Constrained application for mobility management using embedded devices in the Internet of Things based urban planning in smart cities

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\textbf{A B S T R A C T}

The Constrained Application Protocol (CoAP) has been widely used, as the number of embedded sensors or devices increases. To support mobility management in web based Internet-of-Things environment is critical issue. For this purpose, a CoAP-based mobility management protocol, named CoMP has been proposed, but this protocol was designed for a single sensor node mobility. However, it does not perform well in group-based mobility. To overcome this limitation, we propose a CoAP-based group mobility management protocol, named CoMP-G. In the proposed scheme, one of the body sensor will function as a coordinator and it will exchange all the control messages with web-of-things mobility management system (WMMS) on behalf of other body sensors. Besides, each WMMS maintains the information of the group of body sensors. From the numerical analysis, we proved that the proposed scheme gives the best performance in terms of total signaling and handover delay from the existing CoMP protocol.

1. Introduction

Wireless Networks are the biggest components of network industry where computer networking is done using wireless connections by connecting network nodes (Al-Fuqaha, Guizani, Mohammadi, Aledhari, & Ayyash, 2015). With passing days' different devices like mobile phones are now become the basic needs. So there is a need of Internet Protocol which are especially for the mobile devices, so even when they move from one network to another. Nowadays, we are not limited to one network device, so basically communication becomes Machine to Machine, Human to Machine and Machine to Human and Human to Human, this major penetration introduced the idea of Internet of Things (IoT) (Ahmad, Paul, MazharRathore, & Chang, 2016; Guinard et al., 2009; Jin, Gubbi, Marusic, & Palaniswami, 2014; Razzaque, Milojevic-Jevric, Palade, & Clarke, 2016). IoT serves in many fields like Medical sciences, electronic engineering as well as mechanical engineering. IoT play a major role in the field of health care (Ghamari et al., 2016; Islam, Kwak, Kabir, Hossain, & Kwak, 2015; Khan, Silva, & Han, 2016). Intelligent medical small sensors can be worn on or implanted in the human body. These sensors measured the data and send it to external medical doctor. With these sensors the patient can move from place to another. Many people die from different fatal diseases, when it is diagnosed lately. For this purpose, the Wireless Body Area Network is used to detect early and prevent from the fatal diseases (Cavallari et al., 2014; Ghamari et al., 2016; Sharma et al., 2016). A wireless body area network are the specific types of sensor network which are designed to handle multiple medical sensors placed inside or outside of the body.

In most wireless sensor network applications, sensor nodes are small, lightweight, inexpensive, and requires to operate permanently. Current technology is not able to meet most of the requirements for the permanent operation of the sensor node due to the slow development of battery technology is realized. Due to the limitation of sensor battery, the researcher designed a new Constrained Application Protocol (CoAP). CoAP is a RESTful application protocol for low power and constrained devices in Wireless Sensor Networks (WSNs) or Low-power and Lossy Networks (LLNs). The basic communication model for CoAP is the client-server model that exchanges messages between clients and servers. CoAP also provides group communication for effective communication with numerous sensors (Bormann, Castellani, & Shelby, 2012; Kovatsch, Duquennoy, & Dunkels, 2011; Shelby, Hartke, & Bormann, 2014).

The Internet Engineering Task Force (IETF) has designed the CoAP group communication using IP multicast. However, multicast-based group communication scheme may not be reliable in WSNs. It is difficult to receive a response message for CoAP client, since connectivity between sensor and client may not be stable. To solve these problems, the unicast-based group communication scheme was developed. However, such unicast-based scheme has low performance for...
transmission delay and large network overhead. These group communication is for static nodes.

In wireless domain, it is necessary to provide mobility to sensor nodes. So for this purpose, a CoAP-based mobility management protocol, named CoMP has been proposed, but this protocol was designed for a single sensor node mobility. However, it does not perform well in group-based mobility (Chun, Kim, & Park, 2015). To overcome this limitation, we propose a CoAP-based group mobility management protocol, named CoMP-G, in which one of the sensor will function as a coordinator and it will exchange all the control messages with web-of-things mobility management system (WMMS) on behalf of other body sensors. Besides, each WMMS maintains the information of the group of mobile sensors.

The rest of this paper is organized as follows. Section 2 describes the existing candidate mobility schemes for comparison. In Section 3 describes the proposed group-based mobility scheme. Section 4 demonstrates the performance analysis by comparing the proposed and existing scheme by numerical analysis and results. Section 5 concludes this paper.

1.1. Research motivation

In this world, various devices are connected to other devices and things with the help of Internet, 3G/4G, wireless LAN, etc. This enables a rich infrastructure for Internet of Things that aims to connect various things (for instance, cellular phones, wireless body area network, Wi-Fi, access points, etc.) with distinctive addresses and allows these devices to interact with each other in an efficient way, hence generating Big Data. Thus, the primary goal is to select best and optimal features in the IoT Big Data, so that to reduce the energy consumption involved in the IoT during communicating Big Data over the Internet.

In this paper, while aiming for a selection features, we focus on IoT Big Data and present various technologies toward IoT. Specifically, we propose a system architecture that exploits IoT for the different application, such smart cities, smart home, traffic management, healthcare system, which is a novel paradigm in modeling and optimizing Big Data in IoT. The system architecture is used to aggregating Big Data, exploiting feature selection algorithm and forward the data toward Hadoop ecosystem. Also, the IoT-based Big Data architecture is based on feature selection. Thus, feature selection in Big Data using convolution method is considered. Such feature selection aspect pitches us against the problem of optimization. We intend to solve this problem of an optimizing feature selection by considering Ant Colony Optimization technique. Eventually, future directions and open challenges are discussed regarding IoT in 5G network. To the best of our knowledge, this work is the first that exploits the realization of the feature selection for IoT system given the Big Data. We hope and believe that this work will be useful for the IoT systems and will provide state-of-the-art guidance for research vis-à-vis IoT and big Data.

1.2. Research contribution

The main contribution of this paper is as follows.

- At first, we present a hierarchical framework for the extracting feature in IoT Big Data. The framework first internments the scalable features of IoT, which helps in the extension of network commodities.
- The exploitation of Kalman filter is used to enhance the efficiency of big data analysis in a real-time environment. Moreover, the proposed ABC algorithm assists the architecture in extracting features in Big Data.
- The proposed data feature selection algorithm based on ABC improve the accuracy of the system. We have tested ten data sets with the proposed feature selection based on ABC to check the performance of the system in more explainable mode. Moreover, the proposed scheme is compared with well know Swarm approaches to test its capabilities on various platforms.

1.3. Organization

The rest of the paper is organized as follows. Section 2 briefly describes the latest background and related work. Section 3 presents the detailed description of the proposed scheme that includes system architecture of Hadoop-based ABC. Section 4 comprises extensive simulations of the proposed scheme. And finally, Section 5 offers a conclusion.

2. Background and related work

The existing CoMP scheme is based on CoAP protocol (Chun et al., 2015). As shown in Fig. 1, when a set of body sensors are attached with access router (AR), then each body sensor sends POST Request for Registration message to WMMS via AR (Step 1, 2). Upon reception of this POST Request for Registration message from each of the body sensors, WMMS will update the database and responds with a ACK Response for Registration to each of the body sensors via AR (Step 3, 4).

On the other hand, the CoAP web client also registered with WMMS by exchanging POST Request for Registration and ACK Response for Registration messages (Step 5–8). As the CoAP web client want to communicate with body sensors, it sends GET Request for Discovery message for each body sensor to WMMS via AR (Step 9, 10). After
finding each body sensor in the database, the WMMS replies with ACK Response for Discovery message to CoAP web client via AR on behalf of each body sensor (Step 11, 12). After discovery, the CoAP web client and each body sensors can exchange the data via AR’s.

In this section, we consider the case in which the group of sensors moves from previous AR (p-AR) to new AR (n-AR) as shown in Fig. 2. In order to perform the handover operation, each of the body sensors first detect the radio signal strength (RSS) from the previous AR. When RSS drops below by a certain threshold value, each of the body sensor starts handover operation by sending PUT Request for Holding to WMMS via p-AR (Step 1, 2). The WMMS updates the H_Flag status to 1 for all the body sensors. After that, the WMMS replies with ACK Response for Holding to each body sensor via p-AR (Step 3, 4). The WMMS also forwards the PUT Request for Holding on basis of each body sensor to CoAP web client via AR (Step 5, 6). The CoAP client updates its cache for each sensor. The CoAP web client respond with ACK Response for Holding to WMMS via AR for each request on the basis of body sensor (Step 7, 8).

We now assume that the body sensors changes its point of attachment in the same network domain. When the body sensors is detached from p-AR and attached to n-AR and received new temporary address from new AR (n-AR), each body sensor notifies the WMMS by sending PUT Request for Binding Update via n-AR (Step 9, 10). The WMMS update its database for each body sensor and respond with ACK Response for Binding Update to each body sensor via n-AR (step 11, 12). The body sensors also updates the CoAP web client by sending PUT Request for Binding Update via n-AR to CoAP web client (Step 13–15). The CoAP web client update its cache for each body sensor and replies with ACK Response for Binding Update to each body sensor via n-AR (Step 16–18). Now, each body sensor and CoAP web client communication is established through new AR.

3. Proposed scheme

This section first describes the network model of the proposed scheme and then describing the registration and handover operations.

3.1. Network model of group mobility management using CoAP

Fig. 3 shows the network model of group mobility management using CoAP. We consider a group of sensors attached to human body which monitors the measured data. One of them function as a coordinator and on behalf of the other sensors, it can exchange the control signaling messages with Access Router (AR). The AR domain contains Full-Function Device (FFD). The web-of-things mobility management system (WMMS) maintains the information of the group of sensors which is required to perform mobility as shown in Table 1. The IP addresses of sensors are permanent, while the IP addresses of AR are temporary. H_Flag indicate the handover status of the group of sensors. If it is 1, then the corresponding group of sensors are in handover status.

<table>
<thead>
<tr>
<th>Group</th>
<th>P_Addr (Sensor IP Address)</th>
<th>T_Addr (AR IP Address)</th>
<th>H_Flag</th>
<th>Lifetime</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>P_Addr_1</td>
<td>T_Addr</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>P_Addr_2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>P_Addr_3</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
If it is 0, then the corresponding group of sensors are not in handover status. A lifetime is the time in which the binding of permanent addresses of the group of sensors and temporary address of the AR are effective.

Initially, the coordinator communicates with CoAP web client in the previous access router (p-AR) domain, and then it moves to a new access router (n-AR) by handover.

3.2. Initial registration and data delivery

The main purpose of the registration phase is to reduce the amount of control messages. Fig. 4 shows the detail initial registration and data delivery of the proposed scheme. When a group of body sensors enter a CoMP AR domain and the coordinator is attached to AR, it sends aggregated POST Request for Registration message, containing the information on group, to WMMS via AR (Step 1, 2). Upon reception of this POST Request for Registration message from the coordinator, WMMS will make group of body sensors and responds with an ACK Response for Registration to coordinator via AR (Step 3, 4).

On the other hand, the CoAP web client also registered with WMMS by exchanging POST Request for Registration and ACK Response for Registration messages (Step 5–8). As the CoAP web client want to communicate with body sensors, it sends GET Request for Discovery message for finding group of body sensors via AR (Step 9, 10). After finding group of body sensors in the database, the WMMS replies with ACK Response for Discovery message to CoAP web client via AR (Step 11, 12). After discovery, the CoAP web client and coordinator can exchange the data via AR’s.

3.3. Handover operations

In this section, we consider the case in which the group of sensors moves from previous AR (p-AR) to new AR (n-AR) as shown in Fig. 5. In order to perform the handover operation, the coordinator first detect the radio signal strength (RSS) from the previous AR. When RSS drops below by a certain threshold value, the coordinator starts handover operation by sending PUT Request for Holding to WMMS via p-AR (Step 1, 2). The WMMS updates the H_Flag status to 1. After that, the WMMS replies with ACK Response for Holding to coordinator via p-AR (Step 3, 4). The WMMS also forwards the PUT Request for Holding to the group for CoAP web client via AR (Step 5, 6). The CoAP web client updates its cache. The CoAP web client respond with ACK Response for Holding to WMMS via AR (Step 7, 8).

We now assume that the coordinator changes its point of attachment in the same network domain. When the coordinator is detached from p-AR and attached to n-AR and received new temporary address from new AR (n-AR), the coordinator notifies the WMMS by sending PUT Request for Binding Update via n-AR (Step 9, 10). The WMMS updates its database and respond with ACK Response for Binding Update to coordinator via n-AR (step 11, 12). The coordinator also updates the CoAP web client by sending PUT Request for Binding Update via n-AR to CoAP web client (Step 13–15). The CoAP web client update its cache and replies with ACK Response for Binding Update to coordinator via n-AR (Step 16–18). Now, CoAP coordinator and CoAP web client communication is through new AR.

4. Performance analysis

For performance analysis, we compare the registration and handover delays for the two candidate mobility schemes: CoMP, and CoMP-G.

4.1. Analysis model

We consider a network illustrated in Fig. 6, in which each wired/wireless link is represented by bandwidth, latency, and average queuing delay. We adopt a generic model for Multiple Access Control (MAC) scheme to focus on the analysis of registration delay and handover delay associated with the proposed mobility scheme.

We summarize the notations used in our analysis in Table 2.

In the figure, we denote $Tx-y(S)$ by the transmission delay of a message with size $S$ sent from $x$ to $y$ via the ‘wireless’ link, where each message can experience the failure at the probability of $q$ by using ‘iid’ error model. Then, $Tx-y(S) = \frac{1}{1 - q} \times (S/Bw) + Lw + Tq$. In the meantime, we denote $Tx-y(S, Hx-y)$ by the transmission delay of a message with size $S$ sent from $x$ to $y$ via ‘wired’ link, where $Hx-y$ represents the number of wired hops between node $x$ and node $y$. Then, $Tx-y(S, Hx-y)$ is expressed as $Tx-y(S, Hx-y) = Hx-y \times (S/Bw) + Lw + Tq$.

4.2. Total signaling delay (TSD)

As shown in Fig. 1, when the body sensors are attached to an AR, each body sensor exchange POST Request for Registration and ACK Response for Registration messages with WMMS. After that WMMS updates its database. Accordingly, we get the registration delay (RD) of CoMP as follows:

$$RD_{CoMP} = N_s \times [2T_{FFD} + 2T_{FFD-AR} + 2T_{AR-WMMS}]$$

In CoMP, the data delivery delay (DDD) from CoAP web client to body sensors can be calculated as follows. First, the CoAP web client registered with WMMS. After registration, the CoAP web client want to
communicate with body sensors. For finding the body sensors, CoAP web client exchanges GET Request for Discovery and ACK Response for Discovery messages for each body sensor with WMMS via AR. After discovery, the CoAP web client and each body sensors can exchange the data via AR’s.

Thus, the data delivery delay (DDD) of CoMP can be represented as follows,

$$DDD_{CoMP} = N_b \times [2T_{C-AR}(S_i) + 2T_{AR-WMMS}(S_i)]$$  \hspace{1cm} (2)$$

So, we obtain the TSD of CoMP as

$$TSD_{CoMP} = RD_{CoMP} + DDD_{CoMP} \hspace{1cm} (3)$$

As shown in Fig. 4, the CoMP-G uses the aggregated POST Request for Registration and ACK Response for Registration messages between coordinator and WMMS. Thus, we get the RD of COMP-G as

$$RD_{CoMP-G} = 2T_{C-FFD}(S_i) + 2T_{FFD-AR}(S_i) + 2T_{AR-WMMS}(S_i) \hspace{1cm} (4)$$

In CoMP-G, the data delivery delay (DDD) from CoAP web client to body sensors can be calculated as follows. First, the CoAP web client registered with WMMS. After registration, the CoAP web client want to find the body sensors to communicate with them. For this purpose, the CoAP web client exchanges GET Request for Discovery and ACK Response for Discovery messages for body sensor with WMMS via AR. After discovery, the CoAP web client and each body sensors can exchange the data via AR’s.

Thus, the data delivery delay (DDD) of CoMP-G can be represented as follows,

$$DDD_{CoMP-G} = 2T_{C-AR}(S_i) + 2T_{AR-WMMS}(S_i) \hspace{1cm} (5)$$

So, we obtain the TSD of CoMP-G as

$$TSD_{CoMP-G} = RD_{CoMP-G} + DDD_{CoMP-G} \hspace{1cm} (6)$$

4.3. Handover delay (HD)

In this section, we consider handover delay in which the group of sensors moves from previous AR (p-AR) to new AR (n-AR) as shown in Fig. 2. Each of the body sensors first detect the RSS signal from the previous AR. When RSS drops below by a certain threshold value, each of the body sensor starts handover operation by exchanging PUT Request for Holding and ACK Response for Holding messages with WMMS via AR. Then, WMMS also exchange the PUT Request for Holding and ACK Response for Holding messages for each of body sensor with CoAP web client via AR. The CoAP client updates its cache for each of body sensor.

When body sensors change its point of attachment and detached from p-AR and attached to n-AR, each body sensor exchanges PUT Request for Binding Update and ACK Response for Binding Update messages with WMMS. Each body sensor also updates the CoAP web client by exchanging PUT Request for Binding Update and ACK Response for Binding Update messages. Now, each body sensor and

![Fig. 5. Handover Operations.](image-url)

![Fig. 6. Registration Delay Vs handover delay.](image-url)

Table 2
Notation/Parameter description.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$S_i$</td>
<td>Size of control packets (bytes)</td>
</tr>
<tr>
<td>$N_b$</td>
<td>Number of sensors in the domain</td>
</tr>
<tr>
<td>$B_w$</td>
<td>Wired link bandwidth (Mbps)</td>
</tr>
<tr>
<td>$B_wl$</td>
<td>Wireless bandwidth (Mbps)</td>
</tr>
<tr>
<td>$L_w$</td>
<td>Wired link delay (ms)</td>
</tr>
<tr>
<td>$L_{wL}$</td>
<td>Wireless link delay (ms)</td>
</tr>
<tr>
<td>$H_{ab}$</td>
<td>Hop count between node a and b in the network</td>
</tr>
<tr>
<td>$q$</td>
<td>Wireless link failure probability</td>
</tr>
<tr>
<td>$T_q$</td>
<td>Average queuing delay at each node</td>
</tr>
</tbody>
</table>
CoAP web client communication is established through new AR. Accordingly, we get the HD of CoMP as follows.

\[
H_{\text{CoMP}} = N_s \times \left[ 2T_{\text{FPD}}(S_c) + 2T_{\text{FFD-AR}}(S_c) + 2T_{\text{AR-WMMS}}(S_c) \\
+ 2T_{\text{AR-AR}}(S_c) + 2T_{\text{AR-WMMS}}(S_c) + 2T_{\text{FFD}}(S_c) \\
+ 2T_{\text{FFD-AR}}(S_c) + 2T_{\text{AR-WMMS}}(S_c) + 2T_{\text{AR}}(S_c) \\
+ 2T_{\text{FFD}}(S_c) + 2T_{\text{AR-AR}}(S_c) + 2T_{\text{AR}}(S_c) \right]
\]  

(7)

In the proposed CoMP-G scheme, when the group of sensors moves from previous AR (p-AR) to new AR (n-AR) as shown in Fig. 5. Firstly, each of the body sensors detect the RSS signal, if it drops below by a certain threshold value, the coordinator starts handover operation by exchanging PUT Request for Holding and ACK Response for Holding with WMMS via p-AR. Then, WMMS also exchange the PUT Request for Holding and ACK Response for Holding messages with CoAP web client via AR. The CoAP client updates its cache for the group.

When body sensors change its point of attachment and detached from p-AR and attached to n-AR, coordinator exchanges PUT Request for Binding Update and ACK Response for Binding Update messages with WMMS. Coordinator updates the CoAP web client by exchanging PUT Request for Binding Update and ACK Response for Binding Update messages. Now, each body sensor and CoAP web client communication is established through new AR. Accordingly, we get the HD of CoMP-G as follows.

\[
H_{\text{CoMP-G}} = 2T_{\text{FPD}}(S_c) + 2T_{\text{FFD-AR}}(S_c) + 2T_{\text{AR-WMMS}}(S_c) \\
+ 2T_{\text{AR-AR}}(S_c) + 2T_{\text{AR-WMMS}}(S_c) + 2T_{\text{FFD}}(S_c) \\
+ 2T_{\text{FFD-AR}}(S_c) + 2T_{\text{AR-WMMS}}(S_c) + 2T_{\text{AR}}(S_c) \\
+ 2T_{\text{FFD}}(S_c) + 2T_{\text{AR-AR}}(S_c) + 2T_{\text{AR}}(S_c)
\]  

(8)

4.4. Numerical results

Based on the equations, we compare the performance of the existing and proposed schemes. For numerical analysis, we configure the default parameter values, as described in Table 2, by referring to (Chun et al., 2015; Makaya & Pierre, 2008).

Fig. 7 illustrates the impact of wireless link delay (Lwl) on total signaling delay. We can see in the figure, that the total signaling delay linearly increases, as Lwl gets larger for both the candidate schemes. It is shown in the figure that the proposed CoMP-G scheme perform better than the existing CoMP scheme. This is because coordinator in CoMP-G scheme perform signaling operation with WMMS on behalf of body sensors.

Fig. 8 shows the impact of number of sensors (NS) on total signaling delay. We observe from the figure that CoMP gives worse performance than the CoMP-G. This is because each of the body sensor exchanges signaling messages with WMMS and also the CoAP web client sends discovery messages to find each body sensors addresses to WMMS. In contrast, the proposed CoMP-G scheme is not affected by the number of sensors. This is because in the proposed scheme the coordinator can exchange the signaling messages with WMMS on behalf of body sensors.

Fig. 9 shows the impact of wireless link failure probability on total signaling delay. We observe that the total signaling delay linearly increases, as q gets larger for both the candidate schemes. This is because both the schemes use wireless links for the body sensors. We can see in the figure that the proposed scheme gives better performance than the existing scheme.

Fig. 10 illustrates the impact of hop count between AR and WMMS on total signaling delay. From the figure, we can see that hop count between AR and WMMS gives significant impact on both the candidate schemes. In particular, CoMP is more sensitive. This is because each of the body sensor exchanges signaling messages with WMMS. While CoMP-G is less sensitive, this is because the coordinator can exchange the signaling messages with WMMS on behalf of body sensors. We can see in the figure that the proposed scheme performs better than the existing scheme.

4.4.1. Handover delay (HD)

Fig. 11 shows the impact of wireless link delay (Lwl) on total signaling delay. In the figure, we can see, that the handover delay linearly increases, as Lwl gets larger for both the candidate schemes. The proposed CoMP-G scheme gives better performance than the existing CoMP scheme. This is because in the proposed scheme the coordinator can exchange the signaling messages with WMMS on behalf of body sensors.

Fig. 12 illustrates the impact of number of sensors (NS) on handover delay. We notice from the figure that CoMP perform worse than the
proposed CoMP-G scheme. This is because each of the body sensor exchanges signaling messages with WMMS. On the other hand, the proposed CoMP-G scheme is not affected by the number of sensors. This is because the coordinator can exchange the signaling messages with WMMS on behalf of body sensors.

Fig. 13 shows the impact of wireless link failure probability on handover delay. We can see in the figure that the total signaling delay linearly increases, as q gets larger for both the candidate schemes. This is because both the schemes use wireless links for the body sensors. As shown in the figure, the proposed scheme gives better performance than the existing scheme.

Fig. 14 illustrates the impact of hop count between AR and WMMS on handover delay. From the figure, we can see that CoMP is more sensitive as hop count between AR and WMMS increases. This is because each of the body sensor exchanges signaling messages with WMMS. While CoMP-G is less sensitive, this is because the coordinator can exchange the signaling messages with WMMS on behalf of body sensors.

5. Conclusion

In this paper, we propose a CoAP-based group mobility management protocol, named CoAP-G. In the proposed scheme, one of the sensor will function as a coordinator and it will exchange all the control messages with web-of-things mobility management system (WMMS) on behalf of other sensors. Besides, each WMMS maintains the information of the group of mobile sensors. From the numerical analysis, we proved that the proposed scheme gives the best performance in terms of total signaling and handover delay from the existing CoMP protocol.

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References


Khan, M., Silva, B. N., & Han, K. (2016). Internet of things based energy aware smart
