The Institute for **Systems** Research

A Systems Engineering Approach to Wireless Network Design

Senni Perumal, Kiran Somasundaram, Punyaslok Purkayastha, Vahid Tabatabaee, John S. Baras
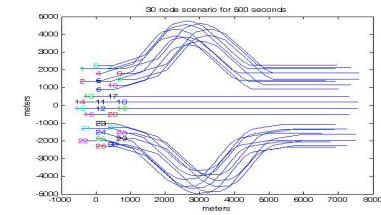
HyNet

Introduction:

- **Objective:** Analyze and design MANET with predictable performance for a baseline scenario so as to satisfy mission requirements
- **Problem:** Develop models that estimate the performance of a MANET fast -- design for predictable performance bounds (specifications)
- **Inputs:** network topology (could be time varying), neighbouring relations (channel conditions), traffic demand (source-destination pairs, data rates, number of paths)

Design and Analysis Framework:

- Our overarching goal is to develop a tool for design and analysis of wireless networks.

INPUTS:
- Node Paths
- Source-Destination Pairs and Offered Loads
- QoS Requirements
- Environment conditions

Baseline MISSION PLAN

MANET Design and Analysis Tool

OUTPUTS:
- Performance Metrics
  - Delay, Throughput, Packet loss
- Sensitivities
- Design Parameter Specification
  - Routing parameters, etc.

Approach:

- We define three sets of equations:
- **1-MAC & PHY:** loss parameters and service time of a link in terms of the incoming rate (throughput) of a link and its neighboring nodes
- **2-Scheduling:** node scheduling rate and throughput as a function of incoming rates and loss parameters
- **3-Routing:** loss parameters and scheduling rate of nodes to obtain the arrival rate of the next-hop nodes
- **Fixed point iterations:** equations coupled iteratively on entire network till convergence to find a consistent solution
- **Sensitivity analysis** and robust/optimal design using ADmaximize the total network throughput

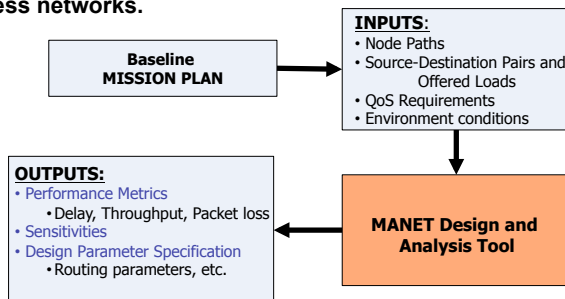## Sample Complex Scenarios (courtesy from AIMS Inc.)

Description:

- 30 ground nodes (3 groups with 10 nodes each) moving with speeds 22-60 mph for 500 seconds
- 2 Aerial Platforms (AP) will join the network to maintain connectivity
- 17 source-destination pairs: 12 intra-cluster loads of 100 Kbps (4 in each cluster); 5 inter-cluster loads between 20 and 100 Kbps.
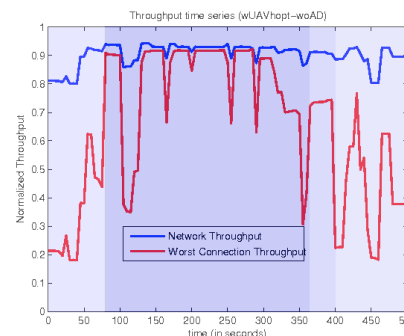
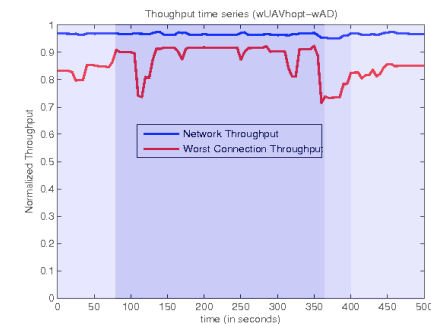30 node scenario for 500 seconds

Sample Throughput outputs (courtesy from AIMS Inc.)

Network and worst connection throughput with multiple-path routing
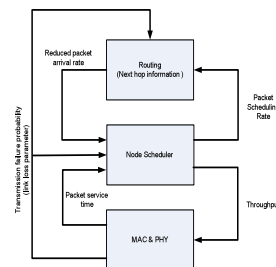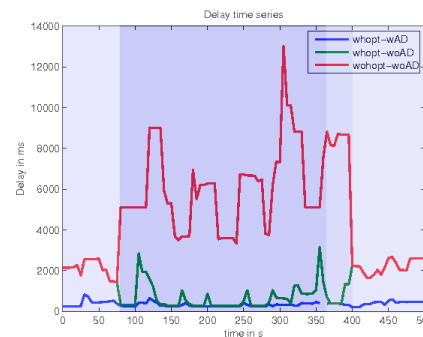
Equal routing probabilities

Optimal routing probabilities using AD

Expected delay

Network Throughput as a function of offered load