

2. M. Balakrishnan, Hong Huang, Rafael Asorey-Cacheda, Satyajayant Misra, Sandeep Pawar, Yousef Jaradat: 'Measures and Countermeasures for Null Frequency Jamming of On-Demand Routing Protocols in Wireless Ad Hoc Networks'. *IEEE Transactions on Wireless Communications* 11(11): 3860-3868 (2012).

**Abstract:**

Distributed network protocols operate similar to periodic state machines, utilizing internal states and timers for network coordination, which creates opportunities for carefully engineered radio jamming to target the protocol operating periods and disrupt network communications. Such periodic attacks targeting specific protocol period/frequency of operation is referred to as Null Frequency Jamming (NFJ). Our hypothesis is that NFJ is a pervasive phenomenon in dynamic systems, including wireless ad-hoc networks. This paper aims to test the hypothesis by investigating NFJ targeted at the on-demand routing protocols for ad-hoc networks. Our mathematical analysis and simulation results show substantial degradation in end-to-end network throughput at certain null periods/frequencies, where the jamming periodicity self-synchronizes with the route-recovery cycle. We also study an effective countermeasure, randomized route-recovery periods, for eliminating the presence of predictable null frequencies and mitigating the impact of NFJ. Our analytical model and simulation results validate the effectiveness of randomized route recovery with appropriately chosen randomization ranges.