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Wireless Overview

Prof. Frank Cassara

CATT Wireless Activities

- OFDM Projects-Profs. Voltz, Lu, and Cassara
- Radar Intermodulation Problem –Prof. Lu
- Wireless Networking Projects- Prof. Panwar

OFDM Background and Motivation

- Future generation wireless communication systems must be able to support high data rate communications
- Symbols with short durations received thru a multipath channel experience ISI-complex equalizer required
- Alternative is to use higher order modulations-but they require higher transmitter power to maintain BER
- To keep symbol duration larger than channel delay spread we employ Orthogonal Frequency Division Multiplexing (OFDM)

OFDM Background and Motivation

- In OFDM high speed serial data is first converted into many parallel streams each of which operates at a much lower rate
- Each parallel stream then modulates its own subcarrier by means of the inverse FFT
- Subcarriers are designed to be orthogonal and overlap each other in the frequency domain to maximize spectral efficiency
- OFDM can support high data rates with little or no ISI by inserting a cyclic prefix or guard interval

OFDM in Fast and Selective Rayleigh Fading Channels- Choi, Voltz, and Cassara

- In slow fading FFT is numerically efficient method for extracting data from the orthogonal subcarriers
- In fast fading orthogonality is destroyed resulting in ICI
- Choi estimates data in time domain from received signal using MMSE with successive detection
- Choi exploits the time varying multipath fading channel as a time and frequency diversity source to achieve capacity improvement

OFDM MIMO Systems

- **Frequency Domain Sample Timing Correction**
  - Clocks used in the OFDM transmitter's DAC and receiver's ADC do not have exactly same period
  - Sampling instants slowly shift with respect to each other Loss of subcarrier orthogonality introduces ICI
  - Novel frequency domain re-sampler developed with lower complexity than competing designs

P. Voltz, H. Teng, I.T. Lu, Y. Yang, R. Olesen, "Frequency Domain Re-Sampler for Clock Sampling Offset in MIMO OFDM Systems," VTC 2006.

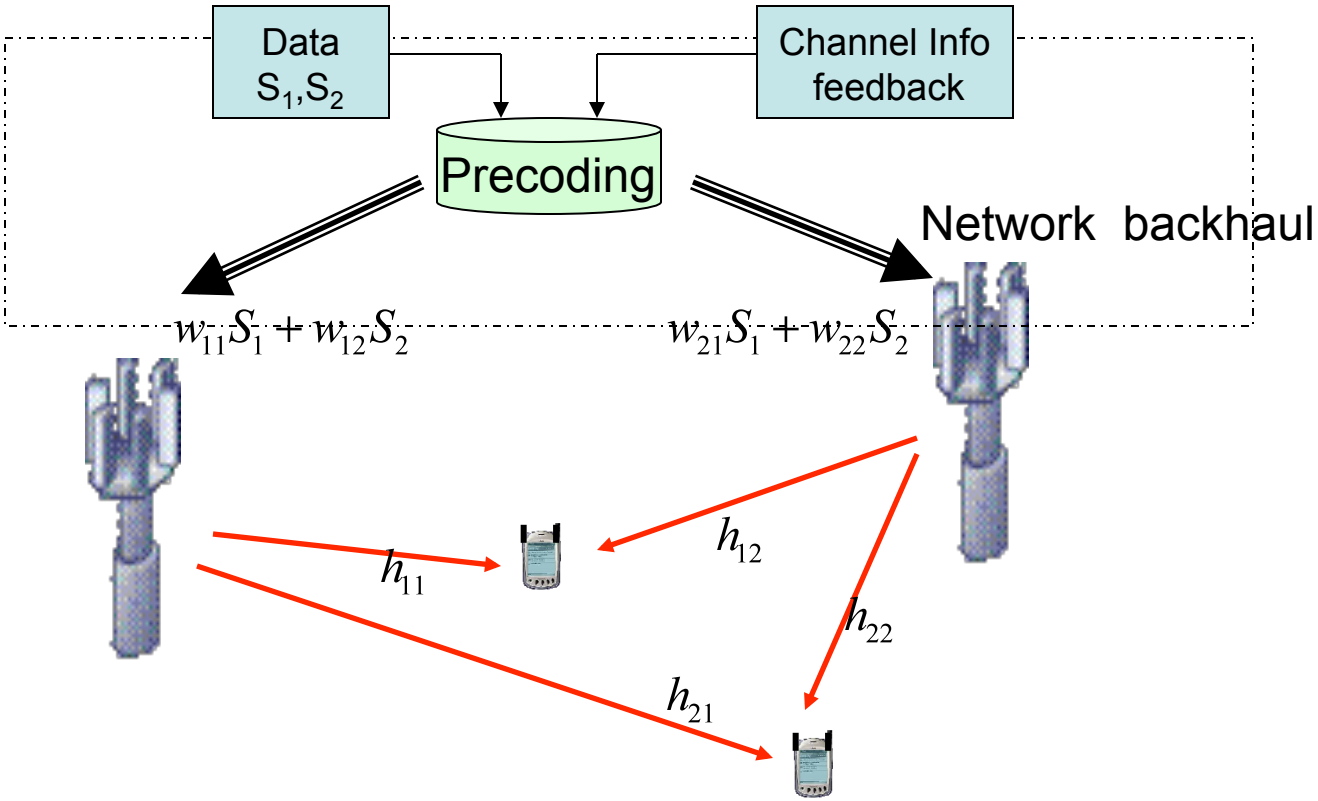
OFDM MIMO Systems

- **Model Based Channel Estimation**
  - Channel estimation based upon pilot symbols
  - Can estimate subcarrier frequency domain channel directly
  - Alternatively can estimate multipath time delays using the MODE technique, and then calculate frequency domain channel
  - The alternative technique shows significant gains in sparse channel case

OFDM MIMO Systems (P. Voltz)

- **Calibration for Reciprocity in TDD Systems**
  - In TDD MIMO systems channel between transmitter and receiver antenna arrays is reciprocal
  - Effective channel modified by transmit and receive RF chains and reciprocity lost
  - Calibration matrix can be inserted at either end of channel to restore the reciprocity
  - New techniques were developed to compute this calibration matrix

Multi-cell MIMO for LTE-A

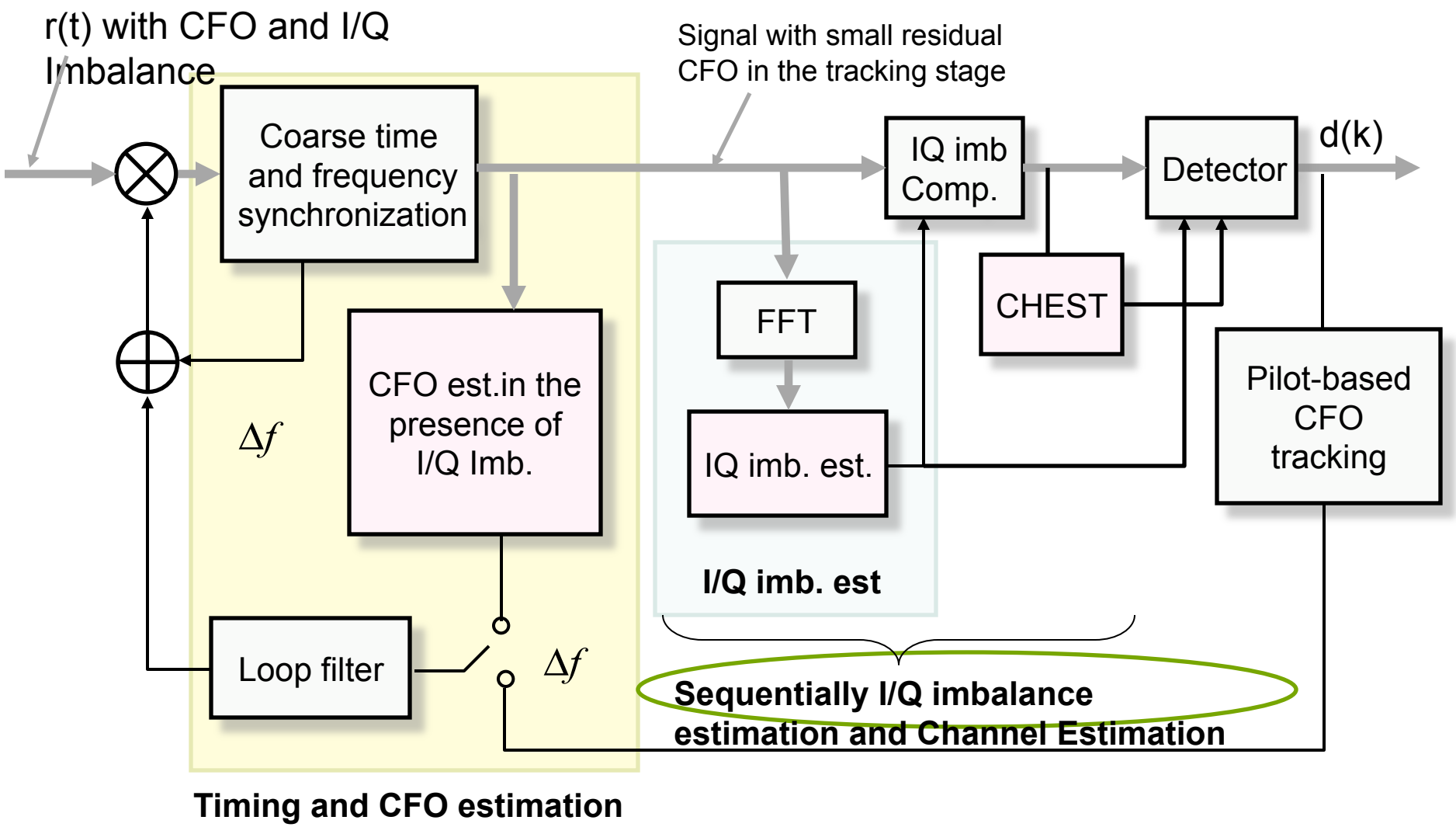


- Less co-channel interference, but more signaling
- Better cell edge performance
- Disadvantages:
  - Increase uplink feedback overhead
  - Synchronization to more than one cell

Zero forcing example:

$$\begin{bmatrix} w_{11} & w_{12} \\ w_{21} & w_{22} \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{bmatrix}^{-1}$$

Carrier Frequency Offset (CFO) and I/Q Imbalance



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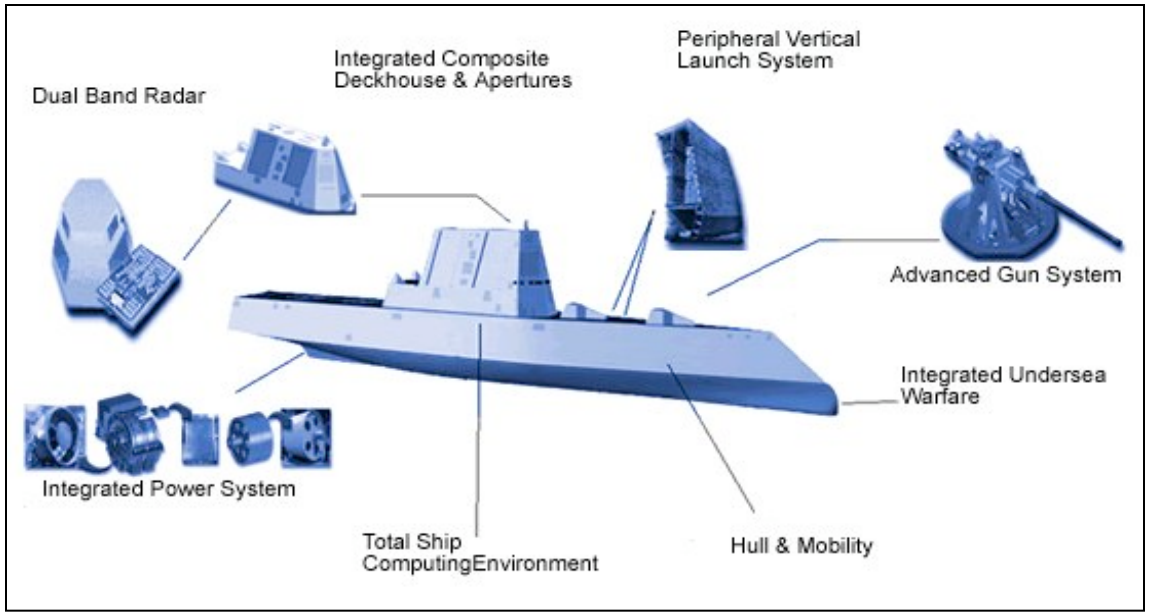
Radar Intermodulation Problem

Prof. I-Tai Lu

Intermodulation Problem Naval Ship Applications

Intermodulation, or third-order products, is one of the byproducts of large interfering signals which are incident upon a receive antenna, along with the signal of interest.

Intermodulation on Phased Array



Interfering signals arrive at the receiver phased array with different angles and different frequencies creating unwanted signals at particular frequencies which can lead to false targets and in turn degrade the performance of the radar receiver.

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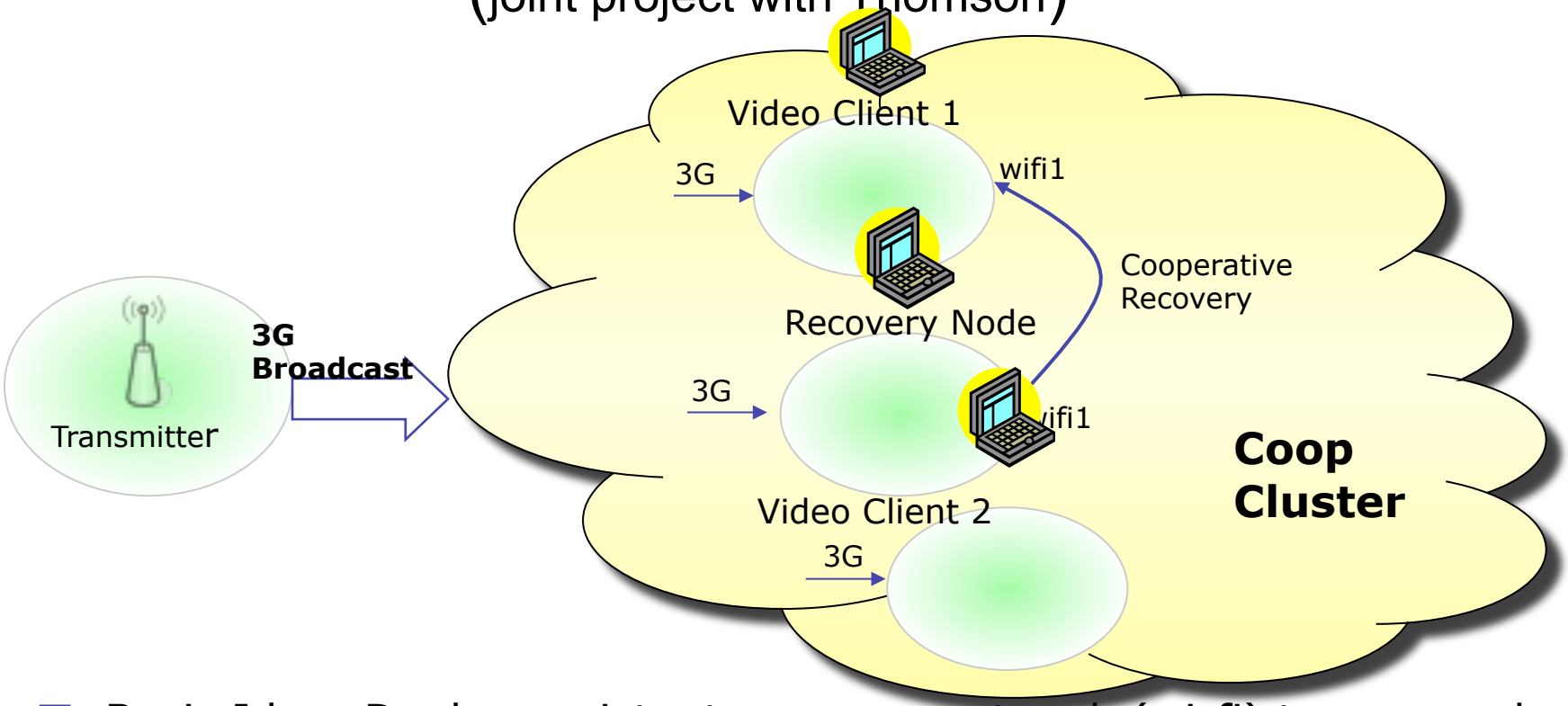
Wireless Networking Project

Prof. Shiv Panwar

Cooperative Recovery in Heterogeneous Networks

(joint project with Thomson)



- Basic Idea: Deploy assistant recovery network (wi-fi) to recover loss of multicast/broadcast data in principal network (3G).

- We studied cooperative recovery by simulating protocol in OPNET and currently we are implementing it over Net socket programming.

Contact Info

- Prof. F. Cassara (cassara@rama.poly.edu)
- Prof. I-Tai Lu (itailu@rama.poly.edu)
- Prof. S. Panwar (panwar@catt.poly.edu)
- Prof. P. Voltz (voltz@rama.poly.edu)