Verification and Validation of Agent-Based Model Using E-VOMAS Approach

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Abstract
The advancements in the information and communication (ICT) technologies have made it possible to test and verify any sort of system before deploying it into the real time environment. The verification and validation (V&V) tools and techniques have also helped in minimizing the risk of the project failure or application. In the recent year, it has been observed that the artificial intelligence and multi agent models have being gaining importance due to the high requirements for the automation of systems or environments. In this research paper, we have presented a system design approach for the verification and validation (V&V) of agent based model and software application. The proposed solution of the E-VOMAS approach is based on the system layered architecture. The E-VOMAS approach can be utilized for the verification and validation (V&V) of the agent based model and software engineering applications. The simulation has been tested using the agent based models. The multi agent meeting scheduling model has been utilized for the simulation and testing of the E-VOMAS Approach. To demonstrate the effectiveness of Multi agent meeting scheduling system and E-VOMAS approach, we will show its broad applicability in a wide variety of simulation models ranging from social sciences to computer networks in spatial and non-spatial conceptual models.

Keywords:
Verification and validation (V&V), E-VOMAS, Agent-based Model, Information and communication (ICT), software engineering.

I. INTRODUCTION

In the modern world of information tools and technologies, the demand of the information system (IS) is increasing day by day. There are number of different organizations which are planning to migrate their solutions from traditional paper based environment to paper less environment. The paper less environment can only be possible with the integration of the advance information and communication network [1]. The information system (IS) can help to automate number environmental processes which require lot of time if performed manually. However, deploying these Information systems in the real time is the critical challenge. If the proper verification and validation (V&V) is not performed, there is a high risk that these information systems (IS) and their applications are failed to achieve the required goals for the purpose these application are developed. In these days, number of information systems (IS) is equipped with agent based models to take the decision without involving the human. So these models and systems require a unified framework approach for the verification and validation (V&V) [2].
The system is designed according to their specifications and requirements criteria which can only be evaluated with the help of the verification and validation (V&V). The verification and validation (V&V) are independent procedure and third party tools and techniques can be integrated for the verification and validation (V&V) of the systems, services, products and application.

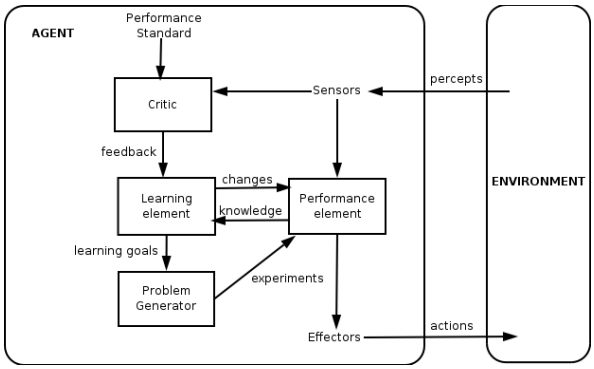

Fig. 1 Intelligent Learning Agents [4]

The E-VOMAS approach is the extension of the VOMAS approach [2]. The VOMAS approach is based on the Companion Modeling [3] that involves Subject Matter Experts (SME). However, we have integrated the E-VOMAS approach with number of software applications and decision support systems. The existing approach of the VOMAS was unable to integrate with the software application working in the context of decision support system (DDS). The primary focus of the research is to develop an advance testing system to integrate with the software or agent based simulation for performing the activities of verification and validation (V&V) [4].
The multi agent systems have also been utilized in the real time environment for performing critical and time

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consuming tasks. The agent can also been utilized in the complex environment if the decision is based on number of calculations.

The scheduling is considered as one of the more critical problems in the field of computing science. There are algorithm and techniques which have been developed for the solution of these problems. The most common solution to these problems are "First in first out, Shortest remaining time, Fixed priority pre-emptive scheduling, Round-robin scheduling, Multilevel queue scheduling, Scheduling optimization problems, Manual scheduling". In this paper, we will be focusing on the scheduling the meeting within the specific domain of office.

The multi agent system is built with the help of the intelligent agents which are integrated together to design and develop an automated environment for performing different tasks and activities. Intelligence application contains number of approaches such as "methodic, functional, procedural or algorithmic search, find and processing approach". The multi agent based systems are simulated under the umbrella of the artificial intelligence. There are number of different type of agents however, few of these agents can be programmed to perceive information from the environment and perform the required task. Still a huge advancements are required in learning agents.

A. Research Objective

There are few research objectives which have been presented in the form of following points:

I. The paper presents a conceptual framework for the verification and validation (V&V) of the agent based model or software engineering application the framework have been simulated on the open sources technology.

II. The performance evaluation of the proposed solution has been conducted on the agent based application. However, we will utilize the Multi agent meeting scheduling system for the simulation of the presented E-VOMAS approach

III. The proposed architecture provides an extension of Virtual Overlay Multi-agent System approach. The proposed system architecture has been built on the overlay system architecture. The virtual overlay of the system contains number of agent which has different duties and activities to perform to exactly evaluate the application.

IV. The proposed approach is the demonstration of the Multi Agent meeting scheduling system. The verification and validation (V&V) will be based on the accuracy of the resources which have been utilized by the meeting agents

B. Structure of the Paper

In the next section of the research paper, we have provided the overview of the related research conducted in the field of the verification and validation of agent based model. The system design and approach is presented in the section III. This section will provide a detailed description of the core component involved in designing and implementation of the proposed solution. In the section VI, we have presented the results and discussions. In the section V, the conclusion and future area is provided.

II. RELATED RESEARCH

The demand of the software information system is increasing day by day, however, number of researches have being conducted in the area of software engineering to identify that around 60% of the software developed time is splendid on the verification and validation (V&V) of the software application. There are numbers of software and application development companies which have always been involved in the design and development of the automated verification and validation without the proper verification and validation. The system can't be designed according to the user specification and its requirements. In this sub section, we have provided the overview of the research conducted at the industrial and academic level.

The importance of the testing tools cannot be denied in the software development. These are number of tools which have been developed for the automated software testing. The automated software testing tools are based on different framework methodologies. These framework methodologies are known as "Test automation interface, Interface engine, Interface environment, Object repository" [5]. Most of the test automation is built on the special software which are acting as a third party application. The software application is integrated with these third party tools for performing the testing, and verification and validation (V&V) of these tools. The testing frameworks have to perform tasks and activities to evaluate the product or services. The core activities of the framework are "defining the format in which to express expectations, creating a mechanism to hook into or drive the application under test, executing the tests, reporting results" [6]. These all activities are performed in sequence to test and performance of the verification and validation (V&V) on the specific system or application. However, still these systems are not intelligent to perform the verification and validation activities without getting the instructions and nature of the application from the developer or tester.

The VOMAS is a virtual overlay multi-agent systems (VOMAS) approach designed and developed for the verification and validation of the agent based model. The

model adds a virtual layer on the agent based model and this layer drops the agent for the verification and validation in the simulation. These agents perform different kinds of verification and send the result to the other agent. The proposed model is quite flexible but in can't be deployed in the software application. The application specifically executes the traditional programming language code such as "C#, C++, JAVA etc." [7]. However, this is one of the main limitations of the VOMAS approach. Due to this limitation still now this approach have not been adopted by the software industry. "The VOMAS Validation scheme [2] can be considered as an extension of Companion Modeling [8] that involves both Subject Matter Experts as well as Simulation Specialists in developing of an overlay multi-agent system for the purpose of validation" [9].

Agent-based entails development of behaviors of individual agents, which changes the internal state of the agents as well as interacts with the environment for example patches in the case of Logo-based environments as well as other agents. The agent based models are designed and developed with the help of the computational models. The models contain autonomous agents. The autonomous agents perform different kinds of activities, collects different sort of parameters from the environment as well as perform the functions and activities accordingly. These autonomous agents can be deployed in the software application also. In the high end databases, these autonomous agents have been utilized [10].

Agent-based modeling (ABM) is based on an advanced programming paradigm where the focus of the simulation design is based on modeling individual entities as "agents". In other words, it allows the more realistic modeling of real-world objects and complex systems. Agent-based modeling has found extensive use in the discovery of emergent behavior in systems consisting of a large number of interacting entities [11].

A. Simulation System

The simulation systems are considered as one of the main aspects in the development of the computing science. Developing a physical system without considering the simulation is determined a good approach and there is a high probability that project may fail. So, to avoid project failure the simulation should be developed during the deployment of the system or application accordingly [12].

Developing the simulation model is not a new idea however, the demand of these system are increasing day by day. There are number of simulation systems which have been based on the agent based model. In the traditional approach, these systems are used to detect the intelligence based on the pattern techniques. Specialized rules such as proposed in (Niazi M. S., 2010) allow for a quantitative approach to the detection of emergent phenomena in complex systems. It is also typically used as a stand-alone simulation tool, which can assist in decision support (Siddiqa et al. 2009). However, to the best of our knowledge, ABM has not been previously used in the context of evaluation of designs of a distributed disaster alerting systems.

Existing tools, techniques and frameworks have number of limitations. This research work is an attempt to provide a unified model for the verification and validation (V&V). The model presented in the previous research can be used for performing different verification and validation (V&V). However, these models can't be used for the software application testing vice versa. The proposed solution in the paper will be utilized for the Extension of the Virtual Overlay Multi-agent System approach. The proposed solution has attempted to design and develop a framework for the verification and validation (V&V) of both software application and agent based model [ABM]. The proposed model is based on the industrial standard according to the software engineering principle. Due to the learning mechanism, the integration in the E-VOMAS the agent can automatically task and decide on their behalf. The proposed solution has several categories of the test automation as presented in the related research. However, this paper is an enhanced solution based on test automation and VOMAS "Virtual Overlay Multi-agent System".

III. SYSTEM ARCHITECTURE

The E-VOMAS system layered architecture has been utilized for the presentation of the E-VOMAS approach. Each specific functionality and process has been divided into different layers. The proposed system architecture can be linked as the third party components in the software application or agent based system. The MSF "Microsoft Solution Framework" has been utilized for planning and development of the whole concept of the proposed solution. The framework have been quiet flexible during its development in the software engineering principles are specially consider so that in future the proposed architecture for the verification and validation (V&V) can be utilized in the software and application development companies.

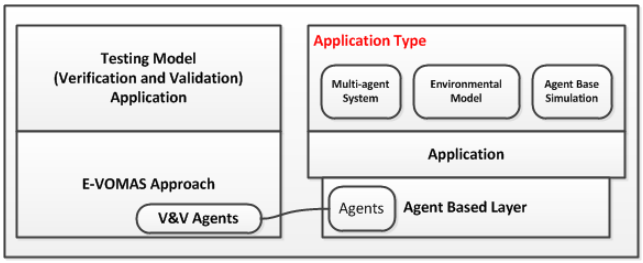

Fig. 2 System Architecture

There are two main types of the applications on which this framework have been tested Software application and

agent based simulated. The application type contains three types of process including "Multi-agent System, Environmental Model, Agent based Simulation". These agent based layer deployed in the framework access the application layer to gain the access of the software or agent based model. On the agent based layer get the access the application the E-VOMAS agents are deployed and the process of verification and validation (V&V) of the application executes. The time duration of the process may be long or small depending upon the complexity and computation calculation involved in the processes. The log files are obtained, once the experiment is completed.

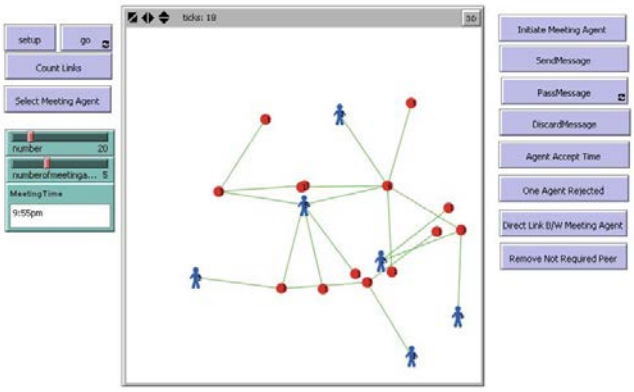

Fig. 3 Simulation Environments

The modules have been implemented in the NETLOGO [13]. The multi agent meeting scheduling system have also been implemented on the NETLOGO so both of the components have quite comparability with each other.

A. E-VOMAS Component

The E-VOMAS have several components which have similar functions as compared to the VOMAS. However, in this research we have enhanced the functionality of the VOMAS by added to the new and updated the existent VOMAS role and responsibilities.

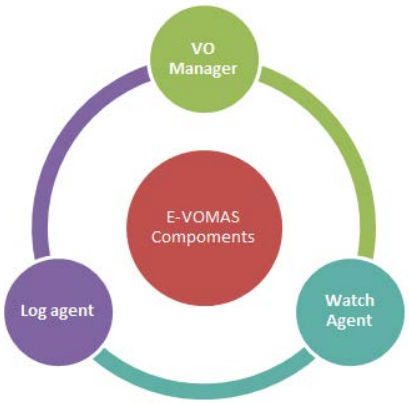

Fig. 4 Logical Components

The log agents maintains the information of all the activities which been simulated by the other agent. In case of the experiment failure, the information can be reviewed and can help to track the location of the problem have been occurred. Each activity is stored in the form list built with the help of different parameters. Main parameters of the list are "Date, Time, Duration, and Process ID (PDI). These lists can be customized as according to the user requirements. this is an extension function which is not provided in the VOMAS framework. The watch agent performs number of different activities used. There are around about ten to eleven agents which are installed on deployed in simulation or software environments. These all agents extract the information from the environment and perform the tasks accordingly. The VO Manager monitors and controls the activities of the log and watch agents deployed in the simulation. The users usually interact with VO manager and extract the required results from the conducted experiments. This proposed solution is automated and can take decision on their behalf that how many testing agent have be deployed in the simulation environment of testing. The framework is based on the open sources technologies so these frameworks can be customized and extended according to the research or tester requirements.

B. Communication and Coordination

The communication and coordination is one of the core aspects in the proposed architecture. There are high computational processes and number of agents involved in the decision. Without the proper communication between the agent effective and efficient can be takes, the agent based system decision is based on the historical data and the information or data perceived from environments. There are different protocols which have been utilized making the communication and coordination between the agents based system. However, we have utilized the multi listing techniques in the proposed solution designed and developed for verification and validation (V&V) approach.

1) Multi listing techniques

The multi listing is new techniques which have been utilized in agent based system for communication and coordination within the agent based system. The communication protocol between the agent models plays an important role in overall performance of the agent communication and coordination network. The proposed solution implements a new data communication methodology for communication between the agent to agent and agent to sink agent. There are number of parameters which have been utilized for the communication between the proposed solution such as "Weight, priority, Security and many others". In the testing phase, the agents are static and there is no specific rule during the deployment of these agents in the meeting scheduling system. Each agent can send the message

directly to the other agent within the specific network or to the sink.

The steps of the approach are as followed:
In the initial step, the shortest distance is calculated with the help of the Dijkstra's algorithm. The equation used for the Dijkstra's algorithm [14] are as followed

$$D\ i,j = \sqrt{(Xj - Xi)^2 + (Yj - Yi)^2}$$

In the next step, the weight is calculated with the help of the residual energy and the radius of the specific agent. In the simulation environment the radius is considered within the range of 5 to 10 millimeters.

$$Pi,j = \frac{Erem + R}{D\ i,j}$$

There are number of parameters which have been analyzed during the priorities of the agent. The parameters include the factors of security, speed and energy. The equation of the solution is as followed:

$$Wi = (\sum_{n}^{n=k} (\varphi i)\ Pi,j$$

The equations have been utilized in the algorithm for performing the data communication tasks and activities. The equations perform different type of calculation and help to set priority of the data packet and the selection of the path on which the data will be transfer. These equations have also been simulated in the customized simulation environment developed using NETLOGO.

C. Implementation and Testing

To implement and test the proposed solution of the E-VOMAS was the critical and time consuming challenges. We faced number of issues during the evolution of the proposed study. The multi agent meeting scheduling model has been utilized for the simulation and testing of the E-VOMAS Approach. To demonstrate the effectiveness of Multi agent meeting scheduling system and E-VOMAS approach. The next section of the research paper presents the evaluation section;

IV. EVALUATION

In this section, we have evaluated various aspects of the Proposed architecture for the analysis for the software and multi agent system using the multi listing techniques for the communication and coordination between the agents. There are number of experiments which have been conducted to identify and analyze the performance of the proposed solution of the verification and validation (V&V). These experiments have conducted on the Multi agent meeting scheduling system.

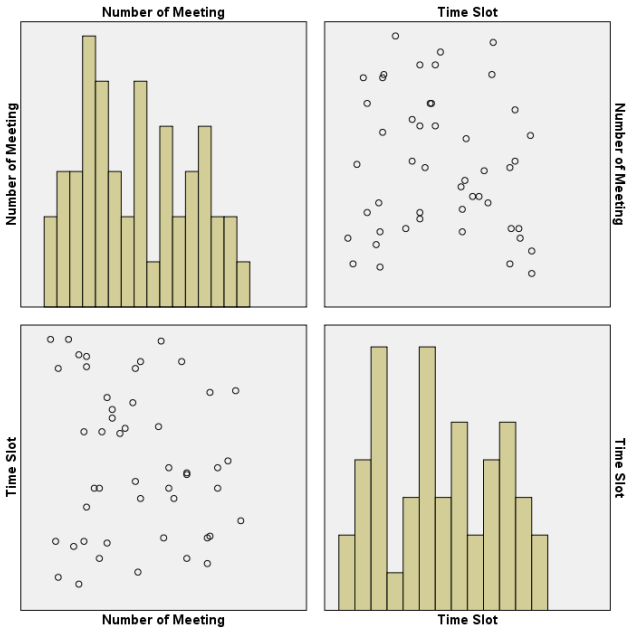

Figure IV-1 SPLOM Matrix (Number of Meeting and Time Slots)

The above experiment was conducted to analyze the relationship between the number of meetings and time slots. It is observed from the above experiments that as the time slots increases, there is a high probability that the meeting request will be accepted. The output of the experiment has been presented in the form of the matrix. The experiments have concluded that Number of meeting and the Time slots have a strong relationship.

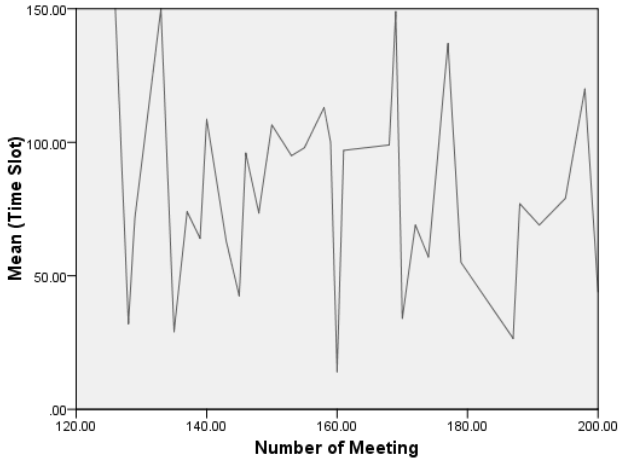

Fig. 5 Number of Meeting vs. Mean (Time Slot)

In the above experiment, we have analyzed the number of meetings with the time slot. The experiment was

successful. however, in some initial stages the meeting were not initiated but later the meeting and number of different meeting have been conducted with the help of the Multi agent scheduler.

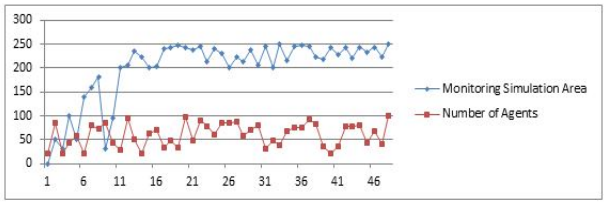

Fig. 6 Monitoring Simulation Area vs. Number of Agents

The experiment was conducted to identify monitoring simulation area and number of agents. The monitoring is the core component of the proposed solution designed and developed for the verification and validation (V&V). The Figure presents that as the monitoring area increases, the number of agent also increases. It can be analyzed that a large number of Monitoring Simulation Area can be covered by specific number of agents. The results have been obtained with the help of the simulations.

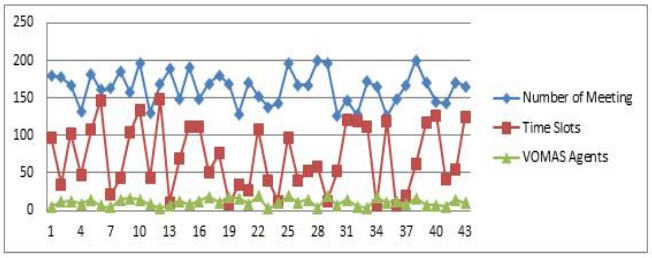

Fig. 7 Number of Meetings vs. VOMAS Agents

In this experiment, we have analyzed the two core parameters of the simulation. These parameters are monitored by VOMAS agents deployed in the simulation environment. It is analyzed from the Figure 7 that only few agents are required for the monitoring to the complete meeting environments. These agents are monitoring parameters including number of meetings and time slots. According to the observation, we can conclude that with the help of few VOMAS agents we can monitor the large number of environments

V. CONCLUSION

In this paper we have presented a system design approach for the verification and validation of the software and agent based model. The proposed solution of the E-VOMAS approach is based on the system layered architecture. The multi agent meeting scheduling system has been utilized for the simulation of the proposed solution. The E-VOMAS architecture is built with the help of the intelligent agent which have been programmed to take decision programmatically according to the environments.

A. Future Area

In future, we hope the introduction of an advance testing techniques for the complex adaptive system (CAS). The E-VOMAS will be enhanced for these complex adaptive systems and applications.

REFERENCE

[1] Gopinath.P and., 123-136 Bihari T, "Concepts and Examples of Object-Oriented Real-Time Systems," *In Readings in Real-Time systems, Y H Lee and C M Krishna ed*, pp. 123-136, June 1993.

[2] et al M. A. Niazi, "Verification \&Validation of Agent Based Simulations using the VOMAS (Virtual Overlay Multi-agent System) approach," *presented at the MAS\&S 09 at Multi-Agent Logics, Languages, and Organisations Federated Workshops, Torino, Italy*, 2009.

[3] et al., " Kosanke, "CIMOSA: enterprise engineering and integration," *Computers In Industry, Elsevier Science*, vol. 40, 1999.

[4] A., Astorga-Paliza F. Onorati T. Pérez D. \& Aedo I. (2008). Malizia, "Emergency Alerts for all: an ontology based approach to improve accessibility in emergency alerting systems," *In Proceedings of the 5th International ISCRAM Conference – Washington, DC, USA*, 2008.

[5] Greece Athens, "Use Case Driven Approach to Self-Monitoring in Autonomic Systems," *In Proceedings Third International Conference on Autonomic and Autonomous Systems(ICAS'07)*, pp. 50 – 56, 2007.

[6] D.L Kuhn, "Selecting and effectively using a computer aided software engineering tool," *Annual Westinghouse computer symposium*, 1989.

[7] C., Kumar S. Chong, "Sensor Networks: Evolution, Opportunities and Challenges," *In Proceedings of the IEEE Press, New York*, vol. 91, No.8, pp. 1247-1256, 2003.

[8] Barreteau O., "Our Companion Modelling Approach," *Journal of Artificial Societies and Social Simulation*, vol. 6, 2003.

[9] M. Jennings, N.R. Kinny D Wooldridge, "The Gaia Methodology for Agent-Oriented Analysis and Design," *Journal of Autonomous Agents and Multi-Agent Systems*, vol. 3(3), pp. 285-312, 2000.

[10] Filippo Neri, "Agent-based modeling under partial and full knowledge learning settings to simulate financial markets," *AI Communications*, vol. 25, no. 4, pp. 295-304, 2012.

[11] Moses Kim, Scott Christley, John C Alverdy, Donald Liu, and Gary An, "Immature oxidative stress management as a unifying principle in the pathogenesis of necrotizing enterocolitis: insights from an agent-based model," *Surgical infections*, vol. 13, no. 1, pp. 18-32, 2012.

[12] M., Niazi and Hussain A., "A novel agent-based simulation framework for sensing in complex adaptive environments," *IEEE Sensors Journal*, vol. 11(0), 2010.

[13] U. Wilensky, "NetLogo," *Center for Connected Learning Comp.-Based Modeling, Northwestern University*, vol. Evanston, IL, 1999.

[14] Donald E Knuth, "A generalization of Dijkstra's algorithm," in *Information Processing Letters 6.1*., 1977, pp. 1-5.

[15] U. Wilensky, "NetLogo Fire model," *ed. Evanston, IL: Center for Connected Learning and Computer-Based Modeling, Northwestern University*, 1997.