Optimisation Techniques for Computer Science project proposal

Network Communities and Robust Spanning Trees

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Description

Mobile Ad hoc Networks (MANETs) are composed of mobile devices or nodes, providing communication interfaces like Wi-Fi and/or Bluetooth, which spontaneously communicate each other without any previous existing infrastructure. Those networks present an heterogenous and dynamically changing topology, conditioned by users mobility and radio-waves propagation physics[1].

In many of those networks, nodes appear to group in subgraphs where the density of internal connections is larger than the connection with the rest of the nodes, forming what is called a **community structure**[2]. Community structure detection is known to be an NP-hard problem[3].

As ad-hoc networks rely on node cooperation to operate, selfish nodes should be avoided, and communication should rely on a trusted subgraph to achieve a given quality of service level. This can be done using **spanning trees** for reliable communication. Such logical structures can be created using the DA-GRS algorithm[4].

Today, no analysis exists on the correlation of the trusted spanning tree structure created by DA-GRS and underlying topological properties like the presence of community structure in a given network. Those results can be valuable to consider spanning trees as an alternative to existing approaches to the community detection problem[5][6][7][8], or be used for more efficient spanning tree management in DA-GRS.

Objectives

- Study the relation between logical structures constructed by spanning trees algorithms (like DA-GRS) and topological network community structures. This analysis will be based on networks with well-known community structures and existing implementation of DA-GRS.

- Based on the previous analysis, metrics used to assess community detection algorithms (such as *modularity*), and the introduction of a cost function in DA-GRS, optimize the matching between community structures and trusted spanning tree construction.

References

[1] Ramin Hekmat. *Ad-hoc Networks: Fundamental Properties and Network Topologies*. Springer-Verlag New York, Inc., Secaucus, NJ, USA, 2006.

[2] M. Newman. Detecting community structure in networks. *The European Physical Journal B - Condensed Matter*, 38(2):321–330, March 2004.

[3] Brian Karrer, Elizaveta Levina, and M. E. J. Newman. Robustness of community structure in networks. *Physical Review E (Statistical, Nonlinear, and Soft Matter Physics)*, 77(4), 2008.

[4] Apivadee Piyatumrong, Pascal Bouvry, Frederic Guinand, and Kittichai Lavangnananda. Trusted spanning tree for delay tolerant manets. In *2008 IEEE/IFIP International Symposium on Trust, Security and Privacy for Pervasive Applications (TSP-08)*, volume 2, pages 293–299, December 2008.

[5] L. Danon, Díaz A. Guilera, J. Duch, and A. Arenas. Comparing community structure identification. *J Stat Mech*, P09008, 2005.

[6] Mursel Tasgin and Haluk Bingol. Community detection in complex networks using genetic algorithm, Apr 2006.

[7] M. E. J. Newman. Finding community structure in networks using the eigenvectors of matrices, May 2006.

[8] J. Duch and A. Arenas. Community detection in complex networks using extremal optimization. *Physical Review E*, 72:027104, 2005.

[9] Natali Gulbahce and Sune Lehmann. The art of community detection, Jul 2008.