Storage Capabilities in Underwater Wireless Sensor Networks for Energy Balancing and Channel Alignment

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Abstract. Underwater sensor node overflow occurs when large amount of sensory data is already stored and it is unavailable to obtain new data when an event happens. This misalignment tends to partitioning of individual node from networks in reporting information to sink. Resilience of individual node to recover from overflow considering channel and storage capabilities is needed. This work tries to avoid unnecessary transmission of the overloaded node. The contemporaneous work of storage and transmission is stated to improve energy efficiency in the desired work using DBR Bayesian network. Two slice Bayesian network is constructed for every node for calculating conditional probability distribution to resurrect links. Number of transmission is being improved considering the facilitation of nodes storage and transit duration reducing the overall energy consumption of a node by constraining unnecessary transmissions.

Keywords: Underwater Sensor Node Storage Capacity, Bayesian Network, Energy Cost.

1 Introduction

Categorizing underwater sensor networks coarsely divided into "lab level" (used for initial testing), "short term" (provides easy transition to emulation, real time test beds) and "long term" (deployed for real time test beds with access control) [2]. This work focuses on lab level works for simulation using aquasim [4] with NS2 simulator. Fixed retransmission timeout implemented in underwater sensor nodes fails due to difference in round trip times which results in failure affecting the network throughput. The process of predicting the retransmission time via "Bayesian algorithm" increases the throughput performance [3]. The impact of changing distance due to sensor mobility and its transmission load which imbalances the node energy is investigated. The work focuses on triangulation to impose

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proper networking in recovering the new location coordinates of sensor with its two nearest neighbours [9]. However, accurate information transfer is difficult if its storage capacity exceeds before channel acquisition resulting in losses. In [10] link factor indicator which judges the transmission path based on threshold values assigned with connectivity is discussed. The work ensures hop link with the astute energy and its time coordinates using link grain metrics. Significance of link resurrection with minimal energy and matching shaky link the higher energy for transmission is dealt. The depth based routing (DBR) [1], comprises of the communicating sensor to choose another sensor for forwarding packet considering the closest distance to sink. In addition, other terminologies such as buffer to avoid same repeated forwarding of same packet are present. However, the protocol does not characterize the forwarding node storage capacity, the independence of the node to other nodes associated via the same communication range. In [13] works of DBR has been extended to ensure energy balance in two hop neighbours. In the proposed work "Bayesian network" which upholds the variable factors in predicting the edges are taken for probabilistic method in calculating channel offset. The proposed work discovers the full joint probability of nodes via directed edges. Thus portioning of nodes which are not associated in forwarding has not been contributing to the conditional probability.

Organization of this research paper has been denoted as follows. Section 2 deals with the related discussions on the resource and its overhead to establish networking in underwater. Section 3 denotes algorithm for constructing wireless underwater communication. Section 4 deals with results of simulation via aquasim and NS2. Section 5 concludes the work.

2 Related Works

Message dissemination algorithms discussion states that the possibilities of newer packets to be lost when compared to older ones. The dissemination probabilities with and without storage overflow has been discussed [5]. The algorithm in [5] states that nodes are perfectly synchronized and mobility alone is discussed with dissemination process. However, there may be losses which occurs when mismatch in time occur during dissemination process. Dual modules of quantum key sharing and acoustic communication for networking has been discussed with measurement basis. The protocol preserves for network security attacks with quantum states [6]. The simulation with wireless multi-hop communication using acoustic and quantum leads to entangling increased the overhead.

Predicting the energy consumption for sensor nodes [17-20] by making a non stationary signal to a stationary form is being done with Auto Regressive Integrated Moving Average [7]. The estimation is done posterior to calculations of data transfer where relationship which influence the fluctuations such as channel response, back off time are not considered and only statistical characteristics are alone inferred. In [8] discussion on the influence of misalignment with optical communication has been studied considered beam divergence in transmitter. The maximum allowable offset calculation has also been done in varying in underwater channel via simulations to validate the bandwidth and its corresponding distance of transmission.

Topological discovery process states that MAC layer takes time to acquire network wide topological coordinates which results in initial packet losses. Hence, the algorithm in [11] incorporates two timers: namely transmission timers and wait timers to ensure minimal packet losses occur. However, the results are achieved for half duplex communication. Sink based reservation using SQ- MAC has been stated in [12]. It ensures the uplink from mobile and static sensors achieves increased access probability and reduced access delay using Ant colony optimization techniques. The discussion of error prone channel has not been considered in SQMAC. In [14], Triangle Formation has been proposed to achieve reduction in measurement errors using rigid graph structure. Compensation error with distance coordinates and periodical synchronization provides appropriate. However, time slice in forwarding is pivotal for networked data transfer. Funnelling effect of one hop neighbour node of the sink with focus on failure and repair times has been discussed using "Weibull metrics" [15]. The discussion of event and its transit duration is not been focused and it considers only delay bound on event reporting. In [16], the physical feature of discriminating the successful transmission from channel error and collision with feedback based approach is discussed. However, calculating channel error probabilities of all nodes may increase the latency of sensor data.

2.1 Problem Definition

Initial storage capacity of a node varies in the process of forwarding sensory data and occurrence of an event. So as the data transit takes place retrieving the resources as time evolves provides lesser retransmission, faster access. The conventional process incurs lot of overhead to minimize the collision, underwater medium access. The process of analysing the interdependence between nodes associated for data transit is needed to bridge the gap.

3 Research Methodology

3.1 Algorithm applied Depth Based Routing-Bayesian Network

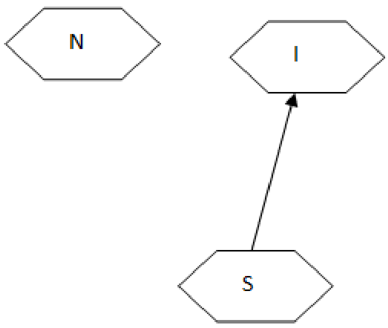

Fig. 1. Source and interlinking forwarder scenario

A scenario for source node (S) and its two forwarder the not eligible forwarder is denoted (N) and eligible forwarder denoted using (I). Since, both are in communication range this has been written as in equation 1.

$$P(N,S,I) = P(N)P(S)P(I|S) \tag{1}$$

Variability of multiple forwarders at the interlinking node I and its connectivity to sink has been shown in figure 2. The sink is denoted using K and the other channel to the interlinking node is denoted by using (C) from another sensor.

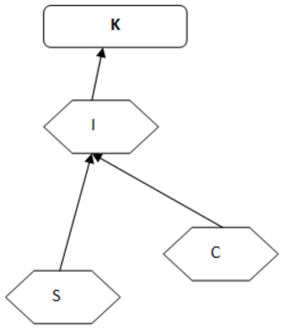

Fig. 2. Source node, interlinking forwarder and sink scenario

The equation 2 denotes the criteria of forwarding based on interlinking node receives packets either from S or C noted as below.

$$P(S, I, K, C) = P(S)P(C)P(I|S, C)P(K|I) \quad (2)$$

Inference of the unknown storage capacity of interlinking node (I) fails due to the temporal mismatch since nodes do not estimate the variable as time changes. Hence, measure time at discrete intervals and forwarding is needed. This is modelled by equation 3 as below.

$$P\left(A^{(0,T)}\right) = P\left(A^{(0)}\right) \prod_{t=0}^{T-1} P\left(A^{(t+1)} \middle| A^{(0:t)}\right) \quad (3)$$

In equation 3 the chain rule of probabilities is used where the chain rule of probabilities is represented as present step of link is the only factor which determines the next step of link. This has been written using equation 4 where in $A^{(t)}$ denotes present step.

$$P\left(A^{(0,T)}\right) = P\left(A^{(0)}\right) \prod_{t=0}^{T-1} P\left(A^{(t+1)} \middle| A^{(t)}\right) \quad (4)$$

There are two time slices associated in forwarding in figure 2 the first is communicating links between S and C to I named as “Inter time slice” and the second is “intra time slice” also known as the computational time in forwarding to sink node.

Every node checks the number of neighbours associated along with the ingress and egress channel. The storage capacity of a sensor node is fixed. The ingress of channel from source node is modelled with fully conditional joint probability distribution at the forwarding node as in equation 2 and its associated time slice as in equation 3. Then depending on the present state of node the process of transit or refrain of packets is done as in equation 4.

4 Results and Discussion

The result of constructed algorithm is simulated via software NS2 enabled with Aquasim patch [4]. Discrete event simulator time slices are preset assuming there is no nodal mobility. The aquasim consists of inbuilt depth based routing protocol.

Table 1. Parameters used for simulation in NS2.

Parameter	Values
Deployment Area	600×600 m^2
Maximum number of sensor nodes	200
Initial Energy of sensor	5 J
Initial Energy of sink	10J
Transmit power of sensor	1 W
Receive power of sensor	0.30 W
Nodes Storage capacity	150 KB to 250 KB
Total simulation duration	1500 s

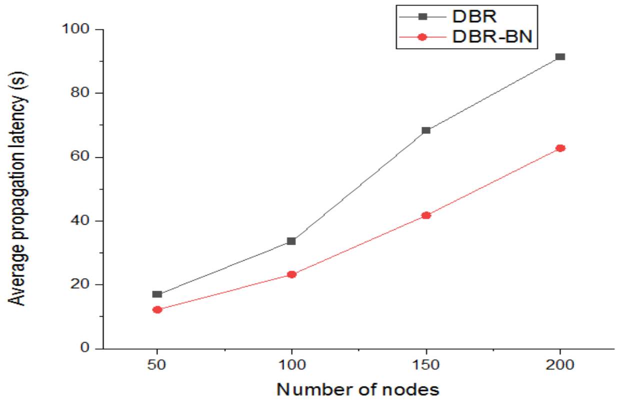

Fig. 3. Average propagation latency versus number of nodes.

In figure 3, the average propagation latency is plotted against the scalability of nodes. Since the intra computational time of storage capacity and the inter communication time of channel access is improved in DBR-BN the protocol has reduced average propagation latency.

$$\textit{Total energy cost} = \textit{Total Intial energy of sensor nodes} - \textit{Total Residual energy of sensor nodes} \quad \textbf{(5)}$$

In figure 4, the DBR-BN protocol energy cost is calculated with varying storage capacity of 150 KB, 200 KB and 250 KB. It states there is a considerable energy cost is reduced is sufficient storage capacity is available. However, certain nodes nearer to event, sink suffer from overflow so the diverse storage and its influence of energy in measured for DBR-BN.

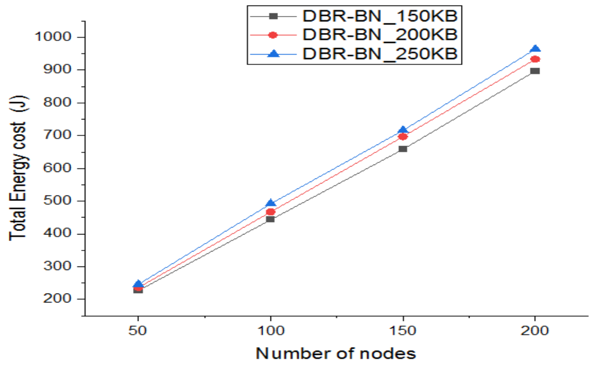

Fig. 4. Total Energy cost versus number of nodes

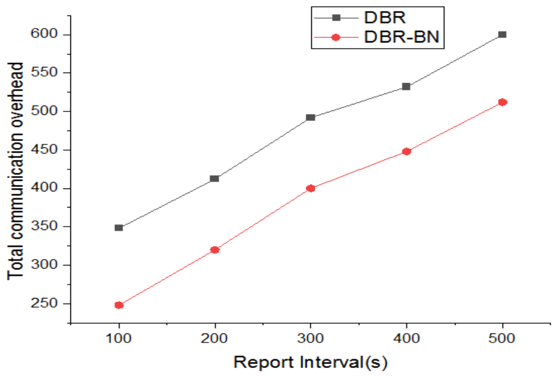

Fig. 5. Total Communication overhead versus Report Interval

In figure 5, the consolidated communication overhead by sensors and sink is calculated in for the proposed DBR-BN and existing protocol. The results states the unnecessary and untimely transfer of control packets is alleviated in DBR-BN.

5 Conclusion

Thus the evolving traffic flow of data was matched using the conditions of two time slices ensuring maximum utility of sensors across the network. DBR-BN the time dependant nature of sensor node its link and storage capacity is improved in quicker recognition time. The intra computation time for nodes storage and inter computation time for transit reduces the retransmission which preserves the total energy cost. In addition, the average channel access using full conditional probability reduces the average propagation latency without much overhead packet exchange. Future work will deal in resilience of a network to communication partitioning and response time of sink in balancing overflow.

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