A Simple Dynamic Jamming Game

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Abstract — **This paper finds optimal strategies for a simple dynamic communication jamming game in which the limitations of transmitter cooling resources impose memory requirements on the strategies of the players.**

I. Summary

An ON-OFF slotted communication-jamming game is modelled as a two-person zero-sum game with memory, with average throughput as the payoff. In one play of the game, e.g., one packet-transmission slot, either side can choose to transmit or not transmit, and each side has knowledge of the opponents prior plays. Dynamics are imposed on the players by the fact that their transmitters have limited cooling resources, and hence future strategies of a player are affected by current decisions to transmit or not transmit a signal.

After normalizing the two-by-two payoff matrix by the throughput when the communicator is ON and the jammer is OFF, the only remaining parameter in the matrix is the payoff when both players are ON. The 2×2 normalized payoff matrix has the following form:

	Jam(off)	Jam(on)
Com(off)	0	0
Com(on)	1	α

In addition, each player has two parameters associated with their transmitter's cooling systems, namely (1) the ratio of the thermal energy capacity of the transmitter to the thermal energy accrued in one transmission, and (2) the time constant of the transmitter's cooling system. Hence, a communicator's strategy is represented by a sequence of energy levels $\{X_t\}$, where each X_t is either 0 or C, subject to the constraint

$$\sum_{n=0}^{\infty} X_{t-n}\delta_{\text{com}}^{n} \le C_{\text{acc}} \quad \text{for all } t.$$

With similar parameters for the jammer's transmitter, this simple dynamic game has five parameters α, C/C_{acc}, δ_{com}, J/J_{acc}, and δ_{jam}.

This game can be solved using dynamic programming techniques, with considerably different solutions occuring, depending on the values of the five game parameters. For certain values of the transmitters' parameters, as the dynamic programming solution evolves, the strategies of the communicator and jammer, which are functions of the energy levels in both transmitters, approach a steady state form. For other values of the players' transmitter parameters, the iterated game structure increases in complexity as the dynamic programming solution proceeds.

In the cases in which a steady-state solution exists, the strategies are characterized as follows:

(1) When the communicator cannot communicate because of energy constraints, neither side transmits.

(2) When the jammer cannot transmit because of energy constraints, the communicator transmits if possible.

(3) When both adversaries can communicate, their transmission probabilities change as the throughput parameter α increases until α reaches a threshold α_1. When $\alpha > \alpha_1$, transmission probabilities no longer depend on α.

Furthermore, when the payoff throughput parameter α is low, optimal strategies are mixed. Otherwise the optimal strategies are pure and exhibit an oscillatory behavior that has connections to cyclotomic cosets for certain values of the players' transmitter parameters.

References

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[2] Ranjan Mallik, "Link Jamming Games with Discrete Levels," Ph.D. dissertation, University of Southern California, January 1992.

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