Reliability Analysis of Heterogeneous Performance Sharing Systems with Conversion Devices Using UGF

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Abstract:

Most existing reliability models for performance sharing systems are developed under the assumption that all components operate with a single, identical type of performance. Such an assumption, however, does not reflect the complexity of practical engineering systems, where components often function with diverse performance types. This work addresses this limitation by developing a reliability modelling framework for systems composed of heterogeneous components. The proposed system consists of several subsystems, each containing performance generating components along with performance conversion devices. Components sharing the same performance type, but located in different subsystems, are connected through dedicated common buses to facilitate performance exchange. In addition, conversion devices are incorporated to transform one form of performance into another, thereby reducing reliance solely on direct performance sharing to compensate for deficits. A structured strategy is adopted in which performance conversion is carried out prior to inter-subsystem performance transfer whenever a deficiency occurs. To improve system effectiveness, a conversion algorithm governed by conversion efficiencies and capacity limits is introduced. The Universal Generating Function approach is employed to quantify system reliability within this integrated framework. The applicability of the proposed model is illustrated through a numerical example based on an energy hub. The analysis highlights how the combined use of performance conversion and sharing enhances system reliability, offering a more realistic and flexible alternative to traditional homogeneous performance models.