

# ECS 455: In-Class Exercise # 14

## Instructions

1. Separate into groups of no more than three persons.
2. The group cannot be the same as any of your former groups in this class.
3. Only one submission is needed for each group.
4. **Write down all the steps** that you have done to obtain your answers. You may not get full credit even when your answer is correct without showing how you get your answer.
5. **Do not panic.**

Date: <u>03/05</u> / 2017			
Name			ID (last 3 digits)
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In a (synchronous) CDMA system, suppose there are only two users. The codes for user 1 and user 2 are  $\underline{c}^{(1)} = [1 \ -1 \ 1 \ 1 \ 1 \ -1]$  and  $\underline{c}^{(2)} = [-1 \ -1 \ -1 \ 1 \ -1 \ a]$ , respectively.

1. Find  $a$ .

This is CDMA. So we know that  $\underline{c}^{(1)} \perp \underline{c}^{(2)}$ .

$$\begin{aligned} \text{Here, } \langle \underline{c}^{(1)}, \underline{c}^{(2)} \rangle &= (1)(-1) + (-1)(-1) + (1)(-1) + (1)(1) + (1)(-1) + (-1)(a) \\ &= -1 + 1 - 1 + 1 - 1 - a \\ &= -1 - a. \end{aligned}$$

For orthogonality, we need  $\langle \underline{c}^{(1)}, \underline{c}^{(2)} \rangle = 0$ .

$$\Leftrightarrow -1 - a = 0$$

$$\Leftrightarrow a = -1$$

2. At the receiver, suppose we receive  $\underline{r} = [5 \ -1 \ 5 \ 1 \ 5 \ -1]$ .

Find the messages  $s_1$  and  $s_2$ .

Ignore the noise and the fading effect.

$$\begin{aligned} \hat{s}_1 &= \frac{1}{N} \langle \underline{r}, \underline{c}^{(1)} \rangle = \frac{1}{6} \left( (5)(1) + (-1)(-1) + (5)(1) + (1)(1) + (5)(1) + (-1)(-1) \right) \\ &\quad \text{This should be } \langle \underline{c}^{(1)}, \underline{c}^{(1)} \rangle = 1^2 + (-1)^2 + 1^2 + 1^2 + 1^2 + (-1)^2 = N \times 1^2 = N \\ &\quad \text{length of the code} \end{aligned}$$

$$= \frac{1}{6} (5 + 1 + 5 + 1 + 5 + 1) = \frac{18}{6} = 3$$

$$\begin{aligned} \hat{s}_2 &= \frac{1}{N} \langle \underline{r}, \underline{c}^{(2)} \rangle = \frac{1}{6} \left( (5)(-1) + (-1)(-1) + (5)(-1) + (1)(1) + (5)(-1) + (-1)(-1) \right) \\ &\quad \langle \underline{c}^{(2)}, \underline{c}^{(2)} \rangle \end{aligned}$$

$$= \frac{1}{6} (-5 + 1 - 5 + 1 - 5 + 1) = \frac{-12}{6} = -2$$