DEPARTAMENTO DE ELETRÓNICA, TELECOMUNICAÇÕES E INFORMÁTICA

MESTRADO INTEGRADO EM ENG. DE COMPUTADORES E TELEMÁTICA

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ASSIGNMENT GUIDE NO. 3

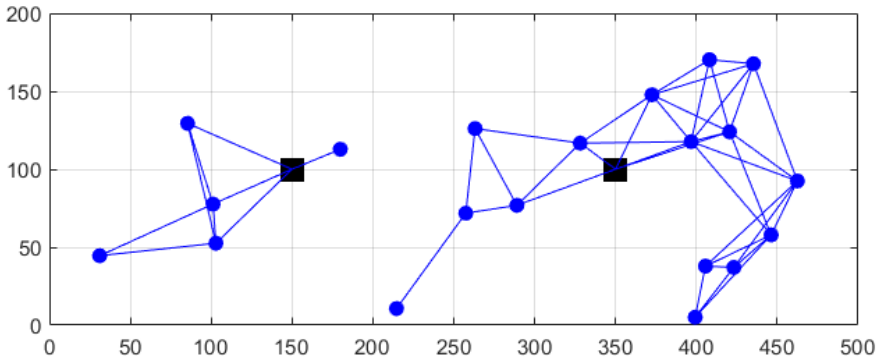
AVAILABILITY PERFORMANCE OF MULTI-HOP WIRELESS NETWORKS WITH MOBILE TERMINALS

1. General Description

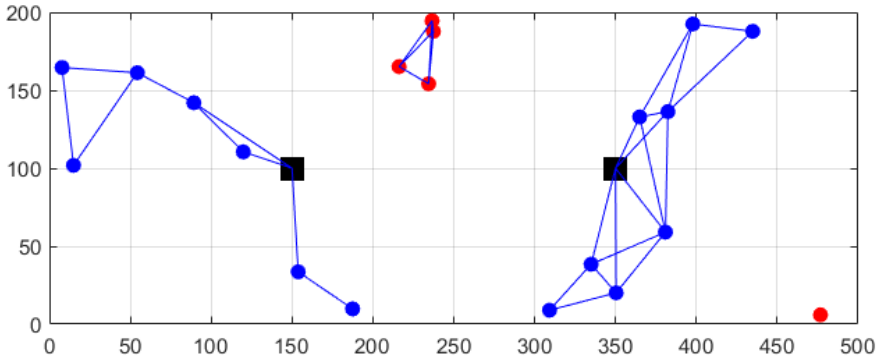
The aim is to analyse by simulation the availability performance of a multi-hop wireless network with mobile nodes moving on a given geographical area. The network provides mobile nodes with Internet access through AP (Access Point) nodes spread over the geographical area. The wireless network is characterized by a given radio range W, i.e., each mobile node establishes a direct wireless link with each of the other nodes (mobile and AP nodes) whose distance from it is not higher than W.

In multi-hop wireless networks, nodes are able to perform routing, i.e., they forward data packets received from other nodes and destined to other nodes. So, at each time instant, a mobile node has connectivity with the Internet if there is a routing path between it and at least one AP node over the set of established direct wireless links.

The geographical area of the network is defined by a rectangle of 500 horizontal meters by 200 vertical meters representing an open space campus where mobile nodes can move freely. Fig 1 presents two snapshots (taken in two different time instants) of a simulation with 2 AP nodes (represented by black squares), W = 80 meters and 20 mobile nodes (represented by circles). Blue line segments represent established direct wireless links between nodes. In the snapshot of Fig. 1(a), all mobile nodes have Internet access since there is at least one routing path from every mobile node to at least one AP. In the snapshot of Fig. 1(b), there are only 15 mobile nodes with Internet access and 5 mobile nodes (in red) have no available routing path to any of the AP nodes.



(a)



(b)

Fig. 1 – Snapshots of the network with 2 AP nodes in black squares (mobile nodes with Internet access are in blue and without Internet access are in red): (a) *all mobile nodes have Internet access and* (b) *5 mobile nodes do not have Internet access.*

The Internet access availability is the probability of a node to be connected to the Internet. For each node, it can be estimated by the percentage of time it is connected to at least one AP node. The aim is to estimate the average and the minimum availability among all mobile nodes.

The network to be simulated is a continuous time system (i.e., the location of the mobile nodes varies continuously over time). To develop the simulator, consider that time is discretized in time slots with equal time duration. Then, the simulator computes only the state of the system at the beginning of each time slot (the slot duration is a trade-off between simulation running time and results accuracy: a smaller slot duration increases the simulation runtime and also increases the results accuracy).

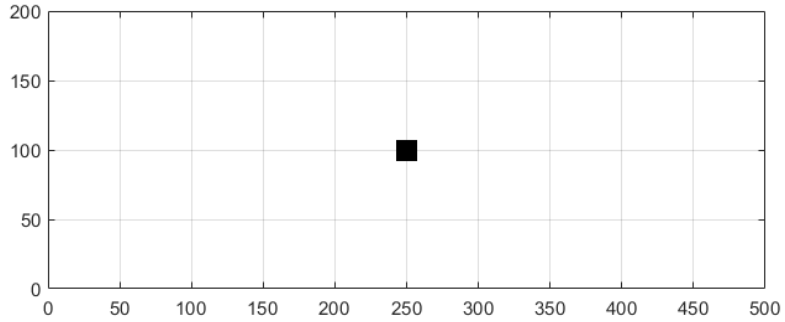
2. Simulator Development

Develop a MATLAB function named `simulatorFunction` implementing a simulator of a multi-hop wireless network as described in the previous section, taking as starting point the MATLAB function provided in file `simulatorFunction.m` (this function already implements the movement simulation of mobile nodes and the simulation visualization). The aim of the simulator is to estimate 2 performance parameters: the average and the minimum Internet access availability among all mobile nodes. The input and output parameters of the simulator are:

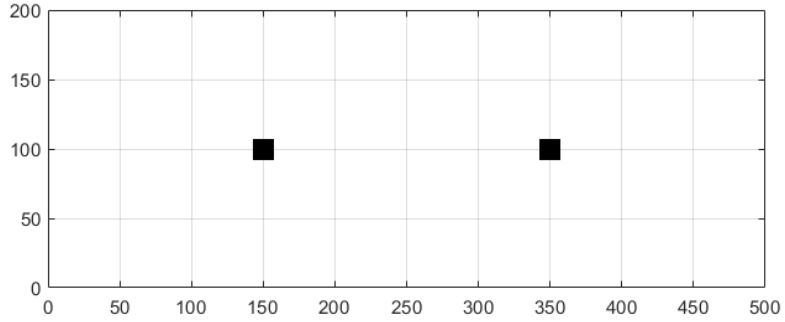
```
>> help simulatorFunction
  [AvgAvail, MinAvail]= simulatorFunction(N,AP,S,W,dlt,T,pl)
  Input parameters:
   N -   no. of mobile nodes
   S -   maximum absolute speed of mobile nodes (in km/h)
   W -   radio range (in meters)
   dlt - time slot (in seconds)
   T -   no. of time slots of the simulation
   AP -  matrix with one row per AP node and 2 columns where the
         first column has the horizontal coordinates and the
         second column has the vertical coordinates of the AP
         nodes
   pl -  plot option: 0 - nothing;
                      1 - nodes' movement;
                      2 - nodes' movement and connectivity
  Output parameters:
   AvgAvail - average availability among all mobile nodes
   MinAvail - minimum availability among all mobile nodes
```

Concerning the AP configuration in terms of number of AP nodes and their locations, consider the following 3 AP configurations:

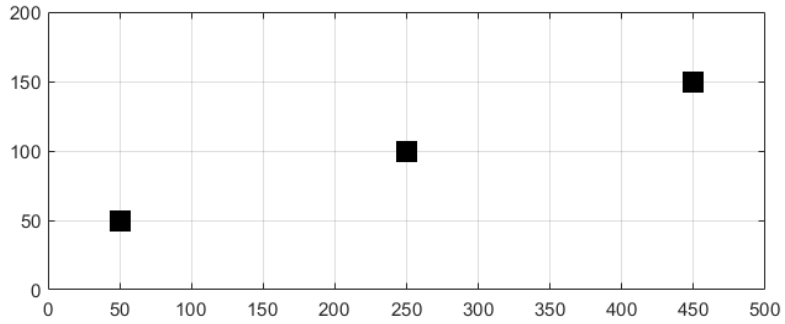
1 AP node



2 AP nodes



3 AP nodes



3. Assignment Tasks

a) For each AP configuration and each of the cases defined in the following table, run 10 simulations and determine the average and the minimum availability of the Internet access among all nodes together with the 90% confidence intervals (run each simulation with a time slot duration of 1 second and T = 7200 time slots).

Case	N	S (km/h)	W (meters)	Average availability	90% confidence interval	Minimum availability	90% confidence interval
1	20	3	40				
2	40	3	40				
3	60	3	40				
4	80	3	40				

5	20	6	40				
6	40	6	40				
7	60	6	40				
8	80	6	40				
9	20	3	60				
10	40	3	60				
11	60	3	60				
12	80	3	60				
13	20	6	60				
14	40	6	60				
15	60	6	60				
16	80	6	60				
17	20	3	80				
18	40	3	80				
19	60	3	80				
20	80	3	80				
21	20	6	80				
22	40	6	80				
23	60	6	80				
24	80	6	80				

b) Does the maximum speed S of the mobile nodes influences the availability performance of the network? Justify your conclusions.

b) Present the simulation results as plots highlighting the influence of the radio range W in the availability performance of the network. Describe and justify your conclusions.

c) Present the simulation results as plots highlighting the influence of the number of mobile nodes N in the availability performance of the network. Describe and justify your conclusions.

d) Present the simulation results as plots highlighting the influence of the number of AP nodes in the availability performance of the network. Describe and justify your conclusions.

e) By analyzing the obtained 90% confidence intervals, take conclusions on the influence of the input parameters on the statistical confidence of the results.

f) Are the suggested AP node locations the best choice for each considered number of APs? Simulate possible alternatives in the cases you think you can obtain better availability performance.

f) Assume that the radio range of the wireless network is W = 60 meters and the maximum speed of mobile nodes is 3 km/h. Determine the minimum number of APs (and their best locations) such that the minimum Internet access availability is not lower than 99% when the number of mobile nodes N is 40, 60 and 80. For all cases, run an enough large number of simulations to reach an adequate 90% confidence interval.