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Negotiating the Construction of Organisational Memory Using Hypermedia Argument Spaces

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Summary

This paper describes an approach to capturing organisational memory in which teams use a hypermedia tool to analyse and discuss complex problems. Graphical argument spaces are constructed as competing ideas are debated. Firstly this supports the *processes* of discussion and negotiation which are central to knowledge work, typically as problems are defined, project constraints shift, and teams reconcile competing agendas. Graphical argumentation provides a *shared working memory* in meetings by focusing discussion. Secondly, the *product* of using such a tool to conduct discussions is a *shared long term memory* of the intellectual investment, thus resisting 'organisational amnesia.' Hypermedia groupware provides a way to link informal, socially embedded knowledge with other work artifacts such as reports, sketches and simulations. Examples of this approach's application are briefly surveyed, followed by consideration of the cognitive, group and organisational dynamics that can support, or obstruct such an approach. The concluding discussion seeks to situate this approach in relation to others, by proposing three questions that an approach should seek to answer. These questions seek to clarify the interdependencies between economics, technologies, work practices, and the power and responsibility that controlling knowledge repositories brings.

Introduction

This paper describes work conducted over the last 6 years, investigating the promise, and the pragmatics, of capturing *group and organisational memory*, that is, 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 recognise? 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. Examples of this approach's application are surveyed, concluding with a discussion of the hands-on practicalities of using it, and the organisational politics that can militate against the successful introduction of organisational memory.

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.

Firstly, on the basis of field studies of knowledge workers, Alison Kidd [21] has proposed several features which distinguish *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.

These features provide a useful orientation to the domain of concern. They paint 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. Experiences are not commonly recorded in conventional documentation, remaining 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 in such an environment. As will be detailed, they can also be used to facilitate organisational memory capture.

The second perspective comes from the formative work of Horst Rittel [34,35]. 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 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, Argumentation 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 interdisiciplinary. 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* [37], Stefik 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 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 et al [13,14] then 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 cumulative argument construction and critiquing can take place around a shared, graphical argumentation structure.

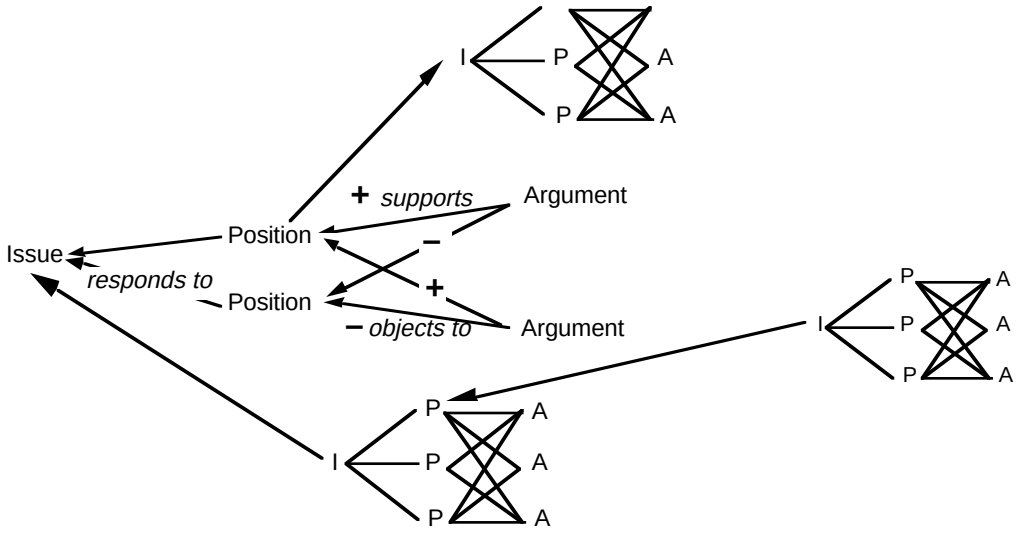

Figure 1: The *graphical IBIS* (gIBIS) notation [13], which allows a team to cumulatively build graphical argument spaces.

The complexity of the notation, 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* [26] 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.

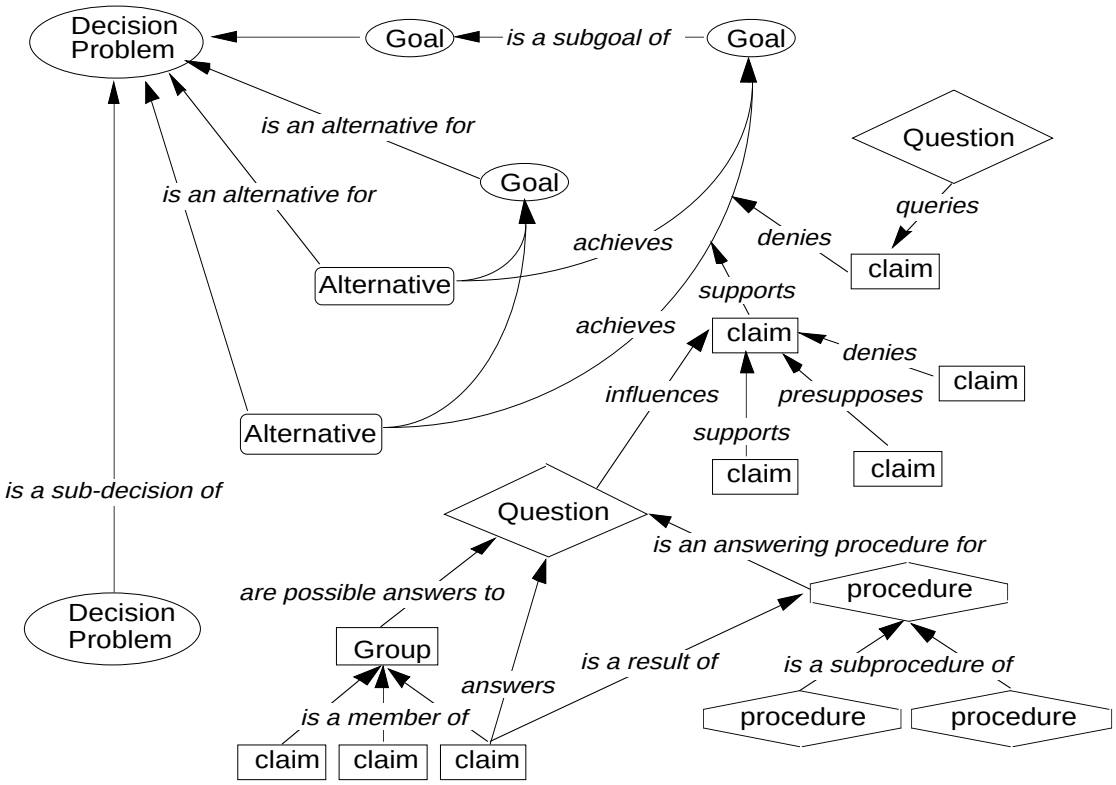

Figure 2: The Decision Representation Language, one of the most expressive notations for capturing collaborative arguments [26]. A support tool [24] provides graphical and tabular views of the underlying argument network.

This paper focuses on notations which are 'lighter weight' than DRL, the emphasis on being on suitability for quick and intuitive use during meetings. Figure 3 shows the *QOC* scheme (for Questions, Options and Criteria) [27], and an example of a QOC design discussion analysing user interface tradeoffs. In QOC, *Questions* are used to encapsulate key issues, *Options* are alternative answers to Questions, and *Criteria* are appealed to in assessing one Option over another. In addition, *Assessments* are the relationships between Options and Criteria (at their simplest, *supports* or *objects-to*). Boxed Options indicate a decision, or at least a working commitment. This is very similar the gIBIS scheme shown in Figure 1.

To summarise so far, 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 next.

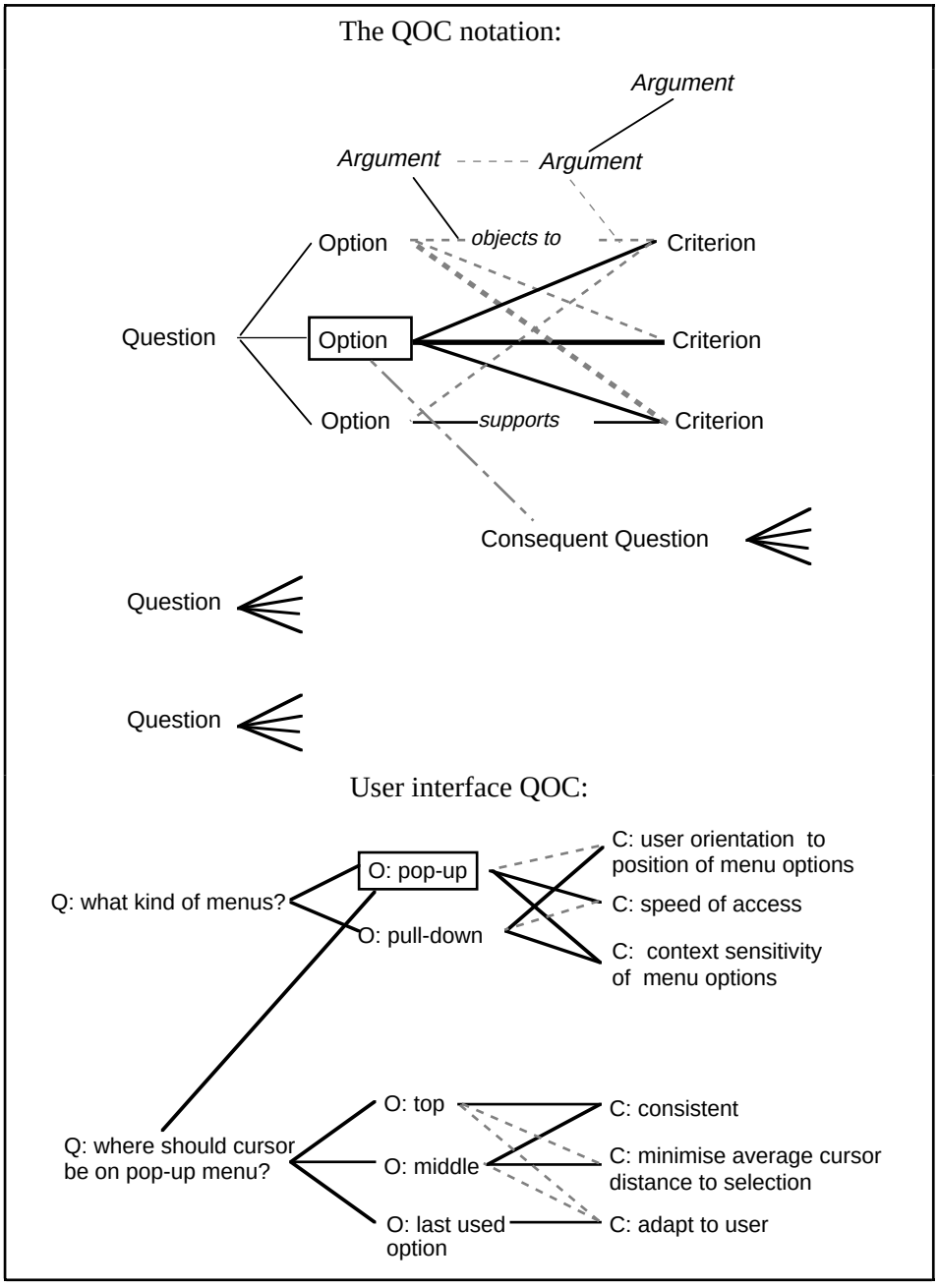

Figure 3: The QOC notation for representing arguments [27], and an example

Collaborative Hypermedia Infrastructure

Hypermedia is an ideal technology for capturing *informal knowledge types* with *inter-relationships which are hard to formalise*. This is in contrast to 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, realistically, 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 [3] which reports 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.

Building on the work on gIBIS (Figure 1), the *QuestMap* collaborative hypermedia system [10] was released as a product, a screen from which is shown in Figure 4.

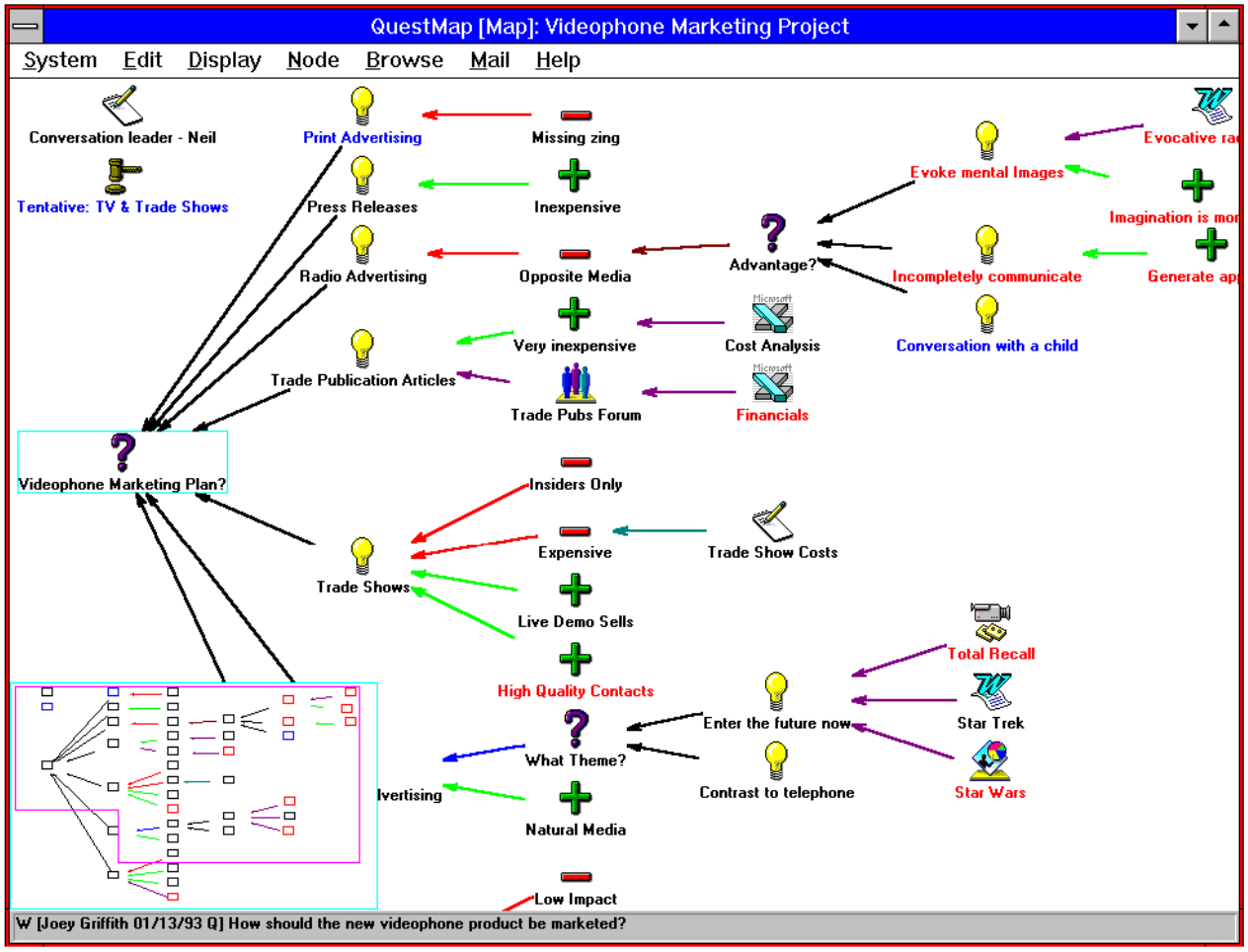

Figure 4: A screen from the QuestMap system [10]. Based on Rittel's IBIS argumentative model, this is a hypertext groupware system provides teams with a way to conduct synchronous or aynchronous debates. *Ideas* are suggested in response to *Questions*, and their *Pros* and *Cons*tradedoff against each other. New *Questions* can be raised by any element of previous discussion. Other media can be integrated into the web of debate through *Reference* nodes (e.g. reports; spreadsheets; video; presentations; code).*Decisions* are marked by linking the hammer icon to an *Idea.*

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.

[8]). The significance of capturing this kind of media-rich, socially contextualised knowledge resource will become apparent in the closing discussion.

Finally, a review of the role of hypermedia cannot ignore the World Wide Web, the first truly global hypermedia system. In response to the need for tools to support asynchronous discussions between geographically dispersed participants, we are now seeing the emergence of partly graphical interfaces to support argumentation of the sort illustrated above. One example is *HyperNews* [23], a Web system which supports discussions as textual threads through a combination of hierarchical indentation, augmented by icons which indicate whether a contribution is for example, an agreement, disagreement, or new idea (Figure 5).

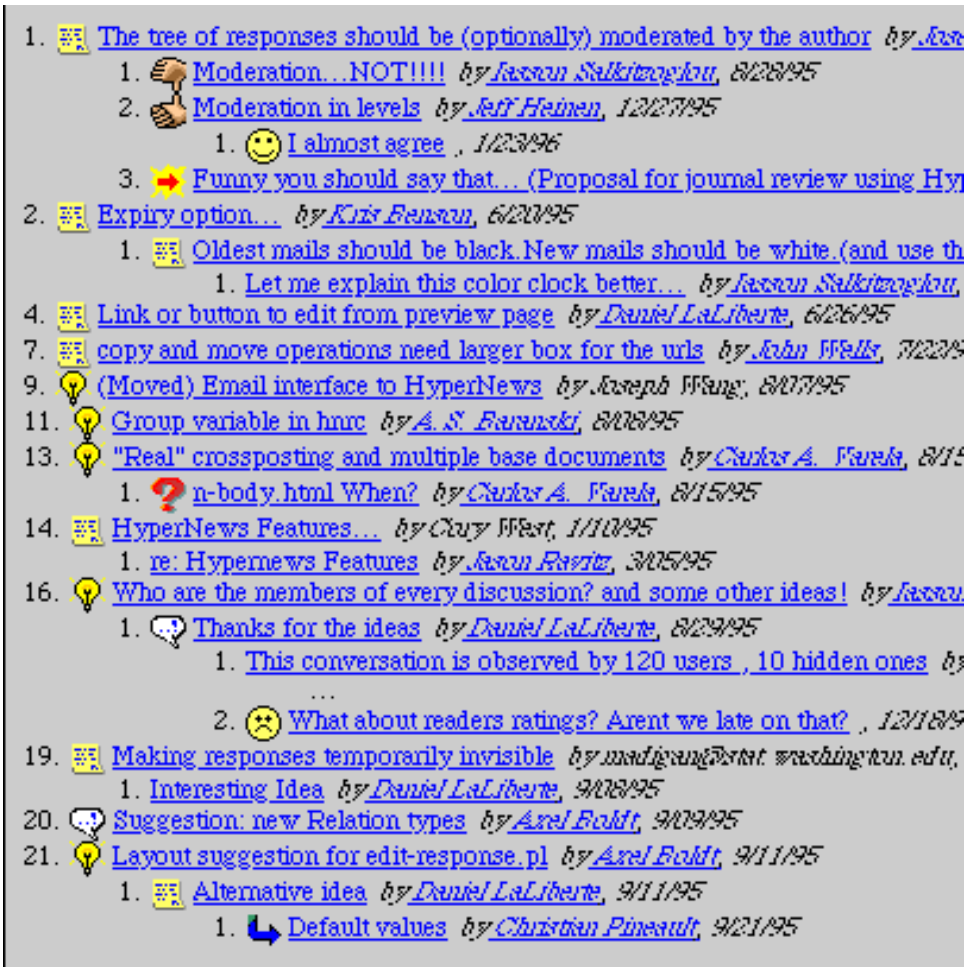

Figure 5: Web-based argumentation using HyperNews [23].

These systems are essentially collaborative argumentation tools (though interestingly, the developers of these systems do not seem to be aware that they are reinventing pre-Web argumentation tools). An textual outline representation was used in one of the most significant design memory case studies [7]. The Web is still a highly impoverished hypermedia system compared to many other systems, indeed, its simplicity is a major factor contributing to its explosive growth. With the possibility of richer interactivity on the Web through developments such as Java and browser plug-ins, direct-manipulation graphical interfaces on the Web will become commonplace (e.g. [22]). Restricted bandwidth makes it hard to disseminate rich media such as video, although again, a corporate intranet can address this problem.

What Kinds of Knowledge are Captured?

The use of a tool like QuestMap (Figure 4) 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. Secondly, it *captures the products* of those negotiations, providing the basis for an organisational memory.

A knowledge team using such a tool builds for itself a form of intellectual trace which they can then draw upon. 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?

A resource based on this kind of approach clearly cannot represent all classes of organisational expertise; it should be seen as one component in the range of methods and technologies required to capture and maintain different organisational knowledge types. Some types of organisational expertise are without a doubt amenable to storage in more conventional databases, such as patents, procedures, employee qualifications, reports, etc. 'Intellectual auditing' [2] can identify this kind of intellectual capital.

However, a strength of the approach described here (explored in more detail by Conklin [11]), is that the knowledge is captured *collaboratively*, and *in situ*, during the meeting or asynchronous debate, in the immediate context of one's work. 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 the static, abstracted entry 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) important elements of the context in which they arose. Such cues are frequently used to recover memories [16].

Argumentation in Action

Collaborative, hypermedia argumentation has been used since about 1986 to support knowledge work in a variety of contrexts. Most of the earlier work on argumentation was taking place in research labs on the leading edge of the emerging technology of hypertext, for which argumentation was an ideal application. However, more recent research has placed an increasing emphasis on application to real, small-medium scale projects. This section seeks simply to point interested readers to relevant sources. More detailed reviews of the research cited below can be found in [4,5].

Firstly, and not surprisingly, there has also been a longstanding interest in the contribution that collaborative argumentation can make to complex, intellectual work where the quality of reasoning and accessibility of rationale for decisions are particularly important. Experimental fields of application have included government policy formulation [13,35], scientific reasoning [36,40], and legal analysis [30]

In the second phase of research as hypertext matured as a technology, some of the most significant design disciplines began, and continue, to look at collaborative argumentation as a way to capture project/organisational memory, and manage the kind of changing environment and competing agendas described earlier. *Argumentative design rationale* is attracting substantial interest in Human-Computer Interaction [9,28,29], Software Engineering [12,20,25,31-33]), Knowledge Engineering [38,41], and Knowledge-based Design Environments [18,19].

Thus far, the only financially costed benefits of this form of organisational memory comes from a software engineering case study, which introduced a version of IBIS argumentation, similar in form to the outline view provided by the HyperNews Web system (Figure 5). This was used by a team working on a large commercial system development [7]. The study reports the discovery of eleven design flaws during the conversion of argumentation from outline to graphical form. The time savings gained for the project as a result were estimated at between three and six times greater than the time cost of converting the argumentation formats.

The third and most recent development came with the release of the QuestMap hypermedia system in 1993 (see Figure 4), based on the gIBIS prototype. Businesses have begun to adopt QuestMap and its underlying model to facilitate and structure their meetings, and in the process construct organisational memory resources. For further details, see Conklin ([11]). This development is clearly a significant point in the history of hypertext argumentation, and in time should clarify more clearly the strengths and weaknesses of this particular approach in the context of different organisational cultures.

Practicalities

In this and the final section, attention focuses on the practicalities of using argumentation schemes. This has been a priority matter, since it is all too easy to propose new tools which should work in principle, only to find that insufficient account has been taken of the actual demands that they make in real work settings (the force of the ‘river’ may be underestimated).

The Costs and Benefits

Organisational memory comes at a cost—someone must construct, index, and maintain it. There is no way for a knowledge capture enterprise to avoid this cost-benefit tradeoff. It is a question of how to negotiate it. Thus, minimal capture effort initially (e.g. video-record every meeting and store every document), simply shifts load downstream (how to recover the relevant records from memory?). The cost of initial knowledge engineering effort provides computational services and eases recovery subsequently.

Midway between these two extremes, the semiformal hypertext approach described here requires knowledge workers (not knowledge engineers) to structure their deliberations using a high level, reasonably intuitive vocabulary (e.g. Questions, Ideas and Arguments).

What are the overheads introduced to a team by such schemes? Analysis of the hands-on practicalities of using such a scheme [3,6] has highlighted four key cognitive tasks:

- **Unbundling—**teasing apart ideas which have been expressed together. A typical example would be when in one utterance someone raises a problem, and proposes a solution plus supporting reasons. Much time is wasted in meetings because a disagreement with one element in an argument is taken to be a dismissal of the whole argument. Graphical argumentation can clarify the different elements and hidden structure.
- **Classification—**deciding whether a contribution is, e.g. a Question, Option or Criterion. This is not always as simple as it sounds, because Options and Criteria may initially be expressed as Questions, or Criteria as solutions. A Yes/No Question can be asked about a particular Option, rather than clarifying the implicit problem to which that Option is one candidate solution. The task here is to cut through the surface form and recognise the ‘deeper content.’

- **Naming—**how to label the new contribution succinctly but meaningfully. It can often be difficult to articulate ideas succinctly. The skill of doing so is nurtured over time, and the discipline involved can be helpful, although it can also be intrusive in a brainstorming mode of working. The overhead which naming creates is also dependent on the anticipated future use of the record, for instance, is it for colleagues present in the meeting, for a formal project review with a manager in three month's time, or for another team taking over from you?
- **Structuring—**how a new element relates to other ideas. Many meta-level representational and rhetorical decisions may arise at this point. For instance, what Question(s) does a new Option address? How does an Option trade-off against existing Criteria? Is this Question sufficiently similar to another in a different context, or should a new Question be introduced? Has this Criterion already been used elsewhere under a different name?

There is evidence that the intellectual rigour that this process encourages (e.g. being encouraged to ask 'what really is the key Question here?') can focus team meetings about complex, wicked problems, cutting through circular reasoning and rhetoric [13,14]. There is also evidence that when a problem is not in fact wicked, by Rittel's definition, such explicit argumentation may not be helpful, slowing down discussion unproductively. It is therefore a case of choosing the right tool for the job; argumentation integrates well with certain workflows, but obstructs others. We have sought to alert practitioners to these hands-on issues when training them.

Modes of Groupwork

How can collaborative argumentation be used in a meeting? What role should it play in the project? There is a range of roles, depending on how committed a team wishes to be to capturing its intellectual investment in this way (see next section for factors that may militate against this). Figure 6 shows various points along a continuum which illustrate the various options which a team can take as to their work patterns.

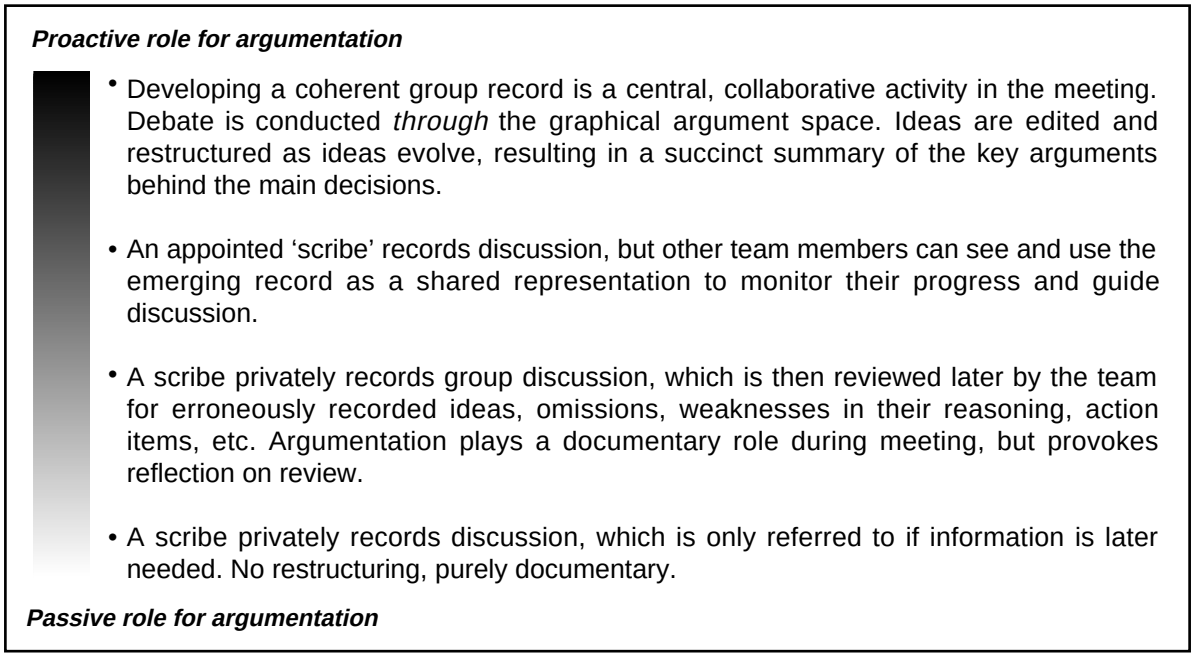

Figure 6: Graphical argumentation can play a proactive or passive role in team deliberation. The more a team interacts through the graphical argument space, the more transparent it becomes—construction of the group memory becomes increasingly a co-product of the deliberation process, jointly owned by the team, and a living resource on which to build subsequently.

A team may move back and forth along this continuum for different meetings, or even within a meeting depending on the kind of problem that is being discussed (see previous section). We expect organisations, and within them individual teams and team members, to adapt a generic representation and tool to their own

priorities and work patterns. Almost invariably, a new method or tool will be used in ways never originally envisaged by its developers.

Organisational Culture

Understanding the human dimensions to a work representation cannot be restricted to the impact on cognition or group dynamics, critical though these are. All representations take on political dimensions as soon as they are introduced into a workplace [1]. Collaborative argumentation requires the adoption of a relatively open, transparent mode of communication, negotiation and accountability. Such an approach contrasts sharply with the harsh realities of some cultures, where there is distrust between employees and managers, and where notions of meeting facilitation, giving space to all stakeholder's voices, and making one's rationale public stand little hope of acceptance. In such organisations, employees might, for instance, refuse to document who was responsible for a particular decision and why, for fear of recriminations in the event of an error. Moreover, certain stakeholders may perceive such approaches as undercutting their power, since their arguments will be represented and treated on a more equal footing with other team members' views. Once displayed in the argument space, an idea is less tied to its owner, and more vulnerable to critiquing from others' ideas. Conversely, for some stakeholders, this will be empowering.

Ultimately, we cannot escape the fact that organisational memory, certainly of the sort described here, requires a compatible working culture. There can be little doubt that even for shared *team* memory resources to work well, members must be prepared to trust each other, and sanction the enterprise. This must take place on a correspondingly larger scale to prevent an organisation-wide memory from dying through neglect or subversion, as seems to be the fate of so many new methods and tools which do not sufficiently appreciate the organisational dynamics they seek to change.

One may hypothesise that current excitement within the organisation and business literature about the shift to 'learning organisations' will create work cultures who will look favourably on collaborative argumentation tools. One may also hypothesise that the dynamic of change is two-way, and that in conjunction with a committed team of users, such tools could influence working culture through the more transparent communication and rigorous reflection that they promote, and the group memory which they provide. In short, collaborative argumentation tools could work from the bottom up as agents of change.

Discussion: Who Controls Organisational Knowledge?

> *Dear Employee,*
>
> *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*

Organisational expertise, corporate memory, intellectual capital, knowledge management, learning cultures—these terms are stirring a lot of interest at present, but it is clear that they signify many different things to different parties, and are being redefined on a daily basis.

This paper has elaborated part of the design space, proposing a particular representation (graphical argument+artifact spaces) and supporting technology (collaborative hypermedia) as an approach to supporting firstly, key *processes* in knowledge work, and secondly, the capture and retrieval of elements of the *products* of this work, to serve as a resource for subsequent organisational learning and problem solving. A lot of emphasis has been placed on human dimensions to this kind of tool—touching on the cognitive, group and organisational dynamics which such a tool impacts, and which therefore constitute potential sources of resistance to its uptake. These are the powerful 'river currents' that need to be recognised and worked with.

But what is this 'design space' just referred to? What are the important dimensions that structure the space of possibilities for organisational technologies of this sort? What is 'important' is always with respect to a particular person with particular priorities. So, we may ask, who are the main stakeholders in this field, and

what are their concerns? Certainly, management are one player on the field—how can they make the most of their investment in quality staff? For technologists, this field represents a challenging opportunity for knowledge modelling and organisational systems—no scheme can work on a realistic scale without computational support. For organisational theorists, understanding and changing working cultures is foremost—knowledge capture technologies can subvert, and be subverted by, working culture. Nor can we ignore the employees whose knowledge and expertise is so central to the whole enterprise, and who may be expected to participate in the capture and subsequent use of any technology. There are no doubt other parties and agendas not covered by the above.

The key point is that all of these perspectives are interdependent. None can be examined in isolation except in an artificial, decontextualised way which ignores the realities of organisational life. There are a number of questions which should be asked of any proposed approach to organisational knowledge capture and re-use (another paper at this conference [15], uses the following questions to critique the 'Stadium' system as a resource for organisational expertise). These draw attention to the interdependencies between economics, technologies, work practices, and the power and responsibility that controlling knowledge repositories brings. As such, they may help to pre-empt the development of approaches which privilege any single set of concerns to the neglect of the others.

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 is to develop a better understanding of the most appropriate media for different kinds of personal and organisational knowledge/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. informal, 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.

Organisational knowledge and expertise cannot be treated as abstract commodities on the stock sheet; it is *people* working *with each other*, in particular *environments* and under particular *circumstances*, who display their expertise. This paper's thesis has been that where the wisdom, insight and judgement of valued knowledge workers is most clearly displayed is 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. No claim is made that all important forms of expertise are addressed by this approach. However, it is grounded in the processes of discussion, and allows knowledge workers to appeal to *any* form of relevant justification in decision-making (from technical to political), taking seriously the centrality of wicked problems in knowledge work.

Considerable effort is now being devoted to applying knowledge modelling and systems design techniques to the capture of corporate memory, but few papers explicitly recognise the informal and social knowledge processes in the organisations (real or imagined) for which they are designing (but see [17,39,42]). Some might respond that it is too early in this field to see serious inter-disciplinary dialogue. Historically, however, the evidence is that even in much more mature applications domains of interactive system design, it is difficult for the computing, human and organisational sciences to engage. We need to learn these lessons, and ensure that from the start, the balance of debate reflects its subject matter: *applied* technology research, intimately tied to the *non-deterministic, tacit, evolving* world of human expertise embedded in collaborative work practices.

In conclusion, a productive step forward would be for the knowledge systems community to dialogue with other relevant disciplines—e.g. human-computer interaction, collaborative computing and organisational change—and begin to develop detailed scenarios of use in realistic organisational contexts. Ultimately of course, we need empirical evidence of their success or failure. The issues raised by the above three questions are therefore proposed as significant items for the future research agenda in this challenging new area.

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