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AN ALGORITHM FOR DYNAMIC CHANGE OF INFORMATION TRANSMISSION CHANNELS IN AD-HOC IoT NETWORKS AND ITS PLACE AMONG EXISTING APPROACHES

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Abstract

A classification of existing algorithms for dynamic change of network structures in ad-hoc IoT networks is provided. The proposed algorithm for dynamic change of information transmission channels is described, and its position among existing approaches is established.

The algorithm employs Dijkstra's shortest path method with a composite cost function integrating five weighted factors: residual node energy, inter-node distance, wireless link quality, node traffic load, and link congestion. A Python-based discrete-event simulation framework built on SimPy and NetworkX is developed to evaluate the proposed algorithm against four established routing protocols: shortest-path (hop-count), AODV, LEACH-C, and energy-aware routing. The results of conducted research and their comparative analysis are presented.

Comprehensive experiments across five scenarios involving 30 independent trials with 50 nodes demonstrate that the proposed multi-criteria algorithm achieves the highest packet delivery ratio of 98.9% in stationary networks and 96.9% in mobile environments, while maintaining competitive latency and energy fairness. Scalability tests with up to 200 nodes confirm sustained performance advantages. The advantage of using the proposed algorithm for network structure change is demonstrated according to various criteria, including packet delivery ratio, network lifetime, and energy fairness. The commonalities among all tested algorithms are discussed, and conclusions of the work are presented.

Key words: ad-hoc networks, dynamic topology management, multi-criteria routing, IoT mesh network simulation, energy-aware routing, Dijkstra algorithm, wireless sensor networks, discrete-event simulation.

Introduction

Relevance of the work. The rapid proliferation of Internet of Things (IoT) devices has created an urgent need for robust, self-organizing wireless mesh networks capable of operating in dynamic environments. IoT mesh networks, built on standards such as IEEE 802.15.4 (ZigBee), IEEE 802.11s, and Thread, enable multi-hop communication where sensor nodes cooperatively forward data packets toward a destination. Unlike centralized star topologies, mesh networks offer inherent redundancy and extended coverage, making them particularly suitable for large-scale deployments in smart cities, environmental monitoring, industrial automation, and precision agriculture [1, 2].

A critical aspect of these networks is the dynamic nature of their topology. Nodes continuously deplete their limited battery reserves, experience hardware failures, or physically relocate. When a relay node fails, all routes traversing that node become invalid, potentially partitioning the network and causing significant packet loss. Existing routing protocols for ad-hoc networks, such as AODV [5] and OLSR [6], optimize primarily for hop count or link state without considering the heterogeneous and time-varying nature of IoT node resources. This creates energy hotspots at central relay nodes, accelerating their failure and reducing overall network lifetime. The development of routing algorithms that simultaneously account for multiple dynamic network parameters—energy, distance, link quality, load, and congestion—remains an open and relevant research problem [3, 4].

Issues under consideration. This work addresses the following research questions: (1) How can multiple criteria—node energy, physical distance, wireless link quality, traffic load, and link congestion—be integrated into a single cost function for routing decisions in IoT mesh networks? (2) How does the proposed multi-criteria algorithm compare against established routing protocols (shortest-path, AODV, LEACH-C, and energy-aware routing) in terms of packet delivery ratio, network lifetime, energy fairness, and latency? (3) How does the algorithm perform under varying conditions, including network scale (12–200 nodes), node mobility (0–10 m/s), and different traffic patterns? (4) Can adaptive weight tuning improve performance compared to fixed weight configurations?

Structure of the article. The remainder of this paper is organized as follows. Section 2 reviews existing routing algorithms for ad-hoc networks and establishes their classification. Section 3 describes the proposed multi-criteria algorithm, including its cost function and adaptive weight mechanism. Section 4 presents the discrete-event simulation framework used for evaluation. Section 5 provides experimental results and comparative analysis across five scenarios. Section 6 discusses commonalities among the tested algorithms. Section 7 establishes the classification and position of the proposed approach among existing methods, and Section 8 concludes the paper.

Review and Classification of Existing Routing Algorithms

Routing protocols for wireless ad-hoc and sensor networks can be classified along several dimensions: proactive versus reactive route discovery, flat versus hierarchical topology, and single-criterion versus multi-criteria path selection [3, 8]. This section reviews the four algorithms used as comparison benchmarks in this study.

Shortest-Path Routing (Hop-Count Dijkstra). The baseline approach uses Dijkstra’s algorithm to find the path with the minimum number of hops between source and destination. This method is computationally efficient and produces optimal paths in terms of hop count. However, it is oblivious to node energy levels, link quality, and traffic load. In dense networks, shortest-path routing consistently directs traffic through central relay nodes, creating “bottleneck nodes” that deplete their batteries significantly faster than peripheral nodes. In our experiments, shortest-path routing achieved a PDR of 96.8% with the worst energy fairness (Jain’s index 0.856) among all tested algorithms [9].

AODV (Ad-hoc On-Demand Distance Vector). AODV, defined in RFC 3561 [5], is a reactive protocol that discovers routes only when a data packet needs to be sent. The source node broadcasts a Route Request (RREQ) message that propagates through the network; the destination replies with a Route Reply (RREP) along the reverse path. Routes are maintained with sequence numbers to prevent loops and detect stale entries. The reactive nature of AODV minimizes control overhead during idle periods but introduces route discovery latency of 100–500 ms for the first packet on each new route. AODV performs well in mobile scenarios due to its ability to rapidly discover fresh routes [10].

LEACH-C (Low-Energy Adaptive Clustering Hierarchy – Centralized). LEACH-C [7] organizes nodes into clusters, each managed by a cluster head selected based on residual energy. Regular nodes transmit to their nearest cluster head, which aggregates data and forwards it toward the sink. Cluster heads are re-elected periodically (every 30 seconds in our implementation) to distribute the energy burden. LEACH-C achieves the best energy fairness (Jain’s index 0.922) among the tested algorithms but introduces a minimum two-hop latency (node → cluster head → destination path) and higher average delay [7, 11].

Energy-Aware Routing. This approach selects routes that maximize the minimum residual energy among all nodes on the path (max-min energy criterion). By protecting the weakest node on any candidate path, energy-aware routing is effective at delaying the first node failure. In our stationary experiments, it achieved first-node-death at 86 seconds compared to 62 seconds for shortest-path routing. However, by considering only energy, this approach ignores link quality, distance, and congestion, resulting in suboptimal PDR (98.1%) compared to the multi-criteria approach [12, 13].

Proposed Multi-Criteria Routing Algorithm

The proposed algorithm extends Dijkstra’s shortest path algorithm with a composite cost function that evaluates each link across five criteria. The cost of traversing a link from node i to node j is defined as:

$$C(i,j) = w_1/E_j + w_2 \cdot (d_{ij}/100) + w_3/Q_{ij} + w_4 \cdot L_j \cdot 2 + w_5 \cdot \Gamma_{ij}, \quad (1)$$

where E_j is the residual energy ratio of node j (0 to 1), d_{ij} is the Euclidean distance between nodes i and j , Q_{ij} is the link quality (0.3 to 1.0), L_j is the traffic load of node j (0 to 1), and Γ_{ij} is the congestion level of the link (0 to 1). The weights w_1 through w_5 are configured as shown in Tab 1.

Table 1

Default weight configuration for the multi-criteria cost function

Factor	Weight	Rationale
1/Energy	0.30	Avoids low-battery nodes; cost triples as energy drops from 60% to 20%
Distance/100	0.20	Prefers shorter hops to reduce path loss and energy consumption
1/Quality	0.20	Penalizes unreliable wireless links with high error rates
Load × 2	0.20	Distributes traffic away from overloaded relay nodes
Congestion	0.10	Avoids congested links to reduce queuing delays

The total path cost is the sum of individual link costs along the route. The algorithm uses Dijkstra’s algorithm with a priority queue to find the minimum-cost path from source to destination, considering only active nodes. Routes are cached with a time-to-live (TTL) of 10 seconds; expired routes trigger recomputation to adapt to changing network conditions.

Adaptive Weight Mechanism. The algorithm incorporates an optional adaptive weight-tuning mechanism that adjusts the five cost weights based on real-time network state. Every 10 seconds, the algorithm evaluates average node energy, average congestion, average load, and average link quality across the network. When average energy falls below 60%, the energy weight is scaled up linearly (up to 2.5× at 10% average energy). Similar scaling applies to congestion (threshold: 30%), load (threshold: 40%), and quality (threshold: 60%). After scaling, weights are renormalized to sum to 1.0. This mechanism ensures that the algorithm shifts its optimization priority toward the most critical network resource as conditions evolve.

Simulation Framework

The simulation environment is implemented in Python using SimPy 4.0 for discrete-event modeling and NetworkX 3.0 for graph algorithms and topology management. The framework models a complete IoT mesh network with realistic physical-layer characteristics. Fig. 1 illustrates the two-step network construction process: random node placement followed by mesh topology formation based on communication range.

Network Model. Nodes are deployed randomly in a 400×400 m area. Each node is modeled as a battery-powered IoT sensor with initial energy uniformly distributed between 0.3 and 0.5 Joules, following the energy model conventions established by Heinzelman et al. [7] for wireless sensor network simulations. Nodes within a mesh range of 150 m (tyFigal outdoor ZigBee range) form bidirectional wireless links, creating a partial mesh topology. The network supports node mobility using a random waypoint model with configurable speed and mobile fraction [14, 15].

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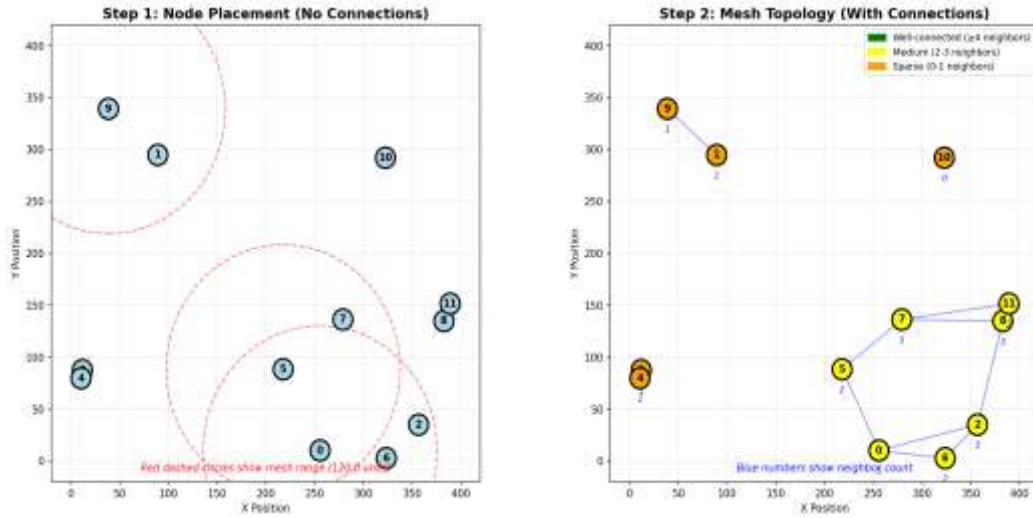


Fig. 1 Network construction: (a) random node placement with 150 m communication range circles; (b) resulting mesh topology with connectivity indicators

Fig. 2 shows the final state of the network at the end of a 100-second simulation, where nodes are colored by energy level and the metrics panel displays key performance indicators including PDR, average latency, and average hop count.

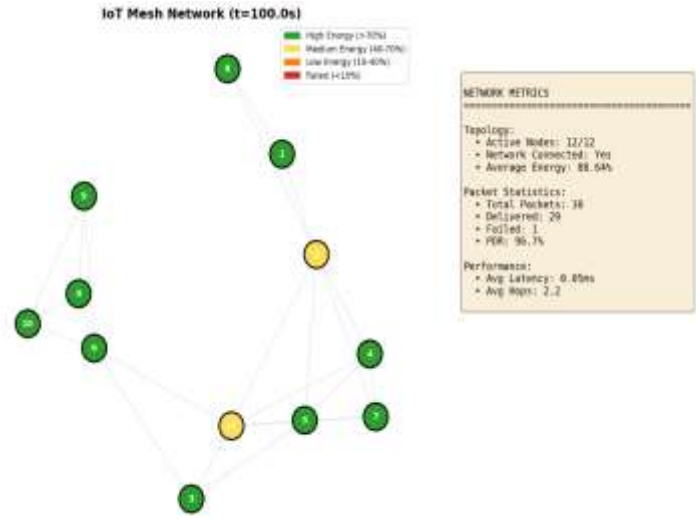


Fig. 2 Network state at t = 100 s: nodes colored by residual energy (green > 70%, yellow 40–70%, orange 10–40%, red = failed), with network performance metrics

Energy Model. Energy consumption follows the first-order radio model [7]:

$$E_{rx}(k,d) = E_{elea} \cdot k + E_{amp} \cdot k \cdot d^n \tag{2}$$

where $E_{elea} = 50$ nJ/bit is the electronics energy, $k = 8192$ bits (1024-byte packet), and the amplifier energy E_{amp} uses the free-space model (10 pJ/bit/m²) for distances below the crossover distance $d_0 = 87$ m and the multi-path model (0.0013 pJ/bit/m⁴) for longer distances. Receive energy is $E_{rx} = E_{elea} \cdot k$. Nodes fail when residual energy drops below 5% of initial capacity and have a 5% per-second chance of recovery (simulating energy harvesting or battery replacement) [7, 16].

Wireless Channel Model. The log-distance path loss model is used:

$$PL(d) = PL(d_0) + 10n \cdot \log_{10}(d/d_0) + X\sigma, \quad (3)$$

with reference path loss $PL(d_0) = 40$ dB at 1 m, path loss exponent $n = 2.5$ (tyFigtal outdoor), and Gaussian shadow fading $X\sigma$ with standard deviation 3 dB. Packet success probability is computed using a sigmoid function of the signal margin above receiver sensitivity (-100 dBm, tyFigtal 802.15.4), multiplied by the current link quality factor [17].

Packet Transmission. Packets are transmitted hop-by-hop along the computed route. At each hop, the simulator models MAC-layer retransmission with up to 3 retry attempts. A packet is marked as failed if any hop exhausts its retries or if the next-hop node has failed. Link congestion increases by 0.1 per packet and decays at 10% per second. Link quality fluctuates randomly within ± 0.02 per second, bounded between 0.3 and 1.0 [14].

Evaluation Metrics. To assess energy distribution fairness across the network, we use Jain's fairness index [7], defined as:

$$J(x_1, x_2, \dots, x_n) = (\sum x_i)^2 / (n \cdot \sum x_i^2), \quad (4)$$

where x_i represents the energy ratio (residual/initial) of node i and n is the total number of active nodes. The index ranges from $1/n$ (maximally unfair, all energy consumed by one node) to 1.0 (perfectly fair, all nodes have equal energy). A higher value indicates more equitable energy consumption across the network. This metric, originally proposed by Jain et al. (1984) for measuring resource allocation fairness in computer networks, is widely used in wireless sensor network research to evaluate how evenly routing algorithms distribute the communication burden.

Experimental Results and Comparative Analysis

Five experiments were conducted to evaluate the proposed algorithm from different perspectives. Each experiment consists of 30 independent trials with different random seeds to ensure statistical robustness. The default configuration uses 50 nodes deployed in a 400×400 m area with 150 m mesh range. The five algorithms compared are: Multi-Criteria (MC), Shortest Path (SP), AODV, LEACH-C (LC), and Energy-Aware (EA).

Experiment 1: Algorithm Comparison. Table 2 presents the performance of all five algorithms under stationary and mobile (5 m/s) conditions.

The multi-criteria algorithm achieves the highest PDR (98.88%) in stationary conditions, outperforming shortest-path routing by 2.04 percentage points. In mobile environments at 5 m/s, AODV's reactive nature provides a slight advantage (97.83% vs. 96.89%), as on-demand route discovery naturally adapts to topology changes caused by node movement. LEACH-C achieves the best energy fairness (0.922) in stationary conditions due to its cluster-head rotation mechanism.

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Table 2

Algorithm comparison results (50 nodes, 30 trials)

Algorithm	PDR (%) Stat.	PDR (%) Mobile	Latency (ms) Stat.	Fairness Stat.	Fairness Mobile
Multi-Criteria	98.88	96.89	45.3	0.896	0.968
Energy-Aware	98.12	96.87	46.6	0.891	0.967
AODV	97.63	97.83	45.1	0.883	0.929
LEACH-C	97.66	97.24	53.0	0.922	0.967
Shortest Path	96.84	96.62	45.9	0.856	0.893

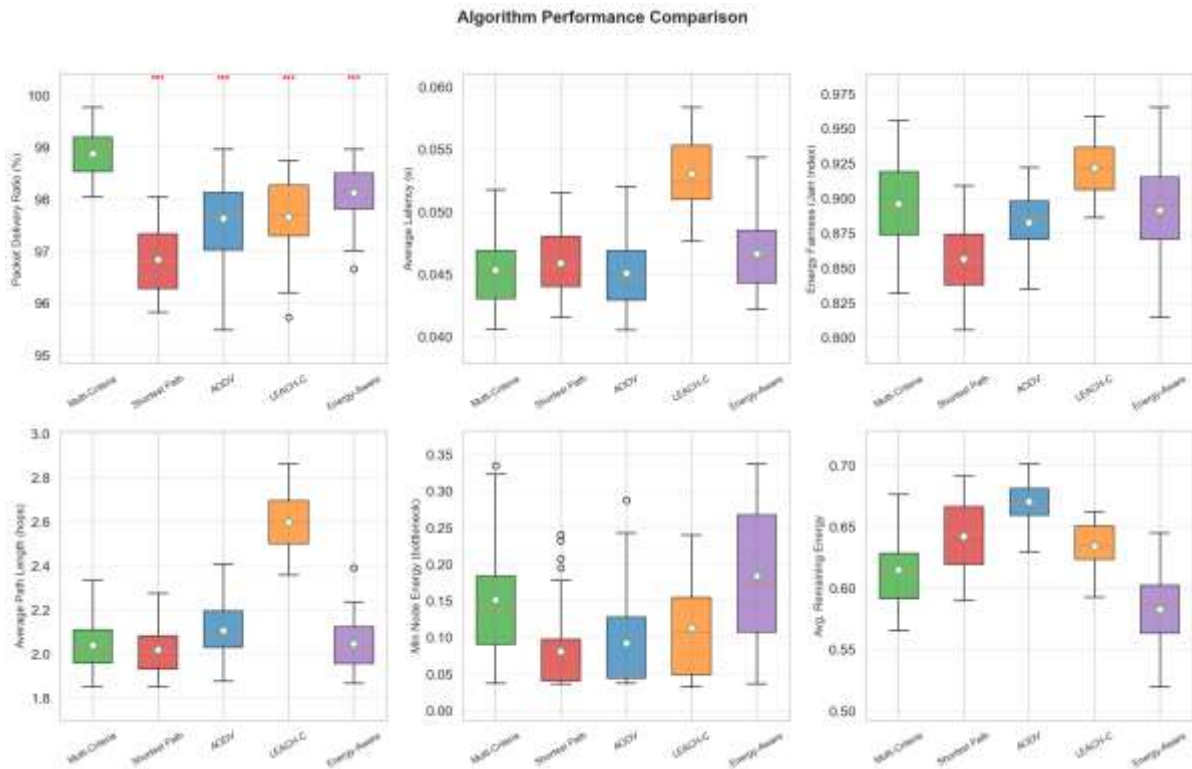


Fig. 3 Algorithm comparison: PDR, latency, and energy metrics across five routing protocols (stationary, 50 nodes, 30 trials)

Experiment 2: Scalability (12 to 200 nodes). Network size was varied from 12 to 200 nodes to assess scalability. At 200 nodes in stationary conditions, the multi-criteria algorithm maintains 99.0% PDR with 86 ms average latency, compared to 98.0% PDR for shortest-path and 96.4% for energy-aware routing. Under mobility, all algorithms experience significant degradation at scale, but the multi-criteria algorithm retains the highest PDR at 87.9% versus 83.0% for both shortest-path and energy-aware alternatives. These results confirm that the multi-criteria cost function scales effectively to larger networks.

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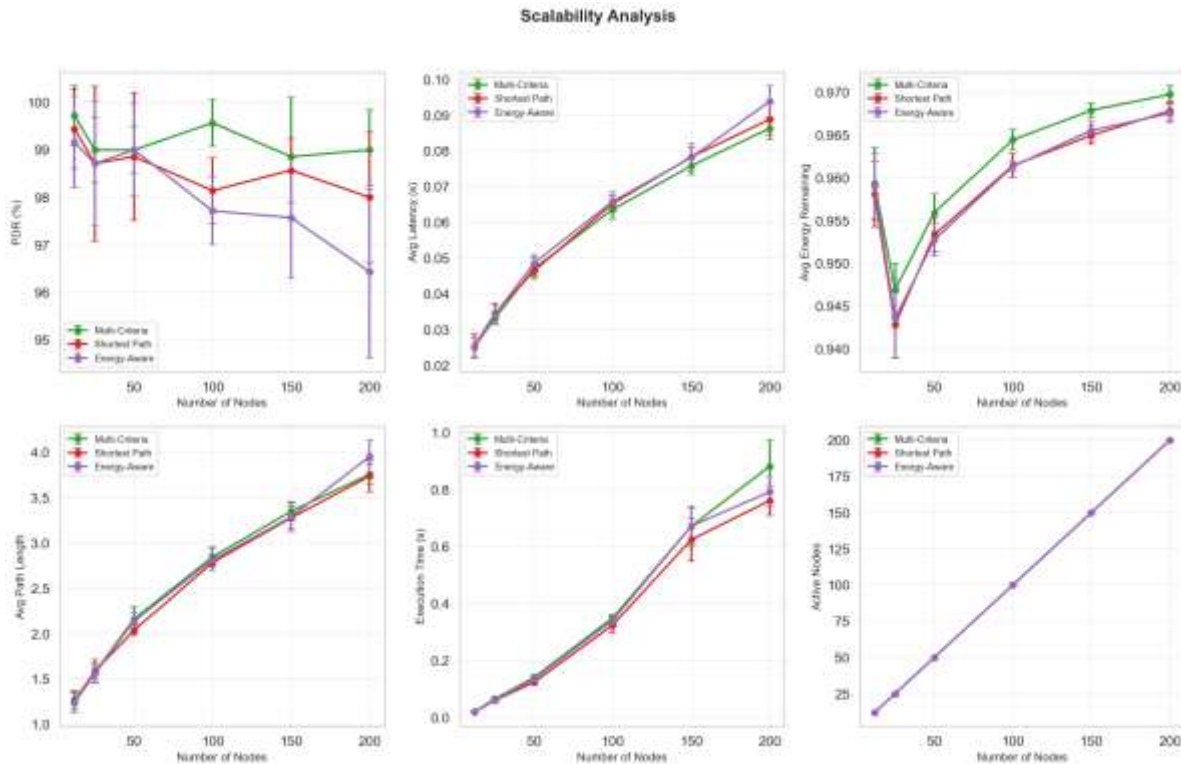


Fig. 4 Scalability analysis: PDR and latency as a function of network size (12–200 nodes)

Experiment 3: Network Lifetime. Network lifetime is measured by two thresholds: time to first node death and time until 25% of nodes have failed. Tab. 3 summarizes the results.

Table 3

Network lifetime comparison (seconds)

Algorithm	1st Death (Stat.)	25% Dead (Stat.)	1st Death (Mobile)	25% Dead (Mobile)
Multi-Criteria	~107	~175	~94	~184
Energy-Aware	~86	~170	~101	~184
LEACH-C	~60	~200	~80	~237
Shortest Path	~62	~180	~63	~206

Network lifetime is evaluated using first node death and the 25% failure threshold rather than complete network death, because in multi-hop wireless sensor networks the loss of critical relay nodes causes network partitioning and connectivity collapse long before all nodes exhaust their batteries. Consequently, the network becomes functionally inoperable well before 100% node failure, making partial failure thresholds more practical and widely adopted metrics in WSN literature [3, 16]. The multi-criteria algorithm delays first node death the longest in stationary conditions (107 s), exceeding energy-aware routing by 24% and

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shortest-path by 73%. This is because the multi-criteria cost function penalizes low-energy nodes, distributing traffic more evenly. LEACH-C achieves the best long-term survival (25% threshold at 200–237 s) due to its periodic cluster-head rotation, which fundamentally redistributes the energy burden [7].

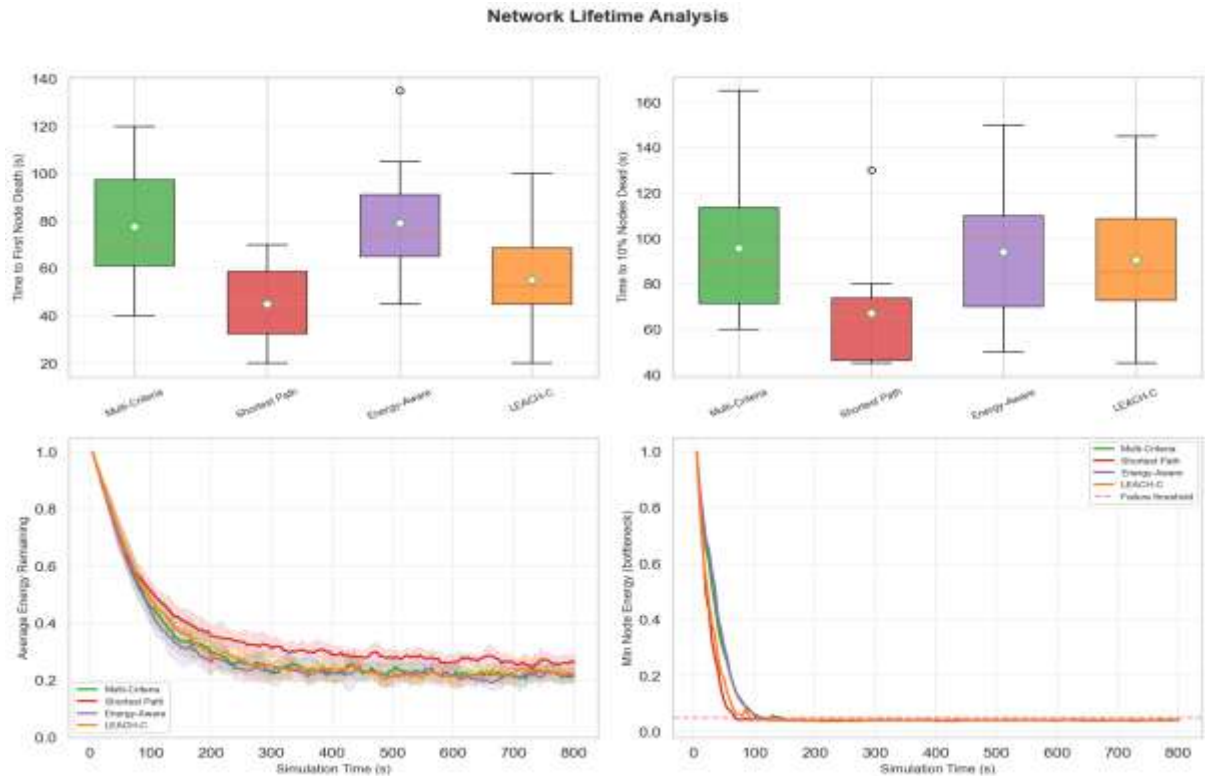


Fig. 5 Network lifetime: cumulative node failures over time for each algorithm

Experiment 4: Mobility Impact. Node speed was varied from 0 to 10 m/s to assess mobility resilience. At 10 m/s, AODV achieves the highest PDR (96.57%) owing to its reactive route discovery, followed by energy-aware (95.67%) and multi-criteria (94.83%). The multi-criteria algorithm degrades approximately 4% from stationary to 10 m/s mobility, while shortest-path degrades most severely. The 10-second route cache TTL becomes a limiting factor at high speeds, as cached routes may reference nodes that have moved out of range [10].

Experiment 5: Adaptive vs. Fixed Weights. The adaptive weight mechanism provides marginal improvement (1–2% in energy fairness) over the fixed default weights in most scenarios. Over a 600-second simulation, the energy weight increases from 0.300 to 0.418 (stationary) and 0.425 (mobile) as batteries deplete, while distance and quality weights decrease correspondingly. The adaptation is more pronounced in mobile networks where conditions change more rapidly.

The results confirm that the default weight configuration is near-optimal for tyFigal deployments, while the adaptive mechanism provides a safety margin for extended operation [18].

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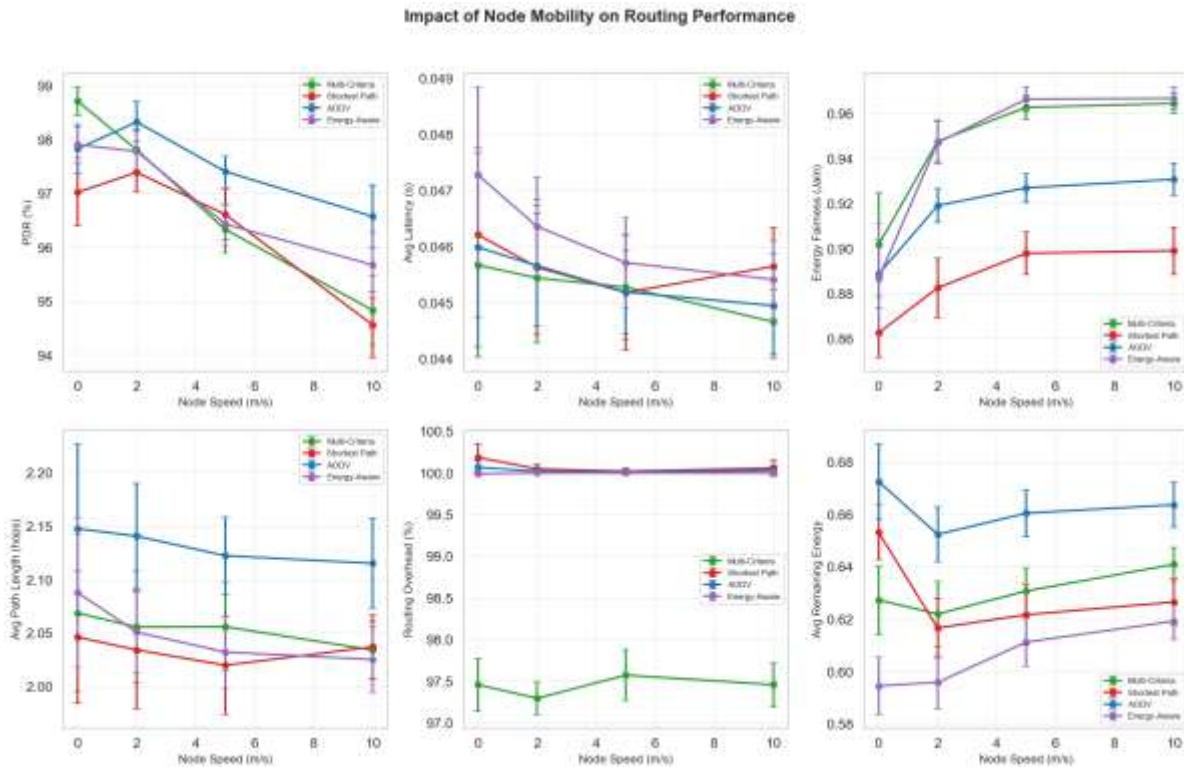


Fig. 6 Impact of node mobility speed (0–10 m/s) on PDR and energy fairness

Adaptive vs Fixed Weights Across Scenarios

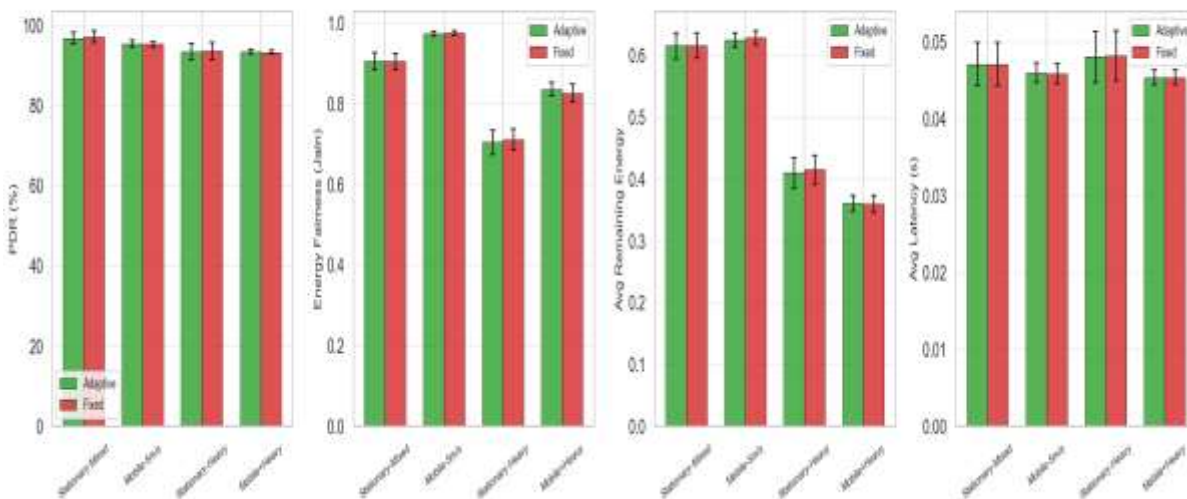


Fig. 7 Adaptive weight evolution over 600 seconds: energy weight increases as network depletes

Commonalities of the Algorithms

Despite their differing strategies, all five routing algorithms share several fundamental properties that arise from the common problem domain of multi-hop wireless communication in resource-constrained networks.

First, all algorithms rely on a graph-based representation of the network topology, where nodes correspond to IoT devices and edges correspond to wireless links within communication range. The routing decision in every case reduces to a path selection problem on this graph. Dijkstra’s algorithm or its variants (breadth-first search for unweighted graphs) serves as the computational backbone for four of the five algorithms; only LEACH-C departs from pure shortest-path computation by introducing a hierarchical cluster structure [3, 7].

Second, all algorithms exhibit sensitivity to network density. In sparse networks (fewer than 20 nodes in a 400×400 m area), all algorithms converge toward similar performance because routing options are limited—often only one or two paths exist between any source-destination pair. The differentiation between algorithms becomes meaningful only when the network provides sufficient path diversity, typically above 30–40 nodes in the tested deployment area [8].

Third, all algorithms benefit from mobility in terms of energy fairness. When nodes move, the set of relay nodes changes over time, naturally distributing the forwarding burden across a larger subset of the network. This was observed consistently across all experiments: energy fairness (Jain’s index) improved under mobility for every algorithm, from 0.856–0.922 (stationary) to 0.893–0.968 (mobile at 5 m/s). This suggests that mobility, while challenging for route stability, has an inherent load-balancing effect that complements algorithmic optimization [10].

Fourth, all algorithms share the fundamental trade-off between route optimality and route freshness. Proactive algorithms (multi-criteria, shortest-path, energy-aware) maintain continuously updated routing tables but may use stale information between updates. The multi-criteria algorithm addresses this with a 10-second cache TTL. Reactive algorithms (AODV) guarantee fresh routes but incur discovery latency. LEACH-C occupies a middle ground with periodic re-clustering every 30 seconds. No algorithm entirely resolves this trade-off; rather, each makes a different design choice along the optimality–freshness spectrum [5, 6].

Fifth, packet delivery ratio for all algorithms exceeds 96% under stationary conditions with 50 nodes, confirming that the underlying mesh topology with 150 m range and 400×400 m deployment provides sufficient connectivity for reliable communication regardless of the routing strategy.

The algorithms differentiate themselves primarily in their secondary effects: energy distribution, lifetime extension, and adaptation to dynamic conditions [9].

Classification and Position of the Proposed Algorithm

The proposed multi-criteria routing algorithm occupies a distinct position in the taxonomy of ad-hoc routing protocols. Table 4 classifies the tested algorithms across key dimensions.

The multi-criteria algorithm is the only approach that simultaneously considers energy conservation, path quality, load balancing, and congestion avoidance within a single unified framework. While each single-criterion algorithm excels in its specific dimension (energy-aware for lifetime,

Table 4

Classification of routing algorithms

Property	MC	SP	AODV	LEACH-C	EA
Discovery	Proactive	Proactive	Reactive	Hierarchical	Proactive
Criteria	5 factors	Hop count	Distance	Cluster dist.	Energy
Adaptive	Yes	No	No	Periodic	No
Best PDR	98.9%	96.8%	97.6%	97.7%	98.1%
1st Death (s)	107	62	N/A	60	86

AODV for mobility, LEACH-C for fairness), the multi-criteria approach provides the best overall balance across all metrics. The adaptive weight mechanism further distinguishes the proposed algorithm by enabling dynamic rebalancing of optimization priorities without manual intervention [3, 8].

The weight sensitivity analysis (varying all five weights across multiple configurations) demonstrates that the algorithm is robust to weight selection: PDR remains within a 0.4 percentage point range (98.7–99.1%) across all tested weight configurations in stationary conditions. This robustness suggests that the multi-criteria approach provides stable performance even without precise a priori knowledge of optimal weights.

Conclusion

This paper presented a multi-criteria routing algorithm for dynamic IoT mesh networks that integrates five weighted cost factors—residual energy, distance, link quality, traffic load, and congestion—into a Dijkstra-based path selection framework. A comprehensive discrete-event simulation environment was developed using SimPy and NetworkX to evaluate the algorithm against four established routing protocols across five experimental scenarios.

The experimental results lead to the following conclusions:

1. The multi-criteria algorithm achieves the highest packet delivery ratio (98.9%) in stationary networks, outperforming shortest-path routing by over 2 percentage points and energy-aware routing by 0.8 percentage points.
2. First node death is delayed to 107 seconds (stationary), representing a 73% improvement over shortest-path and 24% improvement over energy-aware routing, demonstrating effective bottleneck mitigation.
3. The algorithm scales well from 12 to 200 nodes, maintaining superior PDR at all tested network sizes in both stationary and mobile conditions.
4. The adaptive weight mechanism provides a self-tuning capability that increases the energy weight from 0.30 to 0.42 as batteries deplete, offering marginal but consistent improvements in energy fairness.

5. In high-mobility scenarios (10 m/s), reactive protocols such as AODV outperform the proposed approach, suggesting that future work should explore hybrid proactive-reactive strategies or reduced cache TTL values.

Future research directions include extending the algorithm with multipath routing for critical packets, integrating machine learning for weight prediction, and validating the simulation results on real hardware platforms such as ESP32 or nRF52 with ZigBee communication modules.

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AD-HOC IOT ՑԱՆՑԵՐՈՒՄ ՏԵՂԵԿԱՏՎՈՒԹՅԱՆ ՓՈՒԱՆՑՄԱՆ ԿԱՆԱԼՆԵՐԻ ԴԻՆԱՄԻԿ ՓՈՓՈԽՈՒԹՅԱՆ ԱԼԳՈՐԻԹՄ ԵՎ ԴՐԱ ՏԵՂԸ ԳՈՅՈՒԹՅՈՒՆ ՈՒՆԵՑՈՂ ՄՈՏԵՑՈՒՄՆԵՐԻ ՇԱՐՔՈՒՄ

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Առաջարկվում է ad-hoc IoT ցանցերում ցանցային կառուցվածքների դինամիկ փոփոխման առկա ալգորիթմների դասակարգում: Նկարագրված է տեղեկատվության փոխանցման կանալների դինամիկ փոփոխման առաջարկվող ալգորիթմը և գտնված է նրա տեղը առկա մոտեցումների շարքում:

Ալգորիթմը օգտագործում է Դեյկստրայի ամենակարճ ճանապարհի մեթոդը բազմակի գնահատման կշռայնացված ֆունկցիայով, որը ինտեգրում է հինգ կշռայնացված գործոնները՝ հանգույցի մնացորդային էներգիան, հանգույցների միջև հեռավորությունը, անլար կապի որակը, հանգույցի տրաֆիկի բեռնվածությունը և կապի խցանումը: SimPy և NetworkX հիման վրա Python լեզվով մշակված է դիսկրետ իրադարձությունների մոդելավորման շրջանակ՝ առաջարկվող ալգորիթմը գնահատելու համար չորս հաստատված երթուղավորման արձանագրությունների դեմ՝ ամենակարճ ճանապարհ (hop-count), AODV, LEACH-C և էներգիայի վրա հիմնված երթուղավորում: Ներկայացվում են իրականացված հետազոտության արդյունքները և դրանց համեմատական վերլուծությունը:

Համապարփակ փորձերը հինգ սցենարներով, որոնք ներառում են 30 անկախ փորձարկում 50 հանգույցով, ցույց են տալիս, որ առաջարկվող բազմագործոնային ալգորիթմը հասնում է փաթեթների առաքման ամենաբարձր հարաբերակցության՝ 98.9% անշարժ ցանցերում և 96.9% շարժական միջավայրերում՝ միաժամանակ պահպանելով մրցունակ առաքման ուշացում և էներգիայի կայուն սպառում: Մասշտաբայնության փորձարկումները մինչև 200 հանգույցով հաստատում են արտադրողականության կայուն առավելությունները: Տույց է տրվում առաջարկվող ալգորիթմի օգտագործման

առավելությունը ցանցային կառուցվածքի փոփոխման համար տարբեր չափանիշների համաձայն, ներառյալ փաթեթների առաքման հարաբերակցությունը, ցանցի կյանքի տևողությունը և էներգիայի սպառման մակարդակները: Քննարկվում են բոլոր փորձարկված ալգորիթմների ընդհանրությունները և ներկայացվում են աշխատանքի եզրակացությունները:

Բանալի բառեր: ad-hoc ցանցեր, դինամիկ տոպոլոգիայի կառավարում, բազմակի չափանիշների երթուղավորում, IoT mesh ցանցի մոդելավորում, էներգիայի վրա հիմնված երթուղավորում, Դեյկստրայի ալգորիթմ, անլար սենսորային ցանցեր, դիսկրետ իրադարձությունների մոդելավորում

АЛГОРИТМ ДИНАМИЧЕСКОГО ИЗМЕНЕНИЯ КАНАЛОВ ПЕРЕДАЧИ ИНФОРМАЦИИ В AD-НОС IOT СЕТЯХ И ЕГО МЕСТО СРЕДИ СУЩЕСТВУЮЩИХ ПОДХОДОВ

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Представлена классификация существующих алгоритмов динамического изменения сетевых структур в ad-hoc IoT сетях. Описан предлагаемый алгоритм динамического изменения каналов передачи информации и установлено его положение среди существующих подходов.

Алгоритм использует метод кратчайшего пути Дейкстры с композитной взвешенной функцией стоимости, интегрирующей пять взвешенных факторов: остаточную энергию узла, расстояние между узлами, качество беспроводной связи, загруженность узла трафиком и перегруженность канала. На основе SimPy и NetworkX разработана платформа дискретно-событийного моделирования на Python для оценки предлагаемого алгоритма по сравнению с четырьмя установленными протоколами маршрутизации: кратчайший путь (hop-count), AODV, LEACH-C и энергоэффективная маршрутизация. Представлены результаты проведенного исследования и их сравнительный анализ.

Комплексные эксперименты по пяти сценариям, включающие 30 независимых испытаний с 50 узлами, демонстрируют, что предлагаемый многокритериальный алгоритм достигает наивысшего коэффициента доставки пакетов 98,9% в стационарных сетях и 96,9% в мобильных средах, при этом сохраняя конкурентоспособную задержку и справедливость распределения энергии. Тесты масштабируемости с количеством узлов до 200 подтверждают устойчивые преимущества производительности. Продемонстрировано преимущество использования предлагаемого алгоритма для изменения структуры сети по различным критериям, включая коэффициент доставки пакетов, время жизни сети и

справедливость распределения энергии. Обсуждаются общие черты всех протестированных алгоритмов и представлены выводы работы.

Ключевые слова: ad-hoc сети, управление динамической топологией, многокритериальная маршрутизация, моделирование IoT mesh сетей, энергоэффективная маршрутизация, алгоритм Дейкстры, беспроводные сенсорные сети, дискретно-событийное моделирование.

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