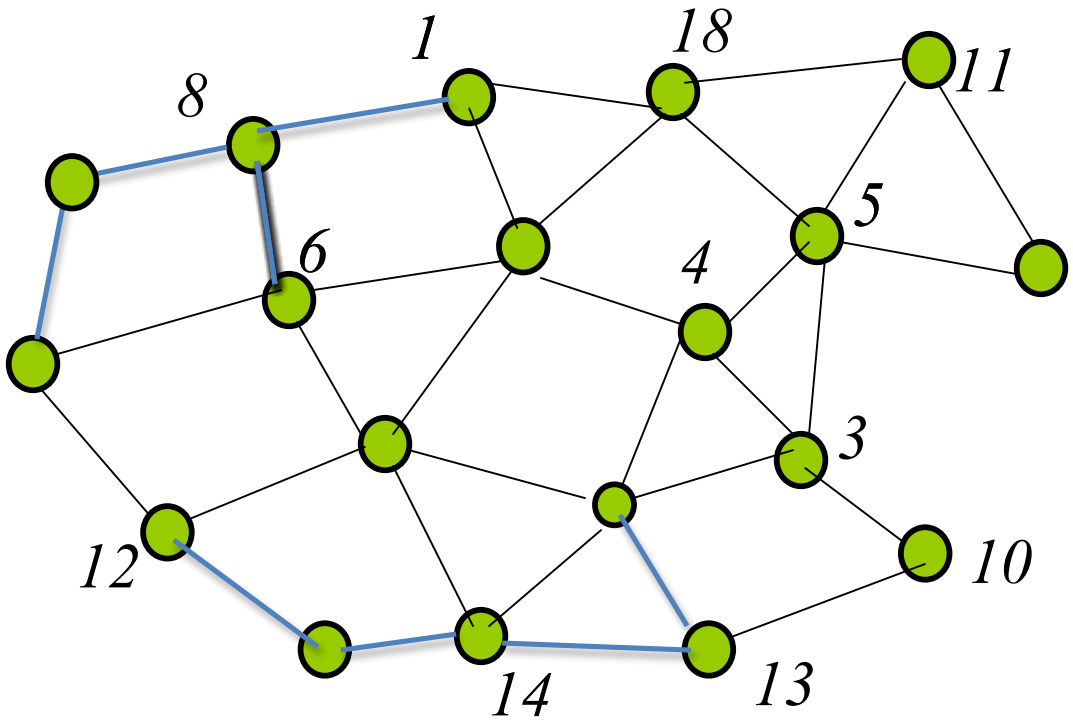
Wireless Ad Hoc Networking: Quiz 1, February 15, 2013
Closed book exam, 120 minutes

Name: _____ Student number: _____

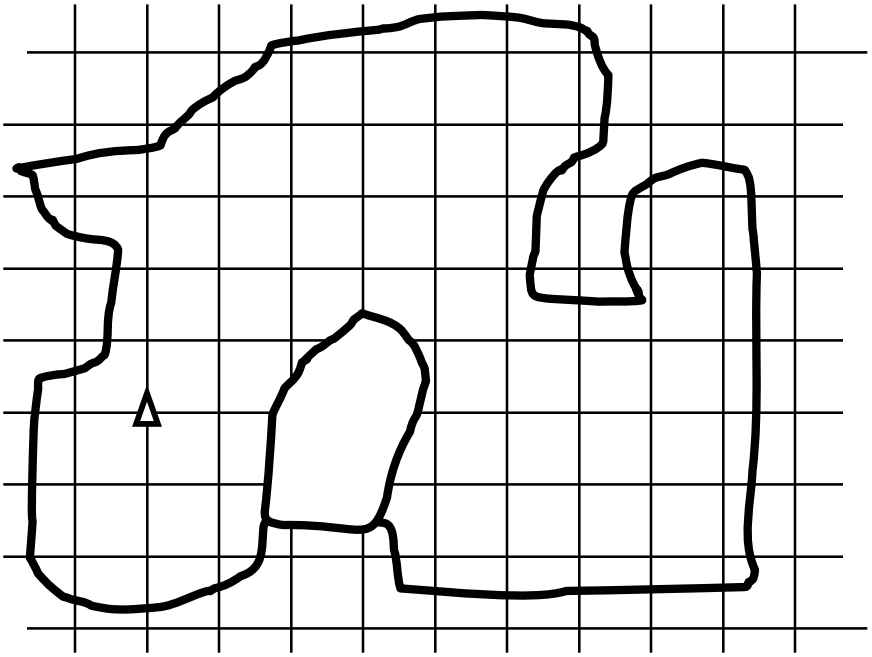
1. (10 marks) Apply the generalized covering rule to determine which nodes do not belong to the connected dominating set. For each such node, list the neighbors that cover it. Node A is covered by neighboring nodes B, C, … if B, C, … are connected (that is, create connected subgraph), any neighbor of A is neighbor of (at least) one of B, C,.. and key(A) < min (key(B), key(C),…). Use key=ID, ordered numericaly (1<2<3<…). Node A is also considered covered is it does not have two unconnected neighbors.



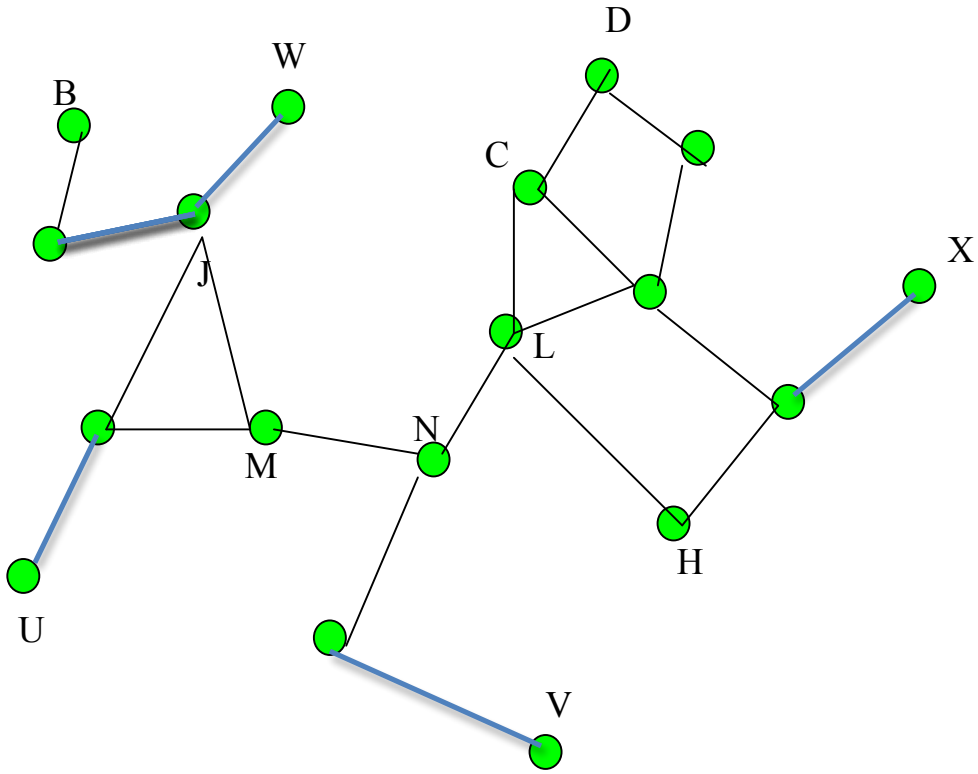
See solution for missing node notations

2. (8 marks) a) Show the expected traversal using the Single Robot BackTracking Deployment (BTD) method (which extends snake like deployment method with obstacles), with the triangle as the starting point. Show regular movement with a solid line and back tracking with a dashed line. Assume the following order of preference for movement in the event of more than one open direction: East, West, North, South. Note that sensors should be deployed at grid points located between two curves. Clearly mark backtracking points (where robot returned based on the pointer).

b) (8 marks) Is there any starting point, and any other priority order among directions, so that the original version, without any backtracking, is able to fill the area with sensors in full? Why?

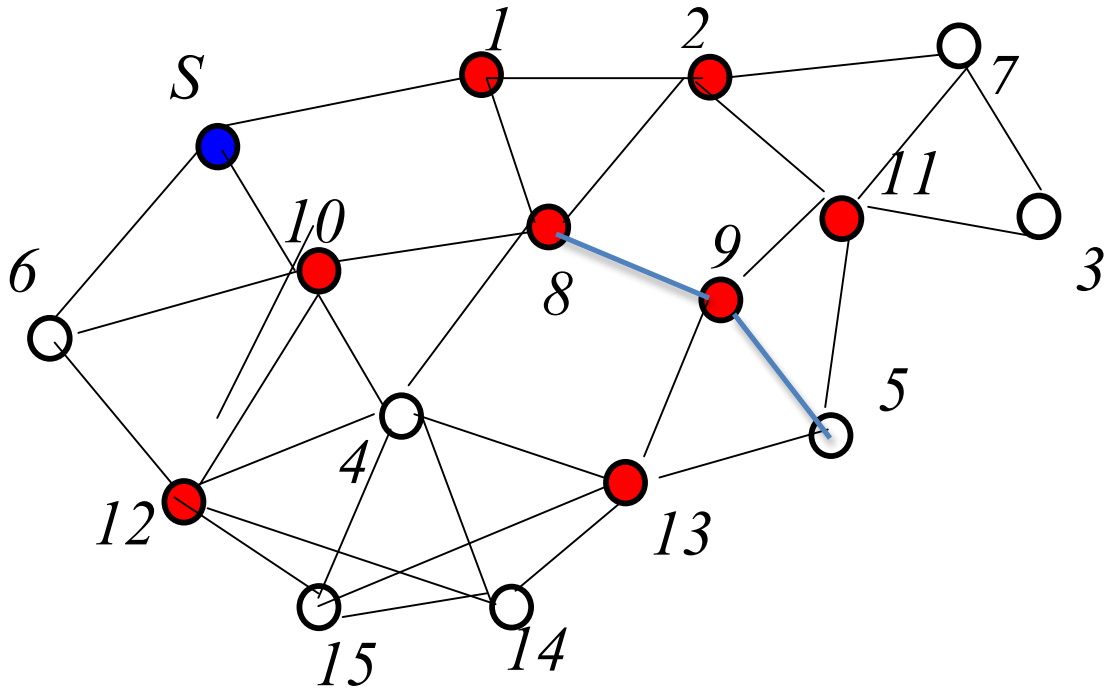


3. (10 marks) Show two recovery paths (by right-hand and left-hand rules) when recovery starts from node H and message is destined for node V. Extend both and show greedy-face-greedy routing steps.



4. (14 marks) Apply the **receiver consensus** algorithm on this example. Broadcasting starts from S, and only CDS nodes could retransmit (dark nodes 1,2,8,9, 10, 11,12,13). To simplify, assume that all messages are correctly received and without collisions, by all intended receivers, as per the unit disk graph in the figure. Also assume that beacons are frequent and without message failures, so P is then always empty (nodes immediately moved to R). Show step by step which nodes retransmit in the current slot, and list the content of R and N sets for each of these eight nodes.

Algorithm: Nodes run artificial timers. They estimate timers of all neighbors, rank them, and use ranking to decide order of retransmissions. Node retransmits immediately if it is top ranked locally. If ranked r then transmits in r-th slot if no one else did it by then. Nodes in R and P participate in ranking. Find centroid C of N. Rank by distances of nodes from R+P from C.



5. (6+10+6 marks) Gabriel graph GG(S) contains an edge (U,V) if ad only if the disk with diameter (U,V) contains no other point from the same network S. RNG(S) contains an edge (U,V) if and only if (U,V) is not the longest edge in any triangle UVW. They can be defined also via 'forbidden' regions. For GG, it is a circle with UV as diameter. For RNG, it is the intersection of two circles with radius UV, centered at U and V. They are illustrated in the figure. (U,V) belongs to the considered graph if and only if there is no neighbor in their 'forbidden' region.

a) Prove that if 'forbidden' region of structure A is always inside forbidden region of structure B then B is the subset of A. Consider the case A=GG and B=RNG as an example.

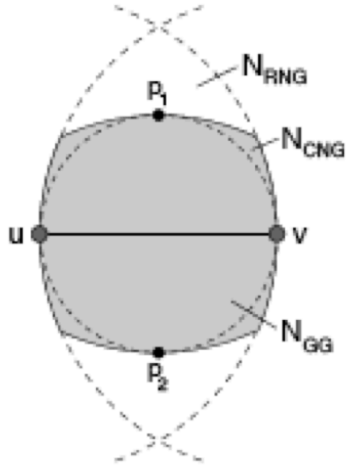
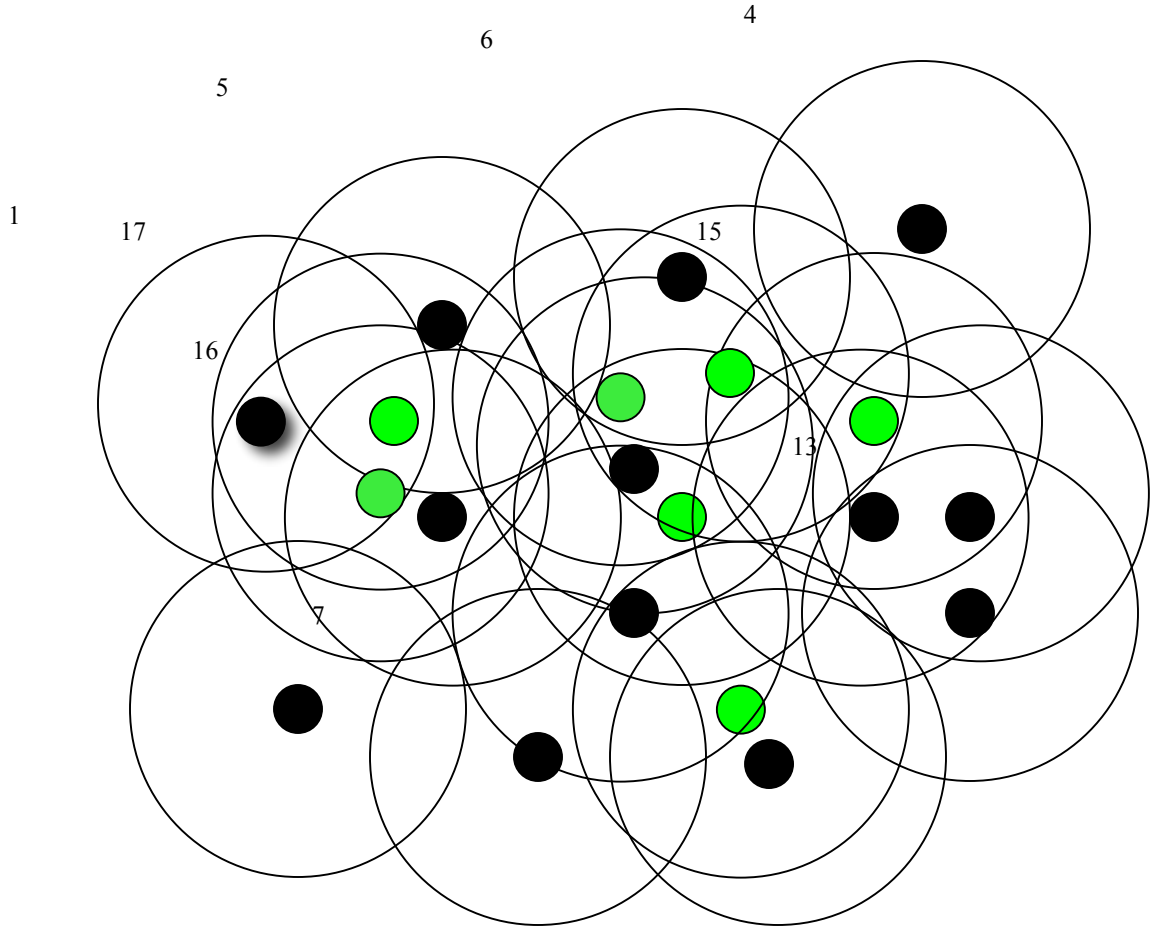


Fig. 8: The proximity region for circlunar neighborhood is between RNG lune and Gabriel circle.

b) The circlunar graph has 'forbidden' structure as drawn in the figure as shaded region. P_1P_2 is a diameter that is orthogonal to the diameter UV of the same circle. The two other arcs are centered at P_1 and P_2 with the same radius $|UV|=|P_1P_2|$. Give a definition of the circlunar graph without refering to the 'forbidden' region. That is, give a definition that looks like the definition of RNG and GG at the beginning of this question.

c) What is the relation between GG, RNG and circlunar graph and why?



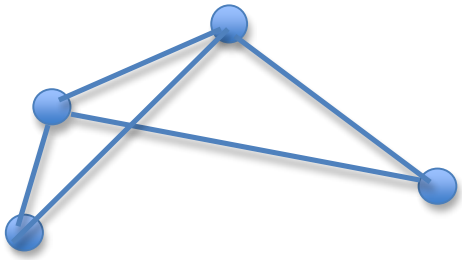
6. (14 marks) Suppose that localized sensor area coverage algorithm initially selected nodes **1, 4,5,6,7,8,9,10,11,13,14,16,18** to be active. We then apply the threshold distance area based algorithm called PEAS. It is asynchronous, sensors have no prior knowledge of neighbors. A sensor sleeps for a while, then sends probing packet. It decides to be active if and only if there is active sensor closer than a threshold distance. Once active, sensor remains active. Non-active sensors periodically reevaluate decision. Suppose that theshold radius is equal to the sensing radius (thus we use same circles for thershold radius). Next, suppose that sleeping sensors wake up or die in their indicated order. So first action is that sensor 1 dies, then sensor 2 wakes up and makes a decision, then sensor 3 wakes up and makes decision, then sensor 4 dies etc.. continues like that.
Please list the decisions made by sensor until all sensors die.

12 4 B 7 C

7. (14 marks) In proactive routing, routing tables contain the first hop / neighbor toward each destination. Bellman-Ford algorithm is used to periodically update tables. Each node exchanges its routing tables with all its neighbors, and

- the best neighbor N for route from S to D is one that minimizes the cost of link S to N, plus cost of routing from N to D (from routing table in N).

In this figure, the costs of routing from nodes A, B and C to the sink S (destination) are measured as ETX (expected number of transmission), and initial values are in the figure. Thus ETX is value from routing tables. Suppose that the quality of link from A to the sink suddenly worsens and becomes equal to 20. Show the ETX values (in corresponding routing tables) for nodes A, B, C in coming iterations, one by one, until it becomes stable.



ETX from A, B, C to sink; note link from A to sink changed to 20, but A believes that C and B provide better paths to sink than direct link until things stabilize.

A **B** **C**