WIRELESS INTEROPERABILITY FOR SECURITY - WINTSEC[1]

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ABSTRACT

Crises management for homeland security, emergency and peace keeping operations is a communication intensive process that requires the involvement of many agencies and actors. Generally, each organization operates a specific communication system. Unfortunately, in major disaster scenarios these heterogeneous and often incompatible radio communication systems form a serious barrier for efficient and mission-oriented communications. Therefore, there is a strong demand for investigations and developments of enhanced interoperability in public and governmental security (P&GS) systems. Based on the analysis of current solutions, the WINTSEC project envisions future P&GS "seamless" interoperable communication systems implementing a "system of systems" approach that is discussed in this paper.

1. INTRODUCTION

Radio networks build an important component in today's communication systems. Besides public networks, like GSM, 3G, and Wireless LAN, there are a number of private networks that play a fundamental role in daily public life. Especially, networks of police, ambulance and fire fighters are crucial for the public's security. Additionally, in the light of major disasters, like hurricane Katrina in the US or the recent tsunami in South-East Asia, there is a strong demand for an efficient disaster and crises management supported by an enhanced and instantaneous interoperability between first response units at the site.

Besides simple voice services also enhanced data services for data base queries e.g. will be requested in future P&GS radio networks. Moreover, enhanced security aspects have to be considered in such communication networks. Therefore, a flexible, adaptable and cost effective radio architecture providing interoperability must be established in future P&GS communication systems [1]. In order to provide interoperability, different approaches can be followed.

In the European WINTSEC project a dual top-down / bottom-up approach is under investigation. This includes efforts in the areas of end-user requirements and system engineering as well as a focus on the technical issues concerning an architectural frame-work, proof-of-concept demonstrations and certification issues.

In this paper, two different strategies of system interoperability are described. After a brief overview over the challenges concerning interoperability in today's public safety communication networks given in section 2, the interoperability envisioned by a system of systems approach is described in section 3. In section 4, the WINTSEC Core Network layer approach is introduced. The usage of Software Defined Radios (SDRs) is discussed in section 5. In section 6 the architectural framework investigated in WINTSEC is presented. Finally, we draw conclusions in section 7.

2. STATE OF THE ART IN CRISES MANAGEMENT

Crises management for emergency and homeland security is characterized by a very heterogeneous radio communications structure. Each organization uses its own radio communication system based on different standards or on vendor-specific waveforms. Therefore, interoperability and communication between users of different networks is not possible due to different physical layer specifications, regarding radio transmission frequency, channel bandwidth, multiplexing or frame configuration. Furthermore, a variety of transmission protocols can be found, e.g. TETRA, TETRAPOL, APCO 25, or trunked radio. They are designated Private Mobile Radio (PMR) systems specified for spectrum access in several frequency bands in the VHF (30 MHz – 180 MHz) and UHF (380 MHz – 450 MHz) range. In the US also public safety frequency bands exist in the range from 700 MHz to 800 MHz. Besides waveform-specific reasons also vendor-specific issues may tighten the interoperability aspects.

If interoperability is needed in today's missions, conventional, multi-mode radios are used or one-type terminals

[1] WINTSEC is a project within the Preparatory Action on the enhancement of the European industrial potential in the field of security research.

are distributed to all partners on site enabling all units involved to communicate with each other. Both solutions are very cost-consuming and inflexible. Especially, distributing one radio type to all units on-site is inefficient and requires huge efforts.

If disaster scenarios, like terrorists' bombing attacks, are additionally taken into account, further aspects of network reliability have to be considered. In these scenarios parts of the established infrastructure can collapse. In order to provide a reliable and efficient communication between first responder units, a flexible, adaptable and robust wireless and mobile communication system is indispensible.

Resulting from the drawbacks of today's P&GS networks the following requirements on future systems can be derived: Generally, interoperability between different networks has to be enabled at a cost-efficient and application-oriented level. This includes compatibility to already established components as well as abilities for enhancements in up-coming system generations. Furthermore, a solution adaptable to a number of different scenarios and configurations provides flexibility that is necessary for such communication networks.

Considering concrete questions of interoperability the conversion of a connection to different protocol stacks is one of the general challenges. Any interface, which may be installed for transition, needs to be transparent to the user because it should not influence the original mission. Furthermore, adequate solutions for a rapid and cost-efficient installation of a communication network including all units involved at the current site have to be defined.

3. INTEROPERABILIY THROUGH A SYSTEM OF SYSTEMS VISION

3.1. Current "stove-pipe" systems

Current solutions to establish interoperability among disparate systems run the gamut from console patches via cross-band repeaters and audio switches to network-based solutions [2],[3]. These approaches provide some limited interoperability, generally confined to a local area, require long deployment times, lack flexibility and do not address the problem as a whole.

3.2. The WINTSEC System-of-systems Vision

From the statement of facts described above, the WINTSEC project envisions future P&GS "seamless" interoperable radio-communications being addressed by a "system of systems" approach integrating functions into the radios and systems that provide the basis for future interoperable European emergency wireless communication systems.

This "system of systems" approach depicted in Figure 2 must support different "hierarchical cells", ranging from short-range communications to long-range communications, encompassing different communication systems at a national or international level and shall address the different system architecture layers contributing to interoperability, i.e.:

- **Application layer:** supports the different applications: voice, email handling, video handling, localization, data base, "Common Operational Pictures" (COP), and "Command & Control" (C2) providing to the end-users the mission-dedicated added value services.
- **Core Network layer:** plays the role of isolating the Application layer from the heterogeneous wireless communications networks and could play the role of an interoperability backbone between different networks.
- **Base Network layer:** regroups the collection of Base Stations (BSs) or Radio Access Points (RAPs) that interfaces the Core Network layer with the wireless world and provides connectivity to the End-users. Currently, these BSs or RAPs are generally allocated to one type of wireless standard like TETRA, TETRAPOL, GSM, etc., but evolution to SDR is occurring.
- **User Terminal layer:** regroups the collection of different User Terminals, distributed to the responders, allowing them to register on the wireless communication network and access to the various mission-dedicated services provided by the Application layer.

Furthermore, Information Assurance functions are distributed over these different layers in order to ensure the level of security requested by the missions.

3.3. Two approaches towards Interoperability

The WINTSEC project focuses on the other system architecture layers and envisions a set of complementary and innovative solutions to address these challenges:

- **A standardized Connectivity Layer at Core Network layer** enabling the linking of existing and new assets to offer improved performance and enhanced adaptive functionalities between the various networks.
- **Standardized SDR solutions** at BS, RAP and User Terminal (UT) layers, in order to be able to provide flexible wireless connectivity.

Because of the variety of crisis scenarios to address, a "unique" technical solution will not be able to fulfill all the situations and requirements (e.g. national or multi-national).

Due to the importance of the installed base, it is essential to propose a set of concepts and solutions that enables a smooth transition from existing "stove-pipe" wireless systems to a more integrated and interoperable "system of systems" vision.

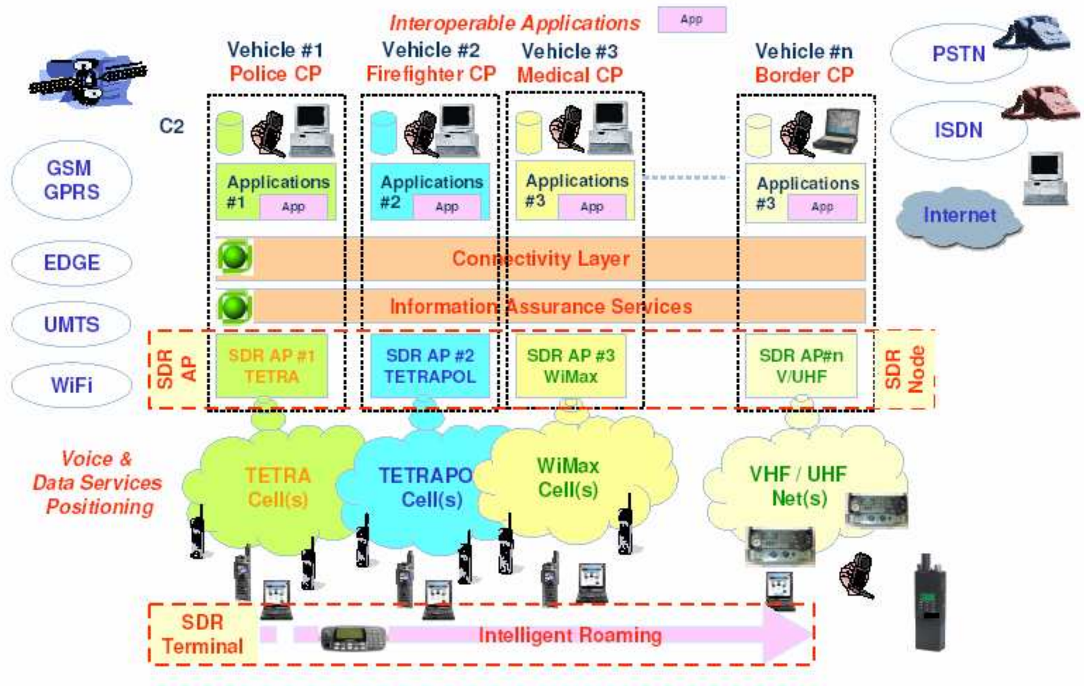

Figure 2 WINTSEC - System-of-systems approach

The use of SDR based devices (Terminals and Base-stations), integrated with solutions defined for interoperability in the Core Network Layer, will guarantee maximum flexibility for future generation European P&GS communication systems, including the possibility to implement different interoperability layers according to the operational scenario.

To address Information Assurance requirements of P&GS applications, the WINTSEC project streamlines standardized security services across multiple radio network technologies: i.e. confidentiality, availability and integrity of information, and authentication of users. This transverse activity addresses the Connectivity Layer and the SDR levels.

4. CONNECTIVITY LAYER AT CORE NETWORK LEVEL

The standardized Connectivity layer at Core Network level is made of improved infrastructure including switches, routers and optical fiber. Microwave and also satellite links may be used as backhaul.

In Figure 3 andFigure 4 the system model of the Connectivity layer at Core Network layer is illustrated. On top of this model there is an Application layer supporting different service applications: E.g. voice and data transmission services, common data bases or localization. The Core Network layer forms the interface between the Application layer and the different communication networks and includes all functions necessary for interoperability between networks. At Base Network layer level all network-specific base stations and access points are pooled. This provides the connectivity to the end users. At the level of the User Terminal layer, all end user terminals in the different networks are combined. Appling a standardized layer above the Core Network Layer enables the linking of existing and new networks without affecting the existing subscriber terminals.

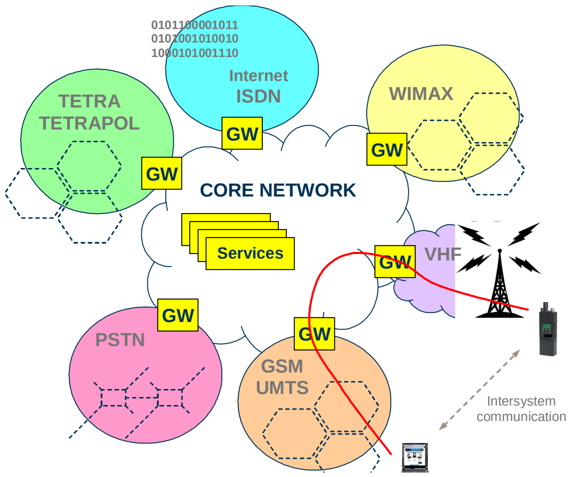

Figure 3 Core Network Interoperability Approach

This approach will result in the following benefits:

- Inter-systems communication,
- Increased coverage and range,

- Multiple access routes to mitigate overload problems in subsystems,
- Information gathering and analysis of subsystems activities,
- Spreading of information to multiple parties (broadcast and multicast services),
- Sharing databases and services, with filters depending on relevance, need and subsystem capacity,
- Implementation of data fusion for enhanced situation understanding.

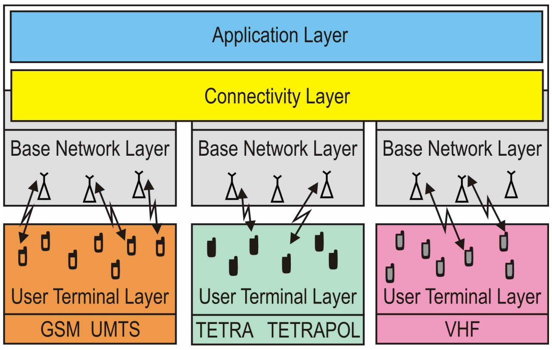

Figure 4 Layer Model for Core Network Interoperability

To implement standardized core network interoperability, several issues shall be addressed in order to provide efficient services and the networks not to be exploited by unauthorized users:

- Introduction of a common name server to deal with addressing issues,
- Introduction of voice and video servers,
- Introduction of gateways to convert between communication formats in general,
- Introduction of a common authentication service for user authorization and accurate data logging,
- Introduction of a firewall to maintain security and to reduce the possibility of entering the secure system through an insecure network,
- Deployment of technology independent peer-to-peer communication,
- Deployment of group classification and encryption technologies for secure data transfer,
- Reception acknowledgement procedures.

These system level aspects will be defined by the WINTSEC project.

5. USAGE OF SOFTWARE DEFINED RADIO

A complementary way to provide interoperability for P&GS wireless systems is to introduce SDR components. This is of special interest in geographical areas where wireless systems may coexist, as it is often the case in crisis management situations.

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.

5.4. Short term vision for SDR

In the short term, SDR can bridge between different wireless systems.

5.4.1. Infrastructure-based SDR

A SDR base station can be reconfigured to adapt its radio channels' configuration and parameters to communicate with the various responder teams deployed within its range (c.f. Figure 5).

A 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.

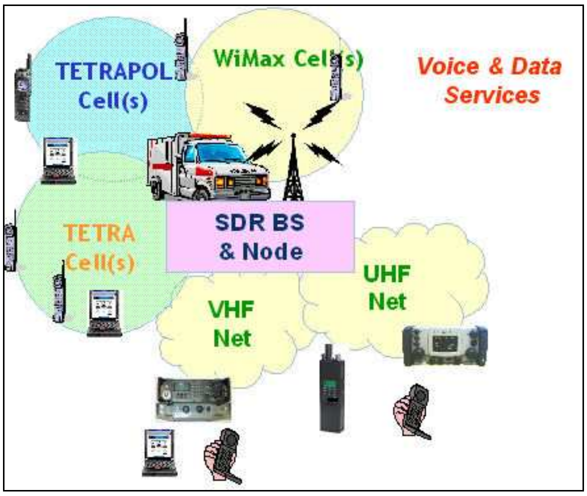

Figure 5: SDR Base Station Vision

5.4.2. Terminal-based SDR

A SDR terminal can be reconfigured to communicate with the network element with which it needs to operate.

Therefore, SDR terminal equipped teams can communicate with several kinds of P&GS wireless networks, and, in absence of any infrastructure network, can establish an ad-hoc network between them (c.f. Figure 6).

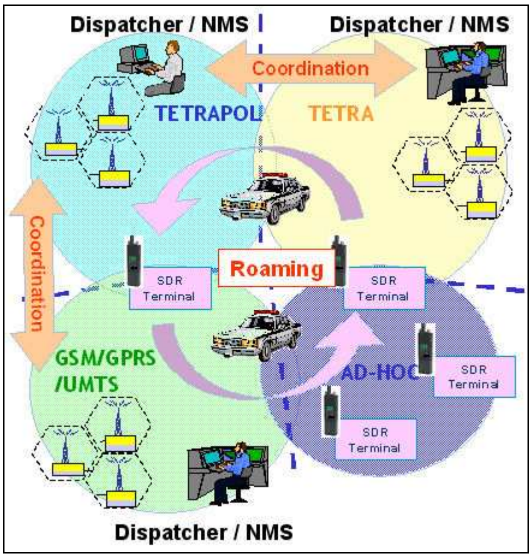

Figure 6: SDR Terminal Vision

5.5. Long term vision for SDR

In a long term vision SDR can provide an efficient, versatile, flexible environment for building multi-mode, multi-band, multi-functional flexible wireless networks able to support intelligent roaming between disparate networks as depicted in Figure 7.

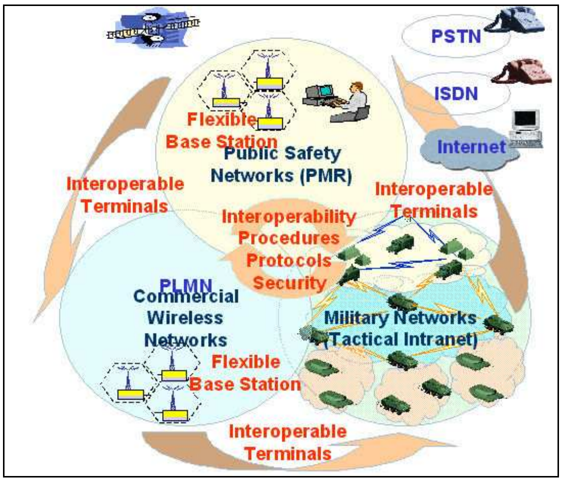

Figure 7: SDR based System Architecture for Interoperability

Furthermore, the future SDR could bring new capabilities into the spectrum management arena for P&GS wireless communications (i.e. Cognitive Radio (CR) concepts for P&GS wireless communications), allowing a fresh new approach for frequency management which could be device based, opposed to the traditional policy based approach.

6. ESRA: AN ARCHITECTURE FRAMEWORK FOR SDR INTEROPERABILITY

6.1. Why an Architecture Framework?

The deployment of SDR technology on heterogeneous reconfigurable radio equipments, ranging from mono-channel terminal to multi-channel base station, implies that each of those equipments is built using a certain SDR Architecture.

To decrease the costs attached to SDR Platforms and Waveform developments, standardized technological solutions are actively defined across the industry, on several reference technical issues relative to SDR Engineering. One solution is the Software Communication Architecture (SCA) promoted by the SDR Forum [4].

The European Software Radio Architecture (ESRA), built on top of reference SDR technology standard achievements such as the SCA, is aiming to give a reference framework to better characterize the SDR Architecture solutions, thus facilitating the emergence of standard solutions for increased economical efficiency.

6.2. The underlying vision for ESRA

The well known “waveform/platform” paradigm is governing the ESRA definition, with:

- **The SDR Platform** which provides the hardware radio-frequency (RF) resources, the input/output (I/O), the security features and the programmable computing resources (Field Programmable Gate Arrays (FPGAs), Digital Signal Processors (DSPs), General Purpuse Processors (GPPs), Application Specific Integrated Circuits (ASICs)) able to support a specified set of Software Applications. Therefore, a SDR platform is designed to establish radio-communication links within a specified range of frequency bands and data rates.
- **The Waveform Applications** (Standards, Waveforms or Air Interfaces) which are supported by the SDR Platform and configure it in front of dedicated radio-communication standards, allowing the SDR equipment to be part of the related radio-communication system.

6.3. What is ESRA covering?

ESRA is addressing the aspects related to the facilitation of waveform capability implementations on SDR Platform.

This starts from a certain number of architecture areas dealing with SDR platforms implementation choices.

The reconfigurable functionalities provided by the platforms for waveform implementations are the first key features making up a SDR Platform. One distinguishes:

- Reconfiguration Infrastructure,
- Radio Devices,
- Radio Services,
- Radio Security Devices & Services.

Second, since the SDR Platform is hosting the waveform application software that is implementing an ever-increasing proportion of the waveform functionalities. One distinguishes in this realm three reference component model families, plus one area dealing with the associated interoperability issues:

- GPP Component Models,
- DSP Component Models,
- FPGA Component Models,
- Connectivity Mechanisms.

To complement the final implementation issues, an important aspect is the study of the aspects related to processes and methodologies applicable for waveform development support.

The ESRA is thus covering the major aspects of SDR implementations: loading and executing on the same SDR platform different types of waveforms, abstraction of the hardware radio resources through APIs and behaviors supporting different waveform implementations.
ESRA is aimed to be scalable, extensible and applicable to different kinds of radio equipments, in compliance with P&GS system and waveform requirements.

The following figure is summarizing the ESRA content:

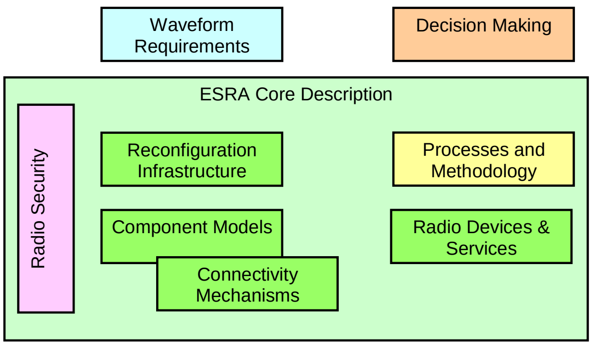

Figure 8: ESRA, a SDR Architectural Framework

6.4. What is WINTSEC aiming to do with ESRA?

WINTSEC is primarily dealing to conduct state-of-the-art, short term trends analysis, then forward looking studies, so as to provide appropriate recommendations concerning the standards and technologies most suited to .

A certain number of reference existing standards will be the baseline matter from which the investigations will start, among which the SCA, due to its maturity and industrial availability, will take a prominent role.

The final recommendations are thus expected to consider, for the most mature architecture areas, existing achievements as viable solutions, while complementary standardization or more fundamental efforts may be recommended on the less mature areas.

7. CONCLUSIONS

In today's P&GS networks interoperability is one of the major challenges. Due to the homogeneous structure and the incompatibility an efficient and mission-oriented communication between all parties cannot be provided. In order to overcome this gap the WINTSEC project investigates a dual top-down / bottom-up approach. The general concept of the system-of-system approach as well as the SDR architecture framework was presented in this paper.

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