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Universal sequencing on an unreliable machine.

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Summary: We consider scheduling on an unreliable machine that may experience unexpected changes in processing speed or even full breakdowns. Our objective is to minimize $\sum w_j f(C_j)$ for any nondecreasing, nonnegative, differentiable cost function $f(C_j)$. We aim for a universal solution that performs well without adaptation for all cost functions for any possible machine behavior. We design a deterministic algorithm that finds a universal scheduling sequence with a solution value within 4 times the value of an optimal clairvoyant algorithm that knows the machine behavior in advance. A randomized version of this algorithm attains in expectation a ratio of e. We also show that both performance guarantees are best possible for any unbounded cost function. Our algorithms can be adapted to run in polynomial time with slightly increased cost. When jobs have individual release dates, the situation changes drastically. Even if all weights are equal, there are instances for which any universal solution is a factor of $\Omega(\log n/\log\log n)$ worse than an optimal sequence for any unbounded cost function. Motivated by this hardness, we study the special case when the processing time of each job is proportional to its weight. We present a nontrivial algorithm with a small constant performance guarantee.

Keywords: scheduling; min-sum objective; single machine; unreliable machine; machine speed; universal solution; worst case guarantee
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