5th NAIST COE 2006

A Novel Design of Multiple Access Technique with User Overloading

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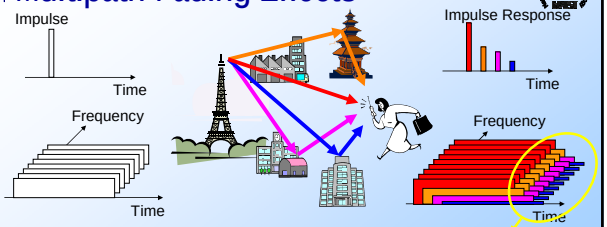
Part of this result has been presented in ACM/IEEE IWCMC 2006, Vancouver, Canada, July 2006.

Presentation Outline

- The need of capacity increasing and low PAPR for Supporting Ubiquitous System
- Spreading code in OFDM and MC-CDMA systems
- Pseudo-Orthogonal Carrier Interferometry codes
- Proposed new codes for multiple access technique
  - Cross correlations
- Performance results
  - PAPR Reduction
  - BER Performance
- Conclusions
- Future Works

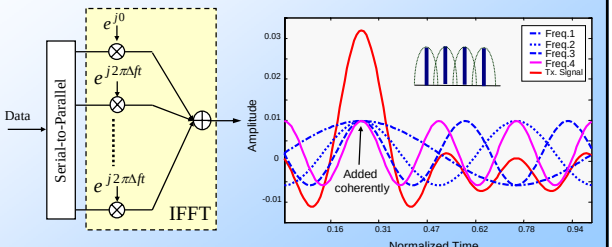
Multipath-Fading Effects



- Inter-Symbol-Interference
- Frequency Selective

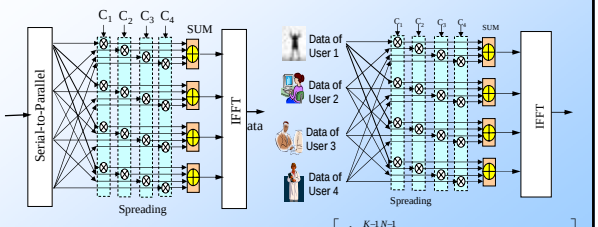
OFDM and High Peak Problem

- OFDM : Technology for high-data rate applications and robust to against frequency selective fading effects.
- One disadvantage of OFDM is its high PAPR.



Spreading Codes in OFDM & MC-CDMA

- Spreading code → Frequency diversity



$$S(t)=\mathrm{Re}\left[\frac{1}{\sqrt{N}}\sum_{k=0}^{N-1}\sum_{i=0}^{N-1}d^{(k)}\cdot e^{j(2\pi i\Delta f)t}\cdot C_{(k,j)}\cdot e^{j2\pi f_c t}\cdot g(t)\right]$$

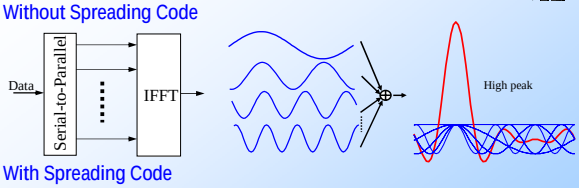
Spread OFDM

$$S(t)=\mathrm{Re}\left[\frac{1}{\sqrt{N}}\sum_{k=0}^{K-1}\sum_{i=0}^{N-1}d^{(k)}\cdot e^{j(2\pi i\Delta f)t}\cdot C_{(k,j)}\cdot e^{j2\pi f_c t}\cdot g(t)\right]$$

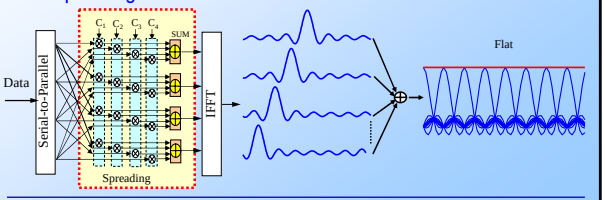
MC-CDMA

The Idea of Peaks Reduction

Without Spreading Code

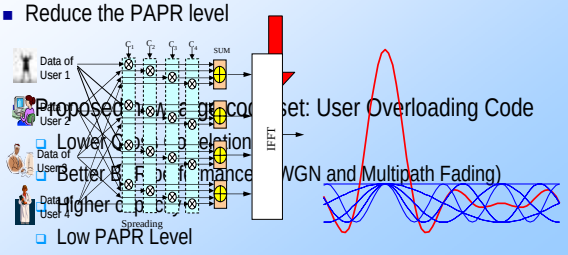


With Spreading Code



Objectives

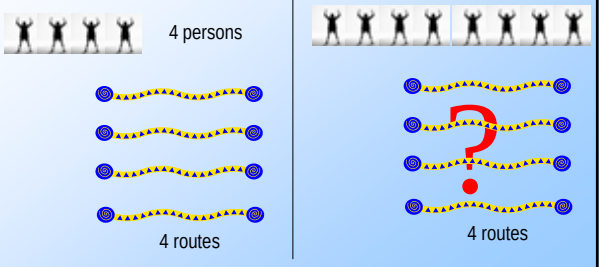
- Increase capacity → increase the number of spreading code but with the same length.
  - Two Orthogonal Code Set (TOCS), [2000]
  - Pseudo-Orthogonal Carrier Interferometry (POCI), [2003]
- Reduce the PAPR level



- Proposed [illegible] set: User Overloading Code
  - Lower C[illegible] eletion
  - Better B[illegible] mance [illegible] WGN and Multipath Fading)
  - Higher c[illegible] c[illegible]
  - Low PAPR Level

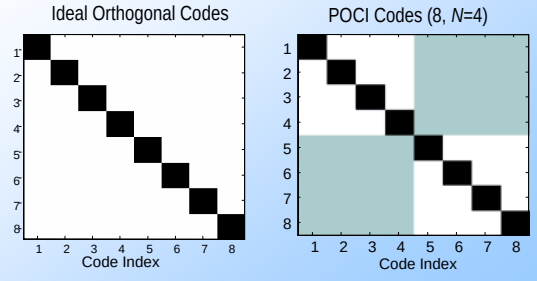
The Need of Higher Capacity: Overloading

- High efficiency → same cost but higher capacity
  - Large number of users
  - High bit-rates



Orthogonality Properties of POCI

- PO-CI has high cross correlation between set 1 and set 2.
- For all codes, POCI cross correlation values are not uniform.



Proposed New Codes

At the transmitter $C(k,n) = e^{j\Delta\theta_k \cdot k}$

At the receiver $C(p,n) = e^{-j\Delta\theta_p \cdot p}$

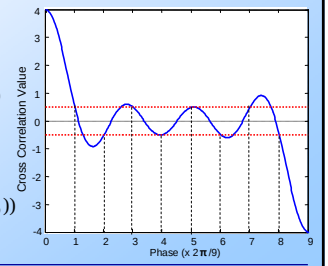
$\Delta\theta_k$ and $\Delta\theta_p$ are any value between 0 and 2π n = 0, 1, 2, 3, ... N-1

Cross correlation

$$R_{k,p}(\Delta\theta) = \sum_{i=0}^{N-1} C_{(k,i)} \cdot C_{(p,i)}$$

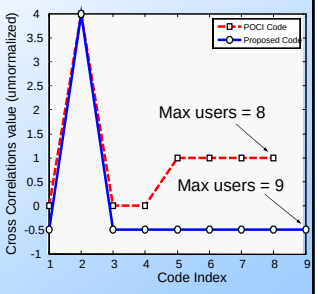
For real signaling:

$$R_{k,p}(\Delta\theta) = \sum_{i=0}^{N-1} \cos(i \cdot (\Delta\theta_k - \Delta\theta_p))$$



Cross Correlation Properties

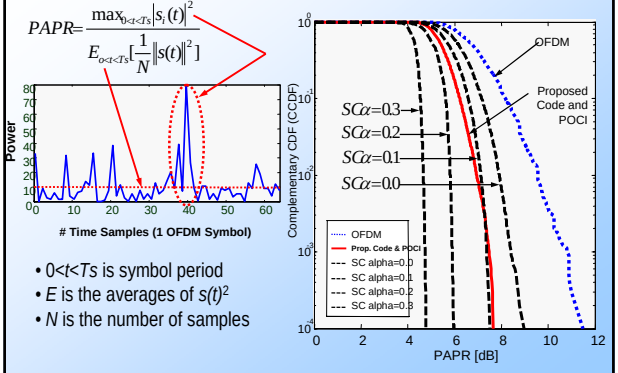
- Uniformly and low cross-correlation is a primary interest to obtain the shape of the ideal cross-correlation [Candran-Jaffe, 1996]
- Selection of $R_{k,p}(\Delta\theta) = \pm 0.5$ is the optimum solution for large code set with uniform cross correlations.
- Additional advantages: higher user capacity compared to POCI codes



Cross Correlation of Code 2 to others

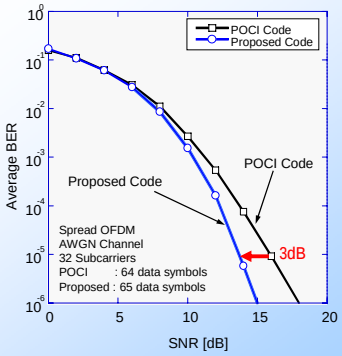
Let's check the result !

PAPR of Proposed Code



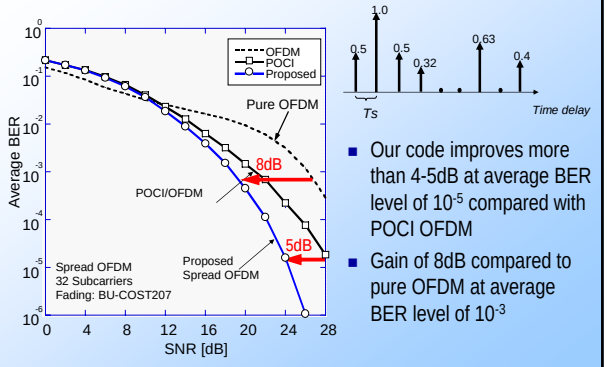
- $0<t<Ts$ is symbol period
- E is the averages of $s(t)^2$
- N is the number of samples

BER Performance in AWGN Channel



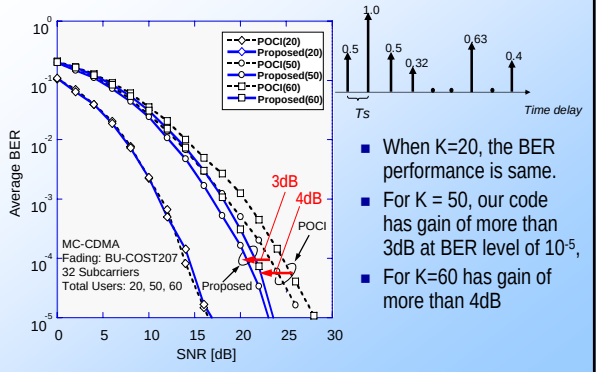
- N=32
- Binary phase shift keying (BPSK) symbols is 64 for POCI code and 65 for our proposed code.
- Our proposed code outperforms POCI code by about 3dB at average BER of 10^{-5}.
- Our simulation suggest that the cross correlation of our code is low enough for better quality of transmission.

BER Performance in Multipath Fading



- Our code improves more than 4-5dB at average BER level of 10^{-5} compared with POCI OFDM
- Gain of 8dB compared to pure OFDM at average BER level of 10^{-3}

BER Performance of MC-CDMA



- When K=20, the BER performance is same.
- For K = 50, our code has gain of more than 3dB at BER level of 10^{-5},
- For K=60 has gain of more than 4dB

Conclusions

- We proposed a new large code set for :
  - PAPR Reduction of OFDM system
  - User Capacity Increasing in MC-CDMA System
- Contributions (compared to POCI codes):
  - Better cross correlations properties (uniform and low).
  - Significant PAPR reduction (up to 7dB at CCDF of 10^{-4}).
  - BER performance improvement of 3dB (AWGN).
  - BER performance improvement is 5dB (M. Fading).
  - Higher capacity of $2N+1$ (Overloading).

Thank you very much for your attentions!

Future Works

- Experiment : Indoor
  - Speed : 0 m/s
  - Speed : 5-6 m/s (pedestrian)
- Experiment : Outdoor
  - Speed : 0 m/s
  - Speed : 100 km/s (vehicle)
- Tools:
  - Agillent Transceiver equipment