Energy Efficient Transmission Scheduling for Non-Stationary Underwater Acoustic Channels

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I. Motivation

In underwater acoustic (UWA) communications, transmissions:
- are the most energy consuming activity of a UWA modem
- may result in packet loss, due to non-stationary statistics of the channel quality
- are used by battery powered devices.

Problem: Define transmission scheduling that minimizes the average number of transmission attempts, therefore energy consumption, under a constant throughput constraint.

II. System description

Assumptions:
- If packets to be transmitted by a deadline \( T \);
- the channel state \( (s) \) evolves according to a Finite State Markov chain;
- no new packet arrival in the queue before \( T \);
- fully-reliability, i.e., packets are retransmitted until correctly decoded;
- any remaining packet in the queue at \( T \) will be dropped.

We propose a new system model that takes into account the outdated Channel State Information (CSI) when a transmission is postponed by the controller.

III. Prior work and main contribution

- Offline optimal transmission scheduling was derived in [1], by assuming a AWGN channel,
- An optimal stochastic control problem was solved in [2].

IV. Finite-state Markov chain as channel model

\[ P_00 \quad G/0 \quad B/1 \quad P_10 \]

Performance of the controller in [2] with Perfect Non-Causal CSI (PNCCSI) and with Perfect Causal CSI (PCCSI). Note that CSI (either at the present stage or at the previous stage) is available independently on the transmission schedule.

Performance of the controller in [2], when perfect CSI is not available whenever the transmission is postponed by the controller, which however assumes that the channel state has not changed since the last transmission.

V. Proposed system model

- \( q_i \) is the number of packets in the queue at stage \( k \),
- \( s_i \) is the CSI available at the controller at stage \( k \),
- \( r_k \) is the channel state at stage \( k \),
- \( e(s_k) \) is the packet error probability associated with the channel state \( s_k \),
- system state \( x_k = (q_k, c_k, l_k) \).

System state evolution:

\[
\begin{align*}
J_k(x_k) &= \min \left\{ 1 + \sum_{i \in \mathcal{U}} p_i(q_i)p_i(c_i), 1 - \epsilon(s_k) + A_{k+1}(q_k, s_k, l_k)(1 - \epsilon(s_k)) + A_{k+1}(q_k, s_k, l_k)(1 - \epsilon(s_k)) \right\}
\end{align*}
\]

VI. Results

VII. References