Milestone 1: Paper Selection Proposal

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Paper Identification:
The Telephone k-Multicast Problem
Authors: Daniel Hathcock, Guy Kortsarz, and R. Ravi
Venue: Accepted in APPROX 2024
Source: arXiv:2410.01048

Problem Statement & Motivation:
In the Telephone Model, a root node must disseminate a message to a set of terminals in as few rounds as possible, with each informed node calling exactly one neighbor per round. This paper focuses on the *k-multicast variant* (reaching any k out of t terminals), which is highly relevant to applications like distributed databases and sensor networks, where not all nodes require simultaneous updates.

Key Contributions (Directed Graphs):

- **Low-Poise Tree Construction:** Builds a multicast tree minimizing "poise" (height + maximum node degree).
- **Greedy Decomposition:** Iteratively finds disjoint "good" trees covering about $\sqrt{k}$ terminals each, connecting them via shortest paths to achieve an additive $\tilde{O}(k^{1/2})$ approximation.
- **Set Cover with Matroid Constraints:** If the greedy phase is insufficient, the algorithm reframes coverage as a set cover problem under partition matroid constraints, leveraging submodular maximization to control degree and height.

Project Focus & Comparative Evaluation:

- **Implementation:** Recreate the directed solution, coding the greedy packing and matroid-constrained set cover components in Python (e.g., using NetworkX).
- **Comparison:** Adapt classic shortest-path algorithms (Bellman–Ford, Dijkstra) for multicast and compare round complexity, maximum node degree, and communication cost.
- **Testing:** Evaluate on synthetic and real-world directed graphs (where available).

Anticipated Challenges & Mitigation:

- Implementing the greedy decomposition and partition matroid set cover may be complex; starting with simplified versions and using clear pseudocode/flowcharts will reduce errors.

Justification & Expected Impact:

- **Relevance:** Central to distributed computing and synchronization tasks.
- **Novelty:** Combines greedy strategies with matroid-based set covering to approximate an optimal schedule.
- **Outcome:** A robust multicast algorithm that potentially outperforms standard shortest-path methods in directed networks.