GRAND CHALLENGES IN MODELING AND SIMULATION OF COMPLEX MANUFACTURING SYSTEMS

John W. Fowler
Department of Supply Chain Management
Arizona State University
300 E. Lemon St.
Tempe, AZ 85287, USA

Oliver Rose
Research Center CODE (Cyber Defence),
Universität der Bundeswehr München
Werner-Heisenberg-Weg 39, 85577
Neubiberg, GERMANY

Tae-Eog Lee
Department of Industrial and Systems Engineering
Korea Advanced Institute of Science & Technology
335 Gwahang-no KAIST
Yusung-gu, Deajeon, KOREA

ABSTRACT

As a result of a 2002 Dagstuhl Seminar (Fujimoto et al., 2002), Fowler and Rose (2004) discussed grand challenges in the modeling and simulation of complex manufacturing systems. In this presentation, we will review the progress on the grand challenges identified by Fowler and Rose (2004) and point out some new challenges.

1 INTRODUCTION

In August 2002, a group of academic and industrial researchers came together at Schloss Dagstuhl (https://www.dagstuhl.de/) to discuss grand challenges related to modeling and simulation in several domains including the manufacturing systems domain (Fujimoto et al., 2002). The entire group agreed on the following definition of a grand challenge. A grand challenge is a problem that (1) is difficult, with the solution requiring one or more orders-of-magnitude improvement in capability along one or more dimensions; (2) should not be provably insolvable; and (3) has a solution that results in a significant economical and/or social impact. After several days of discussion, The manufacturing systems subgroup spent the week discussing challenges faced in the modeling and simulation of complex manufacturing systems which led to the Fowler and Rose (2004) paper. The grand challenges will be presented in the next section.

There have been considerable advancements in computing and advanced manufacturing systems since the 2002 Dagstuhl seminar. Much of this change is captured in the Industry 4.0 concept, also known as the Fourth Industrial Revolution. Industry 4.0 encompasses three technological trends driving this transformation: connectivity, intelligence, and flexible automation. Industry 4.0 converges IT (Information Technology) and OT (Operational Technology), to create a cyber-physical environment. This convergence has been made possible thanks to the emergence of digital solutions and advanced technologies, which are often associated with Industry 4.0 (https://cio-wiki.org/wiki/Industry_4.0).
2 GRAND CHALLENGES FROM 2002 DAGSTUHL SEMINAR

Here are the grand challenges from the 2002 Dagstuhl Seminar.

- Grandest Challenge 1: An Order-of-Magnitude Reduction in Problem-Solving Cycles
- Emerging Grand Challenge 2: Development of Real-Time Simulation-Based Problem-Solving Capability
- Emerging Grand Challenge 3: True Plug-and-Play Interoperability of Simulations and Supporting Software within a Specific Application Domain
- Big Challenge 4: Greater Acceptance of Modeling and Simulation within the Industry

3 REVISITING THE GRAND CHALLENGES IN LIGHT OF INDUSTRY 4.0

In this presentation, we will reflect on the progress made on the previous grand challenges to see if they have been solved or need to be modified. We will also examine the requirements of Industry 4.0 and determine if new grand challenges have emerged. Modern highly automated factories like semiconductor fabs generate massive data from numerous sensors, make decisions from the data, and learn and optimize the decision rules by AI or humans. We, therefore, have new challenges of deriving an explainable, interpretable, or executable model from the data, identifying and modeling complex decision rules that can be explained and simulated, and developing high-fidelity simulation models like digital twins to be used for learning and training for AI or humans.

REFERENCES


AUTHOR BIOGRAPHIES

JOHN W. FOWLER is the Motorola Professor of Supply Chain Management in the W.P. Carey School of Business at Arizona State University. His research interests include discrete event simulation, deterministic scheduling, and applied operations research with semiconductor manufacturing and healthcare applications. He has published 130+ journal articles and 100+ conference papers. He was the Program Chair for the 2002 and 2008 Industrial Engineering Research Conferences, Program Chair for the 2008 WSC, and Program Co-Chair for 2012 INFORMS National Meeting. He was the founding Editor-in-Chief of IISE Transactions on Healthcare Systems Engineering and currently serves as a Departmental Editor. He is also an Editor of the Journal of Simulation and Associate Editor of IEEE Transactions on Semiconductor Manufacturing and the Journal of Scheduling. He is a Fellow IISE and INFORMS and serves on the WSC Board of Directors. His email address is john.fowler@asu.edu.

OLIVER ROSE holds the Chair for Modeling and Simulation at the Department of Computer Science of the Universität der Bundeswehr Munich, Germany. He received an M.S. degree in applied mathematics and a Ph.D. degree in computer science from Würzburg University, Germany. His research focuses on the operational modeling, analysis, and material flow control of complex manufacturing facilities, in particular, semiconductor factories. He is a member of INFORMS Simulation Society, ASIM, and GI. His email address is oliver.rose@unibw.de.

TAE-EOG LEE is the Korea Telecom Chaired Professor of the Department of Industrial and Systems Engineering at KAIST. He joined KAIST in 1991 after his doctoral study at The Ohio State University. His research subjects include modeling, scheduling, and control of discrete event systems such as timed Petri nets and robotized wafer processing tools for semiconductor manufacturing, manufacturing system simulation, and defense modeling and simulation. He was an associate editor of IEEE Transactions of Automation Science and Engineering, and President of KIIE (2017-2018). He received Korea Engineering Award (2021), The Month’s Scientist (1995), and The Year’s KAISTian (2021). His email address is telee@kaist.ac.kr.