EECS Electrical Engineering & Computer Sciences

Wireless Foundations

College of Engineering, UC Berkeley

Functional Forwarding of Channel State Information

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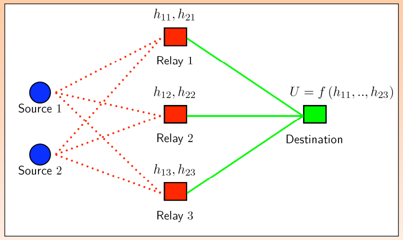
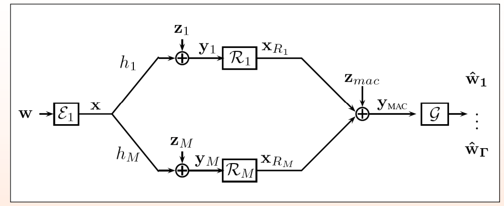
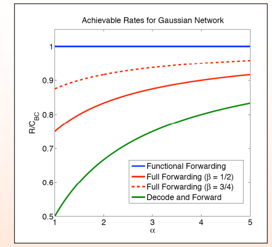
Relay Channels with Local CSI



- channel state information needs to be forwarded to the destination
- full forwarding is expensive
- a function of the channel state information may be sufficient
- forwarding a function of the data is much more efficienet than forwarding the full data [Nazer, Gastpar 07]

Example 1: Gaussian Network





Relays observations: $\mathbf{y} = \mathbf{h}x + \mathbf{z}$

Sufficient statistic: $\mathbf{h}^*\mathbf{y} = \|\mathbf{h}\|^2 x + \tilde{z}$

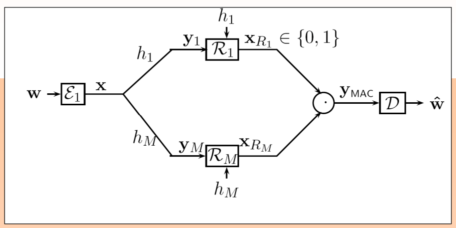
Desired function of CSI: $\|\mathbf{h}\|^2$

Relays Forward Sufficient Statistics: $U_1 = \mathbf{h}^*\mathbf{y}$, $U_2 = \|\mathbf{h}\|^2$

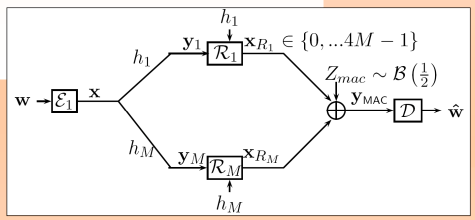
optimal in scaling regime

Example 2: Binary Network

Multiplying MAC



Mod 4M Adder MAC



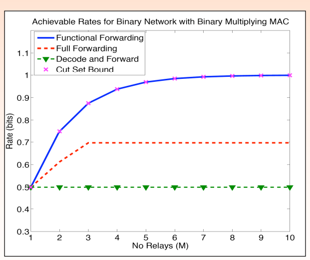
Relays Observations: $\mathbf{y} = \mathbf{h}x$

Sufficient Statistics: $y_1 \vee y_2 \cdots \vee y_M$

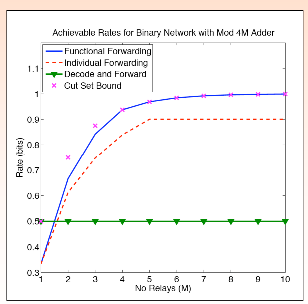
Desired function of CSI: $h_1 \vee h_2 \cdots \vee h_M$

Relays forward the sufficient statistics $U = (U_1, U_2)$

$$U_1 = y_1 \vee \cdots \vee y_M \qquad (1)$$
$$U_2 = h_1 \vee \cdots \vee h_M$$

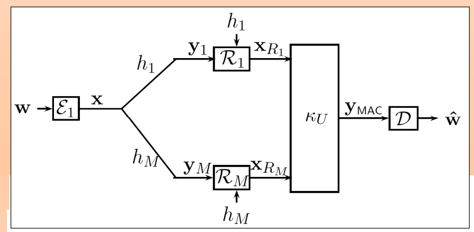


exactly optimal when channel matches sufficient statistic



gain even in unmatched case

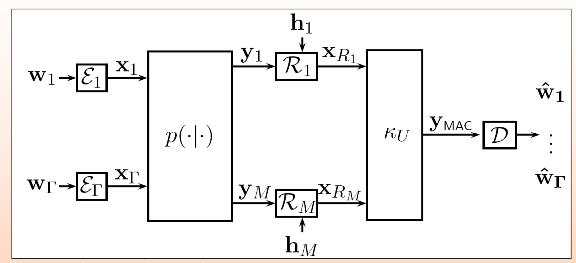
Binary Network with General MAC



Achievable rate

$$R = \min\{\kappa_U \ell, 1\}\left(1 - \left(\tfrac{1}{2}\right)^M\right)$$

Arbitrary Network with General MAC



Theorem 1. *For the two-stage fading relay network, fix an arbitrary broadcast function $U = f_{BC}(Y_1, \mathbf{h}_1, ..., Y_M, \mathbf{h}_M)$ with computation capacity κ_U, the following rate is achievable*

$$\sum_{i \in \mathcal{S}} R_i \le \min\{\kappa_U \ell, 1\} I(X_{\mathcal{S}}; U | X_{\mathcal{S}^c})$$

for all $\mathcal{S} \subset \{1, ..., \Gamma\}$

where $X_1, ..., X_\Gamma \sim$ i.i.d $P(X)$.