Integration of Internet of Things and Social Network

Social IoT General Review

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Abstract. Recently, the concept of the Internet as a set of connected computer peripherals is changed into a set of surrounding elements related to human living space, such as household appliances, machinery, transportation, storage of enterprises and property and so forth which is known as the internet of things IoT.

Social Network and IoT are both among the most promising paradigms, merging these technologies lead to a wide range of intelligent services and application.

A new paradigm known as the Social Internet of Things (SIoT) has been introduced and proposes the integration of social networking concepts in Internet of Things.

In this paper, we intend to examine the approaches used to exploit the concepts of social networking via the Internet of things, the technologies behind them, the proposed architecture, the contribution of SIoT compared to the IoT, the classification of some related works rely on the contribution mentioned above and, research challenges and open issues.

Keywords: Internet of Things · Social Network · Social Internet of Things · Ubiquitous computing

1 Introduction

The Internet of Things (IoT) is a new paradigm which integrates not only the traditional computer but also many kinds of things or objects around us, those objects are managed by a large number of technologies. Additionally, over unique addressing schemes and standard communication protocols, objects can communicate with each other and interact with their neighbors in order to reach common goals.

Currently, Social networks and IoT are the most attractive technologies, Social networks are formed of nodes of people, and the edges between these nodes represent their relationships. Social Network (SN) services are essentially promoted as a huge network of people where the relationships between those are shaped and described.

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Lately the idea of merging the "Internet of Things" and the "Social Networks" worlds is feasible, or even desirable. Things can not only be a component of traditional networks, they can also be a part of a SN of smart connected things that lead to an effective management of relationships by mimic human being behavior, a scalable and efficient service discovery and composition, as well as trustworthiness management [1].

For this reason, the three worlds of Internet, IoT and SN are combined to bring the physical real world into the virtual world. The resulting paradigm, called Social Internet of Things (SIoT), has the potential to support new applications and networking services for IoT in more efficient and effective methods [2], this is due to the increasing of awareness, Hence, SIoT paradigm would carry various desirable implications into a future world populated by intelligent objects permeating the daily life of human beings.

The remainder of this paper is organized as follows, Sect. 2 displays a background about the internet of things and social networks, Sect. 3 presents a general review of Social IoT; its architecture, key improvement, … and so forth, Sect. 4 is devoted for presenting some related works and its classification according to their domain of contribution and in Sect. 5 we present the main challenges and open issues of the SIoT, Finally, we finish this paper by a conclusion.

2 Background

2.1 Internet of Things

The Internet of Things (IoT) is an innovative paradigm that is rapidly gaining momentum in the current wireless telecommunication scenario. The fundamental idea of this concept is the ubiquitous presence surrounding us with a set of things or different objects - such as Radio Frequency Identification (RFID) tags, sensors, actuators, smart phones, and so forth. - Which, through unique addressing schemes, are likely to interact with each other and cooperate with their neighbors to achieve common objectives.

The Internet of Things (IoT) is someway a leading step to a smart world with ubiquitous computing and networking. It proposes to make different tasks manageable for users and give other tasks, such as easy monitoring of various events surrounding us. With ubiquitous computing, computing will be implanted wherever and programmed to act automatically with autonomous triggering; it will be omnipresent.

Indeed, the central power of the IoT idea is the high impact on various aspects of daily life and behavior of potential users. From a private user, the most apparent effects of the IoT will be evident in both working and domestic areas. In this context, assisted living, domestics, e-health, improved learning are simply some examples of possible application scenarios in which the IoT paradigm will play a leading role soon. Thus, from the aspect of business users, the most obvious consequences will be equally apparent in fields like automation and industrial manufacturing, logistics, business/ process management, intelligent transport of people and goods [1].

The principle objective of IoT is to allow us to uniquely identify, signify, access and manage things at anytime and anywhere by using the internet. The interconnected device networks can result in a big number of intelligent and autonomous applications and services bringing significant personal, professional, and economic gains (Fig. 1).

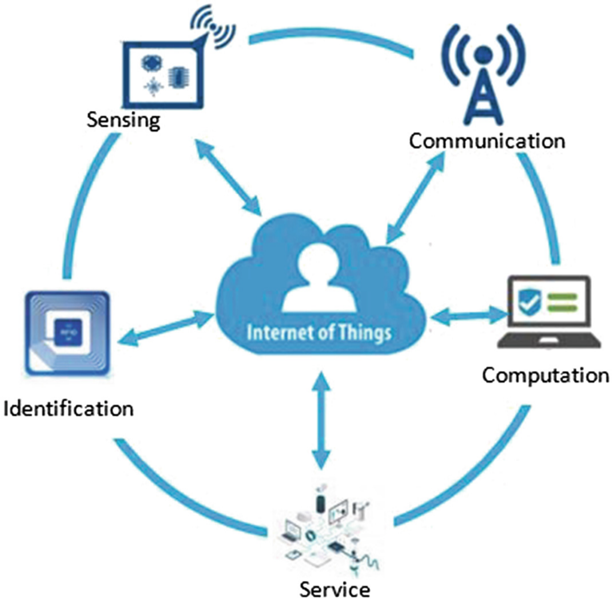

Fig. 1. The IoT elements

2.2 IoT Communication Models and the Problem Related to

From the analysis of the potential communication model of IoT we can summarize:

Thing-To-Thing Communication Model: This model represents that two devices or more can connect directly and communicate to each other without any intermediate application server, this model usually used in applications such as smart home, which use a small packet of data to communicate to each other.

Thing-To-Cloud: In this model, IoT devices connects directly to the cloud Internet service as an application service provider for data exchange and traffic control messages, nevertheless, the interoperability challenges emerge when we use things with different technologies.

Thing-To-Gateway: The IoT devices connect each other through an intermediate gateway application layer as a channel to access the cloud service.

Back-End Data Sharing Model: This model is an extension of the Single Thing-To-Cloud thus authorized third parties can accessed to objects and sensors to export and analyze data from the Cloud (Fig. 2).

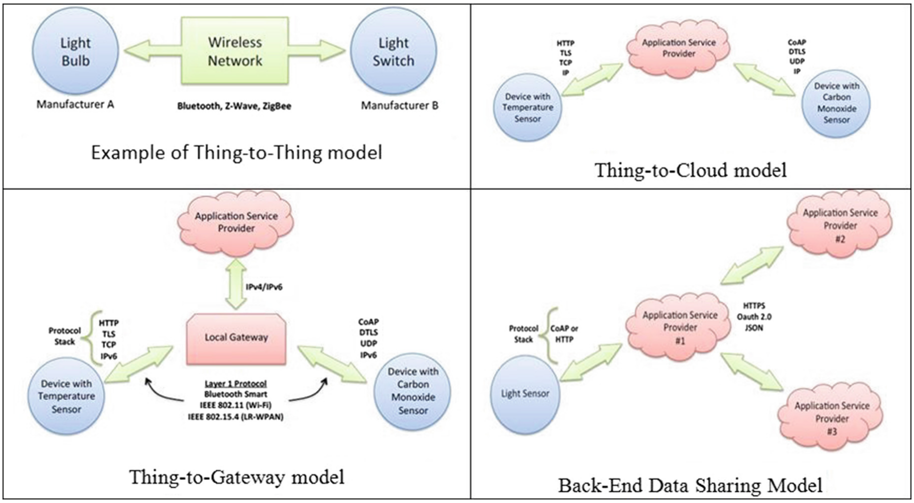

Fig. 2. The 4 models of communication of IoT

Scientist predict that there will be around 50 billions of connected objects by 2020, In addition, The IoT has broader overall scope than conventional host communications, Thus, whatever the application scale, small (smart home) or large (smart city, factory) scalability is an absolute need for the IoT. That can guarantee a seamless communication with objects and people. Each one of those objects might provide functionalities as a service, an efficient service discovery requests a good identification of suitable service, and furthermore, users want to know the available services and the information about their objects.

More than that, objects in IoT establish relationships with “things” that can provide needed services when they come in contact, the malfunction of devices can carry out discriminatory attacks, so it is crucial to assess the trustworthiness of service providers and the performance of the application to satisfy the service requester and maximize application performance.

Besides, IoT encompass a huge number of objects, hence each object has to deal with an enormous number of access and receive a huge number of queries, furthermore the relationships established among those objects have to be managed efficiently by the IoT platform.

2.3 The Social Network (SN) and Its Features

Social network; A social networking sites are an online platform that allow users to create a public profile and interact with other users i.e. SN allow people (1) to build a public or semi-public profile, (2) describe the relationships between People (3) view and browse their list of connections. The nodes in SN refer to individuals and the edges between the nodes describe the relationships between the people. Moreover, the SNs are characterized by the following characteristics:

- Community driven: In fact, social network users want to discover new friends also reconnect their old friends whom lost any contact with.
- Interactive: The SN gives the users a big space to interact with events, news and so forth so we can get and react with the latest news.
- User based: users update the information on social network on real time.

3 Social IoT

Nowadays, SN and IoT are both among the most promising paradigms, merging these technologies lead to a wide range of intelligent services and applications to deal with the many challenges that individuals and organizations face in their daily lives by allowing people to be related to anyone, anywhere, at any time. While IoT studies [2, 3] have typically mentioned communication to the physical world by detecting or acting through many different devices to be the biggest novelty.

A new paradigm called Social IoT (SIoT) which refers to a set of embedded objects connected via internet through unique addressing schemes, considering humans related data such as profiles, preferences, habits i.e.: Social IoT is used for context awareness through engaging users and users' profile in order to provide user-oriented services and recommendations. For this purpose, there are two considerations: (1) increasing sociality (or connectivity) and (2) enhancing pervasiveness (or availability) [4] (Fig. 3).

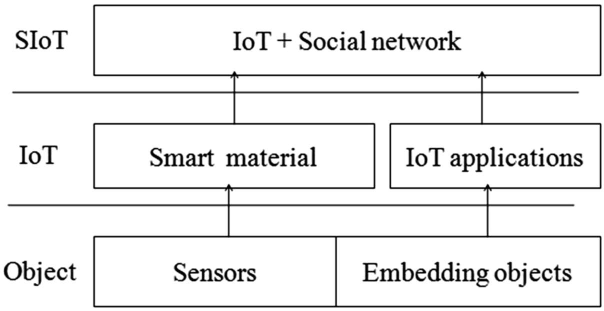

Fig. 3. Combination of social network and IoT

3.1 Key Improvement of SIoT

The actual implementation of the seamless integration between social and IoT worlds brings the main characteristics of social network to the IoT; here we summarized the main improvement expectant of SIoT:

Interactivity: The pairing between humans and things in IoT can take place in two forms: (1) human- to-human, or (2) machine-to-machine interaction, and it can be achieved using the normal physical interaction in case of humans or various computer networks in case of things. Authors in [4] claim that implementing human-to-machine cooperation is essential to achieve the completed vision of SIoT. The SIoT extend the notion of SN from people to the objects so the interactivity is one of the advantages of SIoT that has a positive influence overall system.

Collaboration and Sharing Information: This perspective appears to be the most critical one in order to realize a full convergence of both the social and IoT worlds because the collaboration and sharing information occur between human, between things and between human and things. Considering social values, SIoT ultimately enables humans and things to act as producers or consumers [5].

Handled-Data: It is also very important to consider the kind of data acquisition and handling techniques required to be considered in pervasive environments. Authors in [4] categorize data acquisition techniques into two categories: (1) proactive data recovery that is usually uses crawling techniques, learning algorithms, or various data analysis algorithms and (2) reactive data acquisition which habitually operates in a real-time way using various data mining and query techniques.

3.2 SIoT Architecture

- The SIoT system contain server, gateway and object, these components are distributed to three main layers [8], Sensing layer, Network layer and Application layer [1]. The architecture of each object may vary depending on the model of communication discussed in Sect. 2.2.
- **SIoT server:** the server is situated in the application layer also it encompasses three sub-layers, The Base layer is *The Handling data layer* which consists of database for storing and managing data with their descriptors, ontology databases, semantic engines and communications. *The Resource management Sub-layer* comprises tools which implement the key functionality of the SIoT system such as ID management, profiling and relationships management. *The Interfaces sub-layer* is devoted to ensure the best way of communication between objects, humans, and services.
- **The object:** the sub-layers, which the objects consists of, may mainly vary rely on their nature, we have 2 kind of objects; dummy objects (sensors) and smart objects (smart phone)

In simple scenario, the dummy object' role is just sending the sensing data to another equipment (gateway) in this case the object encompasses just the lowest layer which is the sensing layer. Otherwise, the smart object may contain the three sub-layers, Sensing, Network and Application. This latter encompasses the SIoT application as well as the social agent and the service management agent, which are presented in Fig. 4.

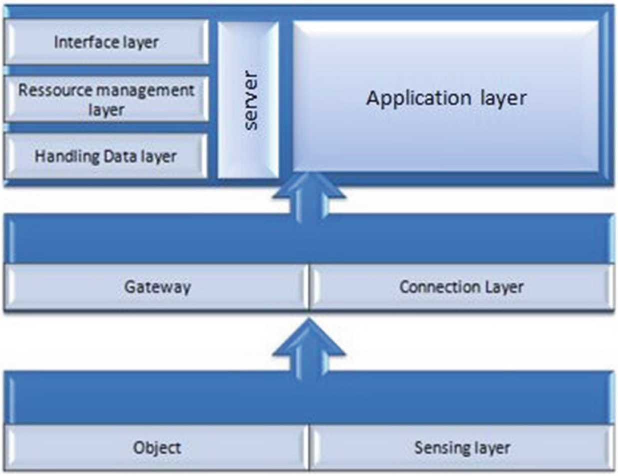

Fig. 4. Architecture for the SIoT ecosystem [1]

The social agent is dedicated to communicate with SIoT servers to update profiles, friendships, discover and request social network services, it also implemented to allow objects to communicate to each other when they are close geographically.

The Service management agent is responsible for interfacing with humans that can control the object behavior of the object when communicating within their social network.

- **The Gateway** made up only of the Network layer to ensure the connection between the SIoT server and objects.

3.3 The Contribution of SIoT Comparing to the IoT

Relationships Management: Things on the Social IoT can mimic the human being behavior on Social Networks, in addition from the analysis of possible service and application typologies, built on the envisaged Social Internet of Things. Authors in [4] propose the followed classifications of the defined relationships:

Parental Object Relationship (POR): established among objects produced by the same production batch, that is to say, generally homogeneous objects from the same manufacturer and in the same period. Furthermore, objects can establish a *Co-location object relationship* (C-LOR), this type of relationships defined among objects (either homogeneous or heterogeneous) worked always in the same place (as in the case of sensors, actuators, and augmented things used in the same environment such as a smart home or a smart city) this relationships can also be established sporadically between vehicle and smart objects when they meet in the same space, also the objects can mimic the relationships between workmates in *Co-work object relationship* (C-WOR) this latter established whenever the objects cooperate to produce a common IoT application (as in the case of objects coming into contact to be used together and cooperate for applications such as emergency response, telemedicine, and so forth.

Heterogeneous objects, which belong to the same owner (mobile phones, music players, game consoles, etc.), can establish a relationships named *Ownership object relationship* (OOR). The last relationships defined in [4] is the *Social object relationship* (SOR) which established when objects come into contact, sporadically or continuously, because their owners come in touch with each other during their lives (e.g., devices and sensors belonging to friends, classmates, travel companions, colleagues) (Fig. 5).

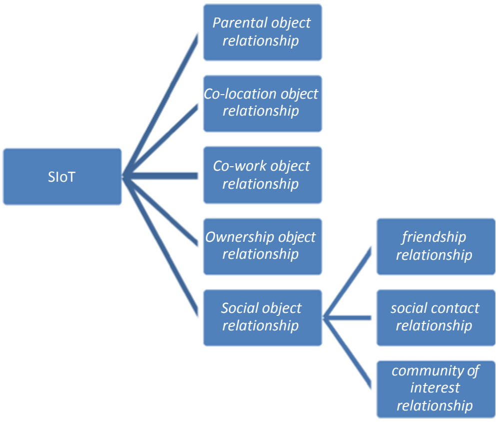

Fig. 5. Type of relationships between object on SIoT

Scalability: SIoT structure can be shaped as necessary to ensure the seamless of the network. Hence, the scalability is guaranteed as on human social network. Further, every node capable to create social relationships with other things.

Service Discovery: based on the scalable system each object can look for the requisite service by exploiting the information about its relationships to guarantee an efficient search for the desired services and objects in the same way humans find for knowledge in SN.

Trustworthiness: fulfilling the trust management consist of: collect the required information in order to make a trust relationship decision, evaluate the criteria of choosing the trust relationship, verify and readdress the existed relationships, Moreover, ensure the dynamic change of trust relationships [6]. A level of reliability can be established to take advantages of the degree of interaction between things that are friends.

4 Related Works

In order to improve the performance of service discovery of resources, the [7] have proposed a new resource discovery mechanism founded on the similarity of preference and motion patterns (RDPMs). In the first place, they abstracted the predilections of the nodes from their profile table and their resources, as well as the motion model of their trajectories using the clustering method AGNES. Then, they generated the cosine similarity of the node's preferences and motion model to construct a sub- community in a three-dimensional Cartesian coordinate system. Forming the virtual global communities using the similarity found among the sub-communities, ultimately to improve the search performance for the resources. Finally, they designed a resource discovery algorithm that can dynamically adjust the search radius to balance performance and communication costs.

In [8], a new framework of services based on a cognitive reasoning approach for the discovery of dynamic SIoT services in smart spaces is proposed. In other words, it is proposed to reason about the users' situational needs, their preferences and other social aspects as well as the surrounding environment to generate a list of services adapted to the situation, corresponding to the needs of the users. This reasoning approach is then implemented as a proof of concept prototype, namely Airport Dynamic Social, within a smart airport. Finally, an empirical study to evaluate the efficiency of the reasoning approach shows a better adaptability of services to the needs of the situation.

The SIoT allows objects to establish various relationships people-to-things and things-to- things. Furthermore, objects belonging to different IoT applications can build their own profiles, which can be shared with the Social IoT. Based on the established relationships and objects profile [9] have provided a concept of exploiting the SIoT for recommendation services among various IoT applications. For more understanding the concept of recommendation, authors provided an illustration application scenario.

Here in [10] Authors went one step further by dealing with the highly heterogeneous environment of IoT from the current state of evolution of the novel SIoT paradigm solved scalability issues. First, they analyzed two features of IoT heterogeneity: (1) object types and formations as well as socialization problems and (2) communication protocols for interoperability. Then, to support seamless service discovery, they presented the on-site service discovery architecture in the heterogeneous IoT environment, consisting of four main functional schemas: discovery region determination, on-site agent selection, query based on the location and management of roaming.

In SIoT, it is very important to define appropriate rules for objects to select good friends, as these affect the performance of the services developed over this social network. The [11] addressed this problem by analyzing the possible strategies for the benefit of the overall navigability of the network. Based on the properties of the local network, Authors proposed five heuristics, which also likely have an impact on the overall structure of the network. Then they conducted in-depth experiments to analyze performance in terms of giant components, average degree of connectivity, local aggregation, and average path length.

Unexpectedly, they found that minimizing local clustering in the network provided the best results in terms of average path length. In addition, they performed further analysis to understand the potential causes, which were related to the number of hubs in the network.

The importance of trust management appears in the case where the owners carry their IoT devices when they move from a friendly environment (e.g., a social club) to an unfriendly environment (e.g., a neighborhood one does not go often). The aim in [12] is improving the security and enhance the performance of social IoT applications more particularly in dynamically changing environments. Authors intend to design and validate an adaptive trust management protocol that can dynamically fit trust design parameter settings responding to environmental changing conditions to afford accurate trust assessment and to maximize application performance. They focused on trust protocol design that can deal with malicious nodes. The proposed protocol had desirable trust convergence, accuracy, and resiliency properties. Further such protocol has to take into consideration the dynamic changing of social relationships among the "owners" of devices in IoT systems in spite of the presence of misconduct of nodes which disrupt the functionality of a social IoT system.

Objects in Social IoT create social relationships autonomously in order to find the trusted objects, which can provide the needed service. The main contributions in [13] is definition of two models for trustworthiness management based on the solutions proposed for P2P and social networks. In the subjective model, which is closer to the social scenario, each node calculates the trustworthiness of its friends based on its own experience and the opinions of friends in common with the potential service provider. In the objective model, obtained from the P2P scenario, the information on each node is distributed and stored using a Distributed Hash Table (DHT) structure so that any node can use the same information.

- Assessment of the benefits of trustworthiness management in IoT, which illustrates how it can efficiently isolate almost all misbehaving nodes in the network at the expense of increased network traffic caused by the exchange of feedback.

Classification of Works According to the Domain of Contribution

In the Subsect. 3.3, we discuss the contribution of SIoT comparing to IoT then we review the majority of work in the area of SIoT environments. In this section, we provide a classification of those related work based on the domain of their contribution in Table 1.

Table 1. Classification of related works based on SIoT contribution

Related work	Relationships management	Scalability	Service discovery	Trustworthiness
[7]			✓	
[9]	✓		✓	
[11]	✓			
[8]			✓	
[10]		✓		
[12]				✓
[13]				✓

5 Challenges and Open Research Issues

Integrating IoT and SN is not a spur of the moment but this technology still an immature. With the aim of making a mature SIoT paradigm, there are still many challenges that must be faced prior to the worldwide deployment of this technology:

Interoperability and Standardization: Due of the heterogeneous nature of IoT things, including the different information processing and communication skills, as well as the characteristics and data, relationships and capabilities of the SN user, the system must be able to Manage this variety of data types, ensuring interoperability between all Components, the most widespread method to achieve the interoperability by using the ontology this latter is a technique of specification and conceptualization of a set of objects and the relationships among them well formulated.

Power and Energy Management: Objects that participate in the SIoT generally move around and are not bound to unlimited power. Therefore, users, who use portable devices that usually, work with batteries. Therefore, energy saving is a conditioning factor in the plan and operation of SOI, and effective energy management should be implemented at all levels, M2M device communications to interface design.

Interactions and Interfaces: The SIoT base will focus on providing users with a high-level experience that can consume and produce data and services from objects and other users. Therefore, the human- centered interface should present a user-friendly way to interact with objects and users. The way users and devices interact with each other is always an open challenge. Some approaches such as [9] and [14] propose a set of possible interactions between the different elements, but most are focused on specific applications. A global set of interactions must be defined, as well as methods for managing these interactions, for example, users can obtain data from their own devices, Authors in [9] propose that SIoT constructs an object profile based on IoT application data that can be exchanged with the SIoT network to be accessible to other IoT applications, in this way, SIoT recommends applications and information to its users.

Semantics and Context Management: The SIoT aims to provide functionality in several situations and a set of devices can be used for several purposes simultaneously. Thus, the ability to properly manage the current context not only improves the performance of the system, but also makes it more usable by providing unequivocal access and interpretation of data. A semantic management context can be made as (1) first analyze existing definitions for each of the terms (2) and from this conclude a definition of the whole term [15] Semantic approaches based on RDF (Resource Description Format) and OWL (Ontology Web Language) can be extended to include descriptors for SIoT users and device characteristics, which facilitates interoperability across all components [4].

Data mining and Emotional Artificial Intelligence: Humans contact their personal device more than their family members; more and more smart devices will be able to aware the emotions and moods of their owner rely on certain data and facts. Further, Emotional AI allows daily life objects to detect, analyze, process and react based on the emotional states and moods of humans. In addition, Emotional AI can lead to high quality of experience i.e. stockholders may base their decision on the emotional reactions rather than the rational ones.

6 Conclusion

In this paper we introduced how the convergence of the Internet of Things (IoT) technologies with the social networking concepts has led to a new paradigm named the Social Internet of Things (SIoT), then we presented a general review of Social IoT; its architecture, key improvement and the contribution of this paradigm comparing to IoT, and for more clarification of the SIoT we have given some related works and its classification according to their domain of contribution next we defined research challenges and open issues which have to be accomplished to obtain a mature technologies.

References

1. Atzori, L., Iera, A., Morabito, G., Nitti, M.: The Social Internet of Things (SIoT) - when social networks meet the Internet of Things: concept, architecture and network characterization. Comput. Netw. **56**, 3594–3608 (2012)
2. Atzori, L., Iera, A., Morabito, G.: SIoT: giving a social structure to the Internet of Things. IEEE Commun. Lett. **15**, 1193–1195 (2011)
3. ITU: The Internet of Things. Itu Internet Rep 2005, no. 212 (2005)
4. Ortiz, A.M., Hussein, D., Park, S., Han, S.N., Crespi, N.: The cluster between Internet of Things and social networks: review and research challenges. IEEE Internet Things J. **1**, 206–215 (2014)
5. Guinard, D.: A web of things application architecture - integrating the real-world into the web. Ph.D. th, ETH Zurich, no. 220 (2011). http://webofthings.org/dom/thesis.pdf
6. Grandison, T., Sloman, M.: A survey of trust in internet applications. IEEE Commun. Surv. Tutor. **3**(4), 2–16 (2000)
7. Li, Z., Chen, R., Liu, L., Min, G.: Dynamic resource discovery based on preference and movement pattern similarity for large-scale social Internet-of-Things. IEEE Internet Things J. **4662**, 1 (2015). http://ieeexplore.ieee.org/lpdocs/epic03/wrapper.htm?arnumber=7140727
8. Hussein, D., Han, S.N., Lee, G.M., Crespi, N., Bertin, E.: Towards a dynamic discovery of smart services in the social Internet of Things. Comput. Electr. Eng. **58**, 429–443 (2017)
9. Saleem, Y., Crespi, N., Rehmani, M.H., Copeland, R., Hussein, D., Bertin, E.: Exploitation of social IoT for recommendation services. In: 2016 IEEE 3rd World Forum Internet Things, WF-IoT 2016, pp. 359–364 (2017)
10. Park, S., Hussein, D., Crespi, N.: On-site service discovery along user roaming over Internet of Things. In: 2015 IEEE International Conference on Consumer Electronics, ICCE 2015, pp. 194–195 (2015)
11. Nitti, M., Atzori, L., Cvijikj, I.P.: Friendship selection in the social Internet of Things: challenges and possible strategies. IEEE Internet Things J. **2**, 240–247 (2015)
12. Chen, I.R., Guo, J., Bao, F.: Trust management for SOA-based IoT and its application to service composition. IEEE Trans. Serv. Comput. **9**, 482–495 (2016)

13. Nitti, M., Girau, R., Atzori, L.: Trustworthiness management in the social Internet of Things. IEEE Trans. Knowl. Data Eng. **26**, 1253–1266 (2014)
14. Beltran, V., Ortiz, A.M., Hussein, D., Crespi, N.: A semantic service creation platform for Social IoT. In: 2014 IEEE World Forum Internet Things, WF-IoT 2014, pp. 283–286 (2014)
15. Jacoby, M., Antonić, A., Kreiner, K., Łapacz, R., Pielorz, J.: Semantic interoperability as key to IoT platform federation. In: Podnar Žarko, I., Broering, A., Soursos, S., Serrano, M. (eds.) InterOSS-IoT 2016. LNCS, vol. 10218, pp. 3–19. Springer, Cham (2017). https://doi.org/10.1007/978-3-319-56877-5_1