A Standardization Effort for Agent Technologies: The Foundation for Intelligent Physical Agents and Its Activities

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Abstract
The purpose of this paper is to advertise the activities of The Foundation for Intelligent Physical Agents (FIPA). FIPA is established to promote the development of standard specifications of generic agent technologies that maximize the interoperability within and across agent-based applications. First, the paper touches the need of standardization for intelligent agents and introduces the framework of FIPA. Secondly, current technical outcome of FIPA’s standardization efforts, the FIPA 97 specifications, is discussed. Thirdly, relationship to other bodies and activities such as Agent Society, ARPA KSE and OMG is presented. Lastly, the paper outlines future plans and open issues which are currently (as of September, 1998) discussed to produce the next version of specifications: FIPA 97 version 2 and FIPA 98.

1. Introduction
The term ‘agent’ is very widely and wildly used in both the academy and the industry. It is used widely for denoting software entities ranging from mobile, lightweight piece of code which migrates from one platform to the other, to a huge AI-based program containing database of gigabytes. It is used wildly because there is no formal definition of what an agent is. Even though many researches are in progress and new applications are constantly announced, we still do not have a common agreement about the essence of the technology. Therefore, many agent systems exist today, but inter-system communication is not always guaranteed.

The necessity for a standard of agent technology is obvious: communicating multiple agents need a common language and a management framework in order to locate others and talk to each other. Several technologies, such as KQML, KIF and Ontolingua, are designed to deal with the problem. However, experience tells us that those de facto standards are insufficient for building a multi-vendor agent applications. For example, the lack of formal semantics in KQML caused interoperability problem between agents who claim to be compatible with KQML. KIF features a strong expressivity of first-order logic but it requires a lot of computational power. It is not practical to force that all agents, including such ones running in a small PDA, must implement a full set of KIF to represent some content expression. Using arbitrary subset of KIF does not solve the problem of the need for the common standard content language. This is a big problem when we want to build an industrial or commercial agent application system by integrating multiple agents from multiple vendors in an open networked environment.

De jure standard, not a de facto one, must be precisely specified for the external behavior of agents to realize the society of communicating agents. It is important to distinguish the external interface of an agent and the internal implementation of the agent. What we need to specify is the external communication of the agent. Internal composition of an agent may vary. We cannot and should not compel anything on that. Given that distinction, the next question is whether agent technology is mature enough for standardization which will benefit the development and deployment of commercial agent applications, or the technology is still in an infant stage and establishing a fixed set of specification becomes a barrier to progress. In December 1995, the founders of FIPA thought some technologies, especially those based on traditional AI techniques, are matured and the advantages of having a standard specification surpasses the disadvantages.

2. Framework of FIPA

2.1. Overview
The Foundation for Intelligent Physical Agents (FIPA) (http://www.csel.it/fipa/ or http://www.fipa.org/) is a non-profit association registered in Geneva, Switzerland. FIPA’s purpose is to promote the success of emerging agent-based applications, services and equipments. This goal is pursued by making available the internationally agreed specifications that maximize interoperability across agents in a timely manner. This is realized through
the open international collaboration of member organizations, 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.

### 2.2. Specification

FIPA has already developed a seven-part specification called FIPA 97. Implementations of FIPA 97 are undergoing field trials that will last until October 1998 when version 2 of FIPA 97 will be produced. FIPA has also issued a Call for Proposals to acquire technology for FIPA 98, the next generation of specifications. Discussions on FIPA 98 are in progress and draft specifications are available online in the web.

FIPA produces two kinds of specification: normative specifications that mandate the external behavior of an agent and ensure interoperability with other FIPA-compliant agents; and informative specifications of applications for guidance to the industry on the use of FIPA technologies.

Three normative parts of FIPA 97 for basic agent technologies are: Part 1 Agent Management, Part 2 Agent Communication Language and Part 3 Agent/Software Integration. Four informative application descriptions of FIPA 97 that provide examples of how the normative items can be applied are: Part 4 Personal Travel Assistance, Part 5 Personal Assistant, Part 6 Audio-Visual Entertainment and Broadcasting, and Part 7 Network Management and Provisioning. FIPA 98 will be comprised of the following parts: normative specifications for Part 1 Agent Management, Part 8 Human/Agent Interaction, Part 10 Agent Security, Part 11 Agent Mobility, and Part 12 Ontology Service; informative application specification Part 9 Product Design and Manufacturing and Part 13 FIPA 97 Developers’ Guide.

### 2.3. Organization

Current membership includes 50 companies, laboratories and universities from 14 countries. General assembly is the supreme body of FIPA which is formed by the members with voting right. Board of directors manages administrative tasks. Fellowship and ‘FIPA Academy’ are introduced to solicit contributions from academicians.

Technical committees (TCs) are responsible for developing the specifications. In 1997, TC 1-7 developed FIPA 97 Parts 1-7 respectively. In 1998, TC1 is working on Agent Management, Mobility and Security, TC2 on Ontology Service, TC8 on Human/Agent Interaction, TC9 on Product Design and Manufacturing, TC10 on FIPA 97 Developers’ Guide and FIPA 97 version 2.

### 2.4. History

The following table summarizes the list of activities FIPA has made so far.

<table>
<thead>
<tr>
<th>#</th>
<th>Place</th>
<th>Date</th>
<th>Major Results</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>London, UK</td>
<td>Apr 96</td>
<td>Workplan settled.</td>
</tr>
<tr>
<td>2</td>
<td>Yorktown, US</td>
<td>Jul 96</td>
<td>First draft of documentation: framework, applications and requirements.</td>
</tr>
<tr>
<td></td>
<td>N/A Geneva, Switzerland</td>
<td>Sep 96</td>
<td>Formal establishment of FIPA.</td>
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<tr>
<td>3</td>
<td>Tokyo, Japan</td>
<td>Oct 96</td>
<td>First call for proposals issued.</td>
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<tr>
<td>4</td>
<td>Turin, Italy</td>
<td>Jan 97</td>
<td>Establishment of TCs for normative technologies. First draft of normative parts of specifications. Second call for proposals.</td>
</tr>
<tr>
<td>5</td>
<td>Reston, US</td>
<td>Apr 97</td>
<td>Establishment of application-specific TCs. First public release of normative and informative parts of specifications.</td>
</tr>
<tr>
<td>6</td>
<td>Cheju, Korea</td>
<td>Jul 97</td>
<td>Revision of the specifications.</td>
</tr>
<tr>
<td>7</td>
<td>Munich, Germany</td>
<td>Oct 97</td>
<td>FIPA 97 approved. Third call for proposals for FIPA 98 issued.</td>
</tr>
<tr>
<td>9</td>
<td>Osaka, Japan</td>
<td>Apr 98</td>
<td>FIPA 97 version 1.1 and FIPA 98 version 0.1 approved.</td>
</tr>
<tr>
<td>10</td>
<td>Dublin, Ireland</td>
<td>Jul 98</td>
<td>FIPA 97 version 1.2 and FIPA 98 version 0.2 approved.</td>
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</table>

The next table shows the future workplan of FIPA.
Table 2. Workplan of FIPA

<table>
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<tr>
<th>Mtg #</th>
<th>Place</th>
<th>Date</th>
<th>Action Plans</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>Europe</td>
<td>Apr 99</td>
<td>FIPA 98 version 1.1 and FIPA 99 version 0.1.</td>
</tr>
<tr>
<td>14</td>
<td>America</td>
<td>Jul 99</td>
<td>FIPA 98 version 1.2 and FIPA 99 version 0.2.</td>
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</table>

3. FIPA 97 technical specifications

One of the objectives of the normative parts of the FIPA 97 specification is to publish the technical standard in a timely manner in order to ground the basic functionalities of multiple communicating agents. Therefore, the specifications aim at fundamental elements of the agent technology. Advanced topics are postponed until FIPA 98. For example, management framework is specified in FIPA 97 but mobility and security matters are deferred. Basic vocabularies, example content language and interaction protocols are defined for the agent communication language but ontology management is postponed.

Please note that the following sections are extracts from the original specification documents. See http://www.cselt.it/fipa/spec/fipa97/fipa97.htm for complete documents.

3.1. FIPA 97 Part 1: Agent Management

This part 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. The intention is that this part is consistent with both mobile and stationary agent requirements. This part contains specifications of the following:

- agent reference model
- agent platform (AP)
- agent management actions
- agent management content language and ontology

The specification 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 entities contained in the agent management specification are logical capability sets and do not imply any physical configuration. In the FIPA vision, the implementation details of individual platforms and agents are the design choices of the individual agent system developers.

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 capabilities 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.

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

FIPA places no restrictions on the intra-platform message routing protocol. The minimum inter-platform protocol a FIPA compliant agent platform must support is the Internet Inter-Orb Protocol (IIOP) from the Object Management Group (OMG). The use of IIOP does not mean that FIPA agent must be based on an ORB. Nor does it preclude an AP from augmenting this inter-platform protocol with other communication protocols.

FIPA 97 does not address how additional services such as security and mobility are implemented within an AP. Such issues will be addressed in FIPA 98. [1]

3.2. FIPA 97 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.

This specification does not define in a precise, prescriptive way what an agent is nor how it should be implemented. Besides the lack of a general consensus on this issue in the agent research community, such definitions frequently fall into the trap of being overly restrictive, ruling out some software constructs whose developers legitimately consider to be agents, or else overly weak and of little assistance to the reader or software developer. A goal of this specification is to be as widely applicable as possible, so the stance taken is to define the components as precisely as possible, and allow applicability in any particular instance to be decided by the reader.

Nevertheless, some position must be taken on some of the characteristics of an agent, that is, on what an agent can do, in order that the specification can specify a means of doing it. This position is outlined here, and consists of an abstract characterization of agent properties, and a simple abstract model of inter-agent communication.

The first characteristic assumed is that agents are communicating at a higher level of discourse, i.e. that the contents of the communication are meaningful statements about the agents’ environment or knowledge. This is one characteristic that differentiates agent communication from, for example, other interactions between strongly encapsulated computational entities such as method invocation in CORBA.

In order for this discourse to be given meaning, some assumptions have to be made about the agents. In this specification, an abstract characterization of agents is assumed, in which some core capabilities of agents are described in terms of the agent’s mental attitudes. This characterization or model is intended as an abstract specification, i.e. it does not pre-determine any particular agent implementation model nor a cognitive architecture.

More specifically, this specification characterizes an agent as being able to be described as though it has mental attitudes of:

- Belief, which denotes the set of propositions which the agent accepts are (currently) true; propositions which are believed false are represented by believing the negation of the proposition.

- Uncertainty, which denotes the set of propositions which the agent accepts are (currently) not known to be certainly true or false, but which are held to be more likely to be true than false; propositions which are uncertain but more likely to be false are represented by being uncertain of the negation of the proposition. Note that this attitude does not prevent an agent from adopting a specific uncertain information formalism, such as probability theory, in which a proposition is believed to have a certain degree of support. Rather the uncertainty attitude provides a least commitment mechanism for agents with differing representation schemes to discuss uncertain information.

- Intention, which denotes a choice, or property or set of properties of the world which the agent desires to be true and which are not currently believed to be true. An agent which adopts an intention will form a plan of action to bring about the state of the world indicated by its choice. Note that, with respect to some given proposition p, the attitudes of believing p, believing not p, being uncertain of p and being uncertain of not p are mutually exclusive.

In addition, agents understand and are able to perform certain actions. In a distributed system, an agent typically will only be able to fulfill its intentions by influencing other agents to perform actions.

Influencing the actions of other agents is performed by a special class of actions, denoted communicative acts. A communicative act is performed by one agent towards another. The mechanism of performing a communicative act is precisely that of sending a message encoding the act. Hence the roles of initiator and recipient of the communicative act are frequently denoted as the sender and receiver of the message, respectively.

Building from a well-defined core, the messages defined represent a set of communicative acts that attempt to seek a balance between generality, expressive power and simplicity, together with perspicuity to the agent developer. The message type defines the communicative action that is being performed. Together with the appropriate domain knowledge, the communicative act allows the receiver to determine the meaning of the contents of the message. [2]

3.3. FIPA 97 Part 3: Agent/Software Integration

This part applies to any other non-agent software with which agents need to “connect". Such software includes legacy software, conventional database systems, middleware for all manners of interaction including hardware drivers. Part 3 specifies the ways agents
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.

This part provides a specification which deals with technologies enabling the integration of services provided by non-agent software into a multi-agent community. This part of the FIPA 97 defines in general the relationship between agents and software systems. The purpose of this standard is twofold: it allows agents to describe, broker and negotiate over software systems; and it allows new software services to be dynamically introduced into an agent community. The specification defines a reference model, identifying agent roles (e.g., broker, client, etc.) and the messages and actions which define each of these roles. This standard operates at the agent-communication level and does not define any mappings to specific software architectures such as Java, CORBA or DCOM. Such mappings are considered outside the scope of FIPA 97.

This specification enables developers to build:
- wrappers for software services which are to be utilized and/or controlled by a community of agents (so-called "public services");
- agents which provide the ARB service to allow the registration in a query repository and the management of such software services; and
- agents ready to access such public services.

In most significant applications, agents may have a need to obtain a service by other entities in the system. Sometimes, such services could be provided by other agents. However, there are and in the future there will continue to be a wealth of non-agent software systems which provide useful services. If agents are to be truly useful they must be able to interface with and control existing software system such as databases, web-browsers, set-top boxes, speech synthesis programs and so forth.

This specification defines how software resources can be described, shared and dynamically controlled in an agent community. Software systems are characterized by software descriptions which define the nature of the software system and how to connect to it. The rationale behind this specification is to allow agents to openly share and trade software resources with each other. Allowing agents to communicate about software resources, means agents can inform each other about the existence of new software resources and thereby facilitate the dynamic inclusion and management of new software systems. This provides agents with a method by which they can dynamically acquire new capabilities.

FIPA 97 concerns itself with how agents can connect to and control external software systems, which are external to and independent of an agent’s execution context. By way of contrast, internal attachment to software, where the software is included in an agent’s execution context, is not considered in FIPA 97 as it would require assumptions to be made about the internal implementation of agents.

Software systems come in all shapes and sizes. Many different types of interfaces implement their own particular networking protocol. Furthermore, there are a number of emerging distributed technologies such as CORBA, DCOM and Java/Java-RMI which are creating (competing) standards for the integration of software systems and resources. To simplify this situation and to provide the freedom to agent-programmers, this specification does not mandate the use of any particular API or distributed technology, rather it treats software integration at the agent-communication level. That is in terms of the types and contents of messages exchanged between agents. To support this, two new agent roles have been identified:

a) Agent Resource Broker (ARB) - an ARB agent brokers a set of software descriptions to interested agents. Clients query it about what software services are available.

b) Wrapper Agent - this agent allows other agents to connect to a software system uniquely identified by a software description. Client Agents can relay commands to the Wrapper agent and have them invoked on the underlying software system. The role provided by the Wrapper agent is a single generic way for agents to interact with software systems. [3]

4. FIPA 97 application specifications

The applications were selected in the third meeting for two reasons. The first reason was to pick up common underlying technologies among the applications which would then become the targets of technical standardization for 1997. The second was to verify the produced normative standard by applying the technical specifications to these applications. This is called field trials. The result of the field trials will be fed back to the technical specifications to revise the documents and produce FIPA 97 version 2.0. Note that FIPA is not going to standardize the applications themselves. These application specifications are informative ones which intention is to encourage people to implement, use, review and verify the technical specifications.
Please note that the following sections are extracts from the original specification documents. See http://www.cselt.it/fipa/spec/fipa97/fipa97.htm for complete documents.

### 4.1. FIPA 97 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, theater, or other attractions and events. [4]

### 4.2. FIPA 97 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, modeling 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. [5]

### 4.3. FIPA 97 Part 6: Audio/Video Entertainment and 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 favorite choice from plenty of programs on offer can be very impractical. The information should be provided in a customized manner, to better suit the user’s personal preferences. 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 the user with 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. [6]

### 4.4. FIPA 97 Part 7: Network Management and 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 97 utilizes agent technology to provide dynamic Virtual Private Network services where a user wants to set up a multimedia connection with other users. [7]

### 5. Relationship to other bodies and activities

Software agent is based on several key technologies like object-oriented programming and artificial intelligence. Therefore, it is important to reuse the results of those fundamental research areas and adopt existing standards when appropriate. FIPA has a Special Interest Group (SIG) on Related Activities. The web page (http://www.phil.uu.nl/~wiet/fipasig.html) summarizes related groups and application areas, interesting conferences, relevant standards and relevant software.

#### 5.1. The Agent Society

On April 18, 1997, The Agent Society and FIPA made a public statement to announce the cooperation of the two bodies.

During the fifth meeting of FIPA in Reston, Virginia, USA, representatives of the respective Boards of Directors of The Agent Society and FIPA met to discuss the relationship between these two international bodies concerned with agent technology. The purpose of the
meeting was to identify areas of common interest and avoid conflict, competition and lack of co-ordination between the organizations.

It was concluded that, The Agent Society and FIPA have a common objective in promoting the use of, and commercial opportunities for agent technology. The two initiatives are complementary, with significant opportunities present for mutually beneficial collaboration. Arrangements were put in place for continuing communication and co-ordination between both bodies.

The Agent Society is primarily concerned with raising the awareness of agent technology through providing opportunities for those in the industry to meet and discuss issues of common interest. It will also act as a group representing the ‘Software Agent Industry’ in appropriate fora and arenas of public debate.

FIPA is concerned with obtaining consensus on appropriate technical standards and has a work-plan established to achieve this. [14]

5.2. ARPA Knowledge Sharing Effort

The ARPA-sponsored Knowledge Sharing Effort has produced well-known software such as KQML, KIF, Ontolingua and OKBC. Individual researchers of KSE including Tim Finin and Yannis Labrou from UMBC, Michael Genesereth and Adam Farquhar from Stanford attended the FIPA meetings and contributed to the discussions to make the specifications. Tim Finin and Yannis Labrou are members of FIPA Academy and Adam Farquhar is being nominated as a new member.

Unfortunately, most of these researchers joined FIPA in the late period of 97 discussions. This is one of the reasons why FIPA did not adopt KQML and KIF as a base of the agent communication language.

5.3. Object Management Group

In April 1998, MASIF team of OMG proposed agent mobility and security framework based on OMG MAF/MASIF specification in response to the call for proposals for agent management at the ninth FIPA meeting held in Osaka. OMG and FIPA, especially Technical Committee 1 which is in charge of agent management, are working together to integrate OMG standard into FIPA technology specification. In September 1998, representative from FIPA attended OMG meeting and presented FIPA technologies.

6. Future plans and open issues

This section describes plans and issues which are currently discussed in FIPA to make FIPA 97 version 2 and FIPA 98, the next version of specifications.

6.1. FIPA 98 Part 8: Human/Agent Interaction

This part of the FIPA 98 defines basic functionality that can be utilized by an agent which interacts with users. The purpose of this standard is to allow agents to learn about users and construct/manage the user models; and to allow agents to interact with users at higher level of operations. The specification defines a reference model, identifying agent functionality and the messages/actions which define each of these functionality. [8]

6.2. FIPA 98 Part 9: Product Design and Manufacturing Application

Product Design and Manufacturing is a very large application domain addressing the overall manufacturing life cycle from the initial formation of virtual enterprises through product design to final execution and supply chain delivery. This scope is perhaps even larger and more complex than Personal Travel Assistance (FIPA 97 Part 4), but in similar fashion serves to show how a large scope requires international, multi-vendor, standards-based integration. The manufacturing industry itself is the primary target of interest, but the virtual network provisioning, agent services, and supporting context also include telecommunication and banking interests within the complete solution.

The purpose of this specification is twofold:
- Demonstrate how the FIPA 97 and emerging FIPA 98 technologies can be applied to product design and manufacturing. The examples should be suggestive to the industry by demonstrating the relevance of FIPA agent standards within the manufacturing business.
- Provide test cases to motivate the FIPA 98 technologies. To ensure the relevance of new FIPA developments, this application provides a rich variety and number of touchstones. This application specification helps ensure that the normative specifications are useful and complete, while providing requirements for their further elaboration.

The test cases will be selected to cover the scope of the FIPA 98 normative specifications as well as some additional provocative items. For instance, tests will include
- Human interface transliteration from forms and markup languages to the FIPA ACL
- Task profiling and multi-user knowledge sharing by use of learning and agent communication
Security risks exist in various domains including agent management, life cycle management, registration, agent platforms, agent-agent interaction, user-agent interaction and mobility. Some of these security risks have been identified and will be handled by existing counter measures that are well known and suitable for inclusion into this specification.

However, there still may be agent specific security risks that so far have not been identified. Particularly, the agent specific paradigm of non-deterministic intelligent autonomous collaboration probably gives rise to new security risks comparable to those known from real world societies. At least for the multi-agent systems, common security measures e.g. denial of service attacks do not exist today.

The deployment of agent technology implies various security risks that need to be addressed. Existing security solutions have to be identified and investigated in order to assess their suitability and applicability.

Existing solutions will be facilitated when appropriate. For example, the use of the CORBA Security Services is recommended and supported by the security capabilities presented in this part. New solutions applied to specific agent related security issues will have to be specified. (Eventually, the use of CORBA Security Services may depend on the use of CORBA in general by the agent platform. This is still under consideration.)

The following six security threats currently exist which all apply to agent systems:
1. Disclosure (eavesdropping)
2. Alteration (including mutilation and corruption)
3. Copy and replay
4. Denial of service (including resource exhaustion)
5. Repudiation
6. Spoofing (masquerading)

The following examples demonstrate the threats in agent systems.
- Disclosure: An entity eavesdrops the interaction among agents extracting information on the goals, plans, capabilities, etc. of the other agents.
- Alteration: An agent communication channel modifies content of messages in order.
- Copy and replay: An agent with privileged access rights to certain resources is illegally copied and sent with new directions to these resources.
- Denial of service: A directory facilitator agent refuses the registration of another agent and hence prevents it from achieving its goals.
- Repudiation: A commitment between two agent as the result of a contract net negotiation is later ignored by one of them denying the negotiation has ever taken place.
- Spoofing and masquerading: An agent registers as a directory facilitator agent and therefore receives information form other registering agents.

FIPA 98 Agent Security addresses mutual agent security issues for agent to agent interaction based upon the following assumptions:
- Platforms, users and software are all represented as agents residing on an agent platform. This implies that the security management for agent to agent interaction also applies to agent - user, agent - platform and agent - software interaction.
- This specification allows for security management to be implemented at agent level, and at transport level (e.g. the use of CORBA Security Services for secure transport of ACL messages).

The following security capabilities will be further explored and specified in FIPA 98 as a normative security framework:
- Authentication
- Integrity
- Confidentiality
- Security management, including:
  - Key generation / deletion
  - Key management
  - Certificate creation / deletion
  - Certificate repository

FIPA 98 Security Management does not produce normative specifications supporting:
- Security measures for regular system administration
- Security measures for non-agent software that is corrupted and poses a security threat to the agent system
- Security measures for non-agent related security issues, for example user identification to operating systems.

FIPA 98 Agent Security will reuse and refer to existing security standards and solutions whenever possible. [10]

6.4. FIPA 98 Part 11: Agent Mobility

This part specifies a normative framework for supporting software agent mobility using the FIPA agent platform. This framework will represent the minimal set of technologies required and will be complementary to the existing FIPA 97 Part 1 specification. Wherever possible it will refer to existing standards in this area. This framework can support additional non-mobile agent management operations such as agent configuration. This part will not mandate that every FIPA-compliant agent platform must support agent mobility, nor does it cover the specific requirements for agents on mobile devices with intermittent connectivity, which is covered by the scope of the existing agent management activity. [11]

6.5. FIPA 98 Part 12: Ontology Service

Borrowing the definition in the Stanford Ontolingua library, an ontology is an explicit specification of some topic. For the practical goals of FIPA (that is enabling development and deployment of inter-operable agent-based applications), this means a formal and declarative representation of some topic which includes the vocabulary (or list of constants) for referring to the terms in the subject area, the integrity constraints on the terms, the logical statements that describe the meaning of the terms, and how they are related to each other. Ontologies therefore provide a vocabulary for representing and communicating knowledge about some topic and a set of relationships that hold among the terms in that vocabulary.

This part of FIPA 98 specifications deals with technologies for definition and management of ontologies. FIPA 98 intends to specify:

- a reference model for ontology definition and maintenance
- the interaction protocol to be used by agents for selecting a common ontology for communication (sharing ontologies)
- a method for defining and maintaining a name space for a hierarchy of ontologies
- an ontology service to be provided by agents for agents
- an interface, at the agent communication level to an ontology agent
- guidelines for the development of ontologies

The ontology service is provided to the agent community by a special agent called the Ontology Agent. Other agents can interact with the Ontology Agent to request:

- translation of terms between two different ontologies
- downloading of meaning of terms, axioms and relationships between terms
- querying for relationships between ontologies
- uploading and updating of ontologies

This specification will only deal with the interface to such a service while internal implementation and capabilities are left to developers. The interface should be specified at the agent communication level as opposed to a computational API (such as OKBC API). Therefore, the FIPA 98 specification will define the interaction protocols, the communicative acts and, in general, the vocabulary that agents must adopt when using this service. It will enable developers to build:

- agents that access such a service
- agents that provide it
- agents which are able to negotiate a shared ontology for communication

In order to keep the applicability of the specifications as unrestricted as possible, the approach used will be platform independent. [12]

6.6. FIPA 97 Developers’ Guide

This guide is under construction during the creation of FIPA 98 as a guide for the use and interpretation of the FIPA 97 standard. This part, in common with all publicly available working FIPA documents, is updated on a quarterly basis - please refer to the FIPA web page for the latest revision, and be aware that substantial changes and corrections may occur between versions.

The Developers’ Guide is an output from the FIPA 97 Evolution Technical Committee (TC10). The contents of this part will be guided by the nature of developer feedback on FIPA 97 during 1998. Such feedback is received through the mediated email list.

One of the main intentions of this part is to clarify issues with FIPA 97, comments on any aspect of this part are therefore welcome from anyone; the mediated email list can be used for this purpose.

The mandate for TC10 is as follows:

“The purpose of the FIPA Evolution Technical Committee (TC10) is to serve as the focal point for comments received, both from field trials, and from other sources, on the FIPA 97 standard - and to use this input to produce:

- FIPA 97 Version 2, parts 1-7 (for publication in October 1998)
- Informative Developers’ Guide to the use of FIPA 97 technologies

Furthermore, to support the production of FIPA 98 Version 1 by disseminating information to the relevant 1998 Technical Committees, where appropriate."

The Developers’ Guide is intended to clarify areas of specific interest, potential confusion, and discussions raised via the FIPA 97 email feedback process. Such areas may include, for example, issues that span more than one of the normative parts of FIPA 97. The feedback process scope includes areas requiring clarification, errors, corrections, and inconsistencies.

The Developers’ Guide will not contain information on extensions to FIPA 97 (these must be addressed in subsequent FIPA standardization efforts). The Developers’ Guide will not contain information on specific implementation issues such as ‘How do we implement a FIPA compliant agent service in language xxx?’ The Developers’ Guide will, however, provide ‘cookbook’ guidance to people implementing FIPA compliant platforms. [13]

7. Conclusions

The paper has described major results and ongoing work of FIPA’s activities. FIPA has successfully installed the first step toward the establishment of the standard specifications for communicating agents. With the specifications, multiple agents from multiple vendors are able to talk to each other in an open networked environment. However, there are lots of things which need to be discussed and decided. As researches discover new technologies and new applications, the domain of standardization will grow. FIPA will continue to work on the standardization. The membership is open to all people who are interested in joining FIPA to produce the specifications together.

8. Acknowledgements

The author would like to thank all FIPA members and non-members who actively participated in the discussions to establish the specifications. Without the effort of those devoted individuals the standard would have never produced.

9. References

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