

Comment Resolution related to 4x4 MIMO Practicality (CID 69)

IEEE P802.22 Wireless RANs

Date: 2014-03-06

Authors:

Name	Company	Address	Phone	email
Gabriel Villardi	NICT	Yokosuka, Japan	+81-46-847-5438	gpvillardi@nict.go.jp
Hiroshi Harada	NICT	Yokosuka, Japan		harada@nict.go.jp

Notice: This document has been prepared to assist IEEE 802.22. It is offered as a basis for discussion and is not binding on the contributing individual(s) or organization(s). The material in this document is subject to change in form and content after further study. The contributor(s) reserve(s) the right to add, amend or withdraw material contained herein.♪

♪

Release: The contributor grants a free, irrevocable license to the IEEE to incorporate material contained in this contribution, and any modifications thereof, in the creation of an IEEE Standards publication; to copyright in the IEEE's name any IEEE Standards publication even though it may include portions of this contribution; and at the IEEE's sole discretion to permit others to reproduce in whole or in part the resulting IEEE Standards publication. The contributor also acknowledges and accepts that this contribution may be made public by IEEE 802.22.♪

♪

Patent Policy and Procedures: The contributor is familiar with the IEEE 802 Patent Policy and Procedures ♪
<<http://standards.ieee.org/guides/bylaws/sb-bylaws.pdf>>, including the statement "IEEE standards may include the known use of patent(s), including patent applications, provided the IEEE receives assurance from the patent holder or applicant with respect to patents essential for compliance with both mandatory and optional portions of the standard." Early disclosure to the Working Group of patent information that might be relevant to the standard is essential to reduce the possibility for delays in the development process and increase the likelihood that the draft publication will be approved for publication. Please notify the Chair Apurva Mody <apurva.mody@ieee.org> as early as possible, in written or electronic form, if patented technology (or technology under patent application) might be incorporated into a draft standard being developed within the IEEE 802.22 Working Group. If you have questions, contact the IEEE Patent Committee Administrator at <patcom@ieee.org>.♪

Comment Resolution (CID 69)

ID	Comment	Suggested Remedy
69	Due to the physical size of the antennas in the VHF and UHF TV broadcast bands, the use of 4 x 4 MIMO will very likely be limited.	Consider the added complexity to the proposed standard and the probability of use of such technology in practice.

Proposed Resolution:

We propose to keep 4 x 4 MIMO configuration in the standard.

We agree with the comment that in TVWS, the distances required to yield uncorrelated fading among the elements of the antenna array are bigger than the distances required by other wireless communication systems operating at higher frequencies. We however think that 4 x 4 MIMO in TVWS is not unpractical therefore not having limited usability. The reasons for the aforementioned judgment is as follows:

Comment Resolution (CID 69)

- Consider the wavelength for $f = 600\text{MHz}$;
 - $\lambda = c/f = 0.5$ meters
- For highly positioned antennas (e.g., base-stations, higher relays)
 - Antenna separation of 10λ to achieve uncorrelated fading [1], [2]
 - $10 \lambda = 5$ meters
- For antennas with comparable height as the local scatters (terminals, lower relay stations)
 - Antenna separation of 0.5λ to achieve uncorrelated fading [1],[2].
 - $0.5 \lambda = 0.25$ meters

Comment Resolution (CID 69)

- Several antenna array configurations exist
 - Uniform Linear Array (ULA)
 - Uniform Circular Array (UCA)
 - Uniform Rectangular Array (URA)
 - Uniform Cubic Array (UCuA)

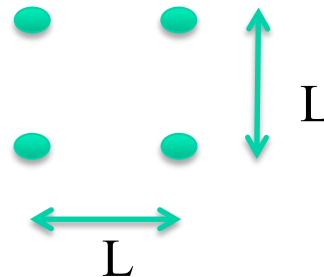
- 4x4 ULA (10λ BS, High relay)

- $L = 15$ meters




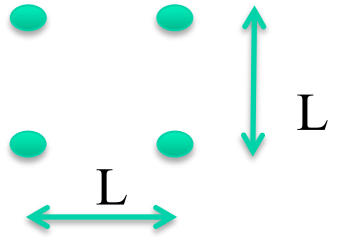
- 4x4 URA (10λ BS, High relay)

- $L = 5$ meters



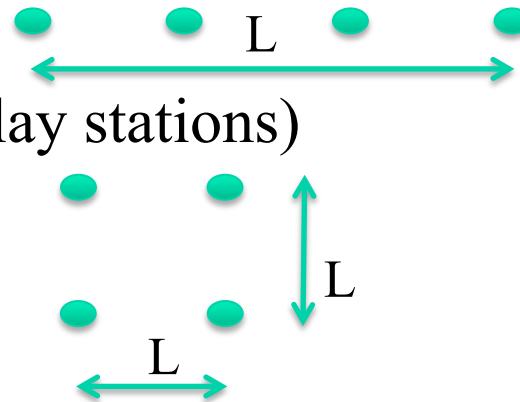
- As stated in [1], 4λ (2 meters) is however capable of achieving 80% of the throughput as compared to 10λ separation.

Comment Resolution (CID 69)

- 4x4 ULA (4 λ BS, High relay)
 - L = 6 meters
- 4x4 URA (4 λ BS, High relay)
 - L = 2 meters
- Despite having a large array, URA of 5 meters (and even ULA of 15 meters) can be practical if one considers that both base stations and relay stations do not necessarily have antennas fixed to it, i.e., antennas can be spread each to different corners of a building roof-top.
- In the case 4 λ is utilized with the cost of 20% throughput reduction, we believe that practicality concerns nearly disappears

Comment Resolution (CID 69)

- 4x4 ULA (Terminals, Low relay stations)
 - $L = 1$ meter
- 4x4 URA (Terminals, Low relay stations)
 - $L = 0.25$ meters



For the case of low height antennas, the array length for 4 antennas is obviously practical.

Comment Resolution (CID 69)

- ULA and URA do have different throughput
 - $ULA_{\text{throughput}} > URA_{\text{throughput}}$
- As shown in [3], URA still provided significant spectral efficiency improvement (throughput) as compared to the SISO system. Therefore being also a useful means to realize 4x4 MIMO in TVWS.
- Additionally, [4] develops a compact MIMO antenna by using polarization discrimination, which would further reduce the distance requirements given in this presentation.

Comment Resolution (CID 69)

References

- [1] D. Chizhik, F. Rashid-Farrokhi, J. Ling, A. Lozano, “Effect of antenna separation on the capacity of BLAST in correlated channels,” *IEEE Communications Letters*, Vol. 4, No. 11, November 2000.
- [2] *Multi-Antenna Transceiver Techniques for 3G and Beyond*, Ari Hottinen, Olav Tirkkonen and Risto Vichman, John Wiley and Sons, 2004.
- [3] A.A. Abouda, H.M. El-Sallabi and S.G. Haggman, “Effect of Antenna Array Geometry and ULA Azimuthal Orientation on MIMO Channel Properties in Urban City Street Grid”, *Progress in Electromagnetic Research, PIER* 64, 257-278, 2006.
- [4] J.B. Andersen and B.N. Getu, “The MIMO Cube – a Compact MIMO Antenna”, *Proc. Of IEEE Wireless personal Multimedia Commun.* Vol. 1, 112-114, 2002.