DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

# Energy Constrained Real Time Wireless Multicasting

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## Motivation

• Multicasting in wireless medium is challenging due to the time varying nature of the wireless channel.

• Also, transmission of real time applications in wireless medium is difficult since:

-Real time applications have strict delay requirements.

-Wireless devices operate on batteries and hence are energy limited.

## Applications

Efficient multicast for real time applications especially in military applications, multimedia streaming, distant learning, gaming, …

## System Model

• A transmitter multicasting T packets to M receivers over a wireless single hop network.

• T packets to be delivered in N time slots and up to a maximum value of E units of energy.

• Erasure channel model between the transmitter and each receiver.

• The probability of successful reception for receiver i in time slot k is given by $p_{ik}$.

• Two cases for $p_{ik}$ :
- $p_{ik}$ is time varying and is modeled by a two state Markov chain.

-$p_{ik}$ is constant in time.

• Binary energy expenditure in every time slot.

• Transmission schemes:

- Simple Automatic Repeat Request (ARQ)

- Random Network Coding (RNC).

## Objective

• Finding the optimal energy allocation that maximizes the number of packets successfully received by every receiver.

• Solving the original problem is intractable.

• A suboptimal approach is provided in which the global constraints are distributed among all individual packets for ARQ (or groups of L packets for RNC).

## Proposed Approach

• Translate the energy and delay constraints for the T packets into constraints for every batch of L coded packets

• The case of ARQ corresponds to L=1.

• For the $t^{th}$ group of L coded packets, the problem is:

$$Max_{u_1,u_2,\ldots,u_{N_t}} E\left\{\sum_{i=1}^{M}\left(z_{iN_t}\right)\right\}$$

Subject to:

$$\sum_{k=1}^{N_t} u_k \le E_t$$

where:

- $E_t$ is the maximum allowable energy to spend per $t^{th}$ batch of L coded packets.

- $N_t$ is the maximum number of time slots to deliver $t^{th}$ batch of L coded packets.

- $u_i$ is the value of energy expenditure in time slot i.

- $\sum_{i=1}^{M} z_{iN_t}$ is the number of receivers who receive the packet successfully up to time $N_t$.

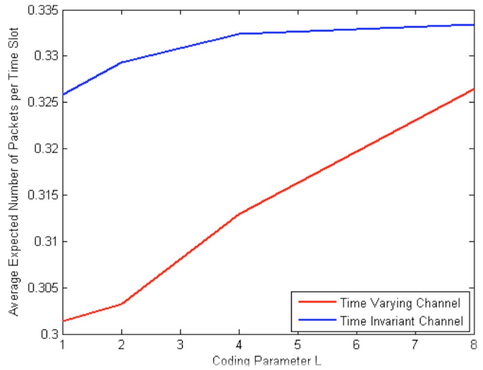
This problem can be solved using dynamic programming.

## Numerical Evaluation

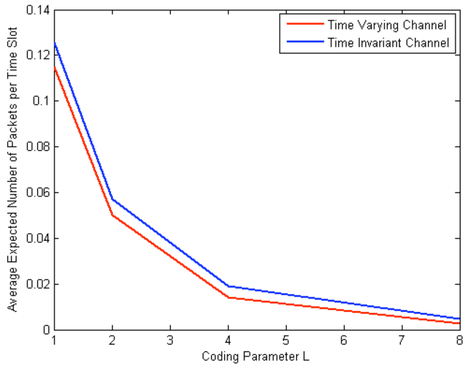
• For the evaluation, the parameters values are T=8 packets, E=16 units, N=24 time slots and M=2 receivers.

• Receiver 1 has good channel quality; receiver 2 has poor channel quality.

Throughput at receiver 1




Throughput at receiver 2




RNC combat the effect of fading more successfully than ARQ for good channels but not for poor channels.

## Conclusion and Future Directions

• We have used dynamic programming to maximize the multicast throughput in a finite delay constraint and within an energy budget over a time varying channel under two transmission schemes: ARQ and RNC.

• The solution can be used for extending the problem to multiple sources and more general multihop topologies.