

Source: Ericsson
Agenda Item: 7.1.6
Document for: Discussion



RECIPROCITY BASED MIMO IN NR

PREREQUISITES FOR MASSIVE MIMO PRECODING



- › Desired conditions for best-performing multi-antenna schemes:
 - **Large eNB array** having many degrees of freedom
 - **Digital eNB implementation** allowing for baseband processing
 - **Explicit eNB knowledge** of instantaneous forward channel matrices

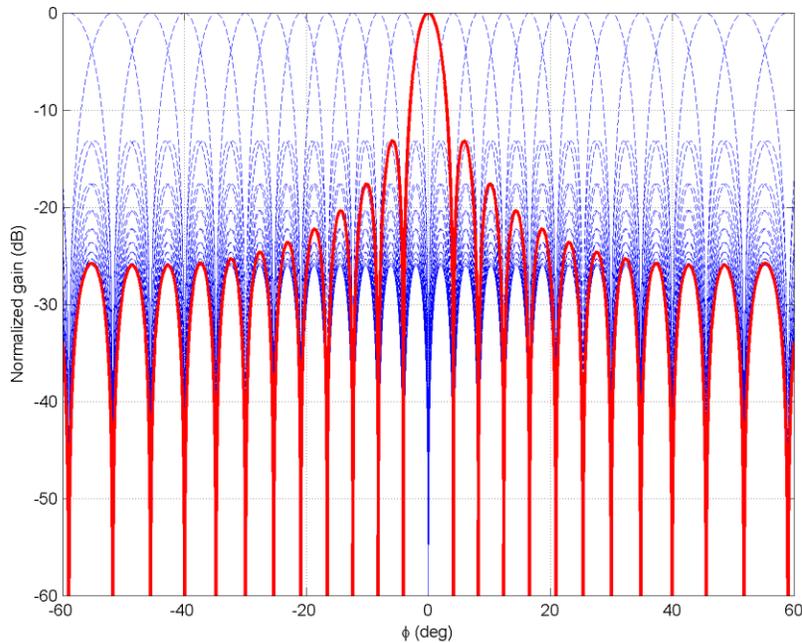
- › Precoding design principles:
 - **Flexible** (non-codebook based) “**beamforming**”, achieving full array gain even in high angular spread channels
 - **Coherent processing**, adapting to multipath propagation, to focus energy in spatial “points” rather than in directions
 - **Interference-nulling**, increasing mux possibilities for MU-MIMO

Accuracy of explicit CSI at transmitter determines performance of massive MIMO precoding

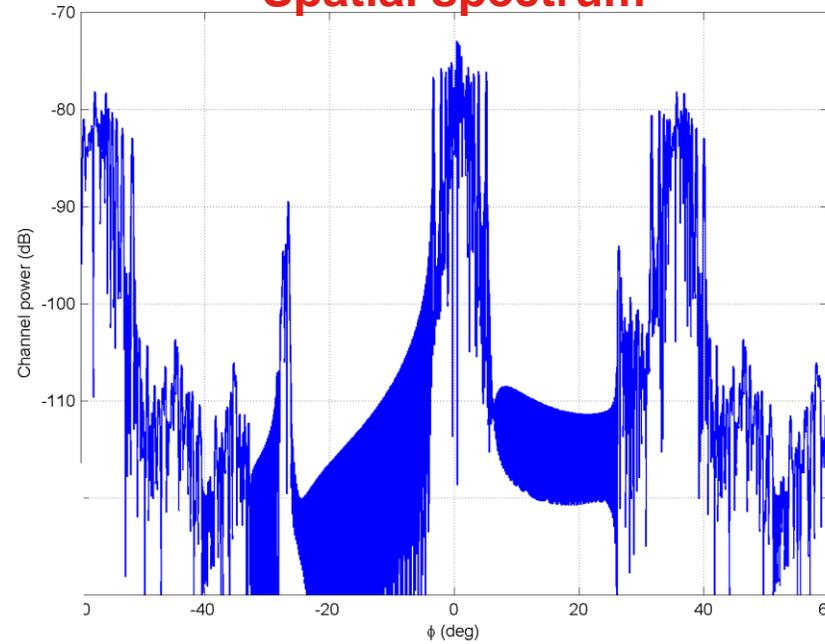


**CSIT unavailable /
normal resolution CSI
feedback:**

**Spatially oversampled grid of
fixed beam codebook**



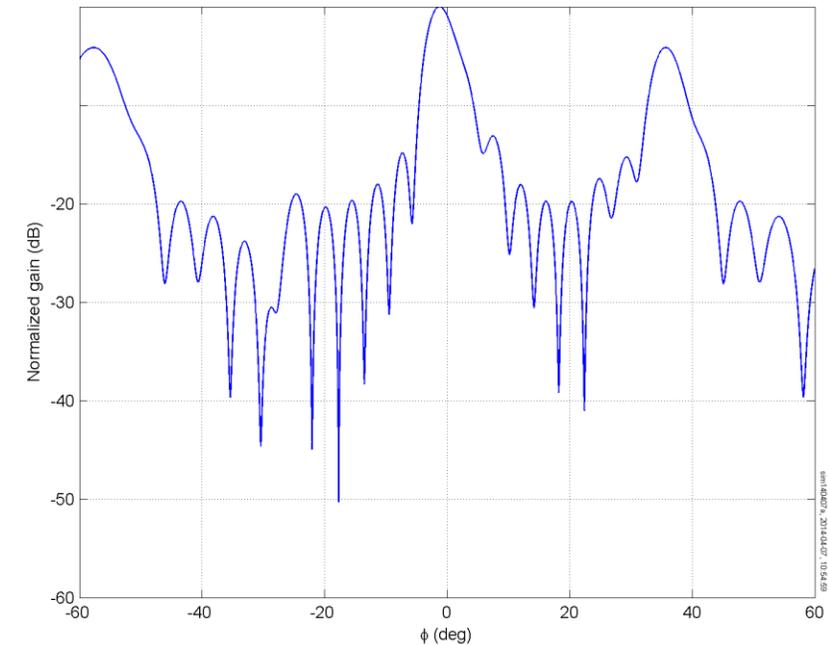
Spatial spectrum



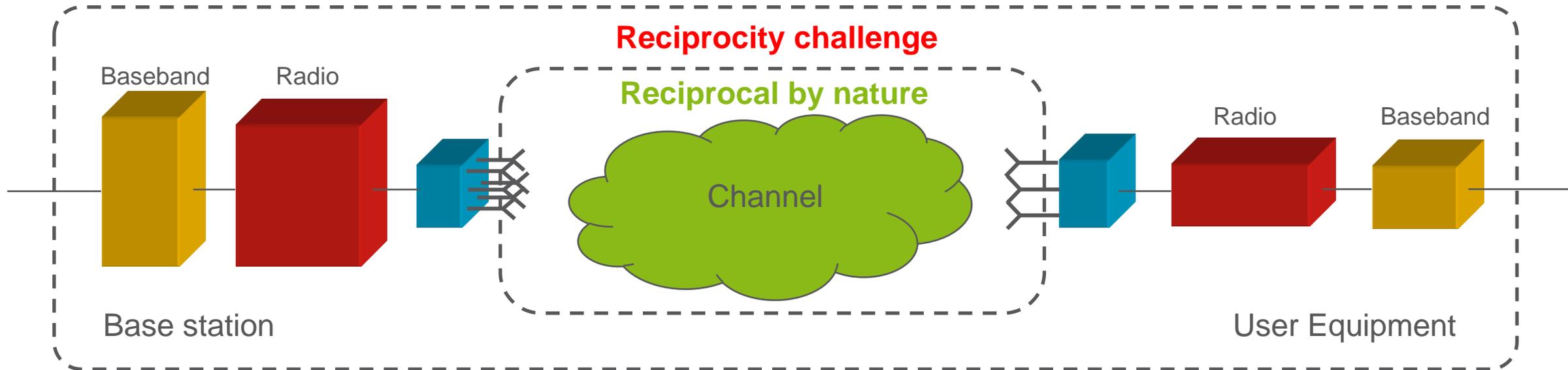
ULA, 20 elements, ITU UMa

**CSIT available / reciprocity
or high resolution CSI
feedback:**

Conjugate beamforming



COHERENT RECIPROACITY



- › Reciprocity can have several forms (e.g. on AoA/D or channel statistics)
- › **"Coherent" reciprocity:** RX and TX channels are the same as seen from baseband within coherence interval
 - Most strict form of reciprocity, but with highest potential
 - Requirement for frequency-selective precoding and efficient nullforming
 - Imposes requirements on antenna TX and possibly even RX calibration and on SRS density

Achieving **coherent** reciprocity will enable best performing multi-antenna scheme in NR

CSIT ACQUISITION VIA COHERENT RECIPROACITY



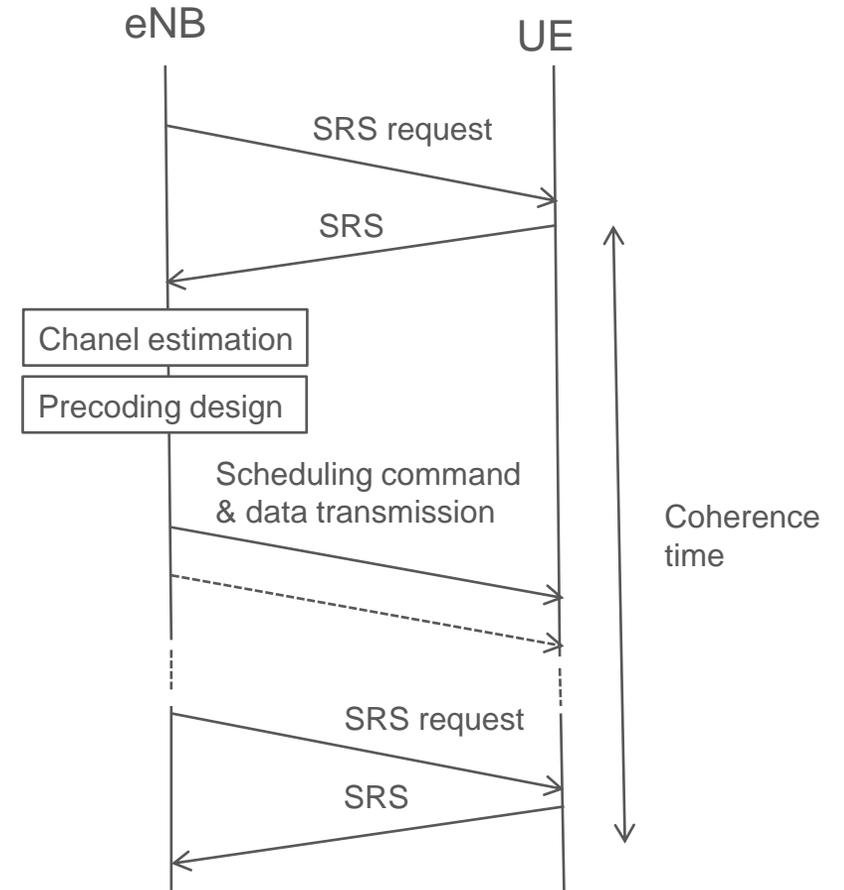
CSIT refinement procedure

› Principle:

- Uplink channel estimation
- Precoding design @eNB

› Approach is attractive for large eNB arrays:

- # of SRS scales with total # of UE antennas
- Feedback can be limited to interference measurements
- Avoid standardizing (super large) antenna-specific codebooks



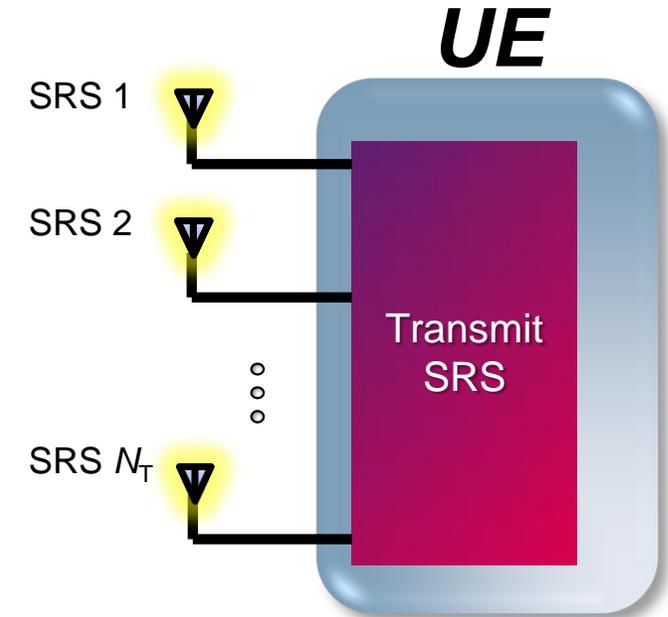
Coherent reciprocity enables explicit CSIT acquisition for large arrays

ACQUIRING CHANNEL ESTIMATES

SRS



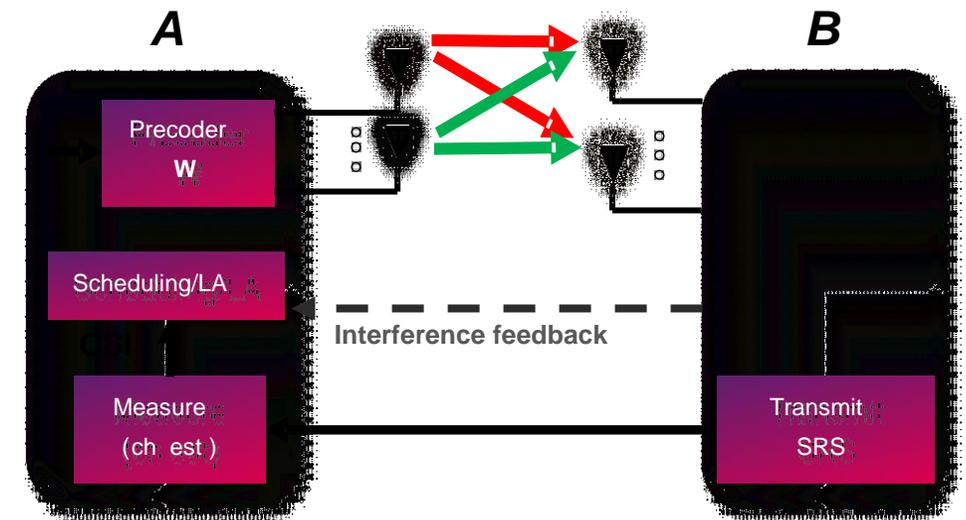
- › Sounding reference signals (SRSs) transmitted from UE to BS
- › Baseline assumption:
 - UE uses the same antennas for TX and RX
 - Antenna switching possible if limited TX chains
 - One SRS per TX antenna – ok if few antennas
- › SRS dynamically scheduled/triggered
 - Many UEs → persistent SRS scheduling mechanism may be useful
- › Design principles for SRS:
 - Create a large number of orthogonal sequences
 - › Avoid pilot contamination for large # of UEs and/or UE antennas
 - Do not precode SRS as baseline
 - › Obtain the entire MIMO channel for multi-antenna UEs
 - › Additional option to precode SRS should also be considered, e.g. when coverage limited
 - › Adapt SRS time density to channel conditions
 - › High mobility is the main limitation



INTERFERENCE MEASUREMENTS



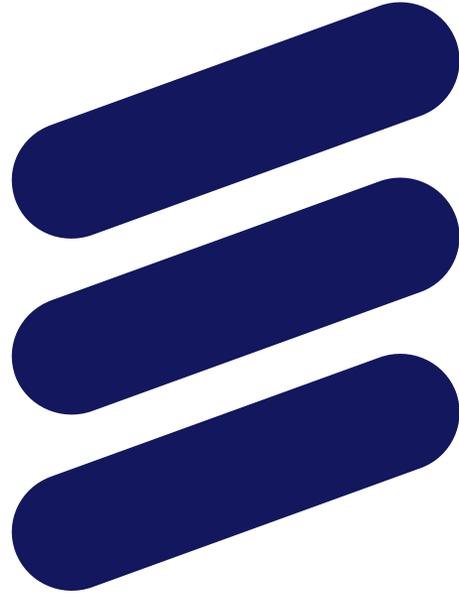
- › Unlike the channel, interference is not reciprocal
 - Interference knowledge required for scheduling and link & rank adaptation
- › Study the options for acquiring interference knowledge, for example
 - Each UE reports CQI based on CSI-RS (and/or CSI-IM)
 - Each UE reports CQI based on DMRS
 - Each UE reports interference, and SINR is derived in BS side



SUMMARY



- › Efficient reciprocity-based transmission schemes need to be standardized as in some use cases they will **have significantly better performance** compared to normal resolution closed loop schemes (as has been specified for smaller arrays, e.g. LTE)
- › Coherent reciprocity allows for efficient acquisition of explicit channel knowledge even for very large arrays, thus enabling frequency-selective precoding and nullforming
- › Achieving coherent reciprocity imposes several additional requirements, e.g., on antenna calibration
 - Whether there is standard impact (RAN1 or RAN4) is FFS
- › **Study proposals to support reciprocity based MIMO in NR:**
 - RAN1 should study Sounding Reference Signal design and the necessary quality of the estimates
 - › Study SRS sequences and SRS density for enabling high-quality channel estimates, to reduce the effects of channel aging and pilot contamination
 - RAN1 should study Interference acquisition schemes for reciprocity based operation
 - › for the purpose of scheduling and link adaptation



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