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AN IMPROVED HONEY BADGER ALGORITHM TO ENHANCE QUALITY OF SERVICE IN WIRELESS MULTIMEDIA SENSOR APPLICATIONS

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Abstract:

Despite Wireless Sensor Networks' (WSNs) initial purpose was transmission of small-volume data, there has been a trend in recent years to use WSNs for multimedia applications. In this regard routing protocols must be upgraded and streamlined in order to meet the growing need for higher throughput and real-time performance when processing multimedia content. In this research work an improved Honey Badger Algorithm is presented which is intended to minimize packet loss and minimize end-to-end packet latency in Wireless Multimedia Sensor Networks. To transmit multimedia packets over the network, IHBA-WMSN chooses an optimized high throughput path rather than the shortest route to the destination. Moreover, it integrates a network void-bypass method to improve network dependability when it comes across network gaps. When compared to other algorithms, the simulation results show that IHBA-WMSN successfully manages energy usage while achieving a reduction in end-to-end delay and packet loss ratio when compared with conventional routing protocols. Simulation results are compared to that of AGEM, TPGF, GPSR, AODV and SGFTEM. The results suggests the IHBA-WMSN performance better under conditions that are similar to these, such as low packet end-to-end- delay and low packet loss.

Keywords: Wireless Sensor Network, Wireless Multimedia Sensor Network, Energy efficiency, Optimization, End-to-End delay, Packet Loss Ratio.

1. INTRODUCTION

The study by Yick et al.[1], wireless sensor networks (WSNs) are a kind of physical monitoring systems made up of self-organizing and networked sensors that are dispersed across a large coverage area. These sensors collect, transmit, and process detected data using specialized communication protocols. After that, multi-hop routing is used to send the data to the intended sink. The hub for computing, data processing, and network control is the sink. Using traditional networks like the Internet, administrators can communicate with the sink. Scalar data like temperature, pressure, humidity, and location have always been the focus of conventional WSN design, which includes data collection, processing, and transmission. These networks have a finite amount of transmission bandwidth.

However, scalar data alone is not sufficient to meet the criteria for extensive environmental monitoring due to the increasing complexity of monitoring environments. As a result, in order to improve data gathering and accomplish more accurate environmental monitoring, support for media-rich content—such as images, video, and audio—is becoming more and more necessary. The cost of hardware for cameras and microphones has significantly decreased as a result of recent technological developments. Wireless communication capabilities have been improved concurrently by advancements in bandwidth capacity.

Within this framework, Wireless Multimedia Sensor Networks (WMSNs) are starting to replace Wireless Sensor Networks (WSNs). As stated by Akyildiz et al.[2], these networks are able to store, process multimedia data in real-time, correlate, and fuse data from several sources.

Wireless Multimedia Sensor Networks (WMSN) are noteworthy and exciting technological development that could improve current WSN applications and pave the way for a host of creative multimedia applications. These include situation awareness (as explained by Wang) [3], location-based multimedia services (as emphasized by Akhlaq Ahmad et al.) [4], visual target tracking (as examined by de San Bernabe et al.) [5], and multi-camera surveillance (as detailed by Natarajan et al.) [6]. According to Google search statistics, the popularity of video and camera sensors has been rising gradually with the advent of various types of multimedia sensors.

The change in search trends demonstrates how WMSN technology is becoming more and more popular. In the field of WMSNs, effective routing with multimedia capabilities has emerged as a major research focus. The creation of routing algorithms, protocols, and procedures for classical WSNs that are particular to the requirements of different applications and network architectures has garnered a significant amount of research attention in recent years. These solutions are designed to provide best-effort services with the primary objective of preserving network system functionality while keeping energy efficiency in mind. However, their demands for processing, storage, and bandwidth far exceed the capabilities of standard WSN platforms like MICA because of the diverse nature of media, the large volume of data, complex data formats and operations, and the requirement for high-speed real-time transmission within WMSNs. A routing protocol is essential to create a reliable and resource-efficient path and to provide different QoS/QoE levels based on requirements in order to facilitate multimedia transmission within WMSNs. Resource efficiency includes both lowering energy use and making efficient use of available bandwidth. Routing design and development therefore require a number of specific considerations.

2. RELATED WORK

Data from sensor nodes is directed to a sink node by the creation of on-demand, non-interfering multiple transmission channels, as demonstrated by the authors of [6]. Two non-interfering pathways are used by the protocol, but nodes in these paths do not alter until they stop working.

A location-based multipath routing technique that uses a maximum of two pathways for data transmission is introduced in [7]. While this protocol performs an excellent job of reducing average end-to-end latency, it ignores important factors such as the nodes' residual energy during packet forwarding.

More information on a multipath routing system are provided in [8], which guarantees better load balancing and dependable data transfer. Despite its effective reduction of interference across parallel routes, this protocol has a greater energy consumption trade-off.

Audio and image streams are separated within multimedia streams using the multipath routing system described in [9]. Content-based priority and end-to-end transmission delay-based priority measurements are the foundations of packet routing. Nonetheless, there is extra overhead associated with this multimedia stream segmentation.

A QoS-focused multipath routing protocol is presented in [10] with the goals of reducing network congestion, energy consumption, and load balancing. However, for the protocol to transmit video data efficiently, sophisticated compression techniques are required.

In particular, the multipath routing system covered in [11] is designed for real-time video streaming in WMSNs. Based on the quality of their connectivity with the sink node; it gives priority to sensor nodes. In order to account for the dynamic topology of WMSNs, the protocol chooses how many pathways to use for multimedia data transfer and

employs adaptive switching. Notably, the protocol provides benefits including extended network lifetime and guaranteed delivery through Quality of Service (QoS).

In [12], the authors devised a geographic multipath routing protocol utilizing a novel metric called triangle link quality to create node-disjoint paths with minimal inter-path interference. While wireless link quality stands as a key consideration in this metric, the protocol doesn't address the challenge of frequent node movements while ensuring load balancing.

The Two-Phase geographical Greedy Forwarding (TPGF) [13] represents a location-dependent node-disjoint multipath routing protocol developed for WMSNs, where each path comprises distinct sets of nodes. While TPGF is praised for its simplicity and speed, it faces a limitation concerning inter-path interference.

A. *Research Gap*

Some studies in the literature survey praised for the speed but faced limitations concerning inter-path interference. Location based algorithms reduced delay but did not consider critical parameters like remaining energy while forwarding the packet. Some studies in the literature survey ensured reliable data transmission with trade off of higher energy consumption. A cross-layer multipath routing protocol used different rates of data transmission to ensure QoS but consumes more energy because of multiple copies of data packets. Some studies in the literature survey focus on energy-efficient QoS-compliant multipath routing protocols, which optimize routing decisions based on the available energy of each node in the network. Despite its advancements, the study has a notable limitation: it does not include tools for monitoring and evaluating end-to-end delay and bandwidth requirements. This absence can affect the protocol's ability to ensure optimal Quality of Service (QoS) in terms of delay and bandwidth, potentially impacting overall network performance.

3. PROPOSED METHOD

A. *Energy Model*

As Wireless Multimedia Sensor Nodes are battery driven it is important to calculate the energy requirements. Figure. 1 shows model of radio energy dissipation.

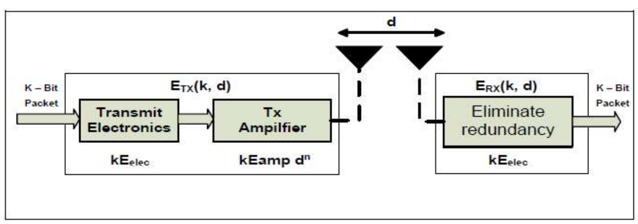

Figure 1. Radio Energy Model

It is possible to calculate the energy required to transfer a k-bit message to d distance by using

$$E_{TX}(k,d) = E_{elec} * K + E_{amp} * k * d \quad (1)$$

It is possible to calculate the energy consumed when receiving k-bit message

$$E_{RX}(k,d) = E_{elec} * K \quad (2)$$

B. ***Network Parameters***

The following network parameters are used for simulation of the proposed routing protocol

Table 1: Network Parameters for Simulation

Parameter	Value
Network Size	**1500X500**
Number of Sink Nodes	**1**
Number of Source Nodes	**1**
Number of Sensors	**35,55,75**
Packet Size	**512B**
Packet Rate	**5 Packet/Sec**
Run time	**500s**
Maximum Radio Range	**200 meters**
Transmit Power	**2mW**
Charging Power **Battery Capacity**	**3.6 W/h (for 8 h)** **59500 J**

C. *Gathering information of neighboring nodes*

The proposed routing protocol for WMSN incorporates a two-phase optimized path selection mechanism.

In the initial phase, it utilizes an optimized path selection algorithm to start the transmission of an RREQ (Route Request) packet from the source node to the sink node. This RREQ packet undergoes a broadcast process by intermediate nodes until it successfully reaches its intended destination.

The packets carrying multimedia data are forwarded through multiple paths to enhance their reliability and perform load balancing. At each forwarding node, the node will take the decision depending upon the node's throughput and distance to the destination before forwarding the packet

The Following factors are considered in the proposed routing protocol to find the distance between source and destination.

1. Shortest route : SR
2. Node Residual Energy: RE
3. Node Mobility: M
4. Node Congestion: C
5. Node Reliability: R
6. Network Load Balancing: LB
7. Trust: T
8. Quality of Service (QoS): Q

Then, the combined equation for route selection could be formulated as:

$$\mathbf{Score} = \mathbf{W_1} * (\mathbf{SR} + \mathbf{Q} + \mathbf{RE}) + \mathbf{W_2} * (\mathbf{T} + \mathbf{C} + \mathbf{R}) + \mathbf{W_3} * (\mathbf{LB} + \mathbf{M}) \quad (3)$$

Where W_1, W_2, W_3 are the initial weights

In the second phase the sink node employs the primary optimized path to transmit an RREP packet back to the source node. Additionally, the network provides access to optimized alternate paths. In the event of a link or node failure within the network, these alternate paths are utilized for data transmission. Detailed implementation steps for the path selection algorithm in WSN are also provided to optimize the process.

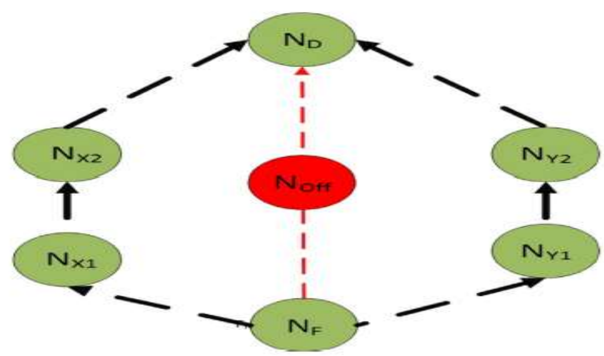

Figure 2. Perimeter Forwarding

During the node failure or if a node turns off, a network gap is created these gaps cause the forwarding node to run out of next-hop possibilities in the greedy forwarding mode, it uses perimeter forwarding as a workaround to get around the problem. When a forwarding node (NF) encounters a gap in its routing path, as shown in Fig. 2, it uses perimeter forwarding to route packets to nodes Nx1 or Ny1, which affects these nodes' standing. The perimeter forwarding technique can be summarized as follows: NF → N_{Off} → ND < NF → Nx1 → Nx2, which is a shorter distance than NF to ND via Nx1 and Nx2. When perimeter forwarding is unable to locate any more forwarding nodes, proposed IHBA-WMSN returns the packet to the original sender and begins looking for another next hop using greedy forwarding or perimeter forwarding.

D. *Algorithm to collect information of neighboring nodes*

Algorithm 1

1: Braodcast_Hello_Beacon

2: Beacon ← Node_Residual_Energy

3: Beacon ← Node_Mobility

4: Beacon ← Node_Congestion

5: Beacon ← Node_Realibility

6: Beacon ← Trust

7: Send_UDP_Packet

4. IMPLEMENTATION

A. *Improved Honey Badger Algorithm*

An optimization algorithm known as "Honey Badger Optimization" is modeled after the natural feeding habits of honey badgers. It is frequently utilized in many domains, such as communication and computer networks, and is well-known for its capacity to manage multi-objective optimization issues.

Honey Badger Optimization can be improved to determine the weight values with combined equation 3 for route selection, following steps are followed:

1. Initialize the weight values.
2. Generate a population of honey badgers.
3. By computing the performance score using the combined route selection equation with the current weight values, assess the fitness of each honey badger solution.
4. Using the search mechanisms of the Honey Badger Optimization Algorithm—random exploration, local search, and global search—update the weight values of the honey badgers in order to find a better weight value.
5. Repeat steps 3 and 4 until a convergence criterion is met.

Motion of the honey badger towards the prey is simulated using

$$x_{prey} = x_{prey} + F * \beta * I * x_{prey} + F * r_3 * \alpha * d_i * \cos(2\pi r_4) * [1 - \cos(2\pi r_5)] \quad (4)$$

Fitness function to alter the direction of the search is given by

$$F = \begin{cases} 1 & \text{if } r_6 \text{ is a random number between} \\ -1 & \end{cases} \quad (5)$$

New position of the honey badger is simulated using

$$x_{new} = x_{prey} + F * r_7 * \alpha * d_i \quad (6)$$

B. Algorithm to find the best route

Algorithm 2

```
Initialize_ weights_ randomly using eq.3
Call Algorithm 1
Initialize_ the_ population_by_ defining N, C, tmax and β
for all i ≤ neighbor_nodes do
Calculate_the_fittness_function_for_ current_ position
Obtain_ best _ position_of_prey_and_fittness_function
if t < tmax
    Calculate_Intensity_update_density_factor
    Evaluate_the_ new_ position
     Update_the_weights
     if new_position > old_position
        update_the_weights
        if convergence_criteria_met
            return_best_solution
        end if
    end if
  end if
end for
```

5. RESULTS

This section showcases the performance of our contribution through the simulation of Novel routing protocol IHBA-WMSN across several circumstances. The empirical simulation results are presented to evaluate the performance of WMSN in handling multimedia data transmission. The node density selected for the simulations are 35, 55 and 75 nodes. We concentrated on end-to-end delay and packet loss ratio. The results of the proposed protocol are compared with AODV, GPSR, TPGF, AGEM, and SGFTEM.

A. *End-to-End delay*

The performance of the protocol IHBA-WMSN is investigated using the network structure, with a varied number of sensor nodes. Presented in Figure 3, the simulation results of the protocol IHBA-WMSN on a simple network topology including 35 nodes are contrasted with those of AGEM, TPGF, AODV, GPSR and SGFTEM. It can be observed that AODV has the highest delay compared to all other existing protocols. The second scenario, with 55 nodes, exhibits the highest end-to-end delay, with AODV coming in first, then AGEM, TPGF, GPS, SGFTEM and IHBA-WMSN. When the density of the nodes is 75, the performance of AODV improved, which clearly indicates that AODV performs better when the node density increases. The protocol IHBA-WMSN outperforms the existing protocols in terms of end to end delay in three different node densities.

B. *Packet loss ratio*

This section elaborates the simulation results for the packet loss ratio (PLR) for the aforementioned protocols. Fig.4 illustrate the three scenarios that were used to evaluate the PLR. AODV has the highest PLR with 35 nodes; GPSR and AGEM do marginally better with the second and third-highest PLRs, respectively; the protocol IHBA-WMSN has the lowest PLR. When the density of nodes is 55 GPSR has the highest PLR, followed by AGEM and SGFTEM, who rank second and third, respectively, but the PLR for AODV has significantly reduced, still the protocol IHBA-WMSN outperformers all the mentioned protocols. Finally for 75 node density PLR of AODV decreased which clearly indicates the performance of AODV gets better for high node density scenarios. Simulations results for three different scenario show that the protocol IHBA-WMSN outperformer the existing routing protocols.

Table 2: End to End delay comparison

Node Density	Protocol	E2E Delay in ms
35	AODV	98
	GPSR	7
	TPGF	6.7
	AGEM	6.5
	SGFTEM	4.5
	IHBA-WMSN	3.8
55	AODV	78
	GPSR	9.5
	TPGF	9
	AGEM	8.9
	SGFTEM	5
	IHBA-WMSN	2.4
75	AODV	8
	GPSR	9
	TPGF	8.8
	AGEM	8.7
	SGFTEM	4
	IHBA-WMSN	1.5

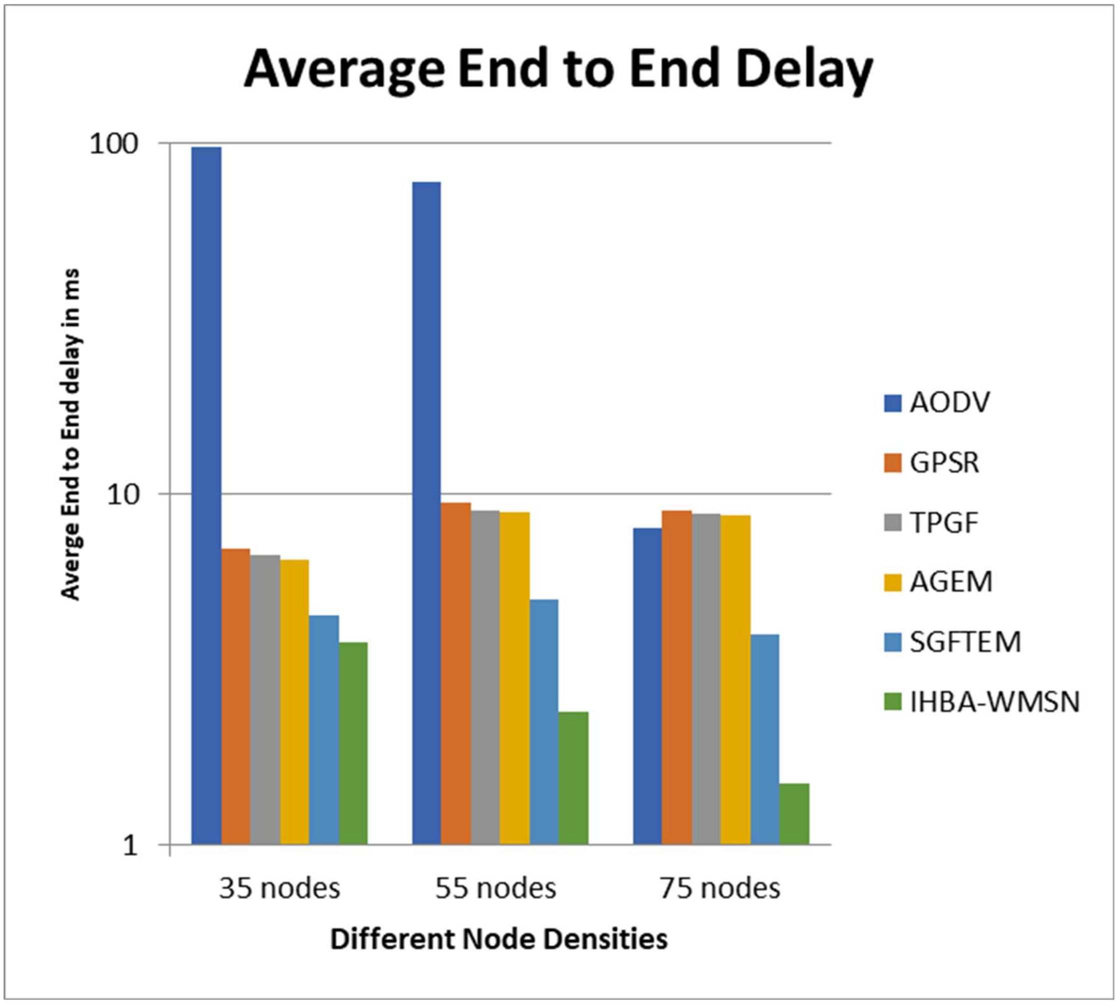

Figure 3: End to End delay of various protocols

Table 3: End to End delay comparison

Node Density	Protocol	PLR in %
35	AODV	2.8
	GPSR	1.9
	TPGF	1.89
	AGEM	1.88
	SGFTEM	1.2
	IHBA-WMSN	1.1
55	AODV	6
	GPSR	5.8
	TPGF	5.75
	AGEM	5.74
	SGFTEM	4.2
	IHBA-WMSN	0.83
75	AODV	1.1
	GPSR	7
	TPGF	6.1
	AGEM	4.9
	SGFTEM	2.9
	IHBA-WMSN	1.3

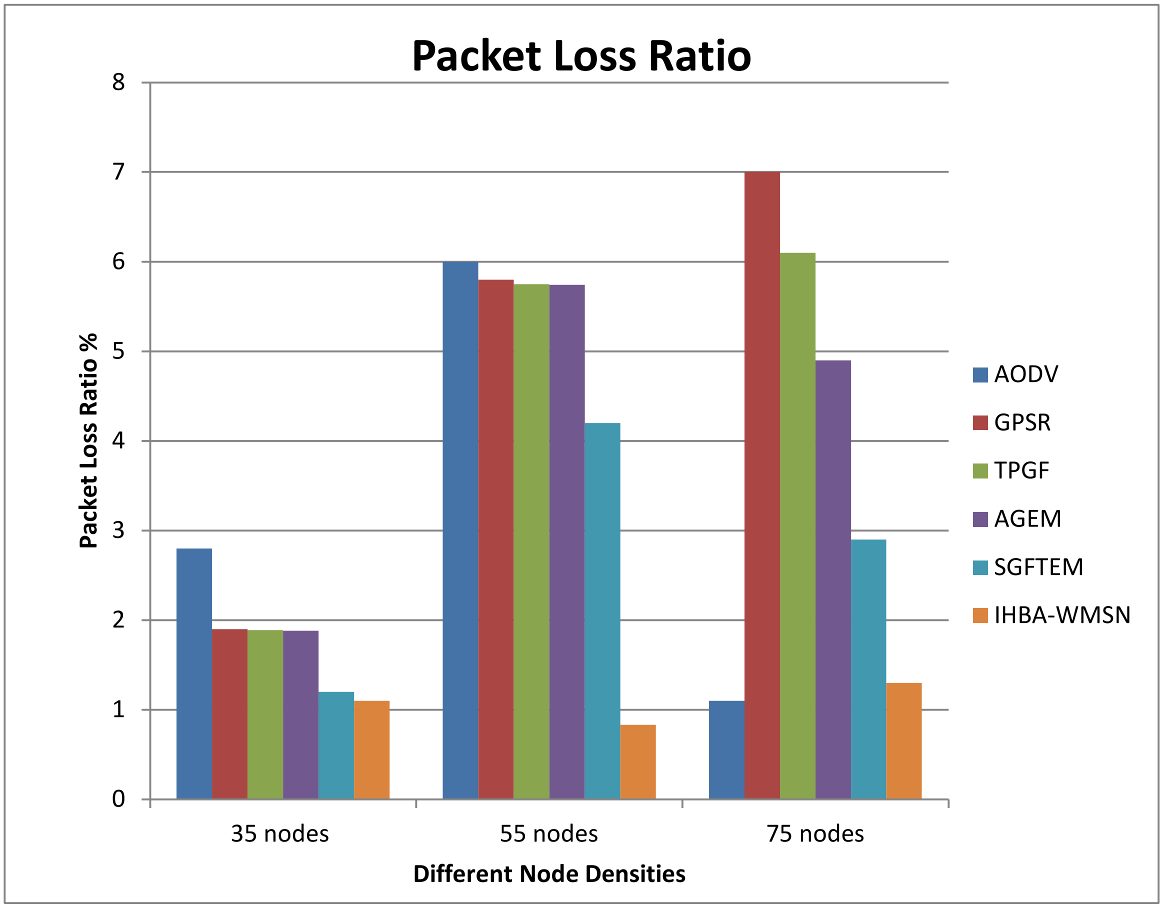

Figure 4: Packet Loss Ratio of various protocol

6. CONCLUSION

This work presents and uses simulations to examine a novel routing strategy. In a basic network topology with 35, 55, and 75 nodes. Tt has been compared against that of AGEM, TPGF, GPSR, AODV, and SGFTEM in various network density scenarios. Additionally, the protocol IHBA-WMSN was simulated with varying network densities in order to examine packet loss ratio and end-to-end delay. When compared to the various routing protocols examined above, the suggested protocol was demonstrated to achieve lower end-to-end latency in every situation, demonstrating its ability to transport multimedia data with less packet loss and end-to-end delay. Therefore, we conclude that the protocol IHBA-WMSN satisfies the conditions needed for multimedia data routing in a wireless sensor network with a severe delay deadline.

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