ORBIT Radio Grid Emulator
Modeling & Scenario Creation

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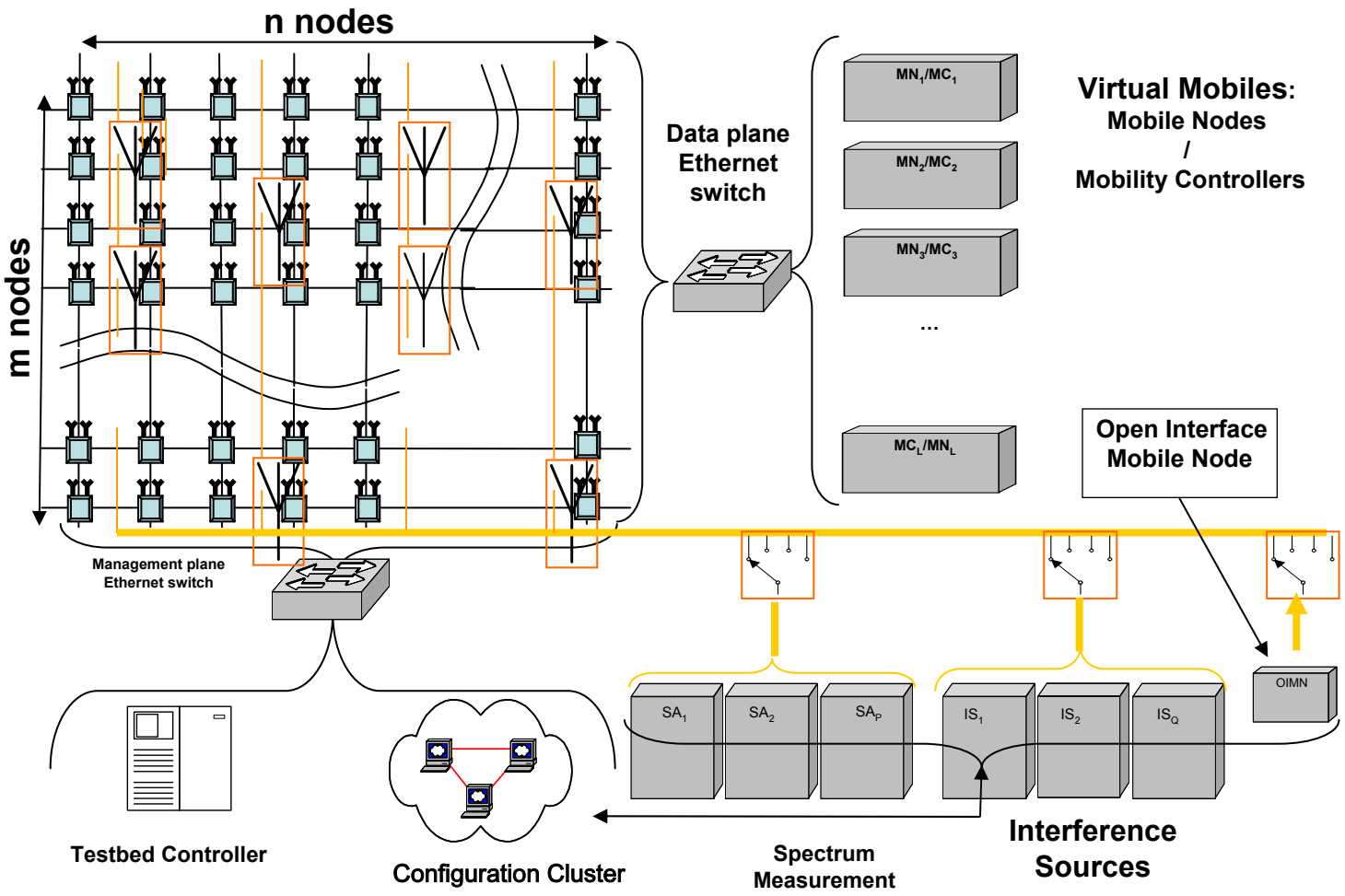
Some ORBIT Project Objectives

- Realistic Experiments
  - Real radios transmitting bits over the air
  - Real network nodes with full protocol stacks
- Repeatable Experiments
  - Requires repeatable wireless network topologies
  - ORBIT Approach: Radio Grid Testbed

ORBIT Radio Grid



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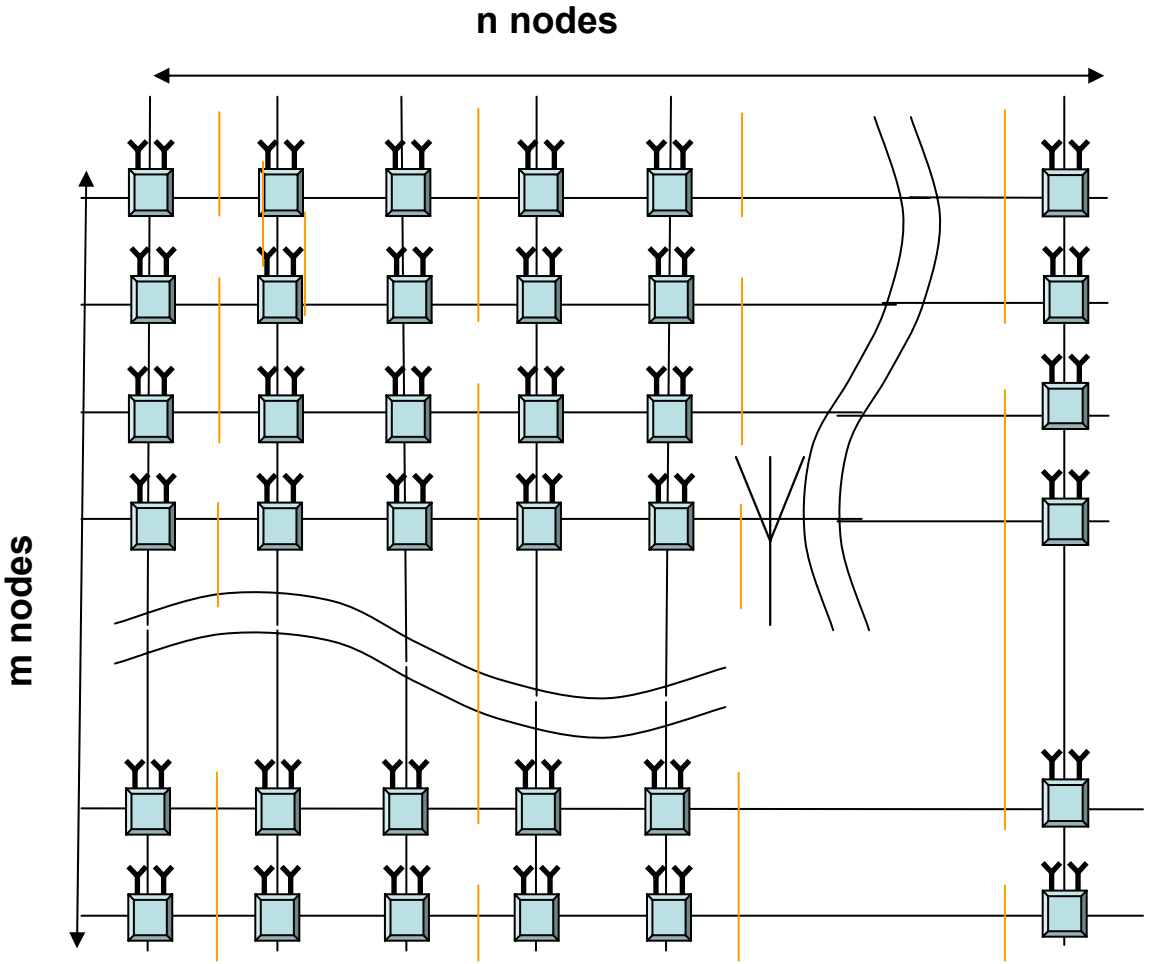
ORBIT Radio Grid



- The 400 node question:

  What network topologies are possible?

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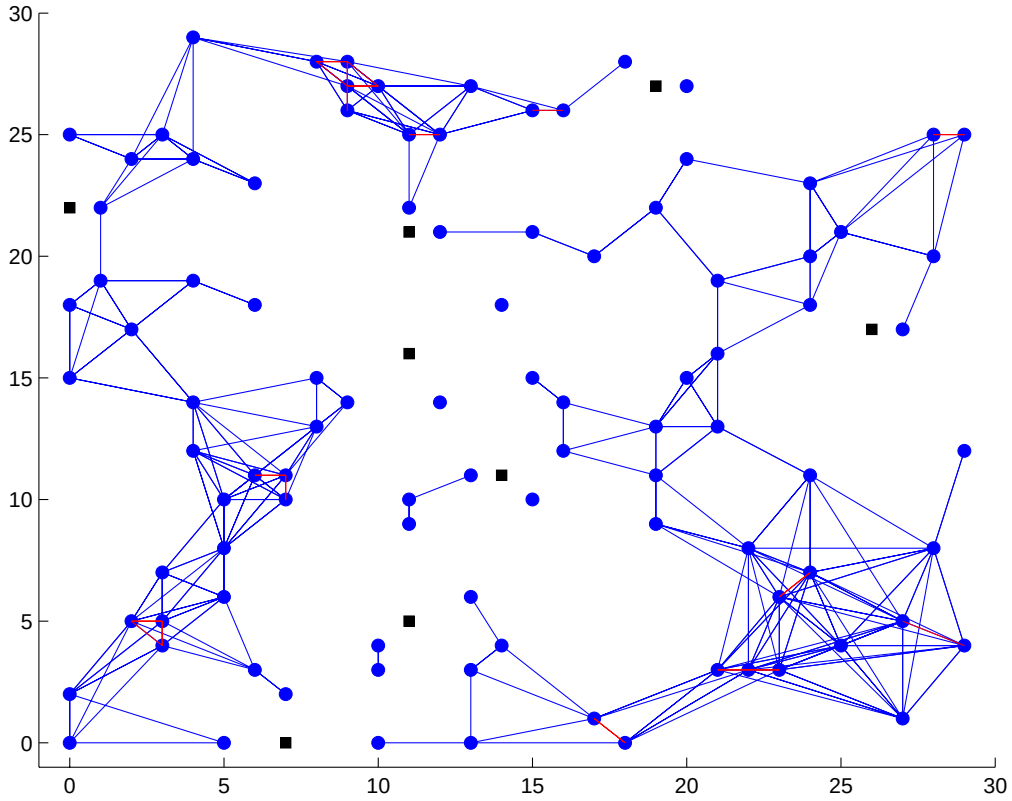
Sample Grid

- N x M Grid of Nodes
- Choose
  - a set of communicators
  - a set of noise interferers
  - node transmit powers
- Determine acceptable quality links
  - Based on receiver SNR > threshold
  - One at a time transmissions
- Graph the "topology" of acceptable links

Sample network (1)



- ● = Communicator
- ■ = Interferer
- _ = Acceptable Link

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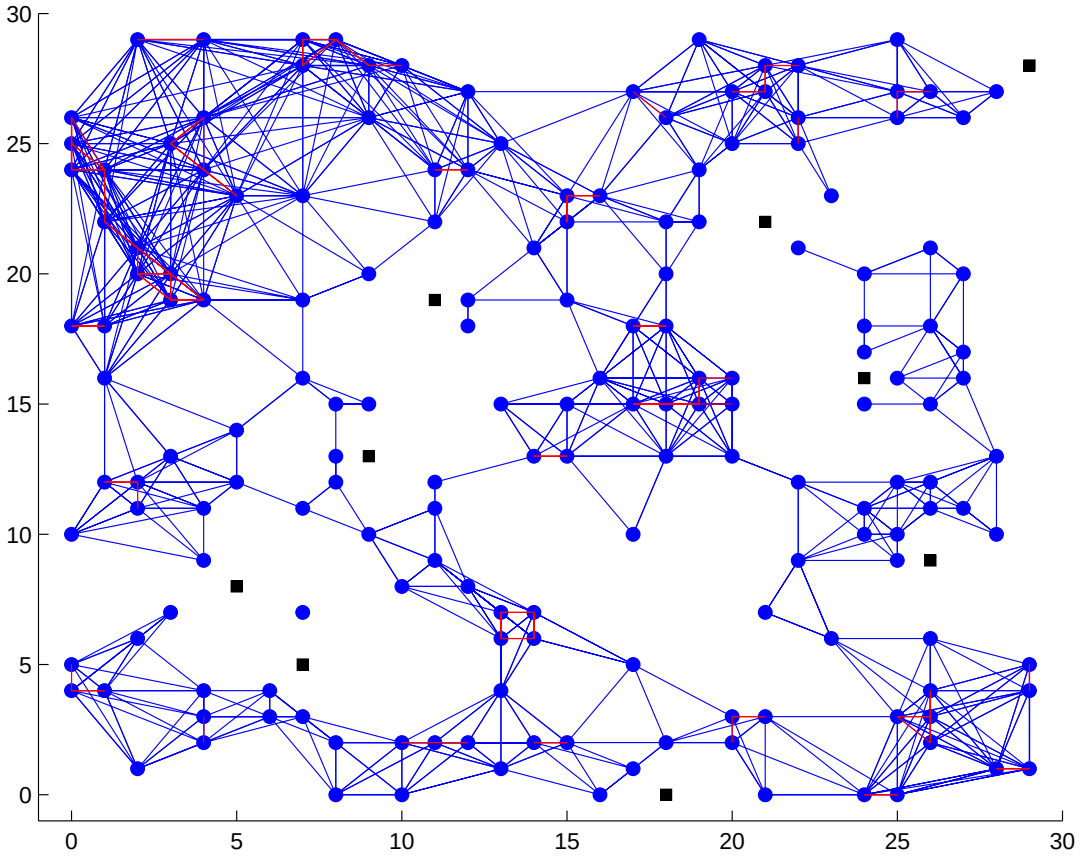
Sample network (2)



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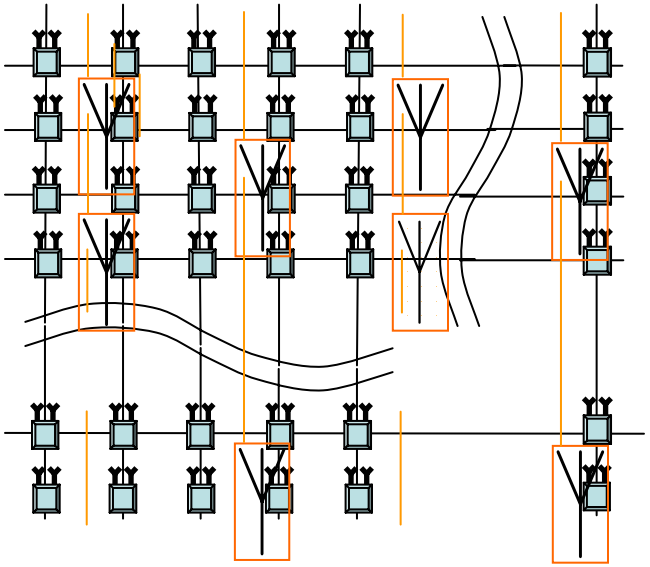
Pictures are pretty, but …

- Are they representative of any actual wireless networks?
- What are the constraints on modeling networks on the grid?

Building a K Communicator Topology

- K communicators $\Rightarrow$
  - K-1 link SNRs for each transmitter
  - N-K interference sources
  - K-1 equations, N-K free variables
- Solution possible for K<N/2, **if**
  - Transmit Powers are continuously variable
  - Interferers are programmed for each communicator
    - If interferer powers held constant:
      - K(K-1) equations, N-K free variables
      - Solution possible if N >= K^2
  - Needs low level control of card (eg CSMA off)

External Programmable Interference



Programmable Interference Source

- 2-8 programmable interference sources
  - Provide precise control of interference, including waveform generation
  - Limited Variety of Topologies

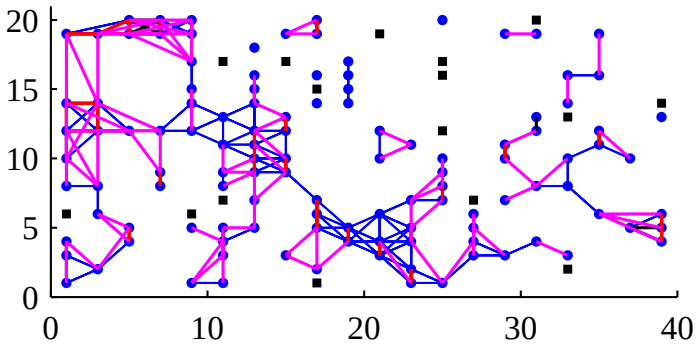
Model Scenarios

- Physical Scenarios
  - sensor network, K terminals in a lecture hall, neighborhood rooftop network, open space, in an office building
- Abstract Scenario Model
  - Mathematical Channel Models for given environment (indoor, outdoor, LOS, NLOS etc)
    - Distance dependent losses
    - Spatially correlated shadowing
- Grid configuration consistent with model?

Grid Consistency

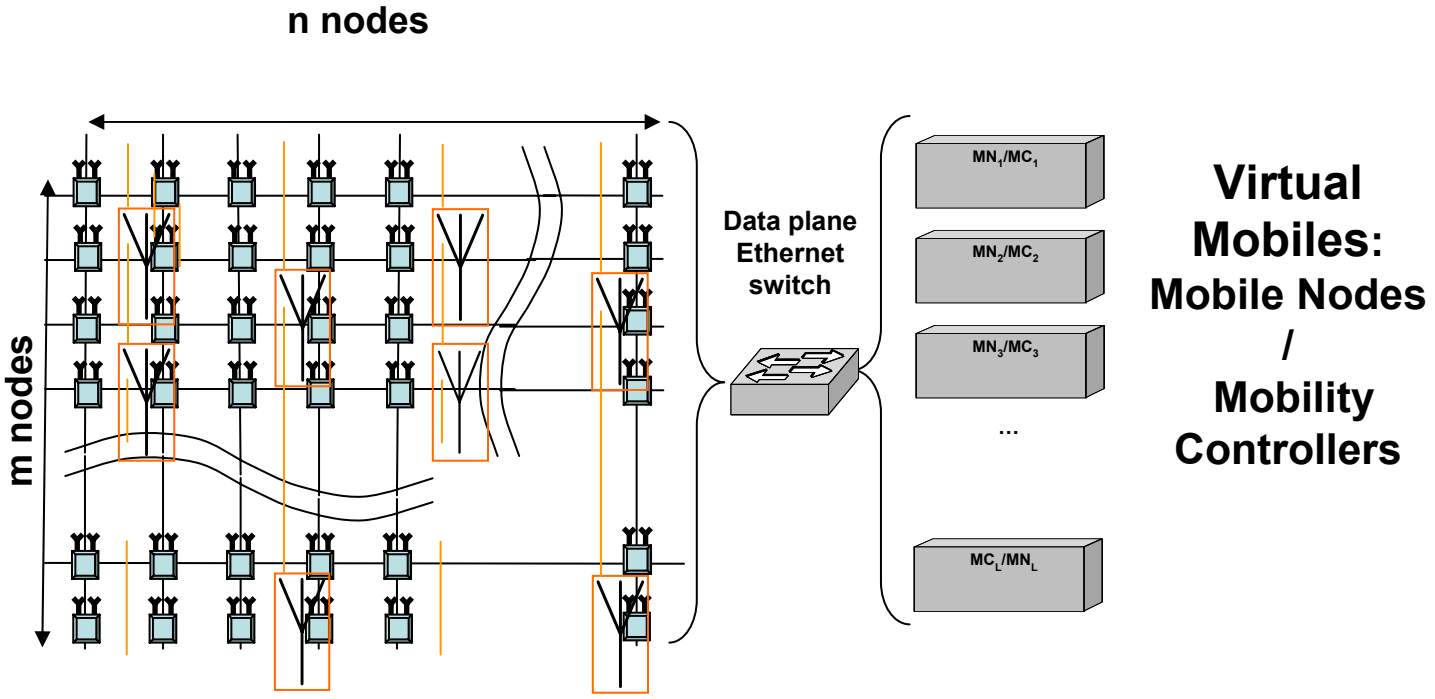
- Definition of consistency?
  - Real network instances are stochastic
  - Grid instances are intentionally repeatable
- MAC Layer Consistency
  - For each subset of active transmitters,
    - Which links are reliable?
    - Which links are above the noise floor?
  - MAC Layer consistency depends strongly on physical geometry

Separation Anxiety



- Practice: Link gains can vary by 60+ dB
- Reuse depends on relative link gains
- N * M grid, spacing d
- Max relative link gain is $R=(N^2+M^2)^{\alpha/2}$
  - 20*20 grid: $\alpha=4$, R=58 dB or $\alpha=2$, R=29 dB
  - For fixed area A=NM, R is minimized by M=N
- Spreading/Coding can be used to enhance separation
  - 1 Mb/s 802.11b enhances separation by 10 dB

Grid Mobility



- Discrete Grid Mobility
  - Virtual Mobiles use radio grid nodes as transceivers via network drivers
  - Virtual mobiles move by changing radio grid assignments

Discrete Grid Mobility

- As virtual mobiles move (on the grid), topology changes depend on spatial correlations of radio link gains
  - Difficult (impossible?) to precisely control radio link quality over space.
  - Characterization of the actual grid radio channel?
- P2P Mobile Infostations
  - Communication between neighbor nodes on the grid
  - Larger R implies more simultaneous exchanges.

Conclusions

- Configuring the grid topology is a research problem.
- We will quickly generate a few representative scenarios
- Scenarios without significant isolation should not be very hard.