ISO/IEC 30140-3

Edition 1.0 2018-07

INTERNATIONAL STANDARD

Information technology – Underwater Acoustic Sensor Network (UWASN) – Part 3: Entities and interfaces

ISO/IEC 30140-3:2018-07(en)

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INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 35.110

ISBN 978-2-8322-5912-2

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INFORMATION TECHNOLOGY – UNDERWATER ACOUSTIC SENSOR NETWORK (UWASN) –

Part 3: Entities and interfaces

FOREWORD

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International Standard ISO/IEC 30140-3 was prepared by subcommittee 41: Internet of Things and related technologies, of ISO/IEC joint technical committee 1: Information technology.

The list of all currently available parts of the ISO/IEC 30140 series, under the general title *Information technology – Underwater acoustic sensor network (UWASN)*, can be found on the IEC and ISO websites.

This International Standard has been approved by vote of the member bodies, and the voting results may be obtained from the address given on the second title page.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A bilingual version of this publication may be issued at a later date.

INTRODUCTION

Water covers approximately 71 % of the surface of the Earth. Modern technologies introduce new methods to monitor the body of water, for example pollution monitoring and detection. Underwater data gathering techniques require exploring the water environment, which can be most effectively performed by underwater acoustic sensor networks (UWASNs). Applications developed for the UWASNs can record underwater climate, detect and control water pollution, monitor marine biology, discover natural resources, detect pipeline leakages, monitor and locate underwater intruders, perform strategic surveillance, and so on.

The ISO/IEC 30140 series provides general requirements, reference architecture (RA) including the entity models and high-level interface guidelines supporting interoperability among UWASNs in order to provide the essential UWASN construction information to help and guide architects, developers and implementers of UWASNs.

Additionally, the ISO/IEC 30140 series provides high-level functional models related to underwater sensor nodes and relationships among the nodes to construct architectural perspective of UWASNs. However, the ISO/IEC 30140 series is an application agnostic standard. Thus, the ISO/IEC 30140 series specifies neither any type of communication waveforms for use in UWASNs nor any underwater acoustic communication frequencies. Specifying communication waveforms and/or frequencies are the responsibility of architects, developers and implementers.[1]

Acoustical data communication in sensor networks necessitates the introduction of acoustical signals that overlap biologically important frequency bands into the subject environment. These signals can conflict with regional, national, or international noise exposure regulations. Implementers of acoustical communication networks should consult the relevant regulatory agencies prior to designing and deployment of these systems to ensure compliance with regulations and avoid conflicts with the agencies.

The purpose of the ISO/IEC 30140 series is to provide general requirements, guidance and facilitation in order for the users of the ISO/IEC 30140 series to design and develop the target UWASNs for their applications and services.

The ISO/IEC 30140 series comprises four parts as shown below.

- Part 1 provides a general overview and requirements of the UWASN reference architecture.
- Part 2 provides reference architecture models for UWASN.
- Part 3 provides descriptions for the entities and interfaces of the UWASN reference architecture.
- Part 4 provides information on interoperability requirements among the entities within a UWASN and among various UWASNs.

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1 Architects, developers, and implementers need to be aware of the submarine emergency frequency band, near and below 12 kHz, and it is recommended to provide a provision for such submarine emergency band in their UWASN design and applications.

INFORMATION TECHNOLOGY – UNDERWATER ACOUSTIC SENSOR NETWORK (UWASN) –

Part 3: Entities and interfaces

1 Scope

This part of ISO/IEC 30140 specifies the various entities in UWASNs. Moreover, it describes the interfaces between different physical and functional entities.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 29182-2, *Information technology – Sensor networks: Sensor Network Reference Architecture (SNRA) – Part 2: Vocabulary and terminology*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 29182-2 apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

4 Abbreviated terms

A/C	analog-to-digital converter
CLM	cross layer management
I^2C	inter integrated circuit
IP	Internet protocol
MLDE	MAC layer data entity
MLME	MAC layer management entity
NLDE	network layer data entity
NLME	network layer management entity
PLDE	physical layer data entity
PLME	physical layer management entity
PWM	pulse width modulation
QoS	quality of service
SAP	service access point
SCI	serial communication interface
SPI	serial peripheral interface

USV	underwater surface vehicle
UUV	unmanned underwater vehicle
UWA-APS	underwater application layer
UWA-BUN	underwater bundle layer
UWA-CH	underwater acoustic cluster head
UWA-DL	underwater datalink layer
UWA-DTN	underwater delay tolerant network
UWA-DTN-GW	underwater DTN gateway
UWA-FN	underwater acoustic fundamental network
UWA-GW	underwater acoustic gateway
UWA-NWK	underwater network layer
UWA-PHY	underwater physical layer
UWA-SNode	underwater acoustic sensor node
UWASN	underwater acoustic sensor network
UWA-UN	underwater acoustic united network

5 Overview

The purpose of this document is to provide basic information about and high-level models for the various entities and interfaces that comprise an UWASN. Entities can be roughly categorized into two classes, physical and functional. An underwater sensor node is a physical entity that contains many sensors. A functional entity represents a certain task that can be carried out on one or more types of physical entities. Routing and authentication are examples of functional entities. More often than not, functional entities are pieces of code that run on physical entities.

UWASN physical entities are categorized into three groups, namely underwater domain physical entities, network domain physical entities, and application domain physical entities. Examples of such physical entities include sensors and actuators, surface gateways, relay nodes, cluster head and user, access and backbone networks, etc. Similarly, more detailed models have been provided for functional entities such as environmental monitoring, disaster prevention, aquafarm monitoring, data forwarding, persistent storage, network coding, data processing, privacy management, self-localization, group management/clustering, collaborative information processing, and device management. A more detailed model can include an input-output relationship for what the entity does, some features of the entity that characterize its capabilities, and a taxonomy of various ways in which the entity can be implemented.

6 UWASN entities

6.1 UWASN physical entities

6.1.1 General

Physical entities comprise hardware, devices and/or components. UWASN physical entities can be divided into three categories:

- UWASN domain physical entities;
- network domain physical entities;
- application domain physical entities.

6.1.2 UWASN domain physical entities

Underwater domain physical entities exist in the seabed. These include underwater moving and fixed gateways (UWA-GWs), underwater acoustic sensor nodes (UWA-SNodes), underwater acoustic cluster heads (UWA-CHs), fouling cleaner, acoustic modem, node reclamation, UUV, etc.

Table 1 shows the UWASN domain physical entities and corresponding examples.

Table 1 – UWASN domain physical entities

Entities		Examples
Surface domain	UWA-GW UWA-DTN-GW	– Moving gateway (ships) – Fixed gateway (buoys), etc. – USV
Controlling domain	UWA-CH	– Ad-hoc UWA-SNode
	Relay node	– UUV, etc.
Sensing domain	UWA-SNode	– Sensors – Acoustic tag – UUV

UWA-GW: UWA-GWs facilitate communication between underwater sensor networks and the Internet. The surface gateway receives underwater related data from sensor nodes (relay node, UWA-CHs or UWA-SNodes) and transmits the data to the monitoring centre via wireless communication channels. In general, UWA-GWs are moving or fixed nodes. For example, a buoy is a fixed gateway, and ships and UUVs are the moving gateways. UWA-SNodes transmit packets to the nearest gateway rather than using a long path.

UWA-CH: UWA-CHs receive information from all cluster sensor nodes and transmit information to the relay node or directly to the surface gateway.

Relay node: Relay nodes transfer underwater data from UWA-SNodes to UWA-GWs.

UWA-SNode: UWA-SNodes, such as acoustic tags, UUVs, and sensors, collect data from water and transmit the data to the UWA-CH, relay nodes, or UWA-GW.

6.1.3 Network domain physical entities

The network domain entities comprise access networks and backbone networks. An access network provides connectivity between the backbone network and underwater domain physical entities.

Table 2 shows the network domain physical entities and corresponding examples.

Table 2 – Network domain physical entities

Entities	Examples
Access network	Wi-Fi®[a], 3G / 4G, Ethernet, and ZigBee®[a]
Backbone network	Internet, and Intranet
[a] ZigBee and Wi-Fi are registered trademarks of ZigBee Alliance and Wi-Fi Alliance, respectively. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO or IEC.	

Access network: Access networks provide connectivity between the Internet and the surface gateway.

Backbone network: The Internet is the most widely used backbone network.

6.1.4 Application domain physical entities

Users are considered application domain entities. Users can connect to the UWASN for accessing of scientific, military, business, and aqua applications.

User: The user can visualize information produced by an UWASN. The applications of UWASN include environmental monitoring, assisted navigation, disaster prevention, and locating intruder submarines.

6.2 UWASN functional entities

6.2.1 General

Typically, the sensor node architecture comprises six functional layers, as shown in Figure 1:

- UWA-APS;
- UWA-BUN;
- UWA-NWK;
- UWA-DL;
- UWA-PHY;
- UWA-Cross layer.

Sensor nodes and gateways can have similar layers; however, the modules in each layer can differ. For example, sensor nodes can integrate different sensors but gateways do not have sensing capability.

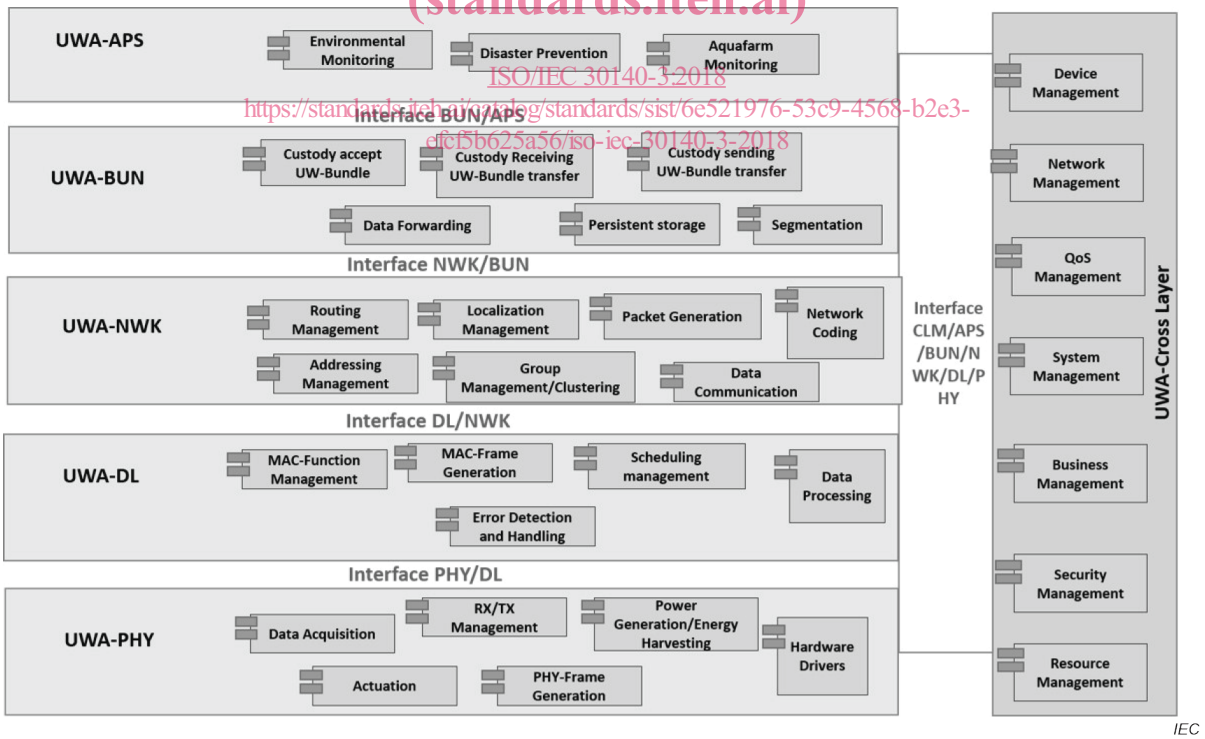

Figure 1 – Interfaces between UWASN functional layers and functional entities

Communication between functional modules in layers is implemented by the interface between the layers (Figure 1). The following interfaces are defined.

- The BUN / APS interface is between the UWA-BUN and the UWA-APS.
- The NWK / BUN interface is between the UWA-NWK and the UWA-BUN.