Dynamic Networks: Robots, Agents, and Topology Manipulation

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Localized Movement Control for Fault Tolerance of Mobile Robot Networks
What is a mobile agent?

1. Special case of a general "software agent"
   - A piece of software
   - Autonomous
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2. Mobile agents are mobile: The code can migrate itself and portions of its execution state to other physical locations.
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Agency Overview

Figure: Agency Overview
Why use mobile agents?

Some commonly cited reasons to use the mobile-agent paradigm of computation: (from Wikipedia)

- Reduce network load: Processing on data may be done in place, rather than collecting data at a central location.
- Parallel processing: Multiple agents may cooperate operating on different hosts.
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- Exploration applications.
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Preliminary work done by Basu

- Proposed that in order to be fault tolerant, a robot network should be biconnected. In other words, the network should contain no cut vertices.
- Robot connectivity determined by limited communication range.
- Robots in a robot network may physically move to ensure a biconnected network.
- Cases presented by Basu include:
  - Linear contraction case.
  - Two dimensional contraction case.
  - Two dimensional block movement case.
Linear Contraction Case

Minimize

\[ D_{\text{total}} = \sum_{i=1}^{N} |x_i - p_i| \]  

With the following constraints:

\[ x_1 \geq p_1 \]  
\[ x_N \leq p_N \]  
\[ x_i - x_{i-1} \geq 0, \quad 2 \leq i \leq N \]  
\[ x_i - x_{i-2} \leq 1, \quad 3 \leq i \leq N \]
2-D Contraction Case

2-D analog of the linear case.

1. Calculate “center of mass” of all robots.

2. Each robot begins to move towards the center at a speed proportional to its distance from the center. Those that are farther away move faster and vise versa.
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1. Divide graph into a bipartite graph of blocks and cut vertices.
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Figure: Basu’s decomposition of a graph into a bipartite block tree.
Issues with Basu’s algorithms

- Requires global knowledge of network topology.
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p-hop neighbors

Figure: The 2-hop network of a certain node.
Critical Nodes

- If a node is a cut vertex within its p-hop subgraph, it is considered a critical node.
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Why is this algorithm cool?

- The algorithm is locally executed. It is a peer to peer algorithm, similar to early versions of Gnutella. There is no need for global topology knowledge.
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Leader Agent/Bot

**Figure:** Conceptual drawing of a leader bot “dragging” a biconnected robot network.
The End

Questions? Comments?
Thanks for your time!