THE APPROACH OF SELEX COMMUNICATIONS ON SOFTWARE DEFINED RADIO

Loris Schettino (SELEX Communications, Pomezia (Rome), Italy,
loris.schettino@selex-comms.com);
Virgilio Cruciani (SELEX Communications, Pomezia (Rome), Italy,
virgilio.cruciani@selex-comms.com)

ABSTRACT

SELEX Communications is the centre of excellence in secure communications within the Finmeccanica Group and a point of reference for its Companies.
SELEX Communications covers Land, Naval, Avionics and Secure Communications.
In 2002 SELEX Communications (at that time Marconi Mobile) started a research program, funded 50% by IT MOD & 50% by SELEX Communications, aiming at demonstrating communications capabilities in accordance with Software Communications Architecture (SCA) standard.
Further to this, SELEX Communications is "today" involved in JTRS MIDS Development.
Based on previous experience and on the current work in progress we are developing a family of radio systems (oriented to different platforms, i.e. naval, tactical, airborne) that can meet JTRS (MIDS JTRS Terminal) as well as other (proprietary) requirements

1. INTRODUCTION

Software Defined Radio is a concept that has been around for years, with studies and proposals covering almost every aspect of radio technologies and techniques. Deep interest has been shown by the Military Communications world, due to the benefits that are envisaged both from a performance and commercial point of view. This new approach to radio communications is based upon a layered SW architecture which has conquered the status of reference standard. It also needs gathering the most advanced technologies from any application field, even in the analogue domain, which, at first sight, may seem unrelated to the SW defined issues.
In 2002 SELEX Communications (at that time Marconi Mobile) started a research program aimed at reaching the following major objectives:

- Acquire a thorough knowledge of the Software Communications Architecture (SCA) and related issues from JTRS program and others;
- Conduct studies and perform tests on HW and SW architectures that are necessary in order to develop SDR SCA compliant platforms.
- Investigate specific technical areas and enabling technologies

The SELEX Communications research program is centred on the realization of a demonstrative prototype, in order to explore the largest number of issues that are part of an SDR development. The characteristics of the test bench are listed in the table below:

Number of channels	8
RF frequency band coverage	2÷400 MHz
Operational environment	Fixed/Naval
User interfaces	Ethernet for voice and data
Form factor	Two 19" racks

Table 1

Figure 1 SDR SELEX Communications Demonstrator

The demonstrator is composed of 2 19“racks [1 Radio Rack & 1RF Distribution Rack] as the previous figure shows.
In the Radio Rack a VME case with GPP Boards is installed.
These boards are:

⇒ Modem Boards
⇒ I/O Boards
⇒ Control Board

The Modem Board is in fact a GPP Board fitted with a DSP/FPGA board, developed by SELEX Communications, that performs digital signal elaboration from digital baseband to IF frequency

The Radio Rack hosts also RF wideband Front Ends and local I/O panel.

The RF Distribution Rack hosts:
⇒ Power Amplifiers (HF-V\UHF)
⇒ Low Power Matrix
⇒ Combiner
⇒ Power Meters
⇒ Directional Couplers

It is important to note that to guarantee integration of a legacy RF distribution System in the SCA Architecture we have developed a CORBA Adapter.
SCA defines “Adapters” as *Resources or Devices used to support the use of non-CORBA capable elements in the domain”*.

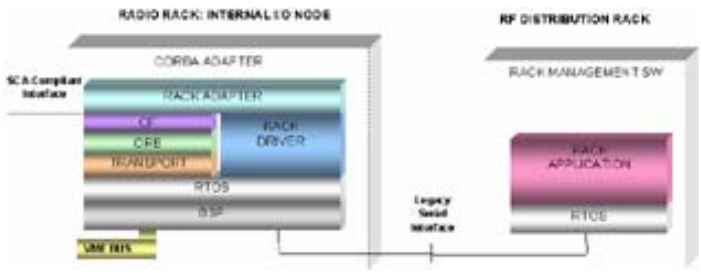

Figure 2 CORBA Adapter

SELEX Communications is also involved in JTRS MIDS Development. This participation started in 2002 with a SELEX Communication feasibility study, continued through 2003 with the Specification Definition as a member of the European–US Team of Industries and finally with the preliminary design as a member of the same team.
Based on previous experience and on the actual work in progress we are developing a family of radio systems (oriented to different platforms, i.e. naval, tactical, airborne) that can meet JTRS requirements (MIDS JTRS Terminal) or possibly other (proprietary) systems

The MIDS JTRS Main Technical Characteristics are:

⇒ 1 Channel for Link-16 & TACAN

⇒ 3 JTRS Channels
- 2 MHz – 2 GHz Frequency Band
- All JTRS WFs can be loaded such as SINCGARS, HAVE QUICK II, DAMA SATCOM, EPLRS, WNW, HF ALE, LINK 11,LINK-22, and SATURN.

2. ON PROGRESS ACTIVITY

A large number of skilled people are working in SELEX Communications on the SDR project development.
The main activities are oriented to:
⇒ Core Framework Development (as per SCA V3.0) & TOOLS
⇒ SHS (Specialized Hardware Supplement) SCA V3.0 experimental (including high speed serial bus test)
⇒ Use of MEMS technology in SDR
⇒ Wideband Power Amplifier
⇒ Wideband Antenna

2.1. Core Framework

Core Framework (CF) architecture is the core of a SCA-compliant system.
Core Framework provides core capabilities and applications for system configuration and control. It defines operations and relationships by which application SW components interact
A SCA-compliant Radio System shall provide very deep reconfiguration architecture.
The SCA specification requires reconfiguration at two levels:

⇒ Dynamic Reconfiguration (At run-time the system is able to switch from an application to another)

⇒ Static Reconfiguration (At design-time the system can be easily extended and adapted)

The SCA specification requires portable software components to provide common information called a Domain Profile. The Domain Profile is one of the features specified in the SCA to meet the reconfiguration

requirements. Domain Profile is a set of XML files that permit to manage radio files (or functions foreseen in the radio)
Actually we are finalizing a Sw tool that permits to modify, manage etc the *Domain Profile*.

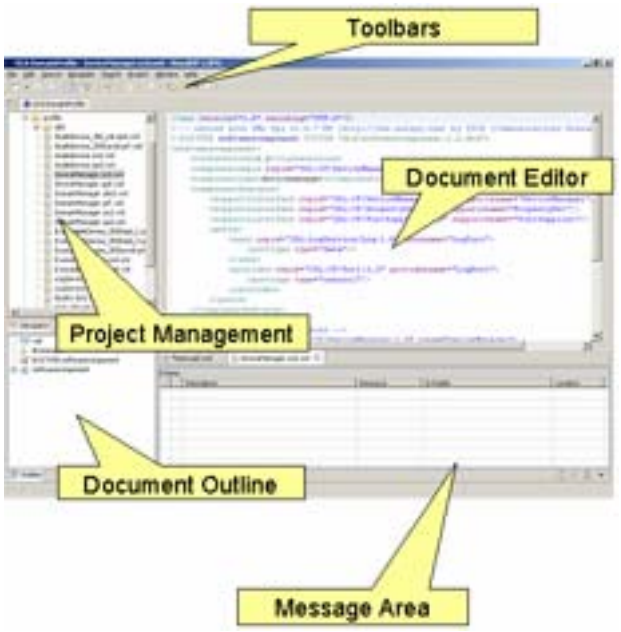

Figure 3 Domain Profile Authoring Tool

The main features of SCA Domain Profile Authoring Tool are:

⇒ XML Editor (Direct access to the XML data format)

⇒ Visual Model of the SCA Domain Profile (Graphical view of the Domain Profile Models) such as
- Components,
- Hw Configurations and Waveform Assemblies)

⇒ SCA Domain Profile Validation (Automatic Domain Profile coherence validation)

⇒ Deploy Management (simplified deploy on SCA-compliant Radio Systems)

It is very important to note that this is Not a Legacy Tool!! Our tool can be used with any SCA Core Framework implementation

2.2 SHS (Specialized Hardware Supplement) SCA V3.0 experimental

Current SCA (POSIX O.S., Middleware RT CORBA) does not fully cover all Hardware areas (FPGA, DSP, etc).
It is mandatory to improve portability in specialized HW by using an extension of SCA 2.2 that already does it only for GPP SW. The SCA 3.0 tries to achieve this goal. In fact our experience suggests that many aspects will have to be clarified in next releases of the SCA and this is supported by many CPs, e.g.: CP 267 "…. SHS requirements are, in general, vague and apt to cause uncertainty and leave room for multiple interpretations"
SELEX Communications have been experimenting in the field the concepts described in SHS document, with particular attention towards FPGAs.
The HAL Connectivity (HAL-C):

⇒ Specifies the communication among GPP SW components and specialized HW components regardless of the HW platform

⇒ Extends SCA concepts to specialized HW

SHS (Specialized Hw Supplement) V3.0 does not specify a communication mechanism for the autonomous component (IPs) in the FPGA, but its previous Proposed Studies mention OCP (Open Core Protocol) as the standard to use. Based on this, to implement HAL-C (Hardware Abstraction Layer Connectivity) concepts SELEX Communications has chosen to evaluate OCP

As to high-speed serial bus test, it is known that Large Bandwidth (~Gbit/s) is required because of waveform distributed in different Processing Elements and overhead due to different levels of abstraction. One possible solution is Serial BUS with Point-to-Point connections. A lot of test with significant results have been performed in our factory.

2.3 Use of MEMS technology on SDR

MEMS is the acronym of Micro Electro-Mechanical System and is a technology to build mechanical system (such as engine, spring, beam, etc.) of micrometric size (few tenth of mm). The reduced dimension gives for instance, very high mechanical stiffness due either to the technological process or to the size.
MEMS are mainly used, today, to implement sensors (either mechanical or chemical): pressure/force, acceleration, vibration, movement, viscosity, etc.)

There is a lot of literature on MEMS for Radio Frequency, but, at present, very few manufacturers offer RF MEMS devices.
Often in RF applications, MEMS technology is used to make, in very small size, the standard electronic microstrip/stripline filters. Considering that, for distributed element filters, the physical dimensions are directly related to frequency this is the best and easy way to increase the working frequency over 20 GHz.
Other RF MEMS applications are:

⇒ Relays and Switches (these are the first and the most studied RF MEMS devices)

⇒ Mechanical filters (beam resonator can be easily made with Q > 1000 in the HF band frequency) either fixed or tuneable

⇒ Electrically tuneable air-dielectric capacitors

SELEX Communications started its study on MEMS considering these last three applications, all usable in the SDR Transceiver frequency range.

2.4 Wide Band Power Amplifier

The development of an UWB RF power amplifier is part of the design of a Software Defined Radio system. The main reason is the need of a PA that is independent from the specific waveform.
The development of a RF power amplifier that covers a 2÷500MHz frequency range represents the most difficult step in the achievement of a 2÷2000 MHz and above final objective. The challenge is to design a single RF power amplifier able to simultaneously operate in the HF and V/UHF band, covering almost 8 octaves.
We are finalizing, for our demonstrator, a 100W power amplifier in the 2÷500MHz frequency band.

2.5 Wide Band Antenna

We have in progress a Research program, funded 50% by IT MOD & 50% by SELEX Communications, to design a wideband antenna, with the following main capabilities:

⇒ 2MHz - 500 MHz frequency band

⇒ Multifunction (NVIS, Sky wave and Ground Wave)

A solution was discovered for a multi port naval structural antenna, that uses the ship structure as part of the antenna.
It allows:

⇒ Significant improvement in multichannel system efficiency (radiated power for channel) compared with the standard approach using combiners (fig. 4).

⇒ Omnidirectional radiation pattern for broadcast communications

⇒ Capability to increase the antenna directivity in case of point-to-point communications.

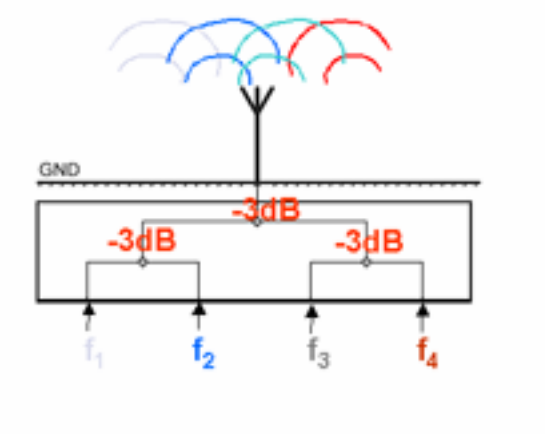

Figure 4 Passive insertion loss scheme

3. SECURITY

Software-based security systems require a new approach. Compared to previous legacy secure systems the following differences apply:

⇒ Crypto algorithms should be reprogrammable, instead of having multiple fixed hard-wired crypto devices;

⇒ Software execution of waveforms in a secure radio system makes many basic system-level functions become sensitive:
- Application download and reconfiguration
- Soft key management

From a technical point of view, two main issues may be envisaged:

⇒ Definition, validation and implementation of policies that discipline how an SDR manages security-related non-crypto functions

⇒ Reprogrammable crypto issues

The security non-crypto issues are mainly connected to the architecture approach. In the SCA SDR architecture we can see that all SDR system is "secure sensitive". We can think for instance to the waveform instantiation. Security standard of SCA current version doesn't cover all the aspect connected to the secure topic.
We are working to realize security features for software radios specifically to prevent and detect unauthorized software installation and execution.

4. ROADMAP

The final target of our development is to evolve to radio systems that:

⇒ Employ a common and open architecture that can be upgraded with minimal cost impact
⇒ Permit Modular replacement of components
⇒ Provide Software upgrades
⇒ Give reduction of logistics cost
⇒ Eliminate single/special purpose radios
⇒ Permit Re-use of waveforms

The figure below shows our development phases:

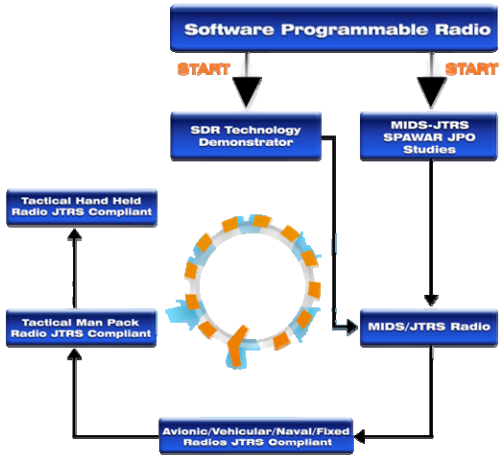

Figure 5 SDR SELEX Roadmap

We are developing a family of radio systems (oriented to different platforms, i.e. naval, tactical, airborne) that can meet JTRS requirements (MIDS JTRS Terminal) or other (proprietary) requirements

5. SUMMARY

The SELEX communications SDR program is oriented to a complete SDR System development.
Target is to create SDR Platforms that work with JTRS or proprietary Waveforms, to solve integration problems and to deliver also additional ancillaries as, for instance, wideband antenna.
The figure below summarizes the main activities run by SELEX Communications in the SDR development.

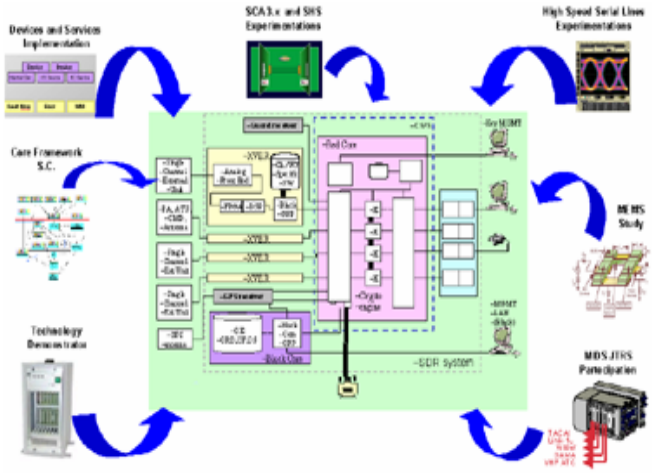

Figure 6 SDR SELEX Communications Activity

In addition to the portability problem that implies clarification in the next SCA release, the Security issue is a field to be explored, especially in the military environment, with Government support.
It is in fact important in the SDR systems to protect its own communications and to find an agreed methodology between nations to exchange essential parameters to port waveform developed by one nation into a platform developed by another one.