International Journal of Engineering Innovation & Research
Volume 3, Issue 5, ISSN: 2277 – 5668

A Survey and Comparison Study of AUV Based Localization in Underwater Sensor Networks

Anil C. B.
Assistant Professor, SNGCE, Kerala, India
Email: anilcb2000@yahoo.com

Dr. Sheena Mathew
Professor, CUSAT, Kerala, India
Email: sheenamathew@cusat.ac.in

Abstract – **Underwater wireless sensor networks (UWSNs) are the enabling technology for various underwater applications, and the interest in UWSNs is growing. Applications of underwater sensing range from oil industry to aquaculture, pollution control, climate recording, prediction of natural disturbances, search and survey missions. Localization is one of the major and challenging tasks in UWSNs. Because underwater environment is usually complex and hostile, and beacons are prone to move offsetting from their origin positions and underwater channel occurs error easily. In UWSN sensor node finds its position communicating with fixed anchor nodes, those know its position or taking the help of some moving objects like under water vehicles or devices which can fall from surface of the sea to bottom of the sea. This paper makes a detailed comparison study about various localization schemes for underwater Sensor networks those using the help of moving objects such as Autonomous underwater vehicles (AUVs) and Detachable elevator transceivers (DETs).**

Keywords – **AUV, DET, Under Water Localization, Underwater Sensor Networks.**

I. Introduction

Underwater sensor networks can be used in various fields such as Pollution monitoring, naval defense, harbor surveillance, undersea archaeology, ocean bottom seismic researches like earthquake or tsunami researches, ocean life observation are among some of the fields to benefit from the wide opportunities that UWSNs offer[1]. For water pollution detection systems, mobile UWSNs can follow polluted waters as they propagate from their source to clean waters and warn authorities to take action. For earthquake or tsunami forewarning systems, UWSNs with underwater sensor nodes mounted on the ocean bottom can detect earthquakes and tsunami formations before they reach inhabited regions. In naval defense UWSNs can provide instant deployment capability and increased coverage in surveillance applications of coastal regions. UWSNs can be used in monitoring sea animals and coral reefs where human operation would provide limited information. Applications of underwater sensing [2] range from oil industry to aquaculture and include instrument monitoring, climate recording, search and survey missions. Scientific applications observe the environment: from geological processes on the ocean floor, to water characteristics (temperature, salinity, oxygen levels, bacterial and other pollutant content, dissolved matter, etc.) to counting or imaging animal life (micro-organisms, fish or mammals). Industrial applications monitor and control commercial activities, such as underwater equipment related to oil or mineral extraction, underwater pipelines or commercial fisheries. Military and homeland security applications involve securing or monitoring port facilities or ships in foreign harbours, de-mining and communication with submarines and divers.

Localization is one of the major and challenging tasks in UWSNs [3]. It is important because raw sensor data without location information from where that data is received is less use and does not provide much information. It is challenging because Global Positioning System (GPS) signal does not propagate through water and positioning schemes in WSN are not applicable in UWSN due to acoustic channel properties.

Underwater communication systems today mostly use acoustic technology. Acoustic communications offer longer ranges, but are constrained by three factors: First, the power loss that occurs over a transmission distance. The second, site-specific loss due to surface–bottom reflections and refraction that occurs as sound speed changes with depth. The third, apparently random changes in the large-scale received power (averaged over some local interval of time) that is caused by slow variations in the propagation medium (e.g. tides). The major challenges in UWSN [4] are acoustic signals have propagation delays as long as a few seconds over a few kilometers, acoustic modems are typically limited to half-duplex operation and battery re-charging hundreds of meters below the sea surface is very difficult.

II. Localization

In UWSN, localization methods can be into different types based on various properties like architecture (static, mobile and hybrid localization), coverage property (2d and 3d localization), computation (distributed and centralized), on the distance measurement (range based and range free methods), the message exchange (passive and active), node cooperation (single stage and multi stage), the anchor placement (surface, under water and hybrid localization) and based on movement of anchors.

In the literature, static UWSN nodes are fixed at a certain location, but in a mobile UWSN, the motion of the nodes may be controlled or the nodes may be drifted by the movement of water. Based on the property of anchors, localization methods can be divided into two groups. In first group, UWSN localization process needs help of some moving objects those know its location and in the second group, localization doesn't need help of moving objects it takes the help of fixed anchor nodes. In this paper detailed study of first group of localization methods is done. Movement of anchor may be available by propelled underwater vehicles such as autonomous underwater vehicles (AUVs), or there may be buoyancy-driven equipment "detachable elevator transceivers'' (DETs), that can move vertically. Although the principles of AUV-aided and DETs schemes are similar, the AUV-aided scheme is more flexible as it can traverse both horizontal and vertical preprogrammed routes while the mobile references in DETs schemes can only traverse vertically.

In UWSNs, determining the location information of each sensor node is a critical issue, because many services are based on the localization results. These unique characteristics pose severe challenges towards designing localization schemes that fulfil the following desirable qualities:

• *Accurate:* The location of the sensor for which sensed data is derived should be accurate and unambiguous for meaningful interpretation of data.

• *Fast:* Since nodes may drift due to water currents, the localization procedure should be fast so that it reports the actual location when data is sensed.

• *Wide Coverage:* The localization scheme should ensure that all nodes in the network can be localized even if the size of the network is small or large in area of coverage and number of nodes. In some localization methods accuracy and speed of localization goes low, when the size of the UWSN is larger.

• *Low Communication Costs:* Since the nodes are battery-powered and may be deployed for long durations, it should not waste energy for unnecessary transmissions during the localization procedure.

III. Localization Techniques

Localization techniques can be divided into two groups based on methods using static references (anchors) and methods using mobile references. Although some of the static reference localization schemes no longer rely on the deployment of sea bed reference nodes is not done because it is difficult, the deployment of fixed reference nodes such as surface buoys is time consuming, limits the localization coverage and may be infeasible or undesirable (e.g., in tactical surveillance applications).Some of these draw- backs may be overcome by employing mobile reference(s) such as AUVs or Dive-aNd-Rise-enabled (DNR-enabled) devices. Table I shows list of localization methods.

Localizations using mobile references are divided into two sub groups in the survey non propelled anchor based localization and propelled anchor based localization.

Table I: Localization methods

Static references	
Single stage	ODAL, AFLA, ALS, UPS, E-UPS, WPS, HYP, PBL
Multi stage	USP, JSL, LABE, 3DUL, L-S, GPS-less, MASL, LSLS, LSL, SLMP
Mobile references	
Single stage	AAL, LDB, UDB, DNRL, LSL-DET, and UEPS
Multi stage	MSAAL, MSL, USP, and PL

A. Non propelled Anchor based Localization

DNR Localization (DNRL) [5] is a distributed protocol. DNRL works in large-scale networks, 3-D space, and considers mobility. This design has simple apparatuses (DNR beacon) that can dive with the help of extra weight. When they reach a certain depth, the weight is released and they rise with the help of a bladder. DNR beacon is responsible for getting its GPS coordinates when floating above the water. Then, while diving it broadcasts its coordinates, and assumes the sensor nodes are equipped with pressure sensors. Hence, they know their depth (z coordinate) and estimating the x-y coordinates is sufficient to determine their location. Sensor nodes listen to time stamped broadcast messages from DNR beacons. Distance measurement between node and DNR beacon is done by using the time of arrival of these messages. DNRL has high coverage and provides accurate result but for that it needs large number of DNR beacons. DNR beacons are more expensive than the other underwater nodes due to their motion capability. DNRL requires synchronization since it uses one-way ranging in Time of Arrival (ToA) calculations. DNR-Positioning can localize 100% nodes with small error. Moreover, no message exchange is required. Sensor nodes are able to learn their coordinates just by listening. This passive learning results in saving energy and reducing communication cost. Moreover, DNR beacons are not able to descend fast because they are not propelled. This leads to nonhomogeneous diffusion of the location information where the nodes that float deeper receive DNR messages later than the nodes closer to the surface and it also increases the localization delay.

In [6], the authors present a multi-stage enhancement to DNR − termed "Multi-stage DNR" (MSL). In this method less number of beacons are required compared previous method. During the first stage some nodes are localized. Then this localized nodes acts as a reference node. During next stages this reference nodes broadcast its location to localize the remaining unlocalized nodes. This iterative localization approach increases the coverage and decreases the delay of DNRL. However, in MSL localized underwater nodes provide their estimated locations, which already include estimation errors. Error accumulates at the nodes that use the coordinates of localized underwater nodes instead of the coordinates of the anchor nodes. Moreover, since localized underwater nodes also send localization messages, overall energy consumption and overhead of MSL is higher than DNRL. MSL uses the ToA method with one-way ranging; therefore, it requires synchronization similar to DNRL.

In [7] the authors present proxy localization (PL), which enhances the DNRL scheme through multi-stage localization. To minimize error propagation, localized ordinary nodes can qualify as new reference nodes only if they are below the maximum depth of the DNR beacons. The localization success and accuracy of PL is lower than the other techniques however it can localize underwater nodes faster when small number of beacons are employed.

A single-stage scheme is proposed Large Scale Localization-DET (LSL-DET) [8], that uses the network architecture of Large- Scale Localization (LSL) [9] but extends the reach of surface buoys by attaching DET to them. The concept is similar to DNRL, except that DETs that dive and rise do not contain GPS receivers, thus reducing the cost.

The hybrid scheme [10] consists of four types of nodes which are Surface Buoys, DETs, Anchor Nodes and Ordinary Nodes. Surface buoy will be equipped with GPS on the water surface for off-shore base station communication. The anchor nodes will compute their positions based on the position information from the DETs by applying least square method. Then anchor nodes starts broadcasting its location. Ordinary node will receive signal from anchor nodes and area localization method will be applied for ordinary node localization.

Detachable Elevator Transceiver Localization (DETL) Protocol*:* In [11], the authors use the DET units that are also employed in [12] and they utilize the same architecture of LSL-DET. DET eliminates the need for long-range communication between surface buoys and anchors and solves the anchor localization problem of LSHL. Surface buoys learn their coordinates from GPS, DET units descend and ascend, and broadcast surface buoy coordinates at several depths, similar to DNRL beacons but this time they are attached to cables. Anchor nodes are localized using the coordinates of the DETs and the distance estimates to those units. Ordinary sensor nodes are localized similar to LSHL. DETL may be a practical solution for anchor localization for deep and narrow UWSNs where DETs can descend until a certain depth and broadcast coordinates with short-range acoustic links. However, for a horizontally wide UWSN, either the number of DETs needs to be increased or DETs would use long-range communication.

B. Propelled Anchor based localization

In the AUV-Aided Localization (AAL) [13] scheme, underwater sensor nodes are stationary, and an AUV travels underwater periodically to localize the sensor nodes. The AUV periodically surfaces to receive GPS coordinates, and does dead-reckoning for tracking self-location while submerged. The AUV broadcasts wake-up messages from different places on its route, and the underwater sensor nodes hearing these messages sends a request packet to the AUV and the AUV replies back with a message containing its coordinates. This communication enables sensor nodes to measure the round-trip time by which the nodes estimate their distance to the AUV. Each node needs a pressure sensor to measure its depth and nodes are either static or have the ability to calculate its motion, it can be localized after getting message from three non-collinear AUV locations. In AAL underwater nodes are no longer silent; they send messages in the two-way ranging process. This alleviates the need for synchronization, but on the other hand, the nodes spend more energy, and the communication overhead of the protocol increases. Another drawback of AAL is its high localization delay due to the slow speed of the AUV and the AUV has to move all over the network. Moreover, the accuracy of AAL is affected by the frequency of the location updates of the AUV, which are attained as the vehicle surfaces for location calibration. Logic of AUV-Aided and DNR-enabled schemes are similar, the AUV-Aided scheme is more flexible, because mobile reference (AUV) can traverse both horizontal and vertical preprogrammed routes while the mobile references in DNR-enabled schemes can only traverse vertically.

Localization with Directional Beacons (LDB) [14] utilizes an AUV to localize a stationary UWSN, similar to AAL. The AUV dives to a certain depth above the UWSN, and travels over the area of operation. In LDB the AUV uses a directional acoustic transceiver to broadcast self-coordinates and the angle of its transceiver's beam. A sensor node uses the angle information to map the AUV coordinates to the horizontal plane on which it resides. LDB is a range-free technique, unlike DNRL, MSL, and AAL, it does not require synchronization. In LDB underwater nodes passively listen to AUV messages; hence, it is energy efficient. One of the drawbacks of LDB is that the AUV is restricted to travel above the UWSN, which may not be possible in practice. Moreover, its accuracy depends on the frequency of the AUV messages. However, it takes more time to localize all the nodes using directional beacons because the AUV needs to traverse the network at least twice.

In [15] AAL is extended to multi-stage AUV-aided localization scheme nodes are localized by the AUV in the first stage become reference nodes for localizing the remaining (non-localized) nodes in subsequent stages. Improved performance with multiple stages is traded off with higher communication costs in general. Multi-stage AUV-aided localization technique, aimed at improving the "Multi-stage DNR" scheme by replacing the DNR with an AUV. This expands the coverage of the mobile beacon in the first stage while utilizing the multi-stage concept to localize the remaining un-localized nodes. This scheme requires Time synchronization.

In 3-D Multi-stage Area Localization Scheme (3D-MALS) [16] that combines the concepts of ALS [17] and LSL-DET. It considers a hierarchical network architecture that comprises surface buoys with DET, ordinary nodes and sink nodes, and extends ALS to 3D. Its performance gain is more compared to ALS in terms of localization accuracy. However, as with ALS, it is a model-based, centralized scheme that provides coarse localization and does not consider node mobility. The network comprises four types of node, which are surface buoys, DETs, anchor nodes and ordinary sensor nodes. DET is attached to a surface buoy and act as a DNR beacon. They broadcast their coordinates at different power levels. Non-localized nodes record mobile anchor location information and their respective lowest power level value and send these to the sink node to estimate the location [18]. It is also a centralized method similar to ALS and also introduces additional overhead by sending the related localization information to the sink where they can already estimate self-location using the periodic anchor messages [18].

Table II: Comparison of Localization methods

Name	Distributed/ centralized	Anchor type	Ranging method	Communication	Synchronization required
DNRL	Distributed	Non propelled mobile anchors	ToA (One way ranging)	Silent	Yes
MSL	Distributed	Non propelled mobile anchors and reference nodes	ToA (One way ranging)	Iterative	Yes
AAL	Distributed	Propelled mobile anchor(AUV)	ToA (Two way ranging)	not silent	Non
LDB	Distributed	Propelled mobile anchor(AUV)	Range free	Silent	NO
UDB	Distributed	Anchor free	Range free	Silent	No
LSL	Distributed	Surface buoys, under water anchors and reference nodes	ToA (One way ranging)	Iterative	Yes
Multi stage AAL	Distributed	Propelled mobile anchor(AUV)	ToA (Two way ranging)	More	Yes
Hybrid	Centralized	Surface buoys, Anchor nodes	Range based & range free	Anchors active & nodes silent	Yes
3D MALS	Centralized	Surface buoys, Anchor nodes, DETs	ToA (One-way ranging)	Active	Yes
PL	Distributed	Non propelled mobile anchors and reference nodes	ToA (One way ranging)	Less active	Yes
DETL	Distributed	Non propelled DETs	ToA (One way ranging)	Silent	Yes

The "AUV-Using Directional Beacons" scheme (UDB) [19] proposes more accurate and efficient ways for localization based on simple calculations using *directional* instead of omnidirectional beaconing and it reduces energy consumption by integrating "Silent Localization" [20] for the localization process. However, it takes more time to localize all the nodes using directional beacons because the AUV needs to traverse the network at least twice, and the impact of node mobility on its accuracy could be significant. Localization with directional beacon [21] is an anchor-free localization method which utilizes an AUV as mobile beacon like the AAL method. In LDB, the AUV uses a directional acoustic transceiver. It is a range-free scheme and an extended version of UDB while it assumed node deployment in 2D and LDB works for three-dimensional underwater sensor networks. Sensor nodes listen to the broadcasting messages from the AUV silently and estimate their locations based on the location of the AUV at the time of entry and exit from the communication range of the sensors. LDB is not accurate enough because its accuracy suffers from both vertical and horizontal errors. Moreover, its accuracy depends on the frequency of AUV messages, although it is an energy-efficient localization method.

UEPS Algorithm [22] the unmanned underwater vehicle (UUV) is moving on a straight-line path setting the beacon points at different time intervals. The geometric cone formed by the directional antennae of the beacons. The UUV sends a directional beacon towards the sensor field; those nodes who have heard the beacon actually fall in the conical beacon beam. This method has a great significance in the field of Navy MCM operations which require a denser deployment of the UWSN including small number of UUVs.

Localization and mapping are the fundamental ability for underwater robots to carry out exploration and searching tasks autonomously. This paper presents a novel approach to localization and mapping of a school of wirelessly connected underwater robotic fish (URF). It is based on both Cooperative Localization Particle Filter (CLPF) [23] scheme and Occupancy Grid Mapping Algorithm (OGMA). Using the probabilistic framework, the CLPF has the major advantage that no prior knowledge about the kinematic model of URF is required to achieve accurate 3D localization. It works well when the number of mobile beacons is less than four.

In Table II, we present the message exchange properties of the localization schemes. Some methods only allow anchors to send localization messages and the underwater nodes do not send messages. These techniques are called as 'silent' while in some techniques underwater nodes also send messages for localization. These methods are called as 'active' methods. Active localization have higher communication overhead than the silent localization. Silent protocols generally require more number of anchor nodes or anchors with long-range communication capabilities. In the iterative localization process localization is done repeatedly, during each iteration some more nodes are localized. Iterative localization approach increases the coverage. Some algorithms need synchronized time for finding the distance between nodes. Synchronization is needed or not is also given in the table. Ranging method used is also mentioned in the table. Properties of anchor node are also mentioned in the table and whether the localization process is distributed or centralized are also shown in the table.

From this survey we understood most of the UWSN localization needs extra device having moving capability through under water like AUV or DET. AUV-aided localization algorithm has the largest average error, as it makes use of the relationship of nodes to compute node's position. AUV-based schemes are better than DET based localization because AUV can move in vertical and horizontal directions. Range measurements using acoustics are much more accurate and range free methods have high communication overhead and energy consumption. TOA-based ranging techniques are generally the preferred mode of range-based schemes, but require synchronization. Nodes can be deployed on the surface of the sea or bottom surface of the sea, but we cannot deploy nodes in between surface and bottom so to monitor the area in between surface and bottom of a very deep sea is difficult. Good localization must be silent localization in which nodes can find its location receiving messages from anchor nodes and gives good accuracy even the node is moving. This paper surveys the different localization algorithms that can be applied to the domain of UWSNs, which uses moving objects through the UWSN to localize the nodes. The different schemes are compared, and their advantages and disadvantages discussed.

IV. Conclusion

In UWSNs, localization is a fundamental task where the location of a sensor is found out and it can be used for data collection, node tracking and target detection. Traditional oceanographic localization techniques and WSN localization protocols do not meet the requirements of UWSNs. Recently, a large number of localization techniques have been proposed for UWSNs. Each algorithm has some advantages and disadvantages. Localization processes in UWSN can be categorized into two groups, first group need help of propelled moving anchor in the system, which knows its current position and second group of localization systems don't have moving anchors. In this survey detailed study of former group of AUV and DET based localizations is done.

References

[1] Melike Erol-Kantarci, Sema Oktug, Luiz Vieira, Mario Gerla, "Performance evaluation of distributed localization techniques for mobile underwater acoustic sensor networks", Ad Hoc Networks, Elsevier, May2011, pp 61-72

[2] Chandrasekhar, V. Seah, W.K. "Area Localization Scheme for Underwater Sensor Networks", In Proceedings of the International Conference on OCEANS Asia Pacific IEEE, Singapore, 16–19 May 2006; pp. 1–8.

[3] John Heidemann, Milica Stojanovic and Michele Zorzi, "Underwater sensor networks: applications, advances and challenges". *Phil. Trans. of the R. Soc*., 2012, 370, 158–175

[4] J. Heidemann, W. Ye, J. Wills, A. Syed, and Y. Li, "Research challenges and applications for underwater sensor networking", in Proc. IEEE Wireless Communications and Networking Conference (WCNC), Las Vegas, USA, April 3-6 2006.

[5] M. Erol, L. Vieira, and M. Gerla, "Localization with dive'n'rise (dnr) beacons for underwater acoustic sensor networks", in Proc. Second workshop on Underwater networks (WuWNet), Montreal, Quebec, Canada, 2007, pp. 97–100.

[6] M. Erol, L. Vieira, A. Caruso, F. Paparella, M. Gerla, and S. Oktug, "Multi stage underwater sensor localization using mobile beacons", in Proc. The Second International Workshop on Under Water Sensors and Systems, Cap Esterel, France, August 25-31 2008.

[7] Erol, M., Vieira, L.F.M., Caruso, A., Paparella, F., Gerla, M., Oktug, S., 2008. Multi stage underwater sensor localization using mobile beacons. In: Proceedings of the IEEE SENSORCOMM, pp. 710–714

[8] Chen, K., Zhou, Y., He, J., A localization scheme for underwater wireless sensor networks. Int. J. Adv. Sci. Technol. 4, 9–16. 2009.

[9] Z. Zhou, J. Cui, and S. Zhou, "Efficient Localization for Large-Scale Underwater Sensor Networks," Ad Hoc Net, vol. 8, no. 3, May 2010, pp. 267–79.

[10] Dr. C. Rama Krishna, Pankaj Singh Yadav, "A Hybrid Localization Scheme for Underwater Wireless Sensor Networks", IEEE 2014

[11] K. Chen, Y. Zhou, and J. He, "A localization scheme for underwater wireless sensor networks," *International Journal of Advanced Science and Technology*, vol. 4, 2009.

[12] Y. Zhou, B. Gu, J. C. K. Chen, and H. Guan, "An range-free localization scheme for large scale underwater wireless sensor networks," *J. Shangai Jiaotong University*, vol. 14, no. 5, pp. 562–568, 2009.

[13] M. Erol, L. F. M. Vieira, and M. Gerla, "AUV-Aided Localization for Underwater Sensor Networks," Proc. of the WASA, pp. 44–51, August 2007.

[14] H. Luo, "LDB: Localization with Directional Beacons for Sparse 3D Underwater Acoustic Sensor Networks," J. Net., vol. 5, no. 1, Jan. 2010, pp. 28–38.

[15] Marc Waldmeyer, Hwee-Pink Tan, Winston K. G. Seah, "Multi-stage AUV-aided Localization for Underwater Wireless Sensor Networks", Workshops of International Conference on Advanced Information Networking and Applications, IEEE 2011

[16] Zhou, Y. He, J. Chen, K. Chen, J. Liang, A. "An Area Localization Scheme for Large Scale Underwater Wireless Sensor Networks," In Proceedings of the WRI International Conference on Communications and Mobile Computing (CMC'09), Yunnan, China, 6–8 January 2009; pp. 543–547.

[17] V. Chandrasekhar and W. Seah, "An area localization scheme for underwater sensor networks," in *Proc. OCEANS 2006 - Asia Pacific*, May 2006, pp. 1–8.

[18] Erol-kantarci, M. Mouftah, H.T. Oktug, S,"A survey of architectures and localization techniques for underwater acoustic sensor networks." IEEE Commun. Surv. Tutor. 2011, 13, 487–502.

[19] H. Luo, Y. Zhao, Z. Guo, S. Liu, P. Chen, and L. M. Ni, "UDB: Using Directional Beacons for Localization in Underwater Sensor Networks," Proc. of the ICPADS, pp. 551–558, December 2008.

[20] X.Cheng, H. Shu, Q. Liang, and D. Du, "Silent Positioning in Underwater Acoustic Sensor Networks," IEEE Trans. Veh. Technol., vol. 57,no. 3, pp. 1756–1766, May 2008.

[21] Luo, H. Guo, Z. Dong, V. Hong, F. Zhao, Y. "LDB: Localization with directional beacons for sparse 3D underwater acoustic sensor networks," J. Netw. 2010, 5, 28–38.

[22] Aditya Tandon1, Kamal Kant2, "A Novel Positioning Technique for 3D Underwater Sensor Networks," International Journal of Computer Science and Mobile Computing, IJCSMC, Vol. 2, Issue. 6, June 2013, pg.19 – 27

[23] SenWang, Ling Chen, Huosheng Hu, Zhibin Xue, Wei Pan,"Underwater Localization and Environment Mapping Using Wireless Robots", Wireless Pers Commun (2013) 70:1147–1170

AUTHORS PROFILE

Anil C. B.
Assistant professor in Computer Science and Engineering Department, Sree Narayana Gurukulam College of Engineering, Kerala, India, received his M.Tech degree in Software Engineering from Cochin University of Science and Technology, Kerala, India in 2007. He received his B. Tech degree in computer Science and Engineering from M.G University in 2002. He is currently a research scholar in department of Computer science in Cochin University of Science and Technology, Kerala, India. His research interest is in wireless sensor networks.
E-mail: anilcb2000@yahoo.com

Dr. Sheena Mathew
She is Professor in computer science and engineering division, School of Engineering, of Cochin University of science and Technology, Kerala, India. She received her M.Tech Degree from Indian Institute of Science, Bangalore, India .She did her PhD. In Cochin University of Science and Engineering, Kerala, India.
Email: sheenamathew@cusat.ac.in