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Design of Product–Service Systems: Toward an Updated Discourse

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Received: 26 October 2020; Accepted: 9 November 2020; Published: 11 November 2020

Abstract: The engineering rationale, composed of established logic for the design and development of products, has been confronted by a shift to a circular economy. Digitalization (e.g., Industry 4.0) enables transformation, but it also increases relational complexities in scope and number. In Product–Service Systems (PSSs), the combination of manufactured goods and services should be delivered in new business models based on value-adding digital assistance. From a systems science view, such combinations cannot be managed by the same approach as if they were one uniform system; rather, it is an interdependent mix of technical, social, and digital designs. This paper initializes an updated conceptual discourse on PSSs and provides a reflection on the expected challenges in the transformation from linear to circular models. For example, the role of systems thinking to guide early design stages is discussed and the importance of processes for creating shared visions at different systems levels is suggested to be addressed in future research. The intention is to formulate thoughts about radical cognitive changes in order to realize the PSS paradigm.

Keywords: product–service systems; Industry 4.0; circular economy; digital services; innovation; socio-technical systems; digitalization

1. Introduction

The idea of manufactured goods as the main, and sometimes the only, value carrier for customers is predominant in product design and development literature for engineers (e.g., [1]). So far, such literature has been utterly useful, while today's digitalization confronts this type of product development tradition. Digitalization transforms our society and brings consequences, not only on how products are produced and consumed, but also on how development work is organized. Shifts in industry—from early industrialization with steam power and mechanization to electrical energy and mass production, then further to automation and electronics, and now to the turn into Industry 4.0 with the Internet of Things and networks—have never had such an impact on society and human life as it has today. This is due to the fact that the locations of factories have become less important since digitalization enables disconnection between physical locations, and that global supply chains have become more crucial (as the pandemic has shown us) [2]. Industry 4.0 goes beyond in-house automation to bring about societal interconnectedness, where customers share their user data with companies and companies create businesses from that data. Product–service systems (PSSs) emerged as a response to make both production and consumption sustainable. For example, reducing waste by reusing, remanufacturing, or repairing [3]is in line with the contemporary recommendation of a circular economy to guide sustainable development.

PSSs also promote a shift in engineering design, from making and selling products to the co-creation of value, which is offered in business models grounded in servitization. This transformation is cognitively not straightforward to achieve. PSSs are initially described as "the result of an innovation strategy" [4]. It is important to understand that the experiences and assumptions among and across development teams lead the work in any given direction; that is, the problem is identified based on their interpretations and they define the solutions that would solve the problem. It has been concluded in previous studies that engineers find team and customer collaborations to be the main concern, while the technical problem can always be solved [5]. The social and collaborative aspects of development are described as soft questions and are therefore perhaps given less attention, thus being often shallowly addressed from start. At worst, the design approach can be driven by hidden assumptions about the product as a standalone manufactured thing, thus leading to the same product as always, just a bit better than the previous one. Kaner et al. [6] describe this as "business-as-usual", where a team just elaborates on familiar options and does not spend enough time seeking peripheral inspiration or elaborating on divergent alternatives. Basically, since they deploy the usual development rationale, they jump to conclusions, or to the idea of a particular product, too soon.

Innovation is central in the PSS paradigm for manufacturing firms. Accordingly, PSSs impose a shift in mindset in early design and concept development. Goedkoop et al. [7], for example, highlight that PSS customers buy value and that the "system" will bring more sustainable alternatives by novel combinations [8]. Furthermore, it is suggested that PSS urges both radical and open innovation to realize a need-driven, user-oriented development [9]. PSSs and new business models have been discussed previously as a possible pathway that highlights cooperation not restricted to traditional value chains [10], also including other stakeholders and strategic alliances that may hold sustainability benefits. However, this research is lacking a "system" perspective. Novel solutions are supposed to be created by joining resources and by collaborating in a larger system context. In simple terms, the system is going to become more than the sum of its parts. In this context, it is important to understand and manage relational and social complexity while simultaneously solving technical problems. The PSS paradigm prescribes socio-technical mixes of products and services as the main resources to build a "system". The "system" part thus seems to convey important knowledge for the transformation. However, limited research addresses such a system point of view. Digitalization and PSSs also shape not only technical features but also new aspects for digital tools and systems analysis. The tools for designing physical/technical products have been deployed over time, but new tools and approaches are needed to support the design of PSS solutions [11]. This paper aims to investigate the PSS paradigm in light of the circular economy and digitalization, hence also addressing the idea of a "system". This is done to contribute an updated conceptual discourse of PSS design and to initialize reflection on the expected challenges that may hinder implementation.

The presented study is conceptual and builds on existing literature, yet is not a comprehensive literature review. The main parts are grounded in our own previous empirical industrial research. The motivation for choosing such an approach is that new concepts have appeared and been established since we first undertook PSS research in 2000. Importantly, over this time period, digitalization has matured and new technologies have gone from being a trend to being everyday support.

In the subsequent parts, the concepts found as essential for our discussion are described. Some of the descriptions are, at least in our view, very basic for each concept but need to be made explicit if the discussed challenges are going to be comprehended. The included concepts are presented under the subheadings "Digitalization and Digital Services", "Industry 4.0", "Circular Economy", and "Systems Thinking". The descriptions serve as a theoretical background. It should also be noted that the descriptions may look like polarization; this is intentional as it helps in understanding the basic reasoning for each position. The closing discussion then puts those concepts into the context of PSSs and concludes with the challenges that can be foreseen from the described background.

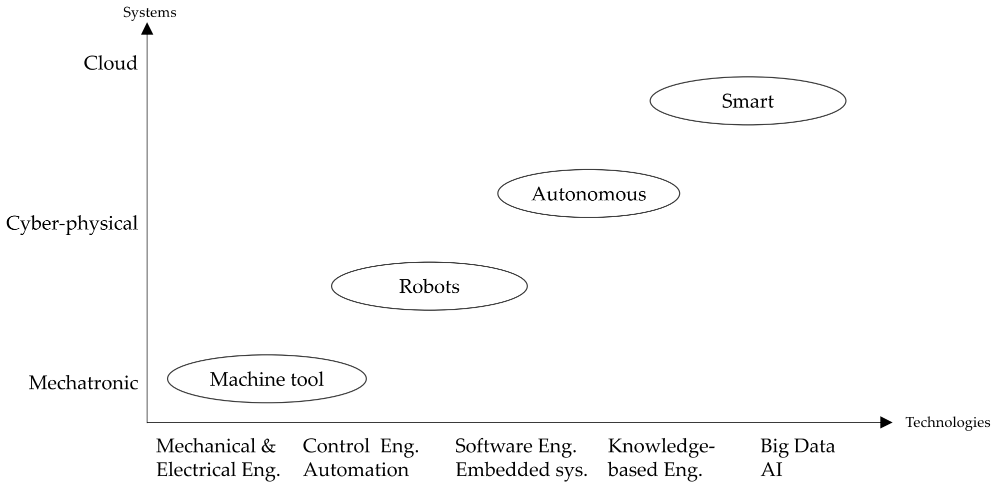
2. Digitalization and Digital Services

Digitalization and digitization are sometimes used interchangeably, but they convey two different degrees of transformation. *Digit*ization is the process of converting analog information or documents to digital bits. *Digital*ization, which is the focus here, denotes the way almost all domains of social and business life are reorganized by the implementation of digital technologies (e.g., [12]). Parviainen et al. [13] provide an example that describes how turning a reporting form into an electronic format to replace a paper format is digitization. Restructuring the whole process as a digital procedure is digitalization, from submitting the form to the organization of receiving and processing it, to the measures of sending back information or decisions. Thus, digitalization is often described as a digital transformation that alters the situations that companies and organizations operate in. From an information system/information technology perspective, digitalization brings about changes at the process level (e.g., new tools), the organizational level (e.g., new services, or old ones in a new way), the business level (e.g., changed or new roles in the value chain, changed customer relationships), and at the society level (e.g., types of work, decision-making) [13]. Yet the description as a transformation or change gives the impression of a smooth progression from one structure to another. The intentions often have an initial focus to improve internal efficiency (e.g., [13]) but, in fact, the impacts of a transformation are afterward discovered to be disruptive to existing procedures, and even make knowledge and skills obsolete while simultaneously also providing new unforeseen internal and external opportunities. Parviainen et al. [13] suggest an approach for organizations to review the current state and to formalize a roadmap before implementing digital tools, concepts, processes, and technologies. The power of their suggested model is the question-driven procedure, as it provides discussions of a gap between the current state and the anticipated future state; that is, it investigates assumptions and makes unspoken expectations of a novel situation explicit. Drawbacks of fixed models that provide "right" answers are, for example, that digital transformations often have stepwise progress and advance by one procedure at a time, often starting with "simple" digitization that leads to more advanced digitalized operations. In addition, a second issue is that the implementation of a plan cannot be finite since the environment is in a flux of change, with versions of technologies being outdated and new ones being introduced.

Kane et al. [14] conclude that a digital strategy and the ability to digitalize with "an eye on transforming the business" is an important factor. They suggest that becoming comfortable in taking risks must be incorporated into the organization's culture. By this, they pinpoint that learning from failures leads to success. Kane et al. [14] also discuss the importance of digital leaders, those who foster collaboration and creativity. They conclude that the digital transformation is not about technologies but building strategies to manage the blurry difference between online and offline worlds.

From an engineering point of view, digitalization is presented in terms of computational elements and products—what can be conceptualized as cyber-physical systems. The Internet of Things (IoT), for example, are products with embedded sensors, software, and data exchanges via the Internet, that enable customer/developer interactions through the use of the digital service. Autonomous, self-driving vehicles and smart grids that can control the distribution of electricity are other examples of digitalization from an engineering point of view. Inherent in the engineering perspective is the use of advanced and smart manufacturing processes, making the development and production processes digitalized.

In Figure 1, the progress from mechatronic systems to cloud systems is described by their areas of application, for example, mechatronics in machine tools and the use of robots. At the cyber-physical level and the cloud system level, digitalization goes outside production plants and beyond traditional engineering fields.



[15].

The suggested technologies, at the bottom of Figure 1, indicate the socio-technical shift in engineering (Eng.), for example, from mechanical/electrical engineering to knowledge-based engineering. Automation can be described as an intention to reduce internal costs by removing expensive labor from the production processes; an interest in covering all processes of design, development, and manufacturing, as well as financial control, marketing, and logistics in product development, is described in relation to the digitalization of the engineering context (e.g., [15]). As a consequence, the areas of applications for engineering have widened beyond traditional manufacturing, as, for example, with healthcare and societal services. It is suggested that the contemporary knowledge-based economies, due to the increased use of digitalization, must redefine the nature of systems, the role of people in the processes, and redefining design and development processes due to system complexity [15]. Seen in this perspective, digitalization within engineering design describes a disruptive and radical challenge for the core competencies, also incorporating the design and development of services.

A digital service is a service provided through the Internet or an online channel. Thus, it must also be described by the elements of a conventional service. Some describe service as an activity, while a more appropriate description is, according to Grönroos [16] "…to facilitate and support another party's practices (processes, activities; physical, mental) in a way that helps this other party achieve its goals in life or business". A digital service can be provided and accessed on different types of platforms (e.g., laptops, smartphones, tablets). A mobile application is critical for many consumers of IoT, for example, a bathroom scale that calculates body mass, muscles, etc., or a training watch that measures heart rate and blood pressure. Additionally, the customer experience of the physical thing depends on how they experience the digital service, that is, the usability of the mobile application. Service design includes both front office and back office elements. The front office is, in the case of a digital service, the online interface with which customers interact, and the back office is, for example, the programming, interface design, and/or, all the traditional services required to execute the service. For example, online shopping uses a software application for ordering, while service personnel have to package and deliver the items. Yet, there are also fully digital services, as, for example, asking for directions via a GPS.

From this background, it can be discerned that digitalization progresses within each traditional position and not on a product–service system level. Nevertheless, digitalization has impacts across societal levels that reach beyond the horizon of each individual discipline. Furthermore, the introduction of new technologies pushes digitalization in given directions. The technology push also happens at a higher pace, compared with the organizations' or companies' ability to include them into a digital strategy or roadmap for PSSs, or even to match them to the existing technological equipment. The research on both engineering and information management is concerned with digital service development, but for different reasons. The information field focuses on services to support users, often citizens or governmental agencies. The engineering field focuses on services to support their products, which are used by customers, consumers, or other businesses. However, different perspectives, including these two and more, need to collaborate to understand and solve problems related to the digitalization of PSSs, and their subsequent consequences on lives and businesses.

3. Industry 4.0

Industry 4.0 describes itself as a digital transformation that builds on previous industrial revolutions; hence, it also inherits reasoning from its history. For example, the second industrial revolution enabled mass production, and coined the better, cheaper, faster paradigm; the third revolution is described as the era of computers, computing, and automation. The fourth revolution, in which Industry 4.0 is a key driver, is foreseen to change the very essence of human life, how we do things, how we work and do business [17]. In line with this, Industry 4.0 can be described as "smartness-ization" of the design, production, and distribution processes, and in the outputs of products and services. Thus, it is expected to become more than the mere digitalization of procedures. Digitalization, as described above and in previous research (e.g., Figure 1), shows that there is a movement in manufacturing industries that goes from the infrastructure of physical products to the provision of added value and service functionalities to their customers. Cross-fertilization between technologies has been suggested to foster development of cyber-physical systems, and such transitions will have an impact on the necessary engineering skills, and will subsequently also change the perspective on development [18]. IoT technologies support manufacturing companies to deploy new applications towards Industry 4.0 in such systems of systems and progress automation of traditional industrial practices.

The computerization, or digitalization, in the third revolution can be described as large, point-by-point investments, while Industry 4.0 is a total and massive implementation across all parts and places [19]. Industry 4.0 is suggested to make the business world equal since success will be independent of company size, under the condition that the necessary capabilities can be incorporated into strategy and business [19].

The smart objects industry, or Industry 4.0, includes the vision of value propositions in the form of smart services, anytime, anywhere [20]. Lasi et al. [21] concluded that the driving forces are a combination of application-pull, and technology-push. The fundamental concepts for Industry 4.0 are smart factories (e.g., sensors and autonomous systems), cyber-physical systems (e.g., systems of systems), self-organization, individualized distribution, individualized product–service development, and the support of human behavior, rather than humans having to adapt to solutions. Lasi et al. [21], also conclude on the central traits of Industry 4.0 (p. 239):

- Time to market will be shorter.
- Individualization on demand, or batch size of one, will be economically doable.
- Agility, or flexibility, in product development will be supported.
- Decentralization, speeding up decision-making.
- Economic and ecologically sustainable development by the transformation of industrial-age production and processes into information- and knowledge-oriented ones.

These traits are also interpreted as driving forces for new PSS business models that also change in the development logic. New technologies and innovation often push for the implementation or redesign of business models, also calling for new external knowledge to be incorporated into the internal activities [22]. Information- and knowledge-oriented logic means that it starts with data/information, which is integrated into applications (processes, products, services, and so on), and, all in all, leads to a data-driven business strategy. This is in opposition to a focus on the products, that is, a business strategy that focuses on certain applications that are integrated into the existing processes for which specific data/information is required (e.g., [19]). Figure 2 visualizes three abstraction levels that describe that the physical world (at the bottom) can be represented in a digital one (i.e., a digital twin at the top), via a digital platform or service (in the middle).

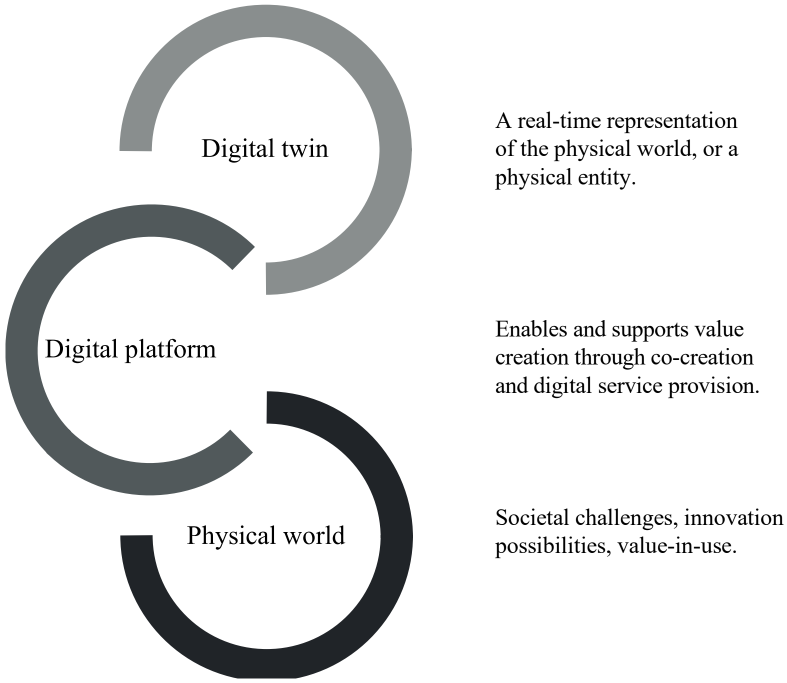


Figure 2. Three abstraction levels for Industry 4.0.

From this description, it can be decided that Industry 4.0 is expected to become an enabler for sustainable development, hence also PSSs, since it allows for the customization of solutions toward individual customers. Thus, it makes it possible to solve a concrete problem for the customer, simultaneously ensuring that precise resources are used for each customer, as opposed to mass-production and heavy marketing campaigns. Industry 4.0 is, from its technology perspective, firmly positioned within the digitalization of PSSs, but it is also connected to the circular economy since it has the capability of transferring data and information from each stage in the loop (e.g., [23]). Therefore, future research is suggested to address Industry 4.0 more evidently in relation to PSSs and the circular economy.

4. Circular Economy

The concept of the circular economy originates from the knowledge that the earth's resources are finite. Consuming and simultaneously generating waste is wrong; instead, closing the loop by reusing and recycling is the way forward. Innovation is thus needed to, for example, prolong life cycles or to increase the use of individual products by servitization. While servitization focuses on adding value to customers in a demand-pull approach, the technology-push approach that is traditionally related to Industry 4.0 intends to create value to the manufacturing process itself [24]. Yet the vision of a circular economy does not rest upon incremental product or service innovations but is rather a reboot of the whole system to redefine how value is generated [23]. Digitalization, smartness, and intelligent assets are enablers for the circular economy's innovation and value creation and are foreseen to radically change products as well as business models. Advanced digital manufacturing technologies assist in enabling circularity and elaborations on novel business strategies for how to use and reuse resources. Such approaches and their link between Industry 4.0 and a circular economy have been suggested to be further explored more in detail [25]. However, going from intentions and ideas to actions and implementation will be demanding. Not only calling for the transformation of companies' development processes but also being truly trans-disciplinary where, for example, private and public actors must cooperate to solve technology, policy, and business issues. Leading such a change is suggested to start with asking useful questions, as questions can convert novel ideas into shared actions. Simultaneously, questions, rather than fixed answers, respond to changed circumstances. Organizing for appropriate enabling conditions in which open collaboration and skills extract value from all stages of a circular process is, therefore, central [23].

Circular development builds on design principles referred to as a number of R's. The 9 R's, for example, [26] suggest the principles of the following:

1. Refuse. Make the product redundant by abandoning its function or by offering the same function by a radically different (e.g., digital) product or service.
2. Rethink. Make the product use more intensive (e.g., through product-as-service or reuse and sharing models, or by putting multi-functional products on the market).
3. Reduce. Increase the efficiency of product manufacturing or use by consuming fewer natural resources and materials.
4. Reuse. Reuse by another consumer a product that is still in good condition and fulfills its original function.
5. Repair. Repair and maintenance of a defective product so it can be used with its original function.
6. Refurbish. Restore an old product and bring it up to date.
7. Remanufacture. Use parts of a discarded product in a new product with the same function.
8. Repurpose. Use a redundant product or its parts in a new product with a different function.
9. Recycle. Process materials to obtain the same or lower quality.

The design principles can be categorized in relation to a cyclical process, which relates to a product's lifecycle. In Figure 3, the early stages of a product development process (upper right section, Figure 3), for example, from planning, idea, and concept generation to detail design, are crucial to ensure that the principles will be incorporated into a solution. Recycling, for example, depends on designing for material separation and reuse. The challenges are also to address a second, and even a third, market.

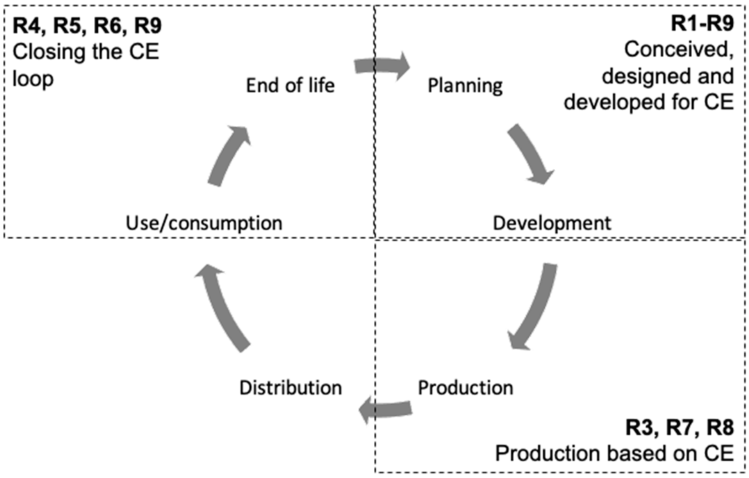


Figure 3. Product lifecycle and circular economy (CE) principles.

The use of fewer natural resources and materials relates directly to production or manufacturing (lower right section, Figure 3), as is also any use of discarded products in new ones, and the repurposing of redundant parts in new ones. The use and end of life stages (upper left) relate to initiatives prolonging the lifecycle, for example, a business model supporting the reuse of products in good condition by another consumer, or contracts for maintenance and repair or refurbishment. In addition, it is important to enable customers to recycle or make it effortless for them to close the loop. The left bottom section of Figure 3 represents distribution and is a challenge for the circular economy. Replacing a product with a digital one reduces the transportation of products, but reusing, repairing, refurbishing, remanufacturing, repurposing, and recycling may increase the need for more transportation, storage, etc., which increases energy consumption and emissions. Distribution, or the complete value chain logistics, seems to be a challenge because offers from manufacturing firms will continuously include physical goods. PSSs and the circular economy propose business models with fewer units in the loop, as, for example, sharing, but this means that the units have to be distributed between customers. There are key points that prescribe the development logic in a circular economy: waste is value, agility, renewable energy, development based on the R-principles, costs and price, and systems thinking. The latter is concluded to guide all the others [23].

From the above description it can be interpreted that there are cognitive challenges in the transformation from the industrial-age linear models—to produce, consume, and to discard as waste—to the suggested closed loop of a circular economy that is the core of PSSs. One key difference between the linear and circular economy is that the whole loop is the industry's/producers' responsibility, that is, the radical change of the whole system [23]. This puts even more pressure on researchers to truly address a larger "system" and elaborate on distinct trans-disciplinary points of view in future studies. The extended responsibility of PSS solutions, in turn, implies that cooperation across companies and organizations, as well as with users and consumers, is inevitable. Thus, this is the main challenge that makes PSSs more complex than traditional product development.

5. Systems Thinking

The expression "systems everywhere" was problematized as a high-listed fashionable catchword already more than 60 years ago in von Bertalanffy's book, *General System Theory* [27], and "system" is still used in everyday language. Yet, from a system scientific perspective, the concept is not just in speaking habits but reinforces how the world is understood. Checkland [28] describes how the first department of systems engineering at Lancaster University, UK, was developed in the mid-1960s. This was done as a reaction to the opinion that "academics" were more often than not used to convey that something was "…unrelated to the rough and tumble of practical affairs". (p. S13). The name Systems Engineering, they thought, did convey that both analyses and to "engineer" something were integrated. Yet the engineering approaches at that time did impose a technical view also on the social parts of engineering.

Soft systems methodology [28] originated as a response to such a technical perspective; instead, the methodology prescribed a socio-technical approach to understand real-world actions and to propose improvements in design and development activities. Today, modern systems engineering promotes a socio-technical view, acknowledges multiple views, and considers human actions [29]. However, systems thinking may still focus on engineered systems, which are, in turn, described as systems that have a defined purpose, are created to achieve a goal or a mission, and comprise engineered hardware, software, people, services, or a combination thereof [29]. Checkland's work [28] contributed to differentiate between closed/hard and open/soft systems as a better ground to understand socio-technical systems. It should be noted, however, that neither of the standpoints is better than the other; they are just different. Closed/hard systems thinking sees occurrences in the world as having a clear (hard) system boundary, that is, something *is* a system, since it, for example, is easy to see what is a car, what is the road, and how the car is different from the road. Thus, because we can see and touch it, we can say that the car is a technical system that *exists* in the world. As engineers, we can say that these systems are technically complex, but their problems can be identified and fixed. Open/soft systems thinking, instead, represents people taking actions. There are no clear or visible boundaries for the actions by which people try to investigate and ease real-world situations; thus, *the process of inquiry* has to be systemic, that is, having system-like characteristics, and can only be perceived as a system [28]. Agreeing on what actually constitutes the problem is often a problem in human activity systems because people are active agents who perceive and interpret situations differently [27,28,30]. The systemic inquiry helps people to understand ill-defined or wicked problems, that is, situations that have useful or meaningful questions, but there are many alternatives, answers, and solutions. Hence, the inquiry instead creates shared meanings to learn about problems and their alternative resolutions. Describing something as a "socio-technical view" can lead to an interpretation that the hyphen means that they together become one concept, and accordingly can be managed in the same way. This is a dilemma. The "socio" part must manage sense-making, while the "technical" part refers to problem-solving. Thus, they are different types of systems with different expectations on the outcome of the activities. The future of engineering design is suggested as even more in need of systems thinking to address a larger system context to manage the system context [31]. Yet, from the above description, the main challenge is to understand what constitutes the larger system, especially when confronted with a fundamental value shift, as in the transition to a PSS. Furthermore, it has been concluded that the established socio-technical view in engineering is challenged by PSSs [32], so there is a need for future research to investigate which kind of new logic would drive the design of PSSs.

6. Product–Service Systems: Toward an Updated Discourse

Stepping back momentarily, the early debate regarding product–service systems (PSSs) has been on the issues of what is a product and what is a service, discussed in the contemporary digitalization era's even more confusing terms of "hardware" and "software" combinations (e.g., [33]). Yet the debate has led to the understanding that products are different from services, or more precisely, that manufactured things are different from activities, processes, or facilitation to support another party in some way [16]. Grönroos [34] (p. 47) distinguished the main attributes that separated products and services, and consequently also provided insights into different reasonings in the development of activities (see Table 1).

Table 1. Distinctions between engineered products and services.

Products	Services
Tangible	Intangible
Production and distribution separated from consumption	Production, distribution, and consumption simultaneous
Core value produced in factory	Core value produced in interactions
Transfer of ownership	No transfer of ownership

The product–service part in the PSS concept is problematic; that is, the "hyphen problem" described for the socio-technical view above is repeated. In the end, leave us with nothing else than a product and add-on services. Let us conclude that products are not services in the context of PSS design. The distinction makes it possible to suggest that combinations would bring something new at a system level. It should be mentioned that PSS is written in numerous ways, for example, as "product service system", "product/service system", or as other variations, like "integrated product service engineering", or "integrated product service offering". Any way it is written, combining two known concepts with the intention to describe a major transformation at all levels of development is a grand challenge. PSS was introduced as a transition from the dominant goods paradigm or from what is described today as "linear development models" to sustainable circular models delivering functionality to its customers (e.g., [4]). In this context, a paradigm shift imposes a fundamental shift in what would be the output of engineering design activities or, to paraphrase Kuhn's [35] explanation of a shift in simple words, since the established logic has put us into unsustainable production and consumption, we cannot find new solutions in how we used to think. Several PSS researchers try to manage a new way of thinking by stressing novel business models. Tukker et al. [36], for example, suggest three types of PSS business models: (1) product-oriented, where services are added onto the offer to support the use of the product; (2) use-oriented, where access to fewer products are given by leasing, sharing, or pooling; and (3) result-oriented, which is the ideal PSS business model, where the functionality of a given solution is billed based on how often and how it operates in the customers' businesses. PSSs hence propose a functional economy [32] as a basis for sustainability; this is also in line with the root cause of the circular economy [26]. Additionally, seen from this view, turning to service-dominant logic will not be sufficient, thus it is suggested here that future research addresses a more radical change of approaches.

Kuhn [35] also discusses that a paradigm shift causes actors to modify, often irreversibly, their worldview. Checkland [28] proposes to investigate in-depth what kind of assumptions build up a worldview. Thus, he introduces the idea of Weltanschauung, that is, to identify a perspective or a viewpoint for each purposeful activity, such as, for example, answering what kind of change is wished for, for whom, and whether or not there are conflicting views that hinder implementation at a system level. Altman and Linder [37] describe that different value logic or worldviews create misalignments in a servitization efforts among collaborating companies. Worldview elaborations may thus be one way to address the missing vision for the transformation of a larger system context, which would integrate Industry 4.0 and PSS rather than managing them as separate or combined entities. Conflicting worldviews may also give direct indications of implementation barriers for an envisioned system, and to help the formalization of a vision that does not impose the status quo consisting of existing products and services. The status quo will be sustained as long as products and services are traditionally developed. In sum, the Meta System level answers the question "which systemic transformation fulfills the purpose of the shared vision?" (see Figure 4, Meta System level). Bengtsson and Kock [38] have introduced the concept of 'coopetition' to describe the complexity of networks of collaborating and simultaneously competing companies. They suggest that the proximity to the end customer matters; for example, two companies that directly address the same customer by their core business is competition, while it is possible to manage the closeness to the customer by repositioning one company to deliver new knowledge or solutions in the collaborative network. A circular economy, the Mesa Loop level in the middle of Figure 4, calls for extensive but complex networks of companies and organizations, thus resources and knowledge have to be repositioned in relation to the kind of network collaborations that will realize the purposeful PSS meta system. Thus, as opposed to supply chains, these networks are likely to be flexible and dynamic, that is, agile. At a Micro Actor level (the bottom of Figure 4), actors or companies need to identify the fundamental problem at the customer place and formalize it into a job statement that is a construct capturing which kind of processes and activities the customers are trying to achieve [39], that is, what should be facilitated or supported, according to Grönroos [16]. Enabling a functional economy might be better off not focusing on customer needs because there is a high risk of a biased view only incorporating the needs related to an existing product. Thus, a functional economy should focus on understanding the functions of an existing product rather than the actual functions that would fulfill the customer's jobs; for example, the need for transport is provided by a car or a taxi, while the function of 'being there' can also be solved by online participation. The Micro level practices systems thinking to incorporate the upper recursive levels, that is, Meta and Mesa, into innovation activities. By this conceptual design, the early stages of development will also include the design at a system level.

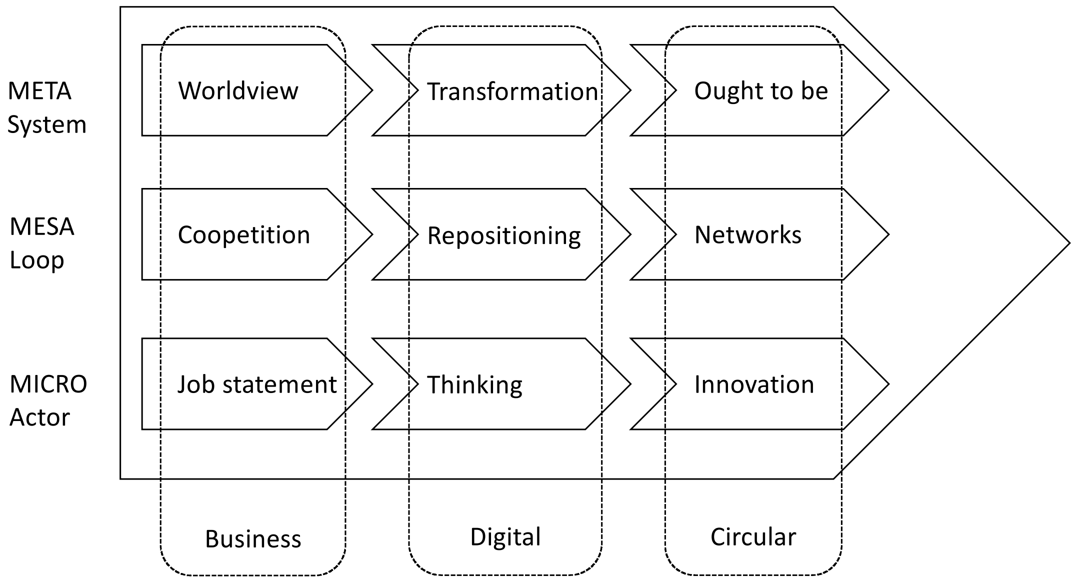


Figure 4. Toward an updated discourse in PSS Design.

The vertical and dashed boxes, or knowledge "silos", in Figure 4 describe a product-oriented view. The first left silo lays the foundation for a traditional business model, and thus decides which solutions in terms of products and services should be designed. The design and development of traditional products and services are supported by digital technologies (middle), and the process is assumed to lead to circular and sustainable development. This does not work well to change the situation or a larger system. Traditional solutions can be designed and implemented as, albeit innovative, combinations of existing products and services. What make PSSs specific is that the goal is to push through a system change; that is, all levels and parts must be considered, and sometimes also reconsidered, to change both production and consumption systems.

The importance to extend the PSS design discourse to incorporate systems thinking and understanding of recursive and interacting systems can be highlighted by the literature review by Reim et al. [40]. They found that the strategy suggested in research to increase service offers could be categorized into five types of practical tactics: contracts, marketing, product and service design, sustainability, and networks. In addition, they concluded that all of the tactics were influenced or dominated by product or service providers [40]. This indicates that design and development efforts revolve around a traditional product or service lifecycle, more or less, making existing solutions better, stepwise, but not supporting radical change. In sum, fulfilling the needs and requirements pointed out by customers may lead to supporting the current behavior. Instead, exploring sustainable visions, breaking them down into opportunities for changed behavior, and providing facilitating solutions might lead to better uptake of transformation toward circularity.

7. Concluding Remarks

This paper started with the purpose of conducting a conceptual study of the PSS paradigm in light of the circular economy and digitalization to address a "system" point of view. With the intention to update the discourse, the paper has revisited the original vision of PSSs and presented a background of digitalization, digital services, Industry 4.0, a circular economy, and systems thinking. Despite the promising visions of digitalization and a circular economy to progress sustainable development, and thus also PSSs, we find that examples of game-changing businesses are limited. In the perspective presented here, it can be traced that the rationale for each vision builds on or inherits an established view of engineering design and development. Accordingly, for example, Industry 4.0 may push us in the same direction to the over-consumption of products as before, just more digitalized ones. An established view in which the value resides in things, products, or services, rather than in the efforts to fulfill supporting functions of a customer's processes, hinders the implementation of PSSs.

The combination of products and services in PSSs risks being interpreted in the design and development stages as a traditional product supported by traditional services. This may happen if there is no reflection on what kind of systemic changes a combination or innovation effort should support. Systems thinking may support developers to start concept design at a larger system context level, that is, to identify a lack of a solution for a certain function that drives a change in consumer behavior.

It is important to understand that people put meaning into the words they use; words are not used randomly. Thus, rethinking the meaning of products and services in the light of Industry 4.0 and digitalization is also important. Assigning the same meanings for a term is positive for rational decision-making and the backbone of optimized processes. However, for the early stages of circular models like PSSs, the creative power is in the elaborations on inconsistent terminology, the results of which should be tested as different systemic alternatives. This could drive new, innovative, and hopefully, more sustainable solutions. The terminology works like tools for a design team to describe what could be done. The objective is to create operational definitions to progress innovation in each case; it is not to settle on absolute definitions because that will lead to minor adaptations. Therefore, it is important to apply systems thinking to develop better approaches for building new shared visions at different system levels in early design. Furthermore, we need to make each perspective transparent to identify and jointly solve the sustainability challenge.

Suggestion for Future Research

This article had the intention to formulate thoughts about cognitive radical changes in order to realize the PSS paradigm and progress a new discourse. We have proposed that understanding similarities and differences in and between stakeholders' visions is important and that worldviews adapted from systems thinking methodologies could benefit from the design of such a model. Investigations to combine traditional products and services will not be enough; instead, integrating larger system elaborations into Industry 4.0 technologies and digitalization have been proposed here as beneficial for the realization of PSSs. Research on these kinds of challenges is limited, so we suggest that future research strives to investigate PSSs at a system-level transformation, as opposed to product and service micro levels.

Author Contributions: Conceptualization J.L. and A.E.; Investigation J.L., A.E., T.L.; Project administration, A.E., T.L.; Resources, J.L., A.E., T.L.; Writing original draft J.L., A.E. and T.L. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by The Kamprad Family Foundation for Entrepreneurship, Research & Charity at Luleå University of Technology, and The Knowledge Foundation in Sweden Through the Model-Driven Development and Decision Support+ (MD3S+) research profile at Blekinge Institute of Technology.

Conflicts of Interest: The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

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