ITEA 4

Project Results

AISSI

Optimising planning and production in the semiconductor domain

In the ITEA project AISSI (Autonomous Integrated Scheduling for Semiconductor Industry), six partners have used digital twins, artificial intelligence (AI) agents and a platform for standardised communication to optimise the throughput of semiconductor wafer fabs and the predictability of semiconductor supply chains.

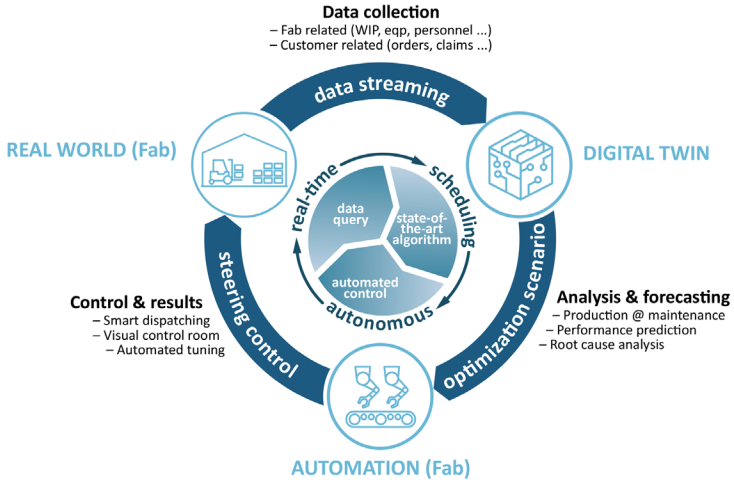
Semiconductors are often considered to have one of the most complex fabrication processes in the world, while global events such as COVID-19 have also highlighted issues in their supply chain. Given the increased recognition of the importance of semiconductors, the industry association SEMI predicts some USD 500 billion in investment in new fabrication capacities worldwide over the coming years. With such growth, even a 1% improvement in throughput or cycle time, such as through optimised scheduling, can lead to huge cost savings for manufacturers and suppliers.

To provide this optimisation across the supply chain, AISSI utilised AI in the form of deep reinforcement learning to increase overall equipment efficiency, maximise throughput, and improve on-time delivery and cycle time prediction. Thanks to strong collaboration within the ITEA framework, the consortium could combine highly diverse domain knowledge into three use-cases at different levels: (1) small-scale epitaxy work centre scheduling, led by Nexperia, (2) medium-scale full factory scheduling, led by Bosch, and (3) global cycle time prediction, led by Bosch Sensortec. AISSI's solutions can therefore be used to optimise existing factories, either in full or at an equipment group level, and to predict material movement through the supply chain and delivery time.

Technology applied

To achieve this, data streaming is used to gather data from real-world factories. This is sent to interactive digital twins developed by D-SIMLAB Technologies and SYSTEMA to provide analysis and forecasting, such as production and maintenance, performance prediction, and root cause analysis. The digital twin interacts with deep reinforcement learning agents created mainly by Karlsruhe Institute of Technology (KIT). This AI performs actions, observes and evaluates results, and tries different actions until it identifies the best strategies, thereby using simulation to schedule the factory effectively. Once the AI is trained, it completes the loop by controlling the real-world factories, such as by providing smart dispatching and automated tuning.

AISSI's three use-cases feature similar components that communicate back and forth: the real-world factory/supply chain, the digital twin and the AI. When companies use AI solutions from the market, the costliest element is often the creation of interfaces to bring their data to the AI, even if the solution is otherwise complete. To address this, the project also created the AISSI platform, an architecture with standardised communication between modules. While the modules for the use-cases have been developed separately, they can be combined within the platform using data schemas created by AISSI, reducing the effort needed to develop interfaces. New data schemas can be developed for the platform as necessary, making it extensible to domains beyond semiconductor manufacturing.



Real-time production and maintenance scheduling framework based on the digital twin and automation technology

Making the difference

Although AISSI was largely research-based, the initial results are now moving into production in different forms according to the domain of each partner. For the use-case providers Bosch, Nexperia and Bosch Sensortec, the results will be rolled out in real production. As solution providers, D-SIMLAB and SYSTEMA aim to commercialise the results in the form of a new software product offering AI training

capabilities and a new scheduling system, respectively. SYSTEMA also aims for revenue growth via the introduction of AI to their wider portfolio and improved horizontal integration of portfolio elements using the AISSI platform. Finally, from an academic perspective, Karlsruhe Institute of Technology will further research the AI developed, including as a basis for two PhD theses.

As the AISSI platform and modules become fully operational, major benefits are expected for the consortium: AISSI's reinforcement learning, for instance, has achieved a 9% higher output compared to a benchmark from the literature, which will result in significant cost savings and a greater competitive advantage through improved productivity. Before AISSI, there was also no functionality to predict cycle time, but the project has achieved an average prediction accuracy of 80-90%. This will increase the resilience and robustness of the supply chain in the highly volatile consumer electronics market and can boost trust between customers and suppliers through improved transparency.

Most important, however, is the potential to extend the AISSI platform into other domains via new data schemas. As a general platform, any industry could hypothetically use the platform to reuse communication events and enable deep reinforcement learning. For factories, the resulting flexibility allows for the seamless replacement of solutions without concern for compatibility or vendor lock-in. For solution providers, it is easier and more cost-effective to sell AI solutions without the need to develop a specific interface for the customer. To make this a reality, a paper describing the platform will be published at the Winter Simulation Conference in December, while the consortium has also shared the precise specification and a demo version showing how multiple modules can be connected and communicate with each other. The longer-term ambition is the establishment of a standard that will further promote the uptake of AI in production environments, achieving a strong impact for AISSI in the semiconductor domain and far beyond.

Major project outcomes

Dissemination

- 5 publications (WSC 2022 & 2024, ASIM, KIT-Neuland Magazin, KIT Research to Business)
- 6 presentations at conferences and 8 at events/fairs (e.g. WSC, KotlinConf' 23, apc|m europe, EURAXES, FoTLog 2022, SEMICON 2022, SEMI Fab Owners Alliance)

Exploitation (so far)

New Products:

- D-SIMCON AI training and evaluation platform.
- AI model that improves the expected cycle time prediction for supply chains, allowing better planning and on-time delivery.
- Several AI models for semiconductor factory scheduling and optimisation.

New Systems:

- AISSI Platform Interface Specification, proposing a new standard for communication between AI and Digital Twin modules which should foster research and speed up productive use of AI solutions.
- Digital twins to enable AI-based scheduling.
- Deep Reinforcement Learning Agent for semiconductor factory scheduling.
- Visualisation module for AI-agents performance analysis.

New Services:

- AISSI Platform Deployment: the AISSI Platform allows for standardised high-performance communication between AI and Digital Twins, enabling the computationally intensive training of DRL agents.

Standardisation and Patents

- 1 standard proposed: AISSI Platform Interface Specification.
- 1 patent application filed.

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AISSI

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Partners

Germany

- Bosch Sensortec GmbH
- Karlsruhe Institute of Technology
- Nexperia Germany GmbH
- Robert Bosch GmbH
- SYSTEMA Systementwicklung Dipl.-Inf. Manfred Austen GmbH

Singapore

- D-SIMLAB Technologies Pte Ltd

Project start

June 2021

Project end

May 2024

Project leader

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