Understanding Products as Services

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Understanding Products as Services: How the Internet and AI are Transforming Product Companies

With 66 Actionable Product–Service Patterns

BY

FELIX WORTMANN
University of St. Gallen, Switzerland

HEIKO GEBAUER
Linköping University, Sweden

CLAUDIO LAMPRECHT
Strategy&, Switzerland

AND

ELGAR FLEISCH
ETH Zurich, Switzerland

United Kingdom – North America – Japan – India – Malaysia – China

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Contents

About the Authors

Prof. Dr. **Felix Wortmann** is Professor of Technology Management at the University of St. Gallen. He is also the Scientific Director of the Bosch IoT Lab, a research collaboration between the Bosch Group, the University of St. Gallen, and ETH Zurich.

Prof. Dr. **Heiko Gebauer** conducts research at Fraunhofer IMW and Linköping University on digital business model innovation, service innovation in industrial companies, and innovation in the service sector, among other topics.

Dr. **Claudio Lamprecht** is a Strategy Consultant at Strategy& Switzerland. As a doctoral student at the Bosch IoT Lab at the University of St. Gallen, he investigated equipment-as-a-service approaches.

Prof. Dr. **Elgar Fleisch** is Professor of Information and Technology Management at ETH Zurich and the University of St. Gallen. A native Austrian, he is the initiator of several research programs at the intersection of computer science and management. He is also a co-founder and adviser to numerous start-ups and sits on a number of supervisory boards.

Foreword

Just a few years ago, all software was delivered on physical CDs. Today, it is available as a wireless service from the cloud. Just a few years ago, we bought music recorded on CDs. Today, we subscribe to Spotify's or Apple's music streaming services. Service has become an economic imperative. This imperative applies to everything that can be digitalized and is now disrupting physical products. Why? Because the digital component of our physical products is constantly expanding. It is becoming part of the core value proposition. Today, a car's software shapes the driving experience. New assistance systems and ever-larger screens in vehicle cockpits are vivid evidence of this development. And now this software is becoming a service. Today, that might only mean keeping the navigation system up-to-date. At some point, however, cars themselves will transform into a service: the self-driving taxi. In the meantime, we will see a huge variety of sharing and rental models on the market.

This book is intended to help product companies evolve from being the sole providers of products to offering customer solutions comprised of hardware, software, and services. With Product as a Service (PaaS), we explicitly do not want to contribute to the next hype and promote the ultimate solution to any kind of business model challenge. Digitalization and servitization do not affect all products in the same way, and PaaS will look different in different contexts. Nor do we argue that the relevance of either physical products or the manufacturing industry is declining. Quite the opposite: we assume that the world will remain largely physical and that manufacturing will remain pivotal. Physical products will continue to generate the lion's share of sales and employment in the manufacturing industry. However, competitiveness is increasingly determined by solutions that are based on hardware, software, and services. For many manufacturing companies, software and services are becoming strategic necessities rather than optional opportunities.

The book is the result of a long-standing collaboration between industry and research at the Bosch IoT Lab at ETH Zurich and the University of St. Gallen. The three partners – Bosch, ETH Zurich, and the University of St. Gallen – founded this lab to better understand how the Internet of Things is changing the manufacturing industry. It quickly became clear that the seamless connection of the digital and physical worlds was creating promising new value propositions. Physical products could now be combined with software and digital services to provide comprehensive solutions to pressing customer needs.

Europe, the world champion of production, had remained too dormant throughout the first major wave of digitalization, led by Amazon, Google, Meta, and Microsoft & Co. US companies were more experimental, more pragmatic, and much faster than their European counterparts. The same was true for companies in some Asian countries, especially China. While Europe may have the best data protection law in the world, it has virtually no digital business. We import almost all digital services from across the Atlantic.

Now the race is moving into a second phase: the digitalization of the physical world. The opportunities for Europe are enormous. Arguably, it is easier to move from hardware to software than vice versa. This, however, requires acknowledging that these two worlds follow different business models and development paradigms and act accordingly. That this is far from easy can be observed in the automotive industry. Here, the first battle was won by Tesla and BYD & Co. But the race has only just begun.

This book explores how the digitalization of products shapes the future business models of product manufacturers. It has three main parts, which can be read separately. Part I – How the Internet and AI are Transforming Product Companies – reflects on the interplay of hardware, software, and services. It is written in the first person and is easily digestible. Elgar Fleisch, the eldest of the authors, describes his fundamental findings and insights along his personal learning path. Part II – The Product as a Service (PaaS) Navigator – introduces a management tool that aims to support the transition toward PaaS. It is written in a more formal style and shows step-by-step how companies can expand their product and service business thanks to digitalization. Part III – The 66 PaaS Patterns – is intended to provide quick reference and inspiration during innovation work.

This book is aimed at practitioners. Excerpts have already been published in scientific publications such as dissertations, journals, conferences, and working papers. To enhance readability, we have omitted long lists of literature and theoretical underpinnings. Only the most important sources are listed at the end of the book. Our research publications are also available on the Bosch IoT Lab homepage (www.iot-lab.ch). Whenever possible, we demonstrate central ideas through concrete practical examples. Many of these examples are cutting-edge. They are in competition and constantly developing. Moreover, they become part of larger initiatives and, in some cases, even disappear. However, their underlying ideas and patterns, which we describe in this book, remain stable over time.

The developments described here also drive the circular economy. Manufacturing companies offering PaaS have a great incentive to optimize their economic and ecological footprint across the entire product life cycle. Product business, digitalization, and sustainability go hand in hand, thus creating another significant opportunity for the European industry.

This book is the result of a significant team effort. We would like to thank everyone who supported us in our research and publishing activities: Johanna Knapp, Dominik Bilgeri, Elisabeth Vetsch-Keller, Malte Belau, and last but not least, Sheena Reghunath and Nick Wallwork at Emerald Publishing. We would also like to thank our industrial partners for their time and trust.

And we wish you, dear reader, an enjoyable reading experience and every success in implementing PaaS yourself.

Felix Wortmann
Heiko Gebauer
Claudio Lamprecht
Elgar Fleisch

Part I

How the Internet and AI are Transforming Product Companies

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Merging Worlds

The journey to this book began in 1999. After completing my post-doctoral thesis, I realized that I could and should delve into a subject of which I was deeply convinced. One that would build on the knowledge and insights that I had gained up to that point, and which would shape the future. It was a gut feeling rather than an intellectual conviction. My training in mechanical engineering, computer science, and economics had shaped my intuition, and I was young enough to trust that intuition. It seemed clear to me that the idea of the physical and the digital world merging was not a dream with a short half-life, but a compelling logical development. The logic was so compelling, and so relevant to society and business, that I was ready to stake my career on it.

Maturing technologies, as I had learned from the thought leaders back then, are getting smaller and smaller. This advancement favorably impacts material consumption, energy consumption, and manufacturing costs. If this technical development significantly benefits businesses, its applications will explode. A typical example is the evolution from large computers that once filled a whole room to small personal computers. If computers continue to shrink in size and become cheaper, I thought back in 1999, then they will soon be part of every physical product, though without the screen and the keyboard we were used to. They will become the eyes, ears, memory, computing, and communications center of every physical object – from machines through coat hooks to bathroom carts.

This might feel obvious, but it wasn't 20–30 years ago. I can still remember how our professor of mechanics, who was also the lead engineer of a Swiss machine tool company, made fun of the new species of computer scientists in an affectionately mischievous way, as only Austrians can. They would, unlike their mechanical engineering colleagues, sneak around the machines barefoot with long hair and a pizza slice in their shirt pocket, trying to control stepper motors. From his point of view, computer scientists could contribute nothing to creating a great milling machine. Even if you didn't agree with him, it was clear that computer scientists thought differently and followed different conventions – just like their subject matter.

Of course, these were the early days, when companies' computer scientists were literally forced to work in dark basements. These individuals and teams were mainly, if not only, concerned with databases, networks, printers, and accounting software. A lot has changed since.

To this day, I observe that in many companies the representatives of the physical world and those of the digital world are still highly skeptical of each other.

Understanding Products as Services: How the Internet and AI are Transforming Product Companies, 3–13

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In many cases, one group thinks its world is more important than the other's world. One group often thinks it can simply manage the other. Or one group might think the other's world has little relevance and hence can be ignored.

An incident that I experienced in 2015 illustrates this phenomenon. I was invited to a meeting with the CFO of a leading German automobile manufacturer who was also responsible for corporate IT. Our conversation was going to be incorporated and published in the next annual report. I was on my way, along with the CFO, to where the meeting was going to take place. An in-house data center had been suggested, but fortunately, they accepted my request that we meet closer to where we could see and touch the cars. I found the CFO to be extremely likeable and I asked him when he thought their head of R&D would be a computer scientist. My counterpart ran his hand thoughtfully over the interior paneling of the luxury car. He began talking about how much knowledge of materials, production, and processing went into that one interior panel alone. His answer to my question was clear: never.

In many similar companies, the names of those involved have changed, but the question remains: When will the physical and digital world be treated equally? This question is not intended to create the impression that the digital world is more important than the physical one. These worlds are of equal merit and equal importance. And when this isn't the case, the customer determines which one is superior.

The Layer Model

In our work over the past 20 years, we have studied, evaluated, and developed hundreds of solutions that derive their customer value proposition, their unique selling point, from a combination of hardware and software. In the early years, we glued minicomputers to all kinds of objects in our research labs at ETH Zurich and the University of St. Gallen (HSG). We did this partly out of sheer technical fascination. Our experiments ran the gamut from Bob the Builder toy drills to radiator valves, wafer boxes for chip plants, and blister packs used by the pharmaceutical industry.

We learned a lot during these years. For example, although the technology-push approach generates many interesting ideas, most of them fail due to one or more of the following three challenges. First, customer value is missing. Which function, or which service, is a customer willing to pay for? Too often, this question isn't answered. Second, the envisioned solution is not technically feasible. The killer arguments here are usually robustness and sustainable energy consumption. Classical digital solutions, for example, demand a power outlet and Wi-Fi access. Third, and finally, even if a solution generates customer value and is technically feasible, it often does not make economic sense. It lacks viability and the costs simply outweigh the benefits. Often, a single company must bear the majority of the costs, while many companies along the value chain benefit from the solution. In such a situation, costs and benefits are not equally distributed among the actors. For example, if a consumer goods manufacturer equips all its products with RFID tags, it bears the costs. The benefits of the tags, meanwhile, are distributed among logistics providers, wholesalers, retailers, and end customers. Hence,

even if the overall business case looks promising, it might not be compelling for all actors that need to be involved.

Understanding where customer value emerges requires disentangling the intertwining benefits provided by digital and physical offerings. To do this, we developed a layer model (Fig. 1) in 2014. On the left of the model is the technology stack, with the physical world (hardware) at the bottom and the digital world (software) at the top. The right side of the model shows the customer value.

Let's start with the familiar: hardware. Layer 1 consists of the physical object that delivers physical benefits. For example, the shelf, the crate, or the bicycle. This layer consists entirely of atoms and molecules. It contains no bits or bytes. Already in 1999, I learned from Kevin Kelly's visionary *New Rules for the New Economy* that what cannot assume different states and react to the environment will soon be perceived as dull and dead. A purely physical transportation crate doesn't respond to anything. At most, it and its contents break if you drop them; or the contents lose value if you misplace the box. The dull box cannot perceive or process any of these events. It knows neither when nor where an accident has happened, nor can it communicate this information to anyone or anything else.

Layer 2 of the hardware stack is perception or sensor technology. Here, the object is equipped with senses that enable it to recognize its own state (e.g., it might know the rate of acceleration it is experiencing, its position, or its operating state) and that of its environment (e.g., temperature, brightness, and distance to next object) in such a way that it can drive beneficial actions over its lifetime. What these actions and benefits might turn out to be is difficult to determine at the time of development and production. For this reason, more and more manufacturers are equipping products with additional sensors that might not even be used when the product is first brought to market. Manufacturers hope that this will give them the opportunity to implement use cases later, thereby realizing long-term benefits. Similar to the growing importance of sensor technology, computing and memory components embedded in the product as well as additional actuators (components

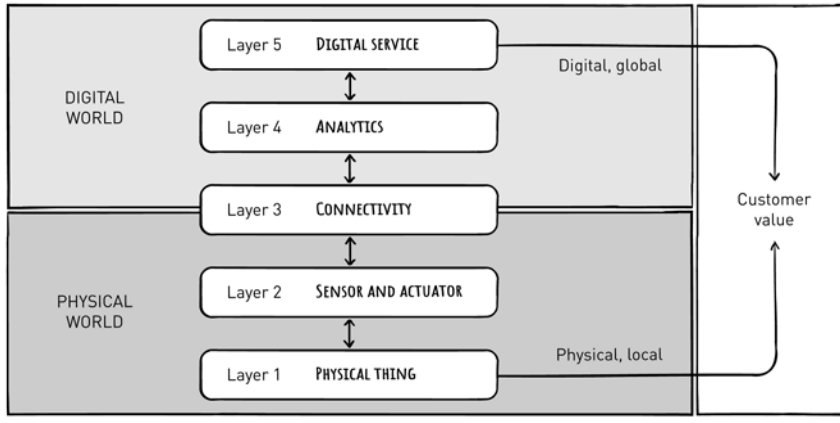

Fig. 1. The Layer Model.

performing an action instead of sensing) are becoming more relevant. Sensors and embedded components do not always need to be installed during the initial production process. They might also be retrofitted (attached to a product later) as part of a newly developed service, such as preventive maintenance.

As a rule, sensor information creates more value when it is part of a broader digital service. This rationale is addressed by the connectivity layer (layer 3), which connects the physical and digital worlds. It enables the digitally enhanced object, often referred to as a smart object, to contact the outside world, announce its changes in state, and receive requests, instructions, and software updates. The engineering aims at maximizing robustness and minimizing energy consumption over the product's life cycle. Finally, it is about maximizing customer benefits while considering production costs, maintenance costs (e.g., the cost of replacing batteries), uptime, and future viability.

At this point in the layer model, our thinking moves from the physical to the digital. These worlds differ substantially in their technical and economic foundations, as we will discuss later. The analytics layer (layer 5) checks the plausibility and completeness of the data received. It substantiates these data using business semantics, breaks them down into time series, calculates features that have already been tried and tested, looks for unusual patterns, suggests interventions, and improves itself based on the gathered data (self-learning system). The analytics layer thereby contributes to the product's value proposition through a digital smart service (layer 6). It's at levels 5 and 6 that the power of machine learning and AI comes into play.

The Rule of Thumb

Only layer 1, the physical product, and layer 6, the digital service, are tangible for customers. Together, these layers generate a hybrid value proposition that combines the characteristics of both worlds. A smart LED light with built-in sensor technology, for example, not only provides light but can also detect moving objects. This information can be used to control the lighting, heating, or alarm system. Hybrid value derives from the physical product (e.g., a pleasant lighting) and from the digital services (e.g., cost savings and quality gains from fine-grained optimization of lighting, heating, cleaning, and security). Thus, the following formula has emerged from the stack model:

$$\text{Thing} + \text{IT} = \text{Thing-based function} + \text{IT-based (smart) service}$$

This formula describes what we see in numerous examples. A drilling machine plus IoT technology extends the direct benefits of drilling to those of fleet management. A vehicle plus IoT technology extends the direct benefits of the vehicle (the ability to move people and things from one place to another) to include driver assistance, navigation, and entertainment systems. A wind turbine plus IoT technology extends the benefits of the turbine to include optimization of power generation and reduction of potential downtime. A machine tool plus IoT technology extends the benefit of the machine to include timely detection of potential malfunctions and better, faster troubleshooting.

From Moon and Mars

It's almost like in the fine arts: What appears almost naturally coherent and therefore appealing is usually anything but easy to design and produce. In the field of connected products, there is a deeper reason for this phenomenon, which I want to discuss now. Hybrids combine two worlds (physical and digital). But these worlds could hardly be more different. And yet, the aim is to create a harmonious solution for the customer. To understand this challenge, let's delve into the obvious differences between the physical and digital worlds.

The speed at which the logistics industry transports a container by sea from Singapore to Bremen is slow, averaging 36 kilometers per hour. Or at least it's slow compared to the speed at which information about that container is transmitted. Here, we are moving in orders of magnitude of the speed of light. The container is also heavy and takes up a lot of space. Its digital twin – that is, the digital representation of the physical container (e.g., including the information where the container is currently located) – weighs nothing and barely requires any storage space. Once I have sold the container, it no longer belongs to me, but to my customer. When the container is shipped, I no longer have physical access to the container. However, the digital information about the container remains with me, and I can multiply it as often as I want. Physically inspecting a container is time-consuming. I have to go to the container's location. Also, access to the container is limited. Spatial restrictions mean that the container can only be inspected by a very limited number of people at the same time. The digital world removes many of these limitations. Hundreds of thousands of people can access a piece of information at the same time, and well-established search algorithms foster information access.

In the physical world, real-life simulations are costly and therefore rare. They are often limited to military exercises and preparations for emergencies. In contrast, running millions of simulations on digital models is an everyday practice in many industries. Unlike the digital world, the physical world has no undo button (e.g., to recover severely damaged objects).

Marginal Costs of Production and Distribution

Among the most important economic differences between the physical and digital worlds are the marginal costs of production and distribution. The marginal costs of production are those costs that arise when an additional item is produced in an existing production facility. In the physical world, these marginal costs often determine whether a company succeeds or fails. In the digital world, they are most often negligible because they are practically zero.

This explains why so-called freemium business models became so popular with the emergence of the internet. In the freemium model, a basic digital service is offered free of charge, with the aim of converting customers to a paid premium service. While a free service only incurs costs, a premium service generates revenues. Customers recognize the benefits of the premium service and are willing to pay for it. In the physical world, the cost of a freemium model would quickly become prohibitive.

The same reasoning applies to distribution costs. The costs of distributing digital content are negligible compared to distribution costs in the physical world. The internet enables providing digital services to every customer, consumer, patient, student, employee, and citizen at virtually zero cost.

Update Capability

When a product leaves the manufacturer's loading dock, it disappears into a black hole from the manufacturer's perspective. The manufacturer knows neither where nor how the product is used, nor by whom. Problems with product quality might lead to costly product revisions or recalls, with the latter requiring the company to somehow identify entire production batches among existing customers. For this reason, manufacturing companies pay great attention to product quality. The smallest quality failure can threaten a company's existence. Thus, R&D processes, production processes, and quality management are designed accordingly. What counts is quality, not speed. Put differently: quality over speed.

In the age of the internet, software is online, which means it can be updated at negligible marginal cost. Users, moreover, are usually identifiable or at least addressable. If the software or the user reports an error, the development department can immediately fix the code and push the changes into the operational system. There are no recalls, just learning cycles. Today, this process works so smoothly that it has become an innovative method. As a software company, I provide my customers with an initial, minimum viable software product, and I am constantly learning from daily customer feedback. A software entrepreneur friend of mine once told me: "If you're not a little ashamed of the first release in retrospect, then you were too slow." In the minimal viable product mindset, speed counts, not quality. Put differently: speed over quality.

Usage Data

Physical products incapable of generating data cannot collect usage data. Software that is delivered over the internet is exactly the opposite. Usage data that describe how a person uses a piece of software is collected, stored, and processed in the software provider's cloud. The same applies to user data. These are the data with which the software customer works (e.g., accounting documents, presentations, or product master data). Even though the terms might be confusingly similar, these two types of data should not be confused. In Software as a Service models, user data are also stored on the vendor's cloud but are not visible to the vendor. The software customer grants the software manufacturer access to the usage data – either explicitly or implicitly.

If a crane manufacturer sells a physical crane without connectivity, they cannot easily learn about how their cranes are used. How many hours is a crane operating a day? How often are the various crane lifting modes employed? What loads are lifted and what speeds are chosen? What distances are covered and how frequently? Is the maximum load exceeded now and then? If so, only marginally or significantly? Which controls are used most often? Which error messages appear most frequently? Which help messages are most effective?