Asian Journal of Information Technology 15 (19): 3870-3876, 2016
ISSN: 1682-3915

F^2vhdr Based Collaborative Routing with Hydrodynamics for Qos Development in Wireless Sensor Networks

[1]T. kalaivani and [2]J. Senthil Kumar
[1]Anna University, Chennai, India
[2]Department of Information Technology, Sona College of Technology, Salem, India

Abstract: The problem of routing in wireless sensor networks can be considered as liquid flow in the floors where there exist friction to suppress the flow of fluid. Even though there exist number of collaborative routing protocols exist earlier but suffers with the problem of achieving quality of service of wireless sensor networks. We propose a novel F^2VHDR (Friction-Flow-Velocity Based Hydrodynamic Routing), which uses different parameters of hydrodynamics to perform routing in wireless sensor networks. The method computes Friction,Flow factor and velocity of any route available in the network. Based on the factors being computed, the node selects a single route to forward the data packets. The source node computes the hydrologic weight for each route based on the above mentioned factors. Based on the computed value of hydrologic weight the nodes performs cooperative transmission and routing to achieve the quality of service parameters.

Key words: WSN, collaborative routing, hydrodynamics, F^2VHDR, QoS development

INTRODUCTION

The wireless sensor network is the collection of sensor nodes which are located in different geographic region of the network. The sensor in the network performs communication with wireless protocol to perform data transmission. The sensor nodes are comes with a radio which has fixed transmission range and battery to store the energy. Each node spends some energy to transmit packet which reduces the lifetime of the networks and the node also. The energy parameter can to be used in more efficient manner to improve the lifetime of the network. Also the nodes of the network has fixed transmission range and can communicate with the other sensor nodes which are located within the transmission range.

In order to send a data packet from a source node to any destination, the node cannot transmit the data packet directly because of the restrictions of the transmission range. So in order to deliver the data packet to the destination node, they involve in cooperative data transmission. In cooperative transmission, all the sensor nodes of the network involve in transmission and reception of data packets. They involve in data forwarding and they discover the route to reach the destination and forward them in the path available to reach the destination sink node. The collaborative routing is such a process which is performed by all the nodes of the network and the source node discovers the route and then forwards through the discovered route.

The problem of routing in wireless sensor network can be relate to the hydrodynamics. The hydrodynamics is the topic related to studying the fluid flow where there exist friction in the surface. The fluid flow in any surface is higher when there is very less friction on the surface and the velocity in the surface is higher when there is no obstacles in the path of fluid flow. The velocity of fluid in any surface can be measured as follows:

$$\text{Velocity } v = Cq/d^2$$

In the Eq. 1 C represents the velocity constant and its value is assigned as 1.273 for fluids. The variable q represents volume of fluid flows and the variable d represents the diameter of the pipe through which the fluid flows. The fluid velocity subject to change when there are number of diversions If there exist more number of diversion then the fluid flow velocity will be less. Also the flow of fluid or the amount of fluid also affects the final result because any route available can transfer only limited amount of fluid. All these parameters can be relate to the routing in the wireless sensor networks. The Friction is relate to the traffic parameter, the velocity is relate to the latency, flow is relate to the amount of packets being sent on each time through the route. So by using the properties of hydrodynamics the quality of routing in wireless sensor network can be improved.

According to the assumptions mentioned above, the velocity of data stream can be measured using the Eq. 2:

Coressponding Author: T. kalaivani, Anna University, Chennai, India

$$\text{Velocity } v = \frac{(TDr / b)}{Nj} \quad (2)$$

From Eq. 2 v represents the velocity of data stream which is computed using the traffic constant T, bandwidth b, Number of hops or junctions Nj and Dr represents the data rate. The velocity also represents the delivery rate of the data stream at any destination point. The delivery rate varies according to the number of junctions or hops the transmission route has and the bandwidth, transmission constant which represents the traffic introduced by sending 1 byte of data.

F^2VHDR: The Friction-Flow-Velocity based hydrodynamic routing algorithm computes the friction in each route and flow factor of the route and velocity of the fluid flow in the route. Based on all the factors the method computes the hydrologic route weight for each of the route available. Based on computed weight a single route can be selected to forward the data packet. The quality of service of wireless sensor network is about the routing protocol being used. Based on the quality of routing the other parameters like throughput, packet delivery ratio can be improved. Also the latency and packet drop ratio can be reduced.

Literature review: There are number of routing protocols has been discussed for the problem of routing in wireless sensor networks and we discuss some of the methods here in this study. Su *et al*. (2013) prescribe a PACO routing algorithm which minimizes the number of hops. Further the algorithm defines the energy distance and discuss a routing algorithm to minimize the distance. The algorithm overrides the performance of ant colony optimization based routing and improves the performance of routing. Kariman *et al*. (2015) discuss a joint routing method which employs the duty cycle scheduling algorithm. Also the algorithm present an energy balance technique for the wireless sensor networks. The author further introduce a flow sharing algorithm for the maximization of network lifetime.

Karkvandi *et al*. (2011) maintains various information of resource nodes using which the method computes the lifetime value for each of the nodes. The method uses transmission range to compute their confidence level. Also the author introduced a lifetime criterion approach to improve the network lifetime. Edith introduce a lifetime maximization technique for the wireless sensor networks. The method computes the task cycles and uses the mean square error function. Finally an optimal multi path routing is described to improve the network lifetime.

Reddy and Jeba (2014), consider the transmission power assignment strategy to maximize the lifetime of wireless sensor networks. The research present a distributed power assignment algorithm to make the network connected. Gribaudo *et al*. (2005) presented a wireless sensor network analysis model based on hydrodynamics. In the model, sensor nodes were taken as fluid entity and distributed in a smooth and continuous space. The authors had defined the concept of local node density, which referred to the quantity of nodes distributed in unit area of the given space. They assumed that nodes in networks were static. Nodes transmitted information received to other nodes by multihop. This mode confined network in a simplified state. Yet, it still solved many problems, such as nodes' energy consumption and nodes' contending for wireless channels, as well as communication routing.

Erkmen presented a novel hydrodynamic simulation method to solve the deployment problem of mobile sensor networks in an unknown environment. This method is based on the physical law in hydrodynamics theory, modeling sensor network as inviscid and compressible fluid and regarding each node in the network as fluid element. As for this, the diffusivity of fluid drove nodes to "flow" with fluid, so as to make the network deployment with an expected effective coverage rate.

Wei *et al*. (2015) discuss a strategic method to improve the lifetime of wireless sensor network which incorporates different scales. The author consider the packets as fluids in field. Also the sink nodes are considered as the sink flow where the packets are flowing to their potential to reach the sink nodes. Schillings and Yang (2009) discuss a theory of games where the players are as nodes of wireless sensor networks. In the theory the algorithm looks to maximize the profits of players.

Khawam *et al*. (2007) discuss an fluid model to improve the network lifetime and accounts the network interference, radio propagation to estimate the network lifetime. Also, the algorithm counts the network density as a key factor to improve the network lifetime. Chiasserini *et al*. (2007) discuss the development of large scale of WSN. The author present fluid scheme which represent the network by continuous fluid flow. The algorithm estimates the network traffic by computing the fluid flow.

Kim and Hou (2004) develop a fast simulation framework where the method consider the large number of packets as a single fluid chunk. Also the method approximate the behaviors in the simulation model. The algorithm adapts various measures to improve the lifetime of the wireless sensor networks. Aysal and Barner (2008a, b) describe a decentralized model to maximize the network lifetime. The algorithm uses the newtons law in estimating the maximum likelihood of the node.

Also the algorithm uses a polynomial algorithm to select the region of interest to schedule the nodes.

The PACO (1) consider the distance which affects the throughput and PDF of the network. Similarly, Kariman *et al*. (2015) the author consider the energy parameter and lifetime of the network. This makes the most nodes to be in sleep mode in most time. Also this affects the throughput and packet delivery of the network. The methods described by Karkvandi *et al*. (2011) are focused on identifying the trusted route and this reduces the lifetime of the network. The power assignment algorithm is discussed which does not consider about the throughput ratio. Gribaudo *et al*. (2005) the hydro dynamics based routing is discussed but not considered many factors. The approaches Pac *et al*. (2006) and Khawam *et al* (2007) has considered the network lifetime and suffers with higher latency. In general, the methods reviewed has the problem of poor efficiency in routing and produces inefficient results.

MATERIALS AND METHODS

F²VHDR based collaborative routing: The proposed friction and flow with velocity based hydrodynamic routing approach identifies set of all available routes. Then for each route being identified, the method computes the friction, flow of fluid and velocity factors. Based on computed factors of hydrodynamics, we compute the hydrodynamic weight to select a single route to perform data transmission. The complete working procedure of the proposed algorithm can be split into number of stages namely route discovery, F²VHDR weight computation and packet forwarding. Figure 1, represent the architecture of the proposed system and shows the functional components in detail.

Route discovery: The route discovery is the process of identifying the available routes in the network. First the method generates Hydrodynamic route request and broadcast into the network. Upon reception of HRR packet the nodes replies with the Hydrodynamic route reply which composes the friction and flow factors. At the time source node receives the reply from the neighbor nodes, it extract the features from the HRRep packet and stores them in a route table. Each node acts when it receives the HDReq packet and forwards them to the neighbor nodes to identify the presence of route. If it has the direct contact then it replies with the HDRep packet. Finally the identified results will be used to perform route selection in the packet forwarding phase.

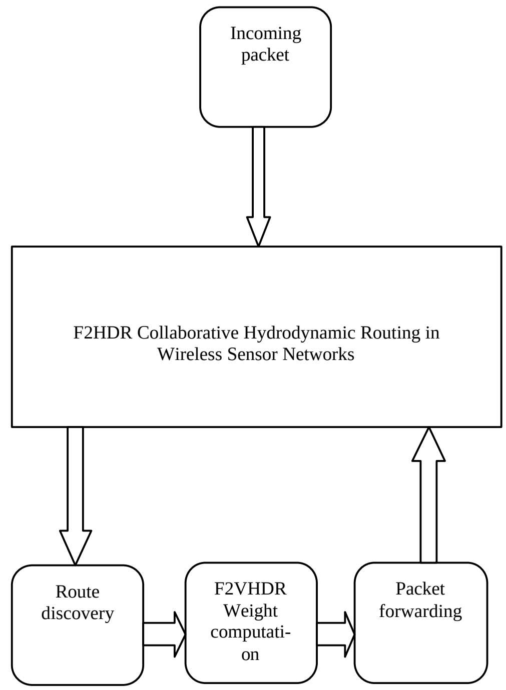

Fig. 1: Architecture of F²vhdr hydrodynamic routing scheme

Algorithm:

```
Input: Neighbor Table Nt
Output: Route Table Rt
Start
        Initialize Route Table Rt
        Generate Hydrodynamic Route Request HDReq.
        Broadcast HDReq packet.
        Initialize Broadcast Timer BT.
        While BT is true
          Receive Hydrodynamic route reply.
          Extract the route Ri from the reply.
          Rs =Σroutes ϵ HD Rep

          For each route Ri from Rs
                    For each hop Hi from Ri
                    Extract Friction or Traffic value  Frv = ∫Ri. Hi.
                    Flow∈HDRep
                    Extract Flow or Data rate value Flv = ∫Ri. Hi.
                    Friction∈HDRep
                    End
                    Generate Route Feature RF = {Ri, Frv, Σflv}
                    Add to route table Rt
        End
Stop.
```

The above discussed algorithm performs route discovery and extract the available routes with the value of friction and flow at each hops.

F²VHDR weight computation: At this stage, the method computes hydrodynamic weight for each hop identified in each route Ri. Each hop in the route has different friction and flow factor which is identified based on the traffic and flow of packets at specific hop. Using the above friction and flow factors the method computes the velocity of the channel. Using all the factors computed the method computes the hydrodynamic weight for the specific route. The computed hydrodynamic route is used to perform route selection in packet forwarding.

Algorithm:

Input : Route Feature Rf
Output: Hydrodynamic weight CHw.
Start
    For each hop Hi from Rf
        Extract friction value (or) Traffic value Trv = Rf.Frv
        Extract Flow value Drv = Rf.Flv
        Compute Fluid Velocity Fv = –Trv/Drv
        Compute Hydrodynamic weight Hw = $\int_{i=1}^{size(hops)}\left(T\times(\sum\frac{Trv}{Drv}/B)\right)$
End
    Compute cumulative hydrodynamic weight CHW = ΣHW/size (Hops)
Stop.

The above discussed algorithm computes the hydrodynamic weight for each route being identified using the factor values of friction and flow.

Packet forwarding: Whenever a source or intermediate node has the packet to be transmitted towards the destination, the node performs route discovery to identify the available routes. Then for each route the method computes the F^2VHDR based hydrodynamic weight. Based on computed hydrodynamic weight, the method selects a single route which has more hydrodynamic weight. The packet will be transmitted through the route being selected.

Algorithm:

Input: Packet P
Output: Null
Start
    Route set Rs = Route Discovery(P.Destination).
    For each route Ri from Rs
        Compute Hydrodynamic weight Hw = F^2VHDR(Ri).
    End
    Choose the route with more hydrodynamic weight.
    Route Rk = $\int_{i=1}^{size(Rs)}\left(select(Ri.max(Hw))\right)$
    Forward packet Fp.
Stop

The above discussed algorithm computes the hydrodynamic weight for each route being identified using the route discovery phase

RESULTS AND DISCUSSION

The proposed F^2VHDR based hydrodynamic routing approach has been implemented and evaluated for its efficiency. The proposed method has produced efficient results in all the factors of quality of service of wireless sensor networks. The method has been simulated and evaluated for its efficiency using the below mentioned parameters.

Table 1: Details of simulation parameter

Parameters	Value
Tool used	Network Simulator Ns2
Number of nodes	50
Transmission range	100
Simulation area	1000/1000 m
Simulation time	5 minutes

Table 2: Details of traffic in hops

Node ID	Traffic Bytes/sec	Node ID	Traffic bytes/sec
2	3	11	8
3	5	12	9
4	7	13	11
5	6	14	9
6	3	15	11
7	4	16	12
8	8	17	11
9	9	18	13
10	8	19	16
21	7		

Table 3: Details of hydrodynamic weights

Source/ destination	Routes	Hydrodynamic dynamic weight	Cumulative Hydro
1-20	1-2-8-9-15-22-20	1.452	0.2900
	1-3-7-10-9-15-12-20	0.998	0.1660
	1-3-6-11-16-19-20	1.494	0.2988
	1-3-6-11-16-19-21-20	2.093	0.3480
	1-3-5-12-17-18-21-20	2.007	0.3340
	1-4-5-3-6-11-16-19-21-20	2.989	0.4270
	1-4-5-3-7-10-9-15-12-20	2.832	0.3540
	1-4-5-12-17-18-21-20	2.719	0.4530

Table 1 present the simulation details being used and lists the set of parameters of simulation. The simulation has been conducted with variable number of nodes and data rate has been varied for different simulations. At each cycle of simulation, the node computes the weight for each route available and based on the value an optimal route has been selected. This represents the route with higher weight will be selected and the route which has more traffic and higher number of hops will be neglected.

Figure 2 shows the sample network topology considered for the evaluation of proposed algorithm. The Table 2, shows the details of traffic present in different intermediate nodes of the network considered. The traffic value is assumed to be present at any point of simulation time Using the details of traffic value and the traffic constant value which is of 1.273, the velocity, hydro dynamic weight and cumulative hydrodynamic weight. For example, for the route "1-2-8-9-15-12-20", we can compute different measures as follows:

$$\text{Velocity } v = ((3/5)/7)+((8/5)/7)+((9/5)/7)+((11/5)/7)+((9/5)/7) = 1.273\times1.1412=1.452$$

Table 3, shows the computed values of hydrodynamic weights and their cumulative weight for

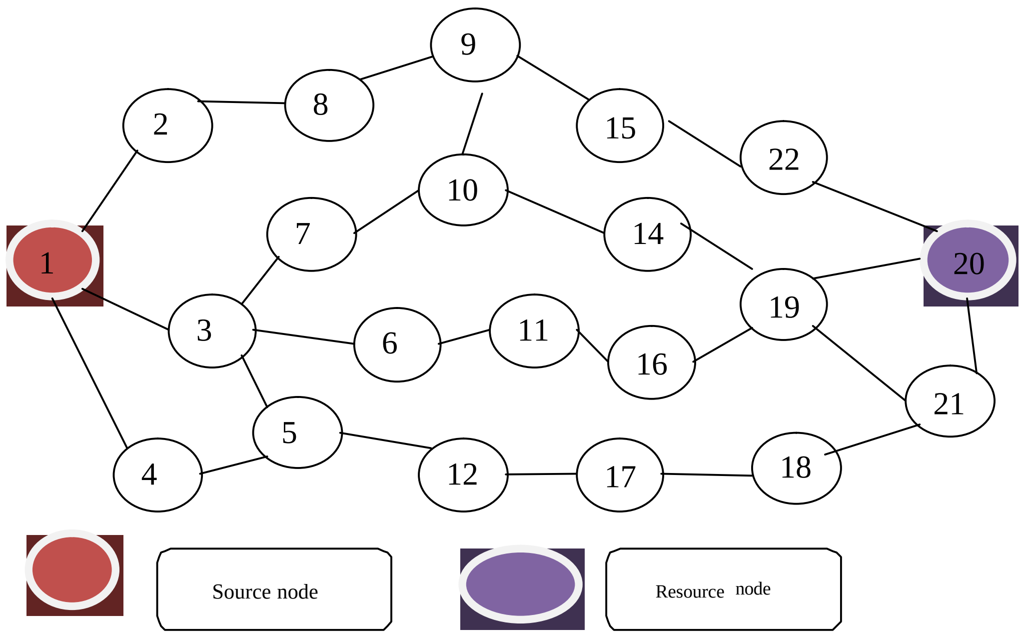

Fig. 2: Example network topology considered

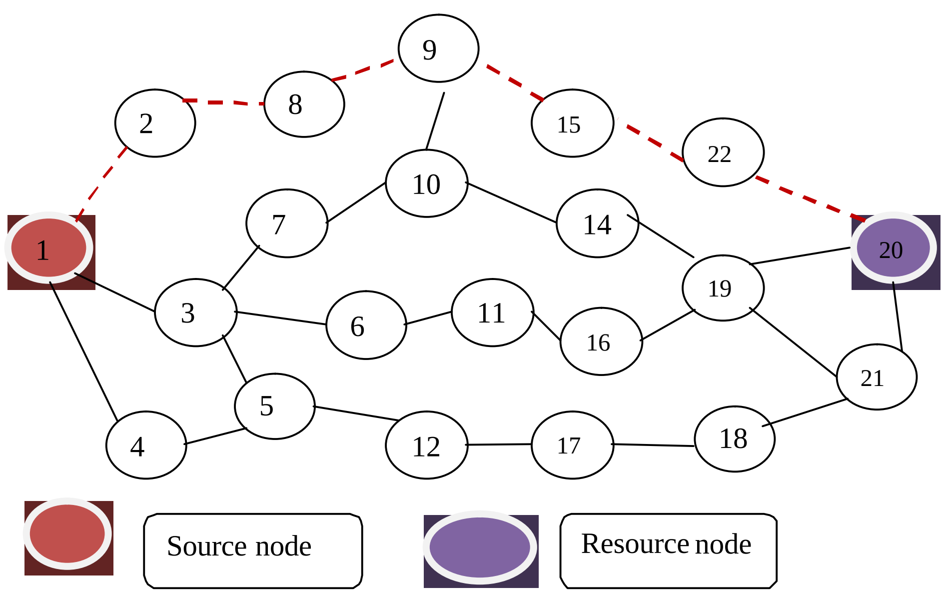

Fig. 3: Result of route selection

different routes available. From Table 3, the method selects the route with less weight which represents the transmission support of different routes. Based on the cumulative hydrodynamic weight an optimal route will be selected to forward the data packets. Figure 3 shows the result of route selection. The route selection is performed based on the cumulative hydro dynamic weight and the hop count. The route "1-3-7-10-9-15-12-20", has less weight than "1-2-8-9-15-22-20" but has higher hop count. So, the route "1-2-8-9-15-22-20" is selected to perform routing. The performance of the proposed method has been measured by computing different parameters namely throughput performance, packet delivery ratio and latency. The throughput performance is computed using Eq. 3:

$$\text{Throughput performance} = \frac{\text{Number of bytes delivered per second}}{\text{Total Number of bytes sent per second}} \quad (3)$$

Figure 4 shows the comparison of throughput performance achieved by various approaches in varying number of nodes. Also Fig. 4, claims that the proposed method has produced higher throughput than other methods. By considering the friction which represent the traffic, flow which represent the amount of data pass through and velocity, the proposed algorithm performs route selection. This helps to achieve higher throughput compare to other methods. Other than comparing the hop count and only traffic factors, the proposed algorithm considers above mentioned three factors to achieve higher throughput. The packet delivery ratio represents the efficiency in packet delivery by the protocol discussed. The packet delivery ratio is computed using Eq. 4:

$$\text{Packet delivery ratio} = \frac{\text{Number of packets delivered successfully}}{\text{Total Number of packets sent}} \quad (4)$$

Figure 5 shows the comparison of packet delivery fraction produced by different methods and it shows clearly that the proposed method has produces higher packet delivery fraction than other methods. Because of the proposed algorithm, considers the friction, flow and velocity features of available routes in route selection stage, the algorithm could deliver the data packets in least time. This helps to improve the packet delivery fraction of the network.

Similarly the latency ratio is measured by computing the time duration between the packet sent time and the packet delivery time. The efficiency of the protocol will be higher when the latency ratio is less. The proposed approach has produced less time complexity than the other methods. Figure 6 shows the comparison of latency ratio produced by different methods and it shows clearly that the method has produces less latency than other methods. The proposed algorithm, performs route selection based on three factors namely friction, flow and velocity. By considering these factors, the algorithm is capable of identifying the traffic free route and transmit through the identified route.

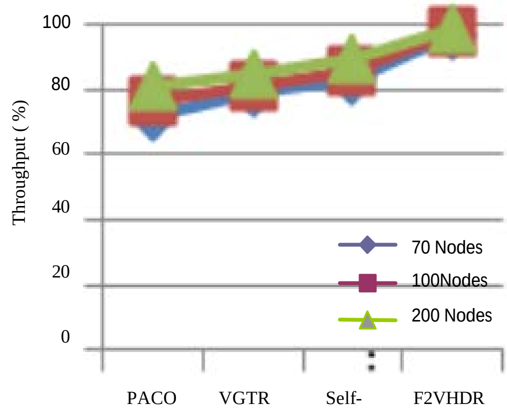

Fig. 4: Comparison of throughput performance

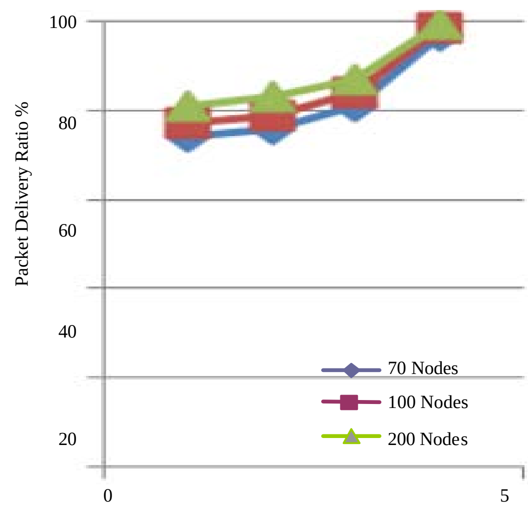

Fig. 5: Comparison of packet delivery ratio

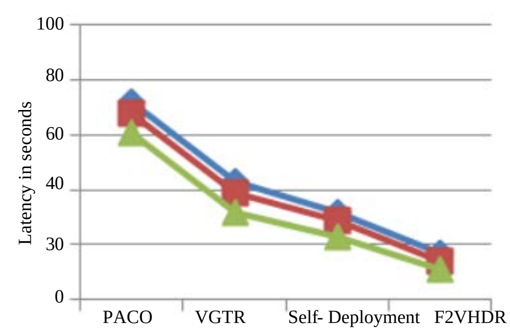

Fig. 6: Comparison on latency ratio

This helps to reduce the latency of the data packets. Table 4 shows the comparative results on various quality of service parameters produced by different methods and

Table 4: Compartative results on various Qos parameters

	Throughput (%) with No. of nodes			Average Delay(ms) with No. of nodes			PDF (%) with number No. of nodes		
Protocol	70	100	200	70	100	200	70	100	200
PACO	72	76	81	72	68	61	74	77.0	81.0
GTR	79	81	85	43	39	32	76	79.0	83.0
Self-deployment	83	86	89	32	29	23	81	84.0	87.0
F2VHDR	96.5	97.8	98.9	17	14	11	97	98.5	99.6

it shows clearly that the proposed method has produces efficient results on all the factors of quality of service of wireless sensor networks.

The friction-flow-velocity based hydrodynamic routing for wireless sensor network has introduced higher impact on the quality of service of the network. The above discussed results shows the efficiency of the protocol in various parameters of quality of service in wireless sensor networks.

CONCLUSION

In this research we proposed a novel F^2VHDR based hydrodynamic routing scheme to improve the performance of wireless sensor networks. First the method performs route discovery to identify the set of available routes. Then for each route available the method computes the hydrodynamic weight using the route features like friction, flow and velocity. Based on computed hydrodynamic weight the method selects a single route and forward the packet through the selected route. The proposed method has produced efficient results in all the factors of quality of service in wireless sensor networks. The protocol improves the performance of throughput upto 96.5 % and reduces the latency to 17 sec.

REFERENCES

Aysal, T.C. and K.E. Barner, 2008a. Constrained decentralized estimation over noisy channels for sensor networks. IEEE. Trans. Signal Process., 56: 1398-1410.

Aysal, T.C. and K.E. Barner, 2008b. Blind decentralized estimation for bandwidth constrained wireless sensor networks. IEEE. Trans. Wirel. Commun., 7: 1466-1471.

Chiasserini, C.F., R. Gaeta, M. Garetto, M. Gribaudo and D. Manini *et al*., 2007. Fluid models for large-scale wireless sensor networks. Perform. Eval., 64: 715-736.

Gribaudo, M., C.F. Chiasserini, R. Gaeta, M. Garetto and D. Manini et al., 2005. A spatial fluid-based framework to analyze large-scale wireless sensor networks. Proceedings of the 2005 International Conference on Dependable Systems and Networks (DSN'05), June 28-July 1, 2005, IEEE, Italy, ISBN: 0-7695-2282-3, pp: 694-703.

Kariman, K.M., M.A. Pourmina and A. Salahi, 2015. Energy balance based lifetime maximization in wireless sensor networks employing joint routing and asynchronous duty cycle scheduling techniques. Wirel. Pers. Commun., 83: 1057-1083.

Karkvandi, H.R., E. Pecht and P.O. Yadid, 2011. Effective lifetime-aware routing in wireless sensor networks. IEEE. Sens. J., 11: 3359-3367.

Khawam, K., A.E. Samhat, M. Ibrahim and J.M. Kelif, 2007. Fluid model for wireless adhoc networks. Proceedings of the 2007 IEEE 18th International Symposium on Personal, Indoor and Mobile Radio Communications, September 3-7, 2007, IEEE, Saint Quentin, France, ISBN:978-1-4244-1143-6, pp: 1-5.

Kim, H. and J.C. Hou, 2004. A fast simulation framework for IEEE 802.11-operated wireless lans. ACM. SIGMETRICS Perform. Eval. Rev., 32: 143-154.

Pac, M.R., A.M. Erkmen and I. Erkmen, 2006. Towards fluent sensor networks: A scalable and robust self-deployment approach. Proceedings of the First NASA/ESA Conference on Adaptive Hardware and Systems (AHS'06), June 15-18, 2006, IEEE, Turkey, ISBN:0-7695-2614-4, pp: 365-372.

Reddy, N.V. and J.L. Jeba, 2014. Lifetime maximization in wireless sensor network. Int. J. Eng. Trends Technol. IJETT., 9: 218-222.

Schillings, A. and K. Yang, 2009. VGTR: A Collaborative, Energy and Information Aware Routing Algorithm for Wireless Sensor Networks through the use of Game Theory. In: GeoSensor Networks. Trigoni, N., M. Andrew and N. Sarfaraz (Eds.). Springer Berlin, Germany, ISBN:978-3-642-02902-8, pp: 51-62.

Su, Y., J. Li, Z. Qin, L. Wang and W. Zhang, 2013. Maximizing the Network Lifetime by Using PACO Routing Algorithm in Wireless Sensor Networks. In: Advances in Wireless Sensor Networks. Limin, S., M. Huadong and F. Hong (Eds.). Springer Berlin, Germany, ISBN:978-3-642-54521-4, pp: 155-165.

Wei, Z., Y. Xiaoyong, S. Fei, T. Xianghong and C. Binghua, 2015. Collaborative routing protocol based on hydrodynamics for wireless sensor networks. Int. J. Distrib. Sens. Netw., Vol. 2015, 10.1155/2015/276276