Input paper: [[1]](#footnote-1) ENAV24-6.1.24

Input paper for the following Committee(s): check as appropriate Purpose of paper:

**□** ARM **□** ENG **□** PAP **X**  Input

**X** ENAV **□** VTS **□** Information

Agenda item [[2]](#footnote-2) 6

Technical Domain / Task Number 2 …………………………………

Working Group WG3

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The VDES Network Protocol: Design and Verification

# Summary

This document introduces the design of VDES network and protocol stack architecture. The service-centric network topology is introduced, which is mainly enabled by two logically centralized functional entities: Network Controller and Maritime Service Gateway. The execution of the functionalities of the VDES Controller and Maritime Service Gateway is through two separate virtual planes, known as the control plane and the application plane. The protocol stack consists of four layers: application layer, network layer, data link layer and physical layer. The protocol layer functions and the data formats design are also provided.

## Purpose of the document

The input document is intended to provide a design solution to the issue identified in [1], wherein it is indicated that “we lack an overview on how VDES, MCP and ship architecture really allow getting services onto the ship”.

## Related documents

1. 20190403\_G1139\_WD\_changelog: G1139ID86.
2. VDES network architecture - functional components and topology, WG3 Intersessional, August 2019, Paris.
3. IALA Guideline G1139, The Technical Specification of VDES, Working Draft.

# Background

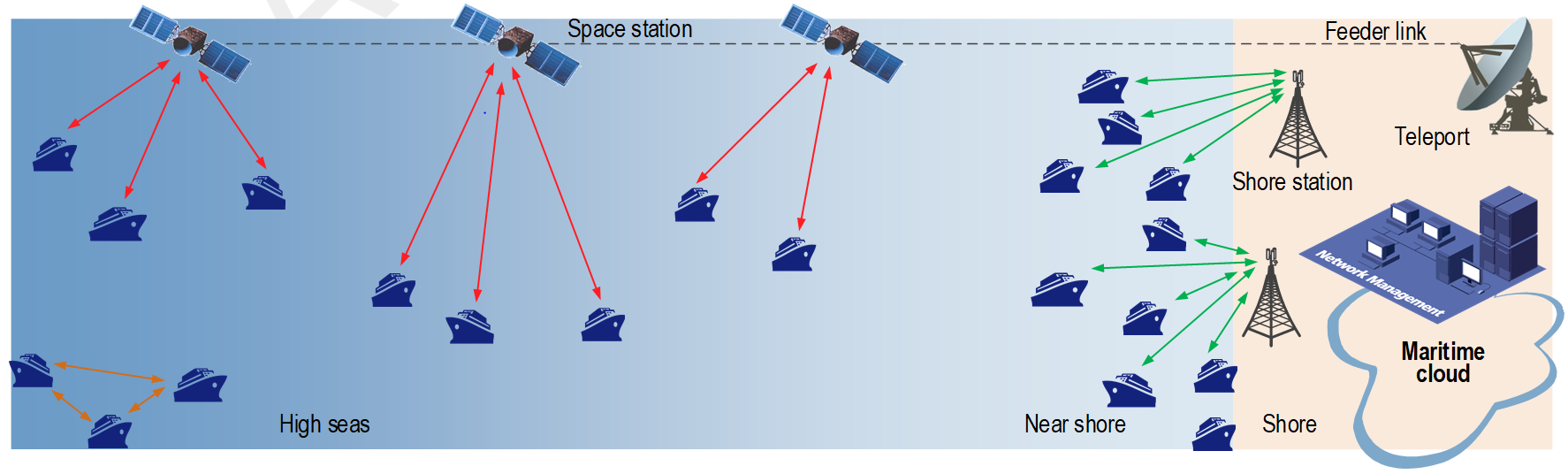


Figure . VDES network architecture.

VDES as a maritime machine-type communication (MTC) network is responsible for facilitating communication between a VDES mobile station and the maritime application and service providers as well as among VDES mobile stations.

Differently from traditional mobile networks where services are built around the network architecture, the maritime MTC network aims at supporting the efficient provisioning, discovery and execution of various types of maritime application and service components distributed over the network in order to reap the full benefits of moving to e-Navigation.

e-Navigation applications and services vary from simple periodic reporting to route exchange and remote control (for, e.g., autonomous shipping). As such, a maritime MTC is expected to facilitate a wide variety of e-Navigation applications; and hence both network configuration and air interface must be made flexible and adaptive to the specific service offered. At the same time, it is important for the network to ensure that only the qualified or authenticated services are available to the vessels or maritime devices, and vice versa, for safety and security.

The VDES network should provide ﬂexible conﬁguration according to the diverse service requirements. A service-centric network is hence desirable.

# Network Layer Protocol

In Figure 5, the network layer is necessary for providing a *common interface* for VDES mobile stations to receive services from the maritime service providers which reside in the IP network. The current VDES spec. (G1139) does not provide the network layer protocol, which prevents VDES network from interacting with the IP network using a standard protocol. This issue has been reported and verified in eNav23 [1].



Figure 5. VDES protocol stack

As depicted in Figure 6, App data is delivered to the network layer for transmission via the Service Access Point, which contains a 32-bit IPv4 or 128-bit IPv6 address of the service provider on the packet data network (IP network), as well as a 16-bit port.

Table 1 VDES Network PDU header

|  |  |  |  |
| --- | --- | --- | --- |
| Type = 00 | End host index (6 bits) | | Service provider: Service ID (16 bits) |
| Type = 01 | Service provider: IPv4 (32 bits) + Port (16 bits) |
| Type = 10 | Service provider: IPv6 (128 bits) + Port (16 bits) |
| Type = 11 | Reserved |



Figure 6. VDES network layer protocol data format

The network layer defines three PDU data formats that are indicated by the 2-bit Type included within the network PDU header, as listed in Table 1. The 6-bit End Host Index represents the different end hosts running the App. Note that the service client is fully addressed with the mobile station’s MMSI and the End Host Index. Considering that the MMSI is used as the data link layer address of the VDES air interface and hence is readily available to the control station, only the End Host Index is delivered over the air to save the overhead.

The minimum size of the network PDU header is only 24 bits (3 bytes), including the 2-bit Type (value of 10), the 16-bit Service ID identifying the service providers in the VDES network, as well as the 6-bit End Host Index.

# Verification: Navigational Warning Service

Experiments were conducted to verify the design. In the experiment, an ECS device is connected to a VDE-TER mobile station aboard a ship (MMSI 413144000) via an Ethernet local area network; while the mobile station is under the coverage of a VDE-TER shore station in a VDES network with a Service Gateway of IP 132.255.168.62.

The following diagram exemplifies the design used in the experiment, where the App data are transferred between a shipborne service client and an IP network based service provider via an VDES network.



Figure 7. An example of the App data transfer between a shipborne service client and an IP network-based service provider via a VDES network, where ECS denotes the Electronic Chart System which is receiving the navigational warning service from the e-Navigation service provider at enav.nhhb.org.cn or 219.137.32.74.

To improve the communication efficiency, the Maritime Service Gateway serves as a gateway that sits between two networks, the internal VDES network and the external IP network where the maritime service providers reside. The Maritime Service Gateway therefore resides in the network layer, encompassing application virtualization and adaption functions that virtualize the maritime services and adapt standard protocols to hide the topology and complexity of the IP packet data network from the VDES network.

To that end, the Maritime Service Registry (MSR) of the Maritime Service Gateway maintains a list of maritime service providers, each of which is identified by a Maritime Service ID (16 bits). For outbound traffic, the MSR client at the mobile station receives the message from the end host, via a LAN (e.g., Ethernet or WiFi), in its service data unit (SDU). It then converts the SDU to a VDES network protocol data unit (PDU) as shown in Figure 6 using one of the three headers, and hands it down to the lower layers for transmission over the VDES air interface. Once the MSR of the control station receives the message from its client (the mobile station), it converts it into an message by attaching the MMSI of the mobile station to the source field of the message; note that MMSI is used as the data link layer address of the VDES air interface and hence is readily available to the control station. The message is then relayed to the Maritime Service Gateway where the Service ID is translated to the IP address of the corresponding service provider as the destination if Type 0 network PDU is used; otherwise, the service provider’s IP address is directly used as the destination. The MMSI is mapped to a port number of the Maritime Service Gateway’s IP address as the source IP, and routes it (the IP packet that contains the application data) to the destination IP address over the packet data network. An IP address supports up to  port numbers. If necessary, the Maritime Service Gateway may be associated with multiple IP addresses to scale with the population of VDES mobile stations.

For inbound traffic, the Maritime Service Gateway takes the incoming IP packet destined to it that carries the service data from a service provider, maps the port number of the IP address (in the destination field of the IP packet) back to the MMSI, and dispatches the service data to the station indicated by the MMSI over the VDES network. From the network address translation table, the LAN IP address of the end host is looked up and the message is delivered to the address over the LAN.

In the actual experiment, the ECS device, i.e., the end host with index 19 requests the navigational warning services that conform to IHO S-124 from an e-Navigation service provider at enav.nhhb.org.cn or 219.137.32.74.

Figure 8 shows the information received from the service provider displayed on the ECS.

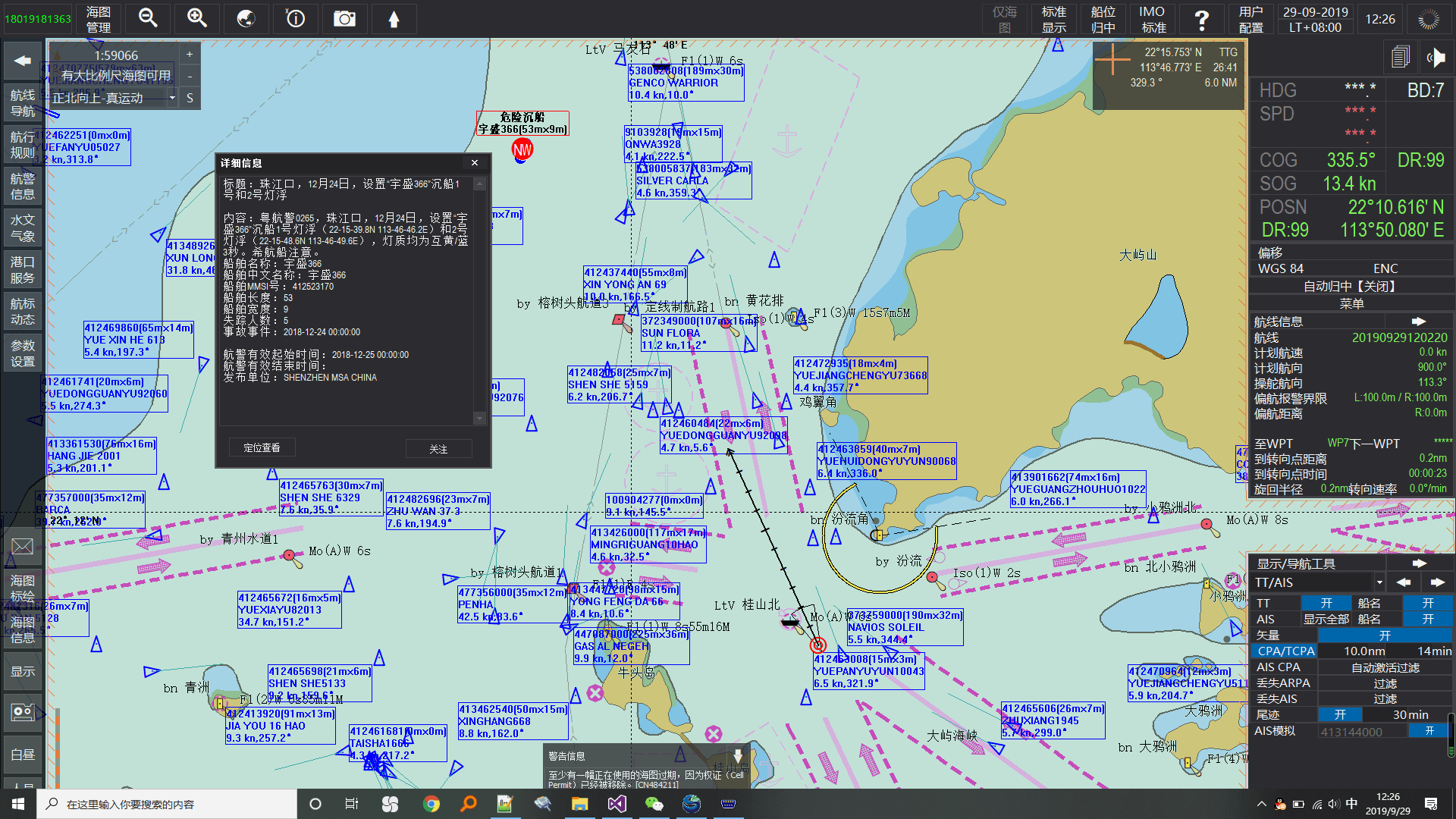


Figure Display of the data received by the ECS.

# Conclusion

The proposed VDES network layer design provides an efficient network layer protocol for ships to receive e-Navigation service from the IP network. The design is further verified in a VDE-TER testbed system.

# References

# Action requested of the Committee

The Committee is requested to review the information and take appropriate action.

1. Input document number, to be assigned by the Committee Secretary [↑](#footnote-ref-1)
2. Leave open if uncertain [↑](#footnote-ref-2)