Efficient Topologies for Ocean Studies

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Abstract:

Climate change and unstable earth's crust are effecting the overall environment. Oceans are one environmental component that has been shown to be heavily affected by those factors. One example would be the melting of the North Pole, which is affecting the temperature of the overall ocean such as the Atlantic Ocean. Another example would be the recent instability of the earth's crust in the ocean floor, which affects the ocean in creating high and dangerous wave lengths (e.g. Tsunami). Sensor communication network is a promising technology that can be used to study more in depth about the ocean changes and its effects on its surroundings (e.g. marine life). This technology needs to be improved in terms of several design factors such as topology, sensing-coverage, routing, etc. In this study, we focus on the underlying topology in sensor networks in two-dimensional environment. This allows us to study the ocean floor, which enables to gather more information about the earth's crust movement that causes high and dangerous ocean wave length. This makes possible early prediction of a prospective ocean disaster and hence, increasing the level of salvational missions.

Many topologies can be implemented on the ocean floor. In our study, we adopt the following topology graph model. Two nodes are connected by an undirected edge if the Euclidean distance between them is at most R, where R is the transmission radius of the nodes. The resulting graph is called a Unit Disk Graph (UDG). For a node u, we denote the set of its neighbors by N(u). The number of the neighbors of u is the degree of u.

A UDG is a common geometric graph to represent ad hoc networks. The UDG is considered poor for some routing protocols for various reasons. The 2-D UDG graph is typically a non-planar graph, which means that it has crossing edges. In addition, since the UDG is a dense graph, it can have a high average node degree, the routing protocols performed on it will take considerable time. Therefore, to resolve some of these issues, we propose a new subgraph, based on the 2-D UDG, referred to as the 2-D Derived_Circle (DC) as the main topology for a specific ocean floor.

The DC subgraph is formed by considering each node in the network and creating an undirected edge with its nearest neighbor. A circle is then drawn on the node with a radius d, where d is the distance between the node and its nearest neighbor. The circle eliminates any edge with the node that falls into the circle (when the neighbor is inside the circle). We repeat the same process for each sensor node. The circle is then moved along the line (the undirected edge) connecting the current node with its nearest neighbor, and the DC subgraph is constructed as mentioned previously. The

position of the circle along the line is expressed by *r*, where $0 \leq r \leq 1$. The reason for varying the circle's position is to see if this affects the average node degree, the weight[1], average number of crossing edges, and the path dilation in terms of hops[2] as the circle moves along the line connecting the current node and its nearest neighbor.

In our simulation model, we used randomly chosen connected unit disk graphs on an area of 100 *m* x 100 *m*. We varied the number of nodes between 65, 75, 85, 95, and 105 nodes. The experimental results have been averaged over 10 graphs for each collection of nodes. For all the graphs tested, the transmission radius *R* used was 15 *m*.

We compare the DC subgraph to the UDG graph and the HSP subgraph [1]. From the comparison, we show that even though the HSP subgraph outperforms the DC subgraph in terms of the average node degree, average number of crossing edges, and weight, the DC subgraph is still much better than the UDG graph in terms of those factors. Moreover, the DC subgraph is much better than the HSP subgraph in terms of the maximum and average path dilation (hops). The path dilation is an important factor since the routing protocols that will run on top of the DC subgraph will be judged on this factor. In other words, routing protocols implemented on the DC subgraph will perform much better than based on the HSP subgraph. This would imply that the routing protocols will find shorter paths to deliver necessary messages (e.g. alarms) to the base station (faster delivery) rather than based on the HSP subgraph. Hence, increasing the level of salvational missions and providing more update to date information about the ocean floor.

References:

[1] E. Chavez, S. Dobrev, E. Kranakis, J. Opatrny, L. Stacho, H. Tejeda, and J. Ur-rutia. Half-space proximal: A new local test for extracting a bounded dilation spanner. In Proc. Of the International Conference on Principles of Distributed Systems (OPODIS 2005) vol. 3974 of LNCS, pages 235-245, Pisa, Italy, 2006.

[11] The weight of a graph is the sum of its edge weights. Between any pair of nodes, there is a path length. In this work, the path length refers to the Euclidean length, which is the sum of all the hops' Euclidean distances in a path.

[2] The dilation for a pair of nodes is the ratio of the shortest length path between the two nodes in the subgraph over that for the original UDG. The path length is computed in terms of the number of hops along the path.