compete. Also, some (usually limited) internal product or process information may need to be revealed to other partners to support proper interaction or contingency planning. Nonetheless, the process and business information required to be shared will not usually reveal trade secrets or endanger privacy and security of the partners or third parties.

Material artifacts: Legal concerns focus on scheduling (and/or cost) and non-compliance plus those interfaces and interactions. Since internal process information typically needs to be revealed only to the extent that it affects safety or other extra-functional requirements, there is generally no need to share process knowledge. Two exceptions exist, though: first, whenever incremental innovations from either side are to be included in the product, at least partial knowledge about business or market strategies must be exchanged; second, when an artifact as a whole (an end product, like a new type of car – or a part, like a new drive control device) is being innovated, also technical and manufacturing processes have to be aligned and therefore revealed to a certain extent. Customer and supplier information, to the extent shared, is also a concern.

Intellectual property: Typically, almost all of the concerns raised above apply. Further, intellectual property, privacy and security issues are inherent in development, not only of software development, but of most production of intellectual property. These issues affect the necessary sharing of internal technical and business processes, knowledge bases, the internal structure of the components, and knowledge produced directly by the product, or indirectly by analysis thereof.

Intensifying product factors in all cases—to some extent mentioned above (but particularly for intellectual property) include: the complexity, novelty and innovation entailed; the degree of dynamicity and evolution expected; the extent, intricacy and robustness of component interaction; direct involvement of protected or confidential information in the product or in interactions with users. Process factors include process novelty and a lack of collaborative history, either in general or with these particular partners.

Nonetheless, the first three forms of product have moderately well-understood intellectual property risks and protections, while development of intellectual property, particularly software development, introduces a wide variety of risks pertaining to privacy, security, trade secrets, and other concerns.

5. PRODUCT AND CATASTROPHIC RISK

Recent news events, particularly the Japanese earthquake, tsunami and nuclear disaster, but also volcanoes, hurricanes, tornados, wildfires, have exposed serious problems in supply-chain manufacturing. Comparable problems will affect most collaborative ventures, and are more substantially affected by the nature of the product and its decomposition into components than by the nature of the collaboration.

Resources: A catastrophic failure to one of the partners, unless it damages a central processing or distribution facility, will generally not impede the collaboration, but at worst reduces the benefit of collaboration, either by limiting the resources available to the other partners, if they are overloaded, or by reducing the work available to the central facility, raising the amortized cost to all other partners. The immediate impact will typically be small.

Services: In the homogeneous case, one partner's failure, unless accompanied by serious damage to the venture's reputation, will have almost no short-term effect on the other partners, or in some cases even a small positive effect, as that partner's business is allocated among the remaining collaborators. In the heterogeneous case, or when the service is to be provided in a single venue, there may be a delay or loss of capacity until that partner is replaced. But this will not usually introduce substantial delays or losses, unless the partner is essentially irreplaceable, or the event occurs at a particularly critical time, since the collaborative knowledge demands are minimal.

Material artifacts: The Japanese disaster illustrates difficulties with supply-chain ventures, when all facilities making a critical part fail catastrophically. Since modern manufacturing processes typically require specialized facilities, and material artifacts often require bottom-up integration, the lack of such a part imposes a bottleneck, as can currently be seen with the automobile industry or the manufacture of laptops. In the meantime, other partners will have either to curtail operations, or to allow large inventories of parts to accumulate. If it is possible to replace the failing partner, there are still likely to be delays resulting from start-up instrumentation and activities, as well as the need to acquire and understand needed information. The risk is greatest when integration is highly structured and sequential, with interaction between physical device components.

Intellectual property: Failure of a generalist partner (one who is simply "sharing the load") will result in more-or-less proportional delays until the partner is replaced, although the other partners can pick up the slack to some extent. The loss of a specialist partner or its key personnel is also problematic for an intellectual property venture, but not usually as severely as in the material artifact case, and some of the other partners may be able to assume some of the responsibility, often at a lesser level of performance. Alternatively, since interaction typically entails exchange of information, rather than interaction of physical parts, there is often significant non-determinism in activities and development. The other partners may be able switch temporarily to parts of the product that do not interact with those being developed by the missing partner, or otherwise adjust to its absence, mitigating the cost and schedule hits. The time to recover full capacity is generally less. On the one hand, the start-up instrumentation will be at most acquisition and training on some development tools; on the other, the high level and dynamism of collaborative knowledge, and the need for specialized learning and training, is likely to continue to have some effect well after the replacement occurs.

Overall, catastrophic failure of one partner is likely to have minimal effects on most resource-sharing and service collaborations, versus great effects on material artifact ventures; intellectual property ventures are between these two extremes.

6. A CASE HISTORY

The nature of the product can, (as previously discussed in the introduction) significantly impact the collaborative structure with some manufacturing processes benefiting. Recent case study work [8,25,26] discusses a small-to-medium enterprise (SME) manufacturing company's interaction with its much larger customer. The key application is a knowledge-sharing network, with implications for collaborative business structure and policy. The final product is thus intellectual property with aspects of service.

The knowledge sharing networks operated on many levels, within the SME and beyond the SME to interact with small teams within the larger customer company. These interactions were developed longitudinally to satisfy a variety of products with success reflecting the SME's earlier experiences of a "whole team flat structure" approach, translating into various team-based projects. This approach provided flexibility needed to produce a variety of products, and the required rapid change in production methods.

The SME capability directly reflected the wide and in-depth knowledge of staff, gained over time (and documented longitudinally), through flexible "working team practices". These practices included working beyond SME teams to incorporate the customer and its supply chain network. These capabilities have resulted in company members acquiring the ability to balance company and project vertical structures with horizontal knowledge experiential exchanges. This is not something that is easily achieved within project-based manufacturing organizations. The various "layers" of experience were developed over time and formed the basis for the application of quick and timely in-depth expertise. The horizontal knowledge exchanges of staff members built over time formed the basis of new individual and company knowledge (from various sources) utilizing internal and external networks to update or advance specific or general knowledge. It is interesting to note that capability supported by various combinations of team or co-workers, were fundamentally initiated by individuals. This more flat structured approach at times resulted in knowledge networks developing and moving between the SME and its customers' supply chains regardless of formal boundaries, blurring product, services and supply chain structures.

Organizations are essentially knowledge-based network systems that are complex, and emerge, evolve and mature through various stages throughout their life cycles, displaying specific features and capabilities. Understanding these capabilities and features are fundamental to building sustainable economic, social and leaning network organizational structures. Long-range strategies require the understanding of emergent behavior within and beyond the organization, including its sociological impact, and its relationships to the explicit formal/physical structures. Looking deeper into the development of informal networks across boundaries highlights the geographic structures, their importance and how knowledge flows influence them.

But the networks are also influenced by the nature, structure and content of the intellectual property developed and the service(s) to be provided—the results would be very different for a regional network aimed at oral history or at coordinating distributed community assistance efforts.

7. CONCLUSION

Collaboration is affected by the organizational, geographical and cultural dispersion of the participants, and by the form of the collaboration [23]. But it is also affected by the goal of the collaboration, that is, the nature of its intended product. In this paper, we have considered three factors—the role of knowledge, the extent and nature of legal—especially intellectual property—risks, and the consequences of catastrophic failure of a single partner, and argued that there are significant differences based on the nature of the product—whether sharing resources, providing a service, making an artifact, or developing intellectual property. While there are further distinctions within each category, and collaborations that produce multiple or hybrid kinds of product, this classification appears to provide some insight into preparing for and evaluating collaboration.

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