Interworking between heterogeneous underwater networks based on underwater delay and disruption tolerant network (U-DTN)
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Scope

This document describes interworking between heterogeneous underwater networks based on U-DTN.

It specifies the followings:
- How to integrate heterogeneous underwater networks based on U-DTN?
- Interworking functional entities in heterogeneous underwater networks
  - Surface UWA-DTN-GW and Mobile UWA-DTN-GW
  - U-FFD and advanced UWA-DTN-GW
- U-DTN functions for heterogeneous underwater network interworking
Interoperability

- (ISO/IEC 30140-4:2018) Interoperability refers to the ability of two or more components, applications, devices, systems, or networks to exchange information.
  - UWASN interoperability in a hierarchical architecture
    1) Interoperability 1: between the user and gateway
    2) Interoperability 2: between gateway and underwater fundamental network
    3) Interoperability 3: between underwater fundamental networks
    4) Interoperability 4: between gateways
Interworking functional entities

- Different functional entities behavior depending on layered architecture
- Underwater devices(entities) can receive, store and forward information to other nodes
- Each entity requires a different type of interworking functions depending on the classification
  - **UWA-DTN-GW**
    - Surface UWA-DTN-GW : connections between terrestrial and underwater networks
    - Mobile underwater UWA-DTN-GW (AUV and UUV) : connections between heterogeneous underwater networks
  - **UWA-CH, UWA-SNode without UWA-BUN layer and U-DTN functions**
  - **U-FFD (Underwater – Full Function Device) with UWA-BUN layer and U-DTN functions (Optional)**
Definition

- **Heterogeneous underwater networks interworking** refers to a cooperative network to provide connectivity between different types of underwater networks (such as underwater sensor network, underwater ad-hoc network and underwater cellular network, etc.).
## Gap Analysis

### Gap Analysis of Interworking

<table>
<thead>
<tr>
<th>Area</th>
<th>Gap</th>
<th>30140 Series (UWASN)</th>
<th>Proposed New Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coverage</td>
<td>○</td>
<td>Cover overall Interoperability element in UWASN domain</td>
<td>Play a key role in interworking between heterogeneous underwater networks</td>
</tr>
<tr>
<td>Functions</td>
<td>●</td>
<td>Include high-abstrocted main functions</td>
<td>Focus on underwater delay and disruption tolerant network (U-DTN) functions</td>
</tr>
<tr>
<td>Requirements</td>
<td>○</td>
<td>Describe high-abstrocted networks concepts of heterogenious UWASN</td>
<td>Present details for heterogeneous underwater networks based on U-DTN</td>
</tr>
<tr>
<td>Underwater delay and disruption tolerant network (U-DTN)</td>
<td>○</td>
<td>Rough explanations for necessity</td>
<td>Dealing with interworking between heterogeneous underwater networks using UWA-DTN-GW and U-FFD</td>
</tr>
</tbody>
</table>

● = Few Gaps  ○ = Partial Gaps  ○ = Significant Gaps
**Surface UWA-DTN-GW**

- With the help of surface gateways using DTN functions, communication between heterogeneous networks can be established.
- Located on surface, DTN functionality only exists on surface UWA-DTN-GW.
- Store and forward, Custody, Segmentation, and Persistent storage operations are provided to perform U-DTN.
- It is required for connection for terrestrial-to-underwater network and connection for different underwater networks.

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**U-DTN Transfers**

<table>
<thead>
<tr>
<th>IP-based network node</th>
<th>Surface UWA-DTN-GW</th>
<th>Underwater network node</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application</td>
<td>Transport</td>
<td>UWA-BUN</td>
</tr>
<tr>
<td></td>
<td>Transport</td>
<td>Non Transport</td>
</tr>
<tr>
<td></td>
<td>IP</td>
<td>UWA-NWK 1</td>
</tr>
<tr>
<td></td>
<td>Data link</td>
<td>UWA-NWK 2</td>
</tr>
<tr>
<td>Physical</td>
<td>Physical</td>
<td>UWA-DL 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>UWA-DL 2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>UWA-PHY 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>UWA-PHY 2</td>
</tr>
</tbody>
</table>

Persistent storage
Custody transfer capability

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**Interworking between heterogeneous underwater networks based on underwater delay and disruption tolerant network (U-DTN)**

**Concepts of Surface UWA-DTN GW and Mobile UWA-DTN-GW (1/2)**
Mobile (underwater) UWA-DTN-GW

- It connects between heterogeneous underwater networks.
- Located in underwater, DTN functionality only exists on mobile underwater UWA-DTN-GW.
- Store and forward, Custody, Segmentation, and Persistent storage operations are provided to perform U-DTN.
- It is required for connection between different underwater networks.
U-FFD and UWA-DTN-GW (advanced)

- When we have frequent interruption and long delays in communication between nodes, U-DTN guarantees end-to-end reliability through UWA-Bundle transfer mechanism.
  : hop-by-hop & custody transfer
- U-FFD uses persistent storage to keep UWA-Bundles (custody) in UWA-BUN when the link is unstable. After the link is available, UWA-Bundles is forwarded to next hop.
- UWA-DTN-GW has persistence storage for heterogeneous underwater networks.
- Interworking between heterogeneous underwater networks based on U-DTN is through UWA-DTN-GW and U-FFD with UWA-BUN as relay DTN node.
Interworking Functional Entities in Heterogeneous Underwater Networks

- **Entities**
  - Surface UWA-DTN-GW / Mobile UWA-DTN-GW
  - U-FFD
  - UWA-CH / UWA-SNode

- **Functions of entities for interworking**
  - Store and forward
  - Persistent storage in UWA-BUN
  - Custody mechanism
  - Segmentation

- **UWA-BUN layer**
  - Provides an appropriate service interface between the UWA-NWK layer and UWA-APS
  - Performing legacy transport protocol functions partially and U-DTN functions
U-DTN based interworking between heterogeneous underwater networks

- UWA-BUN provides functions such as persistent storage, custody transfer, etc. (Refer to ISO/IEC 30140-2).
Standard Development Roadmap

May 2021 Presentation at JTC1 SC41

- 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

May 2022

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November 2022

November 2023

May 2023

May 2024
Thank You