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Delay-aware optimized scheduling algorithm for high performance wireless sensor networks

Soundararajan S[a], Lalitha S[b], B. Jyoshna[c] and Annalakshmi Govindaraj[d]

[a]Department of CSE, Velammal Institute of Technology, Chennai, India; [b]Department of ECE, B.M.S. College of Engineering, Bangalore, India; [c]Department of CSE, Keshav Memorial Institute of Technology, Hyderabad, India; [d]Department of CSE, Koneru Lakshmaiah Education Foundation, Hyderabad, India

ABSTRACT
Because of the phenomenal expansion of Internet of Things (IoT) devices around the world, Wireless Sensor Networks (WSN) have become increasingly important among the technical community, and research in this area has been growing exponentially. Researchers have used a variety of WSN technologies to address issues such as processing power constraints, bandwidth-limited connections, delays and energy consumption outlines that arise with sensor networks. However, in terms of delay optimization, affordability and effective energy consumption, WSN is the most suitable and alluring technology. This paper uses an Enhanced Scheduling Algorithm (ESA) with a probabilistic approach called Random Classical Game Theory (RCGT) to reduce the delay in WSN. Retransmissions are minimized when ESA and RCGT are used, which improve WSN delay. The idea is to improve the scheduling algorithm by using RCGT to lengthen the lifespan of the entire network. It has been demonstrated that the improved technique outperforms the existing algorithms in terms of throughput, energy consumption, hop count, delay and lifespan ratio.

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KEYWORDS
Delay optimization; wireless sensor networks; Gaussian mixture model; enhanced scheduling algorithm; Internet of Things

1. Introduction

The Internet of Things (IoT) is regarded as an important approach that fundamentally alters the manner of our daily lives. People are benefited from the invention of the wireless sensor network (WSN), which has made them ensure structures for promoting a variety of programmes [1]. They have distinct technical advantages and broad potential for advancement in many fields. In the present-day network communication, the WSN can successfully and efficiently sense the environment via the internet thanks to its special features and capabilities [2]. These systems are frequently installed in secluded or difficult-to-obtain locations. It is crucial that such networks may go unattended for extended periods. As a result, one of the main challenges in the advancement of WSN has been extending the lifespan of networks through effective consumption of energy [3]. Data transfer time, including standing and potential transmission delays, is known as transmission delay [4]. Sensor nodes and subside nodes normally set up wireless sensor networks (WSNs). To jointly monitor ecological conditions, sensor nodes are dispersed independently in space, as shown in Figure 1.

Even though a lot of routing methods are studied, the majority of them fall short of the requirements for the present generation of intelligent networks [5]. First, delays are not taken into account by traditional distribution methods like the shortest-routing methodology, which only considers the distance between the source and a destination. Additionally, the majority of routing algorithms ignore the close association between delay and energy, focusing instead on energy use [6].

Sensor nodes in WSNs are powered by power sources, which, in the majority of circumstances, cannot be recharged or renewed. As a result, sensor nodes must modify their senses, manufacturing, interaction and other operations in a conservation of energy manner and fully use battery pack power to achieve longer network lifespans. However, in stationary WSNs, sensor node locations are fixed, and multiple-to-one hop-by-hop communication is the standard mode of communication [7]. There will always be the following issues, no matter how the system is changed: In close contact with a fall node, the sensor nodes forward more data from other sensor nodes, use energy more quickly and fail more frequently. This issue is frequently referred to as the wireless communication hot spot problem or the sink node hole issue [8]. The methodology of this paper is an ESA with a probabilistic approach RCGT to reduce the delay in WSN.

1.1. Problem statement

In terms of power-controlled devices, transmission radii, computational capacity limitations, buffering agents, successful network structure and system

CONTACT Soundararajan S. soundar0789@outlook.com Department of CSE, Velammal Institute of Technology, Chennai 601204, India

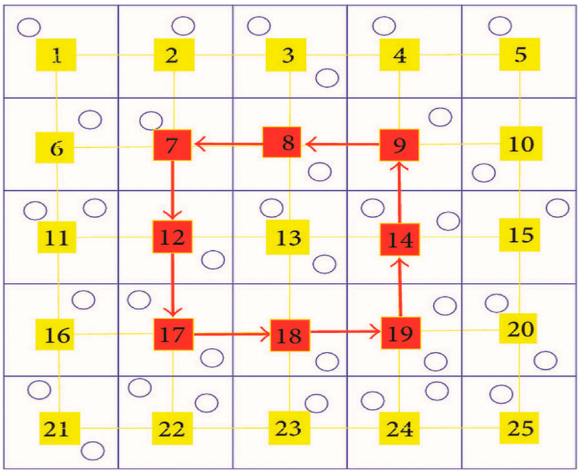


Figure 1. Grids in the sink node activity path and tracking area.

distribution of traffic outlines, wireless sensor networks present challenging problems for design [9]. Because of severe resource limitations in terms of accessibility, power communication and mathematical abilities, these novel creation types of networks are primarily established by the requirements of the application.

The IDS prevents malicious traffic from making any kind of changes in the network that could be harmful and that could lead to hinder production. Once you have determined the root cause, you can then take steps to mitigate the false positive and prevent it from happening again in the future.

1.2. *Objective*

The goal of RCGT is to create logical representations of interactions and disputes between logical, smart executives. Due to its chronological use in evaluating environment, RCGT has been applied to many financial challenges. Despite being used in business, and the field of politics, psychological economics has only recently found use in reasoning and technology. The use of proposed RCGT as a tool for dealing with many reasons for WSN difficulties continues to rise in popularity.

However, the evaluation metrics were only limited to accuracy, with no discussion around recall and precision.

The main contributions of this paper are as follows:

In clustered WSNs, this paper suggests a scheduling algorithm for slot tasks. The optimal flows obtained from the proposed optimization model are used as the basis for this scheduling algorithm's estimation of the timelines, integrating the slot recycle concept from cellular networks. Identify the latency from beginning to end is significantly reduced by the slot recycling concept without compromising the reduction in energy consumption.

2. Literature review

The literature work relating to how to decrease network delay is the main topic of this section. It also looks into the application of recurrent learning or machine learning in WSN. It also notes any technological problems related to each artificial intelligence algorithm covered in this section. The amount of energy that nodes use in a multi-hop atmosphere is determined by this study using an unpredictable model.

Routing algorithms in WSNs must prioritize selecting the path with the best "quality" for providing messages. Various demands of applications have different meanings for satisfactory quality. Plenty of study has been done over the last few decades to calculate excellence on multiple levels [10]. As major indicators of link quality, hardware-driven techniques for estimating choose the received signal strength indicator, signal noise ratio and Link Quality Indicator (LQI). Although using physical indicators has no overhead, they may not always choose the most beneficial path in actual networks because the Received Signal Strength (RSS) evaluation cannot gauge the amount of link integrity in real-time [11].

Responses for delay optimization are suggested to reduce latency in systems. For instance, under the restrictions of delay specifications generates routes with a low overall path expense among every single source node. Nodes in the WSN experience a variety of routing problems in intertidal circumstances, which are not appropriate for the nationwide optimization system [12]. A system is proposed by Broadcasting for reducing the consumption of energy and complications during the transmission process. Broadcasting is not relevant in the WSN because concentrating on lowering the end-to-end delay of data transmission as a metric for the distribution selection [13].

Growing the router's duty cycle is a requirement to decrease the delay, but doing so increases the consumption of energy. The authors of [14] adopted an alternate duty cycle according to the many kilometres between the point location and the source. In this latency, the nodes in the internet access region with high utilization of energy preserve a minimal duty cycle, whereas the points in the far-sink area increase their duty cycles as they get higher from the sink. Although the authors of [15] also take into account the changing period, the change in this study is based on the network's overall load. Although this method of changing the duty cycle setting is unusual, it makes the system more complex. Specifically, the nodes alter their settings when the system's scale is large. The ESA-based RCGT strategy, suggested in this paper, includes duty cycle adjustment and data routing [16].

The remainder of this paper is structured as follows: In Section 2, a literature review of WSN is explained.

Table 1. Simulation parameters.

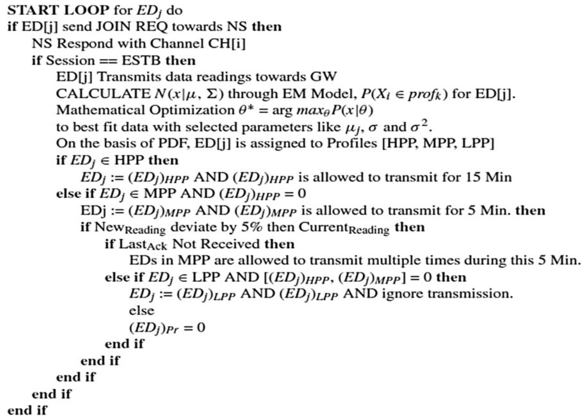
Parameter	Value	Description
E_{INI}	0.5	Initial Energy (J)
T_{SEN}	15	Sensing Cycle (s)
T_{COM}	100	Communication Cycle (ms)
P_T	0.0511	Transmission Power consumption (w)
P_R	0.0588	Receiving Power consumption (w)
P_{SEN}	0.0036	Sensing Power consumption (w)
P_S	2.4×10^{-7}	Sleeping Power consumption (w)
τ_{PRE}	0.26	Preamble duration (ms)
τ_{ACK}	0.26	Acknowledge window duration (ms)
τ_{DA}	0.93	Data packet duration (ms)

Section 3 illustrates the proposed ESA and RCGT approach. The performance of RCGT is analysed in Section 4. Finally, Section 5 gives the paper's conclusions and future work.

3. Proposed method

Since multi-hop relaying in WSNs uses the shortest looking forward separation at each hop for transmitting data, the more conveying hops are necessary apart the receiver and fall are from one another [17]. In contrast, nodes use an autonomous model to conserve power, and they can only send and receive data when they are up. The delay from end-to-end transmission increased with the number of transmit hops required because there is no confidence that the next hop node will be alert for each transfer. The simulation parameters are shown in Table 1.

ALGORITHM: ENHANCED SCHEDULING



```
START LOOP for $ED_j$ do
if ED[j] send JOIN REQ towards NS then
    NS Respond with Channel CH[i]
    if Session == ESTB then
        ED[j] Transmits data readings towards GW
        CALCULATE $N(x|\mu, \Sigma)$ through EM Model, $P(X_l \in prof_k)$ for ED[j].
        Mathematical Optimization $\theta^* = \arg max_\theta P(x|\theta)$
        to best fit data with selected parameters like $\mu_j$, $\sigma$ and $\sigma^2$.
        On the basis of PDF, ED[j] is assigned to Profiles [HPP, MPP, LPP]
        if $ED_j \in$ HPP then
            $ED_j := (ED_j)_{HPP}$ AND $(ED_j)_{HPP}$ is allowed to transmit for 15 Min
        else if $ED_j \in$ MPP AND $(ED_j)_{HPP} = 0$
            EDj := $(ED_j)_{MPP}$ AND $(ED_j)_{MPP}$ is allowed to transmit for 5 Min. then
            if $New_{Reading}$ deviate by 5% then $Current_{Reading}$ then
                if $Last_{Ack}$ Not Received then
                    EDs in MPP are allowed to transmit multiple times during this 5 Min.
                else if $ED_j \in$ LPP AND $[(ED_j)_{HPP}, (ED_j)_{MPP}] = 0$ then
                    $ED_j := (ED_j)_{LPP}$ AND $(ED_j)_{LPP}$ AND ignore transmission.
                    else
                    $(ED_j)_{Pr} = 0$
                end if
            end if
        end if
    end if
end if
```

The entire delay in the distance node area consequently is far greater than in the nearest node area. The geographic area of the point indicates that there are considerably fewer points in the distance node area than the near-destination points [18]. The network's secured node with sensors, which are in charge of passing on data, mean that the separation between each node and the source cannot be altered. As a result, the delay must be decreased from the employed model of nodes. The alertness cycle of every network node is unplanned and separate, and the model employed by nodes is an autonomous continuous alertness model [19].

Only after the node has awakened tasks can be handled. The sending node must wait until a sleeping node wakes up before sending data to it. In some cases, the waiting period might be nearly equal to the length of the cycle. In light of this, increasing the nodes' waking times, or their communication duty cycles, is one efficient way to reduce latency [20].

The term "end-to-end transmission delay" describes the amount of time from the sender's planning for the data to the sink's reception, which is expressed as follows:

$$MIN(D_{end-end}) = MIN\left(\sum_{j=2}^{l} D_j\right) \tag{1}$$

where D_j is the transmission delay; l overall hops transmit at the time of transmission

Algorithm – Random Classical Game Theory approach

Input: Distance of communication (DC), founder mote and location mote.

Output: A route between the source and location motes that includes an adequate zone and a connecting mote that was selected with care arbitrarily.

Details

1. Obtain the route-finding table for the founder motor.
2. The region adjacent to the founder is divided into two regions.
3. Randomly choose one of the regions
4. Select the appropriate region to find the motes.
5. Definitely stop if region motes have an endpoint mote.

4. Simulation results and discussion

This section discusses the simulation results for the delay. Several simulations are run to see how end-to-delay behaves in terms of collision assigns priorities discussed in the previous section. The simulation was run with two producing two game theories simultaneously. In a scenario requiring smart health monitoring is practical to provide data simultaneously while also considering the quality of service. The NSL KDD dataset's network traffic data provides values for each feature corresponding to the network packet properties.

The delay in communication of points at various points in the system is displayed in Figure 2. The figure illustrates how the data is being forwarded in this work. Therefore, reducing distance sink area delay is the initial challenge to be determined to achieve delay in network optimization.

As the transmission duty cycle increases, the system's latency progressively decreases. The system's latency gets very low when the duty cycle is 0.9, as shown in Figure 3.

The energy utilization is high; therefore, if duty cycles of nodes are enhanced, the amount of energy used is significantly increased. Figure 3 shows the energy utilization at various duty cycles. Since the source serves as the central location of the entire system, all data must eventually be passed on there. This results in excessive energy use of the nodes in close proximity to the sink, which leads to the sudden demise of nodes in this region (Figure 4). Several investigations have revealed that when a network is gone, it still contains more than 90% of its original power, as shown in Figure 5.

The one-hop delay time for limited networks under the proposed RCGT approach is shown in Figure 6, which did not take the waiting and transfer delays into account. The graph shows that there are two distinct circumstances for the one-hop delay of the nodes. The initial situation involves the regular nodes and wireless nodes in the system having the same period and an unchanged delay.

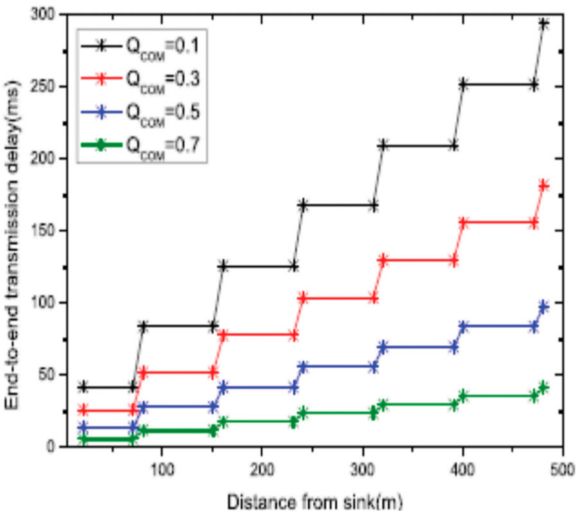


Figure 2. Transmission delay from beginning to end for various sink distances.

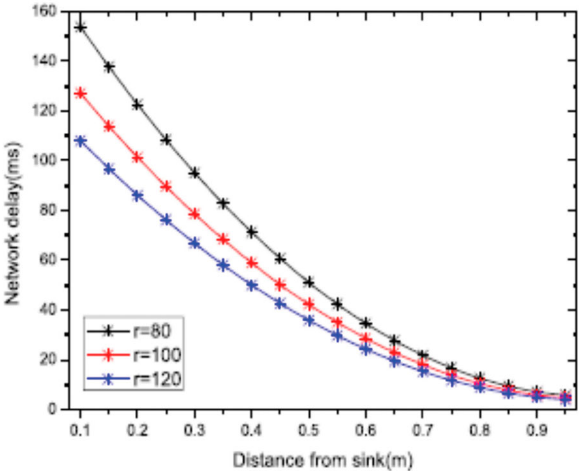


Figure 3. Various duty cycle network delay.

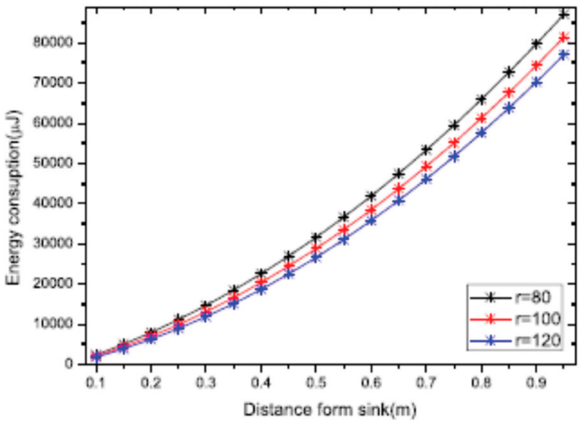


Figure 4. Utilization of energy at various duty cycles.

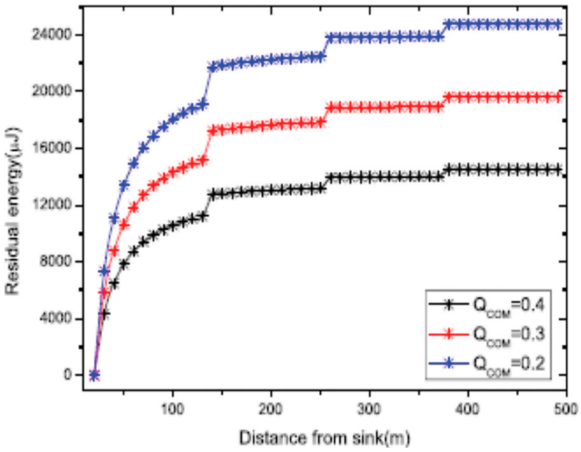


Figure 5. Remaining energy at various sink distances.

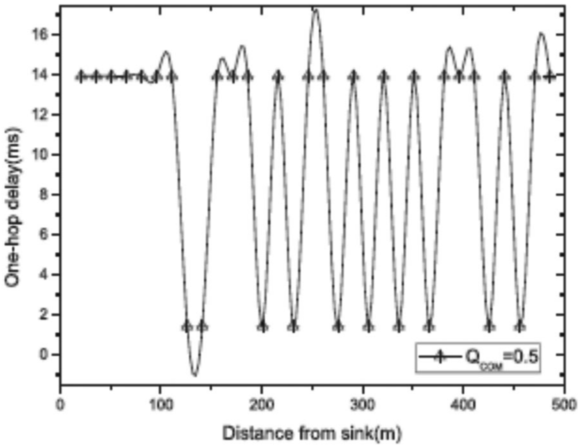


Figure 6. One-hop delay in the proposed limited networks.

The end-to-end delay for the proposed ESA-based RCGT approach is shown in Figure 7. Here, the points within the node differ from the go under-communicate data immediately to the basin, while points outside the node range choose a minimum delay technique

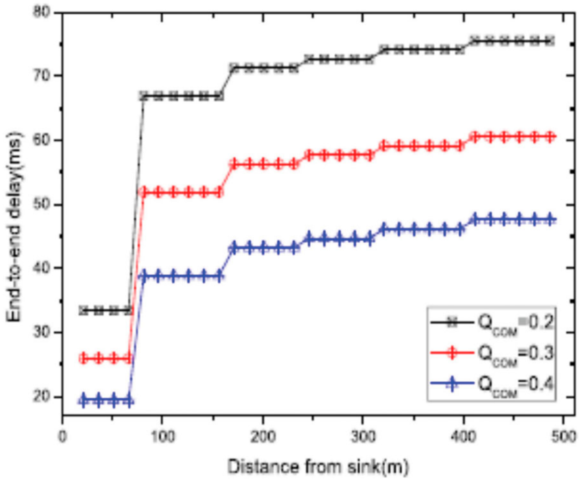


Figure 7. End-to-end delay in the proposed RGT for limited networks.

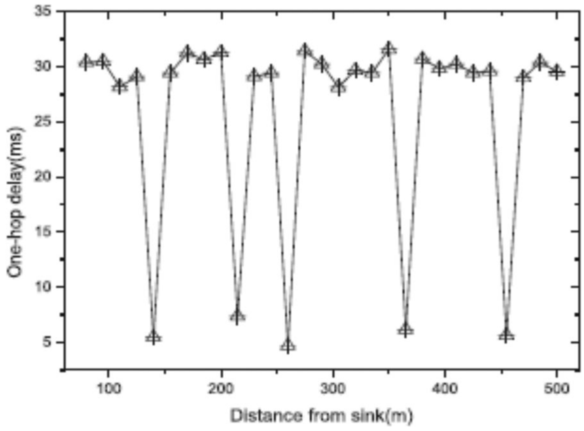


Figure 8. One-hop delay in the proposed ESA with RCGT-constrained large networks.

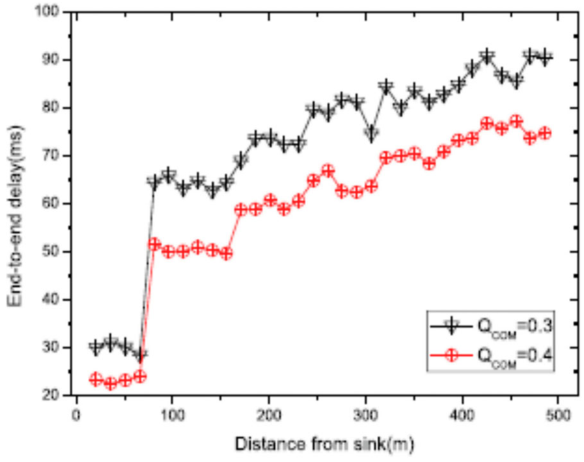


Figure 9. End-to-end delay in the proposed RGT for large networks.

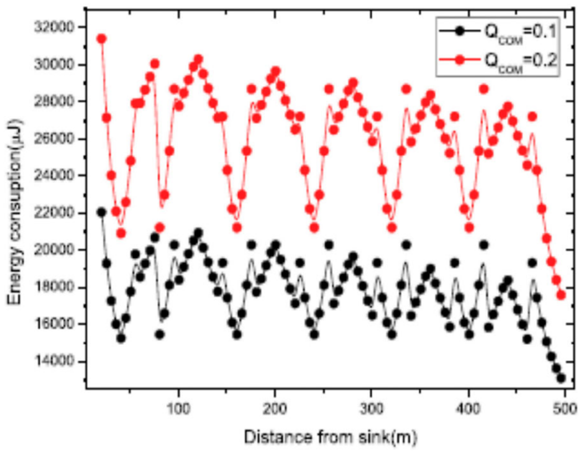


Figure 10. Energy use at various distances under the proposed RCGT approach.

based on straight forwarding on the particulars of the situation.

Regular nodes and wireless nodes that relay information have much higher delay than rapid connectivity transmit nodes. The data transfer links among various nodes also have unique link characteristics, which results in waiting delays and interest in other transmission delays. As a result, each node's one-hop interval in Figure 8 is a parameter that depends on the connection quality of the node in question.

Figure 9 depicts the delay in large networks when waiting and interest in other transmission delays are taken into account. The delay for the hub at various points from the source varies because of the lining-up delay, and the possibility of transfer delay.

The power use of nodes located at various lengths from the source is shown in Figure 10. According to the network's overall use trend, the node closest to the source continues to consume the most energy, whereas the power use of nodes farther away from the sink, particularly those nodes close to ESA, has greatly decreased.

5. Conclusion

A popular subject in the scientific group is quick and efficient communication with the sink under the assumption of ensuring the life span of the network. Few strategies can simultaneously optimize energy and delay because system diameter, node identified as weight and additional variable have high interactions. This investigation might also be developed as research in the surrounding field being developed. The main goal of this study was to establish rapid connectivity foundation directions to reduce network delay. It might nevertheless also take into account ways to optimize the information on the direction like merging that must be sent before each time of communication to minimize the amount of redundant data. The work currently working towards this direction exploring the various capabilities of the system when deployed in a distributed manner.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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