2nd Smart Services Summit

Zürich, September 13, 2019

Jürg Meierhofer (ZHAW) and
Shaun West (HSLU)

Swiss Alliance for Data-Intensive Services
Expert Group Smart Services

Lucerne University of Applied Sciences and Arts
HOCHSCHULE LUZERN
Technik & Architektur
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data service
Swiss Alliance for Data-Intensive Services

Zürcher Hochschule für Angewandte Wissenschaften
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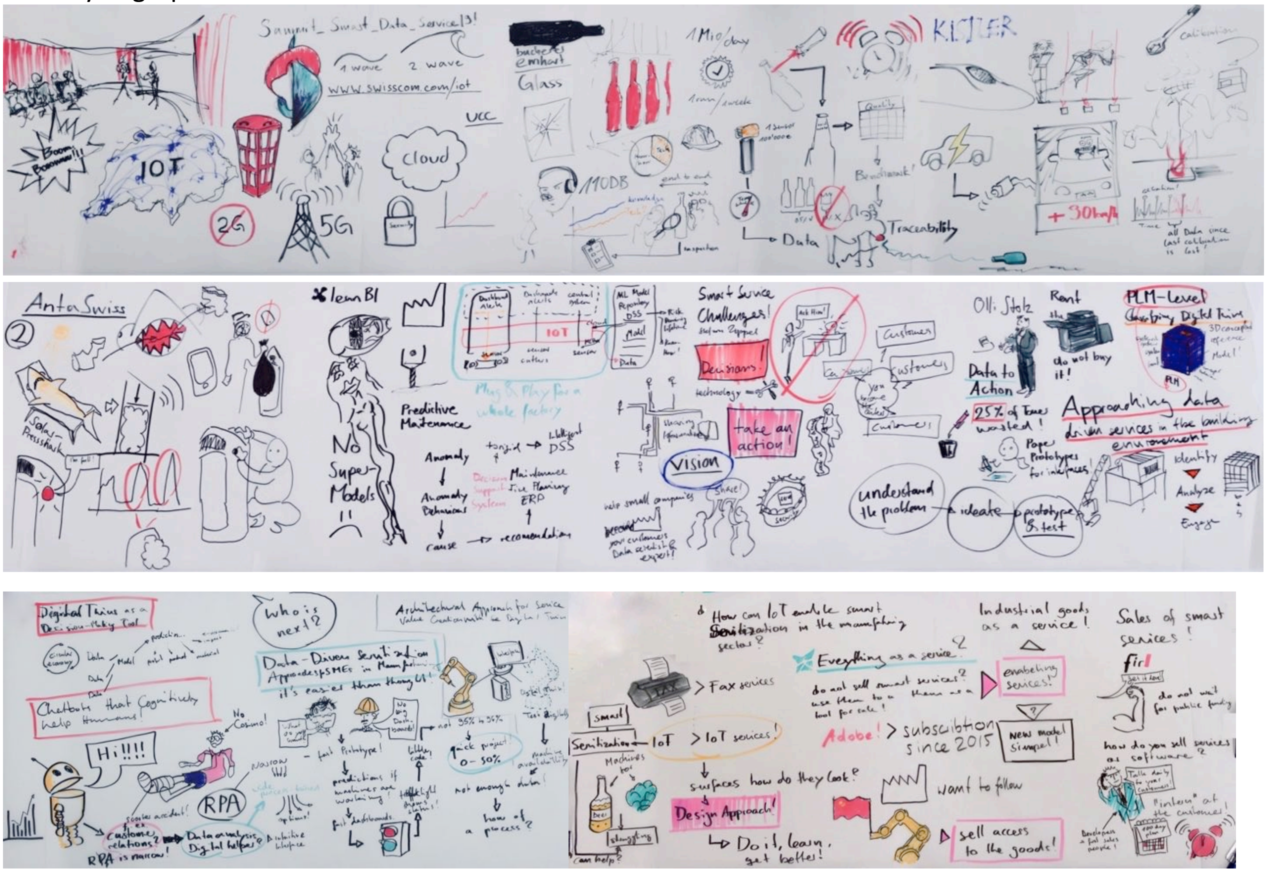
Today, we change the world

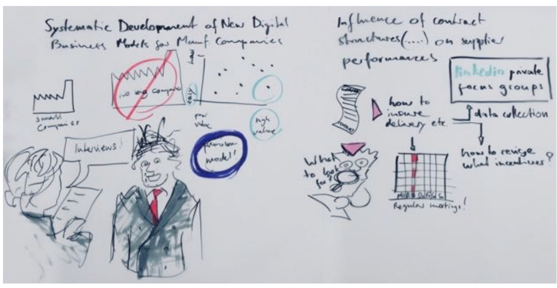
Digitalization changes everything: How we work, how we live, how we make business. In particular data-based services are game-changers.

Swiss Alliance for Data-Intensive Services: the community of innovators.

The Swiss Alliance for Data-Intensive Services provides a significant contribution to make Switzerland an internationally recognized hub for data-driven value creation and is supported by Innosuisse.

The day in graphics





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Foreword

In this proceeding, we include the industrial and academic content of the 2nd Smart Services Summit held on September 13th in Zürich.

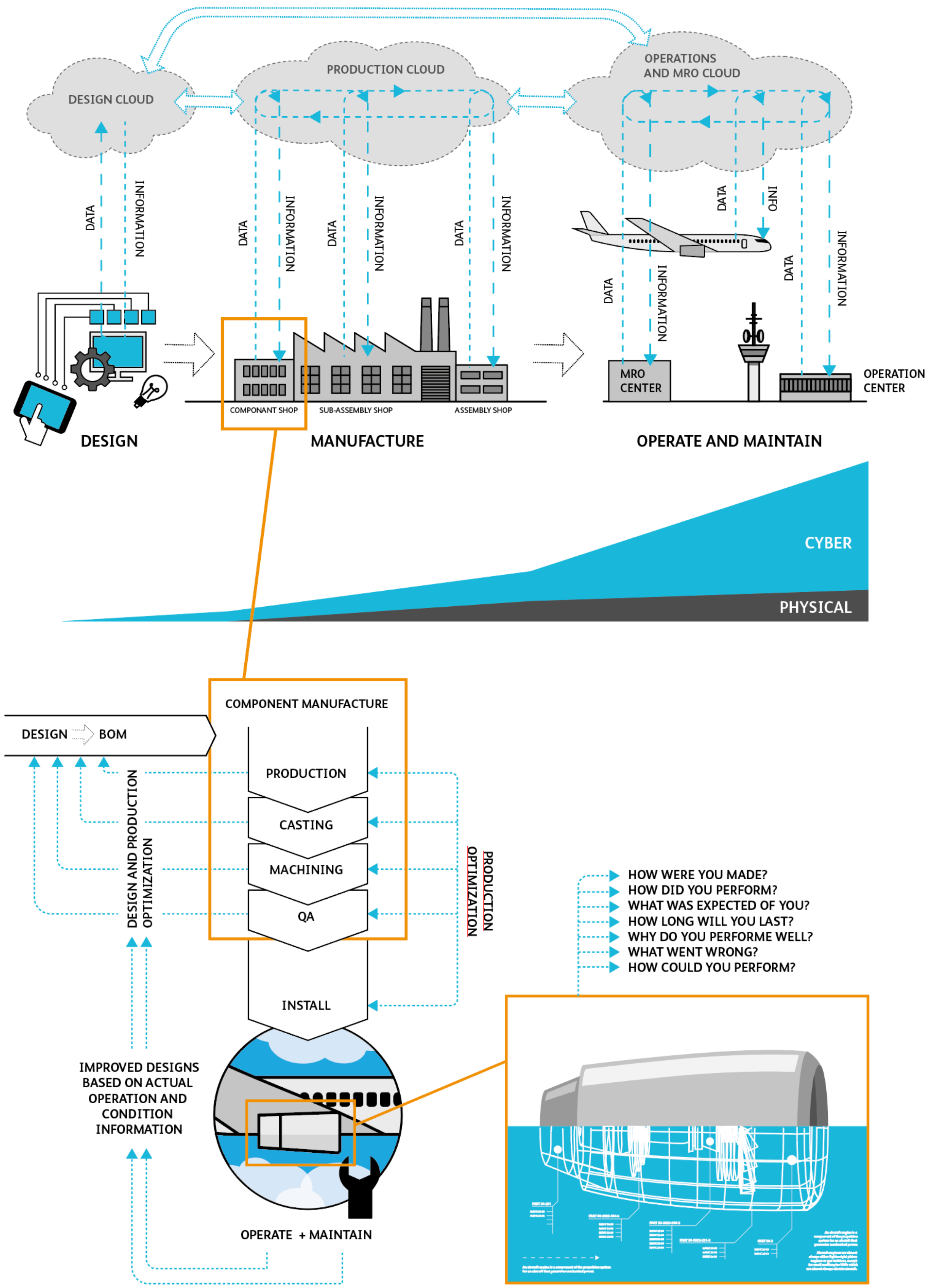
Following on from the successful half-day Smart Services Summit in 2018 we followed up with an extended format of presentations of industrial challenges and contributions from academia to foster closer collaboration. The focus topic of the summit was the development and application of Smart Services to support improved decision-making for manufacturers, operators, maintenance providers, and asset managers. Invited presentations from international industry experts framed the summit. These will be followed by short academic presentations and posters and extended breaks for in-depth discussions. The academic approaches shown in the presentations and posters are described in more details in the short papers (extended abstracts) collected in this book.

The topic of smart services is rapidly evolving and poses new challenges for industry and academia. In particular, the successful development and operations of smart services requires a new approach in a multitude of dimensions. New competences are required in design-based approaches to service engineering, in the modelling, management, and analysis of data, in the management of the installed base, in the design of products and the management of their lifecycle and many more. We tried to group this multitude of topics in the philosophy of the value creation by structuring the summit into an industrial session and then three academic sessions 1) value system design (how to integrate resources to create value in service ecosystems), 2) value creation by value propositions (how to create value for the actors in the ecosystem, and 3) value capturing (how to create value for the companies in the ecosystem.

We were very impressed by the quality of the contributions and the exchange in breadth and depth. The format revealed that the structured exchange of in-depth knowledge can create value in a world which is already rather saturated with presentations and events on digitalization. This book represents the formal part of the exchange. The often informal, very valuable exchanges and discussions between the organized contributions, which are not illustrated in this book, have led to numerous ideas for common projects and new common research directions. The goal to foster collaboration between industry and academia could clearly be achieved. We are looking forward to the 3rd Smart Services Summit in the year 2020.

The editors would like to thank Roger Berliat, Swisscom, for hosting the summit. A big thank you goes to the Swiss Alliance for Data-Intensive Services with its expert group Smart Services for providing the institutional framework for this Smart Services Summit. They also express their thanks to the Zurich University of Applied Sciences and Lucerne University of Applied Sciences and Arts for enabling this collaboration. A special thank goes to our colleagues from the ASAP Service Management Forum in Italy, whose partnership is very important. Last but not least, Finally, a big thank you goes to the contributors of industry challenges and research posters and papers, who make up the very core of the added value of this Summit.

Zurich, September 2019,
Jürg Meierhofer & Shaun West



Smart Service can help us across the whole lifecycle of the equipment and in ways that we're today only starting to imagine what they could do for us!

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Editors

Jürg Meierhofer

juerg.meierhofer@zhaw.ch

The optimization and design of Smart Services are the red thread through his activities in various industries. He is head of the "Smart Services" group of the Swiss Alliance for Data-Intensive Services, industry 4.0 coordinator at the Zurich University of Applied Sciences (ZHAW) and a board member of the Swiss Customer Service Association (SKDV). After various management positions in service and innovation in several industries, he has been teaching and researching at the ZHAW since 2014. He is director of studies for continuing education in the field of Smart Service Engineering and Industry 4.0, leads several cooperation projects with numerous industrial companies and regularly writes publications on these topics. He is now leading a project consortium in the topic of data-driven services for SMEs in the framework of the IBH-Lab KMUdigital (www.kmu-digital.eu) and co-leading the project focused on the application of Smart Twins in complex industrial application together with Shaun West. Jürg holds a diploma and PhD in electrical engineering from ETH Zurich and an executive MBA from the University of Fribourg.

Shaun West

shaun.west@hslu.ch

Shaun West lectures in Smart Service Innovation at the Lucerne University of Applied Sciences and Arts. In his role, Shaun works closely with industry to better understand the application and development of Smart Services in industrial environments. He collaborates with several universities, including Stanford, Aston Business School, Florence, and Bergamo. He is now leading a Swiss 1MUSD project that is focused on the application of Smart Twins in complex industrial application. His experience in digital services dates from the 1990s when National Power was selling its power plant improvement services to other power companies. He worked from GE Energy Services where he was rescuable for the contracting advanced service agreements on advanced turbines. As the VP Business Development at Sulzer, he led the external growth for the division (seeing it grow from 200M CHF sales to 500M CHF, today 800M CHF). He also led the development and rollout of the long-term service business from what had traditionally been a transactional sales business. Shaun holds an MBA from HEC (Paris) and a PhD from Imperial College (London). He lives close to Zurich in Switzerland.

The Presenters

Industrial Panel "Industrial Challenges"

Roger Berliat	Swisscom
Thomas Bewer	Bucher Emhart Glass
Philipp Schenkel	Kistler
Thomas Strebel	ANTA SWISS
Marc Tesch	LeanBI
Stefan Zippel	Stefan Zippel

Research Panel I "Value Identification"

Oliver Stoll	Luzern University of Applied Sciences, Switzerland
Valentin Holzwarth	ETH Zürich, Switzerland
Linard Barth	Zurich University of Applied Sciences Switzerland
Ali Gharaei	EPFL, Switzerland

Research Panel II "Value Creation"

Mario Rapaccini*	University Firenze, Italy
Roman Etschmann	Zurich University of Applied Sciences, Switzerland
Dominique Heller	Zurich University of Applied Sciences, Switzerland
Els van de Kar	Fontys International Business School, the Netherlands

Research Panel III "Value Capture"

Moritz Classen	University St. Gallen, Switzerland
Benedikt Moser	FIR e.V. an der RWTH Aachen, Germany
Helen Vogt	Zurich University of Applied Sciences, Switzerland
Wenting Zou	Aalto University, Finland

* for Barbieri, Cosimo, University Firenze

Pictures and social media

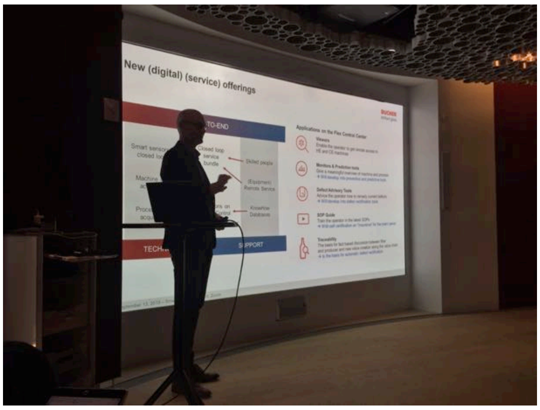

Photo of the attendees at the end of the day. The attendees listening to the review from Elio. Thomas Bewer providing an industrial input on the challenges. Moritz Classen describing the University of St. Gallen approach.

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Shaun West
Expert in Product-Service System Business Model Innovation
2w • Edited

Roger Berliat opening the Second Smart Services Summit in Zürich (amazing conference location... thanks Swisscom). We have 30 attendees both industry and academic partners. Amazing set of presentations and posters. Amazing discussions already over the opening coffee...

#smartservices #cocreation #businessmodel #servicedesign #iito #serviceinnovation #servitization

Swiss Alliance for Data-Intensive Services
Lucerne University of Applied Sciences and Arts
ZHAW School of Engineering

22 • 1 Comment

Reactions

+14

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Manfred Botschek • 1st
Customer success drives me, drives my team and drives the busine... 2w ...

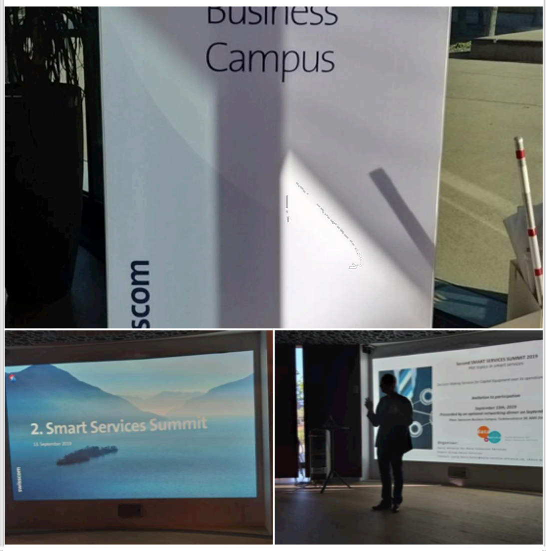
I really enjoyed this summit as it was an excellent mix of content (industry and academy), networking and fun. How to design, test, implement and monetize IOT services was discussed from all aspects and I went home with new insights, expanded network and good memories.

https://www.linkedin.com/posts/shaunwest_smartservices-cocreation-businessmodel-activity-6578179380810522624--33w/

Mario Rapaccini • 1st
Ph.D. Mec. Eng, Professor of Innovation Management @University of Flor...
2w • Edited

Smart Service Summit, nella bella sala del Business Campus di Swisscom a Zurigo.
#Asapsmf #ibislab #smartoperations
Thanks to
Jürg Meierhofer and Shaun West for this organisation

Nicola Saccani Cosimo Barbieri Federico Adrodegari



26 • 1 Comment

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Marco PERONA • 2nd
Head of RISE Laboratory - Research and Innovation for Smart Enterp... 2w ...

ti stai lanciando, Mario!

See translation

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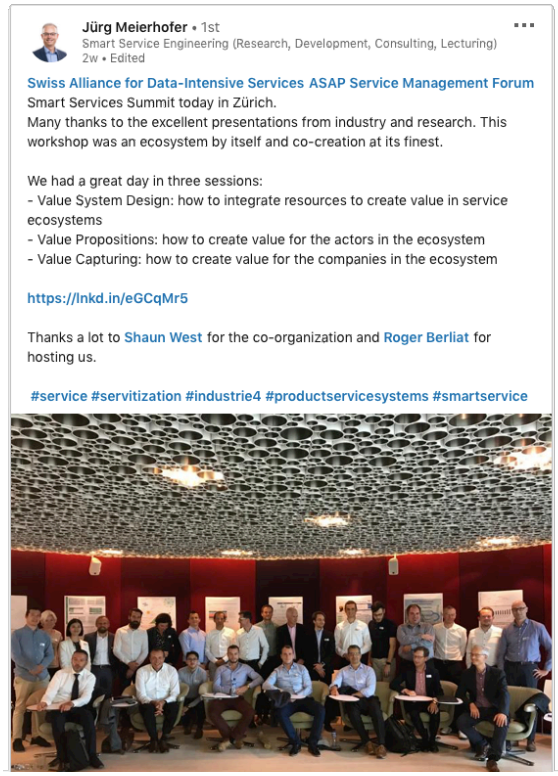
https://www.linkedin.com/posts/shaunwest_innovation-iiot-industry4-activity-6578306169134166019-GkHk/



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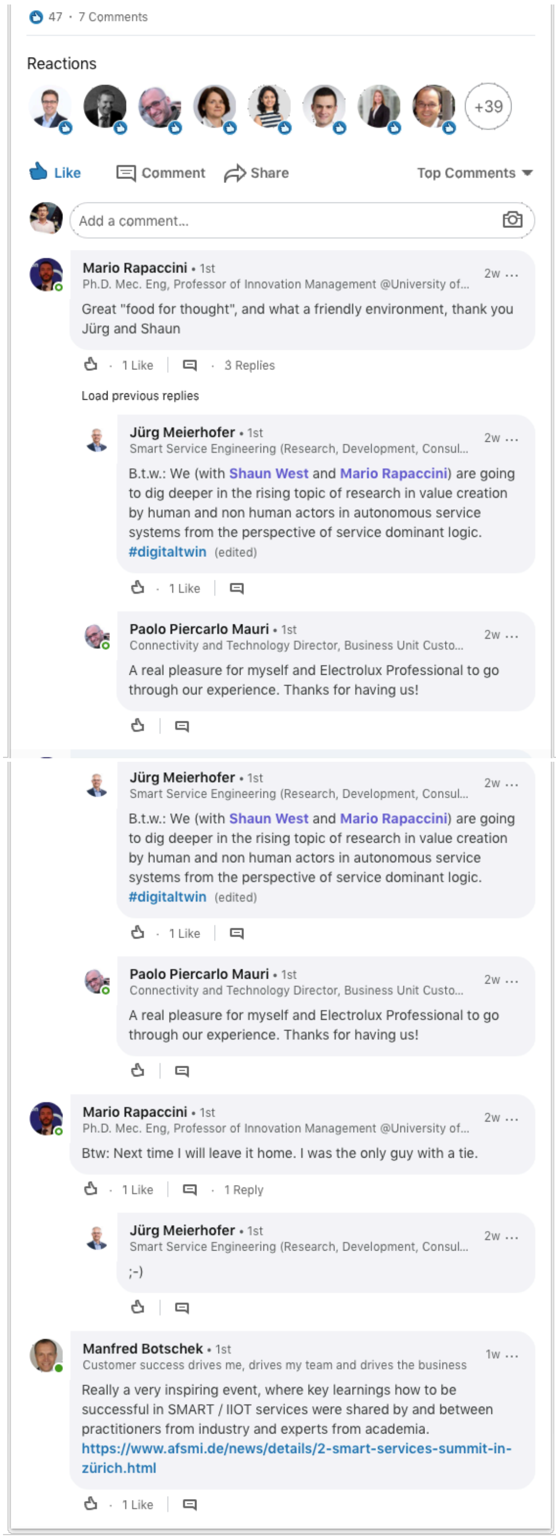

47 · 7 Comments

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Mario Rapaccini • 1st
Ph.D. Mec. Eng, Professor of Innovation Management @University of...
2w ...
Great "food for thought", and what a friendly environment, thank you Jürg and Shaun
· 1 Like · 3 Replies

Load previous replies

Jürg Meierhofer • 1st
Smart Service Engineering (Research, Development, Consul...
2w ...
B.t.w.: We (with Shaun West and Mario Rapaccini) are going to dig deeper in the rising topic of research in value creation by human and non human actors in autonomous service systems from the perspective of service dominant logic. #digitaltwin (edited)
· 1 Like

Paolo Piercarlo Mauri • 1st
Connectivity and Technology Director, Business Unit Custo...
2w ...
A real pleasure for myself and Electrolux Professional to go through our experience. Thanks for having us!

Jürg Meierhofer • 1st
Smart Service Engineering (Research, Development, Consul...
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2w ...
A real pleasure for myself and Electrolux Professional to go through our experience. Thanks for having us!

Mario Rapaccini • 1st
Ph.D. Mec. Eng, Professor of Innovation Management @University of...
2w ...
Btw: Next time I will leave it home. I was the only guy with a tie.
· 1 Like · 1 Reply

Jürg Meierhofer • 1st
Smart Service Engineering (Research, Development, Consul...
2w ...
;-)

Manfred Botschek • 1st
Customer success drives me, drives my team and drives the business
1w ...
Really a very inspiring event, where key learnings how to be successful in SMART / IIOT services were shared by and between practitioners from industry and experts from academia. https://www.afsmi.de/news/details/2-smart-services-summit-in-zürich.html
· 1 Like

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Roger Berliat • 1st
Head of IoT Partnerships bei Swisscom Enterprise Customers - Dedicated...
2w

Drawing (very nice done... 😁👍) of my opening speech at Swisscom Business Campus during the 2nd Smart Services Summit of Swiss Alliance for Data-Intensive Services

Thanks to Shaun West Jürg Meierhofer
#smartservices #iot #ecosystem

31 · 1 Comment

Reactions

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Jorge Mathis • 1st
Experience Designer. Design Sprint Facilitator
2w ...
I like the waves, pretty smooth drawing skills!
· 1 Like

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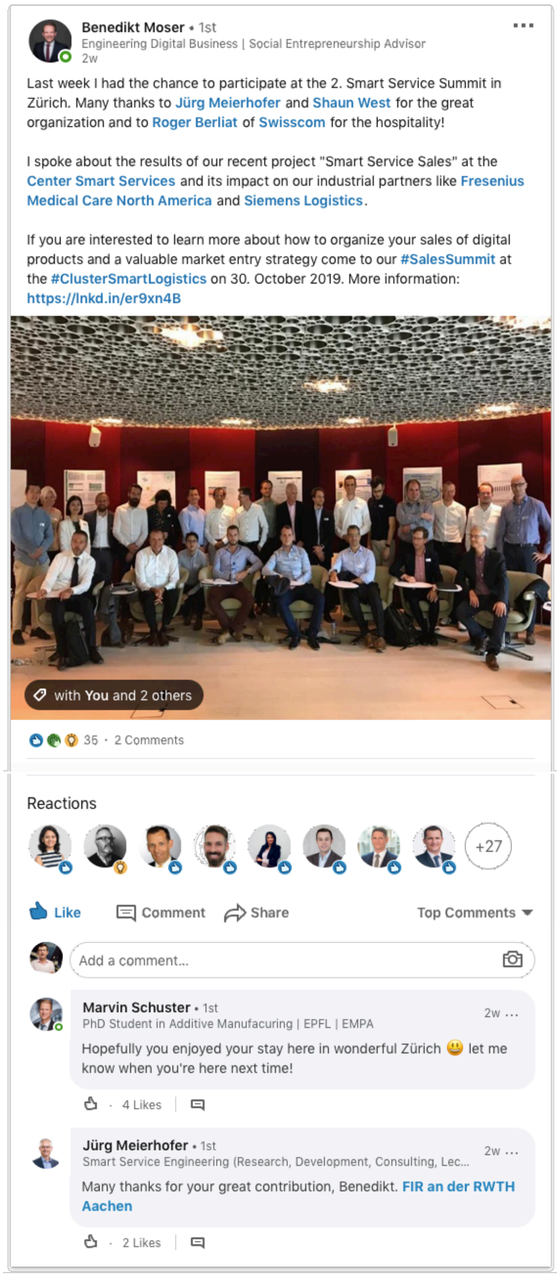

Benedikt Moser • 1st
Engineering Digital Business | Social Entrepreneurship Advisor
2w

Last week I had the chance to participate at the 2. Smart Service Summit in Zürich. Many thanks to Jürg Meierhofer and Shaun West for the great organization and to Roger Berliat of Swisscom for the hospitality!

I spoke about the results of our recent project "Smart Service Sales" at the Center Smart Services and its impact on our industrial partners like Fresenius Medical Care North America and Siemens Logistics.

If you are interested to learn more about how to organize your sales of digital products and a valuable market entry strategy come to our #SalesSummit at the #ClusterSmartLogistics on 30. October 2019. More information: https://lnkd.in/er9xn4B

with You and 2 others

35 · 2 Comments

Reactions

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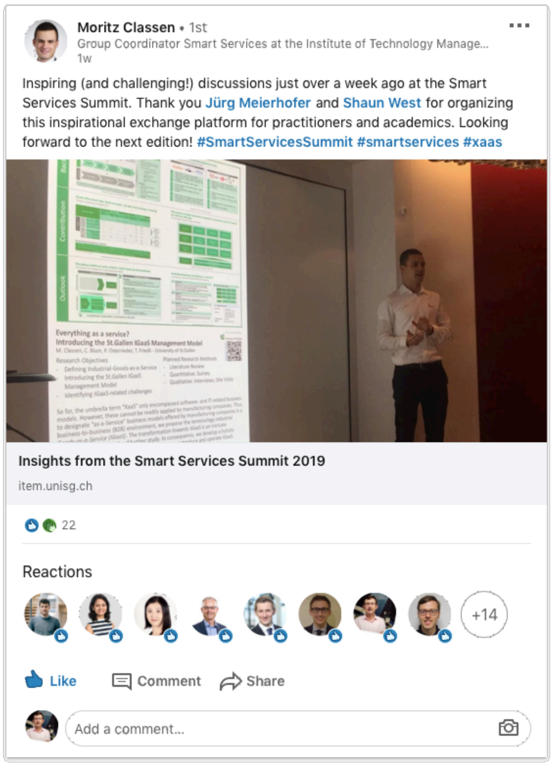
Marvin Schuster • 1st
PhD Student in Additive Manufacuring | EPFL | EMPA
2w ...
Hopefully you enjoyed your stay here in wonderful Zürich 😃 let me know when you're here next time!
· 4 Likes

Jürg Meierhofer • 1st
Smart Service Engineering (Research, Development, Consulting, Lec...
2w ...
Many thanks for your great contribution, Benedikt. FIR an der RWTH Aachen
· 2 Likes

https://www.linkedin.com/posts/benedikt-moser-3060b2a2_salessummit-clustersmartlogistics-activity-6579391307230298112-9n8-/



Moritz Classen • 1st
Group Coordinator Smart Services at the Institute of Technology Manage...
1w

Inspiring (and challenging!) discussions just over a week ago at the Smart Services Summit. Thank you Jürg Meierhofer and Shaun West for organizing this inspirational exchange platform for practitioners and academics. Looking forward to the next edition! #SmartServicesSummit #smartservices #xaas

Insights from the Smart Services Summit 2019
item.unisg.ch

22

Reactions

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Top challenges for Smart Services based on feedback from the attendees

Elio provided a very different feedback on the presentation and the challenges that are faced with Smart Services. You can watch the video by clicking on it. His feedback was important as it provides an 'outsiders' view of the challenges that were presented.

Elio Amato (HSLU T&A) providing feedback to the attendees on what he viewed as the challenges

Challenges according to the attendees' survey were:

Value identification
- Data acquisition
- Data availability and accessibility
- Finding, studying and understanding cases
- Focus on customer value not on technology
- Focus them on customer needs
- Getting data eg. from shop floor
- Getting to a commonly agreed definition
- Good data quality as foundation
- Misunderstanding and ignorance towards passed missed opportunities
- Quality of the data
- Service design
- Uncovering customers' latent needs
- Understanding of what true smart services are

Value creation
- Bringing partners of ecosystems together
- Challenging our mind-set success
- Communication and resource allocation
- Developing comprehensive design methods
- Fear of losing know how and control over established products
- Find the right people to carry out these services
- Generating enough value add for customer to invest in changes
- Including humans in the process to take their fears and doubts
- Intraorganizational capabilities
- Showing business value
- Understanding the concept of co-creation

Value capture
- Knowhow and culture change required
- Selling them through existing sales channels
- Developing a true demand for data driven services
- CAPEX is easier to sell to industries then OPEX
- Monetization solutions
- Lack is setting and selling strategy and focus
- Finding architects for a data driven service landscape
- Trust to external security
- Finding business opportunities with more value for service providers and customers
- Customer acceptance
- Revenue stream innovation
- How to start eg. Incremental approach
- Cooperation between IT and IIOT
- Find the "right people"

Summary of the Industrial challenges

The industrial presentations started with Roger Berliat from Swisscom (Schweiz) AG and how some of the new technologies are disruptive to traditional businesses and that many firms are unable to understand how to implement them. The first wave has come, and the second BIGGER wave is on its way. We need to prepare as so much is new and we need to learn and experiment to find what works and learn why it works.

Thomas Bewer from Bucher Emhart Glass presented their “end-to-end” digital services concept. The glass industry is facing a big problem due to knowledge drain as experienced personnel are retired and new people are difficult to attract. In order to overcome this challenge, the technology is however only about one third of their puzzle, the remaining two-thirds is based on know how (and in some cases know who). The development of Smart Services here can improve their customer’s businesses and provide new opportunities based on operations benchmarking or container tractability.

Philipp Schenkel spoke about Kistler’s digital aspirations in the area of sensors and measurement systems. This is for Kistler an interesting transformation and one that they have many common challenges with other mid-sized firms in Switzerland, Italy and Germany. How can a firm transform from an excellent product manufacturer, to one that provides Smart Services and integrated customer solutions? This is a major challenge to overcome for the firm. That said they are identifying services that people value and are creating new value propositions, which they can then test.

Anta Swiss manufacture the Littershark waste bin and have created a new service to help improve the efficiency of the employing of the rubbish. Thomas Strebel provided details on the really interesting use case of self-crushing solar powered bins that tell people when they need emptying. What Thomas confirmed was really complicated with the optimization of the crushing with the emptying processes. Involving third parties, big (and small) data, new product design and people is really complex.

Marc Tesch from LeanBI focused on the aspects of plug & play predictive maintenance, moving from sensors to anomalies, to understanding anomaly behavior and their causes, providing a recommendation that is injected into the ERP or maintenance planning system. The focus was on the implementation challenges of such an automated Service and a suitable architecture of a centralized Decision Support Service for a dynamic planning of maintenance tasks.

Stefan Zippel talked about the need for a clear vision for smart services and that any real Smart Service should provide decision support to help people to take the right action. What is hard here is developing the processes to get to a point where you take the right actions. He was very clear that most (all?) firms do not have all of the necessary skills and capabilities and that they must learn to collaborate with other firms and universities.

Panel I "Value Identification"

Speakers

Oliver Stoll	Luzern University of Applied Sciences, Switzerland	Application and Development of the Data2action Methodology to Four Industrial Use Cases
Valentin Holzwarth	ETH Zürich, Switzerland	Approaching data driven services in the built environment
Linard Barth	Zurich University of Applied Sciences Switzerland	Classifying Digital Twins: A Three-Dimensional Conceptual Reference Model
Ali Gharaei	EPFL, Switzerland	Digital Twin as a decision-making tool to opt for the most promising Product Design Strategies in a Circular Economy

Application and Development of the Data2action Methodology to Four Industrial Use Cases

Oliver Stoll, Shaun West, Mario Rapaccini, Cosimo Barbieri

RESEARCH MOTIVATION

The motivation for this work is a desire to find a more effective way to support industrial firms with the development of Smart Services. Firms have been expressing their frustration with this type of service development, and this Executive Paper reviews the lessons learnt from the application and development of the Data2Action Framework in four different industrial cases. Three of the cases are based on projects with durations from four months to one year, with one example from a 24-hour hackathon. The methodology was developed to provide a structured practical approach to the design of Smart Services in complex systems.

The basis of the Data2Action framework is "understand – ideate – prototype – test" with iteration and reflection loops (Figure 1). Within each step additional tools are used to help gain deeper understanding and insight. The tools used for each step were from the Design Thinking and Service Design toolboxes and were in the most part visual, to support engagement from developers in different fields. This framework was applied in the four use cases, to provide a similar approach to the challenge of building Smart Digital Services that would augment the services the firms were already providing to their customers. The assessment of the value of these new services was proxied using three Service Dominant Logic (SDL) dimensions: service ecosystem; service platform; and value co-creation. Each case is analyzed considering the following aspects: problem understanding; the ideation of new (valuable) solutions; the ability to prototype solutions (early concepts and AI-based solutions); and the testing of solutions. The assessment applied to the final solutions is based on the three chosen SDL dimensions. Structured reflections on the cases are combined in a cross-case analysis.

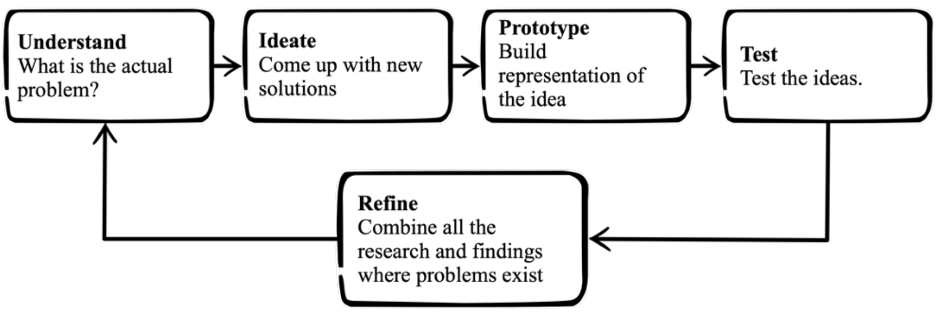

Figure 1. Overview of the D2A framework

The reflections on the testing of the D2A framework are described in Table 1, where the results are broken out into the four phases and the reflections on each are presented per phase. Based on the reflections, and using an Action Research methodology, the framework was adjusted to better support the development of Smart Services. The objective was to use existing tools or to adjust existing tools, so that the framework could gain easy acceptance.

Table 1. Reflections from the four cases

	Aircraft MRO	Glass bottle manufacturing	Water distribution (hackathon)	Printing-as-a-service
Problem Understanding	Very complex system not knowing where to start… Focus on MRO and the aircraft	Understand the equipment and how it is used by the customer	Understand that data scientists and business people are different	Mutual understanding of techies and business at the end of the phase
Ideation	Focused on improving aircraft tracking and MRO resources.	Improve communication within the operations and maintenance teams	Apply solutions from other industries to the water case (low degree of innovation)	Co-creation resulted in new ideas for business problems
Prototyping	Draw conceptual dashboards to support MRO decision making	Digital Twin in excel linked to KPIs for the whole platform	24 hours working digital prototypes	Conceptual (hand drawn) and working (MS BI based) prototypes
Testing	Interviews	Interviews and customer application	Interviews during the development process and judgement of experts at the end of the event	Took places during different stages of the project. Test purpose needed.
Lessons	Comprehend problem Breakdown problems It is not about data it is about business	Digital can support business understanding and provide sales triggers	Techies can do more than we thought – they need support with business and problem understanding	Co-development leads to better results Ongoing testing supports 'better' solutions

CONTRIBUTION TO THEORY AND PRACTICE

With some modifications the methodology was able to support the development of Smart Digital Services in each of the different test cases. The maturity of the methodology evolved with each application, iteration, and reapplication. The visualization of the problem(s) with the value flows, the machines and the actors provided clarity and created a common understanding of the problems and the situations in which they existed. The ideation process using actor and situational analysis helped with value identification and building supporting dashboards. The prototyping phases provided further improvements to the solutions and more clarity, with the data providers and information consumers working first in pen and paper before moving to digital tools. The framework that evolved based on the four use cases is shown in Figure 2. This framework requires further testing, particularly in Phase 4 "Testing", where more formal structure is required to improve the phase's performance.

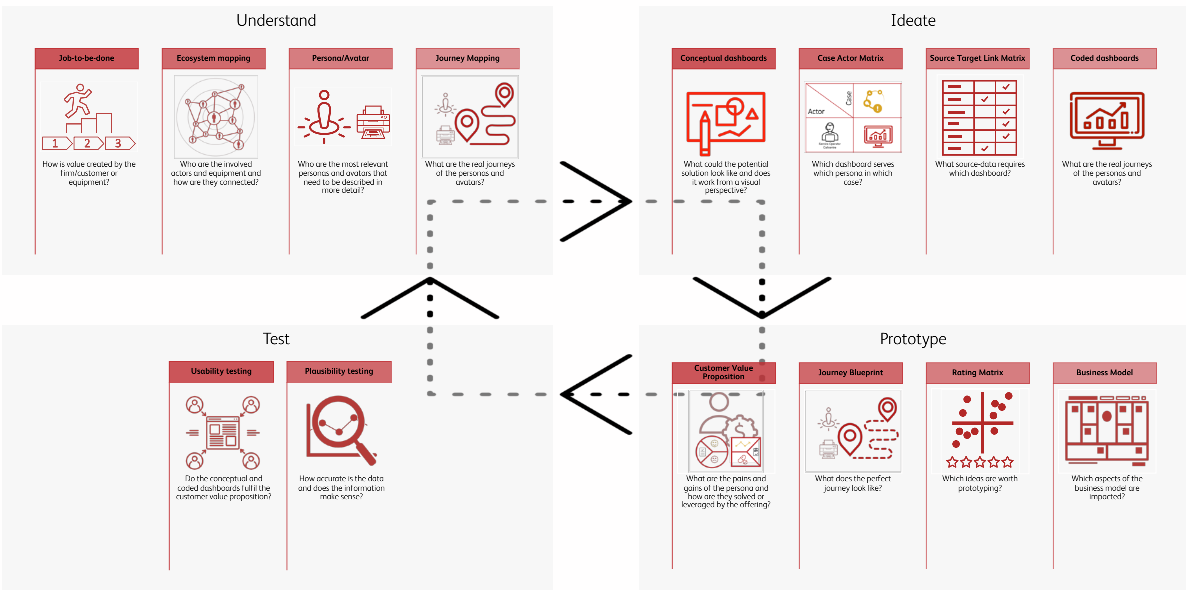

Figure 2. The Data2Action Framework developed to support the design of Smart Digital Services

The Data2Action framework was found to support a number of aspects identified from theory and practice. These will be described in terms of the theory and the practical implications. Academia has developed good theoretical frameworks and concepts. Those with marketing perspective are product centred, those from servitization are generally more human centred and those from data science are centred on analysis. The three disciplines need to interconnect more and perhaps contribute more practically-oriented research.

Industrial firms need to participate in digitalisation to gain advantage from smart digital services and smart advanced services. Digitalisation is a topic that needs to be handled by company leaders, and they need to explore it by doing it. This leads them to experience that facilitates decision-making for the future of an organisation.

The lessons learn from the development and application of the Data2Action framework were that:

- the framework provided a structured approach to understand the problems;
- visuals supported the development of a new common understanding;
- hand-drawn prototypes were highly effective and efficient;
- identification of data producers and information consumers (Source-Target Link matrix) supported the coding.

CONCLUSIONS

Business impacts were found from the application of the modified D2A framework. The development process and collaboration between partners were improved, as well as customer experience and the identification and reduction of waste. The D2A framework supported common understanding of problems, and highlighted poor assumptions made in the past. It supported the ideation phase in a positive way, and gave a pragmatic approach to idea selection/ranking through the addition of two additional tools. The framework was particularly helpful in the prototyping phase with the addition of the Source-Target Link matrix, and it provided a rudimental testing approach. It is recommended that the updated D2A framework is applied to new use cases to determine its applicability and that the testing phase is further improved.

RECOMMENDATIONS

Further testing of the data2action framework in new user cases is needed, this should be in different environments to confirm the usability of the framework. This should also be undertaken with different levels of support; in the cases in this study one of the authors led the use of the framework.

ACKNOWLEDGEMENTs

The authors would like to thank Ricoh Italy, SmartOperations, the University of Florence and Lucerne University of Applied Sciences and Arts.

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Cosimo Barbieri, cosimo.barbieri@unifi.it, University of Florence.

Approaching data driven services in the built environment

Valentin Holzwarth, RhySearch, Buchs SG, Switzerland

Johannes Schneider, Institute of Information Systems, University of Liechtenstein

Andreas Kunz, Innovation Center Virtual Reality, ETH Zurich

Jan vom Brocke, Institute of Information Systems, University of Liechtenstein

Abstract

Interest in the field of data analytics among researchers and practitioners has been rising over the last few years. The ongoing process of digital transformation in architecture, engineering and construction (AEC) leads to increased availability of data along an asset's lifecycle, enabling the introduction of data analytics. Applications of data analytics involve multiple stakeholders, with different motivations that are linked within a data value chain. The engagement in this value chain requires consensus among the actors involved, which occupy specific roles, such as data provider, service provider, or customer. However, such consensus can only be achieved when actors are aware of their individual benefit and consequently aware of the drivers, which reflect their motivation to engage in a certain application of data analytics. This consensus can be achieved through a data driven service, which is developed and offered by one actor, which leads the value creation process. While prior research created a systematic framework for data driven value creation along a building's lifecycle, yet an approach for actors to engage in data driven service development is missing. In this work, we propose an approach, which allows for the identification of the value created through data analytics activities for each involved actor. On this basis, the proposed approach facilitates the creation of novel data driven services. This research in progress takes the first steps in building a method to facilitate the development of data driven services in the built environment by acknowledging industry specific issues and challenges.

Key words

data driven value creation, service design, data science

Introduction

Digitalization is transforming entire industries, allowing for the creation of novel offerings and business models. While the sectors of information & communication technologies as well as media and finance are already highly digitalized, there remains the construction sector at the bottom of the list [1]. However, novel approaches such as building information modeling (BIM), are aiming to digitalize the built environment. BIM enables seamless digital collaboration and continuous data flows between multiple actors and stakeholders along a building's lifecycle, such as architects, planners, contractors, facility managers, and even later users. Along with process improvements and improved communication, goes the increased availability of data along a building's lifecycle. Here, data analytics could create additional value through the provision of information, predictions and prescriptions. However, these potentials yet remain unexplored, due to issues such as high fragmentation, discontinuities or incompatibilities in data transfer, and culture. In this context, data driven services can obtain a key role by facilitating the engagement of the required actors. A popular example for the successful implementation of a data driven service in manufacturing is Rolls Royce's power by the hour, where aero engines are offered as a service to customers (i.e. the customer is charged for the time he uses the engine) [2]. This service offers substantial benefits for plane operators, as the risk for engine downtimes and maintenance is covered by Rolls Royce.

Within prior research, specific applications of data analytics for certain lifecycle phases of buildings were developed e.g. computer vision based helmet detection for workers on construction sites [3], and prescriptive construction waste analytics [4]. Additionally, a framework for data driven value creation in architecture, engineering and construction (AEC) has been developed [5]. However, these approaches stay isolated so far, resulting in a missing data exploitation along a building's lifecycle. Based on these works, we formulate the following research question: How can data driven services be developed for the built environment?

Creating data driven services in the built environment

This work proposes a three-step approach for any actor to develop data driven services in the built environment, which is presented in Figure 1. The approach builds on a framework for data driven value creation in AEC [5] and the theory of the data value chain [6].

First, the *Identify* step requires the actor to identify the following prerequisites: (i) value creating category (ergonomics & comfort, safety & security, ecology, or productivity), (ii) lifecycle phase (planning, construction, operation or end of life) and, (iii) driver, which reflects the individual motivation to engage in a certain data analytics activity (regulations, financial aspects, or others). Second, the step *Analyze* is carried out. In this step, the data value chain required to conduct the desired data analytics activity is analyzed. This includes the segmentation into the phases of data collection, information creation, data transfer, and value creation. For each phase, the required actors and data elements are identified. Third, in the *Engage* step, the actor has to decide on how to engage with the other actors that are part of the data value chain. The level of engagement in a certain data analytics activity depends on an actor's willingness to provide data driven services to another actor and thus to feed the value creation process or to receive a data driven service in order to create value through using the information provided by the service. Based on the level of engagement, a pricing technique for the data driven service can be determined. Common pricing techniques for services include flat pricing (i.e. the customer pays on a regular basis for unlimited use), performance value (i.e. the customer pays based on the created value through usage of the service) and usage-based pricing (i.e. the customer pays only for what he uses in a transactional manner) [7].

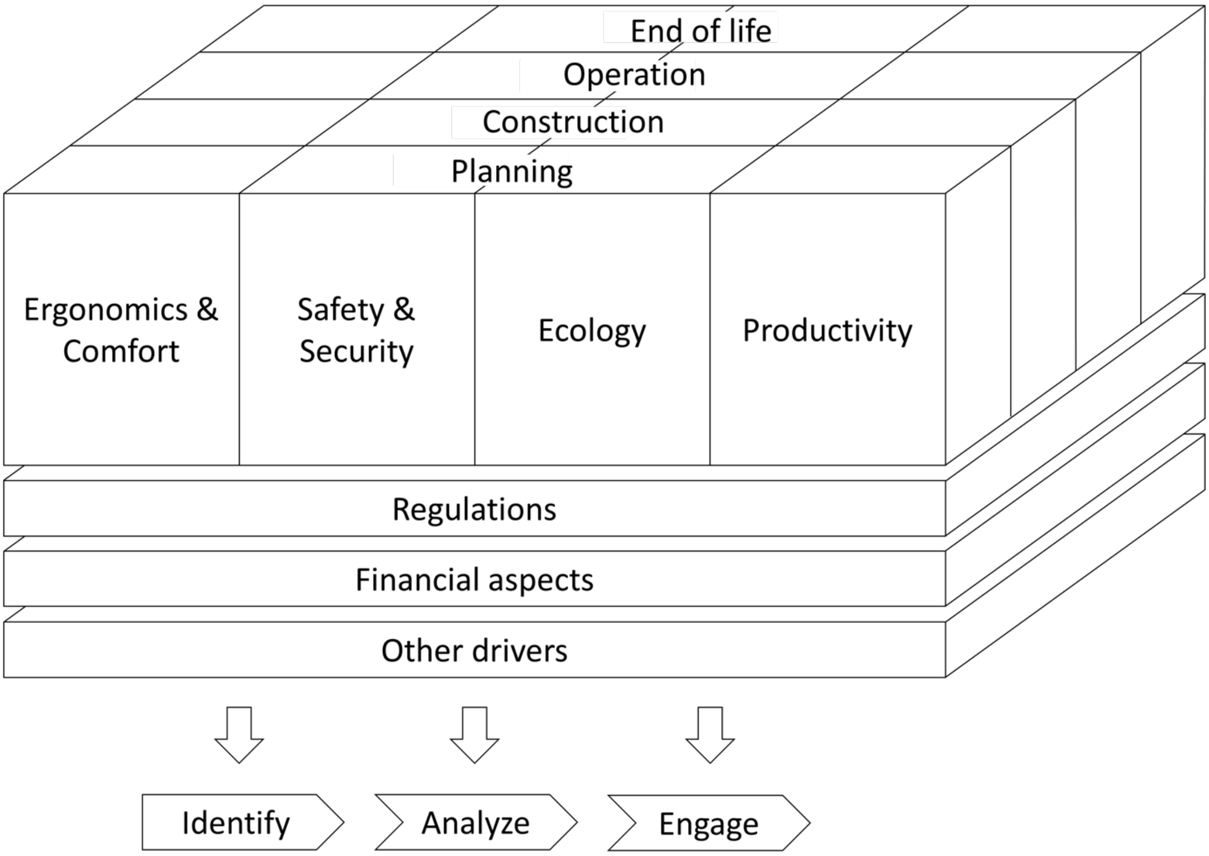

Figure 1: A proposed approach to develop data driven services for actors in the built environment adapted from [5].

In order to demonstrate the working principle of the approach, it has been carried out for an exemplary data analytics activity. This exemplary data analytics activity is predictive construction waste analytics [4], which aims to reduce construction waste by providing building designers with insights on how their decisions will impact the waste generation in the construction phase. A prediction model is generated based on historical building and waste data. The resulting data value chain is presented in Figure 2. In the *data collection* phase, BIM models and corresponding waste disposal records have to be retrieved. These data is then used in the *information creation* phase to generate a model that predicts construction waste based on building parameters, e.g. the difference between concrete and brick-built walls. Finally, value is created through the use of the model's information by the designers to optimize their decisions. After this analysis step, the type of engagement has to be defined, requiring consensus among all four actors involved. Such consensus could be found, if one of the four actors decided to lead the value creation process by developing a data driven service. However, it could be also favorable that a fifth actor entered the data value chain and obtained the role of a service orchestrator by combining a data collection services with a data analytics services in order to sell a construction waste prediction model to designers of buildings.

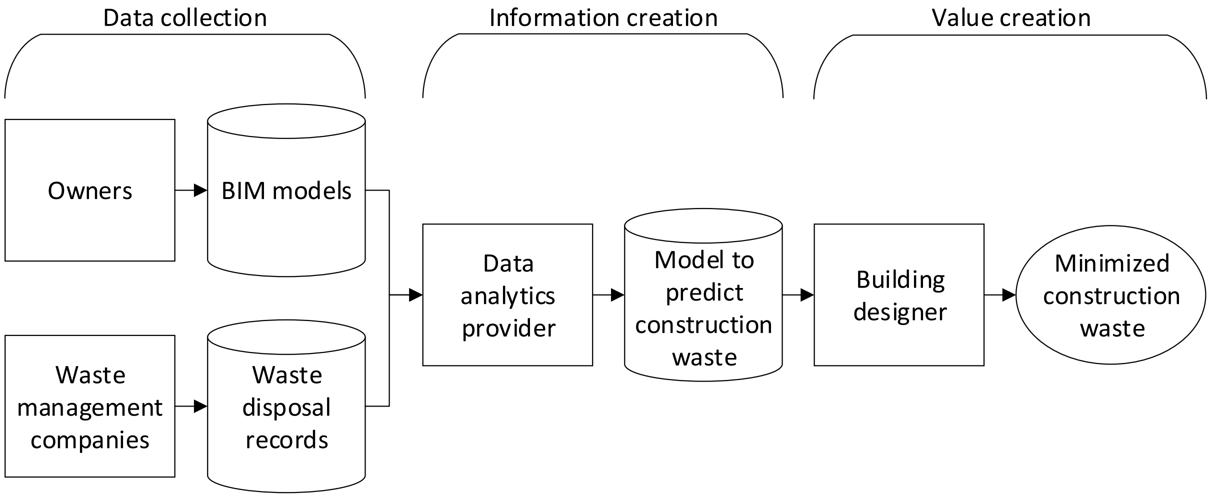

Figure 2: Analyzing the data value chain for the example of construction waste analytics, including actors (rectangular boxes), data elements (cylinders), and the value created (ellipse).

Conclusion and Outlook

In this paper, we presented an approach on how to develop data driven services in the built environment. The approach consists of three steps, wherein value creating categories, drivers, required actors and data elements are identified and analyzed. Future work will focus on validating and refining the approach within real world case studies together with industrial partners.

Acknowledgements

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Classifying Digital Twins: A Three-Dimensional Conceptual Reference Model

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Abstract

The development and progress in information and communication technology will transform traditional products into smart connected products and allow to offer novel smart services. The Digital Twin concept is regarded as a key technology for the seamless integration and fusion of smart connected products and related smart services within cyber-physical systems and as a way to seize the manifold opportunities to create value with novel smart services. However, this interdisciplinary concept is hard to grasp and communicate and hence it is difficult to demonstrate the business value and the resulting return. This is mainly due to the ambiguity in understandings and definitions owing to the relatively young field of research, the few practical implementation cases and the multidisciplinary nature of the digital twin concept.

Given the wide range of interpretations and the different definitions of Digital Twins, it becomes evident that further dimensions for structuring are required in order to get a differentiated yet understandable perspective, especially on the value contribution of Digital Twins. Smart connected products and their cyber-physical systems are an outcome of an integration process over a variety of disciplines and their nature adds another dimension of complexity. To deal with this, it is thus critical to establish a reference model of architecture for digital twins. This paper proposes a novel three-dimensional conceptual reference model with the axes system hierarchy level, product lifecycle management integration level and data categories to contribute to the disambiguation of digital twins. The aim of the model is to support researchers and practitioners in classifying and structuring their digital twin projects and support the communication within research and practice and different fields of expertise alike. It further contributes to model the profile of the digital twin in the servitization area, outlines future research directions and supports the implementation in practice.

Key words
Digital Twin, Conceptual Model, Classification, Dimensions, Literature Review

Introduction

The development and progress in information and communication technologies will transform traditional products into smart connected products (SCP) and allow to offer novel smart services (Dawid et al., 2016; Porter & Heppelmann, 2014, 2015; Wünderlich et al., 2015). The Digital Twin (DT) concept, introduced first by Grieves in a whitepaper (2003), is regarded as a key technology for the seamless integration and fusion of SCPs and smart services within cyber-physical systems (CPS) (Tao et al., 2019) and as a way to seize the manifold opportunities to create value with novel smart services (Barbieri et al., 2019). However, the business value and return of DT investments is hard to see, as the challenges of this complex topic are spread in different domains and as they have a high impact on internal and external processes (Voell et al., 2018). Due to the plethora of existing solutions and concepts of DTs across industries, a diverse and incomplete understanding of this concept exists (Lee et al., 2014; Rosen et al., 2015; Tao et al., 2017, 2019). Although the research and application of DT emerge continuously, the systematic research on DT is rare and many concerns are to be scrutinized (Zheng, Y. et al., 2018). The lack of a shared conceptual framework for DTs with an unambiguous terminology (Schleich et al., 2017), different definitions of DT and the heterogeneity of DT applications intensify the observable imprecisions of the theoretical foundation when it comes to describing and defining what the DT is and represents (Uhlenkamp et al., 2019). Establishing value adding and sustainable DT-based product lifecycle management (PLM) concepts and business models involves collaboration between experts from various disciplines inside and outside a company (Nyffenegger et al., 2018). However, cross-functional discussions turn out to be challenging, since the common language based on a sufficiently abstract, intuitively understandable and easy-to-use reference model is missing (Nyffenegger et al., 2018).

Methods and objectives

Given the wide range of interpretations and different definitions of DTs (Tao et al., 2019), it becomes evident that further dimensions for structuring DTs are required in order to get a differentiated yet understandable perspective, especially on the value contribution (Meierhofer & West, 2019). SCP and their CPSs are an outcome of an integration process over a variety of disciplines and their nature adds another dimension of complexity, to deal with this, it is thus critical to establish a reference model of architecture for DTs (Tomiyama et al., 2019).

This paper aims to provide a classification systematization for DTs and their dimensions. The proposed model could support researchers and practitioners in positioning and structuring their intended DT activities and communicating them to internal and external stakeholders.

Within this framing the research questions followed in this paper are a) *«Which dimensions are used to classify and structure DTs in academic literature?»* and b) «*What are the fundamental differences or specifications within these dimensions?»*

Following these research questions, this paper puts priority on the objective to find classification systematics that are a) conveniently applicable onto future DT business cases and b) universally valid in all DT related domains.

A systematic literature review on the relevant aspects of DTs was conducted (vom Brocke et al., 2009). For the selection of the database, the comparative research (Bakkalbasi et al., 2006; Falagas et al., 2008) was examined and finally Scopus was selected, which claims to be "…the largest abstract and citation database of peer-reviewed literature…" (Elsevier, 2019). The search was performed on 8th of August 2019, the papers found have been filtered in several steps and finally 35 academic articles have been studied in detail, as shown in figure 1.

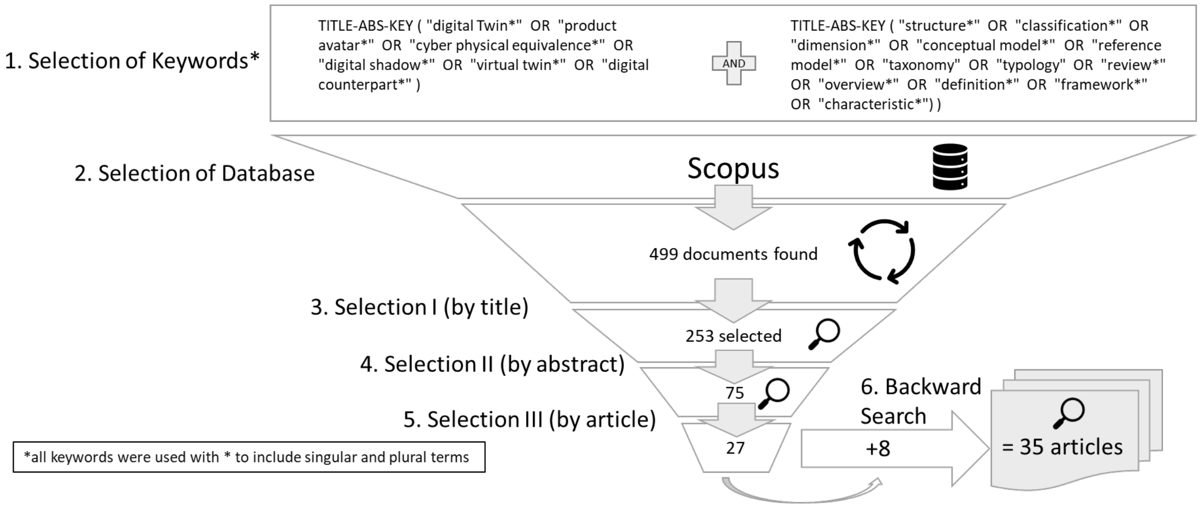

Figure 3: Overview of systematic literature review

Findings

The systematic analysis of the 35 selected articles showed that the DTs differ mainly along three dimensions: Systems hierarchy level, PLM level Integration and used data categories.

Therefore, it is important, that designers of DT concepts and architectures are aware of the intended hierarchy level within the DT ecosystems, the comprehensiveness of PLM level integration and the required data categories to provide the intended services and ultimately business value. Based on these findings a new conceptual model is proposed with three nominal dimensions, each dimension consisting of three nominal specifications. Hence, with the proposed model 3^3 = 27 different DT subcategories can conveniently be distinguished, discussed and combined, forming the composite DT for any specific use case.

System Hierarchy of Digital Twins

Most of the analyzed sources (e.g. Hartmann et al., 2018; Malakuti et al., 2018; Qi et al., 2018; Shangguan et al., 2019; Uhlenkamp et al., 2019; Wagner et al., 2017) suggest dividing the twin into different levels of hierarchy. The number of hierarchy levels mentioned differ, ranging from two (Landahl et al., 2018; Malakuti & Grüner, 2018; Patel et al., 2018) up to six (Meierhofer & West, 2019; Tomiyama et al., 2019), however the most common and comprehensible hierarchy determination based on the conducted research distinguishes three levels, mostly referred to as "component" or "unit", "system" and "system-of-systems" (Barbieri et al., 2019; Guo & Jia, 2017; Lee et al., 2014; Tao et al., 2019; Zheng, P. et al., 2018). Structuring DTs according to such a three-tier hierarchy is also in line with the well-known model of Porter and Heppelmann (2014, 2015) explaining the innovation from SCPs to systems and system-of-systems.

Especially when it comes to the realization of value creation with services, the appropriate granularity of the DT of a SCP or CPS and the corresponding "family of twins" (Meierhofer & West, 2019) forming a system or system-of-systems needs to be determined. DTs of systems composed in such manner may access the DTs of subordinate units or components and simultaneously may have a common objective and be aggregated to a composite system-of-systems DT (e.g. Malakuti & Grüner, 2018; Qi et al., 2018; Uhlenkamp et al., 2019). Rather than locally and individually optimizing single products (e.g. production machines) as it was mainly done and researched until today, there will be major efficiency and effectivity gains when the generated data and interactions are analyzed and optimized at higher system hierarchy levels (Canedo, 2016; Zhang et al., 2018).

PLM (meta-)level of Digital Twins

Another body of research on the DT concerns the application of DTs along the product lifecycle (e.g. Boschert & Rosen, 2016; Qi et al., 2018; Tao & Zhang, 2017) and the integration of the DT into PLM (e.g. Abramovici et al., 2016) as DT-based services can provide value in every phase of a units or systems lifecycle phase. Even though most research is performed in the field of optimization of the usage phase there is also vivid discussion of the potential of DTs to optimize product design, engineering, shop floor design, supply chain management, customer demand analysis and service and value proposition design (e.g. Tao et al., 2019; Tomiyama et al., 2019; Zheng, P. et al., 2018). While the DT emerged as a concept for aerospace application, thus started with the monitoring and optimization of a single physical entity (=product instance), it has later started to show promise also in and during production (e.g. Patel et al., 2018; Qi et al., 2018; Zhang et al., 2018); however, there is also a plethora of possibilities of DT applications in any other PLM discipline, which are not yet fully explored (e.g. Landahl et al., 2018; Meierhofer & West, 2019; Negri et al., 2017). To enable the full potential of DT in PLM it is although necessary to distinguish the different abstraction or meta-levels of PLM integration. Even though most authors, especially in the fields of PLM differentiate instance and type (e.g. Nyffenegger et al., 2018; Voell et al., 2018), authors are increasingly starting to distinguish also a third meta-level, which can be referred to as «product master» (Detzner & Eigner, 2018; Stark et al., 2019; Tharma et al., 2018; Tomiyama et al., 2019) or even more general «product aggregate» (Grieves & Vickers, 2016; Tao et al., 2019). Equivalently to the relation of DT instance and DT type, the DT master monitors and optimizes the lifecycle of the product types with data from different sources. While the product type maps the basic concept and current offering presented on the market (Nyffenegger et al., 2018), describing everything that is required to promote, sell, build, operate, servitize (Baines & Lightfoot, 2013; Vandermerwe & Rada, 1998), and recycle product instances, the DT product master provides design, product and value proposition engineers with the possibility to examine the lifecycle data of instances and types generated by the DTs, in order to discover patterns and to gain insights about changing customer demands and matching novel product and service concepts (West and Pyster, 2015) to be implemented in future product types and instances.

However, no clear direction is given yet on how to improve blending new customer needs and demands into product masters with data of existing physical product instances and types currently in use (Landahl et al., 2018). To do so, the DT must be conceptualized to an appropriate abstraction level suited for the conceptual stages as proposed in the model at hand. The separation of instance, type and master is thus a fundamental concept in the presented model and probably the most relevant novelty to conventional models.

Data categories used in Digital Twins

DTs can be a representation of a product (Grieves & Vickers, 2016) or a process (Rosen et al., 2015) and therefore consist of datasets describing the state (product) and behavior (process-performance). To make sense and form the base for knowledge-based decision making, the third category often described are contextual data (e.g. Damjanovic-Behrendt & Behrendt, 2019 ; Detzner & Eigner, 2018; Tao et al., 2019 ; Voell et al., 2018; Wuest et al., 2015), such as product-instance environment data (e.g. temperature, humidity), third party environment data (e.g. exchange rates, weather data) as well as any customer-related data (e.g. actual owner and his configuration and usage preferences) (Fuchs & Barth, 2018).

Such combined data sets will not only describe how the SCP performs its processes and services, how its state evolves due to deterioration and wearing down of components, but also how it is used by customers and other actors, such as other SCPs and their DTs and therefore are potentially unveiling enormous business opportunities, as these comprehensive DTs illustrate the current lifestyle of users (Tomiyama et al., 2019) and ultimately future or unexploited customer needs and demands. By combining all this data the DT can provide the necessary insights to optimize the lifecycles of product instances, types and masters on the system hierarchy level of the product itself and are further capable of offering these valuable insights encapsulated in DT-based services (Tao et al., 2019) to higher and lower tiers of the ecosystem, even if the actors might be outside of the own company.

It is further worth mentioning that recent interpretations of the DT concept have moved away from the idea that all available data can or should be included in every DT. Instead a selection of data has to be performed depending on the use case (Detzner & Eigner, 2018), system hierarchy level and PLM level of the DT. It is important to understand, that authenticity does not describe the DTs quality, because abstract models specified for the task at hand can support knowledge-based decision-making more efficiently (Uhlenkamp et al., 2019), especially on the product master level.

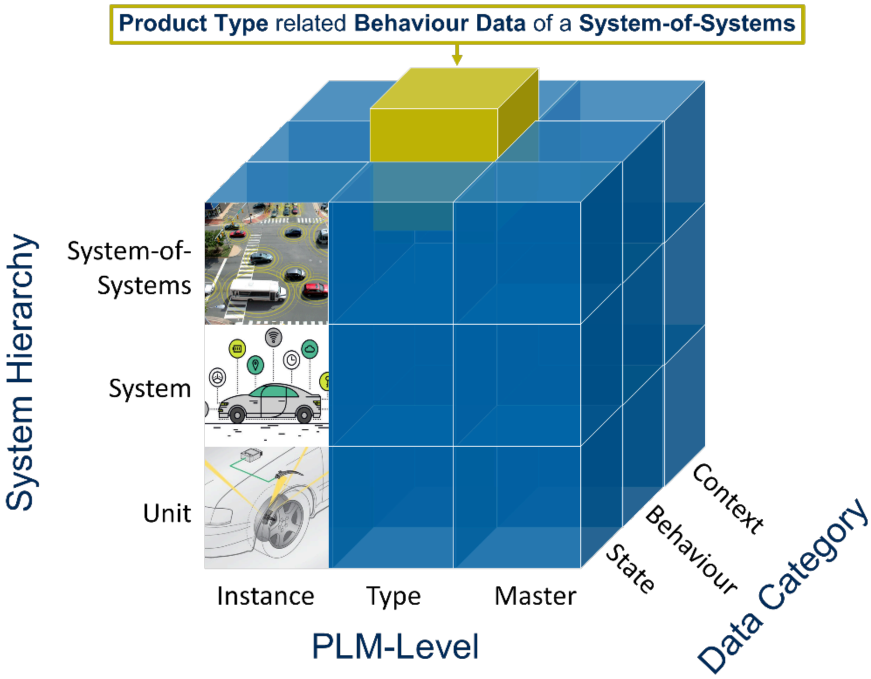

Figure 4: Conceptual reference model with three nominal dimensions

Conclusion

Apart from technical challenges, the successful implementation of DTs requires a holistic understanding of value delivering ecosystems, PLM of products and services and data management. This paper summarizes a first classification approach to structure DT based ecosystems by identifying major distinguishing characteristics of the different approaches and summarizing them in three qualitative dimensions. The current research leads to the assumption, that each dimension can occur in different specifications, which have been outlined in this paper. The motivation for the proposed model is to contribute towards a common understanding of the DT and to develop the theoretical foundation of the concept as well as providing practitioners a profound understanding of the inherent structuring dimensions of DTs. The proposed conceptual model further provides a convenient guide to classify and compare digital twins of all kinds according to the level of hierarchy, product management and used data categories. Eventually, it might contribute to model the profile of the DT in the servitization area, outline future research avenues and support the implementation in practice.

However, several limitations of the proposed conceptual model need to be considered. The differentiating dimensions and their values enclose vague expressions due to the avoidance of features which relate to specific fields, such as industries or implementation technologies. The literature basis was further limited to Scopus database and therefore the research at hand is not representing the academic view comprehensively. Additionally the perspectives and understandings of practitioners haven't been taken systematically into account, as other researchers showed that practitioners and literature are quite aligned about the general definition of what a digital twin is and what it can be used for (Barbieri et al., 2019). However, the proposed dimensions and their specifications or values are thus a mere endeavor to classify DTs, hence they require further examination and validation. The approach has to evolve, as the development of the DT is still at its infancy and research as well as real cases in the field are just emerging. Prospective research and use cases may validate and refine the proposed classification and three-dimensional representation of DTs. This might lead to adding new dimensions or refining the definitions and categories of dimensions outlined in this paper.

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Digital Twin as a decision-making tool to opt for the most promising Product Design Strategies in a Circular Economy

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Abstract

Recently many enterprises have welcomed and applied the concept digital twin to optimize their operation processes, facilitate the task of decision-making, manage their assets, etc. simply to excel their business. In this paper, we explain how a digital twin of a business along with the product life cycle (from its design and production phase to its maintenance and end of life) can be a solution to find the most promising product design strategies in the context of the Circular Economy. So, first the state-of-the-art regarding potential design strategies are explored. Second, the approach where the digital twin with a comprehensive look (including all economic environmental aspects across the whole product's life cycle) is stated. Finally, an applied case is concisely introduced where the digital twin was developed via AnyLogic simulation tool coupled with Excel files containing all required input data for a time horizon of 15 years.

Key words
Digital Twin, Simulation, Product Design Strategy and Circular Economy

1. Introduction

In NASA's Apollo program, at least two real identical space vehicles were built; one was sent into the air space and the real exact copy remained on earth allowing the specialists to monitor the condition of the launched vehicle. This is known as the first time the concept of *twin* was developed [1]. Later on – thanks to technological advances – NASA replaced a digital copy instead of the physical twin and brought its own definition for it; "*an integrated multi-physics, multi-scale, probabilistic simulation of a vehicle or system that uses the best available physical models, sensor updates, fleet history, and so forth, to mirror the life of its flying twin*" [2].

So far, other industries have welcomed the concept of *digital twin*. They applied the concept for various applications in different domains. So, today, it may be generally referred to a digital replica of a physical entity (could it be an object or a product, the assembly line, the warehouse or the factory itself) which facilitates the "means to monitor, understand, optimize the functions" of those physical living and non-living entities [3].

Companies and enterprises usually try to gain benefit from digital twins in order to increase their business efficiency. It may happen in the form of reduction in costs (such as maintenance cost), saving of resources (reducing raw material or energy consumption), optimizing operations (saving time to manufacture or increase in the output or quality), etc.

One way to classify the applications of digital twins is to see it from the product life cycle perspective; digital twin in product BOL stage (beginning of life which corresponds to design, production and distribution phases), MOL stage (middle of life which corresponds to the usage and maintenance) and EOL (which corresponds to products disposal or reverse logistics for reuse or remanufacturing) [4].

The design phase in a product's BOL plays an important role in the product's entire life cycle from production and planning phases towards usage, maintenance and till the product's final fate. This is because the product's functionality, specifications and characteristics are determined in the design phase.

In this paper, the focus will be on the design phase. More specifically, the application case is to propose how to assess impact of various product design strategies in the context of sustainability and Circular Economy (CE): "a regenerative system in which resource input and waste, emission, and energy leakage are minimised by slowing, closing, and narrowing material and energy loops. This can be achieved through long-lasting design, maintenance, repair, reuse, remanufacturing, refurbishing, and recycling" – as M. Geissdoerfer et al. Explains [5].

The CE concept, basically, suggests finding ways to capture values of product and services always at the top to have the highest value of utilization of non-renewable resources. Besides, we need to rethink the way we produce wastes to be able to reuse them as resources to be fed into other processes.

Due to the rapid technological and socioeconomic advances in the last centuries, societies came to the notion that such technological advancements cannot be tolerated without considering environmental and social aspects. Therefore, limitations either are imposed to businesses from top (governments via regulations) or bottom (from end-consumers via their opinion and consumption behavior) [6]. Thus, many businesses are seeking for opportunities to add value to their businesses while complying with those regulations and public demands.

In order to add value in the context of CE, companies should rethink four domains of their businesses; their business model, product design, supply chain, and ICT efforts. Complexity normally are added when a new product design must be coupled with a new business or service model with a different supply chain configuration and new information flow paradigm. In this paper, we try to present digital twin as a solution to reduce such complexities helping businesses to assess various scenarios for their product design strategies.

2. Proposed Approach

2.1. Product Design Strategies in a Circular Economy

Nancy M. P. Bocken et al. [7] extensively explains various main strategies of product design and business model for a Circular Economy (CE) and the need that they should aligned. The figure below shows a snapshot of the framework in question.

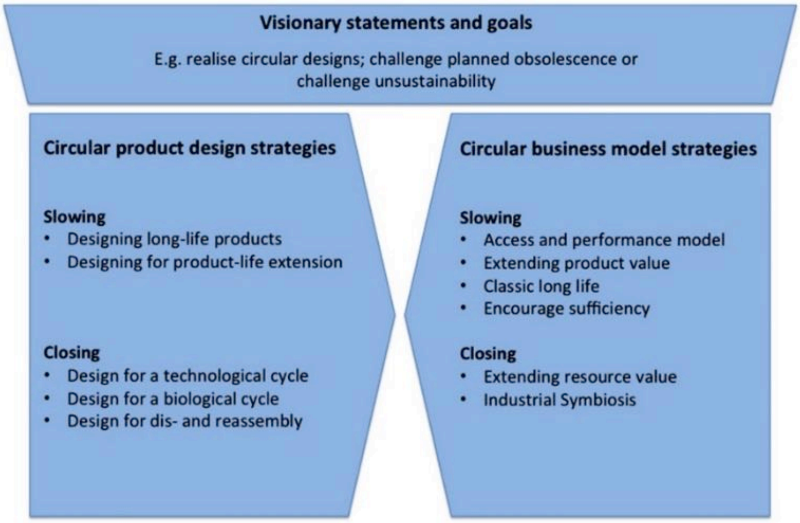

Fig. 1: Product design and business model strategies framework for a CE

According to the article, there are two main strategy branches to approach a CE both regarding the product design and business model; either to close or slow the resource loop. The example of slowing can be designing a blender to live longer for its end-user. In fact, the user can benefit the service (blending food ingredients) for longer time whereby the demand for a new one would be postponed to a later date. Then, less demand of a physical good – at a broader scale – normally leads to less use of resources (capital, material, energy, etc.). on the other side, closing the loop holds for when reverse logistics for used products are viable. Therefore, the use of virgin raw material would go to its minimum as recovered raw materials would replace.

Bocken et al. [7] continues to dig into detailed classification of design strategies as they follow:

Strategies for slowing the loop:

Designing for long-life products

- Design for attachment and trust[1](emotional durability)
- Design for reliability and durability

Designing for product-life extension

- Design for ease of maintenance and repair
- Design for upgradability and adaptability[2]
- Design for standardization and compatibility[3]
- Design for dis-and reassembly

Strategies for closing the loop:

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[1] *Design for attachment and design tries to prevent the end user forfeit the product's use perhaps due to fashion obsolescence rather than technical issues.*

[2] *The strategy suggests designing so that life-time of the product can be extended via upgrading the product and adapting it to a new end-user's desires. Example of such can be a modular mobile phone that can be upgraded with a new camera or a faster processor.*

[3] *Standardization sometimes can extend lifetime of a product. You may consider a standard screw that can be used repeatedly in different products. A screw (being part of a broken chair) may be reused perhaps i's remaining useful life is not negligible.*

- Design for technological cycle[4]
- Design for biological cycle[5]
- Design for dis-and reassembly

2.2. Digital Twin at the Strategic Level

As shown in section 2.1 there could be various design strategies coupled with a specific business/service model. Assessing to adopt or reject all those possibilities brings a high degree of complexity into the decision-making part of the design process. The product manager, for instance, would like to know how changing a strategy toward *design for dis-reassembly* affects the performance and sustainable health of the business along the product life cycle. He may want to know specifically what costs would be incurred to or lifted away from each stakeholder (suppliers, OEMs, retailers, customers, etc.). What happens to other aspects such as competition, customer satisfaction, and many more.

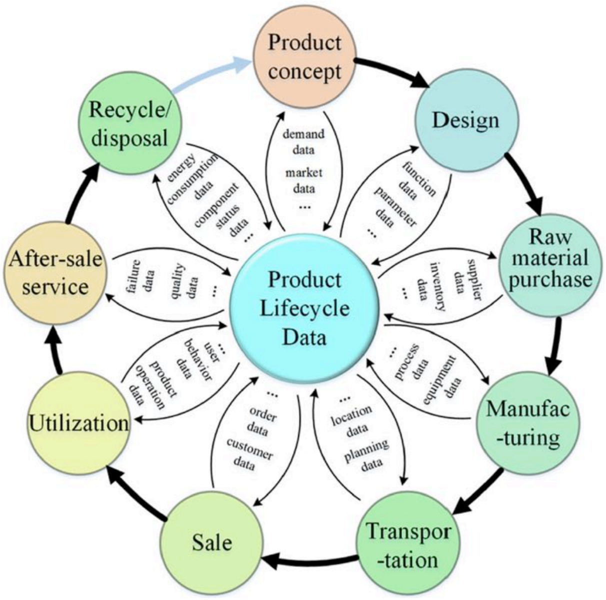

Fig. 2: Product Life Cycle and Product Life Cycle Data [8]

To manage the degree of complexity and bring more visibility and clarity to the system, this paper suggests that a digital twin of the whole business along the product life cycle can be a proper solution to find the most promising product design strategies. Such ambitious aim, however, requires data and information sharing across various departments within a company and even among all the stakeholders.

F. Tao et al. [8] elaborates the importance of the product life cycle and the product life cycle data – see Fig. 2. The figure shown may not represent all aspects of a product life cycle in a CE (as “re” processes should exist: re-manufacturing, re-use etc.) though it properly depicts a typical product life cycle data that are to be generated and to be shared across various phases of the cycle. It typically starts from product concept and design and it continues to production and transportation phases, sale, utilization, after-sale service and recycle/ disposal.

The solution we are referring to is to make a digital twin by modeling the whole business along the product life cycle, feeding the model by various proper data, and validating it by comparing the

[4] *To design the product so that it can be recycled in an optimal way with the least down-grading*

[5] *To design the product with biological components so that it can be degraded naturally at the end of the product life cycle.*

model's output to the real business's outputs. The validated model that mimics the whole business process, the digital twin, finally can be utilized to assess performance of scenarios at the strategic level. In the application case, we tried this approach for evaluating various product design strategies.

3. Application Case

We chose the elaborated approach to develop a twin of the whole business of a household good (to be remained unknown for confidentiality matters but you may think of a household good like a washing machine, a refrigerator, etc.).

We used a simulation software AnyLogic to model the whole business along the product life cycle from cradle to grave. Then, all product life cycle data was collected from all stakeholders and the different company's departments. The data was composed of more than 240 independent key input variables representing planning and product demands, design and BOM, production, end-user's usage pattern, aftersales services and disposal/recycling.

The input variables were stored in an Excel file which was coupled to the model in AnyLogic. We selected a time horizon of 15 years to run the business with that specific product and enabled the model to record all desired output variables over the time horizon and store it in Excel file again for further analyses and creating a dashboard for validation of the model.

To have a comprehensive overview of the performance of the business, we adopted sustainability framework (considering economic, environmental, and social dimensions) to select Key Performance Indicators (KPIs) out of produced outputs – see Fig 3. Therefore, the model can produce outputs that reveal financial balances (costs vs revenues), environmental impacts (resource use, CO_2 emission, etc.) and any social aspects that can be measured and quantified (number of employed workers or man-hour needed for a specific facility).

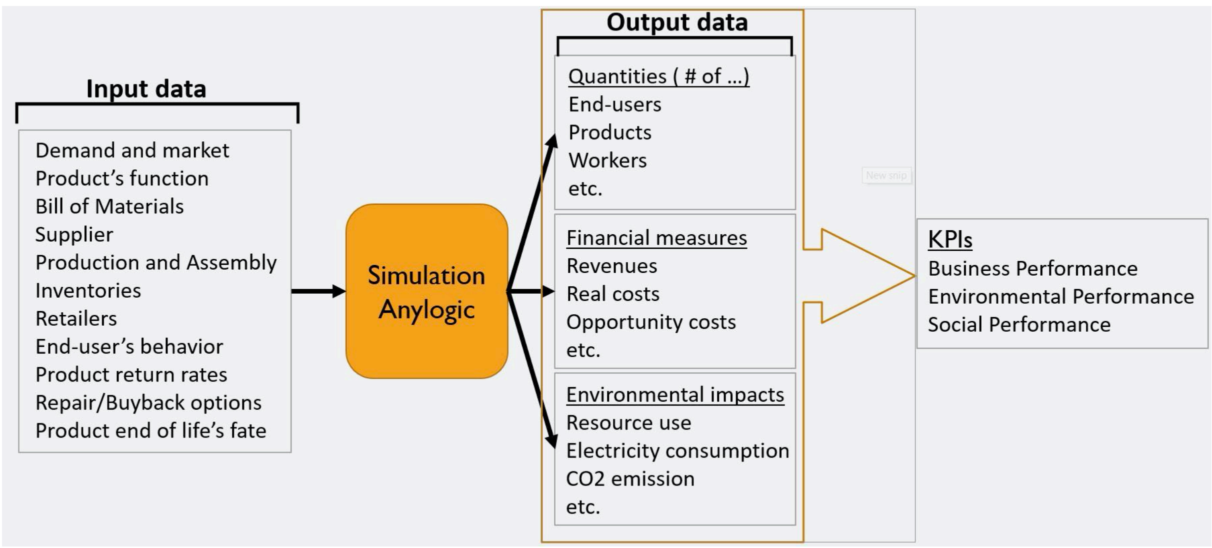

Fig. 3: Input/output data list the twin receives and produces

By comparing the model's behavior with the real company's behavior (for instance, by comparing of simulated financial reports and real financial prints), we could understand the model's limitations, improve it and finally validate it. In our application case, after the validation of the model, we explored for new scenarios where a specific design strategy intertwined with a compatible business model were analyzed. Then each of these scenarios was compared to the current scenario seeking for any leeway for KPI improvements.

For instance, company X decides to design their washing machine for dis-reassembly to promote remanufacturing and reuse. For such a strategy, the company considers an adaptation to its service model such that ownership of the washing machine would not be transferred to the end-user but instead would be kept with the company. This means that the user needs to bring back the product or the company has to buy back it at some point in the future which afterwards the product would be treated accordingly (to be dis-assembled to its parts for reuse, recycling, refurbish, etc.).

For each scenario we make, input data differs from the default. For instance, BOM (bill of material) and production costs may be slightly different due to the necessary measures taken as a result change in the design strategy. The pricing model also may change into a subscription version or pay-per-result (pay per wash). All these changes cause a new set input values to be specified and fed into the model. Therefore, different output variables will be obtained. Comparison of the output variables with the default case would reveal any trade-offs among the different strategies.

One limitation to our development was the connection between the reality and the twin. In fact, we asked for pertinent data on the aggregate level (mostly yearly average values) by communicating with various persons whether in customer service, marketing, production sites, etc. We know that the data we collected are obtained through various means thanks to many studies which had been done so far in different forms. So, prospective efforts should be done in order to make the data-feeding process happens with the least amount of human intervention so that the twin becomes more autonomous and smarter.

4. Conclusion

As many experts are envisioning, we are in the era of smart manufacturing, thanks to new generations of technologies such as Internet of things, artificial intelligence, cloud and edge computing, etc. Unlike the past the virtual space is becoming more connected to physical space. Therefore, the virtual space is playing a much more important role in the company's transformation agenda, known as the digital transformation.

Part of the company's virtual assets are the digital twins that mimic their physical counterparts in behavior. Based on the work presented, we suggest that digital twins can be developed to mimic businesses across the entire product life cycle to provide full perspective of the company's performance. According to the specific application, we successfully applied such a solution to explore which of the product design strategies are the most promising ones. In the application case, the emphasis was given to the model and the services aspects. However, to address other dimensions of the twin, prospective efforts are required to cover issues with the connectivity of data.

The developed model works in AnyLogic simulation tool's environment where it is enabled to receive aggregate data (mostly at yearly level) stored in excel file, mimics the performance of the business across each stage of the product life cycle over the designed time horizon of more than a decade. To have a balanced KPI list in the dashboard, we understood that a comprehensive look at the company's performance has to be made. This is partially because design specifications and the product's functionalities affect all the product's entire life cycle. Moreover, to add value to the business in a Circular Economy all dimensions of products design, business model, supply chain, and Information and Communication Technology (ICT) have to be explored and re-thought.

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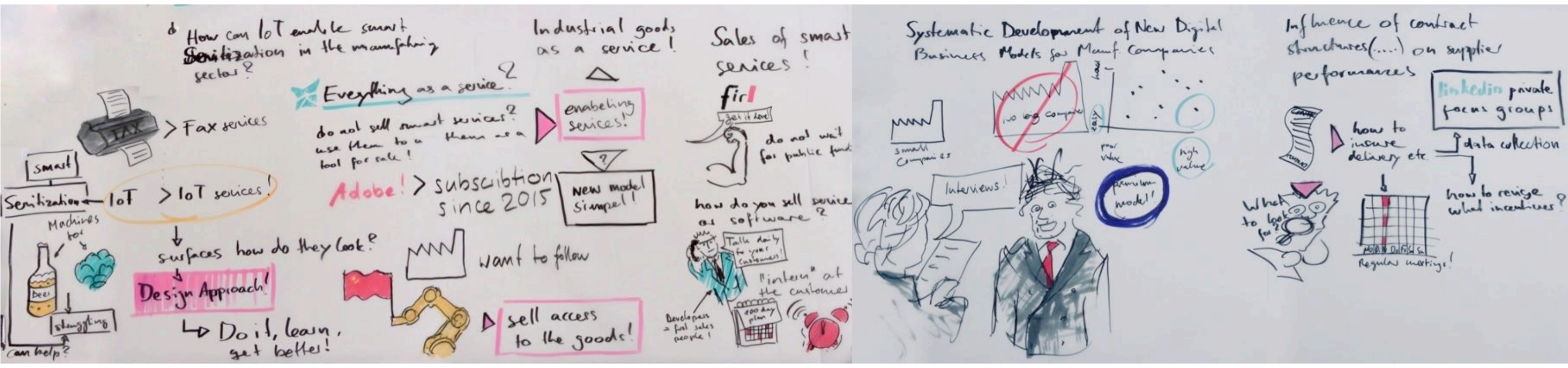

Research Panel II "Value Creation"

Speakers

Mario Rapaccini*	University Firenze, Italy	Chatbots that cognitively helps human: the digital helper as a new way to support the decision making
Roman Etschmann	Zurich University of Applied Sciences, Switzerland	Data-Driven Servitization Approaches for SMEs in Manufacturing
Dominique Heller	Zurich University of Applied Sciences Switzerland	An Architectural Approach for Service Value Creation with the Digital Twin
Els van de Kar	Fontys International Business School, the Netherlands	Smart servitization: an iterative process

* for Barbieri, Cosimo, University Firenze

Chatbots that cognitively helps human: the digital helper as a new way to support the decision making

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Abstract

Worldwide, the recent national development strategies as Industry 4.0 have the aim to support industrial companies in the adoption of the I4.0 technologies such as big data, analytics, cloud, AR/VR, AI, etc. Such intent is justified by the fact that the digital transformation of manufacturing companies is considered a key step to seize game-changing opportunities and gain competitiveness in the market. The servitization of manufacturing companies (i.e. increasingly offering services that are directly coupled to their products) represents one of such opportunities since the service processes (customer support, call handling, help desk, remote monitoring and optimization, etc.) are first digital processes and not physical, as far as the value creation comes from the transformation of input in output of informative type and so it implies the integration of data of different formats, uniform the types, normalize their quality, etc.. The adoption of solutions capable of supporting service operators in such processes and therefore not only favoring the evolution and scalability of service portfolio as the numbers increase (e.g. the interconnected installed base increases) but also to support the reorganization and optimization of the processes involved, can be fundamental. The paper tells how, with the help of a real case (Ricoh Italy), the adoption of digital helpers – which bring together cognitive computing (enables a machine to infer, reason, and learn in a way that emulates the way humans do those things.) with automatic interfaces (i.e. chatbot) – can be a solution to improve the interactions between a given decision-maker (i.e. service operator) and the application portfolio supporting the process (ERP/CRM suite, field service management software, knowledge base for hotline and technical support, ...).

Keywords
Digital helper; Bot; RPA; Industry 4.0

Introduction

In a business environment which is becoming more and more competitive, making the right decision at the right time has become crucial for the survival of even large firms. From execution to strategic planning, the effectiveness of managers' decisions is affected by a big deal of uncertainty [1]. This, in particular, affects manufacturing companies undergoing servitization, that are offering more and more advanced services in their product-service portfolio: as well known, delivering services requires capabilities that are new to manufacturers, to face the variability of contextual and situational factors such as customer demand, arrival and delivery times, environmental conditions, etc. [2]. The uncertainty that affects decision-making in service processes can be reduced if the company can adequately exploit advanced technologies such as IoT, Cloud Computing, Big Data and Predictive Analytics [3]. These, in fact, can be used to collect data from the field – from the installed base [4], from the customers, from the dealer and assistance network, etc. – and then to elaborate and store them in "data lake", becoming the "new oil"[5], potential value that can be leveraged to drive future strategies and business actions. Nevertheless, to transform it in a data-driven process, data are not enough: there is the need to transform them in information, as it is the real source to develop knowledge and wisdom [6], but it is so difficult that only 27% of executives describe their data projects as successful [7]. To this regard, competencies of data scientists are crucial to apply the most appropriate technique of statistical analysis, machine learning, and artificial intelligence, and develop decision-support system (DSS), simulation models and tools that can be embedded into software agents such as chatbots and software robots (bots), to provide answers that can support decision-making [8]. In some cases, the decision process can be directly automated. This is the emerging field of the so-called robotic process automation (RPA), that appears particularly promising for process digitization and automation [9]. On the base of the authors' best knowledge and practical experience carried out on a case study, following the implementation of digital helper in the Ricoh company, this paper aims to develop a conceptual model that would help to discriminate those situations in which RPA can be fully introduced, from other situations in which people keep in their hands the responsibility of taking the right decision on the base of their knowledge about situations, exogenous and endogenous factors. This latter is the domain of what we call digital helper.

Conceptualization of a digital helper

The digital helper is not a technology. It can be considered as a set of prescriptive analytics that can help users to make decisions. In addition to it, there are other reasons due to which it cannot be considered just a bot (as a chatbot or robot): bots deal with modeled scenarios where an if/then syntax can be enough to find a solution to problems; even if modeled through the application of ML algorithms, a bot still faces only cases that it has been trained on; a robotic process automation (RPA) is configured in order to deal with pre-configured tasks and even if empowered by ML reasoning, still it can only operate with the reality for which it is modeled. In synthesis, a bot is limited by the data that are available and by the discrepancy that unavoidably there is between the model and the reality. A digital helper aims to deal with that: facing the contingencies, variability and uncertainty that reality brings, the prescriptive analytics – still through the application of statistics, ML algorithms and advanced analytics on the data available - provide the answers , the insights and – most of all – the scenario analysis that should enable or facilitate the user to make the right decisions.

Take for example Ricoh Italy. As any large firm that carry on field service operations, Ricoh Italy has several backoffice activities to bring on a daily basis: with a PaaS - Printing as a Service business model (pay-per-use type of contracts), for each of the 300.000 and more printer machines located all over the italian territory, a specialized team (the SOC, service operator center) has to validate the orders of consumables and spare parts coming from the customers by means of different communication channels (phone-call, web application, direct remote connection with the machine, email, etc.); the operation managers have to define the daily schedule of activities of the field technicians, based on several variables (shortest route to follow, time of movement, traffic, availability of the customer on premise, traffic problems, uncertainty of the demand, shift and abilities of the technicians, etc.); the sales managers have to engage and define the best contract for each customer; etc.. All of these back office activities are characterized by contingencies, variability and uncertainty, and even if the company is continuosly collecting and storing huge amount of data, thanks – in particular – to the interconnected machines, still it is impossible to automate completely even one of these activities: an operation manager can be supported by a

routing algorithm to define the schedule of the field technician but, with the inability to collect enough data that enable the detailed description of all the variables involved (in this case, for example, data referring to the possibility for the field technician to find a free parking space for its truck near to the customer location), the final decision still needs to rely on the experience of the operation manager. Here, the digital helper would come in handy. Based on scenario analysis, the digital helper would point out to the manager the possibility of the absence of free parking spaces and recommend possible alternative solutions (just recommend, the decision still will be made by the manager) in agreement also with the indications coming from the application portfolio supporting the process (ERP/CRM suite, field service management software, etc.). In particular, the user could receive such recommendation thanks to a powerful visual representation (for example, a virtual 3D representation of the location) and a digital speaking voice that would explain simultaneously the different possibilities of solution. It is important to highlight how the digital helper would be able to point out such possibilities only if it has been trained on the process that generates the events (traveling to, parking, etc.) and not vice-versa.
Supported by the use case of Ricoh Italia, we propose a conceptual model characterizing the digital helper, that marks also the differences with RPA and so the cases where it would be instead used:

	RPA	**Digital Helper**
Automation level in decision making	Fully automated; the bot takes the final decision.	The user takes the final decision.
Focus	Narrow, case-specific and event-driven.	Wide, process-trained and oriented.
Problem encoding	Explicit knowledge, easily coded, analytical.	Implicit knowledge, ill-structured, hard-coded.
Solution	Rule-based, simple evaluation even for an algorithm.	Data- and patterns-based, complex evaluation to make sense of
Source of data	Limited.	Big data.
Interfacing	None.	Intuitive (such as with NLP for I/O commands), powerful visualisation (3D, AR, VR), mobile, touch, etc.

Table 1: Comparison between the characteristics of a bot/RPA and a digital helper.

Conclusion
The conceptual model proposed highlights some key characteristics that help to discriminate the situations in which RPA can be fully introduced from other situations in which a digital helper is needed.
It is important to discriminate when either one or the other can be introduced since the efforts and resources that should be invested, could greatly differ from one case to the other one.
The case of Ricoh Italy has been useful to justify the characteristics that we defined inside the model. Nevertheless, we think that it is possible to easily extend the previous observations to other cases: for example, in the food industry, RPA is applied to recognize and sort the different type of products among the thousands produced pieces [10]; the decision making process can be automatized since the variables that influence the process can be easily defined (i.e. shape, colour of the surface, dimensions), the problem can be easily encoded and so on, following the characteristics explained in the model. Instead, when a team in a company meets up for a brainstorming, the decision making process requires to combine knowledge, instinct and experiences of each of the team member in

order to find a solution to ill-structured problem, case or scenario [11]: a digital helper providing the prescriptive analytics needed in the most intuitive way, so not just with a great visual representation of the informations but also in a conversational way, would fit perfectly giving scenario analysis, predicting possible outcomes in real-time and insights from the past and present thanks to its storage of data.

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Data-Driven Servitization Approaches for SMEs in Manufacturing

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Abstract

This paper discusses the challenges and approaches which are specific for small and medium sized enterprises (SMEs) in the transformation to data-driven smart services. The paper starts with a short elaboration why servitization is relevant for SMEs and a discussion strategic options for servitization in terms of value generation. For SMEs building services on data has a big potential and it is expected to have higher priority in the future. However, there is a lack of data science knowledge and competences in SMEs today. Therefore, simple approaches with very low entry hurdles are required for SMEs which want to enter this field. To do so, data-driven service prototypes and PoCs (proof-of-concepts) are required which reveal the potential benefits at low entry cost and in short development times. Based on a multiple case study, this paper sketches how these prototypes were conceptualized to four types of service concepts.

Key words
servitization, smart services, data science, small and medium-sized enterprises, prototyping

Product-Service Transformation in Manufacturing

The service sector is growing and makes up a significant part of employment and the gross domestic product today (Kindström and Kowalkowski 2014). On the transition from products to services, we move from the concept of "Goods-Dominant Logic" (GDL) to "Service-Dominant Logic" (SDL). In SDL, service is considered the fundamental purpose of economic exchange (Lusch and Vargo 2014). The concept of industrial companies as service providers has emerged (Lay 2014). The focus of the value creation is moved from the manufacturer to the co-creation in the customer interaction (Vargo and Lusch 2008) (Figure 1). This move makes clear that it becomes the longer the more difficult for manufacturers to be successful in the market with purely engineering-based approaches if they are not embedded in customer-centred concepts.
The shift to services is driven by saturated markets and high competitive intensity (Gebauer et al. 2012) as well as the customer demand for the values and benefits provided by services (Kowalkoswki and Ulaga 2017). In particular, there is an evolution of the customers to demand and pay for an agreed performance output instead of the provider's resource inputs. Therefore, the transition from goods to services and the addition of services to products is considered essential for manufacturing firms (Baines and Lightfoot 2013). The omnipresence of information and communications technology is a major driving factor for the development of the service economy (Chen et al. 2010).

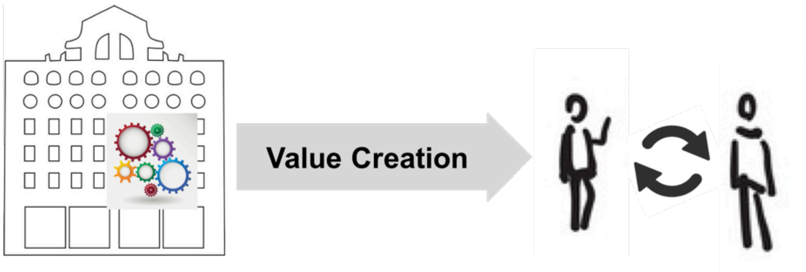

Figure 1: Moving the value creation from the factory to the customer interaction

Analytics Requirements for Advanced Services

The literature provides a classification of industrial services based on the value provided to the customer, who is guaranteed either an input or an output performance (Ulaga and Reinartz 2011, Kowalkowski and Ulaga 2017). A simplified form of this classification is shown in Figure 2. Traditional service models can be located in the box at the bottom of the figure. Examples are installation of new equipment, maintenance, repair or spare parts delivery. When the provider moves to new service models around its products, these services are being complemented or replaced by output-oriented new services like customization, condition monitoring, predictive maintenance, performance optimization, or consulting for the customer along the end-to-end journey, for example. The new service models oriented towards output performance are also referred to as “advanced services” (Baines and Lightfoot 2013). For advanced services, the provider guarantees the customer an agreed performance at an agreed pricing scheme. Therefore, assessing and quantifying the fluctuations and risks inherent to the output provided as well as the production costs to achieve the promised level of output quality becomes a key capability for a provider when moving to output-based advanced services.

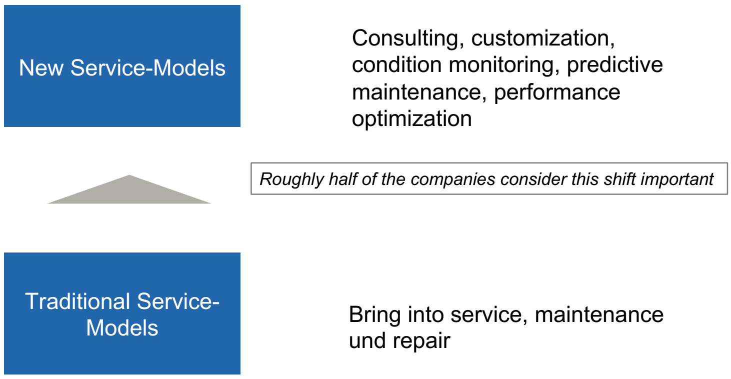

Figure 2: Classification of industrial services (simplified from (Kowalkoswki and Ulaga 2017))

Value Propositions in Smart Services

The benefits of smart services can be structured and modelled according to Porter and Heppelmann (2014) in four increasing levels: 1) monitoring, 2) control, 3) optimization, and 4) autonomy (Figure 3). An example for 1) “monitoring” is monitoring the condition of machines: the service provider can remotely observe the health status of the machine running on the customer’s premises. In level 2) “control”, a feedback loop is established to control the machine, based on the outcomes of the monitoring. This may, e.g., result in adapting operational parameters to improve the health status of the machine. The optimization applied in level 3) “optimization” pursues an optimization target such as energy consumption or number of units produced in a time period. Autonomous systems in level 4) “autonomy” would be, e.g., fully self-organized shop floors.

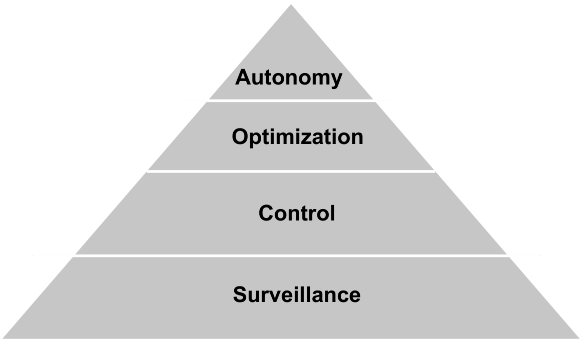

Figure 3: Increasing levels of value creation with smart services.

Data-specific Hurdles for SMEs

The ability to manage, process, and analyse data of the installed base is essential for providing the new service models (advanced services) and for moving up the hierarchy shown in Figure 3. Therefore, with the increasing degree of servitization of manufacturing and the move to advanced services, leveraging data for the development and the provision of services becomes a key prerequisite and represents a key challenge. However, according to (Meierhofer et al., 2019) only roughly 45% percent of the SMEs indicate to know data analytics tools. The tools which are familiar to the SMEs are mainly classical business intelligence (BI) tools (known by close to 70% of the SMEs which are familiar with data science tools). Advanced analytics tools are rather rarely known by the SMEs (in roughly 30% of the cases). Therefore, simple approaches for showing the benefit of data-driven services are required for SMEs approaching this transformation to advanced services.

SME-specific Prototyping Approaches

Possible service concepts were developed in this study. The goal was to understand and model value propositions for real actors or users in a factory and to prototype data-driven services for these as shown in Figure 4. This should help to show a) the potential benefit of smart services to the users in the factory ("factory manager" in the figure) and b) to demonstrate that the underlying technology can be simple and feasible for the SMEs at low cost and in short time ("view below the hood" in the figure).

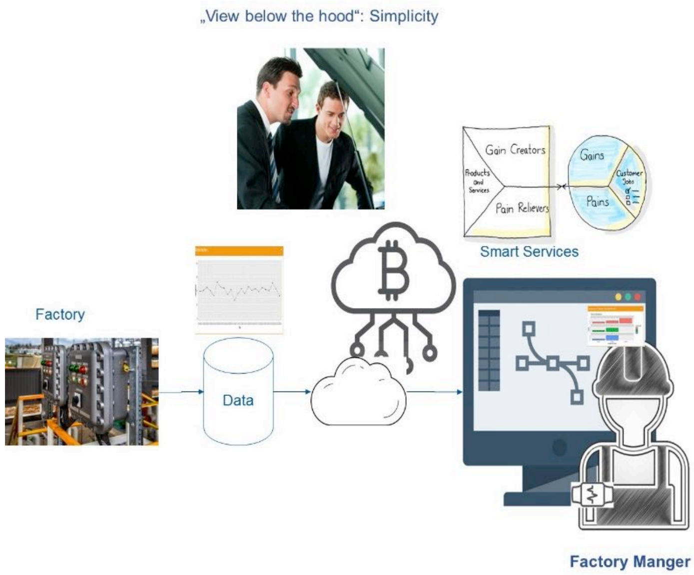

Figure 4: Prototyping and show-casing simple smart services.

The first step was to analyse and model the actors with their jobs, pains, and gains according to the service engineering approach and to sketch the corresponding value propositions. The existing data were then analysed with regard to their suitability for the provision of the value proposition. In selected cases, small concept prototypes with real or synthetic data were then developed. Synthetic data were used when the available real data quality or quantity was not sufficient for prototypical modelling. This resulted in the four types of service concepts described below.

Type 1 service concept: retrospective visualisation and monitoring of the operating status:

- Goal: to transparently present the performance and condition of various machines in production to the operator's personnel. Create understanding for the personnel.
- Time horizon of the service: The service refers to the current point in time as well as to the recent past.
- Typical needs of a production manager: gain an overview of important machine metrics without great effort. Know by simple means what is currently going on with the machines.
- Benefits for the operator: transparency about a previously intransparent situation. Understanding of its production over time.
- Applied Data Methods: descriptive analytics or purely graphical representation of raw data without further processing.

Type 2 service concept: from performance Improvement to optimization:

- Goal: set parameters of production in such a way that better or more performance is achieved with the machine or machine park. The primary aim is to improve the performance by controlling the machines, which can lead to optimisation an advanced development stage.
- Time horizon of the service: show the performance of production at the current time. Potentially, how the performance was in the recent past and how it can be improved.
- Typical needs of a production manager: observe effort, time and resource requirements in production. Derive better planning in order to improve these values. Domain expertise is necessary, i.e. the instructions for better settings are not provided by the service (i.e. no prescriptive service).
- Benefits for the operator: more output (power, effect, quantities) of its machines. Better understanding of the correct and optimal settings of its production over time.
- Applied Data Methods: descriptive analytics or purely graphical representation of raw data without further processing.

Type 3 service concept: predictive condition monitoring:

- Goal: predict whether the condition of individual machines will deteriorate with a lead time given the available data. This involves: a) avoidance of unexpected failures through proactive maintenance or b) preparation for outages by precautionary provision of resources for maintenance.
- Time horizon of the service: since SMEs are typically in an early development stage in the field of data-driven services, only short forecast horizons are usually possible. This lead time before failure must be utilized by the operator for proactive maintenance or the provision of resources for better managing the failure.
- Typical needs of a production manager: increase business continuity by reducing outages or downtime. Avoid operational hecticness, stress situations. Become less reactive and more proactive.

- Benefits for the operator: increased operational excellence, lower operating costs. Better reputation and reduction of stress depending on customer situation.
- Applied Data Methods: simple methods of predictive analytics, see description Demonstrator.

<u>Type 4 service concept: process instruction / decision support for manual activities:</u>

- Goal: support employees in performing manual tasks, in particular decision points in machine operation. This involves the standardization of manual processes as well as the transfer of know-how and the balancing of know-how differences in the case of heterogeneous levels of knowledge among employees.
- Time horizon of the service: usually refers to real-time decisions that have to be made by employees in the process at the moment.
- Typical needs of a production manager: increase of operational excellence through standardization of process flows. Reduction of dependence on the know-how of individual employees who are specific know-how carriers.
- Benefits for the operator: increase operational excellence, reduce variations in processing time or quality.
- Applied Data Methods: for the selection of instructions, typically simple classification methods (from the field of predictive analytics). In this case it is also possible to use an expert system at an early stage, based on expert knowledge instead of technical data and analytics (Lee et al., 2018).

Implementing the prototypes revealed that they can be done in very short time (usually a few weeks) with very low complexity. The algorithms were typically prototyped in R. The resulting code for the type 3 service concept, for example, was in the length of approximately one screen page. The prototype is suited for showing the benefits to SMEs and also to make transparent the complexity and efforts can be kept within limits.

Example Use Case: Demonstrator Pilot for Predictive Condition Monitoring (Type 3):
A further elaborated prototype for type 3 service concept was developed. For a an assumed, but typical situation of a manufacturing SME, a synthetic set of data was used describing a park of 100 machines which provide a stream of physical data for vibration, temperature, pressure and voltage. In addition, the age, location and model type of the machine were saved. Together with the error and failure log, this information provides the data basis for the algorithm that is to predict future machine failures.
Subsequently, a Support Vector Machine algorithm was trained using the statistical environment of R-Studio. This algorithm predicts whether a machine will fail or not in the next 24 hours. During the training, the data set, which contains data for one year, was divided into two parts. The training set contains the data of the months January to August. The months October to December are represented in the test set. The training set was used to train the algorithm and the test set was used to validate the result.
The algorithm works very well. The performance is over 95%. This is excellent performance is partly due to the fact that the data are synthetic and thus of good quality, but also because the data comes from a database and is therefore very well structured.
With the tool Power-BI a dashboard was developed, which now displays these results well-ordered. The following figure shows a part of the dashboard, which is the forecast. At the top of the figure an on-off flag indicates whether a failure state is to be expected on the timeline in the coming 24 hours.

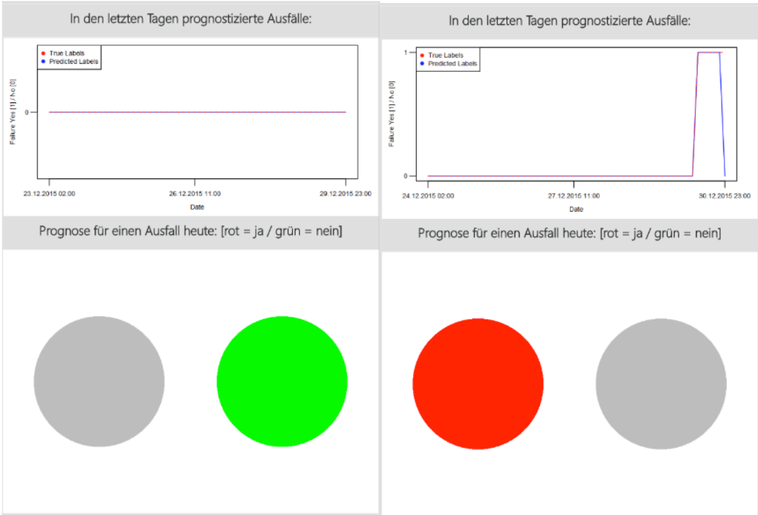

Figure 5: Excerpt from the dashboard with the forecast

In the left plot no machine failure is expected in the next 24 hours, accordingly the traffic light is green. An error is displayed in the right part. The traffic light therefore changes to red. It is immediately apparent to the machine operator that he must take care of the machine. This kind of simple and intuitive user interface is based on the insights gained from modelling the jobs, pains, and gains of actors who work in the context of factory where only limited attention can be paid to a screen by the user.

Discussion and Outlook

Approaching the field of advanced, output-oriented services is essential also for SMEs. Given the fact that building up knowledge and resources in the important field of data analytics requires time and organizational change, it is important that SMEs make their first experiences with data-driven services at an early stage, even if they can still operate and serve their customers with traditional services at the time being.

A lack of knowledge and resources doesn't imply that the SMEs should stay on the sidelines and observe the early movers preparing the market and the customers for the new services. Instead, there are simple and pragmatic procedures for SMEs to make their first steps with data-driven services and to become acquainted with them. In this study, we showed four simple types of service concepts that can be implement in short time and at low complexity. A demonstrator case including a simple user interface was presented additionally. In future studies, the generalisation of these concepts will have to be assessed. Further research is also required to determine when SMEs need to switch to a more professionalised approach once they have become familiar with data-driven services using such simple approaches.

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An Architectural Approach for Service Value Creation with the Digital Twin

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Abstract

This paper discusses the concept of the digital twin for providing data-driven services in industrial environments. There are wide-ranging definitions of the digital twin in the literature confirming that the digital twin is a technology-driven concept while its benefits as an enabler for industrial data-driven services has not yet been thoroughly investigated. The new concept discussed in this paper approaches the digital twin from the perspective of service dominant logic and data-driven service science.

Key words
smart industrial services, digital twin, data-driven services, service dominant logic

Introduction
The digital twin is a concept that has recently received a lot of attention from both academia and practitioners. In the first reading, this concept is technologically clear and obvious, but despite this supposed clarity, the literature lacks systematic approaches to the structuring the design of the digital twin and its data-driven service value. It is a technology-driven concept whose benefit for customers in the form of services and thus for the company has not yet been thoroughly investigated. In particular, the digital twin provides service benefits along the entire product life cycle and thus goes far beyond the pure area of maintenance. This paper therefore considers the whole of the Product Service System (PSS) life cycle as described by (Wuest and Wellsandt, 2016). The terms Beginning of Life (BOL), Middle of Life (MOL) and End of life (EOL) (see also Fig. 1).

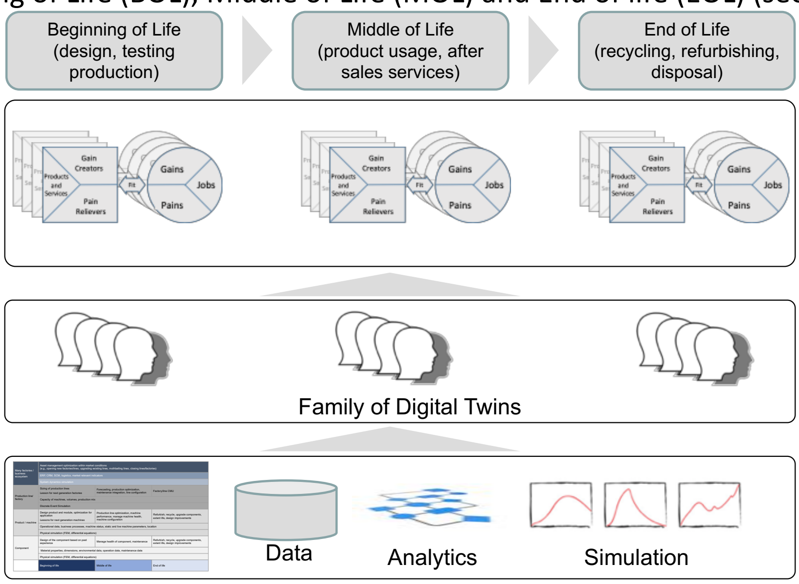

Fig. 1: Data-driven value creation framework of the digital twin.

The approach to servitization taken in this paper is based on the concepts of service science and the service dominant logic (Vargo and Lusch, 2008). The fundamental purpose of economic exchange is the provision of service benefit by the application of knowledge and skills. In the given context of smart industrial services, which are provided by manufacturers of machines to the users of their products, the knowledge and skills applied substantially comes from the data and their analysis, which is incorporated in the digital twin.

According to (Qi and Tao, 2018), value creation based on data and analytics is very similar to the one based on the digital twin. Data and analytics can be considered as an enabling part of the digital twin. Although technical discussions of the digital twin predominate in literature, there are also sources that illuminate the object from the perspective of services and value contribution. According to (Tao and Zhang, 2017), the integration of the Digital Twin and service represents a promising research direction which should be addressed in future paradigms. Reference (Boschert and Rosen, 2016) as well as (Qi et al., 2018) and (Tao and Zhang, 2017) discuss the application of the digital twin along the product life-cycle. It can provide value in the form of services in product design and engineering, in the design and optimization of the shop floor, in product operations and usage monitoring, as well as in after-sales services and prognostics and health monitoring of the product. A layered approach for implementing the value creation along the product life-cycle is described in (Meierhofer and West, 2019) shown here in Fig. 2.

Many factories / business ecosystem	Asset management optimization within market conditions (e.g., opening new factories/lines, upgrading existing lines, mothballing lines, closing lines/factories)		
	ERP, CRM, SCM, logistics, market relevant indicators		
	System dynamics simulation		
Production line/ factory	Sizing of production lines Lesson for next generation factories	Forecasting, production optimization, maintenance integration, line configuration	Factory/line CMU
	Capacity of machines, volumes, production mix		
	Discrete Event Simulation		
Product / machine	Design product and module, optimization for application Lessons for next generation machines	Production line optimization, machine performance, manage machine health, machine configuration	Refurbish, recycle, upgrade components, extent life, design improvements
	Operational data, business processes, machine status, static and live machine parameters, location		
	Physical simulation (FEM, differential equations)		
Component	Design of the component based on past experience	Manage health of component, maintenance	Refurbish, recycle, upgrade components, extent life, design improvements
	Material properties, dimensions, environmental data, operation data, maintenance data		
	Physical simulation (FEM, differential equations)		
	Beginning of life	Middle of life	End of life

Fig. 2. Layers of the digital twin with design objective, data used, and simulation technique applied.

The research question in this study requires framing within the context of data-driven product service systems so that the complexities of the B2B environment and digital twins can be investigated in the industrial world. Around this framing the research question is: "How does the architectural structure of the digital twin look in order to implement the layered approach for service value creation along the product life-cycle?"

Consolidated Concept for the Digital Twin and the Resulting Creation of Service Benefits

The minimum requirements for a Digital Twin concept are given by the following points: sensors that determine a current status, connectivity, defined data structures, and a user interface (Sallaba and Gertner, 2017). The basis is the framework of Tao et al. (Qi and Tao, 2018), whose statement is that everything from the smallest device to production can be regarded as a digital twin. At unit level, the smallest unit is described here as a machine. This could be a single robot arm. In this interpretation, the machine does not need sensors, which is otherwise a mandatory criterion (Sallaba and Gertner, 2017). However, sensors alone are not sufficient. In the best case, they are connected to the Internet. Theoretically, the preliminary stage of the digital twin is the Internet of Things (Sallaba and Gertner, 2017), but in this concept the minimal requirement is seen purely as connectivity between the components. This means that the components must necessarily be linked together, but it doesn't matter how they are linked together. The reason for this "simplified" requirement is that the Internet of Things is often not yet at the desired maturity level. The machine is linked to the computer and to other machines. Several linked machines together form a production line. Several linked production lines result in a shop floor. The production line at system of systems (SoS) level is, according to (Qi and Tao, 2018), the shop floor (SoS) (see Fig. 3). The distinction between the different levels (Unit Level, System Level, SoS Level) is very important. This granularization is crucial to get the most out of a Digital Twin solution. At unit level, each machine is viewed independently of the others, so the operating status of each machine is clear at all times and any potential for optimization per machine is identified. At system level, the entire production line is viewed and the optimization and status is also reflected at this level. At SoS level, a possible optimization is the throughput time, which can be maximized with the help of simulations of the Digital Twins. The third minimum requirement (Sallaba and Gertner, 2017) is a defined data structure. This means that it is clearly defined what kind of data is collected and how it is processed. Many companies currently collect vast amounts of data and do not even know what to do with it. The fourth point is the user interface, i.e., visualization and operation.

The digital twin can and should generate added value over the entire product life cycle (Qi et al., 2018). Instead of building a physical prototype, a virtual prototype can be built during the design phase (Schleich et al., 2017). The production can be optimized with the virtual prototype by simulation of different production strategies and production plans, before the production is started. Value-added services can be offered through the data generated during product use. This is another pillar of the Digital Twin concept. Maintenance, Repair and Operations (MRO) is based on this data, an example of which is predictive maintenance.

The concept is completed with the expansion of services. The basis of this is the service classification framework by (Kowalkowski and Ulaga, 2017). Digital Twin based services can also be differentiated according to this framework: Product Lifecycle Services (PLS), Asset Efficiency Services (AES), Process Support Services (PSS) and Process Delegation Services (PDS). The three services mentioned in Figure 3 (i.e., predictive maintenance, machine availability, augmented reality) are only as examples. They can also be assigned to the classification framework by (Kowalkowski and Ulaga, 2017) as follows:

- **Uptime:** With the help of the Digital Twins, service contracts with a certain machine availability (uptime) can be concluded with minimal risk. This means that the manufacturer guarantees that the machine will function flawlessly, e.g., 98% of the time. The manufacturer demands a certain annual fee for this; if he cannot keep this promise, a certain penalty may become due. The machine is monitored and checked in real time, including usage data and environmental data (e.g. temperature / humidity sensors). Since the performance or lifetime of a machine can vary substantially depending on the environment, it can be simulated using the Digital Twins and thus, the risk of a machine

availability service contract can be minimized. Uptime is a classic example of Asset Efficiency Service.
- **Predective Maintenance:** The topic of predictive maintenance is similar. Here, for example, a service contract can be concluded which states that the manufacturer is responsible for troubleshooting the machine. As with the availability example, the manufacturer can charge an annual fee for this. With the help of predictive maintenance, the risk of errors can be minimized and the profit maximized. Like uptime, predictive maintenance belongs to the Asset Efficiency Services.
- **Augemented Reality:** A somewhat different example, Augemented Reality; the customer's fitters can be equipped with Augemented Reality glasses and thus find faults more quickly. The service would be to provide and operate the Augemented Reality system. This kind of Augemented Reality based service belongs to the Process Support Services.

The long-term goal should be to establish Machine-as-a-Service. According to the service classification framework by (Kowalkowski and Ulaga, 2017)., this would be a Process Delegation Service. What is standard in the IT environment (software-as-a-service, platform-as-a-service, etc.) is still a dream of the future in the machine industry.

The potential of such a solution is enormous, as the following two points show:
- Much higher margins can be achieved and the susceptibility to crises is reduced (Kowalkowski and Ulaga, 2017).
- Another consideration is to offer this as pay-per-use. The customer pays a fixed amount per hour for the machine, which is needed, and the manufacturer takes care of everything. This reduces many hurdles on the customer side, as the risk is completely on the manufacturer side. With the help of digital twins, this risk is counteracted and minimized. In order to be able to provide such services, it is often necessary to transform a company towards the digital era. There are countless challenges that have to be mastered.

In a first step, individual tasks of the customer can be taken over, as mentioned for example, the repair of the machine. The next step could be to conclude a service contract for machine availability. The final and most challenging step would be to offer "machine-as-a-service".

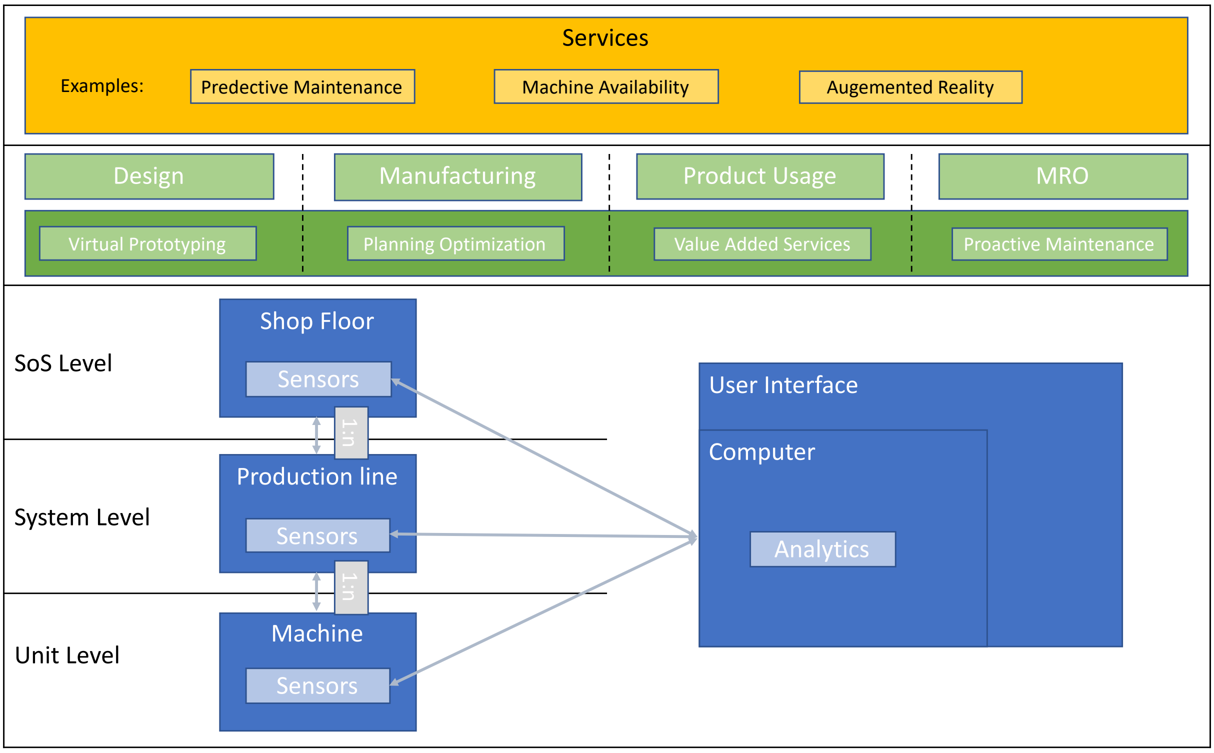

Fig. 3. Minimal requirements of a Digital Twin concept with the product lifecycle and services

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Smart servitization: an iterative process

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The Netherlands

Abstract[6]

This paper describes the challenges for SMEs to fully profit from the opportunities that Internet of Things (IoT) offers. Our aim is to find out how digitalization and more specifically IoT can enable smart servitization in the manufacturing industry. By implementing and using IoT it is possible for SMEs to generate data which makes it possible to customize their services. In this paper, we describe our research project in which we investigate the IoT readiness at manufacturing companies in the Provence of Limburg in the Netherlands. We do this by interviews at the companies as well as workshops with teams of company representatives, researchers and students on specific aspects of the servitization process. The findings are input for our manual with design approaches for smart servitization at SMEs in the manufacturing industry.

Keywords

Servitization, Digitalization, Industry 4.0, Service Design.

Introduction

We are now at the beginning of the fourth industrial revolution. An important development is the Internet of Things (IoT). In smart industry, manufacturing companies use more and more sensors to measure such dimensions as temperature, humidity, pressure, water quality, gases and chemicals, smoke, infrared, fluid levels, images, and movement and acceleration.

Internet of Things (IoT) make a significant reshaping of industry possible (Porter & Heppelmann, 2015). This may materialize through service enhanced products and new business models (Friess & Riemenschneider, 2015). Hence, IoT allows for more efficient production and higher customization levels offering promising opportunities for its application in many industries. Indeed, research recognizes the potential of IoT for manufacturers as they are moving from product-oriented companies to service-oriented ones (de Senzi Zancul et al., 2018; Georgakopoulos, Jayaraman, & Georgakopoulos, 2016).

The context of this research is confined to Small and Medium sized Enterprises (SMEs) in the manufacturing industry. This research responds to calls on further exploring the possibilities of digitization and servitization (Coreynen, Matthyssens, & Bockhaven, 2016; Raddats, Kowalkowski, Benedettini, Burton, & Gebauer, 2019; Rymaszewska, Helo, & Gunasekaran, 2017; Vendrell-Herrero, Bustinza, Parry, & Georgantzis, 2017) and the limited consideration of servitization research in the SME domain (Kowalkowski, Windahl, Kindström, & Gebauer, 2015).

[6] This paper is a further elaboration of Kar, E.A.M. van de, L. Bakir and L.J.M. Nieuwenhuis (2019). IoT as Enabler for Smart Servitization in the manufacturing industry. *Paper submitted to the VIII International conference on business servitization*; San Sebastian.

This research attempts to understand how digitalization and more specifically IoT can enable smart servitization in the manufacturing industry.

Conceptual framework

Cenamor, Sjödin, and Parida (2017) state that digital technologies enable firms to improve service quality and reduce operational costs and, as such, may overcome the service paradox. Digitalization technologies enable the servitization process and IoT is one of those enabling *Technologies*.

Frank, Dalenogare and Ayala (2019) show the complexity level of implementation of Industry 4.0 technologies and they look into the digital platforms with suppliers, customer and other companies units. Together they are needed to create a Smart Supply-Chain, especially SMEs which have fewer resources (and staffing departments) and are more dependent on other companies. Accordingly, a SME is mostly part of a *Network of companies* to be able to provide the value proposition.

Furthermore, the *Customer* perspective is the main attribute of the value proposition (Rabetino, Kohtamaki, & Gebauer, 2017) and the *Value Proposition* design is essential in the servitization process. The usage of visualization tools in workshops support the design process. Iriarte, Hoveskog , Justel , Val & Halila (2018) explain how service design visualization tools in co-creation workshops support the identification, design, and development of value propositions; and how the result can be a change in business logic as the companies become more customer-centered.

In Figure 1 we show how we combined and visualized the iterative design process with the above-mentioned elements of the value proposition, the technology, the customer, and the organizational network.

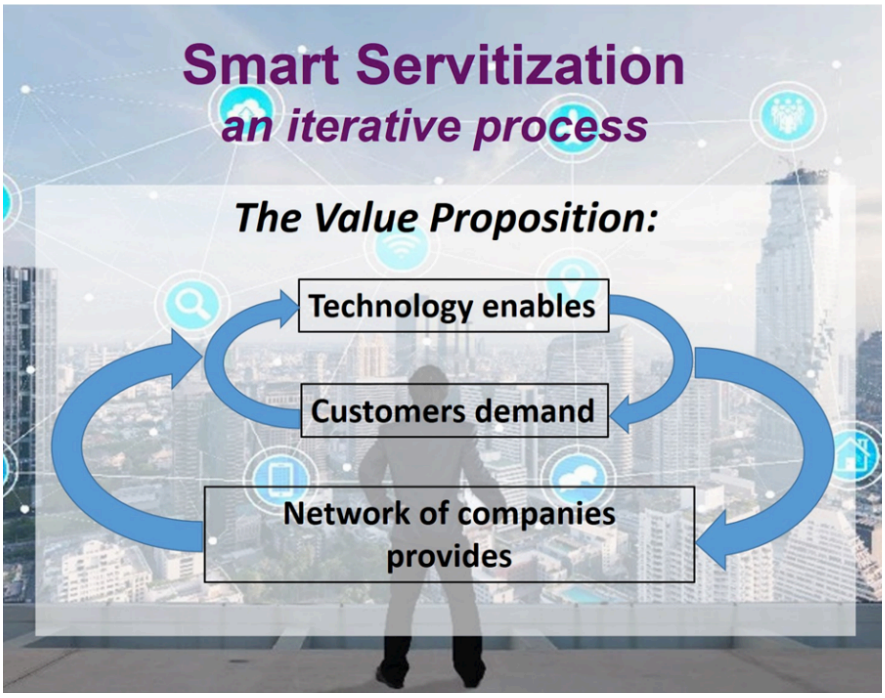

Figure 1: visualization of servitization process

Research method

We are working on a large-scale empirical investigation in SMEs in the Province of Limburg in the Netherlands. We investigated manufacturers operating in several industries who e.g., make brewery machines, solar panels, cheese cutting machines, vegetable washing machines, and garage doors. The research is guided by an IoT readiness matrix based on the Capability Maturity Model (CMM - see appendix; Paulk, Curtis, Chrissis, & Weber, 1993). The framework determines companies' IoT readiness by measuring five dimensions which are: organization, data intelligence, production process, service process, and customer. Our approach is divided into three phases:

1. Literature review and initial survey (pilot) among three companies.
2. 20 SMEs participated in the following 5 steps within half a year (1) online survey; (2) knowledge session; (3) in-depth interviews; (4) reports to individual companies; and (5) a meet and match session with IT or knowledge parties.
3. Longitudinal study on implementation processes of IoT and the success and failure experiences. This phase will take place in 2019 and 2020. This study consists of interviews and workshops. We facilitate the workshops with service design methods and tools. Together with the company's business developers we look into the customers' needs and at the technological trends. Next, we define all required actors & roles and start designing business model scenarios.

Findings

The results of phase 2 are visualized in a radar chart as shown in Figure 2. Each dimension comprised of ten to twenty items. The online survey served as a baseline as companies had to assess their own IoT readiness. Results were further explored by in-depth interviews leading to a more objective outsider view on the status quo.

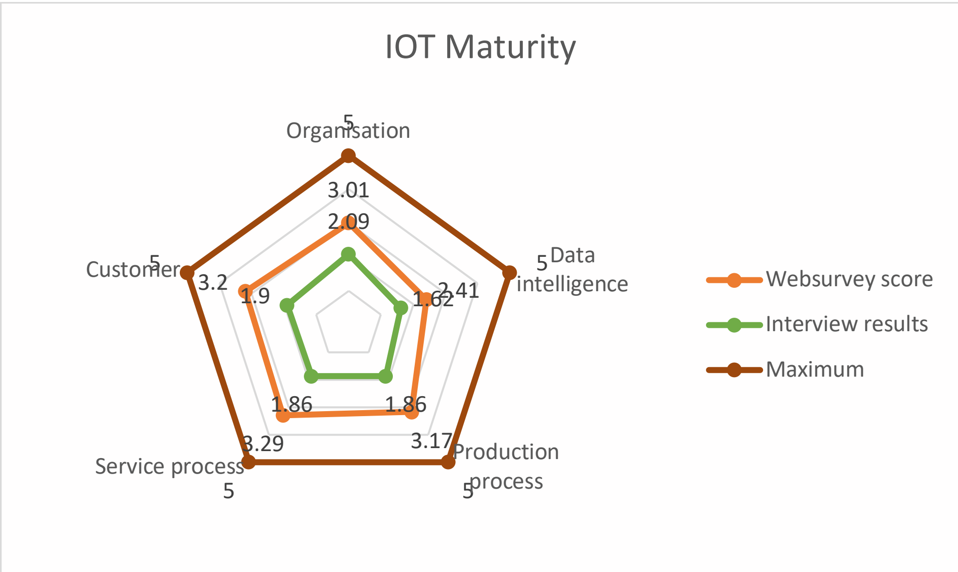

Figure 2: IoT Maturity matrix average for 20 SMEs in the manufacturing industry

The experiences of these 20 companies with IoT implementation vary from none, to just starting, and to having experience. Therefore the average in Figure 2 is not very interesting in itself. In phase 3 we will compare the results of companies with companies who in the same phase of implementation. We observed that the implementation of IoT is a process which influences all dimensions of the matrix and it is an iterative process with 2 steps forward and one backward. We found that the alignment of the five dimensions (each with about the same scoring) is important to realize controlled progress.

Future research

This research attempts to understand how digitalization and more specifically IoT can enable smart servitization in the manufacturing industry. The first step is to understand the IoT readiness of SMEs in the region over a period of time. One of the preliminary conclusions is that there are big differences between companies and that traditional manufacturing companies are still wondering if and how they should implement IoT. Therefore we want to understand how the characteristics of the SMEs are related to success and failure factors of implementing IoT.

Thus, to support SMEs with the servitization process and to overcome the servitization paradox we want to understand their success and failure factors. But we also want to work together with the entrepreneurs at workshops in which we use service design approaches. We gather the methods, tools, and experiences on our digital platform https://ServiceEngineeringLab.com. We have had the first pilot workshops with manufacturing SMEs. The evaluations of those workshops were positive in the sense that the participating company representatives were enthusiastic about the workshop results. Together we looked at the trends and how this influences their business model, for example how the implementation of IoT can support predictive maintenance and how this might lead to the introduction of new revenue models. The next step is to follow and measure the results of the implementation of the workshop results. This is also part of our longitudinal study on the implementation processes of IoT and the SMEs success and failure experiences.

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Research Panel III "Value Capture"

Speakers

Moritz Classen	University St. Gallen, Switzerland	Everything as a service? Introducing the St.Gallen IGaaS Management Model
Benedikt Moser	FIR e.V. an der RWTH Aachen, Germany	Sales of Smart Services: How industrial companies can successfully sell Smart Services
Helen Vogt	Zurich University of Applied Sciences, Switzerland	Systematic Development of New Digital Business Models for Manufacturing Companies with Focus MEM Industry
Wenting Zou	Aalto University, Finland	The influences of contract structure, contracting process, and service complexity on supplier performance

Everything as a service? Introducing the St.Gallen IGaaS Management Model

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Abstract

Manufacturing companies enhance increasingly their hardware products with services. The deployment of digital technologies intensifies the fusion of products and related services towards hybrid offerings consisting of smart products and smart services. If manufacturing companies can control all relevant performance measures of such hybrid offerings in use, they are at the edge to further transform their business.

At this stage, bundles of products and services merge into a single service offering. With such a service, customers may use the product while the supplier ensures the product's functionality. This kind of offering is called Product-as-a-Service. Manifold industry-specific applications of this concept have emerged, such as Lightning-as-a-Service or Windpower-as-a-Service. In a broader sense, these offerings are subsumed under Everything-as-a-Service (XaaS). However, only few manufacturing companies offer XaaS, let alone the number of companies that are economically successful in this endeavor.

In contrast, software vendors show the successful transformation from selling on-premise solutions to offering Software-as-a-Service (SaaS). In order to do so, software companies had to restructure their offering. Far more than just adopting a new business model, switching to SaaS was a strategic move for software firms that entailed fundamental organizational changes. As software vendors demonstrate how profitable SaaS is, the underlying transformation path could be a didactic play for manufacturing companies.

Importantly, a comprehensive framework to transform a manufacturing firm towards XaaS is missing. In order to fill this lacuna, we propose a holistic management model. The four layers strategy, business model, operating model and enablers represent the main levers for turning the transformation towards XaaS into action.

Key words
Digitalization, Everything-as-a-Service, SaaS, Servitization, XaaS

Introduction

Historically, manufacturing companies were driven to mass-produce high quality products and distribute them on every possible channel with the impetus to increase sales volume and, in turn, revenue and profit. The increasing product customization and customer orientation required these companies to improve their flexibility, accompanied with reaping efficiency and effectiveness gains. Nevertheless, margins on hardware products are continuously shrinking, inter alia due to almost equal competition from low-cost regions. To encounter the decreasing margins, manufacturing companies adapt by adding high value services to their portfolio, following a transition to solution providers commonly referred to as servitization (Oliva and Kallenberg 2003, Vandermerwe and Rada 1988).

Besides the option to bundle products and services as a complete solution and sell it to the customers, companies now also look into the possibility of providing products as a service. Moving from transactional sell-and-forget approaches to leasing-alike pilots has been known for decades, but is again of rising interest in the era of digitalization. Back in 1962, Rolls-Royce started renting engines to their customers. Today, the technology-enabled easiness of remote tracing, monitoring and repairing the still supplier-owned products underlines the potential of "as-a-Service" offers.

A similar transformation has already occurred in the software industry. In Software-as-a-Service (SaaS) business models, software is not sold as perpetual license anymore, but customers pay a certain fee for its usage. More and more "as-a-Service" approaches emerged especially in the IT world. Examples include Platform-as-a-Service (PaaS) and Infrastructure-as-a-Service (IaaS) (cf. Porter and Heppelmann 2014), subsumed under the umbrella term Everything-as-a-Service (XaaS).

Besides software companies, manufacturers also move towards "as-a-Service" business models. They are able to draw on insights from the SaaS transformation. Yet, manufacturing companies generally cope with a more complex environment, which is likely to influence the path towards XaaS. This is because manufacturing companies are to some extent constrained by their hardware. They have to respect diverse regulations, approvals, longer innovation cycles and their supplier-distributor network. Manufacturing companies further have to foresee changes within various departments, such as the way the product is marketed or how it is sold. Accounting mechanisms are also subject to change. Overall, the combination of physical and digital elements renders the transformation more complex, compared to pure software products.

A new terminology is needed to account for the idiosyncratic conditions of manufacturing companies. So far, the umbrella term "XaaS" only encompassed software- and IT-related business models. However, these cannot be readily applied by manufacturing companies who serve industrial customers and operate under different conditions. The services provided are different, too. Thus, to designate "as-a-Service" business models offered by manufacturing companies in a business-to-business (B2B) environment, we propose the terminology *Industrial Goods-as-a-Service* (IGaaS).

The transformation towards IGaaS is an intricate phenomenon worthwhile of further study. Beyond being a new business model, IGaaS requires deep change within and across organizational boundaries of manufacturing companies. Yet, literature treating this specific topic is scarce. In consequence, we develop a holistic framework to guide managers in their endeavor to introduce and operate IGaaS.

The remainder of this paper is structured as follows. First, we demarcate IGaaS from existing concepts to put forward a tentative definition. Second, we introduce a holistic model for managing "as-a-Service" business models based on industrial goods. We finish with a conclusion and outlook.

TOWARDS A DEFINITION OF IGAAS

"As-a-Service" models have their origin in the field of information systems, which is why it has still a prominent role around the topic of cloud computing (Durao et al. 2014). Thus, the IT branch of XaaS has already been widely accepted and debated.

To discuss selected forms of XaaS business models, namely SaaS, PaaS and IaaS, we focus on two essential dimensions: the value package and the revenue model. Both elements construct the innovative value proposition of IGaaS and differentiate it from existing offers. **Table 1** differentiates different XaaS business models according to their value package and revenue model.

Table 1: Value Packages and Revenue Models of XaaS business models

Business Model	**Value Package**				**Revenue Model**				
	Service Package		Cyber-Physical System		Pricing Model				…
	Core Services	Enabling Services	Physical	Digital	eOBC	aOBC	Usage-based	…	…
SaaS	x			x		(x)	(x)		
PaaS	x			x		(x)	(x)		
IaaS	x	x	x	x		(x)	(x)		
Leasing	x	(x)	x	(x)		(x)	(x)		
Renting	x		x	(x)			(x)		
IGaaS	x	x	x	x	(x)	(x)	(x)		
Blank: Not applicable. (x): Possible, but not necessary component. x: Necessary component.									

Any *value package* consists of a *service package* and a *cyber-physical system*. The service package reflects the customer's perspective of the offering and is divided in two categories: the *core service* and *enabling services* (Grönroos 2010). The core service is the "basic customer benefit received", facilitated by enabling services (Ozment and Morash 1994, p. 352). Cyber-Physical Systems (CPS) are integrated physical and computation processes (Lee 2008) for delivering the service package.

A *revenue model* details how a business model enables revenue generation (Zott and Amit 2008). The *pricing model* is the subdimension of the revenue model that permits to differentiate between business models.

Three pricing models are relevant for differentiation. *Usage-based models*, also known as pay-per-X or pay-as-you-go, tie payment to the customer's use intensity of the service. In addition, there are there are two types of performance- or outcome-based contracts (OBC): *eOBC* focus on the economic value; *aOBC* focus on the availability (Grubic and Jennions 2018).

SaaS, PaaS and IaaS business models all offer a certain value proposition to the customers, defined as the core service. This core service is of digital nature in all cases and can be billed based on usage (e.g. number of users per month) or availability (e.g. 99.995% uptime). Only IaaS has a physical component included in the value package and may integrate further enabling services. Here, the pricing model can be based on a negotiated availability as well. The same holds true for certain PaaS business models.

In the manufacturing industry, "as-a-Service" concepts stem from leasing or renting business models. Consider the construction industry, where renting or leasing are common. Especially smaller building contractors prefer renting heavy duty machinery for the time required on the construction site, instead of tying up capital by buying these systems.

In the light of recent evolutions, manufacturers start to adopt "as-a-Service" concepts. Importantly, manufacturing companies evolve into solution providers. This is accompanied by the increasing diffusion of digital technologies, digital products and connectivity among industrial goods, often referred to as the Industrial Internet-of-Things (IIoT). The combination of physical and digital components changes the value package of such manufacturing companies radically and enables them to offer new pricing models. Due to this development, we suggest to include the proposed IGaaS business model in the IT-dominated XaaS world under a manufacturing branch.

IGaaS differs from other business models by its idiosyncratic value package and revenue model. A SaaS, PaaS or IaaS value package features four or less of the characteristic dimensions core and enabling services, physical and digital elements. In contrast, IGaaS value packages necessarily include all four components. As for the revenue model, eOBC are not applicable for SaaS, PaaS, IaaS, leasing or renting. Thus, IGaaS is the only business model with the potential to apply eOBC, where payments are tied to performance outcomes. **Table 1** summarizes the differences between IGaaS and other business models.

In alignment with these peculiarities, we derive the following working definition for IGaaS:

IGaaS is a business model consisting of 1) a value package combining core services, enabling services, physical components and digital components, and 2) a revenue model that allows for usage-based, aOBC and eOBC pricing models.

Providing IGaaS has the potential to reap several benefits for the suppliers. It may lead to increased customer involvement and retention. Besides that, it offers opportunities for superior financial performance, as software vendors adopting SaaS business models industry experienced it.

However, providing IGaaS also provokes considerable changes within the whole organization. Responsibilities and tasks of existing roles are changing and new roles are added. Proven processes need to be altered or replaced by new ones. In addition, firms need new governance models.

Consequently, managing IGaaS is not trivial. Therefore, we propose a first approach to a holistic framework in the following.

The St.Gallen IGaaS Management Model

Managers need comprehensive guidance for introducing and operating IGaaS. So far, IGaaS has been discussed predominantly from a business model perspective. That is because the main novelty of IGaaS is an integrated value package, leveraged by innovative revenue models and close customer relationships. However, introducing such as radically new business model is a deliberate, strategic choice. Such decision can only be taken in consideration of the firm's current strategic position, characterized by its objectives, portfolio and resources. In addition, operating IGaaS entails deep changes with regards to the organizational structure, processes and governance. Finally, a set of enablers fuels the introduction and operation of IGaaS. Amongst them, risk management and value network are the most prominent.

Against that backdrop, we introduce a holistic framework to manage IGaaS and name it the *St.Gallen IGaaS Management Model* (SGIMM). The SGIMM is composed of the layers Strategy, Business Model and Operating Model and supported by Enablers, as depicted in Figure 1.

Figure 1: The St. Gallen IGaaS Management Model

Strategy	Objectives	Portfolio	Resources
Business Model	Value Package	Revenue Model	Customer Relationship
Operating Model	Structure	Processes	Governance

Enablers	Risk Management
	Value Network

Conclusion

This paper defines IGaaS as a new concept under the XaaS umbrella term. In the last decade, software companies have blazed a new trail for "as-a-Service" offerings. Manufacturing companies that aim at tapping into the new revenue opportunity of IGaaS need to drive organizational change.

More research is needed to operationalize the SGIMM. The framework's objective is to provide managers in manufacturing companies comprehensive guidance for introducing and operating IGaaS. However, a plethora of questions arises in each of its layers that beg for inquiry. What additional resources do firms need to perform XaaS? Which revenue model fits best to the value package of a given XaaS offering? Are new policies as part of the corporate governance needed? What value network partners are able to absorb the risks underlying XaaS?

The Competence Center Smart Services at the University of St.Gallen's Institute of Technology Management addresses these questions in a forthcoming study. The XaaS benchmarking project "Everything as a service? – Learning from software & manufacturing companies" starts in January

2020[7]. The proven St.Gallen benchmarking approach combines quantitative and qualitative research approaches through surveys, interviews and site visits. Findings from this study will shed more light on how companies can successfully provide XaaS offerings and master the necessary strategic and organizational adaptions.

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[7] Further information is available at https://item.unisg.ch/xaas.

Sales of Smart Services: How industrial companies can successfully sell Smart Services

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Abstract

Smart services offer an innovative opportunity to exploit the economic potential of digitization through innovative business models. These business models are designed to meet individual customer needs. However, the market launch and sales of smart services confront many companies with great challenges. In order to retain customers in these business models over the long term and exploit the economic potential of smart services, companies must focus sales and business model on their customers. This paper presents a developed conceptual framework for the sales of smart services, different market launch strategies besides proven methods and tools to establish a successful sales organization.

Key words
Smart Service, Sales, Digital product, Business model, Digital solution sales

Requirements for smart service sales

The information and communications technology industry is showing the potential of digitization as Amazon and Google became the world's most influential and valuable companies through superior digital business models (Statista 2019). Driven by further technological development, digitization was thus also driven forward in the manufacturing industry. The growth drivers are the increasing amount of data generated, increasing data transmission, and computing power as well as the decreasing costs for data storage. In mechanical and plant engineering, however, digitization alone has not yet led to the expected increase in productivity (Statista 2018, Riecke 2018). This is due to the fact that collecting data and connecting machines alone do not lead to direct benefits in production. Only by implementing value-adding digital business models based on these enablers can exploit the potential. Business models and solutions based on smart services represent the highest level of maturity of digital business models by enabling companies to develop into a complete solution provider for their customers. Smart services are data-based, individualized services based on a combination of physical and digital services as well as intelligent products (Acatech 2014, Kampker 2017). They enable active customer support throughout the entire lifecycle and empower high added value (Bruhn u. Hadwich 2017b, p.9, Kampker 2017).

Existing literature pays particular attention to sales organization and management, customer segmentation and pricing (Meffert 2018, Pufahl 2015, Homburg 2012, Geissbauer 2012, Binckebanck u. Elste 2016, Bruhn u. Hadwich 2017, Bruhn u. Hadwich 2016, Ulaga u. Loveland 2014). For the application of the existing approaches with regard to the sale of smart services, the aspect of the networking of customer and provider, the customer focus based on digitization and the value proposition as a central value for the customer are not sufficiently considered in existing sales models. This existing scientific gap will be tackled in the developed framework displayed in the figure below (Figure 1). The process-oriented model with eight topic clusters for the sale of smart services, taking particular account of aspects of digitization, customer focus and the promise of benefits. This model places the customer in the focus of the sales activities and understands the sale of smart services as a value added contribution to the service offered to the customer.

Customer segmentation is necessary due to different customer requirements and characteristics. Segmentation deals with the division of all customers into smaller segments that are homogeneous in terms of their market requirements and which are processed by sales with adapted strategies (Binckebanck 2016, p. 205). This enables customers to be approached in a targeted manner. In addition to typical segmentation criteria such as size, revenue and geographical location of the customer, the digital maturity, installed base of the customer, the willingness to cooperate and exchange data or the technological and digital affinity of the customer are important factors in the sale of smart services. This leads to the requirement that the (non-personalized) existing data and information about a customer must be created under a fixed customer ID in orderto draw conclusions about the above-mentioned criteria from the products and services sold.

Since the core of the smart services offering is no longer a product, a service or a software, the solution and thus the *value proposition* becomes the focus of sales activities. By fulfilling the value proposition, the customer is satisfied and a long-term success of the supplier company with the smart service is made possible. The value proposition of the smart service can vary individually or according to customer segments due to different requirements of the respective customers. The central challenge in sales is to convince the customer of the individual value offered by the smart service and to create confidence that the promised value can be delivered to the customer. In this context, sales employees are particularly important because they convey the benefits to the customer and establish a relationship of trust with the customer (Geigenmüller 2016, p. 583). An important success factor for sales is precise knowledge of the customer's individual benefit in order to quantify it and present it clearly to the customer.

The *sales organization* is the central element for carrying out sales transactions. For the successful sale of smart services, it must be transformed into a customer-centric organization that focuses on individual customer care rather than traditional product orientation. To achieve this, the organization must offer flexible solutions to the highly individual requirements of the customer (Geigenmüller 2016, pp. 583-584). This includes the adaptation of interfaces and processes to the customer in order to enable a joint value-added process with the customer. In order for the customer to experience a high long-term benefit from the smart service, sales must also ensure that the smart service is successfully integrated with the customer and that the customer benefit is further developed in agile development cycles. Thus, the sales organization must be able to sell all services offered and thus the benefit promise as a bundled overall solution that focuses on high customer benefit.

The most important resource in the sale of smart services is the employee. This is because the tasks and requirements of sales employees for smart services are higher than those for product sales due to the in-depth customer service and the complex overall solutions to be sold in the form of benefit promises. This requires new competencies and skills of the employees, which can be acquired through targeted recruiting of new talents and continuous further training and *qualification of the sales employees* (Acatech 2016, p. 12).

The *internal communication* serves the internal exchange of information about the smart service and the exchange of customer information as well as the motivation of the sales staff. Due to the complexity of the services to be distributed, a targeted and efficient exchange of knowledge about the smart service and about successful concepts in sales becomes a decisive factor in competition. The sales employee must be enabled to sell the smart service by means of aids and internal contact persons without having all the knowledge about performance (Ahearne et al. 2010).

The *sales channels* represent the interface between the company and its customers. The customer receives the smart service from the provider via these channels. Direct sales by the company's own sales staff, indirect sales via sales partners, and digital sales channels can be considered. A combination of these as a multichannel construction may be suitable as well. The specificity of the service, the concentration of demand, the monetary value of the service and the customer situation influence the selection of the sales channel (Homburg 2017, pp. 873).

Pricing has the greatest impact on smart services profit and includes, among others, pricing systems and price metrics for calculating price. In principle, providers can choose between a cost-based, a competition-based and a customer-benefit-based pricing system, although the competitive approach often lacks comparisons due to the high degree of individuality of the offer (Simon and Fassnacht 2016). Smart services are only suitable to a limited extent for the application of classic product-centered pricing systems, in which the customer purchases a product once and thus becomes the owner. The value of smart services does not lie in the physical product, but in the benefit created over a period of use through interaction with the customer (Stoppel and Roth 2016, pp. 381-382; Weiber et al. 2017, p. 69). Therefore, user-based pricing systems are particularly suitable for smart services, in which the provider is remunerated per use, per output or for the economic success of the customer, for example. In this way, incentives are also created for the provider to create the highest possible customer benefit with the offer (Roth et al. 2017, p. 285).

Customer communication refers to the contact between provider and customer, which extends over the entire customer journey from raising customer interest through the life cycle of the smart service to the end of the term of the smart service. The Customer Journey can be divided into five customer phases: 1. perception, 2. consideration, 3. purchase, 4. service and 5. extension. A customer journey can only be successful if the customer is offered a positive experience throughout all phases, because if the customer is disappointed in one phase, he leaves the business. In particular, the service and expansion phases are becoming more important for smart services than tangible products, because in these phases it must be ensured that the customer does not cancel the smart service. All physical and digital contact points with the customer must be simple and consistent (Bruhn u. Hardwich 2012, Daniel 2016, Rusnajak 2018). The design of the contact point is oriented towards the customer. The customer must be enabled to completely and easily cover his information requirements for services and thus make the individual benefit promise as easy as possible for the customer to understand (Dölz et al. 2017, p. 353).

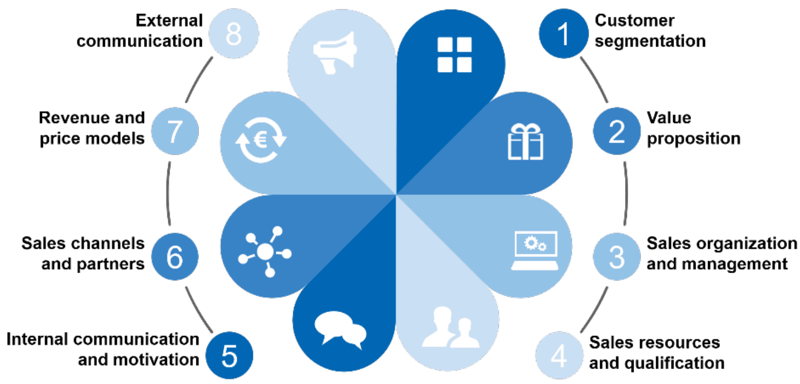

Figure 1: Smart service sales framework (own presentation)

Smart Service Sales

For a successful market launch up to the scaling of a smart service, a precise procedure has to be chosen in which decisive elements of the sales process are adapted to the requirements of the customers and the characteristics of smart services. Due to the digital characteristics, smart services can provide precise information about the customer and the use of the smart service on the basis of data. Furthermore, smart services can be further developed and adapted through cost-effective releases even after the sale to the customer. In addition, digital smart services can be reproduced cost-effectively after development, so that they have great potential for scaling. These characteristics offer high potential for the sale of smart services, but sales must be adapted accordingly.

A phase-based market introduction model for the sale of smart services is presented for this purpose (Figure 2).

	Piloting	Market entry	Standardization	Scaling
Goal	▪ Validate and **improve** the **product** in cooperation with pilot customers	▪ Transfer from development department to **sales department** ▪ **First commercial success**	▪ **Optimize/standardize** the sales organization ▪ Increase commercial success; effort reduction	▪ **Reduction** of **costs** ▪ High **efficiency**
Data	▪ **No** customer **data** available	▪ **First** customer **data** (sales and technical data) available	▪ **Meaningful** customer **data** (sales and technical data) available	▪ **Structuring** and **analysis** of the data ▪ Derivation of decisions
Sales	▪ By **development team**/ product management of the smart service	▪ By **development team** under addition of **first sales representatives**	▪ By **sales employees/ sales teams**	▪ By **sales employees/ sales teams** or **independent department**
Customers	▪ ca. **0 – 5 customers** of smart service	▪ ca. **5 – 15 customers** of smart services	▪ ca. **15 – 100 customers** of smart services	▪ **More than 100 customers** of smart services

Figure 2: Different phases of smart service sales (own presentation)

This model supports companies in the most important fields of action in the sale of smart services to design measures at the right time so that smart services can scale quickly and successfully on the market (Dove 2019).

Since the benefits and possible improvement potential of smart services can only be identified through implementation at the customer, it is necessary to involve the customer as early as possible in the development of smart services. Instead of developing the smart service and then launching it on the market, the first prototypes must be launched as quickly as possible with the first customers when the most important functions of the smart service are available. This is where the pilot phase begins with the sale of the smart service, during which the course is set for successful sales. The aim of this phase is to validate and improve the smart service with the pilot customers. During this phase, sales will be primarily carried out by the smart service development team. Close partners with whom a trusting exchange exists are selected as customers. In contrast to physical products, possible adjustments can easily be made in this phase due to the release capability of the smart services. During this phase, data about the benefits of smart services must already be collected from the customer.

Once the functionality and benefits of the smart services have been proven in the pilot phase with the first customers, the market entry takes place. The aim of this phase is to involve the sales departments and sales staff and to achieve initial commercial success by selling the smart service. Data and information from the pilot phase can already be accessed in this phase, but the sales department must understand the customer even better on the basis of the data in this phase and align the sales department accordingly. This is where success stories are generated and worked out, which can then be used to orient sales.

The first sales successes often represent the biggest hurdles, since uncertainty prevails both for the customer and for the own selling. This still leads to a high expenditure to the argumentation and individualization. Based on the first step, the effort for sales contracts must be reduced within the standardization. On the one hand, the organization and processes must be adapted to the customer-centric sales of smart services, and on the other hand, tools and knowledge must be used efficiently. Investing in successful standardization, simplification and digitization is the prerequisite for low marginal costs and scaling sales.

The main goal of scaling is to automate the processes of the previous phases. Additional revenue through Smart Services should be achieved without proportional effort. The high availability of data is used to create a basis for decision-making by analyzing this data.

Contribution and Discussion

For the manufacturing industry, digitization offers great potential. Despite high investments in recent years, the benefits realized from digitization have fallen short of the high expectations. Smart services make it possible to offer innovative digital business models with a focus on a high benefit for the customer. This allows high added value to be generated efficiently through an individual yet scalable solution. However, offering this highest degree of maturity of digital services presents new challenges and tasks, especially for sales. To date, more than half of all newly introduced smart services fail on the market within the first year. There is no holistic process model for adapting sales to smart services and the associated customer-oriented business models. This article therefore develops and describes a process-oriented model with eight topic clusters for the sale of smart services, taking particular account of aspects of digitization, customer focus and the promise of benefits. This model places the customer in the focus of the sales activities and understands the sale of smart services as a value added contribution to the service offered to the customer. On this basis, companies in industrial production can use digital services to generate high value for customers and thus exploit the potential of digitization. Furthermore, a differentiated approach for a specific sales process for a smart service was reflected. It delivers a standardized breakdown of specific phases of the sales process. Characteristics of each phase were defined. With these characteristics the industry is handed a process diagram that allows a functional view on the smart service implementation through a sales organization.

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Systematic Development of New Digital Business Models for Manufacturing Companies with Focus MEM Industry

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Abstract

More and more manufacturing companies are switching from product to service revenue and are evaluating new outcome-based business models. Many manufacturing companies, however, are struggling to establish a clear business case in order to justify the investments in the Internet of Things (IoT). This research-in-progress paper aims to identify the most attractive business models with regards to the anticipated added value and implementation efforts, with focus on industrial companies within the MEM industry.

Key Words
Business models, data-based services, manufacturing industries, MEM, B2B

Introduction
Digital transformation has long-since played a major role in consumer goods or B2C business, as the development of consumer goods, electronics, retail, media and music industries in recent years has shown (Zollenkopf & Lässig, 2017). However, the corresponding consequences of digitization in the industrial goods or B2B business is not yet very pronounced or has not yet arrived on the mass market. Manufacturing companies in particular are often unable to exploit the potential benefits of Industry 4.0 (SwissMEM, 2016). Although individual companies have meanwhile adopted a systematic approach to digitization, SMEs need support on a strategic level (Capgemini, 2018). This is also reflected in the development of data-based business models: Most SMEs do not use a methodical approach to identify the most attractive business models. Often the selection of services to be developed is carried out by "trial & error" procedures (Demont & Paulus-Rohmer, 2017). The adoption of new business models is not always straightforward, a major barrier to implementing IoT business models are end-customers who are not willing to share the data with their suppliers (SwissMEM, 2018). For this and other reasons, digital business models have not achieved the financial success which was expected (Neely, 2008). The focus of this paper is on the MEM industry and its companies, as they are dependent on digitization and the associated technologies, and the resulting networking of machines and their environment. A current ZHAW research project supported by Innosuisse examines how manufacturing companies can systematically develop new digital business models and focuses on the following questions:

1. *Which data-based services and business models potentially offer the greatest economic benefit for B2B companies in the MEM industry?*
2. *Which factors influence end-customer's willingness to share the required data with the manufacturers?*

Background and Research Methodology

In order to answer the first research question, this research-in-progress paper aims to set the stage for exploring the suitability of IoT business models for manufacturing companies from the MEM industry. The present study has an explorative character, based on the limited number of research papers on this subject. In a first step a systematic literature review (Webster & Watson, 2002) was conducted to identify different types of IoT based business models and the resulting benefits for the firms who adopt these business models (Bauernhansl et al., 2015, Demont & Paulus-Rohmer, 2017, Fleisch et al., 2014, Kralewski, 2016, Schallmo & Rusnjak, 2017, Suppatvech et al., 2019, Voigt et al., 2019). In a second step the content of the selected publications was clustered according to the type of business model (digitally enhanced product, sharing model, usage-based, solution-oriented and sensor-as-a-service), as suggested by Suppatvech et al. (2019), and presented to an expert panel for evaluation regarding the suitability of these models for manufacturing companies. In the third step, 12 IoT business models were selected for further investigation (see Table 1).

Business Model Type		Description	Example for industrial application (packaging machine)
Digitally enhanced products	Physical Freemium	Physical product is offered with free digital service. Additional (premium) services are subject to a charge	Basic services for the packaging machine are free of charge, further premium services (e.g. benchmarking between different locations) are subject to a charge
	Digital Add-on	Physical product is sold at low/medium price, high-margin services can be purchased on demand	Packaging machine is sold with a standard performance (output), the customer can buy a higher performance (output) at a charge
	Object Self-service	Physical product autonomously orders consumables and replacement components	Packaging machine measures the consumption of foil and other consumables and reorders material automatically
	Digital Lock-in	Digital handshake and authentication mechanisms prevent compatibility with competitor systems	Packaging machine detects a non-original component / spare-part and sends a notication to the manufacturer
Sharing models	Fractionalised ownership	Efficient usage through partial ownership. Use and consumption can be measured for all types of products	Several companies share a packaging machine, individual usage and the associated costs can be allocated to each company separately
Usage-based	Flat rate	Unlimited consumption at a fixed price. Use and consumption of physical goods are measured by IoT technology to reduce the risk of a flat rate business model.	Customer pays a fixed fee independant of number of packages being produced
	Subscription	The customer pays a regular fee and thereby receives access to a product or service. The usage of a product or sub-functions may be limited in time for the duration of a subscription	Customer can buy additional packaging output for peak demands
	Pay-per-use	Usage-dependent pricing: Use and consumption are measurable for goods of all kinds, the customer pays a usage-dependent price.	Customer does not buy the packaging machine, istead he pays a fixed price for each packaged product
	Performance based contracting	Performance-related pricing. The price for a product is not determined on the basis of its physical value, but on the value and quality of the service it provides	The price of the service contract for a packaging machine depends on it's performance (output).
Solution oriented	Razor and blade	Physical product offered at a low price or even for free, the associated consumables are sold with high margins	The packaging machine is sold at a competitive price, the customer has to buy the (high-margin) consumables from the manufacturer
	Solution provider	The customer is not only provided with the physical product but also with a comprehensive consulting and digital services	The manufacturer sells the packaging machine including installation, maintenance, training and other corresponding services
Sensor as a service	Two-sided market	Platforms connect data suppliers with data users. Sensor data is collected, processed and made available to other customers for a fee.	Manufacturer and customers sell machine parameters for optimal performance to other customers via platform

Table 1: IoT business models selected for investigation, based on 3-step selection process (based on Bauernhansl et al., 2015, Demont & Paulus-Rohmer, 2017, Fleisch et al., 2014, Kralewski, 2016, Schallmo & Rusnjak, 2017, Suppatvech et al., 2019, Voigt et al., 2019)

The empirical database consists of 11 semi-structured expert interviews with experienced managers and industry experts. The decision to use semi-structured expert interviews as a method of data collection corresponds to the explorative character of this study. This form of interviewing allows a structured collection of data, but also follows the principle of openness to allow the emergence of new information and unforeseen knowledge (Yin, 2003). In addition, each interview partner rated the business models in a survey with regards to potential added value of the business model and expected implementation effort. The criteria "added value" was measured using the items revenue, margin, company image, know-how regarding customer processes and customer relationship.

The criteria "implementation effort" was measured using the items complexity of data acquisition, transfer and analysis, customer acceptance and applicable regulations. The experts also indicated the probability of implementing the different business models in their own company. The semi-structured interviews were conducted in a time period of 6 weeks in June and July 2019.

Results and Discussion

Figure 1 shows the rating of the business models on a scale from 1 (very low) to 5 (very high) in terms of added value and implementation effort.

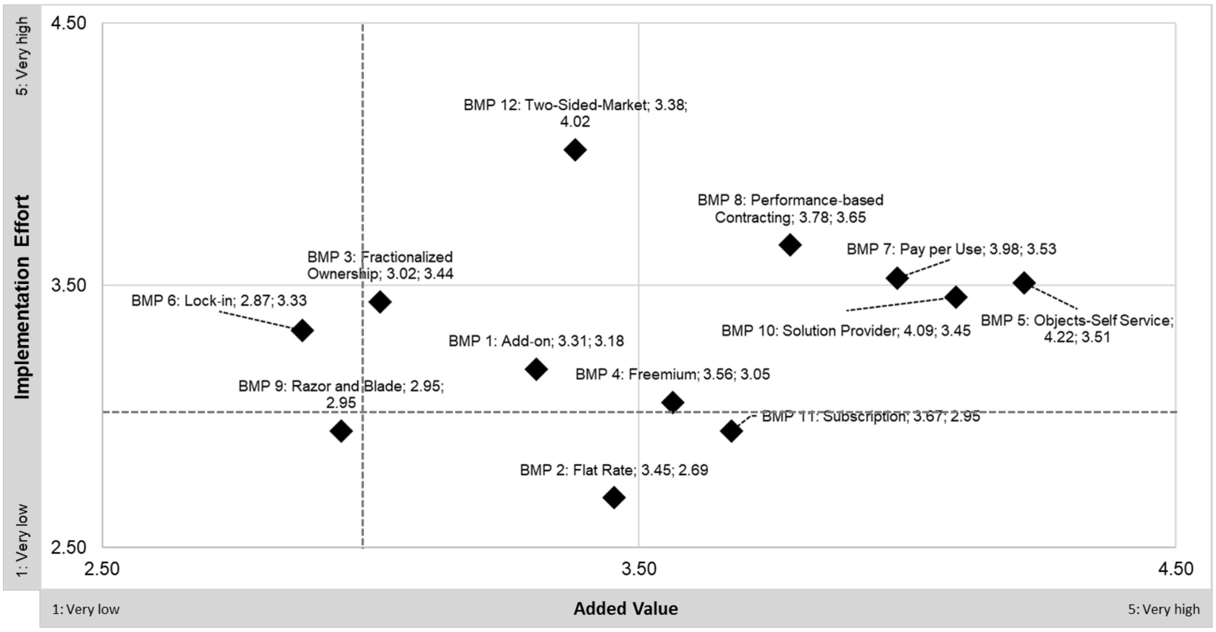

Figure 1: Added value and implementation effort for selected IoT business models

The experts' assessments show that concepts such as Object Self Service, Solution Provider and Pay per Use offer the highest added value in terms of financial return and customer loyalty (see Figure 1). Industry experts and company managers see great potential in the Solution Provider business model, in which the provider does not only supply the hardware, but also the necessary application know-how and software solutions to operate the system. “The customers often have outsourced or reduced the engineering and are therefore dependent on the process know-how of the suppliers.” (Innovation Manager, Mechanical Engineer). These three business models however are considered to be highly complex to implement. Other models, such as Subscription or the Flat Rate model in particular, are easier to implement, but offer less added value for the providers, according to the experts' expectations. Other business models, established successfully in B2C, such as Razor and Blade, often combined with (digital) Lock-in, seem to find little acceptance by equipment manufacturers, maybe due to the relative high production costs of industrial equipment, and are therefore less interesting from the point of view of added value.

The experts also gave an assessment of the probability of implementation of the respective business models, as shown in Figure 2:

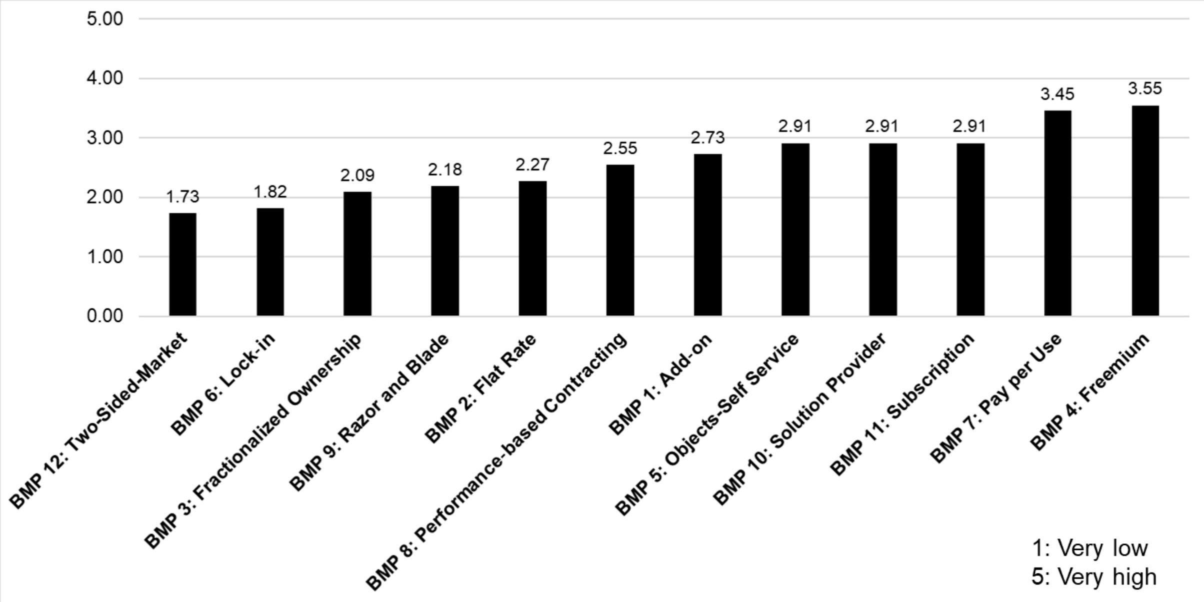

Figure 2: Ranking of the selected IoT business models according to probability of implementation

With regards to the probability of implementation, the Freemium business model has the highest chances among equipment manufacturers, according to the experts' assessment. In this model, the equipment is offered with a free digital service, other (premium) services are subject to a charge. Thanks to this two-tier approach, customers can test the advantages of digital services with relatively little risks and expenses, and then purchase additional services if necessary. The Two-sided Market business model has the lowest chance of being adopted by equipment manufacturers. This is mainly due to the relative novel nature of sensor-as-a-service models and to the expected complexity of integrating external partners.

Future Research

The development of new business models based on a lifecycle and service orientation is still at a relatively early stage. Future possibilities for differentiation in the MEM industry are seen in the area of software and/or services. The actual equipment is only one part of the overall customer solution. Innovative manufacturers, who shift their business model focus away from the pure product sales towards beneficial lifecycle services with Pay per Use approaches, have great opportunities to differentiate themselves sustainably in the market. However, this also entails high investments and challenging rethinking in a completely new world. Which business model offers the greatest benefit needs to be investigated further (Demont & Paulus-Rohmer, 2017). A particular challenge is that business model innovation is not yet an established strategic instrument, especially for equipment manufacturers. Our current research aims to develop a transferable system for identifying and evaluating attractive digital business models. For this purpose, we will conduct a quantitative survey with >300 manufacturing companies in Switzerland, Germany and Austria in order to empirically verify the most attractive IoT business models for equipment manufacturers.

The feasibility of such digital offerings depends in particular on manufacturers' access to the data produced by the equipment during its lifecycle at the customer site and on the acceptance of the new digital offerings by the end-customer. For this reason, we will investigate the factors which inhibit end-customers from adopting these business models, with focus on end-customer's willingness to share data.

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The influences of contract structure, contracting process, and service complexity on supplier performance

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Abstract

The purpose of this paper is to investigate the influences of service complexity, contract structure, and contracting process on the buyer-perceived supplier performance in business-to-business (B2B) services. Based on the survey data of 177 purchasing professionals from 25 countries, the findings indicate that the three major contract dimensions and follow-up management practices positively influence buyer-perceived supplier performance. Furthermore, service complexity amplifies the influences of incentives designed in the contract and the buyer's follow-up contract management on perceived supplier performance. This study suggests a framework and guidelines for purchasing managers to improve the design and management of service contracts to secure good performance from their supplier.

Keywords: Service Contract, B2B services, Perceived supplier performance, Service complexity

Introduction

Reflecting a global shift towards business models with increasing reliance on services, recent research finds that organizations are increasing their spending on the purchasing of business services (Pemer et al., 2014). Despite the potential benefits of well-managed service procurement, the inter-organizational exchanges related to business-to-business (B2B) services inevitably involves complexity that make it difficult to align service procurement with the objectives of exchange parties (Poppo & Zenger, 2002; Stouthuysen et al., 2012).

In general, service deliveries are difficult to describe in contracts due to the uncertainties in specifying the desired outcome or the steps to achieve it. Additionally, services often have the interdependent and interactive character of co-production between buyers and suppliers (Brax et al., 2017). This can also give exchange partners the room to engage in opportunistic behavior that may result in a poor delivery of the service (Stouthuysen et al., 2012). Because of these challenges, designing contract structure and managing the contracting process have become key elements for buying organizations to ensure supplier performance in B2B contexts (Datta & Roy, 2013). The process-based nature, complexity and continued duration of many B2B services imply that designing purchasing contracts and managing contracting process can be much more complicated for business services than for goods. Hence, conventional supply contracts and prescribed specifications that guide the exchange of goods are not suitable for purchasing business services.

The importance and complexity of contracts increase with the complexity of the service , as contracts differentiate the main business model types that are implemented in complex product-service-systems (PSS) offerings (Reim et al., 2015). Buyer companies, especially those that are shifting from buying goods to buying services, struggle with the lack of knowledge on designing contract structure and managing contracting process for B2B services (Datta & Roy, 2011). While purchasing of services has received increasing research attention, very little work has provided guidance on which dimensions or agreements should be incorporated into the service contracts that improve perceived supplier performance. There is an urgent need to investigate the influence of service complexity, contract structure and contracting process on buyer-perceived supplier performance in B2B services.

Drawing on the transaction cost economics (TCE) and the research on service contracting, this study examines how three dimensions of contract structure and post-contract management influence supplier performance as perceived by the buyer in B2B contexts. These three major contract dimensions are the definition of responsibilities, performance criteria, and incentives. Assuming that service complexity increases the importance of contract design and contracting process management in a successful service outcome, this study examines the effect of the complexity of the purchased services on this relationship.

Theory and hypotheses

Perceived supplier performance

Prior empirical studies have shown that a buyer's perception of supplier performance is the main consequence of the supplier's actual performance in influencing the buyer's decision to continue the relationship (Poppo & Zenger, 2002). In B2B service exchanges, perceived supplier performance means that buyers evaluate several explicit and implicit aspects of the delivered services to assess the effectiveness of the inter-firm relationship (Stouthuysen et al., 2012). Therefore, we examine the buyer's satisfaction with the supplier performance, where the underlying logic is that overall satisfaction is a focal consequence of a working partnership (Poppo & Zenger, 2002). This is consistent with previous measurements of perceived supplier performance in the literature (Stouthuysen et al., 2012).

Contract structure – major contract dimensions

In B2B service procurement, the contextual characteristics of services increase complexity and uncertainty, and thus neither buyers nor service providers have complete information to specify all the necessary safeguards and contingencies due (Roehrich & Lewis, 2014). This leads to demanding service contract design processes in order to ensure good service performance with the minimal transaction costs (Brown et al., 2006). According to the TCE perspective, three transaction characteristics determine transaction costs: asset specificity, measurement difficulty, and uncertainty (Williamson, 1985). Asset specificity represents the relationship-specific investment in resources. This investment can generate hazards of hold-up behavior because one party may seek to appropriate gains, such as reducing service quality or raising prices, from the other party's specific investments. Difficulty in measuring the service performance also generates hazards. When performance is difficult to measure, suppliers may limit their efforts to fulfill the agreement. To reduce the transaction costs of asset specificity and measurement difficulty, we identify three dimensions of the contract structure: definition of responsibilities, performance criteria, and incentives.

Definition of responsibilities describes the accountabilities of service providers and customers. B2B service contracts tend to focus on achieving a required outcome rather than fulfilling a set of prescribed specifications that traditionally guides the exchange of goods (Datta & Roy, 2013). Crafting a service contract that clarifies the responsibilities of both parties can reduce role conflicts and ambiguity, guide task fulfillment and better monitor the ongoing exchange between buyers and suppliers (Liu et al., 2009). This could mitigate the opportunism of the service supplier and motivate better performance outcomes. This leads to the following hypothesis:

> H1: In B2B service contract design, a definition of responsibilities positively influences perceived supplier performance.

Performance criteria are defined in contracts to identify and describe the target performance level and the output; this is essential for the successful delivery of long-term service contracts (Enquist et al., 2011). The performance measurement designed in the contracts makes it easier for both parties to understand the process, competencies, and assets required to deliver the required level of performance. Setting performance criteria indicators requires careful consideration because pre-set performance indicators such as quality, speed, and flexibility require an understanding of the service provider's operational capabilities (Datta & Roy, 2011). This can raise the understanding of contractual fulfillment and performance specifications, and be measured to indicate the cause of future problems, thereby they enhance the performance of service providers.

H2: In B2B service contract design, performance criteria positively influence perceived supplier performance.

Incentives are used in the contracts to transfer risks and ensure compliance with performance measures, aligning the goals of the two parties concerned and motivating their cooperation (Datta & Roy, 2011). The TCE perspective suggests that the incentives should describe the cooperation and continuity after transaction-specific investments and penalties in case of a supplier's breach of service delivery. Besides, incentives should include risk sharing between the buyer and the supplier to enhance inter-organizational collaboration (Wacker et al., 2016). Risk sharing as a relationship-bound economic incentive can guide buyer-supplier exchanges and promote accountability. Thus, the following hypothesis is proposed:

H3: In B2B service contract design, incentives positively influence perceived supplier performance.

Contracting process – follow-up management

Uncertainty is the third notable source of transaction costs according to TCE. The uncertainty arising from incomplete specifications demands for the involved parties to coordinate and adapt to unforeseeable problems during the service contracting period (Poppo & Zenger, 2002). This necessitates designing a contracting process that monitors and evaluates suppliers when the transaction is underway. It emphasizes management practices to monitor and assess a supplier's performance based on pre-specified arrangements made (Selviaridis & Spring, 2010). The process, including management practices (e.g., frequent review meetings), allows buyers and suppliers to exchange information, renegotiate when circumstances change, modify the service specifications defined in the contracts, and even revise the contracts because the interaction through review meetings helps the two parties adopt a joint approach to problem solving (Roehrich & Lewis, 2014). Therefore, it is reasonable to propose the following hypothesis:

H4: The buyer's follow-up management of a contracting process positively influences perceived supplier performance.

Service complexity

Complexity is a fundamental characteristic of a service. Complexity in service may arise from numerous factors, including the heterogeneity of contextual factors, interrelated elements, use of sophisticated technologies, need for interactions between the customer and the provider. In PSS, complexity further arises from the broad scope of the service delivery and the technical complexity of the tangible systems, which increase requirements for expert capabilities.

From TCE perspective, complexity increases the risks of opportunism and demands for more costly formal control mechanisms. Prior studies indicate that the complexity of the service increases the need for details in the contract (Kreye et al., 2015). Efficient contracts should encompass promises, responsibilities, and the process for dispute resolution. Clearly defining responsibilities, performance criteria, and incentives decrease role ambiguity and make supplier activities more predictable; thus, service complexity strengthens the effects of contract structure on supplier performance. The post-contract management practices can maintain regular and customary interaction, and structured information flows between buyers and suppliers, thereby mitigating problems with late adjustments. This also promotes continuous open communication between the two parties and fosters relationship bonding, which then enhances supplier performance (Schmoltzi & Wallenburg, 2012). Hence, the post-contract management practices are particularly effective when companies purchase complex services. These arguments build the following hypotheses:

H5: Service complexity increases the impact of responsibilities defined in the contract on perceived supplier performance.

H6: Service complexity increases the impact of performance criteria specified in the contract on perceived supplier performance.

H7: Service complexity increases the role of incentives defined in the contract on perceived supplier performance.

H8: Service complexity increases the impact of the buyer's follow-up management in the contracting process on perceived supplier performance.

Figure 1 presents a model of the hypothesized relationships.

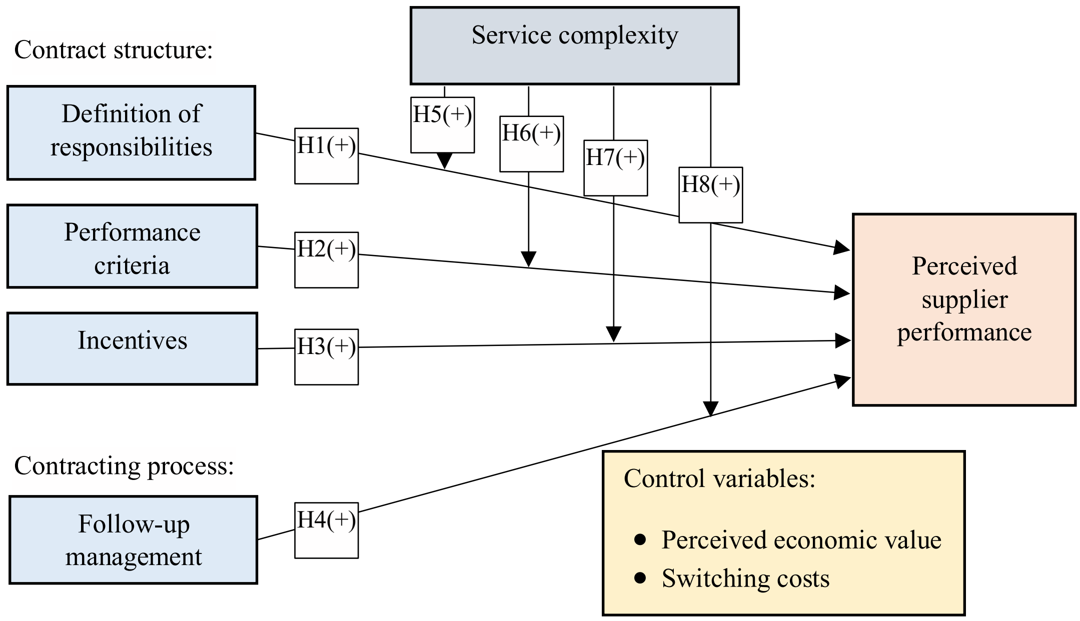

Figure 5 Research model

Research Methods

This study applies a quantitative research approach. The target sampling frame consisted of professionals whose jobs involved the purchase of services with responsibility for designing contract agreements, managing contracts, and controlling supplier performance. To increase the generalizability of the results, we recruited respondents from around the world and from different industries, functions, and levels. LinkedIn, described as the world's largest professional network, was used to access service purchasing professionals in different countries. LinkedIn is informative in terms of individual and organizational profiles and can be used to enlist professionals in producing research data (Maramwidze-Merrison, 2016).

Private focus groups on LinkedIn were used to build the contact list. These groups hold discussions among targeted groups; their membership requires an application and is controlled by the group owner, thus improving the quality of sampling over other social media. Therefore, these groups were considered an effective way to identify and approach service purchasing professionals. The three largest international purchasing private groups were selected as the contact database: Purchasing & Global Supply Chain Professionals; Purchasing & Materials Management; and Purchasing Practices. The contact list with 1500 names was built in two phases – from August to October 2015 and from August to October 2016. Each person was sent an email message containing a cover letter and the link to our web survey, followed by two reminder emails during the data collection phases. The resulting data set consisted of 177 usable responses from 25 countries.

The survey items were developed based on a literature review and refined through a series of pretests, including 18 purchasing professionals and one marketing researcher specialized in questionnaire design. All the constructs has been examined using SPSS Statistics, and met the reliability and validity criteria.

Results

The respondents to the survey represent experts in service purchasing within companies in a wide range of industries. The respondents come from all 18 industries in our sampling frame adapted from the North American Industry Classification System (United States Census Bureau, 2014). The respondents' extensive experience (average 13.2 years) in the purchasing profession makes their answers valuable and relevant to the survey.

The hypotheses were tested with two OLS regressions models. Model 1 was estimated to test H1, H2, H3, and H4. Model 2 was estimated to test the moderating influences – H5, H6, H7, and H8. The regression diagnostics procedures suggested by Hair et al. (2006) were followed. The final statistical results for two regression models are summarized in Table 1. The regression results of model 1, reported in Table 1, reveal that H1, H2, H3, and H4 were supported by the data. Specifically, the definition of responsibilities, performance criteria, and incentives designed in service contracts had significant positive impacts on perceived supplier performance, supporting H1 ($\beta=0.17$, $p<0.001$), H2 ($\beta=0.25$, $p<0.001$), and H3 ($\beta=0.24$, $p<0.001$), respectively. Similarly, support was shown for the impact that a buyer's follow-up management of a contracting process had on perceived supplier performance ($\beta=0.18$, $p<0.001$). These results indicate that both the contract structure and the process can drive supplier performance.

As seen in model 2, H5 was rejected, since the p-value was greater than 0.05 ($\beta=-0.01$, $p>0.05$). For H6, the influence of performance criteria defined in the contract on perceived supplier performance was significantly diminished at higher levels of service complexity ($\beta=-0.07$, $p<0.05$). This finding was the reverse of H6, implying that H6 was not supported. However, in support of H7, the influence of incentives defined in the contract on perceived supplier performance was significantly stronger at higher levels of service complexity ($\beta=0.06$, $p<0.01$). Furthermore, the test of H8 was supported. Service complexity was a significant moderator, with higher levels of service complexity magnifying the impact of the buyer's follow-up management on perceived supplier performance ($\beta=0.06$, $p<0.05$). Consequently, service complexity significantly increased the effects of incentives and follow-up management on perceived supplier performance but significantly decreased the effects of performance criteria defined in the contract on perceived supplier performance.

Table 1. OLS Results for Hypothesized Effects

	Dependent variable: Perceived supplier performance			
	Model 1		Model 2	
	Coefficient	t-Value	Coefficient	t-Value
Main effects				
Definition of responsibility (DR)	0.17	3.78***	0.12	2.72**
Performance criteria (PC)	0.25	7.14***	0.25	7.15***
Incentives (IN)	0.24	6.77***	0.22	6.39***
Follow-up management (FM)	0.18	4.72***	0.18	4.92***
Service complexity (SC)			0.06	1.54
Interaction Terms				
DR*SC			-0.01	-0.41
PC*SC			-0.07	-2.52*
IN*SC			0.06	2.79**
FM*SC			0.06	2.54*
Control variables				
Perceived economic value	0.11	2.70**	0.08	2.03*
Switching costs	0.03	0.92	0.02	0.52
Relationship bonds	0.05	1.31	0.02	0.77
Model fit				
R^2	0.66		0.70	
Adjusted R^2	0.65		0.68	
F statistic	46.61***		32.62***	

Note: *p<0.05, **p<0.01, *** p<0.001

Conclusions and discussion

The service complexity increases risks and uncertainty in service delivery. Our findings reveal that all three dimensions of contract structure have positive impacts on perceived supplier performance. These statistical results in this study validate the findings identified in previous case studies (Robinson & Scott, 2009; Datta & Roy, 2011, 2013), which suggest that the definition of responsibilities, performance indicators, and incentives should be stipulated in the contract to ensure effective service delivery. Therefore, the findings support the TCE theory that suggests that drafting a detailed contract mitigates opportunism and illustrate the theory's relevance in designing the B2B service contract.

The findings demonstrate that the buyer's follow-up management practices in a contracting process have positive impacts on perceived supplier performance. This indicates that contracts that are designed in line with transaction costs minimization can achieve good service performance. These practices consist of establishing frequent review meetings between buyers and service providers, revisiting service specifications throughout the contracting period, and revising the contract if necessary to facilitate adaptation to the service and exchange relationship. The management practices in a contracting process are efficient ways to respond to unexpected contingencies that may arise during the course of the contract.

The study also shows that service complexity has a significant moderating effect on the relationship between incentives designed in the contract and perceived supplier performance. This result indicates that the more complex the service is, the greater the role of incentives in achieving good supplier performance. As the complexity of services enhances difficulties in service specification and then increases risks for buyers to purchase it, incentives including risk sharing can better align two parties and motivate them to work together to achieve better performance. Furthermore, service complexity was found to have a significant moderating effect on the relationship between the buyer's follow-up management in the contracting process and perceived supplier performance, effectively raising the importance of contract management practices in purchasing complex services.

However, the results indicate that service complexity reduces the effect of performance criteria defined in the contract on supplier performance, which is contradictory to H6. The plausible reason is that the initial performance indicators identified in a service contract might be inefficient during the contracting process. This would increase the difficulty of controlling and monitoring the contract, which encourages a supplier's opportunistic behavior and weakens its performance. Under such circumstances, buyers are willing to accept less-precise performance criteria in the formal contract and adjust it to unforeseen contingencies during the contracting process. This yields new evidence that the complexity of services increases the importance of the buyer's follow-up management practices to attain the desired service performance.

Managerial implications

The study has two implications for B2B service purchasing professionals. The results suggest that purchasing managers should specify service contents, set performance indicators, describe responsibilities and shared risks in the contract, and monitor the contract through the entire service delivery process to secure good performance from the supplier. Our findings might be more important for companies that have just begun shifting from buying goods to buying services because conventional supply contracts are not suitable for purchasing services. The framework and guidelines from this study can assist these companies in arriving at a better understanding of the influences of contract design and management of the contracting process for the service supplier's improved performance.

The second implication is that the moderating results show that service complexity increases the importance of incentives and follow-up management to obtain the desired service performance. This finding indicates that when companies purchase more complex services, they should also pay more attention to designing incentives in the contract and developing comprehensive review processes for contract management. In addition, the study may have wider implications for the evolution of service purchasing. A better understanding of how firms can accommodate the complexity of service transactions may improve the productivity of all service-intensive industries.

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Posters

APPLICATION AND DEVELOPMENT OF THE Data2Action FRAMEWORK TO FOUR INDUSTRIAL USE CASES

Oliver Stoll, Shaun West, Mario Rapaccini, Cosimo Barbieri

RESEARCH MOTIVATION

The motivation for this work is a desire to find a more effective way to support industrial firms with the development of Smart Services. Firms have been expressing their frustration with the development of Smart Services, and this Executive Paper reviews the lessons learnt from the application and development of the Data2Action Framework in use in four different industrial cases.

Three of the cases are based on projects with durations from four months to one year with one example from a 24-hour hackathon.

The methodology was developed to provide a structured practical approach to the design of Smart Services in complex systems.

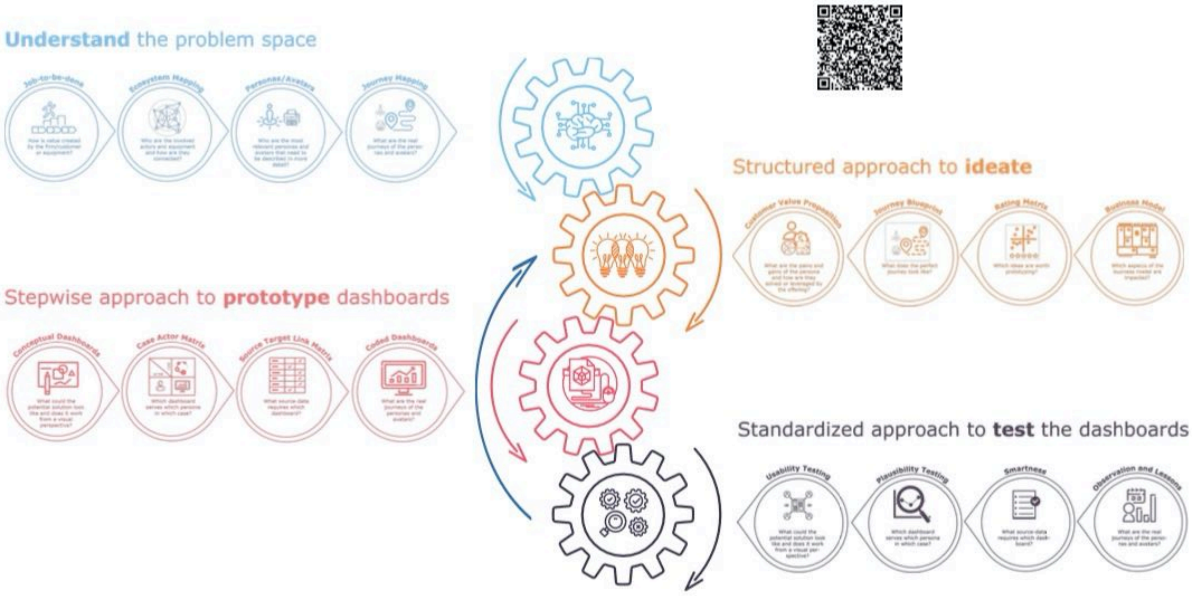
	Aircraft MRO	Glass bottle manufacturing	Water distribution (hackathon)	Printing-as-a-service
Problem Understanding	Very complex system not knowing where to start… Focus on MRO and the aircraft	Understand the equipment and how it is used by the customer	Understand that data scientists and business people are different	Mutual understanding of techies and business at the end of the phase
Ideation	Focused on improving aircraft tracking and MRO resources.	Improve communication within the operations and maintenance teams	Apply solutions from other industries to the water case (low degree of innovation)	Co-creation resulted in new ideas for business problems
Prototyping	Draw conceptual dashboards to support MRO decision making	DigitalTwin in excel linked to KPIs for the whole platform	24 hours working digital prototypes	Conceptual (hand drawn) and working (MS BI based) prototypes
Testing	Interviews	Interviews and customer application	Interviews during the development process and judgement of experts at the end of the event	Took places during different stages of the project. Test purpose needed.
Lessons	Comprehend problem Breakdown problems It is not about data it is about business	Digitalcan support business understanding and provide sales triggers	Techies can do more than we thought – they need support with business and problem understanding	Co-development leads to better results Ongoing testing supports 'better' solutions

KEY DISCUSION POINTS

- The Data2Action framework provided a structured approach to understanding the problems.
- The visuals supported the development of a new common understanding.
- The hand-drawn prototypes were highly effective and efficient.
- The clear identification of data producers and information consumers supported the coding.

Data2Action Model

SCAN ME!



Exhibited at The Smart Services Summit 2019, 13 September, Zürich, Switzerland.

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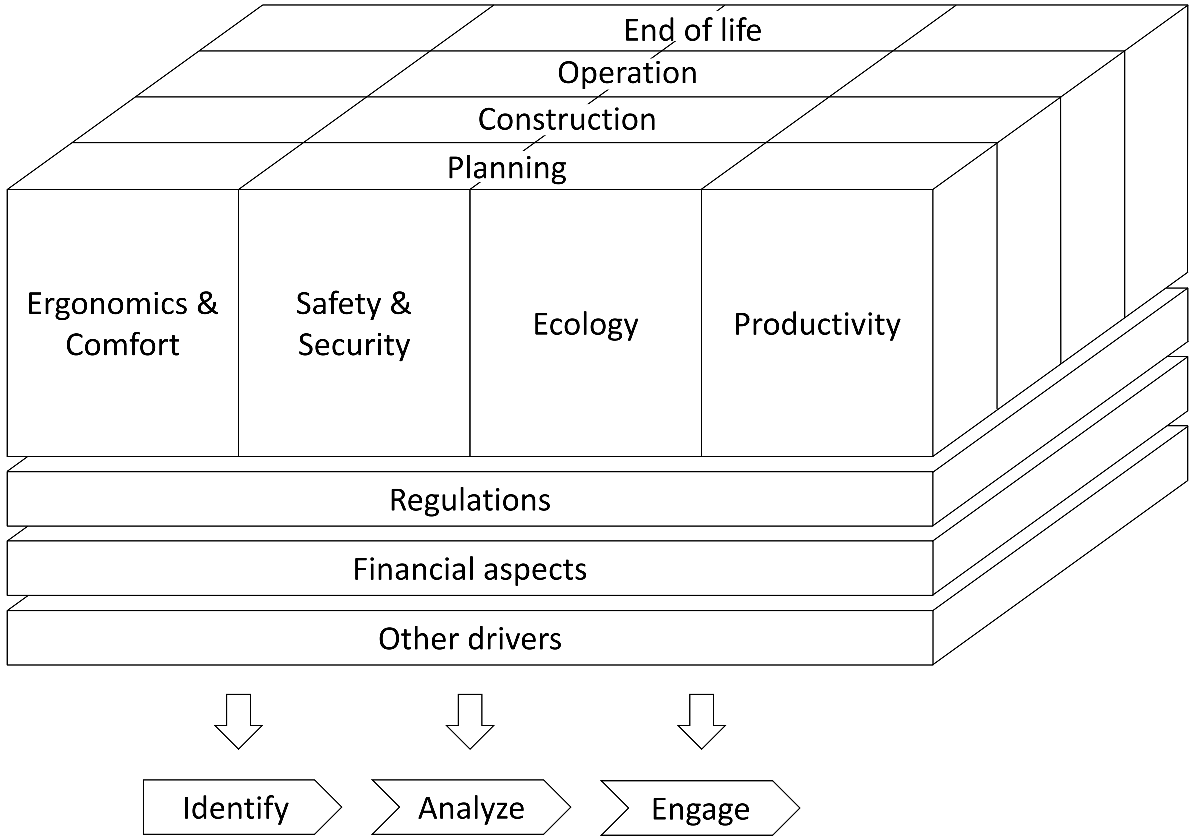

Approaching data driven services in the built environment

Valentin Holzwarth, Johannes Schneider, Andreas Kunz, Jan vom Brocke

Research Objectives

- Investigate on the potentials of data driven value creation
- Transfer value creation potentials into services

Research Methods

- Analysis of stakeholder needs along the building lifecycle
- Synthesis of literature and prototypical mapping of applications

Through the employment of data analytics in the built environment, value can be created in four categories: ergonomics & comfort, safety & security, ecology, and productivity. This process of value creation involves multiple actors, who have to reach consensus. Such consensus can be reached, when one actor creates a data driven service and thus leads the value creation process for all involved actors. Three steps are proposed to develop a data driven service: (i) identify individual goals and drivers, (ii) analyze other actors needed, (iii) engage with other actors.

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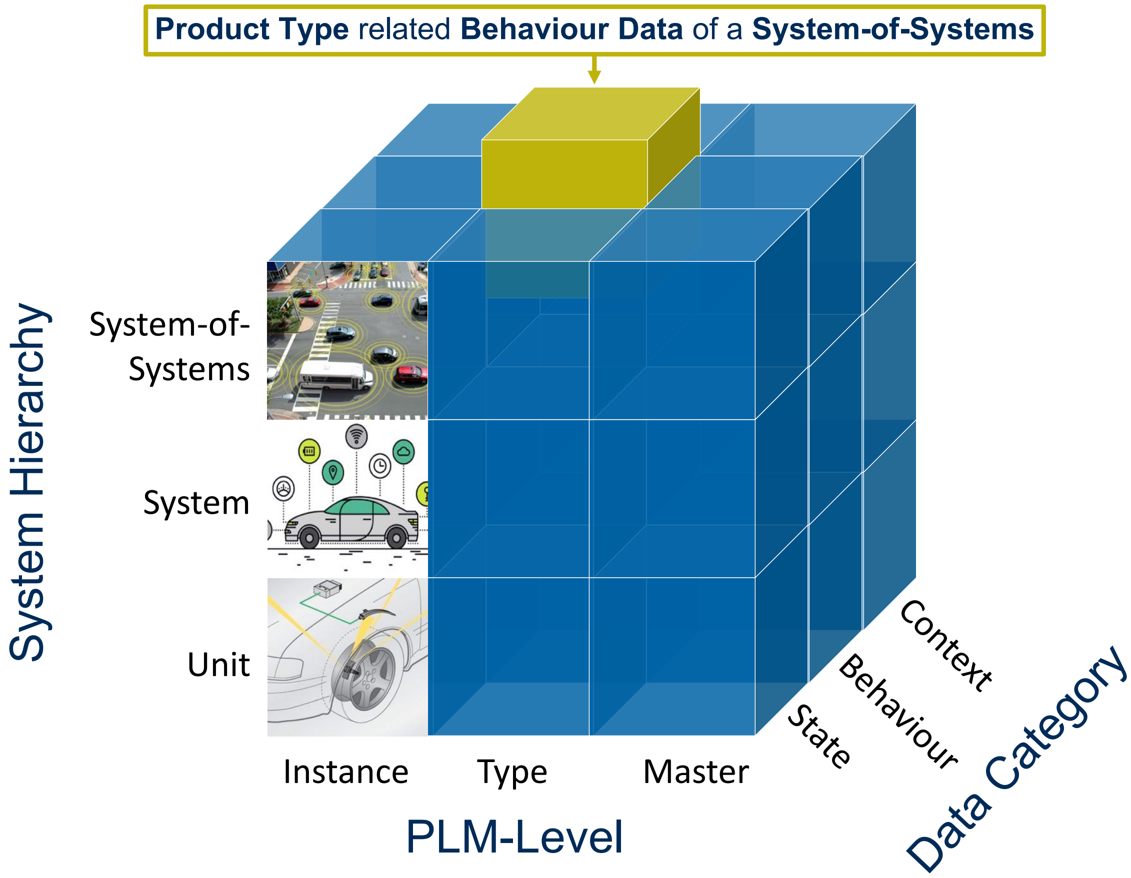
Classifying Digital Twins: A Three-Dimensional Conceptual Reference Model

Linard Barth, Dr. Matthias Ehrat, Prof. Dr. Rainer Fuchs (ZHAW, Product Management Center)



Research Objectives

- State the dimensions to classify Digital Twins
- State the specifications of each dimension
- Explain the characteristics of each specification

Research Methods

- Systematic Literature Review
- Design Science Research
- Survey within practitioners (tbd)
- Business case analysis (tbd)

The next step will be an extensive survey within product managers to validate the conceptual model and examine the application status of the different digital twin classes within practice.

Further research is intended to evaluate which data categories (from which sources) provide value to which PLM levels. And analyzing the impact of CPS hierarchy level, industries, customer types (B2B/B2C) and product types as moderators.

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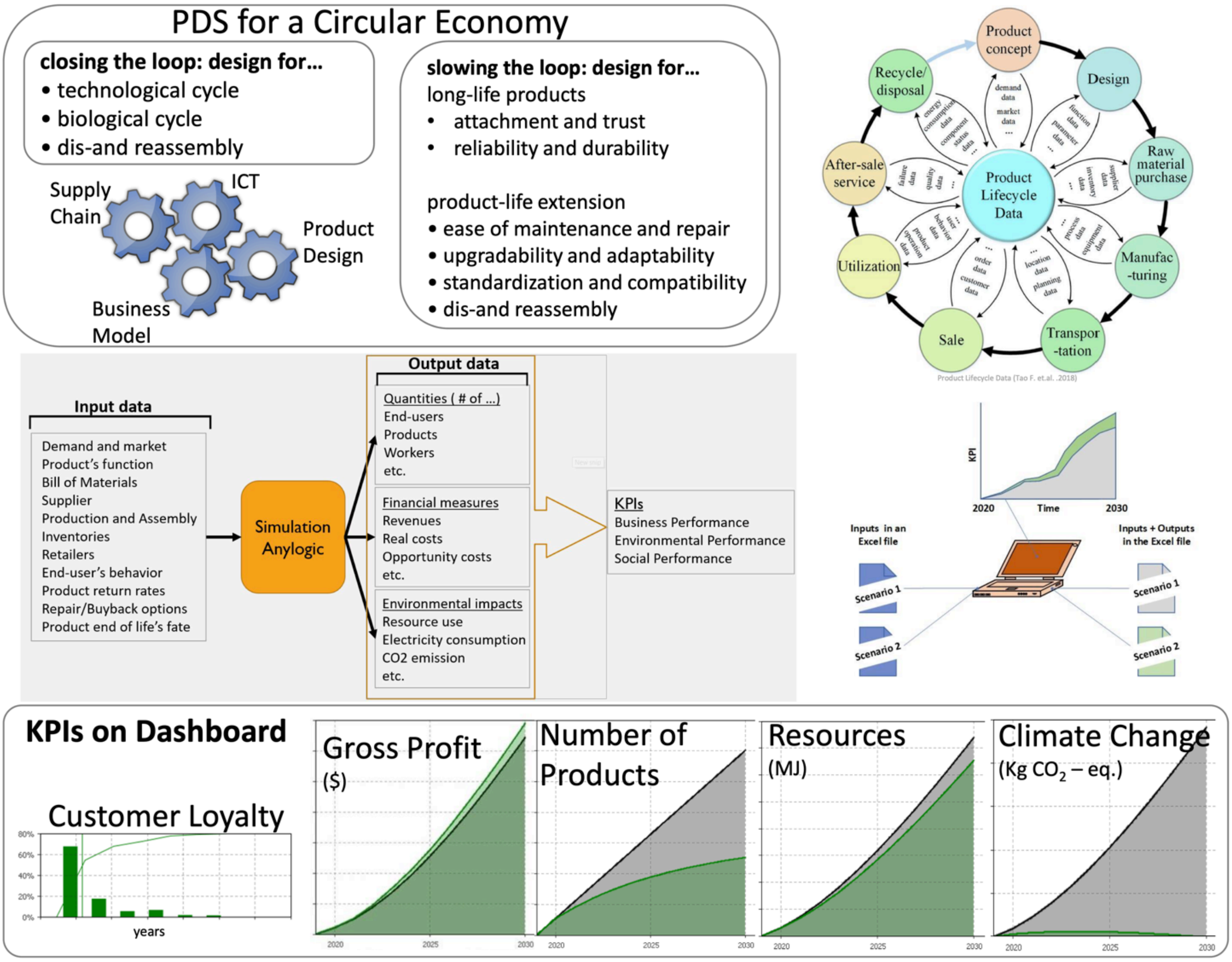

Digital Twin as a Decision-Making Tool to opt for the most promising Product Design Strategies (PDS) in a Circular Economy (CE)

A. Gharaei, D. Kiritsis (ICT4SM @ EPFL)

Research Objectives

- Explore application of DT for PDS
- Facilitate decision-making processes
- Bring a comprehensive look to KPIs

Research Methods

- State-of-the-art on PDS for a CE
- Digital Twin driven modelling in AnyLogic
- Industrial case study on a household good

A digital twin of a business along with the product life cycle (BOL, MOL and EOL phases) can be a solution to find the most promising PDS in the context of the CE. An applied case was done where the digital twin was developed via AnyLogic simulation tool coupled with Excel files containing all required input data for a time horizon of more than a decade. The benefit of such study is to combine all the financial, environmental and even social KPIs to have a balanced comprehensive judgement.

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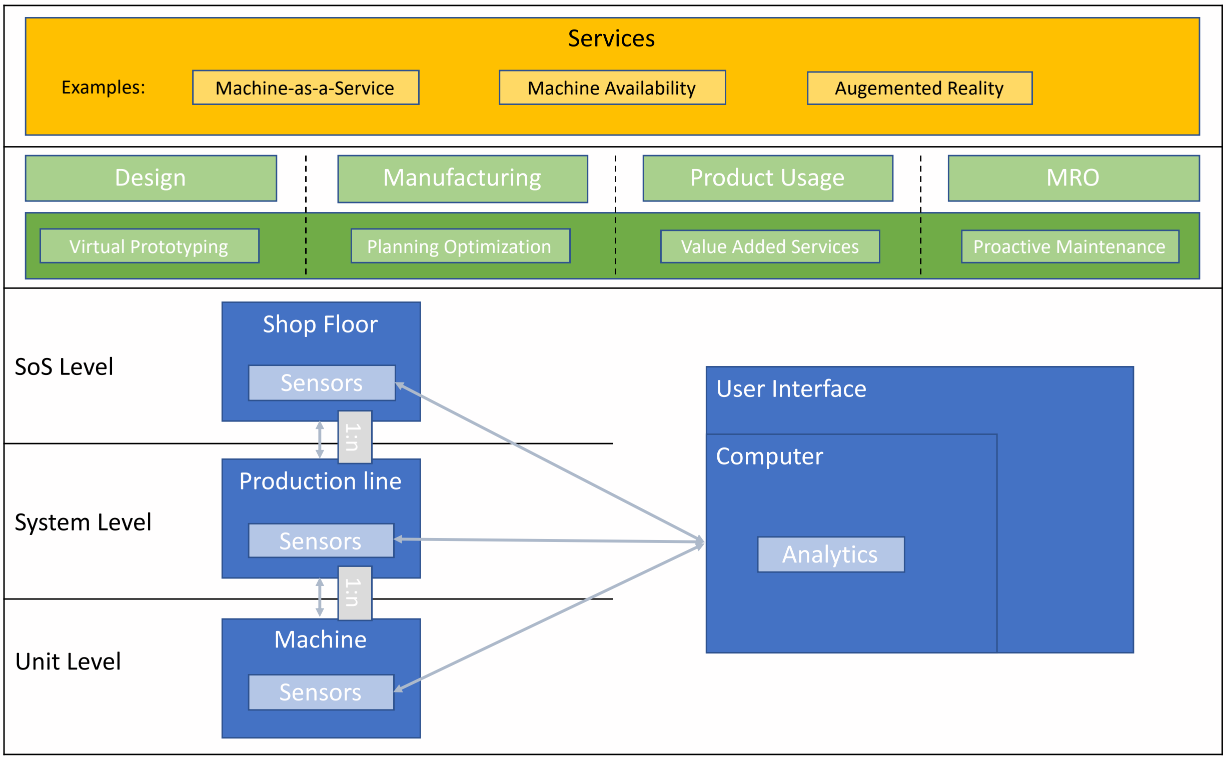

An Architectural Approach for Service Value Creation with the Digital Twin

Dominique Heller, Jürg Meierhofer, Shaun West

Research Objectives

- How to provide smart service value to industrial actors by a digital twin
- How to conceptualize the architecture of the digital twin for this purpose

Research Methods

- Literature Analysis
- Multiple Case Study
- Construction of new concept

This paper discusses the concept of the digital twin for providing data-driven services in industrial environments. There are wide-ranging definitions of the digital twin with the literature confirming that the digital twin is a technology-driven concept while its benefits as an enabler for industrial data-driven services has not yet been thoroughly investigated. The new concept discussed in this paper approaches the digital twin from the perspective of service dominant logic and data-driven service science. We develop an architectural approach to bridge the gap between the technological level and the business level.

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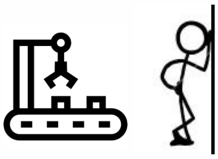
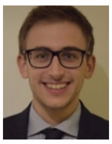
	RPA	Digital Helper
		
Automation level in decision making	Fully automated; the bot takes the final decision.	The user takes the final decision.
Focus	Narrow, case-specific and event-driven.	Wide, process-trained and oriented.
Problem encoding	Explicit knowledge, easily coded, analytical.	Implicit knowledge, ill-structured, hard-coded.
Solution	Rule-based, simple evaluation even for an algorithm.	Data- and patterns-based, complex evaluation to make sense of
Source of data	Limited.	Big data.
Interfacing	None.	Intuitive (such as with NLP for I/O commands), powerful visualisation (3D, AR, VR), mobile, touch, etc.

Chatbots that cognitively helps human: the digital helper as a new way to support the decision making

Authors:



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Our laboratory: IBIS LAB
UNIVERSITÀ DEGLI STUDI FIRENZE
DIEF DIPARTIMENTO DI INGEGNERIA INDUSTRIALE

Part of the community: ASAP Service Management Forum

Research Objective:

- develop a conceptual model to discriminate the introduction of robotic process automation (RPA) *or* a digital helper in a decision making process

Method:

- Case study research

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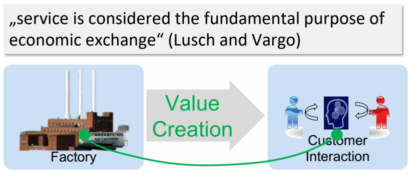

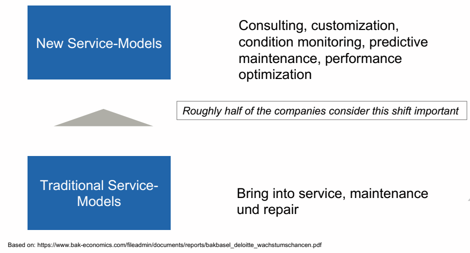

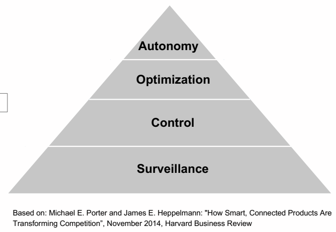

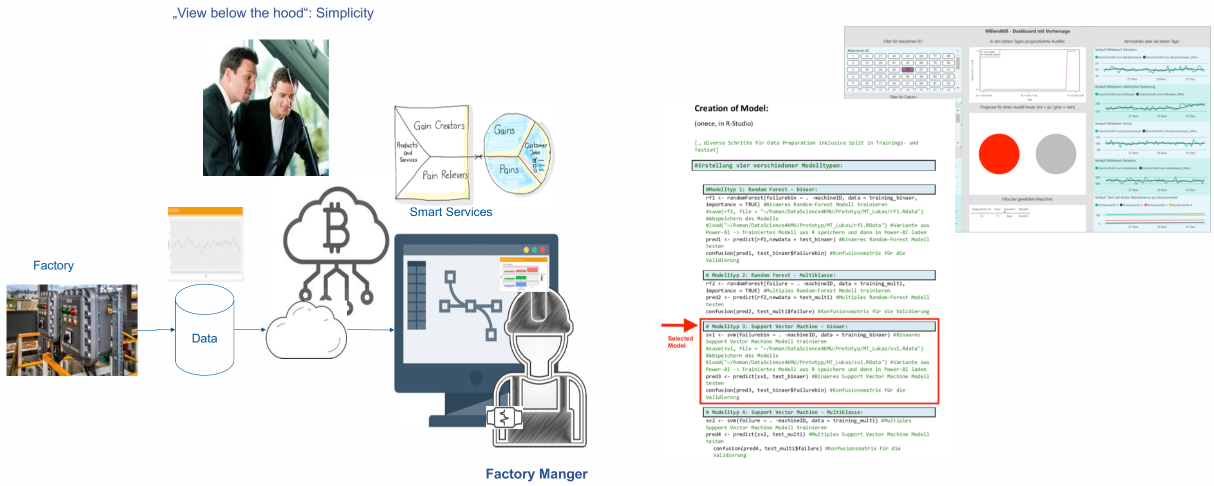

Data-Driven Servitization Approaches for SMEs in Manufacturing

Roman Etschmann, Jürg Meierhofer, Lukas Schweiger
ZHAW Zurich University of Applied Sciences

Research Objectives

- Analysis of needs specific for SMEs in manufacturing
- Development of a concept and prototypes suitable for SMEs

Research Methods

- Literature analysis
- Field research (interviews and survey)
- Rapid prototyping and testing in the field

- For SMEs building services on data has a big potential and it is expected to have higher priority in the future.
- There is a lack of data science knowledge and competences in SMEs
- Therefore, simple approaches with very low entry hurdles are required for SMEs which want to enter this field.
- A first part of the potential benefit at low entry cost and short development time are most suited.

This study was supported by the grant „IBH-Lab KMUdigital“ within the framework of the Interreg V-programme „Alpenrhein-Bodensee-Hochrhein (DE/AT/CH/LI) whose funds are provided by the European Regional Development Fund (ERDF) and the Swiss Confederation. The funders had no role in study design, data collection and analysis, decisions to publish, or preparation of the manuscript.

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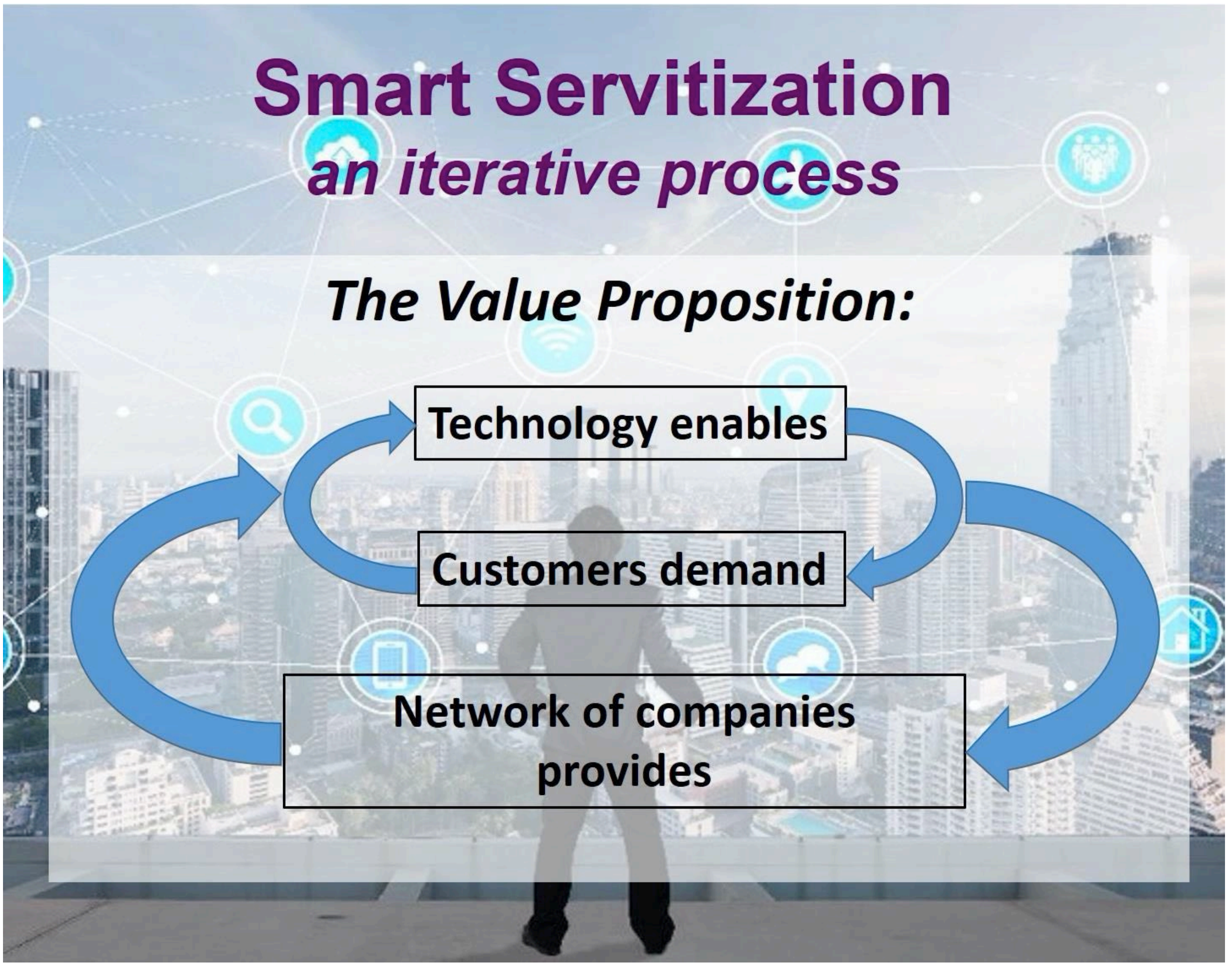


How can IoT enable Smart Servitization in the manufacturing sector?
How to design IoT enabled Services?

Dr. Els van de Kar, Associate Professor at Fontys International Business School, Netherlands

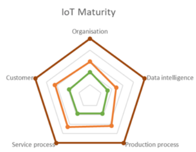
Research Objectives

- Insight on success and failure factors of implementing IoT solutions
- A design approach for smart servitization

Research Methods

- Longitudinal study on servitization at 20 SMEs in the manufacturing sector
- Workshops on specific business cases using service design methods and tools

At the Research Group Business Service Innovation we do empirical research at SMEs in the Province of Limburg in the Netherlands on IoT maturity. We use a framework measuring the companies' IoT readiness by five dimensions: organization, data intelligence, production process, service process and customer.



We also experiment with service design workshops: https://ServiceEngineeringLab.nl

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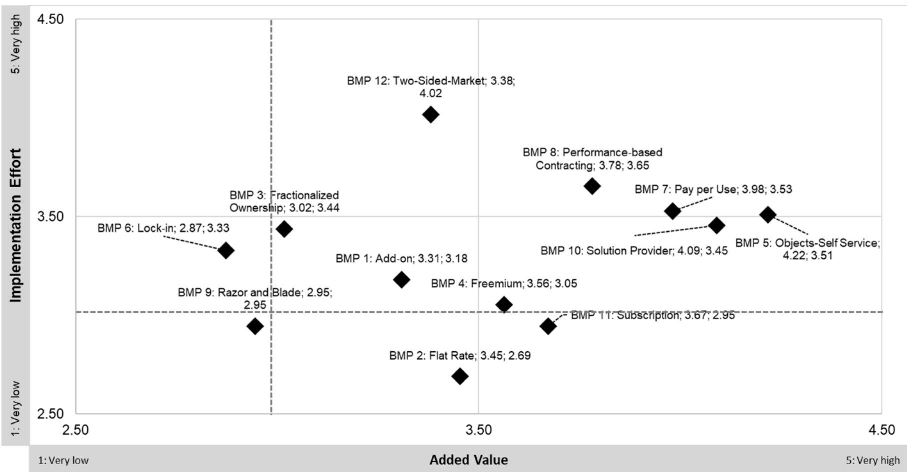

Fig. 1: Added value and implementation effort for selected IoT business models

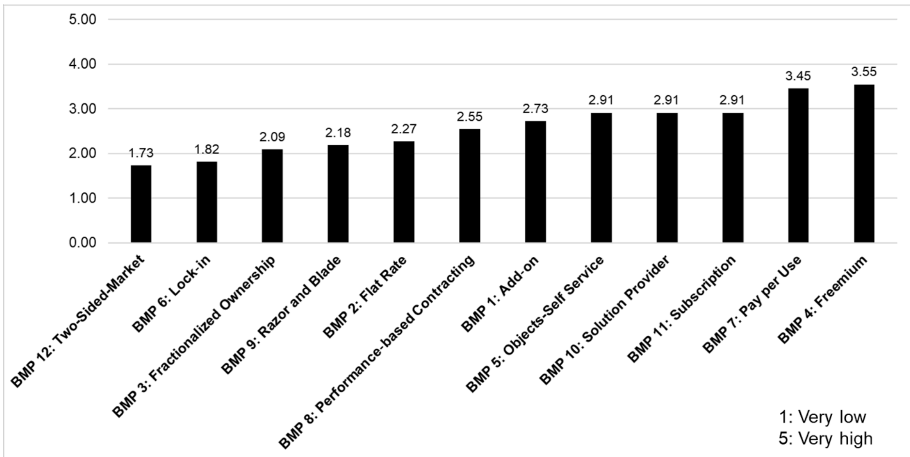

Fig. 2: Ranking of the selected IoT business models according to probability of implementation

Systematic Development of New Digital Business Models for Manufacturing Companies with Focus MEM Industry

Dr. Helen Vogt

Research Objectives

- Which data-based services and business models potentially offer the greatest economic benefit for B2B companies in the MEM industry?

Research Methods

- Systematic literature review
- Expert interviews with experienced managers and industry experts
- Qualitative and quantitative assessment of added value, implementation effort, and probability of implementation

- Top 3 “Added value”: Object Self Service, Solution Provider and Pay per Use
- Top 3 “Probability of implementation”: Freemium, Pay per Use and Subscription
- Next step: Quantitative survey with >300 manufacturing companies
- Long-term goal: Investigation of factors influencing the willingness to share data

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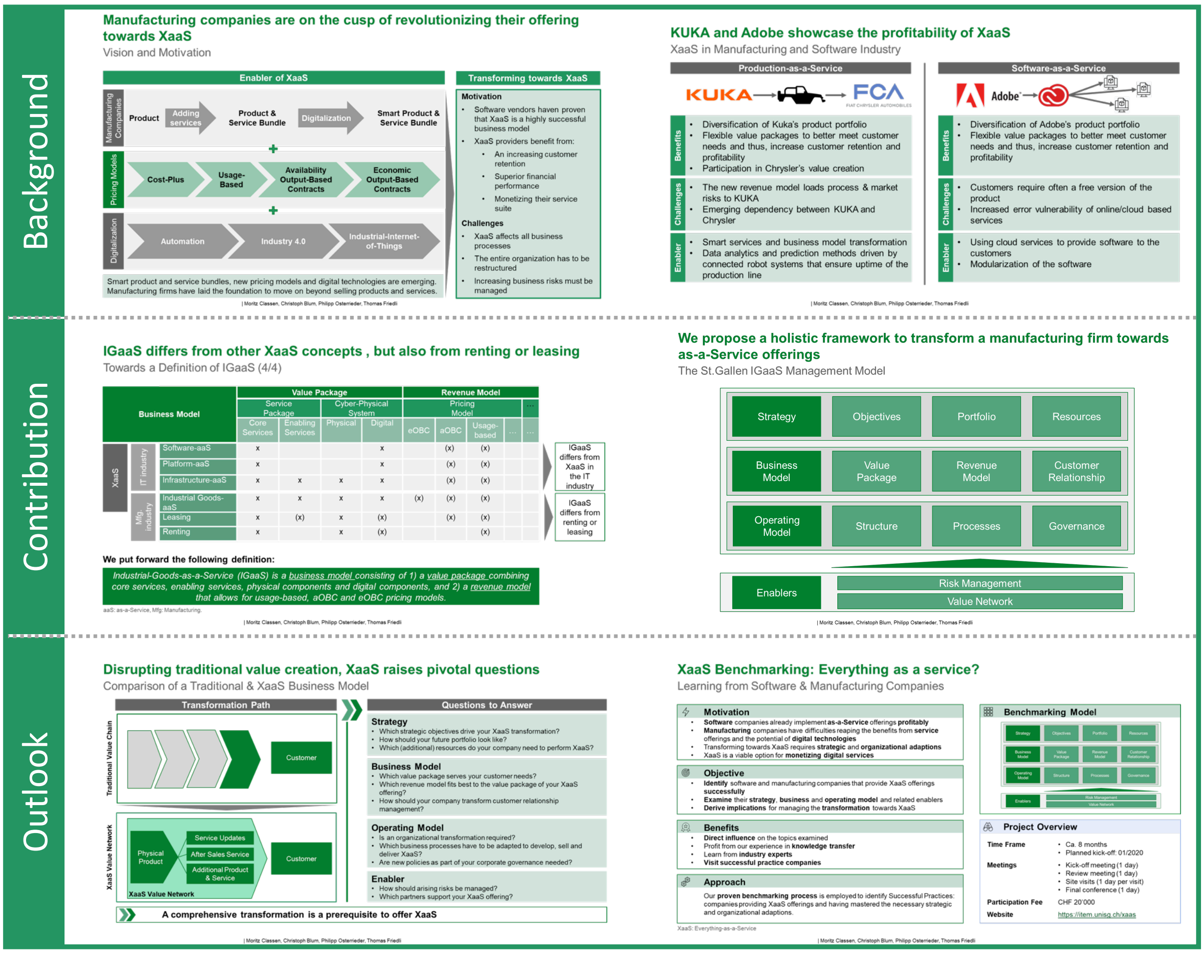

Everything as a service?
Introducing the St.Gallen IGaaS Management Model

M. Classen, C. Blum, P. Osterrieder, T. Friedli - University of St.Gallen

Institute of Technology Management
University of St.Gallen
https://item.unisg.ch/xaas

Research Objectives

- Defining Industrial-Goods-as-a-Service
- Introducing the St.Gallen IGaaS Management Model
- Identifying IGaaS-related challenges

Planned Research Methods

- Literature Review
- Quantitative: Survey
- Qualitative: Interviews, Site Visits

So far, the umbrella term "XaaS" only encompassed software- and IT-related business models. However, these cannot be readily applied by manufacturing companies. Thus, to designate "as-a-Service" business models offered by manufacturing companies in a business-to-business (B2B) environment, we propose the terminology *Industrial Goods-as-a-Service (IGaaS)*. The transformation towards IGaaS is an intricate phenomenon worthwhile of further study. In consequence, we develop a holistic framework to guide managers in their endeavor to introduce and operate IGaaS.

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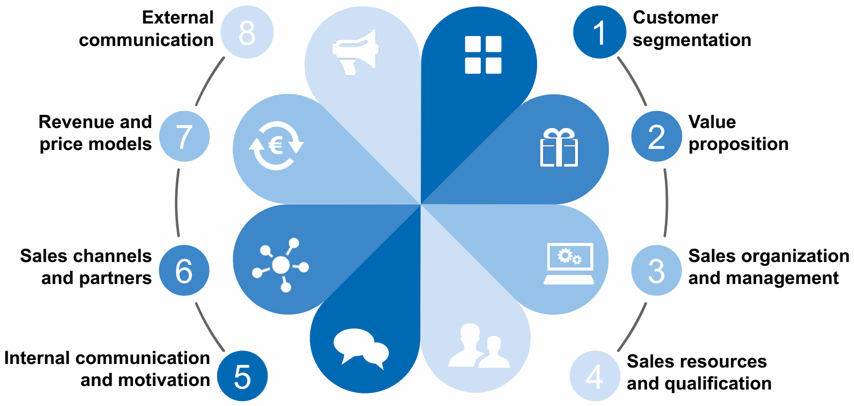
Smart Service Sales framework



Partners

fir an der RWTH Aachen

CENTER SMART SERVICES

- Siemens Healthcare GmbH
- Siemens Logistics GmbH
- TRUMPF Laser GmbH
- GEA Westfalia Separator Group GmbH
- AVL List GmbH
- Fresenius Medical Care Deutschland GmbH
- Drägerwerk AG & Co. KGaA

Different phases of smart service sales

	Piloting	Market entry	Standardization	Scaling
Goal	▪ Validate and **improve** the **product** in cooperation with pilot customers	▪ Transfer from development department to **sales department** ▪ **First commercial success**	▪ **Optimize/standardize** the sales organization ▪ Increase commercial success; effort reduction	▪ **Reduction** of **costs** ▪ High **efficiency**
Data	▪ **No** customer **data** available	▪ **First** customer **data** (sales and technical data) available	▪ **Meaningful** customer **data** (sales and technical data) available	▪ **Structuring** and **analysis** of the data ▪ Derivation of decisions
Sales	▪ By **development team**/ product management of the smart service	▪ By **development team** under addition of **first sales representatives**	▪ By **sales employees/ sales teams**	▪ By **sales employees/ sales teams** or **independent department**
Customers	▪ ca. **0 – 5 customers** of smart service	▪ ca. **5 – 15 customers** of smart services	▪ ca. **15 – 100 customers** of smart services	▪ **More than 100 customers** of smart services

Sales of Smart Services

How industrial companies can successfully sell smart services

Benedikt Moser, Tobias Leiting, Jana Frank, Volker Stich

Research Objectives

- Description of a sales framework
- Design of market launch strategies
- Methods and tools to successfully sell smart services

Research Methods

- Literature research
- Case study research
- Action research

Smart Services offer an innovative opportunity to exploit the economic potential of digitalization through innovative business models. However, the **market launch and sales** of smart services confront many companies with **great challenges**. Together with a **consortium of 7 industrial companies**, this project identified and developed a **conceptual framework** for the sales of smart services, different **market launch strategies** and proven **methods and tools** to establish a successful sales organization.

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Can contract structure and management influence the perceived supplier performance?

Sampling and data collection

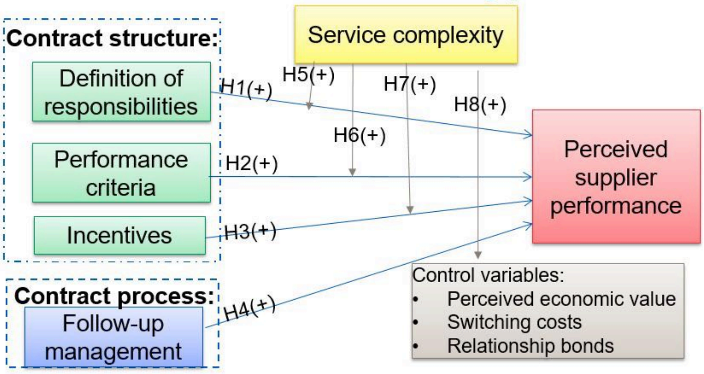
Use LinkedIn private focus groups to build the contact list

Group name	Web link	Member count	
Purchasing & Global Supply Chain Professionals	https://www.linkedin.com/grp/home?gid=50589	74178	A random sample of **1500 names from 46** countries was built
Purchasing & Materials Management	https://www.linkedin.com/grp/home?gid=156598	28323	
Purchasing Practice	https://www.linkedin.com/groups/771367	17086	

Respondents

Data	Effective sample	Usable responses	Response rate
08.2015 - 10.2015 & 08.2016 - 10.2016	1350 (excluded 62+88)	177 (from 25 countries)	13.1%

Research model and hypotheses



Results

OLS regression model

Dependent variable: perceived supplier performance		
Main effects	Coefficient	Results
Definition of responsibilities (H1)	0.12**	Support H1
Performance criteria (H2)	0.25***	Support H2
Incentives (H3)	0.22***	Support H3
Follow-up management (H4)	0.18***	Support H4
Service complexity (SC)	0.06	
Interaction Terms		
DR*SC (H5)	-0.01	Reject H5
PC*SC (H6)	-0.07*	Reverse H6
IN*SC (H7)	0.06**	Support H7
FM*SC (H8)	0.06*	Support H8

Note: *p<0.05, **p<0.01, *** p<0.001

The influences of contract structure, contracting process, and service complexity on supplier performance

Wenting Zou; Saara Brax; Mervi Saarikorpi; Risto Rajala

Research Objectives

- Understand the factors affecting the success of service contracting in B2B
- Investigate the effects of service complexity, contract structure, and contracting process on supplier performance

Research Methods

- Quantitative research approach
- Survey-based research

This quantitative study is based on the survey data from professionals involved in purchasing of services with responsibility for designing contract agreements, managing contracts and controlling supplier performance. The sample consists of 177 purchasing professionals from 25 countries.

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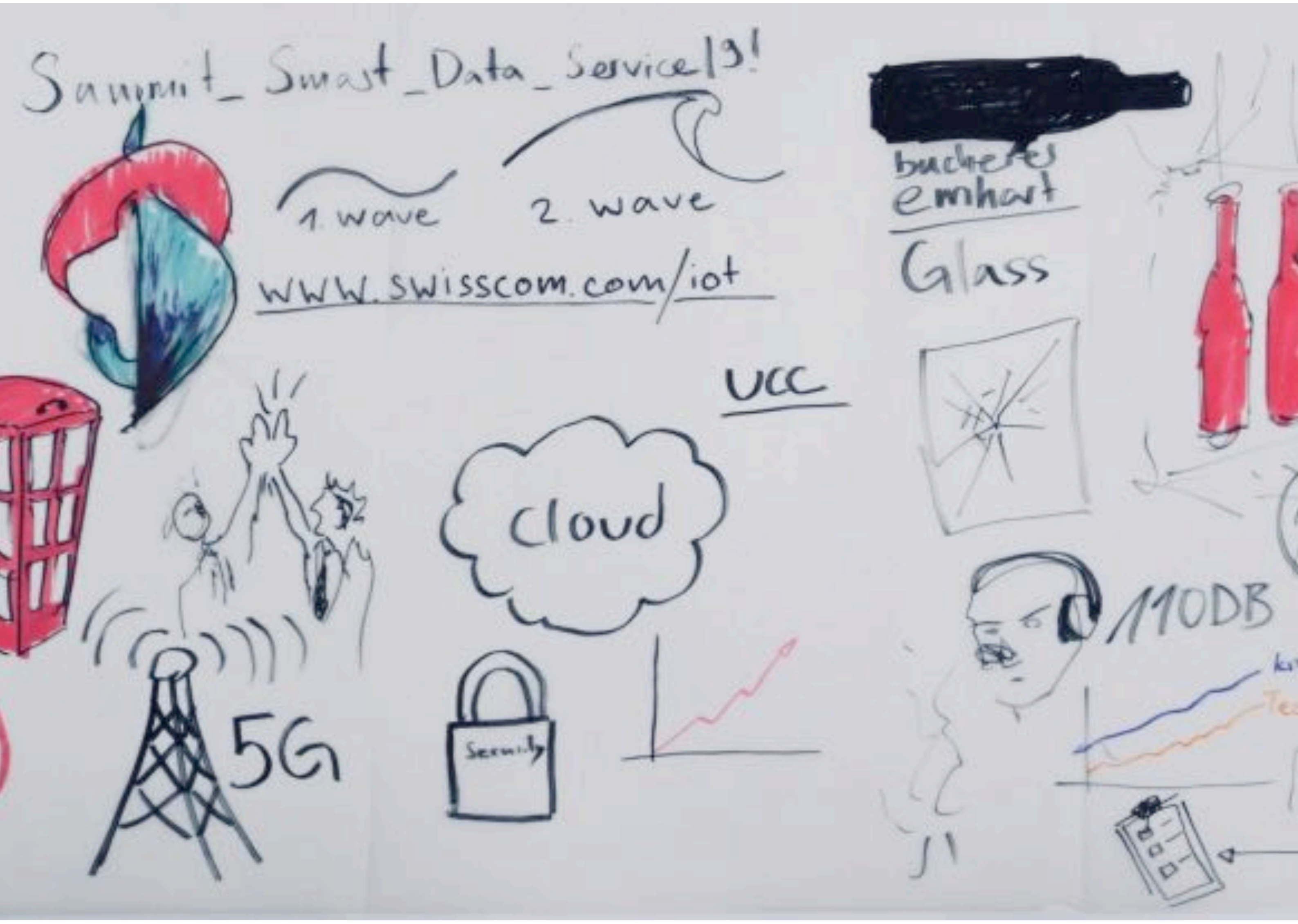

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