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Abstract[1]

Much organisational knowledge is multidisciplinary, hard to formalise, and generated in discussions with competing viewpoints. Knowledge Management (KM) technologies need to be able to capture and share such knowledge. This short paper begins by characterising 'knowledge work'—are there salient features that we can identify? Next, an approach is described by which teams analyse and discuss problems, building graphical argument spaces as competing ideas are debated. Hypermedia groupware provides a way to embed ideas, decisions and rationale in their conversational context, and with other work artifacts such as reports, sketches and simulations. The orientation of this work emphasises the human dimensions to technologies for supporting organisational memory and expertise. The discussion seeks to situate this approach in relation to other KM approaches by proposing three questions that seek to clarify the interdependencies between economics, technologies, work practices, and the responsibilities of modelling and managing knowledge.

Introduction

This paper describes work conducted over the last 6 years, investigating the promise, and the pragmatics, of capturing important aspects of the intellectual effort invested in projects. The orientation of this research places a strong emphasis on the human dimensions to technologies for supporting organisational memory and expertise. History shows repeatedly that it is the human issues which 'make or break' new methods and tools at work.

If we use the analogy of a river to describe the 'work flow' at the level of an individual, team, or organisation, the designers of a new method or technology for organisational memory are placed in the role of 'river engineers' seeking to change the flow of the river in some way. What they want to do is tap into the currents of the river, channelling it in new, productive directions. The question is, do they understand the hidden currents, eddies, and dynamics of that river sufficiently? If not, the result can be destructive 'interference patterns' in the flow, or the force of the flow may simply re-route around the changes continuing as it did before.

This paper seeks to shed light on the 'flow and currents' of knowledge work in general, and more particularly in relation to a particular strategy for tracking and capturing group memory. The first section characterises the *context* of 'knowledge work'—if 'knowledge workers' constitute an organisation's expertise, are there salient features of knowledge work that we can identify? Next, attention turns to representations for capturing group memory, which focus on supporting the discussions and arguments which are central to much knowledge work. These need to be supported by appropriate technologies, and the suitability of collaborative hypermedia is explained. The concluding discussion seeks to situate this approach in relation to other KM approaches by exploring the interdependencies between economics, technologies, work practices, and the responsibilities of modelling and managing knowledge.

Characterising Knowledge Work

Before describing the particular representations and technologies which have been studied, it is worth clarifying some of the salient properties of 'Knowledge Work', given that it is knowledge workers who are providing an organisation's collective expertise. Two perspectives are considered.

Organisational flux and multiple media

On the basis of field studies of knowledge workers, Kidd (1994) has noted several features which distinguish

[1] This is a modified, and shortened, version of a paper presented at the Workshop on Knowledge Media for Improving Organisational Expertise, 1st International Conference on Practical Aspects of Knowledge Management, Basel, Switzerland, 30-31 October 1996. (Buckingham Shum, 1996c,)

procedural work from *knowledge work*. All work is invariably a mix of the two, but increasingly, the procedural features are giving way to knowledge-based features. Kidd makes a number of distinctions, which are paraphrased below:

- *Knowledge workers are changed by the information in their environment, and they in turn seek to change others through information.* Information is to be consumed, and once 'digested', is often of little further value. Information resources which may have longer term use are often left visible and uncategorised (hence the frequent untidy piles and whiteboards), so that they can be quickly referred to. This is the antithesis of more procedural work (e.g. a secretary or administrator), whose work requires a lot of *filing* into *inflexible* structures; the worker is not changed by the knowledge they process in the same way that a knowledge worker is.

- *Diversity and ad hoc behaviour patterns are common in knowledge work.* New information is sought out, reused, and passed on in opportunistic ways, dependent on the changing context and interleaving of the worker's activities. In contrast, consistency of method and output is important in procedural work.

- *Communication networks are highly variable, with different patterns and use of media.* Teams form and disband within the space of a day. The structure and job titles on an organisation chart are thus even less informative as to what someone does or with whom they work.

This evidence provides a useful orientation to the challenge of designing KM tools. It paints a picture of knowledge workers, and consequently their host organisations, as existing in continual flux as teams form and reform. In particular, the mobility of employees within and between organisations (coupled with 'out-sourcing' to external contractors) leads to the fragmentation of any persistent shared memory within a team or division about lessons learned in projects. Furthermore, keeping track of discussions, decisions and their rationale is made harder when teams form on a project-specific basis, proceed to work interdependently but with substantial autonomy, and then disband. Knowledge is meaningless outside of the context in which is it brought to bear. In conventional documentation, much valuable information, particularly the context and rationale underlying decisions, remains locked in individuals' memories—individuals whose memories will fade, or who will take their expertise to other jobs. These are both motivating factors for, and militating factors against, the development of organisational memory resources. Collaboration tools which do not impose rigid models of membership or role, and which are able to integrate many diverse media types would seem appropriate media to facilitate organisational memory capture.

Wicked problems

The second perspective on knowledge work comes from the formative work of Rittel and Webber (1973). Whilst the term 'knowledge work' was not in currency in the late 1970s, Rittel identified crucial features of intellectual work which are highly pertinent to current concerns. Rittel characterised a class of problem which he termed 'wicked', in contrast to 'tame' problems. Tame problems are not therefore trivial problems, but by virtue of the maturity of certain fields, can be tackled with more confidence. Tame problems are understood sufficiently that they can be analysed using established methods, and it is clear when a solution has been reached. Tame problems may even be amenable to automated analysis, such as computer configuration design or medical diagnosis by expert system.

Wicked problems possess a number of distinctive properties that violate the assumptions that must be made to use the problem solving methods of tame problems. Wicked problems:

- cannot be easily defined so that all stakeholders agree on the problem to solve;
- require complex judgements about the level of abstraction at which to define the problem;
- have no clear stopping rules;
- have better or worse solutions, not right and wrong ones;
- have no objective measure of success;
- require iteration—every trial counts;
- have no given alternative solutions—these must be discovered;
- often have strong moral, political or professional dimensions.

The connection between wicked problems and knowledge work should be apparent. Such problems are the typical challenges faced daily in, for instance, software design, government or social policy formulation, and strategic planning in organisations. It is also the case that wicked problems and lessons learned will be extremely hard to represent using the more conventional, formal structures of databases and knowledge bases. What then is involved in supporting the capture of organisational expertise for such real world problems?

Negotiation and Knowledge Work

The starting point is to recognise that knowledge work is dominated by communication, specifically *negotiation* and *argumentation.* There are several reasons for this.

Firstly, much knowledge work is conducted in teams, and members have to communicate, increasingly distributed in space and time.

A second reason is that external factors often remove the control that a team has—the problem space is not stable. Goals, constraints and stopping rules are continually shifting. This demands a mode of working in which requirements, constraints and solutions must be regularly re-negotiated.

Thirdly, Rittel concluded that wicked problems can only be tackled through what he termed an *argumentative* method. Understanding how to frame a wicked problem is the first step to solving it. What are the key questions? What are the key priorities?

Fourthly, knowledge work is increasingly interdisciplinary. The different backgrounds, assumptions and agendas which members bring to a team can be extremely creative, but the inevitable conflict, debate, negotiation and compromise which is involved in reaching such creative solutions must also be acknowledged; this process can then be turned to the team's advantage.

In summary, an approach to capturing and representing organisational memory is required which is capable of supporting knowledge teams in:

- representing and reconciling multiple stakeholders' perspectives;
- re-negotiating project priorities in response to changed circumstances;
- communicating the rationale for decisions to others;
- recovering insights and solutions from past scenarios, to avoid 'reinventing the wheel'.

An organisational memory strategy which recognises the centrality of negotiation and argumentation in its employees' workflow (recalling the river metaphor) assumes from the start that the knowledge invested in a typical project of any complexity is the product of much argument, compromise and the reconciling of different perspectives.

Visualising Argumentation

In *The Next Knowledge Medium*, Stefik (1986) proposes collaborative argumentation tools (p.44) as one example of knowledge media. Such tools, "for arguing the merits, assumptions, and evaluation criteria for competing proposals" could provide "an essential medium in the process of meetings." "The languages provided by the tools encourage an important degree of precision and explicitness for manipulating and experimenting with knowledge", coupled with "augment(ing) human social processes." This conception of knowledge media lies at the heart of the representation and support technologies now proposed.

On the basis of his analysis of wicked problems, as introduced above, Rittel (Rittel, 1972)proposed the *IBIS* (Issue Based Information System) argumentative method, which encourages team members to debate by raising new *Issues* that need to be addressed, *Positions* in response to those Issues, and *Arguments* to *support* or *object-to* Positions. Conklin and Begeman (1988) later took the key step of developing a hypertext prototype called *gIBIS* (graphical IBIS) to support Rittel's IBIS method. In gIBIS, a team conducted its debates by building a graphical 'conversation map'. Figure 1 shows the gIBIS scheme, which illustrates how the core Issue-Position-Argument

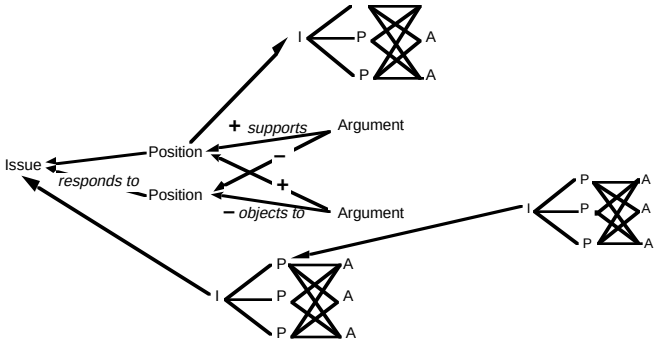

Figure 1: The *graphical IBIS* (gIBIS) notation (Conklin & Begeman, 1988), which allows a team to cumulatively build graphical argument spaces.

(IPA) unit supports cumulative argument construction and critiquing.

The complexity of an argument schema, and its visual layout rules (which vary with different approaches), determine how large and elaborate an argument can be expressed. A much more expressive argument schema is shown in Figure 2. The *Decision Representation Language* (Lee & Lai, 1991) for supporting debate and qualitative decision making, introduces new constructs (e.g. the *Goal* node type), and allows participants to explore *Alternatives*, *Claims* backing them, and even to contest through *Questions* and counter-*Claims* the relationships between these constructs. A related approach called QOC is presented by (MacLean, *et al.* 1991). This paper focuses on notations such as QOC and gIBIS, which are 'lighter weight' than DRL, the emphasis on being on suitability for quick and intuitive use during meetings.

Having proposed that negotiation and argumentation are central to knowledge work, and introduced the representation schemes which allow us to visualise such processes and products, let us now consider the technological support required. IBIS and QOC style representations have been used effectively with paper and pen, but computer supported argumentation is needed for easy editing, scalability and flexible linking, as discussed in the next section. Readers interested in detailed analyses of argumentation in use are referred to Buckingham Shum and Hammond (1994) and Buckingham Shum (1996b).

Collaborative Hypermedia Infrastructure

Semiformal, graphical argumentation is a relatively mature domain of hypermedia application which has been deployed widely over the last 10 years to support knowledge-intensive work. Hypermedia is an ideal technology for capturing knowledge which is partly formalisable. The ambiguity that high level node and link types provide reflect the the *domain* (it is not clear what the problem is, or what the nature of the solutions may be), and *context* and *users* (domain experts who are not knowledge engineers, to facilitate problem solving in meetings). This is in contrast to

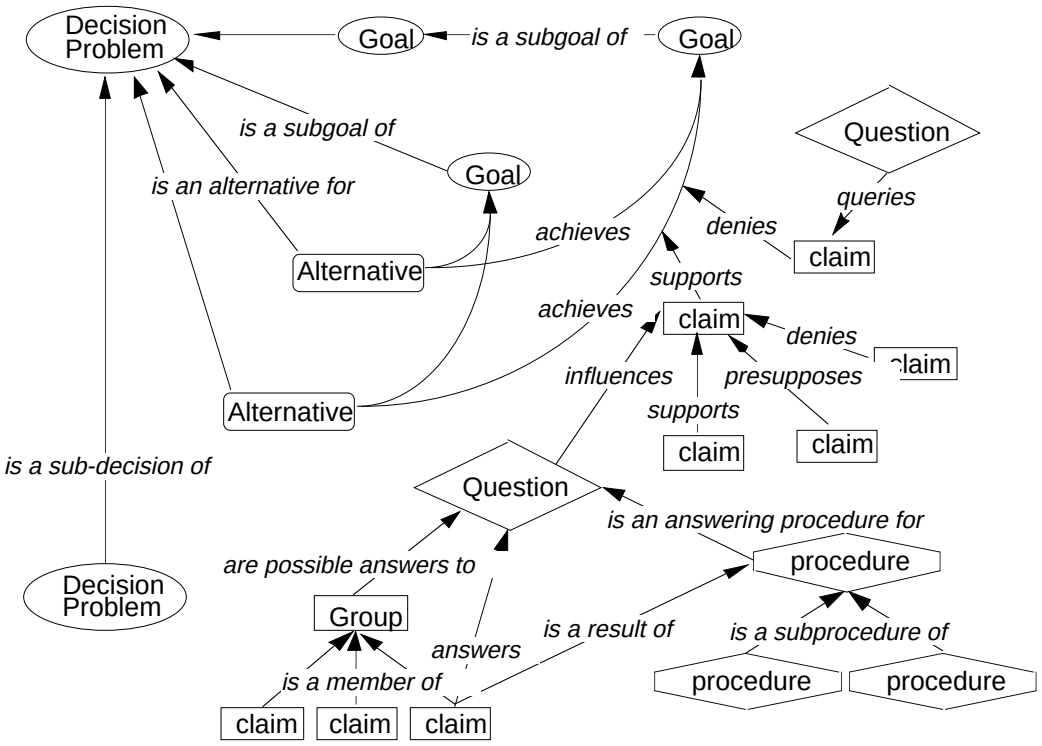

Figure 2: The Decision Representation Language, one of the most expressive schemas for constructing collaborative arguments (Lee & Lai, 1991). A support tool (Lee, 1990) provides filtered graphical and tabular views of the argument network constructed using this schema.

repositories that rely on more structured knowledge bases, requiring well-defined knowledge types and structures. The power that one gains from such systems comes at the cost of initial knowledge engineering effort, perhaps requiring a specialist. As argued earlier, since the subject matter of most interest in knowledge work is often hard to formalise or continually changing, pragmatically, this encoding effort may be hard to justify even if it were possible in principle.

The evidence from cognitive studies of wicked problem solving points strongly to the importance of opportunistic ideas and insights. Hypermedia systems are ideal for linking together ideas without having to specify the precise semantics of their relations or roles (though see (Buckingham Shum, 1996a; Buckingham Shum, *et al.*, 1997) who demonstrate that for certain types and stages of problem solving, even semiformal schemes can be too formal, impeding the creative flow).

Hypermedia is also well suited to organisational memory capture in a second essential respect: *media integration*. Debates, decisions and rationale do not exist in a vacuum, but in relation to ongoing work which relies on, and generates, many forms of artifact (e.g. faxes; email; reports; sketches; prototypes; simulations). It is crucial that these different artifacts can be integrated into the debates captured as semiformal argumentation. Hypermedia systems were designed precisely for this kind of media structuring.

Numerous prototype hypermedia argumentation tools have been developed (Arango, Bruneau, Cloarec & Feroldi, 1991; Fischer, Lemke, McCall & Morch, 1991; Lee, 1990; Marshall, Halasz, Rogers & Janssen, 1991; Oinas-Kukkonen, 1996; Potts, Takahashi & Anton, 1994; Ramesh, 1993; Rein & Ellis, 1991; Schuler & Smith, 1990; Streitz, Hanneman & Thüring, 1989; Vanwelkenhuysen, 1995). Out of the gIBIS protoype (see Figure 1), the *QuestMap* collaborative hypermedia system (CMSI, 1993) is now a product, a screen from which is shown in Figure 3.

This screen shows how the artifacts of everyday knowledge work in one's computing environment —reports, spreadshseets, demos, video recordings—can be integrated into the web of discussion as needed. The ability for example, to summarise rationale and discussions as a short audio or video record, integrated into the argumentation web, provides valuable recall cues, associates real people with particular decisions or projects, and provides the expressive freedom to include nuances and angles on situations which may be essential to really understand later on why a decision was taken, or how complex a problem really was (cf. Carroll, *et al*., 1994).

Finally, a review of the role of hypermedia cannot ignore the World Wide Web. In response to the need for tools to support asynchronous discussions between geographically dispersed participants, we are now seeing the emergence of intellectual descendants to IBIS. Thus, we find AI

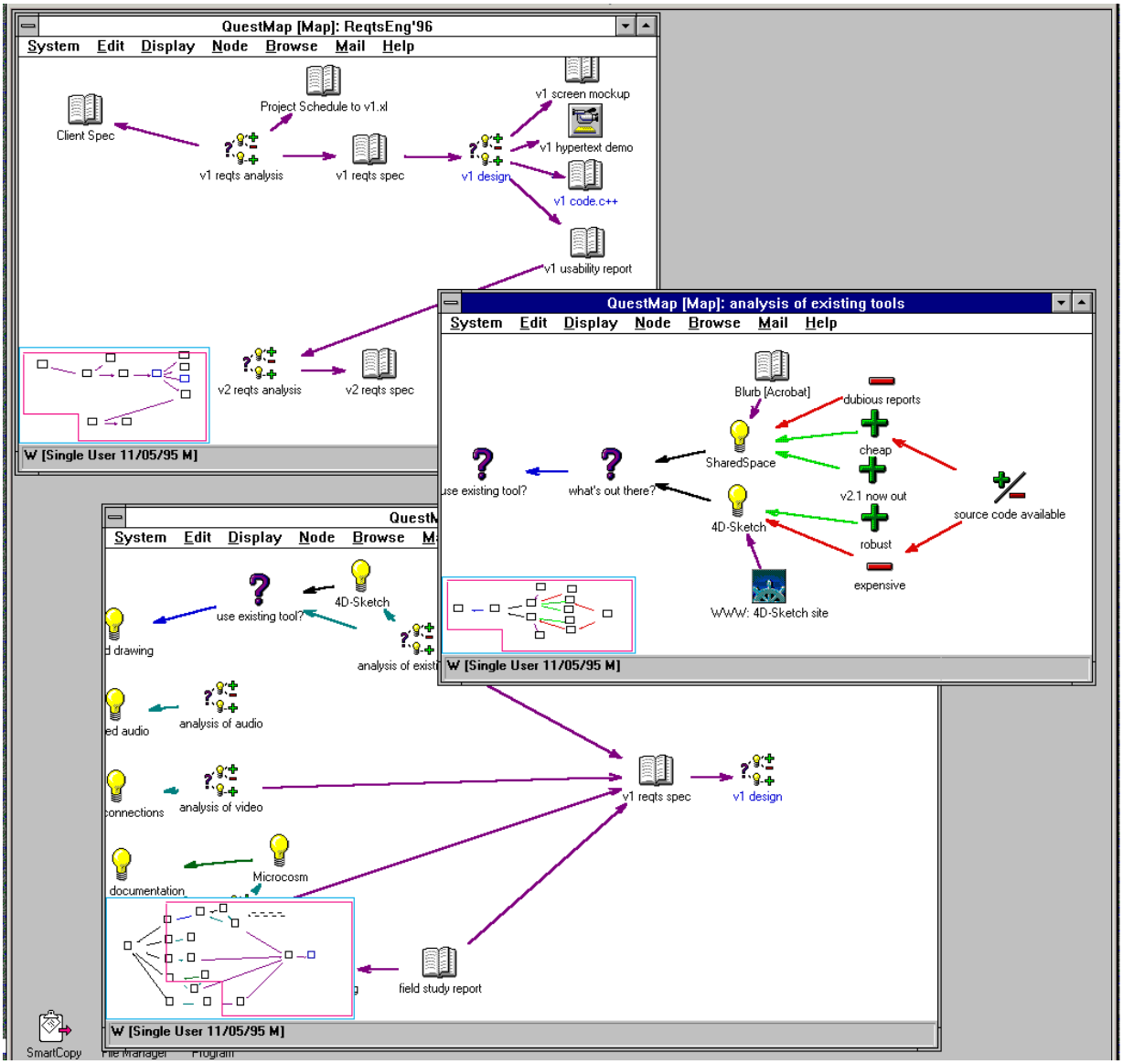

Figure 3: Application of the *QuestMap* system (CMSI, 1993). Based on the IBIS argumentative model, this is a collaborative system providing teams with a way to conduct extended, public discussion about *Ideas* in response to *Questions*, and capturing the *Pros* and *Cons*. In the top window, a high level structure has been defined to track a system development process from requirements analysis through successive prototypes. The team's discussions are made explicit, signalled by the *debate* icons. The debate for "v1 reqts analysis" is in the lower window, and one of the debates embedded in this is shown in the right window.

researchers (Hurwitz & Mallery, 1995) developing knowledge-based Web systems to support structured discussions with tagged contributions, e.g. *agree*, *disagree*, *new idea*.

What Kinds of Knowledge are Captured?

The use of a tool like QuestMap allows teams to visualise their discussions, past and present. The following scenario may help to concretise how this might work in practice:

In June 1995, a meeting agenda is circulated specifying the *Questions* to be resolved; over the network and in their own time, the multidisciplinary team members prepare by tabling their *Ideas*, perhaps beginning to critique these with *Pros* and *Cons*, linking in relevant reports, costings etc. In the meeting, the debate is projected onto a large wall as a shared working memory to track the strengths and weaknesses of each proposal; following the meeting, team members reflect

on the decisions made, and continue to discuss them, updating the map as new results and ideas come in. The conversation map is emailed to others who were not present, who can quickly see what issues were discussed, which ideas were rejected, what decisions made, and on what basis. In September, several issues debated in June suddenly become critical. The relevant part of the space is retrieved to see how things were left then, and it is realised that several Ideas rejected then are now valid. Moreover, links were created in June's meeting back to a previous discussion in May 1994, when a similar problem had been elegantly resolved. This provides a clue to the team as to how to resolve the current issues.

This scenario illustrates the affordances of an organisational memory resource coupling hypertext with argumentation. Firstly, it *supports the process* of discussion and negotation between multidisciplinary stakeholders, providing a working memory, focusing attention on issues of concern, and providing a common space in which all arguments can be assessed. Secondly, it *captures the products* of those negotiations, providing the basis for an organisational memory.

A group memory based on such a trace can help find answers to the following kinds of question:

- Have we faced problems similar to this before, and what was done?
- Who identified this problem/suggested this solution?
- What solutions were considered, but rejected, and why?
- If we change this decision, what might be affected?
- What led to this document being changed?
- What were the main criteria taken into consideration when that decision was made?

This kind of approach clearly cannot represent all classes of organisational expertise; it should be seen as one of a range of methods and technologies required to capture and maintain different organisational knowledge types.

A strength of this approach is that the knowledge is captured *collaboratively*, and *in situ*, during a meeting or asynchronous debate, in the immediate context of one's work (Conklin, 1996). Knowledge is represented, stored and indexed in relation to the real activities by which one's work is accomplished (as well as through some more abstract indexing system if so desired). Discussing through the medium of collaborative, graphical argumentation eases the transition from the messy, changing, contextualised, social, multimedia real world, to its abstract representation in the organisational memory resource. As entries are made in the organisation's long term memory, they bring with them (in the form of the web of discussion and work artifacts) elements of the context in which they arose.

Knowledge-based hypermedia argumentation?

Richer knowledge-based support is clearly possible, but there is an important boundary between semiformal hypermedia as described here, and its possible evolution into decision-support systems and truth-maintenance networks. A finer-grained schema increases the cognitive overhead for real time use, and removes the ambiguity that permits the capture of arguments that are significant but very hard to formalise (e.g. "this would position us well for the next funding initiative"). Rather than trying to analyse the *content* of arguments, it is more appropriate to analyse the *structure* of an argument network in order to detect potentially incomplete reasoning (e.g. a 'good' decision will rarely be made without considering both Pros and Cons). Knowledge-based technologies for incremental formalisation are also highly relevant (Marshall & Shipman, 1995; Shipman & McCall, 1994), for facilitating the process of expressing ideas, from an initially vague and incomplete state to coherently structured networks of named and typed nodes.

To summarise, this paper's thesis is that often, the wisdom, insight and judgement of valued knowledge workers is most clearly displayed in the weighing of complex, competing priorities, and in negotiating with colleagues, often in order to reach mutually acceptable compromises. This is knowledge and expertise which will be sorely missed if that employee is unavailable or leaves the company.

Who Controls Organisational Knowledge?

Dear Staff Member,
In order to maintain and increase the company's competitiveness, an intellectual audit is to be conducted on your department in the coming month, as part of a corporate wide strategy. This will provide Strategic Planning with a better understanding of your skills, communication networks and contributions to the business. This will enable them to ensure that you are receiving the right information at the right time, and that we make the most of your valued expertise. — The Management

This final section takes a broader view of KM technologies, beginning with domain requirements that have influenced the development of the 'argumentative' approach presented.

The presence of multiple stakeholders complicates system development immensely. The whole design process is in a real sense a practical challenge of satisfying multiple, often competing agendas. The key point is that all of these perspectives are interdependent. Given the fundamentally social context of KM (key aspects of people's working lives are being modelled), those who determine the knowledge formalisms are in a powerful position (Buckingham Shum, 1997 considers some representational implications).

There are a number of questions that can be asked of any KM technology. These draw attention to the interdependencies between the competing stakeholders: efficiency; usability; staff autonomy; management power.. As such, considering these questions early on may help to pre-empt the development of approaches which privilege any single set of concerns to the neglect of the others. (See

Eisenstadt, Buckingham Shum and Freeman (1996) for an example of how these questions can be used to critique a system).

1. **What classes of knowledge/expertise are addressed by this approach?** There are many different classes of knowledge and expertise residing in an organisation. Relevant dimensions include tacit—explicit, procedural—declarative, tame—wicked, cognitive—cultural. Obviously, these vary widely in the extent to which they can be made (i) explicit, and (ii) formalised and structured as digital repositories. A central challenge for organisational knowledge research is to develop a better understanding of the most appropriate media for different kinds of personal and collective expertise. It may even be that the knowledge represented by some points in this multidimensional space cannot be formalised, without in the process invalidating it (e.g. tacit, cultural work practices).
2. **What representational scheme is proposed, enabling what kinds of analysis and computation, with what justification?** What computational services over these repositories are proposed, in order to solve what kinds of problems? How does the repository reflect the changing world? Does analysis of such representations make idealised assumptions which do not hold in the real world embodiments of the knowledge/expertise being modelled? Such justification is needed when the contents of the repository relate to staff and their work practices.
3. **Who are the stakeholders? How will knowledge encoding and re-use impact their work practices?** Who is responsible for entering data into the repository—a knowledge engineer; each staff employee? Does one have control over one's own area, e.g. one's 'skills profile'? Is it mandatory for all staff to keep their areas up to date; if so how is provision made for this (access time; user interface)? How does the system start to shape management policy, or inter-departmental relationships, since one's knowledge profile in the repository is now public, and therefore social? Do staff trust the system? If not, on what basis can the management?

These questions can no doubt be further amplified and refined. However, as should be clear, their purpose is to resist the drift towards a form of technological-rationalism which, in the current context, might manifest in reductionist claims such as the following—that the essence of an organisation lies in its information/intellectual capital; that knowledge work and communication are essentially information transfer and transformation; that knowledge resources can be modelled, analysed and transformed without serious reference to the people in whom these resources are embodied. Economic and knowledge efficiency are undoubtedly important criteria for analysing organisations; however, these must be understood in the context of their impact on the knowledge workers who are so crucial to the whole effort.

In the applied, socially embedded domain of KM, the AI community must engage with the undeniable complexities of these issues even as they wrestle with traditional AI concerns.

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