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Efficient Coalition Formation for Web Services

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Abstract

Web services are loosely-coupled business applications willing to cooperate in distributed settings within different groups called communities. Communities aim to provide better visibility, efficiency, market share and total payoff. There are a number of proposed mechanisms and models on aggregating web services and making them cooperate within their communities. However, forming optimal and stable communities as coalitions to maximize individual and group efficiency and income has not been addressed yet. In this paper, we propose an efficient coalition formation mechanism using cooperative game-theoretic techniques. We propose a mechanism for community membership requests and selections of web services in the scenarios where there is interaction between one community and many web services and scenarios where web services can join multiple established communities. The ultimate objective is to develop a mechanism for web services to form stable groups allowing them to maximize their efficiency and generate near-optimal (welfare-maximizing) communities. The theoretical and extensive simulation results show that our algorithms provide web services and community owners, in real-world like environments, with applicable and near-optimal decision making mechanisms.

Chapter 1

Introduction

In this chapter we introduce the context of this research, which is about argumentation-based negotiation dialogue games. We also present the motivations behind this work and the research questions. Also, we discuss the objective of this research and our preliminary contributions. Proposal organization is presented in the last section.

1.1 Context of the research

Autonomous agents and multiagent systems (MAS) provide a technology offering an alternative for the design of intelligent and cooperative systems. Recently, efforts have been made to develop novel tools, methods, and frameworks to establish the necessary standards for wider use of MAS as an emerging paradigm [**?**]. An increasing interest within this paradigm is on modeling interactions and dialogue systems. In fact, several dialogue systems have been proposed in the literature for modeling *information seeking* dialogues (e.g., [?]), *inquiry* dialogues (e.g., [?, ?]), *deliberation* dialogues (e.g., [?]), *persuasion* dialogues (e.g., [?]), and *negotiation* dialogues (e.g., [?]), which are our concern in this paper. Negotiation is a form of interaction in which a group of agents, with conflicting interests, but a desire to cooperate, try to come to a mutually acceptable agreement on the division of scarce resources [?, ?]. It is worth noting that in all types of dialogue systems mentioned above, a dialogue game is a normative model of dialogue, which mainly consists of: i) a set of moves (e.g., challenge, assertion, question, etc.); ii) one commitment store for each conversant where the advanced moves are stored; iii) a communication language specifying the locution that will be used by agents during a dialogue for exchanging moves; iv) a protocol specifying the set of rules governing the dialogues; and v) agents' strategies, which are the different tactics used by agents for selecting their moves at each step in the dialogue [?]. A dialogue correctly proceeds as long as the participants conform to the dialogue rules and eventually ends when some termination rules are achieved [?, ?, ?].

In the recent years, argumentation theory has been widely investigated and used to model and analyze dialogue games [?, ?, ?, ?]. Argumentation provides a powerful tool to represent, model, and reason about dialogue moves, strategies, and dialogue outcomes. The core idea is the ability to support moves with justifications and explanations, which play a key role in persuasion and negotiation settings [?]. In this paper, we will focus on the exchanged moves in a dialogue game (i.e., the dialogue itself) and the agents playing these moves when supporting arguments are used. The main issue we are investigating is the uncertainty index of selecting the right moves during the dialogue, the certainty index that the selected move will be accepted by the addressee, and the uncertainty index of the whole dialogue. Uncertainty can be thought of as being the inverse of information. Information about a particular engineering or scientific problem may be incomplete, imprecise, fragmentary, unreliable, vague, contradictory, or even deficient [?]. Uncertainty about values of given variables (e.g., the disease affecting a patient in medical applications) can result from some errors and hence from unreliability (in the case of sensors) or from different background knowledge (in the case of agents). As a result, it is possible to obtain different uncertain pieces of information about a given value from different sources [?]. Our aim is to investigate the uncertainty issues that the agent faces when choosing an argument to play in argumentation-based negotiations. In the literature, many efforts have been deployed to model negotiation. A brief description of those efforts is given in the following subsection.

A multiagent system is a system where agents (software autonomous entities) are allowed to freely enter and leave the system, thus making the environment continuously changing. These agents need to communicate with each other, with individual or collective tasks, with different resources, and different skills. As a result, these agent societies are becoming more and more similar to the human ones [?].

An attractive characteristic of MAS is that agents can act more effectively in groups. Agents are designed to autonomously collaborate with each other in order to satisfy both their internal goals and the shared external demands generated by virtue of their participation in agent societies.

The languages used by agents to communicate are called Agent Communication Languages (ACLs). The main objective of an ACL is to model a suitable framework that allows heterogeneous agents to interact and to communicate with meaningful statements that convey information about their environment or knowledge [?]. Two main ACLs have been proposed:

the Knowledge Query and Manipulation Language (KQML) [?], and the Foundation for Intelligent Physical Agents' Agent Communication Language (FIPA-ACL) [?].

Furthermore, there is an increasing interest on modeling interactions and dialogue systems. Indeed, several dialogue systems have been proposed in the literature for modeling information seeking dialogues (e.g. [?]), inquiry dialogues (e.g., [?]), persuasion dialogues (e.g., [?]) and finally negotiation dialogues (e.g., [?]).

Evaluating multiagent systems and the dialogues taking place between the participants is a very important issue in the recent developments of multiagent systems. The existing approaches on evaluating these systems are focusing on one aspect at a time, such as evaluating persuasion dialogues ([?]), and measuring the impact of argumentation ([?]). They are more concerned with proposing dialogue strategies and analyzing dialogues. However, nothing is said about the agents' certainty about their dialogues and the goodness degree of the agents in the dialogues. In this thesis, we are interested particularly in negotiation dialogue games. In fact, negotiation is a form of interaction in which a group of agents, with conflicting interests, but a desire to cooperate, try to come to a mutually acceptable agreement on the division of scarce resources [?, ?]. Dialogue games are a set of rules governing the dialogue. such rules specify the allowed communicative acts agents can perform when participating in a dialogue. Precisely, we focus in this work on quantitative negotiation dialogue games such as bargaining. We will focus first on the exchanged moves (i.e. the dialogue itself) in terms of the certainty index of selecting the right moves during the dialogue, and the certainty index of the whole dialogue. Uncertainty about values of given variables (e.g. the disease affecting a patient in medical applications) can result from some errors and hence from non-reliability (in the case of sensors) or from different background knowledge (in the case of agents). As a result, it is possible to obtain different uncertain pieces of information about a given value from different sources [**?**]. The second focus of this thesis is on the agents' strategies in terms of goodness degree of the agents in the real dialogue (i.e. the dialogue that effectively happened between the participants) and the farness degree of the agents from the right dialogue (i.e. the best dialogue that can be produced by two agents if they know the knowledge bases of each other). For example in negotiation setting, the best dialogue is the one in which with a minimum number of moves, two agents can achieve the best agreement for both of them, if such an agreement exists considering the knowledge bases of these two agents.

1.2 Motivations and research questions

Multiagent systems are widely used in everyday life, and to add more value to these systems in the field of software engineering, they supposed to be measurable. Our motivation is to find a way to measure these systems from different aspects such as measuring the dialogues, the performance of the participants in the dialogues, and the protocols governing the dialogues, etc. In order to evaluate dialogues in multiagent systems, we define a new set of measurements from an external agent's point of view. Defining measures for the participants in the dialogues is another motivation in this thesis. The aim behind developing such measurements is to help engineers and developers of agent-based systems in evaluating these systems and their performances.

When monitoring a dialogue between two or more agents, there are many question that should be answered. In this thesis, we are interested in answering the following questions:

- How much are agents certain about selecting a move at each dialogue step?
- How much are agents certain about their dialogues?
- How good are agents in the real dialogue (i.e. the effective dialogue)?
- How far are agents from the right dialogue (i.e. the best dialogue given the knowledge bases of the participants)?

Answering these questions is undoubtedly complex. Therefore, we do not expect a comprehensive answer to all these questions.

1.3 Research objectives and contributions

The main objective of this thesis is to develop a new set of measurements for negotiation dialogue games to help in evaluating and comparing different negotiation dialogues with different participants for the same topic. The importance of introducing measures for negotiation dialogue games at each step of the dialogue such as measuring how much the agent is certain about its move is to help in developing intelligent multiagent systems (MAS) and to help evaluating different agents provided by different developers.

Our research aims to ensure that the agents' certainty about their dialogue is fairly represented at each step during the dialogue by making sure that the agent's certainty about selecting the right move is kept in mind and considered as a property of multiagent systems.

The main contribution of this thesis is the proposition of a new set of measures for dialogue games from an external agent's point of view. In particular, we introduce two sets of measurements. In the first set we use Shannon entropy to measure the certainty index of the dialogue. This involves i) using Shannon entropy to measure the agent's certainty about each move during the dialogue; and ii) using Shannon entropy to measure the certainty of the agents about the whole dialogue with two different ways. The first way is by taking the average of the certainty index of all moves, and the second way is by determining all possible dialogues and applying the general formula of Shannon entropy. In the second set, we are measuring how good are agents in the real dialogue *(Goodness Degree)*, and measuring how far are agents from the right dialogue *(Farness Degree)* [**?**].

As mentioned earlier, there exist several proposals on the argumentation-based negotiation. Most of them are concerned with proposing protocols to show how agents can interact with each other, and how arguments and offers can be generated, evaluated and exchanged during the negotiation process. However, none of them has investigated the agents' uncertainty about the exchanged arguments and how such an uncertainty could be measured at each dialogue step to assist the agents make a better decision. The uncertainty is generally defined as "that which is not precisely known". This definition permits the identification of different kinds of uncertainty arising from different sources and activities, most of which go unnoticed in analysis. To the best of our knowledge, this work is the first of it's kind in dealing with the agent's uncertainty while making a decision at each dialogue step in order to achieve an agreement. In this paper, we define a new set of uncertainty measures for dialogue games from an external agent's point of view. In particular, we distinguish two types of uncertainty: **Type I** and **Type II**.

Type I is about the uncertainty of playing the right move (i.e., advancing the right argument) at each dialogue step. For this type, we use Shannon entropy to measure: i) the uncertainty index of the agent that he is selecting the right move at each step during the dialogue; and ii) the uncertainty index of both agents participating in the dialogue about the whole dialogue. The latter measurement will be conducted in two different ways. The first way is by taking the average of the uncertainty index of all moves, and the second is by determining all possible dialogues based on the union of the agents' knowledge bases and applying the general formula of Shannon entropy.

Type II is about the uncertainty of the agent that the selected move (argument) will be accepted by the addressee (from now on we will call this second type of uncertainty by *uncertainty degree*). In this context, we introduce a new classification of arguments based on their certainty index. These measures are of great importance since they can be used as guidelines for a protocol in order to generate the best dialogue between autonomous intelligent agents.

Figure 1 summarizes the whole proposed approach where the certainty index (CI) and weighted certainty index (W_CI) of the moves and the whole dialogue are measured for Type I. For Type II, different cases are considered depending on how many arguments are in use.

1.4 Research outline

The rest of the paper is organized as follows: In Section 3.1, we present a brief theoretical background on the argumentation system and agent's theory, strategic reasoning, tactic reasoning and risk of failure notions are also discussed in this section. In Section **??**, we present the agent's uncertainty measures using Shannon entropy, which include type I (measuring the uncertainty of the agent about selecting the right move) and type II

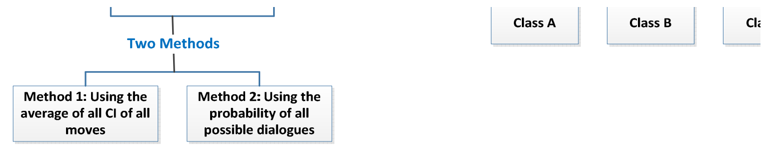

Figure 1: General overview of the approach

(measuring the uncertainty degree that the selected move will be accepted). Argument classification is also presented in this section. Related work is discussed in Section **??**. Finally, conclusion and future work are presented in Section **??**.

Chapter 2

Background and Relevant Literature

2.1 Types of Dialogue Games

2.2 Negotiation Dialogue Games

Negotiation is a form of interaction in which a group of self-interested agents with conflicting interests and a desire to cooperate attempt to reach a mutual acceptable agreement on the division of scarce resources.

2.2.1 Negotiation Component

2.2.2 Approaches to Automated Negotiation

Chapter 3

Contribution and Research Activities

In this chapter we will introduce the important notions in argumentation-based negotiation,

3.1 Argumentation System and Agent Theory

Chapter 4

Efficient Coalition Formation for Autonomous Web Services

4.1 Preliminaries

In this section, we discuss the parameters and preliminary concepts that we use in the rest of the paper.

4.1.1 The Architecture

Our system consists of three main types of entities working together:

1) Web services are rational entities[1] providing services to end users. They aim to maximize their individual income by receiving enough requests from end users. In order to increase their revenue, web services seek for more tasks if they have the capacity and

[1]The term rational is used here in the sense that web services are utility maximizers

throughput to do so. Web services can join communities to have better efficiency by collaborating with others, to have access to higher market share, and to have opportunity of receiving a bigger task pool from end users. Throughout this paper, in our equations, we refer to web services as ws and to the set of web services hosted by a given community as C. To simplify the notation, sometimes we simply write ws instead of $ws \in C$ to go through the elements ws of the set C.

2) Master Web Services or the community coordinators, are representatives of the communities of web services and responsible for their management. Communities receive requests from users and aim to host a healthy set of web services to perform the required tasks. They seek to maximize user satisfaction by having tasks accomplished according to the desired QoS. In fact, higher user satisfaction will bring more user requests and increase the market share and revenue of the community.

3) Users generate requests and try to find the best available services. User satisfaction is abstracted as function of quantity and quality of tasks accomplished by a given service. Higher user satisfaction leads to higher trust of the community by users hence directing more requests towards that service provider.

4.1.2 Web Service Parameters

Web services come with different quality of service parameters. These parameters with a short description are listed in Table 1.

We adopted a real world dataset [1] which has aggregated and normalized each of these parameters to a real value between 0 and 1. Since requests are not shared among web services and are distributed among all of them inside a community, each one of them comes

Table 1: List of web service QoS parameters.

Parameter	**Definition**
Availability	Probability of being available during a time frame
Reliability	Probability of successfully handling requests during a timeframe
Successability	Rate of successfully handled requests
Throughput	Average rate of handling requests
Latency	The average latency of services
Capacity	Amount of resources available
Cost	Mean service fee
Regulatory	Compliance with standards, law and rules
Security	Quality of confidentiality and non-repudiation

with a given QoS denoted by (QoS_{ws}). We assume that (QoS_{ws}) is obtained by a certain aggregation function of the parameters considered in Table 1. We use this quality output later in evaluating the community *worth* or *payoff* function.

4.1.3 Web Service Communities

Figure 2 represents the architecture of web service communities. The communities are essentially an abstract model of web services. They aggregate web services and communicate with other entities such as UDDI registries and users, using identical protocols as web services. Web services join communities to increase their utility by having a larger market share and task pool. Community coordinators or master web services are responsible for community development, managing membership requests from web services and distributing user tasks among the community members. Community coordinators try to attract quality web services and keep the community as stable and productive as possible to gain better reputation and user satisfaction which results in having a higher market share for the community. The way the web services reside inside communities and how communities of

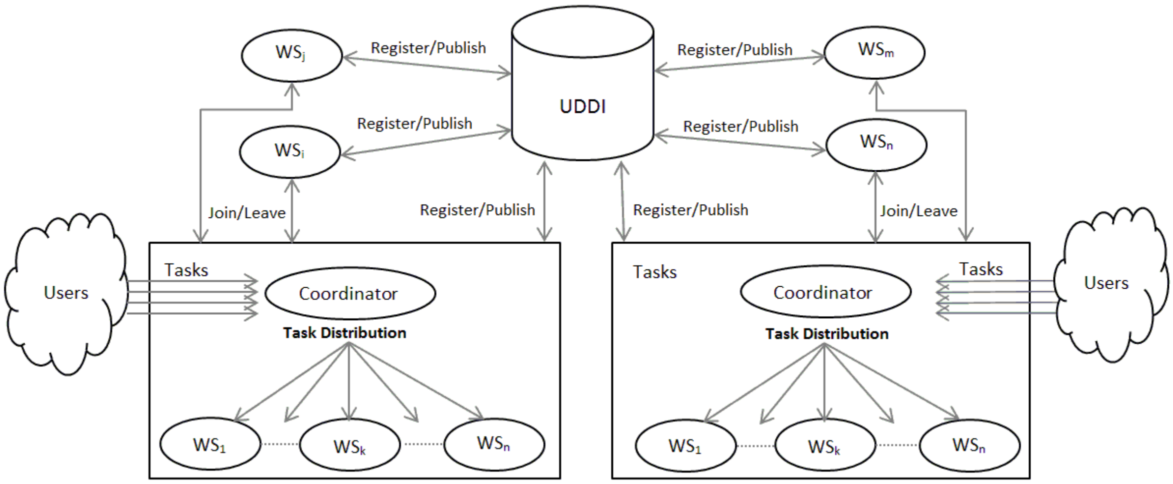

Figure 2: Architecture of Web Service communities

web services are engineered is described comprehensively in [2].

Chapter 5

Conclusion and Future Work

In this chapter, we describe the phases of our plan for exploring the research challenges and investigating the research issues identified in Chapter 4. This chapter also includes research methodology and future publication plan.

5.1 Conclusion

In this report, we proposed a cooperative game theory-based model for the aggregation of web services within communities. The goal of our services is to maximize efficiency by collaborating and forming stable coalitions. Our method considers stability and fairness for all web services within a community and offers an applicable mechanism for membership requests and selection of web services. The ultimate goal is to increase revenue by improving user satisfaction, which comes from the ability to perform more tasks with high quality. Simulation results show that our, polynomial in complexity, approximation algorithms provide web services and community owners with applicable and near-optimal decision making mechanisms.

As future work, we would like to perform more analytical and theoretical analysis on the convexity condition and also minimal ϵ values in ϵ-*core* solution concepts based on the characteristic function in web service applications. From web service perspective, the work can be extended to consider web service compositions where a group of web services having different set of skills cooperate to perform composite tasks. Also bargaining theory from cooperating game theory concepts can be used to help web services resolve the instability and unfairness issues by side payments.

5.2 Future Plan and Timeline

text text

2014	January	Ph.D. seminar	Extend our framework by introducing new negotiation strategies and concession strategies that facilitate achieving an agreement		Submit a Paper to the 13th IEEE Internat Conference on Intelligent Software Method Tools and Techniques (SoMeT 2014
	February				
	March				
	April				
	May			Analyze argumentation-based negotiation to evaluate agent strategies and analyze them from the optimization perspective	
	June				Submit a Journal Paper to the KBS Knowled Systems
	July				
	August				
	September	Thesis writing and defense			
	October				
	November				
	December				

Work done — Work in progress — Work to be done

Figure 3: Research milestones and time line

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