

Efficient Analytical and Numerical Techniques for the Analysis and Design of Wireless Networks

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Objective and Approach:

- A methodology for **Design** and **Analysis** of Wireless Networks.
- **Analysis:**
 - Performance Models for PHY, MAC and Routing.
 - Loss models to abstract cross-layer interaction.
 - Fixed Point methods to derive inter and intra layer solutions.
- **Design:**
 - Design for robust or optimal solutions based on sensitivity of the performance models.
 - Analytical and numerical methods for sensitivity analysis:
 - Automatic Differentiation for implicit deterministic models.
 - Analytical methods for explicit deterministic models.
 - Perturbation Analysis for stochastic models.

The Model

- **Inputs:**
 - Network topology, traffic demand, neighborhood relations.
- **MAC model:**
 - Extension of the Bianchi and Tobagi models for multi-hop, multi-path networks based on 802.11.
- **PHY model:**
 - Fixed error rate or based on computed SINR
- **Routing:**
 - Probabilistic multiple path routing
- **Design:**
 - Optimal routing to maximize throughput
 - Gradient projection method
 - Automatic Differentiation for gradient derivation

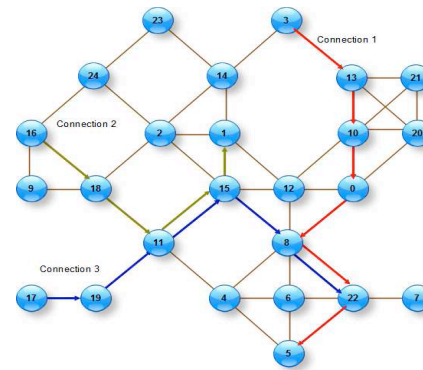
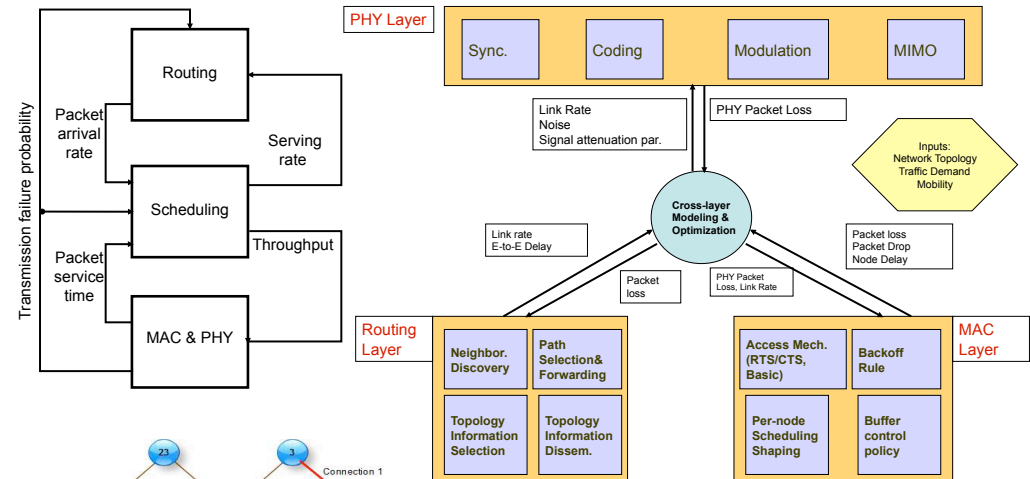
Enhancement of MAC layer Modeling

Enhancements and generalizations:

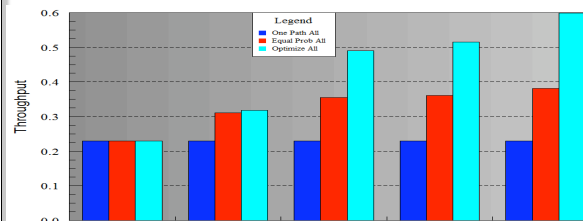
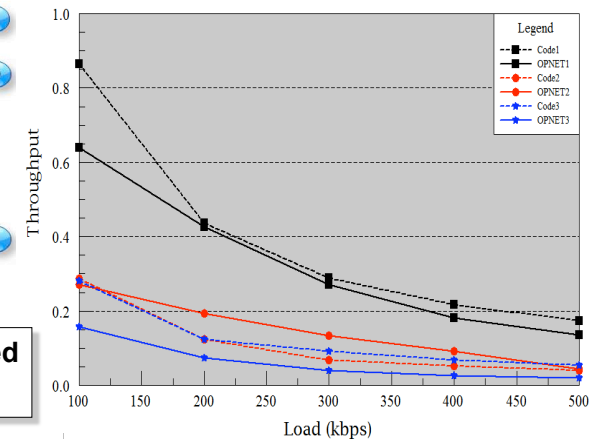
- Hidden nodes
- Multiple paths with common nodes
- Node scheduling algorithms

Computations at each node:

- Every path scheduling rate
- Transmission failure probabilities
- Average service time:
$$\frac{\text{successful transmission} + \text{successful transmissions of neighbors} + \text{failed transmissions} + \text{Average back-off time}}{\text{successful transmission}}$$



Analysis with loss and fixed point models



Multi-path Optimization with AD

S-D pairs	1	3	5	7	9
C code	0.51	2.86	4.37	5.90	10.38
OPNET	190	309	352	466	476

Speed comparison with OPNET