

# Interworking between IP-based network and underwater network

Sept. 2020

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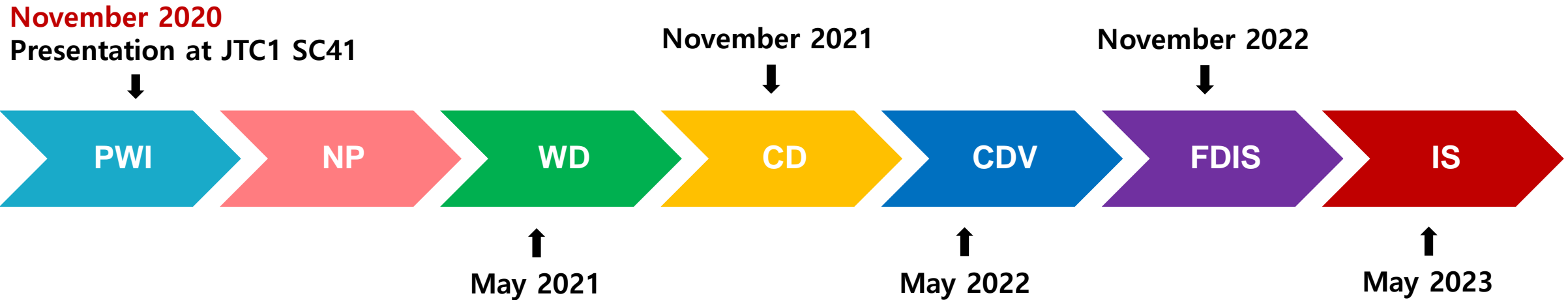
# Outline

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- **Timeline**
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- **Scope & needs**
- **Concepts**
  - **Integration of IP-based network and underwater network**
  - **Interworking functional entities between IP-based network and underwater network**
  - **Core operations for IP-based network and underwater network interworking**

## Timeline

### 1. Standard Development Roadmap



- \* PWI (New work item Proposal)
- \* NP (New work item Proposal)
- \* WD (Working Draft)
- \* CD (Committee Draft)
- \* CDV (Committee Draft for Vote)
- \* FDIS (Final Draft International Standard)
- \* IS (International Standard) publication

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## Scope and needs

### 3. Scope

This document defines the key operations of gateway for interworking.

It further provides an interworking between IP-based network and underwater network.

It specifies following:

- **Integration** of IP-based network and underwater network;
- **Interworking functional entities** between IP-based network and underwater network;
- **Core operations** for IP-based network and underwater network interworking.

### 4. Needs

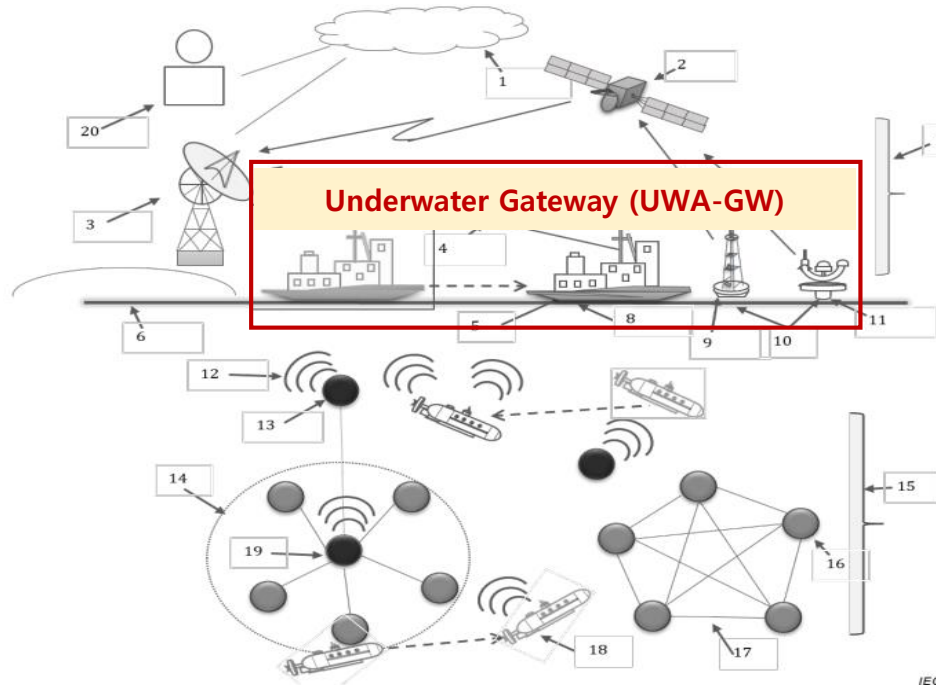
The full interoperability aspect was described in ISO/IEC 30140-4.

However, a detailed description of the connection between the ground and underwater networks, such as delay and disruption tolerant network (DTN), has been omitted and needs to be defined specifically.

# Concepts (1/19)

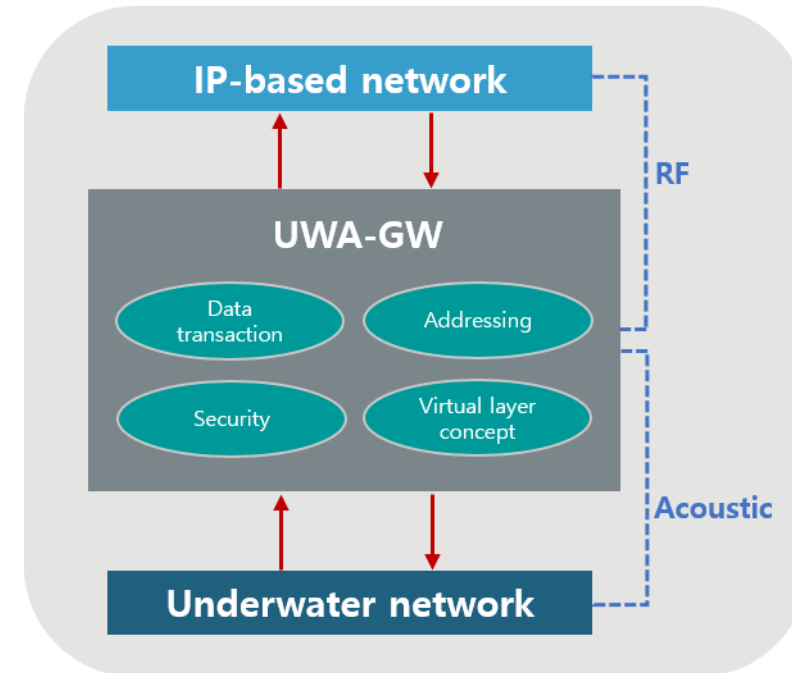
## 5. Integration of IP-based network and underwater network

### □ Conceptual Architecture



IEC

ISO/IEC 30140-1:2018



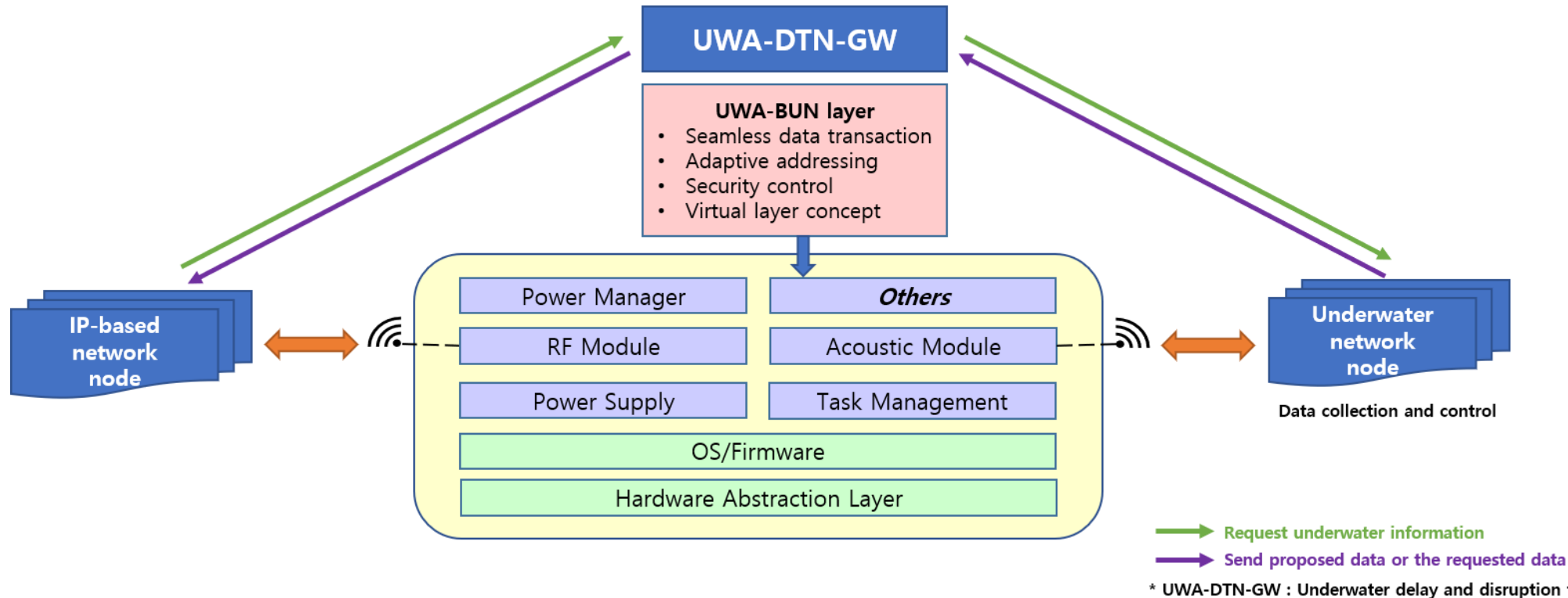


## Concepts (2/19)

# 6. Interworking functional entities between IP-based network and underwater network

## □ Gateway

- Gateway performs crucial functions such as device connectivity, protocol translation, data filtering and processing, security, updating, management, etc.



## Concepts (3/19)

# 6. Interworking functional entities between IP-based network and underwater network

## □ Gateway

### Gap Analysis of Underwater Gateway

Area	Gap	30140 Series (UWASN)	Proposed New Item
Viewpoint	○	Covers overall Interoperability element in UWASN domain	Plays a key role in interworking between heterogenous networks
Classification	○	Focuses on connectivity	Be a nondisruptive data processing and follow-up
Functions	◐	Includes high-level main functions	Contains descriptions and details to support functions
Requirements	●	Describes the three networks classified of UWASN	Presents details based on IP-based and underwater networks
Operations	○	Be not included	Shows detailed interworking operations
DTN	◐	Depicts the concept	Deals with the DTN process in detail
Addressing	○	Be not included	Introduces an adaptive addressing transaction
Virtual layer	○	Be not included	Carries out significant functions in interworking

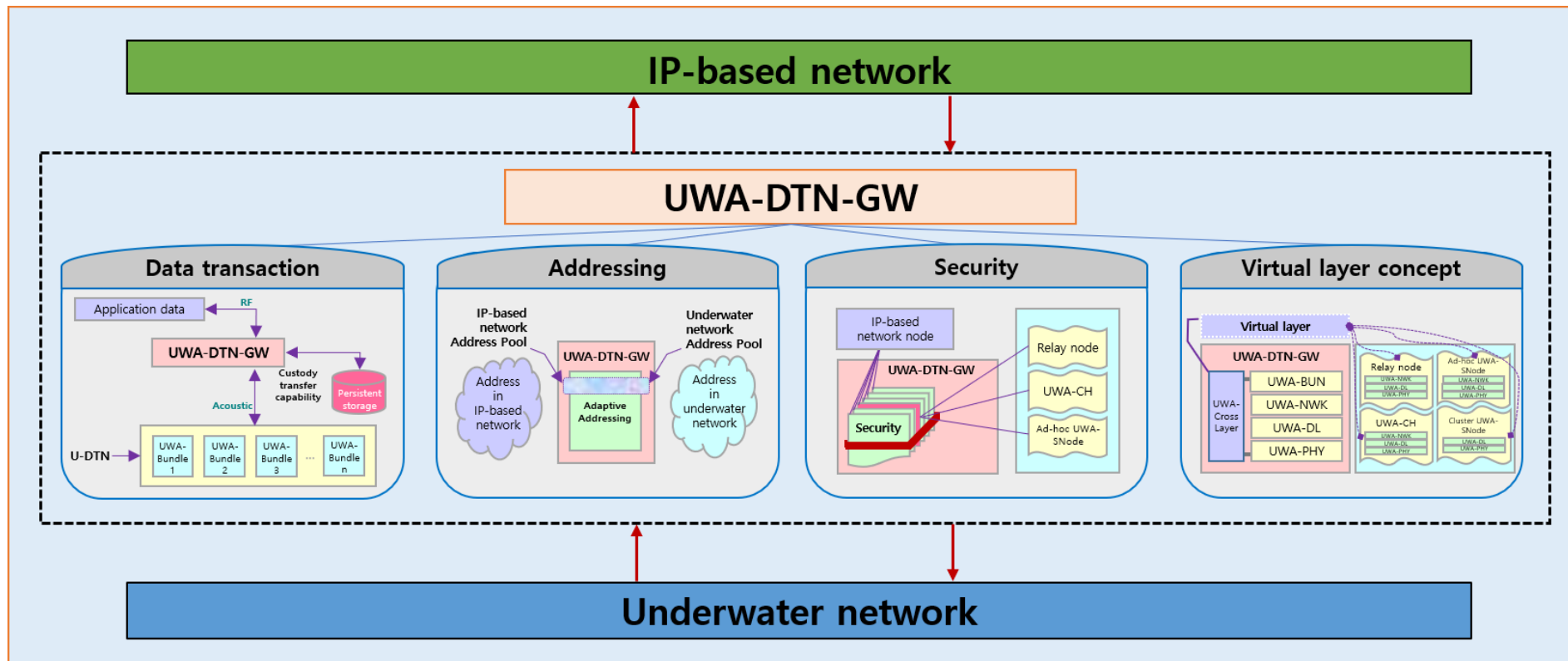
●=Few Gaps   ◐=Partial Gaps   ○=Significant Gaps



## Concepts (4/19)

### 6. Interworking functional entities between IP-based network and underwater network

#### □ Conceptual Interworking of Underwater delay and disruption tolerant network Gateway (UWA-DTN-GW)

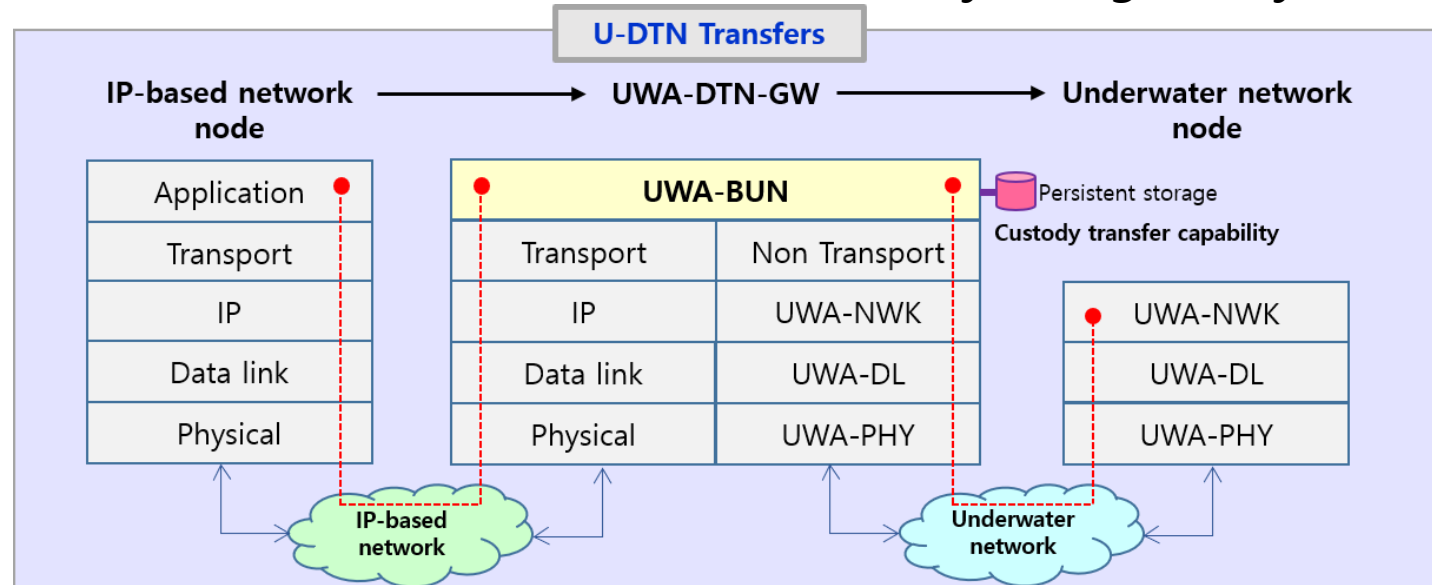


## Concepts (5/19)

### 6. Interworking functional entities between IP-based network and underwater network

#### □ Underwater delay and disruption tolerant network (U-DTN)

- (ISO/IEC 30140-3:2018) DTN is used for heterogeneous communication to transmit asynchronous messages. It introduces bundle layer, which allows communication between different network protocol stacks. **UWA-DTN-GW** acts as a consistent communication medium for interconnection messages.
- After receiving the data, it is forwarded to the different network's destination **through the gateway**. If a connection is unestablished, UWA-BUN layer in gateway stores the data.

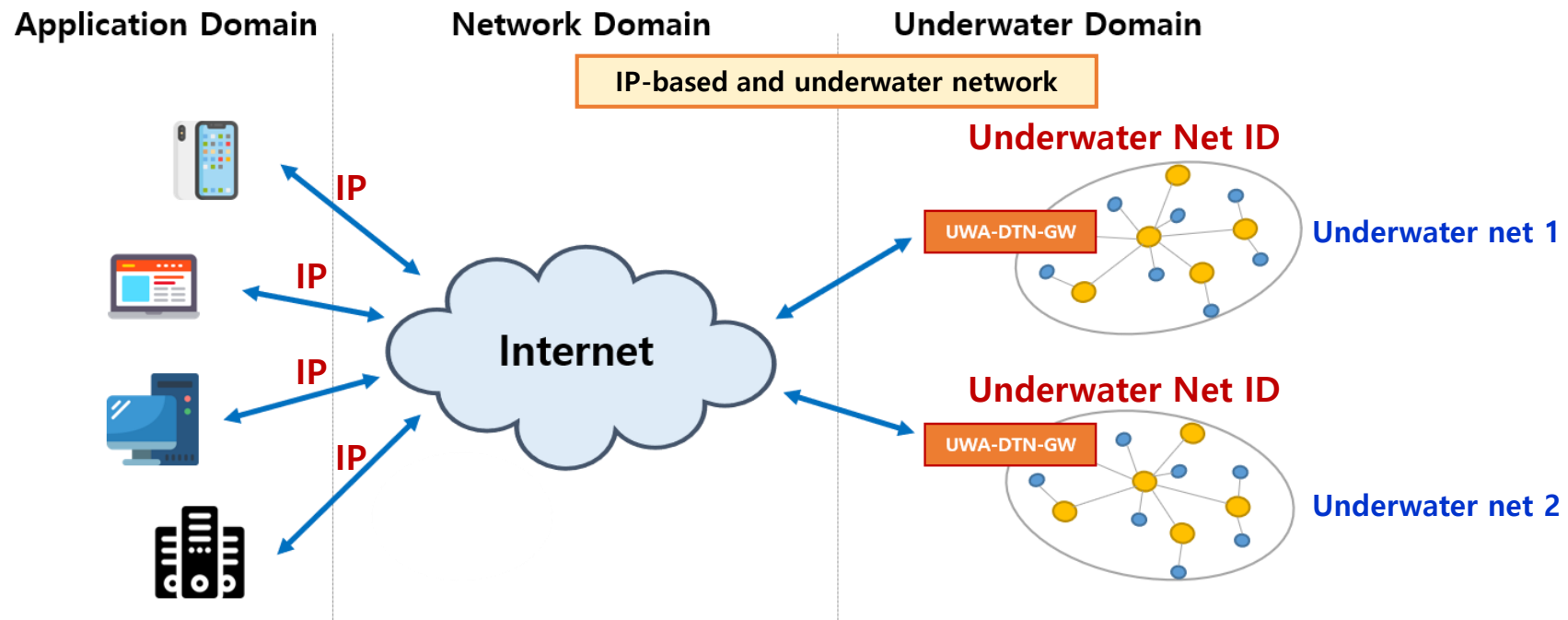


# Concepts (6/19)

## 6. Interworking functional entities between IP-based network and underwater network

### □ Adaptive addressing

- Communication between terrestrial and underwater networks can be used to provide IoT services in various objects and connectivity to this shall be ensured.

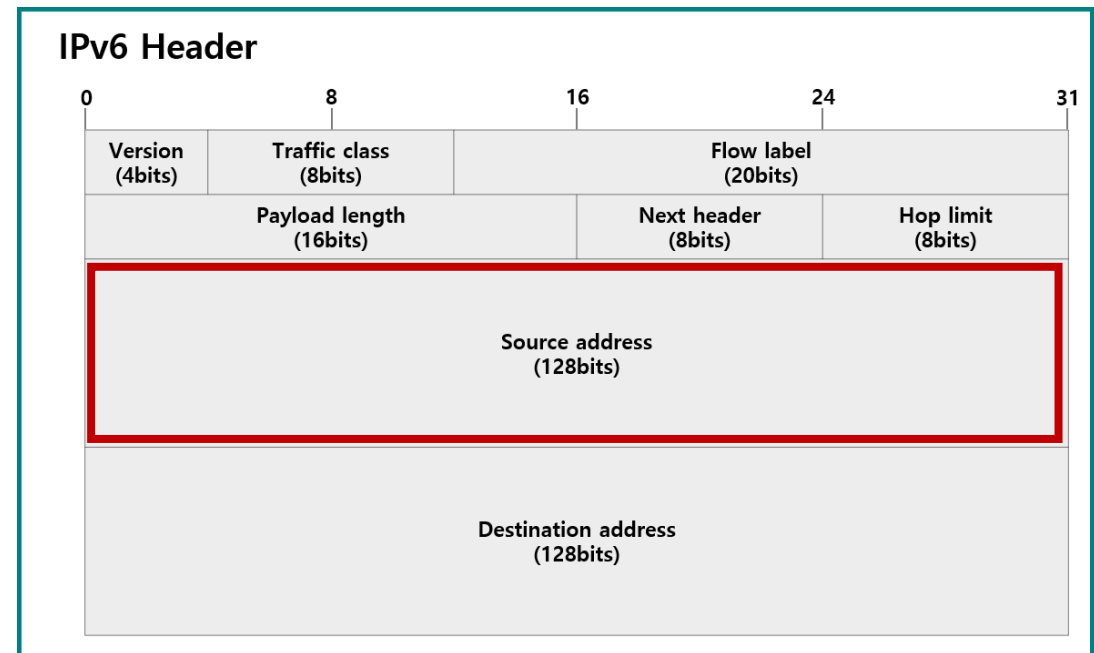
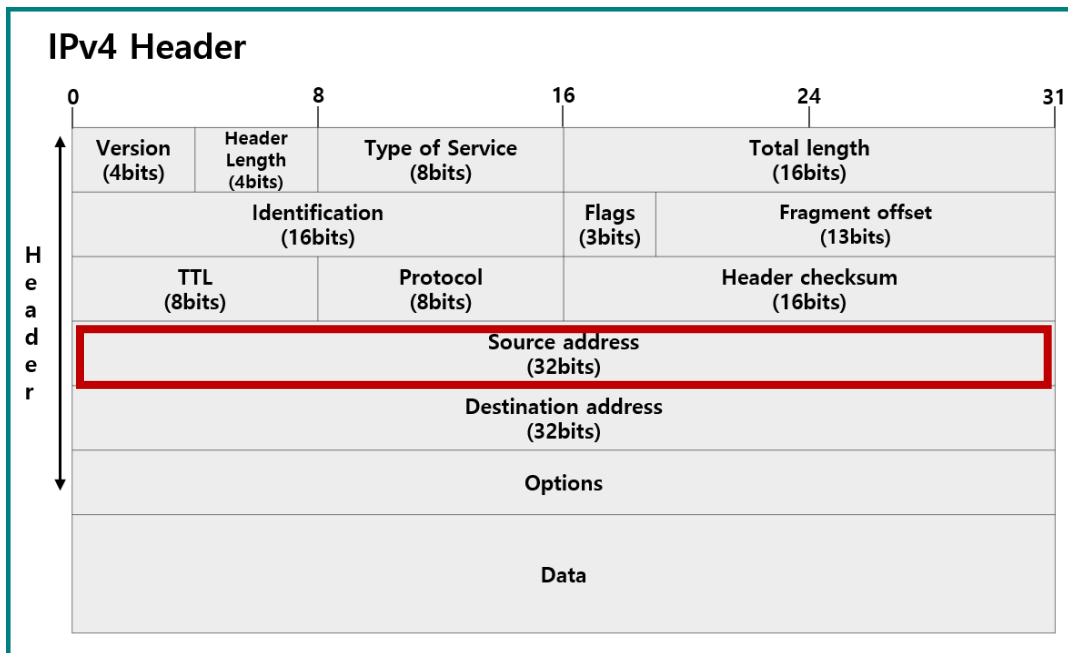


# Concepts (7/19)

## 6. Interworking functional entities between IP-based network and underwater network

### □ Adaptive addressing

- **IoT Devices are assigned a unique IP address for identification and location definition.**
  - Internet Protocol version 4 (IPv4) and Internet Protocol version 6 (IPv6) are the most popularly used versions of the Internet Protocol (IP).





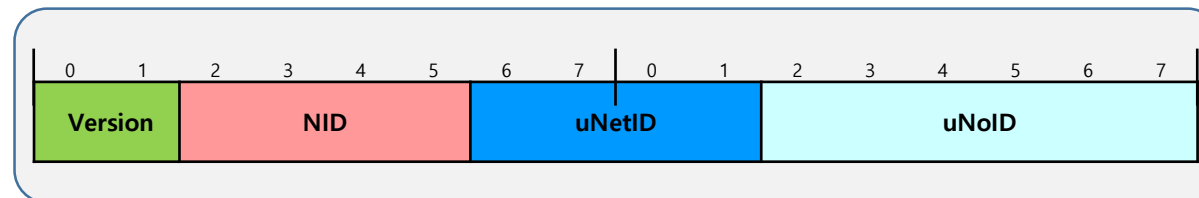
## Concepts (8/19)

# 6. Interworking functional entities between IP-based network and underwater network

## □ Adaptive addressing

### - Lightweight address for underwater network

- It is customized for underwater network to be compatible with different network environments.
- UWA-DTN-GW can distinguish the unique identity and quality of underwater network by utilizing the UWA-Cross Layer. Moreover, it can be useful to notice the change of topology in underwater network.
- In particular, Cluster UWA-SNode has only UWA-PHY and UWA-DL, so address of IP-based network cannot be used. Therefore, customized addressing will be a crucial scheme for interworking in harsh environment.

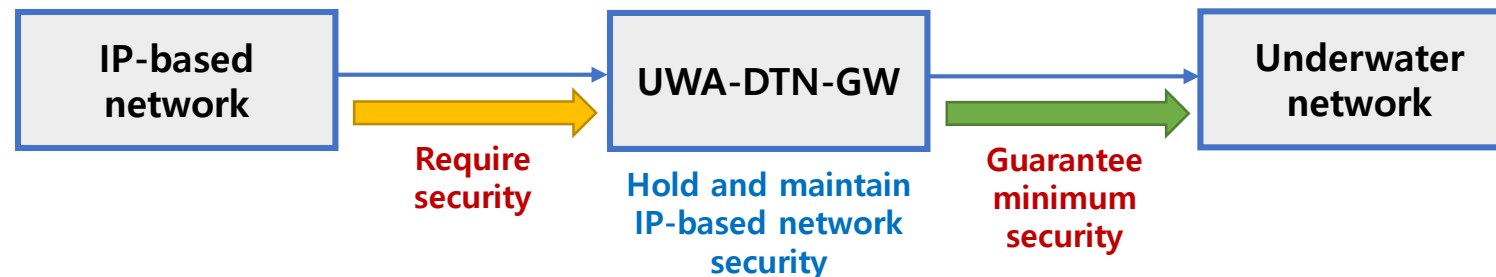


## Concepts (9/19)

# 6. Interworking functional entities between IP-based network and underwater network

## □ Security

- Security and privacy are important issues because underwater sensor networks are typically deployed in harsh environment. Most underwater localization schemes are vulnerable to many attacks.
- Therefore, it is necessary to provide functions such as authentication, privacy, and security for connection of underwater IoT devices with IP-based IoT devices.
- However, it is difficult to accommodate all security modules in underwater network due to the condition of heterogenous networks. Thus, a minimum of security modules is required, such as protecting attacks from DTN resource module or depriving the overhearing module.



## Concepts (10/19)

# 7. Core operations for IP-based network and underwater network interworking

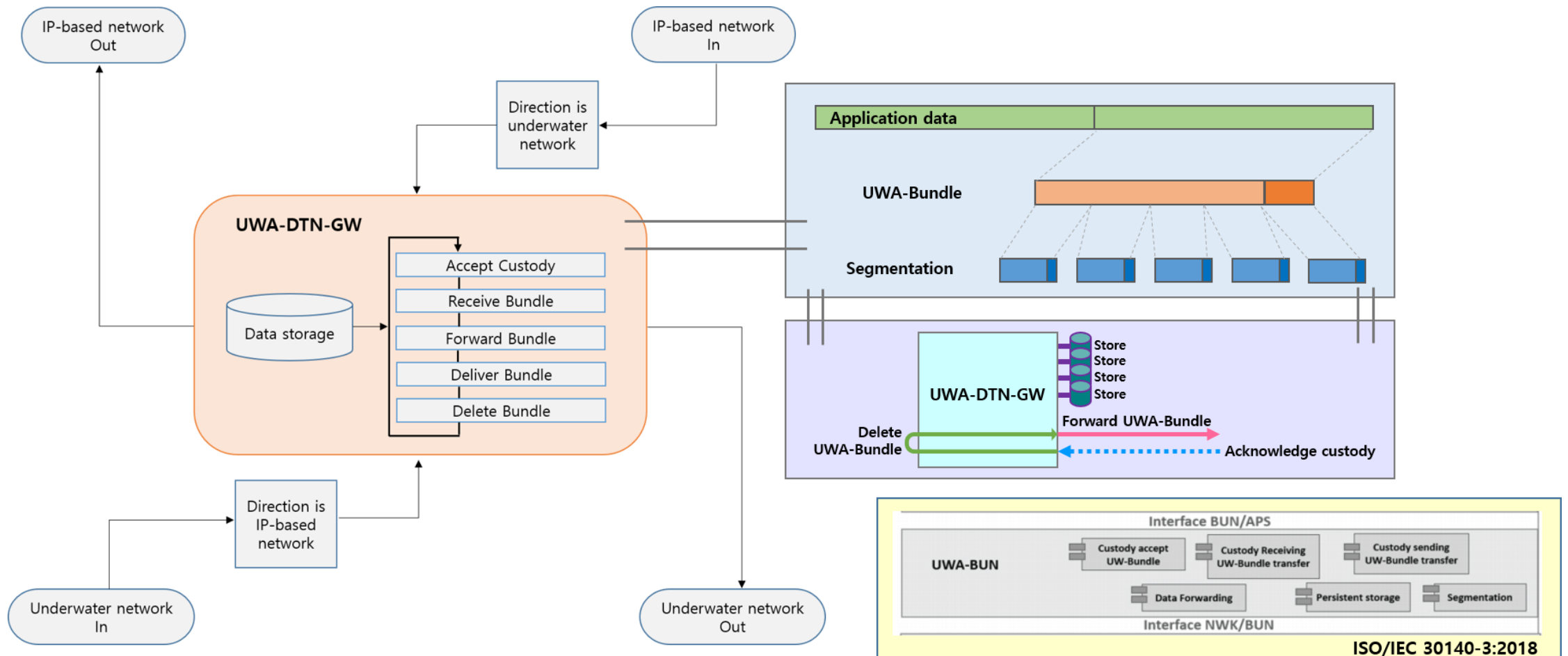
## □ U-DTN

- (ISO/IEC 30140-3:2018) UWA-BUN is transmitted using a store-and-forward approach.
  - **Custody accept UWA-Bundle**
    - This is sent by a candidate custodian after accepting the custody transfer of the underwater bundle.
  - **Segmentation**
    - The UWA-BUN layer divides a bundle into smaller segments to maximize the probability that each can be delivered to the destination correctly.
  - **Data forwarding**
    - After receiving an underwater bundle from a source node, these bundles are forwarded to the destination node via intermediate nodes.
  - **Convergence layer adapter**
    - In each of the corresponding protocols, functions required to carry UWA-DTN protocol data units or UWA-Bundles are provided by protocol specific convergence layer adapters.
  - **Persistent storage**
    - After receiving the data, the UWA-BUN layer stores the data until a connection is established.

# Concepts (11/19)

## 7. Core operations for IP-based network and underwater network interworking

### □ U-DTN

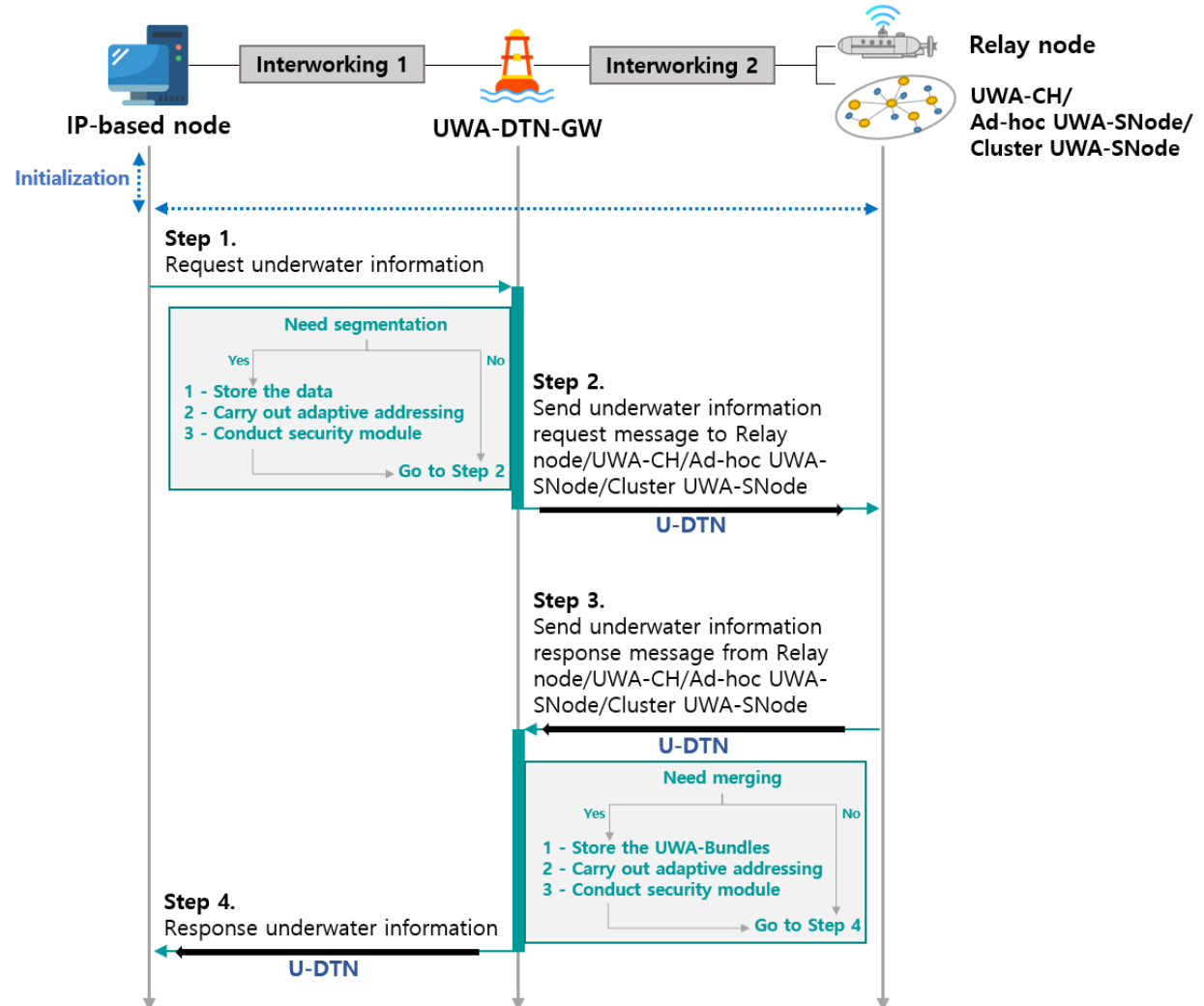
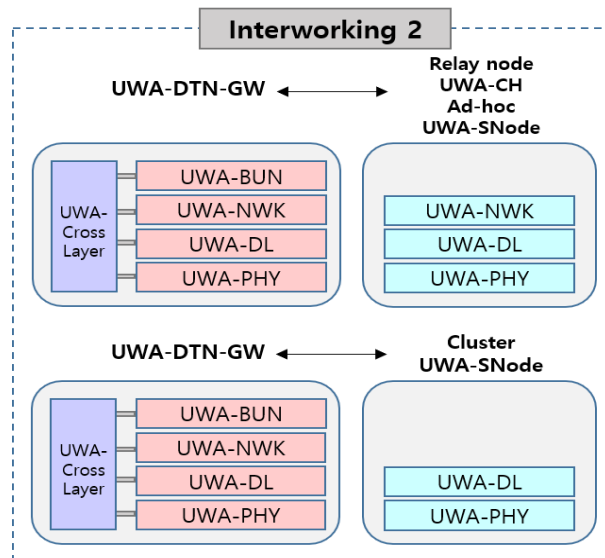
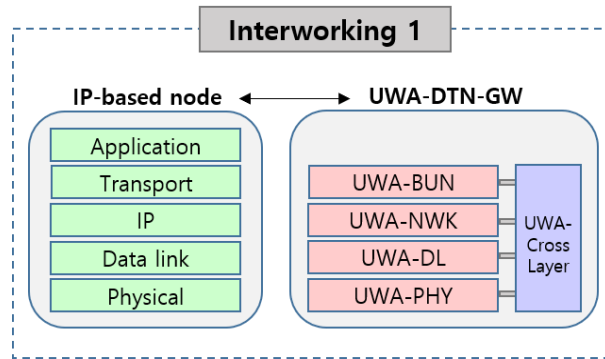




# Concepts (12/19)

## 7. Core operations for IP-based network and underwater network interworking

### □ U-DTN

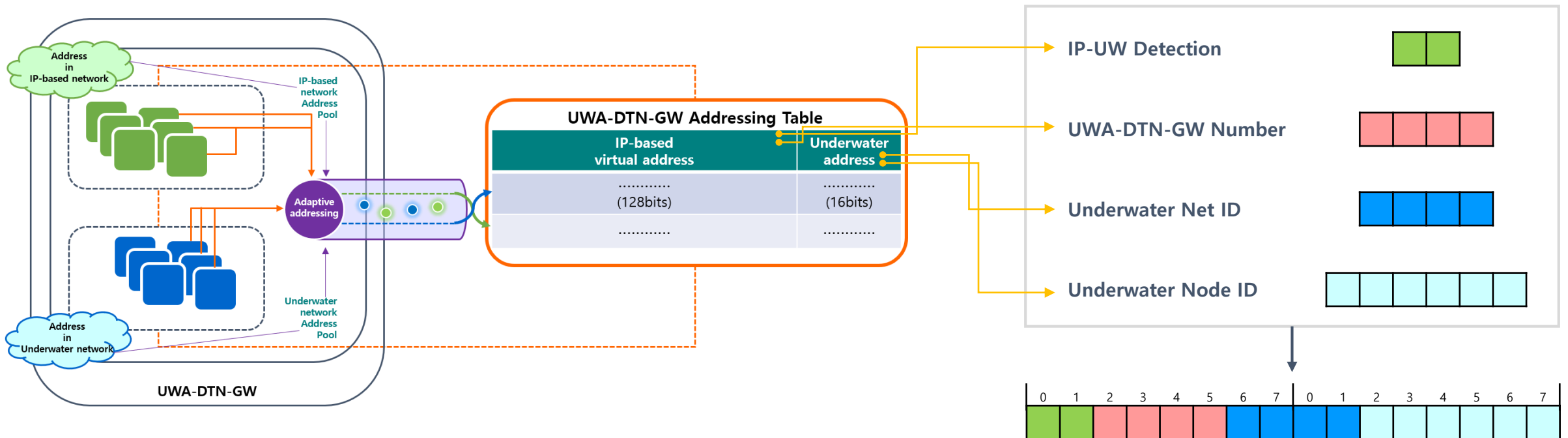


# Concepts (13/19)

## 7. Core operations for IP-based network and underwater network interworking

### □ Adaptive addressing

- For effective interworking in heterogenous networks, UWA-DTN-GW supports its own virtual addressing table, which is used to change to IP-based and underwater adaptive address. It is important for efficient delivery and processing of data in end-to-end communication.

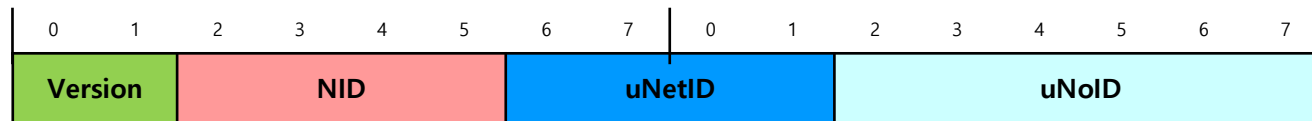


# Concepts (14/19)

## 7. Core operations for IP-based network and underwater network interworking

### □ Adaptive addressing

- A summary of the contents of the adaptive underwater address follows:

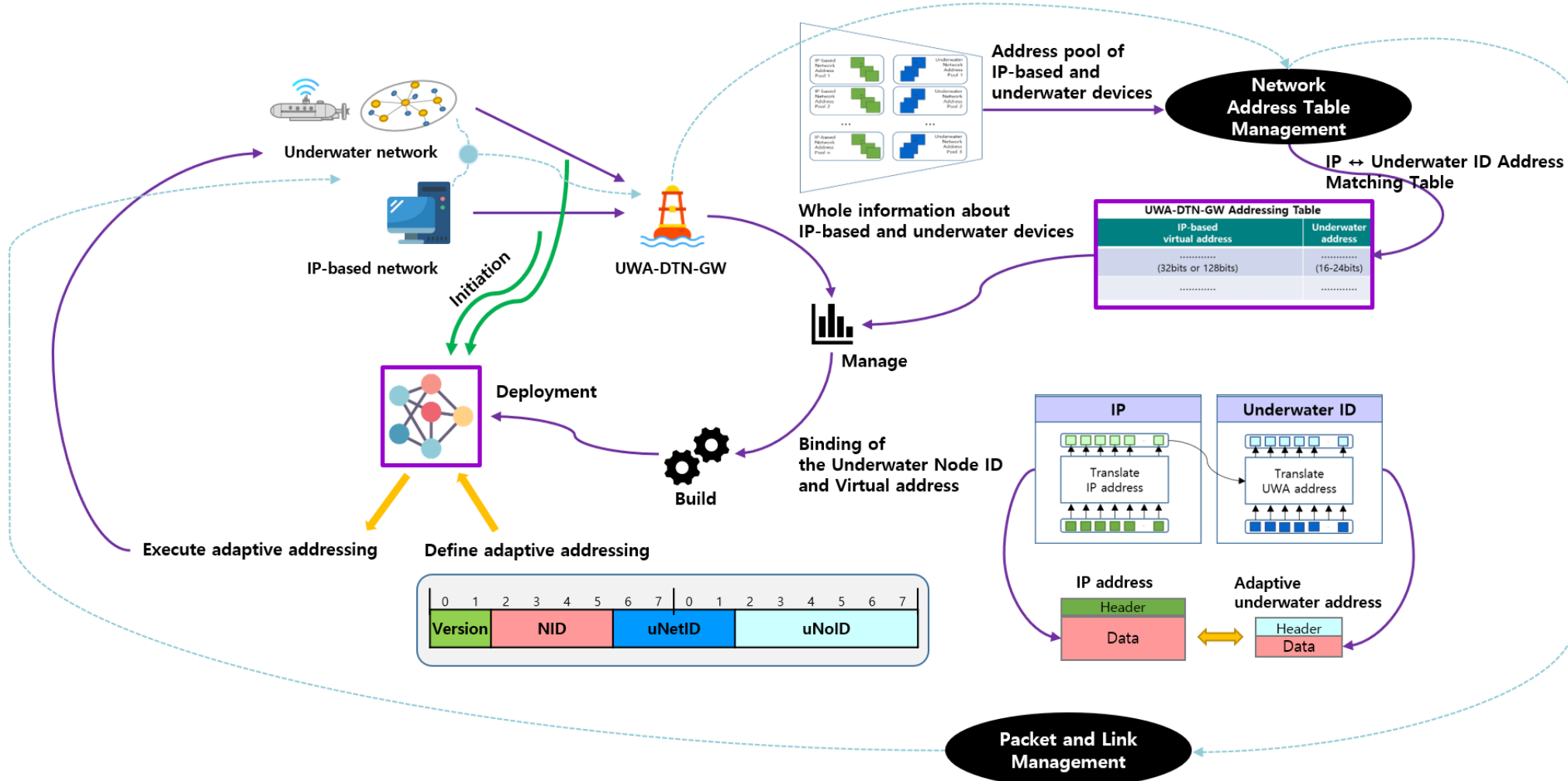


- **Version: 2 bits**
  - The Version field indicates whether the received data is underwater network address.
    - 00 – UWA-DTN-GW
    - 01 – AUV (autonomous underwater vehicle)
    - 10 – UWA-CH or Relay node
    - 11 – Ad-hoc UWA-SNode
- **NID: 4 bits**
  - Network ID means the unique ID of UWA-DTN-GW (up to 16 UWA-DTN-GWs).
- **uNetID: 4 bits**
  - It is composed of the underwater sub-network number (up to 16 sub-networks).
- **uNoID: 6 bits**
  - It indicates the unique name (number) of underwater devices (up to 64 node IDs).

# Concepts (15/19)

## 7. Core operations for IP-based network and underwater network interworking

### □ Adaptive addressing





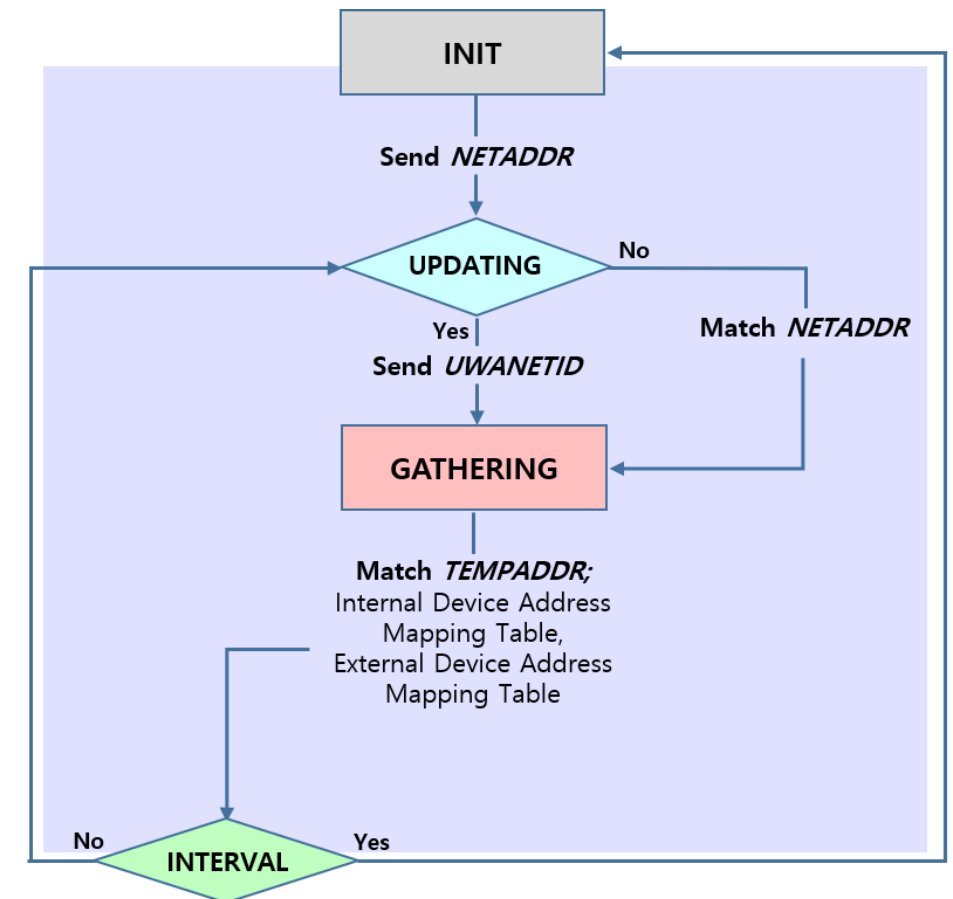
## Concepts (16/19)

# 7. Core operations for IP-based network and underwater network interworking

## □ Adaptive addressing

State	State Description	Event and Transition
INIT	This is the initialization state, where a UWA-DTN-GW begins the process of acquiring address. It also returns here when an adaptive addressing ends or fails.	<b>IP-based or underwater network node Sends <i>NETADDR</i></b> : The IP-based or underwater network node creates a <i>NETADDR</i> message and unicasts it to UWA-DTN-GW. It transitions to the <i>UPDATING</i> state.
UPDATING	The UWA-DTN-GW is trying to update the network address. In addition, it is waiting to send <i>UWANETID</i> messages to nodes within its area.	<p><b>IP-based or underwater network node Receives Offer and UWA-DTN-GW Sends <i>UWANETID</i></b>: The IP-based or underwater network node received Offer to enter the UWA-DTN-GW address pool. The UWA-DTN-GW broadcasts a <i>UWANETID</i> message to tell nodes within its area what is updated. It transitions to the <i>GATHERING</i> state.</p> <p><b>UWA-DTN-GW checks if the address Matches <i>NETADDR</i></b>: If the network address already exists, check the matching <i>NETADDR</i> instead of updating it.</p>
GATHERING	The UWA-DTN-GW begins collecting the underwater network ID, and also has a valid IP address and is in its normal operating state.	<b>UWA-DTN-GW Matches <i>TEMPADDR</i> using Dynamic Host Configuration Protocol (DHCP)</b> : The UWA-DTN-GW is allocated the address lease from DHCP server and utilized in heterogeneous network. Also, it is possible to use fixed IP instead of DHCP. At this time, two types of Internal Device Address Mapping Table and External Device Address Mapping Table operate. It transitions to the <i>INTERVAL</i> state.
INTERVAL	There is the interval at which address is updated periodically in UWA-DTN-GW.	<p><b>YES</b>: It goes back to the <i>INIT</i> state.</p> <p><b>NO</b>: It returns to the <i>UPDATING</i> state.</p>

### Network Address Table Management



# Concepts (17/19)

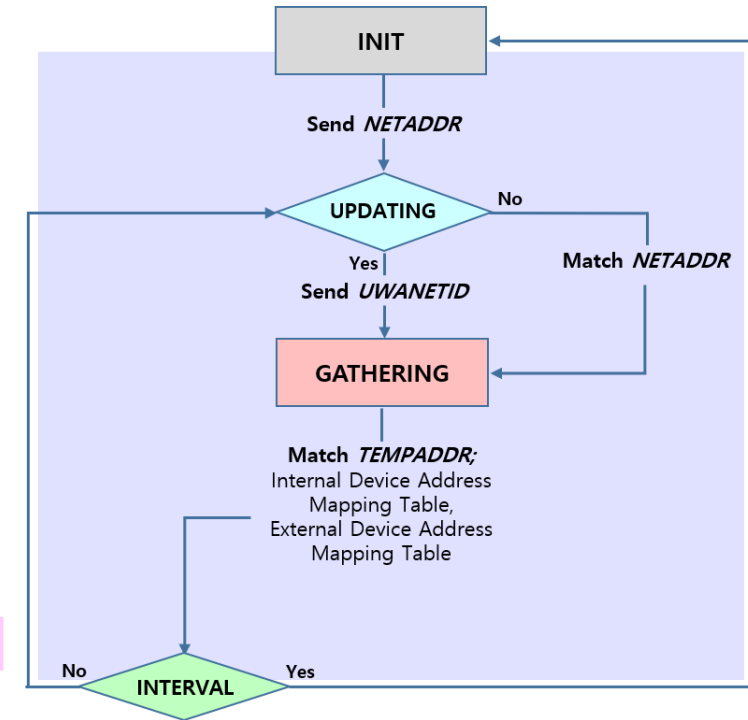
## 7. Core operations for IP-based network and underwater network interworking

### □ Adaptive addressing

#### Example

#### Network Address Table Management

IP Address (128bits)	Underwater Address (16bits)				
	Version	UWA-DTN-GW address	Underwater NET ID	Underwater Node ID	
2041:0000:130F:0000:0000:07C0:853A:140B	01	0001	0001	000001	AUV
2001:0db8:3c4d:0015:0000:0000:1a2f:1a2b	01	0001	0010	000010	AUV
1074:0000:130F:0000:0000:07C0:583A:142F	11	0001	0100	001100	Ad-hoc UWA-SNode
3201:0000:142B:0000:0000:028C:859A:173B	10	0001	0101	001110	UWA-CH
0123:4567:89ab:cdef:0123:2345:89ab:cdef	00	0000	0000	000001	Source temp. address
2041:0000:130F:0000:0000:07C0:853A:140B	00	0000	0000	000010	
1048:0000:120A:0000:0000:0B00:878A:124B	00	0000	0000	000011	



# Concepts (18/19)

## 7. Core operations for IP-based network and underwater network interworking

### □ Adaptive addressing

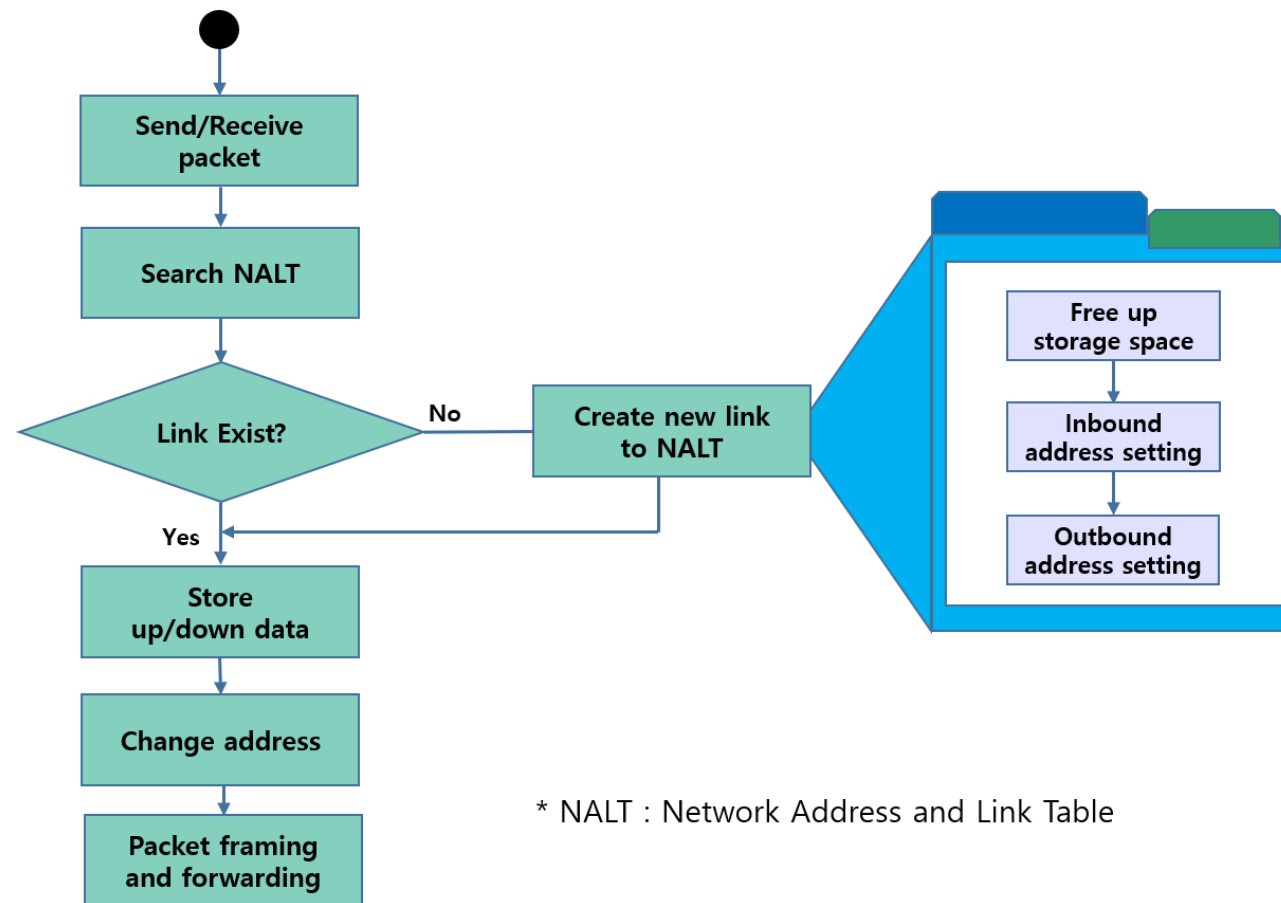
#### Example

#### Packet and Link Management

Sender

Receiver

Underwater Address (16bits)				Underwater Address (16bits)			
Version	UWA-DTN-GW address	Underwater NET ID	Underwater Node ID	Version	UWA-DTN-GW address	Underwater NET ID	Underwater Node ID
01	0001	0001	000001	00	0000	0000	000010
00	0000	0000	000001	01	0001	0010	000010
00	0000	0000	000011	11	0001	0100	001100
10	0001	0101	001110	00	0000	0000	000111
....				....			



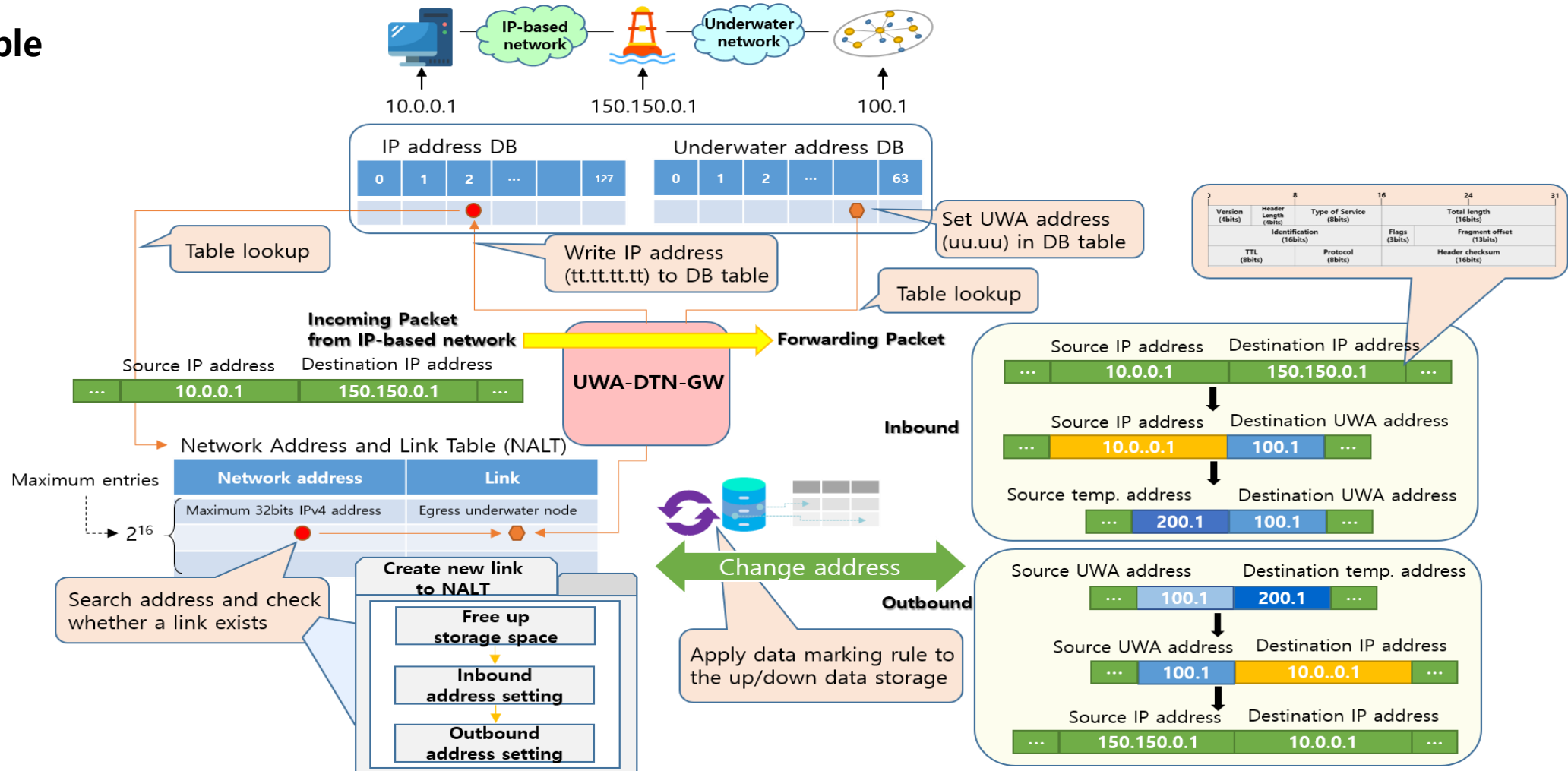
\* NALT : Network Address and Link Table

# Concepts (19/19)

## 7. Core operations for IP-based network and underwater network interworking

### Adaptive addressing

#### Example





The image features a background of rippling water in shades of teal and blue, viewed from an underwater perspective. A dark blue, rounded rectangular box is centered horizontally and vertically, containing the text "Thank You" in a bold, yellow, sans-serif font.

**Thank You**