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Underwater Acoustic Networking Techniques

Springer

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ISSN 2191-8112
ISBN 978-3-642-25223-5
e-ISSN 2191-8120
e-ISBN 978-3-642-25224-2
DOI 10.1007/978-3-642-25224-2
Springer Heidelberg Dordrecht London New York

Library of Congress Control Number: 2011942404

Printed on acid-free paper

Springer is part of Springer Science+Business Media (www.springer.com)

Preface

This SpringerBrief is a spin-off from the EDA (European Defence Agency) research project RACUN (Robust Acoustic Communications in Underwater Networks), which started in August 2010. RACUN has partners from the five countries Germany, Italy, Netherlands, Norway, and Sweden. The overall goal is to develop and demonstrate the capability to establish an underwater ad hoc robust acoustic network for multiple purposes with moving and stationary nodes.

One of the first research tasks in RACUN was a literature survey of state-of-the-art in underwater acoustic communication networks. When this work was done, it was decided that it would be a pity to keep a thorough literature survey on this rapidly emerging topic internal to the project. Therefore, we are glad to publish a slightly edited version of the RACUN literature survey as a SpringerBrief.

This literature survey presents an overview of underwater acoustic networking. It provides a background and describes the state of the art of various 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 underwater network architectures. In recent years, other overview and survey papers have been published on the subject [1–6]. These papers can be consulted in addition to the present survey, which is however more comprehensive. Developments in the field of underwater sensor and communication networks are rapid, and new papers and protocols appear continuously.

The focus of this report is OSI layer 2 “Data Link Layer” and OSI layer 3 “Network layer”. Several definitions can be found on the term “Link layer”. In the OSI model, layer 2 “Data link layer” is split into two sublayers, MAC (medium access control) and LLC (logical link control). LLC is the upper of these sublayers.

After an introduction in Chap. 1, topics bordering the physical layer (time synchronization, full-duplex links, and adaptive data rate) are discussed in Chap. 2. MAC is discussed in Chap. 3, where considerations on frequency-division and code-division multiple access are followed by a detailed study on time-based multiple access technologies. Chapter 4 discusses logical link layer topics, including relatively new techniques such as fountain codes and network coding.

Chapter 5 gives an overview of routing (OSI "network layer"), including considerations on delay-tolerant networks.

The authors are affiliated with FKIE in Germany (Michael Goetz), WTD71-FWG in Germany (Ivor Nissen), University of Padova in Italy (Alfred Asterjadhi, Paolo Casari, and Michele Zorzi), Kongsberg Maritime in Norway (Thor Husøy and Knut Rimstad), and FFI in Norway (Roald Otnes and Paul van Walree). Due to the number of authors, it is inevitable that the writing style and level of detail is varying somewhat. Roald Otnes has been editing the report, and all the other authors are in alphabetical order in the author list.

Chapter 1 was written by Paul van Walree. Chapter 2 was written by Thor Husøy (Sects. 2.1–2.2) and Knut Rimstad (Sect. 2.3). Chapter 3 was written by Paul van Walree (Sects. 3.1–3.2), Michael Goetz (Sect. 3.3), Ivor Nissen (Sect. 3.3), and Roald Otnes (Sect. 3.4). Chapter 4 was written by Roald Otnes and Alfred Asterjadhi (Sect. 4.4.5). Chapter 5 was written by Paolo Casari, Alfred Asterjadhi, and Michele Zorzi.

In addition to the authors, the following helped in reviewing the original RACUN report: Jeroen Bergmans, Henry Dol, and Zijian Tang (TNO, Netherlands), and Svein Haavik and Jan Erik Voldhaug (FFI, Norway).

The RACUN project is part of the EDA UMS programme (European Unmanned Maritime Systems for MCM and other naval applications), and is funded by the Ministries of Defence of the five participating nations Germany, Italy, Netherlands, Norway, and Sweden.

References

1. Akyildiz IF, Pompili D, Melodia T (2005) Underwater acoustic sensor networks: research challenges. Ad Hoc Netw 3:257–279
2. Partan J, Kurose J, Levine BN (2007) A survey of practical issues in underwater networks. SIGMOBILE Mob Comput Commun Rev 11(4):23–33
3. Nguyen HT, Shin SY, Park SH (2007) State-of-the-art in MAC protocols for underwater acoustic sensor networks. Lecture Notes in Computer Science 4809/2007:482–493
4. Pompili D and Akyildiz IF (2009) Overview of networking protocols for underwater wireless communications. IEEE Commun Mag, 97–102
5. Shah GA (2009) A survey on medium access control in underwater acoustic sensor networks. In: Proceedings international conference on advance information networking and application workshops, WAINA'09, Bradford, UK, pp 1178–1183
6. Xiao Y (ed) (2010) Underwater acoustic sensor networks. CRC Press

Contents

Abbreviations

ACK	Acknowledgment
ACM	Adaptive coding and modulation
ACME	Acoustic communication network for monitoring of underwater environments in coastal areas
ADC	Analog to digital converter
ALBA-R	Adaptive load-balancing algorithm, rainbow version
ALOHA	Not an abbreviation, but a protocol name that means "Hello" in Hawaiian
ALOHA-ACK	ALOHA with acknowledgments
ALOHA-CS	ALOHA with carrier sense
AODV	Ad hoc on-demand distance vector routing
ARQ	Automatic repeat request
ASW	Anti-submarine warfare
ATM	Asynchronous transfer mode
aUT-Lohi	Aggressive unsynchronized tone-lohi
AUV	Autonomous underwater vehicle
BEB	Binary exponential backoff
BPSK	Binary phase shift keying
CDMA	Code division multiple access
CRC	Cyclic redundancy check
CSMA	Carrier sense multiple access
CTS	Clear to send
cUT-Lohi	Conservative unsynchronized tone-lohi
DAC	Digital to analog converter
DACAP	Distance-aware collision avoidance protocol
DAMA	Demand assigned multiple access
DBR	Depth-based routing
DBTMA	Dual busy tone multiple access
DS-CDMA	Direct sequence code division multiple Access
DSDV	Destination-sequenced distance-vector routing
DSR	Dynamic source routing