ISO/IEC 30142-2

Edition 1.0 2022-08

INTERNATIONAL STANDARD

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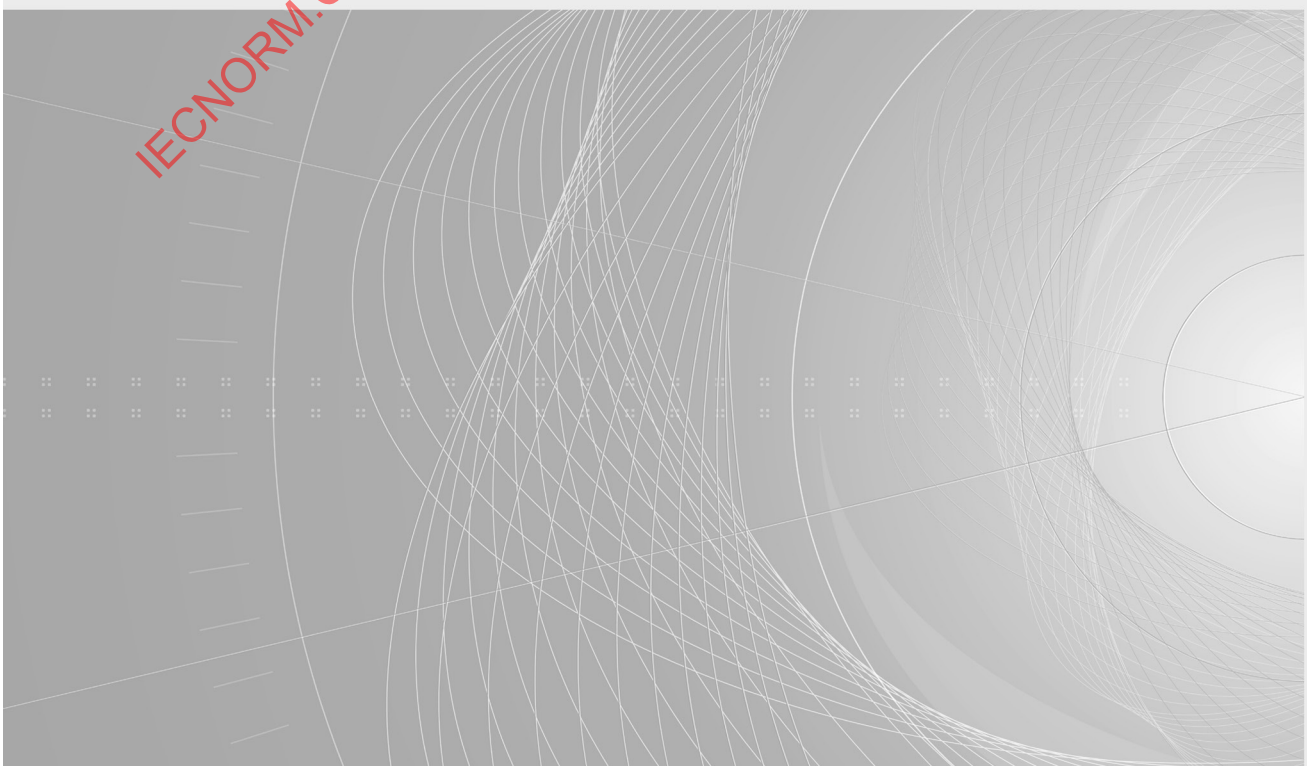
Internet of Things (IoT) – Underwater acoustic sensor network (UWASN) – Network management system – Part 2: Underwater management information base (u-MIB)



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CONTENTS

INTERNET OF THINGS (IoT) – UNDERWATER ACOUSTIC SENSOR NETWORK (UWASN) – NETWORK MANAGEMENT SYSTEM –

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FOREWORD

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ISO/IEC 30142-2 has been prepared by subcommittee 41: Internet of Things and Digital Twin, of ISO/IEC joint technical committee 1: Information technology. It is an International Standard.

The text of this International Standard is based on the following documents:

Draft	Report on voting
JTC1-SC41/288/FDIS	JTC1-SC41/296/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1, available at www.iec.ch/members_experts/refdocs and www.iso.org/directives.

In order to highlight specifically the managed objects in this document, the managed objects are written in italics throughout this document.

A list of all parts in the ISO/IEC 30142 series, published under the general title *Internet of Things (IoT) – Underwater acoustic sensor network (UWASN) – Network management system*, can be found on the IEC website.

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INTRODUCTION

Water covers approximately 70 % of the surface of the Earth. Modern technologies introduce new methods to monitor the body of water, such as 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 find underwater intruders, perform strategic surveillance, and so on.

To build and apply the UWASN technology, most suitable methods for managing the network have been developed based on the ISO/IEC 30140 series. This document describes the network management outline and requirements appropriate to the UWASN under the constraints of an underwater physical environment.

The ISO/IEC 30142 series provides information such as requirements of an underwater network management system (U-NMS), functions supporting U-NMS, and components required for U-NMS in UWASN.

This document provides the underwater management information base (u-MIB) for the U-NMS. u-MIB is a hierarchical database specifically designed for managing the networks or devices in the underwater network management system of UWASN.

Various technical standards derived from the R&D results of the technical areas under the UWASN and underwater communication fields not covered by the ISO/IEC 30140 series are continuously proposed and developed.

INTERNET OF THINGS (IoT) – UNDERWATER ACOUSTIC SENSOR NETWORK (UWASN) – NETWORK MANAGEMENT SYSTEM –

Part 2: Underwater management information base (u-MIB)

1 Scope

This document provides the underwater management information base (u-MIB) of the underwater network management system (U-NMS). It specifies the following:

– general requirements for constructing u-MIB in U-NMS;
– designing the managed objects of the manager and agent u-MIB;
– integrating the managed objects of the manager and agent u-MIB.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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

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

3.1
managed object
abstract representation of an underwater object or resource in u-MIB that is managed using an underwater network management system

3.2
managed objects
collection of underwater objects or resources that are defined in the underwater management information base (u-MIB)

Note 1 to entry: The managed objects (MOs) are the component used for exchanging the information between manager and agent in U-NMS.

3.3
management protocol
protocol used for carrying information between the manager and agent in U-NMS

3.4
TABLE
data type that holds a collection of information related to underwater networks and underwater devices

EXAMPLE The notification record.

3.5
OBJID
data type that holds the unique identity of each managed object

4 Abbreviated terms

MO	managed object
MOs	managed objects
MIB	management information base
OID	object identifier
u-MIB	underwater management information base
U-NMS	underwater network management system
UUV	unmanned underwater vehicle
UWA-CH	underwater acoustic cluster head
UWA-GW	underwater acoustic gateway
UWA-SNode	underwater acoustic sensor node

5 u-MIB overview and basic concepts

5.1 u-MIB definition

Underwater management information base (u-MIB) is a database specifically designed for managing the elements or entities in the underwater network management system (U-NMS). Figure 1 shows the elements of U-NMS where u-MIB is included. The u-MIB is included in the elements such as a manager and an agent.

– In U-NMS, the manager is the program installed in the devices to control the whole functions of underwater networks.
– The agent is the program that is bundled inside the underwater devices such as UWA-GW, UWA-CH, UUV, UWA-SNode, etc.
– Management protocol defines the format of a packet exchange between a manager and an agent in U-NMS.
– u-MIB creates the collection of managed objects (MOs) that uses the structured format for defining the name and objects which are adapted to U-NMS.

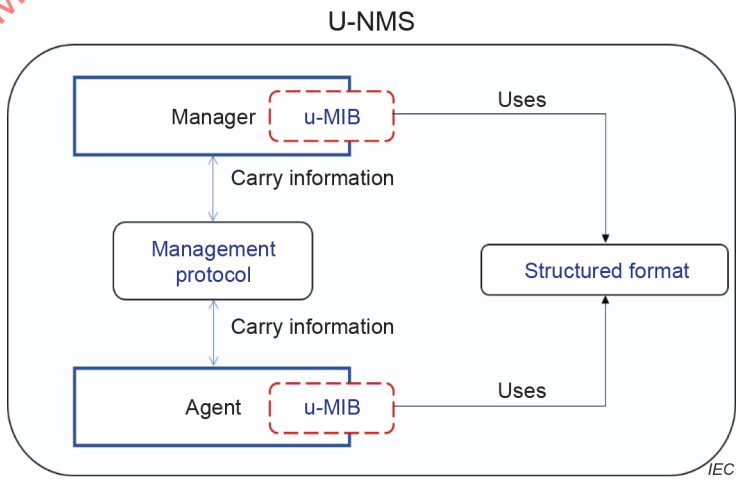

Figure 1 – Elements of u-MIB in U-NMS

5.2 Necessity of u-MIB in U-NMS

The environmental condition of underwater networks is considerably different from that of terrestrial area networks. Hence, the underwater network management system is necessary to handle the networks and devices in the underwater environment. In this case, it is difficult to adapt the legacy management information base (MIB) to the underwater environment because of the following factors.

a) The resource availability of underwater devices is extremely different from terrestrial devices.

b) MIB in terrestrial area networks holds a huge number of MOs. Hence, it is heavyweight and therefore it is difficult to adapt it to underwater devices .

Therefore, it is necessary to establish a unique underwater MIB based on the condition of the underwater environment by reducing the MOs. The reduced MOs can be termed "u-MIB", which has the key functions of U-NMS and is utilized to monitor the status of devices and networks in the underwater environment.

The specific roles of u-MIB in U-NMS are given below.

– Used as the database: u-MIB is used by the manager and agent for storing and retrieving information in U-NMS.

– Avoiding complexity: u-MIB is the lightweight version with limited MOs. Therefore, it is suitable for the U-NMS components such as manager and agent. This can avoid the complexity in U-NMS.

– Easy adaptation/management: Due to the dynamic changes in the underwater environment, the MOs need to be created based on the problems in U-NMS such as memory problems, battery problems, connection problems, etc. Therefore, the U-NMS components can be adapted or managed easily in the underwater environment.

5.3 U-NMS system architecture for using u-MIB

Figure 2 shows the U-NMS system architecture for using u-MIB, which indicates the formation of u-MIB in U-NMS components such as the manager, and agent. The u-MIB is installed separately into the manager and agent components of U-NMS. The installed MOs are extremely different for both manager and agent u-MIB. The methods such as Get Request, Get Response, Set Request and Set Response are used by the manager to MOs from the agent. Trap is the notification message sent by the agent if some critical events occur in underwater devices such as the increase in temperature, reduced battery charge, out of memory space, etc. The exchange of messages between the manager and agents is performed using the network management protocol.

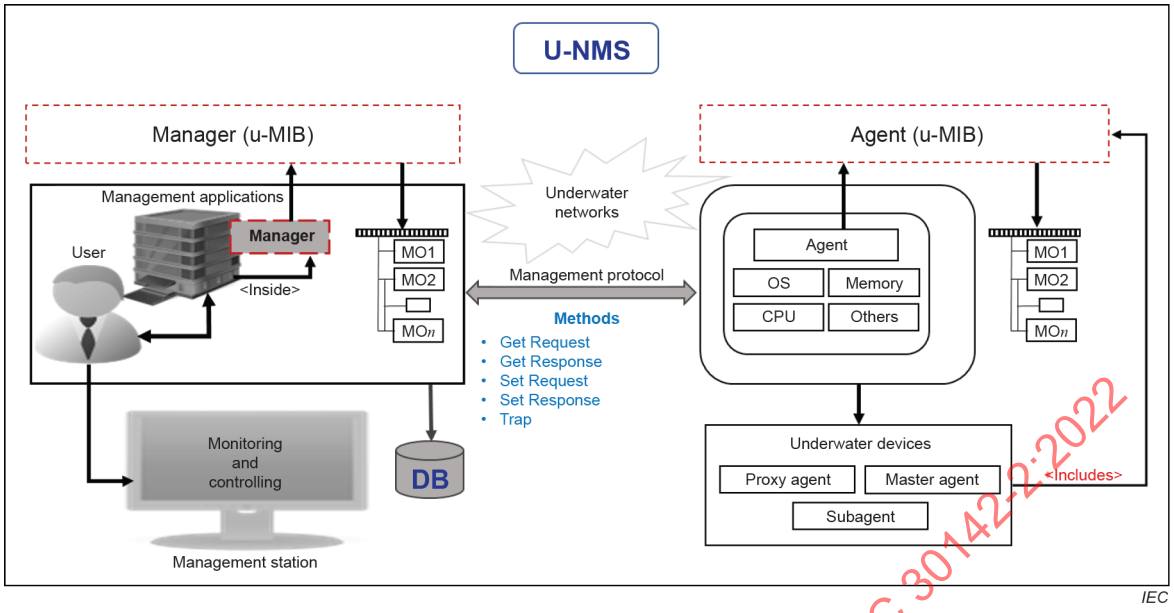

Figure 2 – U-NMS system architecture for using u-MIB

5.4 Structure of u-MIB

5.4.1 General

In general, the u-MIB is designed using the collection of MOs constructed in a hierarchical structure, as shown in Figure 3.

5.4.2 u-MIB objects

It is the collection of MOs in U-NMS. u-MIB objects comprise management information of each device in U-NMS built in a structured format.

5.4.3 u-MIB OIDs

The object identifiers (OIDs) in u-MIB allow the U-NMS to access information inside the U-NMS devices.

5.4.4 u-MIB OID hierarchy

The OIDs of u-MIB are described in a hierarchical format (*u-MIBObjects u_networks* and *u-MIBObjects u_devices*).

– *u-MIBObjects*;
– *u_networks;*
– *u_devices*.

u-MIB in U-NMS can be categorized into two sections.

a) *u_networks*: It is also known as underwater network information. In this case, OIDs are utilized to manage the network link between U-NMS devices.

   MOs of network management are built under the name *u_networks* in *u-MIBObjects*. For example, checking the connectivity between the devices.

b) *u_devices*: It is also known as underwater device information. In this case, OIDs are utilized to manage the specific devices in U-NMS, such as the proxy agent, master agent, and subagent.

MOs of device management are built under the name *u_devices* in *u-MIBObjects*. For example, underwater devices battery management is the u-MIBObjects under *u-devices*.

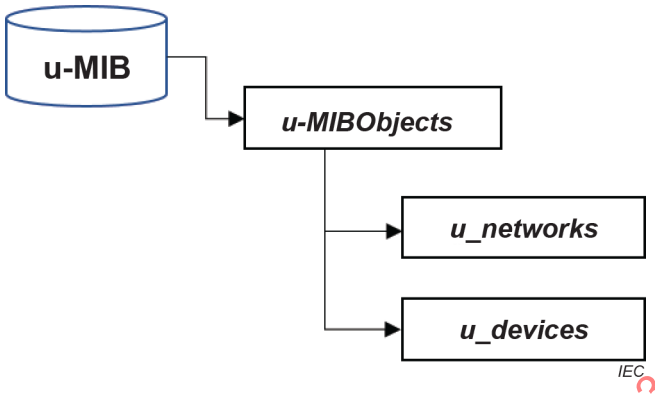

Figure 3 – u-MIB hierarchy structure

Table 1 shows the two-essential u-MIB object groups of U-NMS such as *u_networks* and *u_devices*.

Table 1 – u-MIB object groups

u-MIB Objects	Type	Object Identifier	Object Identifier Name
u_networks	GROUP	*1.1*	*u-MIBObjects(1).u_networks(1)*
u_devices	GROUP	*1.2*	*u-MIBObjects(1).u_devices(2)*

5.5 General format of managed objects in u-MIB

Figure 4 shows the general structure of u-MIB objects in U-NMS. u-MIB includes a collection of MOs that include the network management information of underwater devices. Each MO is designed using the name, data type, right to access, status indicator, and object description customized to underwater communication. Interface description language is used for defining MOs in u-MIB. The structured format is used for defining the name and objects in u-MIB.

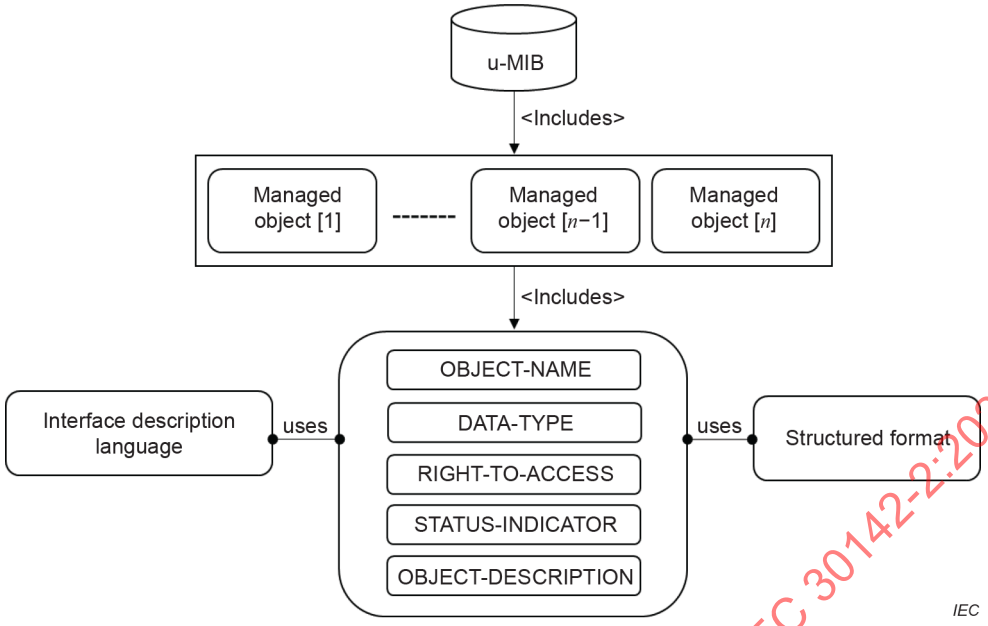

Figure 4 – General format of u-MIB

Table 2 shows the attributes for defining MOs in U-NMS.

Table 2 – Attributes used for representing MOs in u-MIB

Keywords	Description
OBJECT-NAME	It describes the name of the objects such as MIB version, device name, etc.
DATA-TYPE	It describes the data types corresponding to the OBJECT-NAME, such as INTEGER, STRING, etc.
RIGHT-TO-ACCESS	It indicates permission to retrieve objects such as read-write, read-only, etc.
STATUS-INDICATOR	It describes whether the object is mandatory or optional.
OBJECT-DESCRIPTION	It defines the textual description of objects.

6 General requirements for constructing u-MIB in U-NMS

The general requirements of u-MIB design are based on two parts: (1) underwater network requirements for designing u-MIB, and (2) underwater devices requirements for designing u-MIB. The underwater network specification requirements are established based on the factors considering the networks in the underwater environment. Table 3 shows the requirements of underwater networks for designing u-MIB.

Table 3 – Underwater network requirements of u-MIB in U-NMS

Name	Description
Networks connectivity information	Network type, link quality, signal strength, number of devices connected, network active time with devices, network suspended time with devices, etc. shall be used in u-MIB to identify the network connectivity status in underwater networks.
Networks packets information	The packets information of underwater networks such as packets received, packets transferred, Get Request, Set Request, etc. shall be used to send or receive the packets in underwater networks.
Networks notification	Trap messages shall be used in underwater networks when some critical events occur in networks such as link failure and authentication failure.

The underwater device specification requirements are separated into two parts: (1) object information, and (2) object status. The object information represents the general information about the underwater object such as device name, device manufacturer name, device ID, etc. The object status represents the device status such as battery damaged, out of memory, etc. Table 4 shows the mandatory requirements of underwater devices for designing u-MIB.

Table 4 – Mandatory underwater device requirements of u-MIB in U-NMS

Name	Description
Device information	The information such as *u_devices_ID*, *u_devices_firmware*, *u_devices_manufacturer_name*, *u_devices_type*, etc. shall be used to identify the general information of devices in underwater networks.
Device status	Device status information shall be used to indicate the status of underwater devices such as *u_devices_active_time*, *u_devices_location*, *u_devices_suspendedtime*, etc.
Battery information	Information such as *u_devices_battery_available*, *u_devices_battery_total*, and *u_devices_battery_used* shall be used to indicate the resource availability of battery in underwater devices.
Battery status	The battery status information shall be used to report the current status of the battery in underwater devices such as *u_devices_battery_damaged*, *u_devices_battery_low*, *u_devices_battery_normal*, etc.
Memory information	The information such as *u_devices_memory_available*, *u_devices_memory_total*, and *u_devices_memory_used* shall be used to indicate the resource availability of memory in underwater devices.
Memory status	The memory status information shall be used to report the current status of memory in underwater devices such as *u_devices_memory_damaged*, *u_devices_memory_low*, etc.
Location information	The information such as *u_devices_address*, *u_devices_depth*, *u_devices_received_time*, etc. shall be used to identify the position of underwater devices.
Connectivity information	The information such as *u_devices_network_type*, *u_devices_signal_link_quality*, *u_devices_signal_strength*, etc. shall be used to find the connectivity between the devices in underwater networks.
Message information	The information such as *u_devices_max_size*, *u_devices_rcvd_bits*, etc. shall be used to report total data collected in underwater networks such as the total number of messages received, the total number of messages sent, etc.
Notification information	The information such as *u_devices_event_code*, *u_devices_event_description*, *u_devices_event_name*, *u_devices_event_send_time*, etc. shall be used to describe the critical event information in detail such as event name, event code, event ID, event time, etc.
Notification status	The notification status information shall be used to report the critical situation of underwater devices such as *u_devices_battery_trap*, *u_devices_link_failure_trap*, *u_devices_low_signal_trap*, etc.
Temperature status	The temperature status information shall be used to report the current temperature status of underwater devices such as *u_devices_curr_temp_level*, and *u_devices_notify_temp_limit*.

Table 5 shows the mandatory data types required for designing u-MIB in U-NMS.

Table 5 – Mandatory data type requirements of u-MIB in U-NMS

Types	Description
INTEGER	It indicates the MO value of u-MIB that holds a whole number.
FLOAT	It indicates the MO value of u-MIB which uses the combination of a whole number and a decimal number.
STRING	It indicates the MO value of u-MIB with a sequence of characters, which also includes special characters and numbers.
OBJID	It indicates MO's position in u-MIB
TABLE	It indicates types of data inside columns and variables in u-MIB.
TIME	It indicates the DATETIME value inside the u-MIB as two integers. One represents the date and the other represents the time.
BOOLEAN	It indicates the MO value of u-MIB that holds either one of two values. For example, true or false.
LOCATION	It indicates the MO value of type LOCATION (value1, value2, value3) in u-MIB. Value1, value2, and value3 can be FLOAT data type.

7 Designing the managed objects of manager and agent u-MIB

7.1 Object identifiers of u-MIB

Table 6 depicts the OIDs of u-MIB. The u-MIB information like *u_networks*, *u_networks_connectivity_info*, *u_networks_notification_info*, *u_networks_packets_info*, etc. can be accessed using variables such as *Object Names*, *Type*, *OID*, and *Object Identifier Name*. Here, *u_networks*, *u_networks_connectivity_info*, *u_devices*, etc. are the Object Names, and OBJID is the data type used for accessing the u-MIB information.

Table 6 – OIDs of u-MIB

Object Names	Type	OID	Object Identifier Name
u_networks	OBJID	*1.1*	*u-MIBObjects(1).u_networks(1)*
u_networks_connectivity_info	OBJID	*1.1.1*	*u-MIBObjects(1).u_networks(1).u_networks_connectivity_info(1)*
u_networks_notification_info	OBJID	*1.1.2*	*u-MIBObjects(1).u_networks(1).u_networks_notification_info(2)*
u_networks_packets_info	OBJID	*1.1.3*	*u-MIBObjects(1).u_networks(1).u_networks_packets_info(3)*
u_devices	OBJID	*1.2*	*u-MIBObjects(1).u_devices(2)*
u_devices_battery_info	OBJID	*1.2.1*	*u-MIBObjects(1).u_devices(2).u_devices_battery_info(1)*
u_devices_battery_status	OBJID	*1.2.2*	*u-MIBObjects(1).u_devices(2).u_devices_battery_status(2)*
u_devices_connectivity_info	OBJID	*1.2.3*	*u-MIBObjects(1).u_devices(2).u_devices_connectivity_info(3)*
u_devices_info	OBJID	*1.2.4*	*u-MIBObjects(1).u_devices(2).u_devices_info(4)*
u_devices_location_info	OBJID	*1.2.5*	*u-MIBObjects(1).u_devices(2).u_devices_location_info(5)*
u_devices_memory_info	OBJID	*1.2.6*	*u-MIBObjects(1).u_devices(2).u_devices_memory_info(6)*
u_devices_memory_status	OBJID	*1.2.7*	*u-MIBObjects(1).u_devices(2).u_devices_memory_status(7)*
u_devices_message_info	OBJID	*1.2.8*	*u-MIBObjects(1).u_devices(2).u_devices_message_info(8)*
u_devices_notification_info	OBJID	*1.2.9*	*u-MIBObjects(1).u_devices(2).u_devices_notification_info(9)*
u_devices_notification_status	OBJID	*1.2.10*	*u-MIBObjects(1).u_devices(2).u_devices_notification_status(10)*
u_devices_status	OBJID	*1.2.11*	*u-MIBObjects(1).u_devices(2).u_devices_status(11)*
u_devices_temperature_status	OBJID	*1.2.12*	*u-MIBObjects(1).u_devices(2).u_devices_temperature_status(12)*

7.2 Classification of u-MIB tables

Table 7 depicts the TABLE types used in the u-MIB of U-NMS. The TABLE information like *u_networks_notification_table* and *u_devices_notification_table* can be accessed using variables such as Table Name, Type, OID, and Object Identifier Name. Here, TABLE is the data type that holds a collection of information. For example, *u_networks_notification_table* holds the notification information of underwater networks.

Table 7 – Defining u-MIB tables

Table Names	Type	OID	Object Identifier Name
u_networks_notification_table	TABLE	*1.1.2.3*	*u-MIBObjects(1).u_networks(1).u_networks_notification_info(2).u_networks_notification_table(3)*
u_devices_notification_table	TABLE	*1.2.9.5*	*u-MIBObjects(1).u_devices(2).u_devices_notification_info(9).u_devices_notification_table(5)*

7.3 Classification of MOs in the manager and agent u-MIB

Figure 5 shows the MOs of u-MIB. In u-MIB, the MOs are grouped under *u_networks* and *u_devices*. The *u_networks* is classified into three categories: *u_networks_connectivity_info*, *u_networks_notification_info*, *u_networks_packets_info*. The *u_devices* is classified into twelve categories: *u_devices_battery_info*, *u_devices_info*, *u_devices_location_info*, *u_devices_memory_info*, etc.

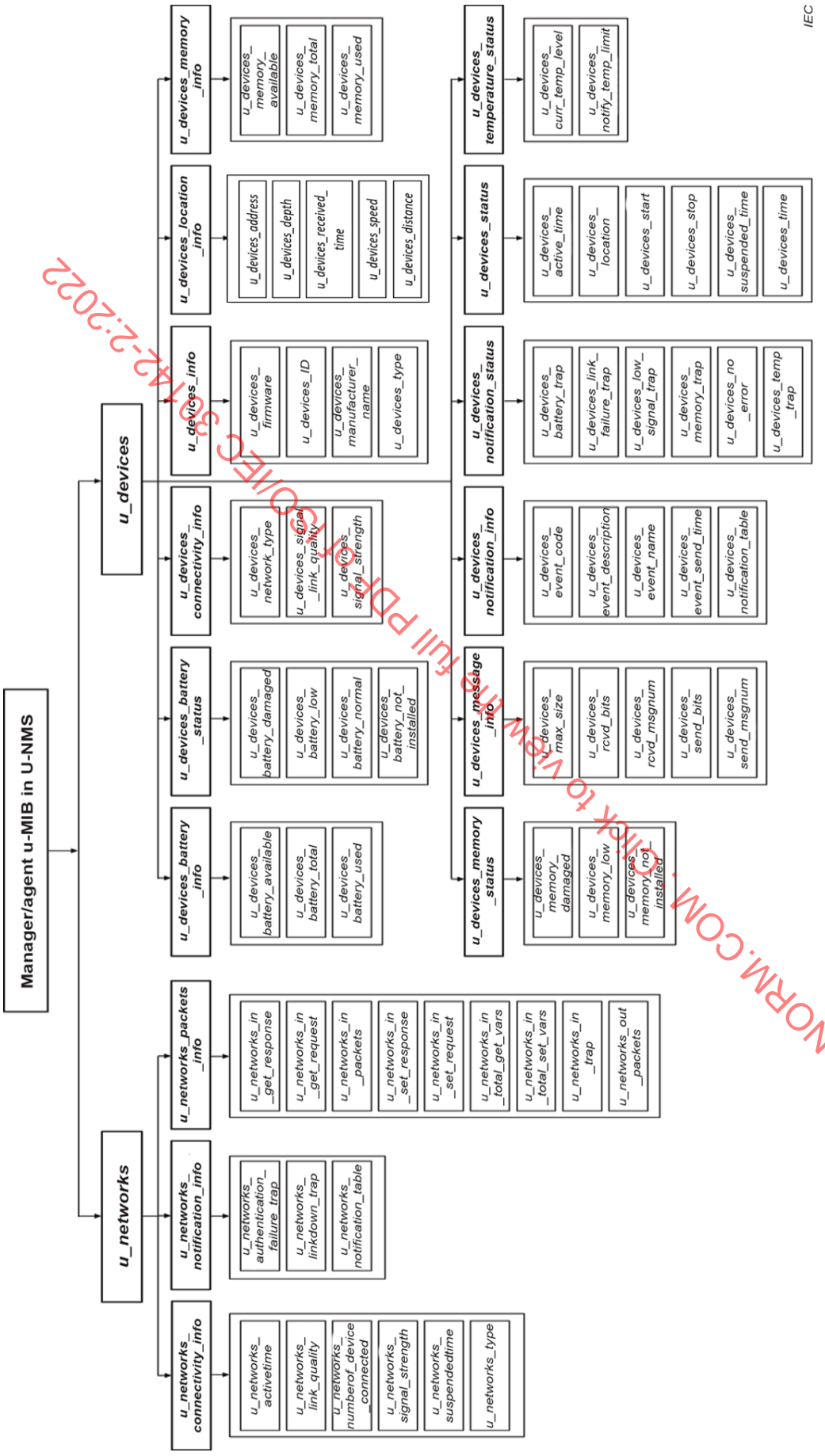

Figure 5 – MOs of the manager and agent u-MIB

Table 8 and Table 9 depict the classification of MOs under the *u_networks* and *u_devices*. For example, in *u_networks*, if the problem occurs in connectivity then the MO value of managed objects such as *u_networks_link_quality*, *u_networks_signal_strength*, *u_networks_suspendedtime*, etc. will be changed in u-MIB. Similarly, in the case of *u_devices*, if the problem occurs with connectivity or battery then the MO values of managed objects such as *u_devices_battery_trap*, *u_devices_link_failure_trap*, *u_devices_low_signal_trap*, etc. will be changed in u-MIB.

Table 8 – MOs of *u_networks*

Object Names	MOs	Data type	OID	Right to access	Description
u_networks_connectivity_info	*u_networks_activetime*	TIME	*1.1.1.1*	read-only	It indicates how long the device was active with the unique *u_networks_type*. For example, how long the device is connected with an acoustic-based network or RF-based network.
	u_networks_link_quality	FLOAT	*1.1.1.2*	read-only	It indicates the link quality between the devices in the acoustic-based network or RF-based network because the network connectivity depends on the link quality of *u_networks_type*.
	u_networks_numberof_device_connected	INTEGER	*1.1.1.3*	read-only	It indicates the number of underwater devices connected to the underwater network. For example, how many devices are connected under the acoustic-based network and how many devices are connected under the RF-based network.
	u_networks_signal_strength	FLOAT	*1.1.1.4*	read-only	It indicates the average received signal strength (RSS) of an acoustic-based network or RF-based network in decibels (dB).
	u_networks_suspendedtime	TIME	*1.1.1.5*	read-only	It indicates when the connectivity was broken under the unique *u_networks_type*. For example, when the device connectivity link was broken under the acoustic-based network or RF-based network.
	u_networks_type	STRING	*1.1.1.6*	read-only	It indicates the type of network connection with underwater devices such as acoustic-based network or RF-based network.
u_networks_notification_info	*u_networks_authentication_failure_trap*	INTEGER	*1.1.2.1*	read-only	It reports the failure when the message sent from the agent to the manager is not authenticated.
	u_networks_linkdown_trap	INTEGER	*1.1.2.2*	read-only	It reports the failure if the communication link of any underwater device went down.
	u_networks_notification_table	INTEGER	*1.1.2.3*	read-write	It updates and stores all the entries inside *u_networks_notification_info*.

Object Names	MOs	Data type	OID	Right to access	Description
u_networks_packets_info	*u_networks_in_get_response*	INTEGER	*1.1.3.1*	read-only	It reports the total number of Get Response accepted and processed by the underwater network management protocol.
	u_networks_in_get_request	INTEGER	*1.1.3.2*	read-only	It reports the total number of Get Request accepted and processed by the underwater network management protocol.
	u_networks_in_packets	INTEGER	*1.1.3.3*	read-only	It reports the total packets received via underwater networks.
	u_networks_in_set_response	INTEGER	*1.1.3.4*	read-only	It reports the total number of Set Response accepted and processed by the underwater network management protocol.
	u_networks_in_set_request	INTEGER	*1.1.3.5*	read-write	It reports the total number of Set Request accepted and processed by the underwater network management protocol.
	u_networks_in_total_get_vars	INTEGER	*1.1.3.6*	read-only	It reports the total number of MOs retrieved successfully using the Get Request method.
	u_networks_in_total_set_vars	INTEGER	*1.1.3.7*	read-write	It reports the total number of MOs altered successfully using Set Request method.
	u_networks_in_trap	INTEGER	*1.1.3.8*	read-only	It reports the total number of Trap received and processed by the underwater network management protocol.
	u_networks_out_packets	INTEGER	*1.1.3.9*	read-only	It reports the total packets transferred via underwater networks.

Table 9 – MOs of *u_devices*

Object Names	MOs	Data type	OID	Right to access	Description
u_devices_battery_info	*u_devices_battery_available*	INTEGER	*1.2.1.1*	read-only	It indicates the remaining power of the individual battery in underwater devices in milliampere hours (mAh).
	u_devices_battery_total	INTEGER	*1.2.1.2*	read-only	It indicates the total power of the individual battery in underwater devices in milliampere hours (mAh).
	u_devices_battery_used	INTEGER	*1.2.1.3*	read-only	It indicates the used power of the individual battery in underwater devices in milliampere hours (mAh).
u_devices_battery_status	*u_devices_battery_damaged*	INTEGER	*1.2.2.1*	read-only	It reports if there is some physical damage of batteries in underwater devices.
	u_devices_battery_low	INTEGER	*1.2.2.2*	read-only	It reports the battery charge is low. So, battery replacement or battery recharging is important in this situation.
	u_devices_battery_normal	INTEGER	*1.2.2.3*	read-only	It reports the battery has no problem, i.e. the battery working is normal for each underwater device.
	u_devices_battery_not _installed	INTEGER	*1.2.2.4*	read-only	It reports the battery is not installed in a particular underwater device, i.e. it indicates the battery in a particular underwater device got broken or damaged due to collision in the underwater environment.
u_devices_connectivity_info	*u_devices_network_type*	STRING	*1.2.3.1*	read-only	It indicates the type of network connection with underwater devices such as acoustic-based network or RF-based network.
	u_devices_signal_link_quality	INTEGER	*1.2.3.2*	read-only	It indicates the link quality between the devices in the acoustic-based networks or RF-based networks.
	u_devices_signal_strength	INTEGER	*1.2.3.3*	read-only	It indicates the average received signal strength (RSS) of acoustic-based networks or RF-based networks in decibels (dB).
u_devices_info	*u_devices_firmware*	STRING	*1.2.4.1*	read-write	It indicates the current firmware version of underwater devices.
	u_devices_ID	INTEGER	*1.2.4.2*	read-write	It indicates the identification number of underwater devices.
	u_devices_manufacturer_name	STRING	*1.2.4.3*	read-only	It indicates the manufacturer's name of underwater devices.
	u_devices_type	STRING	*1.2.4.4*	read-only	It indicates the type of underwater devices such as UUVs, UWA-GW, UWA-CH, UWA-SNode, etc.

Object Names	MOs	Data type	OID	Right to access	Description
u_devices_location_info	*u_devices_address*	STRING	*1.2.5.1*	read-write	It indicates the address of underwater devices.
	u_devices_depth	FLOAT	*1.2.5.2*	read-write	It indicates the depth between UWA-CH/UUV/UWA-SNode and UWA-GW to find the exact deployment depth of each node.
	u_devices_received_time	TIME	*1.2.5.3*	read-write	It indicates the received time or the reflected time of the acoustic signal in seconds to find the exact distance between the underwater devices.
	u_devices_speed	FLOAT	*1.2.5.4*	read-write	It indicates the speed of the transmitted signal.
	u_devices_distance	FLOAT	*1.2.5.5*	read-write	It indicates the distance between two nodes, such as UWA-CH/UUV/UWA-SNode and UWA-GW to find the exact location of each node.
u_devices_memory_info	*u_devices_memory_available*	INTEGER	*1.2.6.1*	read-only	It indicates the available memory space in underwater devices in megabytes (MB) or gigabytes (GB).
	u_devices_memory_total	INTEGER	*1.2.6.2*	read-only	It indicates the total memory space in underwater devices in megabytes (MB) or gigabytes (GB).
	u_devices_memory_used	INTEGER	*1.2.6.3*	read-only	It indicates the used memory space in underwater devices in megabytes (MB) or gigabytes (GB).
u_devices_memory_status	*u_devices_memory_damaged*	INTEGER	*1.2.7.1*	read-only	It reports the memory storage in underwater devices might be broken (some problem in memory).
	u_devices_memory_low	INTEGER	*1.2.7.2*	read-only	It reports the storage memory level is low in underwater devices. So, formatting is important in this situation.
	u_devices_memory_not_installed	INTEGER	*1.2.7.3*	read-only	It reports the memory was not installed or crashed in a particular underwater device.
u_devices_message_info	*u_devices_max_size*	INTEGER	*1.2.8.1*	read-only	It reports the maximum size of the data collected by the devices in bits.
	u_devices_rcvd_bits	INTEGER	*1.2.8.2*	read-only	It reports the size of the data received from the devices in bits.
	u_devices_rcvd_msgnum	INTEGER	*1.2.8.3*	read-only	It reports the total number of messages received from the devices through the network.
	u_devices_send_bits	INTEGER	*1.2.8.4*	read-only	It reports the size of the data sent from the devices in bits.
	u_devices_send_msgnum	INTEGER	*1.2.8.5*	read-only	It reports the total number of messages sent by the devices through the network.

Object Names	MOs	Data type	OID	Right to access	Description
u_devices_notification_info	*u_devices_event_code*	INTEGER	*1.2.9.1*	read-only	It indicates the unique code of each event in underwater devices.
	u_devices_event_description	INTEGER	*1.2.9.2*	read-only	It indicates a detailed description of the error event occurring in underwater devices.
	u_devices_event_name	INTEGER	*1.2.9.3*	read-only	It indicates the device's event name such as memory problem, battery problem, etc.
	u_devices_event_send_time	TIME	*1.2.9.4*	read-only	It indicates the last time the event was generated in underwater devices.
	u_devices_notification_table	INTEGER	*1.2.9.5*	read-only	It updates and stores all the entries inside *u_devices_notification_info*.
u_devices_notification_status	*u_devices_battery_trap*	INTEGER	*1.2.10.1*	read-only	It reports a low battery level in underwater devices.
	u_devices_link_failure_trap	INTEGER	*1.2.10.2*	read-only	It reports the connectivity problem between underwater devices.
	u_devices_low_signal_trap	INTEGER	*1.2.10.3*	read-only	It reports if the devices receive a low RSS value.
	u_devices_memory_trap	INTEGER	*1.2.10.4*	read-only	It reports out-of-memory space problems in underwater devices.
	u_devices_no_error	INTEGER	*1.2.10.5*	read-only	It reports no error in underwater devices.
	u_devices_temp_trap	INTEGER	*1.2.10.6*	read-only	It reports if the temperature is increased and extends its threshold value. This increase in temperature can cause the failure of devices.
u_devices_status	*u_devices_active_time*	TIME	*1.2.11.1*	read-only	It reports the active connection time of a unique underwater device.
	u_devices_location	LOCATION	*1.2.11.2*	read-only	It reports the installed location of underwater devices.
	u_devices_start	BOOLEAN	*1.2.11.3*	read-only	It indicates that the device starts its working process and collects the device management resources such as battery level, memory level, etc.
	u_devices_stop	BOOLEAN	*1.2.11.4*	read-only	It indicates that the device stops its working process to collect the management resources from underwater devices.
	u_devices_suspendedtime	TIME	*1.2.11.5*	read-only	It reports the connection suspended time of a unique underwater device.
	u_devices_time	TIME	*1.2.11.6*	read-write	It reports the current time of underwater devices by increasing the time value in seconds.
u_devices_temperature_status	*u_devices_curr_temp_level*	INTEGER	*1.2.12.1*	read-only	It indicates the current temperature of underwater devices in Celsius.
	u_devices_notify_temp_limit	INTEGER	*1.2.12.2*	read-only	It indicates the limit value of temperature in Celsius. It is useful when the temperature crosses its threshold in underwater devices.

7.4 MOs of u-MIB Trap

The subagent uses the *event_trap* object to report underwater system errors to the manager. If a critical error occurs, the subagent issues an *event_trap* that reports the failure of networks and devices to the manager. The subagent indicates the error by reporting the information such as device name, serial number, code, etc. as shown in Table 10.

Figure 6 shows the hierarchical format for designing of *event_trap* module.

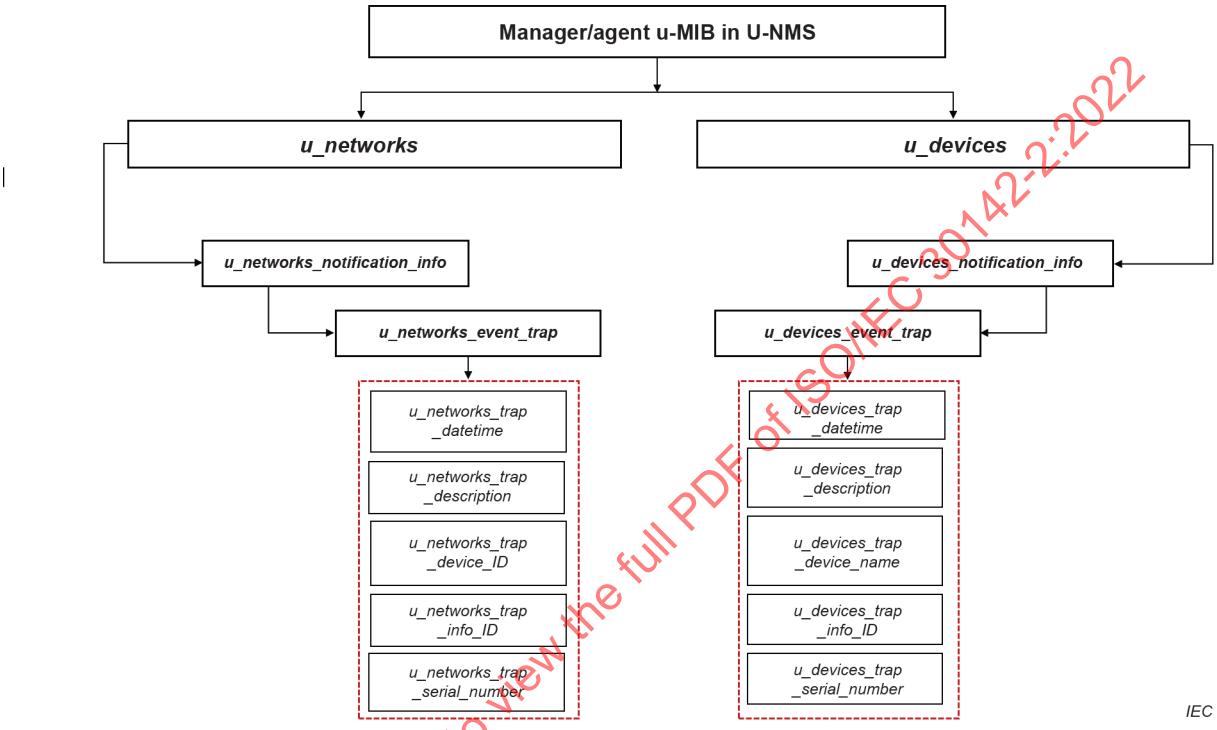

Figure 6 – Structure of *event_trap*

Table 10 – MOs of *u_trap* object in u-MIB

Name	Type	Description
u_devices_trap_datetime	TIME	It indicates the DAY, MONTH, YEAR, and TIME when the failure occurs.
u_devices_trap_description	STRING	It indicates the detailed reason for failure.
u_devices_trap_device_ID	STRING	It indicates the name of a device that sends a trap message.
u_devices_trap_info_ID	INTEGER (OBJECT IDENTIFIER)	It denotes the part where the failure occurs.
u_devices_trap_serial_number	STRING	It indicates the product number of devices that suffer a failure.

8 Integrating MOs of the manager and agent u-MIB

Figure 7 shows the integration of MOs in u-MIB. The u-MIB is integrated inside the components of U-NMS such as the manager, proxy agent, master agent, and subagent. The manager is integrated with manager u-MIB which consists of MOs such as *u_networks_numberof_devices_connected*, *u_networks_activetime*, etc. The proxy agent and master agent are integrated with agent u-MIB which consists of MOs such as *u_devices_ID*, *u_devices_manufacturer_name*, etc. and the subagent is integrated with *u_trap* MIB which consists of components such as *u_devices_trap_serial_number*, *u_devices_trap_device_ID*, *u_devices_datetime*, etc. The MOs from the agent can be accessed based on the request from the manager. The *u_trap* will send the notification message if any critical situation occurs in subagent devices.

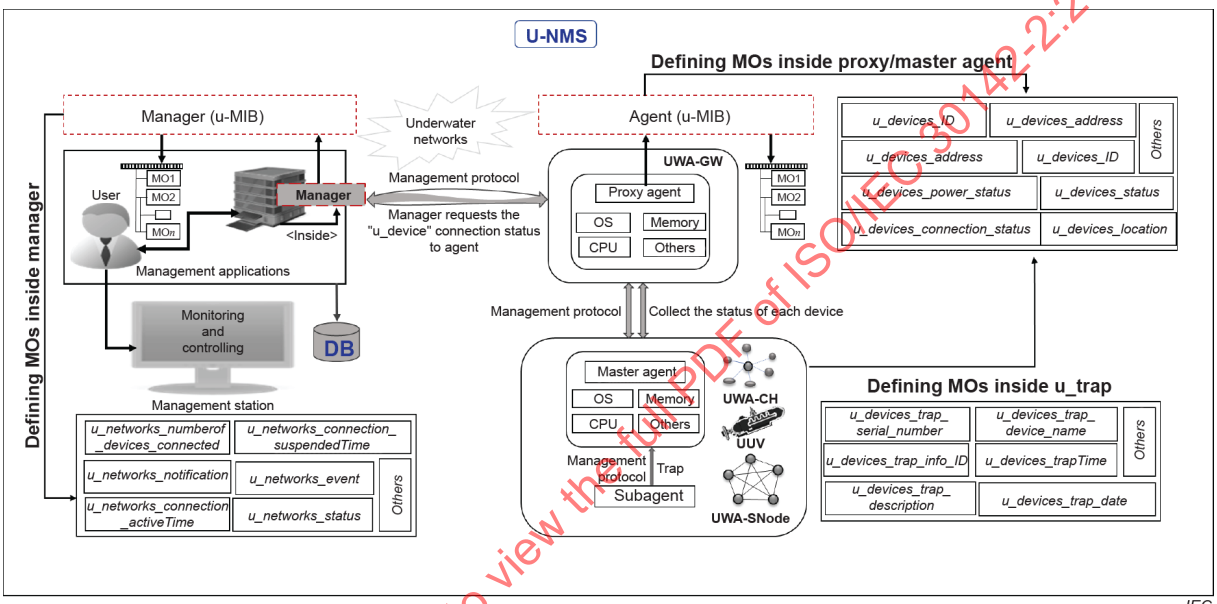

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Figure 7 – Integration of MOs between manager and agent u-MIB

Figure 8 shows the process of exchanging MOs between underwater devices in U-NMS via the network management protocol. The system comprises the manager, proxy agent, master agent, and subagent. The proxy agent collects all information such as underwater device status, power status, memory status, connection status, etc. At the request of the manager, the proxy agent will send the response message to the manager. Using the response information, the manager can analyse and control the problems of underwater devices in U-NMS.

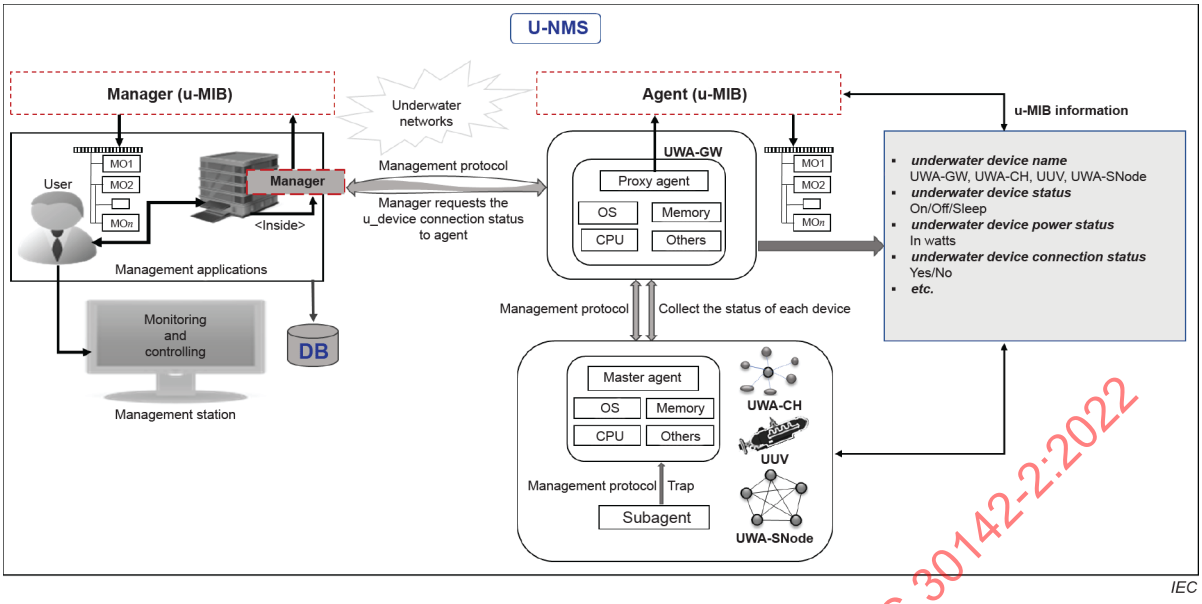

Figure 8 – MOs' requests via the network management protocol

Annex A
(informative)

u-MIB Module

A.1 Example of creating u-MIB objects

Object resource information of u_networks is the collection of objects which describe the underwater networks entities. It contains the information about *u_networks_connectivity_info*, *u_networks_notification_info and u_networks_packets_info*. 'OBJECT IDENTIFIER::= {u-MIB}' indicates the hierarchy or complete path of OID is under u-MIB.

a) *u_networks_connectivity_info* OBJECT IDENTIFIER::= {u-MIB}

u_networks_activetime OBJECT-NAME

DATA-TYPE TIME

RIGHT-TO-ACCESS read-only

STATUS-INDICATOR mandatory

OBJECT-DESCRIPTION

"It indicates how long the device was active with the unique u_networks_type. For example, how long the device connected with an acoustic-based network or RF-based network."

::= { *u_networks_connectivity_info 1* }

u_networks_signal_strength OBJECT-NAME

DATA-TYPE INTEGER

RIGHT-TO-ACCESS read-only

STATUS-INDICATOR mandatory

OBJECT-DESCRIPTION

"It indicates the average received signal strength (RSS) of acoustic-based network or RF-based networks in decibels (dB)."

::= { *u_networks_connectivity_info* 4 }

u_networks_type OBJECT-NAME

DATA-TYPE STRING

RIGHT-TO-ACCESS read-only

STATUS-INDICATOR mandatory

OBJECT-DESCRIPTION

"It indicates the type of network connection with underwater devices such as acoustic-based network or RF-based network. '1' indicates acoustic-based network and '2' indicates RF-based network."

::= { *u_networks_connectivity_info* 6 }

b) *u_networks_notification_info* OBJECT IDENTIFIER::= {u-MIB}

u_networks_authentication_failure_trap OBJECT-NAME
DATA-TYPE INTEGER
RIGHT-TO-ACCESS read-only
STATUS-INDICATOR mandatory
OBJECT-DESCRIPTION
"It reports the failure, when the message sent from the manager to the agent is not authenticated. Error code '2' indicates the manager is not authenticated."
::= { *u_networks_notification_info* 1 }

u_networks_linkdown_trap OBJECT-NAME
DATA-TYPE INTEGER
RIGHT-TO-ACCESS read-only
STATUS-INDICATOR mandatory
OBJECT-DESCRIPTION
"It reports the failure if the communication link of any underwater device went down. Error code '1' indicates the link failure in devices."
::= { *u_networks_notification_info* 2 }

u_networks_notification_table OBJECT-NAME
DATA-TYPE INTEGER
RIGHT-TO-ACCESS read-only
STATUS-INDICATOR mandatory
OBJECT-DESCRIPTION
"It updates and stores all the entries inside *u_networks_notification_info*."
::= { *u_networks_notification_info* 3 }

c) *u_networks_packets_info* OBJECT IDENTIFIER::= {u-MIB}

u_networks_in_packets OBJECT-NAME
DATA-TYPE INTEGER
RIGHT-TO-ACCESS read-only
STATUS-INDICATOR mandatory
OBJECT-DESCRIPTION
"It reports the total packets received via underwater networks."
::= { *u_networks_packets_info* 3 }