DESIGN OF A PR NMD CHANNELIZER-BASED DOWN CONVERTER FOR RECEIVE UPLINK OF COMBINED 3GPP AND UMTS RADIOS

This is not my mistake!

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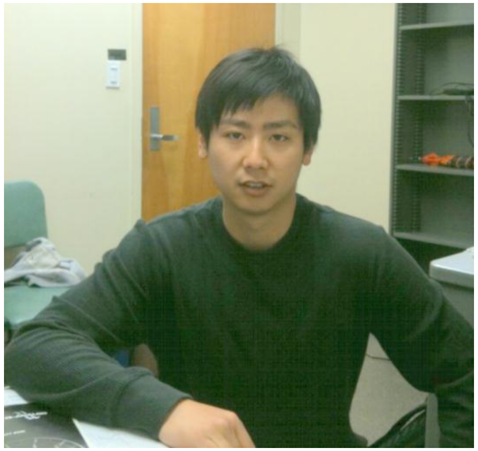
Who we are and what we do…



- Software Defined Radios / **Digital** Modem Design
- Up/Down Conversion
- Synchronization
- Channel Equalization
- Spectral Analysis
- Frequency Hopping Systems
- Efficient Resampling Architectures
- ….

Multirate Signal Processing

The Goal:

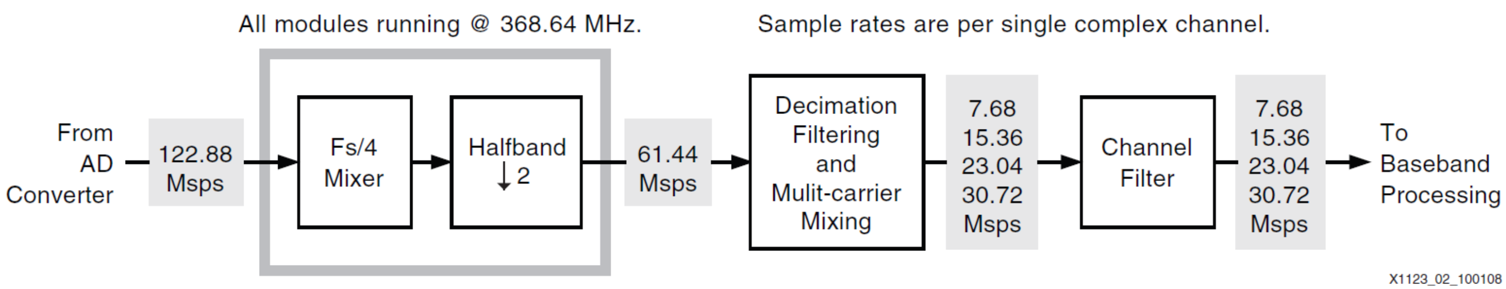
To combine 3GPP LTE digital front ends for receive uplink and UMTS digital front end for receive uplink

The input sample rate, the desired output sample rates and the signal bandwidths are equal for the two systems

In the UMTS case the input sample rate must be wide enough to accommodate multiple WCDMA channels with some flexibility in carrier spacing

WE WANT TO IMPROVE THE EFFICIENCY AND GAIN IN FLEXIBILITY

Where we are Today



3GPP LTE digital front-end architecture for receive uplink

Standard 3GPP LTE and UMTS digital front ends for receive uplink are generally implemented as cascade of half-band filters performing successive 2-to-1 down sampling.

A mixer, based on the assumption that the Intermediate Frequency (IF) is centered at one quarter sample rate, is placed at the beginning of the down converting chain to shift the input spectrum to base-band before the sample rate reduction is performed.

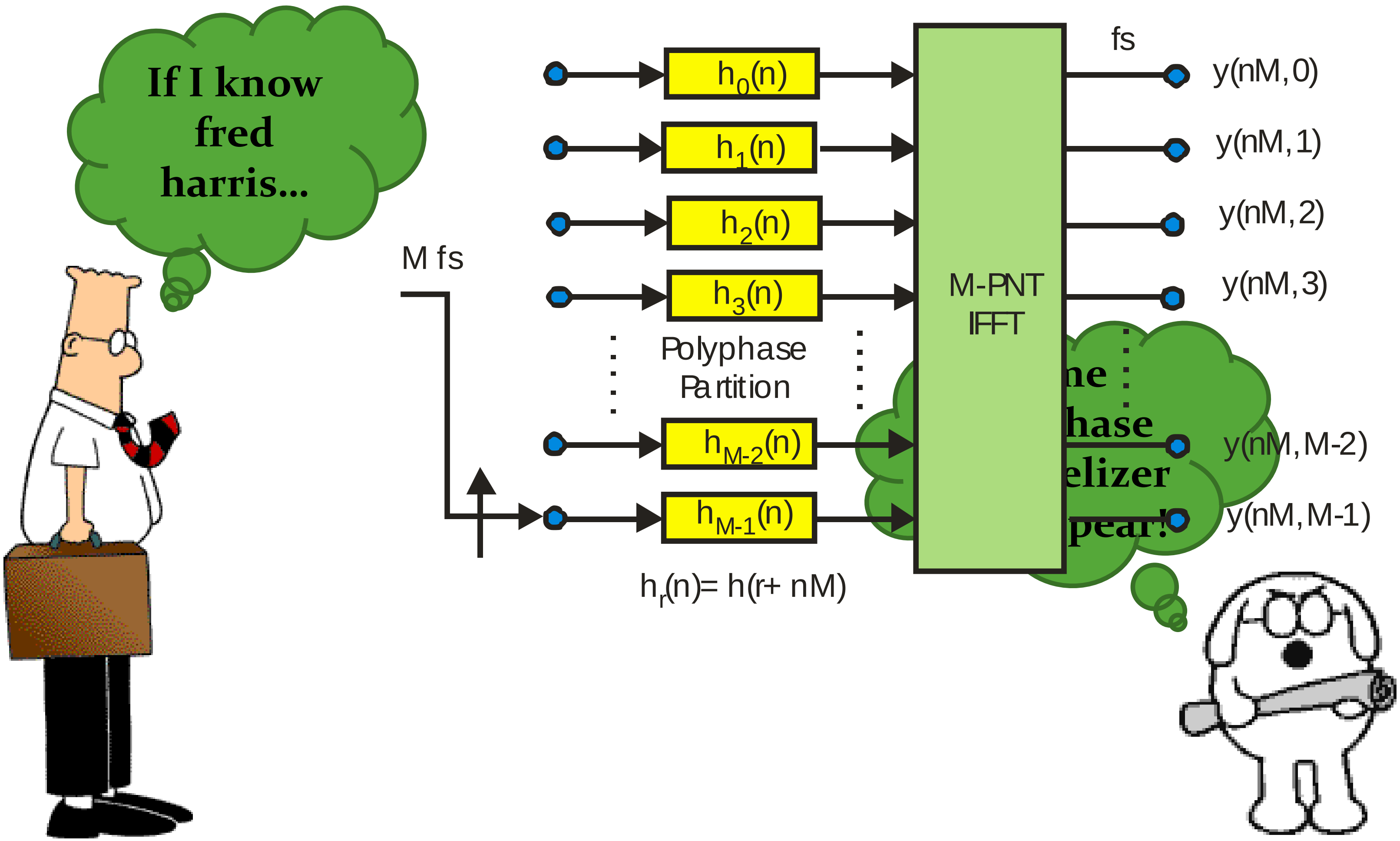
What we would like to have

➢**The workload of standard radios for receive uplink for 3GPP LTE and UMTS communications depends on the input sample rate and also, such a system lacks generality and cannot be utilized when different input or output specifications are given**

Our goal is to design a, single multi-purpose, radios while maintaining

✓Good performance
✓Low computation complexity
✓Cost reduction

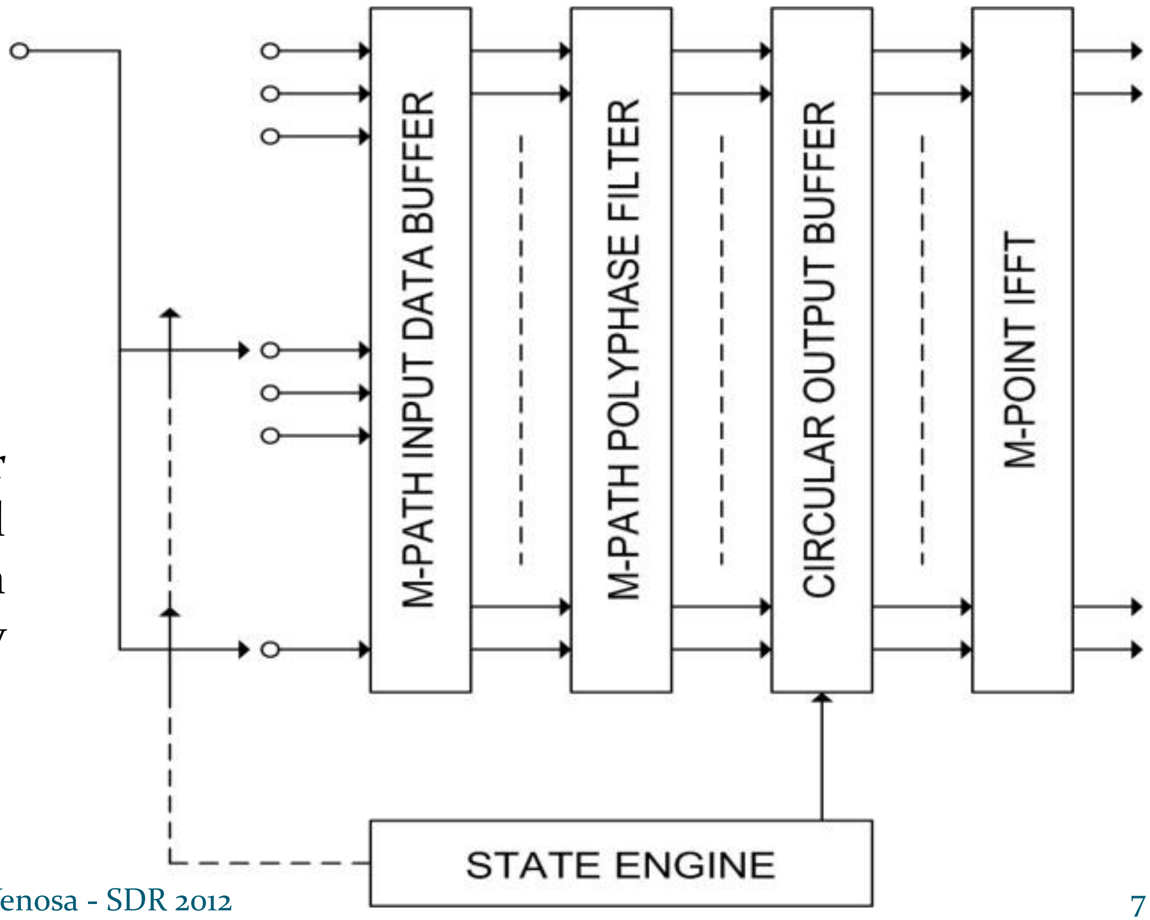
How do we obtain it

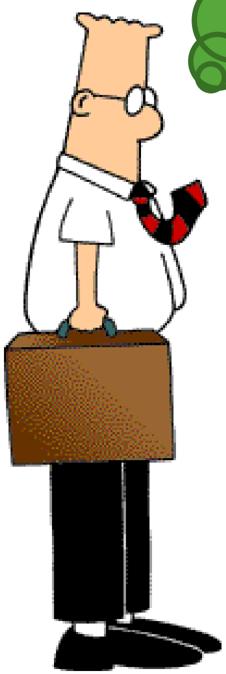


Analysis Channelizer

We have designed an 80-path PR NMD down converter which performs 40-to-1 down sampling of the input time series

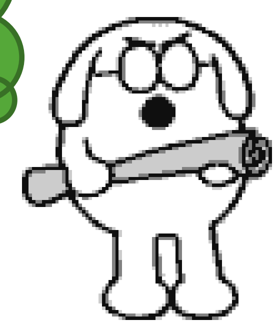
The design of the channelizer size (number of paths as well as IFFT size) has been driven by the specifications given by this application case





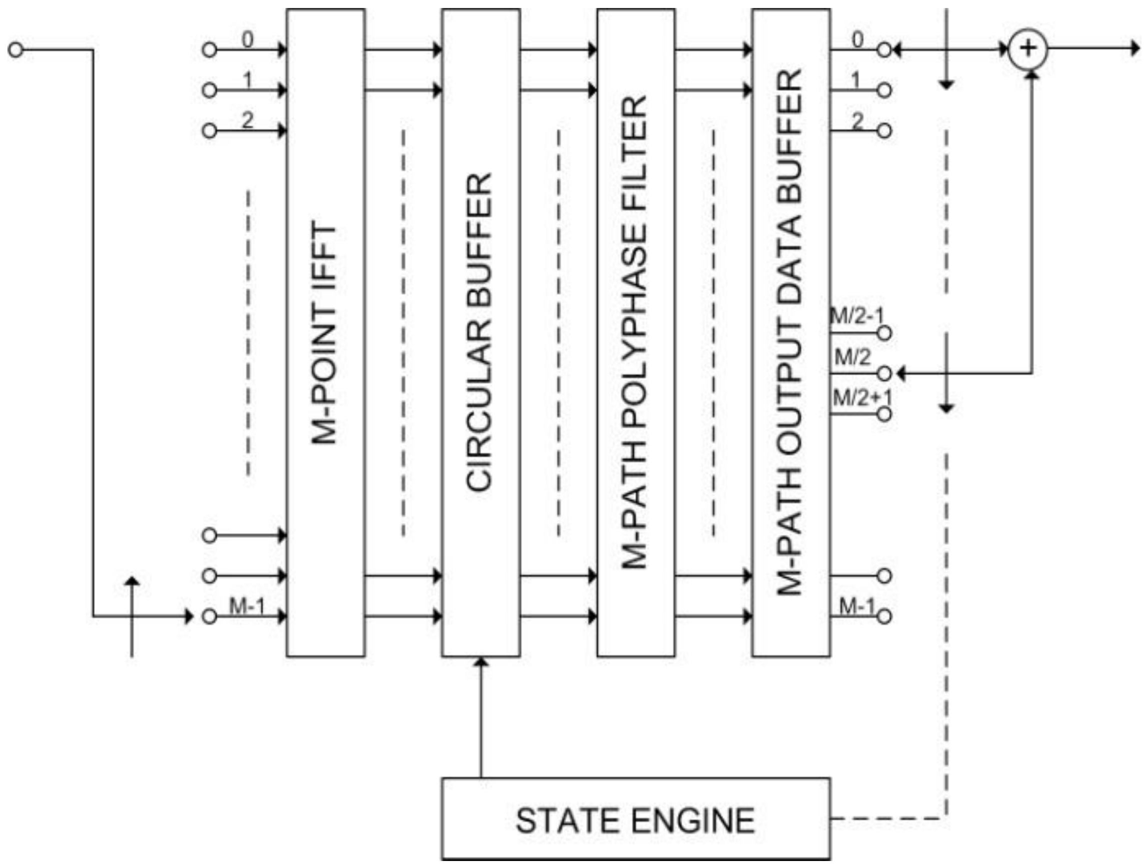
What does that mean: the design has been driven by the specifications given by this application case ?

The input sample rate of both 3GPP LTE and WCDMA signals is 307.20 Msps. The desired output sample rates are: $f_s \in \{7.68, 15.36, 23.04, 30.72\}$ Msps. The smaller of them, 7.68 Msps, is an integer sub-multiple of the input sample rate and, precisely, it is exactly 40 times smaller than 307.20 Msps.. On the other side, 15.36 Msps, 23.04 Msps and 30.72 Msps are also integer multiples of 7.68 Msps



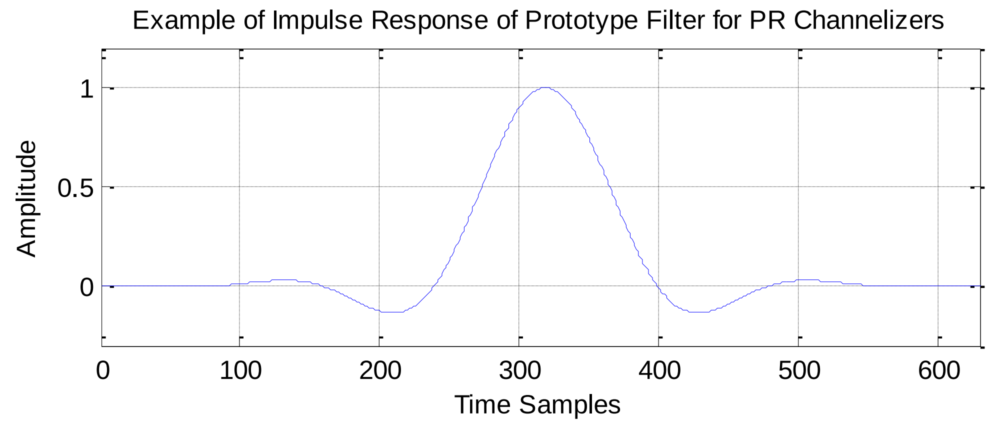
This architecture does avoid additional computation required by the inclusion of arbitrary interpolators in the design.
In addition, because the input signal is real, the computation requirements of the IFFT are almost halved.

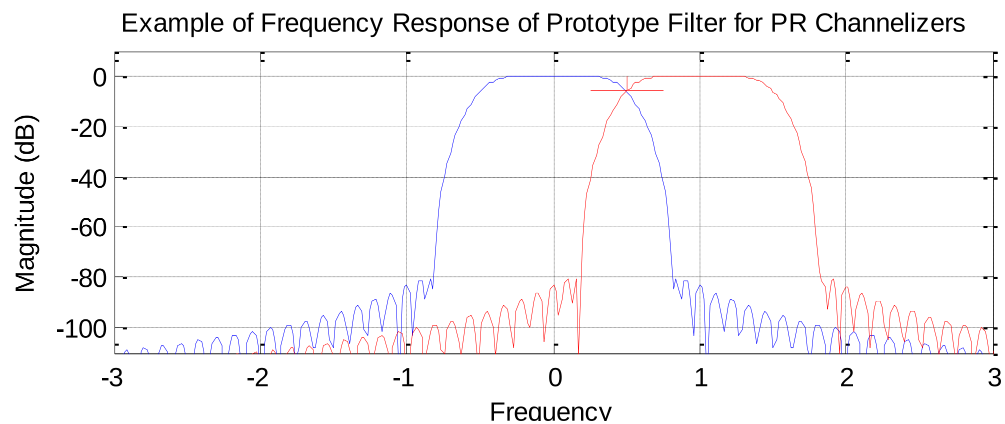
Synthesis Channelizer



The desired output sample rates drive the selection of IFFT size of the small PR, 2-to-N, up converter channelizers. The number of paths for the synthesizers have been selected to be N∊{4,6,8}

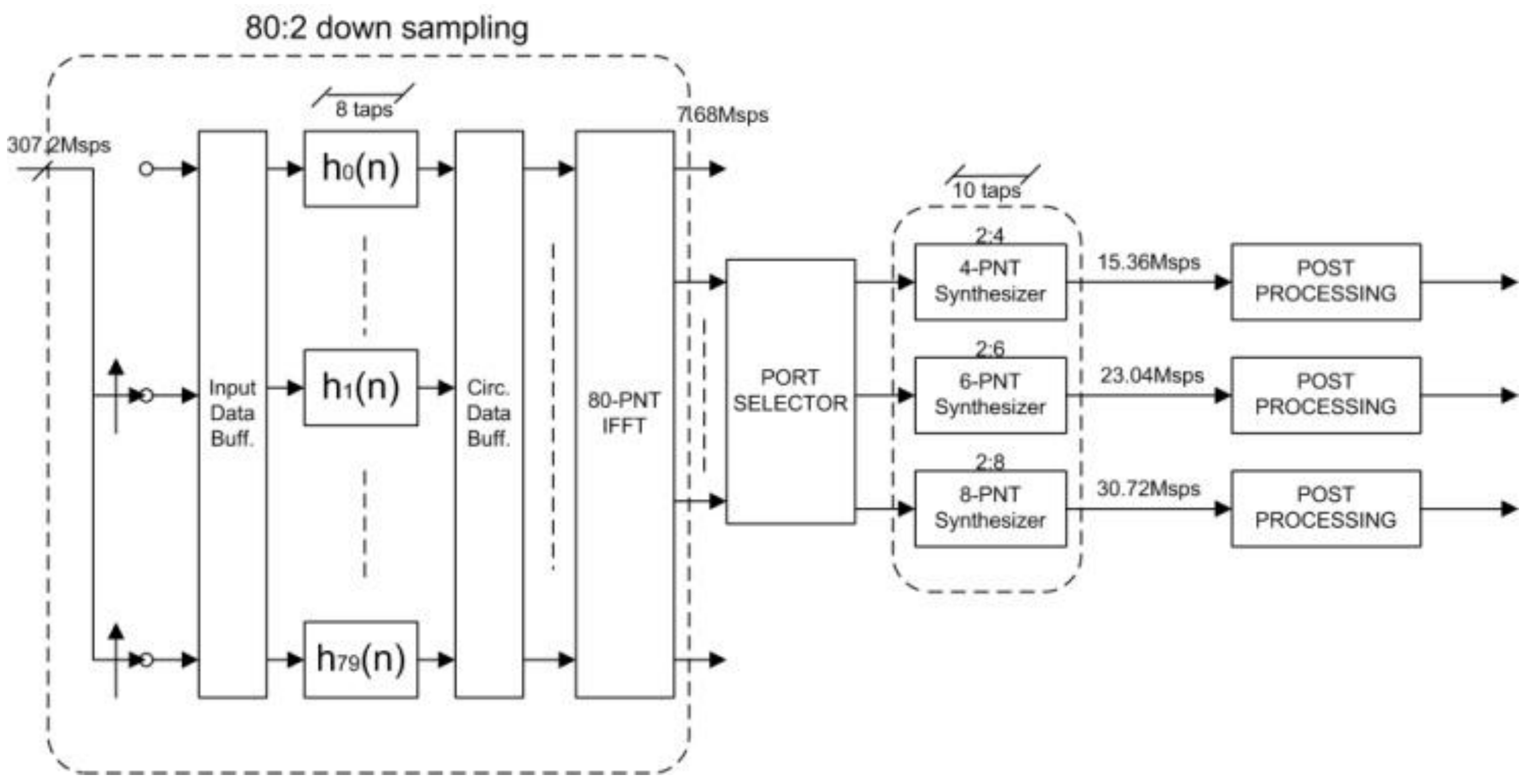
The Perfect Reconstruction Property





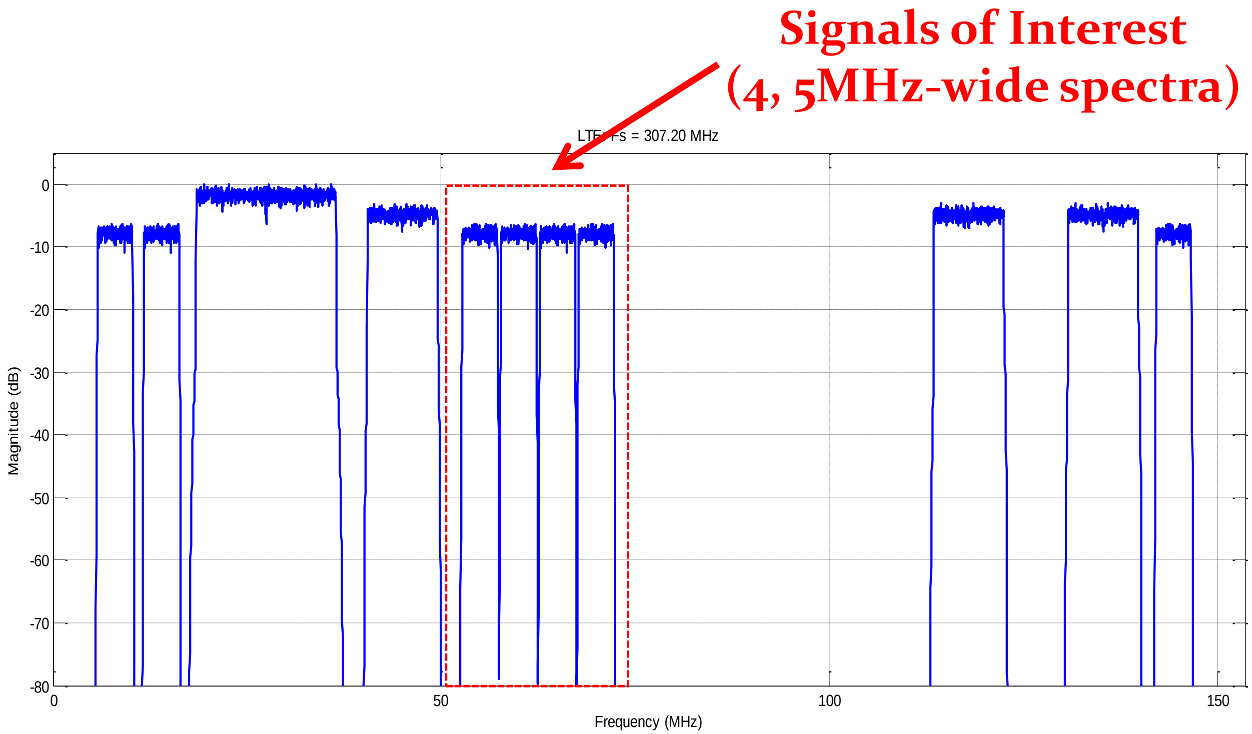
The perfect reconstruction property is achieved when the composite response of the analysis and synthesis prototype low-pass filters form a Nyquist pulse!

Proposed Architecture



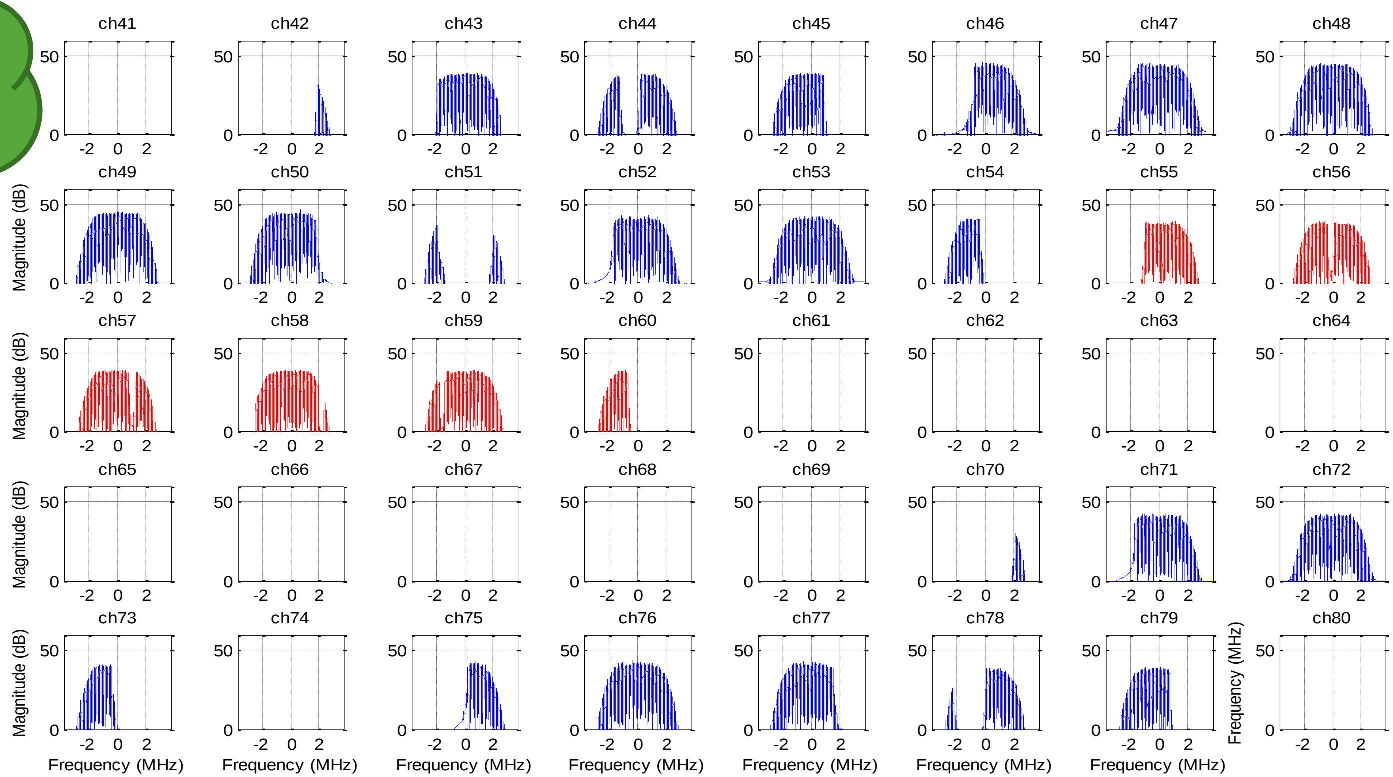
The bandwidth and the frequency location of the input signals also drive the selection of the proper synthesizer to whom the spectral fragments are delivered.

Simulation Results: Input Spectrum

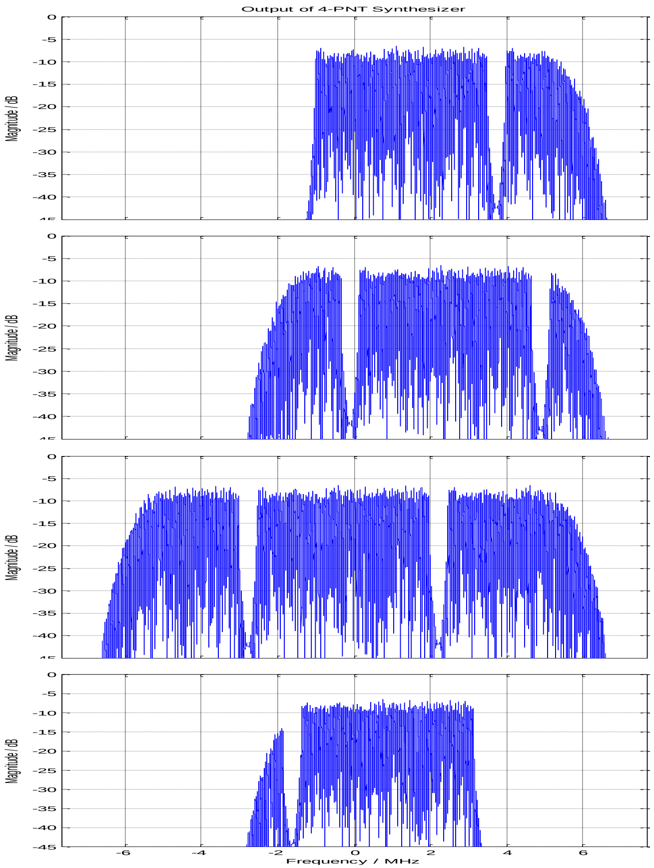


It could be much worse than we think!

Simulation Results: Analysis Channelizer Outputs



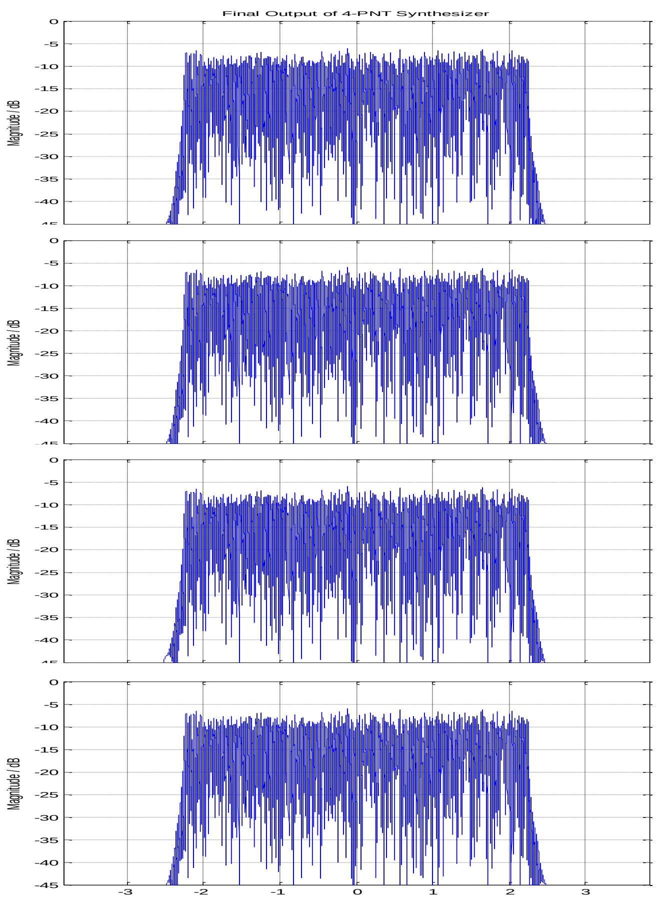
Simulation Results: Synthesis Channelizer Outputs



Because the desired bandwidths are 5 MHz wide, the output ports of the first tier channelizer have been delivered to a four points up converter channelizer

Signal post processing is required for rejecting adjacent signal bands and for correcting the residual frequency offset which is a consequence of the arbitrary center frequency location of the input signals

Simulation Results: Final Outputs



Even though the post processing filter is 144 taps long, because the post processing is performed at the output of the processing chain, its impact on the total workload is strongly reduced

Conclusions

- In this work we have presented a new application of polyphase channelizers

- The desire of achieving DDCs for combined 3GPP LTE and UMTS base station radios has driven us to design a new PR NMD analysis-synthesis chain that minimizes the computation complexity and maximizes the performance

- The structure we present here is the most efficient one between the many options we have tried

We are now Open for Questions!

Thanks for your attention