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Content Based Routing Using Information Centric Network For IoT

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Abstract

Internet of Things (IoT) can be used for many applications across industrial domains. However gathering data from such network increases traffic. To regulate this problem, Content Centric Routing (CCR) technique is adopted. An algorithm named as ETERNAL (contEnT cEntRic aNd loAd baLancing) has been proposed, to transmit data based on content. Routing the interrelated data in same route reduces traffic.Hence latency is reduced, resulting in less traffic and conservation of battery energy. The outcome of the proposed work claims minimal network delay, and higher energy efficiency. Consistency is also ensured that claims the proposed methodology superior to existing techniques.

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Keywords: wireless sensor network; routing, energy consumption;Content Centric Routing;ICN

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1. Introduction

The definition of Internet of Things (IoT) is "a persistent and ever-present network which enables monitoring and manages of the physical surroundings by collecting, processing, and analyzing the data generated by sensors or smart objects". Recently wireless networks has been attracted by distributed computing technique it has more attention specially on promising prototype in communication of Internet of Things (IoT) where the devices of IoT has enough storage capacity, self governing process, and good communication capabilities, the main idea is instead of sending all original data straight through an exclusive(multi-hop) wireless network generally interrelated among high energy utilization and time latency, the most cost-effective method is to first decreases the amount of data locally through the in-network dealing and consequently transfer processed data alone. Therefore, it can have high energy, bandwidth and reduces the latency and also the network lifetime is extend in resource controlled IoT network.

In several cases, highly interrelated data are collected for the similar application and while transferring to the sink it will process together. For example, the process of fusing the various sensor values based on the similar physical event. This kind of data aggregation process will limit the overall amount of data to be transferred over the wireless links, it has an considerable impact on overall network efficiency and energy consumption. The aggregation of unrelated data's and forwarding through the network will increase the traffic level, energy consumption and reduces the network lifetime at the same time the redundant data transmission will increase. Therefore to overcome these difficulties we have proposed an algorithm to improve the network lifetime, energy conserving and limit the traffic and redundant data transfer over the networks by routing the data from the sensors in the separate channels based on the nature of data.

In this paper we have discussed related work in section 2 and is followed by proposed work as section 3 that outlines the proposed ETERNAL model with the relevant architecture. Section 4 discusses the result obtained and then concluded.

2. Related work

Unlike from current fashionable concept of Named Data Networks (NDN) or Content-Centric Networking (CCN) [1-3] have proposed an subscribing information and caching techniques depends upon data rather than based on the host. It has the major focus on CCR technology to give an correct and better routing topology to limit the network traffic and to assist in-network aggregation of data.

The mechanisms of Routing and data aggregation has a significant consideration in the literature [4,5] in the perspective of WSN (Wireless Sensor Network). The presented work can be generally divided into two approaches -distributed and centralized. In Centralized method [6-11] generally pre-compute and make the finest suitable routing structure prior to the network starts to function. In [7], a network duration greatest aggregation tree result is projected.[9] have a attention of Load balancing,[11]authors has consider about the computational cost of aggregation. To control a overhead global network data is introduced in above literatures. In[12-18] has a distributed clustering method such as route to make an hierarchical routing topologies through local data gossiping.[16] has adopted a shortest pathway tree topology. Dynamic clustering method is adopted in [17].While making the clusters high transmission cost is occur when the process of clustering is triggered for each application or event. In addition, like a clustering method, tree ([7,8,19]) or Direct Acyclic Graph (DAG) [20] based methods also necessitate to a precise routing topology to function, and hence reduces their capacity to deal with dynamic network circumstances. This is due to every time a network alteration will take place like a connection breakage or early energy deficiency of several serious routing nodes, the network topology messages needs to be updated to replicate the existing circumstances.

3.Proposed architecture

The process of aggregation of unrelated data and forwarding through the network will reduce the network lifetime and increase the traffic level, latency, energy consumption and redundant data transmission. To overcome these problems the ETERNAL algorithm is developed to enhance the network lifetime, energy conservation and limit the traffic and avoid redundant data transfer over the networks. In Content Centric Routing method shown in Fig. 1 the data coming from the source will be classified as text, video and images then based on this content, the routing path will be allocated to transfer the data from source to destination.

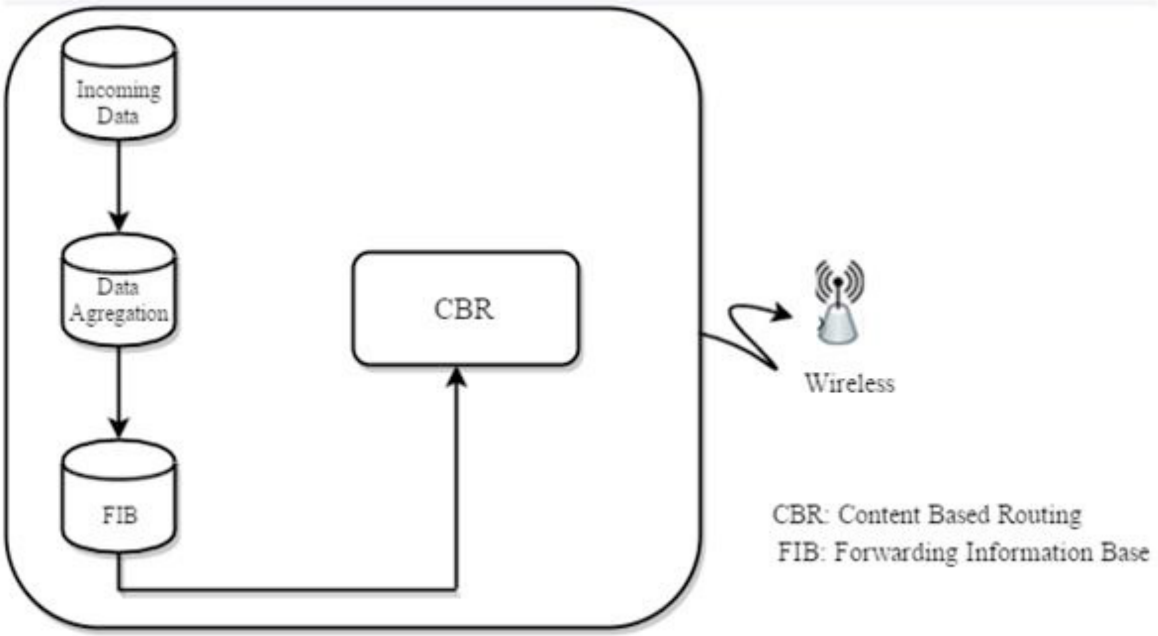


Fig1:Content Centric Routing Architecture

In this the data coming from various applications are collected and aggregated. Data form similar applications are then forwarded over the nodes by using the forwarding information, stored in FIB has the details about the neighbor node through which the data will be forwarded to the next node, based on forwarding information. It has the MAC address, node id, traffic level, hop id and its current state of battery(energy level), by using these information' s the content base routing will take place over the network. In case of node failure or nodes experiencing limited battery power, dynamic routing is invoked to ensure guaranteed data transmission without packet loss.

Network Model

By using N nodes the network will be formed, each node will get the power from the battery, The initial node has a high energy level and the remaining all nodes has the fixed range for communication and through multi-hop links they are connected. Initially the sender node will collect the node id, address of the node and the power range of the node. In this by using the node id the type of data o be transferred through this node will be decided. Before transferring the data to the another node the sender will check all these information and then it will decide the route to be traversed for the data it originating from the respective sensors. In case of any failure at the intermediate nodes, it will send back acknowledgment to the sender that it cannot has the ability to further transfer the data then sender will choose the another neighbor node to transfer the data from source to destination.

Process of Data Aggregation

The inherent nature of WSN (Resource constraints in terms of power, memory and limited processing and communication capabilities) poses severe design challenges to for developing and implementing real time applications. The application developer should take into account the various tradeoffs that are essential in determining the cost effectiveness, longevity, accuracy and efficiency of the system deployed. These trade off may include cost vs. performance, performance vs. security, reliability vs. cost, performance vs. battery life.

It is a verified fact that the energy consumption during communication of data is significantly greater than processing it. The bulk of the battery life is consumed by the communication process alone. So any amount of energy savings that can be achieved by optimizing the communication process greatly increases the overall lifetime of the system. The data from the sensor nodes are sent periodically to the neighboring nodes or to the parent node which requires the data. Owing to the sheer size of the network, flooding of data occurs, where majority of them are redundant. The network topology and organization plays a major role in reducing such flooding. Few instances of such techniques are clustering, hierarchical tree-based network structures, single hop/ multi hop data forwarding, selective forwarding and so on. Although these techniques help in reducing the flooding of data, they do not provide significant energy savings.

Specific methods which are mainly focused on reducing the number of packets that are transmitted include data aggregation, data fusion and data compression. Data aggregation is a process in which a fraction of nodes sends their data to a specific designated node which performs aggregation function. The nature of aggregation function may be sum, mean, average, modulus value of a predefined value or any simple arithmetic/algebraic function. Data fusion primarily involves decision making over the received data based on certain filtering conditions and hard/soft decision rules. Data compression involves applying specific compression techniques which reduce the size of data or number of packets that are being transmitted. Of these three methods we primarily focus on Data aggregation.

When we consider a WSN, the network shall consist of either heterogeneous or homogeneous sensor nodes. In a heterogeneous network the cluster head nodes, repeater nodes and gateway nodes are powerful and energy rich than the sensor nodes. On the other hand, in a homogeneous network except the base station node, all the other nodes are of the same type and hence every network node's capability will be the same. Under these circumstances data aggregation helps the cluster head nodes to save their energy by greatly reducing the quantity of packets that has to be forwarded to the higher level node. In short, Data aggregation process provides significant energy savings by decreasing the amount of energy expended for communication by slightly increasing the amount of computation. This trade-off pays rich dividends since energy spent on processing is much lesser than energy spent in communication. Data aggregation helps in significant reduction of communication overhead, energy expenditure for data communication and the workload of intermediary nodes that communicate with the base station. In several cases, highly interrelated data are collected for the similar application and while transferring to the sink it will process together.

This kind of data collecting process will decrease the total volume of data to be transferred over an exclusive wireless links and it has an considerable impact on overall network efficiency and energy consumption.

Power Consumption

In this work the power consumption place a major role in the evaluation of the proposed work. The process of aggregating all kinds of data and forwarding through all the nodes will consume more energy. This power consumption can be minimized by forwarding aggregated data into selective nodes based on the content will improve throughput and minimize congestion.

Proposed Algorithm

Whether once the condition of the network has change, rather than rebuilding the routing topology, a distributed decision making method has been follow where every node will decide the next node to transfer the data by using the content. In this paper, we propose a ETERNAL hybrid scheme to determine the next hop traffic relay node.

Algorithm: ETERNAL

Input: Data packet originating from sensor nodes.

Output: Identification of next node for data forwarding.

1. Initially objective node *a* in the network collects the incoming data from the sensor node.
2. Based on the FIB content, and at a probability *i,* Node *a* identifies next node ni by executing the objective function *O*.

$$ni = f(pi)$$

3. This objective node *a* will collect neighboring node details like node ID, MAC Address, traffic level, hop id and its current state of battery(energy level) and then forwards to the node ni which has highest hop id meeting out the objective function. Highest hop id is selected to ensure that the node ni is going to succeed node *a* rather than preceding it.
4. If the identified next intermediate node $((ni)$ has experienced failure) or (battery power (ni) < threshold) then the objective node will be reported about node *ni* failure and hence above steps will be repeated for next node identification.

A. Objective Function/ hop Id calculation

To find the next suitable node *ni* to transfer data, the objective function *O* has developed, To communicate the consequent traffic to the objective node *a*.

$$O = \max_{ni \in n}\left(D_g' - D_g''\right) + \alpha\left(\frac{T_l' - T_l''}{T_l'}\right)$$

D_g': Incoming Data

D_g'': Aggregated Data

$\left(D_g' - D_g''\right)$: Is the data reduction through aggregation process

No $\frac{T_l' - T_l}{T_l'}$ al life time gain

α: Tuning parameter

B. Traffic Reduction

Calculation of reduction of traffic R_T over the network.

$$R_T = \sum\sum t_r(in)^{ni} - \sum t_r(out)^{ni}$$

$\sum_{ni} t_r(in)^{ni}$: Calculation Is the total amount of incoming data, $\sum_{t_r \in T} t_r\,(out)^{ni}$: defines the total amount of outgoing data from the node. Reduction of traffic R_T defines the difference between the total amount of incoming data and outgoing data from the nodes.

C. Processing Gain

P_g: Processing gain by routing traffic t_r from objective node *a* to next node ni

$$R_T = \frac{\sum_{t_r \epsilon T} \sum_{ni} t_r(in)^{ni} - \sum_{t_r \epsilon T} t_r(out)^{ni}}{\sum_{t_r \epsilon T} \sum_{ni} t_r(in)^{ni}}$$

D. Network Lifetime

The network lifetime is based on when the network begin process untill the failure of first node by energy exhaustion, Hence network lifetime T_l is calculated,

$$T_l = \min_{n_i \epsilon n} \frac{B_E}{T_E}$$

B_E: present energy level of battery.

T_E: Present total amount of energy consumption for a node.

4. Result and Analysis

Finally, the implementable code will be deployed at the (Arduino-uno) hardware and Executed. In Fig. 2 the experimental setup and implementation model has been showed. It is very difficult to set up a multi-hop network with real hardware nodes, In this the source node will collect the data from various sensor, based on the sensor data collected by the node it will have the separate route to transmit the data. Then the ETERNAL algorithm is compared with some of the existing algorithm like static tree and centralized processing scheme algorithm.

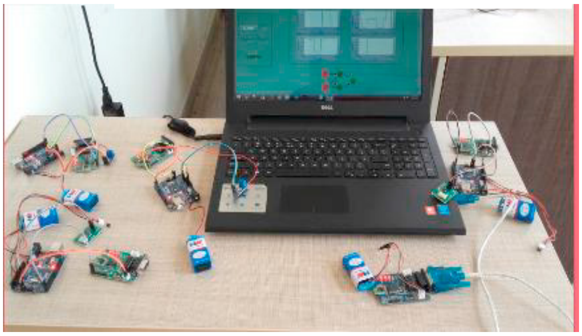
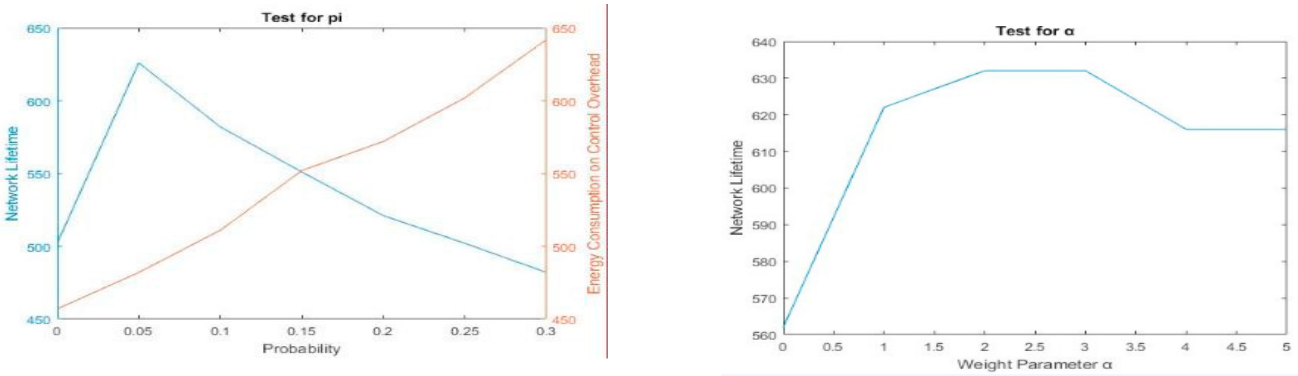


Fig. 2. Implementation Model



a. *Impact of Pi* b. *Impact of* α

Fig. 3(a,b). Impact of *i and* α on network lifetime

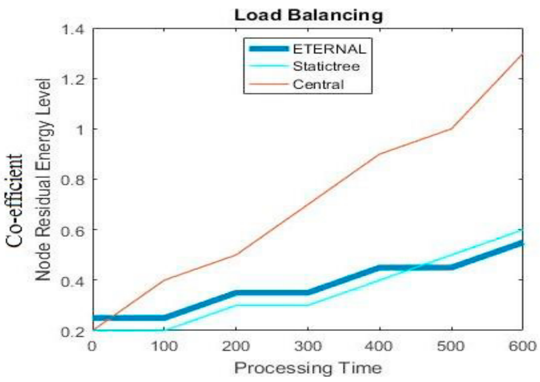


Fig. 4. Load Balancing

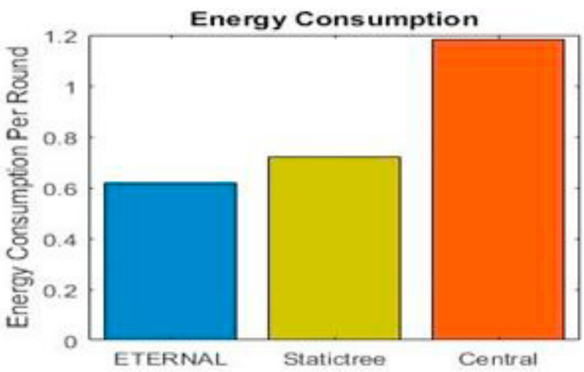


Fig. 5. *Energy Consumption*

The Impact of *i and* α on network lifetime has been shown in the Fig 3.a & 3.b. The variation of node residual energy is represented in the Fig 4. Higher the energy variation, poor the load balancing capacity. It is obvious from the figure that the ETERNAL algorithm has moderate load balancing capacity in comparison with Statictree but has better performance than Central. The total energy consumed for each round that comprises of the following operations namely read, write and transmission of information between nodes is shown in Fig. 5. The proposed ETERNAL algorithm has conserved energy consumption and is approximately equal to that of Statictree but far better than Central.

5. Conclusion

The proposed ETERNAL system has been designed to ensure a reliable data delivery method. In Content Centric Routing the data originating from the IoT network end point through various sensors have been collected and aggregated. These aggregated content has to traverse many wireless links to reach other end point. The IoT applications hoisted on the other end point retrieves the data through content centric routing path, based on the content of a message, each node forwards the incoming packet to the next node in the network. In case of node failure or nodes with limited battery power, dynamic routing is invoked to ensure guaranteed data transmission without packet loss. The typical outcome of the proposed system will have a dedicated routing for the data received from the various applications. By employing the proposed ETERNAL dynamic routing strategy, data transmission will happen by transferring different types of data in network through various routing paths. Hence network bandwidth can be utilized in an efficient manner resulting in reduction of network delay, network traffic and also increase in network lifetime. The dynamic rerouting ensures good load balancing and since similar type of information are collected, aggregated and processed in a specific set of nodes energy consumed by these nodes are under control.

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