ECE-659 Intelligent Sensors and Sensor Networks

Assignment 1

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Question:1

Protocol	**Layer**	**Standard**	**Data Rate**	**Range**	**Freque-ncy Band**	**Topology**	**Power Requirement**
IEEE 802.15.4	Physical and Mac Layer	IEEE 802.15, 2003	250 Kbps	>100 square miles	868/915/ 2450 MHz	Star and Peer to Peer	Low
IEEE 802.11.AH	Physical	IEEE 802.11-2007 wireless networking standard	150 Kbps - 346 Mbps	< 1.5 Km	900 MHz	Star, tree	Low
Wireless HART	Physical , DLL and Mac	interoperable wireless standard	250Kbps	~300 feet	2.4 GHz	Flat Mesh network	medium
Bluetooth Low Energy (BLE)	Physical	Bluetooth standard	< 1 Mbps	< 100 m	Licensed < 5GHz	Scatter net	Low (0.01-0.50W)
LTE-A,	Physical , Data-link and Network layer	Long Term Evolution standard	Uplink- 100 Mbps Downlink- 1Gbps	16-31 Kms	20 MHz - 100 MHz	Single relay Network(RN) with eNodeB serving a group of User Equipments (UEs)	323 mW for Carrier Aggregation with approximate of 0.8 mW per RBs.
Wifi	Physical ,MAC	IEEE 802.11	<1Gbps	~500feet	1-6 GHz	star	low(2-20W)

Question 2 [15 pts]. Can the MAC protocols of the IEEE802.11 standard be used in sensor networks that run on very constrained devices. Justify your answer..

Ans: Individual nodes of sensor network may have limiting constraints in processing power, memory and battery power. IEEE802.11 standard includes huge overhead in data and control packets. The minimum memory requirement for IEEE802.11 standard is given below:

Checksum & Header	34 bytes
IP	20 bytes
TCP	20 bytes
Minimum overhead size	**74 bytes**

The minimum overhead size for IEEE802.11 standard is 74 bytes where as sensor network may be only 2 bytes. So, IEEE802.11 standard is too expensive in terms of memory and processing for sensor networks. The most important problem for using IEEE802.11 standard in sensor network is power consumption. Since the battery capacity of nodes in a sensor network is small, the high energy consumption is the main disadvantage of implementing IEEE802.11 standard in sensor networks.

Question 4. [15 pts] Choose three of the routing protocols we studied in the lectures and summarize their performance indices and pros and cons.

Ans:

Flooding: A mechanism to relay data in a sensor network which requires no network information like topology, load condition, cost of different paths.

Pros:

- Flooding is highly robust. Emergency messages in military applications can be sent immediately.
- It always chooses the shortest path
- All the nodes get the message

Cons:

- High energy consumption
- Data explosion (vast number of duplicate packets)
- Proper damping mechanism should be used

Gossiping: An enhanced version of flooding in which instead of broadcasting each packet to all neighbours, the packet is sent to a neighbour that has been chosen randomly. The selected neighbour receives the packet and chooses another random neighbour to send the packet. The process continues until the packet reaches the destination.

Pros:

- Data explosion (vast number of duplicate packets) can be avoided
- Energy consumption is less compared to flooding

Cons:

- Transmission delay is more compared to flooding.

Rumor Routing: In rumour routing, paths are created leading to each event after the occurrence of each event. Queries take a random walk in order to join the path.

Pros:

- It can be tuned for best effort delivery
- It can be tuned for a range of query / event ratios

Cons:

- Parameters depend highly on topology
- Delivery is not guaranteed

Question:5

In Wireless Sensor Networks Energy utilization is very important. The amount of energy consumed by the network affects its life time. The paper " Multi-level Dynamic Optimization of Intelligent LEACH with Cost Effective Deep Belief Network" proposes a version of LEACH which is optimized and makes the use of multi-hop communication, dynamic cluster boundaries and energy conservation in routing to maximize the life time of the network. In addition, it also proposes different optimization techniques to maximize different gains. Dynamic Programming based intra-cluster optimization technique is used to maximize the gain with respect to energy conservation. For energy efficient cluster head connection with sink node Ant colony Optimization technique is used. In order to maximize the efficient coverage planning which is dynamic formation of cluster Voronoi Tessellation is used. The Deep Belief Network is integrated into distributed nodes to improve the latency of the system. This is mainly done to accommodate the more flexible ad hoc network. The results of this paper outperforms the state of the art method. Here the proposed modified LEACH algorithm minimized the overall energy consumption of the network by achieving significantly better throughput. Using the Voronoi tessellations an optimized cluster boundary was finalized. Therefore, on the basis of node density and energy consumptions a dynamic cluster boundary was formed by using the Voronoi tessellations. It also allowed the minimization of the energy and maximization of the radius of each cluster. Once the cluster boundary is finalized the algorithm uses the Ant colony

Optimization technique to determine the path with minimum cost from the Cluster Heads to the sink in a multi-hop communication model. In order to minimize the cost within the cluster dynamic optimization is used. The proposed modified LEACH algorithm outperforms the state of the art in terms of throughput and network lifetime. The throughput is 6 times better than that of the state of the art method with significant improvement in the lifetime of the network.

The study chooses two different network simulators after a thorough analysis on different network simulators. The two network simulators used are Omnet++ and NS3. The research study uses 5 different routing protocols and compares their performance on these network simulators. The metrics used for performance evaluation of different protocols are Packet Delivery Ratio, Throughput, Average End-to-End Delay, Path optimality and Routing Overhead. Among the 6 metrics NS3 uses all 5 metrics for evaluation whereas Oment++ uses only 3 metrics which are Throughput, End to End delay and Routing Overhead. First the protocols are implemented on Omnet++ and then on NS3. The graph from Oment++ for Routing Overhead clearly shows that AODV protocol outperforms all other protocols. The value for 15 nodes is 0.04 and this value decreases with increase in number of nodes. For 50 nodes AODV gives a routing overhead of 0.03 which is the lowest among all other protocols. For WARP protocol the routing overhead is increases with number of nodes and gives a value of more than 0.11 for 50 nodes which is the highest among all other protocols. In terms of throughput results given by Omnet++, AODV is consistent for all the 20 nodes at 20000 bps which is highest among all other protocols for all three nodes. The lowest throughput is for WARP at less than 14000 bps for 5 nodes and this decreases with increase in number of nodes to less than 13000 bps for 20 nodes.

DSDV is a close match for AODV when the nodes are between 10 to 15. In terms of End-to-End delay AODV and DSDV performs in a similar way however AODV is slightly better for increase in number of nodes. WARP has the highest delay among all the protocols followed by ZRP and then OLSR. The results obtained for Routing Overhead by NS3 is different from that of Omnet++, here DSR is having the least value of approximately 0.04 for 15 nodes and this value decreases with increase in number of nodes. At 50 nodes this value is lowest among all the protocols to approximately 0.2. The value for AODV is 0.5 for 15 nodes and this value increases at 25 nodes to approximately 0.7 and then decreases to 0.5 at 50 nodes. For throughput, DSR has the highest value and this increases with increase in number of nodes to more than 325 for 50 nodes. AODV is second and it closely follows DSR and it attains the highest value at just over 300 at 50 nodes. WARP has the lowest throughput among all other protocols. In the graph obtained for packet delivery ratio AODV has again the highest value among all other protocols and WARP has the lowest packet delivery ratio of 0.4 for 15 nodes however it increases to 0.7 for 50 nodes which is still the lowest among all nodes for 50 nodes. In the graph obtained by End-to-End delay WAPR has the highest delay among all other protocols and this increases with the increase in the number of nodes. ZRP has the lowest delay of all the protocols at higher nodes. OLSR has the least delay for 15 nodes and this increases with increase in number of nodes. AODV has the highest value of path optimality and this value increases with increase in number of nodes and gets the highest value of close to 95 for 50 nodes. WARP has the least optimal path and this remains fairly constant with increase in the number of nodes. In conclusion, both the network simulators provide varying results however AODV protocol seems to outperform most of the time. In addition it is fairly difficult to say which network simulator works best as the results are obtained on different metrics.