Software and Systems Engineering

CPE3202

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Contents

Introduction of OFDM system

Advantages of OFDM

- Efficient usage of frequency bandwidth
- Easy to Use Multi-QAM
- Robustness to the multi-path fading

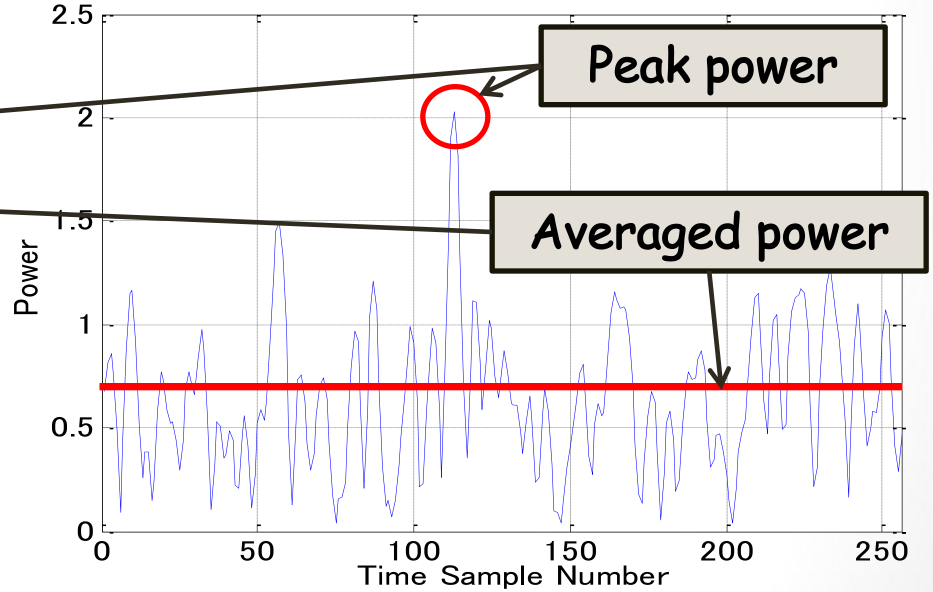
Standard transmission techniques

- Terrestrial digital broadcasting
- Wireless LAN
- LTE

PAPR problem in OFDM Signal

★ High PAPR of its time domain signal

$$PAPR = 10\log_{10}\frac{\max|x(n)|^2}{E|x(n)|^2}$$



★ High PAPR causes

- Degradation of BER performance in non-linear channel
- Frequency spectrum re-growth in non-linear channel

Conventional Methods for Reducing PAPR performance

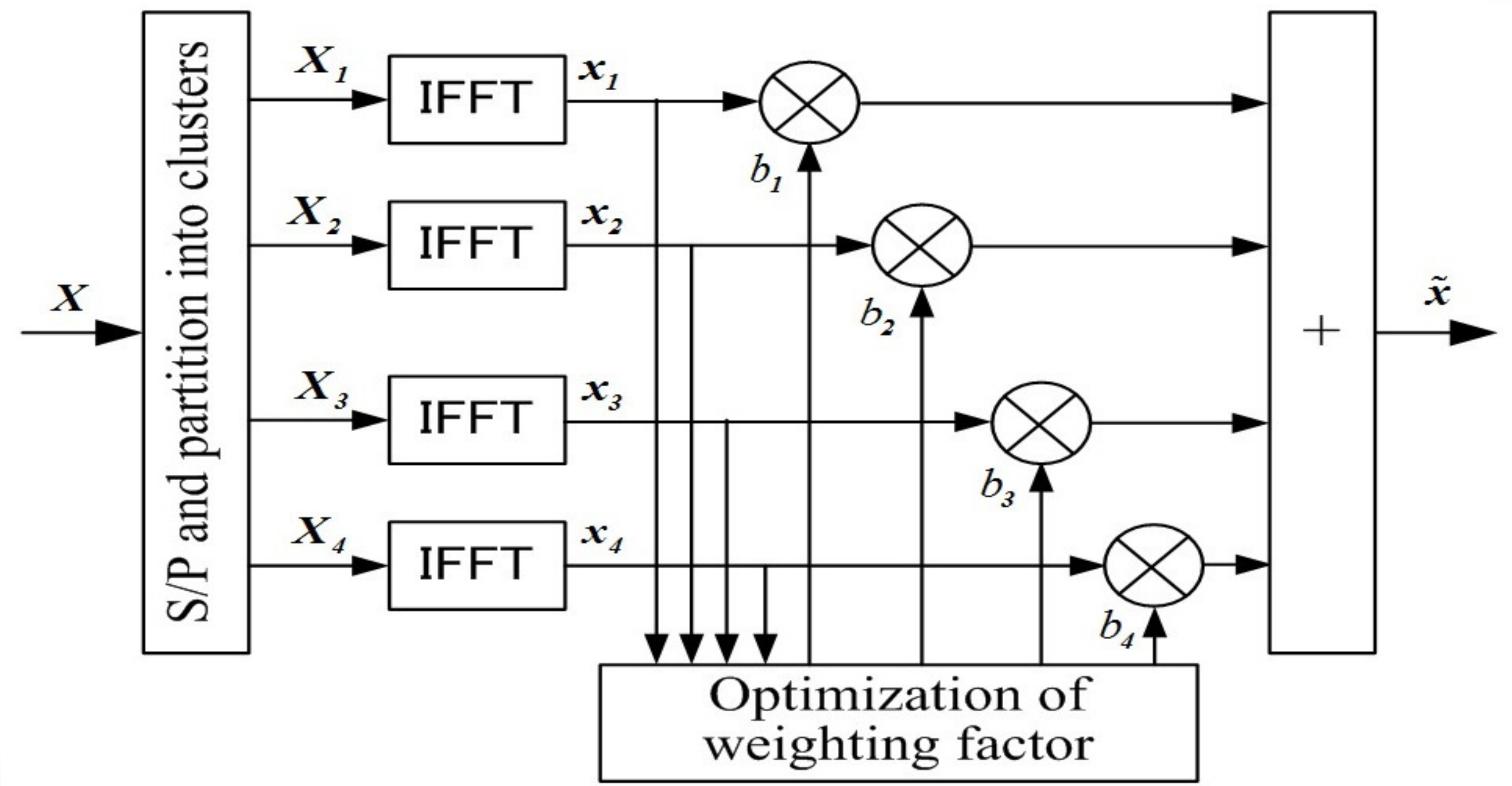
- Clipping and filtering
- Selective Mapping (SLM)
- Partial transmit sequence (PTS)

Reduction of PAPR

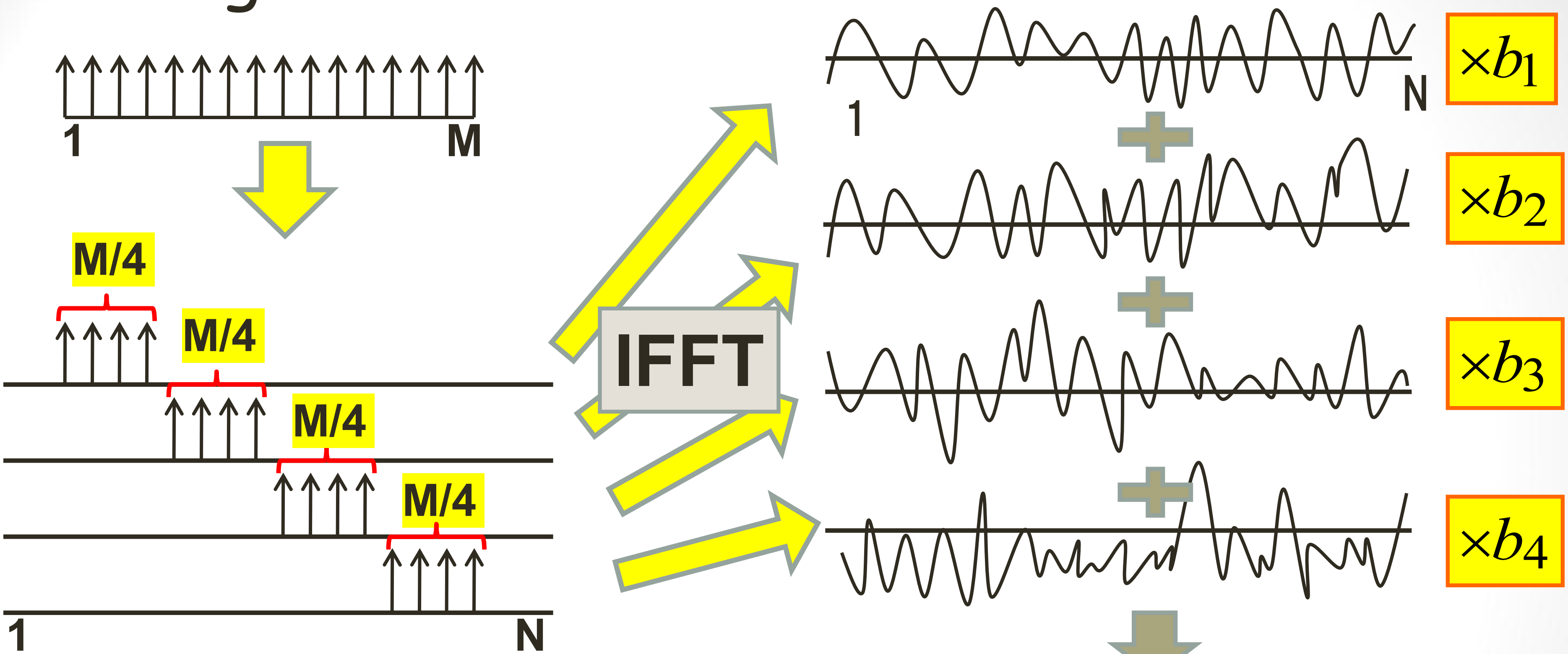
- Signal is partitioned into clusters
- Each cluster is multiplied by weighting factor

Conventional PTS

Structure of Transmitter with Conventional PTS Method



Algorithm of Conventional PTS



$$\left[x'_0, x'_1, \cdots, x'_k, \cdots, x'_{N-1}\right]$$

M: Number of subcarriers

N: Number of IFFT points

$b_v \in \left[e^{j\theta_1}, e^{j\theta_2}, e^{j\theta_3}, e^{j\theta_4} \right]$

$$[b_1, b_2, b_3, b_4] = \underset{[\theta_1, \theta_2, \theta_3, \theta_4]}{\arg\min} \left\{ \max_{0 \le k \le N-1} \left| x'_k \right| \right\}$$

Drawbacks of Conventional PTS

For achieving the better PAPR performance

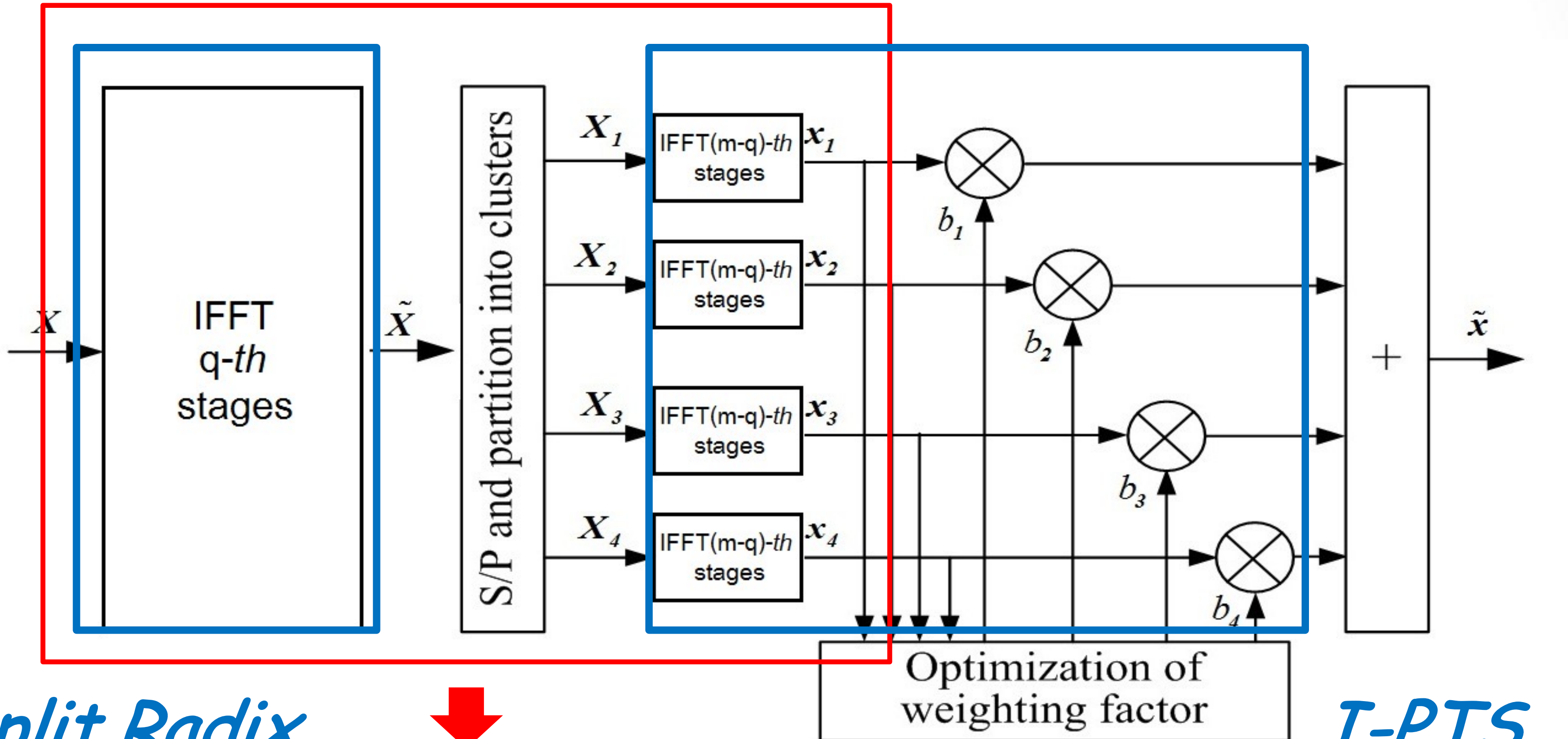
- Increasing the number of clusters (V)
- The number of weighting factors (W)

↓ **Problem**

Increasing the computational complexity exponentially V^W

D-PTS method Based on Radix Technique

Structure of decomposition-PTS (D-PTS) Method [4]



Split Radix

Radix-2 DIF IFFT

I-PTS

PTS-Based Radix Technique

Comparison between D-PTS and Conventional PTS

Computational complexity

D-PTS < Conventional PTS

PAPR performance

D-PTS = Conventional PTS at the middle stages of N-point Radix IFFT

Objective of this study

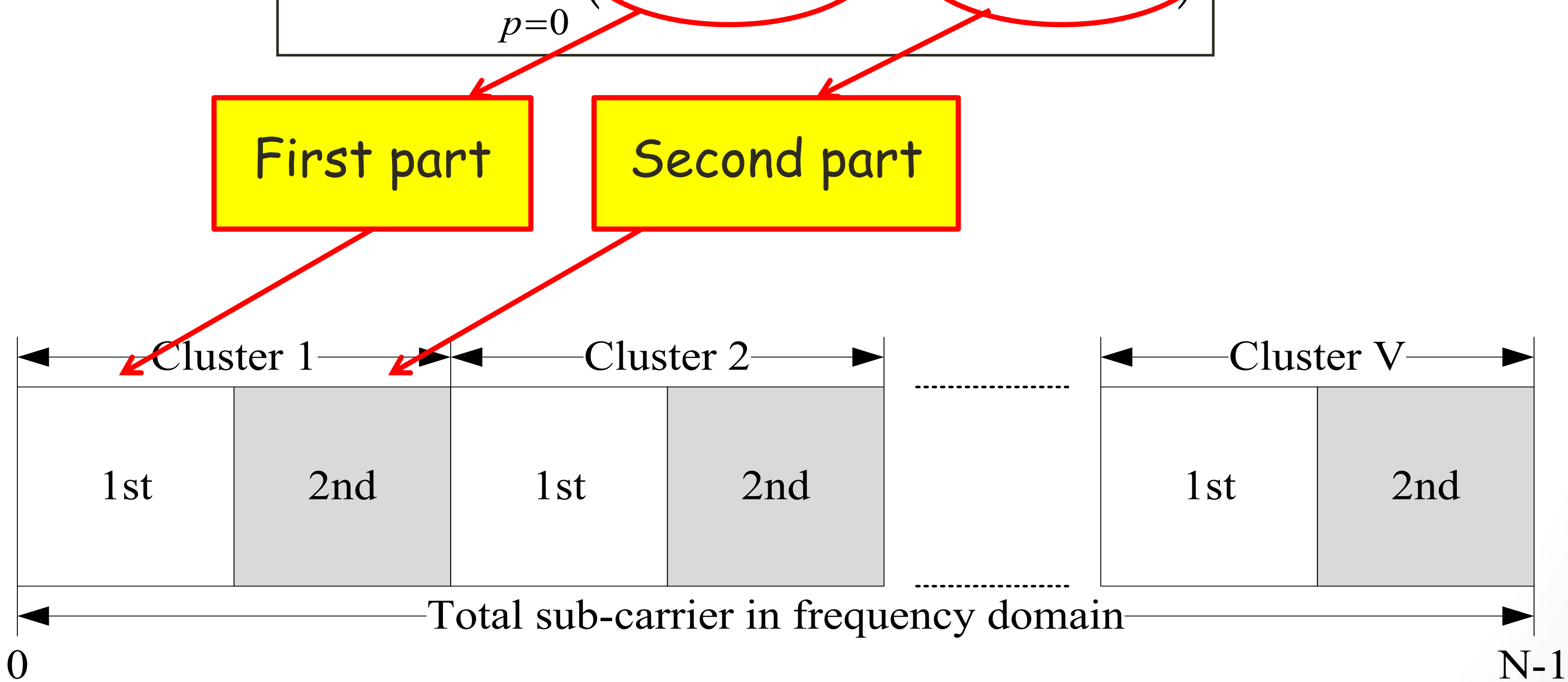
1. Improve PAPR performance
2. Improve Computation Complexity

Split Radix with I-PTS method

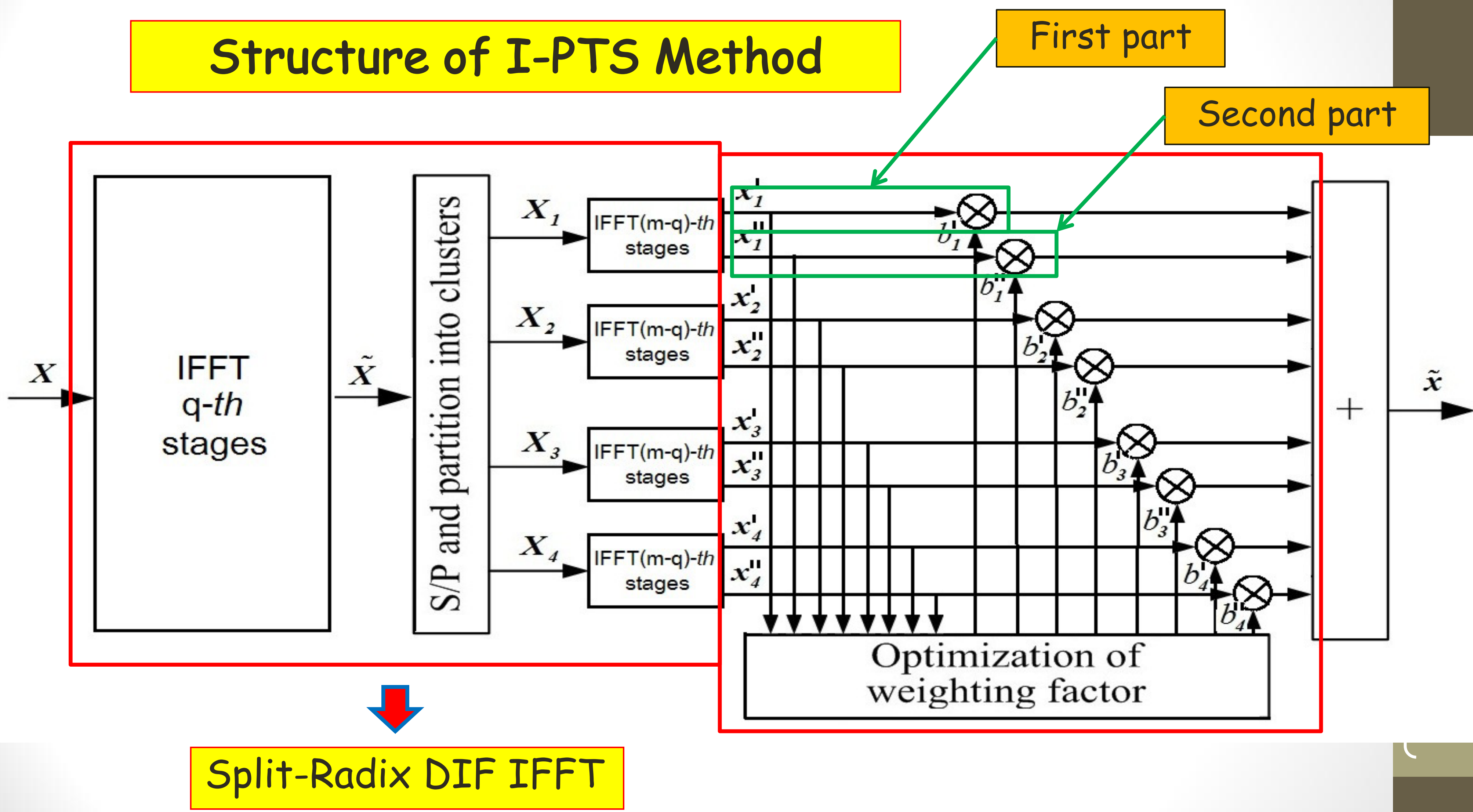
- Each clusters is partitioned by first and second parts and employ the different weighting factor to improve PAPR
- Used Split-Radix DIF-IFFT to reduce computation complexity

A. weighting factor

$$x'(n) = \sum_{p=0}^{P-1}\left(e^{j\theta'_p} x'_p(n) + e^{j\theta''_p} x''_p(n)\right)$$



Structure of I-PTS Method



I-PTS Based Split Radix Technique

Comparison between Split Radix D-PTS and Split Radix I-PTS

Computational complexity

Split Radix I-PTS < Split Radix D-PTS

PAPR performance

Split Radix D-PTS < Split Radix I-PTS

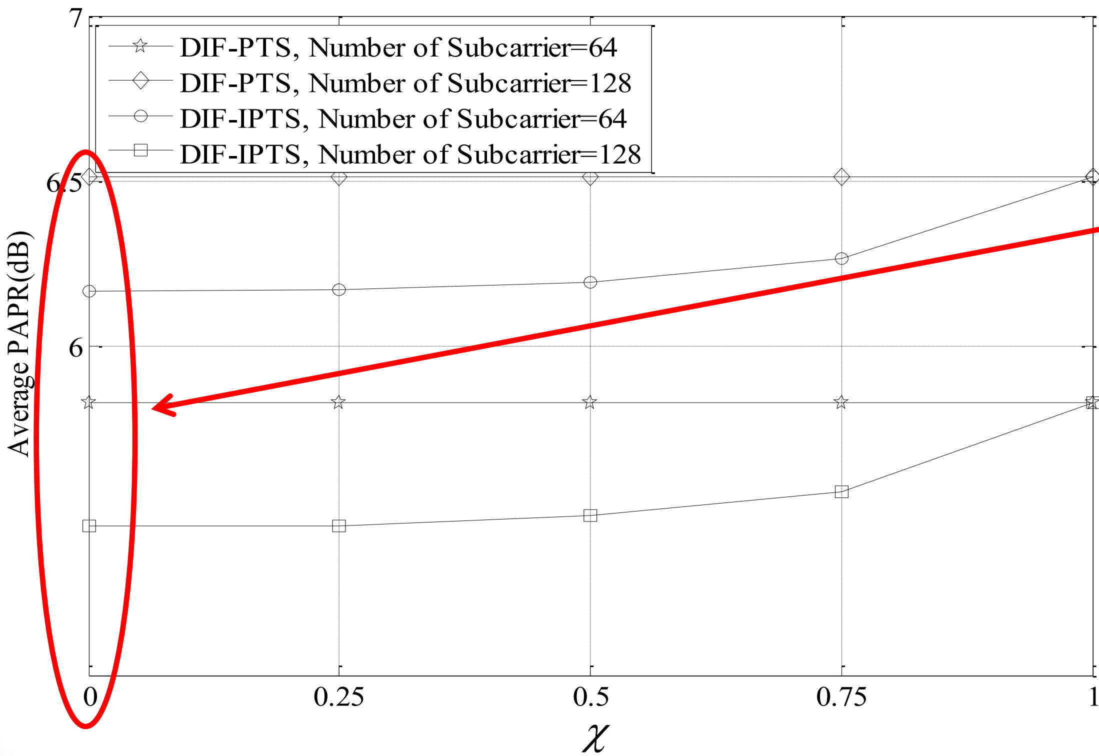
A. weighting factor

$$\theta_p^{'} = \chi \theta_p^{''}$$

$$\theta_p^{''} = \left\{ \frac{2\pi i}{W} \middle| i = 0, 1, \ldots, W-1 \right\}$$

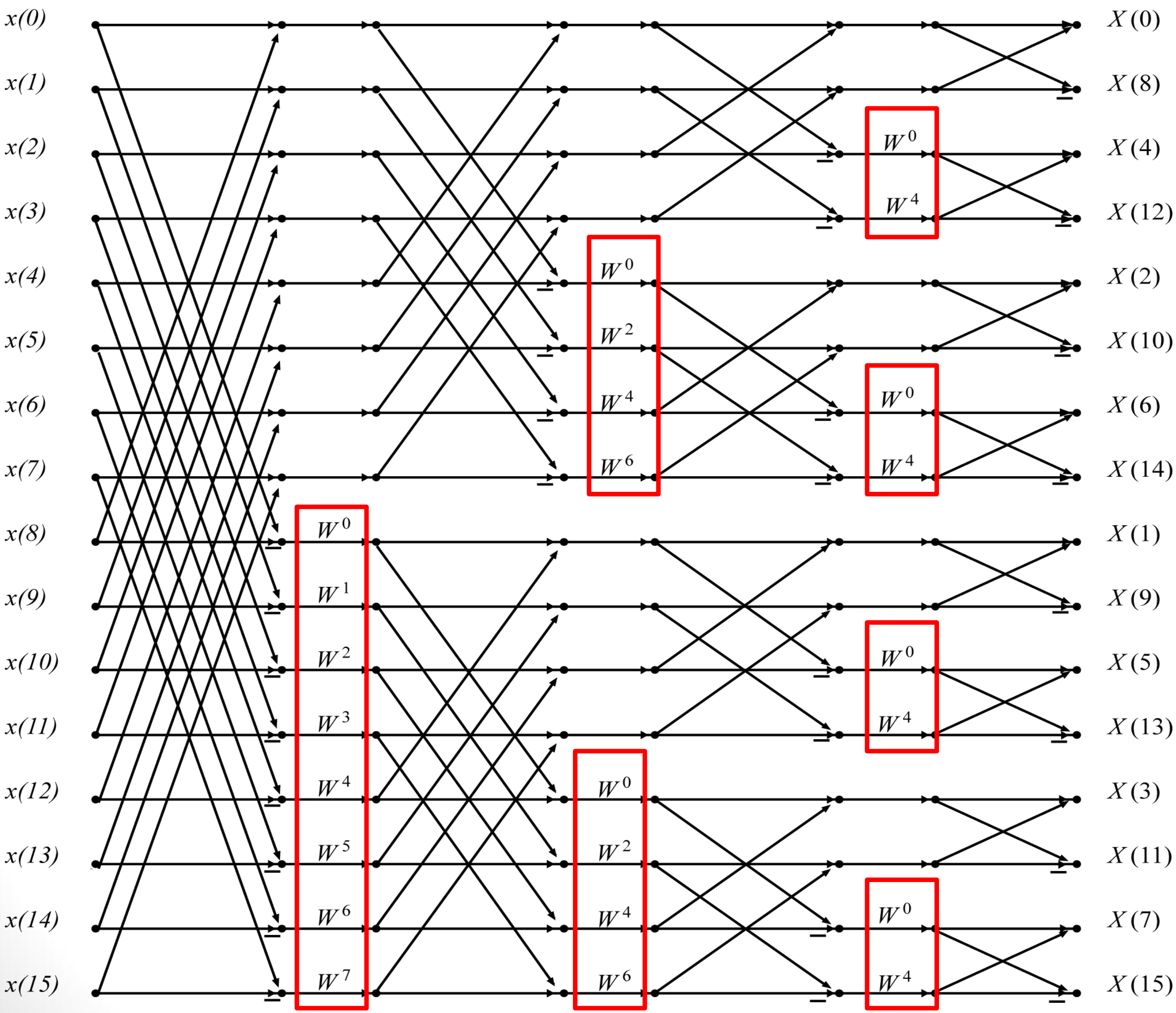
First part

Second part



$\chi = 0$

Radix-2 DIF



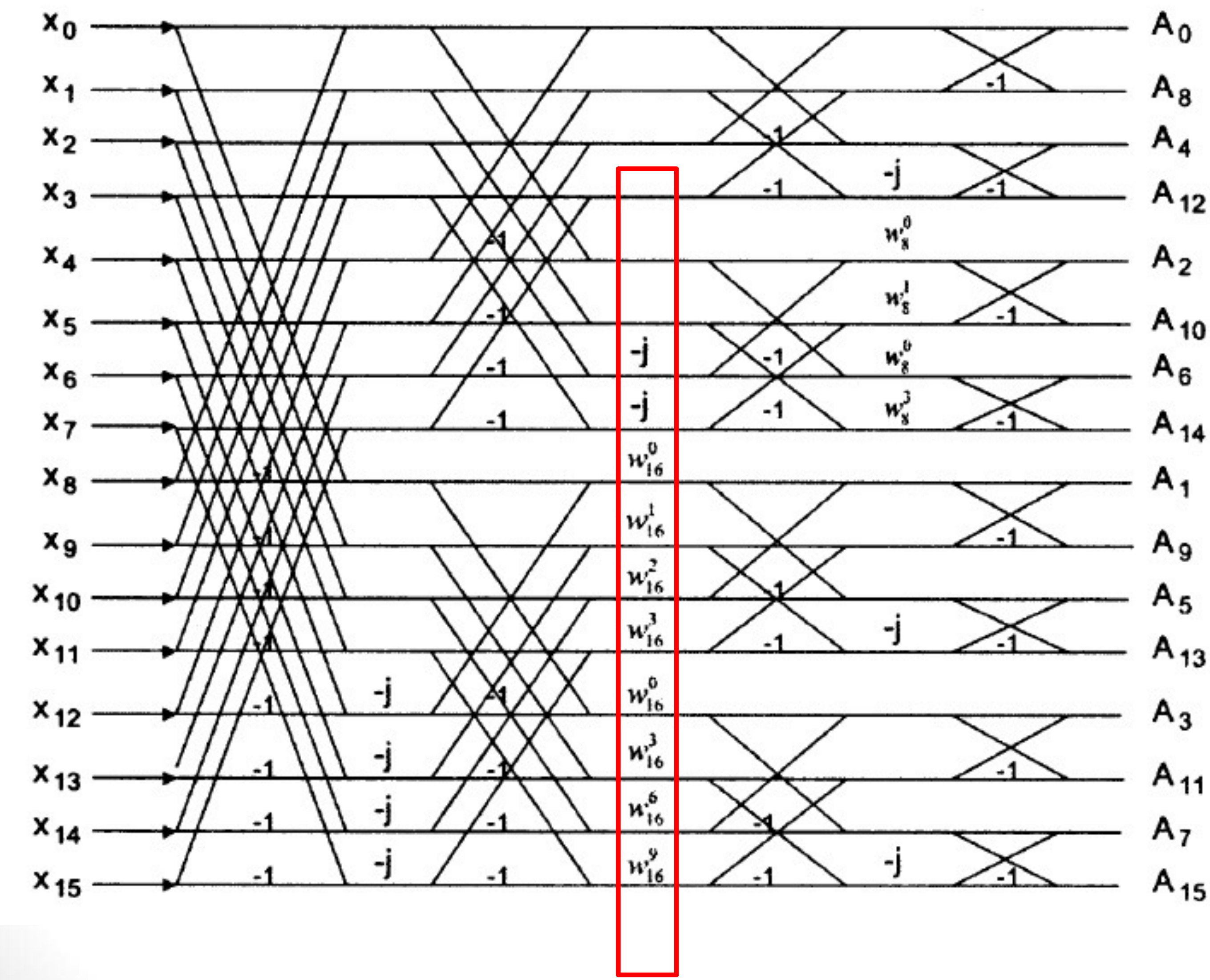
Radix-2 DIF

16 points FFT

Number of twiddle factor = 17

Number of nontrivial multiplication = 17

Sprit Radix DFT



Sprit Radix DIF

16 points FFT

Number of twiddle factor = 18

Number of nontrivial Multiplication = 10

The Low Complexity

B. Analysis of Computational Complexity

The number of twiddle factors

$$\alpha_q^{DIF} = r^{q-1}\left(\frac{N}{r^q}-1\right)\left[(r-1)+(r-2)+(r-1)^2-1\right]$$

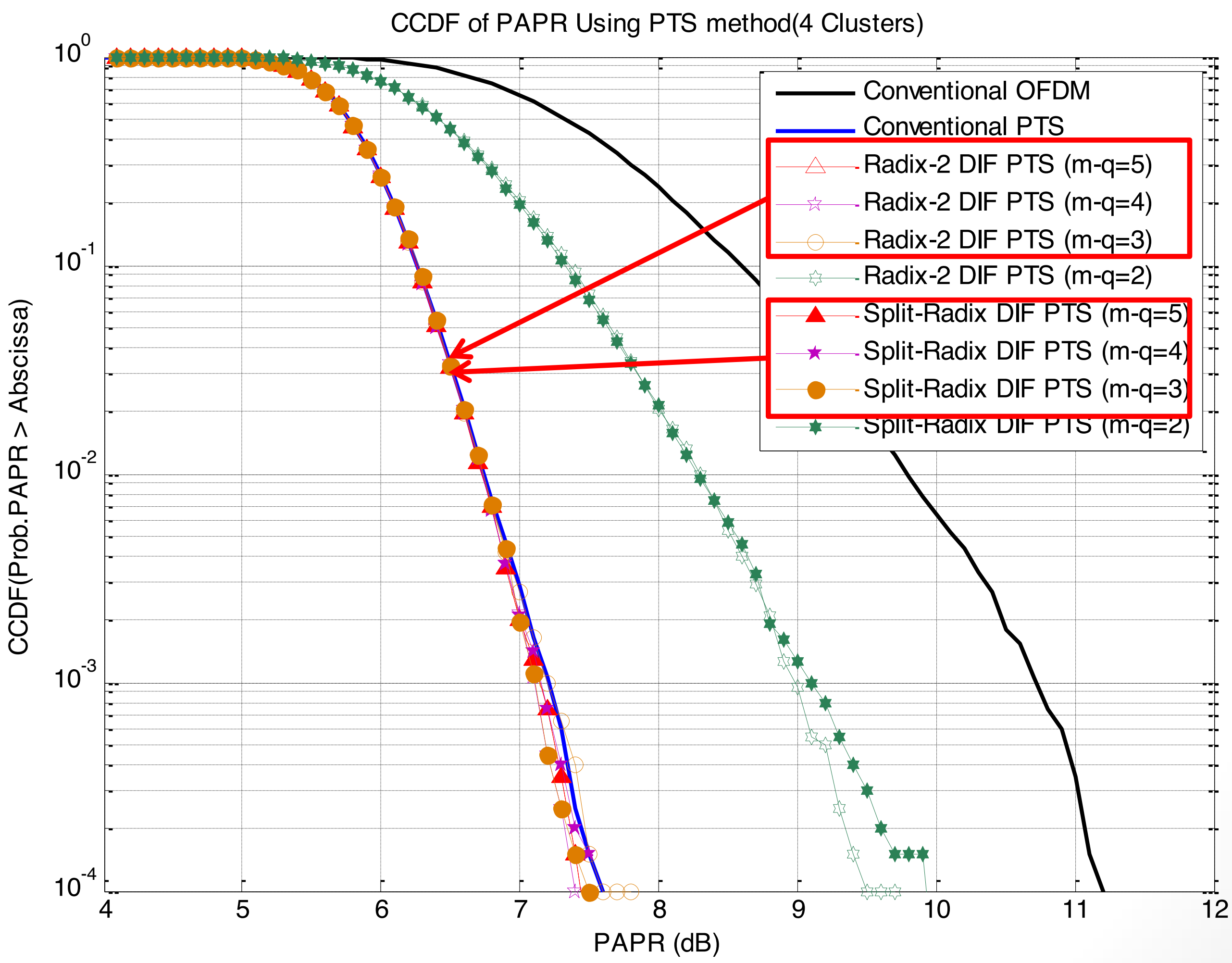
Overall multiplicative complexity

$$M_{total} = \sum_{i=1}^{q}\alpha_q + P\sum_{i=q}^{m}\alpha_q$$

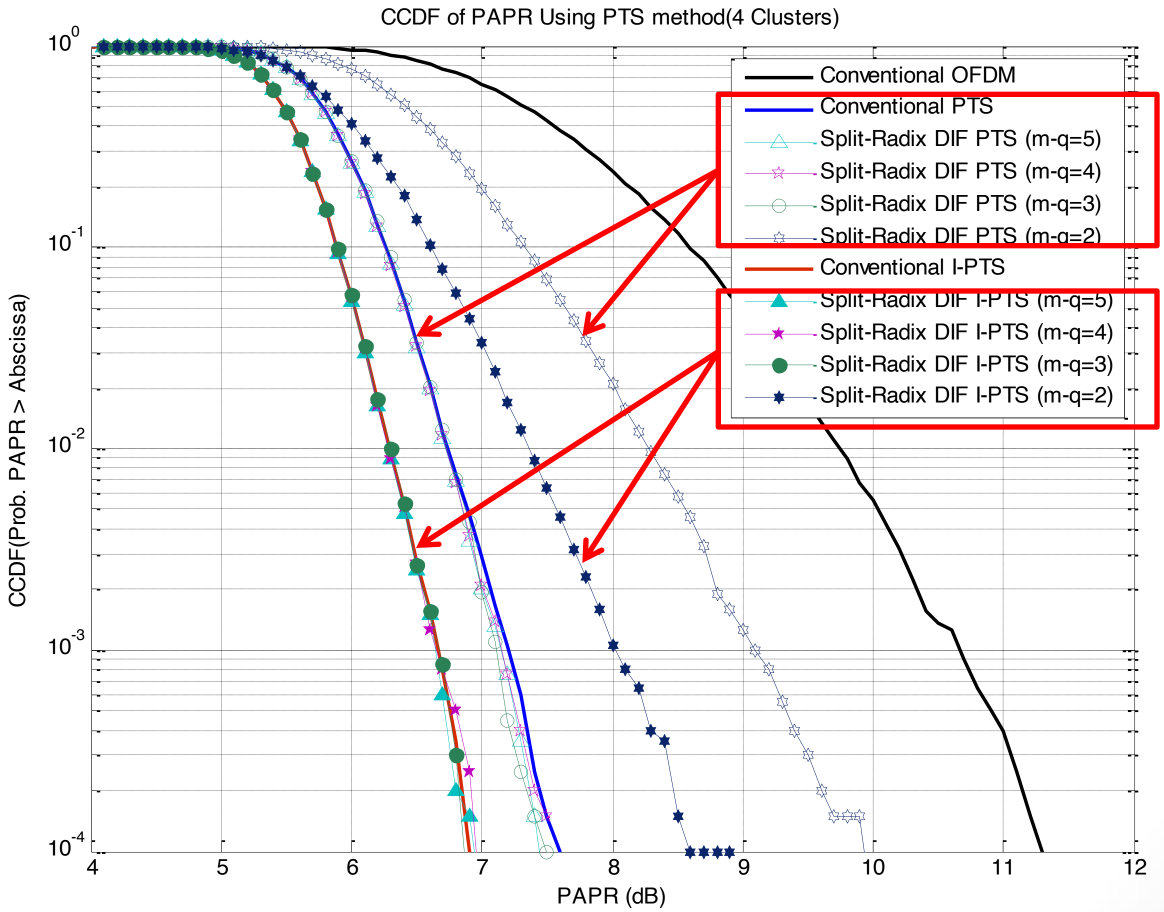
Simulation Parameters

Modulation	QPSK
Demodulation	Coherent
Allocated bandwidth	5 MHz
Number of FFT points	256
Number of sub-carriers	64
Number of cluster (V)	4
Number of discrete phase (W)	4
Symbol duration	12.8us
Guard interval	1.28us

Comparison of PAPR reduction performance among conventional PTS, Radix-2 DIF PTS and Split-Radix DIF PTS



Comparison of PAPR reduction performance among conventional PTS, Split-radix DIF PTS and Split-radix DIF I-PTS



Comparison of computation complexity for difference Methods

	Computation multiplications Complexity (P=4 and N=256)				
	(m-q=6)	(m-q=5)	(m-q=4)	(m-q=3)	(m-q=2)
Conventional OFDM	NA	NA	NA	NA	NA
Conventional PTS	0%	0%	0%	0%	0%
DIF-PTS [4]	24.68%	36.77%	48.48%	59.40%	68.76%
Radix-2 DIF-IPTS	24.68%	36.77%	48.48%	59.40%	68.76%
Split-Radix DIF-IPTS	52.99%	59.04%	67.82%	74.64%	81.08%

* Split-Radix (m-q = 3, 2,1) , respectively.

Conclusions

Split-Radix I-PTS Method

-Used weighting factor technique for PTS method conjunction with Split Radix DIF IFFT

computer simulation results

-Better PAPR performance with keeping the same size of side information

- Lower computation complexity