1 System Model

Consider the geometric channel for the frequency selective massive multiple-input multiple-output (MIMO) composed by a set of L scattering clusters. The nth delay tap of the uth user equipment (UE) is expressed as

$$\mathbf{H}(f) = \sum_{l=1}^{L} \beta_l P(f) \mathrm{e}^{-\jmath 2\pi f \tau_l} \mathbf{a}_{\mathrm{R},i}(\phi_{\mathrm{R},l}, \theta_{\mathrm{R},l}, f) \mathbf{a}_{\mathrm{T}}^{H}(\phi_{\mathrm{T},}\theta_{\mathrm{T},l}, f), \tag{1}$$

Consider the transmitter and receiver beamforming filters $\mathbf{w}_{\mathrm{R}}$ and $\mathbf{w}_{\mathrm{T}}$, respectively. The equivalent digital channel is represented as

$$G(f) = \sum_{l=1}^{L} \beta_l P(f) c_{\mathrm{R}}(\phi_{\mathrm{R},l}, \theta_{\mathrm{R},l}, f) c_{\mathrm{T}}(\phi_{\mathrm{T},l}, \theta_{\mathrm{T},l}, f) \mathrm{e}^{-\jmath 2\pi f \tau_l}, \tag{2}$$

where

$$\begin{aligned} c_{\mathrm{R}}(\phi_{\mathrm{R},l}, \theta_{\mathrm{R},l}, f) &= \mathbf{w}_{\mathrm{R}}^{H} \mathbf{a}_{\mathrm{R},i}(\phi_{\mathrm{R},l}, \theta_{\mathrm{R},l}, f) \\ &= \sum_{i=1}^{I_R} \mathbf{w}_{\mathrm{R}}^{*}[i] \mathrm{e}^{-\jmath \frac{2\pi}{c} \mathbf{u}^T \mathbf{d}_i f}. \end{aligned}$$