

A Novel Framework for Social Internet of Things

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Abstract

Social Internet of Things (SIoT) aims at assimilating the concepts of Internet of Things and Social Networks for providing value added services to the humans. The number of connected devices in the era of Internet of Things is very large and the key challenge is to acquire the required information in an efficient manner. Communication between the connected objects can be enhanced by exploiting the social behaviour of the users of such devices. Recently, there has been a flourish of proposals for giving social like capabilities to the things connected by the internet. The focus has been on developing mechanisms that shall allow direct interactions among the objects that are “friends” with each other. Different models and guidelines have been proposed for materializing this social aspect of the connected objects. They are, however, related to specific device types and their individual functionalities, and often require a dedicated internet connection for the delivery of services. The paper proposes a generic framework that enables interaction among the devices having diverse capabilities and heterogeneous platforms. The work leverages the social relationships among the participants (devices and users) in the system for delivering the required services to the users. The framework relies on the Bluetooth Low Energy (BLE) protocol for disseminating information between the devices. One of the major advantage of the proposed work is that the services can be provided by the devices even in the areas having no internet connectivity. The proposed framework can be employed for developing applications that utilizes the social behavior of the users for providing services to them in an efficient manner.

Keywords: Bluetooth Low Energy, Internet of Things, Social Internet of Things, Social Network

1. Introduction

Social networking tends to connect people having similar interests. The Pew Research Center's Internet and American Life Project, claims that approximately 74% of the online adults are a member of one or more social networking websites⁸. In the era of ubiquitous computing, people are utilizing their social networks as a medium for sharing contents with others. This has motivated the researchers to exploit the social dimensions of different content-sharing domains.

The amalgamation of Social Network and Internet of Things IoT has been gaining momentum in the recent era. This is due to the fact that a group of individuals can provide far more precise solutions to complex problems than a single individual. Social Internet of Things² represents an environment allowing social interaction

among smart devices and humans⁹. Social Internet of Things considers devices as the active participants. Information and services shared with the humans and other devices are governed by their “social” roles in the network. The key requirements for architecting a social network of things are: to allow objects to have their own social networks; to allow objects to share their services as per the privacy policies imposed by the user of the device. Services made available to the humans shall be the result of autonomous inter-object interactions occurring on the objects' social network.

Recently, researchers have shown an increased interest in exploring the social dimension of things in IoT. Vazquez introduced the idea of social devices in⁴ in which the augmented objects utilize the internet for promoting socialization and delivering better services to the users. The authors in² proposed a synergy of social

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and technical networks for offering services not just to humans but other technical systems as well. The early research was followed by a flourish of proposals that aimed at exploring the social paradigm of IoT. Atzori et al. in ³ and ⁴ have reviewed this evolution of the social paradigm in the context of IoT. Ortiz in⁴ proposed a human-centered design for the SIoT. This can be attributed to the fact that the services provided by the devices have a direct consequence on humans. Orchestrating the design of IoT in such a fashion provides a promising aspect of leveraging the social behavior of humans to ensure reliable functioning of the devices. An early effort in this direction was made in⁶, where the APIs exposed by a social networking portal were employed for sharing services of the devices through a proxy host. The work, however, lacks in providing any strategy for searching and sharing services efficiently in the social network of an individual, thereby ensuring trust and accountability. The authors in⁹ Investigates the repercussions of the synergy between the social networks and IoT, thereby providing interesting use-cases as applications. The authors, however, remains vague about the architecture and protocols that shall be employed for the realization of such a vision. They also did not propose any strategy for establishing relationship between objects. The model proposed in ⁷ considers the social dimension of the devices but has scalability issues. The framework proposed in this paper can adapt to a large scale evolving network of devices that leverages the social network of humans for searching and sharing, while ensuring trusted and accountable service delivery.

The remaining of this paper is organized as follows. Motivation for using BLE protocol has been discussed in Section 2. Section 3 explains the architecture of the proposed framework. Section 4 explains the possible use-cases for applications designed using the proposed framework and finally, Section 5 gives the concluding

remarks.

2. Bluetooth Low Energy

BLE offers an opportunistic sensing mechanism where devices search for other BLE devices in their range for querying and retrieving the required information. The application runs as a background process and discreetly listens for other devices running BLE service. Upon finding a BLE enabled device, data is exchanged without any user intervention. This strategy relaxes the requirement of dedicated internet connection for the IoT devices by utilizing nearby BLE devices for finding the appropriate information, which can further be processed as per the requirement.

BLE devices can be classified into central and peripheral devices ¹⁰. The peripheral devices send advertisement packets on specific channels. The advertisement packet contains limited bits of manufacturer specific data (MSD) that provides the flexibility of defining custom payload. The central device intercepts these advertisement messages and upon finding a device with required information, establishes a communication channel with it for performing data transfer.

The BLE Advertisement packet is shown in Figure 1 ¹⁰. The proposed work aims at utilizing the payload (MSD) for the user-defined data rather than using it as an advertisement packet for establishing connections as per the BLE standard. The framework proposed in this paper employs vendor specific libraries and routines for providing a high level interface, thereby facilitating easy development of BLE sensing applications. The main objective of the work is to exploit the process of BLE discovery for transmitting minimal payload to support a certain class of applications.

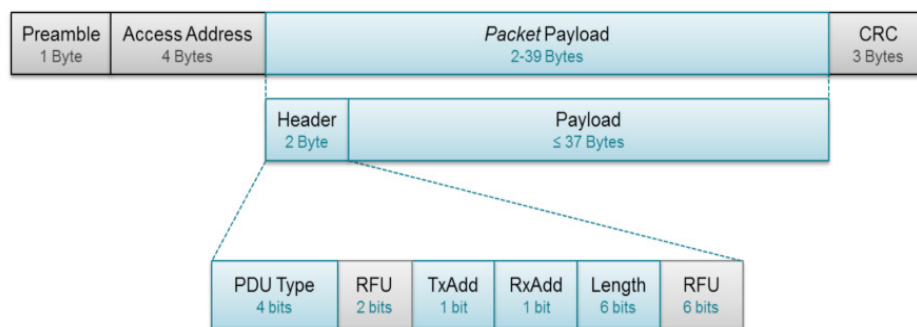


Figure 1. BLE data packet¹⁰.

3. Proposed Framework

Before diving into the framework details, the key requirements for developing the framework needs to be discussed.

- Development of a middleware for realizing the concept of social internet of things.
- Eliminating the use of a dedicated internet connection for materializing the advantages of internet of things.
- Smart scanning/advertisement schemes: time based, location based, etc.

Availability of these functionalities as a standard framework shall enable the development of applications that may utilize the social capabilities of the objects for availing the required services in an easy and efficient manner. Figure 2 illustrates the proposed framework.

The framework uses the libraries provided by the operating system and, in turn, provides services to the application developed on top of it. The components of the framework have been discussed in the following subsections.

3.1 Framework Manager

This module provides a generic interface for the functionalities related to BLE scanning and advertising.

The Framework Manager shall have the provision for inserting user specific data in the advertisement packet. User data can be a simple tag or a character string representing some information. The module shall handle scanning initiation and termination as well as advertisement procedure irrespective of the platform on which the framework has been deployed. The scanner component of this module shall capture all the possible devices available within the range. This can be useful in the areas where multiple devices are advertising their individual data.

On receiving an advertisement beacon, the Framework manager shall invoke the Privacy Manager module for identifying the appropriate privacy policy that shall be used for the extraction of data from the received packet.

3.2 Privacy Control

Privacy is an important issue in almost all the networks that carry data. Privacy Control module applies appropriate privacy policies for securing the data being transmitted. It assigns different levels of privacy for devices belonging to different friend groups. Whenever data is transmitted or received, this module retrieves the group, to which the destination device belongs. This information is provided by the Social Structure Database. Privacy settings are

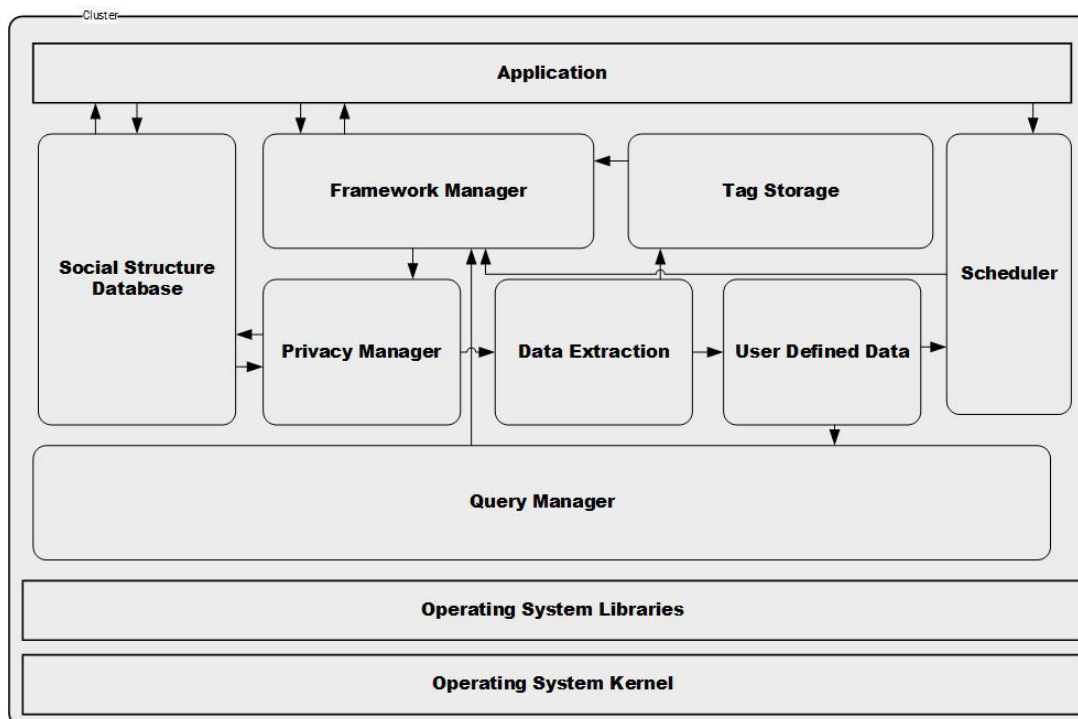


Figure 2. Proposed framework.

applied as per the information retrieved about the destination device. For instance, if data is to be made available publicly, it can be kept as a plain text. Data that is intended for specific friends can be encrypted using either symmetric or asymmetric keys.

3.3 Social Structure Database

This database stores the social network structure of a device. It categorizes the friends list into different groups as per the requirements of the user. This classification of friends into different groups is crucial for deciding the level of privacy that needs to be applied to the data being transmitted to such friends.

3.4 Data Extraction

This module shall extract the payload data from the packet using the appropriate security materials provided by the privacy manager. It shall then identify whether the advertisement data is a tag or some other user-defined data. If it is a tag, it shall be passed to the tag manager, otherwise it shall be stored in the User Defined Data database for retrieving the services as per the requirement.

3.5 Tag Storage

Tags represent the services offered by a device. This component shall store the predefined tags as well as the tags defined by the users as per their requirement. The tag present in the advertisement packet shall be compared with the stored tags. On successful match, an indication shall be sent to the Framework Manager for sending a Scan Request to the advertising device. The request shall contain a receipt of successful tag match and query for some additional data required for providing the service to the advertising device.

3.6 User Defined Data

This module shall store the user data received in response to the Scan Request. This data shall be used to query the database for the requested services.

3.7 Query Manager

This component manages the database related functionalities. It issues the queries formed from the user defined data received in the Scan Response. The result of the query is passed on to the framework manager that

forwards it to the device that is requesting the service. A query can be, for instance, a database search for the shopping items in the inventory of a shopping mall. The result of such a query can be the price list of the requested items that shall be forwarded to the requesting device for confirmation of payment.

3.8 Scheduler

Sensing/advertising mechanisms need not be functional at all the times. They may only be required at certain instances. The scheduler shall manage the smart scanning/advertising component of the framework. It shall provide triggers for initiating the scanning and advertisement mechanism. These smart triggers can be efficient in minimizing the computational overheads when the application shall be running continuously as a background process on the user's device. The triggers can be based on user location, activity or they may even be adaptive considering the battery drainage.

Devices may advertise their requirements in specific regions. To cater for this requirement, the module shall rely on the location services provided by the GPS. A region can be defined in terms of longitude, latitude and proximity radius. The module shall keep track of the user's movement and shall initiate the scanning/advertisement as soon as the user moves into the desired region. Another aspect can be considering use-cases where sensing/advertising is defined by the activity of the user. For instance, consider an office employee who needs to purchase a medicine on his way back to home. This requires advertisement of the name of the medicine so that any shop equipped with BLE sensing device may sense the requirement and inform the user's device about the availability of the medicine. However, as the user is not specific about any chemist shop, he may need this BLE advertisement while driving from his office to home.

4. Application Use-cases

Various application scenarios can be realized considering the heterogeneity and passiveness of Social Internet of Things. For instance, consider a customer who needs to purchase medicines from a chemist shop. The customer shall upload the medicine list on his mobile phone and visit one of the nearby shop. Based on his location the framework manager shall start advertising the

tag/medicine. The inventory server installed at the chemist shop receives the tag and matches it with the tag store at its end. If the tag matches, the server may send a SCAN Request to the customer acknowledging the successful receipt of the tag as well as informing the customer to send the medicine list. The user may share the medicine list in the SCAN Response. On receiving the medicine list, data is extracted at the inventory server and a query is fired to verify if the items are present in its inventory or not. The query shall return the availability and pricing information of the medicine items. This information is sent to the customer who may then place the order and choose a mode for payment as well as delivery. Figure 3 represents the message flow involve in such a transaction.

Another striking use-case can be making people aware about their friends who may be present in their close vicinity. Users who wish to advertise their presence may advertise the tag 'presence' which when received by other users can be used to notify the presence only if the advertising device is in the friends' list of the receiving device. Figure 4 depicts the aforementioned scenario.

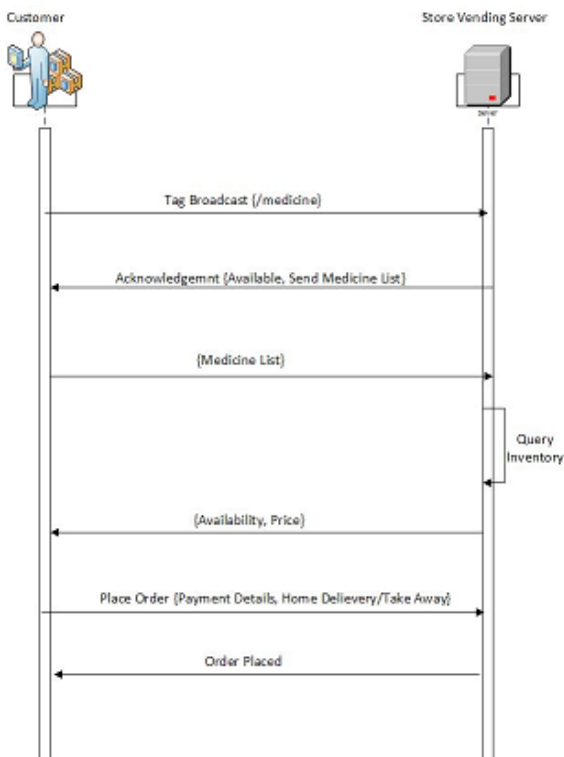


Figure 3. Sample message flow for shopping use-case.

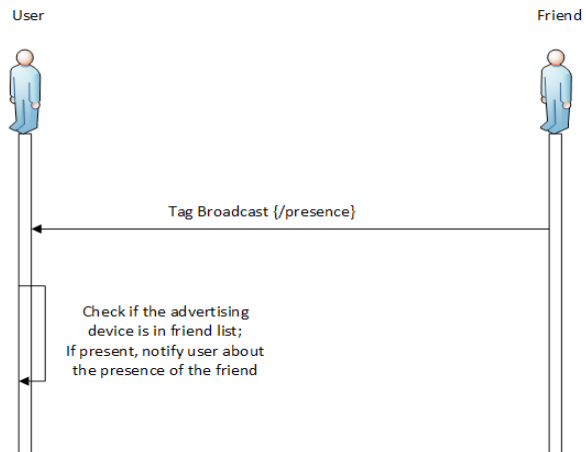


Figure 4. Sample message flow for meeting a friend use-case.

5. Conclusion and Future Work

Recently, the concept of integrating Social Networks and IoT has been the motive of several independent research activities as it promises to deliver efficient solutions for interconnecting large number of objects for providing services in a collaborative manner. In this paper, a novel framework has been proposed that leverages the social capabilities of the objects for providing information and services to the humans as well as among themselves. The focus was on providing a generic framework, irrespective of the platform, that can be employed for developing applications that realize the concept of Social Internet of Things. The framework uses BLE protocol for information sharing and hence, eliminates the need of dedicated internet connectivity which otherwise is a serious bottleneck in remote regions lacking internet connectivity.

In future, the modules of the proposed framework shall be explored in more details. Mechanisms to support resource discovery, privacy enforcement and data maintenance need to be addressed. The framework shall also be enhanced to deliver more efficient and scalable solution.

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