AIF$^+$: Dialogue in the Argument Interchange Format

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Abstract. This paper extends the Argument Interchange Format to enable it to represent dialogic argumentation. One of the challenges is to tie together the rules expressed in dialogue protocols with the inferential relations between premises and conclusions. The extensions are founded upon two important analogies which minimise the extra ontological machinery required. First, locutions in a dialogue are analogous to AIF I-nodes which capture propositional data. Second, steps between locutions are analogous to AIF S-nodes which capture inferential movement. This paper shows how these two analogies combine to allow both dialogue protocols and dialogue histories to be represented alongside monologic arguments in a single coherent system.

Keywords. Argumentation, Dialogue, Interchange, Standards

1. Introduction and Background

Research into argumentation in AI has enjoyed rapid growth over the past ten years, made all the more distinctive by the fact that argumentation-based models have had impact right across the board, from natural language processing, through knowledge representation and multi-agent communication, to automated reasoning and computer support collaborative working. One of the challenges of such wide-ranging models is the need for interoperability – to ensure that the resources developed through argumentation-based CSCW can utilise advances in argumentation KR; to ensure that new models of argument representation can yield to argument-based reasoning mechanisms; to ensure that autonomously created arguments can be communicated using argument-based protocols.

The Argument Interchange Format (AIF) [1] was developed to tackle this challenge. The aim was to develop a means of expressing argument that would provide a flexible – yet semantically rich – way of representing argumentation structures. The AIF was put together to try to harmonise the strong formal tradition initiated to a large degree by [2], the natural language research described at CMNA workshops since 2000, and the multi-agent argumentation work that has emerged from the philosophy of [18], amongst others.

The AIF to date has had significant impact in practical development projects such as the WWAW [9], but in its 2006 form had not integrated modelling of dialogue. This has meant that one important strand of research (spanning philosophy, linguistics, natural language engineering and multi-agent systems) has been excluded from the benefits that the AIF affords. Modgil and McGinnis [6] go some way to addressing this omission. The current paper builds on their work integrating other, more linguistically oriented, models (such as [10] and [20]) to show how an extended version of the AIF, which we call AIF$^+$, can handle dialogic argumentation in the same, broad way that the AIF simpliciter currently handles monologic argument. The motivation for this work can be summarised through philosopher Daniel J. O'Keefe's distinction between argument_1 and argument_2: argument_1 is an arrangement of claims into a monological structure, whilst argument_2 is a dialogue between participants - as O'Keefe [7][p122] puts it, "The distinction here is evidenced in everyday talk by ... the difference between the sentences 'I was arguing_1 that P' and 'we were arguing_2 about Q.' " Clearly there are links between argument_1 and argument_2 in that the steps and moves in the latter are constrained by the dynamic, distributed and inter-connected availability of the former, and further in that valid or acceptable instances of the former can come about through sets of the latter. An understanding of these intricate links which result from protocols and argument-based knowledge demands a representation that handles both argument_1 and argument_2 coherently. It is this that the AIF$^+$ sets out to provide. There are several specific goals for this work:

1. To extend the AIF so that it can support representation of argumentation protocols (i.e. specifications of how dialogues are to proceed).
2. To extend the AIF so that it can support representation of dialogue histories (i.e. records of how given dialogues did proceed).
3. To place little or no restriction on the types of dialogue protocol and dialogue history that can be represented.
4. To integrate the dialogic argument representation of the AIF$^+$ with the monologic argument representation of the AIF.
5. To meet all of 1-4 with the minimum extra representational machinery possible.

There are thus many interesting issues that are *not* being tackled here. Like the AIF, the AIF$^+$ is concerned with representation, not processing. So although there may be any number of software systems that allow the creation or execution of dialogues that conform to a protocol, or that allow the determination of whether or not a given dialogue conforms to a dialogue protocol, the business of the AIF$^+$ is just to represent the data. (This is analogous to the path taken in the AIF: though, for example, it may be possible for a system to compute acceptability according to a given semantics, the task of the AIF is simply to represent the arguments in such a way that acceptability computations can be performed easily). Similarly, the AIF$^+$ maintains a clear separation between the representation of prescriptive or normative structures (in protocol specification) and the representation of actual arguments (in dialogue histories). This again follows the successful pattern of the AIF, wherein the normative structures of inference (in inference rules, schemes, patterns of conflict and preference and so on), are separate from the characterisation of how individual arguments do in fact stand in relation to one another. Finally, though the AIF$^+$ is interested in representing how dialogues should proceed and how they have proceeded, there is no representation of the processing required by, for example, an agent that allowed it to decide what should be said. Again, such tactical and strategic processing is beyond the scope of what the AIF$^+$ should handle.

2. The AIF

The AIF can be seen as a representation scheme constructed in three layers. At the most abstract layer, the AIF provides an ontology of concepts which can be used to talk about argument structure. This ontology describes an argument by conceiving of it as a network of connected nodes that are of two types: information nodes that capture data (such as datum and claim nodes in a Toulmin analysis, or premises and conclusions in a traditional analysis), and scheme nodes that describe passage between information nodes (similar to warrants or rules of inference). Scheme nodes in turn come in several different guises, including scheme nodes that correspond to support or inference (or rule application nodes), scheme nodes that correspond to conflict or refutation (or conflict application nodes), and scheme nodes that correspond to value judgements or preference orderings (or preference application nodes). At this topmost layer, there are various constraints on how components interact: information nodes, for example, can only be connected to other information nodes via scheme nodes of one sort or another. Scheme nodes, on the other hand, can be connected to other scheme nodes directly (in cases, for example, of arguments that have inferential components as conclusions, e.g. in patterns such as Kienpointner's [3] "warrant-establishing arguments"). The AIF also provides, in the extensions developed for the WWAW [9], the concept of a "Form" (as distinct from the "Content" I- and S-nodes). Forms allow the ontology to represent uninstantiated definitions of schemes at the next layer down.

A second, intermediate layer provides a set of specific argumentation schemes (and value hierarchies, and conflict patterns). Thus, the uppermost layer in the AIF ontology lays out that presumptive argumentation schemes are types of rule application nodes, but it is the intermediate layer that cashes those presumptive argumentation schemes out into Argument from Consequences, Argument from Cause to Effect and so on. At this layer, the form of specific argumentation schemes is defined: each will have a conclusion description (such as "A may plausibly be taken to be true") and one or more premise descriptions (such as "E is an expert in domain D").

It is also at this layer that, as [9] have shown, the AIF supports a sophisticated representation of schemes and their critical questions. In addition to descriptions of premises and conclusions, each presumptive inference scheme also specifies descriptions of its presumptions and exceptions. Presumptions are represented explicitly as information nodes, but, as some schemes have premise descriptions that entail certain presumptions, the scheme definitions also support entailment relations between premises and presumptions.

Finally the third and most concrete level supports the integration of actual fragments of argument, with individual argument components (such as strings

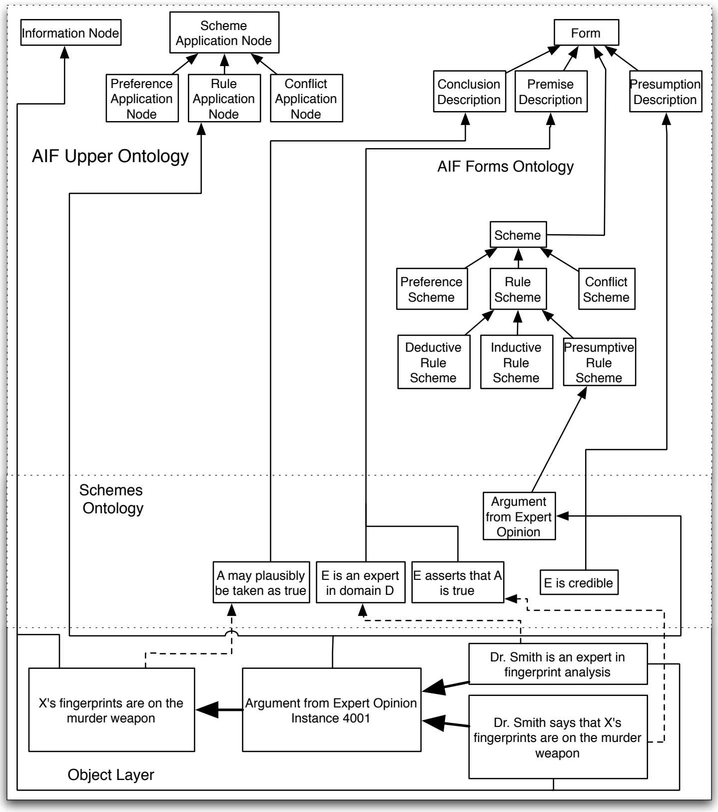

Figure 1. Three levels of AIF representation.

of text) instantiating elements of the layer above. At this third layer an actual instance of a given scheme is represented as a rule application node – the terminology now becomes clearer. This rule application node is said to fulfill one of the presumptive argumentation scheme descriptors at the level above. As a result of this fulfillment relation, premises of the rule application node fulfill the premise descriptors, the conclusion fulfils the conclusion descriptor, presumptions can fulfill presumption descriptors, and conflicts can be instantiated via instances of conflict schemes that fulfill the conflict scheme descriptors at the level above. Again, all the constraints at the intermediate layer are inherited, and new constraints are introduced by virtue of the structure of the argument at hand. Figure 1 shows diagrammatically how all of these pieces fit together (but it should be borne in mind that figure 1 aims to diagram how the AIF works - it is a poor diagram of the argument that is represented). The "fulfils" relationships are indicated by dotted lines, and inference between object layer components (i.e. the arguments themselves) by thick lines. Remaining lines show "is-a" relationships. Note that many details have been omitted for clarity, including the way in which scheme descriptions are constructed from forms.

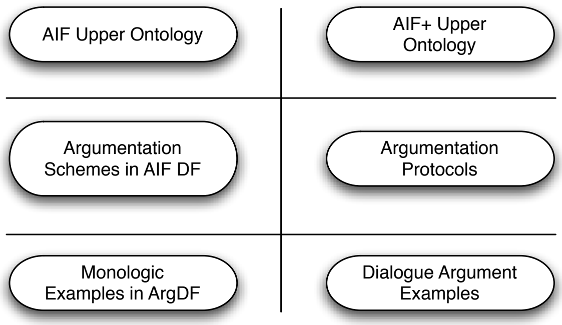

Figure 2. Ontological Architecture

3. Architecture

The aim for the AIF$^+$ is to preserve and exploit the three levels of representation developed in the AIF. First, the upper ontology will need extending to cope with concepts that are unique to dialogue. Second, we will need some examples of dialogue protocol forms to govern what happens at the object level. And finally, we will need an example that provides the argument material conforming to the protocol and using the concepts from the upper ontology. This mapping is summarised in figure 2 and forms the structure for the remainder of the paper.

4. AIF$^+$: Ontological Extensions

We base the construction of the ontological extensions required for the AIF$^+$ on the expanded version of the AIF presented in [9], and specifically, upon the treatment there of argumentation schemes.

The fundamental building blocks of dialogues are the individual locutions. In the context of the AIF, Modgil and McGinnis [6] have proposed modelling locutions as I-nodes. We follow this approach primarily because statements about locution events are propositions that could be used in arguments. So for example, the proposition, *Joseph says, 'COMMA-08 will be in Toulouse'* could be referring to something that happened in a dialogue (and later we shall see how we might therefore wish to reason about the proposition, *COMMA-08 will be in Toulouse*) – but it might also play a role in another, monologic argument (say, an argument from expert opinion, or just an argument about Joseph's communicative abilities).

Associating locutions exactly with I-nodes, however, is insufficient. There are several features that are unique to locutions, and that do not make sense for propositional information in general. Foremost amongst these features is that locutions often have propositional content (there are, arguably, exceptions, such as the locutions, 'Yes,' and 'No'). The relationship between a locution and the proposition it employs is, as Searle [14] argues, constant - i.e. "propositional content" is a property of (some) locutions. Whilst other propositions, such as might be expressed in other I-nodes, may also relate to further propositions, (e.g. the proposition, *It might be the case that it will rain*) there is no such constant relationship of propositional content. On these grounds, we should allow representation of locutions to have propositional content, but not allow it for I-nodes in general – and therefore the representation of locutions should form a subclass of I-nodes in general. We call this subclass L-nodes. There are further reasons for distinguishing L-nodes as a special case of I-nodes, such as the identification of which dialogue(s) a locution is part of. (There are also some features which one might expect to be unique to locutions, but on reflection are features of I-nodes in general. Consider, for example, a time index - we may wish to note that Joseph said, 'COMMA-08 will be in Toulouse' at 10am exactly on the 1st October 2007. Such specification, however, is common to all propositions. Strictly speaking, *It might be the case that it will rain* is only a proposition if we spell out where and when it holds. In other words, a time index could be a property of I-nodes in general, though it might be rarely used for I-nodes and often used in L-nodes).

Given that locutions are a (subclass of) I-nodes, according to the AIF$^+$, they can only be connected through S-nodes. Modgil and McGinnis [6] do not tackle ontological concerns directly, but assume that a new type of S-node will suffice. There is a missed opportunity here. There is a direct analogy between the way in which two I-nodes are inferentially related when linked by an RA-node, and the way in which two L-nodes are related when one responds to another by the rules of a dialogue. Imagine, for example, a dialogue in which Joseph says, 'COMMA-08 will be in Toulouse' and Simon responds by asking, 'Why is that so?'. In trying to understand what has happened, one could ask, 'Why did Simon ask his question?' Now although there may be many motivational or intentional aspects to an answer to this question, there is at least one answer we could give purely as a result of the dialogue protocol, namely, 'Because Joseph had made a statement'. That is to say, there is plausibly an inferential relationship between the proposition, *'Joseph says COMMA-08 will be in Toulouse'* and the proposition, *'Simon asks why it is that COMMA-08 will be in Toulouse'*. That inferential relationship is similar to a conventional inferential relationship, as captured by an RA node. Clearly, though, the grounds of such inference lie not in a scheme definition, but in the protocol definition. Specifically, the inference between two L-nodes is governed by a *transition*, so a given inference is a specific application of a transition. Hence we call such nodes transition application nodes (TA-nodes), and define TA-nodes as a subclass of RA-nodes.

Finally, by analogy to the ontological machinery of argumentation schemes, we can view transitions as forms that are fulfilled by TA nodes. These transitions, however are not all there is to a protocol. A protocol defined by a set of transitions in this way is equivalent in power to a finite state automaton (though the transitions in AIF$^+$ correspond to transition-state-transition tuples in an FSA). Alternative models of protocol composition (such as the declarative language LCC [12], or the representation techniques of, e.g. Dooley graphs [8], or the use of commitment-based semantics [18] and their computational representation [19], [20]) range in sophistication from finite state to Turing complete. In order to represent these protocols in full, therefore, more is required. The most straightforward approach derives from AI planning, specifying pre- and post-conditions on operators that correspond to locutions. These protocol components specify the general forms that locutions can take, and are composed to form transition forms. But in addition, many protocols associate additional constraints with what are here called transitions. A good example is Mackenzie's DC protocol [4], which constrains, for example the *Resolve* locution, when coming after a *Why* locution such that the content of the latter must be an "immediate consequence" of the former. Immediate consequence is a logical notion, but one which only comes into play in the response by one particular locution to another. This specific transition scheme can thus be interpreted as having a presumption (about immediate consequence) in much the same way that specific inference schemes have presumptions (about, for example, the veracity of an expert).

So, in just the same way that an RA-node fulfils a rule of inference scheme form, and the premises of that RA-node fulfil the premise descriptions of the scheme form, so too, a TA-node fulfils a transitional inference scheme form, and the locutions connected by that TA-node fulfil the locution descriptions of the scheme form. The result is that all of the machinery for connecting the normative, prescriptive definitions in schemes with the actual, descriptive material of a monologic argument is re-used to connect the normative, prescriptive definitions of protocols with the actual, descriptive material of a dialogic argument.

With these introductions, the upper ontology for AIF$^+$ is complete. For both I-nodes and RA-nodes, we need to distinguish between the old AIF class and the new subclass which contains all the old I-nodes and RA-nodes excluding L-nodes and TA-nodes (respectively). As the various strands and implementations of AIF continue, we will want to continue talking about I-nodes and RA-nodes and in almost all cases, it is the superclass that will be intended. We therefore keep the original names for the superclasses (I-node and RA-node), and introduce the new subclasses I$'$ and RA$'$ for the sets (I-nodes L-nodes) and (RA-nodes TA-nodes) respectively. The upper ontology is thus as in figure 3.

5. Protocol Representation

To show how the AIF$^+$ supports both argument_1 and argument_2 in such a way that the links between them can be captured, we need an example of a dialogue protocol. For this initial exploration, we need a protocol that is sufficiently simple to be clear, whilst sufficiently sophisticated to exercise the capabilities of the AIF$^+$. A suitable protocol can be found in [11] which extends a simple dialectical game based upon the formal game CB [17] to incorporate argumentation schemes and critical questions. This protocol is called Argumentation Scheme Dialogue, or ASD – but it is important to emphasise, that this is simply an example of a protocol that can be represented in AIF$^+$. We are not arguing either for the utility of ASD, nor for any special role for it in the general theory of AIF$^+$. The rules of ASD are as follows:

Locution Rules

i. Statements Statement letters, S, T, U, ..., are permissible locutions, and truth functional compounds of statement letters.

ii. Withdrawals 'No commitment S' is the locution or withdrawal (retraction) of a statement.

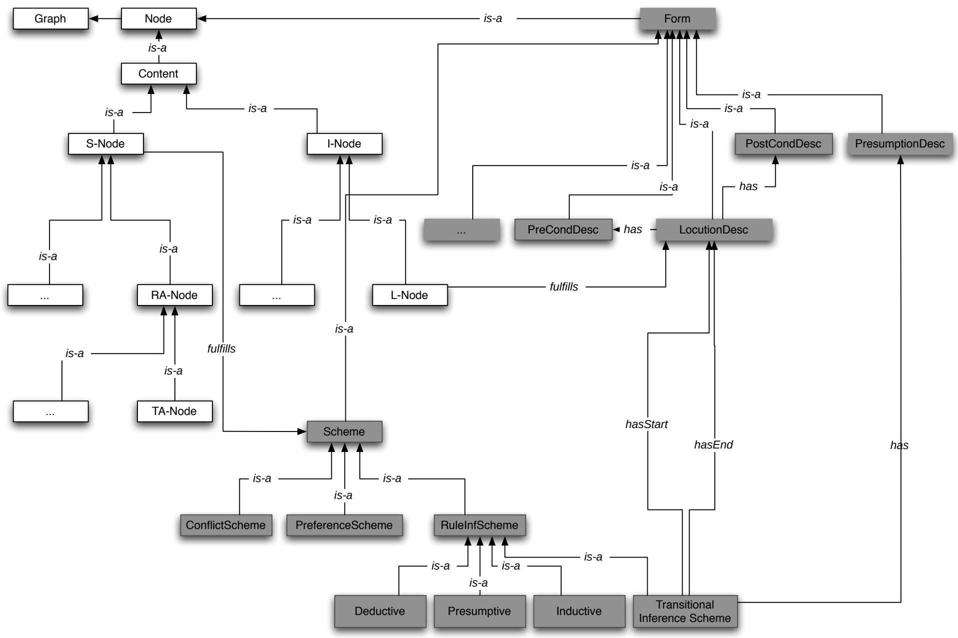

Figure 3. Upper ontology of AIF$^+$

iii. Questions The question 'S?' asks 'Is it the case that S is true?'

iv. Challenges The challenge 'Why S?' requests some statement that can serve as a basis in (a possibly defeasible) proof for S.

v. Critical Attacks The attack 'Pose C' poses the critical question C associated with an argumentation scheme.

Commitment Rules

i. After a player makes a statement, S, it is included in his commitment store.

ii. After the withdrawal of S, the statement S is deleted from the speaker's commitment store.

iii. 'Why S?' places S in the hearer's commitment store unless it is already there or unless the hearer immediately retracts his commitment to S.

iv. Every statement that is shown by the speaker to be an immediate consequence of statements that are commitments of the hearer via some rule of inference or argumentation scheme A, then becomes a commitment of the hearer's and is included in the commitment store along with all the assumptions of A.

v. No commitment may be withdrawn by the hearer that is shown by the speaker to be an immediate consequence of statements that are previous commitments of the hearer.

Dialogue Rules

R1. Each speaker takes his turn to move by advancing one locution at each turn. A No Commitment locution, however, may accompany a Why-locution as one turn.

R2. A question 'S?' must be followed by (i) a statement 'S', (ii) a statement 'Not-S', or (iii) 'No Commitment S'.

R3. 'Why S?' must be followed by (i) 'No commitment S', or (ii) some statement 'T' where S is a consequence of T.

R4. After a statement T has been offered in response to a challenge locution, Why S?, then if (S, T) is a substitution instance A of some argumentation scheme of the game, the locution pose(C) is a legal move, where C is a critical question of scheme A appropriately instantiated.

R5. After a 'Pose C' move, then either (a) if C is an assumption of its argumentation scheme, the move is followed by (i) a statement 'C', (ii) a statement 'not-C', or (iii) 'No commitment C', or (b) if C is an exception to its argumentation scheme, the move is followed by (i) a statement 'C' (ii) a statement 'not-C' (iii) 'No commitment C' , or (iv) 'Why not-C?'

In the AIF$^+$ representation of ASD, there are five LocutionDesc nodes which correspond to the five available locutions specified in the ASD locution rules. There are also six explicit transitions, composed from these locutions, which involve particular constraints or presumptions (transitions which are simply inferable from the locutions themselves are captured by a generic, unconstrained transition scheme in much the same way that unspecified inference is captured by a generic rule of inference scheme). For example in ASD a Question locution may be followed by either a Statement or a Withdrawal. In the case of a Question $\rightarrow$ Statement sequence, the Statement is linked to the preceding Question locution by virtue of the Response transitional inference scheme. When such a *response transition* occurs there is a presumption associated with the transition, that the statement which is uttered in answer to the question actually fulfills the question $\rightarrow$ answer relationship. The locutions of ASD and the explicit transitions associated with them are illustrated in figure 4 which shows the AIF$^+$ upper ontology applied to the ASD formal game.

6. Dialogue Representation

In the example ASD dialogue provided in [11], there appears the following exchange:

(L4) Wilma: Well do you remember that "expert" piece that Alf wrote in *South Western Ontario Philosophy Monthly* that said that most Canadian philosophers go to OSSA?
(L5) Bob: Yes, I remember.
(L6) Wilma: Well Alf should know, so we can take it that most Canadian philosophers do indeed go.
(L7) Bob: Yes, but he'd have a biased opinion.
(L8) Wilma: Why do you think he's biased?

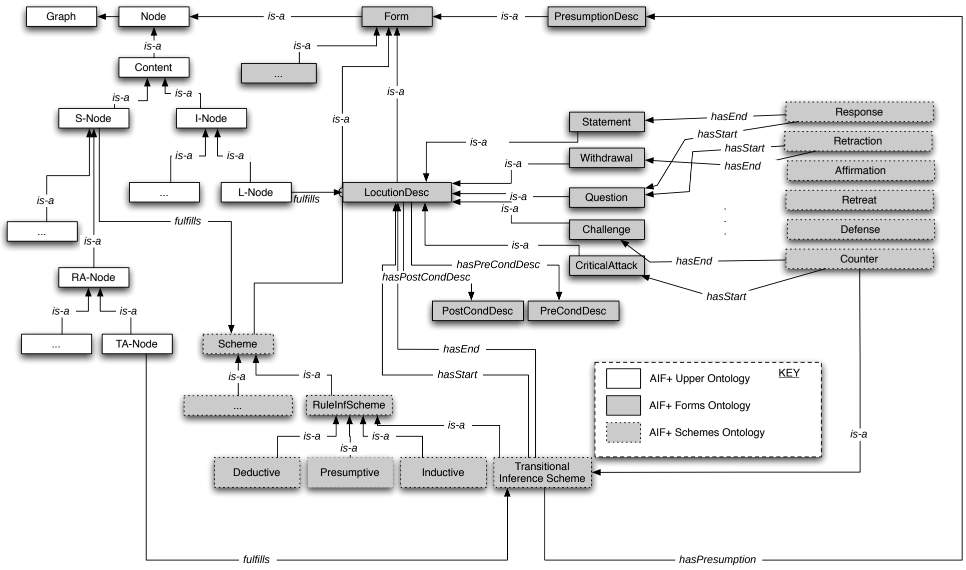

Figure 4. AIF$^+$ representation of ASD

(L9) Bob: Er, not sure- OK so what if he wasn't biased? So what?

As shown in [11], this may be represented in formal ASD terms as follows-

(L4) Wilma: (Alf said most Canadian philosophers go to OSSA)? [Question]
(L5) Bob: (Alf said most Canadian philosophers go to OSSA). [Statement]
(L6) Wilma: (Most Canadian philosophers go to OSSA). [Statement]
(L7) Bob: pose(Alf is unbiased). [Critical Attack]
(L8) Wilma: why(not(Alf is unbiased))? [Challenge]
(L9) Bob: no-commitment(not(Alf is unbiased)). [Withdrawal][1]

In this representation, the locutions and their propositional content are easily distinguishable – at (L4), for instance, the locution is "(Alf said most Canadian philosophers go to OSSA)?", while its propositional content is simply "Alf said most Canadian philosophers go to OSSA".

The AIF$^+$ characterisation of this dialogue history is illustrated in figure 5, which falls into two main sections connected by the 'has-content' links on the right of the figure. The lower section represents the arguments appealed to during the dialogue – they are conventional AIF material. The upper section represents the actual dialogue itself. The solid-bold-bordered elements represent object-layer entities (capturing the actual data), the grey elements represent intermediate-layer entities (capturing protocols and schemes) and the dashed-bordered elements represent upper-ontology entities (capturing AIF$^+$ concepts). Some detail is omitted from Figure 5 for clarity - a fuller account of the monologic aspects of the scheme, for example, are given in [9, pp. 18-19].

[1] In [11] L9 is erroneously listed as the *statement* "(Alf is unbiased).".

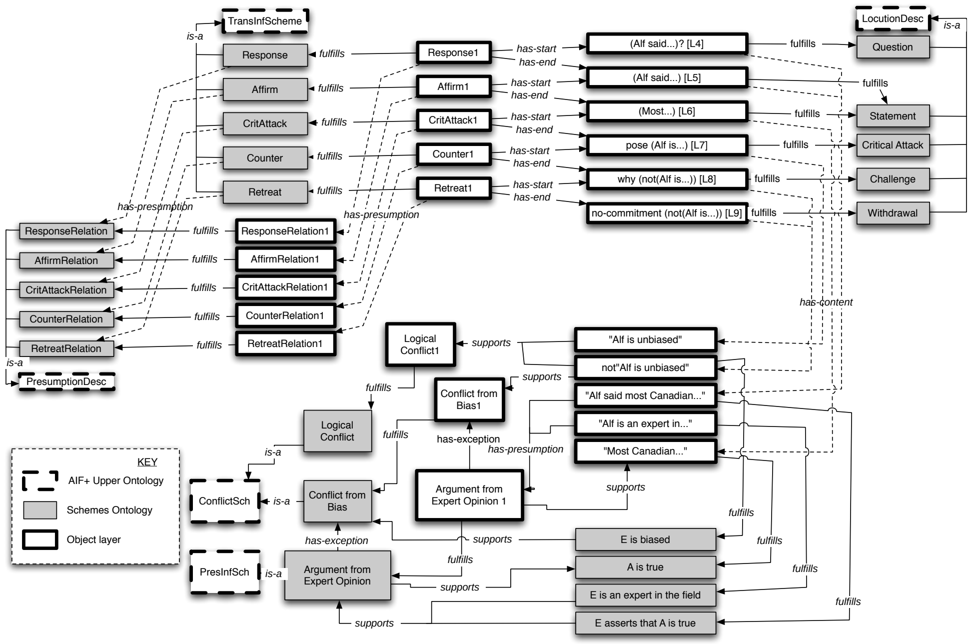

Figure 5. AIF$^+$ representation of ASD dialogue

7. Putting it Together

We have produced a formal description using the Web Ontology Language OWL for both the upper-level ontology shown in figure 3 and the ASD dialogue ontology shown in figure 4. The availability of dialogue game rules in the form of OWL ontologies makes possible the machine processing of dialogue games. In particular, two types of software are under development that make use of these ontologies. The upper-level ontology provides a general framework from which any rule set for any dialogue game can be written by deriving classes from LocutionDesc that describe the particular types of locutions that are permissible in that type of game. The transitional rules between locutions can be formalized by deriving specialized classes from the Transitional Inference Scheme class. Appropriate transition rules are then defined by creating OWL properties corresponding to the 'hasStart' and 'hasEnd' edges for each transitional inference scheme.

We have given one example of this in the present paper in the form of the ontology for the ASD game. However, this was derived "by hand" here by first sketching out the required diagram on paper and then building a specific OWL ontology from this diagram using Protégé. Although Protégé is relatively easy to use, it is not designed specifically for the production of class hierarchies describing dialogue games. A customized software package that allows the user to build the diagrams for a specific rule set and then generate the OWL automatically from the diagram would clearly be useful here. Such a package would be based on the upper-level ontology described in this paper and available as an OWL file.

The second computational application of the theory described in this paper is in the recording of the locutions in an actual dialogue. Once we have produced the ontology for a specific dialogue game such as ASD and formalized this as in OWL, we can then use the OWL source to execute an instance of a dialogue based on the rules for that game. A software package could provide a graphical interface that allows the user to interact with a computer partner in carrying out a dialogue that is constrained by the rules of the game.

8. Conclusions

There have been many examples of generalised machine-representable dialogue protocols and dialogue histories, e.g. [13], [16], but these approaches do not make it easy to identify how the interactions between dialogue moves have effects on structures of argument (i.e. argument_1), nor how those structures constrain dialogue moves during argument (i.e. argument_2). Though there are still challenges that the AIF$^+$ faces in its expressivity and flexibility, we have shown that representing complex protocols that are commitment-based and involve presumptive reasoning forms is straightforward, and that the ways in which those protocols govern or describe dialogue histories is directly analogous to the ways in which schemes govern or describe argument instances. These strong analogies provide ontological parsimony and simplify implementation. This is important because AIF$^+$ representations, like their AIF predecessors, are far too detailed to create by hand, and the range of software systems will stretch from corpus analysis to agent protocol specification, from Contract Net [15] through agent ludens games [5] to PPD [18]. The success of AIF and AIF$^+$ will be measured in terms of how well such disparate systems work together.

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