

Argumentation and Artifacts for Intelligent Multi-agent Systems

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Outline

1 Motivation/Background

- Motivation
- Multi-agent Systems
- Argumentation Theory

2 Solution/What we have done

- Overview
- On Argumentation Systems
- Argumentation and Artifacts
- Implementation of Dialog and Argumentation Artifacts
- Case Study over ADR Systems

3 Conclusions

4 Publications



Why Argumentation in Complex Software Systems

Reasoning under uncertainty is a human capacity that in complex software system is necessary and often hidden

- symbolic representation of knowledge is strategic to develop intelligent systems

Argumentation is useful

- for complex software system to represent conflicting knowledge in order to enable automatic forms of reasoning under uncertain (such as “*commonsense*” reasoning)
- for the construction for systems for legal reasoning in particular collective decision making, negotiation and Alternative Dispute Resolution (ADR) systems
- for Multi-agent Systems for model the communication between agent in order to exchange information, to resolve disputes and to inform each other of pertinent facts



Multi-agent Systems

MAS is a paradigm to manage complex systems

- composed by autonomously interacting and heterogeneous entities
- A&A meta-model for MAS proposes two fundamental abstraction: agents and artifacts [*Omicini et al, 2005*]

Agent is an autonomous and proactive computational entity situated in an environment

Artifact is a reactive non-autonomous computational entity that reacts to interaction events



MAS and A&A Meta-model

Artifacts are resources or tools that are used by agents
[Activity Theory]

- Social properties are expressed outside agents in the environment across artifacts
- Knowledge is not bounded inside agent but distributed across agents and artifacts

Artifact enables mediated interaction that is useful to

- to coordinate activities
- to achieve social goal
- to support the interaction

A&A meta-model

A&A imposes a rigours and useful engineering principle to divide the system among reactive vs. proactive entities



Argumentation Theory

In origin Argumentation was

- a part of rethoric study: to create and present good arguments that logically to be accepted - it goes up to time of Plato and Aristotle
 - Aristotle introduces the study of rhetoric that is generally understood to be the art or of persuasion using oral visual or written language

Actually Argumentation is

- a formal discipline within Artificial Intelligence where the aim is to make a computer assist in or perform the act of argumentation
- useful where formal logic and classical decision theory are unable to capture the richness of reasoning in domain such as law and medicine



Open Issue on Argumentation

Exist several theoretical and dialectical argumentation systems to reason and to communicate

- an open issue is to define an unified approach for communication and reasoning with argument in an efficient computational model and scalable architecture
- a new perspective is introduced by [*Rahwan et al, 2008*] that lays the basis for World Wide Argument Web WWAW
 - ontology representation of arguments enabling the description of web contents through a network of arguments on the Semantic Web

Interesting example of Web argument application

- 1 Discourse DB forum and
- 2 Semantic MediaWiki



Argumentation and Dialog

Argumentation support dialog games

- dialogue is a mutual conversation between two or more people
- definition of dialogues are among two entities e.g. persuasion, inquiry, negotiation, information seeking, deliberation and eristic [*Walton and Krabbe, 1996*]
- objective to extend the dialogue concept in MAS from two agents to N agents providing an infrastructure and theoretical support



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Overview

Map of our work

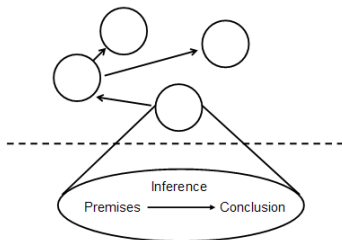
Theory	Argumentation System (AS)	Dialog System (DS)
Model	Co-Argumentation Artifcat (CAA)	Dialog Artifact (DA)
Code	TuCSon	TuCSon
Case Study	Argument Acceptance	Persuasion Dialog



Our Argumentation Approach

The idea

Arguments are build using an underline monotonic logic (with first order language) and non-monotonicity is expressed at the meta level in term of interaction between conflicting arguments



- Abstract Argumentation framework [Dung et al, 1995] - meta level
- Internal structure of argument express with first order language with tuple notation



Argument Representation

Argument is a sequence of inference that leads to conclusion.
It is composed of

- **beliefs** are facts and rules that represent premises
- **inference rules** are labels that represent inference processes such as deduction or induction
- **conclusions** are facts that represent results of the inference process applied to the beliefs

Socrates Argument example

all men are mortal, Socrates is a man $\vdash_{MP}$ *Socrates is mortal*
`arg(name, beliefs([human(Socrates)], [clause(mortal(X), [human(X)])]), inf(MP), conclusion([mortal(Socrates)])) .`



Argumentation System

A conceptual framework for argumentation system consists of five elements [Pranken and Vreeswijk, 2002]

- ❶ a logical language
- ❷ a concept of *argument*
- ❸ a concept of *conflict* among arguments
- ❹ a notion of *defeat* among arguments
- ❺ a notion of *acceptability* of arguments



Argumentation System

Argument is a minimal set of facts that leads to a conclusion through a sequence of inference

- premises $\vdash$ conclusion

Attacks (or defeat) among arguments are

- **Rebuttal** ($\leftrightarrow$)
 - premise1 $\vdash$ conclusion1
 - premise2 $\vdash$ (not) conclusion1
- **Undercut** ($\rightarrow$)
 - premise2 $\vdash$ (not) premise1

Acceptability of an argument follows the notion of abstract Dung framework



Argumentation-based Dialog System

Argumentation is used to model the content of communication and drive the dialog among agents in a MAS

- Argumentation-based dialog system is composed of: communication language, interaction protocol, protocol semantics
- Our model for agent dialog is formalized using a ***process algebra*** capturing the sequence of moves and the update of commitment store
- The operational semantic is described by a labelled transition system considering Charles Hamblin's notion of commitment stores



Example of dialog protocol

- Set of moves, identified as “locutions”
 - e.g. *s:assert*, *s:why*, *s:accept*, *s:reject*, *s:retract*, *s:argue*
- Set of commands to manipulate commitment store
 - *in(C,t)*, *rd(C,t)*, *out(C,t)*
- The rules of dialog are provided in the dialog specification
 - e.g. to find next admissible move; to store a commitment

Specification of Information Seeking Dialog

```

c:OpenDialog.
s:OpenDialog.
!(c:Ask(f).
  s:Tell(f).(
    rd(perm(c,f)).
    s:Provide(f).
    s:Argue(perm(c,f),YES,A)
  +
    s:DontTell(f)...

```



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Multi-agent Argumentation System

In a Multi-agent System *artifacts* and *argumentation* provide the support of basic and advanced functionality for ***automatic mediation services***

Some basic functionality to support the exchange of arguments in a dialog between the participants includes:

- 1 Storage of the dialog protocol (e.g. in a library of such protocols)
- 2 Storage of the specifications of the dialog protocol
- 3 Storage of the complete history of a dialog as it proceeds
- 4 The ability to refuse to allow agent utterances which do conform to the current protocol in use
- 5 The ability to suggest next moves which are legal according to the current protocol in use in a dialog
- 6 The ability to receive and store confidential information from the participating agents, such as their preferences in a negotiation
- 7 Supporting multiple simultaneous bilateral interactions

Co-Argumentation Artifact

Co-Argumentation Artifact Definition

Co-Argumentation Artifact (CAA) as an artifact specialized in managing arguments and providing coordination services for argumentation process in a MAS

CAA is a mediator of agent interaction, it provides functionality to

- to exploit social commitment
- to share, store and exchange arguments
- to calculate: conflict free sets, preferred extensions and admissible sets

Example of Social use

CAA is used to fix social acceptance of arguments



Dialog Artifact

Dialog Artifact Definition

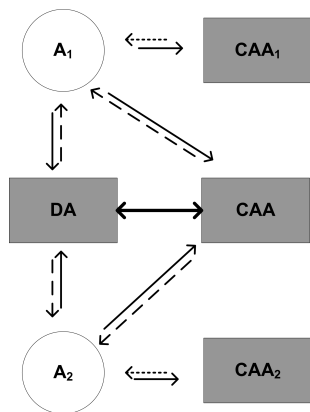
Dialog Artifact (DA) as a mediator of communication between agents that engaged a dialog under the argumentation dialog system.

DA is a triple **DP,CS,IC**, where:

- DP is a collection of specifications of dialog protocols
 - agents make utterances according to the permitted sequences defined by the protocol specification
- CS are a collection of commitments stores
 - they could be private and public of each participant, together with a central for the dialog as a whole
- IC is a collection of specifications of interaction control
 - it identifies which constraints on the future course of dialogs are created by the existing commitments



Architecture



We propose a scalable architecture for the agent society composed of

- local CAA private for an agent to coordinate its mental state
- global DA and CAA common for agent society
 - to provide services for coordination and communication based on argument



Implementation

Technological support to realize the CAA and DA is provided by TuCSon a coordination infrastructure for MAS

TuCSon provides *programmable tuple spaces* where the agents can read write and consume logic tuple

Argumentation process is composed of

- knowledge representation
- computation over argument sets

TuCSon infrastructure supports

- knowledge declaratively represented in term of logic-tuple arguments
- computation over argument set in term of ReSpecT specification tuples

CAA and DA are built as a programmed tuple centres



Implementation

CAA is built as a TuCSoN tuple centre programmed with an argumentation component algorithm

- The programs to manage, verify and compare arguments are meta-interpreters written in Prolog

DA is build as TuCSoN tuple centre where ReSpecT reactions implements the control of dialog interaction

- CS could be realized by several CAA; dialog is written in terms of tuples `dialog(name, AList)`
- The engine of process algebra management is implemented exploiting a transition system defined by the predicates `transition(Currentstate, Action, Newstate)`.

```
transition([Act|S],A,S):-transition(Act,A,zero).
transition(S1+S2,A,R1):-transition(S1,A,R1).
transition(S1+S2,A,R2):-transition(S2,A,R2).
reaction(out(move(Dialog,Id,Act)),( %Start reaction
in_r(dialogstate(Dialog,S)),
out_r(transition(S,act(Id,Act),C,Dialog)))).
```



Alternative Dispute Resolution System

Alternative Dispute Resolution (ADR) is an alternative to litigation (negotiation, mediation, collaborative law, and arbitration)

- Arguments have a central role in the process of formal legal system and also in the trial
- Disputants use arguments in order to persuade the other parts: such as decision makers - juries, judges, clients and attorneys
- Online Dispute Resolution is an online instance of ADR system moving it to virtual environment and providing computation and communication support



Alternative Dispute Resolution System

The idea

We aim to exploit our framework **CAA and DA** such as computation and communication support for conflict resolution in an agent-based society

- In the DA we store the arbitration, mediation or negotiation protocol. The parties exploit the DA to take part of the discussion, which drives the dialog ground on the commitments
 - The advantages are: the management of dialog between multiple entities and the automatic interaction with commitment/argument store
- The CAA provides the right abstraction to made a commitment/argument store where it is possible evaluate automatically the argument validity respect of normative context



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Conclusions

At the theory level

- We propose a unified elegant framework among dialectical/dialog system and argumentative reasoning system

At the model level

- We propose a model for coordination and reasoning in an agent society that merge concepts from argumentation and artifact theories
 - CAA and DA are an elegant framework to make argumentation and dialectical agent interaction to an operative level



Future Work

- We aim to generalize our argument representation with the AIF ontology and with argument based on presumptive inference
- We aim to obtain a tool for a World Wide Argumentation Web based on artifact where agents and humans could indistinctly interact



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Thank you!

Questions?

