Signals & Spectrum and Relay Communications

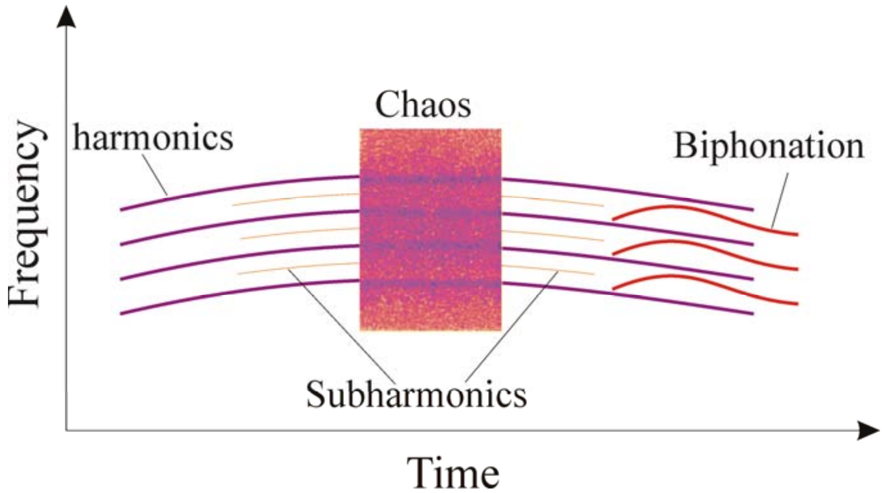
Steve McLaughlin

IDCOM, School of Engineering & Electronics

Steve McLaughlin

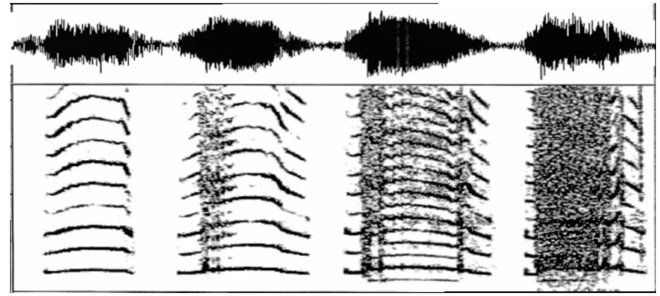
- Signals and Spectrum
  - Signals generated by Nonlinear/Nonstationary mechanisms
- Communications
  - How to do so efficiently
  - Cross-layer optimisation issues

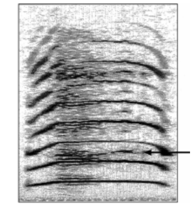
Classes of Nonlinear Phenomena



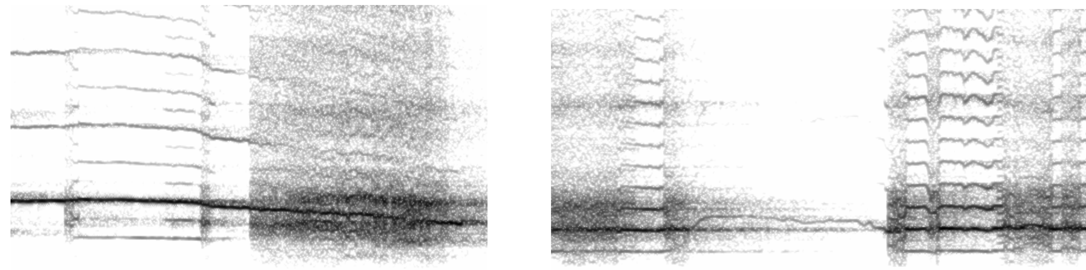
W. Tecumseh Fitch, “Calls out of chaos: the adaptive significance of nonlinear phenomena in mammalian vocal production”, Animal Behaviour, 2002

Macaque

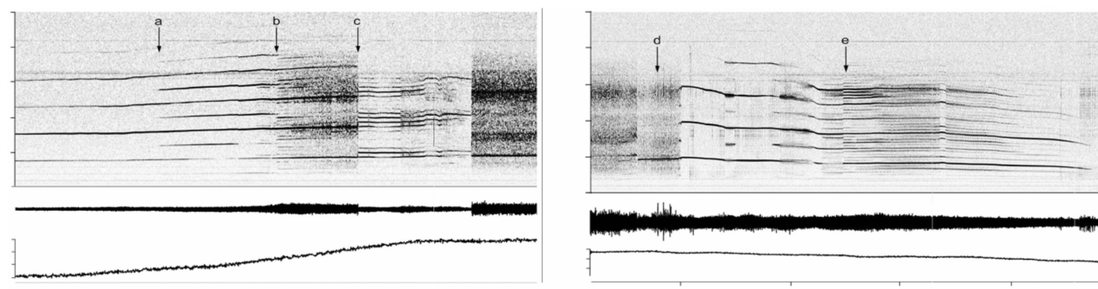




Fatima Miranda



Amolops tormotus



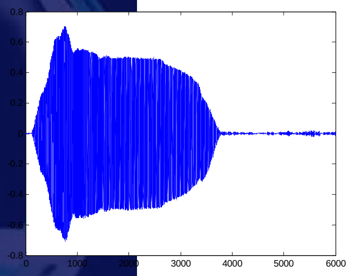
W. Tecumseh Fitch et al, “Calls out of chaos: the adaptive significance of nonlinear phenomena in mammalian vocal production”, Animal Behaviour, 2002

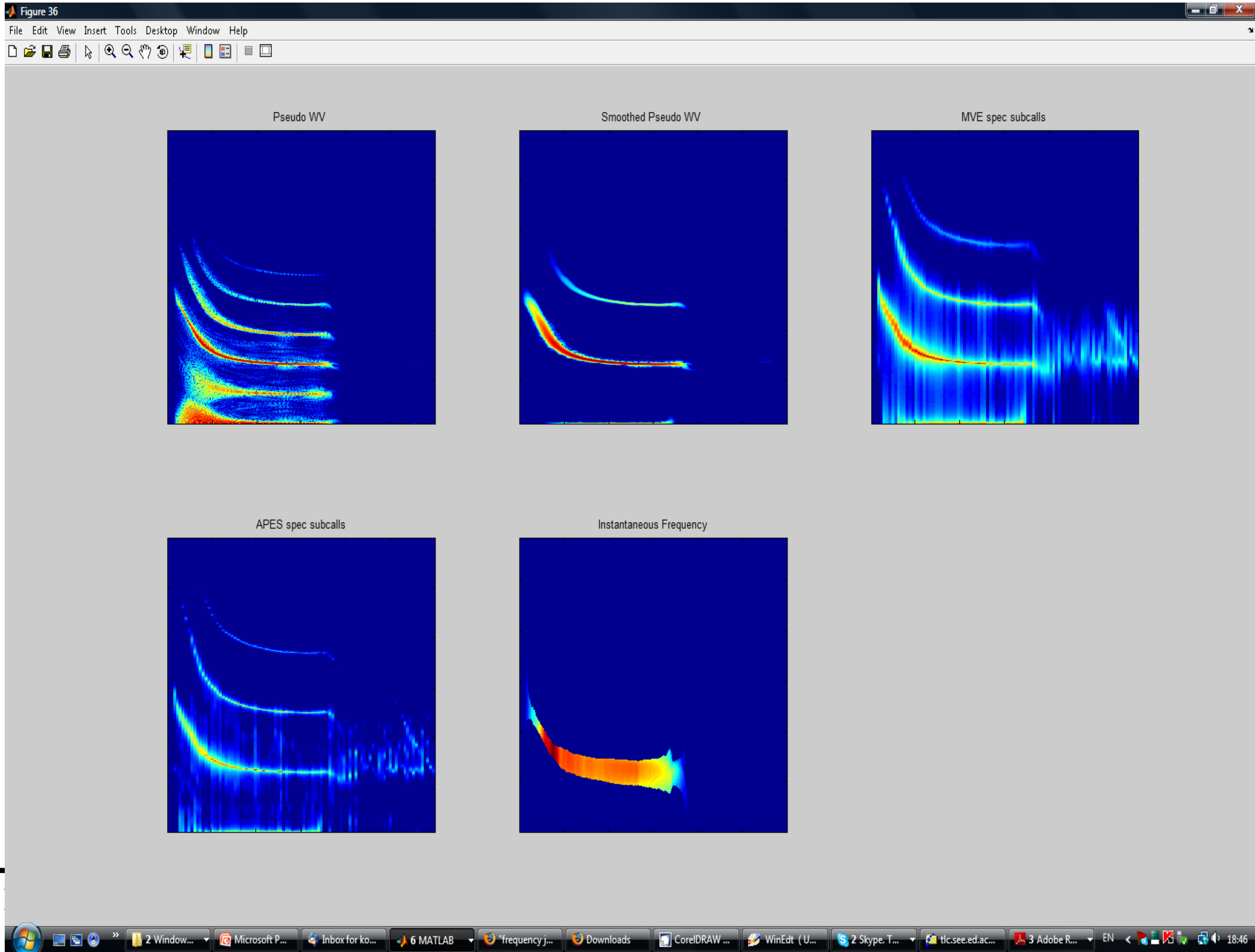
J. Neubauer et al, “Nonlinear phenomena in contemporary vocal music,” Journal of Voice (2003)

P. M. Narins et al, “Old World frog and bird vocalizations contain prominent ultrasonic harmonics,” J. of Acoustic. Soc. Amer. 2004,

R. A. Suthers et al, “Voices of the dead: complex nonlinear vocal signals from the larynx of an ultrasonic frog,” Journal of Experimental Biology, 2006.

Pipistrellus Pygmaeus Spectrograms





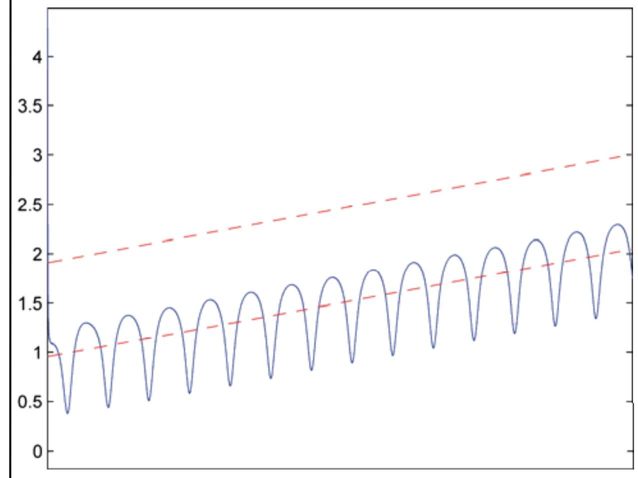
Instantaneous Frequency

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

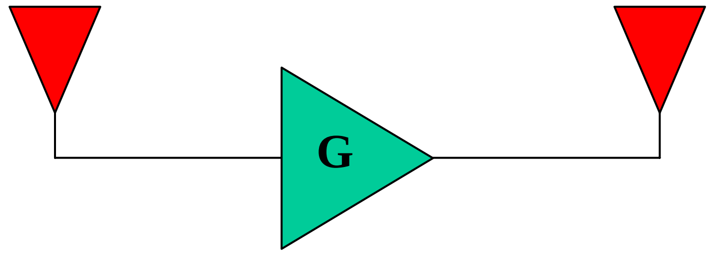
Cascade of adaptive predictors

Empirical Mode Decomposition

Dynamical System Approaches

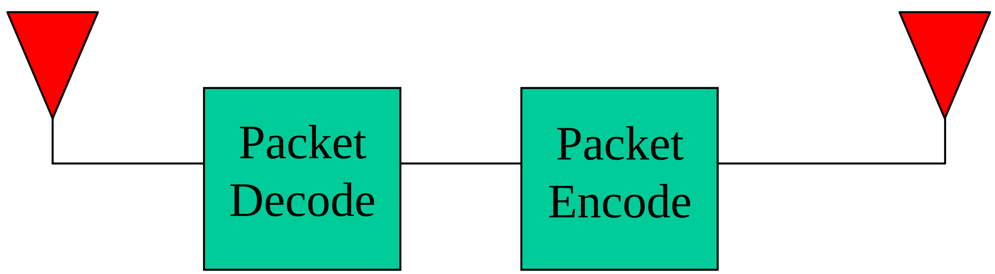
Relay Communications

- 1. Amplify and Forward



  - Amplify and Transmit received signal/noise

- 2. Decode and Forward



  - Decode packet, re-encode and transmit

Cross-layer and AF

Optimization Problem

- Selection of the intermediate router **(NET)**
- Selection of the final destination **(MAC)**
- Selection of the relays **(PHY)**

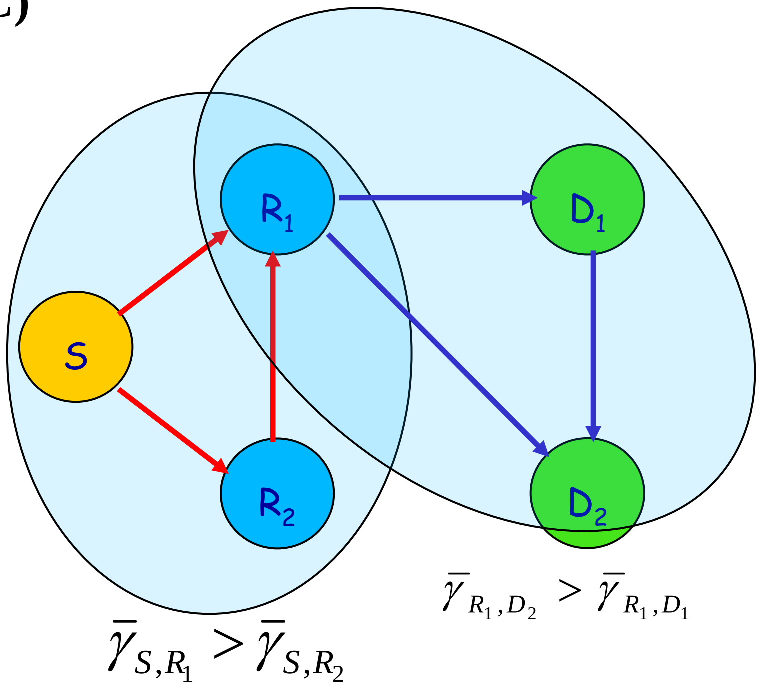
$\Rightarrow$ **Three layer optimisation problem**

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