

We establish a novel link-state regime result for a composite decode-forward (DF) two-way relaying scheme with a direct link. During transmission, our scheme combines block Markov coding and an independent coding scheme that resembles network coding at the relay. A developed novel approach optimizes the composite technique by analyzing the dual variable space to identify link-state regimes in which a particular combination of transmission techniques is optimal. Our results expose an interesting trend: when the user-to-relay link is marginally stronger than the direct link, independent coding is optimal and the relay can conserve power. However, for larger user-to-relay link gains, the relay must use full power and supplement independent coding with block Markov coding to achieve the largest rate region. For Rayleigh fading links, we demonstrate that relay power savings are achievable in most node configurations. The link-state regimes are further applied to perform link adaptation in fading to illustrate significant data rate gains over direct transmission even under a more practical, long-term link state information. These link-state regime results are useful for the application of two-way DF relaying in practice.