Information exchange in multi-agent systems

Khamza Eshankulov*[a], Ilkhom Bakayev[a]
[a]Bukhara State University, 11, M. Iqbol Street, Bukhara, 200114, Uzbekistan

ABSTRACT

This article analyzes the communication protocols and architecture of multi-agent systems. In the introduction, the general purpose of multi-agent systems and the principles of information exchange are described. Annotated with examples and graphs to analyze communication protocols and architectures. The article provides information on the structure, characteristics and areas of use of communication protocols. Also architectural models (SOAA, BDI, Gaia) were comparatively analyzed. This article provides information related to a specific topic of interest to professionals and industry researchers, system administrators.

Keywords: multi-agent systems, communication protocols, architecture of multi-agent systems, system administrators

1. INTRODUCTION

A multi-agent system is a system with multiple variable structures. Each system consists of agents to manage itself, exchange and receive information, and perform a specific task[1]. These systems have a number of necessary elements, their interactions and indicators.

Provides a complete understanding of multi-agent systems based on the following information [2]:

Agents:

- In multi-agent systems, agents are self-directed entities with varying goals.
- Each agent has the ability to manage its properties in real-time to perform changing tasks, establish relationships and work with other agents.

Communication protocols and architecture:

- Communication protocols for communication and information exchange between agents work in the system.
- System architecture plays an important role in establishing communication protocols, communication and management.

Dynamic tasks:

- Agents are created to perform dynamic tasks
- Each agent performs its task independently and serves the overall goal of the system.

Contact:

- It is done to establish communication between agents, to be able to help to accomplish a single task, and to create an opportunity to work together for the common goal of the system.

Monitoring and management:

- Through the monitoring system, the activity of the agents is monitored, and the control module brings the data into a single structure for the management of the agents.

*vivente_2006@mail.ru

Third International Conference on Optics, Computer Applications, and Materials Science (CMSD-III 2023),
edited by Shahriyor Sadullozoda, Ramazona Abdullozoda, Proc. of SPIE Vol. 13065, 130650F
© 2024 SPIE · 0277-786X · doi: 10.1117/12.3024938

Information sharing:

Agents acquire new knowledge by learning about changing information exchange processes [3].

Today, multi-agent systems are used in various fields. For example, trade, robotics, transport, management systems and other areas should be highlighted (Figure 1). For example, digitization of processes through multi-agent systems in the field of trade can be very effective. In doing so, sales agents can help with communication, customer relationship management, delivery and process coordination in an exciting and dynamic environment [4].

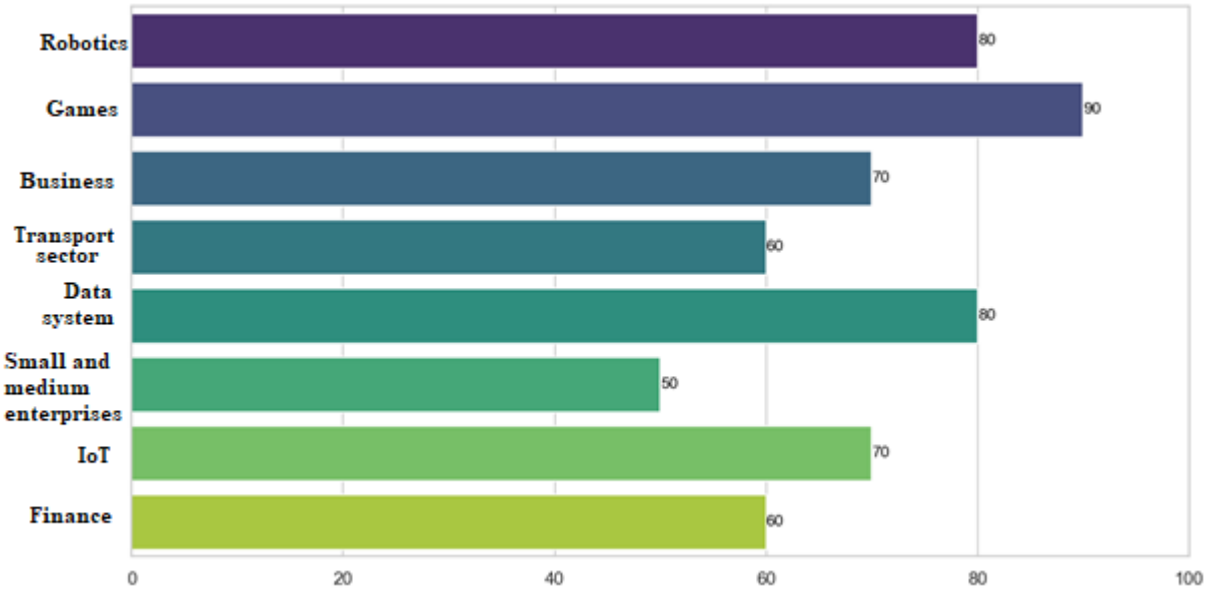

Figure 1. Digitized fields based on multi-agent systems.

Multi-agent systems have agents that act independently and are an innovative technology that performs important tasks based on these agents. Also, multi-agent systems can be used in BI Business Intelligence. These systems offer effective solutions for data acquisition, analysis, and business process management coordination, autonomy, and data integration [5].

2. MULTI-AGENT SYSTEMS FOR BUSINESS INTELLIGENCE

Multi-agent systems for Business Intelligence (BI) are widely used in data analysis and decision support. With the help of these systems, enterprises can be able to effectively and comprehensively study data to develop their management and strategies.

These systems succeed in solving the objectives of enterprise systems by ingesting, analyzing, presenting, and communicating data [6]. Multi-agent systems are effective in collecting critical information through different agents in enterprise settings and sharing them with other agents. Figure 2 shows the working diagram of the BDU_Integro Multi-agent system. In this system, data is analyzed through a system consisting of N sources and agents of each source.

This system enables data identification and analysis to define enterprise management strategies and provide enterprise data to users. In this case, it helps the management of the enterprise to make successful business decisions [7].

In multi-agent systems, communication protocols and architecture are important to ensure effective communication and performance between agents. Protocols and architecture enable each agent to perform its changing tasks and help each other. Figure 3 shows the architecture of interaction of agents based on communication protocols of computer networks of BDU_Integro Multi-agent system.

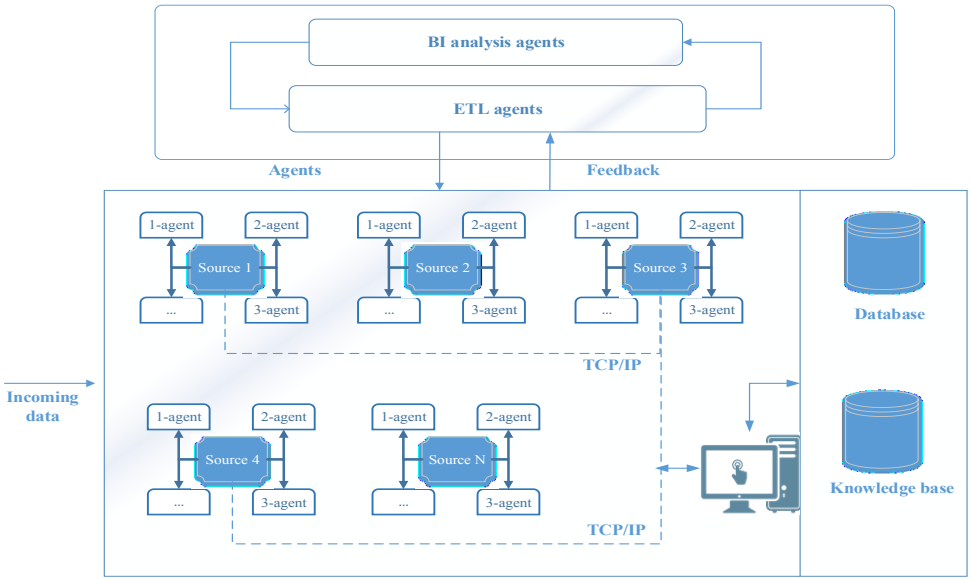

Figure 2. BDU_Integro Multi-agent system.

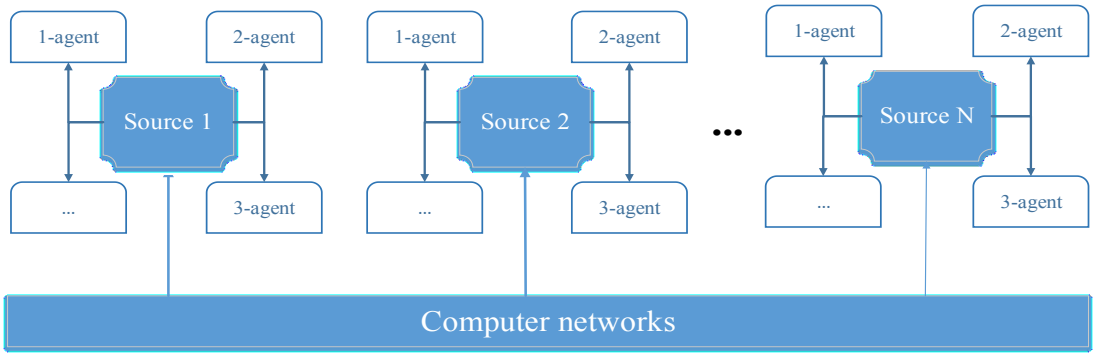

Figure 3. BDU_Integro Information exchange architecture based on communication protocols of multi-agent system.

In multi-agent systems developed for Business Intelligence, communication protocols are important for the exchange of information between agents and the distribution of tasks. These protocols are an important tool in establishing communication between agents and transferring information to each other and in the process of performing a common task. Communication protocols help to monitor the status of agents and the general state of the system during system management and monitoring.

In the efficient operation of multi-agent systems, communication protocols and its architecture are important for perfect control and monitoring of the system and successful completion of the overall task.

3. MATERIALS AND METHODS

In multi-agent systems, communication protocols and architecture are important for exchanging information between agents, coordinating each agent's task, managing the system, and solving a common task. In this type of systems, each agent works to share information and interact and assign tasks according to its characteristics and dynamic tasks. The following main elements are used in the communication process management system [8]:

Organization of communication protocols:

- Protocols are defined for communication between each agent.
- Protocols, used to organize information exchange between agents, management and other communications.
- Communication protocols help define processes for sending information and actions to each other, sharing information and managing them.

Creating a communication model between agents:

- A communication model is used to structure and manage communication between agents.
- A communication model helps to determine the exchange of information through communication protocols, organization of actions between agents, information sharing and decision making.

Create an agent manager (Manager):

- Manager of agents is important in managing the system.
- Manager monitors communications between agents, assists in task allocation, information sharing and mastering other key management.

Communication system monitoring and management

- The communication system controls the countries connected through the monitoring process, communication protocols, agent manager and communication model.
- The monitoring process includes communication establishment and operation, obtaining statistics about communication protocols, and searching for information.

Creating a database

- A database will be created for the learning process of information sharing and management within the system.
- The database maintains relations between agents, works in exchange and storage of information through communication protocols.

It plays an important role in managing the communication process, organizing effective communication between agents and learning how to interact with them. Communication protocols and system architecture are important in managing this process efficiently and fully [10].

Information exchange based on communication protocols in a multi-agent system can be represented in the diagram in Figure 4:

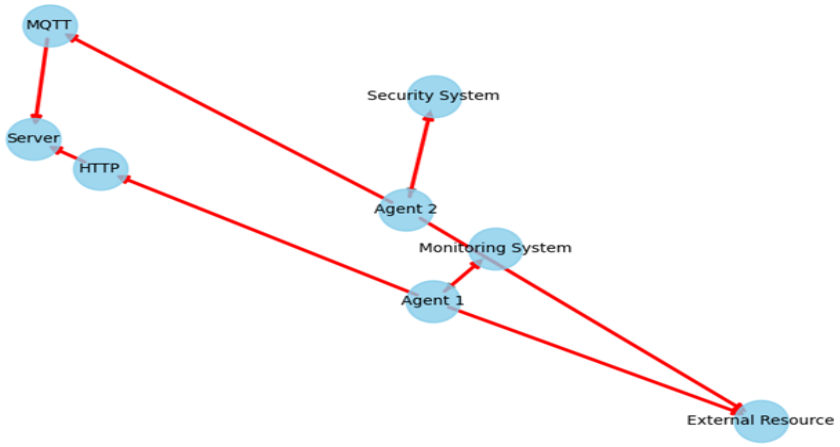

Figure 4. Information exchange based on communication protocols in a multi-agent system.

This graphic depicts the circuit of the communication system. This system consists of "Agents", "communication protocols", "management system", "monitoring and security system", and "external resources". We fully explain this graph with the following descriptions:

Agents:

- "Agent 1" and "Agent 2" are agents in the system that are regularly created to perform a specific task.

Communication protocols

- "HTTP" and "MQTT" are communication protocols used for information exchange between agents.

Boshqaruv tizimi

- "Server" - is used for providing services to users and exchanging information in the management system and communication system.

Monitoring and security system

- "Monitoring System" and "Security System" - used to control the activity of agents and manage security processes.

External resources:

"External Resource" - tizim tashqi resurslar bilan aloqa o'rnatshi uchun ishlatiladi.

A multi-agent system based on this scheme includes management of agents and services, monitoring and security, and communication with external resources.

4. IMPLEMENTATION

Communication protocols include the study of sending requests, receiving responses, exchanging information between agents, and other information exchange operations. Communication protocols are created through the following steps:

- Selection of standards: Before creating a protocol, it is necessary to define the standards used for information exchange. These standards may be designed to define how information exchange between middle agents or system components should be structured. For example, HTTP, WebSocket, MQTT, etc.

- Selection of data types: Specifying the data type is very important in the organization of information exchange in the protocol. This can include XML, JSON, Protocol Buffers, and other data types.

- Defining features and functions: Features and functions of the protocol define the actions performed through the protocol. For example, data transmission, reception, external error detection, etc.

- Security: It is necessary that the protocol covers tasks aimed at ensuring security and confidentiality. For example, data encryption, authentication, security certificates and other methods can be specified.

- Testing: It is very important to create tests to verify the functionality of the protocol. Such tests allow to correct errors of the protocol, eliminate security and other shortcomings.

There may be specific requirements for compliance with communication protocols, amenities and practices. For this, it is very important to conduct analytical studies and analyzes and apply practical experiences before creating a protocol.

The analysis of the information between the agents is carried out on the basis of architectures for setting tasks and managing the process. Table 1 below provides a comparative analysis of SOAA, BDI and Gaia architectures.

These named protocols and architectures are only descriptions and require a lot of experience to analyze and program to see them in practice. For example, the Gaia architecture is structured so that agents in each group communicate, share information, and help each other.

The characteristics of the multi-agent system should be reflected in the architecture. Let's create an Enterprise_agent_system object based on the Gaia architecture. In doing so, we build agents for the processes of adding employees and managers to the list of employees and managers issuing orders to employees.

Table 1. A comparative analysis of SOAA, BDI and Gaia architectures.

Characteristics	SOAA	BDI	Gaia
The main point	Communication between services and agents	Reliability	Communication between agents is based on a communication network
Goals and objectives	Ease of administration	Exchange of information between agents, setting goals	Relationships between agents and systems, identification and optimization of models
Basic communication methods	communication through services, communication protocols for services	The trust-desire-article model, relations between agents	Relations between agents, interactions with other agents
Interconnection	It is managed through communication between agents	Interactions are made through agents	Relations between agents and communication networks
Information analysis	Communication protocols through services, message systems	The trust-desire-article model, relations between agents	Communications between agents, message systems

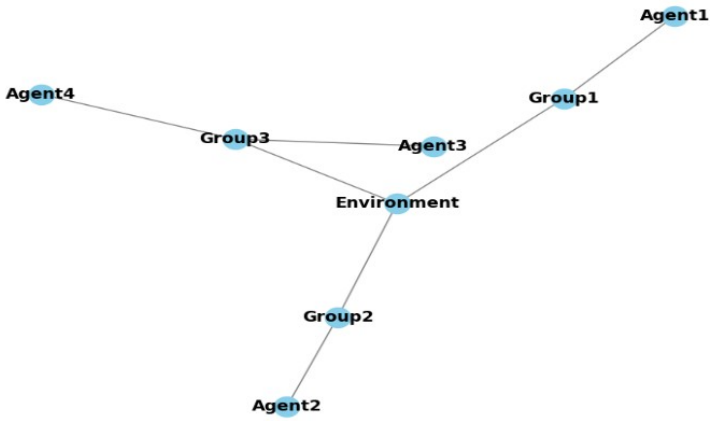

Figure 5. Architecture of Gaia.

5. CONCLUSION

Analyzes communication protocols and architecture of multi-agent systems. In the introduction, the general purpose of multi-agent systems and the principles of information exchange are presented. In the main part, communication protocols and architecture are explained with examples and graphs for analysis. Improved examples and benchmarks for learning communication protocols and architectures.

Illustrations, examples, and graphics are used to explain communication protocols and architecture. This section analyzes how protocols and architectures facilitate interoperability in practice and facilitate simple, reliable information exchange.

REFERENCES

[1] Kravets, A. G., Kravets, A. D., Fomenkov, S. A. and Kamaev V. A., Multi-agent systems componentbased generator: development approach. IADIS Applied Computing 2013 conference, Forth Worth, Texas, USA (2013).

[2] Prokopchuk, Y., Cognitive model of activity Inductive modeling of complex systems. Kyiv, IRTC ITS NAS and MES of Ukraine Publ., 4, 177-188 (2012).

[3] Liu, H., Wen, G. G., Peng, Z. X., Wang, J. L. and Huang, T. W., Fully distributed consensus control for linear multiagent systems with dynamic double-event-triggered mechanism. IEEE Trans. Circuits Syst. II Express Briefs, 69 (3), 1262-1266 (2021).
[4] Starkova, Yu. S., Kulieva, N. V., Starkova, Yu. S. and Kravchenko, Yu. A., Cognitive architecture of agents, Software engineering: methods and technologies for developing information and computing systems (PIIVS-2016) (2016).
[5] He, W. L., Xu, B., Han, Q. L. and Qian, F., Adaptive consensus control of linear multiagent systems with dynamic event-triggered strategies IEEE Trans. Cybern., 50 (7), 2996-3008 (2019).
[6] Cheng, B. and Li Z. K., Fully distributed event-triggered protocols for linear multiagent networksIEEE Trans. Automat. Control, 64 (4), 1655-1662 (2019).
[7] Chen, T. T., Wang, F. Y., Xia, C. Y. and Chen, Z. Q., Containment control for second-order multi-agent systems with intermittent sampled position data under directed topologies.
[8] Huang, N., Duan, Z. and Chen, G. R., Some necessary and sufficient conditions for consensus of second-order multi-agent systems with sampled position data.
[9] Li, Q., Wei J., Gou, Q. and Niu, Z., Distributed adaptive fixed-time formation control for second-order multi-agent systems with collision avoidance Inf. Sci., 564, 27-44 (2021).
[10] Lan, X., Liu, L. and Wang, Y., ADP-based intelligent decentralized control for multi-agent systems moving in obstacle environment IEEE Access, 7, 59624-59630 (2019).