3GPP TSG-RAN WG1 #57 **R1-091928**

San Francisco, US, May 4 – 8, 2009

Opportunistic Space Time Multiple Access for LTE-Advanced

Agenda Item:	**15.6**
Source:	**Nortel Networks**
Document for:	**Discussion and Decision**

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LTE-Advanced Requirements

- According to TR 36.913 v8.0.1:
  - *“Advanced E-UTRA should target the average spectrum efficiency and cell edge user throughput to be as high as possible, given a reasonable system complexity.”*
- Targets for average spectrum efficiency:

Radio env. Ant. Config		Case 1 [bps/Hz/cell]
UL	1x2	1.2
	2x4	2.0
DL	2x2	2.4
	4x2	2.6
	4x4	3.7

- Targets for cell edge user throughput:
  - 10 users uniform-randomly dropped in the cell

Radio env. Ant. Config		Case 1 [bps/Hz/cell/user*]
UL	1x2	0.04
	2x4	0.04
DL	2x2	0.07
	4x2	0.09
	4x4	0.12

SDMA

- Current Rel-8 supports SDMA through Transmission mode 5
  - Multi-user MIMO
  - For 2-Tx, a maximum of 2 UEs can be scheduled for the same resources using different precoding vectors in the same cell site simultaneously
  - For 4-Tx, a maximum of 4 UEs can be scheduled simultaneously
    - Standard is optimized for the support of 2 UEs, with respect to signaling
  - Performance gain limited by the current specification
    - e.g., codebook is not optimized for SDMA operation
- Potential gain by SDMA should be further exploited to improve the performance of LTE:
  - Spectrum efficiency
  - Cell edge user throughput

SDMA through OSTMA

- OSTMA provides support for SDMA
- Further performance gain can be exploited through an optimized system design to:
  - Increase multiple access capacity
  - Improve cell coverage
- With minimal feedback overhead

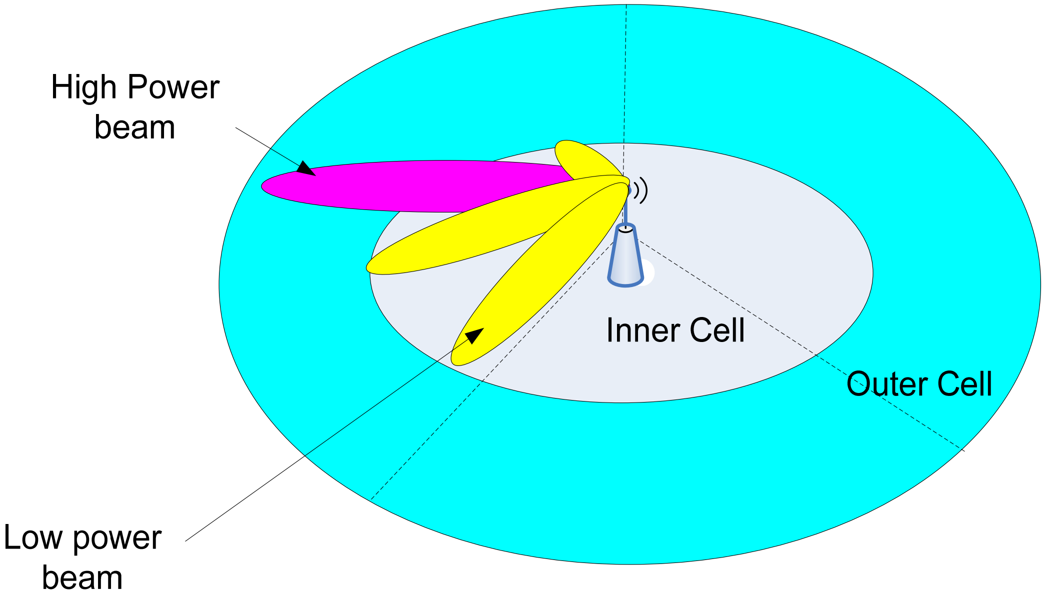
OSTMA = Opportunistic Space-Time division Multiple Access

OSTMA

- OSTMA is a flexible and efficient space-time division multiple access scheme
  - In the basic configuration, there is one antenna panel with multiple sweeping beams
  - In the advanced configuration, multiple antenna panels form a multi-ring structure in the coverage of a cell site
  - A self-contained backhaul network is enabled via the additional antenna panel
  - Improved performance for cell-edge users by flexible beam scheduling and power management
  - Envision major benefits of OSTMA on forward link

OSTMA further exploits space-time division with an added dimension of cell coverage design

Basic configuration of OSTMA : single antenna panel (1)



- eNodeB transmits both high and low power beams simultaneously
  - One or multiple high power beams in a cell/sector to cover cell-edge users
  - Low power beams reduce the unnecessary interference in the system to improve cell-edge user performance
- Beam sweeps in a deterministic or random fashion

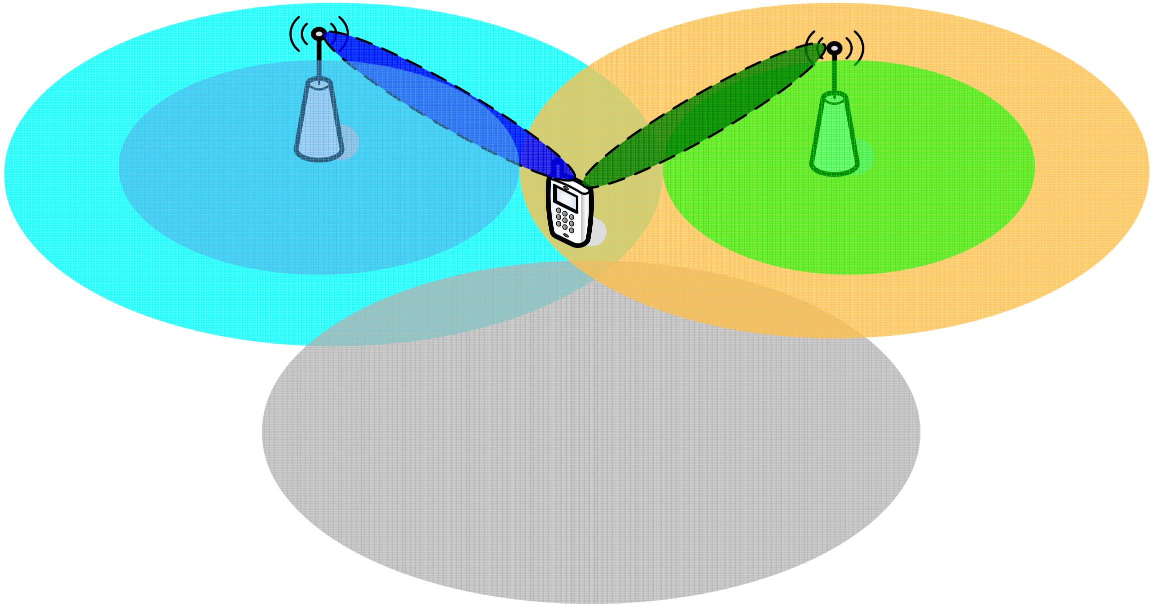
Basic configuration of OSTMA : single antenna panel (2)

- The beam duration, duty cycle and beam scheduling could be dynamic based on channel condition, QoS and loading etc.
- Pre-flash enables advanced radio resource management
  - Designed for UE to report CQI efficiently
  - In the middle of regular traffic transmission, eNodeB sends a sequence of short pilot bursts to all beam directions, known as pre-flashes, for mobiles to make channel measurements and report back.
  - eNodeB schedules traffic transmissions accordingly
    - eNodeB may only schedule beams which have mobiles in it.
  - The pre-flashes and traffic transmissions can be time multiplexed with different periodicities

Support of distributed MIMO

- CoMP can be supported effectively through joint scheduling of OSTMA

Terminal jointly served by two base stations via distributed MIMO



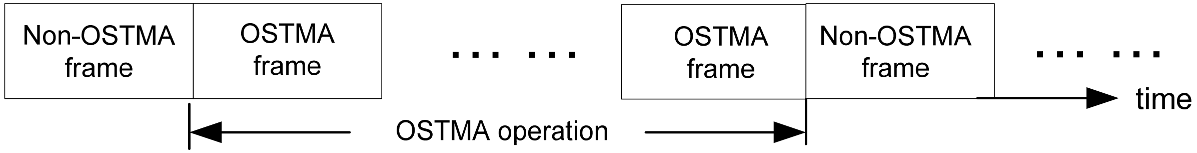
OSTMA potentially facilitates the support of distributed MIMO

Benefits of OSTMA

- Compared to adaptive beamforming, OSTMA has less stringent requirement on tracking and feedback
  - less accurate mobility tracking due to the nature of beam sweeping
  - less frequent feedback due to reduced requirement on tracking accuracy
  - ➢ reduced feedback and tracking overhead
- Comparing with fixed beamforming, OSTMA offers improved performance
  - OSTMA employs advanced radio resource management to dynamically schedule beams, beam duration and duty cycle based on user traffic, QoS, cell loading etc.
- Coverage improvement
  - Flexible beam scheduling and power management reduce interference in the system and improve performance of cell-edge users
- Support of advanced MIMO schemes
  - Flexible beam scheduling offers the capability to support advance MIMO operations, such as distributed MIMO
- Self-contained wireless backhaul

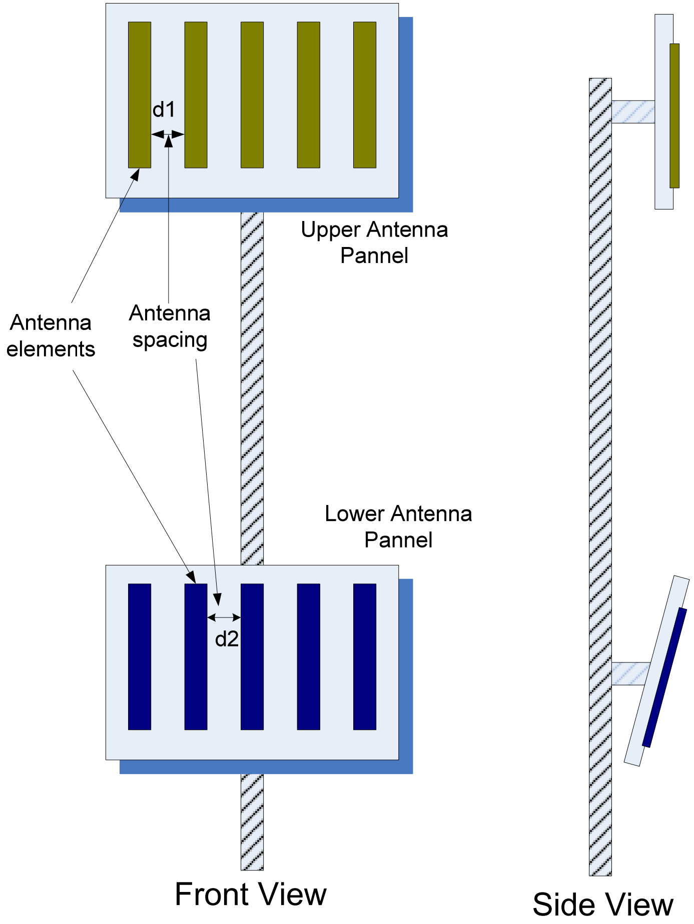
Integrate OSTMA with Release 8 Systems

- OSTMA could be dynamically turned on, for example, if there are lots of cell-edge users



- Include as a new transmission mode which can be applied to some or all subframes, if desired

Advanced configuration of OSTMA : multiple antenna panels (1)



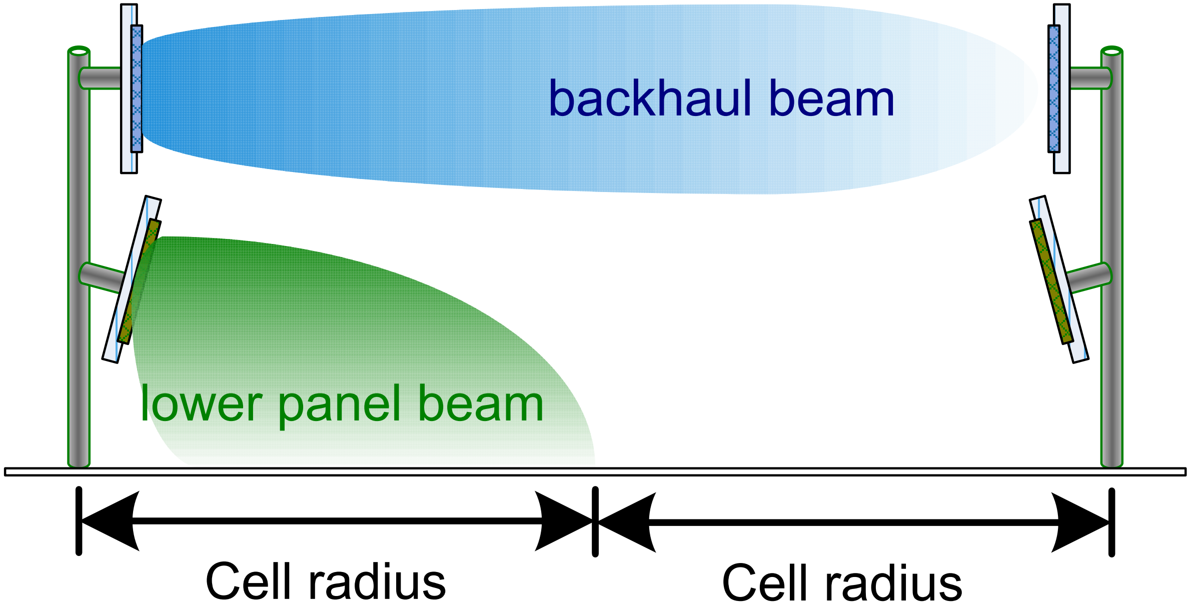
- eNodeB could have multiple antenna panels. In case of two panels:
  - lower panel could point into the cell, i.e., cover cell center and cell-edge area
  - upper panel could point outwards, i.e., cover cell edge area and into the coverage of adjacent cells for backhaul transmission
- The upper panel can be used for:
  - backhaul traffic transmission
  - handover region coverage
  - together with the lower panel, adding additional antenna elements for cell-edge users to enable advanced MIMO schemes

Multiple antenna panels form a multi-ring structure in cell coverage

Advanced configuration of OSTMA : multiple antenna panels (2)

Example configuration 1:

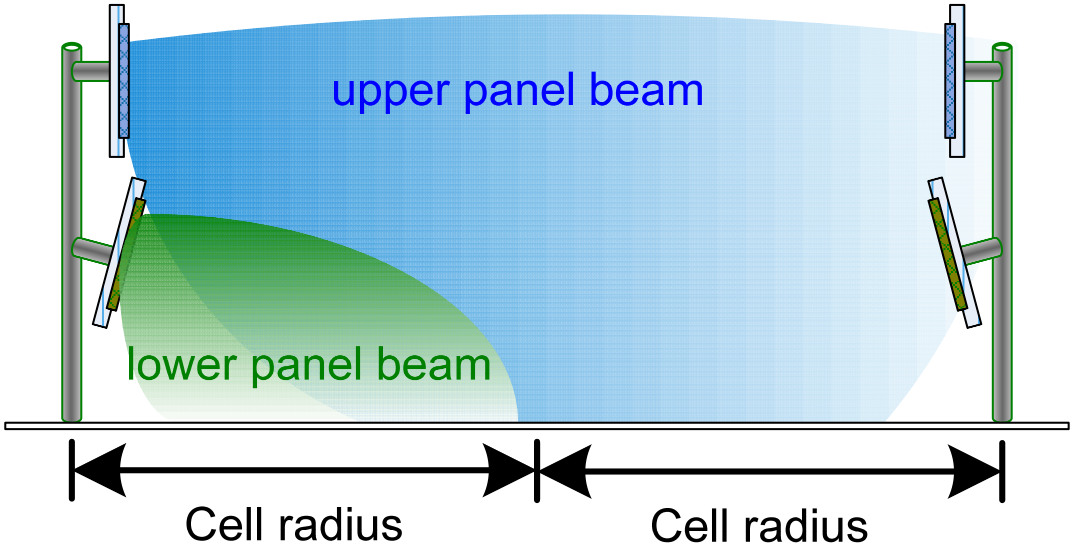
The two antenna panels have no overlapped coverage area. The lower panel transmits both low and high power beams covering the cell, while the upper panel is directed at other cells to form a backhaul network. The upper and lower panels could be located far apart.



Advanced configuration of OSTMA : multiple antenna panels (3)

Example configuration 2:

The two antenna panels have overlapped coverage area. The lower panel transmits both low and high power beams covering the cell, and the upper panel covers cell-edge and into other cells for backhaul transmission. The upper and lower panels are located close to each other.

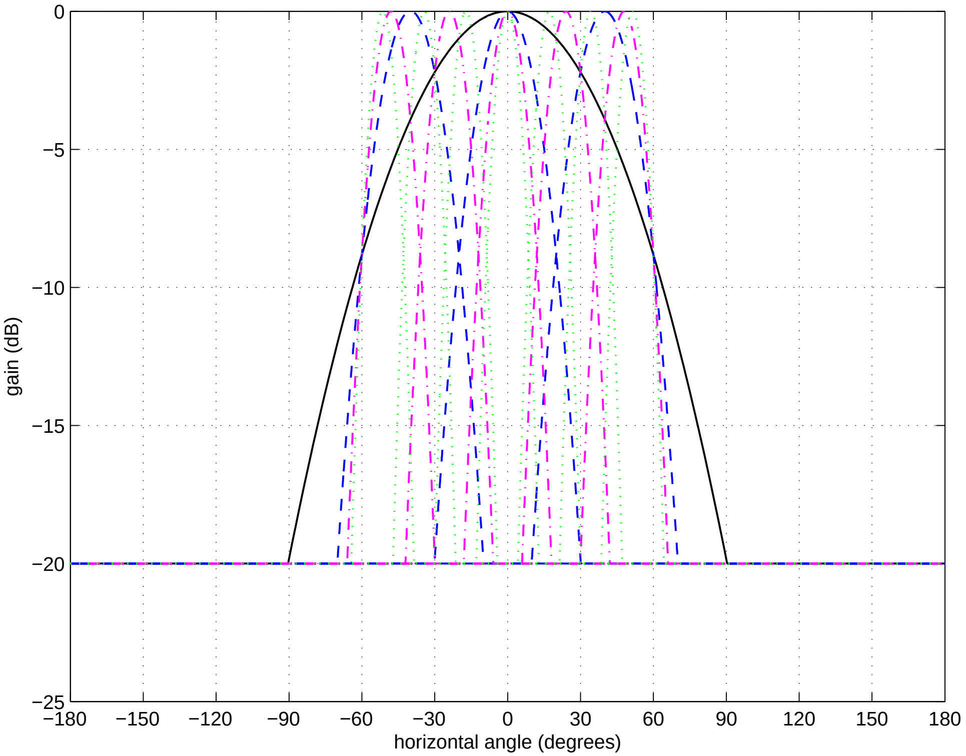


In the overlapped coverage area, i.e. for cell-edge users, the upper panel together with the lower panel forms additional antenna elements to enable advanced MIMO schemes for better signal reception.

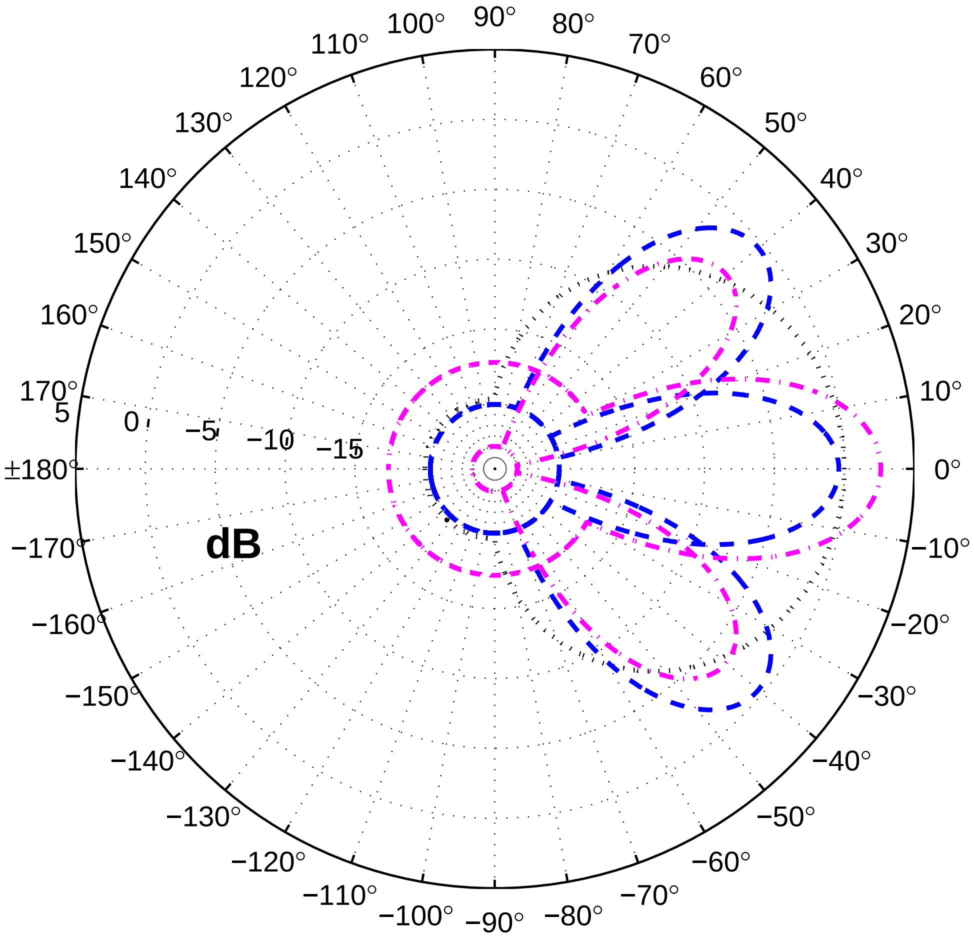
Assumptions: antenna patterns

- For 1 beam per sector, antenna pattern is specified by the equation on the right
  - θ_{3dB} = 70 degrees
  - A_m = 20 dB
- For N beams per sector, we assume:
  - Each beam pattern follows the equation on the top-right
    - θ_{3dB} = 70/N degrees
  - N odd
    - beam direction: 0, ± 120/N, …, ± 60(N-1)/N degrees

$$A(\theta) = -\min\left[12\left(\frac{\theta}{\theta_{3dB}}\right)^2, \; A_m\right], \quad \text{where} \quad -180 \le \theta \le 180.$$



Antenna patterns – example: 3-beam vs. 1-beam



- Black curve
  - 1-beam pattern
- Blue curve
  - 3-beam
  - No power split
- Magenta curve
  - 3-beam
  - 6-dB power split between high and low power beams

Summary

- OSTMA is designed for new technology challenges
  - Enable beamforming in high mobility environment
  - Built-in backhaul capability through an additional antenna panel
  - Aggressive interference mitigation via spatial scheduling and power management
  - Efficient radio resource management with pre-flash feature
  - Potential direct support of distributed MIMO
- OSTMA is backward compatible with LTE Release- 8

Conclusion

- Opportunistic Space Time Multiple Access should be considered for LTE-Advanced as part of:
  - CoMP
  - DL transmission enhancement