OPTIMAL FORWARDER SELECTION BASED ON THE FUZZY TOPSIS MCDM METHOD IN OPPORTUNISTIC ROUTING PROTOCOLS TO ENHANCE THE PERFORMANCE OF THE MANET

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Abstract— Opportunistic routing technique has its own advantages and limitations over proactive and reactive techniques. Finding optimal forwarder in opportunistic routing is a challenging task. The selection of an appropriate best forwarder will result in more packet delivery ratio and less delay that in turn result in increase in overall performance of the MANET. In this paper Fuzzy TOPSIS multi-criteria decision making method has been used to choose optimal forwarder based on four QoS parameters namely hop count, packet delivery ratio, delay and jitter. To assign weight to each QoS parameter criteria, total three decision maker's opinion is been considered. To rank the feasible forwarding neighboring nodes at every node in the entire path, certain fuzzy rules are defined based on the QoS parameters. Fuzzy TOPSIS based algorithms are proposed to find the ranking of each feasible neighboring node. The proposed algorithms were applied to sample network scenario and the results are compared and analyzed with well-known existing OR protocols EX-OR and CORMAN. It has been observed that the proposed Fuzzy TOPSIS based OR protocol outperforms EX-OR and CORMAN protocols in terms of throughput and delay and hence improve the performance of the MANET.

Keywords— Opportunistic Routing, MCDM, Fuzzy TOPSIS based OR, EX-OR, CORMAN, Optimal Forwarder, QoS Parameters

1. INTRODUCTION

In Opportunistic Routing (OR) protocols [1] mainly broadcasting approach is used, but broadcasting data packets at every node result in excessive control overhead. To limit the number of broadcastings, there is need to choose optimal forwarder. In real time network scenario, at a time multiple paths are exist from source to destination. Opportunistic routing technique provides opportunity to all nodes to become a part of the forwarding list as it uses the broadcasting approach for data packets. It results in increase in control overhead, so there is need to select forwarding node list carefully. To select optimal forwarder node already much research has been taking place. Consider, the sample network shown in figure1. There are total five paths exist from source to destination viz. Path1, Path2, Path3, Path4 and Path5.

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Source node broadcast the data packet that may be received by all neighbors (N1, N2, N3, N4, and N5) successfully. Instead of repeating, the same procedure at all the neighboring nodes there is a need to prioritize all the neighboring nodes. The node with highest priority only rebroadcasts the packets and all other neighboring nodes just discard it.

Fig. 1 A Sample Network

So to find optimal forwarding node many researchers have considered multiple criteria. In this paper, we have proposed Fuzzy TOPSIS based optimal forwarder selection approach. To select optimal forwarding node in OR, multiple criteria must have to be considered based on the application requirements. For example in the application of video conferencing, bandwidth and delay are the most important criterion while in Email transfer application, bandwidth and delay are not much important.

In MANET uncertain environment is exist. Hence to tackle with such uncertainty, fuzzy logic can be applied.

In next section Literature Review is carried out which highlights the comparative analysis of OR protocols. The proposed optimal forwarder selection system is discussed in Section III, followed by Numerical Illustration in Section IV. In next Section experimental analysis has carried out and results are compared and analyzed. In the last section concluding remarks are given.

2. LITERATURE REVIEW

By the research carried out by many authors, it has been observed that prioritization of forwarding node is the most important aspect and many OR protocols applied deterministic and probabilistic approach for the same. For example old versions of OR protocols like EX-OR[2], MORE[3], SOAR[4] etc. had considered deterministic approach while CORMAN protocol[5] and ETX based CORMAN protocol[6] has used probabilistic approach in which each neighboring node has equal chance to become forwarder. In WSN energy is the major concern, ENS_OR [7] algorithm is proposed which considered two parameters for the selection of best forwarding node in opportunistic routing one was energy and another was distance. It has been observed that the selection criteria considered for forwarding node have great impact on the network performance and single criteria is not sufficient for the selection. Depending on the various applications different parameters/ criterion must have to be taken into consideration. Hence, in this paper fuzzy logic based approach is applied for the selection of best forwarder in OR.

Table I. Comparative Analysis of OR Protocols based on Criterion used to Prioritize Forwarders

OR Protocol Name	Criteria used to prioritize forwarder	Technique Used	Network for which applied	Advantages	Limitations
EX-OR	ETX	Prepare batches of packets	MANET	Increase performance of the network in terms of delay and throughput as compared to other proactive/reactive routing protocols	1. Duplicate transmissions 2. MAC dependent 3. Not good for multicasting
MORE	ETX	Randomly mixes packets before forwarding	MANET	1. Reduce number of transmissions as compared to EX-OR 2. No Special scheduler to coordinate routers	Implementing network coding is complicated.
SOAR	1. OLT (Optimal Link Transmission) 2. Hop Count	Optimal path metric & optimal node metric	Cognitive Radio Network (CRN)	QoS guarantees Better Throughput Less end to end delay	Improper rate control in source node leads to inefficiency.
EEOR[8]	Minimum Energy depletion	Expected cost of the node added < prefix forwarding list	WSN	1. Less delay as compared to EX-OR 2. Forwarder list size and total energy consumption reduced	Remaining Energy parameter need to measure
Trusted OR [9]	Distance and Trust degree	Node selection based on less distance and more trust degree	VANET	Prohibits malicious nodes to participate in the network	Need to calculate trust degree that may result in extra overhead
Novel Socially aware [10]	Social relations, Profiles of nodes	Social connectivity matching & social interaction	MANET	Routing efficiency improved	More control overhead
CORMAN	ETX, hop count	1) PSR 2) large-scale live update of forwarder list, and 3) small-scale retransmission of missing packets	MANET	Smaller overhead than Ex-OR	Proactive approach is needed
ETX based CORMAN	ETX	ETX based CORMAN	MANET	Outperforms CORMAN in terms of throughput, delay and jitter.	Control overhead reduction methodology need to be added
Markov Chain based OR[11]	PDR, hop count	Markov Decision problem for best route selection	MANET	Find optimal path from source to destination	Best forwarder selection criteria need to be update for better result
FUZZY LOGIC IN Opportunistic Network					
Actor node selection decision algorithm [12]	Speed, density and remaining energy	Fuzzy based approach	Opportunistic Network	Increase the performance of the opportunistic network	High Speed of the nodes may result in reduction of the performance
Buffer Replacement strategy [13]	Priority, timeliness, size	Fuzzy based approach	Opportunistic Network	Network efficiency in terms of delivery ratio and packet loss rate with priority, timeliness and size of messages is improved	More criterion need to be considered for the selection

3. PROPOSED SYSTEM FOR OPTIMAL FORWARDER SELECTION

Fuzzy TOPSIS multi criteria decision making method is a method that may help decision makers in solving different decision-making problems in real time environment. An algorithm of the **multi-person multi-criteria** decision making with fuzzy set approach is applied to solve the problem of selection of optimal forwarder in OR. As fuzzy approach can be used in uncertain environment, nodes are mobile in MANET and hence it is difficult to predict the best forwarding node while using opportunistic routing technique. In Proposed system, all neighboring nodes were considered as an optimal candidate for forwarding the data packet. Hence all neighboring nodes are the possible alternatives. Here total four QoS parameters: namely Hop Count, Packet Delivery Ratio, delay and jitter were considered to measure the efficiency of the node. The most efficient node get the chance to become forwarder and hence take part in the optimal path from source to the destination. Packet Delivery Ratio is Benefit criteria and remaining three: Hop Count, Delay and Jitter are cost criterion.

As shown in Figure 2, Fuzzy approach has been applied for the proposed solution. Qos Parameters were provided as input for the fuzzification system and Fuzzy rules have defined for alternative neighboring node selection. Separate rules for benefit and cost criteria was designed and applied in the process. Fuzzy TOPSIS [14] multi-criteria decision making approach has been applied for the selection of optimal forwarder.

Fig. 2 Fuzzy based Optimal Forwarder Selection System

Fuzzy Rules: Following Fuzzy rules are designed for benefit criteria (like PDR), maximum value of benefit criteria must have highest rating and minimum value should be assigned with lowest rating. Also the in-between ratings were allocated as per the rules defined in Table II. So, accordingly fuzzy rules have been designed and associated rating has given.

Table II. Rules for Benefit Criteria: (Packet Delivery Ratio)

Rule No.	Fuzzy Rule	Rating
Rule1	IF Neighb _i = MAX $\int_{i=1}^N BC_of_Neighb\ i$ where i = 1 to N (Number of Neighbors)	Very Good
Rule2	IF Neighb _i = MIN $\int_{i=1}^N BC_of_Neighb\ i$ where i = 1 to N (Number of Neighbors)	Very Poor
Rule3	IF BC_ of_ Neighb _i > $\frac{Max(BC) + MIN(BC)}{2}$	Good
Rule4	IF BC_ of_ Neighb _i < $\frac{Max(BC) + MIN(BC)}{2}$	Poor
Rule5	IF BC_ of_ Neighb _i = $\frac{Max(BC) + MIN(BC)}{2}$	Fair

Similarly, the rules were designed for cost criteria (like Delay, Hop count, Jitter) as shown in Table III.

Table III. Rules for Cost Criteria: Delay, Hop count, Jitter

Rule No.	Fuzzy Rule	Rating
Rule1	IF Neighb _i = MIN $\int_{i=1}^N CC_of_Neighb\ i$ where i = 1 to N (Number of Neighbors)	Very Good
Rule2	IF Neighb _i = MAX $\int_{i=1}^N CC_of_Neighb\ i$ where i = 1 to N (Number of Neighbors)	Very Poor
Rule3	IF CC_ of_ Neighb _i < $\frac{Max(CC) + MIN(CC)}{2}$	Good
Rule4	IF CC_ of_ Neighb _i > $\frac{Max(CC) + MIN(CC)}{2}$	Poor
Rule5	IF CC_ of_ Neighb _i = $\frac{Max(CC) + MIN(CC)}{2}$	Fair

Flow of Execution:

1. Identify the Fuzzy linguistic scale for criterion (QoS Parameters) weight measurement.
2. Identify the Fuzzy linguistic scale for ranking the alternatives (neighboring nodes)
3. Measure the weight of each QoS parameter by considering the opinion of different decision makers
4. Assign the ranking to each neighboring node as per the fuzzy rules defined in Table2 and Table3
5. Apply the Fuzzy TOPSIS method
6. Return the ranking of each alternative neighboring node and based on that decide the optimal forwarding node.

4. NUMERICAL ILLUSTRATION

Consider the sample network as shown in Figure 1. From source node S there are total five neighboring nodes N1 to N5, here in this numerical illustration the proposed methodology has been applied to rank these five neighbors based on the four measuring parameters i.e., benefit criteria: PDR and cost criterion: Hop Count, Delay and Jitter.

Table IV. Criteria Values for each Neighbor of Source in Sample Network

Alternatives (Neighboring Nodes)	Benefit Criteria	Cost Criterion		
	PDR (%)	Hop Count	Delay (MS)	Jitter (MS)
N1	0.8	5	20	15
N2	0.7	5	5	10
N3	0.4	4	30	30
N4	0.6	5	15	20
N5	0.7	4	22	24

4.1. PROPOSED ALGORITHM

Input: 1. Number of Criterion: N_C
2. List of Criterion from C_1 to N_C
3. Number of Decision Makers: DM
4. Neighboring nodes values as per criteria

Output: Neighboring nodes ranking

Step1: Determine the Fuzzy linguistic scale for assigning the weights (FLSWeight) to the criterion.

Table V. Fuzzy Linguistic scale for criteria weightage

Linguistic Terms	Abbreviation	Fuzzy Triangular Number
Very Less Important	VLI	(1,1,3)
Less Important	LI	(1, 3, 5)
Medium Important	MI	(3, 5, 7)
Highly Important	HI	(5, 7, 9)
Very Highly Important	VHI	(7, 9, 9)

Step2: Determine the Fuzzy linguistic scale for assigning ranking to the alternatives (FLS_{Alt})

Table VI. Fuzzy Linguistic scale for alternative ratings

Linguistic Terms	Abbreviation	Fuzzy Triangular Number
Very Poor	VP	(1,1,3)
Poor	P	(1, 3, 5)
Fair	F	(3, 5, 7)
Good	G	(5, 7, 9)
Very Good	VG	(7, 9, 9)

Step3: Identify the number of decision makers (N_{DM}) for assigning the priorities to the criterion

- Take input from N_{DM} based on the FLS_{Weight} for all N_C
- Assign Weight to each criteria (C_j) by decision makers (DM_k)

Criteria	Decision Makers		
	DM1	DM2	DM3
C1	VHI	MI	VHI
C2	VLI	LI	LI
C3	HI	VHI	VHI
C4	MI	LI	VLI

Step4: Apply fuzzy linguistic scale (refer table no.5) for each criteria based on step3 inputs

Criteria	Decision Makers		
	DM1	DM2	DM3
C1	(7,9,9)	(3,5,7)	(7,9,9)
C2	(1,1,3)	(1,3,5)	(1,3,5)
C3	(5,7,9)	(7,9,9)	(7,9,9)
C4	(3,5,7)	(1,3,5)	(1,1,3)

Step5: To calculate the aggregated weights (W_j) of each criterion based on K decision makers opinion,

$$W_j^K = \{W_{j1}, W_{j2}, W_{j3}\} \dots \dots \dots \text{eq1}$$

Where,

$$W_{j1} = \min_k \{W_{jk1}\}$$

$$W_{j2} = \frac{1}{k} \sum_{k=1}^k W_{j2}$$

$$W_{j3} = \max_k \{W_{jk3}\}$$

Criterion	Fuzzy Number
C1	(3.000, 7.667, 9.000)
C2	(1.000, 2.333, 5.000)
C3	(5.000, 8.333, 9.000)
C4	(1.000, 3.000, 7.000)

Step6: Return the above weight of each criterion.

Step7: To rank the alternatives based on Fuzzy linguistic scale (defined in Table no. VI) and Fuzzy rules (defined in Table no. II & III).

	C1	C2	C3	C4
A1	VG	VP	P	G
A2	G	VP	VG	VG
A3	VP	VG	VP	VP
A4	F	VP	G	F
A5	G	VG	P	P

Step8: Apply fuzzy linguistic scale (refer Table no.VI) for each alternative based on step7 inputs

	C1	C2	C3	C4
A1	VG (7,9,9)	VP(1,1,3)	P (1,3,5)	G(5,7,9)
A2	G (5,7,9)	VP (1,1,3)	VG(7,9,9)	VG(7,9,9)
A3	VP(1,1,3)	VG(7,9,9)	VP(1,1,3)	VP(1,1,3)
A4	F(3,5,7)	VP(1,1,3)	G(5,7,9)	F(3,5,7)
A5	G(5,7,9)	VG(7,9,9)	P(1,3,5)	P(1,3,5)

Step9: To create normalized fuzzy decision matrix two different formulas are being considered *i.e.*, one for benefit criteria and another for cost criterion.

a. Benefit Criteria: Normalized Fuzzy decision matrix $[r_{ij}]$ for i alternatives and j benefit criterion:

Normalized Fuzzy decision matrix $[r_{ij}]$ for i alternatives and j benefit criterion:

$$[r_{ij}] = \left(\frac{a_{ij}}{c_j^*}, \frac{b_{ij}}{c_j^*}, \frac{c_{ij}}{c_j^*} \right) \quad \text{where } c_j^* = \max (C_{ij}) \quad \dots\dots\dots \text{eq2}$$

b. Cost Criteria: Normalized Fuzzy decision matrix $[r_{ij}]$ for i alternatives and j cost criterion:

$$[r_{ij}] = \left(\frac{a_j^-}{c_{ij}}, \frac{a_j^-}{b_{ij}}, \frac{a_j^-}{a_{ij}} \right) \quad \text{Where } a_j^- = \min (a_{ij}) \quad \dots\dots\dots \text{eq3}$$

Normalized Fuzzy Decision Matrix

	C1	C2	C3	C4
A1	(0.778, 1.0, 1.000)	(0.333,1,1)	(0.2,0.333,1)	(0.111,0.142,0.2)
A2	(0.55, 0.77, 1.000)	(0.333,1,1)	(0.111,0.111,0.142)	(0.111,0.111,0.142)
A3	(0.11, 0.11, 0.333)	(0.111,0.111, 0.143)	(0.333,1,1)	(0.333,1,1)
A4	(0.33, 0.55, 0.77),	(0.333,1,1)	(0.111,0.142,0.2)	(0.142,0.2,0.333)
A5	(0.55, 0.77, 1.0),	(0.111,0.111, 0.143)	(0.2,0.333,1)	(0.2,0.333,1)

Step10: To compute the weighted normalized fuzzy decision matrix, Normalized Fuzzy decision matrix is multiplied by the weights of each criterion (return by step6)

Weighted normalized fuzzy decision matrix

	C1	C2	C3	C4
A1	(2.33, 7.66, 9.0)	(0.333,2.333,5)	(1,2.774,9)	(0.111,0.426,1.4)
A2	(1.667, 5.96, 9.0)	(0.333,2.333,5)	(0.555,0.924,1.278)	(0.111,0.333,0.994)
A3	(0.333, 0.852,3.0)	(0.11,0.258,0.715)	(1.665,8.333,9)	(0.333,3,7)
A4	(1.000, 4.259, 7.000)	(0.333,2.333,5)	(0.555,1.183,1.8)	(0.142,0.6,2.331)
A5	(1.667, 5.963,9.000)	(0.11,0.258,0.715)	(1,2.774,9)	(0.2,0.999,7)

Step11: Determine FPIS and FNIS and calculate the distance of each alternative from FPIS and FNIS, respectively.

Fuzzy Positive Ideal Solution (FPIS): Determine Fuzzy Positive Ideal Solution (FPIS): distance between ideal solution and available alternative path and Fuzzy Negative Ideal Solution (FNIS): Distance between negative ideal solution and alternative path. To calculate FPIS following formula is used.

$$A^* = (\tilde{v}_1^*, \tilde{v}_2^*, \dots, \tilde{v}_n^*) \text{ where } \tilde{v}_j^* = \max_i \{v_{ij3}\}, i = 1, 2, \dots, m; j = 1, 2, \dots, n \quad \dots \text{eq4}$$

And to calculate **FNIS** following formula has been applied:

$$A^- = (\tilde{v}_1^-, \tilde{v}_2^-, \dots, \tilde{v}_n^-) \text{ where } \tilde{v}_j^- = \min_i \{v_{ij1}\}, i = 1, 2, \dots, m; j = 1, 2, \dots, n \quad \dots \text{eq5}$$

The distance between FPIS and each alternative is calculated using below equation:

$$d_i^* = \sum_{j=1}^n d_v(\tilde{v}_{ij}, \tilde{v}_j^*), \quad i = 1, 2, \dots, m$$

$$d_i^- = \sum_{j=1}^n d_v(\tilde{v}_{ij}, \tilde{v}_j^-), \quad i = 1, 2, \dots, m \quad \dots \text{eq6}$$

The distance between two fuzzy numbers is calculated by following formula:

$$d(\tilde{a}, \tilde{b}) = \sqrt{\frac{1}{3}[(a_1 - b_1)^2 + (a_2 - b_2)^2 + (a_3 - b_3)^2]} \quad \dots \text{eq7}$$

Where $a = (a_1, a_2, a_3)$ and $b = (b_1, b_2, b_3)$ are two fuzzy numbers.

Fuzzy Positive Ideal Solution (FPIS)

Criteria	FPIS(A1)	FPIS(A2)	FPIS(A3)	FPIS(A4)	FPIS(A5)
C1	3.927076	4.58244	7.692134	5.491723	4.58244
C2	3.103427	3.103427	4.645791	3.103427	4.645791
C3	5.852722	8.086389	4.252337	7.837166	5.852722
C4	6.377978	6.531443	4.488834	6.049565	5.236156
Total	19.2612	22.3037	21.0791	22.48188	20.31711

Fuzzy Negative Ideal Solution (FNIS)

Criteria	FPNS(A1)	FPNS(A2)	FPNS(A3)	FPNS(A4)	FPNS(A5)
C1	6.655636	6.016459	1.568678	4.483572	6.016459
C2	3.103164	3.103164	0.358899	3.103164	0.358899
C3	5.047772	0.468647	6.659515	0.805069	5.047772
C4	0.766104	0.525666	4.314855	1.312565	4.010602
Total	15.57268	10.11394	12.90195	9.704371	15.43373

Step12: Calculate Closeness Coefficient (CC_i) by the following formulae:

$$CC_i = \frac{d_i^-}{d_i^- + d_i^+} \quad \text{where } i=1,2,3,\dots, m \quad \dots\dots\dots eq8$$

Where d_i^+ is the total of FPIS_i for all j criterion $i=1,2,\dots,m$ and $j=1,2,\dots,n$

d_i^- is the total of FNIS_i for all j criterion $i=1,2,\dots,m$ and $j=1,2,\dots,n$

Closeness coefficient of i^{th} alternative neighboring node as follows:

N1	0.447055
N2	0.311989
N3	0.379681
N4	0.301507
N5	0.431703

The alternative with maximum closeness coefficient value (A1) is the best alternative.

Step13: Return the ranking of each alternative (i) based on its CC_i value.

Finally, the overall performance of each alternative forwarding node has given by the closeness coefficient CC_i . Thus, the classification results according to CC_i is $N1 > N5 > N3 > N2 > N4$. Since the best performance is achieved by the alternative 1, the alternative neighboring node1 is the much better option as a forwarding node than other neighboring nodes.

6. EXPERIMENTAL ANALYSIS

The proposed Fuzzy TOPSIS based OR routing protocol is simulated using NS-2 simulators and compared and analyzed with existing well known opportunistic routing protocols EX-OR and CORMAN.

Experimental Setup: The simulation is carried out using Network simulator NS2 (version 2.34) on an Ubuntu 11.10 operating system. AWK scripting language is being used for performance analysis of the network. The following table shows other parameters that had considered for simulation and analysis of the mobile adhoc network.

Table VII. Simulation Parameters for Experimental work

Simulation Parameters	Values
Routing Protocol	EX-OR, CORMAN, Fuzzy_TOPSIS_OR
Simulation Area	500×500, 800×800, ..., 1500×1500sqm
Network Interface Type	Phy/WirelessPhyExt
Mac Layer Protocol	Mac/802_11Ext
Simulation Time	500 seconds
Data Rate	1 Mbps
Traffic Type	Constant Bit Rate (CBR)
Packet Size	1000 bytes
Number of Nodes	100
Mobility Model	Random Way Point
Propagation Model	TwoRayGround
Queue Length	50 Packets
Maximum Node Velocity	10m/s

Following performance metrics were considered to measure the performance of the MANET.

1. Throughput: Total number of packets successfully reached at the destination in stipulated simulation time.

2. Average Delay: Average time require for a packet to reach at the destination in stipulated simulation time.

To measure the performance of the network in terms of above mentioned metrics, total 30 simulations were carried out on mentioned experimental setup and an average of the gained values has been considered for comparative analysis. As shown in figure3, throughput has been measured under the varying network size from 500sqm to 2000sqm with a constant node mobility of 10m/s. It has observed that as the network size increases, throughput decreases for all three opportunistic routing protocols. For small network size (500sqmto 800sqm) there is little difference between CORMAN and Proposed Fuzzy TOPSIS based OR as network size is small there are less chances of link failure. But as the network size increases proposed protocol outperforms the EX-OR and CORMAN protocols. Forwarding Node selection is based on the Qos parameters that may lead to better packet delivery ratio and in turn greater throughput.

Fig. 3 Graph for Throughput Vs Network Size

Figure 4 shows the result of average delay against network size. For large network size >1500sqm, there is around 30% to 18% decrease in average delay as compared to EX-OR and CORMAN respectively due to delay parameter consideration in next node selection.

Fig. 4 Graph for Average Delay Vs Network Size

Along with network size, node mobility also affects the performance of the network. Figure 5 & 6 shows the impact of node mobility on throughput and average delay respectively. For less speed mobility, there is not much difference, but when the speed of the node crosses 15m/s, there is an increase of around 10% in throughput as compared to EX-OR and around 5% increase than CORMAN. As mobility of the node increases, 40% decrease is observed in a proposed system as compared to Ex-OR and around 28% decrease in average delay is observed than CORMAN.\

Fig. 5 Graph for Throughput Vs Max Speed

Fig. 6 Graph for Average Delay Vs Max Speed

7. CONCLUSION

Opportunistic Routing Protocols are new standards in the development of wireless network performance. Optimal forwarder selection is the crucial task in the opportunistic routing. As the appropriate selection of the forwarding node leads to better achievement of the network performance in terms of various QoS parameters, it is necessary to identify optimal forwarding node. In this paper Fuzzy logic based approach has been proposed and applied for the selection of best forwarding nodes.

Hence based upon the requirement of the application, the opportunistic routing mechanism may choose suitable forwarding node. It has been observed that the proposed Fuzzy TOPSIS based OR scheme has increased the MANET performance in terms of throughput and delay as compared to existing well known OR protocols Ex-OR and CORMAN. Further, this protocol can be extended by QoS parameters and can be analyzed for different applications.

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