



INSTITUTE OF INFORMATICS
SLOVAK ACADEMY OF SCIENCES

AGENT PLATFORM EVALUATION AND COMPARISON

**Nguyen G., Dang T.T,
Hluchy L., Laclavik M., Balogh Z., Budinska I.**

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PELLUCID

*a new platform for organisationally
mobile public employees*

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ACRONYMS

ACL	FIPA Agent Communication Language
ADK	Agent Development Kit
AID	Agent Identifier
AMS	Agent Management System
ASDK	Aglets Software Development Kit
ATP	Agent Transfer Protocol
DF	Directory Facility
EPL	Emorphia Public License
FIPA	Foundation for Intelligent Physical Agents
GPL	General Public License
GUI	Graphical User Interface
IIOB	Internet Inter-ORB Protocol
IMC	InterAgent Communication System
J2ME	Java 2 Platform, Micro Edition
JDK	Java Development Kit
JNDI	Java Naming and Directory Interface
JXTA	short for Juxtapose (peer to peer)
KQML	Knowledge Query and Manipulation Language
LEAP	Lightweight Extensible Agent Platform
LGPL	Lesser General Public License
MASIF	Mobile Agent System Interoperability Facility
MIDP	Mobile Information Device Profile
MMS	Mobility Management System
MTP	Message Transport Protocols
PJava	Personal Java
RMI	Remote Method Invocation
RPC	Remote Procedure Call
SOAP	Simple Object Access Protocol
SSL	Secure Socket Layer
TUI	Textual User Interface
WAP	Wireless Application Protocol
WSDL	Web Service Definition Language
XML	Extensible Markup Language

1 AGENT PLATFORM FEATURES

In the last few years, agent technology, especially mobile agents, became a new exciting field in computer science. Agent development is getting more and more interesting, even in commercial infrastructures, so it is worth considering in depth their strengths and the situations in which they can be used effectively. There exist a huge number of approaches, toolkits, and platforms of different quality and maturity (over 100 software products) [1] [2] [3] [4]. Therefore a set of criteria, which collected the requirements to the platforms, is necessary to made.

Each agent platform is evaluated according to the following criteria:

- Standard compatibilities: common standards for agent technology are FIPA, (OMG) MASIF, etc.
- Communication: support for inter-platform messaging
- Agent mobility: strong (ability of system to migrate code and execution state of executing unit), weak (migration of code only) - clean, efficient method of migrating, threads needs to be recreated/restarted by an awaiting daemon.
- Security policy: secure intra-platform and homogeneous inter-platform communication.
- Availability
- Usability and documentations: user and developer level of acceptance
- Development issues: practical applications/development projects

The list of evaluated agent platforms evaluated in this technical report comes from the FIPA recommendation for publicly available agent platform implementations. Other agent platforms (e.g. Aglets - ASDK, etc.) are evaluated due to their general popularity among users/developers.

1.1 Aglets Software Development Kit

The Aglets Software Development Kit (ASDK) [5] is an environment for programming mobile Internet agents in JavaTM. Aglets are Java objects that can move from one host on the Internet to another. That is, an aglet that executes on one host can suddenly halt execution, dispatch itself to a remote host, and resume execution there. When the aglet moves, it takes along its program code as well as its data.

- ASDK is free software from IBM, but it is not developing at this time by IBM. The binary and the open source are available. The last version is 2.0.2 (SourceForge, Feb 2002), clear and simple structure, good GUI (Tahiti server), very accessible use, good documentation and high user acceptance.
- Supported platforms: ASDK is originally declaimed by IBM for JDK 1.1, the use with Java2 is possible now (SourceForge).
- Implemented standards: MASIF, work with CORBA

- Communication: sockets, message-passing between agents, ATP (support HTTP tunneling), problem with firewall (one way without dispatch)
- Mobility: weak mobility, Java serialization (byte code)
- Security policy: build-in security mechanism through Tahiti, three roles (aglet, manufacturer, owner), context and server security, network domain, agents are shielded using proxy object, standard security (JDK keytool)
- Practical uses: TabiCan – electronic marketplace for air tickets in Japan (thousand machines)

1.2 Ajanta

Ajanta [6] is a system for programming agent based applications over the Internet. The main focus of the Ajanta design is on mechanisms for secure and robust executions of mobile agents in open systems. Agents in this system are active mobile objects, which encapsulate code and execution context along with data

- Ajanta is a product of Department of Computer Science, University of Minnesota. The last version is beta-version (May 2000). The binary is free but available upon request, poor GUI, the use is not very accessible through its documentation is nice.
- Supported platforms: JDK 1.1.x, installation requires Perl,
- Implemented standards: no
- Communication: Java method invocation, authenticated RMI, ATP, agent collaboration XML
- Mobility: weak mobility, Java serialization (byte code)
- Security policy: servers use Access Control Lists (for file system) and proxy mechanisms, agent code and state transmission are encrypted, authentication using public-key protocol, server resource and secure inter-agent communication (using Java method invocations) are encapsulated into dynamically created proxy object, agent owner can secure parts of agent state private
- Practical uses: experimental Global File System, Global File Access System, Active Mail System, Web Index Search Service

1.3 Tryllian's Agent Development Kit

Tryllian's Agent Development Kit (Tryllian's ADK) [7] is a complete development and implementation environment. Agent applications typically consist of several Habitats spread across a number of servers, each hosting a number of Rooms. A Habitat is a collection of one or more Rooms that share a Java Virtual Machine. It provides services such as agent lifecycle management, communication, inter-Habitat travel, Room and agent persistence and the basic security model. The product contains Visual Agent Designer that can be used by the non-Java programmer to create, modify and deploy agents.

- It is Tryllian's commerce, expensive software product. The last version is 1.3 (2002).
- Supported platforms: Java 2, J2ME
- Implemented standards: FIPA, SOAP, XML, JXTA, JNDI
- Communication: message-passing, real-time, peer-to-peer architecture with dynamic update, load balancing and fault tolerance
- Mobility: strong mobility, meaning that agents can move to other Habitats during runtime, taking along their (new) Java code and state.
- Security policy: X.509 certification infrastructure, up to 4096-bit encryption, secures transmission through firewalls.
- Practical uses: Agent-Based Scheduling - system to maintain a management overview of the Rotterdam harbor (CMG, Tryllian), Workstation Management - mobile agent based software provides automatic license and version control, SMS Dating (Frog) - a dating application (Tryllian) using SMS messages and the Internet, etc.

1.4 FIPA-OS

FIPA-OS [8] is a component-based toolkit enabling rapid development of FIPA compliant agents. FIPA-OS supports the majority of the FIPA Experimental specifications and is being continuously improved as a managed Open Source community project.

- the last version is 2.1.0 (SourceForge, Jul 2001), average GUI, binary available under EPL (Emorphia Public License)
- Supported platforms: Java 2, JDK 1.1.x
- Implemented standards: FIPA (Agent Communication, Agent Management, Agent Message Transport, Agent Software Integration), work with CORBA
- Communication: ACL, IIOP, RMI, XML data binding mechanism for profiles
- Mobility: has the potential to support mobile agents (as a FIPA platform), but mobility has been implemented as prototype only.
- Security policy: RMI over SSL support for secure intra-platform and homogeneous inter-platform communication.
- Practical uses: FIPA-OS was being used within a number of European Collaborative projects including FACTS, Cameleon and MAPP; it is currently used in a number of European collaborative including SHUFFLE and CRUMPET (small-footprint version of FIPA-OS (μ FIPA-OS), aimed at PDA's and smart mobile phones, which has been developed by the University of Helsinki as part of the IST project). A pre-release has also been used in a number of Universities (notably Imperial College and EPFL)

1.5 Grasshopper

Grasshopper [9] provides new opportunities for the enhancement of electronic commerce applications, dynamic information retrieval, advanced telecommunication services and mobile computing. Global for all Agencies registered to the Region Registry additionally local within an Agency. The region concept facilitates the management of the distributed components, i.e. Agencies, Places and agents. Each Agency is the actual runtime environment for mobile and stationary agents, consists of two parts, i.e. the core agency (communication, registration, management, transport, security and persistence service) and one or more places (logical grouping of functionality of agents).

- Grasshopper is developed by the IKV++ Technologies AG (IKV++ GmbH). The last version is 2.2.3 (Jan 2002). The binary is free, available from the website, good GUI and TUI, very accessible use, very good documentation and high level of acceptance
- Supported platforms: Java 2, tested on WindowsCE, web plug-in supported (WebHopper),
- Implemented standards: MASIF, FIFA, work with CORBA (VisiBroker, Orbix),
- Communication: ACL, synchronous, asynchronous, dynamic, multicast communication, different transport protocols (sockets, RMI, IIOP)
- Mobility: weak mobility, Grasshopper supports possibility to simulate strong mobility
- Security policy: external (X.509, SSL - confidentiality, data integrity, and mutual authentication) and internal security (based on mechanisms provided by JDK).
- Practical uses: for Advanced Telecommunications such as ANIMA Architecture Neutral Intelligent Mobile Agents, CAMELEON Communication Agents for Mobility Enhancements in a Logical Environment of Open Networks, EURESCOM Project 815 - Communication Management Process Integration Using Software Agents, FACTS FIPA Agent Communication Technologies and Services, MARINE Mobile Agent Environment for Intelligent Networks, MARINER Multi-Agent Architecture for Distributed-IN Load Control and Overload Protection, MIAMI Mobile Intelligent Agents for Managing the Information Infrastructure

1.6 JADE

JADE™ agent platform [10] can be distributed over several hosts. The agent system contains the main container (composed of the DF agent, the AMS agent, and the RMI registry). Additional agent containers launched on the same host, or on remote hosts (one container per one host), that connect themselves with the main container of the Agent Platform, resulting in a distributed system that seems a single Agent Platform from the outside. Agents can migrate or clone themselves to other hosts.

- JADE is free software and is distributed by TILab, open source software under the terms of the LGPL (Lesser General Public License Version 2). The last version is

2.5 (Feb 2002). JADE has good GUI, accessible use, good documentation and high acceptance

- Supported platforms: Java 2
- Implemented standards: FIPA, work with CORBA (Orbacus)
- Communication: ACL, support for inter-platform messaging with plug-in MTPs (RMI, IIOP are ready and HTTP, WAP are already scheduled), ACL and XML codec for messages.
- Mobility: weak mobility
- Security policy: JADE Object Manager provides connection authentication, user validation and RPC message encryption. The JADE socket proxy agent acting as a bidirectional gateway between a JADE platform and an ordinary TCP/IP connection,
- Practical uses: number of universities and companies included INRIA, Nice-Sophia-Antipolis, ACACIA research team, ATOS Sophia Antipolis agency within the European CoMMA project, KOD Project IST-12503, CSELT, KPN and Starlab within DICEMAN project, The Business & Technology Research Laboratory, The University of Newcastle (Australia) is evaluating JADE for eBusiness applications, etc. The LEAP is developing a new lightweight runtime environment for JADE deployed in the Internet and in the wireless environment (Motorola, ADAC, Broadcom, BT, TILAB, University of Parma, and Siemens).

1.7 JACK Intelligent Agent

JACK Intelligent AgentTM [11] is an agent oriented development environment fully integrated with the Java programming language. JACK provides agent-oriented extensions to the Java programming language. JACK has a development environment and provides a set of classes, which are available to develop JACK applications. The JACK source code is firstly compiled into regular Java code before being executed, which is then compiled into Java virtual machine code to run on the target system.

- JACK is software developed and maintained by Agent Oriented Software Pty. Ltd. The latest version is 3.5 (2002) free for 1 month testing.
- Supported platforms: Java 2, work with CORBA.
- Implemented standards: FIPA.
- Communication: JACK needs DCI network for communication; similar to TCP/IP it needs one process running as a name-server.
- Mobility: no
- Security policy: internal security provided by JDK.
- Practical uses: number of universities and academic institutions for teaching and research. JACK has been developing by Cambridge Laboratory (UK), Melbourne Product Center (Australia), Instituto Trentino di Cultura - Centro per la Ricerca Scientifica e Tecnologica (Italy) and Adelaide Applications Center (Australia).

1.8 Zeus

The aim of ZEUS project [12] is to facilitate the rapid development of new multi-agent applications by abstracting into a toolkit the common principles and components underlying some existing multi-agent systems. ZEUS provides a set of software components and tools, which are used to design, develop and organize agent systems. Moreover, it provides a runtime environment, which enables applications to be observed and another assistant tools like: reports tool, statistics tool, agents and society viewer etc. ZEUS has excellent GUI and debugging, provides library of predefined co-ordination strategies, general purpose planning and scheduling mechanism, self-executing behavior scripts, etc. ZEUS documentation is very weak, that leads to difficulties on creating new applications.

- ZEUS is a product of British Telecommunications Lab. It is open source, freely available software.
- Supported platforms: Java 2.
- Implemented standards: FIPA
- Communication: KQML and ACL
- Mobility: no
- Security policy: ASCII-encoded, Safe-Tcl scripts or MIME-compatible e-mail messages for transportation; using public-key and private-key digital signature technology for authentication, cash and secrecy.
- Practical uses: Intelligent Business System Groups (for agent based work-flow), Electronic Commerce Groups (for agent based virtual marketplaces), BT North America (for agent based network management), etc.

1.9 Other agent platforms

When a large number of existing agent software platforms exist, there is suitable to mention some of them and reasons white they are not recommended for our project.

The April Agent Platform (AAP) is a FIPA-compliant lightweight and powerful solution for developing agent-based systems. It is implemented using the April language (majority of agent platforms is implemented using Java) and IMC. AAP provides many features to accelerate the development and deployment of agents and agent platforms.

Comtec Agent Platform (CAP) is an open-source, free implementation of FIPA standard. Its unique is the implementation of FIPA Ontology Service and Agent/Software Integration, which require SL2 as the content language. This platform provides minimal documentation that may lead to many difficulties to use.

2 CONCLUSION

Within the scope of the Pellucid project “A New Platform for Organisationally Mobile Public Employees” 5FP RTD project (2002-2004) IST-2001-34519, following agent platforms are recommended (priority as in the order):

Grasshopper:

- very good documentation, very good GUI and TUI, high acceptance of users, used in many development projects
- standards MASIF, FIPA, very good security features, plug-in for web interface, logical grouping of functionality of agents,
- weak agent mobility with possibility to “simulate” strong mobility, various communication protocols,

JADE:

- free open source, good documentation, very good GUI, acceptance of users, used in many development projects
- standard FIPA, very good security features,
- weak agent mobility, various communication protocols,

Aglets:

- free open source, clarity in structure, very good documentation, good GUI, famous product,
- standard MASIF, lack of many features, built-in security,
- weak agent mobility, communication using sockets,

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