Mapping Persuasive Dialogue Games onto Argumentation Structures

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Abstract. This paper reports on some prelimary research into how software tools like InterLoc can be used as an interface to the World Wide Argument Web (WWAW) and how the WWAW in return can provide a useful resource to agents acting within InterLoc. Two persuasive dialogue games, the human-oriented Critical Reasoning Game (CRG) from InterLoc and the philosophy-based agent-oriented game for permissive persuasion named PPD_0 are compared using the Dialogue Game Description Language (DGDL) as an interlingua. The expressiveness of each game is investigated by mapping output dialogues onto argumentation structures represented in the Argument Interchange Format (AIF).

1 INTRODUCTION

This paper reports on preliminary research into developing persuasive online software systems that integrate naturalistic human dialogues, thus spurring increased user engagement, with formally structured argumentation, supporting automated processing by intelligent agents and interconnection of resources online.

InterLoc [4] is software that can be used to support dialogues between groups of users and enable them to interactively explore a topic domain. This has been used thus far in a primarily educational context to facilitate debate between students. This approach can be extended through the use of intelligent tutor agents to enable new domain knowledge to be introduced into the student dialogues enabling the students to explore various paths through the topic and increasing their knowledge. Tutor agents could also be used to scaffold and direct the dialogues so that important topics were covered in sufficient depth or to ensure that the dialogue was steered towards the conclusions that the tutor wishes for the students to discover. Additionally, intelligent conversational agents could play the role of a devils advocate in an adversarial dialogue in which the students defend a given position based upon their knowledge of the domain or in which the agent tries to persuade the students to accept a position that differs from their starting position.

Recently there has also been increasing interest in online argumentation, for example MAgtALO [5] provides an interface for human-agent dialogue whereas ArgDF [3] provides an interface for constructing arguments using argumentation schemes [6]. Some aspects of online argumentation systems, for example the user facing interfaces like that in MAgtALO, suggest a good way to usefully deploy well-reasoned persuasive argumentation. By adopting natural interfaces, that support naturalistic human interaction, users can explore a problem domain, and can be supported and guided towards well-reasoned conclusions, a form of gentle persuasion technology rather than "hard sell" persusasion.

There has also been broad interest in the underlying formal representations that support the widespread sharing and interchange of argumentative resources in online systems. This is useful, not only to support the development and deployment of persuasive argumentation-based interfaces, but also to support more advanced online argumentation processing. Work towards this end has culminated in the nascent Argument Interchange Format (AIF) [1] used to record and share argument resources and a foundational element of the proposed World Wide Argument Web (WWAW) [2].

Initially our research has investigated the argumentative structures that can be extracted from InterLoc dialogues. Our aim in this task is to investigate the suitability of InterLoc as an interface to the WWAW, both as a means to elicit new arguments into the system, but also as a way for humans to explore existing WWAW argument resources using a naturalistic interface. Further to this we have investigated dialogue games from argumentation theory that are useful for implementing agent argumentation, in particular we have investigated dialogue game protocols that can be used to regulate persuasion dialogues according to the criteria of Walton and Krabbe [7].

The aim is to be able to incorporate argumentative intelligent agents into WWAW interfaces, such as InterLoc, without compromising the human friendly aspects of the current InterLoc interaction protocols. To achieve this we aim to balance the more expressive dialogue protocols which support naturalistic human dialogical interaction against the more formally structured protocols that are used in intelligent conversational agents. By doing this we propose the construction of protocols that are sufficiently expressive to allow naturalistic human interaction without introducing significant cognitive overhead but which are also sufficiently structured and formally underpinned to support support agent interaction.

2 TECHNOLOGIES

This research integrates a number of extant technologies from the domains of educational software and argumentation theory. In our preliminary work we have drawn together a range of theoretical tools which we are exploring with the aim of assembling them into a cohesive software architecture to meet the goals discussed in section 1. Our exploration of technologies has thus far been confined to evaluating two dialogue games, the Critical Reasoning Game (CRG) [4] and the Permissive Persuasion Dialogue game (PPD_0) [7]. To support the comparison and analysis of these games other technologies have been adopted, the Dialogue Game Description Language (DGDL) for describing disparate protocols using a common language, and the

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Argument Interchange Format (AIF) for representing the outcome dialogues produced from the dialogue games.

CRG is an interaction protocol used in InterLoc. This is a human-oriented dialogue game based interaction protocol which specifies a permissive, free-ranging dialogue between numerous locutors. An advantage of this protocol is that it is flexible, expressive and permissive and scaffolds dialogues by suggesting ways that the dialogue *can* develop rather than ways that it *must* develop. However this syntactical permissiveness and the lack of a semantic model provides little structure with which to support an intelligent agent interacting with the human locutors in an InterLoc dialogue.

Dialogue games used in agent communication typically incorporate commitment models. One such dialogue game developed to model permissive persuasion dialogues is PPD_0 which incorporates commitment stores which are used to track the commitments of players with respect to the locutions uttered during a dialogue. In PPD_0 the legal sequences of locutions are defined both in terms of the set of locutions that may follow an earlier locution and also the commitment state of the players. Because of these kinds of rule PPD_0 is relatively heavyweight and restrictive in comparison to CRG but this means that at any given point in a PPD_0 dialogue the set of things that can be said, and therefore the set of alternative utterances that an agent must select from, is much smaller.

Both CRG and PPD_0 are, in their original formulations in [4] and [7] respectively, specified using different mechanisms. CRG is expressed using XML and PPD_0 is expressed in a natural language description. To aid in the comparison of the games, and to reduce the complexity of transcribing rules from one game to another, the Dialogue Game Description Language (DGDL) [8] was used as an *interlingua*. DGDL is a domain specific language for describing dialogue games whose syntax is underpinned by an EBNF grammar. This supports the rapid development of syntactically correct dialogue game descriptions that can be deployed in agent software.

3 THE DIALOGUE GAME DESCRIPTION LANGUAGE (DGDL)

Communication is an important topic within intelligent agent research and is a fundamental factor in the development of robust and efficient multiagent systems. Similarly, argumentation has been recognised as a key component of an agents ability to make decisions using complex, dynamic, uncertain, and incomplete knowledge. Dialectical games are a type of multi-player argumentative dialogue game and provide a mechanism for communication which incorporates argumentative behaviours. However there have been very few tools for working with these games and little agreement over how they should best be described, shared, and reused. The Dialogue Game Description Language (DGDL) [8] is a domain specific language for describing dialectical games and provides a grammar for determining whether a game description is syntactically correct and thus provides a foundation for new tools to support the future development and wider exploitation of dialectical games.

The DGDL grammar supports the syntactically correct description of a wide array of dialectical games, whether extant games or wholly new formulations of rules. Games are described in terms of their *composition*, including specification of participants, turn structure, and commitment stores, their *rules*, regulations that manipulate the game components indirectly, and their *interactions*, the moves that players can make that directly manipulate game components.

To support the comparison of PPD_0 and CRG, the original natural language description of rules was formalised into a DGDL game description as follows:

```
PPD0{
  {turns, magnitude:multiple, ordering:strict };
  { roles, {Speaker, Listener} };
  {players, id:black, roles:{ Speaker } };
  {players, id:white, roles:{ Listener } };
  {store, id:Assertions, owner:black, structure:set, visibility:public };
  {store, id:Assertions, owner:white, structure:set, visibility:public };
  {store, id:Concessions, owner:black, structure:set, visibility:public };
  {store, id:Concessions, owner:white, structure:set, visibility:public };
  {store, id:Dark, owner:black, structure:set, visibility:private };
  {store, id:Dark, owner:white, structure:set, visibility:private };

  {Commencement, scope:initial,
    { move(mandate, next, Assertion, Speaker) } };
  {SpeakerWins, scope:turnwise,
    { if { inspect(in,{p},Assertions,Listener,initial)
    & inspect(!in,{p},Assertions,Listener,current) }
    then { status(terminate,PPD0), assign(speaker, winner) } } };
  {ListenerWins, scope:turnwise,
    { if { inspect(in,{p},Assertions,Speaker,initial)
    & inspect(!in,{p},Assertions,Speaker,current) }
    then { status(terminate,PPD0), assign(listener, winner) } } };

  {Assert, {p},
    { store(add, {p}, Assertions, Speaker)
    & store(add, {p}, Assertions, Listener) } };
  {Concede, {p},
    { if { { inspect(!in, {p}, Concessions, Speaker)
    & inspect(in, {p}, Assertions, Listener) }
    || { inspect(!in, {p}, Concessions, Speaker)
    & { event(last, Request, {p})
    || event(last, Serious, {p}) } }
    then {store(add, {p}, Concessions, Speaker) } } };
  {ElementaryArgument, {p, Q},
    { if { inspect(!in, {p}, Concessions, Listener)
    & event(past, Challenge, {p}, Listener) }
    then { store(add, {p}, Assertions, Speaker)
    & store(add, {p}, Concessions, Speaker)
    & store(add, {Q}, Assertions, Speaker)
    & store(add, {Q}, Concessions, Speaker)
    & store(add, <{p}, Q>, Assertions, Speaker)
    & store(add, <{p}, Q>, Concessions, Speaker) } } };
  {Request, {p},
    { if { inspect(!in, {p}, Concessions, Speaker) }
    then { move(mandate, next, Concede, {p})
    || move(mandate, next, WeakRetraction, {p}) } } };
  {Serious, {p},
    { if{ inspect(!in, {p}, Dark, Listener)
    & { event(last, WeakRetraction, {p})
    || event(last, Challenge, {p}) } }
    then { move(mandate, next, Concede, {p})
    || move(mandate, next, WeakRetraction, {p}) } } };
  {Resolve, {p, q},
    { if { inspect(in, {p}, Concessions, Listener)
    & inspect(in, {q}, Concessions, Listener) }
    then { move(mandate, next, WeakRetraction, {p})
    || move(mandate, next, WeakRetraction, {q}) } } };
  {Challenge, {p},
    { if { inspect(in, {p}, Assertions, Listener)
    & inspect(in, {p}, Concessions, Speaker)
    & event(!past, Challenge, {p}, Listener) }
    then { move(mandate, next, ElementaryArgument, {p, Q})
    || move(mandate, next, WeakRetraction, {p})
    || move(mandate, next, StrongRetraction, {p}) } } };
  {WeakRetraction, {p},
    { if { { inspect(!in, {p}, Dark, Speaker)
    & event(!past, Serious, {p}, Listener)
    & { event(last, Request, {p}, Listener)
    || event(last, Serious, {p}, Listener) } }
    || { inspect(!in, {p}, Dark, Speaker)
    & event(!past, Serious, {p}, Listener)
    & inspect(in, {p}, Concessions, Speaker) } }
    then { store(remove, {p}, Assertions, Speaker)
    & store(remove, {p}, Concessions, Speaker) } } };
  {StrongRetraction, {p},
    { store(remove, {p}, Assertions, Speaker) } };
  {EndTurn, {p},
    { assign(Speaker, Listener) & assign(Listener, Speaker) } };
}
```

Similarly, the XML description of the CRG rules was reformulated into a DGDL description thus:

Unfortunately the CTG DGDL description is quite long and takes up several pages due to its extensive set of locutions. For this reason, only a short but representative extract is presented here which includes the header describing the games components and a selection of interaction rules:

```
CRG{
  { turns, magnitude:single, ordering:liberal };
  { players, min:1, max:undefined };
  { player, id:$PlayerID$, role:speaker };

  {Initial, scope:initial,
    { move(,next,Suggest1) || move(propose,next,Suggest3)
    || move(propose,next,Suggest6) } };

  {Suggest1, {p}, "My idea is", { move(propose,next,Suggest3)
    || move(propose,next,Check6) || move(propose,next,Agree2)
    || move(propose,next,Transform6) || move(propose,next,Agree4) } };
  {Suggest2, {p}, "Just imagine", { move(propose,next,Suggest3)
    || move(propose,next,Check6) || move(propose,next,Agree2)
    || move(propose,next,Transform6) || move(propose,next,Agree4) } };
  {Suggest3, {p}, "What if", { move(propose,next,Agree3)
    || move(propose,next,Transform6) || move(propose,next,Agree2)
    || move(propose,next,Agree4) || move(propose,next,Check8) } };
  {Suggest4, {p}, "How about", { move(propose,next,Check6)
    || move(propose,next,Agree3) || move(propose,next,Transform6)
    || move(propose,next,Agree4) || move(propose,next,Suggest3) } };
  {Suggest5, {p}, "I feel", { move(propose,next,Suggest3)
    || move(propose,next,Check6) || move(propose,next,Agree2)
    || move(propose,next,Transform6) || move(propose,next,Suggest3) } };
  {Suggest6, {p}, "I think", { move(propose,next,Suggest3)
    || move(propose,next,Check6) || move(propose,next,Agree2)
```

```
  || move(propose,next,Transform6) } };
 {Suggest7, {p}, "Let me say more about that", { move(propose,next,Question6)
  || move(propose,next,Check6)
  || move(propose,next,Agree5) || move(propose,next,Agree1) } };
 {Suggest8, {p}, "An example", { move(propose,next,Check6)
  || move(propose,next,Check8) || move(propose,next,Transform7)
  || move(propose,next,Agree5) || move(propose,next,Agree1) } };
 {Question1, {p}, "Why?", { move(propose,next,Suggest7)
  || move(propose,next,Transform6) || move(propose,next,Suggest5) } };
 {Question2, {p}, "Can you say more on that?", { move(propose,next,Suggest7)
  || move(propose,next,Suggest5) } };
 {Question3, {p}, "Does this connect with anything for you?",
  { move(propose,next,Suggest5) || move(propose,next,Transform2)
  || move(propose,next,Maintain2) } };
 {Question4, {p}, "What do you mean when you say?", { move(propose,next,Suggest7)
  || move(propose,next,Transform6) } };
 {Question5, {p}, "Why do you think that?", { move(propose,next,Suggest6) } };
 {Question6, {p}, "Why do you feel that?", { move(propose,next,Suggest5)
  || move(propose,next,Suggest6)
  || move(propose,next,Suggest7) } };
 {Question7, {p}, "What are the possible alternatives?",
  { move(propose,next,Transform6) || move(propose,next,Check4) } };
 {Question8, {p}, "Has anyone got another idea?",
  { move(propose,next,Suggest1) || move(propose,next,Suggest4)
  || move(propose,next,Suggest3) || move(propose,next,Suggest6) } };
}
```

The complete reformulation of CRG is available however along with a description of PPD_0 from the DGDL repository[5].

4 MAPPING DIALOGUES ONTO ARGUMENTATION STRUCTURES

To adopt InterLoc as an interface to the WWAW, arguments expressed in CRG dialogues must be mapped onto AIF and ideally the process by which this occurs should be automated so that the process of taking a CRG dialogue, extracting the arguments, and transcribing them into AIF, is low cost and doesn't require transcription by experts. Similarly for PPD_0, argument structures must be extracted from the PPD_0 dialogues and recorded in AIF.

The initial approach has been to map particular dialogical sequences onto argumentation structures which are subsequently expressed as, and recorded as AIF. For example, in the sequence *Assertion–Challenge–Elementary Argument* from PPD_0, the initial assertion can be interpreted as a position taken by one player upon an issue. The Elementary Argument then provides premises in support of the Assertion. However this does not happen in isolation within a dialogue, that the player provides a conclusion and supporting argument and that they are related utterances, but arises as a result of the dialogical interaction between the players due to the intervening Challenge move. This kind of sequence can be consistently mapped onto an AIF argument structure providing a conclusion and supporting premises, licensed by an intermediate, possibly undefined, argumentation scheme. Similarly in CRG, the sequence *Suggest-Check-Suggest* can be consistently mapped onto an AIF argument.

The following four examples explore simple dialogues on the regulation of financial institutions in both PPD_0 and CRG and map the underlying arguments onto AIF which are then compared. Dialogues I and II illustrate the *Assertion–Challenge–Elementary Argument* and *Suggest-Check-Suggest* mappings discussed earlier.

Dialogue I: PPD_0
1. B: I think there should be greater regulation of financial institutions (assert)
2. W: I'm not so sure (challenge)
3. B: Let me say more; by increasing regulation, we reduce the chance of repeating recent problems (elementary argument)

Dialogue II: CRG
1. B: I think there should be greater regulation of financial institutions (suggest6)
2. W: I'm not so sure (check6)
3. B: Let me say more; by increasing regulation, we reduce the chance of repeating recent problems (suggest 7)

It is of interest that in dialogues I and II the AIF representation of the arguments, illustrated in figure 1, is identical even though the dialogues were generated according to the rules of different games. In this case the AIF enables us to easily compare the arguments expressed in the dialogues.

Dialogues III and IV again illustrate interactions from PPD_0 and CRG that exhibit surface similarity in the actual utterances of the players but yield different AIF mappings as a result of their differing underlying dialogue game protocols.

Dialogue III: CRG
1. B: I think there should be greater regulation of financial institutions (suggest6)
2. W: I'm not so sure (check6)
3. B: So what I think you are saying is that we should not regulate at all, that's crazy! (transform1)
4. W: No, that's not what I'm saying (maintain2)

Dialogue IV: PPD_0
1. B: I think there should be greater regulation of financial institutions (assert)
2. W: I'm not so sure (challenge)
3. B: Are you serious that you don't think there should be more regulation? (extractor serious?)
4. W: I am not committed to there being more regulation! (weak retraction)

In dialogues III and IV, although the locutors have expressed similar things, the commitment model of PPD_0 results in a very different AIF representation of the arguments expressed at that stage in the dialogue as shown in figure 1. In the AIF representation of dialogue III, the argument expressed in the dialogue fragment yields a similar structure to that from dialogues I and II but the conclusion is warranted by a different argumentation scheme. The players end up in conflict causing the introduction of a conflict scheme. Although the source dialogues are superficially similar, the AIF generated from dialogue IV is very different, the retraction at turn 4 causes only the I-node for the content of turn 1 to remain. It should be noted that it appears as though in dialogue IV, arguments introduced into the dialogue by player B are being disregarded because they no longer appear in the AIF representation of the argument, *at that point* during the dialogue. This is a result of the underlying commitment model of PPD_0 which demonstrates how different arguments can be produced as a result of commitment rules, altough the locutions associated with those rules are superficially similar.

The example dialogues demonstrate clear differences between the two dialogue games, CRG and PPD_0. The rules of each game are different and this can be verified through visual inspection both of the original rules and also through comparison of the reformulations into DGDL. These games also yield different dialogues, because certain chains of locutions that are legal in a more expressive game like CRG are either prohibited or not possible in a more structured game like PPD_0. However, a further complication occurs in that the particular rules of an individual game can result in similar dialogues but different underlying argumentation structures once those dialogues are analysed for their argumentative content as demonstrated by the AIF diagrams of the example dialogues.

[5] http://www.arg.computing.dundee.ac.uk/projects/a4a/dgdl/repository/

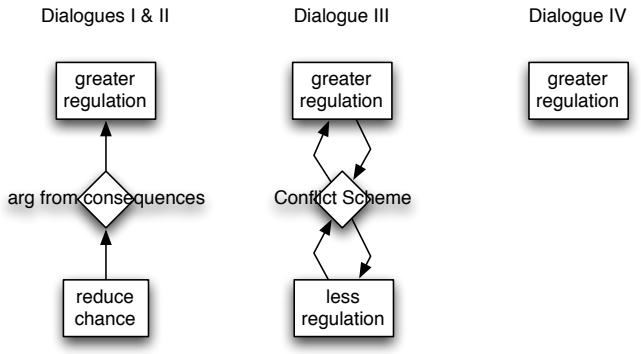

Figure 1. Fragments of AIF diagrams from the example dialogues. Dialogues I and II, produced from PPD_0 and CRG respectively, yield the same underlying AIF argumentation structure from superficially similar dialogues. Dialogues III and IV, whilst superficially similar at the dialogue level, yield different underlying AIF argumentation structures due to the effect of the commitment model of PPD_0 in dialogue IV

5 CONCLUSIONS & FURTHER WORK

It is clear that the expressiveness and naturalness of CRG dialogues contributes to user acceptance of InterLoc, an attribute that would be advantageous if InterLoc is to be used as an interface to the WWAW. However, more restrictive dialogue games like PPD_0 can prove to be better protocols for autonomous agent communication if WWAW resources are to be used to provide knowledge-bases for agents interacting within InterLoc dialogues. An ideal solution would be therefore to select and integrate elements of both games, balancing the expressiveness and naturalness of CRG against the argumentative rigour of PPD_0.

Our future work will therefore explore variant CRG games that incorporate commitment models to make the dialogues more tractable for agents whilst retaining the flexibilty of the current CRG ruleset. This will enable us to pursue the twin goals of adopting InterLoc as a WWAW interface whilst enabling InterLoc users to interact with existing WWAW resources.

REFERENCES

[1] C. Chesnevar, J. McGinnis, S. Modgil, I. Rahwan, C. Reed, G. Simari, M. South, G. Vreeswijk, and S. Willmott, 'Towards an argument interchange format', *Knowledge Engineering Review*, **21**(4), 293–316, (2006).

[2] I. Rahwan, F. Zablith, and C. Reed, 'Laying the foundations for a world wide argument web', *Artificial Intelligence*, **171**, 897–921, (2007).

[3] I. Rahwan, F. Zablith, and C. Reed, 'Towards large scale argumentation support on the semantic web', in *Proceedings of AAAI-07*, pp. 1446–1451, (2007).

[4] A. Ravenscroft, 'Promoting thinking and conceptual change with digital dialogue games', *Computer Assisted Learning*, **23**(6), 453–465, (2007).

[5] C. Reed and S. Wells, 'Using dialogical argument as an interface to complex debates', *IEEE Intelligent Systems Journal: Special Issue on Argumentation Technology*, **22**(6), 60–65, (2007).

[6] D. N. Walton, *Argumentation Schemes for Presumptive Reasoning*, Lawrence Erlbaum Associates, 1996.

[7] D. N. Walton and E. C. W. Krabbe, *Commitment in Dialogue*, SUNY series in Logic and Language, State University of New York Press, 1995.

[8] S. Wells and C. Reed, 'A domain specific language for describing diverse systems of dialogue', *Journal of Applied Logic*, **UNDER REVIEW**, (2008).