Aspects of Protocol Conformance in Inter-agent Dialogue

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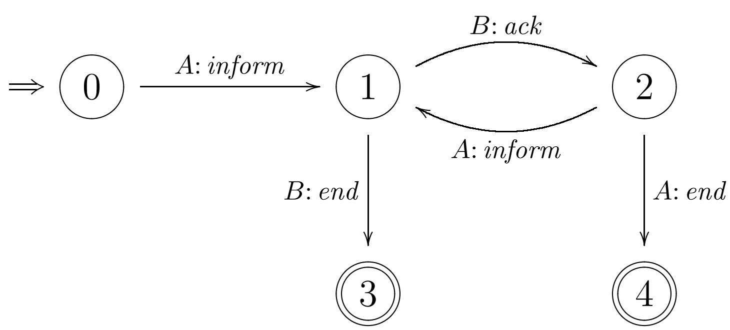
Abstract. An agent communication protocol specifies the *rules of encounter* governing a dialogue between the agents in a multiagent system. In non-cooperative interactions (such as negotiation dialogues) occurring in open societies, it is crucial that agents are equipped with proper means to check, and possibly enforce, conformance to such protocols. We identify different levels of conformance (weak, exhaustive, and robust conformance) and explore how a specific class of logic-based agents can exploit a new representation formalism for protocols based on simple integrity constraints in order to either check conformance *a priori* or enforce it at runtime. An extended version of this paper is due to appear in the proceedings of IJCAI-2003 [1].

Automata-based Protocol Representation

The *continuous update protocol*, taken from [2]:



We call a dialogue move P **legal** wrt. a protocol $\mathcal{P}$ and a given dialogue state Q iff there exists a state Q' such that the automaton's transition function maps the pair (Q, P) to Q'.

Logic-based Protocol Representation

The same protocol, expressed as two sets of integrity constraints (each corresponding to one of the two subprotocols):

$$\begin{aligned} \mathcal{P}_A : \quad & START(T) \Rightarrow inform(T+1) \\ & ack(T) \Rightarrow inform(T+1) \vee end(T+1) \\ & end(T) \Rightarrow STOP(T+1) \end{aligned}$$

$$\begin{aligned} \mathcal{P}_B : \quad & inform(T) \Rightarrow ack(T+1) \vee end(T+1) \\ & end(T) \Rightarrow STOP(T+1) \end{aligned}$$

We call the dialogue moves on the righthand side of a protocol constraint **correct responses** wrt. the **expected input** given on the lefthand side.

Levels of Conformance

We may distinguish three levels of conformance to a given communication protocol $\mathcal{P}$:

- An agent is **weakly conformant** to $\mathcal{P}$ iff it never utters any illegal dialogue moves (wrt. $\mathcal{P}$).
- An agent is **exhaustively conformant** to $\mathcal{P}$ iff it is weakly conformant to $\mathcal{P}$ and utters at least *some* dialogue move whenever required to do so by $\mathcal{P}$.
- An agent is **robustly conformant** to $\mathcal{P}$ iff it is exhaustively conformant to $\mathcal{P}$ and for any illegal dialogue move received from another agent it utters a special dialogue move indicating this violation (e.g. `not-understood`).

Checking Conformance

An example for a **communication strategy** for a logic-based agent (as proposed in [3]):

$$\begin{aligned}\mathcal{S} \;=\; \{ & \mathit{inform}(T) \wedge \mathit{happy} \Rightarrow \mathit{ack}(T{+}1), \\ & \mathit{inform}(T) \wedge \mathit{unhappy} \Rightarrow \mathit{end}(T{+}1)\}\end{aligned}$$

Abstracting from *private* conditions such as happy, we define this agent's **response space** as follows:

$$\mathcal{S}^* \;=\; \{\mathit{inform}(T) \Rightarrow \mathit{ack}(T{+}1) \vee \mathit{end}(T{+}1)\}$$

We can now check weak conformance *a priori:*

Theorem 2. *An agent with response space $\mathcal{S}^*$ will be weakly conformant to a protocol $\mathcal{P}$ whenever $\mathcal{S}^* \models \mathcal{P}$.*

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Shallow Protocols

We call protocols that can be represented by means of our integrity constraints, with a single "trigger" on the lefthand side, **shallow protocols**. Shallow protocols correspond to automata where the value of the transition function is independent from the current state. Many automata-based protocols are in fact shallow or could be turned into shallow ones by renaming only a small number of transitions.

Theorem 1. *An agent that never utters an incorrect response in reply to an expected input of a shallow protocol $\mathcal{P}$ is weakly conformant to $\mathcal{P}$.*

That is, for shallow protocols, weak conformance can be checked without reference to the full dialogue history.

Enforcing Conformance

Agents may simply "download" a protocol $\mathcal{P}$ to guarantee their own conformance to it:

Theorem 3. *An agent generating its moves from a knowledge base of the form $\mathcal{K} \cup \mathcal{P}$ will be weakly conformant to $\mathcal{P}$.*

References

[1] U. Endriss, N. Maudet, F. Sadri, and F. Toni. Protocol Conformance for Logic-based Agents. In *Proc. IJCAI-2003*, 2003. To appear.

[2] J. Pitt and A. Mamdani. A Protocol-based Semantics for an Agent Communication Language. In *Proc. IJCAI-1999*. 1999.

[3] F. Sadri, F. Toni, and P. Torroni. Dialogues for Negotiation: Agent Varieties and Dialogue Sequences. In *Proc. ATAL-2001*. 2001.