TASHKENT UNIVERSITY OF
INFORMATION TECHNOLOGIES
NAMED AFTER MUHAMMAD AL-KHWARIZMI

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TOSHKENT AXBOROT TEXNOLOGIYALARI
UNIVERSITETI

BULLETIN OF TUIT:

MANAGEMENT AND COMMUNICATION TECHNOLOGIES



ISSN:2181-1083 DOI:
Eshmuradov Dilshod, Turaeva Nasiba, Saidova Gulchehra, Muradova Alevtina № 3(23)2024

MODEL OF A MULTI-AGENT SYSTEM FOR MONITORING AERONAUTICAL INFORMATION TELECOMMUNICATION NETWORK

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Abstract. The purpose of the work in this article is to develop models and algorithms to ensure the effectiveness of monitoring the telecommunications network of information transmission in air navigation systems, allowing to systematize and improve the efficiency of the work of employees of the Department of the data transmission network of the aviation industry of Uzbekistan. The relevance of the development of this model is to use intelligent agents to help operators quickly enough to recognize a potential problem and help prevent a wide range of real failures. The development of a model of a network monitoring system based on multi-agent technology was completed and the function of each agent in the system was described. During the development, the formation and stages of operation of the multi-agent technology were studied. The practical results of the study of the work are that the proposed software and hardware for monitoring the transmission of aeronautical information in the airport telecommunications networks were successfully implemented and the efficiency of the network has increased significantly.

Keywords: Imitation modeling, multi-agent system, air navigation, telecommunication network, Python, SimPy, AnyLogic, systems modeling.

Introduction. To achieve the implementation of a system for monitoring the transmission of aeronautical information based on multi-agent technologies, it is possible to choose a problem-structural methodology for the synthesis of hybrid systems, which allows creating self-organizing models, each element of which develops, receiving data and knowledge from other elements [1]. Developing a monitoring system is a voluminous and complex process, which includes a whole algorithm of actions, or in other words, stages [2].

This study to a certain extent serves to fulfill the tasks provided for in the Resolution of the President of the Republic of Uzbekistan No. PR-4699 “On measures for the widespread introduction of the digital economy and electronic government” dated April 28, 2020,

Presidential Decree No. PD-6079 "On approval of the strategy "Digital Uzbekistan-2030" dated on October 5, 2020, Presidential Decree No. PD-5349 “On measures for further improvement of the sphere of information technologies and communications” dated February 19, 2018, in the Resolution of the Cabinet of Ministers of the Republic of Uzbekistan No. 699 “On measures for the further development of the telecommunications infrastructure of the Republic of Uzbekistan” dated November 19, 2021, Resolution No. 185 “On measures to further improve the quality of communication, information technology and telecommunications services” dated March 7, 2018 and other regulatory documents adopted in this area.

This technology, a multi-agent monitoring system [3,4], was chosen to develop a new monitoring system for telecommunication networks transmitting aeronautical information. The new model of the monitoring system will be developed using intelligent agents to help network operators quickly enough to recognize a potential problem and help prevent a wide range of real failures.

During the study, the research works of scientists and the works of authors from other countries were studied, such as A.V.Berezina “Development of a multi-agent system for monitoring network equipment”, I.M.Shamin “Monitoring IT systems and network devices”, A.V. Bogovik, D.M. Safiulov "Analysis of existing systems for monitoring the technical condition of telecommunications equipment in communication networks", G.V.Knyazeva "Monitoring user actions as part of a comprehensive computer systems security system", A.V.Girik "Organization of monitoring in telecommunication networks for the purpose of detecting information threats to data transmission security", E.R.Dakueva "Research and implementation of the enterprise activity monitoring system", Thomas Lindh «Performance monitoring in communication networks», Abul Bashar «Graphical modelling approach for monitoring and management of telecommunication networks», Anand Sreenivasan «Performance monitoring of network systems», Colin Goldsmith «Wireless local area networking for device monitoring», Andrej Novak «Modern telecommunication networks in the Aeronautical Telecommunication Network (ATN)», Vishrant Tripathi «Information freshness for monitoring and control over wireless networks».

In the process of researching the dissertation work, the works of scientists and authors of Uzbekistan were studied such as Professor Isaev R.I. "Multimedia communication networks". M.Abdujapparova, S.Sadchikova "Internet networks and services", Khalikov A.A., Abdujapparova M.B. "Development of a method for evaluating the throughput of broadband access to the telecommunications network", Eshankulov Kh.I. "Multi-agent systems for information monitoring and management in real time", Gulyamov Zh. "System of dispatching and monitoring of engineering systems", Rasulova N., Duseynov N. «A multi-agent

approach to creation of adaptive intelligent learning systems», Sharipov D.K. "Models and algorithms of systems for monitoring and forecasting atmospheric pollution in industrial regions", Khudayarov M. B. "Monitoring energy consumption for assessing the energy efficiency of public buildings", Pisetsky Yu. V. "Methods and devices for remote monitoring", Nasrullaev N.B. "Methods and algorithms for improving the efficiency of the information security monitoring system". The above-mentioned works on reports, calculations and study of the object received information [5], confirming the conducted research on monitoring the data transmission network, as well as in other areas, such as ground transportation, education, logistics, business analytics, etc. [6].

The conducted analysis of research in the field of the system for monitoring telecommunication networks for the transmission of aeronautical information [7,8] shows that the works of the above-mentioned scientists have insufficiently studied the issues devoted to the development of methods, models and algorithms for the system for monitoring the network of aeronautical information transmission based on multi-agent technology, ensuring high reliability and efficiency of information exchange between operators.

In the course of scientific research, software was created that will simulate the operation of a complex system responsible for monitoring data transmission in the aviation sector. This system should be able to simulate various scenarios, from normal operation to extreme situations, and provide valuable information for optimizing and improving the real system.

The relevance of developing this model lies in the use of intelligent agents to help operators quickly enough to recognize a potential problem and help prevent a wide range of real failures.

The following agents are proposed to be used: an information notification agent to the central computer, a data collection and sorting agent, a telecommunications equipment tracking agent, a power supply agent, a database formation agent, a meteorological data agent, and a reference agent.

The author of this research work proposed a model of a network monitoring system based on multi-agent technology.

Agent-based modeling is a method that allows creating models of complex systems using the interaction of autonomous agents. In the context of telecommunications equipment, agent-based modeling can be used to analyze, optimize, and predict the operation of various components of telecommunications networks[9].

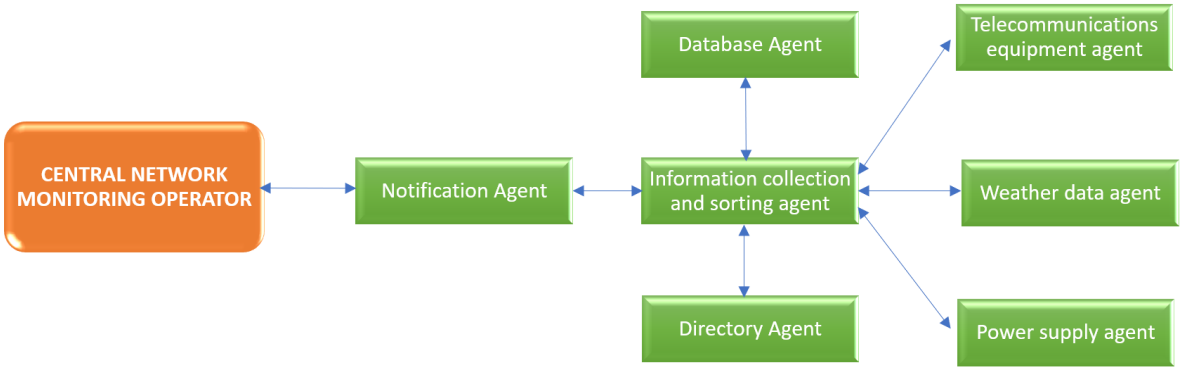


Fig. 1. Model of a network monitoring system based on multi-agent technology

The developed monitoring system is considered an integrated system and serves for the speed of operators and the efficient operation of the network and telecommunications equipment. Agents of modern multi-agent technology will be able to give recommendations in various cases of network failure and emergency situations[10]. During testing of network objects, the proposed integrated monitoring system will compare the test results with the norm and notify about the state of any network object on the central computer screen. The process will take approximately 2-3 minutes, which significantly reduces the testing time compared to the existing system.

Below is a fragment of the code of the developed program:

```
Python
import simpy
class Agent:
    def __init__(self, env):
        self.env = env
        # ... other agent attributes
class Network:
    def __init__(self, env):
        self.env = env
        # ... network creation
def main():
    env = simpy.Environment()
    network = Network(env)
    # ... creating agents and running the simulation
    env.run(until=100)
if __name__ == '__main__':
    main()
import simpy
class Aircraft:
    def __init__(self, env):
        self.env = env
        # ... other attributes of telecommunications equipment
class GroundStation:
    def __init__(self, env):
        self.env = env
        # ... other attributes of the aeronautical information transmission network
def main():
    env = simpy.Environment()
    # ... creating objects and running simulations
    env.run(until=100)
if __name__ == '__main__':
```

main()

Key components of the simulation model of a multi-agent monitoring system for the aeronautical information transmission network:

- **Agents:** Individual elements of the system (sensors, servers, clients), each of which has its own tasks and characteristics.
- **Network:** A structure that connects agents and ensures data transfer.
- **Aeronautical information:** Specific data transmitted over the network (flight plans, weather data, aircraft status data, etc.).
- **Occasions:** Various events that can occur in the system (message sent, packet lost, hardware failure).
- **Time model:** The way time is represented in the model (discrete or continuous).
- • *Selection of tools and technologies:*

• Programming language: Python, thanks to a rich ecosystem of libraries for scientific computing and modeling (NetworkX, SimPy, AnyLogic).

• Simulation tools:

o SimPy: An easy-to-use library for discrete event simulation.

o AnyLogic: A professional tool for modeling complex systems, including multi-agent ones.

OMNeT++: A specialized platform for network modeling.

Development environment: Any modern IDE that supports the selected language (PyCharm, Visual Studio Code).

Program structure.

1. Defining agents:

o Create classes for each agent type.

o Define attributes (identifier, state, resources) and methods (event handling, interaction with other agents).

2. Creating a network:

o Use the NetworkX library to create the network topology.

o Define communication channels, latencies, and bandwidth.

3. Simulating time:

o Choose a time model (discrete or continuous) and implement a time advancement mechanism.

4. Events and event handlers:

o Define all possible events.

o Create functions to handle each event.

6. Data collection and analysis:

o Store data about the state of the system during the simulation.

o Use libraries for data visualization and analysis (Matplotlib, Pandas).

Key aspects of modeling:

• Aeronautical Information: Define the format and content of data (flight plans, weather data, ATC messages).

• Communication Protocols: Model the protocols used (e.g. ADS-B, CPDLC).

• Errors and Failures: Introduce different types of errors (packet loss, delay, data corruption) and model recovery.

• Network Load: Generate different network loads to evaluate its performance.

• Aeronautical Information Network Monitoring: Model a multi-agent monitoring system for the aeronautical information network.

Next steps:

• Requirements Clarification: Define specific modeling objectives, agent types, scenarios, and performance metrics.

• Tool Selection: Determine the most appropriate tools to implement the project.

• Detailed Architecture Design: Create class and sequence diagrams to visualize the system structure.

• Implementation: Implement the individual components of the system step-by-step and integrate them.

• Testing and Debugging: Conduct thorough testing to identify and fix errors.

• Analysis of Results: Analyze the data and draw conclusions.

Additional features:

• Visualization: Using libraries to create interactive visualizations.

• Verification and validation: Comparing simulation results with real data.

• Optimization: Finding optimal system parameters.

• Machine learning: Using machine learning methods to predict and analyze data.

Thus, agent-based modeling provides a flexible approach to studying the dynamics of telecommunication systems and helps make more informed decisions on their management and development.

The figure 2 shows the interface of the developed program for a multi-agent monitoring system of telecommunications network.

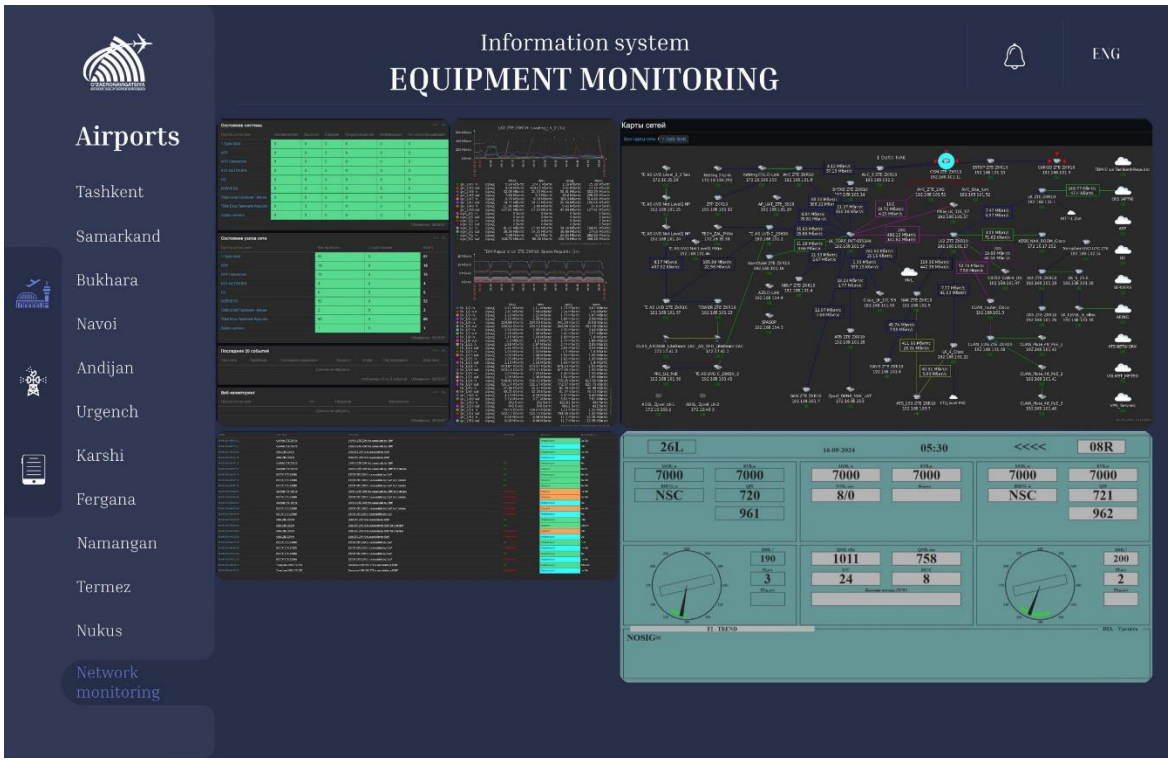


Fig.2. Interface of the program for a multi-agent monitoring system of telecommunications network

The developed model has a number of advantages such as high system reliability - resistance to failures and ensures continuous operation, accuracy and synchronization - all systems and

equipment will work synchronously to prevent errors. To ensure the above, it was necessary to create an integrated monitoring system to track the operability of the aeronautical information transmission network.

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