

FOUNDATION FOR INTELLIGENT PHYSICAL AGENTS

FIPA Agent Discovery Service Specification

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22 **Foreword**

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1 Scope

This document deals with the discovery of agents and their offered services in ad hoc¹ networks. The Agent Discovery Service (ADS) is specified in addition to the well known FIPA agent directory services Agent Management System and Directory Facilitator [FIPA00023]. This document contains specifications for:

- A reference model for the discovery process, based on different technologies, in ad hoc networks.
- The functionality and interface of the ADS.

¹ Ad hoc networks comprise both mobile and fixed networks.

2 Reference

Discovery in ad hoc networks deals with the discovery of agents hosted on agent platforms (AP) on remote devices. Directory Facilitator (DF) federations according to [FIPA00023] enable an agent to discover agents on remote devices without having to know any remote DF. DF federations for discovery in ad hoc networks only work if network nodes do not repeatedly join or leave.

The Agent Discovery Service (ADS) provides discovery functionality in ad hoc networks, in which network nodes join or leave more frequently or less frequently. It provides a high-level DF-like interface for agents, while taking advantage of various discovery middleware (DM), depending on the underlying ad hoc technology. Figure 1 outlines how the ADS fits in the FIPA architecture.

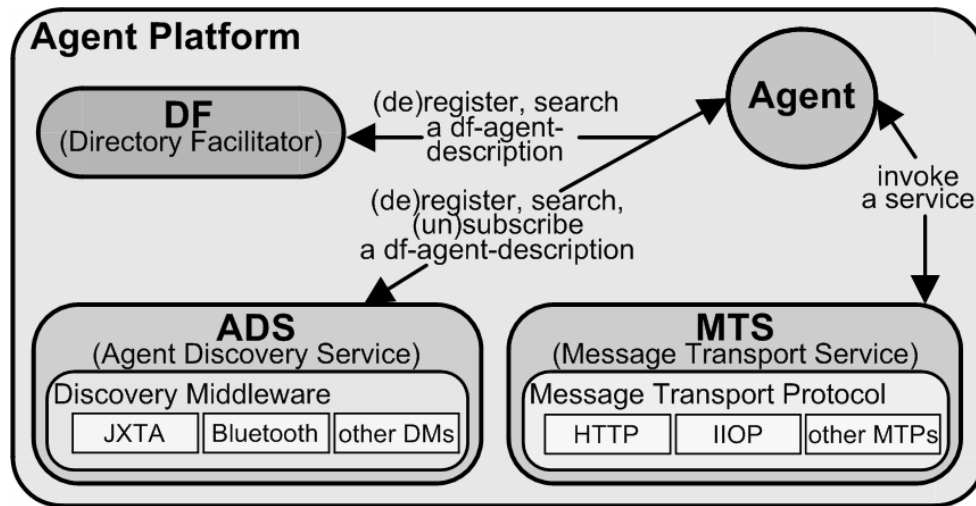


Figure 1: Reference Model of the Discovery Process in Ad Hoc Networks

An AP optionally hosts a DF. If an ADS is present on the AP, the DF should only be used for handling `df-agent-descriptions` related to the local AP. The ADS should only be used by agents of the local AP for provision of their `df-agent-descriptions` to the ad hoc network as well as for discovery of agents on remote devices in the ad hoc network, that is, the ADS allows local agents to be discovered by agents on remote devices and vice versa. This means that the DF should provide a yellow pages service restricted to the scope of the local AP, and the ADS provides a yellow pages service restricted to the scope of the ad hoc network. The ad hoc network accessible via the ADS is a compound of all ad hoc networks supported by the maintained DM technologies, for instance JXTA or Bluetooth.

Agent-to-agent communication is performed by using the Message Transport Service (MTS) according to [FIPA00067]. The MTS might be extended with message transport protocols that are suited for the different ad hoc networks, for example, a JXTA transport or a Bluetooth OBEX transport.

3 Agent Discovery Service

The ADS is an optional entity, which is a reification of the Agent Directory Service in [FIPA00001] for discovery in ad hoc networks. The functionality it provides to agents is similar, but extended, to the one of a DF. The ADS maintains one or more DM technologies, each of which provides access to a certain ad hoc network.

3.1 ADS Functionality

The ADS supports functions that are similar to the `register`, `deregister` and `search` functions as specified in [FIPA00023] as part of the Agent Management Ontology function descriptions. Additionally, the ADS defines a `subscribe/unsubscribe` functionality. All of these functions make use of `df-agent-descriptions` specified in [FIPA00023] as part of the Agent Management Ontology object descriptions.

3.1.1 DM IDs

When using ADS functionality, agents may apply it either to all available DMs or to a subset. Hence, agents must be able to retrieve a list of all available DM IDs from the ADS. A DM ID is a string reserved for a single technology. Table 1 summarizes the currently available IDs.

DM ID String	Identified Technology	Notes
JXTA	JXTA	see [JXTA]
BT	Bluetooth	see [BT]

Table 1: DM IDs

3.1.2 Register and Deregister

The ADS supports the registration and the deregistration of `df-agent-descriptions`. If an agent registers with an ADS, it becomes discoverable for agents on remote devices. If an agent deregisters from an ADS, it is no longer discoverable for agents on remote devices. Each of these functionalities can be applied either to all available DMs or to a subset.

On registration with the ADS, an agent can specify a lease time, which is how long it would like the registration to be kept. When the lease time expires, the registration will be silently removed from the ADS.

The lease-time parameter of the `df-agent-description` is used by a DM to determine the lifetime of the `df-agent-description`. If no lease-time parameter exists in the `df-agent-description`, the lifetime is assumed to be unlimited. In this case, it is important to deregister the `df-agent-description` later on, in order to save system resources.

If the `df-agent-description` has already been registered, its lease-time is renewed according to the value of the `lease-time` parameter.

3.1.3 Search

The ADS supports a search that takes a `df-agent-description` search template and a specified duration. It returns within the specified duration all `df-agent-descriptions` found that match the `df-agent-description` search template. This functionality can be applied either to all available DMs or to a subset.

The search functionality may optionally constrain the number of returned results per agent platform. This is a means to limit both the network load as well as the processing load of a device. This functionality is similar to the one provided by the `max-results` parameter of the `search-constraints` frame in the Agent Management Ontology in [FIPA00023].

155
156 The matching criterion to determine the set of objects that satisfy the search criteria is exactly the same as
157 specified for the `search` function in [FIPA00023].

158 **3.1.4 Subscribe and Unsubscribe**

159 The ADS provides a functionality to subscribe and unsubscribe `df-agent-descriptions` which match a `df-`
160 `agent-description` search template. From the time of subscription on, each newly registered `df-agent-`
161 `description` that satisfies the search criteria will be returned to the agent until unsubscription.² Each of these
162 functionalities can be applied either to all available DMs or to a subset.

163
164 The matching criterion, in order to determine the set of objects that satisfy the search criteria, is exactly the same
165 as specified for the `search` function in [FIPA00023].
166

² Note that, if the ADS should be implemented as an agent, it may be necessary to specify a FIPA Subscribe interaction protocol.

4 Discovery Middleware

Various technologies exist or will appear, which provide for discovery in ad hoc networks, and examples of such DM technologies are JXTA and Bluetooth.

Each DM maintained by the ADS must be described in a FIPA specification of its own. In detail, such a DM specification must describe how the DM functionality, which is imposed by the ADS functionality provided to agents, can be realized on the basis of the respective technology.

This specification does not specify how the actual interface between the ADS and its DMs must look like. However, functionality details of the DM, which are important to consider during DM specification, are summarized next.

4.1 Functionality of a Discovery Middleware

In order to support the ADS in offering agents the expected functionality, each DM in turn must provide similar functionality to the ADS.

4.1.1 Discovery Middleware Identifier

The ADS must be able to retrieve a DM's ID string (see also section 3.1.1). This enables the ADS to differentiate between several DMs and to provide this information to the agents.

4.1.2 Startup and Shutdown

The ADS must be able to start up and shut down a DM at runtime.

4.1.3 Register and Deregister

The ADS must be able to register `df-agent-descriptions` within a DM and to deregister `df-agent-descriptions` from the DM. See section 3.1.2 for the details of registration and deregistration.

4.1.4 Search

The ADS must be able to search for `df-agent-descriptions` within a DM on the basis of a `df-agent-description` search template. See section 3.1.3 for the details of the search.

4.1.5 Subscribe and Unsubscribe

The ADS must be able to subscribe and unsubscribe `df-agent-descriptions` within a DM which match a `df-agent-description` search template. See section 3.1.4 for the details of subscription and unsubscription.

5 Agent Discovery Ontology

5.1 Object Descriptions

The ADS makes use of the `df-agent-description` frame which is specified by [FIPA00023] as part of the Agent Management Ontology object descriptions. Additionally the ADS requires other frames, which are part of the Agent Discovery Ontology. This section describes the set of frames that represent the classes of objects in the domain of discourse within the framework of the `fipa-agent-discovery` ontology.

This ontology does not specify any specific positional order to encode the parameters of the objects. Therefore, it is required to encode objects in SL by specifying both the parameter name and the parameter value (see Section 3.6 of [FIPA00008]).

The following terms are used to describe the objects of the domain:

- **Frame.** This is the mandatory name of this entity that must be used to represent each instance of this class.
- **Ontology.** This is the name of the ontology, whose domain of discourse includes the parameters described in the table.
- **Parameter.** This is the mandatory name of a parameter of this frame.
- **Description.** This is a natural language description of the semantics of each parameter.
- **Presence.** This indicates whether each parameter is mandatory or optional.
- **Type.** This is the type of the values of the parameter: Integer, Word, String, URL, Term, Set or Sequence.
- **Reserved Values.** This is a list of FIPA-defined constants that can assume values for this parameter.

5.1.1 Discovery Middleware Constraints

This type of object represents a set of DMs, on which the different functions of the ADS should be applied.

Frame	<code>dm-constraints</code>			
Ontology	<code>fipa-agent-discovery</code>			
Parameter	Description	Presence	Type	Reserved Values
<code>dms</code>	A list of DMs, which should be used to invoke an ADS function.	Optional	Set of <code>string</code>	JXTA BT

5.1.2 Search Constraints

This type of object represents a set of constraints to limit the function of searching within the ADS.

Frame	search-constraints			
Ontology	fipa-agent-discovery			
Parameter	Description	Presence	Type	Reserved Values
timeout	The time in milliseconds to wait for answers, after a search query has been emitted.	Mandatory	integer	
max-results	The maximum number of returned results per agent platform.	Optional	integer	
dms	A list of DMs, which should be used for the search.	Optional	dm-constraints	

5.2 Function Descriptions

The following tables define usage and semantics of the functions that are part of the `fipa-agent-discovery` ontology and that are supported by the ADS.

This ontology does not specify any specific positional order to encode the parameters of the objects. Therefore, it is required to encode objects in SL by specifying both the parameter name and the parameter value (see section 3.6 of [FIPA00008]).

The following terms are used to describe the functions of the `fipa-agent-discovery` domain:

- **Function.** This is the symbol that identifies the function in the ontology.
- **Ontology.** This is the name of the ontology, whose domain of discourse includes the function described in the table.
- **Supported by.** This is the type of agent that supports this function.
- **Description.** This is a natural language description of the semantics of the function.
- **Domain.** This indicates the domain over which the function is defined. The arguments passed to the function must belong to the set identified by the domain.
- **Range.** This indicates the range to which the function maps the symbols of the domain. The result of the function is a symbol belonging to the set identified by the range.
- **Arity.** This indicates the number of arguments that a function takes. If a function can take an arbitrary number of arguments, then its arity is undefined.

266 **5.2.1 Registration of a DF Agent Description with the Agent Discovery Service**

Function	register
Ontology	fipa-agent-discovery
Supported by	ADS
Description	The execution of this function has the effect of registering a new <code>df-agent-description</code> into the knowledge base of the ADS. The <code>df-agent-description</code> supplied must include a valid AID. To prevent the registration of the <code>df-agent-description</code> with all available DMs, the DM-IDs of the desired DMs can be passed.
Domain	<code>df-agent-description</code> × ³ <code>dm-constraints</code>
Range	The execution of this function results in a change of the state, but it has no explicit result. Therefore there is no range set.
Arity	2

267

268 **5.2.2 Deregistration of a DF Agent Description from the Agent Discovery Service**

Function	deregister
Ontology	fipa-agent-discovery
Supported by	ADS
Description	An agent may deregister a <code>df-agent-description</code> in order to remove all of its parameters from the ADS. The <code>df-agent-description</code> supplied must include a valid AID. To prevent the deregistration of the <code>df-agent-description</code> from all available DMs, the DM-IDs of the desired DMs can be passed.
Domain	<code>df-agent-description</code> × <code>dm-constraints</code>
Range	The execution of this function results in a change of the state, but it has no explicit result. Therefore there is no range set.
Arity	2

269

270 **5.2.3 Search for DF Agent Description Registrations within the Agent Discovery Service**

Function	search
Ontology	fipa-agent-discovery
Supported by	ADS
Description	An agent may search for certain <code>df-agent-descriptions</code> by passing a <code>df-agent-description</code> template to the ADS. A successful search can return one or more <code>df-agent-descriptions</code> that satisfy the search criteria and returned within a fixed amount of time. A null set is returned when no <code>df-agent-description</code> entries satisfy the search criteria. A null set is also returned when the defined search duration is exceeded, even if some results would have been received later on. To prevent a search on all available DMs, the DM-IDs of the desired DMs can be passed. Further, the maximum number of returned results per agent platform can be defined.
Domain	<code>df-agent-description</code> × <code>search-constraints</code>
Range	Set of <code>df-agent-descriptions</code>
Arity	2

271

³ Where × is the Cartesian product.

272 **5.2.4 Subscribe for DF Agent Description Registrations within the Agent Discovery Service**

Function	subscribe
Ontology	fipa-agent-discovery
Supported by	ADS
Description	An agent may subscribe to receive registered df-agent-descriptions by passing a df-agent-description template to the ADS. From the time of subscription on, each newly registered df-agent-description that satisfies the search criteria will be returned to the agent until unsubscription. ⁴ To prevent a subscription on all available DMs, the DM-IDs of the desired DMs can be passed.
Domain	df-agent-description × dm-constraints
Range	The execution of this function results in a change of the state, but it has no explicit result. Therefore there is no range set. But, due to the asynchronous nature of the subscription, a set of matching df-agent-descriptions may be returned to the subscribing agent at later points in time.
Arity	2

273

274 **5.2.5 Unsubscribe from DF Agent Description Registrations within the Agent Discovery Service**

Function	unsubscribe
Ontology	fipa-agent-discovery
Supported by	ADS
Description	An agent may cancel its subscription to receive registered df-agent-descriptions by passing to the ADS the df-agent-description template, which was used for subscription. To prevent an unsubscription on all available DMs, the DM-IDs of the desired DMs can be passed.
Domain	df-agent-description × dm-constraints
Range	The execution of this function results in a change of the state, but it has no explicit result. Therefore there is no range set.
Arity	2

275

276 **5.2.6 Retrieve the Identifiers of Discovery Middlewares Hosted by the Agent Discovery Service**

Function	get-dms
Ontology	fipa-agent-discovery
Supported by	ADS
Description	An agent may retrieve the list of IDs of all available DMs offered by the ADS.
Domain	None
Range	Set of DM IDs
Arity	0

277

278 **5.3 Exceptions**

279 Under some circumstances, an exception can be generated, for example, when an AID that has been already
 280 registered is re-registered. This specification makes use of those exceptions as described in [FIPA00023] in the
 281 Agent Management Ontology.
 282

⁴ Note that, if the ADS should be implemented as an agent, it may be necessary to specify a FIPA Subscribe interaction protocol.

6 References

- [FIPA00001] FIPA Abstract Architecture Specification. Foundation for Intelligent Physical Agents, 2002.
<http://www.fipa.org/specs/fipa00001/>
- [FIPA00008] FIPA SL Content Language Specification. Foundation for Intelligent Physical Agents, 2002.
<http://www.fipa.org/specs/fipa00008/>
- [FIPA00023] FIPA Agent Management Specification. Foundation for Intelligent Physical Agents, 2002.
<http://www.fipa.org/specs/fipa00023/>
- [FIPA00067] FIPA Agent Message Transport Service Specification. Foundation for Intelligent Physical Agents, 2002.
<http://www.fipa.org/specs/fipa00067/>
- [JXTA] Project JXTA.
<http://www.jxta.org/>
- [BT] Bluetooth.
<http://www.bluetooth.org/>

7 Informative Annex A – Control Flow Example

To further clarify how ADS and DMs work together, an example will be given below. Figure 2 outlines the control flow of an ADS based discovery process.

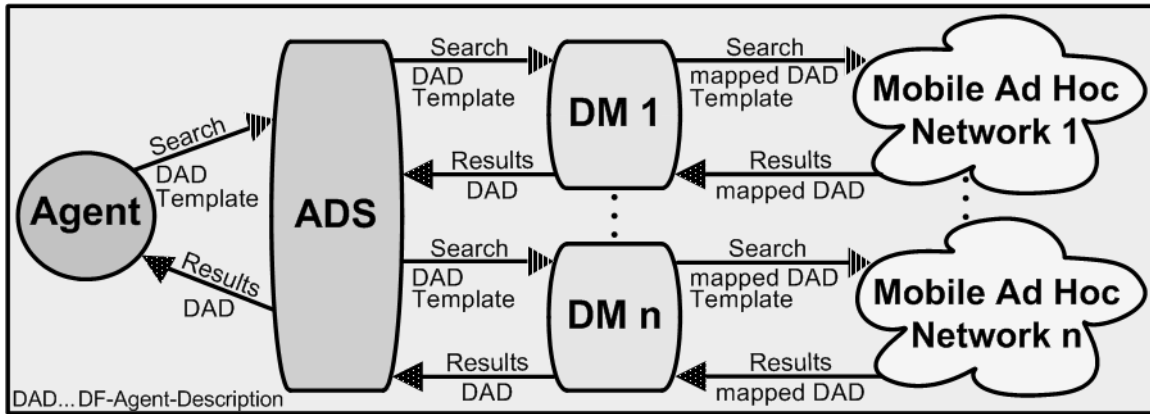


Figure 2: Control Flow of an ADS based Discovery

For searching a certain agent service, first the agent must compose a `df-agent-description` search template describing the service to search. (To find a local service, the agent may ask an existing DF with the same `df-agent-description`.)

To find the service in one or more ad hoc networks, the agent uses the search functionality of the ADS by providing the composed `df-agent-description` search template and the time within which the search must be finished. Eventually the agent might also specify special DM(s) which should be used for this search. This can be done after the agent has queried the ADS for all currently available DMs. Otherwise, the ADS will use all available DMs by default.

The ADS now uses the search functionality of each available DM, in turn by providing the `df-agent-description` search template.

Each invoked DM maps the `df-agent-description` search template to the appropriate representation of the corresponding technology and performs the search in the corresponding ad hoc network.

All available `df-agent-descriptions`, which have previously been registered with the ADS, are represented in the DM's appropriate form and are discoverable by agents on remote devices.

The results of such a search are matching `df-agent-descriptions` in the appropriate representation of the DM. The DM is now mapping the results back to real `df-agent-descriptions` and returns them to the ADS.

The ADS is collecting the resulting `df-agent-descriptions` of all invoked DMs and is returning them to the calling agent.

329 **8 Informative Annex B — ChangeLog**

330 **8.1 2002/10/20 – Initial version by TC Ad Hoc**

331 Entire document: Initial version
332

333 **8.2 2002/11/10 - version A by FIPA Architecture Board**

334 Entire document: Changed some typos and formatting
335