A Fast Forward Error Correction Toolbox: Seminary

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Plan

A Fast Forward Error Correction Toolbox!

Why AFF3CT?

- Knowledge capitalization

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- Knowledge capitalization
- Simulation and prototyping
- Reproducibility of the results
- Software Defined Radio
- Validation of new algorithms
- **Team building**

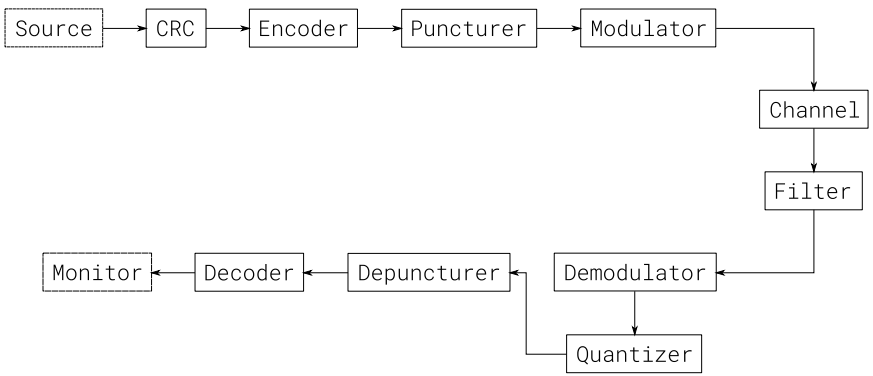
Plan

Simulator

Monte-Carlo simulations

- BER/FER *standard*
- BER/FER *iterative*

Simulation_BFER



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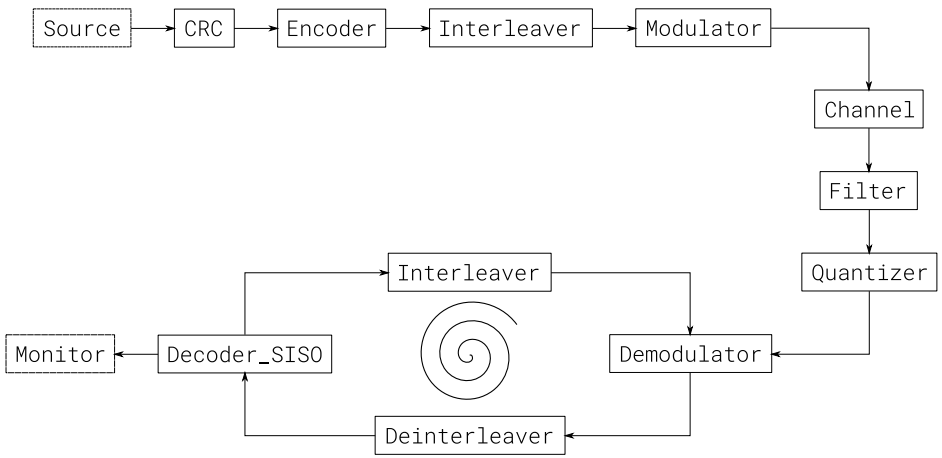

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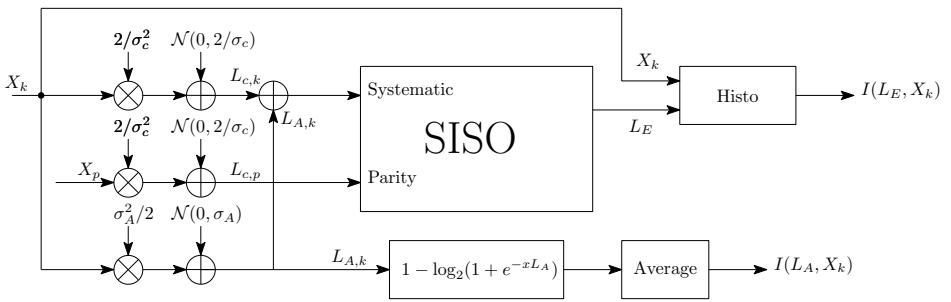
- Parallel EXIT charts

Parallel EXIT



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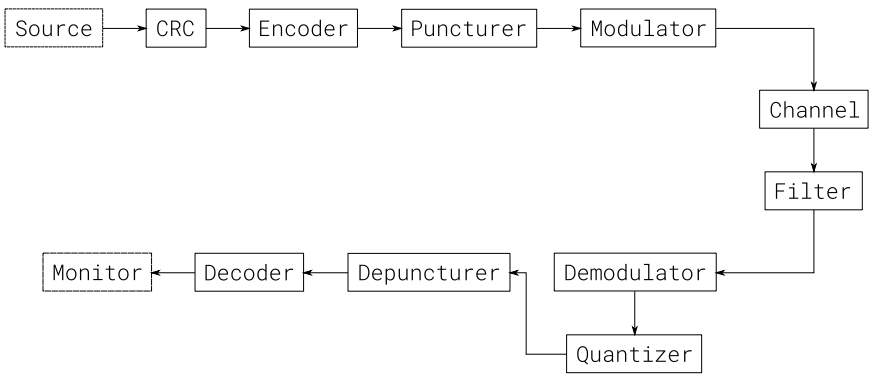

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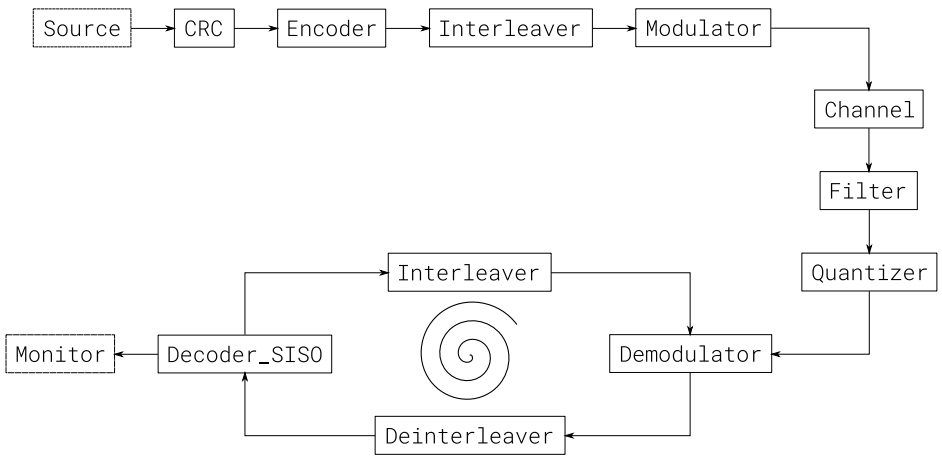

Simulator: Codecs

List of Supported Channel Codes

Channel code	Standard	Decoder	Fixed point	Throughput (Mb/s)
LDPC	5G, WiMAX, WiFi, DVB-S2, 10GE, etc.	Sum Product Algorithm (SPA)	No	5
		Min Sum (NMS, OMS)	Yes	50
		Approximate Min Star (AMS)	No	20
Polar	5G	Successive Cancellation (SC)	Yes	1000
		Successive Cancellation List (SCL)	Yes	500
		Soft Cancellation (SCAN)	No	10
Turbo	LTE (3G, 4G), DVB-RCS, CCSDS, etc.	Turbo BCJR	Yes	100
		Turbo BCJR + CRC	Yes	100
		Turbo BCJR + CRC + Flip aNd Check	Yes	100
BCH	CD, DVD, SSD, DVB-S2, Bitcoin, etc.	Berlekamp-Massey	Yes	100
Convol.	NASA	BCJR - Maximum A Posteriori (MAP)	No	10
		BCJR - Linear Approximation	No	50
		BCJR - Max Approximation	Yes	1000

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		BCJR - Max Approximation	Yes	1000

Codecs come with puncturing patterns, optimized decoders and generic interleavers.

Simulator: Modems

List of Supported Modulations/Demodulations

Modem	Standard	Characteristics
N-PSK	IEEE 802.16 (WiMAX) UMTS (2G, 2G+) EDGE (8-PSK), ...	Phase-shift keying
N-QAM	IEEE 802.16 (WiMAX) UMTS (2G, 2G+) 3G, 4G, 5G, ...	Quadrature amplitude modulation
N-PAM	IEEE 802.16 (WiMAX) UMTS (2G, 2G+) 3G, 4G, 5G, ...	Pulse Amplitude Modulation
CPM	GMSK, Bluetooth IEEE 802.11 FHSS	Continuous phase modulation Coded (convolutional-based) modulation
OOK	IrDA (Infrared) ISM bands	On-Off Keying Used in optical communication systems
SCMA	-	Sparse Code Multiple Access Multi-user modulation
User defined	-	Constellation and order can be defined from an external file

Simulator: Channels

List of Supported Channels

Channel	Mono-user	Multi-user	Characteristics
AWGN	Yes	Yes	Additive White Gaussian Noise
Rayleigh	Yes	Yes	Flat Rayleigh fading channel
User defined	Yes	Not yet	User can import noise samples from an external file

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- Takes a **non-negligible part of the simulation time**
- Efforts to optimize the code
- Dedicated libraries are integrated
  - GNU Scientific Library (**GSL**)
  - Intel Math Kernel Library (**MKL**)

Simulator: Performance

`AFF3CT` simulator is designed for performance

- Compiled language (`C++11`)
- Many functions are optimized by hand
  - **SIMD** instructions (`SSE`, `AVX`, `NEON`)
  - Quantized implementations
  - Data layout
- Automatic and higher levels of parallelism
  - **Multi-threaded** (`std::thread`)
  - **Distributed** (`MPI`)

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Toolbox / Library

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AFF3CT simulator comes with **a finite set** of possible communication chains.

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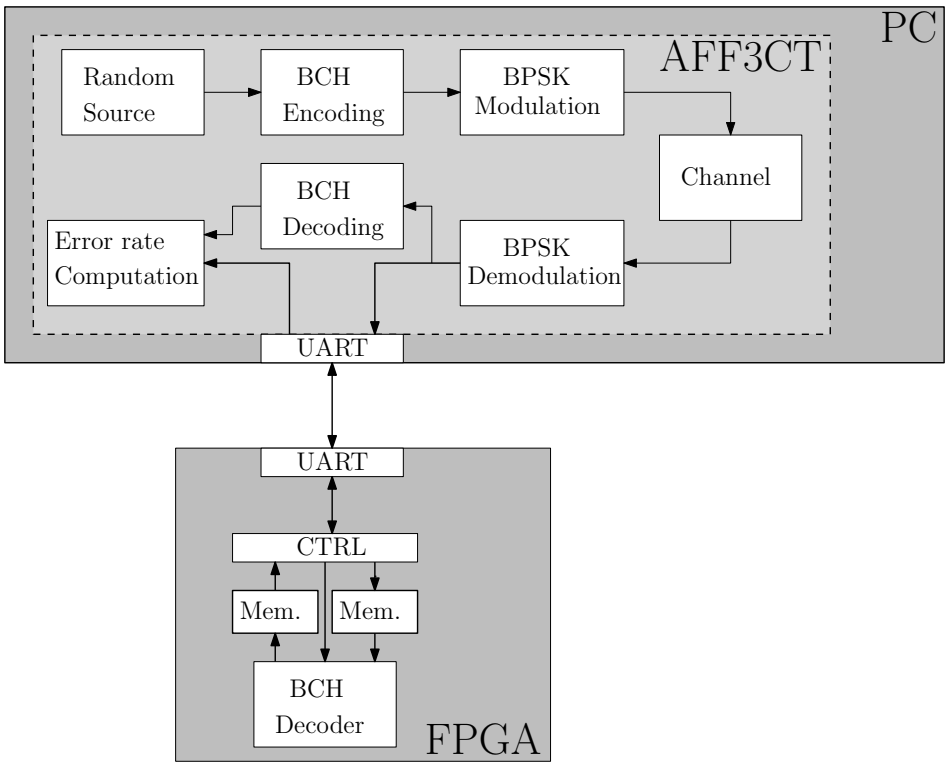
Solution

AFF3CT can be compiled as a **library or a Toolbox** to fit to your specific applications.

- A standard C++11 library
- All the **AFF3CT** elementary blocks can be reused
- **Easy to use**: take what you need from **AFF3CT**, leave the rest

Prototyping / Hardware in the Loop

AFF3CT has been designed to **facilitate prototyping on FPGA**



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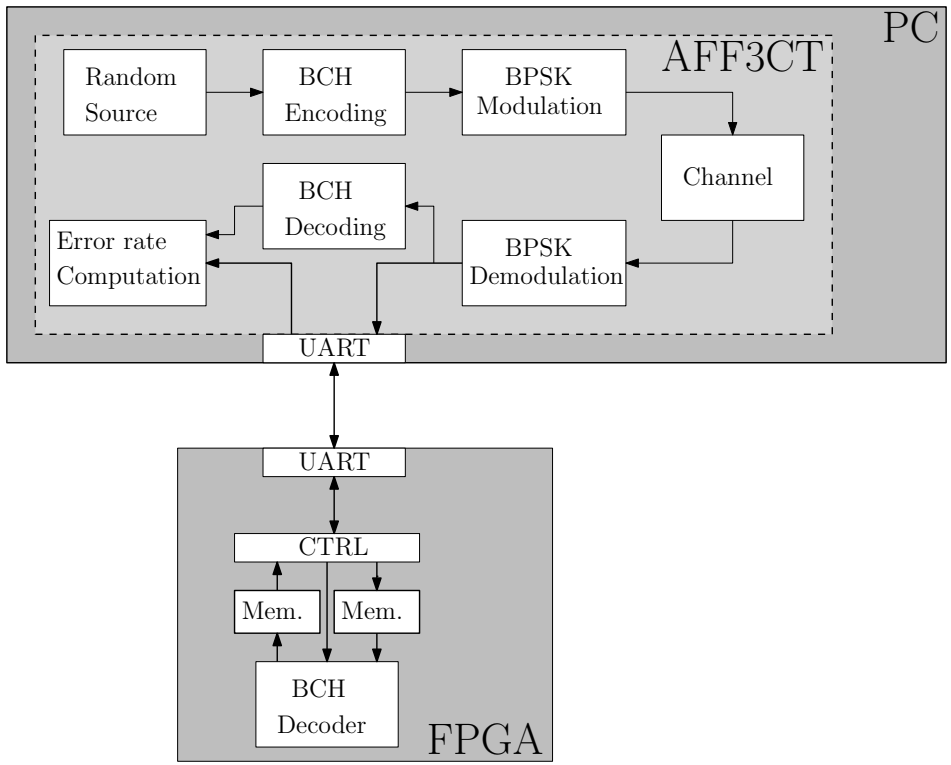

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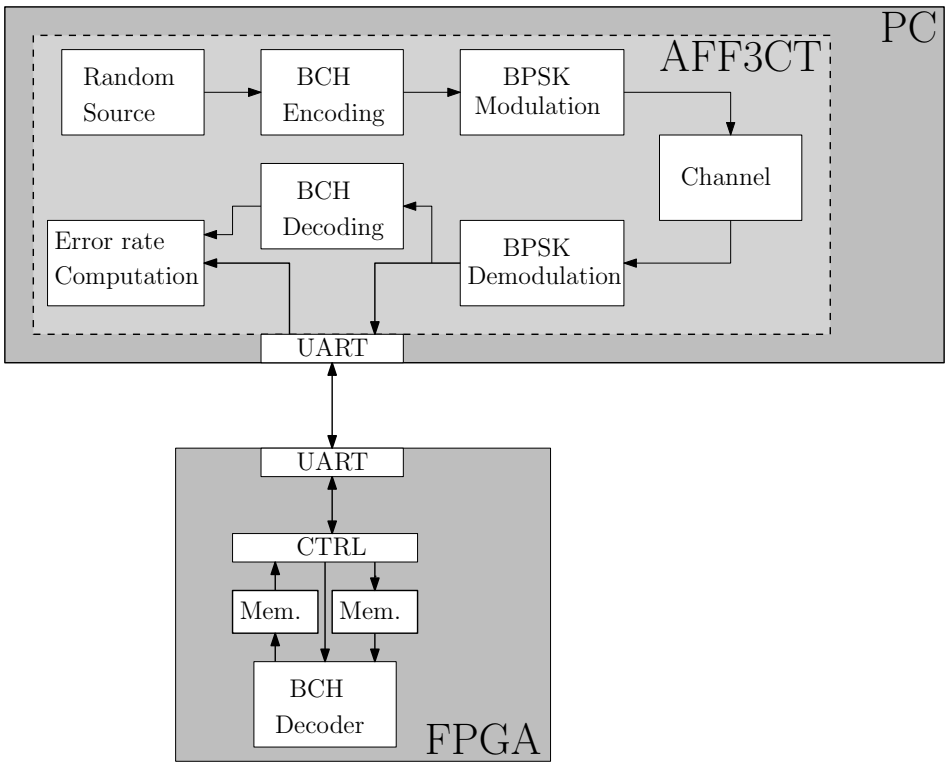
2. Non intrusive parsing of the **AFF3CT** outputs into data files



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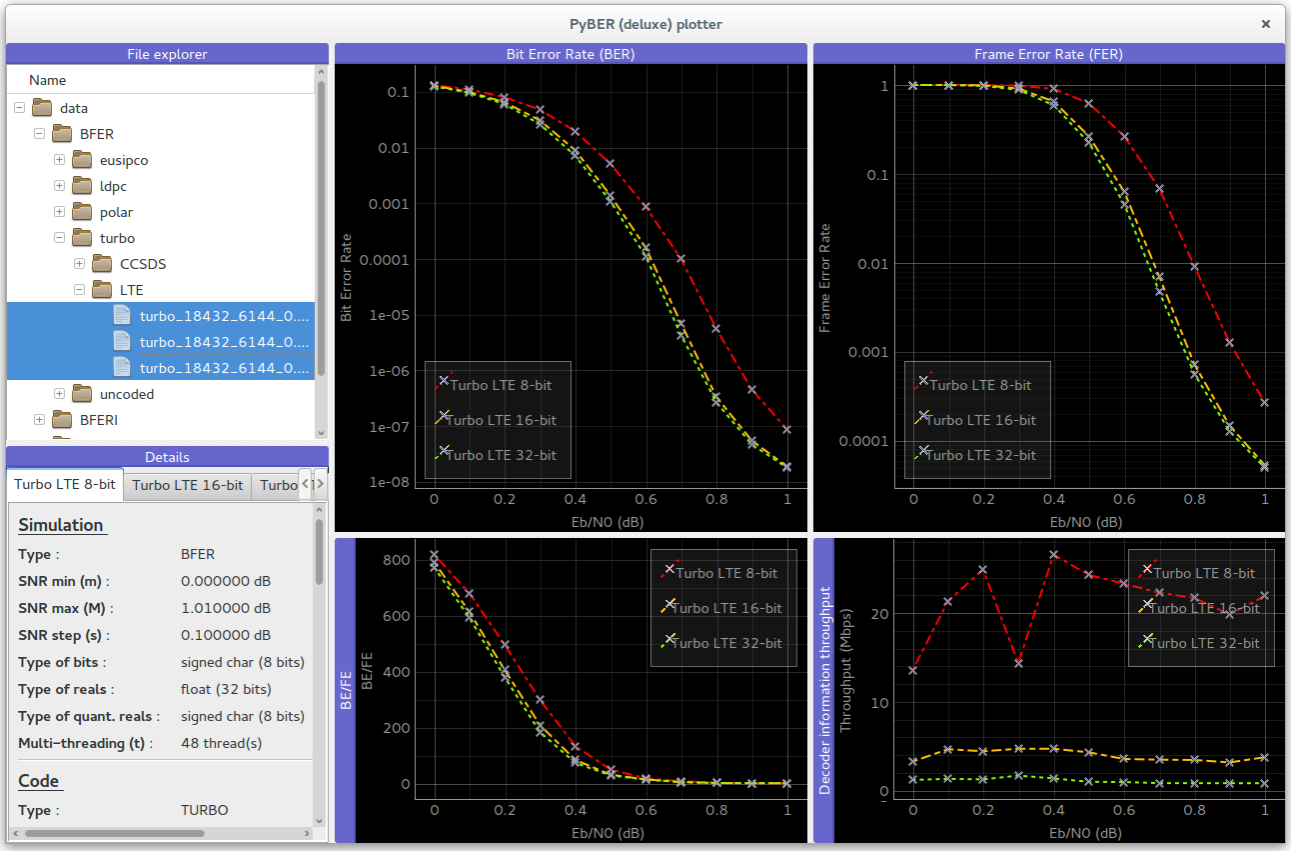

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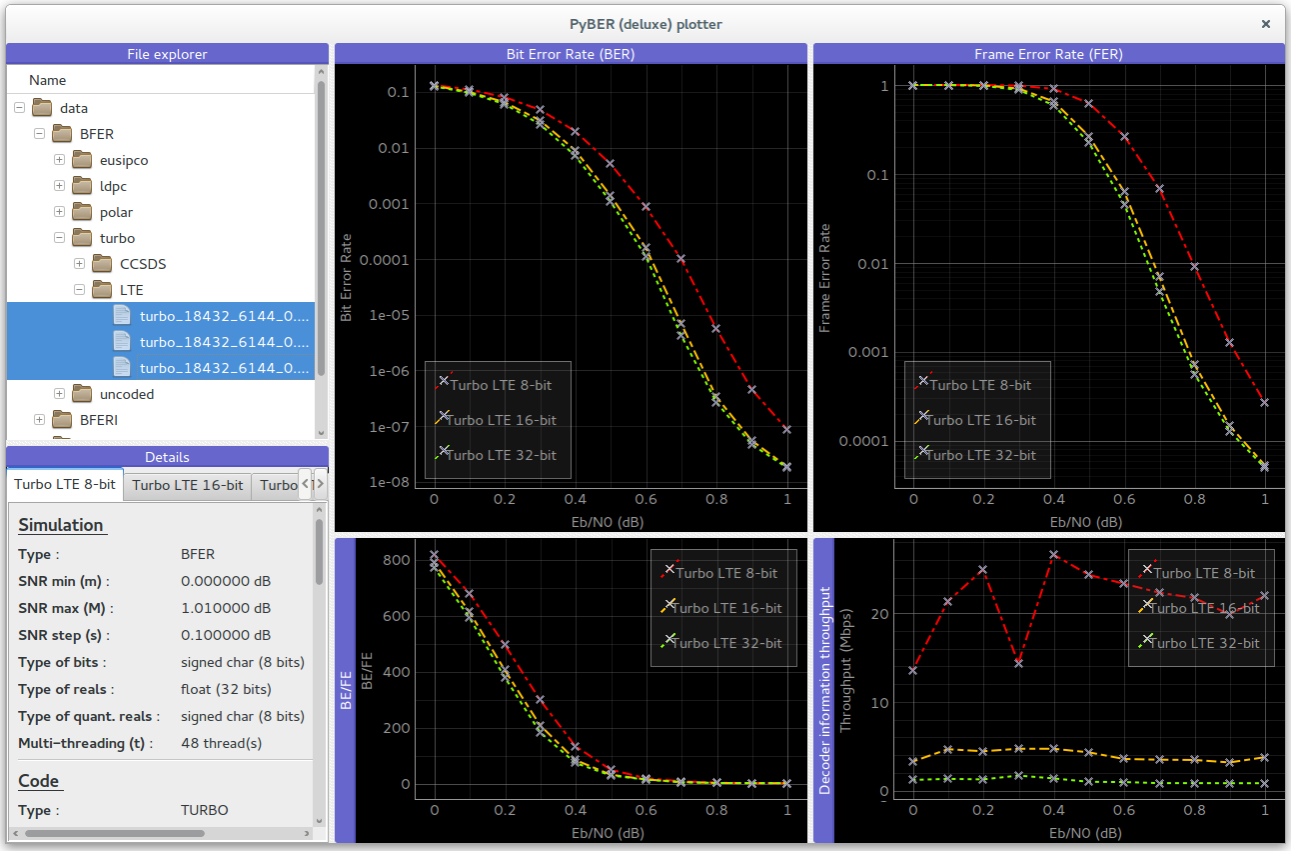

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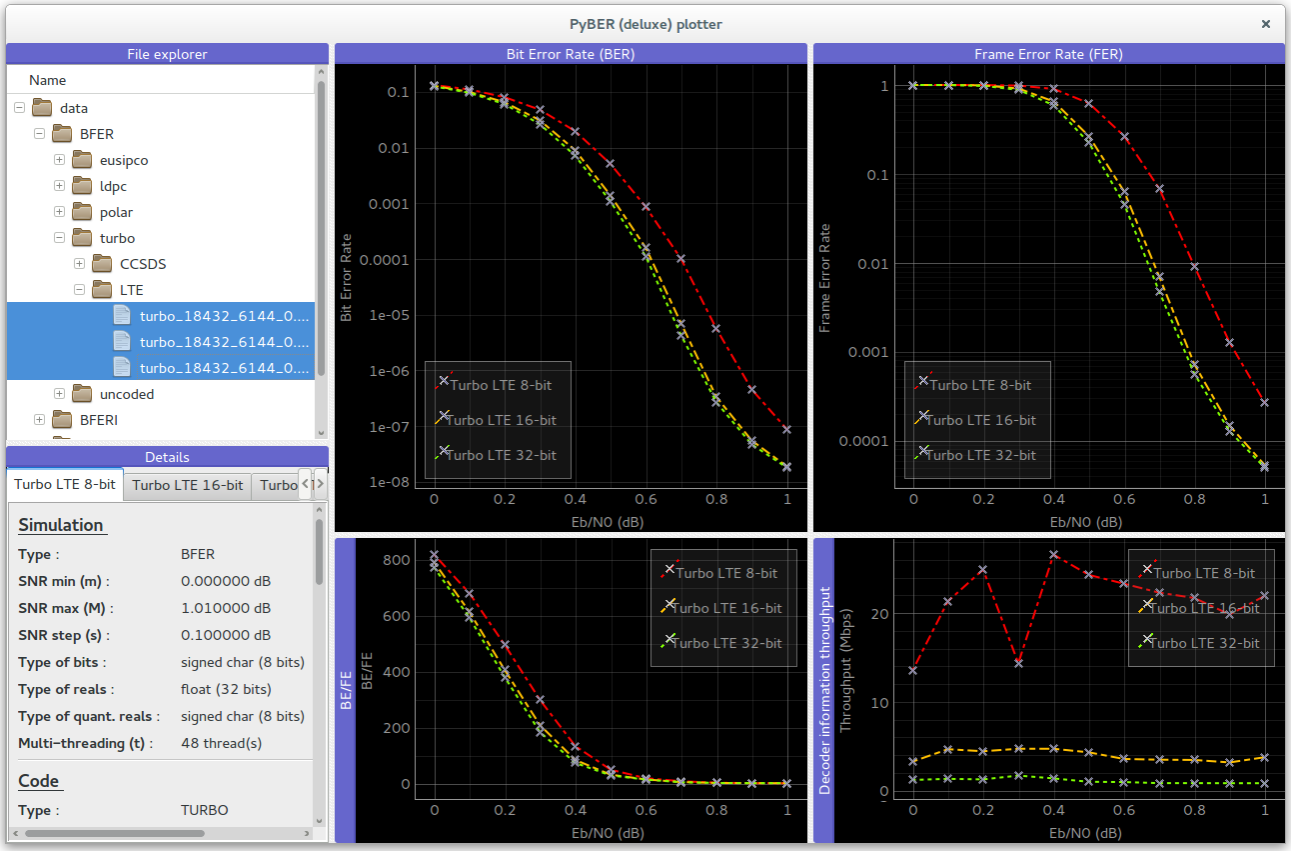
- **Plots BER/FER performance** curves in live
- **Compares** various simulation performances



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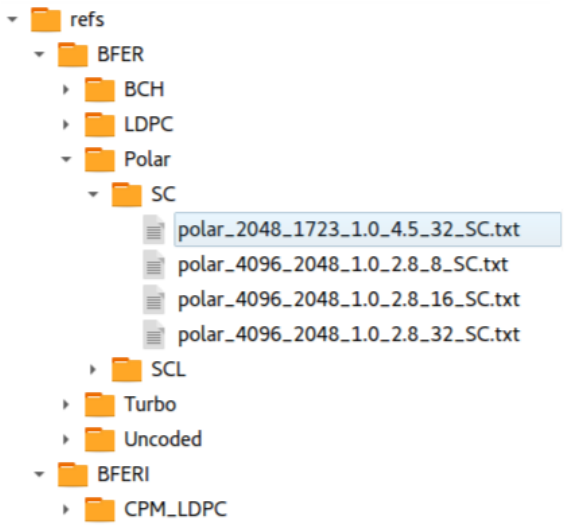

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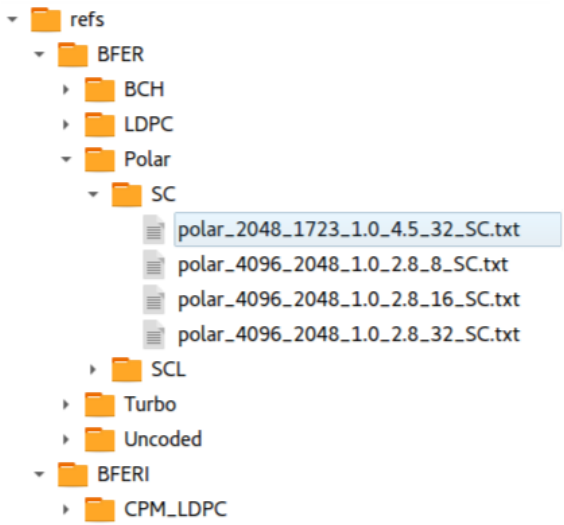
- Running commands are included to reproduce each simulation



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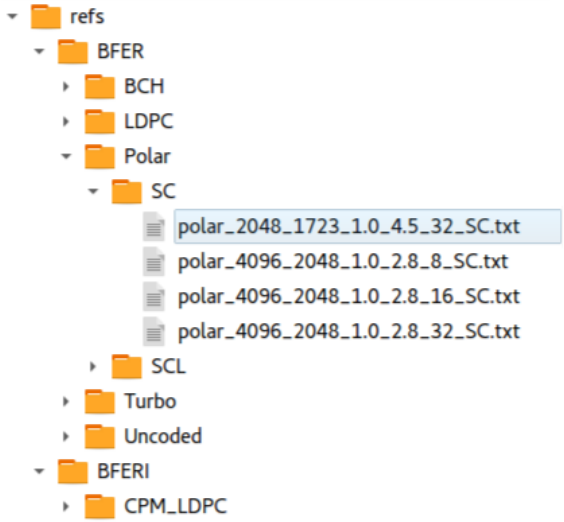
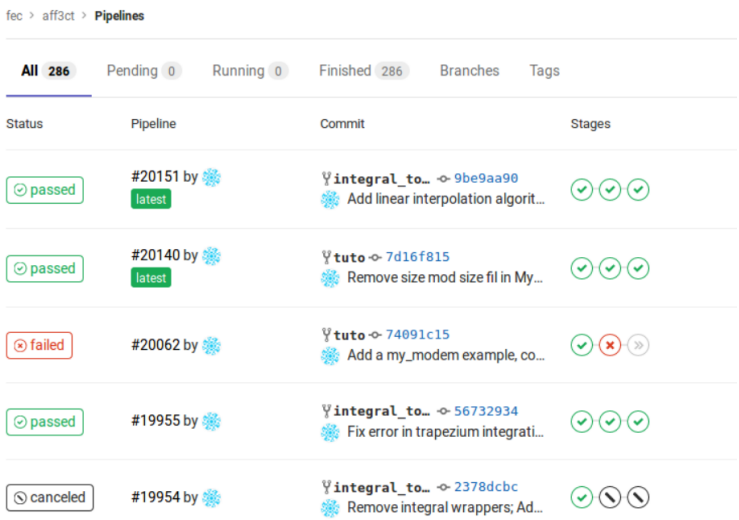
- Running commands are included to reproduce each simulation
- This database is used for automated testing scripts





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  - Maximizes code portability
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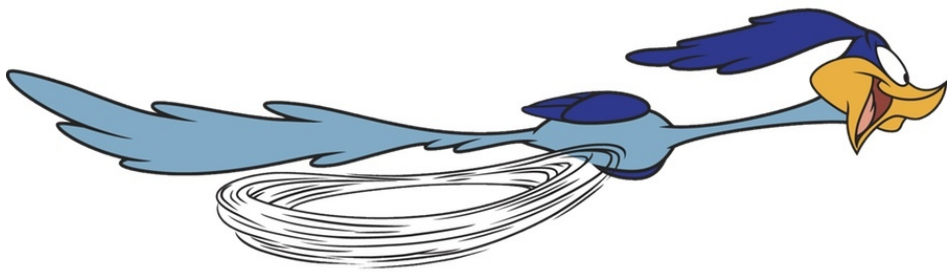
- Open-source: https://github.com/aff3ct/MIPP



MIPP MIPP!

Miscellaneous: Fixed Point API

Management of fixed point numbers in C++11

$$y_{s,v} = \min(\max(2^v.y \pm 0.5, -2^{s-1} + 1), 2^{s-1} - 1).$$

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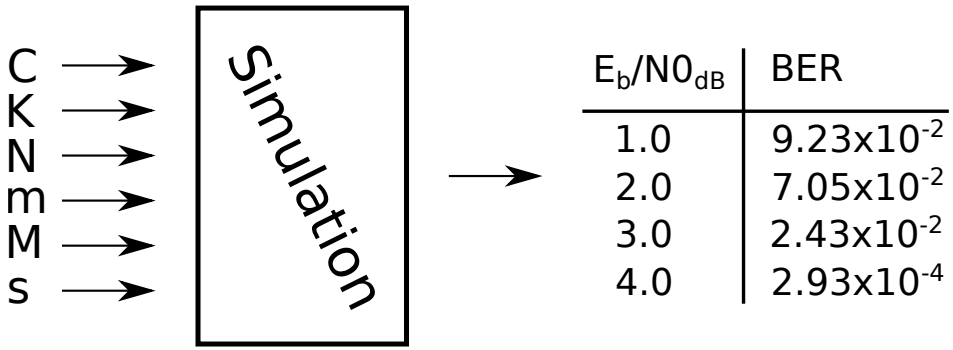
- Supports **arithmetic** operations (+, -, *, /, %)
- Supports **logic** operations (|, &, ^, ~)
- Requires to know the quantification (`S` and `V`) at compile time
- Operations are **optimized for speed**

Plan

What is a Simulation?

Running a simulation in **AFF3CT** with the minimal inputs:

```
$ aff3ct -C POLAR -K 1723 -N 2048 -m 1.0 -M 4.0 -s 1.0
```



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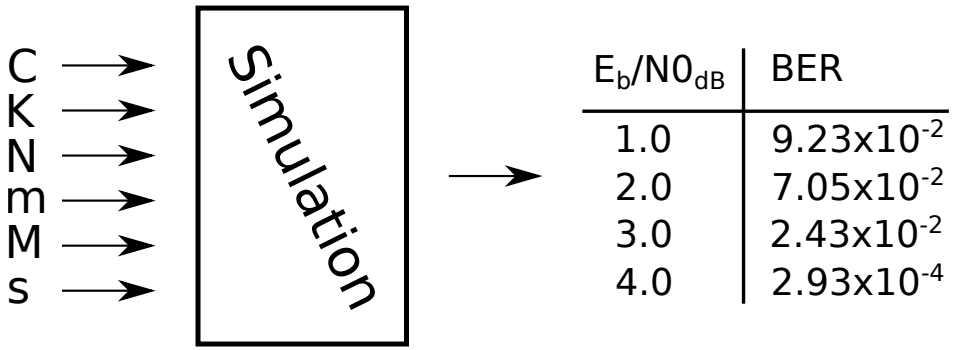
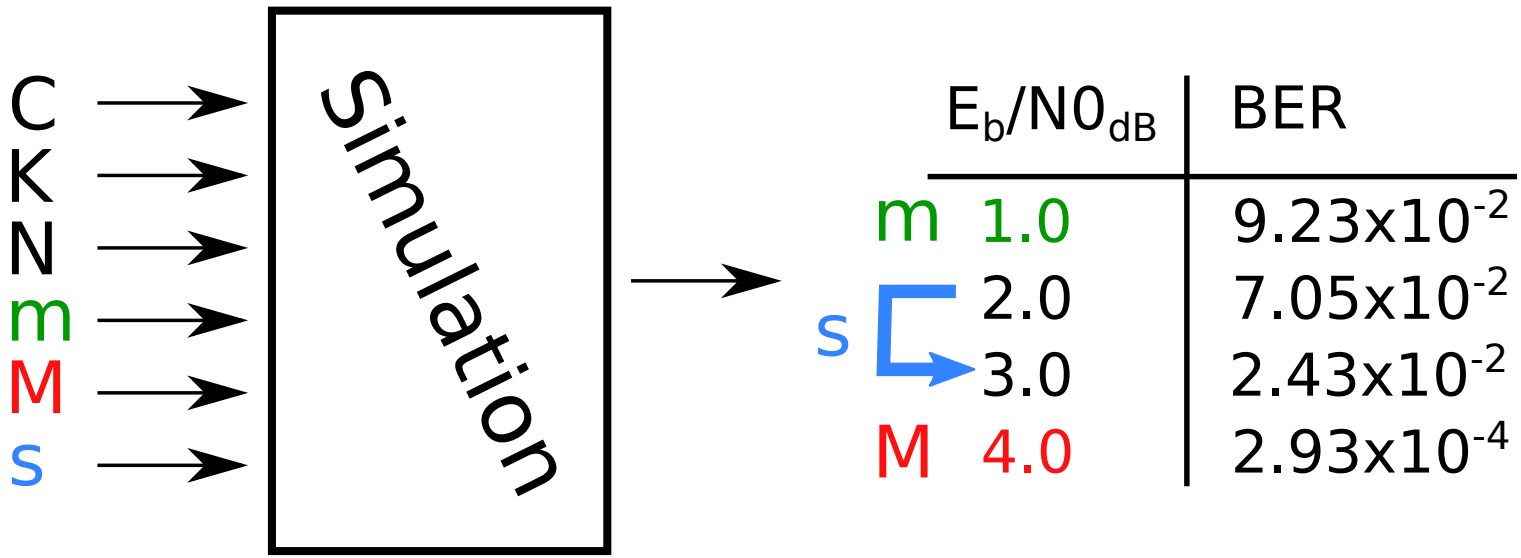



```
# ----------------------------------------------------------------------------|
#       Bit Error Rate (BER) and Frame Error Rate (FER) depending             |
#                    on the Signal Noise Ratio (SNR)                          |
# ----------------------------------------------------------------------------|
# -------|-------|----------|----------|----------|----------|----------|
#  Es/N0 | Eb/N0 |      FRA |       BE |       FE |      BER |      FER |
#   (dB) |  (dB) |          |          |          |          |          |
# -------|-------|----------|----------|----------|----------|----------|
    0.25 |  1.00 |      100 |    15910 |      100 | 9.23e-02 | 1.00e+00 |
    1.25 |  2.00 |      100 |    12151 |      100 | 7.05e-02 | 1.00e+00 |
    2.25 |  3.00 |      129 |     5392 |      100 | 2.43e-02 | 7.75e-01 |
    3.25 |  4.00 |     5467 |     2764 |      100 | 2.93e-04 | 1.83e-02 |
```

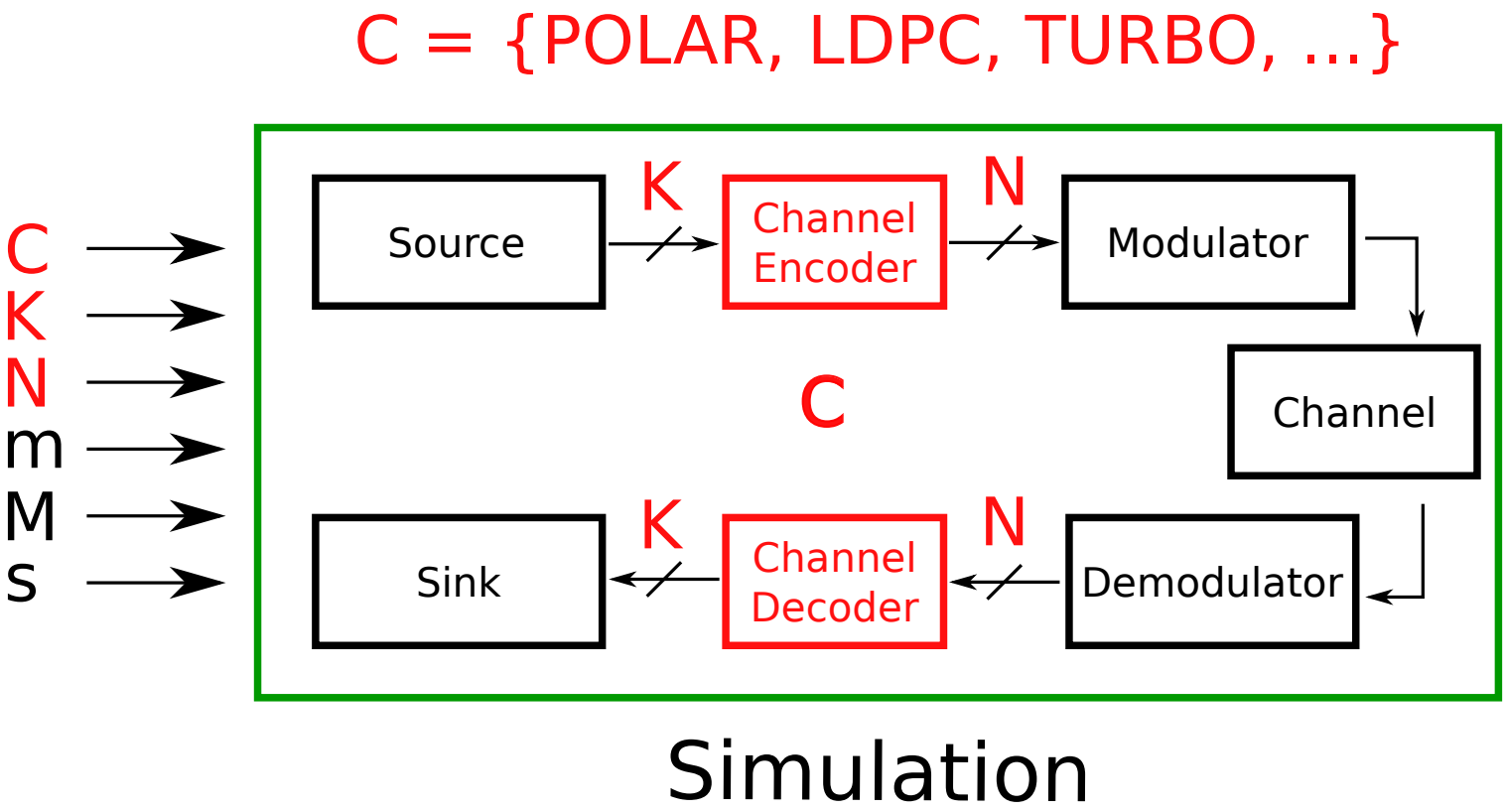
E_b/N_0 Arguments

The SNR related inputs...

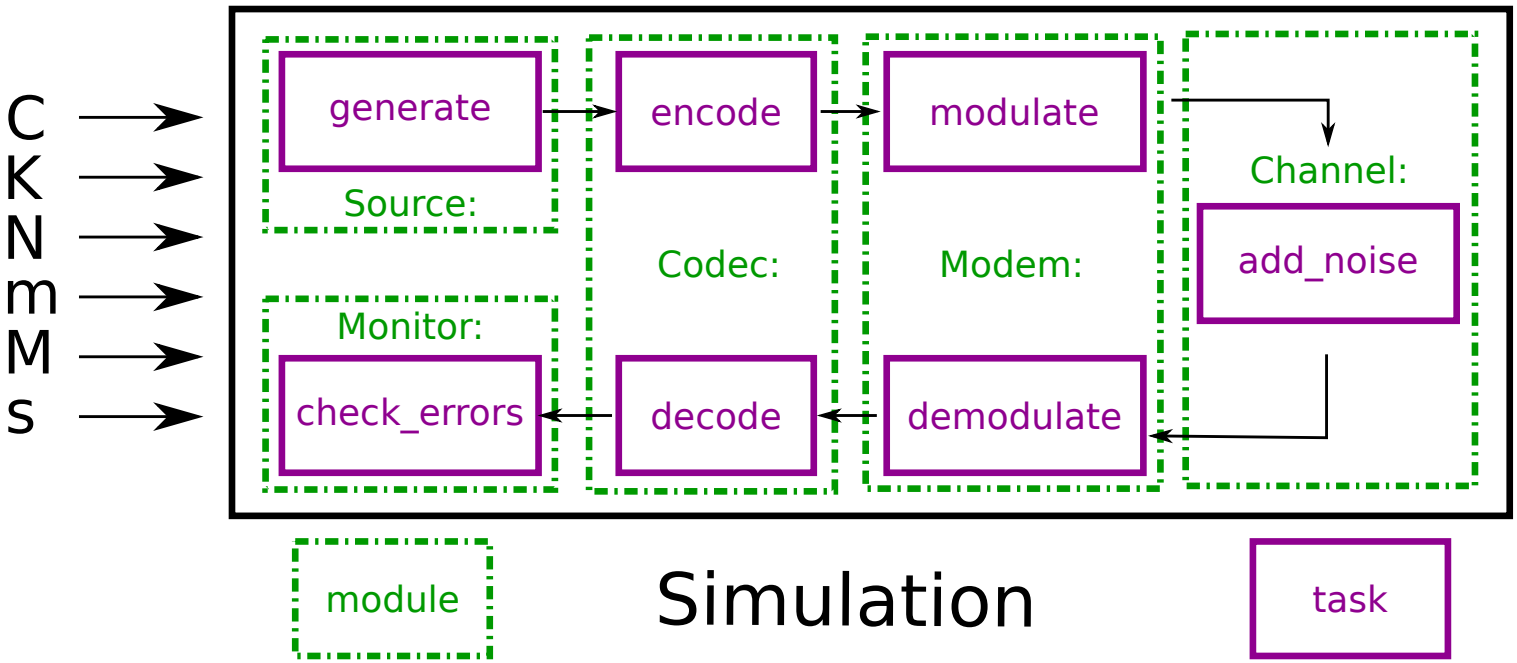


Channel Code Arguments

... and the code related inputs.



Modules and Tasks



Module Arguments

Now, let's dig into the arguments with help mode (`-h`) ...

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Each **module** or **task** has its own set of arguments, e.g. the encoder:

```
Encoder parameter(s):
{R} --enc-info-bits, -K   <integer:positive, non-zero>
      useful number of bit transmitted (information bits).
    --enc-json-path       <file [write only]>
      path to store the encoder and decoder traces formated in JSON.
    --enc-path            <file [read only]>
      path to a file containing one or a set of pre-computed codewords, to use
      with "--enc-type USER".
```

The `{R}` tag denotes required argument for a given code and simulation.

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The {R} tag denotes required argument for a given code and simulation.

Using the uppercase (`-H`) argument, advanced arguments are shown, denoted with a {A} tag.

```
{A} --sim-no-legend
      Do not display any legend when launching the simulation.
```

Tasks and Modules Options

Each **module** or **task** has its own set of arguments. Still, some of the arguments are common to several **modules** and **tasks**:

- `--xxx-type` is often used to define the type of each **module**: the type of modulation, channel or channel decoder.

```
$ aff3ct -C POLAR -m 1 -M 4 -K 1723 -N 2048 --mdm-type BPSK
```

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```

- `--xxx-implem` specifies the type of implementation used. The keyword **NAIVE** is often used to denote a readable but unoptimized source code, whereas a **FAST** stands for a source code that is optimized for a high throughput.

```
$ aff3ct -C POLAR -m 1 -M 4 -K 1723 -N 2048 --dec-implem FAST
```

Debug Arguments

Other arguments allow the user to get advances information about the running simulation

- `--sim-debug` or `-d` enables the printing of the inputs and outputs of each **task**,
- `--sim-debug-limit` limits the number of elements displayed in the debug information,
- `--sim-debug-prec` sets the precision of the real values displayed in the debug information,
- `--sim-debug-hex` sets the format of the real values to hexadecimal, which enables for example to extract the exact value of a floating-point number.

Debug Arguments

Here is an example of a debug output frame:

```
# ------------------------------
# New communication (n°99)
# ------------------------------
#
# Channel_AWGN_LLR::add_noise(const float32 X_N[3084], float32 Y_N[3084])
# {IN}  X_N = [ 1.00,  1.00,  1.00,  1.00,  1.00,  1.00,  1.00,  1.00,  1.00,  1.00, ...]
# {OUT} Y_N = [ 0.37,  0.06,  2.50, -0.32,  2.49, -0.45,  0.91,  0.77,  2.13,  0.83, ...]
# Returned status: 0
#
# Modem_BPSK::demodulate(const float32 Y_N1[3084], float32 Y_N2[3084])
# {IN}  Y_N1 = [ 0.37,  0.06,  2.50, -0.32,  2.49, -0.45,  0.91,  0.77,  2.13,  0.83, ...]
# {OUT} Y_N2 = [ 0.49,  0.07,  3.32, -0.43,  3.31, -0.59,  1.21,  1.02,  2.83,  1.11, ...]
# Returned status: 0
#
# Decoder_turbo_fast::decode_siho(const float32 Y_N[3084], int32 V_K[1024])
# {IN}  Y_N = [ 0.49,  0.07,  3.32, -0.43,  3.31, -0.59,  1.21,  1.02,  2.83,  1.11, ...]
# {OUT} V_K = [    0,     0,     0,     0,     0,     1,     0,     0,     0,     1, ...]
# Returned status: 0
#
# Monitor_BFER::check_errors(const int32 U[1024], const int32 V[1024])
# {IN}  U = [    0,     0,     0,     0,     0,     0,     0,     0,     0,     0, ...]
# {IN}  V = [    0,     0,     0,     0,     0,     1,     0,     0,     0,     1, ...]
# Returned status: 165
```

Statistics Argument

The `--sim-stats` offers interesting arguments concerning the time consumed by each **task** and the corresponding throughputs and latencies.

```
#
# ----------------------------------------||---------------------------||-------------------------------||-------------------------------
#       Statistics for the given task     ||      Basic statistics     ||   Measured throughput         ||   Measured latency
#    ('*' = any, '-' = same as previous)  ||        on the task        ||   considering the last socket  ||   considering the last socket
# ----------------------------------------||---------------------------||-------------------------------||-------------------------------
# ------------|------------------|---------||----------|----------|--------||----------|----------|----------||----------|----------|----------
#      MODULE |             TASK |   TIMER ||    CALLS |     TIME |   PERC ||  AVERAGE |  MINIMUM |  MAXIMUM ||  AVERAGE |  MINIMUM |  MAXIMUM
#             |                  |         ||          |      (s) |    (%) ||  (Mb/s)  |  (Mb/s)  |  (Mb/s)  ||    (us)  |    (us)  |    (us)
# ------------|------------------|---------||----------|----------|--------||----------|----------|----------||----------|----------|----------
#     Channel |        add_noise |       * ||     5533 |     0.48 |  38.70 ||    23.80 |     0.31 |    25.93 ||    86.05 |    79.00 |  6613.54
#      Source |         generate |       * ||     5533 |     0.35 |  28.37 ||    27.31 |     5.44 |    37.58 ||    63.08 |    45.85 |   316.53
#     Encoder |           encode |       * ||     5533 |     0.27 |  21.67 ||    42.51 |     6.55 |    57.17 ||    48.18 |    35.82 |   312.65
#     Decoder |      decode_siho |       * ||     5533 |     0.13 |  10.51 ||    73.74 |     0.35 |    91.15 ||    23.36 |    18.90 |  4973.41
#     Monitor |     check_errors |       * ||     5533 |     0.00 |   0.35 ||  2212.37 |   312.36 |  3065.84 ||     0.78 |     0.56 |     5.52
#       Modem |         modulate |       * ||     5533 |     0.00 |   0.21 ||  4287.62 |   146.28 |  5902.02 ||     0.48 |     0.35 |    14.00
#       Modem |       demodulate |       * ||     5533 |     0.00 |   0.19 ||  4742.44 |   308.06 |  6649.35 ||     0.43 |     0.31 |     6.65
# ------------|------------------|---------||----------|----------|--------||----------|----------|----------||----------|----------|----------
#       TOTAL |                * |       * ||     5533 |     1.23 | 100.00 ||     7.75 |     0.14 |     9.53 ||   222.37 |   180.79 | 12242.29
#
```

Statistics Argument

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#      MODULE |             TASK |   TIMER ||    CALLS |     TIME |   PERC ||  AVERAGE |  MINIMUM |  MAXIMUM ||  AVERAGE |  MINIMUM |  MAXIMUM
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- The measured latency of each **task** includes the time needed to read the input socket and write the output socket (**single threaded**)
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- $Throughput = \frac{N_b}{latency}$

Parallelism

Multi-threading is a simple way to improve the speed of Monte-Carlo simulations. The number of threads can be manually defined with the `-t` option (**by default `AFF3CT` runs with all the available threads**):

- Simulation on Rahan (2× Intel® Xeon® E5-2690 v3)

```
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```

For very computational intensive simulations, **`AFF3CT`** can also be **distributed on multiple servers** using the **MPI** standard, thus increasing the simulation throughput by the number of instances:

- Simulation on OCCIGEN at CINES (4212× Intel® Xeon® E5-2690 v3)

```
$ mpirun -np 64 aff3ct -C POLAR -m 1 -M 4 -K 1723 -N 2048 -t 48
```

Error Tracking

In order to improve channel coding, it can be useful to **track the erroneous frames** that occurred in a simulation. In `AFF3CT`, it is possible to **dump this erroneous frames in files**, in order to run them again later.

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The corresponding arguments are the following:

- `--sim-err-trk` dumps the erroneous frames,
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This is very useful when working on the code error floor!

Inter Frame

Some **modules** can deal with multiple frames simultaneously:

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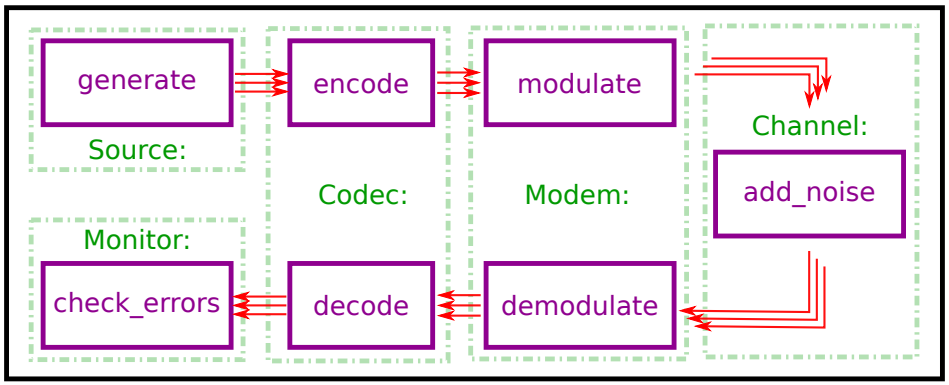

- In order to increase the parallelism with SIMD instructions (`MIPP`)

```
$ aff3ct -C POLAR -m 1 -M 4 -K 1723 -N 2048 -F 3 --dec-simd INTER
```

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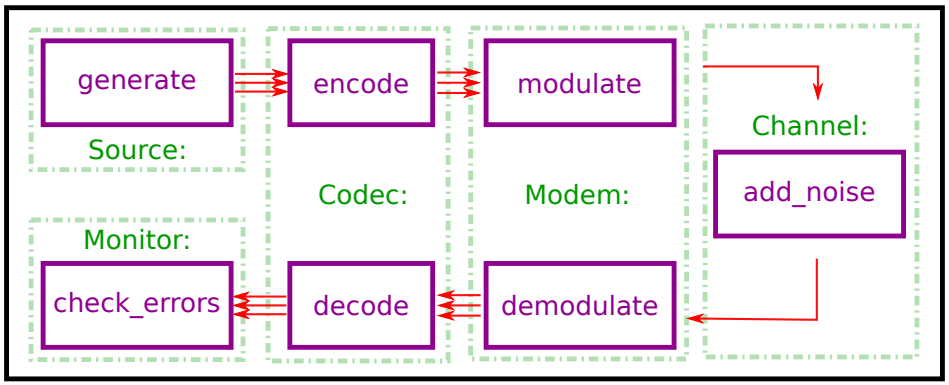

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```
$ aff3ct -C POLAR -m 1 -M 4 -K 1723 -N 2048 -F 3 --dec-simd INTER
```

- In a multi user context, e.g. multiple access methods like Sparse Code Multiple Access (SCMA)

```
$ aff3ct -C UNCODED -m 0 -M 14 -K 12 -mdm-type SCMA -mdm-ite 6 -F 6
```

Plan

Source Code Organization

Folders in the `AFF3CT` Root

ci/	Continuous integration scripts
conf/	Input configuration files for the simulator
doc/	Documentation related files (Doxygen)
lib/	Libraries used by **`AFF3CT`** (like `MIPP`)
refs/	Reference curves, simulated results
scripts/	Miscellaneous scripts like the `debug parser`
src/	**`AFF3CT`** source code

Source Code Organization

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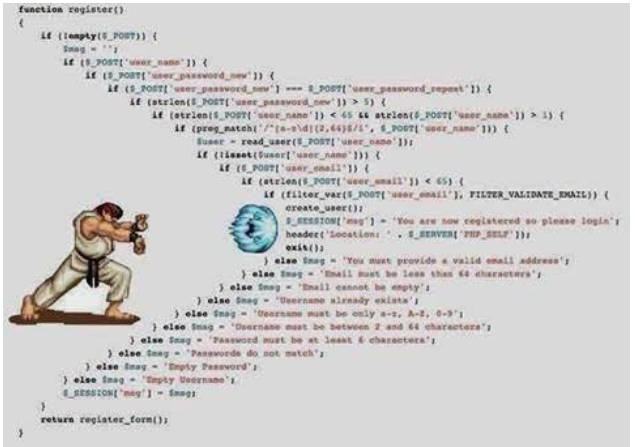
Tools/	Elementary functions that can be reused in all the whole code

Coding Style

- **Indentation with tabulations** (hard tabs)



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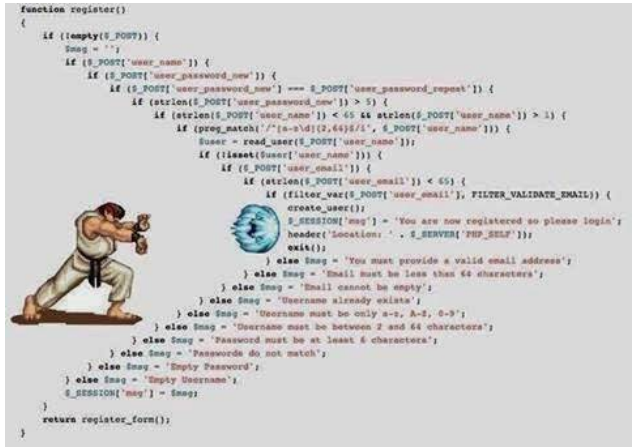

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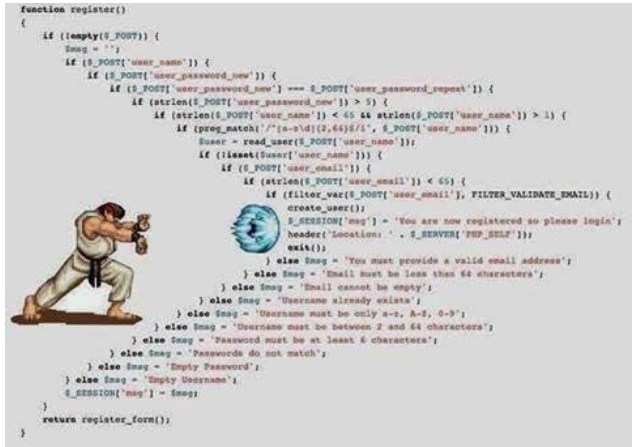

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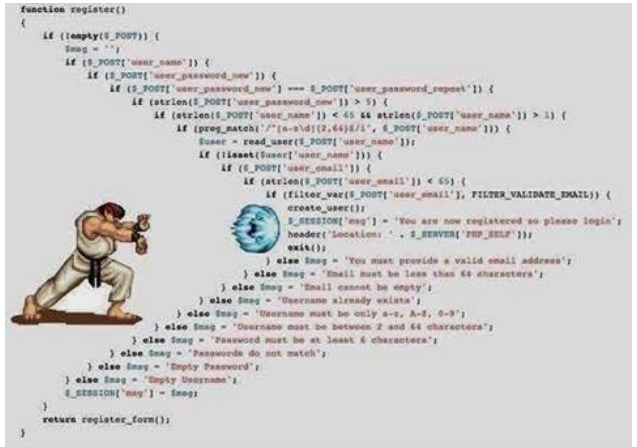

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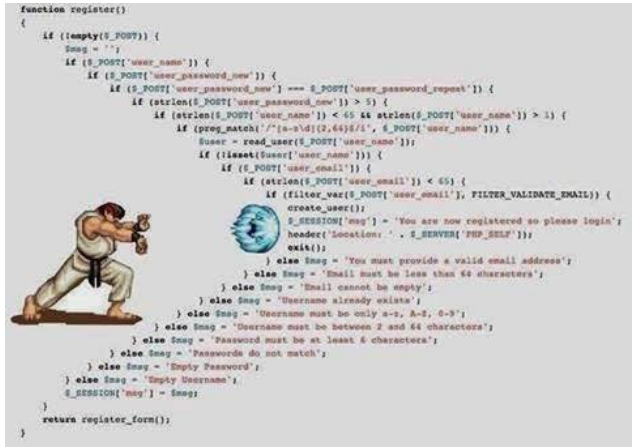

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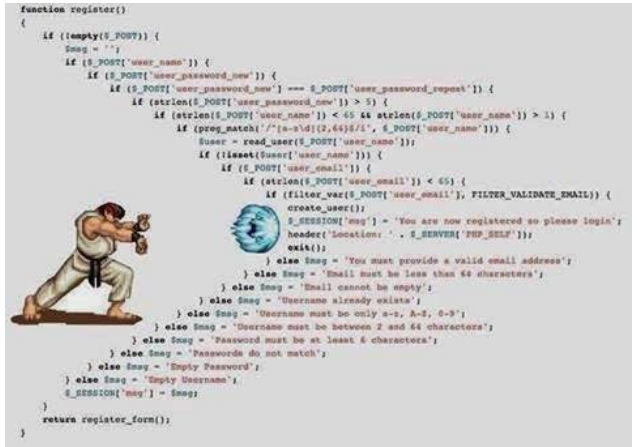

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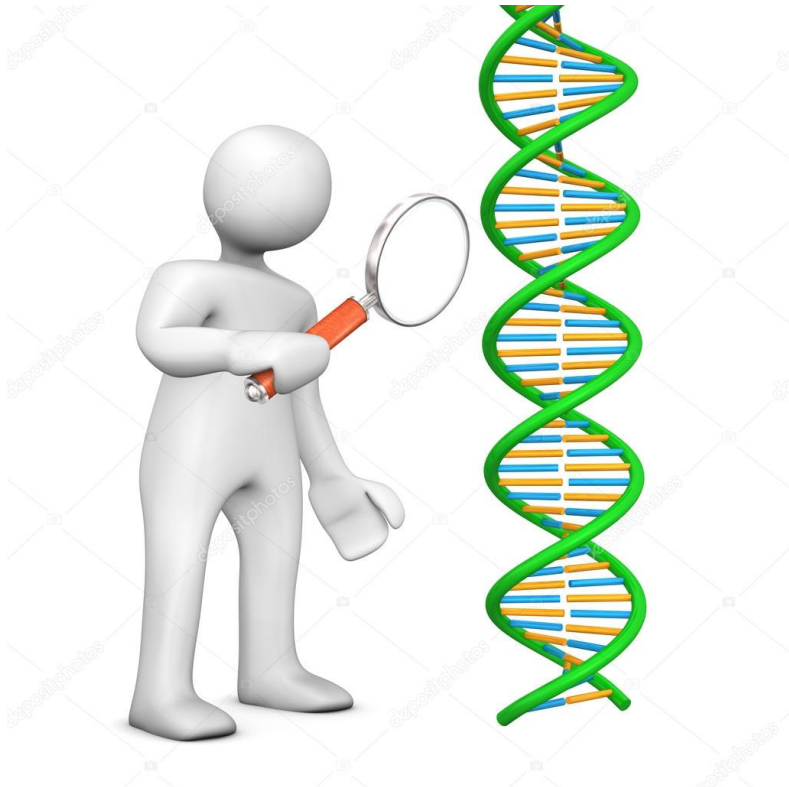
- Acronyms stay in upper case: `Decoder_LDPC.cpp`, `Channel_AWGN`

Documentation: Doxygen

Generating documentation (commands for a Debian-like OS)

```
$ sudo apt-get install doxygen
$ cd aff3ct_path/doc/
$ doxygen config.txt
$ xdg-open doc/html/index.html
```



Documentation: Generation with Doxygen

AFF3CT

A Fast Forward Error Correction Toolbox!

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API_polar_dynamic_inter_8bit_bitpacking (aff3ct::tools)
API_polar_dynamic_intra (aff3ct::tools)
API_polar_dynamic_seq (aff3ct::tools)
API_polar_static_inter (aff3ct::tools)
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Argument_type_limited_T (aff3ct::tools)

B

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BCH (aff3ct::launcher)
BCH_polynomial_generator (aff3ct::tools)
BFER (aff3ct::factory)
BFER (aff3ct::simulation)
BFER_ite (aff3ct::launcher)
BFER_ite (aff3ct::simulation)

Decoder_BCH (aff3ct::factory)
Decoder_BCH (aff3ct::module)
Decoder_BCH_genius (aff3ct::module)
Decoder_BCH_std (aff3ct::module)
Decoder_chase_std (aff3ct::module)
Decoder_HIHO (aff3ct::module)
Decoder_LDPC (aff3ct::factory)
Decoder_LDPC_BP (aff3ct::module)
Decoder_LDPC_BP_flooding (aff3ct::module)
Decoder_LDPC_BP_flooding_approximate_min_star (aff3ct::module)
Decoder_LDPC_BP_flooding_Gallager_A (aff3ct::module)
Decoder_LDPC_BP_flooding_log_sum_product (aff3ct::module)
Decoder_LDPC_BP_flooding_offset_normalize_min_sum (aff3ct::module)
Decoder_LDPC_BP_flooding_sum_product (aff3ct::module)
Decoder_LDPC_BP_layered (aff3ct::module)
Decoder_LDPC_BP_layered_approximate_min_star (aff3ct::module)
Decoder_LDPC_BP_layered_log_sum_product (aff3ct::module)
Decoder_LDPC_BP_layered_offset_normalize_min_sum (aff3ct::module)
Decoder_LDPC_BP_layered_ONMS_inter (aff3ct::module)
Decoder_LDPC_BP_layered_sum_product (aff3ct::module)
Decoder_maximum_likelihood (aff3ct::module)
Decoder_maximum_likelihood_naive (aff3ct::module)
Decoder_maximum_likelihood_std (aff3ct::module)
Decoder_NO (aff3ct::factory)
Decoder_NO (aff3ct::module)
Decoder_polar (aff3ct::factory)
Decoder_polar_ASCL_fast_CA_sys (aff3ct::module)
Decoder_polar_ASCL_MEM_fast_CA_sys (aff3ct::module)
Decoder_polar_SC_fast_sys (aff3ct::module)
Decoder_polar_SC_naive (aff3ct::module)
Decoder_polar_SC_naive_sys (aff3ct::module)
Decoder_polar_SCAN_naive (aff3ct::module)
Decoder_polar_SCAN_naive_sys (aff3ct::module)

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Frame_
Frozen
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AFF3CT

A Fast Forward Error Correction Toolbox!

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aff3ct | module | Module

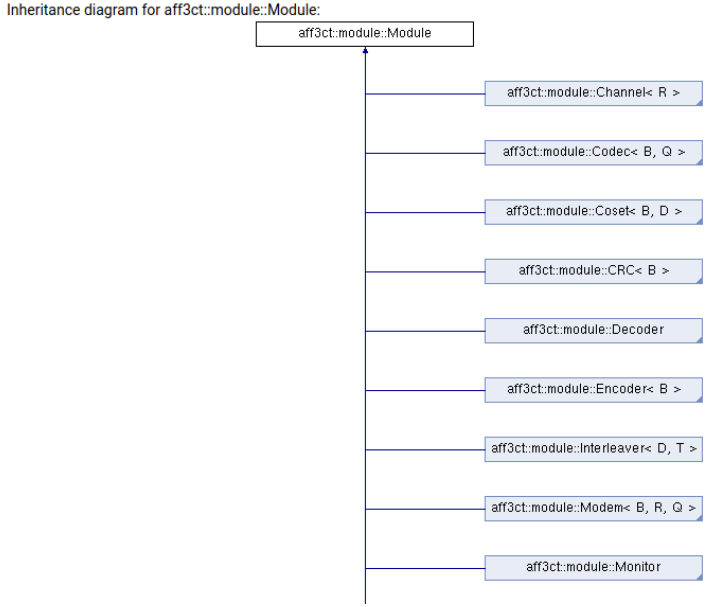
aff3ct::module::Module Class Reference

Public Member Functions | Public Attributes | Protected Member Functions | Protected Attributes | List of all members

A Module is an abstract concept. Basically, all the objects used in a Simulation are a Module. More...

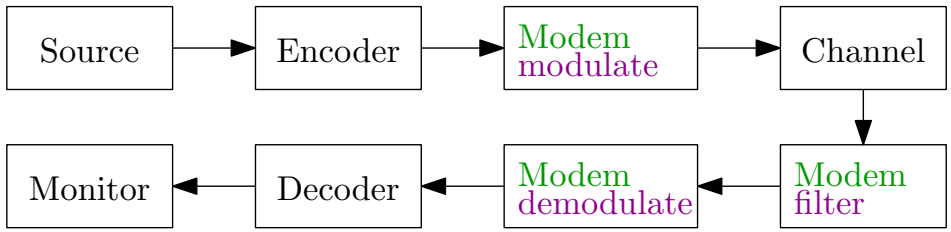
`#include <Module.hpp>`

Inheritance diagram for aff3ct::module::Module:



Adding a New Module in AFF3CT

Let's suppose we want to add a new Modem named 2PSK



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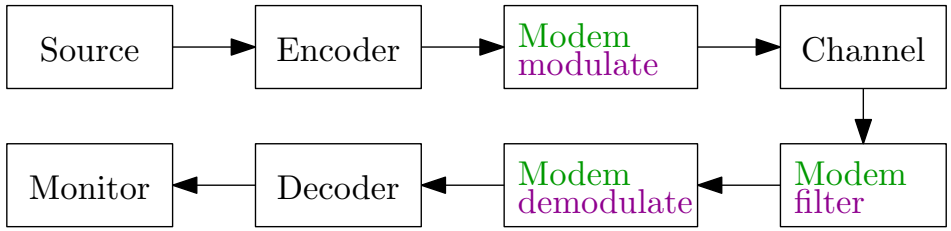

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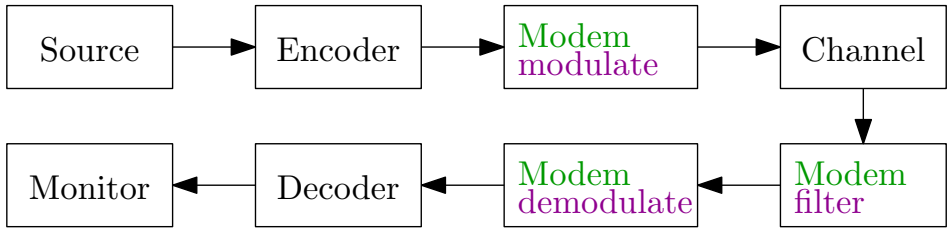

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2. **Add the implementation in AFF3CT**
   - Create a new folder: `src/Module/Modem/2PSK`
   - Create new files: `Modem_2PSK.hpp` and the `Modem_2PSK.cpp`

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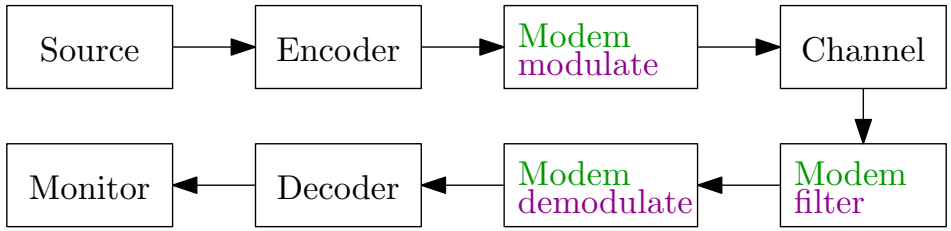

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3. **Link the new code with the simulator**:
   - Add a new entry in the `Modem` factory
   - File: `src/Factory/Module/Modem/Modem.cpp`

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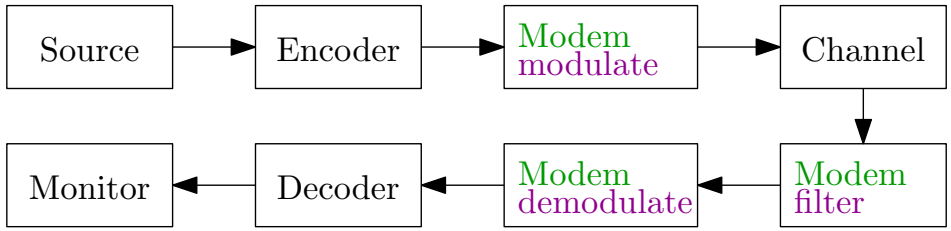

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3. **Link the new code with the simulator**:
   - Add a new entry in the `Modem` factory
   - File: `src/Factory/Module/Modem/Modem.cpp`
4. **Run AFF3CT and simulate** with our new **module**

Example: Adding a Modulator, Modem_2PSK.hpp

Let's create src/Module/Modem/2PSK/Modem_2PSK.hpp:

```
 1 #ifndef MODEM_2PSK_HPP_
 2 #define MODEM_2PSK_HPP_
 3
 4 #include "Module/Modem/Modem.hpp"
 5
 6 namespace aff3ct{ namespace module{
 7
 8 // B is the type of bits, R and Q are the types of real data
 9 template <typename B = int, typename R = float, typename Q = R>
10 // inherits from Modem class
11 class Modem_2PSK : public Modem<B,R,Q>
12 {
13   // class constructor and destructor
14   public:
15   Modem_2PSK(const int N, const R sigma) : Modem<B,R,Q>(N, sigma, 1) {}
16   virtual ~Modem_2PSK() {}
17
18   // specific modem interface (= modem tasks)
19   protected:
20   void    _modulate(const B *X_N1, R *X_N2, const int frame_id);
21   void      _filter(const R *Y_N1, R *Y_N2, const int frame_id);
22   void _demodulate(const Q *Y_N1, Q *Y_N2, const int frame_id);
23 };
24 }}
25 #endif /* MODEM_2PSK_HPP_ */
```

Example: Adding a Modulator, Modem_2PSK.cpp

Let's create src/Module/Modem/2PSK/Modem_2PSK.cpp:

```cpp
#include "Modem_2PSK.hpp"

using namespace aff3ct::module;

template <typename B, typename R, typename Q>
void Modem_2PSK<B,R,Q>::_modulate(const B *X_N1, R *X_N2, const int frame_id){
  for (auto i = 0; i < this->N; i++)
    X_N2[i] = (X_N1[i] == 1) ? -1 : +1;
}

template <typename B,typename R, typename Q>
void Modem_2PSK<B,R,Q>::_filter(const R *Y_N1, R *Y_N2, const int frame_id){
  std::copy(Y_N1, Y_N1 + this->N_mod, Y_N2); // no filtering here so copy
}

template <typename B, typename R, typename Q>
void Modem_2PSK<B,R,Q>::_demodulate(const Q *Y_N1, Q *Y_N2, const int frame_id){
  for (auto i = 0; i < this->N_fil; i++)
    Y_N2[i] = 2 * Y_N1[i] / (this->sigma * this->sigma);
}
```

Example: Adding a Modulator, Modem_2PSK.cpp

Let's create src/Module/Modem/2PSK/Modem_2PSK.cpp:

```cpp
#include "Modem_2PSK.hpp"

using namespace aff3ct::module;

template <typename B, typename R, typename Q>
void Modem_2PSK<B,R,Q>::_modulate(const B *X_N1, R *X_N2, const int frame_id){
  for (auto i = 0; i < this->N; i++)
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template <typename B,typename R, typename Q>
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}

template <typename B, typename R, typename Q>
void Modem_2PSK<B,R,Q>::_demodulate(const Q *Y_N1, Q *Y_N2, const int frame_id){
  for (auto i = 0; i < this->N_fil; i++)
    Y_N2[i] = 2 * Y_N1[i] / (this->sigma * this->sigma);
}
```

The Modem parent class contains the current sigma value (this->sigma) as well as the frame lengths (this->N, this->N_mod, this->N_fil).

Example: Adding a Modulator to the Factory

In the `src/Factory/Module/Modem/Modem.cpp` file:

```
1  // ...
2  #include "Module/Modem/2PSK/Modem_2PSK.hpp"
3  // ...
4  void Modem::parameters
5  ::get_description(tools::Argument_map_info &args) const
6  {
7    // ...
8    args.add(
9      {p+"-type"},
10     tools::Text(tools::Including_set("...", "2PSK")),
11     "type of the modulation to use in the simulation.");
12   // ...
13 }
14 // ...
15 template <typename B, typename R, typename Q, tools::proto_max<Q> MAX>
16 module::Modem<B,R,Q>* Modem::parameters
17 ::_build() const
18 {
19   // ...
20   else if (this->type == "2PSK")
21     return new module::Modem_2PSK<B,R,Q>(this->N, this->sigma);
22   // ...
23 }
24 // ...
```

Example: Adding a Modulator to the Factory

In the `src/Factory/Module/Modem/Modem.cpp` file:

```
1  // ...
2  int Modem
3  ::get_buffer_size_after_modulation(const std::string &type,
4                                     const int          N,
5                                     const int          bps,
6                                     const int          upf,
7                                     const int          cpm_L,
8                                     const int          cpm_p)
9  {
10   // ...
11   else if (type == "2PSK") return N;
12   // ...
13 }
14
15 int Modem
16 ::get_buffer_size_after_filtering(const std::string &type,
17                                    const int          N,
18                                    const int          bps,
19                                    const int          cpm_L,
20                                    const int          cpm_p)
21 {
22   // ...
23   else if (type == "2PSK") return N;
24   // ...
25 }
26 // ...
```

Example: Run the New Modem

Compile and Run

```
$ cd aff3ct_path/build/
$ cmake .
$ make -j4
```

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$ cd aff3ct_path/build/
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$ ./bin/aff3ct -C UNCODED -m 0 -M 4 -K 2048 --mdm-type 2PSK
--sim-pyber "My modem" > pyber_path/data/test.txt
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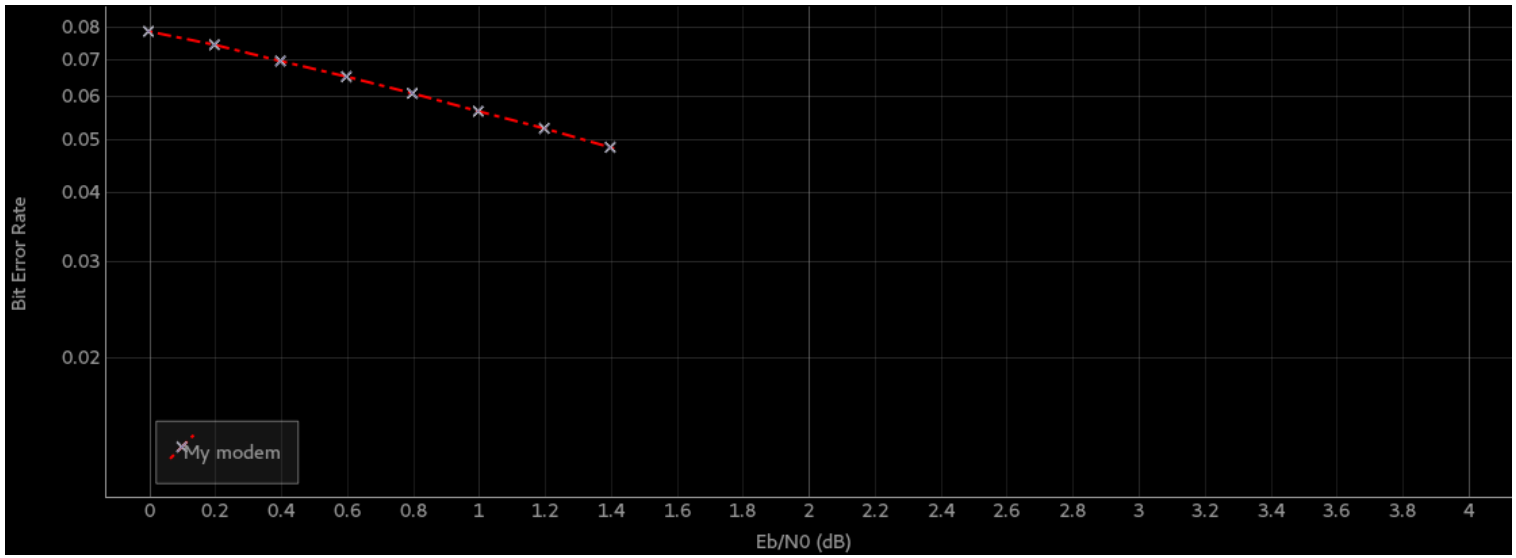

Live AFF3CT simulation on PyBER

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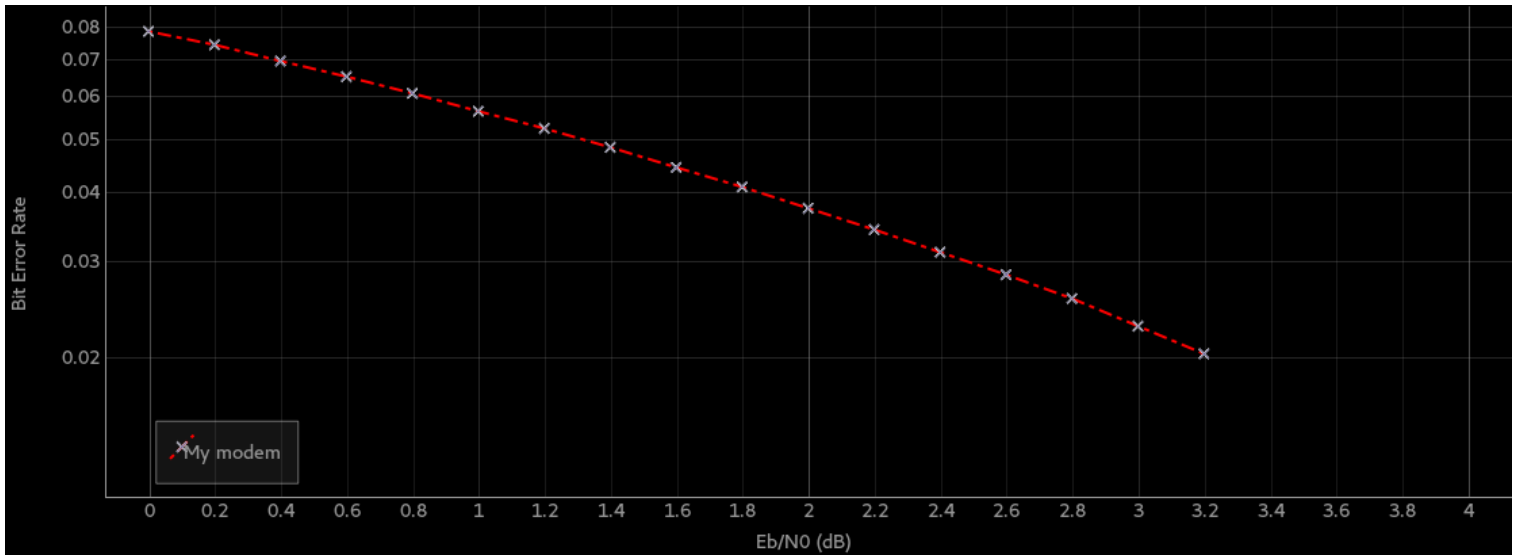

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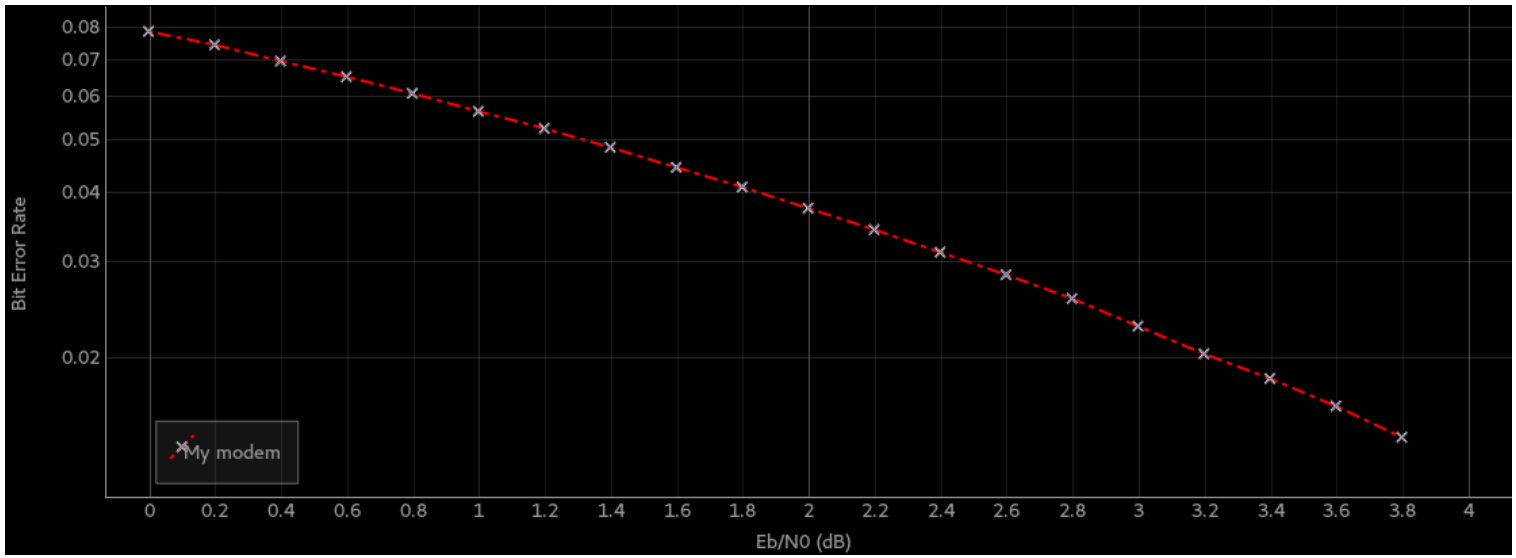

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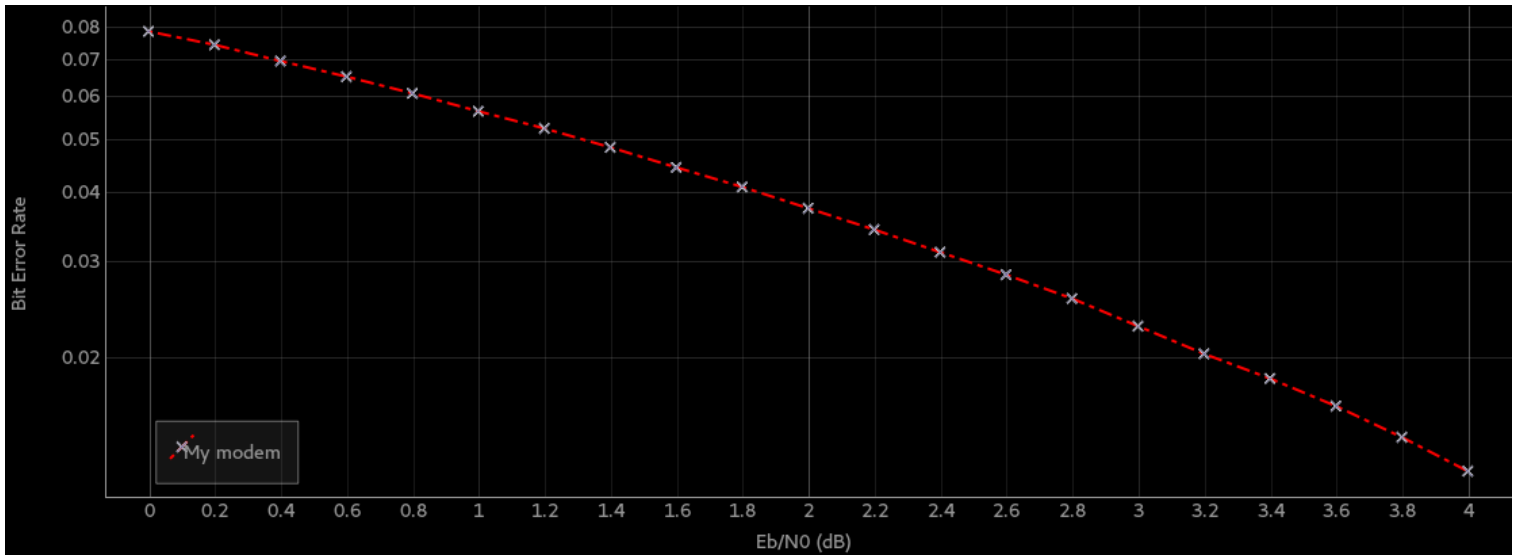

Live AFF3CT simulation on PyBER

My Project with AFF3CT

Use AFF3CT as a **Toolbox** / **library** for your projects

- Low level features
  - **Code-related**: Alist/QC readers, Polar functions API, frozen bits generators, Galois Field generator, ...
  - **Miscellaneous**: Matrix operations, sparse matrices, binary trees, ...

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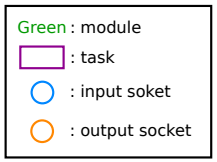
  - **Miscellaneous**: Matrix operations, sparse matrices, binary trees, ...
- High level features
  - **Factories**: Command line arguments management, automatic objects instantiation, ...
  - **Modules**: Sources, CRC, encoders, decoders, modems, channels, ...

My Project with AFF3CT: Modules Allocation

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1  #include <aff3ct.hpp>
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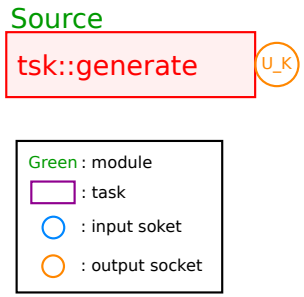


```
1  #include <aff3ct.hpp>
2  using namespace aff3ct;
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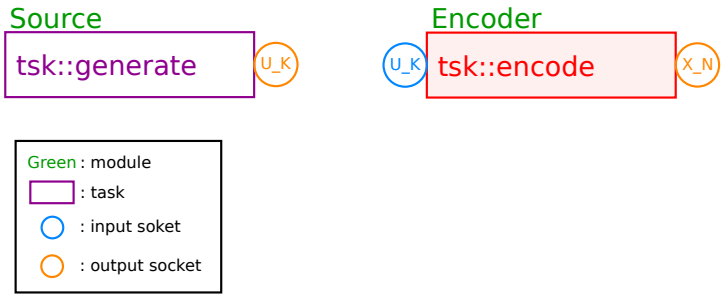


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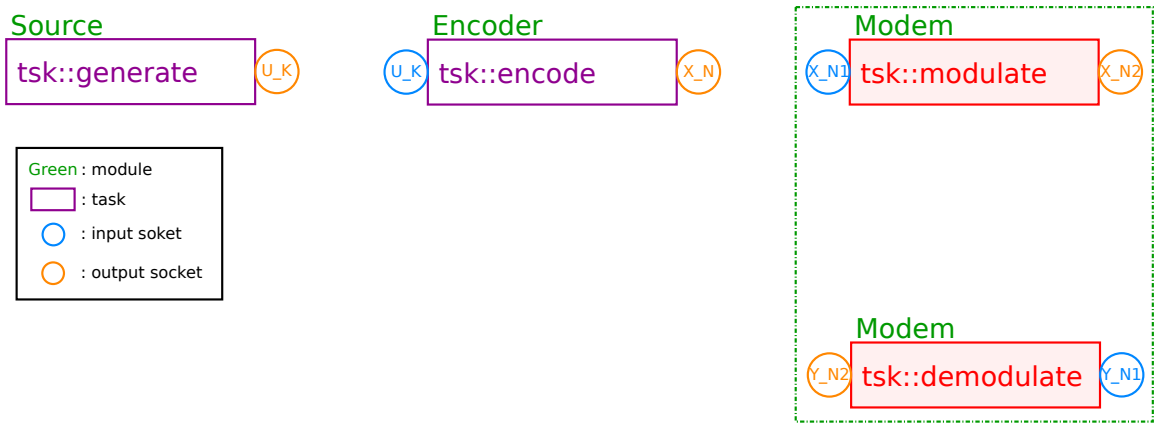


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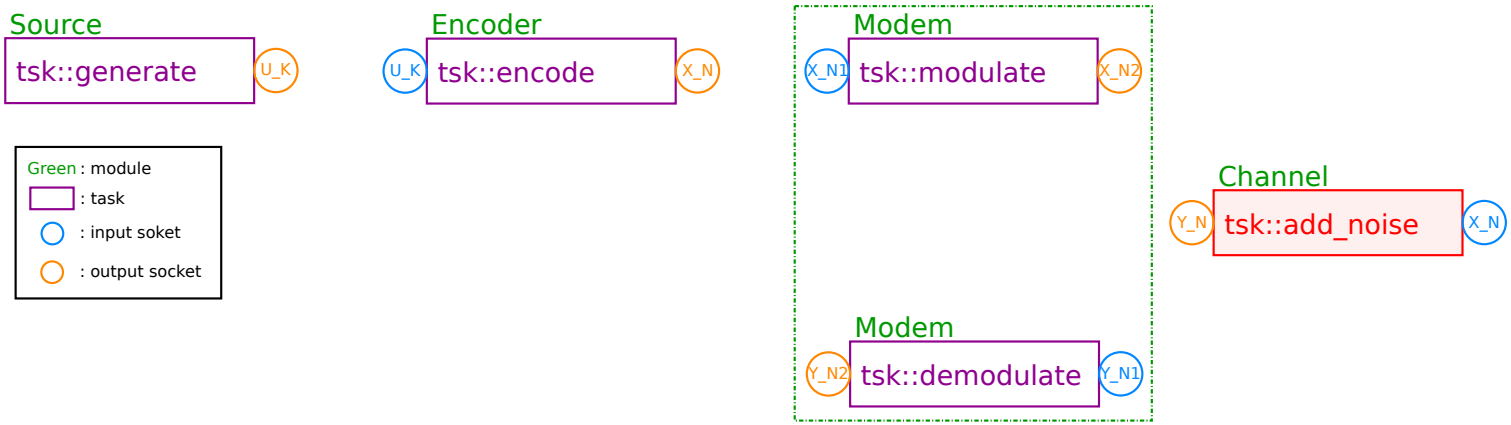


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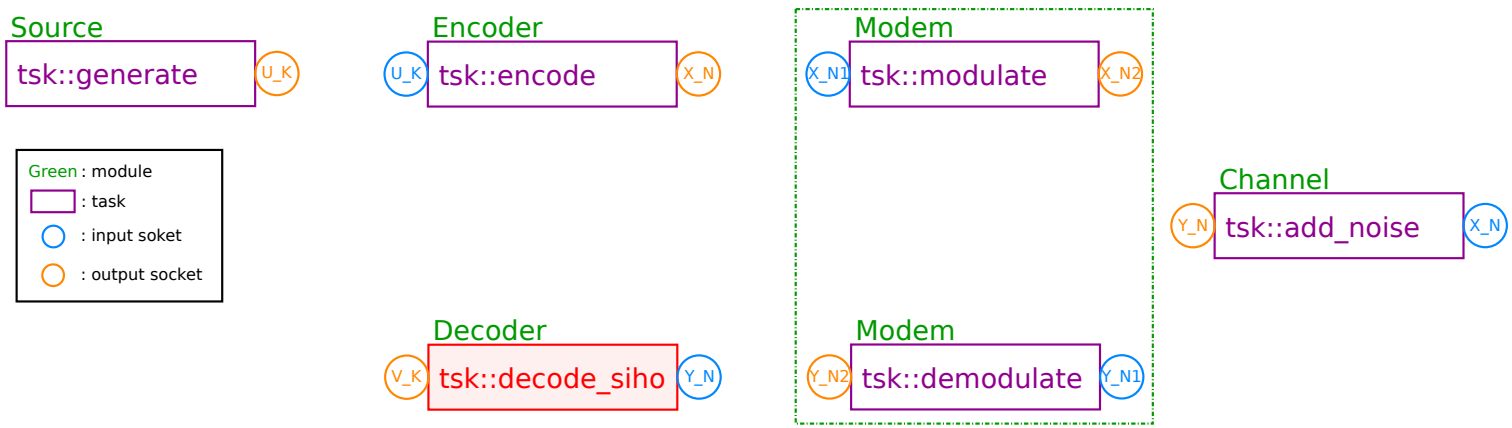


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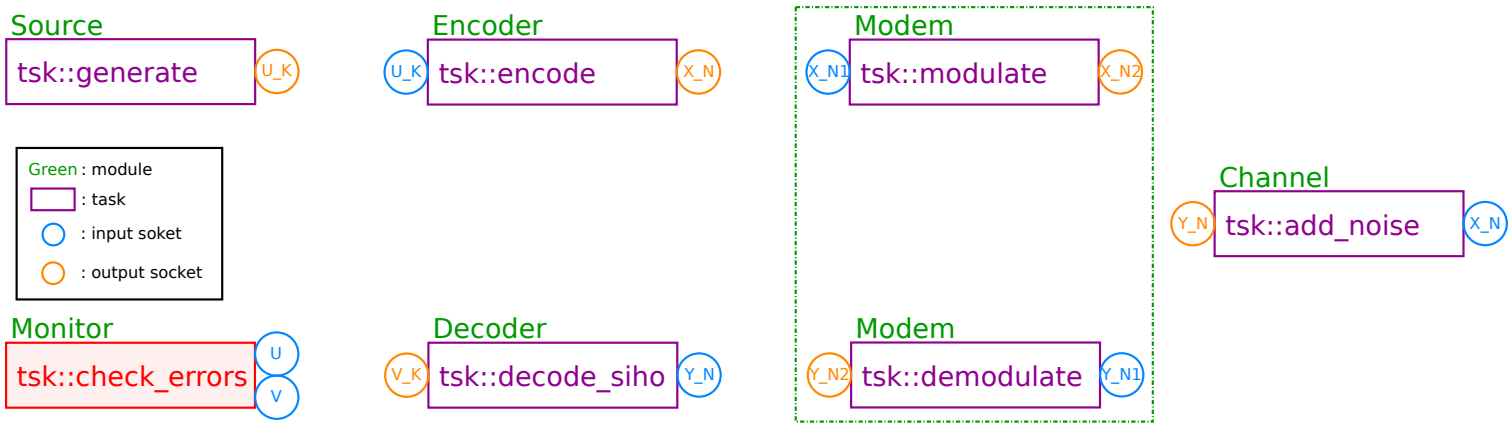


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10 module::Monitor_BFER<>           monitor(K, E);
```

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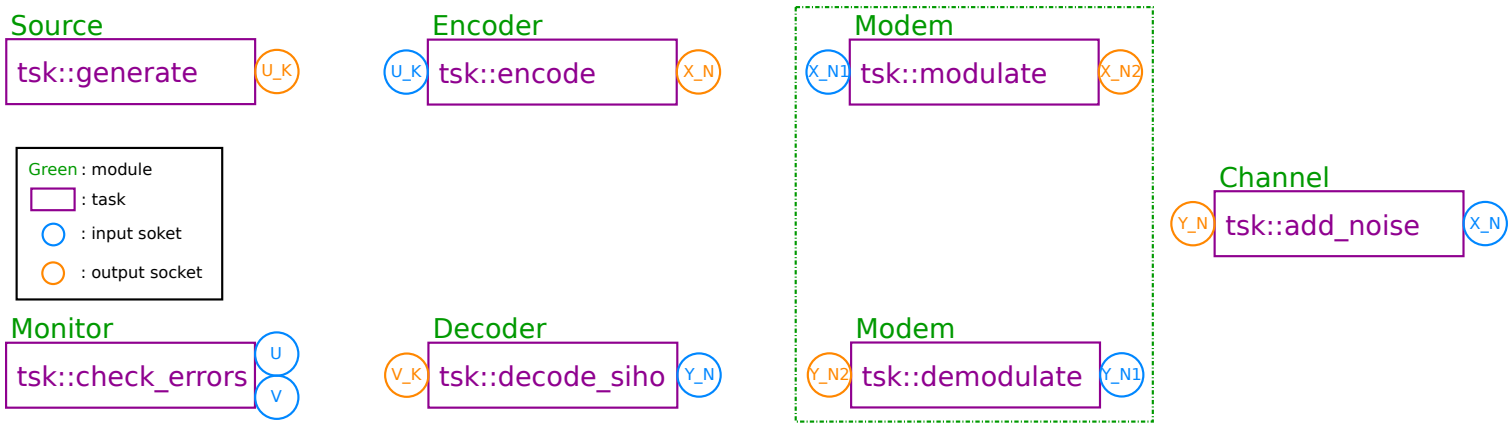


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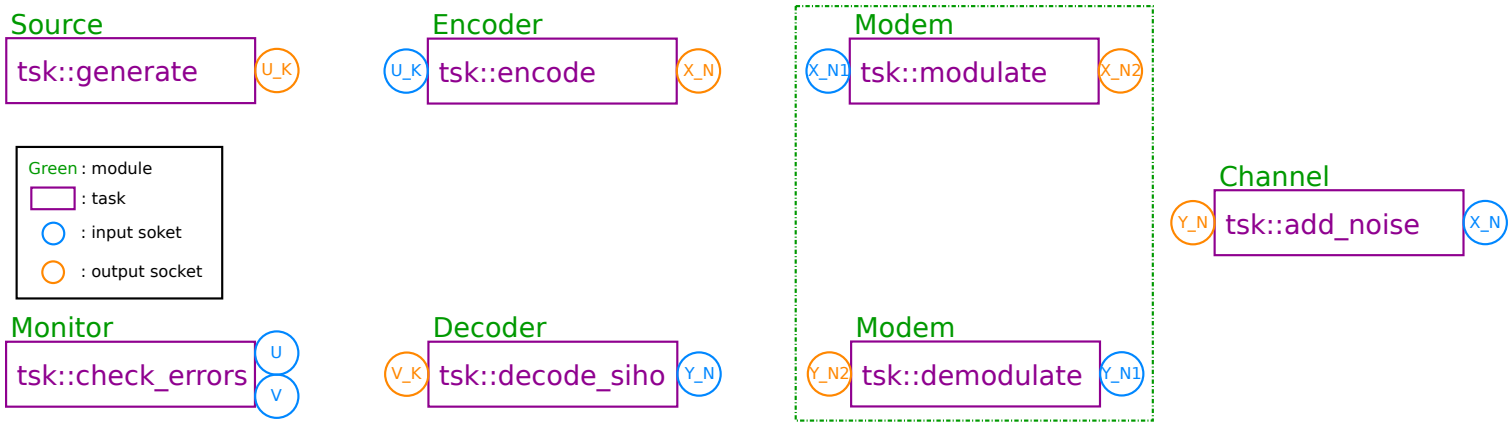
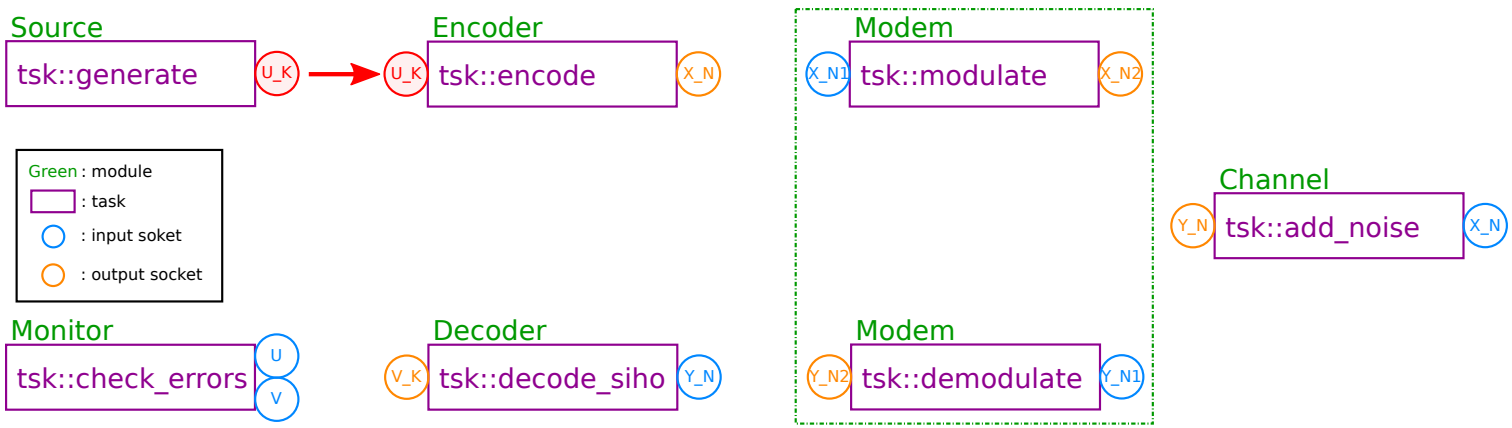
My Project with AFF3CT: Sockets Binding




```
1  using namespace aff3ct::module;
2
3  // bind the sockets over the tasks
4
5
6
7
8
9
10
```

My Project with AFF3CT: Sockets Binding




```
1  using namespace aff3ct::module;
2
3  // bind the sockets over the tasks
4  encoder[enc::sck::encode      ::U_K ].bind( source [src::sck::generate   ::U_K ] );
5
6
7
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9
10
```
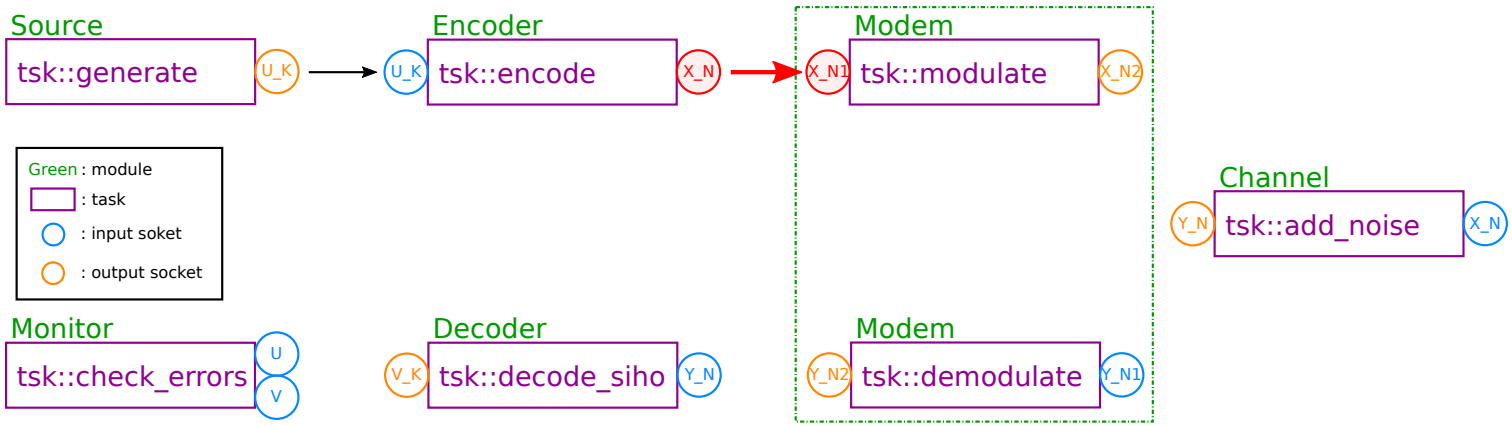

My Project with AFF3CT: Sockets Binding

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4  encoder[enc::sck::encode      ::U_K ].bind( source [src::sck::generate   ::U_K ] );
5  modem  [mdm::sck::modulate    ::X_N1].bind( encoder[enc::sck::encode     ::X_N ] );
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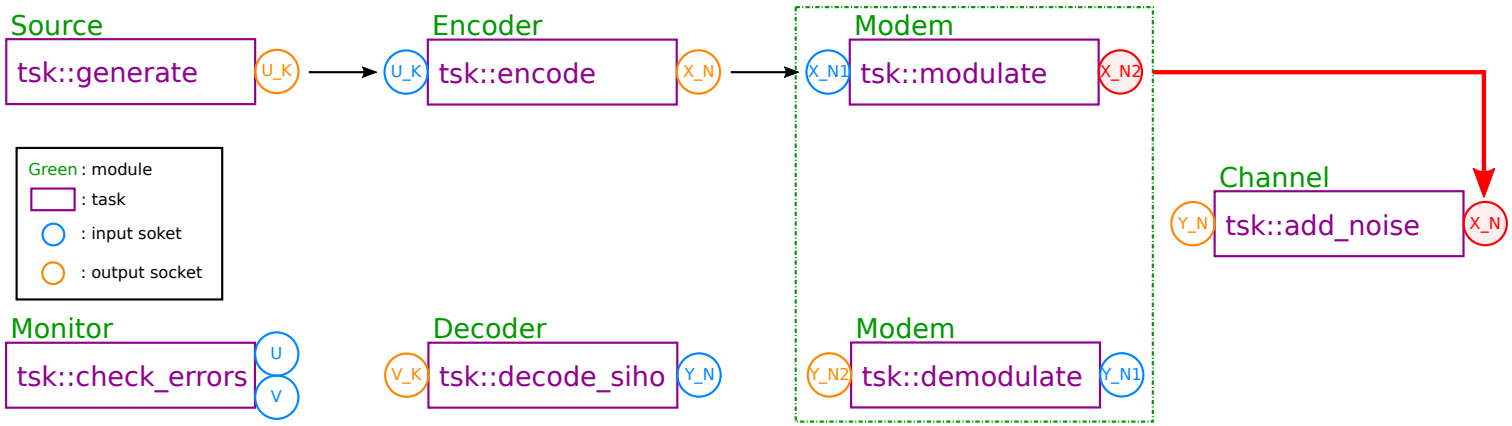


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2
3  // bind the sockets over the tasks
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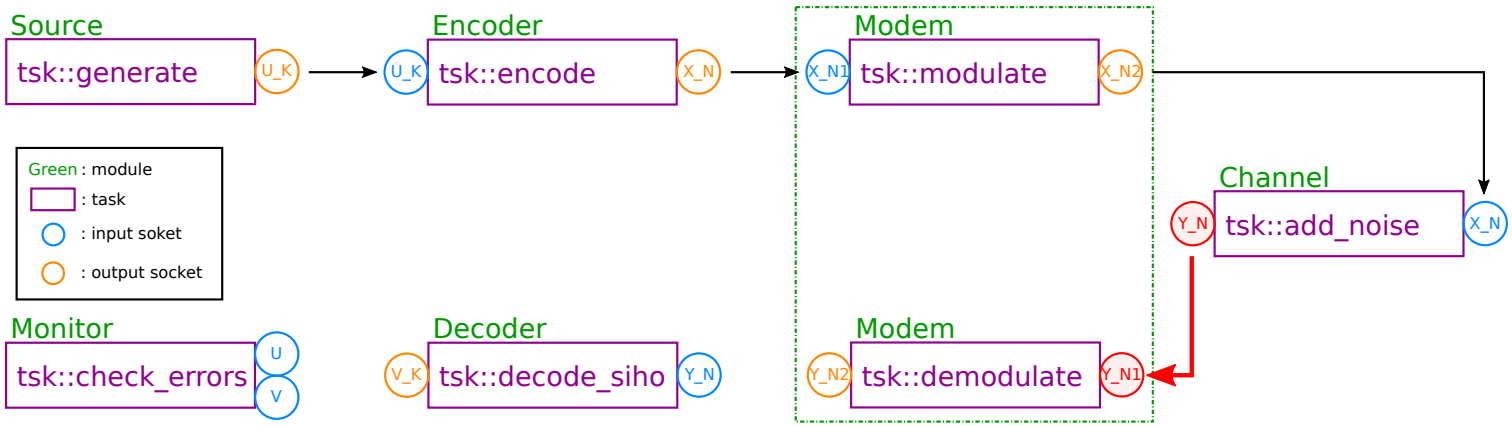
5  modem   [mdm::sck::modulate   ::X_N1].bind( encoder[enc::sck::encode     ::X_N ] );
6  channel[chn::sck::add_noise   ::X_N ].bind( modem  [mdm::sck::modulate   ::X_N2] );
7
8
9
10
```

My Project with AFF3CT: Sockets Binding

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6  channel[chn::sck::add_noise   ::X_N ].bind( modem  [mdm::sck::modulate   ::X_N2] );
7  modem  [mdm::sck::demodulate  ::Y_N1].bind( channel[chn::sck::add_noise  ::Y_N ] );
8
9
10
```
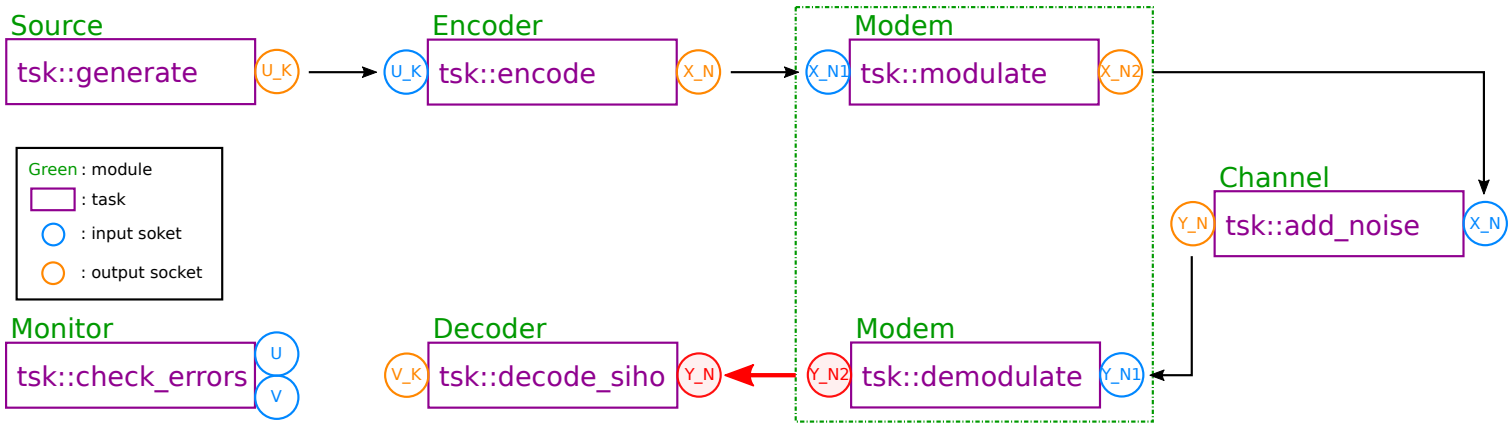

My Project with AFF3CT: Sockets Binding

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9
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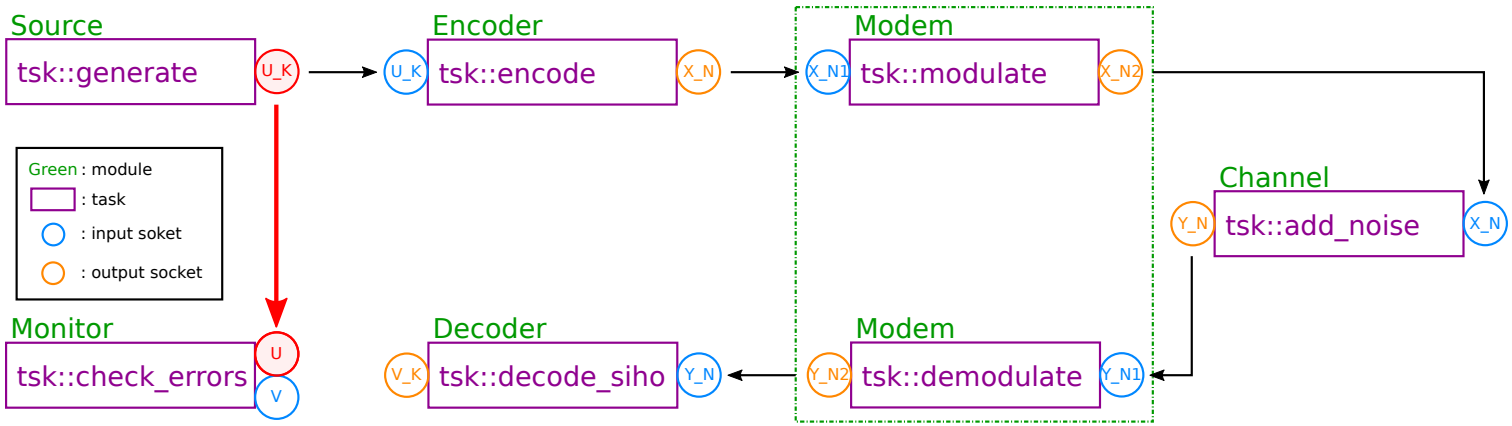
My Project with AFF3CT: Sockets Binding

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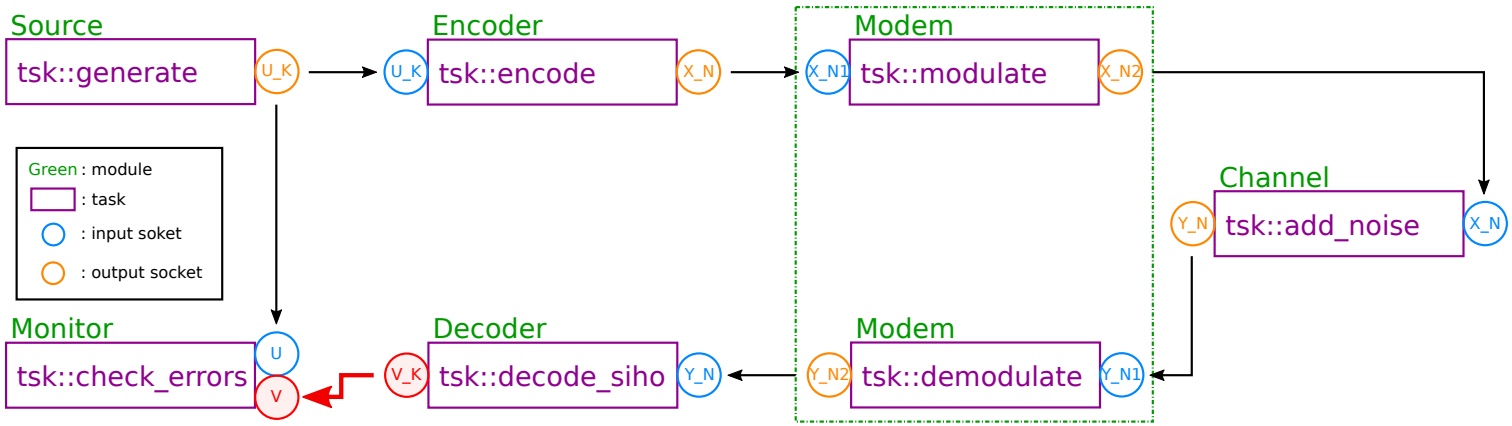


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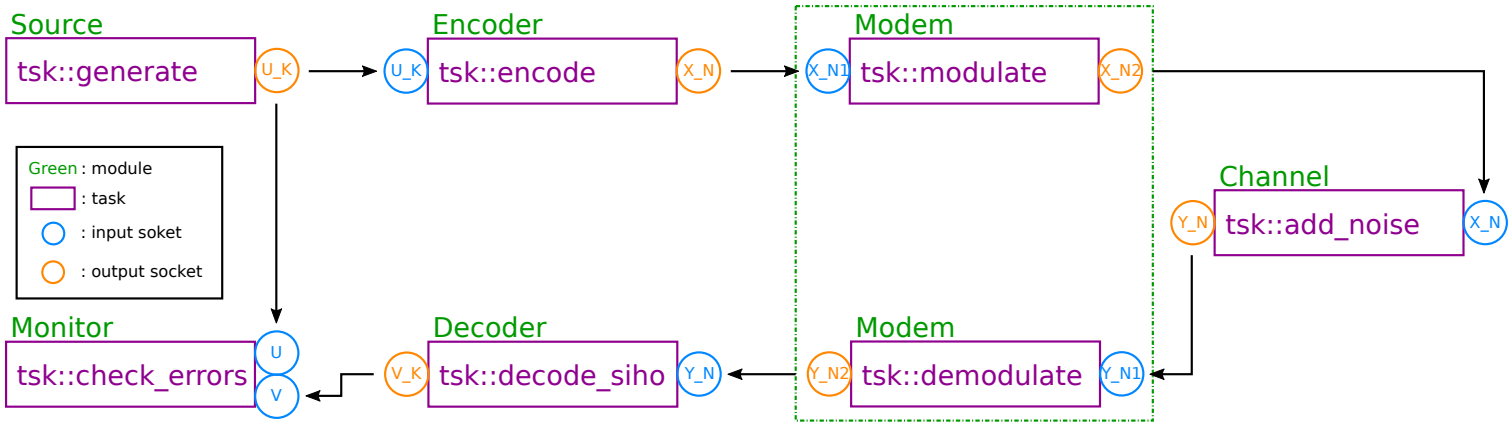


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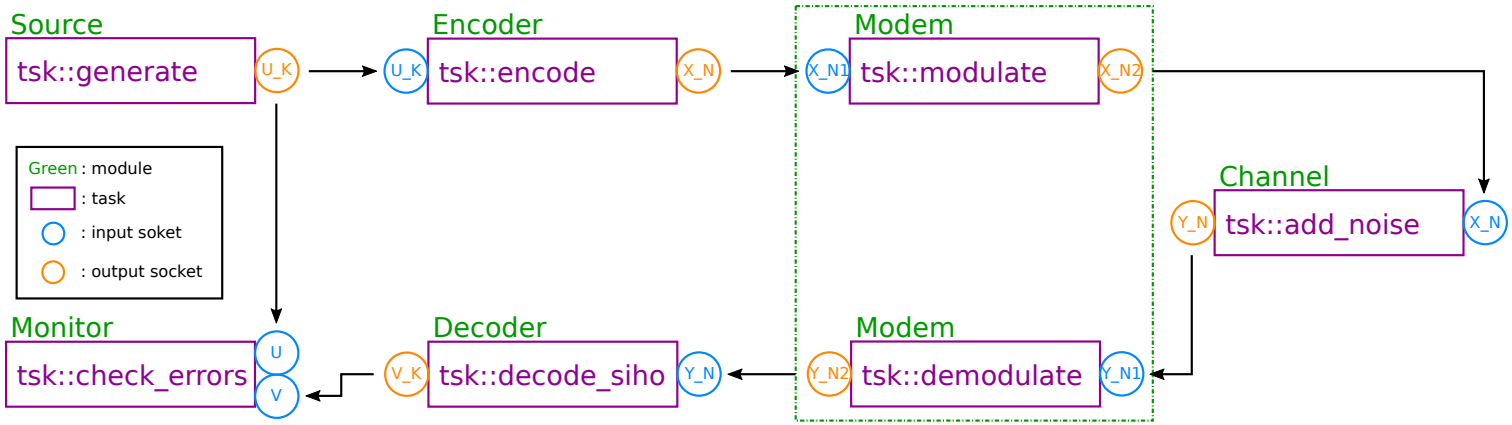


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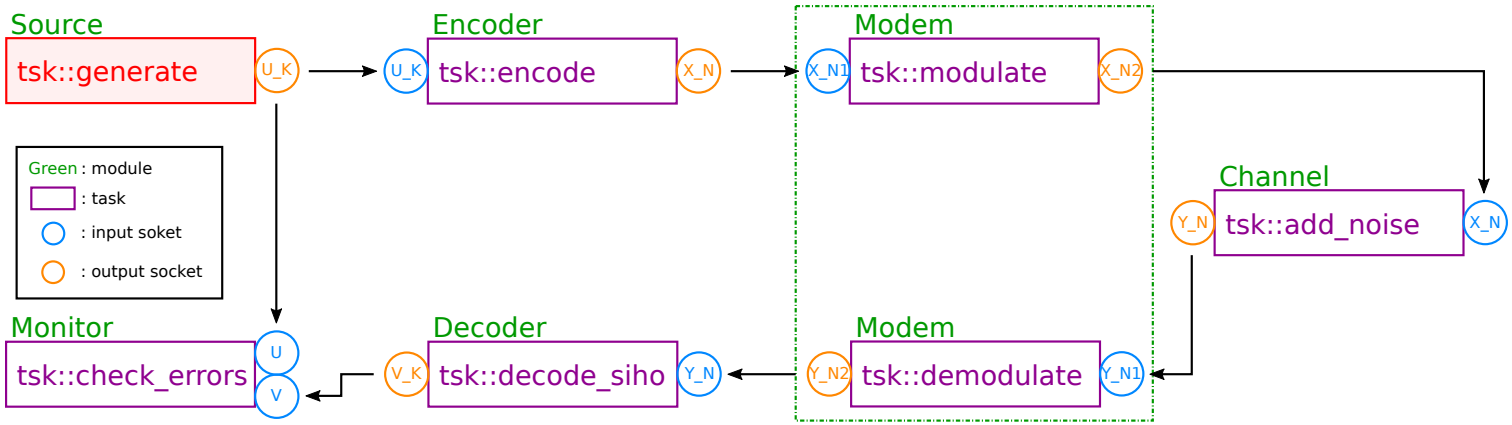


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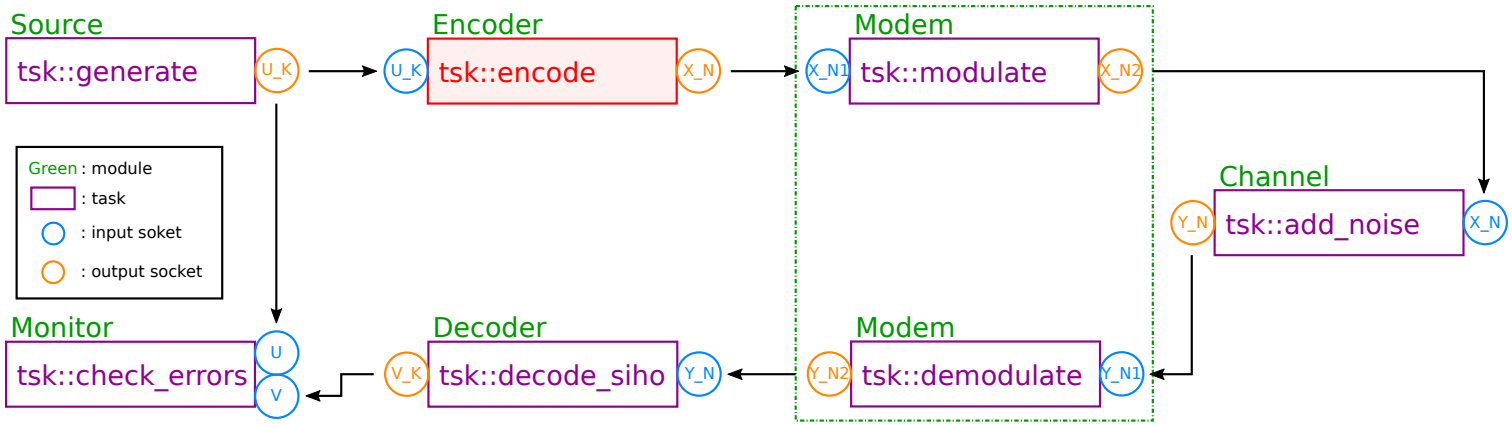


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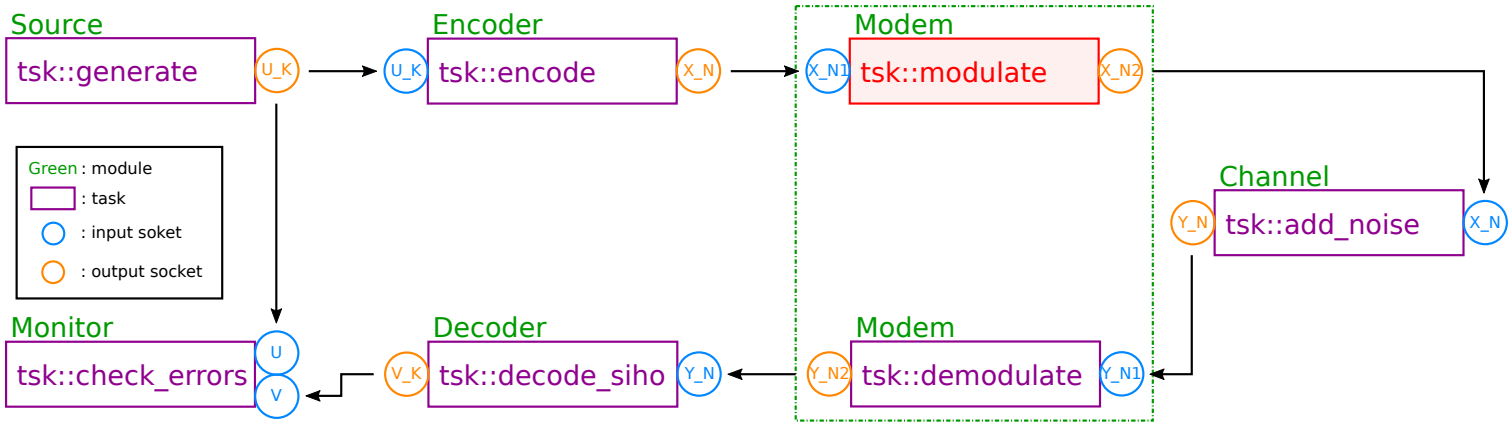


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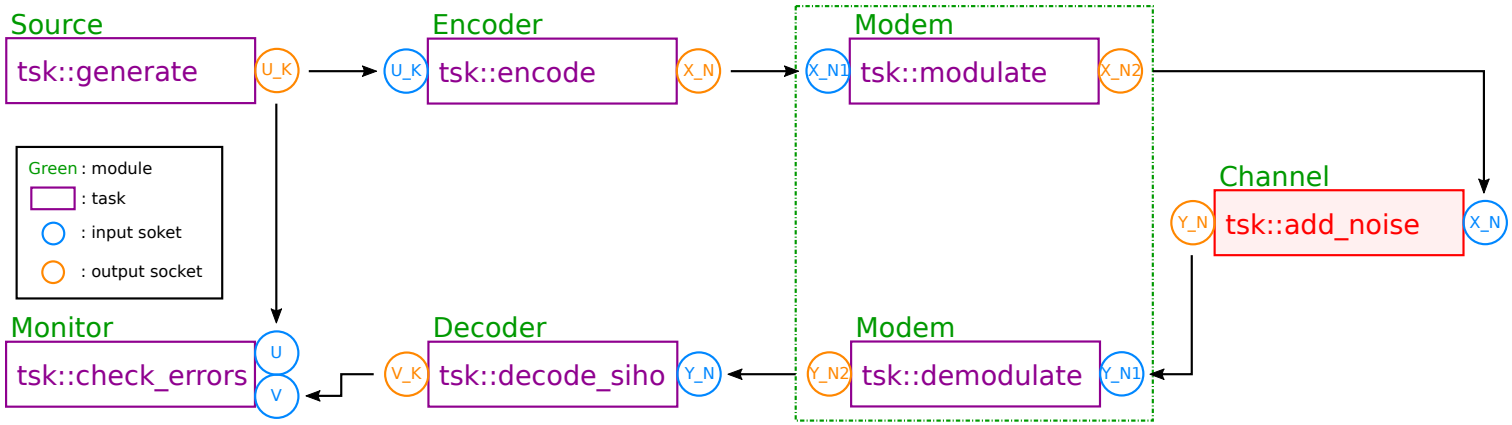


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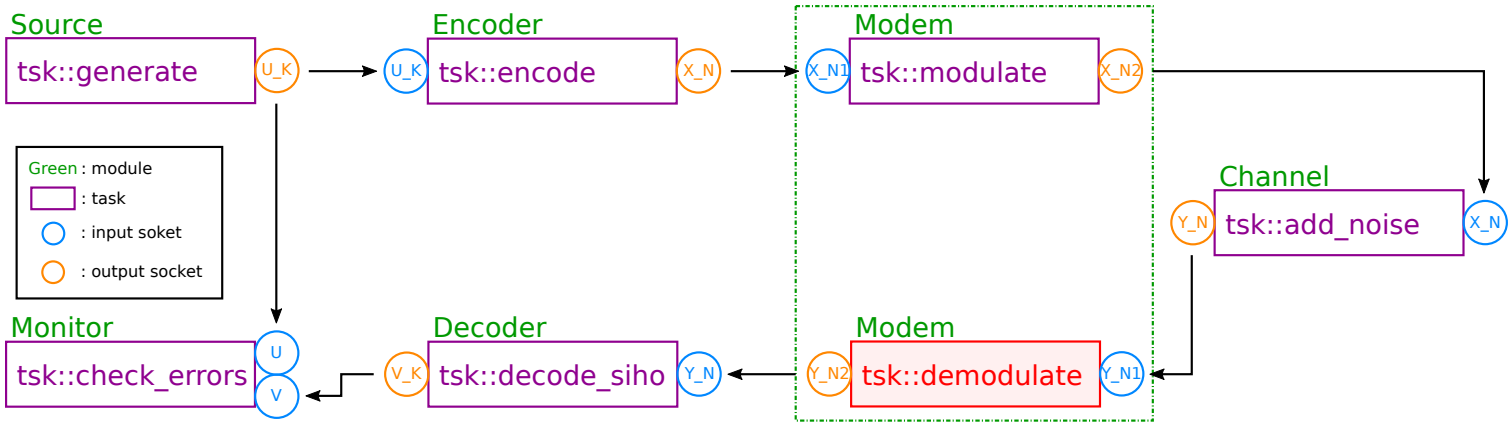


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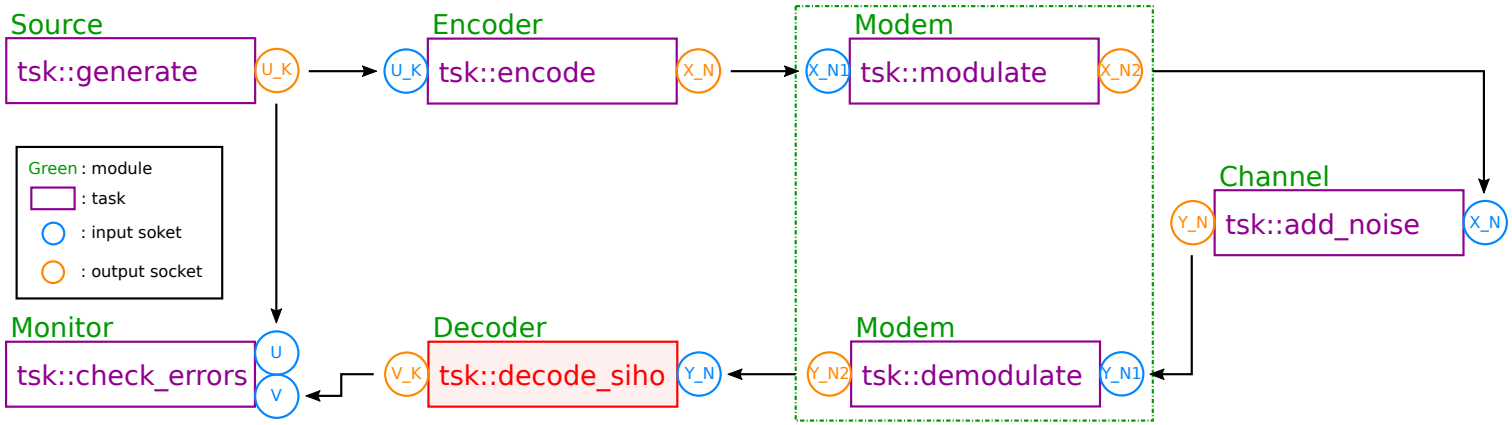


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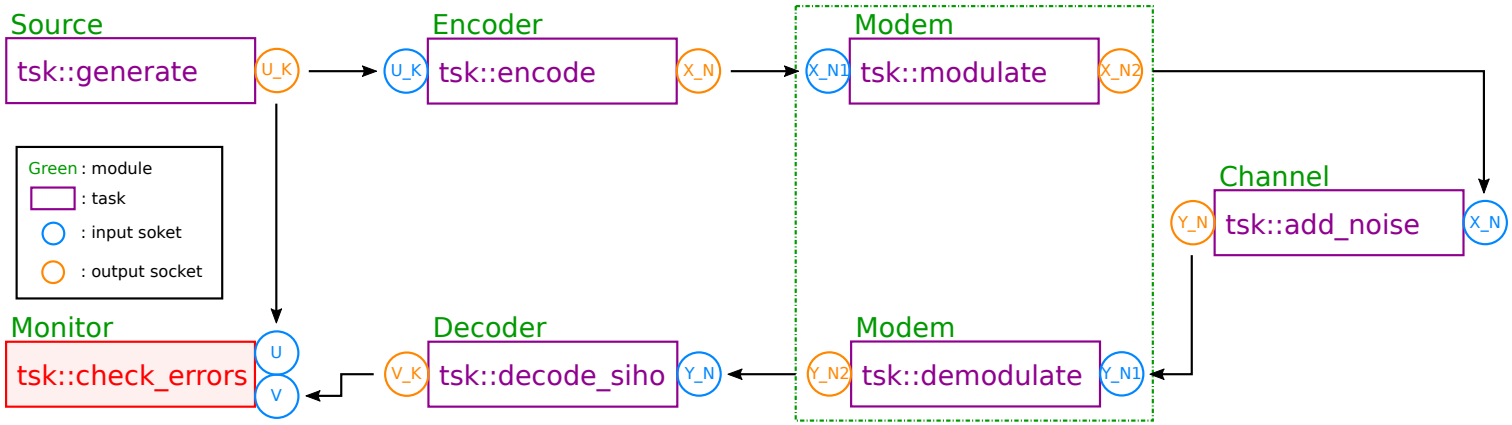


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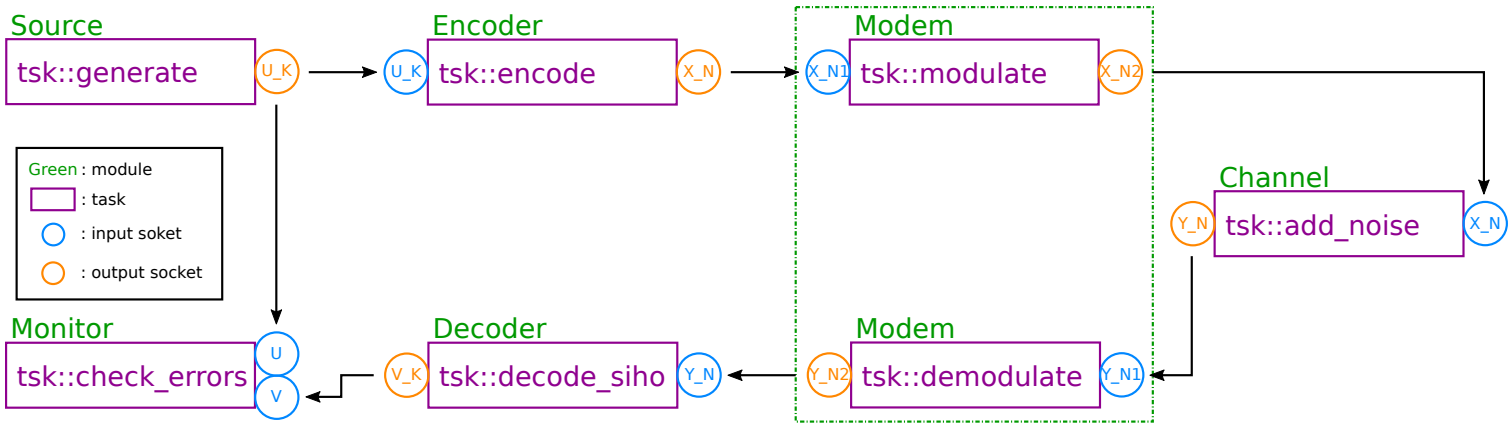


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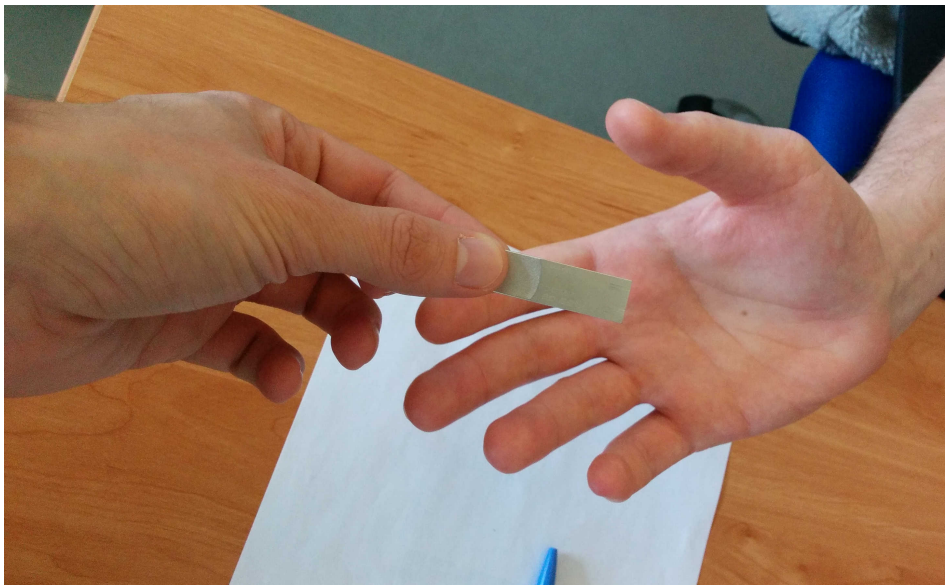
Plan

Source Code Management

Motivation

Sharing source code between team members can be very complicated without the appropriate tools.



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- **Git centralizes the source code** in a repository
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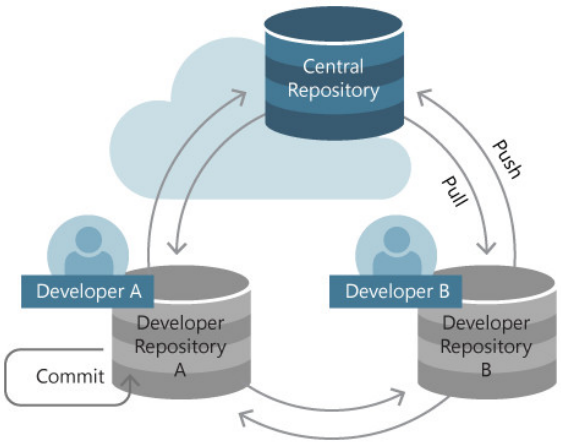
- **Git manages the transactions** between the developers
- Each developer:
  - Has a local repository (`git clone` or `git init`)
  - Can *save* new features in its local repository (`git commit`)
  - Can update its local repository from the centralized one (`git pull`)
  - Can update the centralized repository from its local one (`git push`)



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- New feature = new `feature` branch
  - `feature` branches are **private**
- `feature` branches are **merged** in the `development` branch
  - To keep a `feature` branch **private**, never **merge** it in a **public** branch

Source Code Management: **GitHub** and **GitLab**

GitLab:

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- **GitHub** and **GitLab** are two instances of a Git server
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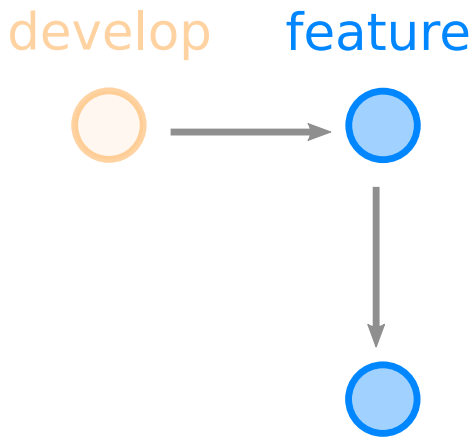

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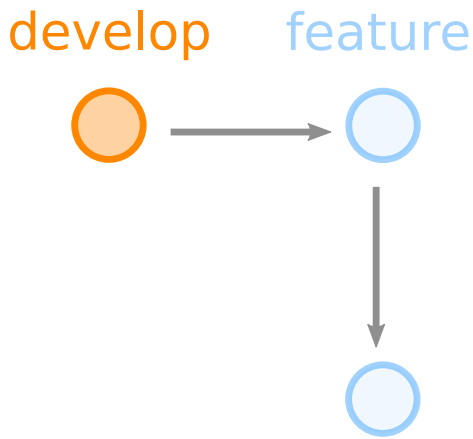

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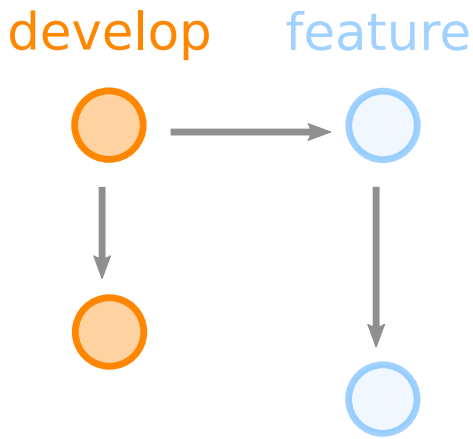

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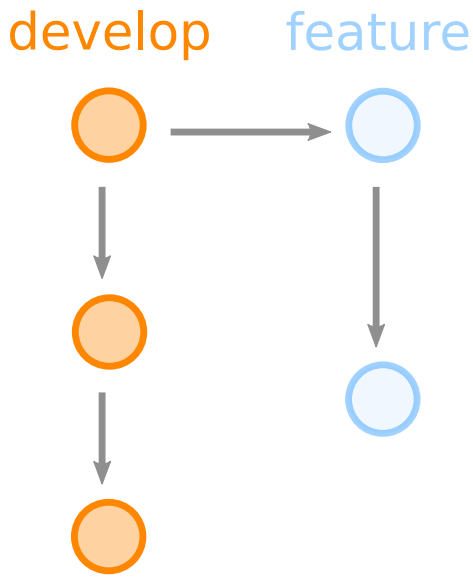

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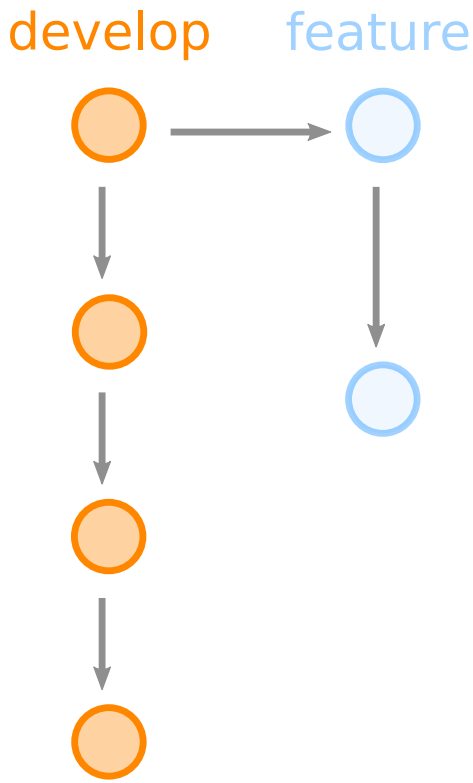

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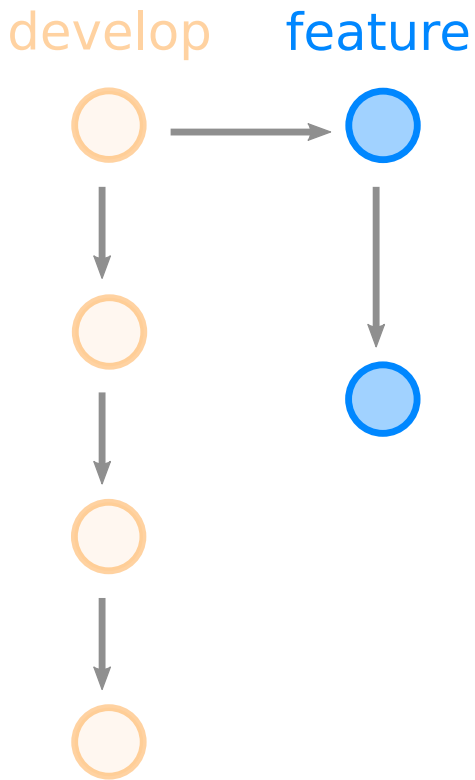

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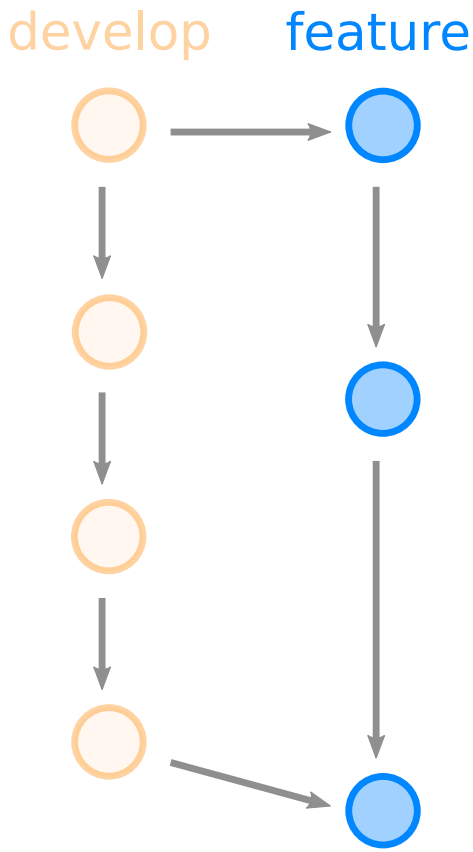

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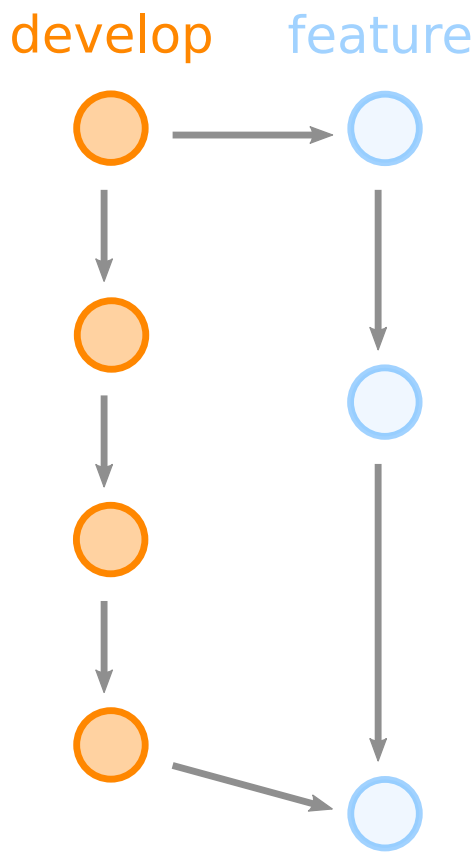

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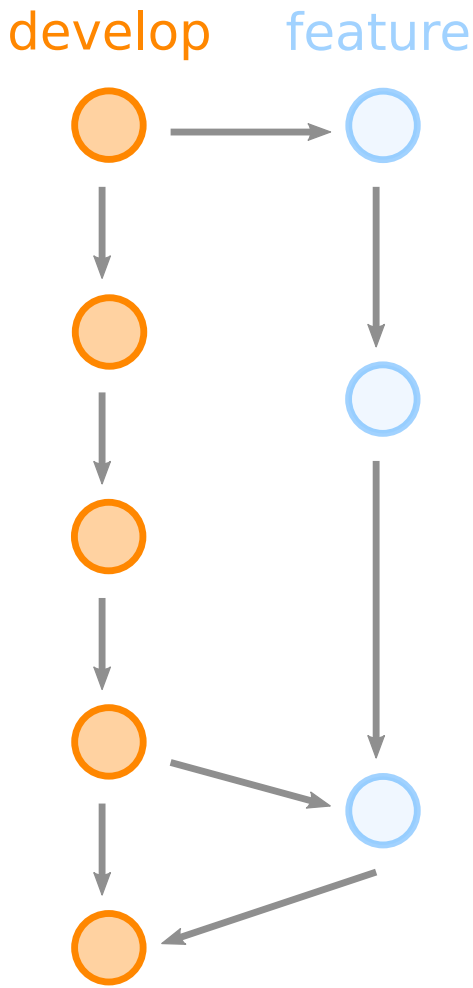

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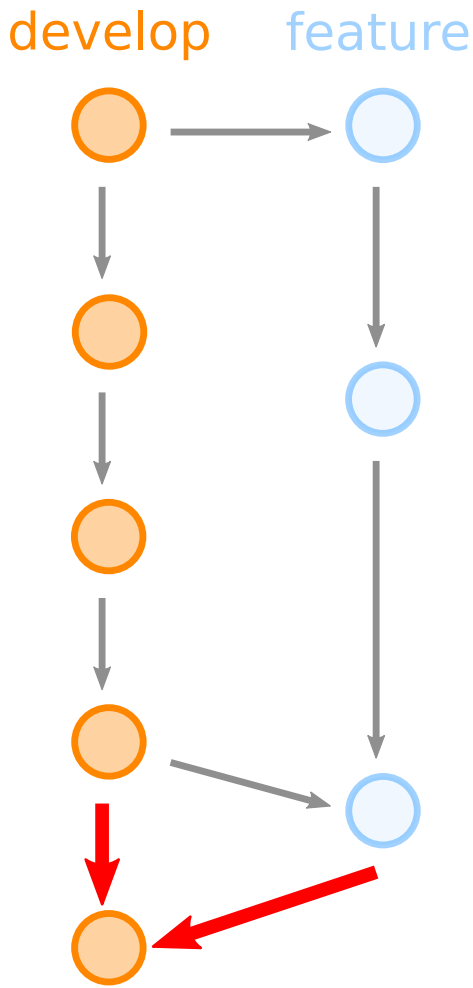

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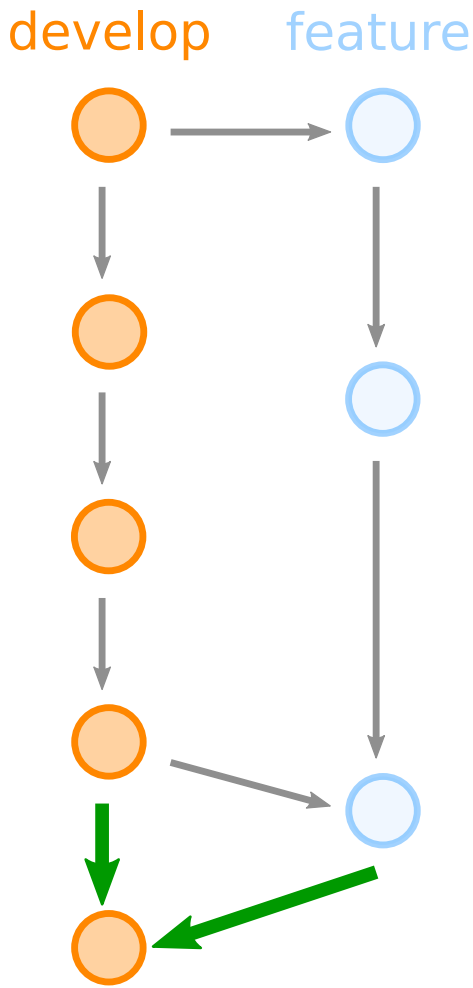

Make a merge request from GitLab!

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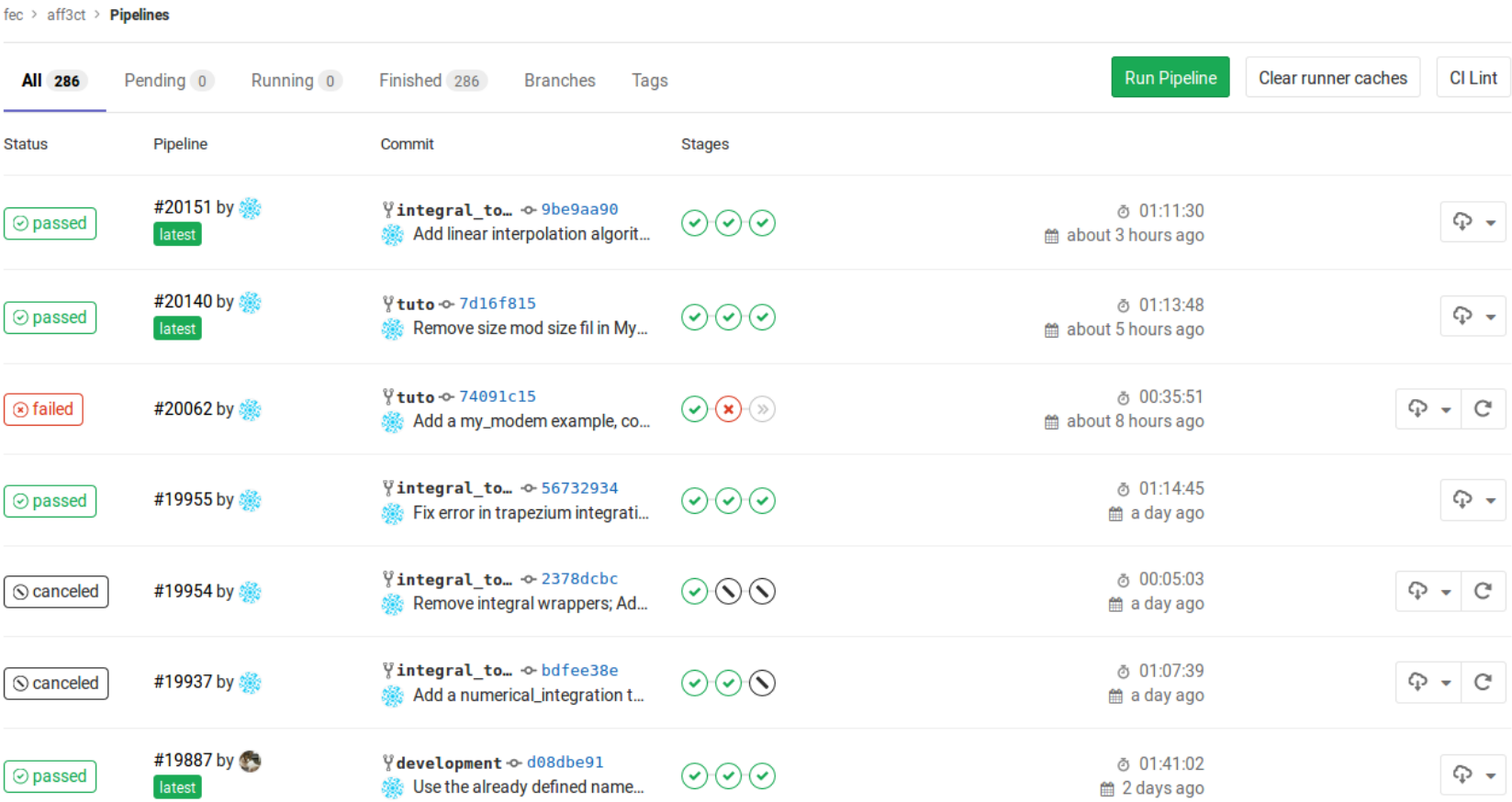
- **Tests are automated**: after each `git push` on **GitLab**
- The developer has **the responsibility** to add the tests covering its features

Continuous Integration: Pipelines

The tests are run for each branches (even on the `feature` branches)



Continuous Integration: Focus on a Specific Pipeline

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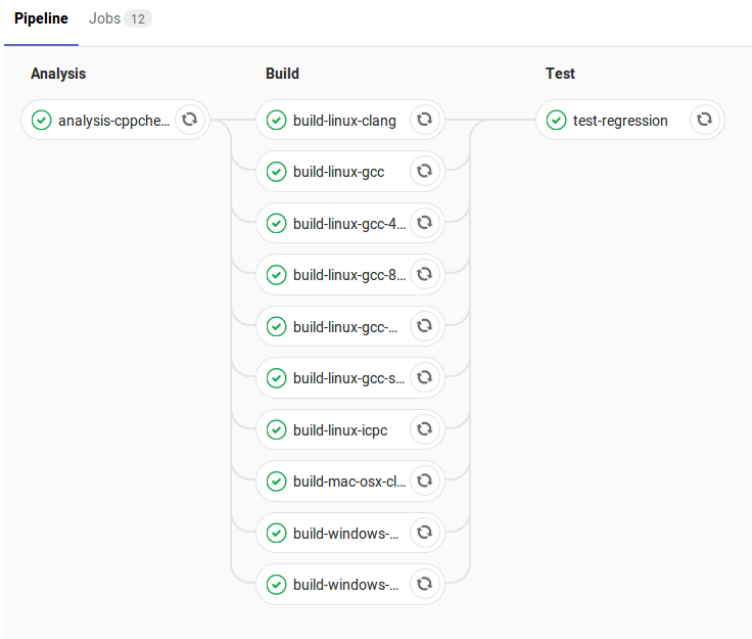

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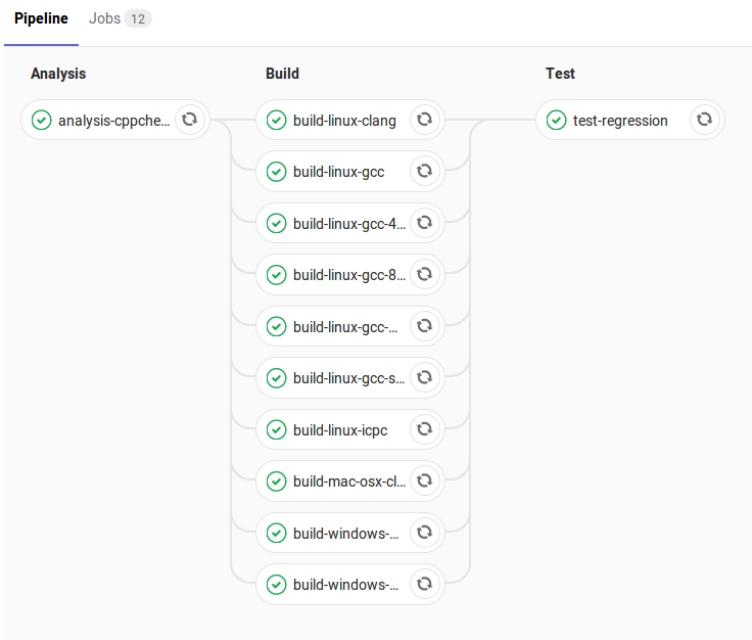

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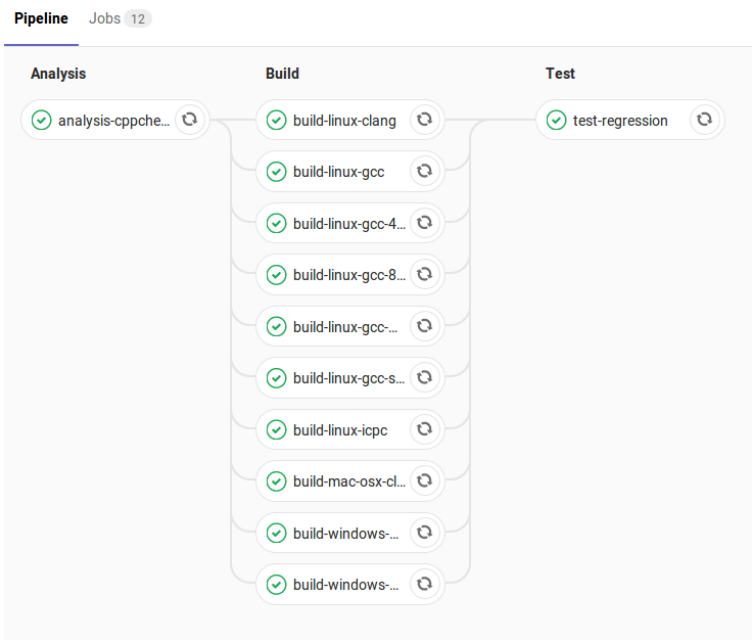
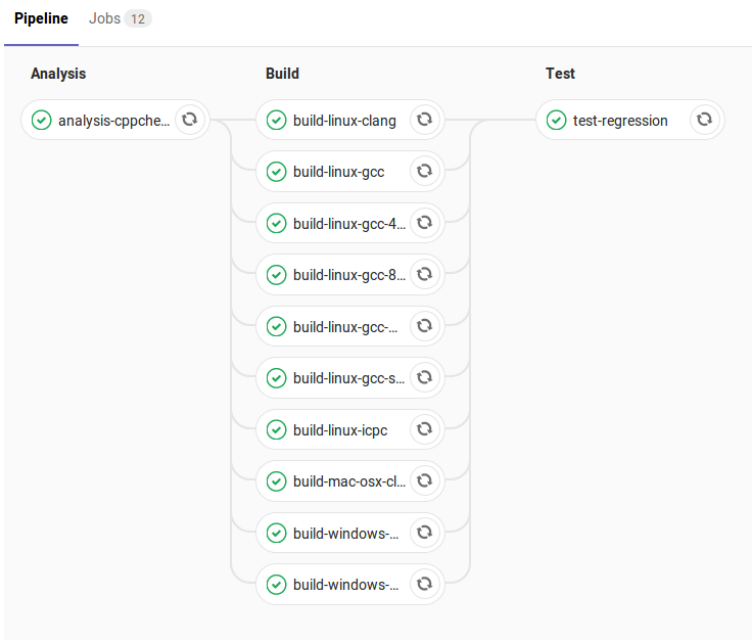


Continuous Integration: Focus on a Specific Pipeline

One series of tests is decomposed in **a 3-stage pipeline**

- **Analysis**: checks if the code syntax is valid (with `cppcheck`)
- **Build**: compiles the code on various systems and on various targets
- **Test**: runs simulations to check the regressions
  - Validates simulations from the `error_rate_references` repository
  - Each developer is **invited to add simulation results** in this repository



Plan

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- **And you, what do you think?**