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Title

Multihop Sensing and Communication Networks (SEN 5)

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Multihop Sensing and Communication Networks

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Introduction: Communicate and estimate variables intrinsic to given network

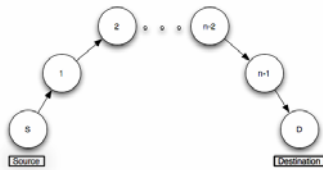
Standard Sensor Networks

- Detect and estimate variables extrinsic to given network
- Communication and estimation are *not coupled* - An optimal communication scheme can be used with an optimal estimation scheme to yield best results

Proposed Sensor Network System Model

- Variables of interest are intrinsic to the given network
 - Example: Channel impulse responses between nodes
- Communication and estimation are *coupled* - One needs poor communication schemes to generate good estimates and vice versa

Problem Description: Minimize sum distortion of channel estimates at the destination



An n-hop Linear Topology

Measure the fidelity of the estimate by : $D_i = \mathbb{E}[|\hat{h}_{i,d} - h_i|^2]$

Also define the distortion diversity by : $d : \lim_{\forall_j \text{SNR}_j \rightarrow \infty} D_i = \Theta(\text{SNR}_i^{-d})$

Assumptions

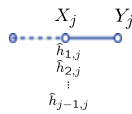
- Time orthogonal communication - one node “Talks” at each point in time
- Block Fading channels with independent, Gaussian channel coefficients and noise

Problem Statement Minimize $D = \sum_{i=1}^n D_i$ given a fixed total time T

Proposed Solution: Employ either Estimate-and-Forward or Amplify-and-Forward

Overview of Results

Estimate and Forward



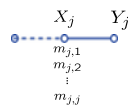
$$X_j = \sqrt{P_j} f_j(\hat{h}_{1,j}, \dots, \hat{h}_{j-1,j}), t \in I_j$$

$$Y_j = h_j X_j + Z_{j+1}, t \in I_j$$

Final Result: The achievable distortion diversity for hop j given the Estimate and Forward scheme is upper bounded by

$$r_i = \min_{j>i} \frac{T_j}{T}$$

Amplify and Forward



$$X_j^i = \sqrt{P_j} \beta_j^i m_{j,i}, t \in I_j^i$$

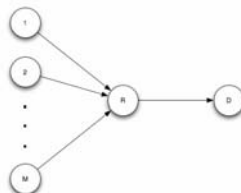
$$Y_j = h_j X_j + Z_{j+1}, t \in I_j^i$$

Where $m_{j,i}$ a sufficient statistic

$$m_{j,i} = \int_{I_j^i} y_j dt$$

Final Result: The achievable diversity for the Amplify and Forward scheme is upper bounded by 1

Building Towards Arbitrary Topologies



Final Result: Time domain multiple access is one of the optimal communication schemes for the first hop in a two hop tree network

Figures

