A Unified Approach for Wireless Resource Allocation Problems

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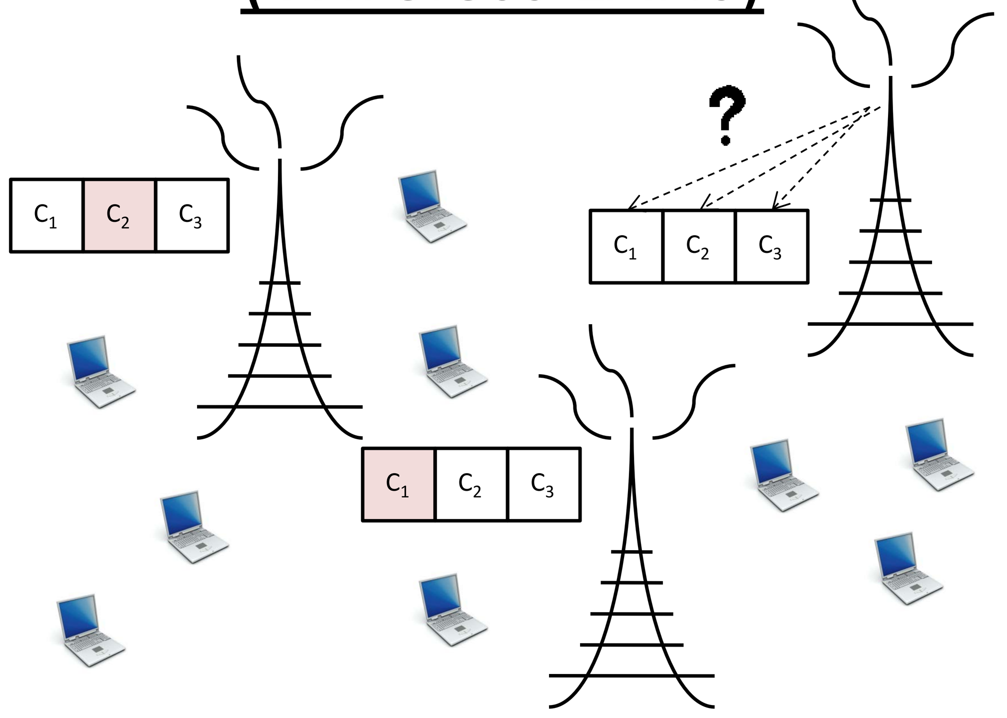
..where theory and practice collide

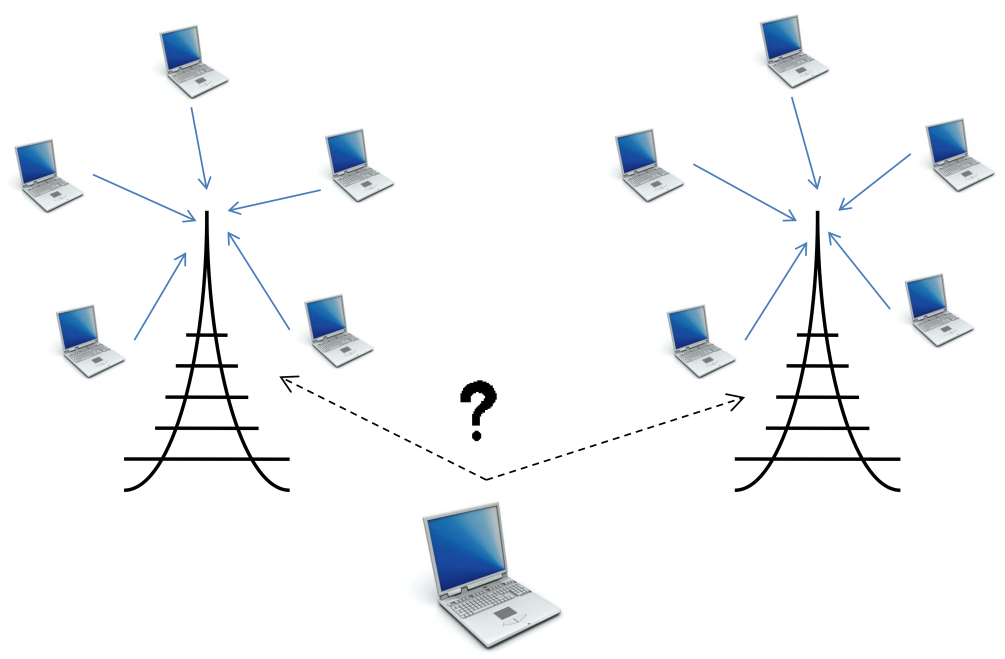
Numerous resource allocation problems arise in wireless networks – currently, ad-hoc, application-specific approaches dominate their design and analysis. Key Common Features : Locality, diminishing returns.

Channel Selection (Wireless LANs)



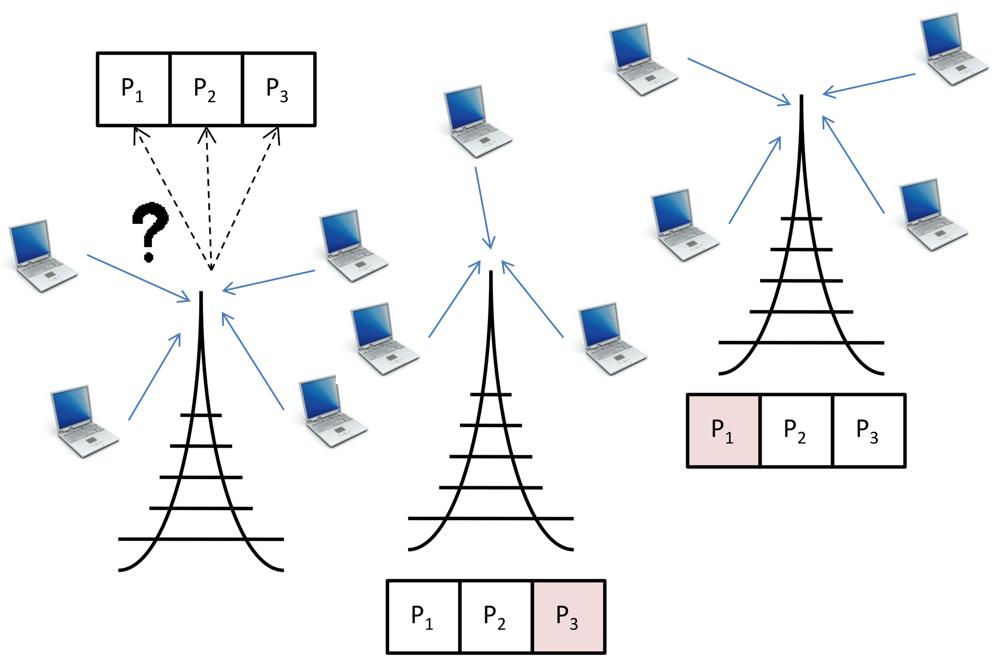
K. K. Leung and B.-J. Kim, "Frequency Assignment for IEEE 802.11 Networks", VTC 2003.

User Association (Wireless LANs)



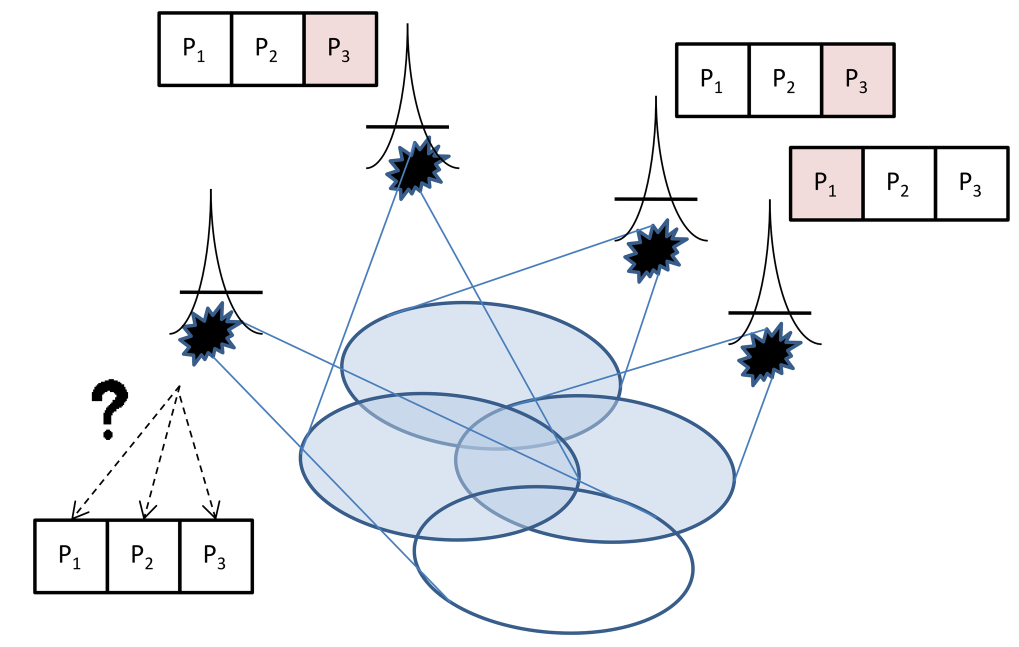
Y. Bejerano and S.-J. Han and L. (E.) Li, "Fairness and Load Balancing in Wireless LANs using Association Control", MOBICOM 2004.

Power Control (Wireless LANs)



V. Mhatre, K. Papagiannaki, F. Baccelli, "Interference Mitigation through Power Control in High Density 802.11 WLANs", INFOCOM 2007.

Power Control (Wireless Sensor Networks)



E. Campos-Nanez, A. Garcia, C. Li, "A Game-Theoretic Approach to Efficient Power Management in Sensor Networks", Operations Research Vol. 56, 2008.

Big Question: Is there a unified approach ?

Closest Existing Result

GIBBS THEORY

Objective function (global energy) → Potential → Local Energy → Gibbs Sampler → Simulated Annealing Algorithm

often an "art"

B. Kauffmann, F. Baccelli, A. Chaintreau, V. Mhatre, K. Papagiannaki, C. Diot, "Measurement based self organization of interfering 802.11 wireless access networks", INFOCOM 2007.

Our Approach

NON-COOPERATIVE GAME THEORY FOR COOPERATIVE CONTROL

Resource Allocation Game

- players = agents
- actions = resources
- equilibria = stable operating points

Distributed Protocol Design: (no art, simply mechanistic)

1. Design the game: *utility functions*

   J. R. Marden and A. Wierman, "Distributed Welfare Games", Under submission.

2. Design the players: *learning rules*

   J. R. Marden and J. S. Shamma, "Revisiting Log-Linear Learning: Asynchrony, Completeness, and a Payoff-Based Implementation", Under submission.

RESULT

Our approach is applicable to all the above problems. The optimal solution can always be made to be an equilibrium, and even the worst equilibria are within a factor 2 of the optimal.

RESULT

Every "local energy function" that can be obtained using Gibbs Theory corresponds to a specific utility design in our approach.

KEY FEATURES OF OUR APPROACH

1. Separates the utility design problem from the learning rule design problem, giving rise to a host of solutions that could not have been obtained using Gibbs Theory.
2. Promises to apply to more realistic models of the problem with relaxed assumptions (due to the mechanistic nature of the approach) – work in progress.

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