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Innovative applications for conventional VHF

SCHNOOR APPLICATIONS
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The German waterway administration decided to introduce a completely new infrastructure for the German coastal waters VHF communication. Radio Specialist Schnoor Industrielektronik GmbH & Co. KG designed and built an innovative IP-based system including simulcast elements which is introduced in this paper in more detail.

**IP connectivity and availability**

Schnoor designed and built an innovative system for VHF voice and DSC. While the air interface is still good old VHF FM radio, the new system is internally fundamentally different to the previous one, particularly in two areas: IP connectivity and availability.

Analog leased lines, E1 or other connections are increasingly replaced by IP-based connections as the sole connection available to customers in public networks. The advantages of choosing IP as transport protocol are clear and can be highlighted as follows:

- Standard transmission lines can be obtained at lower cost (or may even be the only solution available in the future)
- Ethernet based industry standard components such as switches offer lower cost, are efficient to maintain and can be replaced by other industry standard components in future. Besides short term benefits with the system acquisition cost, this provides a good perspective for long term system life compared to bespoke components used in proprietary solutions
Flexible installation of IP-based systems

- The packet switched IP based architecture can be put into a fully redundant system
- Ethernet based cabling in VTS Centers makes a cost efficient setup based on standard architecture
- Supplementary functions such as voice recording and processing can be simply put in between the standard IP data streams

Flexible Installation

IP-based systems are much more flexible to install, maintain and reconfigure. Availability is another area where the new system is a leap forward: Rather than using good design practice and adding some redundant hardware, the solution is more radical. The architecture can not only handle failures of any device within the system but even demolition of any complete subsystem location or building will not lead to a loss of control.

Heart of the system are the three Data Centers (see Figure 2). They are located in different towns and are linked via TCP/IP connections. These form the core of the system from a technical standpoint. 9 VTS Centers (VTS-C) are connected to one of these three Data Centers. A number of other system users include staff at locks and movable bridges, pilot’s stations and the maritime disaster center. These are also connected to one of the Data Centers each.

The air interface to the vessels is formed in total by almost 200 VHF base station radios. The backhaul network connecting these VHF base stations located on the North Sea and Baltic Sea is completely based on IP based infrastructure.

Coming from the 9 VTS Centers, voice and data are directly coded into digital format using the well-known G711 codec, and processed with call header information based on the VoIP protocols Session Initiation Proto-

Fig 2. System Overview
Simulcast technology in the maritime environment

tocol (SIP) and Real Time Protocol (RTP), both then embedded into the standard Internet Protocol (IP) layer structure, physically based on Ethernet. During the routing of the call information through the network and the fully IP based radio exchange system, the call is not earlier decoded back to analog voice information than directly at the radio base station. The same is true in opposite direction for analog voice information received by a radio base station. As to DSC information, it is also modulated and demodulated for radio channel transmission and reception directly at the radio base station.

Within each of the three Data Centers, there are two separate server systems, which provide services and user data management. Each of these are redundant Linux-based “high availability servers”. A Linux-based solution has been preferred to a Microsoft one since task switching and routing are faster. Configuration is different from a Microsoft cluster, a RAID system distributed over the servers within a system site is sufficient. In addition, replication is used between the different Data Centers. As an exception, long term data storage is only provided in two of the three Data Centers. In case of a loss of status and configuration data stored in long term storage, they may need to be manually synchronized with another server.

To support the required overall system redundancy, priority listing is used in the system, described here as an example for an incoming call through one of the radio base stations: The base station radio will normally set up the connection to the Data Center with the highest priority in its list. Should that connection fail, the base station will select the next lower level Data Center for connection setup. Should that also fail, the base station will therefore connect to the lowest priority level Data Center. From time to time, base station radios will search if higher priority level Data Centers are back again.

The connections in the opposite direction from control center work positions to radios follow the same principle. On the radio side, parts of the system are based on Simulcast base stations. This has been decided to provide optimized radio coverage while requiring as little frequency resources as absolutely necessary. Simulcast systems (also referred to as Single Frequency Networks) are not new as such, but this should be the first such implementation of simulcast technology in the maritime environment.

Simulcast Systems

Simulcast systems pose two additional technical requirements over a non-simulcast installation: highest frequency stability of the base station transmitters on one hand. Transmitter carrier frequencies must be highly stable and adjustable in a small range.

On the other hand, modulation at base station radios must also be synchronized. In a typical conventional simulcast system synchronization of modulation is achieved by an equalizer located at the central system location which makes sure that even with different transmission paths of different length to the various base station locations, modulation is synchronous on all of these locations. For the German coast system, the synchronization requirement cannot be achieved with a simple equalizer: Voice is transmitted in coded format over an IP network which does not offer constant transport time for data. Therefore the simulcast IP-connected base stations buffer received encoded information and process them synchronized by a GPS signal received at each transmitter location and the central simulcast controller so that after decoding digitized voice in the radio base stations, modulation on the air interface is synchronous again.

Combining well-known solutions such as analog FM simulcast with IP networks placed new challenges for system design which required the development of new technology.

While the IP network in this system allows smart routing in case any element fails in the network, this has its limits at the end points. In particular on the individual radio base station end, these are extremely reliable Schnoor SEACOM radios, but they might fail as well. In order to provide a solution for such unlikely failures, a detail level analysis has been done based on traffic load, severance of failures and radio coverage. As a result, a backup concept has been built which meets operational needs and uses different solutions as needed while keeping investment at a reasonable level: Some areas can be covered by adjacent base stations, a few channels are considered less critical in case of failure and for others backup base station radios have been installed which can be switched to the channel which has failed on a given site. IP remote control of these radios covers all functions including channel selection. Each radio cabinet has a local RS 485 bus which is
Combining well-known simulcast solutions with IP networks

Fig. 3 Radio base station rack with 3 transmitters/receivers, redundant power supplies and control equipment.

Fig. 4 – Server rack (Data center)

used to interconnect devices with a controller managing switchover in case of failures and providing reports to be transmitted back over the IP network for system management. Further more, tunable combiners had to be used since a single base station in n+1 configuration is used rather than full doubling of all radios in costly 1+1 configurations. Operationally, backup is clearly critical and required to provide full coverage on channel 16 even in case of a radio failure. Figure 3 shows a typical radio cabinet used in the system.

System description

The system described is not a fully duplicate installation to existing facilities in use today. That would have required to double all radio sites and equipment, as well. In order to allow for a reasonable migration and avoid excessive costs, in particular base station radios and the backhaul network go through a migration period. Complete new radio base station sites are installed but for the migration period connected to existing control...
room facilities, sometimes via existing analog backhaul network connections. This was easy to accomplish since SEACOM base stations can be fitted with dual remote control modules to fit the analog connections network in addition to IP interfaces, both working in parallel (see figure 5). At a later stage, control is simply switched to the new system.

Simulation facilities

What has to be considered for the backhaul network, the structure of which had been a given by the customer, is that in case of failure of a Data Center the amount of data traffic on some links in the network will heavily increase. Network connections between Data Centers may require capacities which can by far exceed 32Mbit/s.

Finally, VTS Centers have simulation facilities which allow to train center staff up to the highest professional levels which normal day to day traffic does not provide. Simulation for VHF radio was also included in the scope of delivery with the simulation equipment being connected to the real IP based system rather than being set up a separate training system of its own.

Optimum availability with low operating cost

The fully redundant setup of VTS Centers, transmission lines as well as radio exchange systems provides optimum availability of the entire system. Being based on industry standard IP connections and equipment the solution represents a state of the art system combining optimum availability with low operating cost.