THE INTELLIGENT SUPPLY CHAIN

FROM VISION TO REALITY

Dr Leonard Heilig and Prof Stefan Voß,
Institute of Information Systems, University of Hamburg, Germany

Faster, cheaper, safer, more transparent and reliable: whether products need to be delivered within the same city or across the globe, the requirements on today's supply chains and freight transport networks are higher than ever before. Driven by the rising opportunities of the current era of digitalization, complete industries strive to transform their business processes and redesign their business networks in order to keep up with competitors. The intelligent supply chain combines modern technologies, such as blockchain and IoT, with intelligent decision-making and analytics capabilities in order to improve visibility and predictability, flexibility and customer interaction, interconnectivity and collaboration as well as risk awareness and resilience. Considering those four themes, the article discusses the characteristics of intelligent supply chains and how modern technologies and intelligence can be employed to realize visions.

VISIBILITY AND PREDICTABILITY

The adaption of sensors, smart devices and other IoT technologies can realize real-time monitoring of almost every part of the supply chain. Companies making use of these technologies, such as Walmart and Metro, only need a few days to react to market trends, or are even able to anticipate demand, in order to work with zero safety stock, i.e., just-in-time inventory strategies [1].

Maersk uses sensor data to not only track conditions in reefer containers, but also to operate their fleet of vessels and manage empty container repositioning in a more efficient and sustainable way [2]. The issue of visibility will not be a lack of data, but to select, clean, unite, and standardize the right data in order to extract reliable and useful knowledge for managing supply chains in an adaptive and responsive manner. Thus, the use of data in intelligent supply chains goes beyond traditional descriptive and diagnostic analytics, asking "what is happening?" and "why did it happen?", respectively.

Modeling and analytics capabilities, such as predictive analytics, assist in reducing uncertainties regarding future scenarios ("what is likely to happen?") and help to identify and understand causes of inefficiencies, disruptions, and anomalies in supply chain networks. Amazon, for example, holds a patent for anticipatory shipping, meaning that products are shipped before customers place an order. This data-driven perspective is fundamental for prescriptive analytics, optimization and automation, providing automated decision support regarding the final question "what is the best course of action?"

FLEXIBILITY AND CUSTOMER INTERACTION

The high level of transparency and information density allows new forms

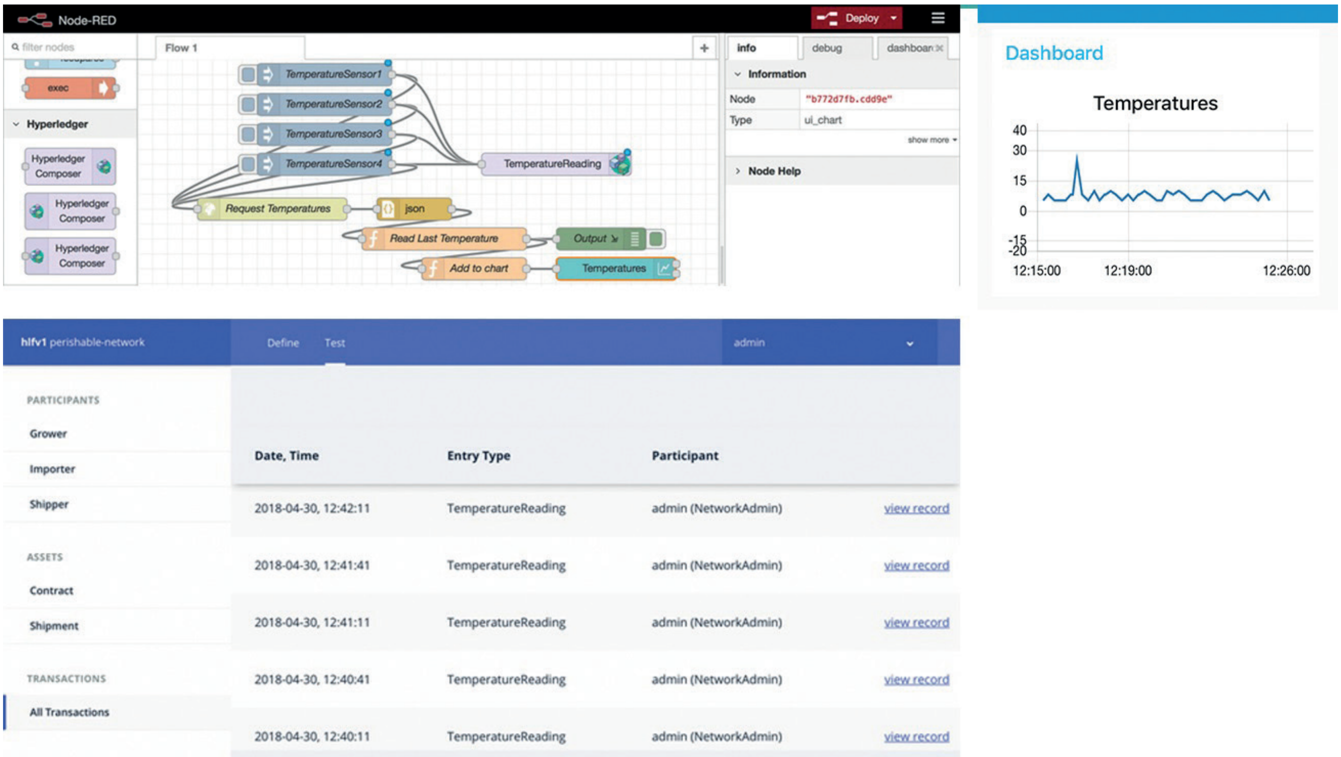

Figure 1: Simple blockchain and smart contract application for temperature monitoring based on an integration of open-source solutions like Hyperledger and node-red

of managing supply chains in a highly adaptive and intelligent way. Operational decisions related to the transport of cargo, such as regarding the mode and speed of transport (e.g., slow steaming) or its final destination (e.g., following a postponement strategy), are made based on the current conditions and market demands, respectively. Synchromodality, defined as an evolution of inter- and co-modal transport concepts [3] and part of the 'physical internet' vision, promotes mode-free bookings allowing to switch between modes or routes during transit. The aim is to better utilize available resources and adapt plans based on real-time information about delays and other circumstances like traffic, weather, or environmental conditions.

A higher flexibility usually requires a high degree of integration, coordination, and collaboration among multiple supply chain actors. Nevertheless, first pilot studies, for example in the transport corridor between Rotterdam, Moerdijk and Tilburg [4], demonstrate the feasibility and potentials of such concepts.

MAJOR PLAYERS, NEW NETWORKS

Thinking one step further, future transportation networks might involve new technologies, such as Hyperloop or drones, allowing to switch to on-demand and autonomous transport modes (e.g. in case of time-sensitive goods or critical delays). New partnerships, such as between DP World and Virgin Hyperloop One in DP World Cargospeed, pave the way for moving from vision to reality [5]. Synchromodality, however, is only one of many possible concepts for increasing the flexibility in intelligent supply chains.

Pervasive computing further enables intelligent supply chains to better integrate customers and to directly sense, adapt, and respond to individual demands and signals, such as from retail shelves, smart maintenance solutions, or virtual assistants (e.g., Amazon Alexa, Siri). With special regard to retail, the focus of analytics will further shift from the product to the customer. Companies like Amazon, having a deep knowledge about its customers and a huge expertise in data analytics, are increasingly entering new supply chain related sectors, such as shipping and retail, to fully exploit their capabilities. Moreover, the increasing customer awareness requires reliable and detailed tracking and tracing information, for instance, to reconstruct whole food chains from the farm to the plate.

BLOCKCHAIN

With the above in mind, blockchain is an essential driver of intelligent supply chains as it allows to process transactional data without the need of a central authority. It is built upon essential security principles, applying means to ensure the authenticity, validity, and integrity of transactions.

In Figure 1, a simple blockchain application for tracking and tracing the temperature in containers is shown using Hyperledger and node-red (for more information, please contact the authors). In this system, transactions are automatically generated by using sensors, smart devices or other IoT technologies. A smart contract between supply chain participants allows us to define rules, for example, regarding temperature thresholds, and automatically triggers a transaction if a rule applies or is breached. A business intelligence dashboard allows the tracking of metrics and key performance indicators of the whole supply chain network based on the transactional data.

INTERCONNECTIVITY AND COLLABORATION

Forming end-to-end delivery networks is a common strategy to respond to new challenges and remain competitive. Integrating large parts of global supply chains under one roof provides more control in optimizing cargo flows based on a unified view on data. Recently, the CEO of Maersk, Søren Skou, once again highlighted that the company's strategy is to become the only point of contact for shipping customers [6]. However, it is often not possible to have all actors of a supply chain network under one roof.

In general, the future challenge is to better integrate different parts of the supply chain and provide tools to facilitate trust and collaboration. This involves the technical integration of enterprise applications and ERP-to-ERP integration. An example is the integration between supply chain management systems (e.g., transportation management systems) and terminal operating systems. Without a sufficient integration and collaboration support, operations remain a black box and it is even difficult for global companies like Maersk, providing shipping, port and freight forwarding services, to operate supply chains in a visible, responsive, and efficient way.

XVELA is an example of one company bridging the gap between the different parts of value chains. Technologies, such as cloud computing, blockchain and smart contracts, might further facilitate trust and collaboration in intelligent supply chains. Moreover, the 'uberization' of the sharing economy, using digital platforms to match demand with available resources, will play a greater role in intelligent supply chains.

An example is port-IO, a mobile cloud platform to manage and optimize truck drayage operations in a network of independent truck operators based on real-time data and prescriptive analytics [7].

In order to facilitate a high degree of inter-organizational transparency, integration, and collaboration in supply chain networks, information systems need to facilitate trust and data security so that companies not only see potential risks in sharing information, but the necessity and chances of doing so. In this regard, blockchain is a promising technology for improving the information sharing and collaboration in supply chains.

RISK AWARENESS AND RESILIENCE

Global supply chain operations are exposed to a range of internal and external risks that might cause disruptions with a low or severe impact on businesses. The increasing digital penetration and advanced analytics capabilities will help in detecting potential supply chain disruptions before they occur. A high visibility is key for a continuous risk assessment and real-time predictive analytics. Decision support systems, e.g., using scenario analysis and hedging strategies (see, e.g., [8]), as well as collaboration tools facilitating joint mitigation strategies will help to better ensure business continuity.

DHL Resilience360, for example, is a cloud-based risk management platform to assess, visualize, and track events in order to identify potential disruptions and mitigation strategies, like alternative transport modes or routes (see synchromodality). A high resilience requires an adoption of plans at all individual nodes of the supply chain in case of a disruption. Container terminals, as essential linking nodes, for instance, may need to recover berth and the crane split plans at the seaside [9] or cope with deviating truck arrivals at the landside [10]. From a scientific standpoint, more research is needed to find appropriate response strategies that neutralize the impact of disruptions and maintain a high resilience.

REFERENCES

[1] Atzori, L., Iera, A., & Morabito, G. (2010). The internet of things: A survey. Computer Networks, 54(15), 2787-2805.

[2] http://blogs.teradata.com/customers/maersk-line-using-internet-things-data-analytics-change-culture-strengthen-global-supply-chain/

[3] Pfoser, S., Treiblmaier, H., & Schauer, O. (2016). Critical success factors of synchromodality: Results from a case study and literature review. Transportation Research Procedia, 14, 1463-1471.

[4] https://www.synchromodaliteit.nl/download/een-stip-op-de-horizon

[5] https://www.porttechnology.org/news/dp_world_and_hyperloop_one_create_cargospeed

[6] https://www.porttechnology.org/news/maersk_ceo_paints_digital_ups_fedex_style_future

[7] Heilig, L., Lalla-Ruiz, E., & Voß, S. (2017). port-IO: an integrative mobile cloud platform for real-time inter-terminal truck routing optimization. Flexible Services and Manufacturing Journal, 29(3-4), 504-534.

[8] Dadfar, D., Schwartz, F., & Voß, S. (2012). Risk management in global supply chains: Hedging for the big bang? In Transportation & Logistics Management. Proceedings of the 17th International HKSTS Conference, HKSTS, Hong Kong (pp. 159-166).

[9] Zeng, Q., Yang, Z., & Hu, X. (2011). Disruption recovery model for berth and quay crane scheduling in container terminals. Engineering Optimization, 43(9), 967-983.

[10] Li, N., Chen, G., Govindan, K., & Jin, Z. (2016). Disruption management for truck appointment system at a container terminal: A green initiative. Transportation Research Part D: Transport and Environment. DOI: 10.1016/j.trd.2015.12.014

ABOUT THE AUTHOR

Dr Leonard Heilig is a researcher and lecturer at the Institute of Information Systems at the University of Hamburg. His research interests are in cloud computing, machine learning, optimization methods and related applications in maritime ports. He serves as guest editor in highly-ranked journals in the area of cloud computing, information systems, and maritime logistics. He spent some time at the University of St Andrews (Scotland) and, most recently, at the University of Melbourne (Australia) as a visiting scholar. His professional background includes positions at Airbus Group Innovations and Adobe Systems. He consults companies in different sectors and international projects.

Stefan Voß is professor and director of the Institute of Information Systems at the University of Hamburg. He also holds a visiting position at PUCV in Valparaiso, Chile. His current research interests are in quantitative / information systems approaches to supply chain management and logistics including public mass transit and telecommunications. Stefan Voß serves on the editorial board of some journals including being Editor of Netnomics and Editor of Public Transport. He is frequently organizing workshops and conferences. Recently, his institute hosted the Global Port Research Alliance (GPRA) conference. Furthermore, he is consulting with several companies.

ABOUT THE ORGANIZATION

The Institute of Information Systems of the University of Hamburg (Germany) specializes in interdisciplinary research for supporting decision-making within various application areas. A strong research focus is on quantitative methods, data mining, and cloud computing for supporting the planning and management in port logistics. Numerous publications in highly-ranked journals emphasize the quality of the institute's research. Several projects in the port industry have been successfully carried out in recent years.

ENQUIRIES

University of Hamburg
Institute of Information Systems
Von-Melle-Park 5, Room 3061
D-20146 Hamburg, Germany
Tel: +49-40-42838-3061
Fax: +49-40-42838-5535
Email: leonard.heilig@uni-hamburg.de