Output-to-Spectrum Assignment Algorithm for a LTE Cognitive Radio Filter Bank

Thomas Schlechter

ALPEN-ADRIA UNIVERSITÄT
KLAGENFURT | WIEN GRAZ

FAKULTÄT FÜR TECHNISCHE WISSENSCHAFTEN

ALPEN-ADRIA UNIVERSITÄT
KLAGENFURT | WIEN GRAZ

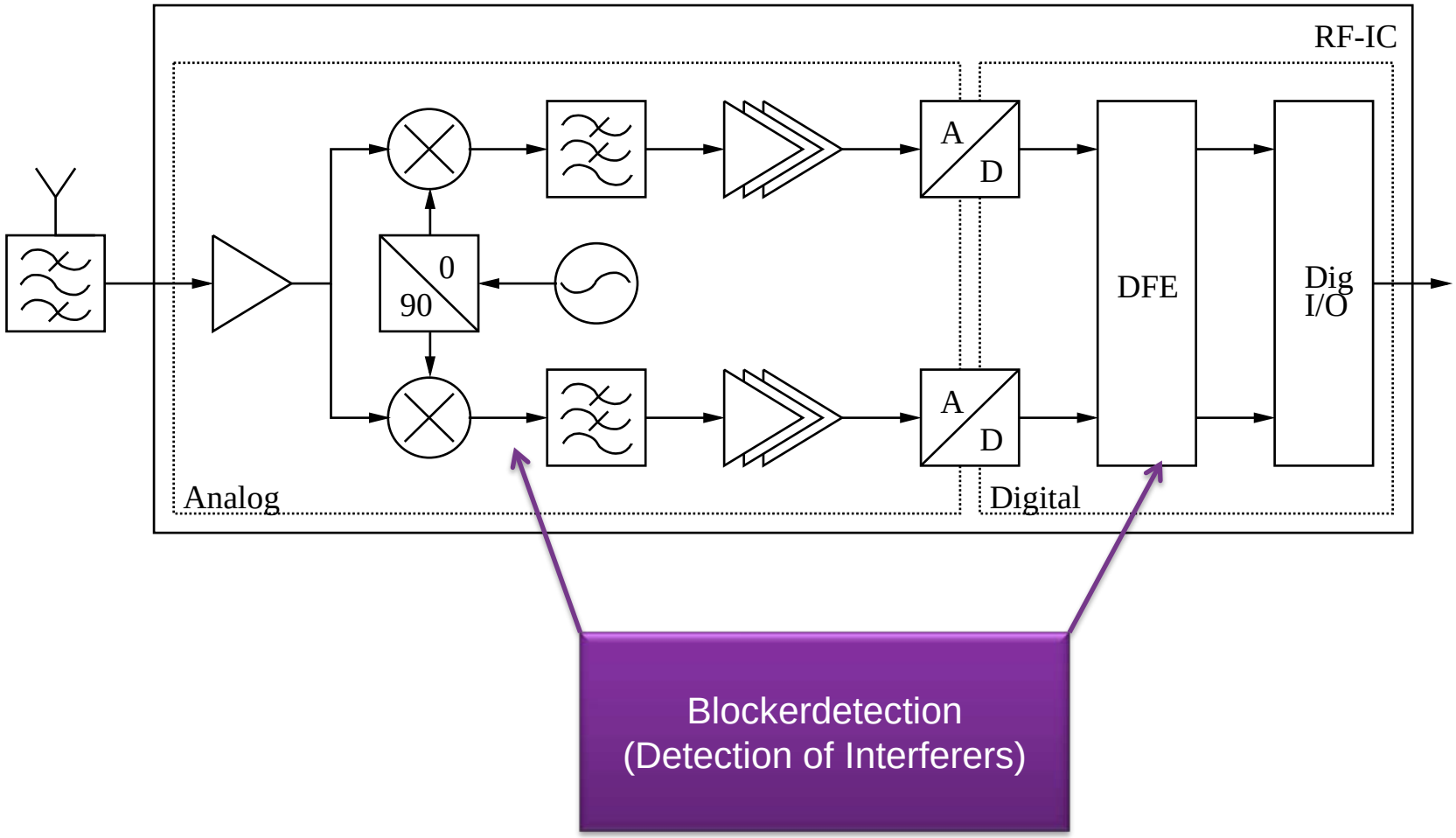
Outline

- Introduction
- Analog and digital frontend – an overview
- Spectral environment – worst case vs. relaxed
- Dyadic filter structure
- Filtering-and-downsample process and assignment algorithm
- Conclusion

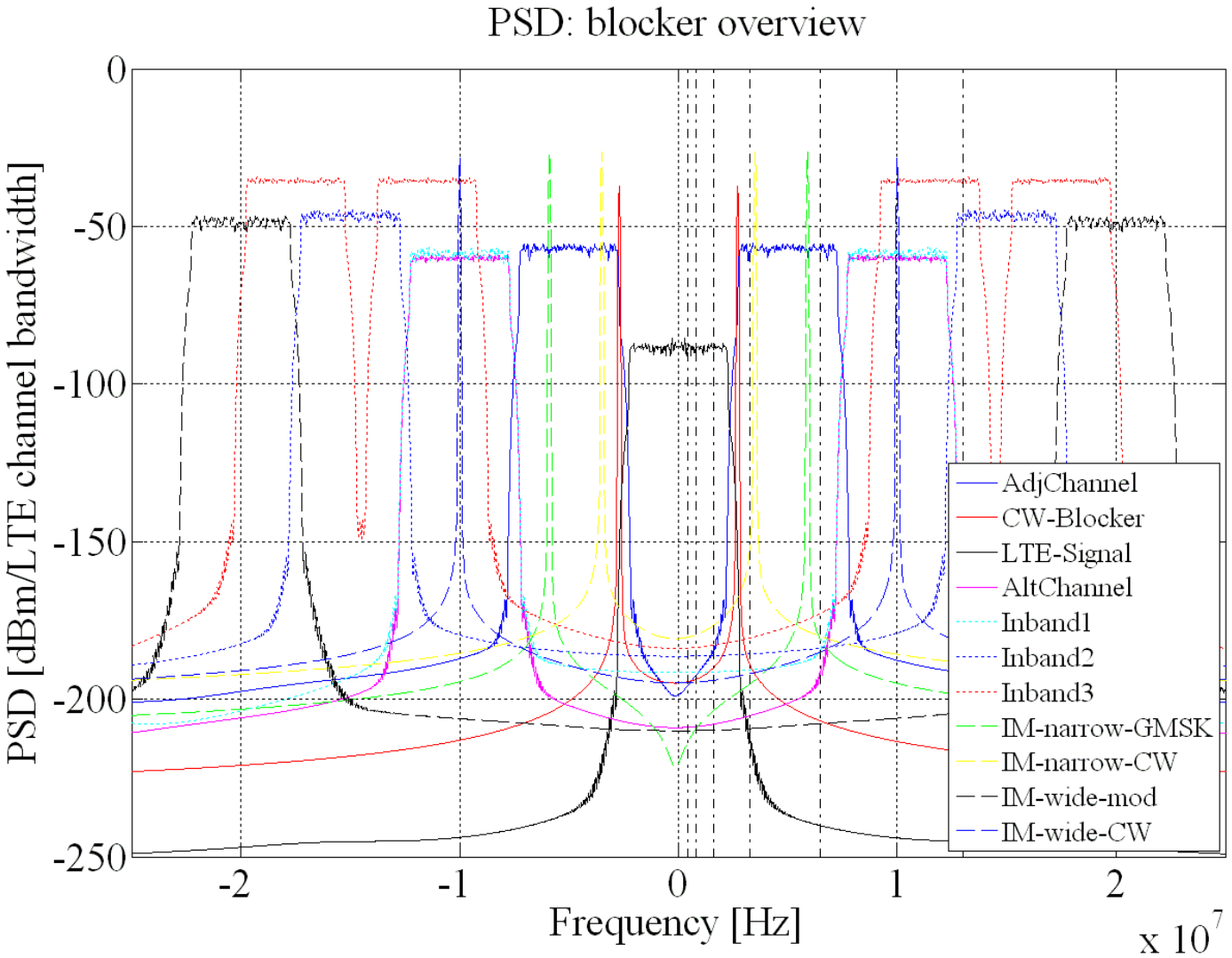
Introduction – Main Idea

- LTE user equipments (UEs) waste energy
- Why? – UEs designed for worst case receiving scenarios defined in the 3GPP standard
- So what? – Adoption to actual spectral environment allows to relax UEs
- Awesome! – Reconfiguring analog and digital frontends to actual needs allows to save energy
- What is needed? – Highly efficient spectrum sensing chain
- Possible implementation? – Dyadic filter bank based spectrum sensing approach containing low complex filters

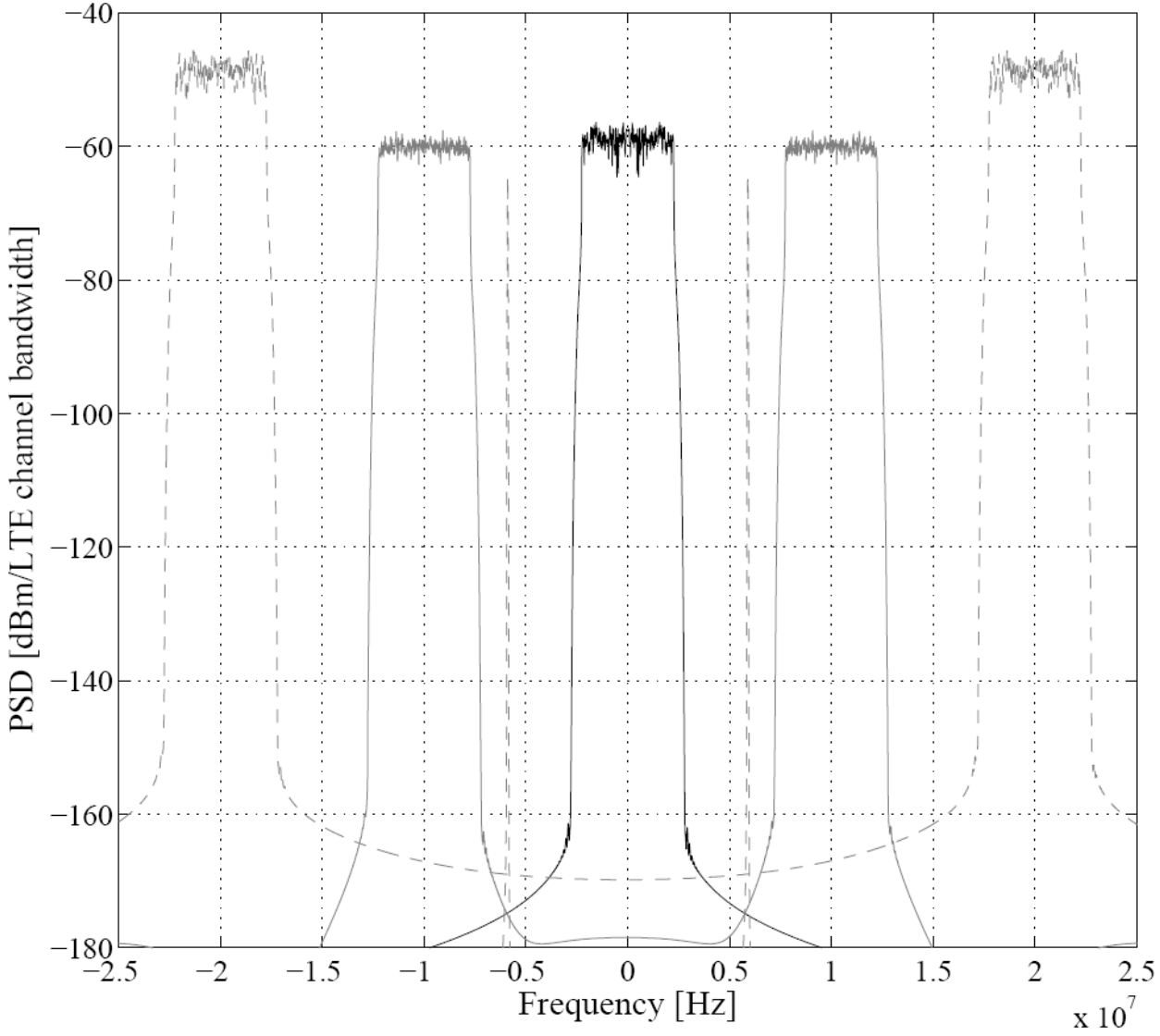
Frontends of a UE



Worst case scenario
according to 3GPP standard



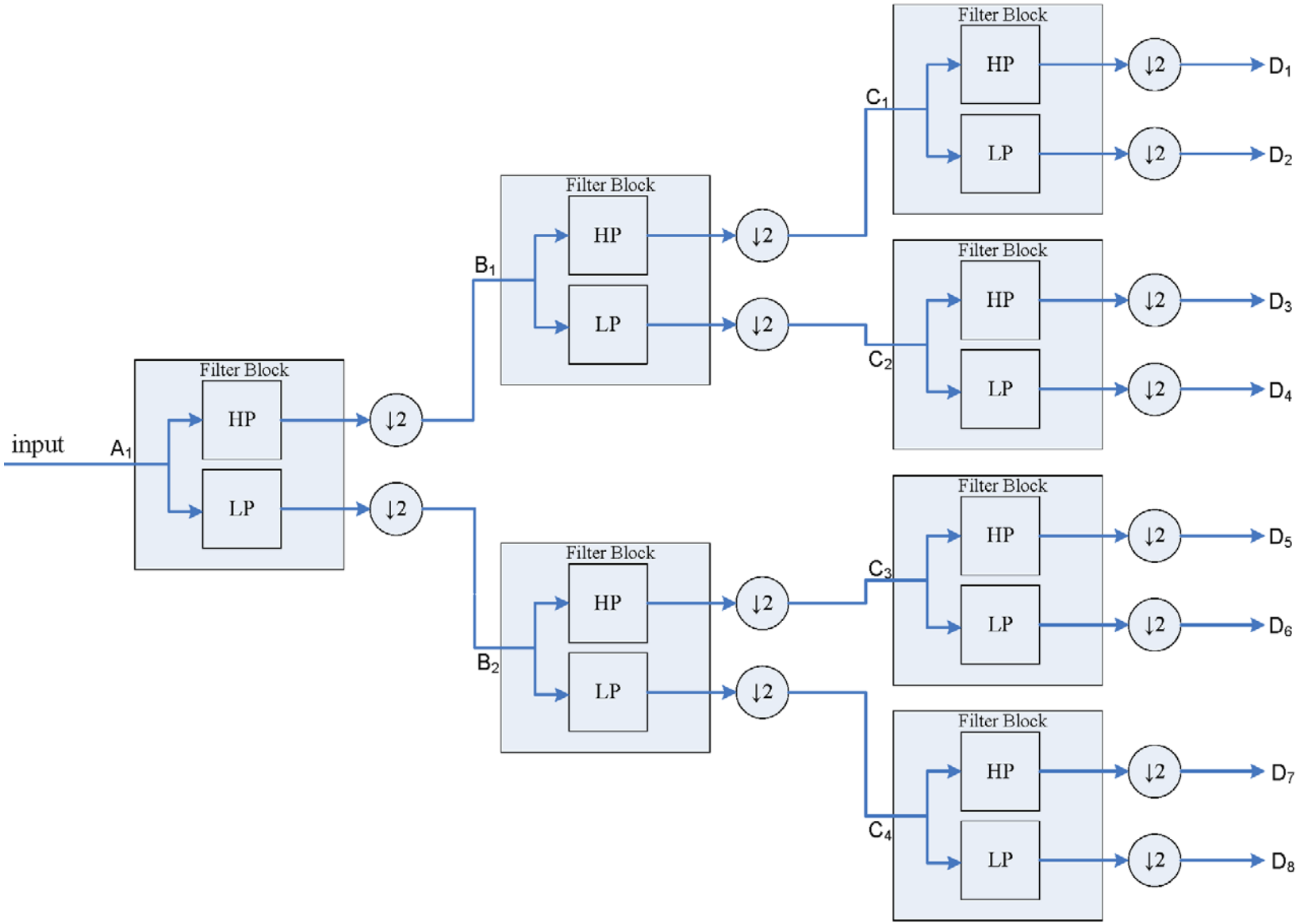
Relaxed blocker environment

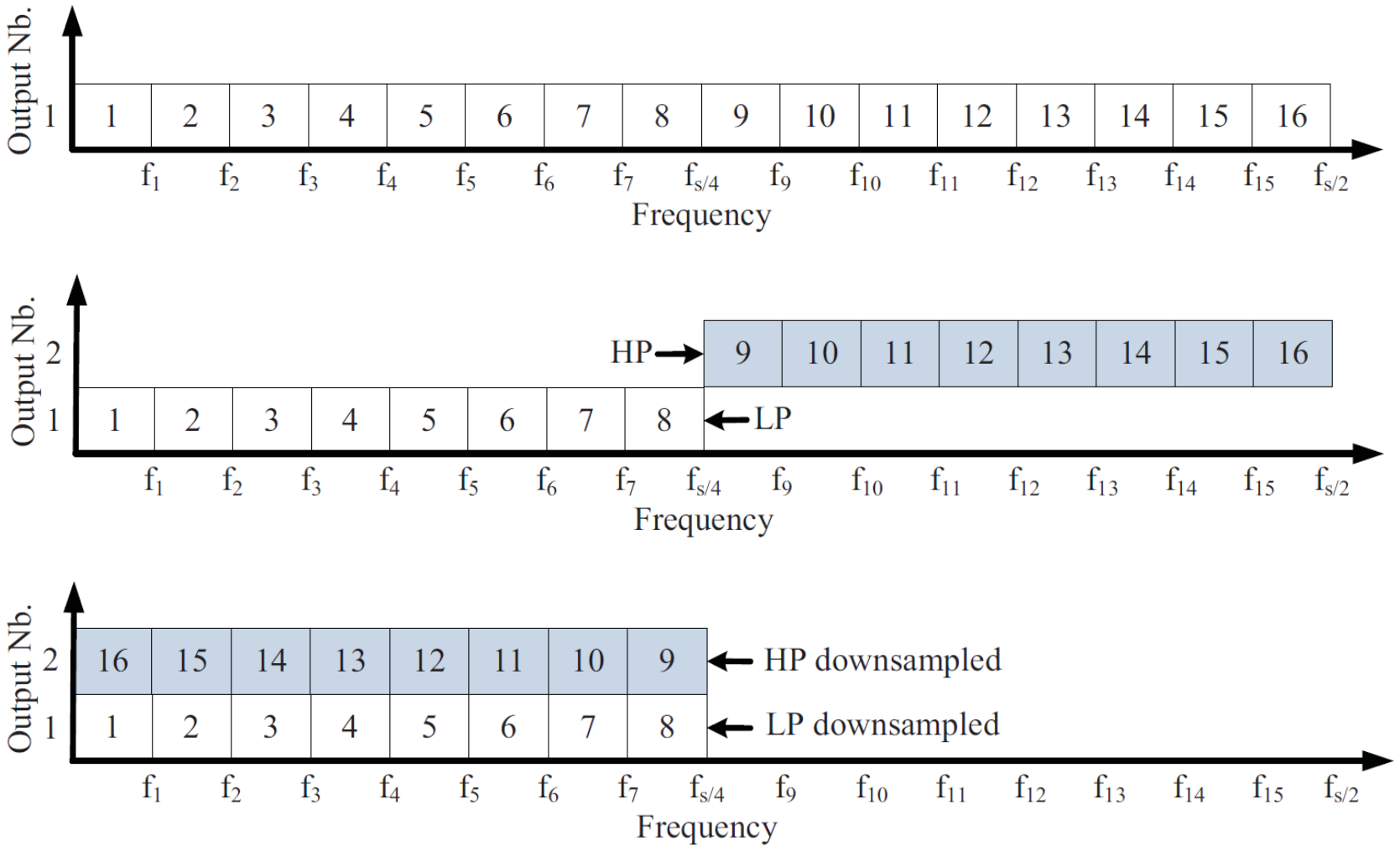


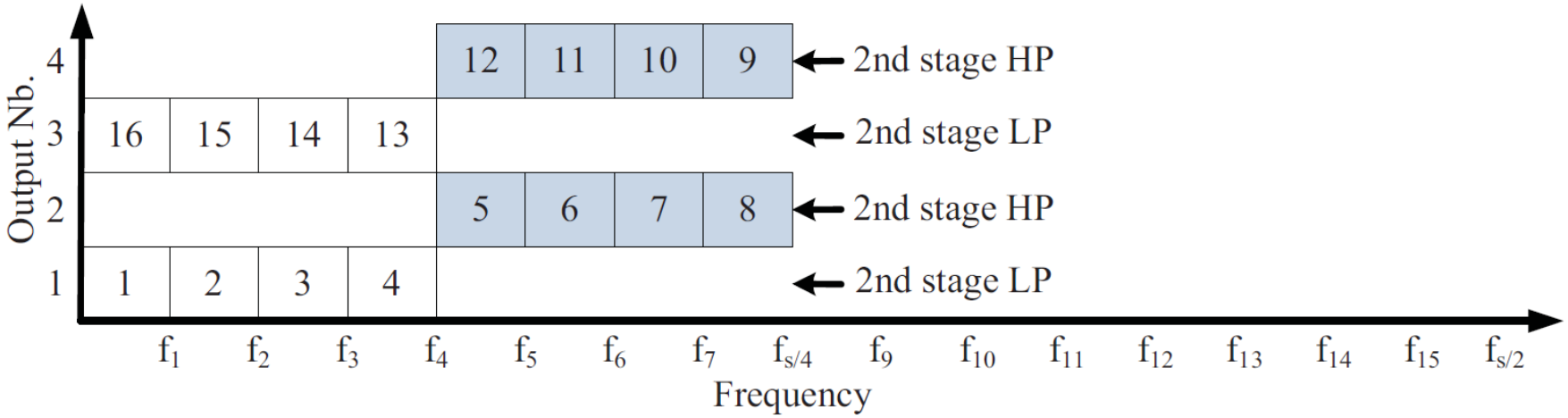
Desired: Blocker Detection Unit

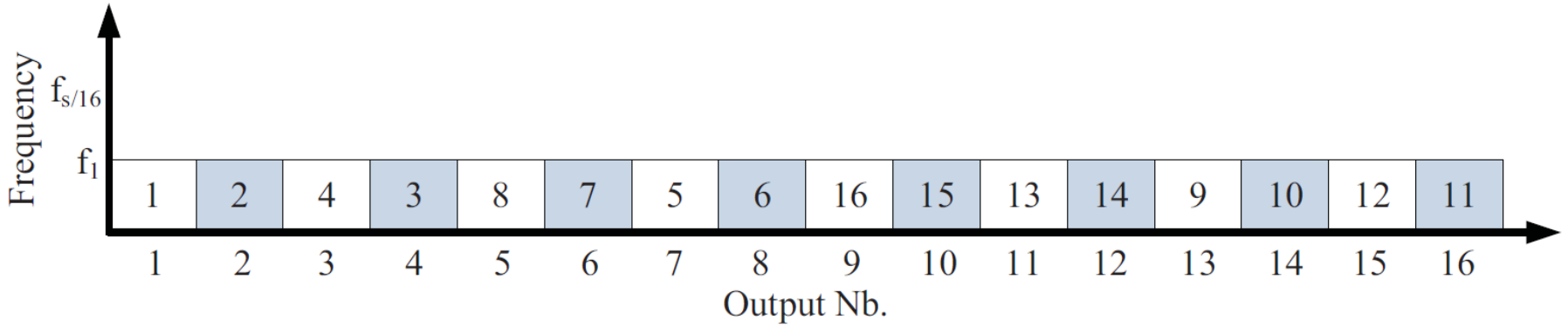
- Blocker Detection Unit with (desired)
  - minimum complexity (computationally -> power consumption)
  - minimum cost (chip area)
  - maximum blocker detection accuracy

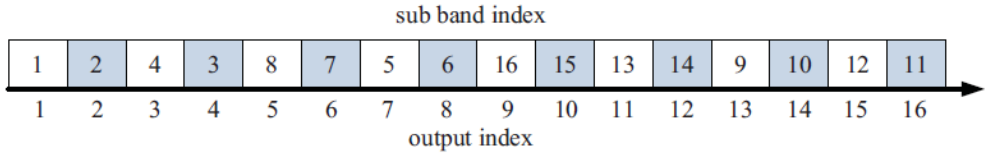
- chosen approach: dyadic filter bank approach


input
A1
Filter Block
HP
LP
↓2
B1
B2
C1
C2
C3
C4
D1
D2
D3
D4
D5
D6
D7
D8

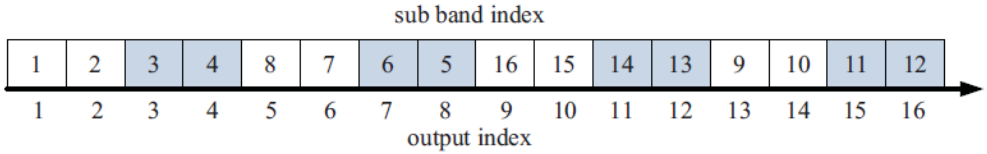

Output Nb.
1
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
f1 f2 f3 f4 f5 f6 f7 fs/4 f9 f10 f11 f12 f13 f14 f15 fs/2
Frequency
Output Nb.
2
HP
9 10 11 12 13 14 15 16
1
1 2 3 4 5 6 7 8
LP
f1 f2 f3 f4 f5 f6 f7 fs/4 f9 f10 f11 f12 f13 f14 f15 fs/2
Frequency
Output Nb.
2
16 15 14 13 12 11 10 9
HP downsampled
1
1 2 3 4 5 6 7 8
LP downsampled
f1 f2 f3 f4 f5 f6 f7 fs/4 f9 f10 f11 f12 f13 f14 f15 fs/2
Frequency


Output Nb.
4
3
2
1
12
11
10
9
16
15
14
13
5
6
7
8
1
2
3
4
2nd stage HP
2nd stage LP
2nd stage HP
2nd stage LP
f1
f2
f3
f4
f5
f6
f7
fs/4
f9
f10
f11
f12
f13
f14
f15
fs/2
Frequency

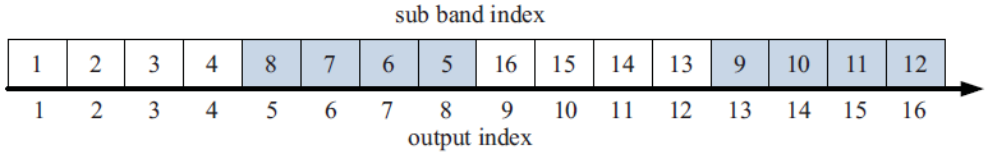

Frequency
fs/16
f1
1
2
4
3
8
7
5
6
16
15
13
14
9
10
12
11
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
Output Nb.



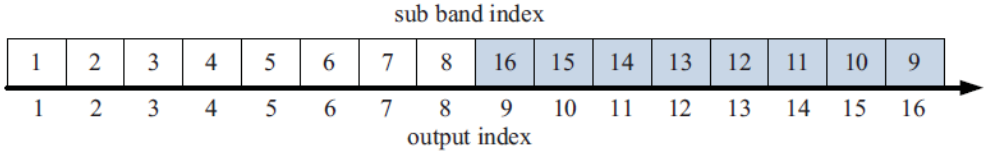
(a) Index of the outputs and the assigned sub bands for a 4 stage filter bank.



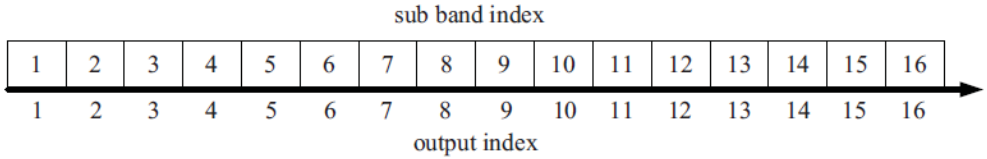
(b) Sample sequence after first mapping process.



(c) Sample sequence after second mapping process.



(d) Sample sequence after third mapping process.



(e) Sample sequence after last mapping process.

Algorithm

1. Start with N = 1,
2. take 2^{N-1} samples iteratively at the filter output stage, starting with the $(2^{N-1}+1)$-th one and stopping with the $(2^{N_{max}}-2^{N-1}+1)$-th one, where $N_{max}= ld(N_{outputs})$
3. mirror this sample sequence (descending order will be ascending order and the other way round),
4. put the mirrored sequence back to the former locations in the complete output sequence,
5. increase N by 1, if the maximum number of steps N_{max} has not been reached yet, go to 2.
6. stop the algortihm.

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Conclusion

- Output-to-spectrum assignment algorithm for LTE cognitive radio
- Highly optimized filters in a dyadic filter bank allow efficient spectrum sensing
- Corresponding frequency slots mapped to filter stage outputs
- if algorithm is hardwired, no cost at runtime
- Simulation results for designed example chain existing (journal publication pending)

Thank you!

Output-to-Spectrum Assignment Algorithm

for a LTE Cognitive Radio Filter Bank

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