5 DECISION FEEDBACK AND WHITENING RECEIVERS

- To this point, the user data values $\underline{b}$ could just as well have been analog. We haven't exploited the fact that they are discrete and finite to reduce interference.

- The analogy between linear MUD and linear equalizers makes the next step irresistable — decision feedback.

- Recall from single-user equalizers that DF removes about half of the ISI — if the fed back decisions are correct (DA, data aided). If decision directed (DD), then some degradation through error propagation.

- If we could remove half of the MAI, we might have more degrees of freedom left for diversity combining.

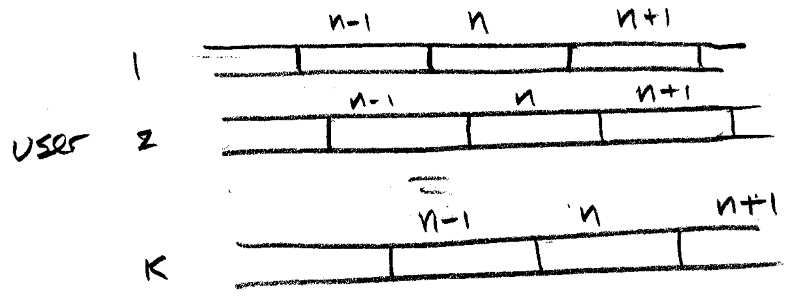
- Several variants of DF, with significantly differing performance.

5.1 Unmodified Decision Feedback

- After MF, Rake/MRC, we have

$$\underline{y} = \underbrace{C^{+}\underline{R}\,C A}_{H}\,\underline{b} + \underline{\eta} = H\,\underline{b} + \underline{\eta}\ , \quad R_{\eta} = N_0\, C^{+}\underline{R}\,C$$

The NK×NK matrix H is block tridiagonal, reflecting the overlapping pulses



- Why not make decisions in order?

$$b_1(n-2),\, b_2(n-2), \cdots, b_K(n-2),\, b_1(n-1),\, b_2(n-1), \cdots, b_K(n-1),\, b_1(n),\, b_2(n) \cdots\cdots$$

- For any $b_k(n)$ we have decision variable

$$y_k(n) = h_1^{(k,n)}(0)\, b_1(0) + \cdots\cdots + h_{k-1}^{(k,n)}(n)\, b_{k-1}(n) + h_k^{(k,n)}(n)\, b_k(n)$$
$$+\ h_{k+1}^{(k,n)}(n)\, b_{k+1}(n) + \cdots\cdots\cdots + \eta_k(n)$$

where $h_k^{(k,n)}(n')$ is element of row $k+nK$ of H corresponding to $b_k(n')$.

- Subtract earlier decisions $\tilde{b}_k(n')$:

$$y_k'(n) = h_1^{(k,n)}(0)\, e_1(0) + \cdots\cdots + h_{k-1}^{(k,n)}(n)\, e_{k-1}(n)$$
$$+\ h_{k,n}^{(k,n)}\, b_k(n) + \eta_k(n)$$
$$+\ h_{k+1}^{(k,n)}(n)\, b_{k+1}(n) + \cdots\cdots$$

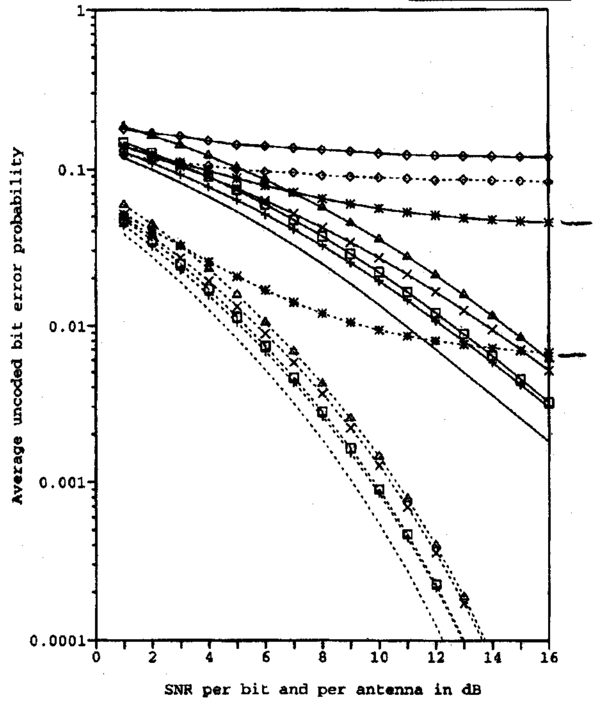
where

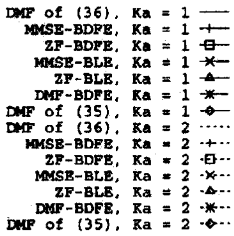
$$e_k(n') = b_k(n') - \tilde{b}_k(n')$$

- But it turns out not to work very well.
  Results from [Jung95], repeated from Section 4.4

  $K = 8$ users $\quad N_c = 14$ chips $\quad N = 20$ sym/burst

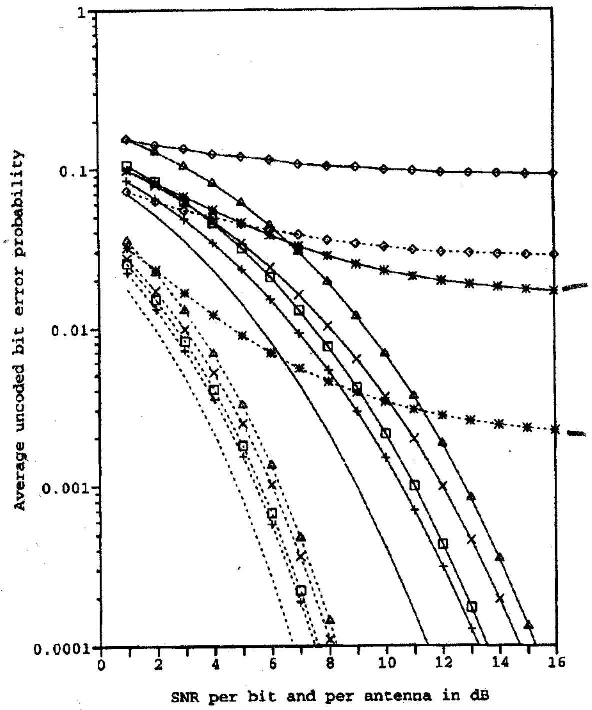
$L = 2$





We are doing DMF-BDFE

$L = 27$



It's a lot better than simple Rake ($\tilde{b}_k(n) = \text{sgn}[\zeta_k(n)]$), but there is still a significant floor.

- What is the problem?
  - We still have MAI from bits yet undetected.
  - The noise samples in η are correlated, so $\zeta_{k'}(n')$ samples can help us in $b_k(n)$ decision through noise minimization as well as MAI cancellation – an unrealized possibility, since we use only $\zeta_k(n)$.
- Note the requirement to know H (channel and signal correlations) in order to subtract interference!