A Generalized Model for Maximizing Routing Requests in Ad Hoc Networks

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Background

Ad hoc networks are multihop communication networks consisting of small computing devices with wireless interfaces. Each ad hoc node has limited battery power, and wireless communication consumes most of the battery power of node.

Routing is a process to send a message from one node (called the source node) to another node (called the destination node) in the network. To maintain the functionality of an ad hoc network, it is critical that users inside the network can always successfully transmit messages to each other.

We are interested in designing energy-efficient routing algorithms in random ad hoc networks with the objective of maximizing the total number of messages that can be successfully satisfied, under the energy constraint of each node. We refer to this problem as **maxR**.

The online version of maxR, where the sequence of messages is not known ahead of time, has been extensively studied. However, the offline version, where the sequence of messages is pre-known, has not been well investigated.

The existing approach has three limitations. First, it assumes that all the ad hoc nodes have the same initial energy level. Second, it assumes sending a message costs one unit of energy while receiving costs zero. Third, the ad hoc networks simulated in current research is a simplistic grid network, which does not represent well the real ad hoc network applications. We extend it to a more realistic ad hoc networks that are randomly generated, and design new energy-efficient routing algorithms in ad hoc networks, **GDP** and **MECBE**. We also compare these to the current state-of-the-art online algorithm **OML**.

Methods

Greedy Disjoint Paths (GDP)

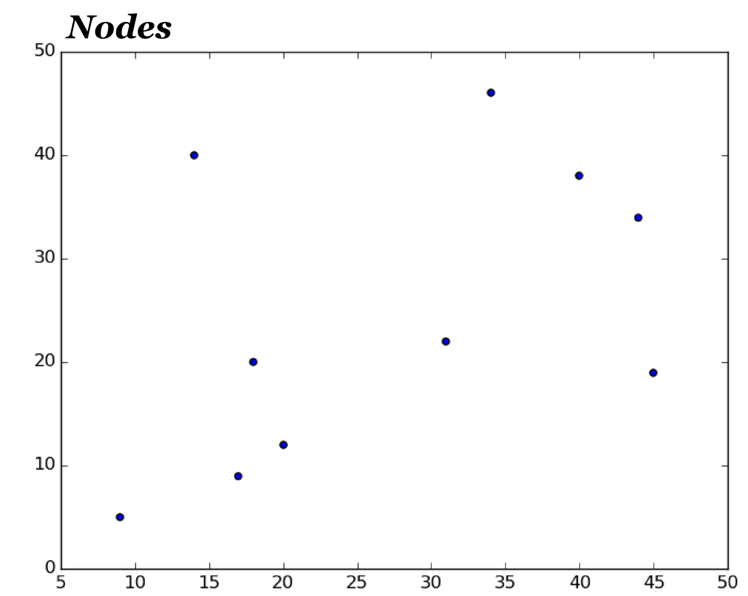
Notations: m' is the total number of edges in G'; ϵ is the initial energy of all the nodes; $\beta = m'^{1/(\epsilon+1)}$
$\mathcal{I} = \emptyset$, $\mathcal{I}$ is the set of completed requests
For all $e \in E'$, set its weight to 1
while There are still requests that can be satisfied **do**
  Let P_i be the minimum weighted path so that adding P_i to the selected set of paths does not use any edge more than ϵ times, and P_i connects some (s_i, t_i) pair not yet connected
  Add i to $\mathcal{I}$ and use path P_i to route the message from s_i to t_i
  Multiply the length of all edges along P_i by β
end while

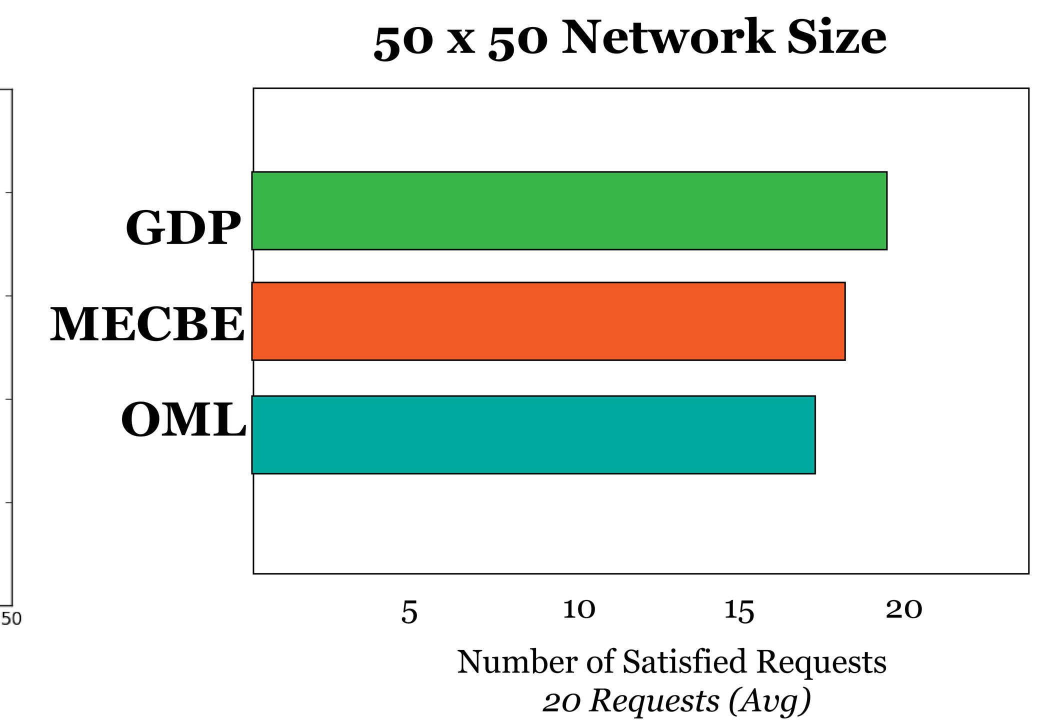
Maximizing total Energy Consumption and Balancing node Energy (MECBE)

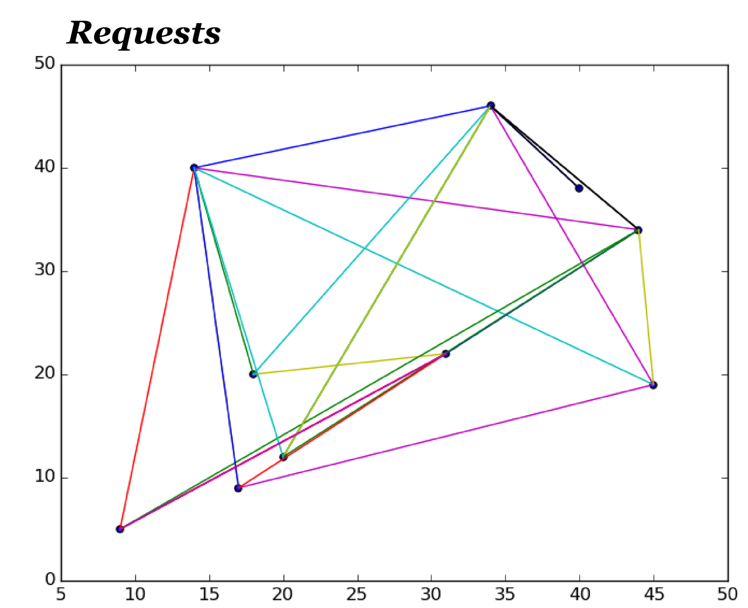
for each request $r_i \in \mathcal{R} = \{r_1, r_2, \cdots, r_p\}$ **do**
  $G' = (V, E')$ where $E' = E - \{(u,v) | ce(u) < w(u,v)\}$
  In G', find the path $\{s_i, u_1, u_2, \cdots, u_q, t_i\}$ from s_i to t_i that can minimize metric $\sum_{j=1}^{q} \frac{1}{ce(u_j)}$
  if the returned path is NULL **then**
    Stop the program
  end if
  for each node u_i on the path found except the sink node **do**
    $ce(u_i) = ce(u_i) - w(u,v)$
  end for
end for

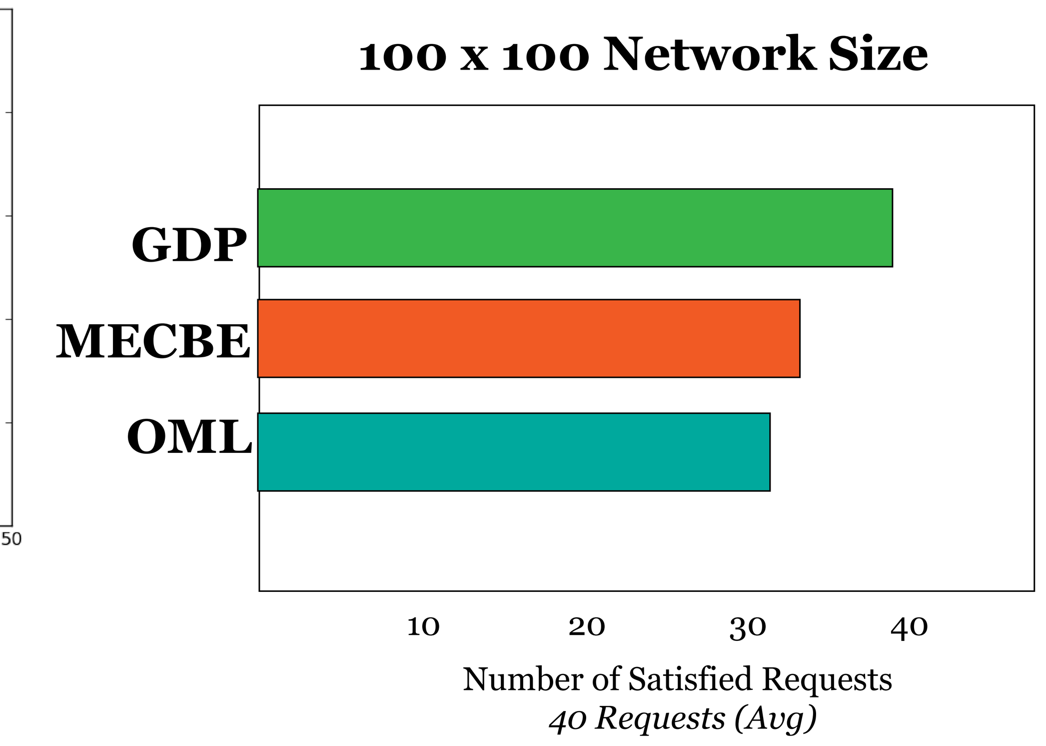
These algorithms were implemented in Python using the Networkx library to handle graph details. Each were fed the same input graph structures, giving the results of each algorithm (which can be found to the right).

Results









Conclusion

Initial tests indicate that implementing these algorithms on random ad hoc networks seem to follow the performance trend of the same algorithms on “static” ad hoc networks regarding the total number of requests served (seen above), the energy consumed by these requests, and other such statistical measurements. However, more tests must be done to verify the energy efficiency of the GDP and MECBE algorithms. These initial results seem to point toward the offline GDP algorithm as being the better choice at maximizing the number of requests in such random ad-hoc networks.

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