From Schiller & AK Garg

CDMA (Code Division Multiple Access) :-

CDMA works on codes and chip sequences which is different for different users. All the users are using the same frequency / bandwidth i.e., the bandwidth, is not divided among various users unlike GSM.

The chip sequences are generated using DSSS (Direct Sequence Spread Spectrum).

Sender A :-

Sends $A_d = 1 = 1$

Key $A_K = 010011 = -1, 1, -1, -1, 1, 1$

(Assign $0 \rightarrow -1$ and $1 \rightarrow +1$)

Sending signal $A_s = A_d * A_K$

$= (-1, 1, -1, -1, 1, 1)$

Sender B :-

Sends $B_d = 0 = -1$

Key $B_K = 110101 = 1, 1, -1, 1, -1, 1$

$\therefore B_s = B_d * B_K = (-1, -1, +1, -1, +1, -1)$

Both signals are superimposed in space.

$\therefore A_s + B_s = (-1, 1, -1, -1, 1, 1) + (-1, -1, +1, -1, +1, -1)$

$= (-2, 0, 0, -2, 2, 0)$

Receiver wants to receive signal from sender A. Apply key A_K bit wise inner product. This will be A_e.

$A_e = (-2, 0, 0, -2, +2, 0) * A_K$

$A_e = (-2, 0, 0, -2, +2, 0) * (-1, 1, -1, -1, 1, 1)$

$= (2, 0, 0, 2, 2, 0)$

$= 6$ (Adding all).

Result > 0, therefore original bit was 1

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Ily, receiving signal from sender B.

$B_e A_e = (-2, 0, 0, -2, +2, 0) * B_K$

$= (-2, 0, 0, -2, +2, 0) * (1, 1, -1, 1, -1, 1)$

$\because B_K = (1, 1, 0, 1, 0, 1)$

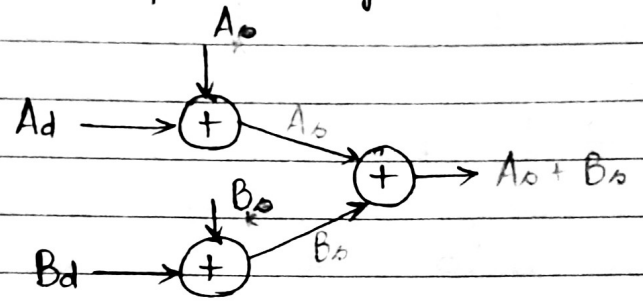
$= (1, 1, -1, 1, -1, 1)$

$= (-2, 0, 0, -2, -2, 0)$

$= -6$ (Adding all).

Result < 0, therefore original bit is 0.

If
Result < 0 ⇒ bit 0
Result = 0 ⇒ silent
Result > 0 ⇒ bit 1



FHSS (Frequency Hopped Spread Spectrum):-
Hopping between frequency bands so as to provide gaps in order to reduce bit error.

→ PN sequence generator in CDMA:-

PN sequence generator
(Pseudo Number)

Walsh code | Gold code

Walsh code:

$W_1 = [+1]$

$$W_{2N} = \begin{bmatrix} W_N & W_N \\ W_N & \overline{W_N} \end{bmatrix}$$

E.g., $W_2 = \begin{bmatrix} +1 & +1 \\ +1 & -1 \end{bmatrix}$ (N=1)

$\therefore W_4 = W_{2(2)} = \begin{bmatrix} W_2 & W_2 \\ W_2 & \overline{W_2} \end{bmatrix}$ (N=2)

$$W_4 = \begin{bmatrix} +1 & +1 & +1 & +1 \\ +1 & -1 & +1 & -1 \\ +1 & +1 & -1 & -1 \\ +1 & -1 & -1 & +1 \end{bmatrix}$$

$$W_8 = W_{2(4)} = \begin{bmatrix} W_4 & W_4 \\ W_4 & \overline{W_4} \end{bmatrix} \qquad (N=4)$$

$$W_8 = \begin{bmatrix} +1 & +1 & +1 & +1 & +1 & +1 & +1 & +1 \\ +1 & -1 & +1 & -1 & +1 & -1 & +1 & -1 \\ +1 & +1 & -1 & -1 & +1 & +1 & -1 & -1 \\ +1 & -1 & -1 & +1 & +1 & -1 & -1 & +1 \\ +1 & +1 & +1 & +1 & -1 & -1 & -1 & -1 \\ +1 & -1 & +1 & -1 & -1 & +1 & -1 & +1 \\ +1 & +1 & -1 & -1 & -1 & -1 & +1 & +1 \\ +1 & -1 & -1 & +1 & -1 & +1 & +1 & -1 \end{bmatrix}$$

Note that the matrices are symmetrical and every row (except first) has equal no. of +1s and -1s. So we say that the codes are orthogonal in nature. (i.e., pr = 0).

Q:- If the CDMA demux received the code (-1, -1, -3, +1), find the bits sent by the different stations.

Sol:- Since we got 4 numbered chip code (-1, -1, -3, +1)

∴ we would have used (4×4) Walsh m i.e., W_4.

For station A, we have Key = {+1, +1, +1

" " B, " " " = {+1, -1, +1

" " C, " " " = {+1, +1, -1

" " D, " " " = {+1, -1, -

For A :

(+1, +1, +1, +1) · (-1, -1, -3, +1) Dot product

= (-1, -1, -3, +1) Adding all

= -4 i.e., bit 0

For B :

(+1, -1, +1, -1) · (-1, -1, -3, +1)

= (-1, +1, -3, -1)

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For C:
$(+1, +1, -1, -1) \cdot (-1, -1, -3, +1)$
$= (-1, -1, +3, -1)$
$= 0$ i.e., silent

For D:
$(+1, -1, -1, +1) \cdot (-1, -1, -3, +1)$
$= (-1, +1, +3, +1)$
$= 4$ i.e., bit 1

Thus the stations have sent bits
0, 0, silent, 1 respectively.

Do from slides

Gold code:-
It is a sequence of 0s and 1s.
It uses LFSR (Linear Feedback Shift Regist
operation.
MLSRS (Maximal Length Shift Register Sequence).

Corelation:- Cross-Corelation and Auto-corelation.
110010
Shift by 0 bits.
110010
∴ Do dot product with itself (Auto-correlation).
$(1\ 1\ 0\ 0\ 1\ 0) \cdot (1\ 1\ 0\ 0\ 1\ 0)$
$\equiv (1\ 1\ -1\ -1\ 1\ -1) \cdot (1\ 1\ -1\ -1\ 1\ -1)$
$= (1\ 1\ 1\ 1\ 1\ 1)$ Adding.
$= 6$ i.e., weightage.

Shift by 1 bit. (right shift).
011001
Do dot product with itself (Auto-correlations).
$(0\ 1\ 1\ 0\ 0\ 1) \cdot (1\ 1\ 0\ 0\ 1\ 0)$
$\equiv (-1\ 1\ 1\ -1\ -1\ 1) \cdot (1\ 1\ -1\ -1\ 1\ -1)$
$= (-1\ 1\ -1\ 1\ -1\ -1)$
$= -2$