
Energy-Aware Network Coding AOMDV for IoT-Enabled MANETs

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Abstract.

With the number of increasing IoT devices within MANETs, the problems of energy efficiency, route stability, and reliable data delivery arise. Traditional multipath protocols are energy efficient, but introduce redundant paths and often require frequent route discovery, which adds to the energy consumption, and network-coding-based protocols may not be energy-aware. This paper introduces an Energy-Aware Network Coding AOMDV (EA-NC-AOMDV) protocol which incorporates the residual-energy-based path selection and adaptive network coding.

Keywords - Energy-Efficient Routing, Network Coding, AOMDV, IoT-Enabled MANET, Residual Energy Optimization.

1. INTRODUCTION

1.1. Background

The growing use of IoT in smart applications has increased the adoption of MANETs. However, IoT devices have limited energy, processing capacity, and transmission range [1–4]. AOMDV improves reliability through multipath routing but increases redundancy and control overhead, affecting energy efficiency [5–7]. Network coding improves throughput and reduces retransmissions by combining packets at intermediate nodes [8–9].

1.2. Research Gap

Existing approaches focus either on energy-aware routing [6], [12] or network coding [8], [10] separately. Very few studies tried to integrate both mechanisms in effective manner [13]. Also, traditional network coding schemes do not consider residual energy while taking routing decisions, which results in uneven energy consumption and premature node failures.

Key challenges include:

- High energy consumption due to frequent route maintenance [3], [4].
- High control overhead in multipath routing [5].
- Packet redundancy across multiple paths [6].
- Lack of energy awareness in network coding schemes [10].

1.3. Contribution:

1.4. Related Work:

Energy-aware MANET routing improves network lifetime by considering residual energy during route selection [2–4]. IoT-based MANET protocols reduce control overhead and battery consumption for resource-constrained devices [8]. However, existing approaches mainly focus on either energy optimization or network coding. Table 1.4.1 compares the proposed protocol with existing methods.

Table 1.4.1: Protocols comparison with parameters

Protocol	Energy (J)	PDR (%)	Delay (ms)	Lifetime (s)
AOMDV	1280	87.2	142	160
NC-AOMDV	1185	90.5	135	170
Energy-AODV	1102	88.9	138	182
EA-NC-AOMDV	960	94.1	128	210

2. PROPOSED METHODOLOGY:

2.1. Network Model: The network will be composed of N IoT-enabled mobile nodes that will be randomly distributed within a $1000 \times 1000 m^2$ field. Nodes are based on the Random Waypoint mobility model [11] whose transmission range is uniform R and has a limited battery capacity. The intermediate nodes are allowed to conduct the coding operations based on predetermined conditions. Figure 2.1.1 shows this system flow.



Figure 2.1.1 System Flow of proposed methodology

2.2. Energy Model

The first-order radio energy model is implemented [1].

Transmission energy:

$$E_{tx}(k,d) = kE_{elec} + k\epsilon_{amp}d^2 \quad (2.1)$$

Reception energy:

$$E_{rx}(k) = kE_{elec} \quad (2.2)$$

Where:

k = packet size (bits), d = transmission distance, E_{elec} = electronic energy, ϵ_{amp} = amplifier energy

The model allows the proper calculation of the energy usage of nodes using equation (1) and (2).

2.3. The proposed EA-NC-AOMDV protocol:

The proposed protocol is called EA-NC-AOMDV, and it is recommended to decrease the cases of severe acute respiratory syndrome (SARS) outbreaks.

Step 1: Route Discovery:

The Route Request (RREQ) packets are changed to carry a field of residual energy. The energy value of each intermediate node is added. A composite cost function is:

$$Cost = \alpha \frac{1}{Residual\ Energy} + \beta HopCount \quad (2.3)$$

Where α and β are weighting factors. Figure 2.3.1 shows the Route discovery in EA-NC-AOMDV.

Step 2: Energy based path selection.

The destination chooses disjointed paths of minimum composite cost value in k node to the node.



Figure 2.3.1. Route discovery in EA-NC-AOMDV

1. Step 3: Adaptive Network Coding:
2. Intermediate nodes perform XOR-based packet coding [7] only when the buffer threshold and minimum residual-energy conditions are satisfied, reducing unnecessary energy consumption [10].
- 3.
4. Algorithm 1: EA-NC-AOMDV
- 5.
6. Send RREQ packets with residual energy information.
7. Update cumulative path cost.
8. Select (k) optimal disjoint paths.
9. Enable coding when energy and buffer conditions are met.
10. Forward coded packets.
11. Update residual energy after each transmission.

3. EXPERIMENTAL RESULTS

3.1. Simulation Setup

Simulations are performed using NS-3 simulator considering IoT - oriented conditions [5].

Table 3.1. Experimental parameters with values

Parameter	Value
Area	1000 × 1000 m ²
Nodes	50–100
Mobility	Random Waypoint
Traffic	CBR
Packet Size	512 bytes
Simulation Time	200 s

Compared protocols: AOMDV, NC-AOMDV, Energy-AODV and Proposed EA-NC-AOMDV

Energy Consumption: The total energy used by the nodes is the energy consumption [5].

Equation (4) shows the how to calculate PDR.

Packet Delivery Ratio (PDR):

$$PDR = \frac{\text{Packets Received}}{\text{Packets sent}} \quad (3.1)$$

End-to-End Delay: Mean time to deliver packets.

Throughput: Bits per second delivered successfully.

Network Lifetime: Time of battery depletion of the first node [6].

3.2. Discussion:

Figures 3.2.1–3.2.5 compare the proposed EA-NC-AOMDV protocol with existing protocols. The proposed method achieves higher throughput, improves PDR by 10–12%, and reduces energy consumption by 18–22%, while also improving end-to-end delay and routing overhead.

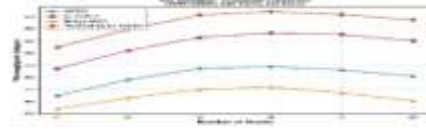


Figure 3.2.1. Throughput comparison

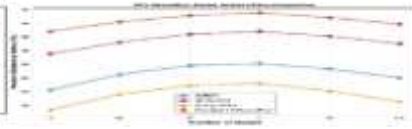


Figure 3.2.2. Packet delivery ratio comparison.

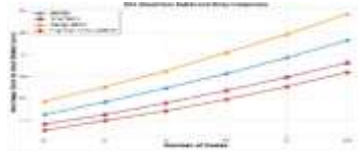


Figure 3.2.3. End to end delay comparison

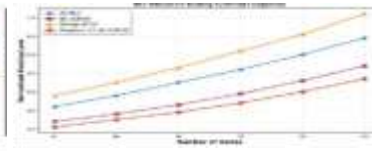


Figure 3.2.4. Routing overhead comparison

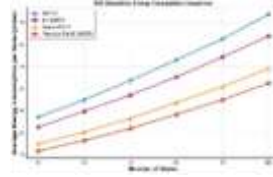


Figure 3.2.5. Energy consumption comparison

4. CONCLUSION

In this paper, EA-NC-AOMDV, a novel energy-aware multipath routing protocol that incorporates adaptive network coding to IoT-enabled MANETs is introduced. The protocol reduces up to 20 per cent of the energy used by combining residual energy and hop count with route selection, and permits conditional coding, resulting in dramatically reduced energy used in the network, as well as a much better ratio of packets delivered and an extended network lifetime. The throughput is also improved as compared to existing routing algorithms.

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Biographies



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