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Examining the impact of critical attributes on hard drive failure times: multi-state models for left-truncated and right-censored semi-competing risks data

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A recent study based on data from Microsoft reports that 76 – 95% of all failed components in data centres are hard drives. HDDs are the main reason behind server failures. Consequently, the ability to predict failures in hard disk drives (HDDs) is a major objective of HDD manufacturers since avoiding unexpected failures may prevent data loss, improve service reliability, and reduce data centre downtime. Most HDDs are equipped with a threshold-based monitoring system named Self-Monitoring, Analysis and Reporting Technology (SMART). The system collects performance metrics, called SMART attributes, and detects anomalies that may indicate incipient failures.

In this talk, we define critical attributes and critical states for hard drives using SMART attributes and fit multi-state models to the resulting semi-competing risks data. The multi-state models provide a coherent and novel way to model the failure time of a hard drive and allow us to examine the impact of critical attributes on the failure time of a hard drive. We derive predictions of conditional survival probabilities, which are adaptive to the state of the drive. Using a dataset of HDDs equipped with SMART, we find that drives are more likely to fail after entering critical states. We evaluate the predictive accuracy of the proposed models with a case study of HDDs equipped with SMART, using the time-dependent area under the receiver operating characteristic curve and the expected prediction error. The results suggest that accounting for changes in the critical attributes improves the accuracy of predictions.

Keywords

Hard disk drives, Critical states, Multi-state models

Classification

Mainly application

Primary author: OAKLEY, Jordan (School of Mathematics, Statistics & Physics, Newcastle University, United Kingdom)

Co-authors: FORSHAW, Matthew (School of Computing, Newcastle University, United Kingdom); PHILIPSON, Pete (School of Mathematics, Statistics & Physics, Newcastle University, United Kingdom); WILSON, Kevin J. (School of Mathematics, Statistics & Physics, Newcastle University, United Kingdom)

Presenter: OAKLEY, Jordan (School of Mathematics, Statistics & Physics, Newcastle University, United Kingdom)

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