Software Defined Radio in Public and Governmental Security Systems

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1. Introduction

Radio communication is crucial for Public and Governmental Security (P&GS) systems. No matter if a police officer waits for a radio message to get to his next scene or a firefighter needs to contact the operator, there will always be the need for a reliable, secure and fast radio communication structure. Besides the legacy requirements, however, there are also increasing demands for the radio devices: They shall be interoperable to other unit devices which perhaps support a completely different system, shall be connected to the World Wide Web and shall support new applications like video conferencing, file transfer, or access to e-mail.

The state of the art in Europe's radio communication structure is about 60 years old and little has changed. In Germany for example there have been efforts to establish digital radio communications since the 1990s, employing the new standard Terrestrial Trunked RAdio (TETRA) but the police is still using analog devices. Now in 2010, the system shall be finally launched but the problem still remains. Development moves along and if one looks to the technical advances of the last decade, the new systems will be out of date in a few years. How can an established radio communications system for public and governmental security issues be changed seamlessly? One solution is Software Defined Radio (SDR).

2. Software Defined Radio

The idea of Software Radio is to digitize the whole spectrum and process the data digitally [1]. Unfortunately, this approach is neither efficient nor practicable. But there is the possibility to filter out only a small band of the spectrum, convert it down to the baseband, and process the desired channel digitally with Digital Signal Processors (DSPs) and Field Programmable Gate Arrays (FPGAs) [2]. Such a system is depicted in figure 1. The Radio Frequency (RF) part is marked in red with the Power Amplifier (PA) on the transmit side and the Low Noise Amplifier (LNA) on the receive side. The red multipliers shift the RF signal with the carrier generated in the Voltage Controlled Oscillator (VCO) on an Intermediate Frequency (IF). The IF-part, highlighted in yellow, converts the analog signal into the digital world. Due to this,

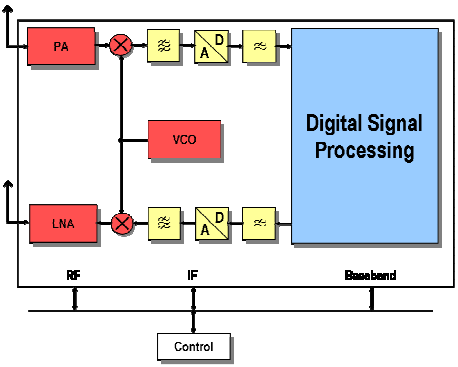

Figure 1: SDR Structure

the signal has to be filtered to prevent aliases and images. The blue part of the radio is essentially designed by software. This means signal processing is done by processors and the intelligence is just a program running on these processors. With this approach, radio communication standards become just C- and VHDL-files and are exchangeable without any additional costs. The change to another standard, e.g. from Frequency Modulation (FM) to TETRA, is just a software upgrade. The digital signal processing and therefore the reconfigurability of SDRs yields to the separation of platform and waveform. In legacy radio devices the hardware was non-switched to the functionality hence the radio standard. In SDR there is on the one side the radio platform with the hardware (filters, oscillators, RF-frontends, processors, etc.) but also the non-functional software like operating system or firmware. On the other side we got the SDR waveform which provides the functionality of the radio standard and reconfigures the platform to be part of the related radio communication system.

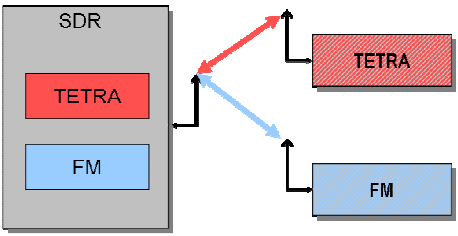

Figure 2: Interoperability in SDR

3. Interoperability of Radio Devices

Another advantage of SDR is the compatibility to old devices and the interoperability to other standards. The exchange of a radio communication structure is per se a challenging task. Most often this yields into a process which can take up to years. It is too expensive to change the whole devices in just days, so some units are equipped with the new devices while others are not. This yields into a problem because they are no longer interoperable to each other. The old devices are not compatible to the new ones and vice versa. SDR is the solution to overcome this problem. If the new devices would be software defined, the compatibility with the old radio standards is just a software upgrade. So anyone with a new software defined device is either able to communicate with the old devices over the old radio standard, but is also able to connect with the new radio communication structure. This scenario is depicted in figure 2. You can also think about border scenarios or about interconnection with other rescue teams. Today there is no communication between theses rescue teams in such scenarios. European projects like Wireless Interoperability for Security (WINTSEC) showed that interoperability issues are crucial for today's P&GS systems and that SDR is the solution to overcome it [3], [4].

4. Scenarios in Public and Governmental Security Systems

WINTSEC was a European project over 2 years with 22 organizations from 12 nations which explored a mix of complementary solutions to overcome the barrier of wireless interoperability across different security agencies taking into account the constraints of the security services and

the legacy bases. Therefore WINTSEC studied the deployment of SDR added value for base stations and terminals.
The project confirmed that SDR is a complementary way to provide interoperability for P&GS wireless systems. Especially in geographical areas where wireless systems may coexist, as it is often the case in crisis management situations. Furthermore, WINTSEC stated that by enabling base stations or terminals to be reconfigured in order to accommodate different waveforms and to operate with multiple wireless networks, SDR technology brings unprecedented flexibility in the use of different wireless systems either simultaneously (SDR base stations) or one after another (SDR terminals), and can relieve the immediate need to install new, common standard, systems to ensure compatibility. WINTSEC proposed two scenarios: An Infrastructure-based SDR and a Terminal-based SDR.

4.1 Infrastructure-based SDR

The infrastructure-based SDR deals with the fact that the base station is software defined and can therefore be reconfigured to adapt its radio channels' configuration and parameters to communicate with the various responder teams deployed within its range. That means if a SDR base station is equipped in an operation scenario where the rescue teams are provided with an FM system, the base station can be reconfigured to support FM. The same is true for any other radio standard the rescue teams are coming with. Even if the rescue teams are dealing with different standards which could come true in border scenarios, an SDR base station, supporting multi-channel capabilities, can be used to perform wireless gateway functions, translating voice and data communications between various agencies' legacy equipments formerly incompatible.

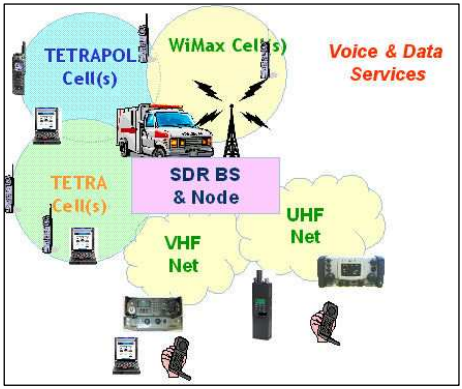

Figure 3: Overview of the Infrastructure-based SDR scenario

The structure of an infrastructure based SDR is depicted in figure 3

4.2 Terminal-based SDR

Different to the infrastructure-based scenario, the mobile device is now acting as the SDR. The terminal can be reconfigured to communicate with the network element with which it needs to operate as shown in figure 4. There is also the possibility to roam between different radio communication networks. For example when the rescue teams loose their TETRA signal but receive a GSM signal, they just adapt their SDR terminal to provide a GSM transceiver. In a terminal- based SDR scenario there is also the possibility to establish an ad-hoc network if no other infrastructure network is available. Therefore the connectivity to at least the rescue teams in the near area is assured. In future scenarios you can also think of SDR ter-

minals acting as relays to provide areas with no base station with a legacy radio network.

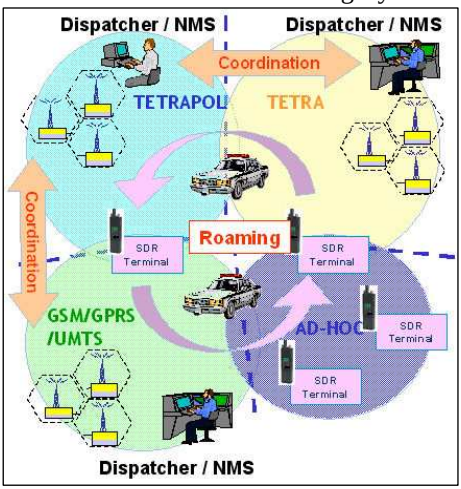

Figure 4: Overview of the Terminal-based SDR scenario

5. Conclusion

P&GS organisations need a reliable, secure and interoperable radio communication structure. In the ongoing technical developments they have to provide modern equipment for an affordable price. While exchanging the whole radio communication network is neither cost efficient nor practicable, SDR could become the solution to overcome this gap. Todays research projects like WINTSEC showed that SDR is a possible solution to solve the problem of interoperability and the interconnection of different networks. To present the technical feasibility of SDR terminals, WINTSEC will present a proof-of-concept SDR demonstrator which is reconfigurable by software and runs either a TETRA waveform or the Polish police radio system which is based on analogue FM on the final project report presentation.

References

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