Scalable PMR networks: The architecture is what counts

In constant change

PMR networks undergo constant, sometimes manifold changes. The causes for this are always linked directly or indirectly to the users in the network:

The subscriber community may grow, alter its structure or be geographically rearranged — which always results in the need to adapt the digital infrastructure. Quick, cost-effective adaptation of these professional networks should be possible during their entire operational life. PMR networks must therefore be scalable in at least the three following dimensions:

- The radio coverage of the area to be covered and the channel capacity of individual network elements if subscriber density increases
- The number of subscribers organized in closed user groups
- The availability of individual network elements (scalable redundancy)

Scalability of radio coverage and channel capacity

A cellular TETRA network is usually set up in two stages. In the first stage, it is made certain that the coverage area has enough base stations for transmitting signals in compliance with quality requirements. One of the characteristics of quality radio coverage is sufficient overlapping of the coverage areas of adjacent base stations to ensure reliable handover of calls as mobile subscribers move from cell to cell.

When a network is being planned, the communications capacity to be provided by the network is distributed on the basis of the assumed subscriber densities. For example, base stations in rural areas normally require fewer channels than those in urban areas.

As the number of subscribers rises, however, it is usually necessary in a second stage to add channels to base stations and to increase the capacity of the exchanges involved for routing and switching or even to install additional base stations.

The requirements defined in the Mobile Radio Communications Architecture IpMCA® specify the unlimited compatibility of the network elements, regardless of how large a network is. The ACCESSNET®-T TETRA mobile radio network from Rohde & Schwarz fully meets this requirement. All network elements of the same type are compatible and can continue to be used if the network is expanded — no matter whether the network is a small, single-cell TETRA system or a nationwide network with hundreds of base stations.
ACCESSNET™-T base stations are available as indoor or outdoor models, and each can have one to eight carriers. The new System Node IpSN®, whose capacity can be increased to supply up to 120 base stations, is used as an exchange (FIG 1).

A number of System Nodes IpSN® can also be interconnected in a nonhierarchical, meshed configuration. This not only makes it possible to configure very large networks but also, as described further below, provides a basis for mission-critical, highly available mobile radio networks.

Adapting a network to the number of subscribers and user groups

Theoretically IpMCA® does not limit the number of subscribers, but in reality this number is limited by the communications capacity installed and the agreed-on quality of service (QoS). Of particular importance with regard to mission-critical communications networks is the ability to manage closed user groups (virtual private networks, VPNs). A network must be able to adapt flexibly to rising subscriber numbers or additional user groups.

In VPNs several user groups share a common network, but the parts of the network allocated to each group remain hidden from the other groups. This also affects access to resources that is exclusively assigned to the different VPNs. VPNs are thus characterized by the following:

◆ Individualized physical address ranges in which calling numbers can be assigned in accordance with the organization’s own concept as to how it should be mapped
◆ Assigned subscriber management
◆ Own key management and authentication (in the case of end-to-end encryption)
◆ Own accesses to private automatic branch exchanges (PABXs)
◆ Own control centers
◆ Own voice recording
◆ Own IP access points (IAPs) for routing to the organization-internal intranet for packet-oriented data transmission (IP over TETRA)
◆ Own software applications that provide user-group-specific solutions

Here, too, there is no objective limitation to the number of definable VPNs. What matters are the technical properties of the network elements and components — for example, whether the network management system supports separate subscriber management for different address ranges and the associated calling numbers or whether all features that will be required later can be implemented in the mobile radio network.

ACCESSNET™-T demonstrates that it meets all the requirements for managing VPNs and integrating the necessary technical resources. For example, a network may contain a number of application servers that, in turn, each run several software applications. This also applies to control centers, PABX switches and voice recording. The network management system allows shared management of separate subscriber addresses and coupling of VPN-specific key management (FIG 2).
Redundancy based on needs

The overall availability of PMR networks is generally very high. However, this does not take into account threat scenarios that are not caused by technical problems. However, mission-critical communications networks must be safeguarded not only against technical failures, but also against uncontrollable natural phenomena as well as against vandalism or acts of terror.

Besides these aspects, it is important to know where failures occur. For example, the failure of radio coverage in an uninhabited wooded area must be evaluated differently than the failure of a cell containing a facility that requires special protection. Essential with all failures is how quickly they can be eliminated. In ideal cases, the system automatically remedies the failure; in extreme cases, the affected network elements have to be replaced by mobile units, for example by the ACCESSNET®-T Cube [2].

These considerations resulted in the concept of scalable redundancy in the IpMCA® requirements profile, for these security aspects affect not only the number of System Nodes IpSN® and their configuration but also the cost of the required connection network. ACCESSNET®-T therefore includes redundancy measures that provide protection against the failure of elementary functional units such as exchanges, base stations, tie lines, gateways to other networks and application platforms (FIG 3).

Site redundancy is the capability of the network to maintain operation if an exchange fails. To ensure this, the base stations must be connected to the exchanges of different sites. Each exchange must be able to handle the overall traffic of the redundantly connected base stations (FIG 4). Site redundancy is relatively cost-effective — it requires merely a second site with a System Node IpSN® and the linking of the base station using a ring or line structure.

There is less availability in area B, which has a ring structure with a single exchange. In area C, the redundancy measures in the event of a line interruption are limited to the autonomous operation of the base stations and the use of dialup lines. Measures such as radio overlapping and standby circuits of a control channel can, of course, be used independently of the redundancy measures.

The overall availability of ACCESSNET®-T mobile radio networks can be further increased by applying the cluster concept (FIG 6). This extremely high avail-

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ability is aimed at the special requirements in security networks for police forces. This concept uses full redundancy on site in the form of half-clusters coupled with site redundancy, i.e. half-clusters are set up at different sites. Topologically this example can be further expanded by chains of base stations between the half-clusters that do not manage shared base stations, e.g. between half-clusters 1 and 3.

Summary

Because mission-critical PMR networks undergo dynamic changes during their operational life, the Mobile Radio Communications Architecture IpMCA® places special emphasis on the scalability of such networks. This is fully implemented in ACCESSNET®-T, the IpMCA®-based TETRA network infrastructure from Rohde & Schwarz. This comprehensive scalability is the basis for the outstanding flexibility with which network operators can respond to changing requirements and conditions for mission-critical mobile radio networks — cost-effectively and during their entire operational life.

Max Zerbst

More information on the comprehensive program for TETRA at www.rohde-schwarz.com ("Trunked Radio" menu)

REFERENCES
