Basic Technology for Creating Mobile Distributed Systems

A.N. Terekhov[1], A.M. Kudinov, S.I. Makarov[2], R.A. Boudagov[3]
St. Petersburg State University and LANIT-TERCOM, Russia

Abstract

Basic technology for creating mobile distributed information systems is considered, and its practical implementation is discussed.

Keywords: business process reengineering, information systems, multiagent technology

1. Introduction

Modern manufacturers are working in rapidly changing environment and cannot make long-term plans based on current market conditions. To prepare to external changes, the structure of the company has to be highly flexible and all changes in the structure of the company should be done in evolutional way. Therefore, the reengineering of the company should be a continuous dynamic process, but not a disaster.

At the present moment every large company has its own information system, but often these systems consist of differing and odd applications and data storages, therefore the control and support of such system seems to be almost impossible.

This explains the necessity of reengineering of information system. The main purposes of reengineering are:

- New business requirements accounting;
- The unification of software tools;
- The substitution of current structure for component-structure of the company;
- Transparency and scalability of the system.

---

[1] Universitetski pr. 28, Petrodvoretz, St. Petersburg, 198504, Russia, e-mail: ant@tercom.ru.

[2] E-mail: msi@rccmrs.ru.

[3] E-mail: roma@rb2094.spb.edu.

- However the evident approach – to replace existing information system with a completely new one, is really unacceptable because of following reasons:
- New information system will not use the experience of using and improving of existing system;
- The changing of information system requires the conversion of data to into new format, and also personnel training for using new tools, which leads to the interruption in the work of informational system and company in whole.
- There fore it is reasonable to divide the reengineering process in two steps. The goals of preliminary stage are:
- The elaboration of unified representation of corporative information;
- The integration of existing applications in one system.

The next stage consist of changes of existing information systems with new ones without interruption of the work of the whole system.

The new idea in creating and reengineering of information systems is usage of multiagent communication mechanisms of applicable tools and toolkits. With usage of such mechanisms, the information system consists of independent components, which can perform some defined operations and even can be moved in information network.

Therefore the multiagent infrastructure of the system represents the semantic shell of the information system, showing the business rules and the intercommunication of its participants.

The main goal of agent technologies is the integration of heterogeneous application in global infrastructure and the creation of flexible and configurable information systems.

The usage of program agents in creation of Information systems provide following possibilities:

- Dynamic reconfiguration the information system;
- The encapsulation of developed programs in integrated system;
- The unification of the used software;
- The access to international information space in order to develop mobile commerce and e-commerce;
- The improvement of the control of information system by means of remote monitoring of its components;
- Reduction of network intercommunication costs by means of agent's mobility;
- Reduction of support's costs by means of remote execution of applications.

2. The Methodology of Construction

In last years the problems of reengineering and construction of new and particularly multiagent technologies became very popular. Many research departments and large companies are working on these problems, therefore there was created a number of standards of different levels.

In our team a special seminar is concerned these problems, five graduation works were defended and also some software tools were developed. The main goal of these work is the studying of new standards and approaches, their approval on real examples, and, finally, the development of new technologies of construction of modern information systems.

To achieve maximum generality, it is suggested to construct technologies on two steps: firstly, base technology (so called "meta-technology") is formulated and being equipped with toolkit, and than for every project domain the special technology is constructed with usage of basic technology.

2.1 Construction Principles

The effective solution of basic technology development's problems for construction of mobile global information systems has to be based on following principles:

- The follow of international standards for all stages of system life cycle – the model analysis and specifications' definition (ISO 10303,ISO 15704, ISO 15288), construction and integration (ISO 10303, ISO DIS 14750, ISO 18876). These standards define the basic rules for company's description, information protocols, the list of standard processes and development stages.
- Usage of GERAM methodology [ISO WD15704 (1998)] and specialized methodologies for construction of organized business-processes. GERAM methodology generalizes basic description methods for data domains and consists of following basic components: referent architecture, special methodologies, languages, common and special models, toolkits, common software modules and specialized modules. On the basis of GERAM methodology special methodologies are created, which represent the data domain's features and used architectural solutions.
- The component construction of applicable tools and toolkits. Component technologies (DCOM, CORBA, EJB) have to provide following functions: transaction processing, object request brokers, message brokers, and configurable security. These functions make the components independent from programming language and used platforms, real-time connection of new components, virtual modules, adaptation of applications to new business rules, independent engineering, integration and usage.
- Multiagent construction of toolkits and applicable tools [FIPA (2001)]. The main feature of engineering and reengineering of mobile information systems is a dynamic of construction of new business rules and effective modeling of network organizations. Multiagent systems are used both for technological and application-oriented problems. Multiagent infrastructure is in fact a multilevel shell of the information system, which

represent business rules and communication of its participants. The main characteristic of multiagent system is its mobility. The mobility is represented in four aspects – mobile users, computers, programs and data. Hereinafter the mobile global information system will be considered as a set of technological and software tools mounted on mobile and stationary objects (cars, airplanes, ships, trains) and executed software modules, represented as mobile agents.

- Electronic communication between all participants of business projects based on e-commerce standards OASIS and ebXML. The requirements for technical architecture, businees projects description, services, agreements, messages, which provide the electronic communication between the participants of business project are described in ebXML. For using these specifications specialized toolkits are needed, which provide the construction of mobile software components following the Open-edi referent model (ISO/IEC 14662) of e-business.

3. Basic Technology

The architecture of basic technology defines:

- Methodologies, which have to be used in different stages of system's life cycle;
- The referent model of data domain as different representations and the unified method of description of company;
- The ontological basis, defining basic terms of data domain and its interdependence;
- Language tools for model analysis of specifications, formalization and programming;
- Toolkits automating basic process of information system construction life cycle (specifications and analysis, engineering, testing, projects management).

The structure of technological platform includes FIPA and OMG MASIF specifications. The agent communications are performing as messages in FIPA ACL language. The software architecture is based on intercommunications between several JAVA virtual machines and communications between them based on JAVA RMI (Remote Method Invocation), and also on the event-mechanism of intercommunication for every virtual machine.

The distributed architecture of agent platform consists of basic storage and agent storages, base technology and application's toolkits.

The actual executed environment for all types of agents is represented as agency, consisted of the core of agency and some places of mounting. The core has all necessary functions for support of several agents execution and represent following services.

3.1. Communication Service

This service is responsible for all remote communications between distributed components such as: interagent communications, agent's transfer, agent's localization through the

regional registers. The intercommunication can be initiated through CORBA IIOP, Java RMI or direct connection.

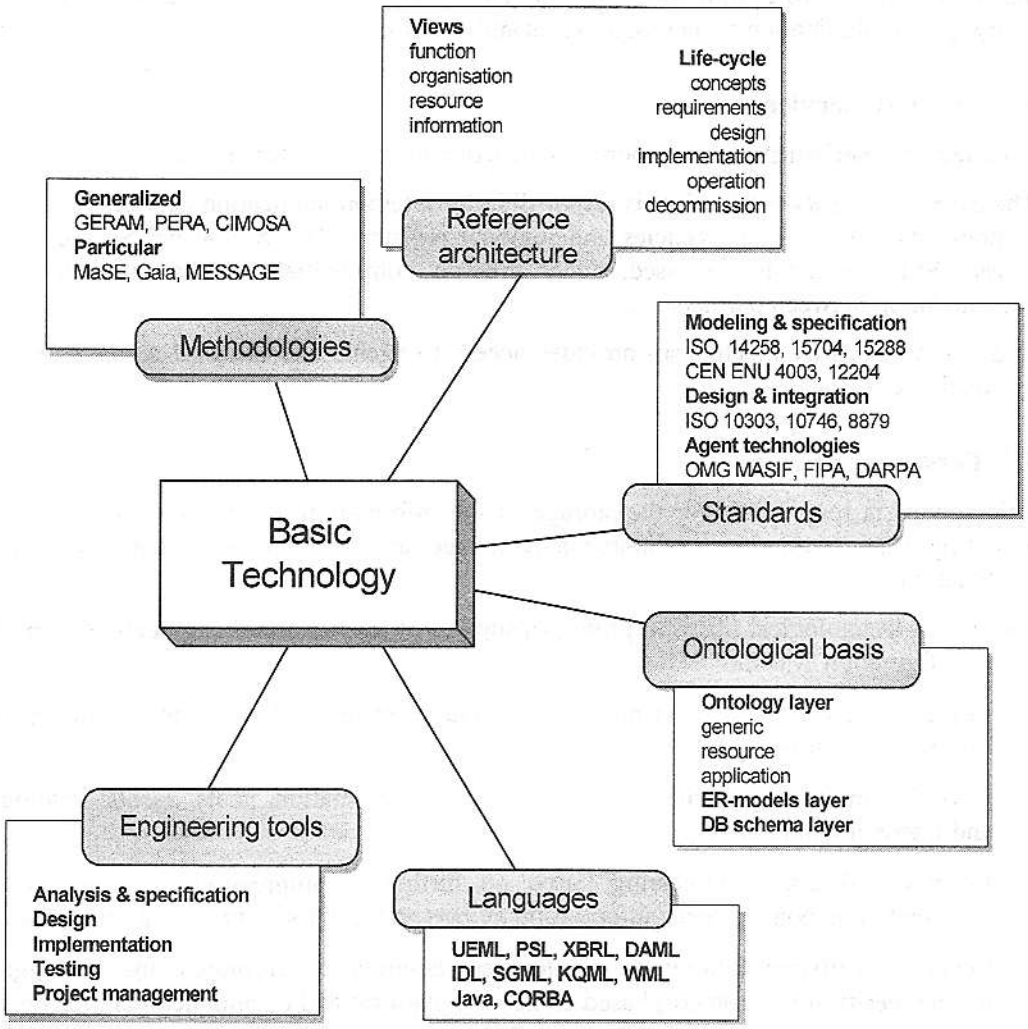

Figure 1: Basic Technology.

OMG MASIF CORBA interfaces can be used instead of communication service. Therefore every agency has MAFAgentSystem interface, and every region has MAFFinder interface.

3.2. Registration Service

Every agency has to get information about all agents and places of mounting and to transfer this information to regional registers.

3.3. Management Service

Management service provide to users necessary monitoring and control information about agents and the places of mounting and also give opportunities of construction, transferring, stoppage and elimination of agents, services and mounting places.

3.4. Security Service

Two security mechanisms are supported – the external and the internal ones.

The external security mechanism is responsible for intercommunication between distributed components, i.e. between agencies and regional registers. The X.509 and Secure Socket Layer (SSL) protocols are used. They provide confidentiality, data integration and authentication between partners.

The internal security mechanism provides access to agents and is based on Java security mechanisms.

3.5. Persistence Service

This service is responsible for the storage of the information about agents and places of mounting. Data is stored on a reliable magnetic mediums for restarting system in case of its malfunctions.

Toolkits of technological platform provide a support of four stages of engineering of mobile global information system.

- Level 1 – conceptual description of structure, main goals, business projects and information components.
- Level 2 – initial engineering of organizational representation, goals, agents, ontologies and intercommunications.
- Level 3 – detailed engineering based on further decompression of organizational representation, goals, agents, information objects and agent's communication protocols.
- Level 4 – software solution in development environment (programming, debugging, testing, verification protocol) based on agent's platform and communication protocols.

As a result, necessary applications are organized from program modules represented as agents and informational description represented as databases schemes.

4. Technology Approval

During the development of the basic technology the approval of main technological elements was initiated.

In considered problem, the informational system is represented as a set of distributed storages of financial information. The existing architecture cannot provide conjoint information about company in whole because of dissimilarity of used software tools.

Accounting operations in multidivisional financial organizations give typical example of such scenario, because their software tools were developed by different companies and in different system environment. Therefore the consolidation of financial information and progressive reengineering becomes crucially important.

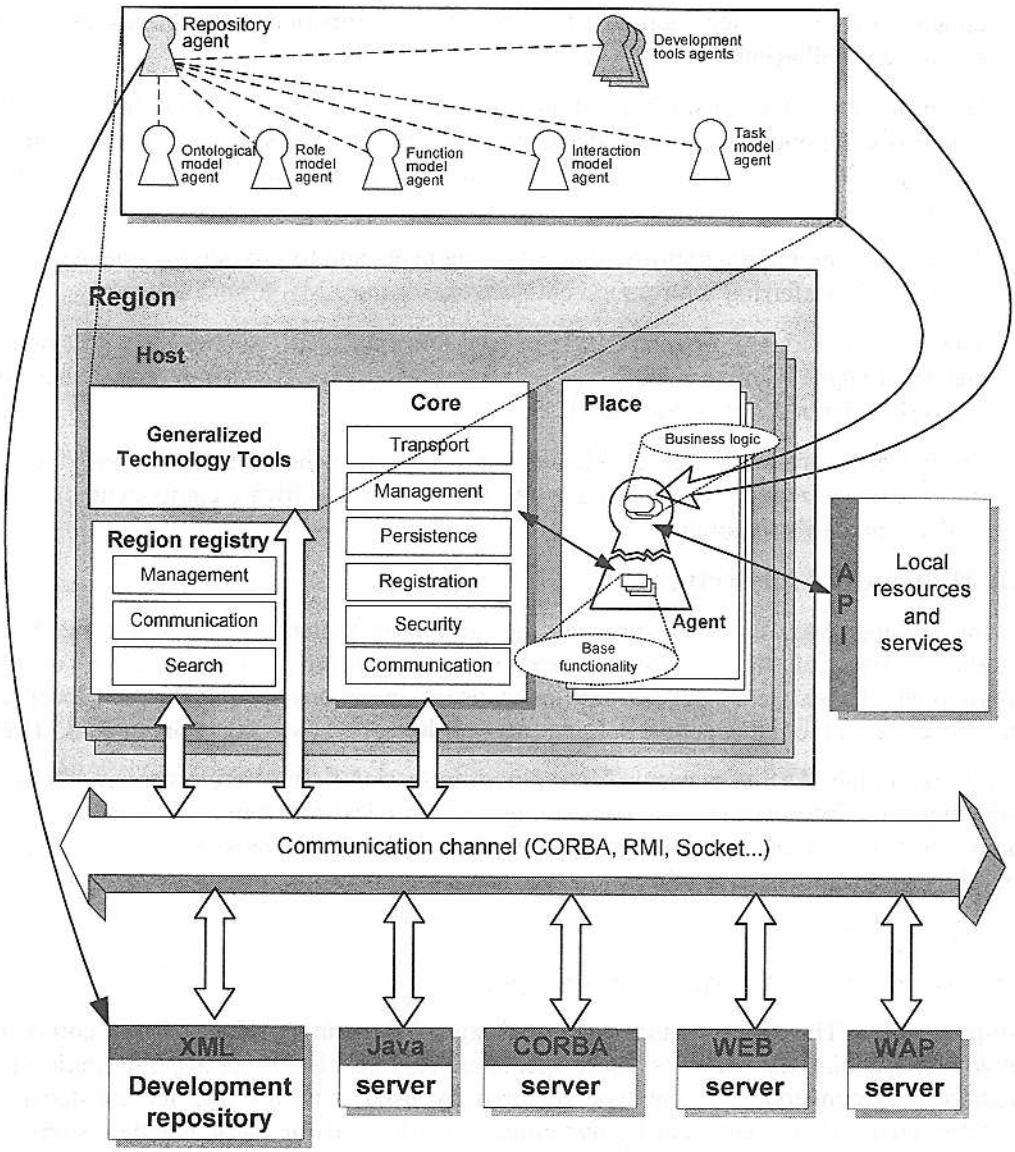

Figure 2: Multiagent Technology.

Following technologies were used for integration of given informational system:

- Suggested solution is based on multiagent infrastructure construction consisted of a set of autonomous, mobile, interactive, configurable shared software agents (Rothermel and Schwehm, 1998);
- The construction of the set of intercommunicated agents requires the description of shared informational entities as ontologies. The usage of ontologies makes possible the creation of the unified storage of corporative information and defines the unified language for all agents;
- For providing effective storing and analysis of corporative information the set of basic business components is created designed as CORBA-servers. Created components fill the Object Management Group (OMG) international standard's requirements in field of finances;
- To increase the interoperability of separate elements and to provide the openness of the system for transferring information between agents the XML format is used;
- The consolidation of financial information from different sources is performed via General Ledger Facility (OMG GLF, 2001). All interfaces to this database also fulfill the OMG standard's requirements;
- Special software tools are developed for organizing the accounting based on the information stored in General Ledger Facility. All these software components fulfill the XBRL standard's requirements.

4.1. Multiagent Architecture

During the approval of basic technology the multiagent system (MAS) was created. This system consists of the set of intercommunicated agents, functioning in common environment. These agents can perform independent operations for solving their local tasks and cooperate with other agent for solving large-scale corporative tasks (Green et al., 1997).

In this project the MAS uses agents for getting information from existing sources, for global collecting of information, for providing communication between basic business components, for remote monitoring and control, and also for increasing the scalability and flexibility of the system in whole.

4.2. Agent Types

For construction of MAS several types of agents were developed.

Adapter-agent. The agents of this type are designed for using on the nodes of corporative network, containing data sources These agents are responsible for getting information from databases, its conversion to the type required by used ontology and its transferring to collector-agent. This agents can be dynamically configured for particular data storage by means of request vocabulary in XML format.

Collector-agent. These agents are responsible for collecting information from distributed sources and its storing in common corporative database represented as a General Ledger

Facility. The mobility of collector-agents increases the efficiency and reliability of intercommunication with adapter-agents. They can be moved to the network node, witch contains data storage and corresponding adapter-agent.

Administrator-agent. This agent provides user's interface for remote monitoring and agent's system control. Administrator-agent may activate the full system of agents by means of only one terminal. Therefore, the information system administrator, using the access to local area network can get information about all agents and CORBA-servers and also configure them without interruption of the work of the system.

The main advantage of creating of business-components and their integration tools is the development process control, improving and scalability of software tools, working in global heterogeneous environment.

5. Conclusion

The further development of the technology can be initiated in following directions:

- The creation of software tools as software agents for modeling of distributed processes;
- The expansion of standard business-components library (scheduling, supply networks management, marketing);
- The creation of software tools for e-commerce mechanisms mased on ebXML specifications and universal modeling methodology (UMM), and also the ontological basis interconnecting for description of companies intercommunication.

6. References

ISO WD15704 (1998). Requirements for enterprise-reference architectures and methodologies.

http://www.cit.gu.edu.au/~bernus/taskforce/geram/versions/geram1-6-2/v1.6.2.html#_Toc422226413

FIPA (2001). Abstract Architecture Specification

http://www.fipa.org/specs/fipa00001/XC00001J.html

Rothermel, K. and M. Schwehm (1998). "Mobile Agents", In: A. Kent and J.G. Williams (Eds.): Encyclopedia for Computer Science and Technology, New York: M. Dekker Inc.

Green S.; L. Hurst; B. Nangle; P. Cunningham; F. Somers; and R. Evans (1997). "Software Agents: A review". Technical Report, Department of Computer Science, Trinity College, Deblin, Ireland. http://www.cs.tcd.ie/research_groups/aig/iag/pubreview.ps.gz

OMG GLF (2001). General Ledger Specification. Formal/01-02-67

http://cgi.omg.org/docs/formal/01-02-67.pdf