Energy Efficient Adaptive Device-Dependent Data Transmission Method for Internet of Things Aided Wireless Sensor Networks

R.Shyamala Devi, J.Suganya, P.Elangovan, K.Sakthidasan

Abstract

Internet of things (IoT) based wireless sensor networks (WSN) are designed for providing fundamental data transmission in the lower level of all the real-time applications. The applications rely on the quantity of data for the requests and responses that are aggregated and disseminated from the IoT-sensor environment. In this paper, adaptive device data transmission (ADDT) is introduced for providing flexible data transmission in the heterogeneous IoT platform. Based on device availability and energy consumption, the modes of transmission are decided as either responsive or non-responsive applicable for both single and multi-path transmission. Error in data dissemination and the density is responsible for recommending and determining the transmitting mode. Such pre-classified transmission mode increases the chances of a high level of request handling and reducing delay under controlled energy consumption.
1 Introduction

Wireless Sensor Network (WSN) is a wireless connection that is implemented in multi-hop fashion obtained from the sensor in the environment. The Internet of Things (IoT), is a device interconnection from the network architecture [1]. The scope of using IoT is to join the device and system elsewhere to make a reliable machine-to-machine (M2M) communications. In this state number of an entity or things communicate with each other and achieves the accomplishment in the environment [2]. IoT is embedded with three constituents such as a sensor that is obtained from the WSN platform. The second is the controller, which makes the devicework from the generated information [3,4]. The connectivity devices include the communication platform for machine to machine or machine to the user. By using this connectivity it faces many security-related problems and privacy risks. To address this some successful methodologies are developed [5,6].

In IoT, the WSN aims to collect, classify, and transfer the data in the network. The IoT is having 5 layers by using these layers the communication is carried out [7]. The IoT layers are as follows, perception, transport, processing, application, and business layers. The objective of using WSN in IoT is for efficient data delivery without any delay and loss. It improves the network lifetime and energy consumption [8,9]. The data transmission is done on finding the optimal route for transmitting the packets from the sender to the relay node. The multi-path transmission is used for effective packet delivery. If one route fails it takes the other route for transmission. In this, the decisions are made while transmission based on the priority of data [10].

Kumar and Chaurasiya [11], proposed a data redundancy in the Internet of Things (IoT) that is processed through the Wireless Sensor network. The analyses are done for mining data. Efficient mining is done to reduce the redundancy from the sensor node.

Multimedia sensor data is used in IoT for ubiquitous transmission is developed by Xu, et al [12]. The proposed method is used to record the cameras and sensor data and give prioritized data to transmit that relevant data. The obtained information is reliable and scalable.

Jarwan, et al [13], introduced a WSN for reliable IoT for data transmission reduction. The aim of this scheme is done on two-tier architecture. In this paper dual prediction and data, compression is done between the cluster node and its head.
M2P data transmission is processed as a one-request approach by using Software-Defined in IoT network is developed by Song, et al. The utilization is done on the spatial distribution mobile sensor. The aim is to forward the rules from the gateway.

Wireless Sensor Network in Heterogeneous platform is used for practical data forwarding is developed by Luo, et al [14]. The proposed method is used for Computational Diffie-Hellman (CDH). IoT is done on a heterogeneous platform and is done efficiently.

Fremantle and Aziz, [15], introduced an event data sharing for modeling and analysis. The author presented a cloud-based IoT environment for data sharing. The sharing is done securely from the fundamental level.

The wireless sensor network is used for multi-channel access in IoT, is introduced by Zhu, et al [16]. The proposed method is used for cognitive users of WSN; the channels are divided into a water filling method which is used in the distributed learning platform.

2 Adaptive Device Data Transmission (ADDT)

In IoT, the wireless sensors are used to exchange the data from source to destination in the limited range utilizing the wireless medium. In this work, IoT is concerned with WSN is used for the sensor data transfer in the network. The main objective is used to improve throughput and reduce energy consumption in the network. This paper addresses the short-range communication and improves the transmission level which is done on multipath routing. The following phase is used to set up the routing

- Discovery of path
- Multipath data transfer

The data are been sensed from the sensor and then transfer from source to destination by using the IoT environment. The above-given phases are used to establish a wireless connection for data transfer. The data are classified based on its time and size that enters the network environment.

**Discovery of the path:** The multipath routing is done by finding the \( m \) number of routes to transfer the data. The neighboring nodes are discovered by this process. The source transfers the data to the neighboring nodes, where the nodes communicate directly with the discovered node in the network that is listed as near. The transfer does not include the relay nodes. The following equation (1) is used to calculate the nearby neighbors.

\[
m_p = s \rightarrow d(i) + n_a
\]
From equation (1), the multipath discovery is calculated and denoted as \( m \) and \( p \) represents the path of transfer, and \( m_p \) is multipath routing. The distance is used to calculate for the nearby node that is represented as \( i \), transfer of data is denoted as \( t \). The distance of data transfer is represented as \( d \), data are denoted as \( d \), and \( s \) is the source node. The nearby nodes are defined as \( n \). The data to be transfer checks for the active state of the nearby node to avoid the time delay which leads to poor data delivery. The active state is denoted as \( a \), if it is inactive the data do not transfer the route are not discovered.

**Multipath data transfer:** After finding the neighboring node it finds how many paths are there to transmit the data and under the path which is reliable to fast communication. After the hop discovery is done, the data are ready to transfer, by doing this it avoids the congestion. For this, the data are classified based on its time and size which is said to be data density evaluation. The density of data is formulated in the following equation (2).

\[
ed = c_d * (h + z) + \prod_{c=0}^{c} s_c \alpha_c
\]  

(2)

From equation (1), the discovery of path is determined and the data transfer is done on the nearby node are evaluated in this equation. By using equation (1) the equation (2) is used to find the density of the data, it is denoted as \( e \) and \( e_d \) is termed as the density of data. The data that is to be transferred is the incoming data which is denoted as \( c \), the classification is based on time as \( h \) and size as \( z \). By using these two the data are transmitted to the destination \( o \). The number of data obtained from the sensor is denoted as \( \alpha \).

The multi-path routing is observed to transfer the data to the neighboring node in the network. Before the data are transmitted the density-based classification is carried out. The classification is based on time and size of data. By utilizing the above two equations (1) and (2) the following equation (3) is obtained for the classification of data.

\[
m_d = s \rightarrow d(i_d) + \prod_{c=0}^{c} s_c \alpha_c
\]  

(3)

By using equation (1) and (2) the above equation (3) is derived. The data are sent from the sender to the neighboring node by calculating the distance. The number of incoming data is sent from source to destination. By doing this calculation the transfer is not applicable to be reliable so they are two methods involved for transmission of data.
3 Data Transfer Methods

The data transfer from source to destination is done through the multipath routing, where the classification is done on the data. The classification is to avoid congestion and also it increases energy consumption. So, to address these issues the data transfer is done on two methods for reliable transmission. The two methods are listed below.

- Response method
- Non-response method

3.1 Response method

After the data are obtained from the sensor it finds the path to transfer which is done by processing equation (1). Initially, the data are to be transferred sent the request to the neighboring node. If the node is ready to accept the data means its response to the source node. By obtaining the response from the node the data are sent in this way there is no data loss happens. After the data are transferred to the node the required node goes to sleep state. In this way, the energy is consumed and the following equation (4) is used for response method data transfer from source to the next node.

\[
k = \begin{cases} s \to n(d) \\ n \to k(s) \end{cases}
\]

In equation (3), the density of the data is classified first the data which are having the smaller size are transmitted follows by the time it arrives. After this, it checks for the response from the next node, by calculating equation (4). Where k is denoted as response time, the formula works in such a way when the source sent the data to the next node in reverse it gets the response about the status of the node. The status reports free to transfer after the response is received the data are transmitted.

After the nearby node transfer, the data to the destination the particular node goes to the sleep state that increases the lifetime of the network and also it satisfies the objective regarding energy consumption. By doing this response method, the data are reliably transmitted to the destination. If the response is not obtained cover in the next phase as a non-response method.

3.2 Non-response method

The non-response method is the reverse method of response transfer. In this they are no response is given from the neighbor node to the source node. In this way, it is not possible to transmit the data to the node, unless there is the response process started. The response and non-response are carried out
in a particular time interval. If the response is not obtained in the fixed time limit it leads to the termination of data transfer. By considering equation (4) for the response method the non-response method is derived. In response method along with the data, the response is attached. The time of data forward is observed. The following equation (5) is used to evaluate the response and non-response concerning the time.

\[
k, k_0 = \begin{cases} 
[s \rightarrow n(d)] & = \delta \\
[n \rightarrow k(s)] & \neq \delta 
\end{cases}
\]  

(5)

From equation (3), the response method is used for data transfer to the near node in another case if they are no response from the node is calculated by using equation (4). In equation (5), \(k_0\) is denoted as non-response, and \(\delta\) refers to the fixed time. The first condition is \([s \rightarrow n(d)] = \delta\) this is the response method is obtained in the particular time which is equal to the fixed time \(\delta\). The second condition is the non-response method \([s \rightarrow n(d)] \neq \delta\), in this the response is not received in the particular time so it denoted as a non-equal symbol.

### 3.3 Data transfer in IoT

The data transfer in IoT is done on two layers they are Perception layer and the network layer. The data are obtained from the WSN through a sensor that enters in the perception layer. The role of this perception layer is to sense the data from the surrounding sensor. The sensed data are already in the form of density classification by using equation (3). In this layer, the data are sent to the network layer. The network layer is used to transfer the data to the destination node to maintain energy consumption and throughput. The following equation (6) is used to equate data transfer in IoT without error rate.

\[
\alpha_\tau = \begin{cases} 
\tau_d, & \text{if } \theta > 1 \\
\tau_d, & \text{if } \theta < 1 \\
\tau_d, & \text{if } \theta = 1 
\end{cases}
\]  

(6)

By using equation (5), response and non-response method are obtained using the limited time after this the error rate for data transmission is calculated by using equation (6). In equation (6), \(\tau\) is denoted as the error rate for the data. \(\theta\) is represented as an accommodating node in the network. The
first condition is $\tau_d$, if $\theta > 1$ here the error rate for the accommodate node is lesser than 1 which means no error found. The second condition $\tau_d$, if $\theta < 1$, in this, the error data are having more in the network. Last condition $\tau_d$, if $\theta = 1$, this is having a lesser error rate.

After the error rate is obtained the sensed data are transferred through the network, in the energy consumption model. The energy consumption is calculated by using equation (7) as follows.

$$\beta_d(t) = \begin{cases} d_s = [\rho * y] + i^2, & \text{if } i > 1 \\ d_0 = [\rho * y] + i^2, & \text{if } i < 1 \end{cases}$$  \hspace{1cm} (7)$$

From equation (6), the error rate is derived from that the above equation (7) is used to find the energy consumption for source and destination node. $\beta$ represents the energy consumption, $\rho$ refers to data transfer for energy consumption, $y$ is denoted as the size of the data. The equation works in two stated the first one is $d_s = [\rho * y] + i^2$, if $i > 1$, it equated for data transfer in the source side. Where the data are sent to the nearby node means this condition works by calculating the distance. The “if” condition is when the distance is lesser than one means the energy consumption is satisfied.

The second state is for destination and the condition is $d_0 = [\rho * y] + i^2$, if $i < 1$ in this the distance is greater than one which is not satisfied. The throughput is overcome by transmission loss of data and error in the network it is observed by calculating equation (8) as follows.

$$\omega = k, k_0 \rightarrow d(i_d) + n_a + \alpha_r$$ \hspace{1cm} (8)$$

By evaluating equation (7), the energy consumption is addressed; the throughput for data transmission is observed in equation (8), $\omega$ is the throughput. The response and non-response are obtained from the incoming data by calculating the distance. By doing this the data loss and error rate are reduced so the throughput is increased. The proposed work satisfies energy consumption and throughput by using equation (7) and (8). Equation (3) is updated for every incoming data. The reliable transfer is done by evaluating equation (5).

4 Performance Analysis

This section analyzes the performance of the proposed ADDT using the metrics delay, requests, and energy consumption along with the existing methods ORSIN and NDM. The performance is verified using network simulation experiments in which, 60 IoT sensor devices are placed randomly in a region of 500m\(^2\) area. The maximum requests handled in unit time are 10 and the maximum response time for a request is 120ms. The devices
are configured with an initial energy of 2 joules each.

4.1 Delay

Figures 1 and 2 present the delay comparison for the varying devices and requests, respectively. The data dissemination process relies on both responsive and non-responsive modes for improving the rate of dissemination. The increasing devices and the requests demand to delay less data transmission that is achieved in both single and multi-path transmission. This transmission relies on the decisions based on energy and neighbor devices to prevent unnecessary retransmission, and thus reducing delay.

**Figure 1.** Devices versus Delay

**Figure 2.** Requests versus Delay
4.2 Requests

The dual-mode of transmission based on the conditions of the available neighbors as differentiated based on energy and response is identified at the initial stage. The later estimation and verification of $[s \rightarrow n(d)] = \delta$ and $[n \rightarrow k(s)] \neq \delta$, are responsible for ensuring maximum requests are handled along with the responses generated. Therefore, the timeout of a request is analyzed for both the validations, achieving high request handling rate (Refer to Figure 3).

4.3 Energy Consumption

![Energy Consumption Comparison](Figure 4)
In Figure 4, the energy consumption of the proposed and existing methods is analyzed. The initial energy consumption for both the transmission process is computed as $\beta_d(t)$ and in the later process, the non-responsive transmissions are deliberated from the estimation if $\omega$ is observed. This indicates that no additional data needs to be transmitted and hence, the energy consumption of the devices is comparatively less. In Table 1, the comparative analysis results are tabulated.

**Table 1. Comparative Analysis**

<table>
<thead>
<tr>
<th>Metrics</th>
<th>ORSIN</th>
<th>NDM</th>
<th>ADDT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delay (ms)</td>
<td>108.58</td>
<td>95.18</td>
<td>86.2</td>
</tr>
<tr>
<td>Requests</td>
<td>134.37</td>
<td>147.26</td>
<td>159.96</td>
</tr>
<tr>
<td>Energy Consumption (Joules)</td>
<td>12.56</td>
<td>11.12</td>
<td>8.91</td>
</tr>
</tbody>
</table>

**5 Conclusion**

This paper introduces adaptive device data transmission for improving the performance of the internet of things based on sensor networks. In this transmission method, the responsive and non-responsive modes of the devices based on availability and energy is adapted by the transmitting IoT sensors. Such transmission helps to reduce energy consumption depending on the classification of data and data sharing mode. This mode identification and data dissemination are unanimously adapted for both single and multipath IoT sensor node availability for handling maximum requests under controlled delay.

**References**


Biographies

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