FOUNDATION FOR INTELLIGENT PHYSICAL AGENTS

FIPA 97 Specification

Part 1

Agent Management

Obsolete

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Contents

Foreword

The Foundation for Intelligent Physical Agents (FIPA) is a non-profit association registered in Geneva, Switzerland. FIPA's purpose is to promote the success of emerging agent-based applications, services and equipment. This goal is pursued by making available in a timely manner, internationally agreed specifications that maximise interoperability across agent-based applications, services and equipment. This is realised through the open international collaboration of member organisations, which are companies and universities active in the agent field. FIPA intends to make the results of its activities available to all interested parties and to contribute the results of its activities to appropriate formal standards bodies.

This specification has been developed through direct involvement of the FIPA membership. The 35 corporate members of FIPA (October 1997) represent 12 countries from all over the world

Membership in FIPA is open to any corporation and individual firm, partnership, governmental body or international organisation without restriction. By joining FIPA each Member declares himself individually and collectively committed to open competition in the development of agent-based applications, services and equipment. Associate Member status is usually chosen by those entities who do want to be members of FIPA without using the right to influence the precise content of the specifications through voting.

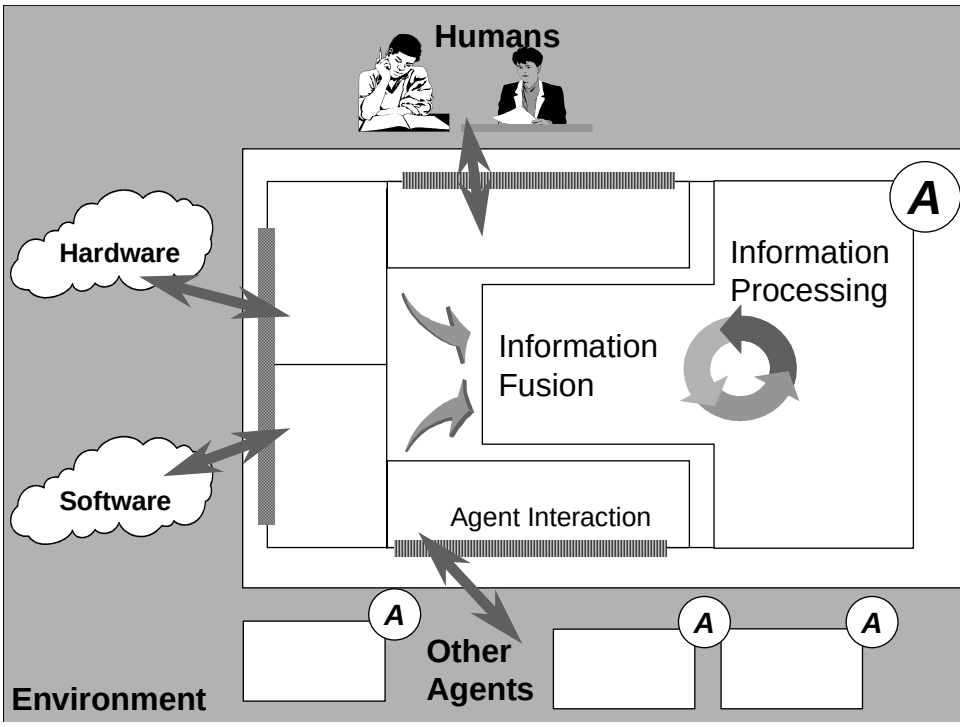
The Members are not restricted in any way from designing, developing, marketing and/or procuring agent-based applications, services and equipment. Members are not bound to implement or use specific agent-based standards, recommendations and FIPA specifications by virtue of their participation in FIPA.

This specification is published as FIPA 97 ver. 1.0 after two previous versions have been subject to public comments following disclosure on the WWW. It has undergone intense review by members as well non-members. FIPA is now starting a validation phase by encouraging its members to carry out field trials that are based on this specification. During 1998 FIPA will publish FIPA 97 ver. 2.0 that will incorporate whatever adaptations will be deemed necessary to take into account the results of field trials.

Introduction

This FIPA 97 specification is the first output of the Foundation for Intelligent Physical Agents. It provides specification of basic agent technologies that can be integrated by agent systems developers to make complex systems with a high degree of interoperability.

FIPA specifies the interfaces of the different components in the environment with which an agent can interact, i.e. humans, other agents, non-agent software and the physical world. See figure below



FIPA produces two kinds of specification

1) **normative** specifications that mandate the external behaviour of an agent and ensure interoperability with other FIPA-specified subsystems;

2) **informative** specifications of applications for guidance to industry on the use of FIPA technologies.

The first set of specifications – called FIPA 97 – has seven parts:

1) three normative parts for basic agent technologies: agent management, agent communication language and agent/software integration

2) four informative application descriptions that provide examples of how the normative items can be applied: personal travel assistance, personal assistant, audio-visual entertainment and broadcasting and network management and provisioning.

Overall, the three FIPA 97 technologies allow:

1) the construction and management of an agent system composed of different agents, possibly built by different developers;

2) agents to communicate and interact with each other to achieve individual or common goals;

3) legacy software or new non-agent software systems to be used by agents.

A brief illustration of FIPA 97 specification is given below

Part 1 Agent Management

This part of FIPA 97 provides a normative framework within which FIPA compliant agents can exist, operate and be managed.

It defines an agent platform reference model containing such capabilities as white and yellow pages, message routing and life-cycle management. True to the FIPA approach, these capablities are themselves intelligent agents using formally sound communicative acts based on special message sets. An appropriate ontology and content language allows agents to discover each other's capabilities.

Part 2 Agent Communication Language

The FIPA Agent Communication Language (ACL) is based on speech act theory: messages are actions, or communicative acts, as they are intended to perform some action by virtue of being sent. The specification consists of a set of message types and the description of their pragmatics, that is the effects on the mental attitudes of the sender and receiver agents. Every communicative act is described with both a narrative form and a formal semantics based on modal logic.

The specifications include guidance to users who are already familiar with KQML in order to facilitate migration to the FIPA ACL.

The specification also provides the normative description of a set of high-level interaction protocols, including requesting an action, contract net and several kinds of auctions etc.

Part 3 Agent/Software Integration

This part applies to any other non-agentised software with which agents need to "connect". Such software includes legacy software, conventional database systems, middleware for all manners of interaction including hardware drivers. Because in most significant applications, non-agentised software may dominate software agents, part 3 provides important normative statements. It suggests ways by which Agents may connect to software via "wrappers" including specifications of the wrapper ontology and the software dynamic registration mechanism. For this purpose, an Agent Resource Broker (ARB) service is defined which allows advertisement of non-agent services in the agent domain and management of their use by other agents, such as negotiation of parameters (e.g. cost and priority), authentication and permission.

Part 4 - Personal Travel Assistance

The travel industry involves many components such as content providers, brokers, and personalization services, typically from many different companies. In applying agents to this industry, various implementations from various vendors must interoperate and dynamically discover each other as different services come and go. Agents operating on behalf of their users can provide assistance in the pre-trip planning phase, as well as during the on-trip execution phase. A system supporting these services is called a PTA (Personal Travel Agent).

In order to accomplish this assistance, the PTA interacts with the user and with other agents, representing the available travel services. The agent system is responsible for the configuration and delivery - at the right time, cost, Quality of

Service, and appropriate security and privacy measures - of trip planning and guidance services. It provides examples of agent technologies for both the hard requirements of travel such as airline, hotel, and car arrangements as well as the soft added-value services according to personal profiles, e.g. interests in sports, theatre, or other attractions and events.

Part 5 - Personal Assistant

One central class of intelligent agents is that of a personal assistant (PA). It is a software agent that acts semi-autonomously for and on behalf of a user, modelling the interests of the user and providing services to the user or other people and PAs as and when required. These services include managing a user's diary, filtering and sorting e-mail, managing the user's activities, locating and delivering (multimedia) information, and planning entertainment and travel. It is like a secretary, it accomplishes routine support tasks to allow the user to concentrate on the real job, it is unobtrusive but ready when needed, rich in knowledge about user and work. Some of the services may be provided by other agents (e.g. the PTA) or systems, the Personal Assistant acts as an interface between the user and these systems.

In the FIPA'97 test application, a Personal Assistant offers the user a unified, intelligent interface to the management of his personal meeting schedule. The PA is capable of setting up meetings with several participants, possibly involving travel for some of them. In this way FIPA is opening up a road for adding interoperability and agent capabilities to the already established

Part 6 - Audio/Video Entertainment & Broadcasting

An effective means of information filtering and retrieval, in particular for digital broadcasting networks, is of great importance because the selection and/or storage of one's favourite choice from plenty of programs on offer can be very impractical. The information should be provided in a customised manner, to better suit the user's personal preferences and the human interaction with the system should be as simple and intuitive as possible. Key functionalities such as profiling, filtering, retrieving, and interfacing can be made more effective and reliable by the use of agent technologies.

Overall, the application provides to the user an intelligent interface with new and improved functionalities for the negotiation, filtering, and retrieval of audio-visual information. This set of functionalities can be achieved by collaboration between a user agent and content/service provider agent.

Part 7 - Network management & provisioning

Across the world, numerous service providers emerge that combine service elements from different network providers in order to provide a single service to the end customer. The ultimate goal of all parties involved is to find the best deals available in terms of Quality of Service and cost. Intelligent Agent technology is promising in the sense that it will facilitate automatic negotiation of appropriate deals and configuration of services at different levels.

Part 7 of FIPA 1997 utilizes agent technology to provide dynamic Virtual Private Network (VPN) services where a user wants to set up a multi-media connection with several other users.

The service is delivered to the end customer using co-operating and negotiating specialized agents. Three types of agents are used that represent the interests of the different parties involved:

1) The Personal Communications Agent (PCA) that represents the interests of the human users.

2) The Service Provider Agent (SPA) that represents the interests of the Service Provider.

3) The Network Provider Agent (NPA) that represents the interests of the Network Provider.

The service is established by the initiating user who requests the service from its PCA. The PCA negotiates in with available SPAs to obtain the best deal available. The SPA will in turn negotiate with the NPAs to obtain the optimal

201 solution and to configure the service at network level. Both SPA and NPA communicate with underlying service- and
202 network management systems to configure the underlying networks for the service.

FIPA Agent Management — Technical Committee 1

1 Scope

This document forms part of the FIPA 1997 standard. It specifies the minimum amount of technology deemed necessary for the management of agents in an open agent system. It provides a normative framework within which FIPA compliant agents can exist, operate and be managed. It is the intention that this document be consistent with both mobile and stationary agent requirements.

The document contains specifications of the FIPA:

- agent reference model

- agent platform

- agent management actions

- agent management content language and ontology

The document is primarily concerned with the interoperability between agents and the agent platform. The internal design of the agent and agent platform is outside the scope of this specification.

The document provides a series of examples to illustrate the agent management actions defined.

2 Normative reference(s)

Internet Inter-ORB Protocol (IIOP) : Common Object Request Broker Architecture (Version 2)

FIPA – International standard for the inter-operation of software agents – Part 2: Agent Cmmunication Language.

FIPA – International standard for the inter-operation of software agents – Part 3: Agent/Software Integration.

3 Terms and definitions

For the purposes of this specification, the following terms and definitions apply:

Action
A basic construct which represents some activity which an agent may perform. A special class of actions is the communicative acts.

ARB Agent
An agent which provides the Agent Resource Broker (ARB) service. There must be at least one such an agent in each Agent Platform in order to allow the sharing of non-agent services.

Agent
An Agent is the fundamental actor in a domain. It combines one or more service capabilities into a unified and integrated execution model which can include access to external software, human users and communication facilities.

Agent Communication Language (ACL)
A language with precisely defined syntax, semantics and pragmatics that is the basis of communication between independently designed and developed software agents. ACL is the primary subject of this part of the FIPA specification.

Agent Communication Channel (ACC) Router
The Agent Communication Channel is an agent which uses information provided by the Agent Management System to route messages between agents within the platform and to agents resident on other platforms.

Agent Management System (AMS)
The Agent Management System is an agent which manages the creation, deletion, suspension, resumption, authentication and migration of agents on the agent platform and provides a “white pages” directory service for all agents resident on an agent platform. It stores the mapping between globally unique agent names (or GUID) and local transport addresses used by the platform.

Agent Platform (AP)
An Agent Platform provides an infrastructure in which agents can be deployed. An agent must be registered on a platform in order to interact with other agents on that platform or indeed other platforms. An AP consists of three capability sets ACC, AMS and default Directory Facilitator.

Communicative Act (CA)
A special class of actions that correspond to the basic building blocks of dialogue between agents. A communicative act has a well-defined, declarative meaning independent of the content of any given act. CA's are modelled on speech act theory. Pragmatically, CA's are performed by an agent sending a message to another agent, using the message format described in this specification.

Content
That part of a communicative act which represents the domain dependent component of the communication. Note that "the content of a message" does not refer to "everything within the message, including the delimiters", as it does in some languages, but rather specifically to the domain specific component. In the ACL semantic model, a content expression may be composed from propositions, actions or IRE's.

Conversation
An ongoing sequence of communicative acts exchanged between two (or more) agents relating to some ongoing topic of discourse. A conversation may (perhaps implicitly) accumulate context which is used to determine the meaning of later messages in the conversation.

Software System
A software entity which is not conformant to the FIPA Agent Management specification.

CORBA:
Common Object Request Broker Architecture, an established standard allowing object-oriented distributed systems to communicate through the remote invocation of object methods.

Definite Descriptor
To be completed

Directory Facilitator (DF)
The Directory facilitator is an agent which provides a “yellow pages” directory service for the agents. It store descriptions of the agents and the services they offer.

Feasibility Precondition (FP)
The conditions (i.e. one or more propositions) which need be true before an agent can (plan to) execute an action.

Identifying Referring Expression (IRE)
To be completed

Illocutionary effect
See speech act theory.

Knowledge Querying and Manipulation Language (KQML)
A de facto (but widely used) specification of a language for inter-agent communication. In practice, several implementations and variations exist.

Message
An individual unit of communication between two or more agents. A message corresponds to a communicative act, in the sense that a message encodes the communicative act for reliable transmission between agents. Note that communicative acts can be recursively composed, so while the outermost act is directly encoded by the message, taken as a whole a given message may represent multiple individual communicative acts.

Message content
See content.

Message transport service
The message transport service is an abstract service provided by the agent management platform to which the agent is (currently) attached. The message transport service provides for the reliable and timely delivery of messages to their destination agents, and also provides a mapping from agent logical names to physical transport addresses.

Ontology
An ontology gives meanings to symbols and expressions within a given domain language. In order for a message from one agent to be properly understood by another, the agents must ascribe the same meaning to the constants used in the message. The ontology performs the function of mapping a given constant to some well-understood meaning. For a given domain, the ontology may be an explicit construct or implicitly encoded with the implementation of the agent.

Ontology sharing problem
The problem of ensuring that two agents who wish to converse do, in fact, share a common ontology for the domain of discourse. Minimally, agents should be able to discover whether or not they share a mutual understanding of the domain constants. Some research work is addressing the problem of dynamically updating agents' ontologies as the need arises. This specification makes no provision for dynamically sharing or updating ontologies.

Perlocutionary Effect
See speech act theory.

Proposition
A statement which can be either true or false. A closed proposition is one which contains no variables, other than those defined within the scope of a quantifier.

Protocol
A common pattern of conversations used to perform some generally useful task. The protocol is often used to facilitate a simplification of the computational machinery needed to support a given dialogue task between two agents. Throughout this document, we reserve protocol to refer to dialogue patterns between agents, and networking protocol to refer to underlying transport mechanisms such as TCP/IP.

Rational Effect (RE)
The rational effect of an action is a representation of the effect that an agent can expect to occur as a result of the action being performed. In particular, the rational effect of a communicative act is the perlocutionary effect an agent can expect the CA to have on a recipient agent.

Note that the recipient is not bound to ensure that the expected effect comes about; indeed it may be impossible for it to do so. Thus an agent may use its knowledge of the rational effect in order to plan an action, but it is not entitled to believe that the rational effect necessarily holds having performed the act.

Speech Act Theory
A theory of communications which is used as the basis for ACL. Speech act theory is derived from the linguistic analysis of human communication. It is based on the idea that with language the speaker not only makes statements, but also performs actions. A speech act can be put in a stylised form that begins "I hereby request …" or "I hereby declare …". In this form the verb is called the performative, since saying it makes it so. Verbs that cannot be put into this form are not speech acts, for example "I hereby solve this equation" does not actually solve the equation. [Austin 62, Searle 69].

In speech act theory, communicative acts are decomposed into locutionary, illocutionary and perlocutionary acts. Locutionary acts refers to the formulation of an utterance, illocutionary refers to a categorisation of the utterance from the speakers perspective (e.g. question, command, query, etc), and perlocutionary refers to the other intended effects on the hearer. In the case of the ACL, the perlocutionary effect refers to the updating of the agent's mental attitudes.

Local Agent Platform
The Local Agent Platform is the AP to which an aget is attached and which represents an ultimate destination for messages directed to that agent.

Software Service
An instantiation of a connection to a software system.

TCP/IP
A networking protocol used to establish connections and transmit data between hosts

Wrapper Agent
An agent which provides the FIPA-WRAPPER service to an agent domain on the Internet.

4 Symbols (and abbreviated terms)

ACC:	Agent Communication Channel
ACL:	Agent Communication Language
AMS:	Agent Management System
AP:	Agent Platform
API:	Application Programming Interface
ARB:	Agent Resource Broker
CA:	Communicative Act
CORBA:	Common Object Request Broker Architecture

DB:	Database
DCOM:	Distributed COM
DF:	Directory Facilitator
FIPA:	Foundation for Intelligent Physical Agents
FP:	Feasibility Precondition
GUID:	Global Unique Identifier
HAP:	Home Agent Platform
HTTP:	Hypertext Transmission Protocol
IDL:	Interface Definition Language
IIOP:	Internet Inter-ORB Protocol
IRE:	Identifying Referring Expression
OMG:	Object Management Group
ORB:	Object Request Broker
RE:	Rational Effect
RMI:	Remote Method Invocation, an inter-process communication method embodied in Java
SL:	Semantic Language
SMTP:	Simple Mail Transfer Protocol
SQL:	Structured Query Language
Sw:	Software System
TCP / IP:	Transmission Control Protocol / Internet Protocol

5 Overview

The agent management specification defines agent registration, agent message passing, agent lifecycles, and an agent platform (AP). An agent management ontology has been defined to facilitate interoperability between agent platforms using FIPA ACL.

The entities contained in the agent management specification are logical capability sets and do not imply any physical configuration.

It should be noted that the concept of an agent platform does not mean that all agents resident on an agent platform have to be co-located on the same host computer. FIPA envisages a variety of different agent platforms from single processes containing lightweight agent threads, to fully distributed agent platforms built around proprietary or open middleware standards.

In the FIPA vision, the implementation details of individual platforms and agents are the design choices of the individual agent system developers.

FIPA does not wish to place restrictions on whatever default intra-platform message routing protocol individual agent-developers wish to support. The minimum protocol a FIPA compliant agent platform will support is the Internet Inter-Orb Protocol (IIOP) from the Object Management Group (OMG). The use of IIOP does not preclude an AP from augmenting this inter-platform messaging protocol with other interoperability protocols, however IIOP must be supported for an AP to be FIPA compliant.

FIPA97 is not concerned with how additional services such as security and transactions are implemented within an AP. Such issues will be addressed in FIPA98.

6 Reference Model

The agent reference model provides the normative framework within which FIPA Agents exist and operate. Combined with the Agent Life-cycle, it establishes the logical and temporal contexts for the creation, operation and retirement of Agents.

The Directory Facilitator (DF), Agent Management System (AMS) and Agent Communication Channel (ACC) are specific types of agents which support agent management. The AMS and ACCsupport inter-agent communication. The ACC supports interoperability both within and across different platforms. The ACC, AMS, and DF form what will be termed the Agent Platform (AP). These are mandatory, normative components of the model.

An Agent will also include a user interface in many cases, but this is not mandatory.

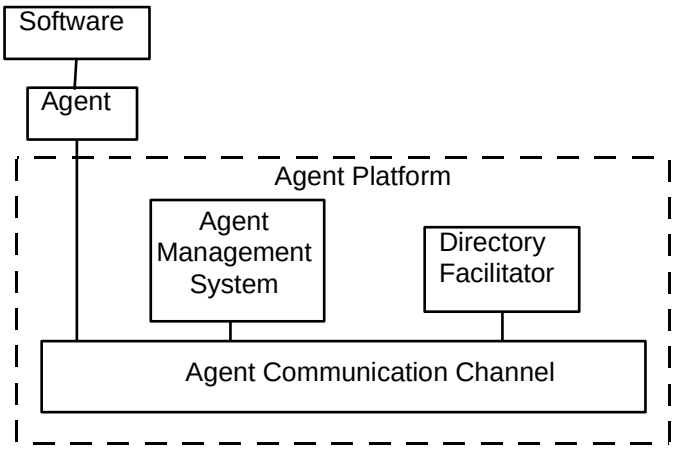


Figure 1 — Agent management reference model

6.1 Agent

An Agent is the fundamental actor on an agent platform which combines one or more service capabilities into a unified and integrated execution model which may include access to external software, human users and communications facilities.

An Agent also defines a unified security perimeter and is thus treated as a single entity in this respect. Note that this does not prohibit differentiated access control to individual Agent services on a secure basis. An Agent must have one or more owners, (for example, based on organisational affiliation or human user). An Agent may have various access control credentials and permissions. Agents may also possess security credentials and security permissions.

An Agent supports several notions of identity. A Globally Unique Identifier (GUID) also known as agent name over all FIPA domains which labels the agent so that it may be unambiguously distinguished in the agent universe. An agent may be registered at a number of addresses at which it can be contacted.

An Agent may have certain resource brokering capabilities for accessing software, (see FIPA Part 3 Agent-Software Interaction).

6.2 Directory Facilitator (DF)

The DF provides “yellow pages” services to other agents. The DF is a mandatory, normative agent which is the trusted, benign custodian of an agent directory. It is trusted in the sense that it must strive to maintain an accurate, complete and timely list of agents including their life-cycle state. It is benign in the sense that it must provide the most current information about agents in its directory on a non-discriminatory basis to all authorised agents. It must respond to queries in a best-effort manner.

The DF may restrict access to information in its directory, and will verify all access permissions for agents which attempt to inform it of Agent state changes. The DF does not control the internal life-cycle of any Agent.

Agents may register their services with the DF or query the DF to find out what services are offered by which agents. At least one DF must be resident on each AP (the *default* DF). However an AP may support any number of DF’s.

DF’s can register with each other. Similarly, AMS, and ACC can register with a DF.

The membership of a DF directory defines an agent domain. A domain is a logical space which provides a context within which Agents may organise and locate each other. An Agent may have a null service set within a domain. One AP can support multiple domains, one domain can span multiple AP´s.

6.2.1 Actions Supported by the DF

Action
deregister
modify
register
search

6.2.2 Reserved Constants in Ontology for the DF

Constant	**Reserved name**
default-df	df@<hostname>:<port>/<target>
service-type	fipa-df
df-state	active, suspended, retired

6.3 Agent Management System (AMS)

An AMS is a mandatory component of the AP. It is an agent which exerts supervisory control over access to and use of the ACC. Only one AMS will exist in a single AP.

An AMS must register with at least the default DF of an AP.

The AMS is responsible for managing the activities of an AP. These responsibilities include creation of agents, deletion of agents, deciding whether an agent can dynamically register a the platform (for example, this could be based upon agent ownership) and overseeing the migration of agents to and from platforms. Since different platforms have different capabilities, the AMS can be queried to obtain a profile of its AP. A life-cycle is associated with an agent on the AP.

The AMS maintains an index of all the agents which are currently resident on a platform. The index includes an agents GUID and their associated transport address for the AP.

6.3.1 Actions Supported by the AMS

actions
authenticate
register-agent
deregister-agent
modify-agent

6.3.2 Reserved Constants in Ontology for the AMS

Constant	**Reserved name**
default-ams	ams@<hostname>:<port>/<target>
service-type	fipa-ams
ap-state	initiated, active, suspended, waiting

6.4 Agent Communication Channel (ACC)

All agents have access to at least one ACC. It provides the path for basic contact and interchange between an agent and other agents, including the DF, and AMS.

The ACC routes messages between agents within the platform and to agents resident on other platforms. The ACC is the default communication method that connects all agents within an AP and between AP's. Only messages addressed to an agent can be sent to an ACC.

The message routing service offered by the ACC must be reliable and orderly and will adhere to the requirements specified in FIPA Part 2.

Inorder for a FIPA compliant AP to be usable it must support at least IIOP[1] .

6.4.1 Actions Supported by the ACC

actions
forward

6.4.2 Reserved Constants in Ontology for the ACC

Constant	Reserved name
default-acc	acc@<hostname>:<port>/<target>

6.5 Software

Software is defined as all non-agent, executable collections of instructions accessible from a domain through an agent. Agents may access software to, for example:

1) add new services,
2) acquire new communications protocols,
3) acquire new security protocols/algorithms,
4) acquire new negotiation protocols,
5) access tools which support migration, etc.

An Agent's access to and use of software may be temporary or permanent. This Reference Model imposes no execution restrictions on the software. That is, the Agent may execute the software internally or remotely and at any time according to its own needs, (see FIPA Part 3 Agent-Software Integration).

[1] This is the minimum which needs to be specified in order to support the interoperability of agent platforms. However, if an agent dynamically registers with a platform, IIOP must be supported inorder to guarantee the exchange of messages between that agent and the agents that already reside on the platform.

7 The Agent Platform (AP)

7.1 Overview

An AP provides the physical infrastructure in which agents can be deployed. An agent must be registered on an AP in order to interact with other agents on that AP or indeed other APs. An AP can support more than one domain[2].

7.2 Relationship between key entities within AP

Figure 2 shows a fragment of the reference model which illustrates the AP concept. This figure shows two agent platforms. On AP1 agents A and B are resident as well as the default AP agents (AMS, DFx). On the second AP (AP2), agents C, D and E are resident. Residency of an agent on the platform implies that the agent has been registered with the AMS.

The ACC provides for the routing of messages between agents on different platforms. Routing messages between AP's requires agreement on a default interoperability protocol including transport protocol, encoding and addressing scheme. However, if an agent dynamically registers with a platform, then method that is always available for exchanging messages between that agent and the agents that already reside on the platform is via IIOP and the ACC.

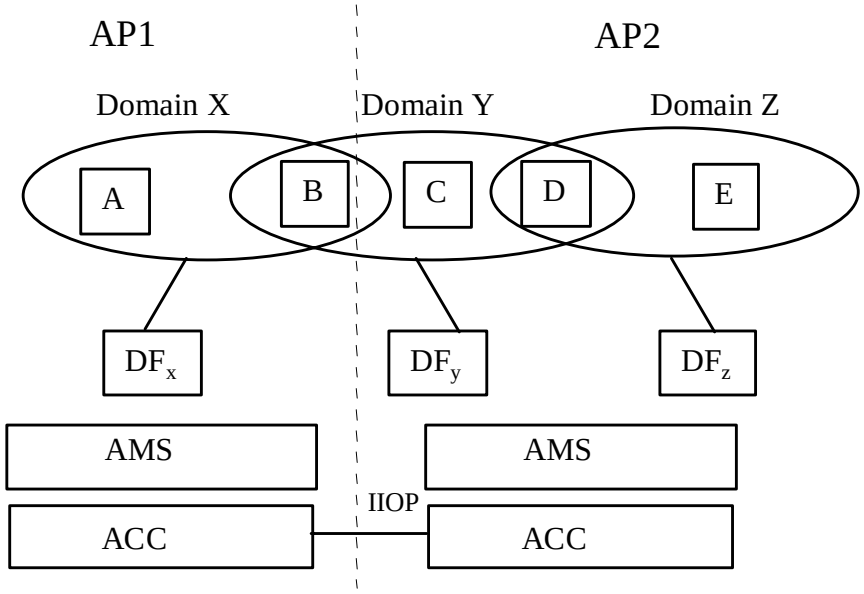


Figure 2 — Agent Platform Reference Model Fragment

Returning to figure 2 on the second AP there are two DFs (DFy and DFz). As can be seen from the figure, DFs provide a logical view of agents which is independent of which particular platform an agent resides upon. Agents D and E have registered their services with DFz; agents B, C and D have registered their services with DFy; while agents A and B have registered their services with DFx. Thus in this example, agents B and D are registered with two DF's.

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[2] The internal design of an Agent Platform is an issue for platform developers and is not a subject of standardisation within FIPA. Agent Platforms and the agents which are native to those platforms, either by creation directly within or migration to the platform may use any proprietary method of intercommunication. For example, a platform could be implemented in Java and message-passing could be equivalent to function calls. FIPA is concerned only with how communication is carried out between agents who are native to the platform; and agents outside the platform, or agent who dynamically register with a platform. Agents are of course free to exchange messages directly by any means they can support.

7.3 The Home Agent Platform

The Home Agent Platform (HAP) is the platform on which an agent was created and is responsible for vouching for the agents identity in it's dealings with other agents and agent platforms. FIPA requires that every agent has an HAP which vouches for the agent to the rest of the agent community. To enforce this, FIPA requires that the GUID can be analysed to obtain the IIOP-URL of the HAP. FIPA requires that the HAP can authenticate the identity of the agent on that platform. To accomplish this the AMS of the HAP supports the following query:

```
(     (request
                  : sender    ams1-agent@iiop://fipa.org:50/acc
                  : receiver  ams2-agent@iiop://fipa.org:50/acc
                  : content
                       (action ams2-agent@iiop://fipa.org:50/acc
                             (authenticate
                               (:agent-name ag@iiop://myagent@cmp.de:99/accid)
                               (:signature     agent-signature) ) )
                       ...)
```

The AMS on the agents HAP is responsible for recording an agents current valid address. For example this facility would be used when agents migrate from one platform to another. It is the agents responsibility to ensure that the address held by its HAP AMS is valid. This message should be transfered in a secure context. An agent will have its name for its entire lifetime.

7.4 Agent Registration on an AP

There are only three ways in which an agent can come to be registered in the AMS:

1) The agent was created on the platform.

2) The agent migrated to the platform, for those platforms which support agent-mobility.

3) The agent explicitly registered with the platform, assuming the platform both supports dynamic registration and is willing to register the new agent. Dynamic registration is where an agent which has an HAP wishes to register on another AP as a local agent.

Agent registration involves registering the following two items of information with an AMS:

1) The globally unique agent identifier (GUID).

2) The local address of the agent.

When an agent is either created or dynamically registers with an agent platform, the agent is registered with the Agent Management System (AMS) using the *register-agent* action. In the following example an agent called *Peter* is registering dynamically with the FIPA agent platform (located at `fipa.org`) . The agent *Peter* was created on the platform (i.e Peter's HAP) at `agentland.com`. and requests that the AMS registers it.

For example :

```
(request
            :sender (   :name   peter@iiop://agentland.com:50/acc
                        :address  iiop://agentland.com:50/acc)
            :receiver ( :name ams@iiop://fipa.org:50/acc
                        :address  iiop://fipa.org:50/acc)
            :ontology   fipa-agent-management
            :language   SL0
            :protocol fipa-request))
            :content
                  (action ams@iiop://fipa.org:50/acc
                     (register-agent
                        (:agent-name peter@iiop://agentland.com:50/acc)
                        (:address    iiop://agentland.com:50/acc)
                        (:secure-encrypted-signature ..…))
      ….)
```

It should be noted that the address which is supplied to the `register-agent` action is the address the agent would like messages directed to, in effect a forwarding address. This represents an agents *local platform*, which is the one to which it is attached and represents an ultimate destination for messages directed to that agent. In this example, the agent registers with `fipa.org` and sets it's forwarding address to it's HAP, so any messages which arrive at `fipa.org` for Peter will be forwarded to `agentland.com`[3] .

By default, the `forward-agent` parameter is set to the `agent-name`. If however, the agent chooses to change this parameter (using `modify-agent` action on the AMS), then messages will be re-directed to another agent.

7.5 The communication act

An agent has two options when it wishes to contact an agent on another platform:

1) It can request that the ACC on which it currently resides routes the message to the target agent and ACC.

2) It can contact the ACC of the target platform directly - i.e. cause a message to be sent directly to the target ACC. The target ACC is then responsible for routing the message to the agent on the target platform.

To contact another agent, the sender agent must be equipped with :

1) the agent name (i.e. GUID) and,

2) a communication address for the agent platform on which the agent resides. Communication addresses are one of the attributes which an agent provides when registering it's services with a DF.

---

[3] When an agent registers with the AMS, the AMS records it's local AP which represnts a forwarding address. This leads to the natural question of what address does Peter have at it's HAP `agentland.com`. FIPA is only concerned with the interoperability between agents and agent platforms. The internal design of an agent platform is an platform-developer issue and not the subject of standardisation. Since Peter was created on `agentland.com` the address registered with the AMS will only have local significance within the platform, for example, if agentland.com were implemented using Java then the address could be a Java Object Reference. Furthermore, it is assumed that platform developers will each specify their own method of enabling agents to contact the ACC.

7.5.1 Agent Communication Channel and Agent Addressing

FIPA requires that each platform provide an ACC which will route messages on an agent's behalf where possible. To support this, FIPA requires that each ACC support at least IIOP (Internet Inter-Orb Operability Protocol) as a default method of communication. This does not mean that each agent must also support IIOP communication. The address an agent provides, for example on registration with the AMS, will determine how a message is routed to that agent. If the address given is the address of a platform (e.g. `iiop://agentland.com/acc`), then the message will be routed to that platform and it is then the responsiblity of the ACC of that platform to route the message to the agent (in a platform-specific manner). On the otherhand, if the agent is able to support direct communication then it is free to use a direct address when registering (e.g. `iiop://agentland.com/peter`).

All agents have a unique identifier also known as its GUID. An agent name is a concatenation of its HAP communication address and a unique name within that AP.

`<name>@<hostname> : <port> / <target>`[4]

1) where `name` is a unique expression for an agent within the HAP. For example, `FipaAgent@info.bt.co.uk:90/"AccId"`

2) where hostname is the IP address of the host on which an ACC is running or a Domain Name Service (DNS) entry which can be further resolved to an IP address

3) the port number of that host on which the ACC is listening; and

4) the `target` is the object key which is used to identify the receiver of the message which the ACC should dispatch the incoming message to. By default, the object key of IIOP messages exchanged between platforms will identify the ACC of that platform.

The payload of the IIOP message will contain an ACL (Agent Communication Language) message which will specify, among other things, the ultimate recipient of the message. Since an ACL message is encoded as a textual string, it can be the responsibility of the ACC to check that the incoming syntax of the ACL message is correct before forwarding the message to the receiver agent. The IIOP protocol supports message failures and re-direct.

The ACC may have a set of rules (implicitly or explicitly) which determine whether an incoming message should be routed to a recipient agent of it's platform. For example:

1) If the Agent is not registered in the AMS, it then rejects the message.

2) If the Agent has expressly requested that access be restricted and the sender does not meet the criteria, it then rejects the message.

3) If the Agent has requested that access be authenticated, then the ACC must authenticate the sender's ACC and the sender itself. It should be noted that since agents can migrate or dynamically register with AP, that the Agent may need to authenticate the sender itself.

Such behaviour is not mandated by FIPA.

Since each agent may register with a number of Agent Platforms, it may be associated with a number of addresses. A FIPA agent address consists of a URL, for example `mailto:agent_server@fipa.org` or `iiop://agent.fipa.org:1755/acc`, it simply defines a means of identifying where to send a message and under which protocol to send it. It is the responsibility of the receiver to handle the delivery of the message to the agent named

[4] The target address is optional depending on the internal architecture of the agent platform, for example, direct IIOP may be used.

as the receiver of the message. A FIPA message contains *sender* and *receiver* parameters. For completeness these can contain both the GUID and the AP address the messages are to be directed to:

```
( :name  <agent name> :address <agent address> )
```

If only the GUID is provided this will be directed to the HAP identified by that name.

7.5.2 Message Routing

Routing a message to an agent involves requesting that the ACC performs the *forward* action. In the following example, agent John is requesting that the ACC at `agentland.com` forwards a communicative act (message) to agent Peter (informing Peter of the weather forecast).

For example

```
(request
      :sender     (:name     john@iiop://somewhere.com:50/acc
                   :address  iiop://somewhere.com:50/acc)
      :receiver   (:name     acc@iiop://agentland.com:50/acc
                  :address  iiop://agentland.com:50/acc)
      :ontology   fipa-agent-management
      :language   SL0
      :protocol   fipa-request
      :content
         (action acc@iiop://agentland.com:50/acc
             (forward
                  (inform
                   :sender (  :name    john@iiop://somewhere.com:50/acc
                              :address iiop://somewhere.com:50/acc)
                   :receiver (:name peter@iiop://agentland.com:50/acc
                              :address iiop://agentland.com:50/acc)
                   :ontology   weather-ontology
                   :language   a-content-language
                   :content   (weather-forecast ‘rain)
                        … ))))
```

When a message arrives at the AP, the ACC extracts the GUID and agent address from the receiver parameters of the message. There are two possibilities, it is either an in-coming message or an outgoing message.

7.5.2.1 Incoming messages

In all incoming messages the agent address identifies the AP on which the ACC operates. The ACC will check to see if the agent identified by the GUID is registered on the platform (with the AMS) and will attempt to forward the message to the address provided by the AMS. If the translated address is a local platform address then the platform will handle this in an implementation-dependent manner. The ACC will send an `inform` message to the originating ACC (as specified in the request protocol) containing the content string `Done(<forward action>).`

If the address is for another platform, then the ACC will substitute the new address in the receiver parameter of the message. The ACC will attempt to forward the message and it is now treated as an outgoing message.

If the agent is not registered on the platform then the ACC will return a `refuse`[5] message containing predicate `(not-registered :name <agent name> :address <agent-address>)).` In the following example, the AP at

[5] The abstract notation for the refuse communicative act is <a, refuse(b, the_action, the_reason)> which reads “agent b informs agent a that it refuses to perform the action *the_action* for reason *the_reason*.

agentland.com refuses to forward the message because the recipient (identified by the receiver parameter of the message) is not registered at agentland.com.

For example

```
  (refuse
            :sender     (:name     acc@iiop://agentland.com:50/acc
                         :address  iiop://agentland.com:50/acc)
            :receiver   (:name   an_agent@iiop://fipa.org:50/acc
                         :address iiop://fipa.org:50/acc)
            :ontology   fipa-agent-management
            :language   SL0
            :context    fipa-request
            :content
               (refuse unavailable
                  (action acc@iiop://agentland.com:50/acc
                        (forward
                          (inform
                          :sender (:name john@iiop://somewhere.com:50/acc
                                   :address iiop://somewhere.com:50/acc)
                          :receiver (:name peter@iiop://agentland.com:50/acc
                                     :address iiop://agentland.com:50/acc)
                          :ontology        weather-ontology
                          :language        a-content-language
                          :content   (weather-forecast ‘rain)
                        … ))))… )
```

7.5.2.2 Outgoing Messages

In the outgoing message the <agent address> identifies another AP. The ACC will attempt to forward the message to this platform. If the address of the platform is not a valid address then the platform refuses to forward the message and the reason given is not-valid-address.

If the address of the other platform is valid, then the platform will execute the communicative act <platform, request(other_platform, forward(…))> (this communicative action is the same type as shown in the example above). The other_platform will respond to this communicative act according to the fipa-request-protocol (typically an *agree* or *refuse*). If it is the latter, then a reason for refusing is also returned, for example, not-registered.

When the other platform attempts to actually forward the message, the agent can be unavailable (simply not answering), in which case the other platform will send a *failure* communicative act containing the reason unavailable.

Otherwise the other_platform informs the originating platform that the action has been performed

```
      <other_platform, inform(platform,
         Done(forward(:communicative-act <message>)))>
```

If agent Peter requested that ACC forward a message to agent jane@iiop://agentland.com/acc, but gave the address of Jane as phone://01/6046001. What happens if the ACC does not support phone communication? In such a case, the forward request is refused with the reason given as no-communication-means.Peter is free to analyse Jane’s address to obtain her HAP and can re-send the message this way.

7.5.2.3 Forwarding Messages to Another Agent

Agents may be physically disconnected from one AP rendering them uncontactable until they are re-connected to an AP. Mobile agents are likely to be uncontactable for short periods of time as they migrate between APs. Similarly, agents may be disconnected from an AP for prolonged periods of time if they are resident on devices such, as laptop computers or mobile phones. In such situations, an agent can request that the AMS forward all messages to another delegated agent[6] .

The delegated authority may have simple functionality such as the ability to buffer messages for later retrieval or more complex ability to act on behalf of the instructing agent.

It is envisaged that this action would be used by an agent prior to it physically being unplugged from an AP or in preparation for its migration to another AP. It is the responsibility of the agent to cancel the forward request once it has re-established itself on an AP.

The ability to delegate authority to another agent is restricted to the instructing agent only. In situations where an attempt is made by a third party agent to delegate responsibility of one agent to another the request action will be refused by the AMS.

The AMS supports the setting-up of an alternate recipient for an agent's messages. Thus Peter could set the AMS / ACC to re-direct any messages sent to Peter to Jane. To do this requires modifying the `:delegate-agent` attribute of the agent entry in the AMS:

For example

```
(request
            :sender     (:name peter@iiop://agentland.com:50/acc
                         :address iiop://agentland.com:50/acc)
            :receiver   (:name ams@iiop://fipa.org:50/acc
                         :address iiop://fipa.org:50/acc)
            :ontology   fipa-agent-management
            :language   SL0
            :protocol fipa-request
            :content
                   (modify-agent
                     (:agent-name peter@iiop://agentland.com:50/acc)
                     (:delegate-agent jane@iiop://agentland.com:50/acc
                           … ))))
```

7.6 The Agent Platform Life-Cycle

The FIPA agents exist physically in an AP and utilises the facilities offered by the AP for realising agent functionalities. In this context, an agent, as a physical software process, has a physical life-cycle that has to be managed by the AP. For each agent, this physical life-cycle and the associated states can be different from the external logical life-cycle and states in the domain, which are managed by the DF. It should be noted that the implementation of a FIPA conformant agent platform can choose to support part of the states and transitions specified below.

The AP life-cycle of an FIPA agent is :

1) AP bounded : An agent is physically managed within an AP. The life-cycle of an agent is therefore always bounded to a specific AP

[6] It is possible for the `:envelope` parameter in ACL to be used to identify the originating agent of a forwarded message.

2) Application independent : The life-cycle model is independent from any application systems. It defines only the states and the transition of the agent service in its life cycle. This is because FIPA shall provide a baseline for various application oriented models.

3) Instance oriented : The agent described in the life-cycle model is assumed an instance (an agent which has unique name and is executed independently). This is because an instance is an essential actor in the system. The instance is an independent executable entity in the system.

4) Uniqueness :Different from the domain life-cycle, where an agent can have different states in different domains at the same time, each agent has only one AP life-cycle state at any time and within only one AP.

The agent AP life-cycle is represented by states (circles) and transitions as showed in the figure below.

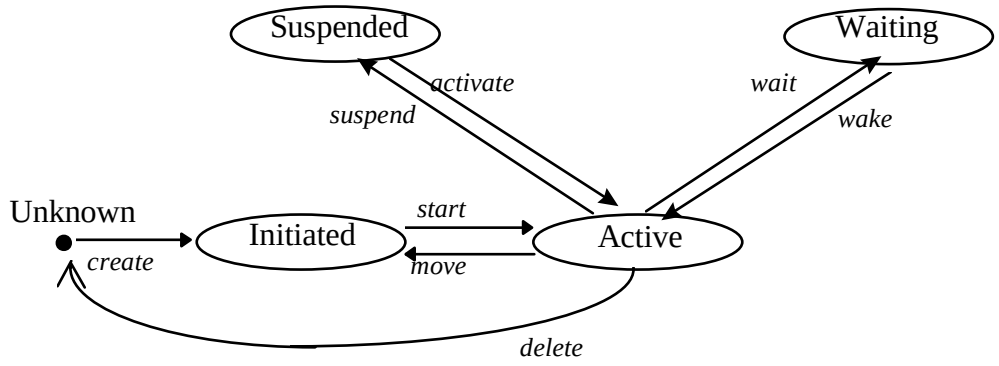

Figure 3 — AP Life-Cycle

7.6.1 State Description

Initiated	The agent is created or just arrived at a new AP. The AP can further initiate its parameters/environment before starting/restarting the agent.
Active	The agent is operating on the AP.
Suspended	The agent execution has been suspended, either by the AP/AMS, or requested by the agent itself. If messages are directed to an agent in this state, the AMS will issue a delivery failure report to the sending agent.
Waiting	The agent is waiting (blocked) for a certain event, e.g. the arrival of new ACL messages or other AP management events. If messages are directed to an an agent that is in the Waiting state, messages will be delivered but the agent might not be able to respond immediately.

7.6.2 Transition Description

Create	The creation (installation) of a new agent.
Start	Starting/Restarting the operation of the agent
Suspend	Suspending the operation of an agent, either by the AP or requested by the agent itself

Activate	Activating a suspended agent
Wait	To put the agent in a waiting state for certain events. Different from the *suspend* action, *wait* can not be initiated by the AP.
Wake	To wake the agent from the waiting state. This can only be initiated by the AP.
Delete	Stop the agent and delete it from the AP.

8 Agent Domain

8.1 Overview

An agent domain is a logical grouping of agents/services defined by membership of a directory maintained by the DF. Each domain has one and only one DF, which provides a unified, complete and coherent description of the domain. The directory lists all Agents in the DF domain and is used to advertise agent existence, services, capabilities, protocols, etc. An agent may be present in one or more domains. As part of its normative life-cycle, an agent must register with a DF in order to be present in a domain. Domains may have (for example) organisational, geo-political, contractual, ontological, affiliation or physical significance.

The entire Agent Universe is represented as the set of all domains.

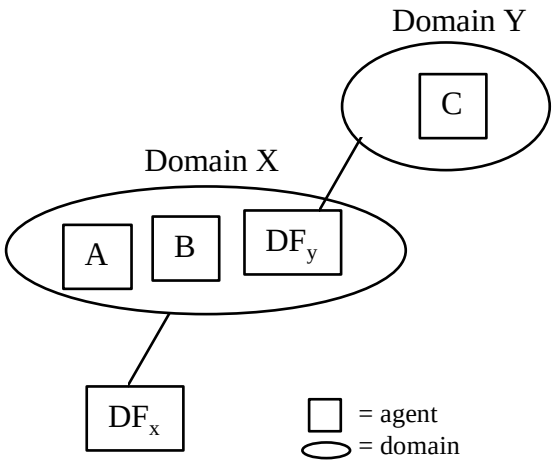

Figure 4 — Agent Domains

Agent domains can be structured where a DF registers with other DFs. Agents can query information on agents in other domains through its DF escalating the query to a level at which it can be resolved. The querying agent can interact either directly with DFs (i.e. interacting with each DF for each domain searched), or indirectly (i.e. interacting only with one DF which interacts with others in order to resolve the query). In the latter case the response to the query is passed through the hierarchy to the agent which originated the query. FIPA does not require the complete interconnection of all DF's.

The agent domain life-cycle model forms a baseline framework for agent management. The model defines the external state of an agent in a particular domain as viewed by the DF and does not necessarily model the internal states of an agent.

The domain life-cycle is :

1) Domain centric : An agent is recognised and managed in the domains to which the agent is registered. The life-cycle model focuses on activities of an agent within one domain. An agent may hold different states in different domains.

2) Application independent : The life-cycle model is independent from any application systems. It defines only the states and the transition of the agent in its life cycle.

3) Instance oriented : The agent described in the life-cycle model is assumed an instance (an agent which has unique name and is executed independently). This is because an instance is an essential actor in the system. The instance is an independent executable entity in the system.

8.2 Registering with the Directory Facilitator

When an agent wishes to advertise its services to other agents, it uses the register action (for the purposes of example we assume that agent Peter has obtained the name of the default DF for its agent platform - which is called `df@iiop://fipa.org/acc`):

For example

```
(request
            :sender     (:name peter@iiop://agentland.com:50/acc
                         :address iiop://agentland.com:50/acc)
            :receiver   (:name df@iiop://fipa.org:50/acc
                         :address iiop://fipa.org:50/acc)
            :ontology   fipa-agent-management
            :language   SL0
            :protocol fipa-request
            :content
                  (action df@iiop://fipa.org:50/acc
                  (register
                  (:agent-name peter@iiop://agentland.com:50/acc
                   :agent-services
                        (:service-type video-on-demand
                         :service-ontology itut-vod
                         :service-description ”......”
                         :service-conditions ”......” )
                   :interaction-protocols (fipa-request)
                   :ontology fipa-agent-management
                   :address iiop://fipa.org/acc
                   :ownership peter
                   :state  active)))
                        ….)
```

In the exampe, agent Peter advertises a weather-forecast service with the DF at `fipa.org`. Note that now Peter has two communication addresses which agents can choose from: his new address at `fipa.org` and the address of his HAP at `agentland.com`. If a some future period, an agent searches the DF for a weather-service and finds Peter's entry, it is free to use whichever address it is most happy with. If it uses the agentland.com address, the ACC of that platform will handle routing of messages to Peter (in a platform-specific manner). If on the other hand, the agent decides to use the fipa.org address, then the ACC will check the AMS for a forwarding address. Therefore in the example above this is `agentland.com`, so the ACC at `fipa.org` will route the message to the ACC at `agentland.com`..

8.3 The domain life-cycle

The agent life-cycle model is represented by states (circles) and transitions (arrows) as shown in the figure below.

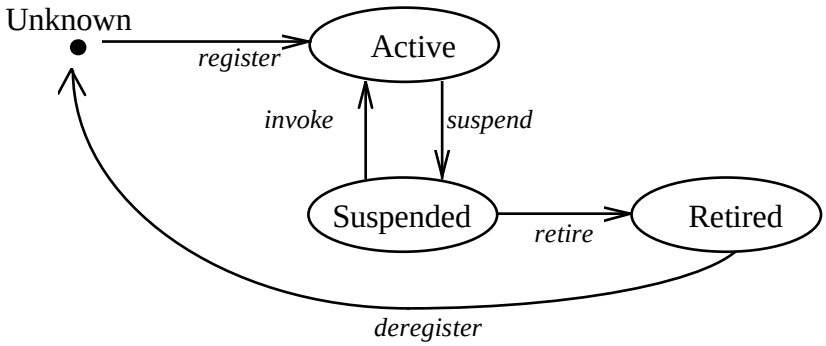

Figure 5 — Agent domain life-cycle model

8.3.1 State Descriptions

Suspended	The agent has been registered to the directory but is off-line and ready to invoke.
Active	The agent is invoked and available. Whilst in this state the agent may hold whatever internal states deemed necessary by the agent developer.
Retired	The agent is de-registered or marked “retired” and no longer available in the domain. The agent in this state may contain its execution history which may be used by the AMS.

8.3.2 Transition Descriptions

Register	An agent provides a DF with its name, a description of its attributes.
Invoke	An agent informs the DF of it becoming available for agents to access.
Suspend	An agent informs the DF of it being temporarily unavailable.
Retire	An agent informs the DF of it being permanently unavailable.
Deregister	An agent requests that the DF delete its entry from the DF’s directory.

9 FIPA Agent Management Ontology

This section defines the agent management ontology.

9.1 Agent Management Grammar

This agent management grammar is the definition of terms for Agent Management using SL0, (see Annex 2, FIPA97 Part 2).

Agent Management Actions

```
SL0FunctionalTerm =     “(“ “register” FIPA-DF-description+ “)”
                        |“(“ “deregister” FIPA-DF-description+“)”
                        |“(“ “modify” FIPA-DF-description+“)”
                        |“(“ “search” FIPA-DF-description+ Constraint+“)”
                        |“(“ “register-agent” FIPA-AMS-description+“)”
```

```
                          |“(“ “deregister-agent” FIPA-AMS-description+“)”
                          |“(“ “authenticate” FIPA-AMS-description+“)”
                          |“(“ “modify-agent” FIPA-AMS-description+“)”
                          |“(“ “forward” ACL-communication-act “)”
```

Agent Management Object Descriptions

```
ManOb-description =       FIPA-DF-description
                          |     FIPA-AMS-description
                          |     FIPA-AP-description
                          |     FIPA-Service-Desc

FIPA-DF-description =     “(“ “:agent-name” AgentName“)”
                          |“(“ “:agent-address” CommAddress“)”
                          |“(“ “:agent-services” “(” FIPA-SerDesc + “)””)”
                          |“(“ “:agent-type” Word“)”
                          |“(“ “:interaction-protocols” “(” Word + “)””)”
                          |“(“ “:ontology” SLTerm“)”
                          |“(“ “:ownership” SLTerm“)”
                          |“(“ “:df-state” DfLifecycleState“)”

FIPA-AMS-description =    “(“ “:agent-name” AgentName“)”
                          |“(“ “:address” CommAddress“)”
                          |“(“ “:signature” Word“)”
                          |“(“ “:ap-state” APState“)”
                          |“(“ “:delegate-agent-name” AgentName“)”
                          |“(“ “:forward-address” CommAddress “)”

FIPA-AP-description =     “(“ “:platform-name” Word“)”
                          |“(“ “:iiop-url” URL“)”
                          |“(“ “:dynamic-registration” Boolean“)”
                          |“(“ “:mobility” Boolean“)”
                          |“(“ “:ownership” Word“)”
                          |“(“ “:certification-authority” Word“)”
                          |“(“ “:default-df” AgentName “)”

FIPA-Service-Desc =       “(“ “:service-type” ServiceTypes “)”
                          |“(“ “:service-ontology” SLTerm “)”
                          |“(“ “:service-description” SLTerm“)”
                          |“(“ “:service-conditions” SLTerm “)”

DfLifecycleState =        “active”
                          |“suspended”
                          |“retired”.

APState =                 “initiated”
                          |“active”
                          |“suspended”
                          |“waiting”

ServiceTypes =            “fipa-df”
                          |“fipa-ams”
                          |“fipa-acc”
                          |“fipa-agent”
                          | Word
```

Agent Management Exception Propositions

```
SL0FunctionalTerm =       “(“ “no-communication-means” ManOb-description“)
                          |“(“ “acc-unavailable” ManOb-description“)”
```

```
                          |“(“ “agent-not-registered” ManOb-description“)”
                          |“(“ “unrecognised-attribute-value”
                                ManOb-description“)”
                          |“(“ “unrecognised-attribute” ManOb-description“)”
                          |“(“ “unauthorised” “)”
                          |”(“ “failed-management-action” “)”
                          |“(“ “unwilling-to-perform” “)”
                          |“(“ “df-overloaded” “)”
                          |“(“ “ams-overloaded” “)”
                          |“(“ “acc-overloaded” “)”
                          |“(“ “unable-deregister” “)”
                          |“(“ “inconsistency” “)”

Constraint =              “(“ “:df-depth” ConstraintFn Integer“)”
                          |“(“ “:recs-req” ConstraintFn Integer“)”

ConstraintFn =            “Max”
                          |“Min”
                          |“Exactly”.

AgentName =               Word “@” CommAddress.

CommAddress =             Word“://”(IPAddress|DNSName) “:” Integer “/” ACCObj.

IPAddress =               Integer “.”Integer “.”Integer “.”Integer

DNSName =                 Word

ACCObj =                  Word
```

Rules for Well Formed Agent Management Messages

The following tables illustrate the mandatory attributes to ensure correct formation for each of the actions defined in this specification. This section aims to clarify the EBNF grammar defined above. Each table describes the use of a single object. Attributes which are listed as optional can be used to form syntactically correct management actions, however the attribute may have no semantics for that action. The syntax for the actions is given above.

FIPA-DF-description

Attribute	**Action**			
	register	deregiser	modify	search
:agent-name	M	M	M	O
:agent-services	O	O	O	O
:agent-type	M	O	O	O
:protocols	O	O	O	O
:ontology	O	O	O	O
:address	M	O	O	O
:ownership	M	O	O	O

:df-state	M	O	O	O

923

923

924 FIPA-AMS-description

Attribute	Action			
	authenticate	register-agent	deregister-agent	modify-agent
:agent-name	M	M	M	M
:address	O	M	O	O
:signature	M	O	O	O
:ap-state	O	M	O	O
:delegate-agent-name	O	O	O	O
:forward-address	O	O	O	O

925

926 The management actions *query-agent* and *search* do not enforce mandatory attributes, however a well formed
927 message must include at least one attribute.

928 All of the attributes of the FIPA-Service-Desc object are mandatory.

929 All management actions using the *FIPA-Request* protocol will, if successful, yield a *inform Done* message from the
930 agent which performed the action. The *search* action is the exception to this rule as it will yield a *inform Result* when
931 successful.

932 The semantics of the Operators used as a Constraint for the *search* action is defined as:

Operator	Description
Max	Respond with no more than the defined number of objects.
Min	Respond with at least the defined number of objects.
Exactly	Respond with the defined number of objects exactly.

933

934 ## 9.2 Agent Platform Actions

935 This section describes each agent platform action. It defines what is considered well-formed management action. It also
936 identifies exceptions that can be raised with each management action.

937

9.2.1 register

Supported by	DF	
Description	An agent registers its services in order to publicise some or all of them to other agents. There is *no* intended future commitment or obligation, on the part of the registering agent implied in the act of registering. For example, an agent can refuse a request for a service which is advertised through a DF. There is a commitment on behalf of the DF to honestly broker information it holds. When an agent applies for registration in a domain an agent description must be supplied containing values for all of the mandatory attributes of the agent description. It may also supply optional and private fields, containing non-FIPA standardised information an agent developer might want included in the directory.	
Content	`fipa-man-df-agent-description`	
FIPA Protocol	`fipa-request`	

Example	`(request`
	`: sender an-agent@iiop://fipa.org:50/acc`
	`: receiver a-df@iiop://fipa.org:50/acc`
	`: content`
	`(action a-df@iiop://fipa.org:50/acc`
	`(register`
	`(:agent-name an-agent@iiop://fipa.org:50/acc)`
	`(:agent-services`
	`(:service-type video-on-demand)`
	`(:service-ontology itut-vod)`
	`(:service-description ”.....”)`
	`(:service-conditions ”.....” ))`
	`(:interaction-protocols (fipa-request))`
	`(:ontology fipa-agent-management)`
	`(:address iiop://fipa.org/acc)`
	`(:ownership fipa.org)`
	`(:state active)))`
	`: language SLl0`
	`: protocol fipa-request`
	`: ontology fipa-agent-management)`	

Refuse Reasons	`unrecognised-attribute-value`	This error occurs when an invalid syntax was detected in one of the attribute values.
	`unrecognised-attribute`	This error occurs when one of the attribute id in the message does not belong to the DF object.
	`unauthorised`	This occurs if the requesting agent is not sufficiently authorised.
	`unwilling-to-perform`	This error occurs if the DF is refusing to perform the action.
Failure Reasons	`agent-already-registered`	This failure occurs if the agent to be registered is already in the DF.

	df-overloaded	This occurs because the DF fails to finish the operation because of processing resource overload.

9.2.2 search

Supported by	DF	
Description	A search action involves a request for information from a DF. The DF does not guarantee the validity of the information provided. A search is satisfied with the DF identifying agent entry(ies) in the directory that satisfy the content of the query. This could entail the escalation of the search to other DF's if the query cannot be resolved locally. A search can be defined to constrain the action of the DF. A search can return more than one agent description that satisfies the search criteria.	
Content	fipa-man-df-agent-description	
FIPA Protocol	fipa-request (see FIPA97 Part 2)	
Example	(request : sender an-agent@iiop://fipa.org:50/acc : receiver a-df@iiop://fipa.org:50/acc : content (action a-df@iiop://fipa.org:50/acc (search (:agent-address iiop://fipa.org:50/acc) (:state active) (:df-depth Exactly 1))) : language SL0 : reply-with id : protocol fipa-request : ontology fipa-agent-management)	
Reply	The above query requests all agent names where the agent is registered as active and owned by bz-ind. The reply would be a result, for example: (inform : sender a-df@iiop://fipa.org:50/acc : receiver an-agent@iiop://fipa.org:50/acc : content (result ((:agent-name agent1@iiop://fipa.org:50/acc) (:agent-name agent2@iiop://fipa.org:50/acc)) : language SL0 : in-reply-to id : protocol fipa-request : ontology fipa-agent-management)	
Refuse Reasons	unrecognised-attribute-value	This error occurs when an invalid syntax was detected in one of the attribute values.
	unrecognised-attribute	This error occurs when one of the attribute id in the message does not belong to the DF object.

	Unauthorised	This occurs if the requesting agent is not sufficiently authorised.
	unwilling-to-perform	This error occurs if the DF is too busy or overloaded with other operations.
Failure Reasons	df-overloaded	This occurs because the DF fails to finish the search operation because of processing resource overload.

940 **9.2.3 modify**

Supported by	DF	
Description	Involves the changing of an agent's details in a particular DF directory. The intention is that the DF will replace previous information stored on the directory with that provided as the content of the modify action.	
Content	fipa-man-df-agent-description	
FIPA Protocol	fipa-request (see FIPA97 Part 2)	
Example	(request : sender an-agent@iiop://fipa.org:50/acc : receiver a-df@iiop://fipa.org:50/acc : content (action a-df@iiop://fipa.org:50/acc (modify (:agent-name an-agent@iiop://fipa.org:50/acc) (:state suspended))) : language SL0 : protocol fipa-request : ontology fipa-agent-management)	
Refuse Reasons	unrecognised-attribute-value	This error occurs when an invalid syntax was detected in one of the attribute values.
	unrecognised-attribute	This error occurs when one of the attribute id in the message does not belong to the DF object.
	unauthorised	This occurs if the requesting agent is not sufficiently authorised.
	unwilling-to-perform	This error occurs if the DF is too busy or overloaded with other operations.
Failure Reasons	df-overloaded	This occurs because the DF fails to finish the modification operation because of processing resource overload.
	inconsistency	DF rejected the modification because e.g. that it failed to keep the consistency of his knowledge.

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9.2.4 deregister

Supported by	DF	
Description	An agent de-registers in order to remove any record of its attribute(s) from a domain. The de-register action has the consequence that there is no-longer a committment on behalf of the DF to broker information relating to that agent.	
Content	`fipa-man-df-agent-description`	
FIPA Protocol	`fipa-request` (see FIPA97 Part 2)	

Example	`(request`
	`: sender an-agent@iiop://fipa.org:50/acc`
	`: receiver a-df@iiop://fipa.org:50/acc`
	`: content`
	`(action a-df@iiop://fipa.org:50/acc`
	`(deregister`
	`(:agent-name an-agent@iiop://fipa.org:50/acc)))`
	`: language SL0`
	`: ontology fipa-agent-management`
	`: protocol fipa-request)`	

Refuse Reasons	`unrecognised-attribute-value`	This error occurs when an invalid syntax was detected in one of the attribute values.
	`unauthorised`	This occurs if the requesting agent is not sufficiently authorised.
	`unwilling-to-perform`	This error occurs if the DF is too busy or overloaded with other operations.
	`unable-to-deregister`	The agent can not be deregistered because it has still pending contracts, or because the agent is not found in the DF.
Failure Reasons	`df-overloaded`	This occurs because the DF fails to finish the operation because of processing resource overload.

9.2.5 register-agent

Supported by	AMS	
Description	The register-agent action involves the registration of an agent's attributes including its GUID and associated communication address(es) with an AMS.	
Content	`fipa-man-ams-agent-description`	
FIPA Protocol	`fipa-request` (see FIPA97 Part 2)	

Example	`(request`
	`: sender myagent@iiop://fipa.org:50/acc`
	`: receiver an-ams@iiop://fipa.org:50/acc`
	`: content`
	`(action an-ams@iiop://fipa.org:50/acc`
	`(register-agent`
	`(:agent-name myagent@iiop://cmp.de:99/acc2-id)`
	`(:address myagent@iiop://inf.co.uk:90/acc-id)`
	`(:signature agent-sig)))`
	`: language SL0`
	`: ontology fipa-agent-management`
	`: protocol fipa-request)`	

Refuse Reasons	`unrecognised-attribute-value`	This error occurs when an invalid syntax was detected in one of the attribute values.
	`Unrecognised-attribute`	This error occurs when one of the attribute id in the message does not belong to the AMS object.
	`Unauthorised`	This occurs if the requesting agent is not sufficiently authorised.
	`unwilling-to-perform`	This error occurs if the AMS is too busy or overloaded with other operations.
Failure Reasons	`ams-overloaded`	This occurs because the AMS fails to finish the modification operation because of processing resource overload.
	`agent-already-registered`	This failure occurs if the agent to be registered is already in the AMS.

9.2.6 deregister-agent

Supported by	AMS	
Description	An agent de-registers in order to remove any record of its attribute(s) from an AMS. The AMS can be requested to deregister on behalf of another agent during agent migration.	
Content	`fipa-man-ams-agent-description`	
FIPA Protocol	`fipa-request` (see FIPA97 Part 2)	

Example	`(request`
	`: sender an-agent@iiop://fipa.org:50/acc`
	`: receiver ams-agent@iiop://fipa.org:50/acc`
	`: content`
	`(action ams-agent@iiop://fipa.org:50/acc`
	`(deregister-agent`
	`(:agent-name an-agent@iiop://fipa.org:50/acc)))`
	`: language SL0`
	`: ontology fipa-agent-management`
	`: protocol fipa-request)`	

Refuse Reasons	`unrecognised-attribute-value`	This error occurs when an invalid syntax was detected in one of the attribute values.
	`Unauthorised`	This occurs if the requesting agent is not sufficiently authorised.
	`unwilling-to-perform`	This error occurs if the DF is too busy or overloaded with other operations.
	`unable-to-deregister`	The agent can not be deregistered because it has still pending contracts, or because the agent is not found in the AMS.
Failure Reasons	`ams-overloaded`	This occurs because the AMS fails to finish the operation because of processing resource overload.

9.2.7 modify-agent

Supported by	AMS	
Description	The modify-agent action Involves the changing of an agent's details in a particular AMS directory.	
Content	`fipa-man-ams-agent-description`	
FIPA Protocol	`fipa-request` (see FIPA97 Part 2)	

Example	`(request`
	`: sender an-agent@iiop://fipa.org:50/acc`
	`: receiver ams-agent1@iiop://fipa.org:50/acc`
	`: content`
	`(action ams-agent1@iiop://fipa.org:50/acc`
	`(modify-agent`
	`(:agent-name an-agent@iiop://fipa.org:50/acc)`
	`(:delegate-agent-name`
	`ams-agent2@iiop://fipa.org:50/acc))))`
	`: language SL0`
	`: ontology fipa-agent-management`
	`: protocol fipa-request)`	

Refuse Reasons	`unrecognised-attribute-value`	This error occurs when an invalid syntax was detected in one of the attribute values.
	`unrecognised-attribute`	This error occurs when one of the attribute id in the message does not belong to the AMS object.
	`unauthorised`	This occurs if the requesting agent is not sufficiently authorised.
	`unwilling-to-perform`	This error occurs if the AMS is too busy or overloaded with other operations.
Failure Reasons	`ams-overloaded`	This occurs because the AMS fails to finish the modification operation because of processing resource overload.
	`inconsistency`	AMS rejected the modification because e.g. that it failed to keep the consistency of his knowledge.

9.2.8 authenticate

Supported by	AMS	
Description	An agent can request that the AMS verifies an agent's identity.	
Content	`fipa-man-ams-agent-description`	
FIPA Protocol	`fipa-request` (see FIPA97 Part 2)	

Example	`(request`
	`: sender an-agent@iiop://fipa.org:50/acc`
	`: receiver ams-agent@iiop://fipa.org:50/acc`
	`: content`
	`(action ams-agent@iiop://fipa.org:50/acc`
	`(authenticate`
	`(:agent-name`
	`an-agent-name@iiop://fipa.org:50/acc)`
	`(:agent-encrypted-signature a-sig)))`
	`: language SL0`
	`: ontology fipa-agent-management`
	`: protocol fipa-request)`	

Refuse Reasons	`unrecognised-attribute-value`	This error occurs when an invalid syntax was detected in the agent name or signature.
	`unrecognised-attribute`	This error occurs when other attribute ids appear in the message.
	`unauthorised`	This occurs if the requesting agent is not sufficiently authorised.
	`unwilling-to-perform`	This error occurs if the AMS is too busy or overloaded with other operations.
Failure Reasons	`ams-overloaded`	AMS failed to authenticate the agent due to internal resource problems.

952 **9.2.9 forward**

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Supported by	ACC	
Description	An agent can ask an ACC to forward a message to a destination agent	
Content	ACLCommunicativeAct (see FIPA97 Part 2)	
FIPA Protocol	fipa-request (see FIPA97 Part 2)	
Example	(request : sender an-agent@iiop://fipa.org:50/acc : receiver an-acc@iiop://fipa.org:50/acc : content (action an-acc@iiop://fipa.org:50/acc (forward (request : sender an-agent@iiop://fipa.org:50/acc : receiver a-df@iiop://agentland.org:50/acc : content (action a-df@iiop://fipa.org:50/acc (modify (:agent-name an-agent@iiop://fipa.org:50/acc) (:state suspended))) : language SL0 : protocol fipa-request : ontology fipa-agent-management))) : ontology fipa-agent-management : language SL0 : protocol fipa-request)	
Refuse Reasons	unrecognised-attribute-value	This error occurs when an invalid syntax was detected in the agent name or signature.
	unrecognised-attribute	This error occurs when attribute ids appear in the message are invalid.
	Unauthorised	This occurs if the requesting agent is not sufficiently authorised.
	unwilling-to-perform	This error occurs if the ACC is too busy or overloaded with other operations.
	agent-not-registered	This error occurs if the destination agent is not registered in that AP.
	no-communications-means	This error occurs if there is no shared communication protocol to reach the destination agent.
Failure Reasons	acc-unavailable	ACC failed to complete the action due to internal resource problems.

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9.3 Agent Management Objects

This section defines the parameters associated with the content of management operations. All descriptions are extensible, in that additional parameters can be defined and used by agent developers.

9.3.1 fipa-man-df-agent-description

Parameter	Description
:agent-name	Denotes the globally unique agent identifier.
:agent-type	Identifies the type of agent described.
:agent-services	Denotes the service(s) the agent can provide. This would include a description of the characteristics of the service description as well as the service description itself. See fipa-man-service-description.
:interaction-protocols	Characterises the protocols supported by the agent. This can include both standardised and/or non-standard protocols.
:ontology	Denotes the ontology(ies) the agent can support.
:agent-address	An agent must support at least one communication address and by definition if only one is provided, it must be the IIOP address of the agent platform on which the agent resides.
:ownership	Identifies the party that is legally responsible for the agents activities.
:df-state	Denotes the domain life-cycle state, for example suspended.

961 **9.3.2 fipa-man-platform-profile**

Parameter	Description
:platform-name	Denotes a globally unique identifier for the agent platform
:iiop-url	Denotes the IIOP URL of the platform
:dynamic-registration	Denotes whether the platform supports dynamic registration
:mobility[7]	Denotes whether the platform supports agent mobility.
:ownership	Identifies the owner of the platform.
:certification-authority	Denotes the certification authority for the platform.
:default-DF	Identifies the GUID of the agent platforms default DF

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[7] This parameter is not used in FIPA97.

963 **9.3.3 fipa-man-service-description**

Parameter	Description
:service-type	Denotes the unique service type.
:service-ontology	Identifies the ontology for the service description.
:service-description	A description of the service. This could be a complex structure using a particular ontology defined in the :service-ontology parameter.
:service-condition	A description of the conditions in which to provide the service.

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965 **9.3.4 fipa-man-ams-agent-description**

Parameter	Description
:agent-name	Denotes the globally unique agent name.
:address	An agent must support at least one communication address and by definition if only one is provided, it must be the IIOP address of the agent platform on which the agent resides.
:signature	Denotes a secure encrypted signature for an agent.
:delegate-agent	Denotes the name of an agent, other than the agent that is the subject of the description, (i.e. identified under :agent-name) that has been delegated as recipient of all messages.
:forward-address	Identifies an agent address to which all messages should be forwarded to. The default value is the agent name.
:ap-state	Denotes the agent platform lifecycle state of the agent.

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9.3.5 fipa-man-exception

Parameter	Description
unrecognised-attribute-value	This error occurs when an invalid syntax was detected in the agent name or signature.
unrecognised-attribute	This error occurs when the attribute identifiers which appear in the message are invalid.
Unauthorised	This occurs if the requesting agent is not sufficiently authorised.
unwilling-to-perform	This error occurs if the recipient agent is refuses to perform a requested action..
agent-not-registered	This error occurs if the destination agent is not registered in that AP.
no-communications-means	This error occurs if there is no shared communication protocol to reach the destination agent.
acc-unavailable	ACC failed to complete the action and it is unavailable
unable-to-deregister	The agent can not be deregistered. For example, it might have pending contracts, or because the agent is not found in the DF.
df-overloaded	This occurs because the DF fails to finish the operation because of processing resource overload.
inconsistency	An action is rejected due to some inconsistency in the original request.
agent-already-registered	This failure occurs if the agent to be registered is already in the DF or AMS
unauthorised	This occurs if the requesting agent is not sufficiently authorised.
ams-overloaded	This occurs because the AMS fails to finish the modification operation because of processing resource overload.

Annex A

(normative)

Agent Communication Channel Interface Description Language

The following IDL specifies the agent interface which is intentionally minimal. The interface contains a single operation operation *message* which supplies a string containing the ACL message as a parameter. Future versions of FIPA agent specifications reserve the right to extend or modify this interface.

```
interface FIPA_Agent_97 {
      oneway void message(in string acl_message);
      };
```

Annex B
(informative)

Many issues in Agent Management remain unresolved most notably mobility and security. This informative annex introduces these issues and points to future work planned for FIPA during 1998.

B.1 Mobility

Mobility aspects of intelligent agents becomes increasingly important as agents are not only restricted to their home agent platform, but are allowed to migrate to other platforms and perform certain tasks locally. The use of mobility is illustrated by the FIPA application scenarios, as well as the possibility to download software and to monitor physical events occuring on a remote platform.

Mobility can be regarded as a refinement and extension to the FIPA 97 specifications by introducing migration among platforms.

B.2 Security

Agents as well as their related services need to be performed in a secure and trusted environment. Many services carry personal data that has to be protected, e.g. banking applications or electronic commerce where parties need to be authenticated, access control checked, integrity, confidentiality, non-repudation and non-repudiation insured.

The security problem is even more critical in the world of mobile agents where in addition to the preceding constraints, it has to insure the security of the platform against viral infections and any kind of attacks by malicious agents or groups of agents. Mobile agents have also be protected against hijacking and mystrivious use.