Assignment 5

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Section – 001

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Total in points (Maximum 100 points)–

Professors Comments –

Affirmation of Independent Effort – Ankit Sati

1. Spectrum Allocation – 12.5Mhz.
   Edge of allocated spectrum – 10 kHz
   Channel Bandwidth – 30 kHz

   $$N = \frac{[12.5 \times 10^6 - 2(10 \times 10^3)]}{(30 \times 10^3)} = \mathbf{416}$$

   in total there would be 416 available channels.

2. Walsh Codes
   a. Walsh Codes are most commonly used in the orthogonal codes of CDMA applications. These codes correspond to lines of a special square matrix called the Hadamard matrix. For a set of Walsh codes of length N, it consists of n lines to form a square matrix of n × n Walsh code.

   $$W[2\text{^}n] = \begin{bmatrix} W[2\text{^}(n-1)] & W[2\text{^}(n-1)] \\ W[2\text{^}(n-1)] & NOT(W[2\text{^}(n-1)]) \end{bmatrix}$$

   A Walsh code of length n consists of n rows. The dimension is n x n.

   $$W[2\text{^}n] = \begin{bmatrix} W[2\text{^}(n-1)] & W[2\text{^}(n-1)] \\ W[2\text{^}(n-1)] & NOT(W[2\text{^}(n-1)]) \end{bmatrix}$$

   b. Special Property of Rows.
      1. Every row is orthogonal to every other row (correlation is zero)
      2. Every row is orthogonal to NOT of each other row

   In mathematics, a Walsh matrix is a specific square matrix of dimensions 2n, where n are some particular natural number. The entries of the matrix are either +1 or −1 and its **rows as well as columns are orthogonal, i.e. dot product is zero**. The Walsh matrix was proposed by Joseph L. Walsh in 1923.[1] Each row of a Walsh matrix corresponds to a Walsh function.

   c. Where n is a power of 2 and indicates the different dimensions of the matrix W. Further, n represents the logic NOT operation on all bits in this matrix. The three matrices W2, W4, and W8, respectively show the Walsh function for the dimension 2, 4, and 8.

   $$W[2] = \begin{bmatrix} W[0] & W[0] \\ W[0] & NOT\ W[0] \end{bmatrix} = \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix}$$

   $$W[4] = \begin{bmatrix} W[2] & W[2] \\ W[2] & NOT\ W[2] \end{bmatrix} = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & -1 & 1 & -1 \\ 1 & 1 & -1 & -1 \\ 1 & -1 & -1 & 1 \end{bmatrix}$$

$$W[8] = \begin{bmatrix} W[4] & W[4] \\ W[4] & NOT\ W[4] \end{bmatrix} = \begin{bmatrix} 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & -1 & 1 & -1 & 1 & -1 & 1 & -1 \\ 1 & 1 & -1 & -1 & 1 & 1 & -1 & -1 \\ 1 & -1 & -1 & 1 & 1 & -1 & -1 & 1 \\ 1 & 1 & 1 & 1 & -1 & -1 & -1 & -1 \\ 1 & -1 & 1 & -1 & -1 & 1 & -1 & 1 \\ 1 & 1 & -1 & -1 & -1 & -1 & 1 & 1 \\ 1 & -1 & -1 & 1 & -1 & 1 & 1 & -1 \end{bmatrix}$$

d. Rather than just demonstrating this for a specific Walsh matric, we prove this for a general 2n × 2 n Walsh matrix, n ≥ 1.
The proof is by induction on n. The claim is trivially true for the base case n = 1. For the induction step, let us assume that the claim is true for a 2n−1×2 n−1 Walsh matrix. Consider any two distinct row vectors wi and wj of a 2n × 2 n Walsh matrix. We consider three cases.

- The first case is when i, j ≤ 2 n−1 . In this case, wi · wj is the sum of two quantities, each of which is the dot-product of the ith and jth row vectors of the 2n−1 × 2 n−1 Walsh matrix. By the induction hypothesis, both these quantities are zero, thus establishing the induction step for this case.
- The second case is when i, j > 2 n−1 . In this case, wi · wj is the sum of two quantities, the first of which is the dot-product of row i−2 n−1 and row j −2 n−1 of the 2n−1 ×2 n−1 Walsh matrix, and the second is the corresponding dot-product of the complement matrix. By the induction hypothesis, both these quantities are zero, thus establishing the induction step for this case.
- The final case is when i ≤ 2 n−1 and j > 2 n−1 . Again, the dot-product is the sum of two quantities, the first being the dot-product of row i and row j − 2 n−1 of the 2n−1 × 2 n−1 Walsh matrix, while the other being the dot-product of row i of the 2n−1 × 2 n−1 Walsh matrix and row j − 2 n−1 of the complement of the 2n−1 × 2 n−1 Walsh matrix.

  Since these quantities complement each other, we obtain a dot-product of 0, thus completing the proof.

3. The following is the example of two CDMA (Code division multiple access) codes that do not allow to extract the original data bits by the two receivers that are transferred by the two CDMA senders is as follows:
   Consider a two sender and two receiver CDMA system.
   Consider the CDMA code sent by the
   Sender1 is (1, 1, 1, -1, 1, -1, -1, -1) and the CDMA code sent by the
   Sender2 is (-1, -1, 1, 1, 1, 1, 1, -1)
   and assume that the senders are using 8-bit CDMA code.

   Let us denote the data sent by two senders as d_0^1 =1 , d_0^2 =1 .

Sender 1 encoding process:
Sender 1's 8-bit CDMA code is (1, 1, 1, -1, 1, -1, -1, -1).

Data bits (d_0^1 = 1)								
CDMA Code(c_m^1)	1	1	1	-1	1	-1	-1	-1
Output ($z^1 = d_0^1 \times c_m^1$)	1	1	1	-1	1	-1	-1	-1

Sender 2 encoding process:
Sender 2's 8-bit CDMA code is (-1, -1, 1, 1, 1, 1, 1, -1).

Data bits (d_0^2 = 1)								
CDMA Code (c_m^2)	-1	-1	1	1	1	1	1	-1
Output ($z^2 = d_0^2 \times c_m^2$)	-1	-1	1	1	1	1	1	-1

Calculate the output generated by the senders as follows:

z^1	1	1	1	-1	1	-1	-1	-1
z^2	-1	-1	1	1	1	1	1	-1
z*= $z^1 + z^2$	0	0	2	0	2	0	0	-2

Receiver 1 decoding process:

Bits in received signal Z*	0	0	2	0	2	0	0	-2
CDMA Code c_m^1	1	1	1	-1	1	-1	-1	-1

Calculate the data received by the receiver
= (0+0+2+0+2+0+0+2)/8
= 6/8
= 0.75

Receiver 2 decoding process:

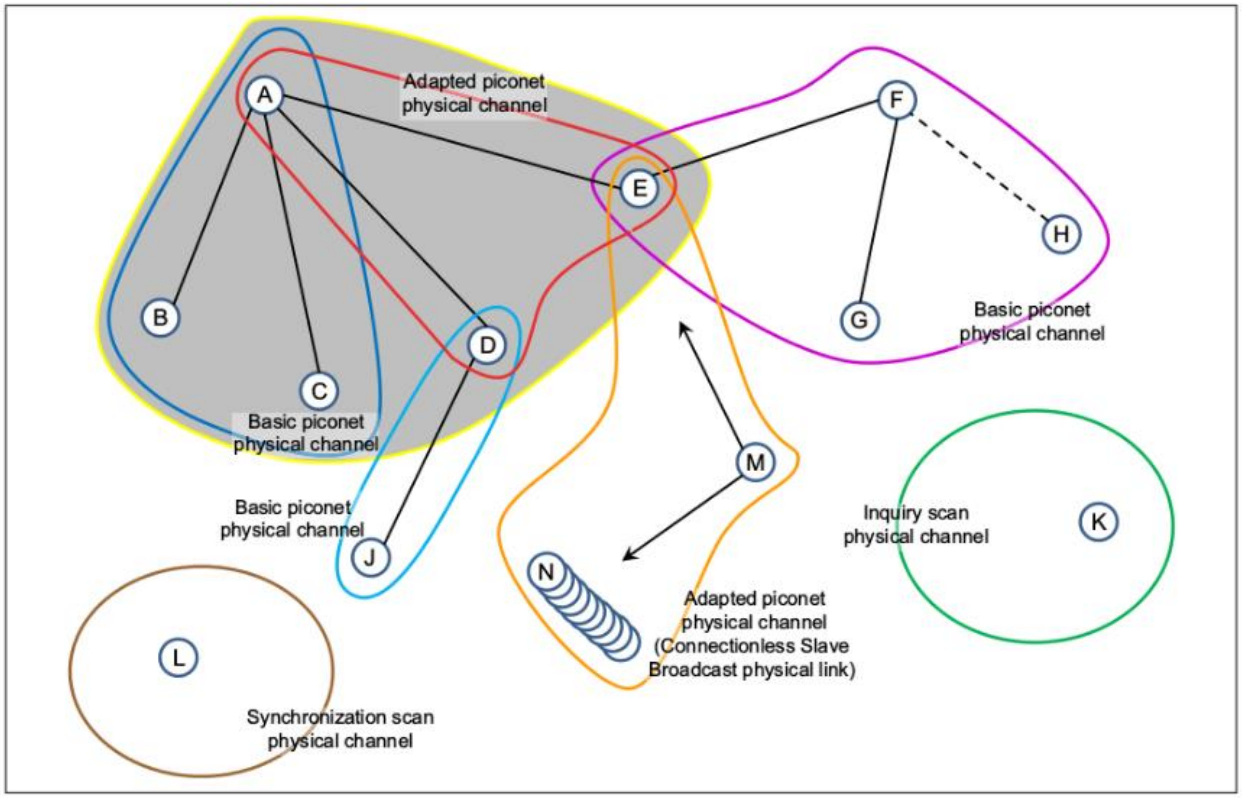
Similarly = 0.75

4. The format of the 802.15.1 Bluetooth frame contains three fields are:

   Access code for 72 bits.
   Header for 54 bits
   Data for 0-2744 bits

   The piconet is address field in the frame format limits for active nodes. The frame format that inherently limits the number of active nodes in an 802.15.1 network to eight active nodes are 3 bit address for header files. It helps to uniquely for active node in the piconet.
   It operates in the unlicensed, industrial, scientific and medical (ISM) band at 2.4 GHz to 2.485 GHz. Maximum devices that can be connected at the same time are 7. Bluetooth ranges upto 10 meters. It provides data rates upto 1 Mbps or 3 Mbps depending upon the version. The spreading technique which it uses is FHSS (Frequency hopping spread spectrum). A Bluetooth network is called a piconet and a collection of interconnected piconets is called scatternet.

   Limitation (inherited fallacies)- The Bluetooth Classic has a limitation of 7 slave devices in a piconet and they are time and hop synchronized to the master (ie master and slaves share a common physical channel and it is not possible to address more than seven slaves for a master when in Active mode). In BLE each connection from a master to a slave operates in an independent physical channel(ie LE slaves does not share a common physical channel with the master), hence there is no limitation imposed by the Specification except as specified by the Connection interval and slave latency rules (Note that individual bluetooth controller manufacturers may decide to limit the number of connections depending on the practical bandwidth limitation). please see the Bluetooth Classic vs Bluetooth Low energy Topology below.



5. Two mobiles could certainly have the same care-of-address in the same visited network. Indeed, if the care-of-address is the address of the foreign agent, then this address would be the same. Once the foreign agent decapsulates the tunneled datagram and determines the address of the mobile, then separate addresses would need to be used to send the datagrams separately to their different destinations (mobiles) within the visited network.