

Computational Complexity of Multiuser Receivers in DS-CDMA Systems

Digital Signal Processing (DSP)-I
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By

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Multuser Detection For DS-CDMA

- **Outline**
 - Overview of FDMA & TDMA Systems
 - Overview of DS-CDMA Systems
 - Multuser receivers
 - Optimal MLSE
 - Advantages
 - Problems
 - Simulation Results

Multiuser Detection For DS-CDMA

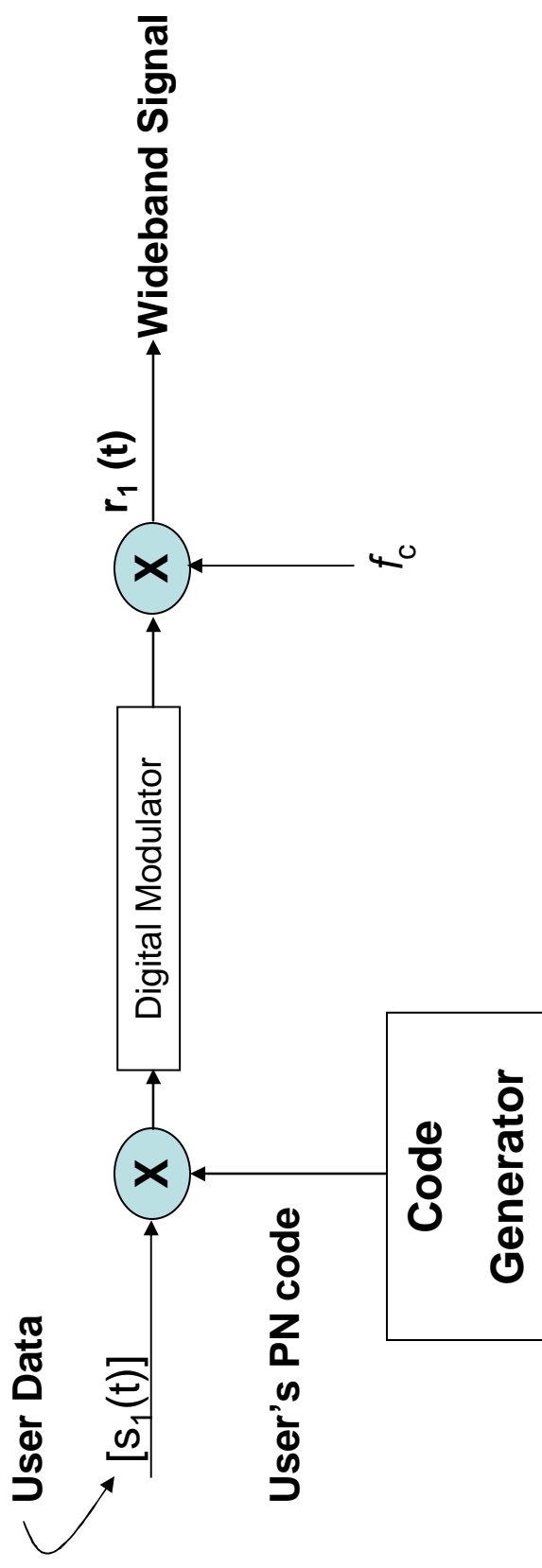
- Overview of FDMA & TDMA
 - FDMA is a fixed assigned protocol
 - Channel bandwidth is divided into non-overlapping frequency bands
 - Transmission time is divided into frames
 - Frames are divided into number of slots
 - Time slots have equal duration
 - User can only transmit in its own time slot
 - Still waste system resources
 - Synchronization is not required
- Problem
 - Wastage of bandwidth

Multiuser Detection For DS-CDMA

- Overview of DS-CDMA systems
 - Each user has its own code sequence
 - Every channel uses the full available spectrum
 - Need to transform the original signal before actual transmission
 - Code is used to perform transformation
 - Original signal changes to wideband signal
 - Not capacity limited

Multiuser Detection For DS-CDMA

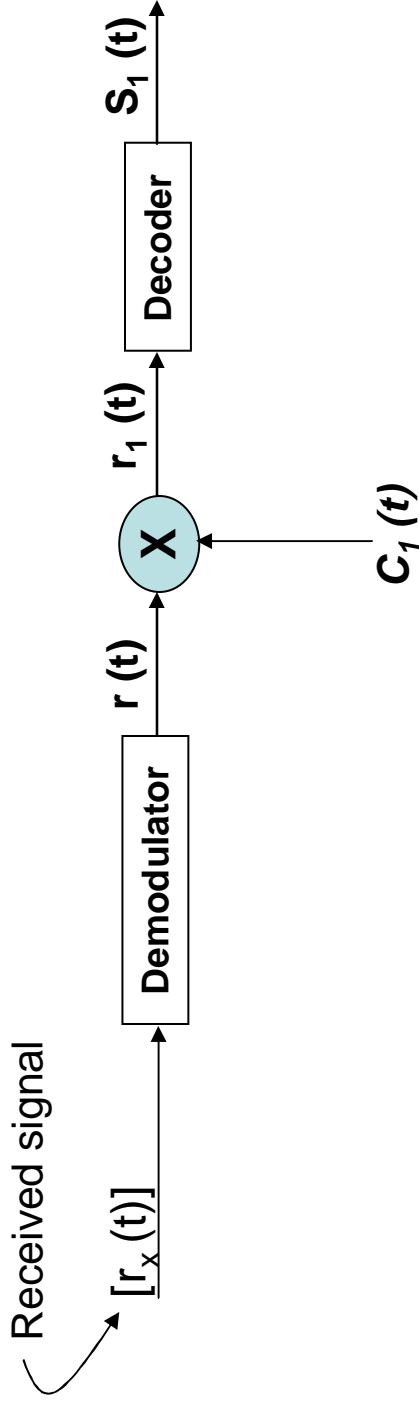
- Overview of DS-CDMA systems



Data transmission in DS-CDMA systems

Multuser Detection For DS-CDMA

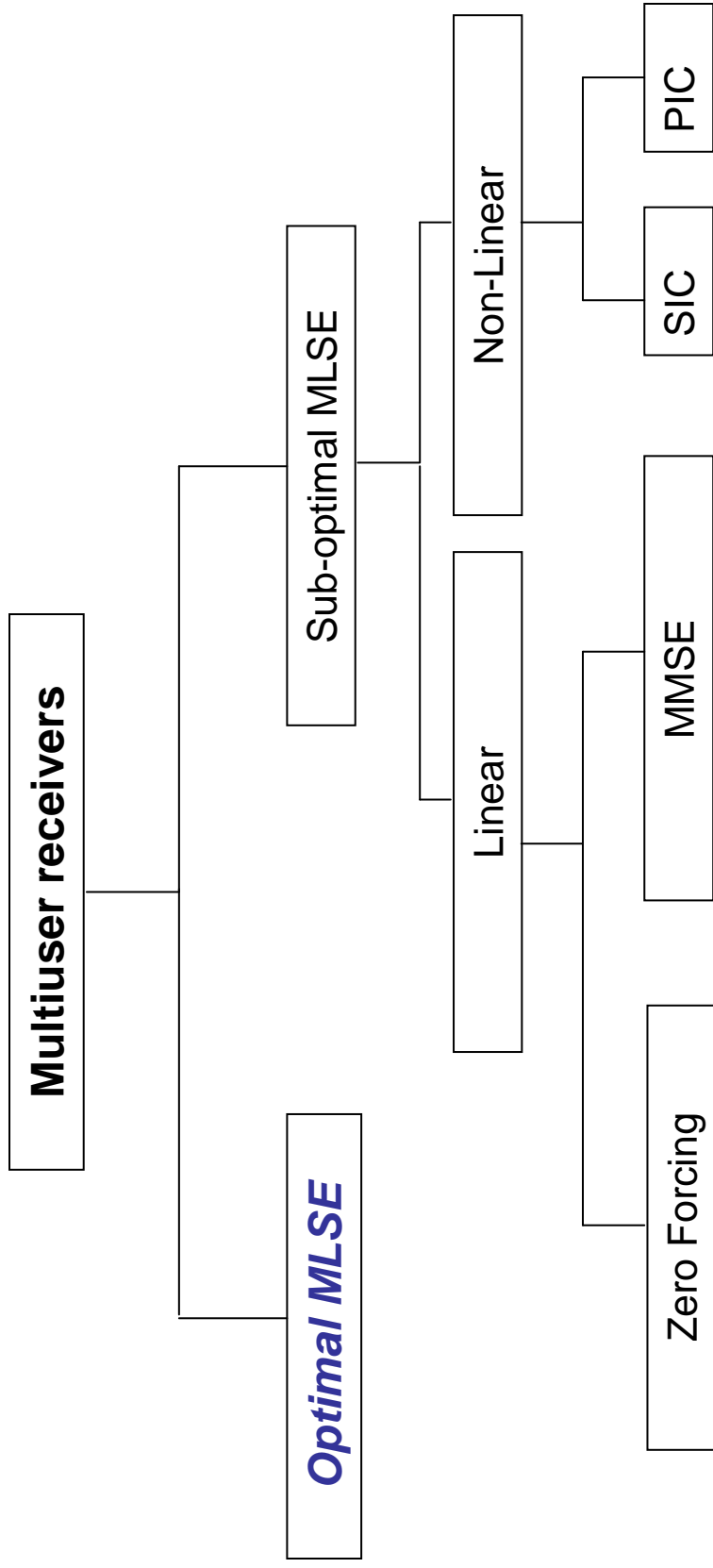
- Overview of DS-CDMA systems



Data reception in DS-CDMA systems

Multiuser Detection For DS-CDMA

- Multiuser Receivers



Multiuser Detection For DS-CDMA

- Optimal MLSE
 - First proposed by Verdu's
 - Consists of a match filter with maximum likelihood detector
 - Choose a good sequence code with good correlation properties
 - Use a maximum likelihood detection instead of linear transformation
 - Give optimal performance

Multiuser Detection For DS-CDMA

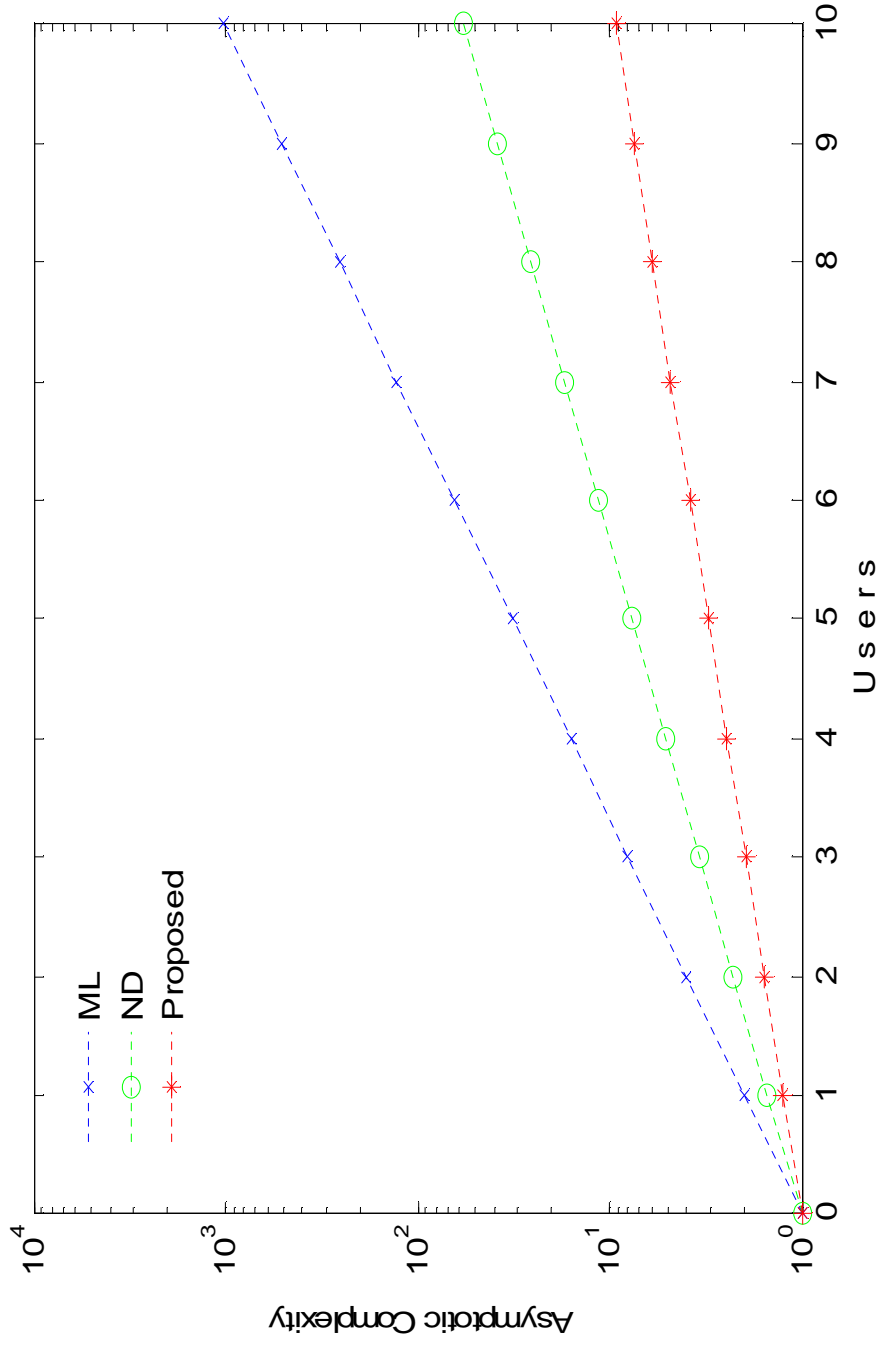
- Optimal MLSE [Problems]
 - Increases receiver complexity
 - Complexity is a linear function of ‘K’
 - Knowledge is required
 - Receiver knows signature waveform for each user
 - Receiver knows time delay, phase shift, and amplitudes
 - Computational complexity is $O(2^k)$

Multuser Detection For DS-CDMA

- Proposed approach
 - Reduces computational complexity
 - Transformation matrix technique
 - Inverse matrix algorithms
 - Combined computational complexity at the receiving end is $O(5/4)^K$

Multiuser Detection For DS-CDMA

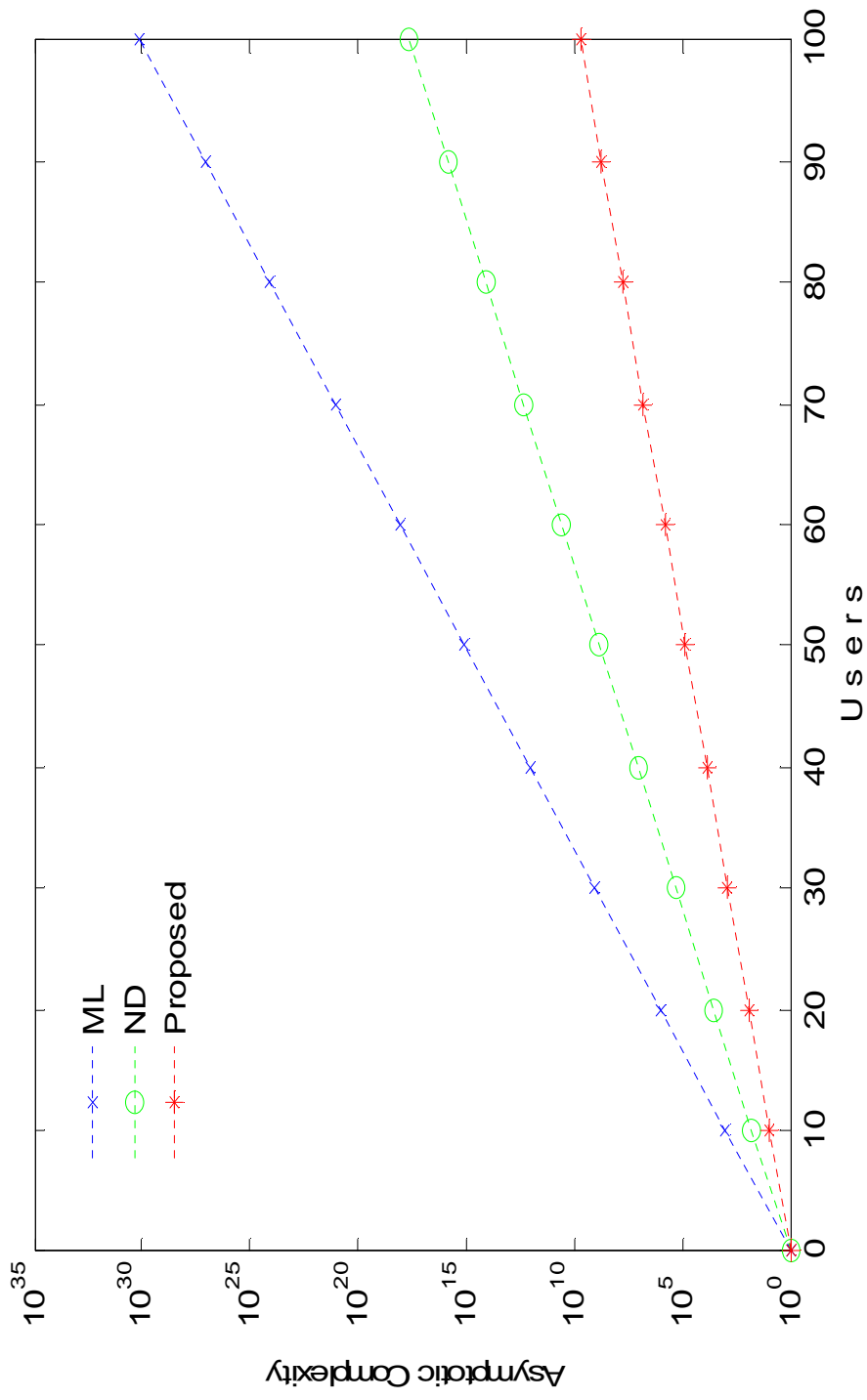
•Computational Complexity (Part-I)



The asymptotic computational complexities versus small number of users

Multiuser Detection For DS-CDMA

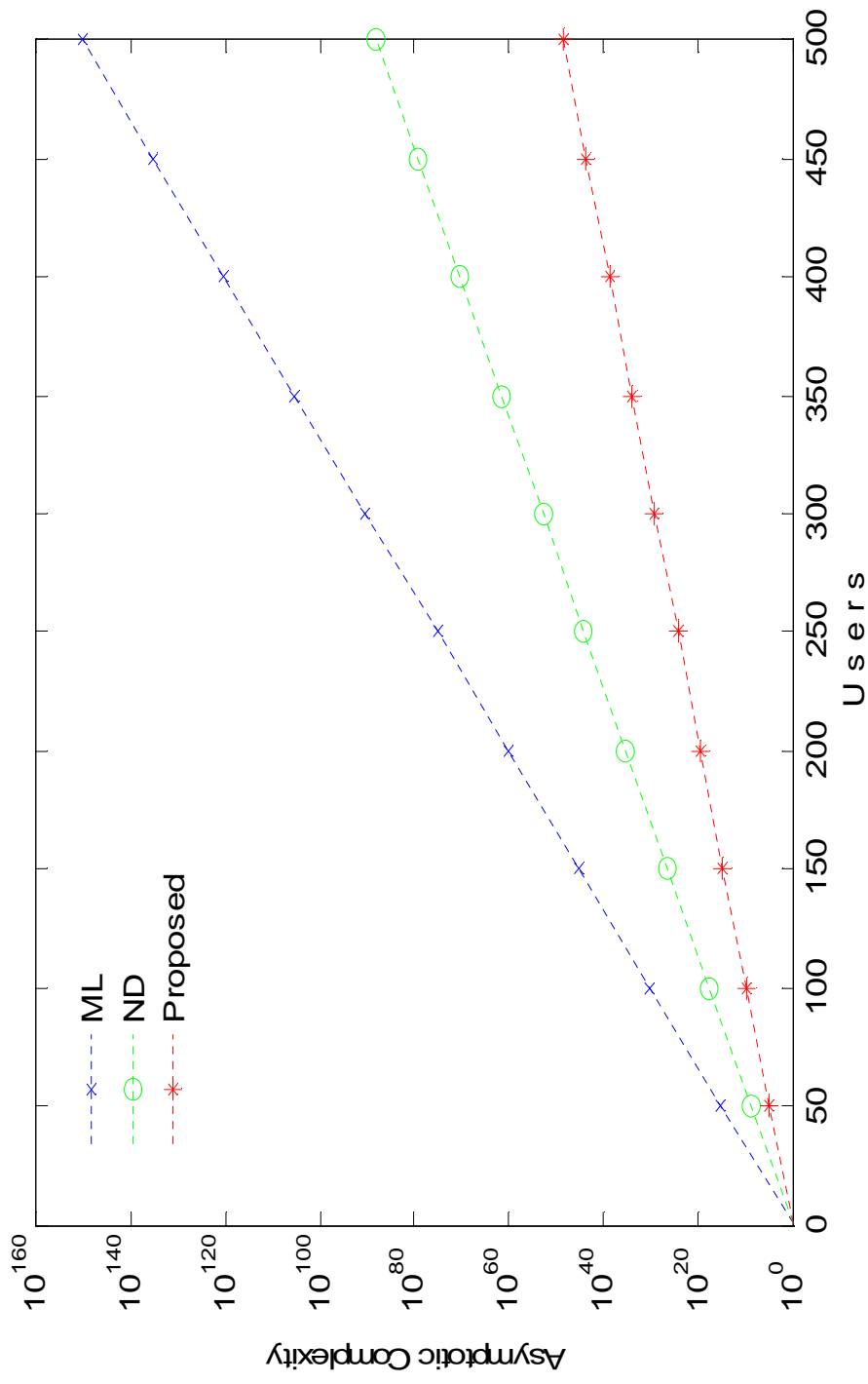
•Computational Complexity (Part-II)



The asymptotic computational complexities versus intermediate number of users

Multuser Detection For DS-CDMA

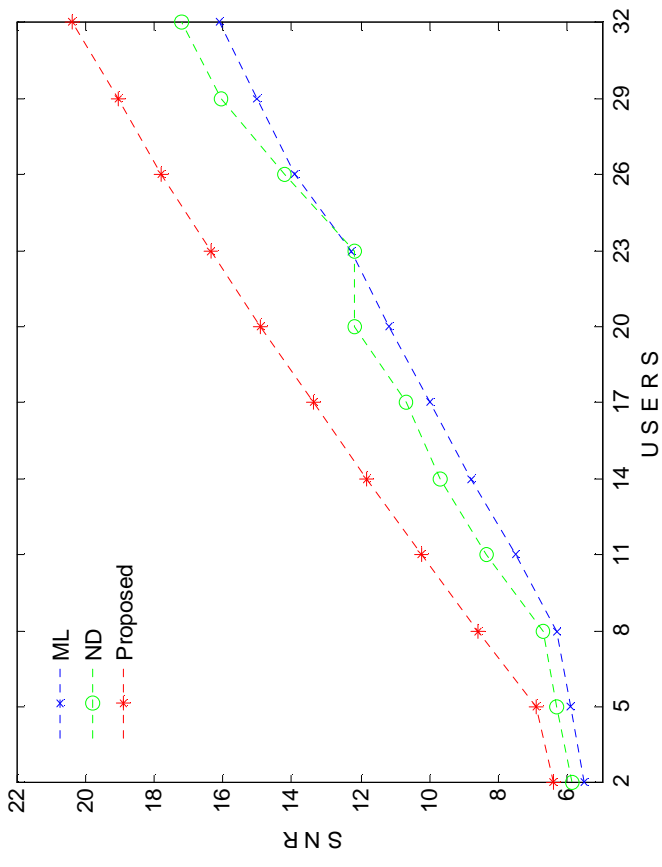
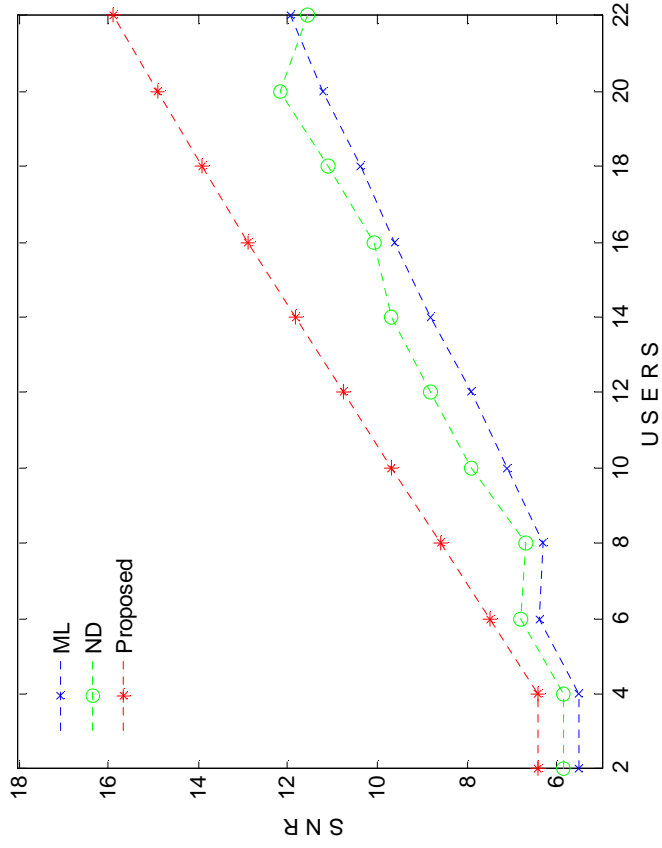
•Computational Complexity (Part-III)



The asymptotic computational complexities versus large number of users

Multuser Detection For DS-CDMA

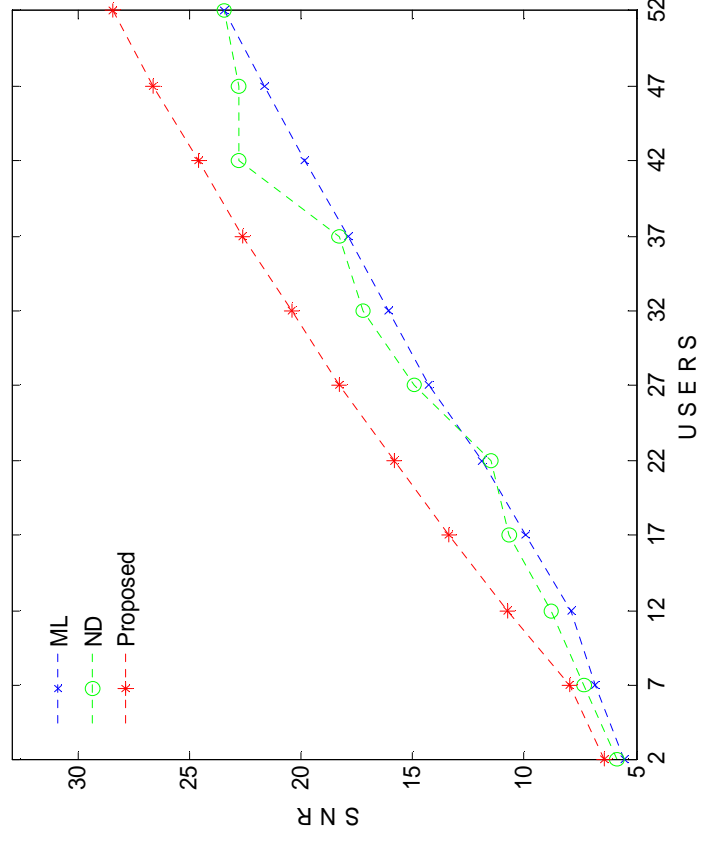
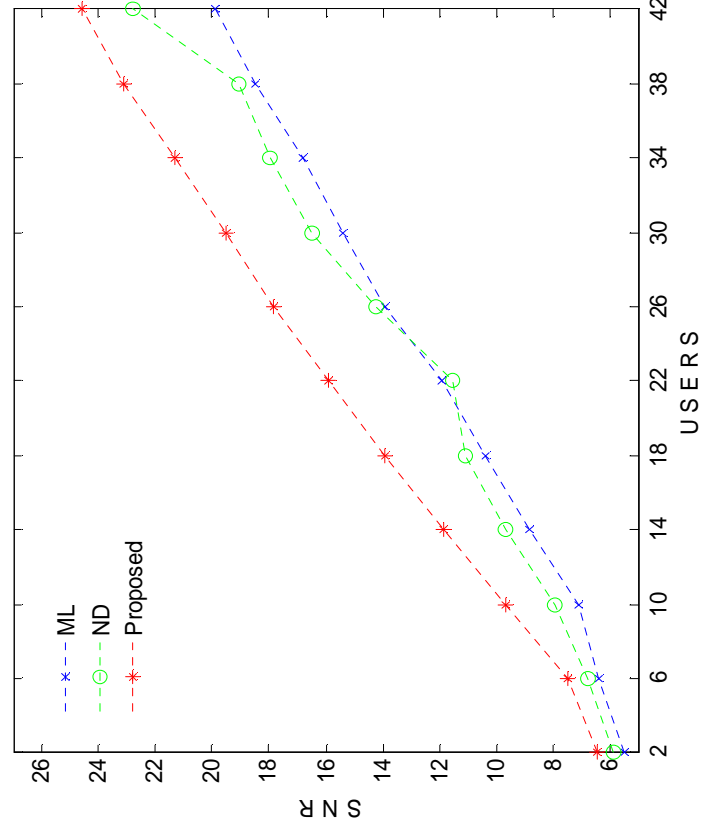
•Signal to Noise Ratio (SNR) for *Lightly-loaded network (Part I)*



Approximate value of SNR (dB) versus number of users (K=22 and 32) with a random amount of variance for a synchronous DS-CDMA system in a Gaussian channel.

Multuser Detection For DS-CDMA

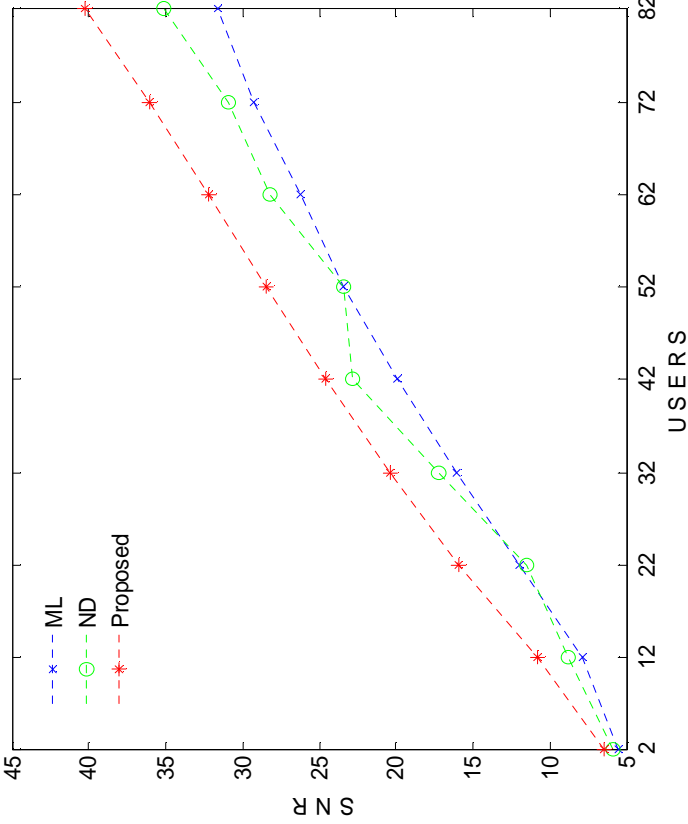
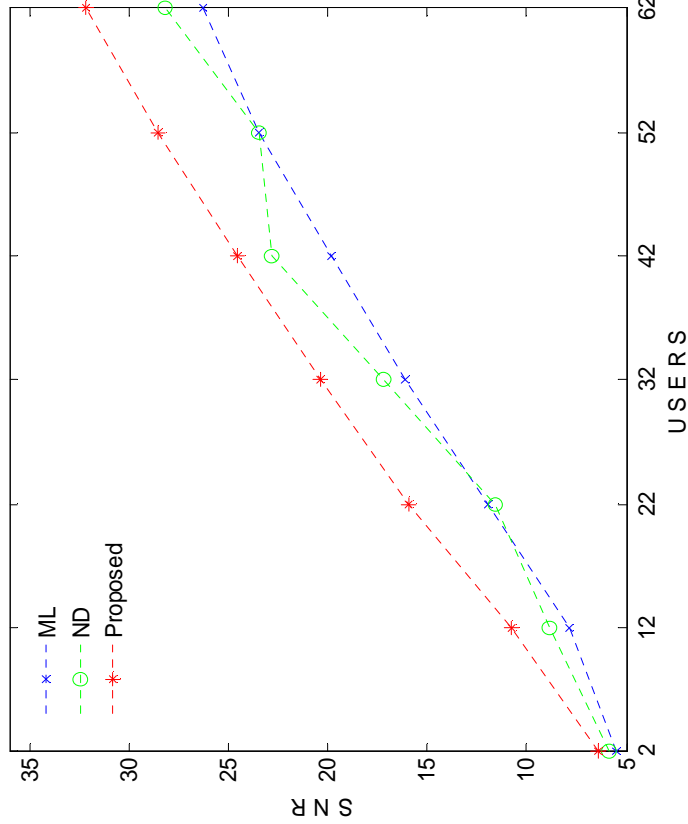
- **Signal to Noise Ratio (SNR) for *Lightly-loaded network (Part I)***



Approximate value of SNR (dB) versus number of users (K=42 and 52) with a random amount of variance for a synchronous DS-CDMA system in a Gaussian channel.

Multuser Detection For DS-CDMA

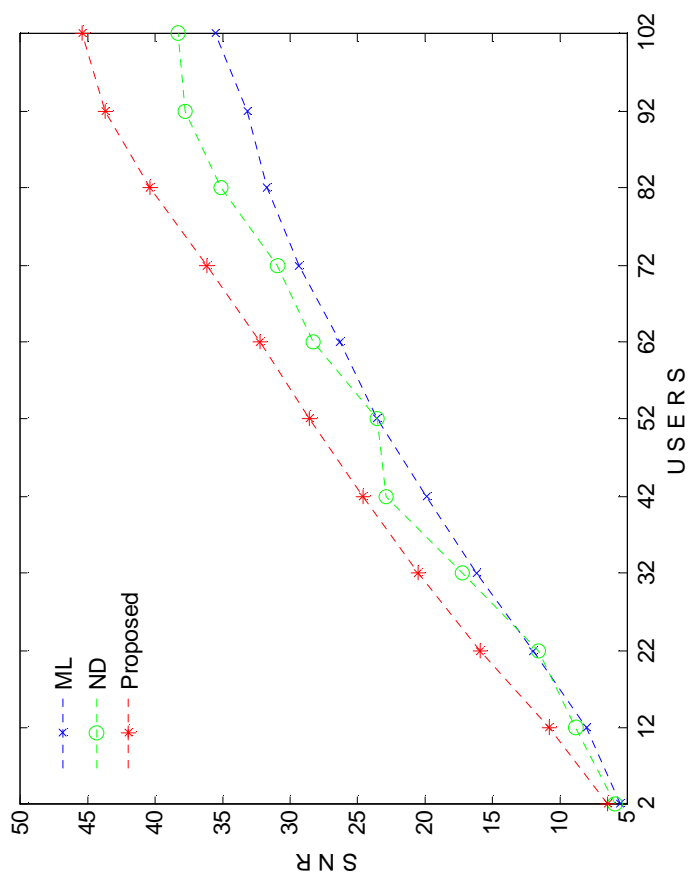
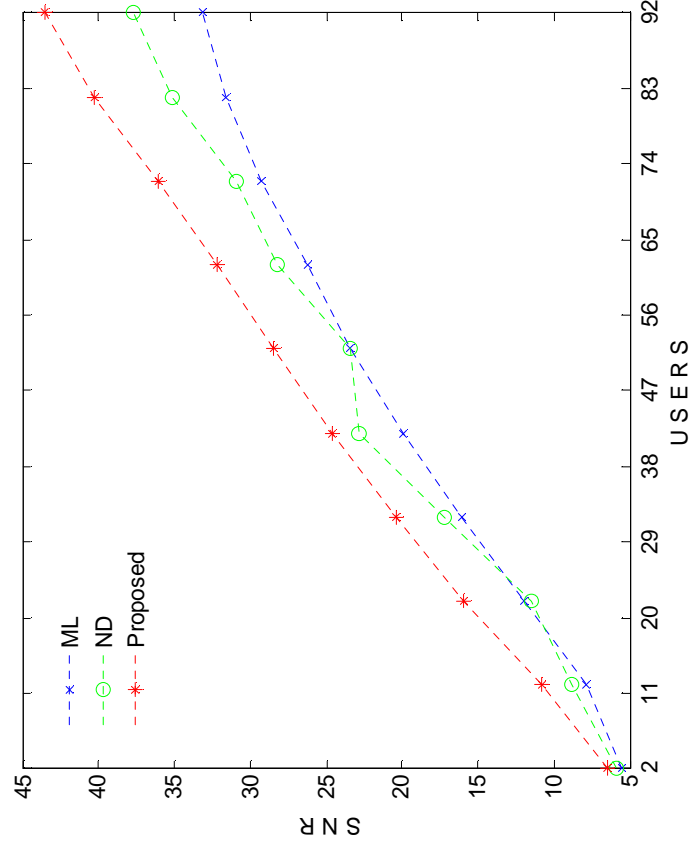
• **Signal to Noise Ratio (SNR) for Highly-loaded network (Part I)**



Approximate value of SNR (dB) versus number of users (K=62 and 82) with a random amount of variance for a synchronous DS-CDMA system in a Gaussian channel.

Multuser Detection For DS-CDMA

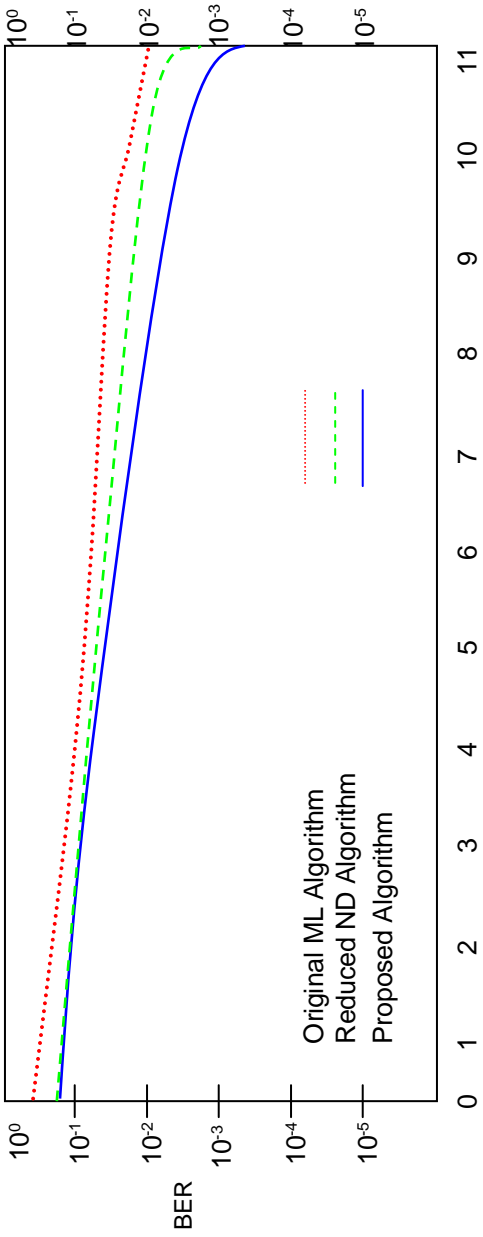
•Signal to Noise Ratio (SNR) for *Highly-loaded network (Part I)*



Approximate value of SNR (dB) versus number of users (K=92 and 102) with a random amount of variance for a synchronous DS-CDMA system in a Gaussian channel.

Multuser Detection For DS-CDMA

•Bit Error Rate (BER) for Lightly-loaded network (Part I)



Number of users 10

Multiuser Detection For DS-CDMA

- **Conclusion**
 - We described Optimal MLSE and the associated problem
 - Too complex for practical implementation
 - Transformation technique can be used to reduce computational complexity
 - Useful for better processing gain

Multiuser Detection For DS-CDMA

Questions?