# Challenges in Modeling and Analysis

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# Sensor/Ad Hoc Networks Research

- Two key themes:

1. Discover the **design principles** for building efficient and adaptive wireless multi-hop data collection and aggregation networks that could scale to infinitely large number of nodes while remaining secure, flexible and fault tolerant.

2. Investigate the theoretical **limits** on how large (space) and for how long (time) can sensor networks grow while maintaining an acceptable performance.

# Tools Used

- probability theory
- queuing theory
- graph and network flow theory
- optimization theory
- analysis of algorithms
- information theory
- control theory

- simulation
- measurement
- heuristic design procedures

# Understanding Networks

**Modeling & Design**

- algorithm choice
- performance
- parameter setting

**Scaling Laws**

- transport capacity
- bounds on performance

**Simulation & Experimentation**

- Real life performance
- Cross-layer interactions
- Reality check?

# Scaling Laws

- What are the limits? Fundamental/Abstract/Across the board problems/questions…

- Scaling laws – capacity, connectivity..etc.

# Modeling Problems

- Design and Performance Evaluation of particular algorithms/schemes:
  - Data aggregation/routing
  - Joint data compression/transmission design
  - Target tracking
  - Topology/power control

- If you add 'mobility' and `communication scheme' (many to one vs. one to many)

# Modeling vs. Simulation/experimentation

- **Why invest in "Test-beds"?**
  - Any implementation is usually so complex and specific that it is not possible to extract meaningful dependencies!

- **Why do modeling?**
  - Any model is an imprecise, and probably distorted view of reality!

→Need both approaches

# Remaining Challenges

- Resource-Quality (rather than quality-quality) trade-offs

- Scaling laws of routing

- Mobility ("mobility increases capacity")

- Effect of traffic pattern

- Faithful modeling of wireless multiple access medium (what is a "link" in wireless?)

- Cross-layer models; MAC, routing, queuing & application

- Sensor networks: data transportation → distributed sensing and actuation

- Sensor applications
  - bps→Mbps (just like the early transition of the Internet to a Multimedia experience)
  - Prototypes: motes→ Motes

# In a nutshell

| System Design | $\leftarrow\rightarrow$ | Realistic models that extract **pervasive dependencies** |
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