Preamble Sequence For Fast Cell Search, Low Computational Complexity, and Low PAPR

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Preamble Sequence for Fast Cell-searching, Low Computational Complexity, and Low PAPR

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Addresses the Needs for Mobile Devices

- Single preamble sequence needed for an entire network
- Different code phases represent IDcell, very low computational complexity
- Inherently low PAPR
- Provide a mechanism for fast-cell searching during HO.
- Reduced processing power to extend battery standby time.
- One preamble scan operation process provides DL channel information of all segments such as CIR, TOA, CQI, IDcell, etc.
- Allow MSSs to automatically adjust for DL RX timing to reduce ISI and UL TX timing to maintain subchannel slot timing orthogonality due to the readily available TOA info.
- Reduce the need for frequent ranging requests.
CAZAC Frequency-Time Duality

- CAZAC: Constant Amplitude Zero Autocorrelation Coefficients.

- Main mathematical properties
  - All cyclic shifts of the sequence form an orthonormal basis of $L^2$.
  - CAZAC in time domain if and only if CAZAC in frequency domain (see contribution for details).
**CAZAC Sequences**

- **Chu sequence** \((L=8,32,128,512,\ldots)\)
  - Frequency-time offset ambiguity
  - Frequency offset of \(k\) subcarriers \((k/(LT_s))\) -> time offset of \(-k\) Nyquist samples.

- **Frank-Zadoff sequence** \((L=16,64,256,1024,\ldots)\)
  - Exhibits Chu-like frequency-time ambiguity (not exact).
  - Frequency offset of \(k\) subcarriers -> time offset of \(-k\) Nyquist samples.
Construction of Low PAPR Sequences

- Straight adoption of CAZAC sequences cannot be done due to guard bands in OFDMA.
- Utilize spectrum folding to inherit CAZAC properties with moderate rise of PAPR due to exclusion of guard bands.
Principles of Constructing Low PAPR Sequences

- Method to construct constant-amplitude frequency sequence and low PAPR time waveform
Preamble Sequences for PUSC

- **Subcarriers are divide into four carrier-sets**
  - Segment 0 uses set 0, segment 1 uses set 1, segment 2 uses set 2
  - All sets use the same CAZAC sequence. *IDcell* is characterized by the code-phase (number of cyclic shifts) of the CAZAC sequence.

- **Carrier-set 3 is used for common segment signaling without boosting by all segments.**
  - For 1024-FFT with 128-Chu, segment 0 sends 0-shifted CAZAC, segment 1 sends 42-shifted CAZAC, and segment 2 sends 84-shifted CAZAC.
  - Used for establishing a timing reference and not for channel estimation.
  - Non-boosted to reduce PAPR degradation
**Low Computational Complexity**

- Operation can be done solely in frequency domain.
- CAZAC MF can be implemented as a multiplierless tap-delay line filter with reduced taps (CORDICs and adders).
- CORDICs can be shared with channel estimators.
- Further hardware complexity reduction by exploring CAZAC symmetry (for example, 16-element Frank-Zadoff are ±1 and ±j).
Example of PUSC In SUI-3 With the 3 Adjacent Sectors of 3 BSs

- 1024-FFT PUSC (frequency locked)
- Robust IDcell identification of all segments
Example of Same Segment Interference In PUSC, Scenario 1

Results of CAZAC Matched Filtering In Frequency Domain

IDcell detection using cross-correlation of CAZAC MF outputs of Seg 0 and common segment signaling

Cross-correlation of Seg 0 and Common Signaling
Example of Same Segment Interference In PUSC, Scenario 2

Results of CAZAC Matched Filtering In Frequency Domain

Cross-correlation of Seg 0 and Common Signaling

Detected IDcell=7
Detected IDcell=14
Example of Severe Multipath SUI-5 in PUSC, Scenario 3

Results of CAZAC Matched Filtering In Frequency Domain

Cross-correlation of Seg 1 and Common Signaling

Detected IDcell=14
Conclusion

- Addresses the needs of MSSs where fast cell-searching is essential.
- Allows for extended battery time where neighbor and other frequency BS scanning can be done quickly and reliably and hardware complexity is very low.
- Allows for accurate adjustment of RX and TX timing to reduce RX ISI and TX multi-user interference in high-speed vehicular mobile environment even during HO.