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INTERNATIONAL STANDARD

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Information technology – Underwater acoustic sensor network (UWASN) – Part 2: Reference architecture

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CONTENTS

INFORMATION TECHNOLOGY – UNDERWATER ACOUSTIC SENSOR NETWORK (UWASN) –

Part 2: Reference architecture

FOREWORD

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International Standard ISO/IEC 30140-2 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.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

Water covers approximately 71 % of the Earth's surface. Modern technologies introduce new methods to monitor the bodies 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 the architectural perspective of UWASNs. However, the ISO/IEC 30140 series is an application agnostic standard. Thus, 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 may 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.

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 2: Reference architecture

1 Scope

This part of ISO/IEC 30140 provides a UWASN conceptual model by identifying and defining three domains (application domain, network domain and UWASN domain).

It also provides UWASN reference architecture multiple views consistent with the requirements defined in ISO/IEC 30140-1:

a) UWASN systems reference architecture;

b) UWASN communication reference architecture;

c) UWASN information reference architecture.

For each view, related physical and functional entities are described.

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*

ISO/IEC 30140-1, *Information technology – Underwater acoustic sensor network (UWASN) – Part 1: Overview and requirements*[2]

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

[2] Under preparation. Stage at time of publication: ISO/IEC FDIS 30140-1:2017.

4 Abbreviated terms

2D	two-dimensional
3D	three-dimensional
3G	third generation
4G	fourth generation
A/D	analog-to-digital converter
AODV	ad hoc on demand distance vector
APS IB	application layer information base
APSDE	application layer data entity
APSME	application layer management entity
ASK	amplitude shift keying
AUV	autonomous underwater vehicle
BLDE	bundle layer data entity
BLME	bundle layer management entity
BUN IB	bundle layer information base
CDMA	code division multiple access
CLA	convergence layer adapter
CM	communication module
CPU	central processing unit
CRA	communication reference architecture
CSMA	carrier sense multiple access
D/A	digital-to-analog converter
DB	database
DG	distance group
DSDV	destination-sequenced distance vector routing
DSR	dynamic source routing
DTN	delay and disruption tolerant network
HAL	hardware abstraction layer
FSK	frequency shift keying
GFG	greedy-face-greedy
GPRS	general packet radio service
HAL	hardware layer
IB	information base
I^2C	inter-integrated circuit
IP	Internet protocol
IRA	information reference architecture
kbps	kilobits per second
LAN	local area network
MAC IB	datalink layer information base
MAC	media access control
MCU	microcontroller unit
MFSK	multiple frequency shift keying

MIMO	multi-input multi-output
MLDE	MAC layer data entity
MLME	MAC layer management entity
MM	micro controller module
MSDU	mac service data unit
NLDE	network layer data entity
NLME	network layer management entity
NWK IB	network layer information base
OFDM	orthogonal frequency division multiplexing
OLSR	optimized link state routing
OS	operating system
PC	personal computer
PDU	protocol data unit
PHY IB	physical layer information base
PIT	passive integrated transponder
PLDE	physical layer data entity
PLME	physical layer management entity
PSK	phase shift keying
PTKF	partial topology knowledge forwarding
PWM	pulse width modulation
QAM	quadrature amplitude modulation
QoS	quality of service
RA	reference architecture
REST	representational state transfer
RF	radio frequency
RFID	radio-frequency identification
ROV	remotely operated underwater vehicle
SAP	service access point
SCI	serial communication interface
SDV	switched digital video
SIM	sensor interface module
SIMO	single-input multi-output
SISO	single-input single-output
SM	service module
SPI	serial peripheral interface
SRA	system reference architecture
TDMA	time division multiple access
UART	universal asynchronous receiver/transmitter
UUV	unmanned underwater vehicle
UWA-APS	underwater application layer
UWA-BUN	underwater bundle layer
UWA-CH	underwater acoustic cluster head
UWA-EUN	underwater acoustic extend united network

UWA-FN	underwater acoustic fundamental network
UWA-GW	underwater acoustic gateway
UWA-DL	underwater datalink layer
UWA-NWK	underwater network layer
UWA-PHY	underwater physical layer
UWASN	underwater acoustic sensor network
UWA-SNode	underwater acoustic sensor node
UWA-UN	underwater acoustic united network
WAN	wide area network
Wi-Fi	wireless fidelity

5 Purpose of UWASN reference architecture (UWASN RA)

This document provides reference architecture views consistent with the requirements which are defined in ISO/IEC 30140-1.

A UWASN reference architecture (UWASN RA) is a generalized architecture sharing one or more common domains of several end systems, giving direction downward and requiring compliance upward. In other words, the developer can reuse entities and elements in the reference architecture that fit the developers' application or target architecture. In addition, the UWASN reference architecture provides standards and guidelines for building a specific architecture for underwater environment.

The combination of these architecture perspectives and views forms a comprehensive architectural description of a UWASN system. Reference architecture perspectives and views are to:

a) specify how UWASNs operate;

b) specify systems of equipment and flows of information which support UWASNs;

c) specify technical rules and guidelines which allow these systems to interoperate.

UWASN RA provides the rules and guidance for developing and presenting the architecture descriptions.

This document provides multiple views of the technical architecture of UWASN:

1) overview of UWASN reference architecture;

2) UWASN systems reference architecture;

3) UWASN communication reference architecture;

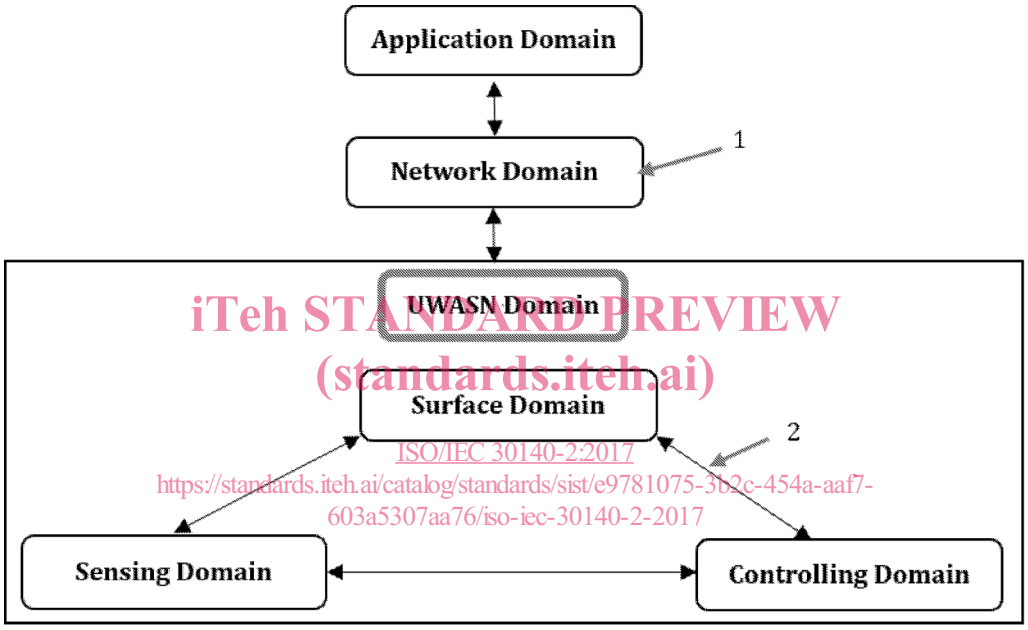
4) UWASN information reference architecture.

The UWASN supports development of interacting architectures. UWASN defines the multiple perspectives of UWASN reference architecture and multiple views of the technical architecture. All views are made up of sets of architecture data elements. The UWASN defines relationship between architectural views and the data elements.

6 UWASN conceptual model

The UWASN conceptual model shown in Figure 1 depicts the common domains that are identified in various UWASN systems and each of the presented domains. In this document, the UWASN reference architecture is described using the domains shown in Figure 1 and this conceptual model is extended to develop the three UWASN reference architectures which describe common entities and interfaces in each domain for various UWASN systems applications and services.

The UWASN RA describes the key technology that enables “a UWASN system”. In most UWASN systems, there are three main technologies involved: system technology, communication technology and information technology. The UWASN reference architecture views are described and focused on these three technologies, resulting in the architecture views mentioned.



Key

1 domain

2 two-way communication link, interface for data/information and/or physical interface

Figure 1 – UWASN system conceptual model

The conceptual model describes the UWASN system in terms of the key domains which are common to the deployed UWASN systems. These domains are identified and defined.

a) Application domain

The application domain includes many types of application users connected to a UWASN system. These are scientific, military, business and aquatic applications. The application users make use of underwater sensor data for monitoring the environment, providing tsunami warnings, etc.

b) Network domain

The network domain can be realized using LAN, WAN and/or backbone networks. This domain provides data/information links between the application domain and UWASN domain. This domain uses RF communication, satellite or optical communication.

c) UWASN domain

This domain is related to the underwater environment, which includes surface domain, sensing domain, and controlling domain. These three domains are described below.

1) Surface domain

In the UWASN system, ships, surface buoys and UUVs may be used as underwater gateways. These gateways gather data from underwater sensor nodes using acoustic communication links and transfer to the backbone network using, e.g. satellite communication or CDMA.

2) Sensing domain

In the UWASN system, the sensing domain is used for sensing the underwater environment using various types of sensors, e.g. temperature, pressure and imaging sensors. The sensing domain can directly communicate with the surface domain in the case of ad-hoc networks.

3) Controlling domain

In the UWASN system, the controlling domain is used for communication between the sensing domain and the surface domain. Intermediate nodes, such as AUVs and relay nodes, are used to gather data from the sensing domain and transform to surface domain with the help of acoustic communication.

7 Configuration of UWASN RA – Systems reference architecture (SRA)

7.1 General

The UWASN systems reference architecture is shown in Figure 2, along with all the entities involved and the interfaces among them. The entity and interface descriptions are presented in Table 1.