Belgian NATO Narrow Band Waveform for Tactical Radios

Belgian RSTD SIC-10 study

- Study, develop and implement waveforms for cognitive radio ad-hoc networks
- The concept of software defined radios (SDR) is to replace special analog hardware components by field programmable gate arrays (FPGA), digital signal processors (DSP) and general purpose processors (GPP)
- Allow fast-prototyping and support multiple radio standards on a single reconfigurable platform
- The concept of cognitive radio (CR) is to have a network of SDRs which can auto configure and autonomously change its parameters (waveform, frequency, bandwidth, power) according to the user needs and the electromagnetic environment
- Several waveforms have been implemented in the RSTD SIC-10 study, the NATO Narrow Band Waveform is one of them

NATO Narrow Band Waveform (NBWF)

- New Combat Net Radio (CNR) STANAG Waveform for coalition interoperability with lower tactical levels
- Bandwiths of 25 kHz and 50 kHz with on-air bit rates up to 82 kbps in very high frequency (VHF) or lower ultra high frequency (UHF) bands
- Continuous phase modulation (CPM)
  - Pros: High spectral efficiency owing to the phase continuity, high power efficiency owing to the constant envelope
  - Cons: High implementation complexity to build an optimal receiver
- Several CPM modes (N1-N6, NR) with slot length 22.5 ms

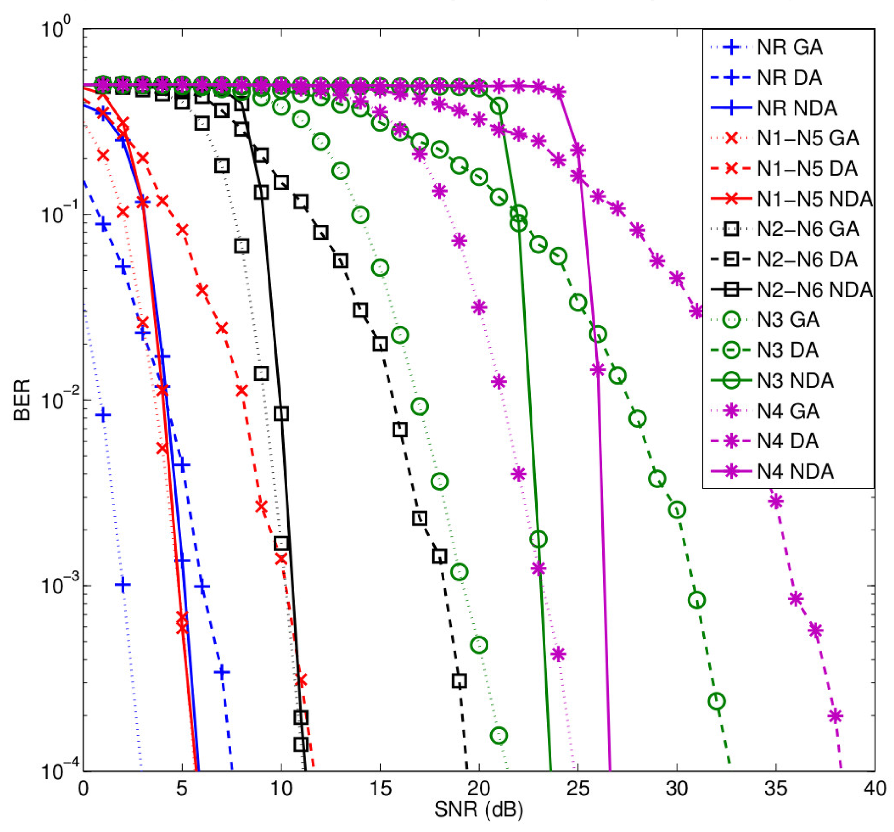
Mode	Data Rate (kbps)	h	Pulse Shape	Code Rate	Symbol Rate (ksps)	BW (kHz)
NR	10	1/2	2-REC	1/3	30	25
N1	20	1/2	2-REC	2/3	30	25
N2	31.5	1/4	2-REC	3/4	42	25
N3	64	1/6	3-REC	4/5	80	25
N4	82	1/9	3-REC	6/7	96	25
N5	40	1/2	2-REC	2/3	60	50
N6	63	1/4	2-REC	3/4	84	50

CW	CPM Pseudo-Random Sequence	CPM Data Sequence

- Time Division Multiple Access (TDMA)
  - Frames composed of 9 slots
  - Hyperframes composed of NRadios x (NRadios+1) frames

Belgian NATO NBWF - Physical Layer Simulation Results

- Low-complexity generic receiver for the different NBWF modes
- Innovative approach for coarse and fine frequency, phase and time synchronization and demodulation
- Bit error rate (BER) performance vs signal to noise ratio (SNR) of the low-complexity generic receiver for the different NBWF modes and algorithms: genie aided (GA) theoretical references in case of perfect carrier frequency and phase estimates, data aided (DA) and non data aided (NDA) fine carrier frequency and phase synchronization algorithms.

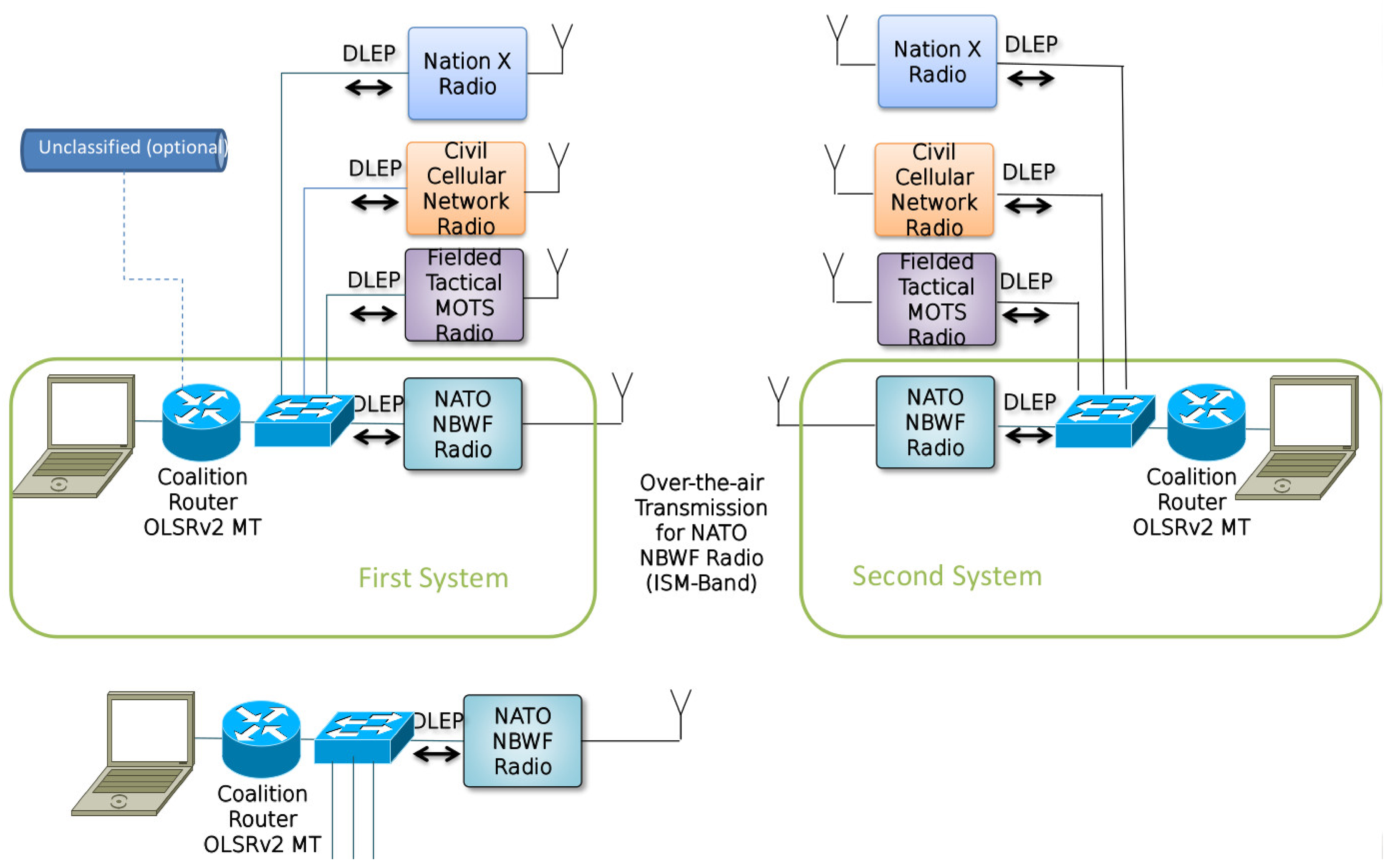


Belgian NATO NBWF - Implementation and SDR Hardware

- Low-complexity generic receiver minimizes and simplifies the receiver, which is important in military portable equipment
- Implemented in C++ using open-source libraries (Qt, UHD, IT++, GStreamer)
- Two services implemented, voice Push-To-Talk (MELP) and IP data over TAP interface (IPv4, IPv6, ARP,...).
- Data Fragmentation and Aggregation
- Broadcast support (Unicast not yet supported by NATO NBWF STANAG)
- Optional Routing (OLSR, OLSRv2) over the TAP interface
- Optional Dynamic Link Exchange Protocol (DLEP) between the DLEP-enabled radio (TAP interface) and a DLEP-enabled router
- Tested on Odroid-XU4 single board computers attached with a USRP B205-mini software defined radios.
  - Odroid XU-4 (Samsung Exynos 5 Octa (5422) system on chip (SoC), 2GB RAM)
  - USRP B205 mini (70 MHz - 6 GHz frequency range, up to 56 MHz bandwidth)
- Physical and data link layers are able to run in real-time on these general purpose processors (GPP) owing to the low-complexity generic receiver, this would have not been possible with maximum-likelihood receivers implemented using Viterbi or iterative algorithms

Participation in CWIX

- Test a prototype SDR implementation of the NATO NBWF in order to determine its performance, to identify strengths and weaknesses, and to improve its implementation.
- Integration of different national radios and waveforms with a coalition OLSRv2 based and DLEP-enabled router
- Feasibility of combining different national radios in a coalition ad hoc network including cross layer optimizations.



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