Network MIMO for Inter-cell Interference Mitigation

IEEE 802.16 Presentation Submission Template (Rev. 9)

Document Number:

IEEE S802.16m-08/xxx , Network MIMO for Inter-cell Interference Mitigation

Date Submitted:

2008-01-16

Source: Howard Huang, Cheeni Kadaba, Kemal Karakayali, Sivarama Venkatesan

Alcatel-Lucent E-mail:{hchuang,skadaba,kemal,sivarama}@alcatel-lucent.com

*<http://standards.ieee.org/faqs/affiliationFAQ.html>

Venue:

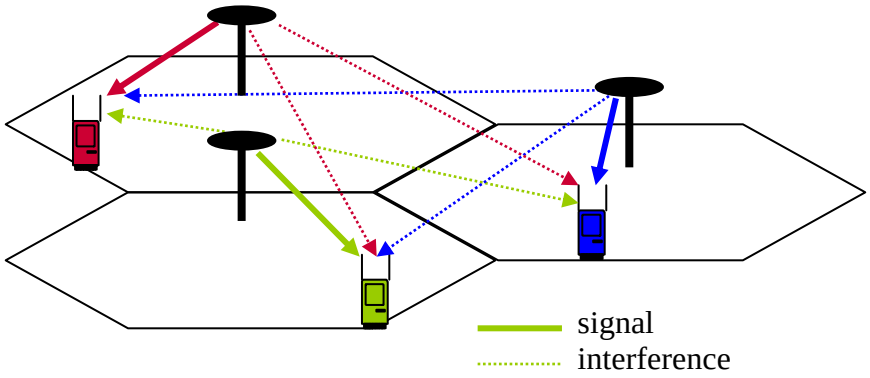
Base Contribution:

IEEE S802.16m-08/xxx , Network MIMO for Inter-cell Interference Mitigation

Purpose:

Input to 802.16m SDD. To drive standardization and the introduction of coherent base station cooperation techniques to mitigate inter-cell interference and increase system capacity.

Cellular Networks: Where are we today?

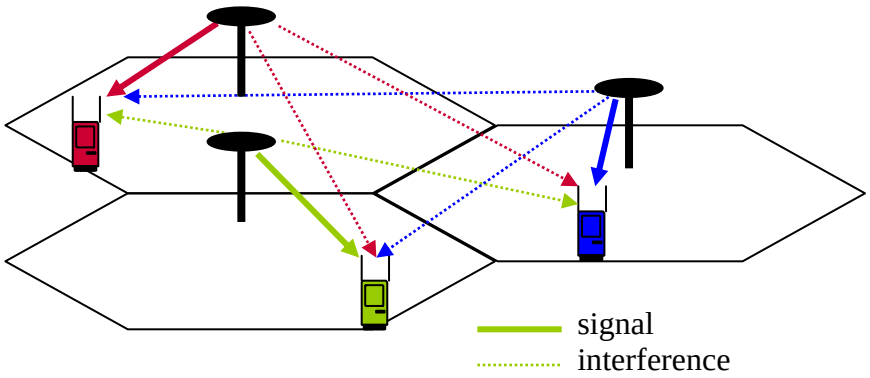


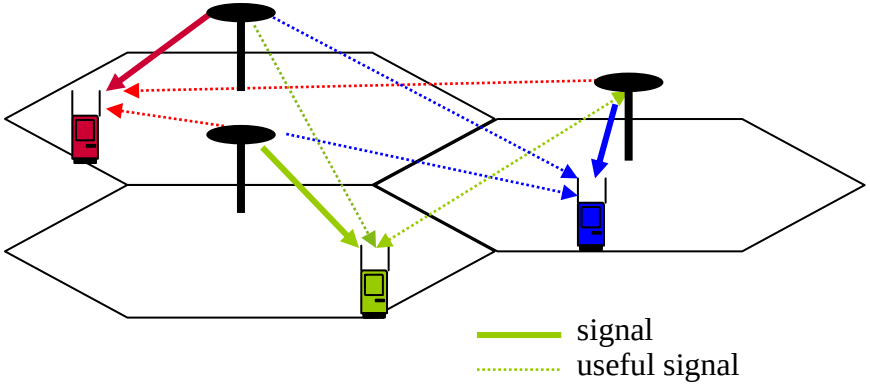
- Well known advances in adaptive modulation and coding, power control and HARQ techniques have greatly improved link level performance
- However, inter-cell interference limits system capacity

  - Very low cell-edge throughput despite use of limited coordination across base stations (e.g. conventional macro-diversity techniques, power control etc).

  - Single user and multi-user MIMO techniques improve rates, but their performance is fundamentally limited by inter-cell interference

Introduction to Network MIMO Concept

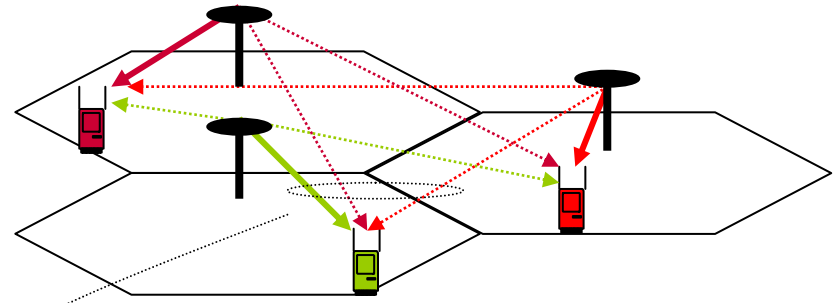




- Coordinated Networks: Base stations act together to mitigate inter-cell interference
  - Downlink: Coherent combining of signals and interference nulling via coordinated transmissions from multiple base stations
  - Uplink: Coherent combining of signals and interference suppression via coordinated receptions at multiple base stations

A Case for Network MIMO: Multiple Antenna Cellular Networks

- Conventional Single User and Multi-User MIMO
  - Linear increase in rate by the use of multiple antennas [Foschini'96].
  - Multiple antenna gains are quite limited at low SINRs (e.g. small marginal rate increase - slope of the capacity vs. number of antennas curve at low SINRs).

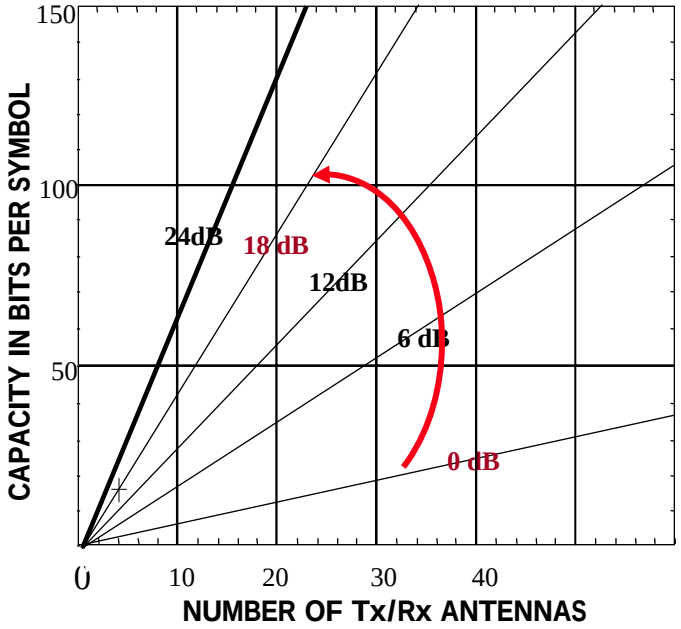


$$\text{SINR:}\ \frac{\text{signal}}{\text{noise+interference}}$$

~ 0 dB (with interference)

~18dB (without interference)

Network MIMO can help improve operating SINR thus closing the gap between interference limited and noise limited regime

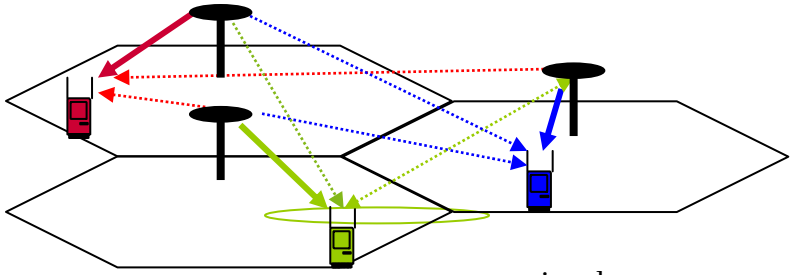


Network MIMO can greatly improve the efficiency of multiple antennas in cellular networks.

Coordinated Cellular Networks

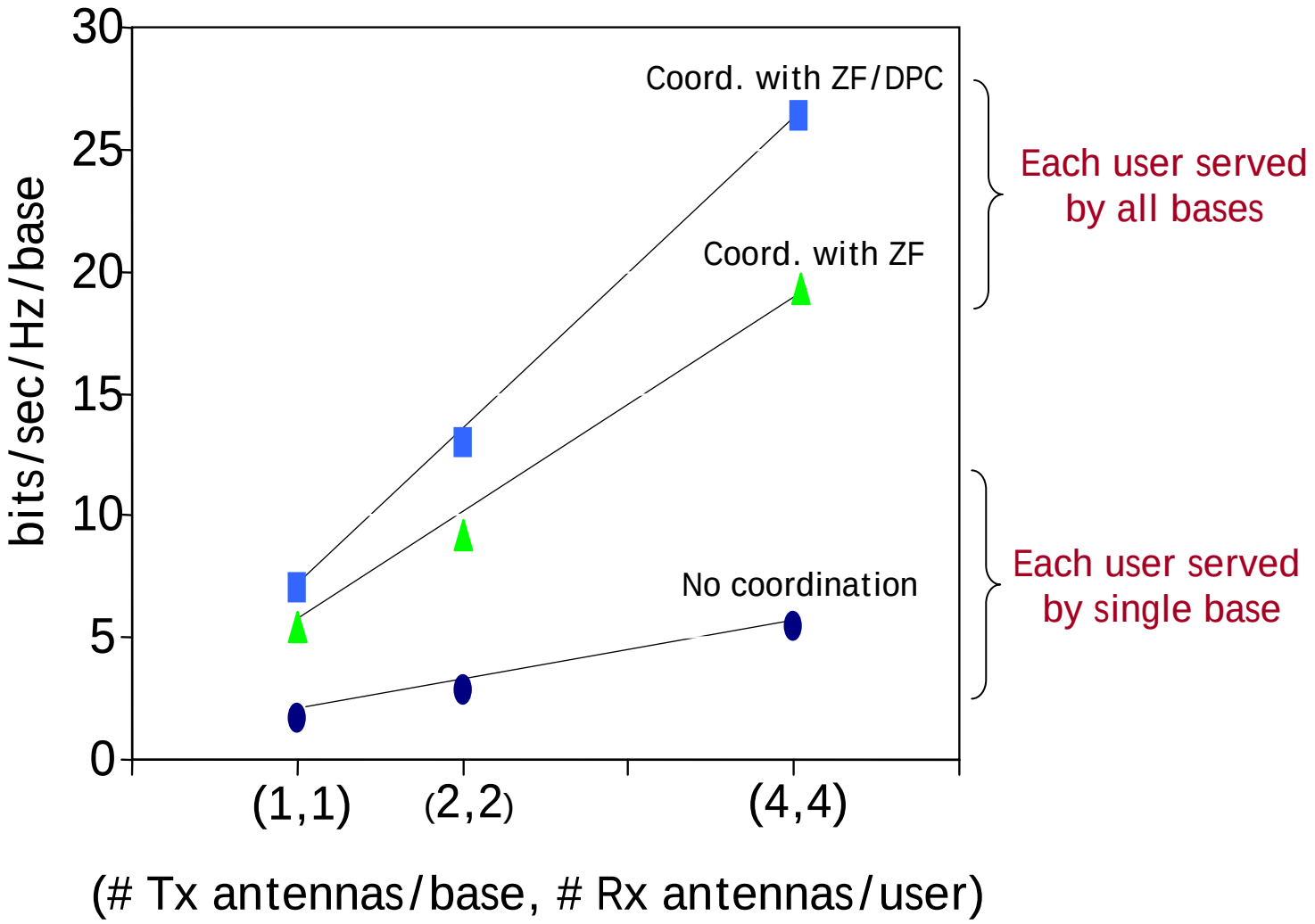
- **Constructive superposition of signals, interference suppression**
  - Linear cooperative beamforming techniques exploiting short-term estimates of channel magnitude, phase information (coherent)
- **Options under consideration for interference avoidance/nulling/suppression**
  - Zero Forcing (Downlink & Uplink)
  - MMSE (Downlink & Uplink)
  - Dirty Paper Coding (Downlink)
  - Successive Interference Cancellation (Uplink)

Applied across multiple coordinated base stations

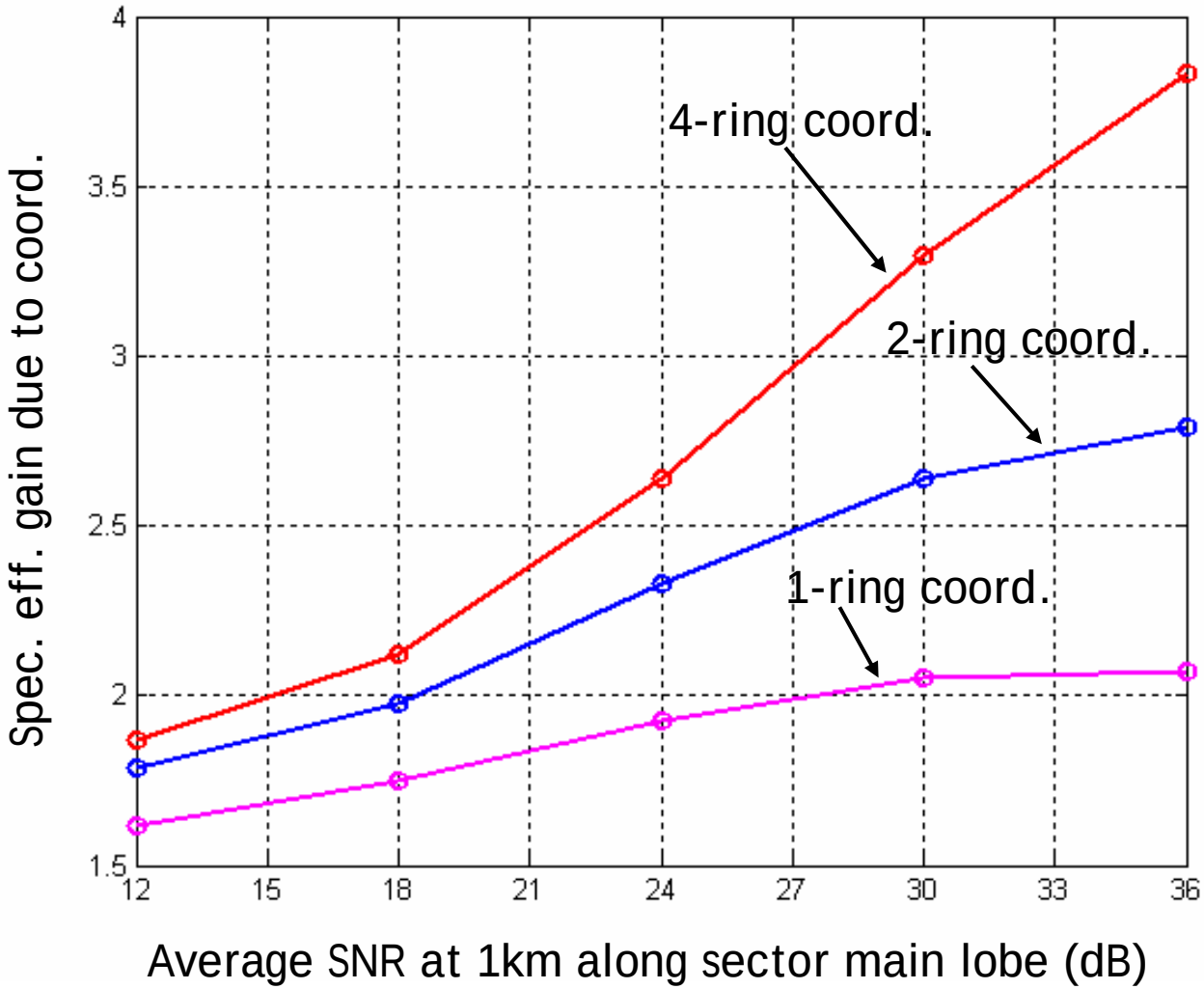


Coherent addition of signals with interference avoidance (nulling)

Achievable Spectral Efficiency With Network MIMO: Sample Downlink Results (Tx antennas/base, Rx antennas/user)



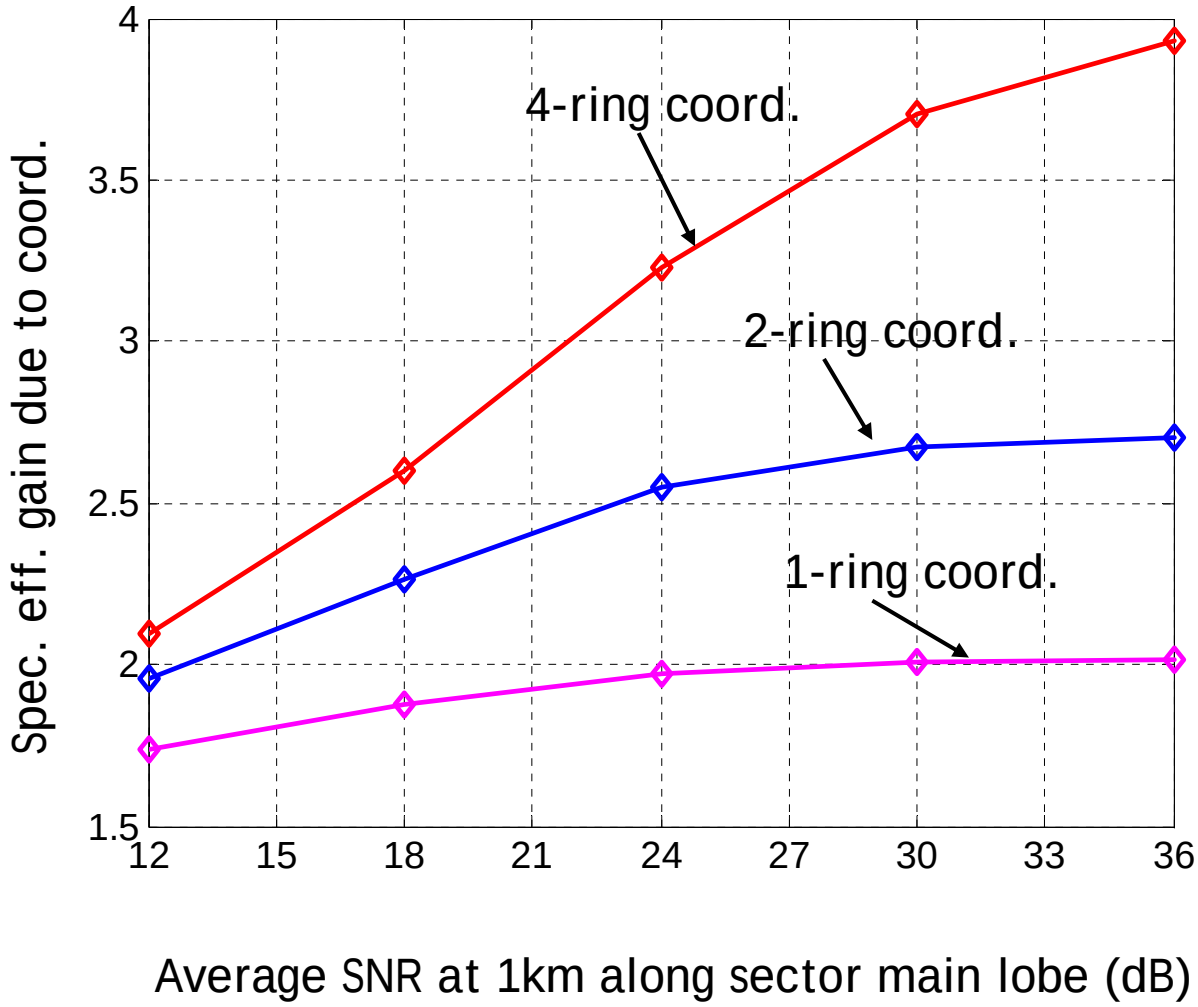
Achievable Spectral Efficiency With Network MIMO (contd.): Sample Uplink Results (1 antenna/user,1 antenna/sector)



Nearly 4x gain in spec. eff. with 4-ring coord.

Approx. 2x gain in spec. eff. with 1-ring coord.

Achievable Spectral Efficiency With Network MIMO (contd.): Sample Uplink Results (4 antennas/user, 4 antennas/sector)



Nearly 4x gain in spec. eff. with 4-ring coord.

Approx. 2x gain in spec. eff. with 1-ring coord.

Network Coordination for 802.16m: Physical/MAC Layer Issues to be addressed

- Assess DL and UL data rate/throughput gains due to Network MIMO
  - Evaluate different alternatives including full and limited coordination
  - Evaluate impact of limitations (imperfect channel estimation, limited/quantized feedback, number of antennas etc)
- Standards Impact assessment for TDD and FDD
  - Pilot structure and sounding channel
  - Feedback design
  - HARQ related issues
  - Signaling channels for resource allocation
- Functional architecture reference model (logical)

Network Coordination for 802.16m (contd.): Network Architecture Issues to be addressed

Network architecture contingent on physical/MAC layer methods

- Functional decomposition and hierarchy
- Backhaul network requirements
- Protocols/messages needed
- Synchronization issues
- Mobility support

Consistency needed with existing and potentially enhanced 802.16 RAN architectures

References

Downlink:

- **Foschini, Huang, Karakayali, Valenzuela, Venkatesan, CISS 2005**
- **Karakayali, Foschini, Valenzuela, Yates, ICC 2006**
- **Foschini, Karakayali, Valenzuela, IEE Proc. Commun., Aug. 2006**
- **Karakayali, Foschini, Valenzuela, IEEE Wireless Commun. Mag., Aug. 2006**

Uplink:

- **Venkatesan, Proc. IEEE PIMRC, 2007**
- **Venkatesan, Proc. IEEE PIMRC, 2007**