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# ROIP VS. TRUNKED RADIO SYSTEMS: A COMPARATIVE STUDY OF TECHNOLOGIES FOR MISSION-CRITICAL COMMUNICATIONS

**Аннотация:** в статье рассмотрены технологии профессиональной подвижной радиосвязи, широко использующиеся в современных системах оперативной связи. Рассмотрены особенности, присущие наиболее распространенным стандартным технологиям, используемым при построении систем профессиональной радиосвязи, отмечены их достоинства и недостатки. Показано, что технология широкополосного радиодоступа RoIP может служить не только экономически обоснованной альтернативной транкинговым радиосистемам при проведении модернизации корпоративных систем связи, но также открывает доступ к услугам, предоставляемым в публичных сетях связи, таких как WiMAX, WiFi и LTE, в то же время обеспечивая необходимый уровень защищенности и отказоустойчивости. Описаны варианты организации систем связи с применением технологии RoIP. Предложенное техническое решение доведено до уровня структурной схемы с указанием типов отдельных блоков и узлов.

**Ключевые слова:** профессиональная радиосвязь, наземная подвижная радиосвязь, цифровые радиосистемы, вокодер, RoIP, транкинговые радиосистемы, системы оперативной связи.

**Abstract.** The article analyses private mobile radio technologies currently used for mission-critical communication systems. The features of the commonly used standard technologies applied for professional radio communications systems were considered. Their advantages and disadvantages were specified. It was demonstrated that RoIP broadband technology may serve as not only an economically sound alternative to trunked radio systems for modernization of corporate communication systems but also gives access to services accessible in public networks like WiMAX, WiFi, and LTE. At the same time assuring the needed level of security and fail-safety. RoIP-based designs of communications systems were described. The proposed technical solution was brought up to the level of a block diagram indicating the types of individual blocks and nodes.

**Keywords:** PMR, LMR, digital radiosystems, vocoder, RoIP, trunked radio systems, mission-critical communications systems.

The term “mission-critical communications” is often used as a synonym for “private mobile radio systems” (PMR) or “land mobile radio systems” (LMR). It is used to designate radio systems destined for transmission of critically important information, on which lives and health of people may depend. However, unlike PMR/LMR, the notion of mission-critical communications is a concept of a wider range and includes the transmission of not only critically important voice information, but also critically important data. The latter has lately become pivotal in the development of this sector of telecommunications and the society at large.

Some of the analog radio networks currently in service are capable of guaranteeing the needed level of fail-safety availability and, in some circumstances, disaster tolerance of a communications system. However, dedicated networks based on narrowband technologies provide insular coverage, limited capacity, reduced range of voice services, and do not allow data transfer. As for public wireless networks (LTE, WiMAX), which significantly outperform dedicated networks in the coverage area, capacity, and variety of provided services, they are incapable of providing professional users with a guaranteed level of availability of services of voice communication and data transmission, and also the needed level of privacy.

The trunked mode (a computer-controlled network that automatically connects users to available radio channels) can be enabled only by the means of cloud over-the-top services that do not meet the requirements of mission-critical communications. As a result, companies and institutions are compelled to make provision of expenses on several types of mobile (wireless) communications to meet various needs.

The technologies used to provide services to mass-market consumers are being increasingly used in a much more closed sphere of communications for public safety and security agencies, where the requirements for the quality of service are higher and the problems to solve are more complex.

A factor that impedes development in this direction is the cost of digital solutions. To change to digital radio systems, an organization should not only replace its radio station fleet but also all the analog switching equipment, used along with them. Huge resources and an extended period will be needed to make the move. Nevertheless, the upgrading of mission-critical radio communications systems is the burning issue of today. Besides that, many organizations have in operation a significant amount of analog radio stations, which proved themselves reliable and inexpensive.

However, the ever-growing occupancy of channels in radio bands allocated for professional radio communications (mainly in the interests of public security agencies) resulted in the regulators in the industrially developed countries of Europe and North America putting restrictions on the operational lifetime of analog equipment and the minimal number of voice channels for a standard frequency band of 25 kHz. Though the terms of their implementation had been delayed several times because of the unreadiness of manufacturers and the inevitable financial load on the consumers, since 2013 the use of radio equipment operating in less than two voice channels in the bandwidth of 25 kHz is prohibited in these countries [5].

The technical realization of such effectiveness was already made possible from the end of the 1990-s grace to the rapid development of digital technologies of voice transmission.

The standardization of the professional PMR market has been continuing during the last ten years, and, the development of various vocoders put aside, come down to the following open standards: TETRA (with four TDMA — Time Division Multiple Access — channels in the frequency band of 25 kHz), DMR Tier II, APCO 25 Phase II (both enabling two TDMA channels in 12.5 kHz frequency bands) and NXDN (which provides FDMA — Frequency Division Multiple Access — channels of the bandwidth of 6.25 kHz) [3; 4].

The above-mentioned digital technologies brought important improvements to the professional mobile radiocommunications, such as the capacity to accommodate more radio channels, improved audio quality, better signal coverage, and higher battery life. However, these advantages of digital PMR over analog systems manifest themselves only if a serious multi-zone digital trunked network (the Tier III DMR, Phase II for APCO 25, or Mode 3 for dPMR/NXDN) is built. Considering the cost of deployment of a full-fledged trunked radio system, it becomes obvious why the main deliveries to the digital radio market fell on the so-called conventional solutions (Tier II, Phase I, Mode 2), which essentially make for ordinary single-channel systems. The only differences from analog equipment are the use of digital modulation, sometimes the possibility to combine repeaters of different standards in a single network, and the availability of additional services due to the use of a core IP network.

Field trials of digital mobile radio stations of the same range, same bandwidth, and even of the same digital standard sometimes demonstrate the impossibility of transmission of voice signal between subscribers using the equipment form different manufacturers. This problem is often due to the characteristics of vocoders applied [1]. It is that in North America and Europe, the use of specific vocoders is strictly regulated by the standards bodies (namely, AMBE+2 for APCO 25 Phase II and NXND, ACELP for TETRA). Other digital standards (such as DMR and dPMR) do not require such rigor in the use of vocoders. In addition to that, the use of proprietary codecs such as AMBE+2 (owned by Digital Voice Systems, Inc.) or ACELP (property of VoiceAge Corporation) requires a license. Therefore, in order to reduce the price of equipment, many manufacturers apply a large variety of alternative free or lower-cost vocoders (RALCWI, TWELP etc.). DMR and dPMR associations allow manufacturers to implement additional features on top of the standards, which has led to practical non-interoperability between radio stations of different brands. For this reason, consumers (especially in countries with no legal restrictions on vocoders) may face the fact that having purchased a certain digital system from a specific supplier once, they remain its forced buyer without the possibility of switching to another digital system or acquiring alternative subscriber equipment.

Some codecs provide sufficient speech compression, but the voice quality is not always acceptable. Others provide an accurate synthesis of speech but do not permit the correct processing of non-speech signals such as police, fire, and ambulance sirens. The comparison of technical characteristics of various vocoders is presented in Table 1.

Table 1. The comparison of vocoders for digital PMR

| Algorithm name | ACELP | AMBE+2 | RALCWI | TWELP |
|---|---|---|---|---|
| Speech coding birate, kbps | 5.3 | 2.5/3.6 | 2.4/2.8/3.6 | 2.4 |
| Frame size, ms | 20 | 20 | 20/40/60/80 | 20 |
| Delay, ms | 30 | 32 | 17 | 40 |
| Sampling rate, kHz | 8 | 8 | 8 | 8 |
| Coding method | Linear Predictive Coding (LPC) | Multi-Band Excitation (MBE) | Waveform-Interpolative (WI) | Linear Predictive Coding (LPC) |
| License required | yes | yes | no | yes |
| Application | TETRA | APCO 25 Phase II, NXDN, DMR Tier 2 | DMR, dPMR | DMR, dPMR |

Taking into consideration the problems mentioned above, professional customers may not be ready to invest in the construction of a digital radio network, especially in the case of a large number of subscribers and extended territories.

The Radio over Internet Protocol (RoIP) technology can be a solution to these problems.

RoIP is a two-way communication method, which involves transmission and reception of radio signals over Internet protocol (IP).

Radio over IP offers a cost-effective way to interconnect radio systems of different standards and generations. Most businesses, military entities, public safety agencies, and emergency services operations already maintain their own private local area network (LAN) or wide area network (WAN). Additionally, there is an abundance of public IP networks that can be utilized conjointly with private LAN's. Consequently, there is no need to build out new communication pathways to deploy a RoIP network in most circumstances [2, p. 188].

RoIP is not a proprietary or protocol-limited construct but a basic concept that can be implemented in a number of ways.

In its most basic form, RoIP technology allows to connect two or more radio stations using a LAN or a WAN. This type of connection is known as site linking or point-to-point linking.

Another common application is IP-dispatching. This option allows to operate transceivers remotely with the use of specific software (free of provided by the equipment manufacturer) typically running on Windows operating system, or in some cases Linux. Dispatchers use an IP-console or a personal computer equipped with a microphone. Deployments range from a single user controlling a single radio, to dispatch centers with multiple operators controlling dozens of radios, IP-telephones, cellphones at several locations, as shown in Figure 1:

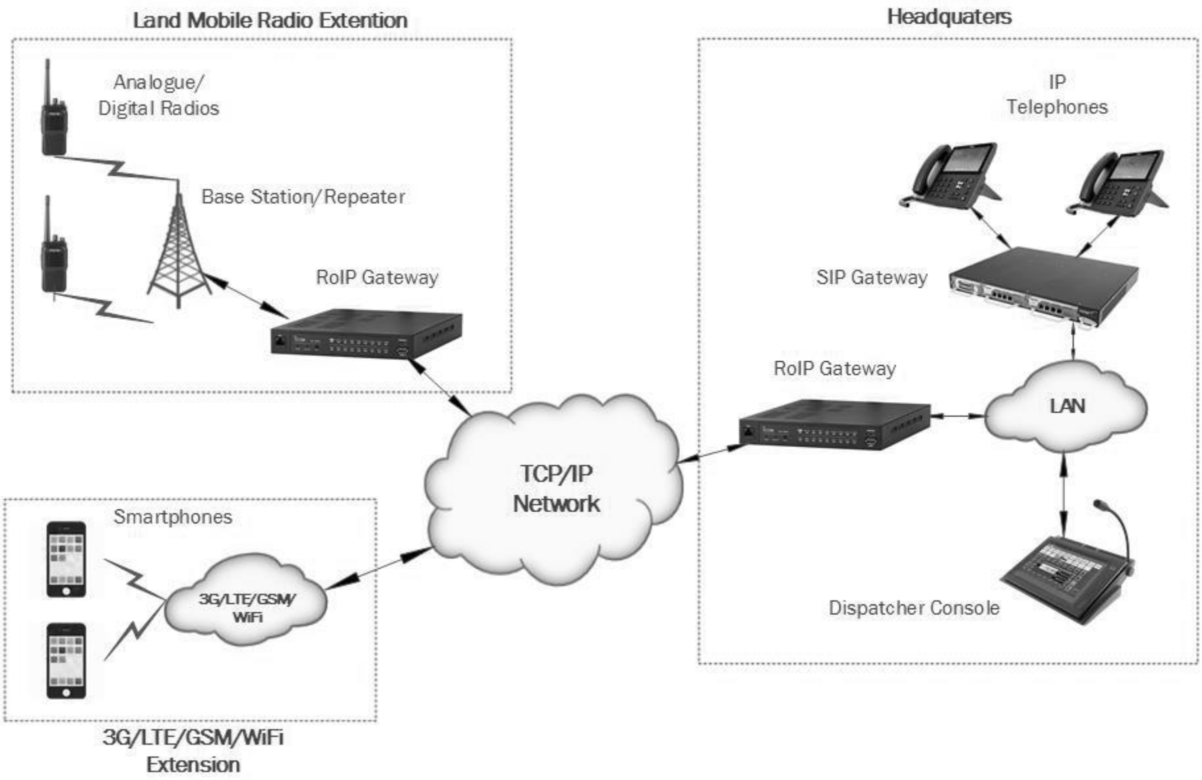


Figure 1 — RoIP network diagram

`The confidentiality of data transmitted in the network within a department or an organization can be ensured either by the virtual division of users into various groups isolated from each other, or, at the physical level, by creating a completely independent core (set of system servers) located within the territory of the organization and connected to the backbone network.

The principal advantage of RoIP technology over trunked communications systems is the simplicity of implementation of a network controlled from a single dispatch center, which allows coordinating various services, creating and managing operational interdepartmental groups, located across extended territories and even in shadow zones, which is especially important for mission-critical communications. However, like other centralized radio systems such as trunked radio systems, issues of delay or latency and reliance on centralized infrastructure can be impediments to their adoption by public safety, defense and national security agencies, and emergency services.

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