Quantum Physics

Trading classical communication, quantum communication, and entanglement in quantum Shannon theory

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We give optimal trade-offs between classical communication, quantum communication, and entanglement for processing information in the Shannon-theoretic setting. We first prove a "unit-resource" capacity theorem that applies to the scenario where only the above three noiseless resources are available for consumption or generation. The optimal strategy mixes the three fundamental protocols of teleportation, super-dense coding, and entanglement distribution. Furthermore, no protocol other than these three fundamental ones is necessary to generate the unit resource capacity region. We then prove the "direct static" capacity theorem that applies to the scenario where a large number of copies of a noisy bipartite state are available (in addition to consumption or generation of the above three noiseless resources). The result is that a coding strategy involving the classically-assisted mother protocol and the three fundamental protocols is optimal. We finally prove the "direct dynamic" capacity theorem. This theorem applies to the scenario where a large number of uses of a noisy quantum channel are available in addition to the consumption or generation of the three noiseless resources. The optimal strategy combines the classically-enhanced father protocol with the three fundamental unit protocols. Interestingly, one octant of the direct-dynamic capacity region applies to an open question concerning the use of entanglement-assisted coding and teleportation for entanglement- and classically-assisted quantum communication.

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