Learning a Protocol for Minimum Probability of Detection Wireless Transmissions: A DQN Experiment

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1 Non-Adversarial Case

Wireless communications operate under many parameters (PHY) and policies (NET, LINK). Given a few minutes of power, time, and frequnecy data (spectrograms), can an optimal wireless communications policy be learned?

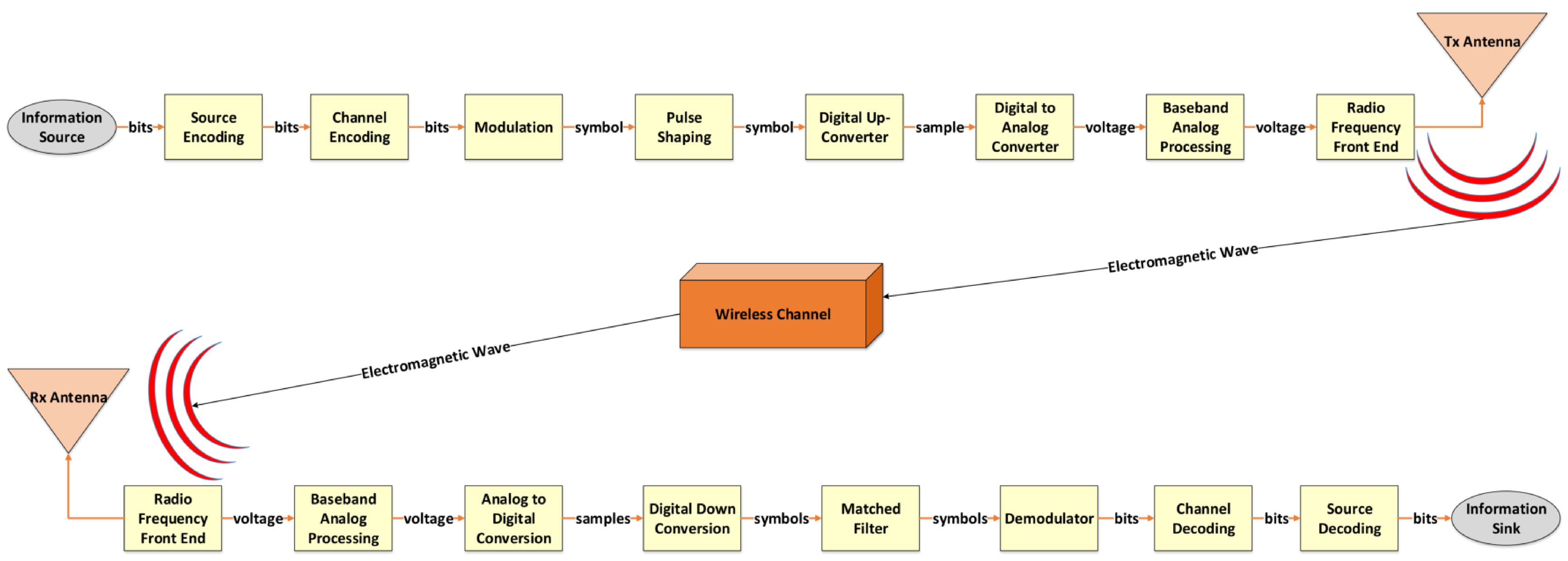

Figure 1: The sequential model for estimating wirelessly transmitted binary data across a noisy wireless channel

$$BER = \frac{correctbits}{incorrectbits} \quad (1)$$

$$reward = \log(1/(BER + \epsilon)) \quad (2)$$

$$f_c \in \{f_s/10, f_s/2\} \quad (3)$$

$$power \in \{0.1, 1.0\} \quad (4)$$

$$action \in \{(power, f_c)\} \quad (5)$$

$$state \in \mathbb{R}^{(BS,1,257,311)} \quad (6)$$

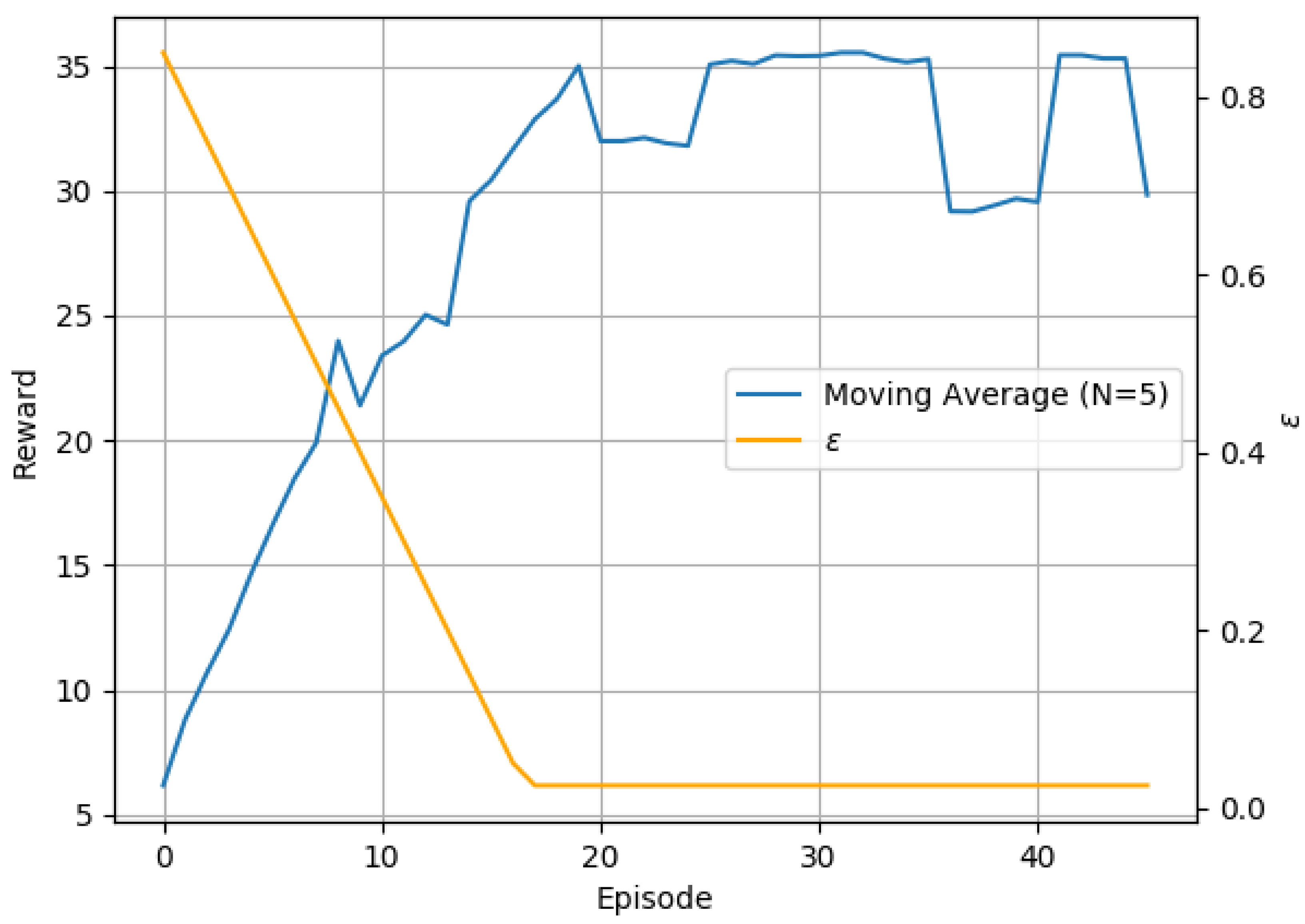

Figure 2: Training reaches a maximum reward very quickly as exploration ceases in this simple problem. Testing average over 100 episodes gave 31.30 reward ($\sim 2.5 \times 10^{-14}$ BER)

2 Adversarial Case

Signal to Interference and Noise Ratio (SINR) is computed as in-band signal power divided by the sum of noise and interference power: $P_s/(P_i + P_n)$. An adversary is assumed to be able to detect our transmission if this ratio exceeds $0dB$ or a one to one ratio. Can a policy be learned to operate as close to this unknown SINR but not above it?

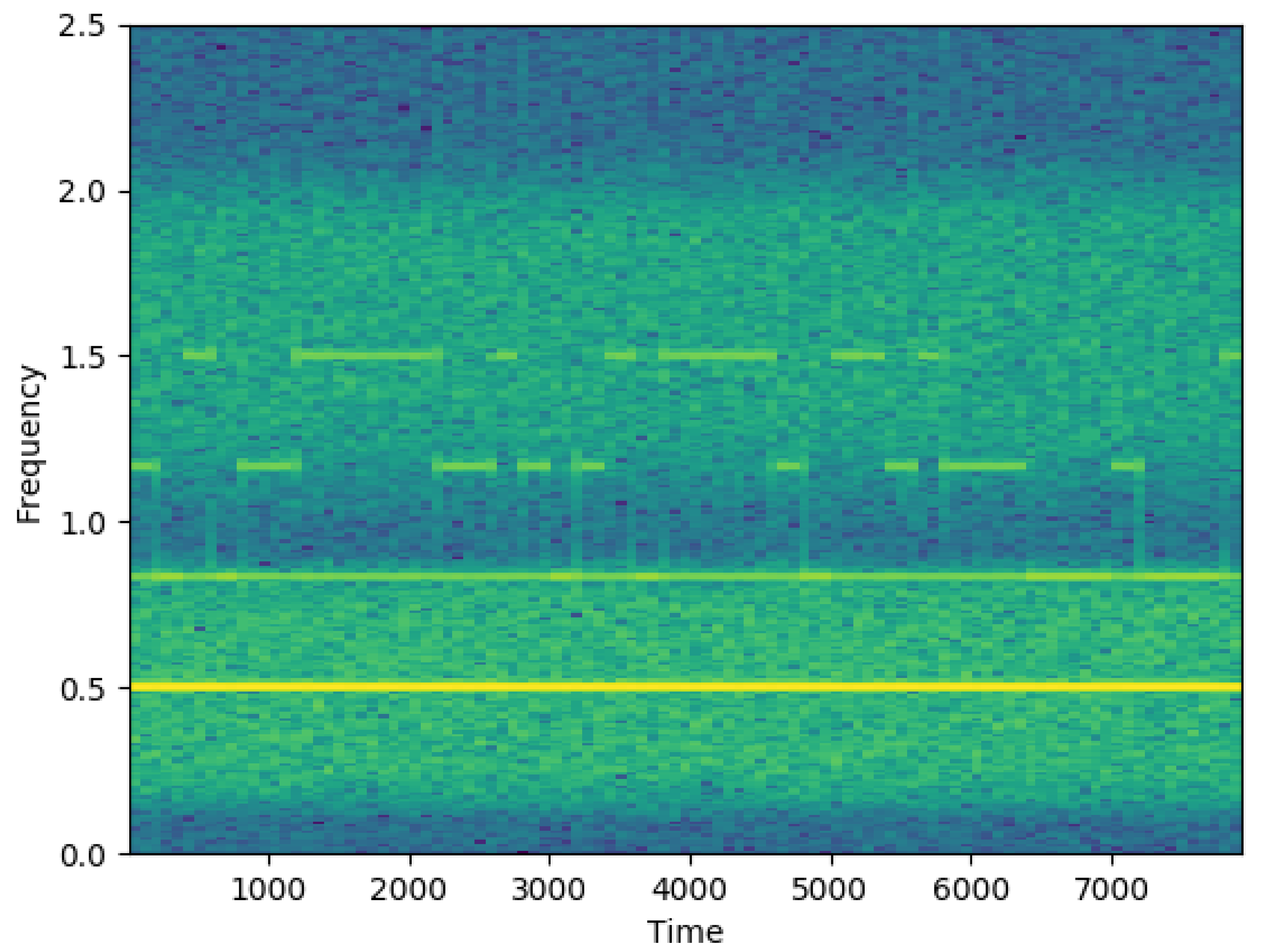

Figure 3: An example state with actions chosen $a_t : \{(gain = 1, f_c = 0.5)\}$. Tone exists at $.83Hz$, hopping tones at $1.16, 1.5Hz$, and wide band signal from $1.2Hz$ to $2Hz$. SINR exceeds $0dB$, so detection and jamming occurs.

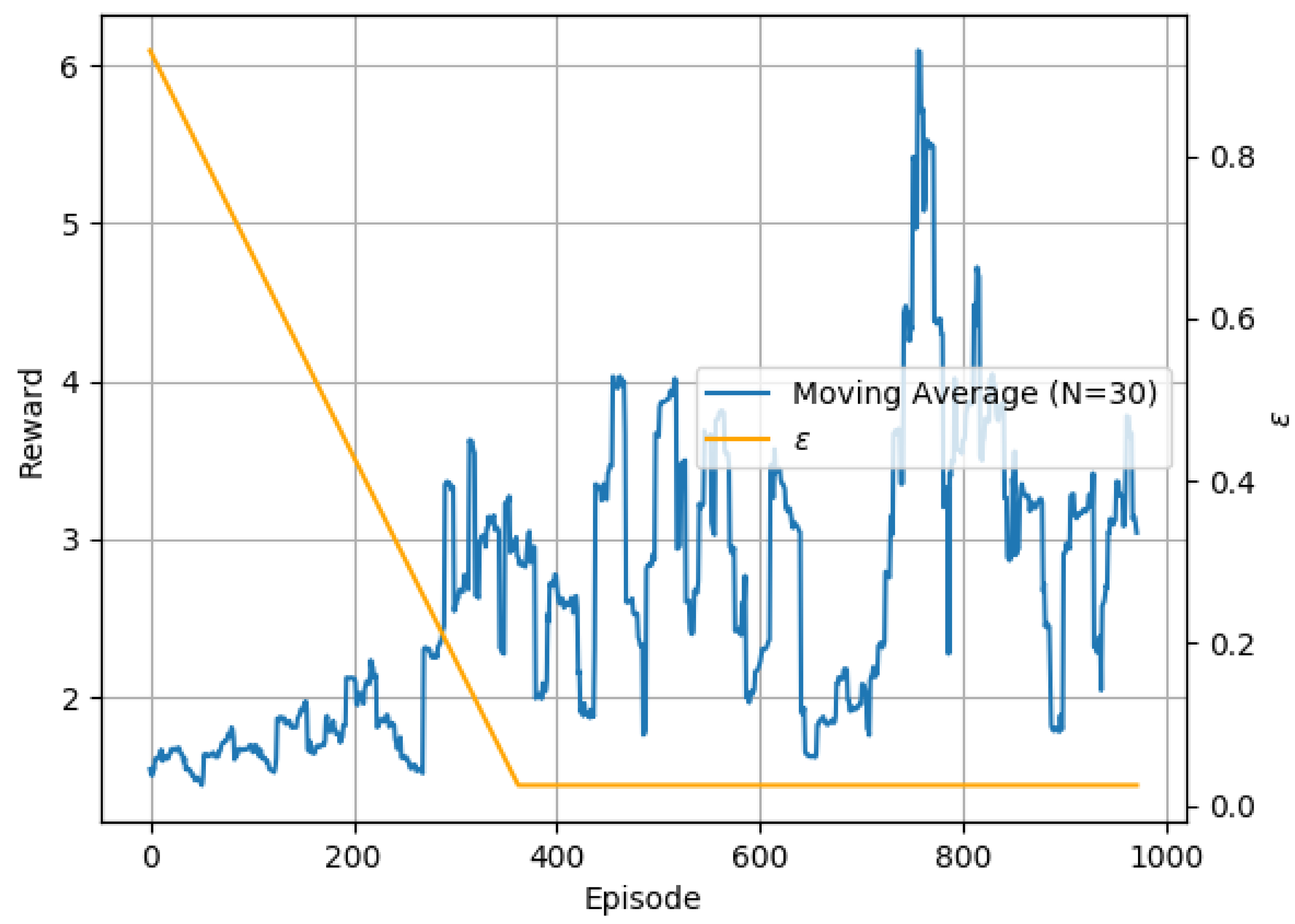

Figure 4: Training reaches a maximum reward more slowly. Testing average over 100 episodes gave 9 reward ($\sim 1 \times 10^{-4}$ BER). A larger sliding window for the average is used to capture the smaller margin between good and bad performance (~ 1 and $\sim 5 - 10$ average reward per time step instead of ~ 1 and ~ 36 non-adversarial margin). DQN additionally learned to avoid wide band interference, SINR equal.