

# Research Proposal:

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## 1 Introduction

Experts believe that clandestine organizations such as terrorist networks are heavily dependent upon a well hidden leadership. Since a member's visibility correlates with the quantity of information passing through that individual, Martonosi and Altner proposed that removal of other, more accessible members of such a network can force more information to flow through a key vertex of interest, causing it to become more visible [4].

We represent the clandestine network as a simple graph with vertices representing organization members, and we quantify the notion of visibility due to communication passing through a vertex as follows.

Given a key vertex  $k$ , let  $e_{ij}(G)$  be the minimum cut between vertices  $i$  and  $j$  in graph  $G$ , let

$$E_k(G) = \sum_{i < j \in V \setminus \{k\}} e_{ij}(G)$$

be the sum of minimum cuts between all pairs of vertices in  $G$  excluding  $k$ , and let  $G' = G \setminus \{k\}$  be the subgraph induced by  $V \setminus \{k\}$ . We define the *load* of  $k$  to be

$$L(k) = E_k(G) - E_k(G')$$

In order to brute force the search for vertices which increase  $k$ 's load, one must compute the change in  $L(k)$  between  $G$  and  $G \setminus \{v\}$  for each of  $|V| - 1$  vertices. In addition, computing  $L(k)$  on a graph  $G$  requires an all-pairs minimum cut operation on  $G$  and  $G \setminus \{k\}$ . Thus, the brute force process may become more computationally feasible if we can quickly determine how the all-pairs minimum cuts of a graph change in response to vertex removal.

## 2 Proposed Research

In order to recompute a graph's all-pairs minimum cuts, we consider recomputing a graph's Gomory-Hu tree which is a weighted graph that concisely expresses all minimum cuts of a given graph [3]. The tree is made up of  $G$ 's vertex set and edges with weights corresponding to minimum cuts between

some pairs of vertices. Minimum cuts between non-adjacent vertex pairs  $u, v$  in  $T$  are obtained by the minimum edge weight among the edges in a unique  $u - v$  path.

I intend to work towards designing an algorithm which efficiently recomputes the Gomory-Hu tree of a graph in response to modifications such as vertex removal.

### 3 Prior Research

In [1] Altner demonstrated that reoptimization heuristics can improve the computational cost of performing a sequence of maximum flow operations.

A 2002 paper surveys methods of recomputing network centrality measures in response to modifications to a graph [2].

### References

- [1] D.S. Altner. Advancements on problems involving maximum flows. 2008.
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- [3] R.E. Gomory and T.C. Hu. Multi-terminal network flows. *Journal of the Society for Industrial and Applied Mathematics*, pages 551–570, 1961.
- [4] S.E. Martonosi and D.S. Altner. RUI: Collaborative Research: Algorithms for Threat Detection: Detecting Clandestine Members of Covert Networks. 2009.