Computer Support for Cooperative Work

BUTLER COX FOUNDATION

A Paper by Giorgio De Michelis
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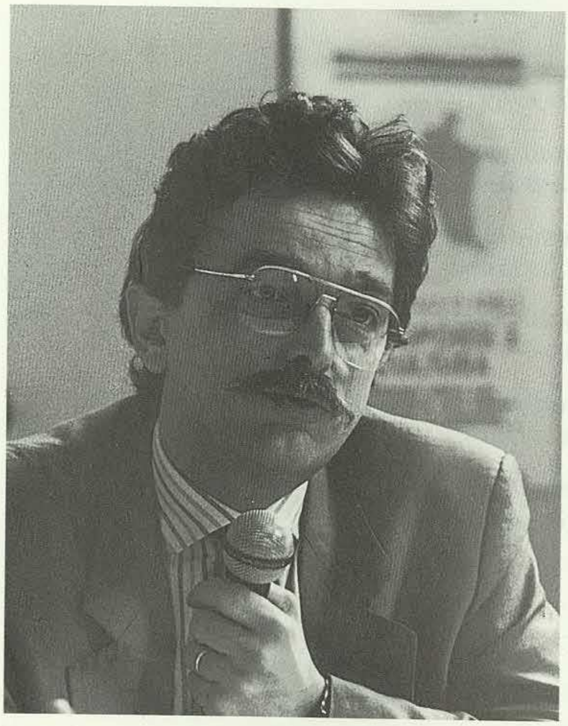

Giorgio De Michelis is associate professor of information science at the University of Milan, and a partner at RSO Spa, a leading consulting and research group based in Milan, Italy, and Butler Cox's Italian agent. He is currently involved in research into models and tools for office automation as part of two Esprit projects. In this field, he has developed a language for representing organisational processes (Gameru) and a prototype of an intelligent system for coordinating office activities (Chaos). At RSO, he is responsible for the group's activities in the area of IT management, and in this capacity, is involved in both education and training, and in consulting assignments. Since 1989, he has served as vice-president of Istituto RSO, the research arm of RSO.

In Report 73, *Emerging Technologies,* we identified groupware, otherwise known as computer support for cooperative work, as one of the key emerging technologies in terms of potential business impact during the 1990s. We described the different classes of groupware and the range of functions that they provide. Foundation members have expressed great interest in groupware during the review sessions held since Report 73 was published, and are seeking advice on how to select and implement groupware tools. In this paper, we take a look at some of the managerial aspects of introducing groupware, and in particular, at the issue of identifying groupware products to support the different kinds of cooperation within an organisation.

This paper is itself the result of a collaborative effort between RSO and Butler Cox. In addition to Giorgio De Michelis, Thomas Schael and Buni Zeller of RSO, and Richard Pawson of Butler Cox, made significant contributions.

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As traditional organisational structures are flattened out, and as businesses seek to become increasingly responsive to changing market conditions, greater use is being made of ad hoc workgroups or project teams. However, work that requires a group of people to cooperate is often less productive than it might be, in terms of results delivered for the total effort expended. This is particularly the case where the group members work in different locations and different time zones, when the effort involved in getting them to agree to commitments can impose a significant non-productive overhead.

The impact of such overheads is illustrated by the systems manager of a large Italian electronics company, who describes his main problem as follows: "Within a few months of establishing my annual software development plan, I have received so many new requests that it has to be modified. I therefore choose the project that seems to me to be least urgent, and I negotiate a later delivery date with its purchaser. Before he can give me a definite answer, however, he must check the acceptability of the delay with his colleagues. Very often, I find myself caught between the urgency of the new request, and the delay in getting a reply from the third party, during which time scarce development resources are being wasted."

Sometimes, the problems inherent in group working can be more subtle — arising from the lack of a common understanding of the task or problem in hand, or the lack of a common language for communicating information. For example, the automation system of one hot-strip mill is controlled by six operators, each in charge of a specific area, but usually out of sight of each other, and communicating by intercom. Faced with a critical situation, the operators must jointly take the decision to shut down the plant. Analysis of the verbal communication prior to shut-down has revealed that much of it is primarily concerned with establishing colleagues' credibility — questioning the basis of their evaluation — rather than purely exchanging information. It is the operators' lack of ability to communicate effectively, rather than any inherent technical weakness or individual wrong judgement, that causes most of the problems.

In the past, computer systems have not explicitly been designed to support group working. Large-scale systems have primarily been concerned with optimising the highly structured procedures within a company — notably, the processing of transactions. Desktop systems, particularly those based on Apple's hardware and on software products from Lotus and Microsoft, have concentrated on personal productivity. Although several software packages have evolved from single-user to accommodate multi-users, they provide little support to the actual process of cooperation between members of a work group.

Recently, several software products have appeared on the market under the banner 'groupware', or alternatively, 'computer support for cooperative work'. Some of these products are radically new in nature; others merely represent minor additions to standard office automation or 'professional computing' packages. The most common functions of groupware products are described in Report 73, *Emerging Technologies*.

Early experiences of using groupware, however, have been a mixture of success and failure. Figure 1, overleaf, which describes two experiments that have been partially successful, illustrates some of the problems that can occur.

Figure 1 Early experiences of groupware have been only partially successful

Pacific Bell conducted a trial of the first version of The Coordinator (produced by Action Technologies) with a geographically and functionally dispersed group of 15 employees. Although no major difficulties were experienced, there was considerable negative reaction to the structured use of language and the emphasis on actions within conversations, which The Coordinator is designed to promote. As confirmed by other satisfied users of the product, the problem was caused mainly by the need to provide extensive education and training. Although all the users attended an initial four-hour training course, the person responsible for providing support had to spend at least two hours subsequently training each user. It was also concluded that the success of a groupware implementation depends heavily on the organisational culture within a particular company or operating division.

At Digital Equipment Corporation, a value-engineering team (with responsibility for improving the value of existing product lines) experimented in 1985 with an in-house groupware development called Contract. It was already known that the effectiveness of the interface between the engineering and manufacturing functions depends heavily on commitments being fulfilled, and on cooperation between departments. However, it is not uncommon for conversations concerning the engineering feasibility of a design change to happen quite separately from conversations concerning its manufacturing feasibility — resulting in considerable wasted effort. The most interesting outcome of the trial was the discovery that people were relatively unaware that most of their conversations involved a commitment of some kind — not merely the exchange of information. Digital concluded that a good groupware system helped to make people more aware of these commitments, but that training in exploiting communications competence and commitment handling would also be beneficial.

In the light of these early experiences, organisations now considering the implementation of groupware need to understand how they can gain the benefits promised by groupware while avoiding the pitfalls. The answer, we believe, is to recognise the nature of the different kinds of cooperative group work within an organisation. These different kinds of cooperation need different kinds of computerised support.

Within a single organisation, there will be several types of cooperative work

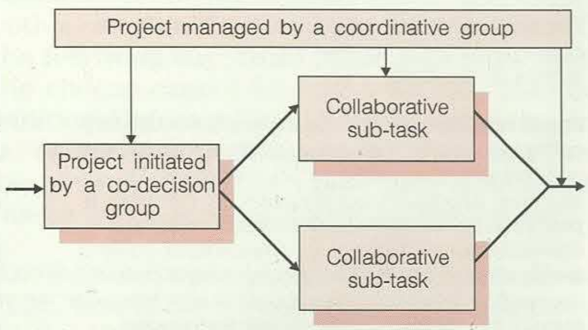
It is usually possible to identify several different types of cooperative group work within an organisation. A cooperative group is defined by the pattern of commitments that group members make with each other and with third parties. Broadly speaking, commitments made and already completed define the organisational structure of the group — in particular, the roles and responsibilities of the members. Commitments made, but not yet completed, represent the agenda for the group.

Within this framework, there are three distinct types of cooperation — which we call coordination, collaboration, and co-decision. Each type implies different types of objectives, communication, and relationships between members of the group:

- *Coordination* is a cooperative process where individuals need to coordinate their actions with those of others. Each new action gives sense to, or builds upon, completed actions, which means that the actions must be synchronised. Successful coordination also depends on breaking down the principal task into appropriate component actions.
- *Collaboration*, by contrast, requires individuals to work together in order to achieve a single common goal. The primary technique for the support of collaboration is therefore the sharing of information. The success of collaboration also depends on having a common understanding of the goal and the process for achieving it.
- *Co-decision* occurs where a group of individuals must reach a joint decision. Sometimes, they will participate equally in the decision-making process, or they may contribute to the process according to specific roles. As with collaboration, a shared understanding is crucial to the success of such processes, but there are additional factors, such as the extent to which members trust the evaluations of others.

Cooperative groups may be ad hoc or permanent. Some will be engaged primarily in coordination, others primarily in collaboration, and so on. Many groups will combine these types of cooperation, either concurrently, or at different stages of a project. As Figure 2 illustrates, a project involving a complex cooperative process might be initiated by a co-decisional group, be managed by coordination, but entail certain collaborative sub-tasks. When considering tools for supporting cooperative work (including information technology tools), it is important to understand that the three principal types of cooperation need different types of support.

Figure 2 During the course of a project, all three types of group cooperation may be needed



Coordination requires that messages be linked and tracked

There are two main requirements for the support of effective coordination. The first is to minimise transaction costs — the costs of communicating each stage of a commitment. The second is to eliminate duplication of effort. One technique for achieving this is to reduce recurring workflows (such as obtaining authorisation for equipment purchases) to single-stage operations. These two requirements imply that computer systems designed to support coordination should have the following specific functions:

- *Easy distribution of messages.* This means providing a system (such as electronic mail) that eliminates the need for simultaneous contact between the message sender and receiver. The system should also be able to route communications to all the appropriate members of a group, possibly by means of automated distribution lists for different kinds of communication. Alternatively, the system could broadcast all communications throughout the network, but provide a filtering system that passes through to each individual only the most relevant messages (MIT's Information Lens project, described in Report 73, *Emerging Technologies*, is an example of such a filtering system).
- *Linking of messages within conversations.* With coordination, the unit of communication is not the message but the conversation — the set of messages that relates to the negotiation and/or execution of a single commitment. Individuals are better able to respond to a new message if they can readily view the overall context — in other words, the historical development of the conversation. Furthermore, by grouping messages into conversations, it is easier to track the development of the commitment, and to identify incomplete actions. This concept is based on theoretical work concerning the relationship between language and actions taken. The background to that work is described in Figure 3, overleaf.
- *Scheduling of actions.* This implies functions that will assist both with the planning of the sequence of actions, and with the execution of those actions. The latter will be achieved by providing automated support for the administration of document movements and the maintenance of the timetable.
- *Recording of all commitments and tracking their current status.* In effect, this function is required to relieve the group members of the need for constant chasing and enquiry.
- *Automating recurring procedures.* Within a group, many multistage procedures will be of a recurring nature (raising a purchase order, implementing a design change, testing a customer reaction), and these can be either formal procedures or intuitive practices. Support systems should automate such procedures, so that the whole sequence of stages can be initiated by a single action.

It should be noted that each of these support requirements can be fulfilled either by conventional means, such as the use of 'Action' columns on the minutes of meetings, or by information technology. Groupware tools will not eliminate the need for meetings or direct contact between group members, but they can make such events more productive. Use of an appropriate groupware tool would, for example, reduce the time taken at the start of a meeting to ascertain the progress of actions initiated at the previous meeting.

As its name suggests, The Coordinator software product is a good tool for supporting many of these requirements. (This product is available from Action Technologies, visited during the Foundation's 1988 US Study Tour.) GRE Personal Financial Management Services has installed The Coordinator at 25 UK sites and at one in Germany. The intention was both to help branch managers to implement policy decisions,

Figure 3 Some groupware systems have arisen from the new theory concerning the relationship of language to actions

The language/action perspective takes language as the primary dimension of human activity and therefore of cooperation. It was developed by Ferdinando Flores, who served as Finance Minister of the President Allende Cabinet in Chile and is currently chairman of the board of Action Technologies Inc, one of the first software companies developing groupware tools in the United States, and by Terry Winograd, of Stanford University, who owes his reputation to the important work he did in many years of research on natural-language processing. Their belief is that human beings act through language. The language/action perspective is not concerned with the syntactic and semantic aspects of language that are used to represent the world or to convey thoughts and information, but with what people *do* with language. (This perspective is grounded in the Hermeneutic school of West European philosophy, which is concerned with studies that do not merely order the raw deliverances of sentences, but seek an understanding of their essentially meaningful subject matter.)

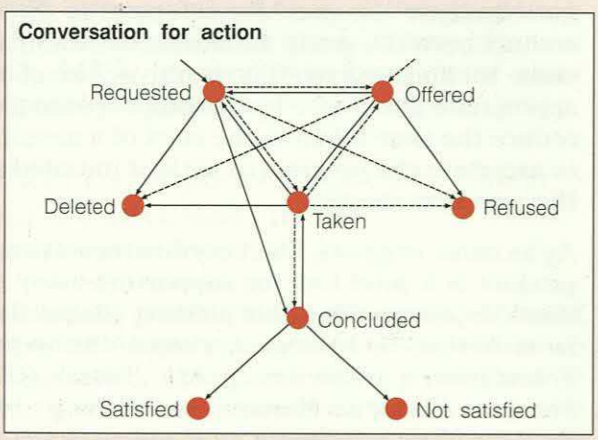
The language/action perspective is also based on the speech-act theory proposed by John Austin and later developed by John Searle. (Austin and Searle were English-language philosophers who examined closely the way words are ordinarily used, without any direct reference to the traditional problems of philosophy.) Austin was concerned about utterances such as "Can you bring me a glass of water, please?", which cannot be considered true or false in any sense. He summarised his work in a general action-oriented theory of meaning in human communication by stating that a speech act is composed of two elements — its referential component and the 'illocutionary force', which puts actions into words. The referential component is given by the speech act's semantic situation. Its force is generated in terms of pragmatic interpretation.

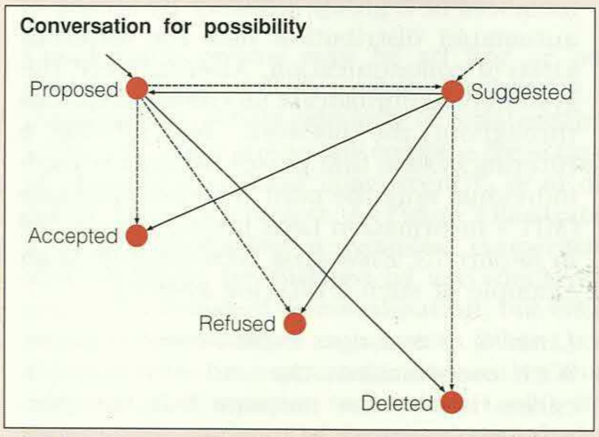
The most important aspect of a speech act is the conveyance of the speaker's intention rather than its form or its meaning.

Searle has identified five fundamental illocutionary categories to which utterances belong: assertives (a commitment of something true), directives (for example, a request), commissives (for example, a promise), declarations (a speech act creating a correspondence between its propositional content and reality — for example, pronouncing a couple married), and expressives (about the psychological state of the speaker). Speech acts exchanged between two partners are not unrelated events, but constitute conversations. Two types of conversation are distinguished: those for action, where two partners negotiate an action that one of them will take for the other one, and those for possibility, where two persons negotiate a modification of the setting, within which they (inter)act.

In a simple conversation for action (see diagram below), for example, one party (A) makes a request to his partner (B). The request is interpreted by each party as having certain conditions of satisfaction, which characterise a future course of action by B. After that initial utterance of A (request), B can accept (and thereby commit to satisfy the conditions), reject (and thereby end the conversation), or make a counter-offer with alternative conditions. Each of these speech acts in turn has its own possible continuations (for example, after a counter-offer, A can accept, reject, or make a further counter-offer).

In a conversation for possibility, on the other hand (see diagram below), two persons explore new possible courses of action, creating the adequate setting for them. The mood is one of speculation, anticipating the subsequent generation of conversations for action.





→ Actions by A
⇢ Actions by B

and to provide them with a means of tracking progress on commission claims. A branch manager can now send a request for a commission cheque to head office, specifying both a complete-by date and a reply-by date of the following day. Head office may reply that the cheque cannot be raised without certain additional information, and the branch manager is automatically informed of this by The Coordinator. Delays for which there is no stated reason are noted and logged by the system.

Another software product, Staffware, from FCMC (one of the companies visited by delegates on the 1990 US Study Tour), is also a support tool for coordination. It provides an easy mechanism for automating routine administrative procedures that require documents to be moved between several people.

Collaboration requires flexible structures to link shared information

The effectiveness of collaboration also depends heavily on information management — in particular, the sharing of information between members of the group. A common form of collaboration is the joint authorship or development of a major document, in which case, information also comprises the final deliverable. However, the same principles apply regardless of whether the end product is a document, a new building, a fighter aircraft, or the formation of a new company. In order to facilitate the sharing of information, support systems for collaboration must provide:

- *Information structures that reflect the way in which the information was created.* When accessing a source of information for the first time, people often adopt an abstract or 'logical' method of searching. However, when they seek to retrieve information that they created or have previously accessed, the natural method is to reconstruct the process by which they created the information, or used it the last time. Hypertext systems, such as Apple's Hypercard or Office Workstation's Guide, are well suited to the storage of an individual's information in this manner. Now, the hypertext concept is being extended to support collaborative information, where it must be as easy to browse through information created by colleagues as it is to access one's own personal database.
- *Different rights of access and modification for different group members.* Collaboration does not imply the fusion of all group members' information, nor equal rights to access or modify the information. It is particularly important to specify who can read certain information, and who can modify it. Brøderbund's ForComment provides excellent facilities for doing this, as does Office Workstation's Idex — although both are designed only for collaboration on document production.
- *Facilities for answering ad hoc questions.* Any member of a collaborating group may need help from others in the group. The system must therefore provide facilities for individuals to ask ad hoc questions that can be considered by the group as a whole. In addition to electronic mail, computer conferencing can help in providing such facilities. Simple computer conferencing systems merely provide electronic bulletin boards on which group members can place information about specific subjects. The more sophisticated systems structure the information in the form of sub-themes and allow the group members to follow the development of a particular line of thought.

Hypertext systems with multimedia facilities are one of the best tools for supporting collaboration. However, good information management systems, particularly if they are designed for a distributed and networked system, can also be valuable. A good example is Lotus Notes, which is described in some detail in Report 73, *Emerging Technologies.*

Co-decision requires conflicting constraints to be resolved

Co-decision is a specific form of cooperation, where the deliverable is a decision. However, because the deliverable is intangible, co-decision requires a different kind of support from that required for other forms of cooperation. The reason is that it is much more difficult to track progress towards an abstract or intangible goal — or even to identify whether progress is being made at all. Broadly, there are two kinds of co-decisions made by groups, which we term 'jury' decisions and 'partisan' decisions.

In a jury decision, all members of the group, at least in theory, have the same constraints or interests — even if they have different opinions, or their arguments carry different weights or have different credibilities. A board of directors deciding on an acquisition or a merger, for example, usually operates on a jury basis, with each member of the board having the same interest in the outcome of the decision, in terms of its ultimate effect on the success of the company. The effectiveness of a jury group depends on its ability to allow opinions to converge to a consensus. The support needed by such a group is essentially that of tracking progress to ensure that intermediate results are not discussed again at a later date. Various experiments have been conducted with 'meeting support' systems that facilitate the recording of decisions and display them in realtime to the group.

In a partisan decision, different members of the group may have different and conflicting interests. Budget decisions often work in this way — more money given to marketing may mean less for research and development, and the group may well include individuals representing each department. Reaching a consensus entails the resolution of conflicting constraints imposed by individual group members. Two different approaches to the support of partisan group-decision-making can be identified.

The first approach, pioneered at the Massachusetts Institute of Technology and elsewhere, attempts to resolve the conflicting constraints according to a sophisticated algorithm that either maximises the benefit or minimises the shortfall between each individual's requirements and the desired result. In our opinion, this approach has serious shortcomings. The final decision is likely to be different from the requirements that most individuals submitted, and this can lead to a reduction of commitment to the decision by the group members.

The second, and in our opinion, more fruitful, approach is to use techniques that encourage group members to relax their constraints, on an iterative basis, until a decision that satisfies all members' constraints can be reached. Because group members have modified their individual constraints on a cooperative basis, they are likely to be more committed to the final decision.

In more general terms, any software for the support of co-decision needs to be able to store (and distinguish) three kinds of information:

- *Information defining the decision to be taken.* Background information about the decision to be made needs to be available and accessible in a way that is complementary to the activities of the group. Such information is often needed during meetings of the group, and if it is not readily available, access to it can interrupt the flow of the meeting.
- *Criteria for decision-making.* Group members need clear specifications of the criteria to be used for any part of the decision in which they are participating. The criteria used by their colleagues in arriving at their own decisions should also be available (perhaps simply in the form of spreadsheet data). Doing this builds confidence and encourages convergence towards a group decision.
- *Decisions already taken.* These fall into two categories: decisions that are subsidiary to the main decision, and decisions taken on other issues that could be considered as precedents or simply as helpful. Ready access to both types of previous decision is vital if the co-decisional group is to avoid constantly going over old ground.

Information technology support for the co-decision type of cooperative work is less well developed than for the other two types of cooperation. Most examples of computer support for co-decision-making exist only within laboratories, although there are several international research initiatives in this area. We believe, nevertheless, that organisations that are devising a strategy for groupware need to be aware of the distinction between co-decision and other forms of cooperation, and to look out for new developments in this field.

For the remainder of this paper, we therefore concentrate on the coordinative and collaborative aspects of group work.

It is important to strike the right balance between activity synchronisation and information sharing

The main technique for coordinating the work of a group is to provide facilities for synchronising the various activities performed by the group, whereas the main technique for promoting collaboration between group members is to provide information-sharing facilities. Striking the right balance between activity synchronisation and information sharing, and hence, between coordination and collaboration, is critical to improving the productivity of cooperative groups. As Figure 4 shows, too little synchronisation makes the group inefficient and duplicates effort; too much synchronisation can lead to the communications between group members becoming over-formal, which can reduce the effectiveness of working as a group. Likewise, too little information sharing makes the group ineffective, while too much sharing leads to inefficiency — characterised by the situation where people spend most of their time in meetings.

The first stage in a groupware implementation is therefore to identify the optimum balance between activity synchronisation and information sharing, which will vary according to the nature of the task being undertaken and the capabilities of the individuals in the group. It will also be necessary to assess the current levels of synchronisation and sharing in the group. The final stage is to identify the support tools that will provide the optimum balance between activity synchronisation and information sharing.

Figure 5, overleaf, illustrates the relative potential of six groupware products for improving activity synchronisation and information sharing. It shows, for example, that Staffware helps to improve activity synchronisation (although not to the same degree as The Coordinator), but has little impact on information sharing, whereas ForComment significantly improves information sharing, but produces only a marginal improvement in activity synchronisation.

Detailed analysis of synchronisation and sharing requirements, or of the applicability of different groupware products, requires considerable skill.

Figure 4 Groupware tools should be chosen to provide the optimum balance between activity synchronisation and information sharing

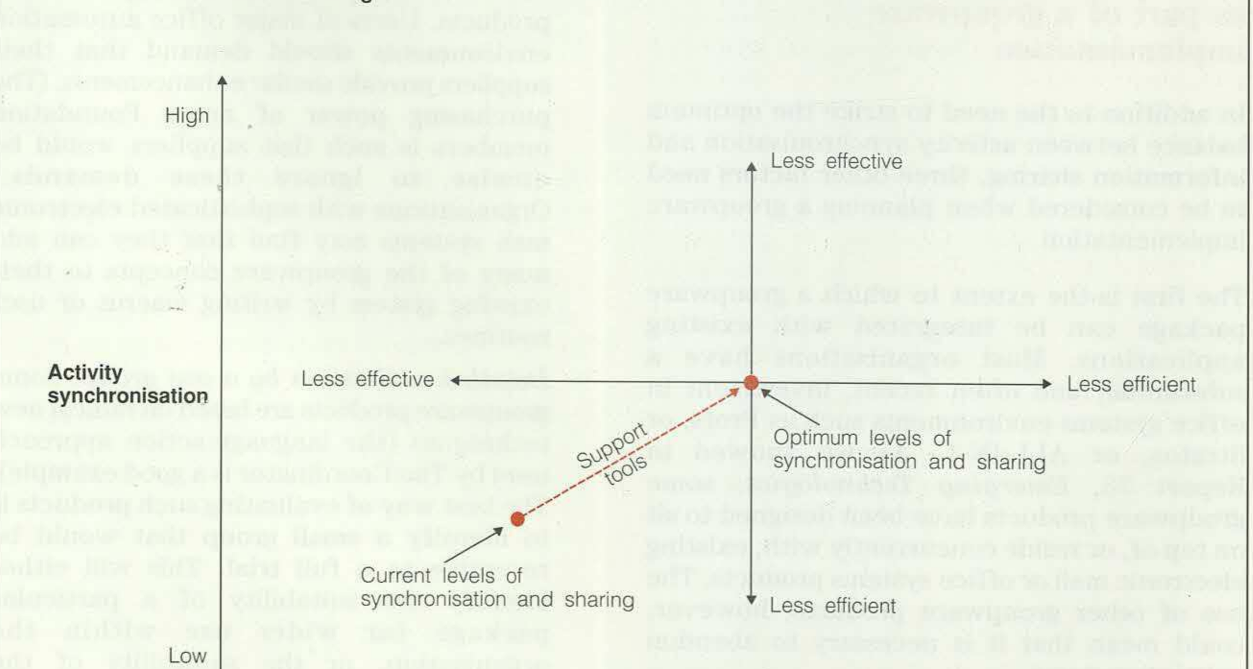
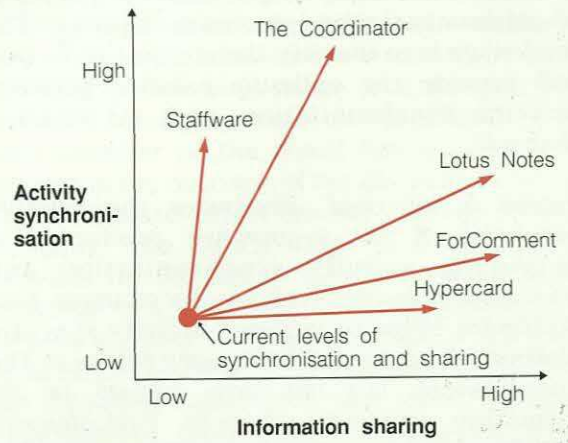


Figure 5 Different groupware products improve activity synchronisation and information sharing to different degrees

The arrowhead for each product indicates the relative improvements that can be expected in activity synchronisation and information sharing.



New methods for carrying out such analyses are now being proposed by various pioneers of the groupware concept, including RSO. These methods, however, provide only part of the answer.

Other factors need to be considered as part of a groupware implementation

In addition to the need to strike the optimum balance between activity synchronisation and information sharing, three other factors need to be considered when planning a groupware implementation.

The first is the extent to which a groupware package can be integrated with existing applications. Most organisations have a substantial, and often recent, investment in office systems environments such as Profs, or Stratos, or ALL-IN-1. As we showed in Report 73, *Emerging Technologies*, some groupware products have been designed to sit on top of, or reside concurrently with, existing electronic mail or office systems products. The use of other groupware products, however, could mean that it is necessary to abandon existing systems.

A second important factor that should be considered when choosing a groupware product is its stage of development. Some products are still at the prototype stage, and should not be considered for use in a commercial environment. Others are new products, currently at beta-test stage or in their first commercial release. These can be usefully employed for experimental projects. Only well established projects should be considered for widespread use throughout the organisation.

The third factor to consider is the suitability of the existing technical architecture. Many groupware systems, for example, are more suited to client/server architectures.

Once all these things have been taken into consideration, three possible approaches to the implementation of groupware become apparent. For most organisations, the optimum strategy towards groupware will include elements of all three:

— *Incremental approach*. This means enhancing existing application packages and software environments to include groupware facilities. Several suppliers of database packages (for example, Oracle), word processors (Microsoft), and spreadsheets (Lotus) have announced, or are developing, groupware enhancements or new packages that are compatible with their earlier products. Users of major office automation environments should demand that their suppliers provide similar enhancements. (The purchasing power of many Foundation members is such that suppliers would be unwise to ignore these demands.) Organisations with sophisticated electronic mail systems may find that they can add many of the groupware concepts to their existing system by writing macros or user routines.

— *Detailed evaluation by a test group*. Some groupware products are based on radical new techniques (the language/action approach used by The Coordinator is a good example). The best way of evaluating such products is to identify a small group that would be receptive to a full trial. This will either identify the suitability of a particular package for wider use within the organisation, or the suitability of the cooperative principles for incorporation into a custom-built system. To ensure that the trial is successful, it is vital to choose a group where each member will gain at least as much from the system as he will be required to put into it.

- *Formal requirements analysis.* The third approach is to build a customised groupware system, or to add customised groupware facilities to existing office or communications environments. This approach means that a formal requirements analysis has to be carried out to determine what customised groupware functions are needed. While this exercise will be similar in many respects to the requirements analysis for any new system, new methods are needed to identify the requirements of a cooperative work group.

In summary, then, to reap the benefits offered by groupware, while avoiding the pitfalls, it is necessary to understand and to identify the three different types of cooperation that will exist within an organisation — coordination, collaboration, and co-decision. Although co-decision is the least well supported of the three, organisations should be aware of its particular support needs. The main issue is to choose the groupware support tools that will achieve the optimum balance between activity synchronisation and information sharing. The right strategy for the implementation of groupware in most organisations will combine the incremental, detailed evaluation, and full requirements analysis approaches.

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