Knowledge as Arguments for Facilitating E-commerce Dialogue

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Abstract

In this paper we present our ideas on using generic arguments as a means of representing the shared knowledge that an agent community has. In this approach each agent's beliefs are represented by actual arguments. Because these actual arguments are drawn from a common generic tree, negotiation between agents can be simplified. The mapping between the negotiation protocol, the negotiation object and the agent's decision making model is discussed and lays the groundwork for developing applications based on multiple agents negotiating outcomes. In this paper a simple application in the domain of Tourism where the TOURIST agent completely trusts the TOUR ADVISORY agent is used to illustrate our ideas. We contend that the generic argument framework is an effective representation for underpinning agent negotiation to provide effective decision support in more complex areas.

Key words: Argumentation, reasoning, e-commerce, negotiation, agents, reasoning for facilitating e-commerce.

1 INTRODUCTION

There are many types and functions of software agents and reviews of the field with broad typologies can be found in the article by Nwana [17]. An agent-oriented based approach has been adopted for many e-commerce applications particularly where the interaction within a community of agents (software or humans) is central to the application [13]. Complex tasks such as engaging a user in a meaningful dialogue, can be performed by establishing a community of agents and defining ways in which negotiation between them can occur.

According to Beer and Jennings [2, 14], negotiation is so central to an agent system that perspectives on negotiation can provide a framework for their design. Adopting this view encourages the articulation of three main components; a negotiation protocol, a negotiation object and an agent decision making model. A negotiation protocol specifies the rules that constrain interaction. This includes the permissible participants and allowable exchanges. The negotiation object is a specification of the issues that agents may discuss. In simple negotiations these are pre-specified whereas new issues can emerge during consultation in more complex exchanges. Each agent requires a decision making model in order to select and apply a protocol to a negotiation object.

Three types of approaches have been used to model negotiation; game theory, heuristic strategies and argumentation. Jennings et al [14] prefer the use of argumentation. Parsons and Jennings [18] have developed an argumentation based logic that is used for agents to make claims, justify the claims to other agents and select the most persuasive arguments. The knowledge representation that underpins their approach is based on clauses of first order logic and they include a non-monotonic

inference mechanism. Their logic is based on a structure of arguments developed by the philosopher Stephen Toulmin [25].

Most researchers that apply the Toulmin structure do not adopt the original structure but vary it in one way or another according to a survey by Stranieri and Zeleznikow [23]. In this paper a variation of the Toulmin structure is presented that is based on a distinction between *generic arguments* and *actual arguments*. *Generic arguments* are applied to represent shared knowledge within a community of agents and *actual arguments* represent a particular agent's beliefs. A knowledge representation frame based on the generic/actual argument structure constrains the negotiation object and protocol thereby providing a convenient mechanism for modelling negotiation.

The generic/actual argument structure has been applied to modelling refugee law [28], family law [22] and copyright law [24]. However, these applications are not agent based and do not model negotiation. This is attempted in this paper in the domain of tourism.

The e-Tourism application describes a framework where software agents engage with tourists and tour operators in order to develop a tour itinerary. Each software agent represents world knowledge as arguments and interacts with other agents according to dialogue rules. The way in which the generic/actual knowledge representation structure provides a convenient way to implement key aspects of a protocol, object and decision making model is discussed. The paper is organised as follows. Section 2 provides background in argumentation necessary in order to describe the distinction between generic and actual arguments which are presented in Section 3. Section 4 introduces a framework for negotiation based on the generic argument structure. Sections 5 and 6 discuses the e-Tourism application.

2 ARGUMENTATION

A number of researchers in recent years have assumed that knowledge is often used in arguing for or against an assertion and have therefore used argumentation theories to model reasoning. The use of argumentation in this way draws heavily on insights from philosophy. Aristotle presented two types of proofs that he called analytic and dialectic proofs. Dialectic proofs concern opinions that are adhered to with variable intensity. The objective of an exponent of this type of reasoning is to convince or persuade an audience to accept the claims advocated. In contrast, analytic proofs do not involve opinions and differ from dialectic proofs in that conclusions are reached by the application of sound inference rules to axioms. For the philosopher Toulmin [25], dialectics portrays human reasoning processes in the vast majority of practical situations far more appropriately than analytic reasoning. Toulmin advanced a structure for arguments that was constant regardless of the content of the argument. He concluded that all arguments, regardless of the domain, have a structure which consists of six basic invariants: claim, data, modality, rebuttal, warrant and backing. Every argument makes an assertion based on some data. The assertion of an argument stands as the claim of the argument. Knowing the data and the claim does not necessarily convince us that the claim follows from the data. A mechanism is required to act as a justification for the claim. This justification is known as the warrant. The backing supports the warrant and in a legal argument is typically a reference to a statute or a precedent case. The rebuttal component specifies an exception or condition that obviates the claim.

Argumentation has been used by researchers in two distinct ways; to structure knowledge [6], [15], [1], [4], and to model dialectical reasoning [10], [20], [19], [12], [5], [11], [26] and [8]. However, despite the immediate appeal of TAS as a convenient frame for representing knowledge, most researchers that use Toulmin structures to represent knowledge vary the original structure. In the next section we illustrate the variation we have used.

3 GENERIC ARGUMENTS AND KNOWLEDGE REPRESENTATION

In trying to acquire and represent knowledge to practically support the tasks of reasoning, justifying and document drafting primarily within legal domains we have modified the basic Toulmin argument structure. An important aspect of our modification is the principle that most arguments, reasoning or justifications within these domains can be represented as a set of *generic arguments* which link together to form a tree or graph structure. Each generic argument represents a class of actual arguments that may be made and structurally embodies the components that go towards shaping well considered decision making in uncertain domains.

3.1 Generic arguments

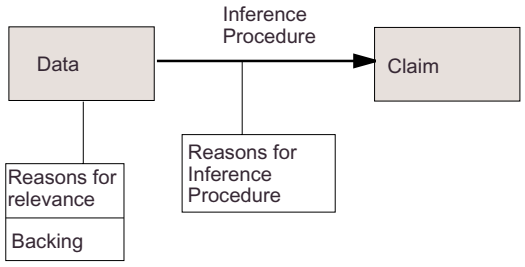

Figure 1: A basic outline of our version of a Toulmin argument

Figure 1 represents the basic template for the knowledge representation we call a *generic argument*. A generic argument is an instantiation of the template that models a group of arguments. The generic argument includes:

- a variable-value representation of the claim with a certainty slot
- a variable-value representation of the data items (with certainty slots) as the grounds on which such claims are made
- reasons for relevance of the data items
- inference procedures that may be used to infer a claim value from data values
- reasons for the appropriateness of the inference procedure.

The idea is that the generic argument sets up a template for arguments that allows the representation of the claim and the grounds for the claim. The claim of a generic argument is a predicate with an unspecified value (which can be chosen from a set when an actual argument is being made). Each data item is also a predicate with an unspecified value which can be taken from a specified set of values. The connection between the data variables and the claim variable is called an inference procedure. An inference procedure is a relation between the data space and the claim space.

It is important to appreciate that the notion of a generic argument can be used to capture a shared understanding about what a core set of arguments in a domain are. The generic argument represents the results of this search as the data items articulated and their reasons for relevance. These are considered to be 'nearly' complete knowledge about the possible grounds for that argument. Establishing the generic arguments in a domain provides considerable structure for developing arguments. Engisch [9] observes that 'reaching a conclusion as such gives rise to a minimum of effort; the main difficulty lies in finding premises for it'. We argue that establishing the generic arguments in a domain is an effective part of acquiring, representing, reasoning and providing justification for decision making.

In our generic argument the Toulmin warrant has been translated to the inference procedure, the reasons for relevance of the data items and the reasons for the inference procedure. The Toulmin rebuttal which is not explicitly represented would be captured within this structure as a different instance argument possibly using a different inference procedure that produces different claim values. Explicitly representing the inference method enables the use of a variety of inference procedures. For example, the method used to infer an assertion in the family law application, Split Up is a rule for some arguments and a neural network for others [22]. Branting [3] provides a framework that captures legal reasoning using both rules and exemplars. In his framework, rules and exemplars differ primarily in that exemplars are much less abstract than rules and can be used to provide a bridge between the abstract rule descriptions and the specific case descriptions. A knowledge representation framework that separates the inference method from other components is very flexible. We argue that our argument based approach captures the granularity of reasoning necessary in the most appropriate way by: collectively deciding on a set of generic arguments; collectively agreeing on the choice of inference mechanisms; allowing actual arguments to be built by instantiating generic arguments; agreeing on the set of values that claims and data items may be drawn from and allowing actual arguments to be built that extend the generic set.

Each generic argument has a claim, data items, reasons for why each data item is relevant, the names of the associated inference procedures and reasons for their appropriateness. Figure 2 shows a generic argument in greater detail. It consists of: a conjunction of data items or slots each with a reason for its relevance and the backing for this; a choice of inference procedures and the reasons for each one of these mechanisms and of course, the claim slot. All data slots act as input to the inference procedures. Each inference mechanism in the inference procedure slot provides a means of reaching a claim value from the input data values. Inference mechanisms may include rule sets, trained neural networks, case-based reasoners or human reasoning. The choice of a particular inference mechanism (other than human inferencing) and the reasons for that inference procedure provide a reason for arriving at a particular claim value. In the case of human inferencing there will still be a need to provide a justification for the claim. At the generic argument level this explanation cannot be given.

Figure 2 also includes *certainty* slots for each data item, claim and inference procedure. These recognise that there is uncertainty in the processes of developing actual arguments. The certainty values are assigned when values are assigned in the process of constructing an actual argument. A generic argument is an agreed approximation to a world but still may only be partial knowledge. We do not explicitly put a certainty or confidence value on a generic argument although we permit generic arguments to change over time. The structure of generic arguments that describe a domain will not be static. As knowledge within the domain evolves new versions of the generic argument structure will be required. New factors emerge as being relevant to some arguments and new inference procedures may be needed as new legal rules emerge or new cases become precedents. Most actual arguments in a domain are then underpinned by a particular version of the generic argument structure. Figure 2 also depicts variables that are required to capture the context of the generic argument. Context variables are conceptualised as factors that are critical for the appropriate instantiation of actual arguments from the generic template. However, context variables do not directly take part in the reasoning within an argument. For example, the reasoning used to infer claims about tours does not include the geographical region as a data item because the reasoning applies regardless of region.

3.2 Actual arguments

Actual arguments made are instances of a generic argument where each data slot has a value (*data item value*), an inference procedure is chosen and executed to deliver a value for the claim slot (*claim value*). Figure 3 illustrates an actual argument with data values set and a particular inference

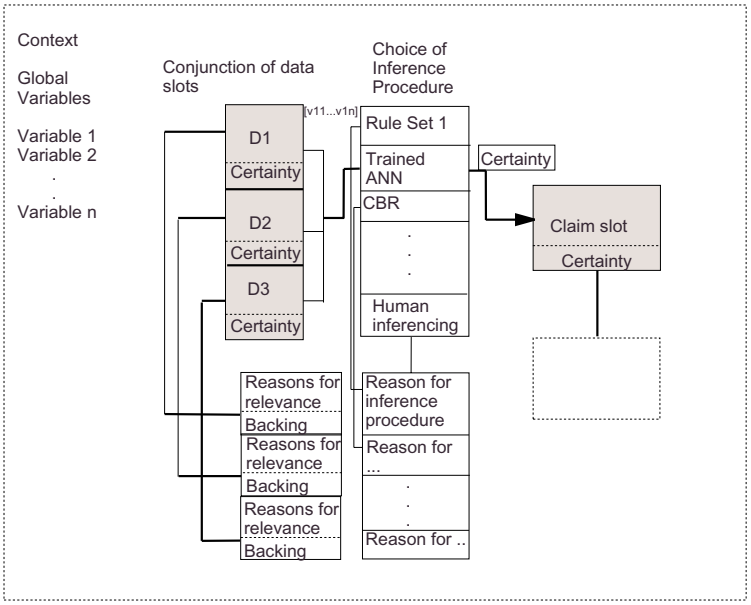

Figure 2: Full representation of a generic argument

mechanism selected. It is an instantiated generic argument from Tourism where the claim is ”The tour is *feasible* for the client”, based on the data items and values given in the diagram. The inference procedure, may simply be a query against a data base of information on tours. The justification can be given as one of the answers that satisfies the query and the appropriate information.

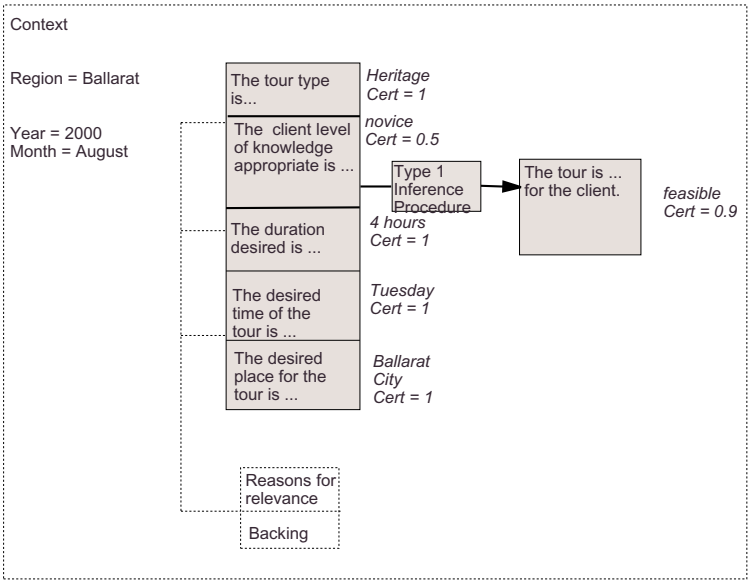

Figure 3: An actual argument in the Tourism domain to support customised delivery of Tourism Information

In the next section, an agent-oriented approach that incorporates the generic/actual argument representation described here is discussed. The use of the generic/actual structure simplifies inter-agent negotiation and constrains decision-making models within each agent so that complex dynamic systems such as the e-Tourism example can be developed.

4 AN AGENT ARCHITECTURE WITH GENERIC/ACTUAL ARGUMENTS

An agent-oriented based approach is appropriate for many e-commerce applications particularly where the interaction within a community of agents (software or humans) is central to the applica-

tion. According to Hauser [13] agent based approaches on the web can be grouped into three categories; those that assist in building communities typically by matching individuals with others with similar interests, those that customise a search for information [eg Farcast www.farcast.com], and those that assist in business transactions. This latter group is represented by shopping assistants [See http://bots.internet.com/s-shop.htm for a list of sites], business facilitators such as auction houses or mediation services [eg. e-mediator http://www.consensus.uk.com/e-mediator.html]. According to Wooldridge and Jennings [27], a precise definition for an agent is difficult to specify. However, key features of the concept of agency for the present study include: *autonomy*, that agent's initiate actions and have some control over their behaviour; *reactivity*, that an agent constantly perceives the environment, decides a course of action and acts on the environment; *social ability*, that agents interact with other agents in order to achieve objectives.

In the e-Tourism sample application, dialogue can occur between three types of agents; tourists, tour advisors and tour operators. The human tourist invokes an instance of a tourist agent on commencing a consultation session. The tour advisor has no human counterpart. The dialogue between the tourist and advisor agents is aimed at realising the community goal of recommending tours the tourist will enjoy. The tour operator invokes an operator agent in order to inform the advisor of tours it operates. A key feature of the approach presented here is that all agents share the same generic argument tree but can instantiate their own actual arguments. In this way, each agent's beliefs are represented by actual arguments, but because these are instances drawn from a common generic argument tree, negotiation can be simplified. Jennings et al [14] note that negotiation underpins any attempt at coordinating multiple agents (human or software). For instance, the architecture for the e-Tourism application is based on an agent-oriented approach where each software agent represents world knowledge as arguments and interacts with other agents according to dialogue rules. An agent based framework that places emphasis on negotiation must include three main components; a negotiation protocol, a negotiation object and an agent decision making model. We discuss each of these components and describe the way in which the generic/actual knowledge representation structure we use provides a convenient way to implement key aspects of a protocol, object and decision making model.

4.1 Negotiation Protocol

According to Jennings et al [14], a negotiation protocol is a set of rules that govern the interaction and includes:

- the permissible players. In an auction negotiation the permissible players are the auctioneer, bidders and sellers but may also include third parties such as independent valuation experts. In the e-tourism system, the permissible players are tour operators, tourists, and the tour advisor. The tourist agent and the tour operator agent interact constantly with the human that invokes them. The tour advisor agent operates more autonomously.

- permissible negotiation states. In an auction, permissible states include ”still accepting bids”, and ”no longer accepting bids”. In the e-tourism system, the permissible states are ”negotiation closed, continuing, paused”.

- events that cause the negotiation state to change. In an English auction system the lack of new bids causes the auction to change from ”still accepting bids” to ”no longer accepting bids”. In E-tourism, the state of ”continuing” changes to ”closed” when the tourist agent is satisfied. In a multiple agent discussion group version of the system, the event ”consensus is reached” is another event.

- valid actions of participants in particular states. Valid actions describe the messages that each agent is permitted to transmit to specified others. In the e-Tourism example, transmissions are

conveyed by speech act theory primitives [21]. The content of the transmission is restricted to the components of an actual argument. For example a transmission speech act INFORM may carry a message that is the claim, claim value and certainty value for the argument depicted in Figure 3.

4.2 Negotiation Object

The object of a negotiation is the range of issues on which agreement must be reached. A negotiation based solely on a single issue such as price is far simpler than one based on multiple issues where each agent has the flexibility to include new negotiation objects at any time. The generic/actual framework imposes a structure on possible issues that facilitate the analysis of differences of belief. Issues are defined as differences in actual arguments between agents. An agent differs from another in any combination of the following:

- claim item values or certainties differ.
- data item values or certainties differ.
- inference procedure selected differ
- claim value reasons differ
- data items differ. This occurs when an agent seeks to modify the generic structure.

Two agents will not disagree on the data items, reasons for relevance of those items, or the claim items in a tree because these components are shared. The advancement of completely new issues is modelled as changes to the generic argument. This is done in two ways, by the addition of a new argument at the leaf of an existing tree or by the addition (deletion) of a data item in an existing argument. In the domain of refugee law, over 200 generic arguments have been identified during a knowledge acquisition exercise with members of the Refugee Review Tribunal. A member's actual argument is represented as an instantiation of the generic arguments, as are an applicant's actual arguments. Differences between the two are clearly apparent when reasoning is structured in this way. Furthermore, all arguments made by members and applicants in over forty decisions explored in that complex domain conformed to the generic arguments identified suggesting that the generic argument was sufficiently expressive and abstract to capture complex reasoning [30]. In the e-Tourism example, the majority of interactions between the human tourist and the tourist agent is directed to eliciting the human's desires as data item values. The simplest implementation of the tourist agent is as a fully trusting agent. As such, the agent trusts that the utterances the human makes are truthful and not malevolent. The tourist agent relays the data items that represent a tourist's preferences to the advisor and negotiates with that agent in order to arrive at a tour plan that will be acceptable to the human. As a fully trusting agent, the tourist agent has a decision making model that adopts the advisor's recommendation (ie. claim value) without question. A sample interaction is provided in section 5. The negotiation object defined as differences in actual arguments becomes more important when there are multiple advisor agents or if the tourist agent is implemented as a non trusting agent.

4.3 Agent's decision making model

The decision making model of an agent acts in accordance with the negotiation protocol and directs its outcomes toward resolving the negotiation object. Within the generic/actual framework, the model dictates how a data or claim value may be ascertained. For example, the tourist agent has a model that prompts the tourist for a value on data items in Figure 3. In addition, other user characteristics can be elicited so that the agent can build up a user model that will assist it

in constructing dialogue. A user model is critical for generating dialogues according to Moore [16] in order to ensure that the vocabulary level, sentence complexity and assumptions about prior knowledge and motivations are appropriate. Jennings et al [14] describe an agreement as a point where a threshold number of agents agree on a solution to the negotiation object. Finding a solution involves a search through agreement space. Moves through this space involve agents suggesting possible solution points, persuading others to move toward the point, or being persuaded to move toward a point. Techniques for searching through the space come from game theory, heuristics such as formulating trade-offs or argumentation. Parsons and Jennings [18] have developed an argumentation based approach that is based on Toulmin structures but differs from our approach in that, there is no generic structure to represent shared knowledge and the Toulmin warrant is interpreted by them as an inference rule and implemented as a logic program. In the generic/actual approach presented here the somewhat ambiguous role of the Toulmin warrant, as a reason for relevance of data items in some situations and an inference procedure in others, is clearly delineated. In the following section, a snapshot of a simple e-Tourism example is presented. This example is kept relatively simple by confining it to the interaction between the human tourist, the tourist agent and the tour advisor agent. It is reasonable to assume that these agents should trust each other and can accept each other's respective claims without question. The interaction between the human tour promoter the tour promoter agent and the tour advisor agent may not be based on mutual trust and requires further discussion.

5 AN EXAMPLE IN E-TOURISM

We are building an application that uses these ideas to facilitate the reasoning for customising the delivery of information on products for tourists. The development of the application so far will be discussed in the next section. Table 1 provides a sample dialogue between the human tourist and the tourist agent as well as some explanation of the agent reasoning and interaction.

AGENT	DIALOGUE	COMMENTS
Human tourist	What organised heritage tours of Ballarat City next Tuesday are available?	TOURIST agent parses the text as speech type 'request'. This agent selects the most appropriate generic argument to make a claim as a response (ie. the one in Figure 3) and instantiates the data item variable tour type with value "heritage". It also instantiates context variables for region, year and month. TOURIST agent is not yet ready to invoke an inference procedure as other data items need to be assigned values, so it prompts for these.
TOURIST	How long would you like the tour to take?	This message is delivered as speech type "request" so the TOURIST negotiation protocol expects an "inform" or "request" act to follow.
Human tourist	No more than 4 hours	TOURIST agent parses this as an "inform" act and fills the value for the second data item in Figure 4.
TOURIST	What level of tour would you like - one for the knowledgeable or the novice?	This message is delivered as speech type "request" so the TOURIST negotiation protocol expects an "inform" or "request" act to follow.
Human tourist	For the novice.	

Table 1: *Dialogue between Human Tourist and TOURIST Agent*

Following the interaction depicted in Table 1, the TOURIST agent now has values for all data items in the argument and could conceivably select an inference procedure from the list available in order

to infer a claim. Assuming that there are a number of inference procedures that differ from one another by the relative importance of each item. For example, an inference procedure that weighed each item equally and allowed no fuzzy matching is equivalent to a database query, perhaps with an additional procedure for ranking results. An inference procedure that assigned a far greater importance to the duration factor may be more appropriate than a database lookup, particularly if the TOURIST agent's model of the user indicated that for this user, ultimate satisfaction is linked to duration. In this way, the selection of an inference procedure could be performed with the use of a user model. However, in this simple interaction, the trusting TOURIST agent prefers to abdicate the duties of applying the inference procedure to infer a claim value to the TOURIST ADVISOR agent. The advantages of doing this are that the TOURIST ADVISOR agent has specialist and up to date information about tour operators. This interaction is shown in Table 2. Furthermore, the same framework can be readily extended to allow multiple tour operators negotiate with each other and the TOURIST agent in order to develop more flexible solutions. In these interactions there may not be complete trust in the interaction. There are two ways of approaching the negotiation in these interactions. One approach would be to invoke a Habermas like [7] philosophy which permits communication based on *strategic action* by the participants. This would require the addition of speech acts to test the validity of the negotiation object. Another approach would be to build the test for credibility and reliability into the generic argument structure within the agents. This would require no additional speech acts but additional data items and claims which would affect the inferencing carried out within each agent. These interactions are the subject of further research.

AGENT	DIALOGUE	COMMENTS
TOURIST	request(TOURIST ADVISOR, claim-value, actual-argument-tour)	This is a request directed at agent TOUR ADVISOR for a claim value given the parameters included.
TOURIST ADVISOR	inform(TOURIST, claim-value, actual-argument-tour, Sovereign Heritage Tours runs half day tours, url=www.sovereign.com.au)	The TOURIST ADVISOR has accepted TOURIST's actual argument and used its own agent decision model to select an inference procedure that accesses a database of tours. The claim value reason certainty values in the actual argument are filled and the entire argument is conveyed back to TOURIST.
TOURIST	Sovereign Heritage Tours runs half day tours that should run next Tuesday. You can find out more from www.sovereign.com.au. Do you think you may be satisfied with that?	This message is delivered as speech type ”request” so the TOURIST negotiation protocol expects an ”inform” or ”request” act to follow.
Human tourist	I am unsure about the novice level.	TOURIST interprets this as a request for information about the relevance of the data item “Client level of knowledge”. So the reasons for relevance can be supplied.
TOURIST	This is important because tour activities and tour guides need to tailor the information to the knowledge level of the group. Would you like assistance in deciding whether you are a novice or expert?	In addition to providing the reason for relevance, TOURIST could now examine the data items of the argument that lead to the claim of novice or expert.

Table 2: *Dialogue between TOURIST Agent and TOURIST ADVISOR Agent*

6 ARGUMENT DEVELOPER AGENT SHELL

As part of projects to support decision making in law we have developed and implemented an 'Argument Developer Agent' shell [29] which allows the building and storage of versions of the generic argument framework within a domain and an interface for the development of actual arguments. The argument shell consists of the following components:

- A generic argument editor that enables a knowledge engineer to enter a tree of generic arguments within a domain. This creates part of both the TOURIST agent and the TOURIST ADVISOR agent.
- An actual argument editor that enables a user to enter actual arguments made by users. This currently identifies the appropriate argument in the generic structure based on the text used by the user in a notepad interface. This is currently being replaced by a dialogue interface to interact with the TOURIST agent.
- An inference engine that can infer a value for a claim from data item values by invoking the procedure embedded in an argument.
- A dialogue generator that models the relationships between arguments such as A supports B, A rebuts C and D, A extends G; This is important for modelling the way in which two or more parties apply arguments in a dialogue.

A knowledge engineer using the argumentation shell first maps out all the generic arguments. The claim of each generic argument except for the culminating one, is a data item for another argument so a tree of arguments is constructed. This generic argument structure forms the basis for both the TOURIST agent and the TOUR advisor agent. The TOURIST agent currently interacts with a human tourist agent via text in a notepad interface which is parsed. This is being developed into a dialogue interface. The shell permits the construction of both agents and the simple trusted negotiation mechanism is being implemented. More complex interactions are also being studied.

7 CONCLUSION

We have presented our ideas on using generic arguments as a means of representing the shared knowledge that an agent community has. In this approach each agent's belief's are represented by actual arguments. Because these instances are drawn from a common generic tree, negotiation between agents can be simplified. The mapping between the negotiation protocol, the negotiation object and the agent's decision making model has been discussed and lays the groundwork for developing applications based on multiple agents negotiating outcomes because knowledge represented as generic/actual arguments helps to: constrain the negotiation protocol; constrain the negotiation objects; constrain the agent's decision making model.

In this paper a simple application in the domain of Tourism where the TOURIST agent completely trusts the TOURIST ADVISORY agent has been used to illustrate the ideas. We contend that the generic argument framework is an effective representation for underpinning agent negotiation to provide effective decision support in more complex areas. The development of this application is continuing and will need to be evaluated when the dialogue components are built.

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