Dynamic Channel Assignment and Power Allocation Strategies in Wireless Multichannel Networks

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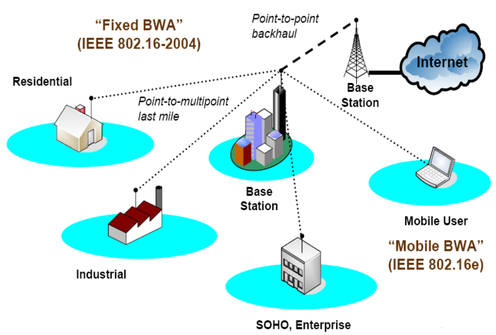
Motivation

In the emerging wireless access point (point-to-multipoint) systems, like those built around the IEEE 802.16 (WiMAX) standard, the broadband channel is divided into multiple narrowband sub-channels using Orthogonal Frequency Division Multiplexing Access (OFDMA) technology. Users can access multiple channels simultaneously in such wireless multichannel systems, therefore channel-aware adaptive resource allocation is critical for achieving high system throughput.

- Characteristics of multichannel networks
  - Channel states differ across channels as well as users and vary with time
  - Users capable of using multiple channels simultaneously
  - Measuring the channel quality introduces a significant overhead
  - Channel assignment and power allocation are closely related
- Research challenges in multichannel networks
  - Determine the optimal dynamic scheduling policy to maximize the system throughput
  - Use inaccurate channel state information to make the scheduling decision
  - Joint channel assignment and power allocation to achieve a higher system performance



Throughput-optimal Scheduling under Infrequent Channel Measurements

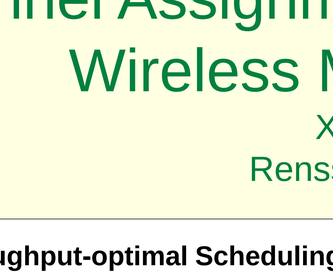
- Our goal
  - Develop optimal on-line adaptive scheduling policies to maximize the system throughput under infrequent channel/queue measurements
- Optimal scheduling policy
  - The user-channel assignment corresponds to the maximum weighted matching in the user-channel bipartite graph.

$$\max \sum_{(i,j)\in\Phi} \tilde{\alpha}_{ij}(kT) Q_{ij}(kT)$$

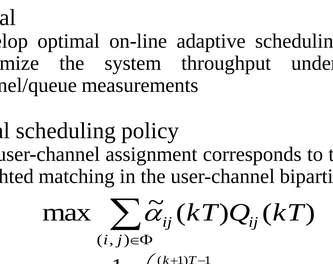
$$\tilde{\alpha}_{ij}(kT) = \frac{1}{T} E\left(\sum_{t=kT}^{(k+1)T-1} \alpha_{ij}(t) \middle| \alpha_{ij}(kT) \right)$$

$\alpha_{ij}(t)$: channel state at time t $Q_{ij}(t)$: queue length at time t

- Simulation results
  - The effect of the infrequent channel measurements is fundamentally different from that of infrequent queue measurement.



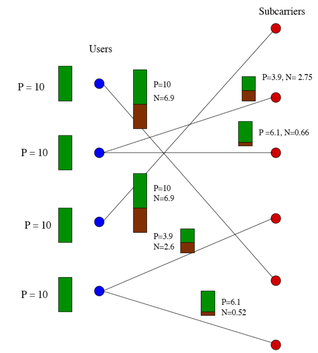
Infrequent measurements of both channel state and queue state introduce the reduction of the throughput capacity as the measurement interval T increases.



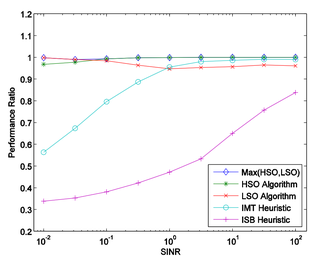
Throughput capacity remains unaltered when the queue state measurement interval increases provided that the channel state are measured every time slot.

Joint Channel Assignment and Power Allocation

- Challenges
  - Overall throughput is a complex non-linear function of the channel allocations.
  - Searching in all channel assignments is computationally expensive (exponential complexity).
- Our goal
  - Obtain optimal or near-optimal channel assignment in an efficient way.
- Optimal scheduling in the high SINR regime
  - Calculate the maximum weighted matching in the extended graph to obtain the optimal channel assignment
  - Obtain the optimal power allocations using the water-filling algorithm



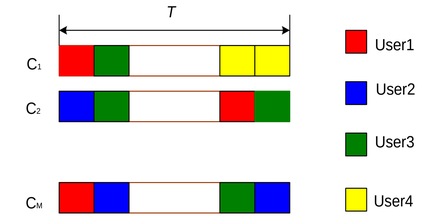
- Simulation results



Simulations show that HSO algorithm achieves the optimal channel assignment under high SINR.

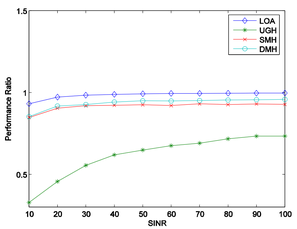
Multi-channel Scheduling with per-user QoS Constraints

- Problem formulation
  - Uplink scheduling and power allocation problem for a single frame
  - QoS constraints for each user in the frame duration



Resource allocation in a frame

- Linear Optimal Algorithm (LOA)
  - Achieve the maximum system throughput for the joint channel assignment and power allocation problem under QoS constraints in the high SINR regime
- Simulation results



Simulations show that LOA approaches the optimal scheduling (performance ratio 1) under high SINR.

References:

- X. Luo, R. Iyengar and K. Kar, "Channel Assignment for Maximum Throughput in Multi-Channel Access Point Network", *Proceedings of IEEE WCNC'07* , Mar. 2007.
- X. Luo, K. Kar, "Joint Scheduling and Power Allocation in Multi-Channel Access Point under QoS Constraints", *Proceedings of IEEE ICC'08*, May 2008.
- K. Kar, X. Luo and S. Sarkar, "Throughput-optimal Scheduling in Multichannel Access Point Networks under Infrequent Channel Measurements", *IEEE Transactions on Wireless Communication*, Vol. 7, No.6, June 2008.