Task Allocation Strategy for Multi Agent: A Review

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Abstract – A multi agent system comprises of various agents that act together to realize a common goal. Primarily, multi agent system (MAS) are required to offer a complete perspective of the system under consideration, global control over the system by enabling decentralization of data and synchronous computation. The agents in MAS can coordinate, cooperate, compete and may go destructive also. To achieve the given goal in real time tasks are subdivided among various software agents. The concept of subdivision and fulfilling the tasks is termed as Task Allocation. This paper examines existing work in the development of various algorithms which helps in assigning the tasks to the resources for fulfillment of the goal. An analysis of the existing research is used to describe the advantages and disadvantages of the given procedure and to identify areas where further research may be required.

Index Terms – *D*istributed algorithms, large-scale multi-agent systems, distributed group formation, agent coalitions.

1. INTRODUCTION

The software systems are recently being conceptualized and designed [1] with the help of agents where agents are the software entities that are able to automate a system and hence could reduce the overhead of users. An autonomous software agent is situated in an environment where it can sense the input from environment, acts on it and produce an output well within time. Software agents [2] react to perform their job as background processes that work on behalf of the user with key attributes like learning ability, co-operation and mobility [3]. Also, they become intelligent if provided with the knowledge base, learning ability, user preferences and search patterns. The motivational facts has to use to use the agents in different domains are quick performance, concurrent behavior, immunity to flaws, no distraction, no tiredness and the ability to control critical jobs [4].

The idea of putting agents forward is much more suitable for environments that are distributed and open. To fulfill the agenda, inter-agent communication is a must.[5] To achieve the given goal in real time tasks are subdivided among various software agents. The concept of subdivision and fulfilling the tasks is termed as Task Allocation. Formally **Task allocation [6]** and partitioning refers to the way that **tasks** are chosen, assigned, subdivided, and coordinated among various software agents.[7]

Various task allocation strategies for inter agent communication have been proposed in literature. The paper aims to compare and contrast various task allocation strategies which have been used for different agent based applications.

The paper is divided into three sections. The first section has described the basic concept and need of task allocation. Section two presents the literature overview and discusses various algorithms used for task allocation. It also compares the existing work done till the time of listing. Section three concludes the paper.

2. RELATED WORK

Extensive research has already been done in the domain of Task Allocation Strategies for software agents. Extensive research has been done towards improving the performance of multi agent systems. As already discussed, task allocation contributes highly towards the existence and outcome of MAS but the issue has not been addressed significantly.

Tosic et al.[8] proposed a distributed algorithm for coalition formation among autonomous agents named as The Maximal Clique based Distributed Coalition Formation (MCDCF). The plan of the algorithm is based on two main ideas. One is computation of maximal cliques that helps in understanding the communication strategy of the agents. The second idea is that each agent chooses its most preferable coalition based on the value the agent gets for its combination with resources or capabilities. Sufficient resources are presumed but preference is given to coalitions which can suffice[9] higher value tasks. The MCDCF algorithm is split into six stages. Four of these six

are iteratively repeated until the consensus on coalition formation is reached. The agents can work in parallel to execute these stages. The best part of this algorithm is that it is a leaderless mechanism for coalition formations and hence less prone to "bottlenecks".

James Parker also explored the use of coalition formation for MAS [10] in real world applications. In such cases it becomes more difficult when the number of agents is increased tremendously but still best cooperation and limited communication is expected. So all this is tried with the team of authors by coalition formation complexity reducing mappings. However these techniques does not fit for long term teams.

Macarthur at el.[11] introduced a novel algorithm for MAS based allocation problems, named as ' Fast-Max-Sum'. As according to him both set of tasks and agents keep changing over time. Moreover agents in such an environment tend to form coalitions to complete the tasks more effectively. With this background, a decentralized , dynamic task allocation algorithm was presented as branch- and – bound – fast – max – sum(BnB FMS).It is combination of two sub – algorithms : one – is there to reduce the number of tasks an agent considers ; two – reduces the number of coalitions. To achieve these goals a pruning algorithm was tailored to reduce the number of potential solutions. Also new technique on branch and bound search trees were applied so that execution time is reduced. Thus tending to reduce both run time and communication cost.

According to Amador at el. [12] In dynamic environments, Multi Agents with realistic application, often put deadlines while executing and also put penalties for late execution of tasks. So this necessitates the quick allocation of tasks to agents. But optimal allocation becomes hard due to spatial and temporal constraints like sequential execution of tasks, etc. For such a scenario a novel algorithm was proposed as FMC_TA hence easily sequencing the tasks resulting in high quality solutions. It first of all searches for fair allocations. By fair it means balancing the load by sharing the tasks between agents. Then it makes the computations and finally settles the allocation taking into account the inter agent constraints. FMC_TA makes sure that allocations are done efficiently and proper scheduling is also possible in dynamic and complex scenarios with less delay. Though it caters to many sections of tasks but still it has less utility sue to high dynamism.

Santos at el [13] proposed a approach named as A swarm intelligence approach. It mainly focuses on grouping and task allocation in an environment where data is distributed and attributes change dynamically. This [14] clustering algorithm is inspired by swarm intelligence techniques, hence the name "Swarm intelligence approach". This approach does not require any prerequisites of information on number of classes, size of partitions, etc. proposed algorithm is called as bee clustering. The algorithm is based on concept of foraging. Accordingly bees travel far from their hive and collect nectar. Then they return and share the information about the source with fellow bees and guide and recruit them to source in their own way. This same metaphor is used in bee clustering algorithm for clustering and task allocation. The clusters are formed with similar or complementary expertise. A set of agents and tasks for them to accomplish are drawn. They try to recruit other agents keeping in view their expertise to accomplish the targeted task and perform the required set of tasks.

Ka-Po Chow at el [14, 15, 16] and his team members have followed various clustering technique, while keeping in mind the load balancing factor as well. As the agents are distributed among all the machines, so it is essential to investigate whether various strategies of load balancing are applied to it or not, to meet the requirements of new tasks .The factors which load balancing techniques takes into consideration are like Affiliation to the machine, Current workload, Communication and Mobility. Keeping in mind the considerations a Communication based load balancing algorithm is proposed to meet the above requirements. According to this new approach a 'credit' of even agents is taken into account. Credit is measured by taking into account the above four considerations. If the credit of agents is low, then accordingly it is being associated with lightly loaded machine. The only drawback of this technique was that it assumed communication to be static among agents rather we have dynamic communication.

Ye and his team [17] has proposed a task allocation method recently and have promised that the proposed protocol overcome several issues but still it suffers from many drawbacks such as communication delays, incomplete information about the available resources, just to list a few.

A work by Santos and Bazzan [18] highlights that distributed clustering is one of the alternatives for dynamic task allocation but again this work also lacks on focusing on the communication costs and costs incurred in group communication.

Jonathan along with his co authors has shown concern for designing of automated agent protocol [19,20] for effective interaction. Best means of communication is considered as Negotiation, to reach a common goal. A strategic model is proposed to allocate common resources as well as tasks. This model takes good amount of time during the negotiation process. It is considered both for Single or multi agent environment situated with complete or incomplete information. Also it considers the situation when some agents lose over time or gain over time. This protocol is considered to be stable, efficient, simple and flexible under various constraints and conditions. Though this protocol has not been tested over a situation which has several resources.

A comparative view of the listing done till date is presented below:

S.No	Name of Model	Pros	Cons
1	Coalition Formation Strategy	• Benefit maximization through performance. • Cooperative Environment. • Low complexities.	Improper outcome distribution among its members.
2	Anytime Algorithm for Dynamic Environment	• Simplifies protocol. • Reduces search space. • Efficient • Less Run Time • Less communication Cost	Lower quality of solution in an environment where the key is to prove the solution theoretically.
3	Dynamic Multi Agent Task Allocation with Spatial and Temporal Constraints	• Effective in complex scenarios. • Scheduling possible • Less Delay.	Less utility due to high dynamism
4	Bee Clustering – A swarm Intelligence Technique	• Effective in distributed environment. • Handles dynamism. • No prerequisites required.	High communication cost.
5	On Load Balancing for Distributed Multi agent Computing	• Communicative • Mobility	Applicable in Static Communication Environment.

TABLE 1 COMPARITIVE STUDY

3. CONCLUSION

This paper discussed the need of task allocation in distributed environment. It further discussed the various task allocation strategies existing in literature till the time of listing. The paper concludes by comparing and contrasting these strategies. As a future work the authors aim to propose a novel task allocation strategy using multi agent systems which overcomes the drawbacks of the existing strategies.

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