Signals & Spectrum and Relay Communications

Steve McLaughlin

IDCOM, School of Engineering & Electronics
• Signals and Spectrum
  – Signals generated by Nonlinear/Nonstationary mechanisms

• Communications
  – How to do so efficiently
  – Cross-layer optimisation issues
Classes of Nonlinear Phenomena

Pipistrellus Pygmaeus
Spectrograms
Instantaneous Frequency
Derivation and Understanding

\[ x(t) = A_1(t) \cos(\omega_1 t) + A_2(t) \cos(\omega_2 t) \]

\[ A(t) = \sqrt{A_1^2(t) + A_2^2(t) + 2A_1(t)A_2(t) \cos(\omega_2 - \omega_1)t} \]

\[ \omega(t) = \omega_1 + \frac{(\omega_2 - \omega_1)[A_2^2(t) + 2A_1(t)A_2(t) \cos(\omega_2 - \omega_1)t]}{A^2(t)} \]

IF deviates from conventional notion of spectral frequency when:
- DC component
- Riding waves
- Many components, large frequency differences, high amplitudes.
Techniques

Cascade of adaptive predictors

Empirical Mode Decomposition

Dynamical System Approaches
Relay Communications

1. Amplify and Forward
   - Amplify and Transmit received signal/noise

2. Decode and Forward
   - Decode packet, re-encode and transmit
**Optimization Problem**
- Selection of the intermediate router (NET)
- Selection of the final destination (MAC)
- Selection of the relays (PHY)

⇒ Three layer optimisation problem

**Optimization Criteria**
- Channel-based selection
- Long-term fairness
- Complexity overhead

**Optimization Results**
- Performance optimization
- Same power consumption on all routes
- Minimization of required feedback
• Relay techniques involve genuine cross-layer optimisation of data transmission, scheduling and routing

• Research is investigating methods for:
  – Scheduling and Resource Allocation for Relay Networks
  – Optimum power allocation schemes for Relay Networks
  – Simplified routing schemes for low power Networks
  – Concurrent relaying to improve spectral efficiency