CDMA Receivers for High Spectral Utilization

Types of CDMA Receivers

- Conventional Matched Filter
- Single User Receivers
- Multiuser Receivers

Why Use Advanced Receivers?

- CDMA is interference limited
- CDMA subject to near/far problem on reverse channel
- Interference and near/far problem limit system capacity
- These problems are not inherent to CDMA , but rather the result of using conventional correlator
- Multiuser and Single User receivers mitigate these problems

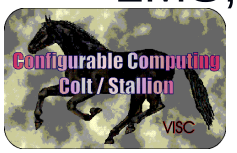
Receiver Architectures

Multiuser Multistage RAKE Receiver

- Estimate the interference and subtract it out.
- Number of stages : 2-3
- Number of RAKE fingers : 2
- Conventional RAKE correlators employed at each stage

Single User Mobile Receiver

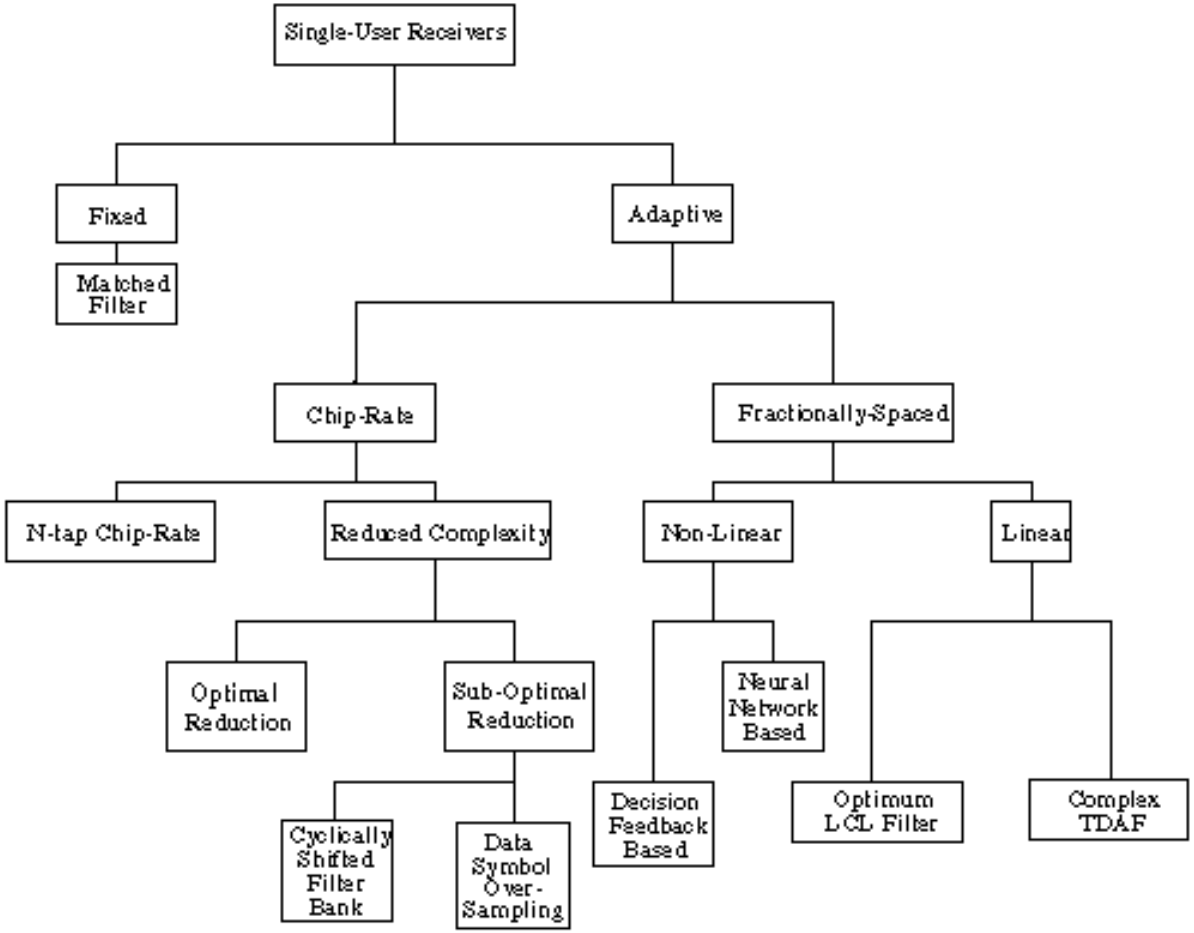
- Linear fractionally spaced adaptive filter of length 45
- Adaptive algorithms: Normalized LMS, Linearly Constrained CMA, Griffiths' algorithm, Soft Decision Directed Normalized LMS, etc.



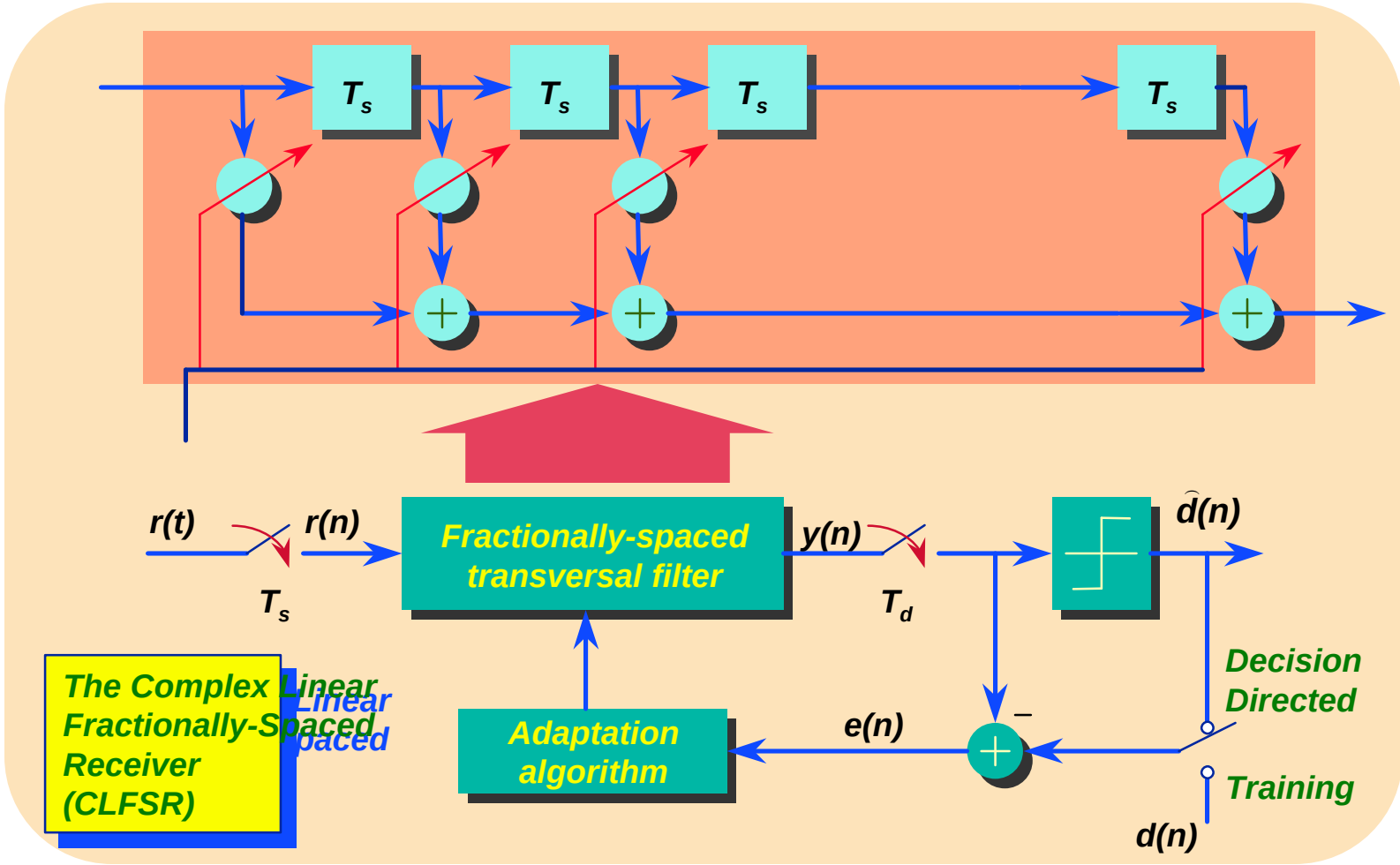
Single User Receiver Objectives

- Design and implement a mobile receiver capable of operating in heavily loaded and multipath environments
- Compare existing receiver structures and algorithms on a common simulation testbed
- Develop novel blind algorithms for CDMA interference rejection
- Implement promising algorithms on a DSP
- Map the algorithms from the DSP to the COLT reconfigurable FPGA processor

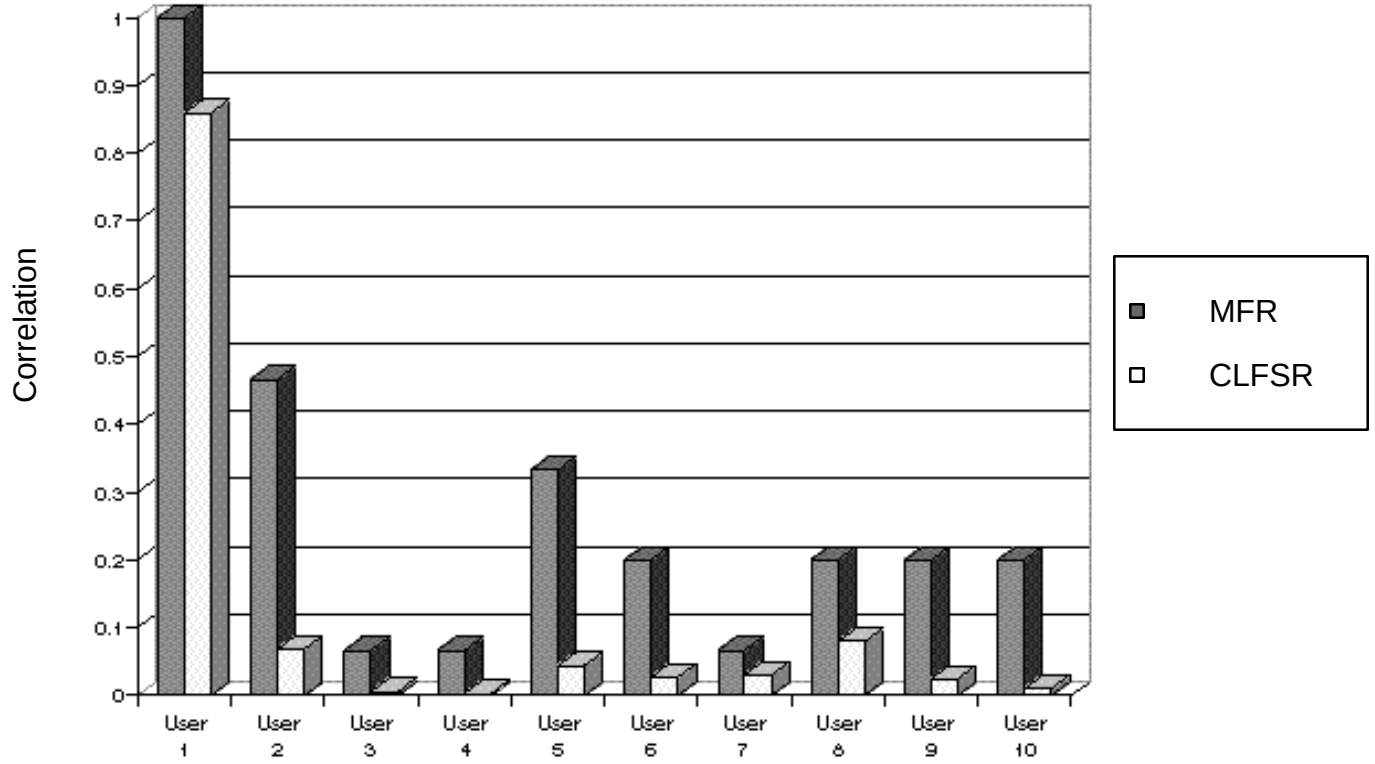
Single User Receiver Structures



Receiver Structures



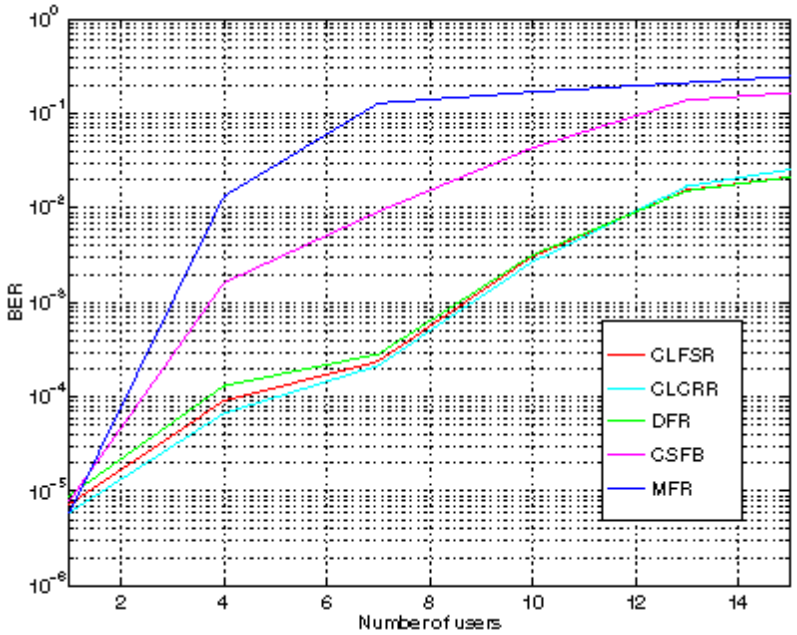
What Single User Receivers Do



Cross correlation of filter weight vector with the spreading code of each user

Algorithms: Trained

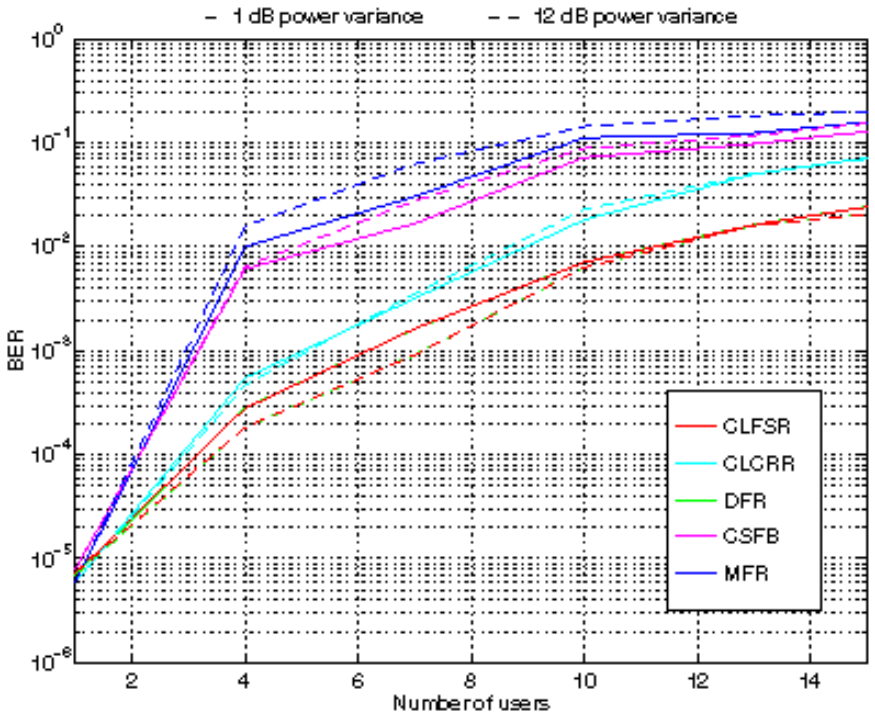
- Algorithms based on MSE cost function
- Adaptive receivers offer significant capacity gains



Capacity curves: Synchronous AWGN channel, E_b/N_0 = 7.5 dB

Algorithms: Trained

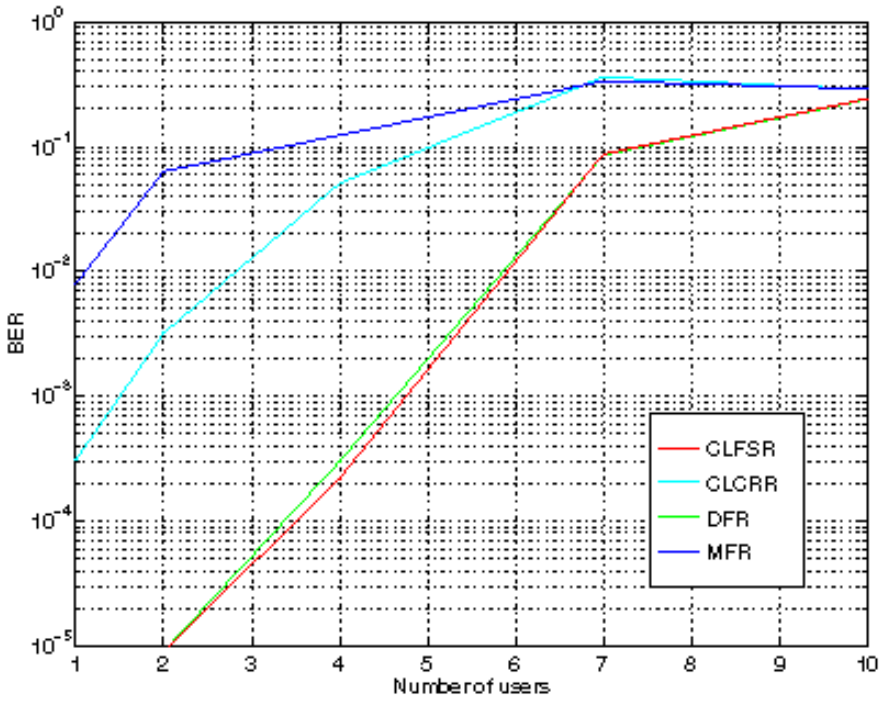
- The adaptive receivers are near-far resistant



Capacity curves: Asynchronous AWGN channel, E_b/N_0 = 7.5 dB

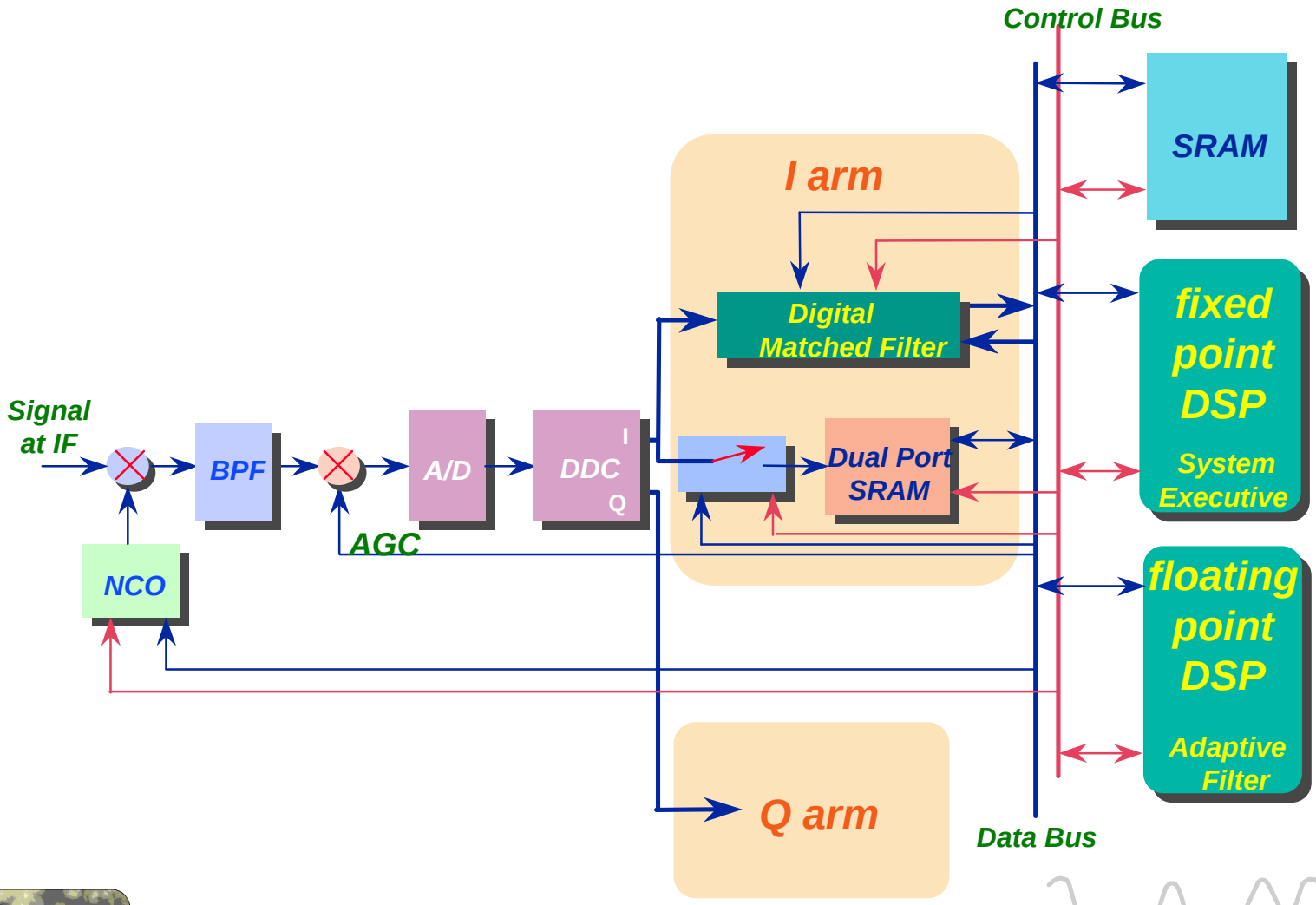
Results

- Can adaptive receivers exploit multipath?



Capacity curves: Urban channel (COST 207 model), E_b/N_0 = 23.5 dB

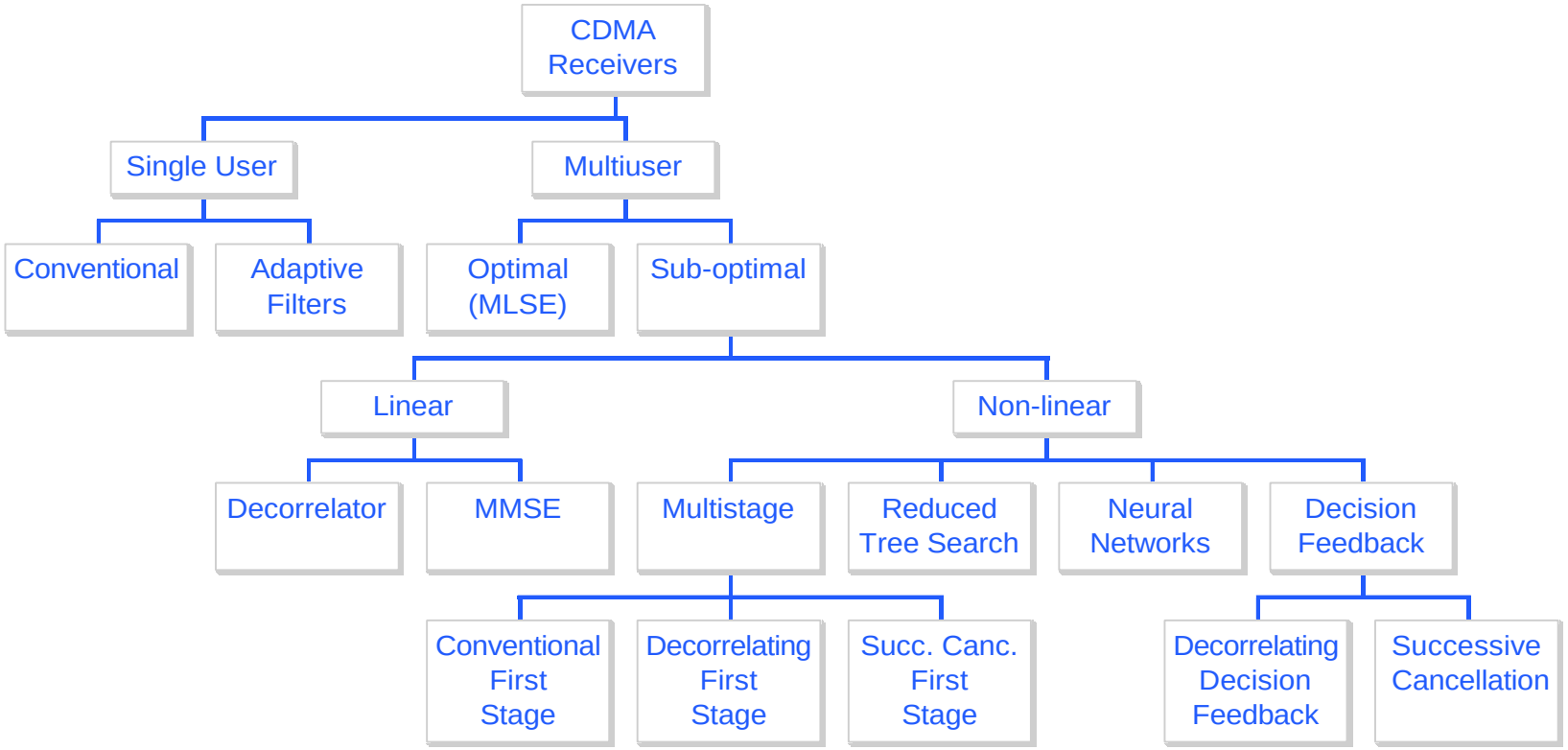
Hardware Architecture



Multiuser Receiver Objectives

- Design and implement a multiuser multistage RAKE receiver for interference cancellation and multipath mitigation at the base station.
- Provide significant capacity gains and near/far resistance compared to current CDMA receivers with a complexity that makes implementation feasible.
- Development of analytical and simulation tools to study multiuser interference cancellation for CDMA.
- Address implementation issues not considered in the literature.

CDMA Receivers



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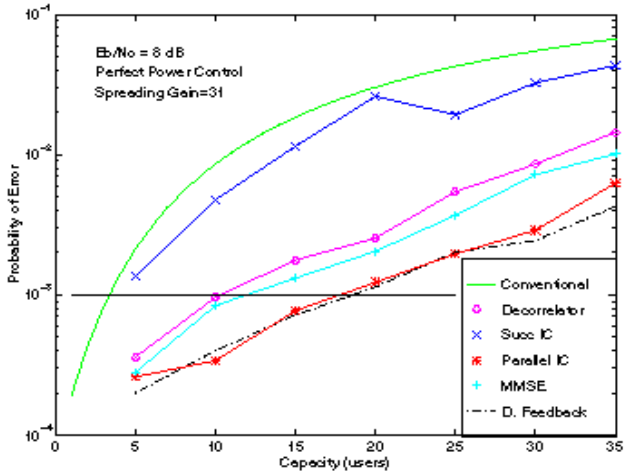
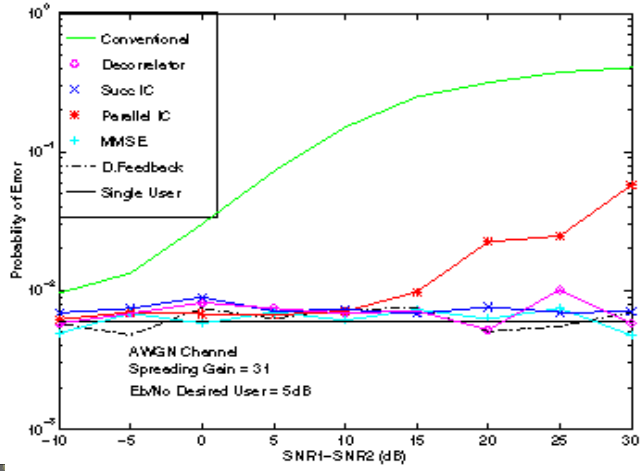
Multiuser Receivers

- Offer significant capacity gains over conventional receiver
- Provide robustness in near/far situations

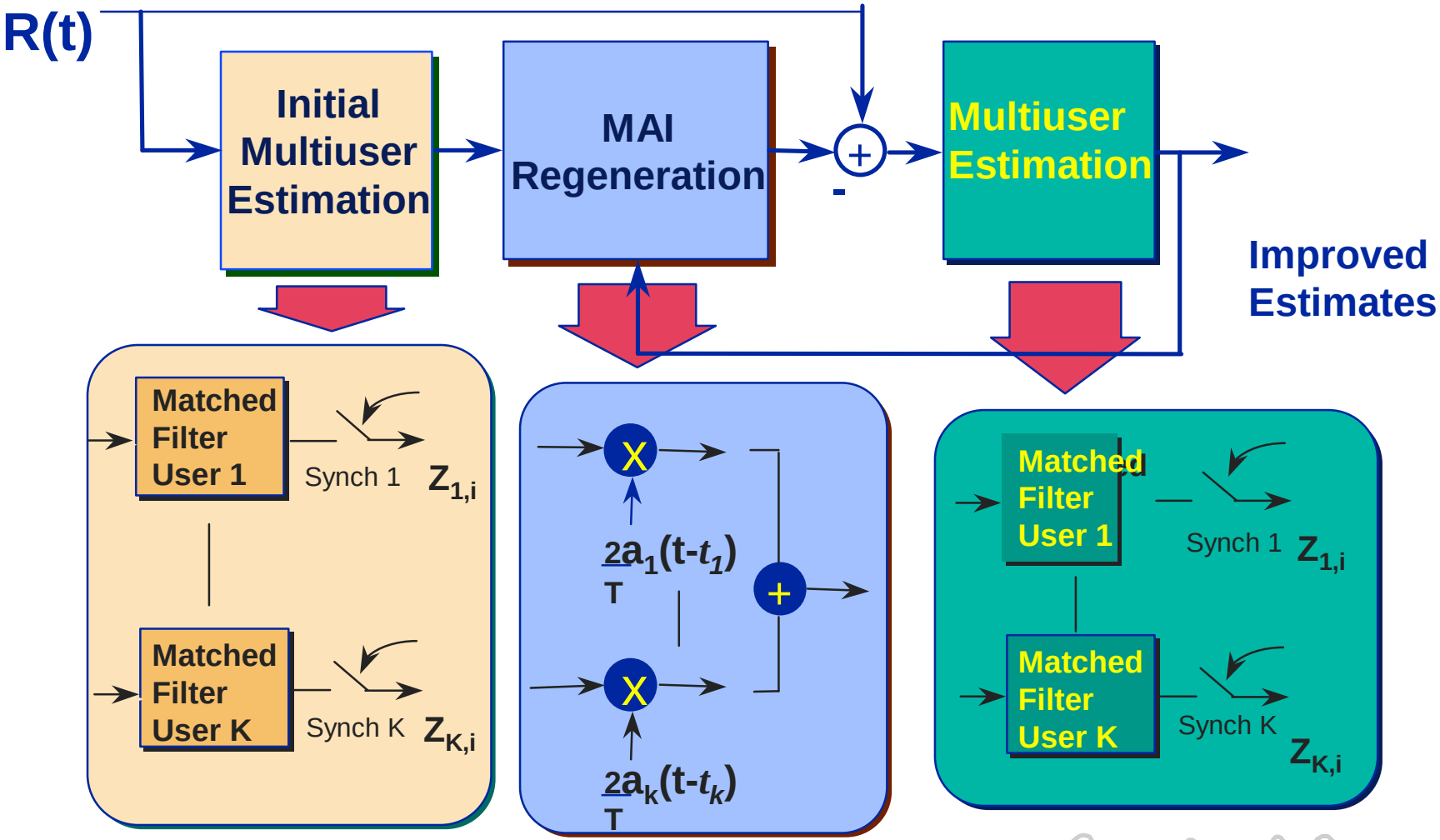




- Parallel cancellation provides excellent tradeoff between complexity and performance

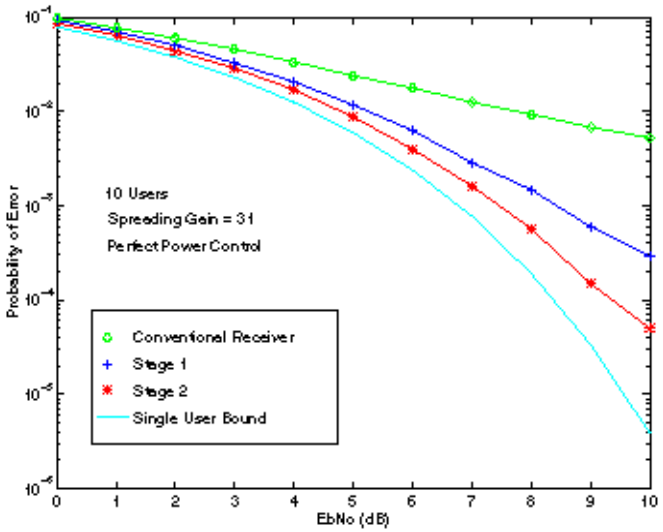
MPRG

Approach


R(t)
Initial Multiuser Estimation
MAI Regeneration
+
-
Multiuser Estimation
Improved Estimates
Matched Filter User 1
Synch 1
$Z_{1,i}$
Matched Filter User K
Synch K
$Z_{K,i}$
X
$\frac{2a_1(t-t_1)}{T}$
+
X
$\frac{2a_k(t-t_k)}{T}$
Matched Filter User 1
Synch 1
$Z_{1,i}$
Matched Filter User K
Synch K
$Z_{K,i}$

Performance

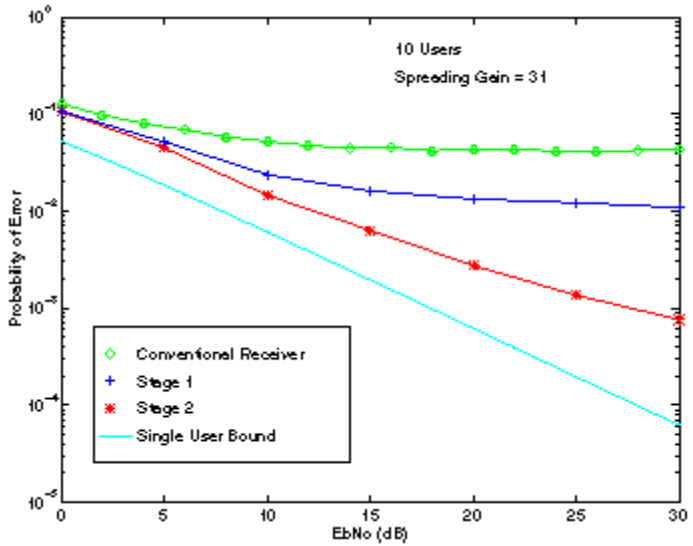
AWGN



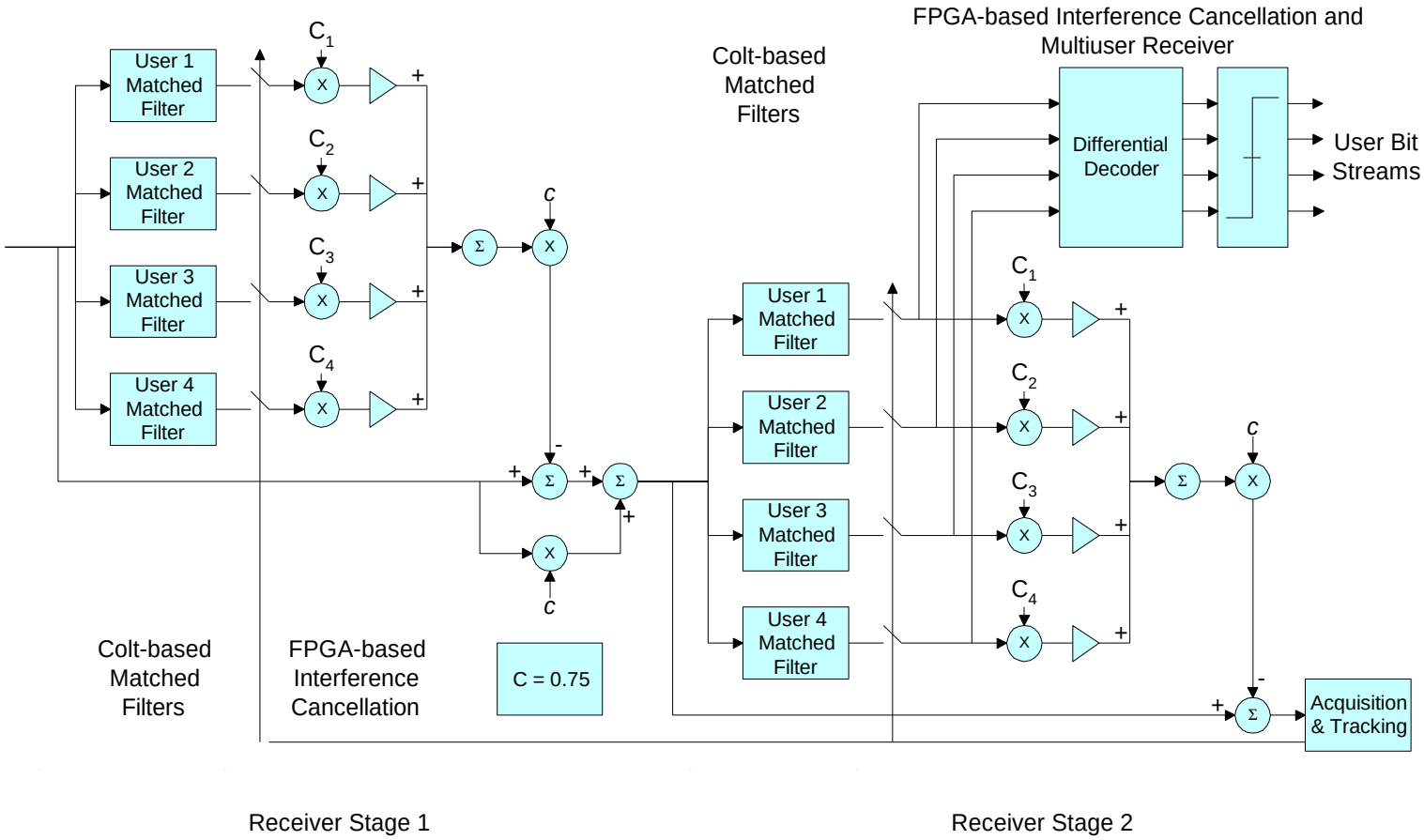
- Significant improvements are observed with few stages of interference cancellation for different channel conditions.

- Multistage cancellation tends to the single user bound as the number of stages increases.

Rayleigh Fading



Interference Cancellation Scheme



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