Department of Computing

**Hong Kong Polytechnic University**

**Comp 5527 Mobile Computing and Data Management**

**Tutorial Two**

1. Can data be transmitted without being modulated with a carrier signal? Discuss why we need modulation.
2. In the *Frequency Hopping Spread Spectrum* (FHSS) modulation scheme, signal is broadcast over seemingly random series of radio frequencies. A number of channels are allocated for the FH signal. Width of each channel corresponds to bandwidth of input signal. Signal hops from frequency to frequency at fixed intervals. Please give an example to describe how FHSS works.
3. CDMA is based on DSSS (but bit different) and is used to implement a broadcast channel shared by all stations. Each node in the wireless network is assigned a unique random chip-code (i.e. spreading code) which is an *m* bit string. To send 1, transmit the chip-code; to send 0, transmit complement of the chip-code. For convenience, uses a bipolar notation: binary 0 being -1 and binary 1 being +1. The following is an example:

For m = 8, if station A is assigned the chip code 00011011, it sends a 1 bit by sending 00011011 and a 0 bit by sending 11100100. Chip sequences in bipolar notation are shown in parentheses. Consider the above example, a 1 bit for station A now becomes

(-1 -1 -1 +1 +1 -1 +1 +1)

When two or more stations transmit simultaneously, their bipolar signals add linearly (think of this as adding voltages). For example:

A: 0 0 0 1 1 0 1 1 A in bipolar: (-1 -1 -1 +1 +1 -1 +1 +1)

B: 0 0 1 0 1 1 1 0 B in bipolar: (-1 -1 +1 -1 +1 +1 +1 -1)

Chip sequences

C: 0 1 0 1 1 1 0 0 C in bipolar: (-1 +1 -1 +1 +1 +1 -1 -1)

D: 0 1 0 0 0 0 1 0 D in bipolar: (-1 +1 -1 -1 -1 -1 +1 -1)

− − 1 − S1 = (-1 +1 -1 +1 +1 +1 -1 -1) (C sends 1)

− 1 1 − S2 = (-2 0 0 0 +2 +2 0 -2) (B and C send 1)

1 0 − − S3 = ( 0 0 -2 +2 0 -2 0 +2) (A sends 1, B sends 0)

1 0 1 − S4 = (-1 +1 -3 +3 +1 -1 -1 +1) (A and C send 1, B sends 0)

1 1 1 1 S5 = (-4 0 -2 0 +2 0 +2 -2) (All stations send 1)

1 1 0 1 S6 = (-2 -2 0 -2 0 -2 +4 0) (A, B, and D send 1, C sends 0)

(− means silence)

Now, given a mixed transmission Si, think about how to know which station transmits, which not. For example, assume the four stations *A, B, C*, and *D* in a CDMA system use 8-bit chip sequences as shown above. If one of the stations gets the following chips: (−1 +1 −3 +1 −1 −3 +1 +1), which stations transmitted, and which bits (0 or 1) did each one send?

Also, explain why CDMA allows for concurrent communications between pairs of nodes and achieves higher bandwidth efficiency.