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INDUSTRY CASE: SEMICONDUCTOR FAB OHT MANAGEMENT SYSTEM AND DIGITAL TWIN FOR OHT OPERATION

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ABSTRACT

The overhead hoist transport (OHT) system, which is the primary automated material handling system (AMHS) in semiconductor fab. We present the framework of the OHT management system (OMS) which effectively controls and manages more than 1,000 OHT vehicles with reinforcement learning algorithm. In this presentation, we focus on the commercialization of the OMS based on novel algorithms and explain its basic architecture. We also present the Digital Twin Solution of the OMS for testing and verification. The OMS Digital Twin (OMS-DT) consists of a vehicle emulator, OMS connectors, and a virtual factory. We demonstrate how this virtual system has been used by major semiconductor fab manufacturers and has ultimately improved OHT deployment processes.

1 INTRODUCTION

The process of manufacturing modern semiconductor wafers consists of numerous steps performed by complex auxiliary machines. Bundles of 25 wafers are loaded into a unit called a front-opening unified pod for transport via an overhead hoist transport (OHT) system to the machine that performs each step. Thus, the OHT system forms the backbone of an automated material handling system (AMHS) in a fab, as shown in Figure 1.

Figure 1: Components of an overhead transport system.

The details of OHT systems, their performance measures, and their operational aspects can be found in (Hwang and Jang 2020). Due to recent increases in production, most semiconductor fabs now operate thousands of OHT vehicles (hereinafter, “vehicles”) on a track. Such large-scale systems may suffer from severe vehicle congestion, especially as many OHT routes overlap. Thus, vehicles often become concentrated in certain locations. This congestion increases vehicle travel time, thereby increasing the overall cycle time of a product. In worst-case situations, a deadlock occurs, thereby halting the passage of vehicles. An intuitive way to solve this problem is for vehicles to be able to recognize congestion before encountering it, and thus select a route to use that avoids congestion.

Accordingly, the Korea Advanced Institute of Science and Technology (KAIST) team, DAIM Research Corp, a spin-off of the KAIST, and their industry partner in the semiconductor industry have collaborated to develop and successfully commercialize the OHT Vehicle Management System (OMS). The OMS is based on artificial intelligence and can operate more than 1,000 vehicles, thereby minimizing congestion and effectively improving lot delivery performance via reinforcement learning (Hwang and Jang 2020; Hong et al. 2022). In particular, the OMS uses the Q-routing algorithm, a reinforcement learning approach that dynamically allocates vehicles to lot delivery jobs and guides vehicles along efficient paths to avoid congestion. The algorithms for job allocation and dynamic path guidance can be found in (Hwang and Jang 2020; Hong et al. 2022), respectively.

In this presentation, we focus on the commercialization of the OMS based on novel algorithms and explain its basic architecture. Unlike conventional optimization path planning and vehicle allocation, which typically use mathematical optimization or rule-based algorithms, our novel algorithms use real-time traffic information and a data-driven optimization method. Therefore, organizing the data structure and the communication network design for the vehicles are as important as algorithm development. We demonstrate the novel database architecture and data-handling algorithm.

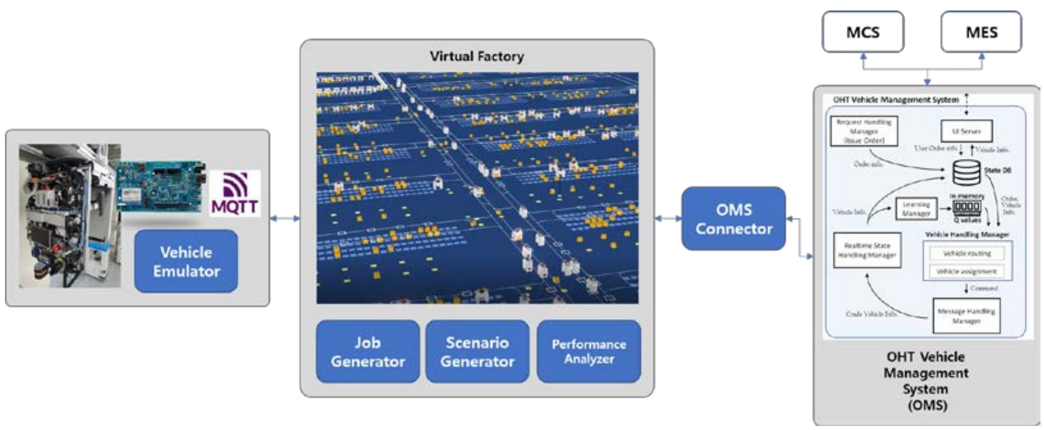

Figure 2: Architecture of the OMS-DT.

We also present the Digital Twin Solution of the OMS for testing and verification. Detailed testing and verification are required to deploy the OMS, before semiconductor fabs can actually operate more than 1,000 vehicles. Thus, before the OMS is connected to actual OHT vehicles for hardware-and-software integration tests, testing in a virtual environment is recommended, as running the hardware (i.e., OHT vehicles) for testing requires lengthy setup times and any unexpected events could lead to hardware breakdowns. The OMS Digital Twin (OMS-DT) consists of a vehicle emulator, OMS connectors, and a virtual factory, as shown in Figure 2. We demonstrate how this virtual system has been used by major semiconductor fab manufacturers and has ultimately improved OHT deployment processes.

REFERENCES

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