



BB-iFEC for DVB-NGH: an Overview

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Presentation Overview



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- BB-iFEC
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Motivation



- BB-iFEC is proposed to provide fast zapping with inter-frame (time) interleaving
  - **Key** requirement for **satellite** transmissions
    - Very long time interleaving (e.g., 10 to 15 s)
  - But also of **interest** for **terrestrial** transmisssions

- **Problem**: DVB-T2 employs a sheer block time interleaver
  - No fast zapping with inter-frame interleaving possible
    - Zapping time is, on average, 1.5 times the time interleaving duration

- Compiting solutions:
  - Convolutional interleaver with single FEC
  - Convolutional interleaver with incremental redundancy

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BB-iFEC Summary

- Based on MPE-iFEC from SH, but integrated in the physical layer
  - **LDPC** encoding instead of RS
- Backwards-compatible solution
  - Generates an additional **iFEC PLP**
  - Important in hybrid scenarios: mobile T2 & NGH; terrestrial & satellite
- Efficient memory management
  - Memory requirement similar to a CI with uniform profile (~**50% less than BI**)
  - **Bit interleaver**: reduced memory than cell interleaving for QPSK and 16QAM
  - **Reduced power consumption** for satellite terminals (IUs Nbch bits)
- Same HW – New logic!
  - New functionalities “for free” for the sheer terrestrial case
- Other benefits
  - Possibility of **soft and hard decoding** at the receivers
  - Nice suit with **rotated constellations** when most protection is in the outer FEC
  - **Reduced overhead** to provide very low code rates (e.g. **1/5**)
  - **Reduced signalling** w.r.t. CI

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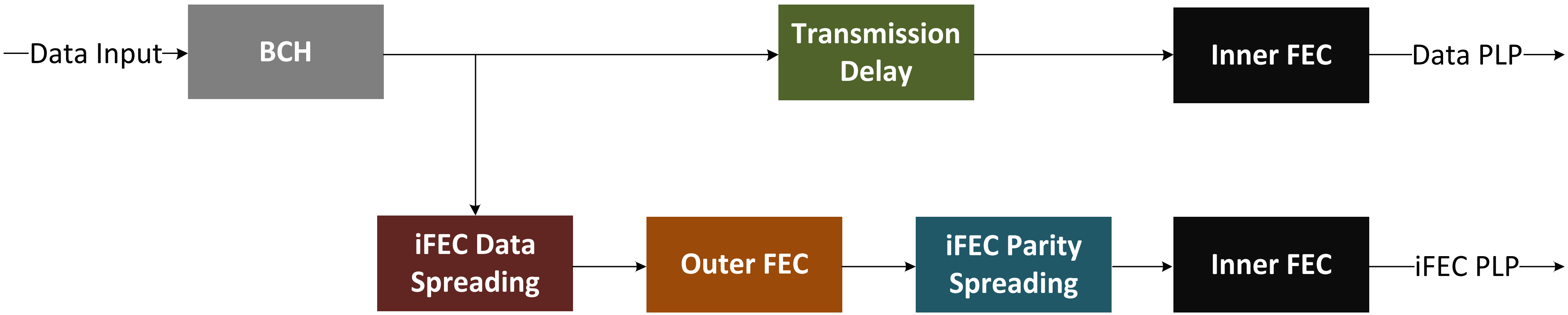
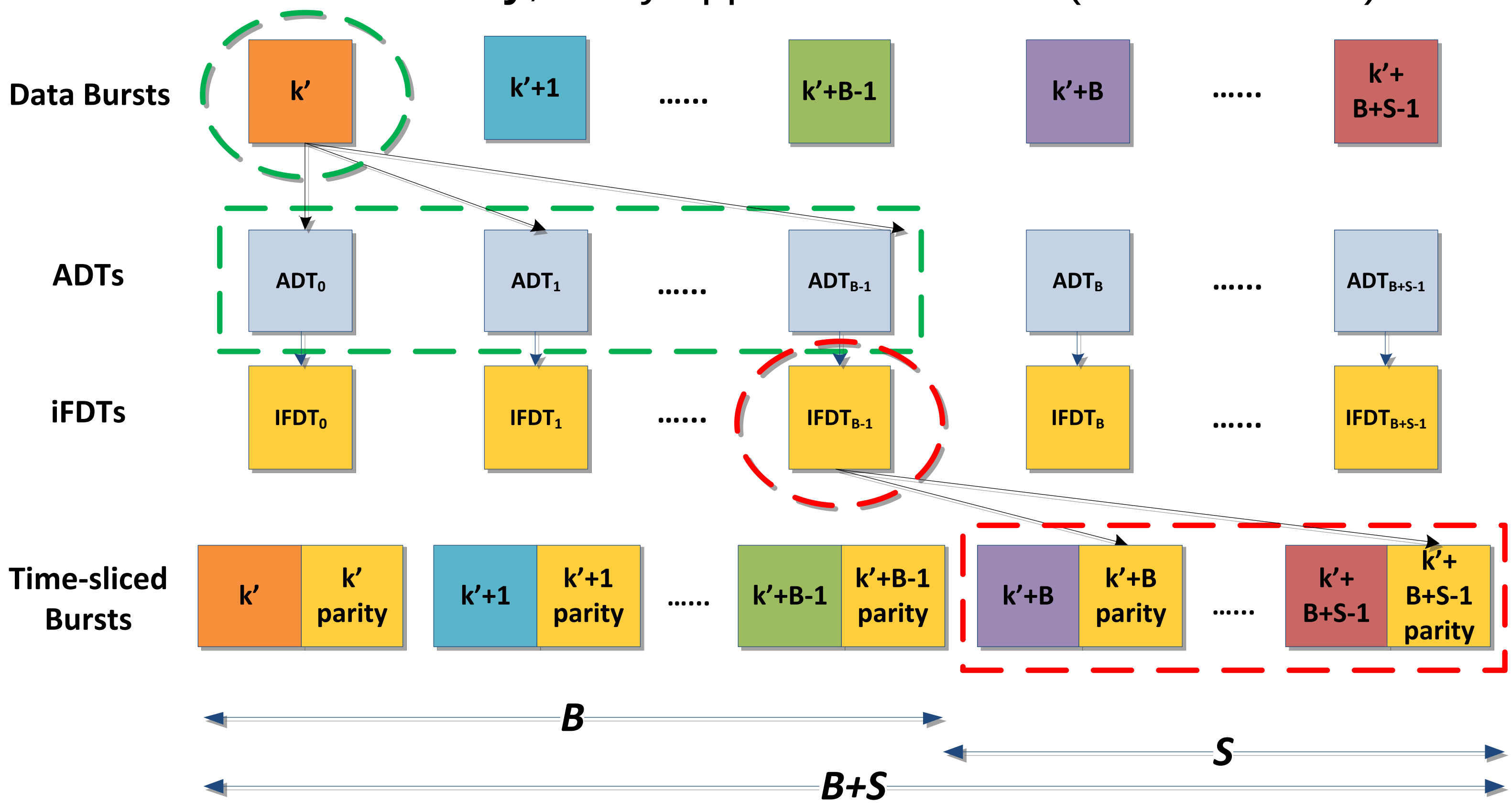
Generation of the iFEC PLP



- Four functional blocks:
  - **Transmission Delay** – buffer parameter D
  - **iFEC Data Spreading** – inter-frame interleaver parameter B
  - **Outer FEC** – FEC parameter CR_{outer}
  - **iFEC Parity Spreading** – inter-frame interleaver parameter S
- The data PLP is only affected by the transmission delay block
- The iFEC PLP is generated with the other three blocks
  - No modification from Inner FEC onwards

Inter-Frame Interleaving with BB-iFEC: $D = 0$

- BB-iFEC time interleaving depth, M, is: $M = B + S$
  - B **Data Spreading Factor,** every data burst distributed over B ADTs
  - S **Parity Spreading Factor,** each time-sliced burst carries parity from S iFDTs
  - D **Transmission Delay**, delay applied to the data (in bursts units)



Inter-Frame Interleaving with BB-iFEC: *D* = *B* + *S*



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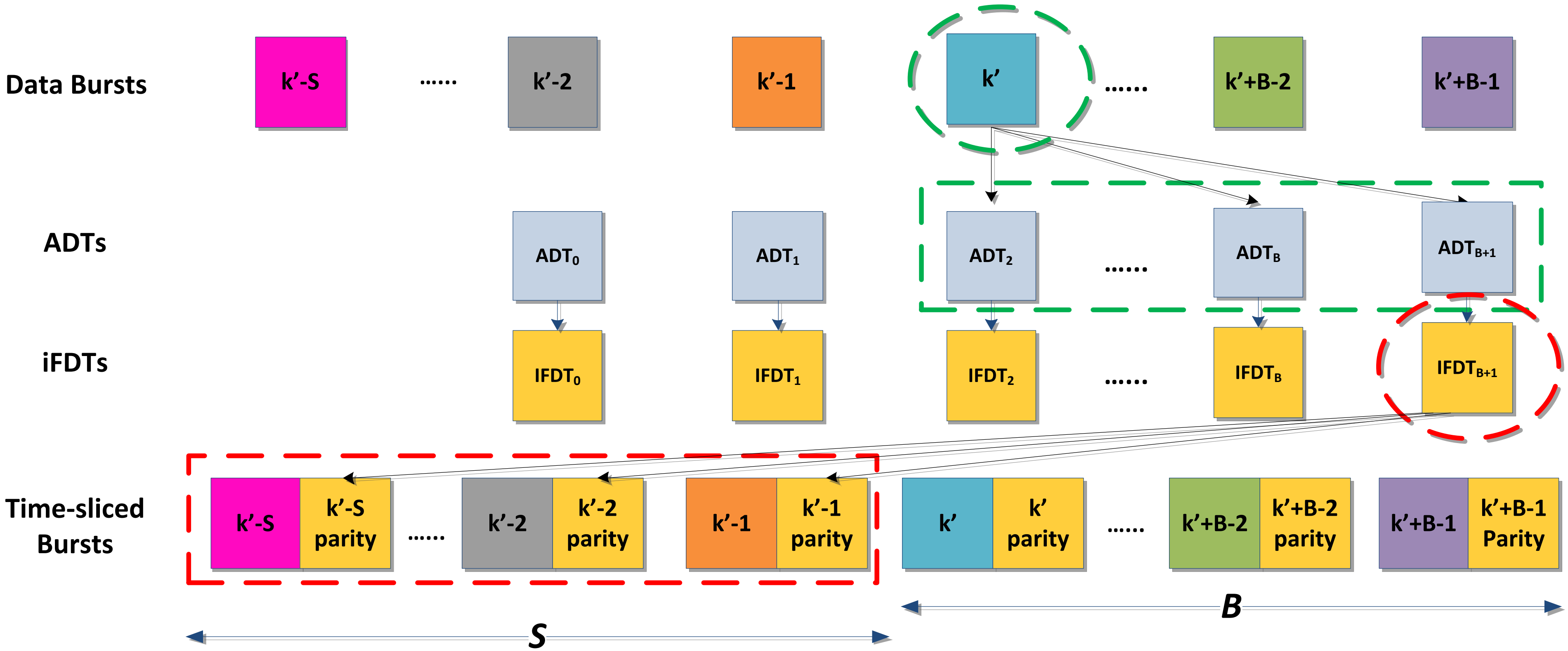

BB-iFEC
Parameters Derivation



- **Step-by-Step**:
  1. Choose target code rate, CR_{outer}, and target interleaving depth, M
  2. Data spreading factor B = floor(CR_{outer} x M)
  3. Parity spreading factor $S = M - B$
  4. Transmission delay $D = B + S$

- By doing this we achieve:
  - Quasi-uniform time interleaving to maximize performance
    - Strict uniform TI is achieved when $CR_{outer} = B/M$
  - Parity is transmitted before the data, this reduces the transition period between early decoding to late decoding to B-1 bursts
    - For $B = 1$, terminals are **in late decoding after receiving the first burst**
    - For $D = 0$, the transition period is M-1 bursts
    - Full protection is achieved after M bursts anyway

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BB-iFEC
Interleaving Examples

- **Interleaving Depth = 10**

Outer FEC	Data Spreading	Parity Spreading
1/5	2	8
1/4	2	8
1/3	3	7
2/5	4	6
1/2	5	5
2/3	6	4
3/4	7	3

- **Interleaving Depth = 6**

Outer FEC	Data Spreading	Parity Spreading
1/5	1	5
1/4	1	5
1/3	2	4
2/5	2	4
1/2	3	3
2/3	4	2
3/4	4	2

- Some configurations do not have strictly uniform TI, but the degradation should not be a problem for medium/large interleaving depths
- The data spreading factor B increases:
  - With the interleaving depth
  - With the code rate

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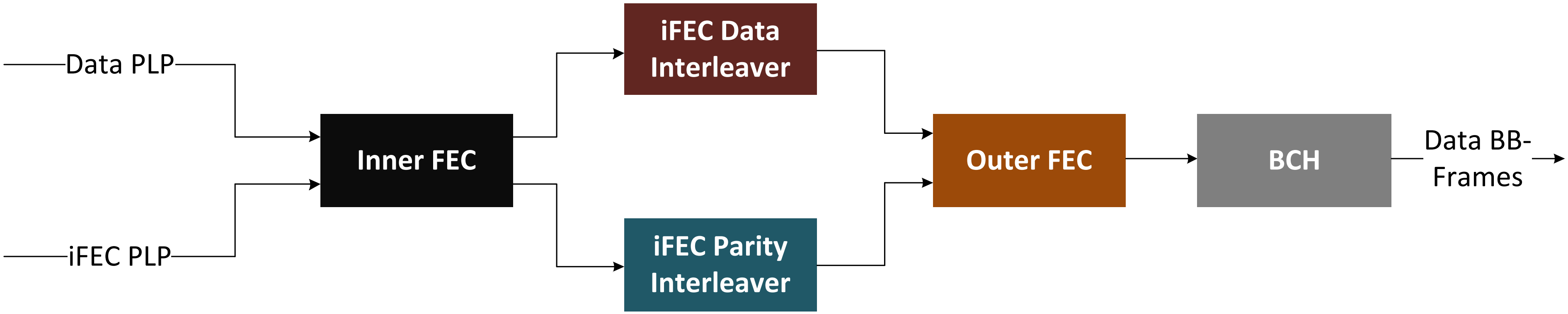
BB-iFEC
Receiver Implementation



- Decoding process (late decoding mode)
  1. **Inner FEC Data PLP** – for all data BB frames in the burst
     - Store LLRs (either soft or hard) and perform de-interleaving (IUs N_{bch})
  2. **Inner FEC iFEC PLP** – for all BB-iFEC frames in the burst
     - Store LLR (either soft or hard) and perform de-interleaving (IUs N_{bch})
  3. **Outer FEC decoding** – for all rows of the iFEC encoding matrix
     - After reception of one burst, there is one encoding matrix full
     - Optional!
  4. **BCH decoding** – for all data BB frames

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Fast Zapping with BB-iFEC



- With BB-iFEC it is possible to display the content after receiving the first burst (early decoding) if the inner TI is limited to intra-frame interleaving.

  The problem is then how to do the transition to late decoding
  - **Early decoding** – protection given by the inner FEC of the data PLP
  - **Late decoding** – protection given by both inner FEC and outer FEC

- **Discontinous transmission case** (time-slicing)
  - **Inner TI**: intra-frame interleaving
  - **Example**: FEF size 200 ms, cycle time 1 s, Inner TI intra-frame interleaving, average zapping time: ~0.5 s; Outer TI inter-frame interleaving e.g.10 s
- **Continuous transmission case**
  - **Inner TI**: inter-frame interleaving, gives the zapping time
  - **Example**: FEF size 200 ms, cycle time 200 ms, Inner TI inter-frame interleaving of 5 frames (*CI uniform profile*), zapping time: ~1 s; Outer TI inter-frame interleaving e.g.10 s
    - Outer FEC operates every 1 s, like in the time-slicing example

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Transition from Early to Late Decoding



- The transition between early to late decoding is B-1 bursts when $D = B+S$
  - Configurations with $B = 1$ provide directly fast zapping
- Typical values of B will range between 2 and 4
  - For the satellite scenario, most of the protection in the outer FEC
  - For the SVC base layer, B will typically be 2 for maximum protection
  - For the terresterial scenario, reduced interleaving depth
- Solutions adopted in SH (RTP re-stamping) can be used, and will require less time in NGH
- But a simple approach based on buffering and re-playing may be enough
  - Transition performed the first time an erroneous burst after Inner FEC decoding is recovered with the Outer FEC
    - No earlier than after receving M bursts
  - Configurations with $B = 2$ can be considered to provide fast zapping
  - For $B > 2$, users would experience B-1 bursts either erroneous or displayed twice

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BB-iFEC Drawbacks



- Because usually, there is no free lunch!
  1. BB-iFEC increases the total number of LDPC decodings w.r.t. single FEC case
     - But the total number of LPDC iterations can be kept constant without impacting performance
  2. BB-iFEC has decreased performance for the same w.r.t. single FEC
     - But compiting solutions also suffer a degradation!
  3. BB-iFEC requires to do a transition from early to late decoding:
     - But the transition time is only few seconds, and it can be performed during the event of an error
  4. BB-iFEC requires an increased implementation effort w.r.t. not implementing it
     - But it provides an important feature: fast zapping with inter-frame interleaving, which outperforms intra-frame interleaving

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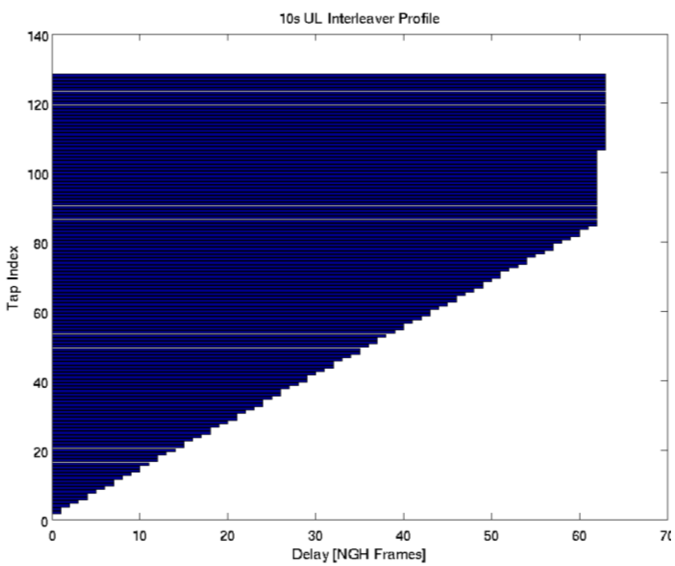
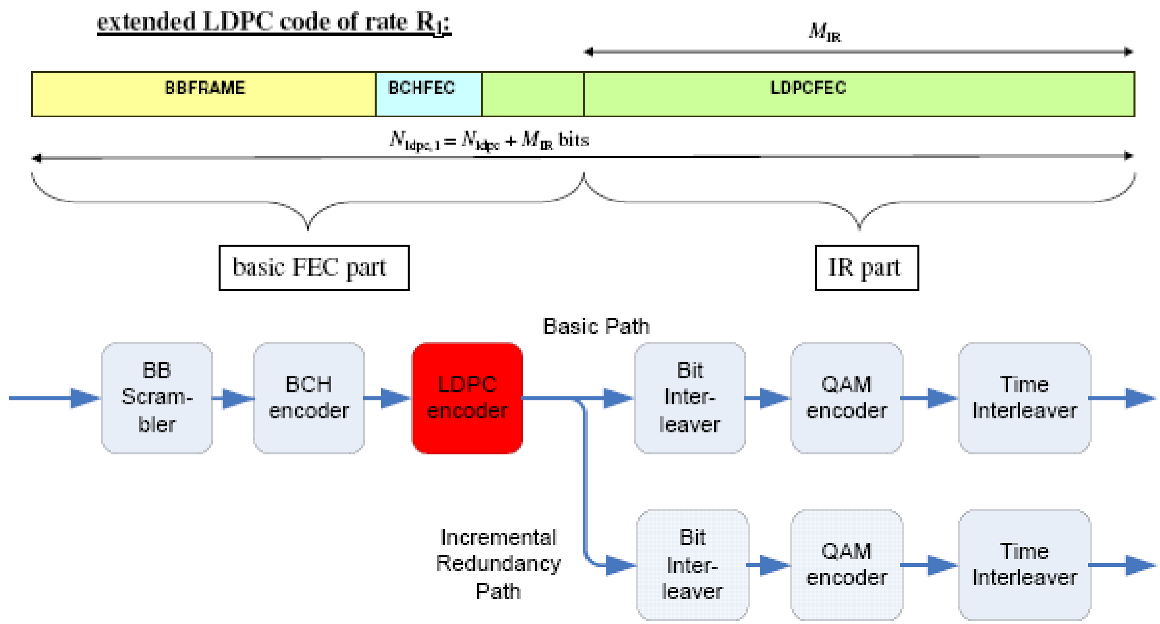
Compiting Solutions



- **Convolutional Interleaving** with **Uniform-Late profile** with:
  - **Single FEC**
  - **Incremental Redundancy** (IR)





- All solutions have lower performance than a single FEC with uniform time interleaving for a given time interleaving duration!

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Performance Discussion



- **BB-iFEC** has a performance degradation because the concatenation of two (three) independent FECs
- The **CI** with a **uniform-late** profile with a **single FEC** has:
  - A degradation due to non-uniform time interleaving
  - A degradation due to heavy puncturing for fast zapping
- The **CI** with a **uniform-late** profile with **incremental redundancy** has:
  - A degradation due to non-uniform time interleaving (late part is 50%)
  - A degradation due to use of 4K LDPC instead of 16K LDPC
  - A degradation due to sub-optimal overall parity check matrix
- For a single receiver class scenario, the code rate distribution of BB-iFEC can be similar to the CI uniform-late case in DVB-SH:
  - **Effective code rate ~4/5 for the late part**: Inner FEC in BB-iFEC
  - **Rest of the protection to the uniform part**: Outer FEC in BB-iFEC
- Our preliminary studies show that BB-iFEC is the best solution!

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BB-iFEC Outlook



- So far, the different FEC and time interleaving proposals have been heavily discussed without making any simulation!
- TU Valencia is about to finish programming its NGH simulator to run simulations comparing the different schemes:
  - CI uniform, uniform-late single FEC, uniform-late with IR
  - BB-iFEC with different code rate distributions
  - Apple-to-apple comparison:
    - First phase simulation campaign:
      - AWGN, Rayleigh, TU6, LMS
    - Second phase simulation campaign:
      - Rotated constellations, TFS, MIMO
- Preliminary results promising for BB-iFEC

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Thanks for your attention!
Questions?

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