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Research Article

Ubiquitous Trust Management and Power Optimization for UAV Assisted Mobile Communication

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ABSTRACT

Mobile ad hoc Networks (MANETs) are the trending dynamic communication technology and it used in the intelligent communication system. The special characteristics of MANETs are that it communicates in the infrastructure less environment with high mobility and speed. Due to the nature the stability of the network is reduced and it results in the increase of the energy consumption, delay and routing overhead during communication. In order to overcome this drawbacks unmanned aerial vehicle (UAV) introduced in MANETs. So that the transmission is performed it an air medium so that the devices are protected from the ground level obstacles. In recent days UAVs are used for the transmission of highly confidential data such as military and medical applications. So that it is very essential to provide security for the devices present in the UAV-assisted MANET. For that purpose in this paper Ubiquitous Trust Management and Power Optimization (UTMPO-UAVs) are proposed and it consists of various segments such as UAVs network model, UAVs traffic model and UAVs trust model. The Trust model consists of both direct trust and indirect trust calculations. This method greatly helps to achieve high packet delivery ratio and efficiency in MANETs. The simulation is carried out in NS2 and the parameters which are used for the parameter analysis are packet delivery ratio, energy efficiency, end to end delay and routing overhead. The proposed UTMPO-UAVs approach is compared with the earlier methods such as STAP-UAV and ITCD-UAV. From outcome it is understood that the proposed approach achieves high delivery ratio and energy efficiency as well as lower end to end delay and routing overhead when compared with the earlier methods.

1. INTRODUCTION

Mobile ad hoc Networks (MANETs) are one among the stable mobile networking model with infrastructure less environment. Using this technology many of the applications are enhanced such as networking applications, traffic control, medical and agricultural applications. MANETs perform multipath communication to achieve effective data transmission where it mitigates from one place to another in high speed [1]. At any emergency condition there is change to the collapse of the conventional communication systems in MANETs so it is very essential to develop temporary user terminals with rapid deployment to enable the communication in MANETs in such situation. For that purpose unmanned aerial vehicle (UAV) incorporated in MANETs so that it can transfer of receive the data even in distant communication. So UAV-assisted MANET can able to transmit the emergency data in highly effective manner and it also acts like a command center that control the mobile nodes at the time of communication in the network [2]. The special characteristics of UAVs are flexibility, scalability, fast movement, frequent changing topology, highly cost effective with lower maintenance, higher maneuverability, highly effective and maintain lower operating model [3-4]. Through the presence of UAVs the mobile devices are escaped from the ground level obstacles that lead to effective communication in MANETs. Using UAVs high confidential operations are performed such as military and medial operation so that it is very essential to achieve high security at the time data transmission between the defined network models. The communication in UAV-assisted MANET network consists of three modules such as mobile device to mobile device communication, mobile devices to UAVs communication and UAVs to UAVs communication. To achieve effective overall performance it is very essential to provide high security at the time of communication. For that purpose in this paper ubiquitous trust management and power optimization is proposed. The contribution of this research is described.

In [5] the authors to improve the spectrum and energy efficiency of the wireless communication system used UAVs and intelligent reflecting surface. The proposed system is based on one UAV and several IRSs, which can be include active beam forming and passive beam forming in trajectory optimization technique. Disadvantage of the network is high routing

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overhead. In [6] the authors developed a novel trust-based security scheme for 5G UAV communication system, to avoid the malicious node during transmission. The malicious UAV gave the false information and destroy the services, to overcome this problem the security system is introduced that filter out the unwanted node but failed to decrease the delay during communication. In [7] the authors proposed a new model to maximize the system average in UAV relaying communication system and it is based on half-duplex decode-and-forward cache enabled downlink scenario. The result shows that the accuracy rate of system in average rate but during data transmission the routing overhead occurred in this proposed technique. In [8] the authors presented UAV-assisted ubiquitous trust evaluation in the proposed work and it is the combination of global trust evaluation and historical interaction based local trust evaluation. In global trust evaluation it eliminates malicious data and it collects the clean data from the environment. After that, a local trust evaluation model is used to select trustworthy MDCs for cooperative data collection. In [9] the authors used a novel approach to find the maximum sum rate for all users, then check the quality-of service requirement of each user and find out communication link for the relaying system. Then this system solves the structure problem based on efficient algorithm and it includes the concept of successive convex approximation.

In [10] the authors introduce the highly uncertain THz channel to the UAV location, use power, and bandwidth allocation. This work deploys UAVs in the THz wireless system. Decrease the optimization problem and to minimize the delay in uplink and downlink transmission between UAV and the ground users. To solve the location optimization sub-problem, power control problem, bandwidth allocation problem this method is utilized and it achieve overall moderate performance. In [11] the authors developed UAV-assisted backscatter communication system. At the initial condition the optimal UAV data collection location is found, and analyse the system probability to optimize the energy efficiency under UAV. The proposed work achieved maximum energy efficiency and but however fails to achieve low routing overhead. In [12] the authors used a novel approach to detect the malicious attacks using Q-learning technology. The proposed Q-learning technology is based on the trust evaluation scheme in UAV and it evaluates the reliability of UAVs. In this work malicious UAV will filtered out from the system using trust threshold and it provides efficient security but failed to decrease the delay during transmission. In [13] the authors proposed power control algorithm in energy harvesting based cognitive mobile relay networks. In this existing method throughput maximization problem is occurred, to overcome this problem an offline scheme with deterministic settings is introduced. Then drive the closed-form expression to find the optimal solutions. This system achieves the maximum throughput and more energy consumption.

In [14] the authors proposed a new method to improve the communication in Unmanned Aerial Vehicles (UAVs) enabled wireless technology called adopting typical trust-building procedures. Through this method the delivery rate is improved but however it fails to reduce the routing overhead and delay during communication. In [15] the authors proposed a UAV assisted trustworthy code dissemination method for 5G-enabled intelligent IIoT systems. This method increases the trustworthiness of UAVs by providing the previous passive, indirect and unverifiable trust evaluation schemes. This method greatly increases the delivery rate and throughput but fails to achieve lower delay and overhead. This related study shows that UAVs based communication model still needs improvement to achieve effective communication. To achieve that in the paper trust management with power optimization for UAV assisted mobile communication is proposed and it is elaborated in the next section.

To achieve effective communication in UAVs assisted MANETs, ubiquitous trust management and power optimization is introduced. Trust management is performed using the calculation of direct trust and indirect trust calculation process. The parameters which are considered for the direct trust calculation are node stability, successful transmission ratio, residual energy, computational delay and reputation value. The indirect calculation is performed using the recommendation of other nodes. Using this method the packet delivery ratio and the energy efficiency of the network is greatly increased. The organization of the sections is listed as follow. In section 1, the introduction and related works about the UAVs and MANETs are discussed and its drawbacks are analyzed. In section 2, the proposed UTMPO-UAVs approach is elaborated. In section 3, the implementation of the proposed UTMPO-UAVs approach is performed and the performance is calculated. In section 4, the results are evaluated and it is compared with the earlier works such as STAP-UAV and ITCD-UAV. In section 5, the conclusion and the future direction of the research is given.

2. Ubiquitous Trust Management and Power Optimization Approach

The proposed UTMPO-UAVs approach is mainly designed to achieve high energy efficiency and accuracy in data transmission. The main segments which are present in the proposed model are that UAVs network model, UAVs traffic model and UAVs trust model. The types of communication models present in this network is mobile devices to UAVs and UAVs to UAVs. The system architecture of the UAVs assisted mobile communication is described in the figure 1.

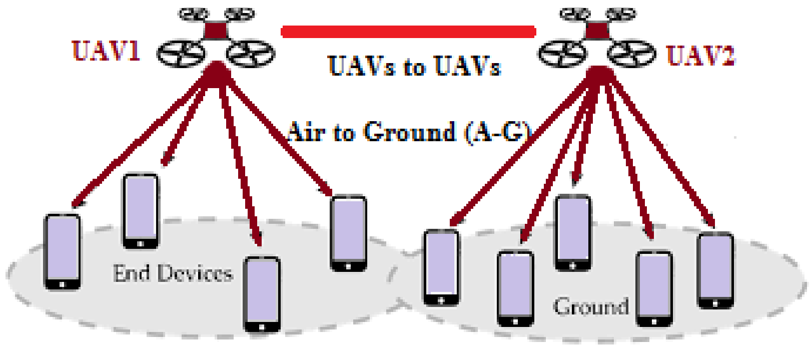

Fig. 1. Architecture of UAVs assisted MANETs

2.1 UAVs *Network Model*

UAVs in MANETs consist of certain special characteristics to adopt extensions and modifications. They are; UAVs mobility – UAVs are highly mobile in nature so that there is a possibility to produce high routing overhead due to considerable dynamically varying topology. UAVs storage – UAVs maintain large storage inbuilt to store huge amount of data with it to achieve performance. Power dissipation – The initial power allocation for UAVs are high as well as through effective communication it is possible to reduce the energy consumption during data transmission. UAVs security – UAVs are performing huge number of confidential data transmission so that it is very indispensable to improve the security of the UAVs. UAVs infrastructure – UAVs maintain its centralized storage with seamless connection to infrastructure.

2.2 UAVs Traffic Model

Designing of multiple UAVs in MANETs are a complication task so that it must be handled over in an effective manner where all the mobile devices are directly connected to the UAVs. To escape from the ground level obstacles the communication between the mobile devices are neglected. The only transmission which is performed in this network is air to ground (A-G) communication model so that the data can be protected from the external environment in ground level and this type of communication is otherwise called as infrastructure-based communication architecture. Using multi-UAV systems the traffic modules are created in an effective manner to perform military and commercial operation.

2.3 UAVs Trust Model

Trust model is developed in UAVs assisted MANETs by measuring the trust values using the direct and indirect trust calculation process. The direct trust is measured using certain parameters in the network and the indirect trust is measured using the recommendation manager. The parameters which are used for the calculation of direct trust factor in the network are node stability (NS_{UAV}), successful transmission ratio (STR_{UAV}), residual energy (RE_{UAV}), computational delay (CD_{UAV}), reputation value (RV_{UAV}). Through this direct trust calculation process the different parameters are aggregated according to its optimal weights.

$$MT_{UAV} = |AT_{UAV} - DT_{UAV}| \tag{1}$$

From the equation (1) the terms MT_{UAV} implies the minimum trust score of the UAV, AT_{UAV} implies the actual trust of the UAV and DT_{UAV} implies the direct trust of the UAVs. The mathematical expression for the calculation of direct trust is described in the equation (2).

$$DT_{UAV} = \sum_{i=1}^{n} NS_{UAV} * STR_{UAV} * RE_{UAV} * CD_{UAV} * RV_{UAV} \tag{2}$$

Using the equation (2) the direct trust of UAV is measured. Now followed by the indirect trust calculation is performed using the recommendation of the others. Recommendation performs positive actions as well as negative actions. Both the direct trust and indirect trust values are collaborated to reduce the negative actions. The mathematical expression for the calculation of total trust (TT_{UAV}) value is given in the equation (3).

$$TT_{UAV} = (\alpha * DT_{UAV}) + (\beta * IDT_{UAV}) \tag{3}$$

From the equation (3) the terms IDT_{UAV} implies the indirect trust score, α *and* β are the corresponding weights of the direct and indirect trust. The average threshold level (TL_{UAV}) of the total trust values are given in the equation (4).

$$TL_{UAV} = \begin{cases} TT_{UAV} < 0.45 \ \ (Poor\ performance) \\ 0.45 < TT_{UAV} < 0.80 \ \ (Normal\ performance) \\ 0.80 < TT_{UAV} < 1.0 \ \ (Good\ performance) \end{cases} \tag{4}$$

Using the equation (4) the recommended list is calculated through that the trusted nodes are identified. The nodes with poor total trust values are neglected and that cannot participate in network data transmission. The workflow of the proposed UTMPO-UAVs approach is illustrated in the figure 2.

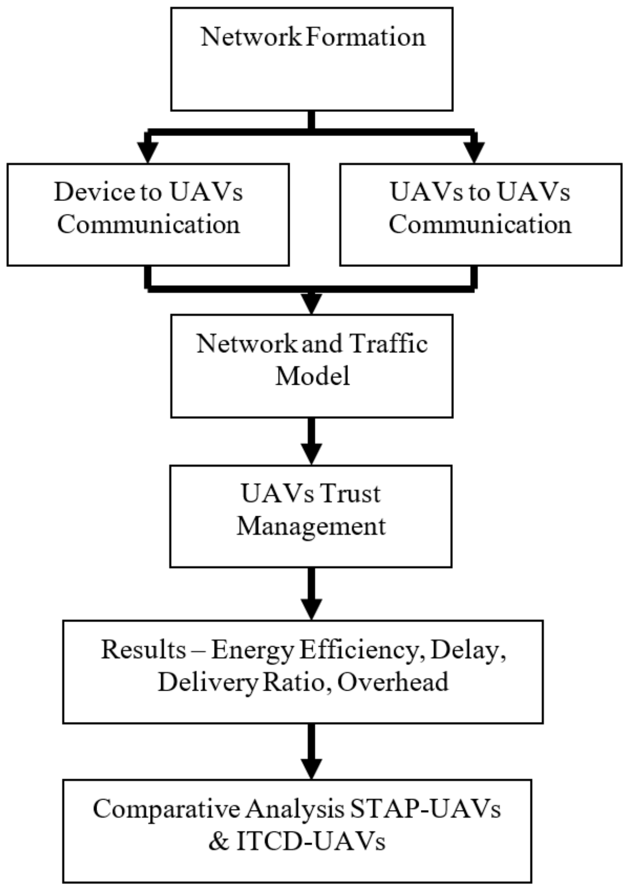

Fig. 2. Workflow of the proposed UTMPO-UAVs approach

3. Simulation Environments and Analysis

In this section, the performances of most of these parameters are evaluated the use of the parameters together with packet delivery ratio, energy efficiency, end to end delay, routing overhead for the proposed system methodology UTMPO-UAV is compared with the past technique such as STAP-UAV [14] and ITCD-UAV [15] with respect to the overall performance in the communication network. This implementation is taking place by the software popularly known as NS2 (Network Simulation) on top of the Ubuntu Operating system with SUMO (mobility generator). This tool is efficient in simulation on network research and communication. This tool allows us to simulate the network prelims such as TCP, routing, protocols and so on.

TABLE I. SIMULATION PARAMETERS

Input Parameters	**Values**
Running Time	500 ms
Dimension	4000m*4000m

Input Parameters	Values
No of Nodes	1000 nodes
Antenna	Omni Directional
Propagation Model	Two Ray Ground
Queue Type	DropTail
Link bandwidth	1Kbps
Initial Energy	100 Joules
Transmission Power	0.500 Joules
Receiving Power	0.050 Joules

3.1 Packet delivery ratio

In the below figure 3 plots the packet delivery ratio of methods such as STAP-UAV, ITCD-UAV based on the proposed UTMPO-UAV. In UAVs based mobile communication, the count of packets transmitted from the source to the destination is known as the Packet delivery ratio. From the below figure, it is admitted that the delivery ratio of the proposed method (UTMPO-UAV), is pretty higher than the PDR of the following methods such as STAP-UAV and ITCD-UAV. And it is achieved by the direct and indirect trust calculation present in the proposed method.

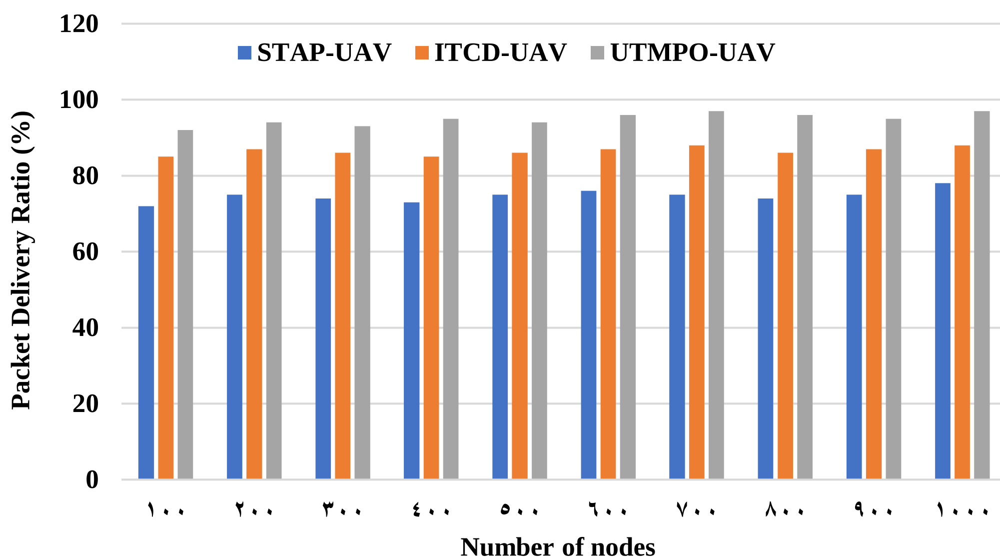

Fig. 3. Packet Delivery Ratio

3.2 Energy Efficiency

It may be considered as the residual energy of the network where it is the subtraction of the energy consumed for each data transmission in the network to the initial energy of the network. The energy efficiency of the proposed method is high when compared with the prior methods such as STAP-UAV, & ITCD-UAV which is captured in the figure 4 and that is achieved with the help of the UAVs traffic calculation process as well as that resulting in the increase of the performance of UAVs assisted MANETs.

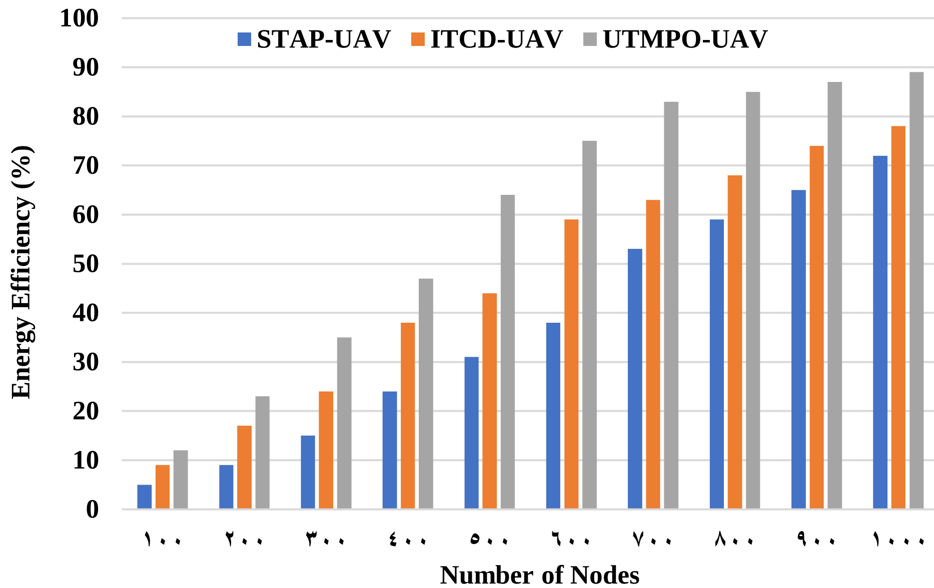

Fig. 4. Energy Efficiency

3.3 End to End Delay

In the Figure 5, the plots are discussed about the end-to-end delay of the committed methods like STAP-UAV, and ITCD-UAV over the proposed method UTMPO-UAV. The time taken by the packets from the source to reach the destination is formally known as the end-to-end delay in the network. In this simulation, the UTMPO-UAV approach shows the little delay when compared to the earlier methods.

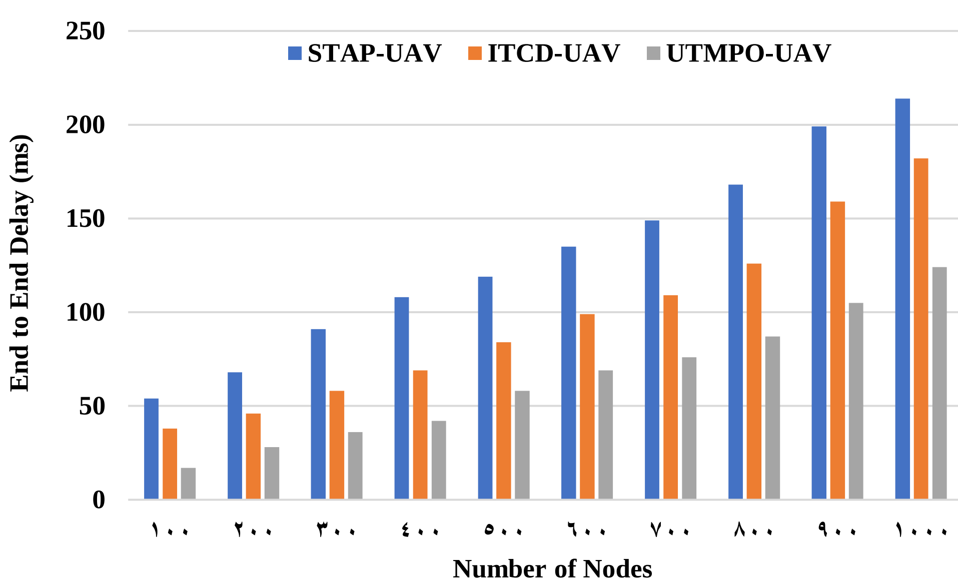

Fig. 5. End to End Delay

3.4 Routing Overhead

In this calculation, the routing overhead of the proposed system is compared with the STAP-UAV, and ITCD-UAV. Meanwhile, in the network communication the routing overhead is the calculated by the number of packets that are returned to the source without reaching the destination. In Figure 6, the routing overhead for the methods such as STAP-UAV, and ITCD-UAV over the proposed method UTMPO-UAV is discussed. Basically, when the routing overhead is decreased the performance of the transmission increases. In this proposed method, the reduction of routing overhead concludes in the effective transmission in the network and it is achieved using the trust estimation process.

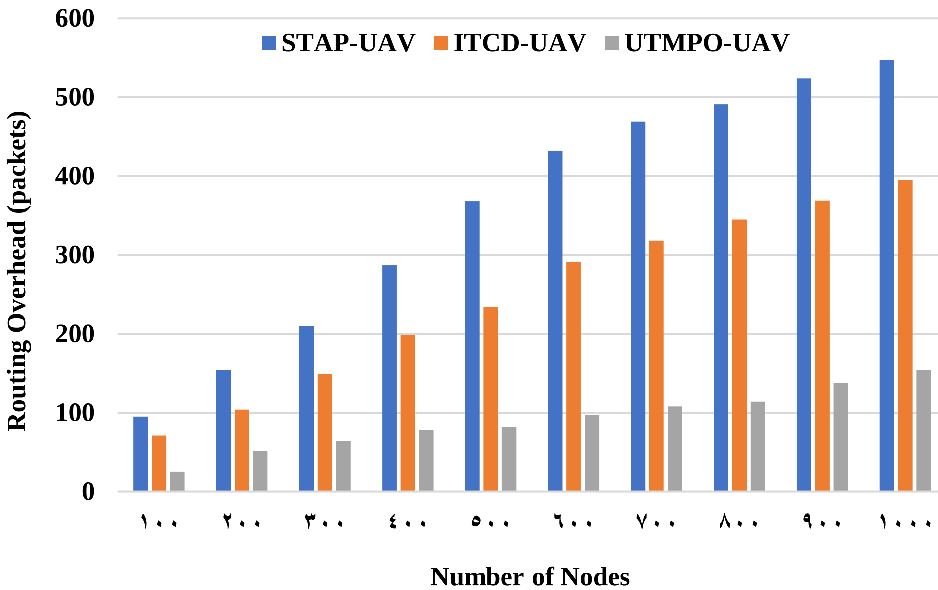

Fig. 6. Routing Overhead

4. Results and Discussion

The terms packet delivery ratio, energy efficiency, end to end delay, and routing overhead on the basis of STAP-UAV, ITCD-UAV and UTMPO-UAV is discussed in this section. The measures of those methods are given in the Table 2.

TABLE II. RESULTS ANALYSIS AND MEASUREMENTS

Parameters / Methods	STAP-UAV	ITCD-UAV	UTMPO-UAV
Delivery Ratio	78%	88%	97%
Energy Efficiency	72%	78%	89%
End to End Delay	214ms	182ms	124ms
Routing Overhead	547 packets	395 packets	154 packets

The packet delivery ratio completed with the aid of using the proposed UTMPO-UAV method is 97% with 9% better efficiency in comparison with the previous strategies such STAP-UAV, and ITCD-UAV it reaches as much as 78% with efficiency reduction of 9% and 88% with the efficiency reduction of 19% respectively. The end to end delay produced via way of means of the proposed UTMPO-UAV approach is 124ms in which as for the sooner techniques such STAP-UAV and ITCD-UAV, it reaches as much as 214ms and 182ms respectively. So, the end-to-end delay of the proposed UTMPO-UAV approach is 90ms less than STAP-UAV and 58ms less than ITCD-UAV. The energy efficiency is calculated by the proposed UTMPO-UAV technique is 89% in which as for the prior techniques such as ITCD-UAV and STAP-UAV, it is reaches up to 78% and 72% respectively. So, the energy of the proposed UTMPO-UAV system is 11% better than ITCD-UAV and 17% better than STAP-UAV. The routing overhead produced by the proposed UTMPO-UAV approach is hundred twenty-five (154) packets whereas for the earlier methods such ITCD-UAV and STAP-UAV, it is reaches up to 395 packets and 547 packets respectively. So, the routing overhead of the proposed UTMPO-UAV method is 393 packets lower than STAP-UAV and 241 packets lower than ITCD-UAV. According to the calculation of these parameters it is understood that the proposed UTMPO-UAV approach achieved overall best performance by using the direct trust, indirect trust and total trust calculation in UAVs assisted MANETs.

5. Conclusion

In this paper to achieve stable communication in UAV-assisted MANET, effective trust evaluation is performed that results in the increase of the packet delivery ratio and energy efficiency of the network. To develop a high protected environment Ubiquitous Trust Management and Power Optimization (UTMPO-UAVs) are proposed in UAV-assisted MANET. This method performs effective trust estimation process with the help of direct and indirect trust calculation. The direct trust calculation is performed using the parameters such as node stability, successful transmission ratio, residual energy, computational delay and reputation value. The indirect calculation is performed using the recommendation of other nodes. This method greatly helps to achieve effective communication in MANETs. The simulation is carried out in NS2 with SUMO. The parameters considered for value calculation are packet delivery ratio, energy efficiency, end to end delay and routing overhead as well as the measured results is compared with the previous researches like STAP-UAV and ITCD-UAV. From the outcome it is understood that the proposed UTMPO-UAVs approach achieves 9% to 19% higher packet delivery ratio, 58ms to 90ms lower end-to-end delay, 11% to 17% better energy efficiency and 241 packets to 393 packets lower routing overhead when compared with the earlier methods. In the future direction to increase the density of the network satellite assisted UAVs enabled mobile communication is concentrated.

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Conflicts Of Interest

The author's disclosure statement confirms the absence of any conflicts of interest

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