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PROACTIVE HOT LOT ROUTING FOR OHT SYSTEMS IN SEMICONDUCTOR FAB

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ABSTRACT

Semiconductor fabs must expedite urgent wafer carriers, known as Hot Lots, yet excessive priority can impair throughput. DAIM Research Corp. categorizes priority into three levels; we address Level 2, where the Hot Lot OHTs wins all local contests for path selection and merging while other moves proceed. We present a two-layer control framework. First, extending the reinforcement-learning-based dynamic routing algorithm, temporarily modify the expected travel time of tracks ahead the Hot Lot, causing regular OHTs to detour proactively. Second, modifying the entrance sequence at the merge of two tracks to reduce Hot Lot stops and waits. The effectiveness of the framework is demonstrated through simulation-based experiments, which show that Hot Lot travel time is shortened with acceptable impact on overall throughput.

1 INTRODUCTION

Overhead Hoist Transport (OHT) systems move wafer carriers across single-lane, unidirectional tracks in semiconductor fabs. Carriers that must meet exceptionally tight lead times—e.g., development samples or delay-sensitive lots—are labeled Hot Lots and given elevated priority.

Recently, DAIM Research Corp. incorporated a three-level priority scheme into its commercial platform, xMS. **Level 1** guarantees the fastest pick-up by dispatching the nearest idle vehicle. **Level 2** lets the Hot Lot vehicle win every tie in path selection, and merge queues, while allowing all other traffic to continue. **Level 3** goes one step further by suspending all competing moves and actively evacuating blocking vehicles to create an exclusive corridor. Among the three levels, **Level 2** is the option most widely adopted in commercial fabs—it expedites Hot Lots without the severe throughput loss to regular traffic. Accordingly, this study focuses on Level 2 and tackles its challenges with a two-layer control framework.

2 METHODOLOGY

2.1 Q Boosting

Q(λ)-Routing is a reinforcement-learning based dynamic routing that stores for each edge (i, j) a value $Q[(d,i), j]$, the expected travel time to destination d when moving from node i to j (Hwang and Jang 2020). After each traversal, the TD error is back-propagated with weight λ, so congested edges receive higher expected travel times and OHTs can avoid congested edges.

Since updates are applied after congestion has been observed, a time-critical Hot Lot can still be trapped in a queue. To address this limitation, we propose *Q Boosting*, a forward Q-shaping layer that preserves the reactive learning of Q(λ)-Routing while proactively adjusting Q values ahead of the Hot Lot.

When a Hot Lot is released, the controller obtains the shortest path $P = \{e_1, e_2, \dots\}$ via Dijkstra search and defines the next L edges relative to the vehicle's current position as the Boosting window. For each edge e_k in this window ($k = 1, \dots, L$), the value is temporarily raised by

$$\Delta Q(e_k) = Q_{\text{boost}} \exp(-\beta k),$$

where Q_{boost} is maximum-boost parameter can be adjusted by urgency or system load, and the decay factor β ensures that edges closer to the vehicle receive stronger protection. The same boost, scaled by λ_1, is

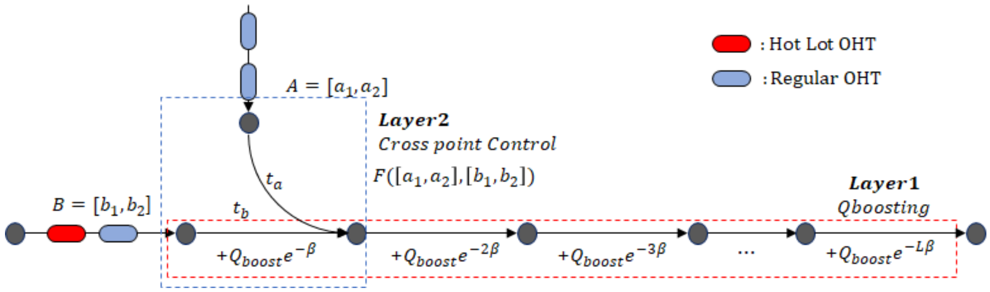

Figure 1: Two-layer scheme of (i) Qboosting and (ii) Cross-point Control.

propagated to adjacent edges to enhance pre-clearing effect. The elevated Q values make the Hot Lot path appear costly, so regular OHTs detour before the Hot Lot arrives. Once the Hot Lot has passes one edge, the corresponding $\Delta Q(e_k)$ and its propagation are retrieved, and the window slides forward.

2.2 Cross-point Control Policy

At a cross-point where two tracks merge in OHT tracks, a Zone Control Unit (ZCU) ensures that at most one vehicle occupies the zone at any time, preventing collisions but causing vehicles to stop, wait, and restart—hence incurring delay.

The ZCU's 'which-track-first' decision is modeled as a dynamic programming (DP) sequence problem to minimize Hot Lot's delay. Let $A = [a_1, a_2, \ldots, a_n]$ and $B = [b_1, b_2, \ldots, b_m]$ be the ordered queues of vehicles waiting on tracks A and B, where a_i (b_j) denotes the i-th (j-th) vehicle counted from the front of its queue. And let t_a (t_b) denote the time required for one vehicle to traverse the zone from track A (track B). Define the weight $w(x) = 1$ if x is a Hot Lot and $w(x) = 0$ otherwise, so that the number of remaining Hot Lots is $\sum_i w(a_i) + \sum_j w(b_j)$. The cumulative Hot Lot delay from any state $[a_1..a_n], [b_1..b_m]$ obeys the recurrence (1). The DP compares the two options and chooses the smaller cumulative Hot Lot delay; the recursion ends when both queues are empty.

$$F([a_1..a_n],[b_1..b_m]) = \min\Big\{ \big(\textstyle\sum_i w(a_i) + \sum_j w(b_j)\big)\, t_a + F([a_2..a_n],[b_1..b_m]), \quad \big(\textstyle\sum_i w(a_i) + \sum_j w(b_j)\big)\, t_b + F([a_1..a_n],[b_2..b_m]) \Big\}. \tag{1}$$

3 EXPERIMENT

The framework was evaluated in AutoMod 14.0 on two different testbeds: 16-port full-layout and 20-bay inter-bay layout that stresses dense cross-bay interactions. Using both layouts allows us to examine how differences in network topology influence the performance of the proposed framework. Traffic load was varied at four levels, depending on OHT utilization levels. We report average delivery time, average transport time, and other related time-based logistics metrics for both Hot and regular lots.

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