Performance Analysis of Code Domain NOMA in 5G Systems

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Outline

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5G, What and Why?

Low latency

- Self Driving Cars

Massive connectivity

- Smart Homes and Cities

Faster Speeds

- Virtual Reality

Larger Capacity

- Higher Interconnectivity

Fig.1 Features of 5G

What is Multiple Access (MA)?

- Techniques to serve multiple users with limited bandwidth
- Time, Frequency, Power, and Code are different domains where MA can be achieved.

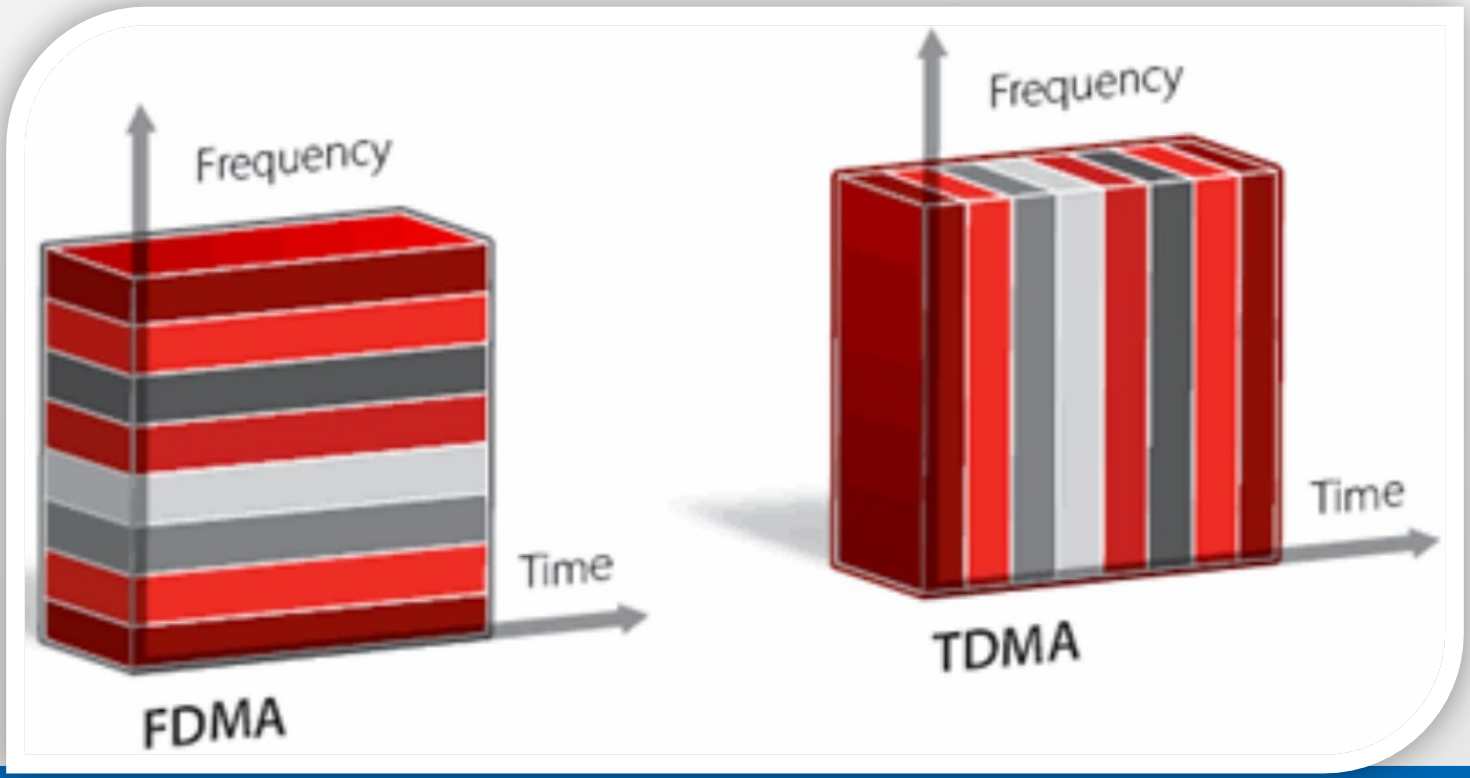


Fig.1 Frequency division (Left) and Time Division (Right) Multiple Access

What is NOMA ?

- **N**on-**O**rthogonal **M**ultiple **A**ccess
  - Novel approach to spectrum sharing.
  - Explores Power Domain for user multiplexing.
  - Essential for massive user influx in 5G.

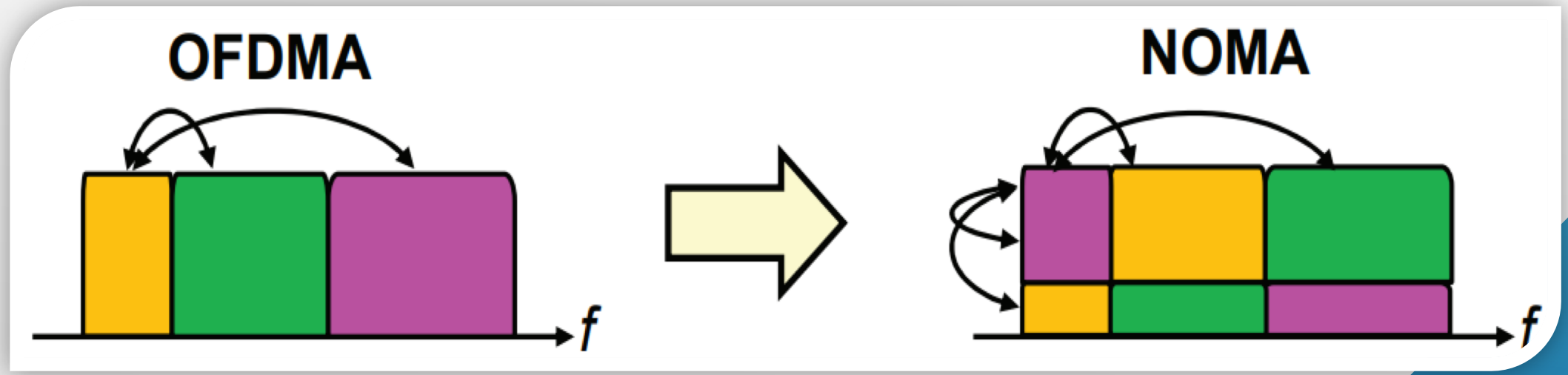


Fig.3 Orthogonal Vs Non-Orthogonal User Multiplexing

Basic NOMA System Model

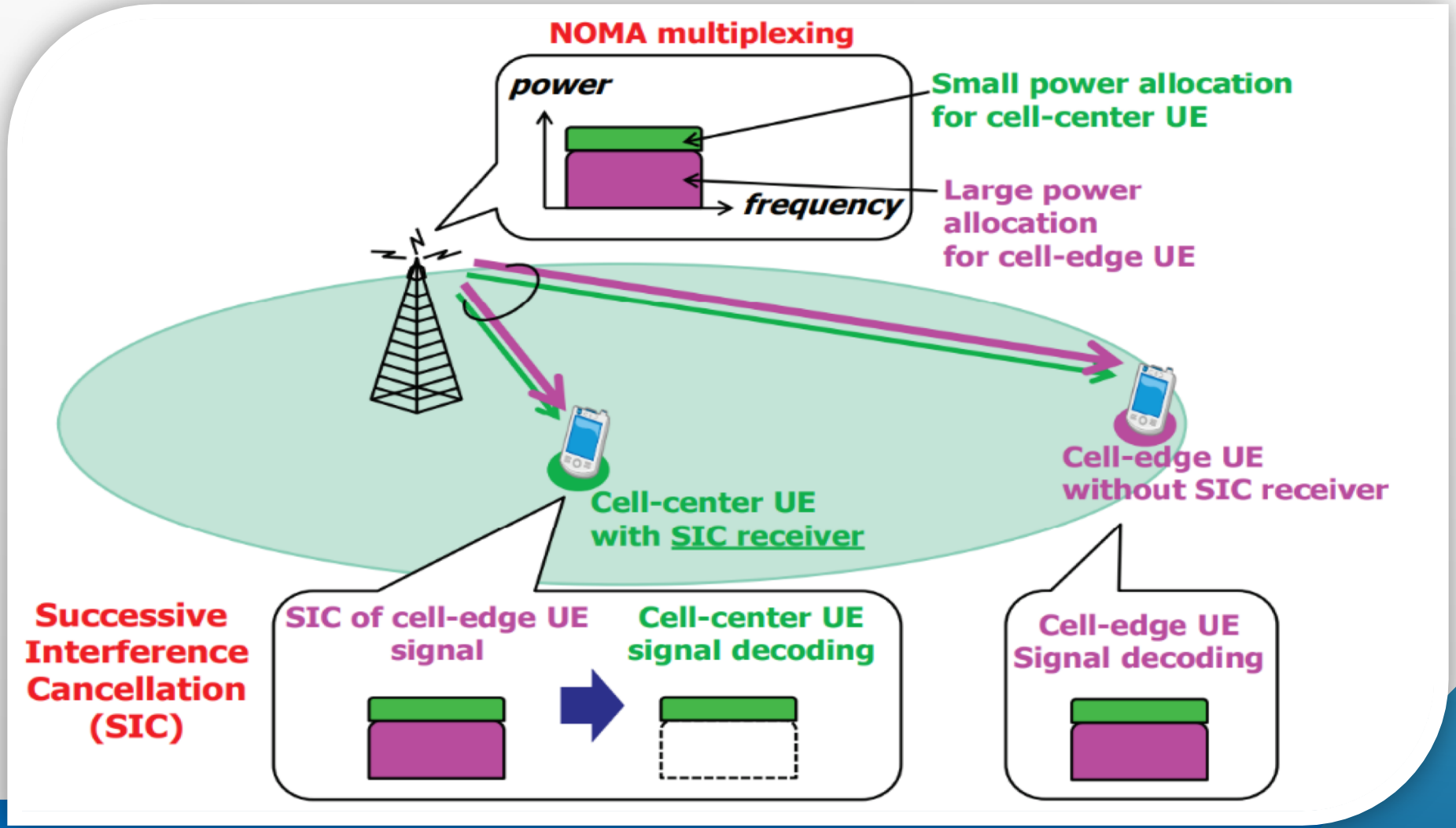


Fig.4 NOMA Power Domain Multiplexing (PD-NOMA)

Types of MA

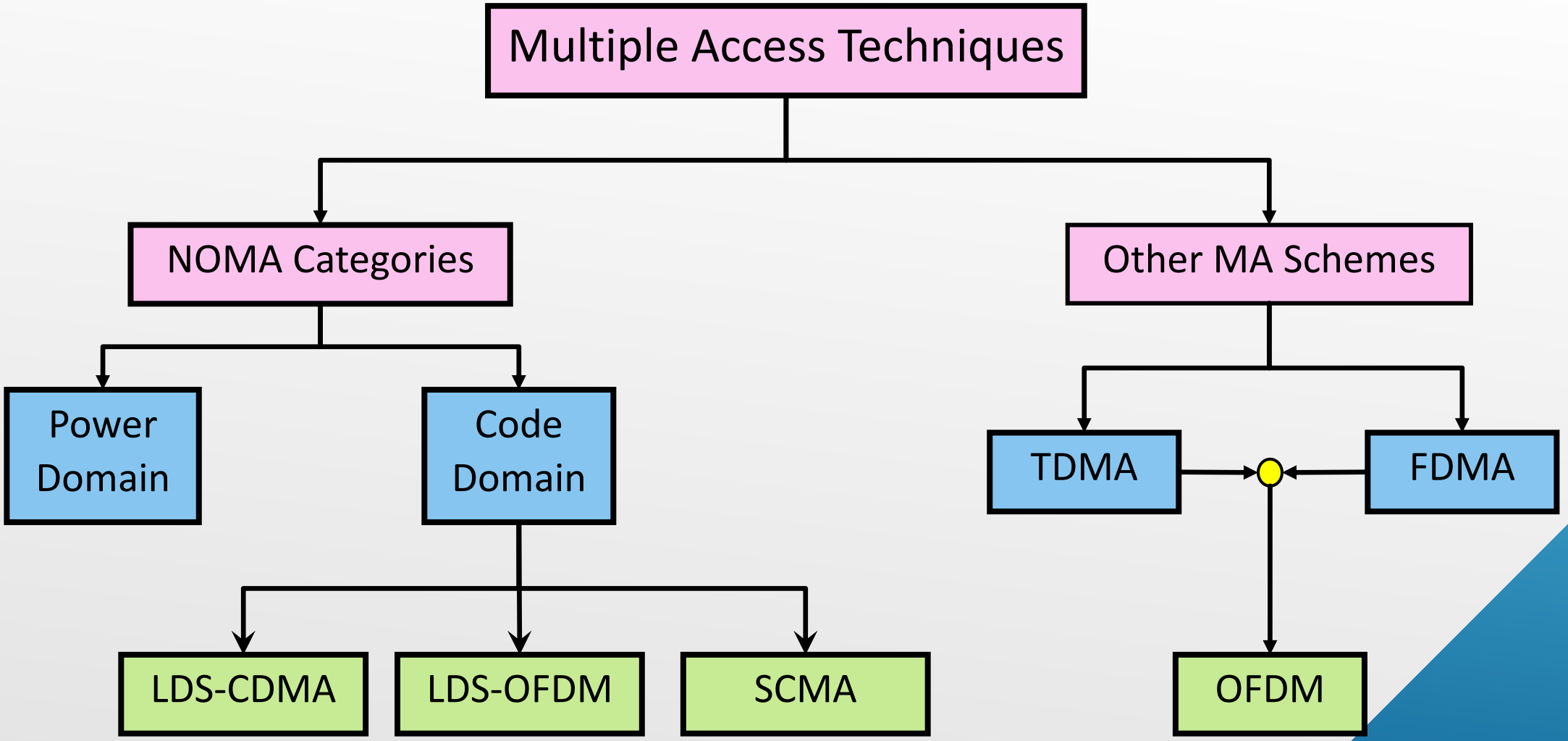


Fig.5 Breakdown of Multiple Access Techniques

LDS-CDMA

- **L**ow-**D**ensity **S**preading **C**ode **D**ivision **M**ultiple **A**ccess
  - Utilizes an LDS technique for signal spreading
  - LDS consists of three phases:
    Signal Spreading, Zero-padding, and Interleaving

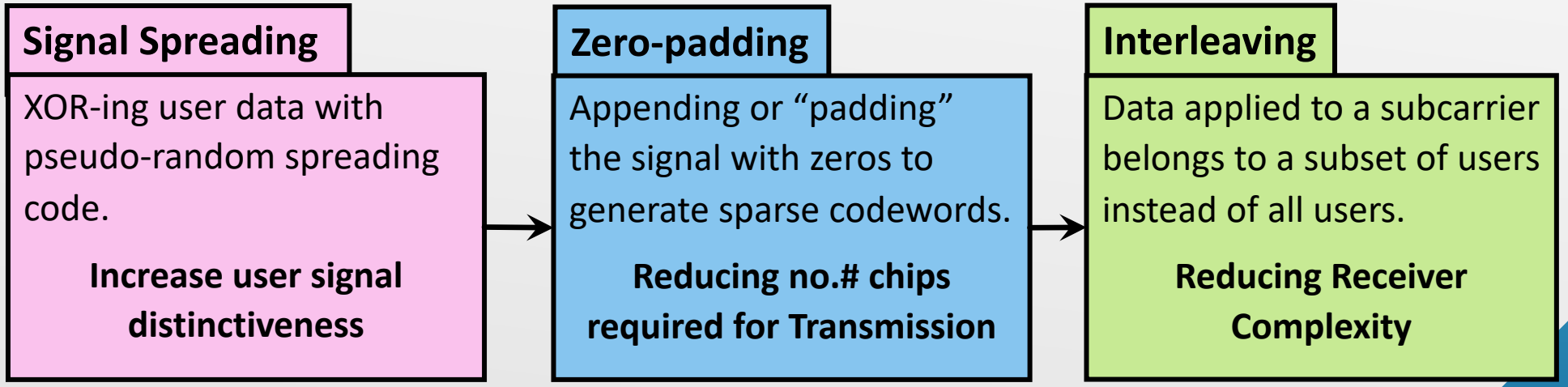


Fig.6 LDS Spreading Process

LDS-CDMA, Pros and Cons

- **Advantages:**
  - Lower Symbol interference than conventional CDMA.
  - Capable of Overloading.
  - Users can be detected at comparable power levels.
  - Moderate Receiver Complexity.

- **Disadvantages:**
  - High Inter-Symbol-Interference (ISI) relative to OFDM.

LDS-OFDM

- **L**ow-**D**ensity **S**preading **O**rthogonal **F**requency **D**ivision **M**ultiple **A**ccess
  - Same Transceiver process as LDS-CDMA
  - Added Exception of an OFDM modulator and demodulator

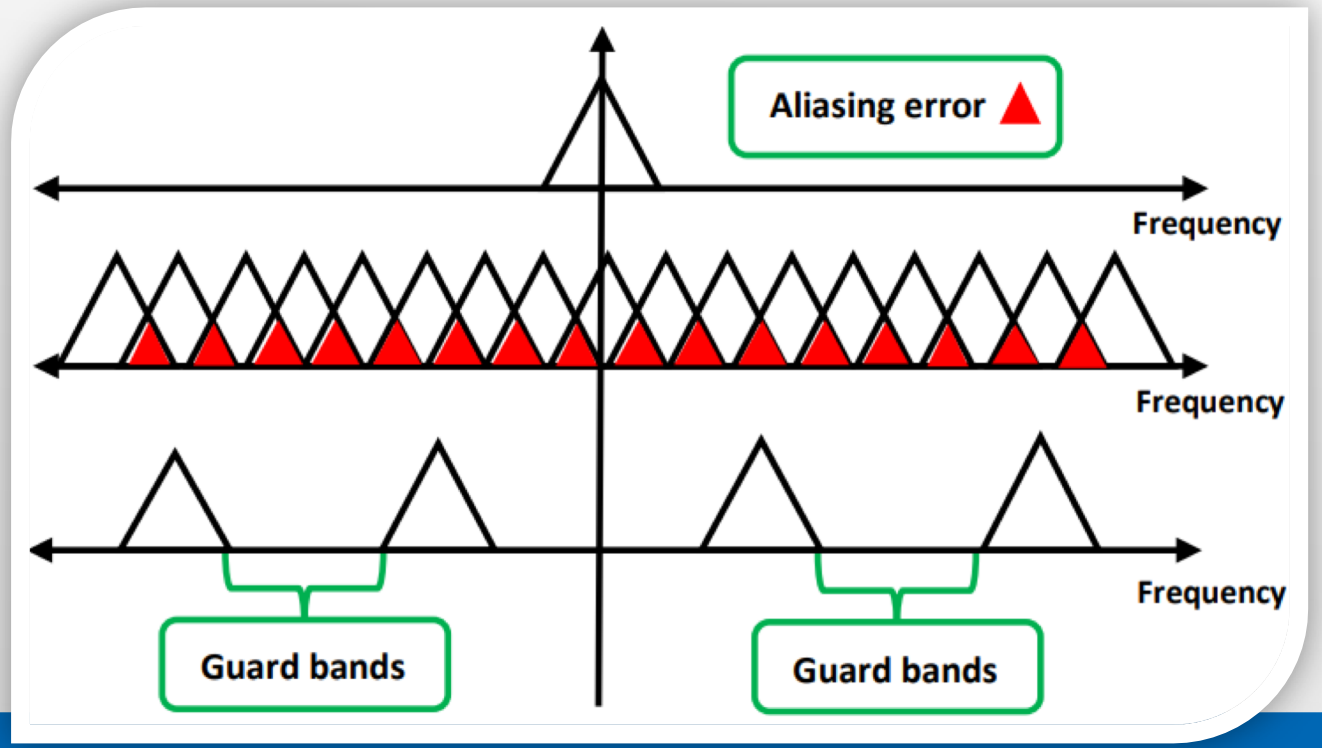


Fig.7 Reduced ISI in OFDM

LDS-OFDM, Pros and Cons

- **Advantages:**
  - Little to no ISI compared to LDS-CDMA.
  - Capable of Overloading.
  - Users can be detected at comparable power levels.

- **Disadvantages:**
  - Very High Receiver Complexity.

LDS-OFDM & CDMA System Model

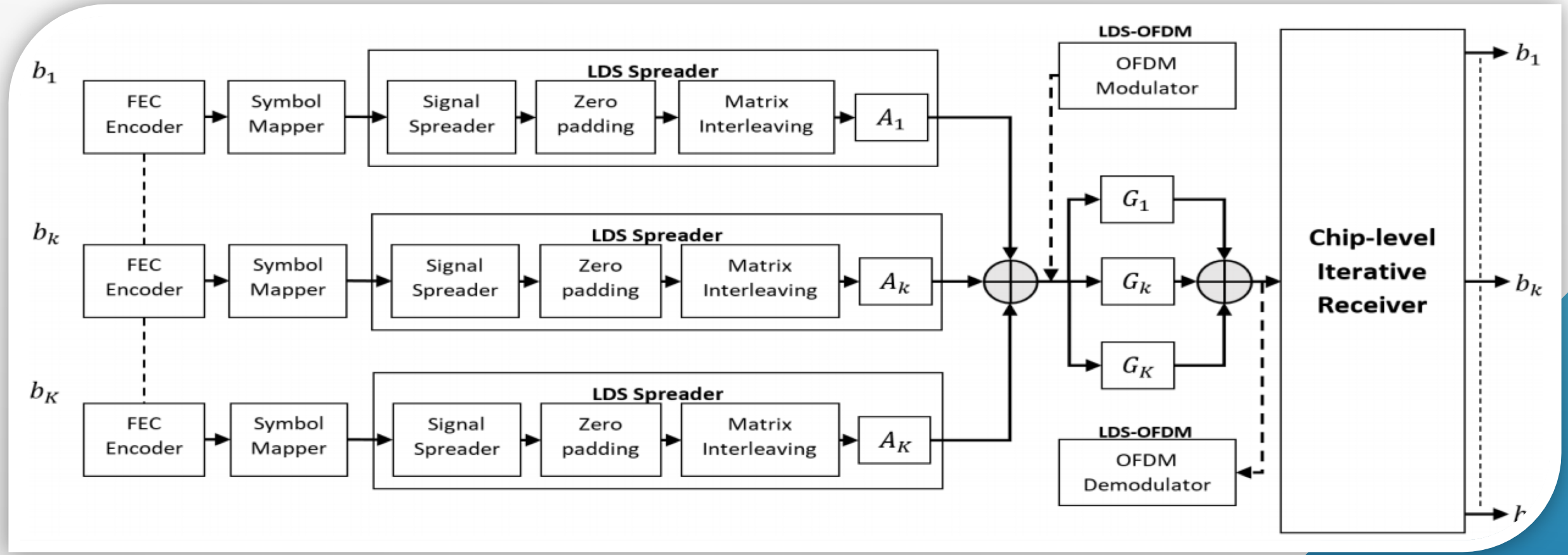


Fig.8 LDS-CDMA and OFDM Block Diagram

SCMA

- **S**parse **S**preading **M**ultiple **A**ccess
  - Utilizes a set of predefined Sparse Codebooks for Signal Spreading
  - Combines LDS with QAM mapping.

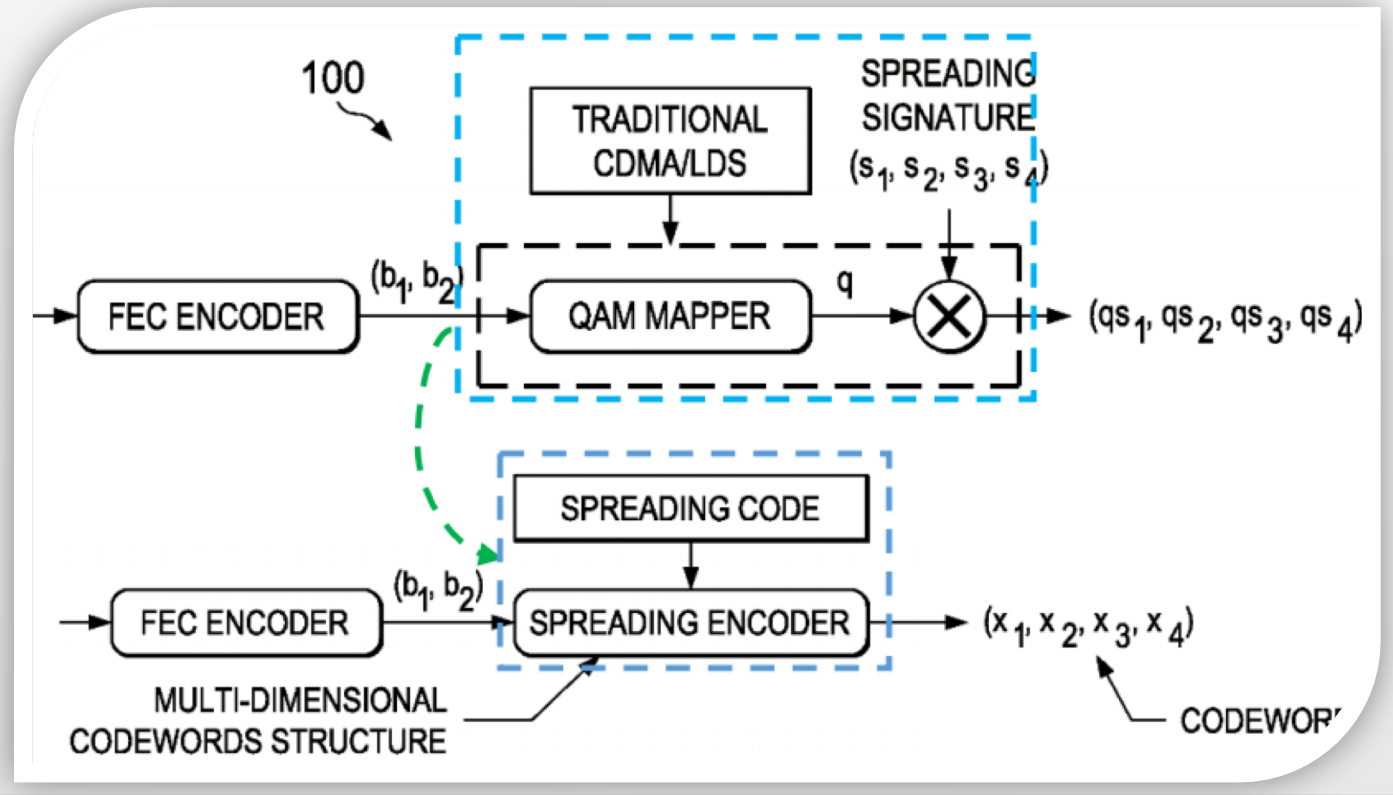


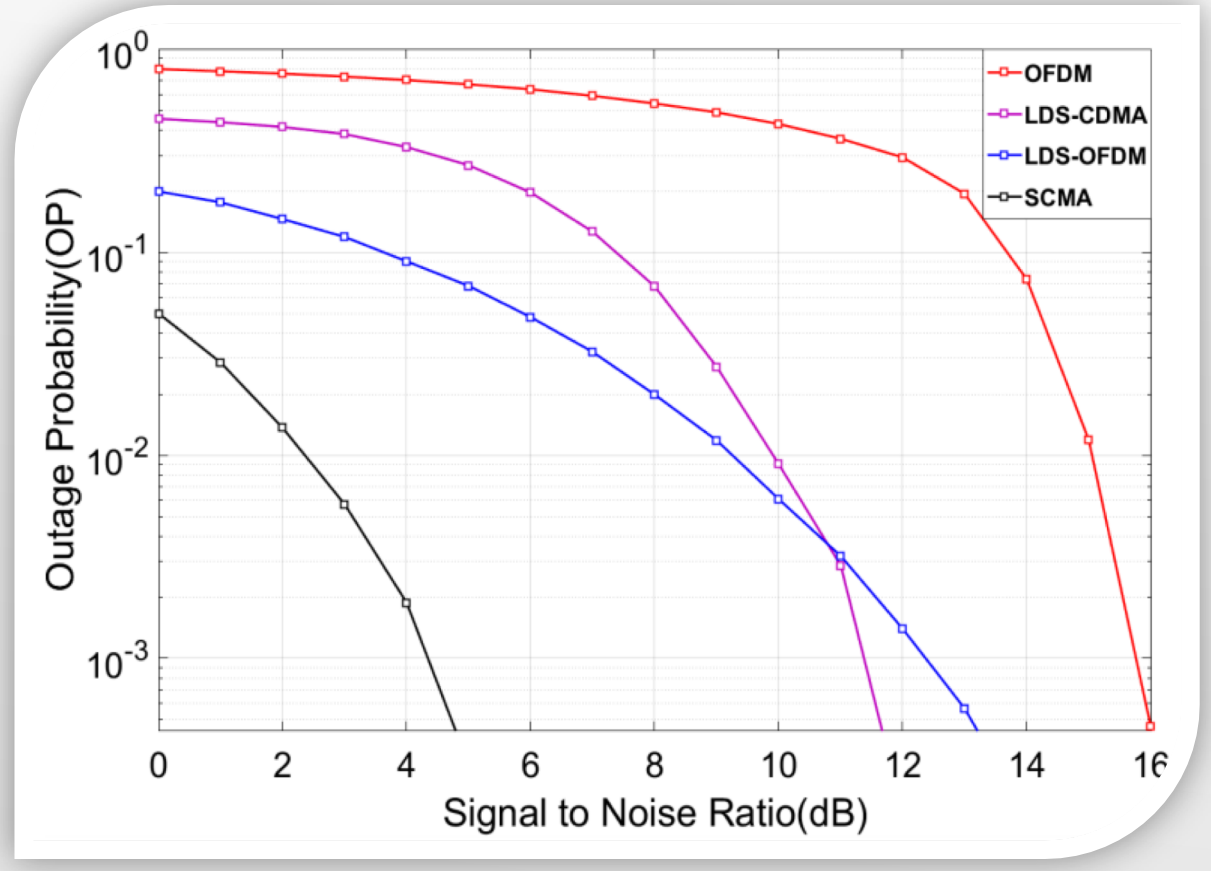
Fig.9 SCMA Encoding Process

SCMA, Pros and Cons

- **Advantages:**
  - Very Low ISI due to high codeword distinctiveness.
  - Capable of Overloading.
  - Users can be detected at comparable power levels.
  - Codebooks are transparent to the receiver.

- **Disadvantages:**
  - Complex Spreading Codeword Generation.
  - Complex Encoding Process.

Test Results



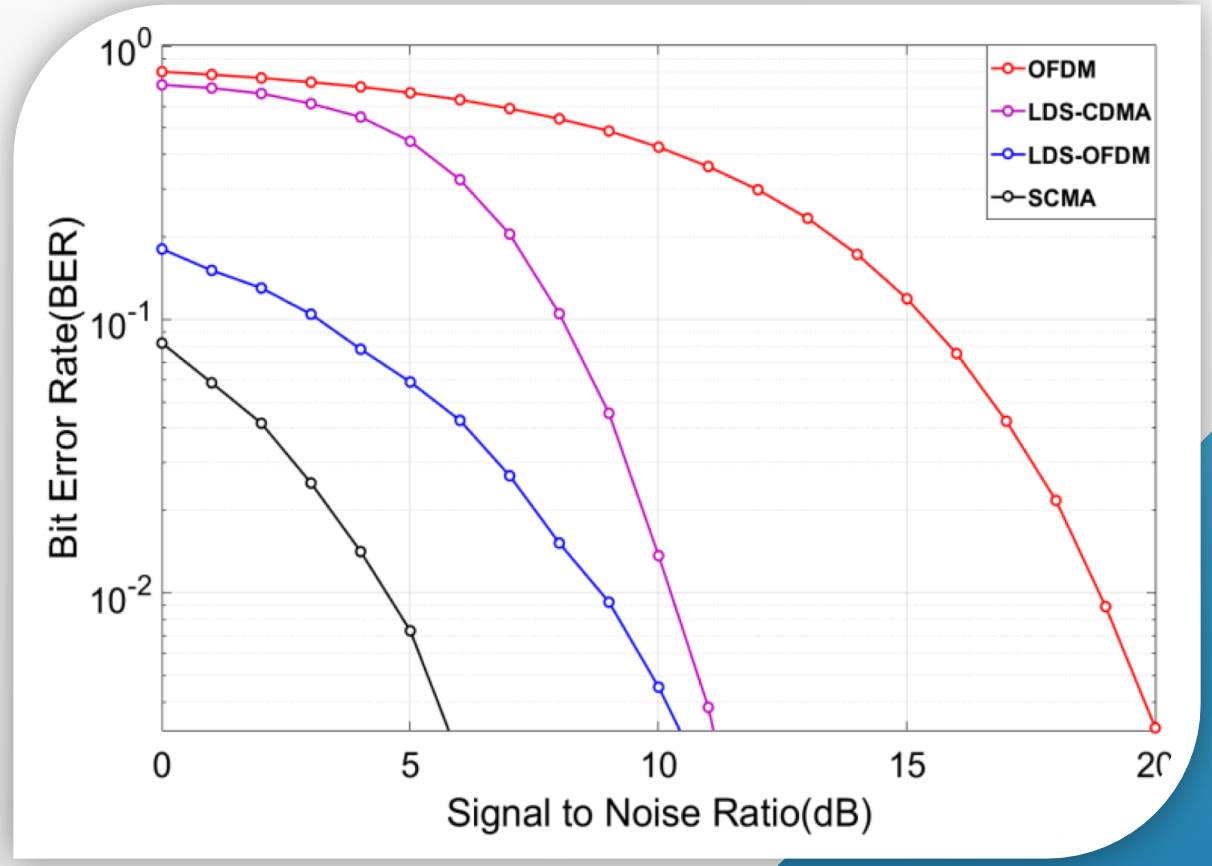


Fig.10 MATLAB Simulation Results, Outage Probability(Left) and Bit Error Rate (Right)

Feasibility Comparison

Criteria / Technique	OFDM	LDS-CDMA	LDS-OFDM	SCMA
Encoding Complexity	Low	Low	Average	Very High
Decoding Complexity	Low	Average	Average	Average
Low-SNR Performance	Very Low	Average	High	Very High
High-SNR Performance	Very High	High	High	Very High
ISI	Very Low	Average	Low	Low
Receiver Complexity	Low	Low	Very High	Average
Overall Feasibility	★★★★	★★★	★★	★★★

Table.1 Implementation feasibility for techniques based on criteria

Conclusions And Future Work

- **Conclusions:**
  - Every NOMA technique outperformed OFDM.
  - SCMA was found to be the highest performing technique.

- **Future Work:**
  - Managing interference in NOMA.
  - Reducing receiver complexity in LDS-OFDM.
  - Applying the NOMA principle to MIMO Networks.
  - Investigating Energy Efficiency in NOMA systems.

Thank You for Listening

Any Questions ?