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Riding a Tiger, or Computer Supported Cooperative Work

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Abstract: The idea of supporting cooperative work by means of computer systems raises, inter alia, the problem of how to model cooperative work and incorporate such models in computer systems as an infrastructure of the work organization. Cooperative work arrangements should be conceived of as emerging formations that change dynamically and involves distributed decision making. Thus, modelling cooperative work and incorporating such models in CSCW systems is a precarious undertaking. The paper explores the dynamic and distributed nature of cooperative work and discusses the implications for CSCW systems design.

The idea of supporting cooperative work by means of computer systems - the very idea! - can be compared with riding a tiger. Cooperative work may seem familiar and tame. And in fact, a plethora of languages and schemes has been furnished that confidently claim to provide reliable models of organizational roles and patterns of communication.

The innocence and familiarity of cooperative work is deceptive, however. Cooperative work is difficult to bridle and coerce into a dependable model. And anyone trying to incorporate a model of a social world in a computer system as an infrastructure for that world is as reckless as a daredevil mounting a Bengal tiger.

The apparent stability of organizational roles and patterns of communication is a superficial hide beneath which a capricious beast is hidden. Cooperative work arrangements should rather be conceived as emerging formations that change dynamically in accordance with the requirements of the situation, and cooperative work involves, inescapably, the vicissitudes of distributed decision making. These characteristics have important implications for CSCW systems design.

The emergent nature of cooperative work

In his concise way, Montesquieu stated that "Man is born in society and there he remains." In the same vein, Marx (1857) posited that

> "Individuals producing in society - hence socially determined individual production - is, of course, the point of departure. The individual and isolated hunter and fisherman, with whom Smith and Ricardo begin, belong among the unimaginative conceits of the eighteenth-century Robinsonades."

Marx' critique of the Robinson Crusoe metaphor is rooted in a conception of work as an intrinsically social phenomenon:

> "Production by an isolated individual outside society - a rare exception which may well occur when a civilized person in whom the social forces are already dynamically present is cast by accident into the wilderness - is as much of an absurdity as is the development of language without individuals living *together* and talking to each other." (Marx, 1857).

Society, that is, is ubiquitous. Work is always immediately social in that the object and the subject, the end and the means, the motives and the needs, the implements and the competencies, are socially mediated. The social character of work is not a static property, however; it develops historically. With the the ever deeper and increasingly comprehensive social division of labor, the subject and object of work, etc. become increasingly social in character. Hunter-gatherers, for instance, work in an environment that is appropriated socially and yet to a large extent naturally given, whereas, in the case of operators in modern chemical plants, every aspect of work is socially mediated - to the extent that it is conducted in an 'artificial reality'.

While work is always socially organized, the very work process does not always involve multiple people that are mutually dependent in their work and therefore required to cooperate in order to get the work done. We are social animals, but we are not *all* of us *always* and in *every* respect mutually dependent in our work. Thus, in spite of its intrinsically social nature, work is not intrinsically cooperative in the sense that workers are mutually dependent in their work.

The essence of the notion of mutual dependence *in work* is not the negative interdependence among workers using the same resource. They certainly have to coordinate their activities but to each of them existence of the others is a mere nuisance and the less their own work is affected by the others the better. The timesharing facilities of operating systems for host computers cater for just that by making the presence of other users imperceptible. Being mutual dependent *in work* means that 'A' relies positively on the quality and timeliness of 'B's work and vice versa. 'B' may be 'down stream' in relation to 'A' but in that case 'A' nonetheless will depend on 'B' for feedback on requirements, possibilities, quality problems, schedules etc. In short, mutual dependence in work should primarily be conceived of as a positive, though by no means necessarily harmonious, interdependence.

Due to their being interdependent in conducting their work, cooperating workers have to articulate (divide, allocate, coordinate, schedule, mesh, interrelate, etc.)

their respective activities. Thus, by entering into cooperative work relations, the participants must engage in activities that are, in a sense, extraneous to the activities that contribute directly to fashioning the product or service and meeting the need. The obvious justification of incurring this overhead cost and thus the reason for the emergence of cooperative work formations is, of course, that workers could not accomplish the task in question if they were to do it individually, at least not as well, as fast, as timely, as safely, as reliably, as efficiently, etc. (Schmidt, 1990). For example, in a study of the impact of technology on cooperative work among the Orokaiva in New Guinea, Newton (1985) observes that technological innovations for hunting and fishing such as shotguns, iron, torches, rubber-propelled spears, and goggles have made individual hunting and fishing more successful compared to cooperative arrangements. As a result, large-scale cooperative hunting and fishing ventures are no longer more economical or more efficient and they are therefore vanishing. Likewise, the traditional cooperative work arrangements in horticulture for purposes such as land clearing and establishment of gardens have been reduced in scope or obliterated by the influence of the steel axe. A similar shift from cooperative to individual work can be observed wherever and whenever new technologies augment the capabilities of individual workers to accomplish the task individually: harvesters, bulldozers, pocket calculators, word processors, etc.

Cooperative work relations emerge in response to the requirements and constraints of the transformation process and the social environment on one hand and the limitations of the technical and human resources available on the other. Accordingly, cooperative work arrangements adapt dynamically to the requirements of the work domain and the characteristics and capabilities of the technical and human resources at hand. Different requirements and constraints and different technical and human resources engenders different cooperative work arrangements.

As befits an emergent phenomenon, cooperative work develops historically. For example, agricultural work and craft work of pre-industrial society was only sporadically cooperative. Due to the low level of division of labor at the point of production, the bulk of human labor was exerted individually or within very loosely coupled arrangements. There were, of course, notable exceptions to this picture such as harvest and large building projects (e.g., pyramids, irrigation systems, roads, cathedrals), but these examples should not be mistaken for the overall picture.

Cooperative work as a systematic arrangement of the bulk of work at the point of production emerges in response to the radical division of labor in manufactories that inaugurated the Industrial Revolution. In fact, systematic cooperation in production can be seen as the 'base line' of the capitalist mode of production. However, cooperative work based on the division of labor in manufactories is essentially amputated: the interdependencies between the specialized operators in their work are mediated and coordinated by means of a hierarchical systems of social control (foremen, planners etc.) and by the constraints embodied in the layout and mode of operation of the technical system (conveyer belt etc.). In Marx' words:

> "To the workers themselves, no combination of activities occurs. Rather, the combination is a combination of narrow functions to which every worker or set of workers as a group is subordinated. His function is narrow, abstracted, partial. The totality emerging from this is based on this partial existence and isolation in the particular function. Thus, it is a combination of which he constitutes a part, based on the his work not being combined. *The workers are the building blocks of this combination.* The combination is not their relationship and it is not subordinated to them as an association." (Marx, 1861-63, p 253).

The societal precondition for the prevalence of this 'fetishistic' form of cooperative work is that manufacturing and administrative organizations are in control of their environment to the extent that they can curtail its complex and dynamic character. By severely limiting the range of products and services offered and by imposing strict schedules and procedures on their customers and clientele, organizations in branches of mass production and mass-transactions processing were able to contrive synthetic work settings where activities, for all practical purposes, could be assumed to be subsumed under preconceived plans.

In view of the fundamental trends in the political economy of contemporary industrial society, the 'fetishistic' form of cooperative work is probably merely a transient form in the history of work. Comprehensive changes of the societal environment permeate the realm of work with a whole new regime of demands and constraints. The business environment of modern manufacturing, for instance, is becoming rigorously demanding as enterprises are faced with shorter product life cycles, roaring product diversification, minimal inventories and buffer stocks, extremely short lead times, shrinking batch sizes, concurrent processing of multiple different products and orders, etc. (cf. Gunn, 1987). The turbulent character of modern business environments and the demands of an educated and critical populace, compel industrial enterprises, administrative agencies, health and service organizations, etc. to drastically improve their innovative capability, operational flexibility, and product quality. To meet these demands, work organizations must be able to adapt rapidly and diligently and to coordinate their distributed activities in a comprehensive and integrated way. And this requires horizontal and direct cooperation across functions and professional boundaries within the organization or within a network of organizations.

In short, the full resources of cooperative work must be unleashed: horizontal coordination, local control, mutual adjustment, critique and debate, self-organization. Enter CSCW.

In order to support and facilitate the articulation of distributed and dispersed work activities, modern work organizations need support in the form of advanced information systems. This is illustrated by the efforts in the area of Computer Integrated Manufacturing to integrate formerly separated functions such as design and process planning, marketing and production planning, etc., and by the efforts in the area of Office Information Systems to facilitate and enhance the exchange of information across geographical distance and organizational and professional boundaries. Common to the efforts in these very different areas are the issues explored by CSCW: How can computer systems assist cooperating ensembles in developing and exercising horizontal coordination, local control, mutual adjustment, critique and debate, self-organization?

These issues all revolve around the problem of the distributed character of cooperative work.

The dialectics of cooperative work

Cooperative work is, in principle, distributed in the sense that decision making agents are semi-autonomous in their work.

Situated action. Reality is inexhaustible. The contingencies encountered in any human action - " in the fog of war," as Clausewitz aptly put it - invariably defeat the very best plans and designs. As pointed out by Suchman (1987), "the relation of the intent to accomplish some goal to the actual course of situated action is enormously contingent." Plans may of course be conceived by actors prior to action but they are not simply executed in the actions. Action is infinitely rich compared to the plan and cannot be exhausted by a plan.

Since the circumstances encountered in human action defeat the very best plans and designs, each individual encounters contingencies that may not have been predicted by his or her colleagues and that, perhaps, will remain unknown to them. Each participant in the cooperative effort is faced with a - to some extent - unique local situation that is, in principle, 'opaque' to the others and have to deal with this local situation individually. For example: misplaced documents, shortage of materials, delays, faulty parts, erroneous data, variations in component properties, design ambiguities and inconsistencies, design changes, changes in orders, cancellation of orders, rush orders, defective tools, software incompatibility and bugs, machinery breakdown, changes in personnel, illness, etc.

No goal or criterion applies to all contingencies. In order to handle local contingencies effectively, actors may have to apply criteria that violate even putatively global criteria such as corporate policy. In fact, on closer examination the putative global goals and criteria are also local in the sense that they are formulated in specific contexts as answers to specific questions.

Thus, due to the 'situated' nature of human action, cooperative work arrangements take on an indelible distributed character. No agent in the cooperative ensemble is omniscient.

Incommensurate perspectives. Reality is inexhaustible in another sense too. The world defies unitary and monolithic conceptualizations. As pointed out by Gerson and Star (1986), "no representation of the world is either complete or permanent."

A representation is a “local and temporary closure.” Accordingly, a multiplicity of distinct perspectives is required to match the multiplicity of the field of work. A perspective, in this context, is a particular - local and temporary - conceptualization of the field of work, that is, a conceptual reproduction of a limited set of salient structural and functional properties of the object, such as, for instance, generative mechanisms, causal laws, and taxonomies, and a concomitant body of representations, e.g., models, notations, etc. Thus, to grasp of the diverse and contradictory aspects of the field of work as a whole, the multifarious ontological structure of the field of work must be matched by a concomitant multiplicity of perspectives on the part of the decision-making ensemble (Schmidt, 1990). Accordingly, the cooperative ensemble reproduces the multiplicity of its environment in the form of the multiplicity of ‘small worlds’ of professions and specialities.

There are two aspects to the multiplicity of perspectives.

First, as demonstrated by Rasmussen in a number of studies (e.g., 1979, 1985), a stratified structure of conceptualizations is characteristic of a number of work domains. In technical domains, for example, Rasmussen has identified five levels of abstraction in a *means-end hierarchy*.

Second, perspectives are not always related to conceptual *levels* in the sense of a stratified order, however (Rasmussen, 1988). In addition to conceptualizations as different levels of generative mechanisms or means-end relationships, conceptualizations may reflect *different functional requirements* that are contradictory in the sense that efforts directed at solving one functional problem interfere with efforts directed toward the others. That is, contradictory ends divides the field of work into distinct object domains, orthogonal to the levels of abstraction of the means-end hierarchy.

An omniscient and omnipotent agent to match the multifarious environment of modern work does not exist. The application of multiple perspectives - whether stratified conceptualizations such as means-end relationships or the orthogonal conceptualizations of distinct object domains - will typically require the joint effort of multiple agents, each attending to one particular perspective and therefore engulfed in a particular and parochial small world. So, in addition to the distributed character of cooperative work stemming from the contingent nature of work, cooperative work in complex settings is distributed in the profound sense that the cooperative ensemble is divided into myriads of small worlds with their own particular views of the world.

This dissolution must be overcome, however. The cooperative ensemble must interrelate and compile the partial and parochial perspectives by transforming and translating information from one level of conceptualization to another and from one object domain to another (Schmidt, 1990). Again there is no omniscient and omnipotent agent to perform these transformations and translations. Rather, the transformations and translations are performed in the context of specific situations, to solve particular problems. The generalizations by means of which the partial perspectives are integrated are not globally valid; they are merely satisfactory to solve the problem at hand. They are local and temporary closures.

Bucciarelli (1984) has provided an excellent example of this aspect of cooperative work. In a study of cooperative work in engineering design he observed that

> "different participants in the design process have different perceptions of the design, the intended artefact, in process. What an engineer in the Systems Group calls an interconnection scheme, another in Production calls a junction box. To the former, unit cost and ease of interconnection weigh most heavily; to the latter, appearance and geometric compatibility with the module frame, as well as unit cost, are critical.
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> The task of design is then as much a matter of getting different people to share a common perspective, to agree on the most significant issues, and to shape consensus on what must be done next, as it is a matter for concept formation, evaluation of alternative, costing and sizing - all the things we teach."

This also applies to the the propagation of goals and criteria from one level of conceptualization to another. Propagation of goals and criteria within a cooperative ensemble is not a simple 'decomposition' or a syllogistic inheritance operation but involves a conceptual translation and a transformation of representations (Rasmussen, 1988). Again, there is no omniscient and omnipotent agent to perform these transformations and translations.

An interesting issue, raised by Charles Savage in a 'round table discussion' on Computer Integrated Manufacturing, illustrates this issue quite well:

> "In the traditional manual manufacturing approach, human translation takes place at each step of the way. As information is passed from one function to the next, it is often changed and adapted. For example, Manufacturing Engineering takes engineering drawings and red-pencils them, knowing they can never be produced as drawn. The experience and collective wisdom of each functional group, usually undocumented, is an invisible yet extremely valuable company resource." (Savage, 1986)

This fact is ignored by the prevailing approach to CIM, however:

> "Part of the problem is that each functional department has its own set of meanings for key terms. It is not uncommon to find companies with four different parts lists and nine bills of material. Key terms such as *part*, *project*, *subassembly*, *tolerance* are understood differently in different parts of the company."

The problem is not merely terminological. It is the problem of multiple incommensurate perspectives. The effort to 'design for assembly,' for example, requires an 'iterative dialogue' involving guardians of incommensurate perspectives: Assembly, Subassembly, Parts Processing, Process Planning, Design, Marketing, etc. The issue raised by Savage is rooted in the multiplicity of the domain and the contradictory functional requirements. In Savage's words: "Most business challenges require the insights and experience of a multitude of resources which need to work together in both temporary and permanent teams to get the job done".

In sum, in complex work settings the multiplicity of the field of work is matched by multiple 'small worlds', each specialized in applying a particular perspective.

There is no omniscient and omnipotent agent to match the multifarious environment or to integrate the specialized and local knowledge.

Incongruent heuristics. In complex environments, decision making is performed under conditions of excessive complexity and incomplete, missing, erroneous, misrepresented, misunderstandable, incomprehensible, etc. information and will thus require decision makers to exercise discretion. In discretionary decision making, however, different individual decision makers will typically have preferences for different heuristics (approaches, strategies, stop rules, etc.). Phrased negatively, they will exhibit different characteristic 'biases'. By involving different individuals, cooperative work arrangements in complex environments are arenas for different decision making strategies and propensities (Schmidt, 1990). Thus, the decision making process of the cooperating ensemble as a whole is distributed in the sense that the agents involved are semi-autonomous in selecting their heuristics.

However, in order to ensure a satisfactory degree of consistency and objectivity in the performance of the ensemble as a whole and thus to meet the requirements of the environment in terms of product quality, reliability, safety etc., the different heuristics must be integrated. To ensure this integration of heuristics, the different decision makers subject the reliability and trustworthiness of the contributions of their colleagues to critical evaluation. This way they are able, as an ensemble, to arrive at more robust and balanced decisions.

For example, take the case of an "experienced and skeptical oncologist," cited by Strauss and associates (1985):

> "I think you just learn to know who you can trust. Who overreads, who underreads. I have got X rays all over town, so I've the chance to do it. I know that when Schmidt at Palm Hospital says, 'There's a suspicion of a tumor in this chest,' it doesn't mean much because she, like I, sees tumors everywhere. She looks under her bed at night to make sure there's not some cancer there. When Jones at the same institution reads it and says, 'There's a suspicion of a tumor there,' I take it damn seriously because if he thinks it's there, by God it probably is. And you do this all over town. Who do you have confidence in and who none."

This process of mutual critical evaluation was described by Cyert and March (1963) who aptly dubbed it 'bias discount.' Even though dubious assessments and erroneous decisions due to characteristic biases are transmitted to other decision makers, this does not necessarily entail a diffusion or accumulation of mistakes, misrepresentations, and misconceptions within the decision-making ensemble. The cooperating ensemble establishes a negotiated order.

Incongruent interests. Any cooperative work arrangement is a tricky - or, in the terminology of 'dialectical logic', 'contradictory' - phenomenon in so far as it is a phenomenon of *individuals working together*. On one hand, since the individuals are mutually dependent in their work, the work of the individual is a particular functional element of the concerted effort of the cooperating ensemble as a totality. But on the other hand, work is an individual phenomenon in so far as labor power happens to be tied to individuals and cannot be separated from the individuals. That is, a cooperative work process, is performed by individuals with individual interests and motives. Because of that, cooperative ensembles are coalitions of diverging and even conflicting interests rather than perfectly collaborative systems. Thus, in the words of Ciborra (1985), the use of information for "misrepresentation purposes" is a daily occurrence in organizational settings. The Russian proverb saying that 'Man was given the ability of speech so that he could conceal his thoughts' applies perfectly to the use of information in organizations.

In sum, then, cooperative work in complex settings is, in principle, distributed in the sense that decision making agents are semi-autonomous in their work in terms of: goals, criteria, perspectives, heuristics, and interests and motives. There is no omniscient and omnipotent agent.

The design of CSCW systems is therefore faced with the challenging problem of supporting the exchange and integration of information within a self-organizing cooperative ensemble of decision makers that have a high degree of autonomy in their cognitive strategies and conceptualizations.

This makes the question of modelling cooperative work and the incorporation of such models in computer systems come to the fore.

The precarious use of models in CSCW

A computer system embodies a model of another system in the 'real world', e.g., in the simple case of a payroll system, a model of the wage calculation system (tariffs etc.) and the staff of the company (names, positions, account numbers etc.).

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. With simple systems the user is normally able to know immediately if and when the system's world model does not apply and to take the necessary corrective measures. However, the more complex the system, the more obscure the validity of the system's performance. Thus, as pointed out by Roth and Woods (1989), a "critical element for effective intelligent systems is that they provide some mechanisms to facilitate the detection and resolution of cases that fall outside their bounds." This facility is rarely provided, however: "One of the major failure modes that we have observed in AI systems is to not provide support for the human problem-solver to handle cases where the AI system is beyond its bounds."

Like any other computer system, a CSCW system is based on a model of an aspect of the world, in this case a model of a social world. And like any other model, a model of a social world has an application area within which it is a valid - abstract and limited - representation of the world. That is, there is a boundary beyond which the model is invalid. Thus a CSCW system is inevitably placed in a situation beyond the bounds of the underlying model. The critical question is what happens to the cooperating ensemble using this system when the underlying model of cooperative relations is beyond its bounds? Unlike a typical expert system, a CSCW system is not controlled by a single agent in a position to switch the machine off if its performance is blatantly unsatisfactory. A CSCW system is part and parcel of the infrastructure of the cooperating ensemble it supports. Thus, with the conventional 'automation' paradigm, CSCW systems are disasters to come. Therefore, CSCW systems should not be designed on the assumption that the system will automate the functions of articulation work. UTo the contrary, users should be in full control of the system so that they are able to know and maintain control when the system is beyond its bounds.

Let us therefore look into the problems of modelling cooperative work in CSCW design.

Different aspects of the social world is modelled in the different approaches to CSCW systems design. For example, even a CSCW facility as 'generic' as a shared view system, must provide a floor-control protocol for managing turn-taking. Of the more elaborate approaches to modelling cooperative work, two categories are of particular here: models of organizational structures and models of conceptual structures.

Models of organizational structures: In the Office Automation tradition, systems incorporated a model of a canonical allocation of tasks and responsibilities or prescribed patterns of communication (e.g., Zisman, 1977; Hammer and Sirbu, 1980; Hammer and Kunin, 1980; Ellis, 1982; Ellis and Bernal, 1982). Although this approach has been stubbornly perpetuated under the CSCW label (e.g., Sluizer and Cashman, 1984; Victor and Sommer, 1989; Smith, Hennesy, and Lunt, 1989), it was critiqued accurately in 1983 by Barber, de Jong, and Hewitt:

> "In all these systems information is treated as something on which office actions operate producing information that is passed on for further actions or is stored in repositories for later retrieval. These types of systems are suitable for describing office work that is structured around actions (e.g. sending a message, approving, filing); where the sequence of activities is the same except for minor variations and few exceptions. [...] These systems do not deal well with unanticipated conditions." (Barber, de Jong, and Hewitt, 1983, p. 562).

In the dynamic environments characteristic of modern work settings, work articulation by means of execution of preestablished schemes of task allocation, procedures, plans, and schedules is no longer adequate. Rather, the radical transformation of work and its organization calls for an 'open systems' approach. In the words of Gerson and Star (1986):

> "Every real-world system is an open system: It is impossible, both in practice and in theory, to anticipate and provide for every contingency which might arise in carrying out a series of tasks. No formal description of a system (or plan for its work) can thus be complete. Moreover, there is no way of guaranteeing that some contingency arising in the world will not be inconsistent with a formal description or plan for the system. [...] *Every real-world system thus requires articulation* to deal with the unanticipated contingencies that arise. Articulation resolves these in-

consistencies by packaging a compromise that 'gets the job done,' that is, closes the system locally and temporarily so that work can go on."

In the analysis of conventional mass-production and mass-transaction processing organizations a cautious and guarded abstraction from the 'open' nature of the system is legitimate and provides valuable insight. The current transformation of work, makes a complete inversion of perspective mandatory. Instead of conceiving of the work organization as a closed and stable system, subject to local and temporary disturbances, a work organization under contemporary conditions should be conceived of as an open system that reduces complexity and uncertainty by local and temporary closures. Thus, in view of the dynamic nature of the environment facing modern work organizations, patterns of cooperative work relations should be conceived as being, in principle, ephemeral.

An alternative approach to the OA tradition, suggested and explored by Barber and Hewitt, posited that systems should embody an explicit representation of the goal structure of the organization: "This builds a teleological structure of the office work within the computer" (Barber and Hewitt, 1992; Barber, 1983). Thus the system provides a resource to handle unexpected contingencies. However, as pointed out by Woo and Lochovsky (1986), while such systems (for instance, Barber's OMEGA) may be useful for office applications that are *logically centralized* and involve only a single user in performing the work, they do not support the *distributed nature of cooperative work*: "Supporting distributed, yet cooperative, office activities by providing a logically centralized office system (i.e., gathering the knowledge of all office workers involved in performing a task into a global and consistent knowledge base) creates a number of problems." First, cooperative work in complex environments involves integration of specialized conceptualizations, and "converting specialized, yet cooperative, office procedures to fit an integrated environment will not be easy since it requires the integrator to have knowledge of all the different kinds of specialization." And second, "In a logically centralized office system, inconsistent office procedures, specified by different office workers, are not allowed." In spite of intentions, the approach suggested by Barber and Hewitt assumes the intervention of an omniscient and omnipotent agent.

Models of conceptual structures: Even in systems that do not prescribe procedures for human interaction but, rather, provide facilities for a community to cooperate via a common information space (Schmidt and Bannon, 1991), the conceptual structure of that space is in itself a model of aspects of a social world. A taxonomy, for instance, is a negotiated order.

Engelbart and Lehtman (1988) have outlined an ambitious vision of a "system designed to support collaboration in a community of knowledge workers." Such a system should support the creation, modification, transmission etc. of messages, as well as cross-referencing, cataloging and indexing of the accumulating stock of messages. With services such as these, they claim, "a community can maintain a dynamic and highly useful 'intelligence' database." And they propose extending this facility toward

> "the coordinated handling of a very large and complex body of documentation and its associated external references. This material, when integrated into a monolithic whole, may be considered a 'superdocument.' Tools for the responsive development and evolution of such a superdocument by many (distributed) individuals within a discipline- or project-oriented community could lead to the maintenance of a 'community handbook,' a uniform, complete, consistent, up-to-date integration of the special knowledge representing the current status of the community.
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> The handbook would include principles, working hypotheses, practices, glossaries of special terms, standards, goals, goal status, supportive arguments, techniques, observations, how-to-do-it items, and so forth. An active community would be constantly involved in dialogue concerning the contents of its handbook. Constant updating would provide a 'certified community position structure' about which the real evolutionary work would swarm."

While this 'community handbook' effectively addresses the issue of supporting cooperation via a common information space, there is no omniscient and omnipotent agent to ensure that the special and local knowledge of the different semi-autonomous agents is integrated in "a uniform, complete, consistent, up-to-date" way. A "uniform, complete, consistent, up-to-date" community handbook is simply a chimera.

First, the data incorporated in the community handbook will be incomplete. It is simply a question of the benefit versus the cost of entering or capturing 'all' data, whatever that may mean. In fact, the community handbook will be a coarse representation of the diversified and multifarious reality of the community.

Second, the data incorporated in the community handbook will not be indexed consistently. The system would of course provide a global classification scheme to support the distributed indexing of information items to be included in the database, for example, taxonomies and thesauri. Such a classification scheme is itself an partial and temporary conceptualization, however. In order to include an information item in the database, an agent needs to *interpret* the conceptual structure of the classification scheme, *relate* it to the specialized conceptualizations of his or her particular perspective, and *translate* it to local circumstances. That is, the scheme will not be applied uniformly, and the database will over time become inconsistent.

And third, the conceptual structure of the community handbook as embodied in the classification scheme is itself of local and temporary validity. The semantics of categories will change and new categories will emerge. In order not to deteriorate, the scheme must evolve with the conceptual evolution of the community it is a reflection of. Integration of the diversified work activities of modern organizations requires that actors from the different subdomains and specialties involved negotiate a shared understanding. Because of the incommensurate perspectives involved, a shared understanding is a local and temporary closure destined to break down in face of a diversified and dynamic environment. To support the ongoing integration work, then, the taxonomies and classification schemes embodied in and supporting company-wide databases and other integrated business systems must be maintained, reinterpreted, adapted, etc. by means of an ongoing cooperative effort. That is, the conceptual structure of the 'community handbook' is itself subject to the vicissitudes of distributed decision making and it will thus itself be incomplete and inconsistent.

In short, irrespective of the approach taken to modelling cooperative work for CSCW systems design, it is a precarious undertaking.

We do not have to despair, though.

The problem with incorporating models of plans (established procedures, organizational structures, or conceptual schemes) in computer systems is not that plans are fictitious. Rather, plans serve a heuristic function in action by identifying constraints, pitfalls and strategic positions in the field of work. As observed by Suchman (1987), in order to serve this heuristic function "plans are inherently vague". Thus, in Suchman's conception,

> "plans are resources for situated action, but do not in any strong sense determine its course. While plans presuppose the embodied practices and changing circumstances of situated action, the efficiency of plans as representations comes precisely from the fact that they do not represent those practices and circumstances in all of their concrete detail."

In fact, 'plans' may serve different functions. Consider organizational procedures, for example: Procedures may of course codify 'good practice,' recipes, proven methods, efficient ways of doing things, work routines. In flexible work organizations such procedures are of little value and may actually impede flexibility. However, a procedure may also convey information on the functional requirements to be met by the process and the product; it may highlight decisional criteria of crucial import; it may suggest a strategy for dealing with a specific type of problems (e.g., which questions to address first?); it may indicate pitfalls to avoid; or it may simply provide an aide de memoir (such as a start procedure for a power plant or an airplane). And third, a procedure may express some statutory constraints in which case disregard of the procedure may evoke severe organizational sanctions. More often than not, a particular procedure will express, in some way, all of these different functions. Whatever the function, however, organizational procedures are not executable code but rather heuristic and vague statements to be interpreted and instantiated, maybe even by means of intelligent improvisation

Therefore, instead of pursuing the elusive aim of devising models that are not limited abstractions and thus in principle brittle when confronted with the inexhaustible multiplicity of reality, models of cooperative work in CSCW systems (whether procedures, schemes of allocation of tasks and responsibilities, or taxonomies and thesauri, etc.) should be conceived of as *resources* for competent and responsible workers. That is, the system should make the underlying model accessible to users and, indeed, support users in interpreting the model, evaluate its rationale and implications. It should support users in applying and adapting the model to the situation at hand; i.e., it should allow users tamper with the way it is instantiated in the current situation, execute it or circumvent it, etc. The system should even support users in modifying the underlying model and creating new models in accordance with the changing organizational realities and needs. The system should support the documentation and communication of decisions to adapt, circumvent, execute, modify etc. the underlying model. In all this, the system should support the process of negotiating the interpretation of the underlying model, annotate the model or aspects of it etc.

An approach similar to this has been explored in some 'shared view' systems. Cooperative work in real world settings is characterized by immense flexibility because people proficiently utilize the rich resources of everyday conversation to handle contingencies. It has therefore been argued (Greenberg, 1989) that 'shared view' systems should provide support for a broad variety of modes of interaction (turntaking protocols etc.) and, most importantly, provide support for users to control the choice of mode of interaction.

Likewise, in the case of models of organizational structures, CSCW systems to support flexible work organizations should not impose prescribed or preestablished patterns of cooperative work relations. Rather, CSCW systems should provide facilities allowing users to interpret and explore prescribed procedures and formal structures as well as conventional patterns of communication, and leave it to the users to abide by or deviate from norm and practice according to their professional judgment of the contingencies of the current and local situation. That is, in CSCW systems, models of organizational structures should be presented as heuristic information that users can appropriate, explore, modify, negotiate, reject, circumvent, or execute according to the contingencies of the situation.

Similarly, in the case of models of conceptual structures, a CSCW system should provide facilities supporting users in appropriating, exploring, modifying, negotiating etc. - cooperatively and yet distributed - 'community handbooks' that are openly incomplete and inconsistent.

Providing support for distributed cooperative appropriation, circumvention, modification of the system is, perhaps, the toughest challenge in designing computer systems for cooperative work. Is it possible to formulate general principles of the design of the functional allocation between humans actors and a CSCW artifact so that the cooperating ensemble can maintain control of the situation when the underlying model is beyond its bounds? Which aspects of social systems are suitable for being modelled in CSCW systems? Roles, procedures, rules of conduct, patterns of communication, conceptual structures? What are the specific problems and limitations of different kinds of models? How can users be supported in designing models of their world for incorporation in CSCW systems? How should the underlying model of the system be made visible to users? How should different users perceive the model? How and to which extent can it be made malleable? Should all users really be allowed to circumvent all constraints of the system? Is it possible to support users in anticipating the consequences of a circumvention or modification under consideration? Should a circumvention affect other users? How should a circumvention of the model be logged, reported, and presented to other users? And so forth. Questions such as these are still open issues in research and development of computer systems for cooperative work in complex and dynamic settings.

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