Wireless Networking

Course code: CS4222/5422, Tutorial session: #10

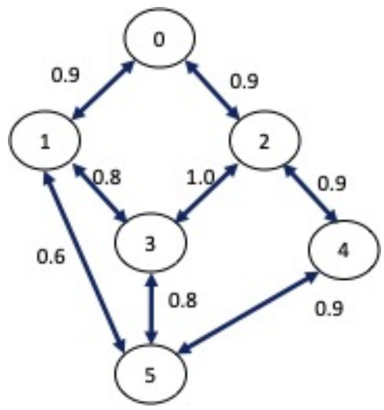
Brief Instructions regarding the tutorial session

1. The attendance to tutorial sessions would contribute towards the determination of final grade
2. Please review the questions before coming to the tutorial session
3. Make an effort to solve the questions before attending tutorial. The teaching assistants will help in case of issues
4. The designated time for the tutorial session is one hour. Please contact the teaching assistants or the instructor if you need any further clarification regarding the tutorials outside the allocated period. Please send them an email.

Question 1: In the figure below, nodes indicate IoT devices and two devices can communicate if there is a link between them. The number associated with each link is the link quality measured in expected packet delivery ratio. For the figure, find the shortest path from node 5 to node 0 using different routing metrics:

- Hop count
- Expected number of transmission (ETX)

Show your working. Let the minimum useable link quality be set to 0.6. If the shortest hop count path is X, how long (in hop) can the path chosen by ETX be in terms of X?



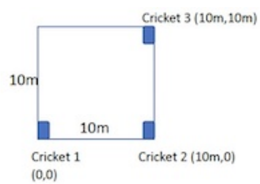
Answer 1: (a)2hops,5->1->0 , (b)1/0.6+1/0.9=2.77, also. 5->1->0 , (c) x/0.6 = 5x/3

Question 2: The per-hop packet error rate on a path with four hops are 0.25, 0.1, 0.5, and 0.2. What is:
(a) path ETX
(b) the probability that a packet can traverse the path with no error/retransmission?

Answer 2:

(a) Path ETX = 1/(1-0.25) + 1/(1-0.1) + 1/(1-0.5) + 1/(1-0.2) = 4/3 + 10/9 + 2 + 5/4 = 5.69
(b) No error = (0.75) x (0.9) x (0.5) x (0.8) = 0.27

Question 3: The figure below shows a 2D square of 10m by 10m with three cricket nodes placed at different locations. The table below shows the wall clock time for the radio and audio signals from the node to be localized to reach each of the three cricket nodes. You can assume that the speed of light is 2x10^8 m/s and the speed of sound is 300m/s. You can also ignore the processing time. Your task is to estimate the (x,y) coordinates of the node to be localized in meters, using cricket 1 as the origin (0,0).



	Cricket 1	Cricket 2	Cricket 3
Radio	1s	1s	1s
Audio	1.028s	1.020s	1.020s

Answer 3:

Using a simple approximation: Y = 5, since the audio reaches cricket 2 and 3 at the same time. Consider Cricket 1, for audio, in 0.028s, distance is 0.028 * 300 = 8.4m
So 8.4^2 = 5^ + x^2, x = 6.75m.

Consider Cricket 2, for audio, in 0.02s, distance is 0.02 * 300 = 6m
So 6^2 = 5^ + (10-x)^2, x = 6.75m. So (10-x) = 3.32, x = 6.68

So answer is roughly (6.7, 5)

Answer 4:

Since the question suggests that time difference of arrival is being used for localisation. We do not need the target to be synchronised with anchors. We want to estimate distance d (target to anchor)

Time for acoustic wave to travel (Tacoustic) = d/v(acoustic) = d/330

Tbase + Tacoustic = 3.0303

Time for light waves to travel (Tlight) = d/v(light) = d/(3 * 10^8)

Tbase +   Tlight = 3.00000003333

d/330 - d/(3 * 10^8) = (3.0303 - 3.00000003333)

=> d = 10 meters

b) No. Both travel at the same speed. You need difference in propagation time for the mechanism to work. We will also have challenges with estimating difference in ns which may be challenging for IoT devices.

Answer 5:

a). You can assume frequency: 920 MHz

Gt=Gr=2 dBi

Use Friis propagation equation for estimation.

For -121 dBm sensitivity: approx 145-150 km

For -135 dBm sensitivity: approx 700-750 km

b)

Frequency for WiFi: 2400 MHz,   Range: 150 km, 750 km

Transmit power (using Friis): 49.5 dBm (150 km)
Transmit power (using Friis): 63.5 dBm (750 km)

c)

WiFi:

Bitrate: 11 Megabit/second, Time to transmit 1 bit = 1/(11 * 10^6)
Power consumption = (3V * 75 mA) = 0.225 Watts
Energy/bit = 0.225 * 1/(11 * 10^6) = 20.45 nJ/bit

LoRa: 980 bps

Time to transmit 1 bit = 1/(980)
Power consumption = 20 * 3 = 60 mW = 0.06 Watts
Energy/bit = 0.60/980 = 612 uJ/bit

LoRa: 21900 bps

Time to transmit 1 bit = 1/(21900)
Power consumption. = 20 * 3 = 60 mW = 0.06 Watts
Energy/bit = 0.60/(21900) =. 27.39 uJ/bit