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:
  - successful transmission + successful transmissions of neighbors + failed transmissions + Average back-off time

\begin{itemize}
  \item S-D pairs
  \item C code
  \item OPNET
\end{itemize}

\begin{tabular}{cccccc}
  \textbf{S-D pairs} & 1 & 3 & 5 & 7 & 9 \\
  \textbf{C code} & 0.51 & 2.86 & 4.37 & 5.90 & 10.38 \\
  \textbf{OPNET} & 190 & 309 & 352 & 466 & 476 \\
\end{tabular}

Speed comparison with OPNET

**Analysis with loss and fixed point models**