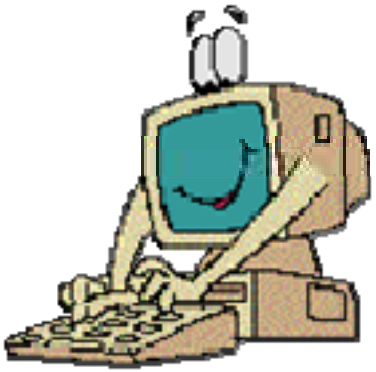

Improved Interference Diversity in Multicellular OFDMA Systems

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MIT Campus of Anna University, Chennai, India

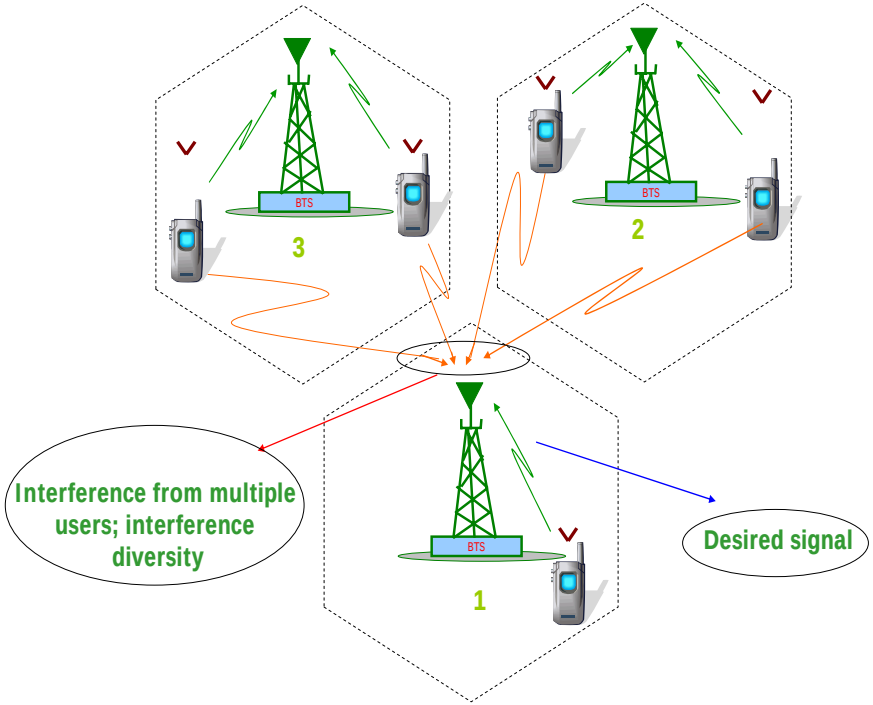
- **Introduction**
- Objective
- Permutation Base for WiMAX Standard
- Interference Diversity
- Measuring Interference Diversity
- Improving Interference Diversity
- Results
- Conclusion

For a WiMAX PUSC deployment

• Co-channel Interference from neighboring cells.

• No interference from within the same cell.

• Interference averaging is used so that the interference level remains as constant as possible.



• In WiMAX networks, interference averaging is realized by the scheme of distributed subcarrier permutation.

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- To create a heuristic to measure the interference diversity for WiMAX PUSC deployments on the downlink and uplink

- To propose a new method for forming subchannels to improve the Interference Diversity

- To compare the interference diversity of the WiMAX ordering of subcarriers with the proposed ordering of subcarriers using the heuristic proposed

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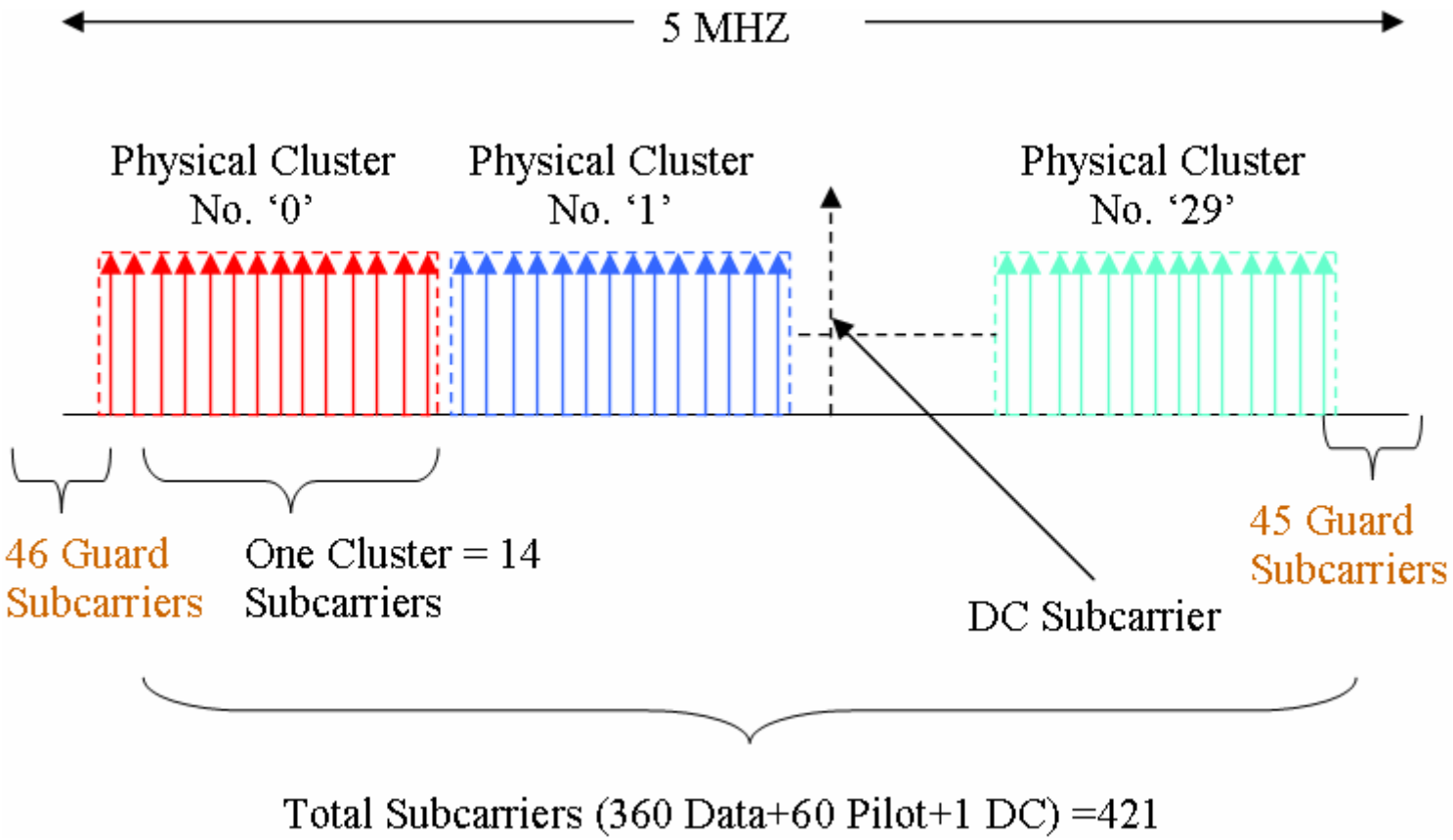
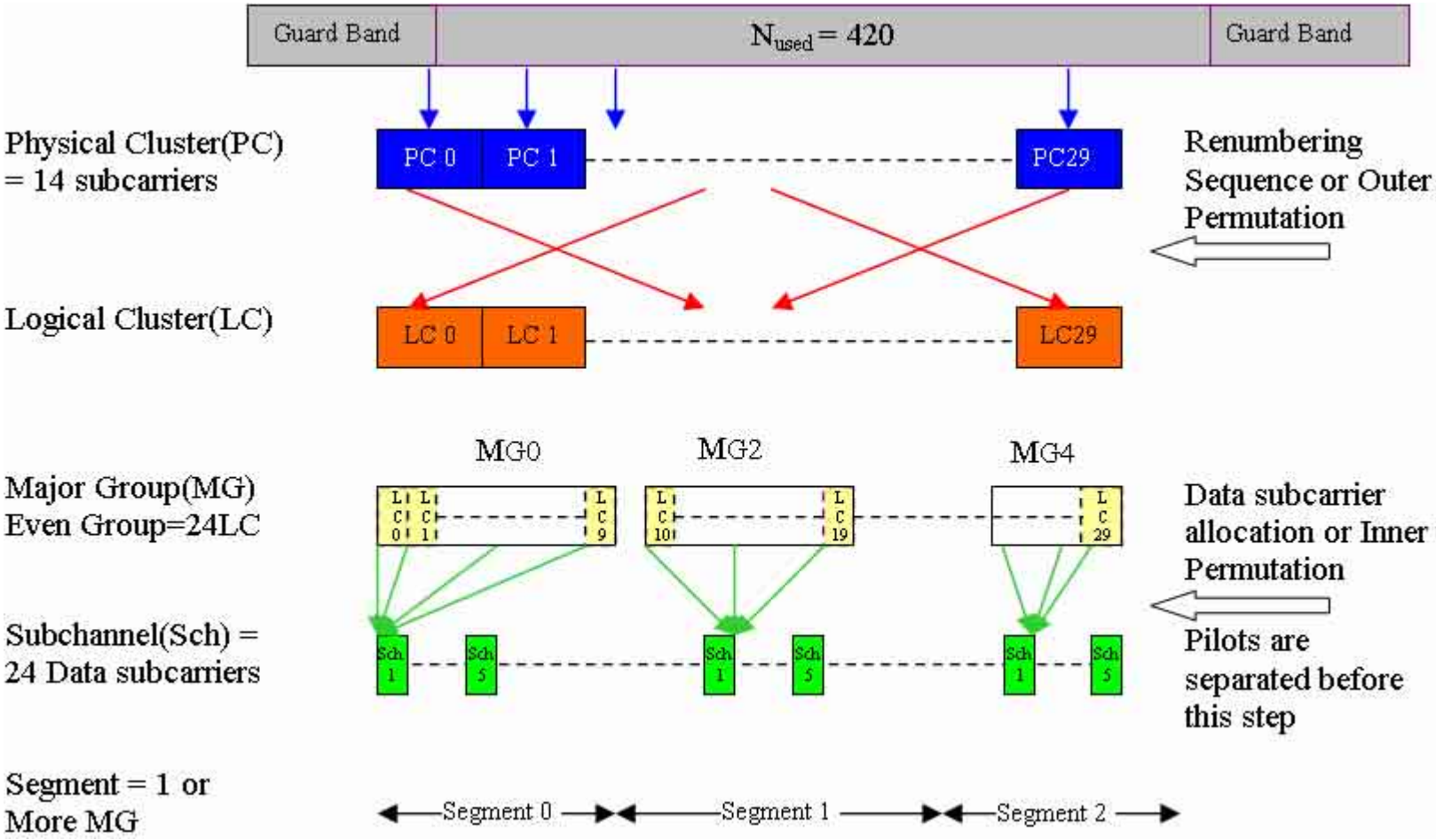

5 MHZ
Physical Cluster No. '0'
Physical Cluster No. '1'
Physical Cluster No. '29'
46 Guard Subcarriers
One Cluster = 14 Subcarriers
DC Subcarrier
45 Guard Subcarriers
Total Subcarriers (360 Data+60 Pilot+1 DC) =421


Guard Band
N_{used} = 420
Guard Band
Physical Cluster(PC)
= 14 subcarriers
PC 0
PC 1
PC29
Renumbering
Sequence or Outer
Permutation
Logical Cluster(LC)
LC 0
LC 1
LC29
MG0
MG2
MG4
Major Group(MG)
Even Group=24LC
Data subcarrier
allocation or Inner
Permutation
Subchannel(Sch) =
24 Data subcarriers
Pilots are
separated before
this step
Segment = 1 or
More MG
Segment 0
Segment 1
Segment 2

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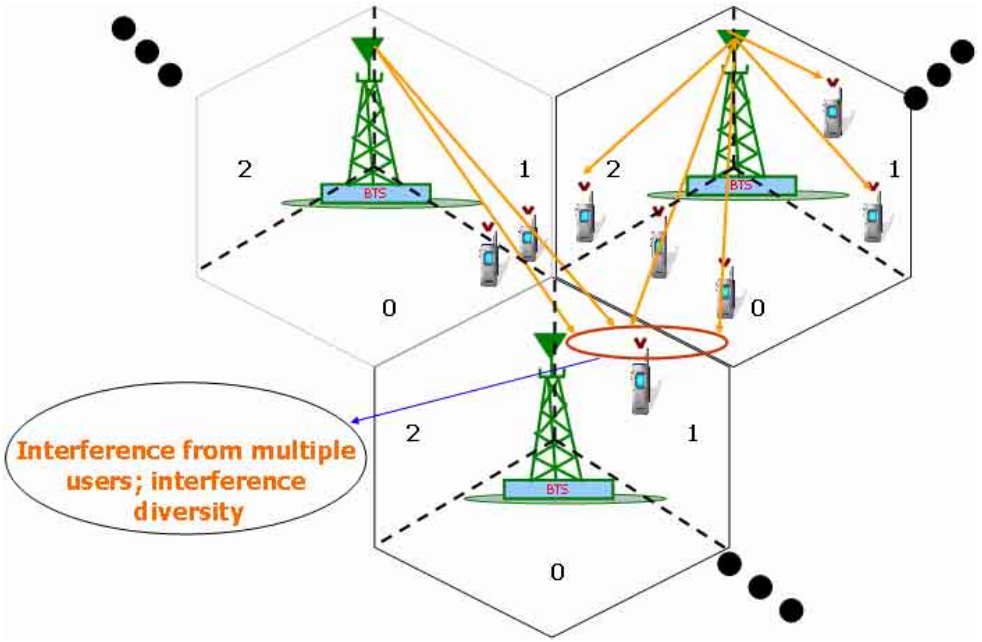
- 512 FFT PUSC on Downlink
- 3 sector deployment



INTERFERENCE DIVERSITY OF AN 802.16E BASED SYSTEM ON THE DOWNLINK

Reference Subchannel	Number of Subcarriers contributing interference to reference subchannel														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	5	0	1	1	1	3	0	3	1	2	3	1	1	0	2
2	2	2	0	2	2	2	5	1	1	0	2	2	1	2	0
3	1	2	4	0	1	1	2	4	1	1	0	2	1	1	3
4	1	1	1	3	0	1	1	1	5	2	3	0	3	2	0
5	0	0	0	1	5	1	4	2	2	2	1	0	0	2	4

- Introduction
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Proposed heuristic for measuring interference diversity

1. Let *n* be the total number of subchannels in the cell.

2. Let *threshold* be the threshold value, above which the contribution from interfering subcarriers in an interfering subchannel towards a reference subchannel is not considered.

3. Determine the number of contributing interference subcarriers from each subchannel in the neighboring co-channel cell towards the reference subchannel in the reference cell.

4. Let *count* be the number of subchannels from which the number of interference contributing subcarriers is less than or equal to *threshold*.

5. The value of x (the interference diversity metric) for the reference subchannel in the reference cell is *count*/*n*.

ILLUSTRATION OF METRIC FUNCTION

Reference Subchannel	Number of Subcarriers contributing interference to reference subchannel														Total weight
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
1	1	1	1	1	1	1	1	1	1	1	1	1	1	4	7	15/15
2	1	1	1	1	1	1	1	1	1	1	1	1	1	11	0	13/15
3	2	2	2	2	2	2	2	2	2	2	2	2	0	0	0	12/15
4	5	5	5	5	4	0	0	0	0	0	0	0	0	0	0	5/15
5	11	11	2	0	0	0	0	0	0	0	0	0	0	0	0	1/15

Hypothetical Example

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Proposed method for improving interference diversity

The proposed permutation base is created as follows:

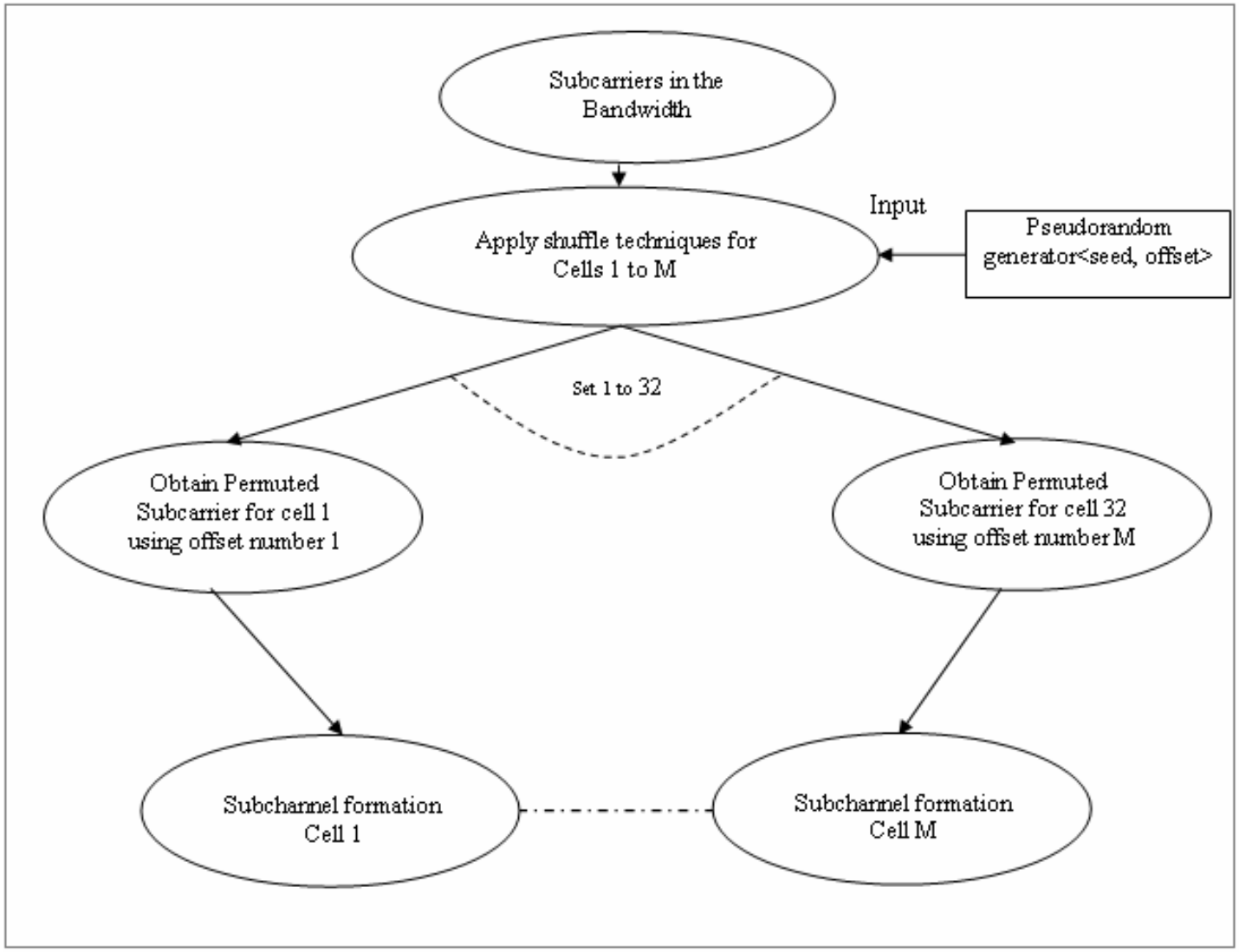
- Permute the physical subcarrier index for each cell using Sattolo's shuffle.

- Use Mersenne Twister (MT19937) PRNG for generating the 'Random' index for Sattolo's shuffle.

SATTOLO'S SHUFFLE ILLUSTRATED

Range	Random	Swap | Result
		1 2 3 4 5 |
1–5	3	1 2 **5** 4 | **3**
1–4	1	**4** 2 5 | **1** 3
1–3	2	4 **5** | **2** 1 3
1–2	1	5 | **4** 2 1 3

Setup of the Proposed Permutation Method



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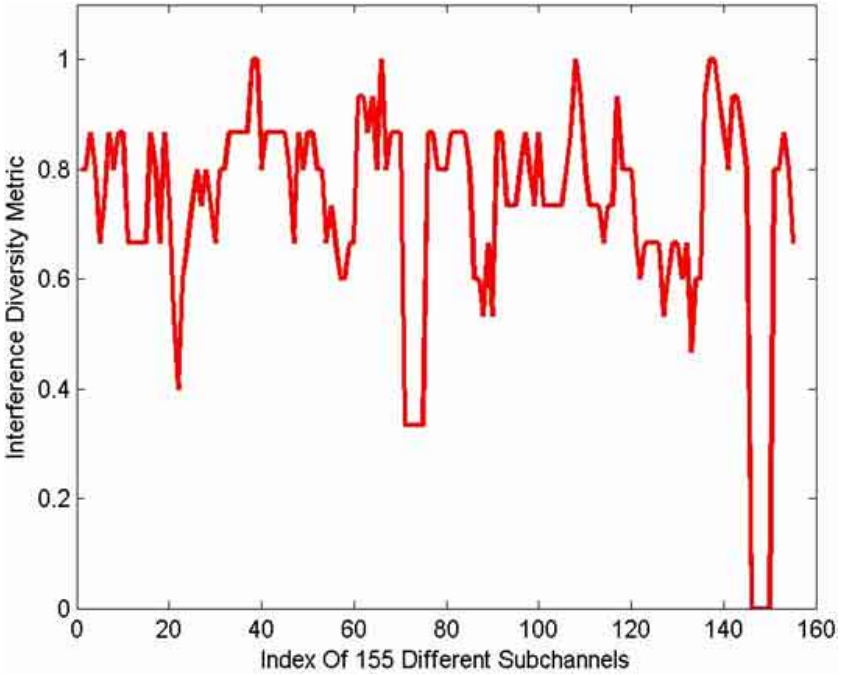
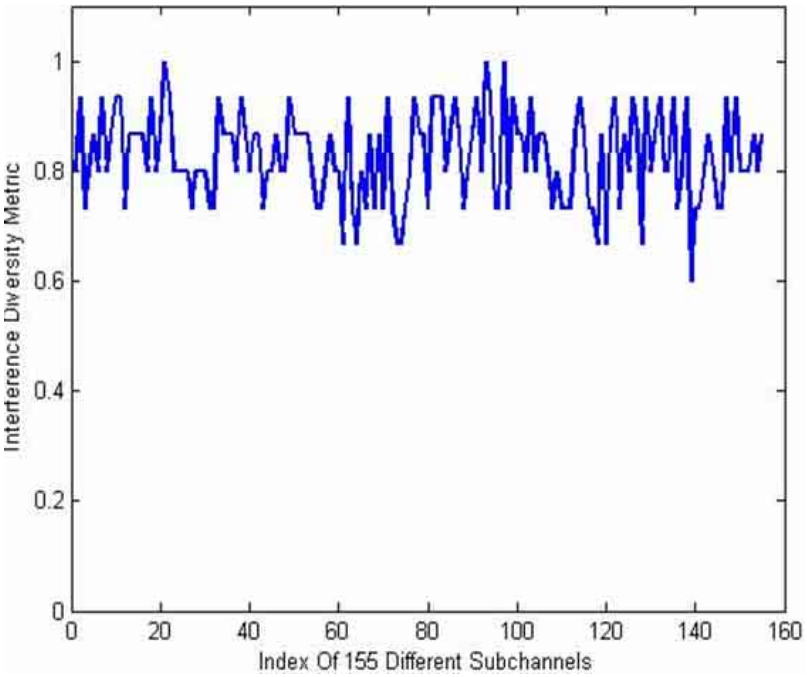
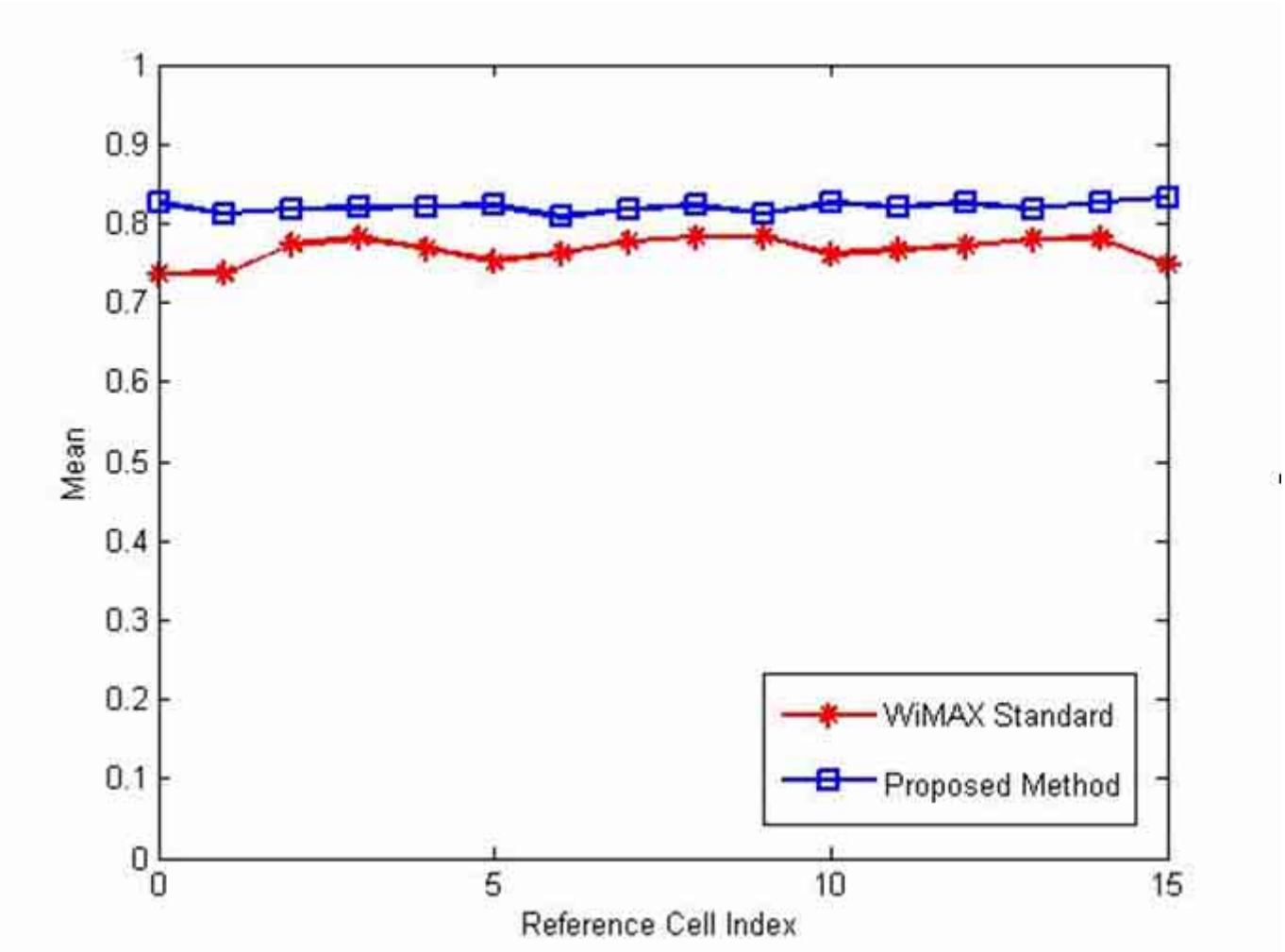
512 FFT PUSC on Downlink



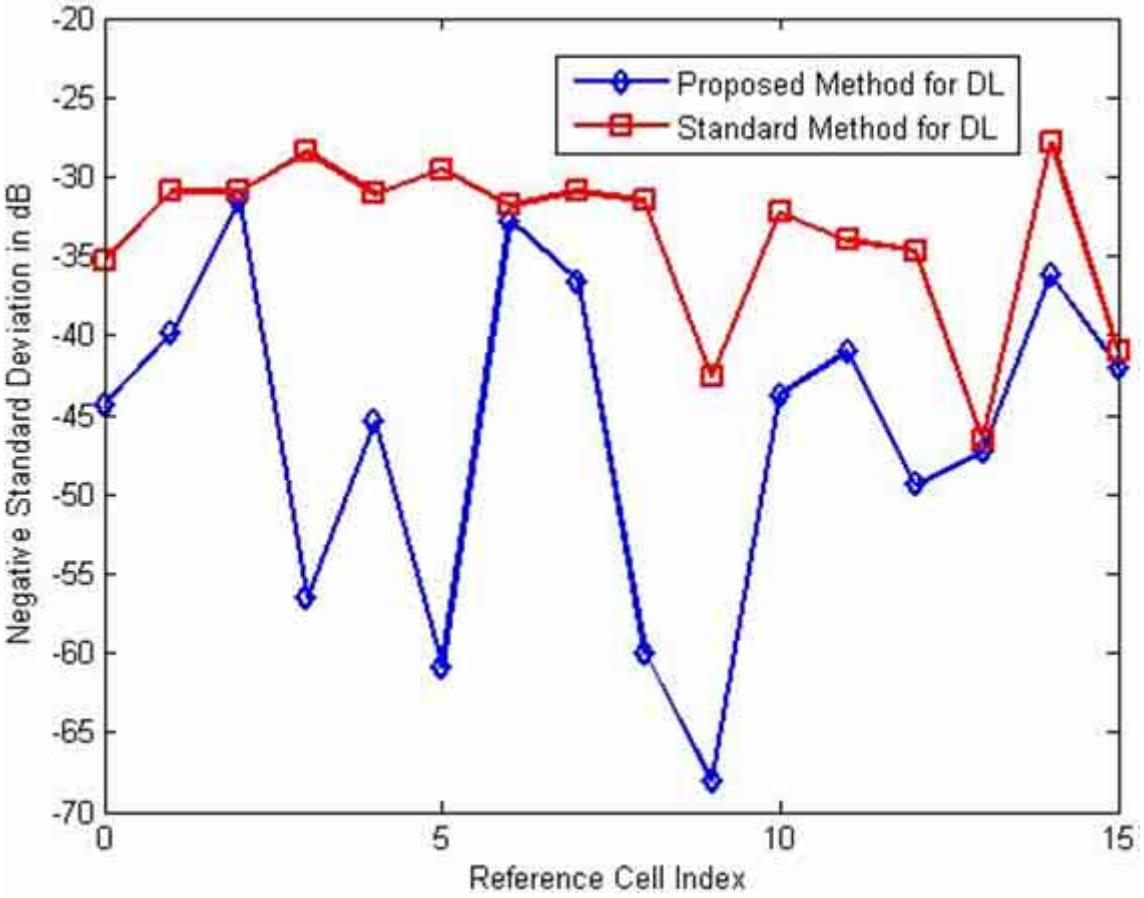
WiMAX 802.16 standard's metric for Downlink, Reference cell 0, reference subchannel 1 to 5.



Proposed method's metric for Downlink. Reference cell 0, reference subchannel 1 to 5.

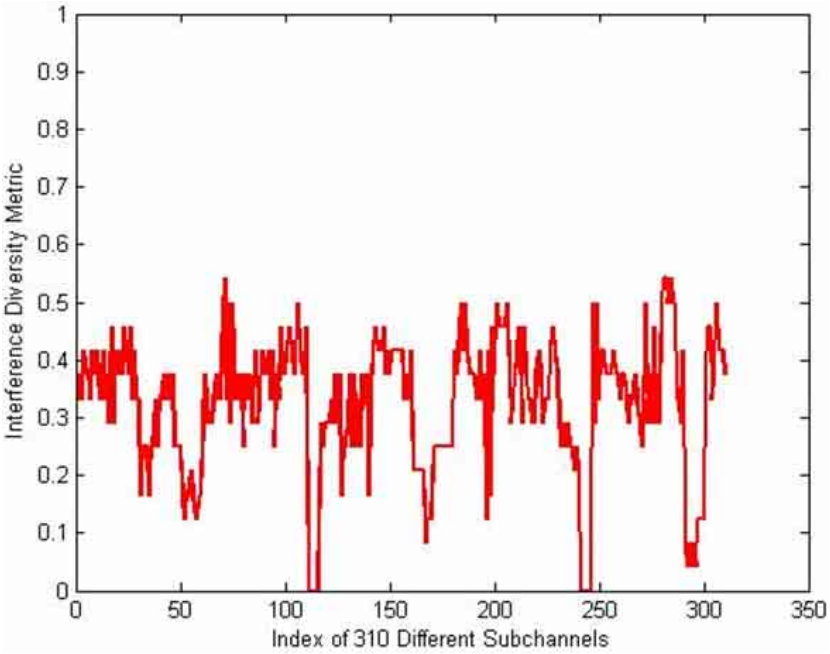


Reference Cell Index Vs Mean , 512 FFT PUSC on Downlink

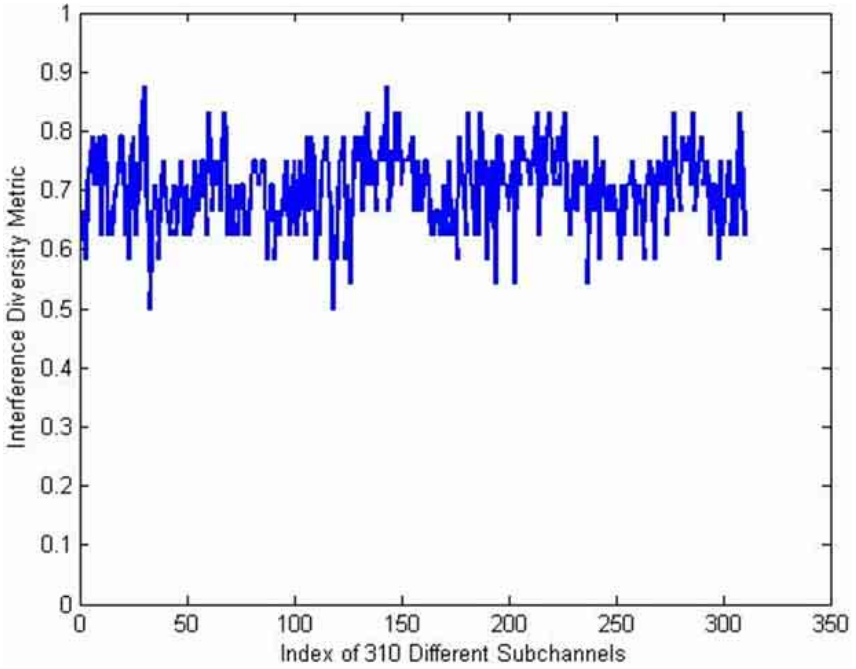


Reference Cell Index Vs Negative Standard Deviation for Downlink
(512 FFT PUSC, DL)

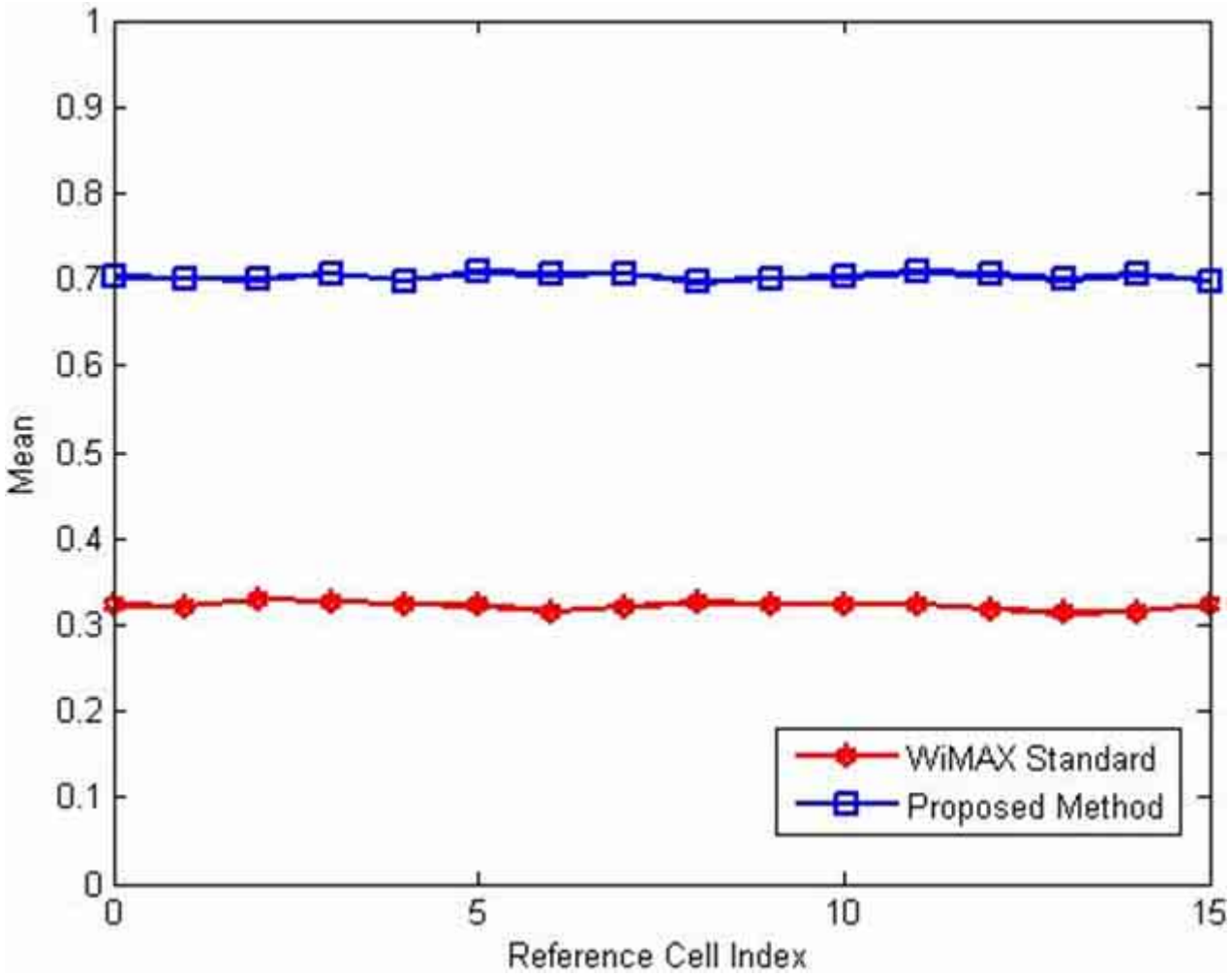
1024 FFT PUSC on Downlink



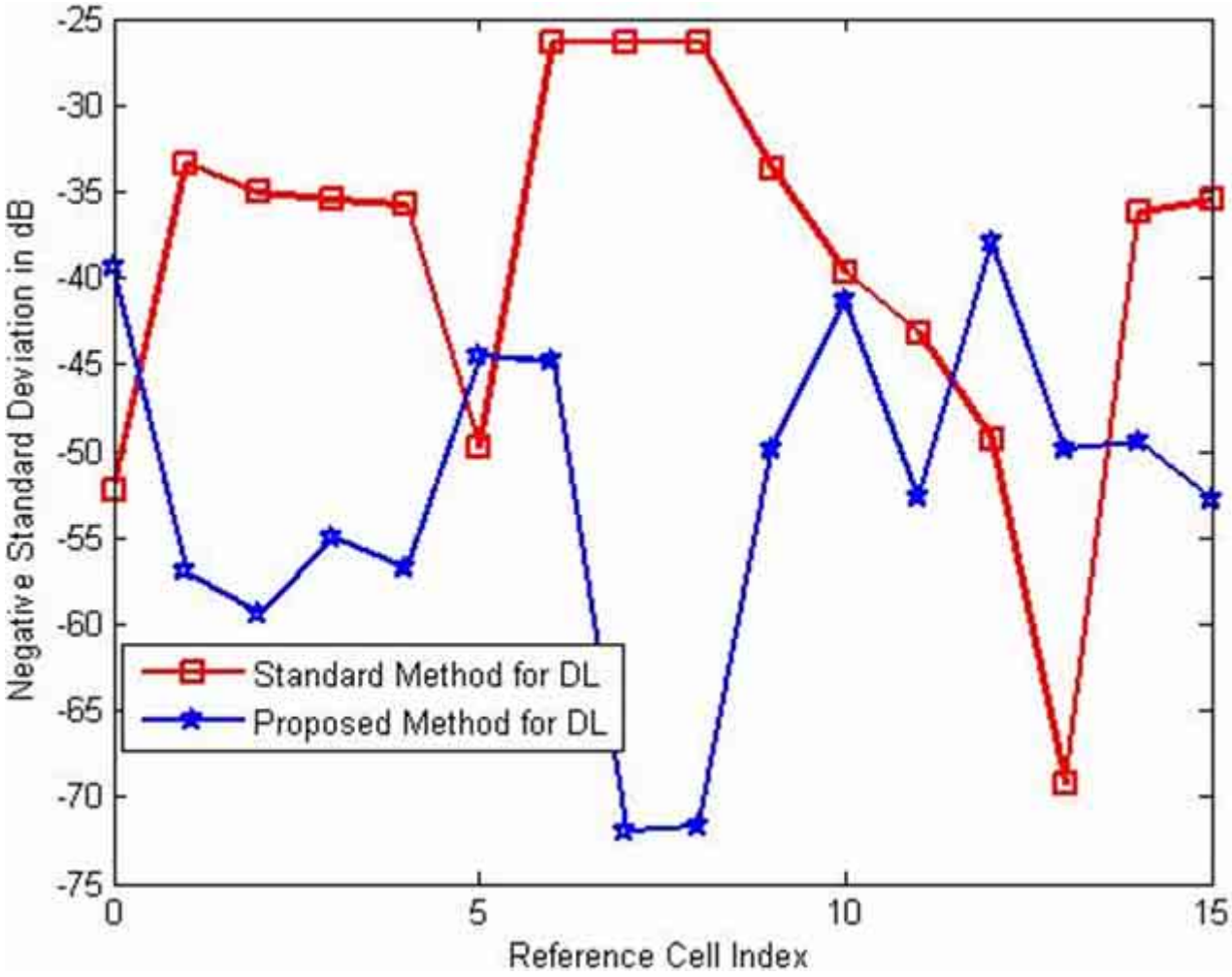
WiMAX 802.16 standard's metric for Downlink, Reference cell 0, reference subchannel 1 to 10



Proposed method's metric for Downlink. Reference cell 0, reference subchannel 1 to 10

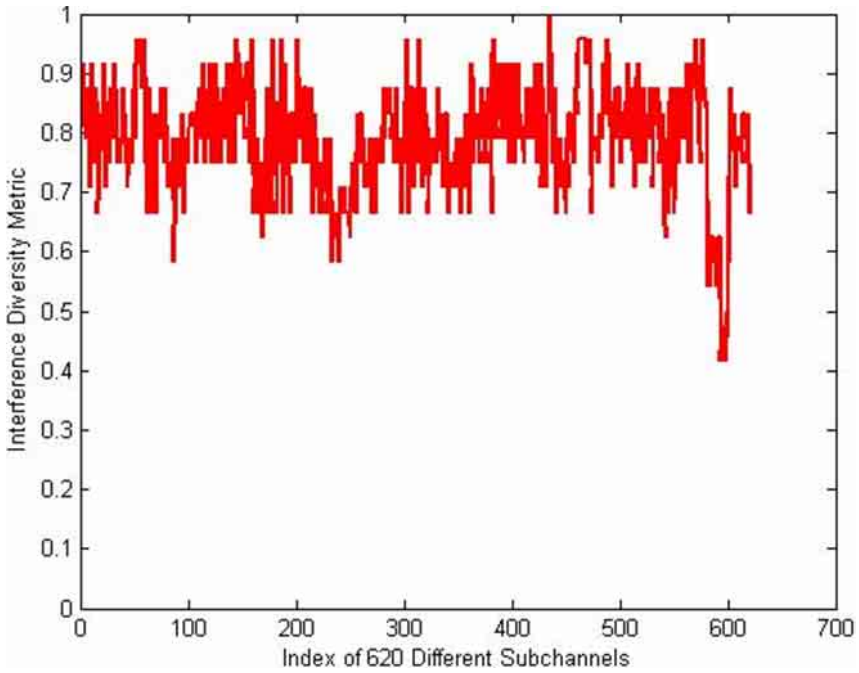


Reference Cell Index Vs Mean , 1024 FFT PUSC on Downlink

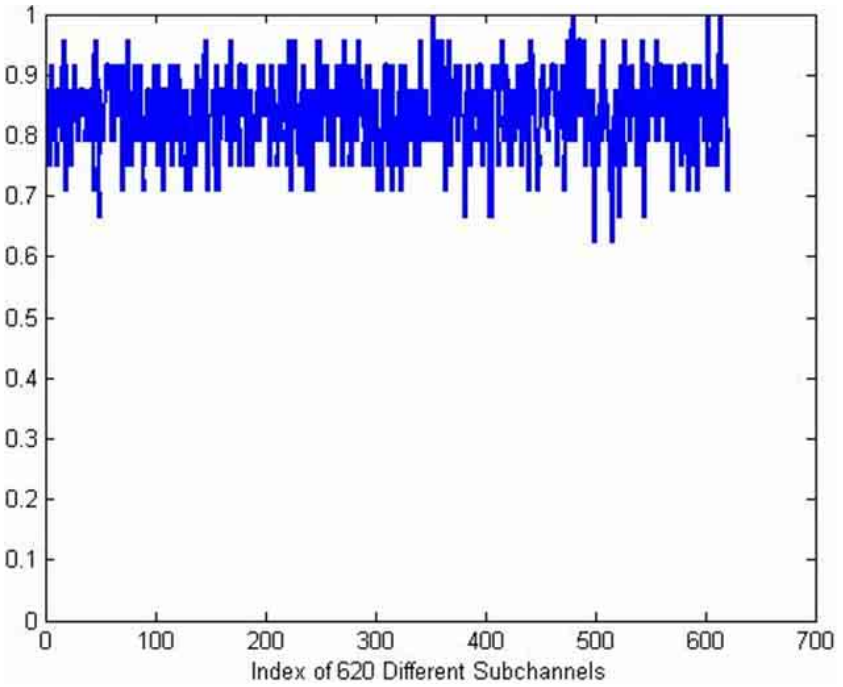


Reference Cell Index Vs Negative Standard Deviation for Downlink
(1024 FFT PUSC, DL)

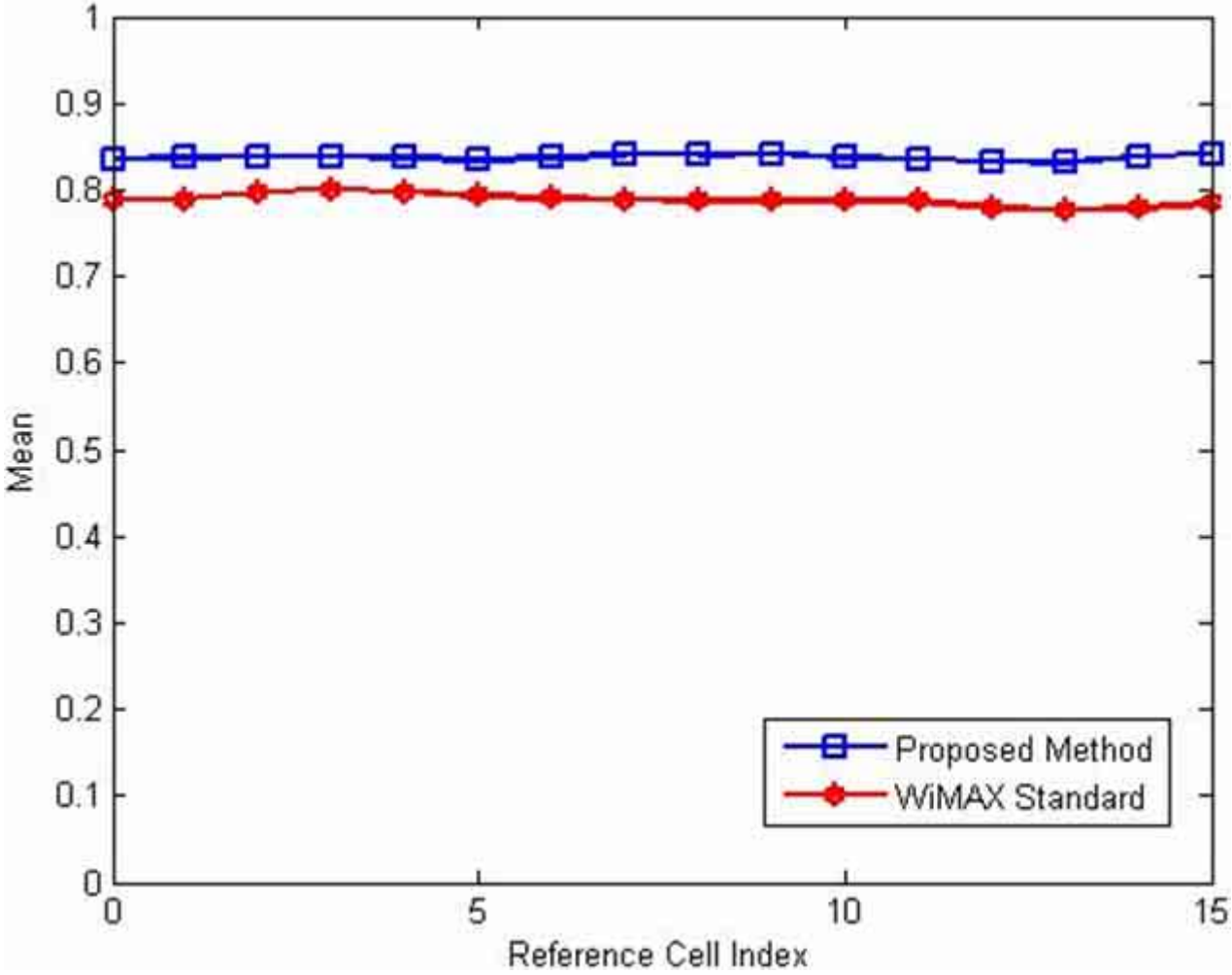
2048 FFT PUSC on Downlink



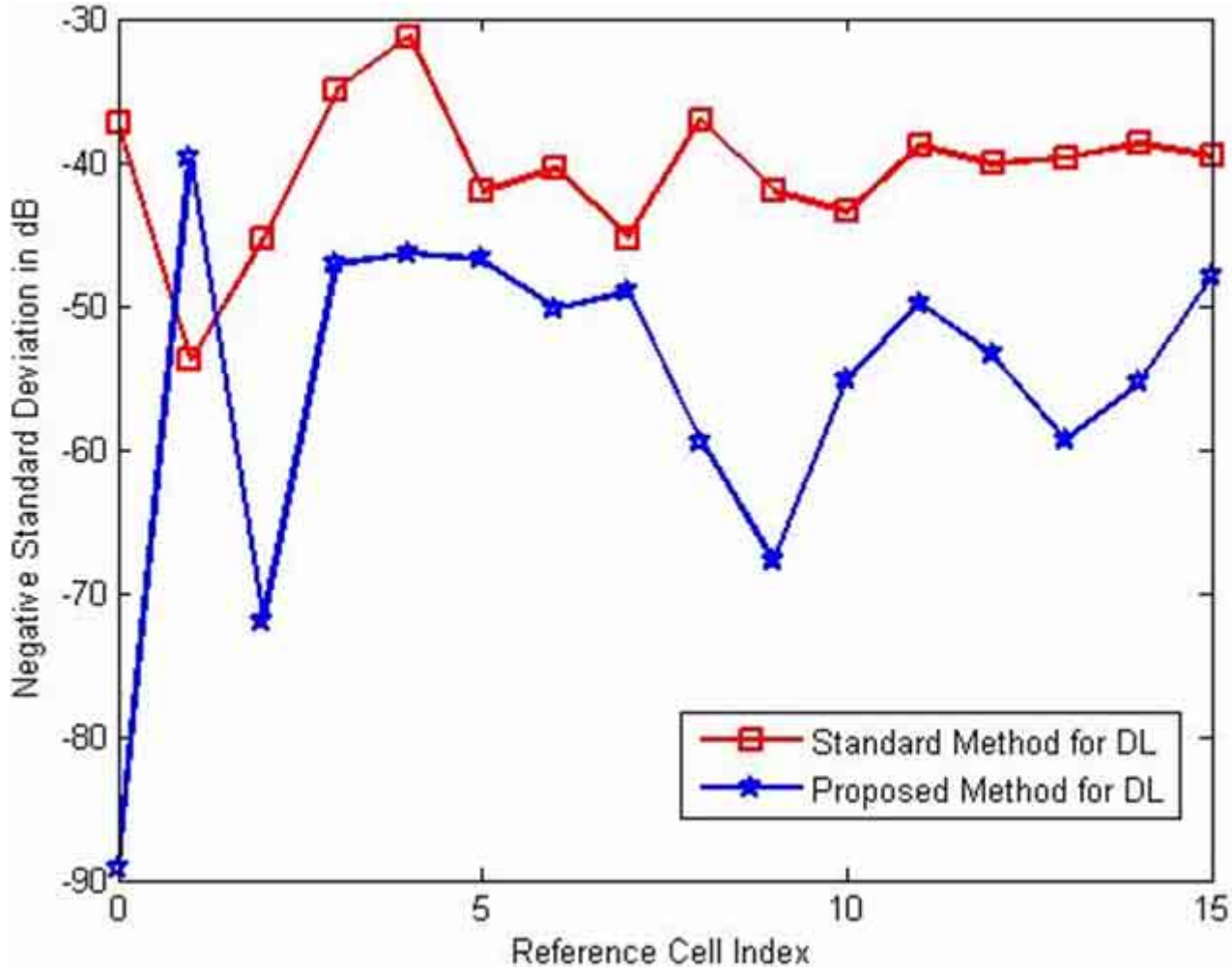
WiMAX 802.16 standard's metric for Downlink, Reference cell 0, reference subchannel 1 to 20



Proposed method's metric for Downlink. Reference cell 0, reference subchannel 1 to 20



Reference Cell Index Vs Mean , 2048 FFT PUSC on Downlink



Reference Cell Index Vs Negative Standard Deviation for Downlink
(2048 FFT PUSC, DL)

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- A heuristic to measure the interference diversity, namely the IDM was proposed.

- The IDM comparisons of the WiMAX standard permutation method and proposed permutation method for various downlink deployments are carried out.

- For 512 FFT PUSC deployment on the downlink, the IDM of the proposed method was found to give 10-15% improvement over the WiMAX standard.

- For 1024 FFT PUSC deployment on the downlink, the IDM of the proposed permutation method was found to be twice better than the WiMAX standard permutation method.

References

1. R.Laroia, S.Uppala and Junyi Li, "Designing a mobile broadband wireless access network", IEEE Signal Processing Magazine, Volume: 21, Issue: 5, pp. 20- 28, Sep 2004.

2. S. Lee et.al. "The wireless broadband (WiBro) system for broadband wireless internet services." Volume 45, pp.106-112. IEEE Communications Magazine, July 2006.

3. DRAFT Standard for Local and metropolitan area networks. Part 16: Air Interface for Fixed Broadband Wireless Access Systems. IEEE P802.16™ (Draft Mar2007), PUSC DL pg 918-919,923

4. DRAFT Standard for Local and metropolitan area networks. Part 16: Air Interface for Fixed Broadband Wireless Access Systems. IEEE P802.16™ (Draft Mar2007), PUSC UL pg 930-931

5. Wilson, Mark C. (2004-06-21). "Overview of Sattolo's Algorithm" in Algorithms Seminar 2002–2004. F. Chyzak (ed.), summary by Éric Fusy. INRIA Research Report 5542: 105–108

6. Makoto Matsumoto, Takuji Nishimura: Mersenne Twister: A 623-Dimensionally Equidistributed Uniform Pseudo-Random Number Generator. ACM Trans. Model. Comput. Simul. 8(1): 3-30 (1998)

7. D. E. Knuth. The Art of Computer Programming, Volume 2: Seminumerical Algorithms, Third Edition. Addison-Wesley, 1997. ISBN 0-201-89684-2. Section 3.2.1`1: The Linear Congruential Method, pp.10–26.

8. Marsaglia, G. (1968). "Random Numbers Fall Mainly in the Plane," Proc. Nat. Acad. Sci., 61, 25-28.

9. The Marsaglia Diehard Battery of Tests of Randomness, Supercomputer Computations Research Institute and Department of Statistics, Florida State University.
URL: http://en.wikipedia.org/wiki/Diehard_tests

10. Andrew Rukhin, Juan Soto, James Nechvatal,Miles Smid, Elaine Barker, Stefan Leigh, Mark Levenson, Mark Vangel, David Banks, Alan Heckert, James Dray, San Vo, "A Statistical Test Suite for Random and Pseudo Random Number Generators for Cryptographic Applications", NIST Special Publication 800-22, revised May 15, 2001

11. Rasmus Bach Nielsen, Anders Norklit Thingholm," Pseudo random bit generator: Practical approach", Dec 2007.
URL: http://www.daimi.au.dk/~ivan/PRGPract.pdf

12. Masood Maqbool, Marceau Coupechoux (2008), Philippe Godlewski, "Subcarrier permutation types in IEEE 802.16e", Département Informatique et Réseaux, Groupe RMS : Réseaux, Mobilité et Sécurité, April 2008. Available at
www.telecom-paristech.fr/_data/files/docs/id_792_1208254315_271.pdf

Thank you!