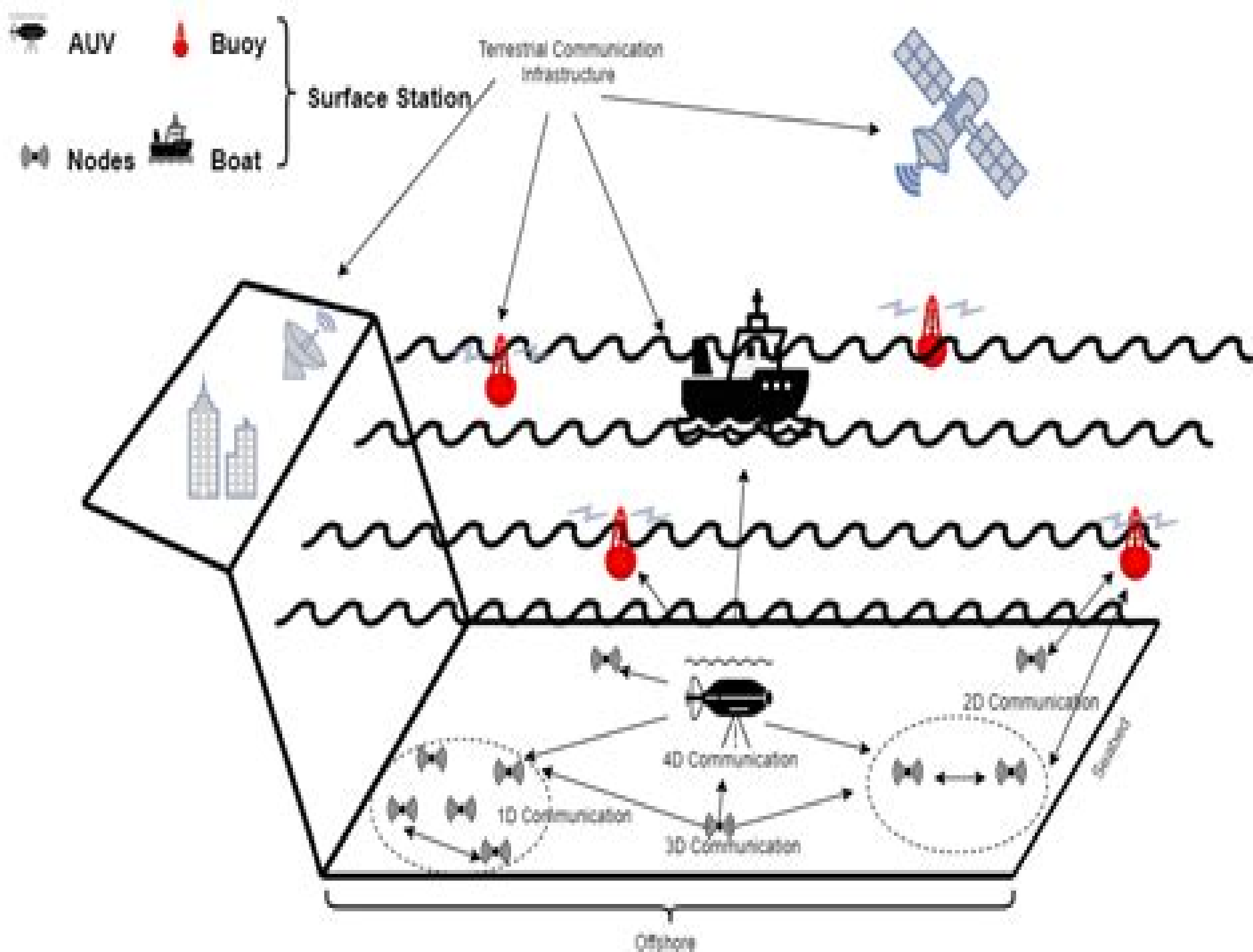




Underwater Acoustic Sensor Networks

Underwater Acoustic Sensor Networks

**Lei Wang, Hong Kong Polytechnic
University. Department of Computing**



Underwater Acoustic Sensor Networks Underwater Acoustic Sensor Networks:

Underwater Acoustic Sensor Networks Yang Xiao, 2010-05-19 A detailed review of underwater channel characteristics Underwater Acoustic Sensor Networks investigates the fundamental aspects of underwater communication Prominent researchers from around the world consider contemporary challenges in the development of underwater acoustic sensor networks UW ASNs and introduce a cross layer approach for effective Design, Optimization, and Applications of Underwater Acoustic Sensor Networks Bhumika Gupta, Kamal Kumar Gola, 2023-02-24 The development of underwater sensor networks opens new possibilities for maritime exploration and data collection Underwater sensor networks have a variety of military and civilian applications that must be studied further to ensure they are utilized appropriately Design Optimization and Applications of Underwater Acoustic Sensor Networks serves as a premier interdisciplinary forum for researchers practitioners and educators to present the most recent innovations trends concerns and practical challenges encountered and solutions adopted in the fields of underwater acoustic communications and underwater wireless sensor networks The book also investigates underwater sensor network applications and challenges Covering key topics such as sensor devices acoustics and environmental processing this premier reference source is ideal for engineers computer scientists industry professionals researchers scholars academicians practitioners instructors and students Underwater Acoustic Networking Techniques Roald Otnes, Alfred Asterjadhi, Paolo Casari, Michael Goetz, Thor Husøy, Ivor Nissen, Knut Rimstad, Paul van Walree, Michele Zorzi, 2012-01-19 This literature study presents an overview of underwater acoustic networking It provides a background and describes the state of the art of all networking facets that are relevant for underwater applications This report serves both as an introduction to the subject and as a summary of existing protocols providing support and inspiration for the development of network architectures Energy-Efficient Underwater Wireless Communications and Networking Goyal, Nitin, Sapra, Luxmi, Sandhu, Jasminder Kaur, 2020-09-04 Underwater wireless sensor networks UWSN are envisioned as an aquatic medium for a variety of applications including oceanographic data collection disaster management or prevention assisted navigation attack protection and pollution monitoring Similar to terrestrial wireless sensor networks WSN UWSNs consist of sensor nodes that collect the information and pass it to a base station however researchers have to face many challenges in executing the network in an aquatic medium Energy Efficient Underwater Wireless Communications and Networking is a crucial reference source that covers existing and future possibilities of the area as well as the current challenges presented in the implementation of underwater sensor networks While highlighting topics such as digital signal processing underwater localization and acoustic channel modeling this publication is ideally designed for machine learning experts IT specialists government agencies oceanic engineers communication experts researchers academicians students and environmental agencies concerned with optimized data flow in communication network securing assets and mitigating security attacks **Underwater Acoustic Sensor Networks Protocol Design** Lei Zhang, 2010-07 The limited bandwidth

and power resources as well as the 3 D topology in underwater acoustic sensor networks have made the geographic routing a favorite choice While most of the detour strategies in the existing geographic routing do not work well for underwater sensor networks the spanning tree routing detour strategy can efficiently find a detour for a packet when greedy forwarding fails In this research we propose novel spanning trees namely Traffic Aware Routing Tree TART and Energy Aware Routing Tree EART which are constructed completely in a bottom up fashion with the traffic load and residual energy level in mind Simulation results show that those spanning trees have very few conflicting hulls result in much higher path throughput and residual energy level when compared against other spanning trees leading to a better routing performance in a 3 D underwater acoustic sensor network *Underwater Acoustic Sensor Networks* Peng Xie,2007 Reliable Communication in Underwater Acoustic Sensor Networks Zheng Guo,2011

Efficient Communication Protocols for Underwater Acoustic Sensor Networks Dario Pompili,2007 Underwater sensor networks find applications in oceanographic data collection pollution monitoring offshore exploration disaster prevention assisted navigation tactical surveillance and mine reconnaissance The enabling technology for these applications is acoustic wireless networking UnderWater Acoustic Sensor Networks UW ASNs consist of sensors and Autonomous Underwater Vehicles AUVs deployed to perform collaborative monitoring tasks The objective of this research is to explore fundamental key aspects of underwater acoustic communications propose communication architectures for UW ASNs and develop efficient sensor communication protocols tailored for the underwater environment Specifically different deployment strategies for UW ASNs are studied and statistical deployment analysis for different architectures is provided Moreover a model characterizing the underwater acoustic channel utilization efficiency is introduced The model allows setting the optimal packet size for underwater communications Two distributed routing algorithms are proposed for delay insensitive and delay sensitive applications The proposed routing solutions allow each node to select its next hop with the objective of minimizing the energy consumption taking the different application requirements into account In addition a resilient routing solution to guarantee survivability of the network to node and link failures in long term monitoring missions is developed Moreover a distributed Medium Access Control MAC protocol for UW ASNs is proposed It is a transmitter based code division multiple access scheme that incorporates a novel closed loop distributed algorithm to set the optimal transmit power and code length It aims at achieving high network throughput low channel access delay and low energy consumption Finally an efficient cross layer communication solution tailored for multimedia traffic i e video and audio streams still images and scalar sensor data is introduced

Stochastic Medium Access Control for Underwater Acoustic Sensor Networks Yu Han,2016 Underwater sensor networks UWSNs the enabling technology for a broad range of aquatic applications rely on acoustic communication for long range transmissions However underwater acoustic communication suffers from several adverse features such as long propagation delay and low bandwidth making the networking design for UWSNs much more challenging than their terrestrial counterparts Medium

access control MAC a crucial component in networking design coordinates among multiple agents that share the same channel resource and is responsible to schedule packet transmissions efficiently and fairly. However, due to the long propagation delay, the traditional handshaking based random access MAC protocols are not channel efficient for UWSNs. In this dissertation, we address the inefficiency issues in random access MAC for UWSNs using a stochastic sending probability based approach. We propose three handshaking free underwater MAC solutions targeting the same goal: high network throughput, low packet end-to-end delay, and robustness under dynamics, and controlled implementation complexity. The three solutions are based on a common utility based probability optimization framework but with different design considerations and objective functions. We first leverage the feature of long propagation delay, often taken as negative, to improve the parallelism between multiple senders. Our proposed protocol, the Delay Aware Probability based underwater MAC protocol (DAP MAC), characterizes the group compatibility relation, a proposed indicator for successful concurrent transmissions, and utilizes this relation in the stochastic optimization framework for the best transmission strategy. The drawback of DAP MAC is it requires long time slots to accommodate concurrent transmissions. We reduce the slot size and explicitly resolve the unique spatial-temporal uncertainty issue in UWSNs in our proposed protocol, the Traffic Adaptive Receiver Synchronized underwater MAC protocol (TARS). In TARS, we consider the data queue status and design the throughput optimal transmission strategy to be traffic adaptive, which is very suitable for mobile and traffic varying UWSNs. Simulation results show that TARS achieves the highest throughput and lowest packet delay among the typical representative MACs, about 13%–146% higher in throughput and 13%–21% lower in delay than others in a mobile ad hoc network. For further throughput improvement, we consider the capture effect and proactively create power capture at the receivers in our proposed protocol, the Stochastic MAC protocol with Randomized Power control (SMARP). We design a randomized power control scheme based on the non-negligible difference in acoustic propagation attenuation and include the capture success probability in the stochastic optimization framework. Simulation results show that SMARP yields better throughput and packet delay than TARS and other representative MACs, about 23%–240% higher in throughput and 27%–60% lower in delay than others in a mobile ad hoc network. Finally, toward the development of wireless networking for enabling marine observatory capabilities at the Northeastern University Marine Science Center, we implement the TARS protocol on our testbed. We conduct in-tank underwater experiments and evaluate the performance of the TARS protocol under a three-node single-hop network. Experimental results show that TARS achieves the highest packet delivery ratio with controlled low packet end-to-end delay than other representative handshaking free underwater MAC protocols and is very suitable for the actual implementation in UWSNs.

Cognitive Underwater Acoustic Networking Techniques Dimitri Sotnik, Michael Goetz, Ivor Nissen, 2020-09-29. This book summarizes the latest research on cognitive network layer methods and smart adaptive physical layer methods in underwater networks. Underwater communication requires extendable and delay tolerant

underwater acoustic networks capable of supporting multiple frequency bands data rates and transmission ranges The book also discusses a suitable foreground communication stack for mixed mobile static networks a technology that requires adaptive physical layer waveforms and cognitive network strategies with underlying cooperative and non cooperative robust processes The goal is to arrive at a universally applicable standard in the area of Underwater Internet of Things ISO IEC 30140 30142 30143 The book is the second spin off of the research project RACUN after the first RACUN book Underwater Acoustic Networking Techniques <https://link.springer.com/book/10.1007/978-3-642-25224-2> Analyzing the Performance of Multi-hop Underwater Acoustic Sensor Networks, 2007 Multi hop underwater acoustic sensor networks constrain the performance of medium access control protocols The efficiency of the well known RTS CTS scheme is degraded due to long propagation delays of such networks Recently interest in Aloha variants has surfaced however the performance of such protocols within the context of multi hop networks is not well studied In this paper we identify the challenges of modeling contention based medium access control protocols and present a model for analyzing Aloha variants for a simple string topology as a first step toward analyzing the performance of contention based proposals in multi hop underwater acoustic sensor networks An application of the model suggests that Aloha variants are very sensitive to traffic loads and network size

Time Synchronization in Underwater Acoustic Sensor Networks Oriol Pallarés Valls, 2017 This thesis deals with the development of a time synchronization algorithm for underwater sensor networks The ease of deployment and maintenance of wireless networks led to the use of an acoustic communication sensor network to share a common base time between all nodes Acoustic signals are well adapted to the underwater medium but experience very challenging impairments such as Doppler extensive multi paths and low transmission speed that can nevertheless be corrected at the reception side Several acoustic waveforms can be invoked to transmit digital data through the underwater medium without loss of generality in this study is considered Orthogonal Frequency Division Multiplexing OFDM communication scheme to exchange data between wireless underwater nodes containing sensor time references This communication link will be used among others to carry time stamp message required for network synchronization Time synchronization is a critical piece of infrastructure of any distributed system UWSN make extensive use of synchronized time for many services provided by a distributed network In UWSN Global Positioning System GPS signals are not available and synchronization systems are mostly based on acoustic communication Owing to high latency of the underwater acoustic transmission channel with respect to cabled or radio network makes the use of conventional synchronization protocols even more challenging underwater Many time synchronization algorithms for underwater wireless sensor networks UWSN can be found in literature such as TSHL D SYNC DA Sync but only a few of them take into account all the water channel challenges such as low available bandwidth long propagation delays and sensor node mobility To solve this problem in this research a further development of the existing time synchronization protocols found in literature is driven To perform time synchronization we apply Precision Time

Protocol PTP std IEEE 1588 which is capable to synchronize two clocks with a precision below hundreds of nanoseconds in a point to point cabled Ethernet Network and DA Sync protocol which is a bidirectional message exchange based method between a master clock and an slave one and refines its time synchronization parameters by using medium kinematic models In cabled synchronization systems such as PTP time stamps are acquired in physical layer PHY in order to achieve maximum precision avoiding indeterministic time like Operating System OS time slots or medium access protocols Analogously it happens in acoustic communication time stamps are extracted from a large acquisition window and the improvement of these time stamps is treated in this thesis Contrary to cable networks the low celerity of wave sound makes underwater acoustic communications system very sensitive to Doppler effect yielding to non uniform frequency scaling represented by compression or dilatation of the time axis This frequency scaling can be induced by two factors motion sensor mobility channel variation etc and clock skew receiver between transmitter and receiver Actually in order to address this problem some systems uses expensive inertial sensors for compensating Doppler scaling due to motion and temperature compensated low drift clocks So in this thesis is evaluated the Doppler scaling caused by motion and skew in order to correct it Finally several tests in the laboratory test tank and at sea are performed in order to check the performance of acoustic communication and time synchronization Results show a correct behavior of hardware and software and also validate the performance of the time synchronization applied to acoustic UWSN

The Underwater World for Digital Data

Transmission Parikshit N. Mahalle,Pooja A. Shelar,Gitanjali R. Shinde,Nilanjan Dey,2021-05-06 This book covers all small details about Underwater Sensor Networks UWSN Researchers can use this book as a prerequisite before starting any research on underwater networks or underwater applications This book covers the introduction challenges different architectural models for UWSN various attacks on UWSN underwater applications and networking layers The target audience includes professors and students in engineering and researchers and engineers working on marine applications In academic level the book is helpful for students having Networking and Information Security as elective subject and doing projects in Wireless Networks It is also helpful for postgraduates and Ph D researchers to learn basics of Underwater Sensor Networks

Cooperative Localization in Mobile Underwater Acoustic Sensor Networks Sergej Neumann,2021*

Effective Medium Access Control for Underwater Acoustic Sensor Networks Wael Gorma,2019

Cross-layer

Protocols for Underwater Acoustic Sensor Networks with MIMO Links Li-Chung Kuo,2013 UnderWater Acoustic Sensor Networks UW ASNs are experiencing a rapid growth due to their high relevance to commercial and military applications such as oceanographic data collection pollution monitoring offshore exploration disaster prevention and tactical surveillance However the design of efficient communication protocols for underwater sensor networks is still an open research problem due to the unique characteristics of the underwater acoustic communication channel such as limited bandwidth high and variable propagation delays and significant multipath and scattering MIMO systems are able to exploit

rich scattering and multipath fading to provide higher spectral efficiencies without increasing power and bandwidth. The objective of this research is to explore the capabilities of underwater MIMO links and to leverage these from the perspective of higher layer protocols with a cross layer design approach. First, a new medium access control protocol named UMIMO MAC is proposed. UMIMO MAC is designed to i) adaptively leverage the tradeoff between multiplexing and diversity gain according to channel conditions and application requirements; ii) select suitable transmit power to reduce energy consumption; and iii) efficiently exploit the UW channel minimizing the impact of the long propagation delay on the channel utilization efficiency. To achieve the objectives above, UMIMO MAC is based on a two-way handshake protocol. Multiple access by simultaneous and co-located transmissions is achieved by using different pseudo-orthogonal spreading codes. An algorithm is proposed that in a cross-layer fashion jointly selects optimal transmit power and transmission mode through the cooperation of transmitter and receiver to achieve the desired level of reliability and data rate according to application needs and channel condition. Second, distributed routing algorithms are introduced for delay-insensitive and delay-sensitive applications with the objective of reducing the energy consumption by i) leveraging the tradeoff between multiplexing and diversity gain that characterizes MIMO links; and ii) allocating transmit power on suitable subcarriers according to channel conditions and application requirements. To achieve the objective above, each node jointly i) selects its next hop; ii) chooses a suitable transmission mode; and iii) assigns optimal transmit power on different subcarriers to achieve a target level of Quality of Service (QoS) in a cross-layer fashion. Extensive simulation results demonstrate that our proposed protocol is adaptive to the unique characteristics of the underwater acoustic communication channel and achieves excellent performance through local cooperations between transmitter and receiver. Finally, we present our ongoing work on developing a reconfigurable underwater networking testbed based on the Teledyne Benthos Telesonar SM 75 modem. The testbed is designed with the objective of allowing researchers and developers to advance research activities in the field of underwater networking and communications through a flexible testbed platform. This platform allows playing processing and recording custom-defined acoustic waveforms to support reconfigurable physical layer experimentation with arbitrary transmission schemes.

Localization in Underwater Sensor Networks Jing Yan, Haiyan Zhao, Yuan Meng, Xiping Guan, 2021-10-27. Ocean covers 70.8% of the Earth's surface and it plays an important role in supporting all life on Earth. Nonetheless, more than 80% of the ocean's volume remains unmapped, unobserved, and unexplored. In this regard, Underwater Sensor Networks (USNs) which offer ubiquitous computation, efficient communication, and reliable control are emerging as a promising solution to understand and explore the ocean. In order to support the application of USNs, accurate position information from sensor nodes is required to correctly analyze and interpret the data sampled. However, the openness and weak communication characteristics of USNs make underwater localization much more challenging in comparison to terrestrial sensor networks. In this book, we focus on the localization problem in USNs taking into account the unique characteristics of the underwater environment. This problem is of

considerable importance since fundamental guidance on the design and analysis of USN localization is very limited at present To this end we first introduce the network architecture of USNs and briefly review previous approaches to the localization of USNs Then the asynchronous clock node mobility stratification effect privacy preserving and attack detection are considered respectively and corresponding localization schemes are developed Lastly the book s rich implications provide guidance on the design of future USN localization schemes The results in this book reveal from a system perspective that underwater localization accuracy is closely related to the communication protocol and optimization estimator Researchers scientists and engineers in the field of USNs can benefit greatly from this book which provides a wealth of information useful methods and practical algorithms to help understand and explore the ocean

An Efficient MAC Protocol for Underwater Acoustic Sensor Networks Lei Wang,Hong Kong Polytechnic University. Department of Computing,2011 **Time Synchronization for Underwater Acoustic Sensor Networks** Tarik-UI Islam Khandoker,University of Western Australia,2012

The unique properties of underwater acoustic communications such as large and time varying propagation low and range dependent bandwidth and adverse operating environment make the synchronization of Underwater Acoustic Sensor Networks UWASNs very challenging In this dissertation to enhance synchronization performance we address three crucial issues of UWASNs time varying propagation consistency of timestamps being used and bandwidth efficiency We show that if not mitigated time varying propagation would lead to a very poor synchronization for UWASNs To address the issue we propose a low complexity algorithm which employs a simple preprocessing method to obtain delay compensated timestamps and avoids the assumption of static underwater node The extensive simulation results demonstrate that with a much lower computational complexity compared with alternative approaches in the literature the proposed approach achieves an improved precision in synchronization We identify the importance of consistency analysis of the timestamps obtained in adverse underwater environment by showing that collisions which are not uncommon during data transmission may cause inconsistent timestamps We propose a robust synchronization algorithm for underwater networks which identifies and eliminates the inconsistent timestamps by utilizing the concept of Cook s distance and achieves an enhanced synchronization as shown through extensive simulations As available bandwidth is extremely limited and energy consumption is critical in underwater networks exchanging many two way signals for synchronization would deteriorate the system performance noticeably To achieve a reasonably precise synchronization through oneway signal transmission we first propose a distance estimation technique that applies MLE Maximum Likelihood Estimation over a set of transmitted and received data symbols To deal with noise in received data symbols and uncertainties associated with nodes mobility the proposed technique simultaneously transmits a sufficient number of known data symbols over multiple underwater acoustic channels A distance dependent attenuation model is then used to derive the maximum likelihood estimator of the propagation distance We finally propose a bandwidth and energy efficient scalable synchronization algorithm which employs the MLE based distance estimation

technique to estimate time varying propagation delay to obtain delay compensated timestamps The proposed approach attains a network wide synchronization through a number of one way signal transmissions By avoiding two way signal exchanges the proposed approach reduces the communication overhead substantially Moreover as it does not require neighbouring nodes to transmit responses the effects of some underwater uncertainties e g collision and node s mobility are mitigated to a great extent

A MAC Protocol for Ad-hoc Underwater Acoustic Sensor Networks Borja Peleato, Milica Stojanovic, 2006 A medium access control MAC protocol is proposed that is suitable for non synchronized ad hoc networks and in particular for the energy constrained underwater acoustic networks which are characterized by long propagation delays The protocol exploits the difference in the link lengths between the nodes instead of waiting times proportional to the maximal link length To do so it relies on a receiver s ability to tolerate a certain level of interference By minimizing the length of the hand shake procedure preceeding the data transmission the throughput efficiency is increased as compared to the previously proposed protocols while collision avoidance minimizes the energy consumption

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