Journal Watch

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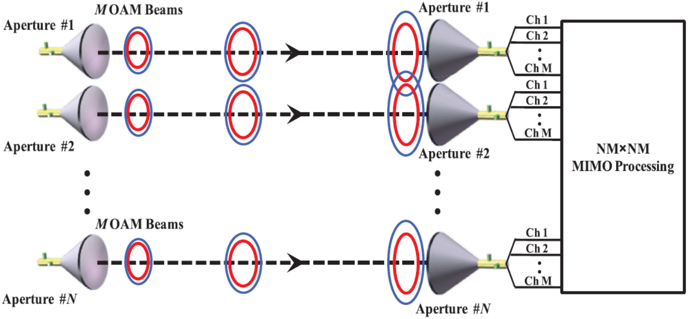
1. Line-of-Sight Millimeter-Wave Communications Using Orbital Angular Momentum Multiplexing Combined With Conventional Spatial Multiplexing

Authors: Yonsieng Ren, Long Li, Guodong Xie, Yan Yan,Yinwen Cao, Hao Huang, Nisar Ahmed, Zhe Zhao, Peichang Liao, Chongfu Zhang, Giuseppe Caire, Andreas F, Molisch, Moshe Tur, Alan E. Willner

Goal: Enhance system capacity given a fixed aperture area of transmitter/receiver.

- Common approach is to use conventional spatial multiplexing for which interchannel crosstalk is reduced by employing MIMO signal processing at the receivers.
- Another approach is to use OAM which employs orthogonality among OAM beams to minimize interchannel crosstalk and enable efficient multiplexing.
- The combination of these two approaches can potential enhance system capacity.

1. System Model



$$y_i = \sum_{j=1}^{N} h_{i,j} x_j + n_i$$

1.Contd.

$$H = \begin{bmatrix} h_{1,1} & h_{1,2} & \dots & h_{1,N} \\ h_{2,1} & h_{2,2} & \dots & h_{2,N} \\ \vdots & \vdots & \dots & \vdots \\ h_{N,1} & h_{N,2} & \dots & h_{N,N} \end{bmatrix}_{NM \times NM}$$

- $h_{i,j}$ is an $M \times M$ matrix denoting the transfer function between OAM channels from aperture T_j to R_i.
- The capacity of an LOS MIMO system in bits/Hz, is given by

$$C = \sum_{i=1}^{\gamma} log_2(1 + \lambda_i P_i/\sigma^2)$$

2. Initial Beam Association in Millimeter Wave Cellular Systems: Analysis and Design Insights

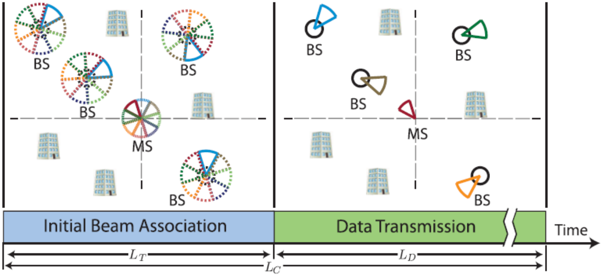
Authors: Ahmed Alkhateeb, Young-Han Nam, Md. Saifur Rahman, Jianzhong Zhang and Robert W. Heath

Goal: Evaluation of mmwave cellular network performances while accounting for the beam training/association overhead.

- We will derive a metric effective reliable rate for the study of beam training overhead.
- Using stochastic geometry, the effective rate of mmwave cellular networks is derived for two special cases:-
  1.Near orthogonal pilots
  2.Full pilot reuse.
- The results show that unless the employed beams are very wide, initial beam training with full pilot reuse is nearly as good as perfect beam alignment.

2. Beam Training and Association Model

$$H_l = \sqrt{\rho_l}\beta_l a_{MS}(\theta_l) a^*_{BS}(\phi_l)$$



- L_C = number of symbols that can be transmitted within the time frequency coherence block.
- L_T, L_D = number of symbols for the training overhead and transmitted data. So, we can write

$$L_C = L_T + L_D$$

2. Coverage and Rate

For Near Orthogonal Pilots,

- SINR Coverage

$$P_c^{Orth}(T) \approx \mathbb{P}\left(\frac{P_T G_{BS} G_{MS} h_0 \rho_0}{\sum_{l:X_l \in \phi m(\lambda), l \neq 0} P_T h_l \rho_l G_{MS} D_{BS}^l(n) + \sigma^2} > T \right)$$

- Effective Achievable Rate

$$\begin{aligned} R_{\mathrm{eff}} = & \left(1 - \frac{\pi \lambda R_{\mathrm{I}}^2 N_{\mathrm{BS}} N_{\mathrm{MS}}}{L_{\mathrm{C}}}\right)^{+} \\ & \times \left[\frac{1}{\ln(2)} \int_{T_{\mathrm{th}}}^{T_{\max}} \frac{P_{\mathrm{c}}^{\mathrm{Orth}}(y)}{y+1} dy \right. \\ & \left. + \log_2\left(1 + T_{\mathrm{th}}\right) P_c^{\mathrm{Orth}}\left(T_{\mathrm{th}}\right) \right]. \end{aligned}$$

2. Coverage and Rate

For Full Pilot Reuse,

- Effective Achievable Rate

$$R_{\mathrm{eff}} = \left(1 - \frac{N_{\mathrm{BS}} N_{\mathrm{MS}}}{L_{\mathrm{C}}}\right)^{+} \left[\frac{1}{\ln(2)} \int_{y=T_{\mathrm{th}}}^{T_{\max}} \frac{P_{\mathrm{c}}^{\mathrm{Reused}}(y)}{y+1} dy + \log_2\left(1 + T_{\mathrm{th}}\right) P_{\mathrm{c}}^{\mathrm{Reused}}\left(T_{\mathrm{th}}\right)\right]$$

Conclusions

With narrow beams, the SINR penalty is low while the resource overhead is relatively high.
Full pilot reuse an yield better reliable rate in mmWave cellular systems.

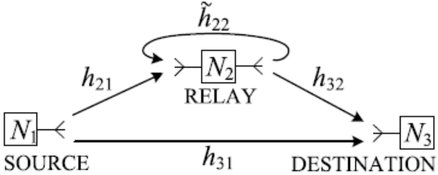
3. Spectral Efficiency and Relay Energy Efficiency of Full-Duplex Relay Channel

Authors: Zhengchaun Chen, Tony Q.S. Quek, Ying-Chang Liang

Goal: Bounds on the spectral efficiency of full-duplex relay channel with decode-forward(DF) relaying, compress-forward(CF) relaying, and amplify forward(AF) relaying in the presence of residual self-interference.

- Due to residual self interference (RSI), increase of the relay power doesn't always contribute to Spectral efficiency(SE) environment.
- Bounds on the relay energy efficieny are presented for different schemes, which are useful for system design under pre-node energy efficiency constraint.

3. System Model



$$Y_2 = h_{21}X_1 + \tilde{h}_{22}\tilde{X}_2 + Z_2,$$
$$Y_3 = h_{31}X_1 + h_{32}X_2 + Z_3.$$

- X_i and Y_j represent the complex baseband signal transmitted at N_i and received at N_j respectively.
- $\tilde{h}_{22}X_2$ is the RSI, where $\tilde{X}_2$ is a random variable with the same variance of X_2.
- Without employing the relay , the system achieves the direct transmission SE in bits/s/Hz is given as $C(S_{ij}) := log_2(1 + S_{ij})$

3. SE and REE for different relay schemes

- $S_{ji} = |h_{ji}|^2 P_i$.
- relay strength, $\eta_1 = \frac{S_{21}}{S_{31}}$
- RSI strength, $\eta_2 = \frac{|\tilde{h}_{22}|^2 P_2}{S_{32}}$
- DF scheme

$$R_{\mathrm{DF}}(S_{32}) = \min\left\{\mathcal{C}(S_{31} + S_{32}),\, \mathcal{C}\left(\frac{S_{21}}{\eta_2 S_{32} + 1}\right)\right\}$$

$$Q_{\mathrm{DF}}(P_2) = \frac{[R_{\mathrm{DF}}(S_{32}) - \mathcal{C}(S_{31})]}{P_2} = \frac{1}{P_2}\mathcal{C}\left(\frac{|h_{32}|^2 P_2}{1+|h_{31}|^2 P_1}\right)$$

3. Contd.

- CF scheme

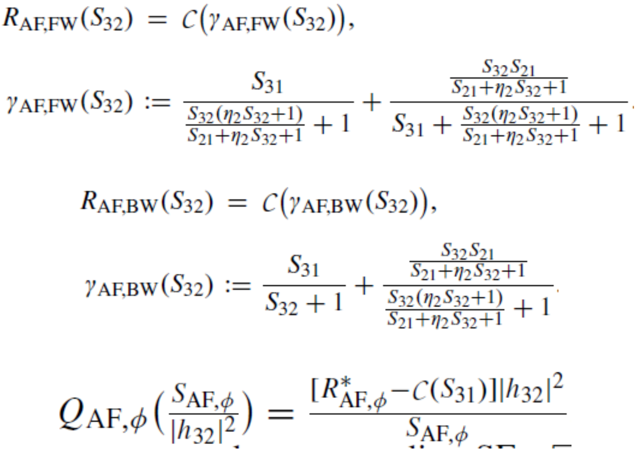
$$R_{\mathrm{CF}}(S_{32}) = \mathcal{C}(\gamma_{\mathrm{CF}}(S_{32})),$$

$$\gamma_{\mathrm{CF}}(S_{32}) := S_{31} + \frac{\frac{S_{21}S_{32}}{\eta_2 S_{32}+1}}{\frac{S_{21}}{\eta_2 S_{32}+1} + S_{31} + S_{32} + 1}.$$

$$Q_{\mathrm{CF}}\left(\frac{S_{\mathrm{CF}}}{|h_{32}|^2}\right) = \frac{[R^{\star}_{\mathrm{CF}} - \mathcal{C}(S_{31})]|h_{32}|^2}{S_{\mathrm{CF}}} = \frac{\mathcal{C}\left(\frac{S_{21}}{[2\sqrt{(1+S_{21}+S_{31})\eta_2}+\eta_2(S_{31}+1)+1](1+S_{31})}\right)|h_{32}|^2}{\sqrt{(1+S_{21}+S_{31})/\eta_2}}$$

3. Contd.

- AF scheme



$$R_{\mathrm{AF,FW}}(S_{32}) = C(\gamma_{\mathrm{AF,FW}}(S_{32})),$$

$$\gamma_{\mathrm{AF,FW}}(S_{32}) := \frac{S_{31}}{\frac{S_{32}(\eta_2 S_{32}+1)}{S_{21}+\eta_2 S_{32}+1}+1} + \frac{\frac{S_{32}S_{21}}{S_{21}+\eta_2 S_{32}+1}}{S_{31}+\frac{S_{32}(\eta_2 S_{32}+1)}{S_{21}+\eta_2 S_{32}+1}+1}.$$

$$R_{\mathrm{AF,BW}}(S_{32}) = C(\gamma_{\mathrm{AF,BW}}(S_{32})),$$

$$\gamma_{\mathrm{AF,BW}}(S_{32}) := \frac{S_{31}}{S_{32}+1} + \frac{\frac{S_{32}S_{21}}{S_{21}+\eta_2 S_{32}+1}}{\frac{S_{32}(\eta_2 S_{32}+1)}{S_{21}+\eta_2 S_{32}+1}+1}.$$

$$Q_{\mathrm{AF},\phi}\left(\frac{S_{\mathrm{AF},\phi}}{|h_{32}|^2}\right) = \frac{[R^*_{\mathrm{AF},\phi} - C(S_{31})]|h_{32}|^2}{S_{\mathrm{AF},\phi}}$$

Other interesting papers

- Ergodic spectral efficiency in MIMO cellular networks.
- Energy and spectral efficiency of cellular networks with discontinous transmission.
- Full-Duplex MIMO in cellular networks:System-Level Performance
- Capacity Bounds for the gaussian IM-DD Optocal Multi-Access Channel