Newsletter

Dear readers;

We hope that this newsletter finds you healthy! After the pandemic years, we have just partially been arriving back to normal conditions, when the Russian attack has whirled around our environments again. Just back in face-to-face contact with our students, we have to hope that we will not be forced to send them home in winter times because the lecture rooms remain cold. The good part is that we are now very experienced to switch from physical to virtual teaching and back. We can, thus, provide the students with structured and efficient lectures as long as the internet is available. Let us hope that it will survive any potential acts of sabotage by any autocratic regimes in this volatile world.

Energy prices are exploding; a huge challenge to economy, but in terms of climate we can also see some positive aspects. The necessity to support the long-delayed turn to renewable energies has received at least some additional attention, and energy saving – another inevitable need of the 21st century – also has moved into the focus of industry and politics. Some years ago, the simulation society ASIM has already started a working group on modelling energy in simulation models. This has been initiated long before COVID-19 and the recent Ukraine war, and even before the European Sustainability Reporting Standards (ESRS) became effective. The results have been drawn together to a book with plenty application examples, which will appear in the upcoming winter with Springer International.

Slowly but steadily we also return to some travel, even if most meetings are still conducted via the internet. Nevertheless, we could attend a few conferences in person, and recently we

could even organize a little colloquium ourselves in Dortmund, looking back to 36 years of simulation in production and logistics. Furthermore, we have been glad to welcome the famous professor Susan Sanchez from the Naval Postgraduate School in Monterey (CA) for two weeks in October, in the framework of a Gambrinus fellowship. Some details on both events follow in this newsletter.

Our research team has now grown to the nice critical mass of 18 Ph.D. researchers. Some have just started, several are in the completion phase of their thesis, and two have delivered their thesis in August, awaiting their final defence in November. A selection of the ongoing research topics can also be found in this newsletter. Several scientific papers could be published about our recent research, which you find listed at the end of this letter.

Our revised study program is still very successful and receives great attention by the students. In our master courses, we had to face around 600 examinations last lecture year; a huge effort, but a very positive signal for the attractiveness of our teaching offerings.

For now, we hope that you enjoy reading this little newsletter and wish that you stay healthy!

Markus Rabe

Teaching Concepts in the Context of Faculty Accreditation and Corona

Since the re-accreditation of the degree programmes by the Faculty of Mechanical Engineering in the winter semester 2019/20, the ITPL has revised and further optimized its teaching for the degree programs for mechanical engineering, industrial engineering, manufacturing technology, and logistics. The modernised course "Introduction to Programming" is now forming a cornerstone of the engineering education in the Bachelor degree programme. In addition, the ITPL offers information technology supplements to bachelor students with the two elective modules "Fundamentals of Simulation Technology" and "IT Systems in Industrial Production". The modelling focus of the ITPL is supported by the module "Modelling of Digital Ecosystems in Production and Logistics". In the master programme, the department continues to offer its own profile for the mechanical engineering degree programme and enriches a variety of other profiles with its courses.

Corona and the associated restrictions on attendance have also led to accelerated digitalisation at the ITPL. In 2021, most lectures have been digitised, and new examination formats for digital teaching were developed and implemented. Despite the success and continuous online teaching, we are glad that in the winter semester 2022/23 most courses can be held in presence again, while additional courses – such as guest lectures by the renowned Professor Goldsman (Georgia Tech) about "Probability and Statistics in Computer Simulation" – are given online.

Teaching Supported by Experts from Industry and Consulting

Cooperations with other departments, institutions, and industrial partners have been strengthened and are reflected in numerous teaching formats. The specialised laboratory "Prototype like a Start-Up", which is a cooperation between the Centre for Entrepreneurship & Transfer and the ITPL, is as popular as always. Dr.-Ing. Christian Knobloch from the company Knobloch & Gröhn supported the teaching in the bachelor's degree with his own teaching module on process modelling.

Highly topical issues that are the focus of our research activities could be transported into teaching through practical examples from industry. The lectures covered topics such as machine learning from PTC (Switzerland), test automation from Redbots, and data structures in the supply chain from Relex. We also had a very interesting guest lecture about Web services from Capgemini and got an insight in the digitalisation by KHS and from Prof. Stautner, research director at ModuleWorks GmbH and Professor at HRW.

The "Case Study Information Systems", which has already been successfully carried out several times with the company CGI, continues to represent a special institution. Here we are pleased that our former student Kilian Hilpert, who now holds the position of director at CGI, has once again made his scarce time available for a great interactive format.

Furthermore, the practice-oriented module "Planning and Implementation of IT Projects" was created. Michael Küsters, thought provoker at Intelygence GmbH, gives an insight from practice in his lectures: From the selection to the design and the implementation of an information system.

Visiting Professors at ITPL

Prof. *Susan Sanchez*, Distingished Professor of Operations Research and co-director of the SEED Center of Data Farming at the Naval Postgraduate School in Monterey, California, stayed at ITPL for two weeks in October 2022. The visit has been supported by a Gambrinus fellowship. Prof. Sanchez is world-wide renowned for her novel research on data farming and has received multiple awards and grants. Her research interests include design of experiments, data-intensive statistics, and robust selection, with applications to simulation experiments, military operations, manufacturing, and health care. She has over 80 scholarly publications and over 2,000 citations. She has been nominated as Titan of Simulation (2016), an INFORMS Fellow (Class of 2017), and is recipient of the INFORMS Women in OR/MS (WORMS) Award for the Advancement of Women in OR/MS (2018). In 2019, she received NPS's Menneken Award for Sustained and Significant Research, and the Distinguished Service Award from the INFORMS Simulation Society.

Visiting the mining history in the Ruhr area with Susan Sanchez (photo: ITPL)

Prof. Sanchez, during her stay in Dortmund, contributed to our master programme teaching, held a public talk about her work, and intensely discussed our research topics within a research colloquium as well as face to face with our researchers. Further collaboration is already on the horizon: Among others, Prof. Sanchez will kindly co-supervise the dissertation of our team member Joachim Hunker.

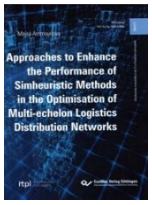
The Gambrinus fellowships have proven to be an excellent means to profit from the excellence and experience of well-known researchers from abroad.

The previous fellowships acquired by ITPL include Prof. Angel A. Juan (Universitat Politècnica de València and Universitat Oberta de Catalunya / Barcelona), Prof. David Goldsman (Georgia Institute of Technology, Atlanta). Prof. Suman Niranjan (University of North Texas), and Prof. Jesus Gonzales-Feliu (Excelia Business School, La Rochelle).

Meta- heuristics for the Optimization of Distribution Networks

Majsa Ammouriova (Dr.-Ing.) has finished her Ph.D. in the field of decision support systems for multi-echelon distribution networks at ITPL, sponsored by the German-Jordanian University. She has submitted her thesis in November 2020 and passed her oral defence in February 2021 "with distinction" (summa cum laude).

Simheuristic Optimisation of Multi-echelon Logistics Distribution Networks



Ammouriova, M.: *Approaches to Enhance the Performance of Simheuristic Methods in the Optimisation of Multi-echelon Logistics Distribution Networks*. Göttingen: Cuvillier 2021.

Management of logistics distribution networks is a challenging task. Decision-makers rely on logistics assistance systems that recommend actions to optimise the networks. These systems can be based on simheuristics to benefit from metaheuristics in exploring possible solutions and on simulation for modelling the networks. This book presents three approaches to recommend promising solutions to optimise the networks with fewer simulation runs. The first approach utilises information from the network to guide the search of metaheuristics. In this approach, domain-specific information is defined and assigned to actions. The metaheuristic algorithm utilises this domain-specific information to find more-promising solutions. The second approach is reducing the number of possible solutions by grouping actions with respect to their domain-specific attributes. Here, the smaller solution space decreases the number of required simulation runs. The last approach looks for equivalent solutions that cause the same changes in the network. This approach aims to skip unnecessary evaluations and, thus, simulation effort.

Series "Fortschritte in der IT in Produktion und Logistik", Vol 3, available in book stores and online; print 89,90€; e-book 63,90€.

Time to Celebrate: 36 Years of Modeling and Simulation

In our world shaped by computers, we are all familiar with the decade system of numbers including all its nice zeroes, an ancient principle from India that was brought to Europe by the Arabian scientists. However, we should not forget that there is another ancient tradition that declares the number Twelve as holy and consummate, and we can easily prove this with a long list. Jerusalem had twelve gates, Israel twelve tribes, Jesus selected twelve apostles, and the sky is structured into twelve zodiac signs. Finally, our time has always been sliced into twelve hours for the day and another twelve for the night. Some currencies involved a factor of twelve until the twentieth century, and there is yet no movie about ten jurymen. Even modern Europe has twelve stars on its flag, which do not count the number of member states (like in the USA), but represent a "perfect" number.

This said, there was no reason to mourn that COVID-19 has destroyed the 10-year anniversary of our department, but we followed the ancient traditions and celebrated *Twelve years of ITPL* in the last days of September this year. The department has started its work on October 1st, 2010 – and, actually, I have started my scientific work in September 1986 at Fraunhofer IPK in Berlin. Thus, I may look back to 36 years or three dozens of modelling and simulation technology, and have been glad that a group of experts, friends, and partners from this long era joined us for a two-day anniversary colloquium. A total of nine talks shed light on the developments of simulation and related disciplines looking back and estimating its future. Summaries of the talks have been published in our proceedings series.

Expert talks: Prof. Uwe Clausen, Prof. Thomas Knothe (photo: ITPL)

Prof. Markus Rabe gratulates the winner of the science slam Felix Stadler (photo: ITPL)

Prof. Steffen Straßburger, Prof. Sven Spieckermann (photo: ITPL)

Prof. Steffen Straßburger, Prof. Christoph Laroque, Prof. Kai Gutenschwager, and in the background Arzu Kocyigit, the "power woman" of our ASIM conference 2015 in Dortmund (photo: ITPL)

The expert talks have been amended by a science slam, which gave ITPL's researchers the chance to present

their research idea and goals in a nutshell to the experts. The presentations have been rated by the audience, and Felix Stadler (M. Sc.) has won the election for the most convincing contribution. Descriptions of the research undertakings, condensed to a summary of two pages, are also included in the proceedings book.

The evening has been used to look back and forward, refresh contacts after the pandemic period in a comfortable environment, and also to discuss the presented research.

Rabe, M.; Scheidler, A.-A. (eds.): Drei Dutzend Jahre Simulationstechnik - Festkolloquium September 2022 (in German). Series "Fortschritte in der IT in Produktion und Logistik", Vol 4, available in book stores and online; print 89,90€; e-book 63,90€. Available for free download at http://www.itpl.mb.tu-dortmund.de/publikationen/files/SR_04_Festkolloquium.pdf.

Failure mechanisms for reliability prediction of heating systems

Sahil-Jai Arora (M. Sc.) is an external Ph.D. student at ITPL and member of the BOSCH Ph.D. programme. He is conducting his research in cooperation with the ITPL and the company Bosch Thermotechnology.

Modern heating systems are often continuously exposed to loads over a long period of time – usually up to 20 years. Due to the variable operating conditions, the actual lifetime in the field can only be estimated to a very limited extent. In particular, the superimposition of different component-specific damage mechanisms and load profiles is challenging.

Defective components are replaced during scheduled service visits or due to unexpected failures. A possible predictive reliability approach can lead to optimized maintenance and service concepts on the manufacturer side by evaluating field data for predictive fault detection. At the same time, existing lifetime models can be optimized through data-driven relation of system and operating conditions.

Different industries face the challenge of developing a reliability prognosis model, hence necessitating standardization of model development. The research addresses this challenge by developing a reference model for reliability prediction of heating systems, which will enable the reuse of knowledge and practices in the form of a design scheme.

In order to strengthen the cooperation between ITPL and Bosch Thermotechnology, milestone meetings are conducted, which also offer opportunities such as a factory plant tour (photo).

Factory visit and work discussion at Bosch Thermotechnik in Wernau: Markus Rabe (supervising Professor), Sahil-Jai Arora (Ph.D. Candidate), Maik Effenberger (Reliability Expert), Linnan Du (Reliability Expert), Drazen Martinovic (Reliability Expert), Andreas Radde (Logistics Expert) (photo: Bosch Thermotechnology)

Urban Logistics Systems Modelling

Jorge Chicaiza-Vaca (M. Sc.) has been funded by a DAAD scholarship and is pursuing his Ph.D. at ITPL and head of the Transportation and Logistics Systems Research Center at the Freight Transportation Chamber in Ecuador.

His research focusses on automated parcel locker (APL) systems such as packstations or locker boxes. In this field, one of the main expectations of users is convenient localization. This includes proximity to home or the path to work and parking availability. In this context, simulation and optimization techniques are used to define the system structure of APLs as an urban logistics solution. A model is designed that combines a system dynamics simulation model with a facility location model for a specific application of APLs in the cities of Dortmund (Germany) and Pamplona (Spain) as case studies. The proposed model aims to improve the system representation of APLs and provide a new evaluation tool for future implementations of this initiative as a last-mile logistics system for cities.

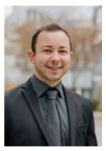
Currently, Jorge Chicaiza-Vaca is part of the Returning Experts Program. This program is made up of people with a history of migration, who have studied and worked in Germany and are using their expertise by returning to their country of origin. Jorge is the head and co-founder of the Transportation and Logistics Systems Research Center at the Freight Transportation Chamber. The center is gaining a leading role in the private transportation sector in Ecuador. It runs several research projects, e.g., (i) the development and implementation of cargo bikes for urban logistics in the city center and their combination with APLs; (ii) the combination of passenger and freight transport using the new metro infrastructure in Quito (Ecuador), and (iii) implementing telemetry for trucks, using sensors and devices to obtain real-time (second-by-second) information on numerous engine parameters, such as distance traveled, revolutions per minute, instantaneous fuel consumption, speed, geographical position, and altitude. These parameters are used to develop a national eco-driving program designed to reduce fuel consumption as well as emissions and to increase road safety.

Adapting Data Preprocessing for Data Mining

Florian Hochkamp (M. Sc.) is a research assistant at ITPL since November 2020. His research interests include knowledge discovery in databases, data mining, data preparation, and data quality.

With growing amounts of data, knowledge discovery in databases is required to cope with analysis tasks. The fact that subject matter experts are also overwhelmed by the volume of data and that there is a shortage of subject matter experts at the same time underscores the relevance of more-sophisticated analysis methods such as data mining. For many manufacturing companies it is unclear, which methods to apply in data mining. An implementation of every data mining technology requires a data preprocessing matching the specific data mining algorithm that deals with data quality deficiencies and ensures the structuredness of the data. However, data preprocessing takes up to 80 % of the time for a knowledge discovery process and prevents a fast and precise analysis. To approach this issue, more-developed preprocessing methods are presented in the literature. The research focusses on an adaptation of the data preprocessing phase to create a framework combining advances in data preprocessing methods with a structuring approach.

A Reference Model for Data-driven Sales Planning



Daniel Büttner (M. Sc.) is a member of the Graduate School of Logistics in Dortmund. He is conducting his Ph.D. studies at the ITPL and works together with the company Vorwerk.

Logistics is a connection in-between countries, companies and departments. Within the emerging digitization, data for planning and coordinating the supply chain become even more important to remain competitive.

Analysing data for planning issues to gain transparency and flexibility through the supply chain is one of the main topics for companies to counteract future challenges in the digital competition. The usage of information in planning processes can provide this transparency and efficiency in supply chains. In order to be more client-orientated and to satisfy consumer needs fast, the forecast of future sales with historical data is vital. Accurate sales planning helps to provide the demanded products in advance to emerging customer demand. Especially when consumer products are built to stock, accurate sales forecasts are needed to plan production, inventory, and replenishment on the distribution warehouses. Consumers are getting used to short delivery times and product availability. This fact and great market volatility increase the importance of accurate forecasting and planning of future customer demand. Daniel Büttner is developing a reference model that shapes (data-driven) quantitative sales planning within the supply chain. The reference model guides the process of sales planning, the usage of methods, and the identification of required data. Thereby, it provides a framework for companies to make appropriate use of data within their sales planning task and gives recommendations on how to start and advance quantitative sales planning within different levels of complexity.

Combining Data Farming and Mining in a Logistics Assistance System

Joachim Hunker (M. Sc.) is a research assistant at ITPL since 2017. His research interests include simulation-based data generation, non-relational databases, and knowledge discovery in databases.

Nowadays, supply chains are fairly complex systems. Due to this complexity, decision-makers in supply chain management are confronted with various logistics tasks that can no longer be answered manually. Therefore, decision makers are supported by IT systems such as logistics assistance systems. A key factor in supporting decisions in supply chain management is gaining and visualizing knowledge. One of the widely established methods in theory and practice is known under the term knowledge discovery in databases. The core phase of the knowledge discovery process is known as data mining. Applying successful data mining, e.g., to find useful and previously unknown patterns, relies heavily on a valid and preprocessed input data basis, which is usually stored in a database. A challenge is that these consist of mainly observational data, which leads to different flaws. Typical examples are low data quality, e.g., missing or out-of-range data. A way to address this problem is simulation-based data generation, called data farming. The process of data farming uses large-scale experiments to grow massive amounts of synthetic data as simulation output. This enables the application of analytical methods on a well-suited database to support decision makers in supply chain management in answering complex logistics tasks. In this context, Joachim Hunker focuses in his research on combining data farming and data mining in a logistics assistance system to support decision makers in supply chain management.

Automated Machine Learning for Quality Control

Reza Jalali Sousanabady (Dipl.-Inf.) is an external Ph.D. student at ITPL and currently working as an IT consultant for Accenture AG in Zurich, Switzerland.

Today, the world stands on the brink of a technological revolution that will fundamentally alter every aspect of people and companies' existence. The scale, scope, and complexity of the transformation in the ways these entities live, work, and inter-relate to one another will be unlike anything mankind has ever experienced before. Manufacturing and logistics companies will not be exceptions. Various aspects including increased competition, demand for reduced time to market, as well as higher complexity of products and processes will be treated using new tools and methodologies. Among these methodologies is machine learning, through which additional knowledge can be obtained. This is achieved by extracting and accumulating critical data, detecting patterns, and extracting new hypotheses representing helpful knowledge. However, a drawback lies in the time-consuming procedures of data preparation and

model development. Additionally, reusability of the models as well as the significant amount of resources required for adjustment of existing models pose as further factors that have to be considered. To address these problems, Automated Machine Learning (AutoML) can be applied for model generation in a variety of cases. Using AutoML increases the speed of model creation, but at the costs of the model quality due to the lack of domain knowledge utilization. The research focuses on tackling this challenge in the domain of quality control in discrete manufacturing. The proposed methodology introduces a novel approach for the integration of domain information in the learning process of AutoML as well as compensating its intractability for the experts.

Digitalization of Control Processes in the Model Upgrade of Motor Vehicles

Emre Kilic (M. Sc.) is an external Ph.D. student at ITPL and currently working at Volkswagen AG in Wolfsburg.

The automotive industry must deal with wide-reaching challenges and changes. A continuous gain of significant competitive advantages in a highly competitive market requires automotive manufacturers to produce new products with a large diversity of variants at ever-shorter time intervals. As a result, the frequency of series launches has increased and the need for a sophisticated vehicle project management and an efficient handling of vehicle changes and model updates along the product process has gained significant importance. However, current project management practices and frameworks utilized by automotive manufacturers do not effectively address this demand, e.g., the goal of increasing operational efficiency and productivity as well as establishing continuous improvement are not sufficiently achieved. While these goals are traditionally common place in certain fields of the automotive manufacturing, e.g., in production, logistics, or warehousing, their dedicated consideration in the vehicle change management and model update of vehicles has not been examined thoroughly in the required extend.

A conceivable solution to establish a progressive and digitally supported vehicle change management and an advanced control of model updates of vehicles is the Digital Twin approach. However, there is still little research regarding the applicability of the digital twin on operational business processes with the aim to increase operational efficiency and productivity. Therefore, a novel concept of a business-process-related digital twin is designed and proposed to provide a substantial leverage to reach the aspired operational excellence in the management of vehicle changes and model updates of vehicles in the automotive industry.

Automated Order Picking for Heavy Flatpacks in Retail and Wholesale

Trang Nguyen-Krogull (M. Sc.) is an external Ph.D. student at ITPL and currently working as Automation Integration Leader in Customer Fulfilment with Automation integration of INGKA IKEA.

The ongoing market and e-commerce developments, combined with the increasing customer expectations in omnichannel customer points and shorter lead times, the home furnisher companies have an increased interest in automated order picking systems. Although technologies for automated order picking processes are developing rapidly, picking of the unergonomically heavy flatpacks is mostly conducted manually. This is due to the flexibility of manual processes, but also to the long planning and evaluation time of these complex processes. Automated order picking solutions support the requirement of a more-ergonomic working environment and can provide more density and productivity. However, it also makes the overall intralogistics process more complex, leading to a more time-consuming and complex planning and evaluation process. Currently, the planning and evaluation still involve years of preliminary studies, development projects, data collection, and evaluation to reach the successful implementation of an automated order picking process of heavy flatpacks. Furthermore, the existing guidelines for the generic determination of performance availability lead to a time-consuming discussion in the specification phase, as they are not specifically dedicated to the technology that is used in intralogistics solutions for heavy flatpacks.

The aim of the research is to develop a reference model to support the decision-making during the planning and evaluation phase for automated order picking processes of heavy flatpacks. The reference model shall provide a conceptual framework with standard process descriptions and best-in-practices. It builds up the foundation for the planning process by providing the planner an understanding of significant concepts, entities and relationships that need to be considered. A major benefit of the reference model is the more efficient and costs-saving planning and evaluation phase. Furthermore, the usage of the reference model in combination with an early integration of simulation into the planning process has the benefit that the complex intralogistics solutions can be validated and verified in an early stage. The application of simulation gives the possibility to consider the pre- and post-processes in addition to the generic guidelines.

Embedding Track and Trace Solutions

Henrik Körsgen (M. Sc.) is an external Ph.D. student at ITPL and currently working as a SCM IT consultant with dxk GmbH in Zurich, Switzerland.

The last years have revealed how production can be severely impacted by distortions in the supply chain. Gaining reliable visibility of the supply chain is considered a must today and – even more – in the future. Track & trace solutions are an important technical basis to reach this goal.

Up to now, track & trace has mostly been just an add-on to the current supply chain system landscape. However, the benefit of such tools unravels best if the complete scope of logistics operations is covered. Our research addresses this challenge by designing a framework that guides enterprises in the precision engineering industry where to start with the integration of track & trace solutions and which procedures to follow in their planning and implementation. In the first step of this investigation, information has been collected about the technical options that are available to organizations. In a second step, their resulting benefits are evaluated.

Track & trace solutions comprise the three major steps (i) identifying the item, (ii) receiving its status, and (iii) triggering the follow-up action. To put this into practice, organizations require detailed information about the set-up of the solution and how to integrate the related processes. Eventually, the digital enterprise architecture represents a suitable basis for the track & trace application.

For this purpose, a track & trace maturity assessment reference model facilitating embedding track & trace solutions is designed, considering the entire digital enterprise architecture. Additionally, the blockchain technology for track & trace solutions is compared to other technologies. The next step is to collect data for the track & trace maturity assessment reference model.

Creating Customized Actions for the Simulation of Logistic Networks

Dominik Schmitt (Dipl.-Inf.) is an external Ph.D. student at ITPL and currently working at the Fraunhofer Institute for Material Flow and Logistics, Dortmund, as a research associate.

Today's logistics networks are very complex systems, which are influenced by many external and internal factors. To adjust the system in order to pay attention to these effects and to guarantee an almost perfect performance of the networks, continuous changes in its structure and configuration are needed. The kind of these changes depends on multiple objectives such as increasing the profit, changing the range of goods, or adding new suppliers.

Optimizing such complex systems can become a huge challenge for managers. Facing this problem, ITPL has developed a decision support system (DSS) that supports the user by suggesting promising actions for the given logistics network. This DSS addresses different logistic areas of the network and chooses the best integrated action sets from a given catalogue of actions to be applied while respecting their interdependencies.

Unfortunately, these suggested changes are typically predefined within the simulation program. To increase the flexibility and usability of the DSS, a concept of deriving specific actions from generic action types has been created. To realize this concept, a method to generate, integrate and execute user-generated generic action types is a precondition.

ITPL is addressing this challenge by creating a formal description of changes in DES models for large logistics networks. Based on the formal description of actions, it is possible to transform the changes from a very technical-level into a more intuitively accessible way, e.g., in a graphical editor. On this abstraction level, it is possible for the user to modify or create new actions and apply these to the simulation model.

Reference Model Based on the Value Stream Method

Tobias Sohny (M. Sc.) is an external Ph.D. student at ITPL and currently working as a research assistant at the Koblenz University of Applied Sciences with Prof. Dr.-Ing. W. Wincheringer.

Suppliers of a customised material flow system guarantee a throughput performance when submitting their offer. There are high risks that the finally realised material flow system does not fully meet this promise. Oversizing the system, with the consequence of additional costs, leads to decreased competitiveness. Therefore, the guaranteed throughput of the system needs to be secured at the time of the bidding phase. The quality of the planning results cannot be adequately evaluated without discrete event simulation (DES). However, DES, especially the required modelling, is too time-consuming and cost-intensive at the time of the bidding phase, taking into account the unclear probability of finally winning the bidding. Therefore, DES is only used when the order has already been placed. As the result, possible planning deficiencies are recognised too late and lead to costly adjustments.

The target of our research is to develop a reference model (RM) for the simulation of material flow systems based on the value stream method (VSM). This RM based on the VSM enables an efficient development of simulation models for customer-specific material flow systems during the bidding phase. This enables suppliers to secure the throughput performance already during the bidding phase.

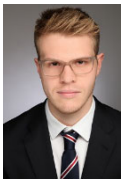
Modeling of Intralogistic Processes for the Implementation of WMS

Felix Stadler (M. Sc.) is external Ph.D. student at ITPL and working in the IT consultancy of Windmöller & Hölscher KG in Lengerich.

Due to the growing complexity of intralogistics systems, the use of warehouse management systems (WMS) is becoming increasingly attractive for companies. As an often business-critical management system of internal material flows, however, their implementation or change is complex and carries risks. Especially the insufficient knowledge of companies about their own processes leads to a high capacity and cost burden due to the time-consuming involvement of their own experts and, often, also contracted WMS consultants. In this context, models and modeling methods are gaining additional importance. But, particularly in intralogistics, with its

special demands and characteristics, there is a lack of methodological support for mapping and transferring process knowledge appropriate for the WMS implementation. The consequences, besides a low level of acceptance among the affected employees, are project abortions and production downtimes. Therefore, we are conducting research to collect experiences from industrial practice during the implementation of WMS. With the assumption that a supporting method is urgently required in this context, we work on a modeling language for mapping intralogistic processes in line with the requirements for the implementation of WMS as well as procedural method components that support the generation and transmission of the process knowledge.

Simulation and Machine Learning for Agile Production Networks



Willian Vent (M. Sc.) is an external Ph.D. student at ITPL and currently working in the manufacturing department of Gira Giersiepen GmbH & Co. KG in Radevormwald.

Determining ideal structures of production networks poses a challenging task for manufacturing companies nowadays. In order to gain competitive advantages, companies are trying to make their production activities more agile.

In recent decades, the term agility has been coined by agile software development and adapted for various disciplines and applications. Currently, agility is experiencing a renaissance in the context of production and is seen as a promising field of research for the production of the future and as the answer to rapid and disruptive change. The challenge of agile production networks is the complexity in their design. Due to the size of the solution space, inadmissible simplifications arise as a result of human preference. Here, it is only partially comprehensible how individual network adjustments can have an effect. As a result, only a few network configurations emerge, which are too quickly inferior to the network variants that become known in the advanced design process.

A way to address this problem is a combined approach of simulation and machine learning. As an approach, besides the generation of a database by simulation, machine learning can be used to generate design strategies for production networks that differ from known solutions patterns.

Method for Real-time Forecasting of Production Key Figures

Erwin Sirovnik (Dipl. Wirt.-Ing.) is an external Ph.D. student at ITPL and working for thyssenkrupp Rasselstein GmbH in Andernach.

Nowadays the production scheduling pursues several objectives inside a flexible flow production in the steel industry, which are mainly located in the field of logistics. Besides an adherence to delivery dates, the primary target within a steel industry – characterized by capital-intensive plants – is represented by running at full capacity. Further objectives based on production key figures like maximized material productivity, minimized energy costs, improved quality, etc. are only covered to some extent, if any, manually by a responsible planner with few general rules. Although there are individual isolated solutions for specific plant-related objectives, e.g., on the subject of quality, a holistic view is still missing. These aspects are gaining importance – especially in situations of unplanned events like plant or material failures within an intermediate production step – regarding re-scheduling of the planning objects in the short-term.

In order to cover this resulting complexity, a production scheduling has to be developed that generates optimized production plans for each individual material unit at each production step considering all available data from the shop floor. Thereby, the multi-objective optimization must be supported by a real-time-capable forecasting of all relevant production key figures derived from machine learning and data mining approaches on data concerning quality, orders, maintenance and further relevant information. On this basis, transparency regarding all key performance indicators concerning the production as well as an immediate reaction to critical situations like insufficient target values will be enabled.

Process-oriented Production Planning along the Value Stream

Alexander Wuttke (M. Sc.) is a research assistant at ITPL since 2022. His research focuses on simulation, digital twins, and analytics on data collected by sensors.

Digital Twins have gained a lot of attention in research as well as in industrial applications. They are the virtual representation of real-world objects and used to find answers to numerous questions concerning their real counterparts. An important source of data for the Digital Twin is constituted by sensors at the objects themselves.

A specific task that Digital Twins are useful for is Predictive Maintenance (PM). For PM, the object and its current state are monitored and analyzed in order to predict when maintenance is required rather than conducting preventive maintenance. Utilizing PM can result in a major saving of costs and is, therefore, of great interest for industrial applications.

In cooperation with an industrial partner, a Digital Twin for the purpose of PM of industrial furnaces is currently worked on and implemented. This includes a simulation model, which is used to gain in-depth insights of the industrial furnace and to generate additional data for the data basis of proven methods for PM.

Reference Model for Process-oriented Lot Sizing along the Value Stream

Gökhan Yücel (M. Eng.) is an external Ph.D. student and is working as director of operations at a manufacturer for safety systems.

The globalization, the integration of supply chains, and the lean management philosophy represent challenges to the definition of lot sizes. The reduction of stocks and the just-in-time supply of customers show a considerable effect on supply chains. However, the past years have shown how sensitively global supply chains react to political developments and natural disasters. Therefore, many companies are building up safety stocks despite the lean philosophy.

In this environment, the question arises whether lot sizing can remain a purely internal activity. Irrespective of the costs and the pass-through or process-oriented approach, the question arises whether the lot size modelling needs to be extended along the supply chain, and which factors have an influence on the consideration of the supply chain in the lot size calculation and have, therefore, to be taken into account.

A simulation-supported reference model for process-oriented lot sizing along the value stream is under development to support the production planner in ensuring a continuous process flow and, thus, delivery reliability.

Lectures Given by the Department IT in Production and Logistics

Bachelor

- Introduction to Programming
- Fundamentals of Simulation Technology
- IT-Systems in Industrial Production
- Modelling Digital Ecosystems in Production and Logistics

Master

- Information Exchange of Manufacturing Companies
- IT Design in Production and Logistics
- Data Analysis and Knowledge Representation in Production and Logistics
- Case Study Information Systems
- Material Flow Simulation
- Planning and Implementation of IT Projects
- Lab “Prototype like a Start-Up”

Contributions to Bodies

Association of German Engineers (VDI)

- VDI GPL Fachausschuss 204 Modellierung und Simulation; Member Markus Rabe
- VDI International Gremium Digital Information (IGDT), Member Markus Rabe
- VDI Richtlinienausschuss (Guideline Committee) 3633.10 “Geschäftsprozessmodellierung” (Business Process Modelling); Chairman Markus Rabe, Member Joachim Hunker
- VDI Richtlinienausschuss (Guideline Committee) 3633.13 “Verifikation und Validierung” (Verification and Validation); Chairman Markus Rabe
- VDI-Richtlinienausschuss (Guideline Committee) 3633.3 „Experimentplanung” (Experiment Planning); Members Markus Rabe and Anne Antonia Scheidler

German Simulation Society (ASIM)

- Working Group “Simulation in Production und Logistics” (SPL); Deputy Chairman Markus Rabe
- Expert Group “Dedicated Conferences”; Chairman Markus Rabe
- Expert Group “Consideration of Energetic Impact Factors in SPL”; Member Markus Rabe

Conference Organization

- ASIM Dedicated Conference “Simulation in Produktion und Logistik”; Chairman Markus Rabe 1998, 2000, 2004, 2008, 2015
- ASIM Dedicated Conference “Simulation in Produktion und Logistik”; Program Committee Markus Rabe 1993-2023
- Winter Simulation Conference; Local Chair Markus Rabe 2012 (Berlin)
- Winter Simulation Conference; Lead Proceedings Chair Markus Rabe 2018; Proceedings Chair Markus Rabe 2019.
- Winter Simulation Conference; Track Chair Markus Rabe 2012, 2013, 2014, 2016–2023.

Board memberships

- Graduate School of Logistics; Board Member Markus Rabe

Journals

- Advisory Board Journal of Simulation (Taylor & Francis); Member Markus Rabe

Publications 2021

Rabe, M.;Jesus Gonzalez-Feliu, J.; Chicaiza-Vaca, J.; Tordecilla, R. D.: Simulation-Optimization Approach for Multi-Period Facility Location Problems with Forecasted and Random Demands in a Last-Mile Logistics Application. Algorithms 14 (2021), 14, article 41.

Rabe, M.; Ammouriova, M.; Schmitt, D.; Dross, F.: Simheuristics Approaches for Efficient Decision-Making Support in Materials Trading Networks. Algorithms 14(2021), article 23.

Rabe, M.; Ammouriova, M.: Utilising Relations between Actions to Improve the Performance of Optimisation Procedures for Distribution Networks. In Franke, J.; Schuderer, P. (eds.): Simulation in Produktion und Logistik 2021. Göttingen: Cuvillier 2021, pp. 227-236.

Rabe, M.; Wincheringer, W. Sohny, T.: Reference Model for the Value-stream-based Simulation of Discontinuous Conveyors in the Rough Planning Phase of Production Systems. In Franke, J.; Schuderer, P. (eds.): Simulation in Produktion und Logistik 2021. Göttingen: Cuvillier 2021, pp. 123-132.

Hunker, J.; Wuttke, A.; Scheidler, A. A.; Rabe, M.: A Farming-for-mining Framework to Gain Knowledge in Supply Chains. In: Kim, S.; Feng, B.; Smith, K.; Masoud, S.; Zheng, Z.; Szabo, C.; Loper, M.: (eds,): Proceedings of the 2021 Winter Simulation Conference. Piscataway: IEEE 2021, DOI 10.1109/WSC52266.2021.9715372.

Arora,S.-J.; Ebbecke, C.;Rabe, M.; Fisch. J.: Methodology for the Assessment of Potentials, Selection, and Design of Predictive Maintenance Solutions. Procedia CIRP 104 (2021) 708-713.

Rabe, M.; Tordecilla, R. D.; do C. Martins, L.; Chicaiza-Vaca, J.; Juan,

A. A.: Supporting Hospital Logistics During the First Months of the COVID-19 Crisis: A Simheuristic for the Stochastic Team Orienteering Problem. In: Kim, S.; Feng, B.; Smith, K.; Masoud, S.; Zheng, Z.; Szabo, C.; Loper, M.: (eds,): Proceedings of the 2021 Winter Simulation Conference. Piscataway: IEEE 2021, DOI 10.1109/WSC52266.2021.9715337.

Büttner, D.; Scheidler, A. A.; Rabe, M.: A Reference Model for Data-driven Sales Planning in Distribution Systems: Development of the Model's Framework and Functionality. Hamburg International Conference on Logistics, 21.24. September 2021, Hamburg, pp. 441-476.

Stoldt, J.; Prell, B.; Rabe, M.; Wenzel, S.; Thiede, S.: A Criteria-based Database for Research and Applications of Energy-oriented Simulation in Production and Logistics. In: Franke, J.; Schuderer, P. (eds.): Simulation in Produktion und Logistik 2021. Göttingen: Cuvillier 2021, pp. 94-102.

Serrano-Hernandez, A.: Martinez-Abad, S.; Ballano, A.; Faulin, J.; Rabe, M.; Chicaiza-Vaca, J.: A Case Study in Pamplona (Spain): In: Kim, S.; Feng, B.; Smith, K.; Masoud, S.; Zheng, Z.; Szabo, C.; Loper, M.: (eds,): Proceedings of the 2021 Winter Simulation Conference. Piscataway: IEEE 2021, DOI 10.1109/WSC52266.2021.9715335.

Büttner, D.; Rabe, M.: Sales Forecasting in the Electrical Industry – An Illustrative Comparison of Time Series and Machine Learning Approaches. 7th International Conference on Innovation and Industrial Logistics, Macao, 9th-11th August 2021, pp. 69-78.

Sirovnik, E.; Schirm, E.C.; Müller, D.; Rabe, M.; Brandenburger, J.; Rajabi, A.; Wolff, A.; Ordieres, J.; Gutierrez, M.; Colla, V.; Iannino, V.; Maddaloni, A.: Implementation of Multi-objective Production Scheduling in the Dynamic Environment of the Flat Steel Industry. 5th European Steel Technology and Application Days (ESTAD), Stockholm, August 30th-September 2nd, 2021.

Theses and Scientific Project Works 2021

Akyol, E.: Untersuchung der Eignung des MapReduce-Verfahrens für den Einsatz in logistischen Assistenzsystemen im Aufgabengebiet des Supply Chain Managements. TU Dortmund University, Department IT in Production and Logistics, master thesis, 2021.

Alić, D.: Backend zu einer datenbankbasierten Webapplikation für den Einsatz in der digitalen Lehre. TU Dortmund University, Department IT in Production and Logistics, master thesis, 2021.

Alić, O.: Frontend zu einer datenbankbasierten Webapplikation für den Einsatz in der digitalen Lehre. TU Dortmund University, Department IT in Production and Logistics, master thesis, 2021.

Bonnemann, M.: Ansätze zur Integration eines Vorgehensmodells des Data Farmings in Supply Chains. TU Dortmund University, Department IT in Production and Logistics, master thesis, 2021.

Fahrenholz, C. M.: Klassifizierung von Algorithmen des Graph-Mining zur Beantwortung logistischer Fragestellungen in Supply Chains. TU Dortmund University, Department IT in Production and Logistics, master thesis, 2021.

Mengering, B.: Erstellung eines Datenqualitätskonzeptes im Kontext der Eigenschaften von Big Data. TU Dortmund University, Department IT in Production and Logistics, master thesis, 2021.

Steinfurth, F.: Implementierung einer auf Graph Mining basierenden Open-Source-Applikation zur Risikoidentifizierung von Supply Chains. TU Dortmund University, Department IT in Production and Logistics, master thesis, 2021.

Christakis, G.: Detektion und Klassifikation von Ausreißern in Messdaten von Pumpentestläufen durch Anwendung von Methoden des Data Mining. TU Dortmund University, Department IT in Production and Logistics, bachelor thesis, 2021.

Feldkamp, T.: Travelling-Salesman-Untersuchung beim Verbund von Drohnen und Lastkraftwagen in Dortmund. TU Dortmund University, Department IT in Production and Logistics, bachelor thesis, 2021.

Glagla, J.: Stand der Forschung, Handlungsfelder und Forschungstrends in der Logistik 4.0. TU Dortmund University, Department IT in Production and Logistics, bachelor thesis, 2021.

Heimeshoff, L.: Data Driven – Untersuchung datengetriebener Prozesse im Umfeld von Produktion und Logistik. TU Dortmund University, Department IT in Production and Logistics, bachelor thesis, 2021.

Langenbach, K.: Entwicklung eines Graphmining-Konzeptes unter Verwendung von MATLAB im Supply Chain Management. TU Dortmund University, Department IT in Production and Logistics, bachelor thesis, 2021.

Türkmenoglu, B.: Systematische Untersuchung der Datenqualität und -strukturen in der Supply-Chain. TU Dortmund University, Department IT in Production and Logistics, bachelor thesis, 2021.

Darmograj, D.: Entwicklung neuer Übungsaufgaben auf dem Gebiet der grafischen Programmiersprachen für speicherprogrammierbare Steuerungen zum Einsatz im Lehrbetrieb. TU Dortmund University, Department IT in Production and Logistics, project thesis, 2021.

Hupe, L.: Entwicklung neuer Übungsaufgaben auf dem Gebiet der grafischen Programmiersprachen für speicherprogrammierbare Steuerungen zum Einsatz im Lehrbetrieb. TU Dortmund University, Department IT in Production and Logistics, project thesis, 2021.

Koymatli, M.: Geschäftsprozessoptimierung unter Nutzung von Parametertuning. TU Dortmund University, Department IT in Production and Logistics, project thesis, 2021.

Schubin, E.: Systematische Literaturrecherche im Hinblick auf den Wandel der Forschungsfelder in der Logistik. TU Dortmund University, Department IT in Production and Logistics, project thesis, 2021.

All our ITPL publications and student theses can be downloaded from our homepage.

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