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Introduction to Wireless Sensor Network

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Abstract: ***Recently underwater sensor network has attracted great attention of many researchers. Here determining the location of sensor node is very important. The required information will not be useful if sensing nodes are not localized. There are various methods for localization in sensor networks but these are different in case of terrestrial sensor network and underwater sensor network. This paper explores some of the localization schemes in case of underwater sensor network and there comparison is made so that they can be utilized on basis of application requirement.***

Keyword: Underwater Sensor network, Localization, Architecture, range-based scheme, range-free scheme, architecture

1. Introduction

About 71 percent of the Earth's surface is water-covered, and the oceans hold about 96.5 percent of all Earth's water. These oceans are a rich source of useful assets, flora and fauna etc. Over the time this field has attracted the attention of many researchers. The ocean environment is unconventional and slightly strange and quite risky as major part of them are submerged under water and this area is usually out of range for humans. Thus humans have to find some other alternatives to reach such areas and Sensor network comes of great use here. These low cost, low power communicating devices can be deployed over a physical space, providing dense sensing close to physical view, processing and communicating devices can be deployed over a physical space, providing dense sensing close to physical view, processing and communicating this information and combine actions with other nodes. These devices have strong processing capability when combined together though not individually so wireless sensor network is made of ten to thousands of interconnected sensors that may be deployed randomly or deterministically deployed in field of interest to collect data about environment [1]. This wireless sensor network is being connected to seas which are accurately called as Underwater wireless sensor networks (UWSN).

During the past three decades there have been agrowing interest in underwater acoustic communications because of its features like easy deployment, self-management, etc. There are a lots of applications of underwater sensor network in many fields for example in marine research, oceanography, marine commercial operations, the offshore oil industry, defense, naval surveillance, earthquake and tsunami forewarning, climate and ocean observation, and water pollution tracking etc. For proper utility in these application almost all the nodes have to come together with other for purpose of sensing the required area by exchanging information with each other. For the accurate exchange of information there is strong need for knowing the position of each and every node. For this there are a lot of localization algorithm proposed.

Underwater sensor network are different then terrestrial sensor network as UWSN has many different specification like limited bandwidth capacity [2] high propagation delay [3], high error rate and temporary losses of connectivity caused by multipath and fading phenomena [4] , restricted transfer speed as acoustic signals are used instead of radio frequency signals. These points must be kept in mind while defining there communication protocol.

Challenges of underwater wireless sensor network

The major challenges while designing underwater sensor network are:

- Available bandwidth is limited
- Underwater path is extremely weak because of multi-path and fading
- High bit error rate and temporary loss of connectivity
- Battery – constraints, usually they have limited energy and cannot be charged beyond some limit
- Propagation delay in underwater is severely high and variable

Underwater sensor network architecture

There are lots of ways to classify UWSN architecture [5]. One classification discriminates between static, semi-mobile, and mobile architectures, another UWSN classification method is dividing UWSNs into two-dimensional (cover ocean floor) and three-dimensional (includes depth as a dimension), UWSN are usually single-hop, multi-hop, or hybrid (single-hop individual sensors, multi-hop clusters). Architectures might be grouped into short-term,time-critical applications, and long-term, non-time-critical applications. The general architecture is shown in fig 1. The network consist of sensor nodes, base station, autonomous underwater vehicles(AUV) and remotely operated vehicles(ROV). Base station are for controlling ROV. Sensor node firstly monitor whole deployment area to collect data and then uses acoustic signal to send data to other nodes. Now radio signals are used for sending the data to user station where it is to be processed.

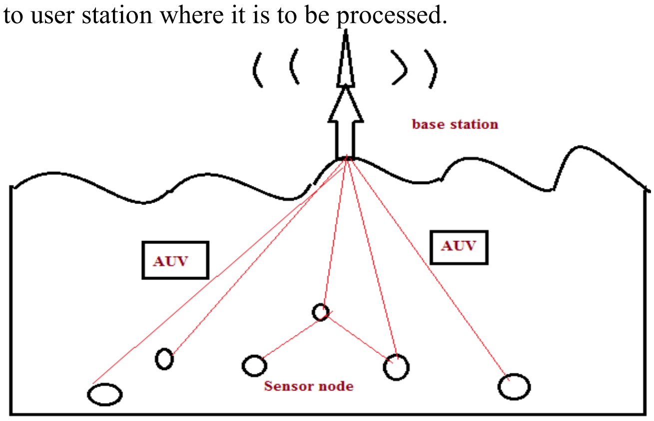

Figure 1: Rest of paper is organized as follows: in section 2, various localization schemes are discussed. In section 3,

comparison of these schemes is done and then section 4 concludes the paper.

2. Localization Schemes in Underwater Sensor Network

Many localization schemes have been proposed for UWSNs taking into account different factors like network topology, device capabilities, signal propagation models, and energy requirements. The location of sensor node is usually required in many of the localization schemes. Anchor nodes are those whose location is known. The localization schemes which use anchor nodes are categorized in two categories: range based schemes, and range free scheme. Range based schemes are those which use range or bearing information and range free scheme are those that do not use range or bearing information.

2.1. Range based Schemes

Range based localization schemes utilize range information for position estimation. Time difference of arrival(TDOI), time of arrival(TOA), received signal strength indicator(RSSI) may be used for distance estimation, angle of arrival(AOA).

An anchor free localization algorithm(AFLA) is proposed in [6]. Here no anchor nodes are deployed. It is self-localization algorithm making use of relationship of adjacent node for estimation of accurate positions. Cables are usually used here to connect sensor node to fixed anchors at sea bottom so as they do not move away from monitoring area.

For large scale 3d network, a hierarchical localization approach is proposed in [7]. In this paper whole localization process is divided into two sub processes: anchor node localization and ordinary node localization. All existing techniques can be applied for anchor node localization, but for ordinary node localization 3d Euclidean distance integrated with recursive location estimation method is used.

A collaborative localization scheme is proposed in [8]. It is anchor-free and cost effective strategy. It is a centralized localization technique where sensor node use buoyancy control to move deeper in ocean. The sensor node travel back to ocean surface once desired depth is reached. When these sensor nodes are moving their depth can be calculated by using pressure sensors, there position keeps on changing which cannot be estimated.

A node discovery and localization protocol (NDLP) is proposed in [9][10]. It is anchor-free localization method. First step in this method is node discovery phase by a node which is aware of its self-position and selects other nodes repeatedly. Large no of unknown nodes can be localized by selecting nodes continuously. This method consumes more energy as each node participates in message exchange.

Dive and Rise (DNR) approach is proposed in [11]. In this dive and rise beacons are used which learn their position using GPS when they are on top surface and dive into sea up to required depth and rise again. Sensor nodes send and receive DNR messages which are time stamped and use TOA technique for calculating distance to DNR beacons. This method has a high energy efficiency.

Underwater sensor positioning (USP) method is proposed in [12]. It is a distributed bilateration project based localization scheme. Here 3d localization problem is converted to 2d problem by utilizing depth information of nodes via projection technique as shown in fig. 1. . This method has low storage and computation requirements.

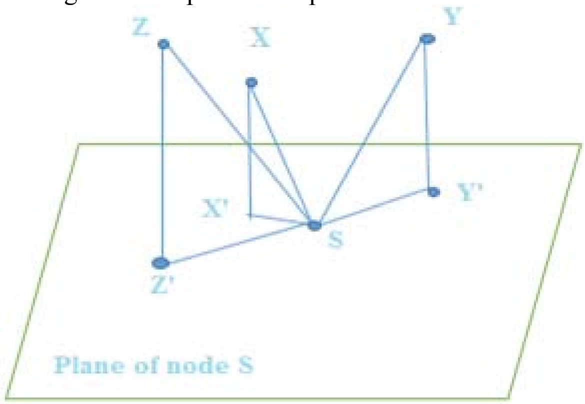

Figure 1: Projection of reference nodes X, Y and Z to the plane of node S as X', Y' and Z' [13]

2.2 Range –free Scheme

Range –free schemes do not use any range or bearing information. They do not use any of the techniques like TOA, TDOA, AOA. They are simple techniques which provide large localization estimate for underwater nodes. Centroid localization technique is proposed in [14]. Here the knowledge of adjacent node connected to anchor node position is used. The anchor node sends signals at periodic intervals. These signals contain location information. Once the receiver receives these signals it estimates it closeness with anchor nodes. This location is used for calculating centroid of anchor nodes. Very large no of anchor nodes are required for this technique to be used.

Area localization scheme is proposed in [15]. The position of unknown node is estimated within a certain area rather than exact location under this scheme. This scheme do not require any synchronization. Anchor node send signals with different power levels. The unknown nodes just have to listen these signals and save the required information like nodes ID etc. these all together are send to central node which calculates the region where these nodes are present.

Underwater localization based on directional beacons(UDB) is proposed in [16].AUV with an antenna continuously moves over a defined route and send signals on some angle as shown in fig. 2. Sensor nodes receives these signals and localize themselves. It is energy efficient technique as nodes only receive moving beacons. This is not usually applicable in large scale UWSNs.

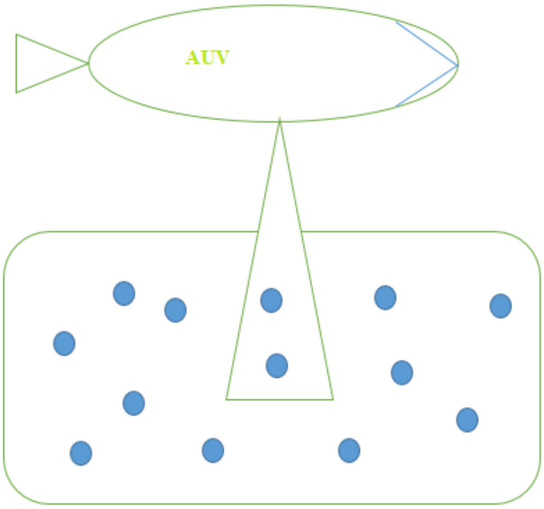

Figure 2: AUV sending Directional beacons [16]

Localization with directional beacons (LDB) is proposed in[17]. It is extended 3d network of UDB scheme. AUV send beacons at regular intervals. Nearby nodes will share first-heard beacon point and last-heard beacon point. Nodes are deployed at different depth to extend it to 3d network. It is silent positioning and energy efficient scheme.

Table 1: Comparison of localization schemes

Scheme	Range Based/ Range Free	Range measurement using	Time Synchronization required	Node Mobility considered
AFLA	Range based	TOA	yes	Yes
HLS	Range based	TDOA	yes	no
CLS	Range based	TOA	Yes	Yes
NDLP	Range based	Not specified	Not specified	No
DNR	Range based	TOA	Yes	Yes
USP	Range based	TOA	yes	No
Centroid	Range free	n/a	No	No
ALS	Range free	n/a	No	No
UDB	Range free	n/a	No	No
LDB	Range free	n/a	No	no

3. Comparison of Localization Schemes

Comparison of different schemes discussed in this paper is done in table 1. These schemes are compared on basis of time synchronization, node mobility, range measurement etc. if TOA is used then nodes synchronization is necessary. Receiving consumes less energy than transmission. In order to increase coverage iterative localization is useful. Localization scheme must be chosen according to need of application. More performance based comparison of these schemes is done in paper [18].

4. Conclusion

Localization of nodes is a very important and a challenging task. Localization is necessary for many applications. This paper presented a survey of various localization schemes used in underwater seas, oceans etc. Few localization schemes of both range based and range free are discussed. Then these schemes are compared. Range free schemes offer a less accurate estimates in comparison to range based schemes. Localization scheme must be chosen according to requirement of application like range free schemes are more useful in areas where sensor nodes may not be able to send signals for range estimation. Whereas range based schemes are generally preferred in areas where various factors like TOA , TDOA etc can be taken in account.

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