Blueprint of an Ant-Based Control of Semantic Web

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Abstract

Semantic Web brings the idea of structuring information available across the web in a meaningful way improving search mechanisms and thus resulting in user satisfaction. This paper initially explores the literature that has been done to improve the performance of Semantic Web (SW) through Ants where ants are hypothetical sophisticated agents that carry information and moreover have the tendency of learning through experiences. Semantic Web along with Ants creates an environment that can achieve the vision of making node able to understand, relate and use information available in a given situation. The work presents a simple blueprint of ant based control of semantic web and throws the ideas of open challenges for future research.

Keyboard: *Semantic Web, Ants, Ontology, Pheromone.*

1. Introduction

Cognitive scientist Allan M. Collins, Linguist M. Ross Quillian and psychologist Elizabeth F introduced the concept of Semantic Network Model in early sixties. The focus of their work was to analyze how human brain uses long-term memory to relate things to ascertain the truth of a sentence. They categorized objects on the bases of their attributes and draw inference on the bases of categorization to decide weather the statement is true or false [30]. Later on Tim Berners-Lee, inventor of the World Wide Web and director of the World Wide Web Consortium ("W3C"), introduced the term Semantic Web in 2001. He defined the Semantic Web as "a Web of data that can be processed directly and indirectly by machines" [10].

In the current scenario, exponential advancements in web technologies have enabled users to experience enhanced delivery of personalized services & information through the integration of various existing technologies. Besides the existence of various algorithms that are used continuously to map the desired information to the available content, the fact is that only 30% to 40 % of the information is relevant to the subject leading to user's dissatisfaction. Moreover, the existing centralized platform and usually a large server cannot ensure the scalability, flexibility, reliability, non-redundancy of information provided to user. Hence, the

need of web which is standard, flexible, adaptive, supports distributive framework for heterogeneous infrastructure and more importantly intelligent, is apparent. It is evident that the understanding level of human beings and a machine is different. The current web structure works on pattern matching i.e. word by word matching and infers the conclusion. However, in semantic network structure, which is initially able to understand words and later relates words with each other to draw inference and produces 80% meaningful information. The current scenario demands the delegation of intelligence of web to a smaller but more intelligent community of components known as intelligent agents more specifically ants. The focus of this work is to propose an ant-based framework for retrieving information from semantic web.

This paper has been broadly divided into four sections**.** Section 2 gives a brief overview of semantic web and on the role of ants in semantic web. Third section presents the proposed work and finally section 4 concludes by presenting open research challenges.

The upcoming section provides an insight into the present scenario and discusses the motivation of deploying Ants in Semantic Web.

2. Background

The term Semantic web implies a web that can process information for both humans and machines in such a way that a machine can interpret and exchange the information on web without human interruption and produces more relevant data. It talks about making machine more efficient such that it can realize the sense of words, can easily relate to user query, change the web services and produces information more close to the subject at ease of surfing.

Sentences are based on grammar or we can say that each sentence has a particular syntax. Human brain has the power to understand the meaning of words, relate them based on their experiences, and long term memory. Now, the challenge remains is to make a machine understand the meaning?. Semantic web addresses the above stated challenge by describing the things in a way that computer applications, web services can understand. It is beyond linear or multi-layer presentation of information. It is not about links between web pages, it describes the relationships between them and their properties.

Semantic web originally talked about a system that enables machine to understand and process complex human requests based on their meaning. But today semantic web is a vision of information that can read user queries and interpret through machines so that machines can perform more tedious jobs involving finding, combining and acting as per information on web. The rapid growth in the amount of data on web is forcing researchers to focus more on creation and dissemination of data, which will become more easier with the innovative concept of introducing ants in semantic web technology is to facilitate automated and efficient processing.

Now, the term "Ants" has been derived from the biological insects, which have developed intellectual skills such as combined parental care, combined hunting, cooperation and labor division etc [7]. In particular, ants have inspired a number of methods and techniques among which the most studied and the most successful is the general purpose optimization technique known as ant colony optimization. Ants follow the principle of "STIGMERGY". Stigmergy is an indirect, non-symbolic form of communication mediated by the environment: insects exchange information by modifying their environment [1]. The insect ants when move in search of food stimulate a hormone named as Pheromones, which attracts other surrounding ants. Other ants perceive the presence of Pheromone and tend to follow paths where pheromone concentration is higher. Through this mechanism, ants are able to transport food to their nest in a remarkably effective way. The Ant based system is inspired by the fact that, using very simple communication mechanism an ant group is capable to find the shortest path between any two points without using any visual clues. Also, they are capable to adapt in the dynamic environment e.g. finding a new shortest path once the old one is no longer feasible due to a new obstacle. Ants move in a straight line that connects a food source to their nests.

Turning our attention on the role of ants in semantic web, many methods being used for combinatorial optimization are inspired by adaptive natural behavior or natural system e.g. genetic algorithms. The statistics shows very good results, even when the problem size makes it impossible to use more traditional but exact methods. Ant based system belongs to this class of adaptive and evolutionary nature inspired systems, based on natural behavior of ants. Ants are dynamic software agents that possess the ability to change their residing locations. These agents move out of a system to perform a task and these may or may not return to the originating node. Ants spread intelligence across networks.

This research work aims to address the problems associated with the implementation of semantic web by analogy of ant behavior with the software intelligent agents in semantic web. Literature presented in the upcoming section indicates that agent technology is a strong candidate that holds the potential to overcome many other limitations as explored further. Next section justifies the incorporation of ants in the existing model of Semantic Web.

3. Literature Review

Extensive research has already been done in the area of semantic web and agent technology. This section highlights the work of distinguished researchers and explores the challenges, which still need to be addressed.

Schneider [19] specified an abstract syntax and a formal semantics for the Web Ontology Language (OWL). In addition, author not only proposed a model-theoretic semantics in the form of a vocabulary extension to the RDF Semantics but also a mapping mechanism from the abstract syntax to RDF triples was also presented. However, the main focus had only been web ontology language and the work could not be made more generic.

Sanchez [9] elaborated the necessity for integrating intelligent agents and Semantic Web and analyzed the potential benefits of this combination. They proposed a SEMMAS (Semantic web services and Multi-Agent System) framework, which is an ontology based framework for seamlessly integrating intelligent agents & Semantic web services.

Kumar and Reddy [17] proposed an Ant Colony Optimization algorithm for a multipurpose reservoir system. To tailor the ACO algorithm for their problem, a finite time series of inflows, classification of the reservoir volume into several class intervals, and defining the reservoir releases for each time period with respect to a predefined optimality criterion, were established. The ACO algorithm was compared to a real coded Genetic Algorithm (GA). It was shown that the ACO algorithm performed better than the GA.

Madhu, Govardhan and Rajinikanth in [13] have emphasized that semantic web can solve the first problem in web with semantic annotations to produce intelligent and meaningful information by using query interface mechanism and ontology's where as others solves the same by the graph-based query models. The semantic web would require solving extraordinarily difficult problems in the areas of knowledge representation, natural language understanding.

Ali et al. [2] used ant colony optimization to accelerate convergence of the differential evolution (DE) technique. Their methodology, entitled ant colony differential evolution (ACDE), initializes the ant population using based learning techniques, utilizes a random localization methodology, and simulates the movement of ants to refine the best solution found in each iteration.

Wu and Aberer [32] used swarm intelligence to create a model for the dynamic interactions between web servers and users, which provide relevant feedback by browsing Web pages. This model is being used for ranking web documents. A swarm intelligent module was added to the web server architecture. The trail laying feature used is composed of an accumulation feature that increases the pheromone amount when a user visits a page, and of as reading feature in which pheromone is diffused to the pages that link to a certain page. The spreading feature does not comply with the Ant Colony Optimization meta-heuristic.

The ant-based control (ABC) algorithm is derived from the biological ohenomenon have releasing pheromone by ants that optimizes the route from source to destination. The natural stigmergy pheromone is replaced by artificial stigmergy which can be modeled by computers. Artificial stigmergy is defined in [24] as the indirect communication mediated by numeric modifications of environmental states which, are only locally accessible by the communicating agents [6].

The proposed work describes a mechanism to search for resources in unstructured ants based control using ant algorithms implemented through software agents. Traditional resource search algorithms in web use an uninformed or blind search among the various nodes of the network. In contrast, the resource search algorithm described in this work performs an informed search using the ant agent. Usually ants have been implemented as software agents and are created in response to a user's relevant search query. An ant

reinforces the route that yields a successful search for directing ants in the future towards nodes with higher probability of locating resources.

Literature indicates they researchers have thought of employing ants in semantic web; however the concept has not been used very frequently. Therefore, aim of this work would be to incorporate ants in semantic web addressing the above shortcomings. A high-level view ant have control ABC (Ants Based Control) of semantic web in given in figure 1.

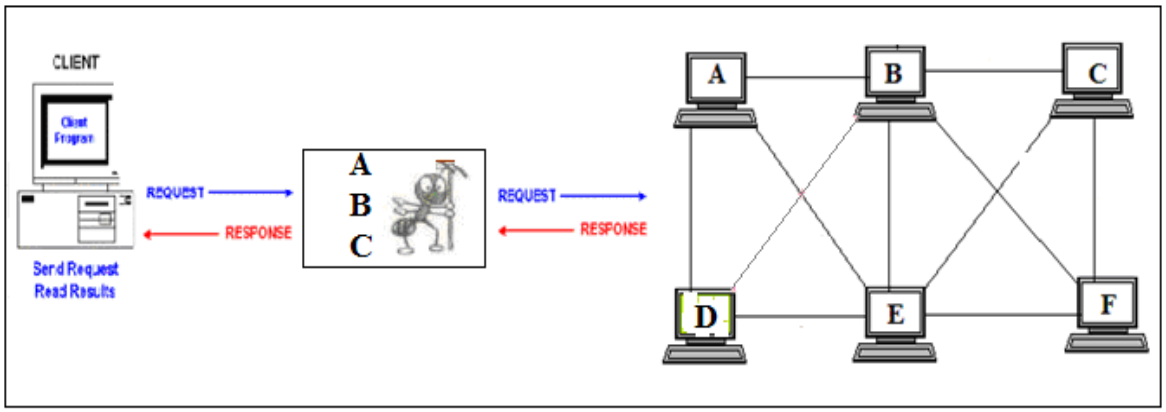

Figure 2: Proposed work

The idea is to deploy ants in semantic web which, would then be responsible for

- Executing the task delegated to them.
- Providing a quicker & relevant response to avoid delay in response time.
- Diverting the traffic/tasks to other server in case of congestion.
- Providing more accurate and subject relevant data.

The foraging behavior of ants agents and their ability to find the shortest paths between destination and their source have attracted wide attention of academicians in a number of disciplines. While traveling from destination to the source and back, ants deposit a chemical substance, called pheromone, at some places on the way. This deposition forms a sort of trail, which helps an ant to find the path back from destination to the source and can also be followed by other ants while searching for destination. As shown in figure 2, when an ant has to choose a path to travel, it chooses a path with high pheromone concentration with greater probability. After a while the pheromone concentration on the shorter path will be greater than the longer path, because the ants using the shorter path will increase the pheromone concentration faster. Thus, eventually all ants will only use this path. It has been observed that this pheromone trails following behavior allows ants in a colony to find the closest located

destination.

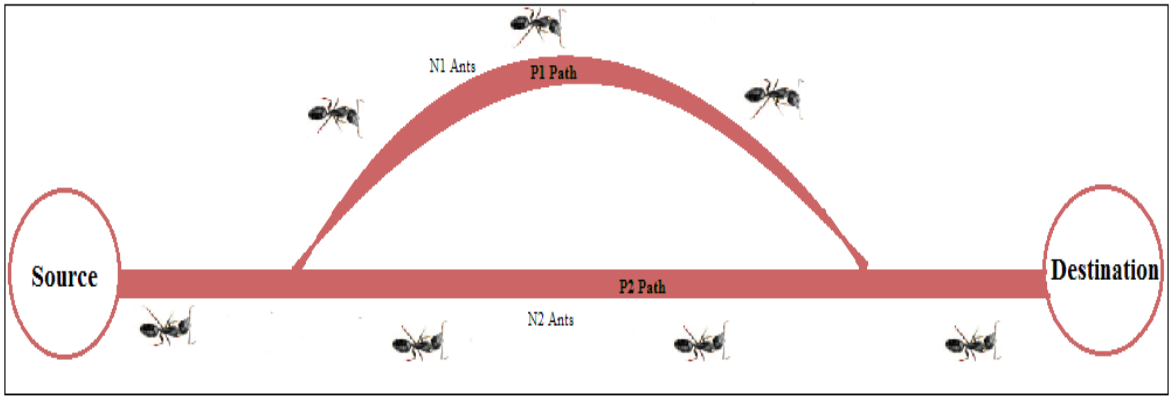

Figure 3: Ants Finding Shortest Path

Initially when there is no pheromone trail to follow path with higher pheromone concentration. Taking into account the pheromone decay as well, this has been mathematically formulated as follows. If we take N_1 and N_2 be the number of ants that have used path P_1 and P_2 respectively, after M (total number of ants) ants have crossed the decision point ($N_1+N_2=D$), the probability S with which the (M+1) ant chooses the path P_1 [31].

$$S = \frac{(N_1+k)^h}{(N_1+k)^h + (N_2+k)^h} \quad (1)$$

Where, h and k are parameters picked to allow the model to fit in to experimental data. This behavior of ants needs to be incorporated into artificial ants to find solutions to relevant and meaningful information. Flowchart and algorithm describing the same is given in figure 4(a) and 4(b).

6. Conclusion

This paper presented the basic design of ant-based semantic web. Works of other renowned researchers were carefully studied and it was discovered that there is ample scope of improvement towards the performance of semantic web. The presented approach basically proposes the decentralization of information and relevant pages and presumes that more relevant response in lesser time could be retrieved. The simulation of the work is in progress and the results may be presented later.

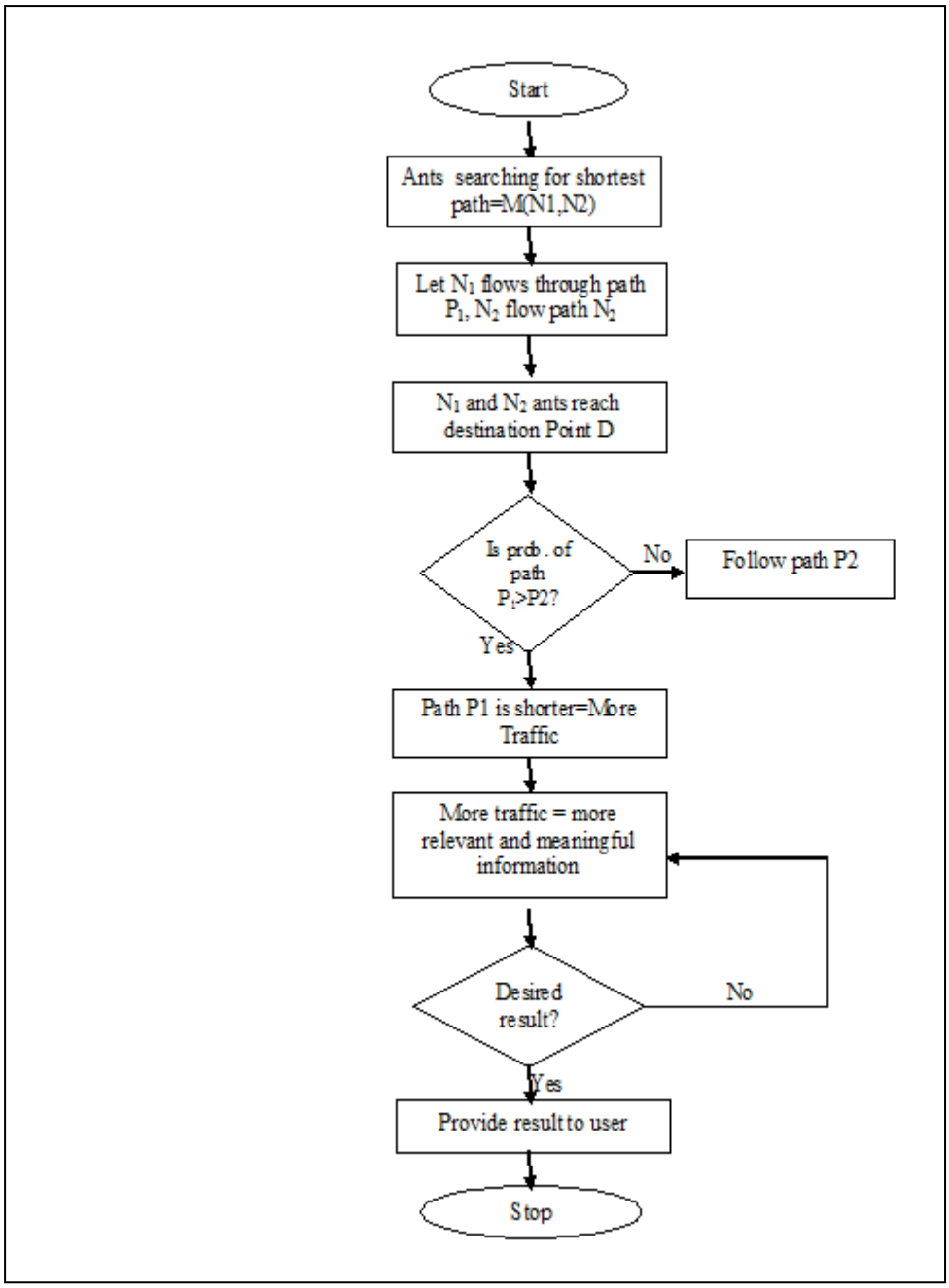

Figure 4(a): Flowchart Depicting ABC Algorithm

1 Initialize
Ants = N_1, N_2=M;
Path = P_1, P_2;
Destination = D;

2 While (N_1==D)&&(N_2==D) repeat
Flow path P_1,P_2 by N_1,N_2 ants repeat until ants reach destination D.

3 If (check probability)

$$S = \frac{(N_1+K)^h}{(N_1+K)^h + (N_2+k)^h} \qquad (1)$$

4 P_1 is a shortest path.
5 Ants agent find relevant result.
End if
End LOOP
6 While (1) repeat cycle
Find relevant and meaningful result.
7 If (relevant-result)
Provide result to user otherwise repeat cycle
Break;
End IF
End LOOP

Figure 4(b): Algorithm Depicting ABC Algorithm

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