International Journal of Scientific & Engineering Research Volume 10, Issue 5, May-2019
ISSN 2229-5518

Review of Opportunistic Communication In UAV Assisted Wsn

Mandeep Kaur, Lovepreet Kaur

Abstract— Wireless Sensor networks comprise of battery limited sensor nodes. These networks use clustering and other routing protocols such as AODV to transfer data to the sink node. UAV in recent times have found their use in data collection from sensor nodes, as a measure to increase their lifetime. Opportunistic Routing, another kind of routing technique that aims at reliable delivery of data by considering benefits of overhearing wireless signals, has been discussed in this paper. In this approach, data is sent to multiple neighbors rather than single neighbor as equated to other routing techniques. This paper explores various opportunistic routing techniques for wireless sensor networks that aims at improving performance of the network.

Index Terms— Wireless Sensor Networks, Opportunistic Routing, UAV, AODV

1 Introduction

Over the course of the past few years, multi-hop Wireless Networks (MWNs) [1] have attracted much attention; they have become a very popular topic in the research communities. In MWNs, radio transmission of nodes is affected by the distance between nodes and environmental elements. Therefore, the quality of wireless links in terms of packet delivery probability is different for each link in a MWN. Unlike wired networks, in MWNs, the transmission of a packet to an identical next-hop node may be heard by many other neighboring nodes.Opportunistic Routing (OR) became popular in the field of wireless networks because it could be used as an approach to increase the performance of MWNs. It considers the benefits of overhearing wireless signals. It is also referred to as diversity forwarding [2] or any-path routing [3-4].

This paper explains opportunistic routing in section II followed by UAV routing in next section. Finally, review of literature has been presented in section IV after which the paper has been concluded.

2 Procedure for Paper Submission

In OR, a set of nodes is selected as potential forwarders. The nodes in the selected set will forward the packet according to some criteria after they receive the packet. This group of nodes in OR is usually called a Candidate Set (CS). This is different from traditional unipath routing, which selects one next-hop forwarder before starting the transmission [5]. A priority is assigned to each candidate in the CS. Candidate priority shows the level of ability of a candidate to act as the next forwarder. The highest priority is given to the candidate that can reach the destination at the lowest cost. By using OR, each packet is allowed to dynamically build the route toward the destination; this is done according to the condition of the wireless links at the moment when the packet is being transmitted. In OR, the nodes do not select an identical nexthop before the transmission starts. OR selects a set of nodes as potential candidates.

The candidates that have received the transmitted packet coordinate among each other to decide which of them must forward the packet and which must discardit. This process is usually called candidate coordination. In other words, a sender broadcasts the data packet first, and one of its candidates that has received the packet will continue the forwarding process; therefore, the chance of delivering the packet to the destination is increased.

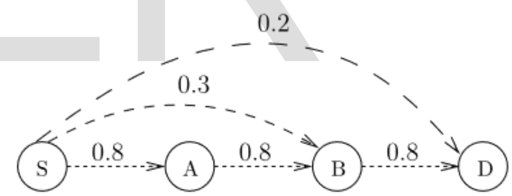

Fig. 1. Example of OR [6]

An example of OR is shown in Figure 1. It presents the meaning of OR and shows the difference between traditional routing and OR protocols.

3 UAV Routing

During the past few decades, unmanned aerial vehicles (UAVs) with small size and the ability to fly have emerged as a promising technique in both military and civilian applications. One of the most important basic problems is the cooperative communication between UAVs. An efficient communication or routing protocol between UAVs plays a vital role in data transmission and various practical applications. In order to efficiently transfer packets, a swarm of UAVs communicate and collaborate with each other to self-organize into a network, called a UAV ad hoc network (UANET) [7]. Since UAVs are mobile, they can work as packet carriers that are responsi-

- *Mandeep Kaur, Research Scholar, Rajasthan Technical University, Kota, India. E-mail: mandeepmaan336@gmail.com*
- *Lovepreet Kaur is* Assitant *Professor, Rajasthan Technical University, Kota, India. E-mail: lovepreetloveys22@gmail.com*

ble for forwarding packets from a source to a distant destination. The routing protocols for UAVs can be classified into two categories: single-hop routing and multi hop routing. In single-hop routing, a UAV first loads packets from a source, then directly transfers the packets to a destination without another forwarding node. The flying UAV works as a single-hop relay node; thus, this kind of routing is called single-hop routing. In this kind of routing protocol, efficient path planning for UAVs is important. Obviously, in multihop routing, the packets are forwarded hop by hop, that is, a swarm of UAVs collaborate with each other to transfer packets through multihop routing paths. Therefore, in multihop routing, selecting a proper next-hop UAV is the core step. Based on different strategies for next-hop selection, multihop routing can be further classified into two categories: topology-based and position-based routing. In topology-based routing, the next hop can be selected according to historical topological information to discover routes (i.e., proactive routing); also, the routes can be established when they are needed (i.e., reactive routing).

4 Literature Review

This paper [8] studies the opportunistic routing (OR) in unmanned aerial vehicle (UAV) assisted wireless sensor networks (WSNs). We consider the scenario where a UAV collectsdata from randomly deployed mobile sensors that are movingwith different velocities along a predefined route. Due to thedynamic topology, mobile sensors have different opportunitiesto communicate with the UAV. This paper proposes the AllNeighbors Opportunistic Routing (ANOR) and Highest Velocity Opportunistic Routing (HVOR) protocols. In essence, ANORforwards packets to all neighbors and HVOR forwards themto one neighbor with highest velocity. HVOR is a new ORprotocol which dynamically selects route on a pre-transmissionbasis in multi-hop network. HVOR helps the sensor which haslittle opportunity to communicate with the UAV to determinewhich sensor, among all the sensors that are within its range,is the forwarder. The selected node forwards the packet. As aresult, in each hop, the packet moves to the sensor that hashigher opportunity to communicate with the UAV. In addition, the authors focus on various performance metrics, including Packets DeliveryRatio (PDR), Routing Overhead Ratio (ROR), Average Latency (AL) and Average Hop Count (AHC), to evaluate the proposed algorithms and compare them with a Direct Communication (DC) protocol. Through extensive simulations, they have shown that bothHVOR and ANOR algorithms work better than DC. Moreover,the HVOR algorithm outperforms the other two algorithms interms of the average overhead.

In this study [9], a crop health monitoring system is developed by using state of the art technologies including wireless sensors and Unmanned Aerial Vehicles (UAVs). Conventionally data is collected from sensor nodes either by fixed base stations or mobile sinks. Mobile sinks are considered a better choice nowadays due to their improved network coverage and energy utilization. Usually, the mobile sink is used in two ways: either it goes for random walk to find the scattered nodes and collect data, or follows a pre-defined path established by the ground network/clusters. Neither of these options is suitable in our scenario due to the factors like dynamic data collection, the strict targeted area required to be scanned, unavailability of a large number of nodes, dynamic path of the UAV, and most importantly, none of these are known in advance. The contribution of this paper is the formation of dynamic runtime clusters of field sensors by considering the above mentioned factors. Furthermore a mechanism (Bayesian classifier) is defined to select best node as cluster head. The proposed system is validated through simulation results, lab and infield experiments using concept devices. The obtained results are encouraging, especially in terms of deployment time, energy, efficiency, throughput and ease of use.

In this paper [10], the authors employ UAV as the relay in WSN, which can move in three-dimensional space to possess a better position tominimize the system power consumption, combine sensors and UAV as an integration,where sensors first transmit signals to a concentrator. Then, the concentrator data will be retransmittedand relayed by UAV to the BS side. By the transmitting power of the UAV, the received SINR of thesignals at the BS side can be largely enhanced. Through this UAV based relay mechanism in WSN,the transmitting power of the concentrator can be cut down to meet the practical configuration ofWSN. On the other hand, the specific staying position of the UAV based relay in the three-dimensionalspace should be appropriately determined to achieve the tradeoff of transmitting power between theconcentrator and UAV, which can minimize the system’s energy consumption. In this paper, in order todetermine the optimal staying position of the UAV based relay, they first propose the architecture of theUAV based relay in WSN with the channel model using the fifth generation of wireless communication (5G). Then, they propose a Location of UAV (LU) algorithm based on the channel gain to obtain theoptimal staying position of the UAV, which can be dynamically adjusted according to the changingwireless channel gain.They use a simple case study to demonstrate the effectivenessof UAV in WSN. Extended simulations are also given to verify the preferable performance of the UAV based relay in WSN.

The aim of the present paper [11] is to propose an agricultural environment monitoring server system utilizing a low-cost Wireless Sensor Network (WSN). Several sensor nodes are scattered in fields several kilometers in size, and they propose collection of the information stored in the nodes by a mobile node, or mule. To cover long distances in a short period of time, they use an unmanned aerial vehicle (UAV), which retrieves the data stored in the ground nodes. In addition, the UAV may be used to acquire additional information and to perform actions. Its elevated position allows observation of the field with a perspective that is useful for detecting changes affecting crops, such as pests, diseases, significant changes in soil moisture, drought or floods.

In this paper [12], considering a general fading channel model for the SN-UAV links, the authors jointly optimize the SNs' wake-up schedule and UAV's trajectory to minimize the maximum energy consumption of all SNs, while ensuring that the required amount of data is collected reliably from each SN. They formulate the design as a mixed-integer non-convex optimization problem. By applying the successive convex optimization technique, an efficient iterative algorithm is proposed to find a sub-optimal solution. Numerical results show that the proposed scheme achieves significant network energy saving as compared to benchmark schemes.

In this paper [13], the authors consider a scenario where an unmanned aerial vehicle (UAV) collects data froma set of sensors on a straight line. The UAV can either cruise or hover while communicating with thesensors. The objective is to minimize the UAV's total flight time from a starting point to a destinationwhile allowing each sensor to successfully upload a certain amount of data using a given amount ofenergy. The whole trajectory is divided into non-overlapping data collection intervals, in each of whichone sensor is served by the UAV. The data collection intervals, the UAV's speed and the sensors'transmit powers are jointly optimized. The formulated flight time minimization problem is difficult to solve. The authors' first show that when only one sensor is present, the sensors transmit power follows a waterfilling policy and the UAV's speed can be found efficiently by bisection search. Then, they show thatfor the general case with multiple sensors, the flight time minimization problem can be equivalentlyreformulated as a dynamic programming (DP) problem. The sub-problem involved in each stage of theDP reduces to handle the case with only one sensor node. Numerical results present insightful behaviorsof the UAV and the sensors. Specifically, it is observed that the UAV's optimal speed is proportionalto the given energy of the sensors and the inter-sensor distance, but inversely proportional to the dataupload requirement.

In this paper [14], the authors have designed a basic framework for aerial data collection, which includes the following five components: deployment of networks, nodes positioning, anchor points searching, fast path planning for UAV, and data collection from network. They have identified the key challenges in each of them and have proposed efficient solutions. This includes proposal of a Fast Path Planning with Rules (FPPWR) algorithm based on grid division, to increase the efficiency of path planning, while guaranteeing the length of the path to be relatively short. They have designed and implemented a simulation platform for aerial data collection from sensor networks and have validated performance efficiency of the proposed framework based on the following parameters: time consumption of the aerial data collection, flight path distance, and volume of collected data.

In this article [15], the authors propose a cooperative framework for unmanned aerial vehicle–wireless sensor network, which is composed of sensor nodes, fixed-group leaders, and an unmanned aerial vehicle-Sink, in which a three-layer hierarchical network is formed. A land-wireless sensor network k-means driven grouping approach is then presented, which considers the communication performance, the position, and other factors. Additionally, a simulated annealing algorithm is employed to detect the optimal flight trajectory according the ground wireless sensor network architecture. Finally, the proposed approach is compared to other related approaches, and the results have shown better performance of the proposal in terms of energy consumption, flying time, and other relevant evaluation criteria.

5 Conclusion

This paper presents a brief survey of various routing techniques used in UAV assisted wireless sensor networks. UAV in these networks are used to collect data from the sensor nodes. Opportunistic routing is one of the techniques that have been mentioned in [8] that focuses on reliable delivery of the data between the nodes. This routing technique has been used by the sensors to forward data to the UAV. This makes use of ANOR and HVOR communication strategies. In future, these strategies can be expanded to multi hop HVOR to increase reliability of the data.

References

[1] Akyildiz and Xudong Wang, "A survey on wireless mesh networks. Communications Magazine", *IEEE 43, S23–S30*, September 2005.

[2] Peter Larsson, "Selection diversity forwarding in a multihop packet radio network with fading channel and capture", *Sigmobile Computing Communication Review 5*, 4 (2001), 47–54.

[3] H. Dubois-Ferriere, M. Grossglauser and M. Vetterli, "Least-cost opportunistic routing", *Proceedings of Allerton Conference on Communication, Control, and Computing*, Pages 994–1001. 2007

[4] H. Dubois-Ferri´ere, M. Grossglauser, and M. Vetterli, "Valuable detours: Least-Cost any path routing", *IEEE/ACM Transactions on Networking* 19, Pages 333–346, April 2011.

[5] Azzedine Boukerche, "Performanceevaluationofroutingprotocols for adhocwireless networks", Mobile Networks and Applications 9, 333–342, 2004.

[6] Azzedine Boukerche, Amir Darehshoorzadeh, "Opportunistic Routing in Wireless Networks: Models, Algorithms, and Classifications", *ACM Computing Surveys (CSUR)*, Volume 47, Issue 2, Article no 22, January 2015.

[7] Jinfang Jiang and Guangjie Han, "Routing Protocols for Unmanned Aerial Vehicles", Amateur Drone Surveillance: Applications, Architectures, Enabling Technologies, And Public Safety Issues, *IEEE Communications Magazine*, Volume: 56, Issue: 1, January 2018.

[8] Xiaoyan Ma, Simona Chisiu, Rahim Kacimiy and Riadh Dhaou, "Opportunistic Communications in WSN Using UAV", 14th IEEE Annual Consumer Communications & Networking Conference, 2017.

[9] Mohammad Ammad Uddin, Ali Mansour, Denis Le Jeune, Mohammad Ayazand el-Hadi M. Aggoune, "UAV-Assisted Dynamic Clustering of Wireless Sensor Networks for Crop Health Monitoring", *Sensors 2018*, 18(2).

[10] Shu Fu, Lian Zhao, Zhou Su and Xin Jian, "UAV Based Relay for Wireless Sensor Networks in5G Systems", *Sensors 2018*, 18(8), 2413.

[11] Polo, Jose, "Design of a low-cost Wireless Sensor Network with UAV mobile node for agricultural applications", *Computers and Electronics in Agriculture*, Volume 119, Pages 19-32, November 2015.

[12] Cheng Zhan, Rui Zhang, Yong Zeng, "Energy-Efficient Data Collection in UAV Enabled Wireless Sensor Network", *IEEE Wireless Communication Letters*, PP (99), August 2017.

[13] Jie Gong, Tsung-Hui Chang, ChaoShen, Xiang Chen, "Flight Time Minimization of UAV for DataCollection over Wireless Sensor Networks", arXiv: 1801.02799, January 2018.

[14] Chengliang Wang, Fei Ma, Junhui Yan, Debraj De, Sajal K Das, "Efficient aerial data collection with UAV in large-scale wireless sensor networks", International *Journal of Distributed Sensor Networks* - Special issue on Energy and Spectrum Efficient Wireless Sensor Networks, Volume 2015,Article No. 2. January 2015.

[15] Hui-Ru Cao, Zhi Yang, Xue-Jun Yue, Yong-Xin Liu, "An optimization method to improve the performance of unmanned aerial vehicle wireless sensor networks", International *Journal of Distributed Sensor Networks*, April 2017.

[16] X. Y. Ma, R. Kacimi and R. Dhaou, "Fairness-Aware UAV-Assisted DataCollection in Mobile Wireless Sensor Networks", International *Wireless Communications and Mobile Computing Conference* (IWCMC 2016), IEEE, September 2016.