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Mining Internet of Things for intelligent objects using genetic algorithm☆

Wail Mardini*, Yaser Khamayseh, Muneer Bani Yassein, Montaha Hani Khatatbeh

Computer Science Department, Jordan University of Science and Technology, Irbid, Jordan

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A B S T R A C T

The Internet of Things (IoT) is overpopulated by a large number of objects and millions of services and interactions. Therefore, the ability to search for the right object to provide a specific service is important. The merger of the IoT and social networking, the Social Internet of Things (SIoT), has made this possible. The main idea in the SIoT is that every object in the IoT can use its friends' or friends-of-friends' relationships to search for a specific service. However, this is usually a slow process because each node (object) is required to manage a large number of friends. This paper addresses the issue of link selection of friends and analyzes five strategies in the literature. Then it proposes a link selection strategy using the Genetic Algorithm (GA) to find the near optimal solution. The results show an improvement over the examined strategies in terms of several parameters.

1. Introduction

The Internet of Things (IoT) is considered the next evolution of the current global Internet [1]. The main idea is to increase its ability to gather, analyze, and distribute data and transform them into information, knowledge, and wisdom. However, it is not about connecting people. It is about connecting things, hence its name. It covers many possible application areas, and it enables objects to connect anytime, anywhere, and to anything.

In the IoT, a thing could be anything and everything, from a mobile device or a dishwasher to a controlling system of a car or a plane. It can be absolutely anything that moves or does not move. If it has an IP address, it is possible to connect it or track it. Thus, these things are not just smart phones and tablets; they are everything [2].

The IoT includes a vast number of objects that generate information about the physical world. This information can be obtained through standard Web browsers. In addition, the IoT can provide new services to end-users. However, in [3], the authors explained that the search of each service in the IoT is huge because the number of objects that connect to the network is continuously and rapidly increasing.

In addition, the traditional interaction model is based on the idea that humans are looking for information (human-object interaction). However, in the IoT, this model must change to object-object interaction, which means that an object will look for a service from other objects. In the literature, several models were proposed for real-time search [1,4]. However,

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* Corresponding author.
E-mail addresses: mardini@just.edu.jo (W. Mardini), yaser@just.edu.jo (Y. Khamayseh), masadeh@just.edu.jo (M.B. Yassein), kmmontaha14@cit.just.edu.jo (M.H. Khatatbeh).

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these traditional models employ centralized systems for their engines; hence, they do not scale properly with the number of devices and queries. In order to overcome this shortage, a new approach based on the Social Internet of Things (SIoT) was proposed [4].

The SIoT can be used as an analog term for "social network of intelligent objects" [5]. Therefore, the SIoT can be thought of as the ability to have integration between the IoT and social networks in an intelligent way [4,6]. In the SIoT, objects will have the ability to search for a desired service using its friends' objects through available connections between them (i.e., friendship connections). As a result, each node will eventually have a large set of nodes (friendships) to manage, which will negatively affect the search time. Therefore, it is advisable to limit the number of friendships for each node. Moreover, choosing which friendships to keep will affect the search efficiency [7].

In the SIoT, every node is an object that can establish social relationships with other things in a predefined way, according to the rules that where set by the owner [6]. Many types of relationships exist [8]:

1. Parent-object relationship (POR).
2. Co-location object relationship (CLOR).
3. Co-work object relationship (CWOR).
4. Owner-object relationship (OOR).
5. Social-object relationship (SOR).

This paper addresses the issue of link selection of friends and analyzes five strategies in the literature for this purpose. It then proposes and implements a link selection strategy using the Genetic Algorithm (GA) to find the near optimal solution (near optimal link selection).

The rest of the paper is organized as follows. Section 2 discusses some works that are related to this topic. Section 3 evaluates the performance of some strategies that are proposed in the literature. Section 4 includes the authors' proposed GA for link selection, and Section 5 discusses sample performance results. Finally, Section 6 provides some conclusion notes.

2. Related work

A social approach for the IoT is expected to change the way nodes (i.e., objects) discover or search for other objects to gather information about the physical world [9,10,11].

The works in [1,2,6,12] are examples of existing approaches for service search in the IoT. In the above-mentioned approaches, the authors used a hierarchal structure of mediators to cope with the large number of objects. While these approaches work well with pseudo-static metadata, they are not scalable in the case of frequent network changes. The search for data from real-world entities and sensors is a major service in the IoT. However, two specific limitations exist. The first one is the frequent changes in the data of objects and the second is the large number of objects.

In [13], the authors proposed a probabilistic centralized system. In this approach, the contact to the objects is based on a prediction model that calculates the probability of matching the query. However, for good scalability with the number of objects, the search engine does not need to contact all the sensors. Some requests may not be required and will only increase traffic on the network.

In [14], the authors presented a method for a friend recommendation system in social networks using the GA. The proposed technique was mainly developed to analyze the importance of two major issues in friendship formation. The first issue is how links are formed in social networks and the second is why links are formed in social networks. The authors employed the idea of the GA to develop a friend recommendation system that aimed to optimize relationship preferences. Their approach resulted in a higher quality friends list that was relevant and appropriate for further future links (friendships).

In [15], the authors presented a design of policy language expression improvement (Ponder) for the SIoT. This improvement simplified the complexity of the general policy languages and was designed to provide easy training for users. Moreover, it was developed to be a policy editor in the SIoT environment. This research deployed a scene for the SIoT named Magic-Home. This scene has two management scenarios: access control and resources interactive. The Magic-Home framework consists of household appliances and three types of sensors (luminance, temperature, and humidity). In the scenario of access control, the authorization is given to the user before sending the control message to the IoT device. In the resources interactive scenario, the policymakers must define a policy for all possible actions that the platform processes when the sensor data are received. The performance measurement of the new IoT policy editor was conducted for three performance indicators: Simplicity, to make the training easy for users; Enforceability, which means the tools must be open source to easily allow for improvements; and Expressiveness, to process the policy requirement of the system. After the analysis of five major policy languages to develop a policy editor, the research selected Ponder. The performance of the new IoT policy editor was evaluated against the performance of a well-known language (PonderTalk). The obtained evaluation results show that the new editor achieved higher accuracy as well as higher spell and syntax error detection.

In [16], Jadhav and Patil designed a system for home monitoring in the SIoT that used appliances with the integration of social networks. The generated information in the system can be monitored using Facebook. In addition, sensors can receive instructions from Facebook comments. The presented system was developed using Arduino Uno board, which is connected to a set of sensors, such as smoke detection, intensity of light, detection of obstacle, and temperature sensor. These sensors are connected to the Raspberry Pi B2 unit, which is used as a gateway to connect the server with the Internet. The Raspberry