Positioning Range Extension Gateways in Mobile Ad Hoc Wireless Networks to Improve Connectivity and Throughput

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Outline

- Introduction
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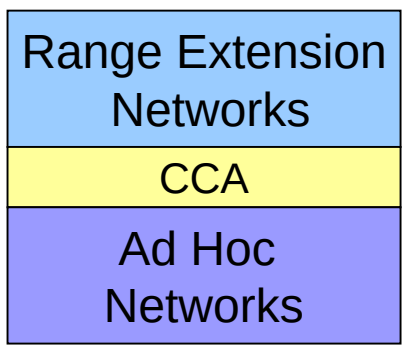
Introduction

- A major challenge in the wide deployment of MANETs has been in achieving scalability.
- The MANETs might often be geographically divided into isolated partitions.

Introduction (cont.)

- How to achieve scalability in terms of efficient communications between geo-graphically distant nodes or between nodes that belong to different partitions?
  - Mobile gateway
  - Cross Layer Communication Agent (CCA)



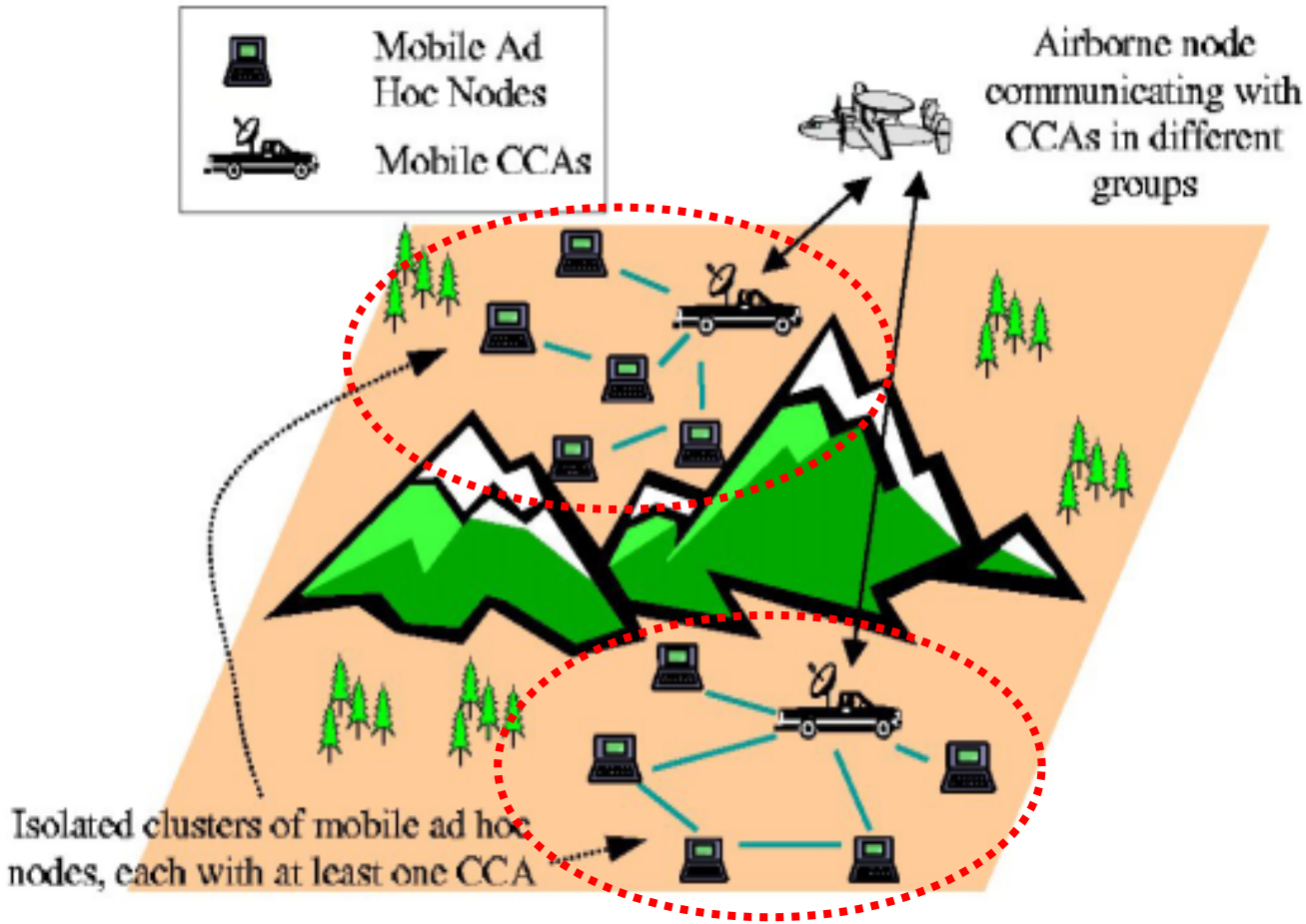
Introduction (cont.)

- The performance metrics that could be improved by optimizing the CCA trajectory:
  - Inter-domain Network Data Throughput
  - Inter-domain Network Packet Transport Delay
  - Total Power Expended
  - Data Transmission Reliability

System Model

- Group:
  - Have one or more CCAs capable of communicating with airborne or satellite node.
- Blockage:
  - A region which the node or the CCA cannot be deployed.

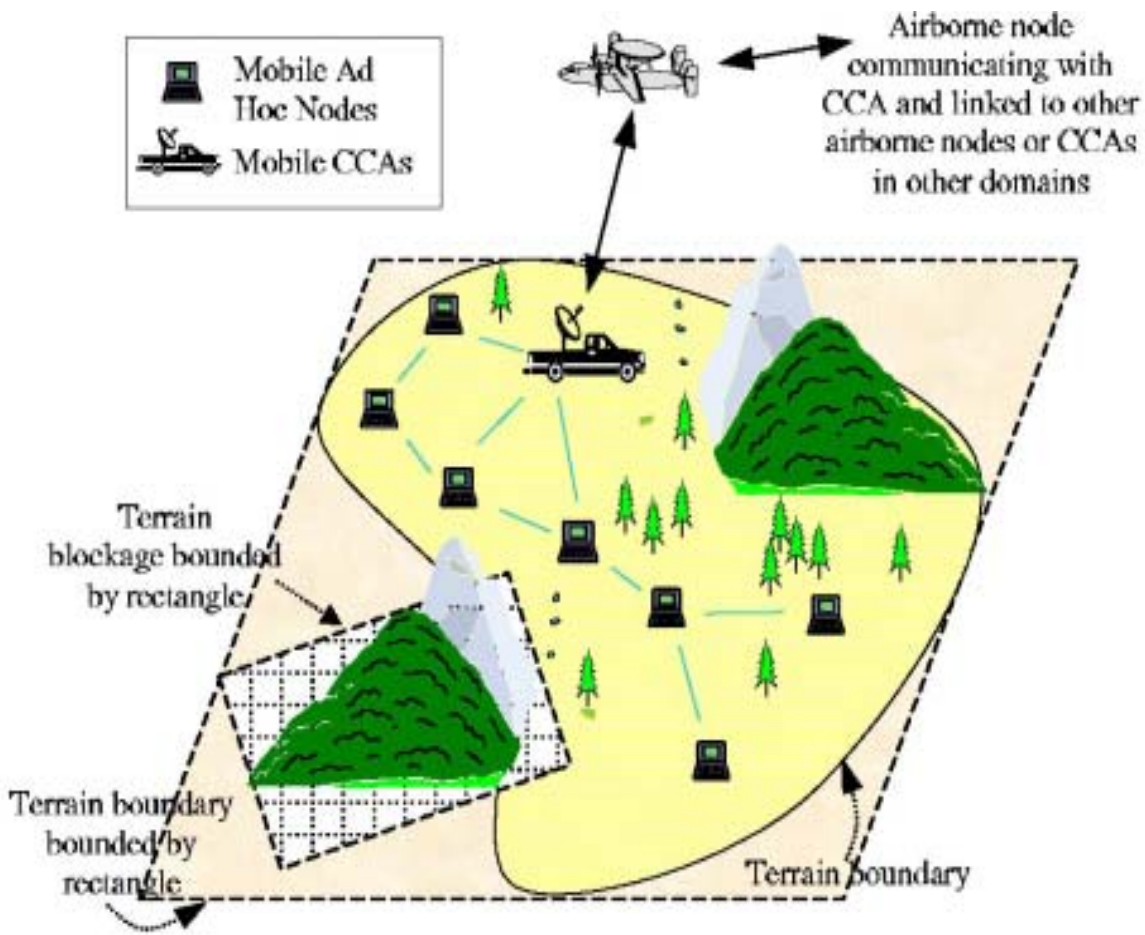
Ad Hoc Network of Two Groups of Mobile Nodes and CCAs



Ad Hoc Network of Two Groups of Mobile Nodes and CCAs (cont.)

- Each node is equipped with a GPS device that enables the node to determine its position.
- Each node can estimate its offered load in real time.
- Terrain information is available at each CCA.

CCA Domain with Location Bounds



CCA Deployment

- Intuitively, one might expect that the performance of the network would be best if we position the CCA near the Weighted geographic centroid of the domain.

- The parameters that the CCA can take into account in formulating the optimization problem could include:
  - Node positions
  - Each node's offered load
  - Data traffic patterns
  - Priority of the generated traffic
  - SIR
  - Others

CCA Deployment (cont.)

- In this paper:
  - Primary parameters:
    - Node positions
    - Each node's offered load
      - (the CCA eventually will be closest to the most heavily loaded nodes)
  - Basic performance metrics
    - Network throughput
    - The average delay experienced by inter-domain data packets

Optimization Formulation

Weighting Factor: User Defined Function

$$\text{minimize} \quad \sum_{i=1}^{n} f(\tau_i, \rho_i) \cdot |\mathbf{x}_0 - \mathbf{x}_i|$$

CCA Trajectory Update Algorithm

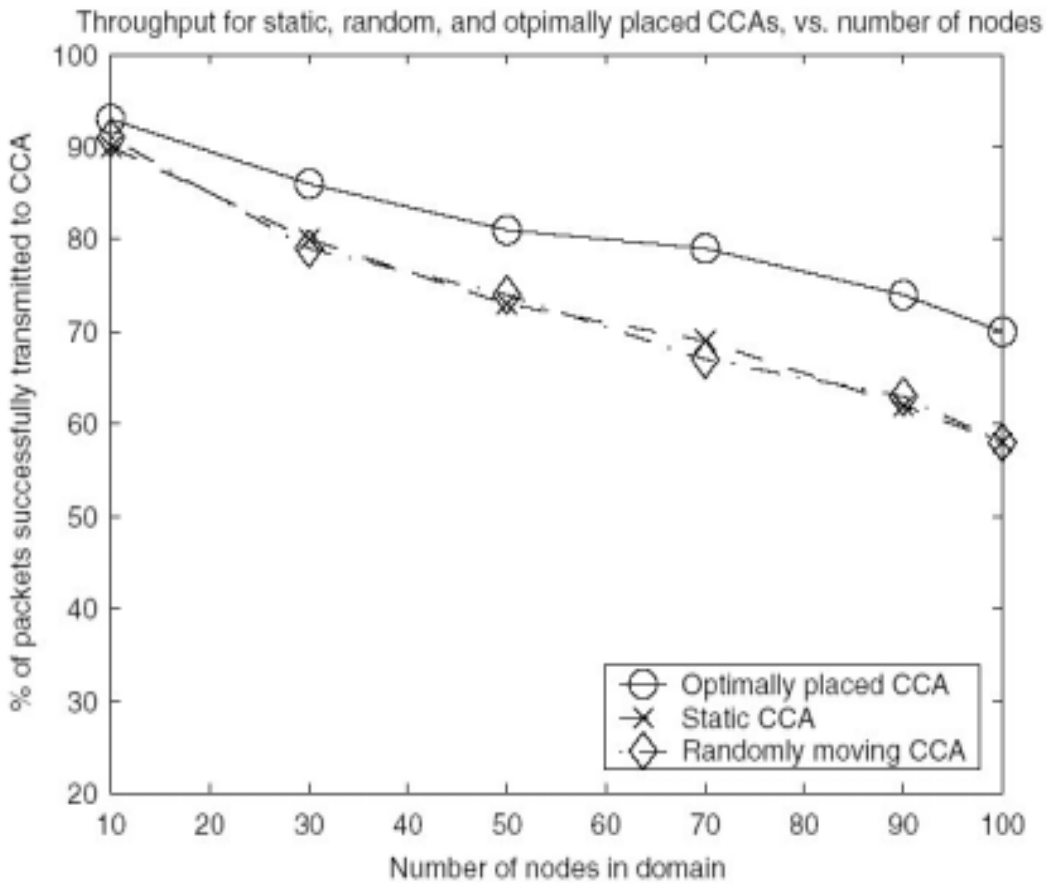
- *Input constants (set 'a priori')*: terrain and blockage boundaries, sampling times, optimization metric of interest.
- *Output*: optimum CCA location computed at specific sampling times.
- {*While nodes in the domain have inter-domain data packets to send*}, **DO**:

1. Collect or estimate the position of each node, $\mathbf{x_i}$, at each sampling instant.
2. Collect from each node, an estimate of its current load and the priority that it desires.
3. Perform a local computation to solve the LP equivalent to the optimization problem in Equation 1 and obtain optimum CCA location for that sampling instant.
4. Move towards the optimal location in the most suitable manner, as allowed by the physical constraints[5].
5. Repeat at next sampling instant.

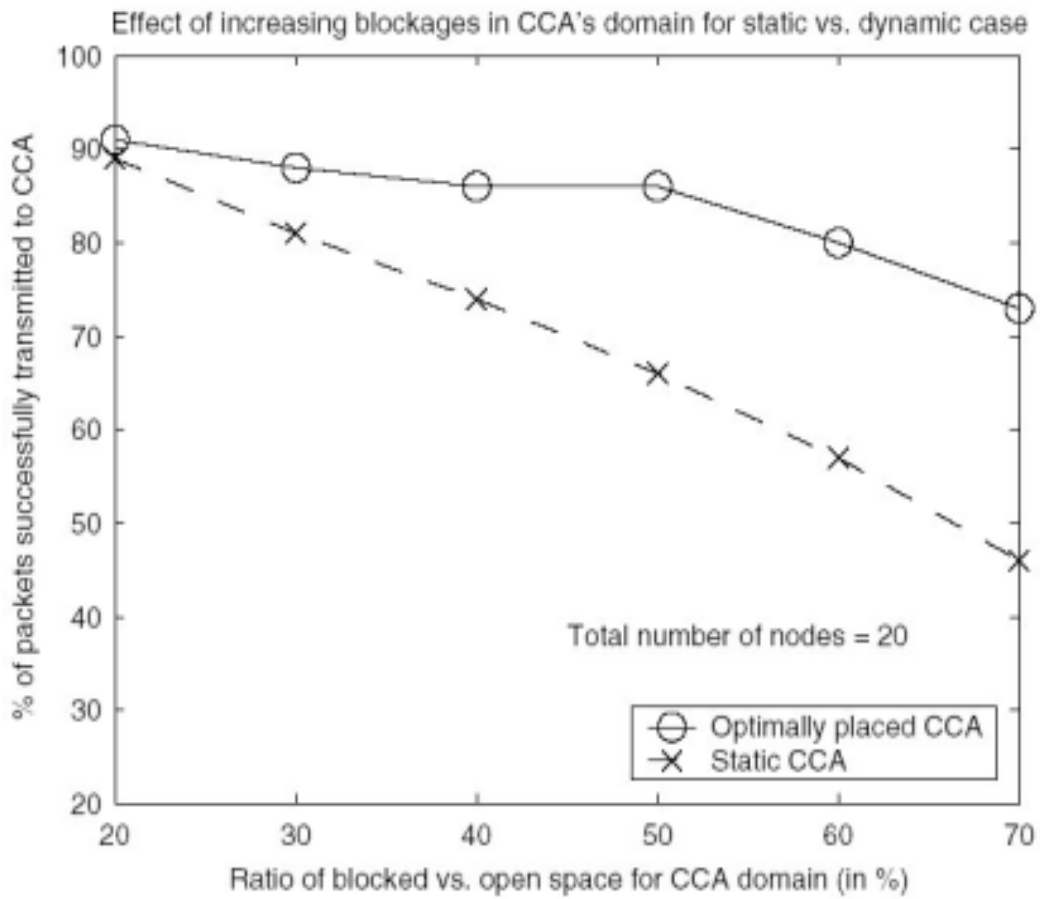
Computational Complexity

- MAC protocol, routing support and overhead
  - The overhead in this case is about the same as in discovering a specific node within a MANET.
  - The number of messages required is on the order of $O(n^2)$.
- Optimization Complexity
  - The worst case is on the order of $O(n^3)$.

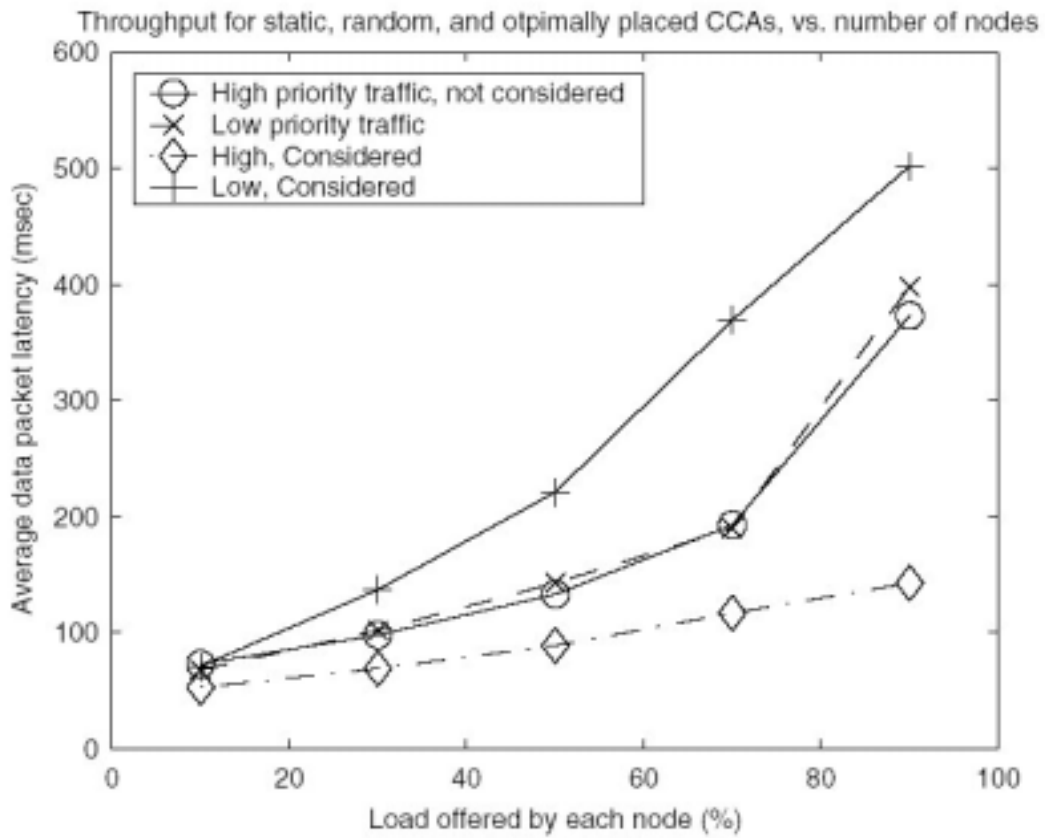
Comparison of Network Throughput with Optimally Placed CCA vs. Statically Placed or Randomly Moving CCA



Effect if Blockages on the Performance of the Static vs. Optimally Placed CCAs



Effect of Including the Effect of Priority in the Optimization Cost Function



Discussion

- Considering the case wherein multiple CCAs are present in a particular domain, where the nodes have the ability to choose different CCAs for relaying their inter-domain traffic.

- Is it practical in common Ad Hoc networks?
  - CCA election?
  - Access Point <-> Airborne or satellite node?
  - …

Conclusion

- The objective of this paper is to determine where the CCA is to be placed relative to the ad hoc group of nodes such that certain network performance metrics are optimized.

- One particular extension of interest is to consider the case wherein multiple CCAs are present in a particular domain, where the nodes have the ability to choose different CCAs for relaying their inter-domain traffic.

References

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