ISSN: 2277-9655
Impact Factor: 4.116

IJESRT

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

MULTI-AGENTS FOR THE DIAGNOSTIC SYSTEMS

A. H. Mohamed*
* Solid State and Electronic Accelerators Dept., National Centre for Radiation Research and Technology (NCRRT), Atomic Energy Authority, Egypt

DOI: 10.5281/zenodo.59641

ABSTRACT

Nowadays, critical and complex systems are widely used in our daily life. Modern technology provides great rapid changes in manufacturing these systems, and so continuous increasing in the complexity of their diagnostic systems. However, many intelligent systems and techniques have been developed in this manner. But, till now there is a great complexity appeared to have good performance for diagnosis these complex systems. This research introduces a novel diagnostic system that can use the multi-agents framework to simplify, extend and scale-up the diagnostic process. The proposed multi-agents diagnostic system can increase the accuracy of the diagnostic process by moving the tasks to the data rather than moving the data in the traditional diagnostic system. This can avoid the data losses and decrease the operation time. Also, the suggested system can simplify the diagnostic process by dividing the tasks of the system to be diagnosed into two main groups. Besides, this can help in increasing the accuracy and decreasing the time for achieving the required diagnosis. The proposed system has been applied for diagnosis the faults of three critical systems. They are: product handling mechanism system and a security network for a radiation centre, and a radiotherapy system. Its results are compared to three diagnostic systems. Their evaluation process proves that the suggested system has a significant improvement of the diagnostic systems' performance.

KEYWORDS: Multi-agents, diagnostic systems, fault diagnosis, critical systems and complex systems.

INTRODUCTION

In the last decade, the critical and complex systems are widely applied in all our daily life fields such as: surgery systems in the hospital, radiation-based systems, airplanes, alarm systems in critical sites, etc. [1]. These complex systems involve hundreds and even thousands of components. Every one of these components has several variables and features that must be evaluated to diagnose failures of their operations. So, researchers have found a clear increase in the complexity and time of the traditional diagnostic process when faced with these critical systems. This drives for designing more flexible and accurate diagnostic algorithms to enhance the operation of this process [2].

The present research concerns the creation of a new solution to solve this problem. It introduces the development of a multi-agents fault diagnostic system. It can simplify and manage the complexity of the diagnostic process for the modern complex and critical systems.

The reminder of this paper is organized as follows: Section 2 provides an overview about the multi-agent diagnostic systems. Section 3 describes the proposed multi-agents based diagnostic system. Section 4 represents the applicability of the proposed system for three applications and their evaluation results. Finally, section 5 handles the conclusion of this research.

MULTI-AGENT DIAGNOSTIC SYSTEMS

Recently, agents have become a very popular paradigm in computing problems. This popularity is based on their modularity, flexibility, and their suitability for applying to a wide range of problems [2, 3]. A Multi-agents system is a computerized system (MAS) that consists of a number of agents those interact with each other or with their environments to achieve task(s) as shown in fig. (1) [4, 5]. Agents are applied in different applications such as

interfacing, diagnostic systems, information retrieval, distributed systems, design systems, knowledge discovery and data mining systems, etc [6]. Agents can be divided into two main categories: static and mobile. Static agents do their tasks in its original system. Mobile agents can move autonomously through different systems to execute their tasks [7, 8].

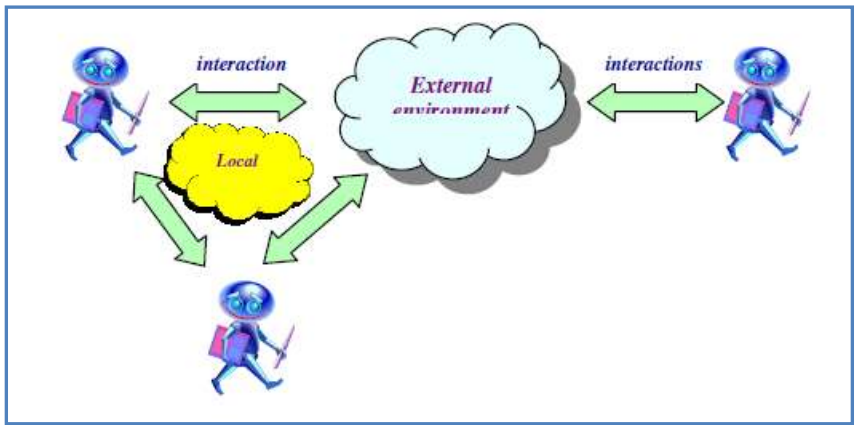

Fig. (1): Multi-agents System

Agents have been used in several diagnostic systems based on their features such as: autonomy, social ability, reactivity and pro-activeness [9].

For the diagnostic tasks, the agents can provide useful features as: Autonomy feature enables the agent to be operated in an unsupervised mode. So, it can automate the diagnostic process. While, social feature enables the agent to co-operate and communicate with other agents in order to exchange the information that is needed for having the diagnostic decisions. An agent has reactivity and pro-activeness properties. Reactivity enables it to react for its surroundings while pro-actively can enable it to take the needed action to solve the diagnostic problems. So, the agents can apply all the diagnostic functions automatically without external help [10].

Therefore, agents and their multi-agents systems (MASs) can automate the diagnostic process, and simplify its needed analysis and time. Researchers have developed many MASs to deal with the diagnosis of the critical systems [11-15]. Although, the valued work has been developed to use the multi-agents methodology for diagnosis the complex systems, there is still some challenges appeared in this topic. Their main limitations referred to the complexity and the time losses of diagnosis and scaling-up the critical and complex systems.

PROPOSED MULTI-AGENTS SYSTEMS

Suggested system is a new multi-agents diagnostic system (MADS). It is capable to overcome the issues of the diagnostic process for the complex and critical systems. The structure of the proposed system consists of three modules, they are: the critical module, the auxiliary module and the on-line monitor module as shown in fig. (2).

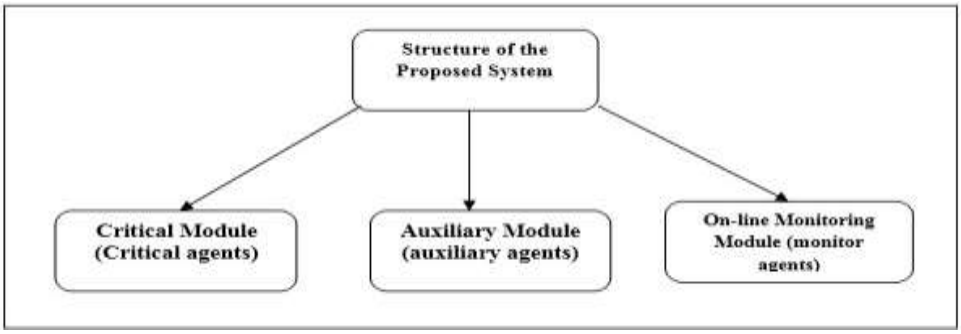

Fig. (2): Structure of the proposed systems

While, the model structure of the proposed multi-agents is decomposed into four main groups. They are: the first group of agents is the critical and important agents, while the second group represents the auxiliary agents, the third group handles the on-line monitor agents and the fourth one deals with the decision agents those are used to drive the diagnostic decision.

The suggested system divides the system to be diagnosed into two main functions: the critical and the auxiliary ones. Each type of these functions is represented inside their corresponding module in the proposed system.
The operation of diagnostic process of the proposed system can be described in the following steps:

1- Decompose the tasks of the system to be diagnosed hierarchally into sub-tasks and the relationship between them.
2- Decompose the tasks and sub-tasks into critical and auxiliary ones.
3- Represent each task and sub-tasks to their corresponding module in the proposed system.
4- Define the ontology vocabulary used by the agents to exchange information and data.
5- Define the agents modeling based on the task hierarchy and the ontology design, the autonomous agents and their functions and interactions.

In the present case, the agents of the proposed system are defined as:
- User interface agents: these agents collect and analyze the input data then format it.
- Events Identification agents: they identify normal and un-normal events.
- Manage agents: they manage the storage media of the data.
- On-line Monitoring agents: They use the analyzed the input data agents and events Identification agents to decide the normal operation or not of the monitored system. Also, it feeds an alarm to the alarm agents.
- Alarm Agents: They alarm the user for detecting un-normal operation of the system. They use two types of alarm audio signals and displays. One signal is defined to the critical functions and the other used for the auxiliary functions.
- Retrieve agents: These agents retrieve from the storage media the most related records of data and analyze it.
- Fault identification agents: Use the analyzed retrieved data by the retrieved agents and the analyzed input data by the analyzed input data agents to identify the fault type in the data.
- Diagnose failures agents: They use the diagnostic reasoning approach to achieve the required diagnosis.
- Replacing agents: for the critical tasks of the system, the replacing agents are used to replace the faulty part of the system to be monitored and diagnosed with another spare part to ensure the continuous operation of the critical and important system. While, the faulty part is repaired.

However, using the multi-agents technique in the proposed diagnostic system can improve its performance as follows:
1- It uses the agents in identifying and retrieving the relevant fault records. However, these processes become autonomous.
2- Using the retrieve agents and the on-line monitoring agents enable the proposed system to use storage media in other connected system through its network. So, it can decrease the size of the storage media and speed up the retrieving process and the on-line detecting of the faults.
3- The proposed system uses the alarm agents to alarm the operator about the fault types and their diagnosis.
4- Decomposing the tasks into critical and auxiliary tasks enable the suggested system to replace the faulty critical parts to ensure the continuous and high performance of the critical system to be diagnosed. Also, this enables the proposed system to stop damaging of other components or parts.
5- Using mobile encapsulated agents that move to the data avoids the uses of inaccurate data caused by the unreliable communications of the system. This can increase the accuracy of the diagnostic process of the proposed system.
6- Using the agents can decrease the time of the diagnostic operation.
7- Proposed system increases the scaling-up, extensibility and flexibility the system to be diagnosed.

APPLICABILITY OF THE PROPOSED MULTI-AGENTS DIAGNOSTIC SYSTEM AND THE EVALUATION RESULTS

The proposed multi-agents diagnostic system is a general purpose diagnostic system. It has been used to diagnose three complex and critical systems as cases of study. These tested systems are:
(1) The first one is the product handling mechanism for a 60-cobalt radiation system in a radiation centre [16].

(2) The second one is security network for monitoring and saving a radiation centre.
(3) The third one is a Leksell Gamma Knife® 4C radiotherapy system that used the gamma 60-radiation in the treatment of the tumors [17].

The proposed system and three diagnostic systems are applied to diagnose the three cases of study. Two of these systems are modern multi-agents diagnostic systems, and a common traditional diagnostic system [18-20].

Each diagnostic system has run 20 times for each case of study to diagnose different type of faults in each time. Then, the average accuracy and time of their diagnostic processes are determined. The results of the multi-agents diagnostic proposed system are compared with those gotten from the three tested systems. Table (1) shows this comparison.

From the results, it is found that, the suggested system can significantly increase the accuracy of the diagnostic process rather than those obtained from the two MAS systems. While, the diagnostic time is decreased clearly by using the proposed system compared with those determined for the other three systems.

It is found that, using the agents inside the proposed diagnostic system can increase its accuracy compared with those can be gotten from the traditional diagnostic one. While, the proposed system has proved its success in increasing the accuracy of the multi-agents diagnostic systems. This referred to its dividing of the system's tasks into hierarchal form, and dividing the tasks of the systems into two main groups can increase the accuracy and decrease the time for achieving the required diagnosis.

Therefore, the proposed system can has improved the performance of the present multi-agents diagnostic systems. It has increased the accuracy and the reliability of the diagnostic process by ensuring the good performance of the system's operation because of replacing the faulty part(s) with the good ones till repairing the faulty part(s). Besides, it is significantly decreasing the diagnostic time. Also, the proposed system can increase the scalability and extendibility of diagnostic system due to its decreasing for the complexity and the time of the diagnostic process. This drives to increase the size of the system to be diagnosed it can handle.

Table (1) shows comparisons between the results of the diagnostic proposed system, and the three systems.

Diagnostic Systems	**Average Time**	**Average Accuracy**
Case 1: Product handling Mechanism System in A Radiation Centre		
Proposed agent based system	2.8 min.	94%
Agent based diagnostic System	3.5 min.	86%
Traditional diagnostic System (1).	3.1 min.	76 %
Traditional diagnostic System (2).	4.2 min.	79%
Case 2: Security Network for a Radiation Centre System		
Proposed agent based system	3.6 min.	95%
Agent based diagnostic System	4.9 min.	86%
Traditional diagnostic System (1).	5.6 min.	76 %
Traditional diagnostic System (2).	7.1 min.	72%
Case 3: Radiotherapy System		
Proposed agent based system	5.7 min.	94%

Agent based diagnostic System	7.4 min.	83%
Traditional diagnostic System (1).	7.8 min.	73 %
Traditional diagnostic System (2).	8.7 min.	71%

CONCLUSION

Diagnosis of the complex, critical and important systems have concerned by many researchers in different daily life applications.

This research has introduced a new multi-agents diagnostic system that uses the agents-based framework for the diagnostic systems. The proposed system has been applied for diagnosis three different types of the critical and complex systems. These systems are: a product handling mechanism system and a security network for a radiation centre and a radiotherapy system. To evaluate the proposed system, its results are compared with those gotten from a common multi-agents diagnostic system and two traditional systems. The results of this evaluation process have proved that the proposed system has a significant impact on the performance of the diagnostic process of the critical and complex modern systems. Therefore, the suggested system has good performance for applying in the real situations.

REFERENCES

[1] S. Sheard and A. Mostashari, (September 2009), "Principles of Complex Systems for Systems Engineering", Systems Engineering 12(4), pp.295 – 311.
[2] G. Y. Sato, H. J. Azevedo and J.-P. A. Barthès, (2012), "Agent and Multi-Agent Applications to Support Distributed Communities of Practice: A Short Review" , Autonomous Agents and Multi-Agent Systems, Volume 25, Issue 1, Kluwer Academic Publishers Hingham, MA, USA, pp. 87-129.
[3] G. Trajkovski, (2011), "Developments in Intelligent Agent Technologies and Multi-Agent Systems: Concepts and Applications", Algoco eLearning, USA, pp. 1-18.
[4] J. M. Vidal, (2010), " Fundamentals of Multi-agent Systems Using NetLogo: Multiagent Systems and Agent-Based Modeling", pp.59-70. G. Wiess, (2013), "Multi-Agent Systems", MIT Press, pp.3-27.
[5] L. S. Passos, R. J.F. Rossetti, and Joaquim Gabriel. (2015), "An Agent Methodology for Processes, the Environment, and Services". In Advances in Artificial Transportation Systems and Simulation, Academic Press, Boston, pp. 37 – 53.
[6] K. ANISHA and K.R. KUMAR, (September 2014), "Design and Simulation of Distributed System Based on Multi Agent Systems", Asia Pacific Journal of Research, Vol: I Issue XVII, pp. 16-21.
[7] P. Khamesra, J. Kasera, R. Mehta, (2014), " Multi-agent Systems Based Intelligent Control of Microgrid ", IJRET: International Journal of Research in Engineering and Technology, Vol.3, Issue:6, pp. 127-133.
[8] M. Wooldridge, (2009), " An Introduction to Multi-Agent Systems", 2nd Ed., John Wiley & Sons, England, pp.15-35.
[9] I. Hwang, S. Kim, Y. Kim, and C. E. Seah, (2010), "A Survey of Fault Detection, Isolation, and Reconfiguration Methods", IEEE Transactions on Control Systems Technology, vol. 18, pp. 636–653.
[10] K.P. Logan, D.A. Cartes and S. K. Srivastava, (2007), "Fault Detection, Diagnostics, and Prognostics: Software Agent Solutions", IEEE Transactions on Vehicular Technology, Vol.56, Issue: 4, pp. 1613 – 1622.
[11] B. Horling, et.al., (2000), "Diagnosis as an integral part of multi-agent adaptability", DARPA Information Survivability Conference and Exposition, 2000. DISCEX '00. Proceedings, Vol.2, pp. 211 - 219
[12] L. S. Passos, R. Abreu and R. J. F. Rossetti, (2015), "Spectrum-Based Fault Localisation for Multi-Agent Systems", Proceedings of the Twenty-Fourth International Joint Conference on Artificial Intelligence, pp. 1134-1140.
[13] L. S. Passos, R. J. F. Rossetti, and J. Gabriel, (2015), "Advances in Fault-Tolerant Multi-Agent Systems. In Encyclopedia of Information Science and Technology", 3rd ed., pp. 7006–7017.

[14] J. Ezekiel and A. Lomuscio, (2009), "An Automated Approach to Verifying Diagnosability in Multi-agent Systems", SEFM '09 Proceedings of the 2009 Seventh IEEE International Conference on Software Engineering and Formal Methods, pp. 51-60.

[15] Technical Report, Guidelines for Industrial Radiation Sterilization of Disposable Medical Products (Cobalt-60 Gamma Irradiation), Iaeâ-Tecdoc-539, "A Technical Document Issued By The International Atomic Energy Agency, Vienna, 1990 .

[16] http://www.valleygammaknife.com/documents/leksell-gamma-knife-perfexion-018479-01-1-.aspx

[17] G. Zheng and N. Fan, (December 2014), "Research on Fault diagnosis and Monitoring System Based on Multi-agent Collaborative Technology", Computer Science Applications and Education Journal, Vol.4, No.1, pp.22-27

[18] M. A. Nekoui, A. R. Kashanipour, and K. Salahshoor, (June 2010), "Hierarchical Fault Diagnosis Using Sensor Data Fusion for Robotic System", Electronics, Vol. 14, No. 1, pp. 55-60.

[19] H. A. Talebi and K. Khorasani, (2007), “An Intelligent Sensor and Actuator Fault Detection and Isolation Scheme for Nonlinear Systems,” in IEEE Conference on Decision and Control, pp. 2620−2625.