Agent Based Software Engineering  
(SENG 609.22)  
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Tutorial for:  

Middle Agents

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Tutorial Abstract:
In this tutorial, an overview of the middle agents and middle agent characteristics will be presented. Coordination and co-operation of agents via middle agents is discussed. Different types of middle agents will be discussed, middle agents such as matchmakers, brokers, facilitator and mediators.

Introduction
There are some tasks that cannot be completed by one agent; therefore co-operation between agents is needed. Middle agents will manage the co-operation and provide co-ordination to other agents. Middle agents in Multi-Agent Systems act as intermediaries between different types of agents. There are three categories of agents:
- Service request agents (Requester agents)
- Middle agents
- Service provider agents (Provider agents)

Basically, Provider agents advertise (broadcast) their services and capabilities to the middle agents; middle agents in return, store the advertisements; eventually a Requester agent asks a middle agent to find and locate a Provider agent that can provide the service. The middle agent is responsible for processing the request that receives against its own knowledge based on capabilities of registered Provider agents. Meddle agent should be able to find the most suitable provider agent for each request based on the evaluation of the capability of the registered provider agents and the description of the service.

Middle agent definition and characteristics
By definition middle agents are agents that help others to locate and connect to agents provider of services (§) [K. Decker et al. Middle agents for the Internet]

As discussed in the previous section, most of the middle agents acquire their knowledge of available service providers through advertisement (service directory, service registry, etc.) while there are different type of middle agents that store only service requests or facilitate in distributing the service requests to the service providers. Blackboard agent is from this type of agents. This will be discussed in detail in the next section.

One of the challenges for the middle agent is dealing with the heterogeneous environment. Most of the applications are not written with integration in mind, which this will make the co-operation among the agents difficult. The following characteristics of middle agent will address this issue.
Here are the main characteristics of a middle agent:

- **Providing basic mediation services**
  - Processing of agent capability and service description
  - Semantic interoperation between agents and systems
  - Knowledge based reconciliation of heterogeneity
  - Management of date and knowledge
  - Distributed query processing

- **Co-ordination of mediation services**
  - Agent registration and naming
  - Inter-agent interaction
  - Accessing sources of date and information
  - Interfacing with users
  - Mediation protocols and policies

- **Reliability of service**
  - Quality of service
  - Trust management

**Different types of middle Agents**

In the following section different types of middle agents will be discussed in detail.

**Broker agents**

A broker is a middle-agent that protects the privacy of both the requester and provider. The broker understands both the preferences and capabilities, and routes both requests and replies appropriately. Neither the requester nor provider ever knows directly about the other in a transaction. (§§)

Broker agent contacts a set of provider agents and picks one of the provider agents. As opposed to matchmaker, broker agent decides which one of the relevant provider agents should be contacted and controls all the communication and returns the result of the service to the requester agent.

Basically, broker agent act as an interface between the requester agent and provider agent. This means that all the communication will go through the broker agent. System designers should consider this fact while designing the architecture of their Multi-Agent System (MAS). In a complex MAS that requester agents and provider agents transfer lots of data, broker agent might become a bottleneck for the system. Matchmakers and blackboard agents are a good choice for the abovementioned system.
**Blackboard agents**

A blackboard is a middle-agent that keeps track of requests. Requesters post their problems; providers can then query the blackboard agent for events they are capable of handling. This class includes newsgroups and bulletin boards. (§§)

Blackboard-based architectures exploit shared data spaces (blackboards) to promote indirect communication. (*)

Generally speaking a blackboard agent has three components. 1- The blackboard itself, an area for storing data which is accessible to all agents. 2- A set of knowledge sources. 3- A control mechanism. All the agents have access to the blackboard and see the information that is written on it. Agents can contribute their knowledge about the posted problem and can add their piece of information and conclusion to the blackboard. Eventually this will help to solve a given problem through knowledge sharing.

Since the blackboard agent does not act like an interface between requester agent and provider agent, unlike broker agent, blackboard agent is a good solution for data driven problems.

Blackboard agents try to increase the co-operation and co-ordination among the agents. Likewise, facilitator agents (mediators) and matchmaker agents have the same intention to increase the co-operation and co-ordination.
**Matchmaker agents**

A matchmaker (yellow pages) is a middle agent that stores capability advertisements that can then be queried by requesters. The requesters then choose and contact any provider they wish (§§).

Matchmaker basically, returns the sorted and ranked list of provider agents that are capable of performing the requested services, while brokers play active role in selecting the provider agents. Matchmaker agents leave the decision of selecting one of the service providers, to the requester agent.

Unlike the brokers, matchmakers only provide the list of service providers that are capable of performing the specified service for the requesters, and then requester agents will communicate directly with provider agents directly.

To some extend matchmakers and brokers have similar functions, One of the advantages of matchmaker is that, it is not involved in the transferring data between requester agent and provider agent. This will eliminate possibility of any data transmission bottlenecks, but requester agents in this case should have capabilities to select the good candidate for that service and also they should have capabilities to communicate directly with the provider agents. This capability will add to the complexity of individual requester agents.

**Facilitator and mediator agents**

A mediator is dynamically and actively interfacing users (requester agents) to relevant data and knowledge resources (Δ Wiederhold 1992)
The concept of facilitator drives form and generalizes the concept of mediator. (!) In this tutorial facilitator term and mediator term will be used interchangeably.

A facilitator is an agent that performs various useful communication services, e.g. maintaining a registry of service names, forwarding messages to named services, routing messages based on content, providing "matchmaking" between information providers and clients, and providing mediation and translation services. (†)

One of the characteristics of facilitator is transparent delegation. In other word, a requester agent does not involve in identifying, locating and direct communication with the provider agent; facilitator will manage the transaction. The delegation feature in the facilitator allows the MAS developers to reduce the complexity in each agent; in other word, the developer of requester agent will focus on the main goal of agent rather than worrying about minor tasks. This will result in a more manageable software development process.

The way that a facilitator work is that, facilitator receives the request for a service from requester agents and answer the request by either using its global knowledge or forwarding the request to a relevant service provider based on the distributed query planing and processing. Then the information will be gathered and sent to requester agent. In contrast to facilitator agent, broker agents are not able to do any distributed query planning and processing.

Basically, facilitator agent tries to complete a task via co-ordination; and does not work as controller in MAS.

**Conclusion**

By definition a middle agent acts as a middle man for identifying and locating service provider agent, and giving that information to the service requesters. Since broker agents, matchmaker agents and blackboard agents are the middle agents and all of them on the surface doing the same thing (identifying and locating service providers and connecting the requester to the provider), but in reality there are big differences in their application. In cases that the anonymity and privacy is important for the requester object the broker is a good choice as a middle agent for the system. The concept of broker allows us to maintain the privacy of the agent.

When privacy and anonymity is not an issue, different type of agent (matchmaker agent) could be used. Matchmaker agent provides the location information of the provider agent to the requester. In this way requester agent can directly communicate with provider agent, I think this direct connection will speed up the
receiving of the requested service. An intelligent requester agent can add this piece of the information (that who is the provider of this service) to its knowledge database for future use. This will omit one step (asking form the middle agent who is the provider of this service) in the whole process of finding a service provider.

Although, there is a definition for each of the middle agents, but these middle agents concept could vary based on the context of the architecture. For example in the OAA architecture, the facilitator has grate role in co-ordinating and managing the activities. Facilitator in OAA acts like an activity manager; it plans and co-ordinates most of the agents’ tasks. While according to general definition of middle agent (in this case facilitator), managing and planning role has not foreseen in the list of activities.

There are definitions and guidelines for implementing middle agents, but depending on each problem domain, the architecture and implementation of middle agent will be tailored (customized) for that environment. Depending the design and architecture of multi-agent system, combination of middle agents could be used in the middle agent layer. In some cases broker agent and blackboard agent could be used to cover the role of a middle agent. Please refer to (‡ Co-operation in multi-agent system) for more information.

The final point is that, pros and cons for different types of middle agents should be considered during the design stage of MAS, and the middle agent that is suitable for that environment should be selected.

References

§ Brokering and Matchmaking for Coordination of Agent Societies: A Survey
Matthias Klusch and Katia Sycara

§§ Middle agents for the Internet
http://www.sofagents.ri.cmu.edu/papers/ijcai97-final.pdf

*Coordination for Internet Application Development (Andrea Omicini, Franco Zambonelli)
http://www.kluweronline.com/issn/1387-2532

∆ Value-added Middleware: Mediators by Gio Wiederhold

‼ Software agents
† Facilitators and Mediators
http://www.cs.umbc.edu/kqml/papers/kqml-acl-html/subsection3.2.2.html

‡ Cooperation in multi-agent system

Open Agent Architecture
http://www.ai.sri.com/~oaa/ also this page:

Communicating Agents in Open Multi Agents System

Larks
http://www-2.cs.cmu.edu/~softagents/larks.html

Middle-agents for the internet:

Facilitating Message Exchange though Middle Agents
http://www-2.cs.cmu.edu/~terryp/Pubs/p538-payne.pdf

Matchmaking among heterogeneous agents on the internet

A Taxonomy of middle agents for the Internet

http://faculty.biu.ac.il/~dgs/papers/CMA.pdf