Cross-Layer Optimization in Decentralized Cognitive Radio Networks

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I. Project Proposal: Plan and Methodology

The proposal is to primarily simulate existing work (Section IV) in the domain of cross-layer optimization for decentralized/distributed cognitive radio networks while also providing a few extensions in terms of additional constraints or additional sub-problems which may lead to the exploration of different techniques to solve the extended problem.

What do I plan to accomplish? What would be my methodology?

- Keeping the QoS requirement as Maximizing the SU Network Throughput, formulate a cross-layer optimization problem including design considerations across all 5 layers of the protocol stack (APP, Transport, Network, MAC, and PHY) **with some novel extensions which are discussed in Section II**
- Solve the formulated cross-layer optimization problem using techniques from Lagrangian Duality Theory, well-known Iterative Algorithms (such as Descent Methods and Gradient Projection using Sub-Gradients), and other heuristic approaches
- Construct an algorithm or a set of algorithms that efficiently solve the formulated cross-layer optimization problem
- Implement the constructed algorithm and **simulate possible real-world scenarios** [real-time traffic flows (prioritized) and non-real time traffic flows in the SU network co-existing with a licensed user (PU)] in NS2 or MATLAB

II. Novel Extensions

What would be novel in my approach to cross-layer optimization as opposed to related work in this arena? What are the aspects I will be focusing on?

- PU Occupancy Behavior is not known to the SUs - Learn this over time by assuming a Markovian Correlation in PU spectrum access behavior and then share a condensed version

of this information over a common control channel to all the SUs - Incorporate this into the MAC layer in the SU Network Protocol Stack

- Incorporating MCS Adaptation into the PHY layer problem - Does this lead to a different sub-problem or just a new constraint in the global optimization problem?
- Prioritized Flow Scheduling - How does adding prioritized flows impact the flow scheduling problem? Can we have Priority Queueing System at the nodes or can we have a Weighted Back-Pressure Scheduler at the nodes?
- Additional Routing Metrics - Adding new constraints to the routing sub-problem (Network Layer) to take into account other relevant routing costs such as Routing Delay and the Quality of the Route (capacity and reliability of the links involved)

III. Deliverables

What do I plan to deliver?

- A consolidated cross-layer optimization problem formulation incorporating MCS Adaptation (PHY), Power Allocation (PHY), Spectrum Access (MAC), Routing (NET), and Flow Scheduling (TRANSPORT) with SU Network Throughput constraints (QoS - APP) for the extended problem (Section II)
- An algorithm or a set of algorithms with variables flowing amongst them, solving this extended cross-layer optimization problem, included in the SU's network protocol stack
- MATLAB or NS2 deliverables - Constructing a topology of SUs in a licensed user's interference region, generating real-time streaming and non-real time generic traffic flows to the SUs, and visualizing plots of *PU Packet Error Rate v/s PU Load* and *SU Network Throughput for the offered traffic*.

IV. Related Work

The following are the papers I will be referring to OR extending from for my project.

1) "Cross-Layer Optimization and Protocol Analysis for Cognitive Ad Hoc Communications"
2) "Throughput-Optimal Cross-Layer Design for Cognitive Radio Ad Hoc Networks"
3) A tutorial on cross-layer optimization in wireless networks"
4) Layering as Optimization Decomposition: A Mathematical Theory of Network Architectures"

The same papers are studied as a part of my ECE64700 Paper Summary.