ENGSCI 313 – Assignment 5

Due date: June 9. Submit by 11am. Total marks: 20

A wireless sensor network (WSN) was deployed as part of a water balance instrument cluster across a forested 1 km^2 headwater catchment in the southern Sierra Nevada of California. The network, which integrates readings from over 300 sensors, provides spatially representative measurements of snow depth, solar radiation, relative humidity, soil moisture, and matric potential. The network was designed to provide greater understanding of the mountain water cycle[1]. The final network design employed a mesh-based topology (see figure 1), with motes (contained in the sensor and repeater nodes) communicating with multiple neighbours to create an internally redundant multi-hop network. With this design, sensor data was regularly transmitted from the sensor nodes to the Base Station via multiple short hops across the network. This solution has a relatively large software-overhead, but is reasonably inexpensive to implement as repeater nodes are cheap.

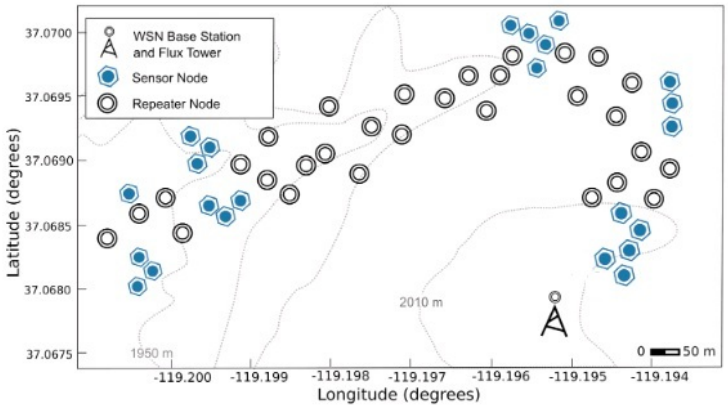

Fig 1: Original Network, employing a mesh-based topology. Each sensor nodes contains 15 sensors. Data is transmitted back to Base Station via multiple short hops.

An alternative design would have been to employ a star-based topology (see figure 2), with a few powerful router nodes to extend the transmission range. Under this topology each sensor node communicates directly with the Base Station (1 hop), or via a single router node (2 hops).

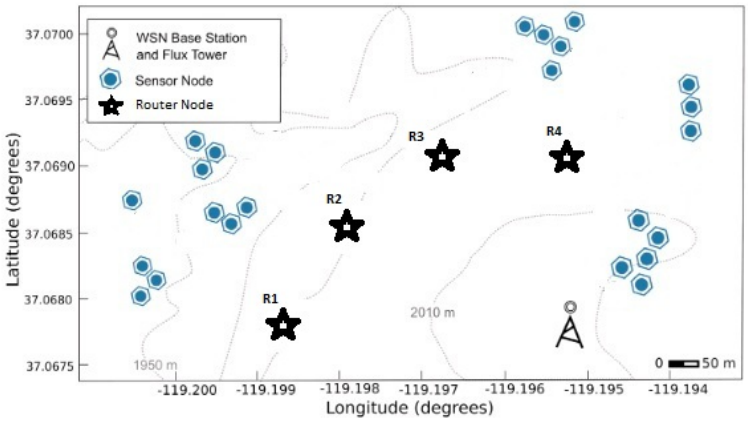

Fig 2: Proposed Network, employing a star-based topology. Data is transmitted back to Base Station via at most 2 hops.

[1] Design and performance of a wireless sensor network for catchment-scale snow and soil moisture measurements. Branko Kerkez, Steven D. Glaser, Roger C. Bales,and Matthew W. Meadows. *Water Resources Research*, Volume 48, Issue 9, 2012.

The distances (in metres) between the various nodes in the network are given below in table1. If the distance between two nodes is too great for transmission then a hyphen is placed in the corresponding table cell.

	Router 1	**Router 2**	**Router 3**	**Router 4**	**Base Station**
Base Station	420	370	350	280	0
Sensor 1	150	200	-	-	-
Sensor 2	140	180	-	-	-
Sensor 3	160	190	-	-	-
Sensor 4	240	220	-	-	-
Sensor 5	145	130	260	-	-
Sensor 6	135	100	250	-	-
Sensor 7	145	90	230	-	-
Sensor 8	260	180	-	-	-
Sensor 9	230	180	260	-	-
Sensor 10	240	170	245	-	-
Sensor 11	-	-	150	145	-
Sensor 12	-	-	160	135	-
Sensor 13	-	-	180	150	-
Sensor 14	-	-	170	130	-
Sensor 15	-	-	140	100	-
Sensor 16	-	-	-	115	-
Sensor 17	-	-	250	105	-
Sensor 18	-	-	245	100	245
Sensor 19	-	-	230	80	100
Sensor 20	-	-	250	105	95
Sensor 21	-	-	255	115	75
Sensor 22	-	-	240	110	55
Sensor 23	-	-	-	125	60

Table 1: distances (in metres) between nodes in the star-based topology network.

The cost of each router (including operational costs for the extent of the study) is $500. The cost of transmission from each sensor node (to a router node or directly to the Base Station) for the extent of the study is $1 per metre. The cost of transmission of data from each sensor for the extent of the study between each router node and the Base Station is $0.10 per metre.

a) Each router node has limited bandwidth, and so can transmit data from at most 5 sensor nodes simultaneously. You need to determine how the star-based topology network should be configured if your objective is to minimise cost

   i. Give the total cost and associated solution.

   [2 marks]

   ii. The distances given in table 1 are accurate to within 3 metres? Could the correction of any one value in table 1 change the solution? Justify your answer.

   [2 marks]

b) Give your mathematical formulation to part a).

[8 marks]

c) It is possible to use more expensive router nodes, capable of transmitting data from more sensors simultaneously. The other types of router nodes available are a $700 node that can transmit data from 8 sensor nodes simultaneously, and a $900 node that can transmit from 10 nodes simultaneously. Note, if you decide to upgrade to one of these router nodes somewhere in the network, it may be possible to not install all 4 router nodes (and so save money). Solve this extension to the problem using excel solver. Give the mathematical formulation, solution, and cost.

[8 marks]