

# Polar Codes in GNU Radio

SOCIS Presentation

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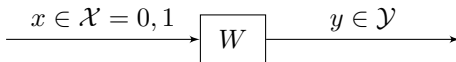


**European Space Agency**

Summer of Code in Space 2015  
In space no one can hear you code.

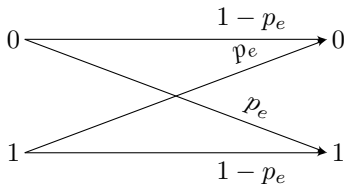
- 1 Theory
  - Fundamentals
  - What are polar codes?
  - Channel Polarization Effect
  - Polar Encoder and Decoder
- 2 Implementation
  - Development approach
  - FECAPI revisited
  - Polar codes in GNU Radio
  - Performance comparison
- 3 Conclusion

## model



$\mathcal{Y}$  depends on underlying channel.

## example



BSC channel

## Repetition code

input  $x \in \mathcal{X} = 0, 1$

codeword  $y \in \mathcal{Y} = 000, 111$

## Properties

$$N = 3$$

$$K = 1$$

$$r = \frac{K}{N} = \frac{1}{3}$$

## decoder

bit-count received codeword

→ majority decision

## problem

$$\lim_{i \rightarrow \infty} \frac{1}{n_i} = 0 \quad (1)$$

→ asymptotically bad code.

Can we do better?

# What are polar codes?

*Channel Polarization: A Method for Constructing Capacity-Achieving Codes for Symmetric Binary-Input Memoryless Channels*, Erdal Arikan, 2009

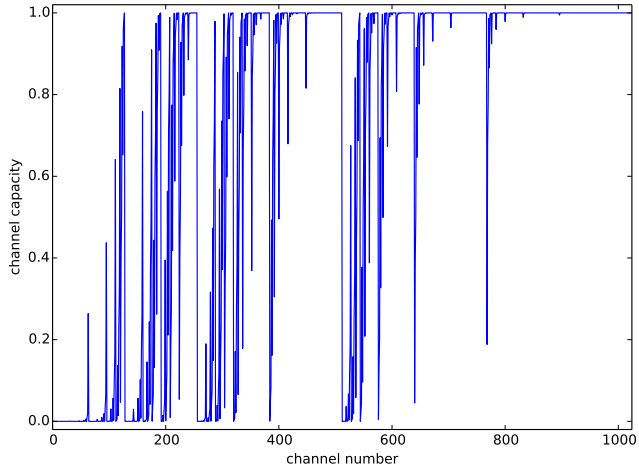
## Properties

- block code
- asymptotically good
- exploit channel polarization effect

## Description

- block size ( $N = 2^n$ )
- number of information bits ( $K$ )
- frozen bit positions ( $\mathcal{A}$ )
- frozen bit values ( $u_{\mathcal{A}^c}$ )

# Channel Polarization Effect



Choose most reliable channels for information bits

# Polar Encoder and Decoder

## basic scheme

$$u_0 \text{---} x_0$$

$$u_1 \text{---} x_1$$

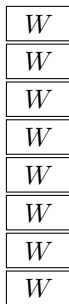
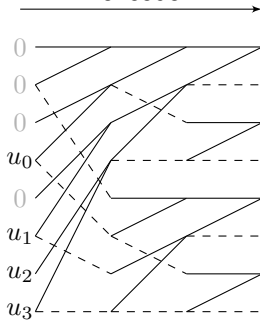
$$N = 8$$

$$K = 4$$

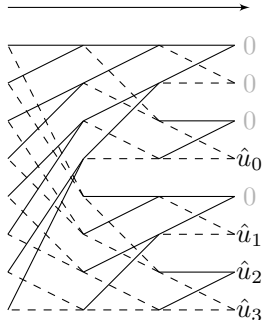
$$\mathcal{A} = 0, 1, 2, 4$$

$$u_{\mathcal{A}^c} = 0, 0, 0, 0$$

encode



decode





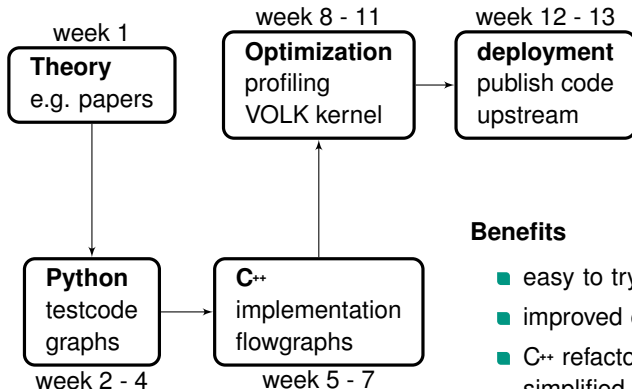
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## Benefits

- easy to try
- improved code quality
- C++ refactoring simplified

## POLAR Encoder Definition

ID: polar\_encoder

Packed Bits: No

Parallelism: 0

Block size (N): 2.048k

#Info Bits (K): 1.024k

Frozen Bit Positions: pola...

Frozen Bit Values: polar\_c...

## FEC Extended Encoder

Encoder Objects: <gn...c60> >

Threading Type: None

Puncture Pattern: 11

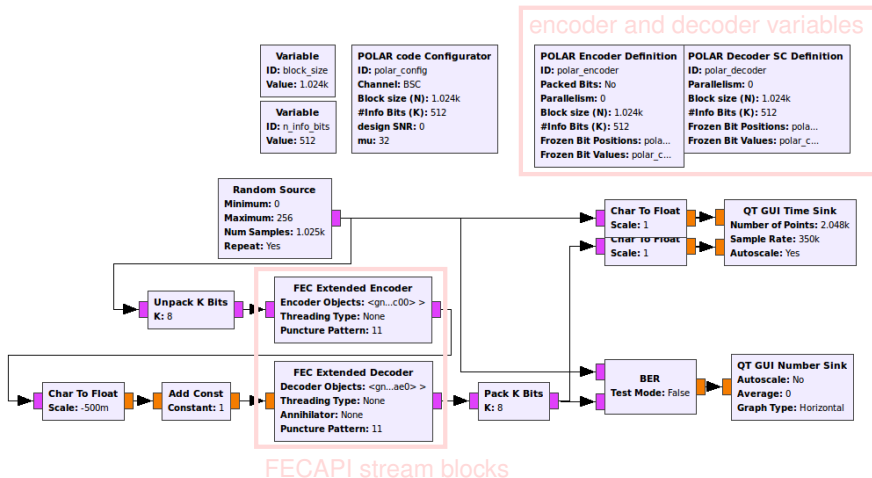
## generic\_encoder

- + get\_input\_size()
- + get\_output\_size()
- + rate()
- + generic\_work(...)
- + set\_frame\_size()

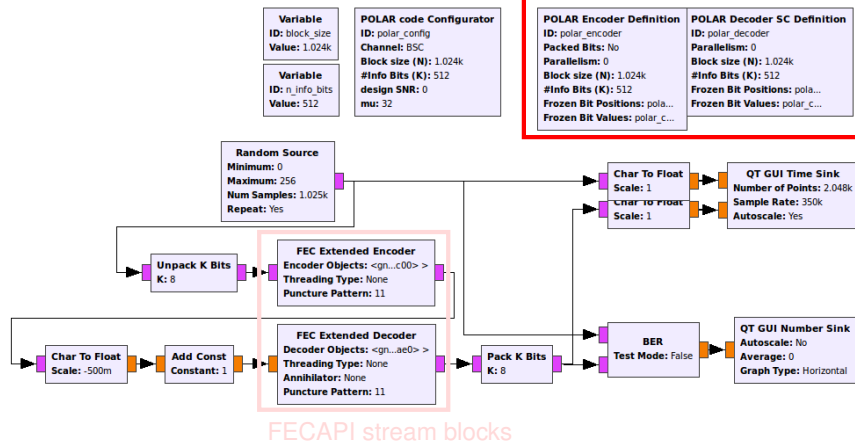
## polar\_encoder

- + polar\_encoder(...)

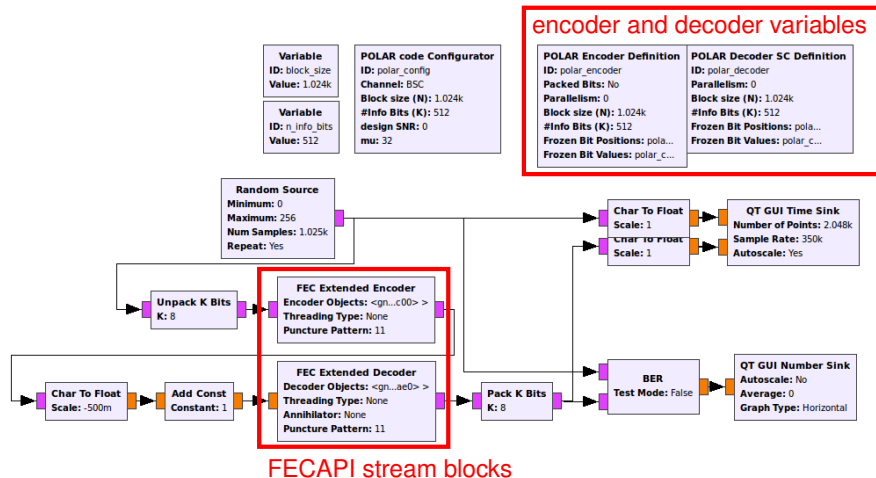
## GRC example



## GRC example

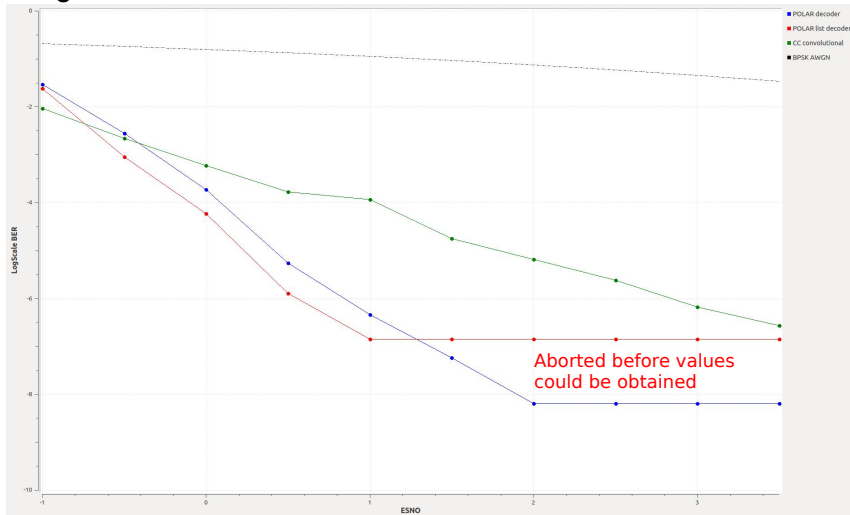


## GRC example



# Performance comparison

## using GRC with Qt GUI sink

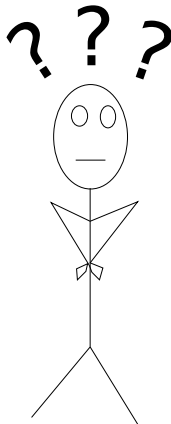


## Lessons Learned

- start with easy Python code
- testcode is vital
- C++ code always has bugs!
- VOLK

## What's next?

- get code merged into mainline
- may rewrite BER graph code
- finish Master thesis and get a job





End

Thank you for your attention!