A Platform for Comparing CDS Discovering Algorithms

M.S. PROJECT REPORT
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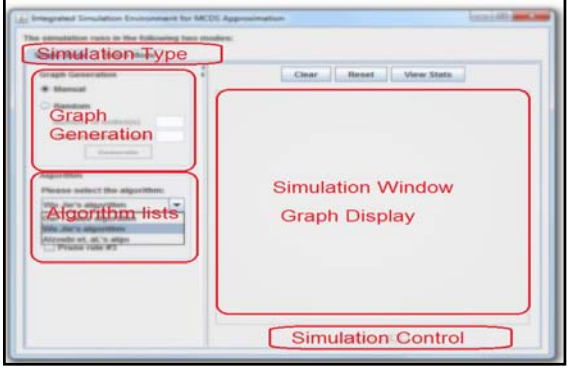
Outline

- Problem and Goal
  - Develop a platform for CDS algorithms comparison
- Background
  - DS, CDS, MCDS
- Three Algorithms
- Design Guidelines
  - OS-independent, MVC, OO design
- Design Architecture
  - Packages, UML
- Demo
- Conclusion

Problem

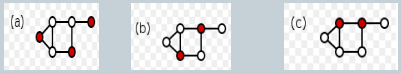
- Connected Dominating Sets (CDS)
  - Important in many applications, e.g., wireless sensor network
- Too many existing algorithms
  - Famous ones: Alzoubi's, Wu Jie's, R-value (Dr. Li's group)
  - Hard to compare their performances as they are implemented in different platforms and languages
- Question:
  - How to provide a research facility to easily simulate, test, and compare various CDS algorithms?

Goal



Background

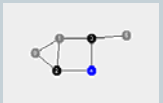
- Dominating sets:
- A **dominating set** for a graph $G = (V, E)$ is a subset D of V such that every vertex not in D is joined to at least one member of D by some edge.



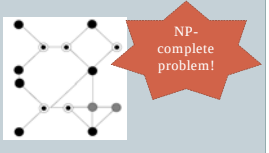
- Connected Dominating sets
  - A connected dominating set (CDS) is a subset of the nodes such that it forms a DS and all the nodes in the DS are connected.

Background

- Minimum Connected Dominating sets
  - A **minimum connected dominating set** (MCDS) of a graph G is a CDS with the smallest number of nodes.



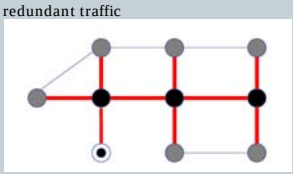
CDS



MCDS

Background

- One example of CDS application
  - CDS is used as a virtual backbone in wireless networks.
  - Network broadcasting:
    - Only nodes in CDS relay messages
    - Reduce communication cost
    - Reduce redundant traffic



Three MCDS Algorithms

- Alzoubi et al. Algorithm
- Wu's Algorithm
- Our R-value Algorithm

Alzoubi's Algorithm

1. Construct a spanning tree

- Assign level 0 to root node v
- Propagate message and assign level for each node

2. Find MIS nodes in even levels

- **Mark nodes to black based on its rank, others are gray**
- **Rank priority:<level1, id1>**

3. Find connectors in odd levels to form a CDS

- A connector should connect to 2 unconnected black nodes, mark as **blue**
- All **black** and **blue** nodes are **dominators**

Wujie's Algorithm

Open neighbor set N(v), close neighbor set N[v]

1. Marking process

- All nodes are initially white
- Check each node v: if two neighbors of v are unconnected, mark v **black**
- All **black** nodes form a CDS

2. Pruning process

- **If u, v are black, and N[v]⊂N[u], unmark v**
- **If u, v, w are black, and N[v] ⊆N[u]∪N[u], unmark v**

r-CDS algorithm

Definition of r-value and deg

- **r(u) = number of 2-hop neighbors – d(u)**
- **deg(u) = number of white neighbors**
- **Rank priority is triplet <r1, deg1, id1>**

1. Marking step:

- Check each node v, mark it **black** if it has lowest rank among neighbors
- Mark black node's neighbors grey

2. Connecting step – find connectors to form CDS

- Mark a grey node **black** if it connects 2 unconnected black nodes
- Mark two grey nodes **black** if they together connects 2 unconnected black nodes

r-CDS algorithm

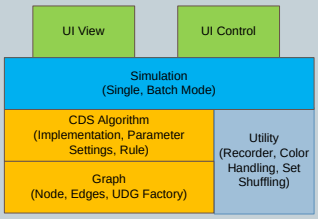
3. Pruning step

- **For two black nodes u, v, mark u grey if**
  - **N[u] ⊂ N[v] or**
  - **N[u] = N[v] and id(u) < id(v)**
- **Mark u grey if u has 2 black neighbors v, w, such that:**
  - **N(u) ⊂ N(v) ∪ N(w) – {u} or**
  - **N(u) –{v, w} = N(v) ∪ N(w) – {u, v, w}, and id(u) is minimum**
- **Mark u grey if u has 3 black neighbors x, y, z, such that:**
  - **N(u) ⊂ N(x) ∪ N(y) ∪ N(z) – {u} or**
  - **N(u) –{x, y, z} = N(x) ∪ N(y) ∪ N(z) – {x, y, z}, and id(u) is minimum**

Design Requirements

- Graph Generation
  - Manual graph construction
  - Automatic graph construction
- Algorithm
  - Implementation (initially 3 algorithms)
  - Parameter specification
- Simulation
  - Step mode simulation
  - Simulation control: forward/pause/stop
- Graph Control
  - Graph Display/Refresh/Clear

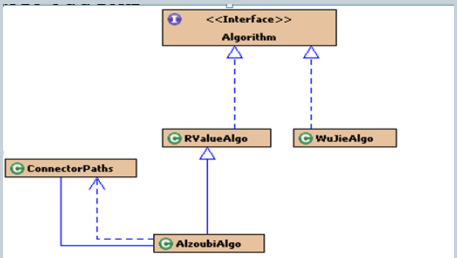
Design Architecture



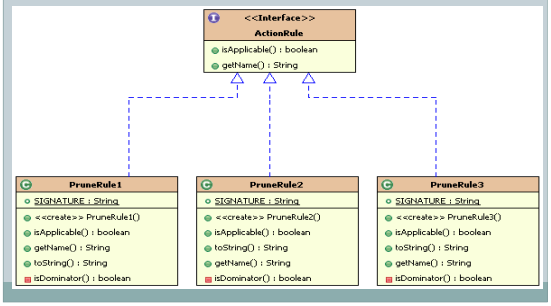
Package Information

- package: algo
  - Implementation of algorithms, and threads for batch runs
- package: algo.rule
  - Implement the Rune pruning for Wu's algo
- package: model
  - Implement node, edge, graph, random graph generator
- package: ui
  - View and control Swing components
  - AlgoPanel, GraphPanel, ...
- package: util
  - Recorder, BatchJobThread, ColorHandler, ElementSet, CurveDataWriter

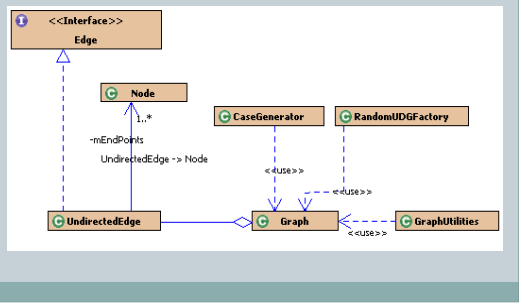
UML Diagram (algo)



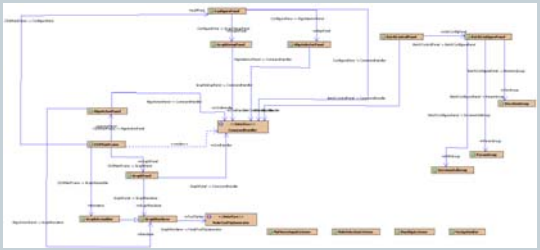
UML Diagram (algo.rule)



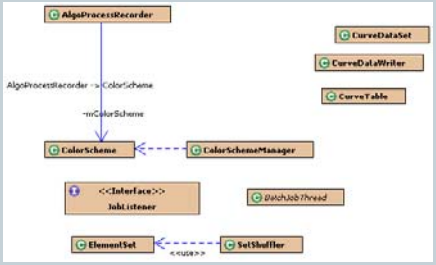
UML Diagram (model)



UML Diagram (ui)

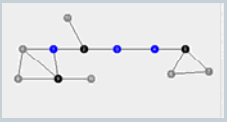


UML Diagram (util)

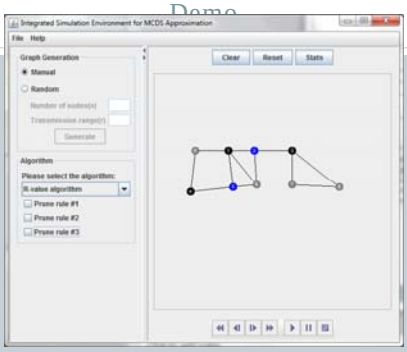


Alzoubi's Algorithm Demo

Demo



Demo



Conclusion

- Goal reached: the platform for research on CDS algorithms has been established
- OO design and MVC architecture has made the platform very robust and extensible
- Good design patterns provide a solid foundation for software development
- Future works: continue adding new CDS algorithms

Thanks for your attention!