Unmanned Vehicles Network Performance Analysis Considering Quality Criteria.

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Abstract: Geographic routing protocols have received more attention in recent years, the GPSR algorithm is a geographic routing protocol and is the combination of forward greedy routing and face routing, which are the pillars of geographic routing.
This article proposes a geographical routing protocol for communication between unmanned vehicles named nodes to improve the performance of the network. This proposal obtains the distance between nodes by means of a GPS device distance is used as a criterion to determine the quality of the link. In the same process a control signal is obtained to validate the stability of the node, using the signal of control and quality of the link to assign a cost of this, this information is compiled by means of a sump of nodes of the network in a way that kruskal algorithm generates the minimum spanning tree of the network. The simulation carried out on the Matlab platform is developed taking into account the behavior of the physical layer and the data link layer using CSMA / CA of the 802.15.4 standard and providing network performance when evaluating 2 transmissions with different origin nodes. The results show that the proposed algorithm eliminates loops, improves the performance of the network and guarantees the delivery of packets to nodes within the network.

Keywords: Geographic routing, performance, quality of the link, Kruskal algorithm,control signal.

1. INTRODUCTION

A routing protocol is needed when a packet needs to be transmitted through different nodes in the network. These protocols find an adequate route for delivering the packets to the correct destination (Garcia-Santiago Alejandro and Mino-Aguilar (2018)).

Geographical routing, also called position-based routing, allows you to find routes from a source node (S) to a destination node (D) taking a criterion the distance that exists between the nodes of the network. The main geographical routes are Greedy Forward Routing and Face Routing (Yujun Li, Yaling Yang, and Xianliang Lu (2010); Brad Karp, H. T. Kung (2000); Laxmi P Gewali and Umang Amatya (2013)).

It is observed in the aforementioned routing and other variants such as (Prosenjit Bose and Urrutia (2006); Evangelos Kranakis and Urrutia (1999); Fabian Kuhn and Zollinger (2003)), that the routing begins with the knowledge of the coordinates of destination node; however in reality it is necessary to perform certain tasks to obtain this data , as for example in (Ashish Nanda and He (2016)) the network decrees a node as a sink node, this node is responsible for obtaining the physical coordinates of all the nodes of the network, one option is to broadcast the network.

1.1 IEEE Standard 802.15.4

The IEEE 802.15.4 standard is defined in the Physical layer and the data link layer in personal area wireless networks with low data transmission rates (Low-Rate Wireless Personal Area Network, LR-WPAN) (Anis Koubâa (2005)).

The physical layer is responsible for the transmission and reception of data using a specific radio channel

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and according to a specific modulation and diffusion techniques.

IEEE 802.15.4 offers three operational frequency bands: 2.4 GHz, 915 MHz and 868 MHz. The protocol also allows dynamic channel selection, a scan function that traverses a list of compatible channels for a beacon, detection of receiver power, indication of link quality and channel change.

The MAC sublayer of the IEEE 802.15.4 protocol provides an interface between the physical layer and the upper layer protocols of LR-WPANs.

The MAC sublayer of the IEEE 802.15.4 protocol uses CSMA / CA (Multiple access by carrier detection / containment avoidance) as a channel access protocol, the support of contention-free and contention-based periods, is characterized by adapting to the LR-WPAN requirements since; for example, it eliminates the RTS / CTS mechanism (used in IEEE 802.11) to reduce the probability of collisions, due to collisions are less likely to occur in low-speed networks.

The MAC sublayer of the IEE 802.15.4 protocol supports two operating modes that can be selected by the coordinator that are slotted and not slotted, in this work the non-slotted mode was used because the approach is a decentralized network.

1.2 Calculations

The maximum performance is calculated by dividing the number of bits in a packet by the time it takes to transmit the packet. The delay of a packet is determined. This global delay explains, on the one hand, the delay of the data that is sent and, on the other hand, the delay caused by all the elements of the sequence of frames, as shown in Fig. 1 (Dhoedt and Demeester (2005)).

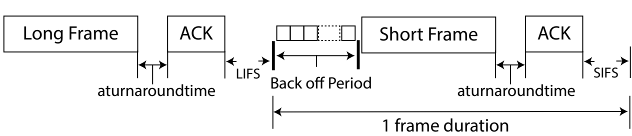

Fig. 1. Frame sequence in 802.15.4.

The delay experienced by each package can be formulated as:

$$delay(x) = T_{BO} + T_{frame}(x) + T_{TA} + T_{ACK} + T_{IFS}(x) \quad (1)$$

where

T_{BO} = Backoffperiod.
T_{frame} (x) = Transmission time for a payload of x byte.
T_{TA} = Turn around time (192μs).
T_{ACK} = Transmission time for an ACK.
T_{IFS} = IFStime.

The Inter Frame Spacing (IFS) period defines the amount of time that separates the transmission of two consecutive frames. In fact, the MAC sub-layer needs a finite amount of time to process data received by the physical layer. The IFS time varies between Short Inter Frame Spacing (SIFS) or Long Inter Frame Spacing (LIFS) depending on the MAC Protocol Data Unit (MPDU), when the MPDU is less than or equal to 18 bytes, SIFS is used, when it is greater than 18, LIFS is used (SIFS = 192 $s, LIFS = 640$ s).

The back off period is defined as:

$$T_{BO} = BO_{slots} * T_{BOslot} \quad (2)$$

$BO_{slots} = [0, 2^{BE-1}]$
$T_{BOslots}$ = Backoff Period constant (320 μs)

The time of transmission of a frame with a payload of x bytes is given by

$$T_{frame}(x) = 8 \cdot \frac{Data}{R_{data}} \quad (3)$$

where,

$$Data = \frac{L_{PHY} + L_{MAC\_H} + L_{add} + x + L_{MAC\_F}}{R_{data}} \quad (4)$$

L_{PHY} = Length of the PHY and synchronization header (6 bytes)
L_{MAC_H} = Length of the MAC header (3 bytes)
L_{add} = Length of the information field of the MAC address using 64 bits (20 bytes)
L_{MAC_F} = Length of the MAC footer (2 bytes)
R_{data} = Raw data rate (250 kbps)
x = Maximum payload length (102 bytes)

The transmission time for an ACK is:

$$T_{ACK} = \frac{L_{PHY} + L_{MAC\_H} + L_{MAC\_F}}{R_{data}} \quad (5)$$

1.3 Kruskal algorithm

The Kruskal algorithm is a graphical algorithm that can generate the minimum spanning tree, (Dayin (2011)). The algorithm of the minimum spanning tree is a network optimization model that consists of linking all the nodes of the network directly and / or indirectly so that the total length of the arcs or branches is minimal.

1.4 Application

Unmanned Vehicle systems can move independently or can be operated distantly. The use of single drone system is very common. However, simple functions of single drone system restrict its further applications. Currently, the need for building multi-drone system to improve the operational efficiency through the cooperation of multi-drones has become very important (K. Geon-Hwan and

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Imtiaz (2016); Md. Hasan Tareque and Atiquzzaman (2015)).

Nowadays, wireless mobile networks and devices are becoming increasingly popular due to they provide users access, communication anytime and anywhere.

The wireless network can be classified in two types: Infrastructured or Infrastructureless (Mohapatra and Krishnamurthy (2005); Taneja and Kush (2010)).

Infrastructured wireless networks. The base stations are fixed and they have a specific range where the mobile nodes can move while communicating as long as they keep into the coverage area. However, when a node goes out of the range of a base station, it can get into the range of another base station whether there is one available, otherwise this node will be without connection. This kind of network can be seen as the conventional wireless mobile networks.

Infrastructure Less or MANETs. There are no fixed base stations and all the nodes in the network operates as routers. For this reason, the mobile nodes can move while communicating in anytime.

It is proposed to improve the performance of networks with infrastructure by using the nodes of the network as a router and allow communication between them, resulting in being able to use them as jumps and generate routes from the base station to an end node to assign control signals.

Fig. 2 shows a typical network topology.

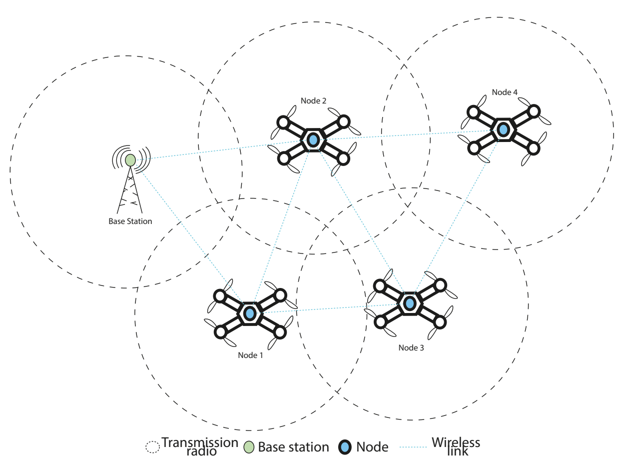

Fig. 2. Network topology.

2. PLATFORM

2.1 Discrete Events simulation

Monte Carlo simulations are used to model the probability of different outcomes in a process that cannot easily be predicted due to the intervention of random variables. It is a technique used to understand the impact of risk and uncertainty in prediction and forecasting models.

A Monte Carlo Simulation was developed using the Matlab software that allows to generate N nodes within a specific area and observe their interactions, providing the topology of the network and the performance of the proposed routing. Fig. 3 shows the general algorithm of our simulation.

The platform has the following characteristics:

- Area: Generates a square-shaped area of variable size that limits the network.
- Nodes: Generates "N" number of nodes randomly with "X" and "Y" coordinates.
- Coverage: It allows to vary the coverage of the nodes and the discovery of the topology of the network.

Our network establishes 4 types of nodes: Source Node (S), Router, Destination Node (D) and Nodes Sinks.

- Source Node: Origin Node where the transmission is requested.
- Router: Allows retransmit the information, generating a path between the O and D.
- Node Destination: Node where the information is directed.
- Sink Node: Node that stores the information of the network.

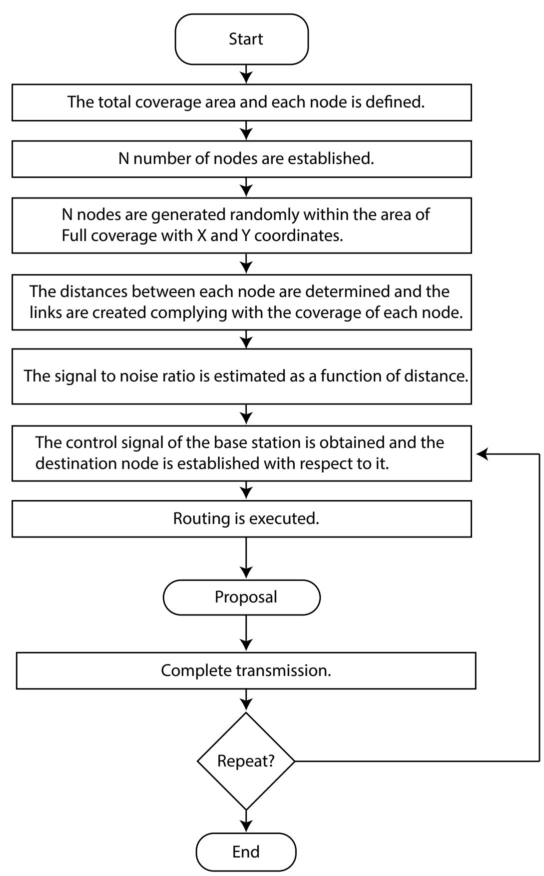

Fig. 3. Platform flow diagram.

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2.2 Proposal

In our work, we propose a geographic routing protocol that, using the same diffusion signals for the knowledge of the physical coordinates of the nodes of the network, allows the sink node to obtain the topology of the network and the costs of links using the signal relationship - interference (SIR) per link and the control signal of the nodes as criteria). With this information, the sink node performs a Kruskal algorithm and, when an "S" transmission request occurs, it will consult with the sink node, that will allow you to select the route with the best performance, eliminate the loops and guarantee the delivery of packets to the nodes within the network, Fig. 4 shows how the proposed routing works.

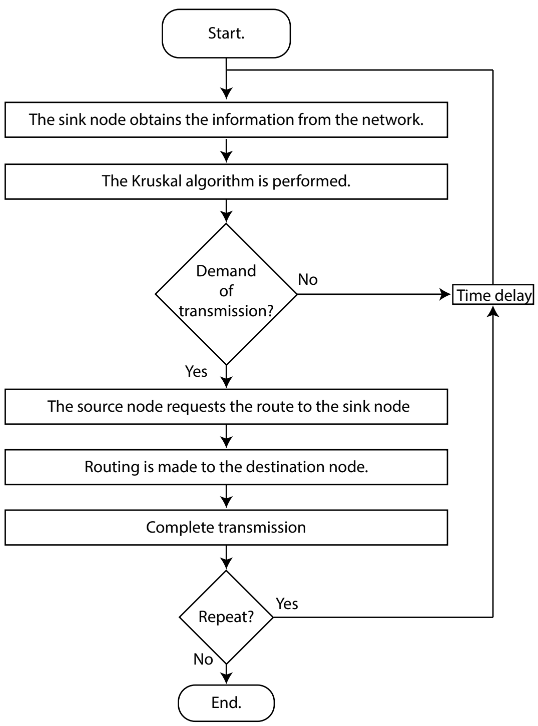

Fig. 4. Proposed routing algorithm.

The development of the kruskal algorithm is carried out by the Sink Node, due to the need to determine a quality in each link, this quality is defined as:

$$SIR = \frac{P_{SRx}}{P_{int}} \quad (6)$$

- P_{SRx} is the signal power received by the device, it is obtained with (7).
- P_{int} is the power of the interference signal received in the device generated by the other devices in its environment, it can be obtained with (8).

$$P_{SRx} = \frac{P_{STx}}{\gamma^{\mu}} \quad (7)$$

- P_{STx} is the potency of transmission.
- γ distance between nodes.
- μ middle constant

$$P_{int} = \sum_{K=1}^{M} P_i \quad (8)$$

- P_i interference from neighboring nodes.
- M number of nodes.

The simulation was performed considering next parameters.

- Area: 100 m^2
- Nodes: 100 elements.
- Coverage: 20 m

For simulation purposes, interferent nodes were generated randomly and with a variable amount of 20, 30 and 40% of the total, each amount was evaluated as a case, in each case the probability of transmission was varied by 40, 60 and 80% of the interferent nodes.

The performance of our network is determined by the number of bits received between the period of time elapsed for delivery. The physical layer and access layer of the 802.15.4 standard was simulated using the equations of Dhoedt and Demeester (2005).

3. RESULTS

The results obtained from the simulation are shown, in Fig. 5. We can see the complete network of 100 nodes in an area of 100 m^2, Fig. 6 shows the Kruskal algorithm which implies the union of the nodes of the network through the links with better weight. We can observe the route between a source node and the destination node.

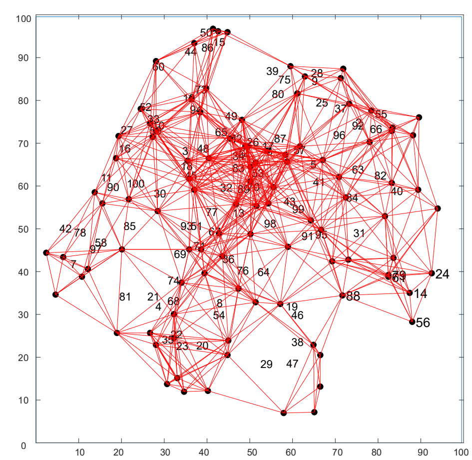

Fig. 5. Complete network.

Fig. 7 shows the delays obtained when making the routing proposal, generating 2 simultaneous transmissions (T1 and T2) with origin nodes and destination nodes determined in random and different origin nodes, the consecutive lines refer to the first transmission, the blue line it

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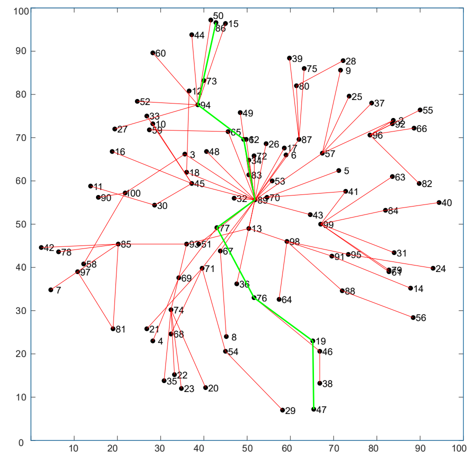

Fig. 6. Network with the Kruskal algorithm.

is with 20% of nodes with low probability of transmission, green with 30% and orange with 40%, in the same way the dotted lines refer to the second simultaneous transmission, the red line is with 20% of nodes with low transmission probability, yellow with 30% and purple with 40% and a comparison is made in Fig. 8, which shows the delays obtained with GPSR routing using the same variables.

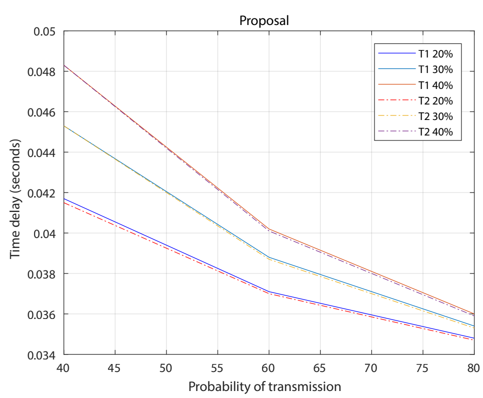

Fig. 7. Network performance with proposed routing.

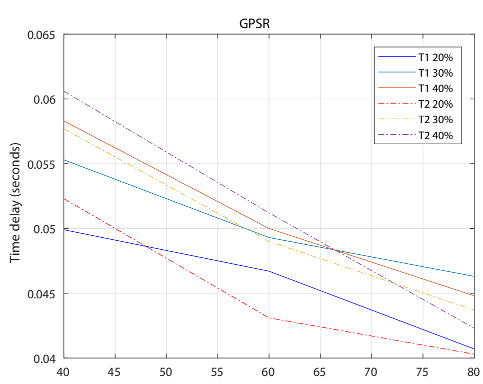

Fig. 8. Network performance with GPSR routing.

4. CONCLUSION

The proposed geographical routing of this work guarantees a route from a source node to a destination node that is within the network; using the Kruskal algorithm, the links with the best quality and the nodes with greater stability are chosen to interconnect all the nodes of the network, unlike the geographical routes by distance that do not take into account the quality of the link and control signal. This routing can generate more jump numbers, but when opting for higher quality links and stable nodes, it is sought to avoid as much as possible the links with low transmission probability and to reduce the delay in transmission. Therefore, greater network performance is obtained.

REFERENCES

Anis Koubâa, Mário Alves, E.T. (2005). Ieee 802.15.4 for wireless sensor networks: A technical overview. technical report.

Ashish Nanda, P.N. and He, X. (2016). Geo-location oriented routing protocol for smart dynamic mesh network.

Brad Karp, H. T. Kung (2000). Gpsr: Greedy perimeter stateless routing for wireless networks.

Dayin, S.T.L.X.W.Y.C.Y.C. (2011). A matlab simulation of the kruskal algorithm for erecting communication network. ©2011 ieee.

Dhoedt, B.L.P.D.M.I.M.N.V.D.B. and Demeester, P. (2005). Maximum throughput and minimum delay in ieee 802.15.4.

Evangelos Kranakis, H.S. and Urrutia, J. (1999). Compass routing on geometric networks.

Fabian Kuhn, Roger Wattenhofer, Y.Z. and Zollinger, A. (2003). Geometric ad-hoc routing: Of theory and practice.

Garcia-Santiago Alejandro, Castaneda-Camacho Josefina, G.C.J.F. and Mino-Aguilar, G. (2018). Evaluation of aodv and dsdv routing protocols for a fanet: Further results towards robotic vehicle networks.

K. Geon-Hwan, N.J.C. and Imtiaz, M. (2016). Multi-drone control and network self-recovery for flying ad hoc networks.

Laxmi P Gewali and Umang Amatya (2013). Node filtering and face routing for sensor network.

Md. Hasan Tareque, M.S.H. and Atiquzzaman, M. (2015). On the routing in flying ad hoc networks.

Mohapatra, P. and Krishnamurthy, S.V. (2005). Ad hoc networks technologies and protocols.

Prosenjit Bose, Pat Morin, I.S. and Urrutia, J. (2006). Routing with guaranteed delivery in ad hoc wireless networks.

Taneja, S. and Kush, A. (2010). A survey of routing protocols in mobile ad hoc networks.

Yujun Li, Yaling Yang, and Xianliang Lu (2010). Rules of designing routing metrics for greedy,face, and combined greedy-face routing.

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