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Decision Aiding

Wisdom, decision support and paradigms of decision making

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Abstract

Many decision support tools have been developed over the last 20 years and, in general, they support what Simon termed substantive rationality. However, such tools are rarely suited to helping people tackle wicked problems, for which a form of procedural rationality is better suited. Procedurally rational approaches have appeared in both management science and computer science, examples being the soft OR approach of cognitive mapping and the design rationale based on IBIS. These approaches are reviewed and the development of *Wisdom*, a procedurally rational decision support process and accompanying tool, is discussed and evaluated.

Keywords: Decision support; Cognitive mapping; Wicked problems

1. Introduction

Many decision support systems have been developed over the last 20 years. Their designers intend them to help humans make decisions in situations that range from the simple to the complex. The term 'decision support system' seems to have been popularised by Keen and Scott Morton (1978), and its abbreviation, DSS, quickly became part of the terminology of management science and of

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computer science. But how should decision support be provided and what form should DSS tools take?

As argued below, conventional DSS are very useful when used to support decision making in situations that are well defined. However, they are less useful when problematic situations are ill defined and, in particular, when there is debate about what should be done rather than how it should be done. In the latter situations, there is a need for methods and tools that support ongoing decision-making processes and that help teams of people to find their way through such messy situations. Furthermore, given the dynamic nature of decision-making teams and the long-term consequences of decisions, there is also a need for decision support systems to allow decisions to be recorded, revisited and changed. Therefore, the requirement is not simply for better support for the process of decision making but, more generally, better support for the entire decision life cycle from initial formulation, through detailed specification, to implementation and change.

In this paper, we discuss a decision support process and associated software support tool (*Wisdom*) that aims to provide extended support for decision making. The *Wisdom* tool and process were devised to support messy deliberation, so as to help people make rational choices when useful information is limited and when there may be disagreement about what should be done and why. In addition, the *Wisdom* tool allows decisions to be recorded in a structured form so that the 'decision space' can be queried, decisions discovered and the arguments made in favour and against these decisions reviewed.

The remainder of the paper discusses different paradigms for decision support and suggests that 'messy' decision making requires procedural support. Different approaches to providing this procedural support are reviewed and we discuss the advantages of adopting an integrated approach that combines cognitive and dialog mapping. We briefly describe the *Wisdom* process and tool that we have developed and discuss its use in supporting long-term decision making in a defence technology company. Finally, we discuss the effectiveness of an integrated approach and reflect on the success of the *Wisdom* approach.

2. Decision support paradigms

2.1. Substantive decision support

Substantive decision support refers to approaches that attempt to provide knowledge-based expertise to address particular decisions. As a simple example, consider the problem of designing a bridge to carry known loads. In concept, at least, we can develop a DSS that supports bridge designers by offering different design options and, within each, carries out the calculations required to proceed towards an acceptable, or even optimal, design. The DSS must include a knowledge base of possible broad design options for bridges and also known calculations of the forces that the bridge must face, given the likely loads, materials used and its structural form. This hypothetical DSS could also provide support for developing economic models of the bridge design and its operation.

Such a DSS would provide its detailed support from established knowledge held in a knowledge base and could be of great use in bridge design. However, this form of DSS is suited only to decisions in which the aims of the work are known and agreed. In the terms used by Rittel and Weber (1973), these are 'tame problems'. As Checkland (1981) puts it, this bridge design DSS would support designers who know what needs to be done and why, but who need help in deciding how it should be done.

A tame problem need not be trivial, for there are many calculations to make when designing a bridge and many decisions to be made. However, it is, essentially, a problem of engineering a solution to a known concern. Building on Ackoff (1979), Pidd (1996) discusses the ways in which people use the term 'problem' and provides a spectrum containing three points as examples.

- Puzzles: situations where it is clear what needs to be done and also, in broad terms, how it should be done. A puzzle solution can be found by applying known methods, e.g. a particular mathematical method.

- Problems: situations in which it is clear what needs to be done, but not obvious how to do it. The problem is well defined or well structured, but considerable ingenuity and expertise may be needed to find an acceptable, let alone optimal solution.
- Messes: unstructured situations where there is disagreement about what needs to be done and why; therefore, it is impossible to say how it should be done. The mess must be structured and shaped before any solution, should such exist, can be found. Messes are what Rittel and Weber (1973) term 'wicked problems'.

Substantive decision support systems provide excellent help in working with puzzles and problems. Puzzles can often be solved by relatively simple DSS based on spreadsheets to provide support for perhaps calculations that may be complicated and error-prone. Problems may require purpose-designed DSS, complete with appropriate knowledge bases and computational support that may employ sophisticated algorithms. However, substantive decision support systems are not well suited to messes or wicked problems.

2.2. Procedural decision support

The usual way to handle wicked problems is to structure them so as to reduce them to problems or even to puzzles that can be solved. However messes and wicked problems are interactive systems of related issues, as the problems and puzzles defined by such structuring are inter-related. What role can decision support play here?

Clearly, restricting the role to mere calculation support is to restrict the help that may be given. Similarly, adding a knowledge base is not enough, since it will be unclear what knowledge is required. A knowledge base for bridge design is not useful if it is unclear whether a bridge is needed at all. A substantive decision support tool helps someone to decide how an objective should be achieved, hence the value of a knowledge base. A procedural decision support tool should support people in addressing the why and what questions, rather than just helping them to think about how an objective should be achieved.

Simon (1976) distinguishes between two forms of rationality. Substantive rationality is an attempt to develop a quasi-machine-based approach in which a range of options can be objectively compared and assessed. Simon (1976) characterises substantive rationality as follows.

The most advanced theories, both verbal and mathematical, of rational behaviour are those that employ as their central concepts the notions of:

1. a set of alternative courses of action presented to the individual's choice;
2. knowledge and information that permit the individual to predict the consequences of choosing any alternative; and
3. a criterion for determining which set of consequences he prefers.

In these theories rationality consists in selecting that course of action which leads to the set of consequences most preferred.

Substantive rationality is suited to situations in which the means to an end are uncertain, but the ends are known. This is the approach to rationality that underlies substantive decision support as discussed above. However, Simon argues that substantive rationality does not work when the argument is about ends rather than means. He uses the term *procedural rationality* for the alternative view that stresses the use of reasoning processes rather than the elucidation and comparison of options. Behaviour is said to be procedurally rational when it results from some appropriate deliberation, which stresses the process of decision making; how it is done or how it should be done. Substantive rationality stresses rational choice, procedural rationality stresses rational choosing.

Procedural rationality requires processes and tools to support participants in their search for alternatives, that encourage systematic information gathering and analysis and that help participants find acceptable solutions when there is conflict. The latter point is especially significant in supporting strategic decision making. Participants need a framework within which they may explore a decision situation and use their reason to find a way through it. As argued in

Pidd (1996), soft OR approaches are attempts to provide decision support that is procedurally rational. Thus, the SODA methodology of Eden and Ackerman (2001) and the strategic choice approach of Friend and Hickling (1987) provide detailed advice on how to manage an intervention aimed at providing decision support. The soft systems methodology of Checkland (1981) helps participants in a complex decision think through their different worldviews and positions.

3. Methods for procedural decision support

3.1. Cognitive mapping

Used originally by Tolman (1948) to refer to people's mental maps of physical space, cognitive mapping was introduced in OR/MS by Eden (1988). The maps are attempts, by a third party, to represent the ways in which people articulate the concepts they use when thinking through decisions. Axelrod (1976) applied similar ideas in analysing political and international conflict. Since Eden's work is well known in the OR/MS community, only a brief summary will be given here and readers are referred to Eden and Ackerman (2001) for a more detailed introduction and to Eden and Ackerman (1998) for a very thorough discussion. Cognitive mapping is often referred to as a problem structuring method alongside others such as strategic choice and soft systems methodology. For an overview of these approaches see Rosenhead and Mingers (2001).

A cognitive map resembles an influence diagram in which the nodes represent the concepts as expressed by an individual. The partial map of Fig. 1 reflects what someone said about how they think it best to develop a computer system. The arcs show the links between the concepts, and their direction indicates a form of causality. In Fig. 1, for example, *allowing 3 months for testing* is believed to lead to *the tool should be robust*. The map is an external model, a representation that is open to scrutiny and argument. However, it is not a would-be map of the real world, rather an external representation of what an individual has said about a situation.

Eden's approach to using cognitive maps is based on SODA (strategic options development and analysis). Eden and Ackerman (1998) discuss two variations on SODA, that are described in Pidd (2002) as SODA I and SODA II. Both aim to provide procedurally rational decision support to teams of people.

3.1.1. SODA I

SODA I is described in Eden (1989) and is intended to operate as follows:

1. After agreeing the ground rules for the intervention with the project sponsor, the consultant interviews each team member separately and constructs a cognitive map for each individual. The consultant analyses each map, by checking its consistency and looking for clusters of related concepts and for concepts that seem to be especially important.
2. The consultant then merges the individual maps into a strategic map for the group. This is done by looking for similar and recurring concepts on different maps, leading to a single map that encompasses the expressed concerns of the individuals that comprise the team. This strategic map is then analysed to develop an agenda for a group workshop.
3. The group then meets for a SODA workshop, facilitated by the consultant. The strategic map is used as the focus of discussion and debate until participants agree on action.

Used in this way, SODA I provides a powerful methodology that supports groups in thinking through unstructured and strategic decisions. It may be a form of problem structuring that leads on to quantitative analysis, or it may itself lead to choices being made.

3.1.2. SODA II

Eden and Ackerman (1998) introduces a second approach that dispenses with stage 1 of SODA I. This is justified on the practical and pragmatic grounds that there may not be enough time to interview everyone separately before the

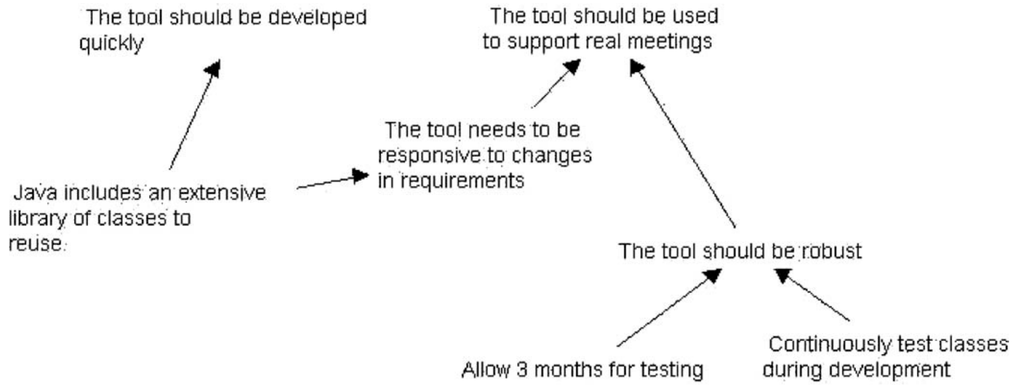

Fig. 1. Example of a simple cognitive map.

SODA workshop. After agreeing the ground rules with the project sponsor, the group is assembled in a SODA workshop that will jointly construct a cause map, which is usually done using computers linked by a LAN and controlled by the facilitator and assistant (called a chauffeur). The workshops then usually proceed as follows:

1. A blind gather in which each group member brainstorms and types into their computer any concepts and ideas that they think are relevant to the subject being addressed. Each person's concepts are only visible to them and to the facilitator and chauffeur. Whilst this is going on, the facilitator and chauffeur organise the display of the whole set of concepts on screen.
2. Once the blind gather is complete, the set of concepts is displayed to the participants who, with the facilitator's help, organise and link the concepts to develop the group's cause map. During this process, other concepts may be added.
3. Aided by the facilitator, the group uses the map as a focus for discussion and debate, much as in SODA I. The idea is to identify the important issues and to agree how to make progress in resolving things.

3.1.3. Cognitive mapping in OR/MS—a reprise

As introduced by Eden, cognitive mapping approaches have four distinct features.

1. A methodology: the intellectual framework within which SODA I and II are justified, providing guidelines for using the associated techniques.
2. A technique: the modelling rules and methods that form the basis of cognitive, strategic and cause maps.
3. A process: the management of the workshop and decision-making procedure captured in SODA I and SODA II.
4. A technology: the computer-based tools developed to support the methodology, process and techniques. Examples are Decision Explorer (Banxia Software, 2002) and Group Explorer (Phrontis, 2002).

It is clear that the SODA approaches aim to provide procedurally rational decision support.

3.2. IBIS and dialog mapping: An example of design rationale

As cognitive mapping was emerging in OR/MS, a similar approach was appearing in computer science, initially in computer supported co-operative work (CSCW). Design rationale approaches seek to aid decision making during a design process by formally capturing the decisions made and the rationale behind them. The design deliberations can then be reused by the same team at a later date; by others engaged on the same project such as the maintenance team; or by a project team engaged on a similar project. A number of different design rationale approaches (Lee and Lai, 1991; MacLean et al., 1991; Potts, 1994) and supporting software tools (e.g. Lee, 1990) have been developed. Each approach uses a structured notation to code and link different elements of the argument and emerging discussion so as to guide map building.

Whereas cognitive mapping found its original justification in individualistic cognitive psychology, design rationale stemmed from work on wicked problems (Rittel and Weber, 1984). Wicked problems (see Section 2.1) have stakeholders who may be physically distributed, who may have different paradigms, may have their own vocabulary and means of expression, hidden agendas, different values and competing interests. Moreover, there may be little hard data available for analysis, the nature of the problem may evolve over time and resources, including time, are inevitably limited. As discussed earlier these are interacting sets of problems that have no correct solution—the hardest and most demanding task is problem definition.

The dialog mapping approach advocated by Conklin (2002) is one example of design rationale. Like SODA (Eden, 1992), it assumes that tackling such wicked problems is "fundamentally a social process" (Conklin and Weil, 1996) in which dialogue and discussion should be supported. Since cognitive mapping was summarised earlier under four headings: methodology, technique, process and technology, the same four will be used here in the discussion of dialog mapping.

3.2.1. Methodology

Conklin and Weil (1996) argue that, in dialog mapping, wicked problem solving is a social process that cannot rely solely on the rational-scientific paradigm of substantive rationality. They insist that meetings are the best tools for wicked problem solving, even though the standard format is often ineffective. Dialog mapping aims to enable meetings to allow information processing while supporting communication and collaboration. Conklin (2001a) states that the key to this is the use of an agreed notation and a map to develop shared understanding and commitment, and the generation of collective intelligence.

Dialog mapping emphasises the importance of a collaborative display (Conklin, 2001a), usually by the projection of a map, built using the agreed notation. The collaborative display reassures participants that their point has been heard, helps the group to structure their thinking and reduces their reliance on memory. This changes the dynamic of the group, as the display itself becomes, in effect, a participant in the conversation. The map is intended to support joint problem solving and to encourage helpful, collaborative conversation around the wicked problem. Dialog mapping does not, however, require consensus, rather it aims for stakeholders to "understand each other's positions well enough to have intelligent dialog about the different interpretations of the problem, and to exercise collective intelligence about how to solve it" (Conklin, 2001b).

3.2.2. Technique

Dialog mapping is based on IBIS (issue based information systems) and the IBIS Manual (Conklin, 1996) provides a complete guide to the mapping technique. It was suggested by Rittel and Kuntz (1970) and its notation is more formal than that employed in cognitive mapping. IBIS constrains nodes to three types that, according to Rittel and Kuntz (1970) support the "identification, structuring and settling of issues raised by problem solving groups."

- Questions: that state an issue in question form;
- Ideas: that propose an option or possible resolution to the question; and
- Arguments (pro or con): that state an opinion or judgement that either supports or objects to one or more Ideas.

The notation constrains the permissible links between the node types so as to help maintain a structured dialogue. The permitted links are shown in Fig. 2 and are not causal, since nodes are connected by links with different semantic types. For example, Ideas respond to Questions and Arguments support or object to these Ideas. Nodes are linked graphically on the display to reflect the nature of the argument, with subordinate nodes strictly to the right. An Idea node can be

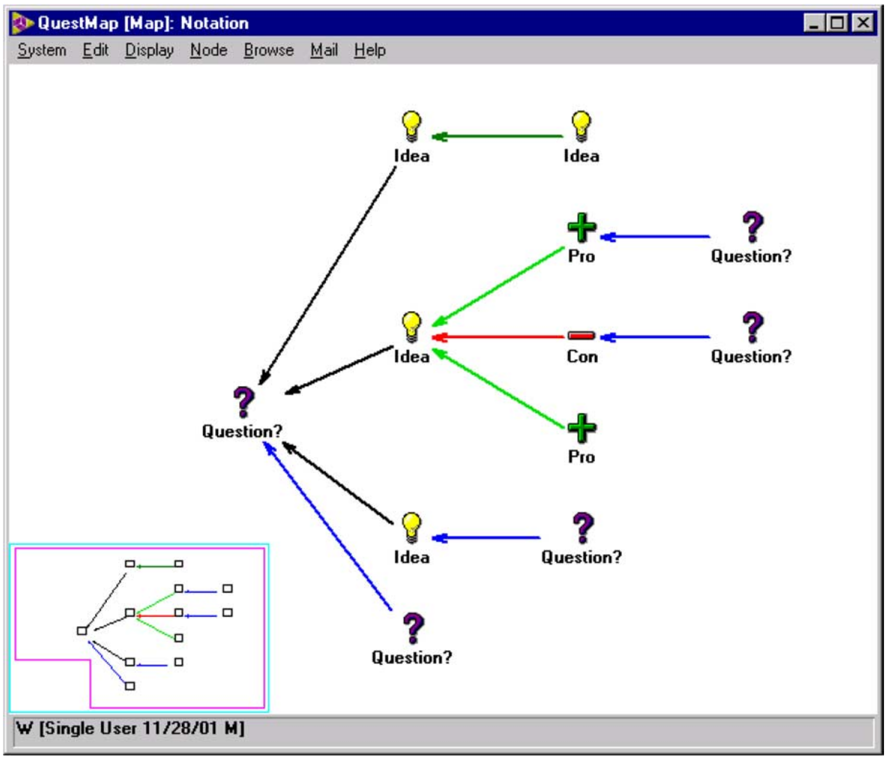

Fig. 2. IBIS notation standard nodes and legal links.

annotated to indicate when the group has agreed an action to resolve a particular Question. Other nodes can be included on an ad-hoc basis, including references or hyperlinks to other maps and documents.

Any use of IBIS is based around questions, each posed in its own node, some of which may be very direct, such as:

What do we need to do?
How should it be done?
How much would it cost?

Others may be more subtle and could be ways of asking about the meaning behind concepts; asking for facts; or seeking clarification or criteria by which to judge issues. When there is disagreement or misunderstanding, it is crucial to frame the issue as a question. Doing so transforms the potential discord into collaborative inquiry that seeks to answer the question that has been framed.

An IBIS map should represent the dialogue that unfolds during a meeting. This means that an Idea, for example, may be included as a distinct node more than once, if it is an option that responds to more than one Question. This avoids multiple links on the map and preserves the different narratives, since an argument made for the adoption of an idea might only be relevant in a particular situation. Preserving the accuracy of narratives is fundamental to IBIS, because the meaning behind the dialogue is represented, rather than the problem itself. In this, it differs from cognitive mapping as used on SODA, since a cause or strategic map represents how people see the decision space, rather than how their debate has unfolded through time.

As an example, Fig. 3 shows that the Question '*how do we increase our market share?*' has been answered by two Ideas. One Idea, '*offer a service provision*', has generated arguments for and against its adoption. The other '*reduce client costs*' has been queried by a Question, which in turn leads to

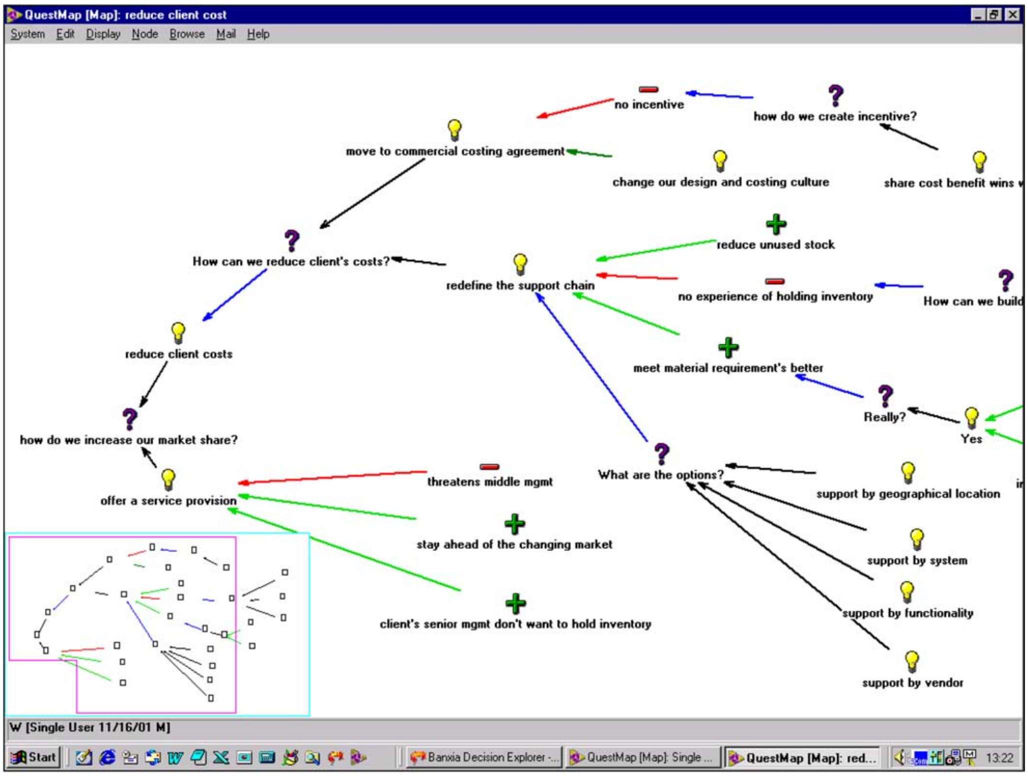

Fig. 3. Example of an IBIS map.

two Ideas that have been further explored. The map reflects the dialogue, rather than an abstract logic, and so its structure depends on the idiosyncrasies of a particular meeting. In other circumstances the Question '*how to reduce client's costs?*' might not have been raised and the two Ideas '*redefine the support chain*' and '*move to commercial costing agreement*' might have been linked directly to '*reduce client costs*'. An example of this type of linking is shown with the Idea '*change our design and costing culture*'.

3.2.3. Process

A dialog mapping session normally begins by posing a Question that asks what should be done or how it should be done. This prompts the group for a handful of Ideas that address the question, along with pro and con Arguments, these being linked to the Ideas on the map. From hereon, the dialogue may go in any one of many directions, with the map reflecting the conversational turns as they arise. This approach differs from that employed in SODA II which often begins by gathering issues in a brainstorm and then agreeing a few of these for detailed consideration.

If participants raise issues that challenge an Argument, these are phrased as Questions and Ideas are added that might resolve them. Later, more Ideas and Arguments may be added against the original Question. Parallel Questions may be introduced, generating a second map that is later linked into the original. Questions might also consider the project objectives or criteria, or even question the validity of the problem itself. The map building may proceed linearly, but often Ideas are mapped before the relevant question has been suggested, and Arguments often precede the Ideas. As each thread of the conversation draws to a close, the map acts as a short-term memory aid to remind the group of what has been

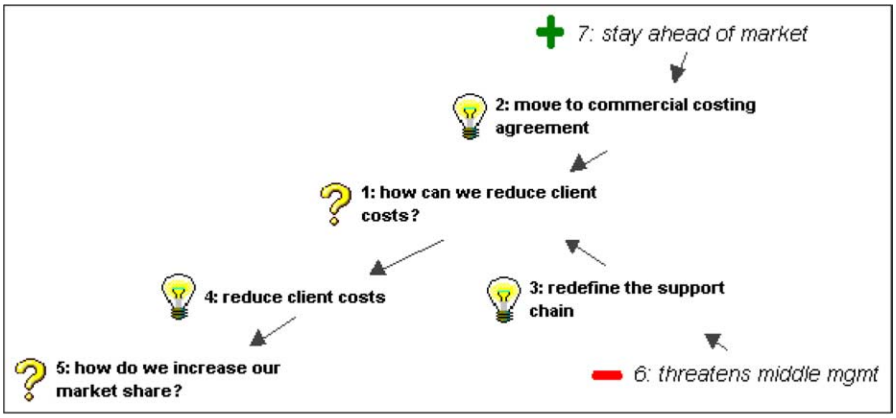

Fig. 4. Representation of a dialogue with a new root question.

discussed and what remains to be elaborated. Conklin (2001c) provides an example of how a typical dialog mapping session might progress.

Questions are central to the use of IBIS to transform the dialogue into one of collaborative problem solving rather than fruitless argument and this may require a facilitator to move the dialogue along. For example, if in Fig. 4 '*reduce client costs*' is suggested as an option, but another participant retorts that client costs cannot be reduced, the facilitator can capture this as '*How can we reduce client costs?*' This recognises the issue raised, but removes the potential for a yes–no confrontation and instead poses it as an issue for collaborative enquiry (Conklin, 1996) and prompts for Ideas to solve it.

Although the underlying technique and methodology of IBIS is very similar to cognitive mapping, the process of using it with groups differs greatly. A SODA strategic or cause map is a visible agenda for the workshop, which is modified and developed as the workshop proceeds. By contrast, a map used in dialog mapping is a record of the discussion and of the shared understanding that emerges through time. Thus, though Eden et al. suggest that voting is often needed to reach agreement in a SODA session, dialog mapping makes no use of voting, as it relies on the group to eliminate options as focus and shared understanding emerge.

The dialog mapping process follows from the IBIS notation and cannot be readily distinguished from its technique. Although the variety of activity is more limited than in a SODA workshop, which makes long workshops less sustainable, this has some advantages. It requires less process planning or expertise in facilitating groups—indeed a dialog mapping session can begin spontaneously in any meeting without the need for preparation. In addition, the format is more like a standard meeting, which may be less threatening than other problem structuring methods and is less of a risk for an individual to introduce to a group.

3.2.4. Technology

Computer support is essential for the effective use of design rationale. QuestMap, a support tool originally developed as gIBIS (Conklin and Begeman, 1988) provides asynchronous, distributed (i.e. different time, different place) groupware support to groups using IBIS over a LAN. Increasingly, particularly with a focus on strategic problems, QuestMap has been used in face-to-face meetings. QuestMap, Decision Explorer and its Group Explorer variant, are all based on hypertext. In QuestMap a new map can be built as a hyperlink when discussion of a concept expands.

Since QuestMap's origins lie in the support of distributed collaborative teams, workshop participants all have direct access to the full model and functionality. Unlike in Group Explorer, the facilitator's machine has no capability beyond the copy displayed to the group via the projector. As such, workshops normally only involve a single machine, perhaps operated by a second facilitator acting as a scribe.

Compendium (Compendium Institute, 2003; Selvin et al., 2001) is an example of a tool that extends IBIS for knowledge management support by providing a complete project repository or organisational memory. Compendium was not available during the *Wisdom* project. Using Compendium, IBIS maps can be interfaced with standard software packages, allowing maps to be exported to web interfaces and supporting distributed and asynchronous map building. The idea is that asynchronous web-based gathers could be used to reduce workshop time and costs, and might improve the quality of contributions as participants are given a longer timeframe to reflect.

4. Integrating soda and dialog mapping

SODA and dialog mapping, and their associated cognitive mapping and IBIS techniques, have much in common. Both take the social element of problem solving as fundamental, both involve building maps with problem solving groups to tackle messy or wicked problems and both may use a facilitator and similar computer technology. The maps are projected onto a public screen to act as a group memory aid and to support collaborative dialogue. They are used for developing shared understanding and commitment to a set of actions. Though the map building techniques differ, there is a time in any workshop where the group develops fluency in any structuring notation and responds intuitively to any map.

Dialog mapping is closer to the standard meeting format and sessions can be brief and indeed spontaneous, perhaps using only a large whiteboard. There is less process planning involved, principally because the process is so embedded within the technique. This places less onus on the facilitator to develop expertise in its use, and indeed less overhead on planning workshops. Learning the technique may also be easier, employing short practice sessions with small groups on a whiteboard. The notation also lends itself to representing fine-grained analysis of a particular component or option within a problem, when the group needs less intervention from the facilitator and more time to consider and discuss the issues amongst themselves. The drawbacks are that there is less variety of activities within a dialog mapping session, which may reduce the length of time a group can stay motivated on a topic. Further, there is no wide ranging brainstorm activity to ensure breadth of coverage or to avoid groupthink.

SODA requires workshops to be specially convened, distinct from conventional daily meetings. Its adoption challenges the organisational culture more, as it appears different and risky. Its workshop format brings the advantages of anonymity and voting, and the model can be analysed by software. The workshop process relies less on the group self-regulating the discussion and guarantees a quicker focus on the key issues. Currently, there is a wider body of literature than for dialog mapping, offering the user more comprehensive process advice. The software and hardware support is however more expensive for a networked SODA workshop, compared with the single PC used in a dialog mapping meeting.

The SODA and the dialog mapping approaches have complementary strengths in supporting decision making, but the more structured representation of decisions used in dialog mapping has clear advantages in decision retrieval and review. Rather than simply being represented as names with associated annotations, decisions in dialog mapping are structured entities. That is, nodes and links in a dialog map have associated semantics that allow the development of automated software tools to analyse their consistency and completeness. Therefore, by using SODA in conjunction with dialog mapping we gain the advantages of a multi-method approach to decision making plus an effective mechanism to recover and review these decisions at a later date.

5. *Wisdom*: Integrating cognitive mapping and design rationale

The original aim of the *Wisdom* project was to develop decision support tools that combined qualitative and quantitative support for teams developing large software engineering projects. Much of this scope remains, but it is clear that the approach is of value in domains other than systems engineering. The qualitative components of the *Wisdom* tool bring together aspects of cognitive mapping and design rationale. The idea is that the relatively informal SODA II process, which encourages creativity and broad thinking, should be combined with the design rationale emphasis on reasoning and the production of maps that serve as a record of deliberations. A cognitive map is relatively informal, since its nodes and arcs carry no semantics, whereas a defined set of meanings applies to IBIS nodes. Thus, a process that starts with a cognitive map developed in an informal way, can lead to a rather more formal IBIS representation through a process of incremental formalisation.

Wisdom marries the soft OR attention to problem definition, procedural rationality and process with the design rationale focus on maintainability. Cognitive mapping may be used to open up and explore the decision space to encourage divergent thinking, negotiate objectives and identify key issues. The IBIS notation may then be used to develop fine-grained analysis around the identified key issues. The IBIS maps can be built, as appropriate, over time during brief meetings, with a scribe rather than the facilitator required in SODA. IBIS maps are easily maintained or updated, as branches can be 'retired' simply by inspecting their root question, rather than looking at each individual concept and its storyline.

5.1. The Wisdom process

Though it is impossible to insist that users of *Wisdom* operate in a particular way, the thinking that led to the *Wisdom* tool also leads to a suggested process that, to some degree reflects SODA II, but with IBIS. It assumes that meetings will be facilitated and that maps will be projected onto a display that is clearly visible to all participants. The *Wisdom* process is shown in Fig. 5.

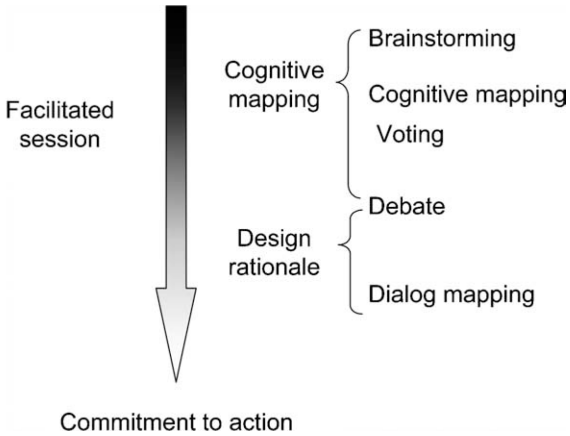

Fig. 5. The *Wisdom* process.

1. Brainstorming: participants are encouraged to think widely about relevant issues and concerns. This may be done using a blind gather to ensure a form of nominal group, or it may be done cooperatively. This is a divergent phase in procedural rationality.
2. Cognitive mapping: the concerns and issues are displayed on a cause map by the facilitator so that all participants can appreciate the causal linkages and interactions. The idea is to help the group identify key issues on which progress can be made and to gain agreement on goals by discussing the 'why' questions. Gaining agreement on the key issues will require debate and may involve some form of voting.
3. Dialogue mapping: using the IBIS notation, the group then builds a dialogue map for each of the key concerns, using hypertext to link them as necessary. As IBIS is used, the group must use its Question, Idea and Argument node types.

The cognitive mapping phase of the *Wisdom* process provides a *macro* view of the problem being discussed by the group. The dialog mapping phase helps the group to develop consistent *micro* views. Both are needed. Cognitive mapping encourages divergent thinking and helps avoid groupthink, whereas dialogue mapping explicitly captures the arguments that emerge for each issue.

Though the process has been primarily designed for use in meetings, the ability to move easily between a cognitive map and IBIS decisions means that asynchronous development of the decisions is possible. Once the overall cognitive map has been created, individuals can work independently to develop and record the arguments associated with decisions before coming together again to finalise agreements on the decisions to be made.

5.2. The Wisdom tool

Wisdom is both a process and a tool. The tool is designed to support the process and is a Windows-based application, written in Java, designed to run on a laptop used by a 'facilitator'. If used by people assembled in a meeting, they suggest input to a facilitator who composes the map and projects it onto a shared display, making their use of the tool indirect. Since it offers network connectivity and a web-enabled interface it supports asynchronous working before a meeting, should that be desirable. The network connectivity can also be used to support individual brainstorming during a meeting. The facilitator is able to invite participants to enter ideas to a map and may give a question for these participants to answer. The participants are simply required to list their answers, rather than to place them, in order, on a map: this is done later by the facilitator.

The shared display has the following main features:

- A Map, which is a white screen onto which 'nodes' can be placed. A *Wisdom* project can contain multiple linked, maps.
- Nodes, which can be one of seven types. Cognitive mapping node, argument node, con node, criteria node, idea node, pro node, question node. The nodes contain text and may be numbered and allow icons to be used to make things more recognisable.
- Links, which show the relationship between the node types.
- Notes, which can be stored 'inside' a node so that they are hidden from normal view. These allow the map to be annotated to make it easier to reuse in a subsequent meeting.

The maps could be drawn manually on a whiteboard, but the tool allows nodes to be repositioned, its text is legible and maps can be stored and printed. The *Wisdom* tool also allows for the generation of project reports in plain text or in a format that supports the use of Saaty's analytical hierarchy process (Saaty, 1980). A screen dump, showing a section of a *Wisdom* map, is given in Fig. 6.

The software does not prescribe the *Wisdom* process, but rather sits very idly and offers a great deal of flexibility. It could for example be used simply as a cognitive mapping or IBIS tool. Following the *Wisdom* process outlined in Section 5.1, the use of the tool could begin by the facilitator using the network function to gather ideas in a brainstorm. The facilitator creates a new map, and creates a special question node. Participants can use their web browser to view this question and input any number of answers. These answers appear on the facilitator's map as cognitive mapping nodes as soon as they are entered, and can be positioned (or deleted) at will. The workshop proper might begin with a cognitive map derived from the brainstorm, which is projected onto a big screen. The facilitator enables negotiation and extension of this map. More specific work may then been done using the IBIS notation. The facilitator might open an IBIS map on a cognitive mapping node, or cut and paste a node or set of nodes to a new map, and reformulate them using IBIS. Often the facilitator will simply start a fresh map. The maps can be stored for future use, and printouts given to participants.

The *Wisdom* software is better than using a whiteboard, but how does it compare with the other tools mentioned in Section 3.2.4? These were QuestMap, Decision Explorer and its Group Explorer variant, and Mifflin. The *Wisdom* software does not seek to offer a better product than these tools, but rather is a research tool used to explore areas that these others do not. The functionality of the *Wisdom* tool is fairly similar to these other tools, but does not prescribe the IBIS process in the same way. *Wisdom* is also designed to be lightweight: with no knowledge management software running in the background and is a much faster and less cumbersome tool for use in a meeting. However, as a trade off, output of node information to different contexts is not as well supported.

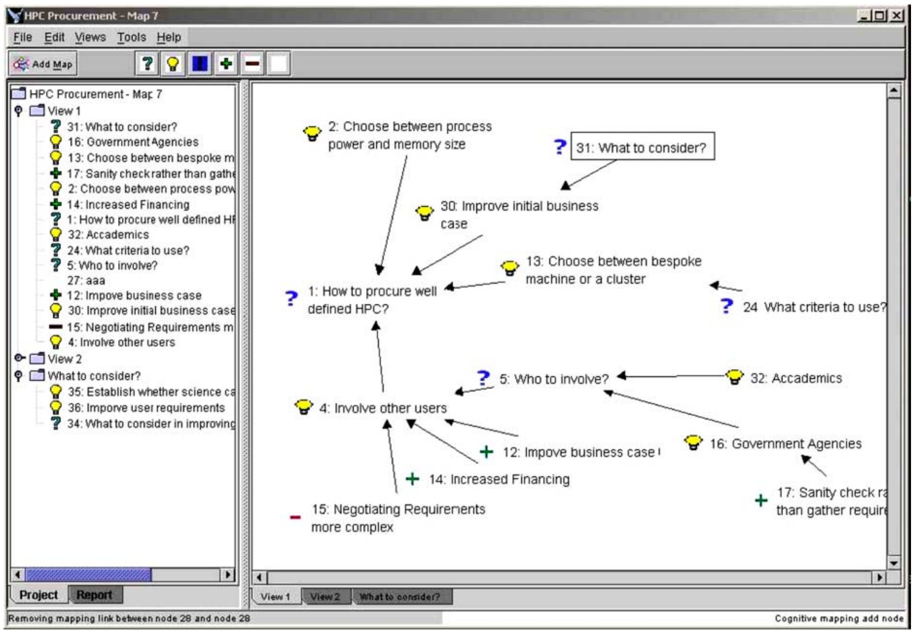

Fig. 6. A simple *Wisdom* map.

6. Experiences in using *Wisdom*

This section describes the use of the *Wisdom* process and tool in workshops held for a co-operative client. For confidentiality reasons, the identity of the client cannot be revealed, but is a large defence technology organisation that is considering its technology vision, looking ahead 25 years to aid its long term strategy. With such a long lead-time, the organisation wished to develop high level technology requirements to serve as a basis for technology assessment and conceptual system design. The *Wisdom* process and tool were used in two workshops and the *Wisdom* tool was used with QuestMap (op cit) in the third. The workshops drew together many high-ranking members of the client organisation each with their own concerns, viewpoints and agendas; an environment in which procedurally rational approaches are needed. The workshops were, however, atypical in that the purpose was not to make a decision or to reach consensus but to produce a map of the issues.

The first workshop was held with 13 participants. In addition an client employee acted as main facilitator, and a second as chauffeur using QuestMap. A member of the *Wisdom* team used the *Wisdom* tool and provided support to the two client employees. QuestMap was used since it is a fully developed product in which the chauffeur was already trained, whereas the *Wisdom* tool is a prototype at proof-of-concept stage. QuestMap and the *Wisdom* tool were used in sessions alternatively. The *Wisdom* tool was used to support a brainstorming session that produced 83 separate nodes. These were then discussed and developed as normal with the SODA II process. Following an expression of views, they were reduced to 15 key issues; safety being one example. That is, the *Wisdom* tool was used to support the initial divergent phase and the following convergent activity. The group agreed that the 15 key issues should be prioritised and so a commonly used voting process was adopted. This involved the use of flipcharts on which the issues were listed, against which participants voted using sticky dots; safety was given a medium priority. Voting allows an assessment of the support for the range of issues. The visible votes were then reviewed with the group to see if they made holistic, as well as individual, sense. The results of the voting were then reviewed with the client so as to be sure where effort later in the workshop should be placed. QuestMap was used in a second group activity that built dialog maps of these prioritised key issues. A modified (to protect client confidentiality) version of the safety issues map is presented using *Wisdom* in Fig. 6. A member of the organisation acted as a summariser at the end of this part of the work. For example, two outcomes of the session were, firstly, that environmental impact from trials and training (but implicitly not from use) was a key issue and, secondly, that standards for platform safety would have to be addressed. Finally, the *Wisdom* tool was brought back into use to gain feedback from the participants, to check their experience of the workshop. This was done by brainstorming and map construction.

Only the *Wisdom* tool and process were used in the second workshop. It was dominated by brainstorming, clustering ideas, validating and voting, with less dialog mapping. The third workshop was run using the *Wisdom* process and the QuestMap tool. Two further workshops using the process have been run in the client organisation as part of another project. The client plans to continue to use this style of workshop, to be run exclusively by internal employees and plans to continue with the *Wisdom* process. This points to the value of the *Wisdom* process and indicates that a fully developed *Wisdom* tool would have considerable value in these situations.

7. Conclusions and reflections

7.1. Incremental formalisation

The notion of incremental formalisation (Shipman and McCall, 1994) lies behind the *Wisdom* tool and process, which aims to provide procedurally rational decision support in complex situations involving groups of people. Incrementalism may seem a recipe for short-term decision making with no radical edge. However, to argue this would be to miss the point of the *Wisdom* project which aims to support people as they consider how best to resolve wicked and unstructured problems. In such work it is hard and may be impossible for people to grasp the full complexity of a new situation without help and it is vital that this support does not act as a brake on their creativity and analysis.

Hence, in the *Wisdom* process, the initial group work involves informal brainstorming and its representation in the form of a causal map. In turn, this is succeeded by a design rationale representation using dialog mapping to provide a much more formal device for debate. The IBIS maps also provide a record of the discussions that were held and the agreements that were made. The initial, informal work helps to expose key issues, to expose conflict and to support negotiations that allow progress to be made. Once the problem situation has been considered in this way, design rationale techniques are used to refine individual issues and to argue about how they can be addressed. In this way, the approach taken and the maps used lead to increasingly formalised and detailed pictures of the decisions and the discussions that led to them. The *Wisdom* tool allows seamless working in which a cognitive map becomes a dialog map, with the associated advantages.

7.2. Wisdom in practice

The workshops were successful, achieving their objectives—most notably agreement by stakeholders on the problem boundary, the identification of key variables and the establishment of a shared, coherent mental picture of the issues. The workshop process was effective in "opening up" the boundary of the problem space and was comprehensive in its coverage. The mapping technique and software was effective in providing a live memory of these discussions that benefited meeting efficiency and aided participant memory. The client's analyst responsible for delivery of the requirement definition for long-term technology solutions also reported that the IBIS maps had proven invaluable as a comprehensive aid for taking the workshop material forward. Indeed she reported that the maps had captured more material than the official minute-taker present, particularly more of the argument.

The process was inclusive, although not anonymous, which may have inhibited some contributions. Conducting a nominal brainstorm through a single PC was difficult to manage effectively and dynamically. Participants inevitably wished to discuss in-depth issues as they were raised, before a complete picture of all the issues and their relationships had been established. There was a tendency for participants to begin dialog mapping during the brainstorming phase. This could have been avoided by exploiting the tool's web interface with networked laptops, although this capability had not been tested sufficiently at this stage for use with a client group. This would have brought anonymity, which would have been helpful in the military environment, where rank can heavily influence the acceptance of a speaker's arguments.

The workshops highlighted an unanticipated difficulty with the marrying of the two techniques. Much of the dialogue during the cognitive mapping stages of clustering, validating clusters, coding concepts in clusters and voting overlaps with the type of dialogue one would want to capture in a dialog map. This is of course facilitated by the tool, but places some demands on the chauffeur and facilitator to identify whether concepts are best coded as part of the causal or dialog mapping. This is not always immediately apparent and at times left inconsistencies within the initial map, although these were easily overcome. During discussion of the voting, however, having only one projector meant that a lot of the rich dialogue captured during this period could not be displayed to the group whilst building the dialogue maps. However, the participants seemed oblivious to this issue and were unaffected by it until later in the dialog mapping stages when they would often correct the coding given to a concept by the facilitator. Certainly many in the group developed a degree of fluency in the modelling technique as each workshop progressed.

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