BBC RESEARCH & DEVELOPMENT

MBS Enhancements

Efficient Broadcast/Multicast and Unicast Superposition Transmission (BMUST) for Single-User MIMO

3GPP TSG RAN Rel-19 workshop
Taipei, June 15 - 16, 2023

RWS-230043

Motivation

- **Use case**
  - Delivery of broadcast/multicast (e.g. popular live events) and unicast (e.g. user personalized) to a high number of users over mobile networks.
  - The target is High Density Demand areas and rural areas

- High-level BBC requirements on media-related topics for 3GPP Rel-19 in [**RWS-230042**]

Motivation

- **High-capacity Broadcast/Multicast and Unicast delivery with Single-User MIMO (SU-MIMO)**
  - Multi-layer MIMO for unicast and broadcast/multicast.

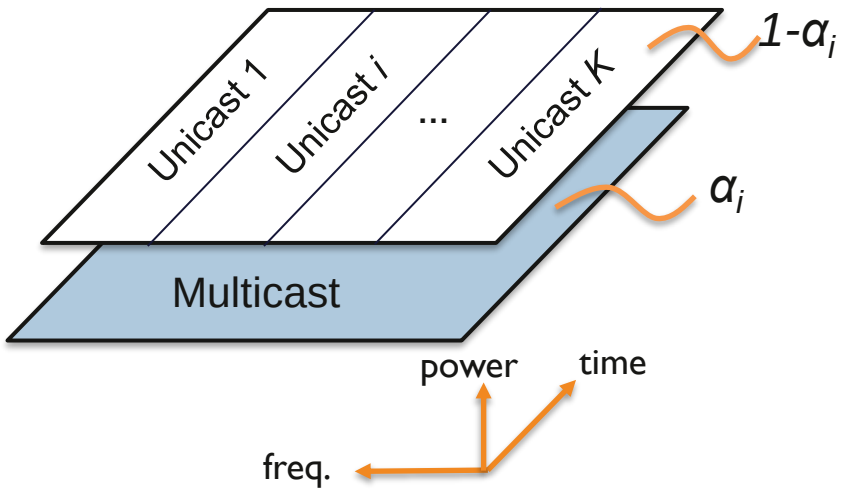
- **SU-MIMO is relevant at lower frequency bands operating in FDD mode (e.g. sub-1 GHz)**
  - **Limited MU-MIMO precoding/beamforming gain:** reduced number of transmit antennas at the base-stations due to size constraints.
  - **Excessive feedback overhead** to report accurate CSI information to the base-station when serving a high number of users and/or in high-speed environments.

- **Broadcast/Multicast and Unicast multiplexing in NR MBS**
  - **Orthogonal** time/frequency multiplexing (NR MBS) of broadcast/multicast and unicast **can be spectrally inefficient**.
  - **Non-orthogonal** multiplexing of broadcast/multicast and unicast **is more spectrally efficient.**

Broadcast/Multicast and Unicast Superposition Transmission (BMUST)

- **With SU-MIMO transmission mode, BMUST is shown to be a sum-rate optimal scheme [1], [2], [3], i.e. maximises cell throughput.**
  - for MU-MIMO transmission mode, see our companion contribution on Rate-Splitting Multiple Access (RSMA) in [RWS-230044].
- **Two-layer simplifies the design. Decoding follows two steps:**
  1. Decode broadcast/multicast first (while treating unicast as noise); then
  2. Decode unicast after (soft-) cancellation of broadcast/multicast.
- **α_i factor can be optimised per parallel channel (e.g. per RB)**

Example of time/frequency/power allocation per MIMO layer

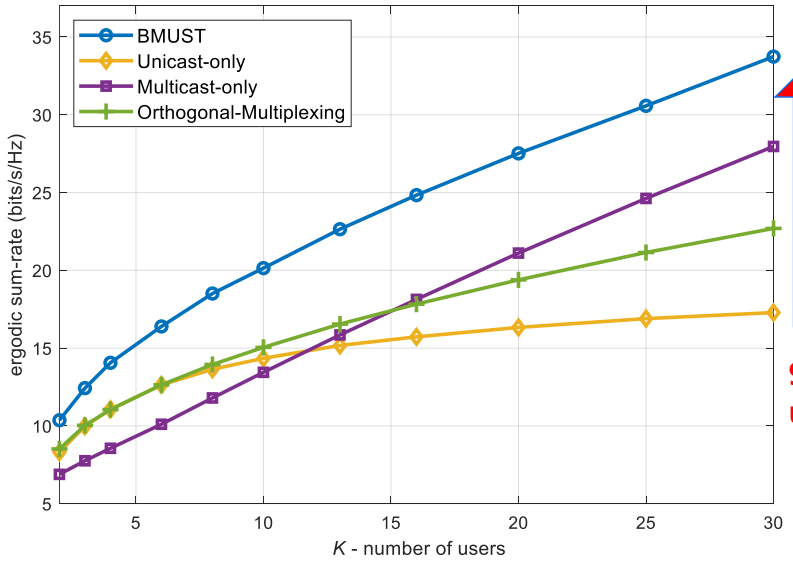


- **BMUST was discussed for Rel-18 with support from service providers, equipment vendors and chip manufacturers [RP-211659].**

[1] D. Vargas and Y. J. D. Kim, "*Two-Layered Superposition of Broadcast/Multicast and Unicast Signals in Multiuser OFDMA Systems*," in IEEE Trans. on Wireless Comm., Feb. 2020 (IEEE, arxiv)
[2] Y. J. D. Kim and D. Vargas, "*Multicast and Unicast Superposition Transmission in MIMO OFDMA Systems with Statistical CSIT,* " arXiv preprint: 2305.15630
[3] R1-2009238, "*On Optimal Multiplexing for Simultaneous Operation of Broadcast/Multicast and Unicast Services*, " BBC, 3GPP TSG RAN WG1 #103-e, October 2020.

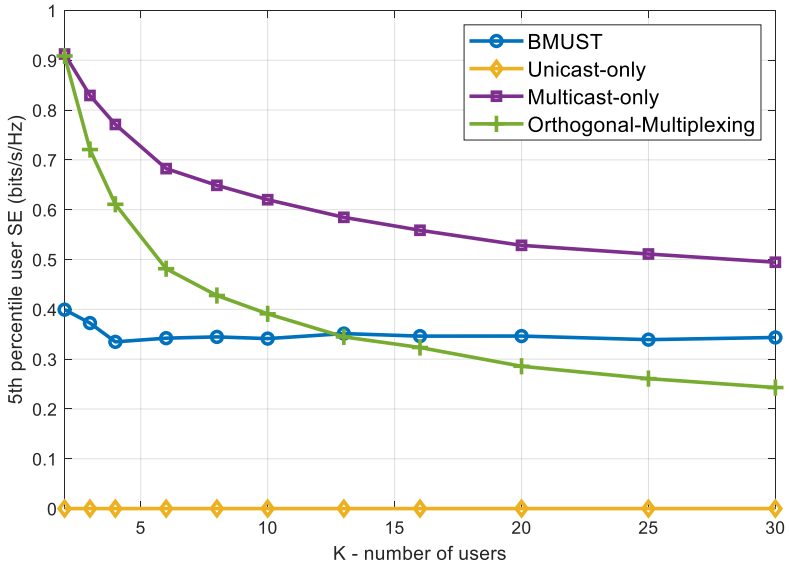
Broadcast/Multicast and Unicast Superposition Transmission (BMUST)

Simulation Results



48% gain over Multicast and unicast orthogonal multiplexing @30 UEs

94% gain over unicast @30 UEs



- Example system-level simulation in rural macro cell (RMa) from 3GPP TR 38.901 at 700 MHz carrier frequency.
  - 19 hexagonal cells/sites with 3 sectors per site, transmitters with 8 antennas, receivers with 2 antennas, and maximum sum-rate scheduler.
  - Orthogonal multiplexing with 50% RBs allocated to multicast and 50% RBs allocated to unicast.
- **BMUST provides significant gains over Unicast-only and orthogonal multicast/unicast multiplexing with good cell-edge performance**.
- More details can be found in [2].

[2] Y. J. D. Kim and D. Vargas, "*Multicast and Unicast Superposition Transmission in MIMO OFDMA Systems with Statistical CSIT,* " arXiv preprint: 2305.15630

Summary and Proposal

- **With SU-MIMO transmission mode, BMUST shown to be a sum-rate optimal scheme, i.e. maximises cell throughput.**

- **Significant capacity gains as compared to orthogonal approaches (TDM/FDM)** [1], [2], [R1-2009238].

- **Proposal: 3GPP RAN to consider a Study of Broadcast/Multicast and Unicast Superposition Transmission (BMUST) as a technical enhancement for NR MBS in 3GPP RAN Rel-19.**