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Research Article

Bi-directional Flooding Protocol for Underwater Wireless Sensor Networks

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Abstract: Underwater Wireless Sensor Networks (UWSNs) are getting more importance in the oceanic exploration. The planet earth is basically a planet of water with less than 30% land mass available for humans to live on. However, the areas covered with water are important to mankind for the various resources which have been proven to be valuable. Such resources are gas, oil, marine products which can be used as food and other minerals. In view of the vast area in which these resources can be found, a network of sensors is necessary so that they can be explored. However, sensor networks may not be helpful in the exploration of these resources if they do not have a sufficiently good routing mechanism. Node mobility, 3-D spaces and horizontal communication links are some critical challenges to the researcher in designing new routing protocols for UWSNs. In this study, we have proposed a novel routing protocol called Layer by Layer Angle-Based Flooding (L2-ABF) to address the issues of continuous node movements, end-to-end delays and energy consumption. In L2-ABF, every node can calculate its flooding zone to forward data packets toward the sinks without using any explicit configuration or location information. The simulation results show that L2-ABF has some advantages over some existing flooding-based techniques and also can easily manage quick routing changes where node movements are frequent.

Keywords: 3-D spaces, flooding zone, horizontal communication, L2-ABF, routing algorithms, sensor networks, UWSN

INTRODUCTION

Throughout the history of mankind, humans have been influenced either indirectly or directly by the oceans. Applications that make use of wireless underwater sensor networks are gaining popularity in the exploration of areas involving oceans that possess resources, such as gas, oil, products used as food and other minerals. Underwater Wireless Sensor Networks (UWSNs) are also utilized for the prevention of catastrophic accidents in the ocean, such as pollution on a disastrous level and tsunami warnings. Although UWSNs are similar to wireless sensor networks on land, the UWSNs possess some characteristics that are quite different from the common wired and other land used sensor networks (Wahid *et al*., 2011). The first difference is the energy consumption in both types of networks. In the UWSN, not only there shall be no possibility to recharge the battery, it is also not trivially replaceable. Moreover, in underwater transmissions, underwater applications consume more energy than applications that are wire-based (Zhou *et al*., 2011). The next difference is that UWSN is normally utilized to rectify some typical issues instead of being used by individual users. The importance is placed on maximizing throughput instead of providing fairness among the nodes. The third difference is that for an underwater wireless sensor network, the primary concern is regarding the distance between the links and number of hops and also the reliability of the network. In concerns to energy, it is preferred to have short term communication rather than long term communication and it has been proven to be more energy efficient when used in underwater networks applications (Basagni *et al*., 2010). Finally, in many situations, UWSNs must be implemented using the existing standards for the economic factors related to operating cost. Another issue with underwater networks is that most of the sensor nodes tend to passively move with the water currents (Ayaz *et al*., 2012). These limitations make the terrestrial ad hoc network's protocols not suitable for UWSN. The limitations mentioned above demand some newly designed protocols for UWSN. Many researchers have been designing new routing protocols for UWSN to support the key characteristics of underwater communications (Basagni *et al*., 2010; Yan *et al*., 2008).

In flooding-based routing techniques, such as Xie *et al*. (2006) and Daeyoup and Dongkyun (2008), each node broadcasts a data packet towards its neighbours or throughout the whole network. Therefore, in the event

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of a node failure or data packet losses, other nodes can rebroadcast the same data packets many times. Due to this frequent broadcasting, the result is end to end delay and more energy consumption.

In this study, we therefore, proposed our routing protocol (named L2-ABF) in detail. The angle-based flooding architecture is used in L2-ABF. In this protocol, we have assumed that each node can compute its angle-based flooding zone to prevent the flooding of the whole network. Although some angle based flooding techniques already exist, this technique may have some advantages like:

- L2-ABF does not require any location information of the sensor nodes.
- It does not depend on a special network setup and hardware.
- In L2-ABF, nodes use a very simple calculation method to forward data packets.
- It is not based on any limitation of deployment of the network.

The L2-ABF protocol is delay and energy efficient. It uses an angle-based flooding architecture in which multi-sinks are anchored on the water's surface to collect data packets. The ordinary nodes are deployed on different depth levels from the surface to the bottom in the form of layers. If any node collects the information and tries to send it toward the upper layer nodes using the angle-based zone and data packet received on one of the sinks on water's surface, it is considered to be delivered successfully.

LITERATURE REVIEW

Many routing protocols for UWSNs have been proposed over last 10 years. In this section, we present some related protocols, such as VBF, DFR and DBR. The Vector-Based Forwarding (VBF) protocol has been suggested in order to solve the problem of high error probability in dense networks. VBF uses a vector-based forwarding mechanism to forward data packets from the source to the destination. A vector is computed from the source towards the destination and the nodes inside the computed radius of the vector can only participate in communication. The limitation of VBF lies in the assumption of the localization of the sensor nodes. The selection of the forwarding nodes are based on the predefined radius of the vector. Due to this selection, the communication of the nodes can be affected in the sparse network.

In Daeyoup and Dongkyun (2008), the authors proposed the Directional Flooding-based Routing (DFR) protocol. In DFR, a packet's transmission is achieved in a type of scooped flooding in order to provide the high reliability. However, the set of nodes which participate in flooding the packet (the nodes create a so-called flooding zone) is limited to prevent the packet from being flooding into the whole network. The flooding zone is decided by the angle between the sender and the destination. The DFR uses two assumptions to complete its transmission round. First, every node in the network knows its location information and second, each node can calculate the link quality, which is not possible without the geographical location information of the sensors nodes.

Since most routing protocols utilize the concept of geographical routing, they have a key limitation in that a localization technique is assumed, which itself is a crucial issue to be solved. In addition, some non-localization-based protocols such as DBR (Yan *et al*., 2008) and H2-DAB (Ayaz *et al*., 2012) were proposed for UWSNs. DBR does not rely on localization but it suffers from the redundant transmission of packets, void regions and the absence of energy balancing. The vertical movements are very little and normally ignored (Nicolaou *et al*., 2007) in UWSNs and the sensor nodes have the same depth. In DBR, since packets are forwarded based on the depth of the sensor nodes, the nodes having smaller depths participate in forwarding the packets most of the time. Consequently, the nodes having smaller depths die earlier than the other nodes. Furthermore, the depth sensors increase the overall cost of the network and they also consume energy. In H2-DAB, the communication is performed based on the unique IDs (called HopIDs) assigned to each sensor node. The consideration of HopID only is not suitable for UWSNs which are resource constrained networks. Similar to DBR, H2-DAB allows the nodes having smaller a HopID to be frequently used for data forwarding. Hence, the nodes having small HopIDs die earlier than the other nodes. In addition, H2-DAB uses RTS/CTS for data forwarding, which is expensive in terms of energy and delay (Ayaz *et al*., 2011). In the above mentioned protocols, none of them has taken into account the residual energy and the physical distance towards the sink node. In particular, DBR uses the depth of the sensor nodes as the metric for forwarding. Hence, it is likely that the packet can be stuck after reaching the surface, due to the drifting of the sensor nodes away from the sink in the horizontal direction depending on the water currents. In our proposed protocol, however, each node can compute its flooding-4based zone towards the sink node. Therefore, it is assured that there exists a path towards the sink node. Furthermore, the consideration of the residual energy balances the work-load among the sensor nodes. Consequently, our proposed protocol can achieve performance improvements in terms of end-to-end delay, data delivery ratios and energy consumption.

The main difference in our proposed protocol and other flooding-based protocols is that L2-ABF does not depend on any type of location information or geographical location.

METHODOLOGY

The proposed Layer by Layer Angle-Based Flooding (L2-ABF) protocol is aimed to reduce the horizontal communication between the peer sensors on the same depth levels in the underwater sensor network. Angle-based flooding architecture was used in L2-ABF to achieve this goal. L2-ABF completes its task in two steps. In the first step, nodes will calculate the flooding zone area by using the angle based technique. In the second step, the nodes forward sensed data towards the upper layer nodes in the define zone.

Control packets: L2-ABF uses two types of control Packets to complete its communication; one is Hello Packet used by the sender nodes to find next forwarder in the upper layers of nodes. The Hello Packet generated by the ordinary node contains the following field as shown in Fig. 1. The Packet Types will be used to identify the type of Packet received; it is either data packets or control packets. The S-Node-ID is used to identify the sender node and the Layer-ID is the information of the current layer of the sender node. On the basis of this information, the receiving node will decide either the data packets will be forwarded or simply discarded. The Energy-Status is used to identify the healthiness of the sender nodes. Second, Fig. 2 shows the Hello Reply format; the R-Node-ID is the information of the replying node to the Hello Packets. The purpose of S-Node-ID and the Layer-ID is the same as in the Hello Packet. The priority field contains the information which is used by the sender node of the data packets to give the priority of the replying node to become the next forwarder of the data packets.

Data packet format: L2-ABF uses the Layer-ID to rout the data packets and the Node-ID is the identifier of the nodes, separately. The Node-ID is a unique address for every node in the network. The data packet format used in L2-ABF is illustrated in Fig. 3. The

Hello packet types	S-node-ID	Layer-ID	Energy-status

Fig. 1: Ordinary node hello packet format

R-node-ID	S-node-ID	Layer-ID	Priority

Fig. 2: Ordinary node hello reply format

Sender-ID	Layer-ID	Packet Sequence No.	Data

Packet header

Fig. 3: Data packet format

packet header consists of three fields: Sender-ID, Layer-ID and Packet Sequence Number. The "Sender-ID" is the identifier of the source node. The "Packet Sequence Number" is a unique sequence number assigned by the source node to the packet. Together with the Sender-ID, the Packet Sequence Number is used to differentiate packets in later data forwarding. The "Layer-ID" is the information of the recent forwarder which is updated Layer-by-Layer when the packet is forwarded.

Data packet forwarding: The angle-based flooding approach is used in our proposed routing protocol. This routing mechanism is not based on sensor node location information and has been designed for delay and power-efficient multi-layer communication in underwater acoustic networks. In this routing mechanism, there is no need for a sender node to know its own location or the location of the final destination (Sink) before transmitting the data packets. Anchor nodes flood the sensed data towards the surface sinks via the upper layer nodes. The forwarder node will define the flooding zone by using the angle formula $\Theta = 90 \pm 10K$ as shown in Fig. 4. Here, K is a variable

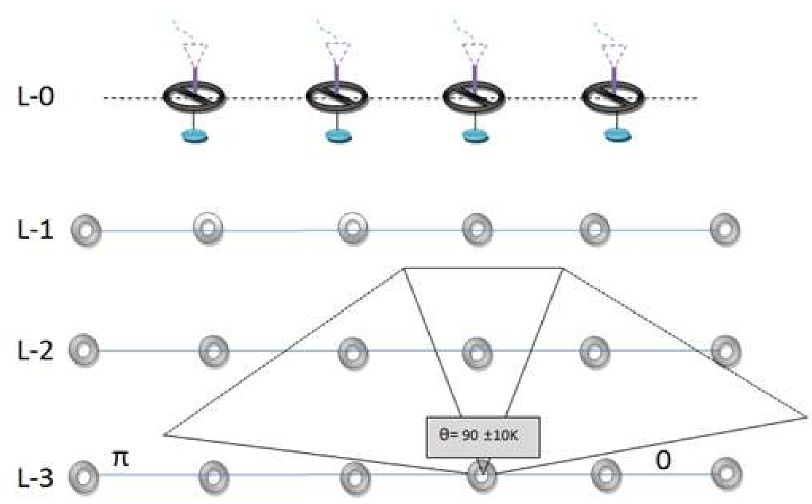


Fig. 4: Data packet forwarding mechanism

Table 1: Mathematical symbol to calculate the power consumption

N	Total number of nodes in the network
A	Defined monitoring area in the network
Ӗ	Initial power level for each sensor node in the network
P	Complete power consumption to forward the data packet from the node to the sink on the water's surface
Pe	Power consumed by the nodes to send data packet from one layer to the next upper layer
Pc	Power consumed by control packets including hello packet and hello reply
Pi→s	Total power consumed when i data packets are forwarded towards the sink
m	Number of layers in the network (divide the depth into layers)
n	Number of sensor nodes in each layer
D	Total number of data packets generated in the network
K = D/N	K is the total number of data packets generated by one node
Pi	The power consumption at the i^{th} layer
Ti	The lifetime of the layers
Ti/n	The lifetime of each sensor node belonging to the i^{th} layers

The power consumption is analyzed only for the static nodes (best case)

and has a finite set of values, K, (1, 2…..8). After defining the flooding zone, the node will send Hello Packets (HP) within the defined zone and wait for the Hello Reply (HR). The Hello Packet and Hello Reply formats are illustrated in Fig. 2 and 3. If there is no HR received, the node will increase the value of K in the initial angle, to increase its flooding zone until the basic condition is met ($0<\Theta<\pi$). Here, we are assuming that after the completion of one round by using different values of variable k and the sender node could not receive Hello Reply, the nodes can send data packets directly to the sink nodes on the maximum power. Here, it is important to note that nodes can use random values of the variable K to increase the size of the flooding zone. The randomness of the K value is more helpful to control the end-to-end delays as well as the power consumption of the nodes. The selection of the random values for K depends on the movement of the nodes.

If a node receives a very small number of Hello Replies, the nodes will be considered to have a slow movement. So, the nodes will use a large value of the variable k to increase the flooding zone.

If a node receives more Hello Replies, the nodes will be considered to have a fast movement. So, the nodes will use a small value of the variable k to increase the flooding zone.

ANALTICAL MODEL FOR POWER CONSUMPTIONS

We assumed N as the total number of sensor nodes to explore area A where these nodes were deployed in the form of layers from the surface to the bottom. We assumed every node had an initial power level Ӗ unit. We considered the power consumptions for the data packets as included control packets, like the Hello Packet (HP) and Hello Reply (HR). In the scenario, nodes only sent the Hello Reply that was inside the flooding zone. Both control packets were of the same size and consumed very little power as compared to the data packets. We used some mathematical symbol to calculate the power consumption in our model as shown in Table 1.

Power consumption with static nodes (best case): In the best case, all of the nodes are static and every node in the network will send only one HP within the calculated flooding zone and also get a single HR. After receiving the HR, the node will save the ID of the replying node in its routing table to send the remaining data packets all of the time. In the first attempt, the power consumed by the node to send one data packet from the lower layer to the next upper layer is:

$$P = 2pc + pe \tag{1}$$

Here, pc + pe are the power consumed by the current layer which has data packets. The pc is the power consumed when the node sends the HP and the pe is consumed to forward the data packets. The reaming pc is power consumed by the upper layer to respond the HP. First, we considered the case of the node at the first layer which has a data packet and can forward it directly to the sink on the water's surface and then the second layer node forwards data packets toward the sink through the first layer and so on. The power consumption at each layer can be calculated by the following equations:

$$\begin{aligned}
&P1\rightarrow s = (pc + pe)\\
&P2\rightarrow s = (2pc + 2pe) + (pc + pe)\\
&P3\rightarrow s = (2pc + 3pe) + (2pc + 2pe) + (pc + pe)\\
&.\\
&.\\
&.\\
&Pm\text{-}1\rightarrow s = (2pc + (m - 1)\ pe) + (2pc + (m - 2)\ pe)\\
&+ \ldots\ldots\ldots.+ (2pc + 2pe) + (pc + pe)\\
&Pm\rightarrow s = (2pc + m.pe) + (2pc + (m - 1)\ pe)\\
&+\ldots\ldots\ldots+ (2pc + 2pe) + (pc + pe)
\end{aligned} \tag{2}$$

Equation (2) shows that the upper layers consume more power due to their frequent use. When one node at every layer generates one data packet and forwards it to the sink, for "m" layers there will be "m" data packets. It is clear that the first layer will process all "m" data packets toward the sink and consume the power of (2pc + m.pe) more than the other layers. The m[th] layer consumes the least power as it will forward only one data packet to the next upper layer, i.e., the power is (pc + pe). When a node generates k data packets on each layer, the power equation is now given by:

$$Pk.m \rightarrow s = (2pc + K.m.pe) + (2pc + K.\ (m - 1)\ pe) + \ldots + (2pc + K.2pe) + (pc + K.pe) \quad (3)$$

From Eq. (3), the power consumption at the i^{th} layer can be calculated when the layer processes its own generated data packets as well as forwards the data packets from all lower layers toward the sink on the water's surface. That is, the power at the i^{th} layer is given as:

$$Pi = (m - i)\ K.pe + K.pe + 2pc \text{ where } i<m$$

Or, it can be written as:

$$Pi = (m - i)\ \beta + \beta + 2pc = (m - i - 1)\ \beta + 2pc$$

where, β is to denote the K.pe.
Now the lifetime of the i^{th} layer can be calculated by:

$$T_i = \frac{n.\text{Є}}{(m - i - 1)\ \beta + 2p_c} \quad (4)$$

From Eq. (4), the lifetime of the nodes at the i layer can be calculated as:

$$T_{i/n} = \frac{\text{Є}}{(m - i - 1)\ \beta + 2p_c} \quad (5)$$

RESULTS AND DISCUSSION

NS-2 was used for the performance evaluation of L2-ABF. Three hundred sensor nodes, both floating and sink nodes, that were deployed in a 3D area of 1000 ×1000×1000 m were taken for use in our simulation. Multiple static sinks at the surface of the water were used with not only Radio but also Acoustic types of communication which was a luxury. Five hundred meter was the maximum possible distance between the layers of the floating nodes (Chen *et al*., 2009). In this experiment, the sink nodes were considered to be static after the deployment but the remaining nodes were floating in nature and the vertical movement of the floating nodes was ignored. The horizontal movement between the floating nodes with various water currents up to 1-4 m/sec at fixed motions was the only movement considered. Table 2 presents the parameters for the simulation.

Table 2: Simulation setup for L2-ABF

Simulation parameter setup	Values
Number of nodes with 8 sinks	300
Deployment area in 3-D	1000×1000×1000 m
Distance between layer of nodes	500 m
Consider fixed motions of nodes horizontally	2 and 4 m/sec
Data packet size	1500 byte
Transmission range	500 m
Protocol	AODV
Antenna type	Directional
Channel types	Wireless

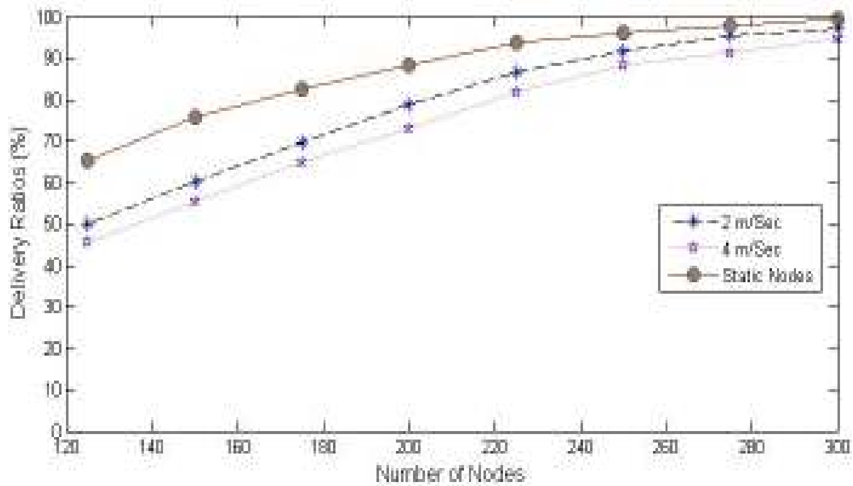
Performance metrics: The data delivery ratio, end-to-end delay and energy consumption were the three matrices considered for the evaluation of the performance of our routing protocol. The ratio of the packets that have been received successfully by all of the sinks on the surface of the water as generated by all of the sensor nodes in the network is known as the Packet Delivery Ratio. The average delay for all of data packets received successfully at the sinks on the surface of the water is known as the End-to-End Delay. The measurement of the energy required for each of the data packets to successfully reach its destination on the surface of the water is known as the energy consumption.

Mobility of nodes: Two different speeds of node movements (2 and 4 m/sec) and also static nodes were considered for the data delivery ratio that is presented in Fig. 5a. Using the suggested number of nodes in the network, the data delivery ratios were at 100% and remained static. Furthermore, these delivery ratios did not even experience any major effect when the density of the nodes was decreased.

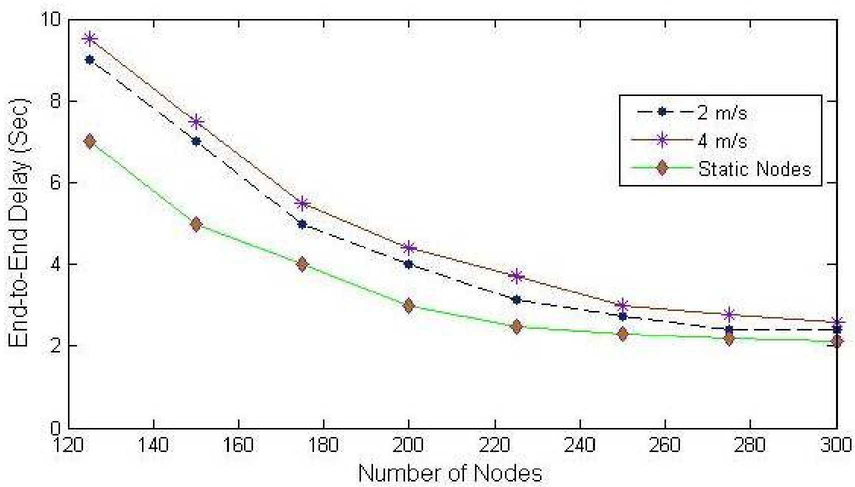
If 30% of the nodes were unavailable in the network, around 90% data delivery ratios could be achieved and even if 50% of the nodes were unavailable, that amount of sparseness of the nodes could still see an achievement of 85% data packets on average node movements. Now, as shown in Fig. 5b and c, the end-to-end delays and energy consumptions were analyzed in regards to various node movements. In this case, a slight variation in the node movement results could be seen as compared to the nodes that were static. There was a minor difference initially that began to rise when the number of nodes began to be reduced. However, even this difference was not very high until 50% of the nodes had become a part of the network.

Throughout the scenario, only a minor difference was noted between the different node speeds. This clearly indicated that there was no serious effect on the end-to-end delays or the energy consumptions caused by the mobility of the nodes. This was the only reason that a complex routing table for information regarding the location of the sensor nodes did not need to be maintained, even if the position of a node was altered.

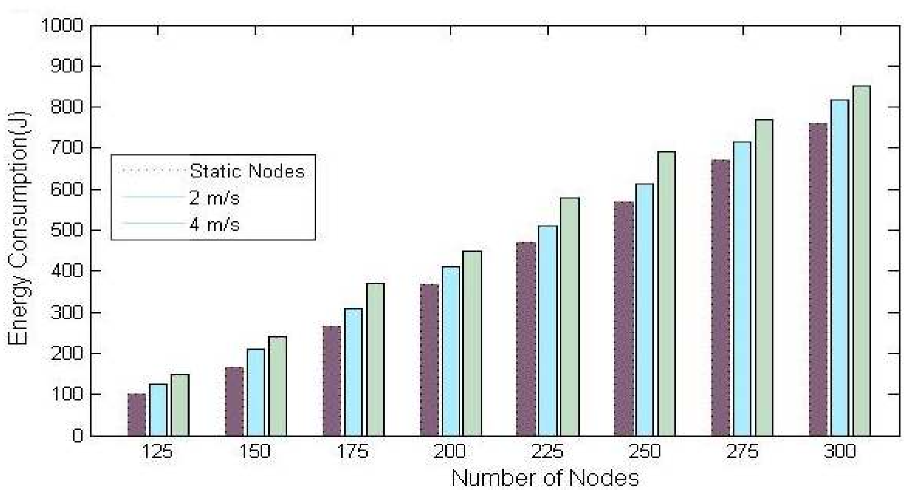
Performance with different loads: The end-to-end delays and the delivery ratios were analyzed by



(a) Delivery ratios

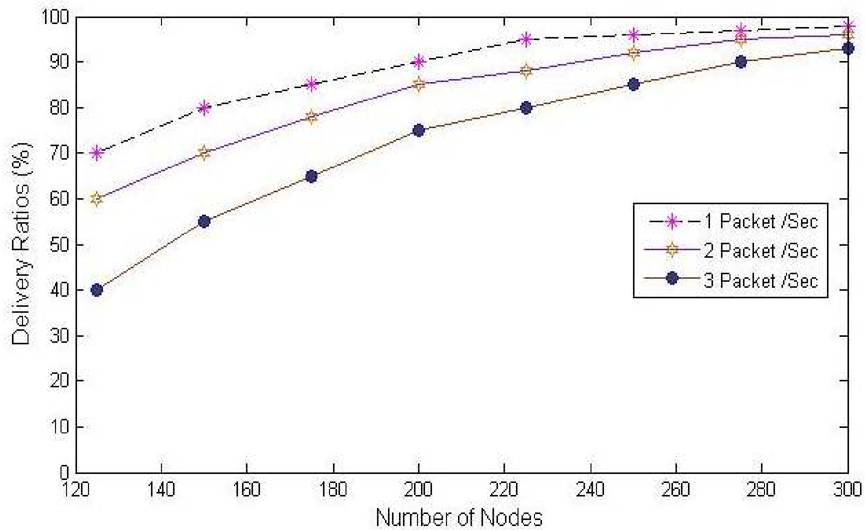


(b) End-to-end delays

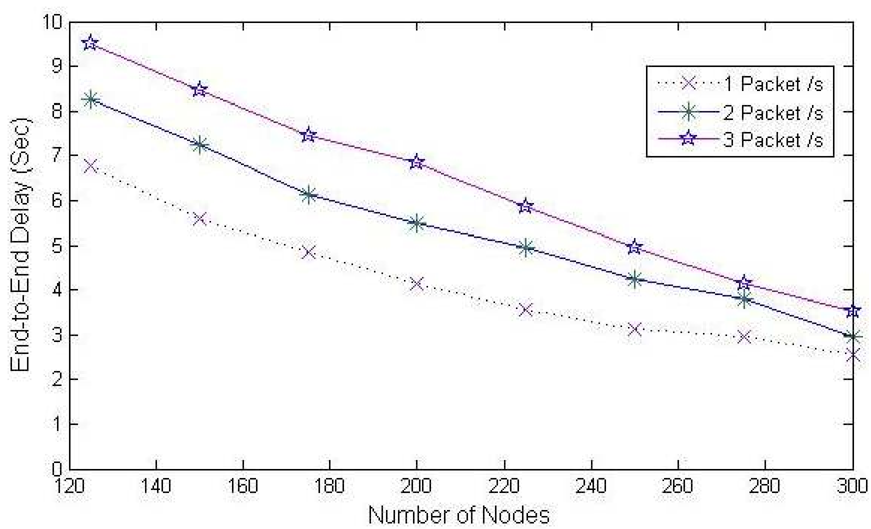


(c) Energy consumptions

Fig. 5: Simulations results



(a) Delivery ratios



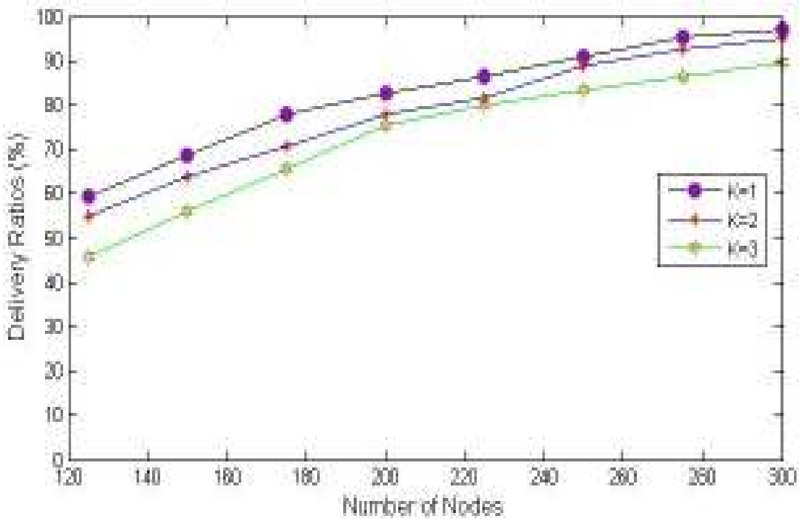
(b) End-to-end delays

Fig. 6: Performance of L2-ABF with a different number of packets generated

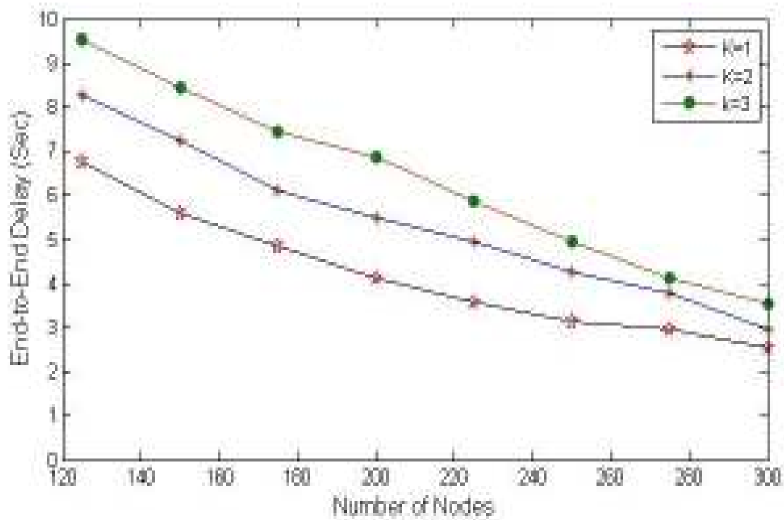
producing more data packets in the network so that the performance of L2-ABF with different loads being offered, could be checked. A network normally generates 1 packet/sec; however, we considered cases that were not normal. First, 3 packets/sec were generated by the network; after that, the network generated 2 packets/sec.

The delivery ratio with various loads being offered is presented in Fig. 6a. It shows that the delivery ratios with dense nodes were almost the same. It was only when the number of nodes started to become sparse that a difference began to appear. When the load offered was high and the network had fewer nodes, there were times that a next hop could not be found by a node so the number of packets began to increase in the buffer. The result was that they began to be discarded. The end-to-end delay variation when the number of packets in the network was increased is shown in Fig. 6b. The figure indicates that it was easy for the network to handle a situation where even 50% more packets became a part of the network. Furthermore, when double packets had been generated in the network, even these delays were affordable.

Analysis with different K values: Figure 7a and b shows the data delivery ratios and the end-to-end delays respectively with different values of the variable K which were utilized by the nodes so that data packets could be forwarded toward the sink nodes. These were used for the analysis. Slight variations can be seen in



(a) Delivery ratios



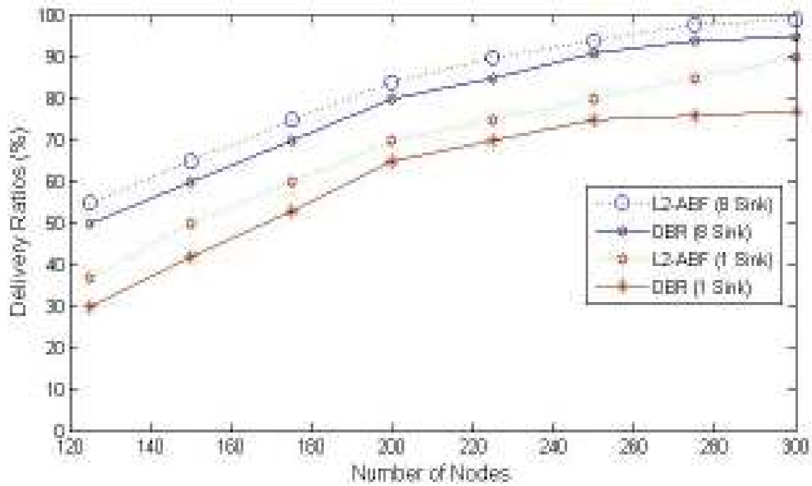
(b) End-to-end delays

Fig. 7: Performance with different values of K

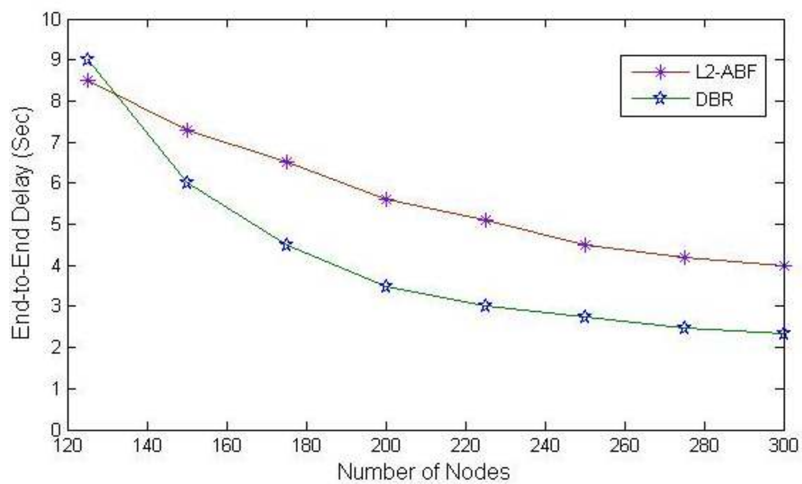
the results with the various values of the variable K. There is very little effect on either the delays or the delivery ratios when a node uses a small value of the variable K to forward the data packets; this is shown in the results. Initially, this is only a minor difference; however, it then begins to rise as the number of nodes begins to be reduced and the node makes use of a large value of the variable K. However, it is obvious that this difference is not very high until around 50% of the nodes become a part of the network.

COMPARISON WITH DBR

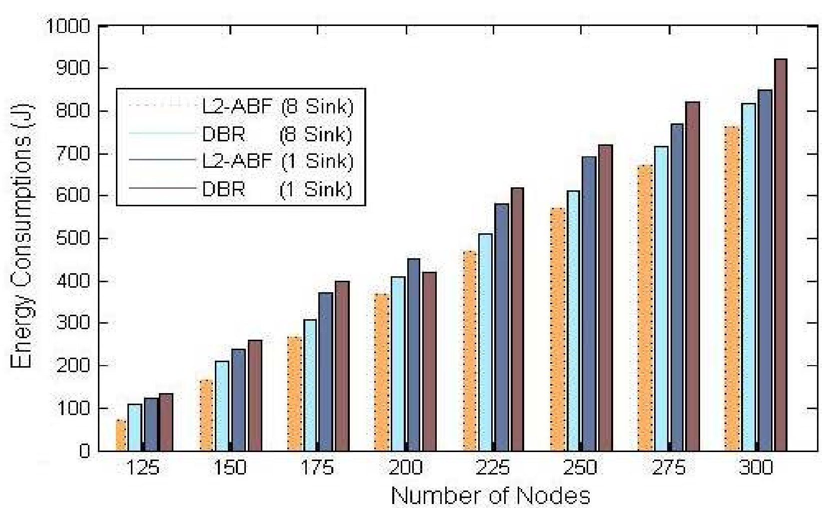
Most of the many routing methods that have been proposed are dependent on information related to the location of the sensor nodes in a network. Getting this location information is quite difficult when there is no GPS system available as in an underwater environment where there is no GPS (Caruso *et al*., 2008). In DBR (Yan *et al*., 2008), location information is not needed as it is instead dependent on the information regarding the depth of the sensor nodes so that it can forward the data packets on to the sinks on the surface of the water. Every node in DBR makes its decision based on its current depth in order to forward its data packets. The first thing that a node does when it has a data packet ready to be sent, is compare the embedded depth in the data packets that have been received with its own current depth. The data packets are forwarded by the node if its current depth is less than the sender's depth



(a) Delivery ratios



(b) End-to-end delays



(c) Energy consumptions

Fig. 8: Performance comparisons with DBR

otherwise the data packets are discarded. Likewise, the current depth is calculated by each node. Then, only the nodes that have a smaller depth level than the depth in the received data packets can forward their data packets. All of the remaining nodes simply discard their packets. As compared to L2-ABF, DBR has some serious problems; two of these problems are as follow: The first issue is that multiple nodes could possibly have smaller depth levels and the data packets could be forwarded simultaneously. This would cause collisions in the network and result in the overhead of power being increased. The second issue is that the problem of a void region in the network cannot be handled by DBR. This is because there could be a situation where no nodes qualify to become a forwarder. Such a case would be where the node has a higher depth level as compared to the sender's depth level. Because of the greedy fashion of the current node, it would make attempts over and over again although there may be other routes available through higher depths (Wang and Wu, 2012).

Later, L2-ABF was compared with DBR so that their performance could be evaluated. The data delivery ratios with a single sink and multiple sinks were compared first. The results are shown in Fig. 8a. Under the condition of multiple sinks, both algorithms were found to provide nearly identical results with the density of the nodes. A difference between the two was noted when the number of nodes was altered. The delivery ratios of DBR started to decrease as the number of nodes started to decrease. However, less effect was noted on the delivery ratios of L2-ABF. This was caused by the greedy mode of DBR where nodes were available in higher depth levels of the network but they were unable to become involved in the data packet forwarding.

A surface sink was placed at the centre of the network for the data delivery ratios with a single sink to provide the comparison of both L2-ABF and DBR. The delivery ratios of L2-ABF were less affected than the DBR delivery ratios as can be seen in the results. This was once again caused by DBR's greedy mode. In this case, data packets could only be forwarded by the nodes to the surface of the water without any consideration being taken as to the position of the sink node (Ali and Jung, 2012).

The comparisons for the end-to-end delays between DBR and L2-ABF are presented in Fig. 8b. In this instance, the holding time was used in DBR and was responsible for L2-ABF delivering data packets with less end-to-end delays than DBR when the network possessed reasonable sensor nodes. In order to control the multiple forwarding of the same packets by different nodes in DBR, each node would hold the data packet for a short time period before forwarding it. On the other hand, in L2-ABF, each node could forward data packets immediately in a short time period because it only used the angle-based zone to flood the data packets.

Later the power consumptions of DBR and L2-ABF were compared with a different number of sinks and the results are shown in Fig. 8c. First, fewer nodes were used for the comparison and the results were almost the same. However, an increase began to be seen in the difference in the power consumptions with the start of the increase in the number of nodes. Firstly, in DBR, the denseness of the network increased for the same data packets because it used the broadcasting for each of the data packets in a greedy fashion. Secondly, in DBR, each node had to calculate its depth each time it needed to decide on whether to send or discard the data packets it received. When there was a burst of data packets, the broadcasting caused more and more power to be consumed during the process of deciding on whether the data packets should be sent or discarded. The concept of the angle-based zone was used to carry out the flooding of data packets in L2-ABF. Therefore, the nodes needed only to calculate the flooding zone; then it flooded that zone with the data packets.

CONCLUSION

In this study, we have proposed the Layer by Layer Angle-Based Flooding (L2-ABF) protocol to handle some critical routing issues in UWSNs. L2-ABF is scalable and efficient for end-to-end delays and energy consumption. Basically, L2-ABF relies on the flooding-based technique to increase the reliability of the network. However, the number of nodes which flood the data packets is controlled by the calculation of the angle for the flooding zone to prevent the flooding over the whole network. The flooding zone is adjusted in layer by layer manner by using the angle-based technique among the upper layer nodes. The novelty of the proposed protocol is that it does not depend on location information and there is no need to maintain complex routing tables. It is very easy to add new nodes in the network at any time and at any location. The real beauty of L2-ABF is that delivery ratios are not much affected with the density or sparseness of the nodes. The simulation results show that it is better for the long term and real time applications. In future, we are planning to merge the idea of L2-ABF with zone optimization to investigate the relative performance.

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