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JADE Architecture Overview

A.1   Introduction

This appendix gives an architectural overview of the JADE platform as retrieved from the http://jade.tilab.com/ website.
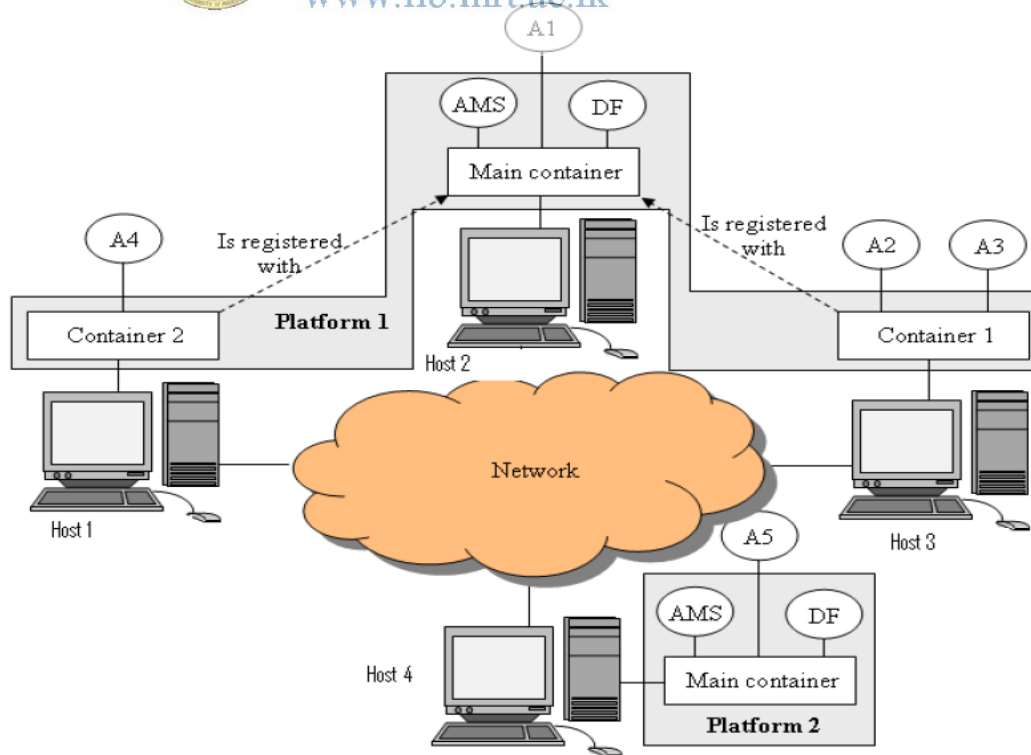
A.2   JADE Architecture Overview

This provides an overview of the JADE Architecture introducing the notions of

- Agent
- Container
- Platform
- Main Container
- AMS and DF

The figure represents the main JADE architectural elements. An application based on JADE is made of a set of components called *Agents* each one having a unique name. Agents execute tasks and interact by exchanging messages. Agents live on top of a *Platform* that provides them with basic services such as message delivery. A platform is composed of one or more *Containers*. Containers can be executed on different hosts thus achieving a distributed platform. Each container can contain zero or more agents.

For instance, with reference to the picture, container "Container 1" in host *Host 3* contains agents A2 and A3. Even if in some particular scenarios this is not always the case, you can think of a Container as a JVM (so, 1 JVM ==> 1 container ==> 0 or many agents). A special container called *Main Container* exists in the platform.

The main container is itself a container and can therefore contain agents, but differs from other containers as

1. It must be the first container to start in the platform and all other containers register to it at bootstrap time.

2. It includes two special agents: the *AMS* that represents the authority in the platform and is the only agent able to perform platform management actions such as starting and killing agents or shutting down the whole platform (normal agents can request such actions to the AMS). The *DF* that provides the Yellow Pages service where agents can publish the services they provide and find other agents providing the services they need.

It should be noticed that if another main container is started, as in host *Host 4*, this constitutes a new platform.

Agent communication

Agents can communicate transparently regardless of whether they live in the same container (e.g. A2 and A3), in different containers (in the same or in different hosts) belonging to the same platform (e.g. A1 and A2) or in different platforms (e.g. A1 and A5). Communication is based on an asynchronous message passing paradigm.

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Message format is defined by the ACL language defined by FIPA, an international organization that issued a set of specifications for agent interoperability. An ACL Message contains a number of fields including

- the sender
- the receiver(s)
- the communicative act (also called performative) that represents the intention of the sender of the message. For instance when an agent sends an INFORM message it wishes the receiver(s) to become aware about a fact (e.g. (INFORM "today it's raining")). When an agent sends a REQUEST message it wishes the receiver(s) to perform an action. FIPA defined 22 communicative acts, each one with a well defined semantics, that ACL gurus assert can cover more than 95% of all possible situations. Fortunately in 99% of the cases we don't need to care about the formal semantics behind Communicative acts and we just use them for their intuitive meaning.
- the content i.e. the actual information conveyed by the message (the fact the receiver should become aware of in case of an INFORM message, the action that the receiver is expected to perform in case of a REQUEST message)

List of simulated users and their routes

B.1   Introduction

This appendix gives the list of users and their routes that were simulated to evaluate the system functionality.

B.2   List of addresses used to simulateuser routes

The below address list taken from a listing of schools in the Western Province of Sri Lanka was used to generate the route list for simulated users. This list was chosen because it gives a well-distributed list of addresses in the Western Province of Sri Lanka. Therefore it can be effectively used to simulate a rideshare system in the Western Province.

1. Maligakanda road, Colombo 10 01000
2. PADOGA ROAD, KOTTE 10100
3. AdikaramMawatha, Kotte 10010
4. Baseline Road, Dematagoda,Colombo-9 00900
5. wp/ja/mahamathayvidyalaya, Athurugiriya 12010
6. Hokandara South, Hokandara 10118
7. AnandaRajakarunaMawatha, Colombo 10 01000
8. Kularathnamawatha, Colombo 10 0015
9. High Level Rd,, Nugegoda, 01
10. Katubedda, Moratuwa
11. Bope, Padukka
12. Buddhagosha M.V., Kalubowila 12056
13. Highlevel Road, Maharagama 10400
14. Bomiriya National School, Colombo
15. Boralesgamuwa M.V, Boralesgamuwa 10290
16. Station Road, Mount Lavinia
17. DanisterdeSilvaMawatha, Colombo 08 00025

18. 155,BandaranayekeMawatha,, Colombo-12 0094

19. Auburn Place, Dehiwala

20. Templer\'s Road, Mount Lavinia 0094

21. Godagama Road, Athurugiriya 90018

22. ., Piliyandala 10129

23. Kynsey road, Colombo 08

24. 62, Gregory\'s Road,, Colombo 07

25. Moratuwa, Moratuwa

26. Brahmanagama, Pannipitiya

27. No 34, Mallay Street, Colombo 02

28. DarmapalaMawatha, Dehiwala 011

29. SriJayawardhanapuraMawatha, Borella 00800

30. Kesbewa, Piliyandala

31. Diyagama, Kiriwattuduwa. 10208

32. Park Road, Colombo 05

33. DharmapalaVidyalaya, Pannipitiya

34. Hotel Road, Mount Lavinia

35. wasala road, colombo 13

36. Temple Road, Maradana 01000

37. habarakada, homagama

38. 45, Husseiniya, Colombo 12 3012

39. Dam Street, Colombo 12

40. Court Road, Homagama

41. Athurugiriya RD, Homagama 10200

42. Salamulla, Kolonnawa 10600

43. 207/1, DharmapalaMawatha, Colombo 7 00700

44. Ministry of Education, Pelawatta

45. Ministry of Education, Pelawatta

46. Jalthara. Hanwella, Hanwella 1224

47. School Lane, Nawala,Rajagiriya, Colombo 011

48. 166, Dematagoda Road,, Colombo 09 011

49. Kosgama

50. kosgama, kosgama 00255

51. MahaVidyalaMawatha, Colombo 13 01300

52. Hokandara Road, Pannipitiya 10230

53. Mulleriyawa New town

54. Kandawala Road, Ratmalana

55. Horana Road, Kottawa, Pannioitiya

56. Hena Road, Mount Lavinia 10370

57. Havelock Town, Colombo 05

58. No. 724, Galle Road, Colombo 03

59. Thalangama North, Bathtaramulla 10120

60. Madiwela, Kotte

61. magammana, Homagama

62. Foster Lane, Colombo

63. Pepiliyana Road, Nugegoda 24250

64. Gammana Road, Maharagama

65. Bokundara, Piliyandala

66. Makuluduwa, Piliyandala

67. New Kandy Road, Malabe 094

68. Horana Road, Mattegoda,Pannipitiya.

69. Mawathgama, Homagama 10220

70. Mayadunna M.V., Hanwella

71. Padukka Road, Meegoda 10504

72. Meegoda, 10504

73. Meethotamulla Road, Kolonnawa

74. Kensington gardens, Colombo 04,, Colombo 0004

75. New Kandy Rd,, Malabe

76. Siridammamawatha, Colombo

77. Hiripitiya, Pannipitiya 10230

78. stanleythilakaratna mw, nugegoda

79. High Level Road, Maharagama

80. Isurupaya, Battaramulla

81. SiriPiyararhana Central College, Padukka

82. Pahathgama, Hanwella

83. Madapatha, Piliyandala

84. Pinnawala , Waga, Padukka

85. WP/HO/Pitipanam.v. Pitpana North, Homagama

B.3 List of simulated users and their routes

Using the above address list in a random pairing algorithm the below user route list was generated. This generated data was used to simulate a rideshare/carpool system. Results of the simulation were presented in the evaluation chapter.

User	Route Start	Route End
1	Maligakanda road,, Colombo 10 01000	Baseline Road, Dematagoda,Colombo-9 00900
2	PADOGA ROAD, KOTTE 10100	Hokandara South, Hokandara 10118
3	AdikaramMawatha, Kotte 10010	Hokandara South, Hokandara 10118
4	AdikaramMawatha, Kotte 10010	AnandaRajakarunaMawatha, Colombo 10 01000
5	Hokandara South, Hokandara 10118	High Level Rd,, Nugegoda, 01
6	Hokandara South, Hokandara 10118	Katubedda, Moratuwa
7	AnandaRajakarunaMawatha, Colombo 10 01000	Katubedda, Moratuwa
8	AnandaRajakarunaMawatha, Colombo 10 01000	Pinnawala , Waga, Padukka
9	Kularathnamawatha, Colombo 10 0015	Pinnawala , Waga, Padukka
10	High Level Rd,, Nugegoda, 01	High Level Road, Maharagama
11	Katubedda, Moratuwa	High Level Road, Maharagama
12	Katubedda, Moratuwa	Siridammamawatha, Colombo
13	Pinnawala , Waga, Padukka	Siridammamawatha, Colombo
14	Pinnawala , Waga, Padukka	Boralesgamuwa M.V, Boralesgamuwa 10290
15	High Level Road, Maharagama	Station Road, Mount Lavinia
16	High Level Road, Maharagama	Danister de Silva Mawatha, Colombo 08 00025
17	Siridammamawatha, Colombo	Danister de Silva Mawatha, Colombo 08 00025
18	Siridammamawatha, Colombo	155,Bandaranayeke Mawatha,, Colombo-12 0094
19	Boralesgamuwa M.V, Boralesgamuwa 10290	155,Bandaranayeke Mawatha,, Colombo-12 0094
20	Boralesgamuwa M.V, Boralesgamuwa 10290	Auburn Place, Dehiwala
21	Danister de Silva Mawatha, Colombo 08 00025	Templer\'s Road, Mount Lavinia 0094
22	Danister de Silva Mawatha, Colombo 08 00025	Athurugiriya RD, Homagama 10200
23	155,Bandaranayeke Mawatha,, Colombo-12 0094	Athurugiriya RD, Homagama 10200
24	155,Bandaranayeke Mawatha,, Colombo-12 0094	., Piliyandala 10129
25	Auburn Place, Dehiwala	., Piliyandala 10129
26	Auburn Place, Dehiwala	Kynsey road, Colombo 08
27	Templer\'s Road, Mount Lavinia 0094	Kynsey road, Colombo 08
28	Templer\'s Road, Mount Lavinia 0094	62, Gregory\'s Road,, Colombo 07

29	Athurugiriya RD, Homagama 10200	62, Gregory\'s Road,, Colombo 07
30	Athurugiriya RD, Homagama 10200	Moratuwa, Moratuwa
31	., Piliyandala 10129	Brahmanagama, Pannipitiya
32	Kynsey road, Colombo 08	Brahmanagama, Pannipitiya
33	Kynsey road, Colombo 08	No 34, Mallay Street, Colombo 02
34	62, Gregory\'s Road,, Colombo 07	No 34, Mallay Street, Colombo 02
35	62, Gregory\'s Road,, Colombo 07	DarmapalaMawatha, Dehiwala 011
36	Moratuwa, Moratuwa	DarmapalaMawatha, Dehiwala 011
37	Moratuwa, Moratuwa	Sri JayawardhanapuraMawatha, Borella 00800
38	Brahmanagama, Pannipitiya	Sri JayawardhanapuraMawatha, Borella 00800
39	Brahmanagama, Pannipitiya	Kesbewa, Piliyandala
40	No 34, Mallay Street, Colombo 02	Kesbewa, Piliyandala
41	No 34, Mallay Street, Colombo 02	Diyagama, Kiriwattuduwa. 10208
42	DarmapalaMawatha, Dehiwala 011	Diyagama, Kiriwattuduwa. 10208
43	DarmapalaMawatha, Dehiwala 011	Park Road, Colombo 05
44	Sri JayawardhanapuraMawatha, Borella 00800	Park Road, Colombo 05
45	Sri JayawardhanapuraMawatha, Borella 00800	DharmapalaVidyalaya, Pannipitiya
46	Kesbewa, Piliyandala	DharmapalaVidyalaya, Pannipitiya
47	Kesbewa, Piliyandala	Hotel Road, Mount Lavinia
48	Diyagama, Kiriwattuduwa. 10208	Hotel Road, Mount Lavinia
49	Diyagama, Kiriwattuduwa. 10208	wasala road, colombo 13
50	Park Road, Colombo 05	wasala road, colombo 13
51	Park Road, Colombo 05	Temple Road, Maradana 01000
52	DharmapalaVidyalaya, Pannipitiya	Temple Road, Maradana 01000
53	DharmapalaVidyalaya, Pannipitiya	habarakada, homagama
54	Hotel Road, Mount Lavinia	habarakada, homagama
55	Hotel Road, Mount Lavinia	45, Husseiniya, Colombo 12 3012
56	wasala road, colombo 13	Dam Street, Colombo 12
57	Temple Road, Maradana 01000	Dam Street, Colombo 12
58	Temple Road, Maradana 01000	Court Road, Homagama
59	habarakada, homagama	Court Road, Homagama
60	habarakada, homagama	Athurugiriya RD, Homagama 10200
61	45, Husseiniya, Colombo 12 3012	Athurugiriya RD, Homagama 10200
62	45, Husseiniya, Colombo 12 3012	Meethotamulla Road, Kolonnawa
63	Dam Street, Colombo 12	Meethotamulla Road, Kolonnawa
		207/1, DharmapalaMawatha, Colombo 7
64	Dam Street, Colombo 12	00700
65	Court Road, Homagama	207/1, DharmapalaMawatha, Colombo 7

		00700
66	Court Road, Homagama	Ministry of Education, Pelawatta
67	Athurugiriya RD, Homagama 10200	Ministry of Education, Pelawatta
68	habarakada, homagama	Ministry of Education, Pelawatta
69	Meethotamulla Road, Kolonnawa	Ministry of Education, Pelawatta
70	Meethotamulla Road, Kolonnawa	Jalthara. Hanwella, Hanwella 1224
71	207/1, DharmapalaMawatha, Colombo 7 00700	Jalthara. Hanwella, Hanwella 1224
72	207/1, DharmapalaMawatha, Colombo 7 00700	School Lane, Nawala,Rajagiriya, Colombo 011
73	Ministry of Education, Pelawatta	School Lane, Nawala,Rajagiriya, Colombo 011
74	Ministry of Education, Pelawatta	166, Dematagoda Road,, Colombo 09 011
75	Ministry of Education, Pelawatta	166, Dematagoda Road,, Colombo 09 011
76	Ministry of Education, Pelawatta	Kosgama
77	Jalthara. Hanwella, Hanwella 1224	Kosgama
78	Jalthara. Hanwella, Hanwella 1224	kosgama, kosgama 00255
79	School Lane, Nawala,Rajagiriya, Colombo 011	kosgama, kosgama 00255
80	School Lane, Nawala,Rajagiriya, Colombo 011	MahaVidyalaMawatha, Colombo 13 01300
81	166, Dematagoda Road,, Colombo 09 011	MahaVidyalaMawatha, Colombo 13 01300
82	166, Dematagoda Road,, Colombo 09 011	Hokandara Road, Pannipitiya 10230
83	Kosgama	Hokandara Road, Pannipitiya 10230
84	Kosgama	Mulleriyawa New town
85	kosgama, kosgama 00255	Mulleriyawa New town
86	kosgama, kosgama 00255	Kandawala Road, Ratmalana
87	MahaVidyalaMawatha, Colombo 13 01300	Kandawala Road, Ratmalana
88	MahaVidyalaMawatha, Colombo 13 01300	Horana Road, Kottawa, Pannioitiya
89	Hokandara Road, Pannipitiya 10230	Horana Road, Kottawa, Pannioitiya
90	Hokandara Road, Pannipitiya 10230	Hena Road, Mount Lavinia 10370
91	Mulleriyawa New town	Hena Road, Mount Lavinia 10370
92	Mulleriyawa New town	Havelock Town, Colombo 05
93	Kandawala Road, Ratmalana	Havelock Town, Colombo 05
94	Kandawala Road, Ratmalana	No. 724, Galle Road, Colombo 03
95	Horana Road, Kottawa, Pannioitiya	No. 724, Galle Road, Colombo 03
96	Horana Road, Kottawa, Pannioitiya	Thalangama North, Bathtaramulla 10120
97	Hena Road, Mount Lavinia 10370	Thalangama North, Bathtaramulla 10120
98	Hena Road, Mount Lavinia 10370	Madiwela, Kotte
99	Havelock Town, Colombo 05	Madiwela, Kotte
100	Havelock Town, Colombo 05	magammana, Homagama

Appendix C:

FIPA ACL Message Structure

C.1   Introduction

This appendix gives a detailed description of the FIPA ACL message structure taken from the FIPA standard specification SC00061.

C.2   FIPA ACL Message Structure

A FIPA ACL message contains a set of one or more message parameters. Precisely which parameters are needed for effective agent communication will vary according to the situation; the only parameter that is mandatory in all ACL messages is the performative, although it is expected that most ACL messages will also contain sender, receiver and content parameters.

If an agent does not recognize or is unable to process one or more of the parameters or parameter values, it can reply with the appropriate not-understood message.

Specific implementations are free to include user-defined message parameters other than the FIPA ACL message parameters specified in *Table 1*. The semantics of these user-defined parameters is not defined by FIPA, and FIPA compliance does not require any particular interpretation of these parameters. The prefatory string "X-" must be used for the names of these non-FIPA standard additional parameters.

Some parameters of the message might be omitted when their value can be deduced by the context of the conversation. However, FIPA does not specify any mechanism to handle such conditions, therefore those implementations that omit some message parameters are not guaranteed to interoperate with each other.

The full set of FIPA ACL message parameters is shown in *Table 1* without regard to their specific encodings in an implementation. FIPA-approved encodings and parameter orderings for ACL messages are given in other specifications. Each ACL message representation specification contains precise syntax descriptions for ACL message encodings based on XML, text strings and several other schemes.

A FIPA ACL message corresponds to the abstract parameter message payload identified in the [FIPA00001].

Parameter	Category of Parameters
performative	Type of communicative acts
sender	Participant in communication
receiver	Participant in communication
reply-to	Participant in communication
content	Content of message
language	Description of Content
encoding	Description of Content
ontology	Description of Content
protocol	Control of conversation
conversation-id	Control of conversation
reply-with	Control of conversation
in-reply-to	Control of conversation
reply-by	Control of conversation

The following terms are used to define the ontology and the abstract syntax of the FIPA ACL message structure:

·   **Frame**. This is the mandatory name of this entity that must be used to represent each instance of this class.

·   **Ontology**. This is the name of the ontology, whose domain of discourse includes their parameters described in the table.

·   **Parameter**. This identifies each component within the frame. The type of the parameter is defined relative to a particular encoding. Encoding specifications for ACL messages are given in their respective specifications.

·   **Description**. This is a natural language description of the semantics of each parameter. Notes are included to clarify typical usage.

·   **Reserved Values**. This is a list of FIPA-defined constants associated with each parameter. This list is typically defined in the specification referenced.

All of the FIPA message parameters share the frame and ontology shown in *Table 2*.

Frame	fipa-acl-message
Ontology	fipa-acl

Type of Communicative Act

Performative

Parameter	Description	Reserved Values
performative	Denotes the type of the communicative act of the ACL message	See [FIPA00037]

Notes: The performative parameter is a required parameter of all ACL messages. Developers are encouraged to use the FIPA standard performatives (see [FIPA00037]) whenever possible.

Participants in Communication

Sender

Parameter	Description	Reserved Values
sender	Denotes the identity of the sender of the message, that is, the name of the agent of the communicative act.	

Notes: The sender parameter will be a parameter of most ACL messages. It is possible to omit the sender parameter if, for example, the agent sending the ACL message wishes to remain anonymous. The sender parameter refers to the agent which performs the communicative act giving rise to this ACL message.

Receiver

Parameter	Description	Reserved Values
receiver	Denotes the identity of the intended recipients of the message.	

Notes: Ordinarily, the receiver parameter will be a part of every ACL message. It is only permissible to omit the receiver parameter if the message recipient can be reliably inferred from context, or in special cases such as the embedded ACL message in proxy and propagate.

The receiver parameter may be a single agent name or a non-empty set of agent names. The latter corresponds to the situation where the message is multicast. Pragmatically, the semantics of this multicast is that the sender intends the message for each recipient of the CA encoded in the message. For example, if an agent performs an inform act with a set of three agents as receiver, it denotes that the sender intends each of these agents to come to believe the content of the message.

Reply To

Parameter	Description	Reserved Values
reply-to	This parameter indicates that subsequent messages in this conversation thread are to be directed to the agent named in thereply-to parameter, instead of to the agent named in the senderparameter.	

Content of Message

Content

Parameter	Description	Reserved Values
content	Denotes the content of the message; equivalently denotes the object of the action. The meaning of the content of any ACL message is intended to be interpreted by the receiver of the message. This is particularly relevant for instance when referring to referential expressions, whose interpretation might be different for the sender and the receiver.	

Notes: Most ACL messages require a content expression. Certain ACL message types, such as cancel, have an implicit content, especially in cases of using the conversation-id or in-reply-to parameters.

Description of Content

Language

Parameter	Description	Reserved Values
language	Denotes the language in which the content parameter is expressed.	See [FIPA00007]

Notes: The ACL content parameter is expressed in a formal language. This field may be omitted if the agent receiving the message can be assumed to know the language of the content expression.

Encoding

Parameter	Description	Reserved Values
encoding	Denotes the specific encoding of the content language expression.	See [FIPA00007]

Notes: The content expression might be encoded in several ways. The encoding parameter is optionally used to specify this encoding to the recipient agent. If the encoding parameter is not present, the encoding will be specified in the message envelope that encloses the ACL message.

Ontology

Parameter	Description	Reserved Values
ontology	Denotes the ontology(s) used to give a meaning to the symbols in the content expression.	

Notes: The ontology parameter is used in conjunction with the language parameter to support the interpretation of the content expression by the receiving agent. In many

situations, the ontology parameter will be commonly understood by the agent community and so this message parameter may be omitted.

Control of Conversation

Protocol

Parameter	Description	Reserved Values
protocol	Denotes the interaction protocol that the sending agent is employing with this ACL message.	See [FIPA00025]

Notes: The protocol parameter defines the interaction protocol in which the ACL message is generated. This parameter is optional; however, developers are advised that employing ACL without the framework of an interaction protocol (and thus directly using the ACL semantics to control the agent's generation and interpretation of ACL messages) is an extremely ambitious undertaking.

Any ACL message that contains a non-null value for the protocol parameter is considered to belong to a conversation and it is required to respect the following rules:

· the initiator of the protocol must assign a non-null value to the conversation-id parameter,

· all responses to the message, within the scope of the same interaction protocol, should contain the same value for the conversation-id parameter, and,

· the timeout value in the reply-by parameter must denote the latest time by which the sending agent would like to have received the next message in the protocol flow (not be confused with the latest time by which the interaction protocol should terminate).

Conversation Identifier

Parameter	Description	Reserved Values
conversation-id	Introduces an expression (a conversation identifier) which is used to identify the ongoing sequence of communicative acts that together form a conversation.	

Notes: An agent may tag ACL messages with a conversation identifier to manage its communication strategies and activities. Typically this will allow an agent to identify individual conversations with multiple agents. It will also allow agents to reason across historical records of conversations.

It is required the usage of globally unique values for the conversation-id parameter in order to allow the participants to distinguish between several concurrent conversations. A simple mechanism to ensure uniqueness is the concatenation of the globally unique identifier of the sender agent to an identifier (for example, a progressive number) that is unique within the scope of the sender agent itself.

Reply With

Parameter	Description	Reserved Values
reply-with	Introduces an expression that will be used by the responding agent to identify this message.	

Notes: The reply-with parameter is designed to be used to follow a conversation thread in a situation where multiple dialogues occur simultaneously. For example, if agent *i* sends to agent *j* a message which contains:

reply-with *<expr>*

Agent *j* will respond with a message containing:

in-reply-to *<expr>*

In Reply To

Parameter	Description	Reserved Values
in-reply-to	Denotes an expression that references an earlier action to which this message is a reply.	

Notes: See notes for Section 2.5.3.

Reply By

Parameter	Description	Reserved Values
reply-by	Denotes a time and/or date expression which indicates the latest time by which the sending agent would like to receive a reply.	

Notes: The time will be expressed according to the sender's view of the time on the sender's platform. The reply message can be identified in several ways: as the next sequential message in an interaction protocol, through the use of the reply-with parameter, through the use of a conversation-id and so forth. The way that the reply message is identified is determined by the agent implementer.