ACIT'2017
The International Arab Conference on Information Technology
Yassmine Hammamet, Tunisia
December 22-24, 2017

Service composition based on the social relations in the Internet of things

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Abstract—The Internet of things (IoT) is a collection of things internet worked via a network that enables to exchange the data. Furthermore, the object in IoT can be offer his functionalities as a physical or software services. The current trend of Web of things faces many challenges especially in the issue of the IoT service composition. However Previous published studies are limited to IOT service composition, there have been no controlled studies which analyze the recent works and very few studies have investigated the exploitation of the social relations; leveraging of the social relationships in composition phases can lead to address many challenges such as the navigability, the availability, and the scalability. Besides, it can establish the trustworthiness and enhance the effectiveness and the efficiency. Hence, in this paper, we aim to highlight on the IoT service composition challenges by analyzing previous studies. Another objective of this paper is to attempt to show the use of the social relation to enable the imposing the social dimension in the Web service composition.

Keywords: Service Composition, social relations, SIOT, Internet of Things service.

I. INTRODUCTION

The basic idea of IoT is the connectivity of real-world things to the Internet [1] that each of device will be able to offer his functionalities as a service. Moreover, enabling other components to interact with it dynamically. As the real-world devices are related directly to the physical world, the service that they provided is often referred as real-world service and also known as IoT-service or cyber-physical service.

In service-oriented computing based IoT, the service composition has been one of the hot issues for its necessity; it promotes the creation of complex applications by aggregating atomic service to provide new functionalities that none of the services could provide individually [2]. Service composition in IoT is still in its infancy with limited research studies has been conducted on this topic to date. Furthermore service composition in the IoT as environment pays particular attention, unlike traditional Web service composition technique, it is more challenging mainly due three features: IoT service requirements, IoT environment requirements and user (consumer or provider or owner) requirements. In this paper, we analyzed the mechanisms used to achieve the composition and we have noticed in most of the work not to exploit the social aspect. This is hampering users, services, and things' sociability. To address the gap, we aim to acquire an initial understanding of service composition based on social relation in IoT, by analyzing the current approaches of IoT service composition to address the most important challenges. Moreover, in this exploratory study we investigate the use of the social aspect in traditional Web service composition to determine their adaptability to IoT service composition.

The remainder of this paper is structured as follows: the second section introduces by analyzing the traditional approaches, which exploited the socialization concept in Web service composition, we continue in Section III analyzing the different IoT service composition approaches. Section IV sketch the outline of challenges of the composition in IoT environment, before the paper is concluded in Section VI we present in the section V the limited researches exploit the social aspect in IoT service composition.

II. APPLYING SOCIAL ASPECT IN TRADITIONAL WEB SERVICE COMPOSITION

Numerous researchers have surveyed approaches related to Web service composition, there are several systems and approaches using social aspect in service composition, in these approaches, the definition of sociability is different, in this section; we survey the Web service composition using socialization.

In [3] the authors proposed planning algorithm called 'Trusty' for semantic Web service composition using user's ratings to find the trustworthy services in social environment, they computed the social trust value base on similarity measures over user's rating about their experiences with the service by considering some behavioral characteristics of service.

In [4] the authors proposed a framework for a trust based dynamic Web service composition, at the opposite of [3] the authors calculated the trust rating of service provider based on centrality measures of social network of service providers.

The paper [5] presented a framework called SOCO (social composer) for service discovery and selection in social network, the last one was defined as a graph representation of all the interactions that occur between people and services in a composition environment. The links in the social graph are used to calculate social proximity between users to build services recommendation system.

In [6] the authors presented the trustworthiness of agents in social network. They considered the social network as a general kind of complex networks, the multi-relation social network (MRSN) which takes into account the semantic aspect of the relationship linking two nodes (two agents), they propose three trust measures : i)- Trust in sociability, ii)- Trust in expertise, iii)- Trust in recommendation.

In [7], the authors exploited the sociability in a collaborative service network, and the nodes are service instances, the social connections are considered between services has two types of links positives such as correlation and negatives like competition. Also [8] use the collaborative service network to provide trustworthy Web service selection by considering not only the individual reputation but also the collaboration reputation of Web services.

The paper [9] presented a social network to facilitate the negotiation (SNRNeg), and they exploited the trust relationships between nodes to extract recommended services in selection process.

Discussion

In this section, we analyze the previous works as shown in TABLE I, we emphasize on the social network definition, and we take on consideration the different relationships were exploited in the service composition process, in additionally the social network analysis (SNA) was used and which measures utilize.

Sociologists define the concept of social network in 1960s as a network of people [10]. In computing, the social network is a set of entities denote users that communicate each other and share their interests and activities easily, In Web-based Social Networks the nodes could represent people, groups, organizations, computers, or any knowledge entity.

A social network in composition environment is a graph representation of all interactions that occur between people and services [11], so we distinct two types of sociality are utilized in Web service composition:

A. User Sociality (US)

Refers to different links between people are common interests or activities, where each one has profile such as in traditional social networks (Facebook, Twitter …etc.), in Web service composition user may be a Web service provider or Web service consumer, the possible relationships of type User-User, that can be exploit are friends, communities, family, knowledge exchange …etc. The social network analysis allows extracting information focus on micro level (individuals) or macro level (social structure) by using different measures like (centrality, similarity …etc.) As used in [3] [4].

B. Service sociality (SS)

Refers to different types of social connections between services, the conversion form isolated service to social service presented in [12], where using social Web service network to improve composition task. Replacement, collaboration, follow and competition are some interactions that can connect Web services together. In literature, the most researches use the links between services to calculate individual or collaborative reputation or trust for service recommendation such [7] [8].

All of the above approaches imposing the social aspect to improve the Web service composition, the value of adding social networks to Web services detailed in [14]. Most of these studies focus on using the social network analysis measures to extract social knowledge such as trust value.

For instance, with the emergence of IoT the sociality is more complex than traditional SN. For example things can be communicate each other's (can be friends), that's known as SIOT (social internet of thing), also the interactions between services are offered by the devices can be construct a service network, in the same time the links between the owners provide another level of sociality in IoT.

Work	**Sociality**	**Nodes/Lies**	**Extracted information**	**Measures**	**Composition step**
[3]	US	Consumer/ consumer	Social trust	Similarity	Planning
[4]	US	Provider/ provider	Trust	Centrality	Planning
[5]	US	Consumer/ consumer	Recommendation en confidence	Social proximity Time of using quantifies the expertise	Discovery Selection
[6]	US	Provider/ Provider	Trust	Sociability Expertise Recommendatio n	selection
[7]	SS	Service/ Service	Recommendation	Negative /positive links	Creation of composition
[8]	SS	Service/ Service	Trust	Collaborative and individual reputation	Selection
[9]	US	Consumer/ Provider	Trust	Similarity Expertise	negotiation

TABLE I. Traditional Web service composition applying socialization analysis.

III. IoT SERVICE COMPOSITION APPROACHES'

IoT service composition has become a critical issue in WOT; various approaches have been proposed to solve this issue. In this section, we sketch the outline of this topic, and we present a categorization of related research efforts for IoT service composition

A. Context aware service composition

In [15] the authors divided the context ontology into upper ontology and domain specific ontology; Upper ontology is a high level ontology which captures general knowledge and is divided into four categories (User context, computation context, physics context, time context), and low level ontology which defines details of concepts.

As the previous work [16] taking context information in consideration to guide real-world service composition, the authors proposed an ontology model for context; the ontology is divided into two levels: top level captures all common knowledge for the IoT (Computing, Environment, user) and low level defines concepts and properties for each sub-domain. They divided the composition process into two sub processes; firstly, they used device context to filter the appropriate services. Secondly, they selected the best service that satisfies user's needs according to user's expectation to the quality of service. A similar approach [17] presented a composition framework for smart cities based on context. In addition [13] addressed discovery of IOT service problem as a contextual bandit problem.

B. Service composition based on BPEL

In [18] gave the extensions of BPEL language to composition of IOT RESTFUL service, with similar purpose [19] used BPEL extensions in his service composition framework. Moreover, designed an activity description model by using ontology to construct a semantic extension of a business activity in BPEL and a logical composition model to express the composition of the services that match the business functionalities in an activity.

C. Qos aware service composition

Various research contributions addressed the issue of QoS reasoning in IOT services composition.

In [20] the authors proposed QoS computational method to find selection algorithm for IOT composite service and make comparison with genetic algorithm, [21] provided model for QoS parameters, which divided the attributes into dynamic (response time, energy level, availability, and Reliability) and static(price, security level). In addition, the authors tackle the problem of optimal service selection using distributed optimization approach in the three patterns of composition (Sequential, loop, parallel).

In [22] the authors took into account not only Qos factors but also QoUE, when the key contribution is design middleware based on QoS requirements (reliability and availability) and QoUE constraints (Execution Time, Response Time, Latency time, Throughput, Capacity), moreover, the composition of the service is modelled as a DAG (Directed Acyclic Graph).

D. Bio-inspired based approach's

Several work takes advantage of the coordination mechanisms of biological societies and use the bio-inspired technique. In [23] proposed a bio-inspired decentralized service discovery and selection model, which it is inspired from the Response Threshold Model (RTM). The authors in [22] used Particle Swarm Optimization (PSO) for ideal service selection. Also [24] formulated the problem of composition as a multi-objective optimization problem, which it can be solved through particle swarm optimization or genetic algorithms.

E. Petri Nets based approach's

In [25] proposed an algorithm to find the optimal composition path using Petri Nets in order to fulfil user requests. Which uses a comprehensive performance function rtc (the sum of three items; reliability, response time and cost) to evaluate the cost-effectiveness.

F. Energy aware service composition

The authors in [26] developed an algorithm that searching for and selecting the minimum number of IOT service in An Energy-aware Service Composition, to satisfy user's requirements. In [24], the authors proposed a mechanism for WSN (wireless sensor network) services composition, which consider three factors (spatial and temporal constraints, and energy-efficiency).

G. Service composition based on Real Time Protocol

In [27] tackled the problem of composition for IP smart Object by using Realtime Web Protocols.

H. Social network aware service composition:

In [28] the authors provided a Web platform called SAC (Social Access Controller), which use the existing social network (Twitter, Facebook…etc.). To enable owners of smart things to connect and share them on the Web with his trusted connections; the advantage of using RESTful interface makes SAC an integral part of Web and its API can be used to create a physical Mashups to compose physical and virtual services.

The authors in [29] proposed trust management to support service composition in IoT system based on SOA architecture, the nodes of the social network are devices and its owners, the considered relationships among users are: friendship(the intimacy), social contact (physical proximity), community of interest (knowledge on the subject matter). In similar social interests of users, used distributed collaborating filtering technique to select trust feedback for recommendation.

Discussion

To evaluate the previous approaches, we need identifying common criteria. These measures focus on answering the three following questions as shown in TABLE II:

- How are IOT services composed? (Strategies)
- What is the technique used? (Mechanisms).
- What challenges have been addressed? (Requirements considered)

Approach	Strategy	Mechanism	Requirements Considered
[15]	Optimization: correlation	context	Dynamicity Interoperability User requirements
[16]	Optimization: filtering selection	context	Dynamicity User requirements Interoperability
[17]	Selection coordination	Matching algorithm	Interoperability Dynamicity Flexibility Availability Correctness
[13]	Discovery	Contextual bandit algorithm	Scalability Dynamicity Availability Runtime
[18]	research	BPEL	Interoperability Scalability Automation
[19]	Modeling: description matching	BPEL WADL	Interoperability Scalability Reusability
[20]	selection	Backtracking algorithm	Reliability Scalability Cost Execution time

[21]	Optimization: selection	DCOP algorithm Multi-Agent	Response time Energy level Availability Reliability Price Security Decentralization
[22]	Optimization: discovery selection	PSO	Reliability Availability Runtime Response Time Latency time Throughput Capacity
[23]	Discovery selection	RTM Agent	Decentralization Dynamicity Scalability
[24]	Discovery selection	AG/PSO	Interoperability Reliability Energy-efficiency Availability Temporal and geographical constraints
[25]	Modeling	Petri nets	Dynamicity Correctness Reliability Response time Cost
[26]	Optimization: Search Selection	E2C2 algorithm	Dynamicity Energy-efficiency User requirements
[27]	N/A	Real time Web protocol	Scalability Availability
[28]	N/A	Social network	Interoperability Security Scalability Connectivity Sociality Sharing Controlling
[29]	Representation Selection	Social network	Interoperability Decentralization Scalability Flexibility User requirements Device management

TABLE II. IOT service composition approaches analysis.

IV. IoT SERVICE COMPOSITION CHALLENGES

In SOC-based IoT each device offers one or more services to offer their capabilities on Web, the composition of this type of services involve new challenges. This section draws the barest outline of service composition requirements in IoT.

A. IoT Environment requirement

One of the most of the characteristics is the heterogeneity of devices (tagging, sensing, and thinking things…etc.) that have different performances; some approaches considered these features such as energy consumption, energy conservation data storage, processing capacity…etc. In addition, the huge and growing number of the devices considers the scalability in composition task. The mobility, the high distribution, sociality and security of devices one of the factors that was not addressed much was the focus on the IoT environment in general.

B. IoT service requirement

On the one hand, the atomic services obtained from discovery process are further used in order to get the best result required new considerations and QoS measures rather than traditional service such as availability and accessibility. Because it is bridge to interact with the physical world, the large number of users and devices as consumers or producers make the scalability an important requirement in IOT service composition, in addition the adaptability and flexibility are core requirements in dynamic environment. There are also temporal metrics that should be considered in composition process as run time and real time. On the another hand the reliability of the composite service is one of the critical factors in the service composition, [20] propose computational model based on QoS for IOT composite service, another requirements and challenges face IoT service composition as reusability, correctness, security, trustworthiness, sociability…etc.

C. User requirements

The user requirements is set of user preferences, may be temporal (response time), spatial (location), financial (price)…etc. Satisfying of user need's is the core features in composition task.

V. SOCIAL ASPECT AWARENESS

The social aspect has little been exploited in service composition, in this section; we attempt to present the different social relations among IoT components could be exploited in service composition.

A. Social internet of thing

SIOT is a novel paradigm of 'social network of intelligent Objects', based on the notion of social relationships among Objects [30], the social relationships of type thing-thing are five : Ownership Object Relationship (OOR) : two things have the same owner. Parental Object Relationship (POR): refers to the similar things created by the same producer. Co-work Object Relationship (CWOR) defined among cooperated things offer a common functionality. Co-location Object Relationship (CLOR): tow objects locate in the same place. Social Object Relationship (SOR): when objects establish companionship with each other.

The exploitation of SIOT addressed in service recommendation [31] [32] [33]. To assuring network navigability and environment scalability and the possibility to support interaction level among things by using the trustworthiness. Some recent researches highlight on the trust management in SIOT [13][34][35].

B. Traditional Social networks

In the work [36]. The authors chosen Twitter as platform to enable the interaction between entities (Human/thing/ service) and to facilitate the integration of things in the Web. In [37] The proposed system allows to the owners of things to share them via traditional social network (Twitter, Facebook…etc.) taking in the consideration some metrics as the energy consumption, also the authors mentioned Web of things constraints like the addressability, uniform interface…etc.

C. Social network model

In [38] the authors proposed an approach based on social network concept to IoT service composition and device management, which addressed relationships between things and services.

VI. CONCLUSION

This paper has explored the different mechanisms and strategies are used in IoT service composition, and has highlighted on the greatest challenges and the major considerations that must be addressed as the IoT environment requirements, IoT service requirements and user requirements. However, far too little attention has been paid to the exploitation of social aspect in the composition task; an objective of this study was to trace the contribution of the socialization to improve the traditional service composition, the purpose of this investigation is to know the possibility of applying the traditional solutions on IoT service composition.

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