Theoretical Limits on Channel Assignment in Mobile Ad Hoc Networks

MidTerm Progress Report

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Outline

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Mobile Ad Hoc Networks

Definition (Ad Hoc Network)

A mobile ad hoc network is a peer to peer wireless network.

Features

- Distributed routing
- All links are wireless
- Dynamic links between peers

Issues

- Competition for resources
- Routing is specialized

Structured MANET

We can simplify these issues if we can simplify the network.

Goals

1. We minimize collisions between peers
2. We maximize network flow subject to (1)

Features

We impose a structure on the MANET such that

1. Links between Nodes are bidirectional
2. Links exist on a subset of possible links
3. Links are persistent, but not permanent
4. Nodes are connected

Creating a structured network of mobile, wireless nodes would improve the performance of ad hoc networks.[2]

Problems

Structured Wireless Networks are worth building

A major assumption of this research is that there is something to be gained by imposing a structure on an ad hoc network. Potential advantages include:

- improvements in battery life
- greater capacity

Problems

Initialization Problem

The wake-up problem confronts initialization of asynchronous nodes. That is, nodes in an ad-hoc network may wake up at different times. The initialization problem confronts joining nodes into a network in the absence of a global clock or an existing network structure.

Channel Assignment Problem

A general problem in Ad Hoc Networking. A network is channelized when it only exploits some subset of its possible connections in such a way as to minimize collisions between messages.

Representation of an Ad Hoc Network

Unit Disk Graphs

An ad hoc network can be modeled as a unit disk graph, that is, a graph
$G(V, E) | \forall e \in E, v_o, v_1 \in V, \exists e(v_0, v_1) \iff d(v_0, v_1) \leq 1$
where d is the euclidean distance from v_0 to v_1.

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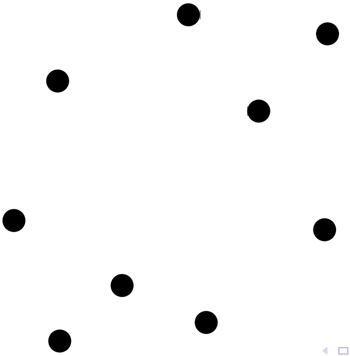

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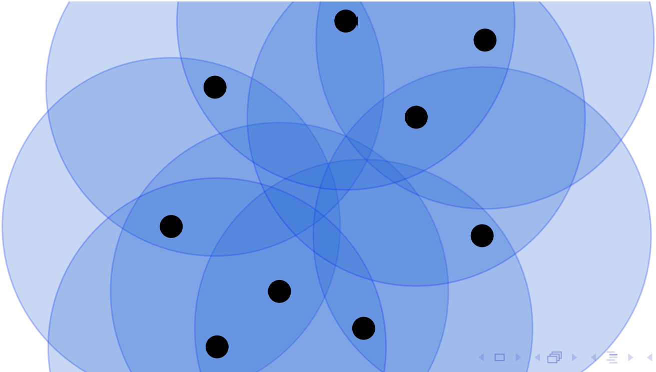

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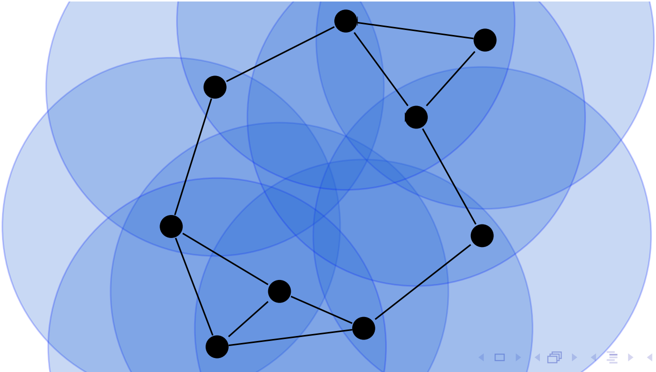


Operational Paradigms

This problem has been studied in several paradigms

- TDMA
- CDMA
- Multi-Radio Multihop (Mesh)

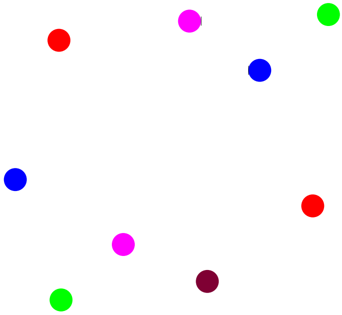
A paradigm agnostic analysis would be helpful

Resource Division & Vertex Coloring

Scheme

Resource Division is a general means of structuring an ad hoc network. In any RD scheme, nodes gain the right to utilize the resource.

- Each color represents a resource
  - resources are divided by color
  - conflict is avoided



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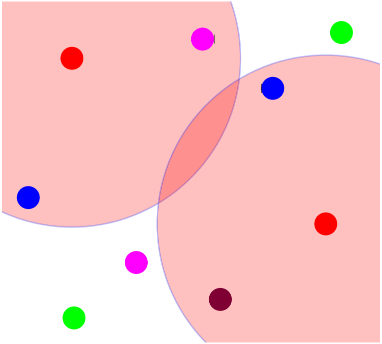

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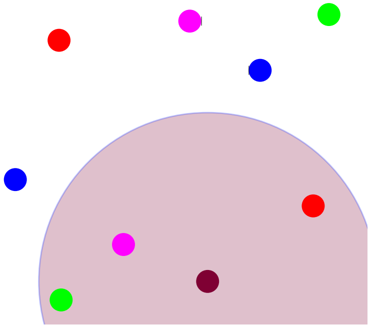

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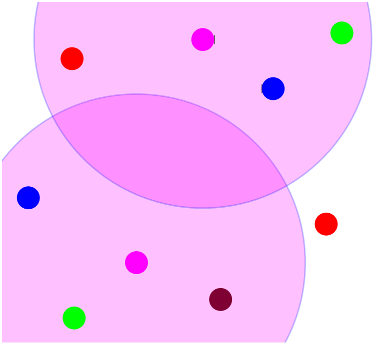

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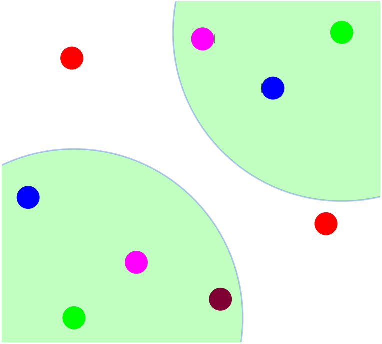

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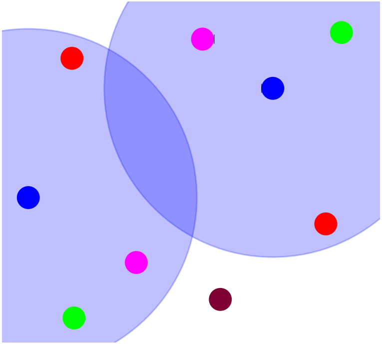

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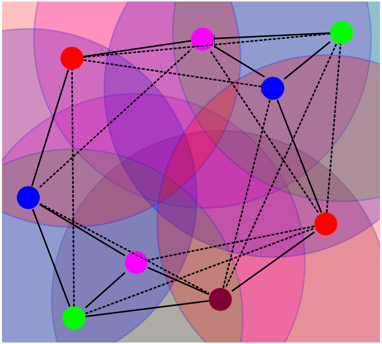
- Must color the square of the graph



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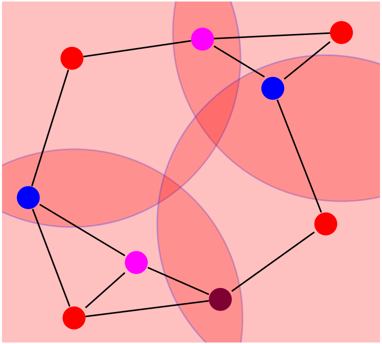
- Must color the square of the graph
- Standard coloring allows conflict



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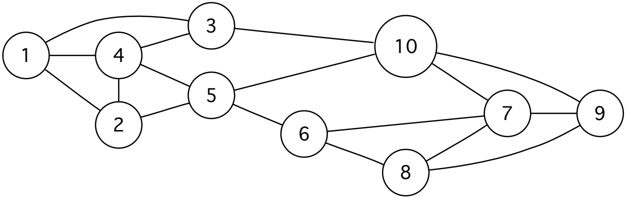
Prior Work

Avonts et. al[1] showed that this problem can be viewed as a graph coloring problem

- Unit Disk Graph $G(V, E)$
  Each network node is a vertex, and an edge exists if the nodes can communicate



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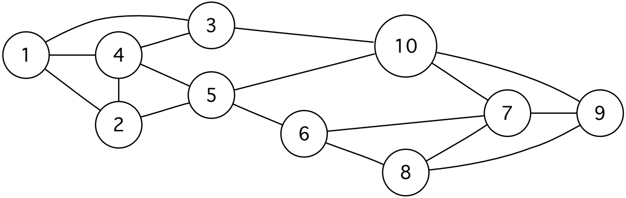

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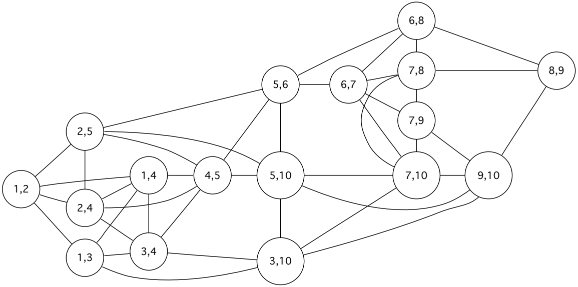
- Edge Conflict Graph $C(G)$
  Each vertex represents a potential communication link, and edge exists if two links share a common network node



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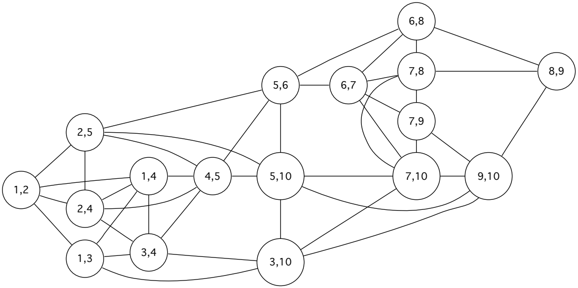

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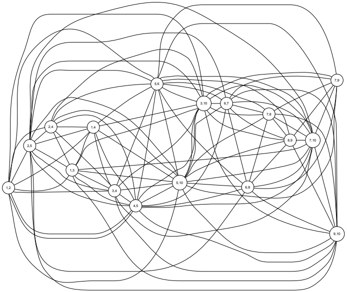
- Link Conflict Graph $C^2(G)$
  Add edges between links that share a common neighbor in $C(G)$



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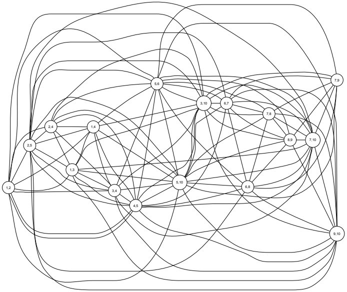

- To solve: a vertex coloring on some selection of ECG^2

Open Formal Questions

This problem has been defined, but a rigourous analyis of the relationship between Graph Density, Graph Magnitude, and the number of required colors has not been established.

1. Given a density, can we predict the number of resources needed to structuer the network?
2. Given some number of resources, can we predict the density and magnitude of the graph that can be colored
3. Can we predict the level of inevitable conflict, and does that inform our conflict resolution schemes?

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