GSOC'12: GNU Radio DRM Transceiver

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1 Introduction

DRM (Digital Radio Mondiale) is a set of standards for digital broadcasting in HF range which is also designed to work over bands currently used for AM transmission. This project proposal mainly gives an idea for the implementation of a DRM Transceiver for GNU Radio as suggested by Jens Elsner (Mentor: GNU Radio; CEL, KIT). The proposal initially concentrates on the implementation of a DRM transmitter. DRM transmitter is chosen for implementation after initial discussion with the mentor as some of the synchronization complexities can be avoided. In section 2 the transmitter block diagram as specified by ETSI standards is reviewed. Section 3 covers the implementation details which discusses about existing usable modules in GNU Radio, portable modules from DREAM project and other modules which needs to be implemented. A rough project schedule is given in section 4. The proposal is concluded in section 5.

2 DRM Transmission System

The following block diagram gives a system overview of the DRM transmitter. A brief explanation of the functionality of each block is given below. Detailed specifics about each block should be learned during the study phase of the project from ETSI ES 201 980 standard.

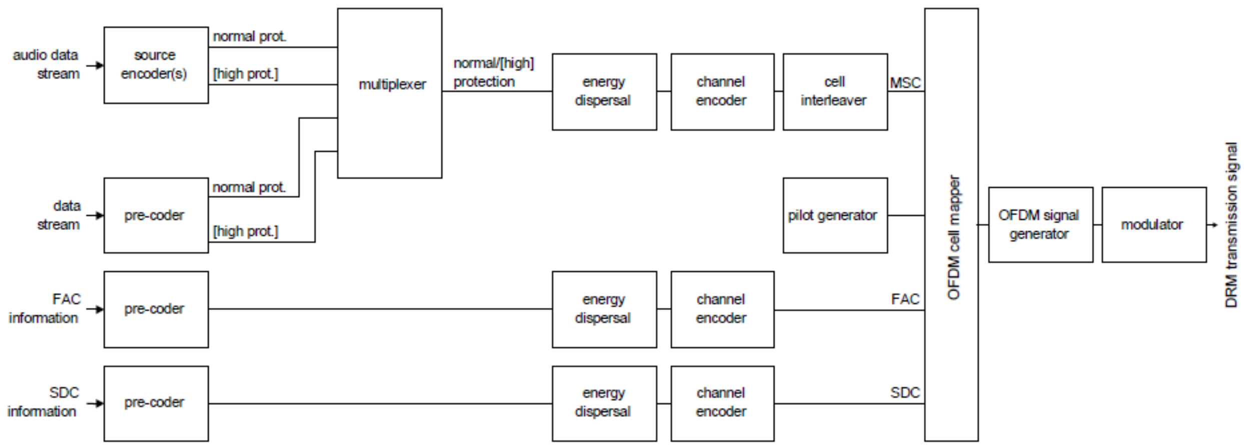

Figure 1: Conceptual DRM transmission block diagram (Ref. ETSI ES 201 980 V3.1.1)

- **Source encoders** - Source coding is applied for input audio and data streams to achieve high bit rates. Various source coding schemes specified in the standard are MPEG-4 AAC, CELP and HVXC.

- **Pre-coder** - Pre-coders also do source coding of data and it prioritizes data/encoded sound streams for giving different protection levels. Usually when speech data is compressed and encoded, there will always be high priority bits and low priority bits. An example is the case of GSM where a redundancy of 3 bits are added for the first 50 bits (out of 260 bits) of vocoder output in the FEC scheme while the next 142 bits are given only 4 bits as they are of less importance. This separation will be done in the source encoder so that the following channel encoder can do proper FEC schemes.

- **Multiplexer** - This block multiplex frames from different logical channels based on priority. The high-priority data should be given high level protection. So high priority data of different streams are appended together before forwarding to the following channel encoder.

- **Energy dispersal** - Energy dispersal can be applied to various channels to reduce the probability of systematic patterns and thus reduces regularity of the transmitted signal. This is usually achieved by making use of a Pseudo Random Sequence generator (LFSR with a primitive polynomial as feedback to get the maximum length sequence which satisfies Golomb postulates of randomness).

- **Channel encoder** - Optimized joint coding and modulation schemes are used to get best transmission performance. Convolutional coding is employed and more details of the coding and puncturing schemes can be found in Section 7.3 of the ETSI standard. Additional forward error correction(outer error protection) is added for packet mode streams making use of Reed-Solomon codes. This RS based error correction is added in such a way that receivers which are not equipped with RS correction schemes can also recover data packets.

- **Cell interleaver**- Interleaving is used to spread the consecutive bit-streams in a time/frequency dispersive channel (flat faded channels). Various inner and outer levels of interleaving is specified in the standard.

- **Pilot generator**- Channel impulse response is derived with the help of a pilot carrier (for periodic channel estimation). Similarly synchronization at the receiver end is also done by calculating the frequency offset by tracking the pilot signals.

- **OFDM cell mapper**- This module selects the proper modulation pattern (64QAM, 16QAM, 4QAM) and encodes the high and low priority bit-streams accordingly. Various modes are selected on the basis of the type of channel used and various data is modulated using different constellations (e.g FAC uses 4QAM while SDC can use 16QAM or 4QAM). Detailed descriptions are given in section 7.5 of the ETSI standard

- **OFDM Signal Generator and modulator**- The group of cells having the same time index are converted to a time domain signal representation. OFDM symbol is obtained from this signal representation after adding proper guard bands(adding cyclic data exploiting cyclic convolution feature of DFT).

3 Implementation details

This section provides implementation specific details by taking into account the available blocks in GNU Radio and DREAM project.

- **Source encoders** - Highly efficient advanced audio coding schemes like MPEG-4 AAC, CELP are not present in GNU Radio as a block till now. Implementation of these coding schemes are present in the DREAM project (Directory: dream/src/sourcedecoders). These coding schemes should be properly ported to GNU Radio to achieve the functionality.

- **Pre-coder** - This is a simple block that does bit-stream separation based on importance. Slicing and dicing modules in GNU Radio can be used for this purpose.

- **Multiplexer** - gr_stream_mux block present in gnuradio can be used for this block.

- **Energy dispersal** - gr_additive_scrambler_bb, gr_scrambler_bb can be used for implementing this block.

- **Channel encoder** - The trellis_encoder_bb class in gnuradio can be used for implementing channel encoders. gr_encode_ccsds_27_bb can be used as a reference for implementation of the encoder based on a polynomial. The trellis_viterbi_b can be used for viterbi decoding of convolutional encoded bit-streams at the receiver end(Even though this module was present, I have seen Piotr Krysik using his custom viterbi detector for the gsm-receiver code in airprobe. Need to investigate the shortcomings). Reed Solomon encoder in gr-atsc (currently moved to gnuradio-core) can be used for implementing Reed Solomon encoding using the generator polynomials specified in the standard.

- **Cell interleaver**- Interleaver blocks(gr_interleaver) in gnuradio can be used based on the specifications in the standard

- **OFDM cell mapper**- digital_ofdm_mapper_bcv can be used with proper constellation as specified in the standard.

4 Timeline

As per the GSOC schedule there are 18 weeks including midterm evaluation, final evaluation, documentation and code cleanup period. In the following timeline each week is given a task like "coding of module #no". The modules to be coded/ported will be updated after initial discussions with the mentor. This is just a rough estimate which is very likely to change after discussions with the mentor and the coding time may vary depending on the coding complexity. Proper unittests shall be also added for each module added to gnuradio.

- **April 23 - May 4** – Initial learning phase of the standard and proper transmitter block diagram prepration with ongoing discussions with the mentor.
- **May 5 - May 11** – Coding of module 1.
- **May 12 - May 18** – Coding of module 2.
- **May 19 - May 25** – Coding of module 3.
- **May 26 - June 1** – Coding of module 4.
- **June 2 - June 8** – Proper testing by adding good unittests.
- **June 9 - June 15** – Midterm evaluation submission
- **June 16 - June 22** – Coding of module 5.
- **June 23 - June 29** – Coding of module 6.
- **June 30 - July 6** – Coding of module 7.
- **July 7 - July 13** – Proper testing by adding good unittests.
- **July 14 - July 20** – Coding of module 8.
- **July 21 - July 27** – Coding of module 9.
- **July 27 - Aug 3** – Coding of module 10.
- **Aug 4 - Aug 10** – Proper testing by adding good unittests.
- **Aug 11 - Aug 20** – Integration, code cleanup, adding documentation, and final submission.

5 Conclusion

A general overview of the DRM Transmitter project is given in the previous sections. Thorough knowledge of the standard and guidance of an experienced mentor is required for the success of such a project. Being a communication project, experience counts a lot as many problems will appear during implementation phase which needs to be solved in a given time frame. The project is very modular and the implementation can be split into various sections which makes progress tracking and future addition easier.

References

[1] Digital Radio Mondiale System Specification, *ETSI ES 201 980 V3.1.1.* 2009-08.

[2] GNU Radio Documentation *http://gnuradio.org/doc/doxygen/modules.html*