Mobile Intelligent Agents for Network Management Systems

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Abstract: *This paper describes work done on ACTS project MIAMI and current work on ACTS project MANTRIP. It discusses how mobile agents can be used in network management and the main benefits of doing that. It concludes that mobile agents can co-operate and complete existing network management architectures in order to provide more distributed and scalable solutions to managing heterogeneous networks.*

1. Introduction

The current telecom environment is characterised by dynamicity, heterogeneity and complexity. Effective management of such an environment requires increased intelligence in management solutions, mobility and dynamic customisation. Mobile intelligent agents [4] are a new network management paradigm, which can offer solutions to these challenges.

2. The MIAMI Enterprise Model

To achieve the above goal MIAMI project [1] came up with the following enterprise model.

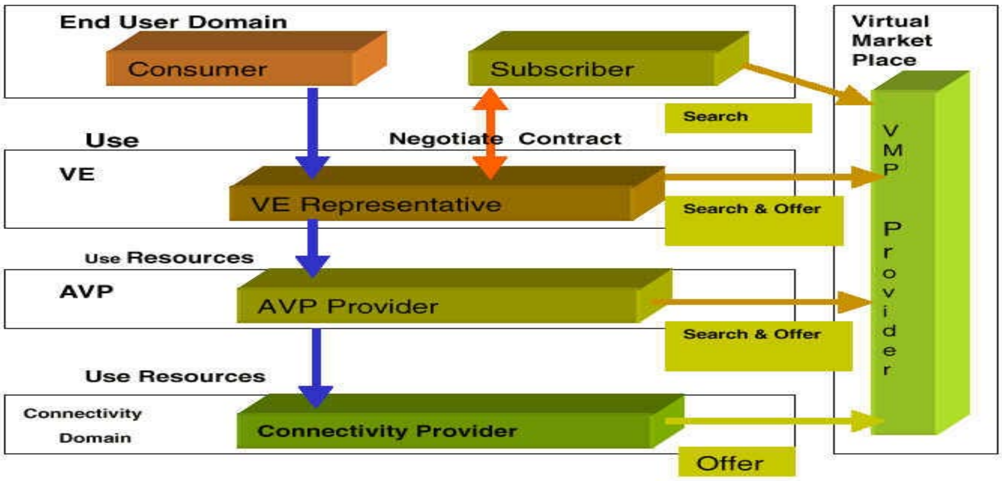

Figure 1: The MIAMI enterprise model

The main component of this model is the Virtual Enterprise (VE). A Virtual Enterprise (VE) is seen as a temporary federation of autonomous, legally and economically independent companies which come together to collaborate on a common business goal. This type of consortium is formed for a particular task, to share the knowledge, the competence, the resources, and business background of the participants, to contribute to the overall business goal of the VE. The federal character of the VE matches the diversity and complexity of the market offerings and products' structure and increases the flexibility for reacting to the rapidly shifting demands of today's markets. A VE usually consists of several partners situated at different geographical locations. This physical separation should be as transparent as possible for the members of the VE to enable effective business activities. The Active Virtual Pipe (AVP) provides this location transparency. The VE does not own any transport networks. Instead it relies on the Active Virtual Pipe (AVP) provider for connectivity between its members and providing connectivity to its customers. The

AVP is a programmable resource of the information infrastructure that supplies to a Virtual Enterprise (VE) with advanced communication and connectivity services with guaranteed QoS. AVP is a novel and key example of an Active Service [6]. It provides an abstract view of the dynamically (self) configurable global connectivity service in charge of the transfer of telecommunication data streams. It is a programmable, dynamic, QoS guarantee Virtual Private Network that can be directly configured according to the demand of the Virtual Enterprise. The AVP is characterised by dynamicity because it provides connectivity with characteristics, which vary according to the requirements of the customers. The AVP does not also own any transport networks but is based on a connectivity provider for connectivity. The Connectivity provider is responsible for managing the transport network (configuration, performance and fault management). The subscriber is the person who pays for the service while the consumer is the actual person who utilises it. The component that glues together all the pieces is the Virtual Market Place (VMP). The VMP is basically a yellow page facility. The VE, the AVP and the CP provider submit their services to the VMP, and they also use it to search for available services. For instance the VE will find the AVP by searching on the VMP and the AVP will find its CPs by looking up the VMP. The AVP will usually chose two CPs, in case one fails.

3. Connectivity Provider

The connectivity provider consists of three components [2], [5]: Configuration, Performance and Fault Management (CM, PM, FM). Each component is implemented using mobile agents and interacts with each other via the AVP. When the VE requests a connection from the AVP, the AVP passes it to the CM component. The CM component, after a successful connection establishment, returns to the AVP a trail info object with information about the specific connection. This information is used by PM and FM in order to monitor the performance of the connection and check for faults, respectively. This is indicated in the following figure. The blue agents are the constrained negotiator agents of the AVP, which will interact with the negotiation agents of CM, PM and FM in order to request configuration, performance or fault management tasks, respectively.

4. Configuration Management

This component is responsible for establishing and releasing end-to-end ATM virtual path connections with specific QoS characteristics. At the network level there is a configuration manager agent which is responsible for interacting with the AVP. This agent has complete topological information about its domain and is stationary because it does not have to migrate to other places. At the network element level there is an ATM manager agent, which is responsible for managing a specific ATM switch. These agents are instantiated by the Element Factory agents and migrated to the agencies, which are located near the switches. These agents interact asynchronously with the configuration manager agent each time a connection needs to be established, modified or released.

This component is to be extended on multi-domain environments [3] in IST project MANTRIP. A Mobile Agent can represent a Bandwidth Broker (BB), a component that is responsible for selling and buying bandwidth between domains. The idea of a Mobile Agent fits well the model of a BB because mobile agents can migrate from domain to domain and in addition they have been used successfully in negotiation procedures. The main requirements of a BB are:

- An intra-domain interface for communication with other BBs and hosts in this domain
- An inter-domain interface for negotiating the parameters of connection between multiple autonomous systems

- An SLA management interface for managing and monitoring the connection after it has been established.
- A network management interface for communicating with the network management system in this domain.

These components are expected to be realised and validated through international trials in the current project MANTRIP.

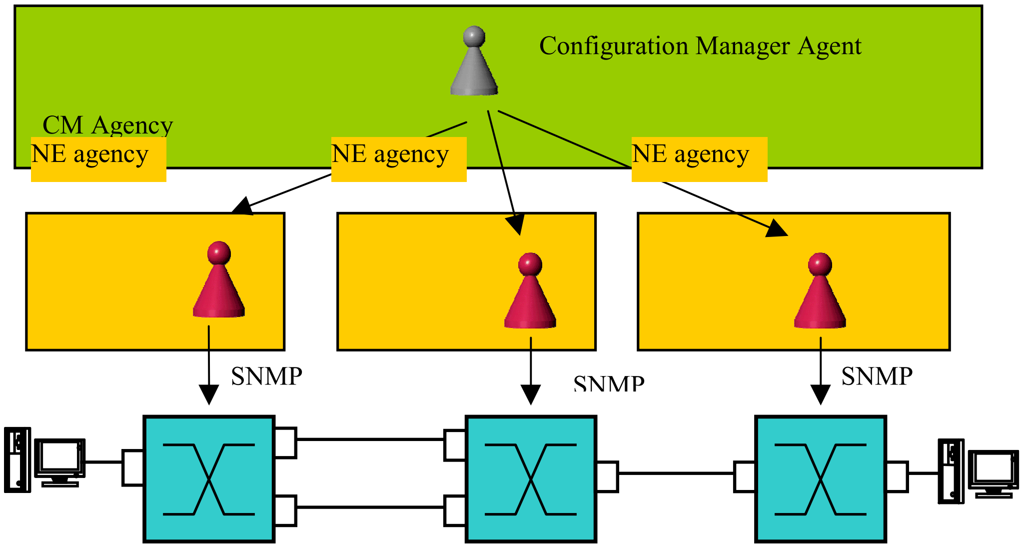

Figure 2: The configuration management architecture

5. MIAMI results

The MIAMI results include the following developments:

- The MIAMI Extended Mobile Intelligent Agent Platform which integrates the OMG MASIF and FIPA specifications and extends them with high-level agent communication via ACL, logging, security and transport services.
- The Active Virtual Pipe as mediator between the business, service, and network management levels and the first implemented prototype of an Active Service.
- Tools, Services, and a Novel Conceptual Design enabling the development and management of virtual enterprises
- A Realistic Demonstration of the mobile intelligent agent framework, which consist of a project-developed, agent-based, multi-domain management platform and selected Virtual Enterprise services and applications, including: Virtual Enterprise Creation. Virtual Enterprise Management. Active Virtual Pipe Service.

6. Summary Advantages/ Disadvantages of mobile intelligent agents

The main advantages of using mobile agents as became apparent in the project are the following:

- Mobile agents are instantiated at a control point by a master static agent and then move to another point (i.e. network node) where they stay until their task is accomplished. This can be considered as an intelligent software deployment activity. The key benefit of this approach, called "weak mobility", is *programmability*, allowing clients to "push" functionality to a point offering elementary hooks, which can be accessed to provide derived, higher-level services. In a similar fashion, we could term "strong mobility" as a situation in which a mobile agent moves from point to point using its built-in logic, adapting to changing situations in the problem domain where it is involved. Provision of dynamic services in network elements that have not been pre-programmed with such facilities. The customisation of mobile agent behaviour can provide a powerful mechanism for "intelligence on demand".

- Higher expected scalability of systems due to the decentralisation through mobile agent technology
- Lightweight Service & Network Management Components - based on the functionality decentralisation through mobile agent technology
- Reduction of management traffic load on and increase of the availability of underlying networks

Among the **costs of the use of mobile intelligent agents** noticed throughout the project the most prominent were the following:

- Migration and machine load overhead. An agent runs on a platform, usually implemented in Java, which in turn runs on top of a Java virtual machine. This has a performance penalty and also requires additional resources from the host. In addition when an agent has to migrate its state has to be captured and the serialised. Then the reverse process has to be executed on the next host. This process is cpu intensive.
- High Costs in Speed for Remote Method Invocation**.** Remote method invocations in the context of a mobile agent platform are at least three times slower than those in Java-RMI or CORBA and this difference could be more pronounced when comparing performance to the protocol-based OSI-SM and SNMP approaches.
- The directory service used by the agents seemed to slow down communication when the number of agents increased. A federation of directory servers would have better results

7. Conclusion

Mobile Agents present a new paradigm in network management that can be used and integrated with legacy components to achieve more scalable and distributed approaches to network management. This was well realised in ACTS project MIAMI, which presented among others the first prototype of an Active Service. On going developments in the MANTRIP project are extending the use of Mobile Intelligent Agents to the management of the IP Networks.

8. References

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