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# Node Level Energy Efficiency Protocol for Internet of Things

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## Abstract

Internet of things (IoT) involves connecting all the devices and networks which work based on our surroundings, and can make our lives safer, healthier and faster. We are going to deliberate and explain energy issues that emerge while using Internet of Things. Universal detecting empowered by Wireless Sensor Network (WSN) innovations cuts crosswise over numerous territories of current living. This offers the capacity to quantify, derive and comprehend ecological pointers, from sensitive ecologies and characteristic assets to urban situations. The expansion of these gadgets in a communicating–actuating system that makes the Internet of Things (IoT) intriguing, wherein sensors and actuators mix consistently with nature around us, and the data is shared crosswise over stages to build up a typical working picture. Filled by the late adjustment of an assortment of empowering remote advancements, for example, RFID labels and inserted sensor and actuator hubs, the IoT has ventured out of its early stages and is the following progressive innovation in changing the Internet into a completely coordinated Future Internet. All these advancements in internet of things involves high energy consumption. The primary goal of our research paper is to propose a novel node level energy efficient (NLEE) routing protocol to improve energy efficiency. The validation of NLEE algorithm is confirmed using an IoT environment with discrete C ++ platform.

**Keywords:** IoT (Internet of Things); Mobile; Wireless; Nodes; Energy; Routing

## Introduction

IoT involves pervasive computing, which will generate data which needs to be managed and devices should talk to each other as well as enforce proper access control rapidly [1,2]. Not long ago, Internet was aimed in helping people stay connected at home, at work and in fact everywhere. Now the aim is to link things to each other and establish a chain of command among them, such as connecting Personal Digital Assistant devices to home appliances in a master-slave relationship to make our life simpler including connecting home applications to start coffee machines, adjust car seats, etc. We are living in the world of internet where everything can be connected. With the current situation, only a few devices can be connected with network and limited tasks are performed. To make it limitless; all the devices should interconnect with each other and perform tasks as per the requirement. The present internet may not be sufficient. Unfortunately, the internet isn't one network; it includes heterogeneous networks, firewalls, proxy servers, etc. All these things might disrupt connectivity [3]. To be more precise, with references only in 2011 did the number of interconnected devices on the planet overtake the actual number of people. Currently there are 9 billion interconnected devices and it is expected to reach 24 billion devices by 2020.

According to the GSMA, this amounts to $1.3 trillion revenue opportunities for mobile network operators alone spanning vertical segments such as health, automotive, utilities and consumer electronics. With the growing presence of WiFi and 4G-LTE wireless Internet access, the evolution towards ubiquitous information and communication networks is already evident [4]. However, for the Internet of Things vision to successfully emerge, the computing paradigm will need to go beyond traditional mobile computing scenarios that use smart phones and portables, and evolve into connecting everyday existing objects and embedding intelligence into our environment. For technology to disappear from the consciousness of the user, the Internet of Things demands: (1) a shared understanding of the situation of its users and their appliances, (2) software architectures and pervasive communication networks to process and convey the contextual information to where it is relevant, and (3) the analytics tools in the Internet of Things that aim for autonomous and smart behaviour.

With these three fundamental grounds in place, smart connectivity and context-aware computation can be accomplished. However, around billions of devices which will be connected to the internet, the data transfer mechanisms and communication architecture used currently couldn't suffice the requirements of emerging IoT devices.

The remainder of the paper is structured as follows. In section II, where we discuss IoT's network related issues and significance of our research. Section III presents summary of advantages and disadvantages of various research papers and their approaches on basic energy issues faced by mobile networks in emerging IoT environment. Section IV provides our suggestions and approach in solving the energy problems of network used by IoT. Section V comprises of Simulation Setup and associated Results. Section VI consists of conclusion.

## Problem Identification and Significance

When developing IoT devices in the lab, the network connects easily, as only few devices are connected [5]. There is a demand for IoT to use a complex network that forms a new type of communication between people and devices, also among the devices themselves. This means that IoT will spread in all regions for some specific task. However, deploying IoT devices globally with millions of users is a big challenge [4].

There are several application domains which will be impacted by the emerging Internet of Things. The applications can be classified based on the type of network availability, coverage, scale, heterogeneity, repeatability, user involvement and impact. We categorize the

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applications into four application domains: (1) Personal and Home; (2) Enterprise; (3) Utilities and (4) Mobile [5]. Hence the major common device linking IoT devices and reporting to us would be smart phones.

While researching ways to provide the best network for signalling and connecting between IoT. We come across many challenges for IoT connectivity the most significant issue is Network Energy Consumption.

The nodes forward acquired data from actuators or sensors to the intermediate nodes due to limited transmission range which needs proper routing. Therefore, the nodes use unintended energy for the packet transfer to the head node, these results in energy wastage and leads to network partitioning. Hence energy efficiency plays a key role that affects network performance and life in distributed networks for IoT [6].

To solve the above issues we need an energy efficient network routing that can seamlessly transmit data between various devices, systems and servers.

## Literature Survey

In this section, the salient features of existing approaches are discussed in detail. With the advent of smart devices and its advanced applications IoT technology can be implemented efficiently and gain huge amount of consumers quickly. However, most of these smart devices use wireless communication medium such as 3G or 4G for transfer of data and the demand for data transfer from these devices is exponentially increasing day by day. In previous year the mobile data traffic was almost 30 times the size of the total global internet, which was used in 2000 and when compared to earlier years this increased by 69% just last year. In this case, network and data transfer architecture that is deployed should have more than enough capability to handle all the active users on the network effectively. However, with IoT in picture potential problems arise due to the overwhelmed amount of data used by smart phone devices. One of these potential problems is Signalling Storms. When we review the usage of smart devices, we find that all of them are active every time which continuously makes use of data and wireless network for running social networking applications and are rapidly increasing in the long run. This leads to increased data traffic than the carrier network can handle and causes signalling surges/storms that produce issues such as congestion, service degradation, dropped calls, disappointed users and energy wastage.

Diameter testing applicati on by Spirent helps solve some of these potential issues. This application evaluates the carrier's network node by node. Diameter is the signalling method used for authentication, authorization, and accounting (AAA) in specific broadband, 3G and 4G/LTE networks. This system helps us to simulate real-world traffic conditions which can be used by carriers and evaluate operations that is taking place on a node-by-node basis. This evaluation can be used to test the impact of new services and devices on the existing network and helps predicting signalling traffic loads. This gives a complete picture to the carriers about the issues in their network in advance and they can adequately and effectively architect their networks. This application tests the carrier's network in all aspects and helps carriers' to optimize their Diameter networks appropriately for maximum utilization [7].

The load awareness in position based wireless Ad-hoc routing provides good results by considering the load capacity of neighbour nodes from time to time to forward data packets from source to destination. The forwarding nodes count the sending, receiving and processing activities of themselves and their neighbour nodes to select optimal node for transmitting data without packet loss [8].

In a clustered wireless sensor network performance can be improved by data aggregation. Data aggregation in clustered wireless sensors is achieved by calculating entropies of data from source nodes and consolidating the data. This reduces divergence in the network layer and improves the network performance greatly [9].

The self-localized packet forwarding concept involves in increasing the network efficiency by self-localization of the forwarding node with its neighbour nodes. The forwarding node checks the history data of the neighbour nodes to forward or multicast data to the neighbour nodes, but if the data is previously received by the previous nodes then the forwarding nodes avoids packet forwarding thus reducing redundancy in a wireless sensor network [10].

These approaches can also be modified and can be used to save energy at network layer level through network design and optimizing network nodes.

The reliable transfer of data from source to destination is a major concern in IoT especially in a large scale and dynamic environment. Several routing protocols have been considered for IoT for reliability. These routing protocols are categorized as *table-driven* and *on-demand driven* which depends on timing when the node routing data is updated which is used in wireless mobile ad hoc networks. In *Table-driven* the node maintains consistent route information in tables from neighbour nodes time to time. This will lead to quick and easy route establishment for the source node to forward packets to the destination.

*Destination-Sequenced Distance Vector (DSDV)* and *Fisheye State Routing (FSR)* protocol belong to this category, and they differ in the number of routing tables used and different methods utilized to exchange and handle routing tables. In on-demand driven the source node first sends a route request packet which is received by neighbour nodes and it is forwarded to other neighbour nodes to increase the vicinity until a route could be established to the destination node. Once the route is discovered a response packet is sent through the same path used by route request packet. In contrast to table-driven routing not all up-to-date routes are maintained at every node. *Dynamic Source Routing* (DSR) and *Ad-Hoc On-Demand Distance Vector* (AODV) are examples of on-demand driven protocols [11].

Previous papers suggest routing protocols such as ad hoc on-demand distance vector (AODV) and dynamic source routing (DSR) which are developed to find the shortest route without considering the energy efficiency of the establishment. In a distributed IoT network a specific one hop neighbour node can be repeatedly selected to transmit packets using the flooding algorithm that forwards route request (RREQ) packets. This excessive RREQ may reduce the life span of nodes and limit data transmission [12].

All existing approaches focused on improving the quality of service, but they completely ignored to maintain the trade-off between quality of service (QoS) and energy efficiency. In this paper, we tried to maintain the fair trade-off between energy efficiency and QoS provisioning.

## Node Level Energy Efficiency Algorithm

Node Level Energy Efficiency Algorithm considers residual energy of its one hop neighbour nodes and the average value of residual energy of all nodes in the network. For this we need to consider two factors first: assumed that each node knows the average value of residual energy of all nodes in network calculated by network controller using periodically receiving info about residual energy from each node. Second, each node knows the residual energy of its one hop neighbour

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nodes from the hello packets which are periodically broadcasted by each node in order to indicate the existence and hop location of the node with respect to source and destination.

This helps us to forward packets using minimum number of hops between source and destination. As each intermediate node consumes considerable amount of energy while forwarding a packet. This approach ensures low energy consumption at node level. Figure 1 is an example of NLEE. When source node needs a routing path for forwarding the packets, it broadcasts the route request (RREQ) packet at its 1-hop neighbourhood to compute the hops from source to destination. Then, when a forwarder node receives the RREQ packet that calculates forwarding probability using its residual energy and expected transmission count value in the NLEE algorithm.

However, the node compares the average value of residual energy of all the nodes with the predetermined residual energy threshold. If an average energy of the node is higher than node's threshold energy, the node regards that the network is in a better energy condition. Hence, it is not required to set the forwarding probability greater. Thus, a node computes the forwarding probability. If an average energy is shorter than threshold energy of node. As, a result, network is referred as lower energy network. In this situation, forwarding probability is made higher by executing our proposed algorithm. The detail of our proposed NLEE algorithm-1 is given as:

**Algorithm 1:** Node level energy efficiency protocol for Internet of Things

1. Initialization: ($Etc$ : Expected transmission count; $Etcj-1$: Expected transmission count value between nodes j-1 and node k; $\Delta Etc$: Maximum $Etc$; $kie$: Initial energy of node k; $\epsilon$: Predefined minimum forwarding probability; $\mu$: weightier factor for variation of the forwarding probability; $\omega$: Previous node's maximum energy; $\rho$: new node's maximum energy; $Fp$: Forwarding Probability; $\gamma$: Threshold energy; $Hlc$: Low hop count)
2. Input: ($Etc$, $Etcj-1$, $\Delta Etc$, $kie$, $\epsilon$, $\mu$, $\omega$, $\rho$)
3. Output ($Fp$)
4. Set $Hlc$
5. Check the energy of node k if $If\ \beta > \gamma$
6. Set other node $\rho$
7. Else calculate $Fp$
8. If $Fp > Ds$ // If forwarding probability is greater than sent data then decision is taken about the packet.
9. Else, Discard the packet
10. End if

In step-1, variables are initialized. In step-2 and 3 shows expected input and output. In step-4, when packets are arrived then forwarded to next hop. The next hop is decided based on minimum hop counts. In step-5, we check the average energy 'β' and threshold energy of the node 'γ'. Based on, 'β' and 'γ' decision is taken of forwarding the packets. If an average energy of node is greater than threshold energy of the node then another node is chosen for forwarding the packet. In step-6, another node is set for forwarding the packet. In stept-7 forwarding probability of node is calculated. In step-8, forwarding probability of the node is compared with sent data. If node's forwarding probability is higher than node's sent data forwarding probability then packets are shown as discarded in step-9 Table 1 (Figure 2).

$$F_p = \left[ \in + k_{ie} \left[ 1 + \frac{(E_{tcj-1,}j - \Delta E_{tc})}{1 - \Delta E_{tc}} \right] \right]^{1/\mu} \quad (1)$$

Here, we show initial energy of node k.

$$k_{ie} = \begin{cases} \frac{1-\in}{2\times\omega}, if\ \beta > \chi \\ \frac{1-\in}{2\times\rho}, if\ \beta \le \chi \end{cases} \quad (2)$$

## Simulation Setup and Results

We have used discrete C++ language as platform and used. Data packet size is set 1 KB. The primary objective of this simulation is to measure the performance of our algorithm NLEE. The scenario consists of 360 nodes.

Among these nodes 358 nodes are intermediate nodes, one source node and one destination node. Intermediate nodes carry data packets from source to destination. Each node is initialized to 10 joules of energy. In this arrangement 50 KB data is transmitted from source to destination at a time. There are 3 types of nodal paths for the transfer of data packets between source and destination.

These three types are shortest, average and longest. The shortest path in this scenario consists of 50 nodes. Average Path consists of 100 nodes. Finally the longest path consists of 300 nodes. Each node

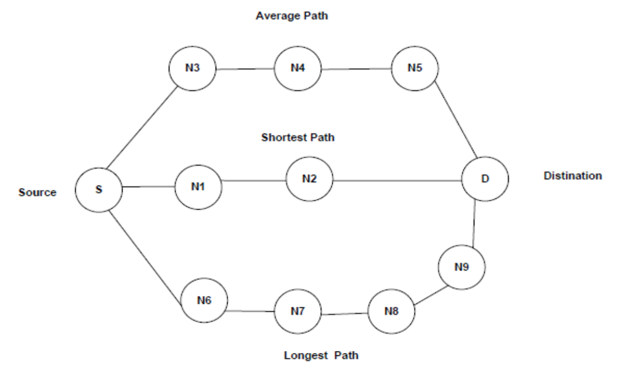


**Figure 1:** Example for NLEE algorithm.

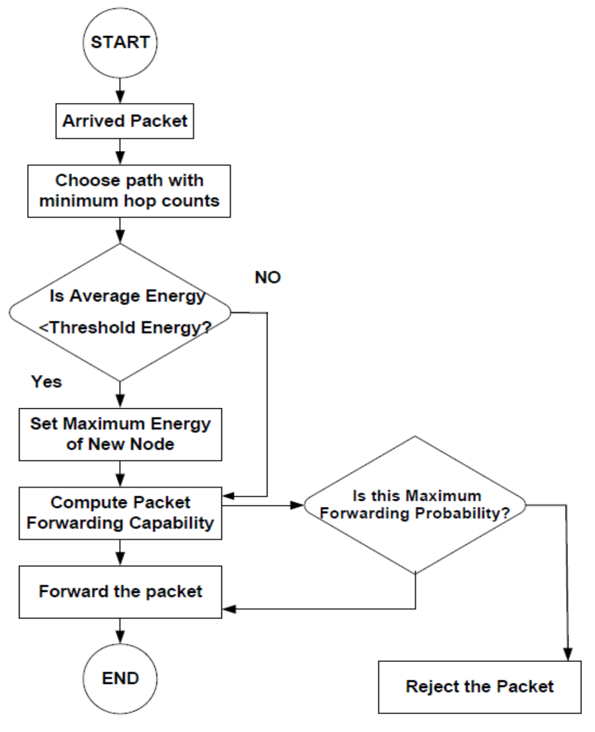


**Figure 2:** Working process of Node level energy efficiency algorithm.

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consumes 1 joule of energy to forward one data packet to its eligible neighbor node in shortest path. Each node in average path consumes 2 joules of energy to forward one data packet to its eligible neighbor node.

Each node in longest path consumes 4 joules of energy to forward one data packet to its eligible neighbor node. The threshold energy for this setup is 2 joules per node, which means the node, cannot be used if its residual energy is less than 2 joules (Table 2). Based on experimental results, we are interested in the following metrics.

- Node Level Energy Efficiency
- Residual Energy of Nodes

**A. Node Level Energy Efficiency**

Figure 3 depicts the result of NLEE algorithm generated from our C language code. The X-axis and Y-axis arrangement here is same as Figure 3. On observing graph in Figure 4, we see that the shortest path is being continuously selected until its nodes reach the threshold energy. Once the nodes in shortest path reach the threshold energy, the average path is selected which holds the nodes with maximum energy and the second shortest path to transmit data packets. And once again the nodes in average path will be depleted and the communication comes to a halt as at this time energies of all the nodes reach threshold energy.

Through the result we observed that excess energy is consumed in transmitting data via longest path with more number of nodes. NLEE protocol selects shortest path to reduce energy consumption during data transmission especially in highly distributed networks used by IoT.

**B. Residual Energy of Nodes**

Here, compare the performance of our proposed NLEE with other known Internet of things routing PROTOCOLS: Optimized Ad-hoc On-demand Multipath Distance Vector with Internet of things (AOMDV-IOT) [12], and energy-efficient probabilistic routing (EEPR) [13]. We measure the residual energy of all the nodes in each approach and also calculates the energy variance when completing the simulation. Residual energy of all approaches is depicted (Figure 4). The trend for all of the approaches show that residual energy ratio decreases with increase of number of sensor nodes. However, we observed that NLEE has maximum residual energy has compared with other competing approaches.

## Conclusion

In this paper, node level energy efficient protocol is introduced to improve the energy efficiency for internet of things. Our proposed algorithm takes decision for finding the shortest hop count. We used expected transmission count, residual energy of nodes, and hop count of nodal paths as routing metrics for improving the energy efficiency. Expected transmission count controls the broadcasted requests for route discovery. Furthermore, the route discovery process is conducted using residual energy and hop count of nodal paths. Furthermore, NLEE algorithm guarantees an improved efficient usage of nodal energies. It also provides the shortest path in the network while routing setup delay is increased. As a result, the routing success probability is decreased. To determine the effectiveness of our proposed NLEE algorithm, the discrete C++ platform is used and based on obtained data, results are plotted using MATLAB. Based on the experimental results, we proved that our NLEE algorithm performs better than AOMDV-IOT and EEPR in terms of energy efficiency. In future, we explore other metrics of QoS provisioning.

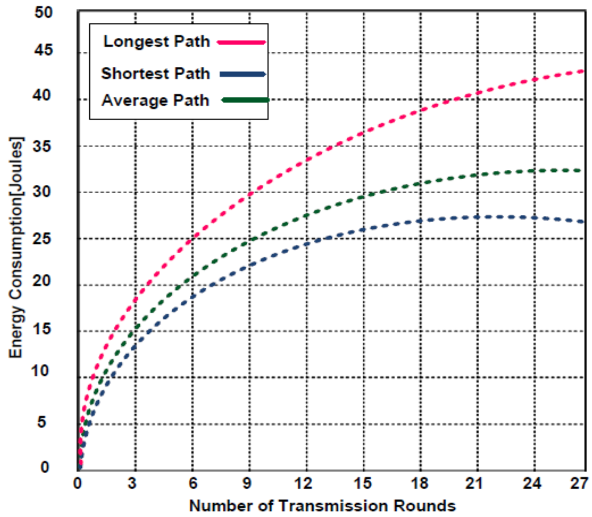


**Figure 3:** Energy Consumption graph of NLEE Protocol.

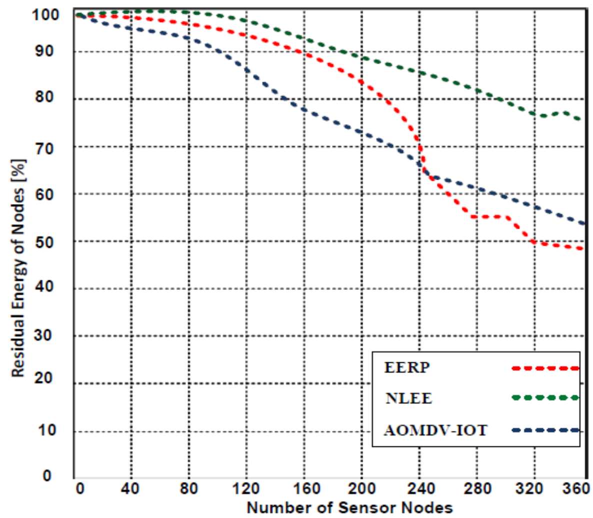


**Figure 4:** Residual energy of nodes.

| Parameters | Specifications |
|---|---|
| $E_{tc}$ | Expected transmission Count |
| $F_p$ | Packet forwarding Probability |
| $E_{tcj\text{-}1}$ | Expected transmission count value between nodes j-1 and node k |
| $\Delta E_{tc}$ | Maximum expected transmission count |
| $k_{ie}$ | Initial energy of node k |
| $\epsilon$ | Predefined minimum forwarding probability |
| $\mu$ | Weightier factor for variation of the forwarding probability |
| $\omega$ | Previous node max energy |
| $\rho$ | New node max energy |
| $\gamma$ | Threshold energy |
| $\beta$ | Average of energy of node |
| $H_{lc}$ | Low hop count |

**Table 1:** Description of used metrics.

| Parameters | Description |
|---|---|
| Initial Energy of Node | 10 Joules |
| No. of Nodes | 360 |
| Data Packet Size | 1KB |
| Routing Protocol | NLEE |
| Operating System | Windows 7 Ultimate |
| Processor | Intel i3 3rd generation |
| RAM | 2.75 Ghz |
| Software | Turbo C/C++ V3.0 |
| Platform | C language |

**Table 2:** Parameter specifications.

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