Lec25-mwf

Tuesday, April 01, 2008 10:55 PM

- Bring slides
- Bring last notes

IS-95 CDMA - 20min

Monday, March 31, 2008 3:00 PM

IS-95

- 869-894 MHz Uplink } same as
- 824-849 MHz Downlink } AMPS/GSM-850
- 1.25MHz Carrier

In GSM

- control channels are implemented by freq/time-slots
- need a way to provide the pointer
  FCCH → SCH → BCCH → RACH → AGCH → SDCCH → TCH

In CDMA:

No assignment of time-slots.
Use code to differentiate channels.

Common control channels are easier to designate
- assign them known codes

How are codes generated?

p220 ① Walsh code

2x2 Walsh matrix is given by:

$$W_2 = \begin{pmatrix} 0 & 0 \\ 0 & 1 \end{pmatrix}$$

- 0 represents -1
- meaning $\begin{pmatrix} 1 & 1 \\ 1 & -1 \end{pmatrix}$
- two rows are orthogonal.

LxL Walsh matrix is defined in terms of L/2 x L/2 matrix.

$$W_L = \begin{pmatrix} W_{L/2} & W_{L/2} \\ W_{L/2} & W'_{L/2} \end{pmatrix}$$

$$\begin{pmatrix} \cdots & \cdots \\ W_{L/2} & W'_{L/2} \end{pmatrix}$$

↑ complement

e.g. $W_4 = \begin{pmatrix} 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 \\ 0 & 0 & 1 & 1 \\ 0 & 1 & 1 & 0 \end{pmatrix}$ ← shifting not allowed

$$W_8 = \begin{pmatrix} 0&0&0&0&0&0&0&0 \\ 0&1&0&1&0&1&0&1 \\ 0&0&1&1&0&0&1&1 \\ 0&1&1&0&0&1&1&0 \\ 0&0&0&0&1&1&1&1 \\ 0&1&0&1&1&0&1&0 \\ 0&0&1&1&1&1&0&0 \\ 0&1&1&0&1&0&0&1 \end{pmatrix}$$

Note:- rows remain orthogonal!
- rows no longer orthogonal if one code shifts

Benefit of Walsh codes

- channels using different codes do not interfere with each other provided that timing is strictly correct

- ok for downlink in one cell.
- $SINR = \dfrac{P}{I + N}$

  ↑ only with other-cells

- If timing is incorrect

  ⇒ create excessive interference between channels

In 2S-95, 64-bit Walsh code is used in the downlink to differentiate traffic/control channels.

(Q) Can neighboring BS use the same set of Walsh codes?

(A) Yes. The Walsh code is multiplied by another code (PN sequence) unique to BS.

For same BS
$$(W_1 \times L_1) \times (W_2 \times L_1) = \underline{W_1 \times W_2}$$
For different BS
$$(W_1 \times L_1) \times (W_1 \times L_2) = (W_1 \times W_1) \times (\underline{L_1 \times L_2})$$

- L_1 and L_2 are roughly orthogonal.

Alternate use of Walsh codes:

- As a modulation mechanism
- Map each symbol to a block of codewords
- Orthogonality ⇒ easier (non-coherent) detection
- in uplink (Fig 8.18)

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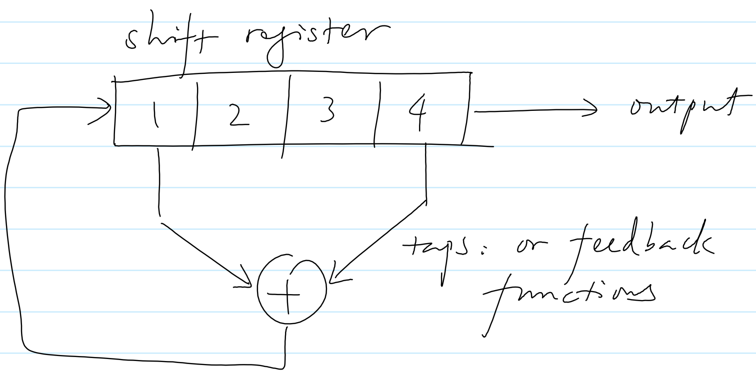
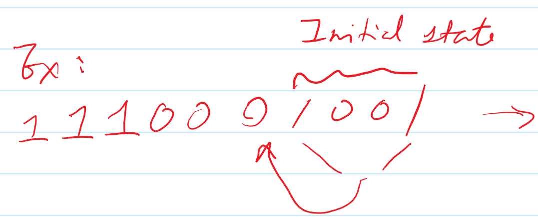
p221
p143

② Maximum length shift register

Definition:





- The current content in the shift register is refered to as the "state".

- A n-bit register has 2^n possible states.
- The all-zero state will produce only zero outputs.
- A feedback function that allows the register to go through all other $2^n - 1$ states is called the maximum-length shift register.
  - ⇒ The output will repeat itself after $2^n - 1$ bits

Properties of MLSR:

- generate a pseudo-random sequence
  - roughly equal # of 1's or 0's
  - repeat after a long time

    Example: long-code

    - at 42-bits, repeats after $2^{42} - 1$ chips
    - at 1.2288 M chips/sec ⇒ 1000 hours.

  - shifting maintains roughly equal # of agreement & disagreement with the original sequence
  - not exactly orthogonal

Ⓠ Can different codes be generated by the same shift register?

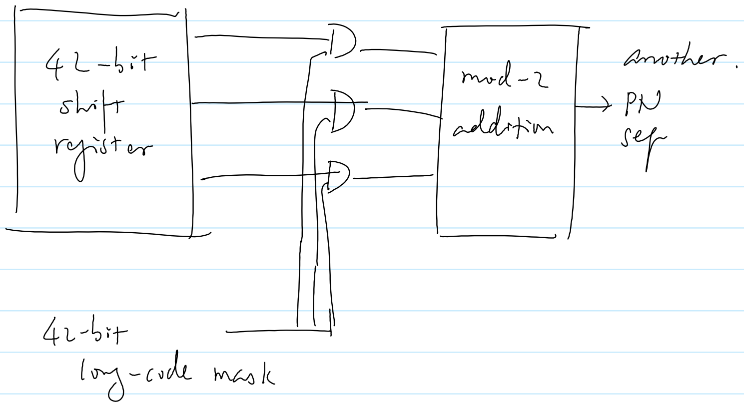
Ⓐ Yes. Two options.

- take different offsets
  e.g. IS-95 downlink.
  each BS assigned one of 512
  .. ..

possible offsets.
- short-code (multiplied by Walsh code)
  2^{15}

- use another mask.
  e.g. IS-95 uplink to differentiate users & access channels
  - long-code

Fig 8.21



The state of the register is "masked" by a long-code mask to generate the PN-sequence for a user.

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(15) Advantage of MLSR:
- can generate a much larger # of spreading codes than walsh codes
- Perfect synchronization not needed.

Spreading codes

Monday, April 19, 2010 10:07 PM

1. Walsh code
   a. Perfectly orthogonal, but require synchonization
   b. Use for spreading at downlink
   c. Multiply with a short code
   d. Use as a modulation scheme at uplink

   - Why not multiply walsh code with walsh code?

$$W_4 = \begin{pmatrix} 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 \\ 0 & 0 & 1 & 1 \\ 0 & 1 & 1 & 0 \end{pmatrix}$$

2. Maximum length shift register
   a. Pseudo random sequence. Shifting still roughly orthogonal
   b. Downlink: short code, take one of the 512 offset.
   c. Uplink: spreading code, using a unique mask for each user.
   d. Need to know the initial state of the MLSR.

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