
Performance of Cognitive Radios: *Myths and Realities*

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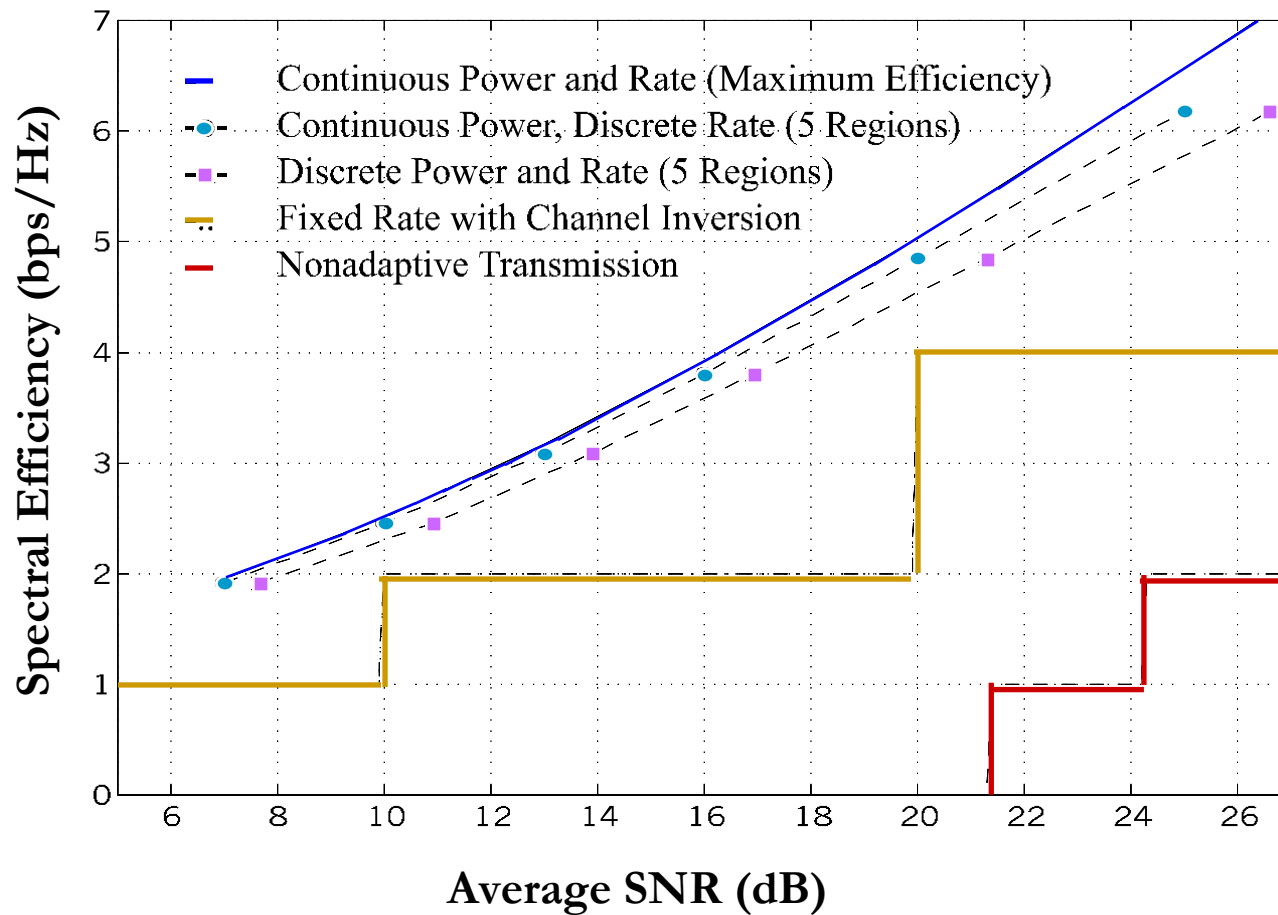
Introduction

- Cognitive radios can sense and learn the environment.
- This knowledge can be used to improve radio and system performance, enhance cross-layer design, or use spectrum more efficiently.
- There are many technical and policy challenges to realizing these performance advantages

Radio Performance Improvement

- Increased data rates
 - Power and rate adaptation
 - ISI mitigation
- Reduced power consumption
 - Power control
- Interference reduction
 - Power control
 - Smart antennas

Capacity in Rayleigh Fading



Crosslayer Design

- Application
- Network
- Access
- Link
- Hardware

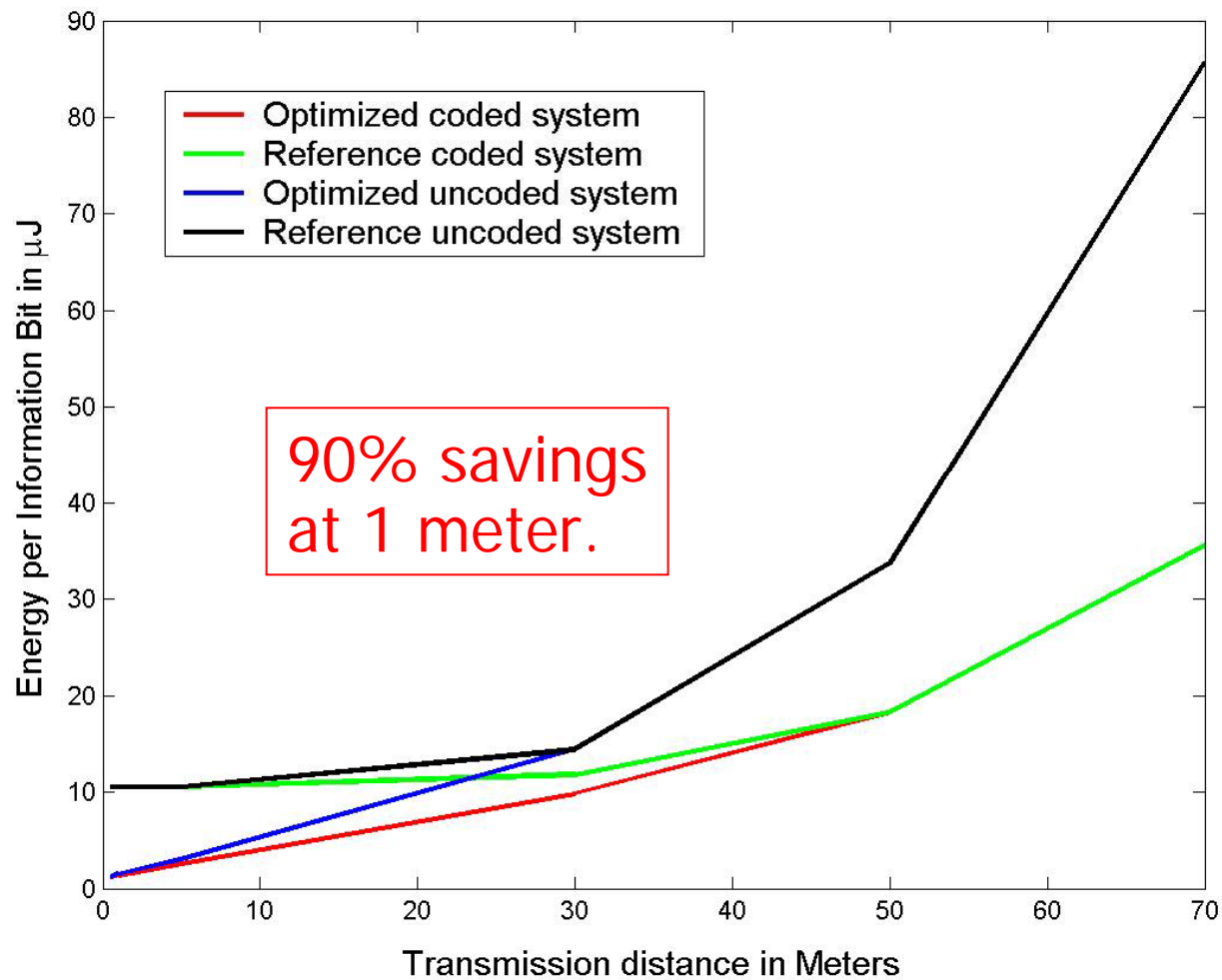


Delay Constraints
Rate Requirements
Energy Constraints
End-to-End Metrics

Substantial gains in throughput, efficiency, and QoS can be achieved with cross-layer adaptation

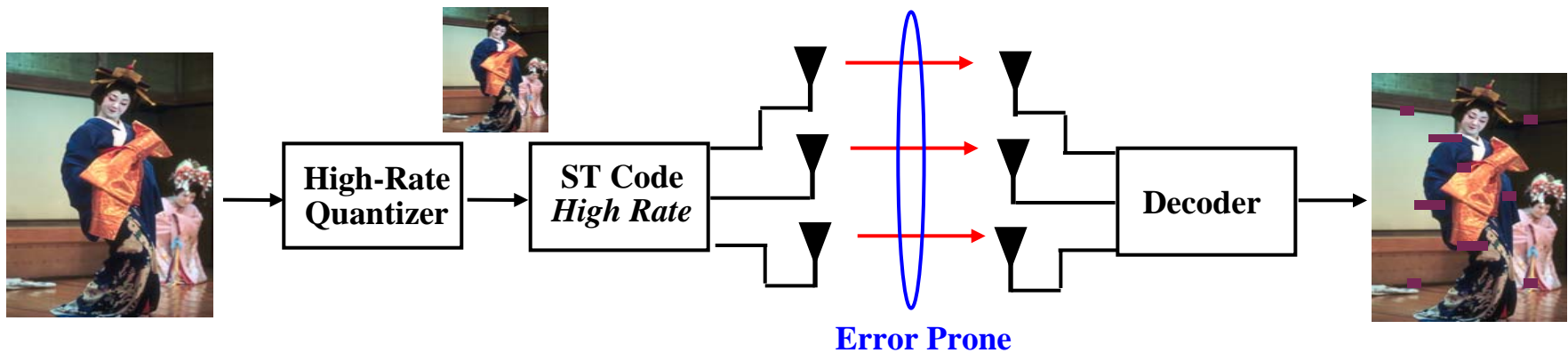
Hardware+Coded MQAM

Reference system has $b_k=3$ (coded) or 2 (uncoded)

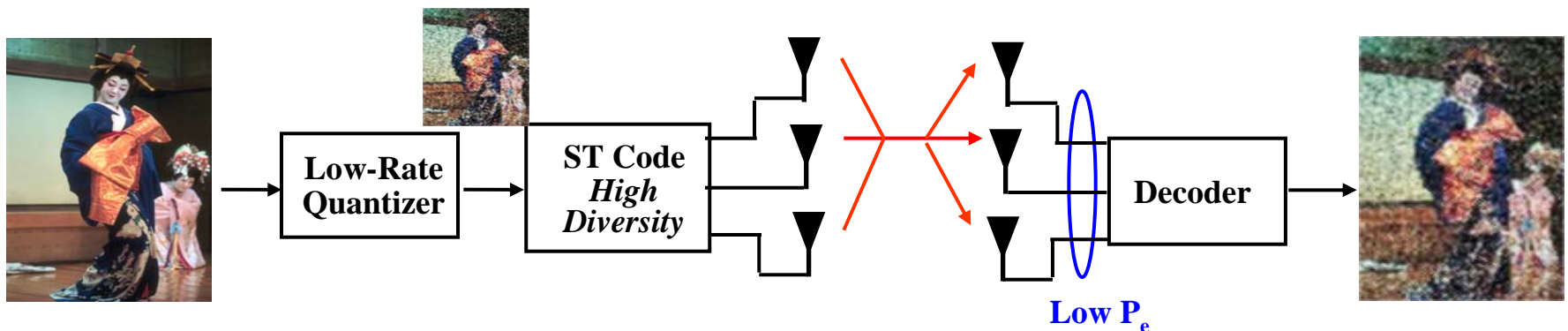


Joint S/C Coding with MIMO

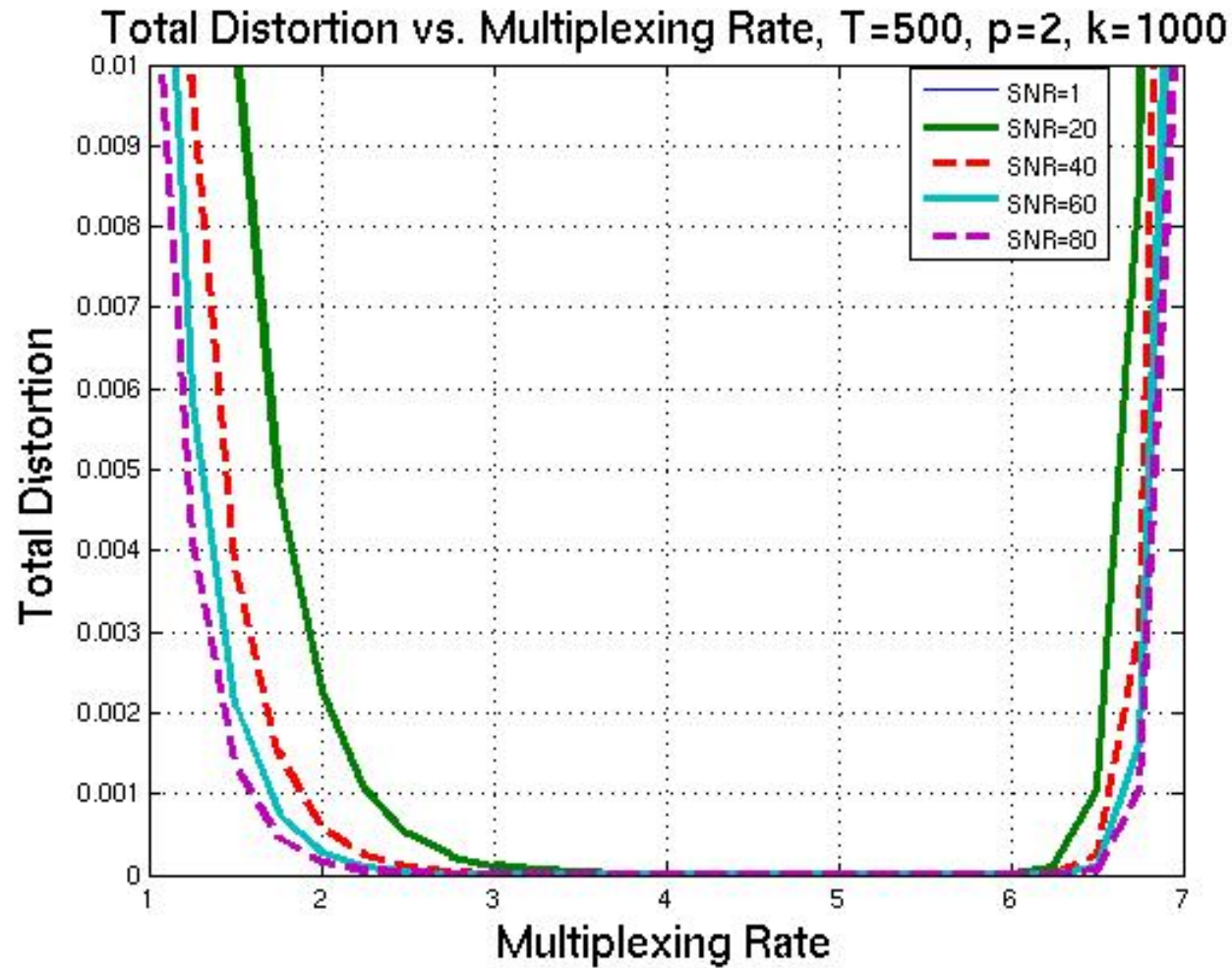
- Use antennas for multiplexing



- Use antennas for diversity



Distortion vs. Multiplexing $N=M=8$ $K=O(T)$

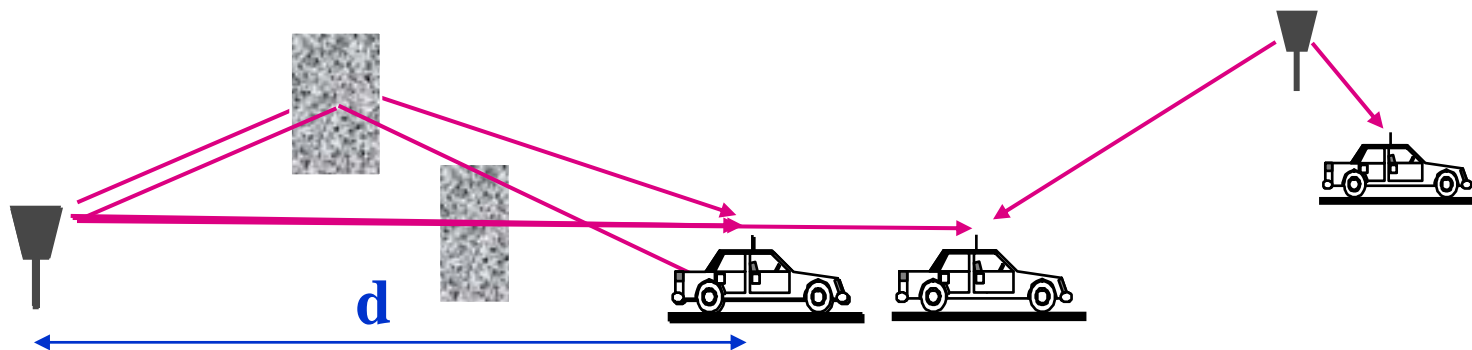


Spectrum-Agile Radios

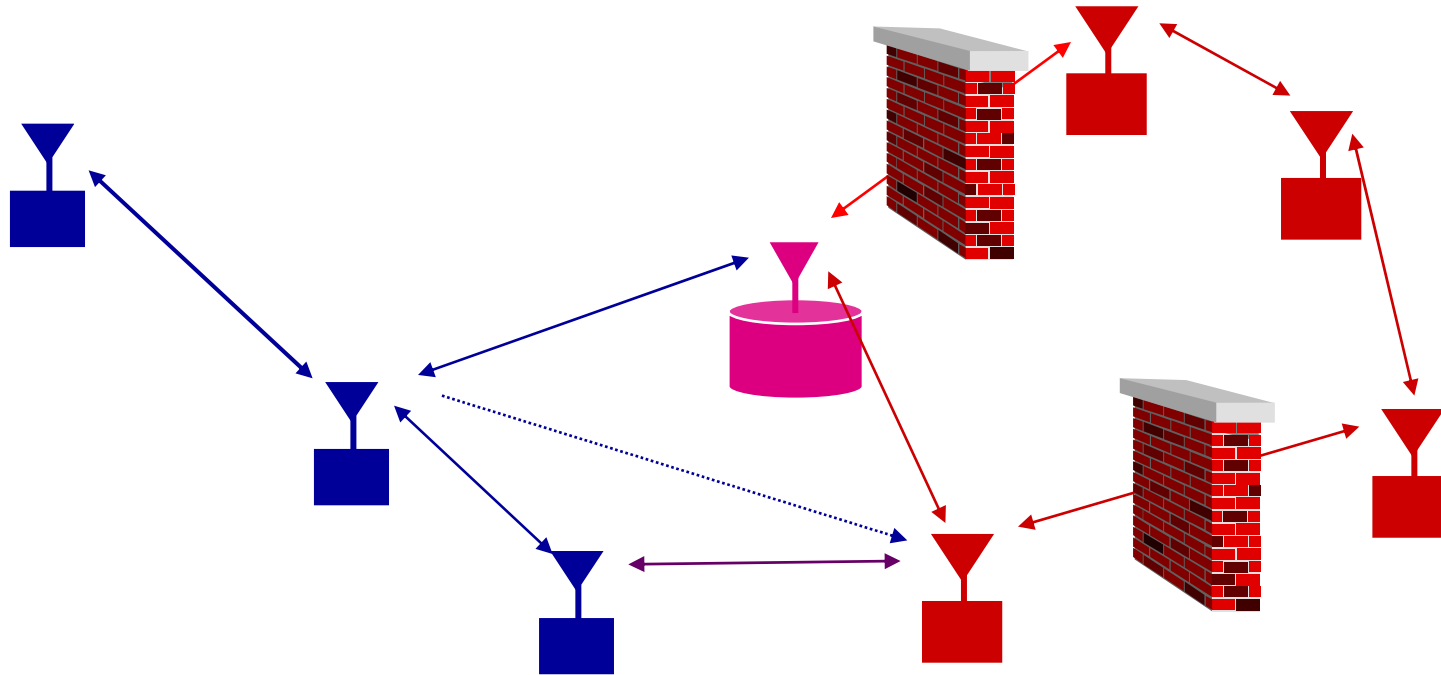
- There is a current movement to change the way the FCC allocates spectrum
- Tremendous amounts of spectrum could be made available for spectrum-agile radios
- Technology and policy barriers:
 - Developing very wideband frequency-agile radios
 - Real-time identification of spectrum “holes”
 - Coordination among multiple users
 - Changes in spectrum allocation policy

Wireless Propagation

- Received power diminishes with distance.
- Self-interference due to multipath (fast fading, ISI).
- Channel changes randomly as users move around.
- Signal blocked by objects (cars, people, etc.).
- Broadcast medium – everyone interferes.



Identifying Spectrum Holes



Interference between users depends on link path loss, shadowing, fast fading, and carrier frequency

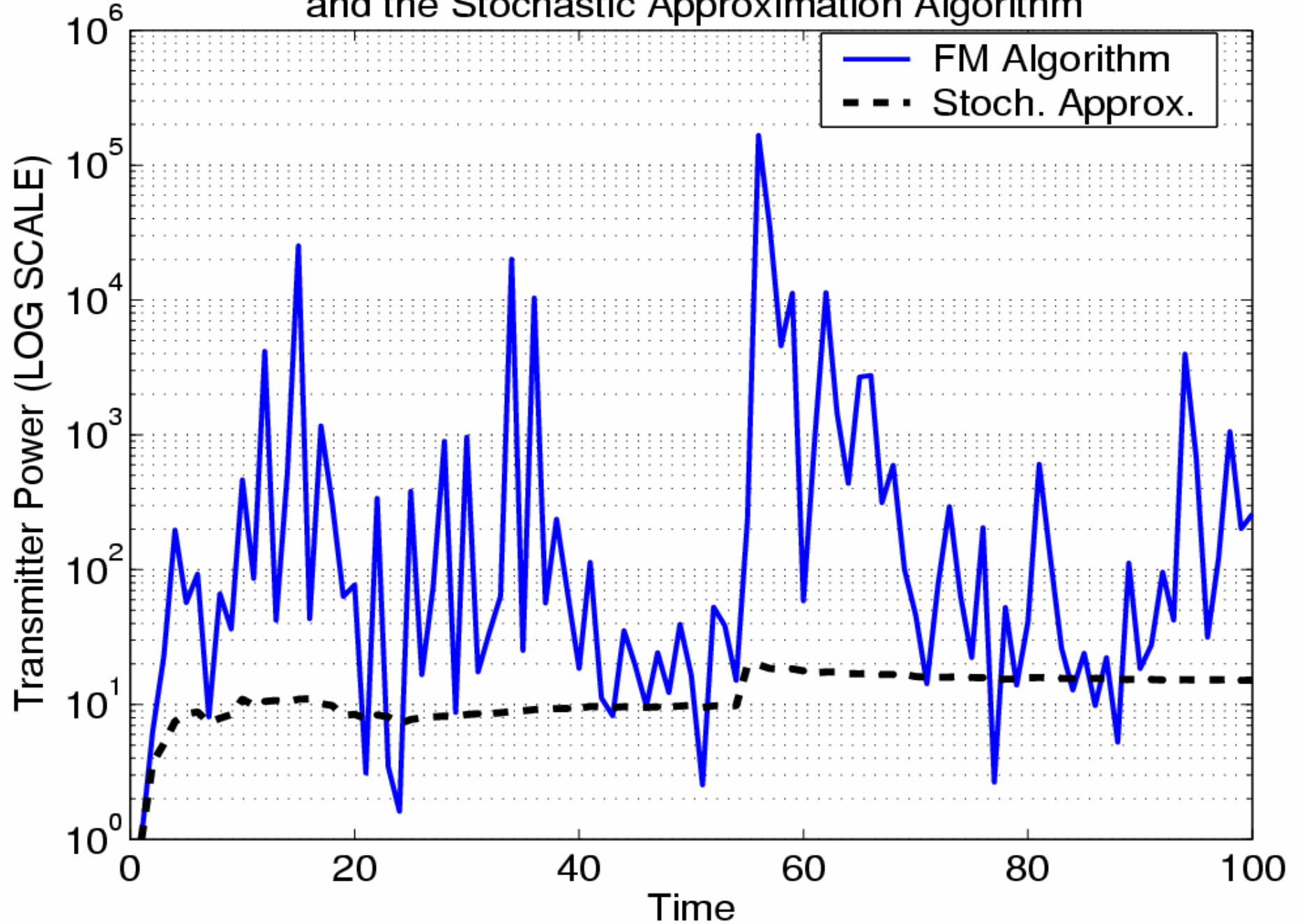
Hard to determine interference between devices in a dynamic and distributed fashion

Measuring interference:

Common Myths

- A device can determine the interference it causes to other devices
- Interference can be treated as noise
- Power control can maintain a fixed SINR among all devices

Fig 1: Transmit Power of the Standard Foschini–Miljanic Algorithm and the Stochastic Approximation Algorithm



Spectrum Coordination

- Spectrum holes must be found between two or more users.
- Users must agree on which spectrum to use
- Changes in interference must be adapted to
- Spectrum coordination for broadcasting and multicasting poses unique challenges

Policy Changes

- The current system of spectrum allocation is highly inefficient *in some cases*
 - There are many ways to improve spectrum efficiency
- UWB spectrum opened the door for new thought process on spectrum allocation
- Entrenched users/operators will resist change
- There is a need for both licensed and unlicensed spectrum allocations
- Spectrum policy and technology advances should be intertwined

Software Radios

- Solution to standards proliferation
- Basic concept:
 - Wideband front end
 - Baseband conversion and processing
- Implementation challenges
 - A/D limitations
 - DSP requirements
 - Performance
 - Cost
 - Energy consumption

Summary

- Sensing the environment can improve wireless system performance
- Tremendous opportunities and challenges for spectrum-agile radios
- Policy changes needed, but not clear what these should be
- Software-radios go beyond cognition: may not be competitive on cost and power consumption