Evaluation of Intelligent & Adaptive Multi-Agent Framework for Semantic Web

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Abstract

This paper elaborates metrics for evaluation of agent based frameworks, exploited in semantic web. It is an extension of authors? earlier work in which different frameworks focusing on different issues of multi-agent system communication were proposed. This work while integrating all our earlier proposed frameworks aims to evaluate this integrated framework on existing metrics to explore its applicability in real world applications.

Index terms— Multi agent Systems, Agent Communication, Semantic Web, Evaluation.

1 Introduction

ulti agent systems (MAS) [2] which have become the backbone of semantic web (SW) [8] are actually exploiting vast chunks of knowledge and information spread across the distributed web. Agent based frameworks actually comprise of multiple agents, possessed with attributes such as autonomy, pro-activity, learning ability and most importantly co-operation. Because of their cooperative nature agents are able to perform complex jobs by dividing it among other agents and thus providing services to the users beyond their own capabilities. But for cooperating with each other, agents in such frameworks need to communicate, which leads to many issues like mapping of ontologies across different frameworks, security of messages communicated, trust establishment among communicating parties and so on.

This work is an extension of authors' earlier works which proposed individual frameworks for agentbased ontology mapping [10], for trust establishment using variation in Contract Net Protocol [13], security engine for providing security in communication and for providing fault-tolerance [4] [11]. This work provides an integrated framework called Multi Agent Framework for Semantic Web (MAFSW), which is combination of all earlier proposed frameworks and is capable of catering almost all issues related to agent communication and thus provides an integrated communication system. However, this framework needs to be evaluated to check its relevance for semantic web applications. This mail : mail :

The paper is structured as follows: Section 2 provides brief introduction of MAFSW. Section 3 explores the evaluation parameters from the existing works and in parallel, evaluates the proposed framework. Section 4 concludes the paper.'

? Security Layer [12]: This layer controls initial handshaking among communicating parties and also decides the level of privileges or resource utilization on the basis of value of TP.

Once the communication starts this layer encrypts and decrypts the message using Elliptical Curve Cryptography (ECC) based cryptosystem which makes this process fast and efficient.

? Fault Management layer [11]: This layer monitors all the other layers and provides fault tolerance to the overall communication framework. This unit rather than working on dynamic replication strategy, works for providing a balance between static and dynamic replication strategy. This layer provides dynamic replication to critical agents and static replication to less critical or personal task agents. This scheme reduces overall replication cost of the system and provides robustness to the system. Next section explores the literature to find applicability of agent bases systems and parameters for their evaluation III.

2   Evaluation Parameters of MAFSW

The insight into the existing literature [1,2,7,9,14,15,16,17] reflects that there are no well defined or standard metrics in literature on which agent-based frameworks can be evaluated and also not many agent based applications are available for such evaluation and analysis. Moreover, the evaluation parameters have been different. For instance, Juneja et. al [5] have evaluated their works using fuzzy logic. Sharma et. al [4] explored evaluation metrics for Multi-agent framework employed in cellular networks. Their work highlighted the non-functional issues like coordination, performance, scalability and security on which agent based frameworks can be evaluated. Hexmoor et. al in [3] provided metrics such as autonomy, timeliness and purposefulness, robustness and fault-tolerance as general evaluation parameters for agent based frameworks. Karageorgos et. al in [6] proposed a framework to evaluate Agent Based System (ABS) engineering methodologies against a number of criteria related to design complexity.

After a careful investigation of the available evaluation parameters, we have considered performance, scalability, stability, trustworthiness, and security as the most suitable parameters for evaluating MAFSW. Upcoming subsections evaluate the proposed work on the basis of these parameters only.

3   Performance

Overall performance of an agent based framework is affected by many parameters such as a) agent knowledge model, no. of agents employed for performing a task, no. of goals being achieved in a unit amount of time and the coordination protocol being employed. Let us consider c ? be the average coordination cost, which is sum of communication cost (c ?) among agents and the communication overheads(c ?) involved in it. Then { , } c c c ? ? = ? ? (1)

Coordination cost is also affected by topology (arrangement) of agents in the framework, as linear topology involves more cost of communication per task compared to the hierarchical arrangement of agents.

MAFSW requires ontological knowledge base for its working. Support of this ontological knowledge base involves complex data structures for its implementation, which incurs cost involved in storing the knowledge base (µ ? = f ( ) , c c ? ?**(3)**

Practically complexity of any system is required to be expressed in the form of general mathematical formulas. Complexity generally refers to rate of increase in time and space requirements of a system as size of input data changes. It has to be expressed in terms of standard functions like n, n 2 , Log 2 n etc. based on the requirement of that algorithm. So now we will try to estimate the complexity of proposed system in terms of standard mathematical function.

Whenever a communication request arises, MAFSW performs many tasks such as:

? Trust establishment with other party ? Initial handshaking and decision on privileges to be provided to other party. ? Once initial handshaking is complete, communication starts in the form of messages, which may required to be mapped in case both MASs are using different ontologies. ? Communicated messages need to be encrypted and then decrypted. ? All agents need to be monitored and their replicas need to be kept updated for providing fault tolerance. To achieve all these objectives, communication task is divided into n sub tasks where each sub-task is performed by an agent based sub-system. Due to this division of one task into n sub-tasks overall time required for its completion reduces and also the memory space requirement for the sub-task gets reduced. Thus complexity of one task becomes Log n, where n is the no. of tasks. Here logarithmic function is adopted as it grows slowly, i.e. increase in value of n doesn't lead to linear increase in time and space requirements.

MAFSW uses Contract Net Trust Establishment Protocol [13] to coordinate sub-task allocation problem. As all sub-systems are also using the same protocol they can further divide the task within the sub-system or to other agent based systems depending upon the nature of the task received. Thus the task may further be divided into n-subtasks. Since complexity for one task in one sub-system is Log n, thus the overall complexity for one task is n* Log n. This relationship is illustrated in Fig. **??** given below.

4   Fig. 2 Complexity of MAFSW

Since a task may be divided in n-subtasks which may be performed in parallel by different participants, thus total time required for completion of a task reduces with increase in the no. of MASs. under consideration, will increase the overall complexity of the system or not? It involves checking that increasing the no. of agents either increases or decreases the load on other agents in the system. MAFSW is scalable since as the no. of participating MASs increases the no. of ontology mapping layer, Trust establishment layer or fault management layer doesn't have to be increased. Only the security layer will have to be replicated as it is associated with each MAS.

If the no of participating MASs increases extremely large then replication of other layers may be required but even than, this addition will be much less than increase in the no of participating MASs, thus reducing overall complexity of the system as well as the cost involved. Scalability of MASs is the average measure of the degree of performance degradation of individual agents in the framework caused by the expansion of size of agent's society [4]. MAFSW is scalable since it is combination of many small frameworks responsible for different functions related to communication. Now if more MASs participate in communication Trust establishment will be performed only once for a session among two parties, thus this layer will not get overloaded easily by addition

of new participants. Ontology mapping may be required for every communicated message, but considering the time involved in actual transmission of a mapped message and getting the response back for mapping, provides reasonable time to this layer for catering the requests of other participants.

5 b)

Thus even increasing the no. of participants, increase in complexity will follow Logarithmic function. This relationship is represented in Fig. 4 given below.

6 Trustworthiness

Agent based systems are more and more employed in critical applications, but still MASs are not optimally exploited due to lack of Trust establishment feature. MAFSW uniquely contributes towards ensuring trustworthiness of agents prior to starting initial communication. Its Trust Establishment Layer computes the value of TP, which helps in ensuring the communicating parties that the other party is trustworthy and also that the agents are what they claim to be. This feature is essential for MAF working on Ecommerce based applications.

7 Security

This parameter focuses on the security of the messages communicated, so as to prevent intruders from either capturing or modifying the message. MAFSW also uniquely contributes towards security of communication through its security layer. Encryption of messages is a traditional solution employed for this purpose, but this layer employs Elliptical Curve Cryptography (ECC) technique for encryptiondecryption, which is unique in itself. ECC provides same security level as provided by DH, DSA & RSA techniques but using considerably small key sizes, compared to these methods. Also ECC based encryption-decryption layer doesn't require installing new infrastructure, it can be implemented on existing infrastructure. Thus security layer of MAFSW increases efficiency of encryption-decryption process without placing any burden of additional cost.

8 IV.

9 Conclusions

Agent based systems are thrust behind implementation of SW. Cooperation among agent societies employed in various domains (homogenous or heterogeneous) gave rise to many issue pertaining to agent communication, which needed attention. This work proposed a novel Multi -Agent Framework for Semantic Web (MAFSW) supporting almost all major issues concerning communication among multi-agent systems in SW. Also this work evaluated the proposed framework on metrics meant for evaluation of agent based frameworks. Empirical results found are sound and meet the desired expectations. This framework has been partially implemented in JADE, complete [1] [2] [3] [4] [5]

Figure 1:

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