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HEALTH INDEX-BASED RISK-AWARE DISPATCHING FOR OVERHEAD HOIST TRANSPORT SYSTEMS IN SEMICONDUCTOR FAB

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ABSTRACT

Overhead Hoist Transport (OHT) systems significantly influence semiconductor fab performance. Traditional dispatching methods such as Nearest Job First (NJF) focus on minimizing travel distance without considering the dynamic health of vehicles. As a result, unstable vehicles may be dispatched to critical areas, increasing the risk of system-wide disruptions. Previous health-aware approaches often rely on Mean Time To Failure (MTTF), which assumes that failure events are observable—a strong assumption given the uncertainty and latent nature of real-world. To address this limitation, we introduce a Reconstruction Error (RE)-based Health Index (HI) derived from anomaly detection models, enabling dynamic and risk-sensitive dispatching. We define a risk-aware dispatching score that incorporates both traffic exposure and health degradation, and simulate diverse HI profiles with varying predictive fidelity. Our experiments aim to evaluate how the quality of the HI affects dispatching performance and system robustness.

1 INTRODUCTION

Overhead Hoist Transport (OHT) systems are widely used in modern semiconductor fabs to automated wafer transport. A typical fab operates hundreds or even thousands of OHT vehicles along an extensive network of tracks, directly affecting overall throughput and cycle time. Therefore, job assignment policies (dispatching tasks to OHTs) play a critical role in maintaining operational efficiency and stability.

Conventional dispatching strategies such as the NJF rule aim to reduce travel time by assigning the closest available vehicle. However, these methods ignore the varying health states of OHT vehicles. Assigning a vehicle with latent faults to a critical route can lead to major disruptions. Thus, incorporating real-time health awareness into dispatching is crucial for proactively mitigating operational risk.

Recent work by Jo (2022) incorporated health information using MTTF-based assumptions. However, MTTF presumes that failure events are known in advance—an assumption too strong for complex, uncertain real-world behaviors. To overcome this, we propose a more flexible, data-driven method that uses Reconstruction Error (RE) from anomaly detection models (Myung and Jang 2022) as a proxy for health. By constructing a RE-based Health Index (HI), we can dynamically assess failure risk and adapt job assignments accordingly.

In this study, we propose a risk-aware dispatching framework based on the RE-derived HI. Recognizing that the true shape of the HI is unknown, we generate diverse synthetic HI profiles with varying levels of predictive accuracy. These profiles reflect different assumptions about how well degradation indicators predict actual failures. Through simulation, we examine how dispatching performance changes with respect to HI quality, ultimately evaluating the robustness of our policy under operational uncertainty.

2 OHT HEALTH INDEX

Myung and Jang (2022) introduced an anomaly-detection algorithm for OHT vehicles and showed that its reconstruction error (RE) cleanly separates normal from abnormal operating states. Leveraging this result, we treat the RE as a real-time Health Index (HI) that quantifies each vehicle's condition. Because the actual degradation mechanism is unknown, we generate families of synthetic HI trajectories via a statistical procedure that adjusts the baseline RE signal to produce curves with differing drift rates and noise levels. These surrogate profiles span a range of prognostic fidelities and provide controlled test beds for evaluating how HI accuracy shapes risk-aware dispatching and overall fab performance.

3 RISK-AWARE DISPATCHING

We propose a risk-aware dispatching heuristic that explicitly integrates the Health Index (HI) into the job assignment process. This heuristic evaluates the risk associated with each vehicle-job pair by accounting for both the vehicle's health and the traffic volume of potential routes. Vehicles with lower HI scores (i.e., higher failure risk) are discouraged from taking high-traffic or critical routes, while healthier vehicles (higher HI scores) continue to follow conventional dispatching rules like NJF.

To guide dispatch decisions quantitatively, we extend the traffic exposure model proposed by Jo (2022) by incorporating the HI into a composite risk score. For assigning job j to vehicle i, we define the total score $S_{i,j}$ as:

$$S_{i,j} = (1 - HI_i)^{\gamma} \times \left[\sum_{k \in P_{i \to d_j}} TV(k) + \min_{m} \left(\sum_{k \in P_{d_j \to m}} TV(k) + \sum_{k \in B_m} TV(k) \right) \right]$$

The formulation ensures that vehicles with lower HI scores are penalized more heavily, thereby discouraging their assignment to jobs involving high-traffic or operationally critical segments.

To assess the effectiveness of the proposed dispatching strategy, we will conduct simulation-based experiments using AutoMod™. The testbed consists of 50 OHT vehicles operating within 6 bays fab layout representative of a typical semiconductor fab. Various failure scenarios and degradation trajectories will be modeled and injected. Specifically, we will examine: (i) how the shape and fidelity of different Health Index (HI) curves affect key performance indicators, and (ii) how the distribution of health conditions across the fleet influences the overall robustness of the dispatching policy under stress conditions.

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