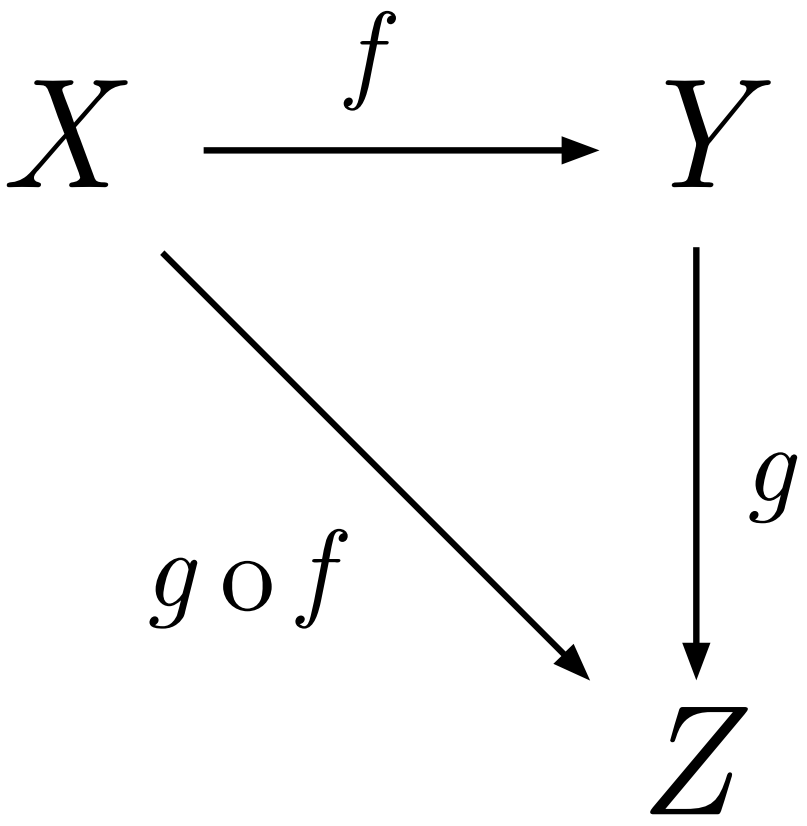
FECAPI



General Abstract Nonsense with an Application to DSP Using GNU Radio

Nicholas McCarthy

namccart@gmail.com

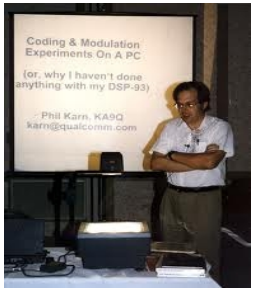
https://github.com/namccart/fecapi

master, next, grcon_cleanup

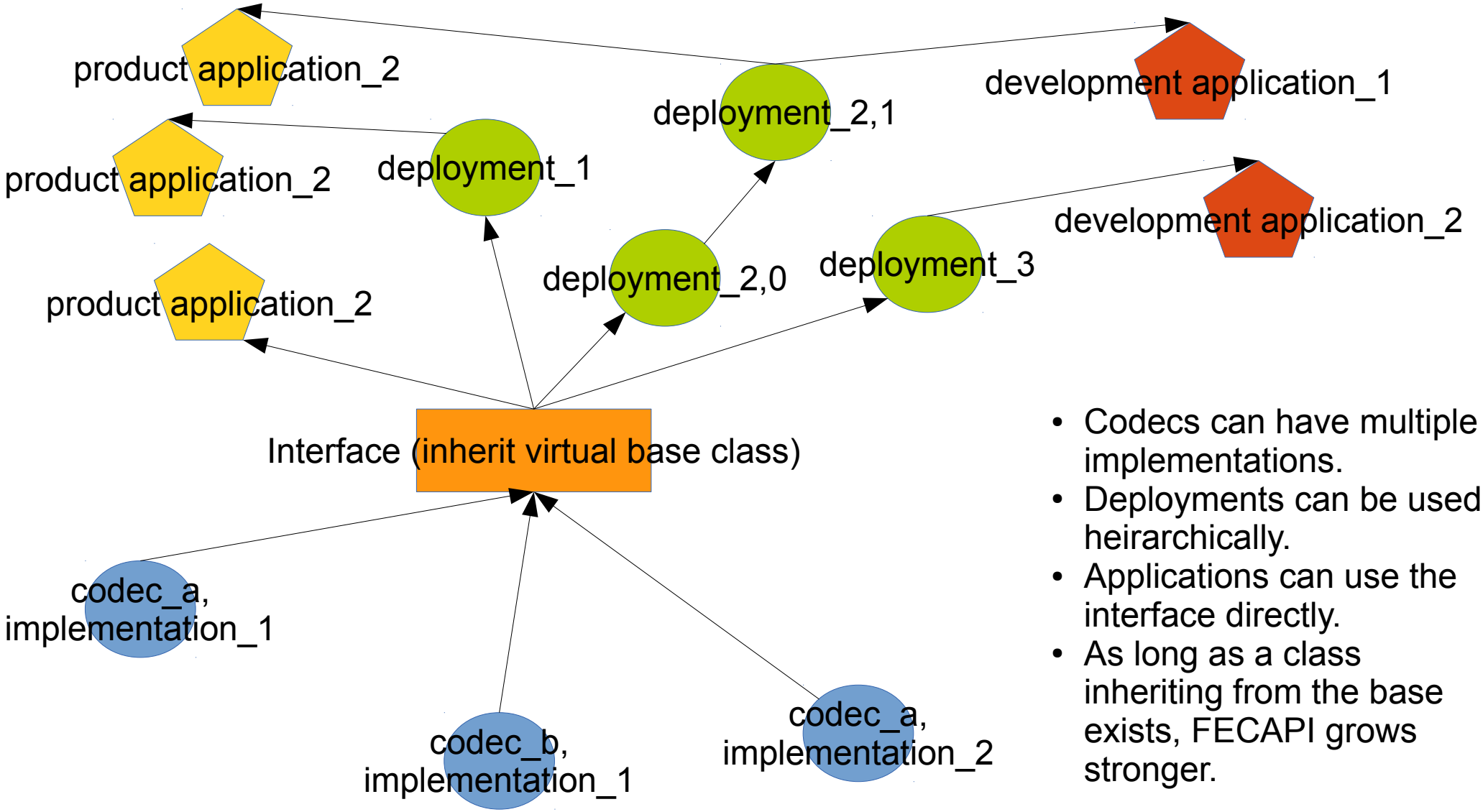
pybombs install fecapi

The State of Play

- Iterative Solutions.
  - Broad selection of mostly Viterbi-based turbo decoders (actual, useful standards), RS.
  - Matlab and C MEX, open source.
- KA9Q.
  - Convolutional (FANO and Viterbi, common parameters), Reed Soloman (already “in” GR).
  - Hand-vectorized.
- Spiral.
  - Parameterizable Convolutional (Viterbi).
  - Machine-vectorized (intrinsics, mostly better than KA9Q).
- OpenFEC
  - Only AL-FEC... meaning application layer... (LDPC “staircase” and Reed Solomon).
  - Nice, unified API with performance applications.
- Tip of the iceberg... journal papers, masters' theses, information theory hobbyists, proprietary implementations.



FECAPI Concepts



- Codecs can have multiple implementations.
- Deployments can be used heirarchically.
- Applications can use the interface directly.
- As long as a class inheriting from the base exists, FECAPI grows stronger.

The Interface

class FEC_API generic_decoder

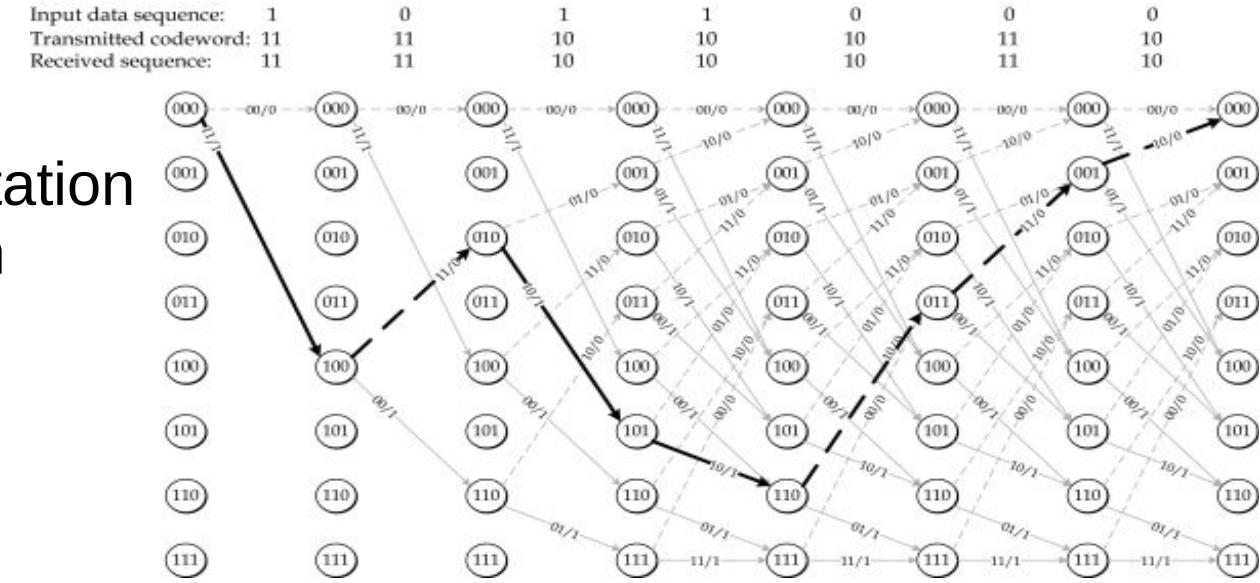
- Pure virtuals:
  - generic_work(void*, void*)
  - int get_input_size()... (k,n)
  - int get_output_size()... (n,k)
- Defaults:
  - no frame overlap.
  - soft float inputs, unpacked bit output.
  - fixed frame size (or simulated frame).
  - no buffered input (memcpy).
- Default overrides (virtuals):
  - get_history()
  - get_conversion()
  - get_input_item_size()
  - get_output_conversion()
  - get_output_item_size()
  - destructive()
  - set_framebits(int)

Intensions: inheritance should be easy, and the interface should have as little impact as possible on codec design.

Codec: cc_decoder

class FEC_API cc_decoder : public generic_decoder

- Features.
  - 8-bit fixed-point implementation using 16-way vectorization (Spiral).
  - r=1/2, k=7.
  - Parameterizable length.
  - Parameterizable defining polynomials.
  - Supports terminated, streaming, tailbiting, and truncated modes.



- Utilizes out-of-tree volk module (volk_fecapi) kernel.
- Mechanism for loading new rate/constraint length-specific kernels as needed.

Intensions: Make Spiral decoder immediately useful to GR. Provide example using all FECAPI aspects.

Other Codecs

- Reed-Solomon.
  - Karn implementation.
  - rs_char version.
  - 8-bit symbols (255 byte codeword).
  - Arbitrary shortening.
- LDPC.
  - Manu,
  - Tracie.

Basic Deployment (Streams)

class FEC_API fec_decoder

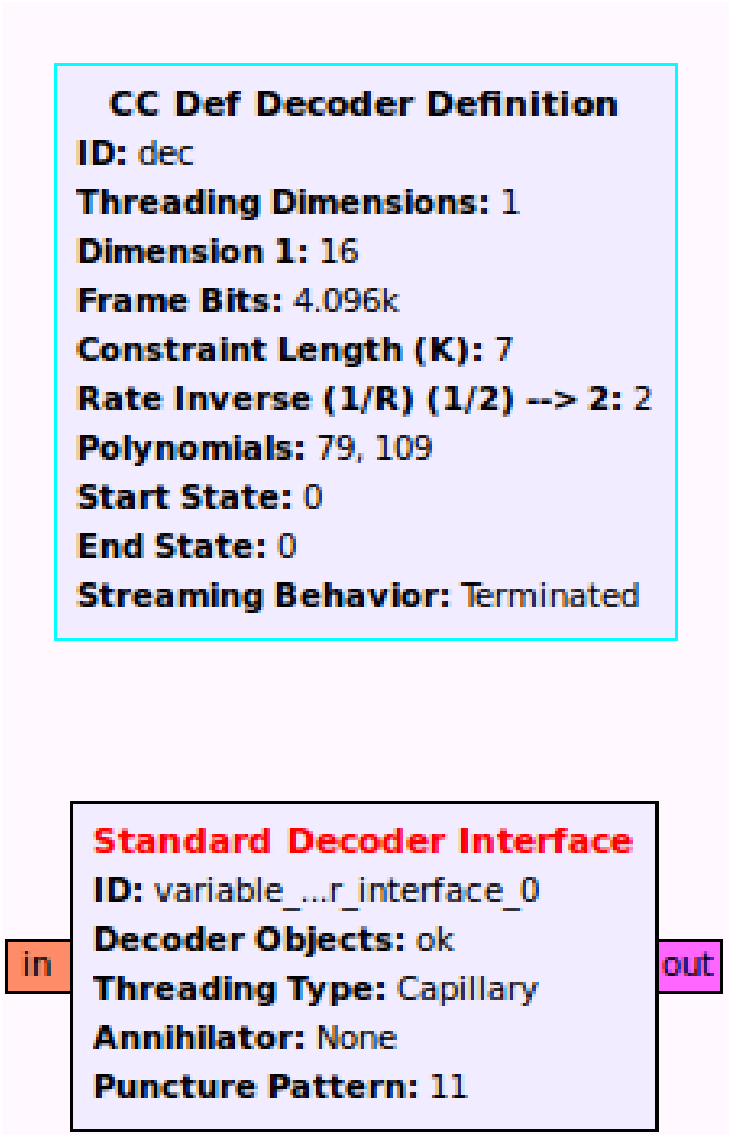
- gr_block
  - Fixed rate decimation.
  - History with no zero-fill.
  - Requires sprt to interface object.
  - Work decodes as many frames as possible.
  - Supports destructive (copy)/non-destructive (non-copy) modes.
- Oddities.
  - Does not inherit from sync_decimator.
  - Does not use set_history (output_multiple manipulation).

CC Def Decoder Definition
ID: dec
Threading Dimensions: 1
Dimension 1: 16
Frame Bits: 4.096k
Constraint Length (K): 7
Rate Inverse (1/R) (1/2) --> 2: 2
Polynomials: 79, 109
Start State: 0
End State: 0
Streaming Behavior: Terminated

Intensions: Promote code into GR without having to (re)implement basic gnuradio inheritance details.

Ordinary Deployment (Streams)

extended_decoder_interface.py

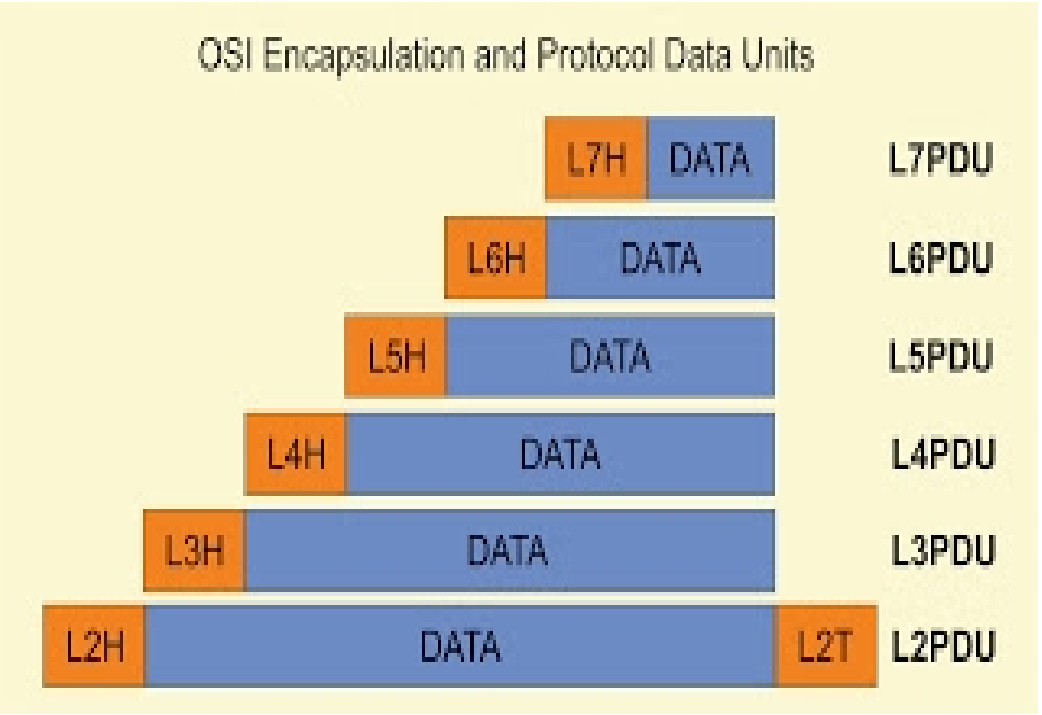


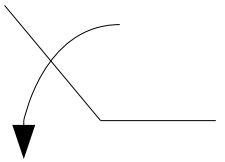
- GRC variable: create a list of generic_decoder objects.
- Standard Decoder Interface.
  - Type conversion based on interface virtual functions.
  - Threading via instantiation of fec_decoder blocks (capillary, ordinary).
  - Access common utilities.

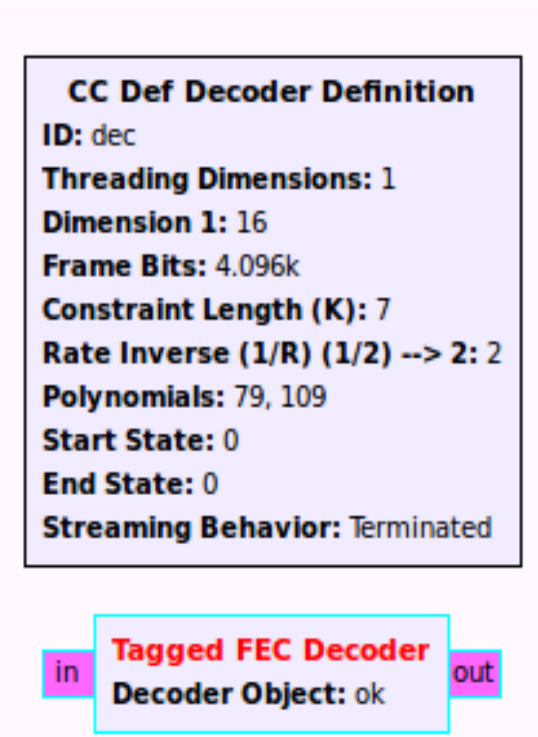
Intensions: Provide a 90% solution for threading, type-converting and soft-bit manipulation.

Framed Deployment (Tagged Streams)

class FEC_API tagged_fec_decoder







- Localized buffer with max size.
- Framesize adjustment.

Intensions: Replicate the basic deployment for variable-length frames in tagged_stream format.

Pooled Resource Deployment (Events)

pooled_resource.h, pooled_decoder.h

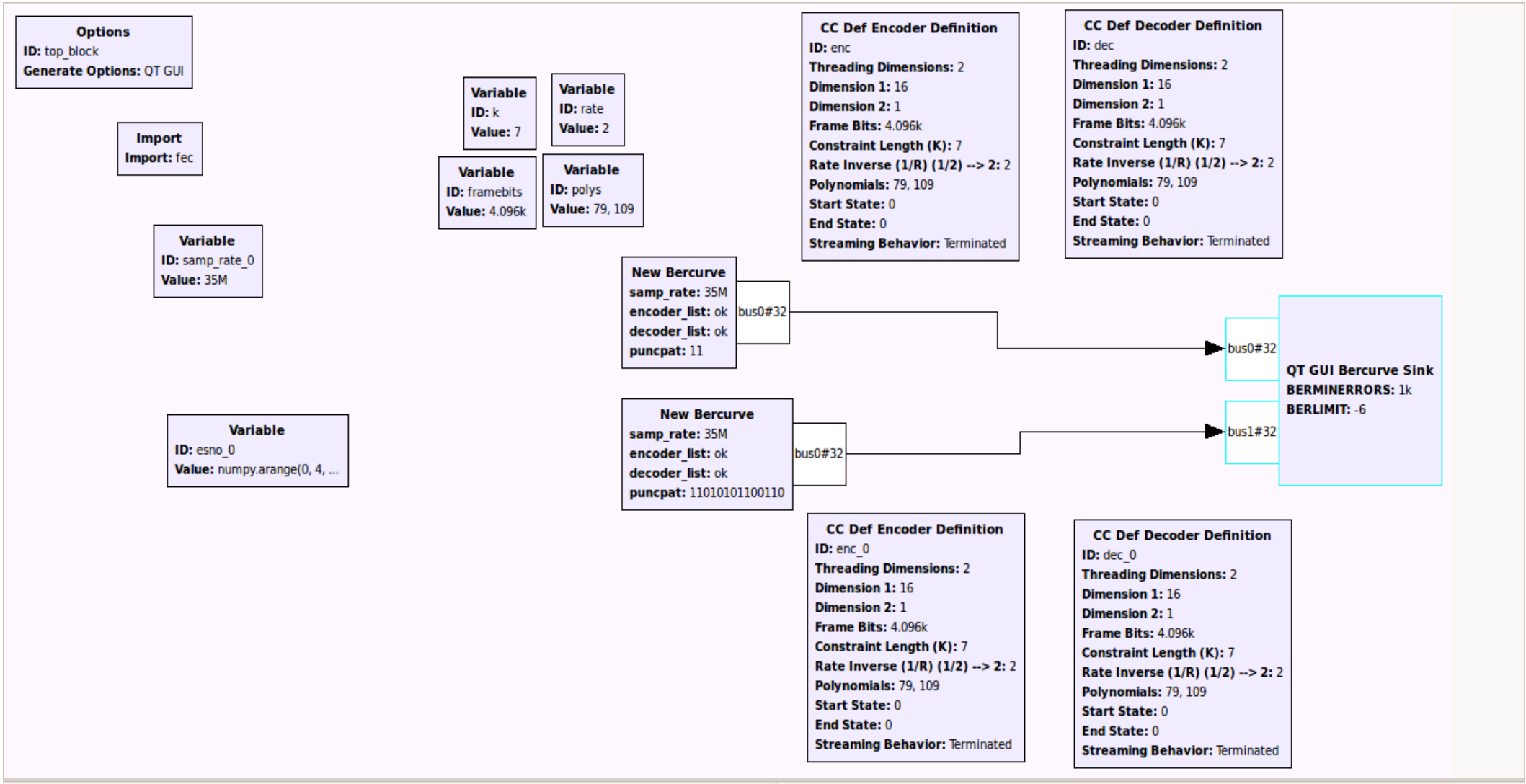
- pooled_resource
  - Type-templated lockfree queue.
  - Grows upon contention (to stated max).
- managed_resource_pool
  - Map of pooled_resource objects.
  - Map indexed by input to a factory function.
  - One pool, different parameterizations of the same resource class.
- decoder_pool
  - Standard implementation of m.r.p. for generic_decoder.
  - Requires static member “make” factory function
  - Make maps indices to parameterizations.


```
pooled_decoder<managed_cc_decoder> cc_dec;
cc_dec.decode(in, out, framesize, VARIANT_0);
```

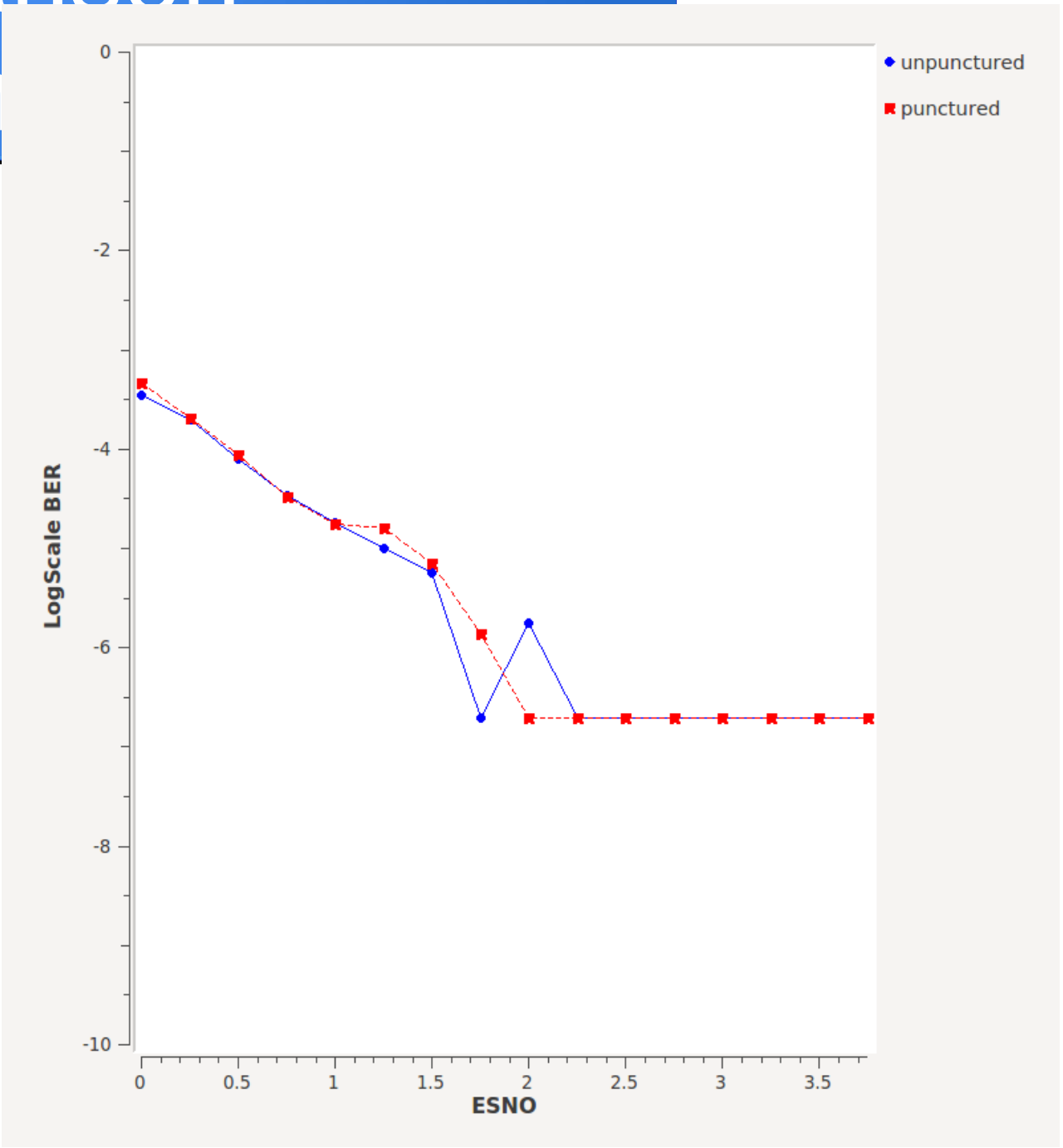
Intensions: threadsafe, runtime configurable resource management with dynamic growth.

BER Comparison Development Ap

cc_bercurve.grc



BER Comparison Developmen



- Real-time visual feedback.
- Settings for # errors until result locks, minimum discoverable BER.
- Cycles through 35 distinct line styles, curves named from grc object parameter.

Other Features

"Any polynomial vector of degree d orthogonal to the generator matrix G of a convolutional code can be converted to a binary "dualword" of length n × (d + 1). This dualword is orthogonal to any shift by a multiple of n bits of the output bitstream of the code."

--Cluzeau, Finiaz, "Reconstruction of Convolutional Codes"

- fec_corr_bb.
- fec_puncture.
- fec_reinflate.

- fec_interleave.
- fec_deinterleave.

Primary benefit: For n output streams of size m items each, fec_interleave and fec_deinterleave can execute work with only m rather than n*m items available. Min buffer size can be m rather than n*m. Breaks forecast: only one stream (not all) might get serviced.

Coming Attractions

- Tagged stream ordinary deployment.
  - Deinterleave.
  - Interleave.
- Tagged stream/ resource pool deployment.
- Tagged Stream base class?
- Rate measurement application.