2.4 The MUD Problem

- We have

$$\underline{r} = \underline{S}\,C\,A\,\underline{b} + \underline{n} \quad \text{or} \quad \underline{y} = R\,C\,A\,\underline{b} + \underline{\nu}$$

or $\underline{\zeta} = \underline{R}\,A\,\underline{b} + \underline{\eta}$

and we want $\underline{b}$. Linear — can't be too hard (!)

- Note similarity with ISI
  - a linear combination of symbols from a finite alphabet observed in noise
  - range of influence of any symbol is limited temporally
  - mutual interference of symbols is also weak because of spreading

- So, many classical solutions to the ISI problem show up here:
  - linear solutions (like linear equalizer) — zero forcing, mmse
  - use of FA property — decision feedback eq'l., ML (like MLSE)

and others unique to MUD.

- This is a glib comparison. Size matters.

  Typical values for quick estimates:

  $K = 80 \quad L = 3 \quad N = 100 \quad M = 2$

  - So $\underline{R}$ is $NKLM \times NKLM = 48{,}000 \times 48{,}000$
  - $\underline{b}$ is $NK \times 1 = 8000 \times 1$ bits (ML enumeration?)
  - $\underline{R}$ is $NK \times NK = 8{,}000 \times 8{,}000$
  - Incorporation of N is misleading. Clearly, we would use a finite moving window, or DF, or other artifice.
  - But even in the most favourable case
    - synchronous
    - flat channel
    - pre combining across antennas

    where each symbol time can be processed on its own, we have

    $\underline{R}$ is $K \times K = 80 \times 80$

    $\underline{b}$ is $K \times 1 = 80 \times 1$ $\quad 2^{80}$ candidates ??

Much of the MUD literature addresses ways to cope with the complexity.

- The use of long codes is another point of difference from classical ISI.
  - constantly changing pulse shape
  - changing "equalizer" coefficients
  - consequent difficulty in adaptation

- It is still too early to rule out any method, even ML. Consider special case:
  - high-speed, low spreading ratio users
  - with higher power to compensate
  - so only a few of them; remaining users have lower rate and power.

Even (especially?) ML may be appropriate for the privileged users. In general, we may need hybrid solutions.