Density-aware Random Clustering in Ad-hoc Networks

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Outline

- Introduction
- Contributions
- Related Works
- Design
- Results
- Future Works
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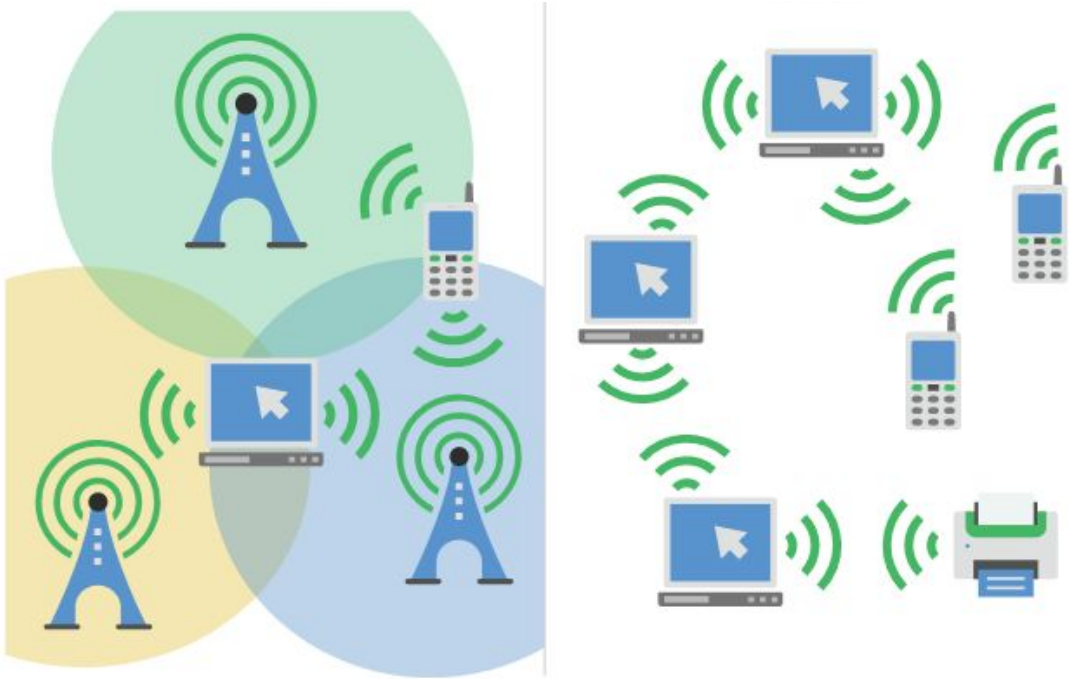
Introduction

- What is ad-hoc network?
- What are the differences between cellular networks and ad-hoc networks?
- What is clustering?

Ad-hoc Networks

- “Ad-hoc” from Latin and means “only for this”
- Peer-to-peer network (no centralized server) set up temporarily to meet some immediate need (Stallings, 2014)
- No infrastructure, “Chinese whispers” in communication
- MANETs, VANETs, SPANs, Army Tactical Ad-hoc Networks, Sensor Networks etc.

Cellular Networks vs Ad-hoc Networks



Cellular Networks vs Ad-hoc Networks

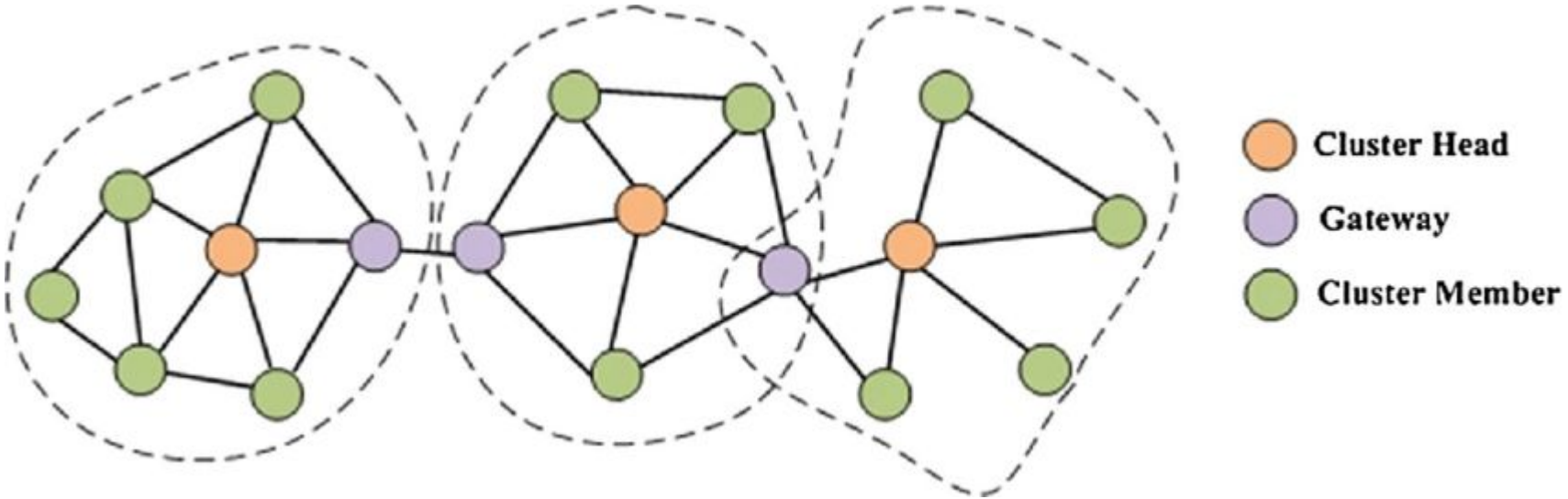
Cellular Networks	Ad-hoc Networks
• Fixed infrastructure • Single-hop links • Guaranteed bandwidth • Centralized routing • High cost and time of deployment • Easy synchronization • High cost of network maintenance	• Infrastructure-less • Multi-hop links • Shared radio channel • Distributed routing • Quick and cost-effective deployment • Bandwidth-required synchronization • Self-organized networks

(Manoj, 2004)

Clustering

- Grouping of nodes based on some common properties to achieve scalability and distributed management
- Nodes have special roles such that cluster head, border-gateway or cluster-gateway etc.
- Rearrange link scheduling, routing and resource allocation
- Creates centrality illusion for local groups with self-organization
- “How” to consider “which” properties and “how often”
- End-to-end PDR, stability, convergence, bandwidth usage etc.

Clustering



Contribution

- Resource and bandwidth efficiency in both number of packets and size of data
- Simple implementation
- Low-cost backbone-routing technique (which is not presented)

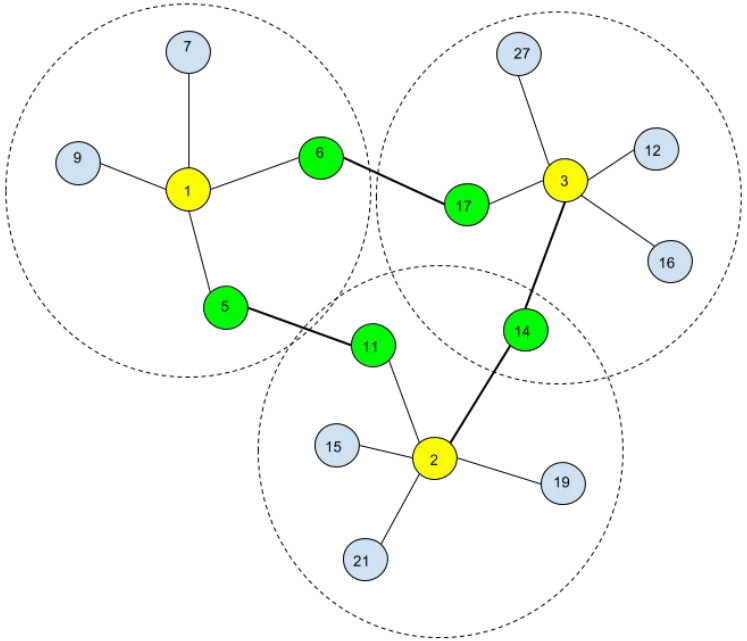
Related Work

- Khamiss et al. introduce a density- aware and energy-efficient clustering algorithm for sensor networks.
- The nodes with less distance from its neighbors are more likely to be selected as cluster head and higher-energy nodes have also more chance to be cluster head.
- In small areas with high number of nodes could be efficient, hard to adapt to larger areas where fewer number of nodes are deployed.

Related Work

- Younis and Fahmy propose Hybrid Energy-efficient Distributed Clustering (HEED) that is also a probabilistic clustering algorithm based on nodes energy.
- A node claims itself as a cluster head with a probability p where p is proportional to node's current energy, or battery power. After a number of iterations clusters become mostly structured.
- Requires extra effort to guarantee nodes with highest energy become cluster head in case of conflicts between nodes.

Related Work



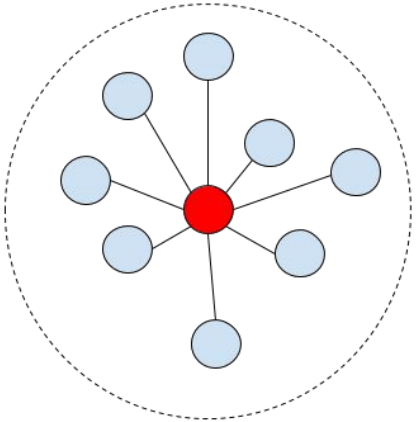
- Lin and Gerla present a simple clustering algorithm that uses node identifiers to determine cluster heads.
- Each node periodically broadcasts its unique identifier.
- The node with the lowest identifier is selected as a cluster head (marked as yellow) and nodes connected to other clusters are gateways (marked as green).
- Consensus for cluster head selection still causes a considerable packet traffic.

Design

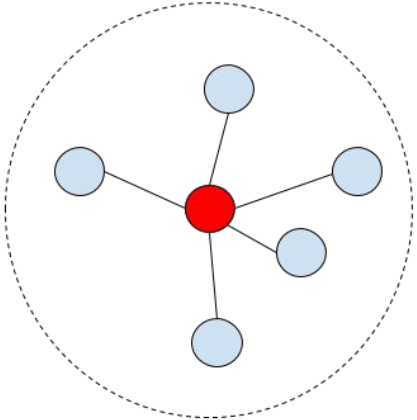
- **Idea:** Instead of identifiers, local density is probabilistically determinative for cluster head selection.
- ג is the overall density and d is the communication range.
- k is the design parameter.

$$p_k^* = \frac{k}{d_c^2 \pi \lambda}.$$

Design: Deciding probability



p = 1 / 8 = 12,5%



p = 1 / 5 = 20%

- The more degree, the less probability for being cluster-head
- Nodes in sparse areas are more probably cluster heads

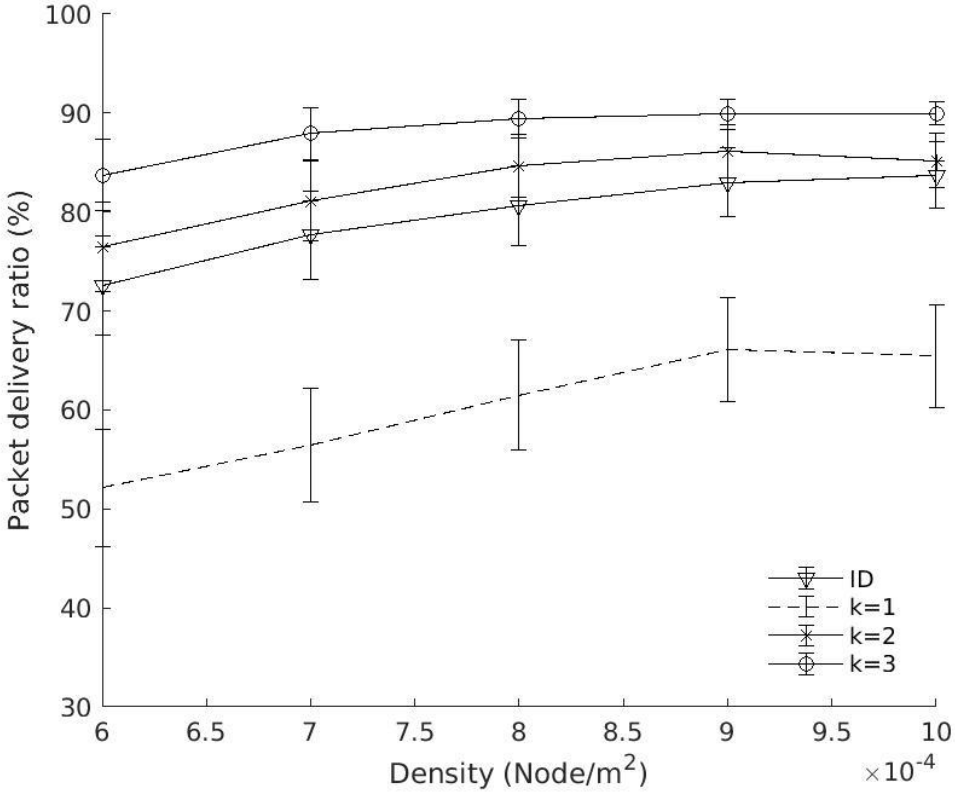
Design: Control overhead

ID-based clustering	Probabilistic clustering
• Initially, each node broadcasts its identity. • All nodes share their IDs and roles. • Both ordinary nodes and cluster-heads can change roles and cluster. Each role change triggers changes in clusters.	• Initially, each node shares MAC frames for a period. • Only self-chosen cluster-heads shares their IDs and roles. • Only ordinary nodes change their cluster (joining to cluster with the lowest ID).

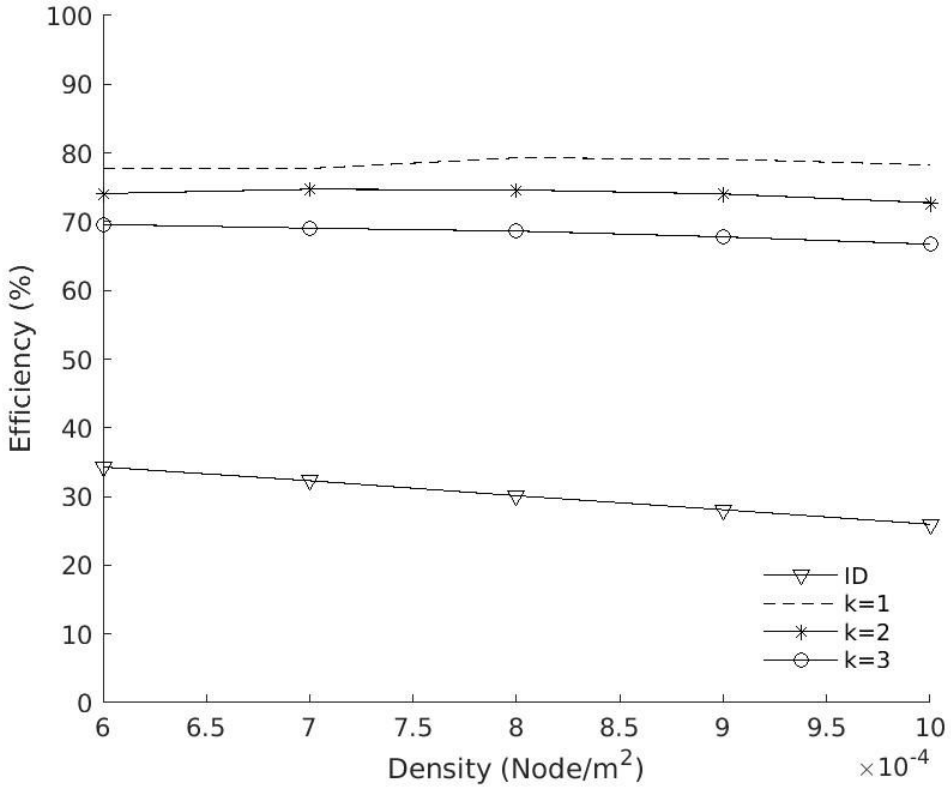
Results

- “PDR” and “Efficiency” measured in static and dynamic topologies
- Compared with known least-cost clustering algorithm, Identifier-based Clustering Algorithm (ICA) by Gerla
- Efficiency = (Data bytes) / (Data bytes + Clustering control bytes)
- Node density and k are control parameters
- Random Waypoint Mobility as a mobility model
- Event-based simulator OMNeT++

Results


100
90
80
70
60
50
40
30
Packet delivery ratio (%)
6
6.5
7
7.5
8
8.5
9
9.5
10
Density (Node/m^2)
$\times 10^{-4}$
ID
k=1
k=2
k=3

Results


100
90
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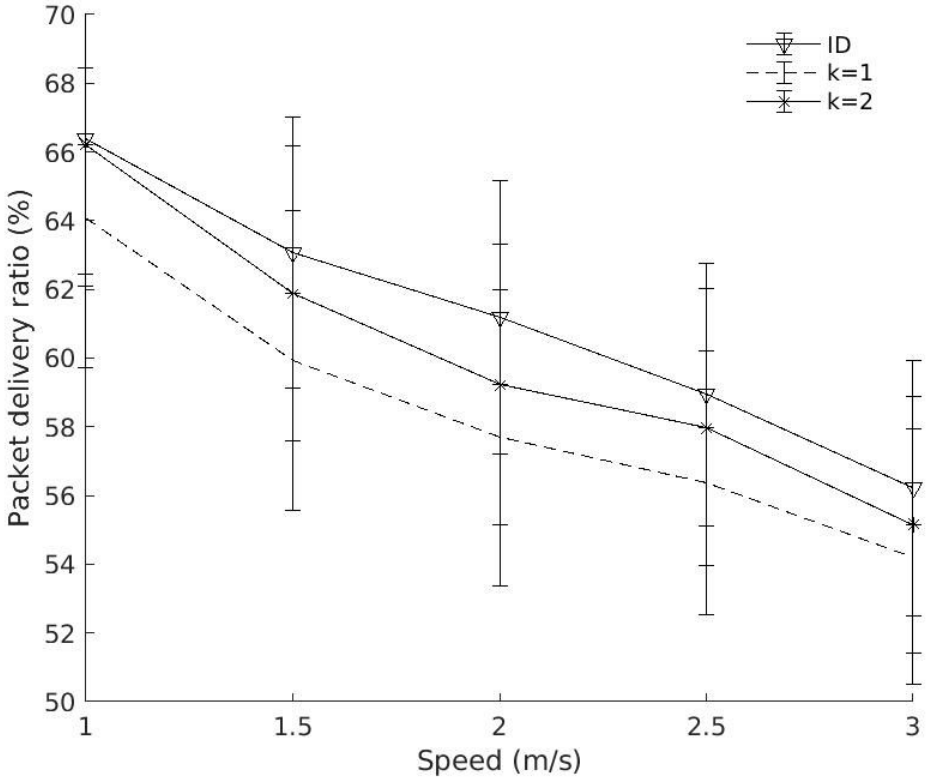
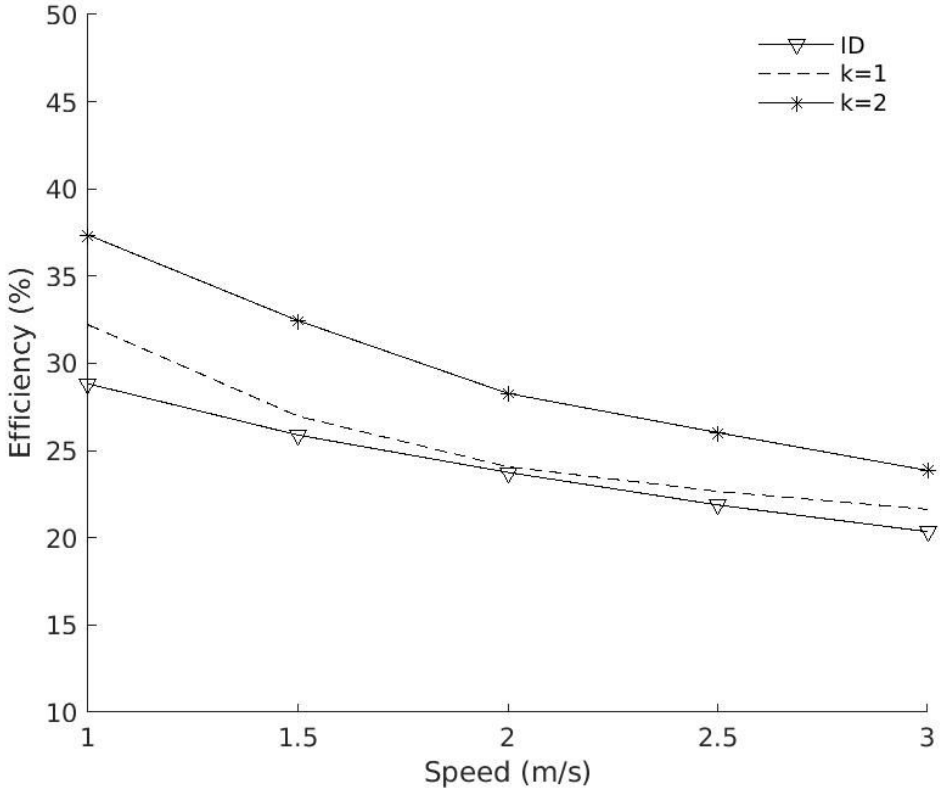

70
68
66
64
62
60
58
56
54
52
50
Packet delivery ratio (%)
1
1.5
2
2.5
3
Speed (m/s)
ID
k=1
k=2

Results



Future Works

- Performance evaluations with different mobility models
- Complete hybrid fish-eye routing
- Comparison with the newest algorithms

References

- Stallings, W. (2014). Wireless communications and networks. Pearson.
- Murthy, C. S., & Manoj, B. S. (2004). Ad Hoc wireless networks: architectures and protocols. Upper Saddle River, NJ: Prentice Hall/PTR.
- A. A. Khamiss, S. Chai, B. Zhang, J. Luan, and Q. Li, “An energy- efficient and density -aware clustering for wsns,” in Proceedings of the 33rd Chinese Control Conference, July 2014, pp. 377–382.
- C. R. Lin and M. Gerla, “Adaptive clustering for mobile wireless networks,” IEEE Journal on Selected Areas in Communications, vol. 15, no. 7, pp. 1265–1275, 1997.
- O. Younis and S. Fahmy, “Distributed clustering in ad-hoc sensor networks: a hybrid, energy-efficient approach,” in IEEE INFOCOM 2004, vol. 1, March 2004, p. 640.

Thank You

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