Sequences for Communication System

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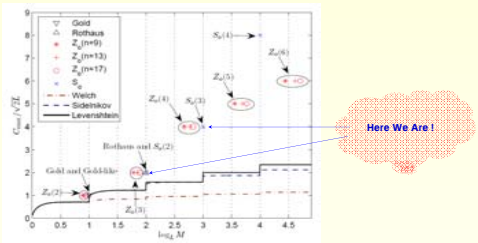
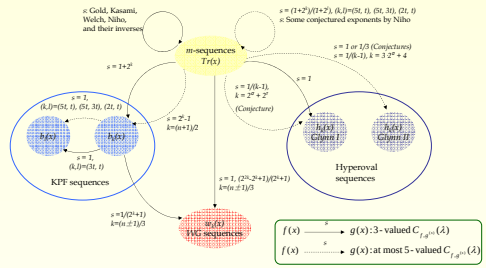
Family of Sequences

- **Sequences with low correlation** are used for identification of users and base stations in multiple access communication systems. Furthermore, such sequences play a role of data scrambling.
- Examples and applications
  - Gold sequences, Kasami sequences, Gold-like sequences, Interleaved sequences, Z_4 sequences, etc.
  - Gold and Z_4 sequences: Scrambling sequences of UMTS
- Research problem
  - In CDMA communication systems, it is desirable to have as many sequences as possible with low correlation preserved → How many sequences can we have with a fixed low correlation?
- Our effort
  - We proposed a new binary sequence family with various family sizes and low correlation values by generalizing Gold-like sequences
  - We studied the asymptotic optimality of known binary sequence families by measuring the closeness of their correlation and family size parameters to well known asymptotic lower bounds



Sequences with Ideal Two-level Autocorrelation

- Sequences with optimal autocorrelation have very important roles in synchronization and positioning process of CDMA and radar communication systems. Also, they are baseline of orthogonal codes which are used as spreading codes in multiple access communication systems.
- Examples and applications
  - Sequences should have impulse-like periodic autocorrelation function
  - *m*-sequences, GMW sequences, Kasami power function (KPF) sequences, Welch-Gong (WG) sequences, Legendre sequences, etc.
  - *m*-sequences: Scrambling and spreading sequences of IS-95 and cdma2000
- Research problem
  - The existence of sequences with ideal two-level autocorrelation is not clear → How to discover or construct unknown sequences with ideal two-level autocorrelation?
  - For practical applications of binary sequences with optimal autocorrelation, aperiodic autocorrelation property of the sequences should be studied explicitly
- Our effort
  - By developing a novel technique, iterative decimation Hadamard transform, we have been trying to discover a new sequence with ideal two-level autocorrelation and to understand the structures of known sequences
  - We studied cross-correlation properties of binary sequences with ideal two-level autocorrelation for potential use of the sequences
  - We proposed a new binary sequence with optimal autocorrelation where period is a multiple of 4

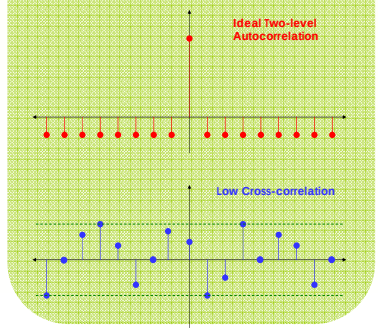


Orthogonal Codes

- In CDMA communication systems, all active users occupy the same frequency band at the same time. They are distinguished by different code assignment. To reduce mutual interference between distinct users, the codes assigned to each user should be mutually orthogonal
- Examples and applications
  - Walsh codes, OVSF (Orthogonal Variable Spreading Factor) codes
  - Spreading codes, channelization codes, and orthogonal modulation of DS-CDMA communication system: IS-95, cdma2000 and UMTS
- Research problem
  - There exist only J distinct orthogonal codes of length J → How to increase the number of codes at the cost of the smallest increase of interference?
  - In uplink transmission, perfect synchronization is not guaranteed because of multi-user transmission and multipath fading → Which codes are good for reducing the interference in asynchronous transmission?
  - In multicarrier-CDMA communications system, the Walsh codes show high peak-to-average power (PAPR) and high dynamic power range → Which codes can replace the Walsh codes to solve the power problem?
- Our effort
  - We are trying to investigate the correlation property of Walsh codes for asynchronous transmission

Sequences !

Correlation of Sequences



Sequences for Multicarrier Transmission System

- Currently, multicarrier transmission techniques such as OFDM and MC-CDMA have been paid much attention for future communication system. In multicarrier technology, we have to concern about peak-to-average power ratio (PAPR) and dynamic range of sequences as well as their correlation.
- Examples and applications
  - Golay sequences: Sum of out-of-phase autocorrelation values of a pair of sequences is zero
    - The power of Golay sequences is always bounded → good for solving the PAPR problem
    - Primary synchronization code (PSC) in UMTS
  - Barker sequences: All out-of-phase aperiodic autocorrelation magnitude is less than or equal to 1
    - Spreading sequences of DS-SS (Direct Sequence-Spread Spectrum) physical layer of IEEE 802.11 WLAN
  - Zadoff-Chu sequences: All out-of-phase periodic autocorrelation value is 0
    - The PAPR and dynamic range of Zadoff-Chu sequences are better than the Walsh codes
- Research problem
  - Barker sequences only exist for length $\leqslant 13$ → How to construct a new sequence of large length with good aperiodic autocorrelation?
  - For multicarrier transmission, which sequence is optimum in terms of PAPR, dynamic range, and interference?
- Our effort
  - We studied low correlation zone (LCZ) sequences for asynchronous transmission
  - We are going to study correlation property of spreading sequences of asynchronous MC-CDMA