BEYOND AUTOMATION: A FRAMEWORK FOR SUPPORTING COOPERATION

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Abstract

This paper concentrates on opportunities to support cooperation processes by means of information technology (IT). Cooperation in an organizational context grounds on communication. We describe a layer framework for cooperation adapted from the framework developed by Malone/Crowston. This approach describes the relationships between coordination, cooperation, communication and communication media in a top-down manner. Beyond automation we propose a method of supporting cooperation by supplying employees with a toolbox of appropriate communication media which will improve communication and, thereby, indirectly contribute to cooperation. The paper concludes with an example of the initiation of a cooperation process which, in our view, requires functionalities not supported by existing communication media.

1 Introduction

CSCW (computer supported cooperative work) research can be divided into three stages [11]: understanding cooperative work, developing tools and concepts for the support of cooperative office work, and the evaluation of these tools and concepts. One approach to understanding cooperative work is to construct models of cooperation processes which, in turn, form the basis for workflow or other applications. It is problematic to construct a comprehensive and sustainable model for all cooperation processes. The following statement adresses the problem of structured processes:

> „Models, however, are limited abstractions; they are only valid within a limited area of application. Thus, a computer system will inevitably encounter situations in which the underlying model of the world is no longer valid“ [18].

The problem is to some extent a question of stable structures in cooperation processes. Cooperation processes can be arranged according to their degree of automation suitability along a continuum consisting of four groups [15]. The most structured and frequently recurring processes are called *pre-determined processes*, unique and

flexible processes are called *ad-hoc processes*. The two groups in between these extremes are referred to as *semi-structured* and *open group processes*. Ad-hoc processes, in any case, offer limited possibilities for the development of a model [16][17].

When cooperation processes which are unsuitable for automation are identified, the following question arises:

> *How can information technology support processes which cannot be automated?*

Approaching this question we first develop a layer framework which provides a useful description of the relationships between coordination and cooperation processes, the underlying human communication processes and communication media. This framework leads to the assumption that appropriate communication media can support ad-hoc-cooperation processes indirectly.

Starting with a requirement for coordination the relationship of the related processes proceeds from one layer to the next: coordination is dependent on cooperation, which, in turn, requires communication and, finally, communication media facilitate communication. In our opinion, it is possible to improve the level of support for cooperation processes which are loosely structured by supplying the employees with appropriate communication media. These communication media will enhance human communication which, in turn, will contribute to cooperation. These media should be flexible and capable of combination by the user. The primary goal should be to provide a toolbox for the user which contains a sufficient set of communication media to deal with a specific context.

It is not our intention in this paper to develop the sufficient toolbox referred to above, but rather to illustrate that a communication medium for n:m-communication between unknown partners would be an essential component of such a toolbox.

Although there are other factors, such as motivation or working procedures which play an important role in cooperation processes [9], this paper concentrates exclusively on the possibilities for supporting cooperation with information technology.

2 The Layer Framework related to Coordination Theory

Difficulties in defining the term coordination are elaborated by Malone/Crowston [13]. Similar definition problems arise with commonly used terms like cooperation, collaboration, communication, and information, the use of which is not confined to CSCW research. Due to their complex semantics there is no widely accepted hierarchy of these terms and it is possible to find virtually endless permutations. In attempting to characterize different coordination processes more precisely, Malone/Crowston proposed to describe them in terms of successively deeper levels of underlying processes, each of which depends on the level below it (see figure 1).

Process Level	*Components*	*Examples of Generic Processes*
Coordination	goals, activities, actors, resources, interdependencies	identifying goals, ordering activities, etc.
Group Decision Making	goals, actors, alternatives, evaluations, choices	proposing alternatives, evaluating alternatives, etc.
Communication	senders, receivers, messages, languages	establishing common languages, routing, delivering
Perception of common objects	actors, objects	seeing same physical objects, accessing shared databases

Figure 1: Layer framework by Malone/Crowston

The order of these layers is based on the observation that most of the coordination processes need decisions which are accepted by the group concerned. These decisions for example concern goal selection, goal decomposition, or the managing of resource and timing interdependencies. The group decision-making itself often requires communication between single members of the group, which, in turn, requires that some form of messages be transported from senders to receivers in an understandable language. For the establishment of such a language and the subsequent transportation of the messages the ability of the actors to perceive the same things, such as physical objects in a shared situation, is of crucial concern [13].

Further to our aim of supporting less structured cooperation processes by supplying employees with a set of diverse communication media, each consisting of certain functionalities, we have to focus on relationships between coordination, cooperation, communication and communication media. For this reason we modified the layer framework of Malone/Crowston by changing the titles of some layers and by adding a communication media layer (see figure 2).

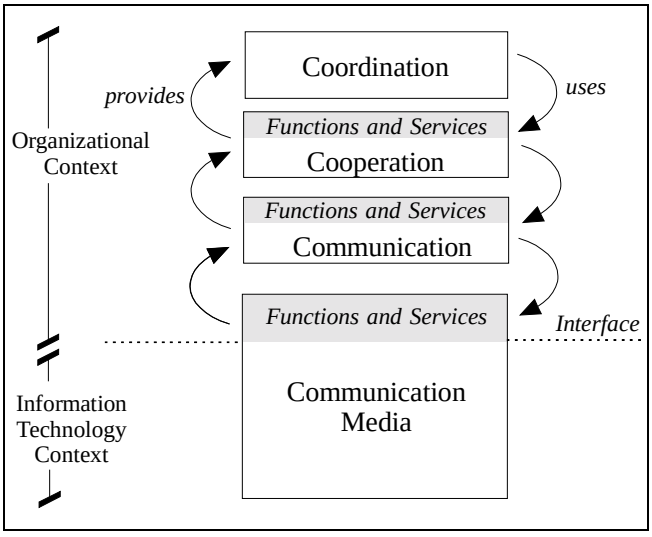

Figure 2: Modified and extended layer framework

Advantages of layered frameworks are reduced complexity, hierarchical ordering of terms and functions, and the identification of dependencies [25][27]. A layer can be accessed by the next superordinated layer. It provides services for this layer and can itself request services from the next subordinated layer. Starting top-down we analyse the relationships between the layers.

The modified layer framework introduced here is divided into the work context, the interface for communication media and the implementation of communication media. According to Malone/Crowston our top layer is *coordination*, ie. „the act of managing interdependencies between activities“ [13]. This definition by Malone/Crowston specifically focuses on one aspect of a situation which is unique to coordination, ie. if there is no interdependence there is nothing to coordinate. The handling of interdependencies takes place in the cooperation layer. Malone/Crowston mention different types of interdependencies [13]: Resource interdependencies arise whenever limited resources are shared by several activities or persons. A second group of interdependencies concentrates on timing problems. Sometimes one activity must finish before others can begin (sequencing) or several activities must all occur at the same time (synchronizing). Further interdependencies are of generic nature (e.g. two tasks duplicate each other) or are specific to the particular actions involved.

For our purposes it is sufficient to say that interdependencies are caused by sharing common objects [23]. The way interdependence is handled in an ad-hoc *cooperation* process and in a predetermined process will differ significantly; but in either case, the key to successful cooperation will be *communication*. Humans communicate using the *communication media* provided by information technology. The interface includes all possibilities for transmitting messages or information from one individual to another using IT. The cooperation and communication layers will be analysed and described in detail in the next section. The bottom layer includes the technical implementation of the communication media (e.g. groupware and network applications).

3 Refined View of Cooperation and Communication Layers

Herrmann [7] describes cooperation processes in organizations by separating the cooperation into three types (see figure 3).

Initiation processes occur before explicit cooperation is established. Employees who need to share resources with others have to contact potential partners and decide about possible cooperation. Examples of initiation processes are seeking and meeting with potential partners, or making cooperation agreements. All processes which occur after cooperation has been established are called execution processes. Examples include sharing of resources and combining of different employees' talents. Results of the proceeding activities are documented in feedback processes.

Cooperation	• Initiation • Execution • Feedback	• ad-hoc • open group • semi-structured • pre-determined
Communication	Compiled Communication Sequences (e.g. negotiation, brainstorm, voting) Basic Communication Sequences (e.g. question, order, apology)	

Figure 3: Layering of cooperation processes and communication sequences

During a cooperation process employees have to communicate with each other. In this situation a communication sequence is started. It is irrelevant for this definition whether the employee knows the communication partner, or whether he is conscious of starting a person-to-person communication sequence. Even a query to an information system is a person-to-person communication sequence, to the extent that one person requires information placed into the system by another unknown person. Examples of communication sequences are conferences, negotiations and meetings. It is not possible to assign communication sequences to one cooperation type. For instance, conferences will take place during initiation, execution and feed-back processes.

We refer to basic communication sequences as communication acts. These are the basic activities of passing information to others. Communication acts are implemented by means of communication media. All communication sequences are combinations of these communication acts. If the chain of communication in the cooperation process is predetermined, the cooperation process itself is predetermined. If there is ad-hoc or semi-structured cooperation, the communication chain can not be predicted [6]. In this case, the flexibility to change easily between the communication media, in order to support the next upcoming communication act, is required [8][12][27].

> „Asynchronous and synchronous operations are complementary subparts of larger tasks or activities. [..] A meeting proceeds in a largely unstructured way, but it can contain islands of structured synchronous operations [..]. This calls for integrating support for structured/unstructured activity on the one hand and for synchronous/asynchronous activity on the other.“ [5]

The user will select the communication medium which best fits the characteristics of the communication act he wants to start. This may result in having to chose a medium which does not support all of the desired functionalities, because such a medium is not available. Selecting a medium from the available options presents the possibility that the nature of the whole communication sequence may be changed by not supporting some characteristics or by adding others. Characteristics which might be added are "text content only", "multiple addressability", "externally recorded memory", "computer processable memory", costs, comfort or reachability (some of these charac-

teristics are taken from Sproull [22]). It may well be inappropriate for the user to have to select a medium. Users will expect a groupware application to "do the right thing" without their having to explicitly define what this "right thing" may be [2], and this is exactly what the IT-interface should do.

4 Example of Missing Communication Media for Initiation Processes

It is instructive to analyze the three types of cooperation processes. During the execution of cooperation a lot of pre-determined processes occur. Numerous attempts to support these processes can be found in workflow literature. The initiation of cooperation, however, is a good example of ad-hoc processes for which there are limited possibilities for automation.

In initiation processes a lot of problems arise due to the lack of informational transparency (for other intransparencies see [10]): Employees frequently search for information, or links to experts who have this information at their disposal. In many cases employees do not search for partners but re-invent the wheel, for instance software designers who re-design routines which have already been written and tested by someone else. At the same time every employee produces information which could later be valuable for other colleagues.

Berthel described three information sets which give a good illustration of the problem of reducing the lack of transparency with information technology (see figure 4) [1]:

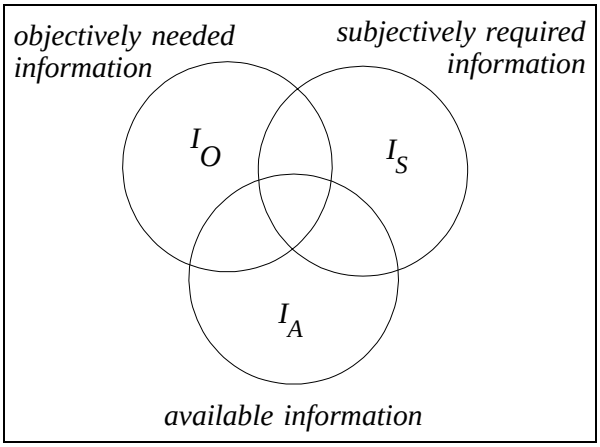

Figure 4: Information sets in organizations [1]

- I_S is the set of subjectively required information by the employee during his work.
- I_A is the information set available in information systems.
- I_O is the information set which is objectively necessary to do employee`s work.

Generally speaking these three sets are not equal. It is obvious that the subset $I_S \cap I_A$ of the employee`s request will be satisfied by the information system, but only the information in $I_S \cap I_A \cap I_O$ is really required for his work.

Problems arise because

- objectively needed information of intersection $(I_S \cap I_O) \backslash I_A$ is not available and
- information of $(I_O \cap I_A) \backslash I_S$ is available and objectively needed, but not requested.

The information in the intersection $(I_O \cap I_S) \backslash I_A$ is not problematic because it is actively requested by the employees. I_A will either be extended by this intersection or employees will use another medium i.e. by asking colleagues. The real problem is the intersection $(I_O \cap I_A) \backslash I_S$. Information contained in this intersection might help to save time, work or money, or to improve the quality of work. Nothing will be gained extending I_A by $I_O \backslash I_A$ if employees do not request this information.

In order to receive the required information the employee passes a request to several potential partners, or requests information which has been put into the system from a variety of other sources. The conspicuous characteristics of these sequences are that every employee:

- requests information of n potential senders,
- transmits requests or information to m potential receivers and
- may or may not know his communication partners.

The first two points are referred to as n:1 and 1:m-relationship. Thus, each employee faces a n:m-communication situation.

The communication partners may be situated in distributed places and time zones, with the result that the employee has to rely on asynchronous communication [5]. Due to the fact that even in routine work there is a need for ad-hoc problem solving and negotiations with experts [19], and bearing in mind that no workplace has entirely structured tasks [24], we can conclude that there is also a requirement for unstructured communication.

The procedure can be summarized as follows: the employee searches for a communication medium which, at the minimum, will allow him to conduct unstructured communication in an asynchronous manner with an undefined number (n:m-relationship) of known or unknown partners. Given the existing CSCW application types, we can show that these specific requirements, which are not considered unusual in the context of every-day-work, have not yet been satisfyingly matched. It is for this reason that we examine available CSCW applications from this particular point of view [5][23][26]:

	Support of asynchronous communication	Support of unstructured communication	Support of n:m-communication with unknown partners
Electronic Mail, Message Handling Systems	yes	yes	no
Bulletin Board Systems, Newsgroups, Computer Conferencing	yes	yes	yes
Multi-user editors	yes	yes	no
Group Decision Support Systems, Electronic Meeting Rooms	yes	no	no
Teleconferencing	no	yes	no
Intelligent semi-autonomous Agents	yes	yes	yes
Business Applications, Workflow Systems	yes	no	no

Table 1: Application-Level Taxonomy

On the whole we find only two types of information media, newsgroups and agents, that might be suitable applications for our needs. Further investigation leads to the following table of performance criteria:

	Newsgroups, Computer Conferencing	Intelligent semi-autonomous Agents	*Missing Medium*
Feedback	low	medium	high
Intimacy	low	medium	high
Information Overload	high	medium	low
Flexibility	medium	high	high
Search and Filter Costs	high	medium	low
Information Set Focus	I_S	$I_S \cap I_A$	$I_O \cap I_A$

Table 2: Performance of n:m CSCW Applications

The last column indicates the optimal possible combination of all criteria which coincide with the requirements. It indicates a direction for the development of a communication media which would provide these functionalities. A more detailed discussion of different kinds of media which we have summarized under "Newsgroups" can

be found at [21] and a definition for “Intelligent semi-autonomous Agents“ can be found at [23].

The *feedback* criterion [3] is comparable to the termination aspect of computer algorithms. The information request, which is sent to a newsgroup doesn’t terminate. Neither does it contain information indicating whether it has been processed or not. The sender can not ascertain whether no information was available, existing answers were lost or the complexity of the question required more time than was allocated. In respect of intelligent agents, feedback between the user and the agent exists, just as it exists between agents, but may need more time. The current status of a request remains unclear to the user until a feedback is received.

Intimacy [3] can be seen as a personal or impersonal type of approach to a partner. This contributes to the probability of a qualitatively satisfying response; impersonal (anonymous) requests are less likely to be processed. Furthermore, intimacy may be complemented by privacy. In both respects, intimacy is preferred in communication. Newsgroups do not contribute to intimacy. The search for and supply of information can be read by all members of the newsgroup which may lead to conclusions being drawn about the information patterns of a particular member.

Information overload can be minimized by sticking to narrowingly defined topics [8]. In agent technology, this is a task of defining goals and algorithms; the more the user has to define the greater the reduction in useability. In newsgroups the overload is multiplied the more members there are using the medium, also reducing useability. This criterion in whole also contributes to search and filtering costs.

The *flexibility* argument [2][21][23] is directed towards cooperation; it addresses the question of whether it is easily possible to interrupt or terminate a communication sequence and immediately construct another. The more flexible an application is, the more likely it is that it will be used in a communication act or as part of a communication sequence. If the cooperation process can not be structured, the communication sequence used can not be predicted. Nevertheless, communication acts occur and can be subsequently arranged in a sequence. In this case, information technology can still support individual acts, but has to remain open for flexible changes in its use while changing from one (even unsupported) act to another.

Search and filter costs are considered high in respect of newsgroups, since the information content of a contribution can not be determined prior to reading. Agent technology may be able to cut these costs by providing search and filtering mechanisms with several independent agents working on different tasks but the user may instead be faced with the task of filtering the output of the agents, not to mention the costs for primary initialization of each agent.

Both newsgroups and agents focus on augmenting the intersection $I_S \cap I_A$ of the *information sets* introduced above. The reason is that the user provides either the agent(s) with tasks and goals, or the newsgroup with direct requests matching his subjective information requirement. In contrast to agents, information requests and supply in newsgroups only match randomly and are transitory (thus not permanently and readily *available*) As a result it is more the whole information set I_S which is adressed by

this application type. It is important to note that none of the examples cited are capable of focusing the employee's attention on the information set $I_O \cap I_A$. As a result, they are all simply attempts to compensate for the absence of an efficient and effective n:m-communication-media to unknown partners which supports the initiation of cooperation.

5 Summary

In this paper we proposed supporting cooperation processes, for which there are limited possibilities for automation, by providing employees with appropriate communication media. This will support cooperation indirectly by improving communication between employees.

As a mean of identifying a need for new communication media we presented a layered framework describing the relationships between cooperation, communication and chosen communication media. Initiation processes are good examples of ad-hoc processes which offer limited scope for automation. In these processes each employee requests information from and produces information for a number of colleagues (n:m-communication) who may or may not be known. A special requirement of media functionality to support this communication has not yet been matched by existing applications. New and existing information technology applications could be bundled forming a toolbox which would support all types of communication.

Future work will concentrate on concepts for these missing media. One promising proposal is the intelligent information trader [20].

6 Acknowledgements

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