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Identification of malfunctioning quantum devices

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We consider the problem of correctly identifying a malfunctioning quantum device that forms part of a network of N such devices. We first study the case of sources assumed to prepare identical quantum pure states, with the faulty source producing a different anomalous pure state. We show that the optimal probability of successful identification requires a global quantum measurement, and investigate several local measurement strategies whose performance is only slightly worse. We also address the case of quantum channels, where the malfunctioning channel is assumed to perform a known unitary, and show that in this case the use of entangled probes provide an improvement that even allows perfect identification for values of the unitary parameter that surpass a certain threshold. However, this advantage disappears for very large networks where product state probes yield the same performance. Finally, we find that for rank-one and rank-two Pauli channels, op- timal identification can be achieved by product state inputs and separable measurements for any size of network; for rank-3 and general amplitude damping channels optimal identification requires entanglement with N ancillas. However, whereas for rank-three Pauli channels entanglement is advantageous for any size of network, for a general amplitude damping channel the advantage of entanglement with ancillas disappears as the size of the network grows.

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