How to Tame a Dynamic Network

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Workshop on the Foundations of Mobile Computing

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Goal For My (Speculative) Talk

To define and promote an emerging area (relevant to wireless) within distributed algorithm theory that seems promising...
Motivating Observation

Distributed computation must tolerate increasingly challenging network environments...
How to Tame a Dynamic Network

Overview

Motivation
How to Tame a Dynamic Network

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- Overview
- Motivation
What Makes These Settings Challenging

*Who* can communication and *when* becomes a question with uncertain and ever-shifting answers.
A Great Opportunity for Theorists

In recent years, many distributed algorithm theorists have begun studying provable properties in models that include this type of dynamic behavior.
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What I’m talking about today is a specific direction within this broader effort.
Introducing Dynamic Network Theory

Standard Approach to Studying Dynamic Models

Fix a model with dynamic behavior. Study problems in this model.
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Standard Approach to Studying Dynamic Models

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The Approach I’m Proposing (Dynamic Network Theory)*

Fix a problem then study the dynamic behavior under which the problem is solvable (efficiently).

* Of course, some existing work already (more or less) asks these questions. I am trying here to unify and clarify this direction...
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- **It enables deep theory.** The structure of dynamism and its connection to computation captures something fundamental and interesting...

- **It is expository.** In the natural and digital world simple things often work in seemingly chaotic settings: this theory can help explain why...

- **It has practical application.** The need for robust primitives will only increase...
In more detail...
In *dynamic network theory* we consider the synchronous execution of distributed algorithms in a network topology graph that changes from round to round. In this context...
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- a set of *communication rules* that maps graphs and transmission patterns to receive patterns.
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- a graph adversary that controls the dynamic topology graph, and
- a set of communication rules that maps graphs and transmission patterns to receive patterns.

A dynamic network type is a set of communication rules and a class of possible graph adversaries (capturing basic constraints of setting in question).
Using this modeling framework we can more formally state the goal of dynamic network theory as follows:

For a given dynamic network type and problem, which adversaries in the relevant class allow (efficient) solutions and which do not?
Many existing dynamic models can be captured in this framework allowing us to ask these types of questions...
Case Study: The Dual Graph Model

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How to Tame a Dynamic Network

Dynamic Network Theory Details

Case Study: The Dual Graph Model

\[ \text{Diagram showing nodes and connections with labels } m, m', \text{ and other nodes.} \]
The Dual Graph Model as Dynamic Network Type...

- **Communication Rules:** Standard radio network collisions.
- **Adversary Class:** Adversaries that must keep the same connected backbone in the graph during every round.
Some Results...
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- **Global Broadcast Depends on Adversary Knowledge.**
  
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Case Study: Interval Connected Dynamic Networks

The Interval Connected Dynamic Network Type...

- **Communication Rules:** Reliable broadcast to neighbors.
- **Adversary Class:** Adversaries must keep graph connected.
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Some open DNT-style questions...

- What are tight results for token aggregation as we consider other adversary strengths?

- Are there problems insensitive to adversary strength but sensitive to other adversary constraints?
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- Can we define universal *hierarchies* or *comparison* operators for comparing different adversary class subsets (e.g., my algorithm is more robust than your algorithm)?
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- For a given model type can we find universal bounds that apply to broad classes of problems (e.g., the oblivious divide)?
- Can we capture a useful notion of smoothing within this modeling framework?
- Can we define universal hierarchies or comparison operators for comparing different adversary class subsets (e.g., my algorithm is more robust than your algorithm)?
- Can we use this style of analysis to describe why certain practical or natural algorithms seem to work so robustly (e.g., basic token aggregation or ant alerts)?