1 The Roots of Computer Supported Argument Visualization
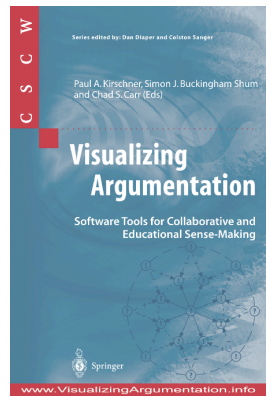
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"root" [n.1]

I. 1. a. That part of a plant or tree which is normally below the earth's surface; in Botany, the descending axis of a plant, tree, or shoot, developed from the radicle, and serving to attach the plant to and convey nourishment from the soil…

8. a. A person or family forming the source of a lineage, kindred, or line of descendants.

9. a. That upon or by which a person or thing is established or supported; the basis upon which anything rests. In 19th cent. use common in the phr. *to have (its) root(s) in* (something).

10. a. The bottom or real basis, the inner or essential part, of anything; *the root of the matter*.

14. c. A unique node or vertex of a graph from which every other node can be reached. Also *root node*.

Oxford English Dictionary Online [dictionary.oed.com]

1.1 Excavating the Roots to CSAV

This chapter considers some of the "roots" to Computer-Supported Argument Visualization (CSAV). The definitions above point to historical ancestors and conceptual foundations, and this chapter seeks to identify the most influential work to whom CSAV owes an intellectual debt. Specifically, we will consider individuals who invented paper-based precursors of argument maps, and/or who envisioned the possibilities that computers opened up. In mapping CSAV's intellectual terrain, I may well omit important branches to its roots that I have not encountered, but hope that this chapter will serve to stimulate the forging of further connections to other traditions.

CSAV is located at the intersection of an eclectic mix of disciplines. We must minimally include philosophy and rhetoric as background disciplines to argumentation

in general, with traditions going back to the dialogues of the Greek philosophers. It is beyond the scope of this book to review this huge literature in any more detail than to provide a few key pointers to Speech Act theory (Searle, 1969), and argumentation theory (e.g. Perelman and Olbrechts-Tyteca, 1969; van Eemeren et al., 1983; Walton, 1996). Law is, arguably, the most argument-intensive profession of all, with greater resources than other professions to devote to analysing the structure of arguments, and extensive research into computer-support for teaching argumentation skills (e.g. Aleven and Ashley, 1994; Marshall, 1989; Bench-Capon, et al., 1998).

The human-centred technology research fields such as computer-supported co-operative work (CSCW), computer-mediated communication (CMC), and computer-supported collaborative learning (CSCL) have developed their own flavours of CSAV, in order to support the coordination of distributed organisational activity (Malone et al., 1987), the structuring of contributions to group support systems (Turoff et al., 1999), and the creation of conversations in which learning takes place (Andriessen et al., in press). The chapters in this book demonstrate how widely CSAV is attracting interest and finding applications.

1.2   Mapping the History of Argument Visualization

There are numerous ways to organise this review, but for simplicity, it steps through chronological history, uncovering roots of different sorts along the way. In some cases, it is known that one individual drew on another's work, while in others we are left to wonder what might have happened had the two met or read each other.

1.2.1   Charting Evidence in Legal Cases

In 1913, John Henry Wigmore proposed a *Chart Method* for analysing the mass of evidence presented in a legal case, in order to help the analyst reach a conclusion:

> Our object then, specifically, is in essence: *To perform the logical (or psychological) process of a conscious juxtaposition of detailed ideas for the purpose of producing rationally a single final idea. Hence, to the extent that the mind is unable to juxtapose consciously a larger number of ideas, each coherent group of detailed constituent ideas must be reduced in consciousness to a single idea; until the mind can consciously juxtapose them with due attention to each, so as to produce its single final idea.* (Wigmore, 1913, 2nd Edition 1931, p.109)

He sets out the "necessary conditions" for such an "apparatus", following what we would now recognise as requirements analysis and schema modelling for a visualization tool. For a given case, one must be able to express different types of evidence, relations between facts, represent and on demand see all the data, subsume subtrees, and distinguish between facts as alleged and facts as believed or disbelieved.

As a tool to comprehend a potentially large dataset:

> It must, finally, be compendious in *bulk*, but *not too complicated* in the variety of symbols. These limitations are set by the practical facts of legal work. Nevertheless, men's aptitudes for the use of such schemes vary greatly. Experience alone can tell us whether a particular scheme is usable by the generality of able students and practitioners who need or care to attack the problem. (p.110)

Wigmore was also clear that:

> …the scheme need *not* show us what our belief *ought* to be. It can hope to show only what our belief actually is, and *how* we have actually reached it. (p.110)

This echoes the difference of most CSAV tools from other classes of computer-supported argumentation that seek to evaluate argument or recommend conclusions based on a formal model of decision processes, or the meaning or relative weight of argument elements. Wigmore's scheme is a cognitive tool for reflection:

> Hence, though we may not be able to demonstrate that we *ought* to reach that belief or disbelief, we have at least the satisfaction of having taken every precaution to reach it rationally. Our moral duty was to approximate, so far as capable, our belief to the fact. We have performed that duty, to the limits of our present rational capacity. And the scheme or method, if it has enlarged that capacity, will have achieved something worthwhile. (p.111)

The final line encapsulates the motivation behind much CSAV work: to augment our intellectual ability in argument analysis and construction. The theme of "intellectual augmentation" resonates, of course, with the work of Engelbart, introduced shortly. Wigmore's Evidence Charts (Figure 1.1), showing how connections between *Testamonial Assertions and Circumstances* may lead to credible *Propositions*, continue to be used today in some law schools (see also Carr's work on legal argumentation mapping with hypertext technology: Chapter 4).

## 1.2.2   Trails of Ideas in the Memex

Having started with the "AV" roots to CSAV, we now start to uncover some "CS" roots. The contribution of Vannevar Bush to the invention of hypertext as a way to easily connect fragments of information has been documented exhaustively (for a retrospective from within the hypertext community, see Brown/MIT, 1995). In his 1945 article *As We May Think*, Bush (1945) envisioned a near future system based on microfilm records that could support the construction of trails of ideas for personal information management, and for sharing with others.

> Consider a future device for individual use, which is a sort of mechanized private file and library. It needs a name, and, to coin one at random, "memex" will do. A memex is a device in which an individual stores all his books,

records, and communications, and which is mechanized so that it may be consulted with exceeding speed and flexibility. It is an enlarged intimate supplement to his memory. (Section 6)

§ 33. **Same: an Example Charted.** We shall thus have charted the results of our reasoning upon the evidence affecting any single probandum. But this probandum will usually now in its turn (*ante,* § 8) become an evidentiary fact, towards another probandum in a catenate inference. The process of charting and valuation has then to be renewed for this new probandum; and so on until all the evidence has been charted, and the ultimate probanda in issue under the pleadings have been reached.

The following portion of a chart will illustrate (taken from the case of *Com. v. Umilian, post,* § 38) :
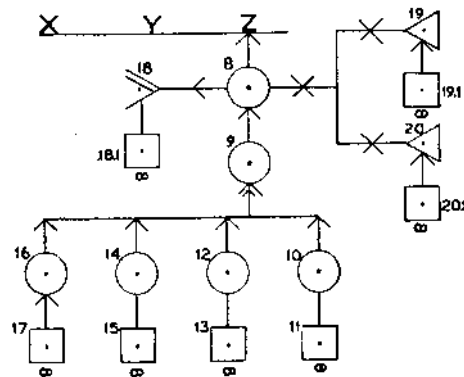
Z is one of the ultimate probanda under the pleadings, viz. that the accused killed the deceased. Circle 8 is one of the evidentiary facts, viz., a revengeful murderous emotion. The arrowhead on the line from 8 to Z signifies provisional force given to the inference.

Figure 1.1: John Henry Wigmore's *Chart Method* for analyzing the evidence presented in a legal case, showing how different kinds of evidence (signaled by different node shapes, e.g. for *Testamonial Assertions and Circumstances*) are assembled to support or challenge (signaled by different arrow types) various *Propositions* (X, Y, Z, e.g. John Smith murdered Anne Baker). Each numbered node has an explanatory entry summarizing the evidence (e.g. John Smith knew that Anne Baker lived at Flat 42). (Reproduced with permission, Wigmore, H.J.A. 1931, p. 56: The Principles of Judicial Proof as Given by Logic, Psychology and General Experience and Illustrated in Judicial Trials. Boston: Little Brown, 2nd Edition).

In describing the "trail blazing" user interface, Bush envisages a rudimentary spatial display for connecting the two 'nodes':

When the user is building a trail, he names it, inserts the name in his code book, and taps it out on his keyboard. Before him are the two items to be

joined, projected onto adjacent viewing positions. At the bottom of each there are a number of blank code spaces, and a pointer is set to indicate one of these on each item. The user taps a single key, and the items are permanently joined. In each code space appears the code word. Out of view, but also in the code space, is inserted a set of dots for photocell viewing; and on each item these dots by their positions designate the index number of the other item.

Thereafter, at any time, when one of these items is in view, the other can be instantly recalled merely by tapping a button below the corresponding code space. Moreover, when numerous items have been thus joined together to form a trail, they can be reviewed in turn, rapidly or slowly, by deflecting a lever like that used for turning the pages of a book. It is exactly as though the physical items had been gathered together from widely separated sources and bound together to form a new book. It is more than this, for any item can be joined into numerous trails. (Section 7)

It is natural for us to want to re-read Bush's article through 'CSAV lenses', for any clues that he explicitly envisioned argumentation as an application of associative linking, perhaps even a particularly important application. Alert to the risks of reading too deeply into a work to bolster one's prejudice, it is interesting, nonetheless, to find that in discussing the application of machine logic to supporting intellectual work, Bush states:

A new symbolism, probably positional, must apparently precede the reduction of mathematical transformations to machine processes. Then, on beyond the strict logic of the mathematician, lies the application of logic in everyday affairs. *We may some day click off arguments on a machine with the same assurance that we now enter sales on a cash register.* But the machine of logic will not look like a cash register, even of the streamlined model. (Section 5, emphasis added)

It is unclear what the intriguing "new symbolism, probably positional" refers to. It has connotations in today's human-computer interaction paradigm of a visual language of some sort. However, his use of the term positional in other places in the article suggests that he may have had a lower level machine processing logic in mind, such as punch card/photocell processing. His focus on argumentation is, however, unambiguous, and consistent with his focus on scholarship as a primary beneficiary of the Memex. Moreover, Bush proceeds to give examples to convince his reader why such a machine might have practical use. He begins with an historian collecting and organising disparate materials into a trail:

The owner of the memex, let us say, is interested in the origin and properties of the bow and arrow. Specifically he is studying why the short Turkish bow was apparently superior to the English long bow in the skirmishes of the Crusades. He has dozens of possibly pertinent books and articles in his memex. First he runs through an encyclopedia, finds an interesting but sketchy article, leaves it projected. Next, in a history, he finds another pertinent item, and ties the two together. Thus he goes, building a trail of many items. Occasionally he inserts a comment of his own, either linking it

into the main trail or joining it by a side trail to a particular item. When it becomes evident that the elastic properties of available materials had a great deal to do with the bow, he branches off on a side trail which takes him through textbooks on elasticity and tables of physical constants. He inserts a page of longhand analysis of his own. Thus he builds a trail of his interest through the maze of materials available to him. (Section 7)

Obviously, we can imagine that the "semantics" of the comment that accompanies a trail might clarify the nature of the unclassified steps along the trail ("…is evidence for…", "…is inconsistent with…", "…tackles the same problem as…"), but Bush does not elaborate. The "twist in the tale" of this scenario from a CSAV perspective is that the trail is used later as evidence to substantiate an historical argument:

And his trails do not fade. Several years later, his talk with a friend turns to the queer ways in which a people resist innovations, even of vital interest. He has an example, in the fact that the outraged Europeans still failed to adopt the Turkish bow. In fact he has a trail on it. A touch brings up the code book. Tapping a few keys projects the head of the trail. A lever runs through it at will, stopping at interesting items, going off on side excursions. It is an interesting trail, pertinent to the discussion. So he sets a reproducer in action, photographs the whole trail out, and passes it to his friend for insertion in his own memex, there to be linked into the more general trail. (Section 7)

With respect to visualization, given the inherently spatial metaphor underpinning the Memex, it is perhaps surprising that Bush does not discuss diagrammatic overviews of trails; trails are constructed, viewed and navigated serially, albeit very rapidly if desired. His contribution to CSAV is nonetheless enormous, having envisaged the hypertextual linking that underpins navigation in many CSAV tools, all in the context of a specifically scholarly application to the organisation of information into coherent trails. It was left to some of his readers to take the project the next step, in particular, Doug Engelbart, reviewed shortly.

1.2.3   Mapping the Structure of Practical Arguments

The second AV root we review is *The Uses of Argument* by Stephen Toulmin (1958), originally written as a challenge to the dominance in philosophy of formal, Aristotelian logic. Toulmin's aim was to develop a view of logic which was grounded in the study of reasoning practice. Taking argumentation as the most common form of practical everyday reasoning, he posed the question, "what, then, is involved in establishing conclusions by the production of arguments?" His analysis of the logical structure of arguments led to a graphical format for laying out the structure of arguments, a representational approach reflected in much subsequent argumentation work.

The notation consists of five components and four relationships (Figure 1.2). According to the analysis, whether or not it is made explicit, all arguments logically comprise a fact or observation (a *Datum*), which via a logical step (a *Warrant*), allows one to make a consequent assertion (a *Claim*). The Warrant can be supported by a

Backing if necessary (why the assumed Warrant is valid), and the Claim qualified with a *Rebuttal* (specifying exceptions to the rule).
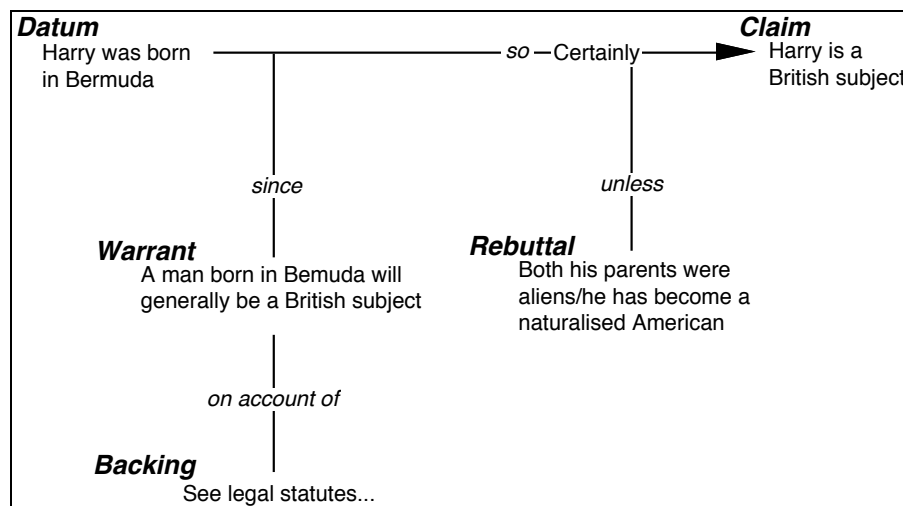

Figure 1.2: An example of Toulmin's graphical argument structure (Reproduced with permission from Toulmin, S., 1958, p.105, *The Uses of Argument*. Cambridge University Press).

Toulmin's scheme, through its use of a semiformal graphical representation, is perhaps the most often cited source (and a common demonstration example) in CSAV, and has found wide application in many other argument-based computer systems (Toulmin: ICAIL; Toulmin: Research Index, 2002).

1.2.4   Augmenting Human Intellect

In his seminal 1962 project report from the Stanford Research Institute, *Augmenting Human Intellect: A Conceptual Framework*, Douglas Engelbart (1962) laid out a framework for enabling people to augment their intellectual faculties by manipulating externalised "concept structures". In a subsequent article (Engelbart, 1963), he stated as follows:

> A concept structure (...) is something that can be designed or modified, and a basic hypothesis of our study is that better concept structures can be developed—structures that when mapped into a human's mental structure will significantly improve his capability to comprehend and to find solutions within his complex-problem solving situations. (Engelbart (1963), reprinted in Greif (1988, p. 54))

This vision of designing better computer-supported symbol manipulation tools marks a milestone on the trail this chapter is following. Engelbart, having been inspired by Bush's article, had available to him the exciting new world of mainframe, timeshare digital computers, albeit unreliable, and with appalling user interfaces. As has been now

widely documented and recognised (Bootstrap; MouseSite), his team implemented the first working demonstrations of the power of a personal workstation with a refreshable cathode ray tube display, direct manipulation of graphics and text with a mouse and chord keyboard, hypertext linking, editable visualizations, shared displays and video conferencing. Much of the hardware and software of the modern personal computer was first built and integrated in the NLS system, decades before others understood its significance.

In his 1962 report, Engelbart presents extended scenarios of how a near-future tool could work. In the following extracts, we see probably the first articulation of what we would recognise as CSAV, detailing how a tool would support argument construction and analysis. The scenarios place the reader in the imaginary position of receiving a demonstration of the system from "Joe", who is speaking:

> "Most of the structuring forms I'll show you stem from the simple capability of being able to establish arbitrary linkages between different substructures, and of directing the computer subsequently to display a set of linked substructures with any relative positioning we might designate among the different substructures. You can designate as many different kinds of links as you wish, so that you can specify different display or manipulative treatment for the different types." (Engelbart, 1962, p. 85)
>
> "[…] let me label the nodes so that you can develop more association between the nodes and the statements in the argument. I can do this several ways. For one thing, I can tell the computer to number the statements in the order in which you originally had them listed, and have the labelling done automatically." This took him a total of five strokes on the keyset, and suddenly each node was made into a circle with a number in it. The statements that were on the second screen now each had its respective serial number sitting next to it in the left margin. "This helps you remember what the different nodes on the network display contain. We have also evolved some handy techniques for constructing abbreviation labels that help your memory quite a bit." (p. 88)
>
> "Also, we can display extra fine-structure and labelling detail within the network in the specific local area we happen to be concentrating upon. This finer detail is washed out as we move to another spot with our close attention, and the coarser remaining structure is compressed, so that there is room for our new spot to be blown up. It is a lot like using zones of variable magnification as you scan the structure—higher magnification where you are inspecting detail, lower magnification in the surrounding field so that your feel for the whole structure and where you are in it can stay with you." (p. 89)

Engelbart's highly interactive systems pointed the way forward for computers as personal, intellectual aids, capable of updating flexible symbolic displays as fast as one could issue the command, making possible a new coupling between one's thinking, and what was reflected back from the display. This computing paradigm lies at the heart of CSAV. Not far from Stanford Research Institute where Engelbart was building his systems, was Xerox Palo Alto Research Center, whose work we will review shortly.

1.2.5 Concept Mapping

A parallel stream of work developing in the worlds of education and critical thinking, goes under names such as Concept Mapping and MindMapping™. The earliest work on these is represented by individuals such as Joseph Novak and Tony Buzan. From the first studies in 1972, Novak has pursued a programme of work on concept mapping as a tool for high school and university students to construct, reflect on and discuss their conceptions of a domain with peers and tutors (Novak, 1976; 1998; Novak and Gowin, 1984). His work, grounded in a constructivist epistemology, has sparked significant research into the pedagogical properties of concept maps, student's ability (or lack thereof) to construct such diagrams, and their utility (e.g. in contrast to traditional essays) as a means of communicating, and assessing, learning. On a related theme, but to a different audience, Buzan has written extensively as a popular writer on improving thinking skills, from his 1974 BBC series and book *Use Your Head* (Buzan, 1974) to educational and organisational consultancy on the use of MindMapping™ (MindMap.com) for analysis and decision making.

Both of these strands emphasise the "visual" as a fundamental, but untapped, dimension for refining and communicating one's thoughts (cf. Horn, 1998, for a detailed analysis of visual communication). From an historical perspective, it is unclear how early on these two roots fused. (This author has not yet tracked down examples from before the 1990s of concept mapping researchers overlaying argumentation schemas to classify nodes and links.) Certainly, relatively recent work on concept mapping in educational technology has introduced the vocabulary of argumentation (e.g. as an aid to teaching scientific reasoning). Together with other educational technology research (Andriessen et al., in press; Baker, 1999; Veerman et al., 1999), diagrammatic reasoning (Diagrammatic Reasoning, 2002; Glasgow et al., 1995) and psychology of programming (PPIG, 2002), theoretical and methodological foundations for the rigorous analysis of diagrammatic representations are being laid, on which the CSAV research community should build. This brings to earth vaguer writings on 'tapping the hidden potential of the visual dimension', which is (not surprisingly) often short on detail when it comes to explaining exactly how visual representations support (or obstruct) individual (or collective) cognition in different contexts.

1.2.6 The Argumentative Approach to Wicked Problems

In the early 1970s, design theorist Horst Rittel characterised a class of problem that he termed "wicked", in contrast to "tame" problems. Tame problems are not necessarily 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. In contrast, wicked problems display a number of distinctive properties that violate the assumptions that must be made to use tame problem solving methods.

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 attempt to build a solution changes the problem;
- often have strong moral, political or professional dimensions, particularly for failure.

Rittel and Webber, made two testable claims of direct relevance to this review: first, that many design problems are "wicked," in contrast to "tame" or "benign" problems which can be modelled computationally, and secondly, that an "argumentative process" was the most effective way to tackle such problems.

> "Wicked and incorrigible [problems]...defy efforts to delineate their boundaries and to identify their causes, and thus to expose their problematic nature." (Rittel and Webber, 1973).

Such problems lack a single, agreed-upon formulation or well-developed plans of action, are unique, and have no well-defined stopping rule, because there are only "better" or "worse" (rather than right or wrong) solutions. Closure is often forced by pragmatic constraints (e.g. managerial or political) rather than "rational scientific" principles. Such problems could not be solved by formal models or methodologies, classed by Rittel as the "first-generation" design methodologies. Instead, an *argumentative* approach to such problems was proposed (a second-generation design method). The essence of this perspective is that an open-ended, dialectic process of collaboratively defining and debating issues is a powerful way of discovering the structure of wicked problems:

> First generation methods seem to start once all the truly difficult questions have been dealt with already (...) The second generation deals with difficulties underlying what was taken as input for the methods of the first generation.
>
> [Second generation] methods are characterised by a number of traits, one of them being that the design process is not considered to be a sequence of activities that are pretty well defined and that are carried through one after the other, like "understand the problem, collect information, analyse information, synthesise, decide," and so on...
>
> My recommendation [for the future of design methodologies] would be to emphasise investigations into the understanding of designing as an argumentative process ... how to understand designing as a counterplay of raising issues and dealing with them, which in turn raises new issues, and so on...
>
> [Argumentative design] means that the statements are systematically challenged in order to expose them to the viewpoints of the different sides,

and the structure of the process becomes one of alternating steps on the micro-level; that means the generation of solution specifications towards end statements, and subjecting them to discussion of their pros and cons. (Rittel, 1972)

This perspective motivated the development of Issue Based Information Systems (IBIS) as a medium to encourage the open deliberation of issues. The three key IBIS entities were *Issues, Positions and Arguments*, which could be linked by relationships such as *supports, objects-to, replaces, temporal-successor-of, more-general-than*, and their converses. Visualised as a graph, an IBIS grows into a network as more Issues are posted and debated (Figure 1.3).
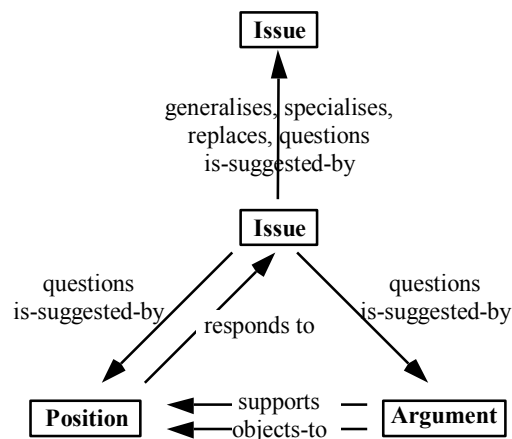

Figure 1.3: The basic IBIS structural unit of Issues, Positions and Arguments, developed in the 1970s by Horst Rittel to support his argumentative approach to wicked problem solving.

To summarise, Rittel's work established a bridge between design and argumentation. The argumentative approach to design elevated the importance of the *process* of understanding a problem from its minor status as a preliminary step to using first-generation design methods, to the central activity in tackling wicked design problems. Rittel and Webber, hypothesised that a particularly powerful way to tackle such problems is by an "argumentative approach," proposing IBIS as an argument mapping notation. In Chapter 6, Conklin reports on the use of an IBIS-based approach called *Dialog Mapping*.

1.2.7   Argument Mapping Meets Hypertext

Engelbart's work set in process research efforts in numerous locations. One of the most influential of these was based at the Xerox Palo Alto Research Center (PARC), where the interest in the early 1980s in human-computer interaction (which led to the modern graphical user interface) made the important move from word processing, to "idea processing". The availability (at least in computing research labs) of graphical user

interfaces and large screens led to a very active decade in the building of prototype hypertext systems (summarised and reviewed in detail by Conklin, 1987), and the formation of what is now the hypertext research community (e.g. ACM SIGWEB). One of the most influential systems of this era was NoteCards (Halasz et al., 1987), a tool for idea processing that drew on the 3x5 inch filing card as its metaphor, each hypertext node being a "card".

"Idea processing" in general then took a specific direction towards argument mapping. In *The Next Knowledge Medium*, Stefik (1986, also at PARC) proposed collaborative argumentation tools 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." Van Lehn (1985) published a technical report documenting his experiences with NoteCards, concluding that using the system to map the argumentation in his thesis had exposed hidden flaws.

Brown (1986) further developed the theme:

> Current communications tools and methods force the crafting of complex arguments into linear form for presentation, so that the web-like connections among ideas is hidden from view, making it difficult to see alternate interpretations and points of view. (...) As a result many of the underlying ideas, arguments and assumptions either remain implicit or are lost altogether. But consider the possibility of crafting new information tools to capture not just conclusions and the view of matters that supports them, but to allow the explicit representation of underlying assumptions and argument structures. (p. 484)

It was noted in particular that work was needed on developing notations with an appropriate vocabulary for the task domain:

> To accomplish these goals, we need a taxonomy of epistemological links for relating ideas, as well as link-related filters. That is, we must now think about giving users access to and utilisation of not just undifferentiated links, but links with appropriate kinds of labels. (p. 485)

In a subsequent project on computational support for meetings, Stefik et al., (1987) envisioned a tool called *Argnoter*:

> [Design] is essentially a dialectic between goals and possibilities... in collaborative design tasks, this interaction and tension between goals and alternatives must play itself out in the communications among collaborators. [...] A major theme of Argnoter's design is that alternatives be made explicit: Proposals themselves are explicit, as are assumptions and evaluation criteria. (p. 38)

A major working hypothesis behind the design of Argnoter is that making the structure of arguments explicit facilitates consensus by reducing uncommunicated differences. (p. 40)

The motivation behind Argnoter was clearly that of a "group CSAV" tool – a way to represent design arguments explicitly, but with the group process adding another dimension. It was hypothesised that the process of striving to agree on rankings and assumptions in Argnoter would help designers recognise where their differences lay. However, the actual system was not implemented.

Meanwhile, Rittel's work was serving as a major source of inspiration for researchers investigating software design as a participatory, dialectic process (Sjöberg and Timpka, 1995), and as the representational basis for capturing design rationale (a record of the reasoning behind design arguments and decisions – Moran and Carroll, 1996). Probably the best known of these was at MCC research labs, where Conklin's gIBIS system (Conklin and Begeman, 1988) pioneered the application of graphical hypertext views for the reification of IBIS structures. Issues, Positions and Arguments became system-recognised node types in a hypertext, and Rittel's rhetorical moves (*responds to, expands on, challenges*, etc.) defined the typology of link types, with direct manipulation, aerial views, and graph layout algorithms assisting in the management of the large network structures (see Figure 1.4 for an example).
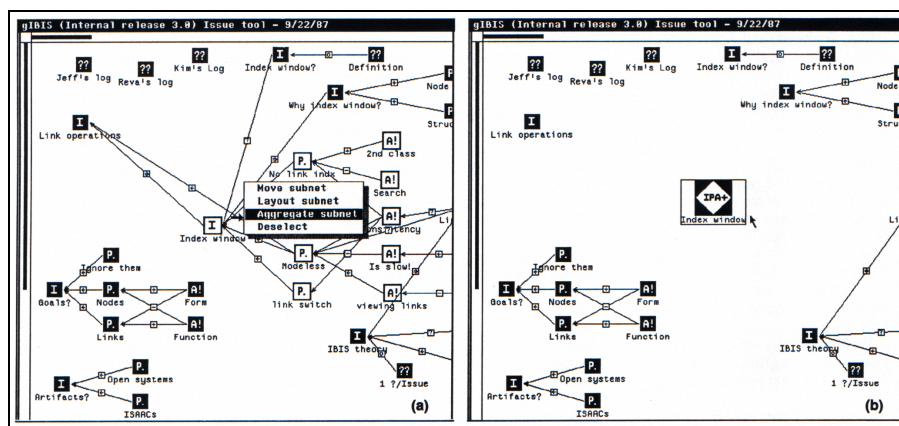

Figure 1.4: Screens from the *gIBIS* (graphical-IBIS) hypertext system to support design and policy deliberation. This example illustrates the support the tool provided for collapsing portions of a large IBIS map (*a*), into an aggregate node (*b*). Reprinted from Begeman and Conklin (1988), courtesy of BYTE <www.byte.com>

Also during the late1980s, Robert Horn was working at the intersection of hypertext and an approach to visual information design called Information Mapping. Horn (1989) published a book which included discussion of the application of hypertext to mapping argumentation, using Toulmin's scheme (see above) as an example.

A final strand of work to emerge in recent years is interest in hypertextual argumentation, that is, ways in which the non-linear aspects of argumentation may be better expressed as hypertext than prose. David Kolb (1994) used the Storyspace

(Eastgate Systems) hypertext writing tool to experiment with such forms, and envisioned how hypertext and visualization could develop in the future to support scholarly argumentation (Kolb, 1997). This thread has continued, with Carter (2000) considering other aspects of hypertextual argument, while Mancini and Buckingham Shum (2002) applied ideas from cognitive coherence relations research to propose how hypertext's disorienting impact can be controlled to support the construction and navigation of scholarly argument structures.

We return to some of these mid 1980's-mid 90's systems towards the end of this chapter, to reflect on their subsequent development.

1.2.8   CMC Meets CSAV

There has been a steady research stream flowing from the spread of Computer-Mediated Communication (CMC) technology, from the early Arpanet, to online communities such as the Well, to the current internet explosion. New research fields such as educational technology and cybersociology have analysed the exchanges between members of different kinds of communities (from students on a course conference, to voluntary members of online fora). It is not clear that CMC can be thought of as a root in terms of strongly influencing the emergence of CSAV in its current state. Rather, it is a parallel branch that has grown from a different research community, focused on asynchronous textual interactions (rather than visualizations).

Educational CMC research has naturally focused on the pedagogical benefits that may accrue from CMC (e.g. Mason and Kaye, 1989), primarily focused on analysing the nature of interactions, and on structuring the normally freeform interactions of email/text conferencing. One cluster of research is that of Dialogue Games, in which a knowledge-based system with a model of different dialogue "trajectories" influences the human-computer dialogue based on its trace of what has taken place so far (e.g. Pilkington et al., 1992; Ravenscroft, 2000; Sillince, 1997).

Another research cluster studies the quality of the argumentation in conventional CMC, and may also introduce a requirement (or user interface option) for an online participant to classify or connect argumentation-oriented contributions to a forum explicitly, such as *Hypothesis* or *Data*, or relational connectives such as *Supports* and *Challenges*. Scardamalia and Bereiter (e.g. Scardamalia et al., 1989) for instance, introduced these as student "scaffolds" in the CSILE (CSILE) and Knowledge Forum environments (Knowledge Forum). The earliest work is probably that of Turoff and Hilz, who comment on their early work from the 1970s on group support CMC systems such as EMISARI and TOPICS:

> Both systems had very specialized structures for group communications, very specific content type classifications and relationships related to the application domains (crisis management and unpredictable information exchange), specific human roles supported by software, and voting capabilities to be able to expose quickly and efficiently areas of agreement and disagreement. (Turoff et al., 1999, Section 1)

Although lacking any visual dimension, "content type classifications and relationships related to the application domains" are clearly an element in CSAV systems, and interestingly, Turoff (1970) describes an early implementation of the Delphi conferencing system which incorporates a meta-discussion structure based on the Hegelian Inquiry Process to scientific discourse. An explicit link to argumentation is made when they proceed to propose a future CMC system that could support varieties of "discourse template", one example being for "debating and argumentation", providing *Argument* contribution types, with *Pro* and *Con* links, plus a voting mechanism to resolve disagreements. Significantly, they conclude by introducing the idea of visualizing discourse grounded in the argumentation template:

> Right now one key missing element in asynchronous CMC systems is the appreciation of the evolution of the discussion that occurs in a face to face meeting. […] What were the crucial arguments that caused agreement to occur? […] The voting process is a logical approach to capturing the resulting group dynamics of the discussion and the type of tool to do this could be the following three dimensional visualization. Let us imagine something akin to a complex organic molecule that, on screen, can be rotated and "zoomed" to focus on different parts and their relationships. More importantly, the history of this structure can be played back through time. We are using the argumentation template for the example and there are two types of nodes or atoms (options and arguments); and three types of links or relationships (pro, con, and opposition). Any member of the group may add to the collaborative construction using these building modules.

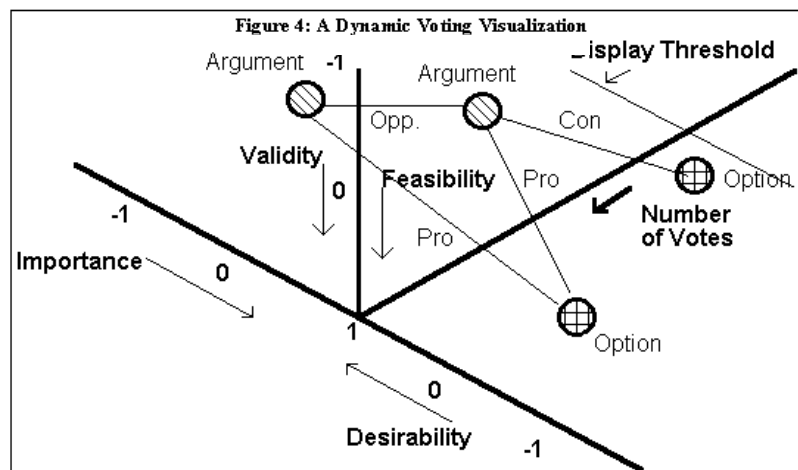Figure 1.5 reproduces the visualization they proposed.

Figure 1.5: A visualization mockup for an argumentation-CMC system, proposed by Turoff et al., (1999). Reproduced with permission from Turoff, M., Hiltz, S. R., Bieber, M., Fjermestad, J., & Rana, A. (1999). Collaborative discourse structures in computer mediated group

communications. *Journal of Computer Mediated Communication*, 4(4). © 2001 IEEE
<www.ascusc.org/jcmc/vol4/issue4>

In the same year, Sillince and Saeedi (1999) published a paper analysing design issues for argumentation-augmented CMC, including the possibility of visualizations. Thus, in this branch of work we finally see the convergence of CMC and CSAV in proposals for future systems, albeit not until the late 1990s.[1] (An ongoing project to implement a CMC-CSAV system for scholarly research discourse is described in Chapter 9.)

1.3   From Prototypes to Sustained Work Practices?

To most of the individuals reviewed above, it was obvious that computer-supported argument visualization had many potential applications. However, the reality of making a new intellectual technology work for real people doing real work with a constellation of existing tools and constraints, often exposes many practical "details" that must be worked through, as the technology becomes sufficiently stable usable to deploy on everyday hardware and software.

Within the hypertext research community, for a decade from the early 1980s to early 1990s, argument mapping became something of an "experimental white rat", with many of the pioneering systems for idea processing and then collaborative hypertext choosing argumentation as one of their standard demonstration applications: consider Textnet (Trigg and Weiser, 1983), NoteCards (Halasz et al., 1987), gIBIS (Conklin and Begeman, 1988), rIBIS (Rein and Ellis, 1991), SEPIA (Streitz et al., 1989), AAA (Schuler and Smith, 1990), Colab (Tatar et al., 1991), and Aquanet (Marshall and Rogers, 1992). In addition to the gIBIS system introduced above, several other design rationale efforts (Fischer, et al., 1991; McCall, 1991) grounded their approaches in Rittel's concept of *argumentative design*. Others developed variations on gIBIS, varying the notation and its visual layout, determining how large and elaborate an argument could be expressed. Design Space Analysis (MacLean et al., 1991; 1993) changed IBIS's *Issues, Positions, Arguments* to the more design oriented *Questions, Options, Criteria*. The *Decision Representation Language* (Lee, 1991) extended gIBIS (e.g. with the *Goal* node type), allowing participants to explore *Alternatives, Claims* backing them, and to contest through *Questions* and counter-*Claims* the relationships between these constructs.[2]

However, after the initial flush of excitement at hypertext's representational possibilities, subsequent analyses of CSAV began to draw more sobering lessons. A number of critiques highlighted cognitive and social challenges for CSAV, and by extension, any approach that seeks to support intellectual work with semi-formal or

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[1]   I of course welcome references to earlier examples that have been omitted in this review, with apologies in advance to those concerned.

[2]   See Conklin (1987) for a review of hypertext systems in mid-1980s, and

[2]   Buckingham Shum (1987) and Hammond (1994) for a more recent review, specifically and Buckingham Shum and Hammond (1994) for a more recent review, specifically from the perspective of argumentation-based design rationale.

formal representations. From a CSCW perspective, see Shipman and Marshall (1999), from a design rationale perspective Buckingham Shum and Hammond (1994), on groupware see Grudin (1994), and on collaborative modelling (Selvin, 1999). Educational applications of CSAV have reported similar initial learning overheads for students in structuring their thoughts into network structures (Suthers and Weiner, 1995).

It has become apparent that CSAV's successes and failures result from a combination of one's expertise in the argument mapping approach, training in CSAV tools, user interface design, the kind of domain and problem being tackled, and the incentive to use CSAV. A focus on any one factor in isolation has proven to be shortsighted. What we have seen with CSAV – at least its history as proposed here – is typical of the maturation of many new intellectual technologies. After an initial (e.g. a decade's) flurry of prototype building in research labs, the complexities of making it work in the real world start to bite. Many move on to the next emerging technology, as is obviously important in technology research, but those who persevere may after a few years create stable versions/products that can be run reliably on what are by then everyday workplace computers. Crucially, in parallel, they slowly acquire the missing knowledge and craft skill that helps them embed and customise the raw tool in the workplace. In CSAV's case, learning ways to introduce it into the classroom or businesses often implicates integration with other technologies (e.g. standard office software; email and the web; specialist tools such as CAD), or organisational processes (e.g. national curricula; design methodologies).

Of all the factors that seem to influence uptake of argument mapping, one in particular is recurring (cf. van Gelder, Chapter 5, and Conklin, Chapter 6). The process of learning the representational notation inculcates a useful new ability to attend to the underlying structure of arguments and debates (whether spoken or written) in the terms of that particular notation. An important consequence of this, however, is that until one has had some practice, often prompted by some initial instruction, argument mapping initially feels like learning a new foreign language, and the temptation is to lapse back into more familiar languages (conversational patterns and modes of writing). The tools can be made user friendly, and the notations lightweight and informal, but the human element of the system must co-evolve as well. We are, in short, talking about a new *literacy* in being able to read and write in the new medium, and a new *fluency* in using these conversational tools in appropriate ways in different contexts.

1.4 Conclusion

Computer-Supported Argument Visualization has roots that this chapter has unearthed as far back as Wigmore's legal evidence charts in 1913. So, for almost a century, thinkers from many disciplines have envisaged and invented aids to assist in the mapping and analysis of arguments to tackle applied problems they were confronting. It is of particular note that "founding fathers" of today's interactive computing such as Bush and Engelbart envisaged argument construction and analysis as a key objective for the intellectual technologies they were conceiving.

As we enter the third millennium, the CSAV community is beginning to have available to it some reasonably usable, robust tools, and a growing body of knowledge about their uptake and application, as evidenced by this book. As the internet becomes the default mechanism for the dissemination of research knowledge, software applications and code, we can expect it to accelerate the evolution, deployment and evaluation of CSAV tools, and help connect the community behind them.

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