FOUNDATION FOR INTELLIGENT PHYSICAL AGENTS

FIPA Brokering Interaction Protocol Specification

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Geneva, Switzerland

consequential, which may result from the use of this specification.

Foreword

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FIPA is a non-profit association registered in Geneva, Switzerland. As of Juneanuary 2002~~0~~, the 56 members of FIPA represented ~~17~~ many countries worldwide. Further information about FIPA as an organization, membership information, FIPA specifications and upcoming meetings may be found on the FIPA Web site at http://www.fipa.org/.

Contents

1 FIPA Brokering Interaction Protocol

The concept of an information brokerage has been widely used in mediated systems and in multi-agent systems in particular (for example, see [Finin97]). The FIPA Brokering Interaction Protocol (IP) is designed to support these brokerage interactions in multi-agent systems.

Generally speaking, a broker is an agent ~~which~~ that offers a set of communication facilitation services to other agents using some knowledge about the requirements and capabilities of those agents. A typical example of brokering is one in which an agent can request a broker to find one or more agents who can answer a query. The broker then determines a set of appropriate agents to which to forward the query, sends the query to those agents and relays their answers back to the original requestor. The use of brokerage agents can significantly simplify the task of interaction with agents in a multi-agent system. Additionally, brokering agents also enable a system to be adaptable and robust in dynamic situations, supporting scalability and security control at the brokering agent.

The FIPA Brokering IP is a macro IP, because the *proxy* communicative act (see [FIPA00037]) for brokerage embeds a communicative act as its argument and so the IP ~~for~~ specified in the embedded communicative act is also embedded in this IP. When the embedded communicative act includes some actions that would be done by the agents determined by broker agents, then this IP would be extended for notifying the result of the actions.

~~The broker agent should record some of the ACL parameters (see [FIPA00061]), for example, `:conversation-id`, `:reply-with` and `:sender`, of the received *proxy* message to forward back the replying message to the corresponding original agent (the sender of the *proxy* message).~~

The representation of this IP is given in *Figure 1* which is based on an extension of UML 1.x. [Odell2001] This protocol is identified by the token fipa-brokering ~~interaction~~ as the value of the protocol parameter of the ACL message.

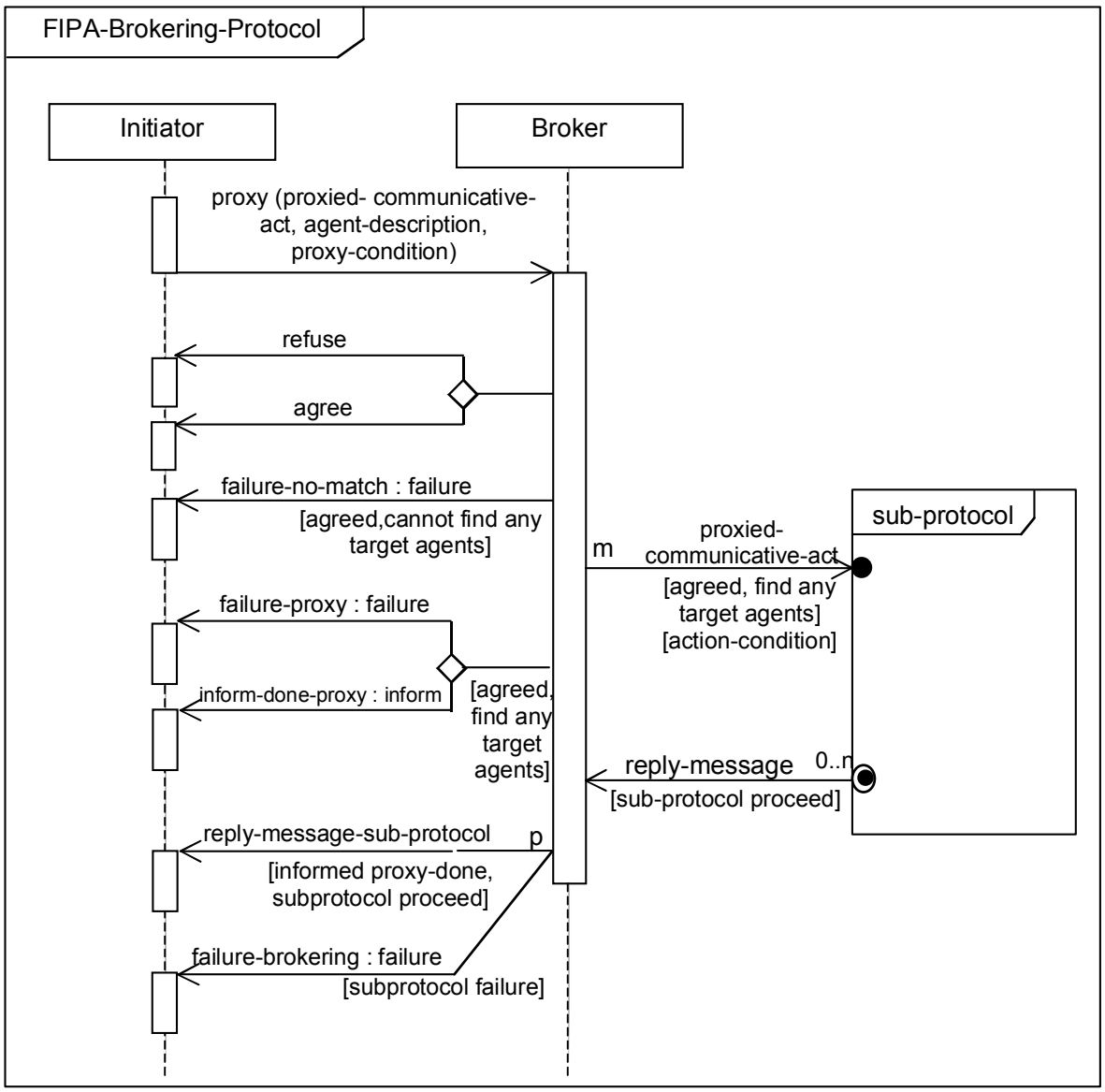

Figure 1: FIPA Brokering Interaction Protocol

1.1 Explanation of the Interaction Protocol Flow

The FIPA Brokering Interaction Protocol (IP) is a macro IP, because the `proxy` communicative act (see [FIPA00037]) for brokerage embeds a communicative act as its argument and so the IP for the embedded communicative act is also embedded in this IP. This embedded IP guides some parts of the remainder of the interaction, thus parts of this protocol are written very generically.

The Initiator of the brokering interaction begins the interaction with a `proxy` communication. The `proxy` communicative act contains the following: a referential expression denoting the target agents to which the broker should forward the communicative act, the communicative act to forward, and a set of proxy conditions such as the maximum number of agents to ~~be~~ which the message should be forwarded. The Broker processes the request and makes a decision whether to agree to or refuse the request, and communicates either an `agree` or a `refuse` communicative act accordingly. Communication of a `refuse` terminates the interaction.

Once the Broker has agreed to be a proxy, it then locates agents per the description from the `proxy` message. If no such agents can be found, the Broker returns a `failure-no-match` and the interaction terminates. Otherwise, the Broker may modify the list of matching agents based on the proxy-condition. It then begins m interactions with the

resulting list of *m* agents, with each interaction in its own separate sub-protocol. At this point, the Broker also should record some of the ACL parameters (see [FIPA00061]), for example, ÷conversation-id, ÷reply-with and ÷sender, of the received proxy message to return in the rreplies to the Initiator.

Note that the nature of the sub-protocol and the nature of the replies is driven by the interaction protocols specified in the communicative act from the proxy message. As the sub-protocol progresses, the Broker forwards the responses that it receives from the sub-protocol to the Initiator. These messages are defined as the reply-message-sub-protocol communications, **and may be either successful replies as defined by the sub-protocol or failures. If the initial proxy was an inform, there may in fact be no replies from the sub-protocol (and in fact means that the interaction is identical to a recruited inform)**. When the sub-protocol completes, the Broker forwards the final reply-message~~-sub-protocol~~ from the sub-protocol and the brokering IP terminates. However, there can be other failures that are not explicitly returned from the sub-protocol, e.g., the agent that is executing the sub-protocol has failed. If the Broker detects such problems, it returns a failure-brokering, which terminates the IP.

A second issue to address occurs because multiple agents may match and therefore multiple sub-protocols (*m* of them) may be initiated by the Broker within the brokering IP. In this case, the Broker may collect the *n* received responses and combine them into a single reply-message-sub-protocol, or may forward the reply-message-sub-protocol messages from the separate sub-protocols individually, thus 1 ≤ p ≤ n. This is complicated by such situations as one agent responding with a failure while a second agent returns a reply-message~~-sub-protocol~~, or the situation where results are inconsistent. The Broker must determine whether to resolve such situations internally or forward the responses to the Initiator. In doing this, the Broker must also be careful to avoid disruptive acts such as directly forwarding a failure from a sub-protocol, which would have the inadvertent effect of ending the brokering IP.

Any interaction using this interaction protocol is identified by a globally unique, non-null conversation-id, assigned by the Initiator. The agents involved in the interaction must tag all of its ACL messages with this conversation identifier. This enables each agent to manage its communication strategies and activities, e.g. it allows an agent to identify individual conversations and to reason across historical records of conversations. In the case of 1:N interaction protocols or sub-protocols the Initiator is free to decide if the same conversation-id should be used or a new one should be issued. Additionally, the messages may specify other interaction-related information such as a timeout in the reply-by slot that denotes the latest time by which the sending agent would like to have received the next message in the protocol flow.

~~1.1~~1.2 Exceptions to Interaction Protocol Flow

At *any* point in the IP, the receiver of a communication can inform the sender that it did not understand what was communicated. This is accomplished by returning a not-understood communication. As such, the figure above does not depict a not-understood communication as it can occur after any communication. The communication of a not-understood within an interaction protocol may terminate the entire IP. Termination of the interaction may imply that any commitments made during the interaction are null and void. However, since this IP broadcasts the sub-protocol to more than one Participant, multiple responses are also possible. Each response, then, must be evaluated separately – and some of these responses might be not-understood. However, terminating the entire IP in this case might not be appropriate, as other Participants may be continuing with their sub-protocols.

At any point in the IP, the initiator of the IP may cancel the interaction protocol by initiating the meta-protocol shown in *Figure 2*. The conversation-id of the cancel interaction is identical to the conversation-id of the interaction that the Initiator intends to cancel. The semantics of the cancel should roughly be interpreted as meaning that the initiator is no longer interested in continuing the interaction, and that it should be terminated in a manner acceptable to both the Initiator and the Participant. The Participant either informs the Initiator that the interaction is done using an inform-done, or indicates the failure of the cancellation using a failure.

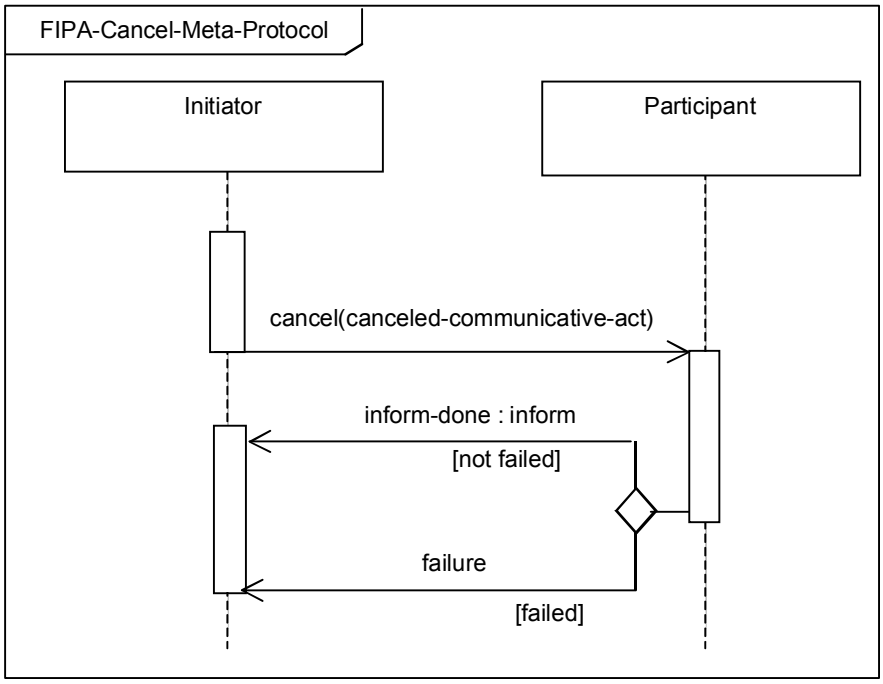

Figure 2: FIPA cancel meta-protocol

This IP is a pattern for a simple interaction type. Elaboration on this pattern will almost certainly be necessary in order to specify all cases that might occur in an actual agent interaction. Real world issues such as the effects of cancelling actions, asynchrony, abnormal or unexpected IP termination, nested IPs, and the like, are explicitly not addressed here.

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2 References

[Finin97] Finin, T. Labrou, Y. and Mayfield, J., KQML as an Agent Communication Language. In: Software Agents, Bradshaw, J. (editor), MIT Press, 1997.

[FIPA00037] FIPA Communicative Act Library Specification. Foundation for Intelligent Physical Agents, 2000. http://www.fipa.org/specs/fipa00037/

[FIPA00061] FIPA ACL Message Structure Specification. Foundation for Intelligent Physical Agents, 2000. http://www.fipa.org/specs/fipa00061/

[Odell2001] Odell, James, H. Van Dyke Parunak, and Bernhard Bauer, "Representing Agent Interaction Protocols in UML," *Agent-Oriented Software Engineering*, Paolo Ciancarini and Michael Wooldridge ed., Springer, Berlin, 2001, pp. 121-140. http://www.fipa.org/docs/input/f-in-00077.

3 Informative Annex A — ChangeLog

3.1 2002/05/10 - version G by FIPA Architecture Board

Page ~~x~~1, line ~~y~~60-63:	Moved paragraph down to be part of new section 1.1, « ~~<blah>~~
Page 2, Figure 1 :	The «not-understood» communication was removed
Page 2, Figure 1 :	The last set of communicative acts was removed and a more generic one was inserted. The more generic one indicates that the Broker is going to forward the responses it received from the sub-protocol. Alternatively, if the Broker notices some failure such as no response at all from the sub-protocol after a given time period, the Broker may send the Initiator a failure of its own.
Page 2, Figure 1 :	Multiple subprotocols were indicated by inserting m, n and p respectively on three arcs. M subprotocols can be started, resulting in n responses, that the Broker can consolidate into p responses to the Initiator
Page 2, Figure 1 :	To conform to UML 2, the protocol name was placed in a boundary, « x » is removed from the diamonds (xor is now the default), and the template box was removed.
Page 2, line 70 :	Added a new section 1.1 entitled « Explanation of the Protocol Flow »
Page 2, line 70 :	Renumbered old section 1.1 to section 1.2. Added a paragraph explaining the not-understood communication and its relationship with the IP.
~~Page iii~~	~~Regenerated Table of Contents~~