Discrete Time Received Signal

Motivation

Why hybrid beamforming systems with low-resolution ADCs?
• Propagation losses are high in millimeter wave bands
• Large-scale antenna arrays are needed to compensate the losses
• High-speed ADCs with high resolution are power-demanding
  ➔ We reduce power consumption by using
  a hybrid beamforming architecture and low-resolution quantizers

Channel estimation is challenging
• Conventional algorithms need significant training overhead
• Hybrid beamformers give only indirect access to channels
• Low-resolution ADCs distort training signals
  ➔ We propose a compressed sensing algorithm

Generalized Approximate Message Passing (GAMP)
• Compressed sensing for nonlinear observations of a sparse signal
  ➔ We modify one-bit GAMP for channel estimation which outperforms other variants of GAMP & least squares channel estimator

Numerical Results

One-bit GAMP vs. Others
• One-bit GAMP outperforms with or without leakage effects
• Leakage degrades performance of all algorithms
• Conventional LSE performs far worse than GAMP variants
• Higher SNR does not necessarily yield better performance

System & Channel Models

Baseband Precoder
DAC
RF Chain
Baseband
Precoder
DAC
RF Chain
RF Precoder
RF Chain
RF Chain
ADC
DAC
RF Chain
RF Chain
ADC
Sparse Channel Vector
Sensing Matrix
Dictionary

Algorithm 1 One-bit GAMP

1. Initialize:
   \[ t = 0, \beta_t^0 = E[h_0], \gamma_t^0 = \text{Var}[h_0], \delta^t = 0, \]
2. for \( t = 1, \ldots, T \)
do
   Measurement update:
   \[ \gamma_{t+1}^k = \frac{\gamma_t^k + \omega_k}{\delta_t + 1}, \]
3. for all \( i \)
do
   \[ \gamma_{t+1}^i = \frac{\gamma_t^i + \omega_i}{\delta_t + 1}, \]
4. for all \( i \)
do
   \[ \beta_{t+1}^i = \frac{\beta_t^i + \omega_i}{\delta_t + 1}, \]
5. for all \( i \)
do
   \[ \delta_{t+1}^i = \frac{\delta_t^i + \omega_i}{\delta_t + 1}, \]
6. end for
7. end for

Application Details

Simulation Details
• 64Tx ant., 16Rx ant.
• 4Tx and 4Rf RF chains
• 2 channel paths
• 64 frames

Simulation Results
• Baseband simulation
• GAMP, EM-GM-GAMP and LSE evaluated
• 1-bit resolution ADCs
• NMSE used as performance metric

Conclusion
• Proposed a modified one-bit GAMP for channel estimation for hybrid beamforming systems with one-bit ADCs
• One-bit GAMP outperforms other GAMP variants and LSE
• More frames and RF chains enhance estimation performance

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