7.4 A Nonlinear Method — Successive IC

- In the past two sections, we considered only the linear multiuser detectors, structured as linear interference cancellers that subtract analog estimates of the bits.
- Subtraction of decisions would seem closer to ML — the use of DF is irresistable, so we'll look at it now.
- [Pate94] was one of the first to propose this explicitly. In operation, it is much like whitening-DF, but without the preliminary whitening stage. For AWGN or for flat, very slow fading:
  - use conventional correlator to create DD estimates of $c_k A_k$ for user k
  - sort users in order of decreasing strength (power control becomes an issue)
  - decide user 1 from simple correlator (plus Rake/MRC if appropriate)

$$\underline{\xi} = C^{+}\underline{R}CA\underline{b} + \underline{\eta}$$

so $\hat{b}_1(n) = \text{dec}\left(\xi_1(n)/[C^{+}RCA]_{(1,n)(1,n)}\right)$, $n = 0, 1, \cdots N-1$

– strip off user 1 by

$$\underline{\xi}^{(2)} = \underline{\xi} - C^{+}\underline{R}CA \begin{bmatrix} b_1(0) \\ \vdots \\ b_1(1) \\ \vdots \\ b_1(N-1) \end{bmatrix}$$

$$\boxed{\text{dec}(x) = \underset{b \in \Omega}{\text{argmin}} |x - b|}$$

$\text{dec}(x) = \text{sgn}(x)$ for x real, $b \in \{-1, +1\}$

– decide user 2; etc

$$\hat{b}_2(n) = \text{dec}\left(\xi_2^{(2)}(n)/[C^{+}RC]_{(2,n)(2,n)}\right), \quad n = 0, 1, \cdots N-1$$

As posed, it is a single pass through the received signal. Susceptible to error propagation. The paper is not clearly written, so none of its results will be shown here.

- There is no reason not to do another pass, this time subtracting the (now tentative) bit decisions of weaker users from $\underline{\xi}$, in order to improve the user 1 decisions, then user 2, etc.

- Note that accurate amplitude and phase estimates are required for each user, in order that they can be subtracted out cleanly.

- Organizing it this way (detect all bits of a user, each user in turn) forces a delay of N symbol times for the measurements to become available. On the other hand, it facilitates use of block codes to correct errors before subtraction of estimates.

- More commonly, SIC is organized by bit, rather than by user, but retains sorting by power (assumed constant over the block). We have

$$\underline{\xi} = \underbrace{C^+RCA}_{G}\,\underline{b} + \eta \quad , \quad \underline{b} = \begin{bmatrix} \underline{b}(0) \\ \underline{b}(1) \\ \vdots \\ \underline{b}(N-1) \end{bmatrix}$$

We want a solution for $\underline{b}$ with components in the constellation

$$b_1^{(1)}(0) = \mathrm{dec}\left[\xi_1(0)/G_{10,10}\right] \qquad G_{k_1 n_1,\, k_2 n_2}$$

$$b_2^{(1)}(0) = \mathrm{dec}\left[\left(\xi_2(0) - G_{10,20}\, b_1^{(1)}(0)\right)/G_{20,20}\right]$$

$$\vdots$$

$$b_K^{(1)}(N-1) = \mathrm{dec}\left[\left(\xi_K(N-1) - G_{K,N-1,\,10}\, b_1^{(1)}(0) - \cdots\right)/G_{K,N-1,\,K,N-1}\right]$$

$$b_1^{(2)}(0) = \mathrm{dec}\left[\left(\xi_1(0) - \text{earlier decisions}\right)/G_{10,10}\right]$$

$$\vdots$$

- We can recognize this as G-S iteration in which the decision non linearity has been applied.

A compact representation [Rooy00]:

$$G = L + D + U$$

$$\underline{\zeta}^{(j)} = \underline{\zeta} - L\,\underline{b}^{(j)} - U\,\underline{b}^{(j-1)}$$

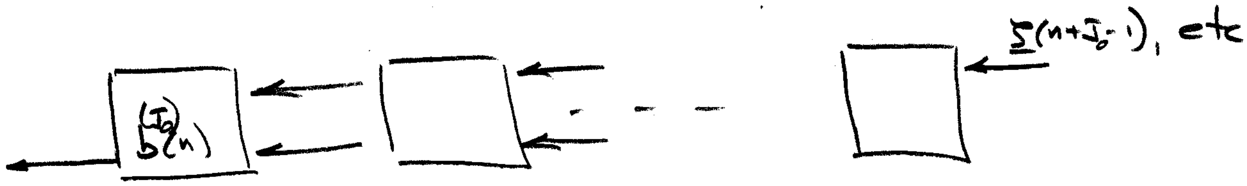
$$\underline{b}^{(j)} = \underline{\mathrm{dec}}\left[D^{-1}\underline{\zeta}^{(j)}\right]$$

- The block tridiagonal nature of G suggests block oriented solution, with outer iteration

$$\underline{b}^{(j)}(n) = \underline{\mathrm{dec}}\left[D_{Bnn}^{-1}\left(\underline{\zeta}(n) - L_{Bn,n-1}\,\underline{b}^{(j)}(n-1) - U_{Bn,n+1}\,\underline{b}^{(j-1)}(n+1)\right)\right]$$

The inner iteration is also done iteratively, in the same G-S, SIC fashion.

Hence the pipeline again:



Each unit performs one or more discrete G-S passes, and releases tentative decisions to the unit on its left. Delay $2J_0 - 1$ bits