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Freiburg, 27 Arpil 2007
Due until 4 May 2007

Exercises of lecture

# Mobile Ad Hoc Networks

Summer 2006/2007

Sheet 2

**SECTION 1:**
Toplogy Control

1. Consider following topology where virtual links showing the distances between nodes in meters. Each node can vary its transmission power such that it can transmit from 2 meters to maximum of 15 meters. By default, each node transmits at maximum radio range. Nodes in this toplogy are not mobile.

   - We wish to apply *topology control*. Topology control is the process of altering the wireless topology by configuring the signal transmission power of the nodes, with the goal to minimize energy usage while maintaining connectivity [1]. You are asked to create a simple topology control (central or distributed) algorithm. Your algorithm is only required to keep the topology connected while reducing transmission ranges on each node [2].

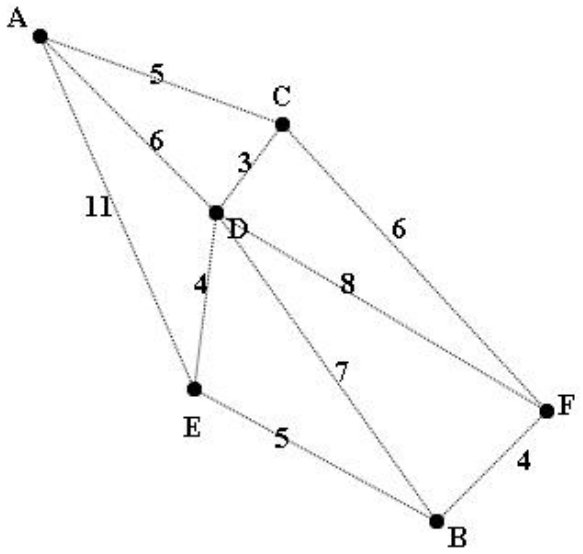


Figure 1: A wireless network where virtual connections showing distances between nodes in meters.

[1] Connected implies that each node can send message to other node directly or using intermediate hops

[2] We will discuss this topic in more detail in future lectures. Hence your algorithm do not have to be perfect.

**Solution**:
Simple solution could be to apply Kruskal's minimum spanning tree algorithm based on nodes distances. The resultant topology will remain connected with minimum distances virtual links selected.

- Now assume that a 10 packets of equal size, has to be sent from node-A to node-B using minimum number of hops. Each node consumes ($x \times transmission\text{-}range$) units of energy for sending a packet and $y$ unit of energy for receiving a packet. How much energy is used for the transmission of 10 packets, when they are sent in original topology and how much energy is used when sent in topology after applying your topology control algorithm?

  **Solution**:
  In original topology, path with minimum number of hop from node-A to node-B is $A, D, B$. Energy consumed by 10 packets using this path is $10 \times (13x + 2y)$. Using above topology control algorithm, minimum number of hop path available between node-A to node-B is $A, C, D, E, B$. Energy consumed by 10 packets using this path is $10 \times (17x + 4y)$.

- Based on the results of above part, what do you think could be the problems of your proposed algorithm and how these problems could be solved?

  **Solution**:
  Based on results of the previous question, we find out that data sent after topology changes due to our topology control algorithm wastes more energy compared to that of the original topology. Possible solution could be to design topology control algorithm which goal is to minimize aggregated energy consumed from n sources to m destinations.

**SECTION 2:**
Modulation

1. Distinguish the analogue modulation and digital modulation, and explain why we need digital modulation.
2. Identify the digital modulation format used in such radio system as IEEE 802.11, Bluetooth, Cellular networks like GSM and CDMA, and so on.

**Solution:**

1. Modulation is the signal processing technique where one signal (the modulating signal) modifies a property of another signal (the carrier signal) at the transmitter so that a composite wave (the modulated wave) is formed.

   Analogue modulation (AM, PM, FM) combines a higher frequency sinusoidal carrier with a lower frequency signal carrying the message.

   Digital modulation combines a high frequency sinusoidal carrier signal and a digital data stream to create a modulated wave that assumes a limited number of states (e.g.

00, 01, 10,11 for QPSK). These techniques are: Amplitude shift key modulation (ASK), Frequency shift key modulation (FSK), Binary-phase shift key modulation (BPSK), Quadrature-phase shift key modulation (QPSK), Quadrature amplitude modulation (QAM).

The techniques used to modulate digital information so that it can be transmitted via microwave, satellite or down a cable pair are different to that of analogue transmission. The data transmitted via satellite or microwave is transmitted as an analogue signal. The techniques used to transmit analogue signals are used to transmit digital signals. The problem is to convert the digital signals to a form that can be treated as an analogue signal that is then in the appropriate form to either be transmitted down a twisted cable pair or applied to the RF stage where it is modulated to a frequency that can be transmitted via microwave or satellite.

The main difference between analog and digital modulation is that while the changes occur in a continuous manner in analog modulation, they occur at discrete time intervals in digital modulation.

2. 802.11b is a direct extension of the DSSS modulation technique. Technically, it employs Complementary Code Keying (CCK), which is a variation of CDMA, to operate at either 5.5 or 11 Mbit/s in the RF band at 2.400 GHz to 2.4835 GHz. Networks using the 802.11g specification employ CCK when operating at 802.11b speeds. At higher speeds (up to a theoretical maximum of 54 Mbit/s), 802.11g WLANs use a more sophisticated modulation scheme called OFDM. This is the modulation method used by 802.11a WLANs in the RF band at 5.725 GHz to 5.850 GHz.

   Bluetooth 2 uses p/4-DQPSK at its lower rate (2 Mbit/s) and 8-DPSK at its higher rate (3 Mbit/s) when the link between the two devices is sufficiently robust. Bluetooth 1 modulates with Gaussian minimum-shift keying, a binary scheme, so either modulation choice in version 2 will yield a higher data-rate.

   A similar technology, ZigBee(IEEE 802.15.4) also relies on PSK. ZigBee operates in two frequency bands: 868915MHz where it employs BPSK and at 2.4GHz where it uses OQPSK.

   CDMA cellular uses DSSS modulation technique. GSM operates based on GMSK, which is a type of continuous phase frequency-shift keying. The baseband modulation is generated by starting with a bitstream 0/1 and a bit-clock giving a timeslice for each bit.