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Multiple-antenna techniques in nonorthogonal multiple access: a review

Key words: Nonorthogonal multiple access; Multiple-antenna technique; B5G; Internet of Things

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Motivation

- Non-orthogonal multiple access (NOMA) is a spectral-efficient multiple access technique to support massive connections over limited radio spectrum but with severe co-channel interference and high implementation complexity. The multiple-antenna techniques can solve these problems by exploiting the spatial degrees of freedom.
- There is no complete analysis to reveal multiple-antenna techniques in NOMA systems in terms of fundamental results, recent advances, and future trends.

Main idea

1. Fundamental techniques

- General concepts
- Categories, methods, modeling, process

2. Various multiple-antenna techniques in NOMA systems

- Two-user, multiuser and massive NOMA
- Heterogeneous NOMA systems

3. Future research directions and challenges

- Challenging issues need to be addressed in future research.

1. Fundamental techniques

(1) Channel state information (CSI) acquisition

Quantized instantaneous CSI
Estimated instantaneous CSI
Statistical CSI
Angular domain CSI
No CSI

(2) User clustering

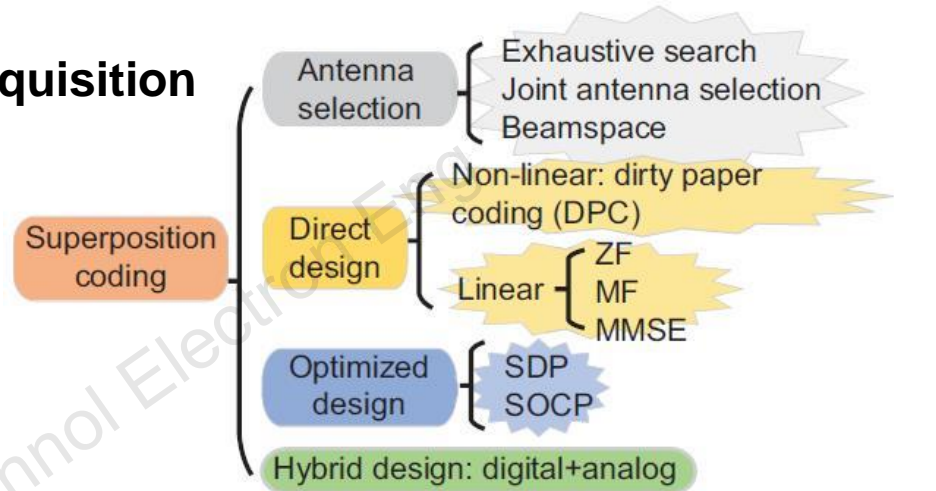
Instantaneous and statistical CSI
Channel gain and user position information

(3) Superposition coding

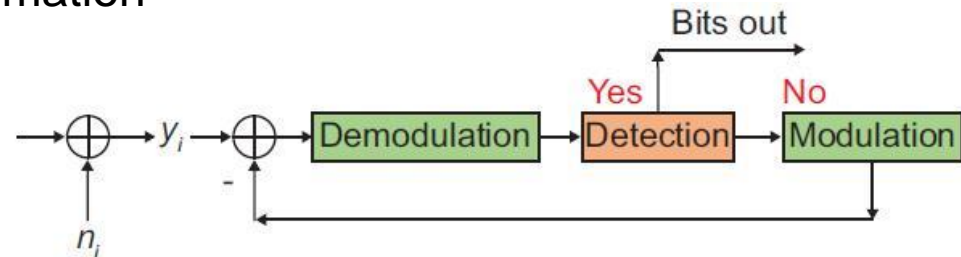
Spatial beamforming
Power allocation

(4) Successive interference cancellation (SIC)

Perfect
Imperfect

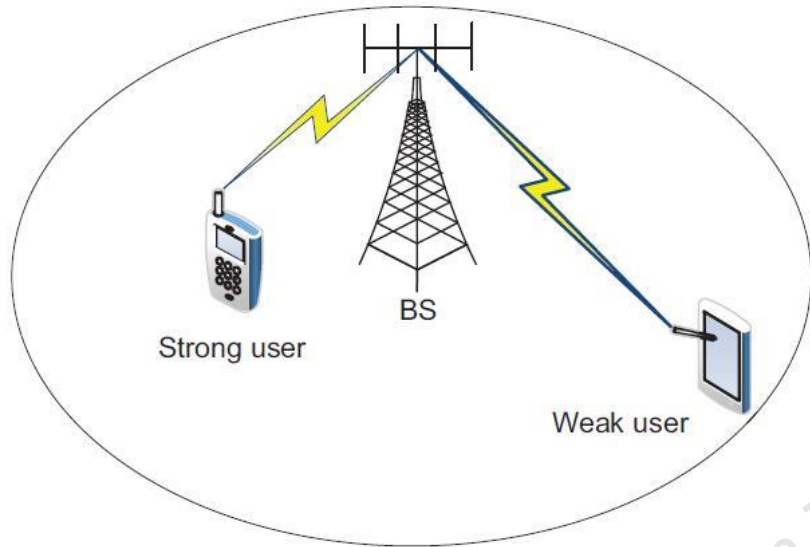


The illustration of superposition coding schemes

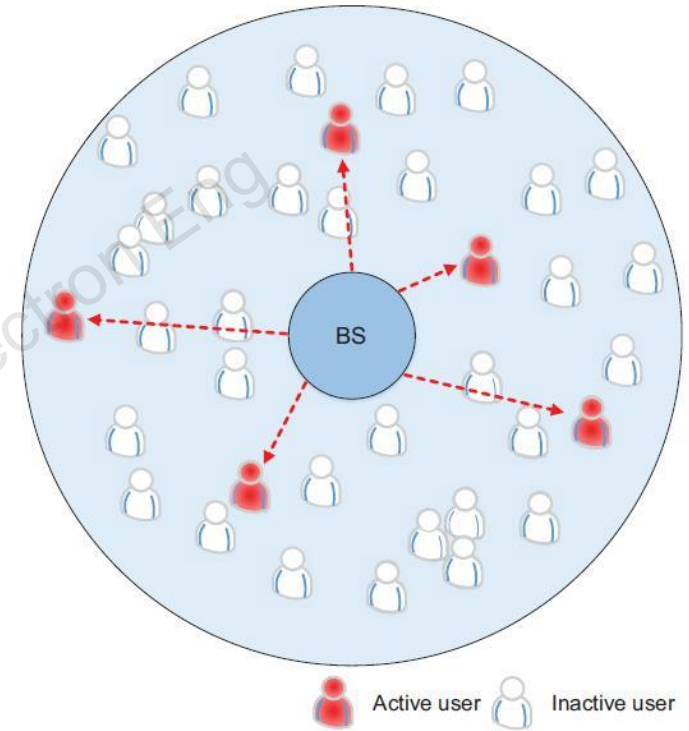


The process of SIC

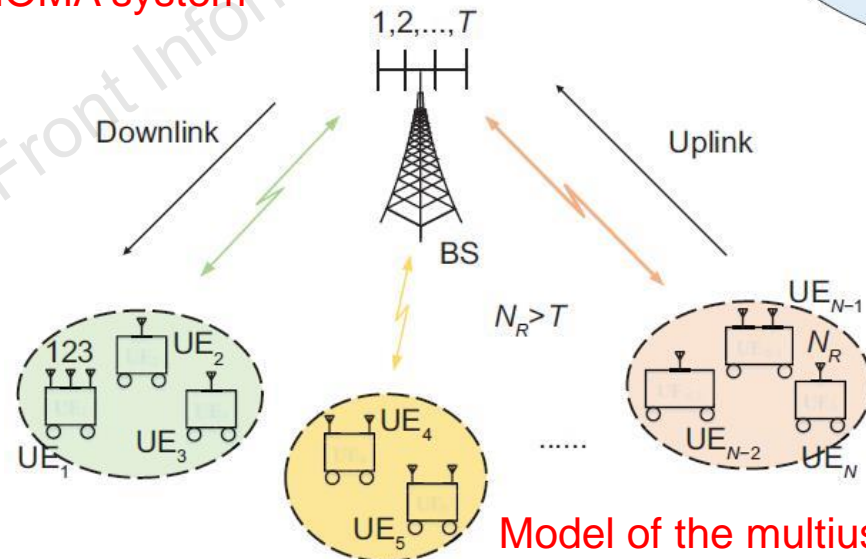
2. Various multiple-antenna techniques in NOMA systems



Model of the two-user NOMA system

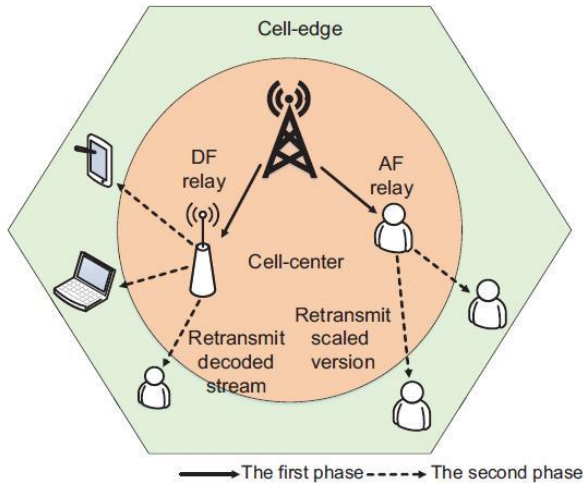


Model of the massive NOMA system

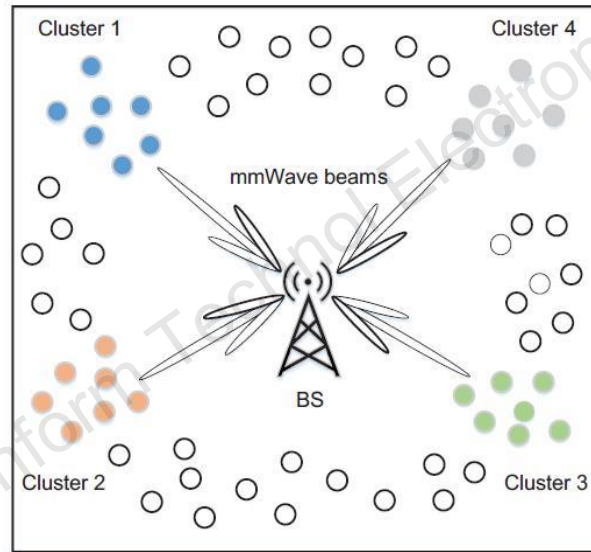


Model of the multiuser NOMA system

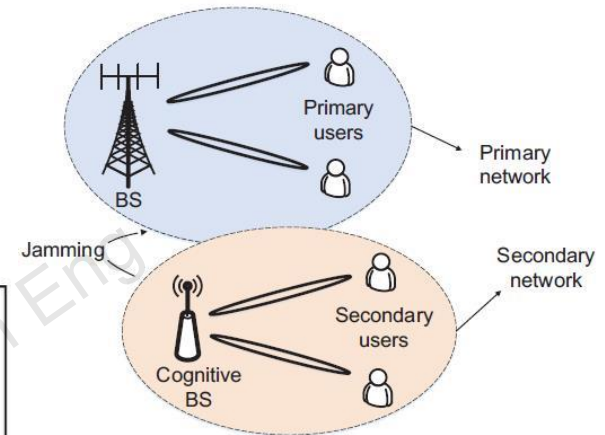
2. Various multiple-antenna techniques in NOMA systems



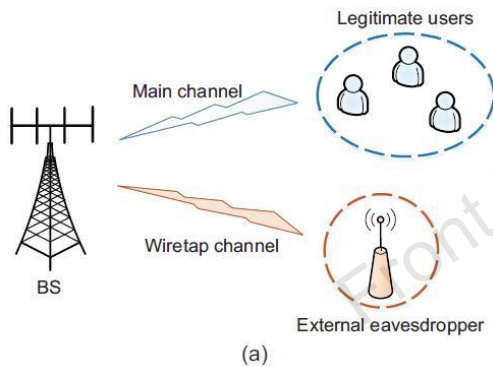
Relay NOMA



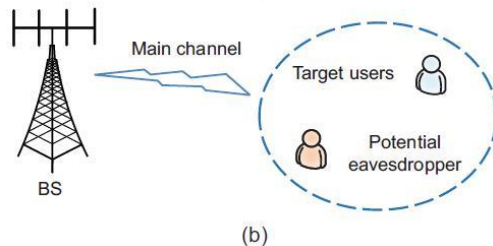
mmWave NOMA



Cognitive radio and NOMA

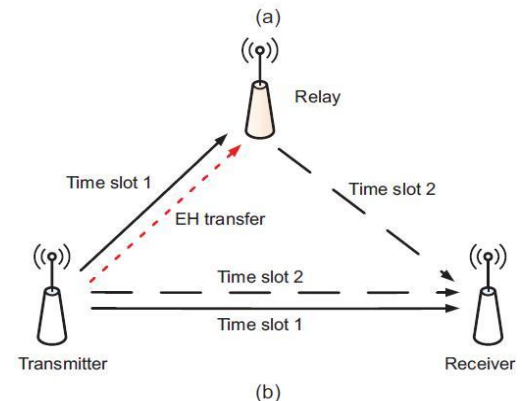
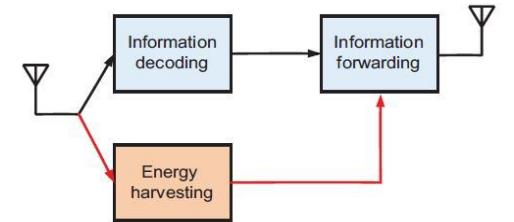


(a)



(b)

Physical layer security in NOMA



(b)

Simultaneous wireless information and power transfer in NOMA

3. Future research directions and challenges

- Access protocol design
- Low-cost multiple-antenna techniques
- Weak coupling antenna structure
- Imperfect SIC modeling
- Cell-free NOMA

Conclusions

- An investigation of various key techniques of multiple-antenna NOMA systems was presented, including CSI acquisition, user clustering, superposition coding, and SIC.
- The issues related to multiple-antenna techniques for two-user, multiuser, and massive-connectivity NOMA systems were reviewed.
- A review of multiple-antenna NOMA in various heterogeneous networks was provided.
- The potential challenges and some possible future research directions were discussed for NOMA based on multiple-antenna techniques.