Technologies for LTE-Advanced

Michael Ohm, Volker Braun, Uwe Doetsch, Cornelis Hoek, Howard Huang, Hans-Peter Mayer,
Le Hang Nguyen, Michael Schmidt, Reinaldo Valenzuela, Sivarama Venkatesan, Andreas Weber, Thorsten Wild

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Agenda

1. Introduction
2. Advanced MIMO schemes
3. Advanced single-site MIMO schemes
4. Advanced multi-site MIMO schemes
5. Conclusion

1 Introduction

3GPP LTE and LTE-Advanced

3GPP LTE and LTE-Advanced

- 3rd Generation Partnership Project (3GPP)
  - Standardization group consisting of operators, network and handset suppliers, etc.
- Standardization of UMTS and its successor Long Term Evolution (LTE)
- Standardization of LTE finished (is now in maintenance phase)
- Standardization of successor to LTE started

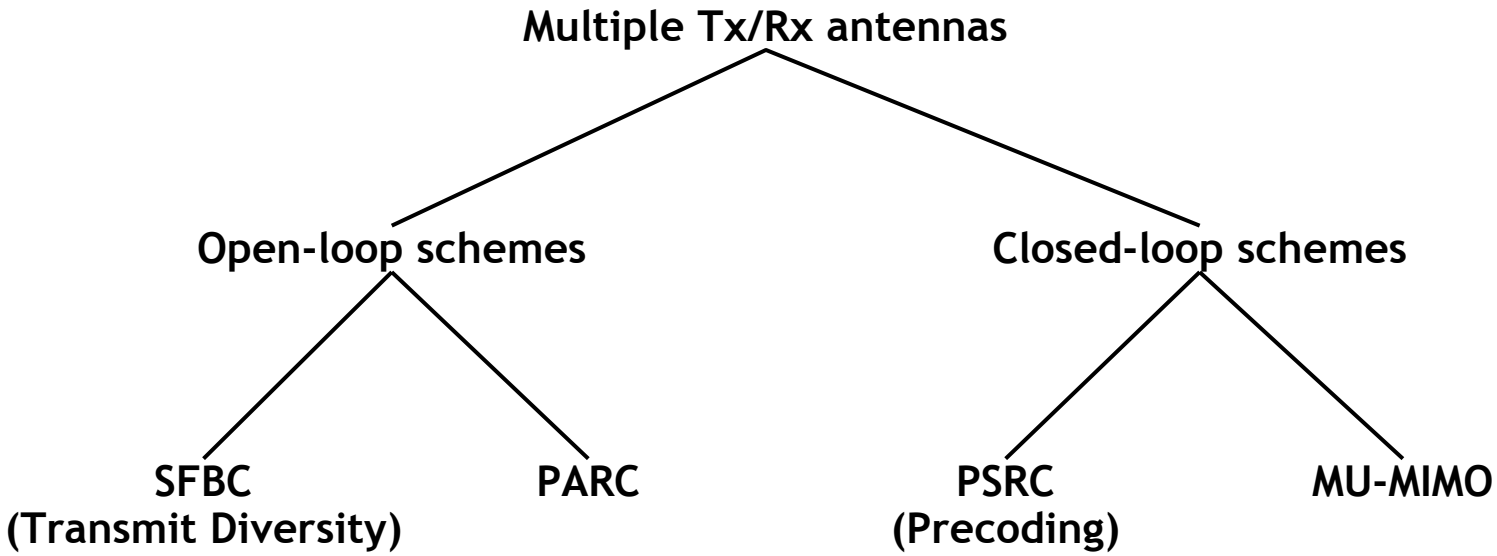
  ➔ Successor is LTE-Advanced

Where do we start?

Key features of LTE

- Air interface
  - OFDMA in downlink (orthogonal frequency division multiple access)
  - SC-FDMA in uplink (single-carrier frequency division multiple access, i.e. DFT-spread OFDM)
- Scalable bandwidth: 1.25 MHz up to 20 MHz
- Frequency-reuse 1 system: Neighboring cells w/ the same carrier frequency
- Multiple transmit and receive antennas at the eNodeB (i.e. base station)
- Single transmit and multiple receive antennas at UE (i.e. mobile station)
- Focus on FDD, but TDD option is also standardized (frequency/time division multiple access)
- Flat hierarchy in radio access network (RAN)

Multi-Antenna / MIMO schemes are an integral part of 3GPP LTE



LTE MIMO schemes are single-site schemes (i.e. operation per cell)

PARC ... Per antenna rate conrol
PSRC ... Per stream rate control
MU ... Multi user
SFBC ... Space-frequency block coding

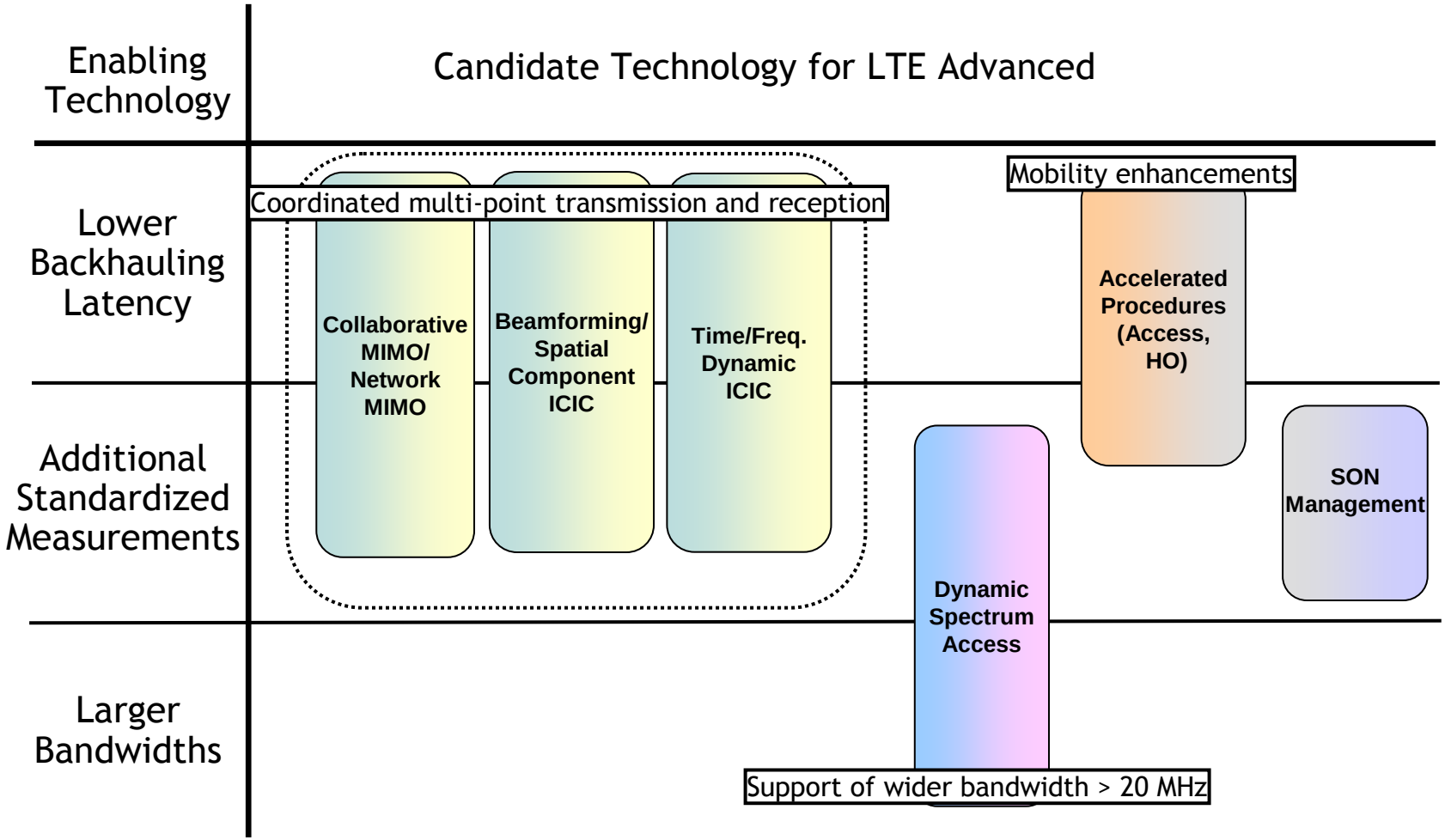
Where do we want to go?

Ambitious performance improvements for LTE-Advanced

LTE-Advanced performance targets:

- **High peak data rates** of 1 Gbit/s in the downlink (DL) and 500 Mbit/s in the uplink (UL)
- **High peak spectrum efficiencies** of 30 bit/s/Hz in the DL and 15 bit/s/Hz in the UL using antenna configurations of up to 8x8 in the DL and 4x4 in the UL
- **High average spectrum efficiencies** of up to 3.7 bit/s/Hz/cell in the DL (4x4) and 2.0 bit/s/Hz/cell in the UL (2x4)
- **High cell edge spectrum efficiencies** of 0.12 bit/s/Hz in the DL (4x4) and 0.07 bit/s/Hz in the UL (2x4)
- **High spectrum flexibility**, e.g. spectrum allocations up to 100 MHz
- Backward compatibility to LTE
- Performance targets in 3GPP TR 36.913 v8.0.0 “Requirements for Further Advancements for E-UTRA (LTE-Advanced)”, June 2008

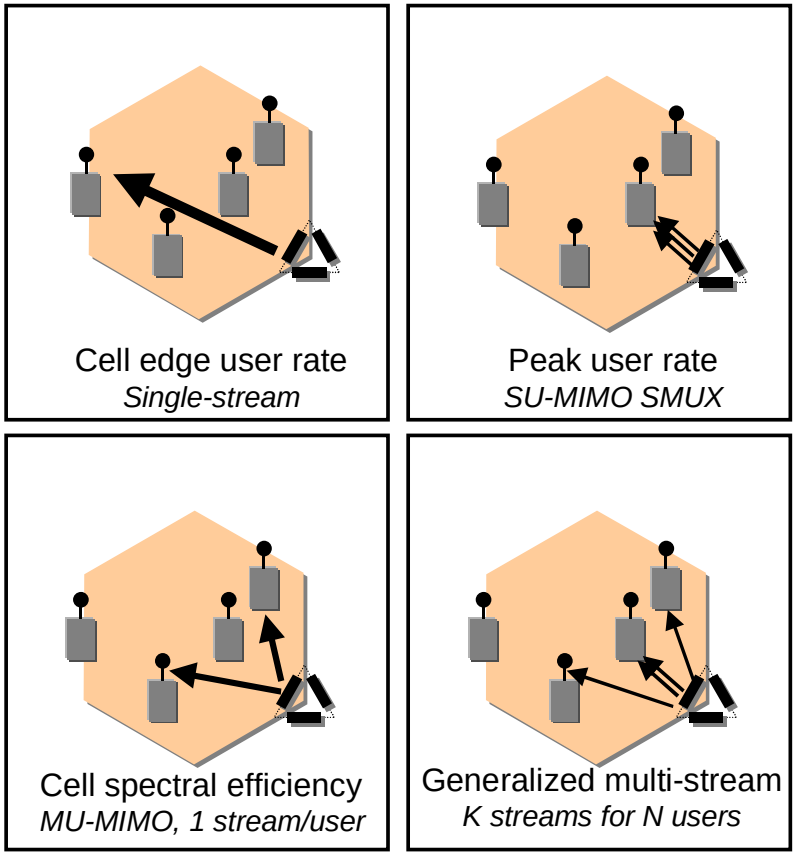
Candidate Technologies for Performance Improvements with LTE Advanced



2 Advanced MIMO schemes

Generalized spatial multiplexing

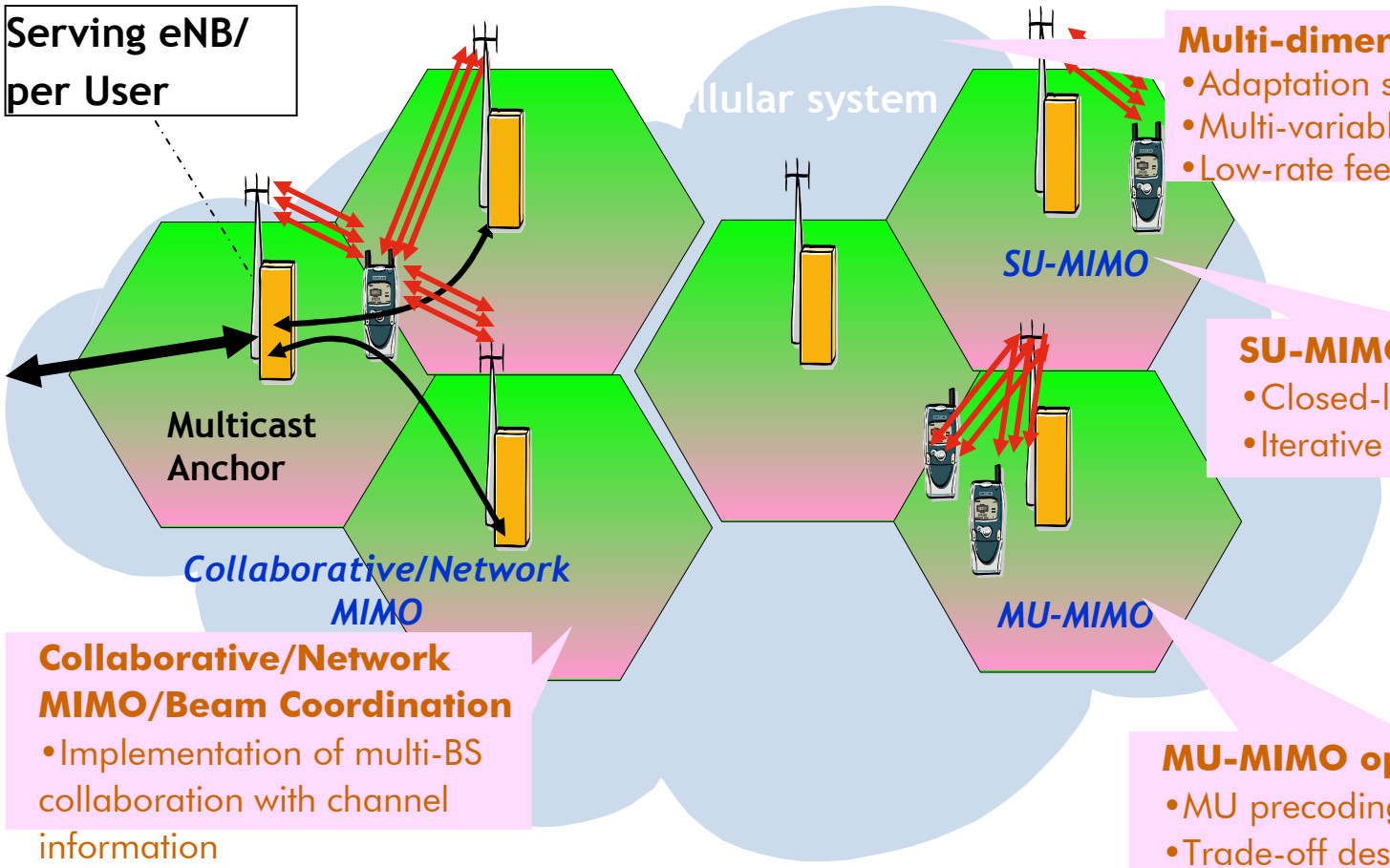
- With M base station antennas, it is possible to transmit up to M spatial streams.
- Generalized spatial multiplexing distributes M streams optimally on a frame-by-frame basis.
  - Performance will be better than SU-MIMO or MU-MIMO alone because it each is a special case.
  - Adapts transmission strategy for each mobile individually based on the number of antennas.



Key technologies in Multi-mode Adaptive MIMO

Data + Sync Protocol for DL (Extension of eMBMS protocol); Data + Channel Estimates for UL

MIMO channel



Multi-dimension adaptation
- Adaptation strategy
- Multi-variable channel measurement
- Low-rate feedback mechanism

SU-MIMO enhancement
- Closed-loop MIMO
- Iterative MIMO receiver

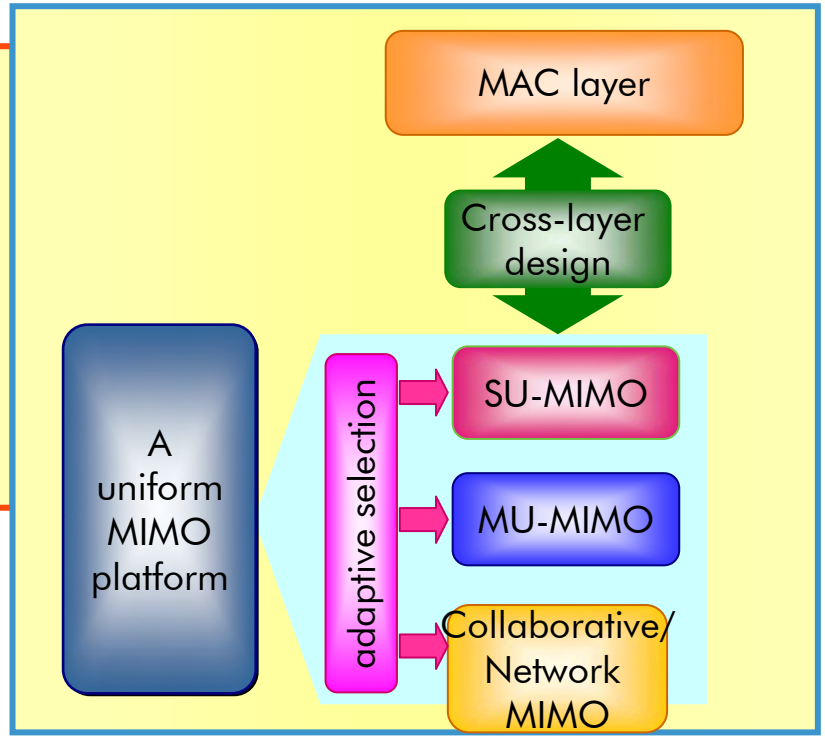
Collaborative/Network MIMO/Beam Coordination
- Implementation of multi-BS collaboration with channel information

MU-MIMO optimization
- MU precoding algorithm
- Trade-off design of scheduler between complexity and performance

Multi-Mode Adaptive MIMO for DL/UL

Use adaptive MIMO to accommodate demand of higher data rate and wider coverage in next generation broadband wireless access

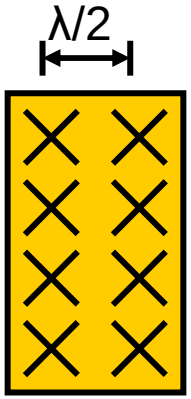
- SU MIMO for peak user data rate improvement
- MU MIMO for average data rate enhancement
- Collaborative/Network MIMO for cell edge user data rate boost

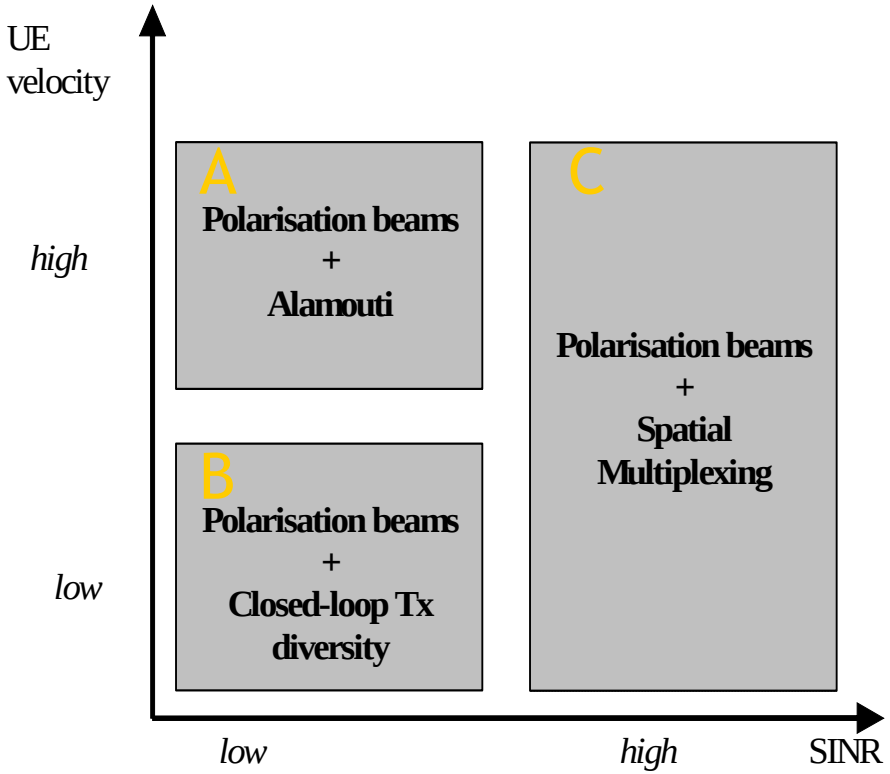


3 Advanced single-site MIMO schemes

New radio systems for LTE advanced
adaptive 4x2 SU-MIMO with dual X-pol transmit arrays

- Exploit combination of:
  - **Beam switching** (always used, low dynamic, low feedback periodicity) **plus**
    - **Open loop TX diversity** in case of high velocity and bad channel quality (no feedback required)
    - **Closed loop TX diversity** in case of low velocity and bad channel quality (higher feedback rate)
    - **Closed loop spatial multiplexing** in case of low velocity and good channel quality (higher feedback rate)





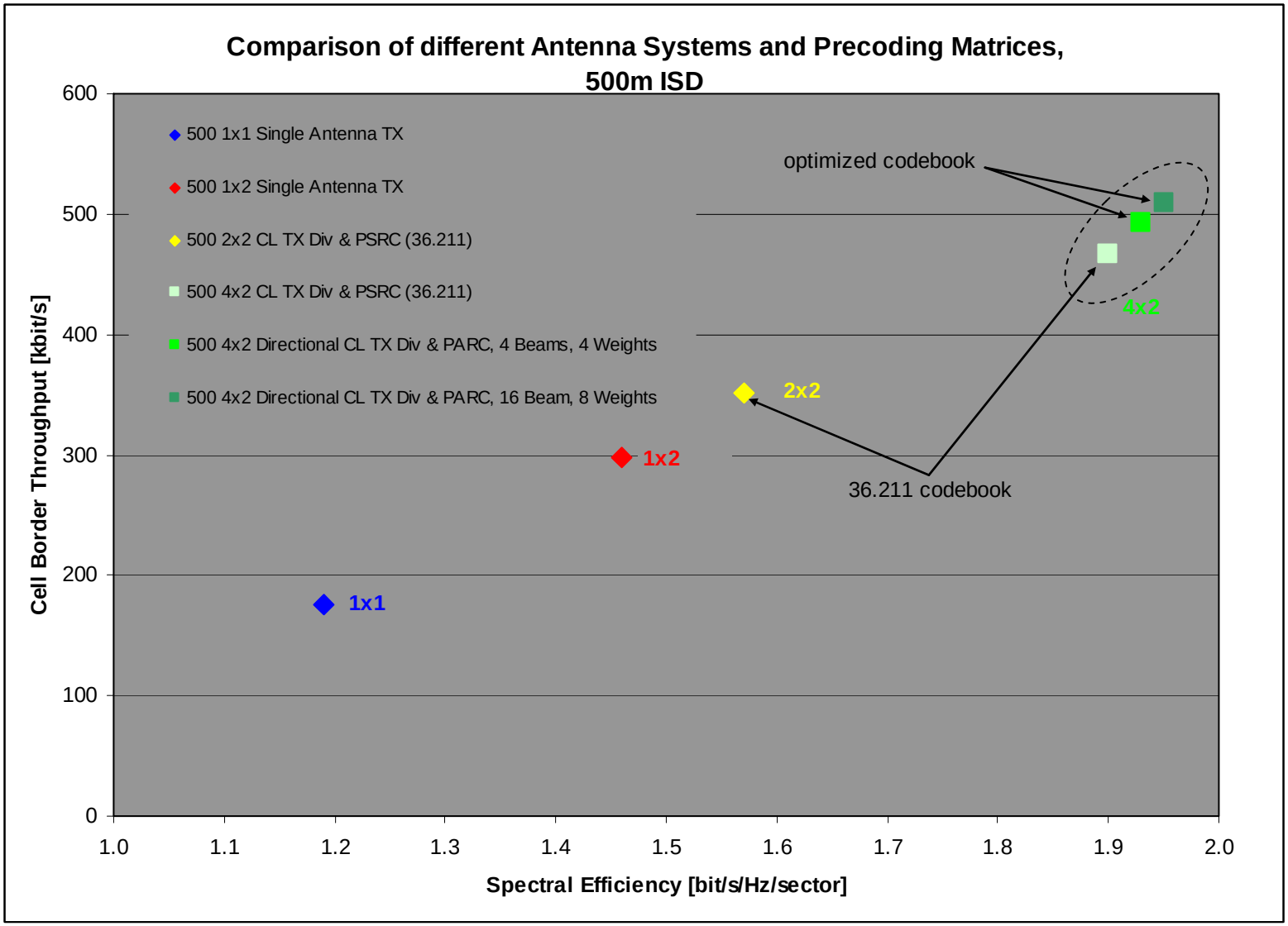
Main Advantage:

low feedback bitrate ->

higher used data rate in the UL

New radio systems for LTE advanced : Downloadable pre-coding code-books (II)

Adaptive 4x2 SU-MIMO System Performance



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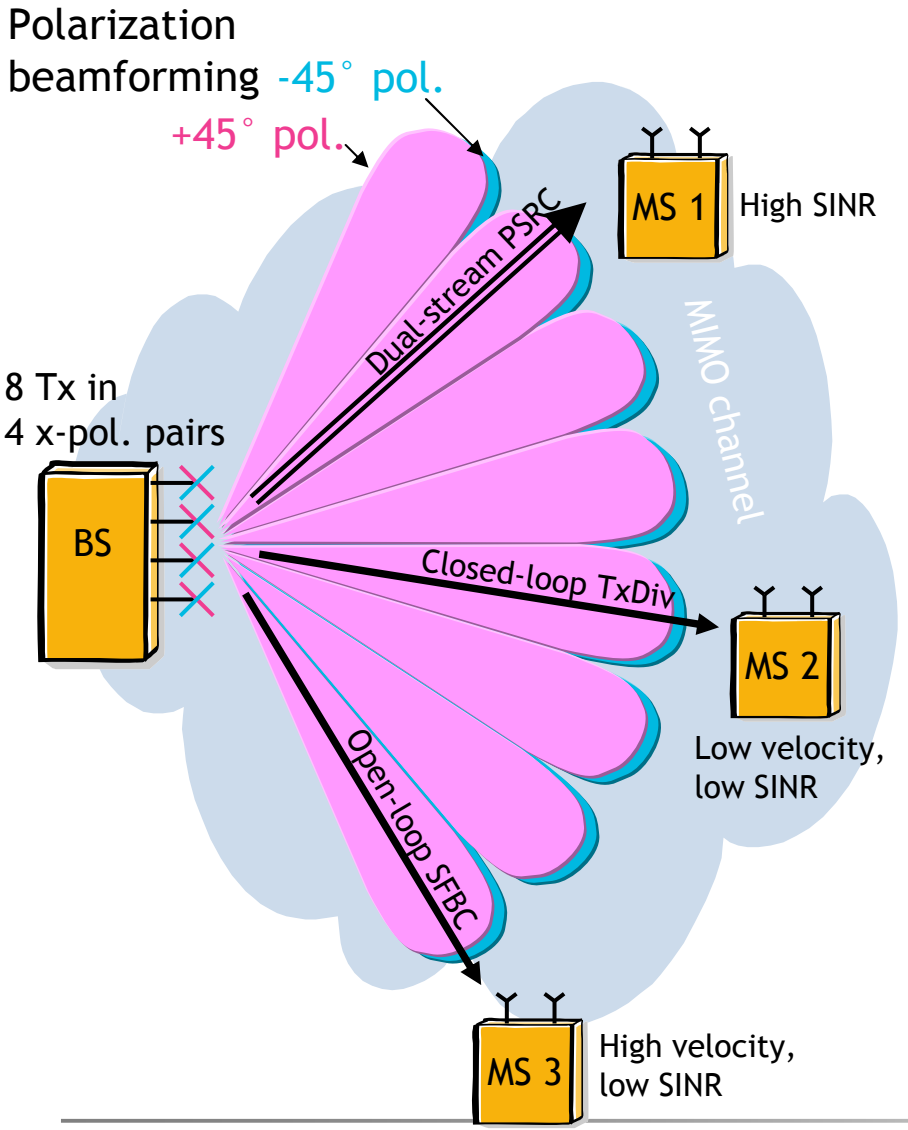
New radio systems for LTE advanced

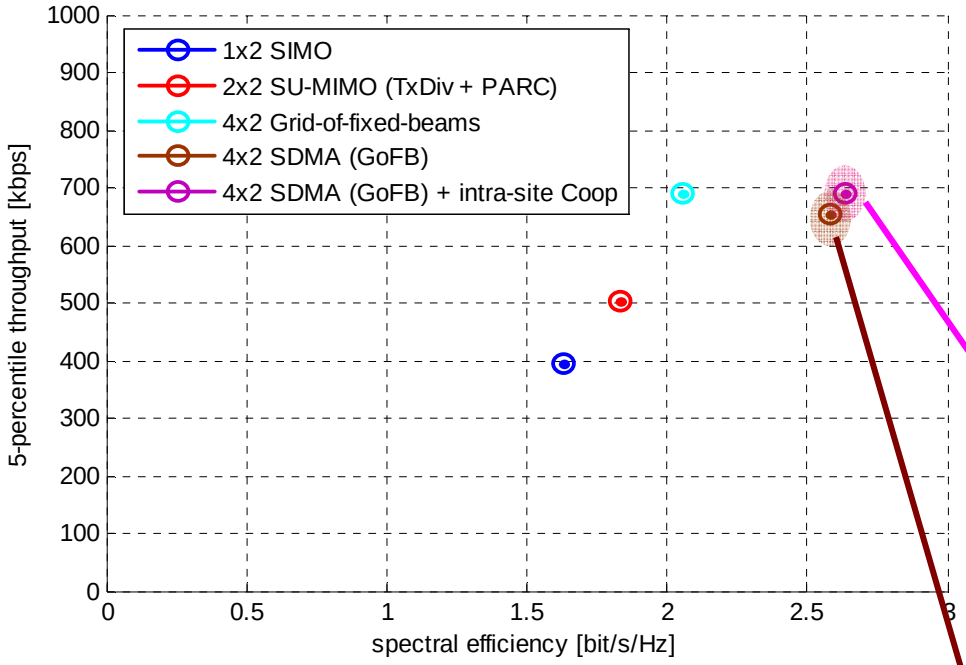
Adaptive 8x2 MU-MIMO with polarization beams

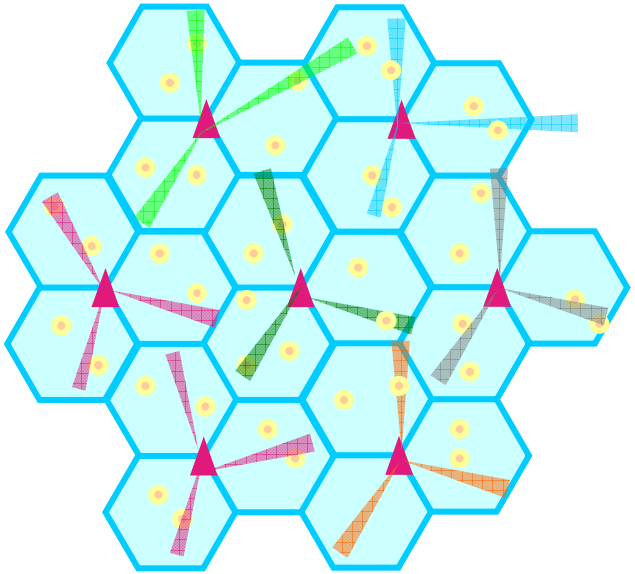


- Polarization beams for MU-MIMO
- Combination of beamforming and diversity transmission
  - Beamforming for MU SDMA based on closely spaced antenna elements (λ/2)
  - Diversity for link enhancement and spatial multiplexing, based on cross-polarized antenna elements
- Requires optimized codebooks for the antenna weights
- Up to 8 antenna elements in 4x2 X-pol. configuration in compact housing

4 Advanced multi-site MIMO schemes

New radio systems for LTE advanced
SDMA using 4x2 Grid-of-fixed beams





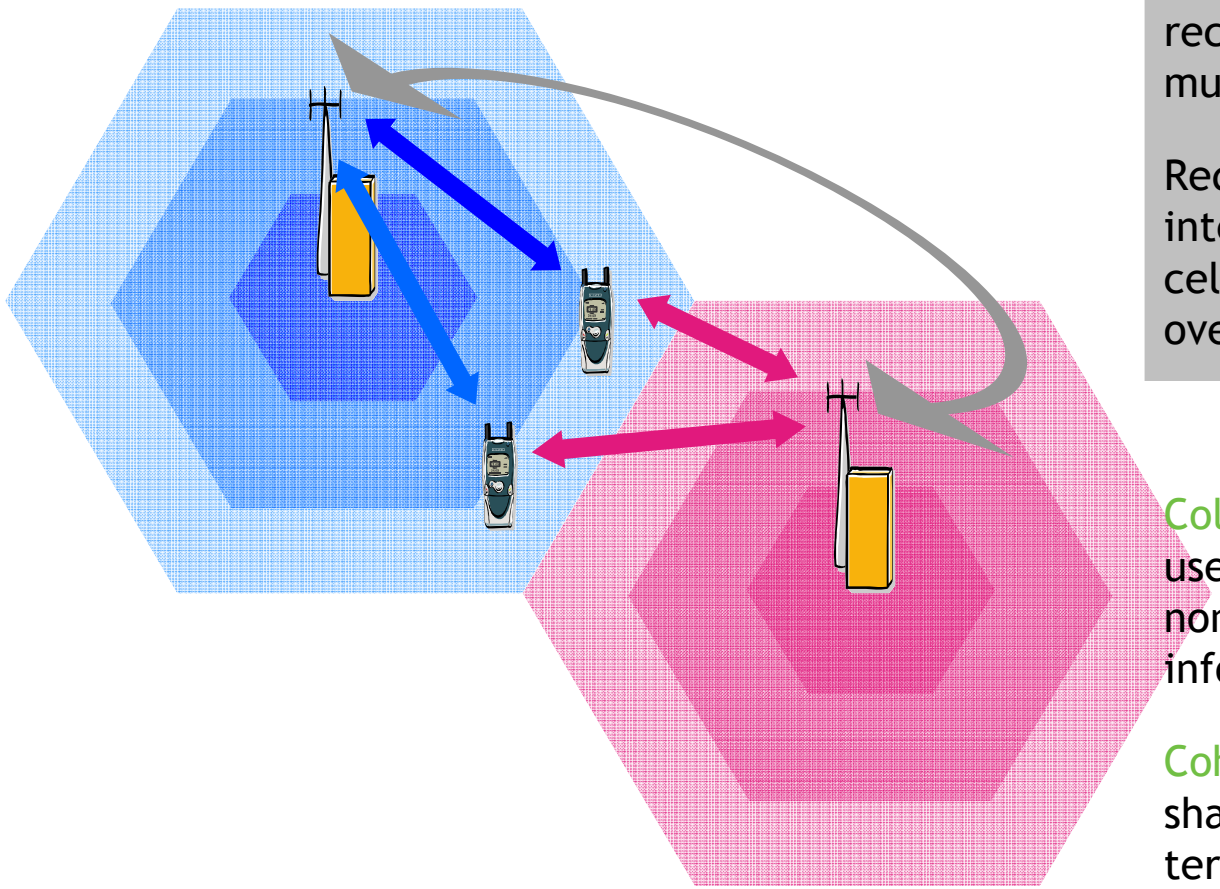
+ Inter-Node B Co-ordination

+ Intra-Node B BF co-ordination

SDMA w/o BF co-ordination

7x3 cells with wrap around, av. 10 users per cell
10 MHz BW
Control and pilot overhead considered
Score based proportional fair scheduling
NGNM case 1 parameter set:
500m ISD, 3km/h, 20 dB Penetr. loss

Collaborative/Network MIMO overview



Coordinate transmission and reception of signals among multiple bases.

Reduces intercell interference and improves cell-edge performance and overall throughput.

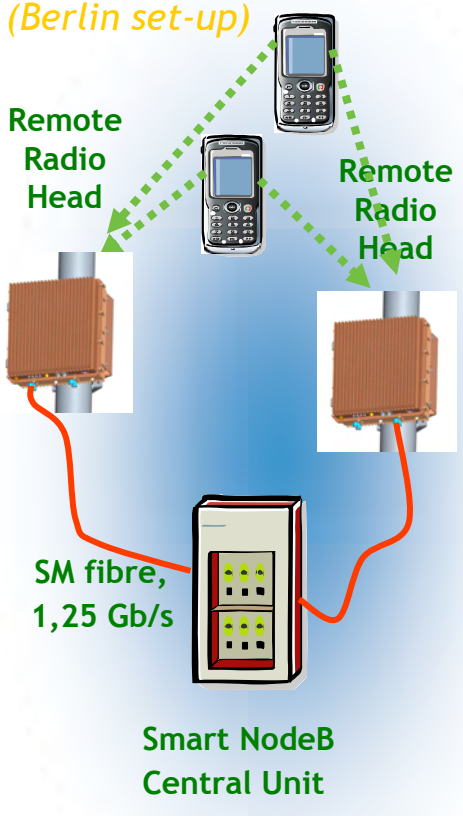
Collaborative MIMO: share user data and long-term noncoherent channel information.

Coherent network MIMO: share user data and short-term coherent channel information.

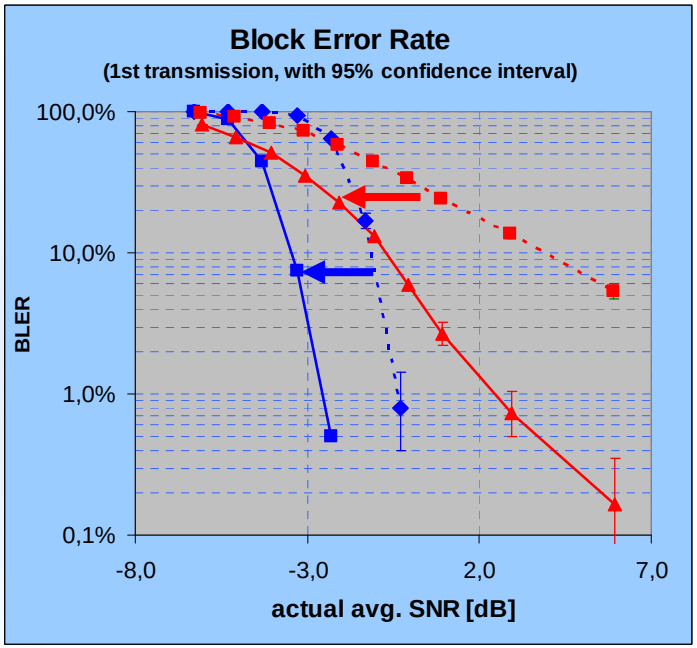
New radio systems for LTE advanced

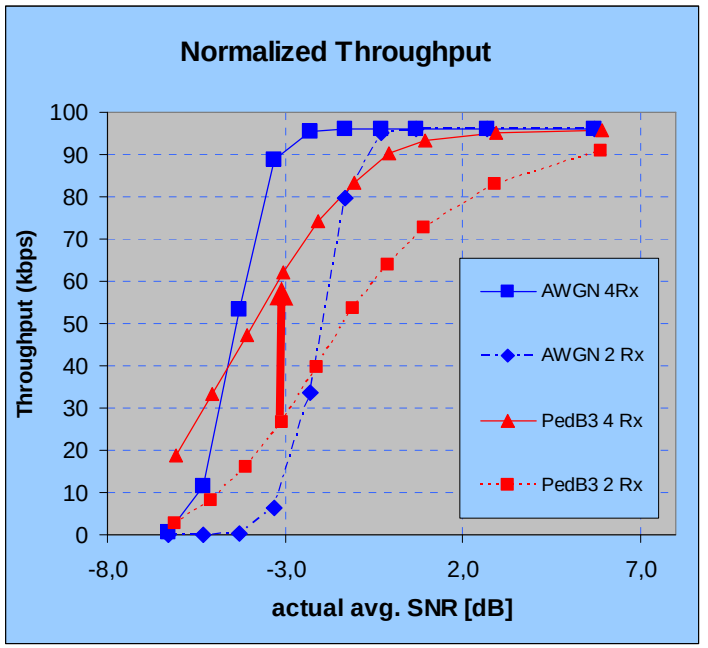
Multi-sector multi-user MIMO for UL - Distributed RRH

Princple
(Berlin set-up)



Simulation results for 1x4 antenna configuration
(QPSK 1/3, near-uncorrelated antennas)





Up to 4.5 dB SNR gain
for frequency-selective channel

Throughput gain
especially on cell edge

Clear improvement of Uplink throughput for UEs at cell edge
Improved fairness → Candidate for LTE advanced

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5 Conclusion

Conclusion

- Ambitious performance targets for LTE-Advanced
- Enhanced single-site transmission schemes
- Introduction of multi-site transmission scheme
- Adaptive selection of schemes in the network for optimal performance

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