Manufacturing the platform economy

An exploratory case study of MindSphere, the industrial digital platform from Siemens

Karolina Emilia Kulawiak

Master's thesis in Screen Cultures
120 ECTS

University of Oslo
Department of Media and Communication
15.06.2021

Manufacturing the platform economy: An exploratory case study of MindSphere, the industrial digital platform from Siemens

Karolina Emilia Kulawiak

http://www.duo.uio.no

Preface

Supervisor: TAINA BUCHER (autumn 2020 -spring 2021)

Abstract

With the development of the Internet of Things (IoT), industrial manufacturers gain a tool enabling them to connect manufacturing devices into smart networks of intelligent items. Industry 4.0 emphasizes intelligent technology, big data, automation, communication and artificial intelligence on the shop floor. Yet digitization is not so much about the technology as it is about societal and infrastructural changes.

The aim of my work is to investigate how the process of platformization can be observed in industrial manufacturing on the example of MindSphere - an industrial IoT platform by Siemens. Tech-giants like IBM or Microsoft, having enough expertise in software production, might overtake the virtual part of the manufacturing and automation processes. Siemens MindSphere represents an industrial IoT software platform that has the aim to create a new digital ecosystem for industrial manufacturing by collecting, analyzing and visualizing all data coming from products, plants, systems and machines. This thesis critically investigates the increasingly influential role of industries outside the tech and social media sector in designing and deploying platform economy mechanisms.

Using van Dijck's multilayered analytical framework, I approach MindSphere as a techno-cultural and socio-economic structure. I analyze the platform's technical components as well as its social and economic context. Platforms as structures are culturally situated and influenced by social, economic, business and other factors. The main findings reveal that this is also relevant in the case of MindSphere, and industrial IoT platforms make up and shape the global ecosystem of digital platforms through the same mechanisms as social media or labor platforms.

Acknowledgements

Working on this master's thesis was a challenge and exploration of new areas, and at the same time a great pleasure and source of satisfaction.

I would like to thank my supervisor, Taina Bucher, for all the advice, constructive comments, useful insights and for being an invaluable guide in the fascinating field of new media, technology and software studies.

I also want to thank my family and friends for their continued support, motivation and encouragement throughout the process. Thank you for taking me outdoors for fresh air, always listening to me whine and cry and cheering me up.

Table of Contents

1. Introduction

Imagine the following: Munich, Augustiner-Hale on a warm October evening. You are sitting in a huge, beautifully decorated tent, sipping a cold beer from a heavy glass mug. Tiny drops of condensed water form on the outside of the mug, slowly beading and dripping down like the sweat on your face. It is hot and noisy inside. Around you waitresses and waiters in traditional Bavarian costumes - *dirndl* dresses and red vests deliver the ordered beer and food to the long wooden tables. Live folk music is playing and people inside the tent are bouncing, swaying, singing and toast. It is Oktoberfest, the great autumn beer festival in Germany.

The locals know well what makes the perfect beer: “It’s got to be cold until the very last gulp,” says one of the revelers. But how to ensure the perfect taste, temperature and the stable pressure of beer during such a large event in such a tight logistical flux? Every year almost 8 million liters flow from 28,000-liter tanks and straight into the throats of 6 million gourmands. German brewers may have centuries-long experience in their profession but they are continuously trying to improve the beer-flow management during Oktoberfest. In a backroom, a quality controller, whose obligatory work tools such as a notebook and a pencil, sometimes also a thermometer, have been replaced by a 15-inch tablet, monitors the condition of every beer station on a touchscreen where a graphic representation of the entire beer system is displayed. New technologies come to brewers’ aid, Siemens’s MindSphere being one of them. Siemens AG, which used to be one of Europe’s largest engineering conglomerates, now pursues the new business strategy aimed at transforming it into a much smaller company that specializes in machine automation. Its MindSphere is an industrial Internet of Things (iIoT) platform that has the ambition to create a new digital ecosystem for industrial manufacturing.

The aim of this work is to investigate how the process of platformization can be observed in industrial manufacturing on the example of MindSphere. To answer this I look at MindSphere as a platform and as an ecosystem. I address secondary research questions: Through which techniques and mechanisms MindSphere creates an ecosystem? What aspects of MindSphere foster the process of platformization?

Industry 4.0 and smart factory

In 2016, the terms Fourth Industrial Revolution or Industry 4.0 began to appear in publications about the future of industrial production, as a way of describing the next stage of the industrial revolution (Schwab, 2016). German chancellor Angela Merkel called for digitalization of manufacturing at the country's 8th IT Summit in Hamburg already in 2014: "Connecting digital technologies with industrial products and logistics – Industry 4.0 – Germany has a chance at taking the lead" (Sarmadi, 2014). In 2016, when Germany took over G20 presidency, it made Industry 4.0 a part of its agenda. (With the country's economy dominated by manufacturing industries including automotive, Germany was hoping to catch up with the United States and China on global competitiveness in the new digital technologies sector.) Industry 4.0 emphasizes intelligent technology, big data, automation, communication and artificial intelligence on the shop floor. With the development of the industrial IoT, manufacturers gain a tool enabling them to connect manufacturing devices into smart networks of intelligent items. This, combined with big data processing capabilities, constitutes a new category of manufacturing – smart factory.

All the physical devices produced by industrial manufacturers, such as controllers, switching devices, turbines, engines are equipped with sensors enabling data collection and analysis. The network of those objects - connected, communicating and exchanging information - forms the Internet of Things. In the case of the manufacturing industry we are talking about the industrial Internet of Things (iIoT). Moreover, data flowing from the physical components is used to form virtual counterparts of each device – a digital twin. Digital twins are particularly important in the context of predictive maintenance or advanced analytics in manufacturing as they are digital representation of real, physical assets and allow to „accurately duplicate and simulate the real-world properties and performance of physical products, production lines and processes" (Siemens, 2017, p.23).

Physical products with embedded sensors share three basic characteristics: physical components (for example mechanical or electronic parts), smart components (microprocessors, sensors, software, controls and digital user interface) and finally connectivity components (antennae, ports, protocols, and networks), enabling data flow between the physical device and the digital twin. Just like real-time devices connecting to each other and performing specific operations, digital twins representing this activity need a virtual environment in which the process takes place. This is the product cloud which runs on remote servers containing the device's external operating system (Heppelmann & Porter, 2015). The great advantage of such a new operating model is that products already in the field generate huge amounts of data, hitherto inaccessible to producers. Before equipment became smart and connected, producers had access to information only about customer needs, demand and costs - all of that generated by a company's internal operations in sales, marketing or finance. Additional data were gathered through external sources such as surveys or research. Now producers have access to data from another, invaluable source - the product itself. Many claim therefore that data has become the most valuable asset for every modern company, the fuel that drives the entire machine of the economy (Andrejevic & Burdon, 2015; Couldry & Mejias, 2019; Zuboff, 2019). Monitoring, remote control and optimization are the key advantages of smart technology transforming the whole supply chain.

Back to our brewers - what does industrial Internet and smart factory mean and bring for modern breweries and many other producers? Digitalization can change the way they will operate in the future. Data collection, tracking and tracing across the entire value chain will for instance give the brewery the possibility to easily connect the batch with the bottle and allow track back where it was sold. Integrating the consumer in this chain will make it possible to receive direct feedback and to inform retailers and end-consumers automatically in case of a quality issue. Moreover, integrating the consumer in this supply chain will allow direct feedback. Modern consumers expect new experiences when drinking beer - we are not talking just about IPA beer but also about low calorie beers or alcohol free beer. Producers need more flexibility as end-consumer’s loyalty is more fluctuating and flexible - they expect more innovative products with an increasing speed. According to a study by International Data Corporation (IDC) from 2020 42% of IoT projects in the German industry are conducted precisely where a high degree of product customization (up to batch size 1) is required. (Becker & Schmaler, 2020). Average producers must introduce new products faster than ever before and in order to do so they have to enhance manufacturing processes with new technologies.

In terms of brand image and market competitiveness also environmental impact is gaining more importance: How much carbon dioxide is generated? How much water is polluted or how much waste is generated by the packaging? These factors play a significant role in the buying decisions of today's generation of end-consumers. The role of marketing departments is to monitor the market and consumer needs, coming up with new ideas on how to increase sales and pushing new initiatives in a product pipeline. It is about combining craft manufacturing and mass production. From a production standpoint, it often means frequent change in recipe, reformulation of raw materials and the quality parameters which need to be checked while producing. An integrated laboratory system connected to the production is key to ensure proper quality in different production sites. Particularly when producing the same product in different locations. The packaging design and the label can also make a substantial difference when attracting new customers. New materials or a new bottle can be easily evaluated by just changing this parameter in a simulation. Design and simulation of new products allows for optimizing marketing demands to fit with the realities of cost and environmental footprint. The process becomes faster and easier if all necessary data is stored in a central digital platform.

Along with production flexibility, secure and transparent supply chains are gaining importance. To ensure the highest quality and reliable production, the logistics and retail have to be completely transparent. Digital technologies such as artificial intelligence can be used to optimize product quality or to predict anomalies. Many new product variants mean an increasing complexity in the production and in the connected logistics and distribution channels. Simulating the whole material flow and logistics processes allows identifying the bottlenecks and overcapacities. Testing the whole production plant in the virtual world makes it possible to determine falls and errors. It also creates the opportunity to optimize the plant equipment and increase the output. The change to smaller batches and additional products is heavily affecting the filling and packaging lines of a brewery. If a new production line is constructed, the need for flexibility is already considered in the design. However, there are also older producing machines or already existing plants, so called “brownfields” that are not integrated in the software systems. If a producer wants to run different products on such a line, it requires a clear concept of how to integrate the different machines to one optimized line. Otherwise the production capacity and efficiency will decrease. The wider variety of items produced, the more it increases the complexity also in the warehouse. On the one hand, consumer demands are flexible which affects the shop floor, for instance retailers are often asking for shorter delivery times. On the other hand, shelf-time means cost. Connectivity brings more flexibility and reliability. Digital twining leverages all aspects of the supply chain helping local operations optimize decision making instead of investing in warehouses. Simulation can reveal free capacities and optimize the production and the storage processes. Specific demands like pack-to-order can be realized with the use of automated guided vehicles. Logistics will forward and consumers will receive exactly what they need whenever they need.

Put simply, the entire plant is producing data. As the pace of change has never been this fast, for the producer it is key to continuously monitor this data, gain quick insights and react immediately. However, connecting devices are not enough to gain momentum in the manufacturing industry. Smart, connected equipment, increasing volume of data and emerging forms of data analysis require a whole new supporting technological infrastructure (Heppelmann & Porter, 2015). Moreover, tech-giants like IBM or Microsoft, having enough expertise in software production, might overtake the virtual part of the manufacturing and automation processes. This tangible threat is perfectly illustrated by the words of Gerhard Fohringer, Head of Strategy Development at Siemens:

> I will always remember the time when our management guys watched CNN in their hotel on a business trip and they saw the Smarter Planet advertising: they saw a train, a power plant, a manufacturing plant, and they expected to see 'Siemens', but instead it said 'Smarter Planet by IBM'. That was a trigger! (Collins & Junker, 2018, p.5)

A recurring problem and a challenge for most industrial manufacturers, is also the interoperability: the fact that data flowing from different physical products have different standards, protocols and data formats. Temperatures, locations, sensor readings or even sales and warranty history are all stored in various forms and unstructured. Also Siemens is open about this problem:

> Digital twins of the product/production can be used to improve the virtual model as well as the product's predictive and diagnostics purposes. The issue is that there is no consistent way to connect virtual models from different applications to the physical assets in an IoT system. It is a complicated process to run these models with IoT data and use the simulated result for further analysis" (Siemens, 2020g, p.1)

Therefore one of the challenges for Industry 4.0 is to develop a distinctive method of unifying those assets. Major companies in the industrial sector have made such attempts. Two of the earliest examples are the American company GE and European Siemens with their respective platforms Predix and MindSphere. GE's CEO Jeff Immelt was among the first who claimed that every industrial company would have to become a software company (Heppelmann & Porter, 2015). Both Predix and MindSphere represent industrial IoT software platforms that have the aim to collect, analyze and visualize all data coming from products, plants, systems and machines. Incidentally, still not all existing industrial devices are equipped with sensors and have their virtual counterparts, which causes many complications and difficulties when it comes to the transition from a traditional business model into a software company.

From *creative destruction* to digital disruption

Due to its disruptive power, digital transformation, perpetuated by a number of developments such as machine learning, data mining, Internet of Things, advanced robotics, networked sensors etc., has contributed to a paradigm shift in the global economy. Yet, digital transformations do not emerge out of thin air but are a result of complex technological and economic processes. The theory of techno-economic paradigm shifts (TEPS), developed by the Austrian economist Joseph Schumpeter and his followers, in particular Carlota Perez, highlights the dynamic nature of the capitalist system through which economic growth is enabled (Kostakis & Bauwens, 2014).

By studying connections between technological development and economic growth, Perez created a model of successive technological revolutions which in effect lead to, what she calls, great surges of development. The process of diffusion of these massive changes - technological revolutions - and of their economic and social effects constitutes „great surges of development" (Perez, 2009, p.190). Perez lists five such revolutions in the last three centuries, each of them lasting approximately 50 years: the first industrial revolution based on machines, factories and canal transportation, the second based on coal, iron, steam and railways, the third in the age of steel and heavy engineering, the fourth with foundations in oil, petrochemicals, automobile and mass production. Perez argues that we are living in the time of the fifth great surge, characterized by information and communication technology (ICT) domination, initiated in 1971 by the American company Intel introducing the first commercially available microprocessor (2009). At the current stage of technological development, computers, smartphones, drones, cameras, self-driving cars etc., all equipped with environmental sensors, have the ability to collect, store, and share vast amounts of data that flow to the institutions that operate and own them. "It is the techno-economic paradigm (TEP), being articulated through the use of the new technologies as they diffuse, that multiplies their impact across the economy and eventually also modifies the way socio-institutional structures are organised" (Perez, 2009, p.194).

According to Schumpeter, capitalism is in the process of a constant "creative destruction", where opposing dynamic and static forces counteract, destroying old and creating new economic structures (Schumpeter, 1994). In the Schumpeterian framework of creative destruction innovations in products or processes create new markets that over time surpass and destroy old and less profitable businesses. These new markets evolve, offer better return on investment, better job opportunities. On the other hand, other and less innovative companies are ruined, workplaces lost and even entire industries are disappearing.

New technologies are changing existing social and economic structures. The technological progress started by the ICT companies and expanding into other sectors is referred to as a digital disruption. Digital disruption was first observed in consumer services and media industry, where online digital platforms were able to create wholly new infrastructures and revolutionize traditional markets. However, there are many examples showing that platform businesses outcompete bricks and mortar companies as well. The most vivid ones illustrate start-ups such as Uber or Airbnb rising to global dominance transforming their respective economy sectors (transportation and hospitality). In this new ecosystem, many incumbent firms are facing uncertainties and challenges.

Rationale of the research and contribution

Digitalization is not so much about the technology as it is about societal and infrastructural changes. As van Dijck et al. aptly observe,

> the values at stake in this struggle are not just economic and social but inevitably political and ideological, which is why we also need to look at the role online platforms play in organizing societies in a globalizing world order. (van Dijck et al., 2018, p.8)

In order to understand digitalization, one needs to investigate, analyze and demonstrate how online platforms affect change through hidden mechanisms of their operation. José van Dijck et al. in *The platform society* (2018) illustrate the platform revolution in the perspective of four different sectors of society: news, urban transport, healthcare and education. In my thesis, I am focusing on another, but equally important sector: industrial manufacturing.

Industrial production remains a significant part of the global economy, often being a backbone of many national markets. As Srnicek observes, “manufacturing in the deindustrialized United States employs four times as many people [as the technology sector]. In the United Kingdom manufacturing employs nearly three times as many people as the tech sector” (Srnicek, 2017, p.10). This sector is in a transitive moment and manufacturing giants, being aware of the digital shift, have taken steps to re-invent their businesses from machine-making into business platforms that would allow them maintain their market position. Although much more is said about digital platforms in the context of consumer services or social media, the process of platformization in industrial manufacturing, in the domain of industrial IoT, remains an under researched topic. The most discussed examples of digital platforms come from social media and the business-to-consumer market where services or products are offered directly to consumers. However, many organizations operating on the business-to-business market – with other organizations or companies as their end-customers – invest in creating proprietary platform solutions as well. Yet digital platforms operating in the industrial manufacturing sector are studied mainly by scholars from disciplines such as computer and information sciences, economics and business or industrial management studies (see Cusumano & Gawer, 2015; Parker et al., 2016). There is no scientific work exploring industrial digital platforms with regard to media and communication studies. This thesis, based on the assumption that the mechanism of platformization can be observed in the manufacturing industry, aims at addressing this gap in research. I argue that it is important to examine industrial platforms as logistical media objects since they also make up and shape the global ecosystem of digital platforms through the same mechanisms as social media or labor platforms. Furthermore, exploring the digitalization of manufacturing situates these changes within the broader social context of shift towards platform capitalism.

Scholars from the field of economics, management or business studies distinguished mainly positive effects of platforms, such as stimulating innovation, competitiveness and increase in productivity (Botsman & Rogers, 2010; Eyal & Hoover, 2014; Sundararajan, 2016; Choudary et al. 2016). The promoters of these changes believe that platforms create greater social good. Yet business-to-business platforms, like business-to-consumer platforms, do not operate in a vacuum and also have a negative impact on the global community. While the digital media industry and the new sharing economy have transformed working conditions, especially within the cultural industries, influencing compensation and organization of work, creating jobs and allowing for greater flexibility (see Duffy & Hund, 2015), there are more and more voices saying that platforms trigger negative social changes, especially in the context of the labor market, unstable professional situation (Rosenblat, 2018; Neff, 2012; Gandini, 2015). I believe that the analysis of the phenomenon of platformization in the context of industrial production contributes significantly to this wider scholarly discussion. My focus here is on the platform economy and specifically how business-to-business platforms enact the mechanisms of platformization on the example of Siemens' MindSphere.

Research question

The starting premise for this thesis is the observation that business-to-business platforms have hitherto functioned as product environments while now they are starting to transform into complex platform environments on the example of Facebook, Google or Apple Apps (Gawer, 2014). New platforms are built according to well-thought-out long-term business strategies, but their models are based on social media and consumer platforms. As mentioned, digital twining, smart factories and cloud computing are increasingly used to improve supply chain. Online platforms allow for the effective integration of these digital technologies and slowly overcoming the problem of interoperability. Gawer classifies three increasingly broader organizational settings of online platforms: within firms, across supply-chains, and within ecosystems (Gawer, 2014). Moreover, platformization gradually leads to a change of business models from product orientation to service orientation (Heppelmann & Porter, 2015). This suggests that platformization or platform economy enters the next stage of development, taking over not only the level of consumer services, but also the area of professional business-to-business services.

These reflections bring me to my research question: How can the process of platformization be observed in industrial manufacturing on the example of MindSphere? In MindSphere I can distinguish similar logics and processes taking place as those applied by high-tech companies or social media platforms. World's industrial giants following in the footsteps of high-tech companies develop industrial platforms that exploit the same mechanisms as popular customer platforms: datafication, platform governance and building multi-sided markets. To investigate platformization I address secondary research questions: Through which techniques and mechanisms MindSphere creates an ecosystem? What aspects of MindSphere foster the process of platformization?

My analysis is theoretically informed by van Dijck et al. on the platformization (2019) and political economy, as well as a dialogue with Rossiter's logistical media theory (2016), allowing to study a business-to-business platform as a media object. For my investigation I use van Dijck's framework of online platforms as techno-cultural and socio-economic structures. According to van Dijck's concept, platforms comprise several layers: technology, content, usage, business model, governance and ownership (van Dijck, 2013). My analysis is based on this model - I disassemble MindSphere into each of these microsystems. Finally, I also look at how MindSphere creates its iIoT ecosystem. As van Dijck points out, „first dissecting specific platforms and then recombining their constitutive elements to detect larger patterns in the ecosystem is also crucial because it fosters broader questions concerning the shaping of sociality and society.” (2013, p.42). I propose the hypothesis that through the creation of a platform ecosystem, industrial IoT platforms nurture and facilitate platform economy.

My research questions will be addressed by employing the walkthrough method - a critical analysis of MindSphere. This approach is particularly suited to explore both technical, cultural, as well as socio-economic aspects of platforms. According to van Dijck et al., “platform is fueled by data, automated and organized through algorithms and interfaces, formalized through ownership relations driven by business models, and governed through user agreements" (2018, p.9). I engage directly with the platform's interface and technology by setting up a MindSphere user account and performing a walkthrough - an investigation into the platform's affordances. This critical approach allows also for the exploration of the economic and political intentions of the platform owner. As emphasized by Light et al.,

> the walkthrough method we propose is used, not to test whether users respond to an interface in the ways its designers intended, but rather to illuminate the traces of those intensions, and thereby to critically examine the workings of an app as a sociotechnical artefact. (Light et al., 2018, p. 886)

In addition to the walkthrough I also examine the platform’s „environment of expected use”: Data sources such as company websites, marketing materials, press releases, public statements from Siemens’ representatives, legal documents, presentations, product sheets etc. (Light et al., 2018). The analysis of these materials is essential for the examination of the platform's business model, governance and vision.

This research is limited to a single case study as a typical example of an industrial business-to-business platform that represents trends in the industrial environment. There are three reasons for choosing MindSphere: the platform represents an information-rich case as being developed since 2015, the presence of Siemens in many industries and its brand recognition allowed for the platform's ecosystem to grow across various industrial sectors, Siemens openly communicates its strategy for an open iIoT system.

Structure

The thesis consists of eight chapters. In chapter one I introduce the concept of Industry 4.0 and digital disruption, providing a context for situating the analysis. I also give information about the purpose, research questions and research design. The second chapter is informed by platform studies and discusses different theoretical approaches towards platforms in order to set up a theoretical framework. Third chapter builds on the previous one and introduces concepts of political economy and platformization useful in critical investigation on MindSphere. In the fourth chapter, I elaborate on the research methodology, project execution and its limitations. Chapter six and seven are dedicated to the close analysis of MindSphere where in the first one I look at the platform as a techno-cultural construct and in the second one I look at the platform as a socioeconomic structure and its ecosystem. Chapter eight covers the conclusion of the research.

2. Literature review and theoretical framework

In this chapter I discuss the conceptual groundwork that guides my analytical approach. I introduce the fields that are of particular relevance for this thesis: literature pertaining to digital platforms (presenting the most representative framings of digital platforms in scientific research) and platformization. I also present the logistical media theory to situate my research in the field of media studies. Finally, I refer to the actor-network theory as a useful theoretical tool offering a good understanding of mutual shaping of society and technology. Other theoretical work on changes within the manufacturing industry that were triggered by the phenomenon of rapid platformization, theories on platform economy and platforms as ecosystems will be applied in relation to Siemens' MindSphere and introduced in the following analysis chapters.

Platform - a myriad of ideas

The Internet, rapid growth of computer power, algorithmic tools, abstraction and virtualization of computing processes, globalization and tightening market competition have brought about transformation of the economy, causing changes in multiple areas from consumption and leisure to services and manufacturing (Kenney & Zysman, 2016). Digital platforms lie in the center of that rapidly reorganizing realm. But what exactly are platforms? What elements decide whether we call some kind of software a platform? The literature on digital platforms spans across a number of academic fields, extending from economics and business studies through information technology to media and communication studies. Below I discuss the approaches I consider to be most representative for this study.

As Tarleton Gillespie observes, shortly after the purchase of YouTube by Google in late 2006, in most company press releases and marketing materials, terms such as *website*, *company*, *service* and *forum* were replaced by one new word: a *platform* (Gillespie, 2010). What was the rationale behind this change and why is this important? The term contains several meanings and, as Gillespie further explains, through its *semantic richness* can be used in numerous different contexts. Digital companies adopted the word in order to underline such aspects of its meaning as equality, sturdiness and openness. They aspired to be associated with a solid structure, open and equal to everyone. Consistent with the linguistic determinism theory, through this deliberate and careful word selection in their corporate communication (which later infiltrated the public discourse as well) tech giants "claim to empower the individual to speak – lifting us all up, evenly" (Gillespie, 2010, p.352). In other words, as the internet industry was just developing, those new technological companies strived to gain trust of the public and build a loyal user base in order to secure a stable and dominant position in the infant industry. Deliberate communication and public relations strategy played an important role in the process. Rhetoric of technological advancement, openness, innovation, better future for the labor market (in opposition to the old system and its structures not able to cope with the effects of the Great Recession) served to discursively frame the operations of new businesses. As Benjamin aptly observes "these tech advances are sold as morally superior because they purport to rise above human bias" (Benjamin, 2019, "Everyday Coding", par.17). In a similar vein, Rosenblat argues that "companies like Uber and Airbnb separate themselves from their predecessors, taxis and hotels, by emphasizing the altruistic premise of their "sharing platforms" (Rosenblat, 2018, "The Myth of Technological Exceptionalism", par.1). Numerous authors have questioned the term "sharing" in the context of this new economic model. "Sharing" is adopted by platforms to emphasize the altruistic and communitarian nature of their activity as it usually suggests a narrow group of people who know each other personally and maintain direct relationships. However, it was, and still is, only rhetoric. By transforming products into services, and services that were not tradable into tradable ones, platforms only accelerated the reorganization of the global economy (Vallas & Schor, 2020). According to Cusumano and Gawer, digital platforms

> as they grow in adoption, they become harder to dislodge by rivals or new entrants, with the growing number of complements acting like a barrier to entry. The rise of industry platforms may also raise complex social welfare questions regarding trade-offs between the social benefits of platform-compatible innovation versus the potentially negative effects of preventing competition on overall systems. (Cusumano & Gawer, 2015, p.39)

Numerous scholars have defined platforms in a variety of ways (Andreessen, 2007a; Parker et al., 2016; Cusumano & Gawer, 2014; van Dijck, 2013). I find particularly informative and intelligible the definition by Gawer:

> Platforms are evolving organizations or meta-organizations that: (1) federate and coordinate constitutive agents who can innovate and compete; (2) create value by generating and harnessing economies of scope in supply or/and in demand side of the markets; and (3) entail a modular technological architecture composed of a core and a periphery. (Gawer, 2014, p.1240)

All the above can be said to describe Siemens' MindSphere, the object of this research. MindSphere is an open digital platform that enables its users to create their own solutions - apps - that are distributed through the platform's app store. By connecting app creators with industrial companies interested in innovative solutions, the platform provider builds a two-sided market where the platform orchestrates economic relations between them.

There is a wide choice of platform typologies available in the literature. Drawing on van Dijck's et al. work (2018), the most influential category is constituted by infrastructural platforms owned and handled by the Big Five platform companies (Alphabet Inc., Apple Inc., Amazon.com Inc., Facebook Inc. and Microsoft Corporation), that form the core of the whole online ecosystem. The second category of platforms described by van Dijck et al. is shaped by sectoral platforms, operating in a specific sector or industry, for example Tinder, TripAdvisor or UpWork. The characteristic feature of these companies is the maximization of the competitive advantages. Those platforms do not own any material assets, offer no goods or services, do not hire sector-specific employees. They are merely intermediaries between service suppliers and recipients. It is this category that causes the most controversy and raises questions concerning labor market transformation, public values and precarious work (van Dijck et al., 2018).

Narrowing down this taxonomy, scholars Alex Rosenblat, Julia Ticona and Alexandra Mateescu introduce two categories of labor platforms: on-demand platforms (such as ride hailing apps) and marketplace platforms (Ticona et al., 2018). On-demand platforms through an algorithmic model facilitate direct and real time user management in order to connect service suppliers and providers. Marketplace platforms enable and facilitate the process of selecting a contractor through making visible large groups of potential workers that can be sorted and ranked according to selected criteria.

A slightly different approach is presented by Vallas and Schor who distinguish five types of platform work, based on different types of labor platforms: architects and technologists, microtasking, creative projects (coding, designing, analysis), high skill gig work (tradespersons, performing artists, caregivers) and low skill gig workers (taxi, courier, cleaning services) (Vallas & Schor, 2020).

From the point of view of the business-to-business sector, it is worth paying attention to Gawer and Cusumano division into product and industry platforms. They define industry platforms as "technologies developed by one or more firms, and which serve as foundations upon which a larger number of firms, organized in an ecosystem, can build further complementary innovations and potentially generate network effects" (Gawer & Cusumano, 2014, p. 420). Product platforms are on the other hand structures developed by companies, independently or in cooperation with suppliers, that form a family of related products or sets of components. Both types of platforms, as the above mentioned scholars suggest, can be considered as business platforms and are expected to become an increasingly significant form of industrial business model (Gawer & Cusumano, 2015). Industry platforms, unlike product platforms, emerge only as a result of deliberate managerial decisions and actions. The strategic aim is in this case to draw together many actors within the industry - users and complementors - which is to secure network effects and a stable growth. Some prime examples of this type of platforms are Apple iPhone, iPad or iPod with iOS operating system, Microsoft Windows, Intel microprocessor designs, Google's Internet search engine, Android operating system, social networking sites such as Facebook, LinkedIn, and Twitter, video game console and the Internet itself (Gawer & Cusumano, 2015). Taking into account the characteristic elements that constitute these objects, MindSphere also represents a business-to-business (offering its product or services to other companies, not individual consumers) industry platform.

A large part of the debate on the development of industry platforms pertains to the questions whether digital platforms in the business-to-business (B2B) field will be adopted along the same patterns as those in the business-to-consumer (B2C) or consumer-to-consumer sectors. The latter are already changing the nature of labor and the structure of the economy. From the adoption of consumer platforms one can infer that industry business-to-business platforms will dominate the industry as well. Companies may be initially averse to joining B2B platforms, however thoughtful business strategies allow the platform owners to solve the chicken-or-egg dilemma, something I will analyze in later chapters.

Different perspectives on platform studies

Spanning over a number of scientific disciplines, my work largely draws from the research in the field of platform studies. The concept first appeared in Bogost and Montfort study *Racing the Beam: The Atari Video Computer System,* followed by a book series titled "platform studies" where the authors discussed different computational platforms. The scholars aimed to address the gap in the digital media research which saw digital platforms merely as tools for online creativity and community building, leaving out the computational and technical aspects of their presence. Bogost and Montfort called for connection between culture, creativity and technical specifics (2009). Following from it, this perspective was adopted by numerous scholars who analyzed social media as complex objects consisting of users, technologies and practices. The establishing of platform studies as a scientific discipline was brought about, among others, by the work in which authors studied the "technocultural logics" of platforms (Gerlitz & Helmond, 2013; Rosenblat & Stark, 2016), examined the role of the platform architecture in shaping networked sociality (van Dijck, 2013) and the politics of APIs (Bucher, 2013), or explored platforms' affordances with regard to their political and economic interests (Elmer & Langlois, 2013; Plantin & de Seta, 2019).

	Social media as networking sites	**Platforms as multi-sided markets**	**Platforms as technological infrastructures**	**Platforms as ecosystems**
Focus	User networks	Exchange mechanisms	Component links and architectures	Input, activity and output links
Key concepts	Network formation, user-generated content	Network effects markets and platforms	Modularity, core and periphery relations	Ecosystem structure and complementarities

Table 1. Different approaches to social media and digital platforms. Reprinted from "Platforms as service ecosystems: Lessons from social media" by C. Alaimo, J. Kallinikos, E. Valderrama 2020, *Journal of Information Technology 35(1)*, p.29. Copyright 2020 by Sage Publications Inc.

While platform studies as a research field is continuously growing, approaches to platforms can be organized around several different perspectives. The first approach understands platforms as sites for online social networking (Alaimo et al., 2020). Researchers focus on the social, personal and political conditions shaping online connectivity. Interestingly, stressing the centrality of users, the research investigates the social media themselves, but uses them often to study phenomena related to other scientific disciplines, such as privacy, interpersonal relations, communication strategies etc. (Bucher, 2013). This approach fails to consider the political, technological and economic forces that model the regimes of users' behavior and user networks. As van Dijck observes, "besides generating content, peer production yields a valuable by-product that users often do not intentionally deliver: behavioral and profiling data" (van Dijck, 2013, p. 16). Nevertheless, this aspect is not taken into account by this sphere of study, interested rather in exploring how and why users create, share and transform online content and how online conviviality affects offline lives.

With time and the advancement of technology, some social platforms have turned into powerful business actors. The second strand of platform studies stems from economics and business studies and foregrounds monetary and organizational aspects of platformization. One of the central and pioneering works in this scholarship understands platforms as "multi-sided markets" (Rochet & Tirole, 2003). Platforms are considered as marketplaces, digital intermediaries facilitating exchanges between different user groups, usually producers and consumers. The more users and different types of platform users enter the network, the higher the number of interactions and the greater the benefits and value created for each of them. This phenomenon is referred to as the "network effects". Parker et al. illustrate it with the classic example of Uber: more drivers offering rides makes riders more willing to start using the platform as the wait time falls. More riders, on the other hand, means no downtime for drivers. The value of Uber for each of its user groups grows the more people use it (Parker et al., 2016, p.18). In contrast to the earlier research on platforms as networking sites, this approach tends to overlook the active role of users in creating content and data and sustaining the operations of platforms. More than critical media perspectives, this body of work was referenced and its insights were put in practice in business management and strategy courses (Poell et al., 2019, p.2).

The third strand of the platform research conceptualizes platforms as complex and dynamic - or to put it in the words of Zittrain "contingently generative" - technological infrastructures embedded in an ever-changing environment (Zittrain, 2008, p.129). Unlike above-mentioned approaches, this perspective acknowledges the fact that platforms operate through a number of technologies and technological operations formed into a system of architectures and technical links (Alaimo et al., 2020, pp.27-28). This outlook builds on and makes a contribution to the growing field of software studies which invites us to focus on the cultural and communicational changes brought by software, and to pay attention to the ways in which online communication is not simply a human activity, but a set of practices negotiated through complex dynamics between software architectures and different categories of users (i.e. software engineers, citizens, activists etc.) (Elmer et al., 2009).

Concerning these, platforms are conceptualized as spaces of inextricably intertwined software, hardware and cultural practices. Furthermore, scholars point out that the platform model creates new conditions for regulation and discipline through algorithms or properly programmed software which is based on fundamental asymmetries of information and power between the platform owner and users. In other words, the platform owner, through technological features and infrastructures, has the power over ecosystem users, guiding and influencing their conduct (Srnicek, 2017; Kenney & Zysman; 2017). In this regard, technology conditions user behavior and participation. Moreover, technologies and tools that appear to be very simple form the users standpoint, are actually very complex and require advanced technical knowledge. As Elmer et al. observe,

> the simplification of technical processes from a user point of view and the greater user-friendliness offered by these spaces is accompanied by comparatively more complex and invisible processes that take place via other types of interfaces that connect software to software, software to hardware, and hardware to hardware. (Elmer et al., 2009)

These processes of obfuscation, motivation behind it and its effects are taken into account in this set of studies.

The more powerful and ubiquitous some platforms become, the more complex the relations and interdependencies they establish. At the core of the next research approach lies the notion of platforms as ecosystems. Ecosystem is considered here as the "organic pattern of multilateral connections between firms and their activities that fosters synergies and complementarities that would otherwise not emerge" (Alaimo et al., 2010, p.28). A case in point represents social media platforms and the apps they host (Alaimo et al., 2020). This strand of research studies the organization of actors around a platform with the concept of ecosystem serving to illustrate the links and interdependencies between ecosystem participants and the forces that determine inception, unfolding and decline of those connections. Ecosystem as a conceptual tool allows for addressing issues that cannot be analyzed through supply chain networks or industry dynamics study. To give an example, network effects and the rapid growth of the platform are frequently secured by an open and complementors friendly ecosystem, achieved through so-called boundary resources, such as software development kits (SDK), application programming interfaces (APIs), and application contracting interfaces (ACIs). Complementors, connected to the central platform by means of technical standards or shared and open-source technologies gain access to the platform's customers. As these connections are not identical with bilateral business relationships, they determine the specificity of the ecosystem model.

Plantin & Punathambekar observe that "having 'disrupted' many sectors of social, political, and economic life, many of the most widely used digital platforms now seem to operate as infrastructures themselves" (Plantin & Punathambekar, 2019, p.163). They continue:

> Google, Facebook, and a handful of other corporate giants have learned to exploit the power of platforms - which hold undeniable benefits for both users and smaller, independent application developers - to gain footholds as the modern-day equivalents of the railroad, telephone, and electric utility monopolies of the late 19th and the 20th centuries. (Plantin et al., 2018, p.306-307)

Following these arguments, I propose to supplement the above mentioned four strands of research on platforms with another one, that conceptualizes platforms as infrastructures. Plantin et al. take the examples of Google, Facebook and WeChat to argue that digital platforms in terms of scale and level of use become increasingly ubiquitous, indispensable and invisible as common infrastructures (Plantin et al. 2018; Plantin & de Seta, 2019). By studying key features of infrastructure such as ubiquity, reliability, invisibility, gateways, and breakdown, scholars offer a new framework that foregrounds the infrastructural dimension of platform evolution. Having its roots in media infrastructure studies and physical network studies, this strand of studies places its focus on software based infrastructures. The concept of platforms as infrastructures is situated, and particularly relevant, within broader discussions on the history and political economy of media infrastructures (Plantin, 2019; Poell et al., 2019).

From platforms to platformization

Combining insights from those various research perspectives "the scholarly community moved from a discussion of 'platforms' as 'things' to an analysis of 'platformization' as a process" (Poell et al., 2019, p.4). And even though research perspectives are often very different and analyze platforms from multiple various angles, at times using entirely different theoretical concepts, they are not mutually exclusive and without them the inception of platformization as a critical conceptual tool would not be possible (Poell et al., 2019). According to Poell et al., "platformization is defined as the penetration of infrastructures, economic processes and governmental frameworks of digital platforms in different economic sectors and spheres of life, as well as the reorganization of cultural practices and imaginations around these platforms" (Poell et al, 2019, p.6). As an example, Poell et al. refer to the media and telecom industries which, on account of network effects and power asymmetries between the platform owner and its users, have been turned into highly concentrated platform markets. Other industries in which this phenomenon is clearly visible are digital advertising, apps, e-commerce, and cloud computing (Poell et al., 2019). Platformization also takes place in more traditional markets such as transportation or hospitality. A common feature of all these industries are business-to-customer relationships: companies, organizations and institutions offer products or services directly to end customers.

The process of platformization unfolds around three institutional dimensions: data infrastructures, markets, and governance. Firstly, data is one of the platform's key resources, and the entire platform's infrastructure and technical processes are subject to continuous collection, comparison, analysis and storage of data. As Mark Andrejevic rightfully points out, "these days, we *generate* more than we participate—and even our participation generates further and increasingly comprehensive 'meta'-data about itself" (Andrejevic, 2015, p.20). Sensors, trackers, APIs and a myriad of other platform extensions allow for its expansion into the rest of the web and thus its ubiquity. Plantin argues for example that "unlike system builders, platform builders do not seek to internalize their environments through vertical integration. Instead, their platforms are designed to be extended and elaborated from outside, by other actors, provided that those actors follow certain rules" (Plantin, 2018, p.298). Secondly, platforms form multi-sided markets connecting a wide variety of actors. For example, Twitch, one of the most popular live streaming platforms for gamers, enables connections between gamers, game publishers and advertisers. Yet the flow of activities, coordination of processes is not handled by the market, it is the platform that, through its architecture and mechanisms such as, for instance, algorithmic management, manages the dynamics of this market. Moreover, when a given platform gathers a large number of users and dominates the respective field, it becomes increasingly hard for other platforms to break into the same market. And this, by and large, affects distribution of economic power and wealth. Thirdly, not only do platforms control market dynamics, but also steer platform-related user interactions. With the help of software but also legal forms such as terms of service (ToS), license agreements, and developer guidelines, platforms decide what type of content users can publish and what content is displayed to them. Moreover, certain content is prioritized over others which as a consequence structures the way users interact with each other. Finally, platformization brings about shifts in key societal sectors, "as platforms tend to employ these different governing instruments - interfaces, algorithms, policies - without much regard for particular political-cultural traditions, there are often clashes with local rules, norms, and regulatory frameworks" (Poell et al., 2019, p.8). Not all markets have been dominated by the platform model. Local and national practices, market arrangements, public institutions and governing frameworks - all these factors have an impact on the future of a given sector. With these considerations in mind, I want to address in this thesis the issue of platformization in the business-to-business market, and specifically manufacturing industry. I am interested in the ways platforms gradually penetrate this market. Although it is not yet dominated by platforms, certain moves in this direction can be observed.

Theoretical framework

This thesis builds on a theoretical framework including platformization, political economy and logistical media theory. Combining these theories helps construct a model that allows looking at platforms as complex objects consisting of technology and sociality, underpinned by cultural values and social norms. I agree with van Dijck in her assertion that, in order to present a complete picture of the phenomenon, platforms need to be investigated both as sociotechnical and socioeconomic objects in the context of a larger ecosystem. I consider this approach to be best suited to study digital platforms as ecosystems and construct my analysis of MindSphere based on this model. As van Dijck rightly points out, "the intimate intertwining of both levels [user-technology interaction and the organizational socioeconomic structure], as well as the dynamics between microsystems and ecosystem, is hard to pinpoint in a single theory or analytical framework" (van Dijck, 2013, p.25). As I place my research in the interdisciplinary field of platform studies, software studies, media and communication studies and related fields such as digital economy, business strategy, new media studies, science and technology studies (STS) and human computer interaction (HCI), an informed analysis requires combined perspectives.

Logistical media theory is another important approach that aids my research. In Rossiter's words, "logistical media—as technologies, infrastructure, and software—coordinate, capture, and control the movement of people, finance, and things. Infrastructure makes worlds. Logistics governs them" (2016,"Introduction - Logistical Media Theory", par.1). The subject of interest of this theory are technologies, software and infrastructure supporting supply chain operations on a global scale. Rossiter encourages research into these systems by "scholars in the fields of media studies, digital humanities, software studies, and network cultures because, as he argues, these structures “generate protocols and standards that shape social, economic and cross-institutional relations within the global logistics industries” (2016, “Introduction - Logistical Media Theory”, par.7). He continues:

> What is required is a truly transdisciplinary collective investigation into the increasingly mysterious centers of power in the age of big data. This would involve work between media theorists, organizational studies, computer scientists, programmers, and designers to open up the black box of SAP and the products of similar software developers, identifying how their algorithmic architectures are constructed, what their business models are, and how they use data extracted from the back end of mostly unwitting clients. (Rossiter, 2016, “SAP and the Birth of Global Logistics Software”, par.4)

Among others, through technologies such as data extraction and algorithmic architectures, logistical media play a central role in economic and social processes as well as cultural changes. They influence, for instance, production and consumption levels, labor organization, or global flow of goods and services (Rossiter, 2016).

Rossiter's theory derives from an interest in a specific type of software - Enterprise Resource Planning (ERP) system of the German company SAP, interesting for its vast domination and prevalent use:

> Given their market and institutional reach, it is therefore not a stretch to say that the power of SAP rivals that of the Murdoch empire. Yet SAP’s ERP and logistics software generally remain a black box to most. Even those who use the software have little idea of how it works. For this reason SAP’s supply chain software can be considered a form of imaginary media. (Rossiter, 2016,“’We Help the World Run Better and Improve People’s Lives’ (SAP)”, par.2)

Present software managing global supply chains makes these processes even more efficient than just by applying ERP programs. In the first chapter, I described a modern brewery and how digitalization with predictive maintenance or advanced analytics, implemented through complex software systems, plays an increasingly important role in the management of modern production. As I mentioned, the highest quality and reliable production, logistics and retail are inextricably intertwined. Digital technologies are essential to optimize product quality or to predict anomalies. As I wrote, the largest enterprises in the industrial manufacturing industry decide to develop software that allows them to realize the potential of digitalization. Interestingly, as observed by Rossiter, “logistical media are shifting to cloud computing services, which in many countries are a national policy priority in an effort to increase productivity, innovation, and trade” (2016, “SAP and the Birth of Global

Logistics Software", par.3).[1] It seems meaningful to look at MindSphere as an example of this kind of software - a logistical medium supporting management and optimization of the global supply chain, within the ecosystem created by the platform. I agree with Rossiter who points out that "broad as the field is, one might expect research into the political economy of media industries to pay some attention to the technology and infrastructure that underpins the global exchange of finance and commodities" (Rossiter, 2016,"'We Help the World Run Better and Improve People's Lives' (SAP)", par.3). My interest is to situate MindSphere within the field of critical studies on these logistical infrastructures, and to extend the analysis of "logistical software and infrastructure as key apparatuses that govern culture, society, and economy within the historical present" by online B2B platforms (Rossiter, 2015, p.137).

At the end of this chapter, I would also like to mention the actor-network theory as it offers a useful approach aiding my analysis. Van Dijck emphasizes that Latourian actor-network theory and critical political economy as points of departure, yet operating on two different levels, provide a good model for understanding complex constructs that digital platforms represent. Baron and Gomez describe actor-network theory (ANT) as "a sociological approach, which focuses on the description and analysis of associations between natural, human and technological entities" (2016, p. 129). This concise definition provides a good insight into understanding society's complex relationship with technology. The theory considers equally both human and non-human elements as actors within a network and underlines the interplay between technology and people. In this sense, ANT seems particularly useful in my analysis of MindSphere as the platform is a transforming object, influenced and shaped by users and technology itself. Neither technical nor social position are privileged. "Latour reaffirmed that ANT did not limit itself to human individual actors but extends the word actor—or actant—to non-human, non-individual entities" (Baron & Gomez, 2016. p. 134). Actors, or *actants* as Latour would say, form relations and connections leading to a dynamic network, a process of constant interactions where both people and technology influence each other, causing a constant change of the network. When examining digital platforms alongside human factors - software developers, users - that determine and shape its environment, one needs to take into account also elements such as software, operations, protocols, algorithms, code as equally accountable for the ecosystem as human actors.

In this chapter I introduced the field of platform studies and platformization as a concept that guides my research. As, being concerned with an industrial platform, I

[1] Germany's initiative Industry 4.0 makes a convincing case for this observation.

investigate the process of platformization in industrial manufacturing, it was also vital to demonstrate that MindSphere can be an important object of research in the broad field of media studies. In this respect I referred to logistical media theory. Finally, I also presented the ANT theory on which insights my work leans.

Before we can go forward to study the platformization on the example of MindSphere, we need to gain a better understanding of the history and the socio-economic shifts at work in this process. In the following chapter, I therefore present a short overview of literature on platform economy.

3. Political economy and the power of platforms

This thesis is a critical investigation of the nature of platformization in the manufacturing industry. Although an exhaustive review of the literature on platforms in their various manifestations is beyond the scope of this study, our understanding of platforms, in my view, needs to be expanded on the impact that these objects not only have on competition, business and innovation, but also on culture and societies. Therefore I provide an overview of critical political economists' perspectives on global growth of platforms with attention to issues of labor, exploitation and surveillance. As Poell et al. argue, “we need to gain insight in how changes in infrastructures, market relations, and governance frameworks are intertwined, and how they take shape in relation with shifting cultural practices” (Poell et al., 2019, p.9). With their multiple analyses and framings such as the information society (Castells, 2010), communicative capitalism (Dean, 2009), platform imperialism (Jin, 2013), platform capitalism (Lobo, 2014; Srnicek, 2017), computational capitalism (Stiegler, 2019) and surveillance capitalism (Zuboff, 2019), scholars investigate the socio-economic changes emerging with the introduction of personal computers in the early 1980s and the Internet in the 1990s, and then social media platforms and smartphones in the early 2000s.

Competing global platform ecosystems

The division of the world after the Second World War into two ideologically opposing systems - capitalist and communist - and geopolitical tensions between those, known as the Cold War, was expressed in technological competitions such as the space race and nuclear arms race. Rapid expansion of the American economy and the growing consumerism of capitalist societies made the USA world economic power and a symbol of success and entrepreneurship. Sudden development of the American manufacturing was possible due to the massive war damage across Europe and the weakening of competition. Technological progress in automation and computerization of the 1950s and 1960s brought a period of prosperity and relative stability. However, starting in the late 1970s, the prosperity was coming to an end and Western neoliberal political leaders of the time such as Reagan and Thatcher began to introduce drastic changes aimed at reducing the cost of maintaining the state. The modern infrastructural ideal of a welfare state, defined as Srnicek points out “at the international level by embedded liberalism, at the national level by social democratic consensus, and at the economic level by Fordism" began to collapse (Srnicek, 2017, p.10). Declining productivity also forced changes in the industrial production system at that time, replacing Fordism by the Japanese Toyotist model with lean production principle and rise of increasingly complex supply chain software (Srnicek, 2017). It was at this time that the shift from mass production of the same goods towards individualized and customized products took place. Today, this process is even more intense as the production processes are more and more complex due to the wide variety of manufactured goods. Interestingly, the digital transformation in industrial production raises new hopes of restoring production levels before the 2008 financial crisis. Many promote platform capitalism as a new way of profit generation, where "manufacturing control systems, supply chain management and advanced industrial equipment can be used and configured as 'shared services': users can interact to create new products, applications and production networks" (Lüthje, 2019). China is making accelerated efforts to develop industrial IoT platforms for manufacturing. A case in point are the so-called "Taobao factories", production clusters representing distribution-driven transformation in Chinese manufacturing sector, where the production process is based on real-time sharing of production lines and complex customer-specific ordering (Lüthje, 2019).

More than a quarter century following the end of the Cold War, we are witnessing the formation of a new power system on the geo-political map of the world, largely driven by the development of modern technologies and technology race between the US and China. China has for many years been recognized as a producer of cheap imitations, a country lagging behind in terms of technological development and innovation. Yet the country adopted in its state economy the path known as the *reverse* Schumpeter triad (Schumpeter, 1994). As a result the Asian empire became a major player in global affairs, threatening overtaking the US as a financial and economic power (Frankel, 2020). This tendency is also reflected in the technology and digital media sector. As van Dijck et al. argue,

> the majority of successful infrastructural platforms that channel the world's online social and economic traffic are either US or Chinese. Few of the core platforms originate in western Europe or Russia, and hardly any of them were built in Africa, Latin America, Australia, or Southeast Asia. (van Dijck, 2018, p.26)

We are now witnessing development and establishing of globally interwoven two platform ecosystems, both of which, the American GAFAM-system (Alphabet-Google, Amazon, Facebook, Apple, and Microsoft) and the Chinese BAT-system (Baidu, Alibaba, and Tencent), are dominant in their geo-economic areas. To these two competing blocs one should also add Europe, being a huge continental and attractive market, culturally closer to the United States. On the one hand, these three blocs compete with each other in economic terms, and this competition for geopolitical power is also reflected in their fight over infrastructural influence in the digital environment. On the other hand, platform ecosystems that they create are similar, based on the same principles and mechanisms, such as vertical integration, infrastructuralization and cross-sectorization (van Dijck, 2020).

The platformization tree

To illustrate the dynamics of platformization van Dijck proposes a metaphor of a tree. The platformization tree symbolizes the whole platform ecosystem comprising infrastructural, intermediary and sectoral platforms (van Dijck expands here the typology I mentioned in the earlier chapter). Platform types form the elements of the tree: the lowest, invisible layer are the roots formed by infrastructure platforms, roots are leading to the trunk formed by intermediary platforms, which in turn branch out into twigs and foliage of sectoral (industrial and societal) platforms. The platform tree is a living organism which is constantly evolving and changing its shape, just as platformization is a process. The three layers that make up the tree - the roots, the trunk and the crown - are inextricably linked and interdependent, feed off each other vertically and horizontally, visibly and invisibly, belowground as well as aboveground. Yet, from the point of view of the platform owner, the key layer is the trunk as from this level the platform can extend and increase its impact upward, downward, and sideways (van Dijck, 2020). I am referring to this metaphor as it allows us to look at platform ecosystems through the political-economic lens. The aforementioned American and Chinese systems are building their own platform ecosystems, based on different ideologies, different organizations and competing companies.

However, as van Dijck notes, their platformization trees are “remarkably similar: both the Californian sequoia and the Chinese bamboo tree have developed sizable tall trunks; both blend state and corporate interests across the roots, trunk, and branches into seamlessly integrated services” (van Dijck, 2020, p.12). The European model differs from the American and Chinese as the trunk of its platformization tree is smaller and shorter whereas its crown is dominant. This translates into a smaller number of platforms that would exert control over the entire ecosystem and more effective and transparent coordination. Such an ecosystem has developed on the basis of the European economic model and legislation.

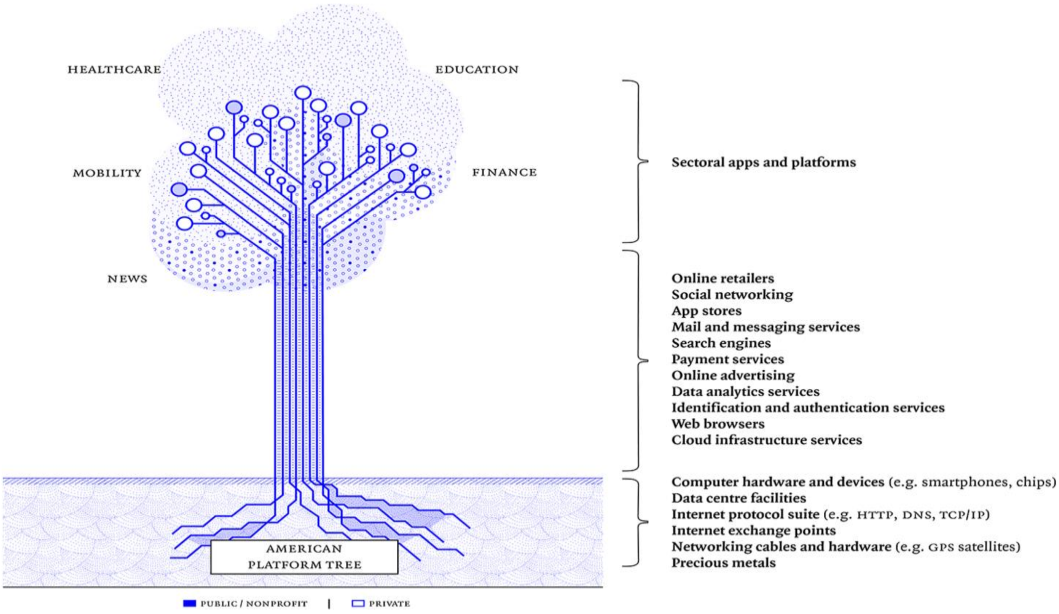


Figure 1. American platform tree. Reprinted from "Seeing the forest for the trees: Visualizing platformization and its governance" by J. Van Dijck, 2020, New Media & Society, 146144482094029, p.6. Copyright 2020 by Sage Publications Inc.

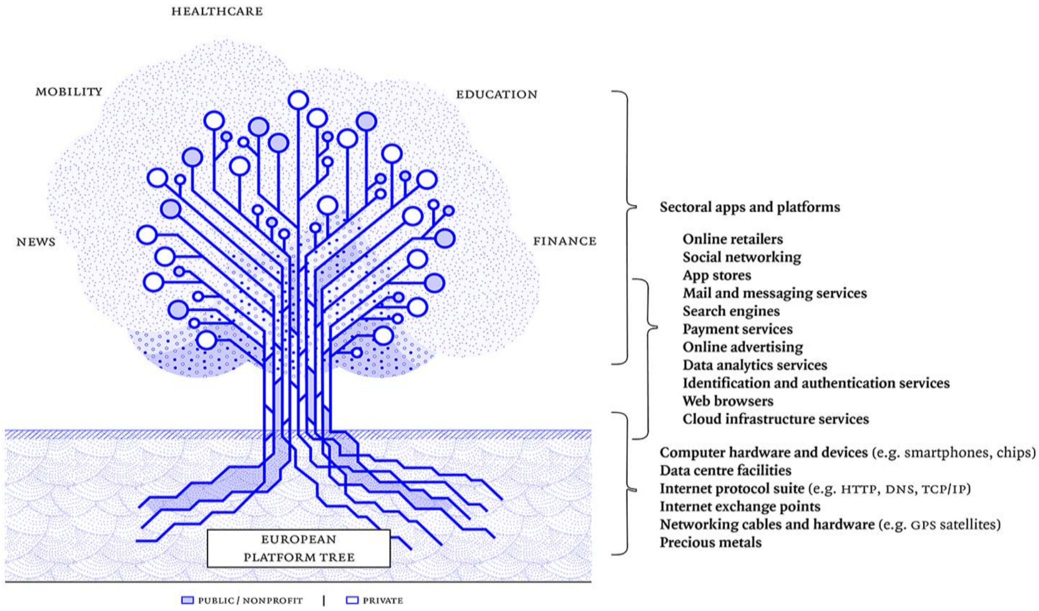


Figure 2. European platform tree. Reprinted from "Seeing the forest for the trees: Visualizing platformization and its governance" by J. Van Dijck, 2020, New Media & Society, 146144482094029, p.6. Copyright 2020 by Sage Publications Inc.

Towards an infrastructuralized platform model

The platform ecosystem is in a constant flux and big tech companies are moving from enclosed models towards open data-infrastructures. Because of the applicable legal frameworks that limit their possibilities they use innovation speak "claiming the need not to be subjected to public regulation because they are breaking new grounds, in effect demanding a new state of 'permissionless innovation' to shape our conditions of existence" (Langlois & Elmer, 2019, p. 248). Tech companies, governing the world's core information systems, begin to supersede nations, elected governments and administrations with regard to democracy or civic life regulations. There is a growing disparity between the legal and economic concepts shaping environments in which platforms operate and their complexity. Legal frameworks defined by states or supranational organizations usually regulate one aspect of governance, i.e. public health, environment, agriculture, while platformization runs into multiple areas and markets and affects them simultaneously (van Dijck, 2020). As Srnicek rightly points out,

> something needs to be done to rein in the increasing economic and political power of big tech, and fast. But the instinctual liberal belief in the value of competition will exacerbate rather than solve the problems. We need to think bigger if we are to take back control of our digital lives. (Srnicek, 2019)

Platform ecosystems are increasingly evolving towards developing infrastructures for users - the process that Plantin et al. have called "infrastructuralization of platforms" (Plantin et al., 2018, p.306). Not only do social media but also other digital platforms take up more and more spaces, extending their presence and embedding themselves in all aspects of life such as transport, smart cities and smart home systems. Digital platforms entering those markets shape new types of services, organizing relationships between users and users and the environment. Moreover, a radical change of the production and distribution logics of all sorts of immaterial and material goods is taking place. We are witnessing the process of forming a new form of service (Plantin et al. 2018). Its outlines are just emerging but are slowly becoming visible on the example of changes in the manufacturing industry, which I will discuss in the following chapters.

Summarizing, we can notice a business model change of platforms that are no more focused in the first place on fostering social connectivity for harnessing user-derived data and meta-data but interested in providing essential services, such as education, urban safety, transportation, healthcare or food. Here, the new model offers additional opportunities of data mining as, besides all kinds of human data, platforms can also collect environmental data, such as weather, traffic, stock markets, availability of material resources etc. (van Dijck, 2020).

Political economy

Drawing upon political science, economy and law, scholars regard platforms as expressions of power relationships between individuals and institutional structures. The main focus of political economy lies on institutional actors and the power relationships between macrostructures. This approach engages more with investigating how institutional agents exert power. In particular in the context of this work, Manuel Castells' political economy of informational networks is a useful analytical tool as it is interested in how technological and computational systems could grow into powerful industrial players, exerting power for instance via algorithms or interfaces (van Dijck, 2013).

This brings me to Michel Foucault's reflections on conduct, freedom and government, and the type of power that Foucault calls "security apparatuses". In the neoliberal economy, labor is perceived as an individual choice. In other words, the decision to work for a certain wage level is dependent on a return of investment for one's human capital (Foucault, 2008). Yet, according to Foucault, work plays a larger social role - it is not only an activity of production that provides livelihood but even more importantly affects the way humans think and act. Analyzing industrial revolution, Foucault stresses the role of control and surveillance in the workplace as a means to increase productivity: "Surveillance thus becomes a decisive economic operator both as an internal part of the production machinery and as a specific mechanism in the disciplinary power" (Foucault, 1995, p.175). Social institutions such as the school, the hospital, the family and the factory constitute the disciplinary system of subjugation, creating and disseminating power relations in the society. Thus it is worth giving thought to whether digital platforms that are enjoying more and more influence and independence can take over the roles of these institutions as they acquire and exercise more power in the internet economy. It is not only the human but also the technical component that affects our reality, as emphasized by Bucher:

> In analyzing power and politics, we need to be attentive of the way in which some realities are always strengthened while others are weakened, and to recognize the vital role of non-humans in co-creating these ways of being in the world. (Bucher, 2018, p.3)

I believe that studying industrial platforms will continue to be enlightening to understanding our changing social reality.

Looking at current productivity and wealth levels one could assume that the technological advances, shifts in the global economy engendered by powerful information technology (IT) would make the disciplinary mechanisms, for instance the routine of the manufacturing assembly line or 40 hours working week, remodel or even disappear. After all, global societies are on their move towards "knowledge", "information" or "post-industrial" economy (Guizzo & Stronge, 2018). We need a new economic paradigm since, as Kostakis and Bauwens aptly observe, "no other economic system than capitalism has produced so much wealth. On the other hand, some might claim that no other system has produced so much destruction" (Kostakis & Bauwens, 2014, p.2). The dispute about the impacts of the platform economy remains unresolved. Optimists call it the "sharing economy" or "creative economy" while sceptics are cautious in making predictions whether the industry platforms are able to answer these challenges. The writings of Nick Srnicek offer some useful insights into how platformization affects the structure of the economy. Changes in the business model have an impact on the entire social system and the labor market. According to Nick Srnicek,

> through a series of developments, the platform has become an increasingly dominant way of organising businesses so as to monopolise these data, then extract, analyse, use, and sell them. The old business models of the Fordist era had only a rudimentary capacity to extract data from the production process or from customer usage. (Srnicek, 2016, Chapter 1 Conclusion, para. 1)

As van Dijck et al. rightfully observe, "the current platform ecosystem is predicated on an architecture that is primarily staked in, and driven by, economic values and corporate interests". Public values, like participation, rule of law, transparency or accountability, are at stake in the platformization of the global market. In a similar vein Shoshana Zuboff discusses the expansion of markets and commodification:

> Over the centuries we have imagined threat in the form of state power. This left us wholly unprepared to defend ourselves from new companies with imaginative names run by young geniuses that seemed able to provide us with exactly what we yearn for at little or no cost.(...) This ideology and its practical implementation bends second-modernity individuals to the draconian quid pro quo at the heart of surveillance capitalism's logic of accumulation, in which information and connection are ransomed for the lucrative behavioral data that fund its immense growth and profits. Any effort to interrupt or dismantle surveillance capitalism will have to contend with this larger institutional landscape that protects and sustains its operations. (Zuboff, 2019, p.47)

Surveillance, privacy, precarious labor, increasing social inequalities and environment damage are only a few recurring issues in the disruption-reproduction debate. As the work by numerous scholars have shown, there is a growing concern over the rise of the platform economy. As we can read in the peer-reviewed journal *Computational Culture*:

> studies of mobile apps, platform native apps, and web browser apps or extensions are particularly encouraged.(...) Contributors are encouraged to move beyond studies of single apps and their users in favor of approaches that explore apps as material artefacts alongside the infrastructures, political economy, and environments in which they are embedded and situationally enacted. (Computational Culture, 2018)

Analyzing platforms from multiple perspectives allows us to develop a comprehensive understanding of digital transformation. My analysis of an industry platform as an ecosystem has the intent to contribute to the growing body of research on digital platforms by combining perspectives from software studies, business studies, political economy, and cultural studies.

4. Methodology

The aim of this chapter is to present the rationale of my choice and methodological approach of the thesis. Such an approach should always be consistent with the type of the academic paper and the adopted research orientation. This thesis is a case study research of an industrial B2B platform MindSphere owned by a German conglomerate Siemens. Digital platforms are complex and multifaceted phenomena. For this reason this study adopts a multi-layered analytical approach and a specific research method allowing for a comprehensive assessment of the subject of research. In this chapter I will introduce the conceptualization of my research.

Case study

The choice of Siemens and its MindSphere platform is not accidental. In the years 2014-2018 I worked as a communication specialist in the Polish subsidiary of the German manufacturing company Rittal. Due to the position held, every year I visited one of the world's largest trade fairs for the industrial sector: Hannover Messe. It was during this event in 2016 that I first encountered the concept of Industry 4.0, promoted both in politics and in business, by both the German Chancellor Angela Merkel and US President Barack Obama (Obama was a special guest at the aforementioned fair). In the following years, I had the opportunity to see how this concept develops on the German industrial production market. Today, Industry 4.0, digitization, smart factories etc. are only some of the ideas, solutions and tools that engineers and software developers practice in their daily work with help of online applications and digital platforms for management of the industrial production cycle. In the Euro-American public discourse, there is a growing body of debate about platform expansion, social consequences and regulation. Scientific studies on these phenomena challenge and contribute to these debates (Plantin & de Seta, 2019, p. 258). Politics, economics and social development are inextricably linked.

Machinery firms, similarly to all other companies in the capitalist system, must follow market changes and invest in development and innovation to maintain their competitive market position. Tech giants such as Microsoft or Amazon, having an advantage in terms of technology and financial resources, want to expand their businesses also in the industrial production sector. But it is the incumbents who know the market better and have the know-how. Huge investments in the development of platforms and competition in this field with the big tech companies proves how significant is the change taking place in this sector. Siemens, as the largest industrial manufacturing company in Europe, began investing in software and digital technologies very early on. As a result of this strategy, in 2007 it took over the American company UGS Corp. specializing in the production of product lifecycle management software (Esterl, Singer, & Berman, 2007). This strategic move was of great importance for maintaining the company's competitiveness and its market position. Rossiter points to the growing importance of software and technology in the management of processes, people and capital. He states that

> finance capital, supply chain operations, and labor-power define three key staples of contemporary globalization abstracted by algorithmic architectures and software systems.(…) Finance capital and supply chain operations intersect with labor-power through logistical technologies that measure productivity and calculate value using real-time computational procedures. Logistical technologies derive their power to govern as a result of standardization across industry sectors coupled with algorithmic architectures designed to orchestrate protocological equivalence and thus connection between software applications and workplace routines (Rossiter, 2018, “Coded Vanilla”, par.1).

The next steps towards digitalization in Siemens were only a matter of time. The subject of this research, industrial B2B platform MindSphere is a manifestation of Siemens’ strategy towards digitalization and software development. MindSphere as a digital platform for managing production and supply chain processes in a so-called smart factory is a typical example of platforms developed in the industrial sector that represent trends in this field.

Siemens is a conglomerate, a company incorporating business units from different, sometimes unrelated industries. However, most of these have their roots in industrial production. I decided to analyze specifically this platform after taking into account the purposeful sampling guidelines. According to Patton, "qualitative research usually focuses on relatively small samples, even single cases, selected intentionally to allow for in-depth study and understanding of the phenomenon" (Patton, 2002, p. 46). As Patton further suggests, cases should be selected in such a manner, that their analysis would allow researchers to answer posed research questions. In other words, cases should be information-rich. Siemens is a company with a global presence, and its MindSphere platform is still being developed, entering another phase of maturity. This guarantees that one can follow its development well. Moreover, the presence of Siemens in many industries and its brand recognition, as well as large financial outlays, allow for the rapid development of the platform.

Moreover, the purpose of my analysis is to investigate how this particular case of the industrial platform illustrates the phenomenon of platformization. I decided to explore MindSphere as a typical example of an industrial B2B platform. As observed by Bryman,

> case may be chosen because it exemplifies a broader category of which it is a member. The notion of exemplification implies that cases are often chosen not because they are extreme or unusual in some way but because either they epitomize a broader category of cases or they will provide a suitable context for certain research questions to be answered. (Bryman, 2012, p.70)

Therefore I believe that choosing MindSphere will help illuminate the phenomenon of platformization in industrial manufacturing.

Situating my research

Most research on digital platforms in media and communication studies explores issues such as surveillance, accumulation of power and capital or labor exploitation, and usually focuses on socio-economic changes in the context of social media or consumer services platforms, such as Uber or Airbnb. There is a lack of scientific work on the larger phenomenon of platformization in media studies that would also take into account computational or infrastructural aspects of platforms (Poell et al., 2019; Dieter et al., 2019). There are growing calls for a multidisciplinary research and exploration of various categories and aspects of platforms functioning in a socio-economic and techno-cultural context. This work is an attempt to present the problem from this broader perspective.

I think it is fair to assume that platformization is not a temporary trend and now one can say that the phenomenon that first appeared in the domain of communication and social media is beginning to occupy new spheres of human activity. In this thesis I argue that the emergence of digital platforms in industrial production is the next stage in the development and dissemination of the phenomenon of platformization. My focus on the industrial digital platforms responds to recent calls for attention to “advance the innovative and critical inquiries into the app / infrastructure stack.” (Gerlitz et al, 2019, p.16). Moreover, in my opinion, such an analysis of the digital platform in the industrial environment may allow for new, interesting observations and conclusions.

Research design: van Dijck’s multilayered model

How to study apps and platforms? What is specific about them? How do they relate to the phenomenon of platformization? Methodology, or research design, describes the relationship between the object under study and a given scientific concept. The purpose of the analysis is to understand this relationship (Verhoeff, 2012).

Researchers distinguish various analytical levels when investigating software (Dieter et al., 2019, van Dijck, 2013, Plantin, 2019). As Dieter et. al point out, “engaging with apps via multiple, connected situations may require navigating different scalar levels and relating

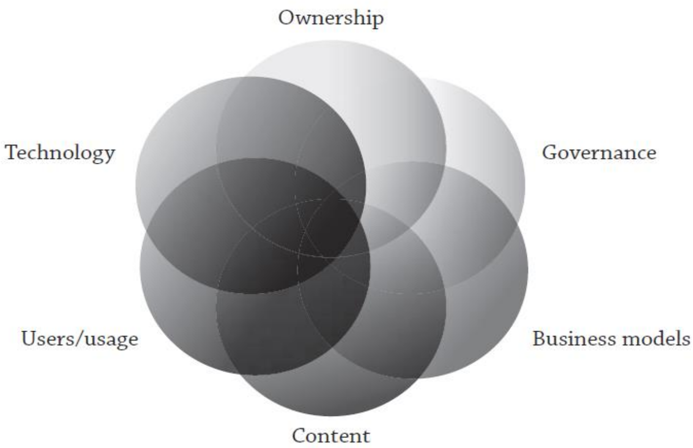


Figure 3. Van Dijck’s multilayered platform model. Reprinted from “the Culture of Connectivity” by J. van Dijck, 2013, *The Culture of Connectivity*, p.28. Copyright 2013 by Oxford University Press.

specific findings in performative embodied situations (e.g. walkthroughs) to global app markets or cloud infrastructures” (Dieter et al., 2019, p.12). Moreover, as Zittrian argues by describing them as "contingently generative", apps are constantly changing. Dieter et al. state similarly that apps should be analyzed both as distinct objects but also as a system of relations, even if investigation into software provides a methodological challenge (Dieter et al., 2019). Several scholars observe that digital objects are complex and their analysis should be carried out by distinguishing between elements such as hardware, software and representations (van den Boomen & Lehmann, 2012; Rossiter, 2017; van Dijck, 2013). According to Gerlitz et al., app research “is highly interdisciplinary and draws on several adjacent research areas, including (mobile) media and communication studies, (information and media) infrastructure studies, software studies, social media and platform studies, business and management studies, and computer and information systems research” (Gerlitz et al., 2019, p.3). Therefore, critical analysis of software requires looking from many perspectives, navigating and scaling from the software to the ecosystem and back.

I argue that this observation concerns digital platforms as well. Therefore, on the one hand, one has to engage with software staging user experience, but also adopt an aggregative bird's eye view to recognize complex relationships, constellations between the platform and the ecosystem in which it is located. Only these two perspectives will complement each other to create a full picture of the platform.

In this thesis, I analyze MindSphere both as a platform and as an ecosystem. For this purpose I take van Dijck's analytical framework conceptualizing platforms as techno-cultural and socio-economic constructs (van Dijck, 2013). Following van Dijck, on the techno-cultural level of the platform I look into the platform's affordances and investigate its technology, users and usage and content. On the socio-economic level I take into account the platform's ownership, governance and business model, as well as the platform's ecosystem (van Dijck, 2013). Analyzing these aspects allow me, firstly, to get to know the platform from the user's perspective, its features and rules that govern it, and secondly, to explore the relationship between the platform and the environment in which it operates, its position in the ecosystem of platforms.

Research method

There is no one-size-fits-all way to research software, e.g. online apps or platforms. According to Gerlitz et al. one should

> engage with various mobile apps and app collections from technical, critical, political-economic, and praxeological perspectives to detail how the relations of apps often stand in for and can reveal much about the interests and strategies of connected stakeholders as well as their implications. (Gerlitz et al., 2019, pp.2-3).

The same can be said of platforms. As mentioned, studying these multifaceted objects requires a multi-angle perspective allowing for their comprehensive assessment. Moreover, while designing the actual analysis, one has to take into account that the method always depends on the specific object of research.

However, choosing the right research method is not always an easy task. As Patton rightfully points out, "no rigid rules can prescribe what data to gather to investigate a particular interest or problem. There is no recipe or formula in making methods decision" (Patton, p.12). The best reason for a certain methodological approach is that it is aligned with the research question. The main research question of this thesis is: How can the process of platformization be observed in industrial manufacturing on the example of MindSphere? To answer this question I decided to use the walkthrough method as this tool allows researchers for accounting both for technical as well as socio-economic and cultural expressions of platforms. In this way I could operationalize in my research van Dijck's multilayered analytical framework.

The walkthrough method consists of two approaches: carrying out a technical walkthrough of the platform and investigating the platform's "environment of expected use" through data collection and analysis. Several of the questions useful in my analysis were: How are things made? What do they afford? What are the built-in assumptions about users and usage? How do platform's features transform, innovate and maintain control etc.?

Walkthrough method

According to Light et al., "the walkthrough method is a way of engaging directly with an app's interface to examine its technological mechanisms and embedded cultural references to understand how it guides users and shapes their experiences" (Light et al., 2018, p.887). This performative technique requires engagement with an app or a platform. It is about observing and documenting in practice, step by step, screenshots, features and activities, which, in relation to the strategy and business model of the app / platform owner, create an "environment of expected use" of the system (pp. 881-886). Building on scholarship in cultural studies and STS this method engages with how digital technologies and culture mutually influence each other. In this two-way process the one is the product of another. I argue that his approach, explicitly framed as critical analysis of apps, is also well suited for my research of MindSphere.

My primary data source was the MindSphere platform itself, and in order to research it I performed a so-called technical walkthrough. For this purpose, I set up a free account on MindSphere and adopted a user persona. In the second part of the analysis, I examined MindSphere's "environment of expected use" - Siemens' websites, corporate documents, press releases, interviews with company's representatives, press articles etc. Exploring these data sources provided me with understanding of the platform's vision, governance and business model which in turn presented the socio-economic layer of the platform.

Exploring platform's affordances

In my analysis of MindSphere I combined the walkthrough method with a second scientific technique - the research of its affordances. The idea of affordances is one of the key terms employed to study platform environments - interfaces and relations between technology and users. According to Bucher and Helmond, "the concept of affordance is generally used to describe what material artifacts, such as media technologies allow people to do" (Bucher & Helmond, 2017, p.4). Affordances as a theoretical formulation have been conceptualized in various disciplines, such as psychology, sociology, communication and media studies and technology and design. Even in media and communication studies there is no one dominant way of problematizing affordances. The authors propose a platform-sensitive approach to study social media. Yet, as Bucher and Helmond point out, this concept cannot be understood only in the context of good or bad design or technical solutions. It must be taken into consideration that not only different platforms but also one platform ecosystem enables different types of behavior to different users which affects social relations and social structure.

Both of these methods - the walkthrough method and the research of platform's affordances - emphasize the fact that applications are media that require engagement and activity on the part of the user. According to Dieter et al. "apps are first and foremost operational media" (Dieter et al., 2019, p.5). Therefore, their designers expect specific behaviors from users. Also when creating platforms, developers have a specific idea of how platform users will use them, what actions will be taken by them in turn when using the system, and what is more, they expect that users will take these specific actions, wanting to influence users' behavior via the technology. The walkthrough method and affordances can be well used to investigate these expected imagined behavior patterns and scenarios (Dieter et al., 2019).

An important issue related to politics of representation is "intentionality" which, according to Bucher, explains "whether someone explicitly authors an artifact to function in a particular way or whether its functioning is emergent" (Bucher, 2018, p.35). Apps and platforms as media designed for doing, through their architecture and features meet specific needs, one could say the policy of their developers. Platforms and apps employ the user interface and built-in functions and default settings to guide the user through the platform environment and suggest specific activities in the way that the developers or the platform provider choose it. I also analyzed these dependencies on the example of the MindSphere platform itself.

Data sources and data collection

After thoroughly familiarizing myself with the research methods on digital objects, I came to the conclusion that the platform itself and publicly available publications would be the best source of data for this type of analysis. The walkthrough method is a relatively new yet an established research method widely applied and recommended in software and digital media studies (Dieter et al., 2019).

My two main data sources were: platform itself (user interface, technical affordances) and publicly available documents. To make my analysis exhaustive, I studied documents published by Siemens: first, the company's 351 press releases relating to MindSphere, company's marketing materials, whitepapers and discussions on developer forums, corporate websites concerning MindSphere and industry reports, technology press reports, some of the industry publications on the platform for the period 2014-2020.[2]

Many of the investigated documents were produced, commissioned or published by the company itself, and therefore represent an element of Siemens's self-presentation. For this reason, it was important to supplement these data with information obtained from publicly accessible government or industry reports. As Anne Ryan observes, "techniques or methods for collecting data are not simply neutral procedures, but carry assumptions that are inextricably related to the epistemological stance of the author" (Ryan, 2006, p. 74). My aim was to examine the market by critical reading of trade sources dealing with the subject of industrial IoT platforms. I also examined technical documentations regarding the MindSphere Application Programming Interface (API) and different software products such as apps available on MindSphere. I also analyzed the company's keynote presentations at the trade fairs SPS Connect 2020 in November 2020 and Hannover Messe 2021 in April 2021 which were organized in a virtual formula due to the restrictions related to the Covid-19 pandemic. Thanks to participation in online industry events, I was able to attend some public presentations on MindSphere and listen about its usage in various industries. Moreover, the corporate website dedicated to MindSphere allows users to ask questions via the chatbot. This tool was also used as a source of data. I decided that the data collected using the above-mentioned techniques will allow me to perform a walkthrough of MindSphere in the fullest possible way.

[2] As previously mentioned, one of the arguments for choosing MindSphere as the subject of the analysis was the wide access to corporate materials about the platform. Siemens competes to establish the platform and gain a strong position in the iIoT market. One of the company's strategies to achieve this is an open marketing communication.

Limitations

Access to data is often difficult not only on the technical level but also often on the organizational level. From my previous work experience, I am familiar with large institutions and businesses who very often are reluctant to share any information on their operations, frequently regarded as trade secrets, especially at the implementation stage. Rossiter seems to confirm these assumptions when writing about the enterprise resource planning (ERP) systems and global supply chain management software. In his theory of logistical media Rossiter argues that

> in studying global logistical industries, much of the software used to manage supply chains and the mobility of people and things is beyond the reach of the critical theorist.(...) The software developed by companies such as SAP and Oracle are under proprietary control and are highly expensive. Even with a knowledge of programming, it is far from straightforward to get a look under the hood. Moreover, the data generated on logistical operations related to supply chain management, procurement, warehousing, and labor productivity from this software is commercially valuable information. (Rossiter, 2016, p.77)

When considering what is concealed and what is available or even brought to the fore, the policy of platform owners is also manifested through the fact that technology companies very often make access to data difficult. As Helmond claims, “apps come with particular challenges as their infrastructural relations are often obscured if not obfuscated” (Helmond, 2015, 3). On the other hand, Dieter et al. claim that the study of the application is difficult due to technological conditions and the specificity of the object, because certain actions or data are only machine readable. (Dieter et al, 2019, 10). The authors, however, postulate that

> rather than seeing these challenges as black-boxed limits, it is more productive to consider instances of obfuscation as offering a spectrum of opportunities to navigate around resistances and re-situate apps to open up alternative (albeit partial) perspectives. (Dieter et al., 2019, p.10)

According to van den Boomen & Lehmann, “analysis is always disentanglement and dissection, but it cannot end there. What is needed after dissection is a reconstruction that accounts for the relations between the elements, relations that matter" (van den Boomen & Lehmann, 2012, p. 12). In a similar vein, van Dijck et al. argue that after dissection into parts, all the elements have to be reassembled to identify the complicated mechanisms and norms that work in this ecosystem and that create our social and economic reality (van Dijck, 2013). My exploration of the platform did not end with a simple analysis, i.e. decomposing this complex structure which is MindSphere into individual elements. Interestingly, through making this decomposition I became convinced of ‘layeredness, interconnectedness, and embeddedness of apps’ (Dieter et al., 2019, 12-13).

Ethical considerations

When designing a study, one should consider the potential risk and take all necessary measures to maintain ethical standards that would protect others from harm. Despite the best intentions, any person undertaking scientific research can unintentionally harm others. Polonski and Waller list three types of harm: psychological, financial and social harm (Polonski & Waller, 2019, p. 53). Not only people directly participating in the study, but also individuals, groups or institutions indirectly related to the study, may be exposed to this type of negative consequence.

Ethical standards include, among others, collecting data in accordance with the guidelines developed by the Norwegian Center for Research Data. In my thesis I was collecting only anonymous, readily and publicly available data. When analyzing the data, however, I took into account the issue of the so-called "contextual privacy" which discusses the problem of intentions, purpose and place of data publication. As Rogers aptly points out,

> although online data is already public, and the terms have been agreed to, a social media user does not necessarily expect that her data will be used outside of the context in which it was originally posted, despite terms of service. (Rogers, 2019, p.32)

Therefore, even if personal data was publicly available online, I did not use it in this publication. No sensitive information was disclosed.

Although my research was not the type of research involving humans, which in consequence has not carried the risk of violating people's privacy, there are many other ethical considerations that should be taken into account when designing the research. When planning my study, I followed the guidelines of The National Committee for Research Ethics in the Social Sciences and the Humanities (NESH) regarding Internet research. These guidelines do not differ much from those required for research carried out in other traditional fields of science.

Despite the fact that research of digital objects is characterized by a certain specificity and complexity, it is also universal in nature. Researcher should always be honest in both preparing the research and presenting the results of his own work, even if these turn out to be surprising or even shocking (Berger, 2016, p. 511). The factors that should be taken into account when undertaking any scientific work are integrity and transparency. In my paper, I have made every effort to maintain these requirements by avoiding misrepresentation or not taking into account important research data.

5. Industrial awakening - MindSphere and the Industry 4.0

The aim of this chapter is to provide a historical and socio-economic context to the analysis of MindSphere as an industrial IoT platform. I hold that presenting the historical background and the organizational culture of Siemens and its market situation at the threshold of the so-called digital revolution is essential for understanding the idea behind the creation and functioning of the MindSphere platform itself and for the further analysis. I present this contextual information in a separate chapter also to make the coming analysis more transparent and less cluttered by contextual yet indispensable details.

The expression "Internet of Things" (IoT) is attributed to a British engineer and technology pioneer Kevin Ashton who used it for the first time in 1999 (Kramp et al., 2013). Even though it has been little over 20 years since that moment, the speed at which this technology is developed proves its significance. According to a market research company IDC, approximately 55.7 billion devices will be connected worldwide by 2025, 75% of which will be linked together in iIoT platforms (IDC, 2020).

One of such iIoT platforms represents MindSphere, created and owned by an industrial conglomerate Siemens, a company active in multiple sectors including energy, industry, healthcare and infrastructure. Below, I will briefly present the history of Siemens and its development strategy, ranging from a traditional German family business to a modern technology conglomerate. It will also describe the biggest technological breakthroughs in industrial production of the post-war period that influenced the strategic business decisions and shaped Siemens' present-day policy.

A short history of Siemens

The Siemens company was founded in 1847 in Berlin and its activity was primarily focused on the telegraph market. As early as 1848, Siemens built the first long-distance telegraph line in Europe, and soon began to carry out projects of this kind across the continent, e.g. building a telegraph line in Russia. Until the end of the 19th century the company owned several important patents and inventions, such as a dynamo or the electrical railway. Over time, the business expanded into sectors such as semiconductors, telecommunications, power plants, light bulbs and home appliances. In the 1920s and 1930s Siemens' factories produced, among others, radios and television receivers (Siemens History, 2021).

The period of the Second World War in Germany was characterized by production subordinated to the war economy and the Nazi regime. Siemens was no exception. The 1950s saw the beginning of the implementation of digital technology and automation for industrial processes. One of the most important inventions was the development in 1958 of the Siemens SIMATIC series of programmable logic controllers and automation systems, which new versions are now used in about ⅓ factories around the world (Siemens History, 2021).. Without going into many technical details, programmable logic controller (PLC) is an industrial computer, a physical hardware that allows production machines to run automatically and enables control of production processes. Depending on the needed function of the machine, an operator only needs to program the PLC, usually stored in a control cabinet near the machine in the production plant. PLCs perform basic actions, activating outputs when the parameters programmed into the system are met. PLCs are one of the most important technologies in the modern industrial landscape.

In the 1970s, as a result of the popularization of microprocessors, the use of control computers in small industrial installations increased significantly. Siemens entered a joint venture with Advanced Micro Devices (AMD) in 1977, the American manufacturer of semiconductors, taking over 20% of AMD's shares, opening a branch in Silicon Valley and thus entering the European and American microprocessor production markets. Despite investments in new technologies, production of industrial automation tools, the company's financial performance deteriorated at the end of the 20th century. This was due to the inadequate business strategy as the more profitable divisions subsidized the poor-performing ones in the changing market conditions. The supervisory board, pressured by shareholders expecting better financial results, decided to restructure and concentrate activities on creating innovation, growth and cost reduction. Siemens spun off their semiconductors, light bulb and telecommunications businesses, but invested in wind turbines and healthcare as future markets, bearing in mind the need for renewable energy sources and an aging population.

Despite the economic crisis in 2008, the company increased its research & development spending. Already at that point the company's management was aware of the potential of digitalization. The new strategy “Vision 2020” assumed the division of the organization into nine units: Power and Gas, Healthcare, Energy Management, Digital Factory, Siemens Wind Power, Power Generation Services, Building Technologies, Mobility, Process Industries and Drives (Siemens, 2018, August 1).. Each of these was categorized into units focusing on prioritized components: electrification, automation and digitalization. Electrification business units were relevant to electromechanical systems, automation pertained to controllers, human-machine interface panels and software around it and digitalization was dealing with vertical software and digital services.

As I mentioned in the previous chapter, in 2007 Siemens acquired the American company UGS Corp. to expand their product portfolio with CAD/CAM (computer-aided design/ computer aided manufacturing) and PLM (product lifecycle management) technology (Esterl, Singer, & Berman, 2007). It was a significant undertaking, the biggest acquisition in the company's history, worth $3.5 billion (Collins & Junker, 2017). With this move, Siemens became the first company in the world to offer a software and hardware portfolio covering the entire product life cycle and production facilities. It is worth adding that the reason for this acquisition was Siemens' strategy to focus on the so-called vertical IT, or domain-specific expertise, where the specialized software was applied for control and management of customers' key business processes. Competition - companies such as IBM, Oracle, Accenture or SAP - offered horizontal IT solutions, i.e. general purpose programs and applications, such as enterprise resource planning (ERP) systems, that could be used simultaneously in various industries. These companies were too strong competitors for Siemens, so the German company decided to focus on the sector in which it had the most expertise, and at the same time a chance to dominate the market, as it was mainly operated by smaller software companies.

Digital enterprise

At that moment the company began to experience the effects of the digital revolution in the form of competition from technology companies such as IBM (Collins & Junker, 2017). Siemens' employees - project managers and engineers - more and more often ran implementations in which they cooperated with technology companies, while in subsequent projects the same companies constituted direct competition for them in the fight for customers. Collins and Junker refer to this phenomenon as "coopetition", when technology companies "tried to cooperate and learn the way that Siemens understood its customers and processes before incorporating that into that business model and competing against Siemens" (Collins & Junker, 2017, p .6). Siemens' reaction was the introduction of the so-called "no-fly-zones", i.e. businesses where the protection of knowledge was of key importance and where cooperation with external partners was too risky, and therefore not an option. On the other hand, the company realized that not all projects could be implemented independently, without cooperation with external companies so it decided to build an ecosystem of business partners.

The first step in this direction was the sale of the business unit specialized in horizontal IT solutions, Siemens Information Systems to the French company Atos. In this way, Siemens got spun off the loss-making business, at the same time entering into a partnership with an European company, becoming its majority shareholder and strengthening its own position on the European market in opposition to competition in the form of IBM and other giants from Silicon Valley. The partnership with Atos turned out to be a success: both companies implemented, among others French toll collection system where Atos developed software for financial transactions and Siemens contributed with their software related to infrastructure - roads and vehicles (Tolling Innovation, 2013).

At about the same time at the Hannover Messe, world's largest trade fairs for industrial production, the German government created and proposed the project “Industrie 4.0”, internationally referred to as “Industry 4.0”. This initiative, in a nutshell, involves efforts to integrate the Internet of Things and services with manufacturing in order to create intelligent and fully autonomous factories. Siemens was already aware of the fact that digitalization requires setting up a completely new business model. Joe Kaeser, Siemens’ CEO in his speech to shareholders commented in January 2015:

> In the future, digitalization will shape our economy and our society much more than in the past. It has already brought about material changes. Just think of the music industry, photography, retail trade, the energy market or the print media. Major brands vanish. And companies that were completely unknown yesterday are suddenly global market leaders. Those who don’t act in time run into acute difficulties. But those who anticipate and shape these changes and develop the right business models have every chance of emerging as true winners. (Siemens, 2015)

However, at this stage, Siemens did not yet have a specific plan on how to practically implement the assumptions of Industry 4.0. Of course, the data available thanks to equipping production devices with sensors and actuators had long been available, and the entire automation of production processes was nothing new. However, the challenge was to develop a data recording standard that would allow for the collection of all available information, analysis, storage in the cloud and work on them to improve the system performance (Collins & Junker, 2017). The problem was the lack of a single standard that would combine data from different devices, stored in different formats, sent using different protocols.

MindSphere is born

Collins & Junker point out that “a key technology for connecting everyday objects to networks was radio-frequency identification (RFID), but it was not the only standard, competing with WLAN, Near Field Communication, and Bluetooth” (2017, p. 4). Another obstacle was the issue of security measures during the transmission of important data. Weak passwords and poor encryption or "defective user interfaces" made data devices a major security risk for businesses. The Internet of Things created great opportunities, but also a great threat. Therefore, the priority on the way to digitization has become to provide reliable, fast and secure access to data collected by Siemens devices at customers' sites.

For this purpose the so-called common Remote Service Platform (cRSP) was developed. Its aim was to ensure connectivity to manage services, e.g. maintenance of all Siemens’ business units. All networked Siemens' products generated at that time 16 terabytes of operating data each month so service business seemed a natural starting point for data analytics. However, the specific needs of different sectors differed from each other and despite the existence of one platform for service management, i.e. cRSP, different business units created their own platforms tailored specifically to the requirements and needs of customers from various sectors, e.g. process industry, healthcare or transportation (Collins & Junker, 2017).

At the beginning of 2014, Siemens took the first steps to create a digital platform for industry. Industrial Data Analytics (IDA) was a common initiative that spanned across business divisions with a separate unit for its management. The platform was created to identify similarities in projects carried out by Siemens in various industries and to expand on their basic knowledge and build innovative solutions for customers from various sectors. Both cRSP and IDA platforms were built with the IT resources stemming from cooperation with Atos. The IDA platform also enabled cooperation with external partners such as Microsoft or IBM. In this way Siemens had been gradually implementing its plan to create a wider ecosystem that I mentioned earlier.

Complementary to cRSP and IDA, in November 2015 MindSphere platform was officially launched by the Digital Factory department in the Industry division. In addition to solutions developed specifically for production industry customers, the platform allowed clients to collect, manage, analyze and visualize data for their own needs. It was the first open IoT operating system, a tool launched as a platform-as-a-service (PaaS) that allowed Siemens to monetize its previous experience in digital platforms for industrial customers (Collins & Junker, 2017).

In the coming chapters I explore the MindSphere platform and disassemble it, taking into account its technology, users and usage as well as data infrastructures, market and governance.

6. Techno-cultural view on MindSphere

By looking at MindSphere through the prism of political economy and platformization, it becomes possible to observe that the emergence of industrial IoT platforms is not only the result of innovation, digitization in production or political initiatives such as Industry 4.0 or Made in China 2025 but also a consequence of deeper social, cultural and economic shifts initiated by digital media and big tech companies.[3] In addition to the transformation of the media industry and consumer services that we are already seeing today, bringing digital technology to the manufacturing industry will advance the implications for economic, political and social practices. My key argument in this analysis is that MindSphere, using politically and economically motivated mechanisms of platformization, exemplifies the platform economy as a new paradigm in capitalism. By directing the reader's attention to the wider political economy of platformization, this thesis aims to make a point of the increasingly influential role of industries outside the tech sector in designing and deploying platform economy mechanisms. In the example of MindSphere one can observe that the platform economy is not only about the emergence of new types of enterprises, operating in accordance to platform business models and displacing competitors, but also about turning traditional companies into platform businesses. With platformization as capitalism’s new paradigm, platforms are emerging “from within”, in the form of structural changes that incumbents undergo.

In the coming two chapters, I analyze the MindSphere platform as an ecosystem taking into account the platform and the actors concentrated around its structure, the dependencies between them and the factors influencing the formation, development and disintegration of these connections. My analytical approach is inspired by van Dijck’s heuristic model of combining the perspectives on platforms as both techno-cultural and socioeconomic structures (2013). These two levels are intertwined and offer a useful vantage point on shifts in technology and society, helping illuminate the phenomenon of platformization and the social, cultural and economic transformations it brings. My analysis is divided into two parts. In this chapter I look at MindSphere from a platform level, analyzing its technologies, user practices and content while in the chapter that follows I

[3] An industrial development plan launched by the Chinese government, aiming at transforming the industrial production in China from manufacturing of low-cost tech goods to one based on modern production systems resting on technology rather than intense human labor (Crawford, 2019).

explore MindSphere as a socioeconomic structure and describe its ownership status, governance, and business model to denote the institutional and infrastructural dimensions of platformization facilitated by Siemens. The analyzed academic literature has a significant share in the creation of this part of the work providing a valuable foundation in interpreting the results of my research.

As this research design seeks to investigate an industrial platform under the conditions of platform economy, my analysis takes into account three characteristic dimensions of platformization, as observed by van Dijck et al. (2019):

- development of data infrastructures which manifests itself in the form of datafication,
- platform governance in which platform organizes not only economic transactions but also platform-based user interactions,
- the reorganization of economic relations around two-sided or multi-sided markets.

The structural elements and the environment of MindSphere are being analyzed in relation to these three above-mentioned mechanisms. Industrial manufacturing, similarly to news, urban transport and hospitality, is undergoing its own transformation towards the platform economy. Siemens, as one of the biggest and well-known industrial conglomerates, provides a good case for investigation of this phenomenon in a brick-and-mortar industry. The first part of the analysis focuses on datafication and platform governance through techno-cultural instruments, while the second part of the analysis highlights platform governance through socio-economic instruments and changes in economic relations around two-sided market. I start with describing the internal structure of the platform and the main technological concepts on which MindSphere's logic rests.

Unpacking the technological dimension

In her multilayered model, van Dijck lists five concepts that allow insights into the technological dimension of a platform: user interface, default, (meta)data, algorithm and protocol (2013). I take a closer look at these objects as they express various dimensions of platformization: datafication, platform governance and the development of a two-sided market. In addition, these instruments, as noted by van Dijck, carry, embedded in their technologies, cultural norms and values which they transfer and reinforce through the platform (2013). The platform, yet, is not only a passive intermediary, but according to the ANT theory on which my thesis leans as well, the platform is a mediator that translates the meaning and elements being transmitted (Latour, 2005). I will now address this view through the analysis of MindSphere's use of technology.

User interface and default as MindSphere's governing instruments

In order to critically examine the platform's affordances and its workings as a sociotechnical artefact, I deployed a walkthrough technique and registered a free user account on MindSphere and connected it to my smartphone.[4] MindSphere can be accessed by choosing one of two subscription plans: MindAccess IoT Value Plan and MindAccess DevOps Plan. The first one is dedicated to industrial users who aim to gather and analyze their machine data and industrial processes via MindSphere. The second option is intended for developers and application providers who want to create and market their own software on MindSphere. Both the first and the second service plan are available from a web browser or in a mobile application. Regardless of which of the plans we choose, access to the platform is provided by the user interface, "a symbolic handle" linking software to users (Fuller, 2008, p.149). This is where the icons of all applications the user decides to download from the MindSphere store appear. (I will return to the store topic in the second part of my analysis). Initially, the user interfaces for both subscription plans look the same, also the integrated set of pre-installed tools is identical and comprises four apps: Asset Manager, Tool Manger, Settings and User Transparency. In the case of the developer subscription plan, the user has access to two user interfaces which originally hold the same four pre-installed apps. Additionally, there are two extra tools available: the so-called Developer Cockpit, designed to register and test applications before they are released, and Operator Cockpit, for running, managing and selling apps. Moreover, the user can download any application from the MindSphere store which will appear on his user interface forming a grid of successive icons, exactly in the same way as we can observe it on our contemporary smartphone screens.

Discussing the architecture of software, Dieter et al. argue that "enquiries into interfaces can tell us not only about the apps but also about the expectations that those interfaces have of users and how certain ideas about users are designed into those apps" (2019, p.4). Their remarks are consistent with the arguments of van Dijck who points out that interfaces "are an area of control where the meaning of coded information gets translated into

[4] Free user account entails limited access to many applications and less data space to be used on the platform. However, such an account still makes it possible to study the main principles of the platform's operation.

directives for specific user actions" (2013, p.31). This is highly relevant with regard to MindSphere, where the main elements of the user interface, the four pre-installed applications

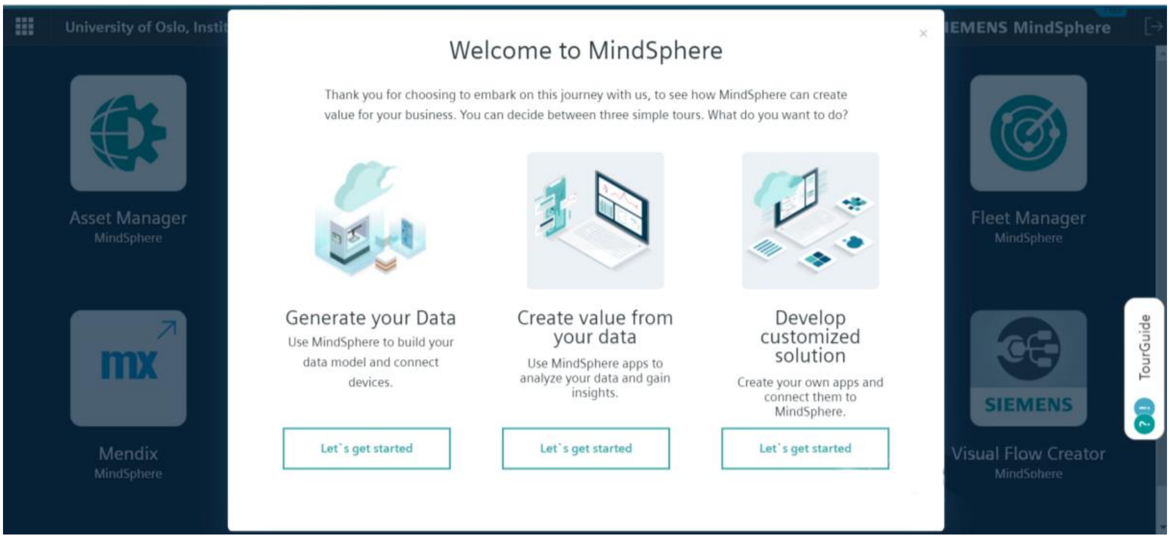


Figure 4. A screenshot of MindSphere user interface. Screen shot from 7.04.2021.

and the developer's / operator's cockpit reveal the basic design affordances, i.e. the desired user types and practices.

The MindSphere user interface represents a perfect reflection of the three desired MindSphere usage models, which the platform provider describes as "user journeys": the first one concerns using the platform to generate data, in the second one the platform is used for advanced analysis of already existing data and the third model serves creating applications and offering them on MindSphere. These three practices are the only modes of use that the platform allows for. And, as in the case of Facebook we can notice that its user interface facilitates connectedness directing users to share information (see van Dijck, 2013), in the case of MindSphere the user interface facilitates dataflow to the platform and production of new applications. In the context of social media, connectedness is one of the main mechanisms eliciting data production, in the case of MindSphere, the data influx takes place by connecting devices to the platform via pre-installed apps. Moreover, it is not possible to delete or remove those apps from the user interface, they are placed there as default. Van Dijck refers to this feature by stating that

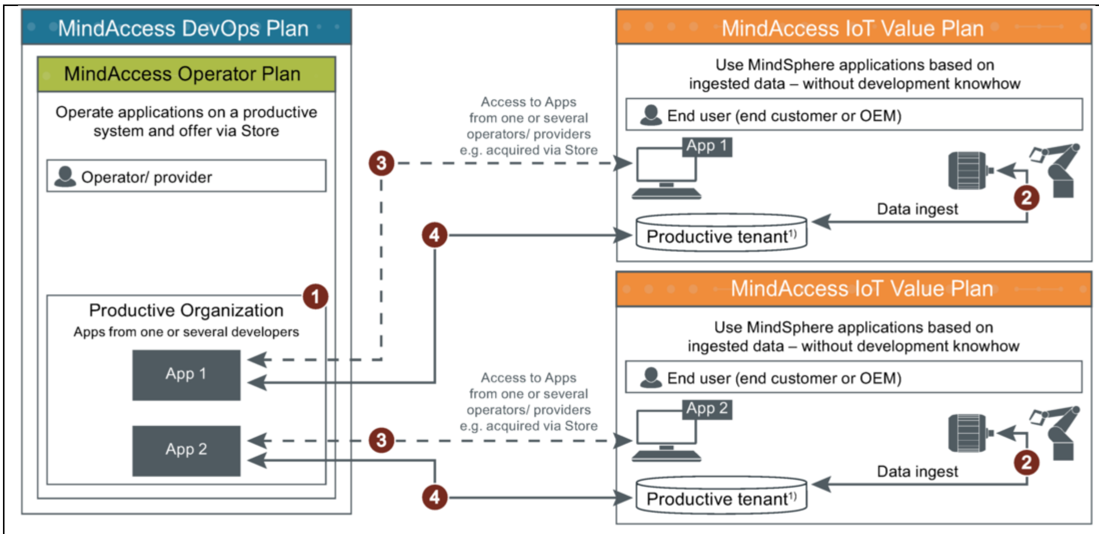
> interfaces are commonly characterized by defaults: settings automatically assigned to a software application to channel user behavior in a certain way. Defaults are not just technical but also ideological maneuverings; if changing a default takes effort, users are more likely to conform to the site's decision architecture. (van Dijck, 2013, p. 32)

Despite attempts, I was unable to remove or change the position of these applications on my user interface. It appears that these four applications are in place not only to make it easier for the new user to get to know the platform, but rather to direct him towards the desired behavior on the MindSphere platform. On the basis of these observations I think it is also reasonable to assume that MindSphere's user interface and default work as governance instruments through which MindSphere steers platform-based user reactions realizing one of the dimensions of platformization.

The industry-driven datafication

Another significant concept allowing for investigation of the techno-cultural layer of platforms are data. Platforms as computational objects are built around data and the development of data infrastructures is one of the main features of platformization.

Data certainly remains the core driver, the heart of the MindSphere platform. A statement which appears in many promotional materials says: "Becoming a digital enterprise in the manufacturing industry means taking advantage of the Industrial Internet of Things (IIoT) to centrally collect, analyze and visualize all data across products, plants, systems and machines" (Siemens, 2018a, p.3). Fourcade and Healy call this drive towards data extraction and collection "data imperative" and argue that organizations are focused on extraction of all possible data, from all sources possible (2017). This industry-driven datafication can also be observed on MindSphere, as the platform offers the Internet of Things as a service which is about connecting industrial assets - production facilities and processes - in order to bring data into the platform. Siemens, being the platform provider of MindSphere, presents it as "open IoT operating system from Siemens that connects your products, plants, systems, and machines, enabling you to harness the wealth of data generated by the Internet of Things (IoT) with advanced analytics." (Siemens, 2018a). As I mentioned in the first chapter, the entire factory, regardless of the industry or type of production, generates data. However, "industrial Internet" and smart factory, smartness and connectivity pose a challenge for industrial producers, particularly for medium and small companies. First, despite the increased number of devices fitted with sensors and growing interoperability, there is a perception that Big Data and analytical tools are expensive and beyond the reach of many businesses. Second, concerns over data security and privacy constitute an additional barrier for digitalization of manufacturing (Thompson, 2015). MindSphere, being a software solution, was launched with the aim to address these challenges (Inauen & Mann, 2019). "MindSphere provides powerful industrial applications with advanced analytics and digital services to unleash increased productivity and efficiency across your entire business", says the sales pitch (Siemens, 2020). Interestingly, MindSphere is not only an offer addressed exclusively to Siemens' customers - manufacturers, system integrators, owners of factories, machines and automation systems, from which all the industrial data stems, but also to the software developers or anyone who has an idea how to productively use the enormous amounts of industrial data. How is this idea put into practice?



1. Operator/ provider uploads App to Store
2. End user buys App in Store (and already has an IoT Value Pack)
3. Route from acquired App to tenant of end user established
4. End user uses App based on ingested data

Figure 5. Interaction between MindAccess Plans. Reprinted from "MindSphereOperator Cockpit" by Siemens, 2021. Retrieved from https://documentation.mindsphere.io/resources/html/operator-cockpit/en-US/108287055243.html). Copyright 2021 by Siemens.

Once a production facility has its digital twin, it can be connected to MindSphere. This can be done in several ways: using MindConnect API, using extensions for third-party devices and services to directly integrate cloud and on premise data. When a connection is established, data starts flowing to MindSphere. According to Siemens' marketing materials, companies wanting to maintain their position in the market have only one option: to take advantage of the amazing opportunities offered by the Internet of Things and analytics (Siemens, 2018a). Otherwise, if they miss "the momentum", they will fall behind and possibly even cease to exist. In order to provide the platform with data from as many different sources as possible, Siemens skillfully uses in its rhetoric the uncertainty and fear of digital transformation, as well as the unpreparedness of many smaller organizations for digitization, thus convincing about the advantages of its platform:

> Companies are struggling with how to start their digital journey and how to leverage digital tools most effectively. The struggle comes in different varieties: the lack of standards and networks of like-minded organizations, determining individual future benefits, the necessary change in mindset, sticking to the proven even in face of disruptive technologies or the challenge to find new business models. It seems that only a few are dealing with this effectively and are really making use of it. (MindSphere World, 2021)

Particular emphasis is placed on informing about the safety of operational data concerning the users' production processes. Yet, organizations that decide to use MindSphere have to send sensitive data concerning their production processes to the platform.

Different categories of data

Now, when analyzing the phenomenon of data, it is necessary to distinguish between operational and personal data processed by MindSphere. Operational data are those generated by technological and industrial processes in organizations using the platform. These can be data from machines such as turbines, pumps or motors and concern physical parameters, e.g. pressure, temperature, power, etc. As a rule, these parameters are monitored in order to measure the performance of devices to monitor user's machine data (e.g. vibration, temperature, speed, acceleration or humidity) and define rule-based alarms to detect anomalies remotely, allowing staff to react faster to issues in order to minimize factory and machine downtime, reduce mean time to repair and repair costs and in the end improve product quality control processes solving problems faster. The second data usage example is to employ advanced analytics and create new knowledge. In both cases, the data in question is production-related and remains the property of the organization throughout the whole subscription period on MindSphere. It is the organization owning the main account on the platform who decides and is responsible for granting applications and users from his organization access to specific data:

> At all times, MindSphere customers own their respective data, which is treated with maximum confidentiality. Customers have full control of access and authorization rights to their data. MindSphere was developed with data security as a top priority: access protection, tenant segmentation and encrypted communications make sure data is kept confidential and protected from manipulation by unauthorized external parties. (Siemens, 2018a, p.8)

In order to protect data against unauthorized access, Siemens emphasizes the use of multi-level security systems and data encryption, in accordance with international standards:

> As the level of digitalization increases, so does the importance of comprehensive security concepts for applications. With defense in depth, Siemens provides a multi-layer concept on security, network security and system integrity as recommended by ISA 99/IEC 62443 and IT Security oriented to industry standard ISO 27001/BSI. (Siemens, 2017)

However, it is worth noting that a completely different type of data is the personal data and metadata that the platform collects and uses to "provide services".[5] This type of data includes information provided by the user, for example, when creating an account on the platform. MindSphere privacy regulations show that: “The Personal Data Processed and contained in Content may include: name, phone number, email address, time zone, address data, system access / usage / authorization data, and any system log-files containing Personal Data or any other application-specific data which Users enter into the Service.” In addition, the platform may collect information about employees and business partners of organizations using its services, i.e. “The Personal Data Processed concerns the following categories of Data Subjects: Data Subjects include employees, contractors, business partners or other individuals whose Personal Data is stored on the Platform” (Siemens, 2018b). When analyzing the nature of these data, we see that they can provide a full picture the platform usage - Siemens is able to collect data on what type of organizations use its platform, what tools and applications they use most often, and for what purpose, and in combination with operational data it allows Siemens to learn about the business strategies of its customers, the MindSphere subscribers. In the terms of use of Siemens Water Quality Inspector Package app, for example, we can read that:

> On aggregated basis with other data and in a form that does not identify you and your Users, Siemens shall own and be free to make Collected Data publicly available to you and others (e.g. for information and industry trends, benchmarking data. Use of Collected Data in accordance with this Section will be at Siemens’ risk. (Siemens, 2020f)

In the Product Sheet and Specific Terms of other Siemens application, SIMATIC Collaboration Board the following entry appears “During and after the term of the agreement, Siemens and its business partners may use Collected Data for Siemens’ own business purposes (e.g. development or improvement of products or services, preparing individual offers for you)” (Siemens, 2020g). After all, data on the customers’ expectations and needs

[5] Metadata are in other words “data about data”, i.e. all additional information relating to the data itself, usually descriptive (e.g. about content of data), administrative (containing technical information, e.g. file type), structural (with information about the containers of data) etc. (van Dijck, 2013).

are a very valuable source of information for marketing activities. Digital platforms allow their owners to collect such data in a very convenient way (see Zuboff, 2020) and MinSphere is no exception.

It should also be noted that Siemens protects itself against potential abuse by users by introducing Special Categories of Personal Data in its regulations, which it defines as

> information revealing racial or ethnic origin, political opinions, religious or philosophical beliefs, trade-union membership, social security measures, administrative or criminal proceedings and sanctions, or genetic data, biometric data for the purpose of uniquely identifying a natural person, data concerning health or data concerning a natural person's sex life or sexual orientation. (Siemens, 2018b, p.3)

Therefore, the platform cannot be used to analyze this type of data: “The Services are not intended for the processing of Special Categories of Personal Data and you and your Authorized Entities shall not transfer, directly or indirectly, any such sensitive personal data to us” (Siemens, 2018b, p.4). Certainly, from the point of view of technology, one could think of tools that make it possible to use such data in an organization, e.g. if an application using algorithms based on this type of data would be launched on the platform. The MindSphere regulations protect the platform owner against such controversial practices.

MindSphere’s multiple uses of data

In the above section I briefly described the process of data obtaining and data categories on MindSphere. I have discussed how the data on MindSphere is collected. However, one should also pay attention to the purposes with which the data is used. Here I will analyze what functions Siemens assigns to the data collected on MindSphere.

Data builds the basis for the functioning of platforms that could not exist without it. Moreover, platforms provide opportunities for capital accumulation for their owners. Sadowski argues that in a data-driven capitalism datafication is a process in which data is a form of capital, not a commodity (2019). He provides a list of five main ways that data is used by platforms to create value. Based on my observation, MindSphere as a data-driven platform uses data in accordance with Sadowski's categorization:

- data is used to optimize systems. Production processes become more efficient by analyzing data that reveal anomalies on machines or other issues within production lines. Interestingly, data can therefore come not only directly from industrial machines but also from devices used by employees. In this sense, data on the MindSphere platform are used, because they come from sensors placed directly on the machines or, for example, from smartphone readings;

- data is used to manage and control things. Data is a processable form of knowledge that can be used to exercise power. The more data MindSphere collects about its customers, the more control it wields over them - the platform through data analysis can gain insights about customer's production quantities and predict demand. This can become the basis for the development of an individual pricing policy, similar to the algorithmic pricing as in the case of Uber (Rosenblat,2018);

- data is used to model probabilities. Typical use of data in this context is the predictive maintenance: “The MindSphere Analyze and Predict packaged solution provides solutions that enable manufacturers to use integrated data sets and modern data analysis to derive deep, predictive insights about asset health and performance” (Siemens, 2019, p.1);

- data is used to build stuff. The whole MindSphere platform is premised on extracting and exploiting data. Also apps offered there would not work without streams of real-time production data;

- data is used to grow the value of assets. “Things like buildings, infrastructure, vehicles, and machinery are depreciating assets. They lose value over time as the forces of entropy – or, wear and tear – take their toll. However, upgrading assets with smart technologies that collect data about their use helps combat the normal cycle of deterioration”, as Sadowski observes. (Sadowski, 2019, p.6). One of the main arguments for using MindSphere is predictive maintenance, which in turn allows extending the useful lives of machines. Physical assets are gaining value instead of depreciating.[6]

However, not only the platform provider can assign different functions to data. Pre-installed applications available on the user interface allow for the collection and analysis of production data, but it is the operator who decides what kind of data will be collected and for what purpose, giving them a specific value, and in turn, the creator of the application writing a specific algorithm for data analysis decides what data and how it will be used by applications. Initially, applications such as Asset Manager or Tool Manager are "empty", there is no data in them, but they allow us to select parameters for analysis. The developer is the creator of the catalog of available options and the operator using a specific application chooses it because it allows him to perform a specific data analysis, it is the operator who knows what analysis he needs. This is due to his expertise, experience and needs of the organization. The SIMICAS Performer Analyzer application available on the platform

[6] Interestingly, these functions of data express the values and norms embedded in MindSphere as provided by an industrial organization: productivity, efficiency, performance, competitiveness, optimization, higher flexibility, quality or innovation.

allows, for example, to analyze Key Performance Indicators (KPIs) measured in turn with the SIMICAS Metrics Performer application which collects data to calculate these indicators. In the description of the application we can read that it delivers “deep insights into Performance, Maintenance and Quality KPIs such as Output, Effectiveness, and Line Through Time through trend analysis, comparisons, data drill-down and customized analysis” (Siemens, 2020b). As we can see, data analysis is tailored to the needs of the application user, he or she decides on the type of data collected to calculate specific indicators. Moreover, the application allows for individual settings: “allows you to compare KPIs chart for different dimensions/perspectives (e.g. the same product but different production lines, the same production lines but different time intervals)” (Siemens, 2020, p.1). From the very beginning, the data is collected by the operator with a specific purpose, serving a specific goal, so we cannot talk about raw data. Lisa Gitelman famously described raw data as an oxymoron. Gitelman aptly observes that

> every discipline and disciplinary institution has its own norms and standards for the imagination of data, just as every field has its accepted methodologies and its evolved structures of practice.(...) Data are not facts, they are ‘that which is given prior to argument’ given in order to provide a rhetorical basis. Data can be good or bad, better or worse, incomplete and insufficient. (2013, p. 7)

As van Dijck argues, “academics looking at data sets from a social science or humanities perspective may pose very different questions than information scientists; and medical doctors are likely to see different patterns than criminologists” (2014, p.202). The food process engineer will likely use the application in a different way and analyze physical parameters other than the construction engineer. Moreover, even people working in the same organization and researching the same productions can use the same data for completely different analyzes. MindSphere as a platform provides a lot of data, but it is up to the operators to evaluate, interpret and use them. It is the operator who decides at the beginning which data he chooses for his needs and how they will be analyzed, interprets the data, gives them meaning even before obtaining the result of the analysis.

Finally, I would like to discuss the challenge posed by a possible combination of industrial data with data derived from human-based actions. The emphasis on MindSphere is primarily on data coming from machines and production processes. Often, however, different industries try to squeeze different types of data through their proprietary applications to realize their own motivations and goals. In fact, any physical object equipped with appropriate sensors can be connected to the platform and generate data. The sensors do not have to be produced by Siemens (Siemens, 2018a). According to Mayer-Schoenberger and Cukier,

> the enthusiasm over the 'internet of things'—embedding chips, sensors, and communications modules into everyday objects—is partly about networking but just as much about datafying all that surrounds us. Once the world has been datafied, the potential uses of the information are basically limited only by one's ingenuity. (2013, "The datafication of everything", paras.6-7)

While there is nothing wrong with analyzing production data, it might be controversial that in the future such data could be combined with information extracted from mobile devices delivered by the organization to its employees. I do not have in mind only data collected to measure employee's performance, but also other data from registering employees online activities during their daily tasks that can optimize production processes. Although MindSphere is a platform intended for business use and the data it operates on comes from industrial assets, we see that it can be combined with data from personal devices as well. MindSphere Mobile Connect application, which allowed me for connecting my smartphone to the platform, processes following personal data: "Information on your interaction with the App, including your device and user identifier, information on your operating system, sites and services accessed during your visit, the date and time of each visitor request, and acceleration data collected by the acceleration sensor of your device" (Siemens, 2020). As Rossiter points out:

> Our everyday activities are monitored and data-mined like never before, though in ways more abstracted and obscure than previously. One thing that particularly stands out in the logistical paradigm is the ways in which labor and workers' knowledge is increasingly transferred to the algorithmic agency of machines and code. (2014, p.57)

Furthermore, such a huge amount of data and hitherto unidentifiable possibilities of compiling information together, leads to the creation of a new type of knowledge, as argued by Andrejevic:

> These forms of knowledge rely upon emergent processes in the sense that their goal is to generate un-anticipatable and un-intuitable correlations: that is, patterns that cannot be predicted in advance.(...)This trove is shaped by the available sensing technology, much of which is, in turn, the result of affordances built into devices, networks, and applications for a range of reasons that might initially have little to do with the goals of those who seek to put the data to use. (2014, p.29)

MindSphere was created as a platform, an operating system that facilitates generating this kind of new knowledge by extraction of business data from all possible computational systems used in an organization. For example, one of the tools, the MindApp "combines data from product lifecycle management, enterprise resource planning, manufacturing execution systems, quality management systems, customer relationship management, IoT and other enterprise data sources into one unified secure data lake for analytics" (Siemens, 2018c, p.2). Companies that do not have the resources to develop powerful databases and analytical tools are the target user group of the MindSphere platform. By using the platform's tools, it becomes possible also for small and medium-sized enterprises to obtain new insights about business processes and become software companies. Platformization embraces more and more sectors of the economy and becomes a new model of capitalism.

Mysterious algorithms

The user interface, default and data represent three key elements shaping the complex MindSphere organism. The remaining two are algorithms and protocols. Bucher describes the algorithm as "as a recipe, understood as a step-by-step guide that prescribes how to obtain a certain goal, given specific parameters" (Bucher, 2012, pp.21-22). The role of the algorithm is to accurately execute the so-called "flow of control", i.e. steps that are to occur at the moment of a specific event. These steps are usually specified by programmers through the programming language. Algorithms are another tool used by platforms to manage platform events and user behavior. Bucher shows that Facebook proprietary algorithms EdgeRank and GraphRank control "visibility" on the platform through data filtering and favoring certain friends, news, items or ideas over others (Bucher, 2012).

One could assume that MindSphere uses algorithms to promote specific applications on the MindSphere Store and prepare recommendations for their industrial customers: "Companies developing applications for MindSphere can market their applications through the Digital Exchange, which offers a monetization and promotion channel to potential customers" (Siemens, 2017,p.14). However, Siemens does not disclose information about the MindSphere algorithms in any corporate materials or developer forums. My analysis of various data sources does not confirm these assumptions. A way of addressing this issue and limitations of the walkthrough method used in this thesis would be a platform analysis using a paid corporate user account. This type of further analysis could illuminate the understanding of the MindSphere ecosystem.

APIs as “protocological objects”

A platform’s computational architecture is also formed by protocols, that is, a technical set of rules governing and data exchange on the network. Alexander Galloway authored the famous term “protocological control” to emphasize the governing abilities of protocols as the rules described by a protocol must be followed in order to participate in online interactions. For example, software developers who want to create applications that run on MindSphere must comply with the requirements specified in the protocols available at https://siemens.mindsphere.io/en/developer. This cooperation, and thus making the platform environment available to third parties, is possible thanks to a specific type of protocological software, applications programming interfaces (APIs). “Generally invisible to end-users, APIs are carefully thought out pieces of code created by programmers for their applications that allow other applications to interact with their application” as defined by Gawer (2014, p.1243). In the coming section I analyze how the relations between data, software and hardware are shaped through APIs.

MindSphere meets the needs of its users by working on data through numerous functions performed by applications. The communication between the platform and the applications in order to create value from the data provided by the platform's customers plays a key role in this process. How does the communication between MindSphere and apps occur? How does the information flow between MindSphere and apps happen? These questions help to illuminate the notion of programmability, which is one of the key concepts in understanding the logic of platforms.

APIs are the technological objects facilitating this process.

> MindSphere offers a wide range of APIs to encourage development that provides a holistic set of IIoT solutions and services, precisely matching the specific requirements of customers. This provides partners with enormous opportunities to build and operate their own digital offerings around MindSphere. (Siemens, 2018a)

The platform itself takes a central position by determining the conditions for sharing data with various applications. MindSphere platform places itself in the center of shaping the processes between the interface, data and applications. Put simply, an app is divided into two main parts: frontend and backend. They are the two fundamental components of cloud computing architecture. Backend being the node.js server running on the cloud and frontend being the html, javascript or ejs interface that we see on the browser (Borah, 2020). The general purpose of the app is being able to present on the frontend some of the data being stored on MindSphere. When a platform user clicks something on the app, she expects to see some information. This generates an event or a request. Frontend sends a request to the backend, backend processes the request and turns to MindSphere to read the necessary data from the MindSphere database. Through the MindSphere application programming interface (API) backend takes the data, sends it to the frontend and displays it. This is how the standard process of app cloud communication takes place. Generally speaking, APIs are software components that enable access of one software component to the resources of another component (Bucher, 2013, p.4). In the case of MindSphere APIs, they provide applications running on the platform with access to data collected by various connectivity devices. Following in the footsteps of many other platforms, MindSphere offers access to APIs as a way to increase the expansion of its offer, and thus the range of the platform:

> (...)customers can deploy software applications in hours or days versus weeks and months. It allows developers to refactor existing monolithic solutions into modular components/applications to offer customers much more flexibility and tailored functionality, as well as faster and more cost-efficient updates and agile development approaches. MindSphere provides developers with a wide variety of APIs, which can accelerate application development and considerably reduce its costs (Siemens, 2018a).

An example would be a situation in which a wind farm manager would like to collect data from wind turbine sensors. On the MindSphere platform, there are applications that enable collecting these data. The manager implements the application which uses the MindConnect API for uploading the data to MindSphere ("MindConnect API", 2021).

App developers employ not only application programming interfaces (APIs), but also a variety of third-party data and developer tools, such as software development kits (SDKs), and integrated development environments (IDEs). As Mackenzie points out, by using these tools platforms become programmable and " enroll many actors in the networked, heterogeneous engineering of connection." (2019, p.1989) But most of all, the sharing of this data takes place under strict platform control and in a controlled manner. Therefore, I agree with the approach to APIs as objects of power. It is the owner of the platform who determines the detailed specification, e.g.

> The MindConnect Service exposes an API that enables shop floor devices to send data securely and reliably to MindSphere. It allows custom applications (agents) to collect and upload data which shall be stored and used by applications in the cloud.(...) For accessing this service you need to have the respective roles listed in MindConnect API roles and scopes. ("MindConnect API", 2021)

It corresponds with Gerlitz's et al. assertion that "platforms enact their programmability to decentralize data production and recentralize data collection" (2015, p. 5). Firstly, the open platform model and data sharing through APIs, and secondly, the sharing rules set by MindSphere indicate that the platform controls the course of these processes. In the case of MindSphere, the number of API calls - requests sent from an app - depends on the subscription plan. As Bucher notes, "software companies adopt different kinds of openness, for different reasons, at different points in time. More than anything, an APIs 'openness' is relational, meaning that it needs to be considered as a negotiation between the various actors involved" (2013, p.7). Finally, by imposing rules on the appearance and design of applications, as well as control of access to data via APIs, platforms make the applications available in their stores, as noted by the above-mentioned researchers "embedded or 'sunk' into other (already existing) structures and systems, which activities and practices it supports, and when certain aspects of the infrastructure which are normally invisible, become visible" (Gerlitz et al., 2019, p.2).

Apps - a specific type of content

Another element mentioned by van Dijck in her multilayered model for platform analysis is content. As she rightfully observes, content forms „a constitutive element in social media, (...) enhances connectedness between people and also helps many acquire a (global) stage for public viewing" (van Dijck, 2013, p.35). MindSphere is not a social media platform and it does not facilitate contacts between users in the same way as, for instance, Facebook. Yet, in my view, connectedness between platform users is established by the availability of applications, provided by the platform through its app store. If a new application is released on the platform, industrial users are notified that there is a new tool in the store, perhaps interesting for them from the point of view of their business needs. As observed by Gerlitz et al., „apps can serve as testing grounds for platform innovation which negotiate users' needs while aiming to intensify engagement" (Gerlitz et al., 2019, p.14). Various applications, apart from analyzes resulting from the production monitoring and operation of industrial systems, are a specific type of user-generated content that triggers and maintains user activity on the platform. Therefore, in the next sections, I will focus on applications as a form of content that is characteristic of MindSphere.

The common feature of the food process engineer and construction engineer and all other MindSphere users is that each of them will use various applications available in the platform environment. In fact, applications play a key role in the process of using MindSphere. As Wade & Ellis claim:

> Each phase of capitalism has a corresponding and identifiable ‘ideal-type commodity form’ that embodies the most powerful economic, technological, and cultural forces at work at any given historical instant. (...) We argue apps represent an ideal delivery mechanism for what we are calling *mundane software*: software that spreads out beyond the computer and into a vast range of everyday routines and activity. (...) The favourable economics of production and distribution behind apps, as well as the variety of devices to which they can be extended make apps a particularly effective commodity form for presenting, distributing and using mundane software. (2015, p.65)

Applications are ubiquitous and accompany most of us in our everyday routines, often even imperceptibly. MindSphere’s provider seems to take advantage of these trends by organizing the two-sided market with applications as its central product. According to Gerlitz et al., “the world’s largest, multi-billion dollar businesses (e.g. Google, Facebook, and Uber), as well as entire market sectors (e.g. social networking and communication, urban transport, gaming, and news), have become significantly dependent on mobile apps and distribution channels” (2019, p.2). This phenomenon of “appliancization”, as touted by Zittrian (2008), can also be observed on MindSphere. Dissemination, availability and a large selection of applications is an important matter from the platform policy point of view. MindSphere provides data and tools for anyone who decides to subscribe to the platform and create proprietary applications that foster innovative use of offered data. Apps realize the programmability of the platforms. According to Andreessen,

> definitionally, a ‘platform’ is a system that can be reprogrammed and therefore customized by outside developers—users—and in that way, adapted to countless needs and niches that the platform’s original developers could not have possibly contemplated, much less had time to accommodate. (2007a)

In one of Siemens' documents we read:

> Applications can be developed and tested in MindSphere for you and your end customer. In addition, you can open up new revenue streams and service models by deploying the application to a production environment. You can also leverage the MindSphere ecosystem to distribute your application to your customers and partners. (Siemens, 2018c, p.2)

Every user of MindSphere has access to the MindSphere store where he can search for applications of interest. Creation and coordination of network effects and multi-sided markets is built around applications. (I will discuss this in more detail in the next chapter, analyzing the governance of the platform. In this part, I would like to focus on the applications themselves as technical and cultural objects.) The platform decides not only about the fate of applications available in its environment but imposes rules for creating applications, before even the finished product appears on the platform. MindSphere determines, for instance, the desired visual form of an application by publishing the so-called MindSphere Design System which describes the entire visual identification system for the MindSphere:

> The MindSphere design system is a collection of patterns, best practices, and products to support you in developing web applications with a cohesive and consistent MindSphere look and feel. The design system is meant to be used by both designers and developers. ("MindSphere Design System", 2021)

At https://design.mindsphere.io/ we can find a detailed description of the design rules preferred for applications intended for distribution on the MindSphere platform. A software developer can also download ready-made graphic elements such as MindSphere OS bar, MindSphere icons and style sheets, e.g. CSS framework so that his application takes on a "look and feel" of MindSphere. Importantly, there are also rules for application icons that clearly distinguish the applications created by Siemens from those created by third-parties: "The design of your App icon must be distinctively different from the design of icons used by Siemens as part of their Services (e.g. Asset Manager, Fleet Manager, Settings)" ("App Icons", 2021). As MindSphere provides third party applications but does not take the full responsibility for their operation and their use of operational data provided to them by customers, it is important that these third party applications are clearly distinguished from applications developed by the Siemens team. The rules for building an application interface such as the appearance and placement of various graphic elements, as Dieter notes, express "expectations that those interfaces have of users and how certain ideas about users are designed into those apps" (2019, p.4). In a similar vein Wade Morris & Elkins note that "developers must adjust their applications to suit the aesthetics of each store and to account for the particular affordances that occur across devices (e.g. smartphones, tablets, game consoles, TVs, etc.)" (2015, p.78). One of the rules that MindSphere imposes on software developers is the obligation to integrate the MindSphere OS bar in the upper left corner of the application's user interface. The name of the specific application is displayed on the bar and a click on it redirects the user to the main desktop of the platform. By clicking on the MindSphere logo, the user opens a drop-down menu containing information about the current version of the software, copyright information, and external links (e.g. for the MindSphere

Store, MindSphere Status or MindSphere Academy). This bar also displays downtime announcements alerts in different colors.

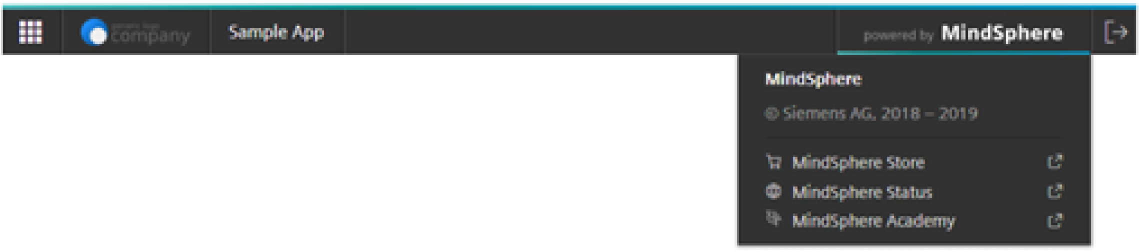


Figure 6. The MindSphere OS Bar, example of the drop-down menu. Reprinted from "MindSphere OS Bar" by Siemens, 2021(https://design.mindsphere.io/osbar/introduction.html. Copyright 2021 by Siemens.

According to Gerlitz et al., "the app is best seen as a layer within a larger computing stack, which not only serves as an interface between a user and its environment but also especially serves as an interface to cloud-based services and larger databases" (2015, p.7). Communication between the application environment and the platform takes place through the menu bar, with its help the user can leave the application and return to the level of the MindSphere user interface. Again, integrating this menu bar into each application allows shaping, automating user behavior. On the one hand, third party applications must be clearly distinguishable from native Siemens' applications. On the other hand, however, all applications must be visually coherent in order to create a professional image of the platform, evoking users' trust. Visual mess, chaos and randomness will not work in favor of the platform.

MindSphere users: Citizen developer

In the above paragraphs I have described various forms of platform governance through its technologies and content. Users and usage constitute another element in the socio-cultural layer of MindSphere. I think it is worth considering what impact its users have on the platform. How do they shape the platform? „To what extent are users empowered or constrained by platforms?", asks van Dijck (2013, pp.32-33).

On the one hand, the application development rules are intended to give MindSphere control of these applications and provide the platform with a consistent uniform, professional appearance. On the other hand, they perform another very important function from the point of view of the platform's development and growth. MindSphere uses a very interesting user empowerment tool in order to develop its ecosystem. Namely, they allow and even facilitate the development of applications by people who are not professional software developers. In order to be able to do anything with the data, an operator on MindSphere should search for an appropriate application or create one. As mentioned before, only through applications is the user able to work with data and use the platform's analytic tools.

Some companies have very specialized tasks and may need special analyzes. Such applications are not always available on the platform. Siemens, having many years of experience with customers, believes that it is the customer who knows best what tools they need. The problem is that engineers and people involved in industrial processes are not programmers and although they know how to solve a given problem, they do not have programming skills. To enable customers to develop applications for themselves, Siemens provides the Mendix platform as part of their MindSphere infrastructure. Without going deep into technical details, Mendix is a platform that allows non-programmers to create their own software solutions using the so-called visual development framework which is based upon creating graphical models depicting the operation of a given application, in other words a framework based on business process diagrams. Users who have no programming experience at all are referred to as citizen developers (“Citizen Developer”, 2021).

To use this tool, we need to open the Mendix application on MindSphere. Siemens advertises for the advantages of this solution: “Mendix uses low-code technology to enable fast and easy app development. Using drag-and-drop components and model-driven logic, non-technical developers with domain knowledge are able to build an app without writing code” (Raise your low-code expectations, 2021). The integration of the Mendix tool is the next stage of the platform’s expansion strategy. The use of a low-code tool is aimed at stimulating the development of MindSphere by enabling an increasing number of users to create applications in an easy way. The platform growth is guaranteed only by an increasing user base. Robert Bodle rightfully points out that “opening APIs was considered a sustainable business move to encourage the growth of a supportive ecosystem of third-party developers, which could increase the value of a platform or web service” (2013, p.325).Van Dijck argues that “a large, active, and demographically interesting user base is usually a platform’s most precious asset. The value of a social media company is often articulated as value per customer—a price that is often speculative and always volatile” (2013, p.36-37). This observation also applies to MindSphere, although it is not a social medium. Currently, the next step in this direction is the ability to create applications, also by those who have never written code but have experience in other fields, allowing them to solve problems. Siemens

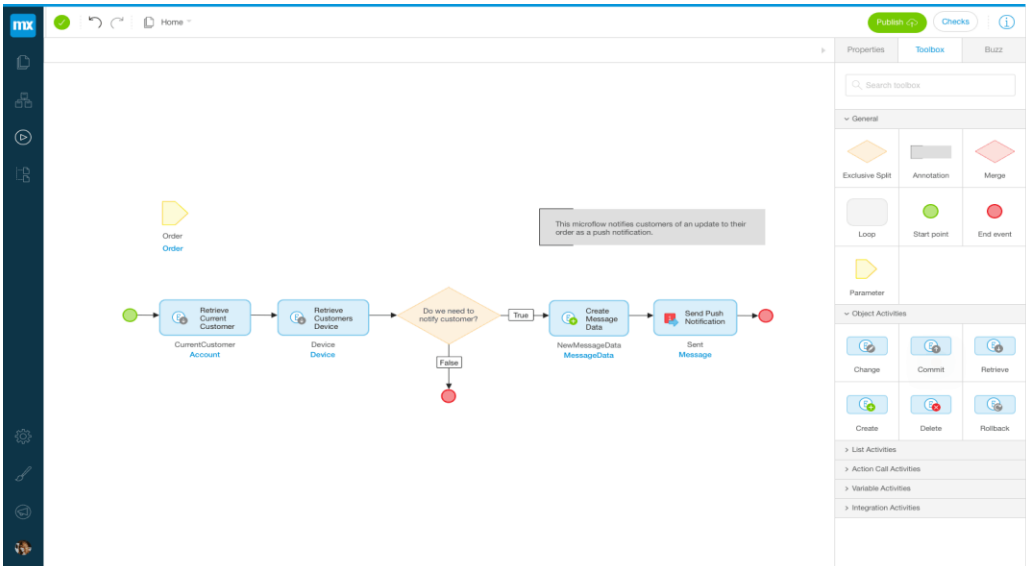


Figure 7. Mendix visual development environment. Retrieved from https://www.mendix.com/collaborative-visual-development/. Copyright 2021 by Mendix Technology BV.

management is open about this. Barbara Humpton, President and CEO of Siemens Corporation noted in an interview:

> I'm going to say Siemens' future is where my focus is. Because across Siemens, you think about this really complicated physical hardware that we're putting out into the world, and often it comes with user interfaces [where] the expectation is the person who's going to be operating this machinery is an engineer. Well, what if they weren't? What if there weren't enough engineers to operate all of this? (Martin, 2019)

A similar problem was raised by Tony Hemmelgarn, CEO of Siemens PLM Software: "Enterprises can 'make with more' because the platform helps conquer the significant challenges and bottlenecks around software development. There simply isn't enough software development talent to go around" (Sendler, 2019). So, it is enough to use Mendix, download from Siemens website the appropriate files containing packages with graphic styles and interface elements and the application is practically created by itself. These approaches are described by Wade Morris & Elkins:

> App stores and the various app-building programs (e.g. AppMakr, iBuildApp, Good Barber, AppMachine) that allow users to design their own apps with little or no knowledge of programming all preach a rhetoric that anyone can build an app, distribute it and find fortune in doing so. (2015, p.73)

According to IT analyst company Gartner, by 2024 more than 65% of all applications will account for low-code applications. In the same period 75% of all large corporations will use low-code development tools in both IT application development and Citizen Development (Wong et al., 2019). Parker et al. predicted in “Platform Revolution” that

> Internet-centered companies like Google *and* Apple are designing interfaces and operating systems that will enable both technology experts and ordinary people to have easy access to the Internet of things and use it in countless ways we’re only beginning to imagine and explore. (2016, p. 170)

Currently, not only technological giants introduce solutions that change markets towards the concentration of all activities being based on IT solutions. Siemens on the example of the Mendix platform confirms and implements this scenario, giving ordinary people the ability to create applications and write code to develop the MindSphere platform.

In this chapter I aimed to answer the questions “How do the mechanisms of platformization play out in MindSphere’s technologies, content and user practices?” I have sought to explain its techno-cultural layer i.e. user interface, data, applications, APIs and code as elements that have power to direct conduct and shape relations between users and the platform, humans and nonhumans. My argument is that the platform, through the illustrated tools, aims to govern interactions taking place in its environment. MindSphere is the focal point that facilitates the organization of work and all processes in the manufacturing. The platform, however, adjusts its features and solutions to the needs of users, their preferences and social trends. I believe that introducing the platform to the industrial market on such a scale would not have been possible without the customers being familiar with digital media, smartphones and apps. Now, the industrial production sector is increasingly based on data. Consumption, work, and information flows take place through platforms that create and make available tools facilitating industrial processes, while at the same time making organizations using these services dependent on them.

In the next chapter I proceed with my analysis of platform mechanisms and turn to the socio-economic dimension through which MindSphere operates. While in this chapter I analyzed the technology and models of the platform’s usage, the next chapter will focus on the ecosystem that is created through and around MindSphere, i.e. on the environment of the platform, the infrastructure on which it is based and its partners. Having discussed the technological elements that build the platform and the mechanisms of their operation, I will also analyze the external environment of the platform and the relations it forms.

7. MindSphere's socio-economic dimension

In the previous chapter I referred to MindSphere as a techno-cultural structure and discussed the phenomenon of platformization through MindSphere's technology, content and usage. I now wish to investigate MindSphere as a socio-economic object, and in particular focus on dimensions of platformization expressed in MindSphere's business model, governance, ownership and its ecosystem.

PaaS business model: platform as a service

The advent of the Internet and online platforms has brought about a shift in the cultural and media industry sector from offering products to offering services (van Dijck, 2013). Currently, this trend can be observed in an increasing number of sectors of the economy. Software companies in particular prefer this business model - generating corporate revenue is no longer based on selling software licenses but on charging fees based on consumption, as is the case with utility suppliers who charge for water or electricity (Chung, 2021). More and more often we come across the expression "XaaS" or "anything as a service", which refers to the vast number of products, tools and technologies that are delivered to the user via the network. The most common examples of XaaS are: Software as a Service (SaaS), Platform as a Service (PaaS) and Infrastructure as a Service (IaaS) (Bigelow, 2017).

The industrial manufacturing sector is also shifting towards this business model. It has become possible, among others, thanks to the development of the Internet of Things and cloud computing. As Srnicek notes, "the IoT enables every good to be turned into a service that charges by the use: cars, computers, doors, refrigerators, toilets" (2017, p. 82). Also according to Siemens, organizations determined to join the MindSphere platform "can develop digital services and innovative new business models focusing for example on predictive maintenance or pay per use." (Digital Industries, 2021). MindSphere itself and all platform-related services are therefore an example of business focus on service delivery. They also support other industrial organizations to implement this model - MindSphere platform is platform as a service (PasS) that "builds upon the typical PaaS to enable customers to develop, run and manage their applications without the cost or significant effort of building an infrastructure or managing complex, rapidly changing software stacks"

(Siemens, 2018a, p.9). MindSphere's task, one could sum up, is to offer specialized services for a fee by means of providing technical infrastructure.

Through this business model, based on the provision of services, the platform provider has constant, regular contact with clients - platform users. Contact is not limited only to the sale of the product once in a few years and then service support. The provision of specialized services takes place through the platform, which plays a key role in enabling interaction between users and ensures the implementation of the service. The process of platformization is reflected in the fact that all user interactions are platform-based and take place over the network.

Moreover, MindSphere not only provides specialized services based on data, but also creates an entire portfolio of services complementary to the platform to develop its ecosystem. An interesting example of such a service related to MindSphere, and thus the implementation of the strategy of attracting new users to MindSphere, is the Learning as a Service offer. These are courses offered by Siemens for both end customers and developers where the attendees can learn the platform's features to analyze production data or create new applications. Siemens advertises for the service on the company's website:

> Our Learning as a Service membership contains training videos, knowledge checks, hands-on labs and exercise files for users and developers of MindSphere. Users will learn more about core components offered by MindSphere. Developers will learn how to connect assets, develop applications with no/low code or traditional development, and use MindSphere capabilities to analyze data. (Develop your MindSphere Skills, 2021).

This service points to another aspect of platformization, namely the multi-sided market building process, as the platform functions as an "aggregator of transactions" between end users, software developers and platform architects (van Dijck, 2019, p. 7). It also creates another group of users focused around MindSphere - instructors, highly skilled employees, platform architects who design and maintain MindSphere's infrastructure (Vallas & Schor, 2020).

Freemium subscription model

The use of MindSphere is based on the so-called "freemium" subscription model. This model was introduced in 2006 by Flickr, as one of the first platforms in the ecosystem of connective media (van Dijck, 2013). Interestingly, the paid model of the platform is an exception when we look at social media, search engines or platforms that offer B2C services. As van Dijck writes: "It is very difficult to reverse this business principle on which the ecosystem was built, now that most users have become used to ‘free’ content" (van Dijck, 2013, p.170). We need to remember, however, that MindSphere is a B2B platform, data collected are owned by industrial users, and the platform does not collect user personal data. That is why the platform is monetized in a different way: MindSphere operates as a software service provider and that is what the user pays for. Van Dijck rightfully observes that “platforms try different models in response to other players in the ecosystem while also experimenting to find out how much intrusion of their online social space users still find acceptable." (2013, p. 41). For MindSphere end customers there is no place for intrusion such as the use of their operational data without their explicit consent. Business relationships in this case are based on trust and data security. Access restrictions to this data play a key role, especially in the environment of fierce competition from other platforms in this sector.

In order to gain access to MindSphere, end customers and developers set up an account on the platform. There is a free account option, the so-called Start for free, but it has much more limited possibilities compared to paid accounts. Yet the free subscription allows, as the name suggests, to try out the platform's functionality before opting for a paid subscription, rather than to use it productively as a business tool (Siemens, 2021). MindAccess IoT Value Plan is a paid subscription plan for end customers that offers three variants: Small, Medium and Large. The subscription period is one year and the monthly price for the Medium plan is £739 (MindAccess IoT Value Plan Medium, 2020). All three subscription plans differ in the limit of users, devices and data to be used per month under the contract.

For application developers, MindSphere offers the MindAccess DevOps Plan which allows for accessing platform data in order to create, test and distribute new applications. Here MindSphere also offers three subscription categories: S, M and L. They differ in the number of applications that can be published monthly on the platform (1, 5 or 10) and the number of developers / test users (10, 50, 100) that can create and manage applications (Siemens, 2020e).

By creating separate offers for industrial end users and software developers, MindSphere reorganizes economic relations around the two-sided market. This strategy, as

MindAccess IoT Value Plan – Size Overview

	Small	Medium	Large
Productive tenant	✓	✓	✓
Access to the Store	✓	✓	✓
Fleet Manager incl. rules and events[1]	✓	✓	✓
Users	50	150	500
Subtenants	10	40	80
Asset types	5	10	50
Asset instances	50	250	1 000
Connected agents[2]	10	25	100
Data ingest rate[3] (time series)	2 KB/s	10 KB/s	100 KB/s
Time series data storage[4]	60 GB	300 GB	3 TB
Data ingest via MindConnect IoT Extension[4] per month	5 GB	5 GB	5 GB
File storage	50 GB	100 GB	500 GB

[1] Limited use of rules and events; one active concurrent rule included in all Plan sizes; [2] Agents connected to MindConnect IoT Extension are not counted; [3] Based on number of assets, number of variables per asset, size per variable, read cycle interval, sending frequency and overhead. The shown values of KB/s are based on an example use case for Plan size M: 200 assets with 10 variables each sending frequency 10s, 20 assets with 100 variables each sending frequency 10s. Further assumptions: 50 Bytes per variable including transport layer overhead – data type float as provided by MindConnect Nano, IoT2040 and S7-FB, read cycle equals sending frequency; [4] Data Volume ingested via MindConnect IoT Extension is included in time series data storage.

Figure 8. MindAccess Value IoT Plan overview . Retrieved from mindsphere.io/terms. Copyright 2021 by Siemens.

noted by Petrik and Herzwurm, is also due to the fact that most of the large industrial concerns, to which Siemens belongs, do not have sufficient resources and expertise "to cope with the functional heterogeneity of iIoT". For this reason they create open platforms to attract to the platform third parties that would bring with them invaluable knowledge and skills (Petrik & Herzwurm, 2019, p. 46).

MindSphere Store

In addition to the monthly subscription fee, another way to monetize the platform is the MindSphere Store. Siemens charges fees both for the use of its proprietary applications and for offering third party apps. In the case of MindSphere, the app store has several important functions. The first is the implementation of a paid user model and monetization of the platform in the form of paid applications (which can be offered by both Siemens and third-parties). Application prices vary widely and the fee is fixed, charged monthly on an annual contract or on a pay-per-use basis, depending on the amount of data used by the application

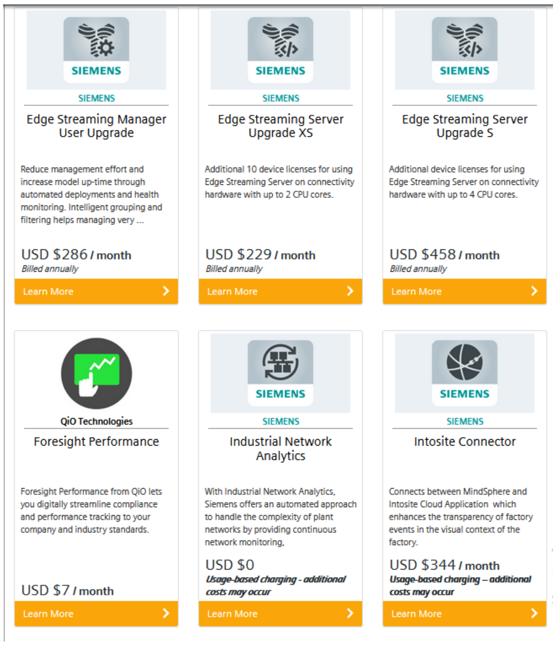


Figure 9. MindSphere Store sample app prices (retrieved from https://www.dex.siemens.com/mindsphere/Applications. Copyright 2021 by Siemens.

(Applications, 2020). The second function of the store is to support the development of the multi-sided market as both industrial users and software developers can offer their products in the app store. Applications that appear in the store can also be promoted by the platform and recommended to specific end customers: "Partners can promote their MindSphere applications, while MindSphere customers benefit from numerous available applications and services that address their toughest challenges" (Siemens, 2018a, p. 22). In this way MindSphere triggers user-interactions. The third function of the app store is the platform governance. App stores are, as Helmond notes, “a 'censored marketplace', choosing centralized app distribution, curation, and billing" (Helmond, 2019, p. 6). Also according to Dieter et al. “App stores function as key gatekeepers— or as ‘obligatory passage points’, which set the rules for how applications can be created, criteria, and search and distribution” (2019, p. 2). Therefore, application developers wanting their products to be on the platform must adapt to the guidelines and rules specified by the platform provider and expressed in terms of use. Plantin describing platform properties argues that

> independent developers benefit from the platform's code base, large audience, and marketing power. Meanwhile, the platform builder reaps profits due to increased buy-in (or lock-in) by both sides. (...) The platform remains a centrally controlled and designed system (often under corporate control), but benefits from the innovations of a large penumbra of third-party developers. (2018, p.299)

I argue that the same argument could be applied to the MindSphere store and the whole platform in general, as the platform provider actively promotes MindSphere among software developers and customers while at the same time the platform remains a controlled environment imposing its own rules.

Network effects and platform lock-in

As shown in the above presented examples, MindSphere bases its operation on building a multisided market, which is one of the dimensions of platformization. Platforms in general match producers with consumers creating value for all users of the platform. As different platforms develop, new groups of users appear, e.g. advertisers, producers of complementary goods, e.g. property management companies commissioned by owners on Airbnb. (Your Home is in Good Hands, 2021). MindSphere is also growing by creating positive network effects (see Parker et al., 2016; Langley & Leyshon, 2017). But the process also has its unintended negative consequences. By definition, platforms function to dominate the sector they operate on - many platform researchers mention the so-called "winner takes all" effect (Dean, 2009; Srnicek, 2017; Gawer & Cusumano, 2014). There is a risk of the formation of monopoly markets as platforms make it costly and burdensome for companies to opt out once they have entered a given platform's ecosystem (see Dube et al., 2018; Khan, 2017). As Plantin claims, "achieving lock-in is among platform builders' principal goals" (2018, p. 298). This pertains especially to the industrial manufacturing industry, where many companies have been cooperating with one supplier of components for years and the entire production is based on a standard known and used for many years (Paranikas et al., 2015). By investing in the development of the MindSphere platform, Siemens aims to transfer to the platform the highest possible number of its customers, suppliers and other stakeholders (Petrik & Herzwurm). Competing organizations are also taking similar steps and developing their own platforms, so the number of iIoT platforms is rapidly growing.

However, experts predict that the iIoT platform ecosystem will be dominated by a few of the largest global organizations operating across industries (Graff et al, 2018). Moreover, each of these platforms will create its own closed ecosystem. As Srnicek claims,

> the field of industrial platform is also almost certain to resolve into a series of enclosed spaces, as Siemens and GE are unable (and unwilling) to communicate with each other. Manufacturers will be locked into whichever ecosystem they choose. This is particularly important in terms of intra-capitalist competition: as non-platform companies are forced to use platforms to continue their business, a divide will grow between these two groups. (2017, “Great platform Wars. Tendencies”, par.10)

That is why Siemens facilitates and promotes advanced technology, analytics and artificial intelligence available on MindSphere. End users who start using these tools gradually make their industrial processes dependent on the platform. If a company wants to resign from the platform, it must take into account techno-economic hurdles not only in the form of financial costs resulting from the subscription, but, most of all, the loss of the entire networked data generated by MindSphere.

Governance

As van Dijck rightfully points out, “to analyze the governance structure of a social media site, one needs to understand how, through what mechanisms, communication and data traffic are managed” (van Dijck, 2013, p. 38). Governance has already been mentioned in the previous chapter when introducing technological governing instruments such as user interface, defaults and algorithms, as well as in relation to the MindSphere Store. However, there is one more important socio-economic tool that also regulates communication and data traffic on a platform. This is the platform's policy expressed through end-user license agreements (EULAs) or terms of service (ToS) (van Dijck, 2013). These documents do not constitute law, yet they impose on the users restrictions and obligations specified by the platform provider. The next section investigates how MindSphere uses this tool for its platform governance.

Terms of service and end-user license agreements

What specific rules apply to a particular MindSphere user depends on the role he takes on the platform, that is, on the user's account type. As previously mentioned, MindSphere offers a free Start for Free account, paid accounts for the end customer (industrial operator), MindAccess IoT Value Plan, and accounts for application developers - MindAccess IoT DevOps Plan. MindSphere precisely specifies the rights and obligations of each type of user. Different rules apply to end customers and to software developers. Moreover, under one user account, user can create numerous sub-accounts and grant their operators different rights, e.g.

> The user rights depend on the following user roles: OperatorAdmin, TenantAdmin. The 'OperatorAdmin' role should be assigned to an operator, in order to access 'Operator Cockpit' and perform all operations on the applications. A user having 'StandardUser' role as a standalone role will neither be able to access 'Operator Cockpit', nor perform any operations on the applications. (User Rights in "Operator Cockpit", 2021)

All ToS are available online and apply to all elements that create the ecosystem of MindSphere. There are, for instance, separate rules that apply to software and services related to MindSphere (these are collected in a package of documents under the name MindSphere Terms and Conditions). Additionally, separate rules apply to elements ensuring connectivity with the platform, i.e. hardware. These are specified in the documents under the name MindConnect Terms.[7] Moreover, each application offered through the MindSphere Store has its own terms of use (Siemens, 2021b).

According to van Dijck, "most terms of service include clauses about the platform owner's right to use or sell (meta)data provided by users; few terms of service define the rights of users to access their data" (van Dijck, 2013, p.38-39). The analysis of MindSphere ToS shows that, indeed, according to van Dijck's argument, not all of them contain information on the use of operational data and rights to data during and after subscription termination. However, each regulation contains the so-called "Security Information" that states: "In order to protect plants, systems, machines and networks against cyber threats, it is necessary that you implement and continuously maintain a holistic, state-of-the-art industrial security concept" (Siemens, 2021b). This formulation takes us away from the virtual world of data and reminds us of a real-world factory and physical items connected to MindSphere via various connectivity devices. After all, plant operators must protect the systems from unauthorized access if MindSphere is to be a secure online environment. Platform security at its most basic level comes down to controlling access to the data sources. Through the above quoted formulations, Siemens as a platform provider transfers the responsibility for access to data to the owner of data-generating resources and forces him to use solutions that meet certain security standards.

MindSphere's work arrangement

Because platformization means penetration of many spheres of life by technological structures and economic processes of platforms, I think it is important to discuss the

[7] For example, the aforementioned Learning as a Service - Siemens is actively developing the platform's ecosystem and for this purpose offers free training and workshops to interested organizations or MindSphere subscribers.

employment relations governed by MindSphere, as an example of platform's diffusion into the social sphere. The social effects resulting from platformization are no less important than the economic effects (such as the risk of the formation of monopolistic markets or lock-in effects mentioned above).

One of the most widely discussed negative consequences is the impact of platforms on work and employment. This issue is raised by researchers analyzing platforms from the point of view of the political economy. A classic example that has been widely analyzed in the literature is Uber. Stark and Rosenblat thoroughly presented the realities of the work of Uber drivers and described how the labor process changes when organized through platforms (Rosenblat & Stark, 2016). While MindSphere is not part of labor-market platforms, it is worth taking a closer look at how the platform governs work arrangements through its terms of service.

Two main groups of MindSphere users that have a direct producer-consumer relationship are the end customers (operators) and the software developers. The developers offer professional services, similarly to platform architects, yet they do not design MindSphere's digital architecture, only its content: applications. Therefore, they are users, in the same way as the end customers. Vallas describes this group as creative projects workers, consultants or freelancers, alongside journalists or graphic designers in social media platforms. From the point of view of the platform owner, Siemens, the developers are not company's employees, even though they create applications utilized by the platform to offer high-quality services to its end customers. Similar to Uber drivers in the case of the Uber platform, developers on MindSphere are referred to as independent contractors. MindSphere ToS state:

> 14.11. Independent Contractors. For all purposes, the Parties will be deemed to be independent contractors, and nothing contained in the MindSphere Agreement will be deemed to constitute a joint venture, partnership, employer-employee relationship, or other agency relationship. Neither Party is, nor will either Party hold itself out to be, vested with any power or right to contractually bind or act on behalf of the other Party. (Siemens, 2018, MindSphere Master Agreement, p.6)

Siemens holds that the developers are independent contractors and not employees. They are neither subject to employment protection law nor eligible for social benefits.

Yet the platform exercises significant control over their labor as the MindSphere DevOps subscription plan regulates the number of new applications that can be transferred to the platform each month. And although each application downloaded from the MindSphere Store generates income for its creators, MindSphere may also affect this process as it regulates store rules. Wade Morris & Elkins openly criticize app stores policies and their economic realities: “this promise of democratized software development is undercut by banned apps and by the economics of app stores, which favour larger companies with a healthy portfolio of software” (2015, p.73) Moreover, research shows that most applications (even up to 60%) are downloaded only once or twice (Lee, 2013). The methods used by Siemens and the relationship between MindSphere and developers are reminiscent of a phenomenon that Kuehn and Corrigan touted as "hope labor" (2013). Providing software developers with access to a large base of potential recipients of their apps, the platform ensures that the work will be carried out in the hope of future potential success. In a similar vein, this approach can be seen in MindSphere's PR and marketing materials formulated in the language of value and benefits (see Siemens, 2017; Siemens, 2018a). Moreover, I believe it is an articulation of a neoliberal ideology based on the free market and deregulation, in the sense that the individual is personally responsible for his own successes and failures, and the need to compete is something desirable and natural (see Elmer & Langlois, 2019, Plantin et al. 2018; Zuboff, 2019). This formal regulation of the status of developers also allows me to assume that on the MindSphere platform the risk related to the lack of interest in applications and the cost of their production are transferred to individual “hope laborers”.

A similar policy can be seen in the regulations regarding the platform's liability towards customers resulting from their use of applications created and provided not directly by Siemens but by third parties, i.e. software developers. Siemens declines all responsibility for the operation of the applications offered in its MindSphere store:

> If you use our Services to access an Application which you developed or which is provided to you by a Third Party (“Third Party Application”), you acknowledge and agree that: (i) any contractual relationship regarding the use of a Third Party Application and any related services or product is solely between you and the provider of the Third Party Application; (ii) Siemens is under no obligation to test, validate, or otherwise review the Third Party Application; (iii) Siemens does not assume any obligation or responsibility with regard to the use of the Third Party Application, its support, or any other related services or products, whether or not they are designated by Siemens as ‘certified’ or otherwise; and (iv) the use of a Third Party Application may enable the provider of the Third Party Application to collect and use Your Content and data regarding a User’s usage of the Third Party Application and/or to transfer copies of Your Content and usage data for the Third Party Application outside the Platform. Siemens shall not be responsible for any consequences resulting from any access to Your Content through a Third Party Application. (Siemens, 2018, MindSphere Master Agreement, p.2)

Not only does the platform treat application developers as independent service providers but it also shifts the responsibility for the decisions made (in this case the transfer of operational data for applications not developed directly by Siemens) to the end customers, expressing neoliberal ideologies.

Based on these observations, it can be concluded that, using van Dijck's typology of platforms, MindSphere represents a sectoral platform: operates in a specific sector or industry, does not own any material assets, does not offer material goods, does not hire sector-specific employees. It is this category of platforms that causes the most controversy and raises questions concerning labor market transformation, public values and precarious work. The characteristic feature of these platforms is the maximization of the competitive advantages through transforming products into services, and services that were not tradable into tradable ones.

Moreover, the platform once again, although this time in a veiled manner, indirectly puts itself in a central position by contrasting its own solutions with those offered by "independent contractors" as potentially safer, more reliable and accountable. Thus, in the terminology of ANT, as an actor, the platform not only enables interactions between platform users but also shapes them.

Ownership and ecosystem

MindSphere is a corporate owner-centered platform launched by Siemens in early 2016 (Petrik & Herzwurm, 2019). In the fifth chapter I shortly presented the history of the platform and platform's ownership status. In this section I will describe how MindSphere, being a private enterprise focused on generating profit and market competition, attempts to build an ecosystem and gain a dominant position in the industrial manufacturing market. For this purpose, it fosters partnerships and user organizations and creates a platform image as a user-centered, community based online space.

Van Dijck argues that in order to illustrate platformization, we need to "move away from imaging platforms as distinct entities, cumulated in 'stacks'" (van Dijck, 2020, p. 4). However, I do not believe that this perception of the platform as a distinct object should be completely rejected. One should imagine and explore the basic structure on which the platform is based, because its structure is important for the subsequent placement of other platform-related organizations in the network. On the one hand, MindSphere represents a designed and hierarchical object consisting of several layers. MindSphere remains, however, also an open system that connects, communicates and changes under the external influence of humans and non-humans. Looking at MindSphere from this perspective, we talk about the platform's ecosystem. My aim is to investigate this complex nature of MindSphere as it allows us to identify mechanisms of platformization working in the ecosystem. I find van Dijck's platformization tree metaphor particularly instructive as a point of entry into this part of my analysis (van Dijck, 2020, p. 4).

Several scholars observe that a platform’s architecture can be illustrated as layered “stacks” manifesting the platform's tendency towards modularity and accumulation (Andersson Schwarz, 2017; Tiwana, 2014; Walton, 2017). MindSphere supports this observation and reflects the fact that “platform ecosystems are organized hierarchically and interdependently” (van Dijck, 2020, p.4). MindSphere’s architecture comprises four “stacks”: field/control stack, edge computing, IoT as a service and low-code platform Mendix. The lowest level or field / control stack refers to machines, factories and systems that generate data. It consists of industrial objects and hardware - devices that ensure connectivity, i.e. data transfer from machines and plants to the network. The second stack, edge computing comprises solutions that allow for storage and analyzing data without sending them outside a given organization. Thanks to this solution, "local data from IoT devices can be preprocessed and sent to the cloud in small packages" (Industrial Edge, 2021).

It is a solution that provides the platform with an offer for customers who want to use advanced MindSphere analytics, but for various reasons cannot send operational data outside their organization. The next, third level is Platform as a Service, i.e. MindSphere virtual environment *sensu stricto*. This level is formed by computing solutions, apps & services. The fourth and last level is represented by Mendix, an environment that allows the creation of applications by people who are not professional software developers. Mendix is available as an application from the user interface after logging into the MindSphere user account. Mendix was a software company founded in 2005 and acquired by Siemens in 2018, as the implementation of corporation’s strategy towards digitalization: “The acquisition of Mendix and entry into the IoT Integration Services business will enable Siemens to rigorously expand its market leadership in industrial digitalization" (Siemens and mendix, 2018).

The combination of these four different levels and functionalities serves to extend MindSphere with as many services as possible that can meet the expectations of very different user groups. MindSphere is not limited to one sector or one type of service. On the contrary, the platform provider attempts to meet the needs of as many organizations as possible and expand the user base through edge solutions, cloud computing and low-code platforms. In this way, platformization penetrates into different economic sectors. Platformization is in this sense a dynamic process of creating relationships and building a network perpetuated by a platform.

As mentioned in the section above, MindSphere can be classified as a sectoral

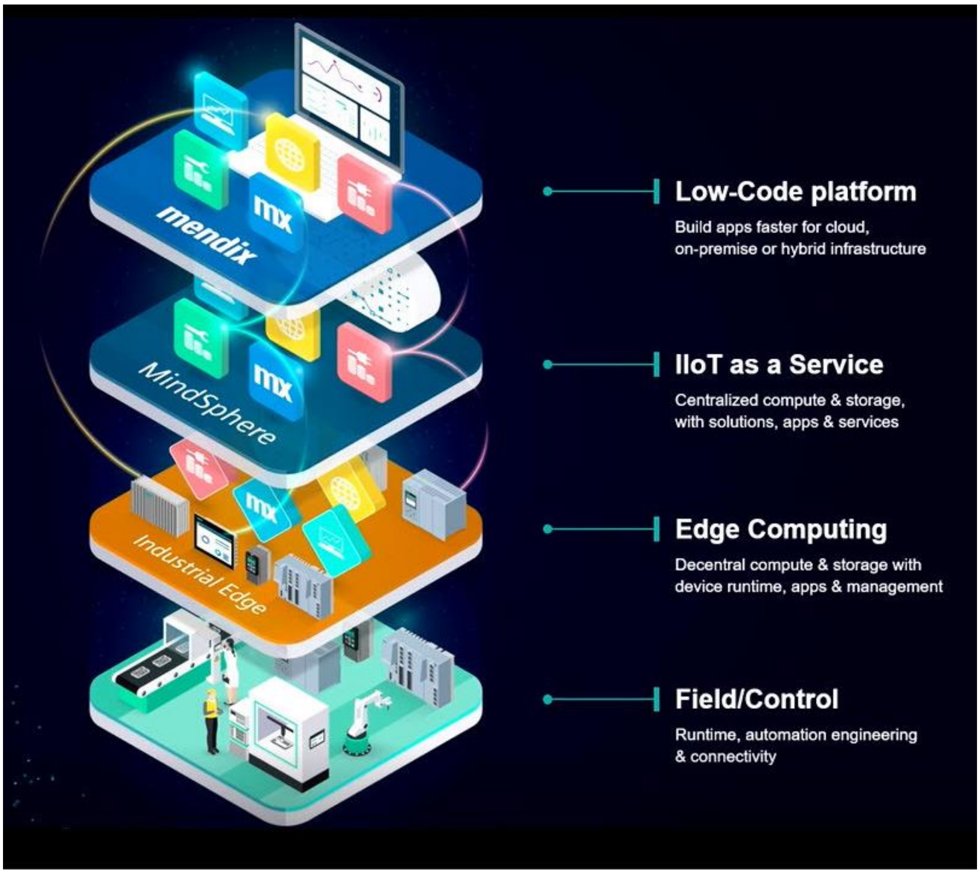


Figure 10. MindSphere's "stacked" architecture. Retrieved from https://ecosystems4innovating.com/tag/build-your-own-platform-as-a-service/ Copyright 2021 by Siemens.

platform. It is also an example of a platform reflecting van Dijck's European platformization tree. Van Dijck argues that platformization "pushes upward, spilling out from the trunk into a wide variety of sectors. A continuous influx of user data happens via the leaves; sucked up by twigs and branches they can be seamlessly transported toward the trunk" (2020, p.8). The components that make up the Field / Control stack, such as hardware in the form of connectivity devices, are at the root level. Then, going up, edge computing connects the roots to the trunk that makes up the MindSphere platform as a service with its analytics and storage. Branches and foliage comprises Siemens proprietary apps and software tools (e.g. Mendix), and third-parties apps. As observed by van Dijck:

> The branches represent the sectoral applications which are built on platform services in the intermediary layer (trunk) and enabled by the digital infrastructure (roots). The numerous branches of the tree represent the many societal sectors where platformization is taking shape. (2020, p.7)

In the next section I will take a closer look at different organizations that constitute the MindSphere branches and foliage, creating and maintaining the platform's open and diverse ecosystem.

Partnerships

When discussing the phenomenon of platformization, the entire complex ecosystem of a platform should be taken into account. The most important resource of a platform is a large and diverse group of users. Therefore, it is nothing exceptional among tech giants to take over young, promising companies or competition with an interesting user base. The most famous examples are the takeover of YouTube by Google and Instagram by Facebook (see van Dijck, 2013). Another way to expand the user base is to enter into partnerships which makes databases of both partners mutually profitable. In the case of social media, data generated by user activities plays the most important role in this process. The situation is different in the case of business-to-business platforms such as MindSphere, because corporate clients are very sensitive to what organizations can access to their data (Martens et al., 2020). According to Petrik and Herzwurm, the main goal of Siemens partnerships was not data collection itself, but fostering MindSphere's iIoT ecosystem. Siemens announces in company's corporate materials:

> To address the broad scope and high complexity of digital transformation, Siemens has created a network of world class partners built around MindSphere. These partnerships enable MindSphere to provide a holistic set of IoT solutions and services, precisely matching the specific requirements of our customers, whereas it provides partners numerous opportunities to build and operate digital offerings around MindSphere. (Siemens 2018c, p.3)

Van dijck points out that tracking such partnerships is a difficult task and a challenge because companies defend access to this information as trade secrets (van Dijck, 2013). Data on entered partnerships is only partially disclosed by Siemens, while some partnerships are not disclosed to the public at all (Petrik & Herzwurm, 2019). Petrik and Herzwurm examined MindSphere's ecosystem emergence process through partnerships entered by the platform provider. Their analysis shows that the nature of the partnerships has changed along with the development and growth of the platform (Petrik & Herzwurm, 2019). In the first phase, Siemens focused on cooperation with large consulting companies to promote the platform, in the second phase, it began to focus on software developers - start-ups, as well as software developing companies. Importantly, at this stage of development, Siemens entered into a strategic partnership with Amazon in order to make the platform available on the Amazon Web Services (AWS) infrastructure (Amazon, 2019).[8]

In the last phase, in turn, the platform established partnerships with industrial companies: machine tool, additive manufacturing, automotive and physical IT infrastructure (Petrik & Herzwurm, 2019). All these activities were aimed at promoting the platform, ensuring the influx of users and solving the so-called chicken-or-egg dilemma, i.e. a situation in which neither party would find the platform attractive enough due to the absence of the other side of the market - users offering the desired goods or service (Parker et al., 2016; Cusumano & Gawer, 2015).

The access to platform data plays an important role from the platform partners' point of view. As noted by Martens et al.

> third-party B2B data sharing platforms may be more successful in closed groups with known participants than in open-ended groups of users.(...)The participants are better off when they have negotiated data sharing conditions with each other; they know what they signed up to and who with. (2020, p.30)

Thanks to a partnership with Siemens and the MindSphere platform, partner companies receive access to the customer base, and through applications and APIs also access to end customers' operational data. This process is well illustrated by the Rittal Smart Service app available from the MindSphere Store. Rittal is a manufacturer of data racks and datacenter containers and one of the strategic partners of MindSphere (Rittal, 2019). Its app

[8] MindSphere is a cloud-based service. Digital infrastructure for these services is dominated by Amazon Web Services, Google Cloud, and Microsoft Azure. Siemens does not compete with these companies on the infrastructural level but makes MindSphere available on all of these three infrastructures (Greenfield, 2021).

allows for predictive maintenance of industrial cooling units as it “provides remote diagnostics and visualization of device behavior for efficient condition monitoring and faster troubleshooting of your Blue e+ cooling units” (Rittal Smart Service, 2021). Making this application available on the MindSphere platform creates not only an additional distribution channel for the manufacturer, but also offers him the access to the database of potential customers and their operational data thanks to MindSphere's APIs. Similarly to Rittal, many other companies from various industrial sectors offer their applications via the MindSphere Store (Applications, 2021). In the vocabulary of the platformization tree metaphor, these sectoral applications symbolize branches and foliage of the MindSphere tree.

User organizations

Unveiling MindSphere as a socio-economic structure, I wish to briefly focus also on user organizations as social initiatives that promote the platform and support the growth of its ecosystem. My research revealed that Siemens started several initiatives and user organizations: MindSphere Application Centers, MindSphere Global Partner Ecosystem, MindSphere Rocket Club, Charter of Trust, MindSphere World. These organizations generally associate companies that are strategic partners and MindSphere users, which means they also represent an extension of the platform itself, though not in a technical sense. In Chapter 2, I mentioned how in the first years of Web 2.0 platforms tried to gain a stable position in the newly created sector through rhetoric of openness, better future and community building. In a similar vein, MindSphere World organization presents itself on the video with slogans: “We love IoT. We live our global community. We share experiences and visions. We learn from each other. We pave the way for innovations. Together we shape the future of the digital economy. We are the power of many” (MindSphere World, 2021). On the same website we read that MindSphere World is an “independent and open community for all interested parties in the Industrial Internet of Things to convene, learn, and grow throughout digital transformation” (MindSphere World, 2021).

Another example, the Charter of Trust organization, initiated by Siemens in 2018 presents itself as an organization that “calls for binding rules and standards to build trust in cybersecurity and further advance digitalization”, as we can read on their official website (Siemens, 2019b). This rhetoric seems reminiscent of Web 2.0 cultural mood of participation and egalitarian connectivity. I think it is also reasonable to assume that Siemens deliberately uses these slogans to create the image of a socially responsible company in the face of the challenges of digitization and an informed, trustworthy leader, expert and business partner.

Summarizing, both partnerships and user organizations initiated by Siemens aim to develop the platform by strengthening its credibility and expertise, particularly through the combined values of the Siemens brand and the brands of all other partner organizations. This marketing strategy aims to convince especially small and medium-sized enterprises and software companies to join MindSphere. MindSphere thus functions as an ecosystem - it is not only and exclusively a distinct structure consisting of the four levels I mentioned earlier, but a whole network of interconnected objects or actors, as if one would say with the vocabulary of the actor-network theory.

In this chapter my aim was to present MindSphere as a socio-economic object through the analysis of its business model, governance, ownership and ecosystem, and to address how the platformization manifests itself in the manufacturing industry through these MindSphere aspects. I started this part of the analysis by describing the platform's business model and showing how the focus on services and creating a multi-sided market serves to strengthen platformization in this sector. Further, I explored platform governance showing how the rules and principles formulated by the platform reflect the changes of platform’s neoliberal policy in the context of user accountability and platform work. I closed the chapter by describing MindSphere’s ownership and ecosystem using the platformization tree metaphor. This chapter complements the previous one in which MindSphere was discussed as a techno-cultural object. Both parts of the analysis provide a consistent picture of the platform as an ecosystem, changing the manufacturing industry both through technologies and economic processes.

8. Conclusion

To return to the example of a brewery, introduced at the beginning of this thesis... Imagine a hot June evening, Berlin downtown, you and a group of friends sitting in one of the city's pubs. On one of the walls there is a huge screen and a lot of football fans around. EURO 2020. Now, when the pandemic has somewhat slowed down, you can finally cheer on your favorite team with flushed faces. Just a glass of cold beer, a comfortable place (somewhere where it's not too loud, but you can also see what is happening on the screen) and you can focus on the game. You quickly take your smartphone out of your pocket, run the application and order a beer. In a moment, the waiter brings a glass of cold drink and places it in front of you on a round coaster, seemingly typical, with a printed beer logo. Nothing could be more wrong. There is a sensor in the coaster that uses a strain gauge membrane to evaluate beer's weight and determine its level in the glass. When the coaster detects that you have drunk enough and need a refill, it reports the information directly to the bartender or using a server, wirelessly. Thanks to this smart device, when you want to order a refill, you do not have to look for the waiter every time and distract yourself from the football match.[9] You can even order an RFID-enabled beer glass branded with your favorite beer, to change the product. The coaster will signal then the beer brand you need to refill (Violino et al. 2020). You do not have to pay at the bar either because the application does it for you by reading the data from the smart coaster after each refill. Moreover, all information about the amount of beer consumed can be used by the pub owner to estimate the actual consumption of beer and optimize the pub's supply process. In this way, the problem of the shortage of your favorite drink is solved (Violino et al. 2020).

I began this thesis by describing Oktoberfest and beer consumption during this event from the point of view of the beer supplier and his needs. Now I am describing the EURO 2020 and a similar situation. This time, however, more from the point of view of the beer consumer. Both cases are related to beer, or rather modern technology and the Internet of Things, which facilitates and makes the process of its consumption easier and even more enjoyable. Throughout the entire beer lifecycle process - from the brewery's decision to produce a specific brand to its consumption in a pub, through processing, delivery, service, and consumption - IoT (Internet of Things) technologies are being used more and more widely and willingly.

[9] Such an innovative IoT sensor was designed by a German start-up Robiotic (Violino et al., 2020).

Key findings

Digital platforms provide integration of all stages of the product lifecycle, not only beer but also other goods or consumer services. The aim of my work was to examine how the manufacturing industry embraces the process of platformization. The subject of my research was the industrial platform MindSphere. My main research question was: How can the process of platformization be observed in industrial manufacturing on the example of MindSphere? To investigate platformization I addressed secondary research questions: Through which techniques and mechanisms MindSphere creates an ecosystem? What aspects of MindSphere foster the process of platformization? I have argued that Siemens, following in the footsteps of high-tech companies, developed an industrial digital platform that exploits the same mechanisms as popular customer platforms: datafication, platform governance and building multi-sided markets.

Although the MindSphere platform mainly analyzes operational data from machines and industrial systems, and enables analytics and tracking of production processes, it triggers and organizes interactions between users and builds its own ecosystem. I therefore believe that my thesis contributes to the scholarship on platformization by offering a theoretical and empirical investigation into industrial digital platforms, showing that even sectors of the economy seemingly unrelated to media and new technologies are building their positions and basing business development forecasts on the platform model.

Moreover, I believe that platformization is the new paradigm for capitalism. In the first chapter I described the theory of techno-economic paradigm shifts (TEPS), developed by the Austrian economist Joseph Schumpeter. According to him, capitalism is a system of continuous, organic change. As he notes: "The fundamental impulse that sets and keeps the capitalist engine in motion comes from the new consumers' goods, the new methods of production or transportation, the new markets, the new forms of industrial organization that capitalist enterprise creates" (1994, p.83). In the past, technical inventions, for instance a weaving workshop, steam engine or railway - caused the greatest civilization changes. The presence of platforms in an increasing number of industries allows the conclusion that they are an example of another such impulse that disrupts the status quo. Platformization is already visible in industries such as journalism, transportation, entertainment, education, finance, and healthcare. Platforms are such an invention that transforms the capitalist system. However, this is not just a deviation of capitalism, as Zuboff argues, but a natural stage in the cycle of consecutive destructive disruptions (see Zuboff, 2019). In the press release accompanying Siemens' financial statements for the year 2020, the company indicates its most important future opportunities and explicitly mentions the MindSphere platform:

> Across our operating units, we are profiting from our strength in the 'Digital Enterprise'. Foremost, our cloud-based MindSphere platform enhances the availability of our customers' digital products and systems and improves their productivity and efficiency. We offer edge computing apps along with MindSphere in individual facilities, so that customers can connect all their facilities to create an integrated data network. (Siemens Annual Report 2020, 2020, p.42)

By pointing to the further development of MindSphere, Siemens clearly confirms MindSphere's position as a strategic element in the company's development.

Methodological reflections

This thesis is an explorative case study. It has provided insights into the phenomenon of platformization in the manufacturing industry. Yet it was based upon a single case, and therefore the described mechanisms and phenomena are not validated by comparison with other, competing iIoT platforms.

I researched the MindSphere platform using a walkthrough method involving direct engagement with the platform and the analysis of external data. For this purpose I used a Start for Free account on the platform. The annual license fee turned out to be a costly obstacle in doing the research with use of alternative options (MindAccess Value Plan and DevOps Plan). Although this method and the free user account provided much valuable information, I believe that accessing the platform through paid subscriptions, or ideally, analyzing its functionality through genuine user accounts that implement real production processes and use various types of data and analytical tools, would provide many illuminating observations.

Furthermore, I have turned down interviews as a research method. Using this tool could have strengthened my argument, however, I believe that the walkthrough method and the analysis of the "environment of expected use" provided exhaustive knowledge about the platform. The studied material was full of useful information. The interviews would not allow examining technical aspects such as interface or defaults of the platform. Asking specific questions about the detailed functioning of these tools might have been in turn too guiding.

Future research

The limitations mentioned above create the possibility for additional research. Further analysis of similar industrial IoT platforms can help broaden the understanding of how platforms operate in the specific domain of industrial manufacturing production.

The latest scholarship in the field of media and communication shows that platforms are increasingly moving towards building infrastructures. Industry digitization is a process that has only just begun and will take years to fully develop a cyber-physical infrastructure. Industry specialists, however, speak openly about these plans (see Siemens Annual Report 2020, 2020). Therefore, it is worth examining this phenomenon in terms of the transformation of these platforms into the dominant infrastructure on which the largest enterprises will build their social and market power. It is worth looking at these platforms as infrastructures because this seems to be the next stage of their development: Questions for further research could be: Are digital platforms in the manufacturing industry undergoing the process of infrastructuralization? What are the interactions between manufacturing platforms and existing internet infrastructures? The second avenue for further research and a very important issue that should also be considered in the context of industrial platforms and the B2B market is regulation. What is the role of governments in overseeing the emergence of digital industrial platforms and regulating their infrastructural ambitions? According to Pasquale, Purely numerical measures of income or productivity only tell part of the story of platform capitalism; indeed, some outside observers worry they may be manipulated by authorities and count as "productivity" the predictable results of social ills. In response to such worries, the social sciences and humanities are helpful guides, painting pictures of alternative (2016, p. 319).

The task of social sciences is to look at what realities are emerging from platformization. What changes does the use of digital technology bring to manufacturing, and does it bring any change to society in the wider scope? What are the wider implications of the platformization in the industry for the economy and society as a whole? The industrial platform market is just developing and it is definitely worth following this process and pose political economic questions.

References

Alaimo, C., Kallinikos, J. & Valderrama, E. (2020). Platforms as service ecosystems: Lessons from social media. *Journal of Information Technology*, 35(1), 25-48.

Amazon. (2019, October 2). *Introducing the AWS Industrial Software Competency Program* [Press release]. Retrieved from https://aws.amazon.com/blogs/apn/introducing-the-aws-industrial-software-competency-program/

Andreessen, M. (2007a, June 12). Analyzing the Facebook Platform, three weeks in [Blog post]. Retrieved from https://web.archive.org/web/20071002070223/http://blog.pmarca.com/2007/06/analyzing_the_f.html

Andreessen, M. (2007b, September 16). The three kinds of platforms you meet on the Internet [Blog post]. Retrieved from https://web.archive.org/web/20071002031605/http://blog.pmarca.com/2007/09/the-three-kinds.html

Andrejevic, M. & Burdon, M. (2015). Defining the Sensor Society. *Television & New Media, 16*(1), 19-36.

Andrejevic, M. (2014). Surveillance in the Big Data Era. *Emerging Pervasive Information and Communication Technologies (PICT) : Ethical Challenges, Opportunities and Safeguards,* 55-69.

App Icons. (2021). Retrieved from https://design.mindsphere.io/patterns/app-icons.html)

Applications. (2021). Retrieved from https://www.dex.siemens.com/mindsphere/Applications

Baron, L. F. & Gomez, R. (2016). The Associations between Technologies and Societies: The Utility of Actor-Network Theory. *Science, Technology and Society*, 21(2), 129-148.

Becker, M., Schmaler, K. (2020) IDC Studie: 40 Prozent der befragten Industrieunternehmen wollen Investitionen in IIoT erhöhen – trotz oder gerade wegen Corona. *IDC Corporate USA*. Retrieved from_ https://www.idc.com/getdoc.jsp?containerId=prEUR147017420

Berger, A. (2016). *Media and communication research methods : An introduction to qualitative and quantitative approaches* (4th ed.). Thousand Oaks, Calif: SAGE.

Bigelow, S. J.(2017, November 29). XaaS (Anything as a Service). *Techtarget.* Retrieved from https://searchcloudcomputing.techtarget.com/definition/XaaS-anything-as-a-service

Bodle, R. (2011). Regimes Of Sharing. *Information, Communication & Society, 14*(3), 320-337.

Bogost, I. & Montfort, N. (2009). *Platform Studies: Frequently Questioned Answers*.

Borah, R. (2020). Cloud Computing Architecture: What is Front End and Back End? *Clarion Technologies*. Retrieved from https://www.clariontech.com/blog/cloud-computing-architecture-what-is-front-end-and-back-end

Botsman, R. & Rogers, R. (2010). *What's mine is yours : The rise of collaborative consumption*. New York: Harper Business.

Bryman, A. (2012). *Social research methods* (4th ed.). Oxford: Oxford University Press.

Bucher T. & Helmond A. (2017). *The Affordances of Social Media Platforms*. Sage Publications.

Bucher, T. (2013). Objects of Intense Feeling: The Case of the Twitter API. *Computational Culture* 3 (16h November 2013). Retrieved from http://computationalculture.net/objects-of-intense-feeling-the-case-of-the-twitter-api/

Bucher, T. (2018). *If ... then : Algorithmic power and politics* (Oxford studies in digital politics). New York: Oxford University Press

Castells, M. (2010). *The rise of the network society* (2nd ed., Vol. 1, Information age;). Chichester, West Sussex ;: Wiley-Blackwell.

Chung, D. J. (2021, March–April) How to Shift from Selling Products to Selling Services. *Harvard Business Review. The Magazine*. Retrieved from https://hbr.org/2021/03/how-to-shift-from-selling-products-to-selling-services

Citizen Developer. (2021). Retrieved from https://www.gartner.com/en/information-technology/glossary/citizen-developer

Clarke, R. (2003). Dataveillance—15 Years On. *Personal Website*. Retrieved from http://www.rogerclarke.com/DV/DVNZ03.html

Collis, D. J. & Junker, T. (2017). Digitalization at Siemens. *Harvard Business School*. Case 717-428.

Computational Culture (2018). Call for Abstracts. Retrieved from http://computationalculture.net/cfps-events/

Couldry, N. & Mejias, U. A. (2019). Data Colonialism: Rethinking Big Data's Relation to the Contemporary Subject. *Television & New Media*, 20(4), 336-349.

Cramer, F. & Fuller, M. (2008). Interface. In M. Fuller (Ed.), *Software studies: A lexicon* (pp. 149-152). Cambridge, MA: MIT Press.

Crawford, E. (2019, May 7). Made in China 2025: The Industrial Plan that China Doesn't Want Anyone Talking About. *Frontline*. Retrieved from https://www.pbs.org/wgbh/frontline/article/made-in-china-2025-the-industrial-plan-that-china-doesnt-want-anyone-talking-about/

Dean, J. (2019). Communicative Capitalism and Revolutionary Form. *Millennium*, 47(3), 326-340.

Develop your MindSphere Skills. (2021). Retrieved from https://siemens.mindsphere.io/en/training

Dieter, M., Gerlitz, C., Helmond, A., Tkacz, N., Van der Vlist, F.N, & Weltevrede, E. (2019). Multi-Situated App Studies: Methods and Propositions. *Social Media Society, 5*(2), 205630511984648.

Digital Industries. (2021). Retrieved from https://new.siemens.com/global/en/company/about/businesses/digital-industries.html

Dube A., Jacobs J., Naidu S. & Suri S. (2018). *Monopsony in online labor markets*. NBERWork. Pap. 24416

Duffy, B. E. & Hund E. (2015). “Having it all” on social media: Entrepreneurial femininity and self-branding among fashion bloggers. *Social Media+ Society* 1(2): 2056305115604337.

Elmer, G., Langlois, G., McKelvey, F. & Werbin, K. (2009). Mapping Commercial Web 2.0 Worlds: Towards a New Critical Ontogenesis. *Fibreculture Journal*, (14), Fibreculture journal, 2009-01-01 (14).

Esterl, M., Singer, J. & Berman, D. K. (2007, January 25). Siemens to Buy UGS As Part of Overhaul. Retrieved April 03, 2021, from https://www.wsj.com/articles/SB116967026348486608

Eyal, N. & Hoover, R. (2014). *Hooked : How to build habit-forming products*. S.l.: N.Eyal.

Foucault, M. (1995) *Discipline and Punish: The Birth of the Prison*. New York: Vintage Books.

Foucault, M. (2008) *The Birth of Biopolitics: Lectures at the Collège de France, 1978-1979*. New York: Palgrave Macmillan.

Fourcade, M. & Healy, K. (2017) Seeing like a market. *Socio-Economic Review* 15(1): 9–29.

Frankel, J. (2020, May 29). Is China overtaking the US as a financial and economic power? *The Guardian*. Retrieved from https://www.theguardian.com/business/2020/may/29/is-china-overtaking-the-us-as-a-financial-and-economic-power

Gawer, A. & Cusumano, M. (2014). Industry Platforms and Ecosystem Innovation. *The Journal of Product Innovation Management*, 31(3), 417-433.

Gawer, A. & Cusumano, M. (2015). Business Platforms. *International Encyclopedia of the Social & Behavioral Sciences*, 3, 37-42.

Gawer, A. (2014). Bridging differing perspectives on technological platforms: Toward an integrative framework. *Research Policy, 43*(7), 1239-1249.

Gerlitz, C., Helmond, A., Nieborg, D.B. & Van der Vlist, F.N. (2019). Apps and Infrastructures – a Research Agenda. *Computational Culture, 7*, Computational Culture, 2019-10-21, Vol.7.

Gillespie, T. (2010). The politics of ‘platforms’. *New Media & Society*, 12(3), 347-364.

Graff, J., Krenz, W. & Kronenwett, D. (2018). IIot Platforms: Source Of Profit Or Inflated Hype? *Perspectives On Manufacturing Industries Vol. 13*, 6-11. Retrieved from https://www.oliverwyman.com/our-expertise/insights/2018/nov/perspectives-on-manufacturing-industries-vol-13/iiot-platforms-source-of-new-profit-or-inflated-hype/iiot-platforms-source-of-new-profit-or-inflated-hype.html

Greenfield, D. (2021, April 29). Google Cloud Targets the Manufacturing Industries with Siemens. *Automation World*. Retrieved from https://www.automationworld.com/factory/iiot/article/21403582/google-cloud-and-siemens-target-the-manufacturing-industries

Guizzo, D. & Vigo de Lima, I. (2017). Polanyi and Foucault on the Issue of Market in Classical Political Economy. *The Review of Radical Political Economics*, 49(1), 100-113.

Guizzo, D. & Stronge, W. (2018). Keynes, Foucault and the 'disciplinary complex': A contribution to the analysis of work. *UWE Bristol Research Repository*. Retrieved from https://uwe-repository.worktribe.com/output/874213

Helmond, A. (2015). The Platformization of the Web: Making Web Data Platform Ready. *Social Media Society*, *1*(2), 205630511560308.

Heppelmann, J. E. & Porter, M.E. (2015) How Smart, Connected Products Are Transforming Companies. *Harvard Business Review. The Magazine*. Retrieved from https://hbr.org/2015/10/how-smart-connected-products-are-transforming-companies

Hu, T-H. (2015). *A Prehistory of the Cloud.* Cambridge, MA: The MIT Press.

IDC. (2020, July 27). IoT Growth Demands Rethink of Long-Term Storage Strategies, says IDC. (2020, July 27). *IDC Corporate USA*. Retrieved from https://www.idc.com/getdoc.jsp?containerId=prAP46737220

Inauen, Ch. & Mann, J. (2019). *Unlock the power of Industrial IoT with analytics. A Siemens and SAS white paper.* Retrieved from https://www.industryweek.com/white-papers/whitepaper/21141465/unlock-the-power-of-industrial-iot

Industrial Edge. (2021). Retrieved from https://new.siemens.com/global/en/products/automation/topic-areas/industrial-edge.html

Jin, D. Y. (2013). The Construction of Platform Imperialism in the Globalization Era. *TripleC, 11*(1), 145-172.

Jorgensen, M.W. & Phillips, L. (2002). *Discourse Analysis as Theory and Method*. London: SAGE Publications.

Kenney, M. & Zysman, J. (2016). The Rise of the Platform Economy. *Issues in Science and Technology*, 32(3), 61–69.

Kenney, M. & Zysman, J. (2017). Entrepreneurial Finance in the Platform Economy Era: What Consequences for Labor?, paper presented at Future of Work conference, Chicago, 5th–6th October 2017. Retrieved from https://static1.squarespace.com/static/5910ee5d1e5b6ca37f0a53b0/t/5a84991ee2c4835ce8cfe21b/1518639391895/Ken+%26+Zys+trimmed+final.pdf May 20th 2018.

Kenney, M. Rouvinen, P., Seppälä, T. & Zysman, J. (2019). Platforms and industrial change. *Industry and Innovation, 26*(8), 871-879.

Khan, L.M. (2017). Amazon's antitrust paradox. *Yale Law J*. 126:710–805

Kostakis, V., & Bauwens, M. (2014). *Network Society and Future Scenarios for a Collaborative Economy* (1st ed. 2014. ed., Palgrave pivot Network society and future scenarios for a collaborative economy). London: Palgrave Macmillan UK : Imprint: Palgrave Pivot.

Kramp, T., van Kranenburg, R. &Lange S.(2013) Introduction to the Internet of Things. In A. Bassi et al. (Ed.), *Enabling Things to Talk*. Berlin, Heidelberg: Springer.

Kuehn, K., & Corrigan, T. (2013). Hope Labor: The Role of Employment Prospects in Online Social Production. *The Political Economy of Communication*, 1(1). Retrieved from https://www.polecom.org/index.php/polecom/article/view/9/64

Langley, P. & Leyshon, A. (2017). Platform capitalism: The intermediation and capitalization of digital economic circulation. *Finance and Society, 3*(1), 11-31.

Langlois, G. & Elmer, G. (2013). The research politics of social media platforms. *Culture Machine*, Vol. 14, 2013.

Langlois, G. & Elmer, G. (2019). Impersonal subjectivation from platforms to infrastructures. Media, Culture & Society, 41(2), 236-251.

Latour, B. (1996). On actor-network theory: A few clarifications. *Soziale Welt, 47*(4), 369-381.

Latour, B. (2005*). Reassembling the Social: An Introduction to Actor-Network-Theory*. Oxford: Oxford University Press. (UBU, electronic resource)

Lee, D. (2013, July, 10). App Store 'full of zombies' claim on Apple anniversary. *BBC*. Retrieved from http://www.bbc.com/news/technology–23240971

Light, B., Burgess, J. & Duguay, S. (2018). The walkthrough method: An approach to the study of apps. *New Media & Society, 20*(3), 881-900.

Lobo, S. (2014, September 3) Auf dem Weg in die Dumpinghölle. *Spiegel Online*. Retrieved from http://www.spiegel.de/netzwelt/netzpolitik/sascha-lobo-sharing-economy-wie-bei-uber-istplattform-kapitalismus-a-989584.html

Lüthje, B. (2019). Platform Capitalism 'Made in China'? Intelligent Manufacturing, Taobao Villages and the Restructuring of Work. *Science, Technology & Society* (New Delhi, India), 24(2), 199-217.

Mackenzie, A. (2006). *Cutting code: Software and sociality*. New York, NY: Peter Lang.

Mackenzie, A. (2019). From API to AI: Platforms and their opacities. *Information, Communication & Society, 22*(13), 1989-2006.

Martens, B., de Streel, A., Graef, I., Tombal, T. & Duch-Brown, N. (2020). Business-to-business data sharing: An economic and legal analysis. (JRC Digital Economy Working Paper Series; Vol. 2020, No. 05). *European Commission*. Retrieved from https://ec.europa.eu/jrc/sites/jrcsh/files/jrc121336.pdf

Martin, D. (2019, May 21). Siemens USA CEO Barbara Humpton: Integration Is Key To MindSphere's Success. *CRN*. Retrieved from https://www.crn.com/slide-shows/internet-of-things/siemens-usa-ceo-barbara-humpton-integration-is-key-to-mindsphere-s-success/3

Mayer-Schoenberger, V. & Cukier, K. (2013). *Big Data. A Revolution that will transform how we live, work, and think*. London: John Murray Publishers.

MindAccess IoT Value Plan Medium.(2020) Retrieved from https://www.dex.siemens.com/mindsphere/mindaccess/iot-value-plan-medium?viewState=DetailView&cartID=&portalUser=&store=&cclcl=en_GB&selected=mindsphere

MindAccess. (2021). Retrieved from https://siemens.mindsphere.io/en/docs/mindaccess

MindConnect API. (2021). Retrieved from https://developer.mindsphere.io/apis/connectivity-mindconnect/api-mindconnect-overview.html

MindSphere Design System. (2021). Retrieved from https://design.mindsphere.io/index.html

MindSphere World. (2021). About. Retrieved from https://mindsphereworld.org/about

National Academy of Science and Engineering (Acatech). (2013). Securing the future of German manufacturing industry. Recommendations for implementing the strategic initiative Industrie 4.0. Berlin: Federal Ministry of Education and Research.

Nissenbaum, H. (2011). A Contextual Approach to Privacy Online. *Daedalus (Cambridge, Mass.), 140*(4), 32-48.

Novak, M. (2018, January 31). Amazon patents wristband to track hand movements of warehouse employees. *Gizmodo*. Retrieved from https://gizmodo.com/amazonpatents wristband-to-track-hand-movements-of-war- 1822590549?IRĽT

Paranikas, P., Puma Whiteford, G., Tevelson, B. & Belz, D. (2015, July-August). How to Negotiate with Powerful Suppliers. *Harvard Business Review. The Magazine*. Retrieved from https://hbr.org/2015/07/how-to-negotiate-with-powerful-suppliers

Parker, G., Van Alstyne, M., & Choudary, S. (2016). *Platform revolution : How networked markets are transforming the economy and how to make them work for you*. New York: Norton.

Pasquale, F. (2015). *The Black Box Society: The Secret Algorithms That Control Money and Information.* Massachusetts: Harvard University Press.

Pasquale, Frank. (2016). Two Narratives of Platform Capitalism. *Yale Law & Policy Review*, 35(1), 309-319.

Patton, M. (2002). *Qualitative research & evaluation methods* (3rd ed.). Thousand Oaks, Calif: Sage Publications.

Perez, C. (2009). Technological revolutions and techno-economic paradigms. *Cambridge Journal of Economics*, *34*(1), 185-202.

Petrik, D. & Herzwurm, G. (2019). IIoT ecosystem development through boundary resources: A Siemens MindSphere case study. *Proceedings of the 2nd ACM SIGSOFT International Workshop on Software-intensive Business: Start-ups, Platforms, and Ecosystems*, 1-6.

Plantin, J.-Ch. & De Seta, G. (2019). WeChat as infrastructure: The techno-nationalist shaping of Chinese digital platforms. *Chinese Journal of Communication*, 12(3), 257-273.

Plantin, J.-Ch., Lagoze, C., Edwards, P. N. & Sandvig, Ch. (2018). Infrastructure studies meet platform studies in the age of Google and Facebook. *New Media & Society*, *20*(1), 293-310.

Poell, T., Nieborg, D. & van Dijck, J. (2019). Platformisation. *Internet Policy Review*, 8(4), Internet policy review, 2019-11, Vol.8 (4).

Polonski, M. & Waller, D. (2019). *Designing and managing a research project : A business student's guide* (4th ed.). Los Angeles, CA: SAGE Publications.

Raise your low-code expectations. (2021). Retrieved from https://www.mendix.com/low-code-guide/

Raley, R. (2013). Dataveillance and Countervailance. In L. Gitelman (ed.), '*Raw Data' is an Oxymoron*. Cambridge, MA:MIT Press.

Rittal Smart Service. (2021). Retrieved from https://www.dex.siemens.com/mindsphere/applications/rittal-smart-service?viewState=DetailView&cartID=&portalUser=&store=&cclcl=en_US

Rittal. (2019, June 24). *Rittal forms global strategic partnership with Atos and Siemens for Edge and IoT initiatives* [Press release]. Retrieved from https://www.rittal.com/com-en/content/en/unternehmen/presse/pressemeldungen/pressemeldung_detail_72448.jsp

Rogers, R. (2019). *Doing digital methods*. Los Angeles, California: SAGE.

Rosenblat, A. & Stark, L. (2016). Algorithmic labor and information asymmetries: A case study of Uber's drivers. *International Journal of Communication* (Online), 3758.

Rossiter, N. (2014). Logistical worlds. *Cultural Studies Review, 20*(1), 53-76.

Rossiter, N. (2015). Coded Vanilla: Logistical Media and the Determination of Action. *The South Atlantic Quarterly*, *114*(1), 135-152.

Rossiter, N. (2016). *Software, infrastructure, labor: a media theory of logistical nightmares*. New York: Routledge.

Rossiter, N., Wilken, R. & Goggin, G. (2014). *Locative media*. Routledge.

Ryan, A. B. (2006) Methodology: Analysing Qualitative Data and Writing up your Findings. In: *Researching and Writing your thesis: a guide for postgraduate students*. Mace: Maynooth Adult and Community Education, pp. 92-108.

Ryen, A. (2004). Ethical issues. In C. Seale, G. Gobo, J. F. Gubrium & D. Silverman (Eds.), *Qualitative research practice*. London: Sage.

Sadowski, J. (2019). When Data is Capital: Datafication, Accumulation, Extraction. *Big Data & Society*. 6 (1): 1-12.

Sanchis, R., Garcia-Perales, O., Fraile, F. & Poler, R. (2020). Low-Code as Enabler of Digital Transformation in Manufacturing Industry. *Applied Sciences*, 10(1), 12.

Santiago F. (2013) *What can policymakers learn from Germany's Industrie 4.0 development strategy?* Vienna: United Nations Industrial Development Organization.

Sarmadi, D. (2014, October 22). Merkel calls for 'Industry 4.0' at German IT Summit 2014. *Euractiv.de.* Retrieved from https://www.euractiv.com/section/digital/news/merkel-calls-for-industry-4-0-at-german-it-summit/

Schumpeter, J. (1994). *Capitalism, socialism and democracy*. London: Routledge.

Schumpeter, J. *The Theory of Economic Development: An Inquiry into Profits, Capital, Credit, Interest, and the Business Cycle*. New Brunswick, NJ: Transaction Publishers, 1983.

Sendler, U. (2019, June 15). Interview with Tony Hemmelgarn, CEO of Siemens PLM Software. *PLMportal*. Retrieved from https://www.plmportal.org/en/news-detail/interview-with-tony-hemmelgarn-ceo-of-siemens-plm-software.html

Siemens and mendix. (2018, August 1) *Siemens strengthens its digital enterprise leadership with acquisition of mendix* [Press release]. Retrieved from https://press.siemens.com/global/en/pressrelease/siemens-strengthens-its-digital-enterprise-leadership-acquisition-mendix

Siemens Annual Report 2020. (2020). Retrieved from https://assets.new.siemens.com/siemens/assets/api/uuid:45446098-6c39-45ba-a5fc-e5f27ebfa875/siemens-ar2020.pdf

Siemens Annual Report 2020. (2020). Retrieved from https://assets.new.siemens.com/siemens/assets/api/uuid:45446098-6c39-45ba-a5fc-e5f27ebfa875/siemens-ar2020.pdf

Siemens History. (2021). Retrieved from https://new.siemens.com/global/en/company/about/history.html

Siemens. (2015). Annual shareholders' meeting of Siemens AG. Retrieved from https://assets.new.siemens.com/siemens/assets/api/uuid:417d5934-5b7c-4524-a91d-a72e2eb8b852/2015-HV-speech-kaeser.pdf

Siemens. (2017). *MindSphere: The cloud-based, open IoT operating system for digital transformation*. Retrieved from https://new.siemens.com/us/en/company/topic-areas/digitalization/mindsphere/mindsphere-whitepaper-download.html

Siemens. (2018, August 1). *Siemens sets future course with Vision 2020+* [Press release]. Retrieved from https://press.siemens.com/global/en/pressrelease/siemens-sets-future-course-vision-2020

Siemens. (2018a). *MindSphere: Enabling the world's industries to drive their digital transformations*. Retrieved from https://new.siemens.com/uk/en/products/software/mindsphere/mindsphere-white-paper.html

Siemens. (2018b) Data Privacy Terms. Retrieved from https://siemens.mindsphere.io/content/dam/mindsphere/pdf/MindSphere_DataPrivacyTerms_v1801.pdf

Siemens. (2018c). *MindApps and Applications for MindSphere.* Retrieved from https://siemens.mindsphere.io/content/dam/cloudcraze-mindsphere-assets/03-catalog-section/03-applications/Siemens-MindSphere-MindApps-and-Applications-fs-68079-A10_tcm76-20915.pdf

Siemens. (2019a). *MindSphere: Analyze and Predict*. Retrieved from https://siemens.mindsphere.io/content/dam/cloudcraze-mindsphere-assets/03-catalog-section/05-solution-packages/solution-packages/03-analyze-and-predict/Siemens-MindSphere-Analyze-and-Predict-sb-72222-A9.pdf

Siemens. (2019a). *MindSphere: Analyze and Predict*. Retrieved from https://siemens.mindsphere.io/content/dam/cloudcraze-mindsphere-assets/03-catalog-section/05-solution-packages/solution-packages/03-analyze-and-predict/Siemens-MindSphere-Analyze-and-Predict-sb-72222-A9.pdf

Siemens. (2019b, February 15). *The Charter of Trust takes a major step forward to advance cybersecurity* [Press release]. Retrieved from https://press.siemens.com/global/en/feature/charter-trust-takes-major-step-forward-advance-cybersecurity

Siemens. (2020a). *MindSphere: The industrial IoT as a service solution.* Retrieved from https://siemens.mindsphere.io/content/dam/mindsphere/partners/overview/MindSphere_Brochure.pdf

Siemens. (2020a). *MindSphere: The industrial IoT as a service solution.* Retrieved from https://siemens.mindsphere.io/content/dam/mindsphere/partners/overview/MindSphere_Brochure.pdf

Siemens. (2020b). *SIMICAS Performance Analyzer, Product Sheet and Specific Terms*. Retrieved from https://siemens.mindsphere.io/content/dam/mindsphere/terms/pdf/App_SIMICASPerformanceAnalyzer_ProductSheet_SpecificTerms_v1.0.pdf

Siemens. (2020c) *Data Privacy. MindSphere Mobile Connect App.* Retrieved from https://assets.new.siemens.com/siemens/assets/api/uuid:30d7ff3a-4da7-4e33-922e-b1c05f7dc577/version:1593789914/mindsphere-mobile-connect-en.pdf

Siemens. (2020d). *Become an expert in MindSphere App Development*. Retrieved from https://siemens.mindsphere.io/en/training/app-development

Siemens. (2020e). MindAccess DevOps Plan. Retrieved from https://siemens.mindsphere.io/content/dam/cloudcraze-mindsphere-assets/03-catalog-section/01-mindaccess/Siemens-SW-MindAccess-DevOps-Plan-FS-66298-C26_published_factsheet.pdf

Siemens. (2020f). Water Quality Inspector Package. Product Sheet and Specific Terms. Retrieved from https://siemens.mindsphere.io/content/dam/mindsphere/terms/pdf/App_WaterQualityInspectorPackage_ProductSheet_SpecificTerms_v1.1.pdf

Siemens. (2020g).MindSphere Closed Loop Foundation. Retrieved from https://siemens.mindsphere.io/content/dam/cloudcraze-mindsphere-assets/03-catalog-section/03-applications/closedloop/foundation/Siemens-SW-MindSphere-Closed-Loop-Foundation-FS-81515-C3_published.pdf

Siemens. (2021a). MindSphere Start for Free. Product Sheet, Specific Terms and Data Privacy Notice. Retrieved from https://siemens.mindsphere.io/content/dam/mindsphere/terms/pdf/MindSphere_StartforFree_ProductSheet_SpecificTerms_DataPrivacyNotice_v1.3.pdf

Siemens. (2021b). MindSphere Terms & Conditions. MindSphere Applications. Retrieved from https://siemens.mindsphere.io/en/terms/region-emea?ap=1655373068

Solon, O. (2018, February 1). Amazon patents wristband that tracks warehouse workers' movements. *The Guardian*. Retrieved from https://www.theguardian.com/technology/2018/jan/31/amazon-warehouse-wristband-tracking

Srnicek, N. (2017). *Platform capitalism* (Theory redux). Cambridge, UK: Polity.

Srnicek, N. (2019, April 23). The only way to rein in big tech is to treat them as a public service. *The Guardian.* Retrieved from https://www.theguardian.com/commentisfree/2019/apr/23/big-tech-google-facebook-unions-public-ownership

Stiegler, B. (2019). *The Age of Disruption*. Newark: Polity Press.

Sundararajan, A. (2016). *The sharing economy : The end of employment and the rise of crowd-based capitalism*. Cambridge, Mass: The MIT Press.

Thompson, H. (2015, June). Road4FAME Consultation Event 'Digital Revolution in Europe: Converging Visions for a Smarter World'. Report from the Road4FAME Consultation. Retrieved from http://road4fame.eu/resources/

Ticona, J., Mateescu, A. & Rosenblat, A. (2018). *Beyond disruption: how tech shapes labor across domestic work and ridehailing.*

Tolling Innovation. (2013, Jauary 4). *World Highways, Route One Publishing Ltd.* Retrieved from www.worldhighways.com/wh12/feature/tolling-innovation.

User Rights in 'Operator Cockpit'.(2021). Retrieved from https://documentation.mindsphere.io/resources/html/operator-cockpit/en-US/115493223051.html

Vallas, S. & Schor, J. B. (2020). What Do Platforms Do? Understanding the Gig Economy. *Annual Review of Sociology, 46*(1), 273-294.

van den Boomen, M. & Lehmann, A.-S. Material Object Analysis. In A.-S. Lehmann, . van den Boomen and de Rijk (eds.), *New Media Studies Method Reader* (Utrecht, n.d.).

van Dijck, J. (2013). *The Culture of Connectivity*. New York: Oxford University Press.

van Dijck, J. (2014). Datafication, dataism and dataveillance: Big Data between scientific paradigm and ideology. *Surveillance & Society, 12*(2), 197-208.

van Dijck, J. (2020). Seeing the forest for the trees: Visualizing platformization and its governance. *New Media & Society,* 146144482094029.

van Dijck, J., Poell, T. & Waal, M. (2018). *The platform society : Public values in a connective world.* New York: Oxford University Press.

Verhoeff, N. (2012) Research design: The theory/object dynamic. In Lehmann, van den Boomen and de Rijk, (eds.), New Media Studies Method Reader (Utrecht, n.d.).

Violino, S., Figorilli, S., Costa, C. & Pallottino, F. (2020). Internet of Beer: A Review on Smart Technologies from Mash to Pint. *Foods*, 9(7), 950.

Wade Morris, J., Elkins, E. (2015). FCJ-181 There's a History for That: Apps and Mundane Software as Commodity. *Fibreculture Journal,* (25), 63-88.

Wong, J., Driver, M., Ray, S. (2019, October 04). *The Future of Apps Must Include Citizen Development.* Retrieved from https://www.gartner.com/en/documents/3970067/the-future-of-apps-must-include-citizen-development

Yin, R.K. (2014). *Case study research. Design and Methods*. 5th ed. California: Sage

Your Home is in Good Hands. 2021. Retrieved from https://pl.airbnb.com/d/hosting-services?_set_bev_on_new_domain=1622989916_MGQxNzM4YmEwMDJi

Zaske, S. (2015, February 23). Germany's Vision for Industrie 4.0: The Revolution Will Be Digitised. *ZDNet*. Retrieved from http://www.zdnet.com/article/germanys-vision-for-industrie-4-0-

Zittrain, J. (2008). *The future of the Internet : And how to stop it*. London: Allen Lane.

Zuboff, S. (2019). *The age of surveillance capitalism : The fight for the future at the new frontier of power*. London: Profile Books PublicAffairs.