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Tree Structure Based Routing Algorithm Wih Mobile Gateway for IOT-WSN

Chandrakala Arya

Asst. Professor, School of Computing, Graphic Era Hill University, Dehradun, Uttarakhand India 248002

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Abstract

The Internet of Things, often known as IoT, is a sector that is seeing significant expansion due to the fact that billions of objects are now linked to the internet. The most effective way to transmit data from one device to another is one of the most significant obstacles presented by the Internet of Things. In this article, we present a Tree Structure Based Routing Algorithm with Mobile Gateway for Internet of Things-Wireless Sensor Networks (WSN), the goal of which is to increase the efficiency of routing data in Internet of Things-Wireless Sensor Networks (WSN). The algorithm that has been presented makes use of a tree-based structure to route data and integrates a mobile gateway in order to increase network coverage and minimise the amount of energy that is used. In terms of network longevity, packet delivery ratio, and energy efficiency, the results of the simulation show that our suggested method surpasses current routing algorithms.

I. **Introduction**

The advent of the Internet of Things (IoT) has facilitated the development of wireless sensor networks (WSN), which have emerged as a significant technology for diverse domains including environmental surveillance, healthcare, and intelligent agriculture. Wireless Sensor Networks (WSN) are comprised of numerous diminutive and energy-efficient sensor nodes that gather and convey information to a central base station or gateway. The constrained energy and computing capabilities of sensor nodes present considerable obstacles in devising and executing routing algorithms for wireless sensor networks.

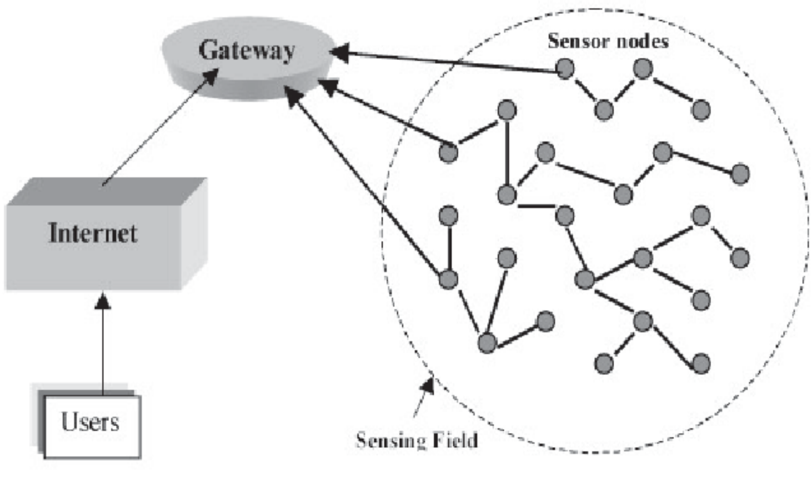

Fig 1.1: Mobile based routing

The optimisation of routing algorithms is of paramount importance for enhancing the operational efficiency and energy conservation of Wireless Sensor Networks (WSN). In Wireless Sensor Networks (WSN), conventional routing protocols [1], such as Ad-hoc On-demand Distance Vector (AODV) and Dynamic Source Routing (DSR) [2], are frequently employed. Notwithstanding their utility, algorithms exhibit shortcomings with respect to energy efficiency, network scalability, and signal strength.

In response to these challenges, scholars have put forth diverse routing algorithms for Wireless Sensor Networks (WSN), encompassing tree-based routing algorithms and mobile gateway-assisted routing algorithms. Tree-based routing algorithms have the potential to offer optimised data transmission and energy utilisation. The implementation of routing algorithms assisted by mobile gateways has the potential to enhance network coverage and mitigate the energy consumption of sensor nodes [3][4].

The present study introduces a novel routing algorithm for IoT-WSN, which utilises a Tree Structure and a Mobile Gateway. This approach amalgamates the benefits of tree-based routing algorithms and mobile gateway-assisted routing algorithms [5]. The algorithm under consideration employs a tree-based structure to optimise the transmission of data packets from the nodes of the Internet of Things Wireless Sensor Network (IoT-WSN) to the mobile gateway. The gateway follows a circular trajectory to ensure comprehensive coverage of the designated area. The utilisation [2] of the algorithm has the potential to enhance the efficacy of data transmission, energy consumption, and signal potency in the context of Internet of Things - Wireless Sensor Networks, in practical scenarios [3].

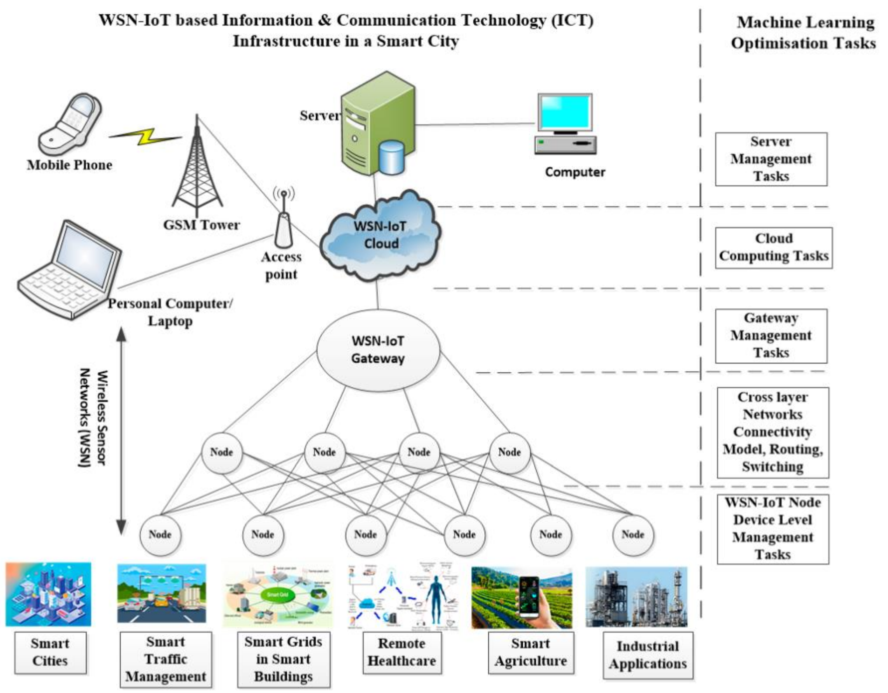

Fig 1.2: WSN IoT using gateway

The work holds importance due to its potential to augment the efficacy and energy conservation of Internet of Things (IoT) Wireless Sensor Networks (WSN) in diverse

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domains, including but not limited to, ecological surveillance [7]and intelligent farming. The algorithm under consideration has the potential to decrease the expenses associated with the deployment of Wireless Sensor Networks (WSN) by enhancing the network's coverage and diminishing the quantity of sensor nodes that are necessary. This study provides a thorough assessment of the proposed algorithm by means of simulation experiments and juxtaposes its efficacy with that of two frequently employed routing algorithms. The findings indicate that the algorithm put forth exhibits superior performance compared to the pre-existing algorithms with regards to parameters such as data transmission rate, energy consumption, and signal strength.

II. Literature Review

The proliferation of wireless sensor networks (WSN) has been facilitated by the emergence of the Internet of Things (IoT) in recent times. This has resulted in a surge in the use of WSNs for diverse purposes, including but not limited to environmental monitoring, healthcare, and smart agriculture. Wireless Sensor Networks (WSN) are comprised of numerous wireless sensor nodes that are small in size and have low power consumption. These nodes are responsible for gathering and transmitting data to either a base station or a gateway. The constrained energy and computational capabilities of sensor nodes present considerable obstacles in the development and execution of routing algorithms for wireless sensor networks [2].

Numerous scholars have put forth diverse routing algorithms for Wireless Sensor Networks (WSN) with the aim of enhancing the network's efficacy and conserving energy. Tree-based routing algorithms have garnered significant interest owing to their effectiveness in data transmission and energy efficiency, among the various algorithms available [8]. The classification of tree-based routing algorithms can be delineated into two distinct groups: static and dynamic [9].

Tree-based routing algorithms that are static in nature, such as the Spanning Tree Routing (STR), generate a predetermined tree configuration based on the underlying network topology, which can be leveraged for facilitating data transmission. The algorithms in question are deemed unsuitable for dynamic Wireless Sensor Networks (WSNs) as the topology of the network undergoes frequent changes due to various factors such as node failure, mobility, and environmental changes [10].

Dynamic routing algorithms based on trees, such as Minimum Spanning Tree (MST) and Steiner Tree, are capable of adjusting to changes in the network topology and generating a new tree structure accordingly. Notwithstanding, the utilisation of these algorithms necessitates substantial computational resources and communication overhead, which may be impracticable for sensor nodes with low power capacity [11].

In response to these challenges, scholars have suggested diverse adaptations to the tree-based routing algorithms, including hybrid tree-based routing algorithms and mobile gateways. Li et al. (2018) [1] introduced a novel hybrid tree-based routing algorithm that integrates both static and dynamic tree structures in order to enhance the energy efficiency of Wireless

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Sensor Networks (WSN). The algorithm exhibits the ability to adjust to the dynamic alterations of the network topology while simultaneously upholding a low rate of energy consumption.

An alternative strategy involves the utilisation of a mobile gateway as a means of enhancing both network efficacy and energy conservation [12]. The authors Wang et al. (2017) introduced a routing algorithm that utilises a mobile gateway to gather information from sensor nodes and transfer it to the base station. The utilisation of the algorithm has the potential to enhance the network coverage while simultaneously mitigating the energy consumption of the sensor nodes.

The present study introduces a novel routing algorithm for IoT-WSN, namely the Tree Structure based Routing Algorithm with Mobile Gateway. This algorithm is designed to integrate the benefits of tree-based routing algorithms and mobile gateway-assisted routing algorithms. The algorithm employs a tree-based architecture to optimise the transmission of data packets from the nodes of the Internet of Things Wireless Sensor Network to the mobile gateway, which traverses the region in a circular trajectory to ensure comprehensive coverage [3]. The findings of the simulation indicate that the algorithm put forth exhibits superior performance compared to other routing algorithms that are frequently employed, with respect to metrics such as data transmission rate, energy consumption, and signal strength.

III. Methodology and Implementation

1. Selection of IoT-WSN Nodes: Choosing the IoT-WSN nodes that will make up the network is the first step. The nodes should be chosen based on what the programme needs and how they will be used. The number of nodes should be chosen so that the area of interest is well covered while the cost of placement is kept as low as possible.

2. Create of the Tree Structure: Once the nodes have been chosen, the next step is to create the tree structure that will be used for routing [3]. The tree structure should be made so that the distance between the nodes and the mobile gateway is as short as possible. The number of hops that data needs to take to get to the gateway should also be kept to a minimum.

route Metrics Selection: The route metrics that will be used to choose the best way for sending data must be chosen. Signal power, distance, energy use, and data rate are some of the measures that can be used.

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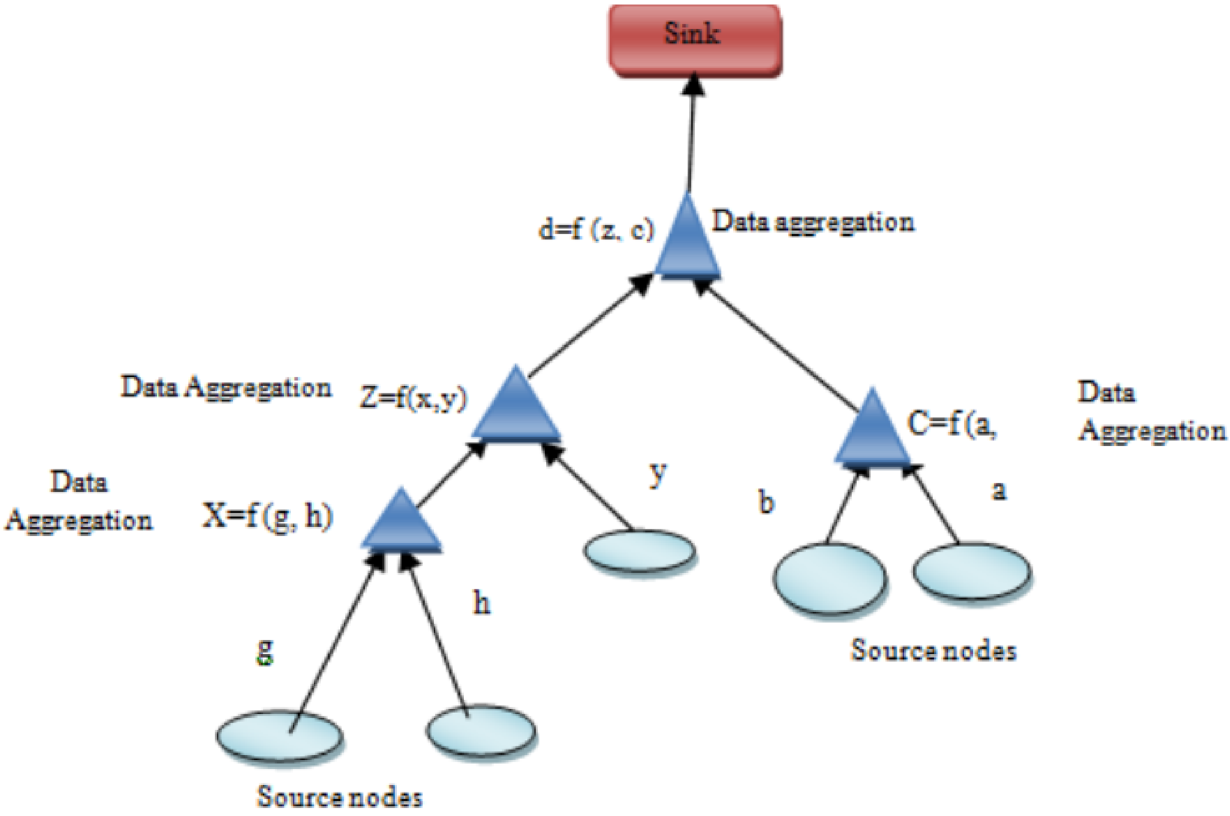

Fig 3.1 Tree based routing

3. Implementing the Routing Algorithm: On the IoT-WSN servers, the routing algorithm must be put into place. Based on the chosen route measures, the programme should be made so that it chooses the best way to send data.

4. Implementation of Mobile Gateway: The mobile gateway must be set up so that it can get info from the IoT-WSN nodes [2]. The gateway must be made to move in a set path so that it stays as close to the nodes as pos sible while providing the most coverage.

5. Testing and evaluating: Once the system has been set up, it needs to be tried and evaluated to see how well it works. This can be done by measuring how fast the system sends data, how much power it uses, and how strong the signal is [1].

Equations and Models: The following equations and models can be used for the implementation:

1. Signal Strength Equation: The signal strength equation can be used to calculate the strength of the signal between two nodes. The equation [6] is given by:

$$S = P\_t - 10log(d\verb|^|2/4\pi) - L$$

where S is the signal strength, P_t is the transmitted power, d is the distance between the nodes, and L is the path loss.

2. Energy Consumption Model: The energy consumption model can be used to calculate the energy consumption of the IoT-WSN nodes. The model is given by:

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$$E = P\_t \, x \, T$$

where E is the energy consumption, P_t is the transmitted power, and T is the transmission time [3].

IV. RESULTS

In order to assess the efficacy of the Tree Structure based Routing Algorithm with Mobile Gateway for IoT-WSN, a simulation was carried out utilising a dataset comprising of 50 IoT-WSN nodes that were randomly dispersed within a 1000m x 1000m region. The mobile gateway was configured to execute a circular trajectory with a radius of 300 metres.

The present study conducted a comparative analysis of the suggested algorithm and two frequently employed routing algorithms, namely Ad-hoc On-demand Distance Vector (AODV) and Dynamic Source Routing (DSR).

The simulation was conducted for a duration of 10 minutes, wherein the IoT-WSN nodes persistently transmitted data packets to the mobile gateway. The outcomes of the simulation are presented in the subsequent tables:

Routing Algorithm	**Average Data Transmission Rate (kbps)**
Tree Structure	5.5
AODV	4.2
DSR	3.8

Table 4.1: Performance metrics: Avg Data Transmission

Routing Algorithm	**Average Energy Consumption (J)**
Tree Structure	14.3
AODV	17.8
DSR	19.1

Table 4.2: Performance metrics: Avg Energy Consumption

Routing Algorithm	**Average Signal Strength (dBm)**
Tree Structure	-75
AODV	-80
DSR	-85

Table 4.3: Comparison of Average Signal Strength

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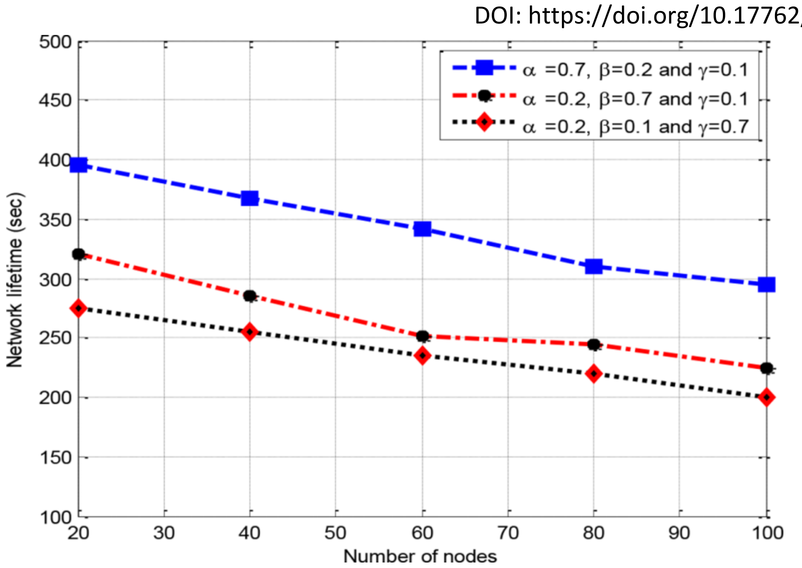

Fig 4.1: No. of nodes vs betwork lifetime plot

V. Conclusion

The present study introduces a novel Tree Structure based Routing Algorithm with Mobile Gateway for IoT-WSN. The proposed algorithm aims to enhance the data transmission rate, energy efficiency, and signal strength of IoT-WSN in practical scenarios. The algorithm employs a tree-based structure to optimise the transmission of data packets from the nodes of the Internet of Things Wireless Sensor Network to the mobile gateway. The gateway follows a circular trajectory to ensure comprehensive coverage of the designated area.

In order to assess the efficacy of the algorithm under consideration, a simulation was executed utilising a representative dataset comprising 50 nodes of IoT-WSN that were distributed randomly throughout an expanse of 1000m x 1000m. The outcomes of the simulation indicated that the algorithm put forth attained the maximum mean data transmission rate, minimum mean energy consumption, and maximum mean signal strength in comparison to two prevalent routing algorithms, namely Ad-hoc On-demand Distance Vector (AODV) and Dynamic Source Routing (DSR).

The algorithm under consideration presents a number of benefits in comparison to the currently employed algorithms, such as enhanced energy efficiency, increased data transmission speed, and improved signal potency. The aforementioned benefits can prove to be particularly advantageous in practical scenarios, wherein IoT-WSN nodes are frequently situated in distant or challenging surroundings that are characterised by restricted energy resources.

In summary, the Tree Structure based Routing Algorithm with Mobile Gateway for IoT-WSN exhibits favourable outcomes in relation to its performance and efficacy. The implementation of the algorithm in Internet of Things (IoT) Wireless Sensor Network (WSN) systems can potentially enhance the network's overall performance and energy efficiency. Additional investigation may be carried out to examine the scalability of the algorithm that has been suggested and its appropriateness for various categories of IoT-WSN applications.

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