Structural Network Properties for Local Planarization of Wireless Sensor Networks

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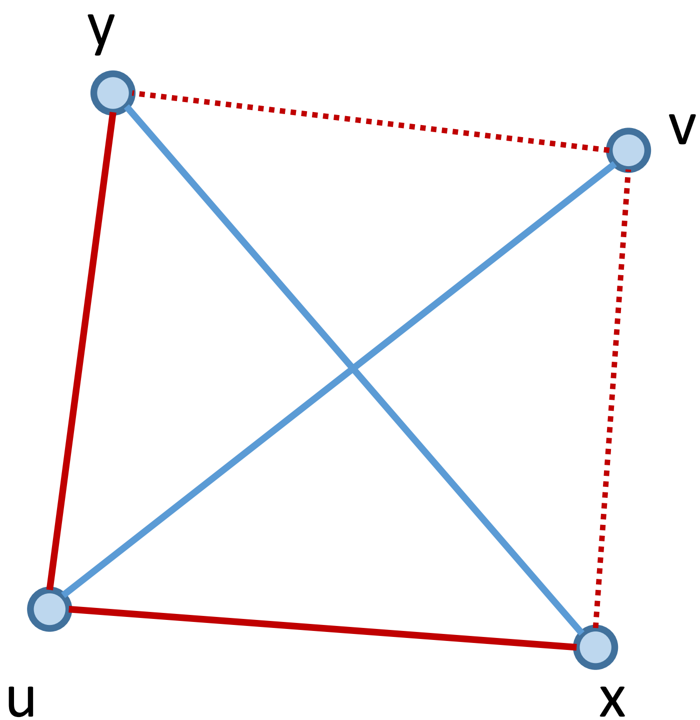
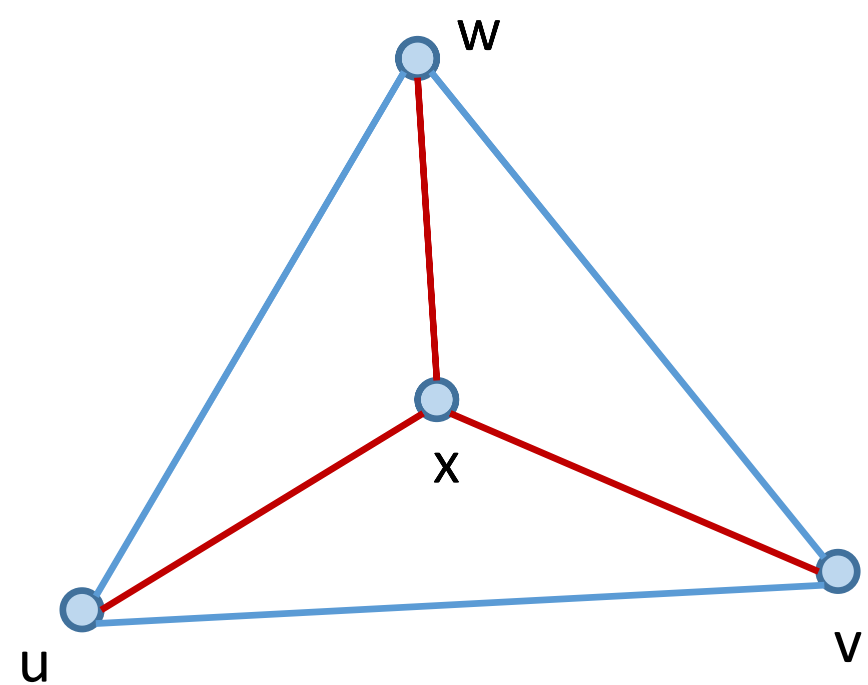
- Background: 2D geometric graphs and planarization
- Getting rid of circle geometry (unit disk graph models)
- Definition of graph properties (coexistence and redundancy)
- Evaluation of the properties on large graphs

Redundancy



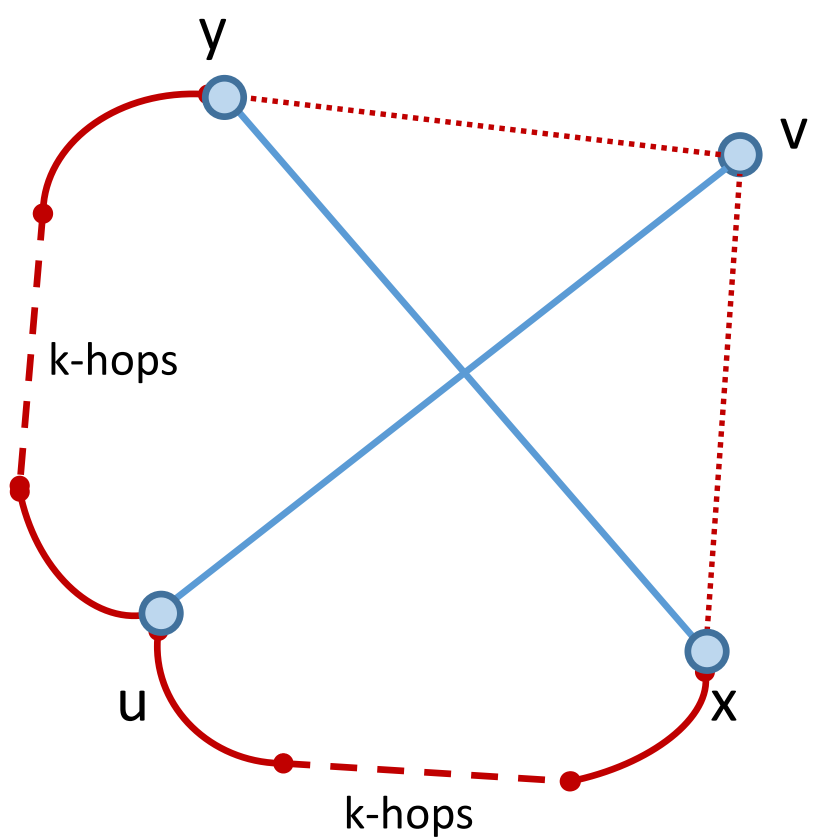
Coexistence



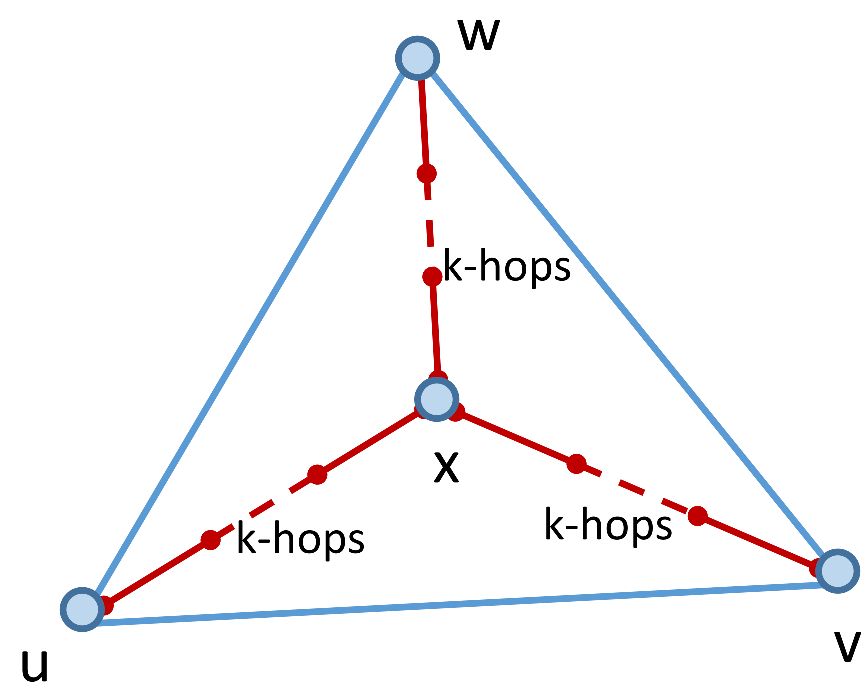
Defined in:

1. Mathews, E., Frey, H.: A Localized Link Removal and Addition based Planarization Algorithm. In: Proc. of the 13th ICDCN, Hong Kong, China (Jan 2012)

k-strong/k-weak redundancy



k-strong/k-weak coexistence



Properties of k-strong and k-weak coexistence and redundancy

- UDG satisfies 1-strong coexistence and redundancy properties [1,2]
- d-QUDG with $\mathrm{d} > 1/\sqrt{2}$ satisfies 1-weak coexistence and redundancy [3]
- In a connected graph with the diameter δ, the graph trivially fulfills δ-weak coexistence and redundancy properties

1. Gao, J., Guibas, L.J., Hershberger, J., Li, Z., Zhu, A.: Geometric Spanners for Routing in Mobile Networks. IEEE J. Sel. Areas Comm. (Jan 2005)
2. Mathews, E., Frey, H.: A Localized Link Removal and Addition based Planarization Algorithm. In: Proc. of the 13th ICDCN, Hong Kong, China (Jan 2012)
3. Kuhn, F., Wattenhofer, R., Zollinger, A.: Ad hoc networks beyond unit disk graphs. Wireless Networks 14(5), (Oct 2008)

What about the “real” networks?

- Large scale networks
  - CitySee Platform
- Generated graphs
  - Based on the log-normal shadowing model
- Clustering
  - 1-hop and 2-hop

Testbed results – CitySee platform

		Prop.	$k=1$	$k=2$	$k=3$	$k=4$	$k=5$	$k=6$	$k=7$	δ_{avg}	$\delta_{\max}$	#Events
CitySee	uncl.	k-w-red	0.55829	0.96406	0.99920	0.99983	0.99998	1.0	1.0	6.039	10	42310.3
		k-s-red	0.20119	0.86075	0.99750	0.99945	0.99990	0.99999	1.0			
		k-w-coe	0.64319	0.94977	0.99679	0.99931	1.0	1.0	1.0			3249.7
		k-s-coe	0.08831	0.74183	0.97082	0.99794	0.99931	1.0	1.0			
	1-hop	k-w-red	0.94352	0.99863	0.99991	1.0	1.0	1.0	1.0	4.086	8	9878.3
		k-s-red	0.72847	0.99650	0.99893	0.99992	1.0	1.0	1.0			
		k-w-coe	0.71016	0.99417	0.99973	1.0	1.0	1.0	1.0			4443.8
		k-s-coe	0.15149	0.90471	0.99863	0.99974	1.0	1.0	1.0			
	2-hop	k-w-red	0.99459	0.99985	1.0	1.0	1.0			2.983	5	153.7
		k-s-red	0.94208	0.99983	1.0	1.0	1.0					
		k-w-coe	0.80770	0.99991	1.0	1.0	1.0					113.4
		k-s-coe	0.19222	0.97859	1.0	1.0	1.0					

- Problem: neighborhood tables contain only 10 neighboring nodes

Generated graphs – Log normal shadowing

		Prop.	$k=1$	$k=2$	$k=3$	$k=4$	$k=5$	$k=6$	$k=7$	δ_{avg}	δ_{max}	#Events
LNS	uncl.	k-w-red	0.99998	1.0	1.0					48.821	55	13406.6
		k-s-red	0.97901	1.0	1.0							
		k-w-coe	1.0	1.0	1.0							3583.9
		k-s-coe	0.91705	1.0	1.0							
	1-hop	k-w-red	1.0	1.0	1.0					24.571	28	112.3
		k-s-red	0.99260	1.0	1.0							
		k-w-coe	1.0	1.0	1.0							37.1
		k-s-coe	0.74459	1.0	1.0							
	2-hop	k-w-red	1.0	1.0	1.0					15.661	19	30.4
		k-s-red	0.99633	1.0	1.0							
		k-w-coe	0.99881	1.0	1.0							14.0
		k-s-coe	0.65195	0.99881	1.0							

Conclusion

- 1-strong redundancy and coexistence are sufficient conditions for local planarization of geometric graphs
- Defined properties do exist in analyzed graphs

Future work

- Analysis of more data from real deployments and testbeds
- Development of planarization algorithms based on the defined properties

Thank you.
Questions?

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