CLDP: A Robust Planarization Algorithm for Geographic Routing in Wireless Networks

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http://enl.usc.edu/projs/gpsr

Introduction

Components of geographic routing
- Greedy forwarding on a radio full graph
- Face (Perimeter) forwarding on a planar sub-graph
- Graph planarization to generate a connected planar sub-graph

Assumptions that can't hold in real world
1. Unit-Disk Graphs
   - A node can hear all other nodes within a fixed radio range
   - Radio-opaque obstacles
   - Multi-path interference
   - Non-circular antenna emissions
   - Heterogeneous transmission power
2. Perfect localizations
   - Error-prone localization algorithms

Problem Description: GG Planarization In Practice and Its Pathologies

Wireless network graph (R_n) from Berkeley SodaHall test-bed

GG sub-graph from R_n

GG (Gabriel Graph)
\[ d(u,v) \leq \min\{d(u,w), d(v,w)\} \]

RNG (Relative Neighborhood Graph)
\[ d(u,v) \leq \frac{1}{2} (d(u,w) + d(v,w)) \]

Radio graph

GG sub-graph

Result:
68.2% routing success between all node pairs due to those pathologies

Claim:
“Graph planarizations can’t generate a connected planar sub-graph from a given wireless graph in practice”

Simulations on TOSSim
- 200 nodes are randomly deployed in 2-dimensional space
- Executes on 1200 radio graphs with obstacles and 200 random graphs
- Compares routing success rate of four algorithms:
  [1] GPSR’GG := Greedy + Perimeter + GG Planarization
  [2] GPSR’NPPLAN := Greedy + Perimeter

Experiments on Berkeley and Intel test-beds
- 100% routing success on both test-beds
- CLDP is immune to all pathologies

Proposed Solution: CLDP (Cross-Links Detection Protocol)

Basic idea
Each node probes its links to determine its link-crossing

Key features
1. Completely distributed protocol
   - it runs on all “links” in a network
2. Can prove that, when CLDP executes on any arbitrary graph, face traversal never fails on the resulting sub-graph

Avoiding partitions
1. keep a link if the probe returns on the link it was sent out on
2. can leave cross-links in the sub-graph, but our proof shows that face traversal cannot fail on the sub-graph

Avoiding race conditions
- Caused by concurrent CLDP probes
- Solution: lazy locking mechanism

Implementation on Micas

Mutual witness is better and still not perfect
- Leave some cross links in sub-graphs
- Convert unidirectional/disconnected links into cross links
- Create collinear links causing failures of the right-hand rule