

# A Classification of Collaborative Knowledge

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## Abstract

Efforts involving multiple institutions, whether aimed at sharing resources, at product development or production, at research, or in other directions, often rely on effective knowledge generation and knowledge management. However, there are inherent new difficulties in knowledge management for such inter-institutional collaborations, arising from the need to standardize and synthesize knowledge from multiple sources, and from the need to provide adequate protections for confidential and proprietary information.

**Keywords:** collaboration, knowledge management.

## 1 Introduction

Modern business practices are increasingly collaborative, involving corporations, non-profit institutions, consultants, academics, and government agencies in projects and in resource creation and sharing. The interaction between partners may be aimed at production or development, or may simply be targeted at the sharing of resources [9] or support services. Regardless of scope, any collaboration will benefit from knowledge management practices tuned for collaboration.

The knowledge produced by collaboration-aware knowledge management may have several purposes, as we discuss below, for individual partners, for the interface between partners, in interfaces between components (whether resources, software, manufacturing operations, or business processes), or in interpersonal and interorganizational interactions in specific sets of collaborators.

In this paper, we consider the knowledge needed for such ventures, categorizing not only in the standard dimension of explicit, implicit and tacit knowledge, but also by whether the knowledge subsists in individual organizations, or requires standardization and integration, or is inherently collaborative.

## 2 Inter-enterprise knowledge management

In any inter-organizational collaboration, knowledge sourcing and use become a matter of inter-enterprise application rather than staying within the organizational boundaries of a corporation and building upon isolated internal knowledge repositories. Systems in support of knowledge management hence have to deliver functionalities which make use of internal as well as external knowledge, offer features like those emerging in the area of social computing, and integrate these into services which can easily be used in inter-enterprise settings. For example, manufacturing or distribution are often dealt with by applying an input-output perspective, while product development or supply maintenance are increasingly organized as a set of networked processes. The implementation of inter-enterprise knowledge management therefore has to meet specific challenges. Some of these appear in the following examples.

First, let us assume the industry-wide collaboration of vendors, wholesalers and retailers of a specific industry, say pharmaceuticals, in the field of shipping and logistics. There are multiple links within different groups of members from the three categories and also between them. The collaboration aims at optimizing the shipping along the vendor – wholesaler – retailer chain while achieving highest standard of delivery time for routine as well as ad hoc deliveries. All participants run their individual business processes and have supporting systems in place. Each of them has to facilitate their participation which is basically putting in and getting out their information to (respectively, from) the collaborative system. The challenge is to ensure and maintain a commonly usable product referencing scheme and to organize the synchronization of member-individual processes.

Second, think of an R&D collaboration between a university, a development lab and a corporation for product development. Knowledge management to facilitate this collaboration shall be implemented. The university runs a legacy application for bibliographical archiving which contains sample knowledge published on the subject areas of concern. The development lab

provides a web based platform for shared document storage and exchange to the entire R&D team. The corporation brings in their explicit and implicit knowledge about product users and markets. All make use of simple tools like eMail for electronic messaging. To get access to external knowledge, manually driven search within the World Wide Web is applied. The system shall be such that the invocation of new services — say, an agent service enabling knowledge search throughout the web — or the introduction of additional partners into the collaboration can be done easily as soon as it turns out necessary. Additionally, it has to provide appropriate means not only to facilitate the collaboration, but also to ensure intellectual property rights and information security management.

Third, we take a look at collaborative software development in general. Technology, and in particular the development and deployment of new software systems for applications in government, business, industry, and entertainment, is one of the pillars of the globalizing economy. The software development process increasingly involves multiple teams, not only within a single organization, but across multiple organizations, and often across national, linguistic and cultural boundaries, motivated by both technical and business concerns. Technically, systems have become larger, more complex, and more interactive — especially over the internet and on the Web — and have a greater need for evolvability as a result of changes in the computer platform, the user community, and the application domain. Business issues involve not only cost-benefit tradeoffs and time-to-market concerns, but a need for high-quality technical and business services and for specialized application domain and development process knowledge.

All this drives the need to include sophisticated knowledge management techniques into collaborative software development. Knowledge management entails (1) elicitation and specification, (2) efficient and effective organization and access, (3) knowledge generation, and (4) abstraction, translation, and views. It also importantly requires knowledge protection, intersecting with intellectual property, privacy, and security concerns.

### 3 Collaborative knowledge

The handling and management of collaborative knowledge addresses three dimensions: the source of knowledge, the nature of the knowledge, and the use, application, and impact of the knowledge, particularly its effect on collaboration. In dealing with collaboration, it is useful to add another category to the standard distinction between explicit, implicit and tacit knowledge, namely whether the knowledge in question exists within individual partners or their people (for example, corporate practices), is common to all partners (scientific knowledge), is inherent in the collaboration (project history), is publically available, or requires collaboration and integration to instantiate; a parallel measure deals with the use of the information—in individual organizations, or in the collaboration itself. A third useful dimension will be the target implications of the knowledge—Is it aimed at improving business or technical practices or processes, or the product, or the structure of the project, or support services and resource sharing?—where, however, some knowledge artifacts may serve multiple purposes. We treat the first two of these in below, and leave the last to future work..

Explicit knowledge (cf [5]) can be found

- in the knowledge bases of the individual partners, repositories such as document libraries or software configuration management tools, and in on-line or printed manuals, handbooks of practices, and the like; also, safety and risk management practices and processes, and information related to non-technical support (especially when the intent of the collaboration is sharing of support services or manufacturing/production resources), and finally databases and other data repositories (cf [10]).
- Common or shared expert knowledge in particular foundational or application domains, specifically including the scientific, economic, and IT literature, and associated with the methods, tools, notations, and frameworks used, both within the individual partners and in the collaboration.
- Common access to social, political, and economic background, including current news, plus regulations and statutes, and the technology environment related to the purpose and nature of the collaboration and the contributions of the individual partners; also, legal expert knowledge.

**Table 1. The collaborative knowledge spectrum**

Source	Level of awareness/concreteness				
	Managed	Partner			Shared
		Explicit	Implicit	Tacit	
Business & Technical Documents	Knowledge bases	Artifact libraries Policies History	Management goals/objectives	Document style preferences	Contracts Project history & configuration
Safety/Risk Information	RMMM plan	Safety procedures	Staff expertise	“Sixth-sense” awareness	Collaborative risks

		Risk assessment Triggers			
Support services		Procedures Service contracts	Day-to-day conduct of service		
Tools and environment		Tools languages, notations, glossaries	Culture Idioms	Work practices	Shared infrastructure
Corporate environment		IT support Business network	Vendor/supplier decisions		History of collaboration
Expert knowledge		Publications White papers Memoranda Plans, etc.	Day-to-day processes Evaluation mechanisms Teaching	Social interaction Judgment	Professional contacts Modes of interaction
Legal knowledge		Documents	Interview & research strategies		International commercial agreements
External environment	External knowledge bases	News, statutes, regulations	Trends		(Inherently shared)
Collaborative		History Metadata	Communication Support	Trust	Protocols for interaction
Metrics & Inputs		Results & Trends	Relationships	Attitudes	Past & current projects
Social networking		Records of interactions	Social relationships		Implicit/tacit protocols

- The current technical and corporate computing and information environment at the partners, the business support network (suppliers, vendors, customers, shippers, markets, ...).
- Histories and metadata associated with past and present projects, especially collaborative projects, located with the partners or in a repository of the collaboration.
- Results of interviews, surveys and metrics within the partners, or of the market, especially as related to collaboration in general, the current collaboration, collaborative knowledge management, or relationships with current partners.
- Contributions of the organizations and their people on social networks, newsgroups, web sites, and the like.

Many of these areas will expand, and be subject to reevaluation and revision, as the project continues. Implicit and tacit knowledge includes not only the standard business and technical knowledge of veterans and experts with individual partners, but, significant for collaboration, also knowledge of language, glossaries, culture, and work practices, both corporate

and arising from a partner's locale and workforce. Moreover, and importantly, it also includes knowledge of implicit and even tacit protocols and conventions adhering to the collaboration itself, which may not be realizable within any single partner.

As can be seen from the examples in chapter 2, the level implicit/tacit knowledge varies in different types of collaboration. The more a collaboration is involving the transaction of standardizeable business information, the less is it dealing with implicit knowledge protocols. On the other hand, when a collaboration is focused on the generation of new joint knowledge, one has to deal more with implicit protocols and interfaces.

Table 1 presents an overview of the collaborative knowledge spectrum—sources and degree of awareness or concreteness. These deduct from the considerations and the examples provided in chapter 2 above.

## 4 Collaborative knowledge transfer

Basic to all sharing of knowledge in a collaboration is to ensure common understanding of it. This affects two aspects of interface decomposition as discussed in [7]: semantic clarification of the explicit, implicit, tacit and collaborative knowledge captured and transferred, and views and purposes relating to its use. We consider the first aspect in the context of supporting technologies for knowledge transfer; the second one in the context of trust within a collaboration.

Based upon the characteristics listed in the collaborative knowledge spectrum (table 1), we break down the transfer path from the capture of collaborative knowledge over its transfer to its use (table 2). Collaborative knowledge has its path of transfer along the collaborative knowledge axis as in Figure 1. We take up the concept of action, activity and practice here as it has been suggested in [2]. Thus the role of collaborators is being introduced into the process of knowledge transfer.

The elements shown on the collaborative knowledge axis in Figure 1 illustrate different levels of collaborative knowledge:

- Intra-institutional means knowledge proper to an individual organization. It is codifiable and builds the knowledge assets the organization can bring in to collaborative activities.
- Common or shared means the knowledge gained by each organization through similar experiences; the challenge here is uniform codification for common utilization.
- Integrative denotes the knowledge arising from the integration of information from multiple organizations.
- Collaborative is knowledge generated from collaboration practice.

Explicit knowledge can be codified and thus shared and transferred easily as such [5]. Different is the case of implicit or tacit knowledge, which by its nature is uncoded; externalization, internalization and transfer of it become subject to inter-personal communication [5]. Most challenging is the codification of collaborative knowledge as a prerequisite to its transfer. In table 2 we have pointed out the main functional aspects of externalization, transfer and internalization. Also highlighted are means of technological support in this context which are being introduced in practice increasingly.

**Table 2. Collaborative knowledge transfer**

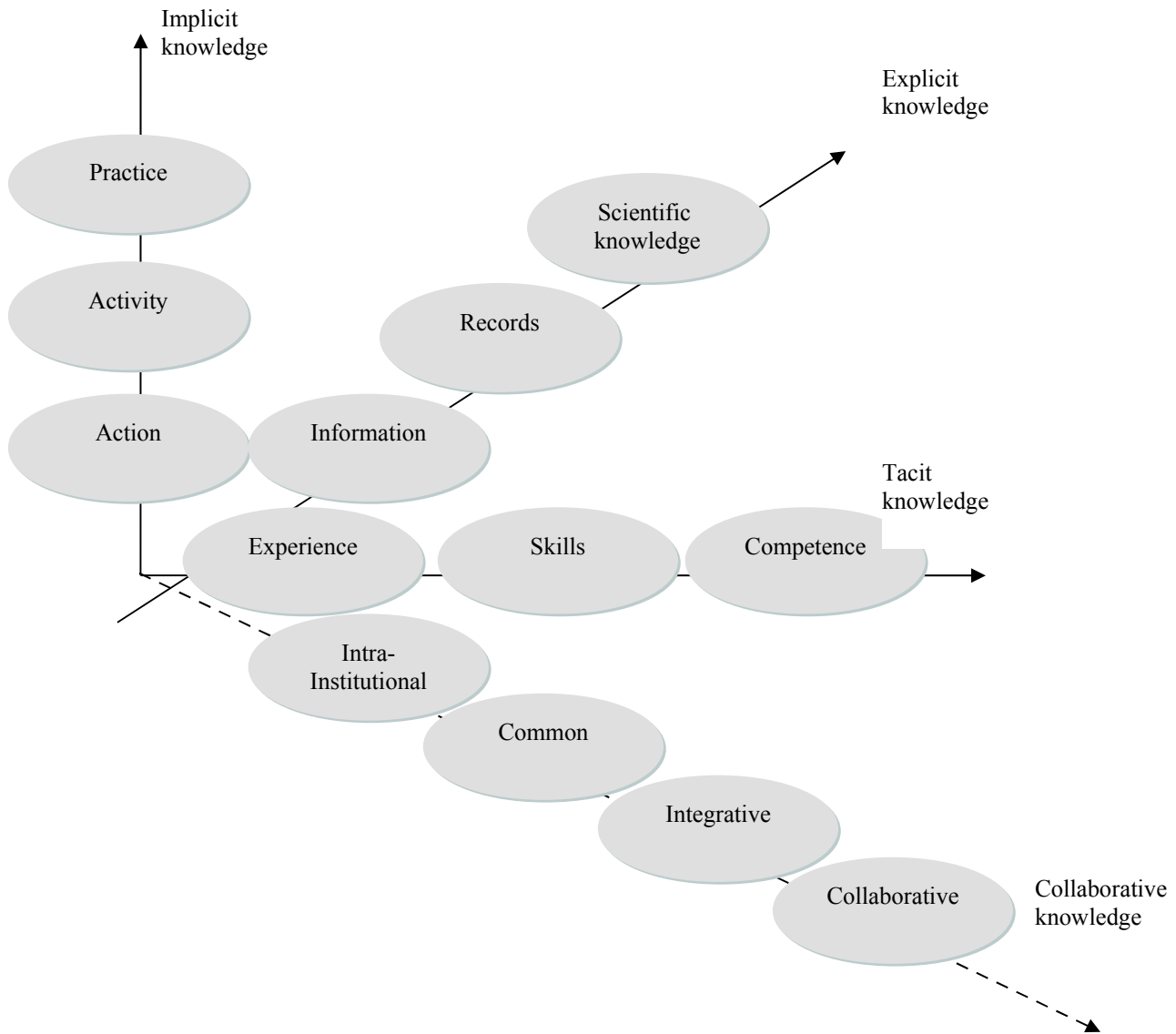
<b>Externalization:</b>	Interaction, Professional contacts, Projects
<b>Transfer:</b>	Contracts, Commercial agreements, Protocols, Interfaces
<b>Internalization:</b>	Interaction, Professional contacts, Projects
<b>Technology:</b>	Process models, Semantic technologies, Shared infrastructure

The issue of collaborative knowledge capture has been investigated by Hayes et al [4]. While focusing on the semantic web, these authors suggest the prototype of a knowledge capture tool combining an ontology environment based on concept maps and tools for knowledge re-use, supporting the construction of ontology maps. Since it is designed to enable intuitive, graphical interface supported capturing of knowledge in a collaborative environment, it can offer an approach to the uniform representation of knowledge originating from different organizations for common use in a collaboration.

A second issue with knowledge sharing in a collaboration is trust. While trust is an essential element enabling the assessment of risk in a collaborative action, activity, or practice, it is also supporting the mutual understanding of knowledge shared. Trust builds upon the transparency of purposes and views between collaborators. and sustains with the mutual experience of reliability.

In [1] Alexander et al consider action-based trust as a form of knowledge-based trust and discuss the relevance of time with regard to the establishment and maintenance of trust in a collaboration. Particularly collaborative settings which are facilitated by shared information systems are in need of action-based and knowledge-based trust. It has therefore to be considered essential especially for the integration of knowledge from different organizations in a collaboration to ensure the exchange of trust-building information through interfaces.

**Figure 1. The collaborative dimension in the knowledge space**



## 5 Conclusions, open questions, and future work

In this paper, we have introduced a classification for the sources of knowledge needed by a collaborative venture, focusing in particular on knowledge that can only be realized collaboratively. In future work, we will consider the implications of knowledge and knowledge management for collaboration, whether arising from single partner or collaboratively. We will also look at the relationships between collaborative knowledge management, collaborative risk management, and composite systems, and factors affecting the

utility of such knowledge, particularly the nature of the collaborative venture and its application and business domains.

As usual with collaboration in a knowledge-intensive environment, the main challenges are likely to prove non-technical: social and legal issues of privacy, security, and intellectual property, constructing precise but flexible contracts and agreements, and assuring continued support by corporate management and legal departments.

The issue of knowledge reevaluation and evolution must also be considered. As a collaborative venture continues, both emergent knowledge and changes in the perception and value of current information will require not only standard ongoing

knowledge management by each partner, but also exchange and collaborative examination, through standard channels, but also among experts across the enterprise concerned with an individual application domain or process facet (“ility”) [3].

Finally, the most important open question is the range of applicability of this approach. Future work will also consider case studies, propose structures for collaborative knowledge management, and demonstrate how this approach can benefit not only the knowledge management of the project, but also the project itself, the process, and their eventual results.

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