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Performance modeling of Next-Generation WiFi networks

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Motivation

- Increasing importance and presence of advanced PHY layer schemes in WiFi networks and standards
- Lack of understanding of large scale deployments of future wireless technologies
- No unifying analytic model for MAC and underlying PHY layer for even the current generation of MIMO-powered WiFi

An analytic PHY/MAC model

- Rate of user k from AP i:

$$R_{ik} = \sum_{\mathbf{m} \in \mathcal{M}} \pi_{\mathbf{m}} R_{ik}^{\mathbf{m}}$$

- MAC (CSMA): $\pi_{\mathbf{m}} = \frac{\rho^{\|\mathbf{m}\|_1}}{\sum_{\mathbf{m}' \in \mathcal{M}} \rho^{\|\mathbf{m}'\|_1}}$

- MAC overhead: OFDM and mapping to quantized rates

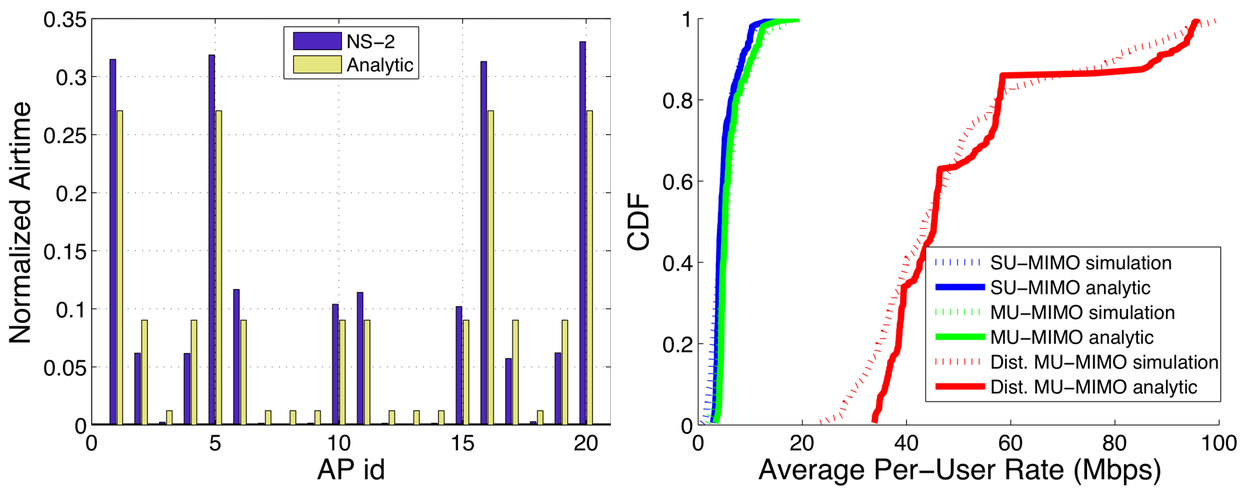
- PHY (MIMO): $R_{ik}^{\mathbf{m}} = m_i \frac{S_i}{|\mathcal{S}_i|} \log\left(1 + \mathsf{SINR}_{ik}^{\mathbf{m}}\right)$

- SU-MIMO: $\mathsf{SINR}_{ik}^{\mathbf{m}} \rightarrow \frac{g_{ik} M P_i}{1 + \sum_{j:j \neq i} m_j g_{jk} P_j}$

- MU-MIMO: $\mathsf{SINR}_{ik}^{\mathbf{m}} \rightarrow \frac{(M - S_i + 1) g_{ik} P_i / S_i}{1 + \sum_{j:j \neq i} m_j g_{jk} P_j}$

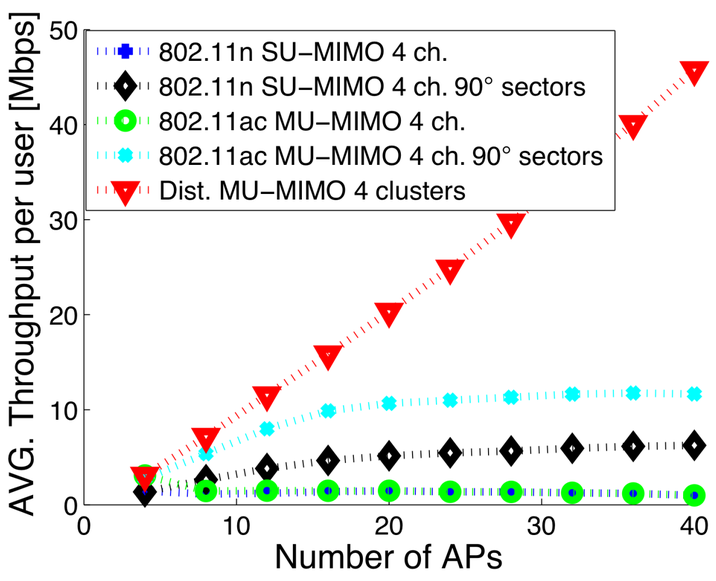
- D. MIMO: $\mathsf{SINR}_k \rightarrow \left(M - \frac{S-1}{B}\right) \left(\sum_{i=1}^{B} g_{ik}\right) \frac{P_{\text{sum}}}{S}$

Model Validation

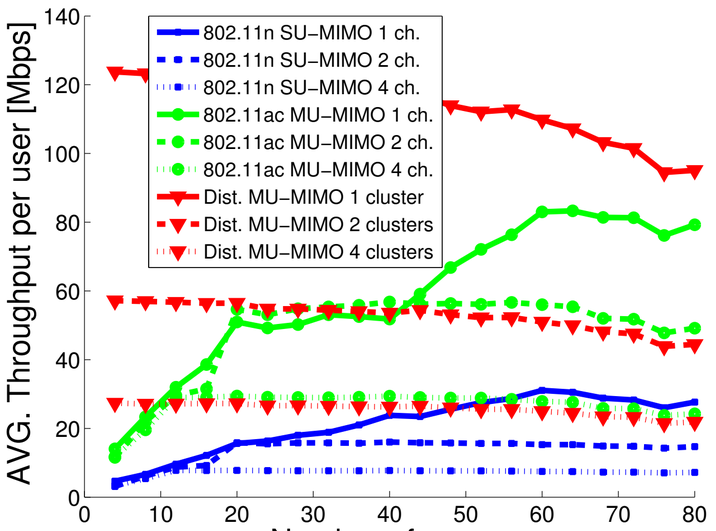


Combined NS-2 and simulation validation approach for various scenarios of interest (here conference hall)

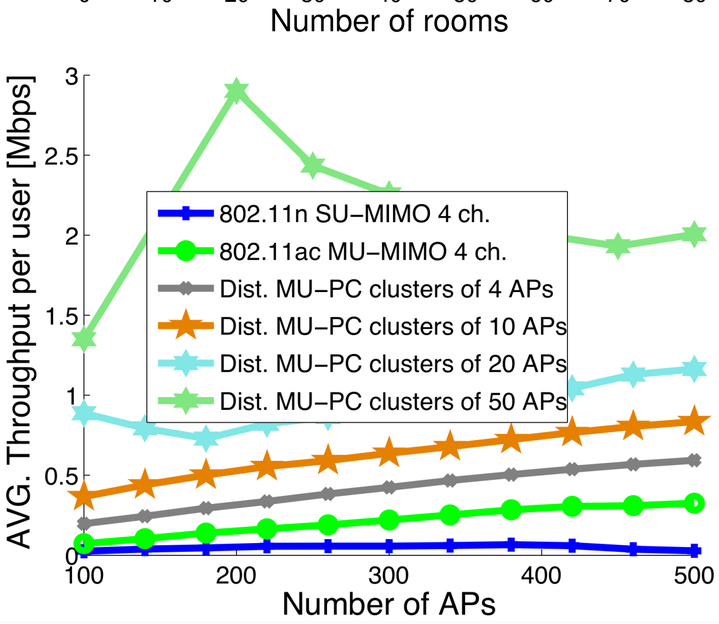
Model Applications



Conference Hall
- 20x20 m^2
- 200 users
- 80 MHZ bandwidth
- 4 channels
- Sector antennas
- Interference-limited regime



Office with Walls
- 23 x 160 m^2
- 200 users
- 80 MHZ bandwidth
- 4 channels



Stadium
- 200 x 200 m^2
- 20000 users
- 80 MHZ bandwidth
- 4 channels
- Clusters for d. MIMO

Discussion & Conclusions

- Significant gains of coordinated technologies in interference limited regimes
- In the presence of walls and well separated users the gains of coordination are vanishing
- Sectorization produces sizable gains with a small deployment cost and no coordination
- The practical clustering for distributed systems unlocks part of the multiplexing gains of MU-MIMO
- Our analytical model has been used successfully for a number of optimization problems arising in network planning such as:
  - AP/user association
  - Channel allocation
  - CCA threshold selection
  - Transmit power selection

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