Multi-Antenna Terminals in sub-6 GHz massive MIMO Systems

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Xperia by SONY

Massive MIMO is an upcoming technology.

SONY as a terminal manufacturer research the terminal aspects.

3GPP A GLOBAL INITIATIVE standardization - decides on mandatory terminal HW.

Massive MIMO - Assumptions

- Mid-band 2.0-6.0 GHz.
- 100 or more antennas at the BS.
- Up to 4 handset antennas (≤ rank 4).
- BS precoding defined by up-link pilots
- Reciprocity → TDD.

Massive MIMO – Handset perspectives:

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What's different

The perceived channel at the terminal side behave different in a Massive MIMO system.

What degree of freedom do we have

The up-link pilots give the terminal a degree of freedom to decide what channel the BS sees and can thereby influence the precoding at the BS.

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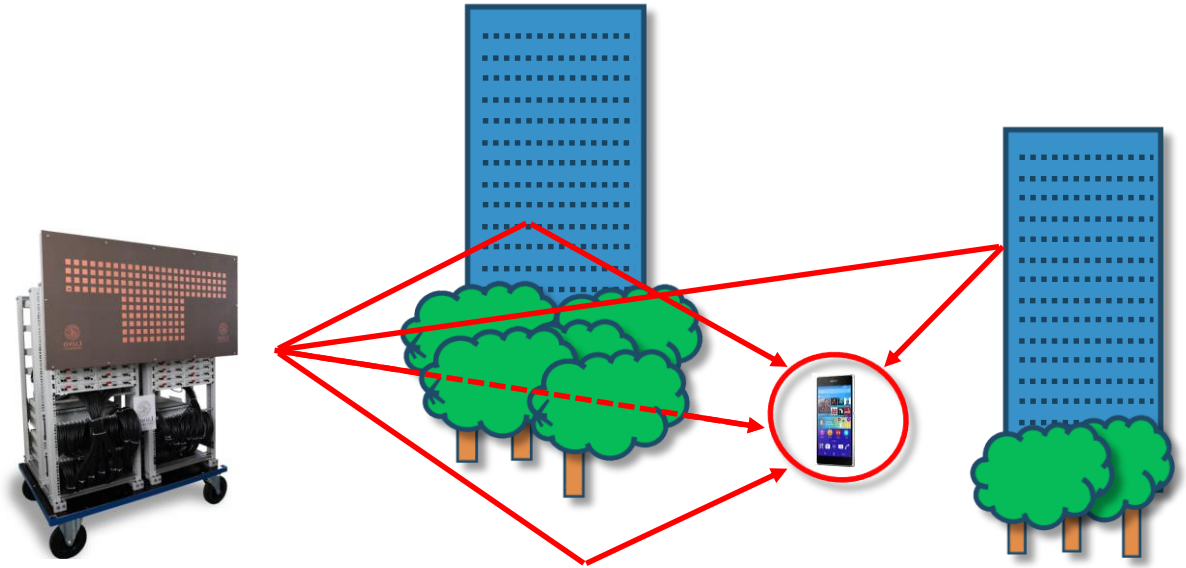
Massive MIMO enables →
Line-of-sight like performance also in scattered scenarios

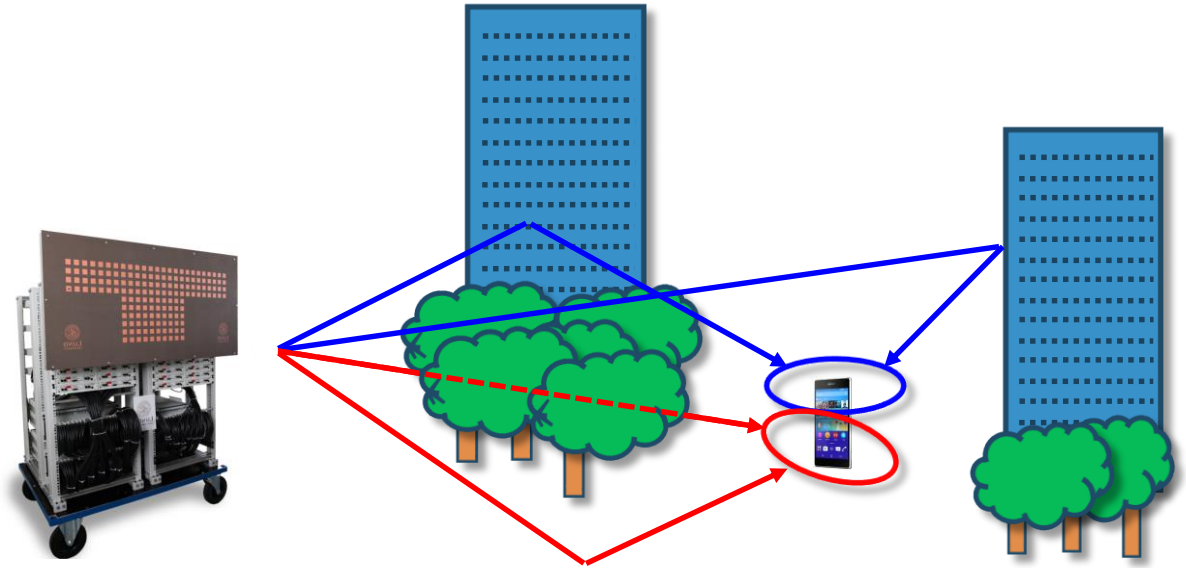


Massive MIMO has the capability to align the phases of signals that propagate along multiple propagation paths.
Results in hardening and full array gain also in scattered situations.

Channel also determined by

- Terminal antennas
- Terminal transceiver architecture
- Largescale fading:
  - Distance to the base-station
  - Shadowing from the environment
  - Terminal orientation
  - User-antenna interaction.

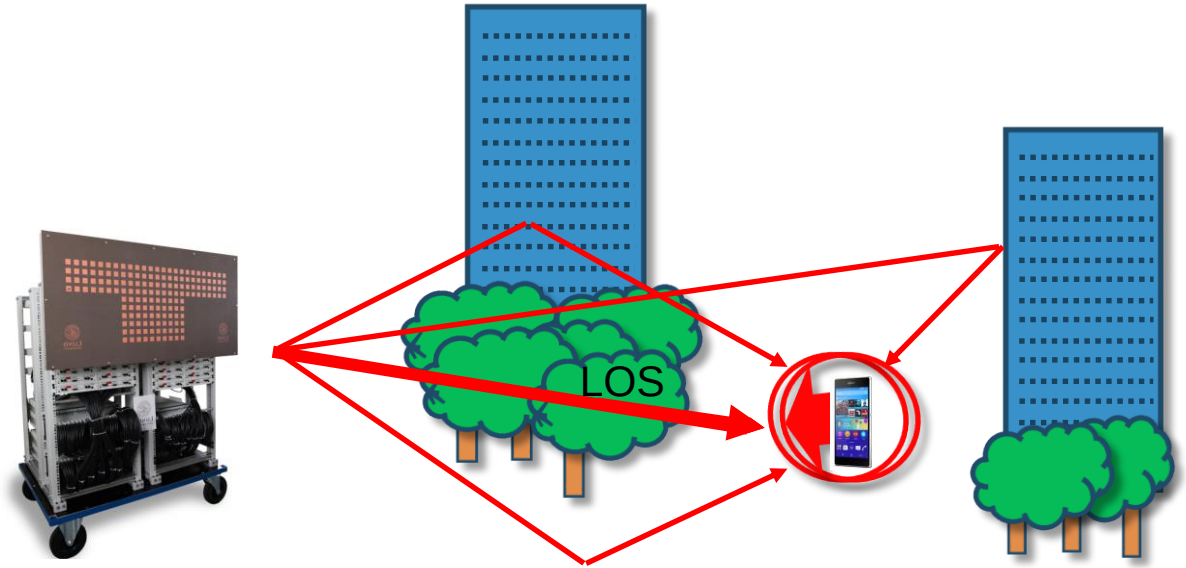
Un-correlated terminal-antennas



Diversity gain:

Relies on antennas capability of seeing different propagation-channels. The redundancy is used to improve the SNR.

Correlated terminal-antennas



Array gain:

Deterministic approach that relies on antennas capability of seeing the same propagation-channels. They can then coherently combine the received signals.

Channel also determined by

- Terminal antennas
- Terminal transceiver architecture
- Largescale fading:
  - Distance to the base-station
  - Shadowing from the environment
  - Terminal orientation
  - User-antenna interaction.

Terminal transceiver architectures

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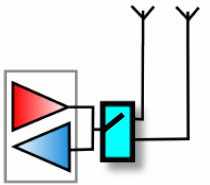
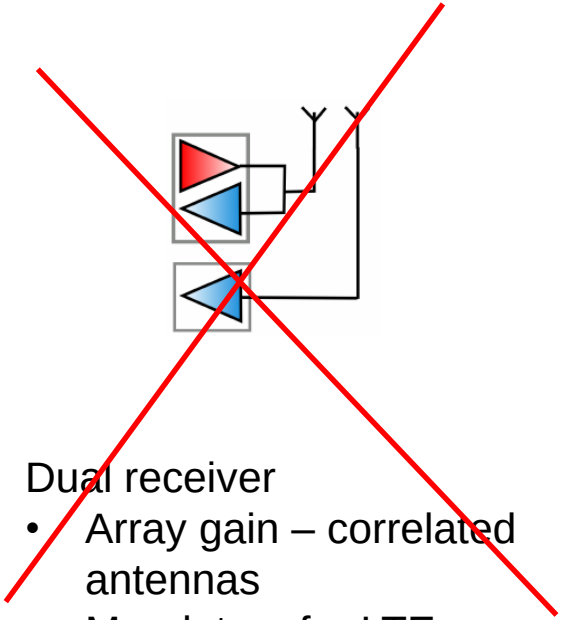
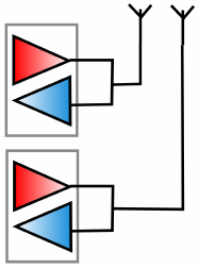


Switched solution
- Diversity gain – uncorrelated antennas



Dual receiver
- Array gain – correlated antennas
- Mandatory for LTE

Low antenna correlation, need pilot → Low or no gain.



Dual transceiver
- Optimal
- Array and diversity gain
- Multiplexed Transmissions
- Reach capacity of the channel

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Channel also determined by

- Terminal antennas
- Terminal transceiver architecture
- Largescale fading:
  - Distance to the base-station
  - Shadowing from the environment

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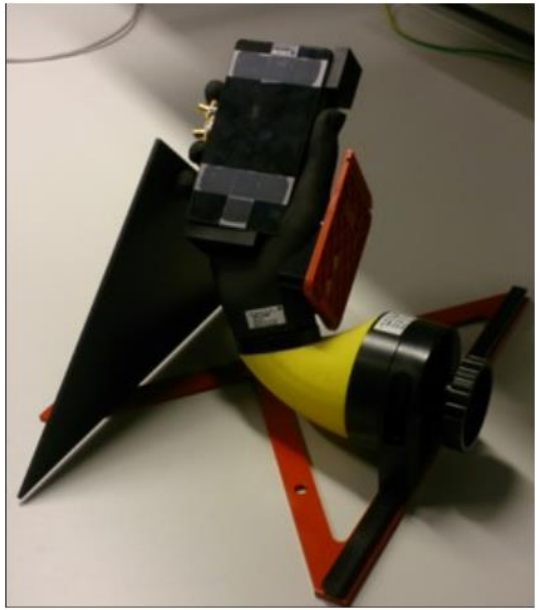
  - Terminal orientation
  - User-antenna interaction.

Measured antenna gain patterns under loaded conditions.



Simulations based on measured antenna gain-patterns

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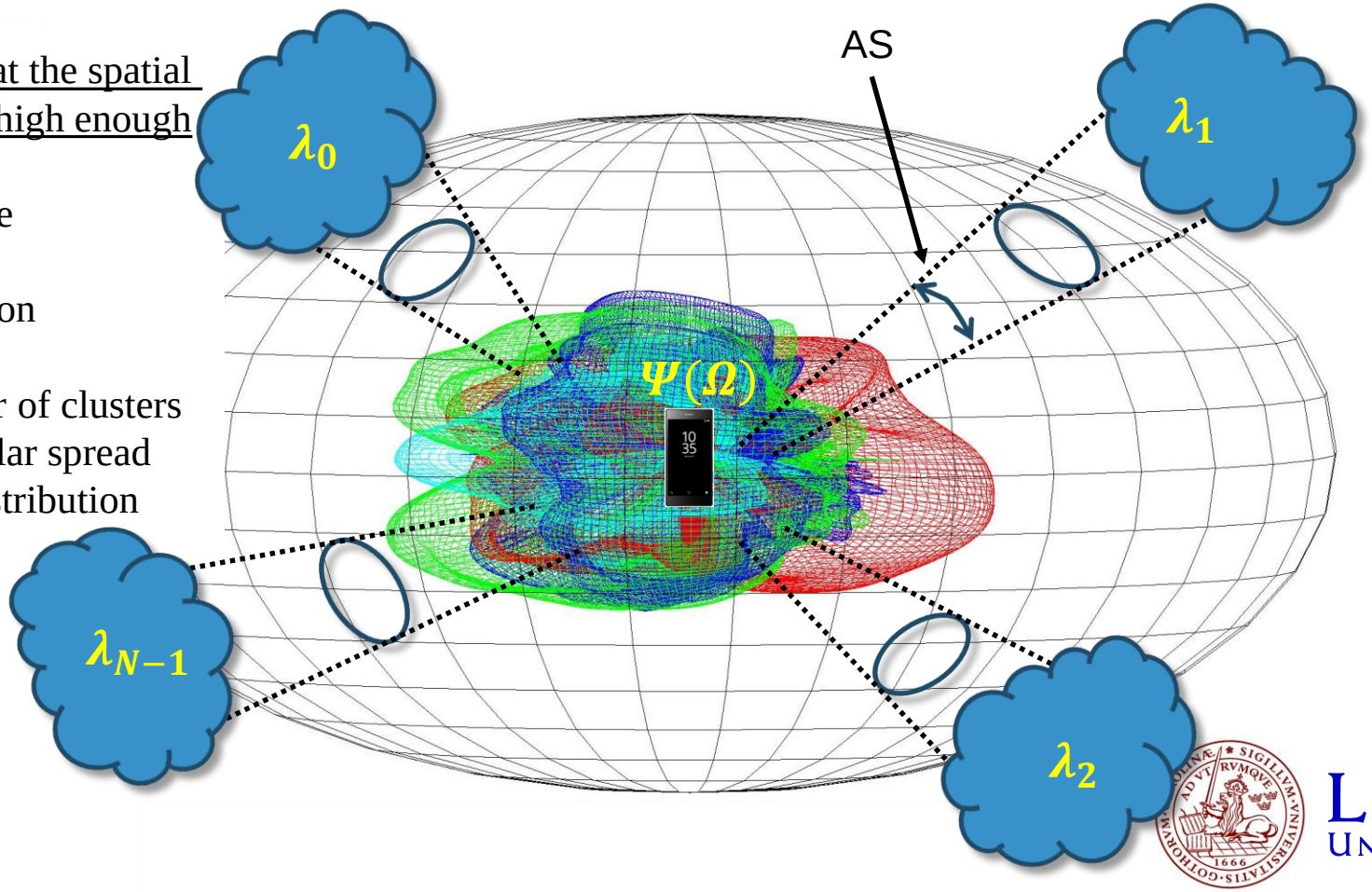
Assuming that the spatial resolution is high enough to control:

- Amplitude
- Phase
- Polarization

Selecting:

- N-number of clusters
- AS- angular spread
- λ-gain distribution



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Simulation based on 4 antenna terminal

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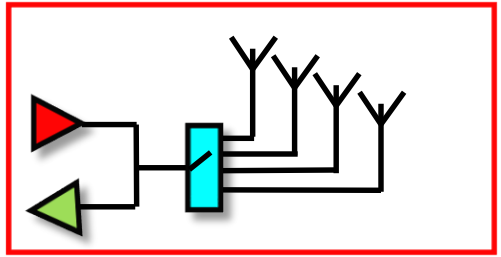
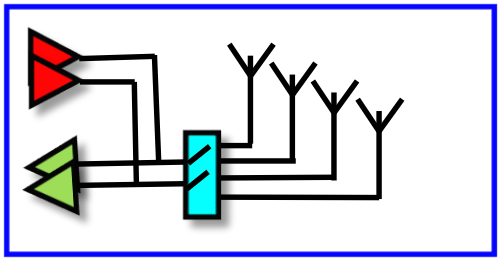
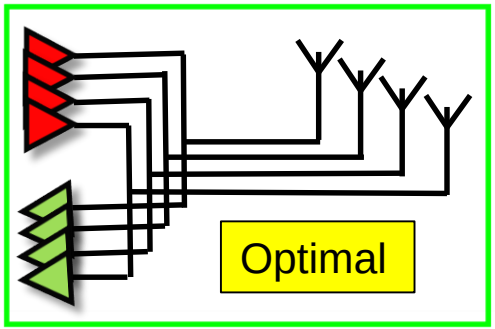
- Single-transceiver (switched) Rank 1
- Dual-transceiver (switched) Rank 2
- Quad-transceiver (eigenmode) Rank 1/2/4

  →Rank conditioned capacity







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Rate-CDFs for different schemes

SNR - 10 dB
2 clusters

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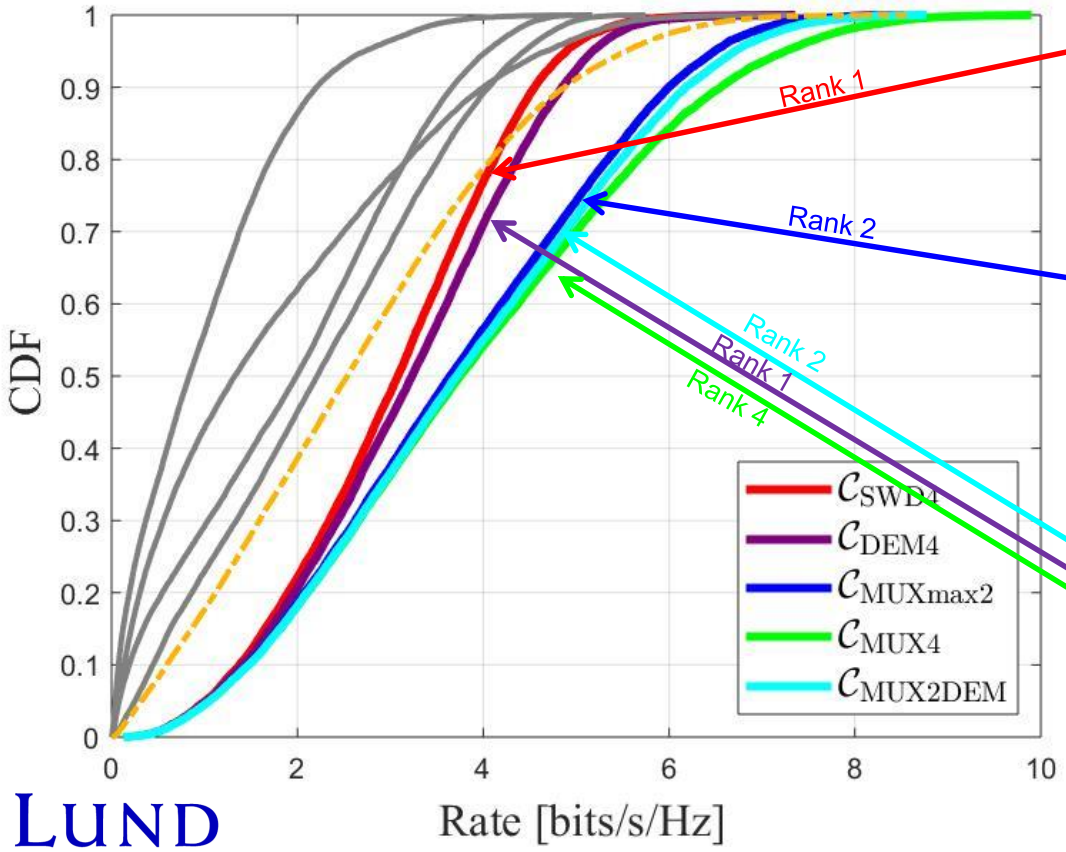

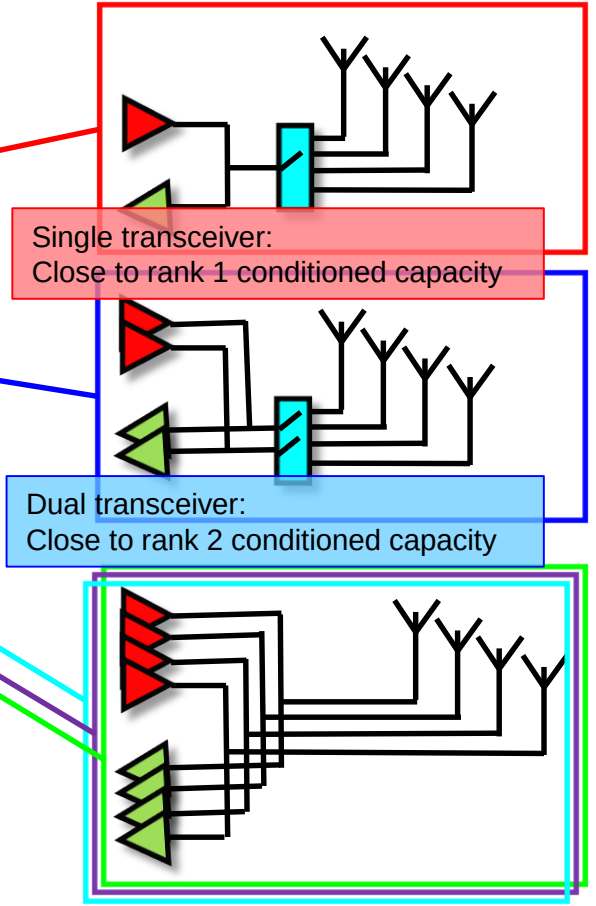

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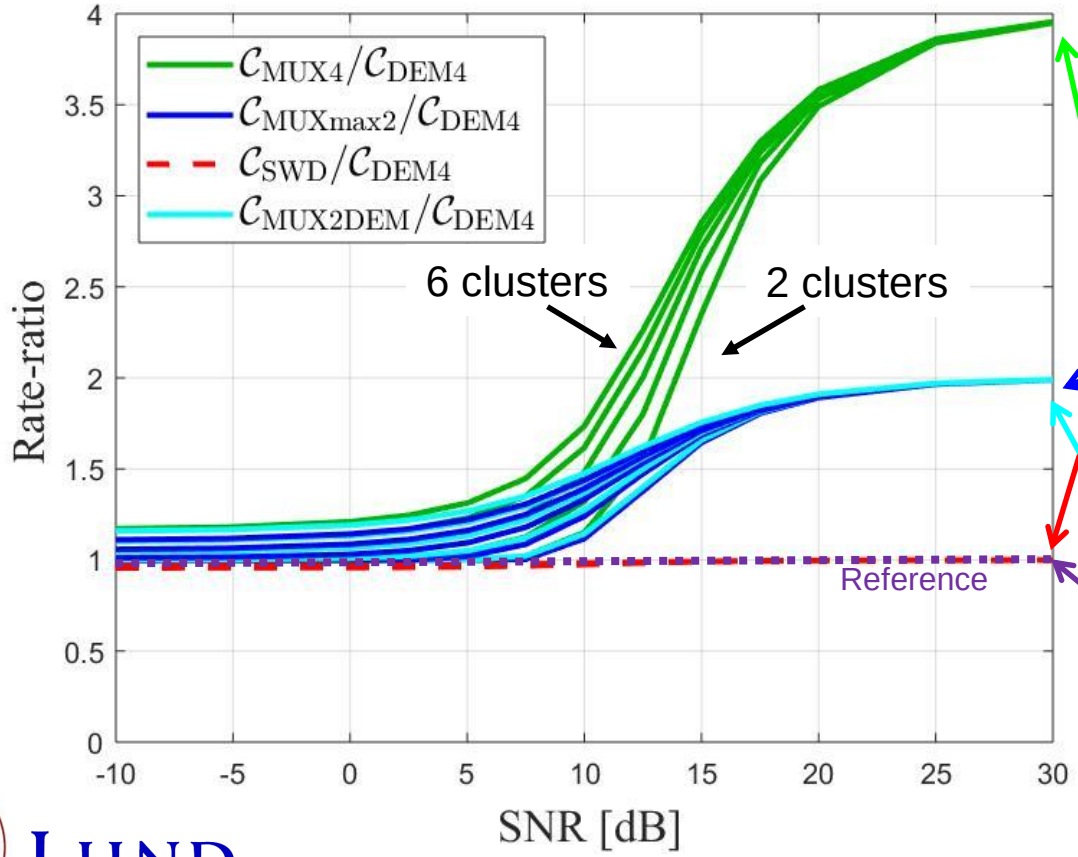
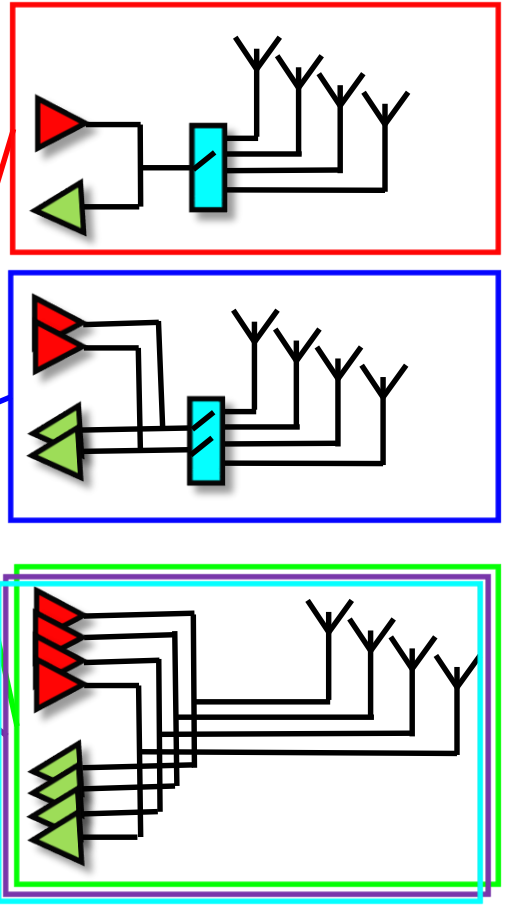
Rate-ratios vs. SNR and number of clusters





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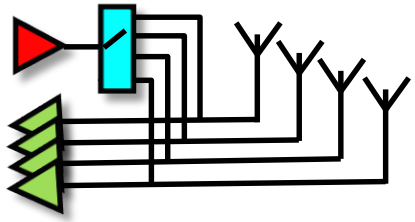
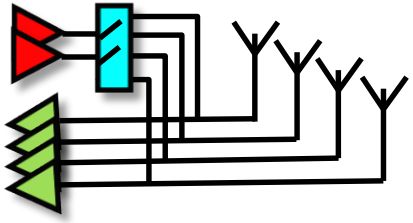
Proposed topologies for asymmetric UL /DL

- Transmit switch diversity with single transmitter reach rank 1 capacity.



- Transmit switch diversity dual transmitter significantly improved if we can get access to all 4 antennas.



System impact

- The number of up-link pilot resources = number of active layers (rank)
- Max number of time-overlapping up-link pilot resources = number of transmitters.

Summary

- We have investigated multiple-antenna terminals in massive MIMO
- Shown that switched transceiver architectures perform close to capacity for the respective ranks.
- Ensure that there is support for switched solutions in the 3GPP specification.