DEPARTAMENTO DE ELETRÓNICA, TELECOMUNICAÇÕES E INFORMÁTICA

MESTRADO INTEGRADO EM ENG. DE COMPUTADORES E TELEMÁTICA

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DESEMPENHO E DIMENSIONAMENTO DE REDES

ASSIGNMENT GUIDE NO. 2

AVAILABILITY PERFORMANCE OF MULTI-HOP WIRELESS NETWORKS WITH MOBILE TERMINALS

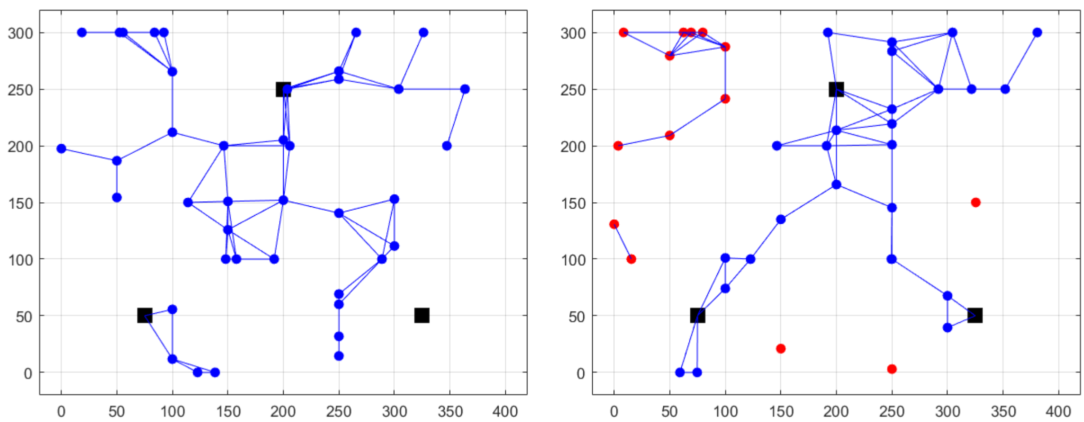
1. General Description

The aim is to conduct a simulation analysis of the availability performance of a multi-hop wireless network where mobile nodes are moving on a given geographical area. The wireless network provides mobile nodes with Internet access through AP (Access Point) nodes spread over the geographical area. The network is characterized by a given radio range W such that any mobile node establishes a direct wireless link with each of the other nodes (mobile or AP) whose distance from it is not higher than W. In multi-hop wireless networks, nodes are able to perform routing, i.e., they can 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 wireless links.

Consider the geographical area of the network given by a rectangle of 400 horizontal meters by 300 vertical meters representing a possible open space campus with 7 horizontal walking paths and 9 vertical walking paths, in both cases separated by 50 meters. Each mobile node moves over one walking path and turns back in the same walking path when it reaches the limit of the rectangle.

Fig 1 presents two snapshots (taken in two different time instants) of a simulation with 3 AP nodes (represented by black squares) and 40 mobile nodes (represented by circles). The walking paths are represented by dashed lines (mobile nodes are always located on one of the walking paths). Blue line segments on the snapshots represent established 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 26 mobile nodes with Internet access and 14 mobile nodes (in red) have no available routing path to any of the AP nodes.

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 one AP node. The aim is to estimate the average and the minimum availability among all mobile nodes.



(a) (b)

Fig. 1 – Snapshots of the network with three 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) *14 mobile nodes do not have Internet access.*

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).

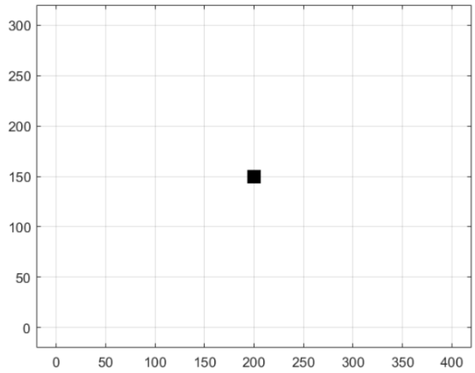
2. Simulator Development

Using the MATLAB script provided in a separate file (named simulator.m), implement the required MATLAB functions to develop a simulator of a multi-hop wireless network as described in the previous section (the provided simulator already implements the mobile node movement). The aim of the simulator is to estimate the average and the minimum Internet access availability among all mobile nodes. The input parameters of the simulator are:

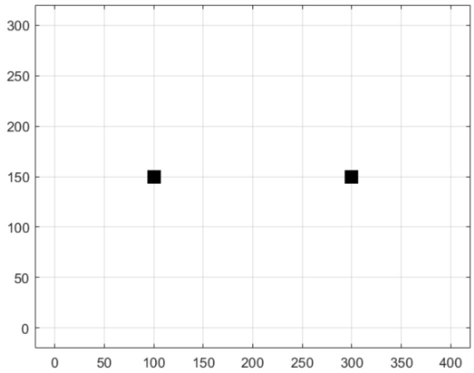
- N number of mobile nodes
- W radio range (in meters)
- Δ time slot duration (in seconds)
- T number of simulated time slots (total simulated time is $T \times \Delta$ seconds)
- AP matrix with one row per AP node and 2 columns where the first column has the horizontal coordinates and the second column has the vertical coordinates of the AP nodes

Concerning the AP configuration in terms of number of AP nodes and their locations, consider the following 4 AP configurations:

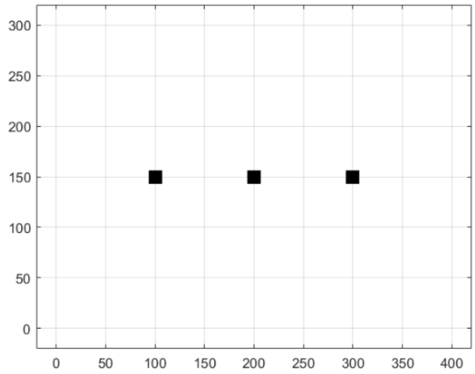
1 AP Node



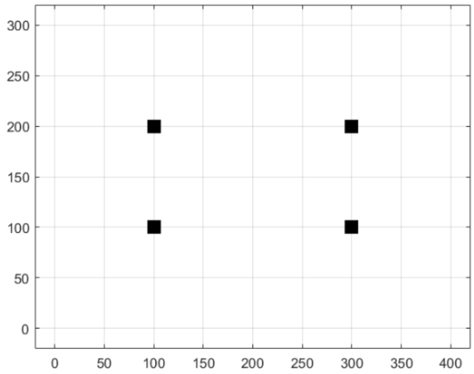
2 AP Nodes



3 AP Nodes



4 AP Nodes



3. Assignment Tasks

a) For each AP configuration and each of the cases defined in the following table, run 20 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 $\Delta = 1$ second and $T = 3600$).

Case	N	W (meters)	Average availability	90% confidence interval	Minimum availability	90% confidence interval
A	60	40				
B	90	40				
C	120	40				
D	150	40				
E	60	60				
F	90	60				
G	120	60				
H	150	60				
I	60	80				
J	90	80				
K	120	80				
L	150	80				

b) Present the simulation results as plots to better illustrate the results and conclusions to be taken in **c)** and **d)**.

c) Based on the simulation results, take conclusions about the influence of the radio range W, number of mobile nodes N and number of APs on the availability of the Internet access. Whenever possible, justify your conclusions.

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

e) Consider that AP nodes can only be installed on streets. Are the suggested AP 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 now that the number of mobile nodes is $N = 150$. For each of the 3 radio range values (W = 40, 60 and 80 meters), determine the minimum required number of APs (and their best locations) such that the minimum Internet access availability is not lower than 99% (again, consider that AP nodes can only be installed on streets). For all cases, run an enough large number of simulations to reach an adequate 90% confidence interval.