AI & Soc (2009) 23:353–377
DOI 10.1007/s00146-006-0069-y

ORIGINAL ARTICLE

Deliberative discourse and reasoning from generic argument structures

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Received: 15 March 2005 / Accepted: 19 October 2006 / Published online: 16 December 2006

Abstract In this article a dialectical model for practical reasoning within a community, based on the Generic/Actual Argument Model (GAAM) is advanced and its application to deliberative dialogue discussed. The GAAM, offers a dynamic template for structuring knowledge within a domain of discourse that is connected to and regulated by a community. The paper demonstrates how the community accepted generic argument structure acts to normatively influence both admissible reasoning and the progression of dialectical reasoning between participants. It is further demonstrated that these types of deliberation dialogues supported by the GAAM comply with criteria for normative principles for deliberation, specifically, Alexy's rules for discourse ethics and Hitchcock's Principles of Rational Mutual Inquiry. The connection of reasoning to the community in a documented and transparent structure assists in providing best justified reasons, principles of deliberation and ethical discourse which are important advantages for reasoning communities.

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1 Introduction

The layout of arguments advanced by Toulmin (1958) has been enormously influential however most studies that have applied the structure in computer based systems have ultimately modified the original layout. In (Stranieri et al. 2001a, b) the variations are explained by drawing a distinction between argument models that are dialectical in that their focus is to represent the exchange of views between participants and those that are non-dialectical. Non-dialectical models use argumentation concepts to structure and organize knowledge and do not represent an exchange or discussion.

In (Yearwood and Stranieri 2006) an argument model for practical reasoning influenced by the Toulmin layout is presented. The Generic/Actual argument model (GAAM) is advanced as a non-dialectical model for organizing knowledge within a community or organization so that effective decisions can be made in a transparent fashion and various elements of a decision may be supported by machine or human inference. The GAAM is a two level model comprising generic arguments and actual arguments. Generic arguments provide a template that organizes all arguments plausibly advanced within a discourse. Actual arguments represent positions that discourse participants hold.

The Generic/Actual argument model has been applied to the development of numerous knowledge based systems: to predict judicial decisions on property split following divorce (Stranieri et al. 1999), support refugee status decisions decision makers (Yearwood and Stranieri 1999), interactive e-commerce and multi-agent negotiation (Avery et al. 2001) determining eligibility for legal aid (Stranieri and Zeleznikow 2001a, b) and modeling reasoning of critical care nurses (Stranieri et al. 2004). Two shell programs that implement GAAM ideas are presented in (Stranieri and Zeleznikow 2001a, b) and (Yearwood and Stranieri 2000a, b).

(Girle et al. 2003) point out the need for formal systems that represent and support deliberation dialogue especially in agent design. This article describes the deployment of the GAAM model to facilitate deliberative dialogue within a type of interacting community that we call a reasoning community. (Lave and Wenger 1991) introduced the concept of communities of practice to refer to individuals that collaborate to share ideas or find solutions to specific problems. Communities of practice are formed around individuals' needs to improve competencies or families of competencies and are accountable to the individuals that comprise the community of practice. They tend to transcend normal organizational boundaries. Associations of industry bodies that aim to self-regulate an industry exemplify communities of practice. Members of these communities share standards of practice.

A community of reasoning describes a group of individuals that engage in dialogue with each other in order to reason toward action. As such the term is broader than communities of practice, communities of action or communities of purpose. A reasoning community engages in a process that involves three main components: individual reasoning, communication of reasoning and a coalescing of reasoning. In individual reasoning, each individual seeks evidence, organizes it and ultimately forms claims that represent his or her preferred position or beliefs. In the coalescing of reasoning phase the reasoning each individual has used to arrive at their individual beliefs is coalesced into a form that represents the reasoning processes acceptable to the entire community. A coalescing of reasoning does not mean agreement about a solution is necessarily reached. Rather, coalescing of reasoning reflects the state where each individual's reasoning is understood and accepted as valid by the community even if there is such a divergence of views that agreement is impossible. Communication of reasoning describes the transmission of all aspects of individual and coalesced reasoning to others.

Members of a reasoning community may or may not belong to the same organization, hold the same values, aim for the same outcomes or share much else in common except the need to reason toward the solution of the same or similar problem. For example, the community of reasoning involved in a decision about an offender's sentence includes the judge, the offender, lawyers for the state and the offender and, more broadly all other judges and lawyers within the jurisdiction who need to predict outcomes in similar cases.

Reasoning communities that are effective are likely to be those where interactions are characterized by deliberative dialogue (Wilhelm 2000). Walton and Krabbe (1995) classified human dialogues into six basic types based on the objectives of the dialogue, the objectives of the participants and the information available to participants at the start of the dialogue. They six types are: information-seeking, inquiry, persuasion, negotiation, deliberation and eristic dialogues. Deliberative dialogues are characterized by a desire to understand all views and reach outcomes which are rationally identified as optimal for the problem even if detrimental to some participants.

Deliberative discourse is often advanced as an ideal for modern democratic states with advanced internet technologies. However, the extent to which this form of dialogue spontaneously occurs within groups is unclear. In his content analysis study of a number of internet discussion groups (Wilhelm 2000) found very little evidence for deliberation. Workshop methods such as the Search Conference advanced by (Emery and Purser 1995) aim to facilitate deliberative dialogue largely because this form of group interaction is not the norm and can so easily be thwarted by power imbalances, organizational rigidity or numerous other factors.

Formal models have been proposed for information-seeking dialogues (Hulstijn 2000), inquiry dialogues (McBurney and Parsons 2001), persuasion dialogues (Amgoud et al. 2000a, b, Walton and Krabbe 1995), negotiation dialogues (Amgoud et al. 2000a, b, McBurney et al. 2003, Hulstijn 2000, Sadri et al., 2001) and deliberation dialogues (Hitchcock et al. 2001). Hitchcock et al. (2001) present a formal model for deliberation dialogues grounded in (Wohlrapp's 1998) theory of retroflexive argumentation for non-deductive argument and fully articulate the locutions and rules of a formal dialogue game for this model. In their discussion of deliberation dialogues they say "Proposals for actions to address the expected need may only arise late in a dialogue, after discussion on the governing question, and discussion on what considerations are relevant to its resolution.'' It is therefore important to recognize the importance of organizing the relevant considerations.

A central claim made in this paper is that a community wide, explicit model of reasoning is central to the facilitation of deliberation dialogue within a reasoning community. The model must be sufficiently abstract to accommodate diverse viewpoints. The GAAM model is advanced to illustrate that a community shared model is feasible. Within a reasoning community a generic argument structure (GAS) is established and provides participants with a constant reminder of shared understanding and interpretative assumptions that have been agreed upon. Between communities it provides a public face to the elaboration and explanation as well as the possibility for encouraging participation. The dialogue to establish the GAS is not the main focus of this paper but is discussed briefly in Sect. 5.

In this paper we study the characteristics of deliberation dialogue that is based on the GAAM. We will assess the discourse by some of the models that have been proposed in the literature mentioned above. In particular, we consider the extent to which there is compliance with McBurney, Hitchcock and Parsons eightfold way of deliberation dialogue (Hitchcock et al. 2001). McBurney et al. (2002) specify a Dialectical System as consisting of:

1. a set of topics of discussion
2. the syntax for a set of defined locutions concerning these topics
3. a set of rules which govern the utterance of these locutions
4. a set of rules which establish what commitments, if any, participants create by the utterance of each locution
5. a set of rules governing the circumstances under which the dialogue terminates

In general terms this paper also describes the extent to which the dialectical system based on the GAAM satisfies this specification and can act as a model for reasoning communities. We begin with a brief review in Sect. 2 of the GAAM and an example to be used later in the paper. Section 3 considers the split between non-dialectical and dialectical notions of modeling reasoning. Section 4 defines the GAAM so that it can be discussed more formally. Section 5 briefly reviews the way in which dialogue to develop a GAS may proceed. In Sect. 6 a dialectical system based on the GAAM is developed. Section 6.2 presents an example dialogue based on the deliberative dialogue structure developed. The paper concludes with some discussion and remarks and a brief look at other approaches described.

2 The Generic/Actual Argument Model

The framework called the Generic Actual Argument Model (GAAM) is an attempt to develop a model for structured reasoning. Often reasoning occurs in the context of a small group of stakeholders involved in dialogue who would like to reach agreement on some issue. Whilst there is much anecdotal evidence for this it is also true that most organizations like to see a team approach to the solution of problems and are keen to have frameworks that permit a range of views. In general we can distil the following characteristics of small group reasoning:

- Membership of the reasoning community is usually well defined
- Members may have different beliefs about the base facts and also have different preferences for how to infer from base facts to claims
- The truth value of a claim or proposition, if it exists at all, is difficult to ascertain.

Our approach is in contrast to other argument-based models such as IBIS (Rittel and Webber 1973) and the Zeno argumentation framework (Gordon and Karacapilidis 1997) which focus heavily on the way in which multiple agents combat and defeat each other. One of the important features of the GAAM is that it invites a community of reasoning to construct an agreed framework for reasoning that is flexible enough to permit a broad range of points of view. This framework is then used to make the reasoning of individuals clear to the group. It is a social ideal to develop models for community reasoning that (1) encourage deliberation; (2) help individuals reach decisions with a better justification; (3) support better collective reasoning; and (4) move groups toward agreement or at least an understanding of the basis for disagreement. Such models, not only have the potential to present a fresh approach to group and organizational decision making but also have the potential to contribute to more effective and informed decision making generally. Increasingly, participants to a discussion are software agents. As agents are not as flexible as humans, their use can more easily be integrated into a highly structured model that is designed for non-combative structured reasoning rather than adversarial based approaches.

2.1 Generic arguments

The Generic Actual Argument Model (GAAM) uses a variant of the layout of arguments advanced by (Toulmin 1958). Arguments are represented at two levels of abstraction; the generic and the actual level. The generic level is sufficiently general so as to represent claims made by all members of a discursive community. All participants use the same generic arguments to construct, by instantiation, their own actual arguments. The generic arguments represent a detailed layout of arguments acceptable to all participants whereas the actual arguments capture a participant's position with respect to each argument. The actual arguments that one participant advances are more easily compared with those advanced by another, in a dialectical exercise because, in both cases the actual arguments have been derived from a generic template that all participants share.

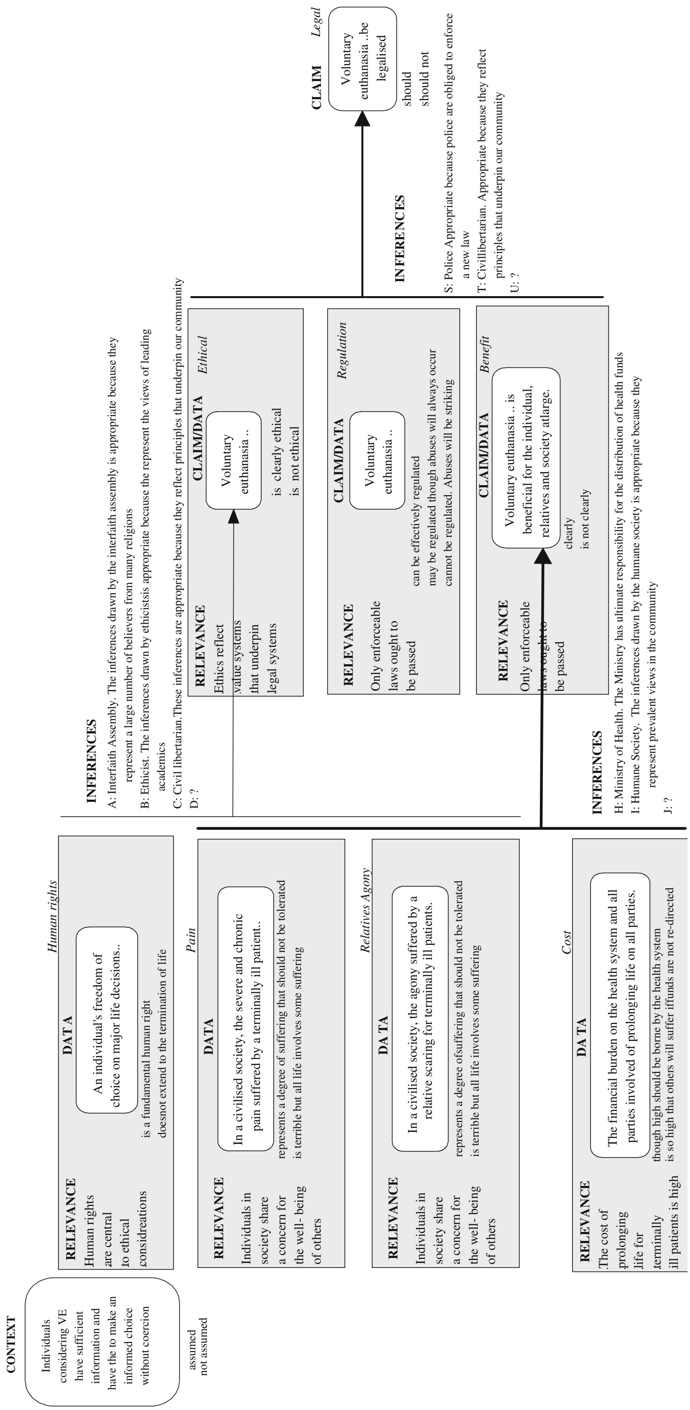

Fig. 1 Generic argument for voluntary euthanasia

Figure 1 represents the structure we call a generic argument that acts as a structured reasoning template for a discussion involving the legalization of voluntary euthanasia. The generic argument differs from the Toulmin layout in that:

- claims and data items are represented using a variable-values representation rather than a statement
- each data item includes a statement indicating its reason for relevance. This replaces the Toulmin warrant
- a list of inference procedures that are used to infer a claim value from data values in place of the Toulmin warrant
- statements indicating reasons for the appropriateness of each inference procedure (optional)
- context variables and values

The claim in Fig. 1 represents the point of the discussion; to ascertain whether voluntary euthanasia (VE) should be legalized. The generic argument structure, developed prior to the discussion, represents agreement amongst discourse participants on concepts deemed to be important to all. The generic argument does not reflect positions held by any participant but is intended to accommodate all positions regarded as reasonable.

Figure 1 illustrates that a claim on the legalization of voluntary euthanasia is advanced on the basis of a position on three concepts; whether or not voluntary euthanasia is regarded as ethical, the extent to which abuses can be curtailed and the extent to which benefits exist. A reason indicating why each of these concepts is relevant has been articulated to validate their inclusion. The process of drawing an inference from data values to claim values is seen as an exercise in mapping data to claim values. There are 24 different mappings possible. For example, one possible mapping represents an actual argument that advances the claims that VE is clearly ethical, can be effectively regulated and is clearly beneficial therefore should be legalized. Two groups of mappings have been assigned a label, (S: Police) that conveniently describe mappings that are consistent with inferences a Police department might draw. A Civil libertarian inference procedure describes mappings that are consistent with inferences that a civil liberties group may raise.

Figure 1 illustrates that the human rights, pain and relatives agony are data items used to infer a claim regarding whether VE is ethical. Pain, relatives' agony and cost are items used to infer the extent to which VE is beneficial. A reason for the relevance of each data item is included and a reason for the appropriateness of each inference procedure label is also included. A context variable describes assumptions regarding the discussion. The assumption that individuals considering VE are fully informed and capable of making a decision is included as a context variable.

The structure illustrated in Fig. 1 is called a generic argument tree. The tree does not represent a true structure for this topic but merely represents an agreed framework for the discussion. Further, the tree illustrated may not be the only tree that could plausibly be defined prior to discussion.

2.1.1 Inference procedures

Trudy Govier (1987) provided a view of the PPC (premise, premise, conclusion) structure as the basic argument structure which can be filled by a variety of different argument schemes. At one level this is the essence of the Toulmin structure as well as the GAAM. The GAAM takes this a step further by regarding an inference as a function and permitting a variety of allowed inference functions in any inference slot as long as they are supported by the community attached to the generic argument structure (GAS).

2.2 Actual arguments

Actual arguments made are instances of a generic argument where each data slot has a value, an inference procedure can be chosen and executed to deliver a value for the claim slot. For example a participant A, may construct an actual argument that claims that VE should be legalized by applying inference procedure T on data values: is clearly ethical, can be effectively regulated and is clearly beneficial. Inference procedure C is applied to leaf node values: is a fundamental human right, represents a degree of suffering that should not be tolerated for the individual and for relatives to infer that VE is clearly ethical.

3 The dialectical, non-dialectical split

Argumentation has been used in knowledge engineering in two distinct ways; with a focus on the use of argumentation to structure reasoning (i.e., non-dialectical emphasis) and with a focus on the use of argumentation to model discourse (i.e., dialectical emphasis). Dialectical approaches typically automate the construction of an argument and counter arguments normally with the use of a non-monotonic logic where operators are defined to implement discursive primitives such as attack, rebut, or accept. (Carbogim et al. 2000) present a comprehensive survey of defeasible argumentation.

Dialectical models have been advanced by (Cohen 1985), (Fox 1986), (Vreeswijk 1993), (Dung 1995), (Prakken 1993), (Prakken and Sartor 1996), (Gordon 1995), (Fox and Parsons 1998), (Farley and Freeman 1995), (Poole 1988) and many others. In general these approaches include a concept of conflict between arguments and the notion that some arguments defeat others. Most applications that follow a dialectical approach represent knowledge with first order predicate clauses and deploy a non-monotonic logic to allow contradictory clauses. Mechanisms are typically required to identify implausible arguments and to evaluate the better argument of two or more plausible ones.

In applications of argumentation to model dialectical reasoning, argumentation is used specifically to model discourse and only indirectly used to structure knowledge. Concepts of conflict and of argument preferences map directly onto a discursive situation where participants are engaged in dispute. In contrast, many uses of argumentation for knowledge engineering applications do not model discourse. This corresponds more closely to a non-dialectical perspective.

Generic and actual argument structures in the GAAM correspond to a non-dialectical perspective. They do not directly model an exchange of views between discursive participants but rather describe assertions made from premises and the way in which multiple claims are organized. Claim values are inferred using an inference procedure from data item values. The inference procedure is not necessarily automated. The reasoning occurs within a context and the extent to which the data items correspond to true values, according to the proponent of the argument, is captured by certainty values.

The generic argument provides a level of abstraction that accommodates most points of view within a discursive community and anticipates the creation of actual arguments, by participants, as instantiations of a generic argument. However, it is conceivable that a participant will seek to advance an actual argument that is a departure from the generic argument, given the open textured nature of reasoning. This is a manifestation of discretion and can be realized with the introduction of a new variable (data, claim or context) value, with the use of a new inference procedure or, with a new claim value reason. Later, in Sect. 5, the progression of deliberative dialogues that include the development of the GAS is described so the dynamic nature of GAS is incorporated in the community's reasoning dialogue. Just as elements may be added to the GAS, there may be cases for removing elements. For example, *The Crimes* (*Homicide*) *Act 2005* in the Australian state of Victoria has recently abolished provocation as a defense to murder. Removal of elements is also possible within the dialogue of Sect. 5.

This framework including the generic/actual distinction, the clear separation of inference procedure from other components and the inclusion of reasons for relevance and context introduces a structure that represents knowledge applicable to a discursive community.

4 Defining the GAAM

The GAAM is a means of specifying generic argument structures to model reasoning within a domain. For a more detailed treatment see (Yearwood and Stranieri 2006).

4.1 A generic argument structure

Definition "*A generic argument structure*" (GAS) is a pair ($\mathcal{CV}, \mathcal{G}$) where $\mathcal{CV}$ is a set of context variables and $\mathcal{G}$ is a connected directed bipartite graph that has two kinds of nodes called, claim slots $\mathcal{C}$ and inference slots I.

Definition *Claim slot.* Every claim slot C has a prefix C_p, set of values C_v and a suffix C_s. Each claim slot also has two variables. A variable r of type string and a variable c of type num $\in [-1,1]$.

The variable r is a place holder for the claim value reason and the variable c a place holder for the certainty factor. These are not instantiated at the generic level but at the actual argument level.

Definition *Inference slot*. Every inference slot I has an arity (n) and a set of pairs of operators and strings (Ij, Jj): $j = 1...k$.

The number of arcs that belong to I is one more than its arity. An inference slot of arity n is represented with n inward arcs and one outward arc. Such an inference slot is called an n-ary inference slot. The set of $n + 1$ claim slots $\langle C_1, \ldots, C_n, C_{n+1}\rangle$ is called the signature of I. The set of operators is a set of n-ary operators. Each operator is of the form Ij: $C_{1_\text{v}} \times \cdots \times C_{n_\text{v}} \times \text{CVV} \rightarrow C_{n+1_\text{v}}$ and operates on the sets of values of the first n claim slots in its signature and the set of context variable values. The strings Jj are intended to store the justification for the jth operator.

Definition *Claim slot to Inference slot Arc.* Every arc from a claim slot to an inference slot is a relevance relation pair (C_i, C_{n+1}) and has two string attributes, RR and B.

For the relevance relation pair (C_i, C_{n+1}), RR is of type string and is the reason that C_i is relevant to inferring C_{n+1}. B is also of type string and is the backing that provides authority for the reason for relevance and in a legal argument is typically a reference to a statute or a precedent case. Note that RR is the reason for relevance to inferring the claim slot and can be used in the cases of both linked and convergent reasoning.

Definition *Inference slot to Claim slot Arc.* There is a unique arc from an inference slot to a claim slot.

4.2 Generic arguments and actual arguments

A generic argument is a GAS that consists of a single inference slot and the claim slots that are attached to its arcs. A full GAS can be formed by connecting individual generic arguments one for each inference slot in G. An actual argument is an instantiation of a GAS with context variable values, a choice of inference operator (and reason pair) for the inference slot, the assignment of claim values and claim value reasons to the claim value reason variables and the assignment of certainty values to the certainty factor variables. Note that a claim slot C_i defines a set of propositions and that the choice of a particular value C_{v_k} from the set of values C_v defines a proposition (claim): $C_\text{p}C_{\text{v}_k}C_\text{s}$. The actual (atomic) argument for this proposition is then represented as being derived by the application of an inference procedure I_h from the inference slot I (leading to the claim slot C_i) to n values $(C_{1_{\text{v}i1}} \ldots C_{n_{\text{v}in}})$ and CVV. So, $I_h(C_{1_{\text{v}i1}} \ldots C_{n_{\text{v}in}}, CVV) = C_\text{p}C_{\text{v}_k}C_\text{s}$.

5 Dialogue for developing a GAS

The Generic Argument Structure can provide a means for improving negotiation and deliberation. Within a reasoning community a GAS is established and provides a constant reminder of the agreed upon, shared understanding and interpretative assumptions. Between communities it provides a public face to the elaboration and explanation as well as the possibility for encouraging participation.

The GAS can be developed in two ways. Participants to a dialogue can collectively deliberate on a structure that will suit as the desired normative structure. Alternatively, a social institution can be charged with the advancement and on-going maintenance of a GAS. Once a GAS is developed for the community then discourse using the structure can proceed.

An example of the latter approach can be imagined in a futuristic legal setting. The social institution charged with the maintenance of the GAS could be the Court that has jurisdiction over the subject matter of the discourse. For example, a future Family Court may advance a GAS. All concepts that are relevant for a Family Court judgment and precisely how each relates to others, is explicitly represented in the GAS. Claims made by all parties to a dispute are made as actual arguments instantiated from the GAS. In this way, points of divergence can more readily be identified and information systems can more easily be integrated to support reasoning. Ultimately, a court judgment is also represented as an instantiation of the GAS ensuring a transparency of reasoning that is well beyond current practice.

Reasoning communities typically have no social institution that can be appropriately charged with the maintenance of a GAS can develop their own GAS. The construction of the generic argument structure can be carried out through structured dialogue between participants and GAAMtalk (a Web version of our argumentation tool) (Yearwood and Stranieri 2002). The basis of this structured dialogue is the repeated use of a meta-generic argument structure. It sets the structure of reasoning and debate for the community on the particular matter for deliberation. As a step toward this (Afshar et al. 2006) describe Consult, a system that enables a community to engage in a Delphi-like communication and a Borda preferendum vote in order to agree on a generic argument structure.

The meta generic arguments are:

1. The top level generic argument claim is: <PREFIX><VALUE><SUFFIX> {is/is not} the top level claim. At this stage <VALUE> is left unspecified.
2. <VALUE SET> {is/is not} the agreed set of values for the top level claim.
3. <PREFIX><VALUE><SUFFIX> {is/is not} a data item for the claim.
4. <REASON FOR RELEVANCE> {is/is not} a reason for the relevance of the data item.
5. <BACKING> {is/is not} is the backing for the <REASON FOR RELEVANCE>.

These can be organized into a tree with the top level claim that the GAS that emerges is the currently agreed GAS for the discourse. Each of the above meta-generic arguments then acts as grounds for this top level claim. The subject of Argument 1 is moved, seconded and voted upon. Once the generic form of the top level claim is established the grounds on which such a claim will be made are adduced. ''<PREFIX><VALUE><SUFFIX> {is/is not} a data item for the claim'', has to be moved and seconded. The support for the data item is then measured. In the case that the support is judged to be sufficient then the reasons supporting the claim (a document) are stored as <REASON FOR RELEVANCE>. <BACKING> is then dealt with in a similar fashion and then the discourse will move onto the next grounds or data item in turn. The appropriate meta-generic arguments are iteratively applied until there is agreement not to go any further.

The collaborative development of the generic structure provides a framework for the development of actual arguments. It involved the contribution of reasons (these are attached as documents) as to why data items are relevant and participants are now in a position to construct their actual arguments. The structure can be displayed as a tree in one of the Windows of GAAMtalk and the contents of each node displayed as each node is traversed.

6 The dialectical GAAM

Dialectical arguments are those that focus on support by reasons and also attack by counter arguments. In a standard view, arguments express how a conclusion is supported by premises. This is largely the notion supported by the GAAM. However, the GAAM sets out a structure for reasoning in a domain that permits reasoning towards different conclusions. In considering how arguments are supported or attacked by other arguments, dialectical argumentation frameworks resort to operators that describe support and attack. Attack operators may be further classified as rebut or undercut or other more specific classifications of attack that relate to the particular argumentation structure or argumentation theory. For example, in Verheij's (1996) CumulA, defeat of an argument can be represented in terms of (Pollock's 1987) undercutting and rebutting defeat but also defeat by sequential weakening and defeat by parallel strengthening. In the argument mediation system ArguMed (Verheij 1999) only undercutters are used. In our approach the structural point at which there is divergence can be identified and is suggestive of dialectical operators that describe these discrepancies.

In the GAAM, a GAS encourages participants to construct actual arguments that are structured following the GAS. This structure then provides a basis for the comparison of arguments and the basis for the dialectical exchange that may occur around participants' reasoning. The particular elements of an actual argument that need to be considered, assuming that the actual arguments comply with the GAS, relate to data, inference and claim or conclusion (assuming the same context variable values). These are data item values, selection of an inference procedure and claim value or conclusion. If one or both of the actual arguments deviates from the domain GAS then the comparison of actual arguments becomes more complex.

Consider two actual arguments A1 and A2. Based on the structure of actual arguments described above we can investigate the different types of dialectical operators that may be suggested by the ways in which the two actual arguments differ. Actual arguments can differ in their data item values, their inference procedures and their claim values as well as the certainty values on each of these. Leaving aside the certainty values, Table 1 summarizes the different types of dialectical operators that are suggested.

Complete Agreement occurs when both arguments make identical claims, from the same premises in the same way. These arguments are labeled identical. *Agreement* occurs if the very similar premises are used to infer the same claims using the same inferences. The arguments are said to be equivalent. A *Questionable divergence* occurs when different claims are reached with the same inference applied to very similar premises.

Divergent inference occurs when the same or similar premises lead to different claims because a different inference is used. In terms of divergence or attack, it is the inference procedure as the connection between the premises and the conclusion that is the point of divergence and in the extreme case the inference procedure reasons may attack each other and so would constitute a Pollock undercut.

Divergent premises occur when different premises lead to different claims despite the same inference. Different claims can also arise from different premises and inferences; (Divergent premise and inference).

A *mistake* occurs when two arguments use identical premises and inferences but somehow arrive at different claims.

An actual argument supports another as *supportive by premise* if both use the same premises to advance the same claim though this is done using dif-

Table 1 Dialectical operators suggested by comparing actual argument components

Dialectical operator	Data of A1, A2	Inference procedure of A1, A2	Claim values of A1, A2	Type
Complete agreement	Same	Same	Same	Identical
Agreement	Similar	Same	Same	Equivalent
Questionable divergence	Similar	Same	Different	Questionable
Divergent inference	Same or similar	Different	Different	Rebuttal
Divergent premise	Different	Same	Different	Different premise
Divergent premise and inference	Different	Different	Different	Different argument
Mistake	Same	Same	Different	Not possible
Supportive by premise	Same	Different	Same	Reinforcement
Supportive by inference	Different	Same	Same	Insensitive inference procedure
Supportive by claim	Different	Different	Same	Support

ferent inference. *Supportive by inference* occurs when the same claim is inferred using the same inference though premises differ. *Supportive by claim* describes those arguments that advance the same claims though premises and inferences are different.

6.1 A GAS provides a theory of normativity

At a fundamental level any actual argument that is instantiated from the GAS should be admissible from the point of view of the associated community. Any argument that is not an instantiation of the GAS may become admissible if the argument can be viewed as an instantiation of a changed GAS by the agreement of the community. Good or admissible arguments are those that comply with the 'norm' of the GAS. A 'bad' argument may be one that cannot be made to conform to any close approximation to the GAS. In attempting to model the usual dialectical positions it is necessary to agree on a definition of which claim value pairs constitute opposites. We do not attempt to make this definition here as it would be a matter for the associated community.

In the following $\neg C$ refers to an opposite (defeater) of C. We make the following definitions.

A statement $C = C_{\mathrm{p}} C_{\mathrm{v}_k} C_{\mathrm{s}}$ is Γ-*justified* if and only if it can be deduced from Γ.

A statement $C = C_{\mathrm{p}} C_{\mathrm{v}_k} C_{\mathrm{s}}$ is universally Γ-*justified* if and only if it has at least one derivation from Γ and $\neg C$ has no derivation from Γ.

A statement $C = C_{\mathrm{p}} C_{\mathrm{v}_k} C_{\mathrm{s}}$ is *unjustified* if it has no derivation in $\mathcal{G}$ and it is *defeated* if it is unjustified and at least one $\neg C$ has a derivation.

In a GAS where there are only computational inference procedures then the status of any admissible proposition is automatically computable. The question of whether one proposition defeats another is not attempted here as the strength of an argument can be defined in different ways as described in (Yearwood and Stranieri 2006) and so the stronger proposition could be established in different ways depending on which approach is adopted.

6.2 Dialogue

In a dialogue the participants of a community reasoning on an issue modeled by a GAS may start anywhere in the tree (GAS). This can be viewed as a claim, an inference slot or their actual arguments associated with the claim slot. The object of a dialogue is to identify whether there is agreement on the claim or where in the associated argument, differences may be considered for reconciliation. If there is agreement then the dialogue ends and another dialogue starting at some other point (outside the sub-tree underneath the agreed claim) in the GAS can occur. If there is no agreement then the participants move to exchanges on each of the claims that are the data for the inference slot. If the claim is a leaf of the GAS then the participants are *irreconcilable on data*. If they agree on all of the data items then they may differ on the context variable values and in this case they are *potentially reconcilable through agreement on context variable values* otherwise they are *potentially reconcilable through agreement on inference*. If there are data items that they differ on, then each of these can be used as the starting point for a new dialogue. A dialogue between participants is illustrated with a sample dialogue from (Govier's 1992) examples on 'conductive argument'. Following the example, we present a more formal treatment of the dialogue.

The discourse involves legalizing voluntary euthanasia for terminally ill patients. (Govier 1992) gives four points for and two against: responsible adults should be able to choose whether to live or to die; that patients could be saved from unbearable pain; that social costs would be reduced; that relatives would be saved from unbearable agonies; (against) that we are never sure that a cure might be discovered and that we risk abuse. The example has been modeled slightly differently using the GAAM and is presented in Fig. 1. A sample dialogue between participants *X* and *Y* is as follows:

1. The discussion commences with *X* and *Y* accepting to use the generic argument structure as a template.
2. *X* proposes the actual argument claim for the argument labeled *Ethical* in Fig. 1, that Voluntary Euthanasia (VE) is clearly ethical. *Y* also believes this. At this point *X* and *Y* have, as their point in common, the claim that VE is clearly ethical.
3. *Y* selects a new node to discuss: the node concerning the regulation of VE and proposes that VE *may be regulated though abuses will always occur*. This is the argument labeled *Regulation* in Fig. 1. *X* is concerned that *abuses will be prominent*. This is a Point of Difference at a leaf node so is listed as potentially reconcilable on data. *Y* selects a new node for discussion
4. The argument labeled *Cost* in Fig. 1 concerning the financial burden of terminally ill individuals is selected by *Y*. *Y* proposes that the financial burden on the State of keeping terminally ill patients alive *is so high that others will suffer if funds are not re-directed*. *X* agrees and adds a Point of Agreement.
5. *X* proposes that VE is clearly beneficial to the individual and society by creating an actual argument from the generic benefit argument labeled *Benefit* in Fig. 1. *Y* proposes that the benefit *is not so clear*. The difference is required to be justified. The set of actual arguments for child nodes of the benefit argument are examined by *X* and *Y*.
6. *Y* re-selects an earlier node: that concerning the regulation of VE and this time retracts the earlier hard line claim and softens it to claim that *although abuses will occur, by and large VE can be regulated*. This claim is removed from the Point of Difference list. *Y* selects a new node for discussion
7. Both *X* and *Y* agree that the individual's pain should not be tolerated in the argument labeled *Pain* in Fig. 1. The relative's agony is similarly

intolerable and costs should be borne by the health system. However, the irreconcilable difference at the node concerning *Benefit* remains despite agreement on all three-child nodes. This is because X has adopted an inference procedure consistent with that advanced by the Humane society whereas Y has used a different mapping. The pair are therefore potentially reconcilable on inference. There are still nodes to discuss.

8. At the root node labeled *Legal*, X asserts that VE should be legalized. Y disagrees. Both have agreed that VE is ethical and that it can be regulated although abuses will occur. Y was not clear of the benefits of VE whereas X remains certain. There are no nodes that have not been discussed so the dialogue is called a complete dialogue and ends.

The discussion has identified numerous points of difference and of agreement for both parties to deliberate on. The generic argument structure has provided a template to structure the dialogue without resorting to combative metaphors or unduly constraining the content or flow of the discourse.

Dialogue involving the use of a generic argument structure involves a number of steps, formally defined below. Comments that relate the formal treatment to the sample dialogue are included in italics.

Define an actual argument A associated with an inference slot I in a GAS $\mathcal{G}$ as a tuple $\left(I_j, C_{1_{i1}}, \ldots, C_{n_{in,}}, C_{n+1_{\mathrm{v}in+1}}\right)$ consisting of an inference procedure I_j from the inference slot followed by a data value for each data variable C_i and a claim value for the claim variable C_{n+1}.

Within a GAS $\mathcal{G}$ the set of *points in common* from the arguments of two participants P_1 and P_2 is the set $\mathrm{PIC} = \left\{C \in \mathcal{C}\colon C_{\mathrm{v}}^{\mathrm{P}_1} = C_{\mathrm{v}}^{\mathrm{P}_2}\right\}$ and the set of *points of difference* is the set $\mathrm{POD} = \left\{C \in \mathcal{C}\colon C_{\mathrm{v}}^{\mathrm{P}_1} \neq C_{\mathrm{v}}^{\mathrm{P}_2}\right\}$.

Definition *A dialogue based on a GAS* $\mathcal{G}$ *is a finite nonempty sequence of moves where* $move_i = (Player_i, C_i \in A)$ $(i > 0)$, *such that*:

1. $A \in A\ (\mathcal{G})$; *An actual argument is an instantiation of a generic argument structure*
2. $Player_i = P_1$ *iff i is odd; and* $Player_i = P_2$ *iff i is even; In the sample dialogue above Player X is odd, Player Y is even*
3. *If* $Player_i = Player_1$, *then* A^1;
4. *If* $Player_i = Playeri_2$, *and* $C^2_{n+1_{\mathrm{v}k_2}} = C^1_{n+1_{\mathrm{v}k_1}}$

Then $PIC = \{C_{n+1}\}$*and* $POD = \emptyset$ *If players advance identical claim values then the claim is assigned to the Points in Common set. For instance after Steps* (1) *and* (2) *in the sample dialogue both X and Y proposed the claim that Voluntary Euthanasia* (*VE*) *is clearly not ethical. So this claim value is in the points in common set* $PIC = \{Ethical_{is\_not}\}$.
otherwise $C^2 \neq C^1$ *and* $PIC = \emptyset$ *and* $POD = \{C_{n+1}\}$ *So, compare data. If players advance claim values that are contrary then the claim is assigned to the Points of Difference set and the data items for the claim are compared.*

(a) *If* C^1_{n+1} *is a leaf node of* $\mathcal{G}$ *then* P_1 *and* P_2 *are potentially reconcilable on data. After Step* (3) *in the sample dialogue, POD = {Regulation*$_{abuses\_will\_occur}$}. *This claim is a leaf node so X and Y are potentially reconcilable on data.*
(b) *PIC =* $\emptyset$ *and POD* $\neq \emptyset$. *For each* $C_i \in signature(I) \subset C$, P_1 *and* P_2 *compare* $C^1_{i_{vk_1}}$ and $C^2_{i_{vk_2}}$ *After Step* (5) *the POD = {Benefit*$_{clear}$ *Benefit*$_{not\ so\ clear}$ }.

The data item values related to claims of Pain, Relative's Agony and Cost are elicited from X and Y and compared.

If $C^1_{i_{vk_1}} = C^2_{i_{vk_2}}$ *then PIC = PIC* $\cup$ {C_i} *At Step* (7) *in the example X and Y agree that the individual's pain should not be tolerated and the relative's agony is similarly intolerable. They also agree that costs should be borne by the health system. These three claims are added to the PIC set.*
else POD = POD $\cup$ *{*C_i*} If the players disagree on any of the child nodes then the claim value disagreement are added to the Points Of Difference set.*

(c) *If POD =* $\emptyset$ *then compare* CVV^1 *with* CVV^2. *If* $CVV^1 = CVV^2$ *then* P_1 *and* P_2 *are potentially reconcilable through agreement on context variable values of* C_{n+1} *of* A^i *else* P_1 *and* P_2 *are potentially reconcilable through agreement on inference to* C_{n+1} *of* A^i. *At Step* (7) *in the example X and Y disagree on the Benefit claim but agree on all three data items that combine to infer the Benefit claim. The difference derives from a difference in inference procedure so the two players are potentially reconcilable through agreement.*
(d) *If POD* $\neq \emptyset$ *then a new dialogue can start for each* C_i *in POD.*

The dialogue procedure avoids differences that lie in the sub-tree of an agreed claim. A top level claim is fully discussed when a set of dialogues that covers the GAS has occurred between participants. We will call this a complete dialogue.

This approach to dialogue suggests a particular approach to deliberation which allows interaction between participants punctuated with deliberation and the possibility of revision. It is also flexible in the selection of arguments that cover the GAS. The procedure can be organized to add claims that participants agree on, to their individual commitment stores (Singh 2000). These claims do not need to be revisited. The alternative (monolithic) approach would be to have each participant deliberate and present their complete actual argument that covers the whole GAS. This has the advantage of enforcing consideration of all items in the GAS as well as encouraging complete independence on all arguments in the tree. The former dialogue approach may support less independence and more interaction in the deliberation process.

6.3 Dialogue with a non-static GAS

The dialogue above is defined for a static GAS but the GAS, in fact, can change over time and often the change is prompted by participants using a GAS in a deliberative discussion rather than developing a GAS. We could refer to this situation as a variable GAS situation. A dialogue using a variable GAS would differ from the above in item (4)(b) above. At this stage the participants would have different data item sets. Only the case of one participant having data items additional to the shared GAS need be considered. If a participant is not using some of the data items in the common GAS then these can simply be taken to have default values. If C_0 is an additional data item for participant P_1 and if POD = Ø for all the GAS data items then P_1 can provide P_2 with an *RR* (reason for relevance) and a *B* (backing) although these are part of the GAS construction dialogues. At this stage C_0 is identified as the point for reconciliation. If POD ≠ Ø then each $C_i \in$ POD can be used to start a new dialogue.

Baker's (1998) main hypothesis is that argumentative interactions impose "a special type of interactive and interactional pressure on participants (to resolve the verbal interpersonal conflict, to be internally coherent, to preserve face,...) that may force meanings and knowledge to be refined". So it is that participants in a discussion with an incomplete GAS may use their discussion to further elaborate the GAS.

6.4 Multi-participant dialogues

One of the advantages of the dialogue above is that it can be easily modified to suit many participants. Consider the following.

Definition *An m-participant dialogue based on a GAS $\mathcal{G}$ is a finite nonempty sequence of moves where move$_i$ = (Participant$_i$, $C_i \in A$) ($i > 0$), such that*

1. $A \in A(\mathcal{G})$;
2. *For Player$_i$,..., Player$_m$,* $C^1_{n+1_{vk_1}} = \cdots C^j_{n+1_{vkj}} = \cdots C^m_{n+1_{vkm}}$

then PIC = {C_{n+1}} and POD = Ø
otherwise $C^i_{n+1_{vki}} \neq C^j_{n+1_{vkj}}$ for *i,j* ∈{*1,..., m*} *and PIC = Ø and POD =* {C_{n+1}};
So, compare data.

(a) *If C^1_{n+1} is a leaf node of G then P_1,..., P_m are irreconcilable on data.*
(b) *PIC = Ø and POD = Ø. For each $C_h \in$ signature(I) ⊂ C, P_1,..., P_m compare* $C^1_{hvk_1} \cdots C^m_{hvk_m}$ If $C^1_{hvk_1} = \cdots C^m_{hvk_m}$ *then PIC = PIC ∪ {C_h} else POD = POD ∪ {Ch_h}*

(c) *If POD = Ø then compare* $CVV^1,\ldots, CVV^m$.
If $CVV^i \neq CVV^j$ *then* P_i *and* P_j *are potentially reconcilable through agreement on context variable values of* C_{n+1} *of* A^i *else* P_i *and* P_j *are potentially reconcilable through agreement on inference to* C_{n+1} *of* A^i.
(d) *If POD* $\neq$ *Ø then a new dialogue starts for each* C_h *in POD.*

6.5 Complete dialogues

We now consider how a complete dialogue based on the GAAM as described in the example above implements the eight-stage model for deliberation dialogues. We use the same set of locutions with their form adapted to suit the constructs of the GAAM. They become:

- *open dialogue*: A participant proposes opening the dialogue to consider the matter in question (top level claim)
- *enter dialogue*: Other participants indicate a willingness to join the dialogue.
- *propose*: Participants *select a node*
- *assert*: Participant asserts value for claims
- *prefer*:The preference for one participant's claims over those of another participant is not used in these dialogues as it relates to some form of evaluation. It may be used in determining agreement between a set of participants that have reasoned towards different actions (values for the top level claim in $\mathcal{G}$).
- *ask_justify*: A participant asks another participant to provide a justification for their value. This is achieved by prompting for data item values.
- *move*: A participant can propose that each participant pronounces on whether they assert *an* action at the top level claim value decided on by the group.
- *retract*: A participant retracts a previous locution,
- *withdraw_dialogue*: A participant announces her withdrawal from the dialogue to deliberate further on the matter privately.

Once a dialogue opens and another participant enters, the progression of the dialogue is quite structured. Consider the progression below:

1. *open dialogue*
2. *enter dialogue*
3. *propose*

(a) If agreement then select another claim
(b) Otherwise, ask participants to justify their claims
(c) If either participant does not revise their claim with a propose then this claim still remains a point of difference.
(d) Otherwise for some child claim Cc, $vk_i \neq vk_j$, so return to the third step with this claim

4. At any stage a participant may *retract*
5. At any stage any participant may *move*
6. At any stage any participant may *withdraw_dialogue*
7. A dialogue terminates when less than two participants have not withdrawn.

In a manner similar to (McBurney et al.) we can conclude that the above supports each of the eight stages of their formal model for deliberation dialogues. Furthermore, the dialogue structure above satisfies Alexy's rules for discourse ethics (Alexy 1972) to the same extent. It also satisfies all but four of Hitchcock's eighteen Principles of Rational Mutual Inquiry (Hitchcock 1991). We would also argue that H5 (Orderliness) is satisfied by virtue of the systematic approach of the dialogue structure.

7 Discussion and remarks

The GAAM makes the following contributions as a framework to support deliberative discourse and reasoning as a generalization of TAS.

1. It abstracts claims into a more general (and computationally useful, variable-value) form, which allows for the expression of a range of views. In doing so, a more general 'matter in question' is captured. This transformation of a specific claim into a more general issue or matter in question sets the scene for the next stage; the finding or adduction of the premises that would be considered relevant to arguing towards a conclusion on the matter in question.
2. At a common sense level the criterion used to decide upon premises (again generalized claim slots) is relevance to inferring a conclusion. This is, however, not the full story as relevance is subjective in nature. The question, 'relevant from whose point of view?' may be legitimately asked. However the GAAM supports a GAS which connects or is associated with a community of reasoners or decision-makers. It does this in a number of ways:

(a) the set of premise slots linked to a claim slot by an inference slot is supposed to allow the presentation of actual arguments that are inclusive of the broad range of perspectives in the community. This requirement is, in practice an approximation to the theoretical requirement of capturing the different frames (perspectives) on the matter in question from the various positions of the participants in the community. This is supported by Wohlrapp (1998), "In general, a conclusion of an argumentation is plausible if it contains a unification of the different frames given to the MIQ (matter in question) by the positions".

(b) the set of premise slots is open to agreement by the community and can be added to at any time.

(c) there are a range of ways of making an inference from the premise slots to the claim slot rather than a unique inference.

3. It separates the structure of reasoning from the details of the inferences. The structure is determined as in (2) above. Permissable inference procedures are determined by the members of the community. Why should the model propose and suggest a choice of many inference procedures within an inference slot? At a philosophical level this is a move away from deductive monism but it is also a move away from the standard dialectical normativity and dialectical rationality. There is no outside rational observer. The participants in general agree on the GAS (premises, structure and inferences) and in specific, decide on the way that these are used in deliberative dialogue. At a more pragmatic level, it is concerned with permitting the expression of different reasoning functions on the premises. One manifestation of this is allowance for different weighing of premises in inferences.
4. The dialogue structures presented in this paper permit freedom in the progression of the dialogue yet provide a procedure for identifying common ground, points of difference and the identification of areas for reconciliation. In the case of a fully developed GAS, agreement can be reached by participants' reasoning leading to the same top level claim by the dialogical process of component dialogues where reasoning for a particular claim is articulated followed by consideration of the other participant's reasoning on that claim and possible revision. When the GAS is variable then dialogue largely proceeds in a similar fashion with some additional proposals for premises (data items). Depending on the level of formality, there may be a need to resort to the judgment of the community on the admissibility of these into the structure.

8 Other approaches

Verheij's (1996) CumulA process-model is different from the GAAM in that it deals not only with forward argumentation or inference but also with the adduction of reasons or justification. Premise-based systems such as in Vreeswijk's model (Vreeswijk 1993, 1997) focus on inference or drawing conclusions from fixed premises. Issue based systems such as Rittel and Webber's (1973) IBIS focus on justification or adducing reasons for a fixed issue. The GAAM separates the adduction of reasons stage from the inference stage in that adduction is used (iteratively) to formulate the GAS and then once the GAS has been developed inferences can be made. In fact the inference stage can be further split into two stages: the determination of admissible inference procedures and then the selection of an inference to a conclusion.

Prakken and Sartor (1996) present a formal framework and logical system for defeasible reasoning for assessing conflicting arguments. An important feature of their system is the assignment of priorities to rules. The priorities are not fixed, but are themselves defeasibly derived as conclusions within the system. This permits modeling debates about choice between conflicting arguments. The proof theory of the system is presented in dialectical style where a proof takes the form of a dialogue between a proponent and an opponent in an argument. An argument is justified if the proponent can make the opponent run out of moves in whatever way the opponent attacks. This is in contrast to the GAAM based dialogues developed above which do not lead to a conclusion of defeat when one participant runs out of moves. Instead the above approach terminates, when having covered the full GAS, each participant has a good picture of points of difference, points in common and opportunities for reconciling these differences. At this stage each participant could ask the system to evaluate the strength of their individual arguments based on criteria for determining strength as discussed in (Yearwood and Stranieri 2006). For example, in the case of the strength of an argument being determined by the number of inference procedures that support the argument and the confidence in each inference procedure, this is somewhat different to a priority being assigned to the inference procedure.

9 Conclusions

A structured approach to reasoning is inherent in the GAAM. In a macro sense the process of reasoning is structured into three stages: in the first stage participants engage in the process of adducing premises for the matter in question—this is an iterative process that generates an agreed tree structure; in the second stage possible sets of inference from premises to conclusions are set out; in the third stage participants use the structure and choose inferences to present their actual reasoning.

There are varied ways in which the GAAM can be used to support and frame deliberative discourse. In complex domains where there is a body of knowledge or guidelines that are used repeatedly to guide reasoning it can be efficient for this to be represented as an almost complete GAS within which participants present their actual arguments. For sole decision makers the GAS provides a normative structure that helps to frame reasoning to a decision as well as transparency for others. In two person deliberative dialogues where a GAS exists then the component dialogues proceed as in Sect. 6.2 and the complete dialogue as in Sect. 6.5. In two person dialogues where there is no established GAS then the dialogue may proceed as in Sect. 6.3. In multi-participant dialogue where there is a GAS then the component dialogues are as described in Sect. 6.4 and the complete dialogue may make heavier use of the move(Pi, action, a) locution.

We have relied on the work of Hitchcock, McBurney and Parsons to demonstrate that these types of deliberation dialogues supported by the GAAM comply with criteria for normative principles for deliberation, specifically, Alexy's rules for discourse ethics and Hitchcock's Principles of Rational Mutual Inquiry and indicated some additional aspects of orderliness over their framework.

The GAAM offers a dynamic template for structuring the pool of reasons relevant to an issue of interest to a reasoning community that is regulated by a community. It is the community accepted GAS that acts to normatively influence both admissible reasoning and the progression of dialectical reasoning between participants. Around this structure can be woven dialogues that are orderly, but flexible and support deliberation. These dialogues may adhere to the two level process of constructing the GAAM and then using it or to interweaving the development of a GAS with a discussion. These provide two different models that have in common a focus on a community determined structure for reasoning that will serve to enable reasoning communities to function effectively in our societies that are continuously increasing in complexity and their need for reasoned deliberation towards action.

We have demonstrated that there can be a range of ways that the GAAM can underpin a dialectical system to support deliberative discourse. The nature of the relationship determines the flexibility that the participants have in the discourse. In a very highly structured domain with a stable GAS participants are more confined to dialogue within the GAS. In a less developed arena where the GAS is less well developed the dialogue and deliberations can proceed in either of two ways. In the first, community completion of the GAS would be required, followed by dialogue within the GAS structure. In the second, completion of the GAS could be interwoven with the formulation of each participant's reasoning. This paper demonstrates that this structure, once developed, supports the development of well justified pieces of reasoning by each individual in a reasoning community and that the process suggested is ethical and deliberative.

Acknowledgments The authors are grateful to Dr. David Hitchcock from the Philosophy Department at McMaster University for carefully reviewing this work and providing suggestions that have greatly helped to improve the paper. This research was supported by the Australian Research Council.

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