

Network Theoretic Approaches for Wireless Systems

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MITRE Sponsored Research



Problem



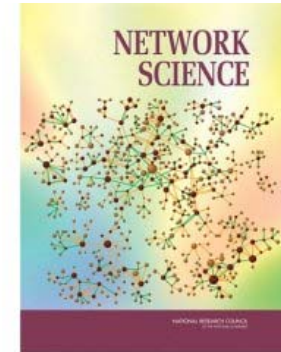
- **Wireless networks are a key enabler of net-centric operations**
- **Yet . . .**
 - **Behavior of complex wireless networks is not well understood.**
 - **Suitable design methodologies do not exist.**
 - **Ad hoc networking is still an open problem.**

“Far too little is understood about MANETs to predict how the system will operate under a wide range of circumstances. Essentially every aspect of MANETs is still an active research area; there is no settled lore.” (JASON Group Report JSR-05-135, “Army MANET”, 2006)

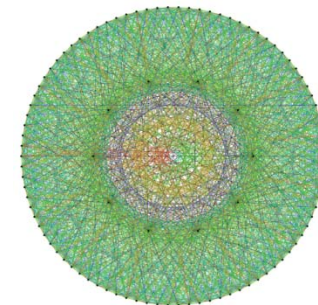
“Current military concepts of ‘net centrality’ are based on applications of computer and information technology that are far removed from likely results of basic research in network science” (Network Science Report, National Academy of Sciences, 2005)

Background

- **There is an increasing consensus that investments in network science R&D is needed to significantly improve the current state of mobile wireless network planning and design.**
- **This is a multi-disciplinary endeavor that includes classical network theoretic tools as well as network science tools from evolutionary biology and social networks.**
- **Research in this area needs to impact planning and design efforts, and tools.**



NAS Report on Network Science led to ARL CTA on Network Sciences



Hall-Janko Graph. Source: Claudio Rocchini

Objective



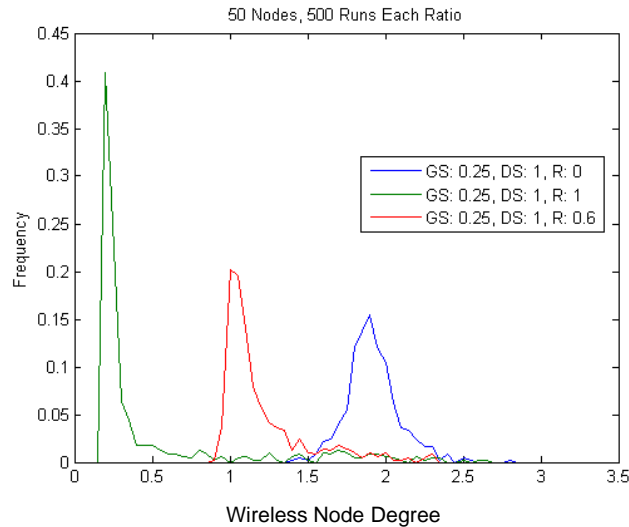
- **To develop a novel set of tools that:**
 - **Can be used to improve our theoretical understanding of wireless networks**
 - **Enable the discovery of fundamental behavioral relationships and guiding principles**
 - **Enable a new and innovative approach to wireless network planning and design.**

Activities



- Analyzed fixed wireless channels with a queue model
 - Publication: “Delay Analysis of Wireless Nakagami Fading Channels,” *IEEE Globecom 2008*
- Developed evolutionary model for fixed wireless networks
 - Publication: “An Evolutionary Model for the Study of Wireless Networks,” *IEEE International Conference on Wireless & Mobile Computing 2008*
- Creating an agent-based tool that incorporates:
 - Wireless environment attributes
 - Flexible mobility models
 - Independence from routing protocol selection
- Submitting conference papers on agent-based modeling approach for mobile wireless networks

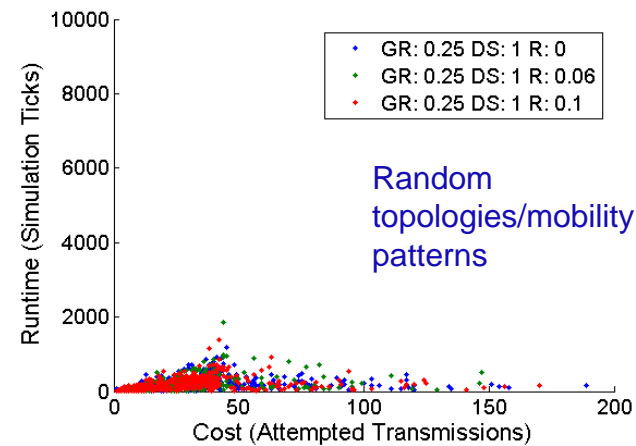
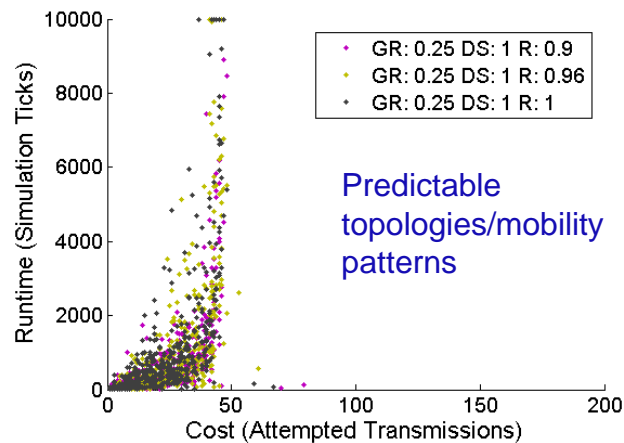
Highlight



Practical metrics are necessary, but elusive.

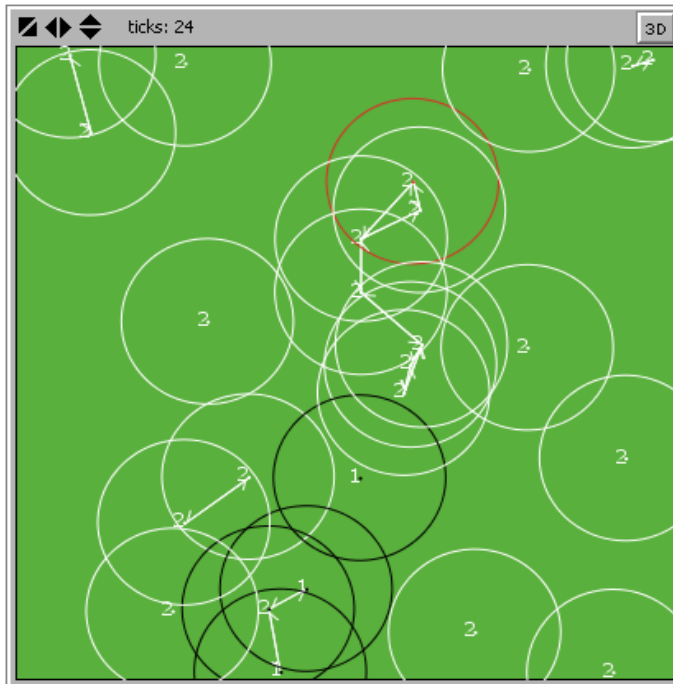
Node degree is a time-dependent process that denotes how well-connected a node is locally.

Topological predictability may not dictate performance.
Data model and topology must also be taken into account.

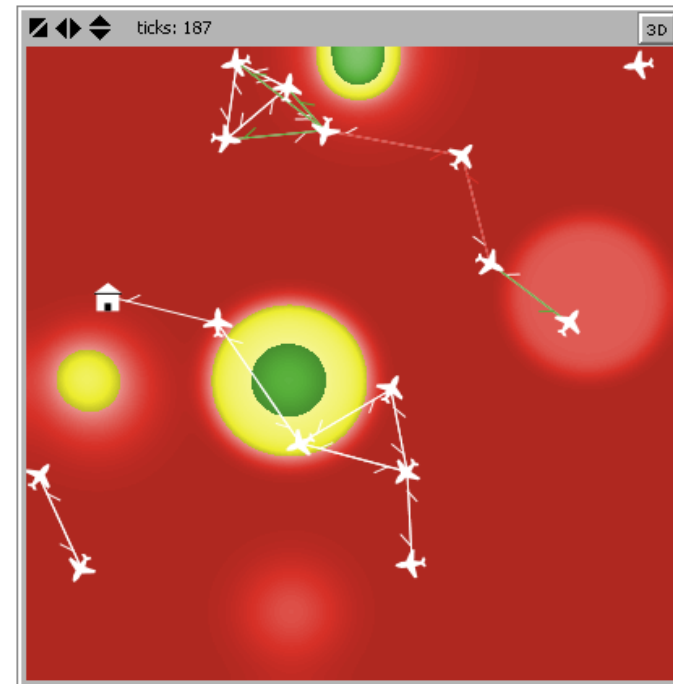


Demonstration

NetSci Planning and Design Tool



MANET scenario illustrates impact of local decision variables and mobility on network performance.



Target acquisition scenario illustrates applicability to sponsor problem space.

Impacts



- **Powerful network science methodology capable of quantifying achievable network performance and studying important tradeoffs**
- **Dissemination of results to scientific community via two conference proceedings and one conference presentation**
- **Development of agent-based modeling tool that provides an innovative strategy for network planning and design**
- **Tailored agent-based modeling simulation scenarios for customer use**
- **Opportunities for sponsor collaboration**

Future Plans

- Further refine and expand capabilities of the agent-based modeling engine
- Demonstrate NetSci planning and design tool prototype, and transition capability to sponsor
- Apply research results and NetSci toolset to the problem of Data-Centric (aka content oriented) network development

