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Unified and Generalized Approach to Entanglement-Assisted Quantum Error Correction

We introduce a framework for entanglement-assisted quantum error correcting codes that unifies the three original frameworks for such codes called entanglement-assisted quantum error correction, entanglement-assisted operator quantum error correction, and entanglement-assisted classical enhanced quantum error correction under a single umbrella. The unification is arrived at by viewing entanglement-assisted codes from the operator algebra quantum error correction perspective, and it is built upon a recently established extension of the stabilizer formalism to that setting. We denote the framework by entanglement-assisted operator algebra quantum error correction, and we prove a general error correction theorem for such codes, derived from the algebraic perspective, that generalizes each of the earlier results. This leads us to a natural notion of distance for such codes, and we derive a number of distance results for subclasses of the codes. We show how the classically enhanced codes form a proper subclass of the entanglement-assisted subspace codes defined by the general framework. We identify and construct new classes of entanglement-assisted subsystem codes and entanglement-assisted hybrid classical-quantum codes that are found outside of the earlier approaches, and we include a quantum communication application.