Ahmed Y. Tawfik
Scott D. Goodwin (Eds.)

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Ahmed Y. Tawfik
Scott D. Goodwin
University of Windsor
School of Computer Science
Windsor, Ontario, N9B 3P4, Canada
E-mail: atawfik@cs.uwindsor.ca;sgoodwin@uwindsor.ca

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Lecture Notes in Artificial Intelligence 3060

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Preface

Following a long tradition of excellence, the seventeenth edition of the conference of the Canadian Society for the Computational Studies of Intelligence continued the success of its predecessors. This edition reflected the energy and diversity of the Canadian AI community and the many international partnerships that this community has successfully established.

AI 2004 attracted high-quality submissions from Canada and around the world. All papers submitted were thoroughly reviewed by the program committee. Each paper was assigned to at least three program committee members. Out of 105 submissions to the main conference, 29 papers were included as full papers in this volume, and 22 as short/position papers. Three workshops and a graduate symposium were also associated with AI 2004. In this volume, 14 papers selected from 21 submissions to the graduate symposium have been included. We invited three distinguished researchers to give talks representing their active research in AI: Fahiem Bacchus, Michael Littman, and Manuela Veloso.

It would have been impossible to organize such a successful conference without the help of many individuals. We would like to express our appreciation to the authors of the submitted papers, and to the program committee members and external referees who provided timely and significant reviews. In particular, we would like to thank Luis Rueda for organizing the reviewing of the graduate symposium submissions, and Eric Mulvaney for providing valuable assistance in the preparation of the proceedings. To manage the submission and reviewing process we used CyberChair developed by Richard van de Stadt. Christine Günther from Springer has patiently attended to many editorial details. We owe special thanks to Bob Mercer for handling the local arrangements. Last, but not least, we would like to thank the General Chair, Kay Wiese and all the steering committee members for all their tremendous efforts in making AI 2004 a successful conference.

May 2004

Ahmed Y. Tawfik and Scott D. Goodwin

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Table of Contents

Agents

Natural Language

Learning

Constraint Satisfaction and Search

Knowledge Representation and Reasoning

Uncertainty

Neural Networks

Short/Position Papers

Graduate Student Symposium

A Principled Modular Approach to Construct Flexible Conversation Protocols

Roberto A. Flores[1] and Robert C. Kremer[2]

[1] Laval University, Department of Informatics, Sainte-Foy, QC, G1K 7P4, Canada,
flores@damas.ift.ulaval.ca
[2] University of Calgary, Department of Computer Science, Calgary, AB, T2N 1N4, Canada
kremer@cpsc.ucalgary.ca

Abstract. Building conversation protocols has traditionally been an art more than a science, as their construction is often guided by designers' intuition rather than by a principled approach. In this paper we present a model for building conversation protocols using inference principles that allow the computational specification and verification of message sequencing and turn-taking. This model, which is based on the negotiation of social commitments, results in highly flexible protocols that support agent heterogeneity while abiding by software engineering practices. We exemplify the specification of protocols using the contract net protocol, a common interaction protocol from the multiagent literature.

1 Introduction

Traditionally, conversations in multiagent systems have been regulated through the use of conversation protocols. More often than not, system designers define these protocols according to the sequences of messages they intuitively believe are best to bring about the actions achieving the goals of their systems. Although such informal approaches free designers of methodological constraints, they reduce protocols to monolithic conversational units with no explicit state properties, a characteristic that limits their implementation in open environments [9][15] and their reuse throughout application domains [1][14]. At the heart of these concerns is the absence of formal principles to build protocols supporting sound software engineering practices (e.g., modularity) as well as designers' autonomy to build heterogeneous agents. Flexible protocols – defined in implementation-independent terms – are needed to achieve seamless interactions between agents programmed using dissimilar techniques and of various levels of sophistication and contextual responsiveness [9]. This versatility requires principles that could be programmed in offline analysis tools (to verify the correctness of protocols at design time) and could also be encoded in deliberative agents as rules (upon which they could infer their most appropriate conversational participation at runtime) [15].

We propose a model to build conversation protocols that fulfill these requirements. This model is based on the notion that conversation protocols aim at the

A.Y. Tawfik and S.D. Goodwin (Eds.): Canadian AI 2004, LNAI 3060, pp. 1–15, 2004.

orderly execution of actions, and that responsibilities to perform these actions are established through a series of negotiations to adopt social commitments. In particular, our proposal explicitly indicates the messages allowed (i.e., sequencing) and the agent expected to issue the next message (i.e., turn-taking) in all conversational states.

There have been several recent efforts to define conversation protocols using social commitments, particularly the approaches furthered in [8] and [15]. We share with these approaches the view that message sequencing is reflected through the properties afforded by the progression in the states of communicated commitments. However, these models differ from our proposal in that they fail to formally specify turn-taking as an emergent property of conversational states, and still rely on *ad-hoc* links to indicate the participant advancing the state of commitments at any point in a conversation. Instead, turn-taking in our model flows logically as agents dispose of their obligations (derived from the negotiation of social commitments) by performing both communicative and non-communicative actions. As we detail in this paper, these obligations indicate the types of messages that could be uttered (sequencing) as well as agents expected to issue the next message advancing a conversation (turn-taking), thus defining state properties on which the verification, compilation and execution of protocols can be based. Lastly, our model achieves this functionality while supporting software engineering principles through the modular composition of protocols from reusable components.

The structure of this paper is as follows: the next section is devoted to describing the elements in our model and their underlying principles. This section includes a detailed example of how conversation protocols are defined for simple one-action activities, and a brief explanation on how larger protocols involving several actions can be composed using simpler ones. A subsequent section reviews the characteristics afforded by our model, and discusses how these characteristics allow the modular and reusable composition of flexible protocols and their support for autonomy in open multiagent systems.

2 Modelling Conversations for Action

The notion of *social commitments* [2][11] has been advanced as a way to raise expectations about other agents' performances. Specifically, a social commitment can be defined as an engagement in which an agent is responsible relative to another agent for the performance of an action (independent of whether the agent responsible is also the performer of the action). In our model, social commitments are represented as a three-term predicate of the form

$$\forall\, d, c : \downarrow Agent;\ a : \downarrow Action \bullet SC(d, c, a)$$

where d and c are agent instances representing the debtor (the agent responsible for the satisfaction of the commitment) and the creditor (the agent on whose behalf the commitment is to be satisfied) of the commitment, and where a is the action that satisfies the commitment. Due to their extent, the description of actions requires a subsequent section of its own.

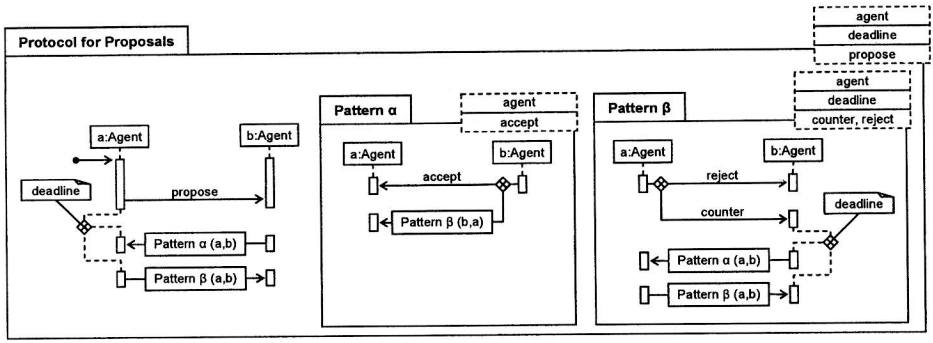

Fig. 1. Interaction diagram of the *protocol for proposals*.

2.1 The Negotiation of Social Commitments

Communicative acts. Inspired by notions from the study of language use [3], we define message interactions as communicative acts from a speaker to an addressee conveying a collection of conversational tokens; and specify the following four tokens to support the negotiation of social commitments:

- *Propose:* to put forth the adoption or discard of a social commitment,
- *Accept:* to accept adopting or discharging a social commitment,
- *Reject:* to reject adopting or discharging a social commitment, and
- *Counter:* to reject a previous proposal while putting forth another proposal to be considered instead.

Lastly, we define a fifth token *Inform* to communicate data.

The protocol for proposals. It is one thing to define communicative acts and quite another to describe how they are used and what they can accomplish in conversations. To that end, we define a negotiations protocol that we call the *protocol for proposals* (*pfp*), which provides a flexible and unambiguous pattern of conversational turn-taking supporting the mutual adoption and discharge of social commitments. As shown in Figure 1, the protocol starts with a proposal from agent a to agent b. This message can be followed (before the expiration of a reply deadline) by the interaction patterns α or β. The interaction pattern α indicates that either agent b sends an accepting message to agent a, or that the interaction continues with pattern β (but with agents a and b's participatory roles inverted, that is, the role of the agent that in pattern α was agent a in pattern β will be agent b, and likewise for agent b). Interaction pattern β indicates that agent a sends a rejection or counterproposal message to agent b, in which case the interaction follows (before the expiration of a reply deadline) by either pattern α or pattern β. In brief, given a proposal from a, b could reply with an acceptance, rejection or counterproposal, or a could issue a rejection or counterproposal to its own proposal. All replies except a counterproposal terminate